DEVELOPMENT OF PROTON-CONDUCTING MEMBRANES FOR SEPARATING HYDROGEN FROM GAS MIXTURES*

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In direct coal liquefaction, the production, compression, circulation, and purification of hydrogen have long been recognized as major cost elements, representing 30-40% of total plant capital and operating costs. Proton membrane technology has the potential to improve the economic viability of direct liquefaction by significantly altering the process economics of hydrogen separation and purification. While other methods for separating hydrogen are presently available, some are expensive and others do not produce the high-purity hydrogen required for certain end-use applications. This presentation describes a recently initiated project whose purpose is to develop dense ceramic membranes for separating hydrogen in a nongalvanic mode (i.e., without electrodes or external power supply). In addition to providing high-purity hydrogen, membrane reactors would selectively remove hydrogen from product streams, shifting the equilibrium–limited reactions toward hydrogen production and away from formation of undesirable byproducts, thereby reducing hydrogen precursor consumption and improving the economics of coal liquefaction.

Certain ceramic materials are known to exhibit significant levels of both electronic and protonic conductivity and are therefore of particular interest for separating hydrogen from gas mixtures. Such mixed conductors offer the potential of internally transporting not only hydrogen (thus separating hydrogen from other gaseous components) but also electrons (thereby obviating the need for external electrodes, circuitry, and/or power supply). Although recent reports indicate that various ceramics exhibit mixed electronic/protonic conduction, the appropriate balance between electronic and protonic conduction has not been demonstrated (protonic and electronic conductivity should be approximately equal). The literature concerning electronic/protonic conductors has been reviewed, and promising candidate materials are identified. The approach to be followed in developing the proton-conducting membranes is illustrated by describing similar, previous work at Argonne in which mixed electronic/oxygen-ion-conducting materials were developed (in collaboration with Amoco) for separating oxygen from air.

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