EXECUTIVE SUMMARY

Wastewater is one of the major problems to human life because it contains contaminants (such as viruses, worms, bacteria, etc.) which pollute the environment and causes various diseases (like cholera, dehydration, skin disease, eye disease, etc.) that are dangerous to human being. Various industries generate high volumes of concentrated oil-water emulsion containing wastewater on a daily basis. Therefore, it is important to reduce the concentration of oil in the oil-containing wastewater to an acceptable discharge limit before its disposal in order to avoid environmental pollution. In view of this, this project was aimed at optimising the synthesis and operational performance of the nanotube-infused polysulfone (PS) membrane with a polyvinyl alcohol layer to separate oil-containing wastewater.

To achieve the afore-mentioned goal, first the carbon nanotubes (CNTs) were produced and infused into the membranes in order to increase their mechanical stabilities. The CNTs were produced using a vertical swirled fluid chemical vapour deposition (VSFCCVD) method at the temperature of 850^{o}C. Ferrocene was used as both a catalyst and a source of carbon, nitrogen gas was run through the equipment in order to make sure that there were no gas leaks and that the contaminants (other unidentified/unknown gases) are removed from the system, and argon gas was used as a carrier. The CNTs were also functionalised and purified using various acids in order to increase their hydrophilic capability and to further enhance the mechanical stability of the membranes. The CNTs were characterised using the transmission electron microscope (TEM), thermogravimetric analysis (TGA), X-ray diffraction spectroscopy (XRD), Raman spectroscopy and many other characterisation methods. The as-produced and the purified CNTs were blended in 20% polysulfone solution. Seven membranes were synthesised using the phase immersion inversion method. A polyvinyl alcohol layer was used to further improve the hydrophilicity and the mechanical stability of the membrane. The improved mechanical stability and hydrophilicity of the membrane, minimises fouling and concentration polarisation on the membrane. The membranes were characterised using the Fourier transform infrared spectroscopy (FTIR), contact angle, Braunner-Emmet-Teller (BET) and the scanning electron microscope (SEM). The separation performance of the membrane was tested using real industrial oil-containing wastewater.

It is known that ferrocene can be used as both a catalyst and source of carbon as it has produced multi-walled CNTs with the lengths that are between 450-850 nm long. The mixture of nitric acid and sulphuric acid in a ratio of 1:3 was able to remove about 59% of the ferrocene catalyst particles during functionalization of CNTs. Hydrofluoric acid, hydrochloric acid together with the oxidation process removed about 99% of the contaminated impurity catalyst particles during the purification of CNTs. The use of 20% PS solution improved the quality but reduced the porosity which in turn reduced the membrane's flux but maintained the separation performance of the membrane since all membranes have rejected the concentration of oil in the retentate of over 82%. BET gave the average pore sizes that ranged between 11 and 24 nm which are capable of rejecting oil droplets of the industrial oil-containing wastewater with diameter that ranges between 0.02-0.2 µm.

During the separation performance evaluation using the oil-containing wastewater, all the membranes tested gave excellent results with high throughput and oil rejections that ranged between 82 and 95%. This was due to the polyvinyl alcohol (PVA) hydrophilic layer that all membranes possessed. These rejections were consistent with those obtained when the synthetic oil-containing wastewater was used. However, unlike when the synthetic oil-water was used, all membranes did not meet the acceptable discharge limit as they showed the concentration of oil in the permeate that ranged between 16 and 64 mg/L at flow rates ranging between 46.8 and 52.2 L/h. The best performing membrane using the as-produced CNTs was 5% CNTs with the rejection of oil in the retentate that ranged between 18 and 52 mg/L at the afore-mentioned flow rates. The as-produced infused membranes were those membranes that their separation performance was first tested using the synthetic oil-containing wastewater. This indicated that the performance of the membrane increases with a decrease in the concentration of the as-produced CNTs as well as the membrane's flux. The overall best performing membrane was p7.5% CNTs (membrane infused with 7.5% of purified CNTs) with oil rejections ranging between 94.9 and 95.7%. The permeate showed the oil concentration that ranged between 16 and 19 mg/L at the mentioned flow rates. This was due to the purified CNTs which further increased the hydrophilicity of the membranes. These results showed that the performance of the polysulfone is directly related to the concentration of oil in the permeate and inversely related to the increase of the concentration of oil in the permeate, the flow rate as well as the membrane's flux.

The utilisation of the purified CNTs increases the hydrophilicity which in turn improves the fouling resistance and enhances the mechanical stability of the membrane.

Thus the separation performance of the PS membrane with the PVA layer and the purified CNTs is greater than that with the infused as-produced/non-purified CNTs.