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ISSN: 2155-9589
Journal of Membrane Science & Technology

Opinion Article

# Advancements in Polyvinylidene Fluoride (PVDF) Membranes for Membrane Distillation (MD)

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## DESCRIPTION

Water is purified using Membrane Distillation (MD), which moves the vapour through a hydrophobic membrane. High water flux, high fouling, scaling, and wetting resistances are all characteristics of an ideal MD membrane. A new technology called membrane distillation has the potential to be crucial in helping to address the problem of water scarcity. To move water vapour over a hydrophobic membrane, MD makes use of the difference in vapour pressure between the hot feed and the cool permeate. The membrane is hydrophobic, which means that it repels liquid water as well as other nonvolatile solutes like salts while being selective to water vapour. The water vapour that is permeating the chilly side condenses.

High flux, strong salt rejection, good wetting resistance, minimal scaling and fouling, and low thermal conductivity should all be possible with a perfect MD membrane. High bulk porosity, abundant surface pores, a low tortuosity factor, and thin membranes are all necessary to achieve high flux. The membrane should also have large enough pores (but not too many) to maintain high Liquid Entry Pressure (LEP), the minimum pressure needed for water to pass through the membrane. Having a membrane with high hydrophobicity and a low Bubble Point (BP) can increase wetting resistance. To achieve high wetting resistance and high flux, the Pore Size Distribution (PSD) must be small, and the median pore must be close to the BP. Using low surface energy materials allows for the development of membrane surface hydrophobicity (i.e., fluorinated). A high-water LEP is facilitated by a low-surface-energy material. The Laplace equation assigns the water Contact Angle (CA) and BP as the markers for identifying membrane surface hydrophobicity.

A highly hydrophobic membrane, meanwhile, also aids in boosting scaling and fouling resistances. Membrane fouling is the deposition of a mineral or particle, collectively known as a foulant, on the membrane's surface, which blocks and plugs the pore mouth. When used for desalination, plugging then decays and lessens the water vapour flux, lowers permeate quality by suppressing salt rejection, or even encourages membrane wetting. Even though heat loss through conduction is frequently considered to be the least importance, it can be minimized by selecting materials with low thermal conductivity or by creating thick and porous membranes. Using a thin and conductive membrane may result in significant conductive heat losses as in membrane distillation, heat flows through both pores and the membrane matrix from the feed side to the permeate side. Due to the reduction in driving power, severe heat transfer from the hot to the cold side might cause flux to decrease.

The development of a PVDF-based membrane for MD is the subject of extensive research. The PVDF polymer exhibits great structural matrices, high heat stability, and good chemical resistance. Moreover, it has exceptional morphologies that make it easier for highly porous, permeable films to develop. PVDF polymers are currently a popular choice of material for MD membrane applications as well as other porous-based membrane applications. The creation of very hydrophobic materials is the subject of recent research on the PVDF membrane for MD. PVDF has a low surface energy, yet phase-inverted materials from strong nonsolvents, like water, typically have low hydrophobicity. The lack of the lotus effect is what causes the low contact angle. Combining micro- and nano-scales on the membrane surface increases hydrophobicity. The membrane surface is flattened, and the surface contact angle is decreased by the phase inversion application of either a strong solvent or a strong nonsolvent.

In Vapor-Induced Phase Separation (VIPS), it has been demonstrated that controlling the water vapour supply from humid air reduces the flattening effect's severity. With this method, it is possible to avoid having the film surface come into direct contact with water. As a result of the occurrence of spinodal disintegration during phase separation, utilizing very low PVDF concentrations with the VIPS approach may result in a superhydrophobic surface with a discontinuous hierarchical structure. Despite the discontinuous structure, crystallization also adds to the surface's morphology and nanoscale roughness. If the crystals are on the membrane surface, as described earlier, this

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**Received:** 29-Dec-2023, Manuscript No. JMST-23-20086;**Editor assigned:** 02-Jan-2023, Pre QC No. JMST-23-20086 (PQ); **Reviewed:** 16-Jan-2023, QC No. JMST-23-20086; **Revised:** 23-Jan-2023, Manuscript No. JMST-23-20086 (R); **Published:** 30-Jan-2023, DOI: 10.35248/2155-9589.23.13.325

**Citation:** Ahring B (2023) Advancements in Polyvinylidene Fluoride (PVDF) Membranes for Membrane Distillation (MD). J Membr Sci Technol. 13:325.

will gradually raise the membrane's surface CA and hydrophobicity. The PVDF polymer crystallizes by phase inversion during membrane production as it is a semicrystalline polymer. Comparatively speaking, the liquid-liquid demixing happens more slowly. By altering the phase inversion parameters, particularly by choosing a nonsolvent type and modifying its temperature, the degree of PVDF crystallization can be changed. PVDF crystals can have their kind and shape altered by altering temperature or by choosing a weak nonsolvent that prevents liquid-liquid demixing and permits more crystallization. To increase overall porosity and the hydraulic performance of the membrane, a low crystallinity membrane is preferred. More research has to be carried out to examine how PVDF crystallinity affects the performance of membrane distillation.