the ENERGY lab

PROJECT FACTS

Carbon Sequestration

High Efficiency Solar-based Catalytic Structure for CO_2 Reforming

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 or reuse 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 of CO_2 is an important component of carbon sequestration and applicable approaches include 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 research will develop a material that may be useful in converting CO_2 into other useful chemicals using sunlight as energy.

Project Description

Researchers at PhosphorTech Corporation are modifying conventional photocatalyst materials to improve their ability to convert/reform CO_2 into other useful species in a cost-effective and energy efficient manner. A photocatalyst is a material that speeds up a chemical reaction when subjected to sufficient light energy (sunlight, in this study). To date, even the most efficient conventional photocatalysts suffer from extremely low concentration yields (0.01-0.1 volume percent), making them impractical for commercial applications. Researchers are looking to improve performance in order to make these types of technologies more efficient and cost-effective for reforming CO_2.

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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
$1,248,504

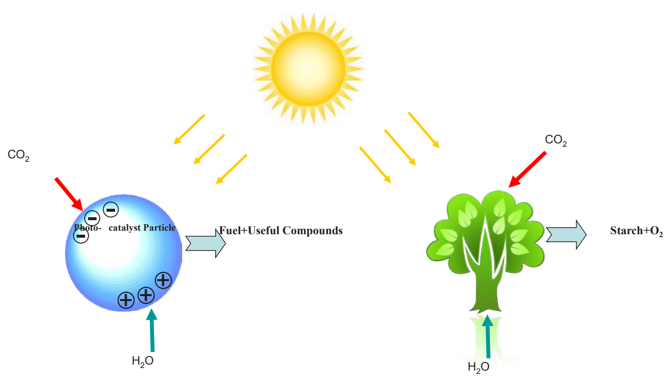
DOE/Non-DOE Share
$998,655 / $249,849

U.S. DEPARTMENT OF ENERGY

An ideal light-harvesting CO_2 catalyst must have the following properties: (a) high quantum yields (the ratio of electron-hole pairs generated per absorbed photon); (b) high sunlight absorption for maximum utilization of solar energy; (c) high hydrocarbon reaction yield for maximum reforming of CO_2; (d) high chemical stability for long-term operation; and (e) low production cost. To achieve this, a revolutionary new and stable CO_2 catalytic structure having high CO_2 reduction potential, high absorption in the visible part of the solar spectrum, and high utilization of infrared solar energy is being developed. The structure will be built using commercially available nanocrystalline materials of titanium oxide (TiO_2), and narrow band gap (NBG) semiconductors such as quantum dots (QDs). The resulting outcome will be a significant increase in CO_2 photo-reduction yield and, for the first time, achievement of a commercially feasible solar-based CO_2 reforming technology that can be used to convert CO_2 into useful commodities such as methane gas.

Goals/Objectives

The objectives of this project are to develop and demonstrate a novel CO_2 catalytic structure having high CO_2 reduction potential, high absorption in the visible part of the solar spectrum, and high utilization of infrared solar energy. Both a low-cost solution manufacturing and a higher-cost vacuum deposition process will be developed and optimized to achieve a semiconducting structure with optical and electrical properties consistent with those of high quality films.



A semiconductor such as TiO_2 is used as a manmade photocatalyst to convert CO_2 into useful materials. The process is similar to how natural plant cholrophyll converts CO_2 into starch and O_2.

Benefits

The proposed pathway for this conversion process will utilize solar energy, a readily available renewable resource. The conversion to methane will only require water as a co-reactant, negating the need for any mined or manufactured consumables, thus greatly enhancing the conversion process's economic viability and moving it toward achieving the DOE target net cost of less than $10 per metric ton.

The chemical conversion of CO_2 back to fuel using a renewable energy source such as sunlight would eliminate many of the issues facing existing and emerging bio-conversion processes or biofuels, such as competing with other land or crop use, increased water demand, ongoing governmental subsidies, etc. A direct chemical conversion process would utilize the high concentration of CO_2 emissions from fossil power plants and convert them into usable fuel at a faster rate—a matter of seconds for the subject process compared to days for bio-conversion of feedstocks such as algae, and months for cane, corn, and oil seeds. An efficient and cost-effective photocatalytic conversion of CO_2 to a fuel such as methane would be a major breakthrough.

Additionally, as a potential alternative to geologic sequestration of CO_2, especially where subsurface storage may not be an optimal solution, chemical conversion to value added products or commodities would provide a very attractive solution.

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