Developing of Polyvinylidene Fluoride Membranes using Superhydrophobic Carbon Nanomaterials for Water Desalination Process Via Vacuum Membrane Distillation By

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The scarcity of fresh water for human, industrial, and agricultural use is a major problem for the environment. Despite water covering the vast majority of the Earth's surface, most of it is salt water, represented by sea and ocean water, groundwater, and well water. Salt water makes up a significant portion of the Earth's surface, so water desalination to remove its salts and minerals is a promising method for producing fresh water from saline water.

In this study, a novel mixed matrix membrane(MMMs) flat sheet of polyvinylidene fluoride (PVDF) at high and low molecular weight with carbon nanomaterials powder activated carbon(CNM/PAC) and perfluorodecyly triethoxysilane (PFTES) was prepared prepared by Non-Solvent Induced Phase Separation(NIPS).It is worth mentioning that this is the first time that polyvinylidene fluoride (PVDF) at high and low molecular weight (1,000 kDa) and (600 kDa) with carbon nanomaterials powder activated carbon (CNM/PAC) and perfluorodecyly triethoxysilane (PFTES) have been associated for preparing the mixed matrix membranes for the water desalination by vacuum membrane distillation (VMD) at various operating condition.

CNM/PAC was incorporated at different concentrations (0- 0.5 wt. %) into a polymeric matrix of 14% PVDF, then chemically modified with different concentrations of (1-2)%PFTES. Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XED), Field emission scanning electron microscopy (FESEM), water contact angle (CA), atomic force microscopy(AFM), mechanical properties, thickness, pore size, and porosity were used to characterize the prepared

(CNM/PAC/PVDF) membranes. Also, this work presents the proposed interaction mechanism of the CNM/PAC/PVDF@PFTES.

The current work was divided into two sections. First, CNM/PAC is embedded into the two types of polymeric matrix (high and low) molecular weight, chemically modifying the optimum membrane with various concentrations of PFTES (1-2 vol.%). The effect of operation condition on the permeate flux and the gain out put ratio and the removal efficiency of salt water was performed at (45, 55, and 65°C) feed temperature, (0.4, 0.5, and 0.6 L/min) feed flowrate, and (21, 28, and 35 kPa(abs) vacuum pressure, and (35, 70, 100 g/L) salt solution. The results showed that the modified MMMs at 0.4wt.% CNM/PAC and chemically modified with 2%PFTES (2%FP4) at low molecular weight of PVDF exhibited optimum performance (23.2 L/m2.h) for the salt-water solution separation test at 35 g/L, 65^{o}C feed temperature, 0.6 L/min feed flow rate, and 21 kPa(abs) vacuum pressure (in vacuum zone) and the GOR 1.41 whereas the salt rejection maintained a high rejection (more than 99%) at high water contact angle (117°).

A MINITAB®21 software was used to optimize the results by response surface methodology (RSM) and central composite design (CCD) and analysis of variance (ANOVA).The results demonstrated that the optimum permeate flux is 23.99 L/m2.h for PVDF at low molecular weight, and the salt rejection 99.99%.

The 2% PFTES, salt concentration 35 g/L, and 21 kPa(abs) were the best conditions for the CNM/PAC/PVDF membrane with the best response.

The freshwater production cost estimation was $101.36/m3 when employing a small lab-scale filtration rig under optimal conditions. This has highlighted the prospective economic feasibility of the adopted VMD process for desalination applications.