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Investigation of Magnesium Chloride-Based Sorbents for Sorbent-Enhanced Ammonia Synthesis

AUTHORS
Aleksandra Zamljen / National Institute of Chemistry
Anže Prašnikar / National Institute of Chemistry
Blaž Likozar / National Institute of Chemistry

PURPOSE OF THE ABSTRACT

With its high energy density and carbon-neutral nature, ammonia is emerging as a potential green energy carrier for the future. The key challenge lies in optimizing its production to align with the intermittent nature of renewable energy sources.1 In conventional ammonia synthesis, ammonia is separated using a condenser, a process that demands high energy input.2 To enhance efficiency, solid sorbents have been explored for ammonia separation before recycling. Recently, various materials have been investigated for this purpose, among which metal halides have shown significant potential due to their ability to coordinatively absorb ammonia, enabling high absorption capacities and good reversibility.2,3 Metal halides face stability challenges due to structural changes during ammonia absorption, with up to 400% volume expansion causing degradation. Sintering and agglomeration reduce surface area and pore volume, especially at high temperatures. To enhance performance, they are often dispersed on porous supports with large surface areas.4,5,6

This work focuses on MgCl2-impregnated porous supports, emphasizes efficient characterization in inert environments, evaluates their ammonia sorption capacities, and introduces new ammonia absorption/desorption kinetic model. The wet impregnation synthesis method was used to impregnate various supports with MgCl2. Breakthrough tests indicate that MgCl2/ZSM-5 and MgCl2/USY (500) have the highest absorption capacity at 25 °C, with performance declining as the temperature rises. The sorbents retain a high ammonia sorption capacity over 10 absorption/desorption cycles, which suggests that MgCl2-supported materials are promising ammonia sorbents, with potential applications for ammonia removal or enrichment in industrial ammonia synthesis processes. The findings also suggest that the ammonia sorption capacity is more influenced by the pore size distribution of the support rather than its BET surface area. Industrial absorbents, often in pellet form, can swell and degrade during cycling, reducing effectiveness. Supports help prevent swelling by providing structural stability, improving sorption efficiency and kinetics for better cycling performance.

The findings highlight the need to enhance sorption materials' performance at high temperatures and emphasize the importance of considering support acidity in ammonia support design as the support has a significant impact on the ammonia capacity. Selecting the right support for metal halides is crucial, with porous materials offering better

dispersion for rapid sorption and high capacity. For high-temperature applications, thermally stable supports ensure material stability and improved cyclic performance. Optimizing support materials can significantly boost the overall performance of metal halides in industrial applications, including gas separation and storage.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS
ammonia separation | sustainable energy | metal halides | kinetic modeling

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