Synthesis of Nano-Light Magnesium Hydride for Hydrogen Storage

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ABSTRACT

Nano-light magnesium hydride that has the capability for hydrogen storage was synthesized from treatment of magnesium ribbon with hydrogen peroxide. The optimum time for complete hydrogenation of the magnesium hydride was 5 hours.

INTRODUCTION

It's widely believed that hydrogen will within a few years to come, become the fuel that would power most vehicles and portable devices due to the depletion in oil reserve and relative facile production of hydrogen from raw renewable elements. As concerns over air pollution and global warming increases the incentive to switch to clean and efficient hydrogen economy becomes greater and the transmission may occur well before oil reserves are depleted completely.

Metal hydrides with light element have large gravimetric hydrogen densities. However the high work temperature (thermodynamic stability) and the slow reaction rate (high activation energy) limit the practical application of the chemical hydride systems[1]. These properties may be improved by nano-composite materials. The Nano-composite materials for hydrogen storage encompass a catalyst and composite chemical hydride at a nano-scale. The catalyst increases the reaction rate. With regard to the catalytic enhancement of the hydrogen absorption and desorption properties of MgH_2, the most successful catalyst found to date appears to be Nb_2O_5. The hydrogen desorption rates obtained using various oxide additives[2]. The reasons for the enhanced absorption and desorption rates are not yet understood and it is possible that the additives do not act catalytically but instead induce further MgH_2 particle or grain size reduction during the milling process[3]. The hydrogen absorption kinetics is accelerated by the nano-sized material and they may change the thermodynamic stability of the material[4]. Hydrogen storage material absorbs hydrogen more dense than liquid hydrogen under moderate pressure and temperature. Today metal hydride compounds are widely used in rechargeable Ni-MH batteries. Many scientific and engineering studies have been carried out on

absorption and desorption of hydrogen in metals and development of such storage devices[5]. Daimler-Benz produced in the early 1980s a car fuelled by hydrogen, where the storage tank was chunks of FeTi metal alloys. The volume of this storage device was less than a factor of 2 greater than equivalent gasoline but the problem encountered was that the hydride was 20 times heavier than normal gasoline. The reviews of Huot et al., (2001)[6] and Zaluska et al., (2001)[7] show the improvement in the kinetics at 573 K, for example. However, alternative methods of producing nanoscale magnesium have also been reported[8,9] and include an electrochemical synthesis method reported recently by Aguey-Zinsou and Ares-Fernández (2008)[10], which results in an average particle size of approximately 5 nm.
When metals/chemical hydrides are mixed with water, they will produce quality hydrogen.

$$MgH_2 + 2H_2O \longrightarrow Mg(OH)_2 + 2H_2$$

Considering a recyclable process, one of the important issues is the ability to regenerate the hydride by heating at high temperature.

MATERIALS AND METHODS

Synthesis of hydride

Ten grams of magnesium metal ribbon was weighed and transferred into a stainless steel pot. 50 cm^3 H_2O_2 was added to the stainless steel pot containing the magnesium metal. The steel pot with contents was transferred to a furnace maintained at 750^oC. The magnesium reacted with hydrogen peroxide as shown below.

$$Mg + H_2O_2 \longrightarrow MgH_2 + O_2$$

The crystals formed were placed in a crucible and kept in a muffle furnace maintained above 800^oC in the absence of air. The crystals were pulverized and subsequently heat treated at 800 ^oC in order to obtain homogeneous and nano sized particle materials.

Hydrogen absorption

1g of the pulverized MgH_2 sample was hydrogenated at time interval of 43 minutes for up to 5 hours and a temperature of 80^oC. The procedure was repeated for 2g, 3g, 4g, 5g and 6g of the pulverized sample.

