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A review of N-functionalized solid adsorbents for post-combustion CO_2 capture

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HIGHLIGHTS

- First holistic review of N-functionalized solid adsorbents for CO_2 capture.
- The criteria of developing high-efficiency and inexpensive N-functionalized solid adsorbents were summarized.
- The opportunities and challenges of N-functionalized solid adsorbents were discussed.

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ABSTRACT

Over the past decade, amine-loaded solid adsorbents for capturing CO_2 from power plants have been widely studied. Various nitrogen (N) sources have been used for this purpose, and the current range of adsorbents, referred to here as N-functionalized solid adsorbent (NFSAs), are the subject of this review. The main synthesis methods of NFSAs are described and recent progress in the field discussed. Criteria for improving NFSA performance are highlighted with reference to a variety of solid supports, providing guidance on the selection of highly efficient, inexpensive adsorbents. A thorough assessment of adsorption mechanisms and factors influencing the adsorption process is given. The review concludes by exploring future research and development opportunities, as well as pathways for commercializing NFSAs.

1. Introduction

About 40% of anthropogenic CO_2 emissions are produced by fossil fuel-based power plants. To meet the targets to maintain global temperatures within 2 °C above pre-industrial levels by the end of the century, emissions need to significantly decrease [1,2]. There are three approaches for capturing CO_2 from power plants: pre-combustion [3,4], post-combustion [5–7], and oxy-fuel combustion [8,9]. Post-combustion capture, which adsorbs CO_2 after fossil fuel combustion using wet/dry sorbents, is the most popular industrial method [10,11].

To date, CO_2 absorption by aqueous amine of 20–30 wt% is still the state-of-the-art for post-combustion CO_2 capture processes, mainly due to the high CO_2 affinity of amines [12–14]. However, its application is restricted by several drawbacks, such as high equipment corrosion [7], intensive energy requirement for regeneration [12], tendency to degrade [15], and foaming issues [16]. Of the proposed alternative technologies for post-combustion CO_2 capture, adsorption-based technology is the most promising, due to its potentially lower cost while avoiding the drawbacks of aqueous amine. Adsorbents are the cornerstones for all adsorption processes, and numerous porous solid adsorbents have been developed for CO_2 adsorption in post-combustion gas conditions. However, these materials suffer either from low CO_2

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