

Nuclear Products of Cold Fusion Caused by Electrolysis in Alkali Metallic Ions Solutions

Reiko NOTOYA
Catalysis Research Center, Hokkaido University
Kita-11 Nishi-10, Kita-ku,
Sapporo, 060, Japan

Abstract

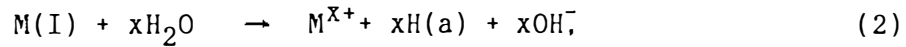
It was confirmed experimentally that some nuclei products of cold fusion were generated during electrolysis by use of cathodes of porous nickel and platinized platinum, in light (usual) water solutions of all alkali metallic ions investigated. The author reported in the previous work that 4ppm of calcium was detected in the electrolyte of potassium carbonate light water solution by flame photospectroscopy. The gamma-ray measurement revealed the formation of ^{24}Na during electrolysis in sodium carbonate solution. ICP-mass spectra of an electrolyte of cesium sulfate solution showed several peaks of the various nuclear products in the region from 132 to 140 amu. In all electrolytes investigated, the distinct increments of tritium were measured by liquid scintillation spectroanalyzer. Simultaneously, the excess heat was measured in the thermally open cell during electrolysis in these solutions of light or heavy water, which amounted to $\geq 200\%$ for the input power in potassium and cesium ions' solutions. From these results we can conclude that alkali-intermetallic compounds formed as the intermediate of hydrogen evolution reaction cause many types of cold fusion with neutron, proton, deuteron, triton and α - particle.

1. Introduction

Since the cold fusion due to electrolysis in heavy water was proposed by Fleischmann and Pons¹, just 6 years have been over. In the meanwhile, new types of cold fusion during electrolysis in light water solutions have been proposed by several groups which are summarized

in review articles^{2,3} recently. The cold fusion takes place in the electrolytic cell of hydrogen evolution reaction(HER) in alkali metallic ions solutions, on the so-called low overvoltage metals.

The mechanism of HER in alkaline solution on the low overvoltage metals has been determined by works of A.Matsuda and his students using the galvanostatic transient method(GSTM). According to the mechanism, HER occurs through the following scheme, on platinum group metals, nickel, silver, titanium and so forth, in the solution of alkali and alkaline earth metallic ions⁴:

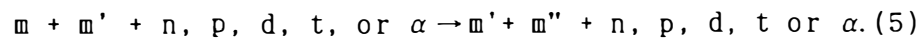


where M^{X+} , $M(I)$ and $H(a)$ denote the metallic cation with the valence $x+$, the intermediate of alkali-intermetallic compound formed with the cathode material, and an adsorbed or absorbed hydrogen species on or in the electrode, and \star , rate determining, respectively.

It has been proposed that the d+d or/and d+d+d cold fusion was occurring in the solid phase of the cathode including $D(a)$, because of using a palladium cathode and heavy water^{1,5}. Recently, it was evident from some new results that the nuclei of the intermediates of HER A_ZM and 1_1p of $M(I)$ and $H(a)$ were undergoing the following nuclear reaction in the surface layer of the cathode, though this possibility had been suggested on the basis of the mechanism of HER⁶:



In general, reaction(4) seems to produce not only ${}^{A+1}_{Z+1}m'$ but also some small nuclear particles and then m and a new nuclei m' also must undergo the following reaction with small particles in the vicinity:



It was observed simultaneously that a certain amount of tritium was produced in parallel with reaction(5). Consequently, the mechanism of the cold fusion may be expressed as the chain reaction which is initiated by the formation of the intermetallic compound $M(I)$ between electrode materials and alkali or alkaline earth metals species.

For the last four years, we have studied to find evidence of the cold fusion mainly caused by electrolysis of light water solutions and obtained the following results:

- i. the excess heat measurement in K_2CO_3 , Na_2CO_3 and Cs_2SO_4 light water solutions⁷⁻⁹,
 - ii. Ca detection by flame photospectroscopic analysis in K_2CO_3 solution⁷,
 - iii. tritium measurement by liquid scintillation spectroanalyzer in K_2CO_3 and Cs_2SO_4 light or heavy water solutions^{7,9},
 - iv. ^{24}Na detection by gamma-ray spectrometer in Na_2CO_3 solution⁹,
 - v. the products analysis by use of ICP-MS in Cs_2SO_4 solution¹⁰.
- The present paper concerns mainly v, comparing with the results from i to iv.

