

## CHAPTER I

### INTRODUCTION

#### 1.1 Membrane Technology : A Historical Background

In chemical technology, membranes have gained an important place and it has been used in a broad range of applications. In membrane technology, the ability of the membrane to control the permeation rate of chemical species throughout the membrane is the important key property that has been exploited. Thus, the goal of membranes in separation applications is to allow a component of a mixture to permeate membrane freely, while hindering permeation of other components. A study about membrane phenomena has started in the eighteen century by a philosopher scientist.

In 1748, Abbé Nolet has discovered the word 'osmosis' to describe the permeation of water through diaphragm. Through the 19<sup>th</sup> century and early 20<sup>th</sup> century, membranes have been used only as laboratory tools to develop physical/chemical theories. Thus, membranes had no industrial or commercial uses yet during that time. Becchold in 1907 discovered the technique to prepare nitrocellulose membrane of graded pore size which was determined by bubble test. In the early

1930s, microporous collodian membranes were commercially available where the production of this type of membrane has been improved from Becchold's technique by Elford, Zsigmondy, Bachmann and Ferry. This early microfiltration membrane was expanded to other polymers (cellulose acetate) during the next 20 years. By 1960, the elements of modern membrane science have been developed. However, the membranes were only used for a few laboratory and small, specialized industrial applications (Baker, 2004).

As for the separation process, membrane suffered from four problems which are: too slow, too unselective, too unreliable and too expensive. However, the solutions towards these problems have been developed during the last 30 years, and membrane-based separation process are now commonplace. In the period of 1960-1980, significant changes have been produced in the status of membrane technology. Interfacial polymerization and multilayer composite casting and coating are other membrane formation processes building from Loeb-Sourirajan technique which have been developed in order to make high-performance membranes. Microfiltration, ultrafiltration, reverse osmosis and electrodialysis were all established in 1980 with large plant installed worldwide for large applications (Baker, 2004).

## 1.2 Textile Industry

Nowadays, textile industry has become a great demand on producing clothes every year. In Malaysia, home-made textile industry was very popular in East Coast of peninsular Malaysia and Sarawak. This industry has become the custom for generations. In producing abundant of clothes every year, this industry needs a huge

amount of water in coloring the clothes. However, there were producers that release the textile effluents into the main stream where lead to the environmental pollution and serious health hazard. Normally, textile wastewater will have high chemical oxygen demand (COD) with the presence of non-biodegradable compounds such as dyes, pigments or other chemicals (ElDefrawy and Shaalan, 2007).

Due to more stringent laws and economic advantages, there were producers willing to invest more money and more time in water reuse in order to ensure the greener environment. In specific of textile industry, the large amount of water are needed for processes such as dyeing, rinsing and other treatment for water reuse (Bruggen et al., 2001). Thus, technologies become the important role in treating textile effluent to water reuse which will make the environment clean and economical use of water.

### 1.3 Recent Technology for Textile Wastewater

In producing abundant of clothes every year, each textile industry should use a large amount of water and huge amount of water also will be discharged from the plant to the main stream as wastewater. This wastewater or textile effluents usually contains synthetic dyes and chemical additives. Moreover, textile effluents also will have high chemical oxygen demand (COD), high biological oxygen demand (BOD) and highly be visible and undesirable (Zheng et al., 2013).

Synthetic dyes normally toxic, non-bio-degradable and can contribute to significantly changes on environmental pollution and serious health hazards. To

ensure the better environment, there are many textiles industrial plant was directed to eliminate or reduce the contents of synthetic dyes in their wastewater (Liu et al., 2012).

Treating textile effluents has become the main concern since it can pollute the environment. Thus, there are many techniques tested by many researchers in treating textile effluents for greener environment. According to Yun et al. (2006), biological treatment has been reported as preferable method other than physico-chemical treatment due to removal of dyes from large volume of water. Furthermore, there is also conventional method that has been study by Chakrabarty et al. (2003) shows that chemical coagulation, flotation, chemical oxidation and adsorption is the most common techniques used in dyes removal from textile effluents.

