Swelling of Natural Rubber/Cassava Starch Crosslinked Membrane in Ethanol Solution

Ukkadate Moonart[1], Punyarat Jantachum[2] and Songkot Utara[3]
Chemistry Program, Faculty of Science, Udonthani Rajabhat University

***Abstract*:** *This research studied the swelling in ethanol of natural rubber/cassava starch crosslinked with Butanetetracarboxylic acid. In the work. The ratio of natural rubber and cassava starch were varied at 50:50, 60:40 and 80:20, and the amounts of Butanetetracarboxylic acid as crosslinking of starch were varied from 0 to 30 % of starch weight.A study of swelling in ethanol found that the swelling increase with increasing cassava starch content. It is also found that the swelling decrease when the amount of crosslinking agent is increased. The comparison of swelling in water and ethanol found that the swelling in water is higher than the swelling in ethanol. Moreover, interaction of the swelling in water is less than interaction of the swelling ethanol. The result shown that water can diffuse into sample better than ethanol.*

Keywords: *Dynamic Swelling, Cassava Starch, Natural Rubber, membrane*

1. Introduction

Membrane separation processes have been seen to offer many advantages over existing separation processes such as "higher selectivity, lower energy consumption, moderate cost to performance ratio and compact and modular design" [1].Pervaporation and vapor permeation are separation technologies in which one of the components of a liquid mixture(pervaporation), or a vapor phase (vapor permeation) is separated from the feed mixture by selective evaporation (pervaporation) or gas transport (vapor permeation) through a membrane.[2].

The membrane is commonly made from latex natural rubber due to the elastomeric properties and natural rubber can be easily fabricated into a thin films. However, the drawback of membrane produced is hydrophobic properties. The addition of hydrophilic material like Cassava Starch is believed to improve the swelling properties of membrane that casted from natural rubber. The increasing of swelling properties lends to improve of PV process in ethanol solution. Because of this, the aim of this work is to study the swelling properties of natural rubber membrane by the incorporation of Cassava Starch Crosslinked with Butanetetracarboxylic Acid . The effect of Cassava Starch loading as well as the ethanol concentration on degree of swelling was studied. In addition, interaction parameters of water-membrane and ethanol-membrane were measured.

2. Experimental Procedure

2.1 Materials

Concentrated natural rubber latex (%60 DRC) was purchased from Thai Hua Rubber Company Concentrated Butanetetracarboxylic Acid and absolute ethanol were purchased from Ajax Finechem. Sodium hydroxide were purchased from Merck company. Cassava starch and Terric acid were used without further treatment.

2.2 Membrane Preparation

Dissolve Cassava starch 200 g into distilled water 100 ml and adjust the pH to 10 with sodium hydroxide 15% w/v , add butanetetracarboxylic acid into Cassava starch solution and varied from 0 to 30 % of starch weight .Then, the starch that is done to adjust the pH to 10 . Heating by waterbath at 80^{o}C for 15 minutes until the starch gelation. then add natural rubber latex weigh 84.3 g which mix teric acid and varied ratio NR: Cassava starch is 80:20 60:40 50 :50 stir mixture continuously for 15 miniute pour out the mixture to cool. Casting into Teflon-coated material, and dried vacuum oven at 40 ° C for 24 hours

2.3 Degree of Swelling and Interaction Parameters

Degree of swelling was measured by immerging membrane as various ethanol concentrations at 20°C for 24 h. After that, the degree of swell was calculated by following equation.

$$\text{Degree of swelling} = \left(\frac{W_w - W_d}{W}\right) \times 100 \quad (1)$$

Where W_w = the weight of swollen membrane
W_d = the weight of dried membrane

Interaction parameter was calculated by Flory–Huggins theory by omitting the elastic free energy contribution [3].

$$\chi_{12} = \frac{-(\ln \varphi_1 + \varphi_2)}{(\varphi_2)^2} \quad (2)$$

Where φ_2 = volume fraction of solvent
φ_2 = volume fraction of membrane
ρ = density of ethanol (0.789 g/cm^3)
χ_{12} = interaction parameter between φ_1 and φ_2

3. Results And Discussion

3. Effect of Cassava Starch Content and Crosslinking Agent on Swelling Behavior and Interaction Parameter of Membranes

The effect of cassava starch content and crosslinking agent on the swelling behavior of the membrane is shown in Figure 1. It was observed that the degree of swelling gradually decrease with the increase of ethanol concentration. The degree of swelling increased with cassava starch content. And. The degree of swelling decreased with crosslinking agent. These phenomenal could be explained by the increase of hydroxyl groups (-OH) in membrane and the decrease of the polarity in ethanol solution. A high hydroxyl groups in membrane lends to improve the water absorption; however, the increase ethanol concentration lends to decrease the solvent polarity.

