



Programmable, Electrified, and Far-from-equilibrium Thermochemical Synthesis

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Abstract: Conventional thermochemical syntheses are often powered by combustion of fossil fuels or natural gas, which is both inefficient and environmentally unfriendly. Moreover, near-equilibrium continuous heating via combustion lacks the rapid, precise, and time-resolved control over the temperature profile (i.e., reaction temperature and timescale), causing many reactions to suffer from limited selectivity, low yield, and/or poor catalyst stability. In this talk, I will first introduce an electrified approach to perform thermochemical reactions under far-from-equilibrium conditions. Specifically, we developed a programmable heating and quenching technique that allows for transient and periodic heating times (e.g., 20–110 milliseconds) as well as ultrafast heating and cooling rates (10000 K/s). These dynamic reaction conditions lead to improved selectivity, energy efficiency, and catalyst stability. We demonstrated the utility of this approach in both homogeneous, endothermic CH₄ pyrolysis and heterogeneous, exothermic NH₃ synthesis. In the second part of the talk, I will discuss how programmable, electrified, far-from-equilibrium processes can enhance material circularity, where we demonstrated efficient plastic and biomass upcycling, as well as the valorization of other waste streams.

Bio: Dr. Qi Dong is an Assistant Professor in the Tarpo Department of Chemistry at Purdue University. He earned his Ph.D. in Chemistry from Boston College and completed postdoctoral training at the University of Maryland. His research focuses on developing programmable, dynamic approaches for thermochemical and electrochemical synthesis to address critical challenges in energy, the environment, and sustainability. Dr. Dong has authored more than 70 publications and holds over 10 patents related to his innovations. In addition to his academic work, he is an entrepreneur and co-founder of Polymer-X Inc., a startup focused on electrified chemical manufacturing. Dr. Dong has received several honors, including the DOE Early Career Research Award, the ARPA-E IGNIITE Award, and the Scialog Award for Sustainable Minerals, Metals, and Materials.

Hosted by: Prof. Erdem Sasmaz