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Review

Mixed matrix membranes for gas separations: A review

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ABSTRACT

Goal of environment protection is improving claims or human's health, while during the process, here are important signals such as "carbon neutral" and "carbon peak". The development of CO_2 capture and separation technology is imperative. Membrane separation technology is widely used in industry because of its obvious advantages in gas separation. According to the different membrane materials, CO2 separation membranes can be categorized into liquid membranes, polymer membranes, inorganic membranes and mixed matrix membranes. At present, mixed matrix membrane separation technology has become an efficient gas separation technology. mixed matrix membranes combine the excellent separation properties of inorganic fillers and the good film-forming properties of polymers, solving the problems commonly found in polymer and inorganic membranes and becoming the next generation of separation membranes with potential. Focusing on membrane materials, this paper introduces several common methods for preparing mixed matrix membranes from the membrane separation mechanism, focusing on various fillers for mixed matrix membranes and their research progress in the field of gas separation. Then, the factors affecting the performance of mixed matrix membranes and their solutions are analyzed. Finally, the challenges and future development direction of mixed matrix membranes in the field of gas separation are prospected. This review provides a theoretical guide to the field of carbon dioxide capture and gas separation technology in the future through methods such as comprehensive and integrated analysis of literature.

1. Introduction

From the 1970 s to the present, the global economy has been growing rapidly, and the energy demand of all countries has continued to rise. The use of fossil energy sources, such as coal, oil and natural gas, generates large amounts of CO_2, and the significant increase in global carbon emissions and per capita emissions will trigger the greenhouse effect, leading to an increase in global temperatures and a series of problems such as melting glaciers, rising sea levels, and the frequent occurrence of catastrophes and extreme weather events, which will result in a serious challenge to the environment for the survival of mankind [1–3]. In 2022, global CO_2 emissions increased by 0.9 %, and according to the 《CO_2 Emissions Report 2022》, China's CO_2 emissions were 11.48 billion tons, which is a decrease of 0.99 % compared to 2021, but still accounts for 31.3 % of the global total emissions, resulting in significant pressure to reduce emissions [4].

The global warming caused by excessive CO_2 emissions and other issues have drawn attention to the need to protect the environment globally, with the goal of improving human health, and in this process, there are important signals such as "carbon neutrality" and "peak carbon". It can be seen that carbon emission reduction is a major trend, which is crucial to domestic and international development and the global ecological environment [5,6]. Therefore, there is an urgent need to develop an effective method to reduce the concentration of CO_2 in the atmosphere and industrial gases. The 2015 Paris climate talks required a reduction of global greenhouse gas emissions by 40–70 % by 2050 to limit global temperature rise to within 2 ℃ [7,8].

CCUS (Carbon Capture, Utilization and Storage) technology refers to the process of separating CO_2 from industrial processes, energy utilization, or the atmosphere, injecting it into the formation or directly utilizing it to achieve permanent CO_2 reduction [9,10]. This technology is an important way to achieve carbon reduction goals. Carbon capture is

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