Investigation, Design and Application of Metal-Organic Frameworks for Atmospheric Water Harvesting

Nikita Hanikel
UC Berkeley Department of Chemistry and Kavli Energy
Nanoscience Institute, University of California, Berkeley, USA
(Present affiliation: Institute for Protein Design, University of Washington, Seattle, USA)

Advancement of supplemental methods for freshwater generation is imperative to effectively address the global water shortage crisis. In this regard, extraction of the ubiquitous atmospheric moisture is a powerful strategy allowing for decentralized access to potable water. The energy requirements as well as temporal and spatial restrictions of this approach can be substantially reduced if an appropriate sorbent is integrated in the atmospheric water generator. Accordingly, in my talk, I will discuss the development, characterization, and practical utilization of metal–organic frameworks (MOFs) as sorbents for water capture from air. In particular, the molecule-by-molecule water uptake mechanism in the state-of-the-art water-harvesting MOF is discerned by utilizing single-crystal X-ray diffraction analysis. Equipped with this knowledge, a strategy to deliberately shape the water-harvesting properties through the mixed-linker approach is developed. This allows for a reduction in desorption temperature and heat, as well as tuning of the operational humidity range without compromises to water uptake capacity and hydrothermal stability. To facilitate the industrial utilization of these materials, a novel, high-yielding synthetic method is devised, which allows for kilogram-scale production of water-harvesting MOFs. Additionally, a new strategy for enhancing the water uptake capacity of these materials is developed. Lastly, the water mobility in these materials is probed and compared to other commercially available sorbents. The insights from studying the water uptake kinetics are implemented in a new and highly productive atmospheric water harvester relying on fast uptake and release cycling. The prototype is successfully deployed in the Mojave Desert, thus establishing MOF-assisted water harvesting as a viable strategy to address water scarcity in arid climates.