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Electroanalytical chemistry in cold fusion phenomenon

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ABSTRACT

Fundamental characteristics of the cold fusion phenomenon (CFP) are explained from the present point of view based on the pile of complex experimental facts obtained in these eleven years after its discovery. Surface nature of the reactions and qualitative reproducibility, two of remarkable characteristics of CFP are explained by a model (TNCF model) with a single adjustable parameter. The Premises assumed in the model indicate importance of atomic processes on the surface of electrodes to realize CFP which should be investigated by electroanalytical chemistry.

1. INTRODUCTION

The cold fusion phenomenon (CFP), or more precisely "Nuclear Reactions and Accompanied Phenomena in Solids including High Density Hydrogen Isotopes", was discovered in 1989 by M. Fleischmann et al.[1] in electrochemical experiments with Pd cathode and an electrolyte LiOD in heavy water D_2O where they expected the fusion of two deuterons occurs by the presumed high pressure of deuterium occluded in the Pd cathode as high as 10^{27} atm. This presumption has induced long lasting confusion in the

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interpretation of the experimental results among both supporters and critiques.

The observed phenomenon had included such sporadic events as the excess heat generation and tritium and neutron productions in several experimental sets with null results in many other sets.

After more than 11 years from the discovery, it is recognized by serious researches that CFP is a rather complex phenomenon including the excess heat, transmuted nuclei, tritium, helium-4, neutron, gamma ray productions and occurring in electrolytic, gas contact, gas discharge and other systems where are solids with high density hydrogen isotopes (not only deuterium D but also protium H).

The electrolytic system is, however, used most often in CF experiments with positive results. Investigation of experimental results shows the cause of this fact and also characteristics of CFP. A unified and systematic explanation of CFP has been given using a model[2] proposed by the author with a single parameter and quantum mechanical explanation of Premises used in the model has been investigated progressively.[3~ 5] It becomes clear that electroanalytical chemistry will give fundamental knowledge related with realization of CFP.

2. EXPERIMENTAL FACTS SHOWING SURFACE NATURE OF THE COLD FUSION PHENOMENON (CFP)

From the present point of view formed with abundant experimental data accumulated in these more than eleven years after its discovery[1] of CFP in 1989, the presumption in the first stage of d - d fusion in PdD_x ($x \simeq 0.6 \sim 1.0$) was false as a principal cause of CFP even if it occurs in special situations. The imbalance of products, the excess heat, neutron, helium-3, tritium, proton, helium-4 and gamma ray inexplicable by the presumed reactions has been insoluble riddles causing unfruitful dispute between supporters and critiques.

In addition to this apparent imbalance of the products contradicting to the presumed reactions, there has been discovered a new decisive clue about nature of nuclear reactions and position where they occur which have shown difficulty of its explanation by the d - d fusion reaction.

In the CFP, such events as nuclear transmutation and helium-4 production have specified the position where occur the events. The direct information has been given by localized distribution of the transmuted nuclei around speckled regions in the surface layer of cathodes in electrolytic experiments[6~ 9] and of cathodes in gas discharge experiments.[10,11] The fact that helium-4 atoms observed in the surface layer of cathodes[12,13] are little in its amount compared with those observed in gas phase[14,15] shows also, somewhat indirectly, surface nature of reactions generating helium-4.

It is interesting to notice that there are two kinds of the nuclear transmutation (NT) observed in experiments; one is so-called "NT by decay" (NT_D) which is explained by decay of a nucleus formed from pre-existed nucleus absorbing a neutron. Another is so-called "NT by fission" (NT_F) which is explained by fission of a nucleus formed from pre-existed nucleus absorbing several neutron.

Other evidences showing surface nature of nuclear reactions causing CFP are distribution changes of minor components in cathode where evolved the excess heat.[16,17]

It is necessary to give a little detailed explanation of the surface nature of reactions to depart completely from the false presumption of the d - d fusion reactions as a principal cause of CFP and to resolve the confusion induced by it in the research community. In the following explanation of several of typical experimental data, discrimination of NT_D and NT_F is not given without exceptional cases because it is apparent from the species of the product nuclei.

Experiment by J.O'M. Bockris et al.[6]

Bockris and his collaborator performed an experiment[6] in which hydrogen was electrolyzed from water in contact with a palladium electrode (size and shape not described). The electrolyte is not described in the paper.

To indicate whether a new nucleus was formed by means of transmutation or whether it came from the solution as an impurity, they utilized Inductively Coupled Plasma method (ICP) to analyze the materials in the solution. They analyzed the surface in two ways. In the first case, they used X-ray photoelectron spectroscopy (XPS) which gives rise to materials which are only 30 Å from the surface. Then, they also used electron dispersive analysis (EDA) to analyze deeper, i.e. 1 μm.

The concentration and depth of impurities were measured by these methods as a function of electrol-