DEPARTMENT OF CHEMICAL AND ENVIRONMENTAL ENGINEERING
COLLEGE OF ENGINEERING AND APPLIED SCIENCE

SUMMER RESEARCH OPPORTUNITIES FOR UNDERGRADUATE students

APPLICATION DEADLINE: 02/25/2022

PROJECT TITLE: Electrohydrogenation of carbon dioxide into ethylene: decarbonizing the ethylene manufacturing process

Jingjie Wu
Department of Chemical and Environmental Engineering
College of Engineering and Applied Science
578 ERC
Email: Jingjie.Wu@uc.edu
Phone: 513-556-2756

Project Description

Ethylene (C_2H_4) is a key building block in the chemical industry to produce a wide range of plastics, solvents, and cosmetics, etc. Globally, C_2H_4 production by steam cracking is ranked as the second-largest contributor of energy consumption (2.8 EJ/year) and greenhouse gas emissions (300 Mt of CO_2-e/year) in the chemical industry. This project aims at decarbonizing the C_2H_4 manufacturing process by electro-hydrogenation of CO_2 into C_2H_4 coupled with renewable electricity. Our goal is to partially replace conventional energy-intensive, fossil fuel-based, centralized C_2H_4 plants with small-scale, high-efficiency, distributed C_2H_4 plants using waste flue gas and renewable electricity. The electrocatalytic CO_2-to-C_2H_4 conversion using Cu-based catalysts is currently restricted by the low selectivity and productivity of C_2H_4. During CO_2 reduction, CO is the key intermediate that is dimerized to form C_2H_4. Instead of direct conversion of CO_2 to C_2H_4 with sluggish kinetics, we propose to design segmented tandem electrodes that divide the electrolyzer into two regions: (i) an inlet region for reducing CO_2 to CO and (ii) an outlet region for further reducing CO to C_2H_4. Thus, segmented tandem electrodes can achieve cascade CO_2?CO?C_2H_4 conversion and promote the yield of C_2H_4 via in-situ spatial management of CO concentration at the catalyst surface. This project helps achieve the zero-carbon emission target by 2050, the Biden’s Administration set up.
Our lab has assembled an automated spraying system for electrode fabrication. The undergraduate students will use this automated spraying system to design tandem electrodes and optimize the microstructure of electrodes to reach maximum selectivity and productivity of C_2H_4. The undergraduate students will learn a broad spectrum of knowledge throughout the project: 1) electrochemical engineering, 2) heterogeneous catalysis, 3) polymer and colloid science, and 4) mass transport. Upon completing this project, the students are encouraged to build a team to participate in EnergyTech

University Prize, a new Department of Energy competition with over $250,000 in cash prizes.