Steps to the Discovery of Electro-Nuclear Collapse

----- Collected Papers (1989-1999) -----

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For the Victims during the Earthquakes
of Okushiri in 1993 and Hanshin-Awaji in 1995

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Preface

Far in the universe, nuclear collapses very often take place by the gravitational force after stars consume their fuel. Since the electromagnetic force is about 40 orders stronger than the gravitational force, it should be easy to induce similar nuclear collapses by the electromagnetic force in laboratory. But we never knew until now how to do that.

Recently, the author discovered a nuclear collapse which was induced by the electromagnetic force in laboratory, during studying the mechanisms of so-called "Cold Fusion (CF)" phenomena. Several kinds of nuclear reaction which were directly induced by the electromagnetic force, called "Electro-Nuclear Reaction (ENR)," were found so far to occur in a special state of hydrogen clusters, called "itonic clusters," or "micro Ball Lightning (BL)." The nuclear collapse was one of the most remarkable reactions among ENRs, called "Electro-Nuclear Collapse (ENC)." Furthermore, very amazingly, completely broken materials by ENC were found to be regenerated again to thin tubes and films of conventional elements such as carbon, oxygen and iron. The latter process was called "Electro-Nuclear Regeneration (ENG)."

This book collects reviews and original papers related to ENRs (published or unpublished) between 1989 - 1999, which were mainly written by the author. Readers could follow steps to the discovery of ENC and understand that ENC related phenomena could take place widely in the natural environment as well as in other technical fields.

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(2) T. Matsumoto, "Mechanisms of Electro-Nuclear Collapse: Comprehensive Explanation by The Nattoh Model," distributed at ICCF-7, Vancouver, (1998). --- p.47

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notes:

1. Papers with # before reference No. were omitted here due to the large volume and the high cost.They will be involved in a future edition with explanations for backgrounds of the study.
2. Several presentations related to ENC were also made at regular meetings of Japan Physical Society, but not listed here since they were overlapped with that during meetings of Japan Atomic Energy Society.

1. Introduction

Nature often shows a tearing at an unexpected place. We can trace the depth of Nature by examining the tearing. For example, we knew by eruption of volcanoes that there are a large amount of magma under grounds. Alternatively, Planck opened the door to the quantum world by studying the inconsistency of thermal radiation. Probably, there might be many those tearing in Nature, but we can understand only very simple ones among them. Electro-Nuclear Reaction (ENR), which will be described in this book, could very often occur everywhere around us, but too amazing to be recognized by researchers so far. It emerges from a deep tearing of Nature.

Far in the universe, a large amount of stars repeat their generation and depletion. Neutron stars and black holes could be produced by the gravitational collapse of those massive stars. However, similar reactions should be easily induced by the electromagnetic force, since it is about 40 orders stronger than the gravitational force. Recently, during the study of so-called Cold Fusion (CF) phenomena, the author discovered a nuclear collapse which was directly induced by the electromagnetic force (August 25, 1990). The phenomenon was called Electro-Nuclear Collapse (ENC), which was one of the most remarkable ENRs.

This book collects the author's review and original papers related to ENC, which were published and unpublished during 1989 to 1999. Readers could trace steps to the discovery of ENC.Chapter 2 describes steps to the discovery of ENC during 1989 - 1999. The study is classified into four kind experiments of electrolysis and discharge, in which effective methods were searched with a high current density. In Chap. 3, ENC is summarized, which is expected to become very important physics in the 21st century. Lastly, references are roughly arranged in order of time.

2. Steps to the Discovery of Electro-Nuclear Collpase (ENC)

In March in 1989, M. Fleischmann and S. Pons published the so-called Cold Fusion (CF) phenomena. They urged that more output energy than input one was generated during electrolyzing heavy water with a palladium rod electrode (J. Electroanal. Chem., Vol. 261, p. 301 (1989)). At the same time, S. Jones et al. also published CF phenomena with a similar electrolysis method, but associated with no remarkable output energy (Nature Vol. 388, No. 27, p. 737 (1989)). Since the issue itself was very scientifically important, in addition to the inconsistency between the data obtained by the two groups, the news of CF became very sensational in many scientific communities as well as in usual media. A big controversy occurred between many researchers with positive and negative opinions, and continued for several years.

As soon as CF was published, many researchers in the world tried to duplicate the original electrolysis method proposed by Fleischmann and Pons. Almost all researchers failed in their attempts and denied the reality of CF. However, a very small number of researchers succeeded in the duplication of CF. The study of CF has been continued maily by those researchers. International Conference of Cold Fusion (ICCF) was periodically held until now, in which the data of CF and new discoveries made later were discussed (see proceedings of ICCFs).

The author's study first started with a revolutionary but primitive idea for the mechanisms of the original electrolysis method. The hypothetical theory was called The Nattoh Model, because a special state of hydrogen clusters proposed by The Model resembled well to fermented soybeans which was called "nattoh" in Japanese. The contents of The Nattoh Model became very rich as the study progressed.

Four kind experiments of electrolysis and discharge were carried out by the author for the last ten years: (a) an original electrolysis method of charging hydrogen (D or H) into a palladium metal, (b) an advanced electrolysis method of compressing hydrogen (H) on a nickel metal, (c) an Underwater Spark Discharge (USD) method with pinched electrodes, and (d) an AC discharge method with titanium electrodes.

Many important discoveries were mainly made during an early study of the original electrolysis method of (a): several kinds of ENR including ENC. The discoveries were more rigidly confirmed in later experiments of (b), (c) and (d). Then the author's study moved to an advanced electrolysis method of (b). Here it was found that discharges took an important role to induce significant ENRs. Next, the author carried out the USD method of (c) by using thin wire electrodes with a high current density. Here special hydrogen clusters were visibly observed shining on the surfaces of the electrodes. They were called itonic clusters or mico Ball Lightning (BL). Many beautiful pictures which made sure the occurrence of ENC were obtained. It was also found that thin tubes and films consisting of mainly a carbon element were regenerated from ENC, called Electro-Nuclear Regeneration (ENG). The AC discharge method of (d) was in parallel investigated. Lastly, natural phenomena as well as other technical fields were examined to search for ENRs. It was strongly suggested that ENRs could very often take place anywhere in the natural environment as well as in other technical fields.

2. a. Study of Original Electrolysis Method

When the original electrolysis method was published, a big scientific confusion occurred. There were two main reasons for that. The first was the low reproducibility of the experiment. The second was that no theory existed for the mechanisms of the CF phenomena. The first was simply overcome as the number of the experiments increased. But the second continued for almost seven years. During the period, the conventional fusion reactions of producing He-3, tritium and neutron from two deuterons were a priori assumed and the experimental data were never discussed from a new viewpoint.

The basic idea of The Nattoh Model was born in the author's head in March in 1989, soon after the publication of CF (4 - 8). The Model predicted that a special cluster of hydrogen could be formed in a palladium rod, but not in lattice. The hydrogen cluster was assumed to be strongly compressed to induce a new fusion reaction of producing He-4 from two deuterons (4 6). Furthermore, a new particle, iton, was predicted to be emitted in order to suppress the emission of a 2. 5 MeV neutron from a compound nucleus of He-4 (10, 11). A concept of chain reactions with itonic clusters was also introduced to explain the production of a high excess

energy (12). Although these earlier ideas were a little modified as the study progressed, many important parts of The Model were still alive and rather became more solidified. The Model contributed very much for the author to search for new phenomena. The contents of The Model were becoming much richer than the original one, by adding many important discoveries. The mechanisms of CF was reviewed in Ref. (1) and some comments were added in Ref. (2).

The Nattoh Model had so different concepts from all of other researchers' models that it continued to be ignored even in the community of CF researchers. However, readers will soon find out that many researchers began to accept the basic ideas of The Nattoh Model. The experimental data, especially new and curious ones, confirmed the propriety of The Model.

On the other hand, the author early carried out experiments of the original electrolysis method with a palladium rod, as many other researchers did. But he employed a different detection method of nuclear emulsion. Later a unique method of USD was employed as well. Many important facts which were never expected by everyone at the publication of CF were discovered by the author. There were two main reasons: the nuclear emulsion technique was the most sensitive method and the USD method with thin wire electrodes had the highest current density.

The first discovery was a fact that CF was feasible not only with heavy water, but also with ordinary water (9). The author first attempted the original electrolysis method with a palladium rod. In order to detect gamma rays from nuclear reactions (4 - 6), a Ge(Li) detector of a high energy resolution was used. It was a challenge to examine whether ordinary water was available as an electrolyte solution or not. This should have sounded too reckless to other researchers, but he had a strong confidence which was based on The Nattoh Model. In general, The Model accepted no difference between heavy and light water for forming hydrogen clusters. Extraordinarily energetic X-rays with a continuous spectrum were successfully detected, although no gamma rays caused directly by nuclear reactions were obtained. It was rigidly confirmed in later USD experiments that the emission of the high energy X-rays was a phenomenon closely related to CF (59).

Secondly a similar electrolysis experiment was performed with a palladium rod, but with heavy water. Here nuclear emulsions were used to catch a new particle, iton, which was theoretically predicted by The Nattoh Model (11). Very soon after a prediction paper of Ref. (11) was submitted, experimental data for the particles were obtained (10). The editor of the journal recommended the author to change the order of the two papers, because the theoretical prediction could be more easily accepted by readers. The author agreed with the proposal, but in real, the theoretical prediction preceded the observation. As the study progressed, it was found that the number of the itons were too small. Comments were described to this point (2).

Thirdly, microscopic features of palladium rods which were used for the above electrolysis experiments with light and heavy water were examined (17). Here a scanning electron microscope (SEM) was used. The Nattoh Model predicted that nuclear reactions causing CF took place not in lattice, but in small vacant spaces such as grain boundaries, defects and interfaces.

The SEM pictures clearly showed the growth of spots in which CF reactions occurred. Almost all researchers believed that nuclear reactions should have taken place in lattice so that the author's assignment was not accepted at the time. Later, this fact was rigidly confirmed as the study progressed, especially during USD. But not a small number of researchers still had the wrong idea of in-lattice model.

Fourthly, a great discovery was made during searching for traces on nuclear emulsions (18). It was microscopic explosions of clusters. In Ref. (18), the microscopic explosions were assigned to be caused by a nuclear collapse of quard-neutrons. The term of "gravity decay" was called after the gravitational collapse in the universe. Later, many traces of microscopic explosions were obtained in experiments with a higher current density, and it was consolidated that the microscopic explosions were induced by Electro-Nuclear Collapse (ENC) of itonic clusters with a large number of atoms (2). Reference (18) reported other types of explosion products like films. They were not assigned in Ref. (18) but at the present time, explained well by Electro-Nuclear Regeneration (ENG) which was confirmed in later studies (2). Thin films of mainly a carbon element were regenerated from ENC. The ENG process was not recognized during the study of the original electrolysis method of (a), but made clear in later experiments of the USD method of (c) which had a high current density to promote the ENG process.

Fifthly, Electro-Nuclear Transmutation (ENT) was discovered by an element analysis of a palladium rod which was used for an electrolysis experiment by the the original method of (a). Since many researchers were narrowly focussed to search for light elements such as helium and tritium during an early period of the CF study, it was unexpected that heavy elements were newly produced during electrolysis (19, 57). Reference (19) was the first observation of ENT during the original electrolysis experiment. Elements were analyzed with an energy dispersive X-ray analyzer (EDX) associated with SEM. Another element analysis was performed by a neutron activation method with a nuclear reactor of Kyoto University (57). The discovery of ENT enhanced the importance of CF except the heat production. Feasible schemes of ENT were proposed by The Nattoh Model (53). The Model predicted that sequential captures of hydrogen nuclei (protons) or electrons could take place with host elements as well as hydrogen itself in itonic clusters (1, 2). Then the idea was far beyond the common sense of nuclear physics so that nobody believed it. However the idea now began to be accepted by several researchers who were carrying out experiments of ENT, although they referred none of the author's papers (74).

Sixthly, strange energetic waves were observed by careful searching on the same nuclear emulsions (15, 23). The contrast of traces was not so enough to examine their details. In latest USD experiments, micro Ball Lightning (BL) were easily made, from which energetic rotational waves were observed to be emitted, just like microscopic tornadoes (79, 80). It could be suggested that there might have been some relationship between the early waves and rotational ones. The property of the waves still remained to be resolved in future.

Seventhly, other curious traces which could be caused by ENC of some clusters were also observed on the same nuclear emulsion (24). There were several kinds of traces, among of

which some similar traces were already reported in a previous paper (18). The others were then assigned to ENC products of multiple neutron nuclei (tiny neutron stars), which could be formed from a heavy nucleus of palladium by the compression with surrounding hydrogen clusters. This assignment was made more clear in later studies. A curious string like trace shown in Fig. 6f in Ref. (24) was found a thin carbon tube which was regenerated from ENC. Although Fig. 9 showed one nucleus of palladium which was covered by itonic hydrogen clusters, a very large number of palladium nuclei were involved in real. The reason why the tiny neutron star could exist for a moment was explained elsewhere by The Nattoh Model (2).

In the preceding study, many important discoveries were successfully made. They were done by setting nuclear emulsion outside the electrolysis cell. Nuclear emulsion was the most sensitive among devices which were employed to catch reaction products, and brought us a plenty of reliable informations. However, the author was unsatisfied in the experimental arrangement, because more direct informations were required in order to examine the mechanisms of the CF phenomena.

In the next study, the author employed a thin foil of palladium as a cathode, which was horizontally placed (33). Hydrogen atoms were charged from the upper surface of the foil which was contacted with an electrolyte solution, and the other surface was in air. Reaction products which emerged from the foil were directly caught with an assembly of nuclear emulsions which were placed under the rear surface. Many important traces were obtained with the arrangement of the palladium foil.

First, simultaneous explosions of ENC were clearly observed (21, 25, 32). Figure 4 in Ref. (25) showed that an assembly of hydrogen clusters were emitted from the rear surface of the foil and that at least three clusters among them simultaneously induced explosions of ENC. The explosions seemed to have occurred soon after the assembly was separated into individual clusters. In Ref. (25), there were no explanation about curious thin films, although the author was aware to those extraordinary thickness. The films had spherical and circular shapes, and the latter was made a break up of the former. Later studies confirmed that the films were regenerated during explosions of ENC (2, 70, 71). There, a tiny black hole should be certainly formed by ENC.

Secondly, curious mesh like traces were also observed on the same nuclear emulsions (33). Figure 3 in Ref. (33) showed traces of microscopic explosions which were associated with mesh like traces. The Nattoh Model predicted that a special state of hydrogen clusters, called itonic clusters, could be formed in the palladium metal (1, 2). Many electrons in the itonic clusters were assumed to be interconnected each other. The mesh like traces clearly indicated the formation of those itonic electrons. Many traces with only broken meshes were also shown in Fig. 4 in Ref. (33). They were fading during the flight.

Thirdly, anomalous and long tube like traces were observed on the same nuclear emulsions, as shown in Fig. 7 in Ref. (33). The assignment was not clear at that time, but later studies confirmed that the tube like traces were caused by the itonic clusters themselves. The

itonic clusters showed curious behavior very similar to that of natural Ball Lightning (BL).

Fourthly, multibody fission reactions were discovered (26). They were found by star like traces which were recorded on the same nuclear emulsions. There were various branches for the multibody fission reactions, which probably depended on the excitation energy of a compound nucleus. The details of the fission fragments were not yet investigated.

2. b. Study of Advanced Electrolysis Method

In 1991, the group of R. L. Mills et al. proposed an advanced electrolysis method of (b) by using a nickel plate as a cathode (Fusion Technology, Vol. 20, p. 65 (1991)). Excess heat was generated as soon as the current began to flow. The author also examined the mechanisms of the advanced electrolysis method of (b) for about ten months in 1992, based on The Nattoh Model (1, 2). As resulted, it was made obvious that The Nattoh Model was applicable not only to the system of palladium and heavy water, but also to that of nickel and ordinary water. This study, in spite of the short period, was a very important step throughout the whole study, because the author was aware to the importance of discharge effects to obtain more significant ENRs.

The author carried out an experiment similar to the advanced electrolysis method of (b), in which a cathode of a thin nickel plate was horizontally placed in contact with a solution of ordinary water (34). Nuclear emulsions were also set under the plate in air, while the electrolysis was employed on the upper side of the plate in the solution. Many traces of explosive reactions were successfully recorded on the nuclear emulsions. They were reliable evidences for the prediction by The Nattoh Model that itonic clusters could be formed between the nickel plate and the solution, because nickel had a low permeability of hydrogen. The formation of tiny white holes was first proposed in Ref. (34).

A similar experiment was repeated again with a strong confidence of obtaining a high excess heat, but the result was unexpectedly an explosion soon after the current started to flow. The author assumed on the second thoughts that the current density was not always uniform over the whole plate and that small local discharges between the electrodes could induce ENRs to lead the explosion. However the explosion was not considered negatively at all, but could rather suggest the occurrence of more significant ENRs.

2. c. Study of Underwater Spark Discharge (USD) Method

The author was aware to the importance of electrical discharges for inducing significant nuclear reactions during the study of the advanced electrolysis method of (b). He repeated discharge experiments many times between 1992 - 1999, enhancing discharge effects (30, 35, 36, 39, 42, 45, 47 - 52, 54, 56, 59, 60, 63 - 73). Many important discoveries were newly made or became more rigidly confirmed.

First, one-point CF experiment was carried out, in which a thin pin of platinum and a copper plate were used for electrodes. The pin was vertically located over the plate with a small gap in a solution of ordinary water and a pulsed current was discharged between them (30, 35).

Itonic hydrogen clusters with large dimensions were obtained, but broken in parts. Collapse products of the itonic clusters were also deposited on the surface of the copper plate: string and film like products. Although no element analysis was made at that time, they were assigned as gravity decay products of the itonic clusters. This assignment was found right as the study progressed.

Secondly, similar experiments of the pulsed discharge were performed, in which two thin wires of palladium were located with a right angle in a solution of ordinary water. A small gap was provided between the wires as well. Nuclear emulsions were set outside an acrylic window of a cell. Many curious traces like rings were recorded on the nuclear emulsions. The traces were assigned to be caused by itonic clusters (50, 51). It was concluded that small itonic clusters generated during USD were very similar to BL which was often observed in the natural environment. The clusters were later called micro BL. Here, the author arrived at a new conclusion of that CF and BL, both of which were so curious and still remained unsolved, could be based on the same physical principle: they both were itonic clusters.

Thirdly, other curious traces were obtained on the same nuclear emulsions during USD experiments (49, 51). They suggested the generation of microbacteria during USD (49, 51). Some traces recorded on the nuclear emulsions looked like a prototype of microbacteria. Since the number of the traces was not sufficient, more studies with high voltage discharges were planned in future. But they have not yet been done.

Fourthly, a new kind of the electrical current was discovered (54, 56). The author was early aware to a fact that thin copper wires of leading cords became dark after electrolysis or discharges, although they were wholly coated by resin materials. The color was darker as the position was closer to a connecting point with an electrode. It was found that the phenomenon was caused by transport of itonic clusters through wires. Since itonic clusters could exist for a moment as stable bodies and have negative charges, they could be driven through the leading wires by the electrical potential to make some kind of electrical current, which could be completely different from the conventional current. So the heavy flow was called the second electrical current. The current was simultaneously a magnetic flow, because the itonic cluster had a magnetic moment (2).

Fifthly, a new discovery was made for sparks (51, 59). In April in 1994, the author was making efforts to increase the current density during USD with a DC mode, by using thin wire electrodes of cadmium. Then, he observed a little spark shining on a bottom tip of a cathode which was covered with a pinched region. The pinch effect worked well over about 50 V, in which gas evolution was stopped and the current was strongly suppressed as well. He examined the detailed property of the curious sparks. As resulted, it was found that the spark was consisted of many microscopic sparks which were consistent with the itonic clusters or micro BL. During electrolysis by the original electrolysis method of (a), itonic clusters should have been formed in a palladium metal, but none of them could have been seen. However, during the USD experiments, itonic clusters appeared shining on the surface of the cadmium metal by two reasons. The current

density was high so that the dimension of the itonic cluster became sufficiently large. Secondly, cadmium had a low hydrogen permeability so the itonic clusters were formed on the surface of the electrode. When the itonic clusters broke up, X-rays with high energy up to about 150 keV were emitted (59). Furthermore thin film like products were left near the bottom tip of the cathode after the discharges (59). It was also found in later studies that the film products were regenerated by ENC (2). The USD method was very easy and effective to generate micro BL so that it was often employed in later studies to examine their details.

Sixthly, a great discovery related to nuclear collapse was made during USD experiments (63 - 66, 68 - 73). When itonic clusters of lead and cadmium were made with a high current density, conventional elements such as carbon were regenerated from their ENC as thin tube and film like products. The phenomena clearly indicated that some kind of nuclear transmutation took place and that at least they were caused by nuclear reactions. But no nuclear reactions of a normal level could have explained the phenomena at all. One example was that if the nuclei of lead and cadmium were assumed to have a structure of many clusters of carbon nuclei and others, they could be recombined to form thin tubes and films after break up. But this hypothesis seemed insufficient. On the other hand, The Nattoh Model proposed the formation of tiny black and white holes which introduced the regeneration of elements. Since the formation of black holes were observed in the universe, This hypothesis seemed more natural than the above-mentioned nuclear reactions. This process was called Electro-Nuclear Regeneration (ENG). Similar products of thin films or tubes were very often observed in earlier experiments (18, 35), but then the mechanisms were left unsolved. The detailed study with USD enabled us to confirm the occurrence of ENG. This was very amazing such that nobody ever expected.

Lastly, the details of micro BL were studied by the USD method (67, 77 - 79). Micro BL could be easily generated during USD and driven on the surface of a copper plate by electrical fields. It sometimes left zigzag traces of one stroke writing and suddenly disappeared to transform to thin carbon films. Alternatively, micro BL could induce an eruption of rotational waves, just like microscopic tornadoes. Anyway, it would be reasonable to consider that micro BL could be very easily generated during other CF experiments and that it caused the CF phenomena very complicated. Many researchers were reluctant to recognize the formation of micro BL during their CF experiments, because the natural BL was too curious to be seriously treated with. Rather, it would be expected that the artificial BL will rapidly progress the study of the natural BL.

2. d. Study of AC Discharge Method

In 1992, I. Yukimura brought the author an AC discharge method of (d) to ask whether it could be related to CF. There, thick rods of titanium were used for electrodes and AC discharges with a high current were continuously applied in a solution of ordinary water (26, 31). Curious phenomena such as luminescence were observed on the surfaces of the electrodes.

The author also examined the AC discharge method of (d) with him between 1992 - 1994. They found that sparks repeated lightning or disappearing, harmonized with the fluctuation

of AC of 50 Hz. They used only titanium for the AC discharge experiments, but it was found later that titanium was special among metals (palladium, platinum, nickel, cadmium, tungsten, copper, aluminum, iron, indium, lead and etc.), which were used during the USD experiments mentioned in Sec. 2. c. With all the other metals except titanium, small sparks first appeared on the surface of a cathode in a low voltage region, and then on an anode with a slightly weak brightness (might be lightning) as the voltage increased. On the other hand, with titanium, similar sparks first appeared on the anode, and then on the cathode as the voltage increased. They had an idea of that the mechanisms for the formation of sparks with titanium should be different from that with the other metals. But no more detailed study was made yet.

They also observed anomalous multiplication of electrical current during AC discharges with titanium rods (37). The current sharply increased near a voltage, at which sparks began to appear. When a spark left the electrode, a small white area was left on the surface of the titanium rods. Since the area was a naked metal surface and had a low electrical resistance, the current remarkably increased. However, the feasibility of multiplication still remained, because break up of sparks (itonic clusters) containing titanium could somewhat contribute to additional current.

In 1994, their cooperative study ended by a reason why they had different ideas about the sparks each other.

2. e. Potential Application of Electro-Nuclear Reaction (ENR)

The USD method mentioned in Sec. 2. c was a revolutionary technique to induce ENRs. Here no electrolysis process which took a long time for charging hydrogen was always required. Since the method was very easy, many applications could be proposed as follow.

The first proposal was energy production as originally proposed by CF. The author proposed the feasibility of sea water for energy production (9) and simultaneously the generation of ordinary water from sea was also proposed (14).

The second proposal was nuclear incineration of radioactive wastes which were produced from reprocessing plants of spent nuclear fuels (2). There were several kinds of ENRs which could be potentially applied for nuclear incineration. Among them, the most effective could be a method based on ENC. Here the rate of incineration could be expected to be extremely high, because a large bulk of radioactive materials could instantaneously collapse. A simple sprayer was also proposed for the nuclear incineration of radioactive materials, which were widely distributed in the natural environment (62). A more challenging method was proposed for a direct nuclear incineration of spent fuel rods (76).

The third proposal was to apply nuclear transmutation (19, 53). There were several kinds of ENRs which could contribute to nuclear transmutation (2). Selecting suitable processes among ENRs, valuable elements were expected to be generated from cheap elements. When ENC was employed for nuclear transmutation, recovery of resources could be expected (64). For example, hazardous materials such as mercury and cadmium could be recovered to new elements (64). Alternatively, ENC could provide a revolutionary generation method of new materials, which

was completely different from normal methods of material production (65). The latter was in principle based on rearrangement of constituent elements, but the former on passing through nuclear collapse. New materials with new property could be made.

The fourth proposal was a driving engine by using explosions of ENC (41). This was expected to be a high power engine, which could be applied for satellite vehicles.

The fifth proposal was the generation of new currents: the second electric current (58, 60) and a magnetic one (2). They all were caused by a flow of micro BL. Furthermore, a multiplication method of electric current could be expected by the same principle (37).

Lastly, a X-ray laser with micro BL was proposed (81). The method could use break up of mico BL which could be stimulated under irradiation of incident X-rays.

All of those proposals were just ideas so that detailed study should be promoted in future as soon as possible.

2. f. Electro-Nuclear Collapse in Natural and Other Technical Fields

It would be reasonable to consider that ENRs could be easily induced in natural and other technical fields (2). The dimension of itonic cluster which sensitively depended on the current density was very widely ranged from a microscopic dimension of several atoms to a macroscopic one of a bulk, say about 100 cm. There were many reports in natural and other technical fields, in which very strange phenomena were observed, but left unsolved. Since ENRs were so difficult to understand, nobody might have been aware to the occurrence of ENRs including ENC, even if they in real witnessed strange phenomena. However, ENRs could be easily found out if researchers would carefully search for them from a new viewpoint of ENRs.

The author searched for ENRs in some natural and technical fields. It was proposed that there were high feasibility of that ENRs could be closely related to many strange phenomena (2). Here natural and other technical fields in which ENRs could be involved will be described, in addition to Ref. (2).

The first was discharges and electrolysis, from which ENRs were discovered. They could widely occur in natural and technical fields. One typical example in Nature was a thunderstorm which was a large scale of electrical discharges. Ball Lightning of a diameter up to about 100 cm were observed, associated with thunderstorms. We now knew that micro BL could be easily generated during USDs in laboratory. The conclusion would be straight forward, i.e., BL in the natural environment could be itonic clusters with a large diameter which was made during thunderstorms with an extremely high current (2, 82). There were many reports about mysterious circles which were often made in farms. The author also observed several mysterious circles in Sapporo in September in 1996, which were generated after heavy thunderstorms (83). The formation was repeated three times at the same location for five days. It would be very feasible that mysterious circles could be made by BL in laboratory.

Other typical example in technical fields was electric welding (83). Radiation damage to materials as well as human beings were often reported with electric welding. But no one was

aware to ENRs during the process. If strange phenomena associated with electric welding were studied carefully, ENRs could be easily found. Since curious vacant spots were observed during laser welding, ENRs could be induced even with laser welding.

The second example was physical compression which could induce ENRs to cause earthquakes (2, 61, 67, 83). Rocks which were strongly compressed by stress underground could potentially induce ENRs to collapse. During the earthquakes, itonic clusters were observed on nuclear emulsions (62, 67). During the Hanshin-Awaji Earthquakes, strange phenomena such as fire balls were observed by many people before heavy seismic vibration occurred. Fire balls could be well explained by the emission of itonic clusters which could be made by collapse of underground rocks by physical compression.

The third example was physical friction which could potentially induce ENRs. One typical example was shooting stars. Recently, shooting stars were carefully observed with cosmic dusts from the Eagle. Here curious weakly shining traces which looked like long tubes were observed after bright light completely disappeared. The formation of the long tubes remained mysterious. If ENC was assumed to occur with shooting stars, long tube like products should be certainly left.

The fourth example was exposure with radiations such as gamma rays and laser (83). When a material was irradiated with intensive ionizing beams, atoms of the material could be ionized and at the same time, many electrons could be emitted. Those particles could recombine to induce ENRs in a situation with a high dose rate.

The fifth example was nuclear explosions of fission or fusion reactions (83). It would be amazing that when a nuclear bomb exploded, itonic clusters could be generated. The author recently proposed a hypothesis of ENRs during fission reactions. Here, a high rate of the fission reactions were required to induce ENRs, as the case of gamma rays irradiation. Furthermore, the author predicted on the same principle that ENRs could be induced at an initial excursion of neutron flux during the JCO accident in Japan (82, 83).

The sixth example was dust plasma, in which tiny particles of dust could be itonic clusters by capturing many electrons in plasma. The itonic dust clusters should show very curious behavior like BL. Although an explosion of the dust particles were treated as an evaporation, it would be highly feasible that the explosion could be caused by ENC. The proof could be easily made by finding out carbon materials of ENG products.

The last example was biology. It would be a little amazing that in a biological tissue, ENRs could occur to induce nuclear transmutation (2).

Searches for ENRs in the natural as well as other technical fields just began from the new viewpoint of ENRs. Careful observation should be required everywhere for curious phenomena in the natural and technical fields.

3. Summary

In the preceding section, steps to the discovery of ENC have been described by following the reviews and original papers. Here, we will summarize the discoveries related to ENC which were made between 1989 and 1999.

Many important discoveries related to ENC were made by the author during the period. They are summarized as follow,

A. Discovery of itonic clusters

A special state of hydrogen clusters were discovered and they were called itonic clusters:

(1) itonic clusters were generated during all of CF related experiments: the methods of (a), (b), (c) and (d),

(2) itonic clusters were generated with heavy hydrogen as well as ordinary one, and

(3) itonic clusters were generated to contain heavy host elements.

B. Discovery of Electro-Nuclear Reactions (ENRs) in itonic clusters

New kinds of nuclear reaction were discovered in itonic clusters and they were called Electro-Nuclear Reactions (ENRs):

(1) a new fusion reaction of producing He-4 from two deuterons was discovered to occur in itonic deuteron clusters as a key reaction to predominantly contribute to excess heat generation during the original electrolysis method of (a), so-called Cold Fusion,

(2) sequential captures of p/e with hydrogen or other host element nuclei were discovered to occur in itonic hydrogen clusters containing host element nuclei which contributed to Electro-Nuclear Transmutation (ENT),

(3) multibody fission reactions were discovered to occur with itonic clusters and they also contributed to ENT,

(4) tiny neutron stars which consisted of only neutrons were discovered to be generated with itonic clusters, which contributed to burst emission of neutrons,

(5) Electro-Nuclear Collapse (ENC) was discovered to occur with itonic clusters, by which a tiny black hole could be formed, and

(6) Electro-Nuclear Regeneration (ENG) was discovered to occur with itonic clusters, from which thin tube and film like products consisting of mainly carbon were regenerated, suggesting the formation of tiny black and white holes,

C. Discovery of micro Ball Lightning (BL)

Tiny shining sparks observed during USD experiments were discovered to be itonic clusters, which were alternatively called micro BL:

(1) itonic clusters (sparks) were discovered to behave just like microscopic BL,

(2) itonic clusters (sparks) were discovered to have negative charges and magnetic moments,

(3) a new kind of electric current was discovered as a flow of micro BL,

(4) a new magnetic current was discovered as a flow of micro BL,

(5) rotational eruption was discovered to occur from micro BL, and

(6) micro BL was discovered to be controlled with electric and magnetic fields, and

D. ENC suggested in natural and other technical fields

ENC was suggested to occur widely in natural and other technical fields:

(1) micro BL was discovered to be generated during earthquakes,

(2) ENC phenomena were suggested to occur during thunderstorms,

(3) ENC was suggested to occur during fission reactions, and so on.

The discoveries mentioned above would be very important to future physics as well as industries in the 21st century. Among them, the discovery of ENC and ENG would be especially important, because they meant that we opened the door to a super microscopic world of 10E-33 cm at a stretch (2).

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The author thanks to many people for their helps during the study. Simultaneously he has to apologize to many people for his impoliteness in official and private fields, because he has been too much devoting to his study. Acknowledgement was written in each paper, but he would like to thank again by writing those people's names here.

The author thanks to Mr. H. Kashihara (Mitsubishi Material Ltd.) for providing a Ge(Li) detector, with which the author succeeded in observing anomalous X-rays (9), to Mr. Y. Hayashi (Nuclear Fuel Development Ltd.) for taking microscopic pictures of palladium rods (16), to Messrs. S. Takahashi and H. Mineo (Fuji Film Inc., both retired) for their courtesy of providing nuclear emulsions during an early study (10, 18, 24), to Mr. H. Harada (Mitsui Bussan Inc., retired) for his company to financially support the author's study with ordinary water (9, 34), to Merrs. A. Honma and Y. Kurokawa (Hokkaido Kaihatsu Agency: Y. K was retired) for their courtesy to place nuclear emulsions at the Matsumae office (61, 63, 67), to Dr. M. Higashi (Kansai Atomic Research Inc.) for his kindness of sending periodical documents related to early CF study, and to Dr. G. Egely (Videoton Automatika Kft.) and Mr. E. Lewis (Illinois Univ.) for discussion of natural BL.

Lastly, the author very much thanks to all the members of his family, especially to his wife, Eiko, for their patience during his devotion to the study.

Biography of the Author

The author was born in Osaka in 1942 to have a parent of Matsumoto Setsuro and Ai, and three senior sisters. He grew up in Osaka and graduated from Sumiyoshi high school in 1960. He learned nuclear engineering in Kyoto University and finished its master course in 1966. Then he worked as an assistant researcher in Kyoto University Research Reactor Institute (KURRI) in south Osaka. During seven years in KURRI, he studied neutron physics (neutron transport, thermalization and scattering). He obtained a doctor's degree of engineering from Kyoto University in 1979, for a study of transient phenomena of neutron thermalization.

The author moved to Hokkaido University in 1973 as a lecturer and became an associated professor in 1974. During several years, he studied neutron scattering by using an electron linear accelerator of 45 MeV. During next seven years, he theoretically studied nuclear incineration of radioactive wastes by using electron or proton accelerators and nuclear reactors. A hybrid nuclear system of a proton accelerator and waste nuclear materials, which is to be built at Japan Atomic Energy Research Institute (JAERI), was fundamentally based on the author's proposal.

The author started to study the CF phenomena in 1989, and continues the study of ENR until now.

Privately, he married with Eiko in 1967 and had a daughter (Hiroko) in 1968 and a son (Tsuyoshi) in 1970.



The author with his wife
against a cherry tree in his garden
(Sapporo, May in 1999)

References

Reviews, original papers and miscellaneous, which were closely related to ENRs including ENC and written mainly by the author, are collected here. They were already published or submitted (but not published) between 1989 and 1999. The references are arranged in order of time. The author hopes that readers follow to enjoy steps to the discovery of ENC.

a. Review Papers

There are three review papers from which readers will understand the whole aspect of ENR: Ref. (1) to (3). But the review of Ref. (3) is not ready for this collection.

b. Original Papers and Miscellaneous

Original papers and miscellaneous are also collected here: Ref. (4) to (84). They include proceedings of oral presentation in international meetings such as International Conference on Cold Fusion (ICCF) and International Symposium of Ball Lightning (ISBL) as well as in domestic ones such as Japan Atomic Energy Society and Japan Society of Energy and Resources. The contents might be somewhat overlapped.

**Ref. (1) Memoires of the Faculty of Engineering.,
Hokkaido Univ., Vol. 19, No. 2, p. 201 (1995).**

Mechanisms of Cold Fusion : Comprehensive Explanations by The Nattoh Model

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Abstract

The phenomena of cold fusion seem to be very complicated; inconsistent data between the production rates of heat, neutrons, tritiums and heliums. Our thoughts need to drastically change in order to appropriately understand the mechanisms of cold fusion. Here, a review is described for the Nattoh model, that has been developed extensively to provide comprehensive explanations for the mechanisms of cold fusion. Important experimental findings that prove the model are described. Furthermore several subjects including impacts on other fields are also discussed.

Keywords

Nattoh model, hydrogen-catalyzed fusion reaction, iton, gravity-decay, multiple-neutrons, tiny blackhole, tiny whitehole

1. Introduction

Since Pons and Fleischmann and Jones *et al.* independently published works on cold fusion (1, 2), many experiments have been carried out over the world to verify whether the fusion reactions can really take place in a metal at room temperature (3-6). Since deuterium gas is charged into the metal, the conventional D-D fusion reactions were initially expected to occur in the metal by any unknown mechanisms, that are familiar in the high temperature plasma physics, are written as follows,

$$D+D \longrightarrow {}^{3}He+n \quad (2)$$

$$\longrightarrow T+p \quad (3)$$

$$\longrightarrow {}^{4}He+\gamma$$

Here the reactions of Eqs. (1) and (2) take place with the approximately equal probability, but the third reaction of Eq. (3) is about 10^7 times less than the formers. Therefore the particles of neutrons, tritiums, and heliums were enthusiastically searched to explain anomalous heat production in metal. Although the data obtained so far show deviations between the studying groups, they are gradually converging. It has at

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least been made clear that the phenomena of cold fusion is too complicated to be explained by the conventional D-D fusion reactions by the following reasons.

(a) The excess heat production was accurately measured by many researchers (3-6). Those amounts are extraordinarily large so that they cannot be explained by the conventional chemical reactions.

(b) The neutron production was observed by many researchers (3-6). The measured neutron energy is verified to be about 2.5 MeV that is consistent with that produced by Eq. (1) (2). However, the production rate of the neutrons is 10^{12} to 10^{13} times less than that was calculated from the excess heat production based on Eqs. (1) and (2).

(c) The tritium production was also measured by many researchers (3-6). The production rate of the tritiums is 10^4 to 10^8 times higher than that of the neutrons (7). Partially because the tritium measurement is more difficult, there exist large discrepancies between the experimental data. This rather suggests that there might be a systematical reason.

(d) The helium production was also measured by the small number of groups (8). Unexpectedly, instead of ^{3}He, shown by Eq. (2), a lot of ^{4}He was produced. Helium -4 might be produced by Eq. (3), but the reaction is associated with the gamma ray. The amount of ^{4}He seems to roughly correspond to the production rate of the excess heat so that if the reaction of Eq. (3) predominantly occurred, the energetic gamma rays should be intensely emitted. However, such gamma rays could not be observed experimentally.

(e) The energy spectrum of the charged particles, such as protons and heliums, was measured by the few groups (9). The charged particles showed the complicated spectrum that cannot be expected by Eqs. (1) and (2).

(f) Ordinary water is available to cold fusion to produce excess heat (10-13). This is surprising because the cross section of the H-H fusion reaction is about 10^{12} times less than that of the D-D reaction, and is extremely important for industrial applications of cold fusion.

(g) Many extraordinary phenomena associated with cold fusion were reported (14-23). For example, microsparks were observed on the metal surface(22), and strange particles and waves were recorded on the nuclear emulsions (14-21). Recently, a metal hydride of palladium showed the good conductivity in a high hydrogen ratio (23).

In order to explain the mechanisms of cold fusion, many hypothetical models were proposed (3-6). Some are based on conventional reactions and others on new reactions, whether they are chemical or nucler reactions. A good model should comprehensively explain all the phenomena of cold fusion mentioned above. Almost all models seem to be only trying to enhance the conventional D-D fusion reactions or the somewhat modified reactions in the metal in order to explain the extraordinary phenomena of (a) and (b). Even if they could succeed, they should answer much more difficult questions such as (c) to (g). It seems that slightly modified conventional theories cannot comprehensively explain these complicated phenomena. Now our thoughts on cold fusion should be changed drastically. How can we arrive at the right answer?

By seeing the sun rise from the east and set in the west, the Ptolemaican theory simply states that the sun moves around the earth. It is somewhat inevitable to us that we have the Ptolemaican theory for any new phenomena because we have to protect ourselves from them. By changing our way of thinking from the Ptolemaican to the Copernican theories, we are now going to understand not only the behaviors of the planets but also the origin of the universe. For cold fusion, on the other hand, we are now in the era of the Ptolemaican theory. Since the deuterium gas is charged into the metal, we are convinced of the conventional D-D fusion reactions, whichever one is for or against cold fusion. We should change our way of thinking to the Copernican theory in which our view point also moves around hydrogen atoms.

The author earlier proposed the Nattoh model ("nattoh" means fermented soybeans in Japanese) that introduces a new "hydrogen-catalyzed" fusion reaction(24-26). The new reaction occurs in hydrogen-clusters that are formed in tiny spaces in the metal, such as grain-boundaries, defects and interfaces. The hydrogen-clusters can be compressed by themselves in a highly pressurized state of the hydrogen atoms, in which new particles "itons" are produced. Energetic hydrogen atoms that can instantaneously be emitted during the hydrogen-catalyzed fusion reaction make additional fusion reactions. This means that the chain-reactions of hydrogen can be maintained in metal. The sequential reactions of the hydrogen-catalyzed fusion reaction are primary for cold fusion, especially for the Pons-Fleischmann method. Furthermore, since the hydrogen-cluster can contain many hydrogens, possibly many millions, many strange reactions are associated with the primary reactions: productions of heavy elements and multiple-neutron nuclei, formations of tiny black and white holes and so on. Readers will easily understand that cold fusion is a small scale simulation of the events that occur in cold stars far away in the universe. By accepting the Copernican theory for cold fusion, we can microscopically arrive at the same position as the origin of the universe.

This paper describes comprehensive explanations by the Nattoh model for the mechanisms of cold fusion, especially Pons-Fleischmann type experiments and important experimental evidences that verify such explanations.

2. Mechanisms of Cold Fusion

Let us briefly consider a fission reactor. There the principle is well known: fission reactions of uranium and/or plutonium are maintained by chain-reactions of neutrons. However, this answer is only 50% correct. There are various additional reactions associated with the primary fission reactions: various neutron-induced reactions, beta-decays of fission products and so on. If detectors are located near the fission reactor core, various kinds of radiations could be measured.

The situation of cold fusion might be similar to the fission reactor. The phenomena of cold fusion seems to be very complicated. But unexpectedly the principle might be simple. When the reactions are appropriately arranged in order, the mechanisms of cold fusion can be well understood.

The mechanisms of cold fusion are summarized in Fig. 1. The processes of cold fusion can be classified into two categories: primary and associated reactions. The primary reactions are the hydrogen-catalyzed fusion reactions that contain both of the

intra- and inter-cluster reactions. The former means the new hydrogen-catalyzed fusion reactions and the latter the chain-reactions of the hydrogen atoms, respectively. The associated reactions involve the conventional D-D fusion reactions and the other branches of the many-body fusion reactions induced in the hydrogen-clusters. Further reactions are mainly induced by the production of the multiple-neutrons. The rate of the reactions shown in Fig. 1 depends on experimental conditions, especially the current density and the pressure of hydrogen. As the current density or the hydrogen pressure increase, the reactions shown in the lower part of the figure can be highly enhanced.

2. 1 Primary Reactions

(a) Hydrogen-Catalyzed Fusion Reaction (24, 25)

The primary reactions of cold fusion are the hydrogen-catalyzed fusion reactions that occur in the hydrogen-cluster. The hydrogens that diffuse from the metal surface are trapped inside and outside the lattice in the metal. The former hydrogens can take no fusion reactions because they are located in specified positions between the metal nuclei and are too distant to fuse each other. The latter hydrogens are mainly trapped in grain-boundaries to form hydrogen-clusters. The hydrogen-clusters are so pressurized by the overpotential of the electrolysis that they can induce the new "hydrogen-catalyzed" fusion reactions by self-compression. The number of hydrogen atoms contained in the cluster is plural, possibly many millions, so that there are a lot of variations for the hydrogen-catalyzed fusion reactions. This fact makes cold fusion burn in various manners. The most probable among them are the fusion reactions between two hydrogens under the many-body interactions for heavy water as follows,

$$2D+e+D \longrightarrow {}^{4}He+i_1+{}^{2}n \quad (4)$$

$$\longrightarrow {}^{4}H+i_1+d \quad (5)$$

$$\longrightarrow {}^{4}He+e+\bar{\nu} \quad (6)$$

for the emission of the single iton i_1, and

$$D+2e+D \longrightarrow {}^{4}n+i_2+d \quad (7)$$

$$\longrightarrow {}^{4}H+i_2+{}^{2}n$$

for the emission of the double iton i_2, where ${}^{2}n$ and ${}^{4}n$ are multiple-neutrons of di- and quad-neutrons, respectively. Here the number of the electrons and hydrogens that participated in the left side of the equations are very large, so other variations are possible, but with the less probability.

The production of the new particle "itons" is clearly related to the hydrogen-catal-

yzed fusion reactions, in that the compression of the hydrogen-cluster can be explained by two steps: (1) effective mass of the electrons increases by following the hydrogens to initially shrink the hydrogen-cluster and (2) in the shrunken hydrogen-cluster, the hydrogen nuclei are depolarized to form the itons that further compress the cluster. In the first process, the electrons take an important role. If additional electrons are induced by flowing electrical current or discharging, the compression is more progressed. The new particle "itons" might be consisted of electrons, positrons and neutrinos. The itons cover up the surface of the product particles such as the multiple-neutrons. Much more electrons than positrons are involved in the itons so that the itonic particles have highly negative charges. When the hydrogen-cluster shrinks into the extremely compressed state, the electrons might be localyzed and/or degenerated so that the itons have the mesh structure. On the contrary, the iton takes the de-ionization effects during passing through a material and finally decays to a pair of an electron and a positron.

In the compressed hydrogen-cluster ("itonic particles"), the distances between the nuclei are so short that other fusion reactions can easily take place. For example, more two-body fusion reactions can simultaneously occur within the same hydrogen-cluster. Here the fusion products such as the quad-neutrons can be emitted, combined each other with the itonic networks. Alternatively, many-body fusion reactions such as three and four body-fusion ones also can occur in the compressed hydrogen-cluster. Those reactions provide not only heavy elements but also heavy mutiple-neutrons. They can be classified into the associated reactions, as mentioned before.

There might be an alternative scinario in the second proccess. When the hydrogen-cluster is compressed, only a mesh structure of the electrons might be formed in stead of the formation of the itonic mesh. Even here, the same particles are produced,

$$2D+e+D \longrightarrow {}^{4}He+e+D \qquad (4a)$$

$$\longrightarrow {}^{4}H+D \qquad (5a)$$

$$2D+2e+D \longrightarrow {}^{4}n+D \qquad (7a)$$

(b) Chain-Reactions of Hydrogens

The hydrogen-catalyzed fusion reactions mentioned above emit energetic hydrogens that can make additional fusion reactions in other hydrogen-clusters. These intercluster reactions are the chain-reactions of the hydrogens that can be maintained under the appropriate condition in the metal (25). This is similar to the neutron chain-reactions in a fission reactor. For cold fusion, the hydrogen-clusters are fuels, instead of uranium and plutonium, and the hydrogens are catalyst particles, instead of the neutrons. There are two modes of the burning with the hydrogen chain-reactions: direct and indirect. The former consists of the sequential fusion reactions that occur within the hydrogen-cluster under the slowing down process of the energetic hydrogens, such that

the burning is local and bursts. The latter, on the other hand, occurs between the hydrogen-clusters that are located comparably distant each other. Those mode can burn continuously and widely over the metal.

The indirect mode was discussed in detail in the previous paper (25), in that the time behavior of the free hydrogens and hydrogen-clusters are separatively written by two diffusion equations, respectively, as follows,

$$\frac{1}{v}\frac{\partial\phi(\boldsymbol{r},t)}{\partial t} \quad D\nabla^2\phi-\sigma_{tp}^h N_h\phi+\left(\nu\varepsilon(N)\sigma_{fu}+\sigma_{tp}^h-\sigma_{tp}\right)N\phi+s\delta(\boldsymbol{r}-\boldsymbol{r}_s) \tag{9}$$

and

$$\frac{\partial N(\boldsymbol{r},t)}{\partial t} \quad \bar{D}\nabla^2 N-\bar{\lambda}N+\sigma_{tp}^h N_h\phi-(\overline{\epsilon(N)\sigma_{fu}}+\sigma_{tp}^h)N\phi \tag{10}$$

for the notations, refered to Ref. 24. Equations (9) and (10) are non-linear due to the cross term of the flux ϕ of the free hydrogen and the number density of the hydrogenclusters N. The stationary solution can be obtained for a special case with the flat distribution of the hydrogens and hydrogen-clusters. The critical condition is written as follows,

(11)

where

$$k_{eff} \quad \frac{(\sigma_{tp}{}^h-\bar{\lambda}_{tp})N}{\sigma_{tp}^h N_h}k \tag{12}$$

$$k \quad \frac{\overline{\nu\epsilon(N)\sigma_{fu}}}{\sigma_{tp}{}^h-\bar{\sigma}_{tp}}+1 \tag{13}$$

At the start-up, the power increases exponentially as follows,

$$P=Q\overline{\epsilon(N)\sigma_{fu}}\int d\boldsymbol{r}\ N(\boldsymbol{r},t)\phi(\boldsymbol{r},t)$$

$$=Q\overline{\epsilon(N)\sigma_{fu}}\,V_r\Big[N^*\phi_s+\sum_{n'}A_{n'}e^{-\{\bar{\lambda}+\bar{D}_N B_{Nn'}^2\}t}\phi_s+$$

$$+\sum_{nn'}A_n'A_{n'}e^{-\{\bar{\lambda}+\bar{D}_N B_{Nn}^2\}t}exp\left\{\phi_{on}t+\frac{\varphi_{1n}}{\bar{\lambda}+\bar{D}_N B_{Nn}^2}(1-e^{-\{\bar{\lambda}+\bar{D}_N B_{Nn}^2\}t})\right\}\Big] \tag{14}$$

When the hydrogen chain-reactions can be maintained, the excess heat is significantly produced. In order to ignite or keep the chain-reactions, it is essential to provide the dense distribution of the hydrogen-clusters in the metal. This means that there exists the critical concentration of the hydrogens contained in the metal. On the contrary, when a crack and/or spot that quickly reduce the hydrogen concentration are produced, the critical condition is broken. The power drop for a simple case of the symmetrical division can be written as follows (25),

$$P=Q\overline{\epsilon(N)\sigma_{fu}}N^{*}\phi_{s}\sum_{nn'}A_{n}'A_{n'}\int_{V_r}d\boldsymbol{r}\ e^{iB_{n'}r-iBr}$$
$$\times e^{-\{\bar{\lambda}+\bar{D}_{N}B_{Nn'}^{2}\}t}exp\left\{\varphi_{on}t+\frac{\varphi_{10}}{\bar{\lambda}+\bar{D}_{N}B_{Nn}^{2}}(1-e^{-\{\bar{\lambda}+\bar{D}_{N}B_{Nn'}^{2}\}t})\right\} \quad (15)$$

2. 2 Associated Reactions

There are several reactions that are associated with the primary fusion reactions. Since many hydrogens are involved during the hydrogen-catalyzed fusion reaction, very significant reactions that cannot be induced by the high temperature plasma at all are possible.

(a) The conventional D-D fusion reactions of Eqs. (1) to (3) are associated to emit 2.5 MeV neutrons, tritiums and so on. These reactions are induced when the energetic hydrogens that are produced by the hydrogen-catalyzed fusion reactions of Eqs. (5) and (7) bombard near hydrogens in the metal. The conventional fusion reactions certainly take place, but as secondary processes, and it is wrong to consider that they are the primary processes. The rate of the conventional reactions is approximately 10^{12} times less than that of the hydrogen-catalyzed fusion reactions, that is one of the main sources of the excess heat. This is a reason why the production rate of the neutron is extremely less than that calculated from the excess heat. On the other hand, the tritiums also should almost be equally produced as the 2.5 MeV neutrons. As discussed in (c) of Sec. 1, the experimental data show that the production rate of the tritiums is 10^{4} to 10^{8} times higher than that of the neutrons. This discrepancy will be discussed later.

There is a special case, in which the chain-reaction of the hydrogen-catalyzed fusion reaction does not sufficiently take place but that of the conventioanl fusion reactions is locally ignited in a compressed gas of hydrogen. This case might sometimes occur in an experiment with the zero or low current density. Here the amount of tritiums and 2.5 MeV neutrons are much larger than that of helium-4, so that the conventional fusion reaction looks like the primary process.

(b) Elements can newly be produced during cold fusion. There are three ways of the element production : transmutation from the nucleus of the host metal and electrolyte, many-body fusion reactions of the hydrogens and many-body fission reaction. The first can take place when the hydrogen-cluster surrounds the nucleus of the host metal and electrolyte and is compressed asymmetrically : one or more electrons, hydrogens and oxygens are first captured by the located nucleus. Here, the product elements are often heavy and are distributed near the original nucleus. For example, elements of ^{40}Ca and ^{115}In can be produced from the electrolyte K and host metal Pd, respectively,

$$^{39}K + p \longrightarrow {}^{40}Ca \tag{16}$$

$$^{41}K + {}^{16}O \longrightarrow {}^{57}Co \xrightarrow[EC]{} {}^{57}Fe \tag{17}$$

$$\begin{pmatrix} ^{108}Pd \\ ^{110}Pd \end{pmatrix} + 6D \longrightarrow 2^{115}In \tag{18}$$

On the other hand, the electron capture can less contribute to the nuclear transmutation, because the product often returns back to the original nucleus by the beta decay.

Secondly, comparatively light elements also can be produced by the many-body fusion reactions of the hydrogens in the compressed hydrogen-clusters. For example,

$$3D \longrightarrow {}^{6}Li \tag{19}$$

$$4D \longrightarrow {}^{8}Be \longrightarrow 2\,{}^{4}He \tag{20}$$

$$5D \longrightarrow {}^{10}B \tag{21}$$

These elements are sequentially distributed from lithium to around iron. As the burning is more violent, heavier elements can be produced. Thirdly, the many-body fusion reaction also can contribute to the nuclear transmutation, as will be discussed in (d).

It is remarkable that the nuclear transmutation occurs without radiation. All of the reactions from (16) to (21) take place in the itonic particle so that excited energy of the compound nucleus is transferred to the vibrating motion of the itonic mesh. Furthermore it is important to keep in mind that among the nuclear transmutation reactions there are reactions with the negative Q value. This is a case of that much heavier elements such as Fe are produced when the hydrogen capture proceeds.

(c) Multiple-neutron nuclei can be produced during cold fusion. The di-and quad-neutrons can be produced by the primary processes of Eqs. (4) and (7). Furthermore, the intermediate multiple-neutrons such as ^{6}n and ^{8}n can be produced by the manybody fusion reactions as follows,

$$3D + 3e + D \longrightarrow {}^{6}n + i_3 + d \tag{22}$$

$$4D + 4e + D \longrightarrow {}^{8}n + i_4 + d \tag{23}$$

Heavy multiple-neutrons, more than 30 neutrons, can be produced by compressing the nuclei of the electrolyte and host metal surrounded by the hydrogens, as follows,

$$^{A}K + Ae + D \longrightarrow {}^{A}n + i_A + d \tag{24}$$

$$^{A}Pd + Ae + D \longrightarrow {}^{A}n + i_A + d \tag{25}$$

Those multiple-neutrons are covered up by the itonic mesh so that they cannot scatter out individual neutrons. Rather they are metastable for a moment and shrink to finally undergo the gravity decay.

(d) Nuclear reactions are caused by the bombardment between cold fusion product particles such as the multiple-neutrons and the nuclei of the surrounding materials. When the multiple-neutron enter the nucleus, the exciting energy of the compound nucleus is expected to be so large that a nuclear reaction with several energetic fragments can be induced. This is the many-body fission reaction. The reaction is also possible with light nuclei such as silver that can induce no fission reaction with the ordinary neutron. And heavy elements also can be produced as fission products, that might be somewhat radioactive. The many-body fission reaction is observed like a star on nuclear emulsions.

(e) "Gravity-decay" (referred to distinguish the microscopic phenomena from the universal "gravitational collapse") can be caused by the multiple-neutron. When the multiple-neutron is produced, it is covered up with the itonic mesh by that the constituent neutrons cannot be scattered out. Rather by the compression force of the itonic mesh, the multiple-neutron is completely distroyed and shrinks to an extremely tiny particle. Finally the multiple-neutron transforms to a tiny blackhole. The tiny blackhole instantaneously evaporates by emitting radiations and/or extremely tiny particles. On the other hand, the materials absorbed in the tiny balckhole are violently destroyed and are emitted from a whitehole through a wormhole that connects both of the holes.

It seems difficult to accept that the blackhole can be generated in the cell, because it is usually considered that the blackhole in the universe needs a mass 10 times over than that of the sun. The fact is contrary. Since the gravitational force is employed to compress and completely destroy an assembly of neutrons, the extremely heavy mass is required. The gravitational force is the weakest among four naturally existing forces. However, if the electromagnetic force is effectively employed, it is easier to generate a tiny blackhole, since the electromagnetic force is about 40 orders stronger than the gravitational force. Here the tiny blackhole is not black in the accurate meaning, but is so light that cannot prevent the light from escaping from the hole.

2. 3 Surface Reactions

Unlike in the metal, the situations become more complicated on the surface : (a) chemical reactions deposit materials such as the electrolyte, (b) overpotential highly compresses the hydrogen-clusters and (c) local discharge enhances the hydrogen-catalyzed fusion reactions. Among them, the chemical reactions are conventional.

(a) Surface Reactions

There is a variation in cold fusion that predominates on the surface of the metal. This is significant for the metal with low hydrogen permeability, such as nickel. Here the hydrogens cannot penetrate deeply so that the hydrogen concentration of the surface increases. And the hydrogens that can freely move around on the metal surface gather in tiny pits to form large hydrogen-clusters. Furthermore they are intensely compressed by the overpotential of the electrolysis to induce the hydrogen-catalyzed

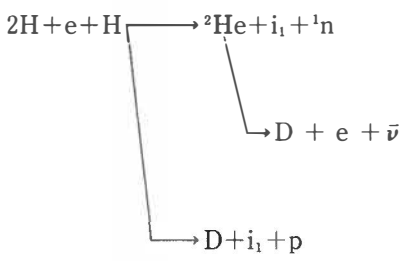
fusion reactions. If the voltage is increased, the high compression can produce tiny black and white holes. Here the chain-reactions of the hydrogens are somewhat limited by the hydrogen leak from the surface. The sequential reactions can be maintained externally by electrolysis. Therefore the excess heat can be released as soon as the electrolysis starts. The nuclei of the host metal and electrolyte also can be burn by surrounding them with the hydrogen-clusters.

(b) Discharge

There are small and local discharges on the surface, even when the electrolysis is continuously maintained. They might occur around irregular points on the electrodes, such as in the pits. The discharges can accelerate the compression of the hydrogen-clusters to enhance the hydrogen-catalyzed fusion reactions. Also they often burst to induce gas explosions.

2. 4 Ordinary Water

It is very important for industrial applications that ordinary water is available to cold fusion. The mechanisms of cold fusion with ordinary water is same as with heavy water, except different elements are produced. The cross section of the H-H fusion reaction is 10^{12} times lower than that of the D-D one, but it does not matter, since cold fusion is based on the different reactions. The most probable reactions for ordinary water that correspond to Eqs. (4) and (7) for heavy water are written as follows,

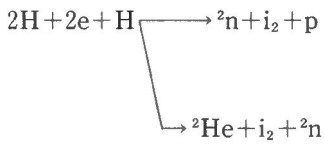


(26)

(27)

(28)

for the emission of the single iton i_1 and



(29)

(30)

for the emission of the double iton i_2. The prediction of ^{2}He might be contradicted with the Pauli's selection rule, but allowed for a short time because two protons are compulsorily compressed by the itonic mesh. For ordinary water, proton and deuterium are the main products, that can induce the chain-reactions similar to heavy water. And instead of the quad-neutron for heavy water, the di-neutron that undergoes the gravity decay is produced. The "single" neutron is also produced, but it might be different from the ordinary neutron; the single neutron produced here is covered by the itonic mesh and collapses rapidly.

The reactions of the hydrogen-clusters from Eq. (26) to (30) produce no radioactive elements. However higher reactions generate those wastes that might be trouble some for industrial applications. For example, tritiums can be produced from three hydrogens as follows,

$$3H+2e+H \longrightarrow T+ i_2+p \qquad (31)$$

3. Experimental Evidence

Almost all researchers who believe the conventional theory have orthodoxically been looking for experimental evidence such as the heat and the fusion products of neutrons, tritiums and heliums (3-6). However, cold fusion is based on the different reactions, therefore other experimental evidences should be researched. The author has been searching for such experimental evidencce by using a special technique with nuclear emulsions. Unusual particles and phenomena were obtained, which clearly indicate that the mechanisms mentioned in the preceding section actually take place. In this section, the experimental evidence that was obtained mainly by the author's experiments is described.

3. 1 Experiments

Many cold fusion experiments using the electrolysis method were carried out by the author (10, 13-22, 27, 28). Ordinary and heavy waters were used as electrolyte solutions mainly mixed with potassium carbonate and sodium chloride. Metals of palladium, nickel, titanium and copper were often used as the cathode and everytime platinum was used as the anode, respectively. Two kinds of cylindrical glass cells were used for the anodes of rod and foil metals. The anode of the rod metal that were surrounded by the helical cathode of platinum was totally inserted in the electrolyte solution. Nuclear emulsions (100 μm thick MA-7B made by Fuji Film Inc.) were often used to observe emitted particles. The nuclear emulsions were set outside the glass cell. On the other hand, for foil method, one of the foil surfaces was contacted with the electrolyte solution and the other with nuclear emulsions in the atmosphere. Here emitted particles from the metal foil can directly be recorded on the nuclear emulsions. Furthermore, optical and scanning electron microscopes (SEM) with energy dispersive X-ray spectroscopy (EDX) were mainly used to analyze the metal structure and fusion products.

3. 2 Hydrogen-Clusters

The hypothesis that the hydrogens form the clusters in the small space to induce the hydrogen-catalyzed fusion reactions is the fundamental consideration of the Nattoh model. Much experimental evidence clearly indicated that the hydrogen-clusters are really formed and that the fusion reactions really take place in the compressed clusters. The first is the break up of the itonic hydrogen-clusters. The hydrogen-clusters that are extremely compressed are covered up by the itons. They are further compressed to form heavy multiple-neutrons by the completely symmetrical compression. However

if it is not complete, for example, one or more fusion reactions precede in the cluster, the hydrogen-cluster might break up. Much experimental evidence suggesting the break up of the itonic hydrogen-clusters were recorded on copper metals during the discharging experiments with pin cathodes (28). Then among the broken itonic hydrogens, there were observed evidences of the fusion processes. The number of the hydrogens contained in the cluster depends on the conditions such as applied voltage and current. For high voltage, such as around 100 V, the number of the contained hydrogens might be more than millions. Traces of the broken hydrogen-clusters containing many hydrogens were observed on the copper plate.

Secondly, the itonic meshes covering the hydrogen-cluster faded while passing through the material so that the linkages of the individual hydrogens become weaken and finally scatter. This is a reverse process of the compression of the hydrogen-cluster. Those evidences were also observed on the back surface of the nickel thin foil, referred to the "hydrogen-frost"(13). They seem to have some structure like solidified vapor.

3. 3 Primary Fusion Products

The most probable reactions during the cold fusion are shown by Eqs. (4) to (8) for heavy water and Eqs. (26) to (30) for ordinary water. For the latter, the charged particles of the electrons, protons and deuteriums that are primary fusion products were clearly observed on the first nuclear emulsion that was contacted with the nickel cathode (13). And the di-neutrons were also measured on the nuclear emulsions and on the metal surface (13, 28). The single neutrons also underwent the gravity decays because they were covered with the itonic mesh. Those traces were separately observed on the metal surface during the one-point discharge experiments (28). For heavy water, on the other hand, no charged particles of the primary products were observed on the nuclear emulsions, because a thin protection sheet was located over the first nuclear emulsion. But Miles *et al.* measured a lot of ^{4}He instad of ^{3}He by the chemical method (8), as predicted by the Nattoh model. And the di-and quad-neutrons were successfully observed on the nulcear emulsions (A micro-explosion that was caused by the gravity decay of the quad-neutron was first observed on August 25 in 1990 on a nuclear emulsion that was located outside of the glass cell in the experiment of palladium rod/heavy water mixed with sodium chloride, shown in Fig. 1 (21)). They are covered up with the itonic meshes that are broken at the explosion of the inner multiple-neutrons. Remarkable traces indicating the explosions of the quad-neutrons associated with the break up of the itonic meshes were found (20). Furthermore a trace indicating that four fusion reactions simultaneously occur in the hydrogen-cluster was also observed (18).

3. 4 New Particle "Itons"

The Nattoh model predicts the production of the new particle "itons" during the hydrogen-catalyzed fusion reactions. The itons are considered to consist of electrons, positrons and neutrinos. Since more electrons than positrons are involved, the itons are negatively charged. When the itons are produced during the compression process

of the hydrogen-cluster, they are emitted to cover up the nuclei of the product particles. Figure 3 in Ref. 20 clearly shows the break ups of the itonic products, inside that the quad-neutron underwent the gravity decay. While the iton passes through the material, the electrons of the iton are torn off by a de-ionization process and the iton finally decays to a pair of an electron and a positron. The sequential break ups of the network of the itonic meshes were successfully observed on the nuclear emulsions, shown in Fig. 4 in Ref. 20. And the pair productions due the itons were also recorded on the nuclear emulsions (14).

3. 5 Chain-Reactions

The Nattoh model predicts that the chain-reactions of the hydrogens can be maintained to predominately produce the excess heat for the Pons-Fleischmann type experiment. And the critical equation for the indirect mode was obtained, Eqs. (11) to (13). It is difficult to obtain experimental evidence that directly prove the occurrence of the chain-reactions in metal. However there is data suggesting it. First, a critical value seems to exist for the atomic ratio of D/Pd, that needs to be over 0.85 in average to ignite the burning (6). Under that value, cold fusion cannot be induced at all. Second, the time behavior of the power can be well presented by Eq. (14) : it approaches exponentially to the constant level that can be determined by the surface condition.

3. 6 Heavy Element Production

The EDX analyses with SEM indicated that there are heavy elements distributed in the grain-shaped defects (21). They consist of wide and continuous nuclei ranging from sodium to zinc (the EDX system is not available to lighter elements than sodium) so that they can be assigned to be produced by cold fusion processes. The Nattoh model predicts that the many-body fusion reactions can easily take place in the compressed hydrogen-clusters to produce the heavy elements. During the explosive cold fusion, the burning was violent so that those heavier elements could be easily produced. The neutron-induced radioactive method found that the isotope of ^{115}In was produced (29). This was caused by the nuclear transmutation of the host metal Pd, shown in Eq. (18). On the other hand, Bush reported that Ca was produced from K during the electrolysis of ordinary water with thin nickel foil, as shown in Eq. (16)(12). Ohmori *et al.* reported the production of Fe on the surface of Au electrode, as shown in Eq. (17)(30). Furthermore Kucherov *et al.* reported the production of 23 nuclei ranging from He to Ru (31). Here the many-body fission reaction should be involved.

3. 7 Multiple-Neutrons

The Nattoh model predicts the production of the multiple-neutrons such as di- and quad-neutrons during the hydrogen-catalyzed fusion reactions. The di-and quad-neutrons are the primary products of cold fusion with ordinary and heavy water, respectively. Those traces were observed on the nuclear emulsions, described in Sec. 3.3. Since many hydrogens are involved in the hydrogen-clusters, the other branches for the production of heavy multiple-neutrons might be possible. Although extremely heavy

mutiple-neutrons can be trasformed to the tiny blackholes, as described in Sec. 3.9, intermediate multiple-neutrons such as ^{6}n and ^{8}n might be produced. They also are compressed by the itonic meshes to explode. Traces suggesting those explosions were found on the nuclear emulsions (17).

3. 8 Defects in Metal

Metals that were used for the cold fusion experiments were analyzed by SEM (27). Strange defects were observed in the grain-boundaries in the metals: spot and grain-shaped defects. The spot defects suggest one-dimensional burning of the cold fusion and by those sequential reactions, the grain-shaped defects are formed. They are arranged in the grain-boundaries so that these defects verify that as the Nattoh model predicts, the cold fusion reactions occur not in the lattice but in the grain-boundaries in that the hydrogens can be trapped to form the hydrogen-clusters.

3. 9 Many-Body Fission

The multiple-neutrons such as di- and quad-neutrons that are predominately emitted during cold fusion are expected to interact with nuclei in the surrounding materials to induce nuclear reactions. The compound nuclei caused by the multiple-neutrons might have a higher exciting energy than by the ordinary neutron. Therefore nuclear fission reactions with many fragments might be possible.

Stars indicating those reactions were obtained in an experiment with palladium foil and heavy water (19). The traces were recorded on the nuclear emulsions located outside the cell. They can be clearly distinguished from the stars caused by the cosmic rays. The stars suggest that the multiple-neutrons induced the many-body fission reactions with heavy nuclei, probably silver, in the nuclear emulsions. The number of the fragments was around seven or eight, and they might somewhat contain radioactive nuclei. The many-body fission reaction should more frequently take place in the cell and somewhat contribute to the heat production and the nuclear transmutation.

3. 10 Tiny Black and White Holes

When the nuclei of the host metal and the electrolyte are compresssed in the hydrogen-cluster, more than 100 neutron nucleus can be produced that might be transformed into a tiny black hole by the gravity decay. The extraordinary trace shown in Fig. 4 in Ref. 18 indicates that a tiny black hole is produced and rolling in the neighboring materials. Due to the light mass, the tiny black hole evaporates instantaneously, as shown in Fig. 1 in Ref. 18.

The black hole is connected with a white hole from which the absorbed materials can be sprouted out. Many tiny white holes were observed in experiments with low hydrogen permeability such as nickel (13). Figures in Ref. 13 show those tiny white holes, in that the broken materials are sprouting from the top of the cone. Remarkably, Fig. 7(i) in Ref. 13 shows both of the evaporation of the black hole and the sprouting of the materials from the white hole. They might have been divided while passing through a warm hole that connects the black and white holes.

It is now uncertain what materials can be sprouted from the white hole. Since the

nuclei are destroyed by the gravity decays and the broken materials pass through the worm hole of the order of 10^{-33} cm so that they might at least be non-baryons, and consist of the tiny particles such as superstrings. The linked materials can somewhat be seen in the exit of the white holes (13). Furthermore traces suggesting that some heavy particles such as X-particle might have been emitted were observed on the nuclear emulsions (13, 20). Those pictures were published in a book (32).

3. 11 Miscellaneous

Several extraordinary phenomena were found during cold fusion. The first is strange microsparks that were observed on the metal surface, such as titanium during the AC electrolysis experiments (22). They can be distinguished from the conventional electrical sparks. The microsparks were found to be related to the tiny black or white holes by setting the nuclear emulsions. Since the electrical charging was continuously employed, the microsparks were shining near the surface like twinkling stars. However during other experiments with the shot charging (33), the microsparks flighted 2 or 3 cm in the solution or air, like ball lightening, and finally stopped to explode. Furthermore strange traces of coupled rings that were suggested to be caused by the tiny ball-lightning were found on nuclear emulsions. They were symmetrically recorded on the first and second nuclear emulsions. This means that the tiny ball-lightning hopped up and down in a small space between the first and second nuclear emulsions. These strange behaviors can be well explained by the characteristics of the itonic hydrogen-clusters.

The second is the extraordinary conductivity that were recently reported by McKubre *et al*. (23). While they were measuring the electrical resistence to know the amount of hydrogens absorbed in a metal, the resistence sharply dropped. According to the Nattoh model, hydrogen-clusters that are locally compressed in small spaces in a metal such as grain-boundaries become the itonic state, that are negatively charged due to the surplus electrons and well conductive. As the hydrogen loading ratio increases, the hydrogen-clusters become densely distributed and interconnects each other. Finally the rod of the metal hydride becomes wholely conductive.

The third is interference phenomena that were also observed on the nuclear emulsions located outside the cell (16). The gravitational and anti-gravitational waves were suggested for them. They should have a weak intensity but might microscopically interact with the material of the nuclear emulsions. But these should be examined in more detail.

4. Discussions

In the preceding sections, the mechanisms of the cold fusion were explained by the Nattoh model and the experimental results that verify the explanations were shown. Here the controversial issues of the cold fusion and the other important subjects are discussed.

4. 1 Controversial Issues

The anomalies of the cold fusion that are controversial issues can well be explained

by the Nattoh model.

(a) The primary controversy is the reproducibility of the excess heat. After cold fusion was published, many researchers tried to replicate the experiments. However very few researchers succeeded. Alternatively, even in same laboratories, results depended on experimental conditions, especially used palladium rods. These are caused by the characteristics of the chain-reactions of hydrogens that is a predominate source of the excess heat for metals such as palladium with the high hydrogen permeability. The hydrogen concentration should be increased such that the critical condition of Eqs. (11) to (13) is maintained. However during the charging of hydrogens into palladium, tiny cracks or pits are produced. The absorbed hydrogens rapidly leak from these place. Then the critical condition cannot be satisfied. Alloys of palladium with about 10% silver that protects them from cracking can improve the reproducibility of the excess heat production (6).

On the other hand, with metals such as nickel with the low hydrogen permeability, the main source of the excess heat is the surface reaction. Since the hydrogen-clusters are mainly compressed by the overpotential, the excess heat can be produced as soon as the charging starts. The reproducibility can be expected to be almost 100%. In the case of the Mills type experiment, the chain-reactions of hydrogens contribute less to the heat production than in the Pons-Fleischmann type experiment, because they occur only on the surface. The other reactions such as the nuclear transmutation given by Eqs. (16) and (17) and the gravity decay reactions contribute more to the heat production. The contribution ratio of the reactions depends on the experimental condition. The nuclear transmutation of the Ca or Fe production is predominate in the low voltage or current density. As the voltage or current density increases, the contribution by the reactions shown in the lower part in Fig. 1 becomes more.

(b) The inconsistency between the production rates of the neutrons and the excess heat described in (b) in Sec. 1, are often controversial for heavy water. This can well be explained by the hydrogen-catalyzed fusion reactions that emit no neutrons. For palladium, the main source of the excess heat is the chain-reactions of the hydrogen-catalyzed fusion reactions where the new particle itons are emitted, taking away about 20 MeV from the excited ^{4}He nucleus for heavy water. The channel of the 2.5 MeV neutron emission can not be opened. Furthermore, the multiple neutron nuclei that are produced in the reactions are covered up with the itonic meshes so that the individual neutrons can not be scatted out. However, the conventional D-D fusion reaction of Eq. (1) that emitts 2.5 MeV neutron takes place as a secondary process, about 10^6 times less than the primary hydrogen-catalyzed fusion reactions. Therefore the production rate of the 2.5 MeV neutrons is at least 10^6 times less than that of the excess heat.

A comment should be added for the itonic multiple neutrons. Especially the di- and quad-neutrons that are emitted during the hydrogen-catalyzed fusion reactions have the itonic mesh with heavy negative charges. They are sometimes confused with the conventional neutrons or alpha particles (6). Those multiple neutrons can be detected by the conventional neutron detector such as scintillators and ionization chambers. Here, the multiple neutrons generate by the gravity decay a peak signal with a very narrow width so it could be easily distinguished from the neutron signal with care-

ful attension. Alternatively, they also generate similar signals to alpha particles in the charged particle detectors such as surface barrier detectors. The multiple neutrons can escape out of the cell or filters that can sufficiently stop the alpha particles.

(c) The inconsistency between the production rates of the tritiums and neutrons, described in (c) in Sec. 1, is an important issue for heavy water. The activity of the tritiums is observed 10^4 to 10^8 times higher than that calculated from the neutron production rate. According to the Nattoh model, ^4H is expected to be produced during the hydrogen-catalyzed fusion reactions for heavy water, as shown by Eq. (5). This isotope undergoes the beta-decay such that the activity might be confused with that of the tritium. Although the lifetime of the ^4H isotope is about 10^{-17} sec, it could be stable for a moment since it is covered up with the itonic mesh. Afetr the mesh fades, the beta decay instantaneously occurrs. So far the isotope of ^4H has not yet been observed in the author's experiments with nuclear emulsions. An assembly of the nuclear emulsions was always covered by a thin protection paper that might have prevented the itonic ^4H from escaping. However, other researchers reported extraordinary results that suggest the production of ^4H. An element with a mass between 4.0026 amu of ^4He and 4.0282 amu of D_2 was observed (34).

(d) As described in Sec. 1, a large amount of ^4He instead of ^3He was reported by Miles *et al.* (8). The production of ^4He would be posssible by the conventional fusion reaction shown by Eq. (3). If so, however, the intense high energy gamma rays should be associated. Rather, this fact can easily be explained by the Nattoh model. The reaction shown by Eq. (4), that is the most probable branch during the hydrogen-catalyzed fusion reactions, shows the production of ^4He. The di-neutrons, associated here, are covered by the itonic mesh and quickly undergo the gravity decays. If a neutron detector, such as a liquid scintillator, is located sufficiently near the metal, the survival di-neutrons might be counted. Almost all of the neutron detectors are located in large moderators so that very few signals are produced by the di-neutrons. Furthermore, ^4He can be produced by the beta-decay of ^4H, as shown by Eq. (6).

(e) The complicated spectra of the charged particles, that cannot be explained by the conventional D-D fusion reactions were reported by a thin foil experiment (9). The spectra were explained by introducing the new particle, iton (26) : therefore, the multiple neutrons such as the di-and quad-neutrons would be emitted as bare particles. It was later found that they are covered up by the itonic mesh with a heavy charge (20). They might be confused with the conventional charged particles such as the deuteriums and heliums in the thin foil experiment. If these factors are enclosed, the agreement between the experiment and calculation will be better.

(f) It is important that ordinary water is available to cold fusion. Despite that the feasibility cannot be expected by the conventional theory at all, the extraordinary signals indicating cold fusion were first obtained with ordinary water by the anthor (10). And Mills *et al.* reported the excess heat production with ordinary water by using a thin nickel foil (11). The Nattoh model equally predicts the feasibility of cold fusion with ordinary water, as well as with heavy water. The excess heat production with ordinary water with the thin nickel foil is somewhat less than with heavy water in the palladium rod, because the chain-reaction of hydrogens is limitted on the surface in the

former case. However, by using the surface reactions, where the nuclear transmutation and the gravity decay reactions contribute to the heat production, many experimental data with the heat production were reported so far (3-6, 30). Many traces that indicate the gravity decays were observed on the nuclear emulsions (13).

(g) Other strange phenomena observed during cold fusion can be partially explained by the Nattoh model. For example the microsparks that were observed on the metal surface can be explained by the formation of the itonic grain (22).

4. 2 Comparison with the Fission Reactor

Let us briefly compare cold fusion with the fission reactor. For the fission reactor, the primary process is the neutron-induced fission reactions of uranium or plutonium and the power is maintained by the neutron chain-reactions. Additionally there are various reactions associated with the neutron chain-reactions: beta decays of the fission products, Cherenkov lights by the beta decay electrons, gamma rays by (n, gamma) reactions and so on. Cold fusion resembles the fission reactor, i.e., the fundamental reactions of cold fusion are the chain-reactions of the hydrogen-catalyzed fusion reactions that are associated with various reactions. The fuel of cold fusion is the hydrogen-clusters and the hydrogens themselves are the chain-reaction particles.

The biggest differences between them are the distance over which the chain-reaction particles can fly and the multiplicity by that they are multified per reaction. The neutrons can fly about 2 m in the fission core, while the hydrogens have very short ranges in metal, only several hundreds μm. And 2.5 neutrons in average are emitted per one fission reaction of uranium or plutonium, however many energetic hydrogens per hydrogen-catalyzed fusion reaction are emitted. This is because the fuel of the hydrogenclusters consist of many hydrogens, possibly more than millions. The former fact makes cold fusion burn very locally. And the latter means that the critical condition can easily be satisfied for cold fusion. Furthermore cold fusion burns more variously. Although the neutron flux in the nuclear reactor is limited to around 10^{14} n/cm^2. sec, the hydrogens in the metal for cold fusion can be densely concentrated. The rates of the associated reactions during cold fusion are so high that the nuclear transmutation such as the heavy element production is more accelerated than in the fission reactor.

It is remarkable that despite of the high production rate of the elements, there are almostly no radiation. This is due to the formation of the itonic mesh that can take away excitation energy of the compund nucleus.

4. 3 Applications

Several applications of the cold fusion technique are promising.

(a) The energy production is the most important at the present time. There are three processes that contribute to the heat production: chain-reactions of the hydrogen-catalyzed fusion reactions, nuclear transmutation and gravity decays of the multiple neutrons. The first is the main source of the excess heat for the Pons-Fleischmann type experiment with the palladium rod, and the two latters for the Mills *et al*. type experiment with the thin nickel foil, respectively. The first that is sustained by the chain-reaction would be good for the efficiency of the heat production to input electrical

power but the most difficult for the controllability of the reaction. We should be care that the nuclear transmutation of heavy elements over Fe contributes to the negative energy production. Then the efficiency of the heat production could not be so improved, even if the hydrogen concentration or the current density are efficiently enhanced. The transforming efficiency from mass to energy is the highest for the third process. For scaling up of power, it is required to achieve the high energy density. Then the method based on the third process might be superior.

For cold fusion, burst burning is easier than continuous burning. Burst burning is suitable to vehicle engines such as automobile, ships and space-crafts. It can be performed by several conditions : direct mode of the chain-reactions, overcritical condition of the indirect mode or the surface reactions. The two formers are enhanced in the metal so that the damage of the materials will have unevitable problems. The last that is especially based on the gravity decays of the multiple neutrons might be more efficient to generate the propulsion power.

(b) Nuclear transmutations also might be possible. There are three ways to obtain nuclear transmutations : production of the elements by the many-body fusion reactions, nuclear transmutation from the nuclei of the host metal and the electrolyte and many-body fission reaction. Unlike in the fission reactor, the transmutation rate for cold fusion is very high because the hydrogen concentration is extremely higher than the neutron flux. The elements produced by the first process continuously distribute from lithium to around iron. The second can produce elements near the host nuclei. With the third process, produced elements could be widely distributed.

(c) Nuclear transmutation might be applied to nuclearly incinerate hazardous materials such as nuclear materials and radioactive wastes. The first method of the nuclear incineration would be to use the capturing one or more protons and oxygens as shown in Eqs. (16) to (17). Cesium-137 or strontium-90 would be contained in an electrolyte solution and transuranium elements such as pultonium and neptium would be mixed in electrodes. Simultaneously they could be incinerated by the bombardment with multiple neutrons such as di-and quad-neutrons. In the former process, the nuclear transmutation takes place in the itonic state so that no radiation would be emitted. In the latter process, on the other hand, additional radioactive materials would be somewhat generated.

4. 4 Safety Problems

When cold fusion is applied in the industrial scale, several safety problems should be resolved.

(a) The first is explosions. The explosions were often experienced during the electrolysis cold fusion. They could sometimes be hydrogen gas explosions, that can easily be avoided with usual care. But even under the normal operation, the preceding explosive cold fusion reactions can easily induce the gas explosions. Here the distance between the electrodes is an important factor. If it is too short, local and small discharges can induce explosive cold fusions. More attention should be payed to controlling the cold fusion reactions as well as the chemical reactions.

(b) Second, radioactive materials could be produced by the fission reactions like in

the fission reactor. For cold fusion, the many-body fission reactions are induced by the multiple-neutrons such as the di-and quad-neutrons. Furthermore, the reaction of Eq. (31) generates tritium with ordinary water. They are secondary reactions so that those amounts are extremely less than the primary one. But in the industrial applications, the burn up should be so high that the amount of the radioactive materials is somewhat of be a problem. Even if so, the problems might significantly be reduced than in the case of the fission reactor.

(c) The third is related to the gravity decays. They newly generate tiny black and white holes that might radiate the gravitational waves and non-baryon products. These might already exist in the natural environment, since the cold fusion reactions seem to easily take place anywhere. However, they will be additionally produced with the industrial scale by the applications of cold fusion. This is similar to the problems of the radiations or radioactive materials in the fission reactors. The materials themselves might not be so hazardous but if those magnitudes are over the limit, they will become problems. The effects of those strange materials on biological tissues should be examined in detail.

4. 5 Impacts on Other Fields

As mentioned in Secs. 2 and 3, various significant discoveries were made during cold fusion: (1) new hydrogen-catalyzed fusion reactions associated with the itons, (2) heavy elements production by the many-body fusion reactions, (3) gravity decays to generate the tiny black and white holes and so on. These discoveries in cold fusion might significantly impact on other fields.

(a) The iton could open new science and technology for nuclear physics and material science. Since energy concerned with nuclear physics and material science is very different each other, the two fields had no direct connection so far. The iton that locates significantly near the nucleus can directly interact with the nuclei and transfer energy of the nuclei to material lattice. The spatial distribution and energy of electrons in the itonic mesh should be investigated in detail.

(b) Elementary physics might be stimulated, since the gravity decays followed by the tiny black and white holes can be produced in our laboratories. There seems to exist the critical mass that distinguishes the light multiple-neutrons such as quad-neutrons from heavy ones, although the exact value is now unknown. The multiple-neutrons with light mass undergo the gravity decay to explode with shock waves that were observed like bubbles on the nuclear emulsions. The bubbles certainly consist of much smaller particles than quarks. Heavy multiple-neutrons, on the other hand, are transformed to tiny blackholes that evaporate to emit radiation and particles. The particles should be much smaller than the particles of the bubbles. Therefore, there might exist the level for the dimension of the particles. Furthermore the quantum-relativity theory can be examined in detail by experiments in laboratory. A simple question arises: why can the significant reactions such as the gravity decay occur in low voltage electrolysis around several 10 V, although no high energy accelerators, exixting or planning, can induce them at all. The answer is the compression effect of hydrogen-cluster that is essentially caused by many-body interaction. Recently, an accelerator

induced cold fusion reactions by accelerating hydrogen-clusters (35).

(c) Extraordinary phenomena were observed in the natural environment so far (36). Many of them are found to be associated with the electrical discharge, but left unexplained. However they also might be made clear by similar mechanisms to cold fusion. For example, tiny ball lightenings were observed during a discharging cold fusion experiment (33).

(d) The astrophysics might modify the senario by the discovery of the new fusion reactions. For example, the solar neutrino problems should be re-examined by inducing the new fusion reactions, because the hydrogen concentration deep in the sun is so high that new fusion reactions can easily be enhanced. Alternatively, the scenario of the element production in the origin of the universe should also be modified. We can remember the events that occur in cold stars faraway in the universe. The prodution of the elements, multiple-neutrons and tiny black holes in cold fusion would correspond to the productions of white dewarves, neutron-stars and big black holes in the universe, respectively. We can say that cold fusion is a small scale simulation of the events that occur in cold stars faraway in the universe. Now we can reproduce the novels of the universe in our laboratory. Therefore, the non-baryons of the gravity decay products might be found during cold fusion, that can be expected to be dark matters.

4. 6 Summaries

In the preceding sections, the mechanisms of cold fusion have been well explained by the Nattoh model. Although important things such as the productions of ^4H and non-baryon particles remain unproven, we have comprehensively but qualitatively understood the extraordinary phenomena associated with cold fusion. It is characteristic that cold fusion burns in various manners depending on the conditions, because the hydrogen-cluster envolves many hydrogens. The branching ratios of the hydrogen-catalyzed fusion reactions are critical factors that are determined by the conditions of the electrolysis, the microscopic structure of the metals and so on. They will be studied quantitatively from now, but it seems very laborious because there are many cases. Furthermore, the study of cold fusion will be progressed towards the high voltage and current to achieve the higher efficiency of transforming mass to energy. There the gravity decays instead of the fusion reactions predominate so that new science such as black and white holes will be fully developed.

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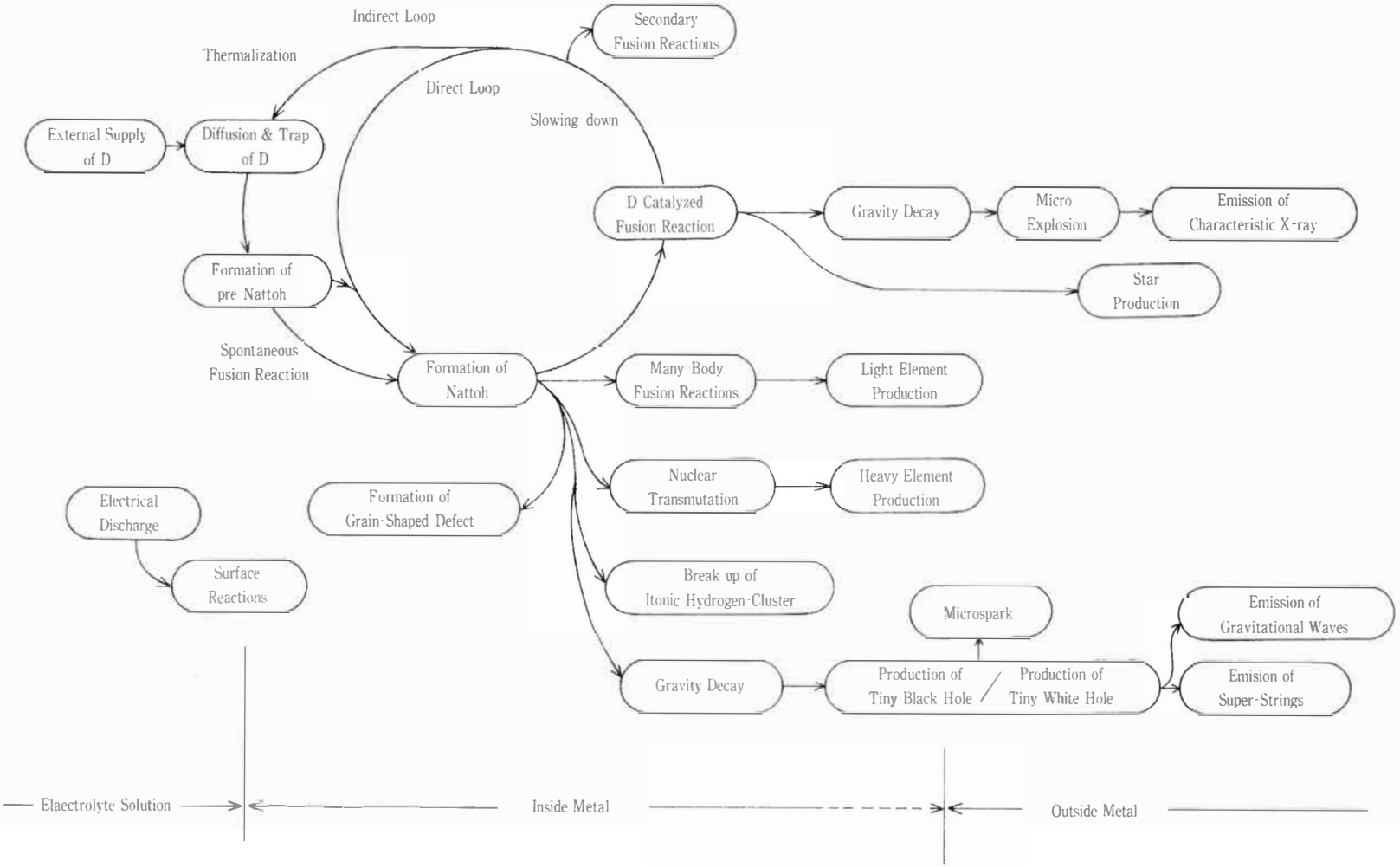

Fig. 1: Mechanisms of cold fusion

Ref. (2)

Mechanisms of Electro-Nuclear Collapse: Comprehensive Explanation by The Nattoh Model

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Abstract

Electro-nucelar reactions which take place in a special state of hydrogen clusters and were recently discovered during cold fusion study were reviewed in a previous paper(1), "Mechanisms of Cold Fusion: Comprehensive Explanation by The Nattoh Model." This paper reviews electro-nuclear collapse which is the most remarkable reaction among the electro-nuclear reactions. Experimental methods of underwater spark discharges are described. A lot of results of the electro-nuclear collapse are obtained. The mechanisms of those products are explained by The Nattoh Model. Natural phenomena caused by electro-nuclear collapse are described. Furthermore, impacts to other scientific fields are also discussed.

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Mechanisms of Electro-Nuclear Collapse:

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Mechanisms of Electro-Nuclear Collapse: Comprehensive Explanation by The Nattoh Model

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1. Introduction

1.a. What is Elecrtro-Nuclear Collapse(ENC)?

Nuclear collapses by the gravitational force take place far in the universe after shining stars consume their fuels. As resulted, black holes which absorb materials could be formed with very massive stars. Many astrophysicists now believe that a black hole really exists even in our galaxy. On the other hand, white holes which emit materials and are an alternative answer for an equation satisfied by the black holes are theoretically expected to exist. The white holes have not been confirmed yet. Both of the holes are considered to be connected with a worm hole of an extremely thin diameter, about 10^{-33} cm. Although the nuclear collapse is one of the most important reactions in astrophysics, those experimental researches have not been progressed so far. The reason is obvious. Ten times huge mass over that of the sun is needed to induce the nuclear collapse, because the gravitational force is the weakest among four forces.

However, the nuclear collapse in laboratory was recently discovered by the author in 1991 during experiments of so-called "***cold fusion***"(1 - 4). Here the nuclear collapse was directly induced by the electromagnetic force which is 40 orders stronger than the gravitational force. So it was callded "***Electro-Nuclear Collapse(ENC)***."

1.b. Electro-Nuclear Reactions(ENRs)

During cold fusion experiments, several kinds of electro-nuclear reactions(ENRs) were discovered by the author(1). They took place in a special state of strongly compressed hydrogen

clusters, called "***itonic state***," in which many electrons were degenerated and interconnected each other so that bonding between atoms became extremely strong. The itonic cluster was a strongly coupled multibody system so that ENRs were new nuclear reactions which were never observed so far. There were five kinds of ENRs that were found until now: ***a new fusion reaction*** of D + D --> ^{4}He(with no gamma rays), ***nuclear transmutation(ENT)***, ***generation of tiny neutron stars, electro-nuclear multiple fission reactions(EMF)*** and ***nuclear collapse(ENC).*** The detail was explained in the first review paper(1). The probability of the reactions depended on the compression strength. The new fusion reaction generating ^{4}He was the major reaction which predominately contributed to the excess heat production in electrolysis cold fusion experiments with a palladium metal and heavy water. On the other hand, ENC was the most remarkable reaction among them and could generate tiny black and white holes. It was difficult to experimentally prove the formation of the black hole but very easy to show that of the white holes, because materials with anomalous structures were explained as being emitted from the white holes.

1.c. This Paper

This review paper is one of the review series which followed a previous paper reviewing cold fusion: "***Mechanisms of Cold Fusion: Comprehensive Explanation by The Nattoh Model***" (1). This paper comprehensively explains the mechanisms of ENC based on The Extended Nattoh Model. First an effective experimental method inducing ENC will be introduced: ***underwater spark discharges(USDs)***. Many experimental products will be obtained to prove ENC, each of which will be explained by The Nattoh Model. Furthermore natural phenomena related to ENC will be described: ball lightning and earthquakes. Finally some topics will be discussed.

2. Experiments of Underwater Spark Discharge(USD)

It was found by the author in 1994 that remarkable tiny sparks appeared on the surface of thin nickel wire electrodes during continuous underwater DC discharges(5 - 7). Examining in detail, the sparks were not normal but "***itonic clusters***" in which ENC took place. The underwater spark discharges(USDs) were fully developed by the author as the simplest and most effective

method for inducing ENC. Here the current density could be increased sufficiently high and pinch effects well worked on the electrode surface. Appropriately selected electrolytes improved the "***itonization***" processes which were essential to induce ENC. Furthermore the USD experiments under a pulsed AC mode were conducted as experiments of ENC with a large scale.

2.a. Continuous Mode

The continuous mode of USD was useful for examining ENC processes in detail. Many experiments of USD were carried out with thin metal wire electrodes under the continuous DC mode(7, 8).

The experimental arrangement is shown in Fig. 1(a). Electrodes of ***thin metal wires***(0.3 - 2.0 mmφ) were vertically inserted in an electrolyte solution contained in a 50 ml beaker. Pure metals such as palladium, nickel, cadmium, iron, molybdenum, titanium, tungsten and platinum, and some alloys were examined. For a reference electrode, a thin platinum wire(0.5 mmφ) was usually used. Ordinary water mixed with potassium carbonate(about 1.5 Mol/l) was used for the electrolyte solution. Heavy water was not neccesarily required(9). Discharges under the continuous DC mode were employed between the electrodes. It was convenient to use the electrodes with different effective lengths. Then the current density on a shorter electrode was higher such that pinch effects could well work.

A ***copper plate***(typically about 25 x 25 mm) was used for a monitoring plate to catch up products emitted during the discharges. Alternatively, similar copper plates were sometimes used for a reference electrode instead of the platinum wire in order to effectively collect the products. The products and those traces caught on the copper plates were examained with an optical microscope(OM) and a scanning electron microscope(SEM). Element analysis for the products was carried out with an energy dispersive X-ray spectroscopy(EDX), but with which no lighter elements than B were analyzed. Two dimensional mapping of elements was sometimes performed with an electron probe microscope analyzer(EPMA). The phenomena of the discharges were also observed by a microtelescope with the multiplication of 10 to 200 times. X-rays or gamma rays were often monitored with a CdTe detector.

The characteristic curve of I/V was shown in Fig. 1 in Ref. 7. Here a thin palladium metal wire(0.5 mmφ and effectively 3 mm long) and a platinum wire(0.5 mmφ and effectively about 25 mm long) were used for the cathode and anode, respectively. The general aspects of the figure were similar for the other metals. The amplitude of the current depended on the experimental arrangement such as the effective length of the electrodes which were inserted in the solution. There were three regions in the I/V curve: (1) a linear region of low voltages below about 40 V, (2) a fluctuating region of mediate voltages around 40 - 50 V and (3) a pinched region of high voltages over 50 V. In the first region, the gas evolution from the electrodes proportionally increased as the voltage increased. In the high voltage region, ***the pinch effects*** worked on the surface of the palladium cathode to strongly suppress the current. Simultaneously the gas evolution was also suppressed. In the mediate region, the pinch effects were sometimes broken and the current violently fluctuated.

2.b. Pulse Mode

The USD method with a pulsed AC mode was the most effective to induce a large scale of ENC(5, 9 - 12). Here tiny sparks which were observed during the continuous USD could perfectly cover the electrode surface so that the whole electrode inserted in the solution could lead to ENC.

The experimental arrangement with the pulsed AC mode is shown in Fig. 1(b), which was similar to that used for the continuous DC mode. Here thin wire electrodes of cadmium(0.5 mmφ) and lead(1.0 mmφ) were used for the cathode. Ordinary water solutions of potassium carbonate(about 1.5 Mol/l), potassium hydroxide(about 1.5 Mol/l) and cesium carbonate(about 0.6 Mol/l) were contained in a glass petridish(inner diameter, about 60 mmφ). When the electrolyte of potassium hydroxide was used, the system was perfectly carbon free. This was useful to examine the generation of C atoms, as will be described in Secs. 3.e. and 3.f. The effects of these electrolytes were examined by comparing K with Ce. A box of copper plates(typically 25 mm x 25 mm x 30 mm) was used for the reference electrode. The box electrode was effective not only for increasing the current density to induce ENC but also for catching reaction products in the

total direction. All of the copper plates was polished with diamond pastes like a mirror and washed in alchol with ultrasonic vibration. The products were analyzed in the same manner as during the continuous USD experiment(Sec. 2.a.).

Discharges were employed with an ***electrical switch*** between the wire electrode and the copper plates under the pulsed AC mode: up to 120 V, 50 Hz, 20 - 800 msec ON, 20 - 60 sec OFF and a fixed phase of 0 deg. Here the amplitude of the potential on the thin electrode changed from 0 to 120 V but forwards the negative voltage. A couple of shots were repeated. Among the shots, the first one seemed especially effective for reactions to occur, because flashes were the most brilliant. Although the microtelescope was connected with a monitoring TV, the speed of recording(time step, 30 msec) was not enough for continuously following reactions during each shot. The contents of the reactions caused by the shot had to be inferred by examining products deposited on the copper plates.

3. Experimental Evidence for ENC

Many experimental evidence for ENC were obtained during a series of the USD experiments with the continuous DC and the pulsed AC modes.

3. a. Microsparks on Electrodes

First of all we have to start with the remarkable ***tiny sparks*** which were observed on the surface of the cathode(6 - 8). During the continuous DC discharges, extraordinary sparks began to appear on the tip of the thin nickel wire cathode around 40 - 50 V in the mediate region of I/V In the pinched region, the number of the sparks increased as the voltage increased, and eventually the whole surface of the cathode was covered by the sparks. Then other sparks appeared on the platinum wire anode in the high voltage over 60 V. By observing the details with the microtelescope, it was found that the tiny spark on the cathode consisted of many ***microsparks***, each of them was a brightly shining ball and slowly moving around on the surface. On the other hand, the sparks on the anode seemed to be no real bodies but just lightning. The light on the anode was weaker than that on the cathode. This fact suggested that different mechanisms should work

on the individual electrodes. A titanium electrode was exceptual among the metals used in the experiments. With titanium, sparks first began to appear on the anode and was followed on the cathode in a higher voltage. A special mechanisms could be suggested for titanium(Sec. 4.a).

The misrosparks on the cathode could exist in the solution as well as in the atmosphere as stable bodies, at least for a moment. An important picture which was shown in Fig. 4 in Ref. 8 was accidentally taken to indicate such free microsparks. While the microsparks were shining on the nickel cathode, a tiny explosion took place and made a group of the microsparks leave the electrode. Then they were driven toward the anode in the solution by the potential and broken up there. This fact clearly indicated that the microsparks were negatively charged. When the 50 ml beaker was put in a bath with ultrasonic vibration, more microsparks were effectively generated and easy to leave the electrode.

3.b. Electro-Nuclear Incineration(ENI)

Experiments of ***Electro-Nuclear Incineration(ENI)*** were attempted with a rolled ballic anode(about 5 mmφ) of a very thin nickel metal wire(0.1 mmφ x about 20 cm long) under the continuous DC mode(7). Here the platinum wire cathode and the potassium carbonate solution were used. When the nickel wire ball was pinched around 50 V, reaction products erupted from the wire surface. The shape of the eruption seemed curiously conic, but hollow inside it. Most of the conic products could not escape from the outer surface of the pinched electrode. Many products also arose upwards along the pinched electrode over the surface level of the solution, and formed like white solidified materials.

Increasing the voltage over around 70 V, the nickel metal wire began to burn and those color became red. While the current was supplied, ENI continued underwater and eventually the nickel wire ball completely vanished.

3.c. Itonic Clusters

The Nattoh Model proposed that it is essential to induce ENC that hydrogen clusters transform to a special state, "***itonic state***," in which many electrons are degenerated and interconnected each other(1). The ***itonic clsuters*** were successfully caught on nuclear emulsions in

earlier experiments of cold fuison(13). The itonic electrons had a mesh like structure as shown in Fig. 4 in Ref. 13 and were broken by an explosive reaction of inner hydrogen clusters as shown in Fig. 3 in Ref. 13. Since the current density was high in the USD experiments, a lot of the itonic clusters which involved much more electrons were observed under the continuous DC mode as well as the pulsed AC mode(5 - 10).

First of all, a lot of traces for the ***itonic electrons*** were observed on the copper plates under both of the discharge modes. They were shown in Fig. 4 in Ref. 14. The traces which had shapes like fern leaves indicated the break up of many interconnected electrons. Especially during the continuous DC discharges, long linked electrons could be observed in a visual sight with the microtelescope, when they left the electrode. Here the ultrasonic vibration accelerated those formation(15).

Secondly a lot of ***itonic clusters involving heavy atoms*** were deposited on the copper plates during USDs with both of the modes: itonic electrolytes such as K and Ce, and itonic electrodes such as Pb. The electrolyte driven by the potential in the solution was itonized on the electrode surface, containing hydrogen atoms. Here the structure of the itonic clusters sensitively depended on its valence electrons because they could determine the number of water molecules assembling around the electrolyte in the solution. The itonic K cluster was shown in Fig. 2 in Ref. 14. Around the K atoms, there were scattered straight debrises of the itonic electrons, in which the hydrogen atoms should be involved as well. The pattern of the scattered debrises suggested the structure of the itonic cover: it was not uniform but had a mesh like structure. This was consistent with the broken itonic meshes observed in the previous cold fusion experiments (4, 13), and would be closely related to similar products obtained during the Matsumae earthquakes as will be described in Sec. 5.e. Furthermore there were a lot of Pb clusters deposited on the copper plates which had thick layers of itonic Cs clusters. This will be described in Sec. 3.d.

An extraordinary energy shift was observed for the characteristic X-rays from the itonic clusters during the analysis with EDX(16). There was a partially break up of an itonic Pb cluster, in which itonic K atoms were somewhat involved. The EDX spectrum showed a slight energy

shift for the K-X rays of the K atoms compared with the normal one. The energy shift directly suggested that outer orbital electrons which were itonized compressed the K atoms and made inner electrons change their energy states.

3.d. Itonic Pb Balls

A lot of tiny ***itonic Pb balls*** were generated during USD with the pulsed AC mode. Their photographs were shown elsewhere(17). Here a thin lead wire (1 mmφ) and ordinary water mixed with potassium carbonate and hydroxide, and cesium carbonate were used for an electrode and an electrolyte solution, respectively. While most of the Pb balls were deposited on the bottom copper plate of a box electrode, some balls were caught even on the lateral or top plates. Many of them were itonized so that some kinds of ENRs could be expected to occur in the balls. Some of the Pb balls remained with slight distortions and others were partially or perfectly broken up. It should depend on the rate of the itonization. The balls with ENRs could be easily distinguished from Pb debrises which were just molten.

In a low itonization rate, the compression should not have been enough to induce ENC. Then the Pb balls were slightly distorted but the itonization processes certainly proceeded even in the ball, as shown in Fig. 1 in Ref. 17. In the SEM view, the itonized Pb clusters seemed like being coated with thin and smooth Pb films, which were caused by the itonized electrons.

In a high itonization rate, ENC was drastically induced during which the reaction was explosive to expand the Pb cluster from the inside. Then ***hollow Pb balls*** were resulted by the explosion, as shown in Fig. 18 in Ref. 17. Here a lot of tiny Pb grains appeared on a spherical surface of the balls. The grains oppositely suggested that the lead metal was really compressed. It was extraordinary that the tiny grains did not scatter out and that the hollow balls did not fall. The spherical shape of the balls was sustained by their inner thin films, which were one product of ENC and consisted of mainly C atoms. The detail of the films will be described in Sec. 3.f.

A lot of Pb balls which were ***combined*** each other were also observed. There were three kinds of those balls. The first was simply made by a collision between two itonic Pb balls while they were flying during the discharges. The second was made during the ENC process, as shown

in Figs. 16 and 17 in Ref. 17. Here the itonic Pb cluster pushed out the hollow Pb balls which was mentioned above, just like a making process of popcorns. The third was assemblies of plural itonic Pb clusters, as shown in Figs. 21 and 22 in Ref. 17. They were probably made either during the itonizatin process of several clusters or during the recombination process between Pb clusters and itonic Ce atoms which were scattered during the discharges. Anyway thick itonic layers of Ce atoms were obviously seen over the Pb balls in the figures just like fermented soybeans ("Nattoh" in Japanese) as was predicted by The Nattoh Model(1, 18).

3.e. Generation of Carbon Tubes

There were two kinds of remarkable products which were generated in the itonic clusters : ***C tubes and films***(6). The C films will be described in Sec. 3.f. First the tube like products were shown in Figs. 25 and 26 in Ref. 17. They were caught on the copper plates during the USD experiments with both of the modes. The tube products seemed to be more generated during the continuous DC mode than the pulsed AC mode. There could be two kinds of tube products: thin rolling tubes(typically 5 μm) as shown in Figs. 25 and 26 in Ref. 17 and Fig. 6 in Ref. 14, and thin flat tubes(typically 50 μm wide).

The EDX analysis revailed that all the tubes consisted of mainly an element of C. The typical EDX spectrum was shown in Fig. 9(a) in Ref. 12. An element of O also appeared in the spectrum but could be somewhat contaminated from molecules of water. In several cases, other heavy elements such as Ti and Fe were also observed along the tubes. The EDX spectra at different locations of a tube were shown in Fig. 9(b) in Ref. 12, in which heavy elements such as Fe, Ca and S were observed near the center of the tip(Fig. 8(b)) while light elements such as C and O were observed on the peripheral surface of the tip(Fig. 8(a)). This fact suggested that some centrifugal effects could have worked during generating the tubes. An important figure for the tube was shown in Fig. 6 in Ref. 14. The tube was cut into several pieces for the presentation. An enlarged view of the top row was shown in Fig. 6(b) in Ref. 14, in which an electrode cluster was associated with the tube. It obviously indicated that the tube was generated in the cluster and emerged from there. It should be difficult to consider the mechanisms for the generation of such

curious tubes in the cluster. A clear explanation will be described in Sec. 4.f., based on The Nattoh Model.

3.f. Generation of Carbon Films

The second remarkable product in the itonic cluster was ***C films***, as shown in Figs. 23 and 24 in Ref. 17. They were generated during the USD experiments with both of the modes, but seemed more frequently produced with the pulsed AC mode. The films were very thin and had various shapes due to folding effects. The EDX analysis also indicated that all the films consisted of mainly C and O, similarly to the tubes. The typical spectrum for the film was shown in Ref. 15. Various elements such as O, Mg, Al, Si, S, Cl, Ti and Fe were observed in some cases. Then the relative distribution of the elements changed for the individual film. When the solution of potassium hydroxide was used, the experimental system became perfectly carbon free. Even then, the C films were found in the same manner. It was obvious that the C element was newly generated by some nuclear reaction during the discharges. Some important pictures which suggested the generation mechanisms of the C films were obtained. They were shown in Fig.s. 14 and 15 in Ref. 17. Here the films were associated with an itonic Pb cluster or a hollow Pb ball. In some cases, the hollow Pb ball directly emerged from the itonic Pb cluster, as shown in Figs. 16 and 17 in Ref. 17.

Similar thin films were already observed on nuclear emulsions in previous experiments of cold fusion(4). Figure 4 in Ref. 4 clearly showed the generation of thin films with ring or spherical shapes during an inner epxplosive reaction. Compared with the thickness of the nuclear emulsion, about 100 μm, the film was very thin. Then the film was asigned to be generated by the nuclear collapse of quard neutrons.

3.g. Generation of Ring Products

Curious ***tiny rings*** were produced during the USD experiments with a thin Fe cathode(8). A small scale of explosion took place during the continuous DC discharges. A lot of rings were caught on the surface of the iron electrode. They were shown in Fig. 8 in Ref. 8. The diamerer of the rings was typically about 50 μmφ. The ring could sustain their shapes for a couple of days

and eventually decayed to a regular hexagonal plate, as shown in Fig. 9 in Ref. 8. Then the inner region of the ring shrinked to the center at which corona like discharges were emitted.

The EPMA analysis showed that a Cd element circularly distributed in the ring. Since the system was perfectly Cd free, the Cd element was generated by some nuclear process. The ring products were not obtained so far in other systems except with the iton wire.

3.h. Electro-Nuclear Transmutation(ENT)

The phenomena of ***Electro-Nuclear Transmutation(ENT)*** were observed not only during the cold fusion experiments(19) but also during the USD experiments(12, 15). During USD, the pulsed AC discharges were especially useful for examining ENT, because itonic clusters in which ENT took place were separately observed from clusters involving ENC. The clusters with ENT were caught on the copper plates which were located in the solution as well as over the solution during the USD experiment with the lead wire electrode. Photographs were presented in Fig. 27 in Ref. 17 and Fig. 10 in Ref. 12. Elements such as Al, Si and Fe observed in the hydrogen clusters. Among the elements, the electrolyte of K should have been much more, if they were just impurities contained in the solution. They were transmuted in the itonic hydrogen cluster. Furthermore a strange phenomenon was observed associated with the ENT cluster: there was an inert zone around the transmuted materials only on the copper plates which were inserted in the solution. This fact suggested that the itonic clusters should have had the capability of making material surfaces somewhat inert. This effect should be caused by the itonization process on the material surface.

3.i. Electro-Nuclear Electro-Magnetic Effects(ENEM)

During the USD experiments, the electro-magnetic conditions of the system could be effected by induced ENRs. They could be called "***Electro-Nuclear Electro-Magnetic Effects (ENEM)***." Three kinds of ENEM were observed so far: the electric power generation, a new kind of electrical current and the magnetization of electrode.

First ***the electric power generation*** could be made by USD. When the itonic cluster induced ENRs in itself, nuclear energy could be transferred to the vibrational energy of the itonized

electrons, without emitting energetic radiations such as gamma rays or neutrons. When the itonic cluster broke up, furthermore, orbital electrons could be released as free electrons. The electric power could be amplified in the sense of the number of electrons as well as their energy. Phenomena of the electric power generation were observed during continuous AC discharges with titanium bolt electrodes(10 mmφ and effectively about 80 mm long) in the potassium carbonate solution(20, 21).

Secondly ***a new kind of electical current*** was the transport of the itonic clusters through a cable wire. The itonic cluster could somewhat exsist as a stable body. Since it had the negative charges, it could be driven through a copper wire by the electrical potential. When many clusters flew along the wire but with the conventional electrical current, they could seem like a new kind of the electrical current. Here the current should be perfectly different from the conventional one, because the fairly massive itonic clusters could really flow through the cable wire.

In the previous USD experiments(22), phenomena of the new kind of the current were observed. Thin copper cable wires which were coated with thin polyvinyl films were used to connect an electrode with a power supply. The copper wires near the connecting points of the electrode became dark. As the voltage or the discharge period increased, the color became darker and the colored area wider. The length of the colored area was about 30 cm at maximum. Here elements of K and Ca were confirmed by EDX. Since K was the eletrolyte element, this fact obviously indicated that the itonic hydrogen clusters containg K ran along the copper cable wires, but inside the coating films. The element of Ca should be transmuted from K in the itonic clusters during the transportation(1).

The third was ***the magnetization of electrodes***. The itonic cluster itself should be so strongly magnetized by its closed electrons like a microscopic magnet. During the USD experiments, the itonic clusters could be deposited on the electrode surface and some of them could enter the bulk. As a result, the electrode could be magnetized. Such phenomena were observed with a thin nickel wire electrode(22). The material showed the magnetization.

3.j. Radiations

Two kinds of radiations were observed during the USD experiments (8): energetic X-rays and unknown radiations. ***Energetic X-rays*** were observed by the CdTe detector under the the continuous DC mode. The X-rays were associated with the appearance of the tiny sparks on the electrode surface and the intensity increased as the number of the sparks increased. The energy spectrum of the X-rays was continuous and decreased monotonically as the energy increased up to about 130 keV. The X-rays spectra were shown in Fig. 6 in Ref. 8. Such energetic X-rays could not be emitted from conventional orbital electrons at all. However it could be emitted by the break up of the itonic electron linkage, those traces were very often observed on the copper plates(14).

On the other hand, ***unknown radiations*** were observed during the continuous USD. They were emitted from near the cadmium cathode on those surface the tiny sparks were shining. Here a special device, the Egely's wheel, was used to detect the unknown radiation(23). The wheel could respond to unknown biological radiations from the hands of a human being. When he or she were vital, the wheel indicated a high value for the radiation. When the wheel was located close to the cathode, it indicated a very high value. The radiation from USD should be same as that of being emitted from the hands of a human being. The detailed asignment of the unknown radiation was not made yet.

Visible light, which was emitted from the tiny sparks, might have some information so that analyses with an optical spectroscopy(OS) were attempted(24). The spectra which were obtained from the thin nickel cathode had no isolated lines but a very smooth hill shape.

3.k. Phenomena Like Ball Lightning(BL)

During the pulsed USD experiments, two kinds of Ball Lightning(BL) like phenomena were observed: itonic clusters with curious voltex traces and ring products.

First ***many traces for BL*** were recorded on the copper plate electrode during USD of the pulsed AC mode(14). They were itonic clusters which were generated during USD and jumped over the surface level of the solution. The itonic clusters left traces of a nearly circular disk, but sometimes with a slight distortion. Associated with the itonic clusters, there were curious voltex

traces. This was inferred that thin C tubes which were emitted from a white hole ran around in the cluster.

Secondly, ***ring products*** which also ran around like BL on the surface of nuclear emulsions were early observed(9). The generation of the ring prodcuts was described in Sec. 3.g.

4. Explanation by The Nattoh Model

The Nattoh Model was initially proposed by the author in order to comprehensively explain the mechanisms of cold fusion, mainly for the method of electrolysis method with a palladium cathode(1). The model proposed a new state of hydrogen cluster, "***itonic cluster***," and several kinds of ENRs occurring in the cluster. Since ENC was the most remarkable reaction among ENRs, the USD method was developed to investigate ENC in detail. As resulted, the remarkable nuclear regeneration(ENG) was newly discovered so that the model was required to extensively involve related physics. Here the comprehensive explanation for ENC based on The Extended Nattoh Model will be described mainly for the USD experiments mentioned in the preceding chapter.

4.a. Itonization Processes

According to The Nattoh Model, it is essential to induce ENRs that a hydrogen cluster should be strongly compressed to transform to an itonic state. Here many electrons are degenerated and interconnected each other to strongly bind hydrogen atoms. The compression is so strong that it makes various kinds of ENRs occur in the itonic cluster. The itonic clusters were really confirmed during the USD experiments(5 - 10). The microsparks which were separated from the electrode left traces with various shapes on the copper plates. The traces were important evidence for the formation of the itonic cluster. There the microsparks on the electrode themselves were such itonic clusters. There were some kinds of itonic clusters: itonic electrons, itonic hydrogen clusters, itonic electrolyte clusters, and itonic electrode clusters, including those mixtures. They all were obseved during the USD experiments mentioned in the preceding chapters.

There seem to be two processes for the itonization: on the electrode and in the electrode.

The first is the itonization on the electrode surface. It takes place between electrons, hydrogens and electrolytes which are gathered on the electrode surface by the potential. The second is the itonization in the electrode during which the electrode material itself becomes itonized. The two processes should be distinguished.

First ***the itonization process on the electrode surface*** is associated with the pinch effect. It is well observed with the 100 % reproducibility during the USD experiments with the continuous DC mode. In the high voltage over about 50 V, the pinch effect works well on the cathode surface. Here the hydrogen atoms are so strongly compressed by the electrical potential that the evolution of the hydrogen gas is also completely suppressed. The hydrogen atoms should be in a critical state of gas-liquid mixtures. Furthermore the electrical current are enforced to flow over the hydrogen clusters. This is a key point for the itonization of the clusters. Many surplus electrons could be degenerated and interconnected each other to form the itonic electrons and clusters. On the electrode surface, the electrolyte such as K can be driven by the potential to become itonic clusters, surrounded by the hydrogen atoms. This direct compression by the electrical potential could be much stronger than that with the eletrolyzing method with a palladium rod, in which hydrogen atoms were indirectly compressed in grain boundaries in the metal.

During the itonization process, an eddy current might have taken an important role. Figure 6 in Ref. 17 showed a lead ring with voltex like patterns, in which tiny Pb grains were generated. When the lead electrode was cut by the pulsed AC discharges, surplus electrons could form eddy current on the electrode surface to be itonized.

