**NUS Graduate School for Integrative Sciences and Engineering**
**Research Project Write-up**

**Title of Project :** Membrane distillation

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## Short Description

The freshwater scarcity is a growing problem all over the world. Both rapid population growth and the impairment of existing freshwater sources cause many dry regions to turn to the ocean as a source of freshwater. However, current desalination technologies are prohibitively expensive and energy intensive. Reverse osmosis (RO), a commonly used desalination technology, is significantly more expensive than the standard treatment of freshwater for potable use. Less expensive methods of desalination are needed to make desalination technologies more competitive with freshwater treatment.

Membrane distillation (MD) for water desalination is a membrane technique for separating water vapor from a liquid saline aqueous solution by transporting through the pores of hydrophobic membranes, where the driving force is the vapor pressure difference created by temperature difference across the membrane. MD systems can be classified into four configurations according to the nature of the cold side of the membrane: (1) direct contact membrane distillation (DCMD), in which the membrane is in direct contact only with liquid phases, saline water on one side and fresh water on the other; (2) vacuum membrane distillation (VMD), in which the vapor phase is vacuumed from the liquid through the membrane, and condensed, if needed, in a separate device; (3) air gap membrane distillation (AGMD), in which an air gap is interposed between the membrane and the condensation surface; and (4) sweeping gas membrane distillation (SGMD), in which a stripping gas is used as a carrier for the produced vapor, instead of vacuum as in VMD. Because AGMD and DCMD do not need an external condenser, they are best suited for applications where water is the permeating flux. SGMD and VMD are typically used to remove volatile organic or dissolved gas from an aqueous solution.

The fundamental operating parameters of the MD process are the hot feed solution temperature; the mass flow rate of feed solution; the air/vapor gap thickness; and the coolant mass flow rate; or the circulating sweeping velocity in the SGMD.

The MD process was introduced in the late 1960s and has many significant advantages: (1) high system compactness; (2) low sensitivity to feed concentration; (3) possibility to operate at low temperatures (~30–90$^{o}$C) which makes it amenable for use with low temperature heat sources, including waste or solar heat; (4) when compared with RO or electrodialysis, the simplicity of the membrane which allows it to be fabricated from a wide choice of chemically and thermally resistant materials;

(5) high product quality comparable with other distillation processes and superior to that from RO; and (6) much larger pores than of RO membranes (and typically larger than in ultra-filtration membranes) that aren’t nearly as sensitive to fouling. Regrettably, so far it has not been used massively in commercial applications, in part because of some negative views about the economics of the process. Another uncertainty is a lack of long-term operation data with natural saline waters to ascertain the stability of the hydrophobicity of the membranes.

Therefore, the purpose of this work is to (1) characterize potential materials for the membrane distillation process; (2) understand the effect of process parameters on the separation performance of membrane distillation; (3) investigate the optimization design of membrane distillation process to decrease its cost; and (4) study the effect of some conditions, such as membrane aging, fouling, and feedwater contamination by surfactants, on the membrane stability during a long-term experimental running.