BLENDED CHITOSAN AND POLY(VINYL ALCOHOL) MEMBRANES FOR THE PERVAPORATION OF METHANOL AND METHYL TERT-BUTYL ETHER

NORHASLINA BINTI MOHD. SAKRI

UNIVERSITI TEKNOLOGI MALAYSIA
BLENDED CHITOSAN AND POLY(VINYL ALCOHOL) MEMBRANES FOR
THE PERVAPORATION OF METHANOL AND METHYL TERT-BUTYL
ETHER

NORHASLINA BINTI MOHD. SAKRI

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Master of Engineering (Chemical)

Faculty of Chemical and Natural Resources Engineering
University Technology Malaysia

MAC 2009
To my beloved family
abah, umi, ekin, enun, ela, epa, apis, chik & adik
and my lovely husband, anas
Thanks for everything
ACKNOWLEDGEMENT

Firstly and importantly, my thankfulness to Allah S.W.T. for His bless in giving me the opportunity to be able to fulfill my task in completing this research in time and giving me the strength to endure all the difficulties that I encounter.

I like to express my heartfelt gratitude to my supervisor, PM Dr. Mohd Ghazali Mohd Nawawi for his devoted supervisions, guidance, assistances, advices and motivation towards the completion of my research. His supports and patience in answering my endless questions was invaluable in my task to complete the research.

My sincere appreciation also goes to my beloved husband, parents, Abah and Umi, my siblings and all my families’ member that always supports me at anytime and anywhere. For all the hard time, they never forget to show their love and their cares. I love you all.

Besides, I would like to express my gratitude to all my friends for their endless support and encouragement. Lastly, I would like to thank to all who have directly and indirectly involve in this research. Thank you very much.
ABSTRACT

In this research project, blended chitosan/poly(vinyl alcohol) (PVA) membranes were produced by mixing PVA and chitosan solutions. Chitosan (CS) was first dissolved in acetic acid aqueous solution before PVA solution was added. The mixture was then cured at room temperature. The modified composite membrane was prepared by coating the mixture of chitosan and PVA solution onto the porous polysulfone membrane by the solution casting technique. The porous polysulfone substrate was prepared via phase inversion process from a casting solution containing 12 wt% polysulfone, 11 wt% polyethylene glycol and 77 wt% N,N- dimethylacetamide. The weight percent of chitosan in the membrane was varied from 20 wt. % to 100 wt. % while the membrane thickness was in the range of 15-30 µm. The unmodified and modified composite membranes with PVA were used in pervaporation separation of methanol/methyl-tert-butyl ether (MTBE) mixture. The swelling degree and the total flux increased with increasing chitosan content in the membranes. 30 wt. % of methanol (MeOH) in feed was chose since it gave the optimal overall pervaporation characteristics in terms of flux and separation factor. The membrane containing chitosan 20 wt. % to 40 wt. % performed the best. At operating temperature of 50 ºC for 20 wt % to 40 wt % of chitosan, the fluxes obtained are at 52.28 g/m².hr and 66.92 g/m².hr with the separation factors of 81.00 and 53.22 respectively. The effect of temperature on flux followed the Arrhenius relationship. The membrane showed excellent performance for separation of MeOH/MTBE mixture when the quantity of MeOH in feed is small. It is a very suitable process for the recovery purpose in order to remove excess MeOH in the MTBE system.
ABSTRAK