Secondly ***the itonization process in the electrode bulk*** could take place in a high current density, i.e., during the pulsed AC discharges. In general, when the current is flown in a metal, electrons run on the surface of the metal rather than in the bulk. Since the metal usually has a polycrystalline structure, the current flows not only on the metal surface but also through grain boundaries in the metal. When many electrons are overflown in the electrode such as lead, the itonization process could take place through the grain boundaries in the metal. Those itonization phenomena were often observed during the pulsed USD experiments with the thin lead wire elec-

trode(17). In broken Pb balls, strange Pb layers like thin films were formed, as shown in Figs. 1 to 3 in Ref. 17. Here they showed the itonization process which proceeded through the grain boundaries of the lead metal. Alternatively tiny Pb clusters like stars were also observed for completely broken Pb balls, as shown in Figs. 9 and 10 in Ref. 17. All of them were clear experimental evidence for the second itonization process.

During both of the itonization processes, the itonization should take place mainly for outer orbital electrons of the atoms. As resulted by the itonic compression, inner orbital electrons should also be affected to have somewhat different energy levels. The extraordinary energy shift of X-rays from the inner orbital electrons should be caused by the itonic compression, as mentioned in Sec. 3.c. In a high current density, more outer orbital electrons should be involved in the itonization process so that the energy shift for the inner orbital electrons increase. It is suggested that the information of the extraordinary energy shift for K-X rays could be useful to examine the details of the electrical structure of the itonic clusters.

The ***titanium*** electrode was special among the metals used in the experiments. Sparks first appeared not on the cathode but on the anode. Here the spark was discharges caused by the removal of brittle materials on the electrode surface. At the sparking point, a tiny white area of the titanium metal was seen with an optical microscope.

4.b. ENRs in Itonic Clusters

Since the itonic cluster is a system of strongly coupled multibodies, several new kinds of nuclear reactions are possible in the cluster. ENRs were explained in detail in the preceding review paper(1). The new reactions are very different from the conventional nuclear reactions which occur in an essentially isolated system. Furthermore the kind of ENRs depends on the bonding strength of the itonic cluster which varies with the number of involved electrons. There are four kinds of ENRs which were found so far: (1) a new nuclear fusion reaction between two deuteriums, (2) the nuclear transmutation(ENT), (3) the generation of multiple neutron nuclei and (4) the nuclear collapse forming tiny black and white holes(ENC).

The first is ***the new nuclear fusion reaction*** which produces ^{4}He from two D nuclei: D

+ D --→ ‘ He(no gamma rays). The reaction seems to violate the conservation law of momentum so that it cannot be allowed in isolated systems at all. However it is possible in the itonic cluster because the momentum can be received by the whole body of the itonic cluster just like the Mossbauer effect. Since many other hydrogens involved in the reaction work as catalysts, the reaction was called "***Hydrogen-Catalyzed Fusion Reaction***" in the previous review paper. Energy released from the fusion reaction is transferred to the vibration of the itonic electrons so that no radiations are emitted. The excess heat which was obtained from the electrolysis of heavy water with a palladium metal was predominately caused by this reaction(25). So the method could be calld "***Cold Fusion***."

The second of ENRs is the electro-nuclear transmutation(ENT) and will be described in Sec. 4.c.

The third of ENRs is ***the generation of tiny multiple neutron nuclei***. Here the nucleus consists of only neutrons like a neutron star. The neutron nucleus is generated by electron captures during the compression of the itonization process. Although the neutron nucleus should be unstable, it is covered by the itonic mesh so that it can exist for a moment as a stable body. When the itonic mesh is broken, multiple neutrons could be instantaneously scattered in all direction. The break up of those neutron nuclei was observed on nuclear emulsions by the auhtor(3). The multiple neutrons were really measured with a coincidence method of neutron detection by a group of Srinivasan, in which the multiple neutron nucleus was called by a different name of "bunched neutrons"(26). Although the third of ENRs might be important in some fields such as coherent neutron generation, the study was not progressed so far because most researchers continued to look for the 2.5 MeV neutrons generated from the conventional D + D fusion reaction.

The fourth, the most remarkable of ENRs, is the nuclear collapse(ENC) and will be mentioned in Sec. 4.d.

4.c. Electro-Nuclear Transmutation(ENT)

The second of ENRs is ***the electro-nuclear transmutation(ENT)*** in which one or more elements are converted to other ones. In 1991, the author first found that the nuclear transmuta-

tion took place in grain boundaries in a palladium metal rod which was used for a cold fusion experiment(19). Then the other co-author of the paper who helped me to analyze elements in a released gas did not agree with the author's idea of ENT. Later, a group of Kucherov also reported ENT with many elements during discharges in gas(27). Recently, many researchers observed ENT with various methods(28). The remarkable properties of ENT are (1) the transmutation rate is extremely high compared with other devices such as a nuclear reactor or accelerator and (2) no energetic radiations such as gamma rays are associated as mentioned before.

There are several processes for ENT which all occur in the itonic cluster: (1) capturing one or more electrons and protons with electrode or electrolyte nuclei, (2) sequential fusion reactions between protons and (3) multibody fission reactions. During the first of ENTs, the capture of electrons or protons occurs in the itonic electrode or electrolyte clusters so that the newly transmuted elements distribute near the original one on the periodic table. Since the capture takes place sequentially, the transmutation rate is high. The second of ENTs occurs in the itonic hydrogen cluster so that the products distribute among light elements such as Al, Si, S and Cl. The third of ENTs is multibody fission reactions which are resulted by the decay of compound heavy nuclei, and will be discussed in Sec. 4.e. Furthermore electro-nuclear regeneration(ENG) which will be described in Sec. 4.f could be an alternative ENT in a broad sense.

4.d. ENC Forming Tiny Black and White Holes

As the itonic bonding becomes more intense in a high current density, the ENR process further proceeds. Then the itonic cluster wholy shrinks and the most remarkable ENR, ENC, takes place in the itonic cluster locally or totally. When the current density is sufficiently high, the whole cluster collapses. Here many hydrogen or heavy element nuclei which are compressed to fuse each other collapse and eventually form a tiny black hole. Since the collapse is induced not by the gravitational force but by the electromagnetic force with the itonic electrons, no extremely huge mass is required for the collapse. The white hole is expected to be connected with the black hole through a worm hole having an extremely thin diameter, about 10^{-33} cm. The formation of the tiny black hole is difficult to prove, but the tiny white hole is easily observed.

Since perfectly broken materials could be emitted from the white hole, they should cause a lot of curious phenomena which we have never seen so far.

In the previous experiments of electrolysis with a thin nickel foil, the formation of tiny black and white holes was already observed on nuclear emulsions(4, 13, 29). We obtained an especially remarkable trace which showed that an explosion caused by the black hole and an eruption of broken materials from the white hole simultaneously took place, as shown in Fig. 7 in Ref. 29. This phenomenon could be explained by the property of the extremely thin diameter of the worm hole. When too much materials collapse to form the black hole, all of them could not penetrate through the worm hole instantaneously so that some potion of materials transformed to the black hole could explode. Then the conventional elements such as C and O are regenerated from the collapsed materials: the thin C tubes could be generated from the eruption of the white hole and the thin C films from the explosion of the black hole, respectively.

4.e. Electro-Nuclear Multiple Fission Reaction(EMF)

It is amazing but very important that the conventional elements such as C and O were generated during ENC of the Pb clusters. During ENC, there should be two different branches to generate other elements by depending on the compression strength: ***electro-nuclear multiple fission reaction(EMF)*** and ***electro-nuclear regeneration(ENG)*** through tiny black and white holes. ENG which could take place in the highest compression is one kind of nuclear transmutation in a broad sense but should be strictly distinguished from ENT mentioned in Sec. 4.c, because nuclei are completely destroyed during ENG so that super elementary particles should be introduced, as will be discussed in the following sections.

Just before ENC takes place in an itonic cluster, many nuclei could fuse each other to form a large compound nucleus. If the compression is enough, ENC could be induced. When the compression is not so strong, the compound nucleus could not lead to ENC but be scattered as multiple fission fragments. This reaction could be called "***Electro-Nuclear Multiple Fission Reaction(EMF)***." While the compression continues, the exciting energy of the compound nucleus which is created by multiple fusion reactions could be transferred to the vibrational motion of

the itonic electrons. Then the compound nulceus could be reduced to a minimum energy state, in which the constituents of the compound nucleus could be divided into several intranuclear clusters. The intranuclear clusters could be light nuclei such as He, C, O and so on. When the nuclear energy is beyond the binding one caused by the itonic electrons, the compound nuclei could be scattered as mupltiple fission fragments. EMFs were already observed as star like traces on nuclear emulsions in the previous experiment of cold fusion(30).

Recently it was reported that a Cu isotope was generated during the discharges with a natural thorium metal(31). Here a compound nucleus which was generated from a Th nucleus by capturing a number of protons might be strongly compressed and divided into a few pieces of intranuclear clusters. During the compression, the minimum energy state could be formed such that it could be divided into tetrahedrons of same nuclei. In the case of ^{232}Th, the compound nucleus resulted by capturing 28 protons could be divided into four ^{65}Cu isotopes(32). No energetic radiations also could be followed.

Here we have to comment: no EMFs could cause the generation of the thin C tubes and films which were mentioned in the preceding chapter. We had important information about the distribution of the generated elements. In the C tubes, light elements such as C and O were found in a peripheral region, while heavy elements such as Fe near at the center of the C tubes, respectively. On the other hand, elements of C, O and heavy ones including up to Fe uniformly distributed in the C films. Such curious distribution of the elements as well as the strange shapes of the C tubes could not be explained by EMFs at all. More drastically different mechanisms, ENG, should be proposed.

4.f. Elecrto-Nuclear Regeneration(ENG)

During ENC with a high compression, the compound nucleus could transform to an extremely tiny black hole. The black hole should be so tiny that instantaneously evaporate. When the compression is further strong, the black hole could lead to a white hole through an extremely thin worm hole. Here completely broken materials could be erupted from the white hole into the space. When too much materials are compressed at the same time, they could not penetrate the

worm hole so that the explosion of the black hole and the eruption of the white hole could take place simultaneously. They could generate the thin C films and tubes. Such simultaneous reaction was already observed on a nuclear emulsion in a previous cold fusion experiment(29). The elements which were observed in the thin films and tubes are conventional ones: mainly C and O, and a small amount of Si, Fe and so on. The EDX spectra indicated precise patterns of X-rays for all the elements. It is very amazing that the materials which were broken by ENC were regenerated as the conventional elements, of course, different ones from that before ENC. This fact suggested that we have to enter a world with an extremely small dimension. The regeneration of the elements should be explained by some more fundamental particles which could hardly sustain their shapes during passing through the worm hole with the diameter of 10^{-33} cm.

4.g. Super Elementary Particles: Misson and Cellron

In order to comprehensively understand all of the ENR phenomena, The Nattoh Model has to be expanded to deal with the extremely small domain, 10^{-33} cm. Here we introduce a new hypothetical theory for the subnuclear domain. The theory could be based on an important hint which was already obtained. It is ENG which should require new components of at least two different kinds, because only one component should fail to explain the regeneration of the destroyed materials. Now we introduce two super elementary particles, called "***misson***" and "***cellron***." Misson is a tiny particle which is distributed in cellron and takes a role of particle like behaviors for the conventional particles such as electrons and nucleons. Misson might be a promising candidate for "***dark matter***" which is expected by many astrophysicts to exist in the universe. On the other hand, cellron which widely and quickly distributes in the free space like thin films takes a role of wave like behaviors for the conventional particles. By comparing the two tiny particles, the dual property of the elementary particles such as electrons and nucleons could be easily explained.

For example, let us briefly consider a case of that an electron is put in vacuum and driven by the electrical potential. The electron could be assumed a combination of a lot of missons and cellrons. Although there could be a lot of structual strata between an electron or nucleon

and the super elementary particles, we now have no information about them at all. The cellrons expand in vacuum with the velocity of light and fully occupy the vacuum. Here the cellrons could be confused with "***ether***," which was very early proposed to explain the propagation of light. Cellrons are perfectly different concepts from ether, because cellrons are one of constituents of matter while ether is independent from matter. The Nattoh Model proposes that the initial state of the vacuum is assumed to be perfectly empty. Here electomagnetic waves could be explained as a vibrational motion of expanding cellrons.

On the other hand, missons are concentrated in a small region of the dimension of the de Broglie's length and pulled by the electrical potential. The distribution of missons could be presented by the density function of the electron on the conventional quantum physics. Since missons and cellrons are connected each other with an unknown force, the moving missons could feel some frictional force and not fly beyond the cellrons. This is a physical reason why the electron increases the effective mass during flying with a high velocity close to that of light.

During ENC, the nuclei are completely destroyed in which an individual nucleus is also divided into a lot of missons and cellrons. The missons and cellrons could hardly maintain their structures during passing through the worm hole. When they are emitted from the white hole, some mechanisms of their combination could work to form some particles of an upper class. After such processes are repeated, the conventional particles such as electrons and nucleons could be eventually regenerated. Here it would be reasonable to consider that the destroyed materials quickly rotate in the worm hole and that regenerated elements are separated by ***centrifugal effects***. Heavy elements such as Fe and light ones such as C or O could be formed in the central and peripheral regions of the thin C tubes, respectively. On the other hand, no such effects could not be expected during the explosion of a black hole so that the distribution of regenerated elements becomes uniform on the thin C films. The coceptual view of ENG is shown in Fig. 2.

At the present time, we have no information about how many structural strata exist between the super elementary particles and the conventional ones such as electrons and nucleons. Considering the small dimension for the former, there should be a lot of structural strata. Among

the strata, we might assume some intermediately tiny particles which have some "***genetic***" information like DNA provided in a bilogical cell. Based on the genetic information, tiny particles of more upper class could be regenerated.

When missons and cellrons are separated, some radiations could be emitted. Of course they should be ***unknown radiations***. A strange radiation was observed with the Egely's wheel during the continuous USD experiments, as described in Sec. 3.j. It was also detected from the hands of human beings. This fact suggested that ENC could take place even in a biological organization as will be discussed in Sec. 6.d. and that the unknown radiation could be explained by the separation of missons and cellrons. On the other hand, no complete recombination of missons and cellrons could be expected when they are reborn to the conventional elements during the eruption of the white hole. Surplus missons or cellrons should be scattered into the space. They were not experimentally observed as independent particles so far. Some special method should be required for the detection of those particles. As will be discussed in Chap. 6, Big Bang could be assumed as a universal scale of ENC. The discovery of ENG could suggest that a universe before Big Bang consists of the same elements as that of this universe. Then huge amounts of missons and cellrons were scattered in this universe as dark matter and free cellrons, respectively. Here free cellrons should be similar to ether.

4.h. Electro-Magnetic Effects Caused by Itonic Clusters

As described in Sec. 3.i, three kinds of ENEM effects were observed during the USD experiments: the electrical power generation, a new kind of electrical current and the magnetization of electrode. They all were caused by the itonic clusters. When the itonic clusters with negative charges run through a cable wire, it could be a new kind of electrical current. When the itonic clusters, strongly magnetized, are caught in an electrode, it could show the magnetization effect. Furthermore, when ENC as well as other ENRs takes place in the itonic cluster, it leads to the electrical power generation.

5. Natural Phenomena Caused by ENC

The preceding chapters described that ENC could be very easily induced in laboratory. Therefore it is reasonable to consider that ENC could very often occur in a natural environment as well. This chapter will describe two natural phenomena related to ENC: ball lightning and earthquakes.

5.a. Natural Ball Lightning(BL)

Ball lightning(BL) which is one of the most curious natural phenomena was observed widely over the world so far(33). BL is often associated with thunderstorms which are essentially electrical discharges with a large scale. There should be some relations between the natural phenomena of BL and the USD products observed in laboratory.

Recently a lot of observation data for BL were collected by several researchers(33, 34) and international conferences were continuously hold to discuss such issues(35). According to eye witnesses, natural BL slowly somtimes rapidly flied in the atmosphere and seemed like a shining and rolling ball or disk. Sometimes it exploded and othertimes disappeared without an explosion. BL appeared not only on days with thunderstorms but also on cloudy days. It entered a room, walked around along a wall and eventually disappeared into a stock. Furthermore pilots witnessed BL entrering a cockpit, hopping up and down on their handles and disappearing. In summary, there seemed to be at least two kinds of BL: violent BL associated with an explosion and mild BL disappearing without an explosion.

Since BL is natural phenomena and not easy to reproduce, few researchers challenged it as a serious object. However, the number of the researchers who are much interested seems now increasing. There were many models proposed for the mechanisms of forming BL so far(35). But they all were unsatisfactory for explaining curious behaviors of BL, because they were usually based on the conventional plasma physics.

5.b. BL Explained as USD Products

Some of natural BL could be explained by the USD products. Some BL like phenomena were observed during the USD experiments, as mentioned in Sec. 3.k. There could be two kinds

of BL candidates: itonic clusters and ring products.

First ***the itonic cluster*** is a candidate for the violent BL. It could exist as a stable body underwater or in the atmosphere. Moreover, the cluster can be driven by the eletrical potential because of its negative charges and finally explode to disappear. Those characteristics are very similar to that of the violent BL. Voltex like traces associated with itonic clusters were recorded on the copper plates during USD. A thin C tube was generated from a tiny white hole in the itonic clusters. In a high itonization, the C tube could not escape from the itonic cluster but roll around inside the cluster. This is a reason why the voltex traces were left on the copper plates. Some natural BL with a long thin tail were observed by eyewitnesses. The tail was potentially made of similar C tubes.

The second candidate of BL is ***ring products*** which were observed during the USD experiments with a thin iron wire electrode, as described in Sec. 3.g. The ring which could also exist as a stable body showed a very curious property: it decays to a regular hexagonal plate and at the end of the decay, corona like discharges are emitted from the center of the plate. The ring might have been generated from an alternative formation of thin C tubes erupted from the white hole. When the amount of collapsed materials is small, thin C tubes could not be long and have a conic shape with a flat top because of a short supply of regenerated materials. Then a hollow ring could be formed by rolling up the side of the conic tube. Here various materials such as water which exist near the occurrence point of ENC could be involved in the ring. The ring product could be a candidate for the mild BL, because of no explosion. Here such BL should seem a disk because the ring is rotating. Among natural BL, there were reports that various kinds of materials were generated at the break up of BL, for example, a couple of backets of water were spilled from BL(34). It was very unbelievable but might be explained by the ring products formed from ENC.

5.c. BL Phenomena with Thunderstorms

When thunderstorms occur, a lot of curious BL phenomena were observed. In 1997, for example, there was an accident of thunderstorms which fell near the author's house in Sapporo.

Residents reported many curious phenomena. Visual conditions of TVs were heavily disturbed during thunderstorms and an electrical switch which was turned off during the thunderstorms emitted blue light when it was turned on after the thunderstorms(36). The author also witnessed a lot of sparks releasing from a transport cable of electricity about 100 m distant from the fall point. Many of them could have been caused by the itonic clusters. The tiny itonic clusters generated by the thunderstorms could run through the cable to arrive at the electrical devices some what far from the fall point. They could disturb TV, or break up to emit blue light when the switch was turned on. EDX analysis of the switch is now under way. In laboratory, an accident of burning a power generator was reported by Chukakov during a similar experiment to reproduce the author's USD experiment(37). It was very feasible that itonic clusters generated by the discharges were kicked back from a cell to the generator through cable wires.

Mysterious circles also might be BL related phenomena. Fortunately, mysterious circles were created in Sapporo City in September in 1996 during thunderstorms(38). Then terrible thunderstorms occurred three times during three days. The author confirmed the formation of several mysterious circles each day, which were formed in a small grassland like by pushing down grasses with something completely but always forwards anti-clock: about 80 cmφ and 20 cm deep. In near future, the formation of the mystrerious circles will be made clear by repeating the USD experiments in laboratory.

5.d. ENC Hypothesis for Earthquakes

Since ENC can be easily induced by discharges, it is reasonable to consider that there could be other natural phenomena caused by underwater ENC. Earthquakes could be a promising candidate. During the Hanshin-Awaji earthquakes in 1995, a lot of extraordinary phenomena were observed by many residents before lands seriously vibrated: BL like emissions, abnormal behaviors of many animals, appearance of seismic clouds and abnormal noises of electromagnetic waves(39). The phenomena could not be explained by the conventional theory of earthquakes so that they were completely ignored by the majority of geologists. Among the phenomena, the BL like emission should be especially remarked. Then the author proposed ***a hypothetical theory*** for

the occurrence of earthquakes as follows,

(1) There could be underground regions in which strong stresses are concentrated by the collision of tectonics, as many seismologists predicted. Here underground water which are stored in strata could be strongly compressed by surrounding rocks. Furthermore weak electrical currents which flow underground could continue to slowly progress the itonization processes during a long period. Then conditions for inducing ENC could be satisfied.

(2) First ENRs could occur underground sequentially and explosively.

(3) Explosions could make severe movements of lands which cause damages to human beings and properties: vibrations, cracks, dislocations and so on.

(4) Tiny BL like products which are released by ENRs could penetrate through deep water and rocks to arrive at far places. They could cause extraordinary phenomena in the atmosphere as well as underground, as mentioned above. Therefore those extraordinary phenomena could appear before the lands begin to seriously vibrate.

5.e. ENC During The Matsumae Earthquakes

In order to verify the hypothetical theory, the measurement with ***nuclear emulsions*** (highly sensitive and especially suitable to detect unknown products) was attempted in the search for tiny BL like products emitted during earthquakes(14). But it was difficult to select a good measuring location, because the nuclear emulsions should be set before earthquakes really occur. Fortunately, there were sequential earthquakes at Matsumae Town (about 100 km west and 180 km south from Sapporo City) on the island of Hokkaido between 1995 and 1996. The nuclear emulsions were located at Matsumae Town from July 19 to August 18 in 1996. The nuclear emulsions were same as that used in the previous experiment of cold fusion(40): 100 μm thick emulsions coated on both sides of an acrylite plate(50 mm x 50 mm x 1 mm thick). 70 % of them were placed at Matsumae Town and the left over 30 % was placed at Hokkaido University in Sapporo City for reference, respectively. During the measurement, three earthquakes that could be relatively felt by people took place at Matsumae Town, but no earthquakes in Sapporo City.

Two kinds of extraordinary results were recorded on the nuclear emulsions placed at

Matsumae Town. Figure 9 in Ref. 14 showed one of extraordinary traces of broken networks which might be caused by the break up of BL. The trace was extended up to an area of about 5 mm x 5 mm, and such large mesh like traces were never obtained in our laboratory experiments so far. Remarkably, the network consisted of many clear and straight lines. Figure 9(b) in Ref. 14 showed an expanded picture for a cross point in the network. Moreover there were another extra ordinary long tube products, as shown in Fig. 10 in Ref. 14. The length was up to about 3 mm. One of the products had a conic pole vertically standing at the center of a hole which had a diameter of about 50 μm. A lot of similar conic products were also observed in the previous experiment of cold fusion wth a thin nickel foil(29).

Comparing the two products with the USD products, the broken network and the long tube could correspond to the itonic mesh and the thin C tube, respectively. During the earthquakes, ENC should be in a great scale. The number of electrons involved in the itonic mesh should be large and the collapsed materials be much more. Especially interesting, the conic pole vertically standing in the center hole could be generated from a white hole and the surrounding tubes could be consistent with the formation of the voltex trases on the copper plates.

6. Discussion

Here several topics such as cold fusion and other discharge experiments, safety problems and impacts to other scientific fields will be discussed.

6.a. Comments to Cold Fusion

In the previous paper(1), the mechanisms of cold fusion was explained by The Nattoh Model. Since a lot of valuable information were obtained by the latest USD experiments, we can comment to the mechanisms of cold fusion.

The first is ***the itonic particles***(41). The Nattoh Model introduced new particles to explain the strong compression of hydrogen clusters as well as aneutron reactions during cold fusion. Then two candidate particles were proposed as called "itons": complex particles consisting of electrons, positrons and neutrinos, and just interconnected electrons. Some traces suggesting

the decay of the former particles were found on nuclear emulsions, although the number of the traces were less than expected(40). As resulted by the latest USD experiments, it was made clear that most of the itonic particles are interconnected electrons. However, as predicted in the paper, the followed conclusions would not be so changed.

The second is ***chain reactions of hydrogen nuclei***. The Nattoh Model proposed two kinds of chain reactions: itonic interclusters and intraclusters. The time dependent power distribution was formulated based on the former. The USD experiments now confirmed that hydrogen clusters really formed the itonic states. But the intercluster chain reactions like neutron chain reactions in a fission reactior seemed to have been too much emphasized. Rather we have to consider that the chain reactions of D + D --- ^{4}He(with no gamma rays) take place locally and sequentially in the itonic clusters. Here the itonic electrons released locally could accelerate more neighbouring reactions in the itonic cluster. When the electrolysis continues, many itonic clusters separated in grain boundaries in a palladium metal could be interconnected by overflowing electrical current or expanding the volumes of the individual itonic clusters. Furthermore the itonic clusters in the metal could be wholy interconnected and reduce the electrical resistence. A group of McKubre reported the drastic reduction of the electrical resistence of the metal hydroxide when the excess heat was observed(42).

The third is ***nuclear transmutation***. A lot of elements were observed during various kinds of cold fusion experiments so far(28). The Nattoh Model proposed several ways how they are generated in the itonic hydrogen clusters. The captures of one or more electrons or protons are the most frequent reactions. Sequential nuclear fusions between the hydrogen nuclei also should contribute to the nuclear transmutation. Furthermore the fact of that no radiations were associated with all the reactions could be explained by the compression of the itonic bonding. However we now have to add another process for the conversion of elements, the electro-nuclear regeneration(ENG). The elements which were observed in the cold fusion and USD experiments should be understood as mixtures caused by both of the processes. During ENG, light elements starting from H could be sequentially generated. Heavy elements were observed up to Fe so far.

ENG should be definitely distinguished from ENTs as mentioned in Sec. 3.h, because the nuclei are completely destroyed during ENG. Here no energetic radiations such as gamma rays are emitted.

The fourth is the production of ***tritium***. The extraordinary production of T was controvertial in the begining of the cold fusion researches, because cold fusion was misunderstood as the conventional nuclear fusion reactions between two deuteriums. The Nattoh Model proposed that the itonic hydrogen clusters could be confused with T. They slowly decay by the break up of the itonic electrons and then seem like beta emitters such as T. Now we discovered ENG during the USD experiments, which should regenerate much hydrogens as will be discussed in Sec. 6.b. It is reasonable to consider that T could be also regenerated during ENG. During the measurement of T, both of the activities from T generated by ENG and the itonic clusters should be mixed. This problem might be resolved by performing two simultaneous measurements of those activity and mass.

6.b. Comments to Other Discharge Experiments

A lot of discharge experiments were carried out by now from early times, especially in order to make a plasma for inducing nuclear fusion reactions. Although the discharges were usually made in gas, similar processes to the USD experiment could have taken place. Many curious phenomena were reported even in early experiments(43). For examle, J. J. Thomson could never remove hydrogen gas from his chamber after discharges. The curious phenomena have to be re-examined.

Discharges in gas or vacuum should be principally same as the USD, except the number density of involved molecules. Ionized gas molecules created during the discharges could be driven to an electrode by the potential and become itonized, in which ENRs should be induced. The nuclear transmutation during discharges in gas was reported by a group of Kucherov(27). Recently, a group of Pankova reported the BL phenomena during glow discharges and observed the appearance of hydrocarbon materials(44). Light elements such as hydrogens which were observed by Thomson could be generated by ENG, although the author have not yet proved this

due to the trouble of a mass spectroscopy.

It would be very ironical that during the discharges for making a plasma to induce nuclear fusion reactions, the nuclear reactions far beyond what fusion physicists expected already took place and that the released nuclear energy was used to make the plasma.

6.c. Safety Problems

Since the whole aspects for the emission of the tiny particles during ENC are not made clear at the present time, the discussion for safety problems will be limitted to the specified particles: the itonic clusters and those transformed particles.

The first is ***radiation risks*** for workers who deal with welding. It is reasonable to consider that the electrical welding could induce ENRs similarly to the USD experiments. Here the current is usually high so that a lot of itonic particles should be emitted. The protection would not be difficult if they are aware the problem.

The second is ***ENG products***. It was thought in the previous review paper that materials broken during ENC should be transformed to unknown and extremely tiny particles, which were probably hazarderous(1). However, it is now obvious that the conventional materials are regenerated. Since most of them are not radioactive isotopes, ENG might oppositely contribute to the safety problems. "***Material Laundering***," which transforms hazarderous materials to safe ones, might be feasible in near future.

The third is ***ENC products during earthquakes***. Various materials such as Si are regenerated from ENG of the itonic particles which could be emitted during earthquakes. If the itonic particles are trapped in a human body, they might continue to regenerate materials there. For example, a renal calculus is sometimes observed in a human body, with those amount could not be created by body materials. It might be caused by ENG products. This suggestion also has to wait further investigations.

6.d. Impacts to Other Fields

ENC is a new physics far beyond what many researchers expected. Since the reaction can be very easily induced anywhere, there are other scientific fields which could be strongly im-

pacted by the discovery. Here we will discuss impacts of ENC to several fields.

The first is ***astrophysics***. In our universe, the gravitational collapse is one of the most important reactions, which effects the structure of the universe. Now we have obtained the effective method for inducing the nuclear collapse so that cosmic phenomena related to the nuclear collapse would be understood more precisely. Alternatively difficult problems which were never resolved so far could be well understood. For example, ***the giant structure of the universe*** is a today's most mysterious problem, which cannot be explained by the conventional astrophysical theory that tiny dusts which were uniformly distributed in the early universe slowly gather by the gravitational force and form galaxies. The generation of extremely long cosmic strings is another difficlut problem. Furthermore we recently observed curious long tails for the Hale-Bopp comet, called "***sychronized bands***." The formation of the bands also seems difficult to explain.

Most of these difficult problems could be resolved by assuming that Big Bang is a universal scale of the nulcear collapse. Here the long cosmic strings could have been generated by a big white hole, like the C tube seen in the USD experiments. On the other hand, spherical films caused by the explosion of a big black hole could be a good answer to the question of the unhomogeous structure of the universe. During ENC, a lot of missons could be emitted and scattered widely in the universe as dark matter. Moreover ENC could make comets which have long strings generated by a white hole. They might be made of light elements such as hydrogens, while they emit unexplainable X-rays.

Here we could propose a very important hypothesis: if Big Bang is a universal scale of ENC and as resulted by ENG, the conventional elements of this universe were created, a universe before Big Bang should be consisted of the same elements as that of this universe. We could discuss ***the universe before Big Bang***. It might be reasonable to consider that the universe continues to repeat ENC.

The second is ***seismology***. There is now a tectronics theory for the mechanisms of earthquakes: bombardment of tectronics causes strong stress of rocks which jump back to cause earthquakes. This theory completely failed to explain the extraordinary phenomena before earthquakes.

Most of seismicists have been ignoring those owen phenomena and spending a lot of research energy for predicting the occurrence of earthquakes. We now had clear evidence of ENC during the Matsumae earthquakes. The products caught on nulcear emulsions were very similar, but with the large scale due to the natural phenomena, to that obtained in the USD experiments. Of course, we have to continue the similar observation systematically and repeatedly. We might have very certain methods for predicting earthquakes by catching the ENC products.

The third is ***geology***, which would be effected by the generation of the C tubes and films by ENC. Since our EDX was not available to lighter elements than B, hydrogens were not confirmed. It is reasonable to consider that hydrogens also should be regenerated by ENC. Recently t he Russian group of Pankova observed the appearance of hydrocarbon materials during BL experiments with electrical discharges(44), although they had no idea of that the hydrocarbon materials were creat-ed by either ENT or ENC. On the primitive earth, a large scale of thunderstorms frequently took place here and there and regenerated a lot of hydrocarbon materials. They were burried underground and highly pressurized. This is an alternative explanation for the generation process of coal and oil. Coal and oil were usually explained as fossiles of plants and animals, respectively. The theory might be modified in near future. The proof would be made clear by really producing coal and oil from the hydrocarbon materials produced by ENC. The carbonized materials were already found during the USD experiments(17).

Another comment for geology is ***volcanos***. The eruption of volcanos might be a process caused by ENC. The eruption could be assumed as an ENC explosion of underground water which is compressed and itonized by moving magmas. But the author has obtained no evidence for ENC yet. Lewis predicted that volcanos, tornades, BL and cold fusion are based on his same principle: common phenomena of "***plasmoids***"(45). Here it should be emphasized that the plasmoid is a different concept from the itonic cluster. The plasmoid could be formed by electrohydrodynamic mechanisms, but no nuclear reactions were proposed in the plasmoid. On the other hand, the itonic clusters are formed on more microscopic principle of electrons as described in the preceding chapters.

Recently, interesting phenomena were reported, called "***Elves***" or "***Splites***"(46). Pilots witnessed during their flights that fire balls emerged over clouds when thunderstorms took place. They might be an alternative phenomena of BL, because itonic particles which were generated during discharges in the clouds could emit upwards as well as downwards. The phenomena might be easily simulated in laboratory by making artificial clouds.

The fourth is ***quantum mechanics***. In 1920s, the quantum mechanics was born to explain the dual property of an electron, in which the concept of probability was introduced. Then a famous controverse was made between N. Bohr and A. Einstein. Although Einstein strongly opposed against the probability concept, the quantum mechanics succeeded to calculate various kinds of microscopic problems so that the physical meaning of the duality of an electron have been left unclear so far. The itonization proccess has remembered us the importance of the precise and physically clear understanding for the duality of electrons. The Nattoh Model proposed two super elementary particles of misson and cellron. Particles with the dual property such as electrons and nucleons are assumed as a complex body of a lot of missons and cellrons. Missons distributed in cellrons represent a particle like behavior, and cellrons expanded in the space show a wave like behavior, respectively.

The fifth is ***elementary particle physics***. The dimension of missions and cellrons are an order of 10^{-33} cm. On the other hand, that of quarks is 10^{-17} cm. The difference is so large that there should be a lot of structural strata between them. We have no information about that at the present time. Only one suggestion might be ENG, during which the conventional elements such as C can be regenerated. We might assume that there are some duplication mechanisms during the formation of elements like DNA working in biological cells. For example, a relatively small number of missions and cellrons might form an intermediately tiny particles which sustain information for restructuring. Some combinations of those particles might be repeated to form an upper class of the structure. By repeating such processes, eventually the conventional elements might be regenerated. It is obvious that ENG could provide a solidified experimental data for super elementary particle theory. Anyway, elementary particle physics have entered an extremely

small domain. Since the experiment needs no expensive device, the research would progress rapidly.

The sixth is ***biology***. This is somewhat speculative at the present time, but might become one of the most remarkables in future. There are some data for suggesting the birth of life during ENC. First some of the C tubes and films which were produced during ENC seem very flexible, and similar to biological tissues. The second is USD products with very curious shapes which were found on nuclear emulsions in the previous experiment(7). They seemed incompleted forms of a biological body. The third is the unknown radiations which were detected by the Egely's wheel, which is sensitive to the vitality of human being. The fourth is nuclear transmutations in biological bodies, which were early reported by a group of Komaki(47).

Now a hypothesis is proposed: ENG could be very closely related to the birth of life. For example, ENG with a small scale might take place even in biological cells. It might cause the nuclear transmutation, emit the unknown radiations, and regenerate the hydrocarbon materials which are needed to make biological cells. Furthermore, a biological body might be generated by ENG with more powerful USD. Anyway the keypoint for the birth of life might be in ENG, especially in the white hole.

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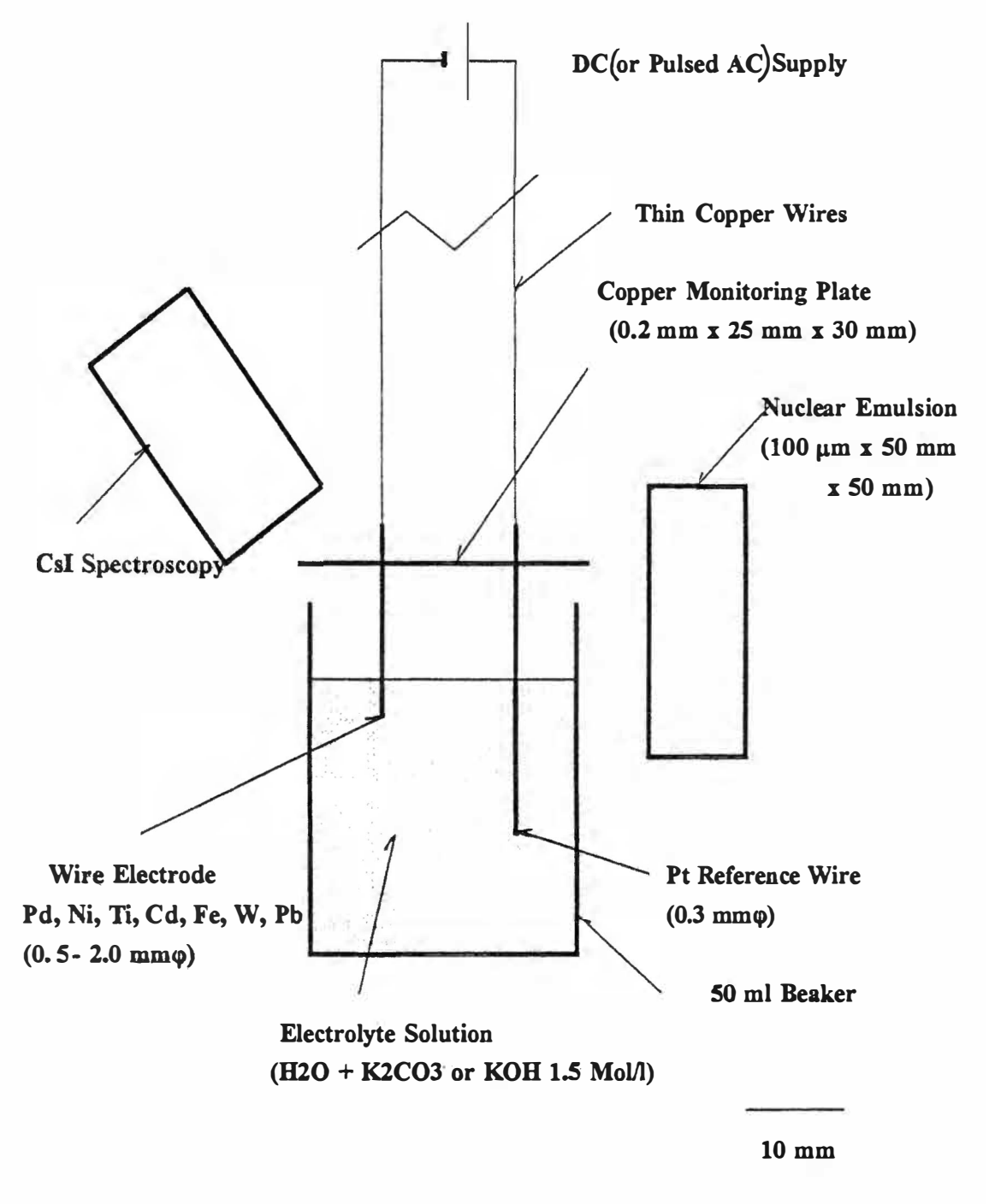

Fig. 1(a): Experimental Arrangement with DC Mode

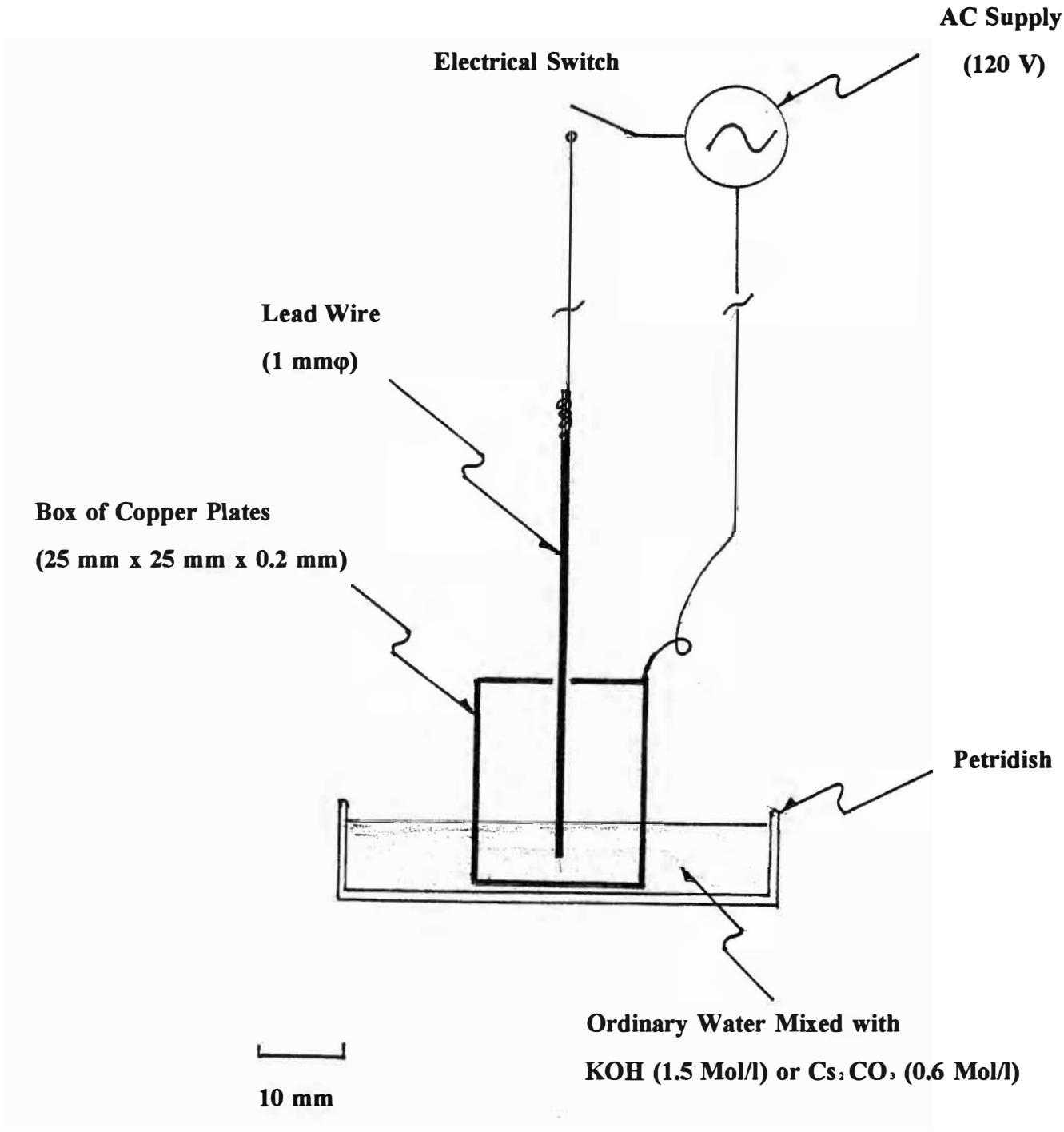

Fig. 1(b): Experimental Arrangement with Pulsed AC Mode

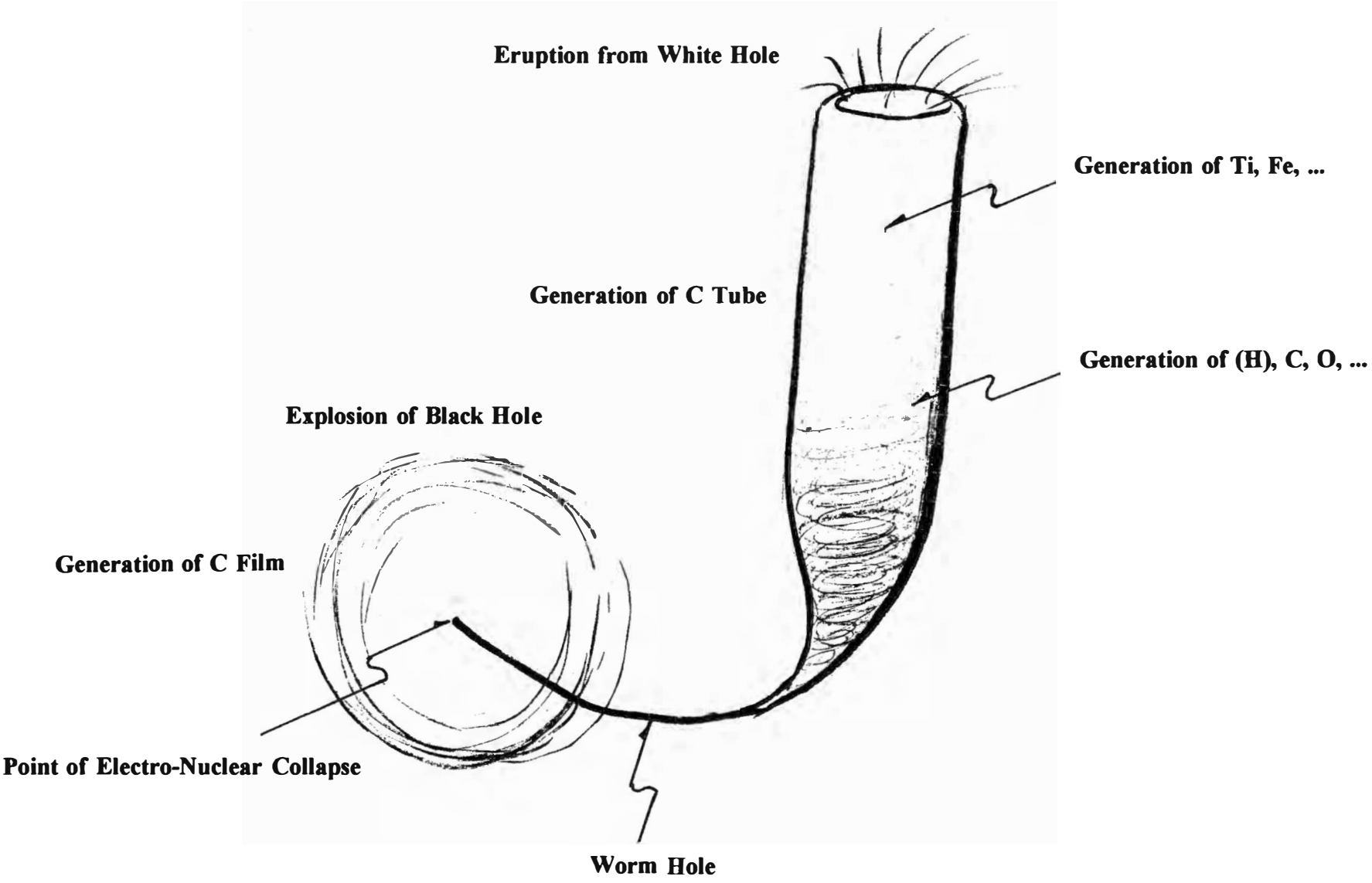

Fig. 2: Conceptual View of Electro-Nuclear Regeneration

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Ref. (6)

"NATTOH" MODEL FOR COLD FUSION

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COLD FUSION

TECHNICAL NOTE

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A hypothetical model, the "Nattoh" model, is proposed to answer the questions that result from cold fusion experiments. This model proposes the formation of a small cluster of deuterons and examines the feasibility of many-body fusion reactions. The gamma-ray spectrum, heat production, neutron emissions, and fusion products are discussed.

I. INTRODUCTION

Two remarkable experimental studies for nuclear fusion have been reported recently by Fleischmann and Pons[1] and by Jones et al.[2] Both groups stated that "cold nuclear fusion" reactions could be observed by electrolyzing heavy water at room temperature. If these reactions prove to be true, it could have a drastic effect on worldwide energy production. However, there are some unanswered questions.

Fleischmann and Pons stated that a large amount of heat production was observed for rod-type electrodes, i.e., ~4-W output for 1-W input. This amount of heat is produced as a result of the following fusion reactions that take place with nearly equal probability under ordinary conditions:

$$D + D \rightarrow T + p \quad (1)$$

and

$$D + D \rightarrow {}^3He + n\ (2.45\ MeV)\ ; \quad (2)$$

the fusion reaction rate corresponds to 10^{11} to 10^{14} fusion/s. On the other hand, the fusion reaction rate of 10^4 fusion/s was obtained from data of neutron and tritium production, which are considered to be direct products of reactions (1) and (2). This value is extremely small compared with the one from the heat production data.

Jones et al. believed that they succeeded in measuring the 2.45-MeV neutrons emitted from reaction (2). However, the heat production rate that is calculated from their neutron emission data is extremely small compared with data from Fleischmann and Pons.

Furthermore, Do Ninno et al.[3] followed the cold fusion experiment in a different manner: They introduced hydrogen into a metal from a gas phase and succeeded in observing two different modes of neutron emission—intermittent and sporadic.

There are several questions that must be answered as a result of cold fusion experimentation:

1. Why is the cold fusion reaction possible at low temperatures such as ~300 K?
2. Why is the neutron emission rate extremely small compared with the corresponding heat production rate?
3. Why are there two different modes for the neutron emission?

II. THE "NATTOH" MODEL

To explain the questions posed in Sec. I, this technical note proposes a hypothetical theory, the "Nattoh" model (nattoh means fermented soybeans), for cold fusion reactions. In the case of μ-catalyzed fusion, which also occurs at low temperatures, μ, like an electron, combines two isotopic hydrogen nuclei to form a μ molecule ($d\mu t$). Since the mass of μ is 207 times the mass of an electron, the distance between the nuclei is so short that a fusion reaction can take place.

On the other hand, in the case of cold fusion in metal, deuterons are compressed to extremely high pressure in and/or on the surface of the metal so that no fewer than three deuterons can gather to form a cluster, for example, in a lattice defect. In the cluster, electrons move around following the deuterons with heavy mass so that the effective mass of the electrons becomes fairly large. The distances between the deuteron nuclei in the cluster are sufficiently short to make fusion reactions possible.

We have noted a new reaction that occurs with the largest probability and predominantly contributes to heat production:

$$2D + D \rightarrow {}^4He + d\ . \quad (3)$$

The recoil energy is transferred to the third deuteron and/or to the deuteron cluster. Reaction (3), which we have not observed, is impossible in the gas or plasma state, because it is essential that the third deuteron that receives the recoil energy exists very near to the reacting deuterons. Reactions (1) and (2), which are ordinary in the D + D fusion reaction, do not occur, because the energy of the colliding nuclei is too low to strip a neutron or proton from the deuteron nucleus.

Furthermore, it is possible that many-body fusion reactions could occur in the cluster, since the size of the cluster is fairly small:

$$3D \rightarrow {}^{6}Li^{*} \begin{cases} \rightarrow {}^{4}He + d & (4) \\ \rightarrow {}^{6}Li + \gamma\ , & (5) \end{cases}$$

$$4D \rightarrow {}^{8}Be^{*} \begin{cases} \rightarrow 2\,{}^{4}He & (6) \\ \rightarrow {}^{8}Be + \gamma & (7) \\ \rightarrow {}^{7}Be^{*} + n & (8) \\ \rightarrow {}^{7}Li^{*} + p\ , & (9) \end{cases}$$

and

$$5D \rightarrow {}^{10}B^{*} \begin{cases} \rightarrow 2\,{}^{4}He + d & (10) \\ \rightarrow {}^{10}B + \gamma & (11) \\ \rightarrow {}^{9}B^{*} + n & (12) \\ \rightarrow {}^{9}Be^{*} + p\ . & (13) \end{cases}$$

III. GAMMA-RAY SPECTRUM

The Nattoh model can be examined by the existence of such fusion products as $^{6}Li^{*}$ and $^{8}Be^{*}$. Fleischmann and Pons measured the gamma-ray spectrum by using a NaI scintillator, shown in Fig. 1A of Ref. 1. They explained that the spectrum corresponds to the gamma ray emitted by the following hydrogen reaction in a water bath and the 2.45-MeV neutron produced by reaction (2):

$$H + n\ (2.45\ MeV) \rightarrow D + \gamma\ . \qquad (14)$$

However, the intensity of this gamma ray is so weak that the assignment is doubtful.

The author considered that the spectrum is due to the gamma ray emitted from the fusion products in reactions (5), (7), (11), etc. Those nuclei emit gamma rays with the following energies at ~2.2 MeV:

$^{6}Li^{*}$: 2.185 and 3.562 MeV

$^{8}Be^{*}$: 1.527, 1.999, and 2.283 MeV

$^{10}B^{*}$: 2.15 and 2.87 MeV .

The gamma-ray spectrum was calculated by the following equation:

$$H(E) = \sum_{i} Ai \exp[-(E - Ei)^{2}/\sigma^{2}]\ , \qquad (15)$$

where σ corresponds to the resolutional energy. Figure 1 shows a calculational result from Eq. (15), compared with the experiment. The parameters Ai and σ were adjusted to fit the experimental data: σ was assumed to be constant at 41.7 keV. The calculational data are shifted to the higher energy side by 15 keV, equal to about one channel.

Comparing the calculated and the experimental spectra, it becomes clear that the main peak of the gamma-ray spectrum corresponds to the 2.185-MeV gamma ray emitted from the excited ^{6}Li nucleus. Furthermore, a hump located at the higher energy side of the main peak is due to the 2.283-MeV gamma ray emitted from $^{8}Be^{*}$. The ratio of Ai between ^{6}Li and ^{8}Be is 100/35. The 2.15-MeV gamma ray from $^{10}B^{*}$ cannot be recognized because of the low intensity.

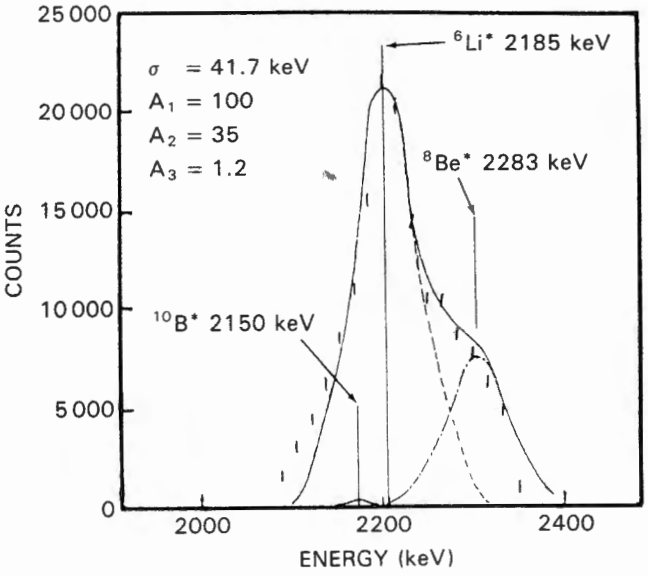

Fig. 1. Gamma-ray spectrum around 2.2 MeV.

IV. TWO MODES OF NEUTRON EMISSION

Although the Nattoh model denies the direct occurrence of two-body fusion reactions (1) and (2), a high-energy deuteron recoiled in reaction (3) collides with the surrounding deuterons to make reactions (1) and (2) possible. This recoiled deuteron, having a kinetic energy of <16 MeV, has a path range of <0.02 cm in Pd-D. The cross sections for reactions (1) and (2) are ~100 mb for deuteron energies >1 MeV. Therefore, the probability that reactions (1) and (2) will occur is $\sim 10^{-4}$ to 10^{-6} per deuteron recoiled in reaction (3). When the recoil energy of reaction (3) is totally received by a cluster, the probability of reactions (1) and (2) decreases. For this reason, the emission rate of the 2.45-MeV neutrons is extremely small compared with the corresponding rate calculated from the heat production data.[1]

The emission of the 2.45-MeV neutrons is based on the secondary process and is intermittent. The Nattoh model, on the other hand, predicts the existence of another mode of neutron emission. Many-body reaction products such as $^{8}Be^{*}$ and $^{10}B^{*}$ have a channel of neutron emission, shown by reactions (8) and (12), respectively.[4] When the concentration of the deuterons in metal becomes so high that the number of the deutrons in the cluster increases, the probability of many-body reactions is enhanced: Neutrons are emitted sporadically through those channels. However, it is predicted that the neutron energy of the second mode will not be 2.45 MeV, but will be much higher, i.e., ~20 MeV.

The excited state of ^{6}Li also may have a channel of neutron emission. However, it is doubtful that $^{6}Li^{*}$ emits neutrons in the case of cold fusion, i.e., three-body fusion, because all the data were obtained by colliding experiments of high-energy particles.[4]

V. FUSION PRODUCTS

The Nattoh model also predicts the fusion products. The production rate of ^{4}He is greatest in the predominant reaction (3). Since reactions (1) and (2) are not direct processes,

the quantities of tritium, ^{3}He, and hydrogen are much less, similar to neutrons. Furthermore, it can be predicted that many-body fusion products such as ^{6}Li, ^{7}Li, and ^{7}Be are produced, but also in fewer quantities.

If the extremely high concentrations of deuterons are obtained, ^{12}C, ^{14}N, and ^{16}O can be produced by a single reaction of many-body fusions. Those isotopes are stable and important constituents of the earth. The Nattoh model suggests some modifications in the theory for the birth of the earth, as well as the feasibility of the production of useful elements such as rare metals.

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Ref. (9)

ANS Reprint

COLD FUSION OBSERVED WITH ORDINARY WATER

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COLD FUSION

TECHNICAL NOTE

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A cold fusion electrolysis experiment using ordinary water is described. A Ge(Li) detector is used to observe signals up to ~130 keV; these signals show the occurrence of fusion reactions in ordinary water. The mechanism for the emission of radiation is discussed by the Nattoh model.

INTRODUCTION

Two remarkable experiments for cold fusion have recently been published.[1,2] In particular, Fleischmann and Pons[1] reported that they successfully produced large amounts of heat. Since the publication of Refs. 1 and 2, other similar experiments have been performed in which heavy water is used for the electrolyte solution and ordinary water is treated as a standard sample. It is *a priori* assumed that ordinary water produces no fusion reactions that would contribute to heat generation.

The "Nattoh" model has been proposed for cold fusion.[3] In the model, several deuterons in a metal form an extremely small cluster, called Nattoh. The following hydrogen-catalyzed fusion reaction, which has never been observed in a plasma state, can occur:

$$2D + D \rightarrow {}^4He + d \ , \qquad (1)$$

where recoil energy is received by the third deuteron or the entire cluster of deuterons. Reaction (1) is the main process that contributes to heat generation. The model is verified by an analysis[4] for measured energy distribution of fusion products.

For ordinary water, the probability of the H + H fusion reaction is small compared with that of the D + D fusion reaction. The Nattoh model, however, suggests that it may be possible for fusion reactions to occur in ordinary water since the protons can also form a small cluster.

COLD FUSION REACTIONS IN ORDINARY WATER

According to the Nattoh model, several strange fusion reactions may occur in an experiment with ordinary water:

$$2H + H \rightarrow {}^2He + p \ , \qquad (2)$$

$$3H \rightarrow {}^3Li^* \rightarrow {}^3He + e^+ \ , \qquad (3)$$

and

$$4H \rightarrow {}^4Be^* \rightarrow {}^4Li + e^+ \ , \quad \text{etc.} \qquad (4)$$

The predominant process is a hydrogen-catalyzed fusion reaction, given by reaction (2). Many-body fusion reactions given by reactions (3) and (4) will also occur, however, much less frequently.

We currently have no information about what processes may result from reaction (2). It seems possible that ^2He will decay to a deuteron with the emission of a positron:

$$^2He \rightarrow d + e^+ \ . \qquad (5)$$

High-energy particles such as positrons e^+, deuterons d, and protons p are emitted. These particles make surrounding atoms in the sample excited or ionized, which results in X rays being radiated. Moreover, the positrons annihilate with electrons to emit gamma rays (0.511 MeV per gamma quanta).

By measuring the gamma and X rays, therefore, it may be possible to verify that cold fusion reactions occur in ordinary water.

EXPERIMENT AND RESULTS

An electrolysis experiment with ordinary water was performed at room temperature. A 50-mm-diam × 50-mm-long palladium cathode rod was surrounded by a 0.5-mm-diam helical platinum wire anode and placed in ordinary water with 3% NaCl. The palladium rod was maintained in a vacuum at ~800°C for more than 10 h to discharge contained gas. The electrolyzing conditions were 1-A current and 5-V bias.

A Ge(Li) detector,[a] which was located beside a 50-mm-diam electrolysis cell, was used for measurements. Both the detector and cell were shielded from natural background by lead blocks (effective thickness: ~15 cm). The energy calibration for the system was made by measuring gamma rays from the standard sources of ^{152}Eu and ^{137}Cs. The background

[a]Made by EG&G Company, Ltd.

was measured when the electrolysis cell was far from the detector and was repeated many times. The instrumental condition was kept steady, and this could be checked by the repeated measurements of the background and standard sources.

Signals began to appear from 11 days after turning on and reached maximum after 15 days. The emission was maintained for 6 days and stopped completely after 17 days.

Figure 1 shows a spectrum with 4096 channels; it was measured after 15 days. The background is also shown. No distinguishable changes in the background spectra occurred during the experiment. The peaks of ^{40}K (1.461 MeV) and ^{208}Bi (2.615 MeV) appear. No appreciable change occurs in the high-energy region between the signal and background measurements. Figure 2 shows the same data as given in Fig. 1, but for the expanded energy region below 1024 channels. The annihilation gamma rays appear at a peak at about 635 channels. However, the background also encloses the annihilation gamma rays due to cosmic-ray-induced isotopes such as ^{22}Na. The enhancement of the peak is indistinguishable.

On the other hand, the enhancement in the low-energy

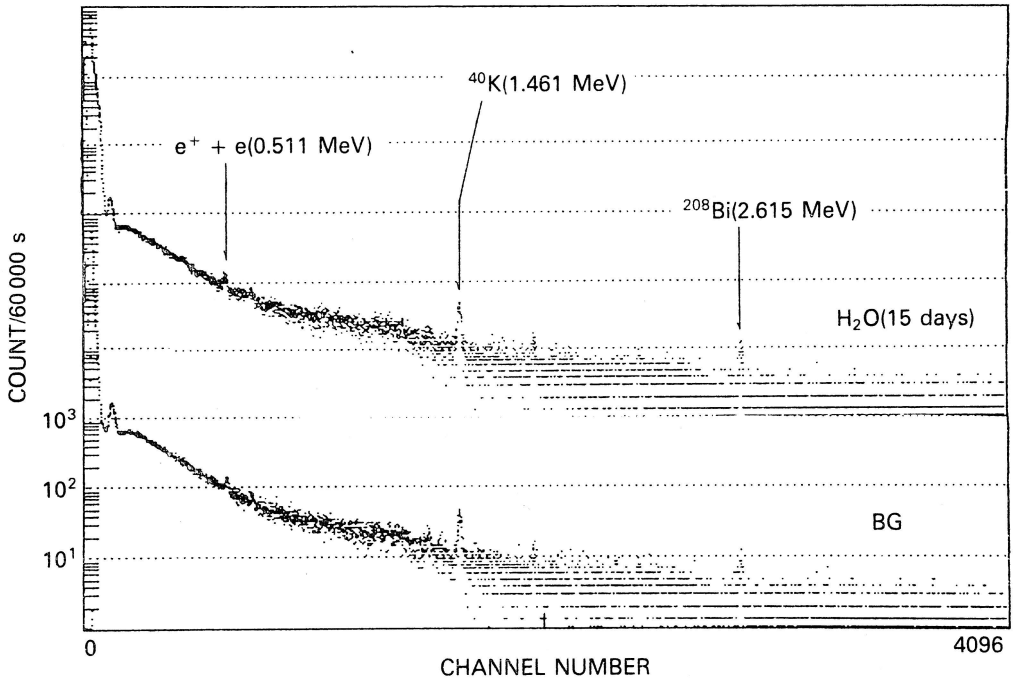

Fig. 1. Ge(Li) spectra in 4096 channels.

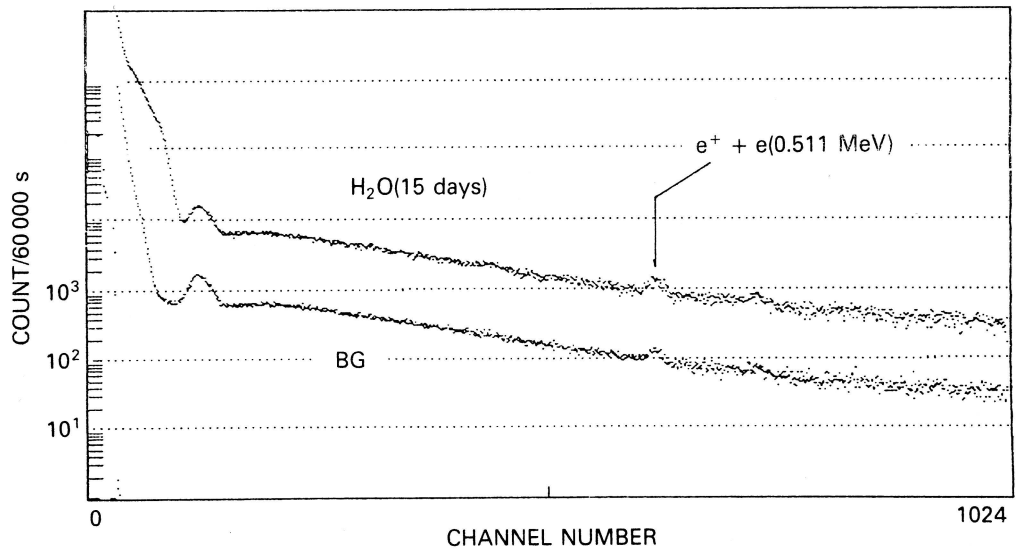

Fig. 2. Ge(Li) spectra in 1024 channels.

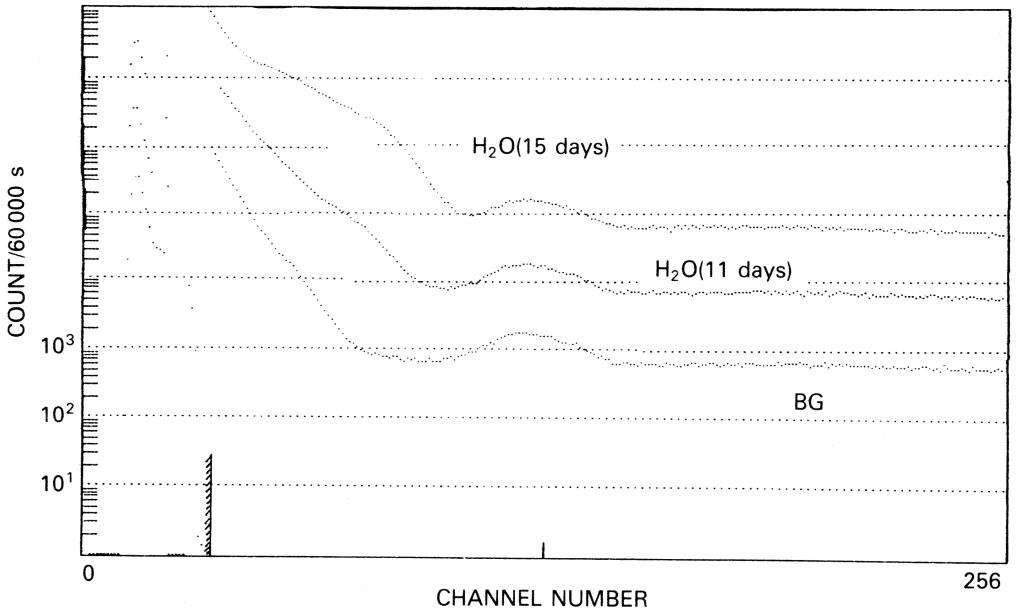

Fig. 3. Ge(Li) spectra in 256 channels.

region is clear. Figure 3 shows a further expansion of the lowest energy region. Data obtained at 11 days are also shown. The enhancement ranges up to ~130 keV.

DISCUSSION

The Ge(Li) detector measurements were carefully performed for the electrolysis of ordinary water, especially to try to detect 0.511-MeV annihilation gamma and low-energy X rays. The results show that the extraordinary enhancement of the signals in the low-energy region can clearly be recognized, while the one of the annihilation gamma rays is indistinguishable. The energy of the former ranged to ~130 keV so the signals cannot be attributed to chemical reactions. It must be considered that a cold fusion reaction really occurred in ordinary water.

However, the assignment of the extraordinary signals in the low-energy region is not clear, because the cold fusion itself is based on a new fusion reaction,[4] i.e., the hydrogen-catalyzed fusion reaction given by reaction (2).

In reaction (5), the emission of positrons was assumed in which atomic excitations induced by high-energy particles such as e^+, p, and d emit X rays. Although the resolution of the Ge(Li) detector was insufficient, the palladium X-ray energies are much less than ~130 keV. Moreover, the positron bremsstrahlung radiations cannot explain the shape of the spectrum. Since we had no measurement for heat generation, it is not clear how much heat was produced. Assuming that ~1 W of heat is produced (the value can be estimated from the data of Fleischmann and Pons[1]), it would be possible to detect part of the positrons that escape from the palladium rod and electrolysis cell. In this case, signals up to ~130 keV can be explained, but the annihilation gamma rays should be more strongly enhanced. Therefore, it is difficult to consider that the decay process with the positron emission of reaction (5) occurred during the experiment.

For heavy water, on the other hand, it is predicted[4] that a new particle "iton" will be emitted in reaction (1), with ~20-MeV energy. The iton that is introduced in Ref. 4 takes long-range interactions between nuclei and can be emitted from the hydrogen-catalyzed fusion reaction if the excess energy is sufficiently large. For ordinary water, the excess energy is not so large, i.e., ~2.2 MeV. If the remaining iton mass is not far from the electron, it is very probable that the iton may be emitted in reaction (2). In this case, the iton will have a positive charge so that the behaviors in the material resemble the positron. We will have a satisfactory explanation for the enhanced signals in the low-energy region as well as no emission of the annihilation gamma rays.

Although the assignment for the signals is not clear, this experiment shows that a cold fusion reaction is feasible in ordinary water. This fact suggests that ordinary water cannot be used as a standard sample in cases where no fusion reactions take place. Furthermore, what is more important is that it is feasible to construct a cold fusion reactor that directly generates power from seawater.

ACKNOWLEDGMENT

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Ref. (10)

ANS Reprint

OBSERVATION OF NEW PARTICLES EMITTED DURING COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *new iton particle, nuclear film, Nattoh model*

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To confirm the emission of the "iton" particles predicted by the Nattoh model, a cold fusion experiment based on electrolysis of heavy water has been performed. The tracks of several kinds of itons have been successfully recorded on nuclear films. The formation and decay mechanisms of itons are included in the Nattoh model.

INTRODUCTION

In the Nattoh model,[1-3] the hydrogen-catalyzed fusion reaction is considered to be the predominant reaction in cold fusion.[4] The third hydrogens play the role of catalyst to combine two hydrogens and make them fuse. They also receive the excess energy of the fusion and lead to additional reactions. Analysis of the energy distribution of fusion products predicts that a new "iton" particle, which means a string contacted with the Nattoh, is emitted through the hydrogen-catalyzed fusion reaction.[a]

[a]This paper offers a new hypothesis about reaction products within the framework of the Nattoh model. Let us assume the emission of one or more light particles through the hydrogen-catalyzed fusion reaction, which can take away the difference energies of Q, ~20 MeV. We call this particle an "iton," which means a string contacted with the Nattoh. If the iton is a meson, it can be neither a pi nor a K meson, because the rest masses of pi and K mesons are ~135 and 494 MeV, respectively. Other mesons have yet heavier masses. The iton, however, is probably a new and unknown type of meson.

The iton should remarkably affect the branching ratio on the two-body fusion reaction. As the result of the two-body fusion reaction, ^{4}He* is formed, excited by 23.85 MeV. In the conventional reaction, ^{4}He* opens channels to neutron or proton production and the difference energies of 3.25 and 4.05 MeV are transferred to the kinetic energy of these particles. In the hydrogen-catalyzed reaction, however, the quantized energies of 22.1, 20.1, and 19.1 MeV would first be transferred to the emission of one or more itons. The remaining difference energies of 3.75, 2.75, and 1.75 MeV are distributed to the kinetic energy of the emitted particles of ^{4}He and deuterons. This explains how a reaction without neutron, proton, or gamma-ray emission can take place in the hydrogen-catalyzed fusion model. Since the iton involves a strong nuclear interaction, it should neither be a neutrino nor a electron-positron pair. Thus, it appears that the iton is a new type of meson.

However, we have no reported observations of the new particle. One possible exception[5] may be the extraordinary low-energy signals that have been measured by a Ge(Li) detector in a cold fusion experiment with ordinary water. This suggests that the iton can produce charged particles such as electrons. To detect the iton, a method using nuclear films seems preferable to counting methods, because it could show very clear evidence.

This paper describes a cold fusion experiment using heavy water in which nuclear film is used to record the tracks left by itons. The mechanisms for the formation and decay of the itons are also discussed.

EXPERIMENT

To observe the emission of itons, a cold fusion experiment with heavy water has been performed. The induction of hydrogen was based on electrolysis. A 5-mm-diam × 50-mm palladium rod was used as the cathode. The material was kept in vacuum at a temperature of ~800°C for >12 h for gas discharging. A 0.5-mm-diam platinum wire anode was wound around the cathode helically. Heavy water added to 3% NaCl was used as the electrolyte solution and contained in a 60-mm-diam glass cell. The experiment was performed at room temperature. The current was 0.7 A and the bias 5 V.

Nuclear film (50-μm-thick × 20-cm × 25-cm MA-7B, made by Fuji Film Company) was used to detect the itons. This film is made for the general purpose of detecting alpha, proton, electron, and other particles. Three groups of film were located around the cell:

1. radially and directly ~10 cm from the center of the cell
2. radially but behind a 50-mm-thick lead block ~15 cm from the center
3. directly ~20 cm from the center but with 45 deg between the radial and film directions.

Another group of films for measuring background was located in a building ~2 km from the experimental room.

All the films were irradiated for ~21 days. After developing, the tracks in the films were examined by a 500×-power microscope. The positions of selected tracks were registered.

RESULTS AND DISCUSSIONS

In a forthcoming paper,[3] we describe how we predicted the emission of itons, as well as the mechanisms for the formation of the "Nattoh." When the Nattoh is formed,

electrons connecting hydrogens are also pressed extremely close to the hydrogen nuclei. In the hydrogen nucleus, the depolarization takes place by inverse beta decay:

$$p \rightarrow n + e^+ + \nu \ . \tag{1}$$

A dipole layer consisting of an electron and a positron is formed. Receiving the quantized excitation energy of the fusion nucleus, the iton is emitted as

$$e + e^+ + \nu \rightarrow i_1 = \begin{pmatrix} e \\ \nu \\ e^+ \end{pmatrix} \ . \tag{2}$$

It is assumed that a neutrino ν is also contained in the iton because no gamma rays are observed due to the annihilation of the electron and positron pair. Of course, this particle is unstable so that it decays in the inverse direction of Eq. (2). Moreover, if two electrons are pressed into the fused nucleus, a double iton is also formed as follows:

$$2e + 2e^+ + 2\nu \rightarrow i_2 = \begin{pmatrix} e & e^+ \\ \nu & \nu \\ e^+ & e \end{pmatrix} \ . \tag{3}$$

Although the double iton eventually decays to two electron and positron pairs, it can decay in various ways; for example,

$$i_2 = \begin{pmatrix} e & e^+ \\ \nu & \nu \\ e^+ & e \end{pmatrix} \rightarrow e + \nu + \begin{pmatrix} & e^+ \\ e^+ & \nu \\ & e \end{pmatrix} \rightarrow e + \nu + e^+ + \begin{pmatrix} e^+ \\ \nu \\ e \end{pmatrix}$$

$$\rightarrow 2e + 2e^+ + 2\nu \tag{4}$$

Figure 1 shows the possible decay schemes for itons i_1 to i_4. The linear lines could be confused with the background, and the double crossing could not be distinguished from two other overlapping lines due to the focusing resolution of the microscope. However, for more than the triple itons, there are triple crossings that can easily be distinguished to prove the existence of the decay of the higher itons.

Many clear tracks were recorded on film groups 1, 2, and 3. The tracks can be classified into five categories according to ionization power: (a) star, (b) y-type, (c) I-type, and (d) rabbit-footprint tracks. Among these, the star, y, and I tracks are induced by cosmic rays and are also observed on the background films.

The rabbit-footprint tracks, which are recorded by particles with the lowest ionization power such as electrons and positrons, are widely distributed. There are two types of rabbit-footprint tracks: a comparatively short and dense track due to background gamma rays and long, less dense, and frequently crossed tracks due to cold fusion.

Figure 2 shows a film of the background, in which short rabbit-footprint tracks left by the background gamma rays are shown. It also shows a star and an I-type track caused by cosmic rays, which appear by chance, although they are less distributed.

On film groups 1, 2, and 3, on the other hand, we observe many rabbit-footprint tracks, which can be identified as the results of iton decay. Figure 3a shows a correlation between the angle and length of the tracks on film group 1. The data were obtained by registering tracks that crossed the y axis at $x = 25$ and 35 mm between $y = -20$ and 20 mm. Figure 3b shows the corresponding correlation for the background. The tracks caused by the itons can clearly be distinguished from

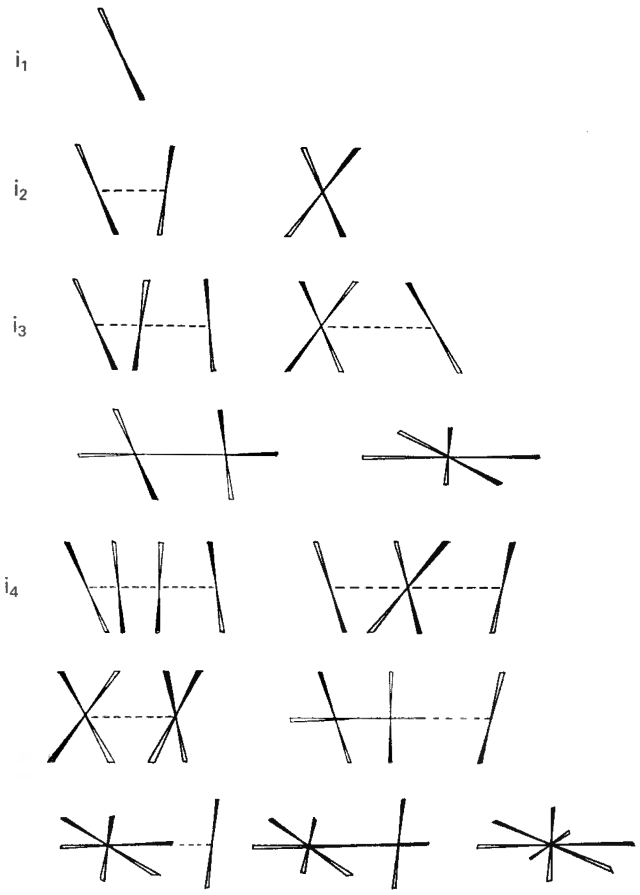

Fig. 1. Possible iton decay schemes.

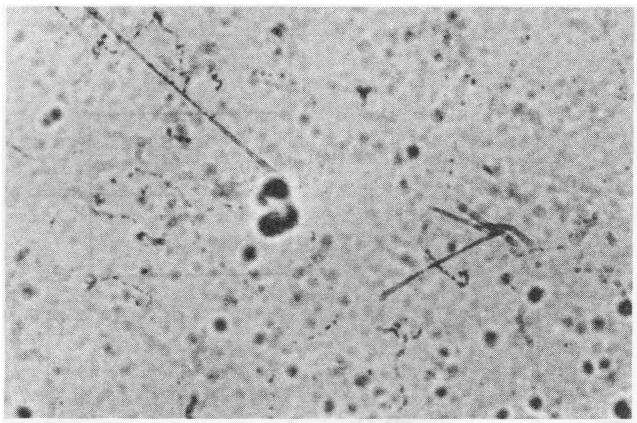

Fig. 2. Background (star and I-type tracks can be observed by chance).

the ones from the background. Figure 4 also shows the angular distribution of the tracks, which was calculated from the summation of the data in Fig. 3 multiplied by a weighting factor $1/(l\cos\theta)$. It can be seen that the electron and positron pairs are emitted almost perpendicularly to the transverse direction of the itons.

Figure 5 shows a triple crossing of the rabbit-footprint

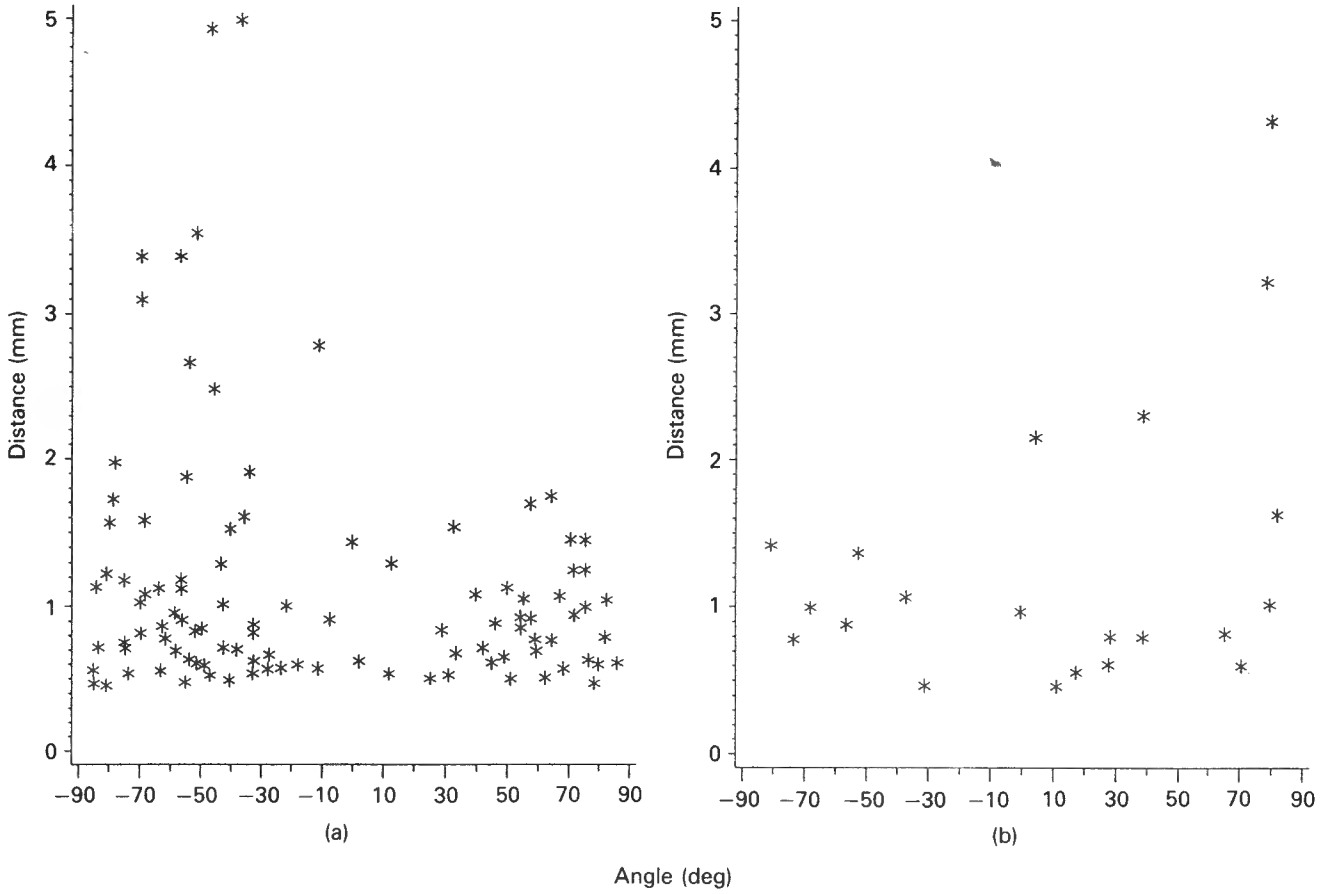

Fig. 3. Correlation between angle and length of itons for (a) D_2O and (b) background.

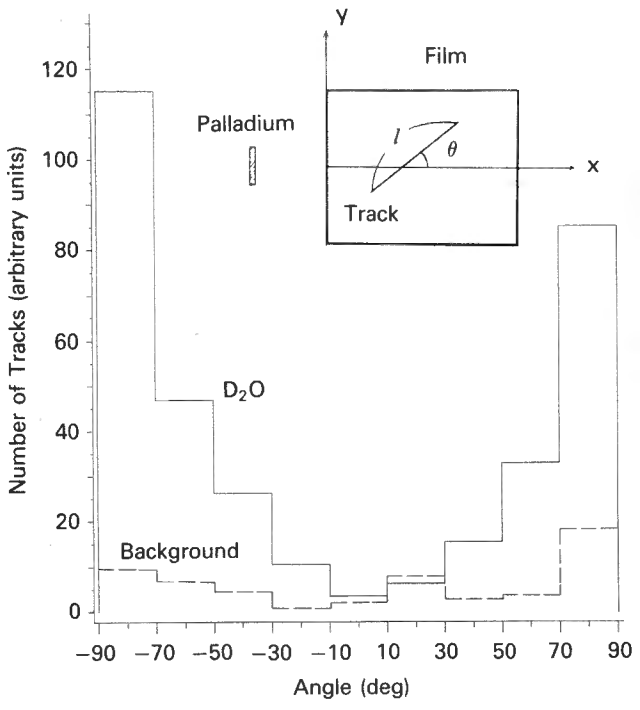

Fig. 4. Angular distribution of tracks.

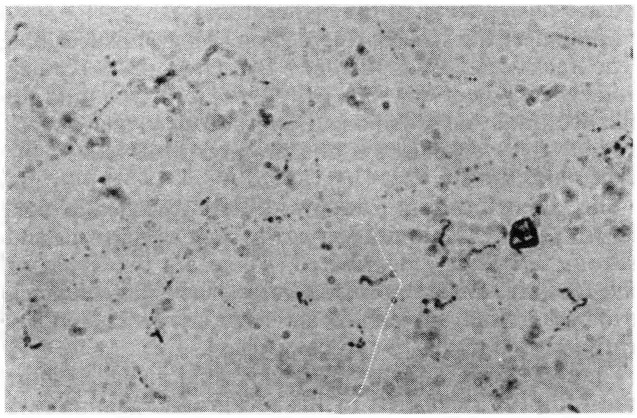

Fig. 5. Triple crossing of i_3.

tracks, which is indicated by the dotted-line circle in Fig. 6. The triple crossings are observed fairly often on the films. The probability of the triple coincidence of the tracks being caused by the background is so small that they can be considered to be produced by the decays of a triple or higher iton. Figure 7 shows the tracks caused by the decays of the fourth itons. Figure 8 shows the circled region in Fig. 7.

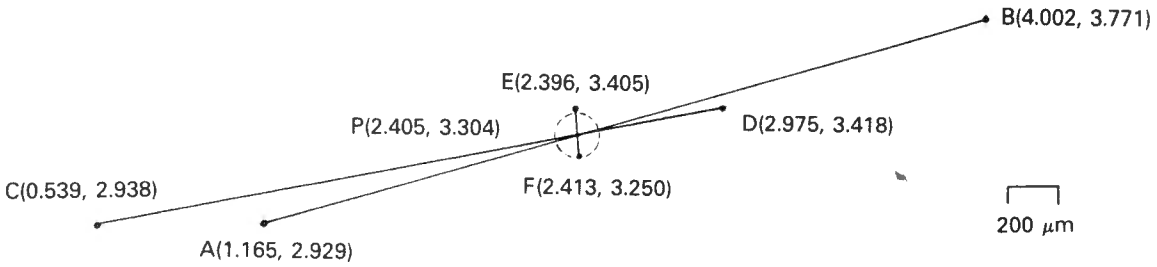

Fig. 6. Triple-crossed tracks caused by i_3.

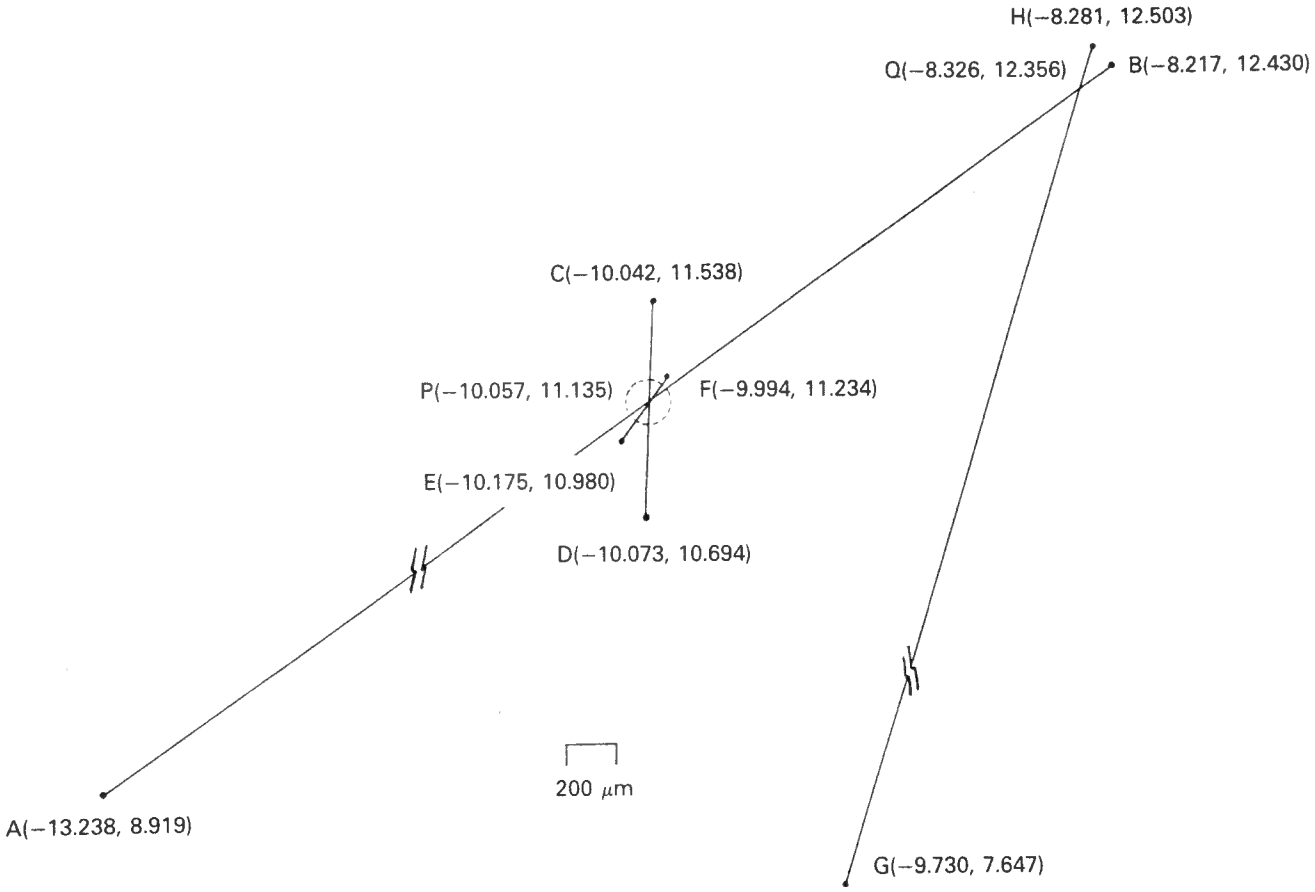

Fig. 7. Triple-crossed tracks caused by i_4.

Now we can see the emission of itons during the hydrogen-catalyzed fusion reaction. The fusion products must be modified on the Nattoh model. When a single iton is emitted, one of the two fused hydrogen nuclei is fermented:

$$2D + e + D \rightarrow {}^4\mathrm{H} + i_1 + d \ , \tag{5}$$

where

$$ {}^4\mathrm{H} \rightarrow {}^4\mathrm{He} + e + \bar{\nu} \ . \tag{6}$$

Connecting Eq. (5) with Eq. (6), i.e., after a sufficient time, the unstable particles such as ^{4}H and itons decay so that we obtain the reaction given by Eq. (3) in Ref. 1. On the other hand, for the double iton,

$$2\mathrm{D} + 2e + \mathrm{D} \rightarrow {}^4n + i_2 + d \tag{7}$$

$$\searrow \ {}^4\mathrm{H} + i_2 + {}^2n \ , \tag{8}$$

where $^k n$ is the neutron nucleus consisting of k neutrons. The beta decay of ^{4}H in Eqs. (5) and (8) could be confused with the beta decay of tritium produced by the conventional $d + d$ reaction. Here, the neutron nuclei can be considered to decay as follows:

$$ {}^4n \rightarrow {}^4\mathrm{H} + e + \bar{\nu} \rightarrow {}^4\mathrm{He} + 2e + 2\bar{\nu} \tag{9}$$

and

$$ {}^2n \rightarrow \mathrm{D} + e + \bar{\nu} \ , \tag{10}$$

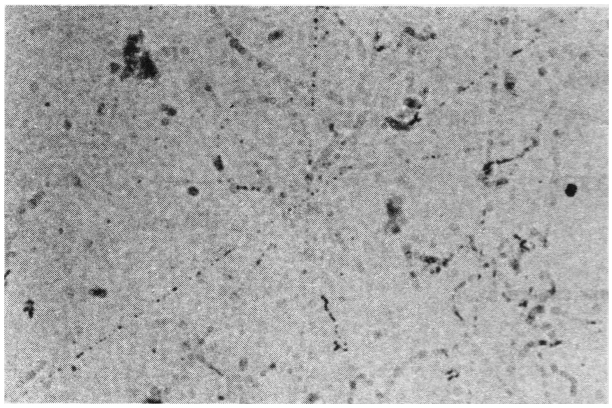

Fig. 8. Triple crossing of i_4.

or alternatively by gravity decay,

$$^4n \rightarrow \nu\bar{\nu} \tag{11}$$

and

$$^2n \rightarrow \nu\bar{\nu} \ . \tag{12}$$

The emission of itons has also been recognized in a similar experiment with ordinary water.[6] Therefore, we have proven that a hydrogen-catalyzed fusion reaction, which emits no neutrons, actually occurs in cold fusion and that the Nattoh model can properly explain the mechanism of cold fusion

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Ref. (11) ANS Reprint

PREDICTION OF NEW PARTICLE EMISSION ON COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *cold fusion, Nattoh model, iton*

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The energy distribution of cold fusion products is analyzed based on the Nattoh model. A new hydrogen-catalyzed fusion reaction is proposed to occur in a metal. From the differences in the Q value and other parameters, a new particle, the "iton," is predicted to be emitted, with a rest mass 2 to 26 times that of an electron.

I. INTRODUCTION

In order to understand the mechanism involved in cold fusion,[1] it is extremely important to know what types of nuclear fusion reactions take place in a metal containing absorbed deuterium. Measurements[2] of 2.45-MeV neutrons have proven that the following reactions, which are known to occur in a plasma state, also occur at room temperature:

$$d + d \rightarrow {}^3\mathrm{He} + n \quad \searrow \mathrm{T} + p \quad . \tag{1}$$

On the other hand, the Nattoh model[3] has been proposed, in which the reactions given by Eq. (1) are considered to be secondary processes, a new hydrogen-catalyzed fusion reaction is assumed to dominate:

$$2\mathrm{D} + \mathrm{D} \rightarrow {}^4\mathrm{He} + d \ . \tag{2}$$

An observation of cold fusion with ordinary water[4] seems to support the validity of key aspects of the Nattoh model.

We need direct and sensitive diagnostics to determine what types of reactions take place during cold fusion. Recently, Taniguchi et al.[5] tried to detect 3-MeV protons emitted from the lower reaction of Eq. (1). They obtained an unexpected energy distribution of cold fusion products that is too complex to be explained by Eq. (1).

In this technical note, the energy distribution of cold fusion products is analyzed based on the Nattoh model. The result is compared with the experiment, and it is shown that the hydrogen-catalyzed fusion reaction really occurs. Lastly, by considering the Q value of the reaction, we arrive at a prediction of the emission of a new particle, the "iton," from cold fusion.

II. ENERGY DISTRIBUTION OF COLD FUSION PRODUCTS

The energy distribution of cold fusion products gives direct and sensitive information about the types of reactions that take place in a metal containing deuterium. For the reactions given by Eq. (1), the energy distribution of the fusion products is simple: 0.81 MeV (^{3}He), 2.45 MeV (n), 1.01 MeV (T), and 3.04 MeV (p). On the other hand, the distribution for the hydrogen-catalyzed fusion reaction given by Eq. (2) is somewhat complex. When the Nattoh consists of N deuterons, $N-2$ deuterons receive the excess energy as one recoil. Therefore, the energy of each reacting deuteron depends on the number of the constituent deuterons N.

II.A. Calculation by the Nattoh Model

Let us calculate the energy distribution of the cold fusion products for the hydrogen-catalyzed reactions based on the Nattoh model. According to this model, the deuterons are considered to be strongly compressed to form a small cluster, called "Nattoh." The distance between the deuterons in the Nattoh is so short that fusion reactions can occur. (The size of the Nattoh is discussed in Sec. III.) Among the compressed deuterons, a two-body fusion reaction is the most probable. As the resulting ^{4}He* has an extremely short lifetime of $\sim 10^{-22}$ s, the Nattoh will be quickly destroyed, scattering the constituent particles. The excess Q energy is distributed to one ^{4}He and the remaining $N-2$ deuterons. The kinetic energy of each particle can then be calculated by energy and momentum conservation laws, if the structure of the Nattoh is known. It is assumed here that just prior to the two-body fusion reaction, the Nattoh has a close-packed structure consisting of hard spherical particles. Table I shows the calculated kinetic energy of the particles for the cases of $N \leqq 6$.

II.B. Calculational Method

Taniguchi et al.[5] tried to detect the 3-MeV protons that are emitted from the lower reaction of Eq. (1). A thin palladium foil (12.5 μm thick) was used for the cathode. One side of the foil was soaked in an electrolyte solution (D_2O + LiCl), while the other side was in contact with a solid-state detector in the atmosphere.

To compare the calculational and experimental results, the effect of the energy loss in the foil must be calculated.

TABLE I

Calculated Kinetic Energy for Hydrogen-Catalyzed Fusion Reactions

N	Type	Deuteron Energy, E_d/Q	^{4}He Energy, $E_{^4He}/Q$
3	^{4}He + d	2/3	1/3
4	^{4}He + 2d	2/7 × 2	3/7
5	^{4}He + 3d	0.228 × 3	0.316
6	^{4}He + 4d	0.120 × 4	0.520

Figure 1 shows the configuration used for the calculation. The energy distribution $\psi(E)$ measured by the detector can be expressed by the following equation:

$$\psi(E) = \sum_{i=1} P(Q_i)\epsilon(E) \int_0^T dz K(z) g_i(z,E) \ , \qquad (3)$$

where

$$g_i(z,E) = \sum_{N=3} r_N \sum_{\nu=1}^{N-1} \delta(E - E_\nu) f_N(E_\nu)$$

$\epsilon(E)$ = detector efficiency

$K(z)$ = spatial distribution of fusion rate

$f_N(E_\nu)$ = energy distribution of ν'th fusion products caused by Nattoh with N deuterons

E_ν = kinetic energy of ν'th particle just after fusion

$P(Q_i)$ = reaction probability with excess energy Q_i

r_N = reaction weight of Nattoh with N deuterons

T = thickness of foil.

The energy $|E - E_\nu|$ is lost while the particle passes through the foil. This energy loss can be approximated as follows:

$$-dE/dx = a/E \ , \qquad (4)$$

where a is a constant (4.327×10^3 and 3.462×10^4 MeV^2/cm were used for d and ^{4}He particles, respectively). Any particle detected with an energy E that satisfies the following relation was registered:

$$E = (E_\nu^2 - 2at)^{1/2} \ , \qquad (5)$$

where t is the transverse distance in the foil before arriving at a detector.

In these calculations, all the fusion reactions are approximated as occurring on the z axis. When the direction of the ^{4}He emission is taken to be the z' axis, the angles θ and ϕ between the z and z' axes are changed by π and 2π, respectively.

II.C. Comparison with Experiment

The calculations reported here are based on the Nattoh model, using Eq. (3). For simplicity, only four types of hydrogen-catalyzed fusion reactions are considered: $N = 3$ to 6. The reaction weights are assumed to be equal for the different N Nattohs. The kinetic energies for the fusion products are taken from Table I. Furthermore, the spatial distribution of the fusion rate is assumed to be exponential: $\exp(-\lambda z)$, where $\lambda = 1.0$ cm^{-1}.

The excess energy Q of the hydrogen-catalyzed fusion reaction is 23.85 MeV. The calculated distribution with this Q value clearly differs from the experimental one. In Eq. (3), the summation is made over three modified Q values. This is due to the assumption that a new particle is emitted.

The calculational results are shown in Fig. 2 and are compared with the experimental observation. Several peaks are observed in the measured energy distribution, Fig. 2a, for heavy water. It is clear that the conventional fusion reactions of Eq. (1) cannot explain the experiment. Figure 2b shows the calculated total distribution, which consists of three partial distributions based on the modified Q values. The values of Q are 4.77, 3.76, and 2.77 MeV, respectively, which all contain the additional energy corresponding to the rest mass energy (1.02 MeV) of the two electrons involved. The reaction probabilities for the different Q values are assumed to be 1:2:4, respectively.

It is seen that the calculation can reproduce the general

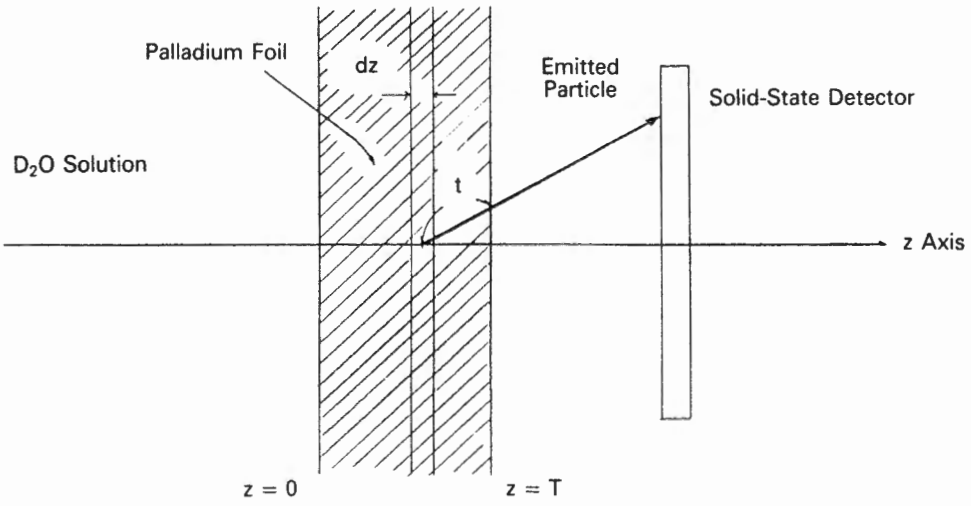

Fig. 1. Configuration used for the energy loss calculation.

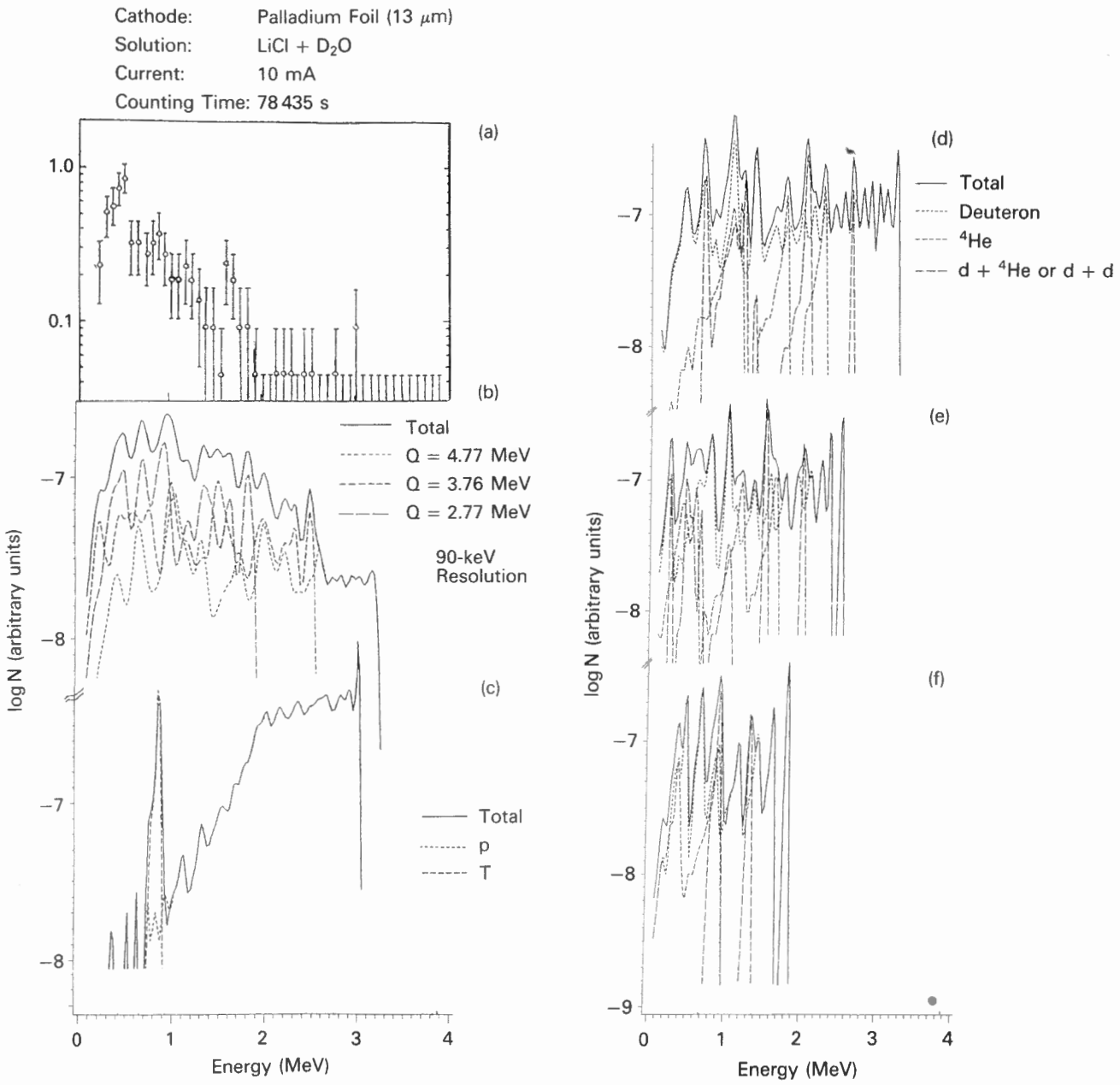

Fig. 2. Comparison of experiment and calculations for cold fusion products: (a) experiment in Ref. 5, (b) total calculated distribution based on Nattoh model, (c) total calculated distribution based on conventional fusion reactions, (d) partial distribution with $Q = 4.77$ MeV, (e) partial distribution with $Q = 3.76$ MeV, and (f) partial distribution with $Q = 2.77$ MeV.

features of the experiment. The statistical accuracy of the experiment is not sufficient, however, and several assumptions are employed in the calculation so the agreement must be viewed as tentative. The amplitude in the spectrum cannot be discussed in any detail. However, what is more important is the information about the energies. The peaks can be explained by noting the partial distributions. Figures 2c, 2d, and 2e show the partial distributions with modified Q values of 4.77, 3.76, and 2.77 MeV, respectively. The monoenergetically emitted particles are split into several peaks due to the mesh effect of the z axis integration in Eq. (3). A smoothing procedure would be possible, but instead it is suggested that the fusion reactions take place in a layer-like region, e.g., in grain boundaries. Since the 12.5-μm foil is divided into 18 layers, the layers in which the fusion reactions take place appear to be effectively separated by ~0.7 μm.

III. PREDICTION OF A NEW PARTICLE

In Sec. II.C, we compared calculated and experimental data for the energy distribution of cold fusion products. We obtained a fairly good agreement between the two based on the Nattoh model. Thus, this provides strong evidence that

the hydrogen-catalyzed fusion reaction predicted by the Nattoh model does take place in a metal containing deuterium.

However, some questions remain that should be answered. The first is the difference in the Q values involved. The modified Q values of 4.77, 3.76, and 2.77 MeV gave good agreement between the calculation and experiment, while the intrinsic value is 23.85 MeV. We have to explain where this difference of ~20 MeV in the Q energy goes. The second is the branching ratio in the two-body fusion reaction. In the conventional reactions of Eq. (1), the p and n production branches are almost equally probable and extremely large compared with the one for $^4He + \gamma$. Furthermore, in the muon-catalyzed fusion reaction, the conventional reactions are predominant, as is observed in a high-temperature plasma. As the Nattoh model *a priori* assumes ^4He production without gamma emission [see Eq. (2)], the reason that the ^4He production branch exceeds the ones for the n, p, or γ production must be explained. The third is the size of the Nattoh, which was not discussed earlier in Ref. 2. The way to form the Nattoh with a given size should also be explained.

To answer these remaining questions, we will add a new hypothesis, keeping within the framework of the Nattoh model. Let us assume that one or more light particles are emitted during the hydrogen-catalyzed fusion reaction. This particle then can take away the difference energy of ~20 MeV. We temporarily call it an "iton," which means a "string contacted with the Nattoh." If the iton is a meson, it can be neither a π nor K meson, because the rest masses of these mesons are ~135 and 494 MeV, respectively. Other mesons have much heavier masses. Thus, the iton could be a new and unknown particle. Another possibility is that the iton could be a neutrino or electron-positron pair.

The itons should remarkably affect the branching ratio of the two-body fusion reaction. Figure 3 shows the energy level of ^4He (Ref. 6). Due to the two-body fusion reaction, $^4He^*$ is formed, excited by 23.85 MeV. In the conventional reactions of Eq. (1), $^4He^*$ opens the channels to n or p production and the difference in energies of 3.25 and 4.05 MeV are transferred to the kinetic energy of the particles. In the hydrogen-catalyzed fusion reaction, however, the quantized energies of 22.1, 20.1, and 19.1 MeV would be transferred to the emission of one or more itons. The remaining difference energies of 3.75, 2.75, and 1.75 MeV would be distributed among the kinetic energies of the emitted ^4He and deuterons. This is how the hydrogen-catalyzed fusion reaction can occur without production of n, p, or γ particles. Since the iton involves a strong nuclear interaction, the iton should neither be a neutrino nor electron-positron pair but instead, should be a new meson.

The last question concerns the size of the Nattoh and the mechanism for deuteron compression. The deuterons in the Nattoh must be compressed within the distance covered by the nuclear force caused by the itons. It is very surprising that a simple technique such as electrolyzing water has the capability of compressing deuterons together within such an extremely short distance. It is natural to look for the reason within the hydrogen itself rather than searching for an external force.

The hydrogens are assumed to be compressed in two stages. The first stage is understood from the concept of the effective mass of an electron. According to the Nattoh model, electrons connecting the hydrogens move around, following the third hydrogen. In the process, the effective mass of the electron increases. Figure 4 illustrates a semiclassical explanation for the mechanism of deuteron compression.

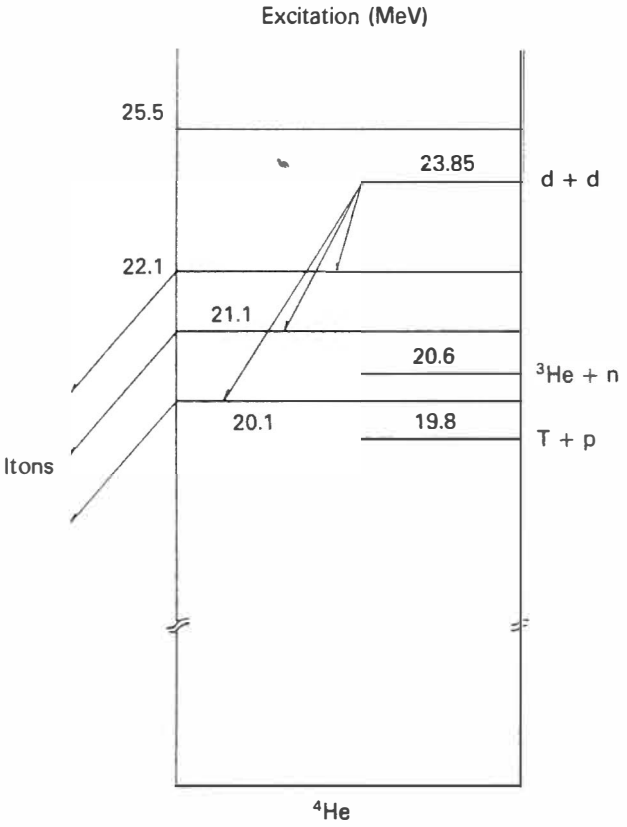

Fig. 3. Energy level of ^4He.

Let us consider a situation in which a molecule of the A and B deuterons exists in a highly pressurized space (hole) such as the grain boundary of a polycrystalline metal. Now, the third deuteron C is assumed to enter in the space. As a result, the pressure increases to a value that is higher than critical. The electron combining the A and B deuterons is pressed by the invasion of the C deuteron so that the effective mass of the electron increases, shortening the distance between the A and B deuterons. Unlike the muon-catalyzed fusion reaction, a symmetry exists in the hydrogen-catalyzed

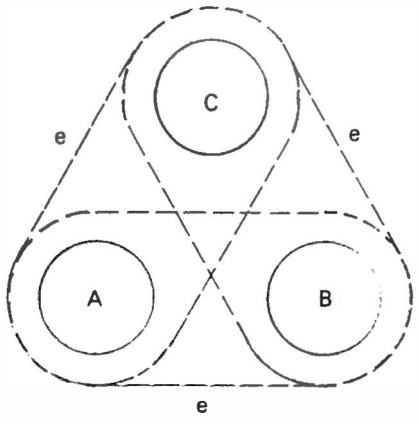

Fig. 4. Semiclassical explanation of deuteron compression.

reaction. The distance between the A and C deuterons is shortened as the B deuteron approaches A. This also shortens the distance between the C and B deuterons. Therefore, the deuterons are compressed into an extremely small cluster by the compression effect of the deuterons themselves. We call this the "scramming effect" of hydrogens.

The second stage is that the deuterons gather so closely that the iton can connect them. The distance between the deuterons is expected to be extremely short. The limit for the distance between the deuterons is $\frac{1}{1672}$ times of the intramolecular distance 0.7 or $\sim 2 \times 10^{-12}$ cm. In this situation, the electrons move with the same velocity as the deuterons. If the range of the new nuclear force is assumed to correspond to this value, the rest mass of the iton is found to be $\sim 26 m_e$ (m_e = rest mass of the electron). On the other hand, as shown in Fig. 4, one or more electrons are pressed during formation of the Nattoh. In Sec. II.C, when the rest mass energies of 1.02 MeV were added to the modified Q value, a better agreement between the experiment and calculation was obtained. The electron might need an antiparticle, e.g., a positron, to produce a mesonic iton. The rest mass of the iton is considered to be $>2 \times m_e$, which corresponds to 2.6×10^{-11} cm for the range of the nuclear force. Therefore, it is supposed that the Nattoh is extremely compressed in view of the deuteron distance of 2×10^{-12} to 2.6×10^{-11} cm. Note that the Nattoh is not a normal compound nucleus.

IV. DISCUSSION

The energy distribution of fusion products provides direct and sensitive information about the types of fusion reactions that take place during cold fusion. By comparing a calculation with experimental energy distribution (Sec. II.C), it has been shown that the hydrogen-catalyzed fusion reaction predicted by the Nattoh model is favored. Furthermore, the scanning effect of deuterons themselves was used to explain why the Nattoh can contain an extremely small cluster of the deuterons with a distance of $\sim 2 \times 10^{-12}$ to 2.6×10^{-11} cm. Earlier, Ref. 3 showed that gamma rays are emitted from many-body fusion reactions. Now this can be understood in terms of the extremely small size of the Nattoh.

It has been made clear that, as a result of the hydrogen-catalyzed fusion reaction, the constituent deuterons of the Nattoh diverge with high energy. Since two deuterons are consumed per fusion reaction, it becomes possible for the deuterons to cause chain reactions in a metal if more than two deuterons are emitted on average in each fusion reaction. Based on this possibility, we have discussed the physics of a postulated cold fusion reactor similar to a fission reactor where chain reactions are carried by neutrons.[7]

The feasibility of the emission of a new particle, the "iton," during the hydrogen-catalyzed fusion reaction has been predicted by analyzing the difference in Q between the calculation and experiment. We estimate the rest mass of the iton to be 2 to 26 times that of an electron. Furthermore, the heavy fusion product that is formed by the hydrogen-catalyzed fusion reaction is not precisely the same as ordinary ^{4}He, due to the emission of the iton. Indeed, this "fermented" nucleus will be somewhat unstable and will probably decay.

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Ref. (17)

ANS Reprint

MICROSCOPIC OBSERVATIONS OF PALLADIUM USED FOR COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *microscopic structure, defect, grain boundary*

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The microscopic structures of palladium metals used for cold fusion experiments are examined. Tiny spot defects suggesting cold fusion have been observed in grain boundaries as the Nattoh model predicts. The relationship between these defects and a series of neutron bursts and an indirect loop of hydrogen chain reactions are discussed.

I. INTRODUCTION

The Nattoh model[1,2] predicts that cold fusion[3,4] is based on hydrogen chain reactions and takes place in the grain boundaries of the host metal. There are two loops of hydrogen chain reactions: direct and indirect. In the indirect loop, high-energy hydrogens emitted from hydrogen-catalyzed fusion reactions experience slowing down, thermalization, and diffusion processes in the metal, similar to the loop of neutron chain reactions in thermal fission reactors. The direct loop, which causes burst emissions of heat and neutrons, is similar to the loop of neutron chain reactions in fast breeder reactors, but enhanced in the case of cold fusion because more short-range particles can be emitted per reaction. If hydrogen clusters distribute densely in the grain boundaries, it is expected that sequential fusion reactions would damage the structure of the surrounding metal to the extent that they could be observed by a microscope.

This technical note describes observations of the microscopic structures of palladium metals that were used for cold

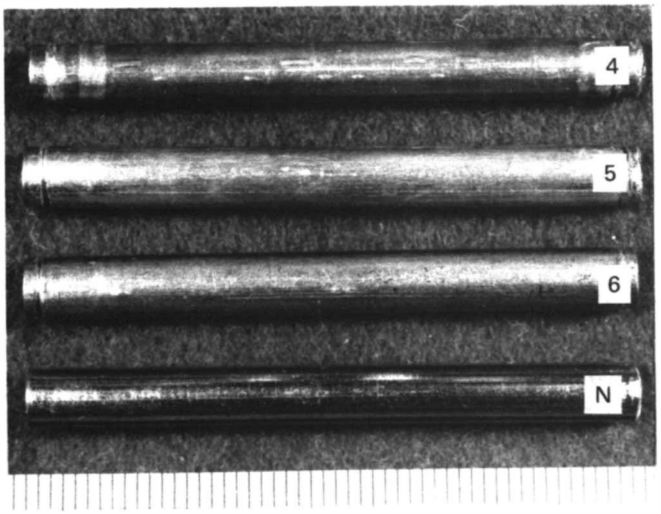


Fig. 1. Specimens of palladium rods used for cold fusion experiments.

