Materials Science & Engineering Thesis Defense

Synthesis, Engineering, and Characterization of Covalent Organic Framework-Based Composite Aerogels

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Abstract

Covalent organic frameworks (COFs) are a recently discovered class of nanoporous materials with ultra-high specific surface areas. These materials are highly promising for applications in molecular capture, nanofiltration, and catalysis, as the dimensions of their nano-scale pores are highly customizable, allowing COFs to be tuned to select for any number of specific molecules. However, these materials have greatly restricted utility because of their extremely fragile macroscopic morphologies, typically existing as low-density powders. Recently developed methods to produce monolithic aerogels from COF ligands yield structures with low compressive yield strengths, as well as low strain at yield. The poor mechanical properties of these COF monoliths can be supplemented through the creation of a composite material. Structurally robust polymer fillers can be incorporated into the aerogel during synthesis, and then later crosslinked to create a secondary network within the gel that improves the strength and elasticity of the material. Through understanding the impact of the polymer inclusion and crosslinking on the pore structure and specific surface area of the COFs, the loading of the structural polymer can be optimized to minimize the decrease in the material's sorbent capabilities while maximizing the improvements in mechanical performance. Furthermore, understanding of the impacts of filler loading can allow for novel composites to be designed that leverage the high specific surface areas of COFs while also incorporating functional materials, such as two-dimensional ceramics and metal nanoparticles, greatly expanding the applicability of the materials.

April 4, 2024; 3:00 PM; ECG G305

Arizona State University