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Chemical Hydrogen Storage

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23.1 Chemical Hydrogen Storage

The term chemical hydrogen storage is used to describe storage technologies in which hydrogen is generated through a chemical reaction. Common reactions involve chemical hydrides with water or alcohols. Typically, these reactions are not easily reversible onboard a vehicle. Hence, the spent fuel or by-products must be removed from the vehicle and regenerated off-board.

Hydrolysis reactions involve the oxidation reaction of chemical hydrides with water to produce hydrogen. The reaction of sodium borohydride has been the most studied to date.\(^1\) This reaction is

\[
\text{NaBH}_4 + 2\text{H}_2\text{O} \rightarrow \text{NaBO}_2 + 4\text{H}_2
\]

(23.1)

In the first embodiment, slurry of an inert stabilizing liquid protects the hydride from contact with moisture and makes the hydride pumpable. At the point of use, the slurry is mixed with water and the consequent reaction produces high-purity hydrogen. The reaction can be controlled in an aqueous medium via pH and the use
of a catalyst. While the material hydrogen capacity can be high and the hydrogen release kinetics fast, the borohydride regeneration reaction must take place off-board. Regeneration energy requirements cost and life-cycle impacts are key issues currently being investigated.

Millennium Cell has reported that their NaBH₄-based Hydrogen on Demand™ system possesses a system gravimetric capacity of about 4 wt.%. Similar to other material approaches, the issues include system volume, weight and complexity, and water availability.

Another hydrolysis reaction that is presently being investigated by Safe Hydrogen is the reaction of MgH₂ with water to form Mg(OH)₂ and H₂. In this case, particles of MgH₂ are contained in nonaqueous slurry to inhibit premature water reactions when hydrogen generation is not required. Material-based capacities for the MgH₂ slurry reaction with water can be as high as 11 wt.%. However, similar to the NaBH₄ approach, water must also be carried on-board the vehicle in addition to the slurry, and the Mg(OH)₂ must be regenerated off-board.

An idea on how the complex metal hydrides would be processed during the hydrogen economy is depicted in Figure 23.1 using sodium borohydride (NaBH₄).

A new chemical approach may be hydrogen generation from ammonia borane materials by the following reactions:

\[
\text{NH}_3\text{BH}_3 \rightleftharpoons \text{NH}_2\text{BH}_2 + \text{H}_2 \rightleftharpoons \text{NHBH + H}_2
\]

The first reaction, which occurs at less than 120°C, releases 6.1 wt.% hydrogen, while the second reaction, which occurs at approximately 160°C, releases 6.5 wt.% hydrogen. Recent studies indicate that hydrogen release kinetics and selectivity are improved by incorporating ammonia borane nanosized particles in a mesoporous scaffold.
References