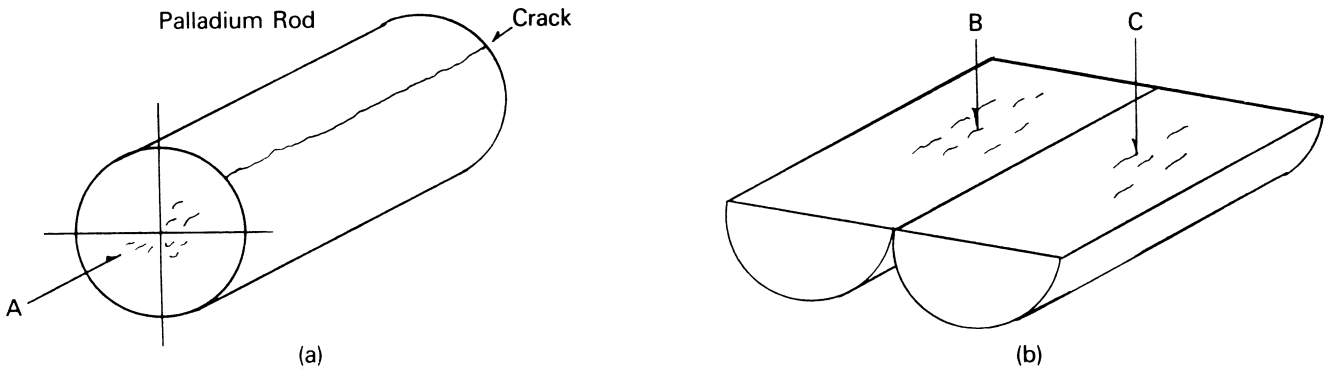


Fig. 2. Specimen cutting procedure.

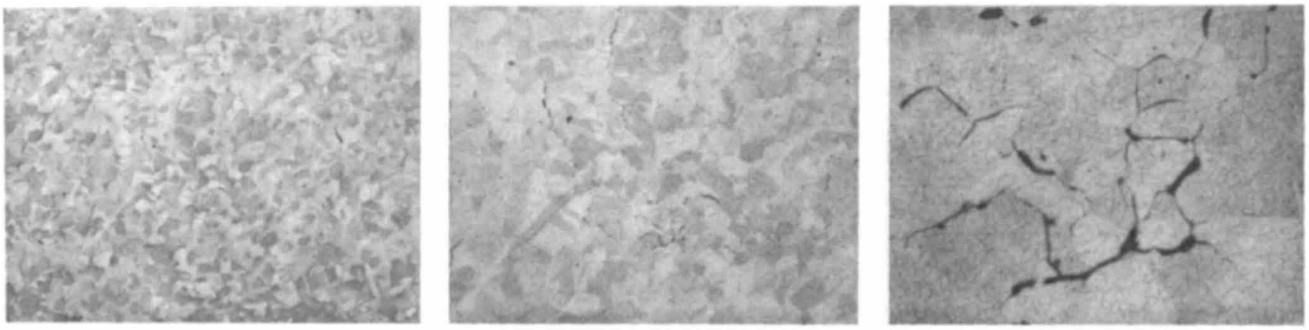


Fig. 3. Radial cross section A (see Fig. 2a) of specimen 5 by OM (a) after first polishing (30×), (b) after second polishing (60×), and (c) after second polishing (360×).

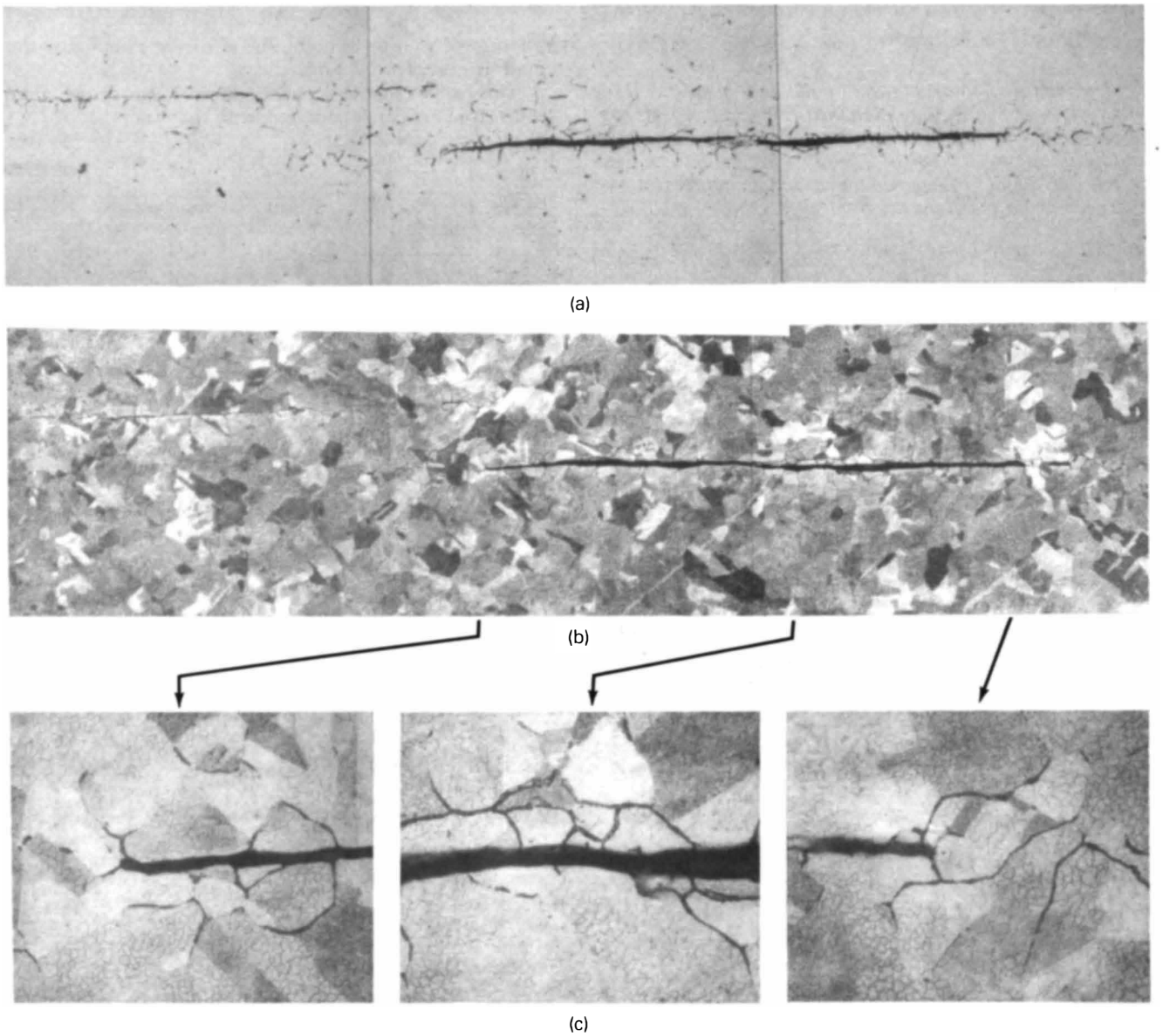


Fig. 4. Longitudinal cross section B (see Fig. 2b) of specimen 5 by OM (a) after first polishing (30×), (b) after second polishing (60×), and (c) after second polishing (360×).

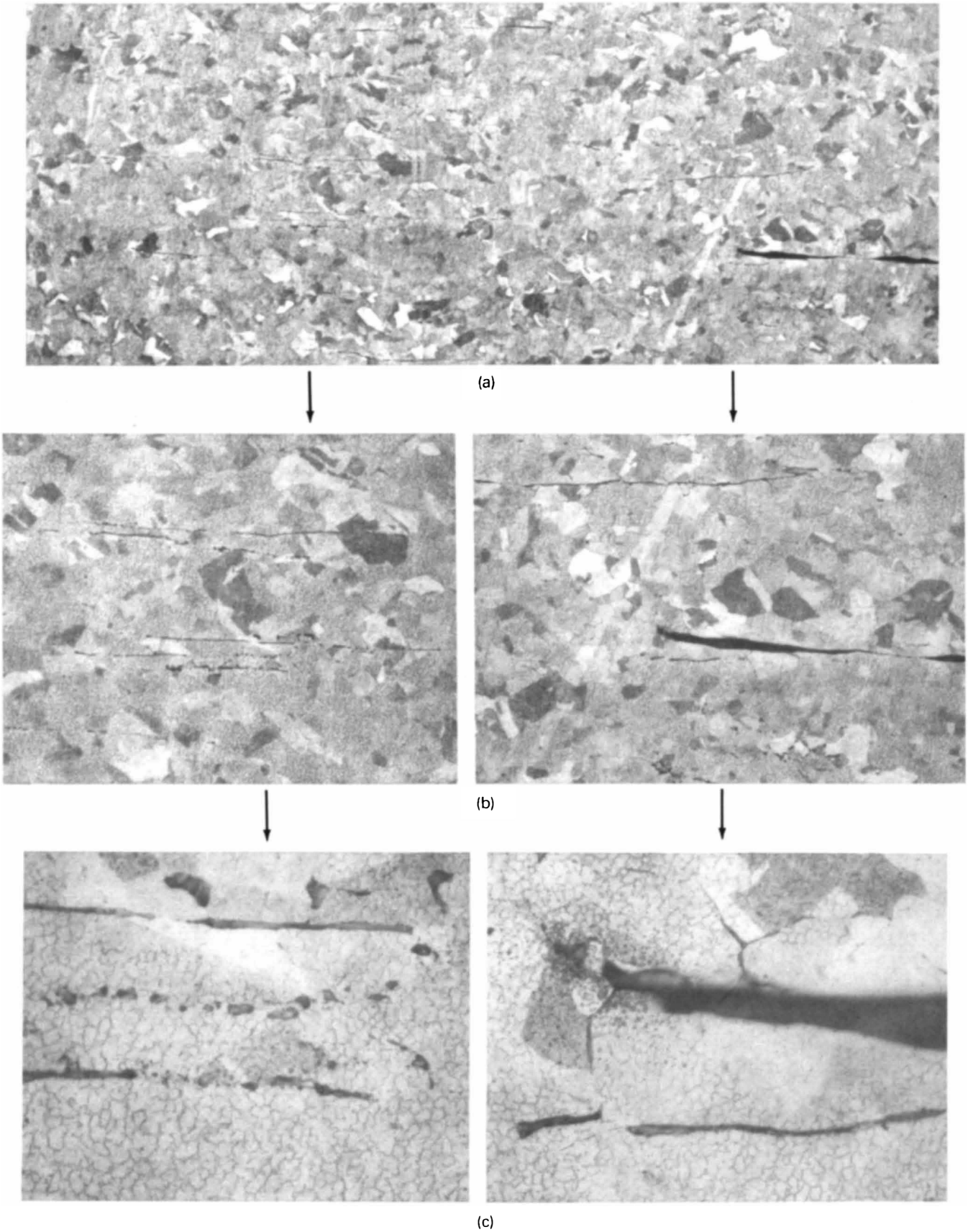


Fig. 5. Longitudinal cross section C (see Fig. 2b) of specimen 5 by OM after second polishing (a) 47.5×, (b) 95×, and (c) 570×.

fusion experiments with light water as well as heavy water.[5-7]

II. OBSERVATIONAL RESULTS

The microscopic structures of the palladium metals were observed by an optical microscope (OM) and a scanning electron microscope (SEM). Figure 1 shows the palladium rods (5-mm diam × 50-mm length) that were used for cold fusion experiments. Specimen 5 was used for a heavy water experiment[6] and charged for ~27 days. Specimens 4 and 6 were used for light water experiments[5,7] and charged for ~19 and 15 days, respectively. The hydrogen charging was done by electrolysis. Cold fusion was successfully observed for all the samples. A new palladium rod, specimen N, which was cut from the same rod as specimen 5, was observed for comparison.

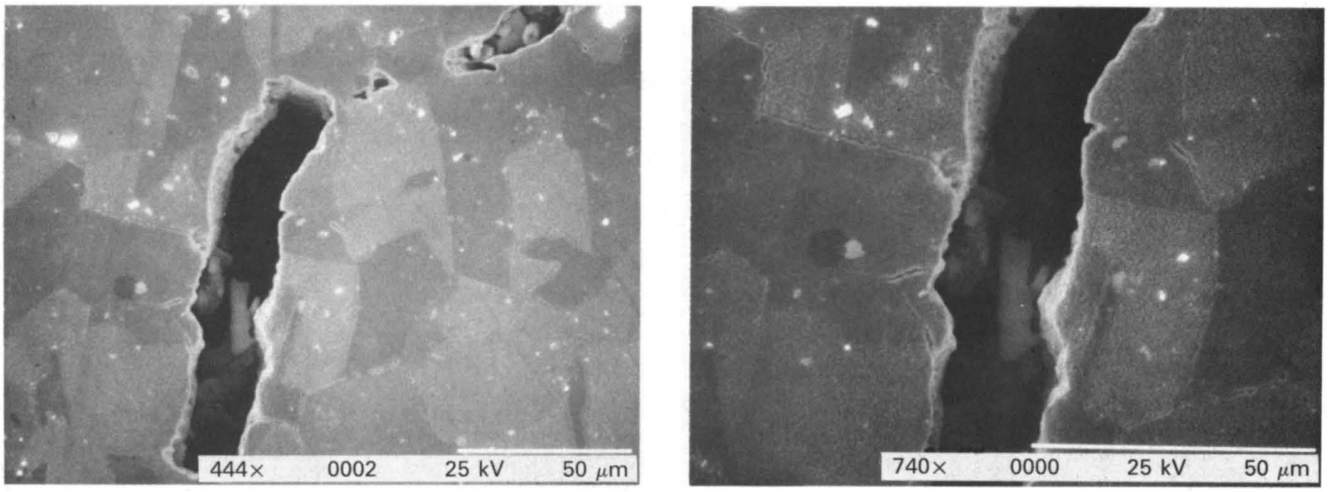
II.A. OM Results

The samples were first radially cut as shown in Fig. 2a, and a cross section was observed by OM. Then one of the radially cut samples was longitudinally opened as shown in Fig. 2b and also observed by OM.

Various defects were observed in specimens 4, 5, and 6. Specimen 5 is shown in Figs. 3, 4, and 5, for example. Figure 3 shows defects on the radial cross section at various magnification powers. It can clearly be seen in Fig. 3c that the defects are radially connected.

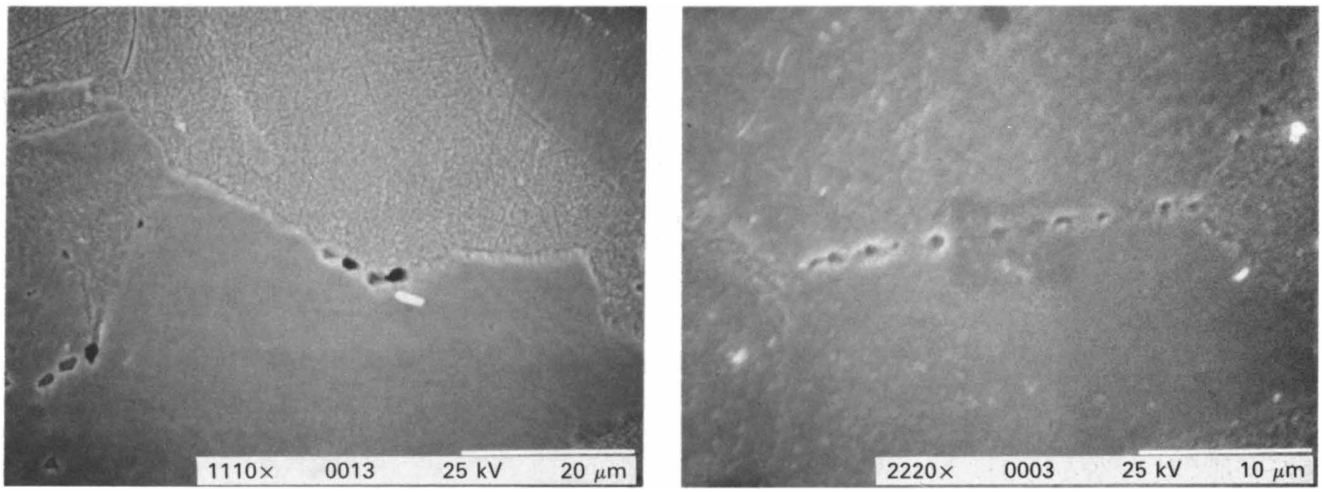
Figure 4 shows the longitudinal cross section of specimen 5. Many cracks have grown longitudinally. In Fig. 4c, it can be seen that several groups of grains have separated from each other around the cracks.

Figure 5 shows other defects on the same cross section. Many longitudinal cracks have grown into broader cracks. On the left side of Fig. 5c, there are defects with an area of



(a) (b)

Fig. 6. Grain-shaped defect in specimen 5 by SEM after etching (a) 444× and (b) 740×.



(a) (b)

Fig. 7. Tiny spot defects in specimen 5 by SEM after etching (a) 1110× and (b) 2220×.

several grains (referred to as grain-shaped defects). These grain-shaped defects seem to be empty and can grow to longitudinally linear cracks by connecting with each other.

Although we observed many defects in Figs. 3, 4, and 5, we cannot determine by OM observations whether they were produced by hydrogen charging, by cold fusion, or by a combination of both processes.

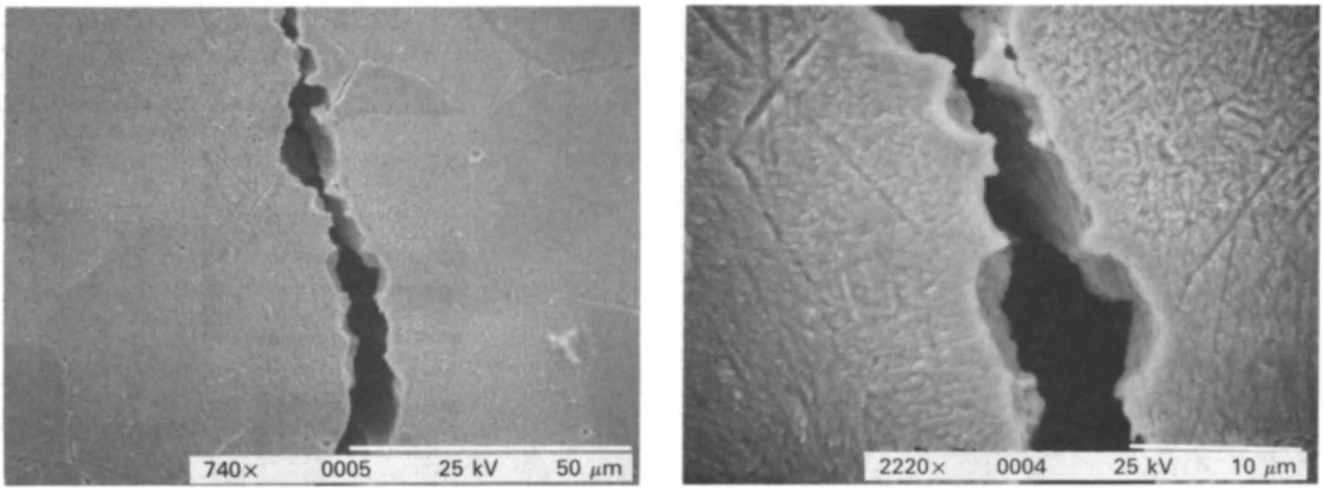
II.B. SEM Results

More details of the microscopic structures of the palladium metals were observed by SEM.

Figure 6 shows SEM pictures for a grain-shaped defect observed on a radial cross section of specimen 5. The defect was caused by depletion of a few grains, and the whole shape of the grains is very well conserved. The materials of the grains have disappeared almost completely. Furthermore, Fig. 7 shows that tiny spot defects, suggesting the occurrence of the cold fusion, were produced in grain boundaries. Figure 7b shows an array of the tiny spots through the grain boundary. It is clear that such tiny spot defects cannot be made by hydrogen charging, but by cold fusion.

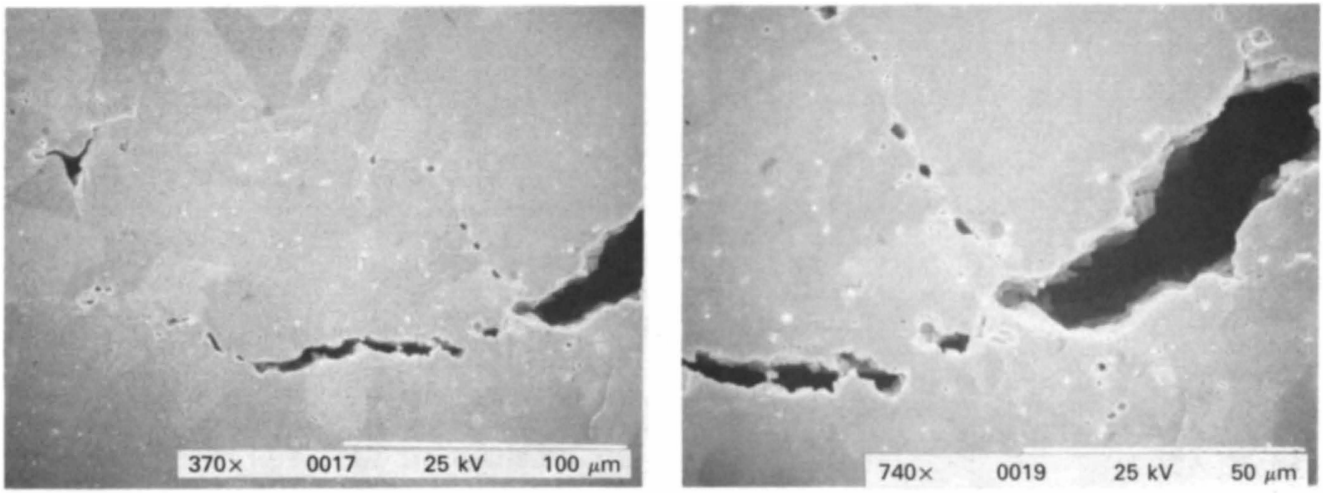
Figure 8 shows the other defect on the same cross section. Here we can see that the spot defects have grown to become connected to each other.

Figure 9 shows the entire history of defect growth in specimen 4, i.e., the experiment with ordinary water. We have reported[5] that cold fusion also takes place with ordinary water. The fusion products may be different, but the mechanisms of cold fusion are the same in heavy and ordinary water. The tiny spots, caused by cold fusion, have been connected to each other to surround a few grains. Finally, whole grains themselves have disappeared to form the grain-shaped defect; in the defects, there is almost nothing, i.e., they are



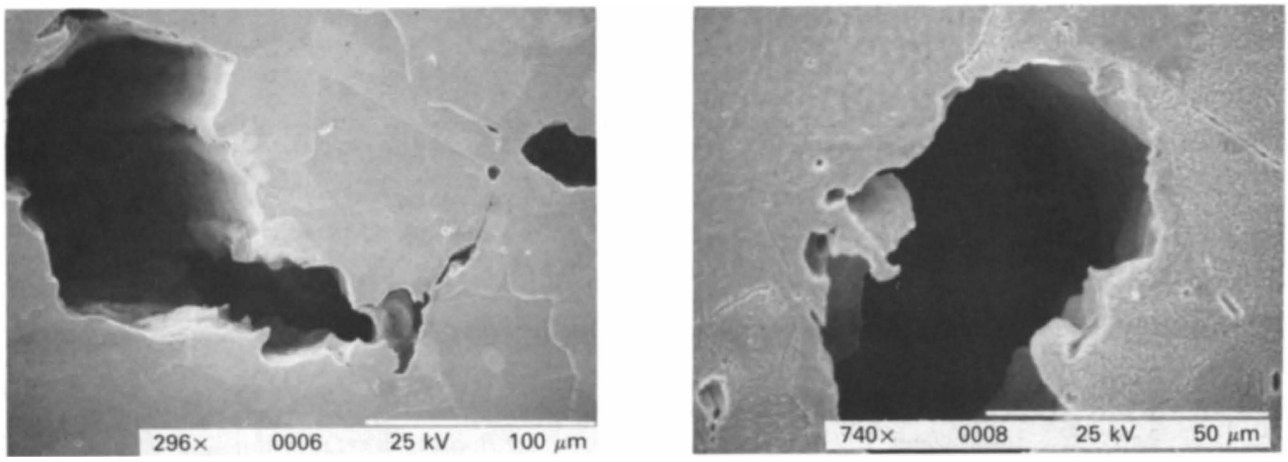
(a) (b)

Fig. 8. Connected defects of specimen 5 by SEM after etching (a) 740× and (b) 2220×.



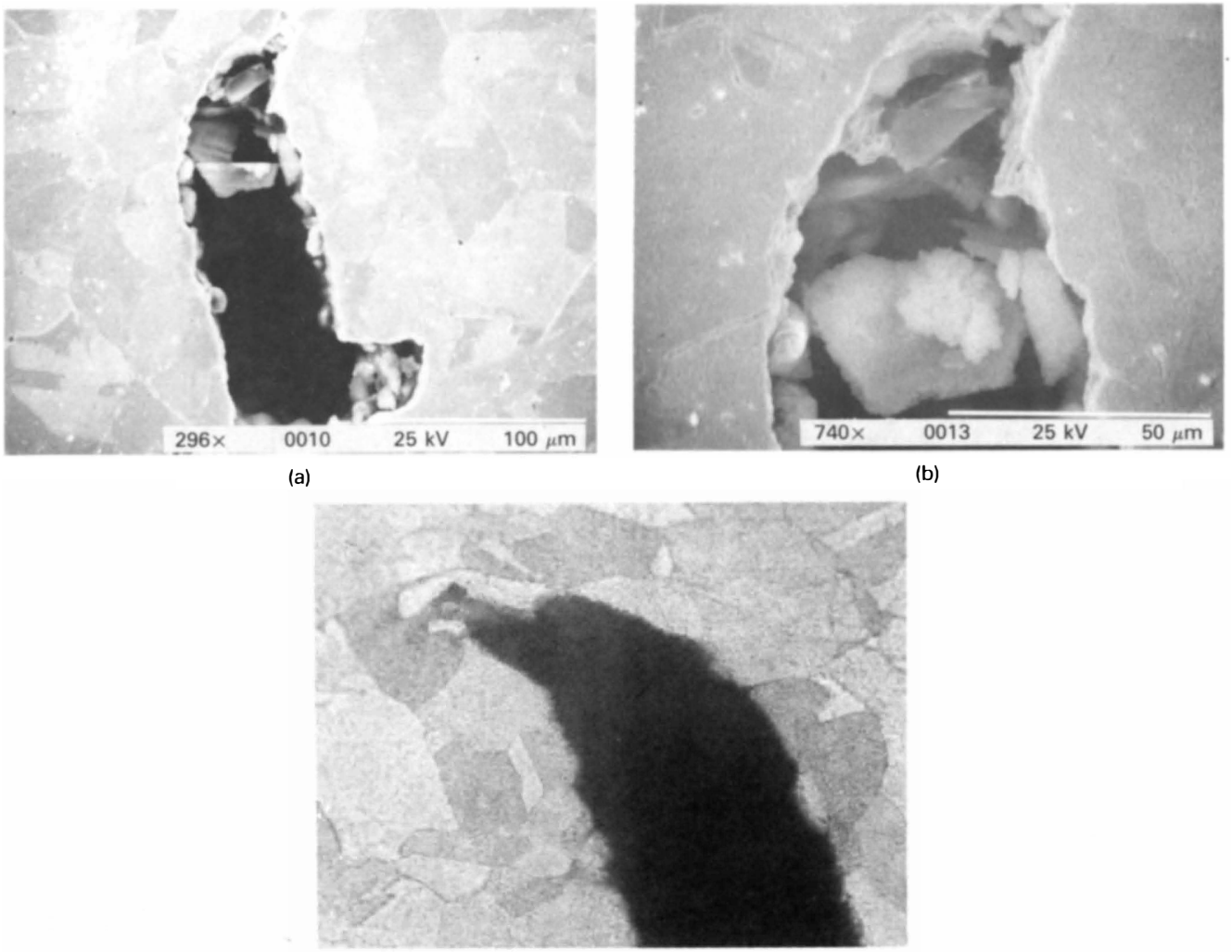
(a) (b)

Fig. 9. Growth of defects of specimen 4 by SEM after etching (a) 370× and (b) 740×.



(a) (b)

Fig. 10. Large defects in specimen 6 by SEM after etching (a) 296× and (b) 740×.



(a) (b)

(c)

Fig. 11. Vanished and remaining parts of specimen 6 after etching (a) 296× (by SEM), (b) 740× (by SEM), and (c) after second polishing 444× (by OM).

empty. Figure 10 shows two different grain-shaped defects for specimen 6. In Fig. 10a, the inside walls seem to have been produced by some drilling procedure. Figure 11 shows another large grain-shaped defect in specimen 6. Some grain materials remain in the defect and have divided into smaller debris, shown in Fig. 10b. Figure 10c, an OM picture of the same defect, shows changes in the structure around the defect. This suggests that inside the defect the temperature and the pressure have increased to some extent because the materials of the grains have burned out.

III. GROWTH OF DEFECTS

In Sec. II, we observed several different stages of the growth of defects. They are summarized in Fig. 12.

At first, tiny spot defects, ~1 μm in diameter, are caused by cold fusion in the grain boundaries. These tiny defects seem to be spots, but they are really distributed one-dimensionally by the sequential fusion reaction. In the second stage, the tiny spot defects grow completely through the grain boundaries to surround a number of grains. The defects are now two-dimensional. In the third stage, the grains are isolated and burn out. Grain-shaped defects appear whose shapes are almost the same as the entire boundaries of the grains. The grain-shaped defects are three-dimensional.

The grain-shaped defects are connected with each other and thus grow into linear cracks, longitudinally and radially in the case of a rod. Moreover, the linear cracks grow into wide cracks by absorbing the surrounding grains. Although those processes evolve through hydrogen charging, they are probably accelerated by cold fusion. Finally, when the hydrogens begin to be released from the metal, the balance of the hydrogens is upset, thus stopping the chain reaction.

According to the Nattoh model,[1,2] cold fusion is based on a new and unknown fusion reaction, i.e., the hydrogen-catalyzed fusion reaction. This reaction is induced by many-body interactions, but the fusion reaction takes place between only two bodies. When the reaction occurs in N hydrogens, $N-2$ surplus hydrogens are scattered with high energy, causing additional fusion reactions. This hydrogen chain reaction causes cold fusion to burn continuously or in bursts.

It is considered that there are two loops of hydrogen chain reactions: direct and indirect. The indirect loop occurs through the entire rod, and it would widen the separation of the grains. Phenomena suggesting the indirect loop can be observed in Fig. 13, which is an SEM picture of Fig. 4. But hydrogen charging, as well as the etching process, would have the same effect so that this conclusion is indeterminate. On the other hand, the direct loop occurs locally and in bursts caused by sequential fusion reactions between neighboring hydrogen clusters in grain boundaries. Therefore, we can

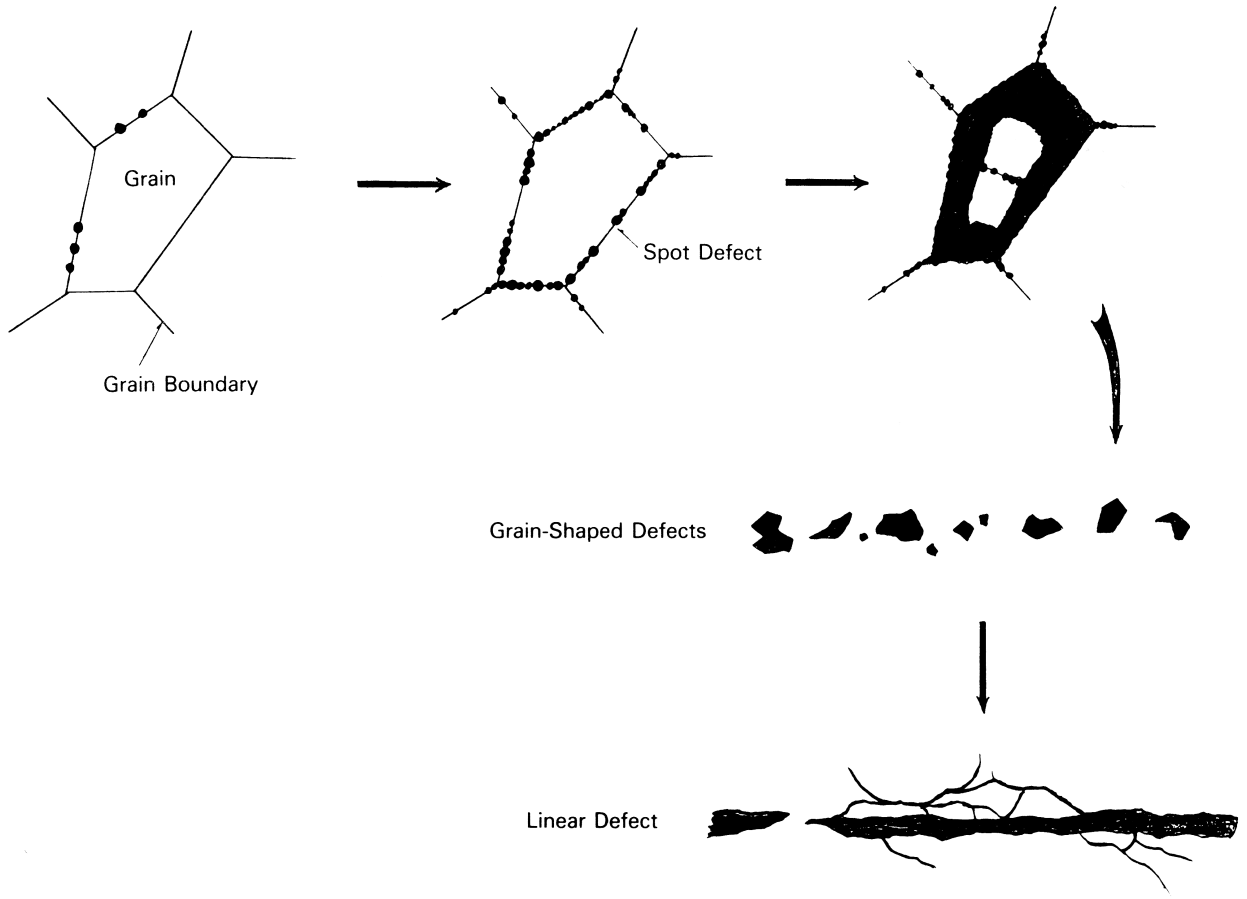


Fig. 12. Growth of defects.

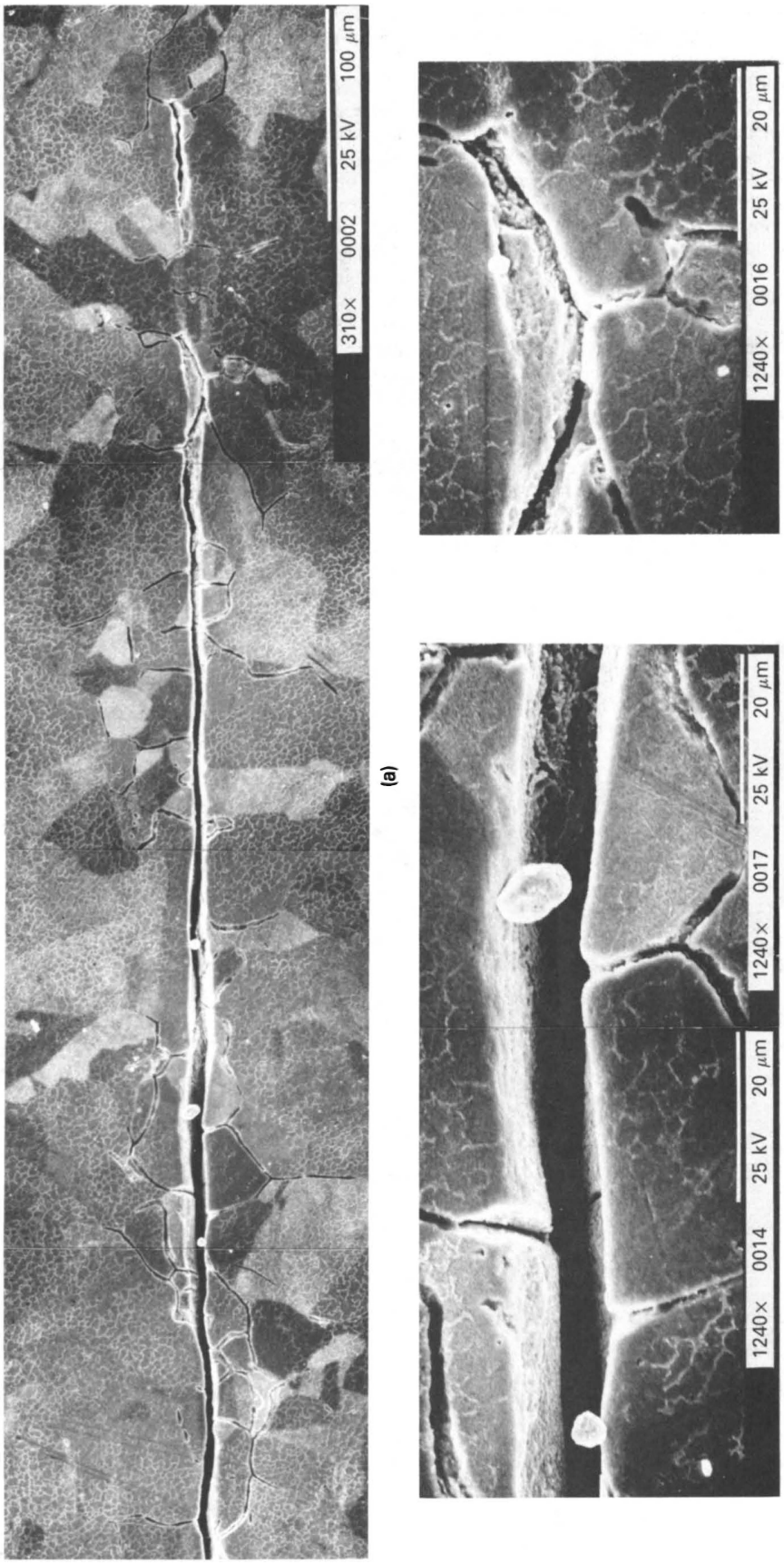


Fig 3. Grain separation in specimen 5 by SEM after etching (a) 3 0× and (b) 240×

observe defects caused by the direct loop of the hydrogen chain reactions.

In the direct loop, other fusion reactions besides the hydrogen-catalyzed fusion reaction could also be enhanced, such as many-body fusion and conventional fusion reactions in high-temperature plasma. The latter reactions produce 2.45-MeV neutrons, but the former produces much higher energy neutrons.[1] If those fusion reactions are enhanced, many neutrons, in addition to heat, are emitted in bursts. The arrays of tiny spot defects, observed in Sec. II, correspond to a series of burst emissions of heat and neutrons, which have been reported in experiments.[8]

ACKNOWLEDGMENT

The author thanks Y. Hayashi, Nuclear Fuel Development Company Ltd., for his useful discussions on the microscopic structure of palladium metals.

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Ref. (18) ANS Reprint

OBSERVATION OF QUAD-NEUTRONS AND GRAVITY DECAY DURING COLD FUSION

COLD FUSION
TECHNICAL NOTE
KEYWORDS: *nuclear emulsion, quad-neutron, gravity decay*

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The Nattoh model predicts that neutron nuclei such as quad-neutrons are produced during cold fusion as a result of the emission of a new particle, the iton. Several quad-neutron decays have been successfully recorded on nuclear emulsions. Especially important, micro-explosions caused by gravity decay have been clearly observed. This indicates that gravitational energy as well as fusion energy may be available in cold fusion.

INTRODUCTION

Many strange phenomena have been reported in connection with cold fusion experiments, such as a very wide range of neutron emission, extremely small ratios of neutrons compared to heat and tritium production, and very fast decay of activity. Therefore, it has been accepted that cold fusion cannot be explained by conventional theory.[1]

The Nattoh model[2] predicts a new fusion reaction in which hydrogen atoms assume the role of catalyst: intra- and interclusters of hydrogen atoms. The latter causes hydrogen chain reactions that are similar to the neutron chain reactions in a fission reactor.[3] On the other hand, in the intracluster hydrogen-catalyzed fusion reaction, the emission of a new particle, the iton,[4] is predicted. Reference 5 reported that itons were successfully observed on nuclear emulsions during cold fusion.

As a result, we have concluded that strange fusion products, such as quad-neutrons, should be produced after the emission of itons as follows:

$$2D + e + D \longrightarrow {}^4H + i_1 + d \qquad (1)$$

for the emission of a single iton i_1 and

$$2D + 2e + D \longrightarrow {}^4n + i_2 + d \qquad (2a)$$

$$\longrightarrow {}^4H + i_1 + {}^2n \qquad (2b)$$

for the emission of a double iton i_2.

Among the fusion products, ^4H cannot be released from the cell. However, neutron nuclei such as quad-neutrons could escape from the cell to decay in nuclear emulsions if they have sufficiently long half-lives.

In this technical note, the nuclear emulsions used in Ref. 5 are carefully re-examined to search for traces of fusion products. Several quad-neutron decays and micro-explosions were successfully observed.

SEARCHING FOR TRACES

We have carefully searched for nuclear traces produced by fusion products. The nuclear emulsions that were placed outside of the cell were recorded during the previous experiment.[5] That experiment was done by electrolyzing heavy water mixed with 3% sodium chloride. The traces on the films were examined by microscopy with a magnifying power of 500×.

QUAD-NEUTRON DECAYS

We have observed several kinds of traces that are different from those seen previously.[5] For example, Fig. 1 shows the decay mode of emitting two neutrons as follows:

$$^4n \longrightarrow 2n + {}^2He + 2e + 2\bar{\nu} \qquad (3a)$$

$$\longrightarrow 2p \,. \qquad (3b)$$

The assignment of the particles is shown in Fig. 2. In this mode, two protons are simultaneously produced by the decay of ^2He, while two neutrons can recoil two protons. However, these are probabilistic processes, and the two additional protons are not always produced. Fortunately, four protons are produced by chance in Fig. 1. The microscopy is well focused on point A, and thus the traces of the recoil protons at points E and G seem to be broader. We have also observed several traces caused only by the decay of ^2He.

Another trace is the beta decay of the quad-neutron, shown in Fig. 3. The assignment of the particles is shown in Fig. 4. These can be written as follows:

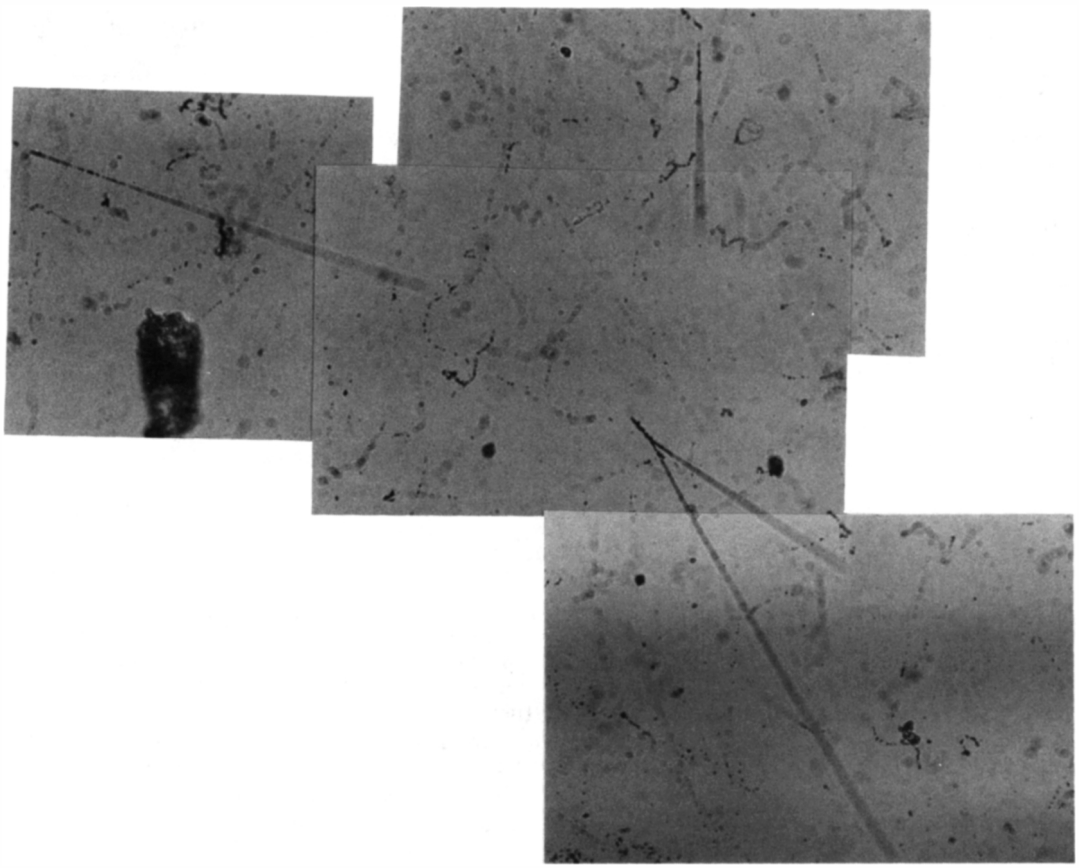

Fig. 1. Track for decays by Eqs. (3a) and (3b).

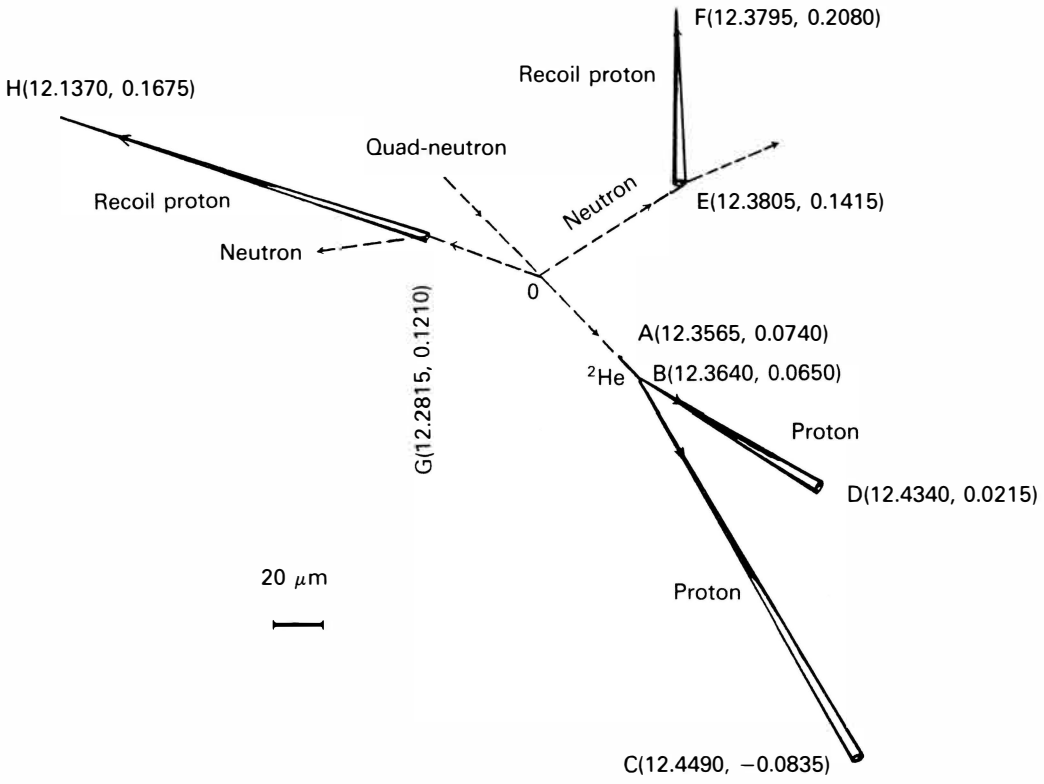

Fig. 2. Decay by Eqs. (3a) and (3b).

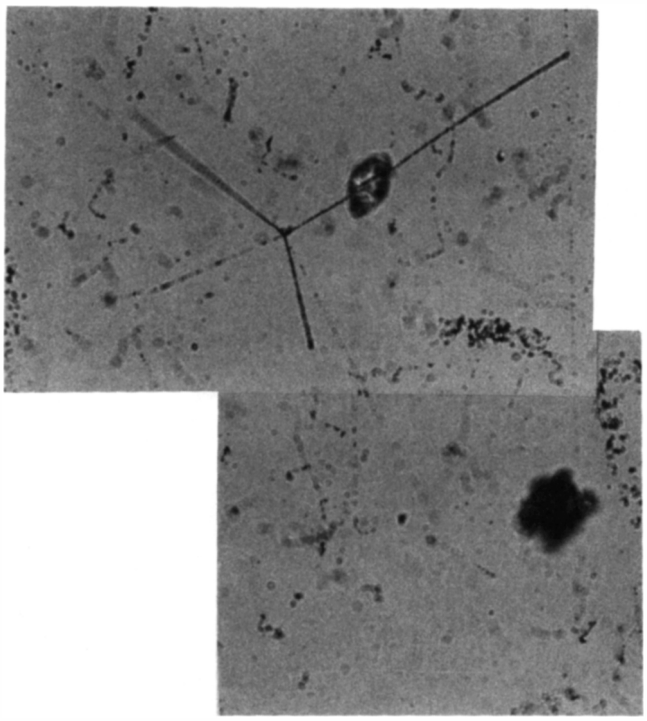

Fig. 3. Track for decays by Eqs. (4a) and (4b).

$$^4n \longrightarrow {}^4\mathrm{H} + e + \bar{\nu} \qquad (4a)$$

$$\longrightarrow {}^3\mathrm{He} + p + 2e + 2\bar{\nu} \; . \qquad (4b)$$

Hydrogen-4 is produced from the decay of quad-neutrons as given by Eq. (4a). Two electrons caused by the beta decay of ^{4}H can be observed in Fig. 3. No electrons from the beta decay of quad-neutrons appear in Fig. 3 because the quad-neutrons decayed outside of this film.

Traces suggesting other decay modes in which ^{4}H might decay to T + p + e + $\bar{\nu}$, T + n, and ^{4}He + e + $\bar{\nu}$ have also been observed. However, these modes are so simple that the assignments cannot be determined.

MICRO-EXPLOSIONS

Quad-neutrons may decay by the force of gravity like a neutron star. In gravity decay, the nucleus is compressed to a single point and it finally explodes.

Figure 5 shows a micro-explosion caused by the gravity decay of a quad-neutron. Two rings, an outer black one and an inner white one, are shown in Fig. 6. The black ring, which was recorded on the surface of the nuclear emulsion, has long flares outside the ring toward the opposite direction of the incident particle. The white ring, which is somewhat transparent, is recorded not only on the surface but totally through the nuclear emulsion. The white ring is separated into four parts, which suggests that the original neutron nucleus

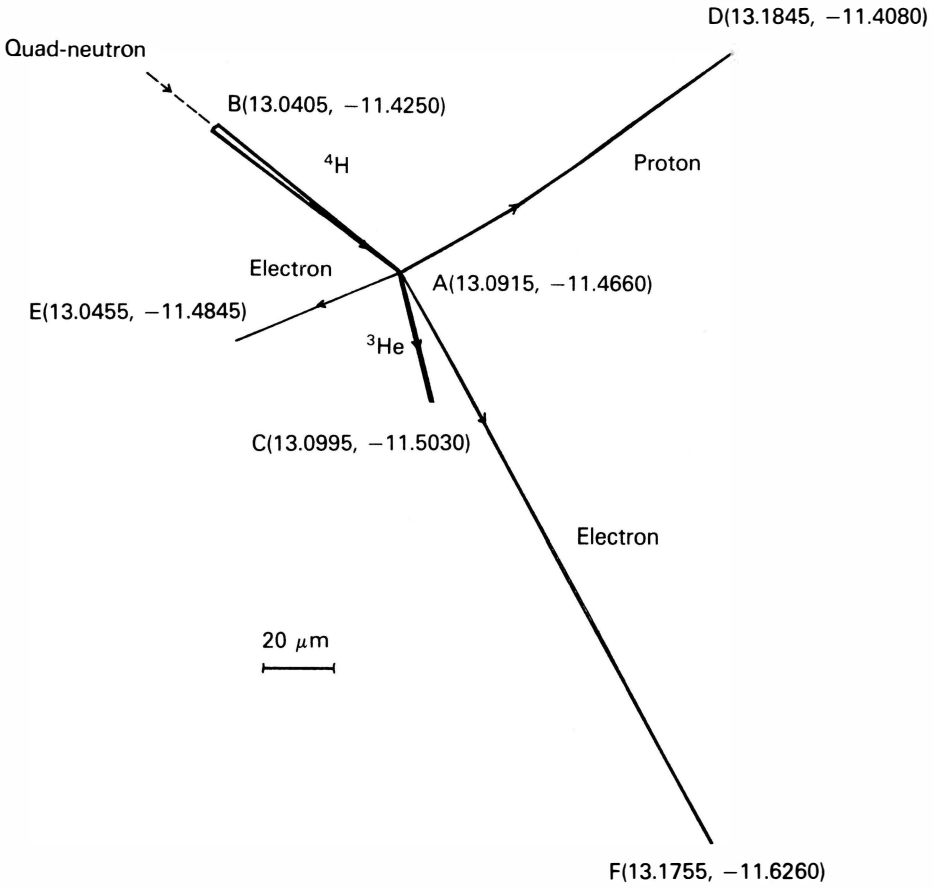

Fig. 4. Decay by Eqs. (4a) and (4b).

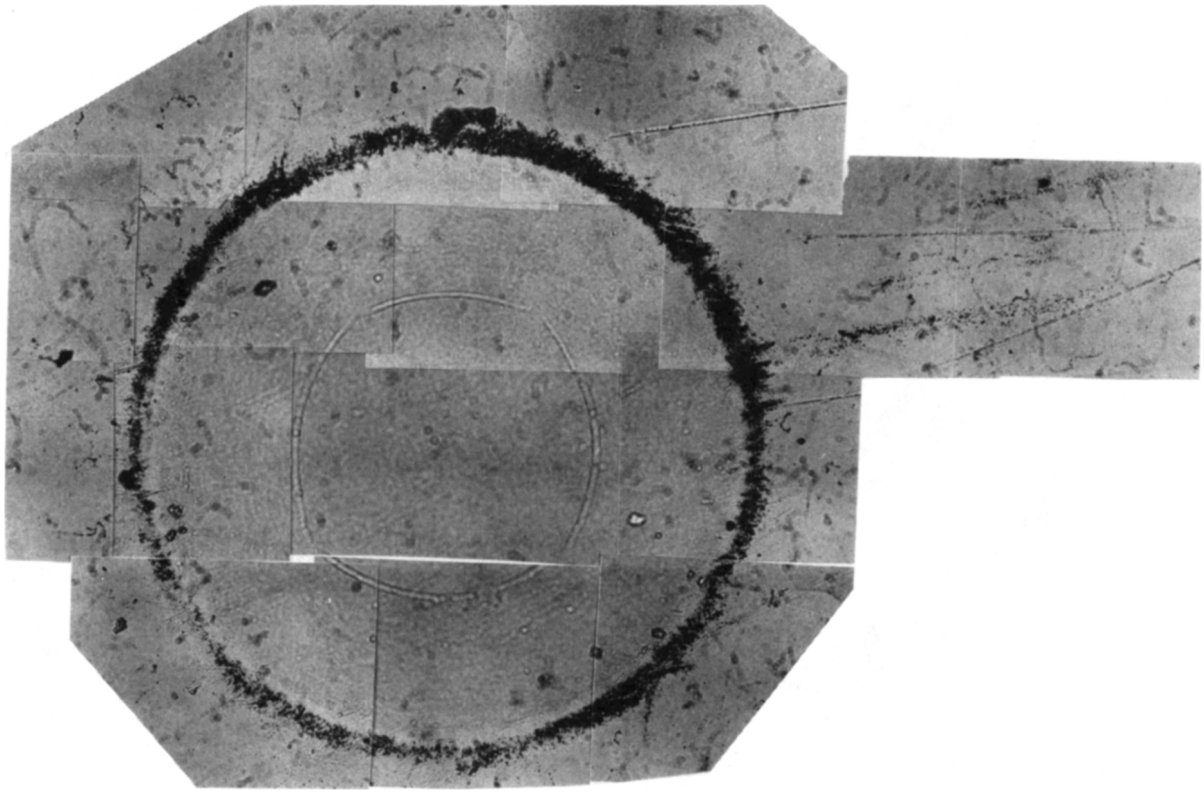

Fig. 5. Micro-explosion caused by quad-neutron decay.

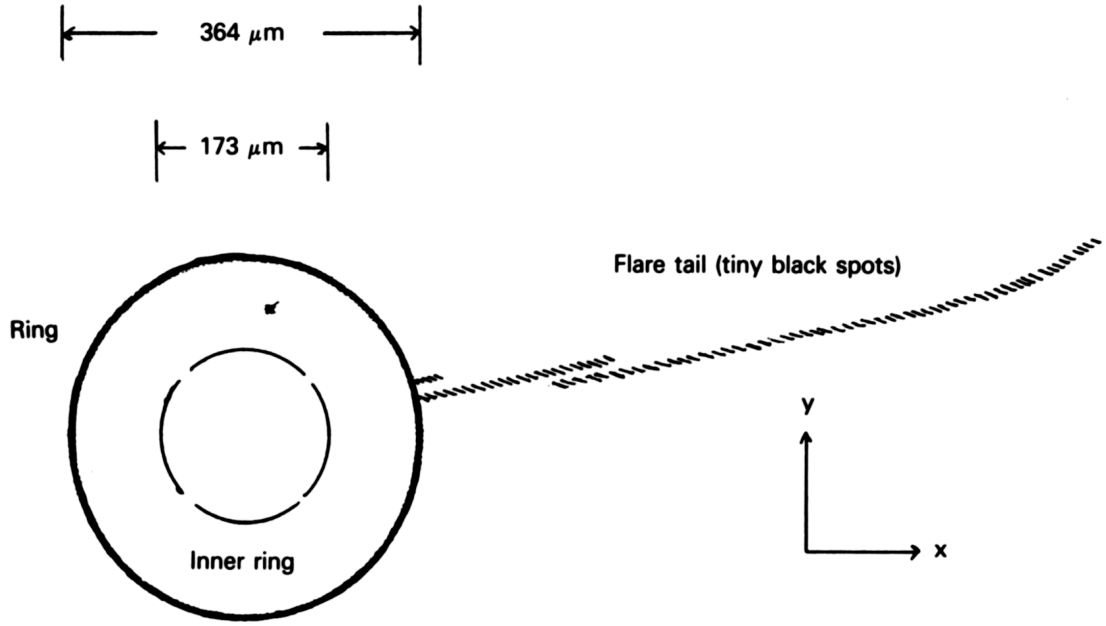

Fig. 6. Micro-explosion of quad-neutron.

was a quad-neutron. When a micro-explosion occurs nearer the surface, the diameters of the rings are smaller. A micro-explosion with an outer diameter of 26 μm is shown in Fig. 7.

We have observed many traces of micro-explosions; for example, see Fig. 8. We can see a swollen region like a tumor and many tiny black spots. Neither are symmetrically distributed. Although we have similar swollen regions in the background measurements, they are generally smaller and have no tiny black spots. Therefore, they are easily identified. However, it has not been determined whether these micro-explosions are produced by the gravity decay of quad-neutrons or by other processes.

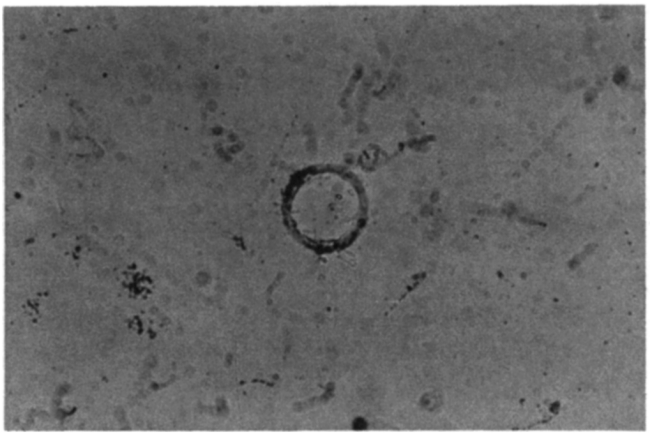

Fig. 7. Micro-explosion at shallow depth.

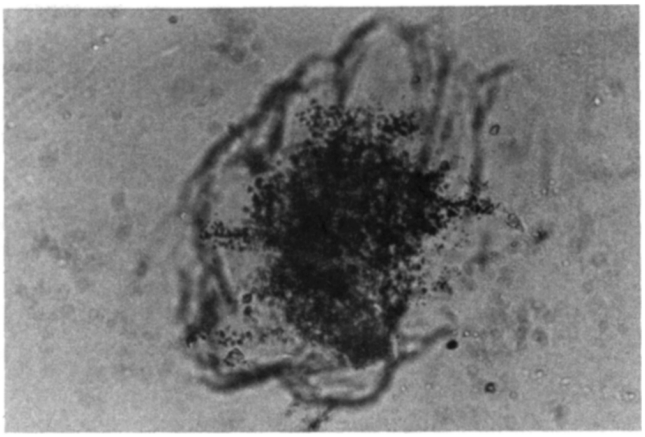

Fig. 8. Other types of micro-explosions.

DISCUSSION

We have seen that quad-neutrons and micro-explosions can result from the gravity decay of quad-neutrons. These phenomena pose questions that cannot be explained by conventional physics.

The first question is the lifetime of the quad-neutron. Conventional theory predicts that the quad-neutron should decay in an extremely short period, $<10^{-23}$ s, and thus cannot reach the nuclear emulsion. The experimental observations are not consistent with the theory and thus require modification of the theory.

The second question is what kinds of particles are emitted after the micro-explosion. It is very difficult to predict the conditions after gravity decay under which the relativity and quantum theories might be broken. The black ring of the micro-explosion cannot be explained by the emission of X or gamma rays. However, there are some hints concerning the emitted particles. For example, the black ring is recorded only on the surface of the nuclear emulsion, and the inner part of the black ring suggests the existence of some critical phenomena.

We introduce a hypothetical model for the mechanism of formation of the traces of the micro-explosion shown in Fig. 9. We assume that the emitted particles can produce the tiny black spots on the surface of the nuclear emulsion only when the particles reflect at a critical angle. The flare tails observed outside the ring in Fig. 5 can be explained by higher velocity particles. All the particles that form the ring have no momentum as a whole. The momentum of the incident quad-neutron should be conserved before and after the explosion. Only the particles with the same direction as the incident particle can take the momentum. Those particles make tails at the far edge of the ring, shown in Fig. 9.

The process of Eq. (2), which produces the quad-neutrons, is predominant in cold fusion, so the particles might be measured on the macroscopic scale. We have successfully observed interference phenomena of the energetic waves.[6]

The third question is what materials are produced after the gravity decay. The inner white ring of the micro-explosion, shown in Fig. 7, may be caused by products of gravity decay, which could be a soup of materials much smaller than quarks, for example, the superstrings proposed by the superstring theory. We have also succeeded in observing stringlike traces that suggest the emission of superstrings.[7]

The fourth question concerns the conservation of matter during cold fusion. The emission of itons causes strange

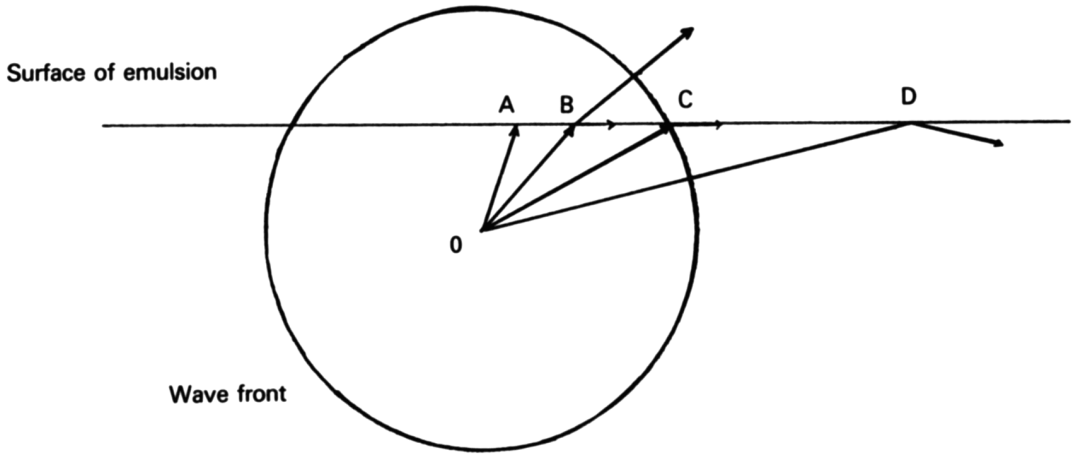

Fig. 9. Reflection of particles.

fusion products such as the quad-neutrons, and the conservation of the fusion products is unclear during cold fusion. The reactions of Eqs. (1) and (2) cause most of the heat production,[2] and the conventional fusion reaction emitting 2.5-MeV neutrons is the secondary process. Among the fusion products of Eqs. (1) and (2), almost all the ^4H can be deposited in the cell and decays to tritium, p, ^4He, and so on. On the other hand, many of the neutron nuclei, such as quad-neutrons, are released from the palladium metal to decay outside. Therefore, we cannot satisfy the conservation law of fusion products only in the palladium metal or cell. It is suggested that the concentration of the fusion products could depend on the measuring positions.

From the observations in this technical note, it can be concluded that cold fusion, because of the extremely high pressure of the hydrogen atoms, is a small-scale simulation of the events that might take place in the death of stars, while high-temperature fusion takes place on the surface of living stars like the sun. It is remarkable that gravitational energy, as well as fusion energy, may now be available. The efficiency of the former is expected to be higher than that of the latter.

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Ref. (19)

ANS Reprint

OBSERVATION OF HEAVY ELEMENTS PRODUCED DURING EXPLOSIVE COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *explosive cold fusion, many-body fusion reaction, element production*

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Many-body fusion reactions may take place during cold fusion. Heavy elements are observed that might have been produced by such reactions during electrolysis of heavy water. Elements such as sodium, magnesium, aluminum, and zinc are observed inside grain-shaped defects in a palladium rod used in a cold fusion experiment.

INTRODUCTION

This technical note describes two subjects: (a) an attempt to cause explosive cold fusion by moving hydrogen through metal and (b) the observation of heavy elements produced by many-body fusion reactions.

Reference 1 indicates that cold fusion takes place in the grain boundaries of a host metal by hydrogen chain reactions. If the concentration of hydrogen exceeds a critical value, direct cold fusion chain reactions can be ignited locally in bursts. When hydrogen atoms are forced to move in metal, they might be stored in layers between media with different structures or properties, and the concentration of hydrogen atoms in those places could be increased far beyond the critical value. Thus, the hydrogen might be burned in bursts or very rapidly, i.e., explosively.

On the other hand, the Nattoh model[2] has indicated that three- and four-body fusion reactions that produce lithium and beryllium, respectively, can take place during cold fusion. Furthermore, many-body fusion reactions that produce much heavier elements could occur under suitable conditions. Microscopic observations of palladium metal used for a cold fusion experiment[3] have shown that as cold fusion proceeds, tiny spot defects grow into grain-shaped defects in which materials disappear by extraordinary burning. The formation processes of the grain-shaped defects seem complicated, but it is highly probable that many-body fusion reactions take place to produce heavy elements.

In the grain-shaped defects, two processes may occur by which heavier elements, rather than direct fusion products such as helium, might be produced during cold fusion: (a) a many-body fusion reaction of hydrogen atoms or (b) transmutation of the host element. The first process produces heavy elements from light hydrogen atoms instantaneously by many-body fusion reactions or sequentially by absorbing hydrogen atoms or electrons. This is similar to processes that take place to form cold stars such as the Earth. The second process produces elements with masses similar to that of the host metal by absorbing hydrogen atoms or electrons.

EXPLOSIVE COLD FUSION EXPERIMENT

An effort to produce explosive cold fusion has been attempted by moving hydrogen atoms inside palladium metal, and the production of heavy elements has been examined.

Hydrogen atoms were charged into palladium metal by electrolyzing heavy water (mixed with 3% NaCl). A palladium rod (5-mm diam × 46.4 mm long) was used as the cathode with a helical wire for the anode. The current was 0.8 to 1.0 A with a 5-V bias. Figure 1 shows the arrangement of the palladium in the cell. After hydrogen was heavily accumulated in the metal, the level of water was decreased to uncover the top of the palladium metal so that hydrogen could easily escape from the top of the palladium metal and an upward flow of hydrogen could be induced. This procedure was performed after a 19-day hydrogen charging period. A small-scale explosion occurred several hours later. (The same procedure had been tried twice earlier but with no explosion because insufficient hydrogen had been accumulated.) As a result of the explosion, an upper plug and a cell cap flew out. This explosion was caused by a hydrogen chemical reaction; it is shown later that cold fusion contributed to heat generation.

The palladium metal used for this experiment was examined by an optical microscope, a scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDX), and radioactive analysis. Gas in the metal also was analyzed by mass spectroscopy.

RESULTS

Figure 2 shows a flowchart of the experiment. The palladium metal also underwent radioactive analysis; the results are reported in Ref. 4.

Figure 3 shows an optical microscopy picture of a longitudinal cross section of the palladium metal. It clearly shows that cold fusion has taken place violently near the surface of

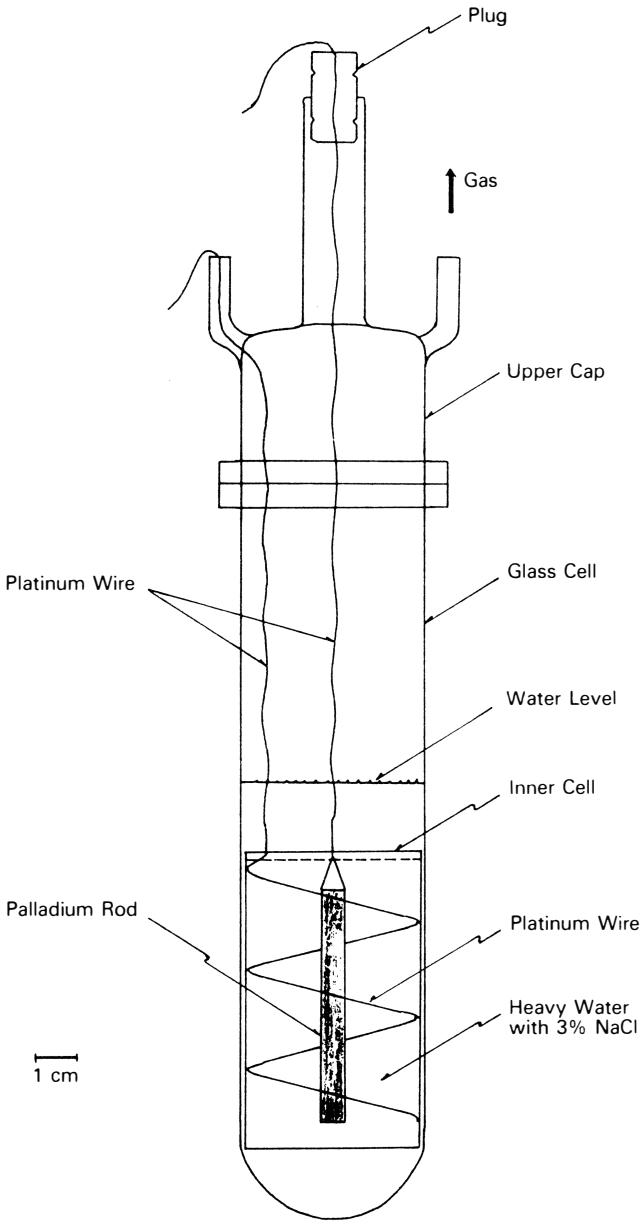


Fig. 1. Arrangement of cell.

the palladium. The surface layers seem to have acted as barriers against hydrogen escape so that hydrogen is heavily concentrated under the surface. Figure 4 shows an interesting burn pattern: A series of grain-shaped defects are arranged along an inclined layer that might have prevented the upward flow of hydrogen.

The gas contained in the metal was analyzed by mass spectroscopy before and after the electrolysis experiment. Before the experiment, gas was discharged by keeping the palladium metal at 800°C in vacuum for >10 h. It has been confirmed that the mass spectrum gives no signal except flat background. Figure 5 shows the mass spectra after the experiment, measured while increasing the temperature from room temperature to 775°C and keeping it at 775°C. Figure 5a shows the spectrum measured at 175°C while increasing the temperature; several remarkable peaks can be seen at masses 2, 3, 4, and 6 in the light region and masses 17, 18, 19, and 20 in the heavy region. Figure 5b shows the spectrum at 775°C measured ~1 h later; the peak for mass 6 disappears. Figure 5c shows the spectrum at 775°C ~2 h later still; only the peaks of masses 2, 3, and 4 remain.

Figure 6 is a SEM picture of a longitudinal cross section showing grain-shaped defects produced near the surface of the metal. The right side is a palladium region, and the left side is a copper region plated on to clarify the boundary of the surface. Pointlike analyses were made by EDX with SEM. Figure 7 shows an EDX spectrum at point A in Fig. 6. The two main peaks at 2.84 and 3.00 keV correspond to characteristic X rays emitted from palladium. In addition to the host element, the very heavy elements of ruthenium and indium can be clearly seen at the energies of 2.56, 3.30, and 3.50 keV, respectively. Reference 4 shows that the ruthenium and indium are produced by transmutation of palladium. This energy spectrum is standard here; similar patterns have been observed elsewhere over palladium metal. For example, the energy spectra at points of B, C, and D in Fig. 6 are almost the same.

Figure 8 is an SEM picture of a grain-shaped defect in which the materials are left somewhat unburned. Figure 9 shows an EDX spectrum at point E in Fig. 8. The energy spectrum is different from the standard one. It is remarkable that elements such as silicon, sulfur, and calcium exist among the materials remaining inside the grain-shaped defects.

Figure 10 shows a SEM picture of another grain-shaped defect. Figure 11 shows an EDX spectrum at point F. The elements sodium, magnesium, aluminum, silicon, calcium, and copper can be recognized.

Figures 12 and 13 show SEM pictures of a radial cross section. Figure 14 shows an EDX spectrum of point G in Fig. 12. Figures 15, 16, and 17 show EDX spectra at points H, I, and J, respectively. The EDX spectrum depends not only on the grain-shaped defects but also on their position.

Finally, the weight of the palladium metal was measured by an electric balance before and after the experiment; the values were 11.3497 and 11.3506 g, respectively, which are very similar. The latter value was obtained after gas discharging; before gas discharging, the value was 11.53 g.

DISCUSSIONS

Explosive cold fusion was easily performed by moving hydrogen in palladium metal, and experimental evidence suggesting the occurrence of explosive cold fusion was observed. Although the explosion was caused mainly by a chemical reaction of the mixed hydrogen and oxygen gas, it is reasonable to consider that fusion energy has also contributed to the explosion by decomposing water. It is not clear how much fusion energy has been consumed to decompose water to hydrogen and oxygen. Not only grain boundaries but also layers between media with different structures or properties could store hydrogen to induce explosive cold fusion. Multilayer materials might be more effective in increasing the power density. Explosive cold fusion might be available as an effective engine for vehicles such as automobiles.

Cold fusion products have been sought using mass spectroscopy, SEM, and EDX. It is remarkable that heavy elements have been observed by EDX inside grain-shaped defects. The elements that have been recognized are neon, sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chlorine, argon, potassium, calcium, titanium, chromium, iron, nickel, copper, and zinc. It is difficult to consider these

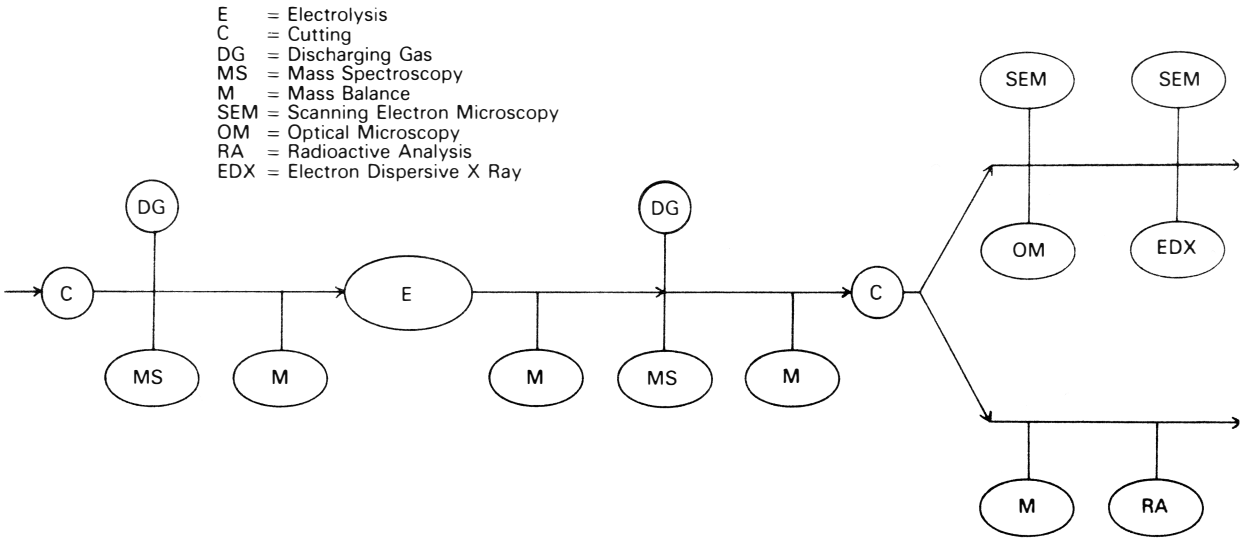
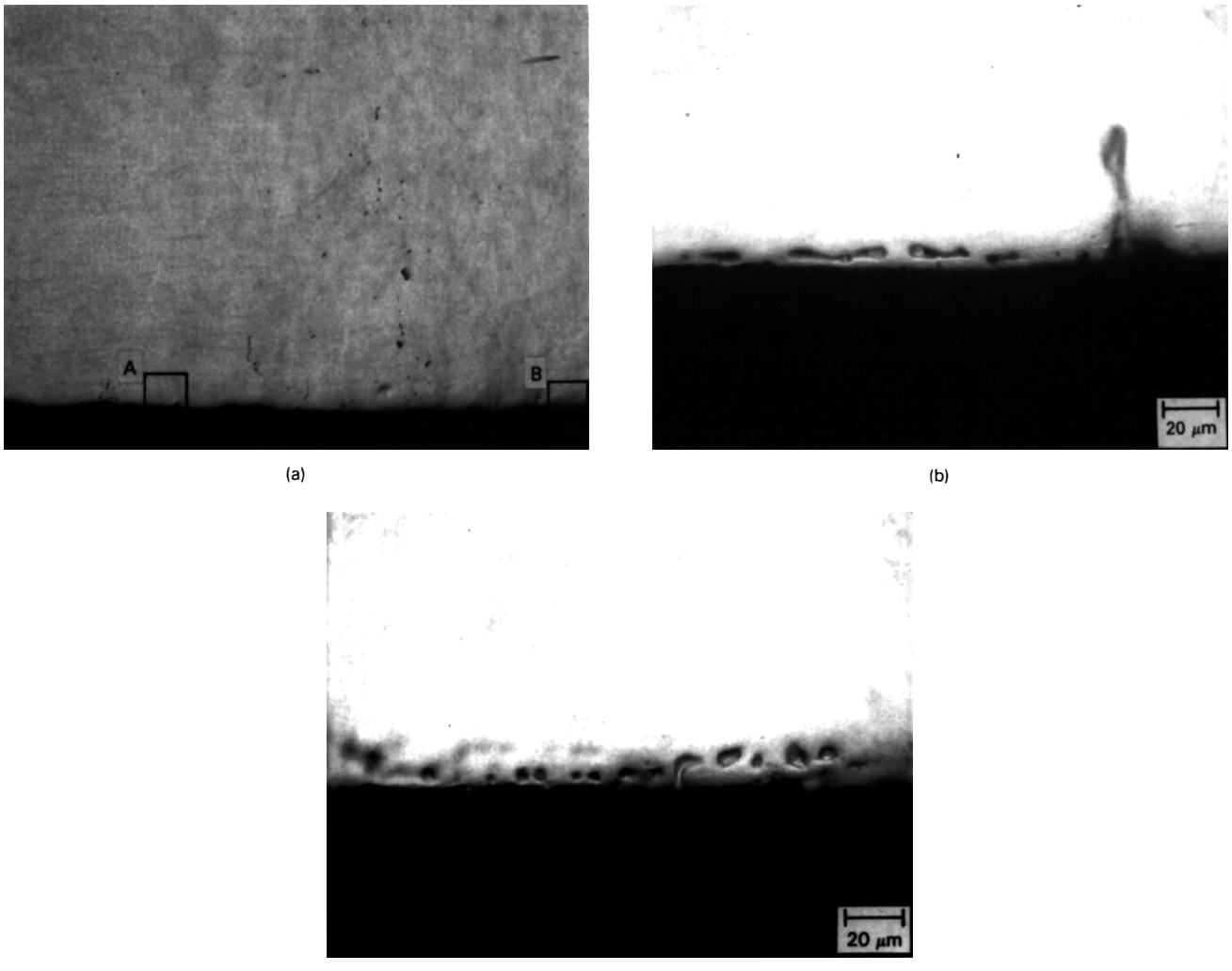


Fig. 2. Flowchart of experiment.



(a) (b)

(c)

Fig. 3. Optical microscopy picture of the top region of the palladium rod: (a) magnified 38.5 times, (b) expanded at point A, and (c) expanded at point B.

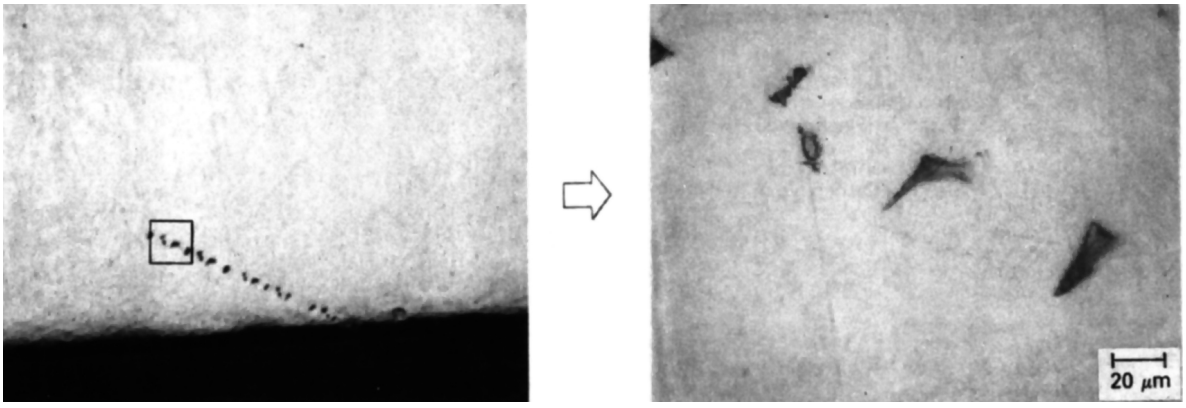


Fig. 4. Optical microscopy picture of grain-shaped defects: (a) magnified 28.5 times and (b) expansion of area indicated in the square.

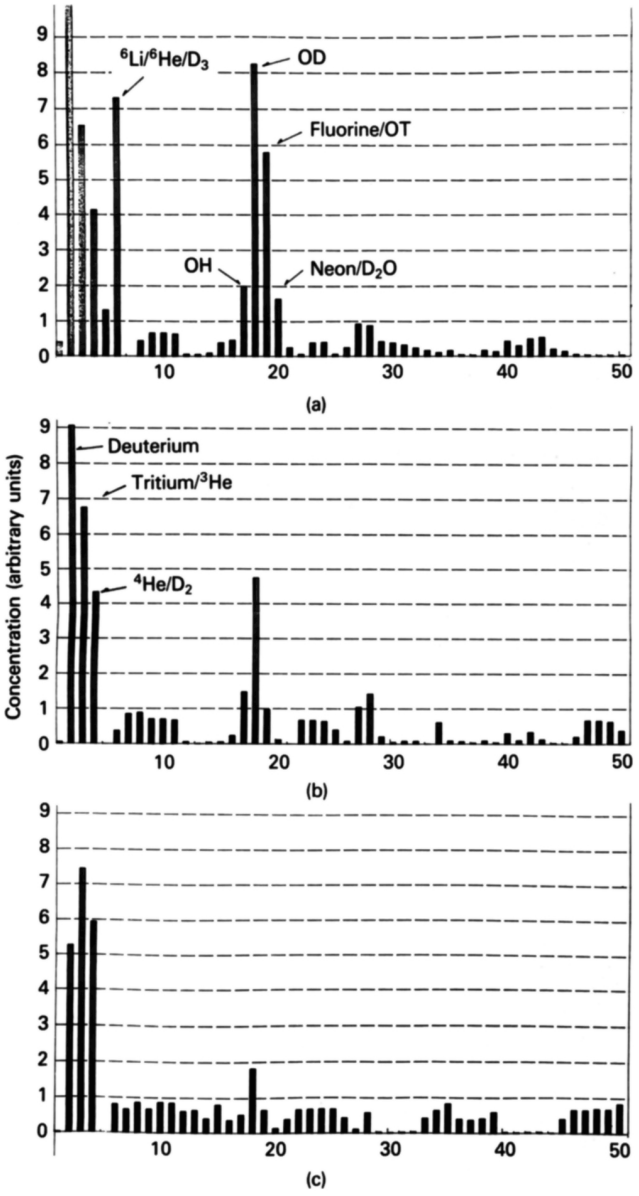


Fig. 5. Mass spectrum of discharged gas: (a) at 175°C, (b) at 775°C ~1 h later, and (c) at 775°C ~2 h later still.

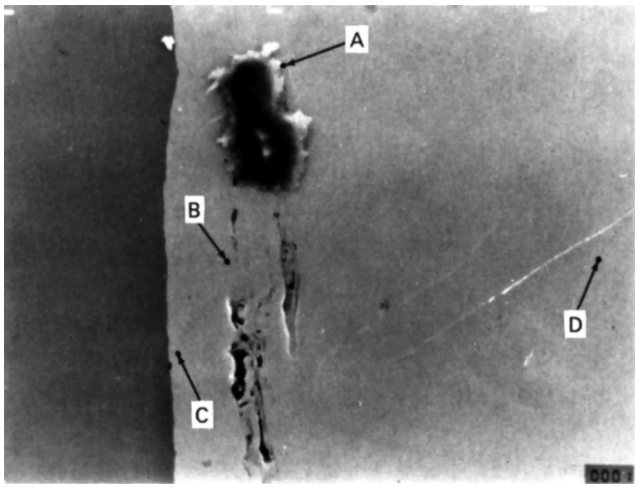


Fig. 6. SEM picture of a longitudinal cross section (297.5×).

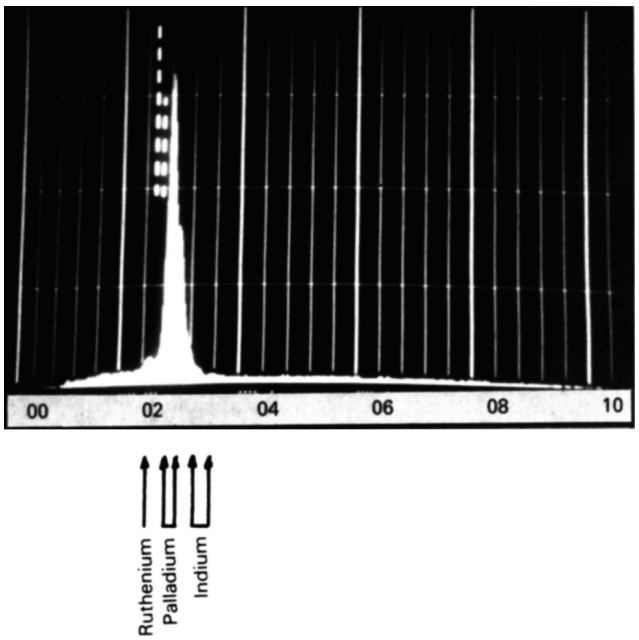


Fig. 7. EDX spectrum for point A in Fig. 6.

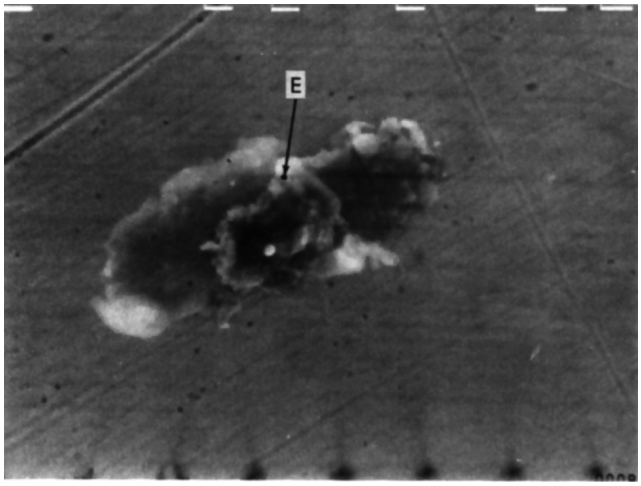


Fig. 8. SEM picture of a grain-shaped defect (935×).

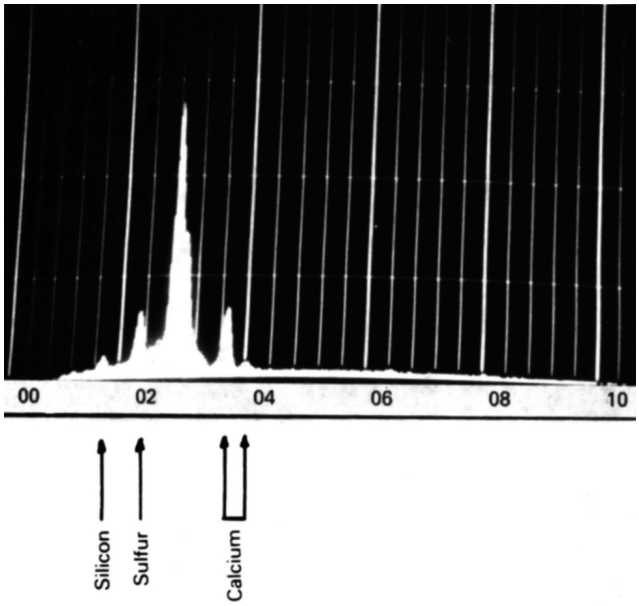


Fig. 9. EDX spectrum for point E of Fig. 8.

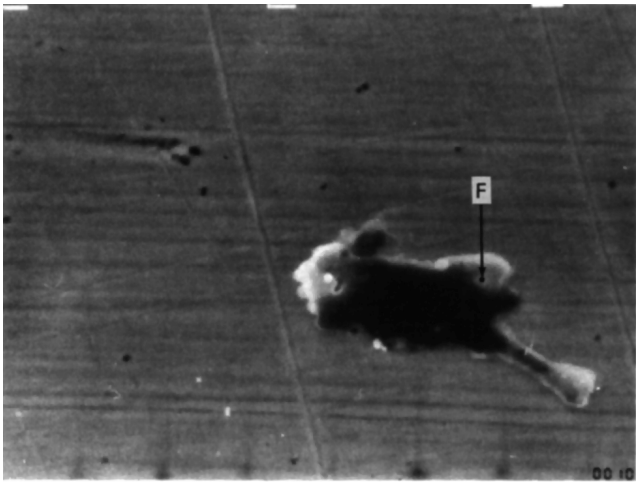


Fig. 10. SEM picture of another grain-shaped defect (595×).

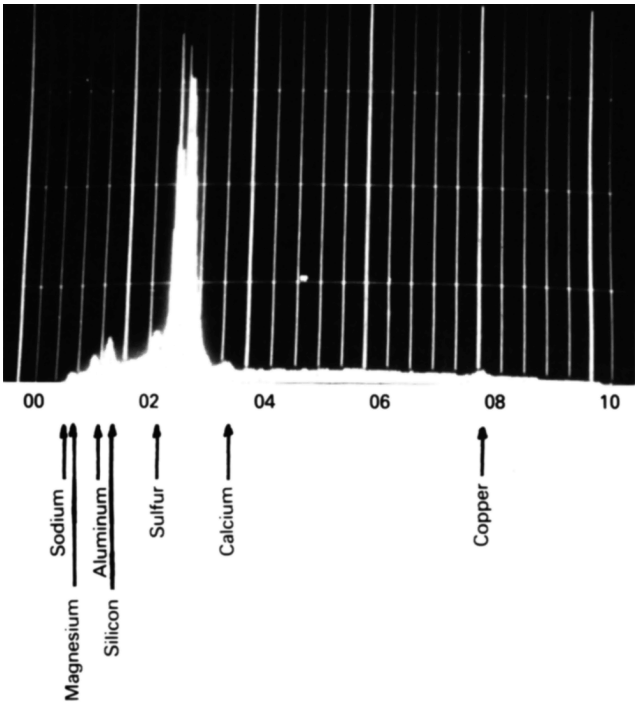


Fig. 11. EDX spectrum for point F.

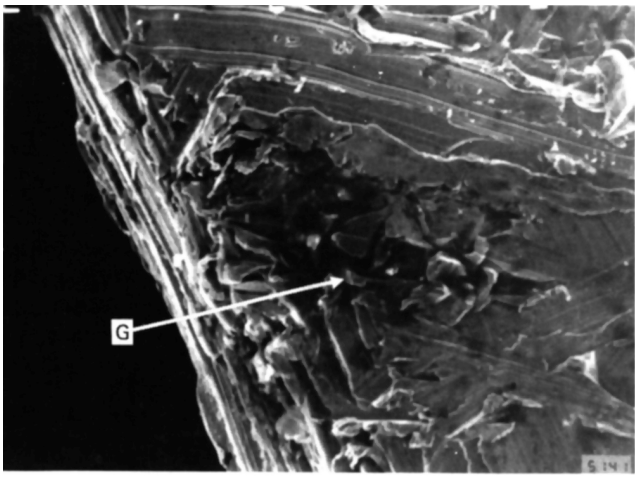


Fig. 12. SEM picture of a radial cross section (1800×, unpolished).

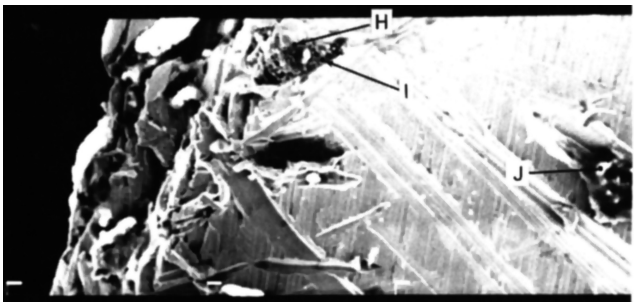


Fig. 13. Another SEM picture of a radial cross section (1800×, unpolished).

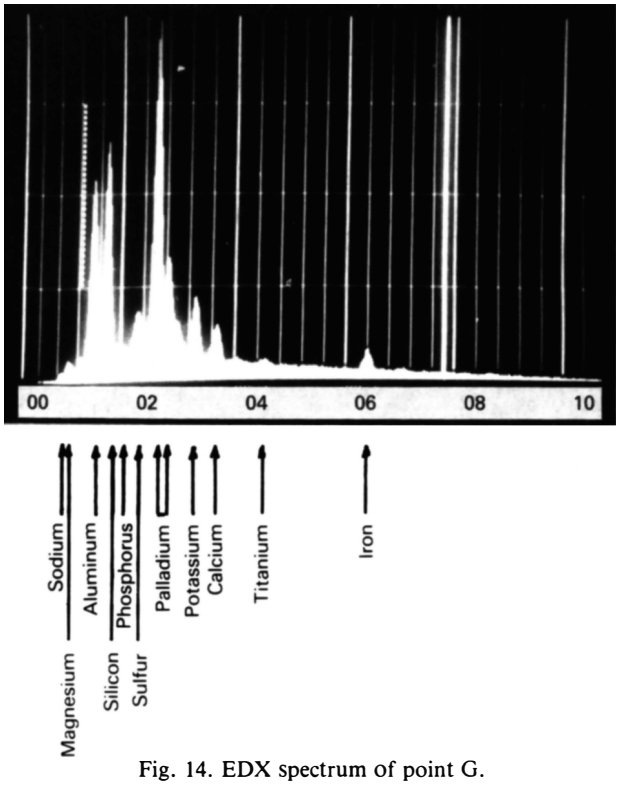


Fig. 14. EDX spectrum of point G.

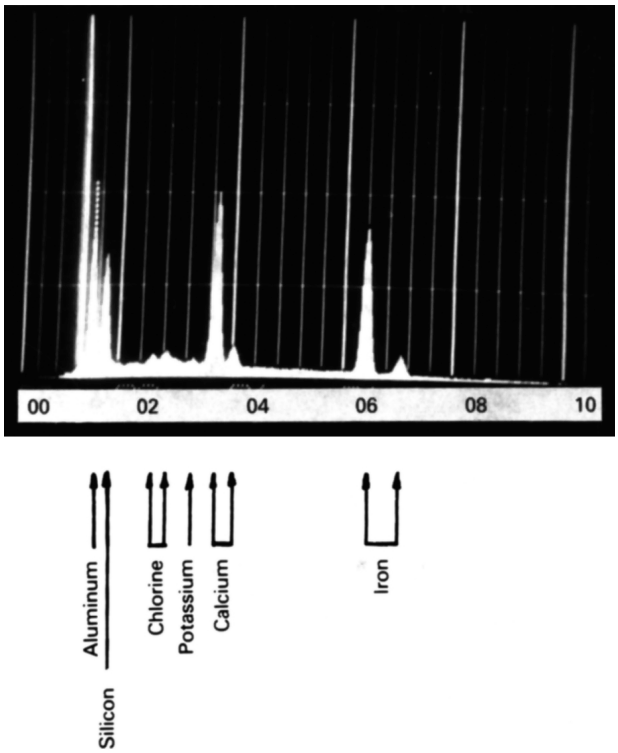


Fig. 15. EDX spectrum of point H.

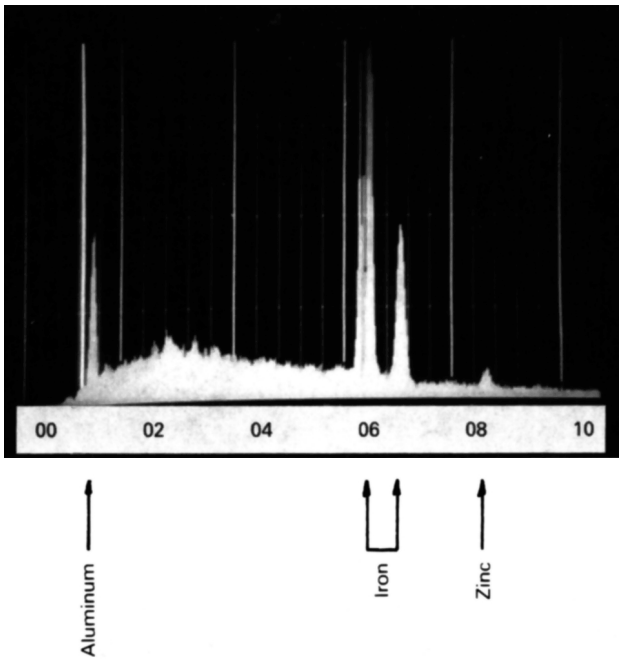


Fig. 16. EDX spectrum of point I.

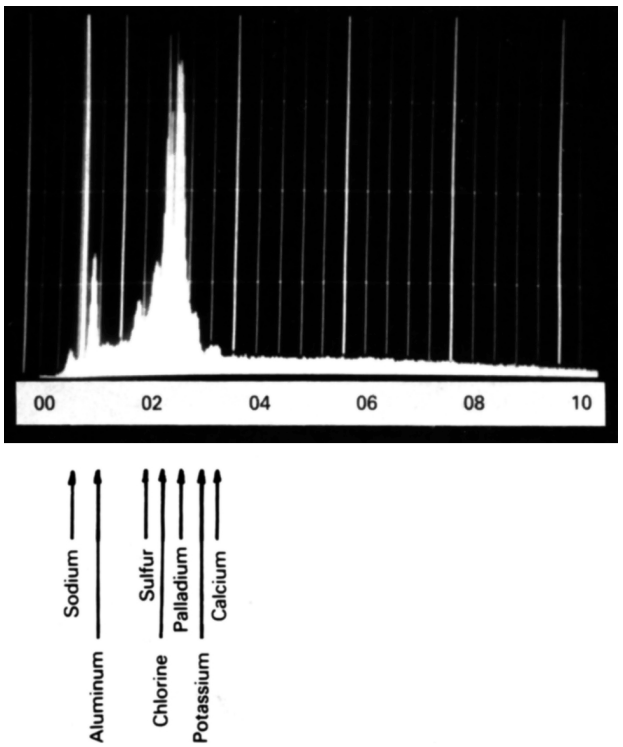


Fig. 17. EDX spectrum of point J.

elements to be impurities. It can be concluded that these elements have been produced by many-body fusion reactions instantaneously or sequentially, as predicted by the Nattoh model.[2] The materials remaining inside grain-shaped defects have extremely different mass distributions, which suggests that the distribution might depend on how much many-body fusion reactions have occurred. No elements heavier than zinc have been observed up to the present. Since fusion reactions that produce heavier elements have negative reaction energies, it is difficult to produce them at a high rate. It needs a higher burning rate.

Strange petals have been observed around the grain-shaped defects, as shown in Figs. 6, 8, and 10. These had not been seen in earlier observations[4]; the etching process applied might have washed them out. The petals might consist of elements lighter than sodium because the EDX system used here cannot be applied to elements lighter than sodium.

Mass spectroscopy of discharged gas shows that light elements or molecules of mass 2, 3, 4, 6, 17, 18, 19, and 20 have been produced. These can be classified into two groups: (a) those with masses of 2, 3, and 4 and (b) those with masses of 6, 17, 18, 19, and 20. The former have been produced inside the metal and the latter near the surface. The probable identifications are shown in Fig. 5. However, all these identifications are not definite as there are multiple candidates. An EDX analysis applicable to those light elements is now planned.

Although clarifications are still needed in the light element region, it has been verified that heavy elements such as titanium, iron, and copper can be produced directly by electrolyzing seawater. These materials are by-products of energy production; thus, industrial nuclear alchemy can be expected in the future.

ACKNOWLEDGMENT

The authors thank Y. Hayashi of the Nuclear Fuel Development Company, Ltd., for his useful discussions on the defects inside the metal.

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Ref. (23)

ANS Reprint

INTERFERENCE PHENOMENA OBSERVED DURING COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *interference phenomena, gravitational wave, antigravitational wave*

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The interference phenomena of waves observed during a cold fusion experiment are described. Nuclear emulsions have successfully recorded two different interference phenomena of waves from an electrolyzing cell. It is inferred that the waves might be gravitational and antigravitational waves, which can be expected to be radiated from gravity decays of quad-neutrons.

INTRODUCTION

Previous reports[1,2] showed that micro-explosions that are caused by the gravity decay of quad-neutrons have been successfully observed on nuclear emulsions outside an electrolysis cell. The traces of the micro-explosions consist of two rings: an outer black ring and an inner white ring. The former, recorded on the surface of the nuclear emulsion, shows a critical phenomenon suggesting that energetic waves might be emitted by the micro-explosion.

The quad-neutron that causes the micro-explosion is produced in a palladium metal rod by the following hydrogen-catalyzed fusion reaction[1]:

$$2\mathrm{D} + 2e + \mathrm{D} \rightarrow {}^{4}n + i_2 + d \ , \qquad (1)$$

where the double iton i_2 is a new particle.[3,4] Reaction (1) is predominant during cold fusion, and thus many quad-neutrons are produced. These decay inside the palladium rod and cell to emit energetic waves with sufficient intensity that we can expect to observe the waves on the macroscopic level.

This technical note describes a trial experiment to observe the interference phenomena of energetic waves on the macroscopic level. Two different waves have been successfully observed on nuclear emulsions located outside an electrolysis cell. It is inferred that they might be gravitational and antigravitational waves, respectively.

EXPERIMENT

The experiment was performed in the arrangement shown in Fig. 1. Three cases were investigated: nuclear emulsions (50-μm-thick Fuji Film emulsion coating a 1-mm-thick × 20- × 25-cm acrylic plate) located (A) directly and radially, (B) radially but behind a 5-cm-thick lead block, and (C) directly but tangentially around an electrolysis cell.

Heavy water mixed with 3% sodium chloride was used as the electrolyte solution. A palladium metal rod (5-mm diameter × 50-mm length) and a helical platinum wire were used for the cathode and anode, respectively. The inner diameter of the glass electrolysis cell was 46 mm, and the glass was 2 mm thick. The current (0.5-A current and 5-V bias) was charged for 21 days.

RESULTS AND DISCUSSIONS

Two different interference phenomena have been observed on the macroscopic level. The first is an interference with linear stripes that are regularly spaced and perpendicular to the propagating direction. Figure 2 shows linear stripes, recorded for case B. The intensity is not very high, but the linear stripes due to the interference effect can readily be recognized. Here the observed wave has penetrated through the 5-cm-thick lead block. For case A, similar stripes are also recognized to some extent, but their intensity is much weaker. In both cases, the linear stripes are recorded only on the surface of the nuclear emulsions.

The second phenomenon is an interference with peaked patterns. Figure 3 shows the peaked patterns observed for case C, which is located tangentially to the electrolysis cell. Here, we can observe two groups of peaked patterns, upper and lower, which are clearly separated from each other. This interference phenomenon is also recorded only on the surface of the emulsions. We observed no interference on the opposite side of the acrylic sheets for case C, whose emulsion-coated surfaces faced the incident side. Furthermore, we can obtain interference traces only at air-emulsion interfaces, and not at acrylic-emulsion interfaces. This is also true for the first interference phenomenon.

Two mechanisms can be proposed for these interference phenomena. One is the total reflection of waves propagating through the inside of the acrylic plate, which is shown in Fig. 4a. Waves with sufficiently long wavelengths can be totally reflected at the interface of two different materials and change the directions of their propagation. At the air-emulsion interface, the waves might be able to deposit some

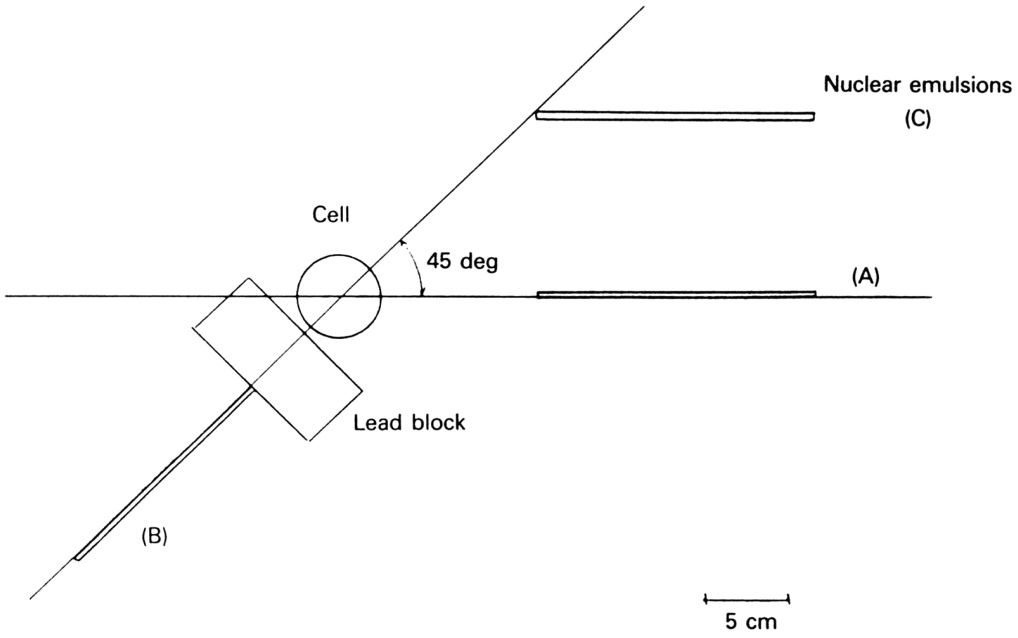

Fig. 1. Experimental arrangement.

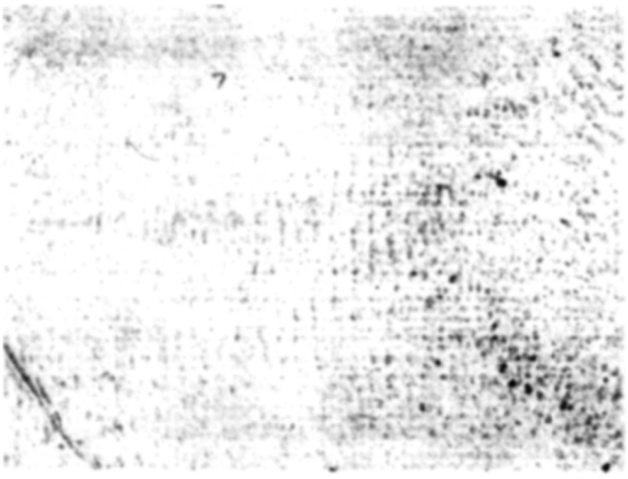

Fig. 2. Interference for case B.



Fig. 3. Interference for case C.

energy on the emulsion to make traces. Although the mechanism is not clear, some mechanism, such as the Cherenkov effect, that follows mass separation can be considered. This might correspond to the interference phenomenon with the linear stripes.

The other mechanism is an interference between two waves, shown in Fig. 4b. One energetic wave emitted from the cell is refracted at the surfaces of the material. This refracted wave can interfere with another wave, which directly penetrates through the material. The amplitude of the second wave is intensified when the traveling distances of the two waves differ by some integral times of the wavelength. This mechanism might explain the interference phenomenon with the peaked patterns.

Figure 5 shows how the peaked patterns may be formed. Assume that two waves radiate from the center point P of the metal. If there were no water and no cell, both waves would be totally reflected at point A on the surface of the emulsion, where the critical angle θ_A is determined by the refractive index of the emulsion. However, the waves undergo refractive effects while penetrating the water and the cell. These materials affect the two waves in opposite ways so that the two waves are totally reflected on points C and E, respectively.

If we assume that point A is the center point of the upper and lower groups of the peaked patterns shown in Fig. 3, we can estimate the critical angle θ_A to be ~155 deg. This value is consistent with the one derived from the micro-explosion, ~150 deg. Here it is assumed that the micro-explosion shown

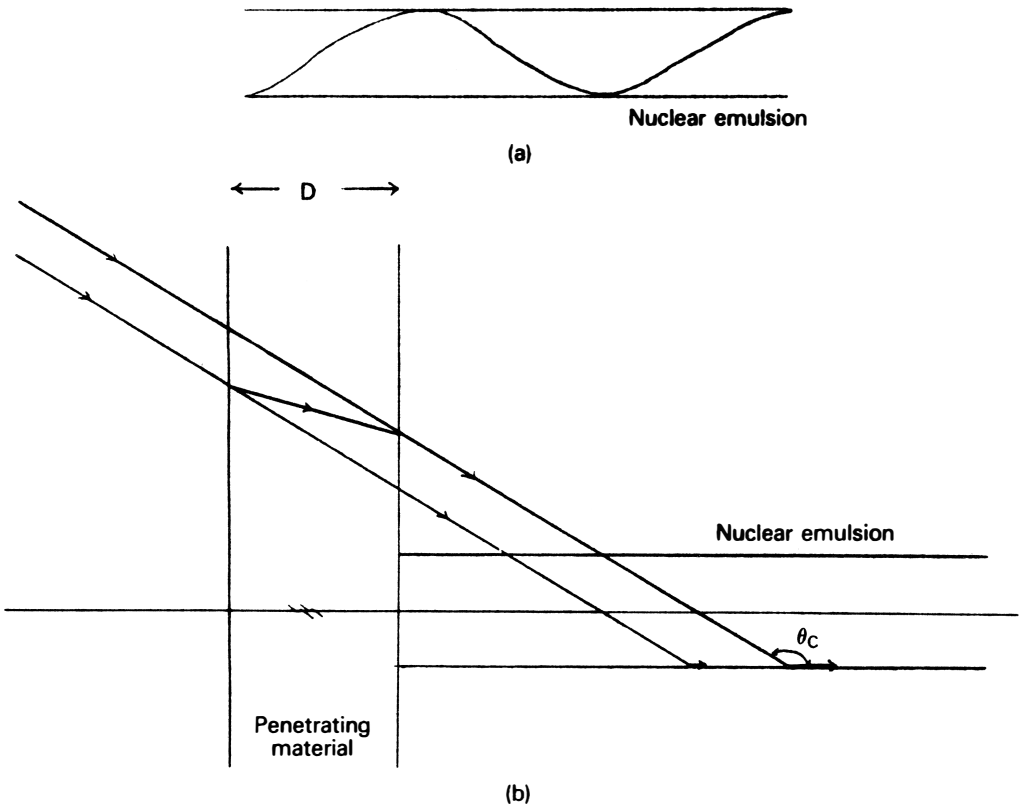

Fig. 4. Interference mechanisms.

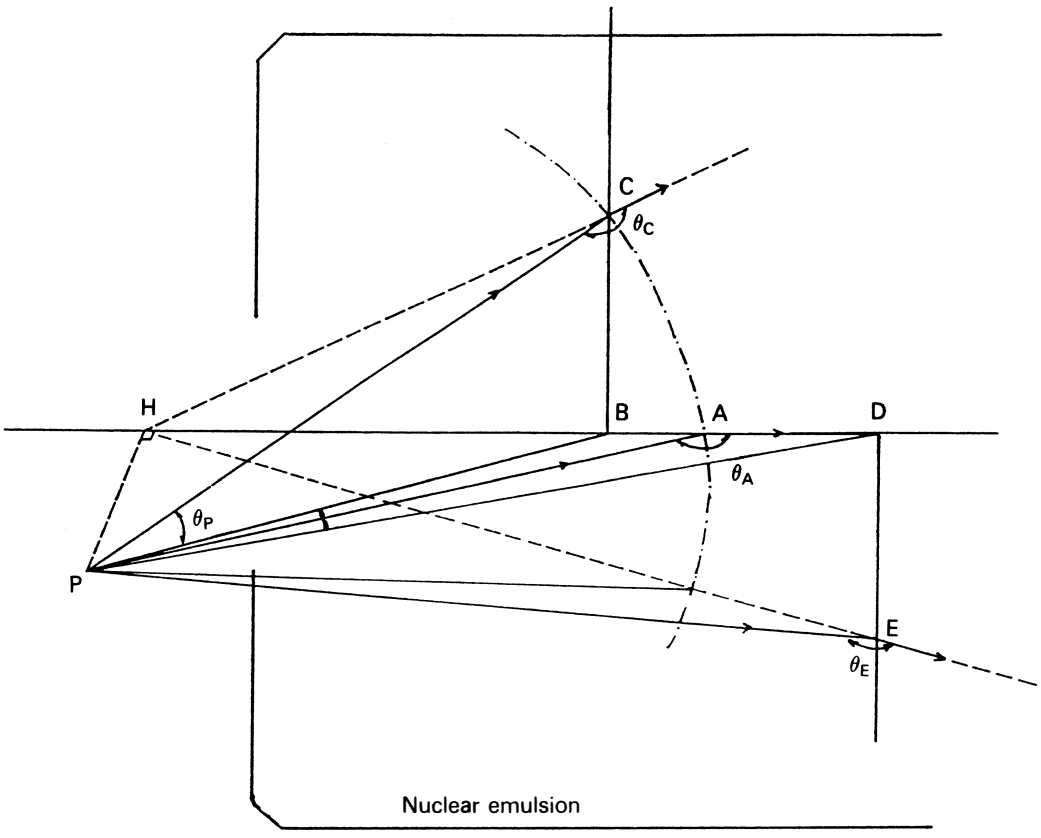

Fig. 5. Schematic explanation of peaked patterns.

in Refs. 1 and 2 is the largest one; i.e., it takes place at the deepest part of the emulsion. This good agreement suggests that one of the energetic waves observed here is probably the same wave recorded as the black ring in the micro-explosion produced by the gravity decay of quad-neutrons.[1,2]

Moreover, the total reflection at point E means more important physics. Point E is outside the circle indicated by the dotted line in Fig. 5, so that angle θ_E is always larger than the critical angle θ_A. This means that the wavelength of the wave arriving at point E is longer than that at point A; i.e., the particle is accelerated. We can infer that earth's gravity might interact with the particle. The wave that arrives at point E might be a gravitational wave, and the upward wave at point C, the antigravitational one.

In Fig. 3, the three neighboring peaked patterns might be caused by refractions at three boundaries: water, the glass of the cell, and the acrylic sheets. Three or four peaked pattern groups might be caused by the position of the palladium rod, which was slightly changed two or three times during the electrolyzing experiment in order to polish the surface of the palladium metal. To verify these situations, an additional experiment was done in which nuclear emulsions were located at the opposite side. Figure 6 shows similar peaked patterns for this experiment. We have only one group for the upper and lower patterns. Moreover, the upper and lower groups are oppositely located. This proves that two waves are reflected in the opposite way when penetrating the water and the cell.

The waves that cause such strange interferences cannot be found among the known waves, such as electromagnetic and sonic waves. The two waves might be propagating by particles that we have never observed. Moreover, the two particles seem to behave in the opposite way to earth's gravity. One is attractive and the other is repulsive. These properties can be seen somewhat in the photographs of the micro-explosion in Refs. 1 and 2. The outer black ring was traced by particles that are attractive to the gravity of the earth. On the other hand, the flare particles that come from the outer black ring are repulsive. Therefore, we can infer that the two waves might be gravitational and antigravitational waves, which are produced by the gravity decays of quad-neutrons during cold fusion.

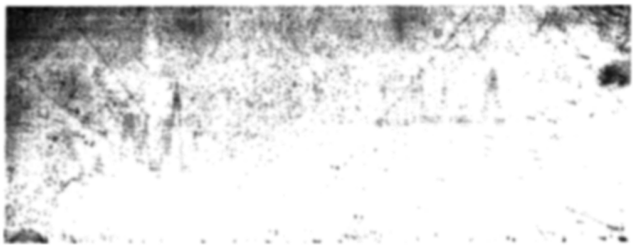

Fig. 6. Additional interference phenomena.

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Ref. (24)

ANS Reprint

OBSERVATION OF GRAVITY DECAYS OF MULTIPLE-NEUTRON NUCLEI DURING COLD FUSION

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *cold fusion, gravity decay, multiple-neutron nucleus*

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The Nattoh model predicted that multiple-neutron nuclei such as quad-neutrons can be produced during cold fusion, and the gravity decays of the quad-neutrons were recorded on nuclear emulsions. Several different traces that might be produced by the gravity decays of di-neutron and multiple-neutron nuclei have been successfully observed. The mechanisms of the production of multiple-neutron nuclei are also discussed.