However, there are better techniques from biological treatment and conventional treatment which is membrane separation process where it has been said to be a practical and competitive alternative for the removal of dyes in large textile effluents. Membrane separation process gives several advantages such as easy of construction and control, feasible recovery and can give optimal solution to remove color (Yu et al., 2010; Gozálvéz et al., 2008). In order to ensure the effectiveness of the dyes removal, the type of membrane pressure-driven also becomes the important part. There are researcher use ultrafiltration (UF) membranes in treating textile effluents. Akbari et al. (2002) in their study use UF membrane and discover that UF membrane can be applied for recycling high molecular weight and insoluble dyes. However, there are limitation of UF in their study that it does not remove low molecular weight and soluble dyes.

Nanofiltration (NF) and reverse osmosis (RO) are usually used by researcher to achieve high water recovery for the reuse purpose. This process involved multi-step processes which has limitation of the membrane technology application. In the end of the process, the membrane processes achieve good permeation qualities with minimum flux decline as simple as possible and have energy efficient integrated process (Capar et al., (2006); Bottino et al., (2001); Ciardelli et al., (2001)).

#### 1.4 Nanofiltration Membrane for Textile Wastewater

Between RO membrane and NF membrane, NF membranes have been chose as effective type of pressure-driven membrane in treating any wastewater including textile wastewater. With properties in between reverse osmosis (RO) and ultrafiltration (UF) membrane, nanofiltration (NF) membrane is a type of pressure-driven membrane. Nanofiltration membranes has been used widely because it offers several advantages such as low operation pressure, high flux, high retention of multivalent anion salts and an organic molecular weight above 300kDa, relatively low investment and maintenance costs (Hilal et al., 2004).

In 1990, nanofiltration has been used in dyeing bath process and has shown to be essential for reusing of dyeing wastewater. In nanofiltration process, the mechanism is the based on size exclusion and differences in diffusion rate for uncharged organic molecules (Bruggen et al., 2008). Other than that, NF also has amazing features that make it use worldwide in wastewater industrial treatment such as have molecular weight-cut off (MWCO) ranging from 200-1000 Da and high permeability of monovalent ion and low permeability of divalent ions. Thus, NF has

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been chose to work in applications for example water softening, municipal and industrial wastewater treatment and separation and concentration in chemical and pharmaceutical industries (Wei et al., 2013).

### 1.5 Problem Statement

East coast of Malaysia has become a famous tourist attraction spot and has been the biggest textile industry manufacturer. Producing large quantities of clothes every year, these textile industries produced huge amount of wastewater containing synthetic dyestuffs. These synthetic dyes are usually toxic, non-bio-degradable and caused serious pollution to environment. In wastewater treatment, the most promising technology used is membrane separation process, where this technology offers an economical and environmentally approaches.

Nanofiltration (NF) membranes has been used widely especially in treating wastewater. Having properties between ultrafiltration (UF) and reverse osmosis (RO) membranes, NF membrane offers several advantages such as low operating pressure, low maintenance cost, high permeation flux and high rejection. furthermore, many researchers has conducts the application of NF in the treatment of textile wastewater and the result shows, NF could reject almost 98% of colors and has high flux. However, in NF separation process, membrane fouling caused by retention of inorganics or organics components, colloids, bacteria and suspended solids reduced the membrane performance. Thus, to overcome this problem, the addition of new material such as surfactant is one of the effective techniques to improve membrane performance as well as membrane fouling.

## 1.6 Objectives

The main objectives of this project are:

1. To fabricate asymmetric nanofiltration-surfactant membranes via phase inversion process.
2. To examine the major effects of hydrophilic surfactant on performance and structural properties of NFS membranes.
3. To evaluate the performance of NFS membrane for dyes removal.

## 1.7 Research Scope

This novel project involves the following:

1. Fabrication of asymmetric polymer-surfactant membrane via phase inversion process.
2. Analysis of the major effects of hydrophilic surfactant on performance and structural properties of NFS membranes.
3. Evaluation of performances of NFS membrane for dyes removal.
4. Analysis of dyes removal via NFS membranes.