Condensed matter nuclear reactions with metal particles in gases

Dennis Cravens[1,]*, Mitchell R. Swartz[2] and Brian Ahern[3]

[1]P.O. Box 1317, Cloudcroft, NM 88317, USA
[2]JET Energy, Inc. Wellesley, MA 02481, USA
[3]Acton MAS 01720

Various metals have been used by a number of researchers to study the condensed matter nuclear reactions occurring within the metal lattice when exposed to gases containing hydrogen, its deuterium isotope and various mixes. This article will give a brief overview of such studies.

Keywords: Activated carbon, gas loading, metal powders, nanoparticles.

Introduction

THIS article relates to the use of metal particles, metal powders and nanostructured metals which are loaded with an isotope of hydrogen to generate excess heat by active condensed matter nuclear reactions (CMNR).

Majority of the work in CMNR has focused on aqueous electrochemical methods. These reactions were first reported in aqueous LiOD on a palladium cathode driven by an applied electric field; but today, they involve palladium, nickel and other alloyed lattices and nanomaterials, loaded from both aqueous and gas phase. It has been long known that such reactions have a positive heat coefficient and thus supply greater yields at elevated temperatures[1]. Therefore, aqueous electrochemical systems are limited due to the boiling points of their solutions and the availability of their metal surfaces which lose material transport to the bulk due to contamination and low dielectric constant layers (bubbles). The use of gas-based, and combination, systems overcomes some of these limitations. There have been several approaches generating CMNR in gas-loaded systems. Researchers have used a wide range of configurations like wires, foils, layered foils, disks and powders[2–5], including loading by high-pressure gas applied to the metal surface and by ultrasonic[6] irradiation which loads the materials by collapse of bubbles. In addition, excess heat has been observed directly, and increases by diffusion of gas through foils of these materials, and by applied electric fields to these materials.

*For correspondence. (e-mail: physics@tularosa.net)

Metals

The size of nanostructured metals is key. The desired nanostructure islands of NiPdD have characteristic widths of 2–20 nm size. This nanostructure size is selected because it can react cooperatively, generating large-amplitude low-frequency oscillations. The characteristic width is between 7 and 14 nm. These size structures tend to be Raman-active, with the islands having anharmonic terahertz vibrations. Furthermore, the storage capacity decreases rapidly when the nanostructure size is greater 30 nm. It is not unreasonable to see rapid drop in LANR success if the sizes are larger than 20–30 nm. The vibrations of nanostructured metals, linked to size, are also important for activity. It is reported that some of the modes are so large that they can cause a sudden structural phase change to a lower free-energy state. This can cause difficulties. Fine metal particles sinter together at temperatures much lower than the melting point for the same bulk metal. This means that samples of metal particles can become less responsive to the gas interactions at high temperatures.

In some cases, materials are added to minimize such sintering. For example, in ZrO_2–PdNi–D LANR/cold fusion nanostructured metals, there is believed to be a composite distribution of nanostructured ferromagnetic ‘islands’ separated among a vast dielectric zirconia ‘ocean’. The dielectric zirconia embeds uncountable number of nanostructured metal alloy islands. Today, second and third generation nanostructured ZrO_2–PdD and ZrO_2–PdNiD powders, such as Zr 67% Ni 29% Pd 4% (by weight before the oxidation step), absorb a large number of deuterons for each nickel and palladium nuclei; with loading ratios that appear to be near 3.5, and perhaps higher.

Preparation of active nanostructured metals that are able to undergo preloading and are CF/LANR-active, requires pure materials. Contamination remains a major problem leading to rapid quenching. Potential toxicity must be considered. Nanostructured and nanocomposite materials have potential human and environmental health hazards. CF/LANR nanostructured metals include palladium powder, deuterated palladium-black, both as solids, as colloidal suspension and deposited on ceramics, glasses, fibres, membranes, aerogels and materials.

Another approach to avoiding sintering is to form the nano-scaled materials within a framework. Approaches include the use of carbon selected with pore sizes that match the desired metal sizes and the use of zeolites, or molecular sieve materials. Most of these use porous materials in metal salt solutions followed by chemical reduction. This restrains the metal particles to a predetermined size.

Results

Case

Leslie Case conducted some of the early studies on a significant gas-based system[7,8]. He approached the difficulties using a commercially available carbon based-catalyst. Case found that coconut shell-based catalysts containing 0.5–2.0% metals (Pd, Pt, Rh and Ir) actively produced excess heat at elevated temperature. The activated carbon containing lower percentages (i.e. 0.5% Pd) was preferred.