INTRODUCTION

According to the Nattoh model for cold fusion,[1,2] a new light particle, the iton, is emitted during the hydrogen-catalyzed fusion reaction. As resulted, strange products of neutron nuclei such as di-neutrons and quad-neutrons should be left, as follows:

$$2\mathrm{D} + 2e + \mathrm{D} \longrightarrow {}^{4}n + i_2 + d \quad (1)$$

$$\searrow\ {}^{4}\mathrm{H} + i_2 + {}^{2}n \quad (2)$$

for double-iton emission. A previous technical note[3] reported that micro-explosions caused by the gravity decay of quad-neutrons were successfully observed on nuclear emulsions. Several different traces that might be produced by the gravity decays of di-neutron and multiple-neutron nuclei have been successfully observed. The mechanisms of the production of the multiple-neutron nuclei are discussed.

SEARCHING TRACES OF GRAVITY DECAY

Nuclear emulsions that were used for a previous cold fusion experiment[4] (electrolysis of heavy water mixed with 3% NaCl) were carefully observed using an optical microscope. The nuclear emulsions were located around a glass electrolysis cell in which a palladium rod (5-mm diam × 50 mm) and helical platinum wire were used as cathode and anode, respectively. The nuclear emulsions (MA-7B, made by Fuji Film Company) were provided for general measurement of radiation and coated 50 μm thick onto acrylite plates (20 cm × 25 cm × 1 mm thick). The background was measured by placing nuclear emulsions in a similar building ~2 km from the experimental room.

GRAVITY DECAYS AND ASSIGNMENTS

By carefully examining the nuclear emulsions (over a total area of ~200 cm^2), many traces that could be ascribed to micro-explosions by gravity decay have been successfully observed. In general, they are explosive traces so that they can be easily distinguished from other traces. None has been observed on the background measurements. The explosive traces can be classified into six groups depending on their magnitude and structure.

The first group, already reported,[3] is traces that consist of two rings: an outer black ring and an inner white ring. The first group was attributed to the gravity decay of quad-neutrons by evaluating other traces of different decays. Figure 1 shows a variational trace of the first group. Six traces

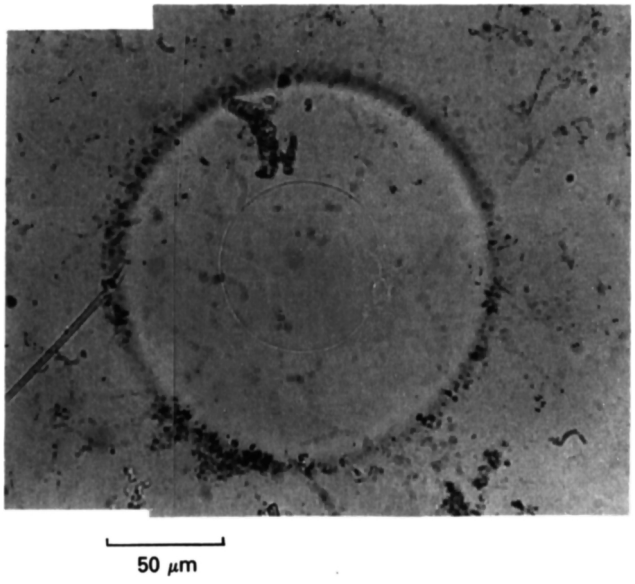

Fig. 1. Traces of the first group.

of the first group have been observed up to now. The largest was shown in Fig. 5 in Ref. 3, and its outer diameter was 364 μm. There are some variations. For example, one has a flare tail contacting the black ring, but the other has no tail; one has a completely spherical white ring, but the other white ring has debris. The outer black ring is well separated from the inner white ring. No other group has such black rings because the black rings are caused by the gravitational wave.[5]

The second group consists of smaller circular traces, as shown in Fig. 2. Eight traces have been observed. They are always smaller than those of the first group. Characteristically, the second group has regular structures inside the circle. Tiny circles are regularly arranged and usually number 42. The maximum diameter is ~22 μm.

The third group includes circular traces with diameters between those of the first and the second groups. They are

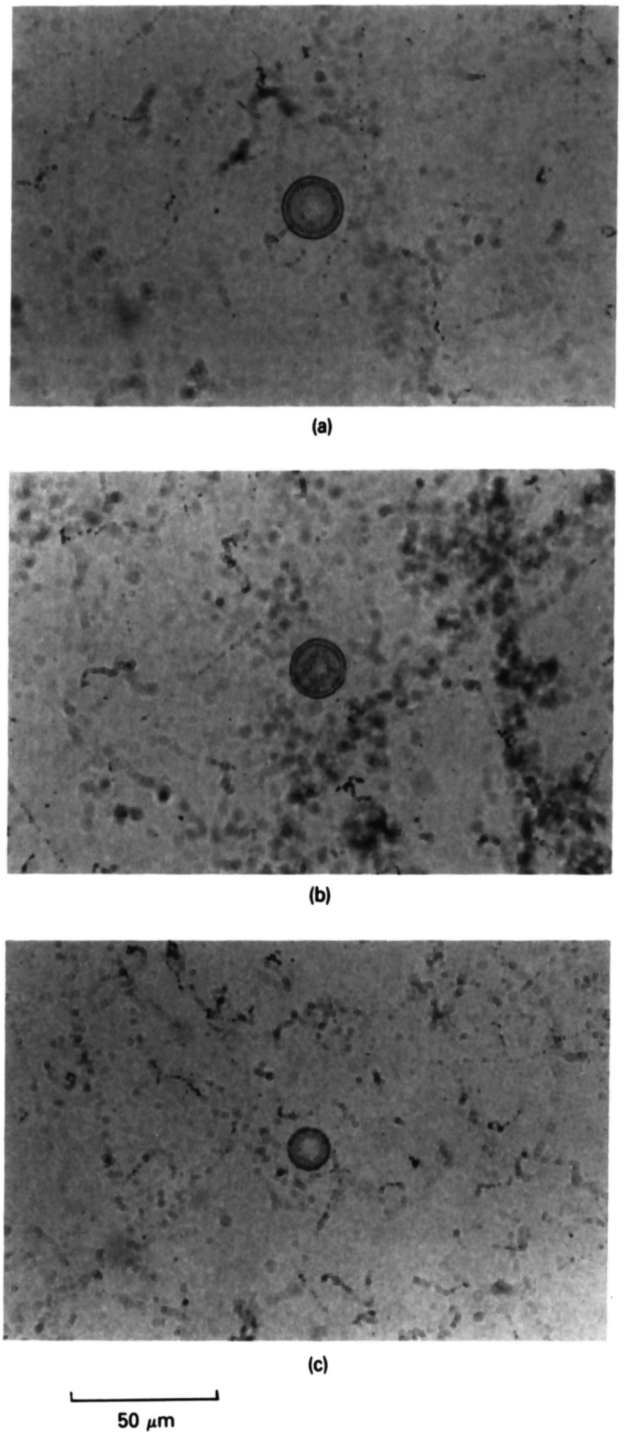

Fig. 2. Traces of the second group.

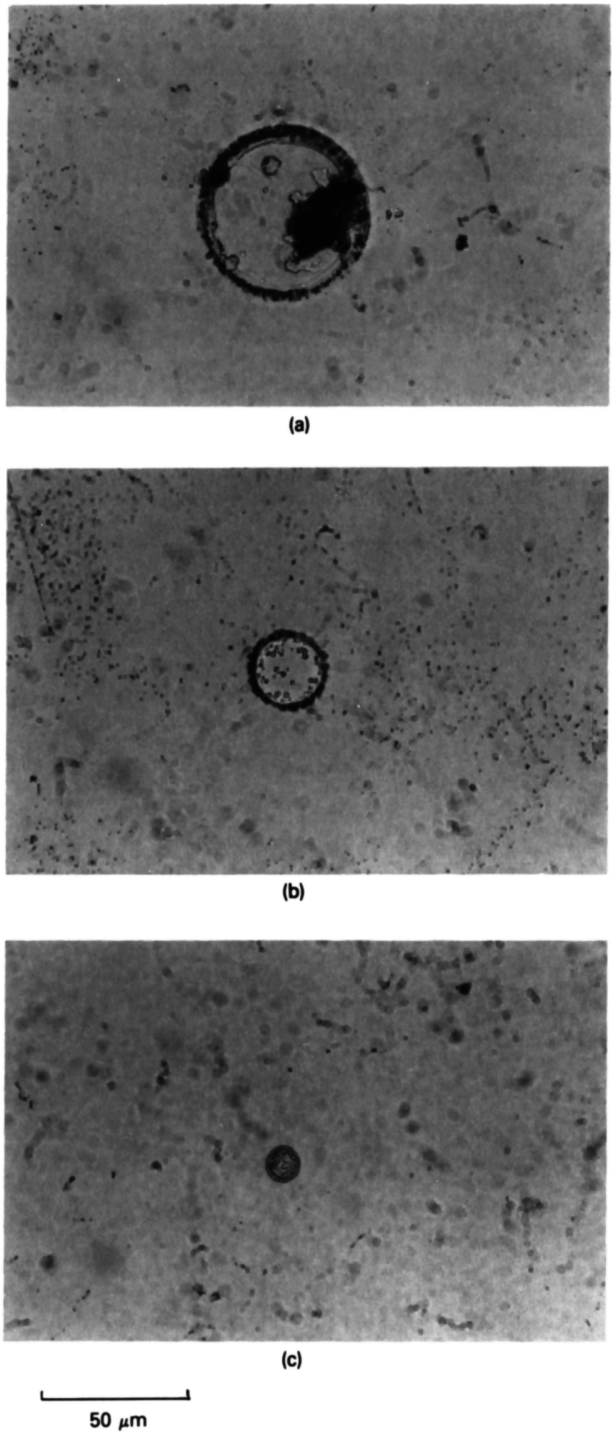

Fig. 3. Traces of the third group.

mostly populated, and 73 traces have been observed. Figure 3 shows the variations in the third group. They have tiny traces distributed inside the circle but are irregularly structured. The maximum diameter is ~60 μm.

The fourth group is simple rings, as shown in Fig. 4. They have nothing inside the circle. Only two such traces have been observed. The maximum diameter is ~248 μm.

The fifth group consists of traces similar to a biological cell. These variations are shown in Fig. 5. Four traces have been observed. They have an outer double layer in which small traces are distributed. The outer layer is nearly spherical for the smaller trace in Fig. 5a but becomes unspherical as it grows. The magnitude of the explosion is greater than that of the four earlier groups, especially for the trace in Fig. 5c.

The sixth group is assemblies of widely scattered traces. Only two such assemblies have been observed. Many traces shown in Figs. 6a and 6b are distributed in a very wide area. Partial traces of an assembly are shown in Figs. 6c and 6d. Strange loop-like and string-like traces are associated with the explosion, as shown in Figs. 6e and 6f, respectively. The magnitude of the sixth group is extremely large.

It is reasonable to assign the traces of the six groups as follows. The first group was already attributed to the gravity decay of quad-neutrons.[3] It was suggested that the inner white ring might consist of tiny particles such as superstrings.

The third group might be caused by the gravity decay of di-neutrons considering the magnitude. The second group could be a variation of the third group because an intermediate trace between the second and third groups has been observed, shown in Fig. 3c. The tiny circles regularly arranged inside the traces of the second group could also consist of tiny particles such as superstrings, and as the trace expands, the tiny circles connect with each other to form an irregular bubble for the second group.

For the fourth group, some uncertainty remains. The fourth group could be a fully developed stage of the third group. The small traces distributed inside the circle of the third group disappear as the circle develops. Alternatively, the fourth group could be differently assigned because of the smaller number density.

The fifth group can be assigned to the gravity decays of intermediate multiple-neutron nuclei such as ^{6}n and ^{8}n by considering the magnitude. The following section discusses how such neutron nuclei can be produced by many-body fusion reactions. Lastly, the sixth group can be assigned to the gravity decay of nuclei with many neutrons such as ^{A}n (A = ~100), which can be produced by the nuclear transmutation

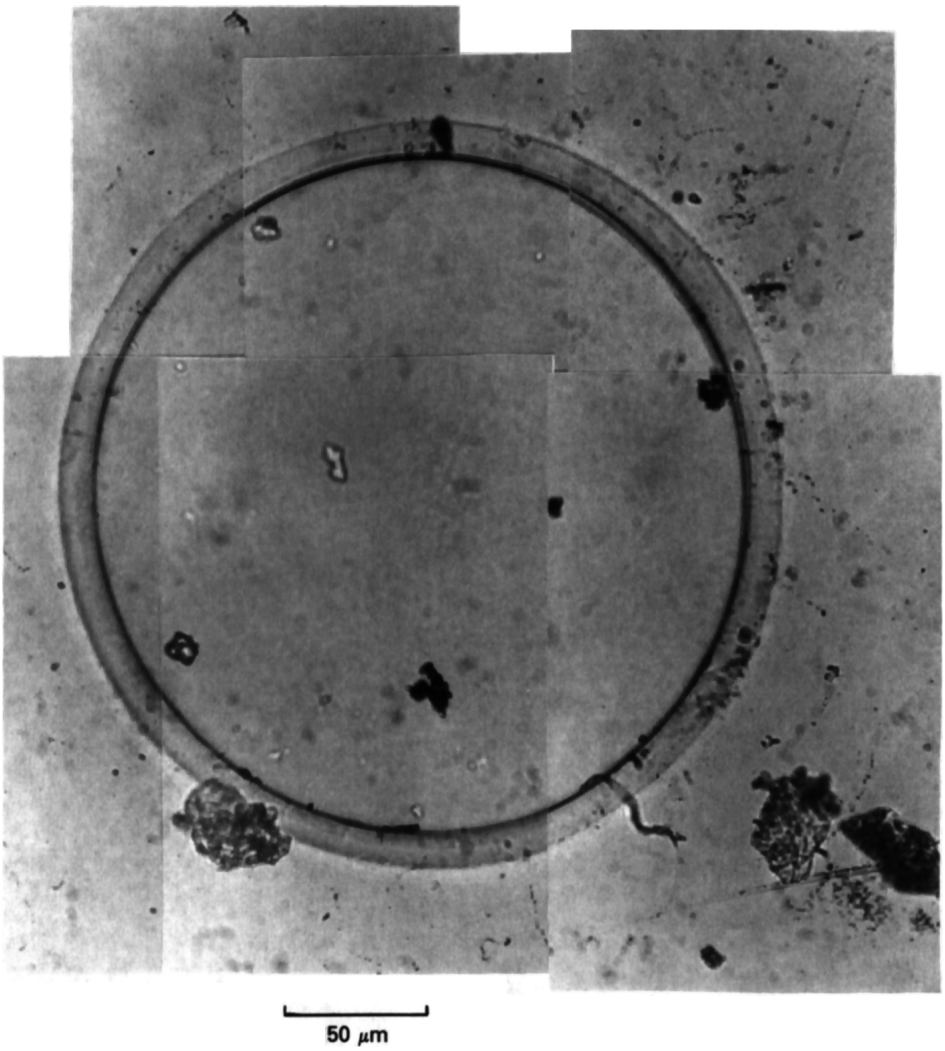

Fig. 4. Traces of the fourth group.

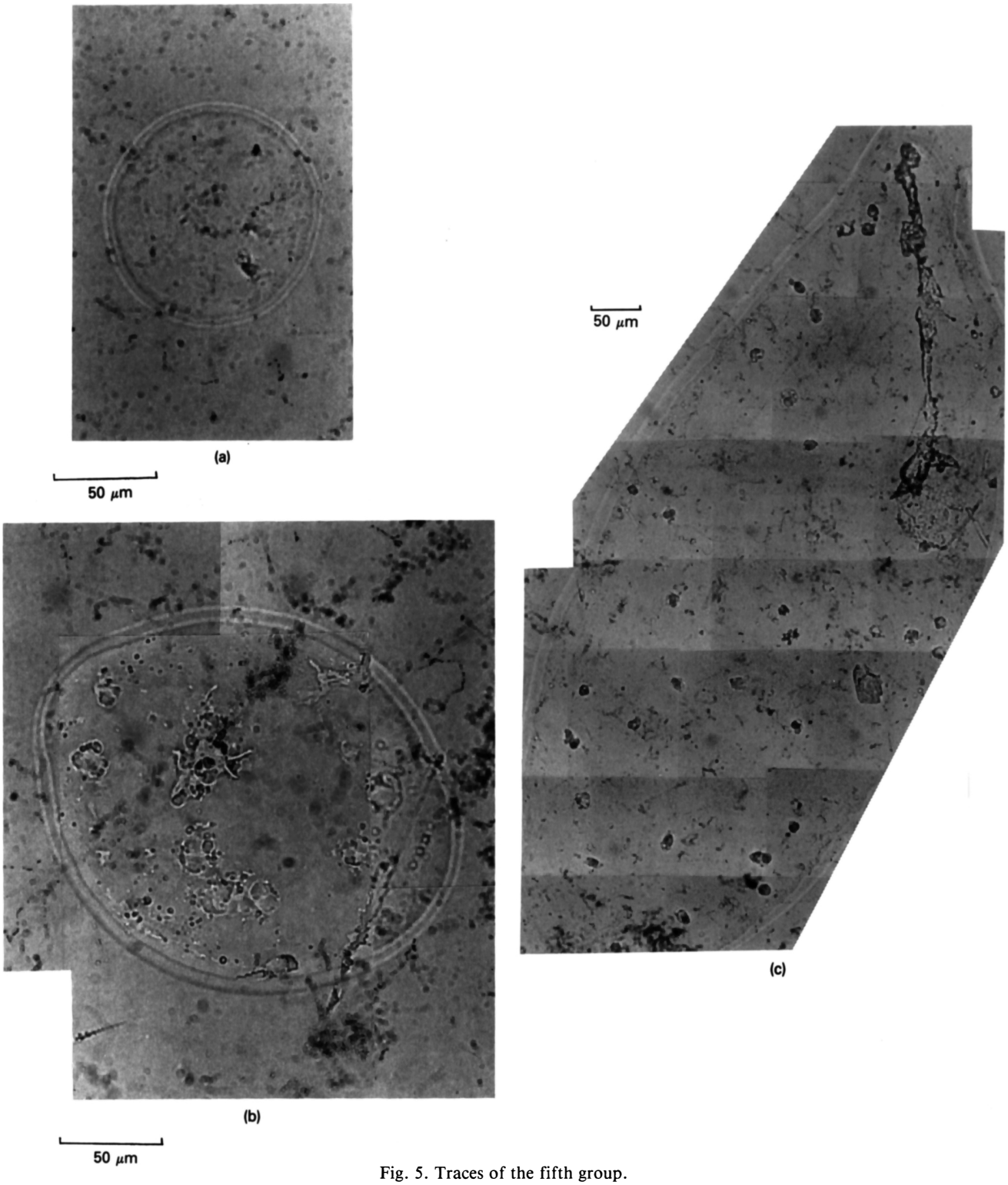

Fig. 5. Traces of the fifth group.

of palladium. The loop-like traces have been frequently observed in experiments,[6] which suggests a pair of heavy particles such as an X particle and a corresponding antiparticle. The strange stringlike trace could also consist of tiny particles such as superstrings.

Other interesting traces have been also observed. One is a broken ring, shown in Fig. 7. This could be a variation of the third group. A bubble that consisted of gravity decay products of di-neutrons broke into two parts as soon as it arrived at the surface of the nuclear emulsion.

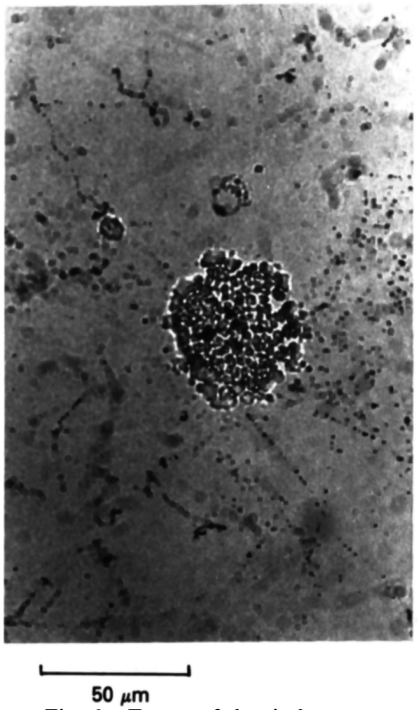

Fig. 6a. Traces of the sixth group.

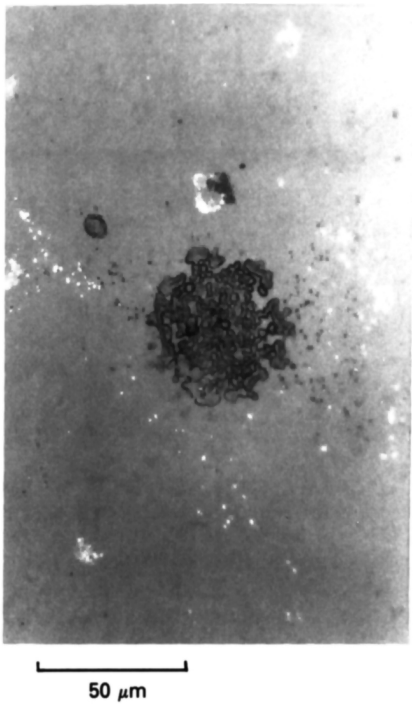

Fig. 6b. Traces of the sixth group.

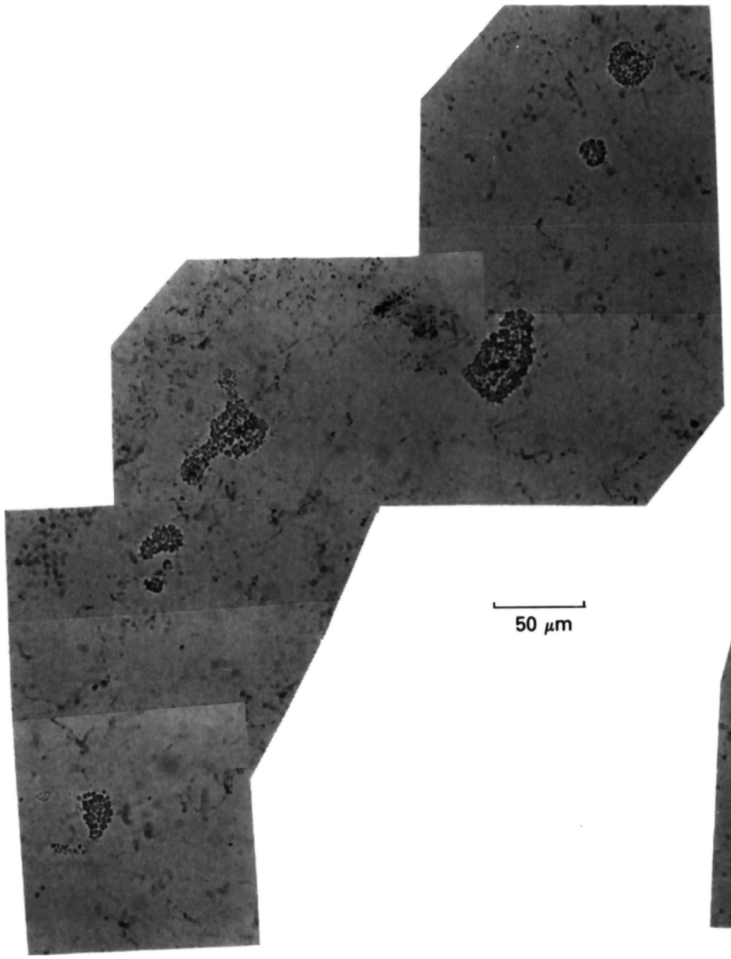

Fig. 6c. Traces of the sixth group.

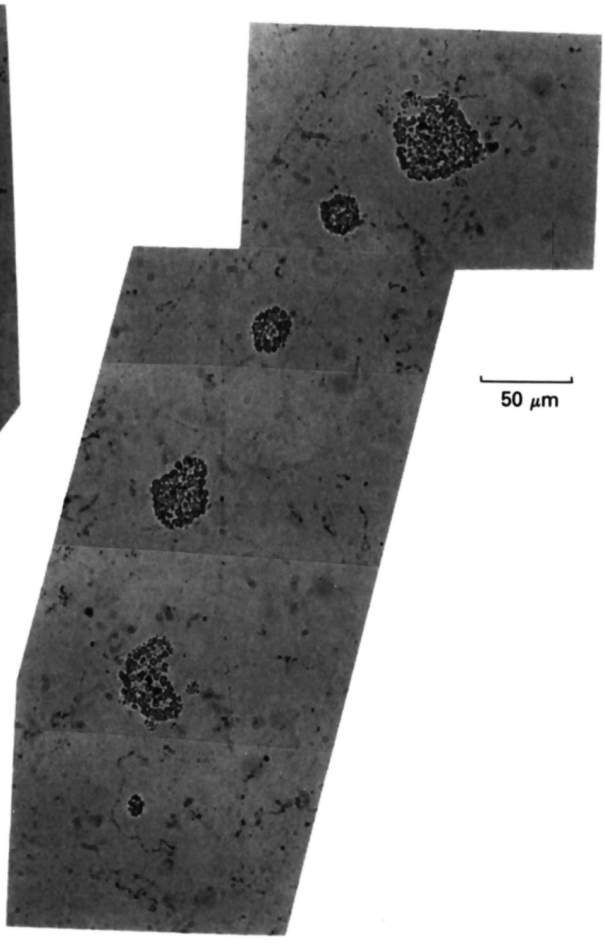

Fig. 6d. Traces of the sixth group.

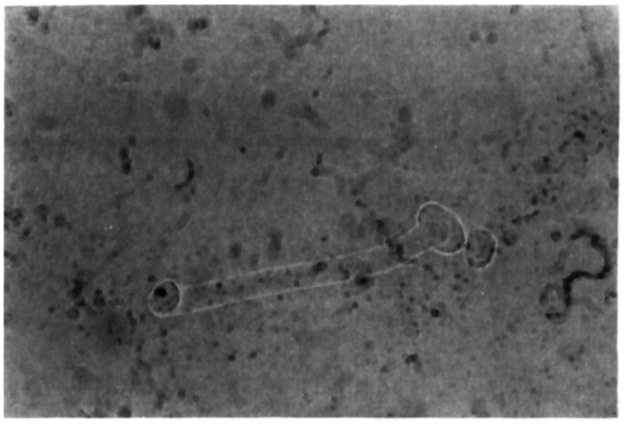

Fig. 6e. Traces of the sixth group.



Fig. 7. Trace of broken ring.

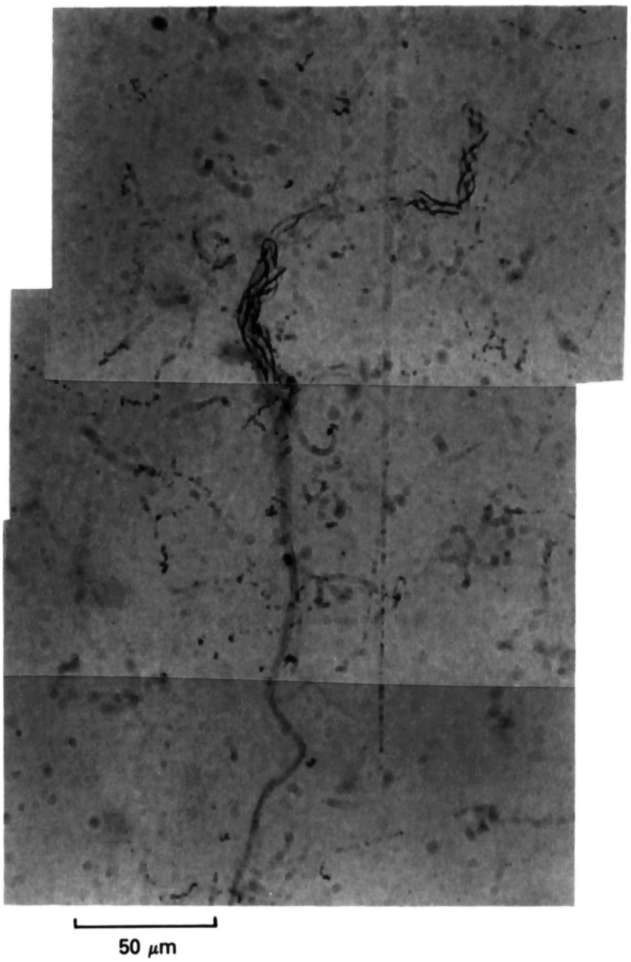

Fig. 6f. Traces of the sixth group.

Another trace is a superstar, an assembly of a large number of stars, as shown in Fig. 8. A star can be produced by cosmic rays, as shown in Fig. 2 in Ref. 4. Although cosmic rays could also produce such superstars, a superstar could also be produced during cold fusion. When the neutron nucleus bombards a constituent nucleus of a nuclear emulsion, the exciting energy of the formed nucleus can be expected to be so high that many stars could be scattered.

MECHANISMS OF THE FORMATION OF NUCLEI WITH MANY NEUTRONS

The Nattoh model can predict the production of di-neutrons and quad-neutrons by Eqs. (2) and (1), respectively. Furthermore, the production of nuclei with many neutrons also can be expected by the model.

When a hydrogen cluster is formed in a grain boundary, it is feasible that a large number of hydrogen atoms, for example, more than ten hydrogen atoms, are contained in the cluster. As a result, many-body fusion reactions can take place in a metal so that heavy elements such as iron and zinc can be produced in grain-shaped defects.[7] During this process, it is reasonable that nuclei with many neutrons can be produced simultaneously. One promising mechanism is as follows:

$$k\mathrm{D} + ke + (N-k)\mathrm{D} \rightarrow {}^{2k}n + ki_1 + (N-k)d \ , \quad \text{for } k \geqq 3 \ , \quad (3)$$

where N is the number of hydrogen atoms in the cluster. There could be many variations on the right side of Eq. (3), depending on the formation of itons. We can expect the production of multiple-neutron nuclei (^6n and ^8n) for $k = 3$ and 4, respectively.

On the other hand, nuclei with many neutrons with a mass of >100 could be produced. The production of ruthenium and indium was verified by the analyses using energy dispersive X-ray spectroscopy[7] and radioactive methods.[8] From the latter method, ^{104}Ru and ^{115}In were produced. This indicates that nuclear transmutation of palladium takes place during cold fusion. The mechanisms of the nuclear transmutations can be understood by extending the Nattoh model.

It can be expected that a hydrogen cluster has a self-compression effect.[2] One or more elements of palladium, for example, on the grain surface are surrounded by hydrogen

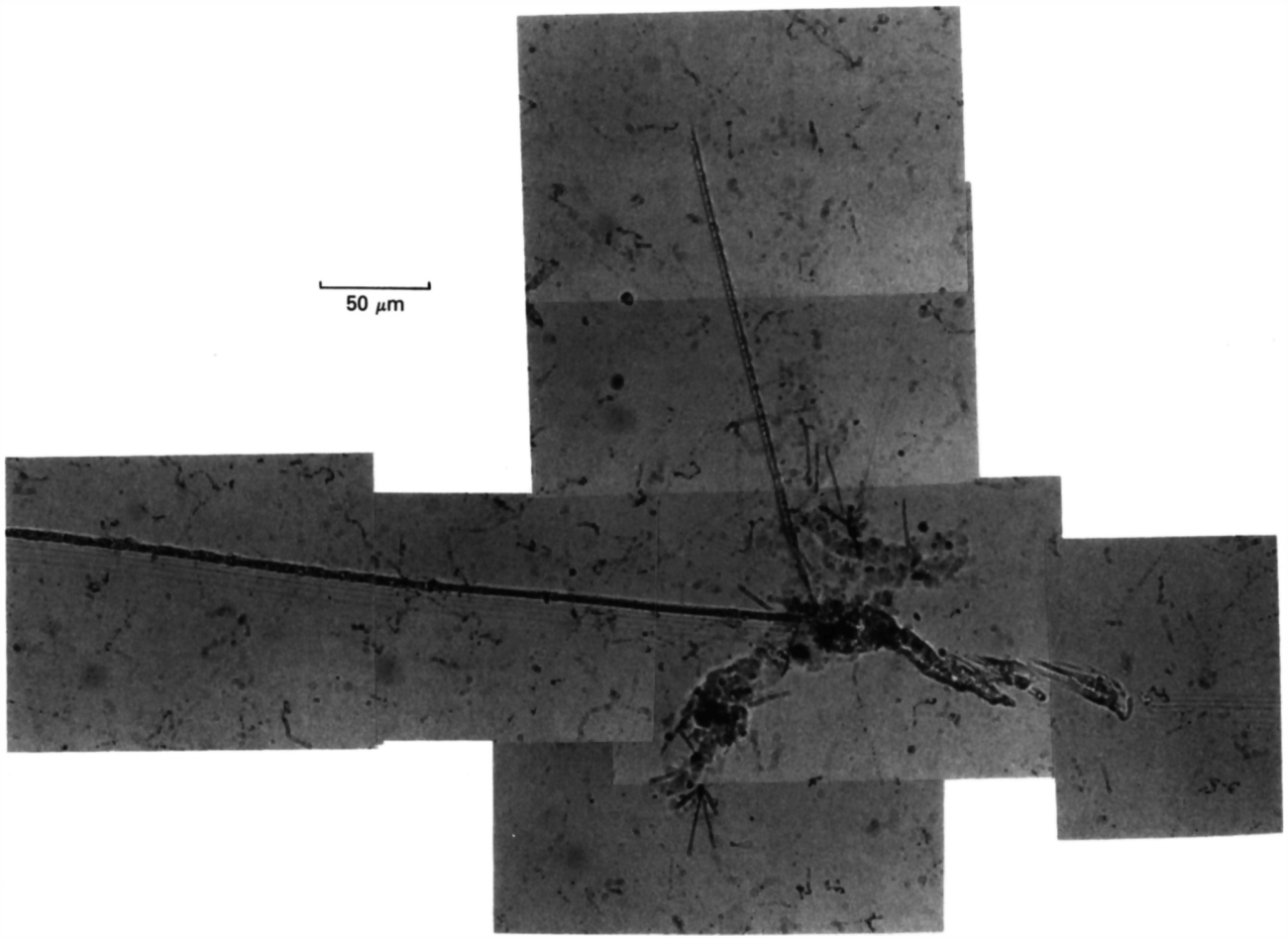

Fig. 8. Trace of superstar.

clusters, as shown in Fig. 9. The palladium nucleus can sequentially capture atomic electrons around itself and transfer them to another nucleus associated with iton emissions. The new nucleus might be unstable and take beta decays. The process of capturing and emitting electrons is then repeated in the grain boundary. Finally, the palladium nucleus transfers to a neutron nucleus with the same mass, as follows:

$$ {}^{A}_{46}\mathrm{Pd} \underset{\beta}{\overset{ze+i}{\longleftrightarrow}} {}^{A}_{46-z}X \underset{\beta}{\overset{(46-z)e+i}{\longleftrightarrow}} {}^{A}n \ . \qquad (4) $$

The resulting neutron nucleus can easily escape from the grain boundary. The processes also take place in the grain-shaped defects. This is why the shape of the grains can be very well conserved during the formation of the grain-shaped defects.[9]

An exception occurs for ^{104}Pd, which captures two electrons to produce stable ^{104}Ru:

$$ {}^{104}_{46}\mathrm{Pd} \xrightarrow{2e+i} {}^{104}_{44}\mathrm{Ru} \underset{\beta}{\overset{44e+i}{\longleftrightarrow}} {}^{104}n \ . \qquad (5) $$

The production of ^{115}In can be explained by the capture of deuterium atoms. For example,

$$ {}^{110}\mathrm{Pd} + 3\mathrm{D} \rightarrow {}^{116}\mathrm{In} \rightarrow {}^{115}\mathrm{In} + n \ . \qquad (6) $$

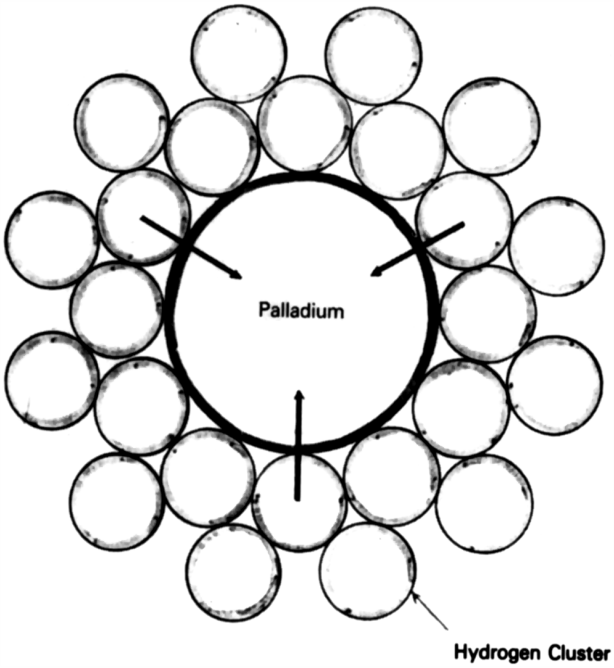

Fig. 9. Self-compression effect of hydrogen + cluster.

The self-compression effect was recently proven by the observation of the gravity decays by the contacted quad-neutrons.[10]

DISCUSSION

In the preceding sections, micro-explosions were classified into six groups corresponding to the gravity decay of nuclei with different numbers of neutrons. Now new questions should be answered.

The first question is how the nuclei with many neutrons as well as di-neutrons and quad-neutrons can be stable, at least for a fairly long time. The traces due to the gravity decay of neutron nuclei have been observed up to ~10 cm from the center of the palladium rod. Even if the velocity of the nuclei is assumed to be that of light, the nuclei should be stable for $\sim 3 \times 10^{-8}$ s. This is inconsistent with conventional theory. The answer is concerned with the associated emission of itons. When the itons are formed as real particles, the proton in the hydrogen nucleus must decay into a positron and a neutrino. The fused nucleus is neutral and "fermented" (the broken state of the inner structure) so that the repulsion force between the constituent nucleons would be weakened to stabilize the nucleus for a long time. Alternatively or simultaneously, the fused nucleus is covered by the itonic mesh, which could prevent the nucleons from scattering.[6]

The second question concerns the energy/mass balance. If the mass of the grain-shaped defects were totally transferred to energy by the gravity decays, an extremely large amount of energy should be released by cold fusion, and the weight of the palladium metal should be lightened such that the deviation could be easily measured before and after the experiments. We have recognized no significant difference in the weight of the palladium rod.[7] Therefore, it is suggested that during the gravity decay, a percentage of the nuclear mass is transferred to other materials in the metal. The inner white rings of the traces caused by quad-neutrons (Fig. 1), the broken ring caused by di-neutrons (Fig. 7), and the strange loop-like trace caused by nuclei with many neutrons (Fig. 6) show the production of some new material. It is suggested that the material might be heavy and bubblelike and consist of tiny particles such as superstrings. These might be left predominantly in the palladium metal but escape by the gravity of the earth. The material might be critically related to the safety problem of applied cold fusion.

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Ref. (25)

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SEARCHING FOR TINY BLACK HOLES DURING COLD FUSION

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COLD FUSION

TECHNICAL NOTE

KEYWORDS: *cold fusion, gravity decay, black holes*

A previous technical note suggests that cold fusion is a small-scale simulation of events that occur in cold stars faraway in the universe. Therefore, it is expected that tiny black holes might be produced during cold fusion. A search for tiny black holes whose traces might have been recorded on nuclear emulsions is described. Several traces suggesting the production and evaporation of tiny black holes have been successfully observed.

INTRODUCTION

The Nattoh model[1,2] predicted that the hydrogen-catalyzed fusion reaction is primary during cold fusion and emits new particles called "itons." As a result, quad-neutrons are left, whose gravity decays were successfully observed on nuclear emulsions.[3] It was shown that multiple-neutron nuclei can be produced during cold fusion.[4] The neutron nuclei can be attributed to small debris from neutron stars faraway in the universe. Moreover, many heavy elements such as iron, copper, and zinc can be produced by many-body fusion reactions during cold fusion.[5] Therefore, it was suggested that cold fusion is a small-scale simulation of events that occur in cold stars faraway in the universe. This endows cold fusion with reality.

In a previous technical note,[6] direct measurements using a thin palladium foil suggested that X particles might be emitted during the gravity decays of nuclei with many neutrons. In order to produce one X particle, a mass energy of more than $\sim 10^{15}$ hydrogen or 10^{13} palladium nuclei is needed. Therefore, it can be considered that palladium metal including hydrogen with the size of a few crystalline grains might be transmuted to nuclei with many neutrons by the capture of electrons and hydrogen atoms by the self-compression effects of surrounding hydrogen atoms. In that situation, it also can be expected that tiny black holes might be produced associated with the gravity decays of these nuclei.

This technical note describes a search for tiny black holes whose traces may have been recorded on nuclear emulsions. Several traces suggesting the production and evaporation of tiny black holes have been successfully observed.

SEARCHING FOR TINY BLACK HOLES

Reference 6 showed that direct measurements using a thin palladium foil are effective for the observation of emitted particles. It was successfully observed that "itonic" quad-neutrons covered by itons with a mesh structure undergo gravity decay.

The same nuclear emulsions have been carefully searched for tiny black holes. Thirty nuclear emulsion plates (100 μm × 25 mm × 25 mm) were located nearly in contact with the thin palladium foil (0.05 mm thick). Hydrogen atoms were charged into the metal by electrolyzing heavy water (mixed with 3% NaCl). Despite the thin foil, a small deviation of the temperature of the foil was observed, which indicated the occurrence of cold fusion.

The black hole itself can emit neither radiation nor particles. But by capturing antiparticles such as positrons, the black hole reduces in magnitude to finally evaporate. It would take an extremely long time for large black holes produced in the universe to disappear by evaporation. However, the tiny black holes produced during cold fusion might have fairly short lifetimes, and radiation and/or particles might be emitted at the final stage. Those distributions might be spherically symmetrical, so that such traces have been sought on the nuclear emulsions.

RESULTS AND DISCUSSION

By carefully searching for tiny black holes, several traces that suggest the evaporation of tiny black holes have been successfully observed on nuclear emulsions.

Figure 1 shows spherically symmetrical traces with different diameters. These traces were recorded inside the nuclear emulsions so that they can easily be separated from patches that are produced on the surfaces of the emulsions during the film developing process. All of the traces consist of two regions. The inner region is almost completely black. But in the outer region, tiny black dots are radiatively distributed. This suggests that some radiation and/or particles might have come out from the center region.

Figure 2 shows asymmetrical traces. For these traces, the direction of the evaporation is not symmetrical. Figure 2a shows one directional evaporation; i.e., the inner black region is oval shaped, and tiny black dots are distributed far to the left. On the other hand, Fig. 2b shows a different feature of

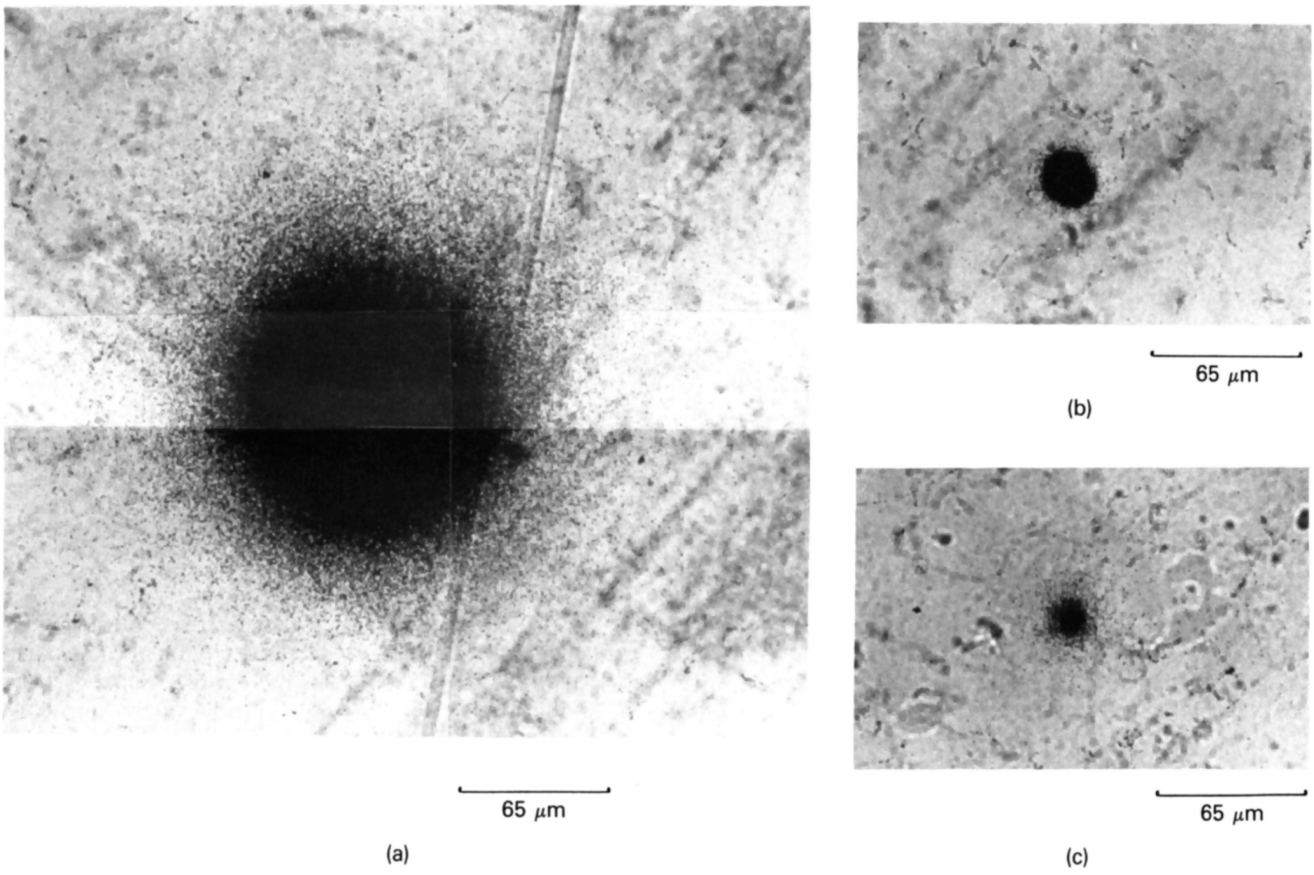


Fig. 1. Spherical traces made by tiny black holes.

the evaporation. A long tail is seen in the right side, and that region is dense. This suggests that the spatial distribution of the curvature of space in this black hole might not be completely symmetrical so as to provide an exit for radiation and/or particles.

Figure 3a shows a larger trace for a tiny black hole, which is associated with particles shown in Figs. 3b to 3e. Their relative positions are shown in Fig. 3f. It is obvious that the assembly of the white liner traces (Fig. 3b), are caused by the itons that cover the surface of the neutron nucleus.[6] They were scattered on the gravity decay explosion. It can be surmised that the magnitude of the explosion was so large that most of the itons were scattered not symmetrically, but to one direction. The trace shown by Fig. 3c, on the other hand, is the same as the ones that were already found in Ref. 4 and are inferred to have been caused by an X particle.[6] Figure 3d

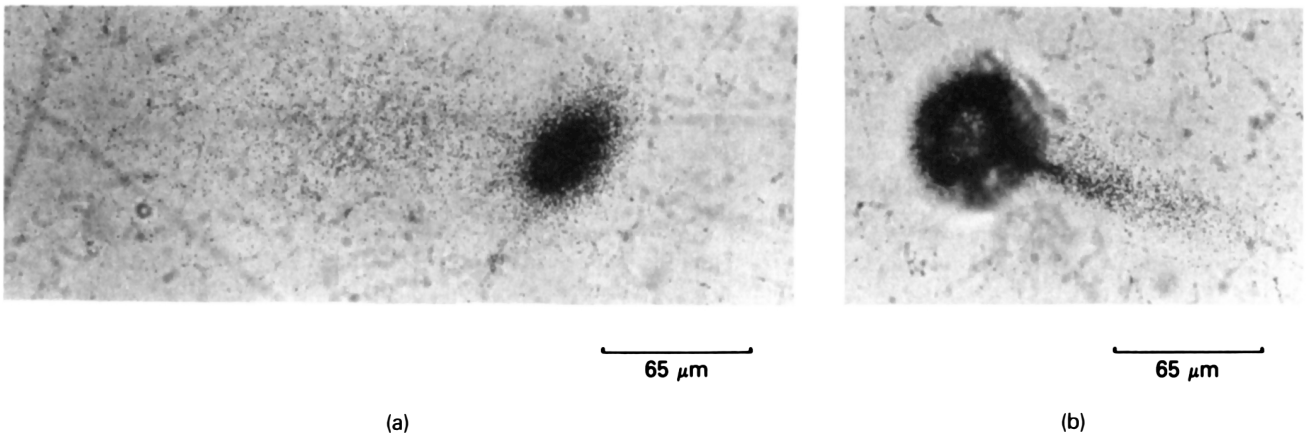
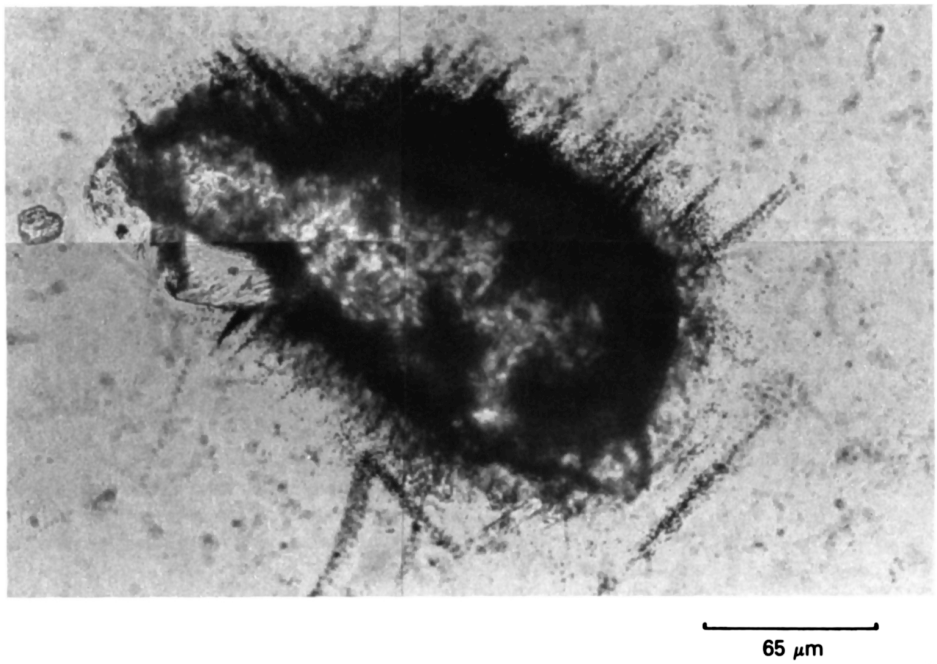
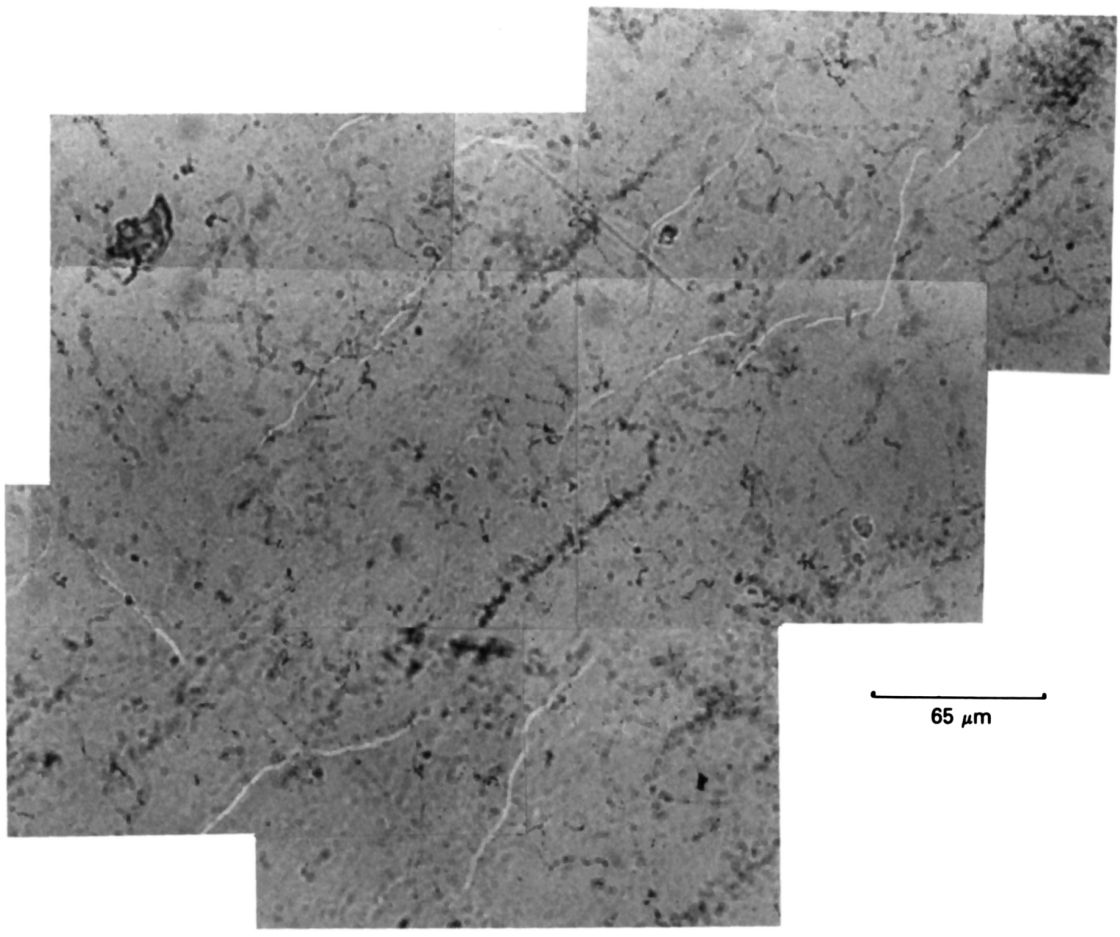


Fig. 2. Directional traces made by tiny black holes.

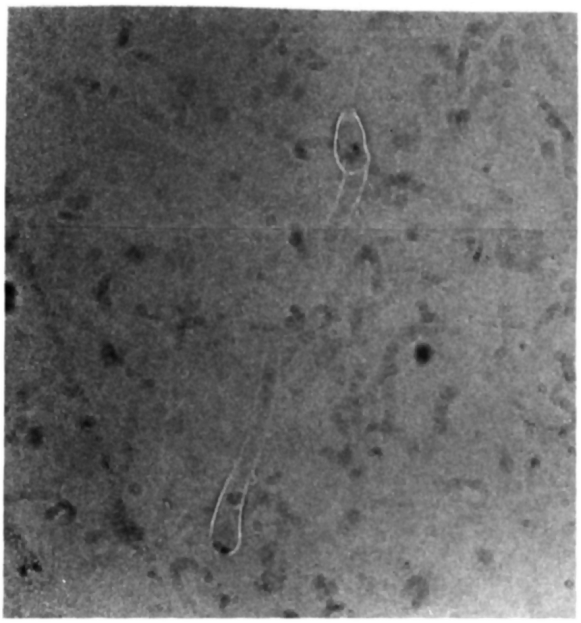


(a)

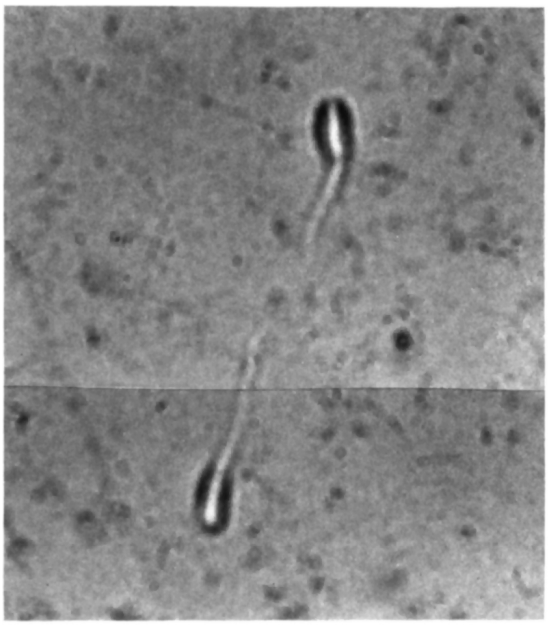


(b)

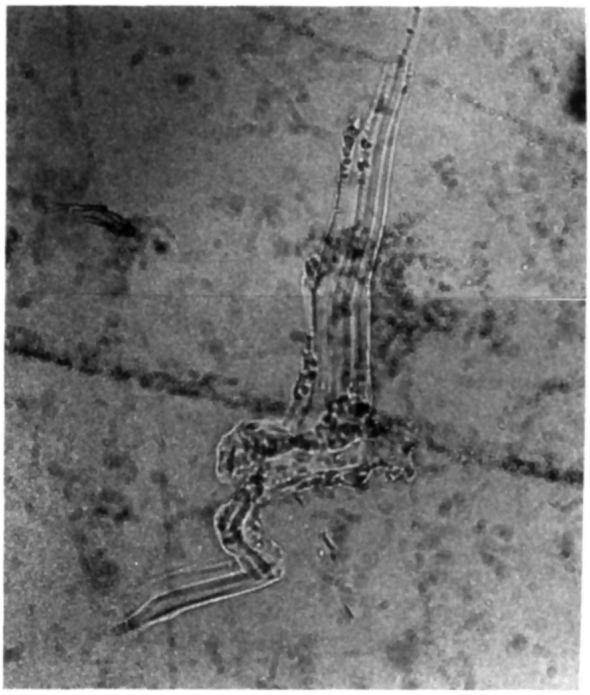
Figs. 3a and 3b. Trace with associated particles: (a) evaporation of a tiny black hole and (b) scattered itons.



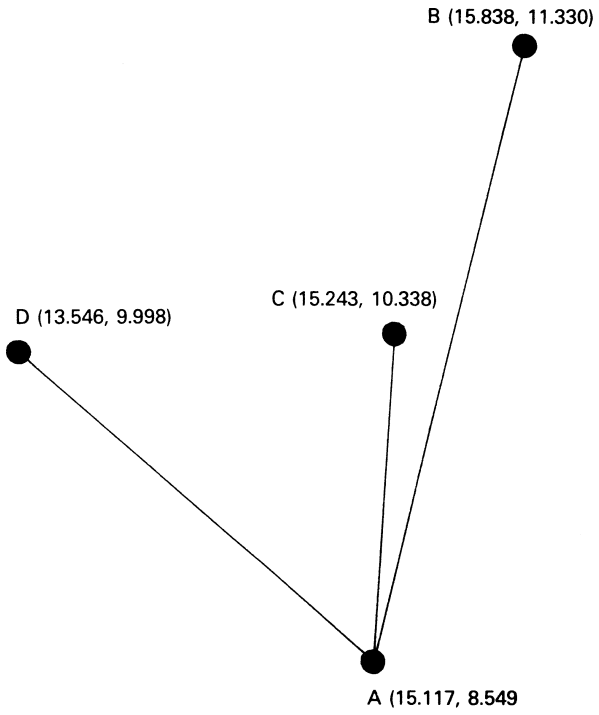
(c) 65 μm



(d) 65 μm



(e) 65 μm



(f)

Figs. 3c through 3f. Trace with associated particles: (c) traces suggesting X and anti-X particles, (d) same as (c) but with different focusing, (e) indeterminate trace, and (f) relative positions.

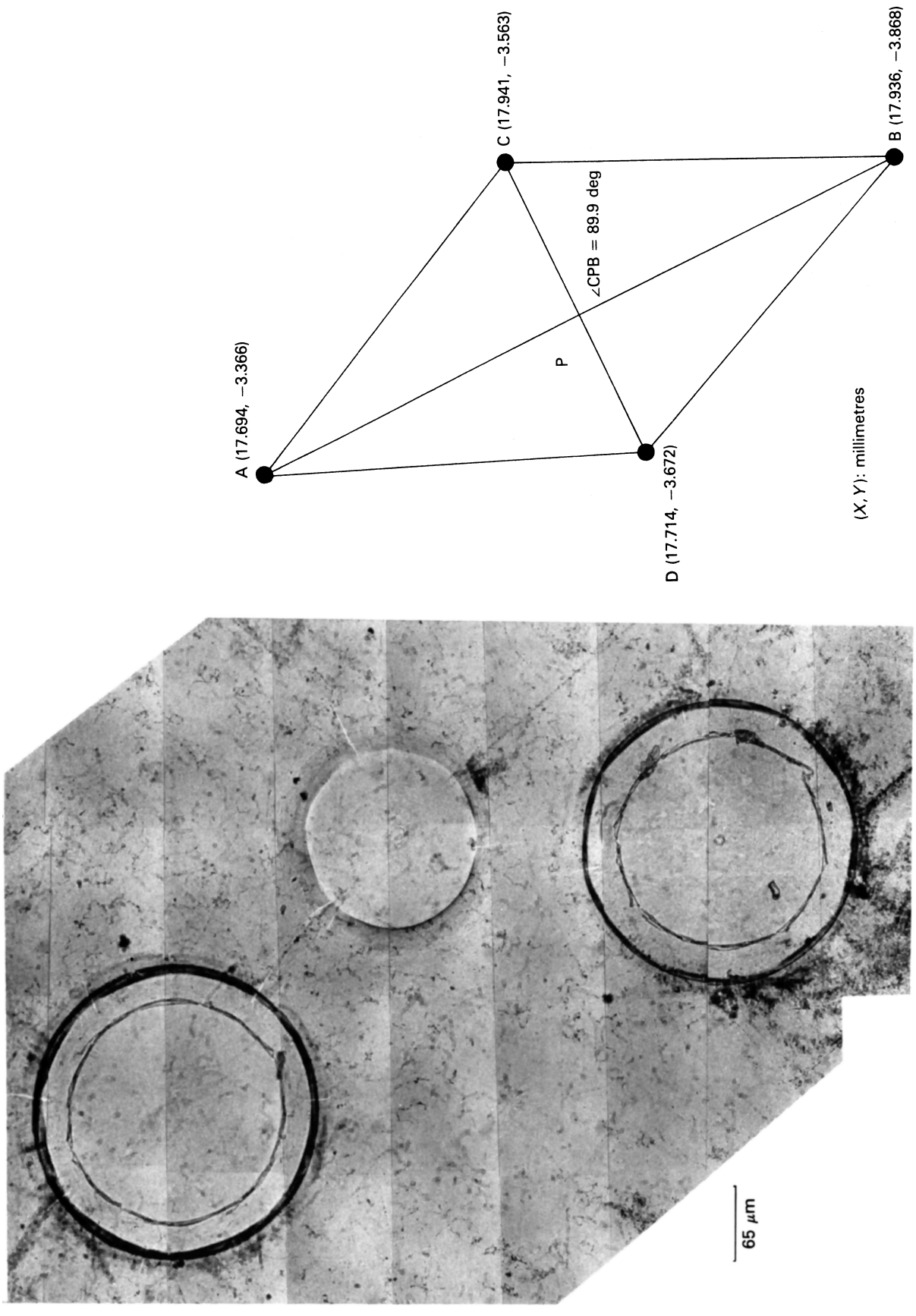


Fig. 4. (a) Four connected traces and (b) positions of centers.

shows the same trace with a different focusing of the optical microscope. It can clearly be seen that the trace consists of two oppositely oriented particles. They might be an X particle and an anti-X particle, respectively. The trace shown by Fig. 3e cannot be definitely attributed: It is undetermined whether it might be same as the one made by X particles or different. The tiny black hole shown by Fig. 3a is obviously different from the black holes shown in Figs. 1 and 2. This has a large enough magnitude that it can emit heavy associated particles. This may have been caused by a nucleus with many neutrons, which was produced by the self-compression of a hydrogen cluster including many palladium nuclei.[4]

On the other hand, evidence for the production of tiny black holes has also been obtained. Figure 4a shows four connected traces. The relative positions are shown in Fig. 4b. Among them, traces A, B, and C are caused by the gravity decays of quad-neutrons, as discussed earlier.[3,6] However, the strange trace D has never been observed before. The surrounding materials seem to be rolled up inward to the center, and from Fig. 4b, the particle for trace D might be heavier than the quad-neutron. Therefore, trace D clearly indicates a tiny black hole, which was produced from the gravity decay of a nucleus with many neutrons.

Other comments on Fig. 4 should be added. It is remarkable that the four connected traces were recorded simultaneously. Because there are so few particles, it is unlikely that the traces occurred in the same small region by chance. The itonic linkage can be seen somewhat between the explosive traces A and C in Fig. 4a. Therefore, it is reasonable to consider that these four particles were connected with each other during their birth by cold fusion and traveled together until they were separated just in front of the film. This means that four fusion reactions occurred simultaneously at one point in the metal. This can be explained by the Nattoh model, which proposed self-compression of a cluster including many hydrogen atoms.[6]

The process of the explosion due to gravity decay can be well observed in Fig. 4a. The traces A and B are almost at the same stage of the explosion process, but trace C is at an earlier stage. It was predicted that materials consisting of tiny particles such as superstrings might be products of gravity decay.[3] Their condition might be like a soup so that bubbles grow during the explosion. The inner ring zones in traces A and B clearly represent the partial breakup of such soup bubbles. The broken parts of the ring zones show that the bubble consists of a very thin skin layer. On the other hand, the small inner ring in trace C is not broken. It might be thinner than the surrounding region and will break up as the bubble grows. The ring might correspond to Newton's black ring in a soap bubble, which consists of layers of soap molecules. So it is suggested that by studying the thin layer, the structure of gravity-decay products, including other materials of the nuclear emulsions, might be made clear.

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ANS Reprint

COLD FUSION

TECHNICAL NOTE

KEYWORDS: *multiple-neutron, quad-neutron, stars*

OBSERVATION OF STARS PRODUCED DURING COLD FUSION

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It has been indicated that multiple-neutron nuclei such as quad-neutrons can be emitted during cold fusion. These multiple-neutrons might bombard the nuclei of materials outside a cold fusion cell to cause nuclear reactions. Observations of nuclear emulsions that were irradiated during a cold fusion experiment with heavy water and palladium foil are described. Various traces, like stars, showing nuclear reactions caused by the multiple-neutrons have been clearly observed.

INTRODUCTION

Multiple-neutron nuclei such as quad-neutrons can be produced during cold fusion.[1] The quad-neutron results from the emission of the new iton particle during the hydrogen-catalyzed fusion reaction, in which the hydrogen cluster is extremely compressed to depolarize the hydrogen nuclei.[2] More multiple-neutron nuclei, with six or eight neutrons, can be produced during many-body fusion reactions of hydrogen.[3] Furthermore, nuclei consisting of >100 neutrons can be produced from a host metal of palladium by capturing hydrogen atoms and/or electrons.[3]

These multiple-neutron nuclei seem stable for a fairly long time, while neutron coupling is impossible for the ordinary neutrons that are produced in a fission reactor. This is so because the internal structure of the multiple-neutrons might already be broken by the emission of the itons. Among the multiple-neutrons, light ones such as the quad-neutrons collapse by self-gravity to make micro-explosions, whose traces have been observed on nuclear emulsions.[1,4] On the other hand, nuclei with a great number of neutrons undergo similar gravity-decay to produce tiny black holes, whose evaporations have also been observed,[5] although the critical multiplicity that determines the branching is not clear at this time.

When multiple-neutrons are born in the palladium metal, they are covered with the itonic mesh.[4] Although the itonic mesh slowly fades in the materials of the electrolyte solution and nuclear emulsions, it might be so sticky that it can easily cause the multiple-neutrons to interact with the nuclei of the media. Nuclear reactions might be seen outside the electrolyzing cell during cold fusion.

This technical note describes observations of nuclear emulsions that were irradiated during a cold fusion experiment with heavy water and palladium foil.[4] Stars that were caused by the nuclear interactions between the multiple-neutrons and the nuclei of the nuclear emulsions were successfully observed.

SEARCHING FOR TRACES OF NUCLEAR REACTIONS

A thin foil of palladium was used in the previous experiment,[4] whose method is direct and effective for observing emitted particles. The observations of itonic quad-neutrons and tiny black holes were reported elsewhere.[4,5]

The same nuclear emulsions were again searched for nuclear reactions. The nuclear emulsions (100 μm × 25 mm × 25 mm) were located outside an electrolyzing cell and placed in contact with the thin palladium foil (0.10 mm thick). Hydrogen atoms were charged into the palladium metal by electrolyzing heavy water (mixed with 3% NaCl). The temperature showed an insignificant increase, but it was proven by the successful observations of itonic quad-neutrons and tiny black holes that cold fusion certainly occurred.[3,5]

RESULTS AND DISCUSSIONS

Four traces were successfully observed on the nuclear emulsions, suggesting nuclear reactions by the multiple-neutrons. They all are starlike (referred to as "cold fusion stars"), similar to traces that are produced by cosmic rays. The number of emitted particle products is larger for the cold fusion stars than for the cosmic stars, shown in Fig. 2 of Ref. 6. It is easy to distinguish them.

Figure 1a shows a cold fusion star. The trace was recorded on film number 7. The coordinates (x, y, z) of the trace are shown in Fig. 1b. The number of recorded particle products is very large, 14. There seem to be various kinds of

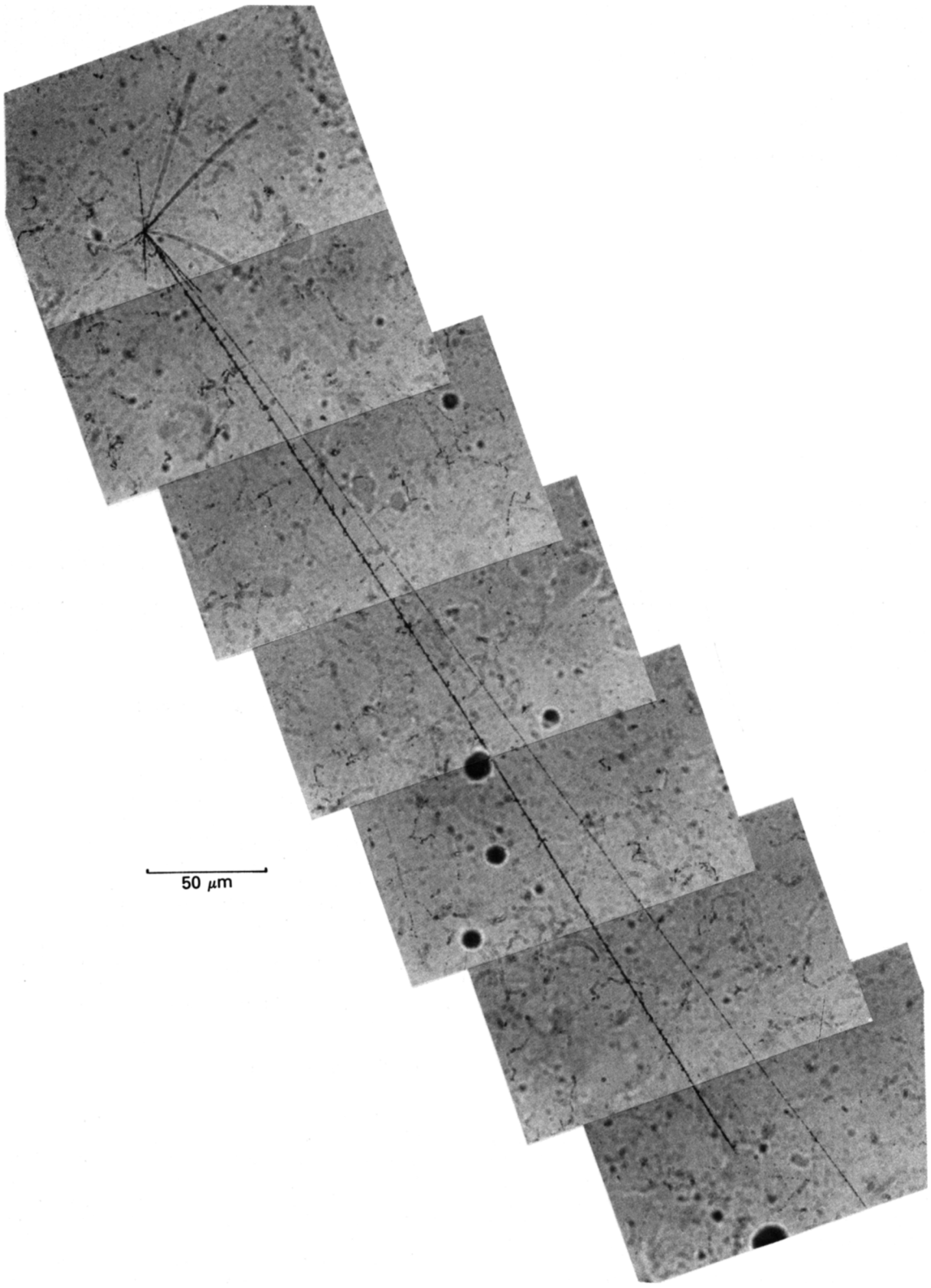

Fig. 1a. Cold fusion star.

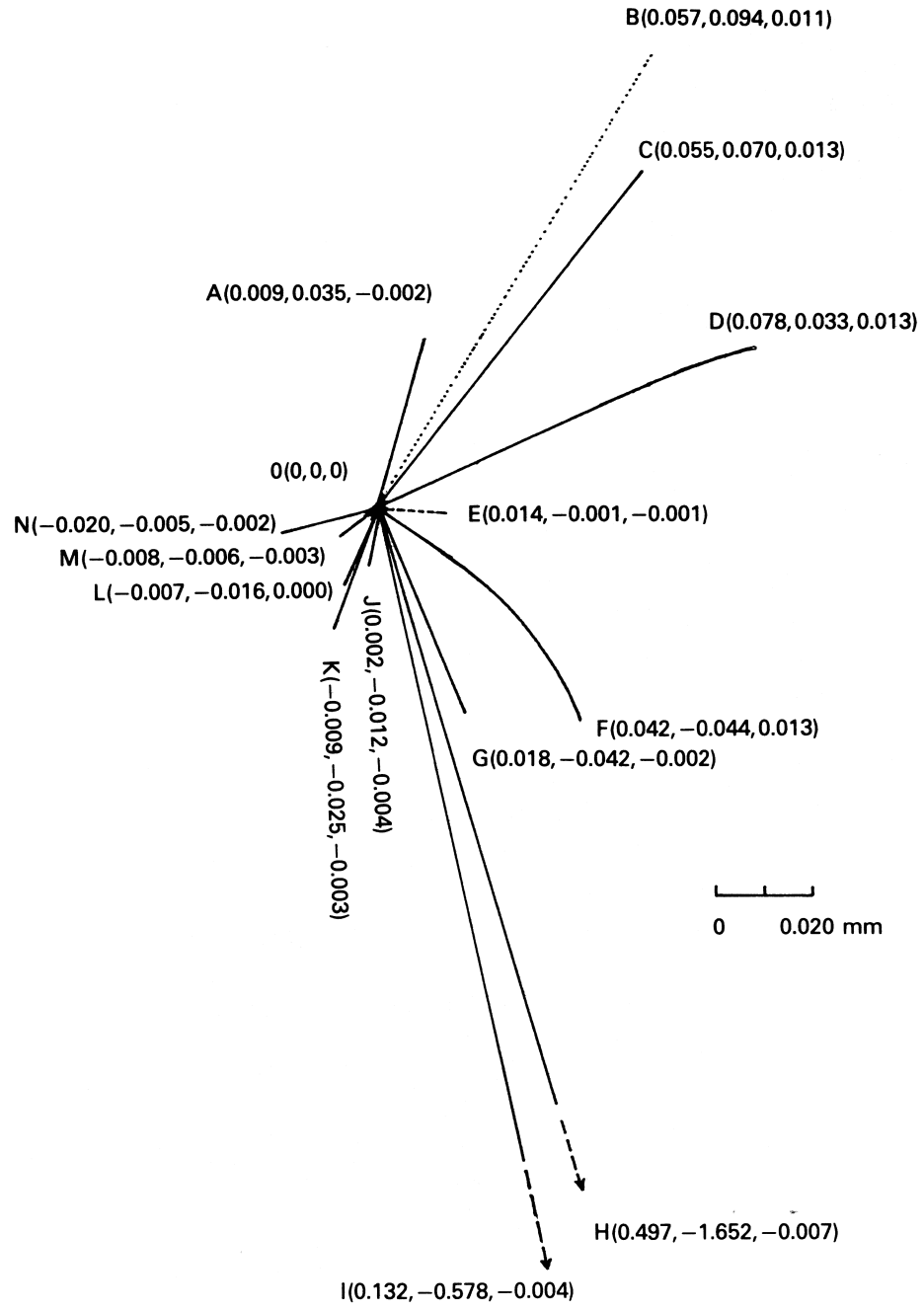

Fig. 1b. Coordinates of traces.

particle products with various masses and charges. The particles generally have a high ionization power, but particles B and E have a lower one. Trace B especially resembles that of an electron or positron. Moreover, the cold fusion stars typically have some extremely long traces, for example, 1.725 and 0.593 mm shown by traces H and I in Fig. 1b, respectively. This means that the nuclear reaction producing the cold fusion star has a high Q value. On the other hand, particle F has a large curvature, so it might be an incident particle such as an itonic quad-neutron, because the itonic cover is highly charged.[4]

Figure 2a shows another cold fusion star, which is partly omitted. Figure 2b shows the coordinates of the traces. The number of the recorded particles is 12. Particle A might be an electron or positron, although it can be hardly seen here because of the focusing condition. Particle F might be an incident one. Figure 3 shows a cold fusion star whose traces are generally short. It is suggested that the Q value might be small. Figure 4 shows the fourth cold fusion star. This also has shorter traces.

The stars were obviously caused by some particles that were produced during cold fusion. It is inferred that multiple-neutrons such as quad-neutrons might have collided with the nuclei of the nuclear emulsions to produce the stars.

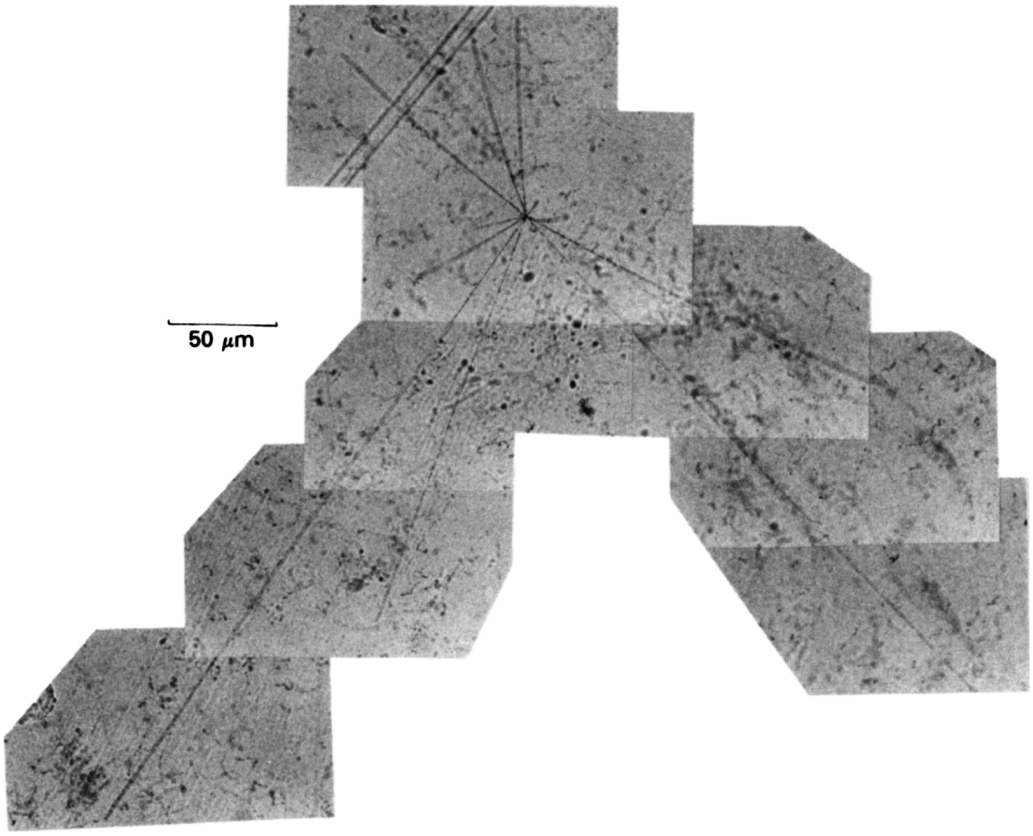

Fig. 2a. Cold fusion star.

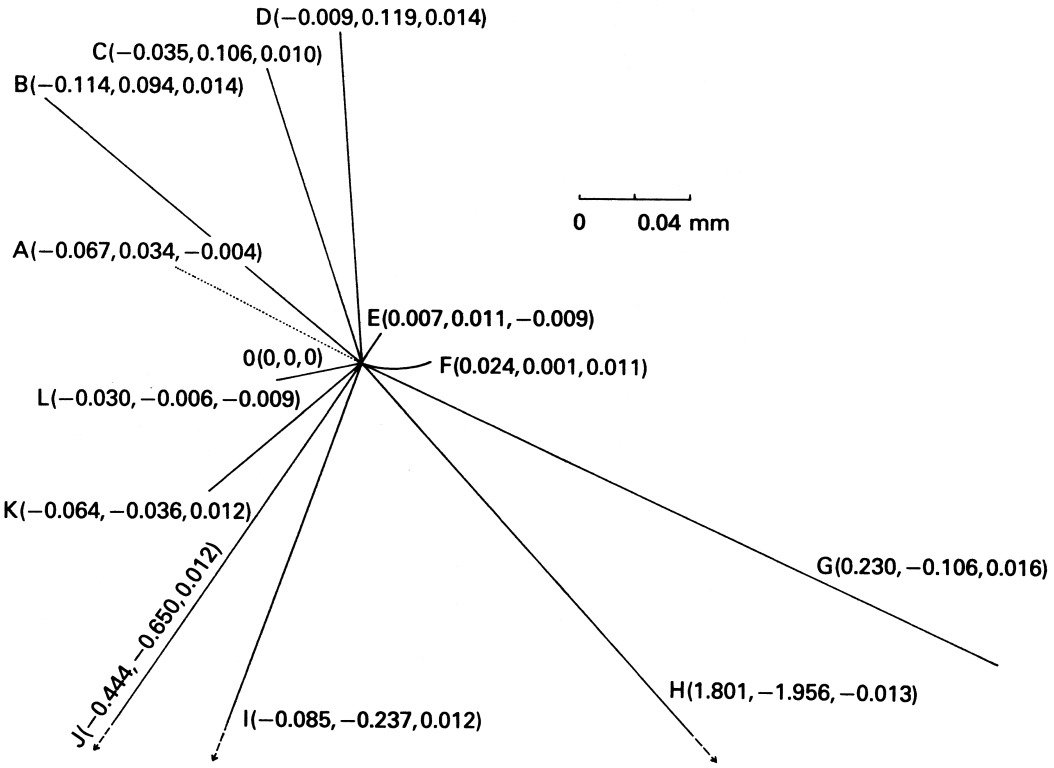

Fig. 2b. Coordinates of traces.

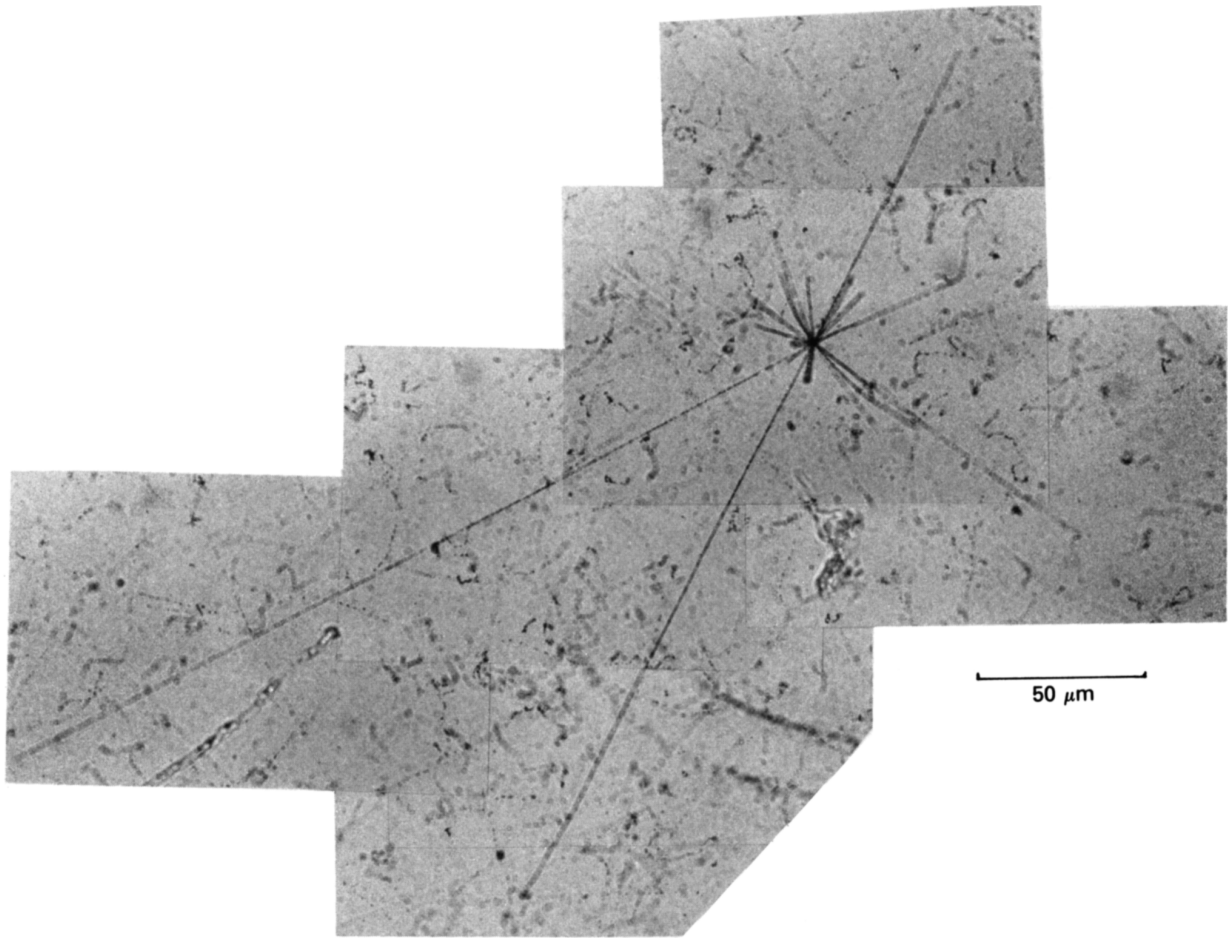

Fig. 3. Cold fusion star.

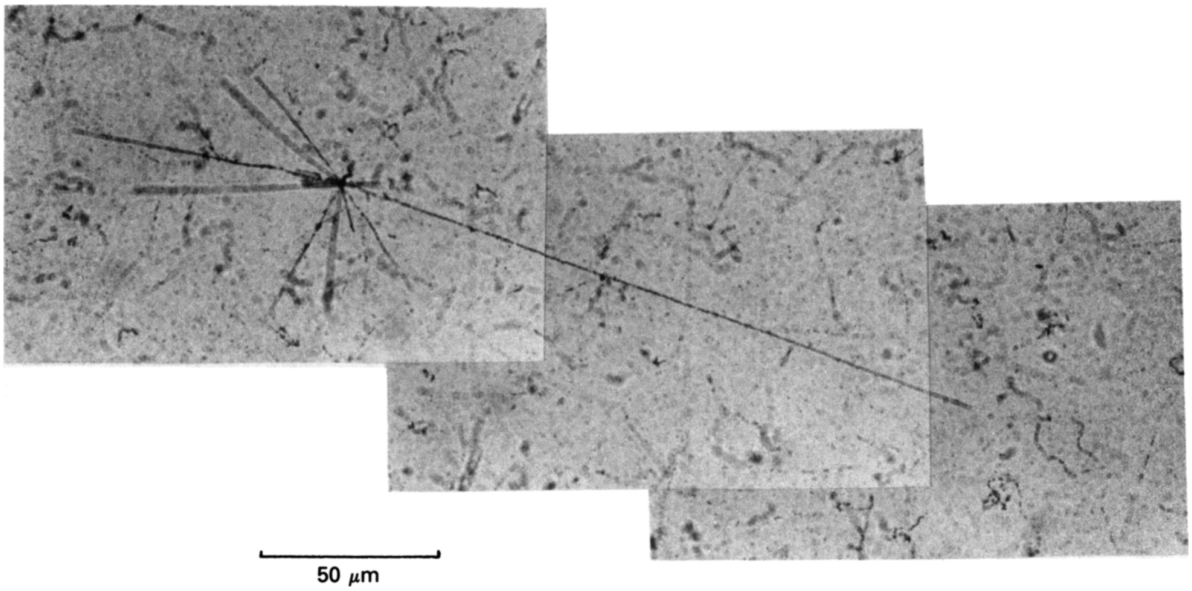

Fig. 4. Cold fusion star.

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Ref. (33)

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COLD FUSION

TECHNICAL NOTE

KEYWORDS: *cold fusion, gravity decay, itonic quad-neutrons, itonic bead*

OBSERVATION OF MESHLIKE TRACES ON NUCLEAR EMULSIONS DURING COLD FUSION

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Cold fusion products from the electrolysis of heavy water have been directly measured by using a thin palladium foil. Several anomalous traces have been clearly recorded on nuclear emulsions. Some traces have meshlike structures, which are classified into two types: (a) ones associated with ring traces that are caused by the gravity decay of quad-neutrons and (b) ones with no ring traces. The mechanisms that form these meshlike traces are discussed in terms of the Nattoh model. It is inferred that multiple-neutron nuclei such as quad-neutrons, covered by itonic mesh and iton beads, are born during cold fusion. Furthermore, other anomalous traces suggest the production of a new heavy particle during gravity decay.

INTRODUCTION

The Nattoh model proposes a hydrogen-catalyzed fusion reaction as the elementary reaction during cold fusion.[1,2] The reaction involves plural hydrogen atoms and electrons and thus may have many variations. The primary reaction is a two-body fusion reaction under many-body interactions, which can be written as follows[2]:

$$2D + 2e + D \rightarrow {}^4n + i_2 + d \ , \qquad (1)$$

where ${}^4n$ is a quad-neutron and i_2 is a double iton.

Gravity decay of quad-neutrons was successfully observed on nuclear emulsions in a previous experiment.[3] The traces consisted of two spherical rings, an inner white one and an outer black one. The former could be a broken soup of tiny materials such as superstrings, and the latter may be the result of gravitational and antigravitational waves.[4] Measurements were made by setting nuclear emulsions outside an electrolysis cell so that the quad-neutrons born in a palladium rod might have been somewhat affected during passage through the electrolyte solution and the glass cell.

This technical note describes a direct measurement of cold fusion products through an experiment with a thin palladium foil. New anomalous traces have been successfully observed. Some of them have mesh structures. The mechanisms that form these anomalous traces are also discussed in terms of the Nattoh model.

EXPERIMENT WITH THIN PALLADIUM FOIL

A cold fusion experiment was performed with heavy water electrolysis[5,6] in which a thin foil was used.[7]

Hydrogen atoms were charged into a thin palladium foil (0.05 mm thick) by electrolyzing heavy water (mixed with 3% NaCl). A helical platinum wire was used for the anode. The current was 0.88 A, and the bias was 6.0 V. Figure 1 shows the arrangement of the thin palladium foil and the nuclear

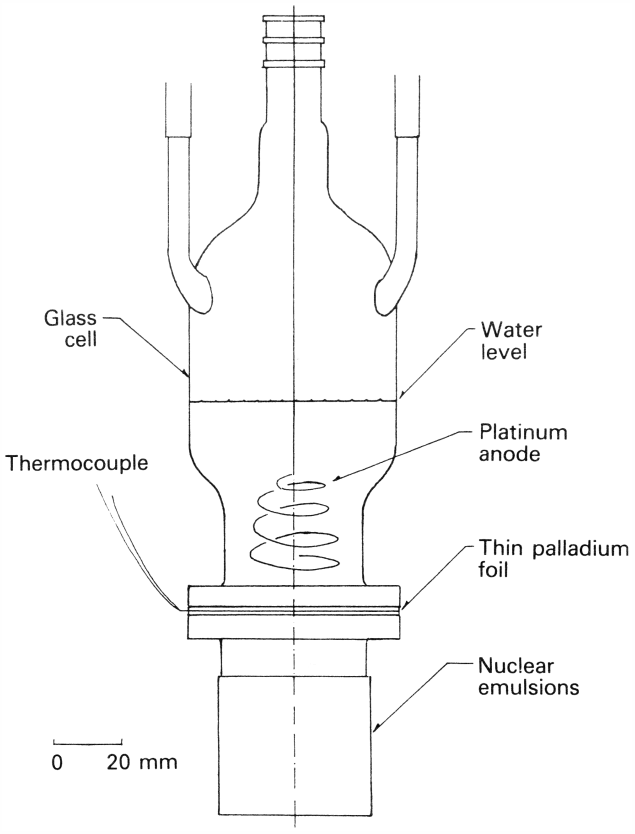


Fig. 1. Arrangement of palladium foil and nuclear emulsions.

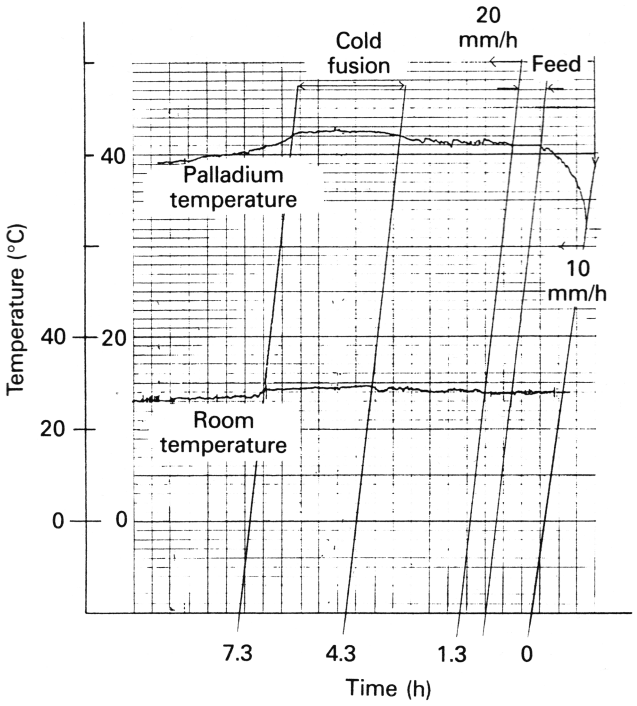


Fig. 2. Temperature during cold fusion.

emulsions. Thirty nuclear emulsion plates (100 μm thick, coated on 1- × 25- × 25-mm acrylite plates) were located under the palladium foil, so as to directly measure any fusion products.

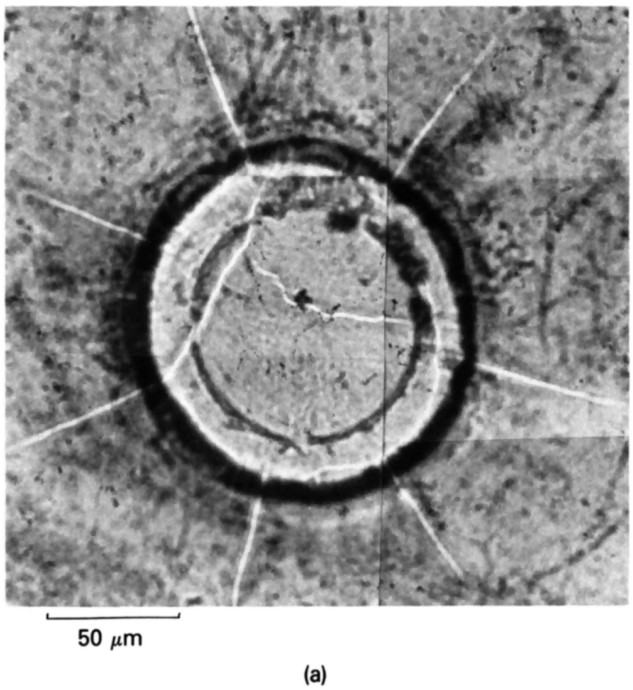
After hydrogen charging for ~4 days, the experimental setup was cooled in a refrigerator for ~19 h to charge more hydrogen atoms. Ignition of cold fusion was attempted through the use of a thermal trigger. Figure 2 shows the temperature variation of the thin palladium foil after the cell was removed from the refrigerator. Although the room temperature is decreasing, the temperature of the palladium foil continues to slowly increase. It can be inferred that the cold fusion continued for ~3 h.

RESULTS

The traces recorded on the nuclear emulsions were carefully observed by an optical microscope, and as a result, new anomalous traces were successfully observed.

The first type of anomalous trace is the explosive rings caused by the gravity decay of quad-neutrons. An example is shown in Fig. 3. It is remarkable that this time, each micro-explosion is associated with an anomalous white meshlike trace. The white lines are linked to each other inside the ring but partly broken outside. There were six to eight broken lines. In the previous experiment,[3] no meshlike traces were observed with micro-explosions caused by the gravity decay of quad-neutrons.

The second type of trace is white meshes without rings, which were simultaneously observed, as shown in Fig. 4. The three shown in Figs. 4a, 4b, and 4c have a closed linkage around the center and are more or less hexagonal. Figures 4d through 4g show how the linkage breaks. Figures 4h through 4k show some scraps of those linkages. Figure 5 shows the spatial distribution of the anomalous traces. Four traces were observed for the first type and seven traces for the second type. For the second type, the amount of linkage decreases as the distance from the surface of the palladium foil increases. This means that the highly linked traces become less closely linked when passing through the acrylite plates of the emulsions.



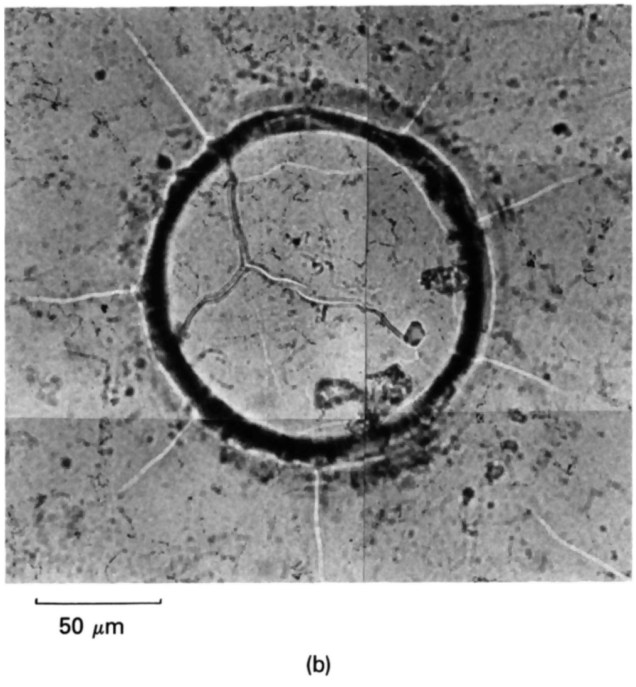
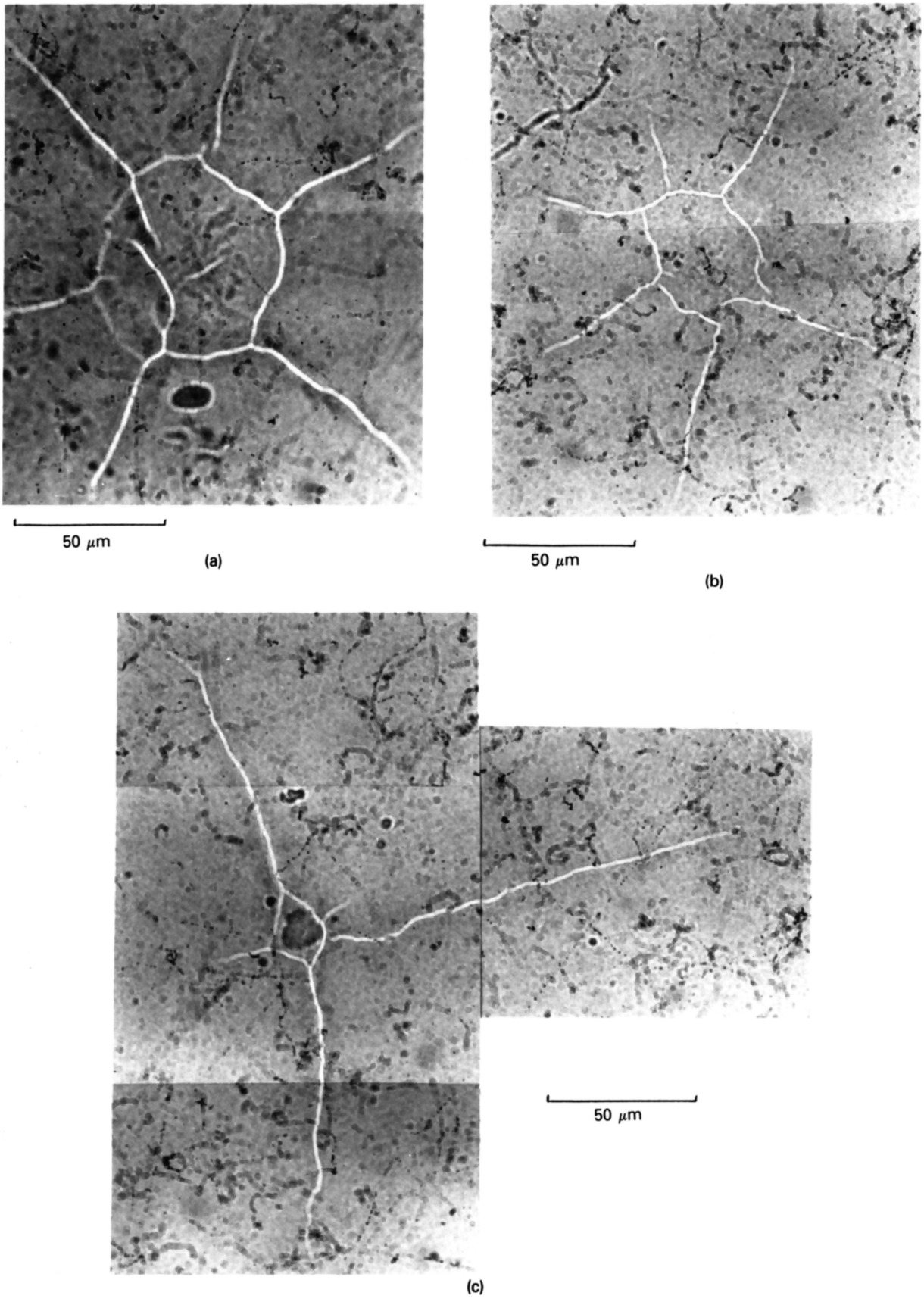
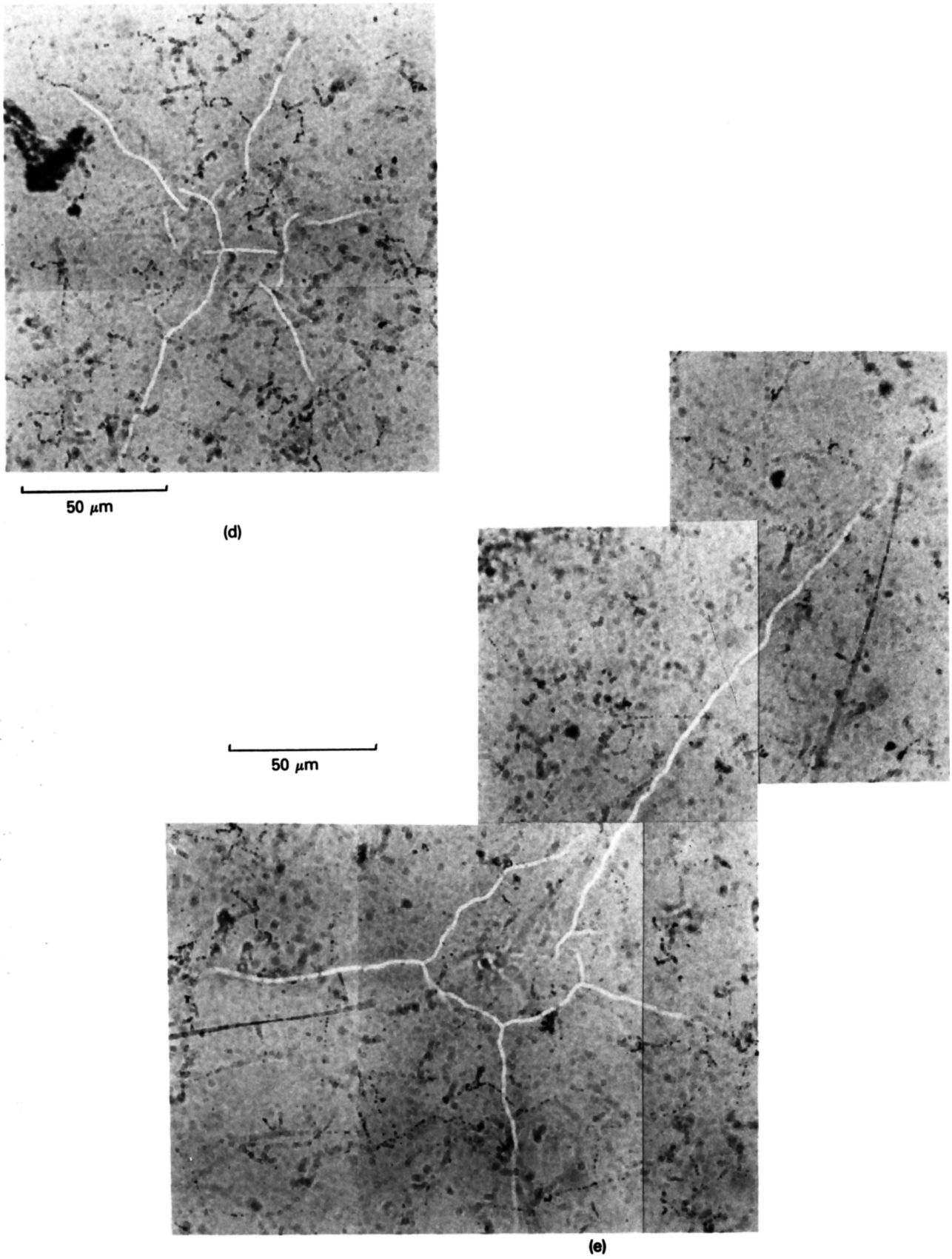


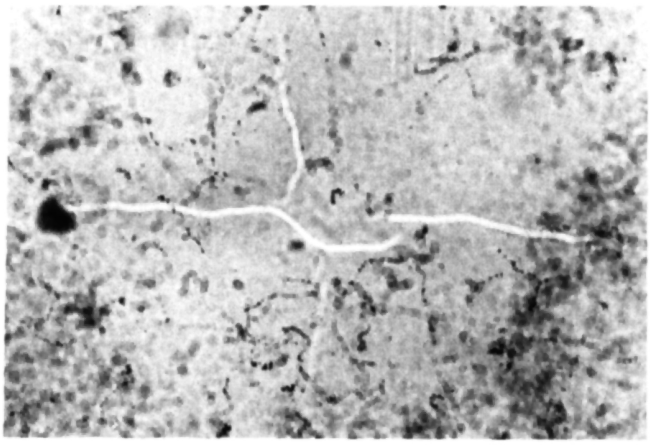
Fig. 3. Meshlike traces with micro-explosions.



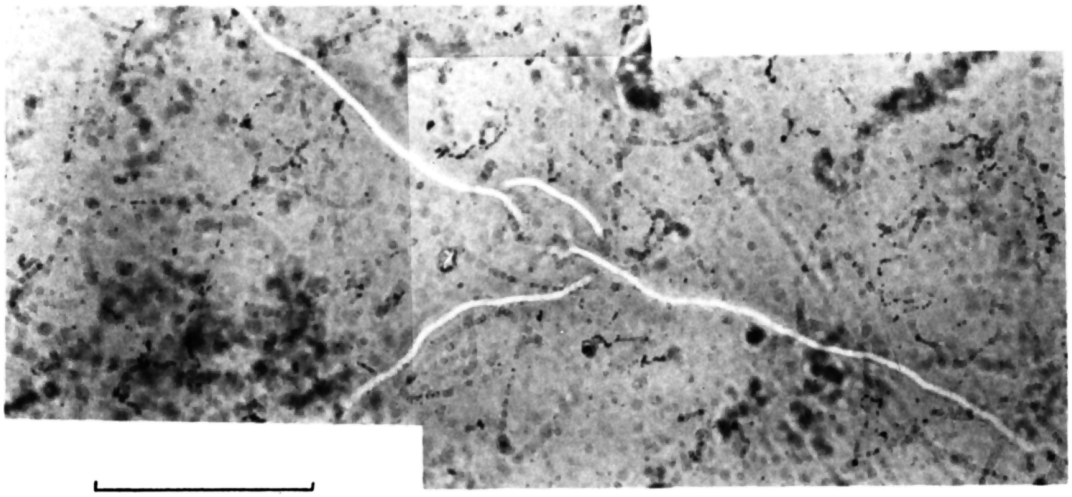
Figs. 4a, 4b, and 4c. Meshlike tracers without micro-explosions.



Figs. 4d and 4e. Meshlike tracers without micro-explosions.



(f)



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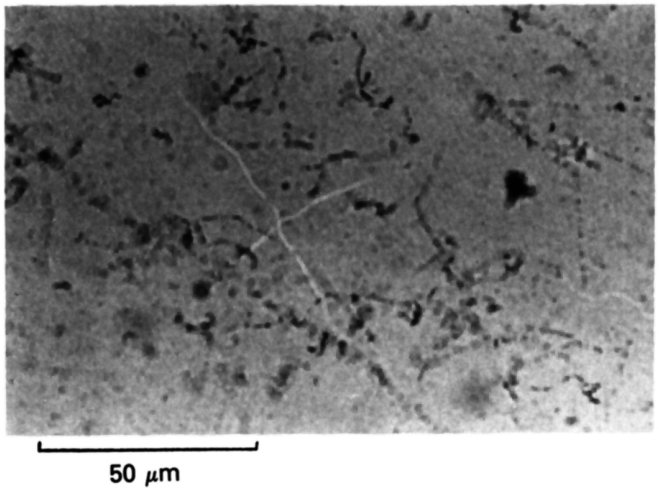
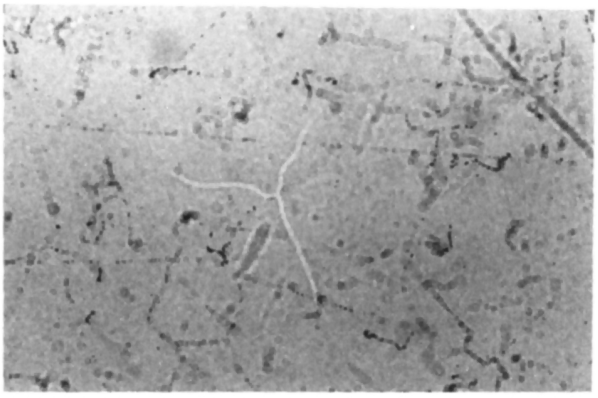
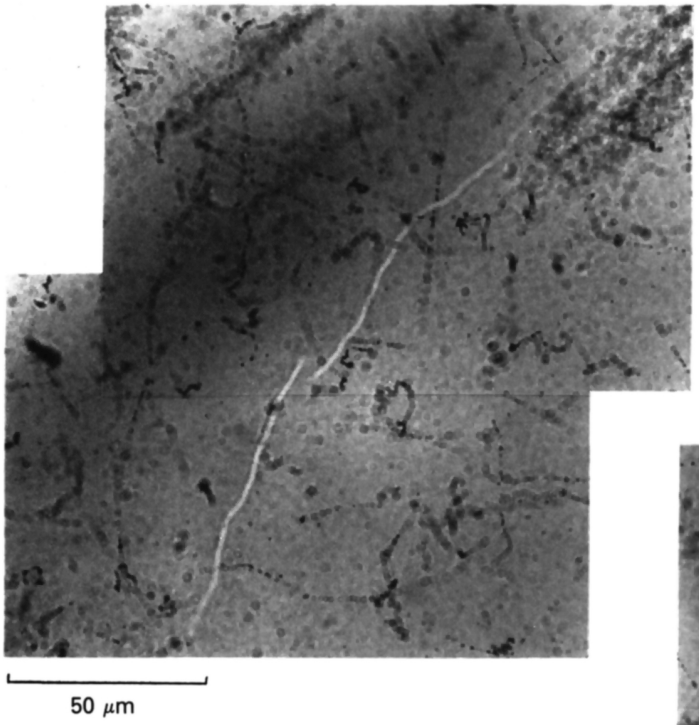


(h)

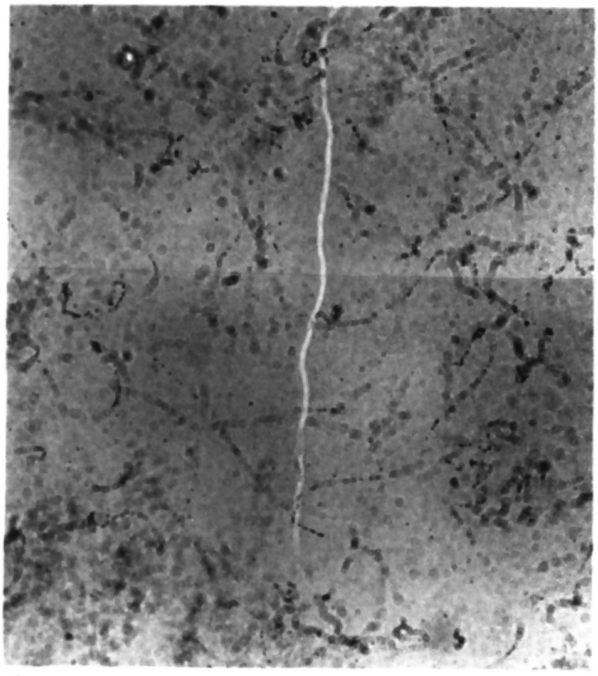
Figs. 4f, 4g, and 4h. Meshlike tracers without micro-explosions.



(i)



(j)



(k)

Figs. 4i, 4j, and 4k. Scraps of meshlike tracers.

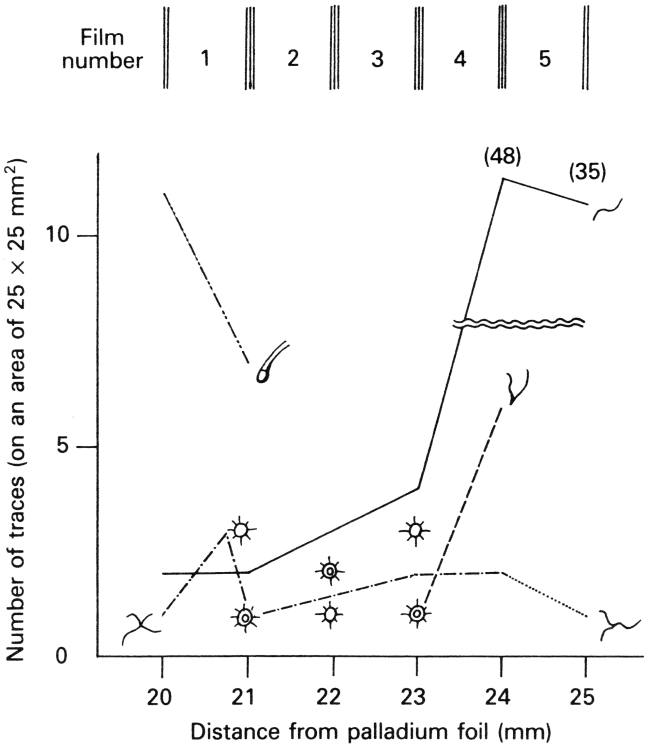


Fig. 5. Spatial distribution of traces.

Figure 6 shows the third type of trace, a curved trace, as was frequently observed on the nuclear emulsions. Similar curved traces produced by multiple small-angle scatterings of protons were observed in a previous experiment,[3] but the curvature rate is significantly larger here.

This suggests that some highly charged particle with low mass might be emitted from the palladium foil.

A fourth type is broad zigzag traces, as shown in Fig. 7. A similar trace was observed in a previous experiment,[8] found among scattered debris produced by the gravity decay

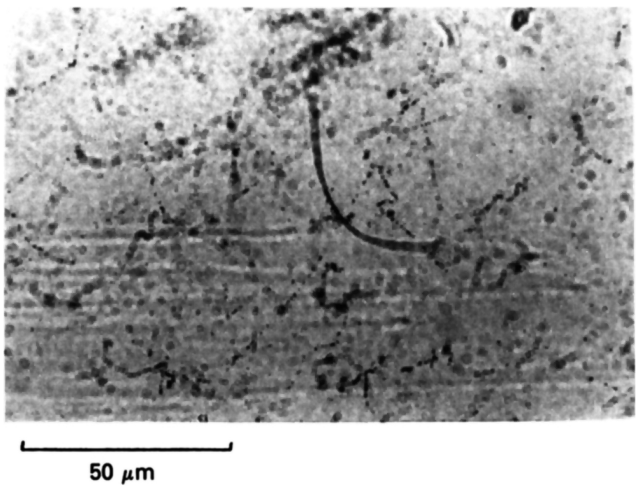


Fig. 6. Curved trace.

of a nucleus with many neutrons. As seen in Fig. 5, this type of trace is mainly observed near the surface of the palladium foil. This means that the particle that causes the fourth type of trace has a fairly short range in the acrylite plates.

The foil method applied here is very reproducible, unlike the rod method,[5] in which the material is frequently cracked during the hydrogen charging. Sixteen experiments have been carried out so far by the foil method, varying the metal, solution, electrolyte, and so on. More than 90% were successful in igniting cold fusion. The nuclear emulsion method was also applied to ordinary water, in which similar phenomena, such as gravity decay and the production and evaporation of black holes, were successfully observed.[9] In another experiment, a strange picture was taken on the back side of the palladium foil by a scanning electron microscope (SEM), as shown in Fig. 8. The itonic linkage can be clearly seen, as explained in the next section.

MECHANISMS FOR THE FORMATION OF ANOMALOUS TRACES

Four types of anomalous traces were described earlier. In this section, the mechanisms that form those traces are explained by the Nattoh model.

Figure 9 shows a conceptual view of the mechanisms that form the meshlike traces. In the first type of trace, the meshlike traces appear to consist of closed links and broken lines. It is reasonable that the outside broken lines are produced by the breakup of the linkage. Therefore, quad-neutrons might be born covered by a mesh of some material. The first type of trace is caused by a micro-explosion due to the gravity decay of an inner quad-neutron. The explosive energy breaks up the linkage of the mesh structure of the covering material.

The mesh of the covering material does not seem very strong, to that the linkage breaks up by itself in a moment. The spontaneous decay of the mesh structure records the second type of trace, i.e., the one with no ring trace of the gravity decay. Simultaneously, the breakup of the mesh emits a bare quad-neutron that can fly a long distance. The gravity decays of bare quad-neutrons were observed on the nuclear emulsions in a previous experiment,[3] located outside the electrolyzing cell.

