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Original Research Paper

Adsorption and thermodesorption characteristics of benzene in nanoporous metal organic framework MOF-5

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ABSTRACT

This study has been prepared and characterized a highly nanoporous metal organic framework (MOF-5). The nitrogen adsorption isotherm, gravimetric adsorption and thermodesorption method that utilize a quartz spring balance are used to examine the unusual adsorption behavior. Especially, the hybrid Langmuir–Sips isotherm equation is employed to correlate the experimental isotherm data. Moreover, the unusual adsorption behavior in MOF-5 is discussed in relation to its isosteric enthalpy of adsorption, adsorption energy distribution and desorption energy distribution calculated from benzene adsorption and thermodesorption measurements.

1. Introduction

The development of porous materials possessing a high surface area and well defined pore networks has been a crucial task in adsorption related areas over the past decades. Metal organic frameworks (MOFs) or porous coordination polymers (PCPs), consisting of organic linkers and inorganic joints, are relatively new microporous materials with novel structural topologies and promising sorption properties. Thus, these novel porous adsorbents have been explosively and intensively studied as promising nanoporous materials that may make a great impact in fields such as catalysis, chemical sensing, gas storage, gas or liquid separations, ion exchange and polymerization [1–4].

On the other hand, when compared with the conventional porous materials, such as activated carbons, zeolites, and metal oxides, the unique feature of MOFs (or PCPs) is their extraordinary network flexibility, which is closely related with the coordination bonds, noncovalent bonds, and weak interactions [2,4]. Because of this framework flexibility (or guest induced framework), some MOFs (or PCPs) exceptionally exhibit the unusual (or stepwise/sigmoid/multistep) adsorption isotherm pattern. This behavior has been frequently observed for water, small molecules (i.e., nitrogen, argon, oxygen, carbon dioxide and methane) and organic compounds (i.e., acetonitrile, methanol, ethanol and xylene isomers). Thus, a lot of effort, both in design and in synthesis, has been consistently devoted to the search for novel features which could open conceptual and practical applications. In addition, the development of MOFs (or PCPs) which could apply the classical areas [2,4–9] and several studies have been conducted on unveiling the novel phenomena occurred in MOFs (or PCPs) [6,7,9]. However, there are still many other unknown properties concerning the adsorption behavior on MOFs as well as desorption behavior. Especially, fundamental studies on adsorption and thermodesorption of organic compounds have still been very limited.

In this study, we prepared and characterized a highly porous MOF-5 among the various kinds of MOFs to examine the adsorption and thermodesorption behaviors of hydrocarbons on nanoporous MOFs. Especially, nitrogen adsorption isotherm was used to characterize the sample prepared. Gravimetric adsorption and thermodesorption method utilizing a quartz spring balance was also employed to examine the adsorption/thermodesorption properties of hydrocarbons on MOF-5. Here, we present unusual benzene adsorption isotherms measured over a wide range of temperatures (303.15–343.15 K) and pressures (0–8 kPa). A hybrid adsorption isotherm model consists of Langmuir and Sips was applied to fit

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