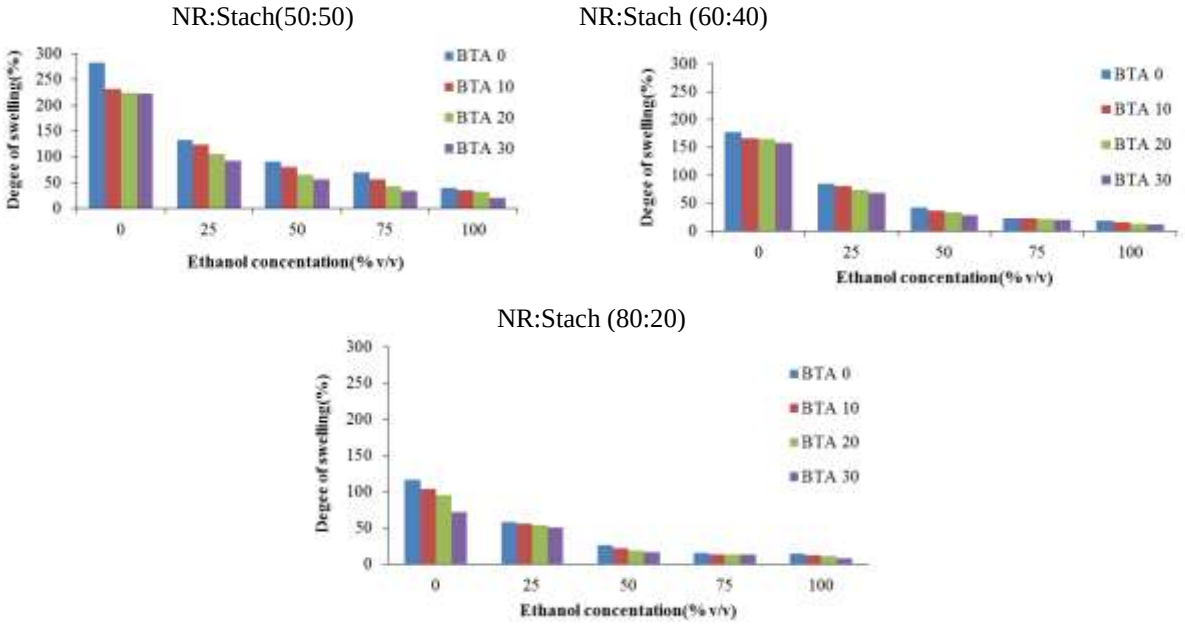

Fig. 1: Effect of ethanol concentration on swelling degree of membrane

From Table 1, it found that the interaction parameter of water-membrane and ethanol-membrane lend to decrease with increasing of starch content. The explanation is due to the amount of water in side membrane increase and the Interaction parameter values decrease [4]. Interaction of water toward membrane was higher as compared to that of ethanol. Thus, sorption of water in membrane was higher. This explanation was supported by Figure 1.

TABLE I: Interaction parameter (χ_{ip}) of water and ethanol with membrane

NR : Starch	χ Water with membrane			χ Ethanol with membrane		
	50:50	**60:40**	**80:20**	**50:50**	**60:40**	**80:20**
BTA 0	0.61	0.67	0.74	0.93	1.28	1.42
BTA 10	0.62	0.68	0.76	0.98	1.38	1.48
BTA 20	0.64	0.68	0.79	1.02	1.45	1.58
BTA 30	0.65	0.68	0.86	1.22	1.57	1.75

4. Conclusion

The swelling behavior of membrane increased with .This was due to the increase of ionic groups and decrease when butanetetracarboxylic acid was increased. The interaction parameters of membrane-water and membrane-ethanol decreased with the increase of starch content.

5. Acknowledgement

The authors are grateful to Udonthani Rajabhat University for funding this research.

6. References

[1] F. Lipnizki, R.W. Field, P.-K. Ten, Pervaporation-based hybrid process: a review of process design, applications and economics, J. Membr. Sci. 153 (1999)183.

http://dx.doi.org/10.1016/S0376-7388(98)00253-1

[2] H. Strathmann, "Synthetic Membrane and Their Preparation", In: Porter, C, M.(ed.s) *Handbook of Industrial Membrane Technology,* New Jersey, Noyes Publication: 1-56 (1990).

[3] U. Moonart, "Pervaporation Separation of Ethanol/Water Mixtures using Natural Rubber-Polyvinyl alcohol Semi-Interpenetrating Polymer Network Membranes", Khon Kaen, Khon Kaen University.(2008)

[4] U. Moonart, and S. Utara. Swelling of Cross-linked Natural Rubber-Silica Gel from Rice Husk Membranes in Ethanol/Water solution. In The preceding the 6th Thailand Material Science and Technology Conference (MAST6)26-27August 2010 (286-288).Thailand : MTEC.