Synthesis of High Surface Area Materials for Solid Oxide Fuel Cells

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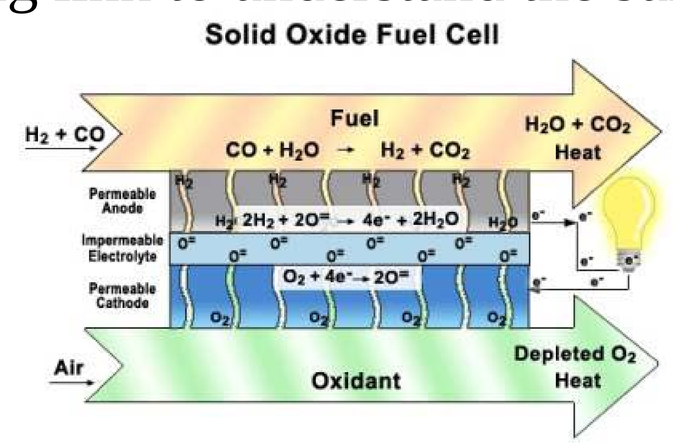
Project Goal

The goal of this project is to synthesize high surface area perovskites in order to apply direct surface measurement to investigate the relationship between surface properties of catalysts and their surface reactivity for applications in fuel cell technologies and CO_2 separation

Project Motivation

- ➢Solid oxide fuel cell (SOFC) is a energy conversion device with high efficiency and reduced CO_2 emission
- ➢Currently, commercialization of solid oxide fuel cells is limited by cathode performance
- ➢Indirect measurements of surface adsorbed species provide insufficient information to establish the reduction reaction mechanism at cathode
- ➢Direct surface measurement can provide the missing link to understand the surface reaction



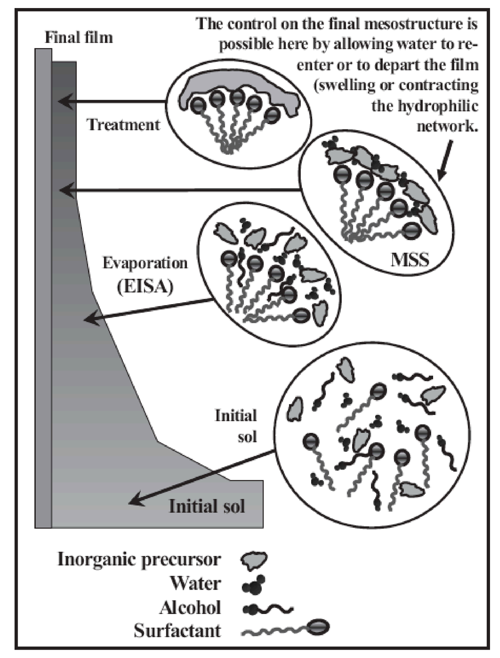
http://science.nasa.gov/headlines/y2003/18mar_fuelcell.htm

