edu.sg) have found a way to create biocement from two common waste materials — industrial carbide sludge (a waste product of acetylene production) and urea (from urine).

To make the biocement, carbide sludge is first treated with an acid to produce soluble calcium. Urea is then added to the soluble calcium to form a cementation solution. A bacterial culture is then added and the bacteria break down the urea into carbonate ions, which react with the soluble calcium ions in a process called microbially induced calcite precipitation (MICP). When this reaction occurs in soil or sand, the resulting calcium carbonate generated bonds soil or sand particles together to increase their strength, and fills the pores between them to reduce water seepage through the material. The same process can also be used on rock joints, which allows for the repair of rock carvings and statues.

The soil reinforced with biocement has an unconfined compression strength of up to 1.7 MPa, which is higher than that of the same soil treated using an equivalent amount of cement.

The proof-of-concept research was described in a recent issue of the *Journal of Environmental Chemical Engineering*.

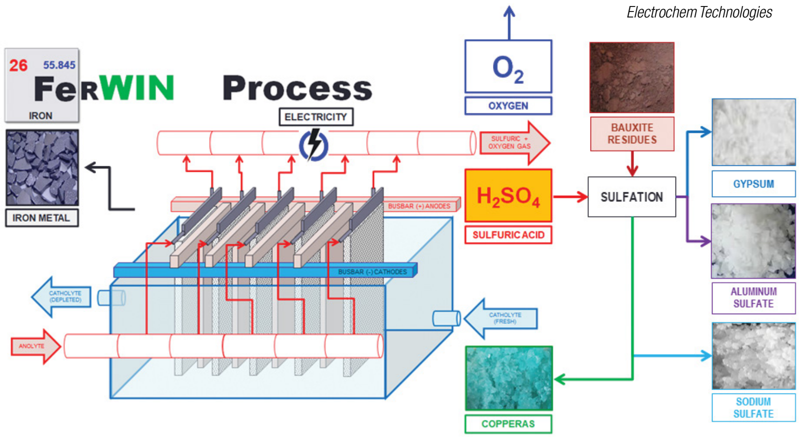
BIOFUEL

Researchers from the University of Agder (UiA; Kristiansand, Norway) and the University of Jaffna (Sri Lanka; www.jfn.ac.lk) are collaborating to develop a more environmentally friendly transportation fuel in Sri Lanka. The biofuel — made from bioethanol and castor oil — is suitable for the engines used in the three-wheeler

(Continues on p. 8)

Recycling bauxite residues and electrowinning iron

Electrochem Technologies



Electrochem Technologies & Materials Inc. (Montreal, Canada; www.electrochem-technologies.com) produced pure electrolytic iron (99.995% Fe) using its patented FerWIN process (diagram) — a sustainable zero-carbon iron-making technology — from ferrous sulfate heptahydrate (copperas) originating from the sulfation of bauxite residues. This pilot test work involved reacting concentrated sulfuric acid with bauxite residues, from which iron, aluminum and sodium sulfates, along with gypsum, are recovered. Then, the electrowinning of iron metal was performed on the crystallized copperas. Pure electrolytic iron flakes were electrowon inside a rectangular electrolyzer with 10 ft^2 of cathodes, while regenerating the concentrated sulfuric acid to be recycled upstream during sulfation.

"Based on the excellent faradic current efficiency (98%), low specific-energy consumption (2.9 kWh/kg Fe) and operating expenditures ($315/m.t. of Fe), we are optimistic that combining the sulfation of bauxite residues and the electrowinning of iron could represent a possible route for neutralizing, dewatering, recycling and valorizing red mud and bauxite residues," says Francois Cardarelli, president of Electrochem Technologies & Materials. "This is particularly true in locations having an oversupply of sulfuric acid from nearby smelters and affordable nuclear power or hydroelectricity," he says.

From an environmental standpoint, the FerWIN process also releases pure oxygen gas to the atmosphere generating carbon tax credits. The patented technology is now granted and enforced in 16 key jurisdictions (within Canada, China, Japan, South Africa, Europe, Brazil and India) where red-mud landfills represent a serious environmental hazard. As the technology is now technically proven, de-risked, and the costs and benefits analysis favorable, the company is currently seeking to secure licensing agreements for the FerWIN process across the aluminum industry, Cardarelli says.

Scaleup project for simultaneous carbon capture and conversion

A multidisciplinary project to scale up a system capable of simultaneously capturing carbon dioxide from fluegas and converting it to ethanol has received $1.9 million from the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E; Washington, D.C.; arpa-e.energy.gov). The electrochemical capture-and-conversion process has been proven in a laboratory system designed by Mohammad Asadi, assistant professor at the Illinois Institute of Technology (IIT; Chicago; www.iit.edu) and has the potential to lower the cost of carbon capture to less than $40 per ton of CO_2 (compared to the $60–100 per-ton cost observed today).

To accomplish the one-step capture and conversion, Asadi's laboratory synthesized a catalyst consisting of transition-metals specially functionalized with organic ligands. "We are unifying two problems — capturing CO_2 and converting it to useful chemicals — into one system," Asadi says. The bifunctional material is able to address a number of recalcitrant scientific and engineering challenges, including the mass-transport challenge of bringing CO_2 molecules to a surface, and the thermodynamic challenge of reducing CO_2 while also forming a carbon-carbon bond.

To address the mass transport issue, the nanostructured surface sets up a CO_2 gradient to hasten the diffusion of CO_2 to the reaction surface, where the local environment makes an ethanol-forming electrochemical reaction favorable, Asadi explains.

A multidisciplinary team is now assembled to study the economic feasibility and lifecycle costs of a scaled-up version of the simultaneous capture-and-conversion system. Scaling up the prototype will involve assembling stacks of the electrochemical systems containing the catalyst material, Asadi notes.