H₂ unit combines production, purification and compression

A recently developed hydrogen generation unit combines an autothermal, fluidized-bed methane reformer with a metal hydride compressor. Aside from combining the reforming, H₂ separation and compression, which are part of conventional H₂ generation (top diagram), the engineers behind the system demonstrated the use of Pd-alloy membranes in a fluidized-bed environment. The unit is designed to produce H₂ outputs of 15 m³/h (standard temperature and pressure) and has achieved H₂ purities of 99.99%.

The system, originally supported under a U.S. Dept. of Energy (DOE; Washington, D.C.; www.energy.gov) program, was developed by Membrane Reactor Technologies Ltd. (MRT; Vancouver, B.C., Canada; www.membranereactor.com), along with partners Ergenics Corp. (Ringwood, N.J.; www.ergenics.com) and Linde North America Inc. (Murray Hill, N.J.; www.us.lindesgas.com).

MRT developed a steam methane reformer equipped with 25 palladium-alloy membranes that allow in-situ separation of H₂ generated by the methane reforming reaction (bottom diagram). The Pd alloy membrane selectively allows H₂ molecules to diffuse out of the reforming zone through the foil. "The H₂ removal actually drives the thermodynamic reaction equilibrium forward," says MRT president Tony Boyd, "so methane conversion rates are high at relatively mild operating conditions" (550°C reactor temperature).

The purified H₂ is absorbed into cool metal hydride beds, then desorbed at higher pressure after heating. A series of metal hydride beds can compress H₂ from sub-atmospheric pressure to 100 bar in a single system by engineering the hydride composition in each compression stage, Ergenics says.

Boyd envisions the system being used in smaller industrial markets for onsite H₂ production, to avoid transporting large numbers of H₂ cylinders. In addition, the system could be located at future H₂ filling stations that supply fuel-cell automobiles.

The team is working to address remaining technical issues before moving to the design of a commercial prototype, Boyd says.

Using DME to extract ‘green crude’ from algae

Algae has recently become an R&D focus for making third-generation biofuels because these oil-containing microorganisms reproduce so quickly and can be grown away from arable farmland. However, getting the oil from the cells — and the water — is energy intensive. Traditionally, the cells are first concentrated into a slurry by compression or centrifugation. Then, the cell walls are broken down by acid hydrolysis or pulverization. Finally, liquid-liquid extraction with an organic solvent (such as hexane or acetone) is used to extract the oil, and the solvent recovered by distillation.

A simpler process, which also promises to be more efficient while consuming less energy, is being developed by Hideki Kanda, chief scientist of the Energy Engineering Research Laboratory, Central Research Institute of Electric Power Industry (CRIEPI, Tokyo, criei.denken.or.jp/en). The process takes advantage of a unique property of liquified dimethyl ether (DME) — its miscibility in both oil and (to a lesser extent) water. In the process, liquified DME is continuously circulated through a column containing algae slurry at room temperature and 0.5 MPa pressure. After about 10 minutes, the oil is extracted into the DME. The oil-laden DME can then be phase separated from the water, and the DME recovered as (Continues on p. 16)

Pt-free fuel cells

Solvay S.A. (Brussels, Belgium; www.solvay.com) has increased its stake in ACAL Energy (Runcorn, U.K.) by investing £1.5 million (£1.75 million). ACAL will use the funds to accelerate the next stage of development of its FlowCath Pt-free cathode technology for fuel-cell systems. This technology uses a proprietary liquid catalyst in the cathode instead of precious metals. Solvay and ACAL are currently preparing to install the world's first demonstration fuel-cell system using FlowCath at Solvay Interex's industrial site at Warrington, U.K. Expected to be operational later this year, the £1.9-million investment will consist of three fuel-cell stacks with an electric power of 5 kW per unit. The units are manufactured by SolviCore, a 50:50 joint venture of Solvay and Ultimoric (Brussels; www.ultimoric.com).

Water-free solar plant

Construction has begun on a solar Brayton-cycle demonstration plant and research facility at CSIRO's National Solar Energy Center (Newcastle, New South Wales, Australia; www.csiro.com). The project is a joint effort of the CSIRO Energy Transformed Flagship and the Australian National University (ANU; Canberra; www.anu.edu.au).

Unlike conventional solar-thermal plants, which concentrate the sun's energy to generate steam for driving a turbine, the Brayton thermodynamic does not use water. Instead, the concentrated solar energy is used to heat compressed air, which then expands through a gas turbine to generate power. Energy to compress the air is obtained from batteries. The Brayton cycle consists of four steps: adiabatic compression, isobaric heating, adiabatic expansion of the heated gas, and isobaric cooling.

The CSIRO system includes 450 heliostats to reflect the sun onto a 30-m-high solar tower, which will power a 200-kW turbine. The plant will be capable of operating at temperatures above 900°C and will be fully operational by March 2011.