Enhanced Hydrogen Storage in Mg Thin Flakes with dispersed Ni Nanoparticles prepared by High Energy Ball Milling.

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Hydrogen, with its high energetic density (119.7 MJ/kg) and facile production through water electrolysis, is a viable alternative energy source. Nevertheless, its low volumetric density and high flammability present challenges for mobile applications [1]. In response, solid-state storage of hydrogen using metal hydrides has emerged as a promising solution for secure transport and storage of this energy carrier, facilitating its utilization as a clean fuel source [2], [3]. Magnesium, with its low density, natural abundance, affordability, and reversible hydrogenation/dehydrogenation capabilities, stands out as one of the most promising metals for this purpose [4]. However, optimizing its thermodynamics and kinetics for practical applications remain a challenge [5]. Researchers have explored modifications, including morphological changes and nanoparticle additions via high-energy ball milling (HEBM). While these alterations show improvements in hydrogen storage properties, they often negatively impact gravimetric capacity, theoretically set at 7.6 wt.% for pure Mg [6]. Achieving this full capacity is rare due to limitations in reaction mechanisms, such as the sluggish diffusion of hydrogen through the newly formed MgH_2 on the surface of Mg, leading to capacities below 4 wt.% [7]. Hence, a systematic approach that includes both morphological modifications through HEBM and the addition of Ni nanoparticles to pure Mg could help to improve the gravimetric capacity of commercially pure Mg and kinetics of absorption.

In this research, we propose a novel two-step method of surfactant assisted HEBM to synthesize Mg thin flakes with a thickness of 260 ± 67 nm. This method enables a storage capacity of ~4.8 wt.% hydrogen at 350°C and 20 bar, owing to the combination of interfacial effects and the shortening of diffusion pathways in one dimension for hydrogen atoms [8]. This showcases the potential use of this flake-like shaped Mg for efficient hydrogen storage. Additionally, the dispersion of Ni nanoparticles (5 wt.%) on the surface of Mg ultra-thin flakes leads to a reduction in the time for maximum absorption from 5 min to 3 min, at the expense of a slight decrease in the hydrogen uptake capacity to approximately 4.5 wt.% at 350°C and 20 bar. A Sieverts-type apparatus of our own design and construction is employed for pre-activation and sorption/desorption tests; SEM-EDS analysis is conducted to characterize the morphology and elemental composition of the samples before and after hydrogen tests. During the activation process, the formation of the complex Mg_2NiH_4 phase is observed through XRD analysis, suggesting potential for lower hydrogenation temperatures and improved thermodynamics for the system [9]. Ni nanoparticles could potentially act as both catalysts and thermodynamic destabilizers of the obtained Mg thin flakes.

KEYWORDS

Magnesium flakes, Nickel nanoparticles, Hydrogen storage materials

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