PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

PROCESS DESIGN FOR THE BIOCATALYSIS OF VALUE-ADDED CHEMICALS FROM CO_2

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Background

Organic compounds available from U.S. agricultural enterprises include glycerol, a renewable material generated as a by-product in the production of biodiesel, whose production volume is anticipated to increase significantly, and glucose, the primary carbohydrate generated from agricultural enterprises in the U.S., such as corn wet-milling. This project is studying the production of a suite of specialty chemicals by biocatalytic fixation of CO_2 and co-substrates, such as glycerol and glucose. Although several chemical products can be produced using the sequestration technology being developed by this project, the focus of this study is on succinic acid. Recent advances in the metabolic engineering of the production microbes have made feasible the commercial biosynthesis of succinic acid from CO_2 and these co-substrates.

The biochemical pathways leading to succinic acid are similar in structure to those of *archaea*. However, unlike many species of *archaea*, the bacterium used in this project, can attain a high cell density in a short time and thereby provide high productivities, does not have fastidious media requirements, is well characterized genetically, does not require light to generate ATP, and is immediately amenable to process scale-up. Moreover, the proposed biocatalytic process is designed to operate under non-growth (stationary phase) conditions. This permits a high product yield to be achieved and minimizes the formation of excess biomass.

Primary Project Goal

The primary goal of this project is to produce a suite of specialty chemicals by biocatalytic fixation of CO2 with other inexpensive organic substrates, such as glycerol and glucose. The primary product from this operation is succinic acid.

PARTNER

University of Georgia Research Foundation, Inc.

COST

Total Project Value
$384,275

DOE/Non-DOE Share
$384,275 / $0

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Objectives

The objectives of this project are to:

- Modify the bacterial strain to make it suitable for industrial applications.
- Evaluate process robustness.
- Evaluate succinic acid production as a function of CO_2 mass transfer.
- Determine the effect of other process variables, such as pH and H_2 in the gas stream.
- Determine the effect of NO_X and SO_X and other potential inhibitors in flue gas.
- Optimize the fermentation medium to achieve and maintain a high cell density which supports succinic acid production.
- Develop a reactor design that optimizes CO_2 mass transfer and produces succinic acid at high rates and yields.

Benefits

This biological reaction to sequester CO_2 promises to be a practical way to convert CO_2 into value-added chemicals. An advantage of this process is the potential to use flue gas directly in the succinic acid production process and, thus, avoid the need for CO_2 capture and transport. The anticipated future application of the project will result in the synthesis of other chemical products from CO_2, such as formic acid, malic acid, and fumaric acid. This research will form the basis of a biorefinery approach for the production of value-added chemicals from CO_2 and serve as a niche process for CO_2 sequestration.

Accomplishments

- A strain has been developed which prevents the formation of ethanol as a by-product, and therefore a step which would generate CO_2 has been removed.
- The effect of pH and temperature on the CO_2 sequestration has been studied, with the result that the process can operate in the temperature range of 30 °C to 39 °C and the pH range of 6.2 to 7.0 without a deleterious effect on sequestration rate.
- An inexpensive defined media has been developed which promotes the growth of the microorganism, and permits subsequent sequestration. The process using this media has consistently attained a volumetric CO_2 sequestration rate of about 700 mg/Lh.