STUDY ON POLYESTER COMPOSITE NANOFILTRATION (NF) MEMBRANE BY INTERFACIAL POLYMERIZATION FOR NATURAL ORGANIC MATTER (NOM) REMOVAL

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ABSTRACT

The polyester composite nanofiltration (NF) membrane has been prepared by interfacial polymerization for natural organic matter (NOM) removal. The effect of reaction time on the production of thin film composite NF and it affect on the NOM and Sodium Chloride (NaCl) removal performance was conducted. The thin film composite membranes were synthesized through interfacial polymerization with monomer concentration of 2% w/v of triethanolamine (TEOA) and then react with organic solution of trimesoylchloride (TMC) at different reaction time to produce a new layer polyester on top of polyethersulfone (PES) miroporous support. The fabricated thin film composite membranes were characterized in term of water flux and permeability. It was found that the Polyester NF membrane with different reaction time (15, 25 and 35 minute) which prepared through interfacial polymerization can reduce the humic acid concentration. Besides that, the variation of reaction time in interfacial polymerization technique improved the filtration performance of the membrane. The result shows that the flux and permeability were decreased as the reaction time increased while opposite trend for NOM and NaCl rejections were observed.

KAJIAN BAGI PENURASAN NANO POLIESTER KOMPOSIT MEMBRAN OLEH PEMPOLIMERAN ANTARA MUKA UNTUK PENYINGKIRAN ORGANIK SEMULA JADI

ABSTRAK

Penurasan Nano Poliester Komposit membrane disediakan melalui proses pempolimeran antara muka untuk penyingkiran organik semula jadi. Kesan masa tindak balas penghasilan Penurasan Nano komposit membrane dan kesan penyingkiran ke atas organik semula jadi dan natrium klorida (NaCl) telah dijalankan. Komposit filem nipis membrane disintesis melalui pempolimeran antara muka dengan kepekatan larutan 2% w/v trietanolamine (TEOA) dan seterusnya bertindak balas dengan larutan organik trimesoylchloride (TMC) pada masa tindak balas yang berbeza untuk menghasilkan lapisan poliester baru di atas permukaan mikro berliang polietersulfon (PES) membrane. Komposit filem nipis membrane yang telah dihasilkan dicirikan dari segi fluks air dan kebolehtelapan. Didapati Penurasan Nano Poliester membrane dengan tindak balas masa yang berbeza (15, 25 dan 35 minit) yang dihasilkan melalui proses pempolimeran antara muka boleh mengurangkan kepekatan humik asid. Selain itu, perubahan masa tindak balas dalam pempolimeran antara muka teknik boleh meningkatkan prestasi penurasan membran. Keputusan menunjukkan fluks dan kebolehtetapan menurun apabila masa tindak balas meningkat manakala bertentangan dengan hasil penyingkiran organik semula jadi dan garam (NaCl) telah diperhatikan.

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LIST OF SYMBOLS

A	Area of Membrane
Cp	Concentration of permeate
Cf	Concentration of feed
Cr	Concentration of retentate
g	Gram
hr	Hour
J	Permeate flux
L	Liter
M	Meter
mL	millilitre
P	Permeability
ΔP	Filtration pressure
R	Rejection
Δt	Filtration time
V	Volume

LIST OF ABBREVIATIONS

ABS	Absorbance
DOC	Dissolved Organic Matter
ED	Electro Dialysis
FTIR	Fourier Transforn Infrared Spectroscopy
IP	Interfacial Polymerization
MF	Microfiltration
NaCl	Sodium Chloride
NaOH	Sodium Hydroxide
NF	Nanofiltration
NOM	Natural Organic Matter
PES	Polyethersulfone
RO	Reverse Osmosis
TEOA	Triethanolamine
TMC	Trimesoylchloride
UF	Ultrafiltration

CHAPTER 1

INTRODUCTION

1.1 Research Background

Natural Organic Matter (NOM) is organic matter from plants and animals present in natural waters for examples in reservoirs, lakes and rivers. NOM is present in most surface waters that can affect the odor, colour and taste of waters. Therefore, the treatment needs to remove NOM to get the clear, clean and safe water which is can be used for others applications. NOM is the main component of organic carbon in aquatic systems. It is complex and difficult to separate mixture of similar macro- organic molecules. In addition, NOM can be categorized into hydrophobic and hydrophilic compounds, mono and multivalent ions, low molecular mass organics and inorganic colloids (Schäfer, 2001).

