Energetic Particle Emission in Pd/D Co-deposition: An Undergraduate Research Project to Replicate a New Scientific Phenomenon

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Abstract The experiments described here were part of independent research projects done by different groups of upper division, chemical engineering undergraduate students over a three year period. The purpose of these experiments was to replicate track formation in solid state nuclear track detectors (SSNTDs) resulting from Pd/D co-deposition and to rule out a chemical origin for the tracks. The experiments took several weeks to run. Not only did the students learn about the importance of replication in science, they were introduced to metal electroplating and Faradaic efficiency as well as the use of solid state nuclear track detectors (SSNTDs) and their analysis using optical microscopes. The students also had the opportunity to use freeware programs to model tracks in SSNTDs and calculate linear energy transfer (LET) curves to determine energy loses of energetic particles as they traverse through matter. Most importantly, the experiments demonstrated the importance of using controls and simulations to test a hypothesis, especially for experiments that give unexpected, or anomalous, results whose origins are only understood later.

Keywords Replication, Reproducibility, Controls, Simulations, New Scientific Phenomena

1. Introduction

On March 23, 1989, Pons and Fleischmann announced that their Pd/D electrochemical cells were producing more heat than could be accounted for by chemical means. They speculated that the heat had a nuclear origin. Many laboratories world-wide attempted to replicate the Fleischmann-Pons results. Some succeeded but many more failed. Knowing that one of the key issues to initiate the effect was a high deuterium loading within the Pd lattice, our group developed the Pd/D co-deposition process. The original Fleischmann-Pons experiment electrolytically loaded a bulk Pd electrode with deuterium. Depending upon the size of the Pd cathode, this process could take weeks or months to fully load the Pd cathode with deuterium before the effect could occur. In Pd/D co-deposition, working and counter electrodes are immersed in a solution of palladium chloride and lithium chloride in deuterated water. To assure high deuterium loading in the palladium deposit, the counter electrodes must not absorb deuterium. When a current is applied, Pd metal plates out on the cathode in the presence of evolving deuterium gas and a high degree of deuterium loading (D/Pd ≥ 1) is achieved instantly [1, 2]. Using the Pd/D co-deposition process, we and others have reported, in peer-reviewed journals, on the production of excess heat [3-6], tritium [7-9], and energetic particles [10-16]. The process to generate energetic particles has been patented [17].

As was aptly demonstrated by the Fleischmann-Pons events in 1989, two necessary requirements to achieve acceptance in the scientific community of a new phenomenon are replications and reproducibility. To this end, we approached chemistry professors at a local university asking them if they would be willing to replicate our results of track formation in solid state nuclear track detectors (SSNTDs) as a result of Pd/D co-deposition. The professors thought it would be a good exercise for a group of their undergraduate students to do as part of their independent research project. So, over a period of three years, different groups of senior undergraduate students replicated our Pd/D co-deposition process and obtained tracks in solid state nuclear track detectors. Controls and simulations were done by the students to rule out a chemical explanation for the tracks. We provided the students with chemicals, a protocol, and copies of pertinent publications. The students conducted the experiments independently of us and came up with their