

# Possible Role of Oxides in the Fleischmann-Pons Effect

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**Abstract--** The mechanism of the Fleischmann-Pons effect is not yet fully understood. It appears that in many occasions an oxide layer, or an insulating one covers the surface of the active material. In this paper we list a number of experiments displaying such a situation, and suggest possible role of these layers.

**Index Terms--** Electrostatic fields, excess heat, insulating films, zeolites.

## I. INTRODUCTION

It is well known that the Fleischmann-Pons effect needs specific situation where nuclear cold fusion reactions occur [1]. It has been established for instance that high loading is necessary in order to observe excess heat [2]. However, this condition is not sufficient. For instance, the variation of the flux of the deuterium through the surface of the palladium electrodes is also a necessity [2]. In order to understand the mechanism of Cold Fusion many theories have been developed in order to explain the effect, but none of them is completely satisfactory. However, from an experimental point of view there are indications that the metals involved in the reaction are rarely free of impurities. An oxide film very often covers their surfaces. It is very possible that these layers play a role in the reaction. In this paper we will review some experimental results showing the existence of such oxide films on the active metal surfaces. The existence of these oxide layers have been observed in electrolysis experiments as well as in gas loading ones.

## II. ELECTROLYSIS EXPERIMENTS

### A. The original Fleischmann and Pons experiment

The original Fleischmann and Pons experiments were performed in Pyrex cells using LiOD as an electrolyte. This solution being basic slowly etches the walls of the Pyrex container, and the etched material then deposits on the palladium cathode. This behavior has been discussed in details by Lonchamp et al. [3]. Analysis of the deposit on the electrode showed the presence of silicon, oxygen, carbon, oxygen [4]. The role of the oxide layer has been confirmed by the impossibility of getting excess heat with Teflon cells unless oxide materials were added [5]. Studies using polymer coated glass cells also failed to give any excess heat effects even when previously active electrodes were used [6].

The mechanism of formation of the oxide film can be described as follows:

LiOD reacts with the Pyrex glass producing lithium silicates in the electrolyte solution. Silicon and lithium based deposits forms on both cathode and anode. Such deposits result in the production of an overvoltage on the electrodes. As a consequence, the input power increases due to the fact that most experiments are performed at constant currents; the temperature rises then up to boiling. On the other hand, the consequence of the deposit is an increase of the  $D^+$  electrochemical potential, which in turn increases the loading of deuterium in the cathode. As mentioned before, the higher loading helps the excess heat generation. This mechanism explains why long electrolysis times are required.

Fleischmann has proposed another approach to the role of the oxide layer [7]: the silicate deposits onto the palladium cathode blocks the surface and prevents the flow of the current in most of the surface of the electrode. The current is restricted to small regions of cracks in the silicate layer. In these regions, the current density becomes very high, and as the overvoltage varies with the current density, the deuterium loading increases greatly. Also, another advantage of the silicate layer is that it prevents de-loading by blocking the recombination of deuterium atoms at the palladium-oxide interface. The deuterium atoms enter through the cracks and are blocked by the silicate layer, therefore increasing the loading ratio, and then producing excess heat.

### B. Miles et al.

In order to create this oxide layer, Miles et al. [8] have added boron and cerium to the palladium. With this method, excess heat has been obtained nearly every time [8]. The boron composition ranged from 0.25 to 0.75 weight %, with boron atom ratios as high as 7%. Excess power was observed during the first 57 hours of electrolysis in an isoperibolic calorimeter [9].

## III. GAS DIFFUSION EXPERIMENTS

### A. Yamagushi and Nishioka

As early as 1990, Yamagushi and Nishioka [10] have observed a gigantic neutron burst of  $(1-2) \times 10^6$  neutrons/second from deuterated palladium plates with heterostructures in a vacuum chamber. An explosive release of  $D_2$  gas, biaxial bending of all samples, and excess heat were also observed at the same time. It has been concluded that these phenomena are caused by the cooperative production of deuterium atoms accumulation layers at the palladium surfaces due to the controlled out-

diffusion of deuterium atoms. Figure 1 shows a schematic of the palladium sample, with a thin film of manganese oxide on one side and a gold film on the other.

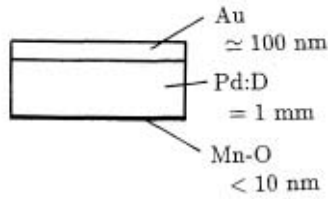


Fig. 1. Palladium sample with MnO on one side and gold on the other.

#### B. Lipson et al.

Lipson et al. [11] have shown the production of 3 MeV protons, X-ray emission when deuterium desorbs from Pd/PdO films. These observations are in agreement with those of Yamagushi and Nishioka described above.

