Calorimetry on Low Energy Nuclear Reactions (LENRs) in Hydrogen Pressurized Nanoparticles

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Background

This is a continuation of earlier work on LENR in metal hydrides[1].

We hypothesize that defects in metal hydride crystal structures could become sites for LENRs by becoming densely packed with hydrogen via chemical absorption.

By exciting packed hydrogen in crystal defects, the long-term goal of this project is to create and observe LENRs in metal hydrides.

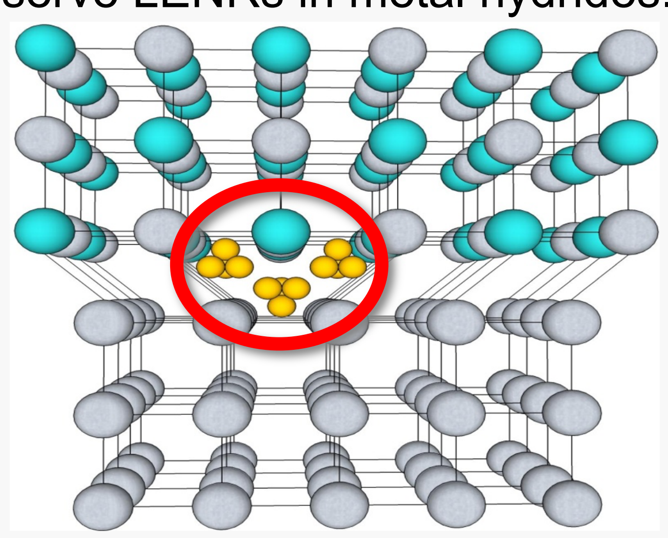

Figure 1: Defects in the $PdZrO_2$ crystal structure can house densely packed hydrogen.

[1] G. Miley, IH UIUC Lab LENR Team, "Study of a Power Source Based on Low Energy Nuclear Reactions (LENRs) Using Hydrogen Pressurized Nanoparticles," Tech Connect Conference, Washington, DC, Vol. 2, Tech Connect Briefs, 2017.

Reactor Anatomy

The reaction vessel consists of a heated and insulated vacuum chamber, a gas line that allows for pressurization and evacuation, two thermocouple probes to measure the temperature of the metal hydride nanoparticles, all insulated in an outer vacuum chamber to minimize heat loss. By measuring the heat input and the resulting temperature of the nanoparticles, we hope to find an indication of excess heat.

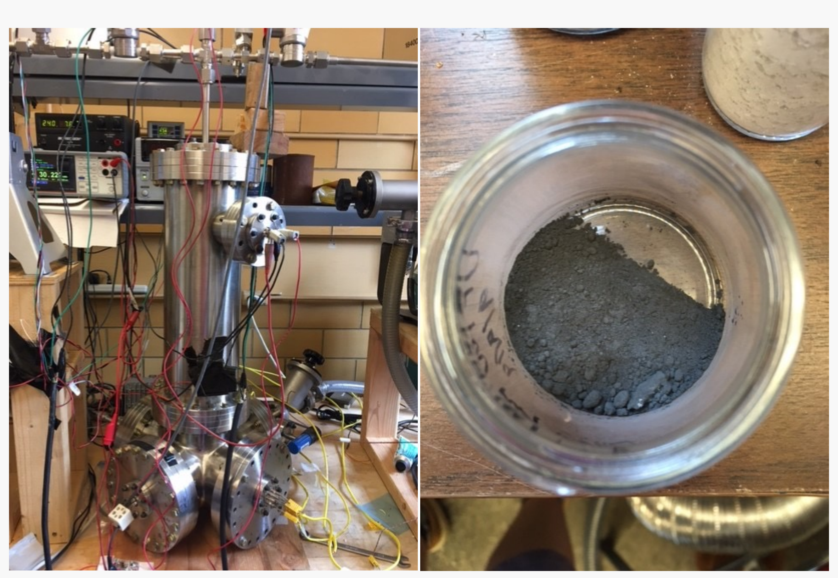

Figure 2: The reactor assembly inside the outer vacuum chamber (left). Nanoparticles used as potential reaction sites (right).

Experimental Features

When the reaction vessel is pressurized with hydrogen, a number of reactions affect the temperature of the nanoparticles. First, temperature varies proportionally to pressure according to the ideal gas law. Second, the chemical absorption of hydrogen into the nanoparticles releases heat. Third, Joule-Thomson cooling occurs in the gas as it expands into the reaction chamber. These processes reverse during depressurization.

We employed a convenient calorimetry to estimate excess heat caused by potential LENRs in the reactor. By converting the temperature signal to an equivalent input heater power signal, we could integrate to find the energies of each endotherm and exotherm.

