PAPER • **OPEN ACCESS**

Performance study of hydroxyapatite cow bone based polysulfone mixed matrix membrane: Effect of hydroxyapatite morphology

To cite this article: Siti Nor Suhaida Rasman *et al* 2021 *J. Phys.: Conf. Ser.* **2051** 012027

View the article online for updates and enhancements.

You may also like

- Effect of Combination of Anionic Polymer with Calcium Phosphate Coating on Corrosion Behavior of Magnesium Alloy in Physiological Solution
  Sachiko Hiromoto and Kotaro Doi
- Fabrication and Characterisation of Gelatine/Hydroxyapatite Porous Scaffold
  M.I. Mazlam, H.H. Ho and A. Nurazreena
- Dental resin composites with improved antibacterial and mineralization properties via incorporating zinc/strontium-doped hydroxyapatite as functional fillers
  Yechen Li, Daixing Zhang, Zhuo Wan et al.

This content was downloaded from IP address 161.139.222.42 on 06/07/2022 at 08:35

 2051 (2021) 012027 doi:10.1088/1742-6596/2051/1/012027

Performance study of hydroxyapatite cow bone based polysulfone mixed matrix membrane: Effect of hydroxyapatite morphology

Siti Nor Suhaida Rasman[2], Mohd Riduan Jamalludin[12*], Suraya Najieha Kamarudin[2], Siti Khadijah Hubadillah[3], Mohammad Arif Budiman Pauzan[4], Mohd Hafiz Dzarfan Othman[4]

[1]Frontier Materials Research, Centre of Excellent (FrontMate), Universiti Malaysia Perlis (UniMAP), Malaysia.
[2]Faculty of Mechanical Engineering Technology, Universiti Malaysia Perlis (UniMAP), Kampus UniCITI Alam, Sungai Chuchuh, Padang Besar, 02100, Perlis, Malaysia.
[3]School of Technology Management and Logistic, Universiti Utara Malaysia, Sintok, 06010, Kedah, Malaysia.
[4]Advanced Membrane Technology Research Centre (AMTEC), Faculty of Chemical Engineering and Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.

*riduanj@unimap.edu.my

Abstract. In this work, polysulfone (PSf)/ hydroxyapatite (HAp) ultrafiltration mixed matrix membranes (MMMs) were prepared for wastewater treatment by using phase inversion method. The effect of hydroxyapatite (HAp) dispersion on the PSf/PVP membrane surface were investigated. Characterizations were done to observe the distribution of HAp on the membrane surface by using X-ray diffractometer (XRD) and scanning electron microscope (SEM). The XRD analysis showed the crystallinity of the HAp derived from cow bone. The dispersion of HAp in polymer matrix is a promising materials that can change the structure of the PSf membrane.

1. Introduction

Increasing population trends in major cities have put tremendous strain on natural water supplies, while insufficient method to provide water have resulted in severe shortages [1]. Membrane technology has been recognised as an effective separation process for water treatment due to the durability and efficiency of contaminant rejection, as well as the flexibility provided by a range of membrane materials such as ceramics, silica, alumina, titanium and polymer [2]. Due to its simplicity in operation, no addition of chemical additives (or less), cost-effective, no phase shift, high efficiency, simple scaling up and high removal power, membrane technology contributes up to 53% of the total world processes for clean water supply and is an efficient approach for water treatment [3].

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

Polymeric membrane is mainly used due to their greater durability, strong film forming properties, mechanical strength, high selectivity, low cost for fabrication and sufficient pore size for pressure-driven processes [4][5]. Due to its properties, such as chemical, mechanical and thermal stress resistance, and excellent film forming capabilities, polysulfone (PSf) is a widely used polymer for the preparation of membranes [6]. However, PSf has hydrophobic nature and susceptible towards fouling problems which can affect the membrane's performance such as rejection and flux permeation [7].

As a result, various methods of modification have been approached to solve the problems of the polymer membrane over the last decade. Mixed matrix membranes (MMMs) have gained significant importance in meeting new demands and requirements due to their ability to combine the characteristics of above-mentioned membrane materials, providing better approaches in term of efficiency, fouling, permeate consistency and longevity. MMMs are classified as membrane with inorganic fillers dispersed in a continuous phase (solid, liquid, or both) which is made up of polymeric materials [8]. Incorporation of inorganic additive into polymer matrix could provide the desired properties in the membrane such as high selectivity and high mechanical, chemical and thermal strength [9][10].

Hydroxyapatite, HAp (Ca_{10} $(PO_4)_6(OH)_2$) is a low cost material, high adsorption capacity, low water solubility and high stability at low temperature and oxidation condition. HAp has a large number of hydroxyl group (-OH) on the surface which can increase the hydrophilicity of the polymer membrane [11]. The increasing hydrophilicity of the membrane could reduce fouling effect and also increasing the permeation performance of membrane.

