MINIA UNIVERSITY
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# *Polymer Composite Membranes and its Applications in Membrane Distillation*

**A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Chemical Engineering**

*Submitted by*

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# Abstract

Ethanol, a vital industrial chemical, serves various purposes including as an additive in gasoline and as a solvent in organic compound synthesis. Vacuum membrane distillation (VMD) emerges as an appealing technique for separating aqueous mixtures. Unlike pervaporation, VMD's separation factor relies on the vapor-liquid equilibrium of the feed solution rather than membrane type. This study investigates VMD's efficacy in extracting ethanol from water mixtures, with emphasis on temperature, feed flow rate, and initial ethanol concentration. Ethanol additions ranging from 2-10 wt.% were introduced to the ethanol-water solution during VMD operations conducted at temperatures between 20-60 °C, with feed flow rates varying from 0.06 to 0.18 L/min. Commercial polyvinylidene difluoride (PVDF) and functionalized multi-walled carbon nanotubes with PVDF (FMWCNTs/PVDF) membranes were utilized in the process. SEM analysis, FTIR, and contact angle measurements were employed to assess membrane characteristics and the quality of permeate. The study evaluated total permeate reflux of ethanol separation from the mixture using fabricated membranes in a VMD cell. Another membrane of PVDF/MWCNTs was used with MWCNTs wt% ranges from 0.1 to 0.4 %. Results indicated feed temperature as the primary influencer, significantly enhancing PVDF membrane permeation flow. Moreover, increasing initial ethanol concentration augmented permeate and ethanol fluxes while reducing separation factor. Despite a slight decrease in separation factor at high feed flow rates, overall permeate flux, ethanol flux, and separation factor increased. PVDF/FMWCNTs membranes exhibited similar trends, with enhanced performance compared to PVDF. These findings suggest increased ethanol production potential with modified membranes due to decreased hydrophobicity. The addition of more MWCNTs with a wt% less than 0.2% causes the membrane to be more hydrophobic slightly increasing the total permeate flux, ethanol flux and separation factor. Adding MWCNTs more than 0.2 wt% causes the total permeate flux to increase more but the ethanol flux and separation factor decreases. A predictive model was