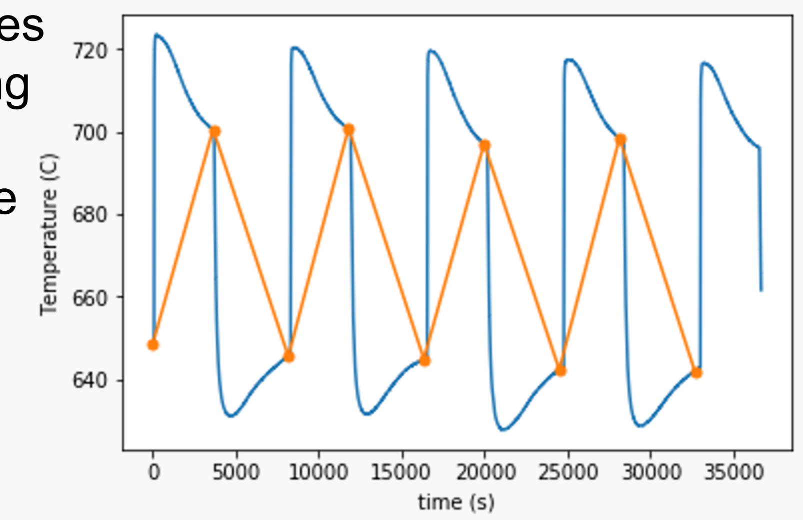

Figure 3: Temperature over time as the reaction vessel is repeatedly pressurized and depressurized. Pressurization and depressurization events are marked in orange.

Data Analysis

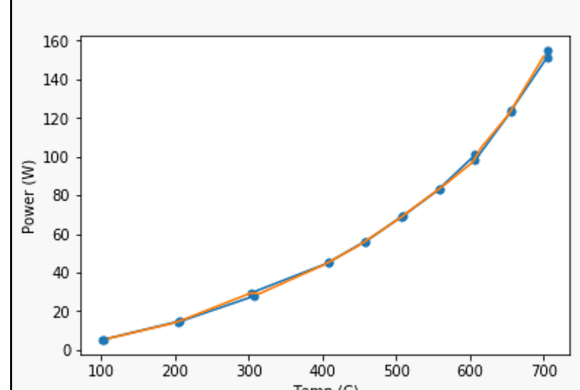

Figure 4: Input heater power versus nanoparticle temperature

We created two temperature to heater power conversion functions, one for a pressurized reactor (fig. 3), and one for a reactor under vacuum. We then subtracted the heat of each exothermic period and endothermic period from the input power to estimate their energies. In theory, an exothermic period would indicate excess heat if it was more energetic than its corresponding endothermic period.

