OHIO COAL DEVELOPMENT OFFICE
ANNUAL PROJECT ABSTRACT
AS OF DECEMBER 2004

1. PROJECT SPONSOR:

Dept. of Chemical & Materials Engg
497 Rhodes Hall, ML0012
University of Cincinnati
Cincinnati, Ohio 45221-0012

2. PROJECT MANAGER/TITLE:

Dr. Jerry Y.S. Lin
Adjunct Professor
U. of Cincinnati
Phone: (480) 965-7769
Email: Jerry.Lin@ASU.edu

3. OCDO GRANT NO. OCRC4-00-1D1.27

4. PROJECT TITLE: Hydrogen Production from Coal-Derived Syngas by Proton-Conducting Ceramic Membranes

5. PROJECT TERM FROM: September 1, 2004 TO: August 31, 2005

6. PROJECT UPDATE ×

7. BUDGET:

CO-SPONSOR'S NAME	COST-SHARE
OCDO	$79,980
University of Cincinnati	$30,600
Ohio University	$20,000
TOTAL PROJECT VALUE	$130,580

I. ABSTRACT

8. OVERVIEW OF PROJECT & OBJECTIVES:

Separation of H_2 from coal- derived syngas is a critical step as it produces a CO rich gas stream, which is an efficient fuel for solid oxide fuel cells (SOFC), and a pure H_2 stream, which is a valuable and clean energy source for transportation section. To maximize the economy of the overall process the H_2 separation must be carried out at about 900^{o}C. The overall objective of this four-year project is to develop low cost, effective inorganic membranes that can produce a "pure" stream of H_2 from coal-derived mixture of H_2-CO-CO_2 with concentrations of H_2S as high as 500 ppm at pressures of up to 30 atmospheres and temperatures of 900°C. In the first year of the project, research will be conducted to identify the optimum composition for strontium cerate membranes, $SrCe_{1-X-Y}Tm_XM_YO_{3-\delta}$ (SCTM), with improved electronic/protonic conductivity, and chemical stability against CO_2. Here M represents a lanthanide element.

9. WORK TO DATE & CONCLUSIONS:

In the first quarter of the year, research was done to find the optimum doping content of thulium (Tm) that gives the highest electronic conductivity. SCTm

membranes of composition $SrCe_{1-x}Tm_xO_3$ with varying Tm doping (x-0.0-0.5) were prepared using citrate method. It was found that the single perovskite phase could not be formed beyond 15% Tm doping. Four-point DC method was used to measure the total electrical conductivity of different SCTm disks in different partial pressure of O_2 (10^{-23}-1.0 atm). The total electrical conductivity decreased on increasing Tm doping from 5 to 25%. It was also observed that a fraction of SCTm material reacted when exposed to CO_2 while measuring electrical conductivity at 900^oC in a period of one week. X-ray diffraction of the reacted material indicated peaks of cerium oxide and strontium oxide. These results indicated that the chemical stability of the cerate based protonic conductors in CO_2 is a serious problem. We decided to first identify materials that are chemically stable in CO_2 and also high electronic/protonic conductivity.

10. PLANS FOR COMING YEAR:
SCTm has high electronic conductivity but their chemical stability in CO_2 low. On the other hand electronic conductivity of zirconates and titnates are low but they are very stable in CO_2. Hence, in the coming year we will focus on the solid solution of strontium cerates with other dopants. Chemical stability and H_2 permeation properties of the doped proton-conducting ceramic membranes will be studied in simulated syngas atmosphere for prolonged period of time. These stability data will help us determine the suitability of the improved membranes developed in the first year for the separation of H_2 from coal-derived syngas.

II. HIGHLIGHTS/ACCOMPLISHMENTS

11. Liquid citrate method was determined to be an effective method to synthesize strontium cerate based ceramics with various dopants of particular doping level. Reactivity of these materials with carbon dioxide was identified as one of the major problems that is detrimental to its performance. Target materials were identified with optimum protonic/electronic conductivity and chemical stability. We also finished manufacturing high temperature permeation set-up for H_2 permeation behavior of these membranes.

III. ARTICLES/PRESENTATIONS

12. V. Gupta, and J. Lin, “Hydrogen Production from Coal- Derived Syngas Using Proton- conducting ceramic membranes”, presented at the Ohio Air Quality and Coal Research Symposium December 2-3, 2004. Athens, OH.