Metal-Organiic and Covalent-Organic Frameworks (MOFs and COFs): from Single Crystals to Novel Functional Materials

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The development of novel materials with enhanced performance is a continuous process mainly driven by everyday demands. Optoelectronics is an excellent example of a field where constantly growing societal demands in energy consumption have forced material evolution to speed up. Metal-organic or covalent-organic frameworks (MOFs and COFs), crystalline porous materials consisting of organic and inorganic building blocks, have been evaluated as promising candidates for a variety of renewable energy applications.[1,2] The self-assembled nature of MOFs provides a very powerful tool for arranging hundreds of organic compounds with high structural organization and, therefore, provides an opportunity to utilize MOFs as light-harvesting mimics of the natural photosystem. At the same time, MOF crystallinity allows one to determine the precise distances and angles between self-assembled organic linkers and, therefore, study and model short- and long-range energy transfer processes. Furthermore, MOFs can be used as a “three-in-one” platform, which integrates the three aspects of artificial photosynthesis: photon absorption, generation of charge-separated excited states, and charge transfer to a reaction center into a single material to enhance, for instance, sensing efficiency or be applied as a photocatalyst. MOFs also offer a high degree of synthetic tunability, which could help to adjust optical, electrical, and sometimes even mechanical properties through postsynthetic modification (Figure 1).

Thus, MOFs have ideal properties for the development of new systems with improved functionalities. To highlight this concept in my presentation, I will summarize the recent advancements achieved in my group focusing on postsynthetic modification for understanding of MOF photophysics with an emphasis on energy transfer processes[1]. We also applied the acquired fundamental principles toward mapping of changes in material properties, which could provide a pathway for monitoring material aging or structural deterioration. I will also discuss our progress in understanding the tunability of electronic structure for bimetallic frameworks as well as recent developments towards utilizing MOF modularity and porosity for novel wasteforms [2].

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Figure 1. Postsynthetic modification of MOFs and COFs for tailoring material optoelectronic properties.