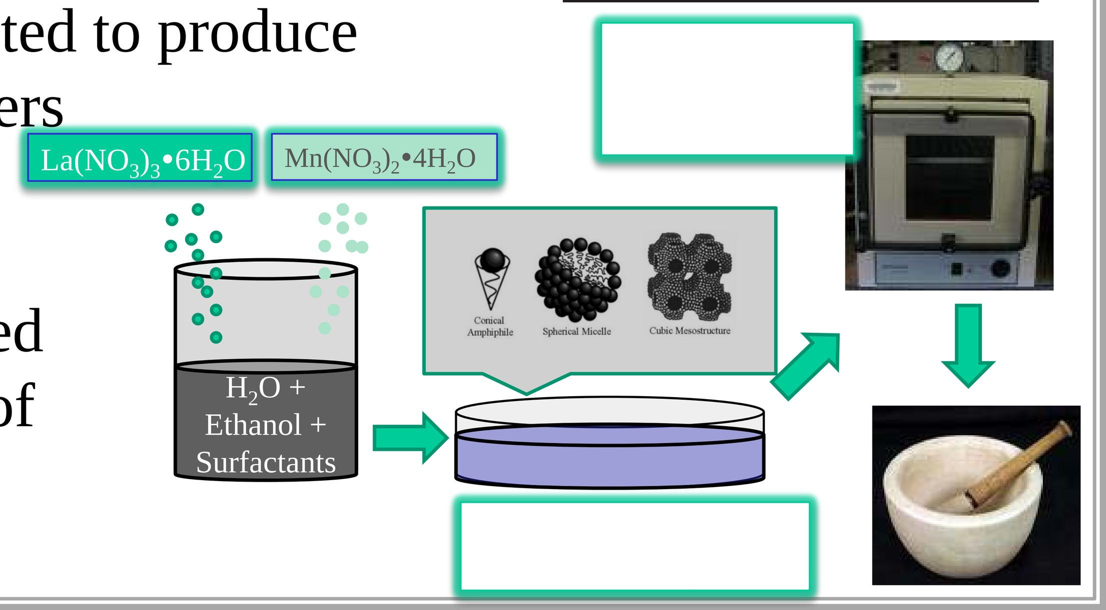
Challenges and Approaches

- ➢Data quality from the direct measurement of surface species is limited by the surface/bulk signal ratio
- ➢Conventional synthesis of Perovskites produces low surface areas ($4m^2/g$ ~$30m^2/g$) insufficient to obtain useful surface signals
- ➢Synthesis for high surface area perovskite powders need to be developed

Evaporation-induced Self-assembly (EISA)

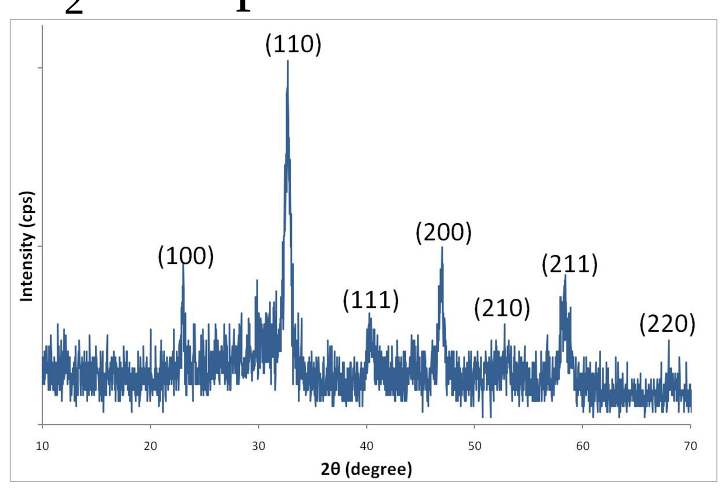
- ➢Developed by Mobil researchers
- ➢It uses the self-assembly nature of the amphiphilic surfactants in with increased concentrations to invoke a templating effect
- ➢Method is simple, low cost, and produces mesoporous structures
- ➢EISA has been adopted to produce various oxide powders
- ➢The packing arrangement of the product is determined by the mesophases of the surfactant used

