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Synthesis of Nanoporous Palladium Powder with Controlled Pore and Particle Size for Hydrogen Storage Applications

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Materials capable of rapidly storing and delivering hydrogen are currently in demand for numerous energy applications. The high surface area exhibited by nanoporous palladium has the potential to greatly improve its kinetics of hydrogen charge and discharge versus nonporous metal while retaining favorable operating temperatures, pressures, and volumetric capacity. In addition, the void space imparted by porosity should accommodate the volumetric expansion of palladium upon hydriding, mitigating plastic deformation and improving cycle life.

By chemically reducing palladium salts in the presence of various surfactants, we are able to synthesize palladium powders having size-tunable mesopores from a few to tens of nm, in a scalable fashion. Our results suggest that Pd nanoparticles form and sinter around micelles present in the aqueous media. Changing the size of the surfactant molecules affects the size of these micelles and ultimately determines the pore dimensions. We demonstrate that pore size affects not only surface area, but also pore thermal stability under vacuum, and in the presence of hydrogen gas.

In addition to pore geometry, particle size and shape are important factors in determining gas flow characteristics. Using nonporous copper particles as sacrificial reductants for palladium salts, in the presence of surfactants, we are able to synthesize micron-sized particles of uniform size and shape. This is in contrast to continuous aggregates and films that are obtained using soluble chemical reductants or planar electrodes.

We will present details of the synthesis of nanoporous palladium, demonstrating control of both pore and particle size. Bulk measurements of hydrogen storage properties and pore characteristics, as well as microscopic measurements, including in situ heated-stage TEM under vacuum and in the presence of hydrogen, will be included, as well as details on the kinetics of hydriding/dehydriding.

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