

## V.B Carriers

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

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*Subcontractors:*  
*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<sub>2</sub>.
- Perform an economic evaluation of the delivery and storage system for the liquid carrier H<sub>2</sub> 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**

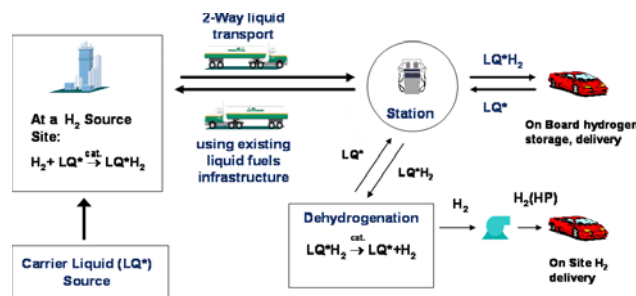
This project is directed at providing the dehydrogenation reactor technology, economic analysis and raw materials sourcing data for a liquid phase carrier that will enable an integrated delivery and storage of hydrogen meeting the DOE 2010 targets for hydrogen storage density and refueling time.

## Approach

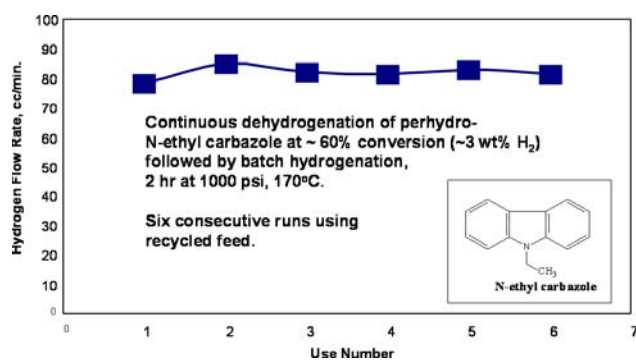
Our approach to an integrated production, storage and delivery of hydrogen using reversible liquid carriers is illustrated schematically in Figure 1. At any H<sub>2</sub> source a liquid carrier LQ\* is catalytically hydrogenated, and then transported in this LQ\*H<sub>2</sub> hydrogenated form to a distribution center for vehicle fueling or stationary H<sub>2</sub> 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."

## 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 (~3 wt% H<sub>2</sub>) 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 1.** An Integrated Production, Storage and Delivery of Hydrogen – Using Reversible Liquid Carriers (LQ\*H<sub>2</sub>)



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