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Study on Polydimethylsiloxane Desorption Membrane of CO_2-Dimethyl carbonate System

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Abstract

Global warming is a topic of great concern all over the world. The current CO_2 capture methods, such as absorption, cryogenic separation, adsorption, etc., may have some deficiencies in capture cost and device investment. A novel solvent- absorption coupled membrane-desorption process is expected to be one of candidate with industrial feasibility. The membrane reported in the literature has great potential for improvement. In this paper, membrane modification was carried out from dissolution activity, the diffusion activity and the reaction activity. Compared with the literature data, the flux ($5144 g \cdot m^{-2} \cdot h^{-1}$) and enrichment factor (36.5) of membrane made in this work has been significantly improved.

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Keywords: CO_2 capture, membrane desorption, membrane modification, pervaporation

1. Introduction

In recent years, greenhouse effect has exerted seriously negative impacts on society and the economy. It has become a global climatic issue. The main factor giving rise to the greenhouse effect is CO_2, whose contribution accounts for more than 60% [1-3]. As the global industrialization process quickens, the amount of CO_2 emission is increasing at an alarming rate, and emission reduction is a matter of great urgency [4-6]. Carbon capture and storage

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(CCS) is regarded as an effective way, and solvent absorption is a relatively mature technique, but the capture costs have to be reduced. Aimed at that, puts forward a new CO_2 capture technology--- solvent absorption and membrane desorption process.

Polydimethylsiloxane (PDMS) is a high-molecular polymer with a semi-organic and semi-inorganic structure. It has both hydrophobic inorganic main chain and active organic component side chain molecule, therefore, it possesses the characteristics of both organic polymer and inorganic polymer in terms of performance and also has good processability. More because of its low transmission resistance and high affinity with organic matters, it becomes the common material of pervaporation membrane [7-9]. Also, in this work, choose the internationally recognized efficient green solvent dimethyl carbonate (DMC) as the absorbing solvent

The key of solvent absorption and membrane desorption is the preparation of high performance membrane. Li [10] proposed to improve the membrane separation performance by enhancing the dissolution activity, the reaction activity and the diffusion activity. This paper intends to use this method for reference adding 6 active crosslinking agent to modify the PDMS desorption membrane. The active crosslinking agents show in table 1.

Table 1 Selection of crosslinking agent

Active cross-linking	Abbreviation	Chemical formula	Active group
Ethyl orthosilicate	TEOS	$SiC_8H_{20}O_4$	Si-O-Si
Tetraethyl Titanate	IV	$TiC_8H_{20}O_4$	Ti-O-Ti
N1-(3-(Trimethoxysilyl)propyl)ethane-1,2-diamine	DAMO	$C_8H_{22}N_2O_3Si$	$-NHCH_2CH_2NH_2$
3-Aminopropyltriethoxysilane	APTES	$C_9H_{23}NO_3Si$	$-NH_2$
Phenyltriethoxysilane	PTES	$C_{12}H_{20}O_3Si$	-ph
Triethoxyvinylsilane	VTEO	$C_8H_{18}O_3Si$	$-CH=CH_2$

2. Experiment part

2.1. Preparation and making of PDMS composite membrane

Dissolve fully the PDMS (30wt%) at the indoor temperature in n-heptane solvent and successively add cross-linking agent and catalyst dibutyltin dilaurate (DBTL). Keep the amount ratio PDMS, cross linking and catalyst 15:5:1. Scrape the casting membrane solution on the cellulose basement membrane on the glass pane to make the membrane. Initial experiments show that 15μm membrane thickness has a good result, so in this paper keep all the membrane thickness 15μm and then put the menbrane at 100 ℃ for 4 hours to make the solvent fully volatilize and crosslink into the membrane.

2.2. Data processing

The most important parameters to evaluate the pervaporation membrane are the enrichment factor α and permeation flux J

Permeation flux: $$J = Q / (A \times t) \quad (1)$$

Q is the mass of the permeate, g; A is the effective area of the pervaporation membrane, m^2; t is the operating time, h. The permeate side mass of DMC was obtained by weighing balance, and the membrane area was 23.75cm^2 and the desorption time was 1h.

Selectivity：: $$\alpha = X_A Y_B / X_A Y_B \quad (2)$$

α reflects the membrane's selectivity, and the bigger the α is, the better the membrane's selectivity is; Y_A and Y_B are the mass fraction of DMC and CO_2 in the permeate respectively; X_A and X_B are the mass fraction of DMC and CO_2 in the rich solution respectively.