R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Sequestration

4/2006

Bauxite Residue/Brine for CO_2 Sequestration

Background

An ever-increasing amount of scientific evidence suggests that anthropogenic release of CO_2 has led to a rise in global temperatures over the past several hundred years. Assuming this is true, unabated release of greenhouse gasses will result in global warming that may lead to significant and possibly catastrophic alteration of climate and natural cycles throughout the world. One feasibility study underway at the National Energy Technology Laboratory (NETL) involves sequestration of CO_2 from the atmosphere by promoting the trapping of CO_2 as mineral carbonates using Ca, Mg, and Fe-bearing caustic waste streams.

More than 70 million tons of bauxite residues are generated annually when alumina is extracted from bauxite ore. The residue is mostly composed of iron and titanium oxides, silica, calcium carbonate, and unrecoverable alumina and soda. The pH of the liquid can be as high as 13.5, and the solids also contain high alkalinity. The caustic nature of the residue causes concerns associated with long-term environmental liability and impact. Worldwide, there are about 200 million tons of bauxite residues; these are mostly stored in tailings ponds. For decades, the aluminum industry has been investigating options for treating, disposing, and utilizing these bauxite residues. Traditionally, dewatering and impoundment of these residues has been the only viable management option. Recently, the addition of CO_2 has been used to achieve partial neutralization of liquid and solid phase alkalinity (to a pH of approximately 10) of this caustic material prior to impoundment. In addition to partial neutralization, carbonation promotes a limited amount of CO_2 trapping through dissolution and mineral carbonate formation. Carbonation, therefore, helps to decrease the threat of environmental impact posed by storage of large volumes of the caustic residue. However, direct carbonation does not succeed in fully neutralizing the bauxite residue byproduct.

Currently 20 to 30 billion barrels of saline wastewater are produced annually with the production of oil and gas in the USA. About 35 percent of this acidic wastewater (pH 3 to 5) is treated and discharged as surface water. Many of the gas/oil-field brines have high concentrations of dissolved Ca, Mg, and Fe ions. Carbonate minerals could be formed in the presence of CO_2 under certain conditions. This suggests the possibility of using Ca, Mg, and Fe ions from saline wastewater for CO_2 sequestration *via* the formation of carbonate minerals.

CONTACTS

Yee Soong
Research Group Leader
Geosciences Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4925
yee.soong@netl.doe.gov

Robert Kleinmann
Division Director
Geosciences Division
National Energy Technology Laboratory
P.O. Box 10940
626 Cochrans Mill Road
Pittsburgh, PA 15236
412-386-6555
robert.kleinmann@netl.doe.gov

ADDRESS

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

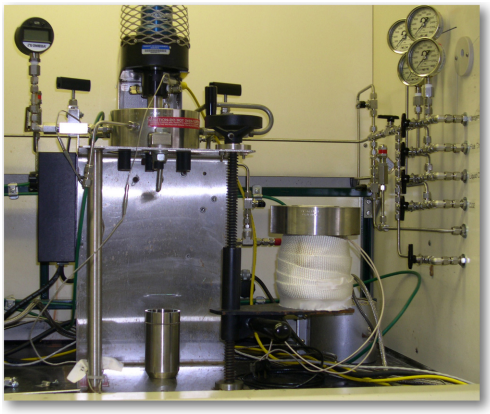
1-800-553-7681

WEBSITE

www.netl.doe.gov

Primary Project Goal

This project is designed to explore the applicability of bauxite residue/brine reactant mixtures to absorb and sequester CO_2 from both concentrated gas streams and as a component of a mixed flue gas.



Autoclave Reactor

Objectives

The objectives of this project are to provide initial assessment of CO_2 and SO_2 sequestration in bauxite residue/brine/CO_2 mixtures and bauxite residue/brine/flue gas mixtures.

Accomplishments

Alcoa and NETL have entered a Cooperative Research and Development Agreement to further advance a novel concept that achieves full neutralization of bauxite residue through reaction with acidic oil and gas field wastewater brines with subsequent carbonation. Experiments are being conducted to determine the ability of bauxite residue/brine mixtures to absorb and sequester CO_2 both from a concentrated CO_2 stream and as a component of a mixed flue gas. The use of bauxite residue/brine mixtures to capture and store CO_2 will serve to not only help mitigate the impact of anthropogenic CO_2 on global warming but will also serve to achieve complete neutralization of the caustic industrial waste for safe storage and potential reuse. Finally, the ability to sequester SO_2 in the reactive slurry and the fate of the absorbed sulfur is also under investigation. Geochemical equilibrium modeling will be used to predict precipitation and mineralization phenomena. An internal NETL report of possible invention has been filed and reviewed by the internal patent review panel. Collected data provide a preliminary assessment of process feasibility and probe the influence of several variables on treatment efficiency. Maximum observed initial sequestration capacities ranged from 2 to 7.2 grams of CO_2 per liter of reactant for mixtures ranging from pure brine to pure bauxite residue, respectively. Product pH for CO_2 carbonated mixtures of bauxite and brine varying in composition from 10 percent brine/90 percent bauxite residue by volume to 90 percent brine/10 percent bauxite residue by volume resulted in product slurry neutralization to pHs of between 7.37 and 5.99, respectively. Geochemical equilibrium modeling was conducted to predict the composition, pH, and CO_2 solubility of bauxite residue/brine mixtures. Despite the relatively short duration of batch experiments (hours), results of preliminary equilibrium modeling efforts compare favorably with experimental results while observing CO_2-absorbing capacity and trends in dissolved constituent concentration in agreement with model results over the range of bauxite/brine mixtures. Experiments conducted to date have proved the concept of CO_2/SO_2 absorption and bauxite residue neutralization.

Benefits

- Solubility and potential mineral trapping of CO_2 from industrial waste gas with concomitant neutralization of reactive byproduct.
- NETL opportunity to collaborate with industry.