Membrane technology has been widely used in water and wastewater treatment and industrial separations process. Membrane processes have many advantages over conventional method such as it is simple in concept and operation, do not involve phase changes, low energy consumption, equipment size may be decreased and greater efficiency for raw materials use and potential for recycling of by- products.

Membrane filtration processes involving microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) in potable water production. These membranes use pressure as the driving force to separate out contaminants from water supplies. NF is a widely accepted process for the removal of particulate matter from surface waters. Nanofiltration (NF) membrane is a liquid separation membrane technology positioned between ultrafiltration and reverse osmosis (RO) (Schäfer et.al, 1998). NF membrane separations are widely used in various industrial fields such as water treatment, biochemical industries, pharmaceutical and others because NF has low pressure in operation, high permeate flux, low investment and high retention of multi-valent ion salts (Tang et.al, 2008). The NF membrane has the ability to remove NOM until certain standard quality.

Interfacial polymerization is widely used today for the production of ultra thin films for encapsulation, chemical separations, and desalination (Srebnik et.al, 2009). Most of NF membranes are thin film composite which can be prepared by interfacial polymerization. The NF membrane is prepared through interfacial polymerization of trimesoyl chloride (TMC) with the triethanolamine (TEOA) solution. The advantages of interfacial polymerization are the thin layer can be optimized for particular function by varying the monomer concentration in each solution, rapid reaction rates under ambient conditions and low requirement for reactant purity.

1.2 Problem Statement

The high demand for clean water has led to the increasing development of membrane technology. Water is the backbone of the global economy that very important for agriculture, industry, energy production and domestic consumption. Natural organic matter (NOM) present in water not only affects the odour, colour and taste of water, but it can forms complexes with heavy metals and also can reacts with chlorine. Therefore, the sustainable manner should be considered to produce clean water and also protect the environment.

1.3 Research Objectives

The objectives of this research are to identify Nanofiltration (NF) Polyester membrane for natural organic matter (NOM) removal and to study the effect of reaction time on the production of thin film composite NF and it effects on the NOM and Sodium Chloride (NaCl) removal performance.

1.4 Scope of Study

In order to achieve the research objective, the scopes have been identified as follows:

i. Production and characterization (flux and permeability) of thin film NF composite by interfacial polymerization method using 2%w/v of triethanolamine (TEOA) as monomer at different reaction time (15, 25 and 35 min).
ii. Performance of salt, Sodium Chloride, NaCl removal.
iii. Removal of NOM by the synthesized NF membrane.

1.5 Significance of Study

The purpose of this research is to identify the polyester nanofiltration membrane which suitable for removal natural organic matter. If the NOM completely can be removed by this filtration method, the wastewater discharged could be minimized and reducing impact on environment. In addition can produce clean water when NOM removal completed which can be use for other application in daily days. The NF process becomes more important in water treatment for domestic and industrial water supply.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water is the important sources for agriculture, industry, recreation, energy production, and domestic consumption. Therefore, it is important to improve the effectiveness and efficiency of water purification technology to produce clean water and protect the environment (Jeong *et.al*, 2007). This chapter will describe detail about the basic concept of membrane, types of membrane that usually used in industries, nanofiltration membrane, interfacial polymerization process and also information about natural organic matter (NOM) which present as humic acid.

2.2 Membrane Review

2.2.1 Definition of Membrane

The word of membrane is come from the Latin word *membrane* which means skin (Nath, 2008). According to Geankoplis (2003), membrane act as a semipermeable barrier and separation occurs by the membrane controlling the rate of movement of various molecules between two liquid phases, two gases phases or a liquid and a gas phase. Membrane is defined as a thin layer of material which acts as a semipermeable barrier that allows some particles to pass through it, while hindering the permeation of others components (Silva, 2007).