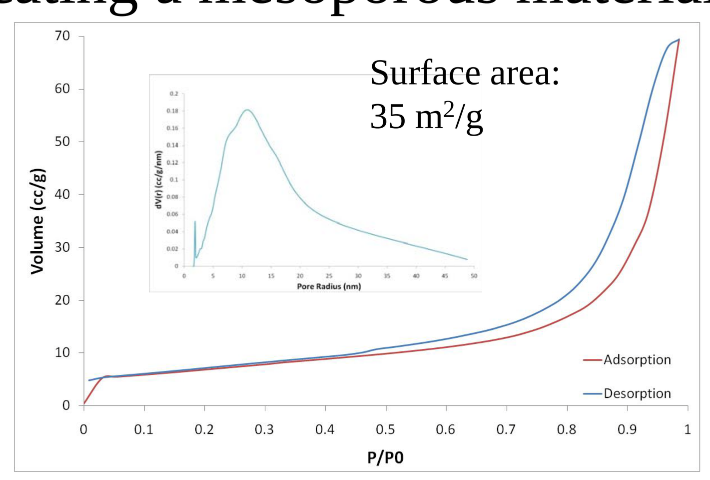




Powder Characterization

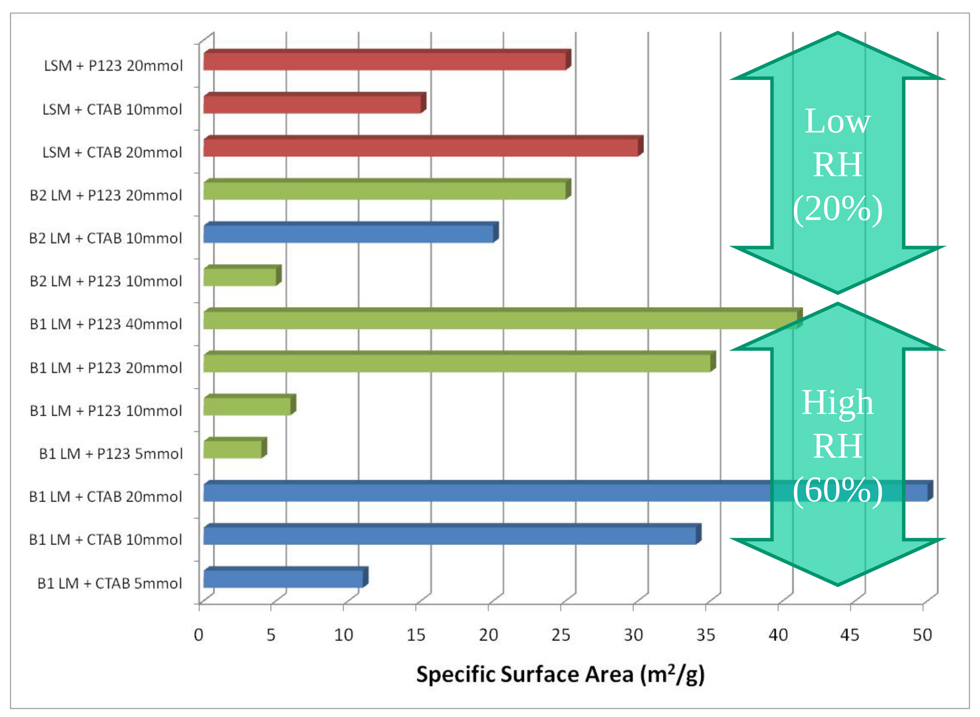
- ➢Synthesized powders are characterized with XRD to examine the structure and BET/BJH analysis to determine the porous properties
- ➢EISA produces pure lanthanum manganese oxide
- ➢N_2 adsorption isotherm indicating a mesoporous material