In this work, a new adsorptive membrane by dispersing HAp into PSf membrane was prepared via phase inversion technique. The effect of addition HAp into the structure of polysulfone membrane were investigated.

2. Materials and methods

2.1. Preparation of hydroxyapatite

Hydroxyapatite were prepared by using cow bones. The bones were crashed into smaller pieces and boiled into 100°C hot water. The bones were then dried in oven for 24 hours. Then, the bones were crushed and calcined in furnace at 800°C for 3 hours. The bones were then ground into powder using ball mill and were sieved to get fine powder with average size 20μm.

2.2. Membrane preparation

Polysulfone (PSf) mixed matrix membrane were prepared using immersion precipitation by phase inversion method. PVP were first mixed with NMP and stir with magnetic stirrer for 15 minutes. Then, HAp powder was added and continuously stirred for 6 hours to ensure uniform powder dispersion in the solution. After that, PSf was added and stirred at heating temperature 60°C until the solution fully homogeneous. The casting solution was then sonicated for 1 hour to release the bubble. Next, the solution was cast using a flat sheet membrane casting method and immersed in distilled water for coagulation bath. The flat sheet were then dried for 24 hours.

2.3. Membrane analysis

The XRD analysis was done by using XRD Bruker D8 advance with 40kV scaled copper tube as source and a graphite crystal as monochromator. The diffraction angles of 2θ used were in range between 10-60°. The membrane surface were observed using JEOL JSM-6380LA scanning electron microscope (SEM).

3. Result and Discussion

3.1. X-ray diffraction (XRD)

Figure 1 demonstrated the XRD result for HAp derived from cow bone through calcination at 800°C. The XRD pattern were observed from 2θ range of 10° to 60° at 40kV and 20mA. From the graph, it showed the crystallinity of the HAp via the sharp peaks that are present in the XRD spectrum. The graph was almost in line with the result demonstrated by [12] for natural HAp. The highest peak was obtained at the 2θ value of 31.7823°.

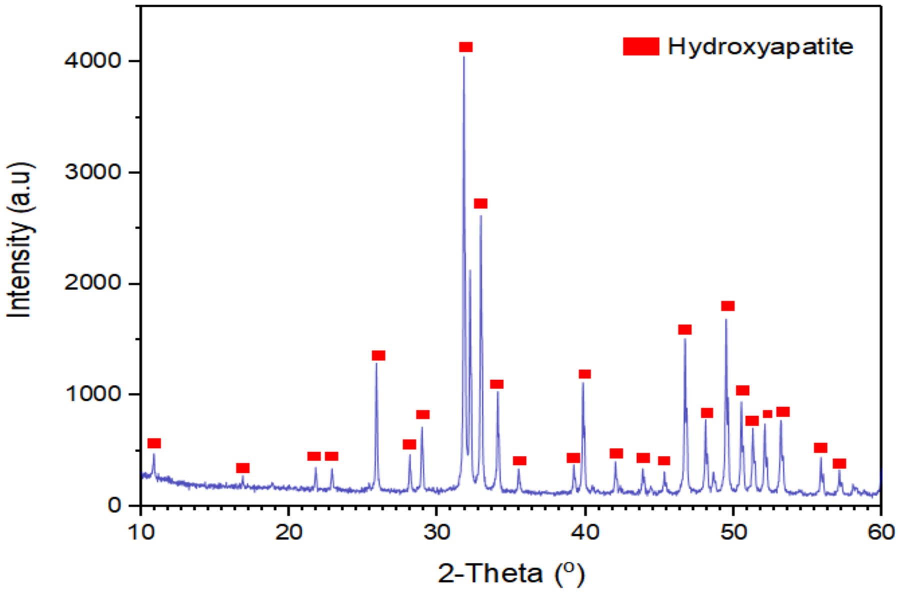

Figure 1: Diffraction patterns for hydroxyapatite derived from cow bone

3.2. Membrane Morphology

The top layer surface view of mixed matrix membrane is depicted in Figure 2 with various loading of HAp into polymer matrix. The SEM image indicated that the dispersion of HAp has successfully occur on the membrane. The formation of pore and surface porosity in the fabricated membrane is resulted from the presence of HAp as fillers [13].The fabricated membrane have more porous surface that neat membrane as the HAp concentration increase. This situation might due to the hydrophilicity nature of the fillers. The increasing pores can lead to the increasing porosity as well as membrane performance [14].

The SEM image also demonstrated the cross section of the membrane. It can be seen the membrane having an asymmetric structure that consists a dense surface layer at the top of the membrane and a porous sub-layer. The presence of HAp in the polymer matrix of the PSf membrane resulting in the formation of finger-like porous structure [15]. The finger-like structure in fabricated membrane is more bigger than the neat membrane.

