Iran Polym J (2017) 26:431–443
DOI 10.1007/s13726-017-0532-2

ORIGINAL RESEARCH

Hydrophobicity optimization of polypropylene hollow fiber membrane by sol–gel process for CO_2 absorption in gas–liquid membrane contactor using response surface methodology

Parya Amirabedi[1,2] · Reza Yegani[1,2] · Amir Hossein Hesaraki[1,2]

Received: 26 December 2016 / Accepted: 15 May 2017 / Published online: 27 May 2017
© Iran Polymer and Petrochemical Institute 2017

Abstract In membrane technology, wettability is one of the most crucial points for successful industrial application of membrane contactors. To solve this issue, a non-wetting polypropylene (PP) hollow fiber membrane was prepared by the incorporation of modified silica nanoparticles (CH_3SiO_2) synthesized through sol–gel process on the surface and the cross-section of the membrane. Tetraethylorthosilicate (TEOS) and methyltriethoxysilane (MTES) were used as precursor and hydrophobic agent, respectively, to synthesize CH_3SiO_2 nanoparticles (NPs). In preparation procedure of NPs, the influential parameters including MTES/TEOS and H_2O/TEOS molar ratios and NH_4OH concentration were optimized using central composite design of response surface method (RSM) by considering contact angle (CA) as response variable. The CA of 168° was obtained using analysis of variance (ANOVA) when the MTES/TEOS molar ratio, H_2O/TEOS molar ratio and NH_4OH concentration were, respectively, 3.774, 8.000 and 0.511 M. ATR-FTIR, FE-SEM, mechanical strength and porosity measurements were used to characterize the optimum membrane. The neat and modified membranes were also tested for the CO_2 absorption process in a gas–liquid membrane contactor system. The CO_2 absorption flux of modified membrane almost remained constant within 30 days, while the neat membrane slightly suffered from wetting problem, resulted in a continuous decline in the CO_2 flux.

Keywords Superhydrophobic membrane · Sol–gel · Response surface methodology (RSM) · Membrane contactor

Introduction

In recent years, gas–liquid hollow fiber membrane contactor has been considered as one of the potential alternatives for CO_2 removal compared to conventional equipment. This technology exhibits several superior advantages, such as operational flexibility, linear scale-up, high surface-area-to-volume ratio and modularity [1]. However, the membrane contactor also has its own disadvantages. One of the main challenges of membrane contactor technology is the membrane wetting by absorbent in long-term operations, which leads to rapid reduction in absorption performance [2–4].

The microporous polymeric hollow fiber membrane is the core element of a membrane contactor device [5]. Generally, there are different methods, including phase separation, track etching, stretching and electro as well as bubbfil spinning methods to prepare polymeric hollow fiber membranes. According to the literature reports, phase separation process is a good candidate to produce hollow fiber membranes with diameters bigger than 1 µm, which are more applicable in large-scale systems [6, 7].

According to experimental results, selecting a hydrophobic membrane is the first step required for avoiding the problem of wetting. Polypropylene (PP) is one of the common hydrophobic membranes applied in the membrane contactor systems. PP membrane shows wide-ranging applications

Electronic supplementary material The online version of this article (doi:10.1007/s13726-017-0532-2) contains supplementary material, which is available to authorized users.

✉ Reza Yegani
ryegani@sut.ac.ir

1 Faculty of Chemical Engineering, Sahand University of Technology, Tabriz, Iran

2 Membrane Technology Research Center, Sahand University of Technology, Tabriz, Iran