#### C. Iwamura et al.

Iwamura et al. have observed the transmutation of cesium into praseodymium, and strontium into molybdenum [12] by permeation of deuterium gas through a palladium foil where a multilayer of palladium and CaO is deposited. Cesium and strontium were deposited on the surface of the last palladium layer as shown on figure 2. More experiments have shown the transmutation of barium into samarium [13].

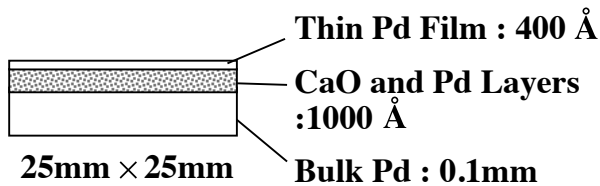


Fig. 2. Palladium foil covered of five alternate layers of palladium and CaO.

#### D. Arata and Zhang

Arata and Zhang [14] using palladium and Pd-Ni nano-crystals embedded inside a zirconium oxide matrix have observed excess heat as well as production of helium-4 without any input energy. Figure 3 shows that the Pd-Ni nano-crystals produce more energy than the pure palladium. On the contrary no excess heat was observed with hydrogen.

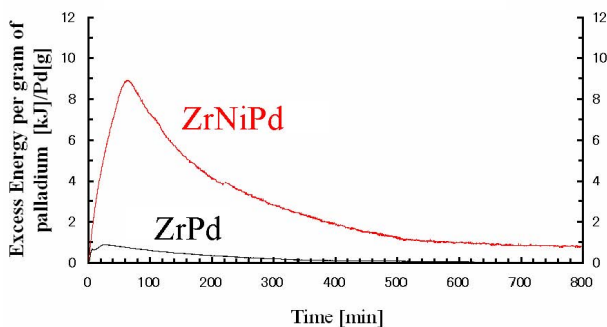


Fig. 3. Comparison between ZrPd and ZrNiPd.

#### E. Nickel-Copper ZrO<sub>2</sub>.

At 523K, Miyoshi et al. [15] have shown that in Ni-Cu-Zr oxide compounds hydrogen produces an excess heat of 300 eV/nickel atom, whereas the deuterium run was endothermic.

#### F. Zeolites

Zeolites are interesting substrates for LENR. They are micro-porous crystalline inorganic hydrated aluminosilicate materials having a highly regular structure of pores and chambers with extremely large surface areas. Zeolite framework structure encloses cavities or pores occupied by cations such as sodium, potassium, cesium, ammonium, and other ions. Figure 4 shows a schematic view of a zeolite.

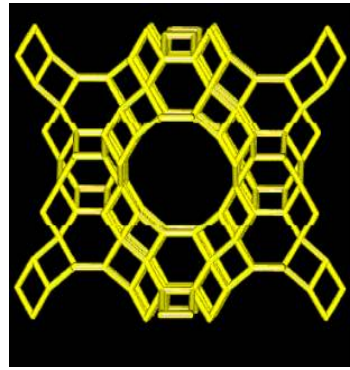


Fig. 4. Schematic of the structure of a zeolite.

Addition of nano-particles of palladium in zeolite cavities had a significant temperature effect observed in presence of deuterium gas, whereas no increase in temperature was observed in the presence of hydrogen [16].

#### G. Palladium in alumina

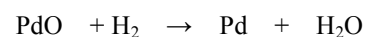
Excess heat was observed in an alumina powder impregnated with palladium upon loading of deuterium in the compound. No excess heat was observed when hydrogen is used [16].

## IV. DISCUSSION

Experiments by electrochemistry or in gas phase show that an insulated layer on the active metal plays an important role. In the first experiments performed by Fleischmann and Pons, Johnson-Matthey palladium was prepared under cracked ammonia:



Hydrogen converts oxides to H<sub>2</sub>O during melting



The palladium oxide is converted to H<sub>2</sub>O vapor, minimizing PdO in bulk palladium. This is probably the cause of the good success for excess heat in the first experiments of Fleischmann and Pons.

In the case of boron-doped palladium, the boron would react with and remove oxygen in the form of the substance,  $B_2O_3$ , which would skim off the metal surface during the arc-melting process. It is very possible that some boron remains on the surface as  $B_2O_3$ . This explains why it is not necessary to have a long-term electrolysis to form the surface oxide. Good reproducibility has been observed with this system.

Several experiments have shown that an insulating or oxide layer plays an important role in gas loading experiments.

## V. CONCLUSIONS

It seems important not to have any metal oxide inside the metal, whereas an oxide film at the surface of the metal is favorable for LENR. Excess heat has been observed in glass cells, but not in Teflon cells or polymer coated glass cells. In glass cells, a large loading time is necessary in order to build the oxide layer at the surface of the cathode, or by adding aluminum oxide powder in the electrolyte in order to build quickly the insulating layer.

The oxide layer has several roles, which can be important. On one hand, the electric field at the interface can be very high and create conditions for LENR. On the other hand, it is difficult to say if the reaction occurs at the interface, or at the near surface of the metal.

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