Surface Dynamics of Monolayer Thin Materials: from 2D Polymers to Molecular Motors

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Deciphering the structure and dynamics underlying the formation of covalent and non-covalent organic-based two-dimensional (2D) crystalline materials is crucial for controlling their quality, including defect density and dimensions. A deep understanding of these factors enables fine-tuning of their properties.

This work highlights the application of scanning probe microscopy, particularly scanning tunneling microscopy (STM), in exploring:

1. The self-assembly and light-induced dynamics of molecular motors and switches on solid substrates.
2. The light-induced synthesis of 2D polymers
3. The structure and behavior of substrate-supported metal-organic frameworks (sMOFs) and covalent organic frameworks (sCOFs) at the liquid-solid interface.

We present our ongoing efforts to monitor molecular-scale “switching” at the liquid-solid interface, alongside strategies to optimize the crystallinity of sMOFs. Additionally, we provide an in-depth analysis of sCOF monolayer growth, focusing on real-time observation of nucleation and expansion processes. The study also explores the morphological features of sMOFs and sCOFs, including their chirality, and discusses techniques to induce and regulate multilayer formation.

Furthermore, we investigate the role of the STM tip’s electric field in initiating and controlling (de)polymerization processes, offering new insights into the dynamic manipulation of these materials.

1 G. Zhan, Z.-F. Cai, et al., *Nature*, **2022**, *603*, 835

1 G. Zhan, B. Koek, et al. *Nature Chemistry*, **2025**, in press