Pebax 1657 Nanocomposite Membranes incorporated with nanoadsorbent derived from Oil Palm Frond for CO_2/CH_4 Separation

Alia Aqilah Ghazali [a], Sunarti Abd Rahman[b *] and Rozaimi Abu Samah[c]

Faculty of Chemical & Process Engineering Technology, College of Engineering Technology,

Universiti Malaysia Pahang, 26300 Kuantan,

Pahang, Malaysia.

[a]aliaaqilah07@gmail.com, [b]sunarti@ump.edu.my, [c]rozaimi@ump.edu.my

Keywords: nanoadsorbent, oil palm frond, nanocomposite membrane, CO_2/CH_4 gas separation

Abstract. Membrane technology has attracted great attention by the researhcers especially in gas separation process due to their simple process design and low capital cost as compared to the conventional techniques. Interestingly, in this work, oil palm frond (OPF) waste was used as nanoadsorbent embodied in polyether block amide (Pebax 1657) nanocomposite membrane to improve the CO_2/CH_4 separation. The effectiveness of the nanoadsorbent derived from OPF was evaluated by varying the nanoadsorbent concentration (2–8 wt%) and controlling the Pebax 1657 concentration (5 wt%), dipping time (5 s) number of sequential coatings (3 layers). The pore characteristics of the nanoadsorbent was analysed using Brunauer–Emmett–Teller (BET) analysis. The morphology and the existence of active groups in the newly synthesized nanoadsorbent and nanocomposite membranes were investigated by field emission scanning electron microscopy (FESEM) and fourier transform infrared spectroscopy (FTIR), respectively. The single gas permeation process was carried out at constant pressure (2 bar) and at room temperature (25± 5 °C). The optimum condition with 5 wt% nanoadsorbent made the nanocomposite membrane exceed the trade–off limit of Robeson plot with a CO_2 permeability and CO_2/CH_4 selectivity of 1475.09 Barrer and 40.48, respectively.

Introduction

The increasing of carbon dioxide (CO_2) concentration in the earth's atmosphere remains as one of the major challenges by the humankind. According to the statistics, power plant contributes approximately 30% from the total CO_2 emmisions due to large burning of fossil fuel. This acid gas has destructive effect on humans and environment due to its acidic and corrosive properties. Therefore, there is an urgent need to reduce the CO_2 level to bring the CO_2 concentration to an acceptable level. For the last decades, membrane separation technology is gaining large acceptance by the industry for CO_2 separation due to their energy efficiency, simple process design and relatively economic. On top of that, numerous studies have been performed on finding the most ideal membrane.

Recently, mixed matrix membrane (MMM) formed by dispersing fillers into polymer matrix has attracted great attention by the researhcers due to its outstanding separation efficiency. The incorporation of fillers such as zeolite and graphene oxide can alter the polymer matrix chain structure and chemical properties, as well as enhance the membrane selectivity towards targeted gas species. However, the current available fillers have significant drawbacks mainly related to the high cost, which are substantial barriers to the large-scale commercial deployment required for gas separation. Since then, researchers have evaluated MMM incorporated with fillers derived from agricultural wastes such as rice straw [1] and rice husk [2] due to their abundance and inexpensive. The results showed significant improvements of the MMM as compared to pure polymeric membrane which indicate that agricultural wastes are capable to replace the conventional fillers due to their reasonable performances. Despite their excellent performance, they still operate below the Robeson

Acknowledgement

The authors wish to thank Ministry of Education, Malaysia for supporting the study under Grant Number RDU1901164 (FRGS/1/2019/TK02/UMP/02/17), PGRS1903117 and Faculty of Chemical & Process Engineering Technology for providing the research lab facilities.

References

[1] M. Bhattacharya and M.K. Mandal, Synthesis of rice straw extracted nano-silica-composite membrane for CO_2 separation, J. Clean. Prod. 186 (2018) 241-252

[2] N. Waheed, A. Mushtaq, S. Tabassum, M.A. Gilani, A. Ilyas, F. Ashraf, Y. Jamal, M.R. Bilad, A.U. Khan, and A.L. Khan, Mixed matrix membranes based on polysulfone and rice husk extracted silica for CO_2 separation, Sep. Purif. Technol. 170 (2016) 122-129

[3] M. Mozafari, R. Abedini, and A. Rahimpour, Zr-MOFs-incorporated thin film nanocomposite Pebax 1657 membranes dip-coated on polymethylpentyne layer for efficient separation of CO_2/CH_4, J. Mater. Chem. A 6 (2018) 12380-12392

[4] D.F. Sanders, Z.P. Smith, R. Guo, L.M. Robeson, J.E. McGrath, D.R. Paul, and B.D. Freeman, Energy-efficient polymeric gas separation membranes for a sustainable future: A review, Polymer 54 (2013) 4729-4761

[5] P.D. Sutrisna, J. Hou, H. Li, Y. Zhang, and V. Chen, Improved operational stability of Pebax-based gas separation membranes with ZIF-8: A comparative study of flat sheet and composite hollow fibre membranes, J. Membrane Sci. 524 (2017) 266-279

[6] M. Mohammad Zainol, N.A. Saidina Amin, and M. Asmadi, Preparation and Characterization of Impregnated Magnetic Particles on Oil Palm Frond Activated Carbon for Metal Ions Removal, Sains Malaysiana 46 (2017) 773-782

[7] M. Saadia, B. Ahmed, O. Nazha, A. Abdlemjid, and C. M'Hamed, Preparation and Characterization of Activated Carbon from Residues of Oregano, J. Surf. Coat. Tech. 28 (2012) 91-100

[8] M.B. Ahmed, M.A. Hasan Johir, J.L. Zhou, H.H. Ngo, L.D. Nghiem, C. Richardson, M.A. Moni, and M.R. Bryant, Activated carbon preparation from biomass feedstock: Clean production and carbon dioxide adsorption, J. Clean. Prod. 225 (2019) 405-413

[9] E. Taer, A. Apriwandi, Y.S. Ningsih, R. Taslim, and Agustino, Preparation of Activated Carbon Electrode from Pineapple Crown Waste for Supercapacitor Application, International Journal of Electrochemical Science 14 (2019) 2462-2475

[10] A.F. Rugayah, A.A. Astimar, and N. Norzita, Preparation and Characterisation of Activated Carbon from Palm Kernel Shell by physical activation with steam, J. Oil Palm Res. 26 (2014) 251-264

[11] C.S. Casari, A. Li Bassi, A. Baserga, L. Ravagnan, P. Piseri, C. Lenardi, M. Tommasini, A. Milani, D. Fazzi, C.E. Bottani, and P. Milani, Low-frequency modes in the Raman spectrum of $sp-sp^2$ nanostructured carbon, Physical Review B 77 (2008)

[12] Y. Li, R. Xu, B. Wang, J. Wei, L. Wang, M. Shen, and J. Yang, Enhanced N-doped Porous Carbon Derived from KOH-Activated Waste Wool: A Promising Material for Selective Adsorption of CO_2/CH_4 and CH_4/N_2, Nanomaterials (Basel) 9 (2019)

[13] M.S. Abdul Wahab, S. Abdul Rahman, and A.L. Ahmad, Biomethane Purification Using PVDF/Pebax 1657 Thin Film Composite Membrane, J. Phys. Sci. 28 (2017) 39-51