However, the second type of trace, without ring traces, might be produced by other processes. It is feasible that some particle that causes the second type of trace might be directly produced from the hydrogen-catalyzed fusion reaction, i.e., an intrinsically vacant mesh. The closed linkage of the vacant mesh might break up because of the instability of the material itself. Alternatively, nuclei with many neutrons in the mesh cover might produce the second type of trace. They can be produced by many-body fusion reactions of hydrogen atoms or the hydrogen compression of massive nuclei such as the electrolyte and host metal. When they are transferred to the black holes,[10] no explosive rings are left.

Now the questions are what the cover material with the mesh structure is and how it can be produced. The Nattoh model proposes the hydrogen-catalyzed fusion reaction of Eq. (1) as the elementary reaction during cold fusion, occurring in a hydrogen cluster trapped in a grain boundary. When the pressure of the hydrogen atoms is beyond some value, the hydrogen cluster can be compressed by a self-compression effect, and then the hydrogen atoms in the cluster come very near each other. The electrons of the hydrogen atoms are also compressed between the hydrogen nuclei. Positive charges are

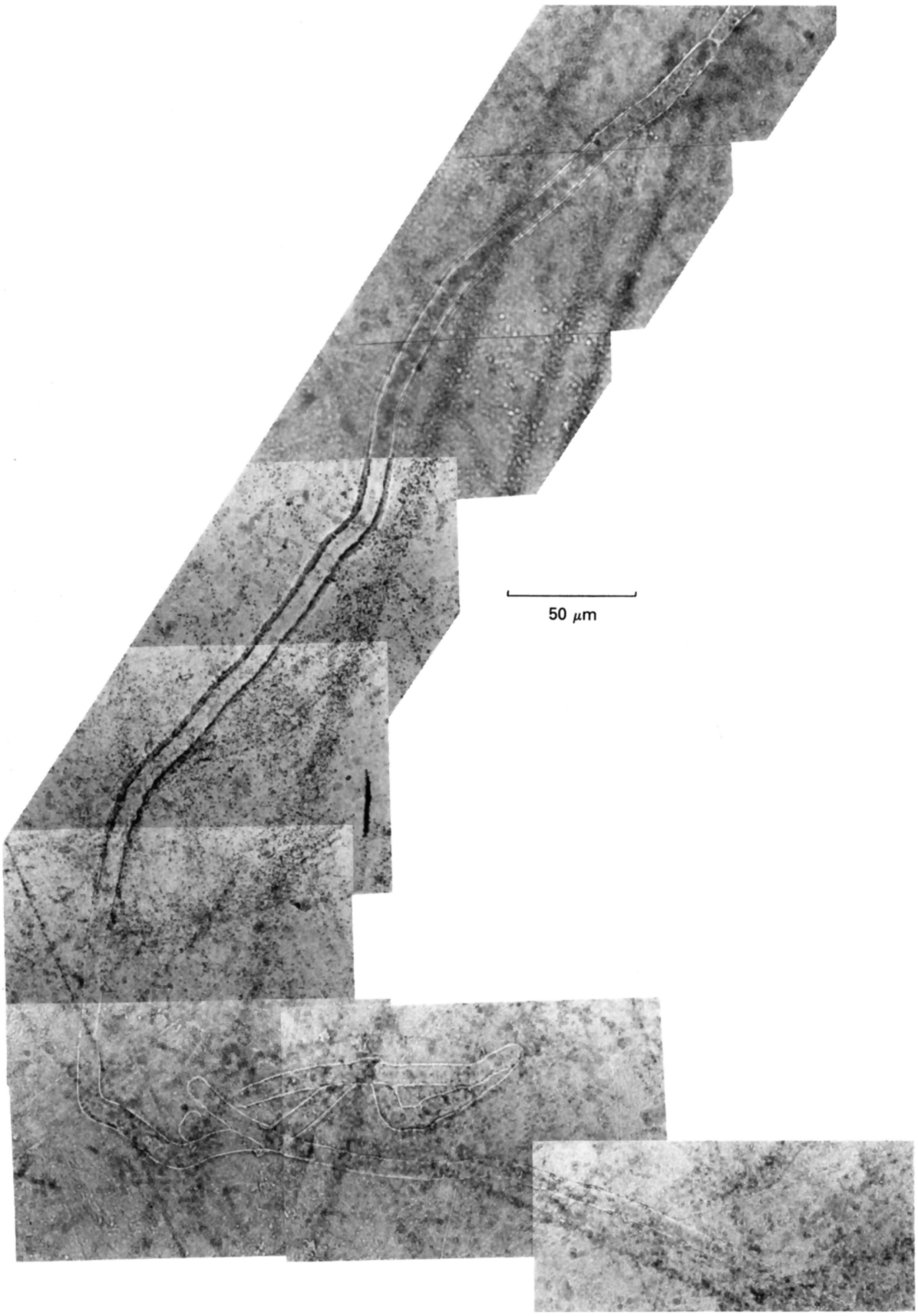


Fig. 7a. Anomalous traces near the surface of the palladium foil.

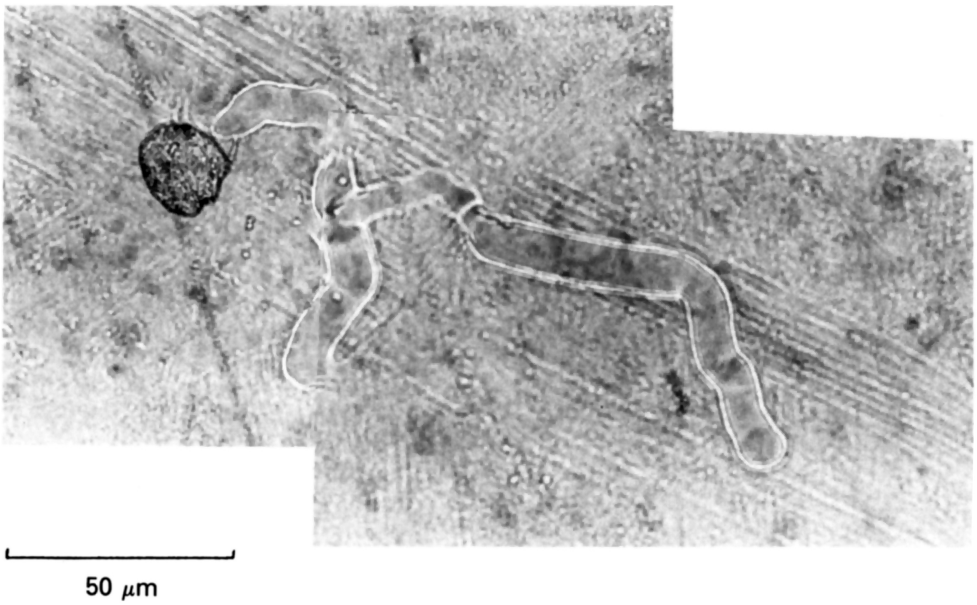


Fig. 7b. Anomalous traces near the surface of the palladium foil.

induced on the surface of the hydrogen nuclei by the negative charges of the compressed electrons that come from the inverse beta decay of neutron to proton. The hydrogen nuclei are now depolarized. The itons are fluctuating quantum mechanically, created or sometimes depleted, and take very short distance interactions between the nuclei.[11]

Figure 10 shows a conceptual view of the two-dimensional arrangement of the hydrogen atoms. In an extremely compressed state of the hydrogen atoms, Fig. 10a, it is very easy for hydrogen nuclei or di-neutrons to pass through the barrier between the nuclei and to fuse with each other. In Fig. 10b, a quad-neutron is produced as well as a hole in the compressed hydrogen cluster after the fusion. The large Q value of the fusion reaction enables one or more itons to be emitted as real particles. The quad-neutron is emitted, covered by itons with a mesh structure. On the other hand, the hole is emitted as an iton bead, which has a vacant mesh structure. The curved trace shown in Fig. 6 might be caused by an iton bead.

The structure of the itons can be determined by the way the hydrogen atoms are packed in the cluster, shown in Fig. 9. If the hydrogen atoms are compressed in a close hexagonal package, the iton beads have a nearly octahedral mesh structure. Alternatively, if the hydrogen atoms are packed in a cubic arrangement, the iton beads have a square mesh structure. While the emitted itons are passing through the acrylite

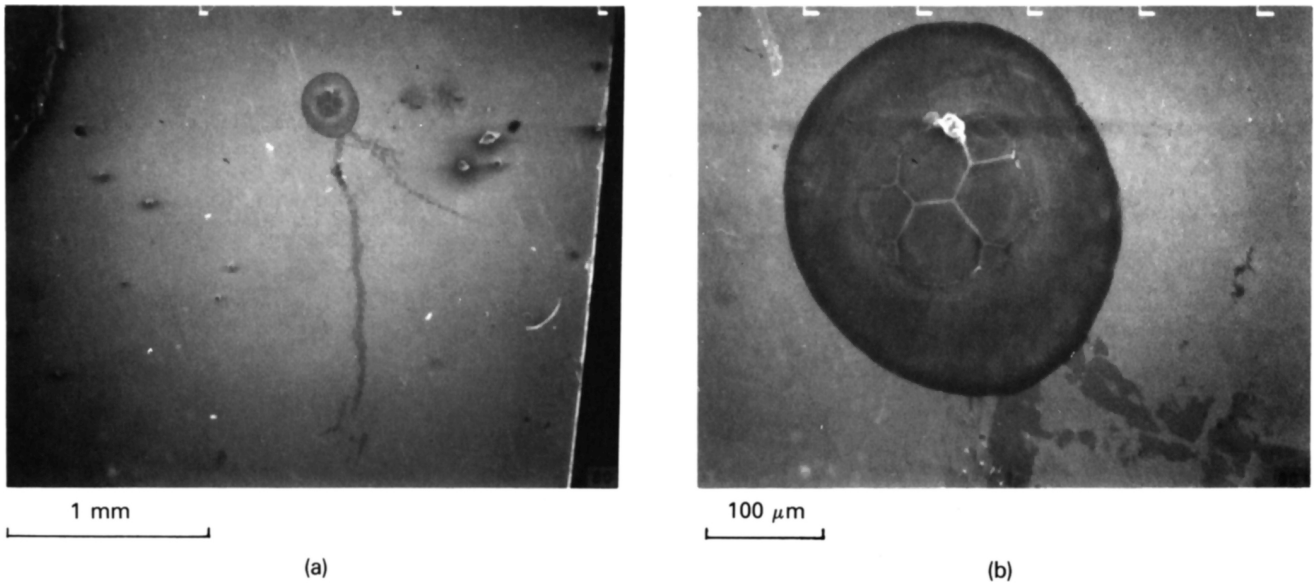


Fig. 8. Strange SEM picture on the back side of palladium foil: (a) assembly with long tails and (b) itonic linkage.

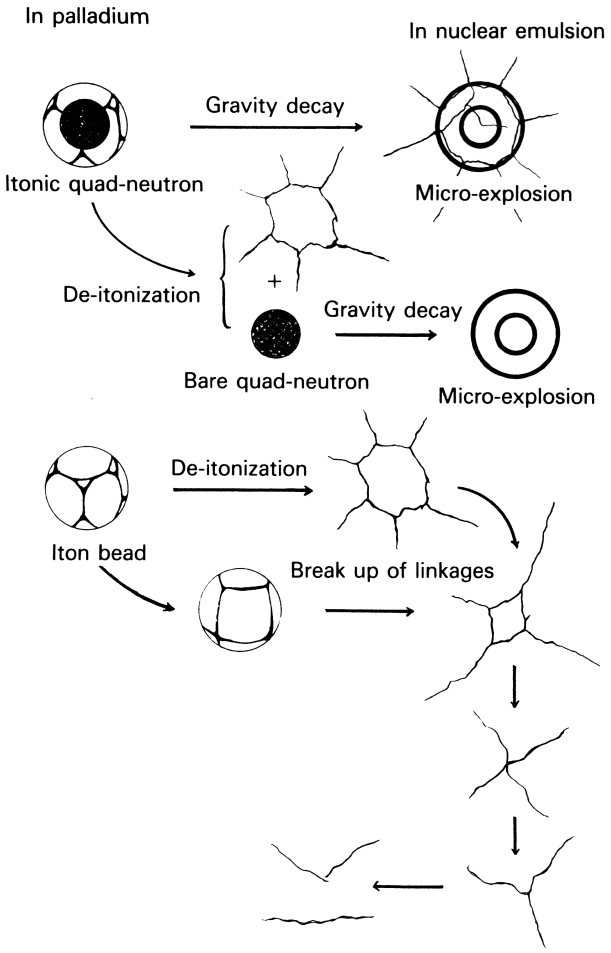


Fig. 9. Mechanisms for forming meshlike traces.

plates, they might undergo "de-itonization," in which electrons, constituents of the iton beads, are torn off by interactions with the material. The mesh structure breaks up, and the amount of linkage decreases, as shown in Fig. 5. After the itons with more linkages decay, one- and two-dimensionally linked itons are sharply built up on films 4 and 5.

A comment should be added to Eq. (1) of the Nattoh model, which produces the quad-neutron. Recently, Miles et al.[12] indicated that ^{4}He rather than ^{3}He is produced in significant amounts during cold fusion. The ^{4}He production rate seems to nearly correspond to that of heat. This experimental result seems inconsistent with Eq. (1). However, in Fig. 9, the hydrogen atoms that are extremely compressed in the cluster are depolarized, as mentioned earlier, but the states of the hydrogen atoms are fluctuating quantum mechanically; i.e., they become deuterons or di-neutrons. Therefore, some variations should be added to the hydrogen-catalyzed fusion reaction; for example,

$$2\mathrm{D} + e + \mathrm{D} \longrightarrow {}^4\mathrm{He} + i_1 + {}^2n \qquad (2)$$

$$\longrightarrow {}^4\mathrm{H} + i_1 + d \qquad (3)$$

$$\longrightarrow {}^4\mathrm{He} + e + \bar{\nu}\ . \qquad (4)$$

The branching ratio of Eq. (2) might be the largest among the hydrogen-catalyzed fusion reactions so that ^{4}He can be produced in significant amounts. Here, ^2n might be emitted, or alternatively, a positron needed to form an iton might be supplied from another deuteron. On the other hand, ^{4}He might be confused with tritium because of the beta decay. One reason the tritium production rate has been reported to be several orders higher than that of neutrons might be contamination by ^{4}H (Ref. 13).

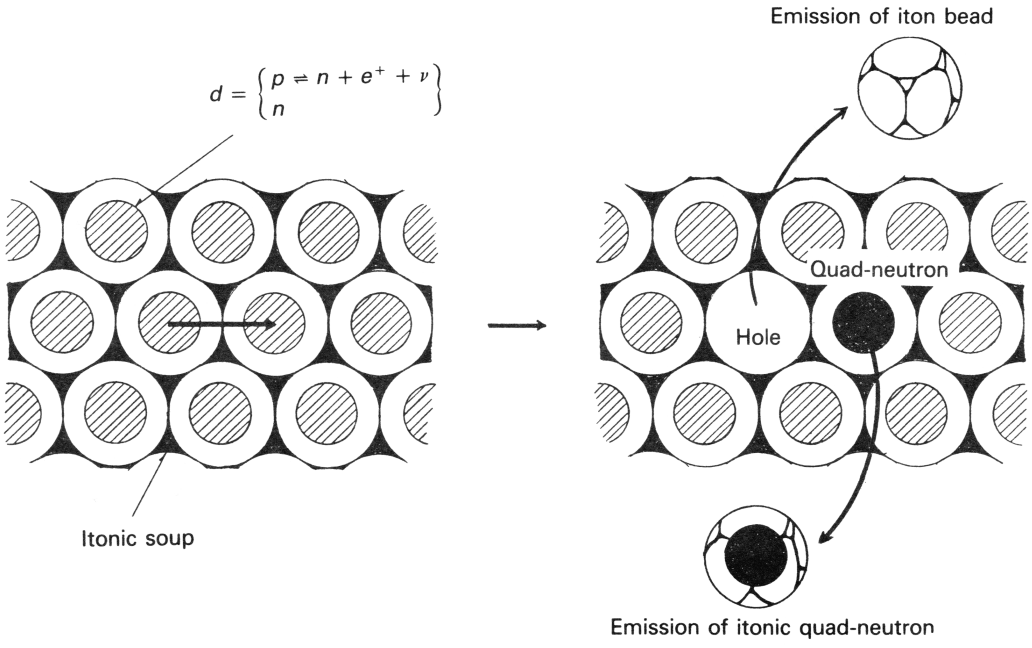


Fig. 10. Two-dimensional arrangement of compressed hydrogen atoms.

The fourth type of trace was observed near the palladium foil, as shown in Fig. 7. If the traces are recorded by a particle, its range in the acrylite plates should be very short. A similar trace was observed in an earlier experiment[8] placed far away from the palladium rod and behind the electrolyte solution and glass cell. The anomalous trace was found among the debris produced by the gravity decay of a nucleus with many neutrons. Therefore, it is reasonable to suggest that the anomalous traces might be recorded by an unknown particle that is produced during gravity decay. However, no similar traces were observed to be associated with the gravity decay of quad-neutrons. The particle should be heavy such that more energy than the mass energy of four neutrons is needed to be produced. The particle might be the "X" particle that is considered to have been emitted early on during the birth of the universe. To produce the X particle, extremely high energy should be supplied, more than $\sim 10^{15}$ protons or 10^{13} palladium nuclei. It seems difficult to compress so many protons during cold fusion. However, grain-shaped defects were observed by SEM (Ref. 14) that correspond to the disappearance of >1 μg of palladium, i.e., 5×10^{16} nuclei. Therefore, the X particle might be produced from the gravity decay of nuclei with a very large number of neutrons, which can be formed by compressing palladium in grain-shaped defects.

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Ref. (34)

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COLD FUSION

TECHNICAL NOTE

KEYWORDS: *cold fusion, ordinary water, nickel foil*

COLD FUSION EXPERIMENTS WITH ORDINARY WATER AND THIN NICKEL FOIL

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Cold fusion experiments with ordinary water and thin nickel foils are described. The temperature variation and the surface condition of the foils are examined. It has been proven that ordinary water can produce excess heat. Furthermore, reaction products are recorded on nuclear emulsions. Charged particles, electrons, protons, and deuterons, are observed. Micro-explosions caused by gravity decay of neutron nuclei are also recorded. Many traces indicating tiny black holes and white holes are clearly observed. The mechanisms of cold fusion with ordinary water are discussed in terms of the Nattoh model.

INTRODUCTION

Cold fusion experiments are currently carried out with heavy water because Fleischmann and Pons[1] and Jones et al.[2] stated that cold fusion occurred only with heavy water. However, the Nattoh model predicts that cold fusion can take place by the same mechanisms as the hydrogen-catalyzed fusion reaction with both heavy and ordinary water.[3] Extraordinary signals indicating the occurrence of cold fusion with ordinary water have been measured.[4] Recently, Mills and Kneizys[5] reported that excess heat could be produced as soon as electrolysis with ordinary water starts when a thin nickel foil is used for the cathode. They proposed a new chemical reaction, the shrunken molecule model. Noninski[6] and Bush[7] followed with further experiments with ordinary water. Bush proposed the mechanisms of nuclear transmutation from potassium to calcium. That explanation is now controversial.

The Nattoh model is based on only one hypothesis—that hydrogen clusters, consisting of more than two hydrogen atoms, that are trapped in tiny cavities, such as grain boundaries, defects, and interfaces in metal, compress themselves to induce hydrogen-catalyzed fusion reactions when the hydrogen pressure exceeds some critical value under electrical current flow. Previous cold fusion experiments with heavy water and palladium foil showed that three quad-neutrons and a higher multiple-neutron combined with each other and simultaneously decayed.[8] This observation clearly indicates that a self-compression effect of the hydrogen clusters does exist in the palladium metal.

When a metal with lower hydrogen permeability, such as nickel, is used for cold fusion experiments, hydrogen clusters might be formed on the surface of the metal to induce cold fusion by the overpotential of the electrolysis. This technical note describes cold fusion experiments with ordinary water and thin nickel foils. The temperature variation and the surface condition of the foils are examined. Also, reaction products are measured by nuclear emulsions. The cold fusion mechanisms for the system are also discussed.

EXPERIMENTS

Cold fusion experiments with ordinary water were carried out by the electrolysis method. Thin foils of nickel metal were used as the cathode.

The experimental arrangement was analogous to that used in a previous experiment.[9] The hydrogen atoms were charged into a thin nickel foil (50- × 50-mm^2 cross section, 40-mm effective diameter, 0.10-mm thickness). A solution of ordinary water mixed with 0.50 mol/ℓ potassium carbonate was mainly used. The 50 ml of solution was contained in a glassy cell. A helical 0.5-mm-diam platinum wire was used as the anode. An anode of three parallel 0.5-mm-diam platinum pins was also tested. The current was changed stepwise from ~0.3 to 3.0 A and the corresponding bias from ~3.7 to 7.6 V. Temperature variations in the nickel foil, solution, and atmosphere were measured by thermocouples. The reference temperature was measured by locating a resistance heater in the cell. After the charging, all the foils were examined by an optical microscope. To directly measure the reaction products, 30 nuclear emulsion plates (50- × 50-mm, 100-μm-thick MA-7B provided by Fuji Film) were located under the nickel foil. As a reference, three nuclear emulsion plates were located ~5 m away from the electrolyzing cell in the same room. After they were developed, the nuclear emulsions were examined by an optical microscope (×50).

RESULTS

Temperature

Figure 1 shows the temperature deviations of the potassium carbonate solution and the nickel foil for three experiments.

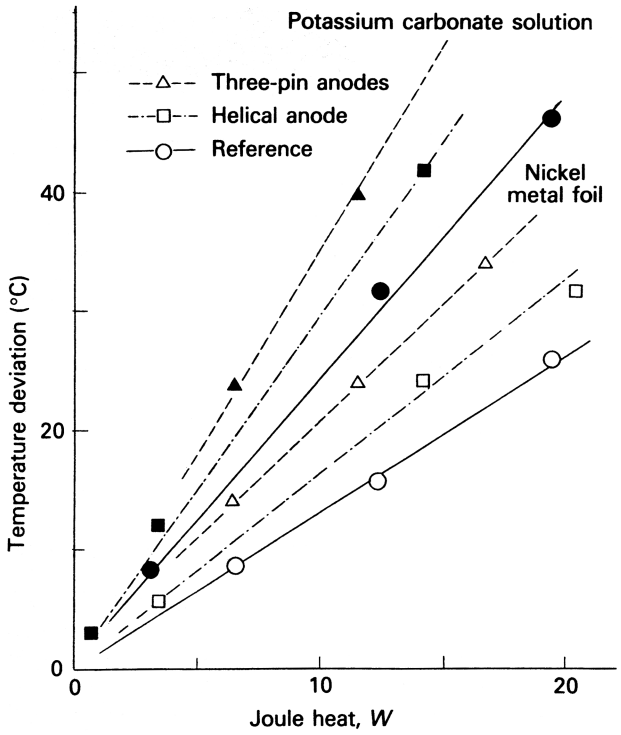


Fig. 1. Temperature variation for nickel foil and ordinary water.

Since the nickel foil was conducted with the atmosphere, the two temperatures were different. The temperatures were subtracted from room temperature, which remained <2°C for 7 h. The Joule heat was calculated from the equation $W = I(V - 1.48)$, where 1.48 V is consumed for decomposing water. By comparing the temperature with the reference, the excess heat was obtained, ~40%. In Fig. 1, the temperature increase is also shown for the three-pin platinum anode. The anode consisted of three parallel 0.5-mm-diam × 15-mm-long pins that were separated by ~9 mm from each other. The excess heat with the pin anode is higher than that with the helical wire anode.

Optical Microscope Observations

The surface condition of the foils was examined with an optical microscope after the charging. For the potassium carbonate solution, the front surface of the foils was covered by deposited materials, but the back surfaces were hardly changed. Many circular spots with various colors were observed on the deposited layers of the front surface, as shown in Fig. 2. These circular spots were distributed over the front surface and suggested a local and rapid temperature increase. To prove that the circular spots were caused by local discharging, a platinum pin anode was tested; however, there were no similar spots. It is reasonable to consider that these spots might have been produced by the local burning of cold fusion.

For reference, a 0.55 mol/ℓ sodium chloride solution was also tested. Thin hydrided layers were partly formed on the front surface of the nickel. Many colorful rings were recorded on the back surface of the nickel foil that can be classified into the two groups shown in Figs. 3a and 3b. The rings shown in Fig. 3a might be micro-explosions caused by the gravity decay of the neutron nucleus, while the ring shown in Fig. 3b might be an erosion pit. This is discussed later.

Observation of Nuclear Emulsions

Several kinds of traces were recorded on the nuclear emulsions. First, three kinds of charged particles, protons, deuterons, and electrons, were observed. Protons and electrons were also observed on the reference emulsions. However, the number densities of these particles were much higher for the irradiated emulsions than that for the background, and they decreased as the thickness of the nuclear emulsions increased. Thus, it was obvious that the particles were produced during cold fusion and penetrated through the nickel foil. Figure 4 shows traces of deuterons. Deuterons were mainly recorded on the front surface of the first nuclear emulsion, but a few traces were observed at a greater depth. Figure 4b shows a trace of a scattered deuteron. The emission of these

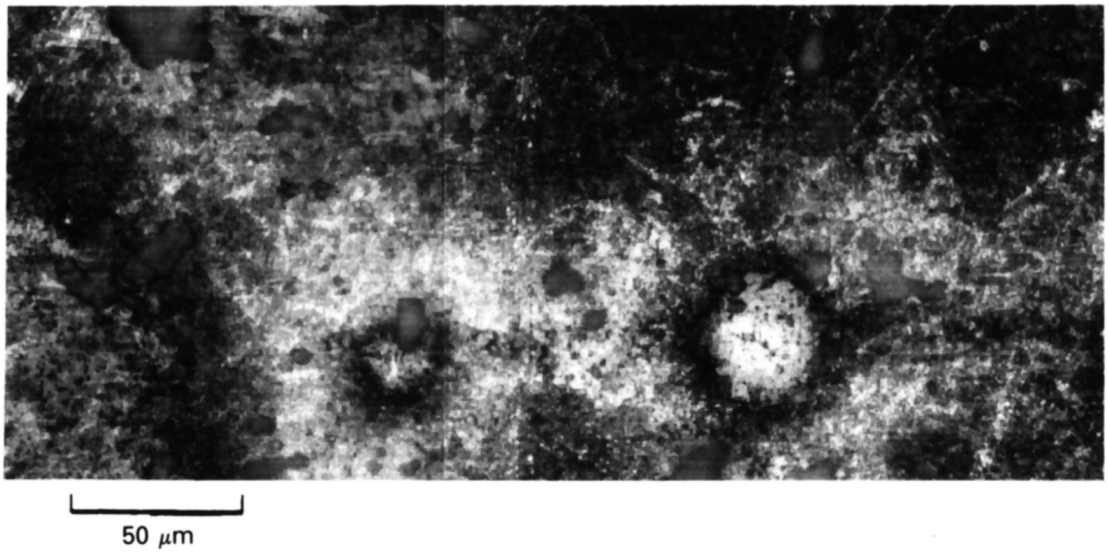


Fig. 2. Circular spots on the front surface of nickel foil with potassium carbonate solution.

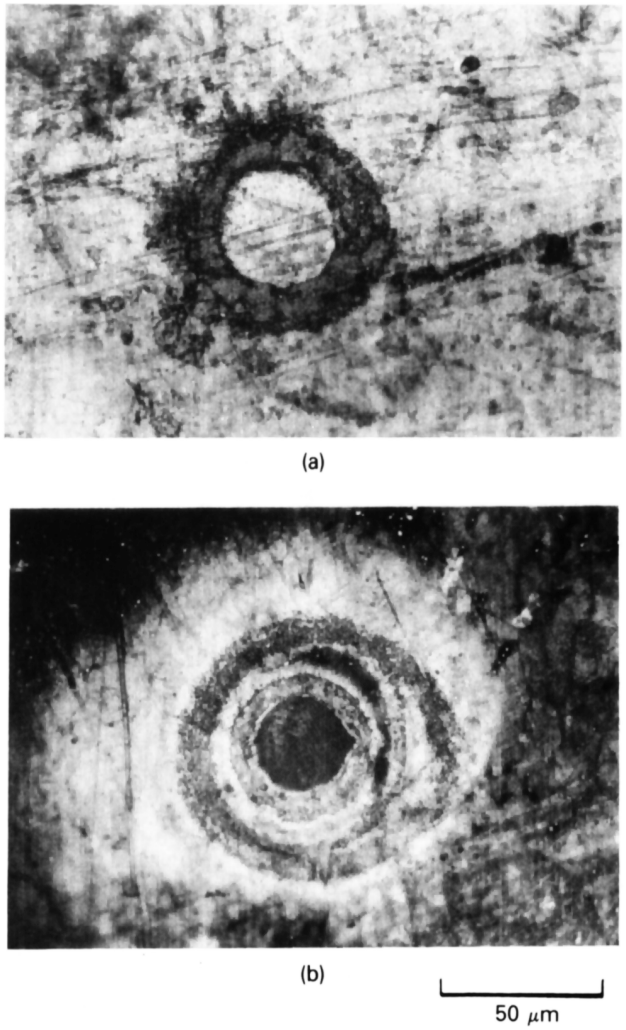


Fig. 3. Rings on the back surface of nickel foil with a sodium chloride solution: (a) micro-explosion ring and (b) erosion ring.

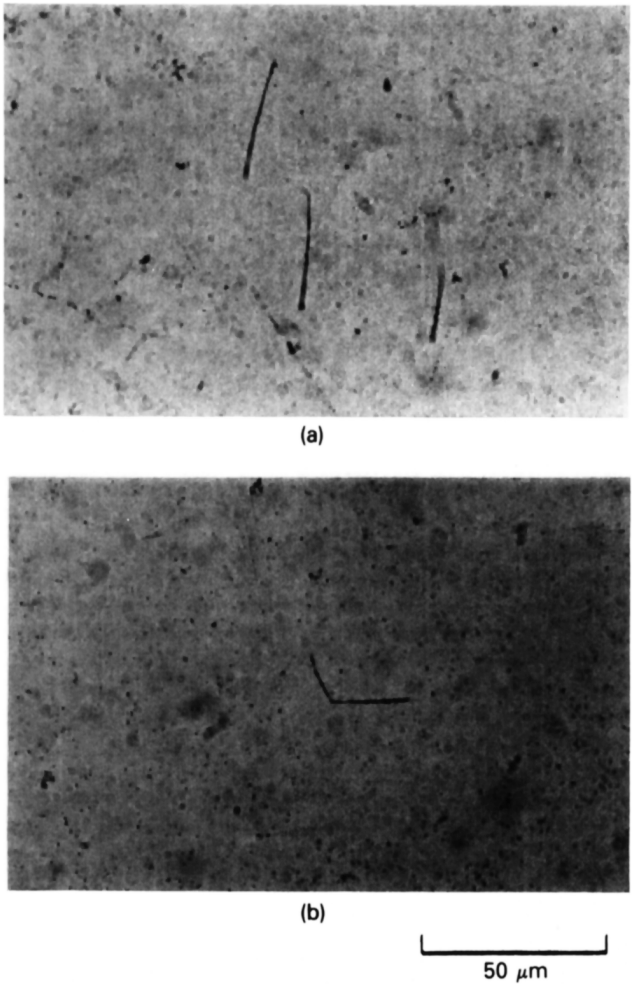
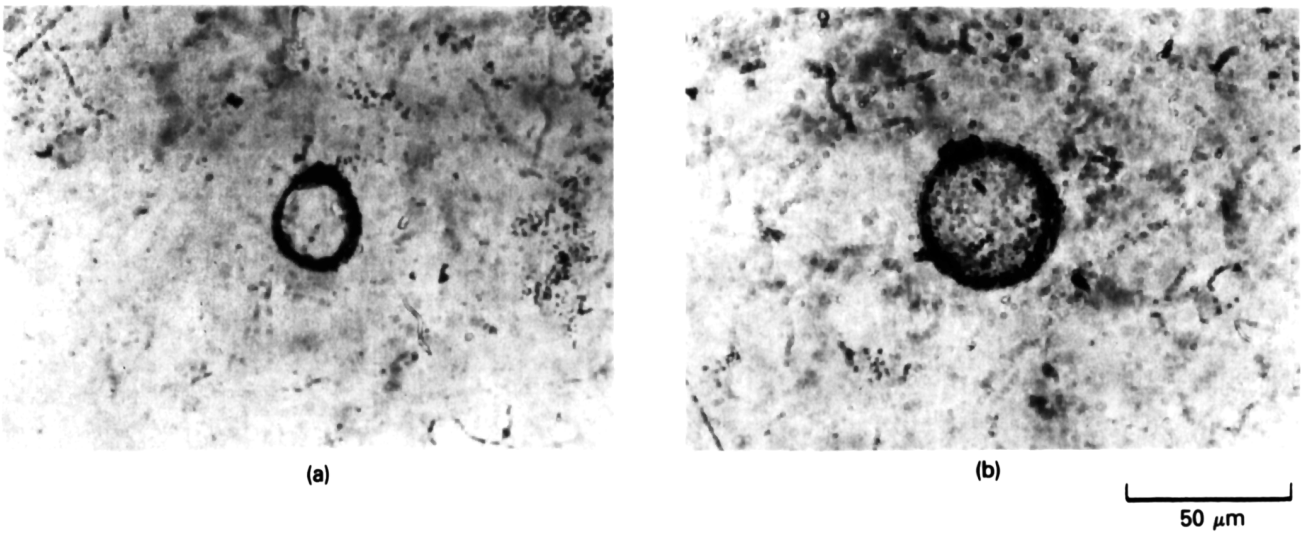


Fig. 4. (a) Deuteron and (b) scattered deuteron.

particles was predicted by the Nattoh model. [See Eqs. (2), (3), (4), and (5) in the next section]. On the other hand, electrons can be released by the breakup of itons.[10] Alternatively, a micro-explosion of a neutron nucleus can emit electrons. In Fig. 4a of Ref. 8, the emission of atomic electrons of the nuclear emulsion was clearly observed on the front surface of the shock wave caused by a micro-explosion.

Second, micro-explosions of neutron nuclei were observed. The single and di-neutrons that are produced by Eqs. (1), (4), and (5) in the next section are "fermented" and collapse by self-gravity like quad-neutrons.[11] Figures 5a and 5b show micro-explosion rings caused by gravity decay of single or di-neutrons. Not all the mass of the collapsed neutrons is necessarily transferred to energy; some is transferred to the unknown gravity decay products. The rings shown in Fig. 5c are associated with widely distributed materials that might have been produced by the gravity decays of a combined single and di-neutron that can be caused by simultaneous fusion reactions.[8] Furthermore, Fig. 5d shows another product, strings, that might be linked to the superstrings that spout from a white hole. Larger micro-explosions have been observed, as shown in Fig. 6. They may have been caused by the gravity decays of multiple-neutrons that can be produced by many-body fusion reactions.[12] Figures 6a and 6b show traces caused by quad-neutrons frequently observed for heavy water[8] that were obtained by transmitted and reflected light, respectively. In Fig. 6b, colorful Newton rings can be observed. Figure 6c shows the gravity decay of multiple-neutrons. These micro-explosions have high energy so that they can be recorded not only on the nuclear emulsions but also on the metal foil. The circular spots on the front surface of the nickel foil shown in Fig. 2 and the ring on the back surface shown in Fig. 3a are caused by micro-explosions of the neutron nuclei.

Third, many traces indicating tiny black and white holes were observed on the front surface of the first emulsion, as shown in Fig. 7. A tiny black hole was expected to be generated from the collapse of multiple-neutrons that might be produced from massive nuclei such as the host metal and the electrolyte. The evaporation of tiny black holes has been successfully observed in heavy water.[8] Figure 7a shows Hawking radiation at the evaporation of a tiny black hole, which is similar to the traces observed in the previous experiment with heavy water.[8] However, the traces shown in Figs. 7b through 7o were first observed in this experiment. The traces



Figs. 5a and 5b. Gravity decay products: micro-explosion of single or di-neutrons.

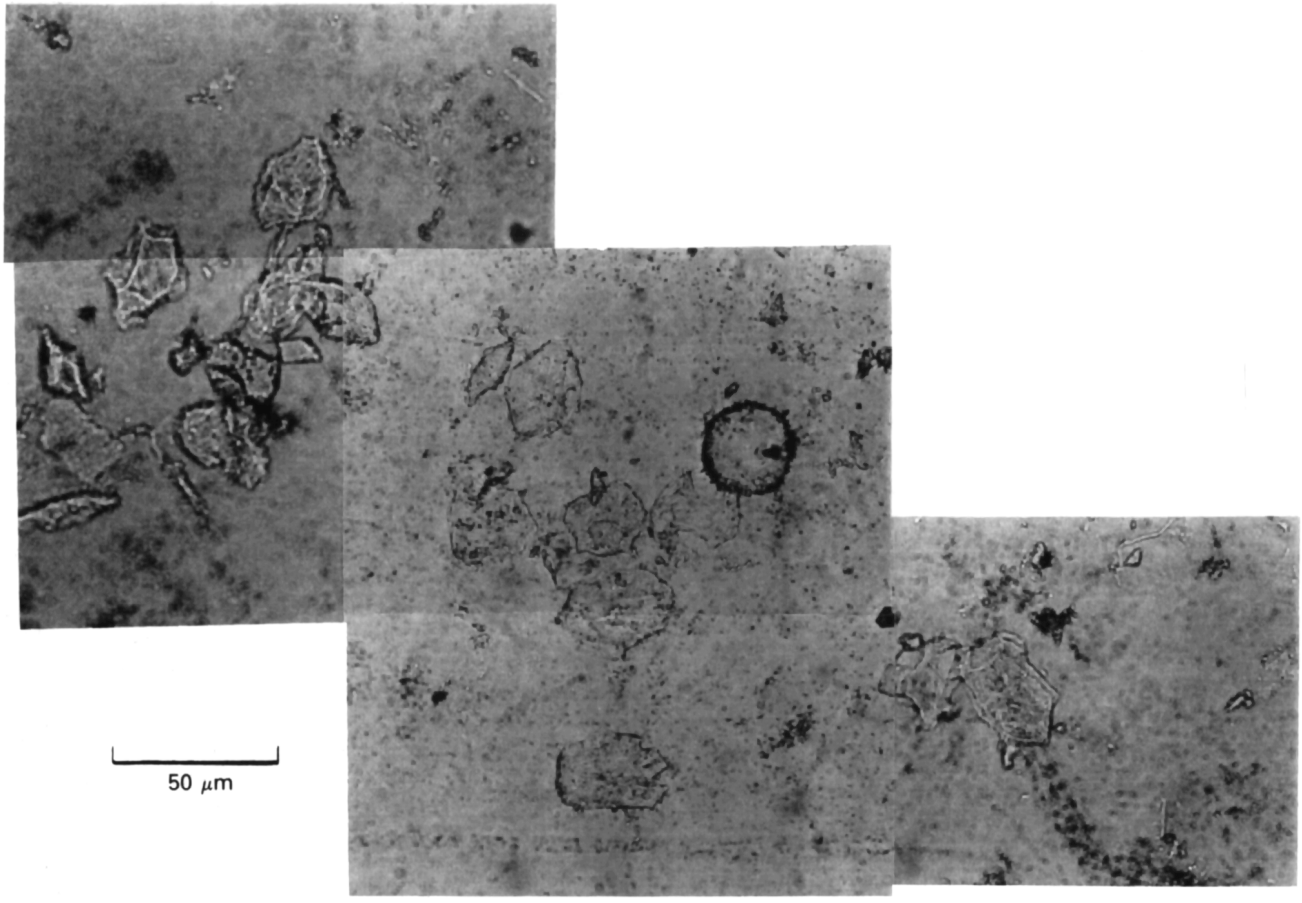


Fig. 5c. Gravity decay products: micro-explosion associated with gravity decay products.

in Figs. 7b through 7f, vertical views, show a typical feature of the black hole, the conic shape. Materials seem to spout energetically from the bottom of the cone. The traces shown in Figs. 7g through 7l have little shape variation, and the traces shown in Figs. 7m, 7n, and 7o are bottom views of the black holes.

It is reasonable to consider that the traces shown in Figs. 7b through 7o were not caused by materials spouting

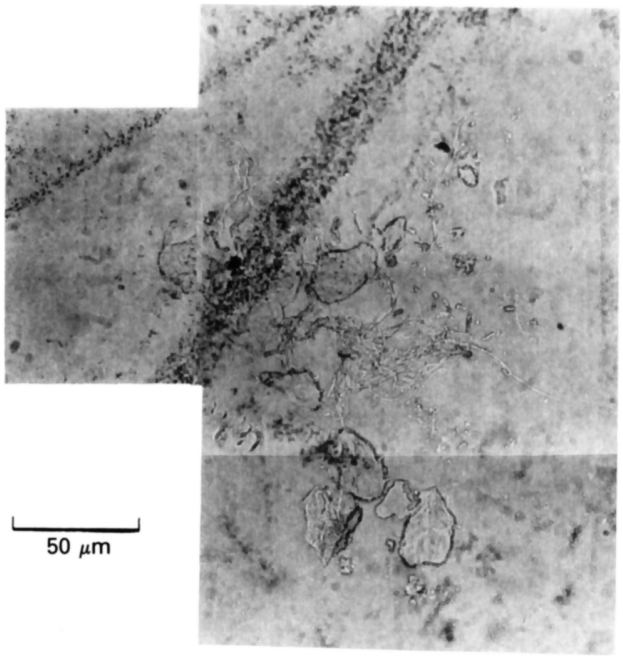


Fig. 5d. Gravity decay products: gravity decay products with strings.

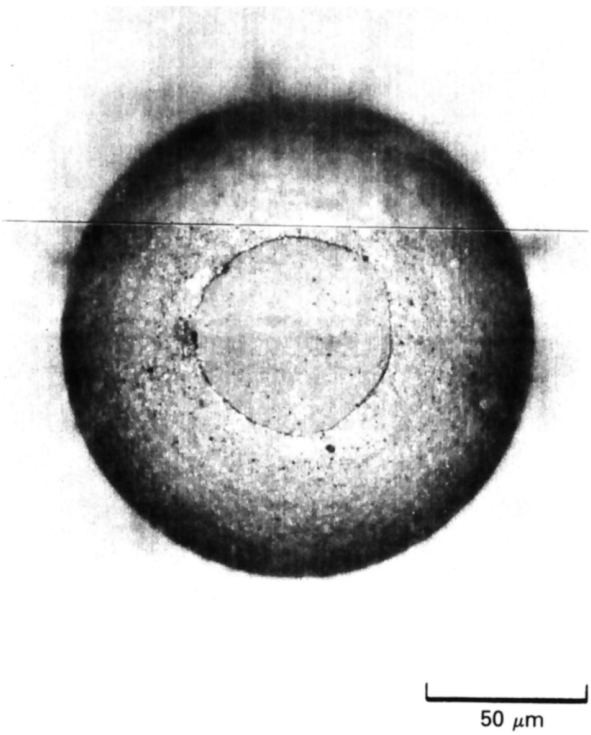


Fig. 6b. Micro-explosions by multiple-neutrons: micro-explosion of quad-neutron (with reflected light).

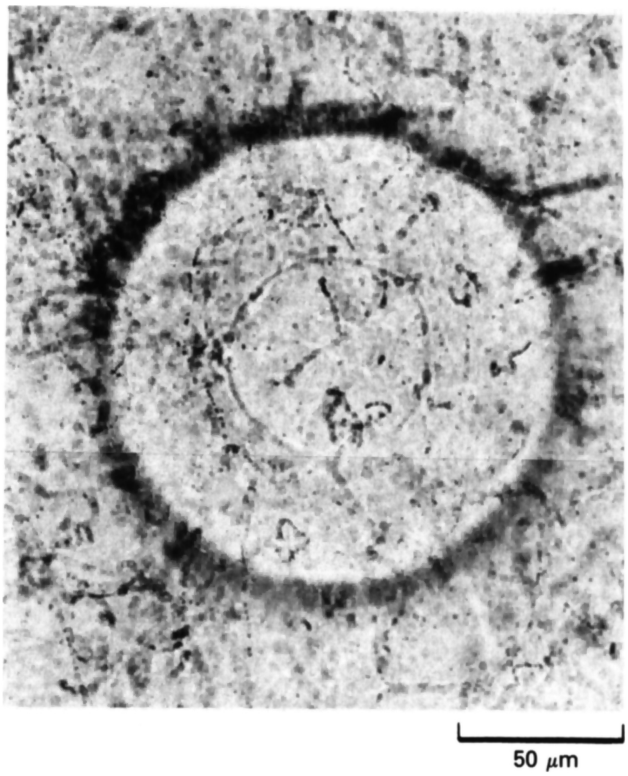


Fig. 6a. Micro-explosions by multiple-neutrons: micro-explosion of quad-neutron (with transmitted light).

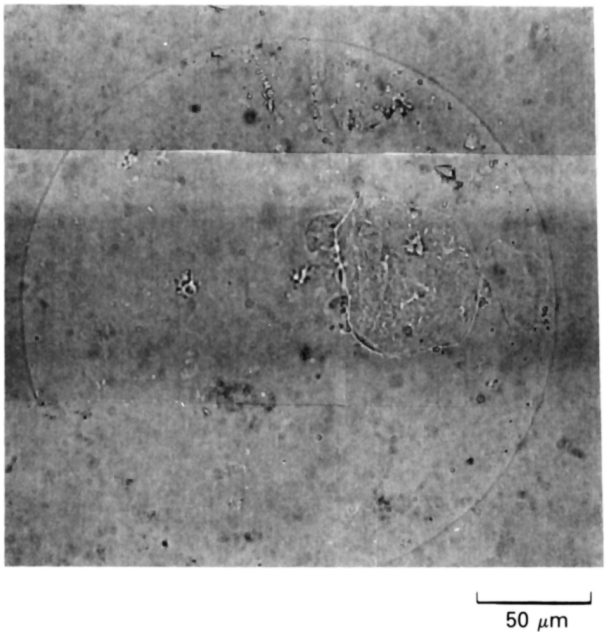


Fig. 6c. Micro-explosions by multiple-neutrons: micro-explosion of multiple-neutron.

from the entrance of the black hole but rather from the exit of the black hole, i.e., the white hole. The situation can clearly be seen in Fig. 7i, in which the evaporation of the black hole and the exhaust from the white hole were simultaneously recorded on the nuclear emulsion. Thus, the tip of the cone shown in Figs. 7b through 7l should be the material-absorbing point. The absorbed materials, after they are broken down, should spout from the bottom of the cone.

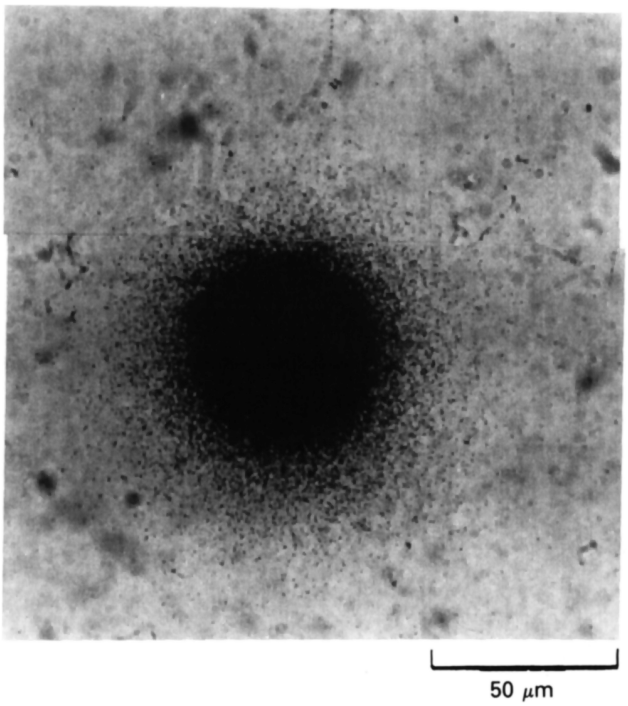


Fig. 7a. Tiny black and white holes: top view of black hole.

Fourth, a star might be produced by a collision between multiple-neutrons and the nuclei of the nuclear emulsion. For heavy water, four stars were successfully observed on nuclear emulsions.[13] For ordinary water, it can be expected that single or di-neutrons or multiple-neutrons can generate stars on the nuclear emulsions. Figure 8 shows a star that was recorded on the front surface of the first emulsion.

Lastly, strange traces were observed on the front surface of the first emulsion, shown in Fig. 9, that were never observed in the previous experiments with palladium foil.[8,9,13] When a metal foil with lower hydrogen permeability such as nickel is used, the hydrogen cluster is compressed on the metal surface to form an extremely small assembly by the self-compression effect.[14] A single assembly could be of the order of $<10^{-8}$ cm even if millions of hydrogen atoms were compressed because the itonic interaction range might be of the order of 10^{-11} cm (Ref. 14). The assembly can easily penetrate through the metal barrier. After penetration, the assembly would rapidly expand to scatter many hydrogen atoms because the itonic cover fades somewhat. The traces shown in Figs. 9a, 9b, and 9c might be caused by those scattered itonic hydrogen atoms. When the hydrogen cluster is so compressed as to be condensed, some structure could be constructed, as water vapor is condensed into frost. Traces like frost can be seen inside an envelope in Figs. 9a and 9b. The "hydrogen frost" could become droplets as it expands; these can be seen among the widely scattered itonic hydrogen atoms, as shown in Fig. 9c.

EXPLANATIONS BY THE NATTOH MODEL

In this section, the mechanisms for cold fusion with ordinary water and thin metal foil are explained by the Nattoh model. First, the fundamental reactions of cold fusion with ordinary water should be considered. The Nattoh model is based on the hydrogen-catalyzed fusion reaction, which is caused by the self-compression effect of the hydrogen cluster.[14] Thus, cold fusion can take place in ordinary water as well as in heavy water. Since the hydrogen atoms and electrons involved in the reaction are plural, many variations can occur in the hydrogen-catalyzed fusion reactions. The main reactions for ordinary water can be written as follows:

for the emission of a single iton i_1:

$$2\mathrm{H} + e + \mathrm{H} \rightarrow {}^2\mathrm{He} + i_1 + {}^1n \quad (1)$$

$$\rightarrow \mathrm{D} + e^+ + \nu \quad (2)$$

$$\rightarrow \mathrm{D} + i_1 + p \ , \quad (3)$$

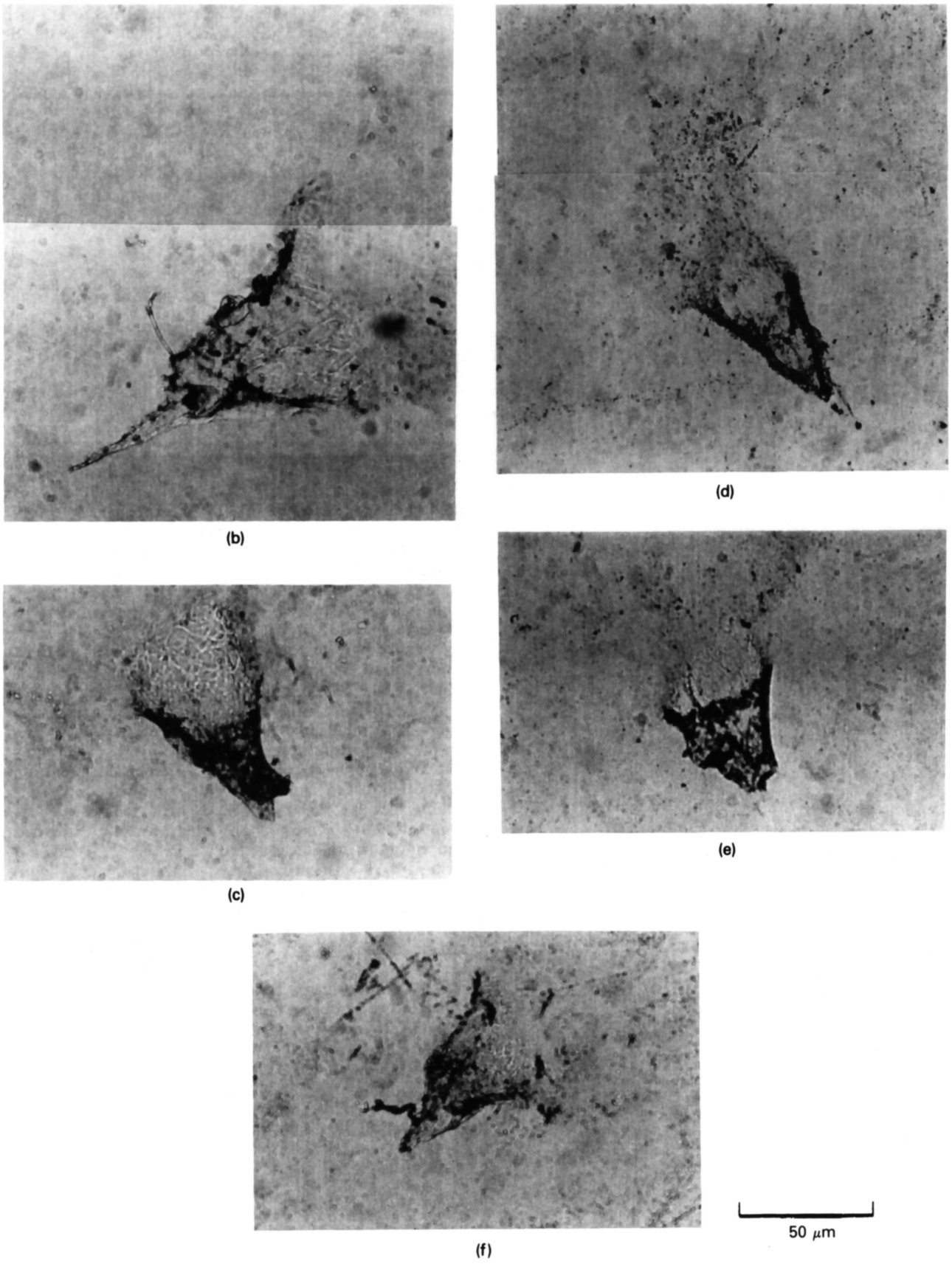
for the emission of a double iton i_2:

$$2\mathrm{H} + 2e + \mathrm{H} \rightarrow {}^2n + i_2 + p \quad (4)$$

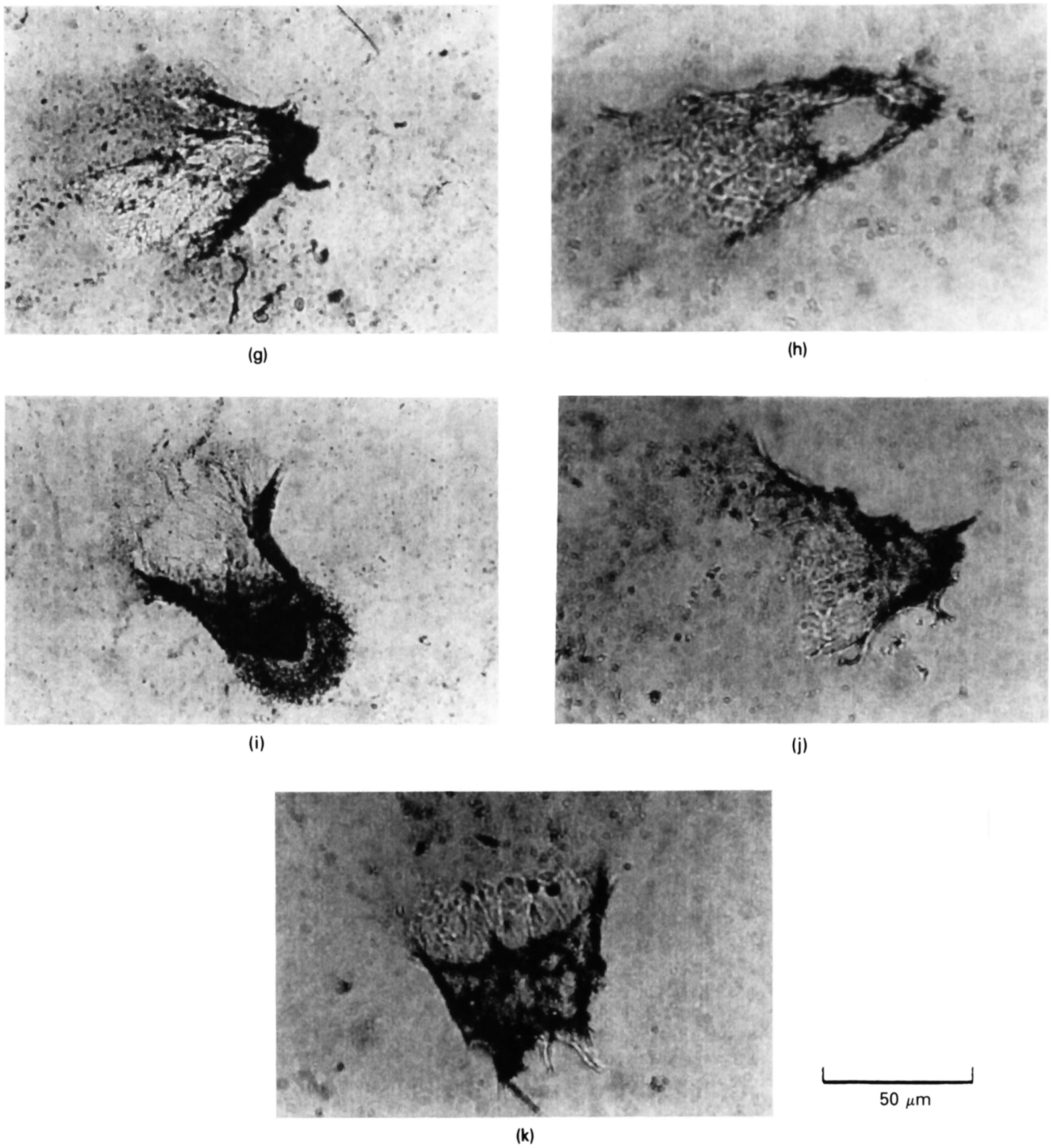
$$\rightarrow \mathrm{D} + i_2 + {}^1n \quad (5)$$

where the strange products ${}^1n$ and ${}^2n$ are fermented single and di-neutrons, respectively. The itons are found to cover up the fusion products in the previous experiment.[9] The prediction of ^{2}He might be contradicted by Pauli's selection rule, but here the itonic cover might allow it to exist for a moment. Furthermore, the fermented neutrons shrink and finally undergo gravity decay. Gravity decays of the fermented neutrons have been observed in the second traces in the preceding sections. When the nuclei of the metal or solution are surrounded by a hydrogen cluster, multiple-neutrons might be produced[12] that can be collapsed into a tiny black hole. The tiny black hole instantaneously evaporates with the Hawking radiation or changes into a white hole and contributes to heat production; these traces have also been observed on the nuclear emulsions of the third traces.

Second, let us consider regions in which these reactions can be maintained. For a metal with lower hydrogen permeability, such as nickel, thin layers of hydrogen clusters a few atoms thick are formed on the surface, where the hydrogen concentration is high enough to induce self-compression of the hydrogen clusters. For a metal rod, high-energy hydrogens produced in Eqs. (2), (3), (4), and (5) can cause additional hydrogen-catalyzed fusion reactions so that the chain reactions of the hydrogen atoms can be maintained under certain conditions.[15] For a thin metal foil, on the other hand, the chain reactions might be somewhat limited by the leakage of the high-energy hydrogen atoms from the foil. The range of the hydrogen atoms is hundreds of microns in the metal hydride, so that the thickness of the foil is an important factor. Fortunately, the hydrogen chain reactions have a very high multiplicity, unlike the neutron chain reactions in a fission reactor, so that they could well be maintained two-dimensionally on the surface. Alternatively, cold fusion might be maintained even without the chain reactions. It was found that nickel atoms can be picked up by the hydrogen atoms, and this leaves pits on the surface.[16] Hydrogen clusters can probably be formed in the pits and surround the heavy nuclei of the nickel metal and electrolyte. Here, the hydrogen-catalyzed fusion reactions can be maintained by the supply of hydrogen atoms externally from the electrolyte solution. This is why cold fusion is ignited as soon as the charging starts, unlike in palladium.



Figs. 7b through 7f. Tiny black and white holes: vertical view, conic shape.



Figs. 7g through 7k. Tiny black and white holes: vertical view, variational shape.

DISCUSSION

Cold fusion experiments with ordinary water have been described. It has been proven that cold fusion really does occur with ordinary water to produce excess heat, as previously predicted.[4] Measurements with nuclear emulsions have verified that charged particles, such as electrons, protons, and deuterons, and neutron nuclei are produced during cold fusion. The fundamental reaction during cold fusion is neither the conventional fusion that dominates in high-temperature plasma nor the new chemical reaction proposed by Mills et al.[5] It is a new fusion reaction, i.e., the hydrogen-catalyzed fusion reaction that was proposed by the Nattoh model.

The difference between nickel and palladium foils is remarkable. For the thin palladium foil, hydrogen atoms can easily penetrate through the foil so that cold fusion reactions

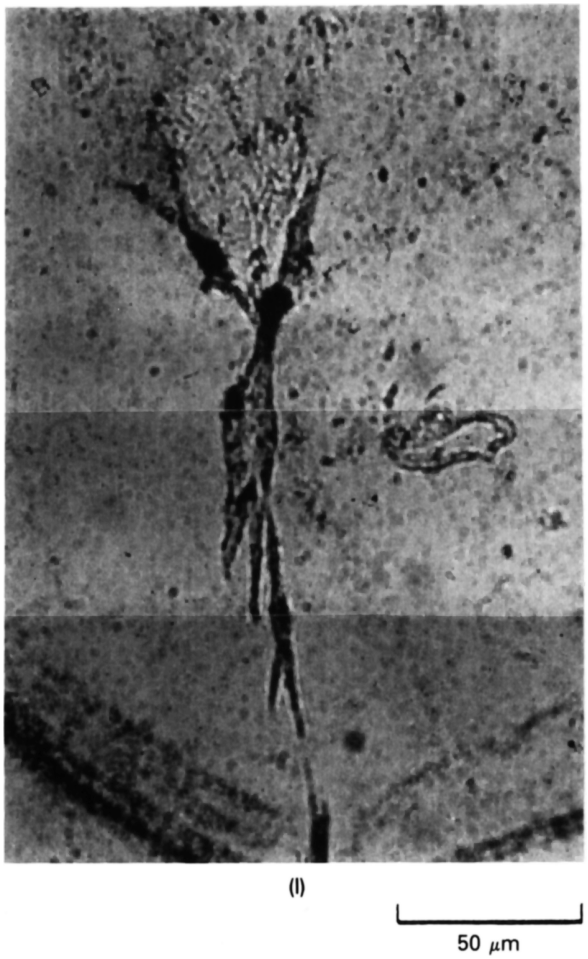
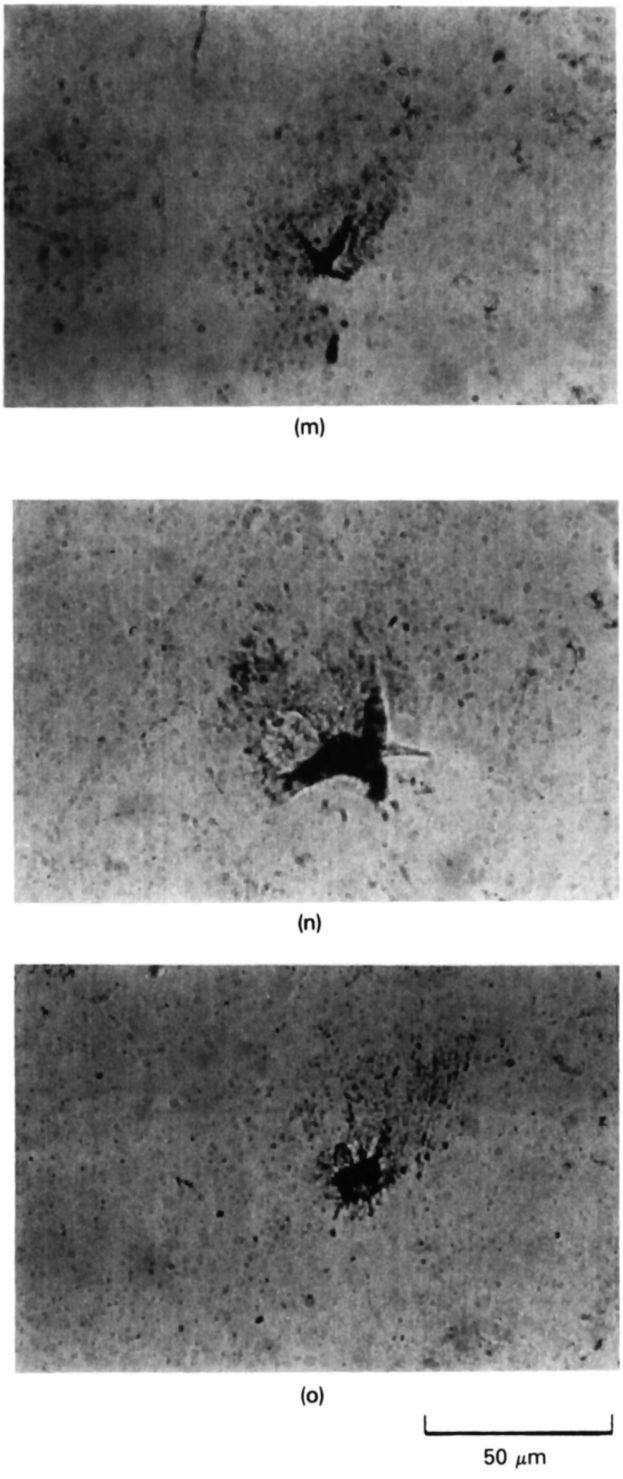


Fig. 7l. Tiny black and white holes: vertical view, variational shape.



Figs. 7m, 7n, and 7o. Tiny black and white holes: bottom view.

take place all over the foil including near the back surface. However, for nickel, with low hydrogen permeability, the hydrogen atoms are trapped on the front surface of the foil, so that cold fusion predominantly takes place on the surface. Here the reaction products should penetrate through the foil to be recorded on the nuclear emulsions. In particular, the itonic nuclei that are heavily charged might be stopped in the foil. This is why no traces of the breakup of itonic beads and micro-explosions of the itonic nuclei were observed on the nickel foil, unlike palladium. On the other hand, hydrogen frosts were found for the first time during this experiment. They were not observed in the previous experiment with palladium.[9] This inconsistency might be caused by thin protection sheets that were usually located on each nuclear emulsion. In this experiment, no sheet was placed on the front surface of the first nuclear emulsion so that the particles could directly be detected.

Gravity decays of neutron nuclei and the production of stars were observed as associated reactions during cold fusion. It is especially remarkable that many tiny white holes were discovered. The tiny white hole has spouting and conic zones. The nucleons that are absorbed in the black hole are violently destroyed so that unknown tiny materials such as superstrings might spout from the white hole. White strings can be seen in the spouting region of the white hole, for example, in Fig. 7c, and they might be something linked to superstrings. On the other hand, the conic zone of the white hole seems highly reactive, so that it is recorded on the surface of the emulsion. The tiny black hole might have a reactive filmlike zone around the horizontal zone of the event.

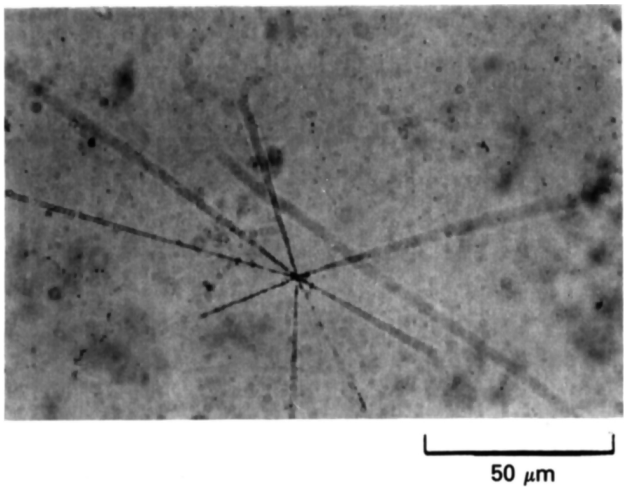
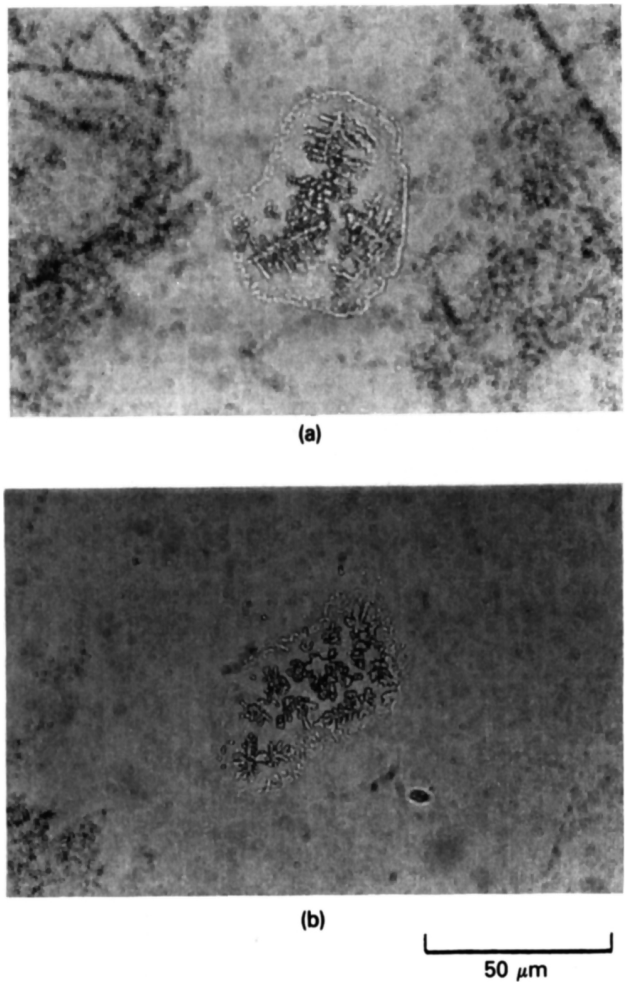


Fig. 8. Star (long traces are partly omitted).



Figs. 9a and 9b. Scattered itonic hydrogen atoms: frost.

It seems difficult to accept that gravity decay takes place on the neutron nucleus because the gravitational force is 40 orders of magnitude less than the comparably weak electromagnetic force. It should not be understood that the gravitational force predominantly works itself to collapse as soon as the neutron nucleus is produced. On the birth of the neutron nucleus, the itonic mesh covers it up so that it would not scatter neutrons, and it compresses the nucleus to destroy its nuclear structure. As the shrinking of the nucleus progresses, the gravitational force effectively begins to work on it. Finally, gravity decay takes place. As micro-explosions of neutron nuclei without an iton were found,[11] the compression process can somewhat be maintained initially after the breakup of the itonic mesh. Recently, traces of the white holes have been reproduced in an experiment involving alternating current charging with titanium bolts.[17] Tiny sparks have been observed, and the traces resulting from the sparks are very similar to those found in the white holes observed in this experiment.

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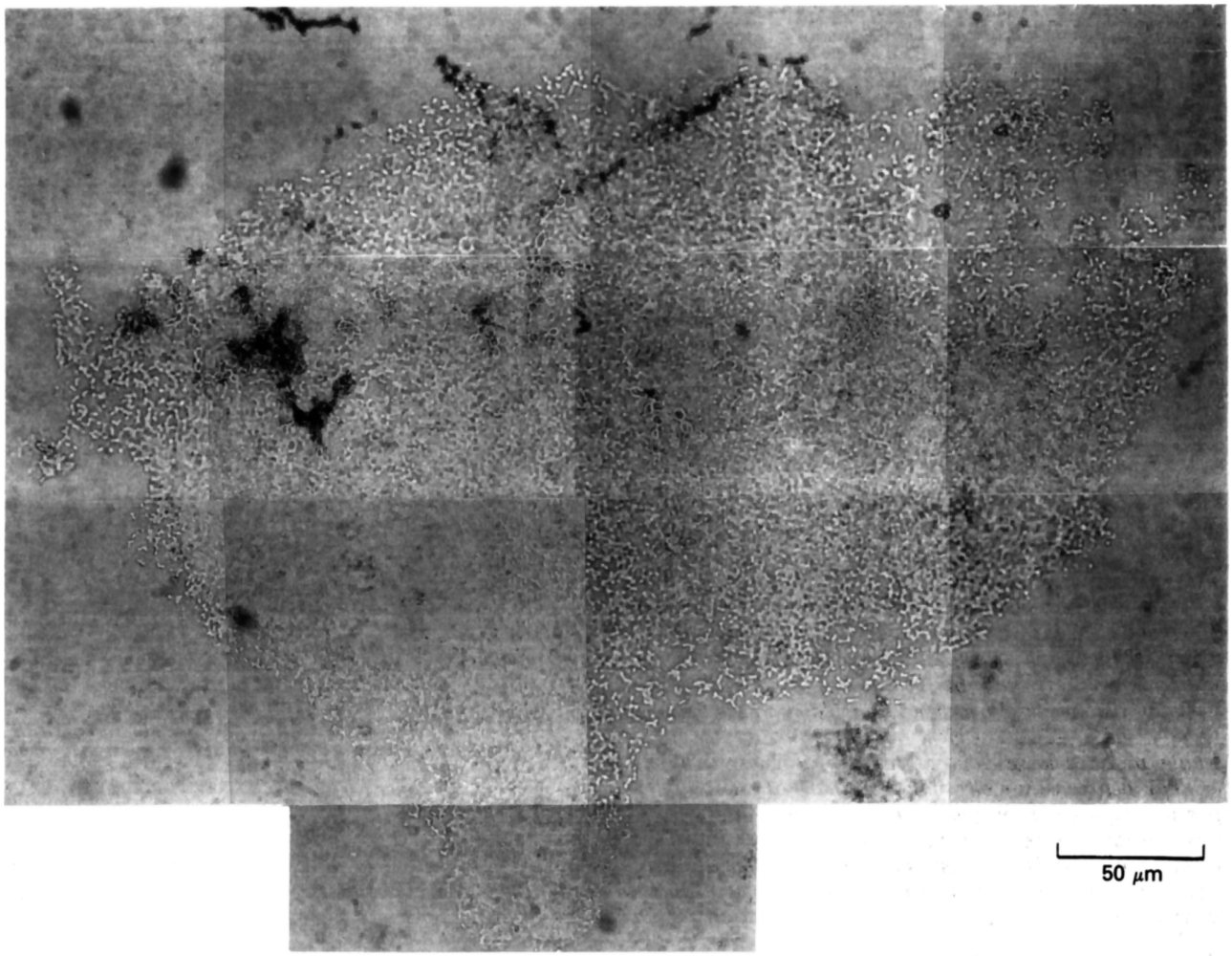

Fig. 9c. Scattered itonic hydrogen atoms: droplets.

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ANS Reprint

COLD FUSION

TECHNICAL NOTE

EXPERIMENTS OF ONE-POINT COLD FUSION

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KEYWORDS: *one-point cold fusion, di-neutron, itonic hydrogen cluster*

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Experiments of one-point cold fusion have been performed by electrical discharging in ordinary and heavy water mixed with 0.6 mol/ℓ potassium carbonate. A platinum pin anode was located perpendicular to a copper plate cathode. After discharge, the surfaces of the copper plates were examined by an optical microscope. Many ring spots caused by gravity decay of single and di-neutrons were separately distributed on the plates. Furthermore, several kinds of traces that might be produced by itonic hydrogen clusters and by tiny black and white holes were observed. The mechanisms of cold fusion by electrical discharge are also discussed in terms of the Nattoh model.

INTRODUCTION

There are several ways of performing cold fusion: electrolysis,[1,2] gas loading,[3] and ion induction.[4] Among these, the electrolysis method has been widely applied to obtain excess energy. The distance between the electrodes is a critical factor, and explosions have sometimes been experienced with a short distance.[5] These have been regarded as hydrogen gas explosions because hydrogen gas evolves in the air during electrolysis. However, these explosions might instead be caused by other reactions that contribute to the excess energy. A previous experiment[6] showed that more excess energy was produced when an anode made of three platinum pins is used at which small and local electrical discharges might easily occur.

The Nattoh model[7] proposes that cold fusion is based on a new "hydrogen catalyzed" fusion reaction. This is induced by the self-compression of hydrogen clusters, in which electrical current also plays an important role in forming itonic meshes that compress the hydrogen cluster to cause fusion reactions.[8] Therefore, an electrical discharge can be expected to enhance cold fusion reactions. Furthermore, by employing a pin anode, the position at which cold fusion occurs will be clearly specified so that the mechanisms of cold fusion can be investigated in detail.

This technical note describes experiments of one-point cold fusion in which a platinum pin anode was employed. Many ring spots, indicating the gravity decay of cold fusion products such as di-neutrons, were observed. Furthermore, traces suggesting itonic hydrogen clusters and tiny black and white holes were also observed. The mechanisms of cold fusion by electrical discharge are discussed in terms of the Nattoh model.

EXPERIMENTS

Experiments of one-point cold fusion were performed by electrical discharging in both ordinary and heavy water.

The discharge cell was similar to that used in the previous experiment.[7] The 0.6 mol/ℓ potassium carbonate solutions of ordinary and heavy water were used for the electrolyte solution. A 0.5-mm-diam platinum pin was located perpendicular to the cathode of a copper plate. The effective length of the pin was ~1 to 5 mm, and its tip was ~1 to 2 mm away from the surface of the cathode. The distribution of the reaction products was very sensitive to the size of the length and the gap. Copper plates (mainly 0.20 × 65 × 65 mm) were set at the bottom of a glassy cell after they were finely polished with 1-μm diamond paste and cleaned in an ultrasonic bath. A 5-mm-thick × 72-mm-diam single-crystal copper plate was also used that was produced by slowly cooling a molten metal in a cylindrical graphite cell with a conic bottom. The copper plate was cut from a single-crystal rod such that the surface was near the (311) plane. The single-crystal plate was used for another purpose, which was not achieved. It was, however, useful for clearly recording traces of reaction products on the surface because it has fewer defects. The (311) plane was near the bottom plane of the rod.

Copper was selected for three reasons: It has low hydrogen permeability but high electrical conductivity and good sensitivity to energy deposit. The first property causes a high hydrogen concentration on the surface, which effectively causes cold fusion. On the other hand, copper is somewhat corrosive in the electrolyte solution, so that it is sensitive to the energy deposit.

An electrical discharge was employed in the solutions, in which pulsed alternating current (ac) currents of ~70 to 90 V were applied. An ON mode ran for 20 ms (50 Hz), and an OFF mode followed for 5 s. The phase of the ac was fixed

to zero so that the pulsed current started with positive polarity. The discharge was maintained for 5 to 20 min.

RESULTS AND CONSIDERATIONS

After the electrical discharge, the surfaces of the copper plates were examined by an optical microscope (× 50). Several reaction products were successfully observed.

The surface of the single-crystal copper plate that was discharged in ordinary water with 70 V is shown in Fig. 1; the copper plate was set vertically to avoid trivial deposits on the surface. Cold fusion products were separately distributed in several circular zones, according to their masses. In central zone A, there was a clean region where the deposits had been flushed away by shock waves produced by the electrical discharge. There was an ~45-mm-diam × 52-mm-deep hole in the center of zone A that was produced by the electrical discharge. The other deposits were located near the hole. They were solidified debris of platinum that were molten from the anode during discharge. In zone B, many ring spots were distributed, as shown in Fig. 2a. The shape and magnitude of the spots were regular so that they could easily be distinguished from irregular circular spots that were produced by a bubble of the solution. The ring spots were very similar to traces that were observed in the previous experiment.[6] Therefore, the ring spots can be considered to be micro-explosions caused by the gravity decay of di-neutrons. Figure 2b shows the ring spots linearly distributed on a dislocation line. Since the di-neutrons are heavily charged with the itonic mesh, they might easily be caught in a gap in the dislocation line.

In zone C, there were also many ring spots, as shown in Fig. 3. The ring spots were smaller than those in zone B. The smaller spots can be considered to be micro-explosions caused by the gravity decay of single neutrons. Because of their lower mass, they were scattered farther than the di-neutrons. In zone C, there were also circular spots slightly apart from the others, as shown in Fig. 4. Many of these had no rings, so that they might have been caused by single neutrons in which the itonic mesh had faded away. In zone D, many tiny spots were distributed, as shown in Fig. 5. They might be electrons or itons because they have the lowest mass.

An electrical discharge was then carried out in heavy water, and the voltage was changed from 70 to 90 V. A discharge with 100 V was also tried, but the pin cathode was melted in some of the ac shots. The reaction products significantly depended on the applied voltage. Figure 6 shows very strange traces that were recorded on a 0.20-mm-thick polycrystalline copper plate with 70 and 90 V, respectively. They were not found on nuclear emulsions in the previous experiment[7] but were first observed in discharges with the higher voltages. The shape and magnitude of the traces varied greatly. They seemed to be the breakup of clusters. It is reasonable to consider these as the breakup of itonic hydrogen clusters.[7] The mechanism of forming those clusters is explained later. Figure 7 shows various breakups of itonic hydrogen clusters that were obtained by the discharging with 90 V. The single-crystal copper plate was used, but the crystal structure had no significant effect. The traces show that the compressed hydrogen cluster was just then breaking up because of inner explosions.

When the voltage was raised to 90 V, the ring traces disappeared, but different kinds of traces were observed. Figure 8 shows the tiny holes that were frequently recorded on the single-crystal copper plate. The diameter of the tiny holes was ~40 μm, and their depth was ~60 μm. These holes could easily be distinguished from holes that were directly produced by the electrical discharge. Since they were distributed in a region lower than the point of the discharge, it is reasonable to consider that they were produced by some heavy materials. They might be consistent with the tiny black holes that were observed before.[8] Figure 8b shows a variational hole

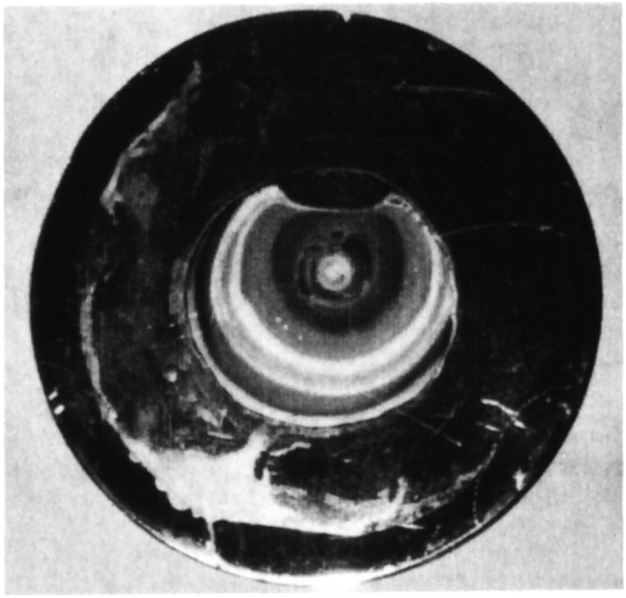


Fig. 1. Separated zones on single-crystal copper.

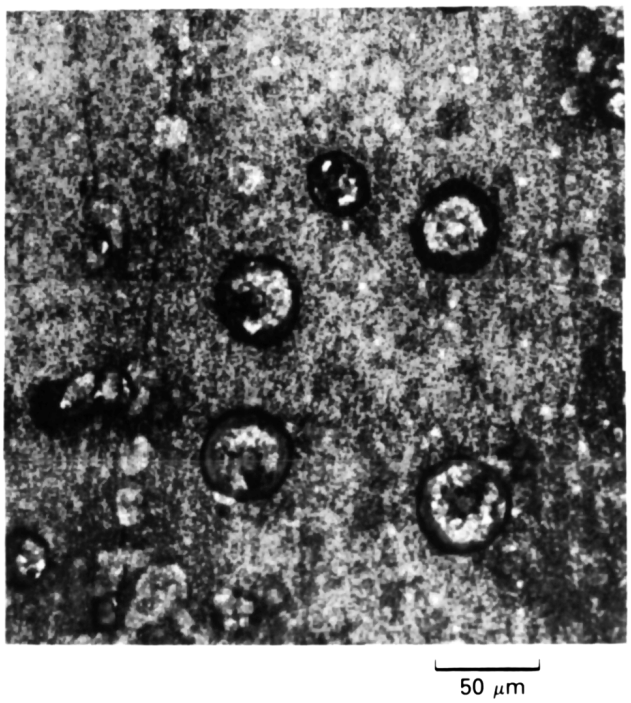


Fig. 2a. Gravity decay of di-neutrons in zone B: gravity decay of di-neutrons.

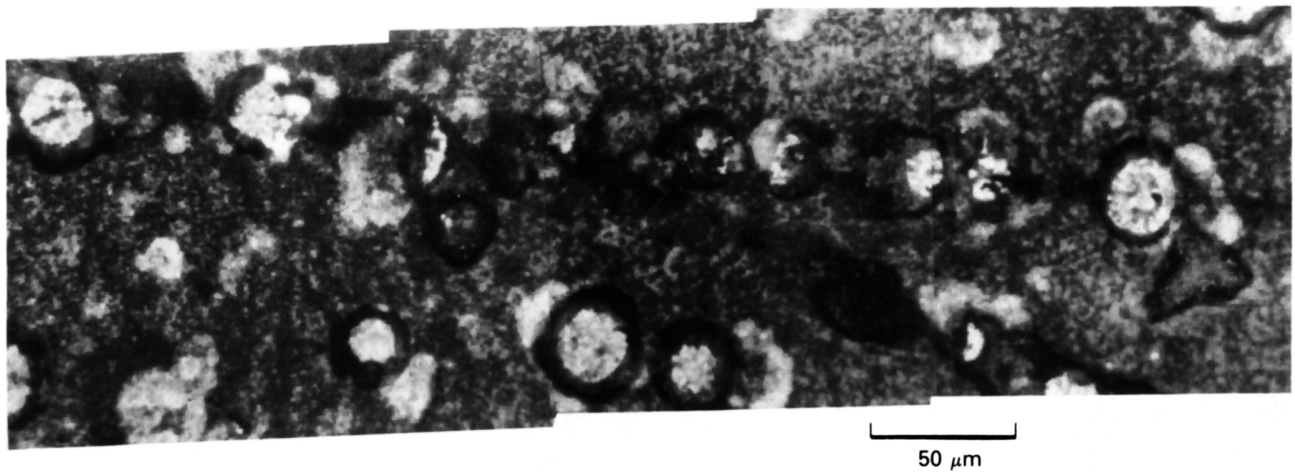


Fig. 2b. Gravity decay of di-neutrons in zone B: gravity decays of di-neutrons through dislocation line.

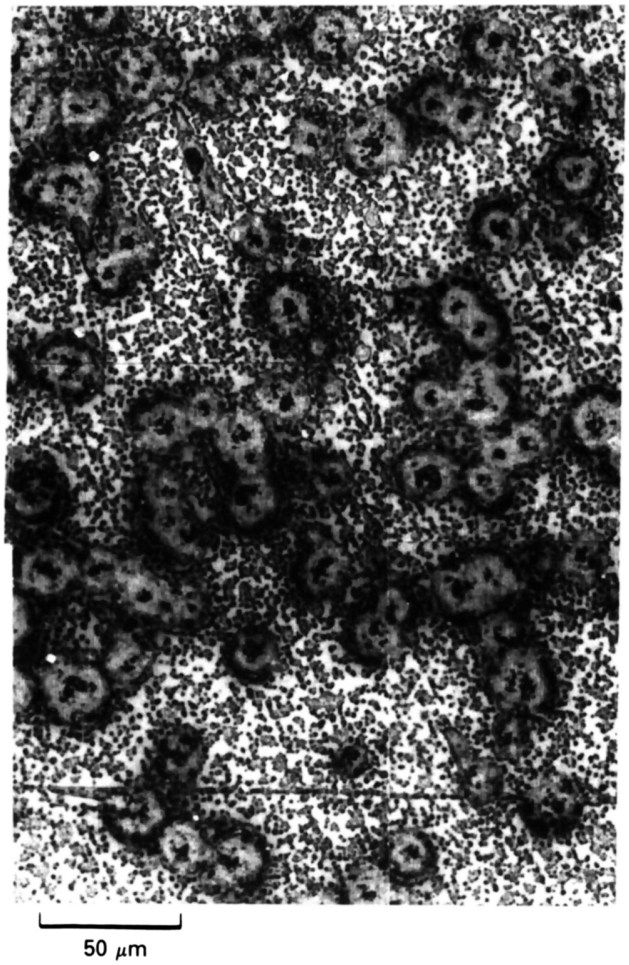


Fig. 3. Gravity decay of single neutrons in zone C.

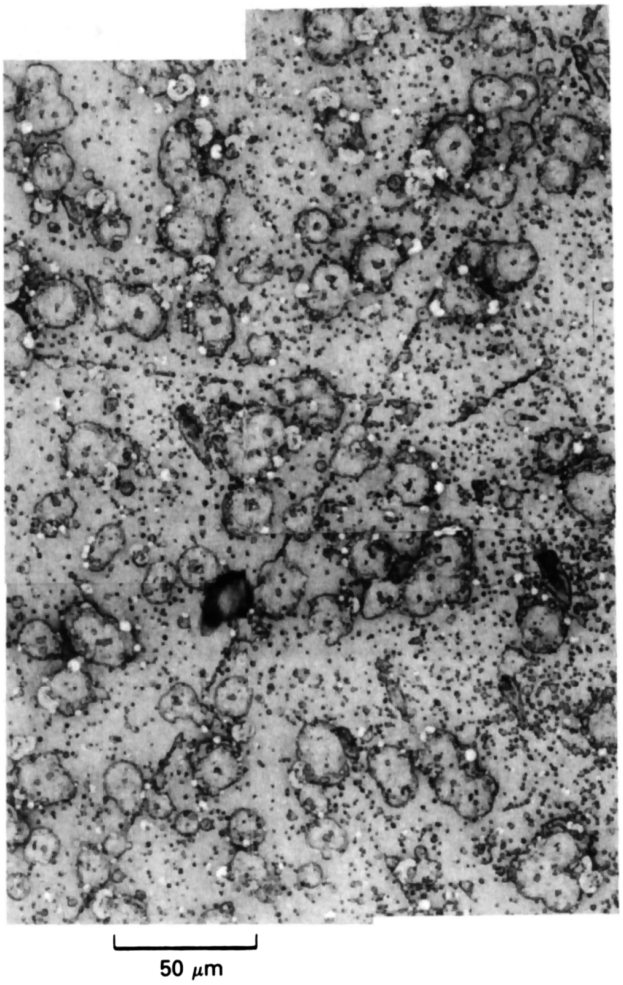


Fig. 4. Gravity decay of single neutrons without itonic mesh in zone C.

that was associated with a directional radiation. It was very similar to a tiny black hole that also had a directional radiation.[8] Furthermore, Fig. 9 shows other traces that appeared white and brightly shining in the microscope. The white traces were densely distributed on the copper plate, and many of them likely had some structure in the center. Since they were considered to be produced by energetic reactions, these traces might be consistent with the tiny white holes that were also observed before.[6] In the tiny white holes, there were two separate zones: an outer reactive filmlike zone and an inner

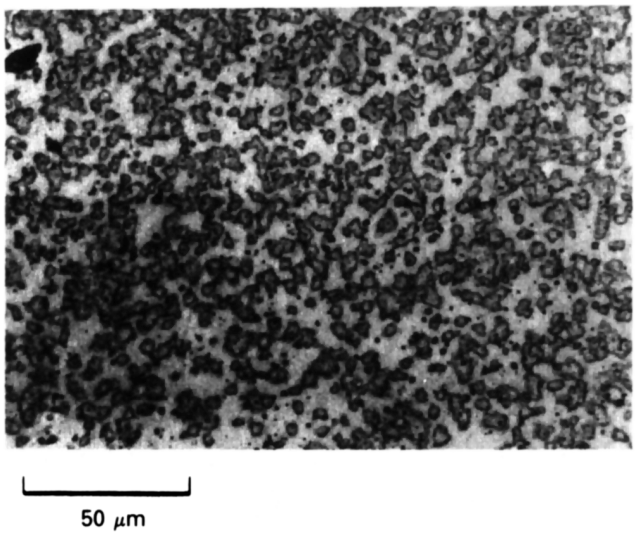


Fig. 5. Electrons or itons in zone D.

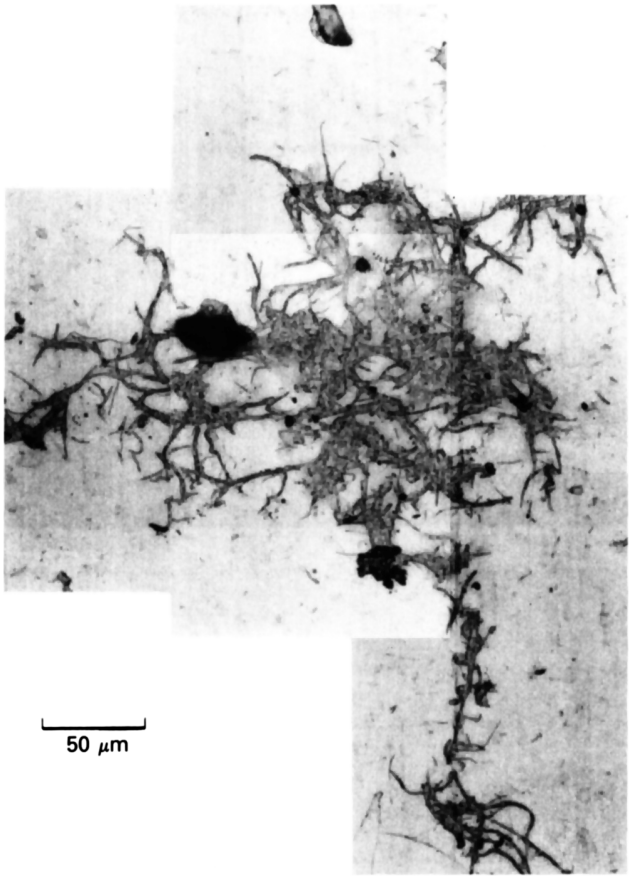


Fig. 6a. Itonic hydrogen clusters with 70 V.

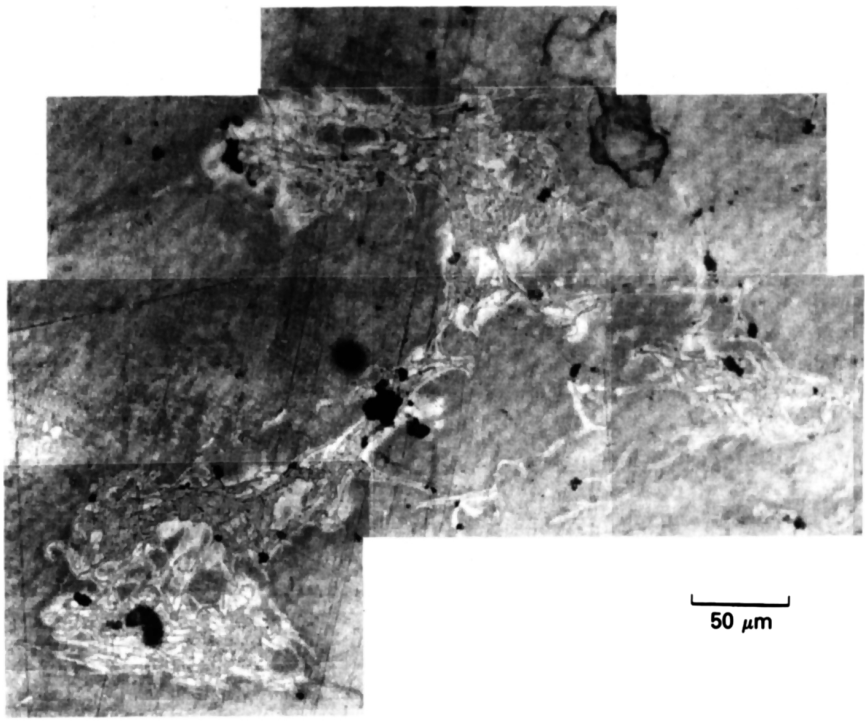


Fig. 6b. Itonic hydrogen clusters with 90 V.

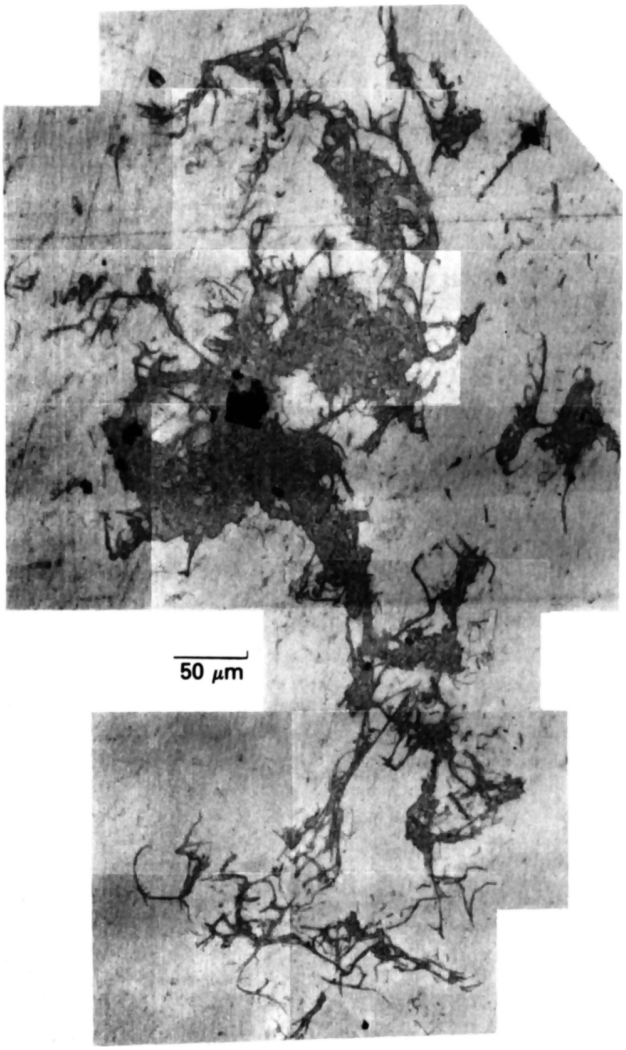
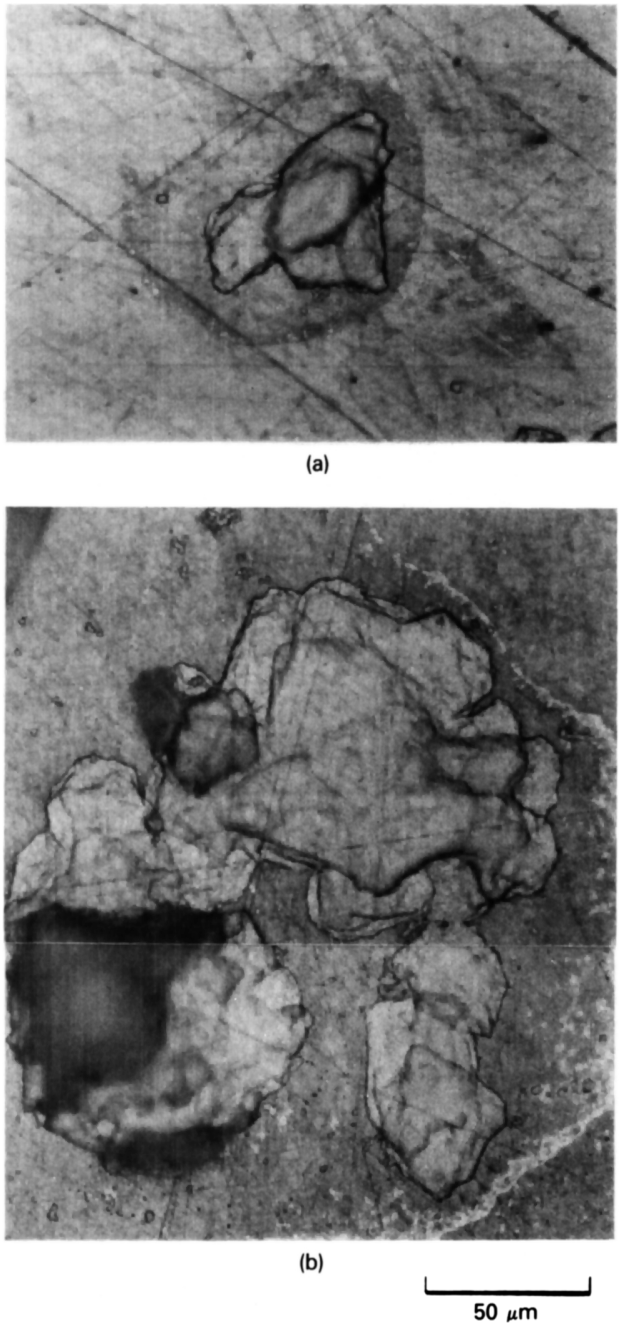


Fig. 6c. Itonic hydrogen clusters with 90 V.



Figs. 7a and 7b. Variational breakup of itonic hydrogen clusters: gravity decay product with (a) energy deposit and (b) fusion reaction.

material spouting zone. The structure of the white traces shown in Fig. 9 might reflect those structures. Figure 10 shows a stringlike trace; similar traces were already observed on nuclear emulsions in the previous experiment but remained uncertain.[9] The trace might be considered as a gravity decay product that might consist of linked superstrings. Figure 11 shows a very strange trace that was whirling around. It suggests a violent reaction, but its meaning is now uncertain.

MECHANISMS OF SURFACE REACTIONS AND DISCUSSIONS

The Nattoh model predicts that cold fusion is based on a new hydrogen-catalyzed fusion reaction and that chain reactions can produce excess heat in metal such as palladium.[10] However, for a metal with low hydrogen permeability, such as copper, the hydrogen atoms cannot penetrate deeply, and instead of inner reactions, surface reactions might predominate.

Figure 12 shows a conceptual view of the mechanisms of the surface reactions. The Nattoh model emphasizes that two processes are essential for igniting cold fusion: the formation of hydrogen clusters and their self-compression. Hydrogen atoms can move freely on the surface of the metal, and they are trapped to form hydrogen clusters in tiny pits that might be generated during several cold-rolling processes or hydrogen charging.[11] Because of the electrical discharge, many electrons flow easily to form the itonic bindings that compress hydrogen clusters to induce catalyzed fusion reactions. Fusion reactions sometimes take place between the hydrogen

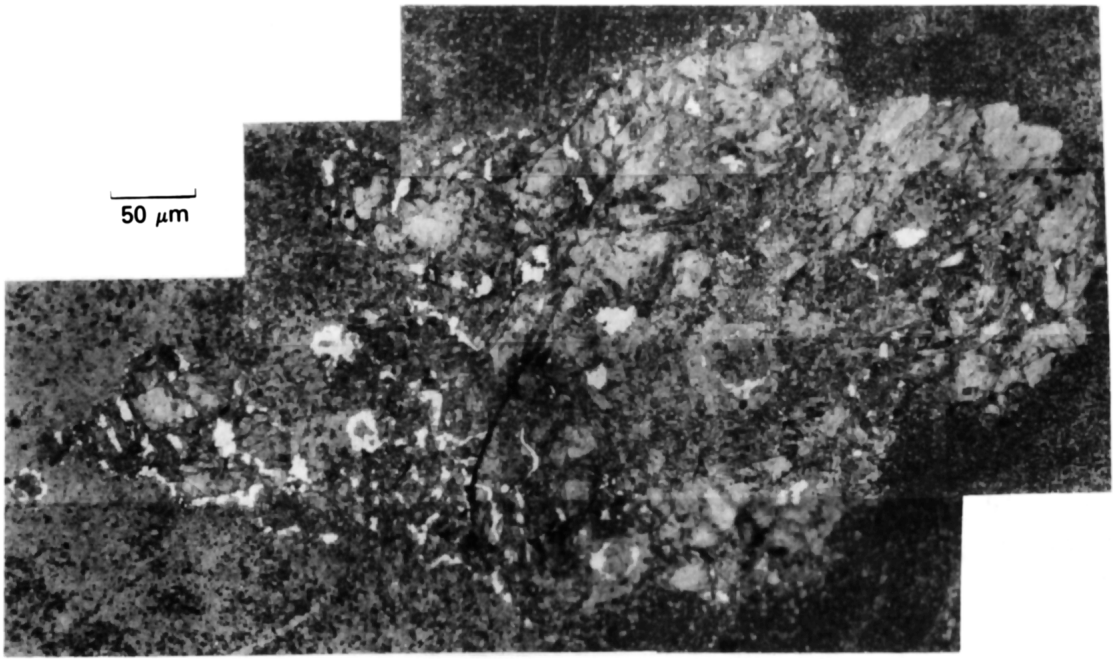


Fig. 7c. Variational breakup of itonic hydrogen clusters: gravity decay product with fusion reactions.

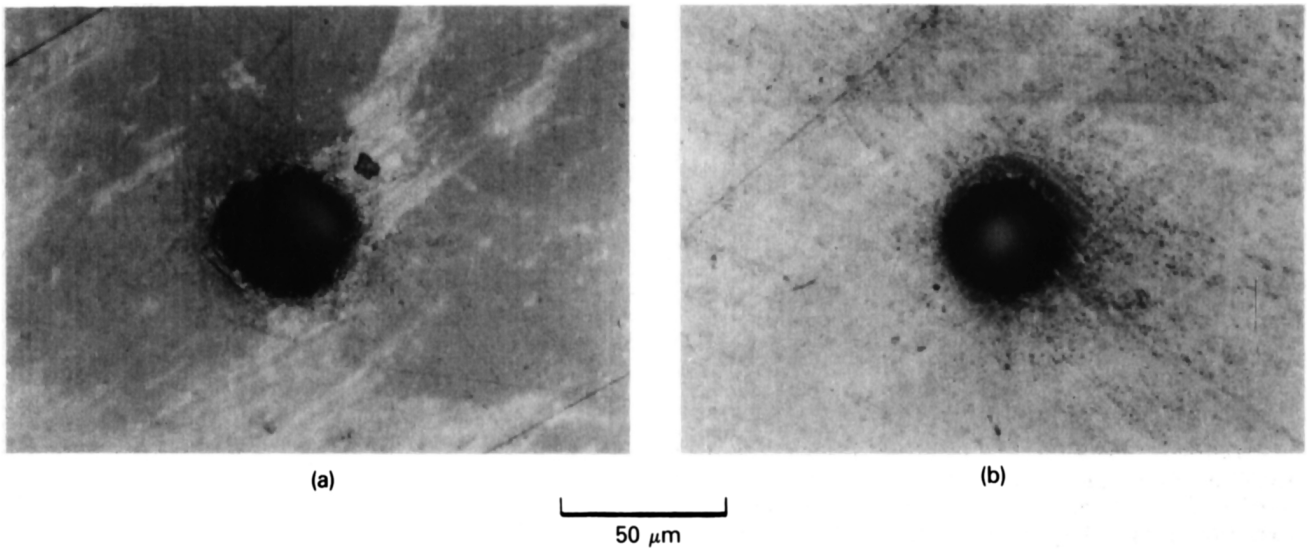


Fig. 8. (a) Tiny black hole and (b) variational trace of tiny black hole.

atoms alone and at other times between the hydrogen atoms and the host metal surrounded by the hydrogen clusters. Once the catalyzed fusion reactions are induced, the reactions are the same as those in the metal.[6,9] Surface reactions might still occur with continuing electrolysis but can be enhanced by the electrical discharge method. Here, since the surface reactions take place in bursts, it is effective to sequentially apply pulsed voltage to obtain excess energy. Recently, Mills and Kneizys[12] reported that in their experiments with a thin nickel foil, excess energy could be enhanced by employing radio-frequency fluctuation. The optimum frequency was determined to be ~500 Hz. This means that surface reactions might occur in bursts for ~2 ms.

When low voltage is applied, the compression effect is weak so that hydrogen clusters with many hydrogen atoms cannot completely be compressed. The catalyzed fusion reactions are limited to hydrogen clusters with a small number of hydrogen atoms. Therefore, fusion products such as single and di-neutrons and protons are emitted. The di-neutrons are "fermented" and covered with itonic mesh so that they undergo gravity decay and explode. Ring spots are caused by those explosions, as shown in Fig. 2. The single neutrons also undergo gravity decay, as shown in Fig. 3.

With high voltage, on the other hand, hydrogen clusters with many hydrogen atoms can be compressed by the electrical discharge. Various reactions can take place in extremely

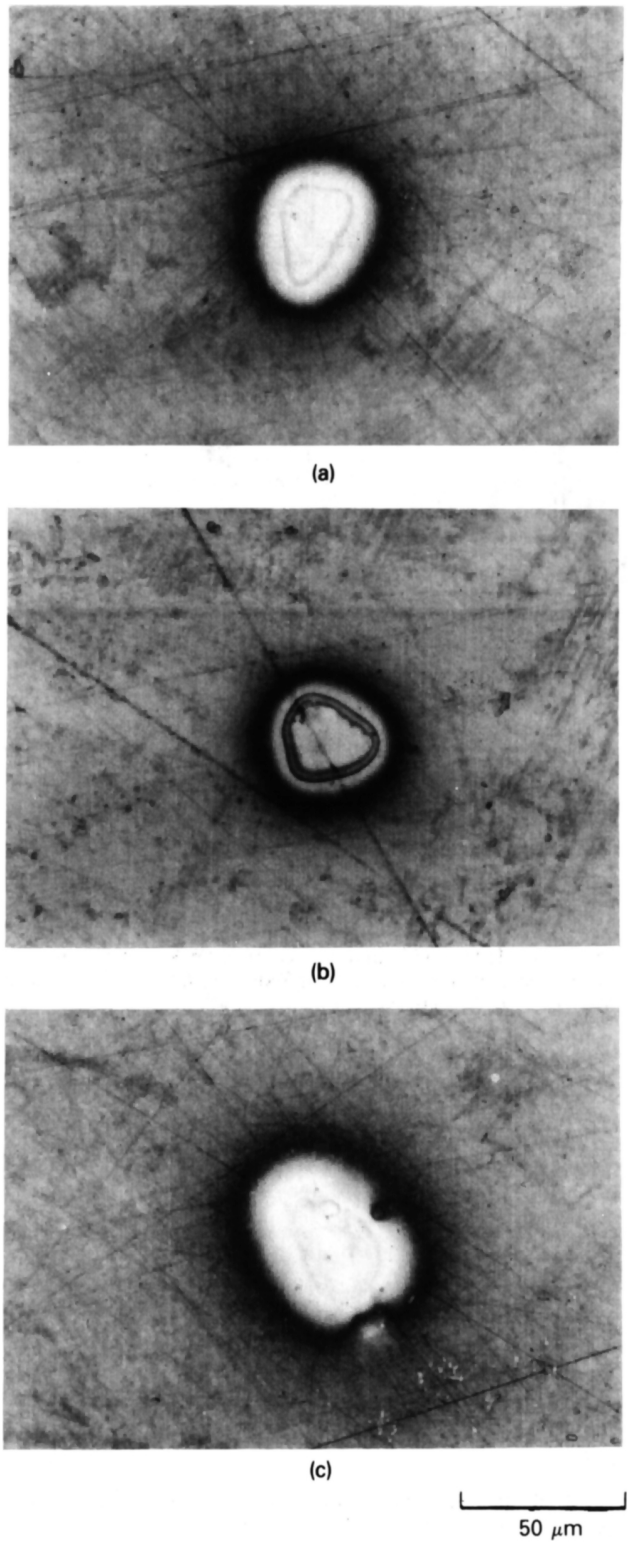


Fig. 9. (a) Tiny white hole and (b and c) variational traces.

compressed clusters. For example, more than two fusion reactions can simultaneously occur,[9] or multibody fusion reactions can produce heavy elements.[5] Most remarkable is the production of tiny black and white holes that are caused by

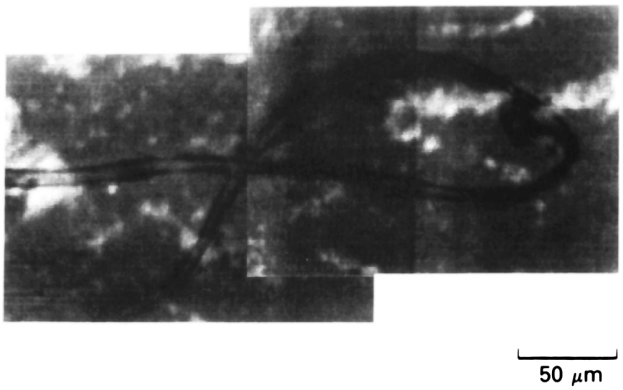


Fig. 10. Gravity decay product like string.

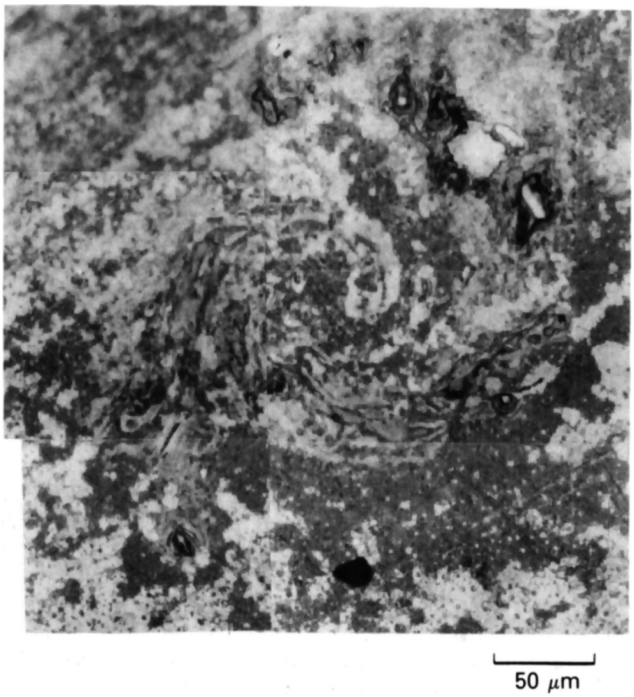


Fig. 11. Whirling trace.

the gravity decay of heavy hydrogen clusters. These were predicted by the Nattoh model,[13] and traces suggesting these events were successfully observed on nuclear emulsions.[8] When the compression is completely symmetrical, tiny black and white holes can be produced. However, the compression of large clusters is not always complete, or alternatively, several fusion reactions precede and release energy. Then, the itonic hydrogen clusters are broken down, as shown in Figs. 6 and 7.

As mentioned earlier, it has been proven that cold fusion can be induced by electrical discharges in water. Explosions during electrolysis have been regarded simply as hydrogen gas explosions so far. However, they may initially be induced by cold fusion reactions and followed by gas explosions. To avoid explosions, the distance between the electrodes should be chosen properly. Even if the electrolysis is maintained

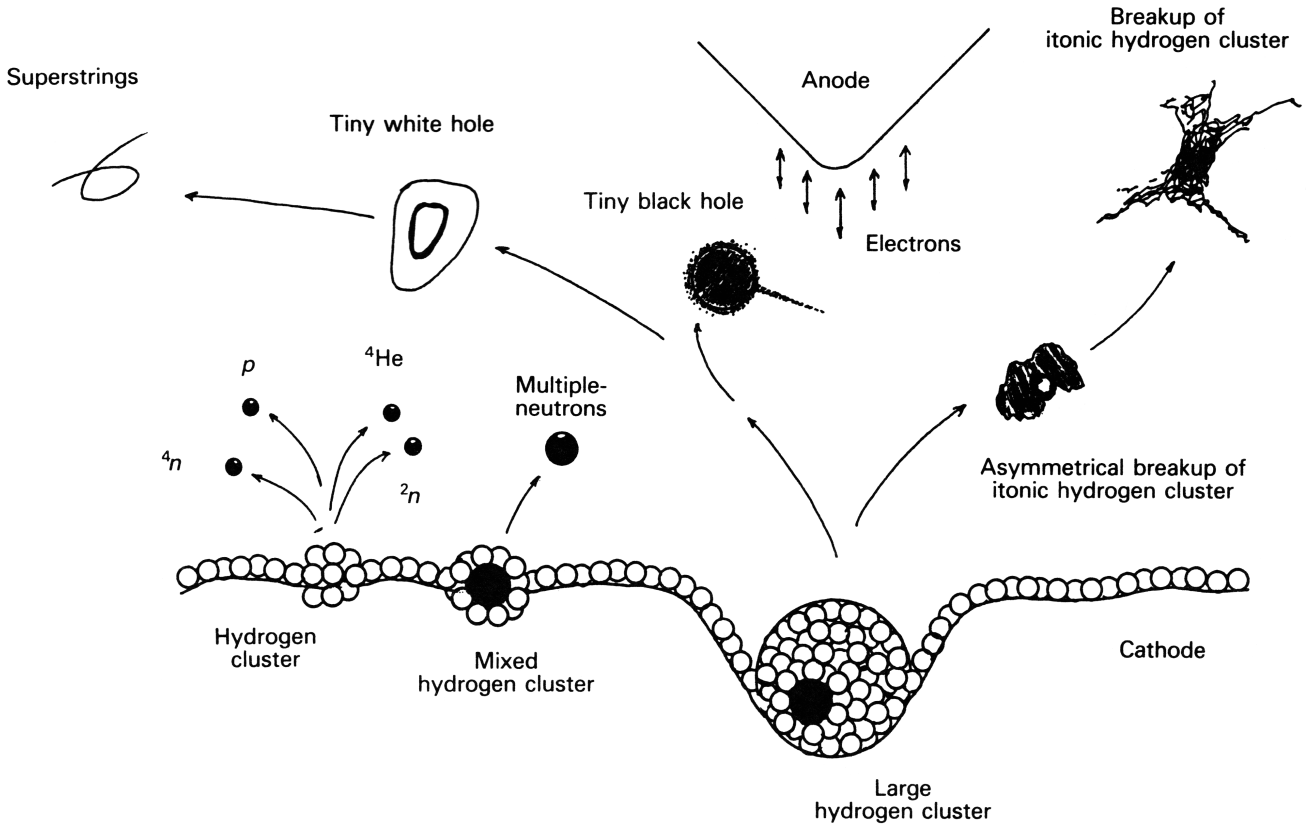


Fig. 12. Conceptual view of surface reactions.

continuously with low voltage, there might be local and small discharges that would enhance energy release.

Lastly, an important suggestion should be added. During cold fusion, hydrogen-catalyzed fusion reactions and gravity decay both contribute to the excess heat production, more or less. Their relative contributions significantly depend on the applied voltage. By increasing the voltage, the ring traces caused by the former disappear, and tiny black and white holes are produced by the latter that are more effective for transforming mass to energy. Therefore, it is possible to obtain more excess energy by increasing the voltage used in the electrolysis.

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EXTRAORDINARY TRACES PRODUCED DURING PULSED DISCHARGES IN WATER

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Abstract

This paper describes experiments of electrical discharge in water, in which AC shots of up to 100 V were applied to wire electrodes of palladium and platinum. Various kinds of anomalous traces were observed on nuclear emulsions. Some of them were similar to those observed in previous electrolytic cold fusion experiments. Extraordinary combined rings were newly observed, suggesting that tiny ball-lightning was hopping up and down between the nuclear emulsions. The mechanisms of forming the traces are also discussed by the Nattoh Model.

