The Catalysis Club of Philadelphia

Thursday, February 16th, 2023

Brandywine Plaza Hotel
630 Naamans Road, Claymont, DE 19703

Electrochemical Systems for Carbon Dioxide Utilization

Speaker: Prof. Feng Jiao

University of Delaware

Tuning Oxygen-Containing Functional Groups and Reactivity of Carbon Surfaces

Student Speaker: Jiahua Zhou

University of Delaware

Meeting Schedule:

Social Hour ..... 5:30 PM
Dinner ..... 6:30 PM
Meeting ..... 7:30 PM

Meeting Fees:

Members: $45.00
Non-Members: $55.00
Stud. & Retired Members: $35.00

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Meeting and Meal reservations – Please register online by ***Thursday, February 9th*** at http://catalysisclubphilly.org/meeting-registration-with-paypal/

Or contact our Treasurer Steve Hardwick (sjh.wilm.de@gmail.com) or Chair Udayshankar Singh (udayshankar.singh@grace.com)

Membership – Dues for the 2022-23 season will be $25 ($5 for the local chapter and $20 for the national club). Dues for students, post-docs and retirees will be $10 ($5 for the local club and $5 for the national club).

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Prof. Feng Jiao

Department of Chemical and Biomolecular Engineering, University of Delaware

Electrochemical Systems for Carbon Dioxide Utilization

Abstract:

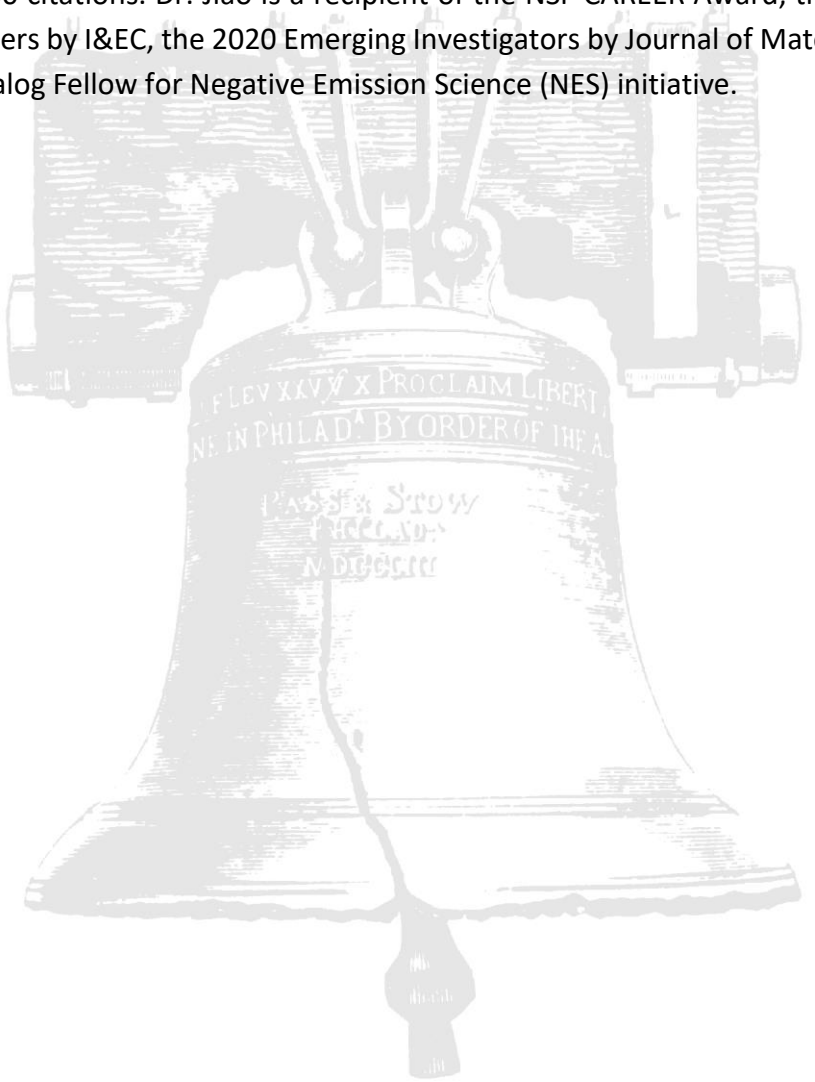
Our society is facing the climate change and global warming challenges caused by the ever-increasing CO_2 level in our atmosphere. Reducing the CO_2 emission becomes a critical mission for us to fight for the sustainable future. In traditional chemical industries, most processes are driven by fossil sources, which inevitably emits a large quantity of CO_2. Recently, electrochemical processes attracted attentions as they could be more environmentally friendly with a much smaller carbon footprint if powered by renewable electricity. Our research group currently focuses on the development of CO_2 electrolysis devices that convert CO_2 into value-added chemicals and fuels through innovations in electrocatalyst design and reactor engineering. In this talk, we will present our recent work related to a two-step tandem CO_2 electrolysis system, which allows us to achieve an acetate selectivity as high as 55% at high purities and concentrations. [1] The ability to convert CO_2 into acetate made it possible to create an electrochemical-biological hybrid approach to produce foods from CO_2 with a much higher efficiency than nature's photosynthetic pathways.[2] Additionally, we will discuss our techno-economic assessment of major CO_2 reduction products to provide guidelines to future research and development of ambient temperature CO_2 electrolysis technologies.[3]

