Nuclear Transmutations in Polyethylene (XLPE) Films and Water Tree Generation in Them

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Abstract

An explanation of the nuclear transmutation (NT) observed in XLPE (cross-linked polyethylene) films is presented based on the neutron-drop model used in the theoretical investigation of the cold fusion phenomenon in other cold fusion materials (CF materials); transition-metal hydrides/deuterides. The NT's, K → Ca, Mg → Al, $^{56}_{26}$Fe → $^{57}_{26}$Fe and Fe → Ni, are explained by a single-neutron absorption with or without a succeeding beta-decay to get final nuclides. On the other hand, the NT's, $^{56}_{26}$Fe → $^{64}_{30}$Zn and $^{56}_{26}$Fe → $^{60}_{28}$Ni, are explained by an absorption of a neutron drop $^{8}_{4}\Delta$ and $^{4}_{2}\Delta$, respectively, in the cf-matter formed in CF materials. Production of extraordinary elements Li, Pb and Bi is discussed from our point of view. Thus, we concluded that the generation of water trees in XLPE samples is caused by nuclear reactions induced by cold fusion phenomenon at around spherulites. The NT found in XLPE may have a relation with the NT's found in biological bodies (biotransmutation).

1. Introduction

We have tried to explain the wide-spread experimental facts in the cold fusion phenomenon (CFP) from a unified point of view using a phenomenological models, the trapped neutron catalyzed fusion model (TNCF model) at first [1] and then the neutron-drop model (ND model), a generalized version of the former [2]. It should be remembered here that the development of the model demands an explanation for NT's with large changes of the nucleon and proton numbers observed in the CFP.

In the process of verification of the basic premises of these successful models, we have developed a quantal investigation of the CF materials such as transition metal hydrides/deuterides composed of a host lattice of transition metals and interlaced lattice of interstitial protons/deuterons [3]. It was shown that it is possible for cf-matter to exist when it is composed of neutron drops $^{A}_{Z}\Delta$ with Z protons, Z electrons and (A – Z) neutrons in a dense neutron liquid at boundary /surface regions of the crystals.

Recently, Kumazawa *et al.* [4, 5] observed the nuclear transmutation (NT) in XLPE (closslinked polyethylene) including water trees, and then detected weak mission of gamma or X-rays from similar samples [6]. Their results show, generally speaking, that water trees are formed macroscopically at boundaries of XLPE samples and microscopically at amorphous portions of the sample among spherulites composed of crystalline lamellae. Use of heavy water instead of light water did not show any positive effect on the occurrence of NT [5]

The NT observed in the XLPE films by Kumazawa *et al.* [4–6] has characteristics in common with CF materials as a part of the CFP. Therefore, it is natural to apply the same model (TNCF model) [1, 2] to explain the NT in XLPE that successfully explained the NT in the CF materials [3].

2. Experimental Facts about Water Tree in Cross-linked Polyethylene (XLPE)

We give an explanation of characteristics of the experimental data sets obtained by Kumazawa *et al.* [4 – 6] in this section.

2.1 Summary of Experimental Data Sets obtained by Kumazawa *et al.*

We can summarize the experimental results obtained by Kumazawa *et al.* [4–6] as follows:

In the experiments, a XLPE (cross-linked polyethylene) sheet 0.5 mm thick was used. Au was deposited as a ground electrode onto the bottom surface of the sample. Then, the sample was dipped in aqueous solutions of electrolytes (a) KCl, (b) NaCl and (c) $AgNO_3$ to make the Blank samples. The Blank samples were placed in the aqueous solutions, and electric fields with high -frequency (2.4–3.0 kHz) and high-voltage (3.0 – 4.0 kV/mm) were applied between the voltage application wire above the sample and the ground electrode for 140 – 320 hours to obtain “the samples after voltage application” (let us call them the Experimental samples, for simplicity). Quantitative analysis of elements were performed for (I) the **Original**, (II) the **Blank** and (III) the **Experimental** samples for three electrolytes (a) **KCl**, (b) **NaCl** and (c) **$AgNO_3$.** In the case (c), there are no data on the blank samples but data on the two distinct regions selected visually (i) **with water trees** and (ii) **without water trees**.

Characteristics in the changes of elements from (I) the Original to (II) the Blank and (III) the Experimental samples were summarized as follows:

In case (a) (KCl),

(1) K decreased and Ca increased,

(2) ^{56}Fe decreased and ^{57}Fe increased,

(3) ^{64}Zn increased while other isotopes of Zn decreased.

In case (b) (NaCl),

(4) Mg decreased and Al increased in which the gross weight of the two elements was hardly different compared to the Blank or the Original samples.

In case (c) ($AgNO_3$),

(5) Fe decreased and Ni increased,

(6) New elements Li, Na, Pb and Bi were detected, and

(7) There are changes of elements in both regions with and without water trees.

Furthermore, there are interesting features of the blank samples (II) in case (a);

(8) In Blank samples, Mg and Ca are increased from those in the Original one while Fe is decreased.

In their second paper, [5] Kumazawa *et al.* reported detection of weak and burst-like radiation, which they assumed was low energy gamma or X-rays. In the CFP, there are a few observations of gamma and X-rays but they are peripheral (cf. Section 6.3 of [1] for the data of gamma ray observation). We concentrate our investigation in this paper to the data reported in the first paper [4].

3. Explanation of Nuclear Transmutation in XLPE by the TNCF Model

3.1 Microscopic Structure of Polyethylene (PE), Lamella and Spherulites in XLPE

The lengths of the C-C and C-H bonds of PE are estimated as 1.54 and 1.09Å, respectively. The carbon chain is composed of tetrahedrally connected carbons with an angle between two C-C bonds of 109.5 degree. A lamella has a lattice structure with ordered carbon nuclei (lattice nuclei) interlaced with ordered protons even when the structure is not so simple, as in the case of transition-metal hydrides/deuterides. The size of spherulites, crystal components of solid polyethylene, also depends on conditions in which the sample is produced and ranges from ≃ 1 μm to ≃ 1 mm, in general. The ratio of portions occupied by crystalline component and amorphous component of a solid PE sample depends also on the conditions.