There was about 1000 sq. m surface area for each gram of Pd in such materials. His materials were designed with Pd on the surface of the carbon. Case prepared his material by cycling both the temperature and gas pressure to clean and reduce the sample. He found that excess power was produced when the material was heated between 130°C and 300°C. He conducted his experiments at around 2 bar of D_2 pressure.

Due to an untimely death, much of Case's later work went unpublished and unnoticed. However, one of the present author was able to access some of the devices and meagre notes. In his later devices, Case was producing supported Ni and Pd metals *in situ* by thermal decomposition of organometalics. Additionally, he found movement of the gas added in the reactions and had begun acoustic stimulation to create gas fluxes at the metal surfaces. McKubre *et al.*[9] were able to detect He-4 levels produced by one of Case's devices that were consistent with the energy production assuming a D + D to He-4 reaction.

Arata and Zhang

Arata and Zhang[10] and later others[11] have successfully generated excess heat by gas loading of nano-scaled powders. He-4 has been observed from such arrangements[12]. Many of these use Pd held within a zirconium oxide-based structure, but others have successfully used palladium black powders alone[13,14]. These studies indicate that fine particles and allowing separation of particles for ease of gas reactions are beneficial for excess heat.

Cravens

Cravens and Gimpel[15] made a demonstration using Pd and later Ni held within the pores of activated carbon. The metal was deposited by chemical reduction into the pores which limits the size of the particles to a preselected one (ranging from a few nanometres to a few microns). In the case of Pd, Y and Au were added to reduce the energy of vacancy of formation of the material and to increase the gas diffusion rate through the material. In the case of Ni, Pd, Th and Ce were added after the initial chemical reduction to allow for greater gas dissociation and loading rates. Some samples were observed to be self-heating, but only when placed within a heated environment above 80°C. The net heat production seems to be exponential in temperature.

Swartz

Swartz discovered that the development of more reproducible nanostructured CF/LANR components is directly linked to improved materials, with complete avoidance of low-threshold electrical breakdown states with their CF/LANR quenching tendencies. Control of these breakdown states and quenching tendencies is critical and also requires surmounting the extremely high electrical resistances (as high as hundreds of gigaohms) of these nanomaterials and their complicated polarization/transconduction phenomena, including an electrical current 'avalanche (transconduction electrical breakdown) effect', which has a critical negative role on excess heat generation[16–18]. Swartz has successfully conducted extended demonstrations at MIT, of heat generation about 20 times the input power supplied to his sample. These are electrically stimulated samples containing ZrO_2 and Pd that have been preloaded with deuterium and sealed.

Ahern

Ahern[19] was able to produce 8 W of thermal energy for 4 days from 10 g of metal nanopowder. The original material was Zr66%–Ni21%–Cu13% that was baked to form zirconium oxide. Nickel holds great promise in the area of CMNS; however, it is hard to load since hydrogen does not easily dissociate at its surface. It is useful to add a catalyst to promote the dissociation. Cu is one such material. Others include Pd, Th, Ce, Zr and to a lesser degree Fe and various rare earths.

Biberian

Biberian and Armanet[20] have investigated the reactions of Pd powders held within Pd diffusion tubes and observed excess heat from such configurations.

Others

Other groups are also involved in this area of research[21] and are covered in separate articles in this special section of *Current Science*. Notable among these are Kitamura and Takahashi[22] and Kidwell *et al.*[23].

Commercial work

Lenuco and his group has tested a small unit at yielding 350 W/kg under room temperature when using deuterium (D_2 at 4 bar) with 23 g of Pd-rich nanoparticles. The unit produced a net of 1479 J of heat. They are hoping to develop a 3–30 kW system.

PointSource of California is now working on a zirconium oxide-based ceramic material and other refractory oxide materials bearing nanoparticles of Pd and/or Ni. They are currently studying materials and configurations. They have successfully had a patent granted on the use of Pd and Ni held in a ceramic matrix for the case of alpha (i.e. helium 4) production[24].

Nanortech, Inc. (Massachusetts) has developed a small-scale 'NANOR' that produces power gain up to the watt level. It uses $Pd/ZrO_2/D$ and $Ni/ZrO_2/D$ and material that is electrically excited and yields very high energy densities of more than 19,500 W/kg of nanostructured material[10].

Leonardo Corporation (A. Rossi) has claimed the production of kilowatt levels of thermal energy released from a nickel-based material using proprietary processing. The technology of Rossi has been acquired by Industrial Heat. His original demonstrations were met with skepticism and a new independent testing of his devise was released during the writing of this paper[25]. The exact details of his materials and methods are not yet public. The recent report indicates that Rossi may be observing a depletion of natural abundance Ni isotopes and the production of Ni 62 and a depletion of Li^7, as well as substantial heat. His working temperatures are in the 1000°C range. It is too early to verify and critically analyse this new report.

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