V.B Carriers

V.B.1 Reversible Liquid Carriers for an Integrated Production, Storage and Delivery of Hydrogen

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United Technologies Research Corporation, East Hartford, CT
Pennsylvania State University, College Park, PA
Battelle, Richland, Washington

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Objectives

- Develop liquid phase hydrogen carrier raw materials
- Develop a conceptual design and fabricate an initial 0.1 to 1 kW prototype of a dehydrogenation reactor/ heat exchange system to deliver H_2.
- Perform an economic evaluation of the delivery and storage system for the liquid carrier H_2 delivery concept.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Delivery section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A. Lack of Hydrogen/Carrier and Infrastructure Options Analysis
- E. Solid and Liquid Hydrogen Carrier Transport
- F. Hydrogen Delivery Infrastructure Storage Costs

Technical Targets

This project is directed at providing the dehydrogenation reactor technology, economic analysis and raw materials sourcing data for a liquid phase carrier that will enable an integrated delivery and storage of hydrogen meeting the DOE 2010 targets for hydrogen storage density and refueling time.

Approach

Our approach to an integrated production, storage and delivery of hydrogen using reversible liquid carriers is illustrated schematically in Figure 1. At any H_2 source a liquid carrier LQ* is catalytically hydrogenated, and then transported in this LQ*H_2 hydrogenated form to a distribution center for vehicle fueling or stationary H_2 delivery. The latter requires the development of an appropriate catalytic dehydrogenation reactor, which is the principal objective of this project. The "spent" dehydrogenated liquid carrier LQ* is then returned to the hydrogen source for re-hydrogenation. The liquid carrier and dehydrogenation catalyst discovery and development work is being performed in a complementary DOE project entitled "Design and Development of New Carbon-Based Sorbent Systems for an Effective Containment of Hydrogen."

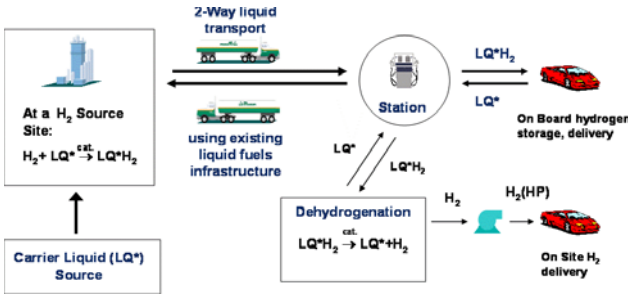

Figure 1. An Integrated Production, Storage and Delivery of Hydrogen – Using Reversible Liquid Carriers (LQ*H_2)

Accomplishments

We have demonstrated a continuous production of hydrogen of 99.9+ purity from a catalytic dehydrogenation of perhydrogenated N-ethyl carbazole at ~60% conversion (Figure 2) using a packed-bed reactor at 190°C. The partially dehydrogenated product was re-hydrogenated in batch mode. Six consecutive dehydrogenation/re-hydrogenation sequences were carried out without significant loss in hydrogen carrier capacity.

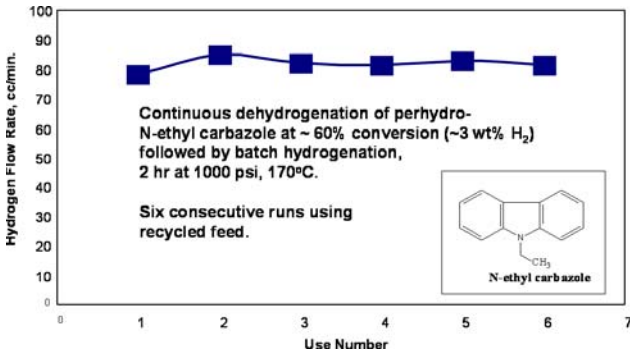

Figure 2. Packed-Bed Reactor Dehydrogenation/ Hydrogenation Cycling Demonstration