Hypercrosslinked Polymer Design and Implementation

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Porous organic polymers (POPs) are exciting materials for a wide range of applications due to their high surface areas, tuneable textural properties, and excellent chemical, thermal, and mechanical stabilities. The vast number of synthetic routes to POPs permits readily modifiable chemical functionality and/or broad bottom-up design. However, many synthetic routes to sophisticated POPs require precious metal catalysts, which are typically not recycled, significantly driving up cost and hindering scale-up. Furthermore, specifically polymerizable groups in monomeric material are often required for the formation of POP networks. Such monomers are seldomly commercially available or are expensive.

Hypercrosslinked polymers (HCPs) are a low-cost class of POPs with excellent tunability. HCPs are densely crosslinked amorphous networks, produced using simple Friedel–Crafts chemistry. HCPs are synthesised from non-functional aromatic compounds (i.e. without specifically polymerisable groups) that can be 'knitted' together in a variety of ways. Hypercrosslinking typically requires only abundant Fe- or Al-based Lewis acid catalysts or simple organic acid catalysts. Owing to their low costs and broad design scope, HCPs are developed for a variety of applications including gas separation and storage, solid state extraction, and energy storage.

In this talk, I will give an overview of POPs and HCPs more specifically. I will go on to describe some of our previous and ongoing work in both the design of new and innovative routes to HCPs, as well as their implementation. In HCP production, we are investigating ever simpler routes to networks, with an aim to reduce waste without sacrificing performance. In their utilisation, we employ HCPs in a broad range of applications, including as heterogeneous catalysts for liquid-phase transformations, photocatalysts for CO_2 photoreduction, and even as electrode materials in energy storage. Given the versatility of HCP synthesis, an unfathomable number of design iterations are possible, presenting a huge opportunity to use HCPs as a platform for robust designable organic adsorbents.