2. Intermetallic Compounds

As reported previously¹⁰, the measurement of the pseudo differential capacity on the decay process of overvoltage after switching off of the polarizing current provided the behavior of the intermetallic compound M(I). On the basis of that, it was found that M(I) was formed by cathodic polarization and increased steeply at the potential $\phi = -0.7 \pm 0.1$ volt (vs NHE) in a solution of every kinds of alkali metal ions on both cathodes Pt and Ni. The excess surface concentration of the alkali metallic species attained about 10^{16} atoms per true unit area in the region more cathodic than -0.8 volt. Taking into account of the composition of M(I), it was obvious that M(I) could penetrate more than 1000 monoatomic layers of any electrode material.

It was possible to determine the time constant τ_1 of the electron transfer step(1) by applying GSTM to the analysis of the initial region of the potential-time curve. The kinetic behavior of τ_1 showed clearly that the discharge of M^{x+} was occurring as the electron transfer step of HER in an alkaline solution. Fig.1 shows the $\log \tau_1$ plotted against pH or $\log C_{M^{x+}}$. As seen from this figure, in pure hydroxides $\log \tau_1$ varies linearly with pH with a gradient -1/2 but no regularity can be seen in pH-dependence of $\log \tau_1$ in sulfate solutions. However, when $\log \tau_1$ is plotted against $\log C_{M^{x+}}$, a definite linear relation is observed with gradient -1/2 in any case of pure hydroxides and sulfate solutions. τ_1 is defined by the product of the differential capacity C_D of the double layer and the reaction resistance r_1 of the most rapid electron transfer step at the equilibrium potential of HER, and further more from r_1 we can deduce the exchange rate of the electron transfer step i_{10} , as follows:

$$\tau_1 = C_D \cdot r_1, \quad (6)$$

$$r_1 = RT/F \cdot i_{10}, \quad (7)$$

where R, T and F denote respectively the gas constant, the Faraday and the absolute temperature. The above results mean that the exchange rate i_{10} is proportional to the square root of the alkali metal ion concentration, since C_D remains constant in these solutions,

$$i_{10} = k(C_M^{x+})^{1/2}. \quad (8)$$

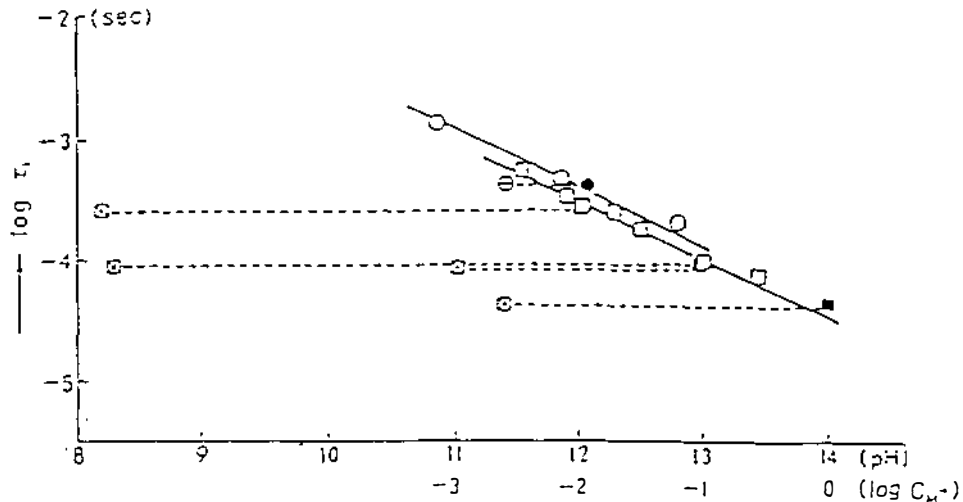


Fig.1 $\log \tau_1$ at the equilibrium potential of HER plotted against pH or $\log C_M^+$:

- (□) - NaOH_{aq} ; (⊠) - $\text{Na}_2\text{SO}_{4,\text{aq}}$ plotted against pH;
- (■) - $\text{Na}_2\text{SO}_{4,\text{aq}}$ plotted against $\log C_M^+$;
- (○) - CsOH_{aq} ; (⊕) - $\text{Cs}_2\text{SO}_{4,\text{aq}}$ against pH;
- (●) - $\text{Cs}_2\text{SO}_{4,\text{aq}}$ plotted against $\log C_M^+$.

It means that this behavior consists with the kinetics for electron transfer reaction of M^{1+} with the Tafel constant 1/2. It can be concluded from this fact that the electron transfer step of HER in alkaline solution consists in the discharge of alkali metallic ion, but not water molecule which has been widely shown in the literature.

