Researchers explore key interaction sites and pathways in ammonia capture

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The design and development of high-performance materials are crucial for efficient ammonia capture. Generally, these materials are characterized by abundant ammonia adsorption sites and rapid ammonia transport channels, enabling the effective capture and release of ammonia molecules.

Based on their properties and capture mechanisms, NH_3 capture materials can be classified into four categories: functional absorbents, adsorbents (porous solids), absorption-adsorption composites (porous liquids), and membrane separation materials.

Researchers Bai Lu and others from the Institute of Process Engineering, Chinese Academy of Sciences, have reviewed the recent advancements in ammonia capture materials, focusing on the key separation media in NH_3 capture processes, with particular emphasis on interaction sites and transport pathways.

They also discuss the potential applications of emerging hybrid technologies that utilize porous liquids as key capture materials.

Looking forward, integrating artificial intelligence to design and predict the ammonia capture performance of materials, as well as to optimize synthesis conditions and process parameters, is expected to shorten development cycles. Additionally, further research is warranted on large-scale green production methods, process optimization, and adaptive ammonia capture techniques.

The work is published in the journal *Nano-Micro Letters*.

Functional absorbents

Ionic liquids (ILs) have garnered significant attention in the field of gas separation due to their unique properties, including low volatility, high chemical and thermal stability, excellent gas solubility and selectivity, and the tunable structure of their anions and cations. The development of high-performance, reversible ammonia-absorbing ionic liquids is currently a research hotspot.

Bai Lu and colleagues discussed the absorption-desorption performance, physical property changes before and after absorption, and structure-performance relationships of various ionic liquids and their derivatives (e.g., deep eutectic solvents) by examining specific examples and focusing on the types, quantities, and strengths of NH_3 interaction sites.

Porous solid adsorbents

In addition to liquid absorbents, porous solid adsorbents have also been applied in ammonia capture and separation. The abundant pores in porous solid materials provide channels for the rapid transport of NH_3, while effectively avoiding the corrosion issues associated with acid washing methods.

Currently, reported porous adsorbent materials can be broadly classified into four types: conventional inorganic porous materials (CIPMs), porous organic polymers (POPs), crystalline porous materials (CPMs), and composite adsorbent materials.

Generally, CIPMs are low-cost and easy to prepare, but their interactions with NH_3 molecules are relatively weak. Consequently, research has primarily focused on acid modification methods to enhance the ammonia adsorption capacity of these materials. The pores formed by the stacking of polymer chains and the functional groups on these chains in POPs can significantly enhance the ammonia adsorption performance.

Additionally, CPMs with ordered pore structures and strong interactions exhibit high NH_3 adsorption capacities and rapid adsorption kinetics. Meanwhile, composite materials, particularly those incorporating ionic liquids, also demonstrate excellent NH_3 adsorption performance.

Porous liquids

Porous liquids combine the fluidity of liquids with the inherent porosity of solid materials, making them easily compatible with existing equipment. Unlike traditional liquids, porous liquids consist of porous frameworks with permanent cavities that act as gas transport pathways, offering high capacity and fast adsorption kinetics.

However, the synthesis of porous liquids remains challenging due to issues such as the collapse, decomposition, or molecular self-filling of these porous cavities. Although porous liquids specifically designed for NH_3 capture and separation have not yet been reported, they hold significant potential for future development.

Membrane materials

Membrane separation is another promising method for NH_3 capture, allowing for the direct recovery of gaseous ammonia. However, in contrast to CO_2 capture, research on ammonia separation membranes is relatively limited. Current research focuses on the design and development of membrane materials to enhance NH_3 permeability and selectivity.

One effective strategy to improve performance is the introduction of interaction sites to enhance NH_3 adsorption on the membrane surface. Another approach is to construct transport pathways that accelerate NH_3 diffusion within the membrane.

More information: Hai-Yan Jiang et al, Advanced Materials for NH_3 Capture: Interaction Sites and Transport Pathways, *Nano-Micro Letters* (2024). DOI: 10.1007/s40820-024-01425-1

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