Effective Gas Separation/Storage Performance Enhancement Obtained by Constructing Advanced Porous Materials

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Porous materials including metal-organic frameworks (MOFs) and zeolites have attracted increasing attention due to their applications in adsorptive gas separation and energy storage over the past few decades thanks to their ultra-high surface area and tuneable pore chemistry. Most MOFs and zeolites feature large pore volume and surface area and thus can provide relatively high adsorption capacity for all components in the gas mixture, but result in relatively low selectivity based on equilibrium adsorption.

Combining synchrotron radiation with various sample environment setups, we are able to study the mechanism of several tailor-made advanced absorbent materials. In-situ X-ray powder diffraction (XRPD) measurements have been conducted to discover a “molecular trapdoor” mechanism for exclusive gas discrimination, which is demonstrated as an unusual operating regime for a chabazite zeolite in which the adsorption selectivity for N_2 over CH_4 inverts from being more selective for N_2 at 253 K, to becoming less selective with increasing temperature and eventually becoming selective for CH_4 over N_2 above 293 K. XRPD also demonstrates it as an outstanding tool to reveal the novel MOF structures and monitor the progress of a new acid solvent synergistic ligand exchange synthesis method. A novel core-shell MOF composite constructed with above method from a high adsorption capacity MOF-Core as the high capacity gas storage core and a MOF-Shell with high gas selectivity as the outer shell has been fabricated to achieve merits of both simultaneously.

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