CHAPTER 5

ULTRAFILTRATION MEMBRANE FOR POME WASTEWATER TREATMENT

Teshini Hari Ram and Norhaniza Yusof

5.1 INTRODUCTION

Membrane and membrane separation processes have undergone many developments throughout the years. It has gone from being used in mere laboratories to now being used in industrial processes in wastewater such as palm oil mill effluent (POME). Compared to traditional separation techniques, membrane separation requires less time, and less money, and is more efficient. Abey's Nolet first introduced water permeation using diaphragm in 1755 and this process was referred to as osmosis. Later on, in 1855, Dr. Adolf Eugen Fick proposed the diffusion law, and he created the first high-pressure synthetic membrane made of nitrocellulose, a mixture of nitric esters of cellulose. The first experiment using the ultrafiltration concept was successfully conducted by Schmidt in 1861 (Li et al., 2018) but the term "ultrafiltration" was only officially proposed in 1906 by Dr. Bechhold who produced the first low-pressure membrane.

In 1926, Filter GmbH commercialized the use of ultrafiltration (UF) membranes. However, the first real UF membrane was only discovered in the early 1960s. The development of artificial membrane technology was able to further grow the use of UF membranes. Loeb and Sururajan

(1963) introduced the phase inversion process as a new method for membrane fabrication. This significantly improved the membrane in terms of mechanical strength, membrane morphology, and performance.

In 1962 Loeb and Surirajan developed a new method of polymeric membrane fabrication, called dry/wet phase inversion process through the development of anisotropic cellulose acetate membrane (Baker, 2004). After the breakthrough of phase inversion, the history of the synthetic membrane was entirely changed which was active properties regarding mechanical strength, membrane morphologies, and ten times higher performance than the earlier membrane.

In 1966, Amicon by Koch developed PVDF and polysulfone UF membranes at a laboratory scale. They then continued to make the first hollow fibre UF membrane in 1967. In 1969, Abcor by Koch successfully installed a tubular membrane module ultrafiltration membrane system which was used to separate electrocoat paint. In 1973, Romicon by Koch introduced hollow fibre capillary UF plants and in 1980 Abcor commercialised spiral wound UF modules. They also then developed the first commercially available ceramic membrane in 1988. The early designs which used tubular membranes were relatively high in cost, which is why newer, more cost effective designs were eventually developed.

The UF membranes' use developed over the years. Due to the growing strictness of the environmental regulations, the use of UF membranes developed into treating POME wastewater. UF membranes are effective in the removal of suspended solids, oil and organic matter (Wu et al., 2007). They are also efficient in the removal of fine suspended particles, emulsified oil, and dissolved organic compounds. Another advantage of UF is that since it helps in water recovery, the amount of freshwater needed for the palm oil mill operations is lesser. By using UF membranes also, the environmental footprint can be reduced, and the environmental regulations will be complied (Abdulsalam et al., 2018).

Over time UF membranes have been modified and advanced for the use of POME treatment. These advances include improving the membrane materials, improving the design, and operational efficiency.

Generally, UF membranes are used with other bigger POME treatment processes like anaerobic and aerobic treatment (Zhang et al., 2008). The history of UF membranes is closely linked to the development of UF membranes in industrial and wastewater treatment applications in general. The use of UF membranes in POME began due to growing environmental concerns and the need for a treatment method that is sustainable and has a high performance.

5.2 PRINCIPLE AND CONCEPT

In the ultrafiltration (UF) process, the solutions are separated, purified and concentrated (Li et al., 2018). UF separation process is basically using the UF membrane to remove large molecules and bacteria from contaminated water source to purify the water. UF membranes are also a great option for the treatment of effluents from industrial sources because it can be modified to target specific compound removal. UF membranes usually come in anisotropic structures (opposite of isotropic and have direction-dependent properties) which are made through the Loeb-Sourirajan process.

The principal driving force of the UF membrane is by using the difference in pressure between the two sides of the membrane. Through static pressure, UF is used as a filter medium. The solvents in the effluent and the solutes with small enough molecular weight and pore diameter are able to pass through the UF membrane from the high-pressure side to the low-pressure side. The solutes that have larger molecular weight and pore diameter are trapped at the high-pressure side. Hence, when the effluent flows through the UF membrane surface, only the purified residue will be able to go through the membrane and the contaminants will be successfully separated.

The main retention mechanism of the UF membrane is physical screening (Li et al., 2018). In some UF membranes, however, the pore size of the membrane might be bigger than both the solutes and the solvents. In this case, it still has an obvious separation effect, but it will not trap the solutes. This could be due to the chemical properties of the