Sulfur-Tolerant Palladium-Copper Alloy Membranes for Hydrogen Spearation with High Pressur CO2 for Sequestation

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Energy from coal-fired power plants will remain as a dominant energy source well into the 21st Century. Furthermore, coal gasification processes, such as integrated gasification combined cycle (IGCC), provide an excellent alternative for the production of synthesis gas, electricity, fuels, and chemicals from coal. The production of pure hydrogen and CO2 requires the utilization of gas separation processes that will provide high fluxes, high selectivity of separation, sulfur resistance, ability to operate at elevated temperatures (450 - 550°F) and high pressure CO_2. The proposed research and development of composite Pd/Cu alloy porous stainless steel membranes can satisfy all the above described requirements.

The primary objective of the proposed program is to develop sulfur-tolerant composite Pd/Cu alloy porous stainless steel membranes for hydrogen separation from coal gases with high pressure CO_2 appropriate for recycling or sequestration, or conversion to industrially useful products or creation of natural CO2 sink. The specific objectives of the program are: (1) to synthesize sulfur tolerant composite Pd/Cu alloy porous stainless steel membrane by electroless plating, based on our patented technology [1], which uses an innovative controlled in-situ oxidation concept to produce a thin intermediate oxide layer to minimize intermetallic diffusion, (2) to understand the kinetics of Pd/Cu alloy formation and changes in nanostructure properties of the Pd/Cu as a function of temperature and rate of heating/cooling using High Temperature XRD (HTXRD), SEM (with EDX) and TEM, (3) to characterize the membrane permeation performance and its relation to the changes in nanostructure properties of the alloy and (4) to test the membrane in both ½ in lab scale and 1 in lab scale units using simulated coal gases to achieve the ultimate goal of the proposed research, which is to apply the obtained knowledge to develop low-cost, high-flux ultra-thin sulfur-tolerant Pd/Cu membranes for simultaneous hydrogen separation from coal gases and production of pressurized CO_2, readily for sequestration.

Electroless plating will be used to synthesized sulfur tolerant Pd/Cu alloy PSS membranes in conjunction with our patented technology [U. S. Pat 6,152,987], using an innovative controlled in-situ oxidation concept to produce a thin intermediate oxide layer to minimize intermetallic diffusion. High Temperature XRD (HTXRD) at ORNL will be used to study the kinetics of Pd/Cu alloy formation and changes in nanostructure properties of the Pd/Cu as a function of temperature and rate of heating/cooling. The membrane permeation performance characterization will be carried out in several membrane testing units in our laboratory and Shell laboratory using simulated coal gases to achieve the ultimate goal of the proposed research, which is to apply the obtained knowledge to develop low-cost, high-flux ultra-thin sulfur-tolerant Pd/Cu membranes for simultaneous hydrogen separation from coal gases and production of pressurized CO2, readily for sequestration.