Organic 2D Membranes in Emerging Energy Devices

Xinliang Feng
[a] *Max Planck Institute of Microstructure Physics*
[b]*Technische Universitaet Dresden*
Xinliang.feng@tu-dresden.de

In the pursuit of sustainable energy solutions, the advancement of novel materials that enhance performance while minimizing environmental impact is of paramount importance. This is particularly true with regard to the development of membrane technologies. Significant efforts have been made to go beyond the conventional polymer membranes. Consequently, the 2D membranes with a laminar transport mechanism offer distinctive prospects due to their well-defined ion transport channels. Nevertheless, the transport pathway of laminar transport would remain relatively lengthy and predominantly influenced by the sheet size and the presence of defects or grain boundaries in the 2D materials with their stacked structures.

In this lecture, we will focus on organic 2D membranes as a novel type of membranes, with a particular focus on their potential for the development of innovative energy devices. These materials are distinguished by their molecular thinness and extensive lateral dimensions, which afford precise control over structural features such as pore size, thickness, stacking structures, and functional group positioning. Two-dimensional polymer thin films represent the most significant category of organic 2D membranes. We will commence with the presentation of the bottom-up synthesis methods, which employ on-water surface chemistry to program the supramolecular assembly of monomers on the water surface. This is the crucial step in guiding the subsequent 2D polymerization and formation of crystalline 2D framework structures. Specific attention will be devoted to the role of these membranes in energy storage and conversion devices, including batteries and osmotic power generators. In this context, the unique and selective ion transport properties of organic 2D membranes towards various metal and proton ions will be particularly discussed, underscoring their potential to transform energy device technology.