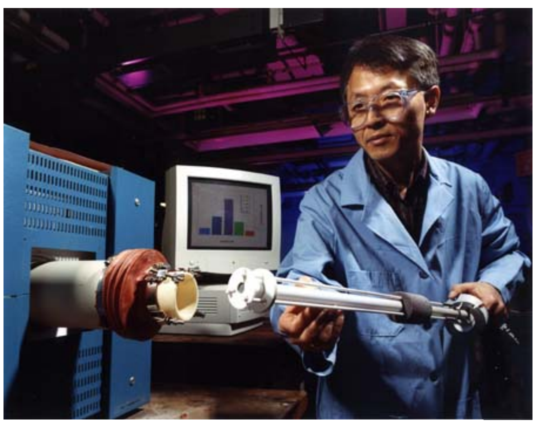
Hydrogen Transport Membrane (HTM) for Separation of Pure Hydrogen at High Temperatures

Argonne National Laboratory

Scientists at Argonne National Laboratory and National Energy Technology Laboratory, have taken a step toward the "hydrogen economy" – the basic infrastructure required to make hydrogen an abundant available fuel – by showing the potential for the development of a ceramic membrane that can isolate pure hydrogen gas. Hydrogen gas has wide potential applications in transportation, power generation, petroleum refining and food processing but is not found in elemental form anywhere in the world (except in trivial amounts).

The material, called a hydrogen transport membrane (HTM), works by allowing only hydrogen from a mixture of gases to pass through it. Researcher Balu Balachandran, the manager of the ceramic section of Argonne's Energy Technology Division, says the new membrane material works on a different principle than conventional porous membranes. "Argonne's dense phase membrane is composed of a special ceramic-metal composite," he said. "Hydrogen is the only specie that passes through it because it dissolves in, and diffuses rapidly through the metal phase in the composite." This membrane is especially distinctive because it is effective at temperatures as high as 900ºC, whereas other membranes have problems operating above 550ºC. HTM transports hydrogen based on the difference in hydrogen partial pressure across the membrane, thus, the HTM does not require external electrodes or circuitry to separate hydrogen.



Researcher preparing to insert the HTM ceramic membrane assembly into a furnace to measure its hydrogen permeation and stability

This technology was recognized with an R&D 100 Award by *R&D Magazine*, as one of the "most technologically significant new products" of 2004.

Balachandran said the preferred source of hydrogen is methane, a naturally occurring gas molecule that contains carbon and hydrogen. "Right now, when companies drill for oil, associated natural gas is often also produced, and it is largely methane. It gets used for power generation, home heating, and chemicals when there is access for transport; however, natural gas produced in remote areas often has to be reinjected into the well or burned in a flare, so it is not released to the atmosphere," he said. Methane is considered a strong greenhouse gas and a substantial contributor to global warming, if released.

Methane can be broken down into its useful components, carbon and hydrogen. Argonne scientists combine methane with oxygen, creating a mixture of carbon monoxide and hydrogen called "syngas." Syngas is reacted with steam to form carbon dioxide and more hydrogen. Scientists then can isolate the hydrogen by forcing the gas mixture over one side of an HTM. The hydrogen molecules pass through the membrane, leaving the carbon dioxide behind. The hydrogen gas, thus isolated, is collected, while the carbon dioxide can be stored to reduce global warming.

Now that the Argonne team has created a functional hydrogen membrane in the laboratory, one of its next priorities is to build scaled-up versions for larger operations such as industrial plants. Balachandran's team is also working on improving the stability of the membrane in the presence of trace impurities, so it will be effective even when there are contaminants in the processed gas. Finally, the researchers are working to make the membrane more durable so it can withstand higher temperatures and pressures, conditions that improve the rate at which the hydrogen is separated from the mixture.

Jim Gleeson, manager of this technology in Argonne's Office of Technology Transfer, says "the commercial potential for HTM technology will extend beyond the hydrogen economy to the chemical production and refining arenas once certain technical and scale-up issues are successfully addressed."

The membrane was patented in 2003, and development of the technology is underway with industrial partners Eltron Research, Inc. and ITN Energy Systems, Inc. The technology is expected to advance the "hydrogen economy" by enabling the economical and environmentally friendly production of hydrogen from carbon-based feedstocks, permitting the highly efficient generation of electricity via fuel cells and use of hydrogen as a non-polluting transportation fuel.

Balachandran developed the membrane with colleagues Stephen Dorris and Tae Lee, in collaboration with Gary Stiegel, Richard Dunst and John Winslow at the National Energy Technology Laboratory in Pittsburgh.

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For additional information contact the Office of Technology Transfer (800-627-2596, partners@anl.gov).