CHAPTER 6
MEMBRANE DISTILLATION FOR PALM OIL MILL EFFLUENT TREATMENT

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6.1 INTRODUCTION

Membrane distillation (MD) was first introduced in the 1960s. The first patent for it was granted by Bodel in 1963 (Reza Shirzad Kebria & Rahimpour, 2020). For the past decades, membrane technologies have been continuously evolving due to the constant increase in demand for high-quality drinking water worldwide. While more than two-thirds of the planet is covered in water, 99.3% of the water is either too salty (seawater) or is not accessible (ice caps). Since water becomes potable if it contains less than 500 ppm of salts, much research has gone into finding efficient technologies for removing salt from seawater and brackish water called desalination processes. MD exhibits various advantages over the industrially well-established reverse osmosis (RO) process in the field of water desalination. RO process that is widely known for desalination of seawater or brackish waters is an isothermal process. On contrary, MD is a non-isothermal technology that requires a thermal driving force to establish the necessary transmembrane chemical potentials or partial vapor pressures. MD is a process mainly suited for applications in which water is the major component present in the feed solutions to be treated such as desalination and wastewater treatment.

6.2 FUNDAMENTAL OF MEMBRANE DISTILLATION

Fundamental principles of MD separation process such as types of membrane material, membrane characteristics and MD configurations will be briefly discussed.

6.2.1 Mechanism of Membrane Distillation Process

The majority of membrane transport processes occur in isothermal conditions, where transmembrane hydrostatic pressure, concentration, electrical or chemical potentials are the driving forces (Khayet, 2011). On the contrary, MD is known as a non-isothermal separation process. In MD process, difference in temperature between hot feed and cold permeate solutions induces vapor pressure difference over membrane surface (Eykens et al., 2017). MD is a term that is similar to conventional distillation, as it involves the vapor/liquid equilibrium (VLE) principle for liquid-liquid separation. To achieve latent heat of vaporization, both processes need heat to be supplied to the solution (Khayet & Matsuura, 2011).

Membrane distillation can be used as a method for non-volatiles solutes separation from a mixture of volatiles and non-volatiles solutes as only volatiles components can successfully pass through the membrane while membrane retained liquid feed together with dissolved components. Water is typically the main volatile component recovered on the permeate side because it has a low boiling point. Recently, aside from desalination process, MD has been widely explored in application of wastewater treatment involving produced water, textile wastewater, valuable components recovery from seawater or brine and rubber wastewater oil-water emulsion treatment (Guo et al., 2018). Besides, MD can be used to remove organic compounds which are volatile from water as they are transferred more easily through pores of membrane compared to less volatile water molecules (Eykens et al., 2017).

Membrane distillation is the main component of MD system where it is a medium for water vapor transfer and acts as a barrier for direct liquid water transfer. Conventional MD membranes are typically made using hydrophobic polymeric materials such as polypropylene (PP), polyvinylidene fluoride (PVDF), and polytetrafluoroethylene (PTFE). Hydrophobicity is a crucial factor in preventing direct permeation of liquid through membrane pores (Wang & Lin, 2017). Although hydrophobic commercial microfiltration (MF) membranes are not specifically designed for MD, their use in the MD process is widespread. To improve MD performance further, optimization is required. Generally, during the MD process, water vapor is formed at the hot interface of the feed solution-membrane. Membrane pores allow water vapor to pass through and condensate on the cold side of the solution interface. Figure 6.1 illustrates the process of MD separation.

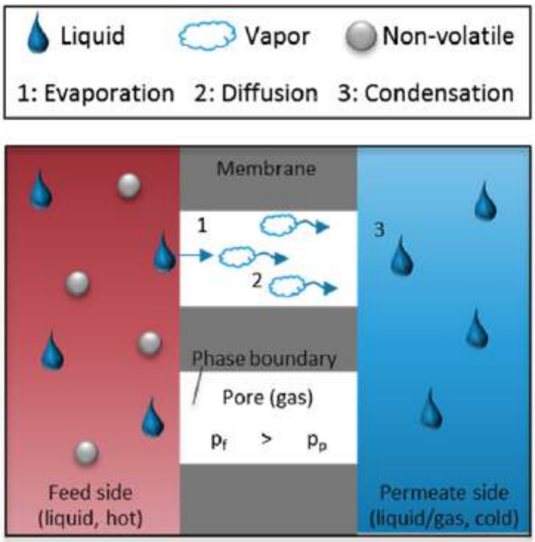

Figure 6.1 Mass transport principle of membrane distillation

Membrane distillation has a significant advantage over conventional separation technologies due to its lower operating temperature and hydrostatic pressure, which make it a significant advantage over conventional separation processes. Normally, the temperature of the feed solution is much lower than its boiling point under constant pressure, no phase changes or chemical additives, modular system that