# Membrane Distillation For Efficient Utilization Of Unconventional Energy Sources to Face Water Deficiencies

In the last few years, global demand for drinkable water has substantially increased, due to population growth. The worldwide demand of fresh water for agricultural, industrial and domestic applications is expected to reach about 6900 billion m3/ day by the year 2030, which would surpass the present available fresh water sources by about forty percent. As of now, roughly 2.53% of worldwide water reserve is fresh water. Around 68.7% of this reserve is trapped as ice in the north and south poles. Salt-water presents the other 97.47% of the water reserve but cannot be consumed due to its high salinity. Natural fresh water resources scarcity increases the necessity of searching for alternative means of water supply, like salt-water desalination. With the growing energy and water crises, it is vital to search for pioneering techniques for efficient utilization of unconventional energy sources to face water deficiencies. One of the possible techniques for this is membrane distillation (MD).

MD is a thermal membrane separation technique, which employs partial vapor pressure difference generated due to temperature difference across a semipermeable hydrophobic membrane to drive vapor through the membrane pores. It can be used for desalination, waste water treatment, food industries and many other applications. The membrane used is usually hydrophobic, which means that it prevents the penetration of liquid but allows vapor to pass through its pores and thus trapping the salt on the other side. There are four principal configurations for MD systems. The simplest and most frequently used configuration is direct contact membrane distillation (DCMD), in which vapor penetrates the membrane pores from the hot feed side to the cold permeate side where it condenses. Other MD configurations include; air gap membrane distillation (AGMD), sweeping gas membrane distillation (SWMD) and vacuum membrane distillation (VMD). MD technique has numerous benefits over other conventional distillation techniques, such as; the ability to produce high quality distillate at relatively low working pressures, using low temperature differences as a driving force which allows for utilization of low grade energy resources such as waste heat or solar energy and low susceptibility to fouling and scaling compared to other separation techniques.

MD suitable membranes should exhibit certain qualities such as, hydrophobicity, high vapor ?ux, low thermal conductivity and high chemical stability. So far, most frequently used MD membranes are micro and nanofiltration membranes such as; polypropylene (PP), polyvinylidene ?uoride (PVDF) and Polytetrafluoroethylene (PTFE); as they exhibit hydrophobic qualities. However, the search for novel membranes specifically designed for MD applications is an interesting point of research. Previous efforts for acquiring novel MD membranes included; using new materials such as ceramic, polysulfone, polyethylene and metal – organic framework (MOF) membranes and treating them to change their qualities to be better suited for MD applications. Other researchers focused on enhancing membrane characteristics using surface coating, plasma surface modifications, and additives like carbon nanotubes, Titanium dioxide and graphene. Research efforts for new membranes also included using composite and dual layer membranes, Others investigated the effect of the membrane fabrication technique, and post-treatment on the membrane characteristics.

There are several techniques for MD membrane fabrication such as, phase inversion, sol-gel and melting. However, recently, there has been an increasingly growing interest in the electrospinning technique. Electrospinning utilizes high voltage applied to a polymeric solution in a syringe to generate nanofibers that can by collected over a plate or a drum to constitute a nanofibrous membrane. Produced membranes have some favorable advantages including, high surface area to volume ratio, enhanced hydrophobicity and porosity. The membrane thickness and pore size can be adjusted by varying the operating conditions such as, applied voltage, solution flow rate, syringe movement, process time and distance between the syringe and the collector, which makes it easier to fabricate a membrane with specific characteristics.

Polyether sulfone (PES) is considered one of the promising materials for MD applications. It is a thermoplastic polymer with favorable qualities such as; high glass transition temperature, chemical stability, mechanical strength and relatively low price. PES membranes are widely utilized for micro and ultra-filtration. However, due to the existence of ether bonds in their chains, PES membranes have limited hydrophobicity and exhibit a partial hydrophilic behavior. This limits their utilization in MD applications. In order to benefit from the qualities of PES membranes, their hydrophobicity must be enhanced. Some of the previous efforts for accomplishing this objective included, fluoroalkylsilane treatment using Sol-gel method, Surface modification via CF plasma treatment, incorporating titanium oxide nanotubes in the membrane blend, using grafting agents for surface treatment and coating using silica nanoparticles and subsequently vacuum filtration coating.

Though multiple efforts have been performed to enhance to fabricate a suitable membrane for MD applications, there is yet an available research area.