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Review

Metal-organic framework-based composites for biogas and natural gas uptake: An overview of adsorption and storage mechanisms of gaseous fuels

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ABSTRACT

Biogas and natural gas are potential renewable energy sources. They primarily contain CH_4, H_2, CO_2, CO, C_2H_6, C_3H_8, H_2S, N_2, and moisture. To be used as fuel, raw biogas and natural gas require upgrading to enrich the CH_4 content (≥97 %). The development of a practical technique to effectively trap gas molecules in a limited space for a variety of uses has been acknowledged as a major technical difficulty. Among the various practical enrichment processes, the adsorption-based method is particularly attractive for upgrading because of its ease of use and economy. A new family of versatile porous solid-state materials, metal–organic frameworks (MOFs), possess controllable structures, tunable thickness and pore size, chemically adjustable architectures, vast surface areas, and favorable mechanical flexibility. Therefore, MOF-based adsorbents can play an exceptional role in the adsorption of gas molecules like CO_2, CH_4, H_2, and C_2H_2 for gaseous fuel uptake and eliminating greenhouse gases from the atmosphere. The mechanism of gaseous molecule adsorption/separation using MOF materials was critically evaluated. Fluorinated MOFs, such as ZIF-8, ZIF-67, UiO-66, and nanosheets (2D MOFs), are considered potential adsorbents for moisture-stable, cost-effective, and efficient biogas and natural gas adsorption. Moreover, the prospects and further research ought to concentrate on comprehending the dynamics of gas adsorption and desorption in massive columns loaded with MOFs, effectively packing MOF particles, cost-effective manufacturing, and enhancing the reusable nature of MOFs. The comprehensive review provides an in-depth understanding of MOFs by focusing on the most recent advancements in gas storage and adsorption.

1. Introduction

Modern society has witnessed significant improvement in living standards owing to technological advancements, which have contributed to the enhancement of global energy demand. Currently, fossil fuels cover 80 % of the global energy requirements, which leads to the emission of hazardous gases, such as NO_x, SO_x, CO, H_2S, and NH_3, and deteriorates the states of the global ecosystem and human health

Abbreviations: ANG, adsorbed natural gas; AMX, amoxicillin; BET, Brunauer–Emmett–Teller; BTC, 1,3,5-benzene tricarboxylic acid; CB, carbon black; CNG, compressed natural gas; DMF, dimethylformamide; DOE, U.S. Department of Energy; FTO, fluorine-doped tin oxide; GCMC, grand canonical Monte Carlo; GHG, greenhouse gas; HKUST, Hong Kong University of Science and Technology; IRMOF, isoreticular metal-organic framework; LCD, largest cavity diameter; LNG, liquefied natural gas; MEM, maximum entropy method; MOF, metal-organic frameworks; MW, microwave; OMS, open metal site; rGO, reduced graphene oxide; STP, standard temperature and pressure; ZIF, zeolitic imidazole framework; EDA, electron-donator-acceptor; SSA, specific surface area; vdW, van der Walls.

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