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Executive Summary

Department of Energy is funding a research program on the development of large-scaled distributed power systems (1-30 MW) by solid oxide fuel cells (SOFC) with coal-derived syngas. Syngas, rich in CO and H_2 with some H_2S impurity, is produced by coal gasification reaction at 900ºC. Separation of H_2 from the syngas is a critical step as it produces a CO rich gas stream, which is an efficient fuel for 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 900ºC. Under these requirements, dense, thin ceramic membranes fabricated from mixed protonic and electronic conductors provide a simple and efficient means for separating H_2 from the syngas at high temperatures. The objective of this project is to develop such low cost effective inorganic membranes for high temperature hydrogen separation from the coal-derived syngas produced in the DoE sponsored SOFC program. The membrane separation process is based on an improved proton conducting ceramic membranes extended from a new membrane recently developed in the PI's laboratory: thulium doped strontium cerate ($SrCe_{0.95}Tm_{0.05}O_3$, or SCT). In the first year, we will conduct research to identify optimum composition for modified SCT membranes with improved electronic/protonic conductivity and chemical stability under the operating conditions for separation of hydrogen from coal-derived syngas. The research efforts in the second year will be directed towards making thin membranes of the desired composition in order to increase hydrogen permeance and reduced membrane costs. In the third year, we will consider fabrication of the improved SCT membranes of optimized composition in tubular geometry for practical application. Finally, the work in the fourth year will be devoted to testing the performance of the new tubular proton-electronic conducting ceramic membranes for separation of H_2 from the coal-derived syngas at high temperatures and pressures. The research in the first year will be directed towards (1) identifying the optimum composition for the doped SCT, $SrCe_1$-X-YTmXMYO_3-δ (SCTM, where stands for a lanthanide element), with improved electronic/protonic conductivity and chemical stability, (2) synthesizing the SCTM membranes of optimum composition and SCT-metal dual phase membranes, and (3) studying chemical stability of the membrane materials and H_2 permeation properties of the membranes with simulated syngas. These permeation and stability data will help us determine the suitability of the SCTM and dual-phase membranes developed in the first year for the separation of H_2 from coal-derived syngas.