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Chemistry and Application of Soft Porous Crystals

With the Industrial Revolution in the 19th century, humans began to create technologies that consume huge amounts of energy. Initially, people used solid coal as an energy resource. In the 20th century, the focus changed to liquid petroleum. In the 21st century, where the depletion of petroleum has become a critical concern, gases (e.g., natural gas and biogas, and even air) should play important roles—an “age of gas” is dawning. However, a gas is a form that is difficult to handle because it is easily dispersed, creates mixtures, has a low concentration under normal conditions, and is invisible. In particular, new porous materials are indispensable for advancing science and technology to control gases at will.

As the promising materials to address global issues of clean energy technologies and environmental sustainability, the emerging class of crystalline microporous materials, porous coordination polymers (PCPs) or metal-organic frameworks (MOFs), have been applied in fields of gas storage and separation, delivery vessel, sensors, catalysis, supercapacitors, FETs, batteries, proton conduction, and so on. We have found the 3rd generation (3G) PCPs/MOFs (Soft porous crystals, SPCs) that possess flexible or dynamic porous frameworks reversibly respond to external stimuli, not only chemical but also physical, unlike robust PCPs/MOFs (2G). In particular, by controlling the local motion of organic ligands that construct the framework, we discovered and developed an effective mechanism for separating gas mixtures with very similar properties, such as oxygen/argon, and light water/heavy water isotopologue mixtures.

This talk provides an essential and accessible overview of the chemistry of SPCs, their current features, and the outlook of further developed materials as 4th generation PCPs/MOFs which exhibit multi-functions simultaneously or alternately in combination.

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