Dalam kajian ini, membran campuran kitosan/poli(vinil alkohol) (PVA) telah dihasilkan dengan mencampurkan larutan PVA dan larutan kitosan. Kitosan (CS) telah dilarutkan terlebih dahulu dengan asid asetik sebelum larutan PVA dicampurkan. Campuran tadi kemudianya dikeringkan pada suhu bilik. Membran komposit diubahsuai dengan menyelaput campuran larutan kitosan dan PVA ke atas membran poros polisulfona dengan menggunakan kaedah penepungan larutan. Membran poros polisulfona disediakan melalui proses pembalikan fasa daripada larutan penepungan yang mengandungi 12 % berat polisulfona, 11 % berat polietilen glaikol dan 77 % berat N,N-dimetilasetamida. Peratusan berat kitosan dalam membran adalah antara 20 % hingga 100 % manakala ketebalan membran adalah dalam lingkungan 15-30 µm. Membran komposit yang tidak diubahsuai dan yang diubahsuai dengan PVA ini digunakan dalam proses penelapsejatan untuk pemisahan campuran azeotropik metanol (MeOH) dan metil tert-butil eter (MTBE). Darjah pembengkakan dan jumlah penyerapan fluks meningkat dengan peningkatan kandungan kitosan di dalam membran. 30 % berat metanol di dalam suapan dipilih kerana sifat penelapsejatan yang optima secara keseluruhannya dari segi fluks dan faktor pemisahan. Membran yang mengandungi 20 % berat hingga 40 % berat kitosan menunjukkan prestasi terbaik. Pada suhu operasi 50 ºC bagi 20 % berat hingga 40 % berat kitosan, fluks yang diperolehi masing-masing ialah 52.28 g/m².j dan 66.92 g/m².j dengan faktor pemisahan sebanyak 81.00 dan 53.22. Kesan suhu terhadap penyerapan fluks adalah mengikut hubungan Arrhenius. Membran telah menunjukkan prestasi yang baik untuk pemisahan campuran MeOH/MTBE apabila kandungan MeOH dalam suapan sedikit. Ini adalah sesuai untuk proses perolehan semula untuk menyingkirkan lebihan MeOH dalam sistem MTBE.
LISTS OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td></td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td></td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td></td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td></td>
<td>v</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td></td>
<td>vi</td>
</tr>
<tr>
<td>LISTS OF CONTENTS</td>
<td></td>
<td>vii</td>
</tr>
<tr>
<td>LISTS OF TABLES</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>LISTS OF FIGURES</td>
<td></td>
<td>xi</td>
</tr>
<tr>
<td>LISTS OF SYMBOL</td>
<td></td>
<td>xiv</td>
</tr>
<tr>
<td>LISTS OF APPENDIXES</td>
<td></td>
<td>xv</td>
</tr>
</tbody>
</table>

I  INTRODUCTION 1
1.1 Background 1
1.2 Problem statement 6
1.3 Objective 7
1.4 Scopes of Work 7

II LITERATURE REVIEW 9
2.1 Overview of Pervaporation 9
2.2 Pervaporation Membranes 14
2.2.1 Types and Fabrications of Membranes 15
2.2.2 Modifications of Polymer 16
2.2.3 Chitosan (CS) Membrane 19

2.3 Composite Chitosan Membrane 22

2.4 Blended Chitosan (CS)-Poly(vinyl alcohol) (PVA) 23

2.5 Effect of Process Condition 26
   2.5.1 Feed Concentration 26
   2.5.2 Feed Pressure 27
   2.5.3 Influence of Temperature 28
   2.5.4 Permeate Pressure 29

2.6 Poly(vinyl alcohol) (PVA) 29

2.7 Methanol 31

2.8 Methyl Tert-Butyl Ether (MTBE) 32
   2.8.1 Physical and Chemical Properties 33
   2.8.2 The Effects of MTBE to the Environment 35

III METHODOLOGY 37
3.1 Materials 37
3.2 Membrane Preparation 38
   3.2.1 Production of Chitin 38
   3.2.2 Extraction of Citosan from Chitin 40
   3.2.3 Preparation of Chitosan Solution 40
   3.2.4 Preparation of PVA Solution 41
   3.2.5 Preparation of Chitosan/Polysulfone Composite Membrane 41
   3.2.6 Preparation of BlendedChitosan/PVA and Polysulfone Composite Membrane 43
3.3 Preparation of Methanol and MTBE Mixture 45
3.4 Pervaporation Experiments 45
3.5 Characteristic and Performance Study of the Membrane 49
   3.5.1 General Overview 49
   3.5.2 Sorption Experiment 49
   3.5.3 Scannning Electron Microscope (SEM) Test 50
   3.5.4 Pervaporation Performances 51

IV RESULTS AND DISCUSSIONS 53
4.1 Morphologies of the Membranes 53
4.2 Different Composition of CS/PVA Composite Membrane 55
4.3 Sorption Effects 60
4.4 Membrane Performance Study on Pervaporation System 62
   4.4.1 Flux Analysis 63
   4.4.2 Separation Factor Analysis 73
   4.4.3 Optimum Condition of Membrane Preparation 76

