Project H-13: High-density hydrogen storage for fuel cell vehicles based on $NaAlH_4$

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Background & Approach

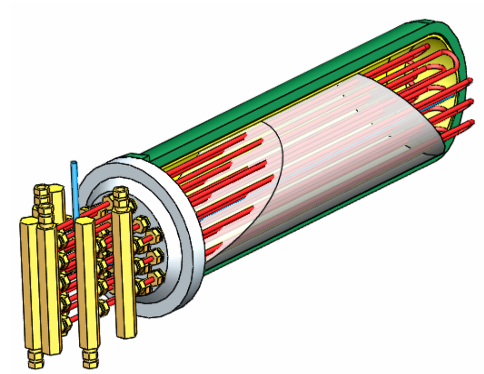
One of the most significant barriers to the widespread application of hydrogen based propulsion is the development of on-board storage systems which can provide the needed quantity of hydrogen with acceptable volume, weight, cost and safety risk. The current project is focusing on the reversible chemical hydride, $NaAlH_4$, with a theoretical hydrogen capacity of 5.5 wt%, and seeks to enhance the material for improved charging and discharging rates as well as increased capacity. Safety studies of the enhanced material will also be conducted to support the technology as it is driven toward commercialization. The project seeks to apply this material in the design and evaluation of a system which will reversibly store a high wt% of hydrogen at low pressure for an indefinite amount of time.

2003 Progress

Kinetics: The first round charging and discharging reaction rates for four catalyzed $NaAlH_4$ compositions have been completed. Hydrogen discharge rates sufficient to deliver hydrogen to PEM fuel cell powered vehicles at ~40 mph using 90°C water have been achieved. Hydrogen charging rates required to accomplish 1hr charging times are also achievable with significant improvements in this area foreseen.

Safety*:* Safety issues related to accidental damage of CCH systems and subsequent environmental exposure is a concern and little information is available in the open literature. Safety studies were completed examining how this material reacts upon dispersion in air, dust cloud ignition with temperature and electric spark. These tests have found the material to be highly explosive when finely divided and dispersed in a dust cloud in air under all charging conditions tested. Subsequent observations of the material after sorption cycling have shown, however, that the powder fuses into a soft solid mass similar to chalk mitigating the possibility of dust cloud dispersion.

System: A design has been selected optimized around the special properties of thermally driven alanate hydrogen storage materials, which are significantly different than those of conventional metal hydrides. These differences include a very low thermal conductivity, slow charging kinetics at low hydrogen pressures and air and humidity reactivity. Analytical and numerical models using a finite element code were constructed and experiments performed which evaluate the heat transfer performance of different designs. Cost, weight, chemical compatibility and manufacturability were also factored into the optimal selection of the method. A solid model of the resulting 1 kg H_2 system design is presented in the attached figure.



Schematic solid model of 1kg H_2 storage system designed and being fabricated for demonstration of $NaAlH_4$ hydrogen storage system.