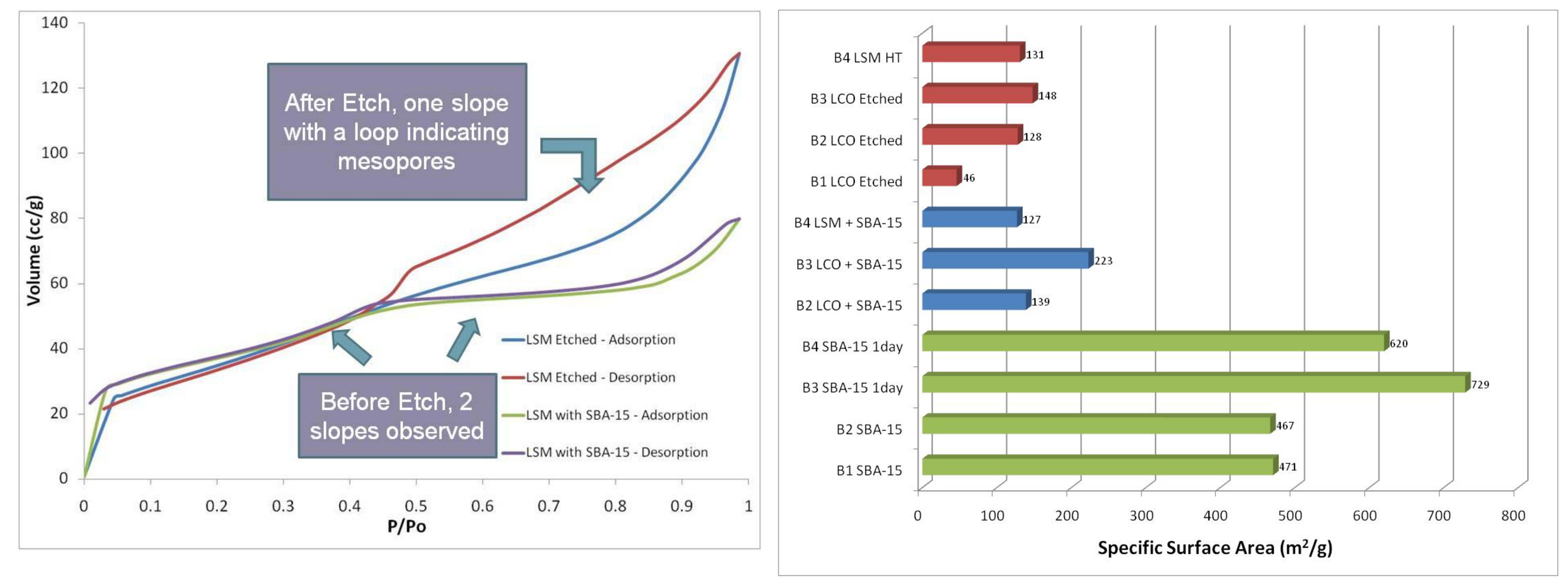
Experimental Parameters

- ➢In studying various parameters in EISA, it is found that by varying precursor/surfactant ratio, the surface area of the powder can be adjusted
- ➢Relative humidity and choice of surfactants also play important roles
- ➢Best Surface area reaches $50m^2/g$ for LM and $30m^2/g$ for LSM



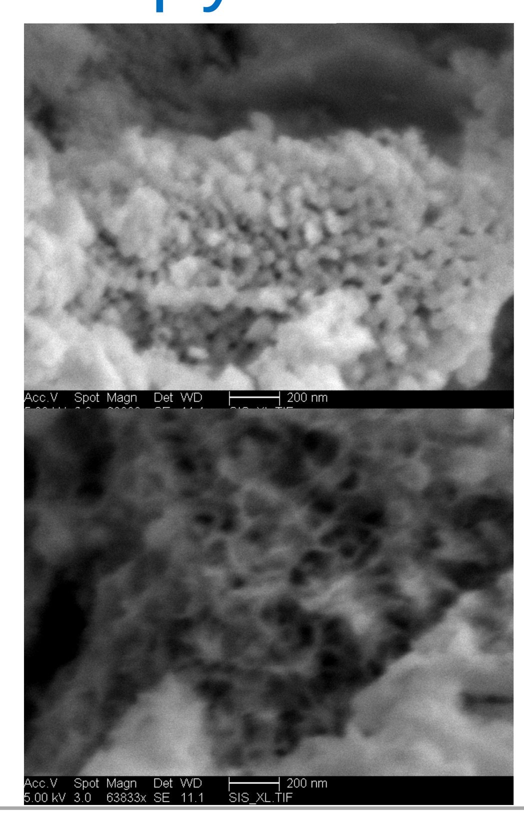
Silica Hard-templating Synthesis

- ➢Recently, it was reported that using the ordered silica as a template produced high surface area lanthanum cobaltite
- ➢The first step is to synthesize the high surface area, mesoporous silica template
- ➢The template is impregnated with LSM precursors, and calcine at high temperature after solvent evaporation
- ➢Silica template is then etched away
- ➢The surface area of synthesized LSM powders is $131m^2/g$



Scanning Electron Microscopy

- ➢Micrograph Showed two different structures
  - ➢Top: Sintered particles Structure made by EISA route
  - ➢Bottom: Open pores from leaching of the silica
- ➢Both showed porous nature that contributes to the high surface area
- ➢The structure would investigated under TEM for their mesoporosity



Potential Applications

- ➢The high surface area perovskite catalysts increases the SOFC efficiency
- ➢The hybrid material of silica template with catalysts is beneficial to be used as a support in a CO_2 capture device due to its high surface area and mesoporous structure

Conclusions

- ➢The surface area of the synthesized lanthanum manganese oxide is higher than that synthesized from conventional process
- ➢Silica hard-templating synthesis shows promising results to produce high surface area perovskites