

Electrically Conductive MOF-Based Gas Sensors: Recent Advances, Mechanistic Insights, and Future Prospects

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Electrically conductive metal–organic frameworks (cMOFs), composed of periodically arranged metal clusters and organic linkers, are promising room-temperature gas-sensing materials owing to their charge-transport properties, compositional and structural tunability, catalytic activity, and intrinsic porosity [1]. However, achieving reliable electrical conductivity remains challenging because charge transport is highly sensitive to crystallinity, framework ordering, and film quality. Despite this challenge, cMOFs based on triphenylene- and phthalocyanine-derived ligands have been actively developed for electronic and sensing applications. In this presentation, recent advances in cMOF-based gas sensors are discussed from two perspectives: (i) cMOFs as chemiresistive sensing materials themselves and (ii) cMOFs as heterostructured functional layers.

First, the inherent conductivity of cMOFs enables their direct use as chemiresistive sensing materials. Many cMOF-based sensors have been interpreted in terms of redox-mediated resistance changes induced by gas adsorption and desorption. However, the high structural tunability of cMOFs also introduces substantial complexity, and many aspects of their charge-transport pathways and gas-sensing mechanisms remain unclear. In particular, humidity-dependence, changes in conduction pathways, gas-adsorption-induced structural distortion, variations in charge mobility, and photoactivation effects should be carefully considered.

Second, cMOFs can also be used as catalytic layers or molecular sieving layers by utilizing their intrinsic catalytic and porous properties. In this case, it is important to distinguish whether the separation effect originates from chemical filtering or physical filtering. In particular, when conductive MOFs are used as functional layers, additional electrical interactions can arise between the cMOF layer and the underlying sensing material. Understanding how these interactions affect gas-sensing behavior is essential for establishing systematic design strategies for cMOF-based gas sensors.

This presentation will highlight our recent studies on cMOF-based gas sensors from these two perspectives [2-5], emphasizing how structural design and interfacial interactions can be used to modulate gas-sensing characteristics.

Keywords: Conductive metal-organic frameworks; Gas sensors; Sensing mechanisms; Catalytic layers; Filtering layers;

References

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