3. Transmutation of Cesium

Cesium ion is one of the most appropriate reactant among alkali metallic ions to measure the amounts of the products of the nuclear reactions, owing to 100% of the natural abundance of $^{133}_{55}\text{Cs}$, as well as $^{23}_{11}\text{Na}$. Platinized platinum (Pt/Pt) and porous nickel cathodes were used for simultaneous experiments, namely, the measurement of excess heat and the determination of fusion products. Pt/Pt cathode was made of platinum mesh (1.0 × 0.5 cm size) which was covered with ca. 50 mg Pt-black by electrodeposition. The density of porous nickel (1.0 × 0.5 cm

size, 0.1cm thickness) was 5.9 ± 0.1 . The anode was made of platinum wire (ca.10cm length, 0.5mm diameter). Electrolyte used for a series of these experiments was 0.1mol/l Cs_2SO_4 (Merck, Suprapur) solution of light water, which meant twice distilled subterranean water prepared in the same ways as described in the previous works⁸. 20 ml of the electrolyte was used for each electrolysis. As described in the previous works^{8,9}, each test cell equipped with Pt/Pt or porous Ni cathode (hereafter it will be cell_{Pt} or cell_{Ni}, respectively) was polarized galvanostatically. When the electrode potential and the cell temperature attained to these steady values, the current value was changed without intermission of polarization. Thus polarization was repeated several times. The electrolyte in the control cell was used as "the control electrolyte" in which the same electrodes of porous nickel and the platinum wire were immersed in the same way as the test cell, except for polarization, during the test cell's electrolysis. After a series of electrolysis, the electrolyte in cell_{Pt} and cell_{Ni} as well as the control electrolyte were analyzed by means of ICP-MS (SPQ-6500, Seiko Instruments). The ion counts (cps) were calibrated using the standard solutions of $^{138}_{56}\text{Ba}^{2+}$ which concentration were from 10 to 200 ppb. As the sample for ICP-MS measurement, the test electrolyte were diluted quantitatively with pure water 4000 or 10000-fold. On the other hand, the control one was diluted merely 100-fold. Therefore strong contamination with the control electrolyte remained at 133 amu and some others' on mass spectra. But it was not changing for measurements of the test samples.

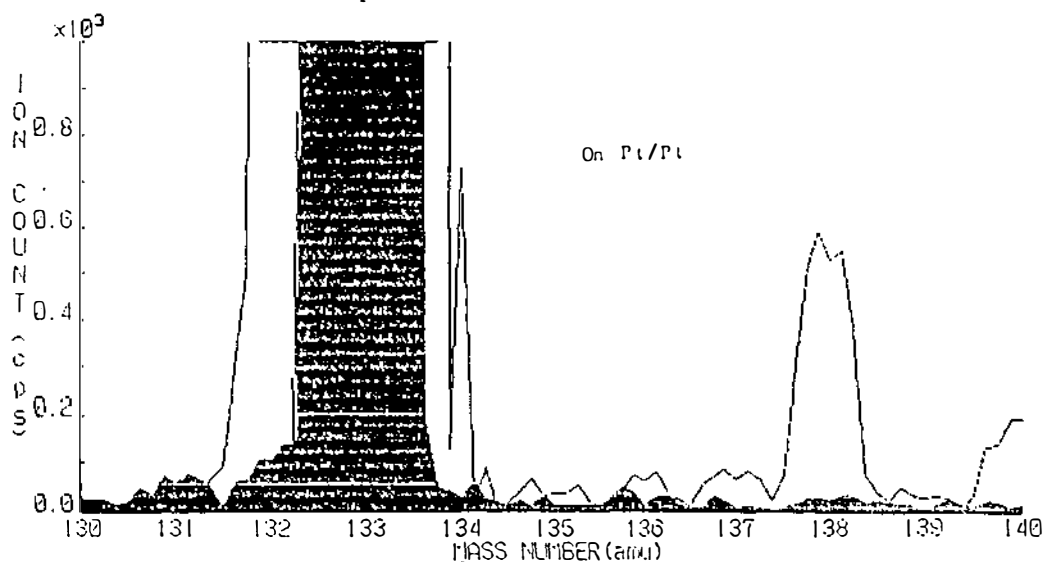


Fig.2 Mass spectrum of a test electrolyte in a cell with Pt/Pt cathode after 18.2 hours electrolysis; the spent electricity = 18000 ± 200 coulomb.