V CONCLUSIONS AND RECOMMENDATIONS 78
5.1 Conclusions 78
5.2 Recommendations 79

BIBLIOGRAPHIES 80

APPENDIXES 93
APPENDIX A - B 93 - 100
## LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE NO</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Properties and applications of technically relevant synthetic</td>
<td>2-3</td>
</tr>
<tr>
<td></td>
<td>membranes</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Previous studies in separation of methanol/MTBE by pervaporation</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Physical Properties of Poly(vinyl alcohol), PVA</td>
<td>30-31</td>
</tr>
<tr>
<td>2.3</td>
<td>Physical Properties of Methyl Tert-Butyl Ether</td>
<td>34</td>
</tr>
<tr>
<td>3.1</td>
<td>Chitosan/PVA ratio for the pervaporation</td>
<td>43</td>
</tr>
<tr>
<td>3.2</td>
<td>Liquid mixture composition for the pervaporation</td>
<td>45</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Basic schematic diagram of pervaporation</td>
<td>11</td>
</tr>
<tr>
<td>2.2</td>
<td>Simplified flow sheet for preparation of chitosan</td>
<td>21</td>
</tr>
<tr>
<td>2.3</td>
<td>The structure of PVA</td>
<td>30</td>
</tr>
<tr>
<td>2.4</td>
<td>The structure of methanol</td>
<td>32</td>
</tr>
<tr>
<td>2.5</td>
<td>The structure of MTBE</td>
<td>34</td>
</tr>
<tr>
<td>3.1</td>
<td>Procedure to prepare chitin from shell waste</td>
<td>39</td>
</tr>
<tr>
<td>3.2</td>
<td>Procedure to extract chitosan from chitin</td>
<td>40</td>
</tr>
<tr>
<td>3.3</td>
<td>Procedure of preparing composite membranes</td>
<td>42</td>
</tr>
<tr>
<td>3.4</td>
<td>Procedure of preparing blended membranes</td>
<td>44</td>
</tr>
<tr>
<td>3.5</td>
<td>Schematic diagram of the pervaporation cells</td>
<td>46</td>
</tr>
<tr>
<td>3.6</td>
<td>Schematic diagram of the pervaporation apparatus</td>
<td>47</td>
</tr>
<tr>
<td>3.7</td>
<td>Picture of pervaporation apparatus</td>
<td>48</td>
</tr>
<tr>
<td>4.1</td>
<td>Micrograph image for unmodified chitosan composite membrane (A) Surface area; (B) Cross-sectional area</td>
<td>54</td>
</tr>
<tr>
<td>4.2</td>
<td>Micrograph image for 20 wt. % of chitosan composite membrane (A) Surface area; (B) Cross-sectional area</td>
<td>56</td>
</tr>
<tr>
<td>4.3</td>
<td>Micrograph image for 40 wt. % of chitosan composite membrane (A) Surface area; (B) Cross-sectional area</td>
<td>57</td>
</tr>
<tr>
<td>4.4</td>
<td>Micrograph image for 60 wt. % of chitosan composite membrane (A) Surface area; (B) Cross-sectional area</td>
<td>58</td>
</tr>
<tr>
<td>4.5</td>
<td>Micrograph image for 80 wt. % of chitosan composite</td>
<td>59</td>
</tr>
</tbody>
</table>
membrane (A) Surface area; (B) Cross-sectional area

4.6 Effects of chitosan composition in membranes on swelling degree

4.7 Effects of chitosan composition in membranes on separation factor

4.8 Flux of modified chitosan composite membrane in Different feed of methanol

4.9 Individual permeation flux versus feed concentration of methanol for 20 wt. % CS at room temperature

4.10 Individual permeation flux versus feed concentration of methanol for 40 wt. % CS at room temperature

4.11 Individual permeation flux versus feed concentration of methanol for 60 wt. % CS at room temperature

4.12 Individual permeation flux versus feed concentration of methanol for 80 wt. % CS at room temperature

4.13 Individual permeation flux versus feed concentration of methanol for 100 wt. % CS at room temperature

4.14 Individual flux versus composition of chitosan in membrane at room temperature (30 wt. % methanol in feed)

4.15 Flux versus composition of chitosan in membrane for different feed concentration at room temperature

4.16 Effects of feed temperature on total permeation flux at 30 wt. % methanol in feed

4.17 Arrhenius relationship between methanol flux and feed temperature at 30 wt. % methanol in feed

4.18 Arrhenius relationship between MTBE flux and feed temperature at 30 wt. % methanol in feed

4.19 Separation factor versus feed MeOH concentration at room temperature

4.20 Separation factor versus composition of chitosan in membrane at room temperature
4.21 Separation factor of chitosan composite membrane at different temperature in 30 wt. % of methanol in feed
**LIST OF SYMBOL**