Keywords

AC shots discharged in water, wire electrodes, nuclear emulsion, extraordinary traces, tiny ball-lightning, the Nattoh Model

1. Introduction

Since Pons and Fleischmann published the cold fusion phenomenon (1), many experiments have been performed throughout the world initially to reproduce similar results and recently to progress in excess heat production (2). The method of electrolysis has been mainly employed, but it is well known that this method has low reproducibility due to cracks induced in metal electrodes. The method of electrical discharge, on the other hand, has been remarkable due to its simplicity and high degree of reproducibility (3, 4). There are two methods of electrical discharge: in water and in hydrogen gas. The author reported that many of the extraordinary traces that were observed on a copper plate with pulsed discharge clearly indicated that cold fusion reactions could occur associated with the formation of hydrogen clusters (3). Furthermore, Kucherov et al. attempted experiments of discharge in the hydrogen gas phase, in which many elements were produced during discharge (4).

The key reason why the electrical discharge is superior in inducing cold fusion reactions is because of the high density of electrical current, and simultaneously the high concentration of hydrogen on the surface of the electrodes, generated by the electrical potential. Plasma generated by the discharge has such a dense region on the electrode surface that it cannot be treated as an ideal plasma at all. At this location, hydrogen forms clusters which include surface materials, and many induced electrons take an important role in accelerating the formation of the hydrogen clusters. Cold fusion reactions can be induced in the hydrogen clusters under the strong interaction of many bodies, including hydrogens and electrons. Therefore, the cold fusion reactions are very different from the conventional D-D fusion reactions.

The author has been using the method of nuclear emulsion for experiments in electrolytic cold fusion (5–7), and has successfully obtained many extraordinary traces. Nuclear emulsion is highly sensitive for any emitted products and has provided us with rich information.

This paper describes an experiment of AC shots discharged with wire electrodes of palladium and platinum in water, in which the method of nuclear emulsion was employed. Traces similar to those obtained in the previous electrolysis experiments of cold

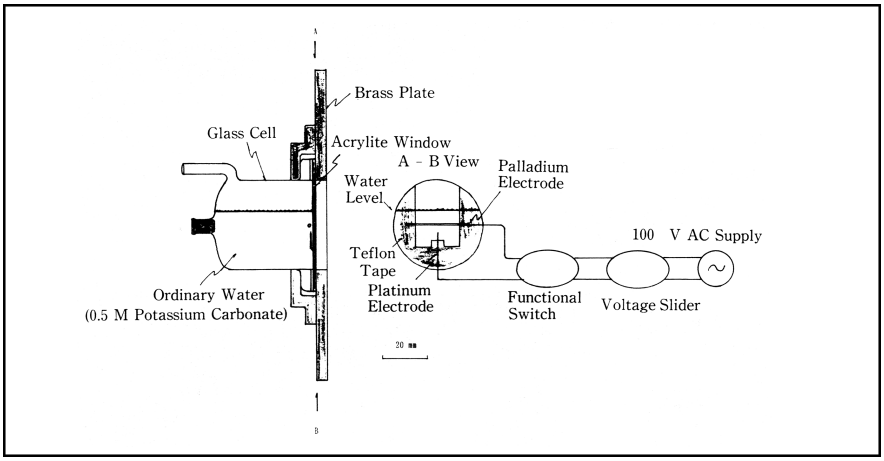

Fig. 1: Experimental arrangement.

fusion (5, 6) were observed on some of the nuclear emulsions. Furthermore, extraordinary traces that were likely generated by the hopping behavior of tiny ball-lightning were newly observed. The mechanisms of forming the traces are also discussed by the Nattoh Model.

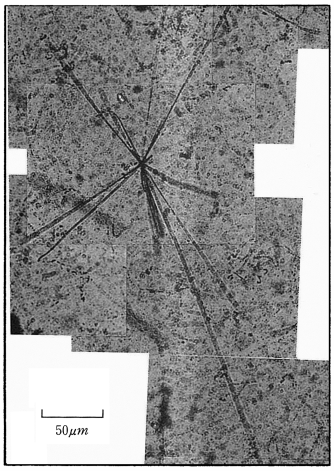

Figure 3. Cold fusion star.

2. Experiment

A series of experiments of electrical discharge in water were carried out applying AC shots with wire electrodes of palladium and platinum.

Figure 1 shows the experimental arrangement. Wires of palladium (0.5 mm ϕ × 25 mm long) and platinum (0.3 mm ϕ × 2 mm long) were used for the electrodes, perpendicular to each other. The gap between the top of the platinum electrode and the center of the palladium electrode was 2 or 3 mm. The electrodes were fixed with a teflon tape, close to the window of the glass cell. The window was made from a plate of acrylite (2 mm thick) and had an effective diameter of about 40 mm ϕ. The electrolyte solution consisted of ordinary water mixed with 0.5 mol/l potassium carbonate.

The electrical discharge was employed with AC shots of up to 100 V (50 Hz; 20–80 msec ON and 1–15 sec OFF). The AC shots were generated with a functional electrical switch, and the voltage was varied with a voltage slider. The phase was fixed such that the voltage at the platinum electrode started to increase positively. Reactions were observed using a microtelescope and VTR (video tape recorder) system, and nuclear emulsions, alternately located outside the vertical window. Pictures from the microtelescope (amplified 10–100 times) were recorded on the VTR. Important pictures were then stepwise picked up with a color copier. The nuclear emulsions were similar to those used previously (5–7) (100 μm thick emulsions coated on both sides of a thin acrylite plate 1 × 50 × 50 mm).

Reference nuclear emulsions were located about a 5 m distance from the cell in the same room.

3. Results

Figure 2 [*Not all figures are shown.*] shows a sequence of pictures for one shot with 100 V taken by the VTR system. The time step was 33 msec. Here explosive reactions can be seen on the platinum pin electrode. In figure 2a, an electrical discharge took place in the gap of the electrodes and simultaneously a spherical reactive region appeared on the platinum electrode. In figures 2b and 2c, high-energy clusters seem to be emitted almost isotropically and a couple of wave fronts were clearly formed due to the AC cycle. After the shots, the electrode of platinum remained hot, as shown in figure 2d.

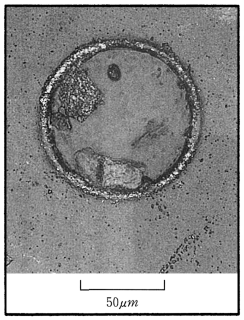

Figure 4b. Explosive traces.



Figure 5a. Combined traces.

Several kinds of traces were recorded on the nuclear emulsions located outside the acrylite window. When the nuclear emulsions were placed, the AC shots of 100 V (40 msec ON and 2 sec OFF) were applied for 19 minutes. Unlike the usual discharges, a loud sound was associated at the last shot, where the platinum pin completely disappeared and the palladium wire sharply bent down at the shooting point. Simultaneously, the solution was blackened by fine, scattered materials.

The first kind of trace was a star, shown in figure 3. Similar traces of such stars were already observed in previous experiments (6). This time, however, the number of fragments was greater. The production of the star was predicted by the Nattoh Model; the star can be generated by a multibody fission reaction of a highly excited compound nucleus that results by the capture of a multiple neutron emitted from the cell (6).

The second kind was a ring trace that results from an explosive reaction, shown in figure 4. Similar ring traces were also observed in previous cold fusion electrolysis experiments (5). There, the ring trace was assigned as an explosive decay of multiple neutrons, such as di- and quad-neutrons. This trace was one of the most credible pieces of experimental evidence, indicating that cold fusion reactions had taken place. When the hydrogen cluster is compressed to induce cold fusion reactions, surplus hydrogen atoms that are not directly involved in the fusion reaction should scatter. Those traces could be seen in the traces in this experiment, shown in figures 4a to 4c.

The third were combined traces, shown in figure 5. These traces could indicate two or three simultaneous reactions, because they were recorded on fortunately mismade nuclear emulsions

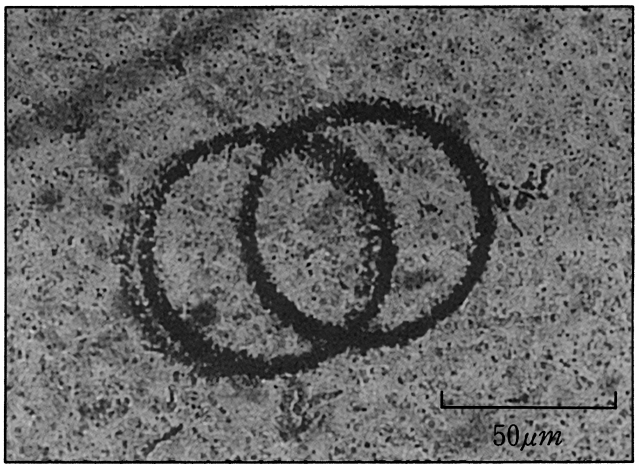

Figure 6a. Combined ring traces

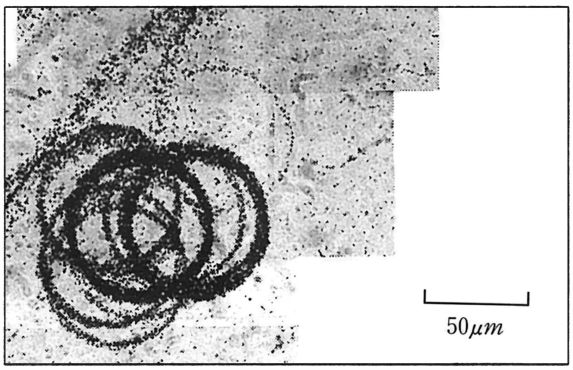

Figure 6c. Combined ring traces

that were thinner than usual. If the emulsions were thicker, individual explosive traces would grow and combine with each other to form a larger trace as is shown in figure 4c. A similar combined product was also observed on the rear surface of a thin palladium foil that was used in a cold fusion electrolysis experiment (7). There the boundary line between each of the products could obviously be seen.

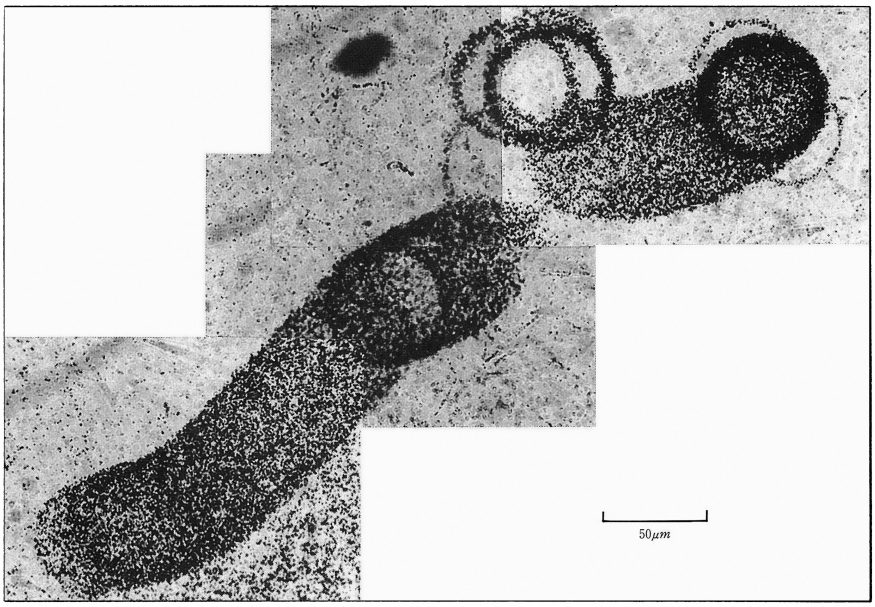

Figure 6f. Combined ring traces.

The fourth were strange combined rings, shown in figure 6, first observed in this experiment. These rings could be clearly distinguished from the second explosive traces, because the combined rings were recorded only on the surface while the second traces were distributed three-dimensionally. Some rings seemed to have been moved on the surface of the nuclear emulsion and then remained as continuous traces, shown in figures 6c to 6f. The diameters of the combined rings were different in different events, but almost the same within the same event. The combined rings, shown in figures 6a to 6d, were registered by independent events, but figures 6e and 6f were made by the same event. Two events, shown in figures 6e and 6f, were recorded on the backside of the first nuclear emulsion and on the front side of the second one, respectively. They were almost symmetrical. During the development process, the nuclear emulsions were placed in a development solution with a gap of more than 3 mm, so no combined rings could be simultaneously generated on the separated nuclear emulsions by any reason such as chemical reaction in tiny bubbles. It is reasonable to infer that the traces were generated by the same particle emitted from the cell during the discharge. Figure 7 shows the spatial distribution of the events of the combined rings. The events were densely concentrated between the first and the second emulsions. It shows that the particles did not have enough kinetic energy so that they could be sufficiently slowed down during the passing through of a 3-mm thick layer of acrylite (2-mm thick window and 1-mm thick emulsion plate).

The fifth was a ringlike product that was observed on the surface of the nuclear emulsion, shown in figure 8. This kind of product, first observed in this experiment, could be clearly distinguished from both the second and the fourth traces. The relationship between the fifth product and the fourth combined rings will be discussed later on in this paper.

The sixth were strange traces like microbacteria, shown in figure 9. Four traces were observed so far and all were found on the surface of the nuclear emulsions. They all had common shapes with similar dimensions of about 60 μm long, and seemed to have organlike objects in the body. Especially in figure 9c, something like a mouth and feeler appeared. However, they were not complete microbacteria such as exist in the natural environment. They might be prototypes of microbacteria. Since they were not seen on the reference emulsions but were observed on both the emulsions that were separately coated in our laboratory and at Fuji Film, Inc., it is reasonable to infer that they were newly created by the electrical discharge. More data should be required for a detailed discussion about this topic.

4. Discussion

In the previous experiment (3), extraordinary traces were recorded on copper plate, suggesting that hydrogen clusters were formed to induce cold fusion reactions. In this experiment, on the other hand, sensitive nuclear emulsions also recorded explosive traces similar to that which were previously measured in electrolytic cold

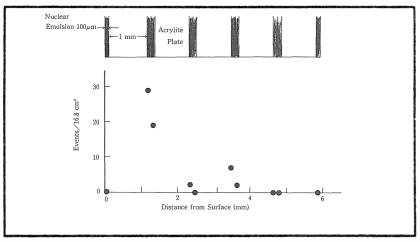

Figure 7. Spatial distribution of combined ring traces.

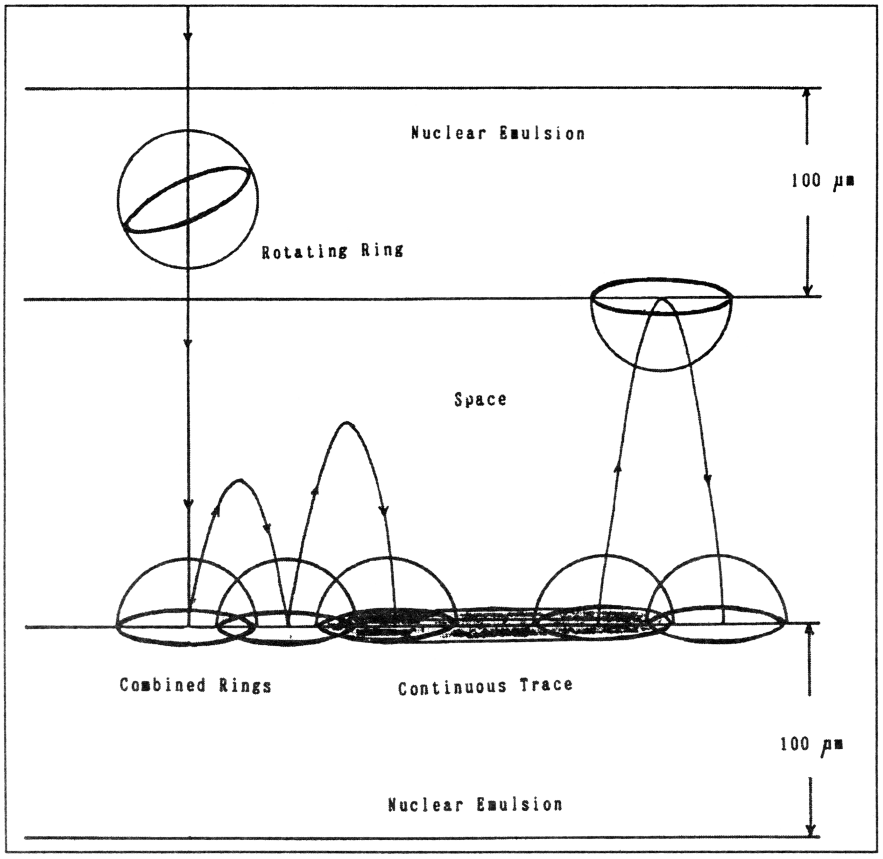

Figure 10. Conceptual view of forming combined ring traces

fusion experiments (5–7). It can be concluded from those experiments that as soon as an electrical discharge is employed between the electrodes in water, cold fusion reactions can be induced on the surface of the metal. Among the traces recorded on the emulsions, the first to the third were already discussed in the previous papers (5–7), so that the fourth and the fifth, newly observed in this experiment, will be discussed here.

Figure 10 shows a conceptual view of the recording of the third kind of traces, the combined rings. A rotating and vibrating ring, generated by the discharge, might enter the nuclear emulsions. While passing through the emulsion material and acrylite plates, it somewhat loses it's kinetic energy. Mainly between the first and the second emulsions, the moving ring can be trapped and leave a ring trace on the surfaces it touches. The ring could have an electrical charge so that it hops up and down in the space between the emulsions. While touching the surface of the nuclear emulsions, a portion of the electrical charge could transfer from the ring to the emulsion. Then, a static electrical repulsive force could work between the ring and the nuclear emulsion to make the ring jump up. Many ring traces could be left before the moving ring escapes from this space. When the ring moves on the surface, a continuous trace should remain, as is shown in figures 6e and 6f.

Now, the problem is to discover the nature of the moving ring. In a somewhat similar recent experiment, although with continuous discharge in water (8), a large number of similar rings, but of smaller diameter, were observed when tiny sparks appeared on the surface of the electrode. The ring could leave the electrode, driven by the electrical potential. The ring walked around on the surface of the nuclear emulsion and finally decayed to a regular hexagonal plate. According to the Nattoh Model (9, 10), hydrogens form a hydrogen cluster on the surface of the electrode or within the metal, when the pressure of the hydrogen is increased sufficiently by the electrical potential. The cluster may assume the shape of a sphere or ring. The shape should be determined by the condition of the energy minimum. The fifth ringlike product, shown in figure 8, might be the remains of a ring cluster that faded during its period of motion.

Recently, tiny ball-lightning-like phenomena were observed twice by the author, with similar experiments of electrical discharge in water (11). The first was on 13 August 1992, when an electrical discharge was attempted on wire electrodes of palladium and platinum that were perpendicularly arranged to each other. The second was on 25 August 1992, when an electrical discharge was also attempted, but on a parallel arrangement of palladium wires. In the first case, tiny ball-lightning was emitted from a point about 1 cm distant from the discharging point. It flew about 1 cm in the opposite direction and exploded when it stopped. The emission of the ball-lightning took place with some delay after the discharge, and this was very often repeated. In the second case, two bolts of tiny ball-lightning were emitted upwards from the wire showing S-curves, also finally exploding.

In the natural environment, on the other hand, ball-lightning has been observed by many people and many reports have been documented (12, 13). It seems often to be generated by a thunderstorm with large-scale electrical discharge. The ball-lightning can move around, up and down, enter a house through a window and very often explode at its stopping point. Ball-lightning has a large diameter but those extraordinary behaviors are very similar to those of the ring clusters mentioned earlier. Lewis early pointed out that the cold fusion phenomena are closely related to those of ball-lightning (14). If ball-lightning with large enough diameter is generated by an electrical discharge in the laboratory, it's structure and property could be revealed in more detail.

Ref. (51)

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Extraordinary Traces Produced during Pulsed Discharges in Water

Takaaki MATSUMOTO

(Received June 14, 1995)

Abstract

This paper describes experiments of electrical discharges in water, in which AC shots of up to 100 V were applied to wire electrodes of palldium and platinum. Various kinds of anomalous traces were observed on the nuclear emulsions. Some of them were similar to that which were observed in previous experiments of electrolysis cold fusion. Extraordinary combined rings were newly observed, suggesting that tiny ball-lightning was hopping up and down between the nuclear emulsions. The mechanisms of forming the traces are also discussed by The Nattoh Model.

Keywords

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1. Introduction

Since Pons and Fleishmann published the cold fusion phenomena (1), many experiments have been performed in the world in order to initially reproduce the similar results and recently progress in the excess heat production (2). The method of electrolysis has been mainly employed, but it is well known that this method has the low reproducibility due to cracks induced in the metal. The method of electrical discharges, on the other hand, also has been remarked due to it's simplicity and it's high degree of reproducibilty (3, 4). There are two methods of electrical discharges : in water and in hydrogen gas. The author reported that many of the extraordinary traces that were observed on a copper plate with pulsed discharges clearly indicated that cold fusion reactions could occur associated with the formation of hydrogen-cluster (3). Furthermore, Kucherov et el. attempted experiments of discharges in hydrogen gas phase, in which many elements were produced during the discharge (4).

The key reason why the electrical discharge is superior to induce cold fusion reactions is because the high density of electrical current, and simultaneously the high concentration of

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hydrogen on the surface of the electrodes that is generated by the electrical potential. Plasma generated by the discharge has such a dense region on the electrode surface that it cannot be treated as an ideal plasma at all. At this location, hydrogens form a cluster including surface materials, and many induced electrons take an important role to accelerate the formation of the hydrogen-cluster. Cold fusion reactions can be induced in the hydrogen-cluster under the strong interaction of many bodies including hydrogens and electrons. Therefore, the cold fusion reactions are very different from the conventional D - D fusion reactions.

The author has been using the method of nuclear emulsion for the experiments of electrolysis cold fusion (5 - 7) and has successfully obtained many extraordinary traces.The nuclear emulsion is highly sensitive for any emitted products and has provided us with rich information.

This paper describes an experiment of AC shots discharge with wire electrodes of palladium and platinum in water, in which the method of nuclear emulsion was employed. Traces similar to those obtained in the previous electrolysis experiments of cold fusion (5, 6) were observed on some of the nuclear emulsions. Furthermore extraordinary traces that were likely generated by the hopping behavior of tiny ball-lightening were newly observed. The mechanisms of forming the traces are also discussed by The Nattoh Model.

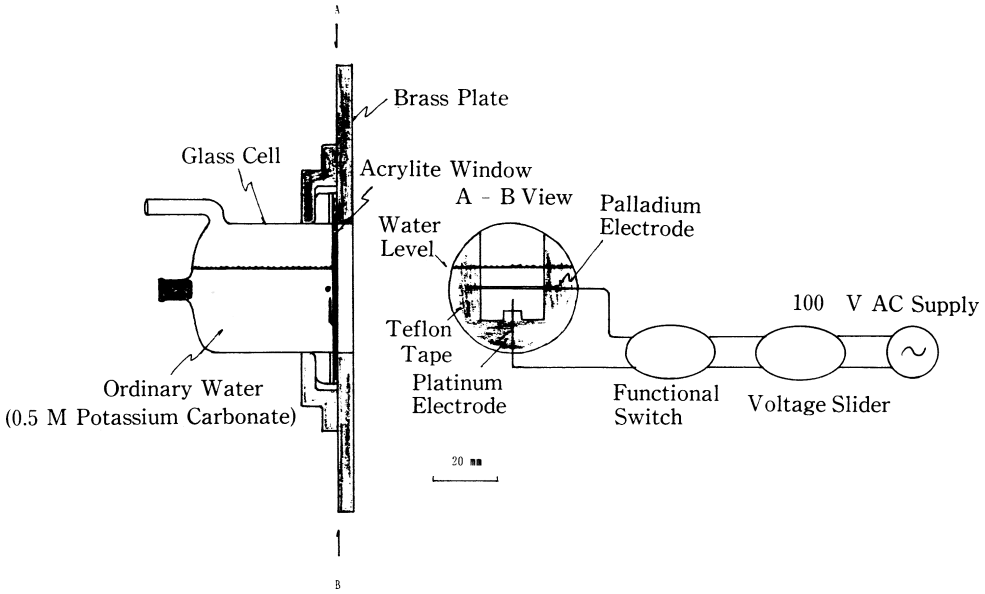

Fig. 1: Experimental arrangement

2. Experiment

A series of experiments of electrical discharges in water were carried out applying AC shots with wire electrodes of palladium and platinum.

Figure 1 shows the experimental arrangement. Wire electrodes of palladium (0.5 mm $\phi \times$ 25 mm long) and platinum (0.3 mm $\phi \times$ 2 mm long) were used for the electrodes, that

were vertically located to each other. A gap between the top of the platinum electrode and the center of the palladium electrode was 2 or 3 mm. The electrodes were fixed with a teflon tape, close to the window of the glass cell. The window was made from a plate of acrylite (2 mm thick) and had the effective diameter of about 40 mmϕ. The electrolyte solution consisted of ordinary water mixed with 0.5 Mol/l potassium carbonate.

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Reference nuclear emulsions were located at about a 5 m distance from the cell in the same room.

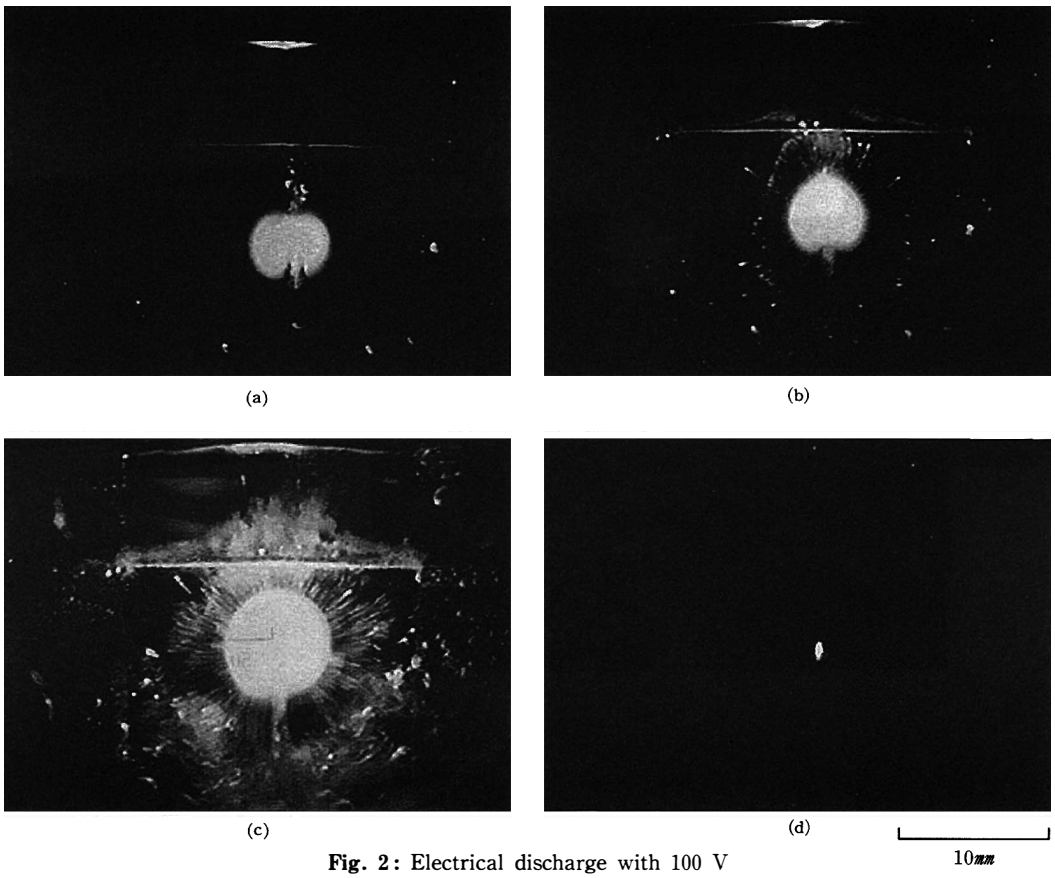


Fig. 2: Electrical discharge with 100 V
(time step ; 33 msec)

3. Results

Figure 2 shows a sequence of pictures for one shot with 100 V taken by the VTR system. The time step was 33 msec. Here explosive reactions can be seen on the pin electrode of platinum. In Fig. 2(a), an electrical discharge took place in the gap of the electrodes and silmultaneouly a spherical reactive region appeared on the electrode of platinum. In Figs. 2(b) and (c), high energy clusters seem to be emitted almost isotropically and a couple of wave fronts were clearly formed due to the AC cycle. After the shots, the electrode of platinum remained to be hot, as is shown in Fig. 2(d).

Several kinds of traces were recorded on the nuclear emulsions located outside the acrylite window. When the nuclear emulsions were placed, the AC shots of 100 V (40 msec 0N and 2 sec 0FF) were apllied for 19 min. Unlike the usual discharge, a large sound was associated at the last shot, where the platinum pin completely disappeared and the palladium wire sharply bent down at the shotting point. Simultaneously the solution became black by fine scattered materials.

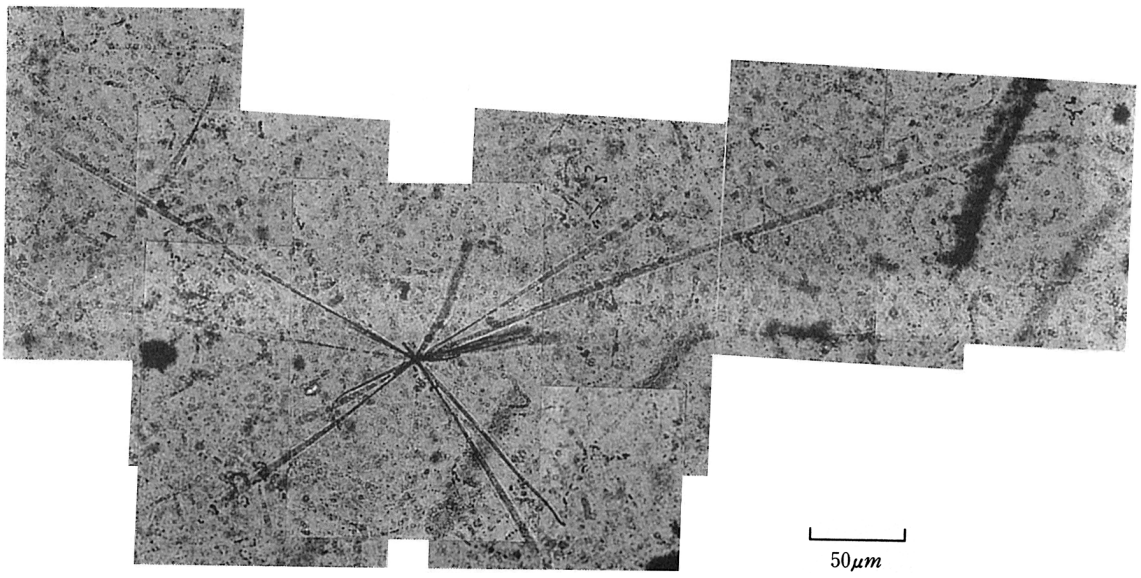


Fig. 3: Cold fusion star

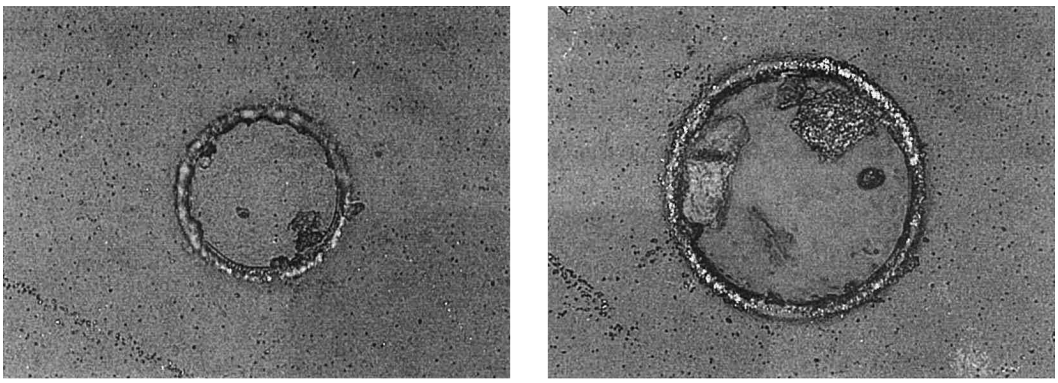


Fig. 4: Explosive traces

The first kind of the traces was a star, shown in Fig. 3. Similar traces of the star were already observed in previous experiments (6). This time, however, the number of the fragments was the greatest. The production of the star was predicted by The Nattoh Model; the star can be generated by a multibody fission reaction of a highly excited compound nucleus that results by the capture of a multiple neutron emitted from the cell(6).

The second kind was a ring trace that results from an explosive reaction, shown in Fig. 4. Similar ring traces were also observed in previous electrolysis experiments of cold fusion (5). There the ring trace was asigned to be an explosive decay of the multiple neutron such as di- and quad-neutrons. The trace was one of the most credible pieces of experimental evidence, indicating that cold fusion reactions had taken place. When the hydrogen-cluster is compressed to induce cold fusion reactions, surplus hydrogen atoms that are not directly involved in the fusion reaction should scatter. Those traces could be seen in the traces in this experiment, shown in Figs. 4(a) to (b).

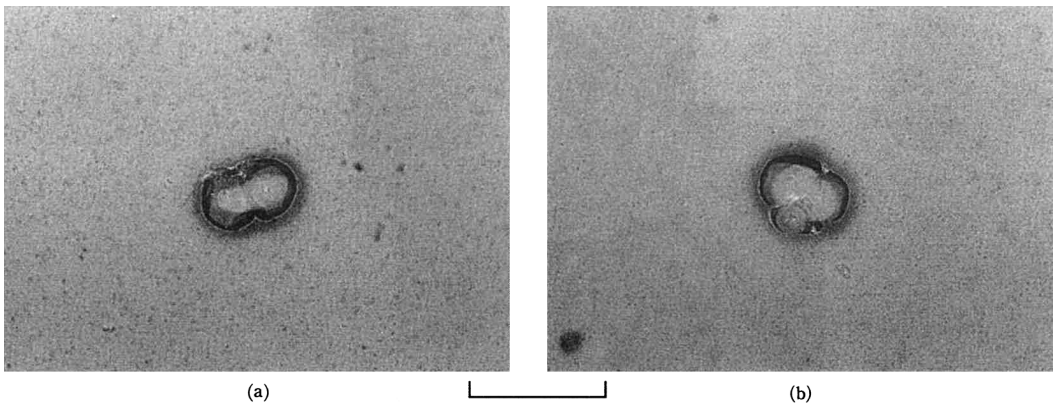
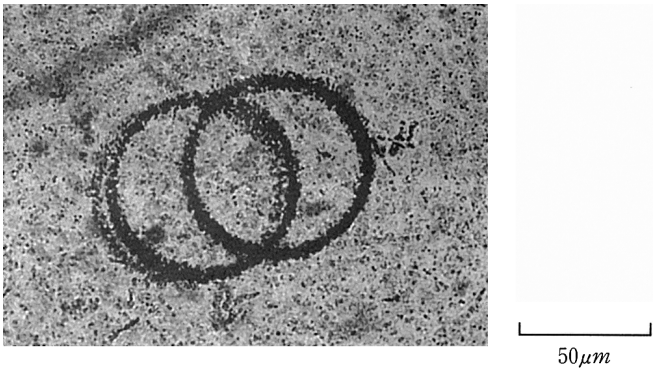


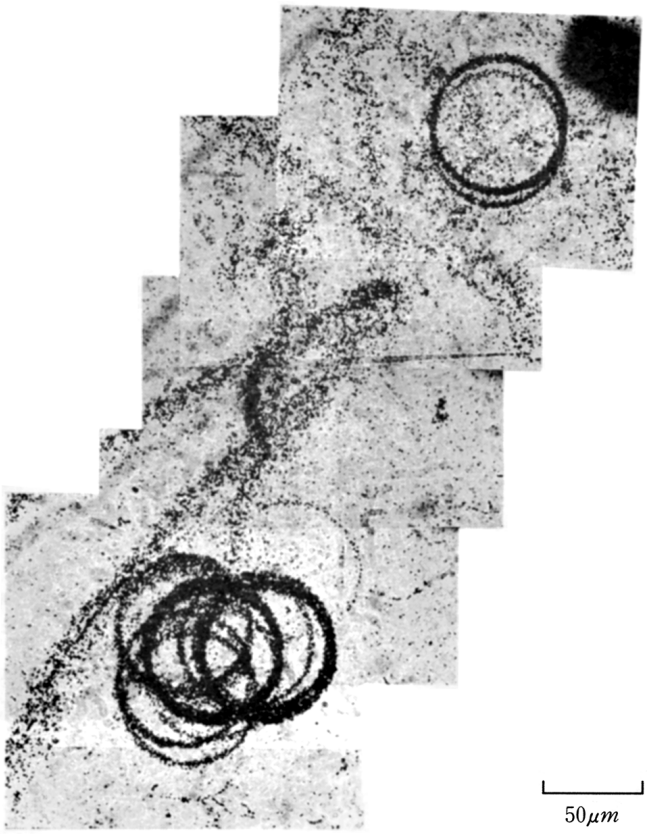
Fig. 5: Combined traces

The third was combined traces, shown in Fig. 5. The traces could indicate two or three simultaneous reactions, because they were fortunately recorded on mismade nuclear emul-

sions that were thinner than the usual ones. If the nuclear emulsions were thick, individual explosive traces would grow and combine with each other to form a larger trace as is shown in Fig. 4(b). A similar combined product was also observed on the rear surface of a palladium thin foil that was used in an electrolysis experiment of cold fusion (7). There the boundary line between each of the products could obviously be seen.



(a)



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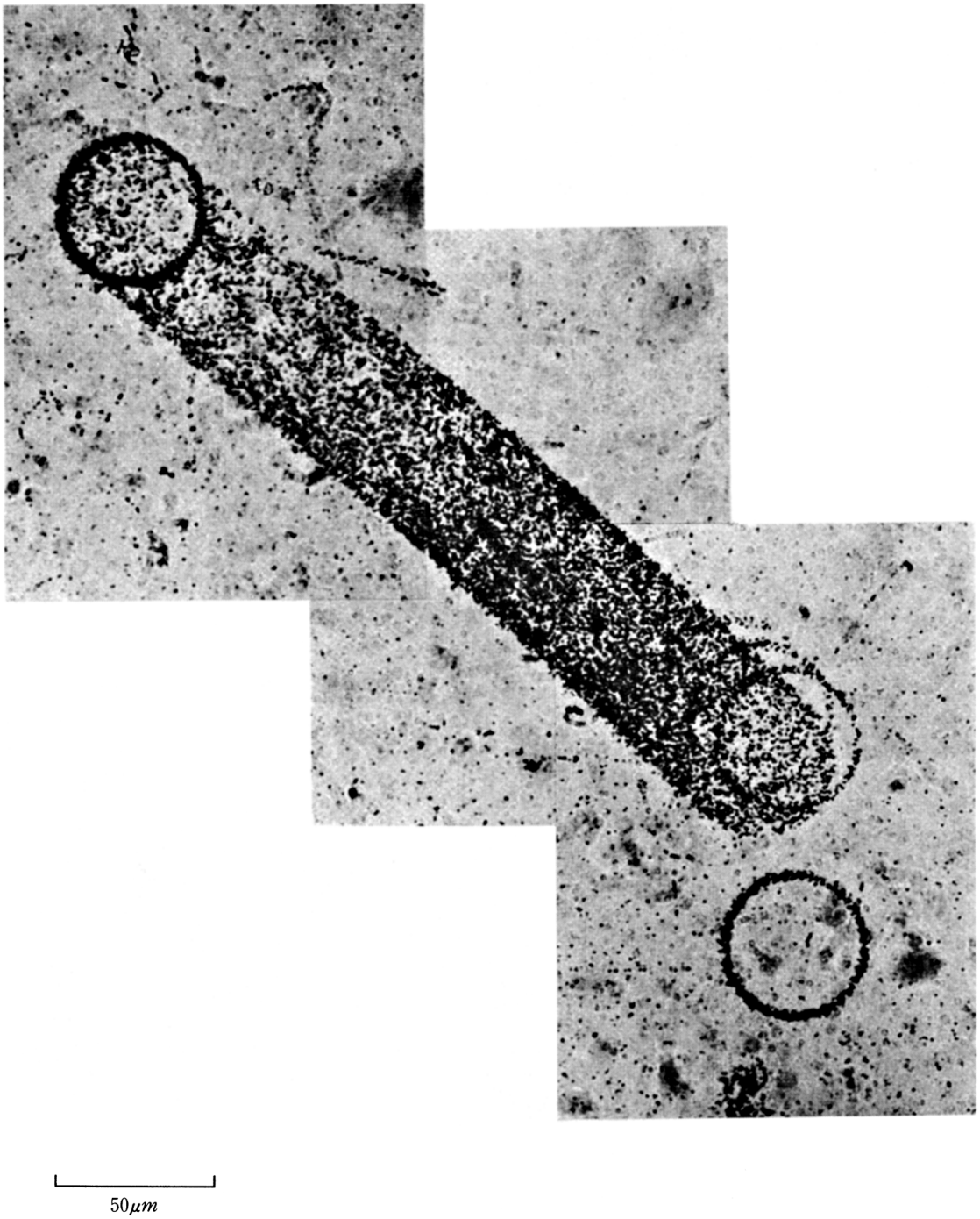
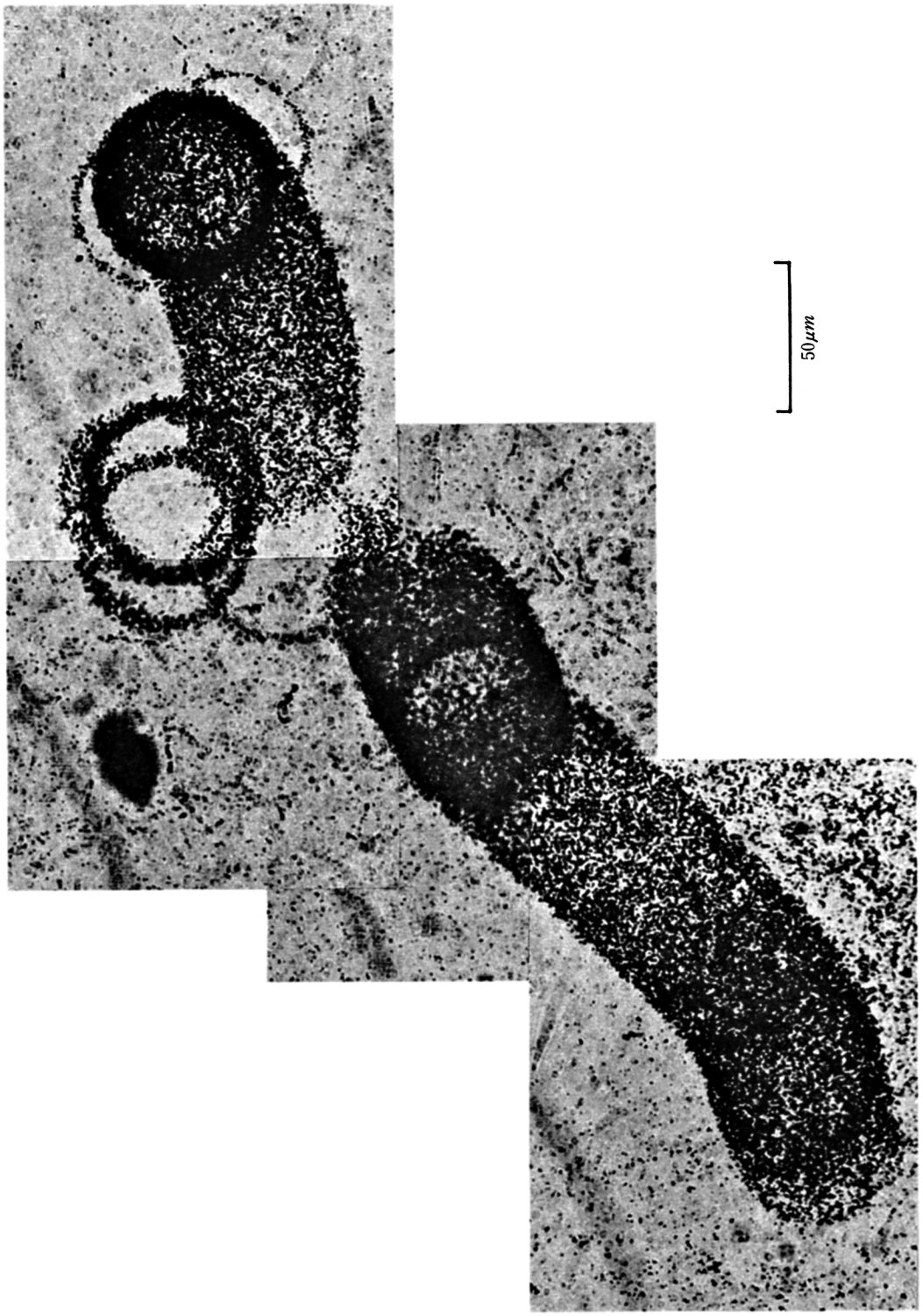


50μm

(c)



(d)

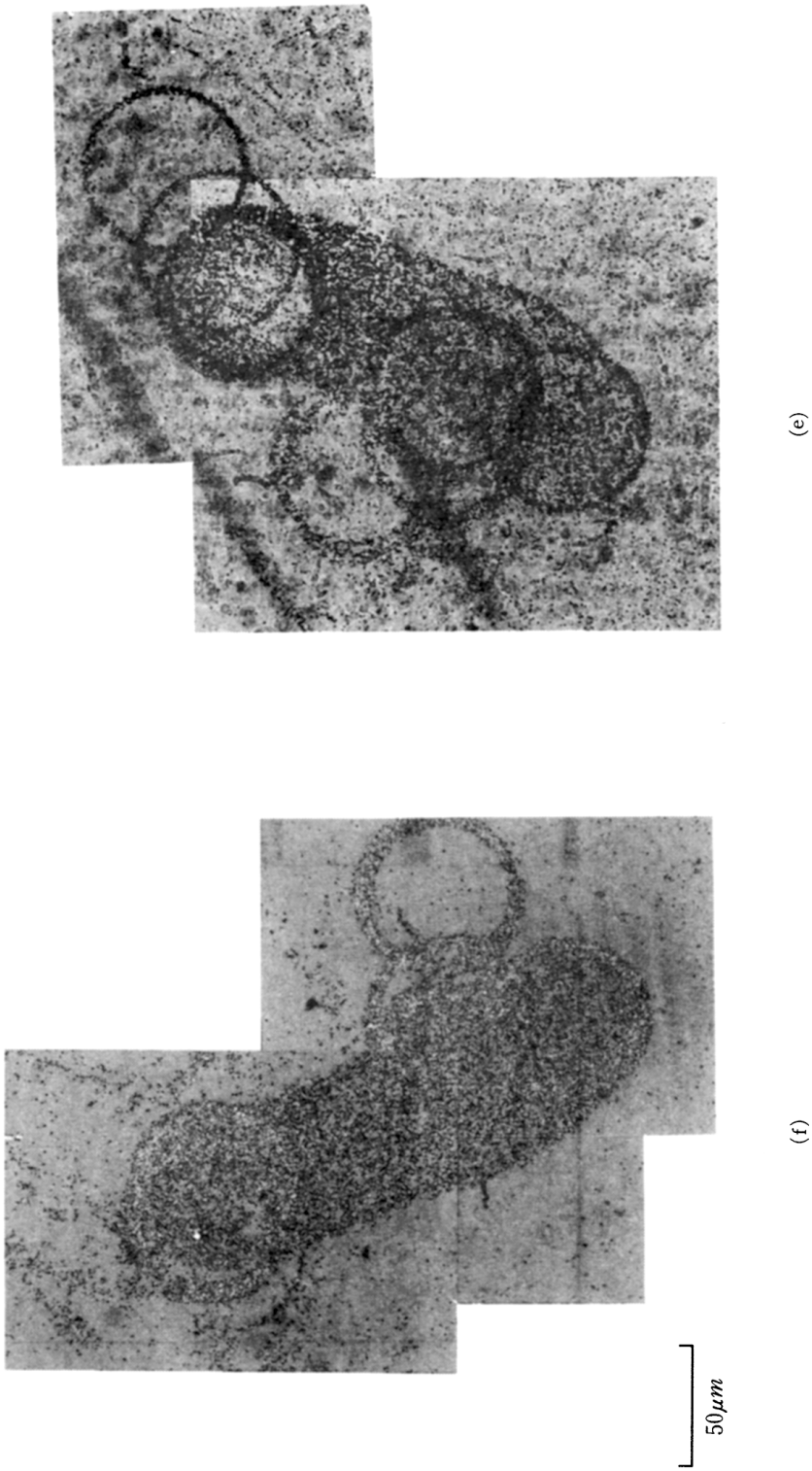


Fig. 6: Combined ring traces

The fourth was strange combined rings that were first observed in this experiment, shown in Fig. 6. These rings could be clearly distinguished from the second explosive traces, because the combined rings were recorded only on the surface while the second traces were distributed three dimensionally. Some rings seemed to have been moved on the surface of the nuclear emulsion and then remained as continuous traces, shown in Figs. 6(c) to (f). The diameter of the combined rings were different in each event but almost the same within the same event. The combined rings, shown in Figs. 6(a) to (d), were registered by independent events, but Figs. 6(e) and (f) were made by the same event. Two events, shown in Figs. 6(e) and (f), were recorded on the backside of the first nuclear emulsion and on the front side of the second one, respectively. They were almost symmetrical. During the development process, the nuclear emulsions were placed in a development solution with a gap of more than 3 mm, so no combined rings could be simultaneously generated on the different nuclear emulsions by any reasons such as the chemical reactions of tiny bubbles. It is reasonable to infer that the traces were generated by the same particle emitted from the cell during the discharge. Figure 7 shows the spatial distribution of the events of the combined rings. The events were densely concentrated between the first and the second nuclear emulsions. It shows that the particles did not have enough kinetic energy so that they could be sufficiently slowed down during the passing through of a 3 mm thick layer of acrylite (2 mm thick window and 1 mm thick nuclear emulsion plate).

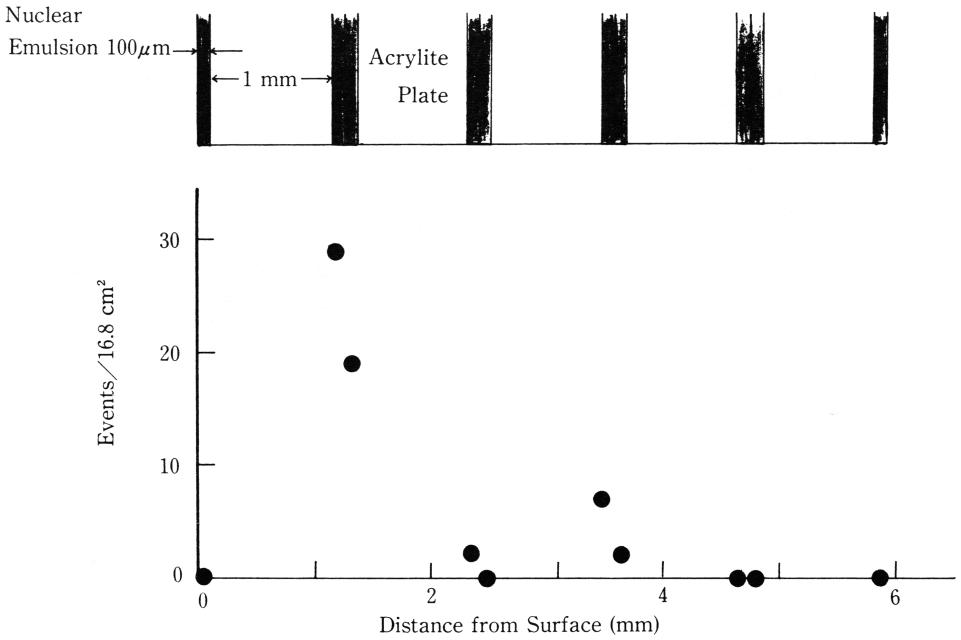


Fig. 7: Spatial distribution of combined ring traces

The fifth was a ring-like product that was observed on the surface of the nuclear emulsion, shown in Fig. 8. This kind of product that was first observed in this experiment could be clearly distinguished from both of the second and the fourth traces. The relationship between the fifth product and the fourth rings will be discussed later in this paper.

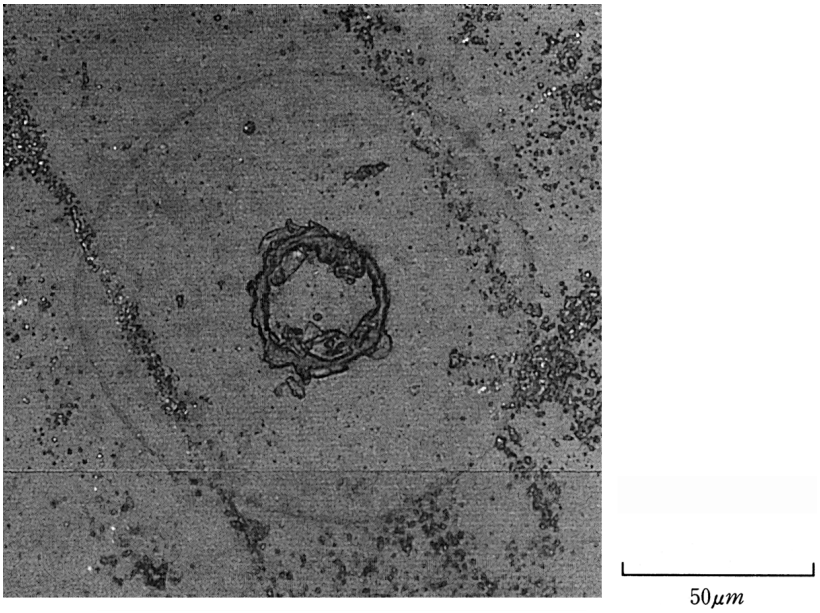


Fig. 8: Ring-like product

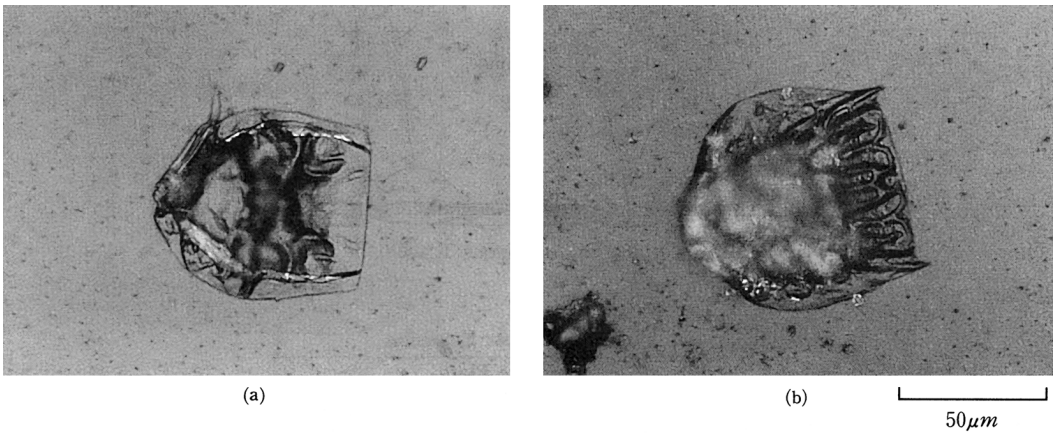


Fig. 9: Prototype of microbacteria

The sixth was strange traces like microbacteria, shown in Fig. 9. Four traces were observed so far and they all were found on the surface of the nuclear emulsions. They all had common shapes with the similar dimensions of about 60 μm long and seemed to have organ like things in the body. Especially in Fig. 9(a), something like a mouth and feeler appeared. However, they were not complete microbacteria that exist in the natural environment. They might be the prototypes of microbacteria. Since they were not seen on the reference nuclear emulsions but were observed on both the nuclear emulsions that were seperately coated in our laboratory and at Fuji Film Inc., it is reasonable to infer that they were newly created by the electrical discharge. More data should be required for a detailed discussion about this topic.

4. Discussion

In the previous experiment (3), extraordianry traces were recorded on the copper plate, suggesting that a hydrogen-cluster was formed to induce cold fusion reactions. In this experiment, on the other hand, sensitive nuclear emulsions also recorded explosive traces similar to that which were previously measured in the electrolysis cold fusion experiment (5 - 7). It can be concluded from those experiments that as soon as an electrical discharge is employed beteween the electrodes in water, the cold fusion reactions can be induced on the surface of the metal. Among the traces recorded on the nuclear emulsions, the first to the third were already discussed in the previous paper (5 - 7), so the fourth and the fifth that were newly observed in this experiment will be discussed here.

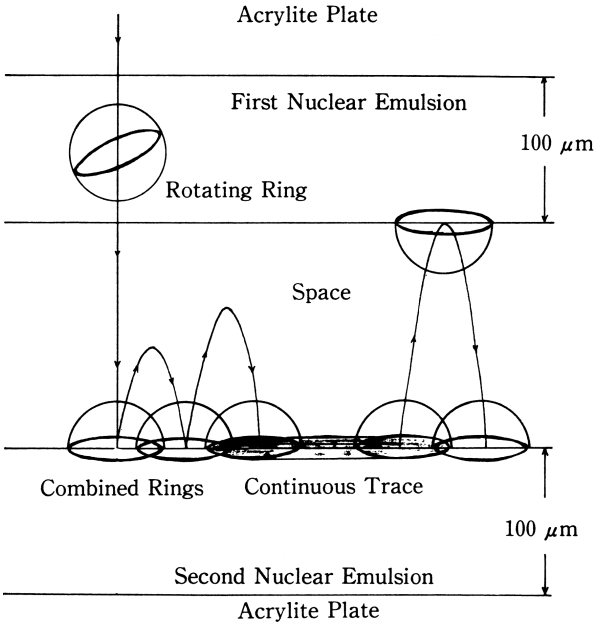


Fig. 10: Conceptual view of forming combined ring traces

Figure 10 shows a conceptual view of the recording of the third kind of traces, the combined rings. A rotating and vibrating ring, generated by the discharge, might enter the nuclear emulisons. While passing through the emulsion material and acrylite plates, it somewhat loses it's kinetic energy. Mainly bewtween the first and the second nuclear emulsions, the moving ring can be trapped and leave a ring trace on the surface of which it touches. The ring could have an electrical charge so that it hops up and down in the space between the nuclear emulsions. While the ring touches the surface of the nuclear emulsions, a portion of the electrical charge could transfer to the nuclear emulsion. Then, a static electrical repulsive force could work between the ring and the nuclear emulsion to make the ring jump up. Many ring traces could be left until the moving ring escapes from it's space. When the ring moves on the surface as it touches, a continuous trace should remain, as is shown in Figs. 6(c) to (f).

Now, the problem is finding out what the moving ring is. In a recent experiment of similar but continuous discharge in water(8), a large number of similar rings, but with the smaller diameter, were successfully observed, when tiny sparks appeared on the surface of the electrode. The ring could leave the electrode and could be driven by the electrical potential. The ring walked around on the surface of the nuclear emulsion and finally decayed to a regular hexagonal plate. According to The Nattoh Model (9, 10), hydrogens form a hydrogen-cluster on the surface of the electrode or within the metal, when the pressure of the hydrogen is increased sufficiently enough by the electrical potential. There, the hydrogen-cluster might be a sphere or ring. The shape should be determined by the condition of the energy minimum. The fifth ring-like product, shown in Fig. 8, might be the remains of the ring cluster that faded during it's moving around period.

Recently, tiny ball-lightening-like phenomena were observed twice by the author, while similar experiments of electrical discharges in water were carried out (11). The first was on August 13, 1992 when an electrical discharge was attempted on wire electrodes of palladium and platinum that were vertically arranged to each other. The second was on August 25, 1992 when an electrical discharges was also attempted but on a pallarel arrangement of palladium wires. In the first case, tiny ball-lightening was emitted from a point about 1 cm distant from the discharging point, flew about 1 cm in the oposite direction and exploded when it stopped. The emission of the ball-lightening took place with a somewhat delayed time after the discharge, and this was very often repeated. In the second case, two bolts of tiny ball-lightening were emitted upwards from the wire showing S-curves, and it also exploded at the end.

In the natural environment, on the other hand, ball-lightening was observed by many people and many reports were documented (12, 13). It seems to be often generated by a thunderstorm, that has a large scale electrical discharge. The ball-lightening can move around, up and down, enter a house through a window and very often explode at its stopping point. The ball-lightening has a large diameter but those extraordinary behaviors are very similar to that of the ring cluster mensioned earlier. Lewis early pointed out that the cold fusion phenomena are closely related to the ball-lightening phenomena (14). If the ball-lightening with a large enough diameter is generated by an electrical discharge in the laboratory, it's structure and property could be revieled in more detail.

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Radioactive Analysis of Palladium Used for an Explosive Cold Fusion Experiment

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Abstract

A radioactive analysis of palladium metals that were used for an explosive cold fusion experiment was performed. The samples were irradiated by thermal neutrons at the graphite column of the Kyoto University Reactor (KUR). The production of ^{115}In and ^{104}Ru was clearly observed. The production of the elements is discussed based on The Nattoh Model, in which the nuclear transmutation of the palladium element was proposed.

Keywords

cold fusion, radioactive anlalysis, KUR, nuclear transmutation, production of In and Ru, The Nattoh Model

1. Introduction

The nuclear transmutation was discussed earlier in The Nattoh Model (1, 2) and was proposed by one of the authors (T. M) related to cold fusion phenomena (3). The model proposed three processes for the nuclear transmutation: (1) sequential many-body fusion reactions of hydrogen isotopes, (2) capturing of electrons or hydrogen isotopes by a host element, and (3) multi-body fission reaction induced by a multiple neutron. All three processes simultaneously take place during cold fusion experiments. The distribution of the produced elements depends on the process. The first process sequentially produces light elements, and the second process generates heavy elements near the host element.

An explosive cold fusion experiment was carried out with a palladium metal rod in a previous experiment (4), in which light elements such as Na, Mg, Ti and Fe and heavy elements of Ru and In were found in the metal by an analysis with a scanning electron microscope (SEM) and an energy dispersive X-ray spectroscopy (EDX). A portion of those elements was asigned to be not impurities but to be nuclearly transmuted during the electrolysis. The nuclear transmutation was suggested to be closely related to the cold fusion phenomena (2).

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This paper describes a radioactive analysis (RA) of the palladium metal that was used in the previous experiment. The RA method was applied to confirm the production of the heavy elements through the second process. The palladium samples were irradiated at the Kyoto University Reactor (KUR). The RA method was a sensitive analysis so that provided an alternative method to the SEM-EDX method.

2. Experiment

An experiment of explosive cold fusion was carried out in the previous paper (4), in which hydrogen isotopes were moved through a palladium metal rod to violently burn hydrogen fuel. The experiment was made by electrolyzing heavy water mixed with 3 % NaCl. After charging a sufficient amount of hydrogen into the palladium rod for 19 days, a special procedure of moving hydrogen through the metal was made to induce a small scale explosion several hours later. The detailed result was described elsewhere (4).

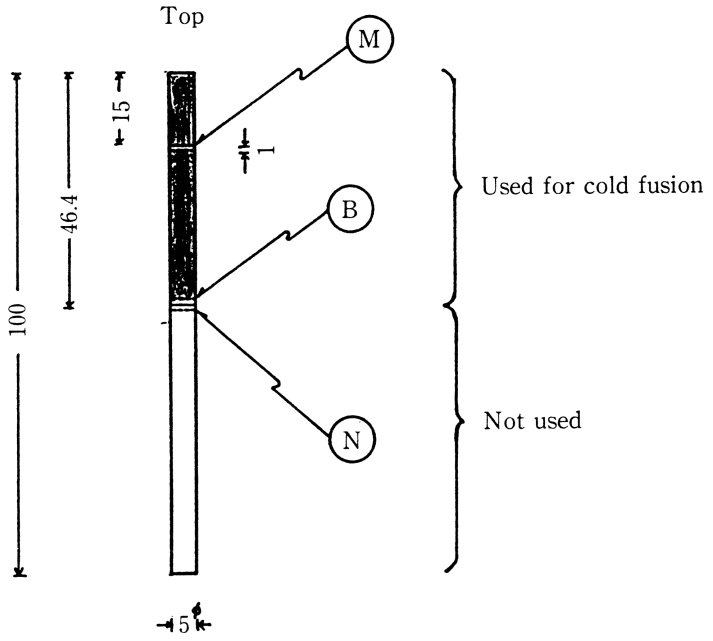

Fig. 1; Sample discs cut from Pd rod

In this paper, the palladium rod used in the previous experiment was analyzed by the RA method. Figure 1 shows the preparation of three disc-like samples (about 1 mm thick) of palladium, that were cut away from the palladium rod (purity 99.95 %, 5 mmϕ x 100 mm). A half upper portion of the palladium rod was used for the electrolysis experiment of cold fusion and the other lower portion was left for the measurement of the background. The samples of M and B were cut at the center and the bottom of the used rod, respectively, and N was the top of the reference rod. In order to avoid impurity problems as much as possible, careful treatments were carried out. The adjacent samples of B and N were selected because of reducing the impurity problems. All the samples were simultaneously irradiated

under thermal neutrons at the graphite column of KUR (5), in which the thermal neutron flux was about 2.6×10^{10} n/cm^2.sec. The neutron spectrum at the irradiation field was sufficiently thermalized so that only the reaction of (n, gamma) contributed to activate the samples. The neutron-induced gamma rays were detected by a Ge(Li) detector.

3. Radioactive Analysis

The activity of the neutron-induced gamma rays is related to the number density of a parent isotope as follows,

$$C(E_k : T_m) = fN_0\phi \qquad (1)$$

where
- C : counting rate of activity
- E_k : k-th energy of gamma ray
- T_m : measuring time
- f : modification factor.
- N_0 : number density of parent isotope
- ϕ : thermal neutron flux

The modification factor, f, can be given as follows,

$$f = \varepsilon(E_k)\,\sigma_k\delta(1-e^{-\lambda T_e})\frac{1}{\lambda}e^{-\lambda(T_m-T_e)}(1-e^{-\lambda\Delta T}) \qquad (2)$$

where
- $\varepsilon(E_k)$: detector efficiency
- γ_k : gamma-ray intensity
- σ : cross section of (n, gamma)
- λ : decay constant
- T_e : irradiation period
- ΔT : measuring period

The detector efficiency, $\varepsilon(E_k)$, was measured by using a standard source of ^{233}U, located at the same position as the samples. Numerical values derived from Ref. 6 were used for γ, σ and λ.

4. Results

Figure 2 shows a comparison of the energy spectra of the neutron-induced gamma rays, that were measured immediately after the irradiation. Figures 3 and 4 show the similar spectra that were measured two hours later and after sufficient time elapsed, respectively. Several peaks due to the palladium isotopes (^{109}Pd, ^{111}Pd and ^{111m}Pd) were seen for all the samples of M, B and N with many peaks due to impurities.

Three peaks due to ^{116m}In (1097, 1294 and 2112 keV) was obviously observed for M and B, but not for N, as shown in Figs. 3 and 4. After sufficiently time elapsed, on the other

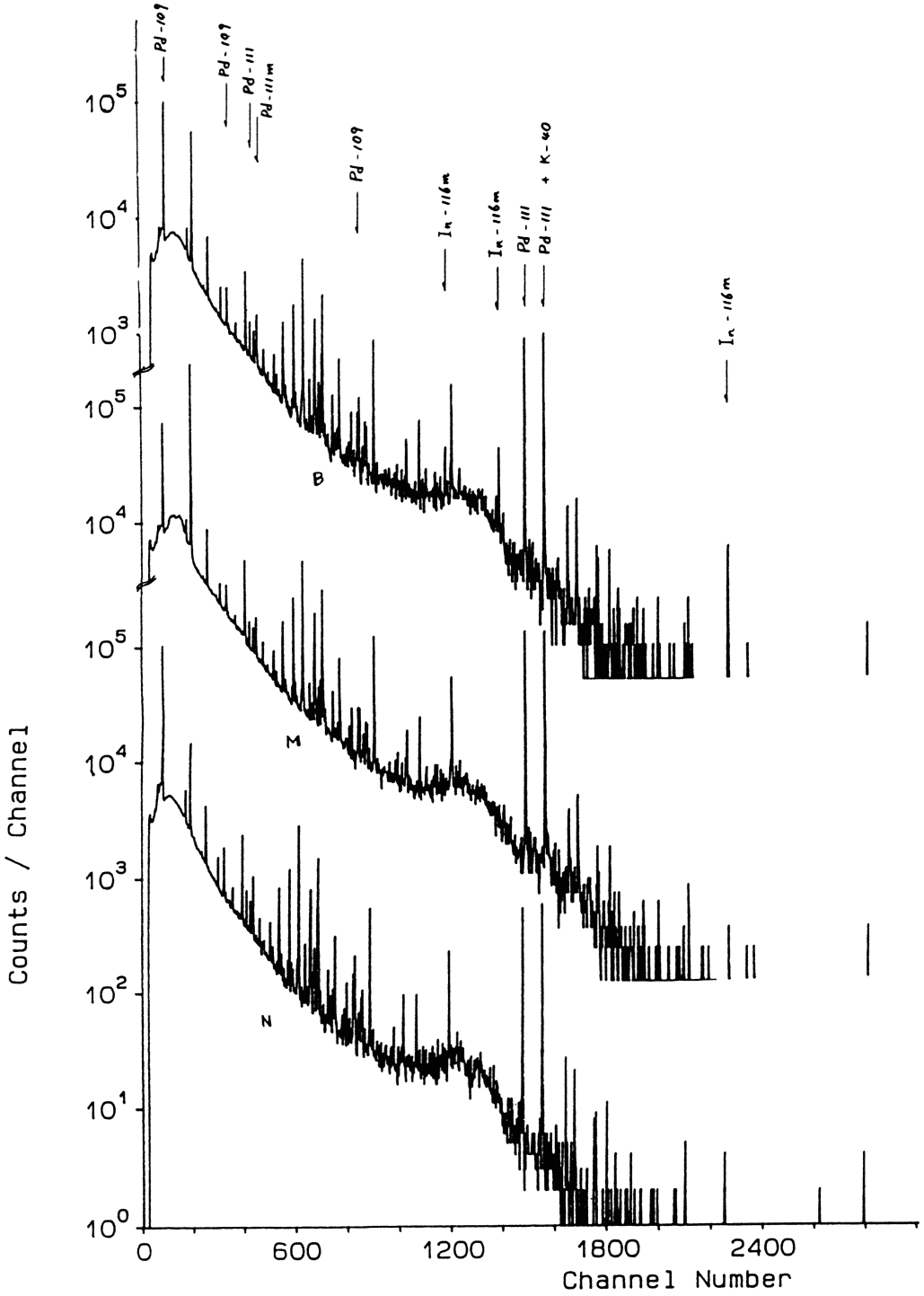

Fig. 2: Gamma ray energy spectrum immediately after irradiation
M: middle in used Pd
B: bottom of used Pd
N: top of non-used Pd

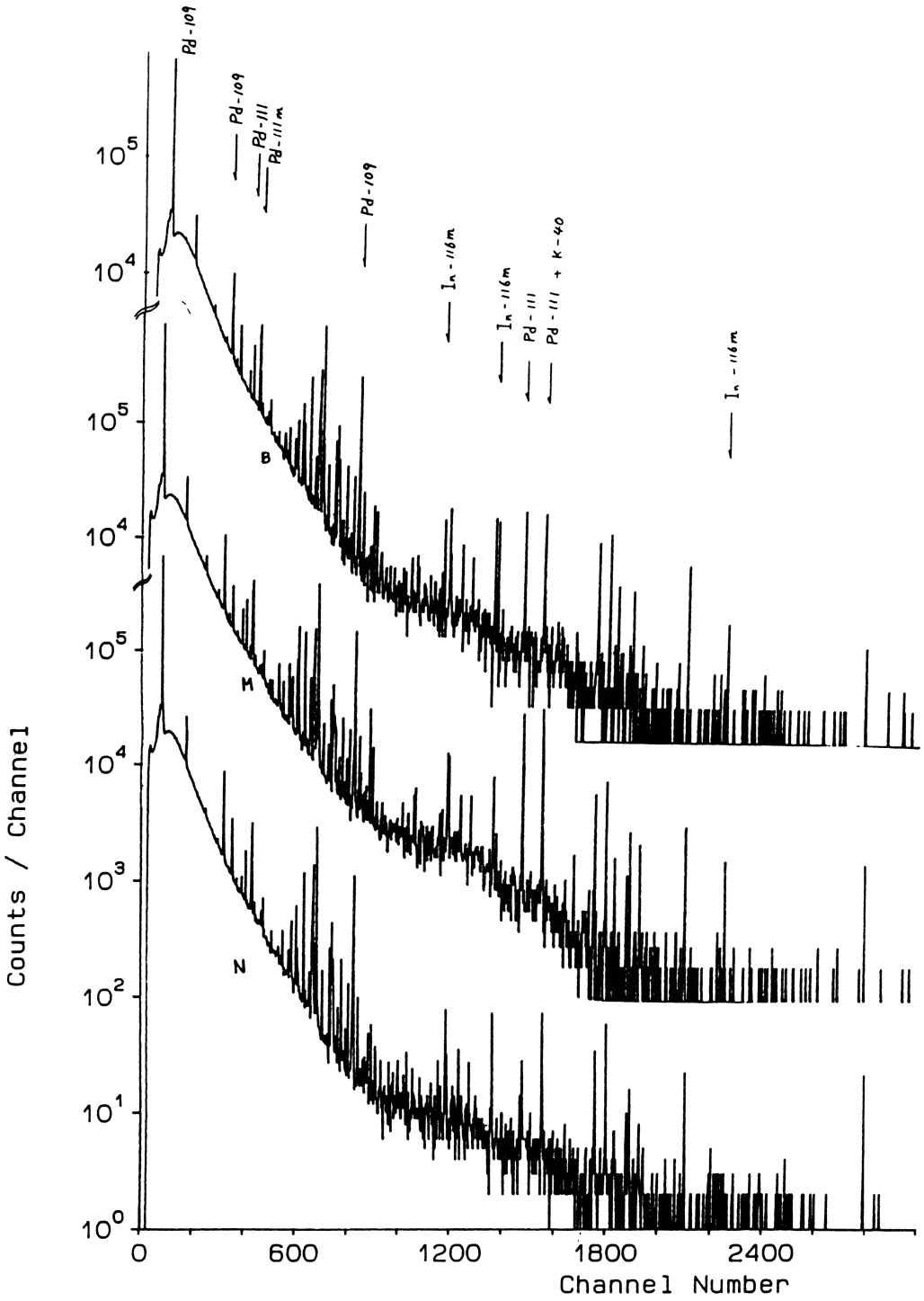

Fig. 3: Gamma ray energy spectrum at 2 hrs
M: middle in used Pd
B: bottom of used Pd
N: top of non-used Pd

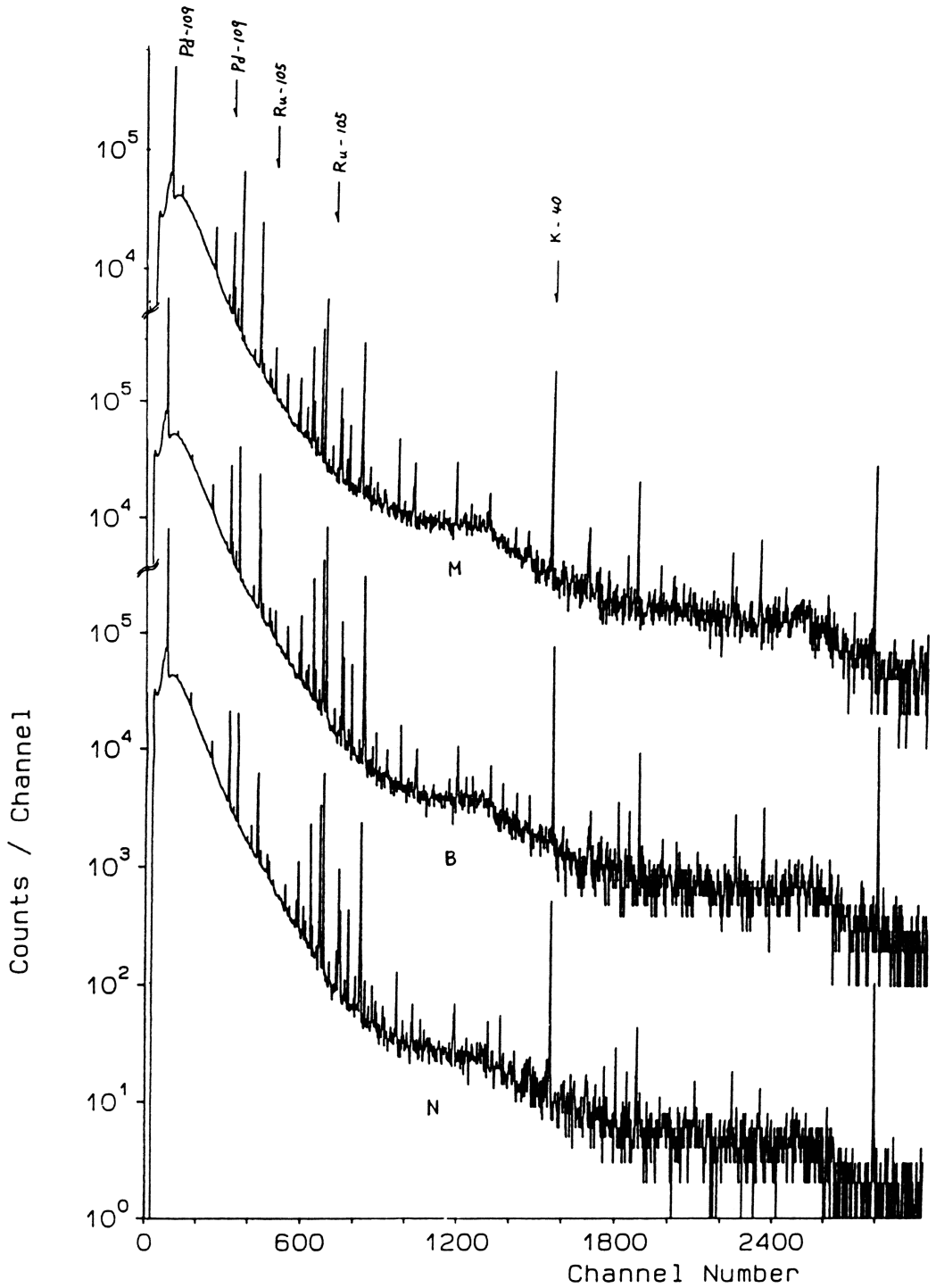

Fig. 4: Gamma ray energy spectrum after sufficient time elapsed
M: middle in used Pd
B: bottom of used Pd
N: top of non-used Pd

hand, two peaks due to ^{105}Ru (675 and 724 keV) appeared. No gamma rays due to ^{116m}In and ^{105}Ru were not observed for the background N that was adjacent to B. Therefore, it is reasonable to consider that those parent isotopes of ^{115}In and ^{104}Ru were not impurities but produced during the electrolysis.

The relative number density was calculated by using Eqs. (1) and (2), and those results are shown in Table 1. The relative number density of ^{108}Pd, deduced from the activity of ^{109}Pd, was in good agreement for the background N with the isotope ratio 26.7 % of the natural palladium. The values of the samples of M and B seemed to somewhat deviate around the natural isotope ratio, but it was difficult to draw a conclusion that the isotope ratio of palladium changed during the cold fusion experiment (7). The relative number density of ^{111}Pd, deduced from the activity of ^{111m}Pd, was also consistent with the natural isotope ratio 11.8 %. However, for the case of ^{111}Pd, the values seemed to be larger for the samples of B and N, but no clear reason was found. Table 1 also shows the relative number density of ^{115}In and ^{104}Ru. Although the number density of ^{115}In was very small, the detection was made possible due to the large cross section. On the other hand, the number density of ^{104}Ru was shown to be large. Since the intensity of gamma rays of ^{105}Ru was not sufficient, the value

Table 1: Relative number density of isotopes

	isotope ratio half-life cross-section	gamma-ray energy (keV)	ralative number density*(%)		
			M	B	N
Pd-109	26.7 13.46h 12.0b	311 781	27.4 26.4	26.4 26.0	26.5 26.5
Pd-111m	11.8% 5.50h 0.020b	390	11.3	10.9	11.1
Pd-111	11.8% 23.4m 0.20b	835	11.2	15.9	14.9
Ru-105	4.44h 0.47b	675	7.91×10^{-2}	1.89×10^{-1}	no
In-116m	54.15m 157.0b	1294	2.02×10^{-5}	1.23×10^{-5}	no

*N/N where N : total number density of Pd

should be considered as the upper limit.

Rolinson et al. (7) reported that the elements of Rh and Ag were produced during cold fusion. This RA method was not applicable to those elements because the half-life of the neutron-induced radioactive isotopes and the cross section were inadequate.

5. Discussion

The nuclear transmutation of the elements was explained by The Nattoh Model (2). According to the model, an extremely compressed hydrogen-cluster is formed in the metal,

in which electrons are degenerated and interconnected with each other. The special state is called the "itonic" state. During that state, nuclear reaction processes including fusion reactions easily take place. The nuclear transmutation also can be induced in the itonic state through three processes mentioned in Chap. 1.

First, the nuclear transmutation by the electron capture with palladium can be written as follows,

$$^{102}\mathrm{Pd}\ (\ 0.96\ \%) + \mathrm{e} \longrightarrow {}^{102}\mathrm{Rh} \xrightarrow[\mathrm{EC}]{2.9\mathrm{y}} {}^{102}\mathrm{Ru} \tag{3}$$

$$^{104}\mathrm{Pd}\ (10.97\ \%) + \mathrm{e} \longrightarrow {}^{104}\mathrm{Rh} \xrightarrow[\mathrm{EC}]{42.3\mathrm{s}} {}^{104}\mathrm{Ru} \tag{4}$$

$$\beta^- \searrow \quad \mathrm{Pd} \tag{5}$$

$$^{A}\mathrm{Pd} + \mathrm{e} \longrightarrow {}^{A}\mathrm{Rh} \xrightarrow{\beta^-} {}^{A}\mathrm{Pd} \tag{6}$$

for A = 105(22.2 %), 106(27.3 %), 108(26.7 %) and 110(11.8 %).

Here, EC and β^- indicate the electron capture and the beta decay, respectively, and the half-life shows a value for the conventional isolated state of the isotope. Since orbital electrons distribute closely to the compound nucleus in the itonic state, the halflives of EC that appear in Eqs. (3) and (4) should drastically be shortened. Furthermore,the beta decay should strongly be surpressed by the same reason so that the schemes of Eqs. (5) and (6) should be ruled out. As resulted, the stable isotopes of ^{104}Ru and ^{102}Ru can be generated by the electron capture. Since the isotope abundance of ^{102}Pd was small and the half-life of ^{102}Ru was fairly long, the production of ^{102}Ru was not recognized here.

Second, palladium can be transmuted by the deuteron capture as follows,

$$^{102}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{104}\mathrm{Ag} \xrightarrow[\mathrm{EC}/\beta^+]{69.8\mathrm{m}} {}^{104}\mathrm{Pd} \tag{7}$$

$$^{104}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{106}\mathrm{Ag} \xrightarrow[\mathrm{EC}/\beta^+]{24\mathrm{m}} {}^{106}\mathrm{Pd} \tag{8}$$

$$^{105}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{107}\mathrm{Ag} \tag{9}$$

$$^{106}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{108}\mathrm{Ag} \xrightarrow[\mathrm{EC}/\beta^+]{2.39\mathrm{m}} {}^{108}\mathrm{Pd} \tag{10}$$

$$^{108}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{110}\mathrm{Ag} \xrightarrow[\mathrm{EC}]{24.6\mathrm{s}} {}^{110}\mathrm{Pd} \tag{11}$$

$$^{A}\mathrm{Pd} + \mathrm{d} \longrightarrow {}^{A+2}\mathrm{Ag} \xrightarrow{\beta^-} {}^{A+2}\mathrm{Pd} \tag{12}$$

for A = 106, 108 and 110.

Here, the stable isotopes of Pd can be generated through Eqs. (7), (8), (10) and (11).

Therefore, the isotope ratio can change by the deuteron capture.

Two or three deuterons can almost simultaneously absorbed in the itonic state. The nuclear transmutation can be written as follows,
for two deuterons capture,

$$^{105}\mathrm{Pd} + 2\mathrm{d} \longrightarrow {}^{109}\mathrm{Cd} \xrightarrow[\mathrm{EC}]{464\mathrm{d}} {}^{109}\mathrm{Ag} \tag{13}$$

$$^{A}\mathrm{Pd} + 2\mathrm{d} \longrightarrow {}^{A+4}\mathrm{Cd} \tag{14}$$

for A = 102, 104, 106, 108 and 110.

and for three deuterons capture,

$$^{A}\mathrm{Pd} + 3\mathrm{d} \longrightarrow {}^{A+6}\mathrm{In} \xrightarrow[\mathrm{EC}/\beta^{+}]{} {}^{A+6}\mathrm{Cd} \tag{15}$$

for A = 102, 104, 105, 106, 108 and 110,

$$^{A}\mathrm{Pd} + 3\mathrm{d} \longrightarrow {}^{A+6}\mathrm{In} \xrightarrow[\beta^{-}]{} {}^{A+6}\mathrm{Sn} \tag{16}$$

for A = 106, 108 and 110.

Here, Eqs. (12) and (16) should be special due to the following beta decay. Unlike the electron capture shown by Eq. (6), the deuterons capture themselves should proceed here, but the itonic state of the induced isotopes should remain for a moment. The special state should slowly decay as the itonic cover fades. As resulted by the deuteron capture, the isotopes of Ag and Cd can be newly generated. However, they were not recognized in this RA analysis due to the small cross section of the neutron capture and/or the inadequately long or short life-time. On the other hand, the stable isotope of ^{115}In that was observed by the RA method cannot be genarated by Eq. (16). Therefore, a complex nuclear transmutation by the deuteron capture can be introduced here as follows,

$$\binom{^{104}\mathrm{Pd}}{^{110}\mathrm{Pd}} + \binom{3\mathrm{d}}{3\mathrm{d}} \longrightarrow 2^{113}\mathrm{In} \tag{17}$$

$$\binom{^{106}\mathrm{Pd}}{^{108}\mathrm{Pd}} + \binom{3\mathrm{d}}{3\mathrm{d}} \longrightarrow 2^{113}\mathrm{In} \tag{18}$$

$$\binom{^{108}\mathrm{Pd}}{^{110}\mathrm{Pd}} + \binom{3\mathrm{d}}{3\mathrm{d}} \longrightarrow 2^{115}\mathrm{In} \tag{19}$$

Here, two stable isotopes of In can be generated by the nuclear transmutation. The isotope of ^{113}In was not detected due to the small cross section of the neutron capture and the inadequately long and short half-lives (^{114}In ; 3.9 b and 72 sec, and ^{114m}In ; 4.4 b and 49.5 day). Therefore, only ^{115}In was detected with the large cross section and the adequate half-life (^{116m}

In : 157 b and 54.15 min).

It might be surprizing that the nuclear transmutation takes place during the low voltage electrolysis. Especially, for the deuterons capture, the deterons have to overcome the Coulombic barrier. The reason why these processes are possible was explained by The Nattoh Model (2). The key point is the formation of the compressed hydrogen clusters, in which the electrons are degenerated and interconnected to each other to narrow the internuclear distance. Recently, many reports began to be published on the nuclear transmutation (3). It is important to remark that no energetic radiations are emitted (2). The exciting energy of the compound nucleus can be transfered to the vibrational energy of the itonic mesh that covers the nucleus to eventually disappear as thermal energy of the metal.

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EDITOR'S CHOICE

EXPERIMENTS OF UNDERWATER SPARK DISCHARGES WITH PINCHED ELECTRODES

Takaaki Matsumoto [1]

ABSTRACT

Experiments of sparking discharges were performed in ordinary water mixed with potassium carbonate. Here thin metal wires of palladium, nickel, titanium, iron, cadmium, molybdenum and tungsten were used as electrodes. In high voltages over 40 V, the surface of the electrode was pinched so that sparking appeared on the cathode or anode, and simultaneously extraordinary phenomena were observed. Especially, microscopic ring-clusters generated on the cathode caused tiny ball-lightning-like phenomena. The extraordinary phenomena was explained by The Nattoh Model.

INTRODUCTION

Recently many experiments of the electrolysis of heavy water have been performed since the cold fusion phenomena was published [1]. The studies have been mainly focussed to reproduce and enhance the excess heat, in which deuterium is charged into a metal to induce the cold fusion reactions. On the other hand, the author earlier proposed The Nattoh Model predicting that the cold fusion reactions can be induced in an extremely compressed hydrogen-cluster ("itonic" state) that can be easily generated by an electrical discharge [2], and showed that many extraordinary phenomena appeared associated with the cold fusion reactions in the experiments of the pulsed electrical discharge in water [3, 4].

This paper describes experiments of continuous discharges in ordinary water mixed with potassium carbonate, in which thin metal wires were used. Here the pinch effect of the current effectively worked to compress hydrogen-clusters on the cathode so that sparking appeared, associated with many extraordinary phenomena. Especially, many microscopic ring-clusters generated on the cathode caused tiny ball-lightning-like phenomena. The extraordinary phenomena were explained by The Nattoh Model.

EXPERIMENT

Experiments of the sparking discharge were performed using the DC continuous discharge in ordinary water. The experimental arrangement is shown in Fig. 1.

Thin wires of pure metals of palladium (99.95 %, 0.50 mm ϕ), nickel (99.7 %, 0.50 mm ϕ), titanium (99.9%, 1.0 mm ϕ), iron (99.998 %, 1.0 mm ϕ), cadmium (99.9999 %, 1.0

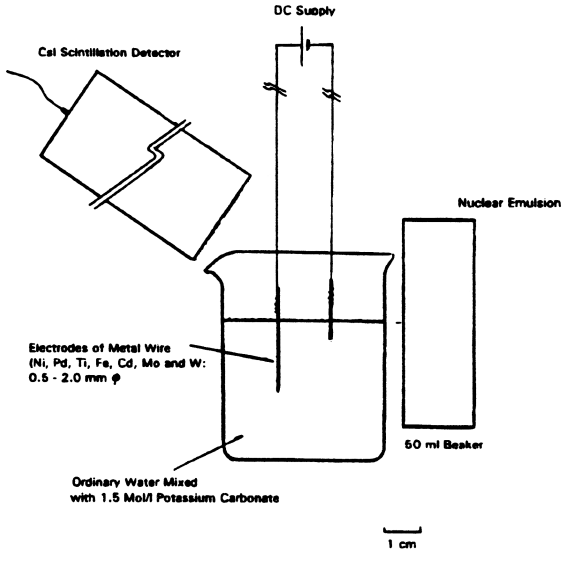

Fig. 1

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mm ϕ), molybdenum (99.95 %, 1.0 mm ϕ) and tungsten (99.95 %, 2.0 mm ϕ) were used as the electrodes. The wire electrodes were vertically immersed in ordinary water mixed with about 1.5 mol../l potassium carbonate, that was contained in a glass beaker (45 mm ϕ). The effective lengths of the cathode and anode that were inserted in the solution were about 3 mm and 15 mm long, respectively. On the shorter electrode, the current density could be increased such that the pinch effect of the current effectively worked to compress hydrogen molecules [2].

The DC discharge was continuously employed between the electrodes, in which the voltage was varied up to about 150 V under the constant voltage mode. The sparking that appeared on the surface of the electrode over 40 V was observed by a system of a micro telescope and a video tape recorder (VTR). The emission of radiation was monitored by a spectroscopy with a CsI(Tl) scintillation detector (12.5 mm x 12.5 mm x 20.0 mm). Furthermore, nuclear emulsions were located near the cathode. The nuclear emulsions (100 μm x 50 mm x 50 mm, coated on both sides of 1 mm thick acrylic plate) were the same as those that were used in previous experiments [5, 6]. After the discharges, the electrodes were analyzed by an optical microscope (OM), a scanning electron microscope (SEM) with an energy dispersive X-ray spectroscopy (EDX), an electron probe microscope analyzer (EPMA) and a X-ray spectroscopy (XS).

RESULTS

A. Nonlinear Characteristics of I/V

The DC current was employed between the electrodes under the constant voltage mode. Fig. 2 shows the strong nonlinearity of the I/V characteristics in which the nickel wires were used for both the electrodes and the cathode was shorter. They were divided into three regions. In the lower voltage region, about 40 V, the current proportionally increased as the voltage increased. Here, the layer of the resolved hydrogen gas also was steadily increased on the cathode. In the intermediate voltage region between about 40 V and 60 V, the hydrogen gas seemed to burst and evolve from the cathode, and the current strongly fluctuated. In the higher voltage region, about 60 V, the pinch effect of the current effectively worked to suppress the gas evolution, and tiny sparks appeared on the surface of the cathode. They initially appeared on the bottom tip of the cathode and as the voltage increased, the number of the tiny sparks increased to eventually cover the whole surface of the cathode. Here, the current was strongly suppressed to a stable level of about 0.1 A.

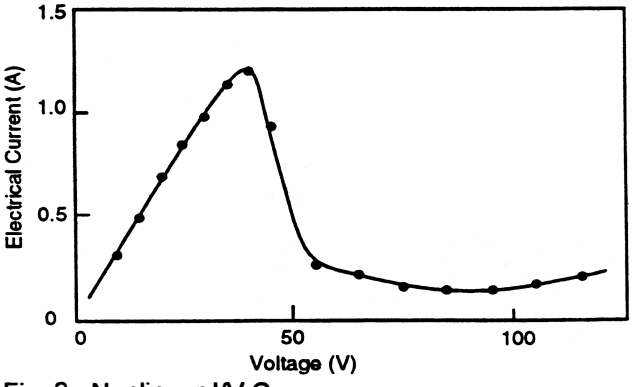

Fig. 2 Nonlinear I/V Curve

The I/V curve somewhat depended on the condition of the electrodes. Fig. 2 was obtained with new nickel electrodes. With old electrodes, impurity deposits on the surface, such as the electrolyte of potassium somewhat changed the I/V curve. However, the general aspect of the I/V curve showing three divided regions was maintained throughout the experiments.

B. VTR Observation of Microsparks

How the tiny sparks appeared depended on the kinds of electrode materials. Titanium was special among the metals used in these experiments. When the same metal wires were used for both of the electrodes, the tiny sparks appeared only on the anode of titanium, while with all the other metals, they initially appeared on the cathode and sequentially on the anode in the high voltage. With all the metals except titanium, it was also possible to generate the tiny sparks on the anode, but in that case, platinum was used as the cathode and simultaneously the voltage was required to increase higher than about 150 V. We made the tiny sparks appear on the cathode even with titanium, but the other metals, such as platinum, were used as the anode. This

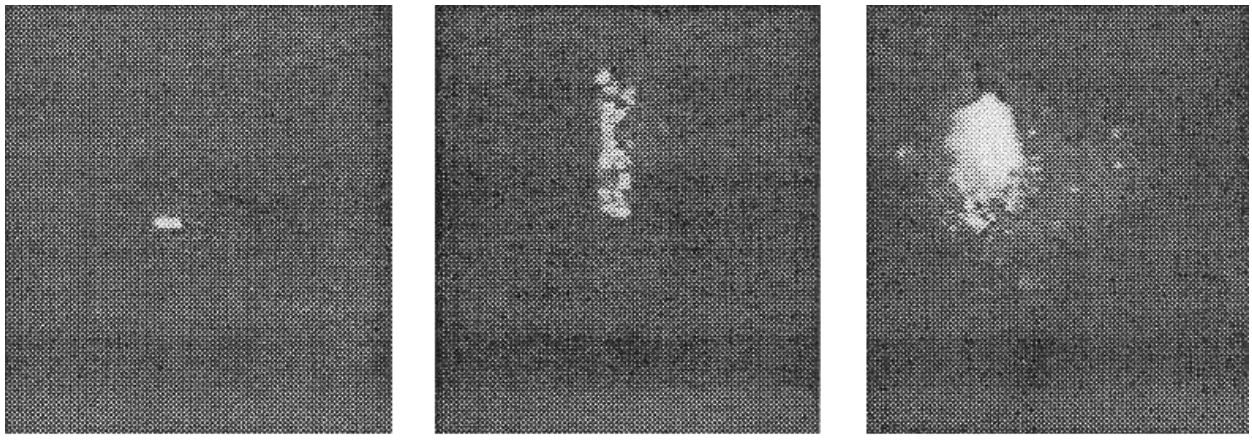

Fig. 3 Tiny sparks on the Palladium Cathode (x 10)
a) about 45 V, b) about 60 V, c) about 70 V.

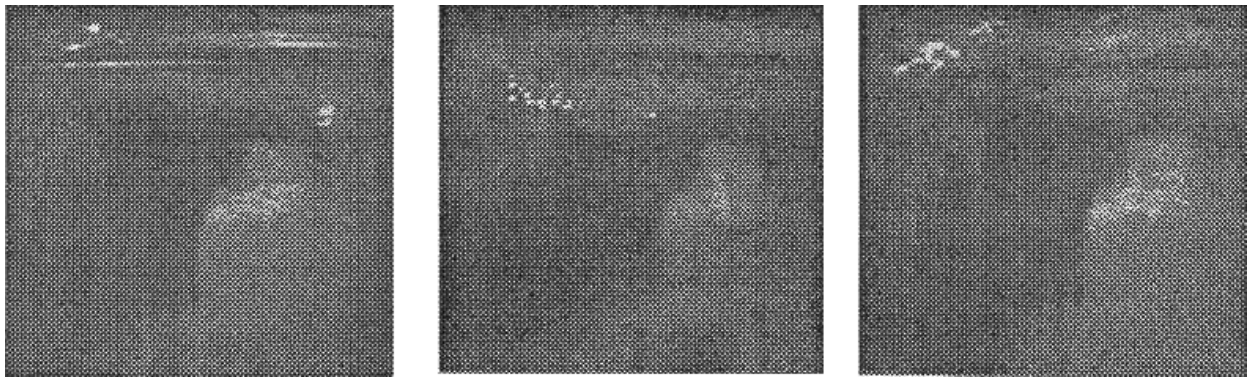

Fig. 4 Separated Tiny Sparks (time step 33 msec)

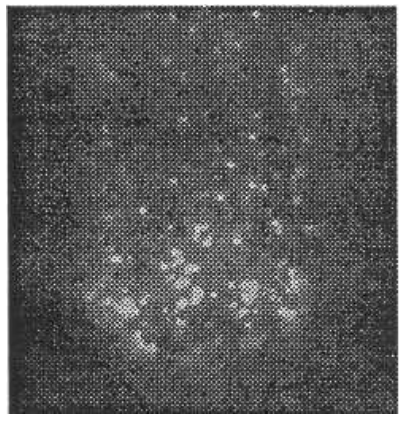

Fig. 5
Microsparks on the Cadmium Cathode
(x 200)

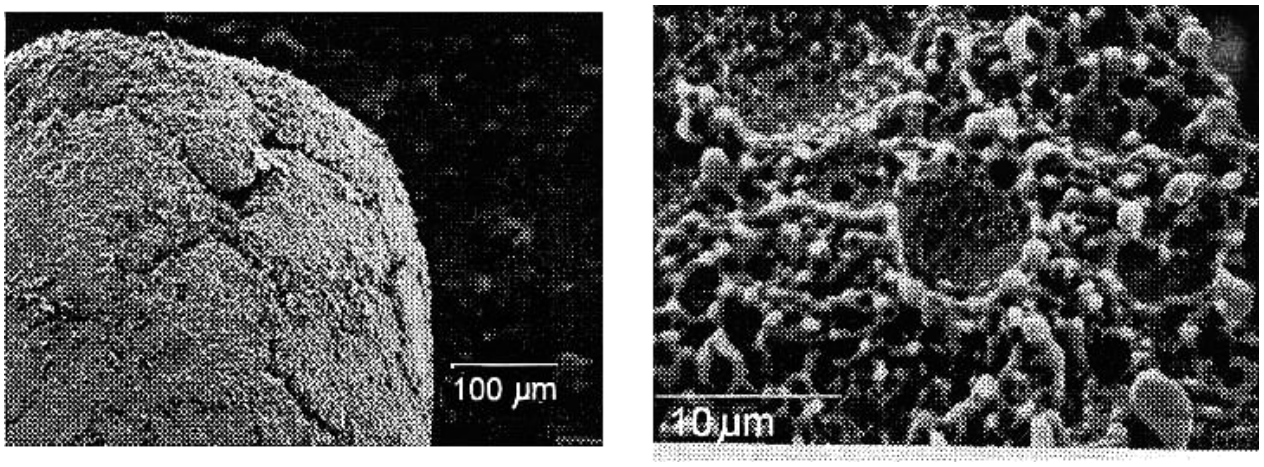

Fig. 7 Deposited Materials on the Ni Cathode (left) deposits with fracture, (right) tiny hole on deposits

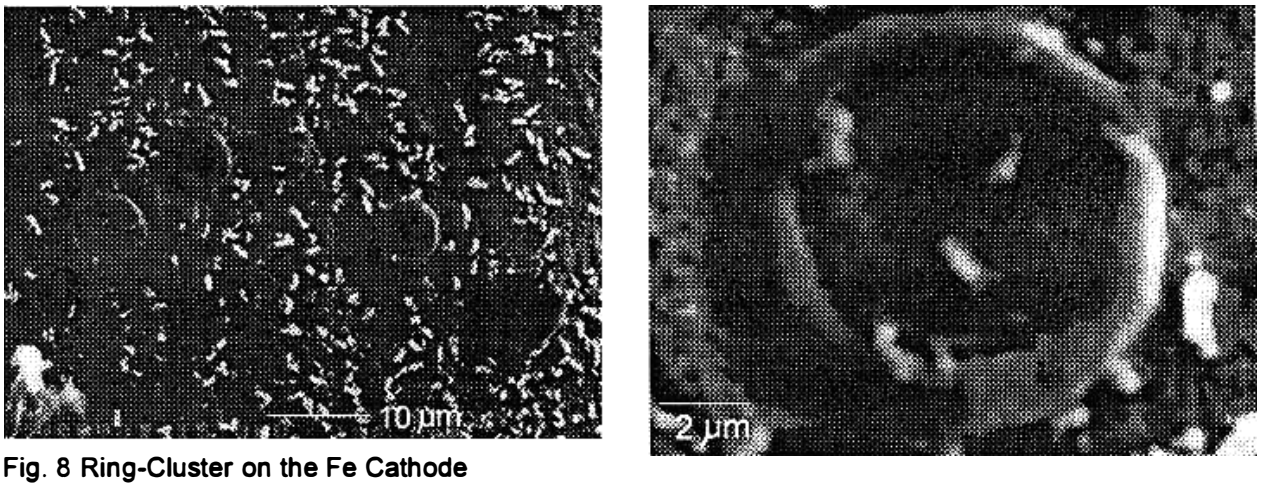

Fig. 8 Ring-Cluster on the Fe Cathode

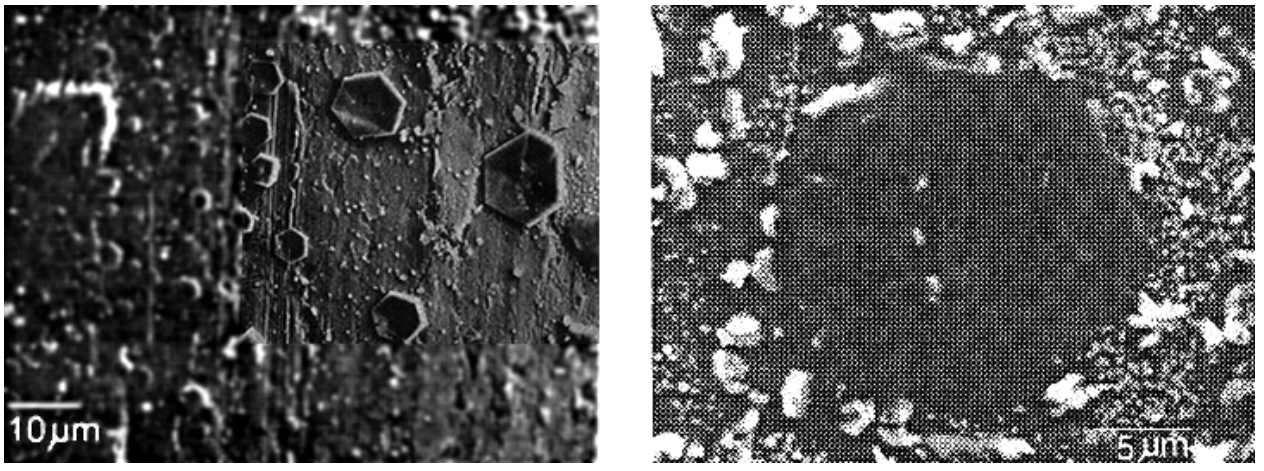

Fig. 9 Hexagonal Decay Products: (left) hexagonal plates, (right) intermediate stage of decay.

suggested that there might be different processes for sparking on the cathode or anode, and with titanium or the other metals.

The tiny sparks were observed *in situ* using the VTR system. Fig. 3 shows the tiny sparks appearing on the surface of the nickel wire cathode (with 10 times amplification of the VTR monitor). Figs. 3(b) and 3© show that the number of the tiny sparks increased as the voltage increased, but no sparks appeared on the anode.

Fig. 4 shows a sequence of pictures for the tiny sparks, in which they were accidentally separated from the surface of the palladium cathode by two explosions. The first small explosion took place in the gas atmosphere over the water level, which was triggered by the tiny sparks, as shown in Fig. 4(a). Due to mechanical shock from the explosion, a group of the tiny sparks were separated from the cathode, and were driven by the electrical potential towards the anode, as is shown in Fig. 4(b). The tiny sparks were decayed on the anode to trigger the second explosion, as shown in Fig. 4(c). These pictures showed that the tiny sparks were negatively charged and could exist in water solution as independent bodies.

The tiny sparks were observed in more detail using the VTR system with amplification of 200 times. Fig. 5 shows the expanded pictures of the tiny sparks appearing on the cadmium cathode. The tiny sparks were found to consist of a large number of microsparks, that were frequently created or broken. The microsparks sometimes formed ring-clusters with a diameter of about 100 μm and decayed to something like a black cloud that prevented the backside light from shining through. Furthermore, there were bright spots among the microsparks. A corona-like discharge was observed from the bright spot. The decay of the microsparks will be examined in more detail.

C. Emission of Radiation

The emission of radiations was monitored by the CsI(T1) scintillation spectroscopy. Certain kinds of radiation were observed to be released through the wall of the glass beaker.

The CsI(T1) scintillation detector was alternatively placed outside the glass beaker and over the water surface. The detector measured the emission of radiation in the high voltages in both cases. The energy spectrum of the radiations were continuous and monotonously declined as the energy increased. The typical spectra are shown in Fig. 6. The background was measured with no discharges. The counting rate was significantly higher than the background. As the voltage increased, the energy tail expanded more widely. The intensity of the radiation sharply dropped as the distance between the detector and the cathode increased. The radiation detected was neither gamma rays nor X-rays. The signals were generated by electromagnetic waves picked up with the electrical circuit. The emission of the electromagnetic waves will be discussed relating to the break-up of the ironic clusters.

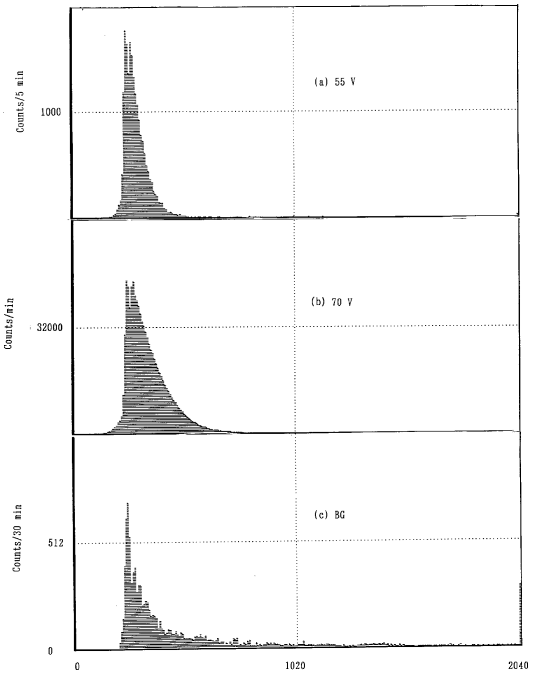

Fig. 6

D. Nuclear Transmutation

Discharge products deposited on the electrode surface were examined by SEM-EDX, EPMA and XS. Several kinds of the nuclear transmutation occurred.

Fig. 7 shows a SEM picture of the deposited materials on the cathode of the nickel wire. Thick layers including potassium were deposited **and there were many tiny holes (about 10 μmϕ)** over which the microsparks might be shining through [emphasis by Ed.].

Several elements were found by EPMA among the deposited materials on the anode of palladium wire: nickel, calcium, titanium, sodium, aluminum, chlorine, cadmium and iodine. They were not observed in a reference region of the palladium wire. Furthermore, nickel was clearly detected by XS. These elements could not be assigned to impurities but rather suggested to be transmuted during the electrical discharges associated with the microsparks. For example, chlorine, calcium and nickel could be transmuted by the capture of electrons, a proton and hydroxide with a potassium nucleus, respectively. On the other hand, cadmium and iodine could be transmuted by the capture of a proton and oxygen with a palladium nucleus, respectively. Such captures could occur in the highly compressed state of the hydrogen-cluster.

E. Microscopic Ring-Clusters

When the iron wires were used for the electrodes, tiny ring products were successfully caught on the surface of the cathode. The discharge was maintained with 70 V and 0.3 A for 27 min. and in the last period, there was a small explosion.

Many ring products could be observed with SEM around the zone on the surface of the cathode that touched the water level, as shown in Fig. 8. Simultaneously regular hexagonal products were observed in the same zone, as shown in Fig. 9. After a few days, the ring products all disappeared, and in place of them, only the hexagonal products remained. This suggests that the ring products decayed to the hexagonal plates. Fig. 9(b) shows the intermediate stage of the decay in which an inner circular zone still remained.

The ring and the hexagonal products were examined with EPMA. Fig. 10 shows dimensional distributions of the elements that were found near the products. Besides iron from the host metal and potassium from the electrolyte, some elements of calcium, sodium, chlorine and cadmium were both observed in the ring and the hexagonal products. Two circular zones, especially, could be seen for cadmium that were clearly separated from each other in the ring products, as shown in Fig. 10. Those observations suggest that the ring product could consist of a hydrogen-cluster and that the process of the nuclear transmutation took place in the clusters.

F. Nuclear Emulsions

Five plates of nuclear emulsions were placed to monitor particles that were emitted during the electrical discharges. Fig. 11 shows extraordinary rail-like traces observed on the surface of the first nuclear emulsion. Similar traces were not found in the other nuclear emulsions. Reference nuclear emulsions were located at 5 m distance from the cell in the same room, but similar traces were found neither in nor on the reference nuclear emulsions. The traces suggested that some particles walked around on the surface. Fig. 11(b) shows a ring product left with the rail-like trace. This clearly indicates that the extraordinary rail-like traces were generated by the ring products that escaped from the cell and walked around on the surface of the first nuclear emulsion. The diameter of the ring was about 10 μm, which was approximately the same as that of the ring products observed on the iron electrode. This observation suggests an extraordinary result that the ring product could penetrate through the glass wall of the beaker and the water solution. The curious behaviors of the ring product will be further discussed in Sec. 4.

G. Miscellaneous

The other extraordinary phenomena were observed during or after the discharge experiments.

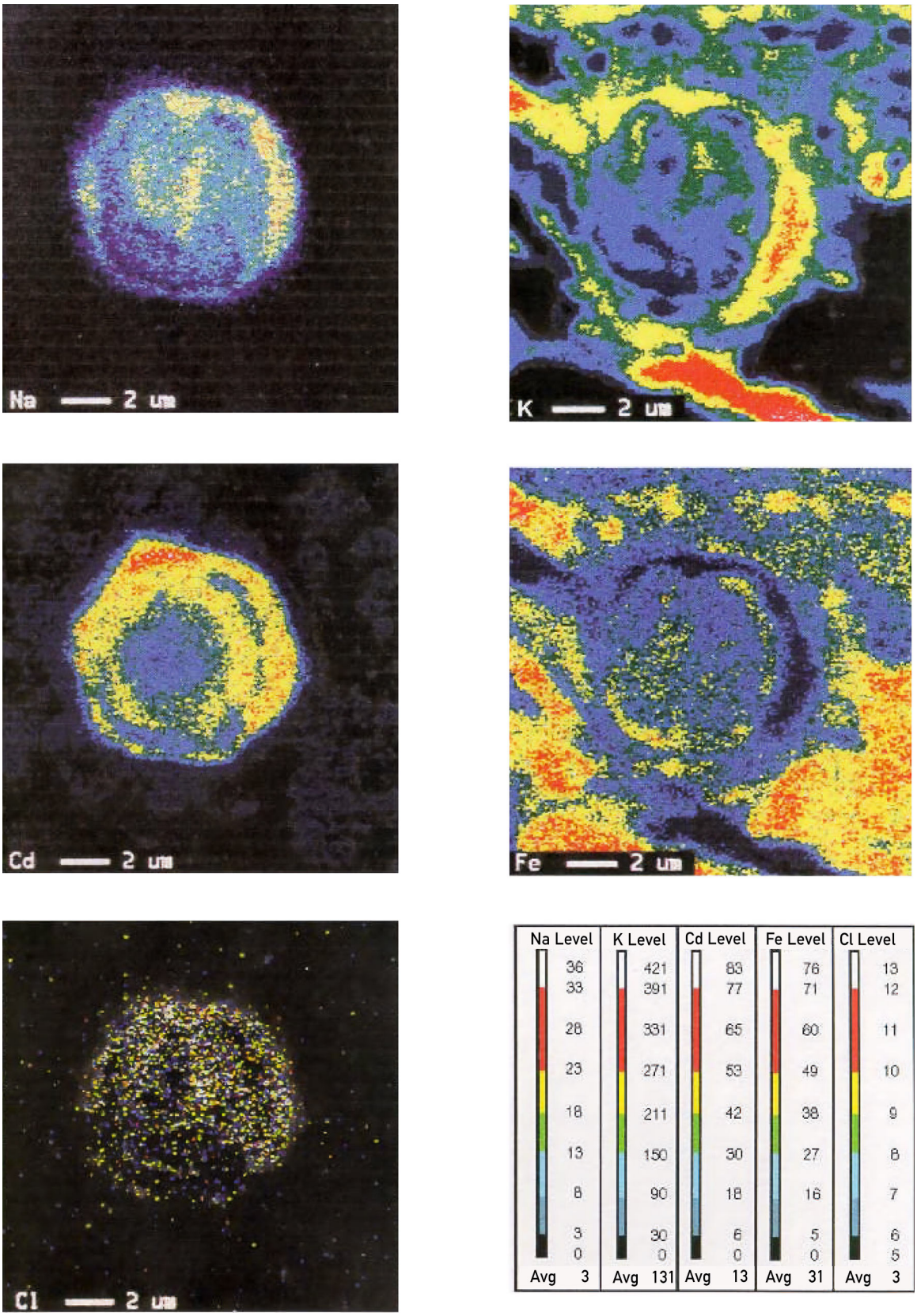

Fig. 10 EPMA Analysis of the Hexagonal Decay Product

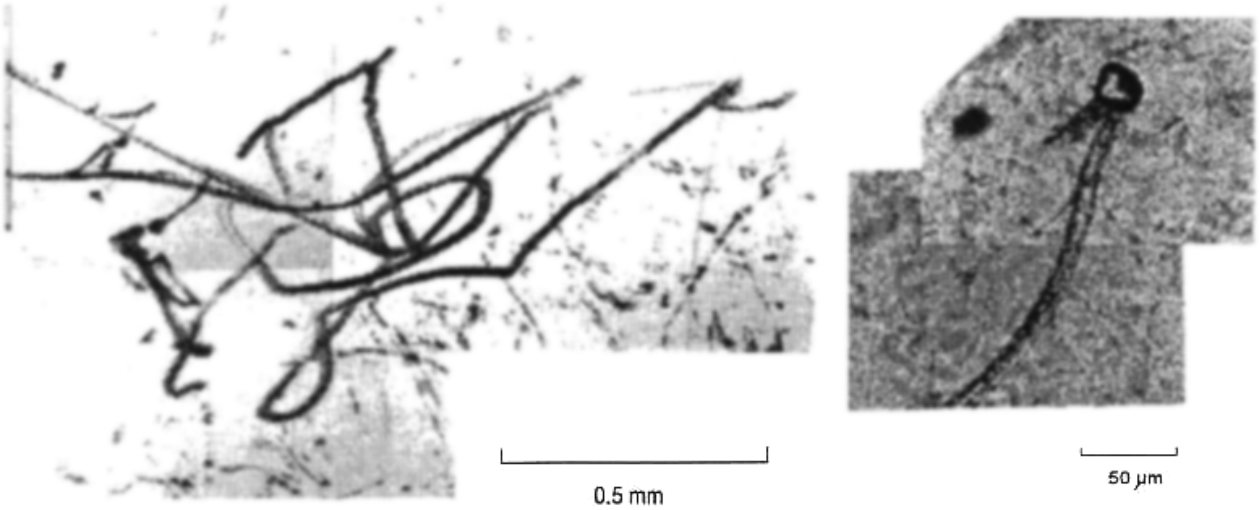

Fig. 11 Rail-like Traces: a) trace-like written with one stroke; b) trace with ring-like product.