Fig.2 shows the typical mass spectrum concerning the test electrolyte in cell_{pt}, in the range of mass number from 130 to 140. The total quantity of electricity spent during 18.2 hours electrolysis in cell_{pt} was equal to 18000±200 coulomb. In the control electrolyte, only 138amu species in the mass spectrum was found to be 0.4ppm except for 133amu, which consisted well with the total Ba determined to be 0.6ppm by a flame photospectrometer.

Comparing the mass spectra in the test electrolyte in cell_{pt} and the control electrolyte, the increment of the species at each amu is

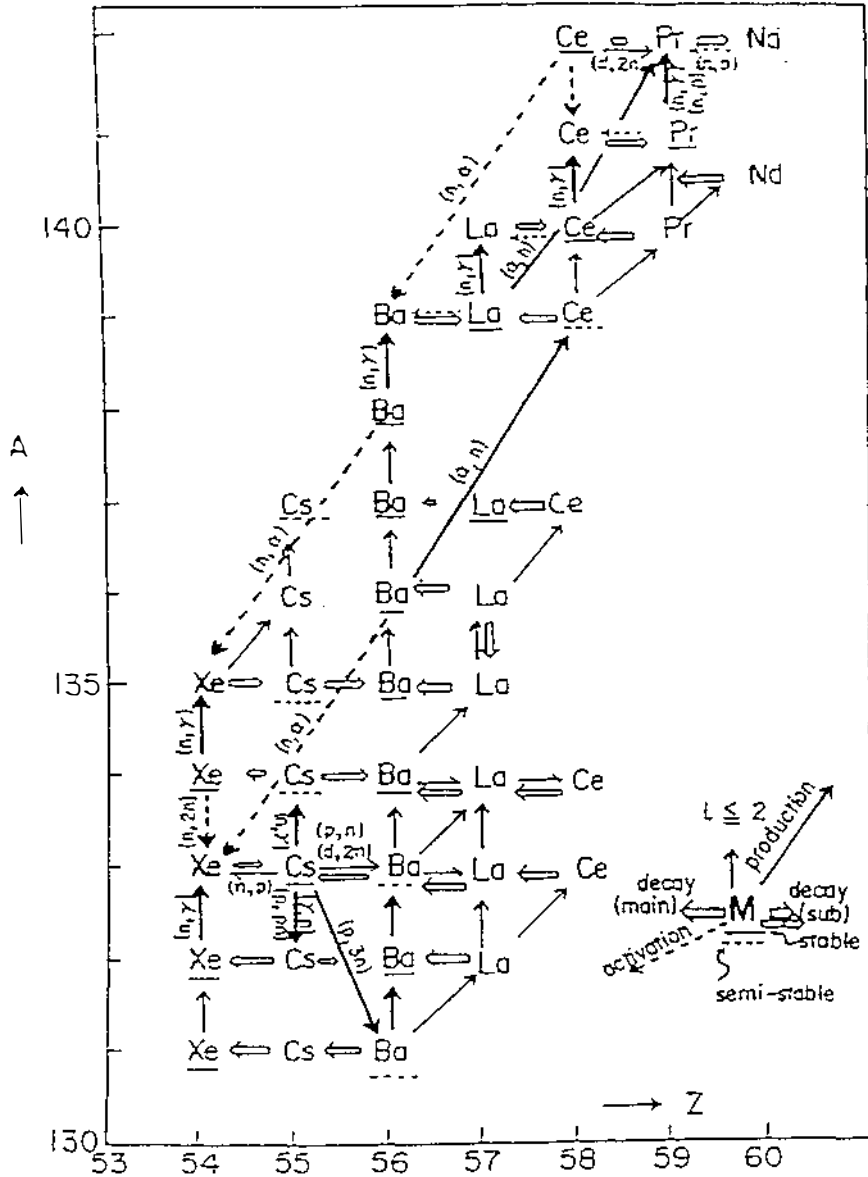


Fig.3 Diagram composed of known reactions occurring in a nuclear reactor and possible reactions of $l \leq 2$.

Table I Amounts of cold fusion products of electrolysis of 0.1mol/l Cs₂SO₄ light water solution on Pt/Pt cathode,investigated by ICP-MS.

Mass No(amu) :	132	134	135	136	137	138	139	140
Δ amount(ppm):	+	+	0.4	0.3	0.5	4.7	0.2	1.8

summarized in Table I. The increments denoted by + in Table I at 132 and 134 amu couldn't be determined quantitatively because the resolution was insufficient, that was caused by too large ion counts for 133 amu species, but they seemed to be almost the same amount as 138amu.