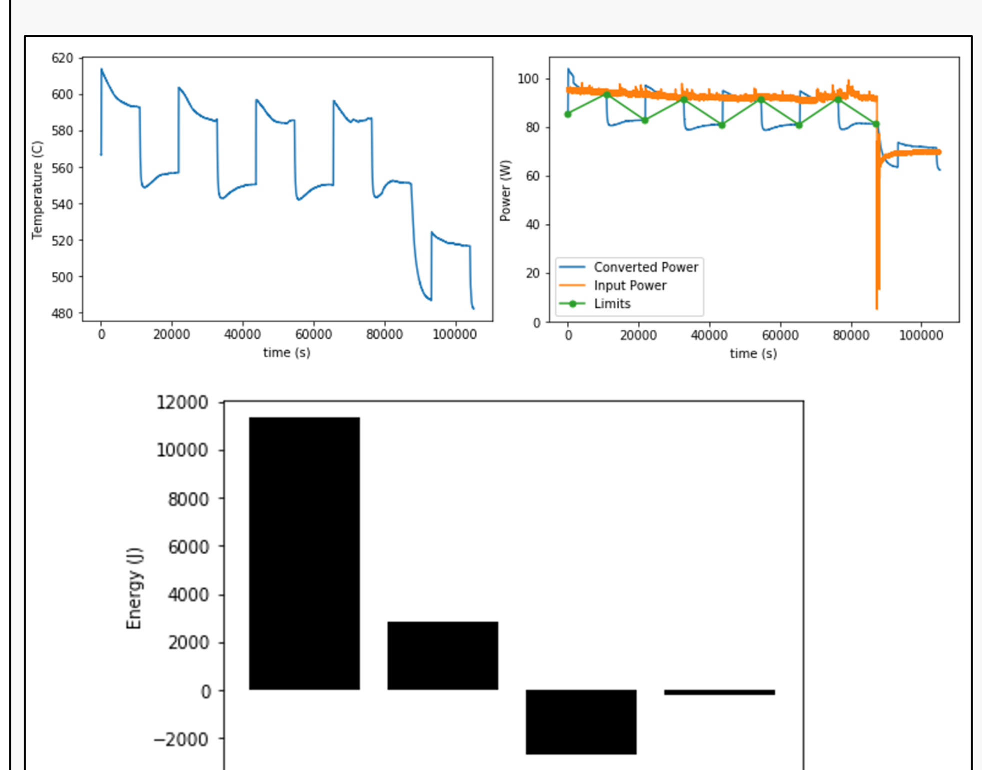

Figure 5: A temperature signal converted to a heater input power signal then integrated to get energy estimates of each exotherm.

Results proved difficult to interpret when we used this method of calorimetry for many experiments. One problem that arose in determining energy estimates was possible inaccuracies in our temperature equilibrium values for a given input heat in the process of converting temperature to heat (the baseline). Another is difficulty in determining when a given heat reaction has ended (the limits of integration).

Analysis of Variance

There are several important variables to consider in this series of experiments. There are two sets of particles: legacy $PdZrO_2$ (L) and unreactive (U). There are two gasses: hydrogen and helium. And the reactor was either pressurized or unpressurized. We only expect to see LENR under one set of conditions: legacy particles pressurized with hydrogen.

Our data was insufficient to show a full covariance matrix, but fig. 6 shows a positive covariance between legacy particles, high pressure, and temperature per watt (TPERW). This result could indicate excess heat, but not a significant amount, and not a very large amount. Future work will be focused on experiments that might find greater levels of excess heat.

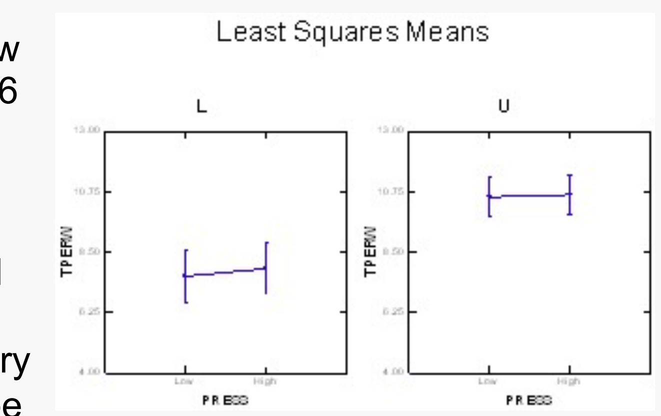

Figure 6: The thermal properties of the unreactive particles result in higher average TPERW, but the greater slope under legacy particles (L) a positive but statistically insignificant excess heat

Future Work

While we may be able to produce a more conclusive analysis of variance by collecting more data, the process would be time consuming, and the result would at best be a modest amount of excess heat. We'd prefer to find greater excess heat through other means, which would be both more exciting and easier to detect.

Our current and future work involves the schematic in fig. 7. By introducing various catalysts to the reactor, we hope to induce more energetic LENR events. Catalytic mechanisms include magnetic field pulses, high voltage sparking, RF pulses, acoustic shocking, etc.

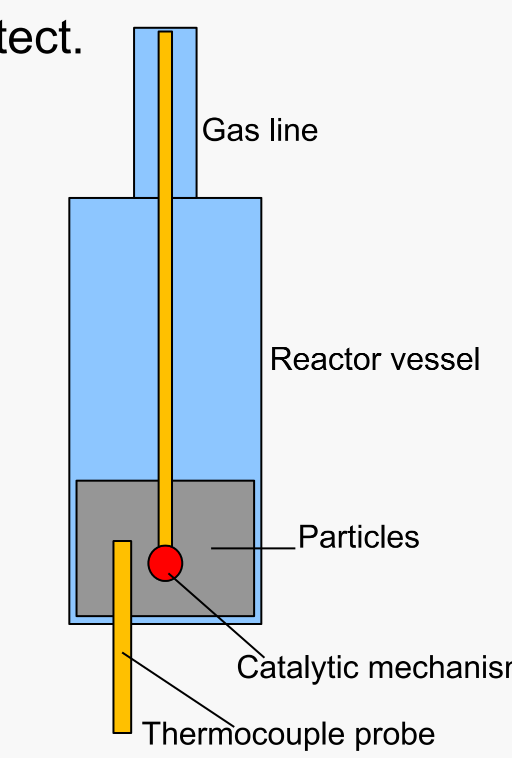

Figure 7: A schematic of the reactor including spark plug catalyst

Disclaimer: All excess heat claims have not yet been verified