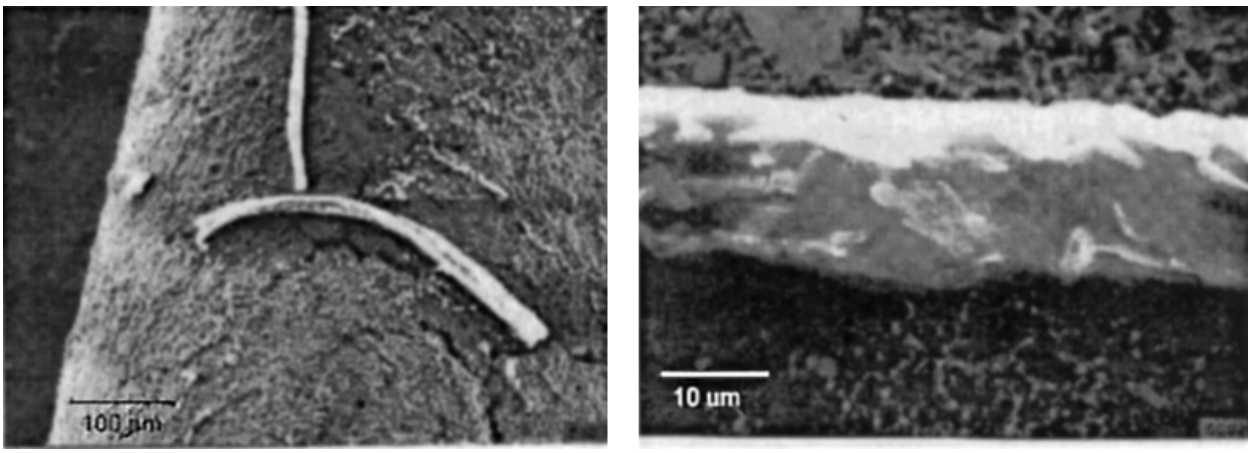

Fig. 12 String Product on the Pd Cathode

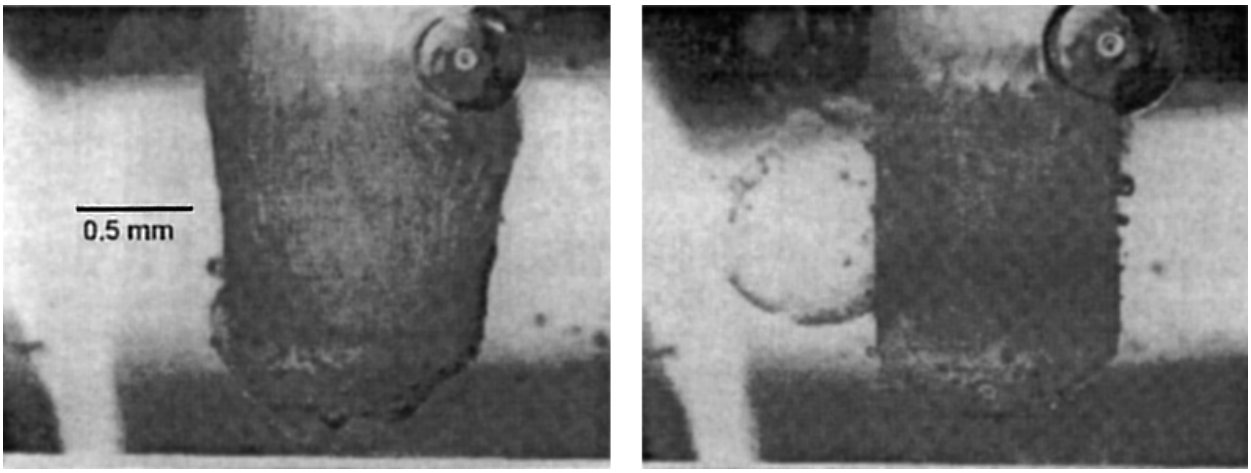

Fig. 13 Film Product on the Cd Cathode

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The first was the formation of string products. Fig. 12 shows the string product that was observed by SEM on the surface of the palladium cathode after the discharges. The analysis with EDX, in which no lighter elements than sodium could be analyzed, indicates that only potassium was found in the string products. Similar string products were often observed by the VTR system with the amplification during the discharges.

The second was the formation of film products. Fig. 13 shows the production of the film with the VTR system (100 amplification). The film product was formed at the bottom top of the cadmium cathode, where the microsparks were frequently generated due to the effective compression of the hydrogens.

The third was the magnetization of the platinum wires (0.5 mm ϕ) that were used for the connecting wires between the wire electrode and the copper leading wire. The magnetization effect was noticed at the tip of the platinum wires, at which the electrodes were connected. The mechanisms of the magnetization also will be further discussed.

DISCUSSION

Many extraordinary phenomena were observed during the sparking underwater discharges. The mechanisms of some important phenomena are discussed here.

A. Formation of Microsparks

The first phenomena is concerned with the tiny sparks. The appearance of the tiny sparks somewhat depends on the kinds of the electrode materials. Titanium was special among the metals used in these experiments. With metals such as palladium and nickel, the tiny sparks initially appeared on the surface of the cathode, and as the voltage increased, they also appeared on the anode. These facts suggest that there were two processes for the formation of the tiny sparks.

On the pinched cathode, hydrogens were compressed to the high concentration on the surface of the electrode by the electrical potential, and simultaneously the high current density of the electrons were charged so that the itonic state of the hydrogen-clusters was formed [2]. The itonic hydrogen-clusters could emit the visible light from the microsparks because the itonic mesh was excited by the nuclear fusion reactions. On the other hand, on the anode, the hydroxyl radicals were compressed by the electrical potential. The itonic state of the hydroxyl radicals were also formed to emit the visible light. Here, since the heavy atoms of the oxygen were included, the higher voltage was required to generate the microsparks than on the cathode.

In the intermediate voltage region between about 40 V and 60 V, where the voltage was critical to the formation of the itonic hydrogen-clusters, the resulted clusters would sometimes break up. This was a reason why the rapid evolution of the hydrogen gas seemed to occur on the cathode. On the contrary, the current was strongly suppressed by the appearance of the microsparks in the high voltage region. This was because the itonic hydrogen-clusters, negatively charged, covered the cathode to prevent the free flow of the current. Furthermore, the break up of the microsparks caused the spatial charge effects to reduce the current.

With titanium, different processes were suggested for the generation of the microsparks, that appeared on the anode in the low voltage region. The microsparks on the titanium anode were examined in a previous experiment of the AC discharges [7]. Here the microsparks appeared when the deposited materials were taken away and the local, but rapid, electrical discharges occurred. Fig. 14 shows a picture of the microspark products that were caught by a copper plate placed near the titanium electrode over the water level. The figure showed that the microspark products had the mesh structure. This means that the deposited materials were in the itonic state. Furthermore, inside the meshes, there were observed bright spots suggesting some nuclear reactions.

B. Extraordinary Ring-Cluster

The second concerns with the ring-cluster. It could easily penetrate materials like glass and eventually decayed to the almost hexagonal plates. There are two candidate models for mechanisms of forming the ring-cluster.

The first is the hydrogen ring-cluster with the closed current. When the compression of the hydrogen-cluster was proceeded on the pinched electrode in the high voltage region, some phase transition might have occurred in the hydrogen-clusters, because the hydrogens had no places to escape. The compression of the hydrogens was made two dimensionally on the surface of the pinched cathode so that the ring could have the minimum total energy. In the ring-cluster, closed electrical current could flow and it induced the magnetization effect. The ring-clusters could be negatively charged.

The second is a special kind of product represented by tiny white holes. The tiny white hole was early observed by the author in a previous Mills's- type experiment of electrolysis with light water and a nickel electrode [2]. There a lot of conic [sic] products were observed as evolved products resulted in the tiny white holes. In this experiment, especially with cadmium, the collapsed mass should be heavy so that evolved products might be curled up to form the ring structure.

It is remarkable to note that the ring-clusters could penetrate the regions such as glass, walk around on the surface of the nuclear emulsions and hop up and down between the nuclear emulsions [4]. These phenomena could be explained by charges associated with the ring-clusters. When the ring-cluster touched the material, a portion of the charges of the ring-cluster transferred to the material, and the repulsive force was generated between the ring-cluster and the material. This force could make the ring-cluster jump-up. When the ring-cluster penetrated through the material, the constituent atoms of the material could be sequentially absorbed into the ring-cluster. Then a microscopic hole having the similar diameter could be left in the solid state material.

However, the curious penetration of the ring-cluster cannot be explained by the first model. On the other hand, the second model seems to easily explain the penetration, because a tiny white hole is produced from a tiny black hole that should have the extremely small dimension compared with interatomic distance. Here the hexagonal plate generated from the decay of the ring-cluster should be explained as the crystallization of compressed materials included in the ring-cluster.

The magnetization effect was observed on the tip of the leading wires of platinum that were connected with the electrodes. The effect could be explained by the existence of the tiny magnets, i.e., the ring-clusters. Furthermore, when the decay proceeded further, corona-like discharge phenomena could be induced at the center of the ring-cluster, as observed *in situ* by the VTR system. Here the break-up of the ring-clusters could make the electromagnetic waves emit, as were detected by the CsI(Tl) scintillation detector. Similar radiation could also be emitted by the break-up of the itonic hydrogen-clusters.

The extraordinary behavior of the ring-clusters were very similar to those reported about the curious natural phenomena, ball-lightning [8, 9]. Ball-lightning is often born associated with a thunderstorm, that is, the electrical discharges on the large scale. It is reasonable to consider that during the thunderstorm, some products like the ring-cluster obtained in this experiment might be generated, move around and eventually explode, as were reported in the references [8, 9].

C. Nuclear Transmutation

The nuclear transmutation took place during the underwater spark discharges. The nuclear transmutation can take place in the itonic hydrogen-clusters, explained in Ref. [2]. Here, the hydrogens were so highly

compressed that various kinds of the nuclear transmutation became possible. The feasible schemes of the nuclear transmutation are described in an appendix for the case of the iron electrodes and the potassium electrolyte.

Furthermore, the analysis with EPMA showed that the nuclear transmutation was possible in the ring-cluster. This fact suggests that there might be another process for the nuclear transmutation, different from the nuclear transmutation in the itonic hydrogen-clusters. The ring-cluster showing the crystallization effect should have higher concentration of the atoms than the solid state. This makes the nuclear transmutation possible. In the appendix, the production of the cadmium element is explained by the fusion reaction between two iron nuclei.

CONCLUSIONS

In the experiments of the underwater discharges, the microsparks on the pinched electrodes were examined in detail. It was found that they were not normal sparks but consisted of the itonic hydrogen-clusters that were sometimes transformed to the ring-clusters. The itonic hydrogen-cluster and the ring-cluster could exist for a moment as an independent body. The ring-cluster can easily penetrate through the layers of glass or acrylic despite their heavy mass and charges, and hop up and down on the nonconductive materials such as nuclear emulsions. It is remarkable that the nuclear transmutation caused by the nuclear fusion reactions took place in the ring-cluster as well as in the itonic hydrogen-cluster. The ring-cluster was very similar to ball-lightning that was observed in the natural environment, although the scale was different. As the current density or voltage were increased, the ring-cluster with the larger dimension could even be produced in laboratory. The reproducibility of the underwater spark discharges method is so good that the property of ball-lightning should be examined in detail in laboratory.

Acknowledgments

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APPENDIX: Feasible Schemes of Nuclear Transmutation

Feasible schemes of the nuclear transmutation are discussed here by the Nattoh Model. The model predicted that a hydrogen-cluster is formed on the surface of the electrodes. Since the nuclear reactions take place under the multi-body interaction of the cluster constituents such as electrons, protons, oxygens and the heavy nuclei of the electrolyte and the host metals, there are various kinds of feasible schemes for the nuclear transmutation. The different kinds of nuclei produced by the nuclear transmutation depend on the applied voltage or the current density. As the voltage is increased, the higher order reactions could be enhanced. In this appendix, however, only the principal reactions will be considered here, taking an example of the iron electrode and the potassium electrolyte. The higher order reactions are straight forward.

A. Iron electrode

Natural iron contains four stable isotopes: ^{54}Fe (5.84%), ^{56}Fe (91.68 %), ^{57}Fe (2.17 %) and ^{58}Fe (0.3/%). The capture of an electron is not so effective for the nuclear transmutation of iron. Only the lightest isotope ^{54}Fe can be transformed by capturing an electron as follows:

$$^{54}Fe + e \rightarrow {}^{54}Mn \xrightarrow[EC]{313d} {}^{54}Cr(st) \tag{1}$$

The other isotopes of iron cannot be transmuted by capturing an electron because the products of ^{56}Mn, ^{57}Mn and ^{58}Mn rapidly undergo the beta decay to return back to the original nuclei.

When the iron isotopes capture a proton, new elements and different iron isotopes can be produced,

$$^{54}Fe + p \rightarrow {}^{55}Co \xrightarrow[EC]{17.5\,h} {}^{55}Fe \xrightarrow[EC]{2.7y} {}^{55}Mn(st) \tag{2}$$

$$^{56}Fe + p \rightarrow {}^{57}Co \xrightarrow[EC]{271d} {}^{57}Fe(st) \tag{3}$$

$$^{57}Fe + p \rightarrow {}^{58}Co \xrightarrow[EC/\beta^+]{70.8d} {}^{58}Fe(st) \tag{4}$$

$$^{58}\mathrm{Fe} + \mathrm{p} \rightarrow {}^{59}\mathrm{Co}\ (\mathrm{st}) \tag{5}$$

where EC and β^+ indicate the capture of an electron and the emission of a positron, respectively. The half-life of EC or β^+ in the itonic state should be drastically shortened, because the electrons of the itonic state distribute very closely to the nucleus. Through Eqs. (3) and (4), the isotope ratio of the iron element should deviate from the natural value. Furthermore, the iron isotopes can fuse each other and heavy elements such as cadmium can be produced, for example,

$$^{54}Fe + {}^{54}Fe \rightarrow {}^{108}Te \dashrightarrow {}^{108}Sb \dashrightarrow {}^{108}Sn \xrightarrow[EC]{10\,m} {}^{108}In \xrightarrow[EC/\beta^+]{40\,m/58\,m} {}^{108}Cd(st) \tag{6}$$

$$^{54}Fe + {}^{56}Fe \rightarrow {}^{110}Te \dashrightarrow {}^{110}Sb \dashrightarrow {}^{110}Sn \xrightarrow[EC]{4.2\,h} {}^{110}In \xrightarrow[EC/\beta^+]{69\,m/5\,h} {}^{110}Cd(st) \tag{7}$$

$$^{56}Fe + {}^{56}Fe \rightarrow {}^{112}Te \dashrightarrow {}^{112}Sb \xrightarrow[EC/\beta^+]{54\,s} {}^{112}Sn(st) \tag{8}$$

B. Potassium Electrolyte

Natural potassium consists of three isotopes of ^{39}K (93.2 %), ^{40}K (0.01%) and ^{41}K (6.7 %). The feasible schemes can be derived similarly as for iron.

For the capture of one electron,

$$^{40}K + e \rightarrow {}^{40}Ar\ (st) \tag{9}$$

where ^{39}K and ^{41}K cannot transmute by the electron capture.

For the capture of one proton, the calcium element can be produced as follows,

$$^{39}K + p \rightarrow {}^{40}Ca\ (st) \tag{10}$$

$$^{40}K + p \rightarrow {}^{41}Ca \xrightarrow{10^5 y,\ EC} {}^{41}K\ (st) \tag{11}$$

$$^{41}K + p \rightarrow {}^{42}Ca\ (st) \tag{12}$$

It should be emphasized that during the nuclear transmutation in the hydrogen-clusters, neither energetic radiation nor activities could be generated. Even if the nuclei fuse each other to form an excited compound nucleus, the exciting energy could be transferred to the vibrational motion of the itonic mesh. Therefore, the nucleus could go to the ground state without emitting radiation. When the itonic mesh breaks up, however, the excited nucleus could emit high energy radiations as in the normal manner, and the activity also could somewhat persist.

Ball Lightning during Underwater Spark Discharges and the Matsumae Earthquakes

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Abstract

This paper describes ball lightning(BL) phenomena during experiments of underwater spark discharges and the Matsumae earthquakes. In the former, two kinds of tiny BL,sphere and ring, were generated in laboratory. In the latter, a hypothetical theory for the occurrence of earthquakes was examined by measuring two kinds of BL-like products with nuclear emulsions. The machanisms of forming BL are explained by the Nattoh Model.

1. Introduction

Since phenomena of so-called "cold fusion" were published by Pons and Fleischmann in 1989, many experiments have been performed in the search for nuclear reactions with various electrical methods such as electrolysis and discharges(1). The author has proposed The Nattoh Model for the mechansisms of cold fusion, in which hydrogen clusters are strongly compressed to become a special state, called "itonic" cluster(2). Here many electrons are degenerated and interconnected each other so that the bonding between the atoms is so strong that nuclear reactions can be easily induced inside the cluster(referred to "electro-nuclear reaction(ENR)"). Depending on the bonding strength, four kinds of ENRs were found so far: a new fusion reaction of D + D $\rightarrow {}^{4}$He, the nuclear transmutation, the generation of a tiny neutron star and the nuclear collapse (ENC). Such ENRs are remarkably different from the conventional nuclear reactions which occur in an isolated system.

The electro-nuclear reaction could be easily induced anywhere under some conditions so that it would be reasonable to consider that phenomena caused by ENRs can occur in the natural environment, for example during lightning and earthquake(3). The itonic cluster can somewhat exist as a stable body and move around underwater as well as in the atmosphere. Curious behaviors of the itonic cluster very much resemble to those of BL which were obverved in the natural environment(4, 5). Therefore the recommendation of the BL study in order to understand cold fusion as well has been proposed(6).

This paper describes BL phenomena during experiments of underwater spark discharges and the Matsumae earthquakes in 1996. Itonic clusters were undoubtedly generated and it's curious behaviors were discussed related to BL.

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2. BL during Underwater Spark Discharges

2.1 Experiment

Experiments of underwater spark discharges were performed in a similar device that was used in previous experiments(7, 8). Discharges were carried out between metal wire electrodes which were inserted in an electrolyte solution in a 50 ml beaker. Thin metal wires such as Pd, Pt, Ni, Cd, Pb and Fe(0.1 - 2.0 mmφ) were used for the electrodes. The solution was ordinary water mixed with potassium carbonate and potassium hydroxide(about 1.5 Mol/l). Discharges were usually made under a DC mode and sometimes a pulsed AC mode. The I/V curve of DC showed the strong non-linearity due to pinch effects which worked well on a cathode over about 40 V and extremely surpressed the current. Simultaneously tiny sparks appeared on the cathode surface. The sparks were found to consist of many microsparks which were found to be itonic clusters(7, 8). The itonic clusters causing BL phenomena were caught on a monitoring copper plate(typical dimensions 25 mm x 50 mm x 0.2 mm), which were placed under as well as over water. Sometimes the copper plate was used as an anode. The surfaces of the electrodes and motinitoring plate were examined with an optical microscope(OP), a scanning electron microscope(SEM) and an energy dispersive X-ray spectroscopy(EDX).

2.2. Experimental Results

Two kinds of BL were obtained during the underwater spark discharges experiment.

(a) BL with spherical structure

The tiny sparks were observed with a telescope connected with a video tape recorder (VTR) and were confirmed to consist of an abundance of microsparks(7, 8). Although the microsparks could naturally leave the electrode, the separation was stimulated by instantaneous turn off of the current and/or ultrasonic vibration. Figure 1 shows several groups of hydrogen clusters which were caughted on the copper plate located over the solution. They could be clearly distinguished from the water bubbles. Since the hydrogen clusters were in the "itonic" state, the linkage caused by the itonic electrons to be clearly seen between the clusters. Figure 2 shows examples for the break up of itonic potassium cluster. A lot of those break ups were observed on the copper anode, especially on the bottom of a L type anode. The feature for the broken up electrons had two parts: a nearly symmetrically radiative part and one that is randomly orientated as shown in Fig. 2(b). This could provide important information about the structure of the itonic electrons. Figure 3 shows examples of hollow lead balls, which were deposited mainly on the bottum of thecopper plate anode. The hollow balls were generated from the itonic lead clusters, in which ENC took place to emit carbon tubes as will be mentioned later from a small window. Figure 3(b) shows a hollow ball with a special shape, in which a part of the itonic clusters still remained. It suggests that in a large cluster the "itoning" process could take place locally and independently. Figure 4 shows examples for the break up of the itonic electrons, a lot of what was observed on the copper monitor plates as well as the cathode. The figures clearly indicate that many electrons were interconnected each other. Probably the itonic electrons initially had a ball-like shape and during its path, electrons were sequentially taken away.

(b) BL with ring structure

Ball lightning with ring structure (inner diameter about 10 μmφ) was also observed on the Fe wire (0.5 mmφ) electrodes used for the DC discharges(7). Figure 5 shows BL with the ring structure and those traces. The ring was somewhat stable and could run around. It was strange that the ring decayed to a hexagonal plate, emitting a corona likedischarge at the center, as shownin Fig. 5(b). Figure 5(c) shows an example of those traces recorded on nuclear emulsion, which was located outside an acrylite plate of a cell. It was concluded that BL with the ring structure can penetrate through the plate.

(c) carbon tube and thin film

Two curious materials were associated with BL during the discharges: a carbon tube and thin film. Since they were generated through ENC, they had anomalous properties.Figure 6 shows examples of the carbon tube, which was produced with the Pb and Cd wire electrodes, respectively. They had the thin diameter of about 50 μmφ and up to several mm long. This tube was different from the conventional carbon nano-tube, because this tube was generated with the carbon-free device. The carbon tube obtained here was generated in the itonic cluster, because Fig. 6 (b) clearly shows the carbon tube interconnected with the itonic cluster. Figure 7 shows an example of the thin film which was obtained on a copper monitoring plate during the DC discharges with a Cd wire cathode. The thin film was already observed under a macroscopic scale in the previous experiment(8). Furthermore, it was clearly confirmed that the film was directly generated by ENC, as shown in Fig. 4 in Ref. 9.

(d) BL with spiral traces

A group of BL which was somewhat in a progressed state was observed on the copper plate anode during the pulsed AC discharges with a Cd wire cathode. An example for those BL is shown in Fig. 8. Curious traces were associated with BL, as shown in Fig. 8(b) and (c). Inside the traces, there were peculiar spiral lines which should be generated when the carbon tube was violently emitted because of ENC.

3. BL during Matsumae Earthquakes

3.1. Hypothetical Theory for Earthquake

The electro-nuclear reaction which can be easily induced by the discharges would certainly occur in the natural environment: an example is earthquakes. On the Hanshin-Awaji earthquake in 1995, a lot of extraordinary phenomena were observed before the land seriously vibrated (10): the BL-like emission, abnormal behaviors of many animals, the appearance of seismic clouds and abnormal signals of electromagnetic waves. Among them, the BL-like emission especially should be remarked. Therefore the author proposed a hypothetical theory for the occurrence of earthquake(11), as follows,

1. First ENRs occur underground sequentially and explosively,
2. The explosion induces several movements of land which cause damage to human beings and property: vibration, cracks, dislocations and so on,

3. Tiny BL-like products which are released by ENRs penetrate through rocks and water to arrive at far places. They could cause many extraordinary phenomena before the seismic vibrations.

3.2. Measurement

In order to verify the hypothetical theory, the measurement with nuclear emulsions (highly sensitive and especially suitable to detect unknown products) was attempted in the search for tiny BL-like products emitted during earthquakes. Matsumae Town (about 100 km west and 180 km south from Sapporo City) on the island of Hokkaido was selected in order to certainly catch earthquakes, in which sequential earthquakes had been taking place from 1995. The nuclear emulsions were 100 μm thick emulsions coated on both sides of an acrylite plate (50 mm x 50 mm x 1 mm thick). 70 % of them were placed at Matsumae Town from July 19 to August 18 in 1996. The left over 30 % was placed at Hokkaido University in Sapporo City for reference. During the measurement, three earthquakes that could be relatively felt by people took place in Matsumae Town, as shown in Table 1, but no earthquakes in Sapporo City.

3.3. Results with nuclear emulsion

Two kinds of extraordinary results were recorded only on the nuclear emulsions placed in Matsumae Town. Figure 9 shows one of extraordinary traces of broken networks which might be caused by the break up of BL. The trace was extended up to an area of about 5 mm x 5 mm, and such large mesh-like traces were never obtained in our laboratory so far(12). Remarkably, the network consisted of clear and straight lines. Figure 9(b) shows an expanded picture for a cross point in the network. Figure 10 shows an example of the other extraordinary long tube products. The length was up to about 3 mm. One product had a conic pole vertically standing at the center of a hole which had a diameter of about 50 μm, as shown in Fig. 10(b). A lot of similar conic products were also observed in the previous experiment of cold fusion with a thin nickel foil(13).

4. Discussion

Performing the experiment of underwater spark discharges, many strange products were obtained. They can be explained well by The Nattoh Model(2), which assumed the formation of the itonic hydrogen cluster. The itonic cluster has a special state of interconnected electrons so that it shows anomalous behaviors: the penetration through unconductive materials such as glass, the hopping up and down, the transfer through thin copper wires like electrical current and eventually explode. Such anomaly very much resembles to BL phenomena reported in the natural environment, in which BL seems to often appear associated with thunderstorms. Since lightning is a large scale of electrical discharges, an itonic hydrogen cluster with a large dimension could appear. Furthermore various kinds of ENRs can occur in the itonic cluster. The most significant, ENC, generates a tiny black and white holes. Materials that are completely broken should be emitted from white hole. During the discharge experiments, many remarkable products which indicate the emission from white hole were obtained: ring and tube products. The ring product can shows anomalous penetration and hopping up and down. It is an alternative of BL.Here BL

should have no violent explosion at it final state(7, 8). Since the tube products are continuously generated in the itonic cluster, some of them could appear to be interconnected with the cluster. Here BL should have a long tail. Recently the tubes were found to mainly consist of carbon atoms, despite of the fact that it can be generated with a carbon free device. It was concluded that the conventional carbon (perhaps including hydrogen and oxygen) atoms can be regenerated from the white hole.

During the Matsumae earthquakes, on the other hand, two kinds of results indicating BL phenomena were observed. The first trace, network, could be the itonic electron mesh. During the earthquakes, the discharges could be in such a large scale that a lot of electrons could be interconnected to make a large network. The second, tube product, could be the carbon tube which was observed in the discharge experiment. But, in the experiment, we obtained no special products having a conic pole at the cavity center. It should be proposed that such products could consist of spiral carbon tubes, because the spiral tubes were generated in the itonic cluster.

Lastly, there remain two important questions: (1) how can electrons be interconnected to each other and (2) how can the conventional atoms such as carbon be made from a white hole? The first question is a serious challenge to the quantum mechanical theory,in which the concept of probability was induced so that no physical understanding was provided for the dual properties of the electron. The second question suggests that we have to consider super elementary particles having the dimension of 10^{-33} cm. Among them, we could expect a candidate particle for dark matter.

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1. August 7, 1996
   03:28, North 41.3, East 140.0
   Magnitude 3.2, Depth about 10 km
   Seismic Intensity at Matsumae 1
2. August 13, 1996
   19:49, North 41.3, East 140.0
   Magnitude 3.6, Depth about 10 km
   Seismic Intensity at Matsumae 1
3. August 16, 1996,
   11:32, North 41.4, East 140.2
   Magnitude 3.2, Depth about 10 km
   Seismic Intensity at Matsumae 1

Table 1

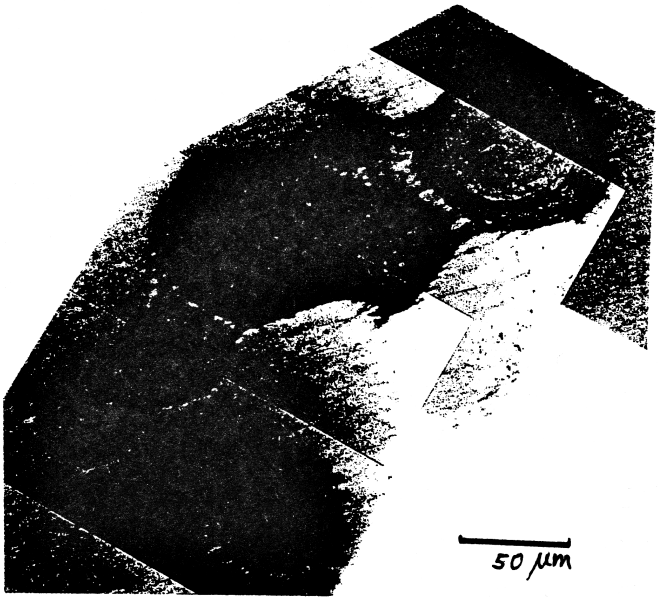

Fig. 1

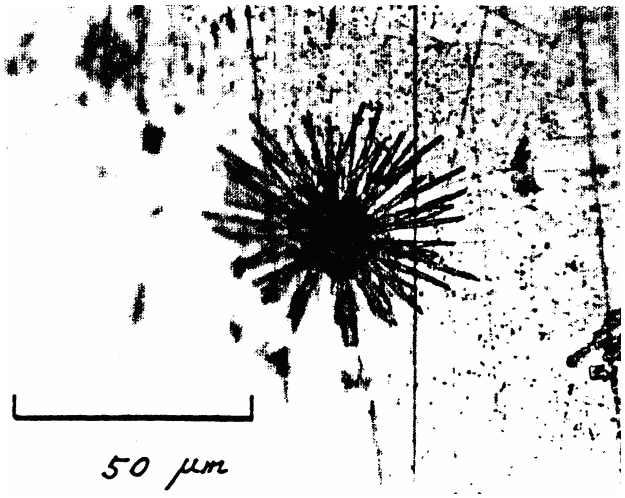

Fig. 2(a)

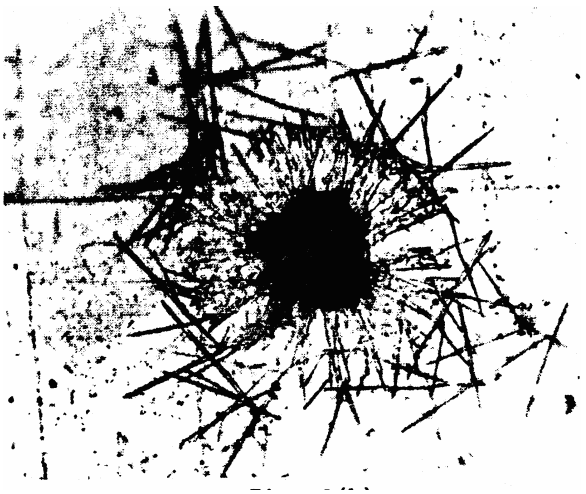

Fig. 2(b)

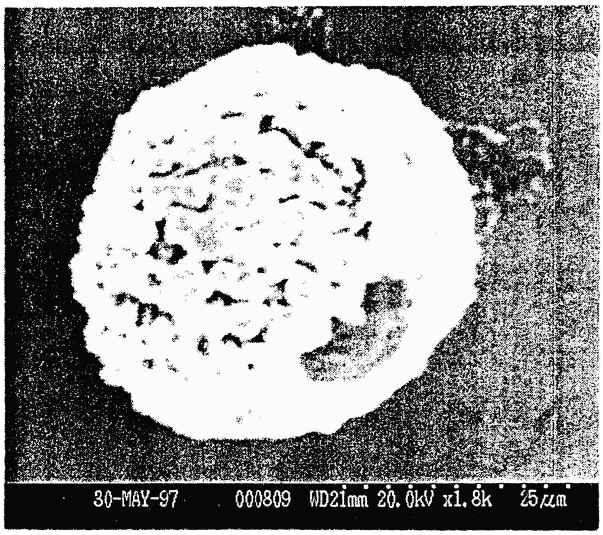

Fig. 3(a)

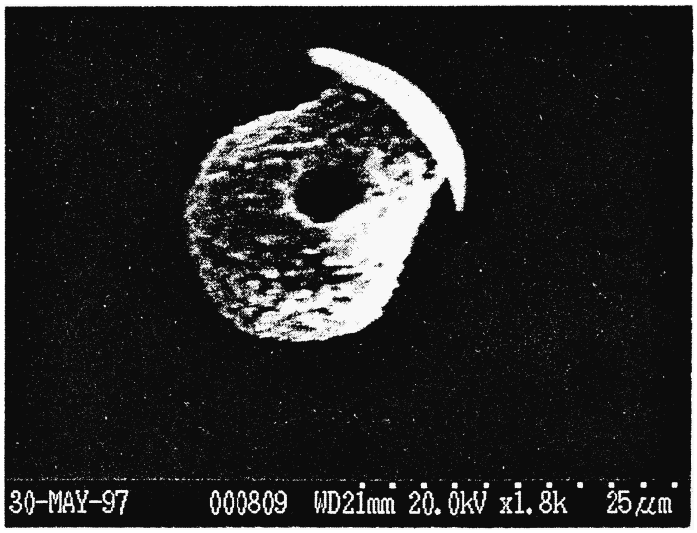

Fig. 3(b)

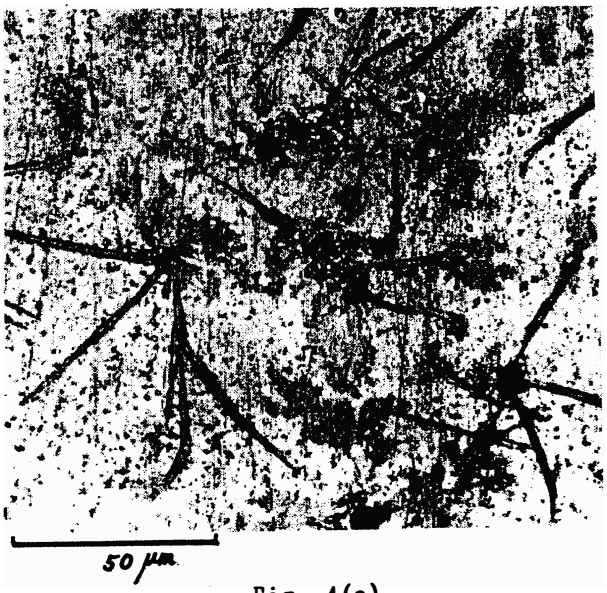

Fig. 4(a)

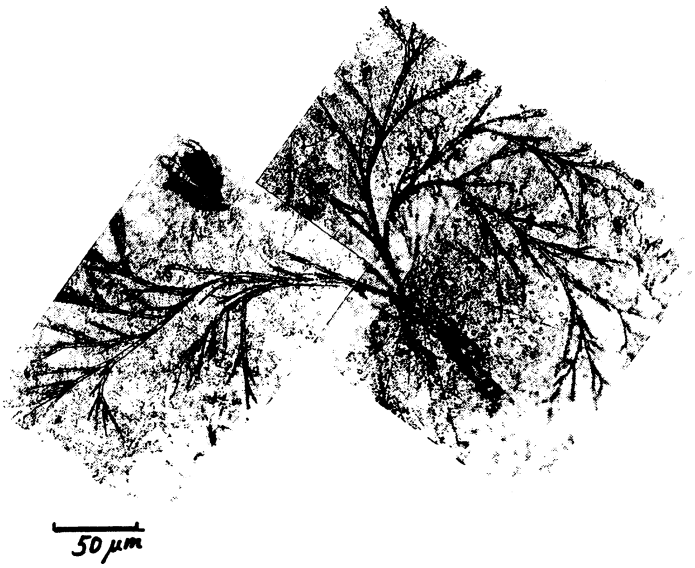

Fig. 4(b)



Fig. 5(a)



Fig. 5(b)

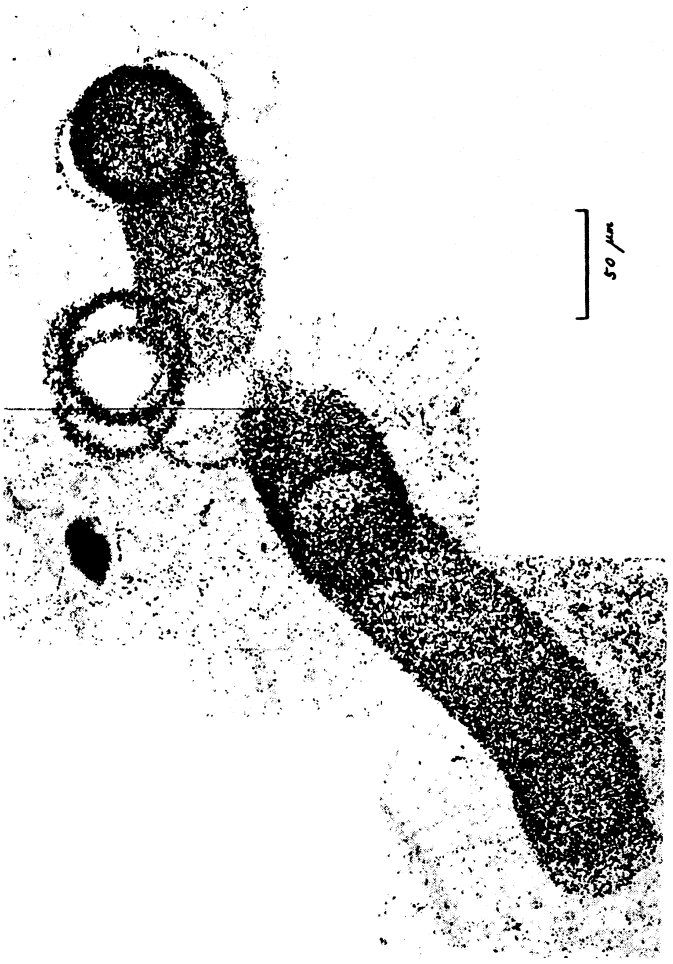

Fig. 5(c)

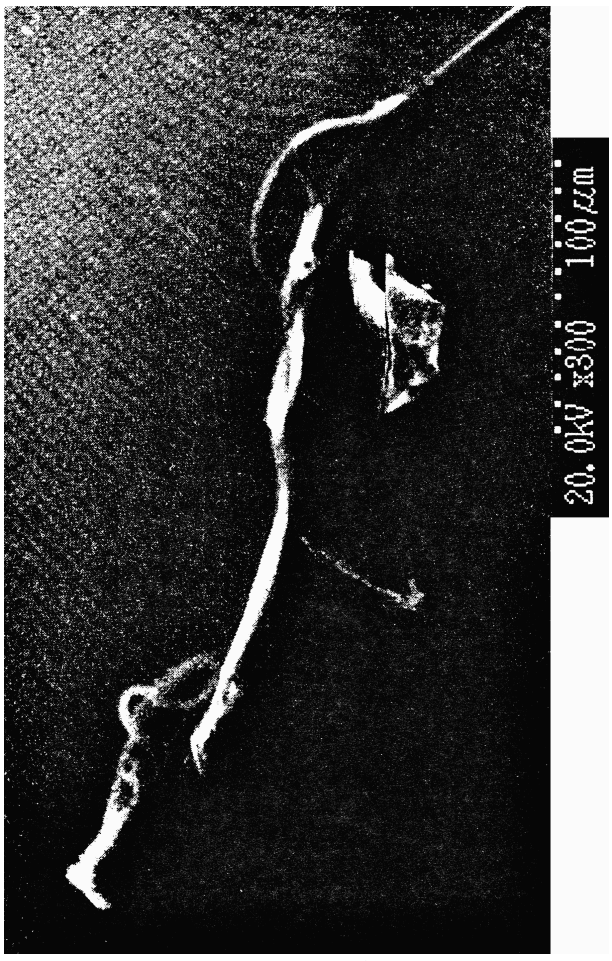

Fig. 6(a)

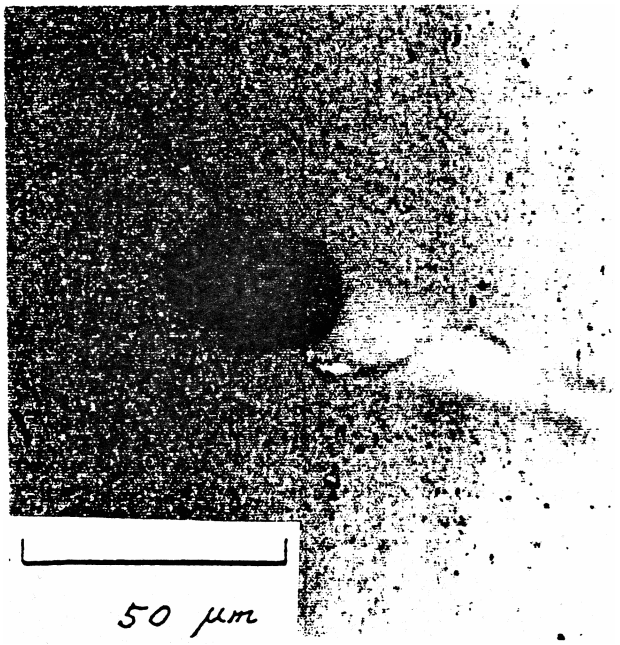

Fig. 6(b)

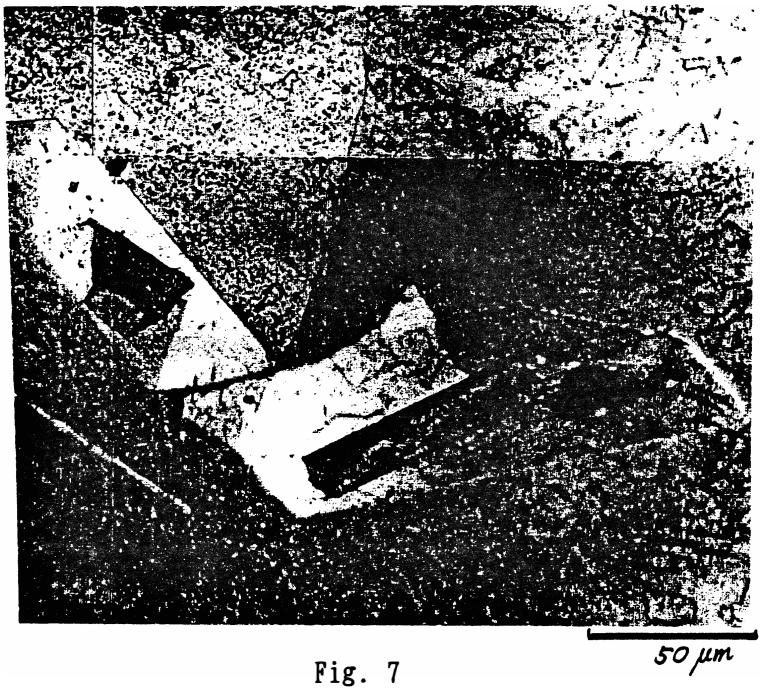

Fig. 7

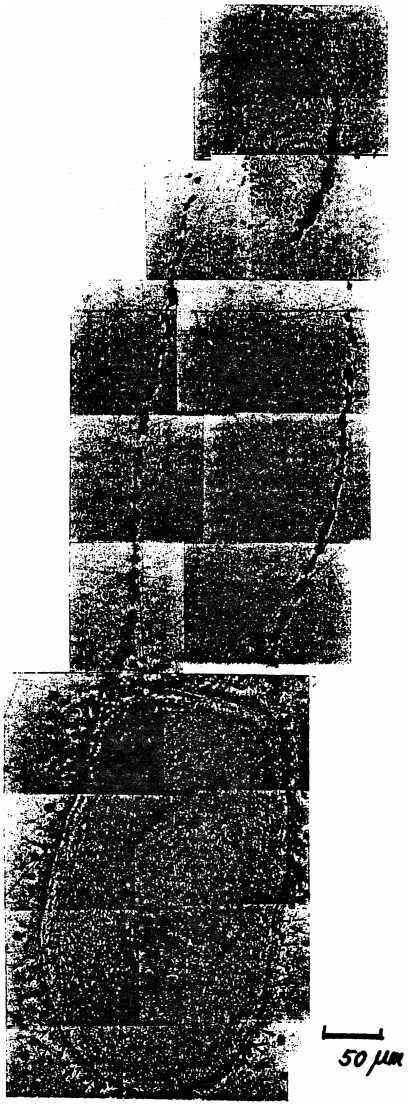

Fig. 8(a)



Fig. 8(b)

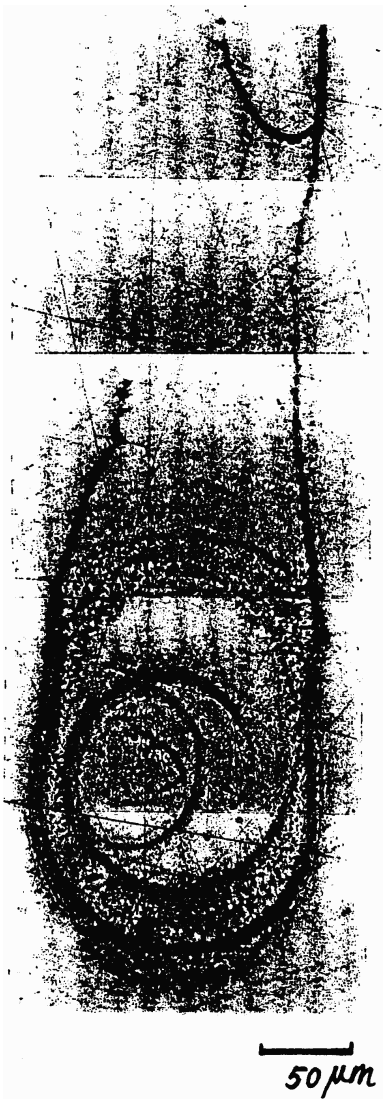

Fig. 8(c)

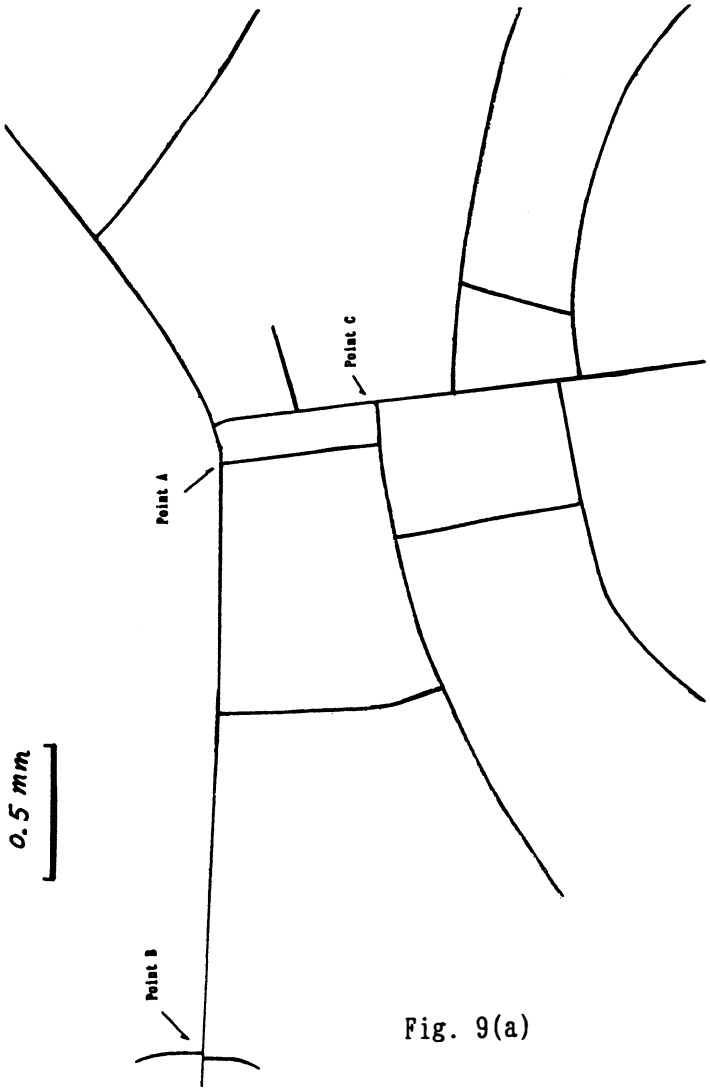

Fig. 9(a)

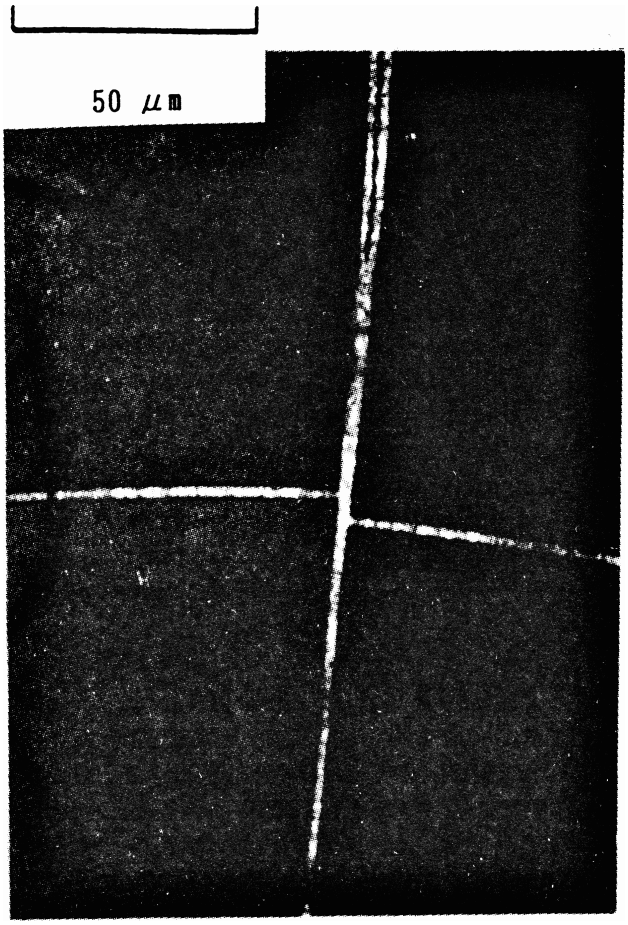

Fig. 9(b)

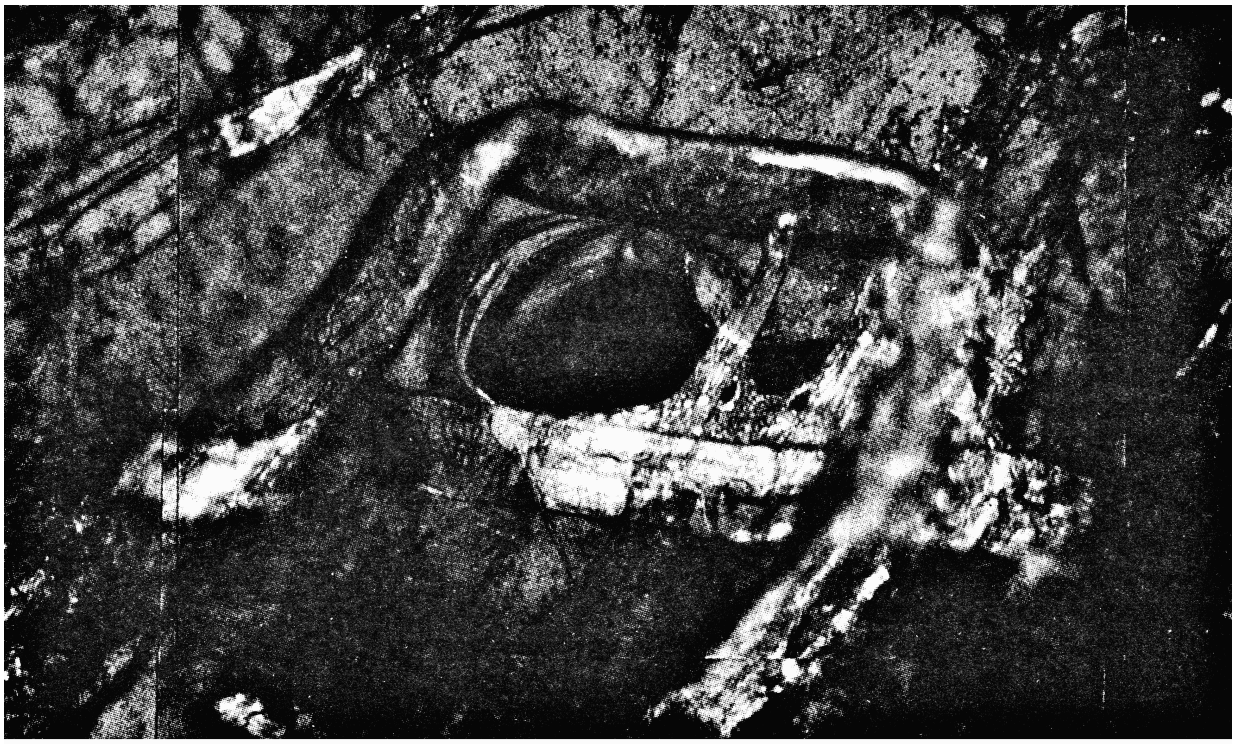

Fig. 10

CARBON TUBES AND FILMS PRODUCED IN A LEAD ELECTRODE

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Abstract
Experiments of underwater spark discharges were performed with a thin lead wire. Discharges were made under two modes of DC and pulse AC. Ordinary water mixed with potassium carbonate and hydroxide were used as electrolyte solutions. Products were observed with SEM, and those elements were analyzed with EDX and EPMA. Many remarkable products were obtained: interconnected electrons, transmuted products, thin C tubes, thin C films and hollow Pb balls. Here two processes of nuclear transmutation were separately observed: sequential e/p captures and nuclear collapse. The C tubes and films were produced by the nuclear collapse in the Pb balls. It would be amazing that the conventional light elements such as C, O and Fe were regenerated by the nuclear collapse.

1. Introduction

The Nattoh Model proposed that during electrolysis and discharges, the electro-nuclear reactions(***ENR***s) could be induced in a special state of hydrogen clusters, ***itonic clusters***. The details were described in Refs. 1 and 2. Several kinds of ENRs were found so far: ***a new fusion reaction*** of producing ^{4}He from two deuteriums(with no gamma rays), the nuclear transmutation(***ENT***), the generation of ***multiple neutron nuclei***, the electro-nuclear multiple fission reaction(***EMF***), and the nuclear collapse(***ENC***). Usually those reactions parallelly occurred but the occurence probability sensitively depended on the current density. The most remarkable reaction, ENC, frequently occurred in a high current density. The mehtod of underwater spark discharges(***USD***) was very effective to induce ENC. Then extraordinary products such as carbon tubes and films were observed during previous USD experiments(3 - 6), even when a carbon-free device was used. This paper describes USD experiments with a lead wire electrode, in which many extraordinary products were obtained as the results of ENC.

2. USD Experiments

The USD experiments were carried out to induce ENC under continuous DC and pulse AC modes. The electrode of a thin ***lead wire***(1 mmφ) was inserted in electrolyte solutions of ordinary water contained in a glass petridish(60 mmφ). The effective length of the electrode which was attached with the solution was about 2 or 3 mm in order to increase the current density. A reference electrode was a box(25 mm cubic) of 5 or 6 copper plates(0.2 mm thick). There was a hole(about 5 mmφ) on the top plate through which the lead wire electrode was vertically located. All of the copper plates was polished like a mirror with diamond pastes and washed in methanol with ultrasonic vibration. Two electrolytes were used: ***potassium carbonate and hydroxide***(about 1.5 Mol/l). Later ***cesium carbonate***(0.6 Mol/l) was used to examine effects of the electrolytes. When the potassium hydroxide soltution was used, the system was perfectly carbon-free so that very useful to examine the carbon generation as will be mentioned later.

Discharges were employed between the lead electrode and the copper box mainly under ***the pulse AC mode***(120 V, 20 to 800 msec ON and about 1 min OFF, fixed phase with 0 degree). Lightning was observed with a microtelescope, and reaction products caught on the copper plates were examined with an optical microscope(OM) and a scanning electron microscope(SEM). Element analysis was carried out with an energy dispersive X-ray

spectroscopy(EDX) and an electron probe microscope analyzer(EPMA).

3. Reaction Products

A lot of extraordinary products were observed on the copper plates. The details were described in the review paper(2). Photographs of the products were also presented elsewhere(7). Several kinds of itonic clusters were found: itonic electrons, itonic hydrogen clusters, itonic electrolyte clusters, itonic electrode clusters and their mixtures. In some clusters, different kinds of ENRs occurred.

The first was tiny ***itonic Pb balls***. Many tiny Pb balls were generated during the discharges. Although some balls were just molten Pb materials, others were itonic Pb balls those electrons were strongly interconnected. A typical picture of the itonic Pb balls is shown in Fig. 1. Here needle like products appeared on the Pb surface, which was partially break up of itonic electrons. Alternatively, when the itonic Pb was completely broken up, star like products of Pb were generated, as shown in Figs. 9 to 10 in Ref. 7. They were interconnected needle products of Pb. These pictures clearly indicated that an explosive reaction took place in the itonic Pb ball.

The second was thin ***carbon films*** which were generated in the itonic Pb balls. Some films emerged from the itonic Pb ball, as shown in Figs. 2 to 4. When carbon films were first discovered as shown in Fig. 23 in Ref. 7, it was not clear how they were generated. Since many similar C films which emerged from Pb balls were found this time, the mechanisms for the generation of the films were clearly understood. The EDX analysis indicated that the films consisted of mainly C but other elements such as O, Na, Mg, Al, Si, S, Cl, K, Ca, Ti, Cr and Fe were sometimes involved. The element distribution seemed uniform. Although no lighter elements than B were detected by this EDX, it would be reasonable to consider that other light elements such as H could be generated(2). Since the C films were generated even in the carbon-free system, it was obvious that the C atoms were not impurity but generated by ENC in the itonic Pb.

The third was ***hollow Pb balls***, as shown in Figs. 5 and 6. They were also generated by the compression of the itonic Pb cluster(Fig. 5). The carbon film was ejected from another hollow Pb ball(Fig. 6). These pictures indicated that the compression by the itonic bonding induced ENC to generate the C films near the center and made a lot of tiny Pb grains. The hollow Pb ball was ejected from the itonic Pb ball like popcorn. However, when the compression was sufficiently strong, no hollow Pb balls were formed, as shown in Figs. 13 to 15 in Ref. 7. The hollow Pb ball sustained its spherical shape by the thin C films coated inside the ball, as shown in Fig. 18 in Ref. 7.

The fourth was thin ***carbon tubes***(5). Figure 7 shows one example of the tube products. It was already made clear that the tubes emerged from the itonic clusters, as the carbon films did(4). The tube also consisted of mainly C and less O. The element distribution for the tube was different from that for the C films. Near the surface of the tube, lighter elements such as C and O were predominately observed. On the other hand, near the center of the tube, heavy elements such as K, Ca and Fe were more involved.

The fifth was ***assemblies of itonic Pb clusters*** which were obtained with the cesium carbonate solution, as shown in Fig. 8. Thick layers of itonic Ce, C and O clusters perfectly covered the Pb balls. The assemblies of the itonic Pb balls very well resembled to "fermented soybeans(***Nattoh***)" as predicted by The Nattoh Model(1, 2). Figure 8 shows a C tube which could be generated from one of the itonic Pb clusters.

The sixth was ***itonic electrolyte clusters***, which suggested the structure of the itonic states. The itonic Ce clusters showed lattice like structure, as shown in Figs. 11 and 12 in

Ref. 7. On the other hand, the itonic K clusters had a different structure as shown in Ref. 5. The structure seemed to have depended on the valence electrons which detemined the number of water molecules associated with the electrolyte ions.

The seventh was ***itonic hydrogen clusters***. One example was shown in Fig. 27 in Ref. 7. Elements such as Ca, S and Ti were found, which were generated by ENT of sequential e/p captures. This time it was confirmed that ENT and ENC took place in the different itonic clusters.

4. Discussion

The preceding chapter described a very important discovery: the tubes and films consisting of the conventional elements such as C and O were regenerated from ENC of the itonic Pb balls. The process could be called "***Electro-Nuclear Regeneration(ENG)***." ENG should be strictly distinguished from ENT which had no process of the nuclear collapse. This experiment successfully observed that ENT and ENG took place in the different clusters, respectively. The comprehensive explanation for ENC including ENG was made by The Nattoh Model elsewhere(2). Briefly saying, the Pb ball was strongly compressed by the itonic bonding to induce the nuclear collapse. Then tiny black and white holes were formed, in which they were interconnected each other with a worm hole of an extremely thin diameter, 10^{-n} cm. From the white hole, completely collapsed materials were emitted as a thin carbon tube. Light elements such as C and O were concentrated on the surface of the tube by some centrifugal effects and heavy elements such as Fe in the center, respectively. On the other hand, when the itonic bonding was stronger, for example, with the cesium carbonate solution, too much collapsed materials could not penetrate the worm hole instantaneously Then the broken materials were exploded back from the black hole. Here the film products appeared, over which the elements were uniformly distributed.

During the USD experiments, several curious phenomena were observed. For example, ball lightning phenomena and a new kind of the electrical current. The details were described in Ref. 2.

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(8) T. Matsumoto, "Cold Fusion Experiments by Sparking Discharges in Water," Proc. of ICCF-5, Monaco, p. 583 (1995).

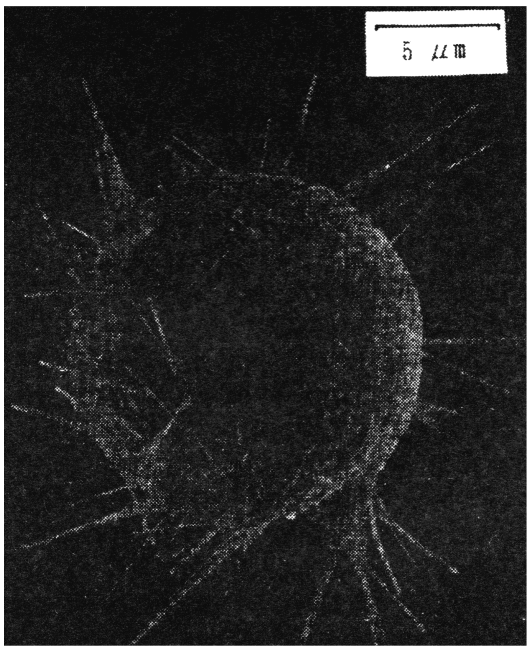

Fig. 1: Itonic Pb ball

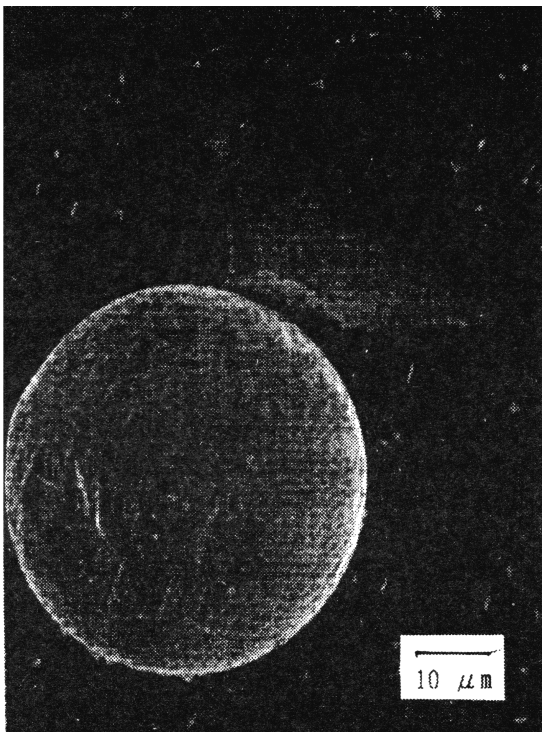

Fig. 2: Carbon film generated from itonic Pb ball



Fig. 3: Carbon film generated from itonic Pb ball

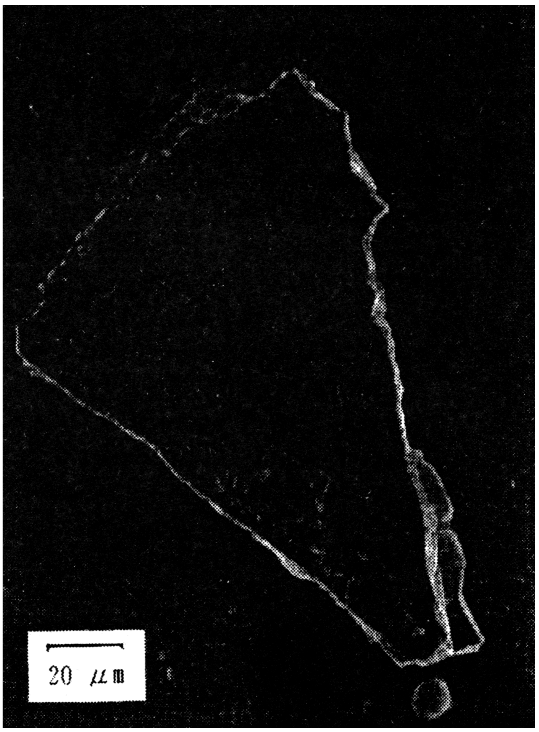

Fig. 4: Carbon film

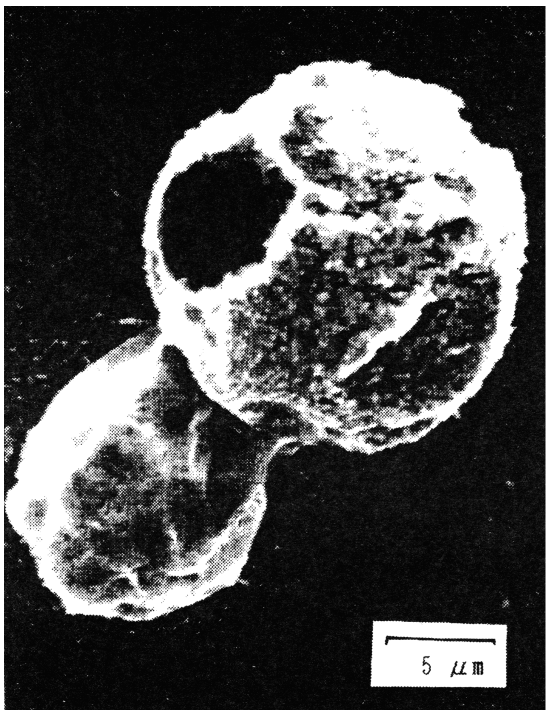

Fig. 5: Hollow Pb ball

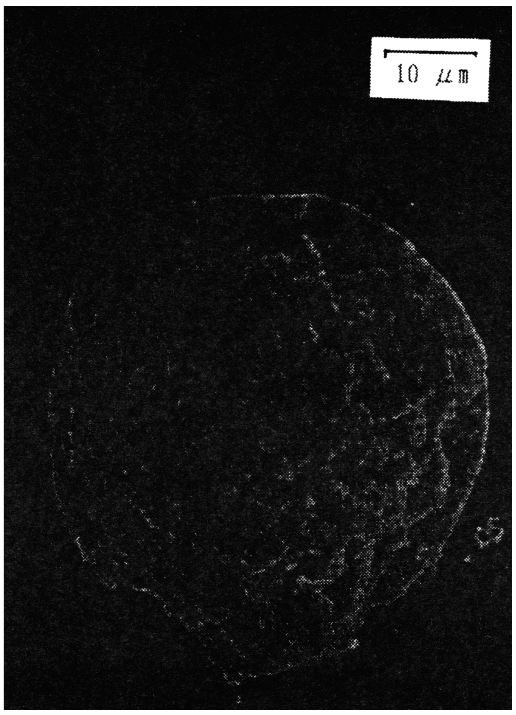

Fig. 6: Carbon film ejected from hollow Pb ball



Fig. 7: Carbon tube

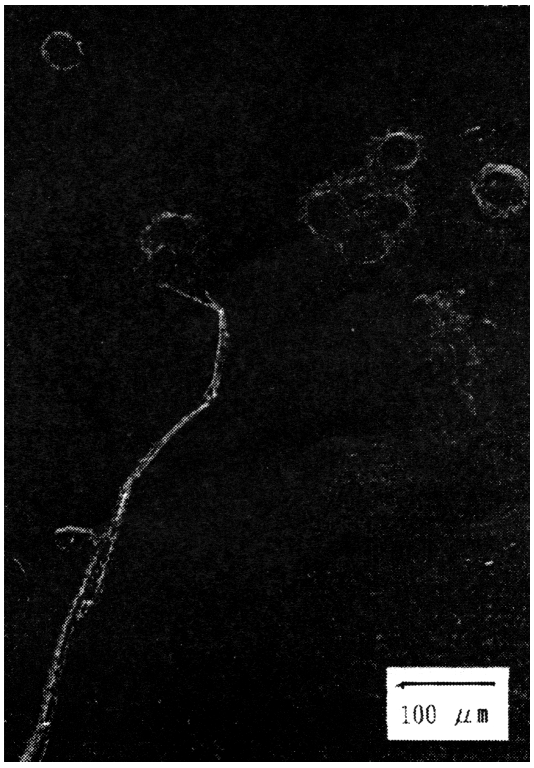

Fig. 8: Assemblies of itonic Pb clusters

Ref. (71)

Photographs of Electro-Nuclear Collapse

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Sapporo 060, JAPAN

This book represents remarkable photographs which were obtained during three experiments of Underwater Spark Discharge(USD)(1). Here "Electro-Nuclear Collapse" took place(2 - 9). The mechanisms for the generation of the photographs were explained elsewhere(10, 11).

The experiments shown in Fable 1 were carried out with a thin lead metal wire electrode (1 mmφ), which were inserted in ordinary water solution. Copper plates were used for a reference box electrode as well as for monitoring plates. Discharges were made under a pulsed AC mode of 120 V. The products on the copper plates were examined by a scanning electron microscope (SEM) and those elements were analyzed with an energy dispersive X-ray spectroscopy(EDX).

Table 1: Experimental Conditions

	Solution	ON	OFF	No. of Shots
Exp. S70:	KOH(1.5 Mol/l)	80 msec	20 sec	4
Exp. 71:	KOH(1.5 Mol/l)	800 msec	20 sec	1
Exp. 72:	Cs2CO3(0.6 Mol/l)	20msec	20 sec	5

Captions of Figures

Fig. 1: Tiny Pb balls
(a) S70TCE (b) S70TCC (c) 72BDN (d) 72BDM

Fig. 2: Itonic Pb balls
(a) S70ABF (b) S70TAK (c) S70ABA (d) S70TAJ
"Itonization" means that many electrons are degenerated and interconnected each other.

Fig. 3: Pb balls with itonic thorns
(a) 72BDO (b) 72BDG (c) 72BAA (d) 72BAH
"Thorns" consisted of Pb.

Fig. 4: Pb balls with itonic Cs layer
(a) 72BDW (b) 72BDV

Fig. 5: Break up of itonic Cs layers
(a) 72BCG (b) 72CDA
The itonized area was thicker for Cs than for K, because of the larger number of water molecules contained in an electrolyte cluster.

Distributed at ICCF-7 in Vancouver, 1998

(The 7-th International Conference of Cold Fusion)

Distributed at ICOPS in Monterey, 1999

(The International Conference of Plasma Science)

Fig. 6: Pb ring with voltex like patters
(a) S70TAQ (b) expanded S70TAQ
Tiny Pb grains were generated in voltex like patterns and eddy current seemed to take an important role.

Fig. 7: Combined Pb balls
(a) 72BCL (b) 72BCM (c) 72BDA (d) 72BAF

Fig. 8: Break up of itonic Pb
(a) S70DDG (b) S70TCB (c) S70ADE

Fig. 9: Perfect break up of itonic Pb
(a) S70TCJ (b) S70ADC (c) Expanded S70ADC

Fig. 10: Perfect break up of itonic Pb
(a) S70ADD (b) Expanded S70ADD (c) Expanded S70ADD
Star like products consisted of itonic only Pb.

Fig. 11: Mesh like itonic Cs
(a) 72LDB (b) 72LDC
Itonic Cs layers had mesh like structures.

Fig. 12: Mesh and lattice like itonic Cs
(a) 72TDA: Break up of itonic Cs with mesh like structure
(b) 72BDD: Itonic Cs with cubic lattice like structure

Fig. 13: Eruption of C film from Pb ball
(a) S70CDA (b) 72RAA (c) 72BBG
Systems of Exps. S70 and 71 were perfectly carbon free.

Fig. 14: Eruption of C film from Pb ball
(a) 72BDP (b) 72RAF (c) 72BBF

Fig. 15: Eruption of C film from Pb ball
(a) 72BDC (b) 72BCH (c) 72RAD (d) 72BCD

Fig. 16: Eruption of hollow Pb ball from itonic Pb ball
(a) 71RBE
The mechanisms of eruption could resemble pop-corns.

Fig. 17: Eruption of hollow Pb ball from itonic Pb ball
(a) 71BBG (b) Expanded 71BBG

Fig. 18: Hollow Pb ball
(a) S70TAR
Many of hollow Pb balls sustained a spherical shape.

(continued to p. 31)

10-JUL-97 S7JTCE WD21mm 20.0kV x2.5k 20μm

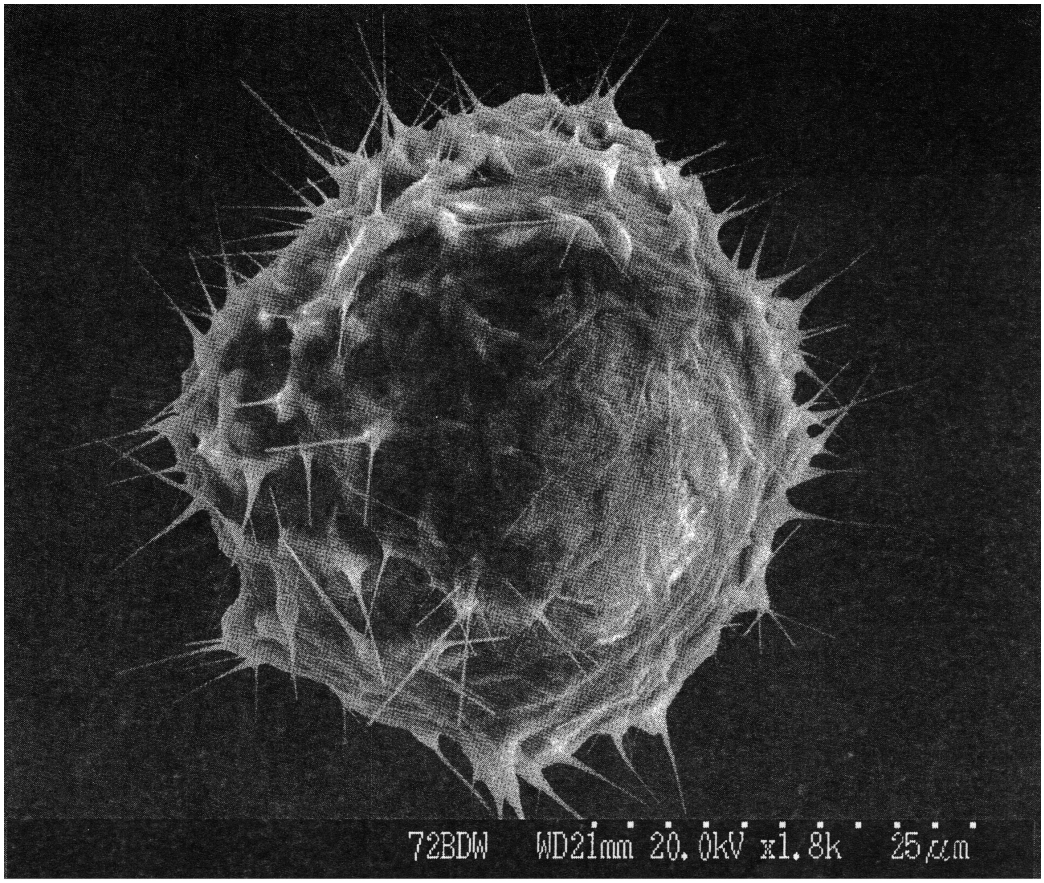
10-JUL-97 S7JTCC WD21mm 20.0kV x2.0k 20μm

72BDM WD21mm 20.0kV x4.0k 10μm

72BDM WD21mm 20.0kV x4.5k 10μm

11-JUL-97 S70AFF WD21mm 20.0kV x2.5k 20μm
09-JUL-97 S70TAK WD20mm 20.0kV x2.5k 20μm
10-JUL-97 S70ABA WD19mm 20.0kV x8.5k 10μm
09-JUL-97 S70TAJ WD20mm 20.0kV x8.0k 10μm