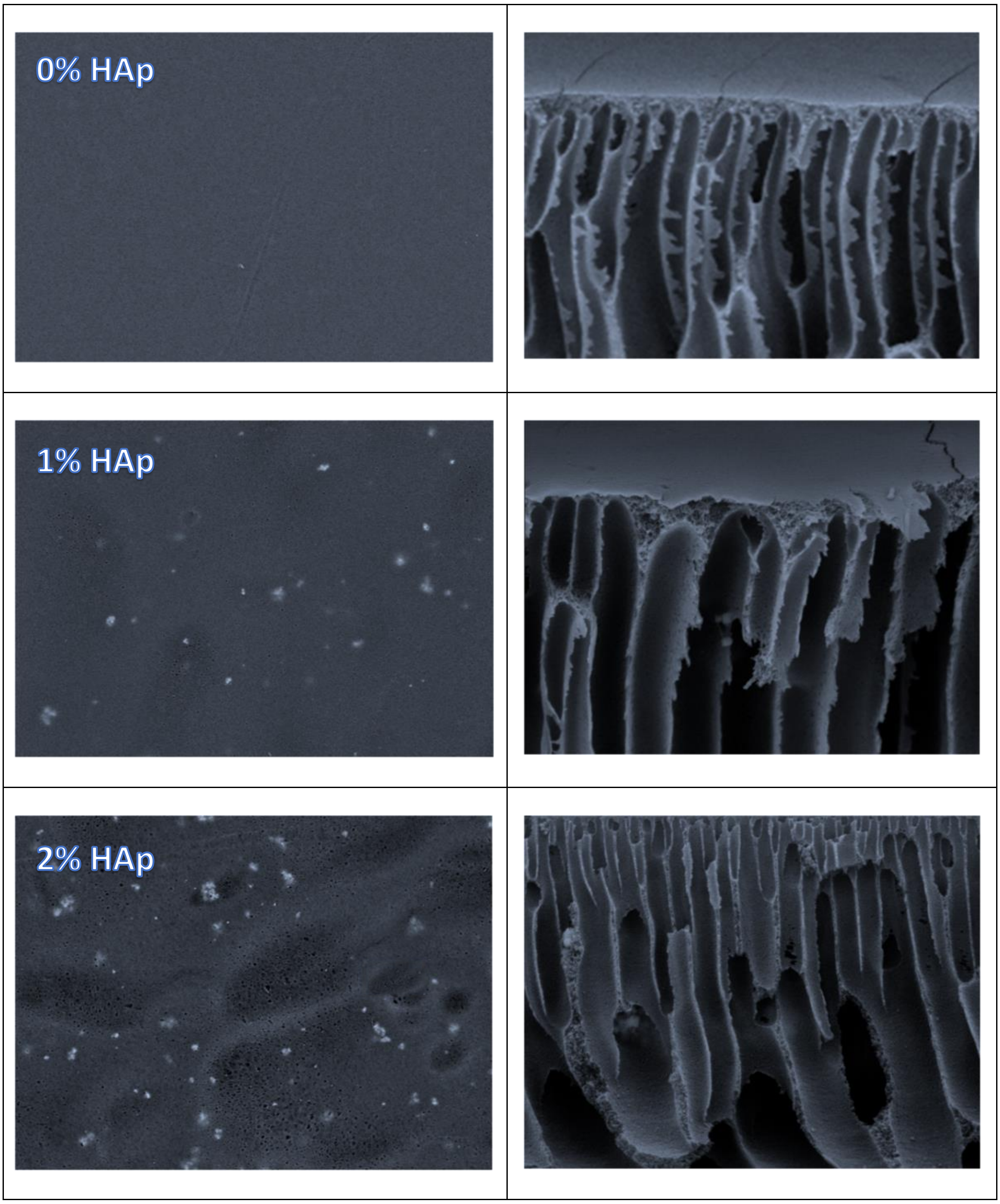

Figure 2: SEM images of top surface (left) and cross section (right) of membrane

4. Conclusion

Both hydroxyapatite and fabrication of PSf/HAp were successfully synthesized and prepared using thermal treatment and phase inversion technique. In this work, the effect on HAp on membrane morphology was investigated. The XRD result showed that the HAp was synthesized perfectly as the sharp peak exists in the XRD graph. The SEM image demonstrated that the dispersion of HAp in the polymer matrix can be seen in the membrane surface. Furthermore, the enlarged, increasing number of pores and finger-like structure of the membrane morphology indicated that the porosity of the fabricated membrane is enhanced from neat membrane. The enhanced porosity will intensify the membrane performance and pure water flux.