X-ray powder and single crystal diffraction

X-rays are scattered by the electrons surrounding the nucleus of the atom in the crystal. The scattering factor for each atom is to a first approximation directly proportional to the number of the electrons surrounding the nucleus. The contribution from the hydrogen atoms in the x-ray diffraction (XRD) patterns are therefore very small compared to the heavier metal atoms.
Hence, XRD pattern measurement was done for pure magnesium and magnesium hydride for 2g, 3g and 6g being hydrogenated for 2 hours, 3 hours and 5 hours respectively.

XRF analysis

The XRF analysis was carried out to determine the other elements that may be

present in magnesium as part of its structure, and other impurities incurred during the synthesis of the hydride. XRF analysis shows the percentage of the elements present.

RESULTS AND DISCUSSION

The XRF analysis of the magnesium sample confirmed its association with Al and Si as shown in Table 1.

XRD analysis

The XRD patterns for the hydride after hydrogenation for 2g [a], 4g [b] and 6g [c] at different times of 2 hours, 3 hours and 5 hours respectively, were measured. X-ray diffraction measurements of the powder of both magnesium and magnesium hydride were conducted on a D max 2400 diffractometer. For the hydride hydrogenated for 2 hours a few peaks corresponding to magnesium hydride were observed. On increasing the time for hydrogenation to 3 hours, more hydride phase was formed and at 5 hours of hydrogenation, magnesium was completely transformed to magnesium hydride. X-ray diffractogram of Mg and MgH_2 is shown in Figure 1.

XRD pattern measurement for pure magnesium which is the mother component and magnesium hydride is shown for (a),(b) and (c) corresponding to 2g, 3g and 6g being hydrogenated for 2 hours, 3 hours and 5 hours respectively. The synthesized magnesium hydride was found to be effective in the absorption of hydrogen which desorbed efficiently to release the hydrogen.

Table 1: XRF analysis of Mg crystal

Element	**Mg**	**Al**	**Si**
% composition	**71.5**	**17.4**	**11.1**

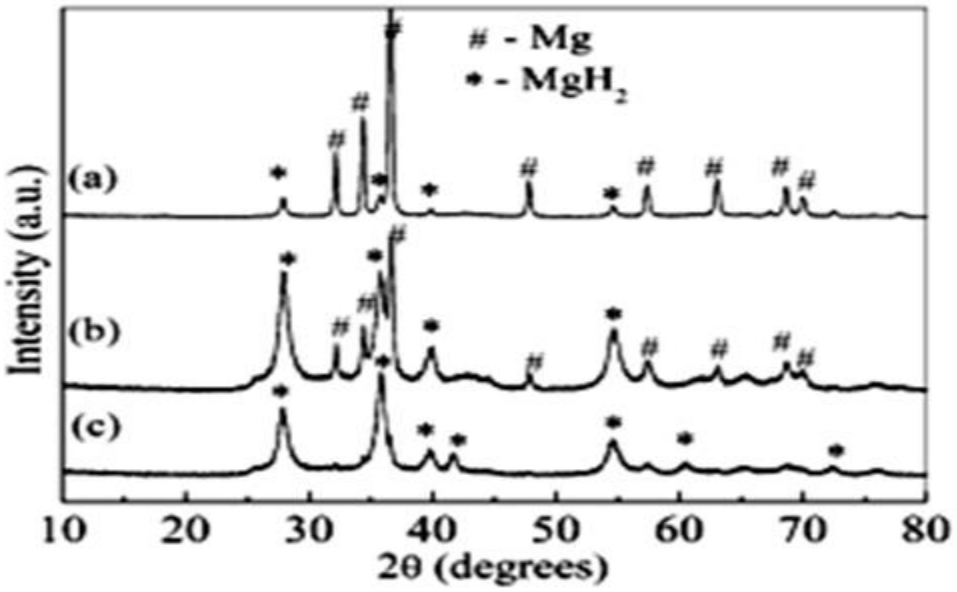

Figure 1: XRD Pattern showing peaks corresponding to magnesium and its hydride

CONCLUSION

Nano-light magnesium hydride that has the capability for hydrogen storage was synthesized.

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