P84 Co-Polyimide Based-Tubular Carbon Membrane: Effect of Heating Rates on Helium Separations

N. Sazali[1,2,3*], W.N.W. Salleh[1,2], A.F. Ismail[1,2] K. Kadirgama[3], F.E.C. Othman[1,2],

[1]Advanced Membrane Technology Research Centre (AMTEC), Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia.

[2]Faculty of Chemical and Energy Engineering (FCEE), Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia.

[3]Faculty of Mechanical Engineering, University Malaysia Pahang

* Correspondence concerning this article should be addressed to Norazlianie Sazali (N. Sazali) at melya.jandi@yahoo.com

ABSTRACT

Helium is one of the most valuable gases with unique features and properties as well as widely used in various applications. Helium sources was extracted from natural gas and it is very crucial to develop efficient technology for helium recovery from natural gas sources, in order to overcome the deficit of the helium supply. Up to now, there are various available traditional separation methods for helium recovery, however these methods possessed several disadvantages such as expensive in cost and energy intensive. Recently, gas separation by using membranes have been utilized and showed potential in recovering and purifying helium from natural gas. This method directly separating the helium from the methane through natural gas liquefaction process where in this process the helium is recovered from the nitrogen rejection unit (NRU) exit gas. Due to the potential benefits that can be obtained from this membrane-based separation method, this current study is aiming to provide more comprehensive scientific reports on the effects of preparation parameters on the performance of tubular carbon membranes (TCMs) for helium separation. In this study, the carbonization heating rate was varied from 1 to 7°C/min by controlling the final temperature at 800°C under Argon environment for all polymeric tubular membranes. The permeation performance of the resultant TCMs have been determined by using a single permeation apparatus. It is necessary to fine-tuning the carbonization conditions in order to obtain the desired permeation properties. From the results, it can be concluded that the most optimum heating rate was found to be at 3°C/min with 463.86±3.12 selectivity of He/N_2 separation.

Keywords: Tubular carbon membrane, Nanocrystalline cellulose, heating rates, P84 co-polyimide, and Helium recovery.

[8] Adewole, J. K., Ahmad, A. L., Ismail, S. & Leo, C. P. (2013). "Current challenges in membrane separation of CO2 from natural gas: A review". *International Journal of Greenhouse Gas Control,* 17**,** 46-65.

[9] Salleh, W. N. W. & Ismail, A. F. (2012). "Effects of carbonization heating rate on CO2 separation of derived carbon membranes". *Separation and Purification Technology,* 88**,** 174-183.

[10] Centeno, T. A., Vilas, J. L. & Fuertes, A. B. (2004). "Effects of phenolic resin pyrolysis conditions on carbon membrane performance for gas separation". *Journal of Membrane Science,* 228**,** 45-54.

[11] Sazali, N., Salleh, W. N. W., Ismail, A. F., Nordin, N. A. H. M., Ismail, N. H., Mohamed, M. A., Aziz, F., Yusof, N. & Jaafar, J. (2018). "Incorporation of thermally labile additives in carbon membrane development for superior gas permeation performance". *Journal of Natural Gas Science and Engineering,* 49**,** 376-384.

[12] Sazali, N., Salleh, W. N. W. & Ismail, A. F. (2017). "Carbon tubular membranes from nanocrystalline cellulose blended with P84 co-polyimide for H2 and He separation". *International Journal of Hydrogen Energy,* 42**,** 9952-9957.

[13] Wang, C., Hu, X., Yu, J., Wei, L. & Huang, Y. (2014). "Intermediate gel coating on macroporous Al2O3 substrate for fabrication of thin carbon membranes". *Ceramics International,* 40**,** 10367-10373.

[14] Yong, W. F., Lee, Z. K., Chung, T.-S., Weber, M., Staudt, C. & Maletzko, C. (2016). "Blends of a Polymer of Intrinsic Microporosity and Partially Sulfonated Polyphenylenesulfone for Gas Separation". *ChemSusChem,* 9**,** 1953-1962.