References:

1. S. Overa, B. Crandall, B. Shrimant, D. Tian, B. H. Ko, H. Shin, C. Bae and F. Jiao*. Enhancing acetate selectivity by coupling anodic oxidation in carbon monoxide electroreduction. Nature Catalysis 5, 738-745 (2022). 10.1038/s41929-022-00828-w
2. E. C. Hann, S. Overa, M. Harland-Dunaway, A. F. Narvaez, D. N. Le, M. L. Orozco-Cardenas, F. Jiao* and R. E. Jinkerson*. A hybrid inorganic-biological artificial photosynthesis system for energy-efficient food production. Nature Food 3, 461 (2022). 10.1038/s43016-022-00530-x
3. H. Shin, K. U. Hansen and F. Jiao. Techno-economic assessment of low-temperature carbon dioxide electrolysis. Nature Sustainability 4, 911 (2021). 10.1038/s41893-021-00739-x

Speaker Bio:

Professor Feng Jiao received a BSc in Chemistry from Fudan University (P. R. China) and a PhD degree in Chemistry from University of St Andrews (United Kingdom). After postdoctoral training at Lawrence Berkeley National Laboratory, Dr. Jiao joined the University of Delaware in 2010 and is now Professor of Chemical and Biomolecular Engineering and the Director of Center for Catalytic Science & Technology. The Jiao group develops novel electrochemical devices for solving critical issues in energy and sustainability. To date, Dr. Jiao has published 100 papers, which have received over 15,000 citations. Dr. Jiao is a recipient of the NSF CAREER Award, the 2017 Class of Influential Researchers by I&EC, the 2020 Emerging Investigators by Journal of Materials Chemistry A, and the 2020 Scialog Fellow for Negative Emission Science (NES) initiative.



Tuning Oxygen-Containing Functional Groups and Reactivity of Carbon Surfaces

Jiahua Zhou

Advisor: Prof. Dion Vlachos

University of Delaware

Oxygen-containing carbons are promising support and metal-free catalysts for many reactions. Distinguishing the role of various oxygen functional groups and quantifying and tuning each functionality is still limited. Here we investigate the role of Brønsted acidic oxygen-containing functional groups by synthesizing a diverse library of materials. By combining acid-catalyzed elimination probe chemistry, comprehensive surface characterizations (XPS, AP-XPS, TPDE-MS), ^{15}N isotopically labeled acetonitrile adsorption coupled with magic-angle spinning nuclear magnetic resonance (MAS NMR), machine learning, and density-functional theory calculations (DFT), we demonstrate that phenolic (-OH) is the main acid site in gas-phase chemistries and unexpectedly Ar/R-carboxylic (-COOH) groups are much less acidic than -OH in the graphitized mesoporous carbon due to electron density delocalization induced by the aromatic rings of graphitic carbon. The methodology can identify acidic sites in oxygenated carbon materials in solid acid catalyst-driven chemistry.

Speaker Bio

Jiahua Zhou is a fourth-year Ph.D. student at the University of Delaware working with Prof. Dion Vlachos. Jiahua received her Master's degree from Tianjin University in Chemical Engineering. Her current research interest lies in heterogeneous catalysis for the fundamental investigation of the role of surface oxygen functional groups on carbon support as well as the inverse metal-metal oxide catalysts including materials synthesis/characterizations.