

**ANNUAL PROJECT REPORT
AS OF DECEMBER 2001**

1. Project Sponsor
Department of Chemical Engineering
The University of Cincinnati
601 ERC, ML0171
Cincinnati, OH 45221-0171
2. Project Manager
Dr. Jerry Y. S. Lin
Professor

Phone: (513) 556-2761
Email: jlin@alpha.che.uc.edu
3. OCDO Grant No. OCRC3-00-1.C1.84. Project Update OR
Final Report
5. Project Title: Novel Ceramic Materials for High Temperature Carbon
Dioxide Separation_____
6. Project Term: From: September 1, 2001 To: August 31, 2002
7. Budget:
- | <u>Name</u> | <u>Cost Share</u> |
|---------------------------|--------------------------|
| <u>OCDO</u> _____ | <u>\$ 79,385</u> |
| <u>UC</u> _____ | <u>\$ 26,553</u> |
| _____ | <u>\$ _____</u> |
| _____ | <u>\$ _____</u> |
| TOTAL PROJECT COST | <u>\$ 105,938</u> |

I. ABSTRACT

8. OVERVIEW OF PROJECT & OBJECTIVES:

The objectives of the four-year research project are to develop the carbon dioxide semi-permeable dense inorganic membrane or CO₂ selective adsorbent for separation of carbon dioxide from flue of coal gasification gas at high temperatures (400-700°C). The specific

objective of the research in Year I was to identify a suitable dense inorganic membrane material for carbon dioxide perm-selective membrane.

9. WORK DONE & CONCLUSIONS:

The research has been focused on addressing several fundamental issues of lithium zirconate (Li_2ZrO_3). These fundamental issues include material synthesis, and phase and microstructure of the material and the mechanisms of carbon dioxide sorption on the material. The results show that lithium zirconate can absorb a large amount of CO_2 (up to 20 wt% = 4.5mmol/g) at the desired temperature range (400-600 °C) and can be regenerated. In the pure Li_2ZrO_3 , however, sorption rate is very slow in spite of a large CO_2 sorption capacity. On the other hand, doping of molten carbonate in Li_2ZrO_3 (referred to as the modified Li_2ZrO_3) promotes CO_2 sorption 40 times faster than pure case. The analysis of the CO_2 sorption/desorption mechanism on the pure and modified Li_2ZrO_3 was performed with the help of TGA, DSC-TGA, and XRD. The results show that Li_2ZrO_3 is potentially an excellent sorbent for separation of CO_2 at high temperature. However, pure Li_2ZrO_3 is not a good material for the CO_2 semi-permeable membrane proposed originally. Nevertheless, the CO_2 sorption and microstructure results of the molten carbonate doped Li_2ZrO_3 show that molten carbonate is highly CO_2 semi-permeable. With these results, we have decided to pursue the direction of preparing high temperature CO_2 permselective membrane using the molten carbonate material instead of lithium zirconate.

10. PLANS FOR COMING YEAR:

The objectives of the second year research are to: (1) demonstrate experimentally a concept of the new CO_2 semi-permeable membrane using molten carbonate; (2) synthesize Li_2ZrO sorbent with a significantly improved CO_2 sorption rate; and (3) study the properties of the membrane and improved Li_2ZrO sorbent.

II. HIGHLIGHTS/ACCOMPLISHMENTS

11. The major accomplishments achieved in the first year are the identification of the microstructure of Li_2ZrO_3 and the mechanism of CO_2 sorption on this material. The analysis shows that in the pure Li_2ZrO_3 , the formation of solid Li_2CO_3 shell inhibits transport of CO_2 , resulting in very slow carbonation rate. On the other hand, doping a molten carbonate in Li_2ZrO_3 helps transforming the solid carbonate film to the liquid one during the carbonation reaction. CO_2 diffusion in this liquid (molten) carbonate film is very fast, promoting CO_2 sorption rate considerably. The results suggest that membrane prepared of a molten carbonate will have very high carbon dioxide permeability and selectivity.

III. ARTICLES/PRESENTATIONS

12. a) Junichi Ida and Jerry Y.S. Lin, "Mechanism of Carbon Dioxide Sorption/Desorption on Lithium Zirconate", Oral presentation at 2001 Annual AIChE Meeting; Reno, NV, November 9, 2001