Cationic Covalent Organic Frameworks as Anion Exchange Membranes for Electrochemical Energy Applications

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The COFFEE project combines expertise across multiple areas of materials chemistry and electrochemistry to develop innovative anion exchange membranes (AEMs) for electrochemical energy conversion and storage technologies. We have employed a bottom-up approach to design an entirely new class of membranes based on covalent organic frameworks (COFs). By functionalizing the inside of the cyclic COF structures with cationic groups, we can promote ionic conductivity through the self-assembled COF networks. The formation of these highly ordered nanochannels has the potential to enable ultrafast hydroxide transport across the membrane. These highly ordered COF structures are then embedded in a polymer matrix to form membranes with an optimal balance of ionic conductivity and mechanical stability.

Through careful selection of the molecular building blocks for COF synthesis, we can provide tailor-made membranes for a range of electrochemical energy technologies, namely anion exchange membrane water electrolysis (AEMWE) and zinc-air battery (ZAB) technologies. Ex-situ measurements (ionic conductivity, ion exchange capacity, swelling, zincate diffusivity) have been carried out to elucidate the structure-property relationship of various COF structures. In-situ measurements have been conducted to validate the performance of the COF-based AEMs under real operating conditions.

This presentation will highlight the synthesis and characterization of COF-based AEMs developed in the COFFEE project. Specifically, these materials exhibit promising characteristics as membranes for electrochemical energy applications such as good conductivity, appreciable ion exchange capacity, tuneable swelling, and low zincate diffusivity. In-situ ZAB measurements demonstrated the potential of the COF-based AEMs to replace traditional inorganic or nonwoven separators characterized by high zincate diffusivity and low hydroxide selectivity. The COF-based AEMs therefore have the potential to increase the performance and lifetime of solid-state zinc air batteries.

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