**SYMBOL**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>pervaporation</td>
</tr>
<tr>
<td>MTBE</td>
<td>methyl-tert-butyl ether</td>
</tr>
<tr>
<td>PVA</td>
<td>poly (vinyl alcohol)</td>
</tr>
<tr>
<td>CS</td>
<td>chitosan</td>
</tr>
<tr>
<td>MeOH</td>
<td>methanol</td>
</tr>
<tr>
<td>PS</td>
<td>polysulfone</td>
</tr>
<tr>
<td>DMAc</td>
<td>N,N-dimethylacetamide</td>
</tr>
<tr>
<td>PDMS</td>
<td>polydimethyl siloxane</td>
</tr>
<tr>
<td>$J$</td>
<td>permeation rate, g/m$^2$.hr</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>pervaporation separation factor</td>
</tr>
<tr>
<td>$x$</td>
<td>weight fractions in the feed</td>
</tr>
<tr>
<td>$y$</td>
<td>weight fractions in the permeate</td>
</tr>
<tr>
<td>$A_p$</td>
<td>Arrhenius</td>
</tr>
<tr>
<td>A</td>
<td>area, m$^2$</td>
</tr>
<tr>
<td>t</td>
<td>time, hr</td>
</tr>
<tr>
<td>Q</td>
<td>weight of permeate, g</td>
</tr>
</tbody>
</table>


LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Sorption Data</td>
<td>93</td>
</tr>
<tr>
<td>B</td>
<td>Pervaporation Data</td>
<td>97</td>
</tr>
</tbody>
</table>
1.1 Background

A membrane has been defined by the European Society of Membrane Science and Technology as “an intervening phase separating two phases and/or acting as an active or passive barrier to the transport of matter between phases. Membrane also can be simply defined as a barrier. This barrier separates two phases and restricts the transportation of various chemicals in selective manner. Geankoplis (2003) defines; membrane can act as a semi-permeable barrier where the separation occurs by the membrane controlling the movement of various molecules between two liquid phases, two gas phases, or a liquid and a gas phase.

Membranes can be homogenous or heterogeneous, symmetric or asymmetric in structure, solid or liquid can carry a positive or negative charge or be neutral or bipolar. Transportation through a membrane can be affected by convection or by diffusion of individual molecules. Other factors are induced by an electric field or concentration, pressure or temperature gradient. The membrane thickness may vary from as small as
100 micron to several mms. A summary of technically relevant membranes, their structure and area of application is tabulated in Table 1.1.

**Table 1.1: Properties and applications of technically relevant synthetic membranes**  
(Strathmann, 1986)

<table>
<thead>
<tr>
<th>Membranes</th>
<th>Basic Materials</th>
<th>Manufacturing Procedures</th>
<th>Structures</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic membranes</td>
<td>Clay, silicate, aluminium oxide, graphite, metal powder</td>
<td>Pressing and sintering of fine powders</td>
<td>Pores from 0.1 to 10 micron diameter</td>
<td>Filtering of suspensions, gas separations, separation of isotopes</td>
</tr>
<tr>
<td>Stretched membranes</td>
<td>Polytetrafluoroethylene, polyethylene, polypropylene</td>
<td>Stretching of partially crystalline foil perpendicular to the orientation of crystallyst</td>
<td>Pores of 0.1 to 1 micron diameter</td>
<td>Filtration of aggressive media, cleaning of air, sterile filtration, medical technology</td>
</tr>
<tr>
<td>Etched polymer films</td>
<td>Polycarbonate</td>
<td>Radiation of a foil and subsequent acid etching</td>
<td>Pores of 0.5 to 10 micron diameter</td>
<td>Analytical and medical chemistry, sterile filtration</td>
</tr>
<tr>
<td>Homogeneous membranes</td>
<td>Silicone rubber, hydrophobic liquids</td>
<td>Extruding homogeneous foils, formation of liquid films</td>
<td>Homogeneous phase, support possible</td>
<td>Gas separations, carrier-mediated transport</td>
</tr>
<tr>
<td>Symmetrical microporous membranes</td>
<td>Cellulose derivatives, polyamide, polypropylene</td>
<td>Phase inversion reaction</td>
<td>Pores of 50 to 5000 nanometres diameter</td>
<td>Sterile filtration, dialysis, membrane distillation</td>
</tr>
</tbody>
</table>
Table 1.1: Properties and applications of technically relevant synthetic membranes (Strathmann, 1986) (continued)

