Georgia Tech

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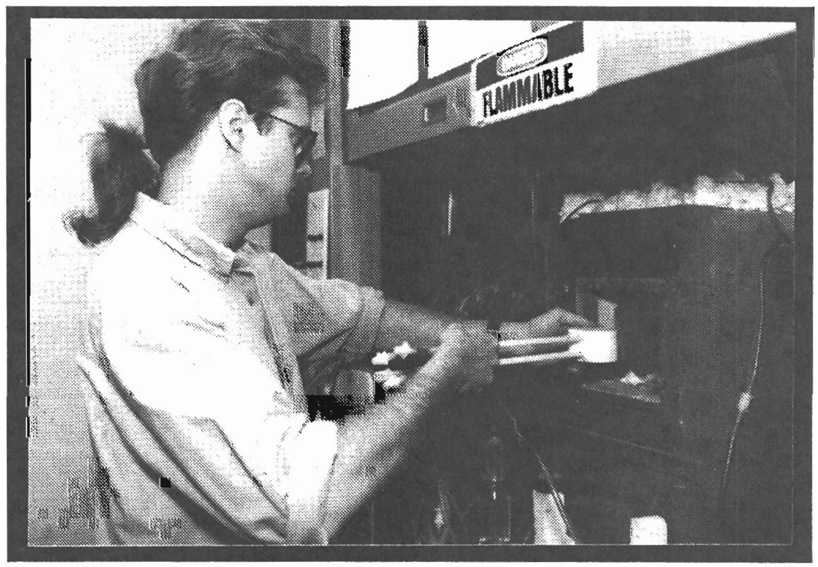
IMPROVED SULFUR REMOVAL PROCESS COULD INCREASE USE OF COAL & NATURAL GAS WITHOUT WORSENING ACID RAIN

An experimental process for removing hydrogen sulfide from fuel gases prior to combustion could help the United States make better use of its coal and natural gas reserves -- without worsening acid rain problems.

Researchers at the Georgia Institute of Technology say the new process could help make coal gasification economically feasible and reduce the cost of processing natural gas. The one-step electrolytic process removes hydrogen sulfide and converts the pollutant to hydrogen gas and elemental sulfur, both of which are useful materials.



Steve Alexander places experimental electrochemical cell into a furnace for testing. The cell uses a membrane composed of a molten salt and porous ceramic matrix. (Color slide/B&W Avail)

"If you can clean up the gas at the front end, you don't have acid gas in the downstream," explained Dr. Jack Winnick, professor of chemical engineering at Georgia Tech. "It's a much cleaner way to generate electricity."

Information on the work was presented April 17 to the meeting of the American Chemical Society. The presentation was part of the Symposium on Membrane Technology for New Applications.

Most electric powerplants in the United States burn coal to produce steam, which is then used to turn a turbine. The process, said Winnick, converts just 35 percent of the coal energy to electric power and requires costly scrubbing equipment to remove sulfur from the flue gases.

In the future, he predicts, steam turbines will give way to combined cycle

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systems which use two energy conversion steps: fuel cells or gas turbines, followed by a steam turbine. He said combined cycle systems operating on gasified coal could recover up to 50 percent of the energy, offering significant improvements in energy efficiency and reducing the amount of carbon dioxide released to produce a given amount of electricity.

But because it would contaminate the fuel cells, the hydrogen sulfide will have to be removed from the coal gas before use. Clean-up techniques currently exist, but their high cost has so far made coal gasification uneconomical, Winnick explained.

Because it uses a one-step process and operates at high temperature (600 degrees Celsius), the electrochemical process under development at Georgia Tech could substantially reduce the cost of removing hydrogen sulfide -- and perhaps help make combined cycle generation more economically feasible, he suggested.

The process depends on an electrochemical membrane composed of a porous ceramic material filled with a molten carbonate salt. An electrical current passing through the membrane induces the chemical reaction.

On contacting the membrane, the hydrogen sulfide splits into sulfide ions and hydrogen, explained Steve Alexander, a graduate student who is working on the process. The sulfide ions migrate to the anode -- the positively-charged electrode -- where they are converted to sulfur gas and blown off. The combustible hydrogen becomes part of the fuel stream used in power generation.

The process could remove hydrogen sulfide from any gas stream, though it was initially developed for coal gas and natural gas -- which must also be processed prior to be use.

"Our process is only one step," he explained. "You have separation of hydrogen sulfide from the gas with direct production of elemental sulfur. The only thing you are using is electricity."

Some of the molten salt evaporates, however, requiring periodic replacement. Alexander believes the membrane and electrodes should last at least 10,000 hours, but would require periodic replacement. Still, he noted, a cost analysis shows the system could operate for 30 to 50 percent less than conventional removal techniques.

Existing processes use columns of liquid absorbents to remove the hydrogen sulfide. The hydrogen sulfide must be extracted from the liquid before it is recirculated through the system.

Coal gas is produced at a high temperature, but because conventional hydrogen sulfide removal processes operate at ambient temperatures, the coal gas must be cooled before it can be cleaned. The cooling and reheating require substantial energy inputs which would not be needed by the electrochemical system.

Researchers have so far obtained removal rates as high as 99.9 percent for gas mixtures containing 2.5 percent hydrogen sulfide, while removal rates of 95 percent have been measured for leaner gas mixtures which contain just 100 parts per million of hydrogen sulfide.

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Removal rates, however, depend on the concentration of the hydrogen sulfide. "The less concentrated the gas, the more resistance you have to transporting it through the membrane," Alexander noted.

Though similar to molten carbonate fuel cell technology which is nearing commercialization, the hydrogen sulfide removal process has so far only been operated at the laboratory scale. But the researchers say only minor materials-related issues must be solved before it can be commercialized.

Tight control over the electrical potential is needed to ensure the most efficient removal of hydrogen sulfide. At high electrical potentials, Alexander noted, the membrane also removes some carbon dioxide in addition to the hydrogen sulfide.

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