CHEMICAL & BIOMOLECULAR ENGINEERING

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BREAKING THE RULES OF CLASSICAL CRYSTALLIZATION: AN UNCONVENTIONAL GUIDE TO CRYSTAL ENGINEERING

JEFFREY RIMER

University of Houston
Abraham E. Dukler Professor

Ph.D., University of Delaware, 2007

ABSTRACT

Crystal engineering is a broad area of research that focuses on methods of designing and/or optimizing materials for diverse applications in fields spanning from energy to medicine. The ability to selectively control crystallization to achieve desired material properties requires detailed understandings of the thermodynamic and kinetic factors regulating crystal nucleation and growth. Combining this fundamental knowledge with innovative approaches to tailor crystal size, structure, and morphology can lead to the production of materials with superior properties beyond what is achievable by conventional routes. In this talk I will discuss two general mechanisms of crystal growth: (1) classical pathways involving growth by the addition of monomers (ions or molecules); and (2) nonclassical pathways, termed crystallization by particle attachment (CPA), involving the formation of metastable precursors that play a direct role in crystal nucleation and growth. A ubiquitous approach in crystal engineering to selectively alter the rate(s) of anisotropic growth is through the use of modifiers, which are molecules (or macromolecules) that interact with specific crystal surfaces and mediate the attachment of growth units. In this talk, I will show how we use modifiers in unique ways to control crystallization in two distinctly different, yet fundamentally similar, applications. In the first part of my talk I will discuss our work on the development of therapeutic drugs for crystals implicated in two pathological diseases: kidney stones (calcium oxalate monohydrate) and malaria (hematin). In the second part of my talk, I will discuss how we are using organics that operate as either modifiers or structure-directing agents to tailor the properties of zeolites, which are microporous aluminosilicates used in catalysis, adsorption, and ion-exchange processes. In order to elucidate the mechanisms of crystal growth and the role of modifiers, we developed a unique atomic force microscope (AFM) liquid cell that enables time-resolved imaging of surface growth under solvothermal conditions. I will show how in situ AFM has created new opportunities to probe complex pathways of nonclassical crystallization as part of our broader effort to develop new methods to tailor the physicochemical properties of crystalline materials for commercial applications.

BIOGRAPHY

Jeffrey Rimer is the Abraham E. Dukler Endowed Professor of Chemical Engineering at the University of Houston. Jeff received B.S. degrees in Chemical Engineering and Chemistry from Washington University in St. Louis and Allegheny College, respectively, and his Ph.D. in Chemical Engineering from the University of Delaware. He was a postdoctoral fellow at New York University before starting his research program in crystal engineering. Jeff has received several teaching and research honors at Houston, and national awards that include the NSF CAREER Award, the 2016 Owens Corning Early Career Award and 2017 FRI/John G. Kunesh Award from AIChE, and the 2018 Norman Hackerman Award in Chemical Research from The Welch Foundation. Jeff is a former chair of the Southwest Catalysis Society, an executive committee member for the American Associate for Crystal Growth and International Zeolite Association, and has chaired two Gordon Research Conferences. He also serves on the advisory boards for the AIChE Journal, Molecular Systems Design & Engineering, and Reaction Chemistry & Engineering.

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