5. Acknowledgment

Financial support by Ministry of Higher Education with Research Grants Scheme vot No: 9003-00759 and Collaborative Research Grant with vot No: 9023-00012 are gratefully acknowledged.

References

[1] Bhojwani, S., Topolski, K., Mukherjee, R., Sengupta, D., & El-Halwagi, M. M. (2019). Technology review and data analysis for cost assessment of water treatment systems. Science of the Total Environment, 651, 2749–2761. https://doi.org/10.1016/j.scitotenv.2018.09.363

[2] Esfahani, M. R., Aktij, S. A., Dabaghian, Z., Firouzjaei, M. D., Rahimpour, A., Eke, J., Escobar, I. C., Abolhassani, M., Greenlee, L. F., Esfahani, A. R., Sadmani, A., & Koutahzadeh, N. (2019). Nanocomposite membranes for water separation and purification: Fabrication, modification, and applications. Separation and Purification Technology, 213(September 2018), 465–499. https://doi.org/10.1016/j.seppur.2018.12.050

[3] Zahid, M., Rashid, A., Akram, S., Rehan, Z. A., & Razzaq, W. (2018). A Comprehensive Review on Polymeric Nano-Composite Membranes for Water Treatment. Journal of Membrane Science & Technology, 08(01). https://doi.org/10.4172/2155-9589.1000179

[4] Ulbricht, M. (2006). Advanced functional polymer membranes. Polymer, 47(7), 2217–2262. https://doi.org/10.1016/j.polymer.2006.01.084

[5] Yampolskii, Y. (2012). Polymeric gas separation membranes. Macromolecules, 45(8), 3298–3311. https://doi.org/10.1021/ma300213b

[6] Singh, R., & Purkait, M. K. (2017). Role of poly(2-acrylamido-2-methyl-1-propanesulfonic acid) in the modification of polysulfone membranes for ultrafiltration. Journal of Applied Polymer Science, 134(37), 1–16. https://doi.org/10.1002/app.45290

[7] Mansourizadeh, A., & Ismail, A. F. (2010). Effect of additives on the structure and performance of polysulfone hollow fiber membranes for CO2 absorption. Journal of Membrane Science, 348(1–2), 260–267. https://doi.org/10.1016/j.memsci.2009.11.010

[8] Qadir, D., Mukhtar, H., & Keong, L. K. (2017). Mixed Matrix Membranes for Water Purification Applications. Separation and Purification Reviews, 46(1), 62–80. https://doi.org/10.1080/15422119.2016.1196460

[9] Shohur, M. F., Harun, Z., Yunos, M. Z., Hasan, S., & Jamalludin, M. R. (2013). The effect of sodium chloride (NaCl) coagulant medium of polysulfone ultrafiltration membrane. Applied Mechanics and Materials, 372, 3–7. https://doi.org/10.4028/www.scientific.net/AMM.372.3

[10] Farrukh., Akhyar. M., (2018). Zeolites-Mixed-Matrix Nanofiltration Zeolites-Mixed-Matrix Nanofiltration Membranes Membranes for for the Next Generation Generation of of Water Water Purification Purification. Mmm. https://doi.org/10.5772/intechopen.75083

[11] Lin, K., Pan, J., Chen, Y., Cheng, R., & Xu, X. (2009). Study the adsorption of phenol from aqueous solution on hydroxyapatite nanopowders. Journal of Hazardous Materials, 161(1), 231–240. https://doi.org/10.1016/j.jhazmat.2008.03.076

[12] Sossa, P. A. F., Giraldo, B. S., Garcia, B. C. G., Parra, E. R., & Arango, P. J. A. (2018).

Comparative study between natural and synthetic hydroxyapatite: Structural, morphological and bioactivity properties. Revista Materia, 23(4). https://doi.org/10.1590/s1517-707620180004.0551

[13] Abdel-karim, A., El-naggar, M. E., Radwan, E. K., & Mohamed, I. M. (2021). High-performance mixed-matrix membranes enabled by organically / inorganic modified montmorillonite for the treatment of hazardous textile wastewater. Chemical Engineering Journal, 405(September 2020), 126964. https://doi.org/10.1016/j.cej.2020.126964

[14] Ma, Y., Shi, F., Ma, J., Wu, M., Zhang, J., & Gao, C. (2012). Effect of PEG additive on the morphology and performance of polysulfone ultra fi ltration membranes. 272, 51–58. https://doi.org/10.1016/j.desal.2010.12.054

[15] Marjani, A., Nakhjiri, A. T., Adimi, M., Jirandehi, H. F., & Shirazian, S. (2020). Effect of graphene oxide on modifying polyethersulfone membrane performance and its application in wastewater treatment. Scientific Reports, 10(1), 1–11. https://doi.org/10.1038/s41598-020-58472-y