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Nanoscale grain refinement of commercial MgH_2 powders using different mechanical processing routes

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Abstract – In this work, we have used different mechanical/metallurgical processing routes to produce MgH_2-based nanocomposites with lower cost than the more studied high-energy ball milling (HEBM) procedures. Promising results were obtained in terms of microstructural refinement and H-sorption kinetics improvements.

Magnesium is light, abundant and it can store up to 7.6 wt. % of hydrogen forming MgH_2 and therefore it is a promising material for H_2 storage. However, the H-sorption of conventional Mg occurs at high temperatures (~400°C) with slow kinetics.

Mg or MgH_2-based nanocomposites prepared by high-energy ball milling (HEBM) have been studied in the last few years to overcome these limitations [1-3]. The particle and grain size reduction of Mg or MgH_2 to the nanometric scale and the addition of so-called catalysts as transition metals (among others additives) can promote fast kinetics at around 300°C or even lower temperatures.

Severe plastic deformation (SPD) processing techniques are now being explored as an alternative to long duration HEBM in order to obtain more air-resistant materials and to reduce the processing times [4, 5].

In this work, we report on the preparation of compacts of nanocrystalline MgH_2 and MgH_2-based nanocomposites from commercially available microcrystalline MgH_2 powders using different mechanical/metallurgical processing routes performed at the ambient temperature: pressing, rolling, forging and high-pressure torsion (HPT).

Structural analysis was carried out by X-ray diffraction (XRD), transmission and scanning electron microscopy (TEM and SEM).Thermal analysis was performed by differential scanning calorimetry (DSC) coupled to thermogravimetric analysis (TG) and mass spectrometry. H-sorption kinetic measurements were made in a Sievert's apparatus.

The typical microstructure of the compacts consists of nanometric MgH_2 crystallites with a very fine dispersion of the additives (transition metals and transition metal fluorides). The observed improvements in H-sorption kinetics indicate the potential application of the prepared compacts in hydrogen storage, using or not a subsequent short-time processing by HEBM.

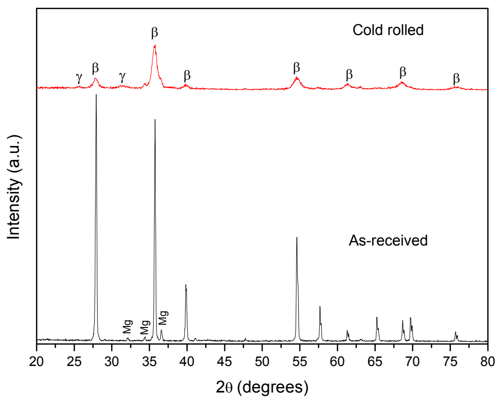

Figure 1 XRD diffraction patterns of the as-received commercial MgH_2 powders and of the compacts produced by cold rolling. In the cold rolled sample, a small amount of the metastable γ-MgH_2 phase is present. The β-MgH_2 hydride is highly oriented accordingly to (101) and presents a crystalline grain size of 20 nm, as estimated by Scherrer analysis.

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