Reproducible Method for Porous Poly (vinyl alcohol)/Sodium Alginate (PVA/Na-Alginate) Membrane Synthesis

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Introduction

Porous polymers have gained high attention recently due to the material's combined properties of porosity and functionality.[1] Such synergistic properties lead to applications in gas adsorption and storage, gas separation[2] and selective permeation, adsorption, clean energy, and food safety. [3] Although this field is emerging, there is still need to improve the synthetic methods leading to a more green and environment-friendly approach while not compromising its significant potential for scalability.

This study demonstrates an easy yet environment-friendly approach by using biopolymeric materials, namely, Sodium Alginate and Poly (vinyl alcohol). Aside from being sourced from sustainable resources, its synthesis involves direct cross-linking chemistry in an aqueous system with simultaneous pore forming strategy by salting method. This straightforward methodology was created to ensure its future amenability to large-scale production.

Synthetic Approach

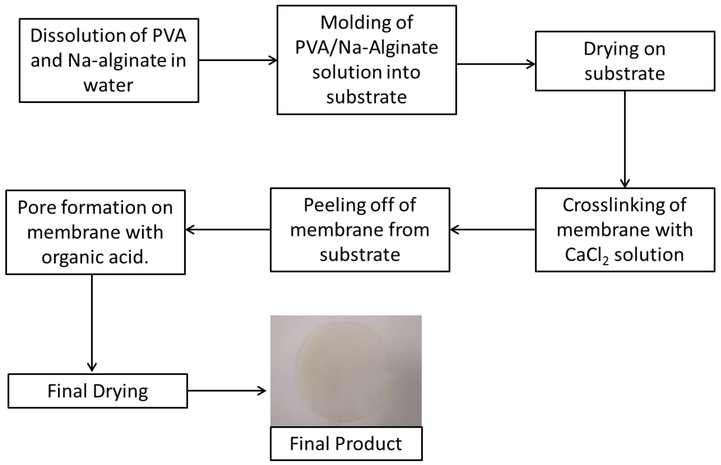


Figure 1. Schematic diagram on the synthesis of Poly(vinyl alcohol)/ Sodium alginate (PVA/Na-Alginate).

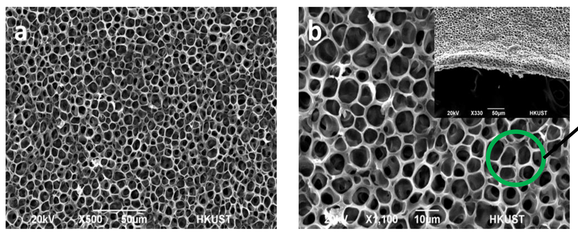


Figure2. SEM images of PVA/Na-Alginate membrane a) in 50μm magnification b) in 10 μm magnification, inset b shows the cross-sectional view of the film and its pore consistency.

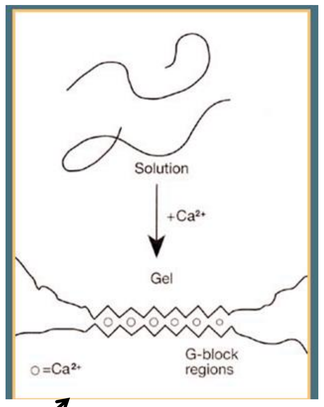


Figure 3. Diagram showing the cross-linking of divalent calcium ions that led to immediate gelation of the alginate component due to ionic crosslinking and simultaneous dissolution of the water soluble PVA phase, eventually making a porous film. This occurs during the immersion of films in aqueous solution.

Advantages of Our Approach

- ✓ **This water-based synthesis is simple and environmentally friendly, which can be done in one pot.**
- ✓ **The PVA/Na-Alginate composite membrane resulted into uniform and well-defined macroporous polymeric sheets with adjustable pore size diameters ranging from 10 to 50 microns.**
- ✓ **This type of membrane is specially made as part for Time- Temperature Indicators (TTI) developed with patent pending. [4]**

References

1] Tan, L.; Tan, B. Hypercrosslinked porous polymer materials: design, synthesis, and applications. *Chem. Soc. Rev.*, 2017,46, 3322-3356
2] Lu, W., *et al.* Porous Polymer Networks: Synthesis, Porosity, and Applications in Gas Storage/Separation. *Chem. Mater.*, 2010, *22* (21), 5964–5972.
3] Wu, D., *et al.* Design and Preparation of Porous Polymers. *Chem. Rev.*, 2012, *112* (7), 3959–4015.
4] Tan, NPB.; Cheu, CKW.; He, MM.; Li, W.; Christianto, J.; Lau, YT. US Patent pending No. 62/603,637. Time-temperature recorder device for quality monitoring and method of manufacture. 07 June 2017.

