Carbon neutral, Energy storage, Sensing devices

Adsorption, separation, and storage of gas molecules through the development of organic porous materials that can be shape-controlled and surface-modified

Department of Applied Chemistry, Graduate School of Engineering
Professor Norimitsu Tohnai Researchmap https://researchmap.jp/read0089607
Assistant Professor Kouki Oka Researchmap https://researchmap.jp/k.oka


Abstract

Organic porous materials are increasingly being applied not only for adsorption, separation, purification, and catalyst, but also for various applications such as sensors and imaging by adding optic, electronic and magnetic properties.

Our research group has proposed a new organic porous material called porous organic salts (POS). In this study, we modified the porous surfaces of POS with various halogen elements, and were able to change the adsorption properties, such as selectivity to gas molecules and adsorption amount, depending on the halogen elements.

Background & Results

Inorganic porous materials have long been used in various fields such as storage, separation, purification, and catalysts. However, there are limits to the materials, structures, and properties that can be used, and over the past 20 years, organic porous materials with organic components have been actively investigated.

Among them, POSs presented by our group are constructed by simply mixing acidic and basic molecules, and can be produced very easily. The size, shape, and surface properties of the pores can be controlled by designing each component. Furthermore, it is easy to add optic, electronic and magnetic properties and can be applied to a variety of sensors and imaging. Additionally, they can be easily reused by washing or chemically regenerated by decomposition, contributing to the development of sustainable materials.

In this study, we constructed a porous structure of porous organic salts with hydrogen and four halogen elements exposed on the surface of the pores. The hydrogen-exposed porous material selectively adsorbed only carbon dioxide. On the other hand, the fluorine-exposed porous material adsorbed more carbon dioxide and was also able to adsorb oxygen and nitrogen. Furthermore, the chlorine-exposed material changed its selectivity for gas molecules and adsorbed oxygen best. As described above, by controlling the chemical environment of the pore surface, we succeeded in changing the adsorption properties for chemical substances.

Significance of the research and Future perspective

Our porous organic salts can be chemically modified in terms of the shape and size of the vacancies and their surfaces. In this work, we have achieved modification of the pore surfaces with halogen elements and demonstrated that the properties of the porous materials can be controlled.

It is noteworthy that the amount of adsorption, selectivity, and molecular recognition ability can be controlled. Such chemical modification is also possible with other substituents and elements, and can be deployed in various applications such as the recovery and separation of gaseous species that have a negative impact on global warming, such as carbon dioxide, methane, and CFCs; storage of green energy such as hydrogen and ammonia; and sensitive and highly selective sensing and recovery of toxic substances such as dioxin, PFOA, and PFOS.

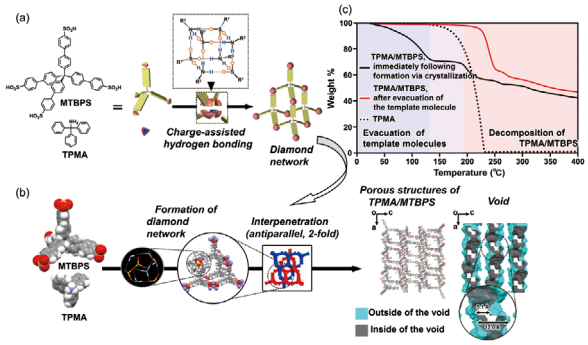

Fig.-1 Hierarchical construction of porous organic salts

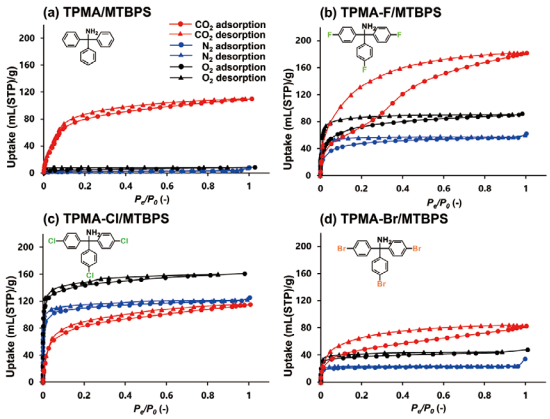

Fig.-2 Gas adsorption behavior of various porous organic salts

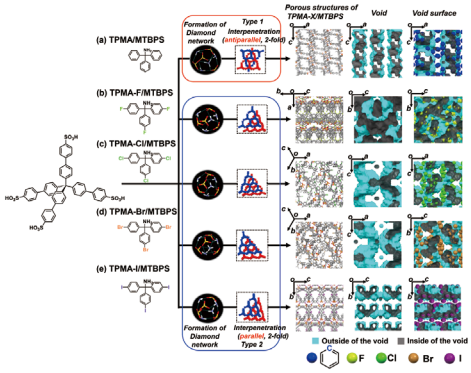

Fig.-3 Porous structures depending on various halogen elements

Patent	
Treatise	Ami, Takahiro; Oka, Kouki; Tohnai, Norimitsu et al. Porous Organic Salts: Diversifying Void Structures and Environments, Angew. Chem., Int. Ed., 2022, 61, e202202597, doi: 10.1002/anie.202202597
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