Metal hydrides for hydrogen storage at low charging pressures

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Abstract

$LaNi_5$ alloys are been extensively study as hydrogen storage material due their easy activation and good kinetics. $LaNi_5$ alloys, containing substitutional elements such as Al or Ce, allow adjustments of the equilibrium pressure and absorption kinetics of the metallic hydrides making them storage candidate materials susceptible to be used in fuel cells systems. In this work, the thermodynamic properties of $LaNi_{5-y}Al_y$ and $LaNi_5$, $La_{1-x}Ce_xNi_5$ alloys were evaluated using a purpose built Sievert-type apparatus.

Keywords: *Hydrogen Storage, Metal Hydrides, $LaNi_5$ type Alloys*

1 Introduction

The development of a safe and efficient way to store hydrogen that may exhibit good gravimetric and volumetric efficiencies is considered instrumental to hydrogen utilization as an alternative to fossil fuels.

Research efforts multiply with the objective of developing storage materials for hydrogen to comply with DOE targets for 2010 (mobile applications):

- System gravimetric capacity 2 kWh/kg
- System volumetric capacity 1.5 kWh/L
- Storage capacity 6 wt%
- Operating temperature –30 to +50ºC
- Recharging time 5 min
- Charging rate 1.5 KgH_2/min
- Retrieved hydrogen 90%
- Cycle life 1000 cycles

Furthermore, cost, safety and ease of production must be considered when evaluating storage options. Currently, no available system satisfies the requirements for wide scale acceptance.

The metallic systems that allow reversible absorption/desorption of hydrogen, at compatible temperatures and pressures suitable for practical applications, are centred on metallic hydrides.

Metallic hydrides are one of the most studied storage options, for applications where weight is not an issue, representing more compact systems (by factor of 3x) when compared with high pressure compressed gas.

AB_5 type intermetallics are within the most studied alloys because the hydrides are easily activated, forming small particles, which readily absorb and desorb hydrogen, even at low temperatures. They also have a good kinetics and tolerance to gaseous contaminants [1-2]. On the other hand, slow decomposition with successive cycles of absorption/desorption and a low hydrogen capacity (~1.28 wt% of reversible capacity) are included within the limitations.

$LaNi_5$ alloys, containing substitutional elements such as Al or Ce, allow adjustments of the equilibrium pressure and absorption kinetics of the metallic hydrides [3-4] making them storage candidate materials susceptible to be used in fuel cells systems.

In this work, the thermodynamic properties of $La_{1-x}Ce_xNi_5$ and $LaNi_{5-y}Al_y$ alloys were studied.

2 Experimental and Results

Using a purpose built Sievert-type apparatus [5], the thermodynamic properties and the absorption/ desorption capacity of $LaNi_5$, $La_{1-x}Ce_xNi_5$ and $LaNi_{5-y}Al_y$ alloys, were studied.

$LaNi_{5-y}Al_y$, absorption/desorption cycles were implemented for alloys with different contents of Al ($0 \geq y \leq 0.4$) and at different temperatures.

Figure 1 shows the obtained Van't Hoff diagram for a family of $LaNi_{5-y}Al_y$ alloys.

The increase in aluminium content in $LaNi_5$ alloy decreases the equilibrium pressure of the hydride. It is evident that the Al content in the alloy increases the enthalpy of formation and therefore the stability of the metal hydride, consequently smaller pressures are needed to charge the alloy but higher temperatures are required for desorption. The alloys can absorb hydrogen at sub-atmospheric pressures at ambient temperature.
A slight decrease in the hydrogen storage capacity was noticed.

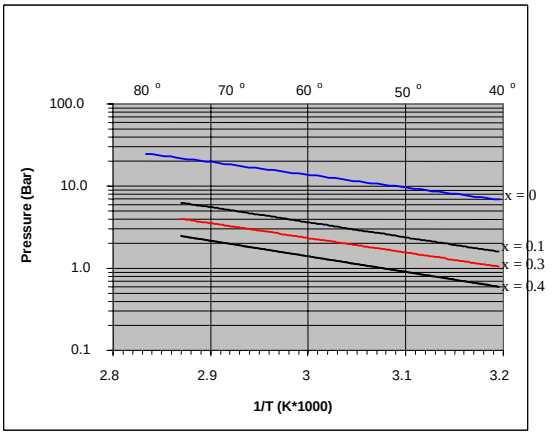

Fig. 1 Van´t Hoff plot for $LaNi5_{-x}Al_x$ ($0 \geq x \leq 0.4$) type alloys.

In the case of cerium additions to $LaNi_5$ it was evident that the stability of hydrides is reduced, characterized by increasing equilibrium pressure and hysteresis. The additions have no effect on hydrogen storage capacity. Larger hydrogen pressures are necessary for absorption but desorption can be achieved at near room temperatures.

References

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