17th International Conference on Inorganic Membranes
New Frontiers for Inorganic Membranes
July 1 - 5, 2024
Oceania Convention Center - Florianópolis - Brasil

Network engineering of organosilica membranes for efficient pervaporation dehydration

Linglin Cheng, Meng Guo, Jing Zhong*
Jiangsu Key Laboratory of Advanced Catalytic Materials and Technology, School of Petrochemical Engineering, Changzhou University, Changzhou, 213164, China
* zjwyz@cczu.edu.cn

Abstract

In the petroleum industry, the mixing of ethanol, isopropanol, and n-butanol with water is a common occurrence during the production and recovery stages [1]. Obtaining the required level of purity through dehydration presents a significant obstacle to overcome [2]. Pervaporation, because of its energy efficiency and independence from vapor-liquid equilibrium constraints, has emerged as a promising method for separating azeotropic mixtures [3]. In this study, organosilica precursors, 1,2-bis(triethoxysilyl)ethane (BTESE), 1,2-bis(triethoxysilyl)ethylene (BTESEthy), and 1,2-bis(triethoxysilyl)acetylene (BTESA), were employed to fabricate organosilica membranes via the sol-gel technique. These membranes were then utilized for pervaporation dehydration of ethanol, isopropanol, and n-butanol. This study delves into the influence of the degree of unsaturation of the bridged group, feed composition, and carbon atom count of alcohol on membrane dehydration performance. Notably, among the examined alcohol/water systems, the membranes exhibited superior separation performance for the n-butanol/water mixtures. As shown in Figure 1, the BTESE membrane demonstrated a pronounced separation factor, albeit with a diminished permeation flux. Conversely, the BTESA membrane exhibited a reduced separation factor but an enhanced permeation flux. For the isopropanol/water and n-butanol/water systems, the BTESE membrane demonstrates satisfying separation performance. Specifically, for a 90 wt% isopropanol/water mixture, the separation factor increases to 824, with a permeation flux of 1.95 kg m^2 h^{-1}. Similarly, for a 90 wt% n-butanol/water mixture, the separation factor reaches 1756, while sustaining a permeation flux of 1.66 kg m^2 h^{-1}. More importantly, the comparison between gas permeation and pervaporation confirmed that the separation mechanism was dominated by molecular sieving through the organosilica membranes (Figure 2) [4].

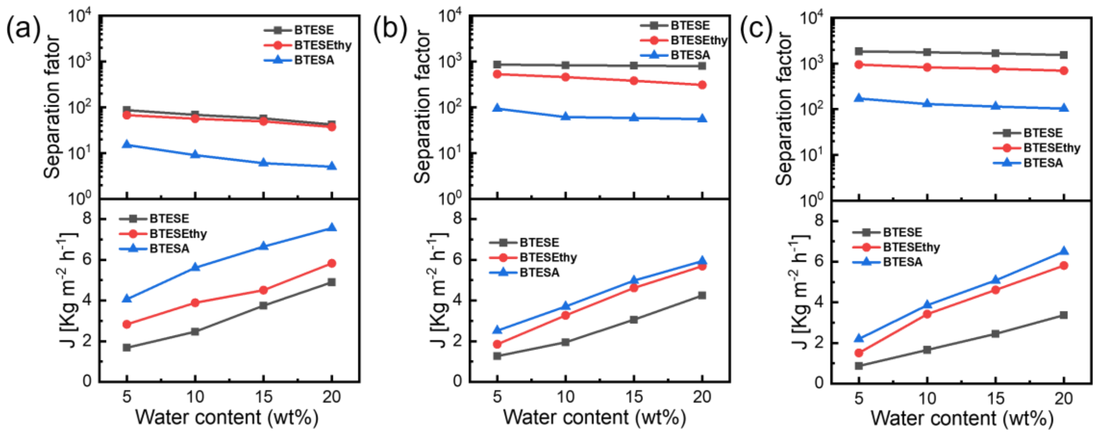

Figure 1. BTESE, BTESEthy, and BTESA were used for pervaporation dehydration of (a) ethanol/water, (b) isopropanol/water, and (c) n-butanol/water systems at 70 ℃.

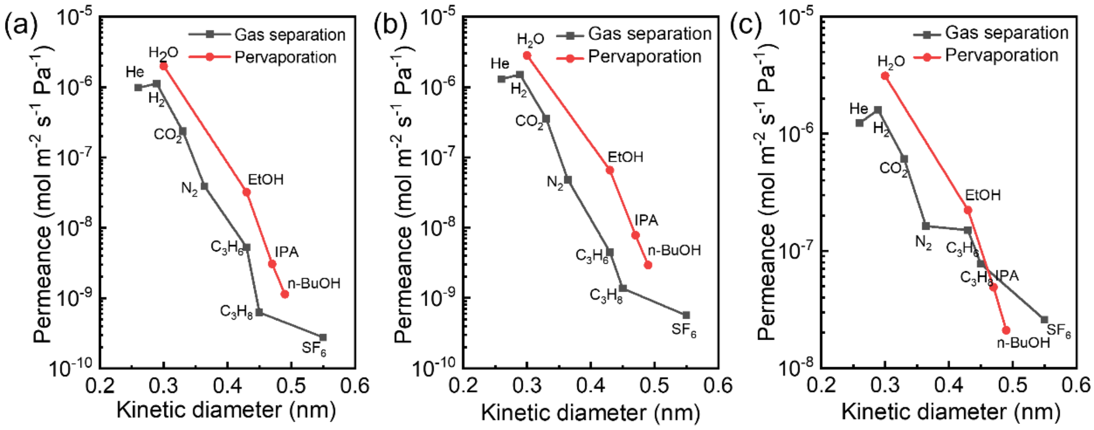

Figure 2. Molecular size dependency of gases and vapors molecules permeance for (a) BTESE, (b) BTESEthy (c) BTESA membrane.

References

[1] D. Saygin, M.K. Patel, C. Tam, D.J. Gielen, Chemical and Petrochemical Sector. Potential of best practice technology and other measures for improving energy efficiency, iea information paper, (2009).

[2] A.J. Ragauskas, C.K. Williams, B.H. Davison, G. Britovsek, J. Cairney, C.A. Eckert, W.J. Frederick, Jr., J.P. Hallett, D.J. Leak, C.L. Liotta, J.R. Mielenz, R. Murphy, R. Templer, T. Tschaplinski, The path forward for biofuels and biomaterials, Science, 311 (2006) 484-489.

[3] P. Shao, R.Y.M. Huang, Polymeric membrane pervaporation, Journal of Membrane Science, 287 (2007) 162-179.

[4] N. Moriyama, H. Nagasawa, M. Kanezashi, T. Tsuru, Pervaporation dehydration of aqueous solutions of various types of molecules via organosilica membranes: Effect of membrane pore sizes and molecular sizes, Separation and Purification Technology, 207 (2018) 108-115.