Pushing the limits: reversible H2 exchange in Mg-Ti-H nanoparticles in the 100-150°C range

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Abstract

Nowadays, the development of efficient energy storage systems that make use of light and non-expensive materials is drawing attention for application such as seasonal energy storage and onboard hydrogen storage in heavy vehicles. The holy grail for practical implementation is a system that exchanges hydrogen at room temperature at pressure close to the ambient one.

Mg-based H_2 storage systems partly fulfill these requirements showing high volumetric and gravimetric H_2-storage capability. The main drawbacks of MgH_2 are the high stability ($\sim -74 kJ/molH_2$) and the sluggish sorption kinetics. As a strategy to overcome these limits, nanostructuring and mixing with catalytic additives (such as Nb_2O_5, Pd, TiH_2) by ball milling has been successfully demonstrated to accelerate H_2 exchange kinetics, but still in the 200-350°C temperature range.

In this work, a study of the thermodynamics and kinetics of H_2 sorption by Mg/MgH_2 in the 100-150°C range is presented. We are able to investigate this unexplored range tanks to a novel concept of nanocomposite (Mg-Ti-H) in which TiH_2 and MgH_2 coexist at the single nanoparticle level, determining remarkably fast H_2 sorption kinetics [1]. These Mg-based materials can complete the H_2 absorption in minutes (up to 4.8 wt%) and fully release it in 1-2 hours in the <150°C range without the addition of expensive noble metal catalysts [2]. In this temperature window, the measured equilibrium pressures are slightly above those of bulk Mg and increase with the Ti content[3]. Furthermore, the stability against coarsening and the transformation rates increases with the Ti content in the nanocomposite at the expenses of H_2 gravimetric capacity.

We critically evaluate the influence of nanostructure, morphology and phase mixing at the single nanoparticle level on the equilibrium and kinetic properties of H_2 sorption. The proposed nanocomposite opens an unexpected window for Mg-based reversible hydrogen storage close to ambient temperature.

Bibliography

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