titanium-oxide drying process at the Yokkaichi factory of Ishihara Sangyo Kaisha Ltd., will be stored and used to warm the low-temperature TiO_2.

ETERNAL BIOCATALYSTS

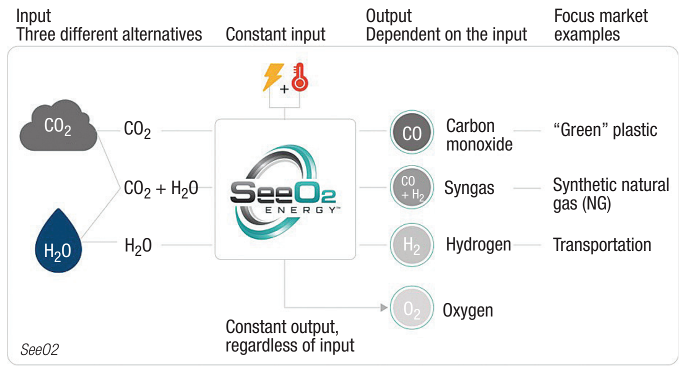
Efficient catalysts for converting H_2 into electricity in fuel cells are often based on expensive, precious metals, such as platinum. Alternative catalysts based on less expensive metals or biological components may work just as efficiently, but have a short service due to sensitivity to oxygen. A research team, led by professor Nicolas Plumeré from the Ruhr Explores Solvation (Resolv) Cluster of Excellence at Ruhr-Universität Bochum (RUB; Germany: www.rub.de), with Vincent Fourmond and Christophe Léger from the Centre national de la recherche scientifique Marseille (CNRS; France; www.cnrs.fr), has succeeded in integrating such a catalyst within an extremely thin protective film of molecular building blocks that shields it from O_2, and thus makes its service life practically infinite while maintaining its ability to work efficiently.

Although protective films had been developed previously, they were found to be unsuitable for catalyst applications because the films were so thick (>100 µm), they hampered efficiency, says Plumeré.

In the current work, reported in the September 19 issue of *J. Am. Chem. Soc.*, the researchers show that, even in a much thinner polymer film, hydrogenase enzymes are safe from O_2. "Surprisingly, these films, which are only a few

(Continues on p. 9)

Symmetrical fuel-cell design simplifies CO_2 conversion



A new carbon-utilization technology developed by SeeO2 Energy Inc. (Calgary, Alta., Canada; www.seeo2energy.com) takes advantage of thermodynamics in a high-temperature electrolyzer to efficiently convert carbon dioxide into CO and O_2 with 100% selectivity. Based on the principle of a reversible solid-oxide fuel cell, the technology employs a perovskite-based catalyst that can withstand not only high temperatures and impurities, such as sulfur, without coking or decomposition, but also enables symmetrical operation on both sides of the electrochemical cell, explains Beatriz Molero Sanchez, SeeO2 co-founder and chief technology officer. "Normally, there would be one material for the electrode on each side of the cell. Our catalyst allows us to have a symmetrical design to make the fabrication process easier and less expensive," says Molero Sanchez. Beyond CO_2, SeeO2's cell can also electrolyze water, and can co-electrolyze water and CO_2 into syngas and O_2.

For scaleup purposes, however, the company is focusing on processing CO_2 streams — the technology has demonstrated effectiveness with high-purity CO_2, as well as streams with just 30% CO_2 content. Operating at high temperatures avoids some of the disadvantages of other CO_2-conversion processes, including catalyst poisoning, delamination within the cell and low selectivity. "At high currents, with some catalysts, the electrolyte and electrode physically separate and the device goes into failure mode. This catalyst provides a stable interface between the electrode and the electrolyte, and provides both electronic and ionic catalytic activity," adds Molero Sanchez.

SeeO2 was established in April 2018 and since then, it has developed a prototype unit that can convert 10 kg/d of CO_2. The company is currently working with Equinor ASA (Stavanger, Norway; www.equinor.com) to accelerate the technology, and plans are in place with Calgary-based energy company ATCO Ltd. to launch a pilot project in 2020. In preparation for commercialization, SeeO2 is also verifying the technology's use with direct fluegas streams to prove that impurities do not hinder CO_2 conversion. "Our next milestone is to field test the prototype in the real world. That's our stepping stone to commercial units that convert 1–3 ton/d of CO_2, with eventual plans to scale up to larger-capacity units in the range of 1,000 ton/d," adds Molero Sanchez.

Modifying waste biomass to catalytically degrade pollutants

Sewage and wastewater often contain pollutants and environmental hormones (endocrine disruptors) that can have a negative effect on the environment and on human health. Catalysts currently used to destroy such pollutants involve high costs. And up to now, research has mostly focused on developing single-substance catalysts and enhancing their performance. Little research has been done to develop an eco-friendly nanocomposite catalyst capable of removing environmental hormones from sewage and wastewater.

Now a research team from the Korea Institute of Science and Technology (KIST; Seoul, South Korea; https://eng.kist.re.kr), led by Jae-woo Choi and Kyung-won Jung, has utilized biochar created from rice hulls to produce an eco-friendly, low-cost and highly efficient catalyst. They coated the surface of the biochar with nano-sized manganese dioxide to create a nanocomposite.

To make the catalyst, the KIST team used a hydrothermal method — a type of synthesis that uses high heat and pressure — to produce a nanocomposite. The team observed that giving the catalyst a three-dimensional, stratified structure resulted in the high effectiveness of the advanced oxidation process, due to the large surface area created.

The catalyst developed at KIST removed more than 95% of bisphenol A, an environmental hormone disruptor, in less than one hour, compared with 80% removal by the catalyst currently used. When combined with sonication (20 kHz ultrasound), the KIST catalyst removed all traces of bisphenol A in less than 20 min. Even after many repeated tests, the bisphenol A removal rate remained at about 93%.