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Synthesis of carbon nanotubes - polyphenylene sulfone composite membranes for waste water treatment from petroleum sources

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Abstract

Oil and gas operations produce high volumes of wastewater in the form of finely dispersed oil/ water (o/w) emulsions, which have detrimental effects on the environment. The current most feasible method used to mitigate the environmental impacts caused by the emulsion (produced water) from oil and gas operations is polymer membrane technology. However, polymer membranes are susceptible to fouling and concentration polarization, which leads to the necessity for frequent membrane replacement, thus loss of operating time and high operation cost. This motivates the need to investigate ways of modifying the polymer membrane in order to make it more resistant to fouling and concentration polarization. This study is concerned with circumventing the challenges experienced by polymer membrane during crude oil/ water mixture ultra-filtration by infusing the polymer membrane with nano particles. The aim of the research was to investigate the influence of addition of CNTs on the modified membranes in treatment of waste water from petroleum source.

The Wet Impregnation method was used for the preparation of the bimetallic catalyst (Fe-Co catalyst supported on Zeolite), Chemical vapor deposition (CVD) method was used to prepare the carbon nanotubes (CNTs) and Phase inversion (PI) method was used for the preparation of the polymer nanocomposite membrane. The bimetallic catalyst was characterized using scanning electron microscope (SEM) and X-ray diffraction (XRD). The CNTs were characterized using Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR) and Transmission electron microscopy (TEM). The prepared polymer nanocomposite membranes were characterized using SEM, FTIR, goniometer (for contact angles) and TAXT plus texture analyzer (for tensile strength test).

Functionalized carbon nanotubes were used as membrane fillers or modifiers to improve the filtration properties of the polymeric membrane, ultimately forming nanocomposite polymer membranes. This increased hydrophilicity, chemical, mechanical and physical properties of the polymer membrane, made them to perform better during filtration than pristine polymer membranes.

The performance of the nanocomposite membranes were evaluated and it was determined that the nanocomposite polymer membrane with a loading 0.4 wt.% functionalized carbon nanotubes performed better than pristine membrane and other CNTs loaded nanocomposite polymer membranes.

The pristine membrane (0 wt% CNTs) showed a higher contact angle (79°) which crosses ponds to the inability to soak up water. The 0.4 wt% nanocomposite polymer membrane showed the lowest contact angle of 72 ^{o}, this validated an improvement in the properties of the membrane, in particular hydrophilicity. The 0.4 wt% nanocomposite polymer membrane showed a superior mechanical strength, with a breaking force at 4 N relative to the other membranes of the same thickness.

0.4 wt% nanocomposite polymer membrane showed the highest permeate flux of 120 $L/m^2.h$ compared to the pristine membrane, which showed a permeate flux of 63 $L/m^2.h$. The permeate flux of 0.4 wt% nano-composite polymer membrane increased with the operating pressure.