Characterization of Metal Organic Framework Thin Films using Atomic Force Microscopy and Nano-FTIR Spectroscopy

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Metal–organic framework (MOF) thin films are promising materials for applications in catalysis, sensing, separation, and electronics. For these industrial implementations, precise control over the crystallinity, orientation, and thickness is crucial. A key structural feature that requires careful attention is the coordination bonding between metal ions and polar functional groups in the organic ligands. In this study, we demonstrate nanoscale structural characterization of a MOF thin film called NAFS-1 [1], using atomic force microscopy (AFM)-based infrared scattering-type scanning near-field optical microscopy (IR *s*-SNOM; Neaspec GmbH) [2]. This technique enables simultaneous acquisition of structural and vibrational information at the nanoscale.

NAFS-1 films were fabricated at the air/liquid interface using a Langmuir trough and subsequently transferred onto solid substrates. Both multilayer and monolayer NAFS-1 films deposited on Si wafers and Au films on mica were characterized. AFM topography images revealed grains with lateral dimensions of several tens of nanometers and a thickness of ~1.2 nm in monolayer samples. Nano-FTIR measurements showed strong signals associated with uncoordinated carboxyl (COOH) groups across all samples, while peaks attributed to coordinated carboxylate (COO^-) were not clearly observed. Additionally, we investigated the effects of fabrication conditions. Our results underscore the importance of optimizing both the fabrication procedure and post-transfer treatment, as well as the need for a deeper understanding of the underlying self-assembly mechanism.

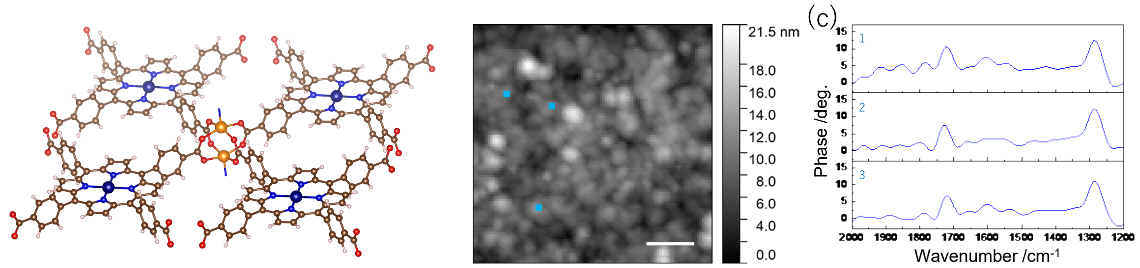

Figure 1. (a) Structural model of NAFS-1. (b) AFM topographic image of the 10-times transferred NAFS-1. (c) Nano-FTIR spectra recorded at three locations marked in (b).

Reference

[1] R. Makiura, et al. Nat. Mater. **9**, 565 (2010).

[2] Y. Matsumoto, et al., in preparation.