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Hydrogen Storage and Generation Through Nanoparticlised Metal Hydrides

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ABSTRACT

Hydrogen, as a clean and efficient energy carrier, has garnered significant attention in the quest for sustainable energy solutions. This abstract explores the promising avenue of hydrogen storage and generation through nanoparticlised metal hydrides, a cutting-edge approach aimed at addressing the limitations of conventional storage methods. Basic well-known hydrogen storage methods, such as physisorption and liquid hydrogen storage, have proven inadequate in terms of efficiency, safety, and practicality. Furthermore, the high-pressure hydrogen storage technique is often impractical due to safety concerns and the energy-intensive compression requirements. In contrast, the utilization of nanoparticlised metal hydrides offers a unique opportunity for safe, compact, and reversible hydrogen storage. In addition, this abstract delves into the novel concept of hydrogen generation from magnesium hydride through the use of organic acids, a groundbreaking innovation that further enhances the practicality and sustainability of the metal hydride approach. Such advancements hold great promise for unlocking the full potential of hydrogen as a clean energy source, facilitating its integration into diverse applications and contributing to a greener, more sustainable future.

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Introduction

Hydrogen storage encompasses a diverse range of technologies, especially vital for portable applications, where the selection of a suitable technique demands a balance of safety, lightweight properties, high storage capacity, and cost-effectiveness. Four primary hydrogen storage methodologies are recognized: physisorption, liquid storage, high-pressure storage, and chemical-bond storage.

Physisorption storage involves retaining hydrogen molecules on a material's surface via Van der Waals forces without dissociation. Carbon nanotubes exemplify this method, albeit being an immature and costly process. Current research indicates a hydrogen storage capacity of less than 1 wt% under ambient conditions. Liquid storage necessitates cooling hydrogen to 20K and storing it in cryogenic tanks, offering a substantial capacity of 70.5 kgHm-3, surpassing the 25 kgHm-3 of pressurized hydrogen storage. However, drawbacks include low process efficiency and the need for additional insulation equipment.

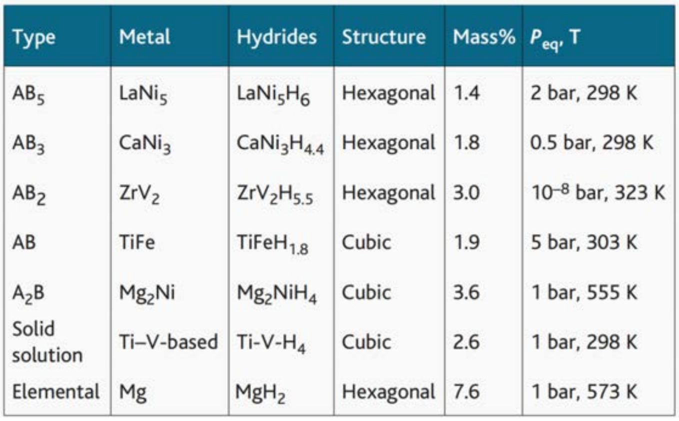
High-pressure storage, commonly utilized in industry, involves storing hydrogen gas in high-pressure steel cylinders at pressures of 350 or 700 bar. Despite its commonality, it exhibits low volumetric capacity and safety concerns regarding potential leaks or explosions during improper operation. The technique's application in vehicles poses challenges related to added weight and limited space.

In contrast, chemical-bond hydrogen storage, often referred to as "hydride," offers advantages such as high volumetric energy density, simple reactions, safety, and a purer form of stored hydrogen after the reaction. Among these, magnesium hydride (MgH2) emerges as a promising material for solid-state hydrogen storage, boasting a theoretical capacity of 7.6 wt%. Research suggests that ball-milling magnesium enhances its hydrogen sorption properties, particularly when used in a composite material like Mg + 10% Ni after 30 minutes of ball milling, demonstrating superior performance. Additionally, magnesium hydride in combination with 5% MgO powder exhibits high hydrogen generation rates, outperforming various other materials.

Notably, magnesium hydride stands out as a non-corrosive material that releases hydrogen at room temperature and offers higher hydrogen capacity than most hydrides. Controlling the weight of MgH2, catalyst concentration, and its structural configuration holds potential in positioning MgH2 as a prime candidate for efficient hydrogen generation. These advancements pave the way for magnesium hydride to become one of the most promising materials in the pursuit of effective hydrogen storage solutions.

Table 1: Structure and Hydrogen Storage Properties of Typical Metal Hydrides

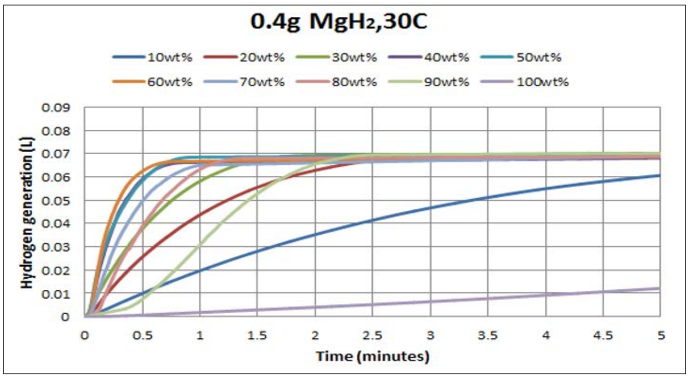
Several candidates of metal hydrides were taken in the past, here mentioned in the table.



Type	Metal	Hydrides	Structure	Mass%	P_{eq}, T
AB_5	$LaNi_5$	$LaNi_5H_6$	Hexagonal	1.4	2 bar, 298 K
AB_3	$CaNi_3$	$CaNi_3H_{4.4}$	Hexagonal	1.8	0.5 bar, 298 K
AB_2	ZrV_2	$ZrV_2H_{5.5}$	Hexagonal	3.0	10^{-8} bar, 323 K
AB	TiFe	$TiFeH_{1.8}$	Cubic	1.9	5 bar, 303 K
A_2B	Mg_2Ni	Mg_2NiH_4	Cubic	3.6	1 bar, 555 K
Solid solution	Ti–V-based	$Ti\text{-}V\text{-}H_4$	Cubic	2.6	1 bar, 298 K
Elemental	Mg	MgH_2	Hexagonal	7.6	1 bar, 573 K

Sodium borohydride (NaBH4) has been investigated in many ways before the No-Go decision made by US Department of Energy (DOE). Although the hydrogen storage capacity of NaBH4 can't reach the DOE's target, its hydrogen generation progress and regenerate process are not suitable for portable or on-board application, which the byproduct, sodium metaborate, is a corrosive material that is not safe for the regular operation. Lithium aluminum hydride (LiAlH4) is another potential hydrogen resource. However, LiALH4 needs the high temperature (above 200°C) environment for processing the dehydrogenation comparatively. Magnesium hydride (MgH2) is a non-corrosive material, and can be release hydrogen in room temperature. MgH2 has high hydrogen capacity than most hydrides [1,2].

Different Concentration of Acetic Acid with 0.4g MaH2 at 30°C in 5 minutes



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