From the Soni *et.al*, (2009), membrane can be defined as a barrier which can separates two phases and limits the transport of various chemicals components to pass through that membrane. According to Nath (2008), membrane is defined as a structure having lateral dimensions much greater than its thickness that mass transfer occur under variety of driving forces. Also membrane can be homogeneous or heterogeneous, symmetric or asymmetric in structure, solid or liquid and carry a positive or negative charge.

2.2.2 Historical Development of Membranes

The first studied of membrane was traced on eighteenth century philosopher scientist. The first recorded study of membrane was on 1748 by Abbé Nollet. He discovered quite accidently that when a pig's bladder was brought in contact on one side with a water-ethanol mixture and the other side with pure water, the latter would pass preferentially. Nollet is the first recognize the relation between a semipermeable membrane, osmotic pressure and volume flux (Strathmann, 2000). According Baker (2004), the measurements of solution osmotic pressure made with membranes by Traube and Pfeffer were used by Van't Hoff in 1887 to develop the behaviour of ideal dilute solutions that work directly to the Van't Hoff equation. In 1907, Bechhold developed a technique to prepare nitrocellulose membranes for controlling the membrane pore size which he was determined by bubble test. Membranes first application in the testing of drinking water supply in Germany and elsewhere in Europe had broken down due to air raids at the end World War II. It is the first microfiltration membrane producer by Millipore Corporation (Nath, 2008). In1944, Kolff was developed the artificial kidney as one of the first practical application of dialysis (Lee, 2009). In 1960, the modern membranes science was developed but membranes were used only in few laboratory and small industrial. And in 1980, microfiltration, ultrafiltration, reverse osmosis and electro dialysis were established process in large plant worldwide (Baker, 2004).

2.3 Concept of Membrane Process

2.3.1 Membrane Separation Process

Separation process is a process to transforms a given mixture of chemicals into two or more composition end –use products. A membrane separation process is to separates an influent stream into two effluent streams known as permeate and retentate with the help of a membrane (Soni *et.al*, 2009). Figure 2.1 shows the basic membrane separation process:

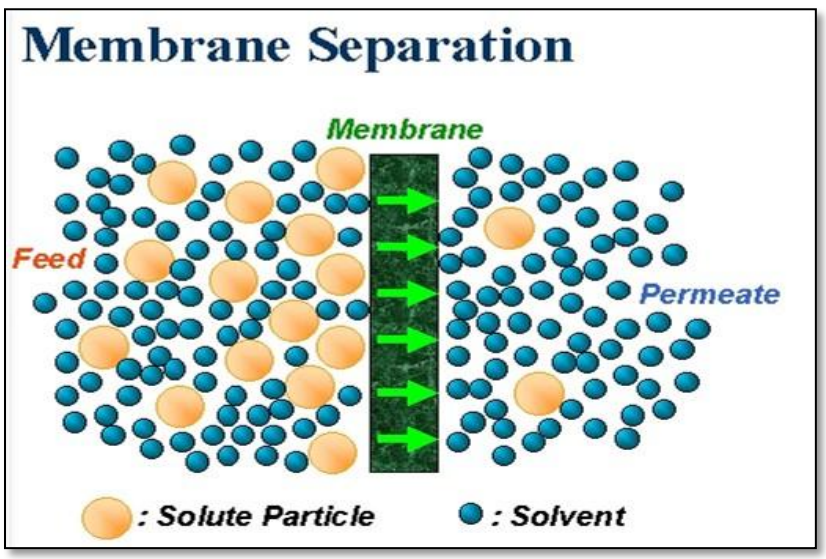

Figure 2.1 Basic Concept of Membrane Separation Process

According Nath (2008), porous membrane discriminate according to the size particles or molecules while non- porous membrane discriminate according to the chemical affinities between components and membrane materials. Membrane sharply can be change the rates of mass transfer because physical and chemical interactions between the membranes and separating components. The flux membrane depends on the membrane permeability and driving force of membrane as shown in Equation 2.1:

$$\text{Flux} = \frac{\text{Membrane Permeability}}{\text{Membrane thickness}} \times \text{Driving Force} \tag{2.1}$$