In relation to the mass numbers in Table I, a diagram can be composed of known¹¹ reactions for nuclear production and activation in a nuclear reactor, and possible reactions whose spin changes l are found to be ≤ 2 . Fig.3 shows it. It is possible to suppose that some nuclear species in the diagram are produced in cell_{Pt}.

On the other hand, in cell_{Ni} violent dispersion of porous Ni was caused by cathodic polarization in Cs₂SO₄ solution. After a few hours' polarization the nickel cathode began to spurt a lot of very fine nickel powder. Such a violent dispersion of porous Ni occurred often in Cs₂SO₄ solution. There was nothing of the fusion products in cell_{Ni}, except for 132 and 138 amu which were found to be + and 1.0ppm by ICP-MS, respectively. The total electricity spent during 160 mins' electrolysis in cell_{Ni} was equal to 180 coulomb. In spite of the little electricity, it was very surprising that the product of 138amu amounted to 0.6ppm in cell_{Ni}.

Before starting the dispersion, the heat evolution in cell_{Ni} was far greater than that in cell_{Pt}, at the same current. For example, at 10m ampere, temperature increased 0.3°C in cell_{Pt}, but 7.0°C in cell_{Ni}. The excess heat in cell_{Pt} was found to be 260%, but the input power in cell_{Ni} wasn't determined because the potential fluctuated strongly.

4. Discussion and Conclusions

It is quite evident from Table I that cesium atomic species in the surface layer of these electrodes is undergoing the same types of nuclear reactions as that in a nuclear reactor. In both cases of the electrolysis in cesium and potassium solutions, the nuclear products amounted to ca.5ppm, simultaneously with the considerable excess heat evolution. During electrolysis of ²³Na₂CO₃ solution, ²⁴Na was detected by gamma-ray spectroanalyzer, but it was far less than those. In this case, the excess heat was not observed practically. From these results we can conclude that the transmutation of the intermetallic compound

M(I) like as reaction(5) is occurring in all alkaline solutions on platinum or nickel cathode as well as the low overvoltage metals and it is predominant for heat evolution. However, it is sure that d+d or d+d+d is occurring in parallel with the cold fusion of M(I), because the increase of tritium was observed in all electrolytes.

References

1. Fleischmann and Pons, "Electrochemically Induced Nuclear Fusion of Deuterium," *J. Electroanal. Chem.*, **261**, 301 (1989).
2. Fox, "Cold Nuclear Fusion, Space Energy Devices & Commercialization," Cold Fusion Source Book, Minsk, Belarus, May 24-26, 1994, p. 12. Fusion Information Center, Salt Lake City, Utah, (1994).
3. Storms, "A Critical Review of the Cold Fusion Effect," Proc. ICCF-5 Monte-Carlo, Monaco, April 9-13, to be published (1995).
4. Matsuda, Notoya, Ohmori, Kunimatsu, Kushimoto, "Effect of Surface Potential on the Rate of Electron Transfer Step of HER," *J. Res. Inst. Catal. Hokkaido Univ.*, **24**, 187 (1977).
5. Takahashi et al., "Excess Heat and Nuclear Products by D₂O/Pd Electrolysis and Multibody Fusion," *Int. J. Appl. Electromagnet. Mat.*, **3**, 221 (1992).
6. Notoya, "Alkali Metallic Intermediate of Hydrogen Electrode Reaction," Abs. 18th Mtg. Hokkaido Electrochem. Soc., Sapporo, Jan. 18 (1990).
7. Notoya, "Cold Fusion by Electrolysis in a Light Water-Potassium Carbonate Solution with Nickel Elec.," *Fusion Tech.*, **24**, 202 (1993).
8. Notoya et al., "³t Generation and Large Excess Heat Evolution by Electrolysis in H₂O⁻ and D₂O-K₂CO₃ on Ni," *ibid.*, **26**, 179 (1994).
9. Notoya, "Cold Fusion in HER of Active Metals in Solution of Alkali Metallic Ions," Proc. EEWWCE2, Sintra, Portugal, March, 12-15, (1995).
10. Notoya, "Alkali-Hydrogen Cold Fusion Accompanied by Tritium Production on Ni," *Transactions of Fusion Tech.*, **26**, 205 (1994).
11. Japanese Isotope Association, Isotope Handbook, "Chapter 4, 5, 7, 10, Maruzen, Tokyo (1992).