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Development of Mg-alloy for hydrogen storage and processing by severe plastic deformation

G. F. de Lima(1)*, F. L. R. Oliveira(2); C. S. Kiminami(2); W. J. Botta(2) and A. M. Jorge Junior(2)

(1) Post Graduation Program in Science and Materials Engineering, Materials Engineering Department, Federal University of São Carlos, Rod. Washington Luiz, Km235, São Carlos-SP-13565-905, Brazil.
(2) Materials Engineering Department, Federal University of São Carlos, Rod. Washington Luiz, Km235, São Carlos-SP-13565-905, Brazil.

Abstract – In this work we describe the production of Mg-powder hydrides through reactive milling under hydrogen atmosphere, followed by the investigation of the powders consolidation by severe plastic deformation (SPD) using the torsion method (high pressure torsion-HPT). X ray diffraction (DRX) patterns of both samples (powder and HPT) indicated the following phases: Mg, Fe, MgH_2 and Mg_2FeH_6. The first de-hydrogenation reaction was studied by differential scanning calorimetry (DSC), revealing that the hydrogen desorption temperature of both samples are very close with significant temperature reduction in comparison with commercial MgH_2.

Mg-based hydrides are promising solid-state materials for hydrogen storage, being more effective and safe storing media than pressurized or liquefied hydrogen. The H_2 storage capacity in MgH_2 is about 7.6 wt% and about 5.5 wt% in Mg_2FeH_6. The latter has the highest known volumetric density (150 kg H_2/m^3). However, these alloys present high desorption temperatures and slow desorption kinetics. High energy ball milled (HEBM) nanostructured and nanocomposites materials exhibit higher storage capacities and faster sorption kinetics than conventional materials [1-3]. In addition, severe plastic deformation (SPD) have been shown as a promising route to produce bulk Mg-alloys for hydrogen storage due to the improvement in the activation process, chemical stability, and kinetics [4-8]. In this work, powders from a mixture of 46.6Mg-53.4Fe (at.%) were synthesised in hydrides by reactive ball milling using a SPEX high energy ball mill, with ball to power ratio of 40:1, under 3 MPa of H_2. Disks of the resulting powder were processed by high pressure torsion (HPT), by applying 5 turns at 5 GPa. Powder and HPT samples were characterised using a Rigaku X-ray diffractometer and the phases were identified as: hc-Mg, bcc-Fe, Mg_2FeH_6 and MgH_2, in both samples. After HPT processing the grain refinement was not significant and Mg_2FeH_6 presented (220) preferred orientation, which was expected due to the high deformation imposed. The first de-hydrogenation reaction was studied by calorimetry in a Netzsch DSC 404 equipment. This analyses revealed that the hydrogen desorption temperature of both powder and HPT samples are very close (~318^{o}C, Fig. 1-a) and that the reduction of desorption temperature was quite significant (~131^oC) when compared with commercial MgH_2 (Fig. 1-b). This behaviour was correlated with the effect of Fe in the Mg matrix.

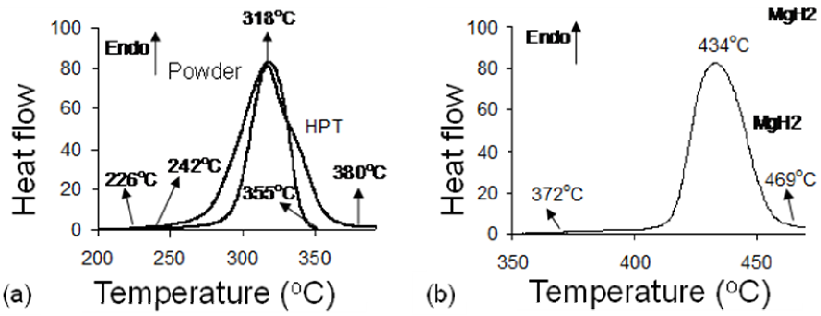

Fig. 1 – DSC curves: (a) comparison between powder and HPT sample, and (b) commercial MgH_2.

References

[1] Sakintuna B, Lamari-Darkrimb F and Hirscher M 2007 *Int. J Hydrogen Energy*. **32** 1121 –40.
[2] Porcu M, Petford-Long A K, Sykes J M 2008 *J. Alloys Compd.* **453** 341-346.
[3] Hanada N, Hirotoshi E, Ichikawa T, Akiba E, Fujii H 2008 *J. Alloys Compd.* **450** 395-399.
[4] Lima G F, Jorge Jr A M, Leiva D R, Kiminami C S, Bolfarini C, Botta W J 2009 *J. Phys.: Conf. Series* **144** 012015
[5] Ueda T T, Tsukahara M, Kamiya Y and Kikuchi S. 2005 *J. Alloys and Compd.* **386** 253-57.
[6] Dufour J and Huot J 2007 *J. Alloys and Compd*. **439** L5–L7.
[7] Takeichi N, Tanaka K, Tanaka H, Ueda T T, Kamiya Y, Tsukahara M, Miyamura H and Kikuchi S 2006 *J. Alloys and Compd.* in press.
[8] Kusadome Y, Ikeda K, Nakamori Y, Orimo S and Horita Z 2007 *Scripta Materialia.* **57** 751-53.