TITLE: DEVELOPMENT OF A CO_2 SEQUESTRATION MODULE BY INTEGRATING MINERAL ACTIVATION AND AQUEOUS CARBONATION

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1. ABSTRACT

Program Introduction: Rationale and Objective

Mineral carbonation is a promising concept for permanent CO_2 sequestration due to the vast natural abundance of the raw minerals, the permanent storage of CO_2 in solid form as carbonates, and the overall reaction being exothermic. However, the primary drawback to mineral carbonation is the reaction kinetics. To accelerate the reaction, aqueous carbonation processes are preferred, where the minerals are firstly dissolved in solution. In aqueous carbonation, the key step is the dissolution rate of the mineral, where the mineral dissolution reaction is likely to be surface controlled. In order to accelerate the dissolution process, the serpentine can be ground to very fine particle size (<37 μm), but this is a very energy intensive process. Alternatively, magnesium could be chemically extracted in aqueous solution. Phase I showed that chemical surface activation helps to dissolve the magnesium from the serpentine minerals (particle size ~100 μm), and furthermore, the carbonation reaction can be conducted under mild conditions (20°C and 650psig) compared to previous studies that required >185°C, >1850psig and <37 μm particle size. Phase I also showed that over 70% of the magnesium can be extracted at ambient temperature leaving amorphous SiO_2 with surface areas ~330m^2/g. The increase in surface area obtained is particularly important because the extraction process only occurs on the surface. The overall objective of the proposed research program is to optimize the active carbonation process developed in Phase I in order to design an integrated CO_2 sequestration module for Vision 21 plants.

Accomplishments Achieved During the Current Period of Performance

During the current period of performance, August 2003 – March 2004, serpentine, a magnesium rich mineral, is being used as the carbonation feedstock. Surface activation studies are being

conducted to promote the inherent carbonation reactivity of serpentine. Several variables have been identified as potential contributing factors in the optimization scheme for serpentine surface activation. An array of experimental variables is under study, including serpentine particle size, acid concentration, temperature, and reaction time, to identify optimum activation conditions. The parent samples and their activated counterparts are being studied by thermogravimetric analyses and inductively coupled plasma-atomic emission spectrometry. Carbonation studies will be conducted on the treated samples.

Plans for the Remaining Period of Performance

The work planned for the upcoming months of this research program includes:

- Continued activation studies of the serpentine with experimental optimization for the generation of activated carbonation minerals.
- Further characterization of surface properties with X-Ray Diffraction, BET, and SEM analysis.
- Integrated carbonation studies on the raw materials and their activated counterparts as well as carbonation experiments will also be conducted.
- Publish the outcome of these investigations.

2. LIST OF PUBLISHED JOURNAL ARTICLES, U.S. PATENT APPLICATIONS, CONFERENCE PRESENTATIONS AND STUDENTS RECEIVING SUPPORT FROM THE GRANT

Conference presentations

- M.M. Maroto-Valer, M.E. Kuchta, Y. Zhang, J.M. Andrésen, and D.J. Fauth, Comparison of physical and chemical activation of serpentine for enhanced CO_2 sequestration. Prepr. Am. Chem. Soc. Div. Fuel Chem., 2004, 49(1), 373-375.
- M. M. Maroto-Valer, M. E. Kuchta, Y. Zhang, and J. M. Andrésen, Towards the development of a CO_2 mineral sequestration module, Seventh International Conference on Greenhouse Gas Control Technologies, 2004, Submitted.
- M. M. Maroto-Valer, M. E. Kuchta, Y. Zhang, and J. M. Andrésen, Optimization of the mineral activation process to sequester CO_2 at low pressures and temperatures, Third Annual Conference on Carbon Sequestration, 2004, Submitted.

Patent applications

- Provisional patent based on Phase I, M.M. Maroto-Valer, Y. Zhang, M.E. Kuchta, J.M. Andrésen, and D.J. Fauth, "Utilization of serpentine mineral for CO_2/SO_2 capture and sequestration", # 2003-2790

Students Supported under this Grant

- George Alexander, graduate student, Department of Energy and Geo-Environmental Engineering, The Pennsylvania State University.
- Hui Ou, undergraduate student, Industrial Engineering, The Pennsylvania State University.