72BDG WD21mm 20.0kV x4.0k 10μm
72BDO WD21mm 20.0kV x2.5k 10μm
72BEH WD25mm 20.0kV x1.0k 50μm
72BEA WD25mm 21.0kV x900 50μm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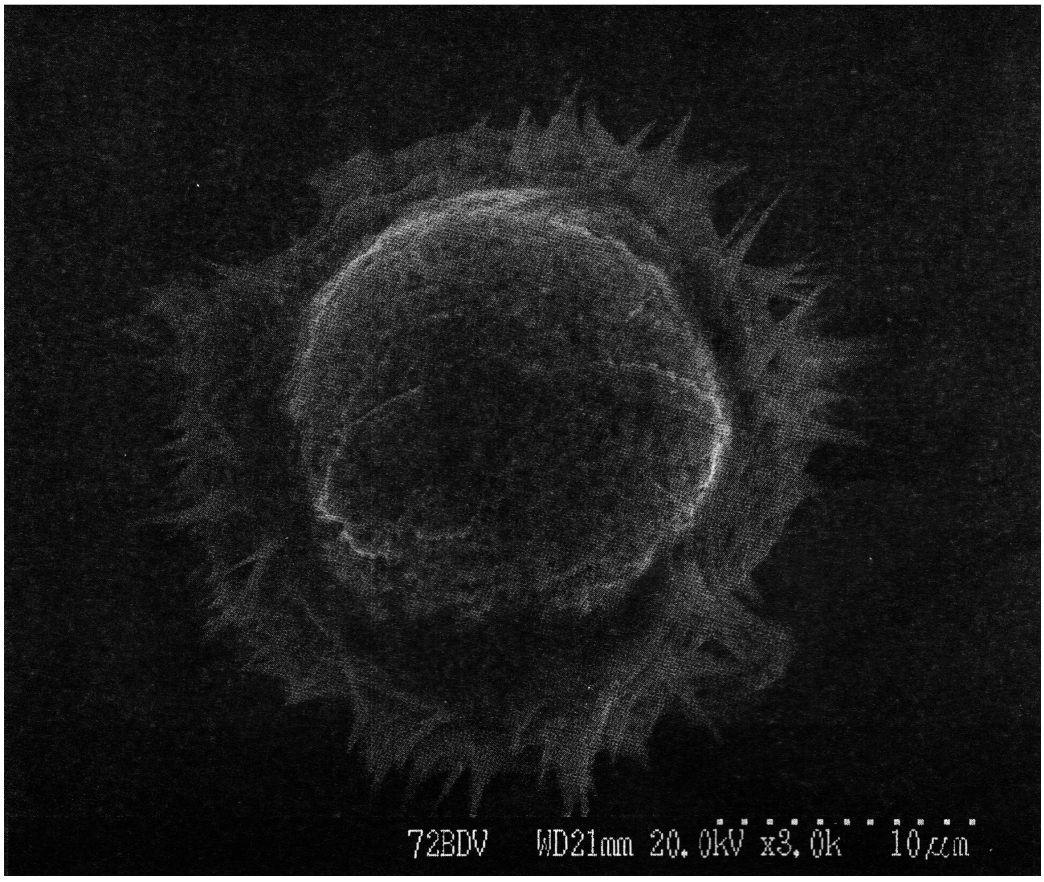
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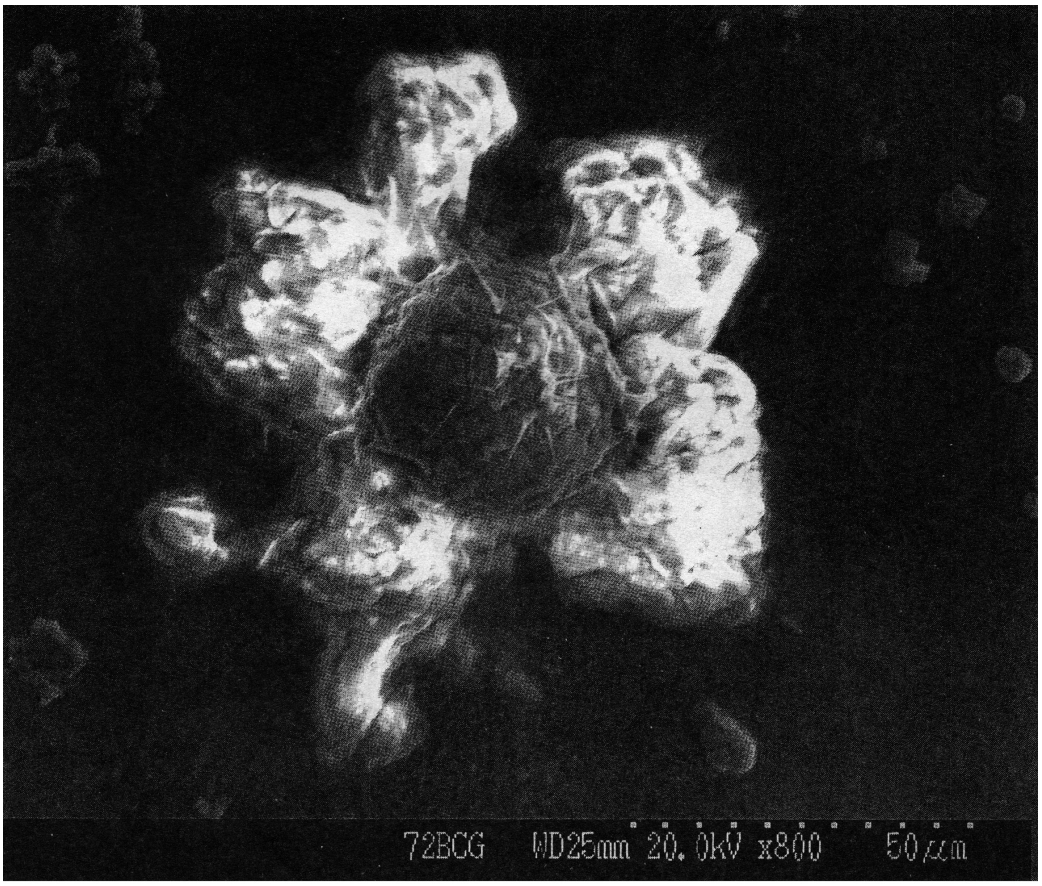
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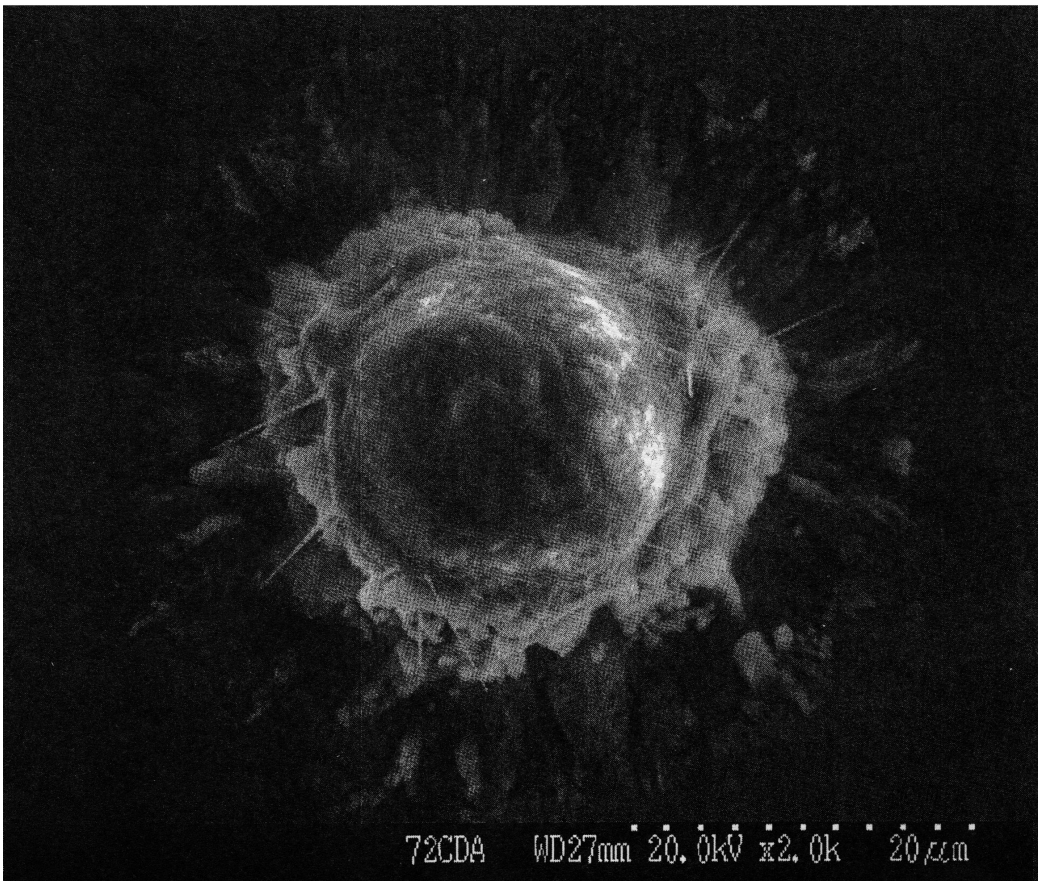
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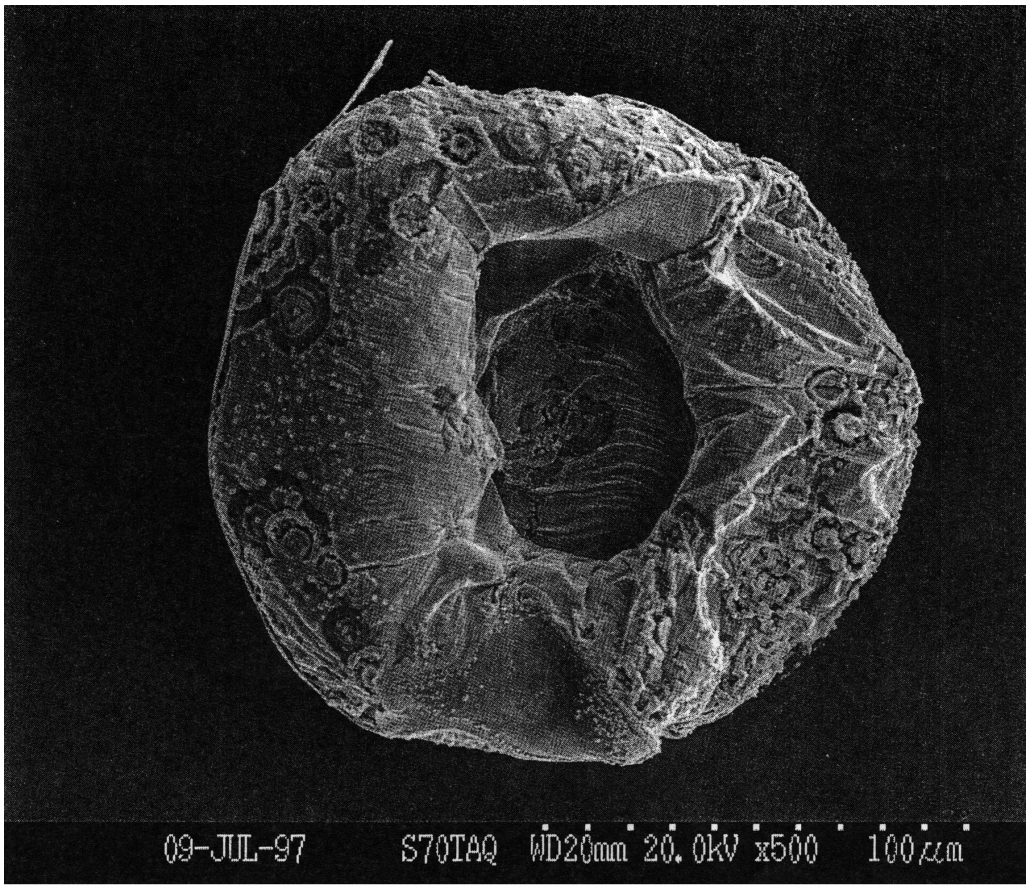
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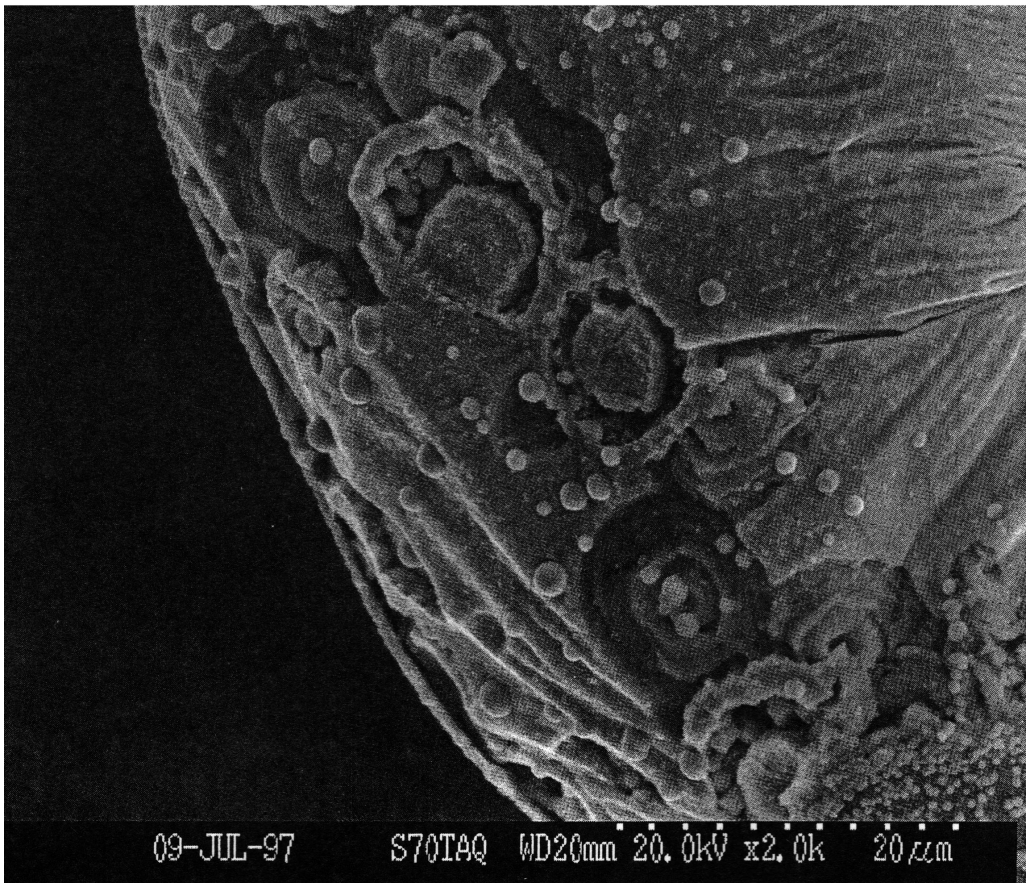
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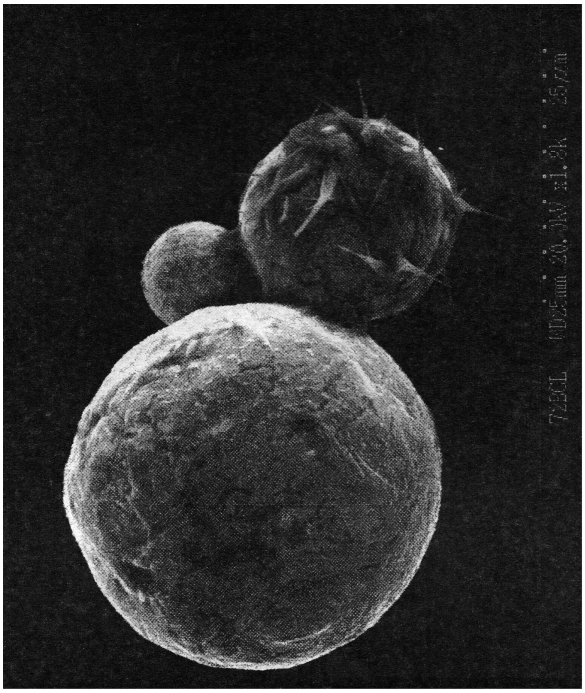
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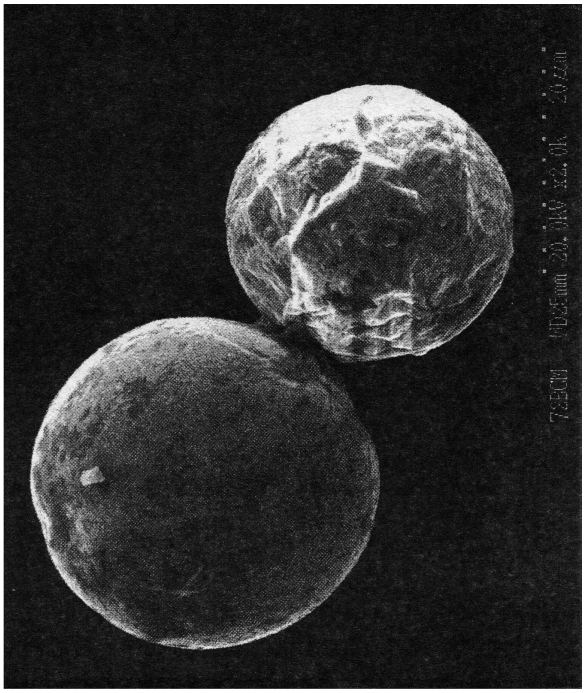
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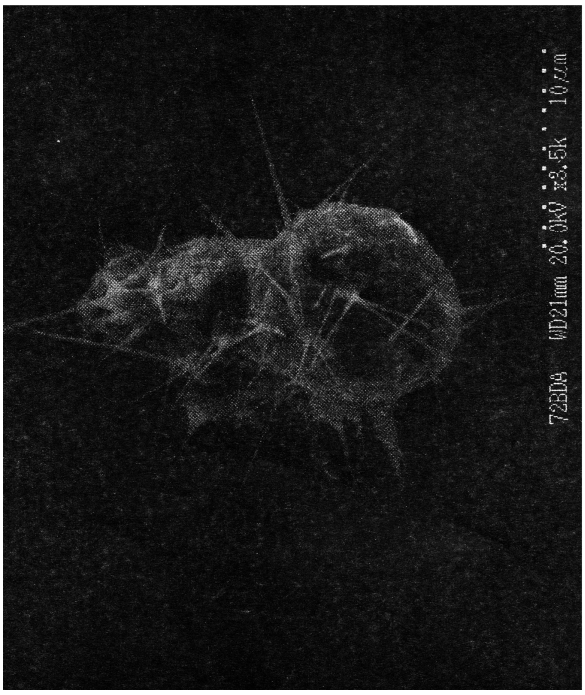
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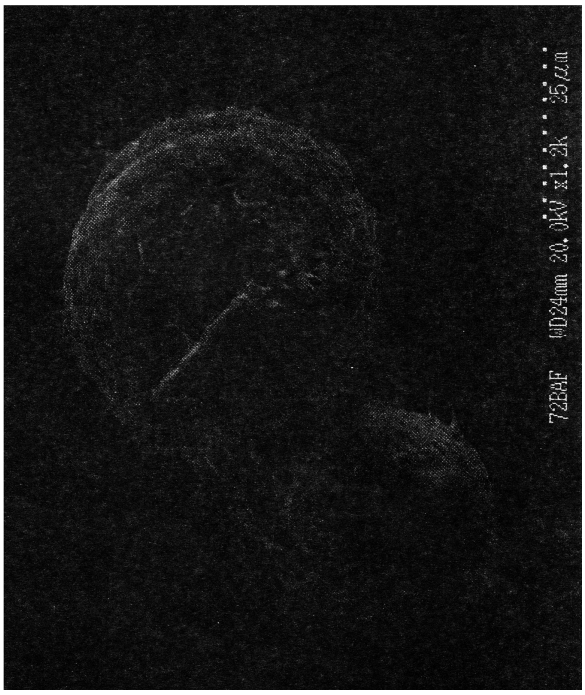
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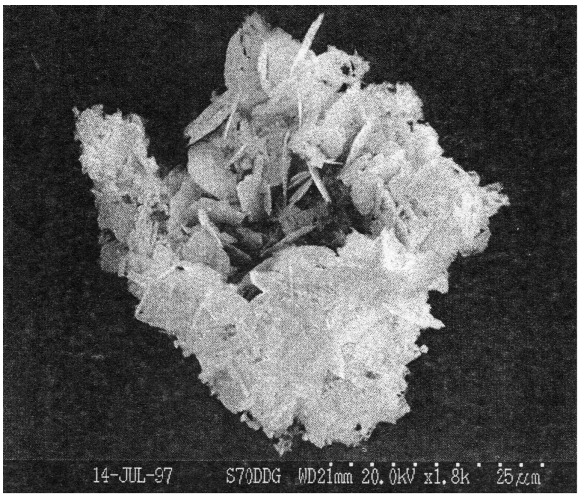
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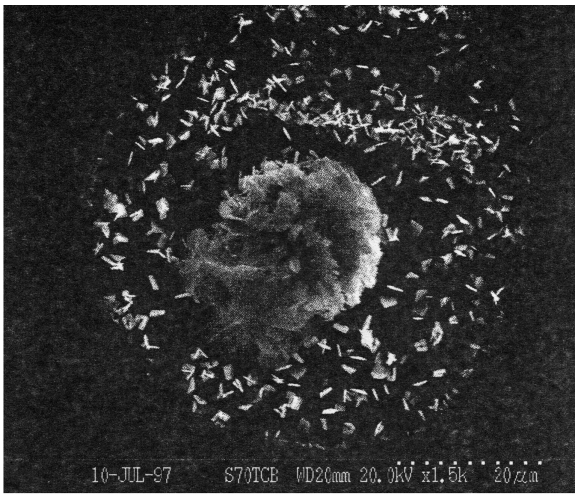
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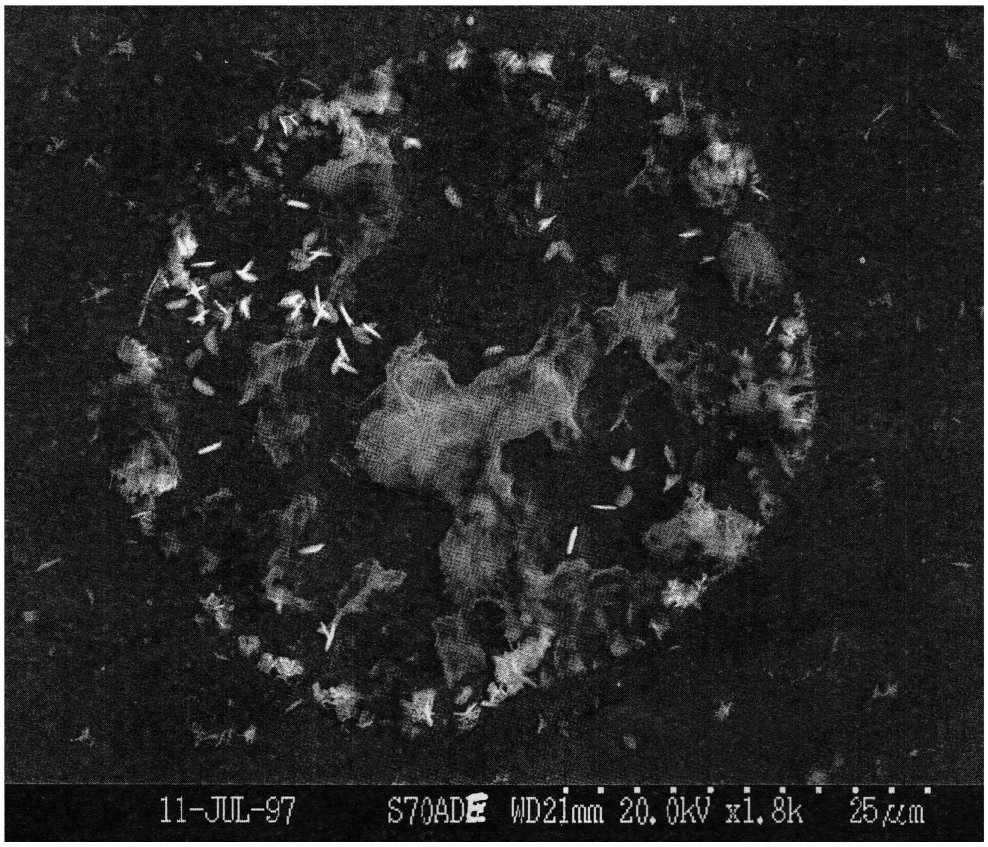
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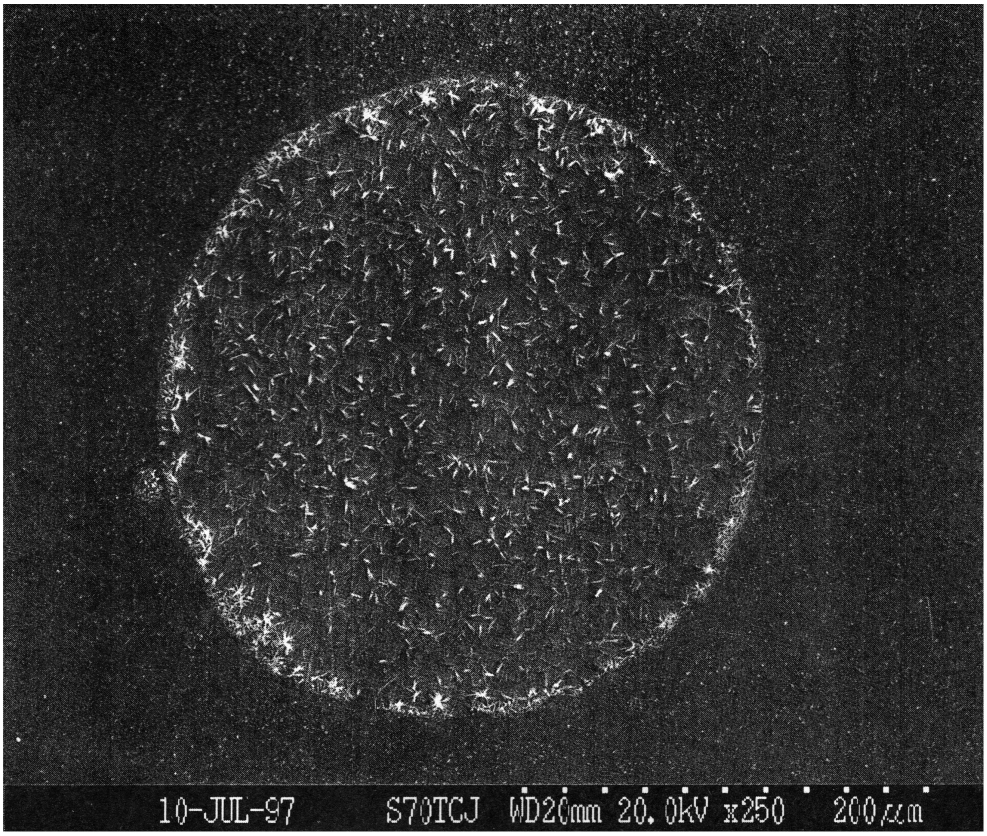
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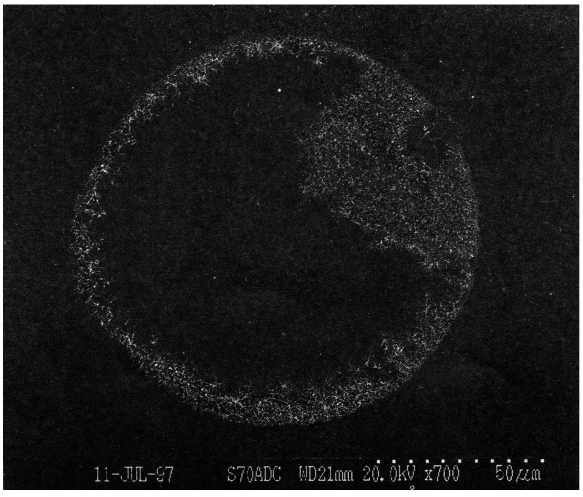
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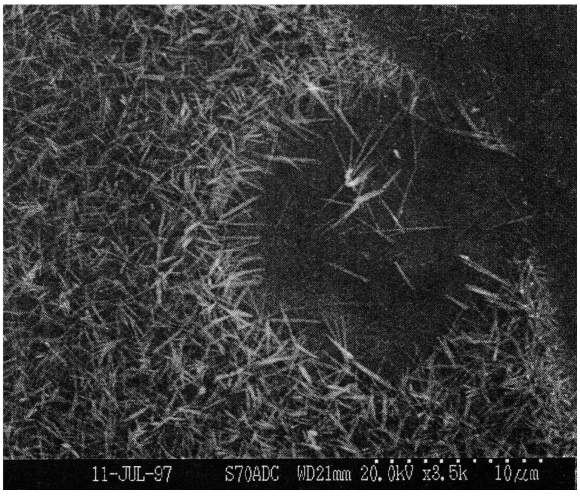
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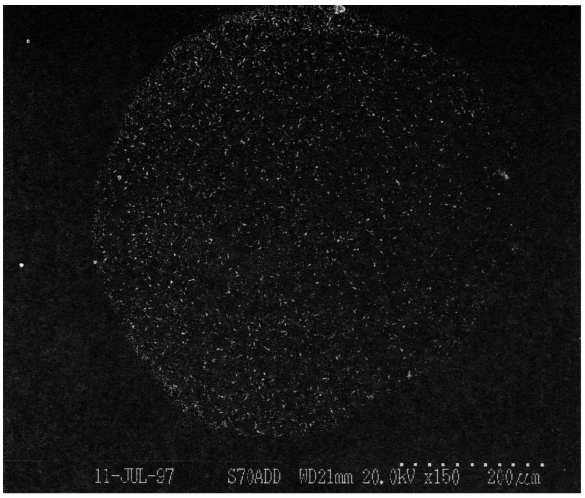
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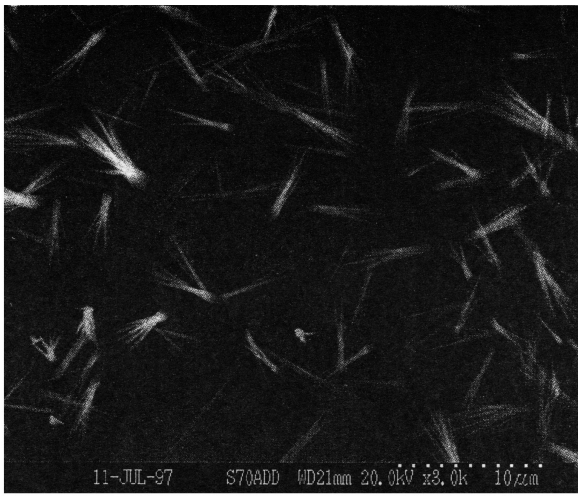
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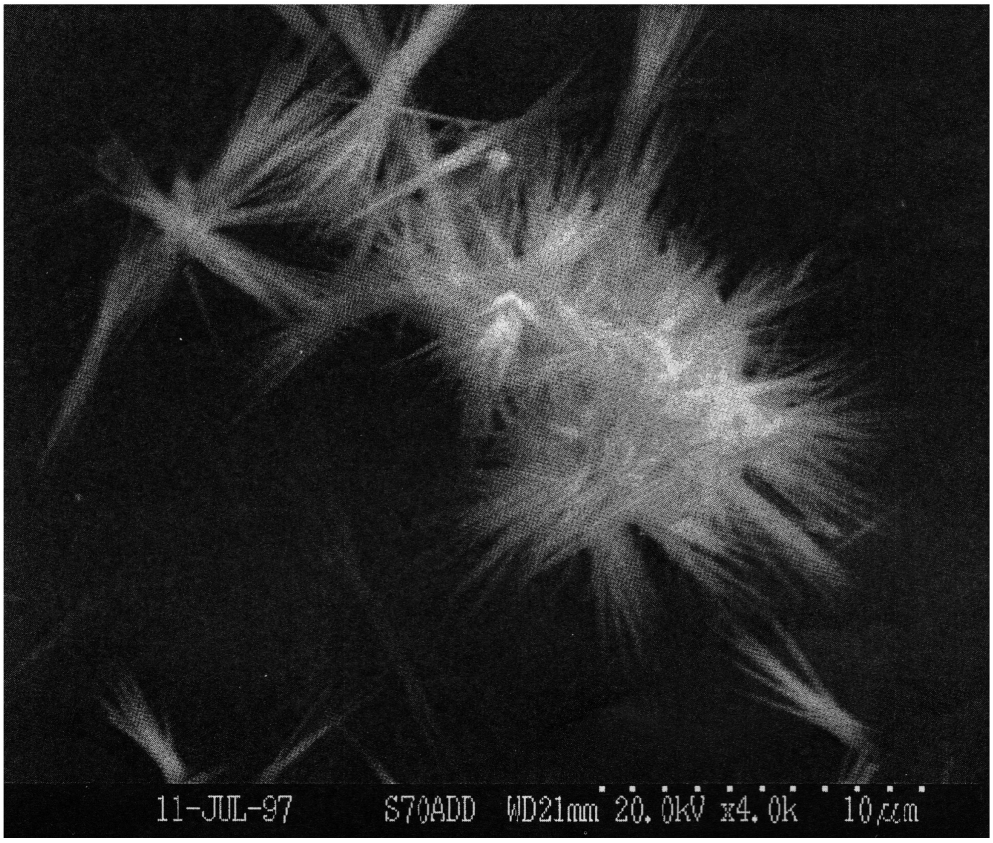
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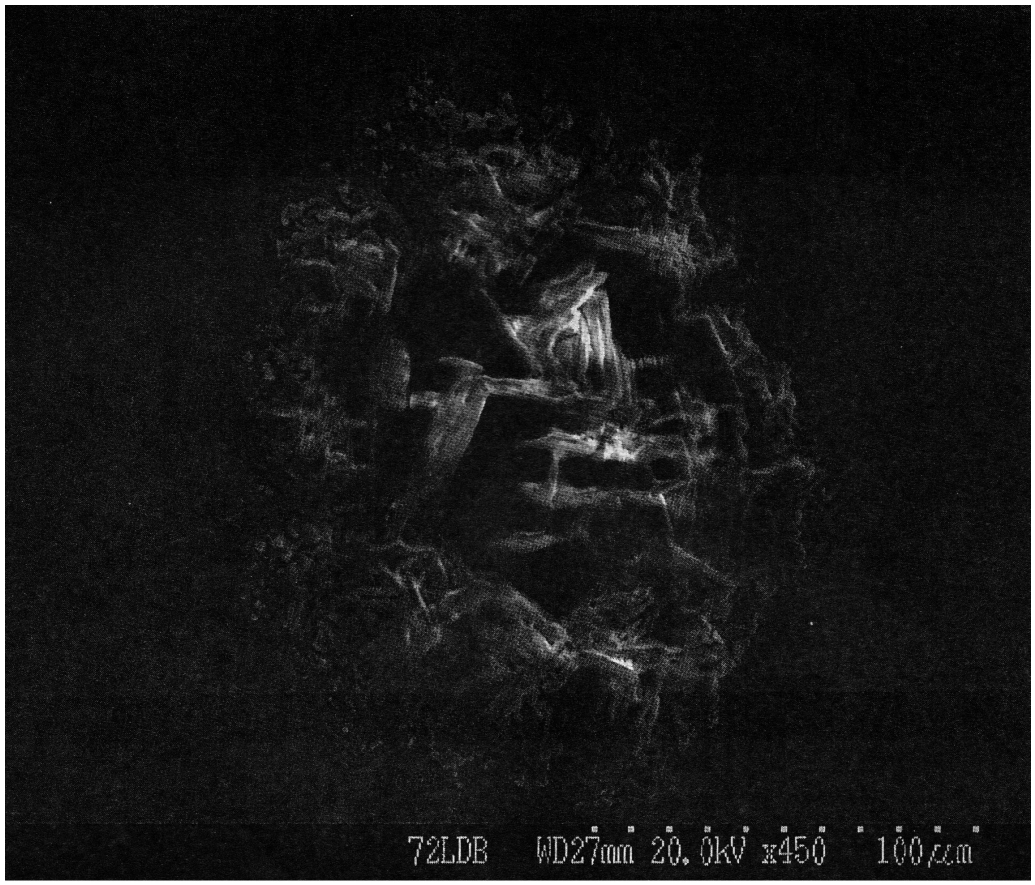
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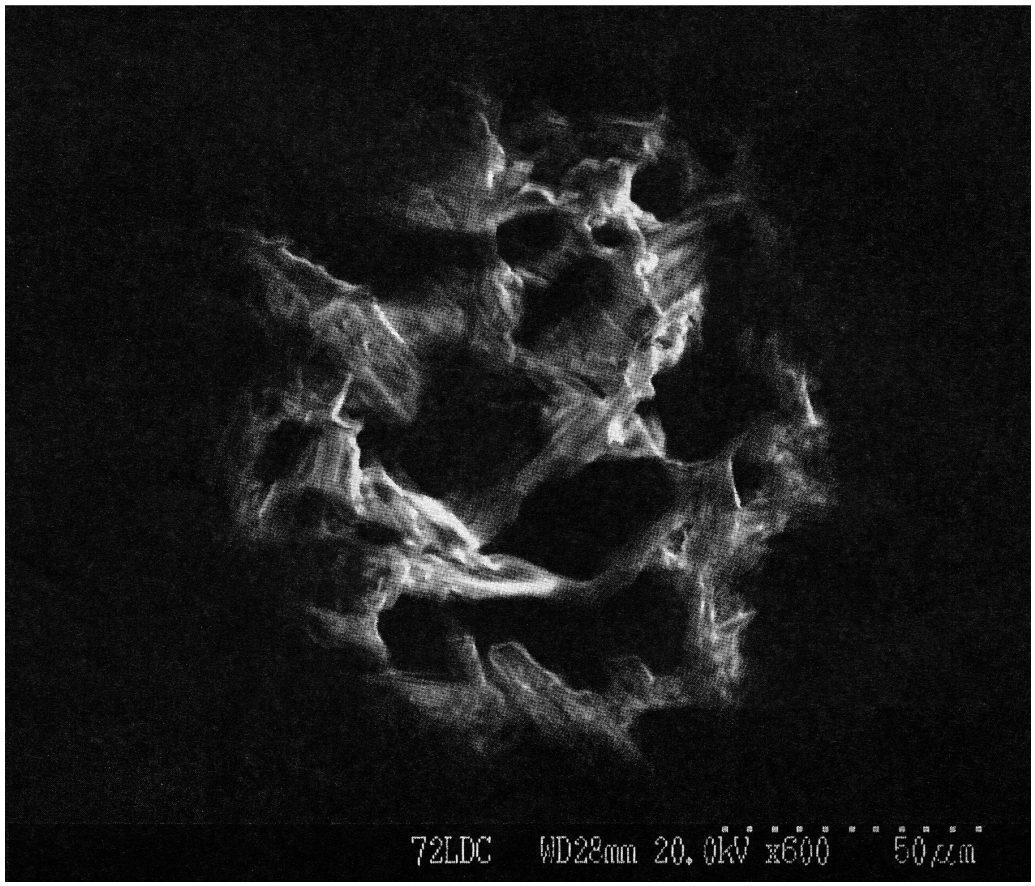
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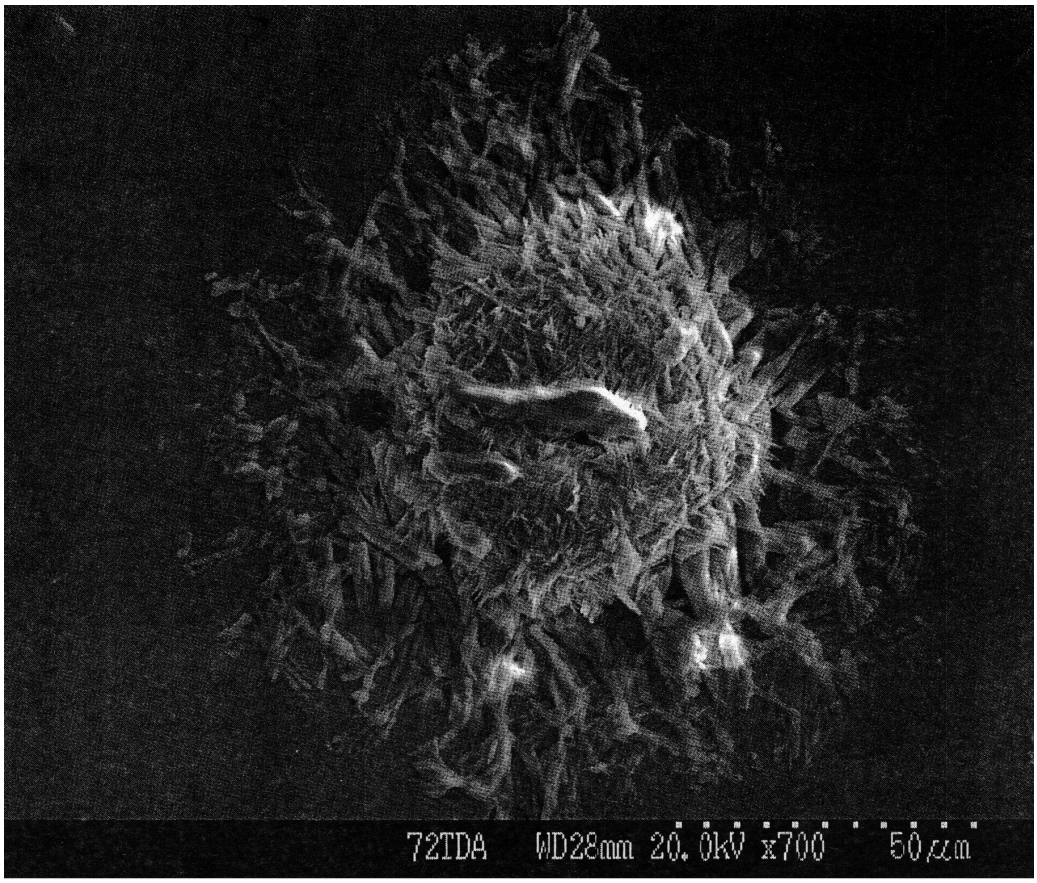
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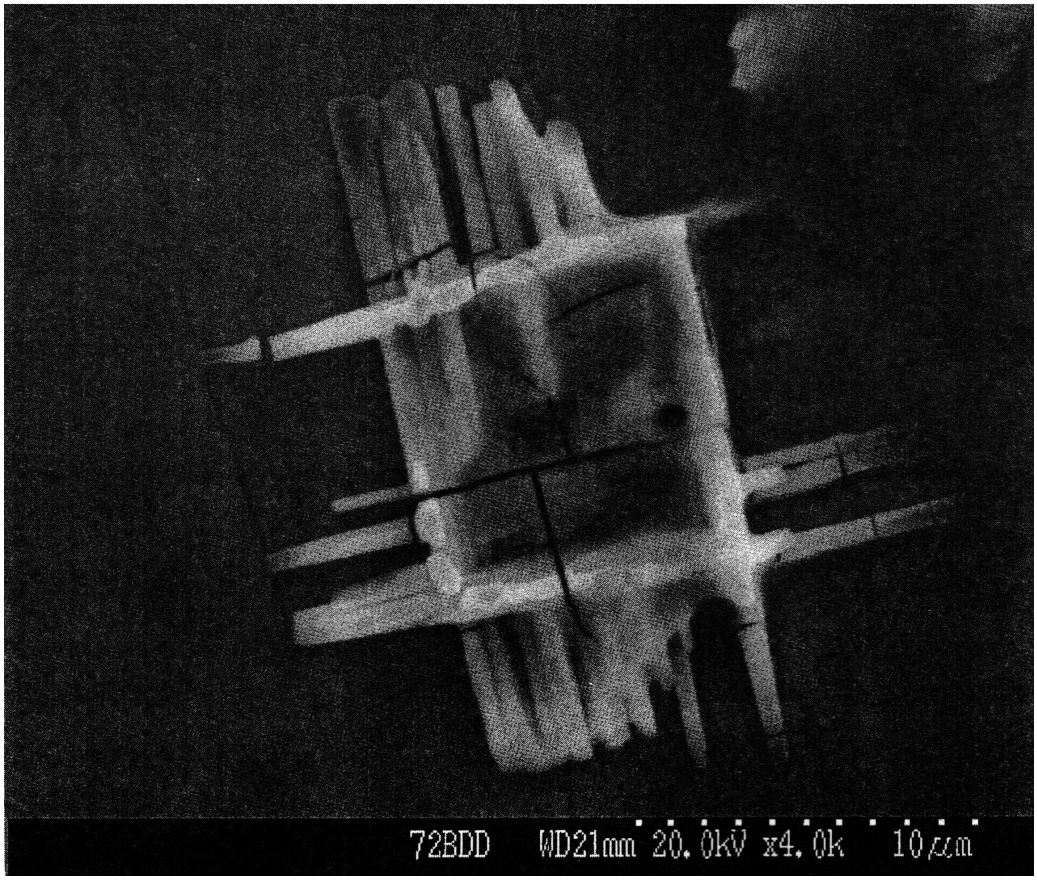
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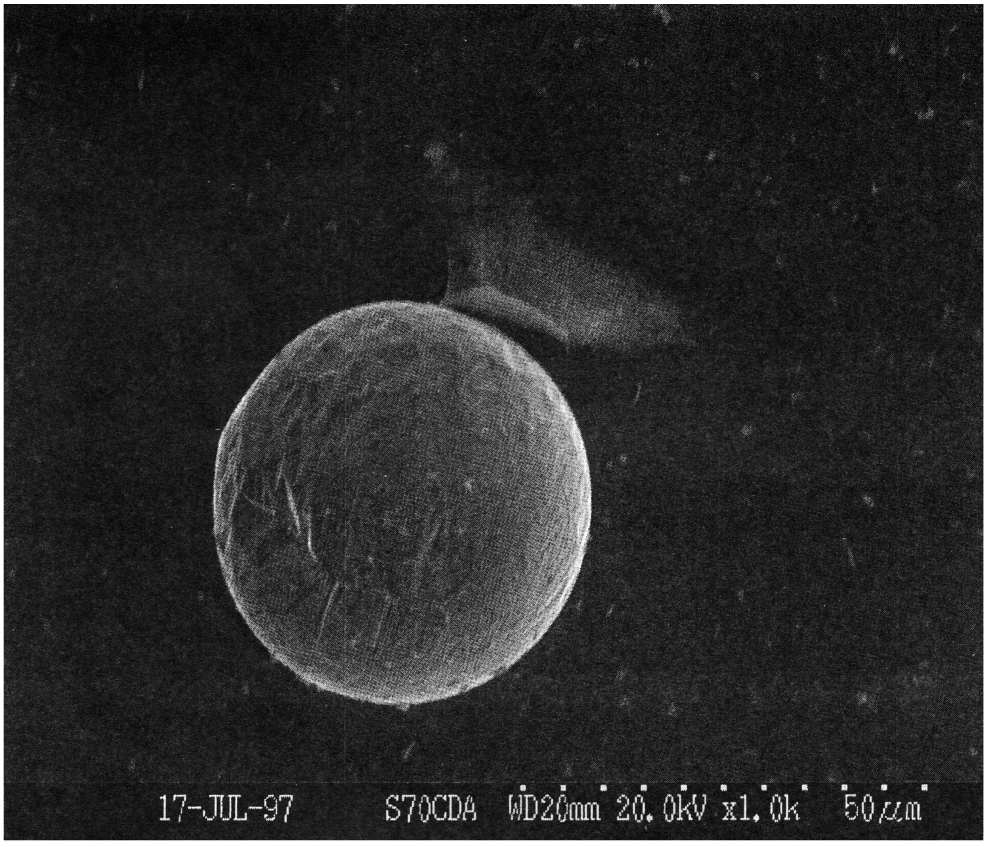
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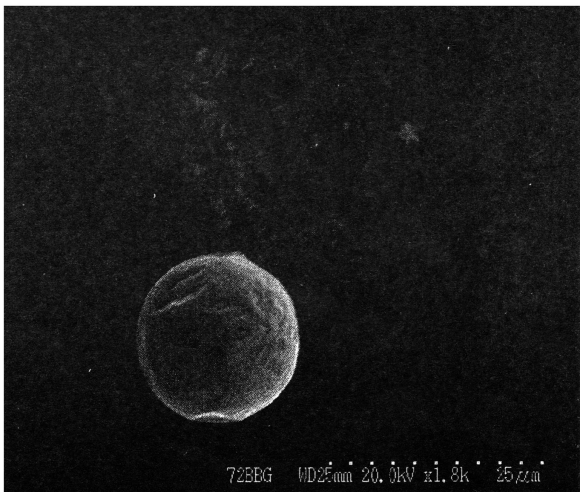
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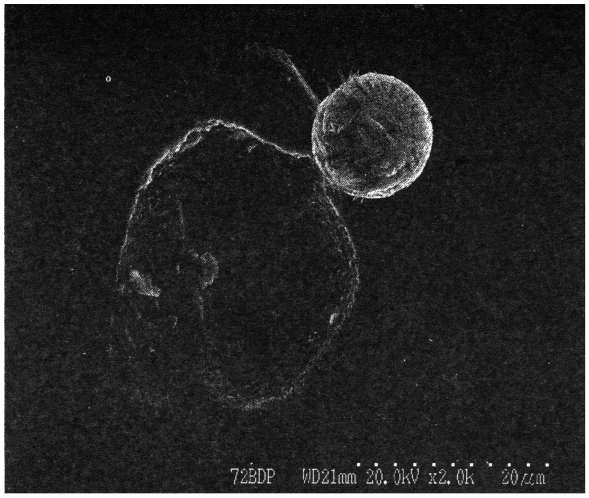
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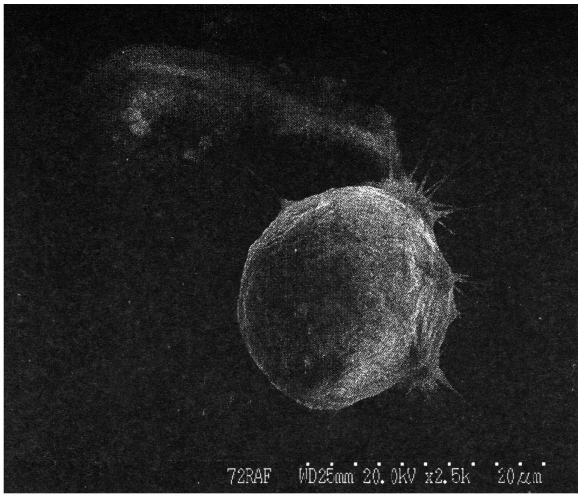
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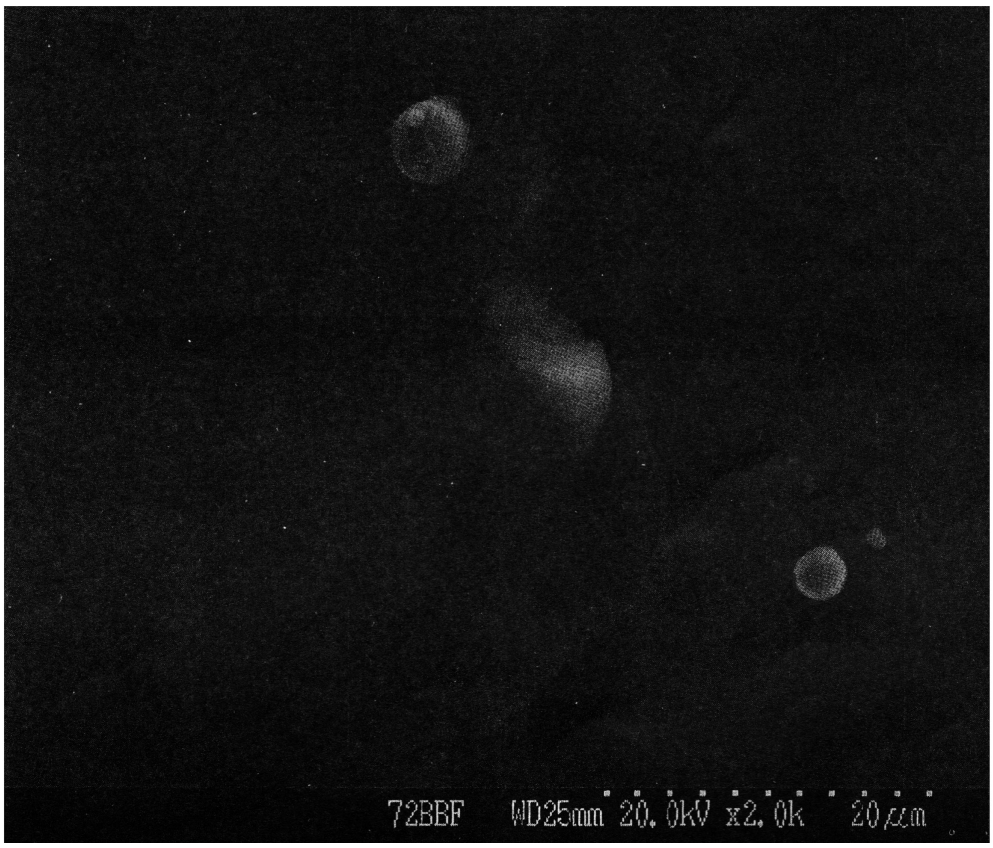
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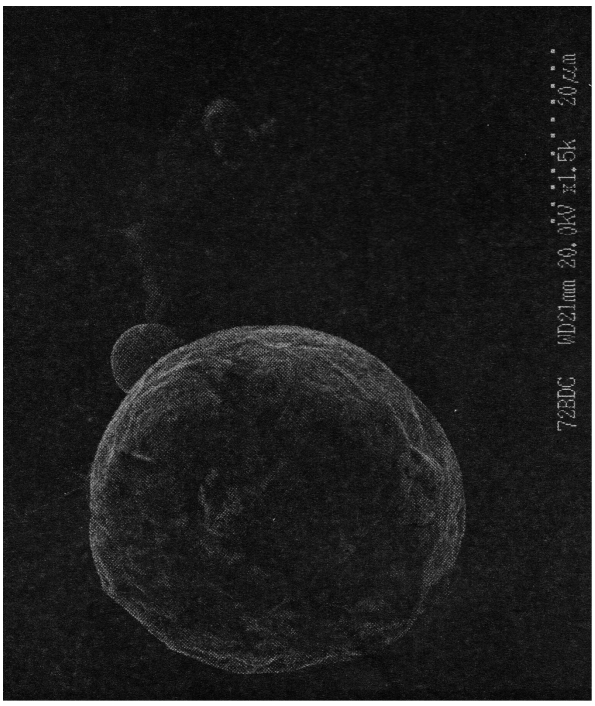
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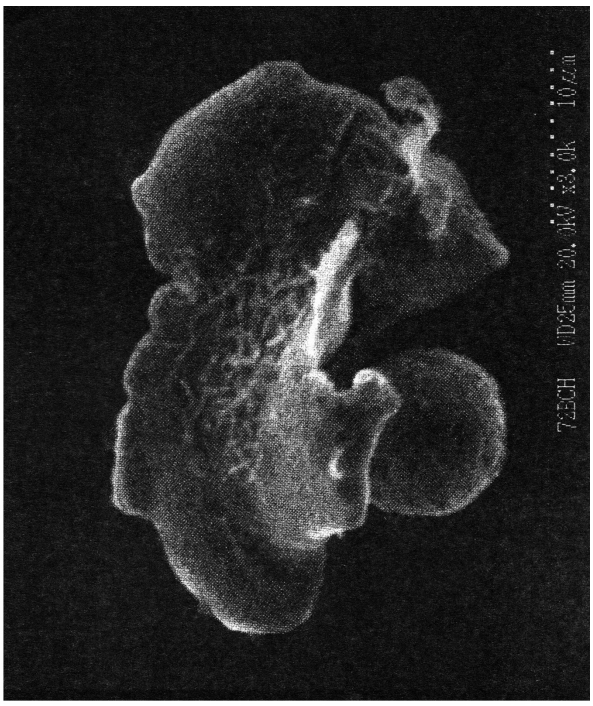
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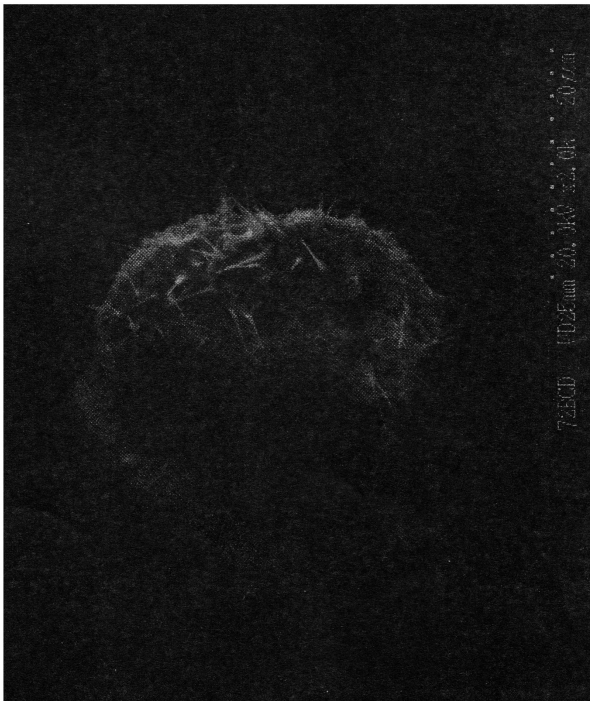
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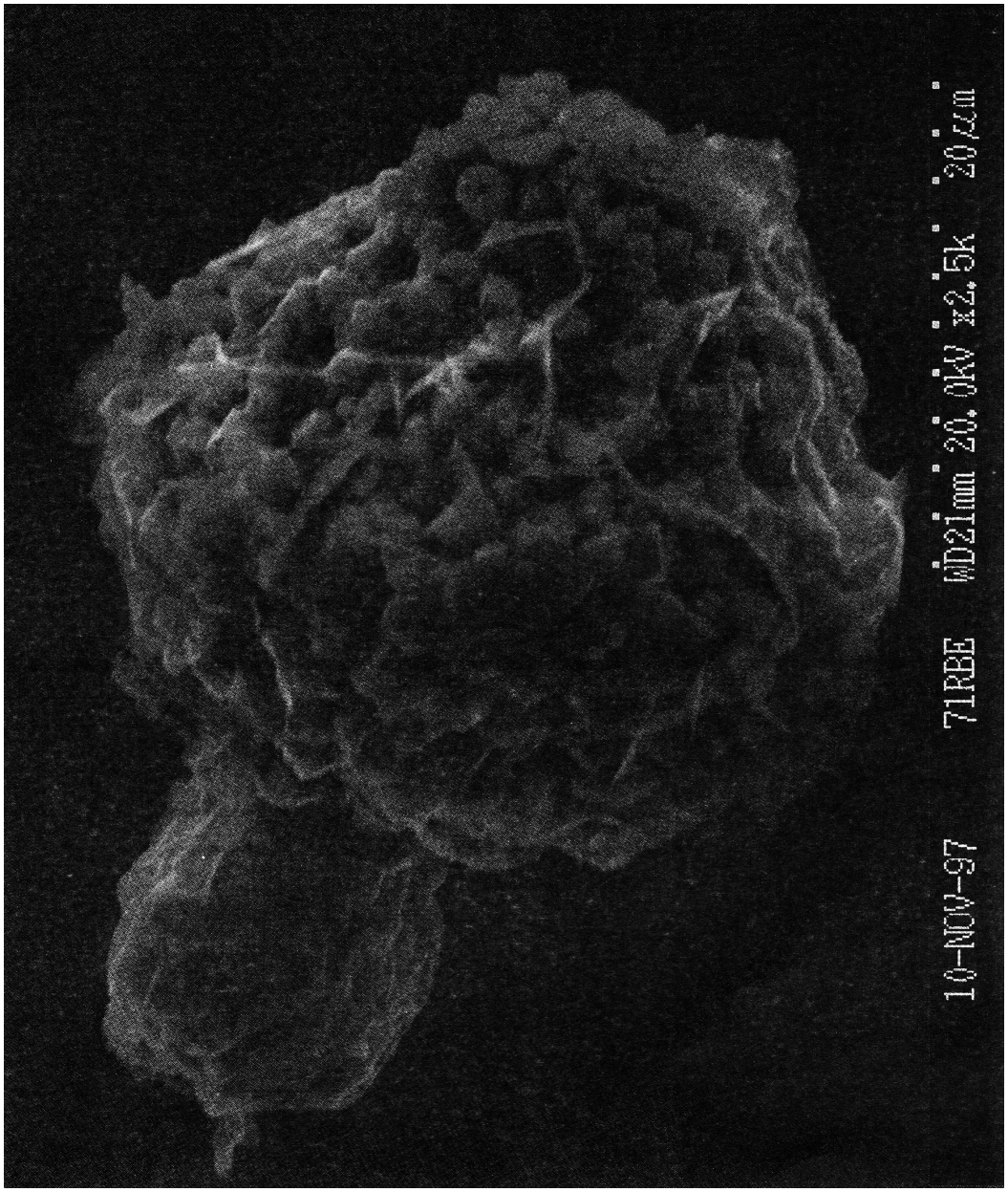
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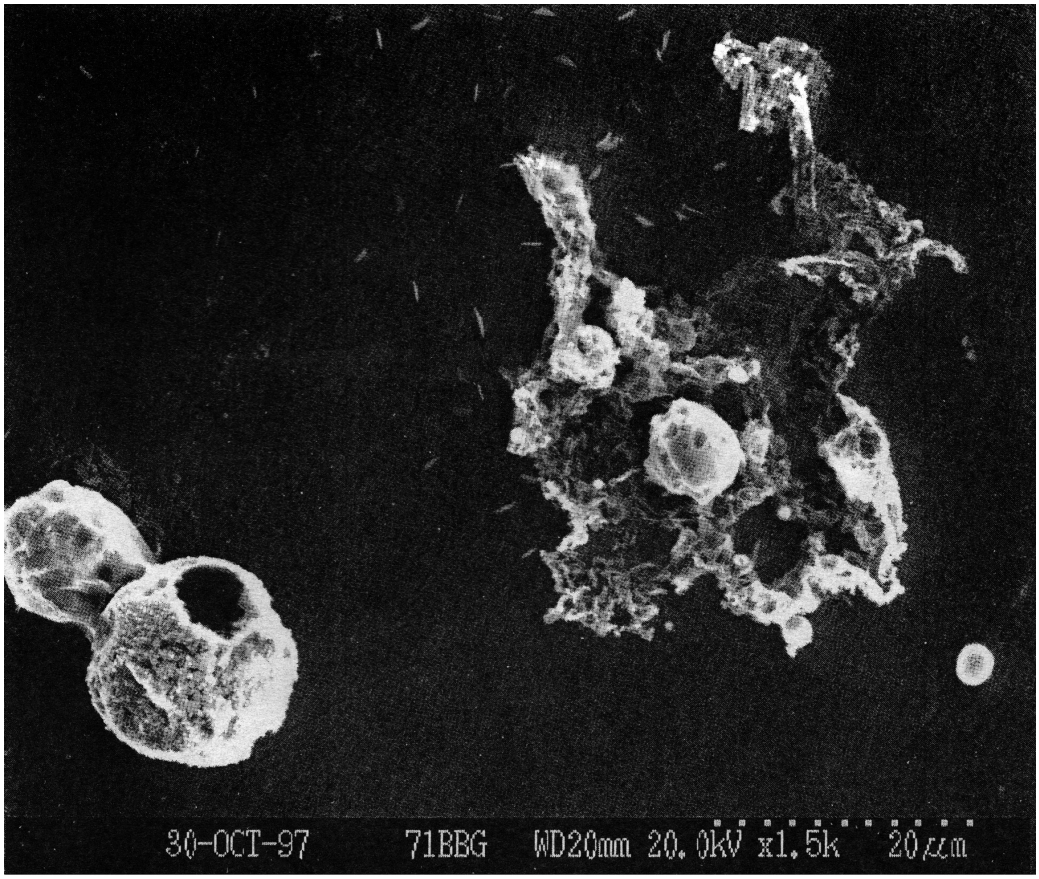
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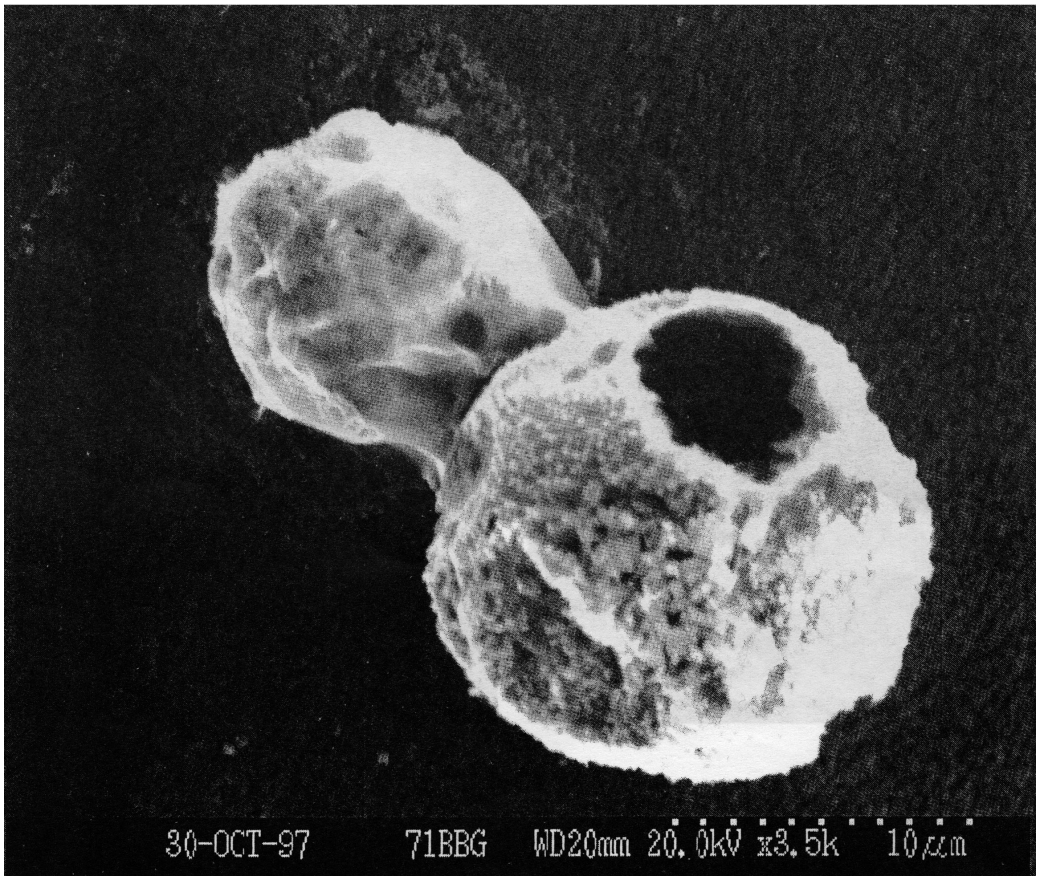
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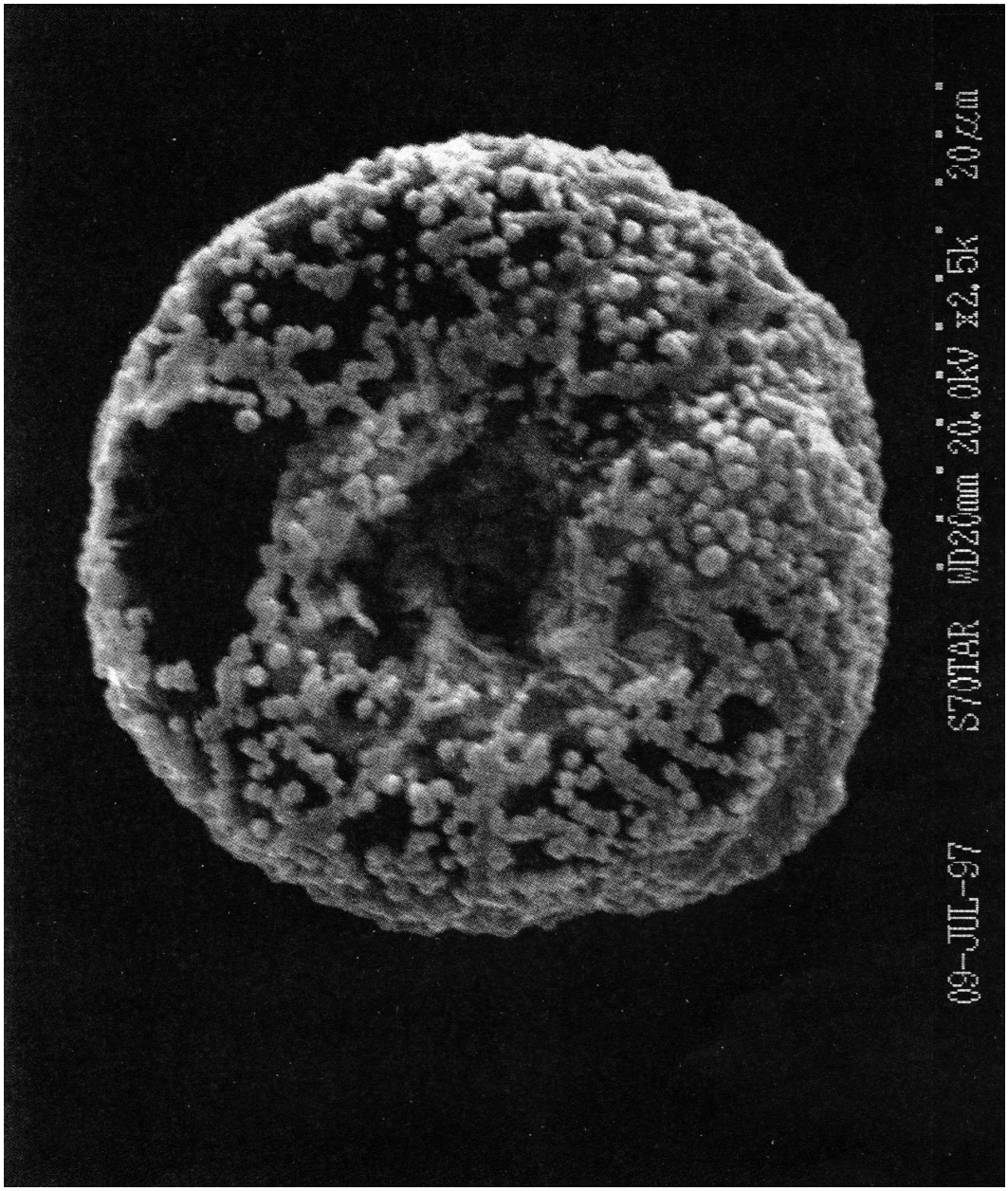
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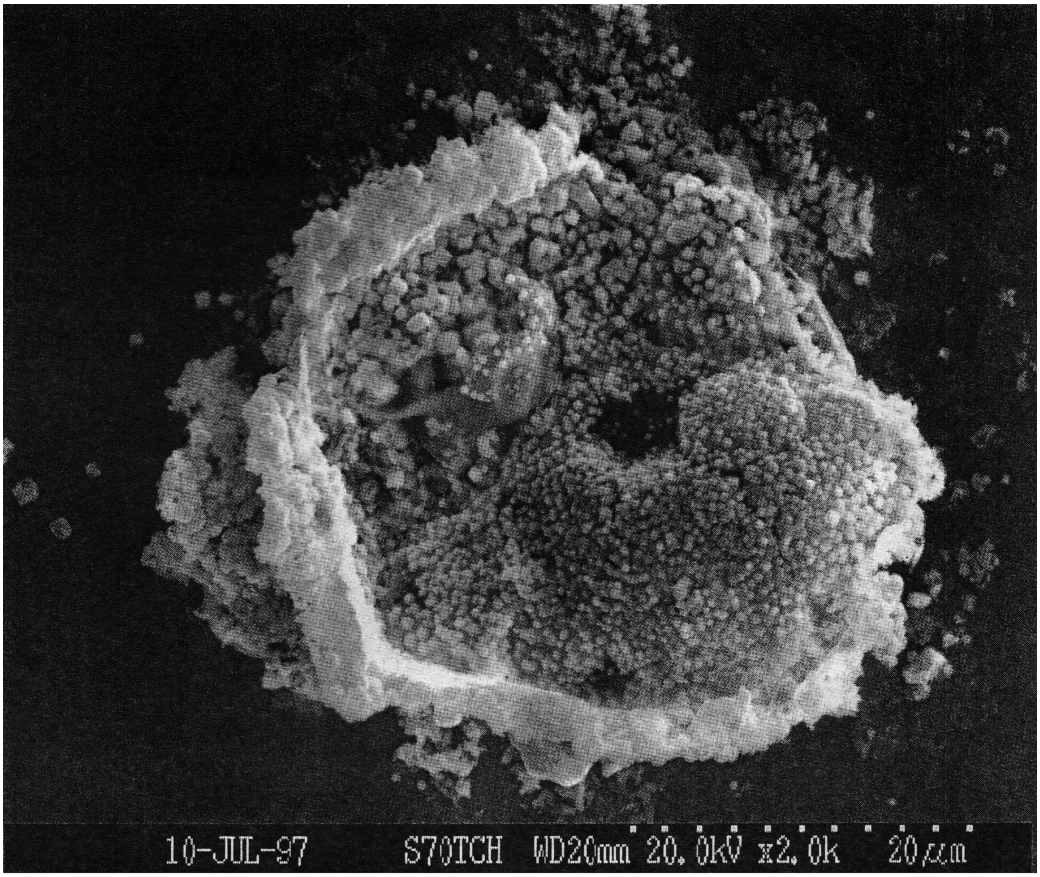
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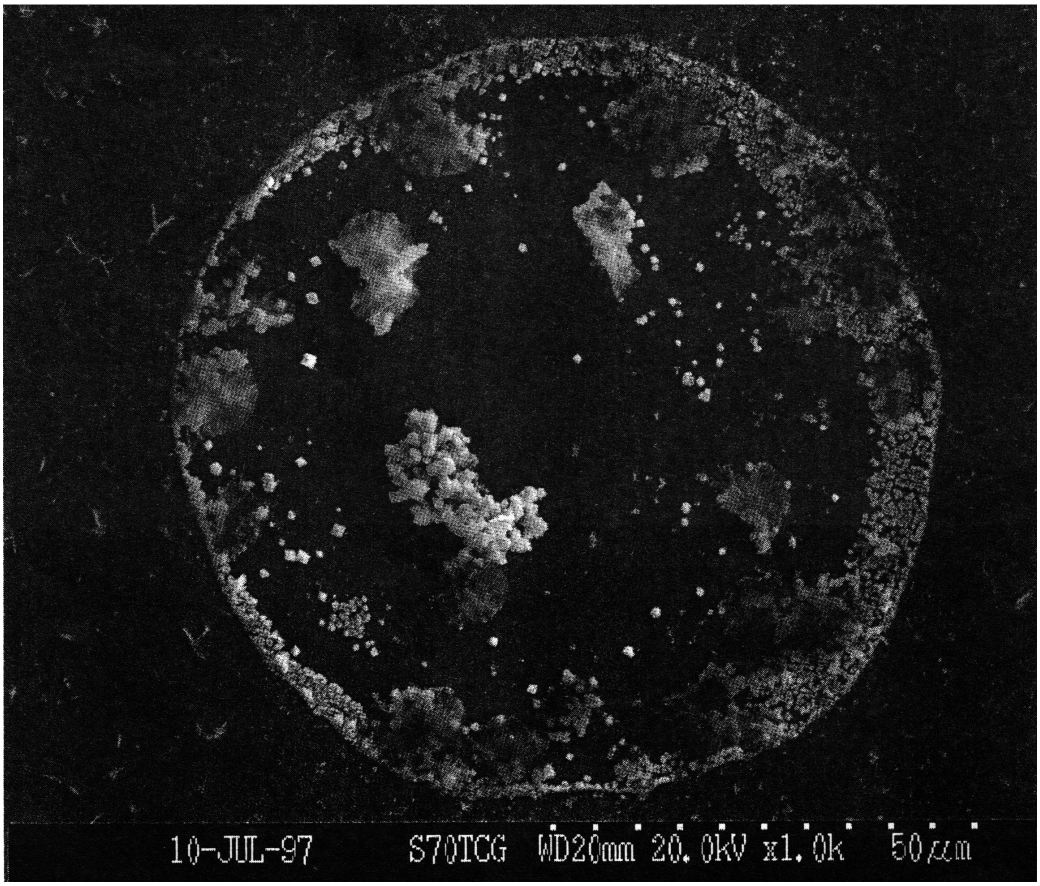
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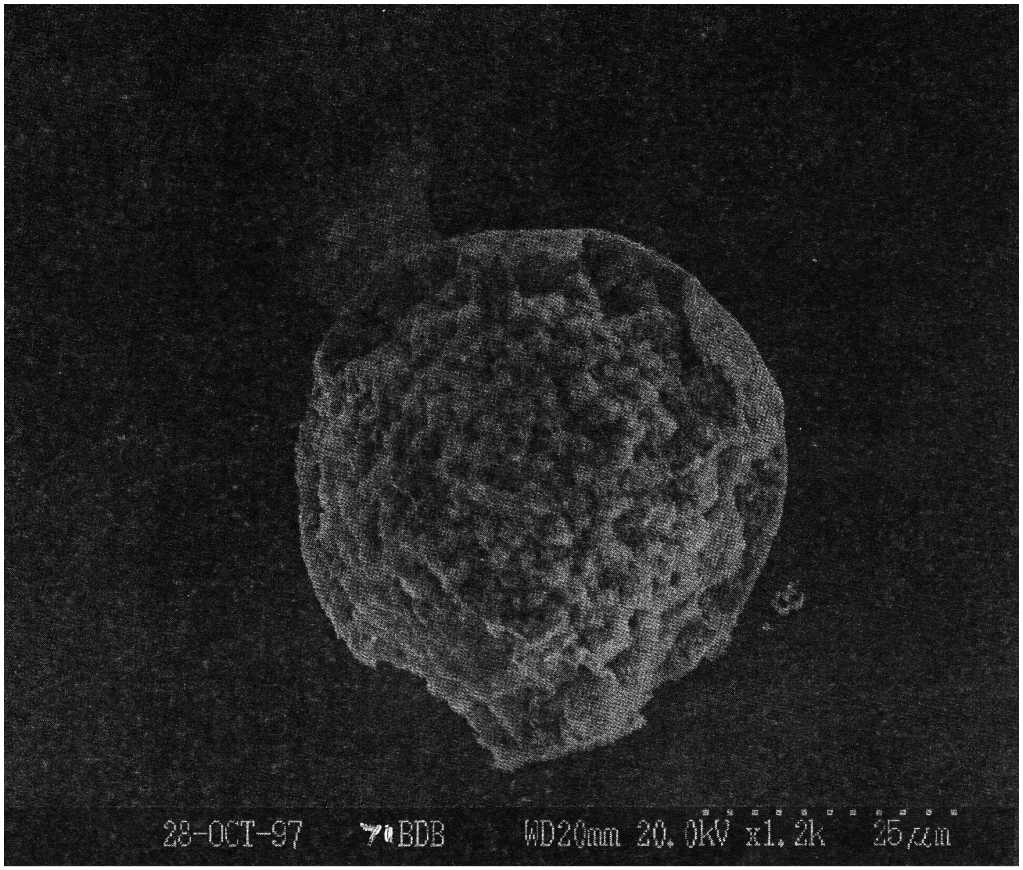
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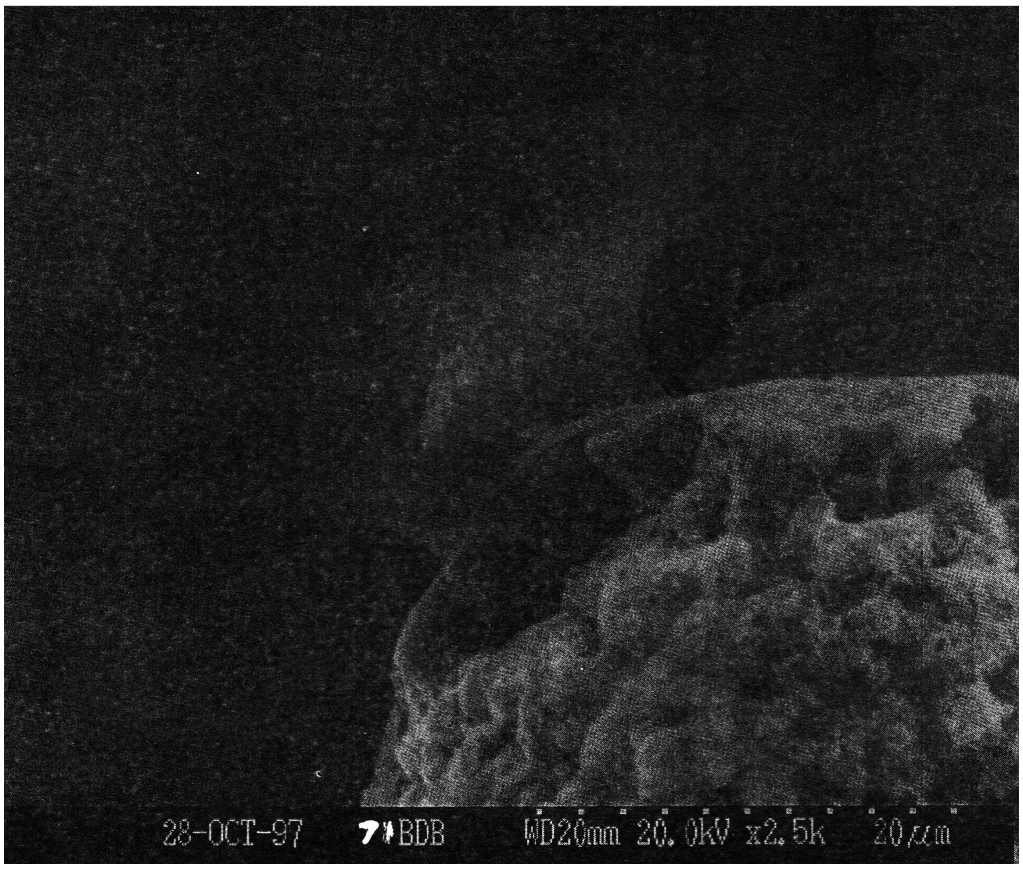
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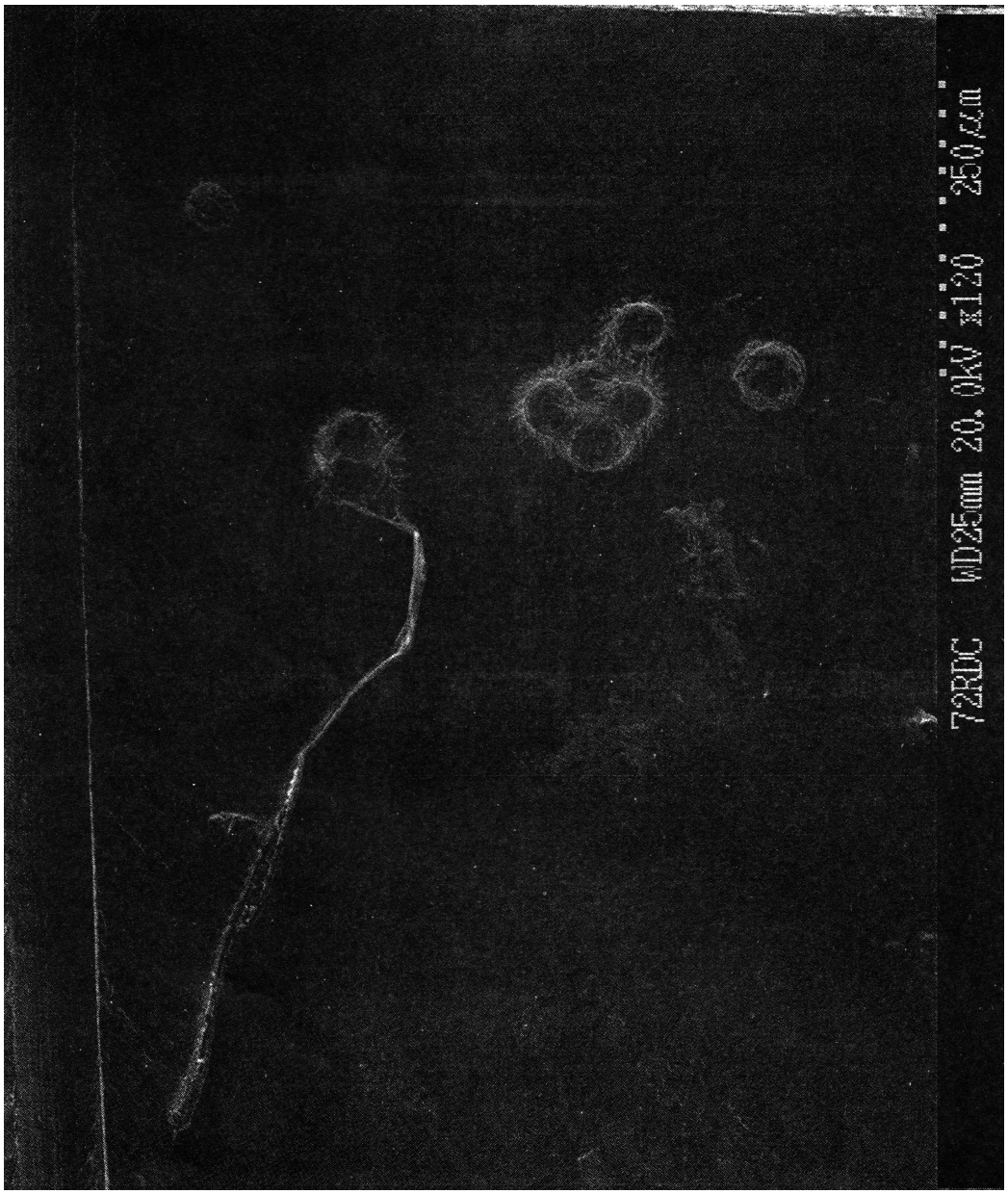
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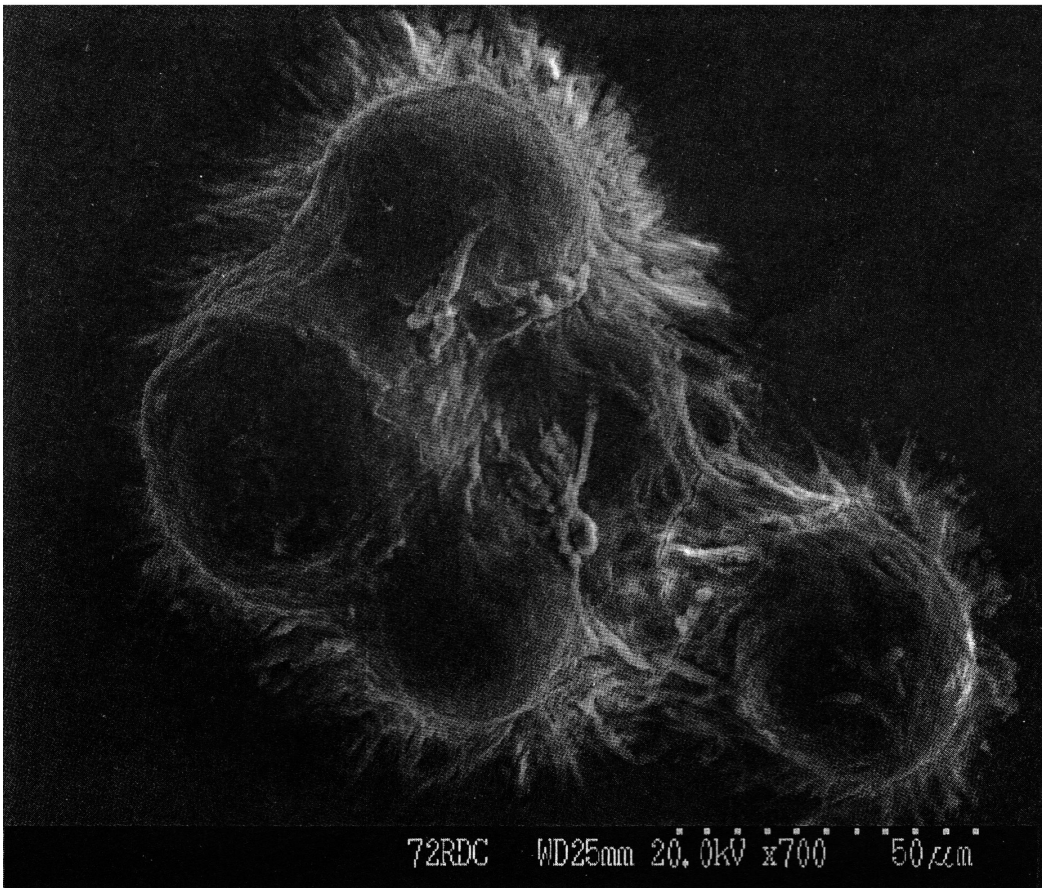
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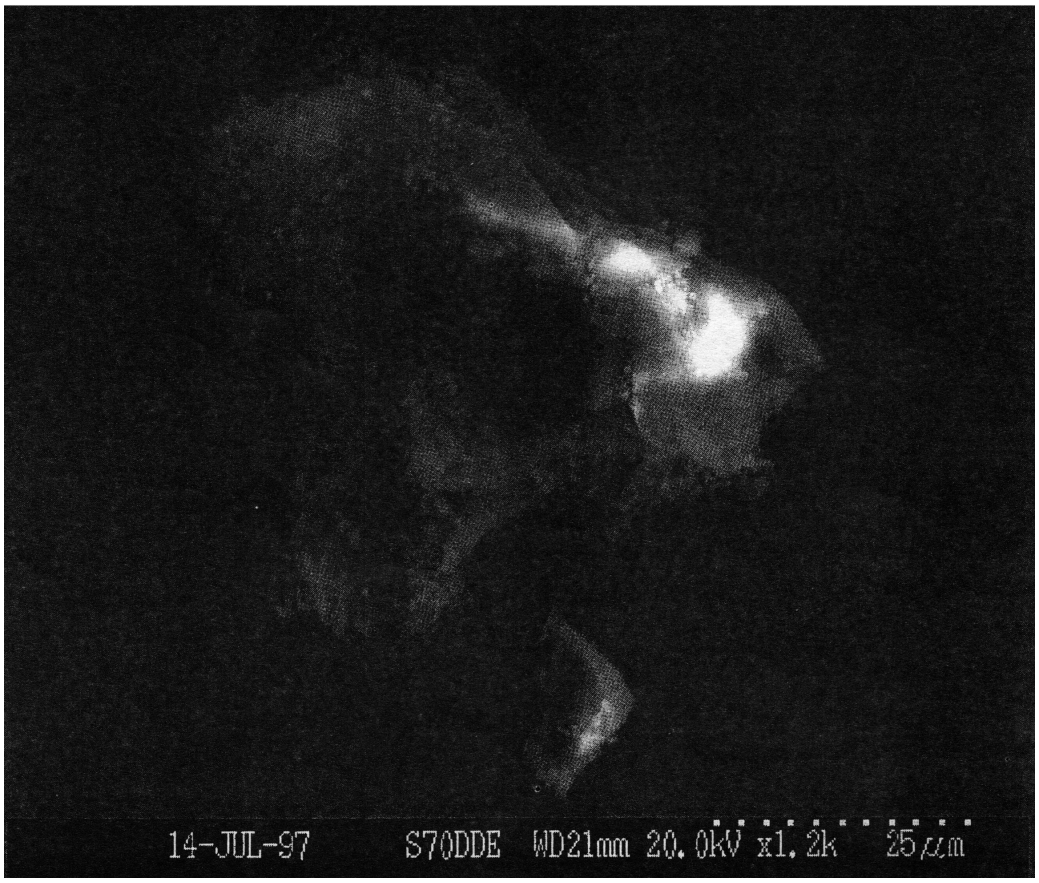
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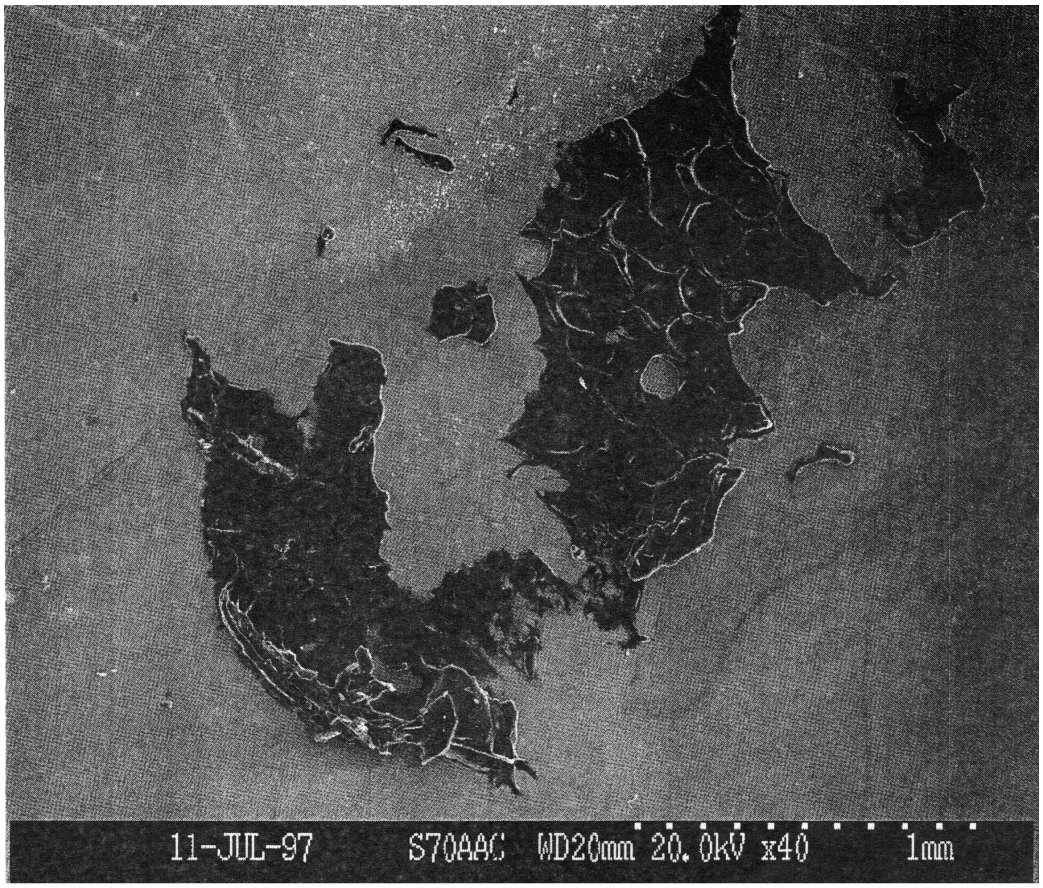
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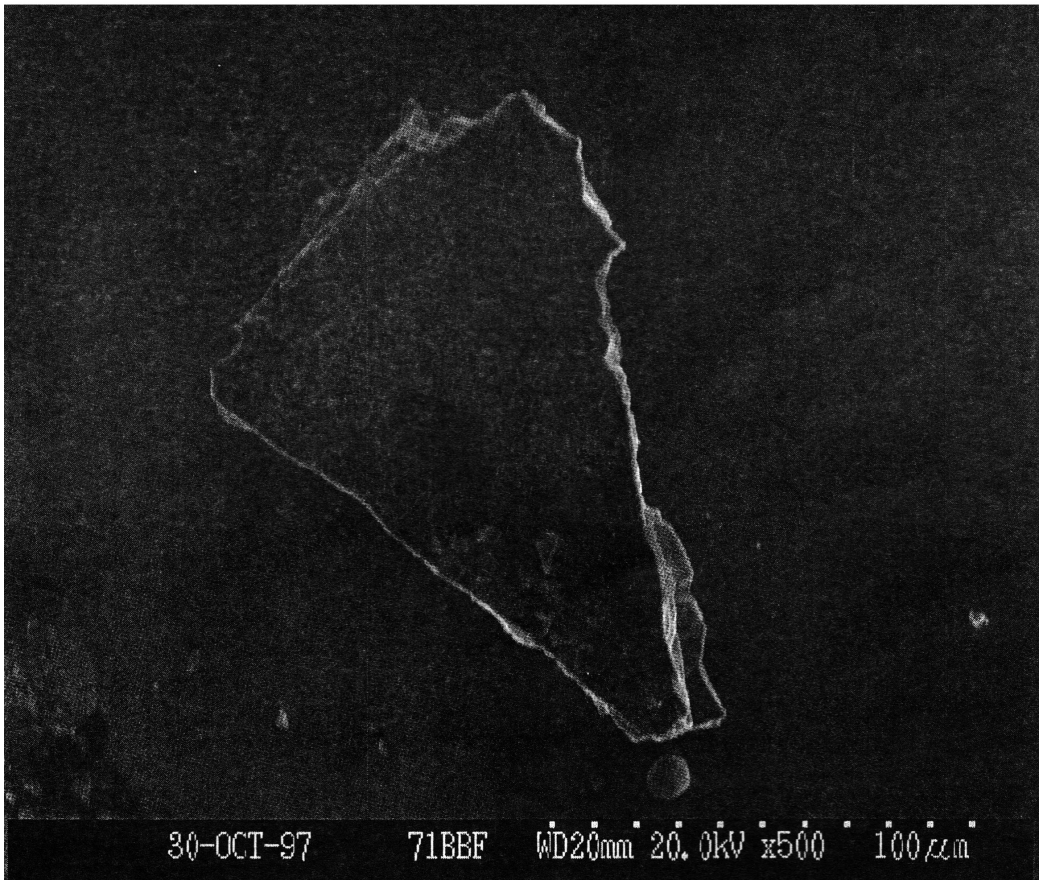
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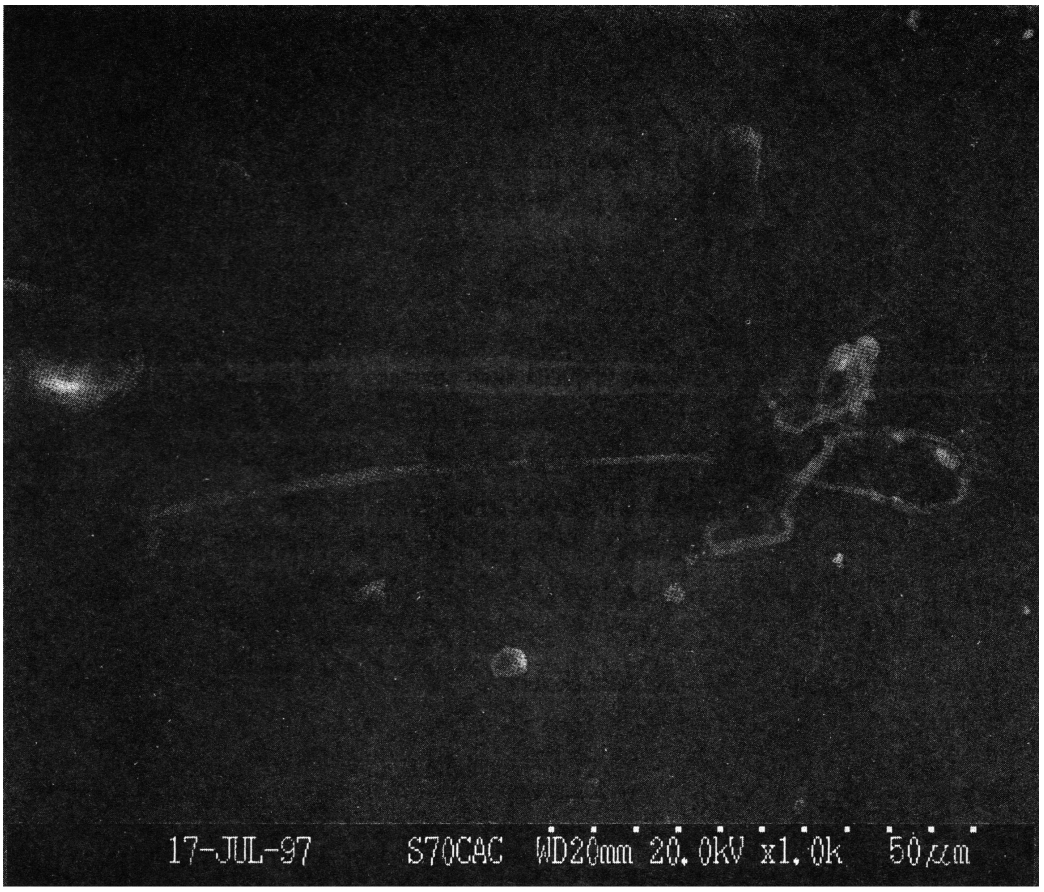
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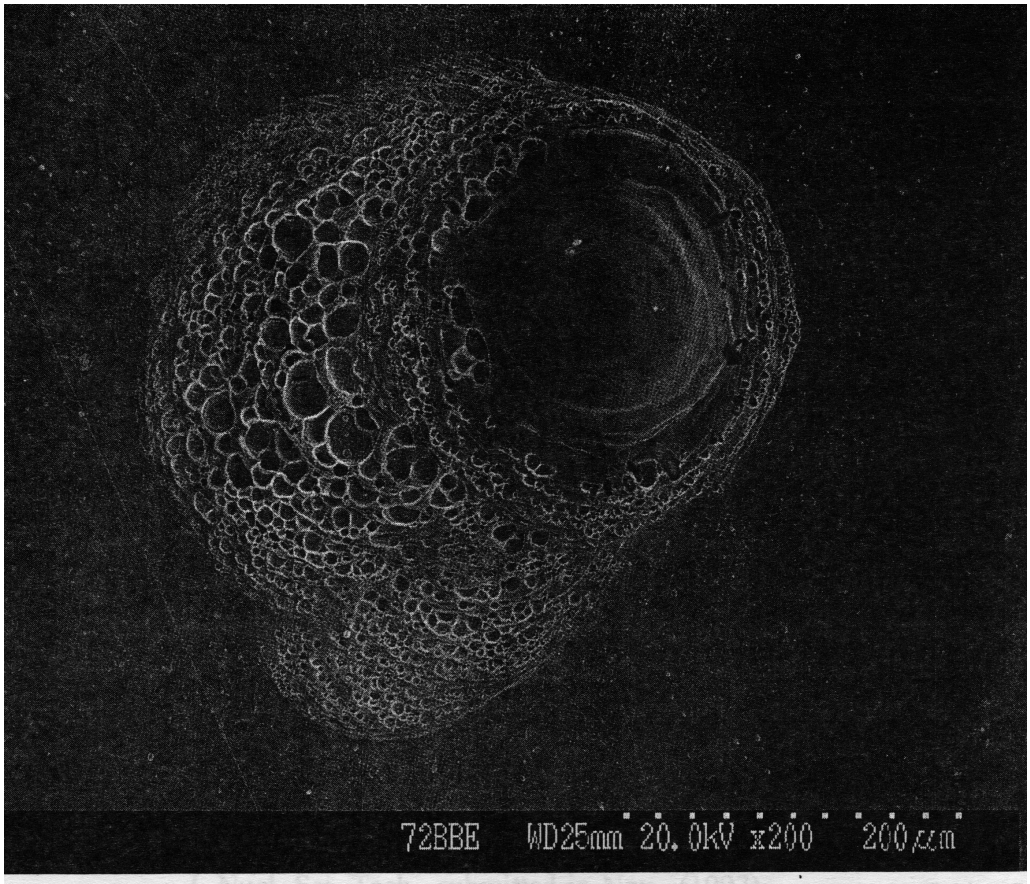
17-JUL-97 S70CAC WD20mm 20.0kV x3.0k 10μm


16-JUL-97 S70DAB WD20mm 20.0kV x150 200μm


16-JUL-97 S70DAB WD20mm 20.0kV x2.0k 20μm

15-JUL-97 S70DC4 WD21mm 20.0kV x1.5k 20μm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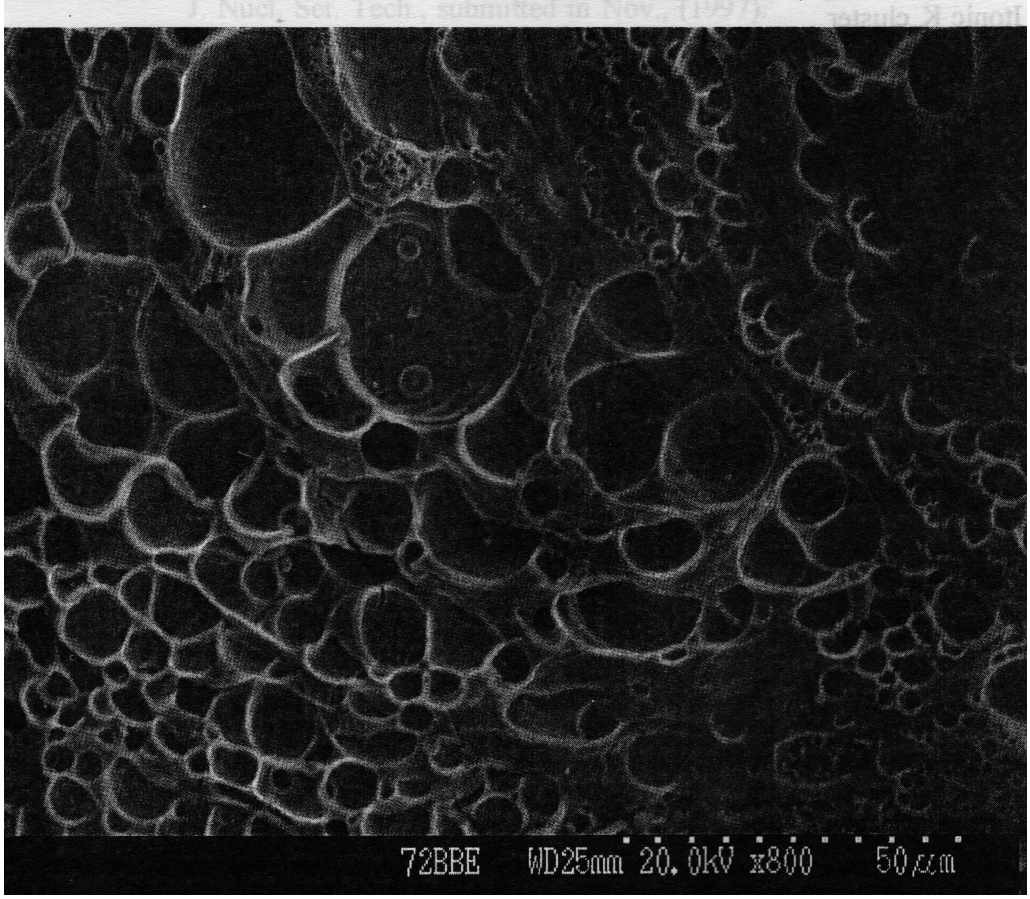
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Fig. 19: Break up of hollow Pb ball
(a) S70TCH (b) S70TCG
Fig. 20: Eruption of C film from hollow Pb ball
(a) 71BDB (b) Expanded 71BDB
Fig. 21: Clusters of itonic Cs - Pb balls associated with C tube
(a) 72RDC
Fig. 22: Itonic Cs - Pb balls
(a) Expanded 72RDC (b) Expanded 72RDC
Itonic clusters looked just like fermented soybeans, "Nattoh" in Japanese.
Fig. 23: Generation of thin C films
(a) S70DDF (b) S70DDE
Fig. 24: Generation of C films
(a) S70AAC: Carbonized film
(b) 71BBF: Containing Fe
Fig. 25: Generation of C tubes
(a) S70CAC (b) Expanded S70CAC
Fig. 26: Generation of C tubes
(a) S70DAB
(b) Expanded S70DAB: Left tip of the tube of (a)
Light elements such as C, Al and Si were found in the peripheral zone of the tube and heavy elements such as Fe near at the center, respectively.
Fig. 27: Itonic K cluster
(a) S70DCA
Electro-nuclear transmutation took place in a different kind of itonic clusters.
Fig. 28: Bubbles of Pb
(a) 72BBE (b) Expanded 72BBE
The mechanisms were not clear.

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Ref. (74)

"Comments to Electro-Nuclear Reactions"

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(Fusion Technology, submitted on February 10, 1999)

I would like to comment to Electro-Nuclear Reactions, including the response to a paper by the group of Ohmori et al. (1) and a letter from Lewis (2), both of which discussed the author's works.

Let us consider a situation in which lots of electrons were enforced to charge over an atomic cluster which was isolated. What kind of state did the cluster become? The Nattoh Model (3, 4) predicted the formation of a special cluster, called "***itonic***" cluster, in which lots of surplus electrons did not scatter out but they were interconnected with each other and probably degenerated. The bonding with those electrons was so strong that nuclear reactions took place in the cluster. The reactions were called "Electro-Nuclear Reactions(ENRs)," because the nuclear reactions were directly induced by the electric force with no process of accelerating particles. Several kinds of ENRs were found so far(4).

First, one example of ENRs was Electro-Nuclear Transmutation (ENT). The author first discovered ENT for various elements in a palladium rod during the electrolysis of heavy water(5). Then many researchers opposed to ENT by the reason of the too amazing results, saying that the elements observed should be impurities. Even a co-author of the paper(5), Kurokawa, did not believe ENT. However, many reports which supported ENT continued to be published until now with various devices(see the proceedings of ICCF). The paper(1) by the group of Ohmori et al. also obtained a result which supported the author's claim of ENT, by originally finding some deviation of isotopic composition with a Mills type device. They confirmed that the reaction of ENT locally occurred in craters, as the author earlier indicated(5). But they claimed that ENT took place in craters with curious shapes like volcanoes and that the author obtained little unambiguous evidence to support some nuclear reactions because the author's craters had not volcano like shapes(6). They distorted the fact. The main object of the paper(6) was to verify what kind of nuclear reactions took place and it was succeeded. Lots of pictures indicating the nuclear collapse were taken on nuclear emulsion, shown in Fig.s. (5) to (7) of Ref. (6). The nuclear collapse was really a nuclear reaction. Nuclear emulsion which seemed unfamiliar to the electrochemists was one of the most sensitive and popular techniques to examine nuclear reactions. They did not consciously refer the author's paper(5) in which an element analysis similar to the group's paper(1) was made around craters. A detailed comparison between the craters was made in the letter of Lewis(2). Here attention should be paied to the property of the electrode materials: Pd, Ni and Au. Since Pd had the high permeability of hydrogen, ENRs took palce deeper under the surface(3). A big crater of a about 2 mm diameter was generated on the backside of a thin palladium foil(0.05 mm thick), as partially shown at a upper and left corner in Fig. 8(a) of Ref. (7) (but no

description was given). The crater was associated with a curious assembly which was generated by simultaneous ENC reactions. The shape of the craters was not a so important problem. The group continued the discharges for 30 days for the case with the craters like volcanoes, whilist only about 1.5 hours were consumed in the author's case. During their longer period, more reaction products were accumulated around reaction places, as described by them.

Secondly I would like to point out a much more important fact the group missed: the formation of the ***itonic*** cluster which was essential to induce ENT. When the ***itonic*** cluster was generated with a high current density, it began to shine and its lightning could easily be seen; for example, during underwater spark discharge(USD) experiments in which an thin electrode was pinched(8). Recently, the group again followed the author's USD experiment of having a strong nonlinear I/V curve caused by the formation of pinched electrodes(9). They had to increase the current higher, due to a larger electrode. There they will soon recognize similar clusters. Furthermore the missing made them insufficiently understand the mechanisms of ENT. They proposed Eqs. (2) to (14) in Ref. 1 for ENT, which was based on an idea of that a compound nucleus caused by absorbing many protons could induce multibody fission reactions. The idea was already proposed by The Nattoh Model, although no specified equations were written. Not only the idea but also experimental evidence were provided by the author, as shown in one of the author's earlier experiments(10) and in Fig. 8 of Ref. (6). The equations of (2) to (14) in Ref. 1 proposed by the group could not escape from the feasibility of emitting high energy gamma rays. Intensive neutrons also should be emitted from Eq. (15) in Ref. 1. But experimental facts related to the radiations which were obtained by many researchers so far were not consistent with the prediction. This inconsistence could be easily resolved by accepting the formation of the itonic clusters which could carry away nuclear energy. Their understanding of The Nattoh Model was not enough yet. It is more important to see the essential principle rather than the surface phenomena.

Tirdly another good example of ENRs was so-called cold fusion phenomena(CF), in which the extraordinary generation of excess heat was published by Fleischmann and Pons in 1989. CF became very controvertial and confusive. Ten years passed since the publication. The device was improved with a high reproducibility so that the fact of the excess heat generation was confirmed by many researchers(see the proceedings of ICCF). But several years among them were wasted for searching for products of the conventional D-D fusion reaction such as 2.5 MeV neutrons. The trials failed completely. The group of Ohmori et el. also continued to claim a wrong idea(the crack model) for a long time. It is now obvious that the generation of the excess heat was mainly caused by a new fusion reaction as The Nattoh Model earlier proposed: D + D produced He-4. The fusion reaction took place in the ***itonic*** cluster which was a strongly coupled multibody system. No high energy gamma rays were emitted, because the momentum could be received by the whole body of the ***itonic*** cluster like the Mossbauer effect. The author's claim has been ignored for ten years, but the number of researchers who accepted the fundamental ideas of The Nattoh Model is recently increasing. The group of Ohmori et al. was one of the researchers who changed their ideas. But, as mentioned above, the group unfairly invaded the author's scientific

priorities for three points: the discovery of ENT, the idea of the multibody fission reaction caused by absorbing many protons and the effective ENR device with the pinched electrodes.

Fourthly, I would like to comment to the most significant reaction of ENRs, Electro-Nuclear Collapse(ENC)(4). ENC was furthermore followed by the phenomenon, called Electro-Nuclear Regeneration(ENG). The experimental details will be soon published in Fusion Technology. In this letter, a clear evidence for ENG is introduced as shown in Fig. 1, which was obtained during pulse AC discharges(11). Figure 1 obviously indicates that a cluster of cadmium was strongly compressed and that a thin tube emerged from the inside of the cluster, as a result of ENC of cadmium. The element analysis with EDX showed that the film consisted of mainly carbon. It was extremely amazing that the conventional elements such as carbon and iron were regenerated from ENC. It was reasonable to consider that ENG which could contribute to ENT in a broad sense also took place in the craters observed by the group of Ohmori et al. When we specify the schemes of ENT, ENG should be precisely accounted. But it would be premature at the present time because unexpected elements suddenly appeared during ENG.

Fifthly, the ***itonic*** cluster could exist for a moment as a stable body and run around underwater as well as in air. Moreover, it was kicked back through leading wires of copper, since it had negative charges. Those curious behavior very well resembled Ball Lightning(BL) which was sometimes observed in the natural environment(12). Lewis has been discussing the similarity between BL, CF and other natural phenomena by the term of "plasmoids." Plasmoids were locally generated in a plasma by the macroscopic mechanisms of electro-hydrodynamics, whilist the ***itonic*** cluster could be generated from normal condensed materials by the microscopic mechanisms. Since it was very easy to generate lots of the itonic clusters and to control them, the study for the properties of the natural BL could be significantly progressed from now. Alternatively, by scaling up with a high power supply, the artificial BL with a large diameter, at least like a tennis ball, could be easily generated in laboratory. The application might be widely opened such as to an effective device of power generation. I hoped that Fusion Technology could actively accept many papers related to BL(13).

Lastly, Roentgen discovered X-rays in the end of the 19th century. It stimulated the microscopic study for the atomic world of 10^{-8} cm in the 20th century and was followed by the Rutherford's discovery of the nuclear world of 10^{-13} cm. Now the quark world of 10^{-17} cm is facing a high barrier. On the other hand, the discovery of ENC opened the door to a super microscopic world of 10^{-33} cm at a stretch. Subnuclear physics will be widen to the field between 10^{-17} cm and 10^{-33} cm in the 21th century.

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Micro Ball Lightning Generated During Underwater Spark Discharges

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Abstract

Experiments of Underwater Spark Dicharge(USD) were carried out under a pulse AC mode with electrodes of the metal wires of cadmium, iron and gold. A counter electrode of a copper box was used for catching reaction products during USD. Ordinary water mixed with potassium carbonate and hydroxide were used as an electrolyte solution. Two kinds of remarkable products casued by Electro-Nuclear Collapse were obtained: thin carbon films and tubes. The mechanisms of ENC are also discussed by The Nattoh Model.

1. Introduction

The Underwater Spark Discharge(USD) was one of the most effective methods for artificially generating Ball Lightning(BL) in laboratory(1). The principle was completely different from other methods such as based on plasma states. BL which was generated by USD with a small power device was called micro BL, but it could exist for a fairly long time as a stable body and showed very curious behavior like natural BL.

Two different kinds of micro BL were found so far: ballic and ring BL. The ballic BL, a direct product of USD, was examined in detail and was found to consist of a special state of an atomic cluster, called "itonic" cluster(2, 3). Here many electrons were assumed to be inter connected with each other, and the bonding of those electrons was so strong that several kinds of nuclear reactions took place in the cluster: (a) a new fusion reaction of producing He-4 from two deuterons with no gamma rays, (b) nuclear transmutation by capturing many protons and electrons, (c) generation of multiple neutrons(tiny neutron star) and (d) nuclear collapse and re generation. On the other hand, the ring BLwas the second product of USD, in which no explosive reactions occurred(2).

This paper describes an experiment of the pulse AC-USD with electrodes of thin metal wires. A similar experiment with a lead wire was already carried out with many remarkable results(4, 5). In this paper, thin wires of cadmium, iron and gold were used as an electrode. Results not only duplicated the important parts of the previous ones but also provided clear evidence to explain the mechansims.

2. USD Experiments

The pulse AC-USD experiment was carried out to generate micro BL in laboratory. A similar arrangement as in the previous one(4) (with a thin lead wire electrode) was applied, as shown in Fig. 1. Thin wire electrodes (1.0 mm ϕ x about 10 mm long) of cadmium(99.9999 % pure), iron(99.998 %) and gold (99.95 %) was used in this experiment, which was vertically placed in an electrolyte solution. Ordinary water mixed with potassium hydroxide and cesium

carbonate(about 1.5 Mol/l) were used as electrolyte solutions. The effective length of the wire those portion were inserted in the solution was about 2 - 3 mm so that it enhanced the current density. A counter electrode was a cubic box(25 mm x 25 mm x 25 mm) of five or six plates of copper(0.2 mm thick) which covered the central wire electrode. The copper plates were simultaneously used to catch up products emitting during USD. All of the copper plates were polished with diamond pastes and washed in an alcholic solution in a bath with ultrasonic vibration.

Discharges were performed between the wire and the box electrodes with an electrical switch: 120 V(50 Hz), 20 msec ON, 20-30 sec OFF and phase=0 deg(fixed). A pinched region was generated over the wire electrode by the potential, in which molecules of decomposed gas was strongly compressed to form micro BL including the atoms of the electrode as well as the solution. As resulted by nuclear reactions in micro BL, explosive reactions associated with lightning occurred on the tip of the electrode. The details of the mechanisms were examined in the previous experiment with the continuous DC-USD, changing the polarity of the wire electrode(2, 3).

Products during USD which were caught on the coper plates were analyzed by an optical microscope(OM) and a scanning electron microscope(SEM). Analysis of elements was performed with an energy dispersive X-ray analyzer(EDX). The window of EDX which was made of a special material enabled us to analyze light elements until C.

3. Experimental Results

As resulted by the pulse AC-USD experiment, many remarkable products were obtained. They were classified into three categories: (1) micro BL and its break up, (2) thin carbon films and (3) thin carbon tubes.

First, lightning during the pulse AC-USD was an effective indicator of reactions. As the generation of the itonic clusters was more effective, lightning was more bright. Lightning during the discharges with cadmium and gold are compared in Fig. 1. Since the cadmium atoms were reactive to hydrization, the cadmium atoms as well as the electrolyte ones could be well itonized. On the other hand, the gold atoms could be hardly itonized so that only moderate reactions occurred with week lightning.

Secondly, many micro BL were observed on the copper plates. There were two kinds of the clusters: electrode cluster and electrolyte one. The former was formed by the itonization of the electrode by electron erusion into a bulk and was usually covered by the latter. The latter was formed on the electrode surface by the compression of the electrolyte atoms together with decomposed gas. A typical clsuter of the former is shown in Fig. 3, in which the cadmium electrode and the cesium carbonate solution were used for USD. A spherical core of cadmium was covered by the itonic electrolyte(cesium carbonate), which was partially broken up at a bombardment on the plate. Figure 4 shows the slight break up of the cadmium electrode cluster, in which some explosive reaction was suggested to occur. For the electrolyte cluster, on the other hand, the bonding of the cluster was sensitive to the valence electrons of the electrolyte which determined the number of water molecules associated with the electrolyte atom in the solution. When the bonding was not so strong, the cluster was easily destroyed on the surface of the copper plate. A

typical case with the potassium hydroxide solution is shown in Fig. 5, in which the gold electrode was used. The electrolyte cluster was scattered out into many small debris. Since gold was less reactive with hydrogen, it was difficult to obtain clusters of the former type . For the cesium carbonate solution with the strong bonding, on the other hand, it was easy to obtain the clusters of the former. Figure 6 shows the break up of the electrolyte cluster of cesium carbonate.

Thirdly, one of the remarkable results was the generation of thin films which consisted of mainly carbon. Figure 7 shows one of the typical films. A lot of such films were observed on the copper plate. The analysis with EDX confirmed that the films consisted of mainly carbon element and that oxygen and other heavy elements such as iron were also included. Most of the films were observed separatedly from the electrode clusters, but some were obtained associated with the cluster, as shown in Fig. 8. The figure clearly indicates the mechanisms of the generation of the films. The film was generated in the cadmium cluster and emerged from there. The number of the films which were associated with the cluster was not so large.

Fourthly, the other remarkable result was the generation of thin tubes which also consisted of maily carbon. The thin tube of carbon was also generated in the cadmium cluster and emerged from there. Figure 9 shows a clear evidence for the fact. The elements of the tube were analyzed with EDX: C and O were found. Figure 10 shows a faily long tube which was also generated with the cadmium electrode and the cessium carbonate solution. The left tip of the tube is expanded in Fig. 11. The figure clearly indicated that the tube was folded to have a cross section of a literature of U.

4. Discussion

In the previous similar experiments of USD with a lead electrode, many remarkable results were obtained on copper plates(4, 5). The most remarkable one was the generation of the thin films and tubes which consisted of maily carbon. We obtained many figures which clearly indicated that the films and tubes were generated in the lead clusters and that thery emerged from there. Since a system of USD was carbon free with the potassium hydroxide solution, it was considered that the C element was transmuted from the Pb element by nuclear reactions. Furthermore, it was concluded that "Electro-Nuclear Collapse(ENC)" reactions were induced by the discharges to contribute the element transmutation, called "Electro-Nuclear Regeneration(ENG)." Similar thin films were already found associated with explosions on nuclear emulsions in earlier experiment(6).

The present experiments with cadmium, iron and gold duplicated the previous results of the generation of the thin carbon films and tubes. It was reconfirmed that the thin films and tubes were generated in the electrode clusters and that they emerged from there. The clusters which were associated with the thin films and tubes clearly indicated the facts. In the present experiment, we found the tube of an approciate length which was associated with the cadmium cluster, as shown in Fig. 9. The shape of the films was very various, since the films were folded or tilted during the explosion. The shape of the tubes shown in Figs. 10 and 11 was also folded during the generation to have the cross section of a literature of U.

In the previous paper(2), the mechanisms were discussed for the generation of the thin

carbon films and tubes, based on The Nattoh Model. During USD, ENC took place in the center of the cluser and generated a tiny black hole. Since the electromagnetic force is 40 orders stronger than the gravitational force, the nuclei could be easily destroyed. The black hole was so small that instantaneously exploded to generate the thin spherical films of carbon. In a highly itonized cluster, the compression by the electromagnetic force was so strong that a tiny white hole could be formed, from which the thin carbon tube was generated. Here the nuclei should be completely destroyed during the transport through a worm hole of 10^{-33} cm so that the elements such as C, O, and Fe shoulde be regenerated from extremely elementary particles. More discussions about this process, ENG, were described in the review paper of Ref. 2.

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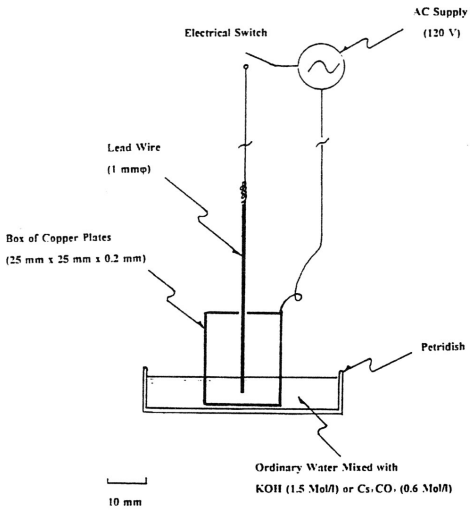
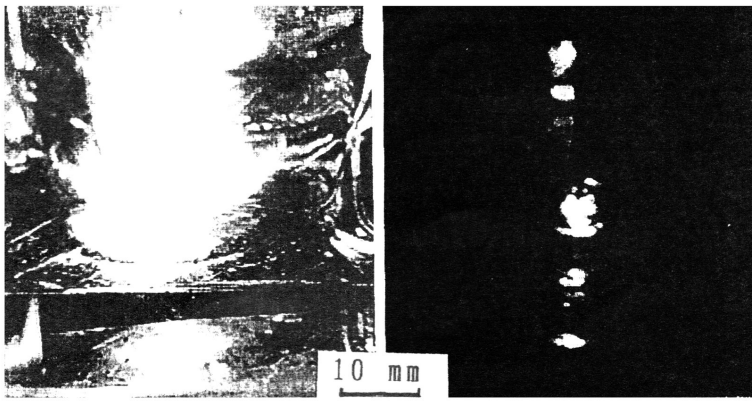


Fig. 1: Experimental arrangement



(a) cadmium (b) gold

Fig.2: Sparks with thin wires

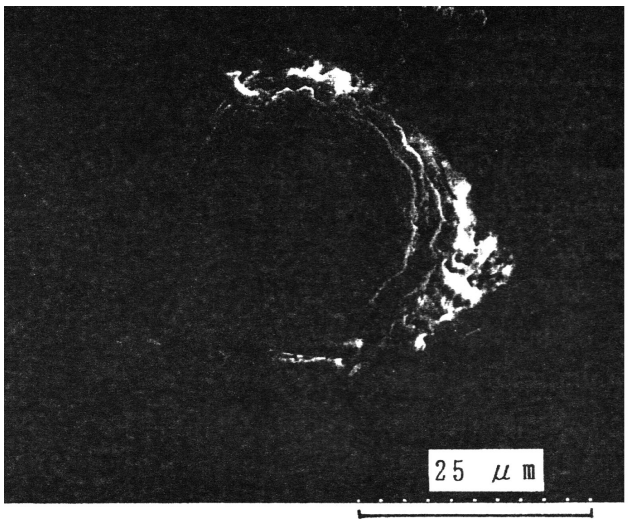


Fig. 3: Cadmium cluster covered by itonic electrolytes(SEM)

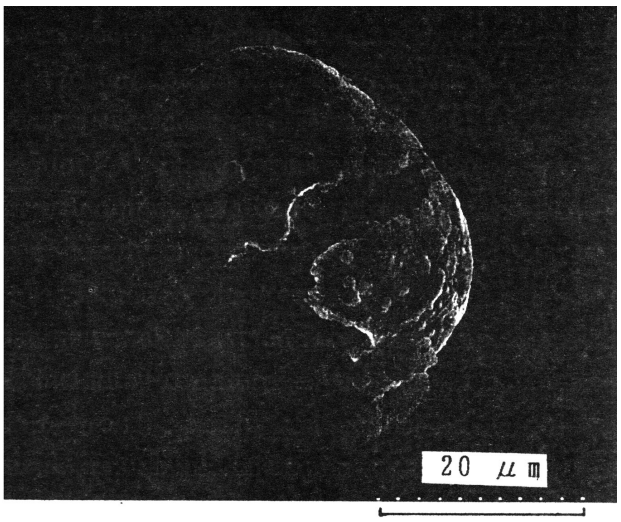


Fig. 4: Break up of cadmium cluster(SEM)

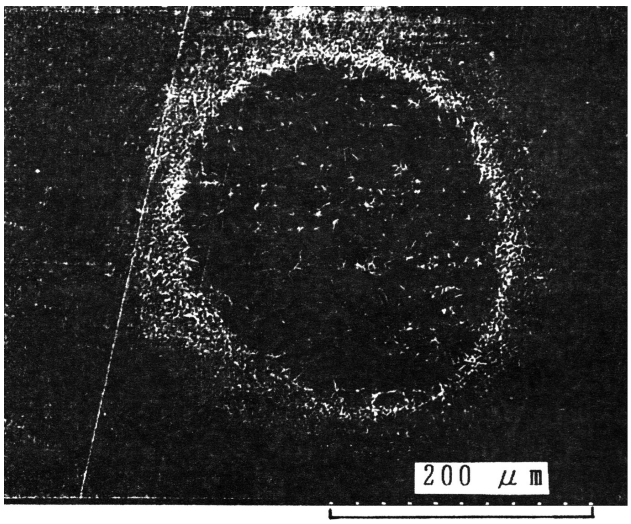


Fig. 3: Break up of potassium hydroxide cluster(SEM)

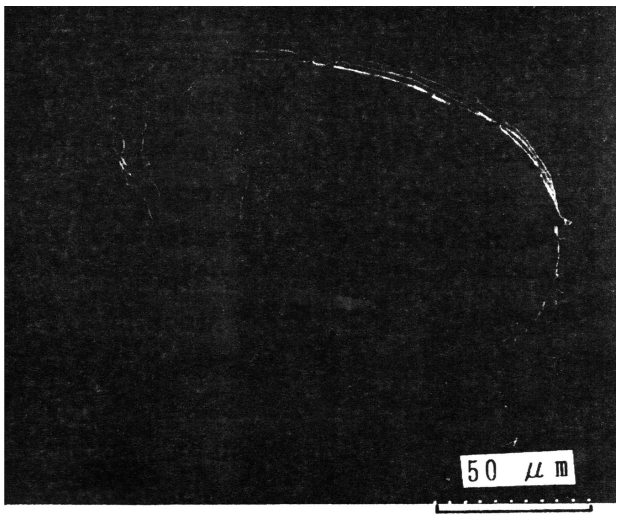


Fig. 4: Break up of cesium carbonate cluster(SEM)

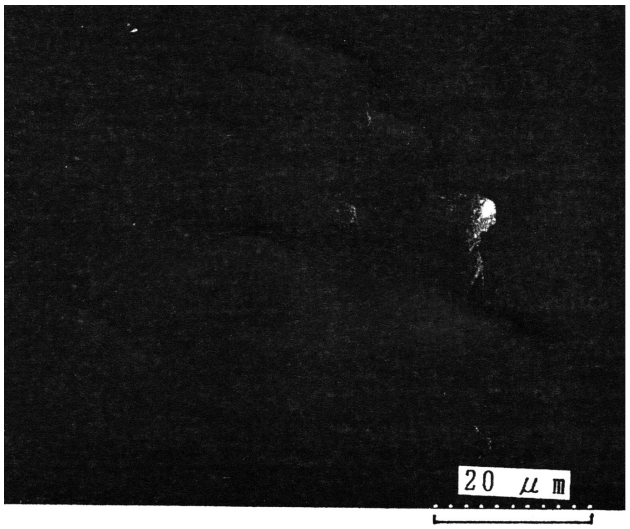


Fig. 7: Carbon film generated during USD(SEM)

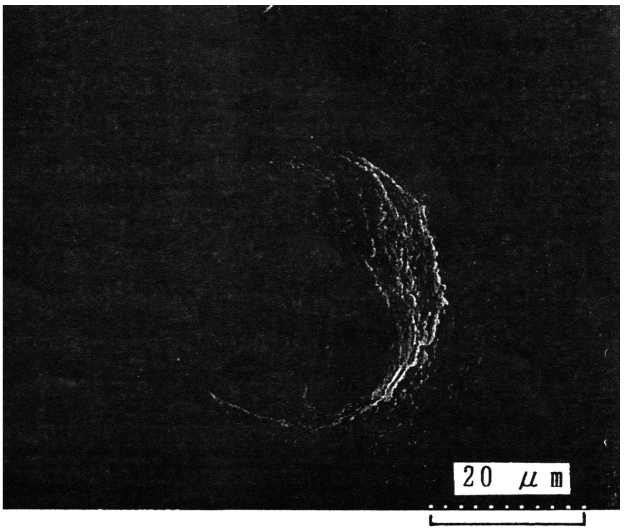


Fig. 8: Carbon film emerged from cadmium cluster(SEM)

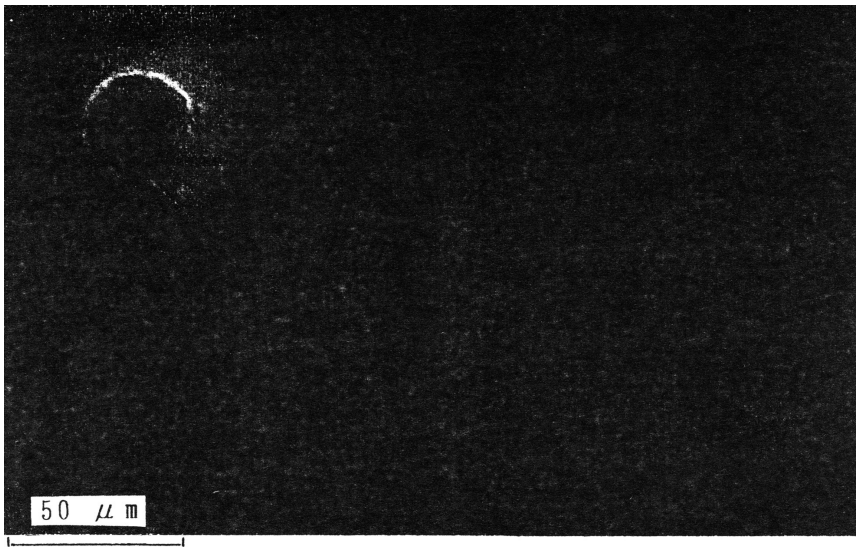


Fig. 9: Carbon tube emerged from cadmium cluster(SEM)

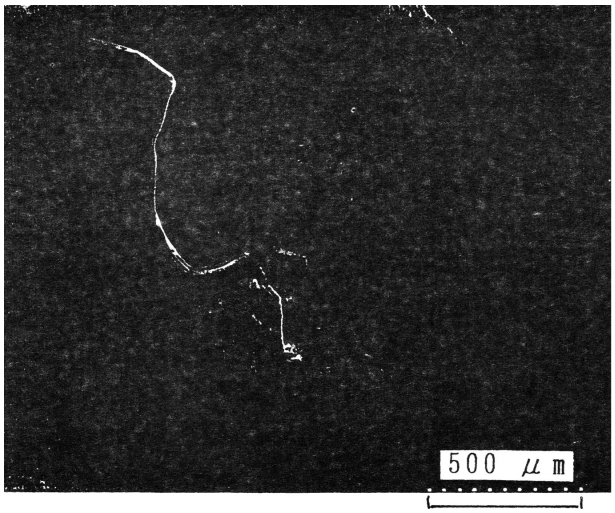


Fig. 10: Long tube generated with cadmium electrode(SEM)

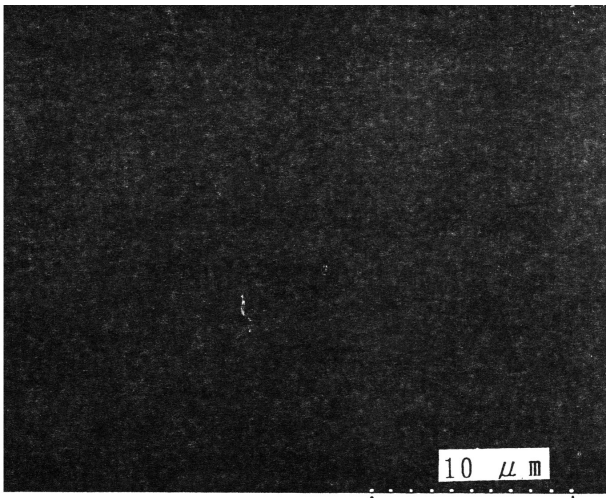


Fig. 11: Left tip of carbon in Fig. 10(SEM)

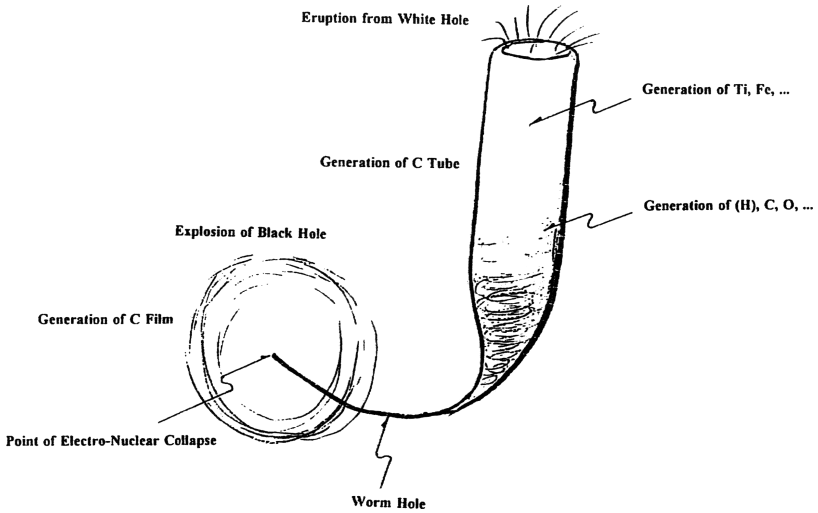


Fig. 12: The Nattoh Model for nuclear regeneration

Ref. (79) Proc. of Int. Symp. of Ball Lightning (ISBL'99), Antwerp, p. 255 (1999).

Transport of Micro Ball Lightning

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Abstract

This paper describes experiments for the transport of micro Ball Lightning(BL) which was generated during underwater spark discharges. Here micro BL was formed on a tip of two pinched anodes: a thin palladium wire and a thin copper plate like a knife. While micro BL was derived towards another tip of the anode by the potential, micro BL or traces were left on the wire or the plate. One of the remarkable products was an eruption with a speedy rotation from moving micro BL, just like "micro tornado." Furthermore, thin carbon films and tubes were generated from nuclear collapses of micro BL during its transport. The mechanisms of the results are explained by The Nattoh Model.

1. Introduction

The Nattoh Model was proposed by the author to explain the mechanisms of so-called Cold Fusion(CF) phenomena(1, 2), which predicted the formation of a special state of an atomic cluster, called itonic cluster(3). Since Electro-Nucelar Reactions(ENRs) causing the CF phenomena took place in the palladium rod of a cathode during electrolysis of heavy water, no clusters could be seen with normal devices. However, the author succeeded in observing such special clusters on the back side of a thin palladium foil or on nuclear emulsions(4, 5). In 1994, furthermore, the author observed extraordinary sparks which were shining on the surface of a thin wire electrode of cadmium during underwater discharge experiments(6). The sparks were found to be really the itonic clusters and showed very curious behavior like Ball Lightning(BL) which was observed in the natural environment. Therefore, the itonic cluster was called micro BL, which could be easily generated on a pinched electrode by using Underwater Spark Discharge(USD) mehtod(7). The itonic cluster was assumed to have interconnected electrons, which made the cluster stable and negatively charged. The cluster could be derived through a leading wire by an electrical potential(3).

This paper describes several USD experiments to confirm the transport of micro BL by the potential. Here micro BL was generated on a tip of two pinched anodes: a thin palladium wire and a thin copper plate like a knife. Micro BL and its traces which were left on the wires and the plates during the transport were examined in detail. Remarkable results were obtained.

2. Transport Experiments

Transport experiments of micro BL through metals were carried out with an electrical potential.

We could have selected any of electrodes to generate micro BL, but an anode was used in this experiment. This situation was convenient to make micro BL transport on the metal. Two

kinds of the anodes were used: a thin palladium wire(0.5 mm ϕ and about 12 cm long) and a thin copper plate with a tapered tip like a knife(0.2 mm thick, 4 - 5 mm wide, 10 cm long and about 15 deg). A cathode was a thin platinum wire(0.3 mm ϕ and about 15 cm long). Figure 1 shows the experimental arrangement for the anode of the copper knife. Since the copper knife was tightly covered with a cap of sulfated papers, the contamination by water drops were effectively avoided. Solutions of ordinary water mixed with potassium carbonate and hydroxide, and cesium carbonate(each solution was about 1.5 Mol/l) were used as electrolyte solutions. The effective lengths of the electrodes those portions were inserted in the solution were about 3 - 5 mm and 35 mm for the anode and the cathode, respectively. On the other hand, for the palladium wire anode, an upper tip of the wire was put into two small strips of copper(7 mm x 20 mm, 0.2 mm thick), one of which was connected with a leading wire.

Disharges were carried out mainly under a continuous DC mode(around 150 V and 0.3 A). The voltage was sufficiently over a critical value for the generation of a pinched region. One experiment with the copper knife anode was performed under a pulse AC mode, in which the pulse was made by an electrical switch (120 V, 50 Hz, 10 msec ON, 20 - 30 sec OFF, phase =0 deg(fixed)).

The transport of micro BL was examined by catching it on copper plates. The plate of the anode itself was used for the copper knife anode, but the two small copper strips contacting the upper tip of the palladium wire was available for the wire anode. All of the copper plates were polished with diamond pastes like mirrors, and washed in an alcholic solution with ultrasonic vibration. Micro BL and its traces on the copper plates were examined with an optical microscope(OM) and a scanning electron microscope(SEM). The latter was associated with an energy dispersive X-ray analyzer(EDX) to determe elements. The window of EDX was made of a special material such that light elements until C could be analyzed.

3. Experimental Results

Many remarkable results which were related to the generation and the transport of micro BL were obtained with both of the anodes. Results with the palladium wire are first described. The generation and the transport of micro BL through the wire were confirmed, which were associated with a related phenomenon of nuclear transmutation. First, large clusters with curious shapes were caught on the surface of the palladium wire over the water level. Figure 2 shows micro BL with a hole which was obtained with the cesium carbonate solution. The EDX analysis confirmed that micro BL consisted of a cluster of Ce, C and O elements which were the constituents of the electrolyte solution.

Secondly, the transport of micro BL through the palladium wire was confirmed. Many traces caused by micro BL were recorded on the small copper strips which were contacted with the upper tip of the palladium wire. Figure 3 shows one of the traces, which was recorded about 12 cm distant from the lower tip of the wire. Micro BL was scattered out due to the inuniformity at the connecting point. The fact clearly indicated that micro BL was derived through the wire by the potential.

Thirdly, the nuclear transmutation was observed on a lower tip of the palladium wire,

those portion were inserted in the solution of potassium carbonate and was pinched during 3 min. DC discharges with about 120 V and 0.1 A, as shown in Fig. 4. The EDX spectrum at a dip is shown in Fig. 5, in which transmuted elements such as Al, Si, Ni and Cu appeared. They were not impurities at all: because highly pure materials were used for the palladium wires, electrolytes and water, no impurity elements were not observed with EDX for the materials before the discharges. Furthermore, if the small amount of the impurities solved in the solution were gathered by the potential, they should have appeared on another surface of the pinched wire. But no impurity elements were observed with EDX. The nuclear transmutation was a related phenomenon to the formation of the itonic clsuter(3).

Next, other remarkable results were obtained during the USD experiments with the copper knife electrode, which further confirmed the transport of micro BL. This was due to a fact that copper was sensitive to the charges of micro BL. Fourthly, curious traces which were recorded on the copper knife by moving micro BL. Two different kinds of the traces were observed: two parallel rails and one stroke writing. Figure 6 shows one of the typical traces for the former. There were many similar traces which were highly concentrated in a lower portion of the knife. Some of them were overlapped each other and eventually made the knife dark as the discharge time became longer. In Fig. 6, a brown portion was observed between two rails, which might have been caused by a direct touch with micro BL. The latter was mysterious traces like being made by one stroke writing. It was very long, but with not so frequently appeared. While the former was uniformly derived towards the positive potential, the latter suddenly changed its direction. Similar traces as the latter were already observed in previous USD experiments(8). Some reactions in micro BL to change its direction were suggested to occur. But the detailed mechanisms of forming the latter was still unclear.

Fifthly, micro BL with a slightly different shape was observed. One of the typical products is shown in Fig. 8, which was caught on the copper knife with the potassium carbonate solution. Micro BL had a core in the central region, over which itonic clusters including the potassium carbonate electrolyte were coated. The surface clusters consisted of many small clusters. Figure 9 shows a partial break up of such cluster, in which many surface clusters were left on the copper plate during the tranport and a core became bare. Figure 10 shows a complete break up of the cluster. While the cluster ran on the copper plate, many cluster debris were left through the path. Here no core was found. The core might have gone away or the cluster might have no core.

Sixthly, remarkable products of thin tubes were obtained, which consisted of mainly a carbon element. Figure 11 shows one of the tube products which was associated with an itonic cluster. In previous experiments(9, 10), many similar tube products were already observed during USD. But most of the tubes were separated from the clusters, because they should have emerged with a high velocity. It was rare to find the tube associated with the cluster(11).

Seventhly, remarkable products of thin films were left on the copper plate and also consisted of mainly a carbon element. There were many thin films which had various shapes due to folding. Figure 12 shows one of the typical thin carbon films. This was generated just from the collapse of micro BL which ran from left with a trace of two parallel rails. In the previous papers

(9, 10), many products of thin films were already observed during similar USD, but with different materials of an electrode and electrolyte. Even when the different materials containing no carbon element were used, the same element of carbon appeared as a constituent of the curious tubes and films. More heavy elements such as iron were sometimes generated.

Lastly, remarkable products of micro tornadoes were obtained. Many products with a long curling string of connecting debris were observed on the copper knife, as shown in Fig. 13. This looked like an eruption with a high speed rotation. There were both of clock wise and anti-clock wise rotations. Figure 14 was an important figure, which clearly indicated that the eruption with the rotation was generated from micro BL. It ran from left recording a trace of two rails and an eruption occurred in a central area. Here, the rotation was anti-clock wise so that an upper product of the eruption was left behind but a lower one was pushed ahead, respectively. The eruption could be called "micro tornado."

4. Discussion

Experimental results related to the transport of micro Bl were obtained in the preceding section. Several properties of micro BL were made clear.

First, the generation of micro BL was reconfirmed by really catching it on the palladium wires and the copper plates. There were two kinds of micro clusters: electrode clusters and electrolyte ones. The number of the former was small in this experiment. This meant that the clustering process on the anode was more moderate than on the anode(7). Anyway micro BL consisted of an atomic cluster in the special state, as The Nattoh Model predicted. Since the electrons were taken away during the transport, micro BL eventually broke up into a large number of debris, those traces were left on the copper plates, as shown in Fig. 10.

Secondly, the nuclear transmutation was also observed on the tip of the palladium wire. Since various nuclear reactions in the itonic cluster could contribute to the nuclear transmutation, the schemes of the trasmutation were not so simple. However, this phenomena were another evidence for the formation of the itonic cluster.

Thirdly, the transport of micro BL was cleaerly confirmed for both of the electrodes of the palladium wire and the copper knife. For the former, traces caused by micro BL were found about 12 cm distant from the lower tip of the anode. This was an obvious evidence for the fact that micro BL moved through the wire under the potential. The other evidence was traces with two pallarel rails, which were recorded on the copper plates by moving micro BL. The plates were so sensitive to the charges of micro BL that its transport was clearly recorded.

Fourthly, the generation of thin carbon films and tubes were reconfirmed in this experiment as well. Many products of carbon films and tubes were already observed in the previous experiments(9, 10), and it was found that they emerged from the clsuter. In this experiment, however, individual micro BL was taken out from the birth point and was made to release the similar products of films and tubes. This was an additional evidence for the generation of the thin carbon films and tubes from micro BL.

Fifthly, the mechanisms of those remarkable results could be well explained by The Nattoh Model(3). As the model predicted, micro BL was the special cluster with the negative

charges and was strongly compressed to induce the Electro-Nuclear Collapse(ENC) reactions. Here it would be reasonable to consider that a tiny black hole was formed instantaneously. There were two branches of completely broken materials: an isotropical explosion with a thin spherical film and a release of a thin tube via a white hole. It would be extremely surprising that the conventional elements such as carbon and iron were regenerated by ENC(called Electro-Nuclear Regeneration(ENG)). A hypothetical mechanisms for ENG was proposed elsewhere(3).

Lastly, it should be noticed that ENRs could easily take place in the natural environment. Natural phenomena related to ENRs have been searched so far and evidence during earthquakes were already obtained by the author(12). Micro tornado which was observed in this experiment was very suggestive to an origin of natural tornadoes. The natural tornadoes have the rotation of an extremely high speed which could not be explained by the conventional hydrodynamics. Here we could propose a promising hypothesis for the origin of the natural tornadoes: first, discharges with a very high current took place in a cloudy atmosphere, and secondly, BL with a large dimension are generated and lastly, eruptions with a high speed rotation could be induced. We could expect that the mechanisms of the natural tornado could be studied in detail by examining micro tornado which can be easily generatged in laboratory.

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(2) T. Matsumoto, "Mechanisms of Cold Fusion: Comprephensive Explanations by The Nattoh Model," Mem. of the Faculty of Eng., Hokkaido Univ., Vol. 19, No. 2, p 201(1995).

(3) T. Matsumoto, "Mechanisms of Electro-Nuclear Collapse: Comprehensive Explanation by the Nattoh Model," Distributed at ICCF-7, (Vancouver, 1998).

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(12) T. Matsumoto, "Ball Lightning during Underwater Spark Discharges and the Matsumae Earthquakes," Proc. of Int. Symp. of Ball Lightning(ISBL'97 at Tsugawa), p. 193(1997).

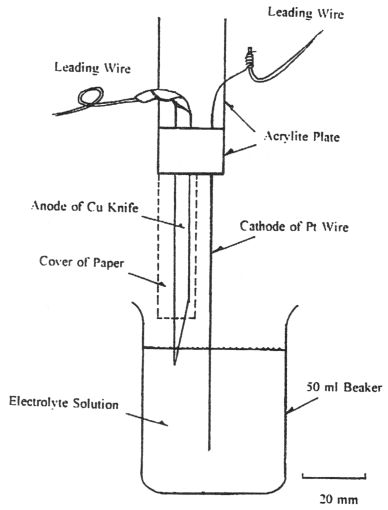

Fig. 1: Experimental arrangement

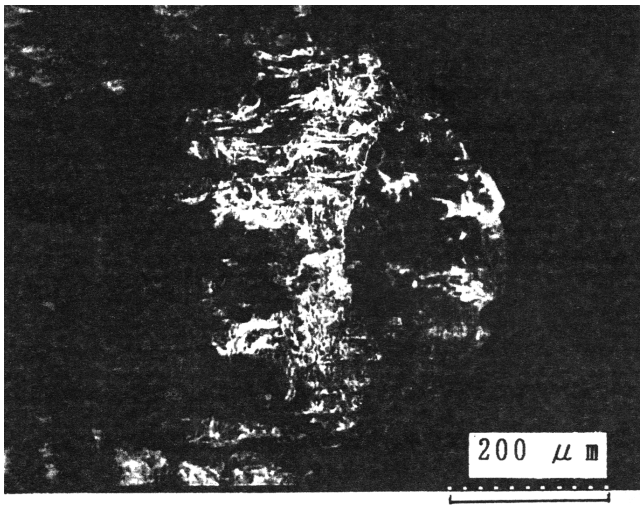

Fig. 2: Electrolyte cluster caught on palladium wire (SEM)

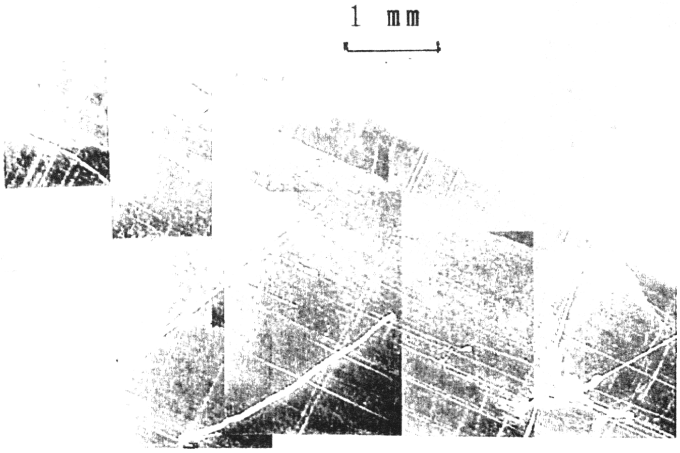

Fig. 3: Traces of micro BL on small copper strip (OM)
(strip was touched with upper tip of palladium wire)

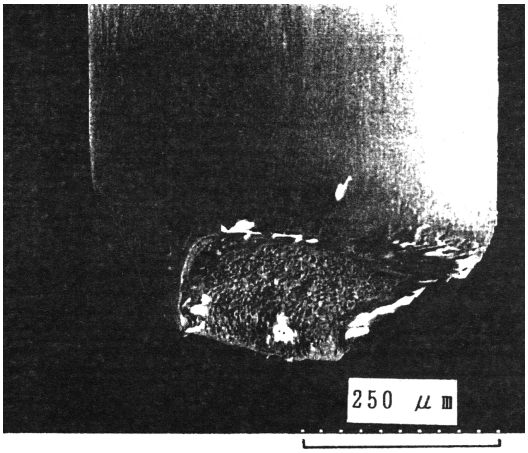

Fig. 4: Tip of palladium wire
with nuclear transmutation (SEM)

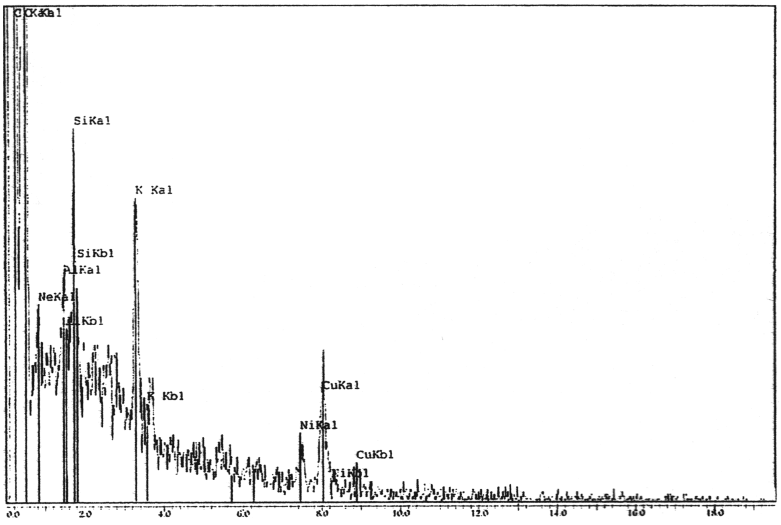

Fig. 5: EDX spectrum for tip of palladium wire shown in Fig. 4

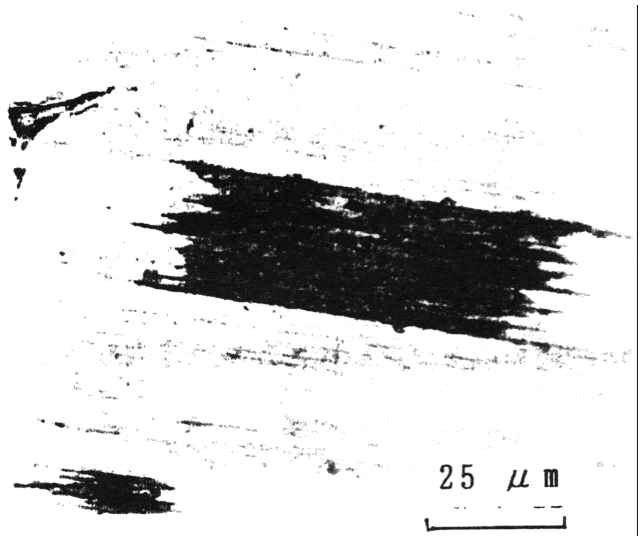

Fig. 6: Trace left during transport of micro BL(OM)

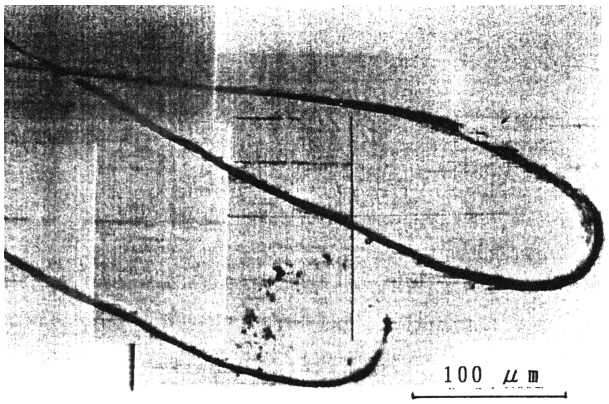

Fig. 7: Trace of one stroke writing (OM)

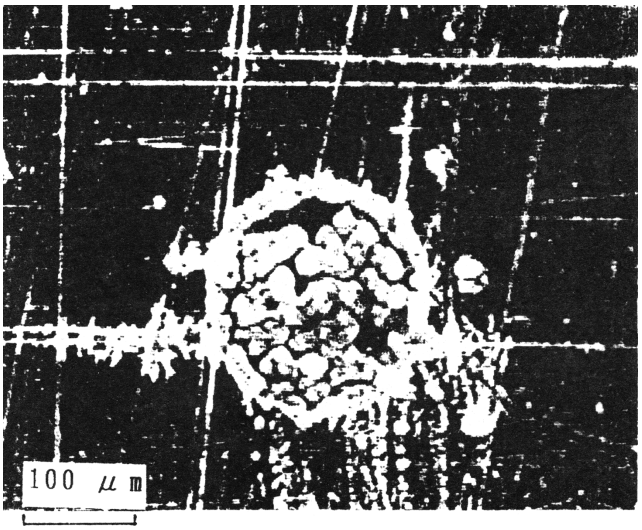

Fig. 8: Micro BL caught on copper plate (OM)

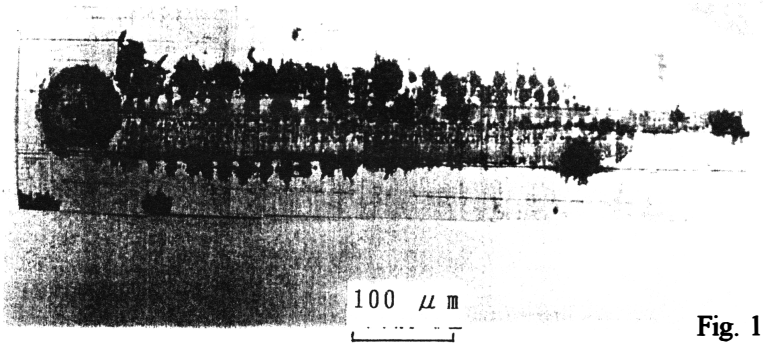

Fig. 9: Partial break up of micro BL (OM)

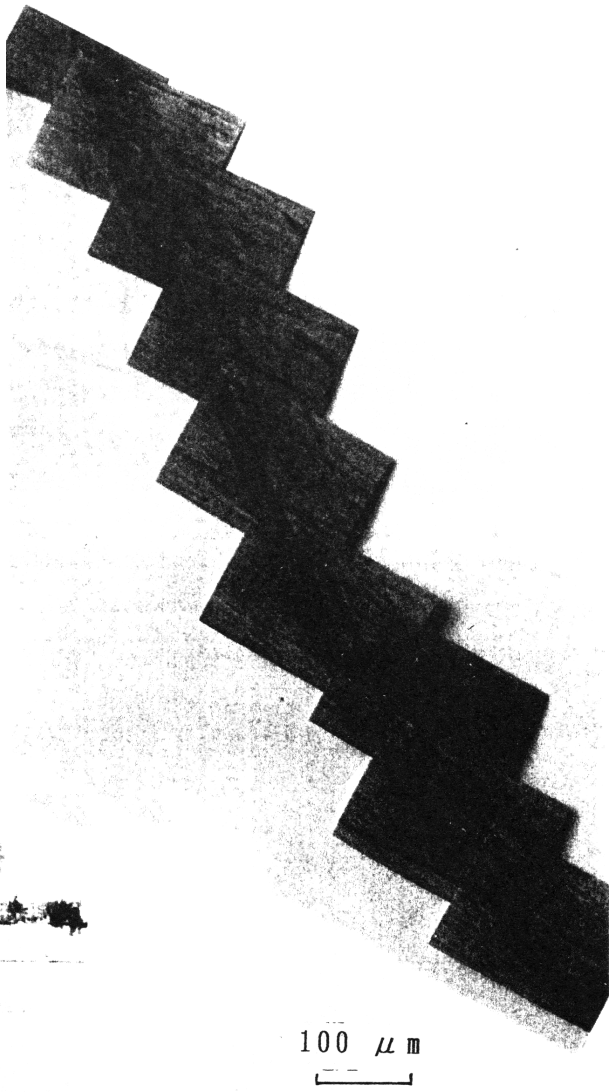

Fig. 10: Complete break up of micro BL (OM)



Fig. 11: Carbon tube generated from micro BL (OM)

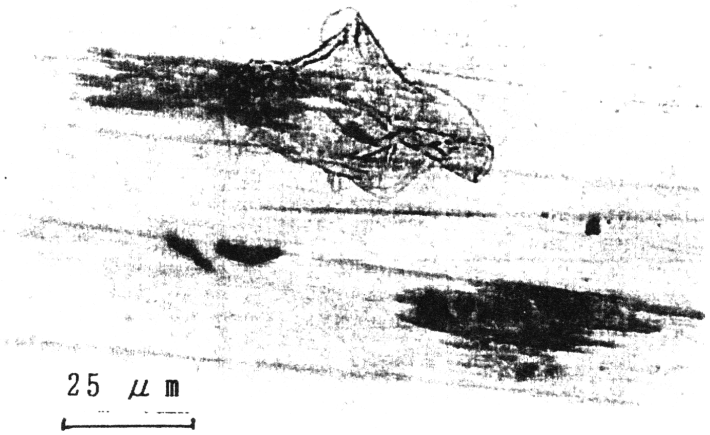

Fig. 12: Carbon film just generated from micro BL (OM)



Fig. 13: Micro tornado (OM)

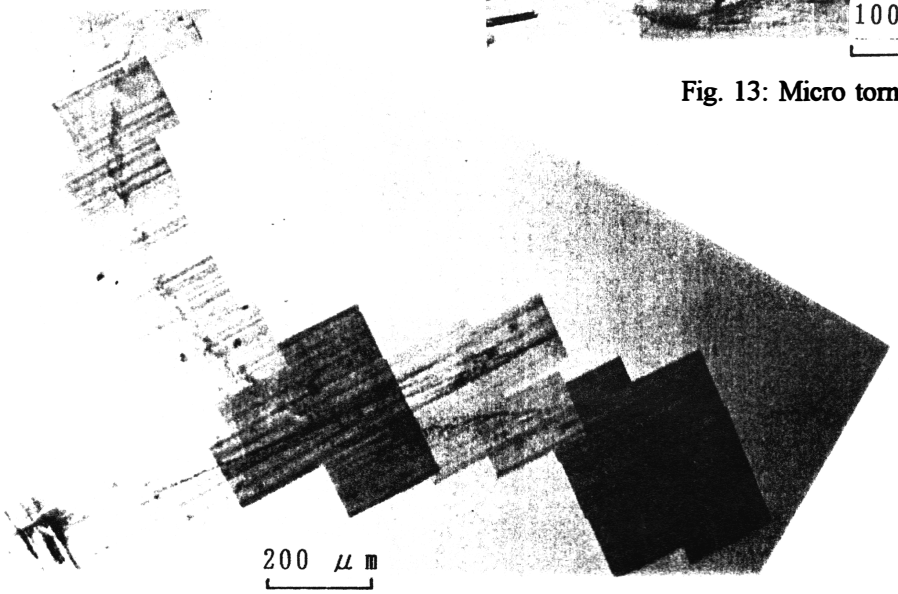

Fig. 14: Micro tornado with anti-clock wise rotation (OM)