The Effects of Surface Composition and Microstructure on the Hydrogen Uptake Properties of Alloys

Michael D. Hampton*, Janice K. Lomness*[a], and Lucille Giannuzzi[a]

University of Central Florida

*Department of Chemistry

[a]Department of Mechanical, Aerospace, and Materials Engineering

Orlando, FL 32816

In order for hydrogen to be used as a fuel, it is necessary that safe and efficient storage methods be developed. Storage of hydrogen in the solid state by reacting it with metals, metal mixtures, and alloys to form metal hydrides is very promising. In fact, this type of storage has been shown to provide a greater volumetric efficiency for storing hydrogen than either the liquid or gaseous form of the pure element.

The hydrogen storage characteristics of metals and alloys depend on many factors. Among those factors are the nature of the surface and the microstructure of the material. The effects of the surface composition of the magnesium nickel alloy, Mg2.35Ni, on its hydrogen storage characteristics will be discussed. Mechanically alloyed mixtures of Ti, Mg, and Ni will be used to illustrate the effects of microstructure.

Magnesium nickel alloy has a large hydrogen capacity, is environmentally benign, and forms a very stable hydride. The major hurdle in the application of this alloy for hydrogen storage applications is the difficulty of activating it for the initial hydrogen uptake. This difficulty has been attributed to the surface of the alloy. It is believed that an oxide coating is responsible for rendering the alloy unreactive with hydrogen. Thus water and oxygen have long been considered undesirable substances that are to be excluded if the alloy is to react with hydrogen. In this lab, we have demonstrated that in fact water quickly and completely activates magnesium nickel alloy for initial hydrogen uptake and also favorably affects uptake and release temperatures. Furthermore, for the first time we have shown the presence of hydroxides on the surface of an active alloy.

The hydrogen interaction properties of mechanically alloyed mixtures of Ti, Mg, and Ni have been shown to be strongly dependent on the time and energy of ball milling. Mixtures ball milled at a ball to powder ratio (by mass) of 70:1 were able to absorb up to 11 wt % hydrogen. The dependence of hydrogen uptake on ball milling time and energy as well as microstructural data will be presented.