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Review

Pebax membranes-based on different two-dimensional materials for CO_2 capture: A review

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ABSTRACT

Since the onset of the industrial age, annual global CO_2 emissions have risen, significantly affecting the climate and natural ecosystems. Addressing this, the development of carbon capture, utilization, and storage (CCUS) technologies becomes crucial. Gas membrane separation, recognized for its efficiency, low energy consumption, and eco-friendly nature, is rapidly gaining prominence in global carbon capture efforts. Polyether-block-polyamide (Pebax), with its high CO_2 affinity and resilient mechanical properties (attributed to its elastic polyether and robust polyamide segments) is gaining traction in CO_2 separation research. Yet, the inherent trade-off effect poses challenges for its industrial application. This article delves into the current research landscape of gas separation membranes made of Pebax and assorted 2D nanomaterials for CO_2 separation. It outlines the separation mechanism of Pebax materials and elucidates the CO_2 separation membrane's transport mechanism. Further, the application of gas separation membranes formed by combining Pebax with various 2D nanomaterials for CO_2 capture is also described in detail. Relevant studies underscore that these gas separation membranes offer enhanced separation efficacy and stability, positioning them as potential leaders in CO_2 separation solutions. The paper concludes by highlighting challenges in Pebax-based research and suggesting future research avenues.

1. Introduction

Since the industrial revolution, there has been a marked escalation in greenhouse gas emissions, primarily CO_2, analogous to wrapping the Earth with a "cotton jacket." This impedes the atmosphere's capacity to radiate heat, amplifying the greenhouse effect. This alteration skews the global ecological balance, leading to notable concerns like accelerated glacier melting, rising sea levels, and increased extreme weather episodes [1–5]. In a proactive response, China has unveiled its "dual carbon" goal, setting sights on peaking carbon emissions by 2030 and aspiring for carbon neutrality by 2060. This plan promotes sustainable, environmentally conscious, and low-carbon ways of life, emphasizing a reduced dependence on fossil fuels. It encourages the creation of a renewable energy system, spurs green technological breakthroughs, and aspires to boost the global standing of its industries and overall economy [6–9]. Recognizing the hazards of the greenhouse effect, capturing and curbing CO_2 emissions is pivotal. Apart from the CO_2 resulting from fossil fuel burning, specific energy sources inherently have CO_2, which compromises the energy efficiency of fuel gases. Moreover, when mixed with water, CO_2 can corrode pipelines, driving up storage and transport expenses and hampering the efficient deployment of energy gases [10,11]. Consequently, extracting CO_2 from energy gases becomes a necessity. To counteract the global ramifications of CO_2 and minimize its release, extensive R&D into cost-effective CO_2 recovery and separation techniques is essential, enhancing energy efficiency, fortifying environmental stewardship, and fostering sustainable initiatives.

Among various separation technologies, membrane separation technology has the prospect of wide application as an efficient separation technology that can optimize the use of resources, protect the environment, and promote the energy saving and emission reduction of carbon dioxide compared with traditional separation technologies [12,13]. However, the traditional commonly used techniques, such as solvent absorption, variable pressure adsorption and low temperature distillation, have inherent limitations. For instance, solvent absorption often relies on organic amine solutions that are subject to evaporation and degradation, resulting in solvent loss [14]. Such solvents can be

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