3.2 Cold Fusion (CF) Matter in XLPE

It is natural to investigate nuclear transmutations observed in XLPE with the same phenomenological approach as that used to analyze the CFP observed in transition-metal hydrides/deuterides as a first step.

We have to notice common factors in transition-metal hydrides/deuterides and XLPE if we take the point of view explained above. First of all, (1) there are crystalline structures of host and hydrogen isotopes in both cases. Second, (2) the reaction products of nuclear transmutations were found localized in boundary or surface regions of crystalline structure in both cases. Third, (3) the neutron affinity we have defined to specify responsibility of nuclides for the CFP [1, 2] is positive (favorable for the CFP) for C (2.22 MeV for ${}^{6}{}_{12}C$) in XLPE and Ti (0.602 for ${}^{22}{}_{48}Ti$, for instance), Ni (4.80 for ${}^{28}{}_{58}Ni$), Pd (2097 for ${}^{46}{}_{105}Pd$) in transition-metal hydrides/deuterides. Lattice constants of CF materials are tabulated in Table 1.

Table 1. Lattice constants of host nuclides lattices

Host nuclides	**Lattice constants** (Å)
Ti (*hcp*)	a = 2.95, c = 4.792
Ni (*fcc*)	a = 3.52
Pd (*fcc*)	a = 3.89
XLPE (*orthorhombic*)	a = 7.40, b = 4.93, c = 2.53

From our point of view, the super-nuclear interaction between neutrons mediated by protons/deuterons in lattice nuclei (carbon in the case of XLPE), cross-linking in XLPE is decisive; cross-linking protons (covalent bonded to two carbon atoms) mediate the interaction of neutrons in carbon nuclei ${}^{12}_{6}C$ on adjacent PE chains.

3.3 Explanation of Nuclear Transmutation in XLPE where observed Water Trees

We give explanations of the seven characteristics of the nuclear transmutations (NT) in XLPE giving counterparts in the CFP for reference.

(1) Decrease of K and increase of Ca in the case (a) are explained by such a reaction in the solids by absorption of a neutron followed by beta decay with a liberated energy ΔE = 1.31 MeV;

$$n + {}^{39}_{19}\mathrm{K} \rightarrow {}^{40}_{20}\mathrm{K}^{*} \rightarrow {}^{40}_{20}\mathrm{Ca} + e^{-} + \underline{\nu}_{e}, \ (\sigma_{nK39} = 2.10 \text{ b}) \qquad (3\text{-}1)$$

where $\underline{\nu}_e$ is an electron neutrino. As a measure of the reaction cross-section in solids we cited the value in free space in the parenthesis behind the equation.

(2) Decrease of ${}^{56}_{26}Fe$ and increase of ${}^{57}_{26}Fe$ in the case (a) are similarly explained but without beta decay due to the stability of ${}^{57}_{26}Fe$ with an energy Q = 1.15 keV transferred to the lattice system instead of gamma ray emission in free space;

$$n + {}^{56}_{26}\mathrm{Fe} \rightarrow {}^{57}_{26}\mathrm{Fe} + Q. \ (\sigma_{nFe56} = 2.81 \text{ b}) \qquad (3\text{-}2)$$

(3) Increase of ${}^{64}_{30}Zn$ and decrease of ${}^{66}_{30}Zn$, ${}^{67}_{30}Zn$ and ${}^{68}_{30}Zn$ in the case (a) are explained by using the neutron drop ${}^{A}_{Z}\Delta$, for example;

$${}^{56}_{26}\mathrm{Fe} + {}^{8}_{4}\Delta \rightarrow {}^{64}_{30}\mathrm{Zn}. \qquad (3\text{-}3)$$

The decrease in other isotopes may be explained by nuclear reactions to transform them into other elements but its details are left for another work.

(4) Increase of Al and decrease of Mg in the case (b) are explained by reactions similar to (3-2) with Q = 7.08 MeV and Q' = 12.11 MeV and a reaction similar to (3-1) with ΔE = 2.61 MeV.

$$n + {}^{24}_{12}\mathrm{Mg} \rightarrow {}^{25}_{12}\mathrm{Mg} + Q. \ (\sigma_{nMg24} = 0.05 \text{ b})$$
$$n + {}^{25}_{12}\mathrm{Mg} \rightarrow {}^{26}_{12}\mathrm{Mg} + Q'. \ (\sigma_{nMg25} = 0.19 \text{ b})$$
$$n + {}^{26}_{12}\mathrm{Mg} \rightarrow {}^{27}_{12}\mathrm{Mg}^{*} \rightarrow {}^{27}_{13}\mathrm{Al} + e^{-} + \underline{\nu}_{e}. \ (\sigma_{nMg26} = 0.04 \text{ b})$$

(5) Decrease of Fe and increase of Ni in the case (c) are explained similarly with use of the neutron drop, for example;

$${}^{56}_{26}\mathrm{Fe} + {}^{4}_{2}\Delta \rightarrow {}^{60}_{28}\mathrm{Ni}.$$

Thus, we may imagine the following scenario of growth of a water tree: (i) a NT of impurity nuclides occurs at a boundary region heating there by a liberated energy, (ii) a seed of a water tree is induced by the liberated energy, and (iii) the applied high-frequency electric field makes the water tree grow.

The NT's in phenanthrene [7] may have close relation with that in XLPE discussed in this paper.

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