Title: **Development of a Catalyst/Sorbent for Methane Reforming**

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Grant Number: DE-FG26-04NT42182
Performance Period: October 1, 2004 to September 30, 2005

ABSTRACT

OBJECTIVES

The overall objective of this project is the development and demonstration of a combined catalyst and sorbent that will greatly improve the efficiency of steam reforming of methane to produce hydrogen which is free of carbon oxides. A secondary objective is to show that the combined catalyst and sorbent can also find application in converting carbon monoxide into hydrogen via the water gas shift reaction.

ACCOMPLISHMENTS TO DATE

The present investigation represents a continuation of the Phase I innovation research project which laid the foundation for a novel combined catalyst and sorbent for use in reforming methane to produce almost pure hydrogen in a single step. The Phase I project showed that a promising material can be made in the form of spherical pellets where each pellet consists of a CaO core surrounded by a protective shell made largely of partially sintered alumina particles. It was also shown that by incorporating γ-alumina particles with a large surface area into the shell-forming mixture of α-alumina particles and limestone particles, the resulting shell material would serve as a good support for the nickel catalyst required for reforming. In addition, by having a CaO sorbent present to capture the CO_2 byproduct, the reforming reactions were driven nearly to completion and the H_2 product was largely free of CO and CO_2.

During the present Phase II project the catalytic activity and stability of the catalyst and sorbent will be improved through the addition of various stabilizers and catalyst promoters. Extended stability of both the nickel catalyst and the CaO sorbent is an important requirement for practical application of the material. Also the crushing strength and attrition resistance of the material will be improved through optimization of the pellet shell formulation and preparation conditions.

Encouraging results have already been achieved by incorporating small amounts of lanthanum in the shell material. Lanthanum is reputed to be a good stabilizer for alumina catalyst supports. In the present study it has been introduced by impregnating pellets of shell material with a lanthanum nitrate solution. When the pellets are calcined, the lanthanum nitrate is converted to

lanthanum oxide which increased the crushing strength of the pellets. Ferric oxide has also been found to increase the crushing strength of the shell material, but it appears to reduce the activity of the nickel catalyst. On the other hand, ferric oxide is a known catalyst for the water gas shift reaction, and this property has been confirmed.

FUTURE WORK

Further improvements in the shell material will be addressed by conducting a thorough investigation of the factors which affect the important properties of the material such as physical integrity, catalytic activity, transport properties, and long term stability. These factors include the proportions of α-alumina, γ-alumina and limestone as well as the particle size distributions of the materials and the temperature and time used for calcining the material. Another factor which will need to be considered is lanthanum, not only the amount but how and when it is incorporated.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Article

J. A. Satrio, B. H. Shanks, and T. D. Wheelock, "Development of a Novel Combined Catalyst and Sorbent for Hydrocarbon Reforming," *Industrial and Engineering Chemistry Research* (in press).

Conference Presentation

J. A. Satrio, B. H. Shanks, and T. D. Wheelock, "A Combined Catalyst and Sorbent for Enhancing Hydrogen Production from Coal," presented at the Clearwater Coal Conference, Clearwater, Florida, April 17-21, 2005.

Students Supported by this Grant

- Karl Albrecht, graduate student in chemical engineering at Iowa State University
- Janine Kelley, intern in chemical engineering at Iowa State University