2.3.2 Classification of Membrane Separation Process

There are various types of membrane separation process. The processes in membrane can be classified according to the driving forces that involve in the process as shown in Table 2.1. Usually the most relevant processes is the pressure driven process such as reverse osmosis, ultrafiltration, microfiltration, pervaporation and gas separation (Nath, 2008). According Zularisam *et.al*. (2005) states that membrane filtration processes including microfiltration (MF), ultrafiltration (UF) and nanofiltration (NF) have increased rapidly day by day especially in the water production.

Table 2.1 Classification of Membrane Process according Driving Force (Sources: Nath, 2008)

Driving Force	Membrane Process
Pressure Driven	Reverse Osmosis (RO)
	Microfiltration (MF)
	Ultrafiltration (UF)
	Nanofiltration (NF)
	Pervaporation
	Membrane gas separation
Concentration Gradient Driven	Dialysis
	Membrane Extraction
Electrical Potential Driven	Electro dialysis (ED)
Temperature Different	Thermo Osmosis
	Membrane Distillation

2.3.3 Types of Membrane in Pressure Driven

There are various types of membrane based on the driving force which is applied to accomplish the separation process such as reverse osmosis, nanofiltration, ultrafiltration and microfiltration. However, all these membrane can be differentiated according to the size range of particles or solutes that are separated as shown in Figure 2.2. These processes are appropriate to different size of molecules where the microfiltration differentiates the largest size of molecules and reverse osmosis differentiating the smallest molecules that can pass through the membrane (Silva, 2007).

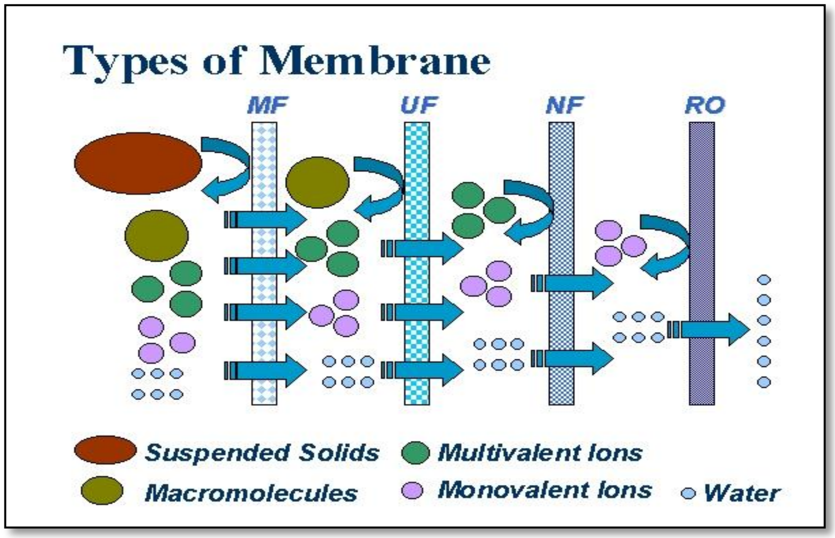

Figure 2.2 Types of Membrane Separation Process

2.3.3.1 Microfiltration

Microfiltration is a filtration process which use porous membranes to separate suspended particles with diameters between 0.1 and 10 µm and pressure below 2 bars. Thus, microfiltration membrane can categorize between ultrafiltration membranes and conventional filters (Baker, 2004). According to the Strathmann (2000), microfiltration membranes are used to separate macro molecule components or particles mostly in aqueous solution. Another concept of microfiltration is to remove particulate contaminants such as clay, algae and bacteria from drinking water (Haack *et.al*, 2002). Microfiltration is not suitable for removal of dissolved contaminants such as natural organic matter (NOM) (Taylor, 1996). Nath states that, a microfiltration membrane is generally porous that enough to pass molecules through the solution even if the large particles.