the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Utilization of CO_2 in High Performance Building and Infrastructure Products

Background

In an effort to reduce carbon dioxide (CO_2) emissions from various industrial and power generation processes to the atmosphere, the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is currently funding research intended to advance current state-of-the-art technologies that address the use or reuse of carbon dioxide (CO_2) in a variety of different economic and industrial processes.

Carbon dioxide utilization efforts focus on pathways and novel approaches for reducing CO2 emissions by developing beneficial uses for CO2 that will mitigate greenhouse gas emissions. Utilization of CO2 is an important component of carbon sequestration and applicable approaches include conversion of CO2 into useful chemicals and polycarbonate plastics, storage of CO2 in solid materials having economic value, indirect storage of CO2, and other breakthrough concepts.

Critical challenges identified in the utilization focus area include the cost-effective use of CO_2 as a feedstock for chemical synthesis or its integration into pre-existing products. The efficiency (CO_2 integration reaction rate and the amount of CO_2 sequestered in a product) and energy use (the amount of energy required to utilize CO_2 in existing products) of these utilization processes also represent a critical challenge. This research will use CO_2 to create a high-strength Portland cement substitute for use in high-performance building materials.

Project Description

CSS Materials, Inc. (CSS Materials) is working to create an energy efficient, CO_2-consuming inorganic binder that will act as a suitable substitute for Portland cement in concrete. The process being developed by CCS Materials will enrich CO_2 in a concrete admixture. The process utilizes a binding phase based on carbonation chemistry. Utilizing this chemistry requires no pyro-processing and eliminates the need for large Portland cement kilns, thereby saving significant amounts of energy and reducing CO_2 emissions in the process.

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PARTNERS

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PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2013

COST

Total Project Value
$1,473,861

DOE/Non-DOE Share
$794,000 / $679,861

The project will involve investigating the dependence of the reaction rate and carbonation yield on temperature, pressure and particle size. Various types and compositions of minerals and aggregates will also be evaluated across these parameters.

Success in this work will allow CCS Materials to significantly reduce the energy required to make concrete by approximately 60 percent and lower total CO2 emissions by approximately 90 percent. This will permit the sequestration of large amounts of CO2 via construction materials.

Goals/Objectives

The goal of the project is to develop an alternative to Portland cement that requires less energy to create, generates minimal CO_2, and has high-strength mechanical properties. This project will be an interdisciplinary laboratory/engineering process study with three main focus areas:

- Reducing energy consumption during the material creation process: Processing of Portland cement requires very high temperatures (approximately 1,450 °C) whereas the processing of CO_2-containing product requires much lower temperatures resulting in less energy use.
- Increasing carbonate yield: The addition of CO_2 to the cement processing sequence results in a significant reduction (up to 90 percent) of CO_2 emissions relative to the Portland cement processing sequence.
- Improving the mechanical strength of cement: The microstructure and chemistry resulting from CCSM's process creates a much stronger material than what is created with traditional Portland cement processing.

Benefits

Concrete is one of the world's most widely used materials. Concrete production consumes approximately 500 trillion British Thermal Units (BTUs) of energy and produces approximately 40 million tons of CO_2 per year. By developing a CO_2-consuming inorganic binder and reducing both the energy required to make concrete and the resultant emissions, this research could facilitate the sequestration of large amounts of CO_2 in construction materials. The LTS process has the potential to revolutionize the industry by creating the possibility of reaching the overall goal of a negative CO_2 balance, meaning that more CO_2 is sequestered in the concrete production process than is emitted during manufacturing.

Figure 1: Concrete prepared with CCSM's new cement binder