<table>
<thead>
<tr>
<th>Integral asymmetric membranes</th>
<th>Cellulose derivatives, polyamide, polysulfone</th>
<th>Phase inversion reaction</th>
<th>Homogeneous polymer or pores of 1 to 10 nanometres diameter</th>
<th>Ultrafiltration, hyperfiltration, gas separations, pervaporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite asymmetric membranes</td>
<td>Cellulose derivatives, polyamide, polysulfone, polydimethylsiloxane</td>
<td>Application of a film to a microporous membrane</td>
<td>Homogeneous polymer or pores from 1 to 5 nanometres diameter</td>
<td>Ultrafiltration, hyperfiltration, gas separations, pervaporation</td>
</tr>
<tr>
<td>Ion exchange membranes</td>
<td>Polyethylene, polysulfone, polyvinylchloride</td>
<td>Foils from ion exchange resins or sulfonation of homogeneous polymers</td>
<td>Matrix with positive or negative charges</td>
<td>Electrodialysis, electrolysis</td>
</tr>
</tbody>
</table>

There are many reasons why the membrane separation process is commercially being practiced in industrial applications such as to recover hydrogen from off-gases, or to fractionate, concentrate and purify molecular solutions in chemical and pharmaceutical industry (Strathmann, 1986). The main reason is due to the fact that the membrane process replaces the conventional processes such as filtration, distillation, ion-exchange and chemical treatment systems which is more energy savings and environmental benign. On top of that, this ease of operational process is able to produce high and better quality products.

Nowadays, membranes are significantly being preferred in chemical technology and being used in variety of applications in our daily life routines. Various types of membrane separation have been developed for specific industrial applications such as
reverse osmosis, ultrafiltration, microfiltration, electrodialysis, gas separation and pervaporation. Yamada and Nakagawa (1980) reported that membrane separation techniques have a great importance in chemical and petrochemical because it is believed to be much less energy consuming process than conventional separation techniques.

According to Bruschke and Tusel (1986), separation of liquid mixtures by means of membrane, whereby a vaporous product is obtained on the permeate side of the membrane, has been known for about 80 years. Separation of liquid mixtures using pervaporation process is considered as a basic unit operation with significant potential for the solution of environmental problem and energy cost compared to the distillation process (Kim et al., 2000). The separation mechanism in pervaporation is not based on the relative volatility of components like distillation process. It is based on the difference in sorption and diffusion properties of the feed components as well as permselectivity of the membrane (Dubey et al., 2005).

Pervaporation, which name originates from a combination of the terms permeation and vaporization, is a hybrid between a liquid and a gas separation process (Nawawi, 1997). There are three applications of pervaporation; dehydration of organic solvents (water removal from organics), removal of organic compounds from aqueous solution (organic removal from water) and the separation of organic mixtures like methanol and MTBE. Among the membrane processes, pervaporation technique is considered to be the best process in separating the organic mixtures especially for the close boiling point and azeotropic mixtures due to its high separation efficiencies coupled with energy saving (Durmaz-Hilmioglu and Tulbentci, 2004). Pervaporation is also being recognized as an effective process for separating mixtures consisting of heat-sensitive compounds and isomers (Kim et al., 2000).
The separation of methanol from methyl tert-butyl ether (MTBE) is an organic-organic separation whose economic importance has increased with the industrial production of octane enhancers (Gozzelino and Malucelli, 2004). MTBE is produced by reacting isobutene with excess methanol, and the reacted methanol is subsequently distilled off and recovered. However, the distillation of methanol (bp 64.7°C) and MTBE (bp 55.3°C) mixtures involves the formation of minimum-boiling azeotrope (bp 51.6°C) (Ray et al., 1999) with a composition of 14.3 wt. % methanol at 760 mmHg (Yang et al., 1998) and it is very difficult to be separated (Kim et al., 2000). In the conventional process, the operation requires high capital cost and is not energy efficient. Therefore, pervaporation process has been considered as a favourable alternative separation technique for the separation of methanol and MTBE mixture.

The selection of the right polymer is a key in the development of pervaporation membranes. Membranes used for pervaporation separation process are generally dense (non-porous), homogeneous thin polymer films, or membranes that have a dense polymer top-layer (skinned of composite). In fact, the characteristics of pervaporation processes are a rate-controlled process. Thus asymmetric and composite membrane structures have been introduced into the membrane. The basic idea is to reduce the flow resistance by depositing thin and dense active layers on the supporting membrane (Huang et al., 1999).

