Georgia Tech

Research Update
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REDUCING ACID RAIN: ONE-STEP ELECTROCHEMICAL PROCESS CLEANS FLUE GASES WITHOUT PRODUCTION OF WASTES

Researchers have reported significant progress in the development of a new one-step electrochemical process for removing sulfur-containing compounds from smokestack gases. The work could become increasingly important as coal-burning utilities face tighter restrictions on their emission of the sulfur oxide compounds which cause acid rain.

Progress on the technique was described April 17 at the national meeting of the American Chemical Society. **Earlier stages of this work were reported in a news release Electrochemical Sandwich Promises..." dated February 13, 1990.**

The process under development at the Georgia Institute of Technology would provide an alternative to "scrubber" technology now used for cleaning up flue gases. The electrochemical technique is particularly attractive because it requires no chemical input and produces a saleable product instead of waste materials. It also offers cost advantages over existing methods.

"If you use scrubbers, you are adding lime or slurries of lime and you are making a waste sludge," noted Dr. Jack Winnick, professor of chemical engineering at Georgia Tech. "With our process, there is no waste stream and no chemical input. Instead of trying to find a place to dump a waste, we are finding products that are useful."

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The process relies on an electrolytic membrane composed of a molten sulfate salt held in a porous ceramic matrix. An electrical current applied to gas diffusion electrodes on either side of the membrane induces the removal of the sulfur oxides.

The removal technique works like this: Flue gases containing sulfur oxides flow past the porous negatively charged electrode (the cathode), where a series of complex chemical reactions begin.

The sulfur oxides are transformed to sulfur trioxide, which reacts to form sulfates as it moves across the membrane -- which is made of a material which has a special affinity for

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sulfur oxides. The sulfates pass through the membrane and contact the positively-charged anode, where they are fully oxidized to sulfur trioxide. The sulfur trioxide can then be removed, and with the addition of water, converted to commercially valuable sulfuric acid.

Within the past year, Winnick and graduate student Dennis McHenry have made important improvements to the electrolytic cell which have enhanced its efficiency and improved its lifetime.

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>
> *Dr. Jack Winnick*

One improvement came in the manufacture of the membrane's matrix, which is composed of an inert ceramic material such as silicon nitride or silicon carbide. McHenry mixes the ceramic powder with a commercial polymer then allows it to dry, forming a flexible tape which can be used to create larger shapes.

Once the tapes is formed into the proper configuration, the polymer is burned away, leaving a ceramic matrix with a regular structure of empty cells much like a sponge.

"Once you burn out the polymer, you can fill the tape with electrolyte and get very high retention of the electrolyte in the membrane," McHenry explained. "The interstices are just the right size to generate enough capillary force to hold the electrolyte in the membrane and keep it from flowing into the electrodes."

The researchers have also improved the gas diffusion electrodes, obtaining substantial improvements in their operating lifetimes.

A key remaining challenge is to increase the current density which can be handled by the electrolytic cells. Researchers have determined how much electrical energy will be required to remove the sulfur oxides from the smokestack emissions. Boosting the amount of current which can be handled by a given portion of the electrolytic cell increases the amount of flue gas it can clean, allowing a reduction in the size of the pollution control equipment.

Researchers have recently increased the current density by a factor of five, but hope to make further improvements to boost gas flow through the device.

Winnick believes the electrochemical process offers significant economic advantages over current scrubber technology, and could cut environmental costs by more than 50 percent.

In a typical electric generating facility, he said, chemical scrubbing of flue gases can account for between 20 and 30 percent of total power generation costs. The electrochemical process would consume only about two percent of the power generated by the facility, less than half the amount used by existing methods, Winnick added.

The process could be retrofitted to any existing coal-burning facility, and incorporated in the design of new facilities.

In addition to its value in cutting the production of sulfur materials which cause acid rain, the process would also make more efficient use of natural resources.

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This research was sponsored by the U.S. Department of Energy.

Editor's Note: Earlier stages of this work were reported in a news release "Electrochemical Sandwich Promises..." dated February 13, 1990.