the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Integrated Electrochemical Processes for CO_2 Capture and Conversion to Commodity Chemicals

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 state-of-the-art technologies that address the use of CO_2 in a variety of different economic and industrial processes.

Carbon dioxide utilization efforts focus on pathways and novel approaches for reducing CO_2 emissions by developing beneficial uses for CO_2 that will mitigate greenhouse gas emissions. Utilization is an important component in carbon sequestration and some of the applicable approaches are conversion of CO_2 into useful chemicals and polycarbonate plastics, storage of CO_2 in solid materials having economic value, indirect storage of CO_2, 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 project will investigate an electrochemical process that chemically sequesters CO_2 by using it in the creation of organic carbonate chemicals, which will ultimately provide modeling data for chemical synthesis, energy usage, and economic viability.

Project Description

Researchers at the Massachusetts Institute of Technology (MIT) and Siemens are investigating the feasibility of integrating CO_2 from carbon dioxide emitting sources (power plants, manufacturing facilities, cement plants, or fertilizer facilities) into a chemical reaction process that will create organic carbonate commodity chemicals for later use. The researchers also are designing an electrochemical cell to allow for a multi-stage, continuous organic carbonate synthesis process, and conducting multiple lifecycle analyses of the electrochemical process and commodity

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PARTNERS

Siemens Corporate Research

PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2012

COST

Total Project Value
$1,250,067

DOE/Non-DOE Share
$1,000,000 / $250,067

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chemicals synthesized during chemical CO_2 sequestration activities. The basis of this technology is the chemical affinity of electrochemically active carriers for CO_2 molecules that facilitate their effective capture from a dilute gas stream (effluents from carbon dioxide emitters) through formation of chemically activated species. The proposed technology will exploit the characteristics of these activated species to undergo chemical reaction with various reagents to yield commodity chemicals. The proposed technology has the potential not only to capture CO_2 from industrial carbon emitters but also to utilize the CO_2 in the activated state as a raw material to produce useful commodity chemicals in an energy efficient process.

Goals/Objectives

The goal of the project is to chemically sequester CO_2 by the creation of organic carbonate commodity chemicals and to develop various models to evaluate reactivity, environmental lifecycle analysis, and economic parameters. This project will be a laboratory/process engineering study with the following three main focus areas:

- Scientific assessment of the integrated chemical sequestration process: The proposed technology will allow for the capture of CO_2 and its chemical sequestration in commodity chemicals. The initial study will examine the synthesis of organic carbonates from CO_2. As research progresses, more complex organic carbonate molecules will be synthesized using electrophiles (reagents attracted to electrons that participate in a chemical reaction by accepting an electron pair in order to bond to a nucleophile) in combination with CO_2.
- Engineering assessment of the integrated chemical sequestration process: A multi-stage, continuous function electrochemical cell will be designed and implemented to allow for the synthesis of organic carbonate commodity chemicals and the chemical sequestration of CO_2. A process model will also be developed to illustrate operating parameters and power usage demands of the electrochemical cell. Numerical and fluid dynamic simulations will supplement the process model.
- Lifecycle analyses of the integrated chemical sequestration process: Evaluation of the environmental and economic performance for each CO_2 utilization pathway, consisting of the CO_2 source, the CO_2 capture and conversion process to commodity chemicals, and potential industrial application of the carbon-utilization model will be considered. Several alternative pathways leading to commercially viable and desirable commodity chemicals will also be considered.

Benefits

This chemical sequestration of CO_2 will help minimize CO_2 emissions and supplement geologic CO_2 storage, particularly in areas where such storage might not be a viable option. The proposed technology has the potential not only to capture CO_2 from industrial carbon emitters but also to utilize the CO_2 in the activated state as a raw material to produce useful commodity chemicals in an energy efficient process. The added value of this research includes a single-step, integrated, CO_2 capture and chemical sequestration process; production of various commodity chemicals depending on the reagents used to react with the activated species; and minimal energy requirements.

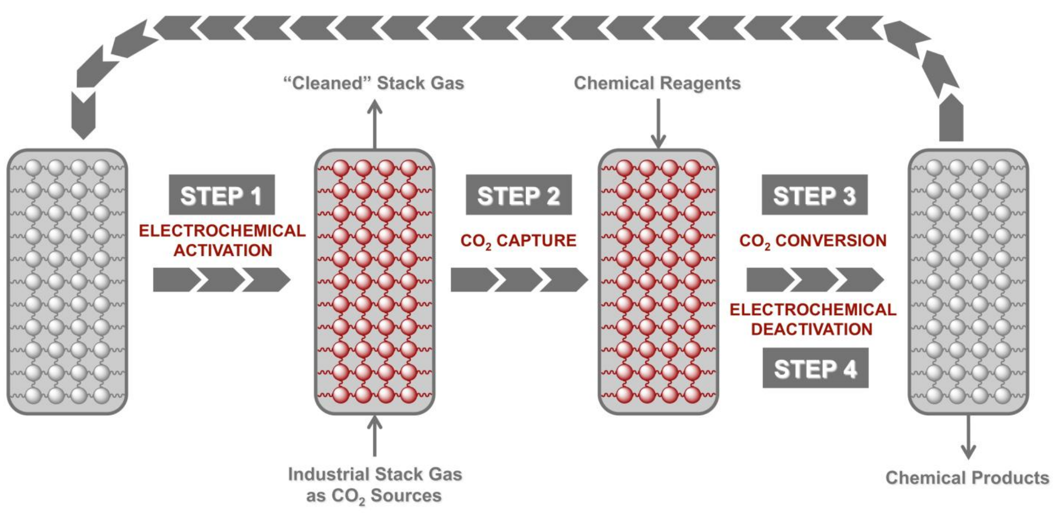

Figure 1: Schematic diagram of the integrated process to capture CO2 and utilize it as a raw material to produce useful commodity chemicals in an energy efficient manner.