Blending a hydrophilic polymer with a hydrophobic polymer can control the hydrophilic-hydrophobic balance properties of a membrane (Nawawi, 1997). Thus, an optimal combination of flux and separation factor can be achieved. A membrane with high flux gives a low separation factor and vice versa. Besides, the hydrophilic group swells the membranes significantly under aqueous mixture due to its plasticization action which results in poor separation factor (Huang and Xu, 1989; Uragami and Takigawa, 1990).
1.2 Problem Statement

Many studies have been done for chitosan as membranes (Nawawi, 1997; Hamdan, 1999; Yaakub, 1999; Yunus 1999; Muda, 2000; Nawawi and Pamin, 2000; Tan, 2000; Zakaria, 2000; Tan et al., 2002; Ahmad et al., 2005 and Taib, 2006) because of its good film forming properties, highly hydrophilic and good chemical resistant properties. However, Nawawi, (1997) found that chitosan has a reasonably poor stability in water and in aqueous mixtures because of the existing of amino group in its chain. The stability has to be improved to fully utilize its potential as a membrane especially in aqueous solution.

On the other hand, the separation factor or flux also needs to be improved in order to achieve a better result of separation. These problems may be solved by implementing some modifications. Many attempts have been made using various techniques to improve the separation factor of chitosan membrane and also to control degree of swelling by crosslinking, grafting, zeolite filled and blending. Researchers have reported modified chitosan membranes by blending it with other polymers such as PVA (Muthukamaru, 1999; Wei, 1999; Tan et al., 2001; Wong, 2002; Jalil, 2005 and Svang-Ariyaskul et al., 2006). As it is well known, PVA exhibit enhanced mechanical properties such as tensile strength, modulus elasticity and elongation (Mohd, 1999). Besides, its many hydroxyl groups cause it to have high affinity to water, with strong hydrogen bonding between the intra- and intermolecular hydroxyl groups, greatly impeding its solubility in water (Nawawi, 1997).

Tan et al. (2001) studied the separation of aqueous isopropanol through chitosan/PVA blended membranes by pervaporation. Yusof (2005) and Magedonna (2006) studied the pervaporation separation of ternary DMC/methanol/water mixtures and DMC/water respectively. Svang-Ariyaskul et al. (2006) studied the pervaporation
dehydration of isopropanol using blended chitosan and PVA membranes. Through this research, blended chitosan/PVA membranes were used for the pervaporation separation of organic-organic solvent mixture which is methanol/methyl tert-butyl ether. Thus, it is best hope that the separation of methanol/MTBE will be improved after combination chitosan with PVA using pervaporation process.

1.3 Objective

Based on the background of this study, objectives of this study are categorized as following:

i. To determine an optimum preparation condition of chitosan composite based membranes for membrane pervaporation separation process.

ii. To analyze the performance of membrane in pervaporation separation of methanol/MTBE in terms of separation factor and flux using the membrane that has been developed.

1.4 Scopes of Work

In order to achieve the objectives mentioned in 1.3, below are the steps in order to accomplish this experiment. The scopes of work will be carried out:
Preparing unmodified chitosan/polysulfone composite based membrane where their characteristics will be studied.

Preparing chitosan blended with PVA and polysulfone composite based membrane where their characteristics will be studied.

Determining an optimum preparation condition chitosan composite based membrane for membrane pervaporation separation process. The composition chitosan and polyvinyl alcohol of modified composite membrane will be studied to reach the effective wt. % of chitosan-PVA membrane.

Pervaporation separation of methanol/MTBE mixtures, the membranes will be used for separation of methanol/MTBE. This experiment will use several different feed compositions of methanol/MTBE mixture. This is to compare and investigate the effective composition of mixture for pervaporation. The membranes performance will be studied based on the flux and separation factor.

Determining the separation condition for the membranes been developed in the range of separation temperature at 27 °C, 35 °C, 40 °C, 45 °C and 50 °C while permeate pressure is maintained at 0.07 bar.

Characterizing and determine the structure and morphology of modified and unmodified membranes using Nikon Microscopes and PHILIPS XL-40 Scanning Electron Microscopy (SEM).
REFERENCES


Binning, R. C. and James, F. E. (1958). New Separations by Membrane


of Poly(acrylic acid) and Poly(vinyl alcohol). *Journal of Membrane Science*. 90, 265-274.


Rhim, J., Lee, S. and Kim, Y. (2002). Pervaporation Separation of Water-


Science: Polymer Chemical. 22, 2159.

