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A review of recent trends and emerging perspectives of ionic liquid membranes for CO_2 separation

Nadeem Hussain Solangi [a], Amna Anjum [a], Faisal Amri Tanjung [b], Shaukat Ali Mazari [a,*], Nabisab Mujawar Mubarak [c]

[a] Department of Chemical Engineering, Dawood University of Engineering and Technology, Karachi 74800, Pakistan
[b] Faculty of Science and Technology, Universitas Medan Area, Jalan Kolam No. 1, Medan 20223, North Sumatera, Indonesia
[c] Department of Chemical Engineering, Faculty of Engineering and Science, Curtin University, 98009 Miri, Sarawak, Malaysia

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ABSTRACT

Ionic liquids (ILs) possess low vapor pressure, thermal stability, wide chemical solubility window and ease of tunability of physical and chemical properties, which make them attractive solvents. ILs have been successfully examined for CO_2 capture processes alone and in combinations with different materials. Recently, ionic liquid-based membranes have exhibited attractive characteristics for CO_2 separation. This manuscript introduces various CO_2 separation technologies including the ionic liquid membranes (ILMs). The various types of ILMs, such as supported ionic liquid membranes (SILMs), room temperature ionic liquid based SILMs, functionalized ILMs, polyionic liquid membranes, composite membranes, IL-gel membranes, and mixed matrix membranes (MMMs) are discussed in detail. The CO_2 permeability and selectivity of CO_2 over N_2 and CH_4 for various membranes are reported and critically analyzed. Furthermore, the stability of the ionic liquid membranes is reported and discussed with respect to the addition ionic liquids, proper size of the porous support, the selection of support of the membrane etc.

1. Introduction

In the recent era, the concentration of greenhouse gases such as carbon dioxide (CO_2) dramatically increased. These greenhouse gases (GHGs) are responsible for climate change and global warming, which are the major concerns for the world at present. The presence of greenhouse gases (GHGs) in the environment are the reason for several environmental problems including the increase in the heat stress, extremity of tropical storms, sea level rise, ocean acidity, and the melting of glaciers, sea ice, snowpack, etc. [1]. The energy needs and industrialization are major contributors to the CO_2 emissions. Among energy producers and industries, oil, gas or coal-fired power fired power plants, cement, steel, iron industry, oil refining, fermentation, and ammonia production are the major contributors to the CO_2 emissions [2]. According to the international energy agency (IEA), the CO_2 emissions in the atmosphere increase up to 6% every year [2–4]. The transportation and processing of natural gas needs the elimination of impurities including CO_2, H_2S, and heavier hydrocarbons [5]. This enhances the heating value (HV) of natural gas and lowers the pipeline corrosion.

There are several carbon capture and storage (CCS) technologies in the developing phase for industrial CO_2 emissions. The major CCS approaches include pre-combustion, post-combustion and oxyfuel combustion. The pre-combustion capture involves mitigation of CO_2 before combustion, which refers to gasification process to produce synthesis gas. The synthesis gas then can be processed to produce H_2 and CO_2 rich streams or converted into light fuels and chemicals through catalysis [6, 7]. The oxyfuel combustion requires the use of pure oxygen for burning the fuel [8]. Both the pre-combustion and oxyfuel combustion techniques cannot be applied on existing plants. Whereas post-combustion CO_2 separation techniques can be applied on existing plants as a retrofit option [9]. The post-combustion CO_2 separation techniques used for gas processing are similar for CO_2 capture as both the techniques involve cryogenic separation, amines solvent based absorption, porous solids based adsorption and membrane separation [5,10] Post-combustion CO_2 capture using amines is a mature technology that may be retrofitted to existing plants [11]. The amine-based CO_2 separation technique being highly efficient is still not a long-term environmentally benign and economical solution [12]. The amine-based

* Corresponding author.
E-mail address: shaukat.mazari@duet.edu.pk (S.A. Mazari).

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