MEMBRANES AND LAMINATES FOR WATER PURIFICATION

It is estimated that less than 1% of Earth's water is available as fresh drinking water. An expanding population and climate change are making this precious commodity even more scarce. On the other hand, two thirds of the Earth is covered with sea water but because it is not fit for human consumption, scientists have looked for economical ways to desalinate the oceans to produce drinking water. This has led to the development of pressure driven processes such as reverse osmosis, nanofiltration and ultrafiltration and these are now considered well established and reliable separation processes.

Membrane distillation is an alternative and emerging process which provides purified water on a large scale. It is useful for applications involving bulk water removal, such as seawater and brackish water desalination, process water treatment and water purification. Compared to reverse osmosis, membrane distillation processes are thermally driven rather than pressure driven and thereby use lower amounts of electricity and are more economic.

Membrane distillation is a novel separation and purification process that uses a hydrophobic non-wetting microporous membrane for the separation. One side of the membrane is in contact with a liquid feed which is warmed and thus a liquid/vapor interface forms at the membrane's pores.

The vapor passes through the membrane until it reaches the other, relatively cooler side, whereupon the vapor condenses. The hydrophobicity of the membrane restricts the entry of water completely and ensures the passage of water vapor only. The liquid water that condenses on the cooler side is highly pure.

As the vapor condenses, it releases heat which can be re-claimed and used to warm the liquid feed. The vapor pressure on the cooler side is lower than the warm side of the membrane, so a water flux occurs through the membrane, from the warm to the cooler side. Thus, the unique feature of membrane distillation is the driving force is temperature rather than pressure, as is the case with the other membrane separation techniques.

ADVANTAGES:

The main advantages of using membrane distillation compared to other membrane pressure driven separation processes are:

- **High rejection rates for non-volatile components (salts, colloids)**
- **The ability to work with high solute concentrations in the feed**
- **Less demanding of the membrane's mechanical strength**
- **Lower operating pressures**
- **Less fouling due to the relatively large pore size employed**
- **The feed water does not require any pre-treatment even for highly concentrated solutions**
- **Low operating temperatures, typically 30 - 90°C (meaning low-grade heat such as solar energy, waste heat and geothermal can be used)**

Parker manufactures a range of **aspire expanded PTFE membranes**, the properties of which lend themselves to being successfully used for membrane distillation.

Product	Nominal Pore size (µm)	Hydrophobic ePTFE	Support Polymer	Thickness (µm)	Wet Mullen's (psig)	Porosity (%) (Estimated)
QL217	0.2	Yes	Polypropylene	152 - 254	≥ 35	70 - 85%
QL218	0.2	Yes	Polypropylene	177 - 356	≥ 35	70 - 85%
QL822	0.45	Yes	Polypropylene	127 - 229	≥ 37	70 - 85%
QP952	0.2	Yes	Polyester	127 - 229	≥ 35	70 - 85%
QP955	0.2	Yes	Polyester	127 - 229	≥ 55	70 - 85%
QM902	0.45	Yes	None	-	≥ 80	70 - 85%
QM022	0.2	Yes	None	-	> 80	70 - 85%

All the hydrophobic ePTFE membranes provide high flux rates. Wet Mullen's pressure is a measure of water intrusion pressure and in all cases, this is higher than the typical operating pressure of <14psig. Different pore sizes, thicknesses and support polymer can be selected to modify the membrane permeability. The polymeric support layer also improves the membrane's processability and improves robustness during operation.

SEPARATION PARAMETERS

The main separation parameters are feed temperature, feed concentration (in the case of desalination) and vapor pressure. The process efficiency is affected by the membrane characteristics. The membrane should have high permeability, low thickness, high liquid entry pressure and low thermal conductivity to prevent heat loss across the membrane. It should also exhibit good physical and thermal stability and high chemical resistance, such as to acids and bases.

PERMEABILITY FACTORS

The membrane used in the system is generally characterized by four parameters, all of which affect the permeability:

- **THICKNESS**
- **MEAN PORE SIZE**
- **POROSITY (defined as the volume of the pores divided by the total membrane volume)**
- **TORTUOSITY (defined as the ratio of pore length to membrane thickness) Membranes with average pore diameters in the range of 0.1 µm to 1 µm are used. To allow the mass transfer of vapor, the pores must be large, yet small enough to inhibit the intrusion of water during operation.**

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