509d Hydrogen Sulfide Removal with Polymer Membranes for Fuel-Cell Applications

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Hydrogen sulfide is a common contaminant in the hydrogen that poisons the fuel cell anode catalyst. Since this poisoning mechanism is irreversible, even trace concentrations of H2S (> 10 ppb) in the hydrogen can significantly degrade fuel cell performance. So it must be almost completely removed prior to feeding hydrogen to fuel cells. In this study, polymer membranes containing amino groups were investigated to remove H2S for hydrogen purification for proton-exchange membrane (PEM) fuel cells. The membranes require no regeneration step and have no moving parts in the pressure driven separation, all of which enable the H2S removal process both compact in size and effective in operation.

We synthesized H2S and CO2-selective polymer membranes by incorporating amino groups, in polymer networks, which react with these acidic gases reversibly and enhance their removal. A circular gas permeation cell with countercurrent gas flows was used to study the H2S removal. Two feed gases were used, one consisted of 50 ppm H2S, 1% CO, 17% CO2, 45% H2, and 37% N2, similar to the composition of synthesis gas from autothemal reforming with air, and the other had 100 ppb H2S in N2. The membranes showed high H2S and CO2 permeabilities and H2S/H2 and CO2/H2 selectivities in temperatures ranging from 110oC to 140oC. The transport properties for H2S were significantly better than those for CO2 because of the faster reaction mechanism with H2S. Using this membrane cell with a membrane area of 45.6 cm2, the H2S concentration in the gases was reduced from 50 ppm to less than 80 ppb, or from 100 ppb to less than 10 ppb, at 120oC. In addition, a gas permeation model based on the hollow fiber configuration has been developed, and the modeling has shown that < 10 ppb H2S is achievable from typical reforming synthesis gas with small membrane area requirement.