Results

Thermogravimetric and Attenuated Infrared Spectra of Na-Alginate/PVA films

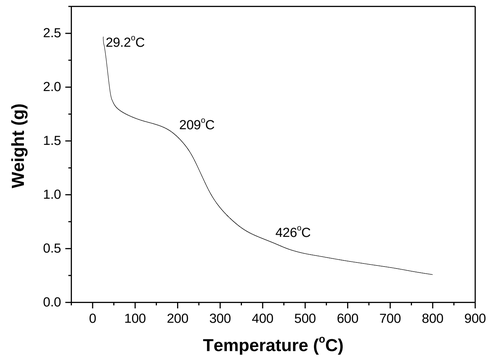


Figure 4. Thermogravimetric analysis of optimized Na-Alginate film.

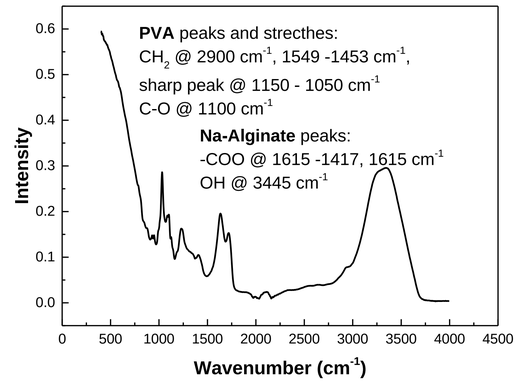


Figure 5. Attenuated Infrared (ATIR) Spectra of the optimized Na-Alginate film.

Optimization of TTI Protection layer based on critical process parameters

Effect of Poly(vinyl) alcohol (PVA) molecular weight on the Na-Alginate/PVA film

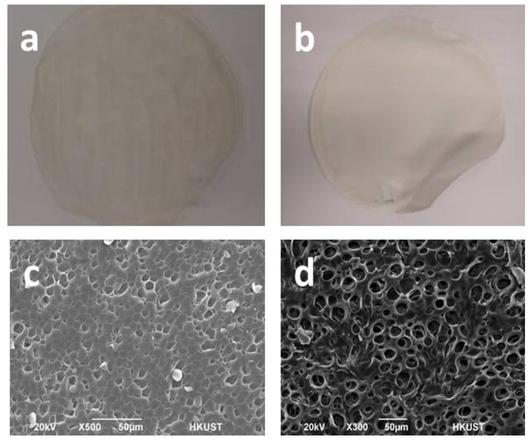
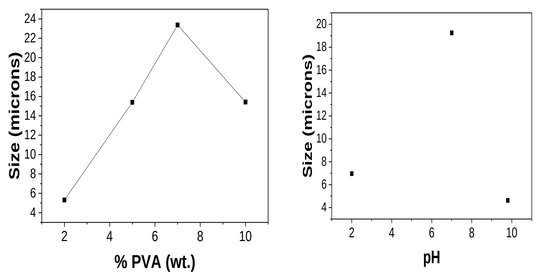


Figure 6. Physical features of Na-Alginate/PVA films using different molecular weights of PVA, a) 89K, b) 9K and its corresponding porous structure based on SEM images c) 89K, d) 9K. Other conditions remain constant.

Effect of %PVA and pH on pore size of films



Effect of Drying Tempearture

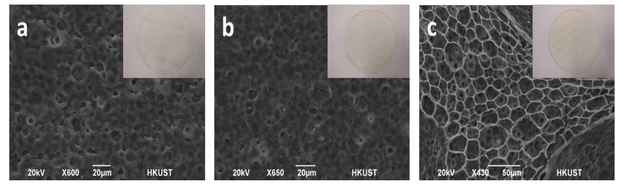


Figure 7. SEM images of Na-Alginate/PVA films synthesized in different drying temperature a) 60°C , b) 80°C, c) 100°C. Insets are the solid films produced. Other conditions remained constant during the synthesis.

Effect of Calcium chloride soaking time

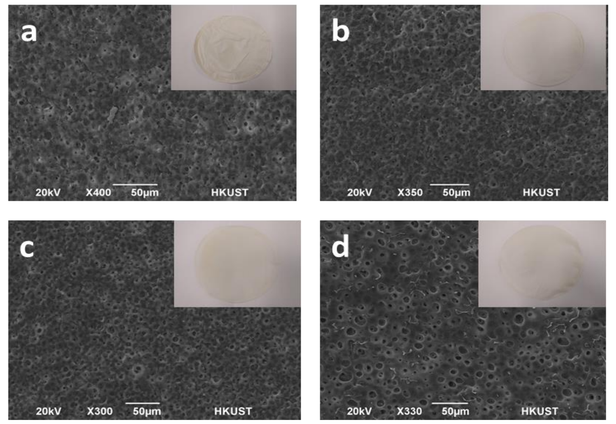


Figure 8. SEM images of Na-Alginate/PVA films synthesized in various $CaCl_2 \cdot H_20$ (0.3M) soaking time, a) 1 hr., b) 3 hrs., c) 8 hrs., d) 24 hrs. soaking time. Insets are the solid films produced. Other conditions remained constant during the synthesis.

Conclusion

We demonstrated a simple and green route of fabricating porous films from PVA and Na-alginate. Optimization was based on critical parameters such as polymer's molecular weights, drying temperature, soaking time, pH and PVA content on the film.

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