# Investigating the Filterability of Oil Containing Waste Waters Using Polymeric Membranes

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## Introduction

Every day, about 100 million barrels of hazardous oily wastewater from oil and gas exploitation industry, called “Produced Water”, are discharged into environment around the world (Igunnu & Chen, 2014). Over time, stricter and more advanced regulations for discharging produced water have being passed. Concurrently, the potential of using produced water as fresh water is gaining more attention and interest in water-stress oil-producing countries, therefore, efficient treatment methods are required (Bilstad & Espedal, 1996). Hence, membrane filtration emerges as a promising technology in this field. Nevertheless, studies about the fouling mechanisms are very limited, most of them focused on the effect of the membrane material and hydrophilicity (Faibish & Cohen, 2001; Koltuniewicz et al., 1995). In this study, the efficiency of UF and MF membranes in removing oil from synthetic nanoemulsions was investigated. A close attention has been paid to size-related fouling mechanisms.

## Material and Methods

Two types of chemically identical nanoemulsions with oil droplets Sauter mean diameters of 360 nm and 68 nm were prepared from crude oil using high-pressure homogenization. To avoid any interferences of the dispersing agents on the fouling mechanisms, as it was claimed by Faibish and Cohen (2001), all feedwaters were prepared without application of any dispersing agents. Filtration experiments were conducted on flat sheet MF and UF membranes in accordance with standards of measuring the Silt Density Index (SDI) (ASTM D 4189–95, 2002). Hydrophilic MF membranes had a mean pore diameter of 0.45 µm while polyether sulfone UF membranes had an MWCO of 150 kDa. TOC analysis and Fluorescence Excitation−Emission Matrix (FEEM) measurement was used to quantify the oil content of feed and permeate.

## Results and Discussion

As depicted in **Figure 1** for MF membranes, bigger-size oil droplets showed higher fouling rate during the first minutes of filtration. This behaviour of the bigger-size droplets might be explained by the high percentage of oil droplets in the size range of the MF membrane pores causing complete blocking of the pores. This hypothesis was verified by UF experiments, where different droplet sizes showed no significant difference in initial fouling behaviour, as droplets in the size range of the membrane pores are missing. In further course of filtration, filtration curves for smaller size droplets appear different to these of bigger-size droplets indicating different fouling

mechanisms. In case of smaller-size droplets, the fouling rate increases with time probably due to cumulative constriction of the pores or accumulation of oil droplets in the inner membrane structure. Whereas bigger-size droplets filtration curve has linear slope indicating cake filtration.

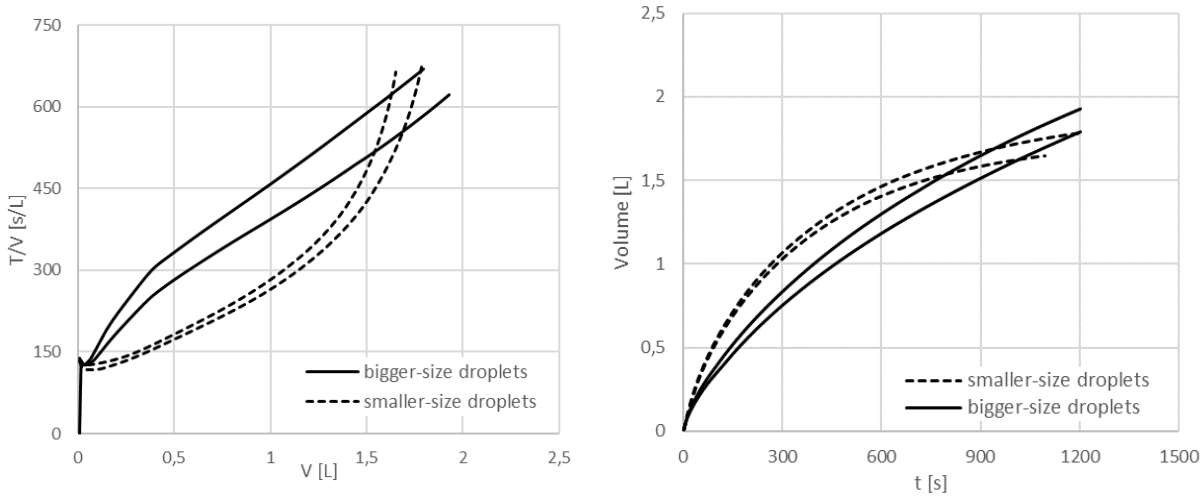


**Figure 1**: Filtration curves of two types of feedwaters with different oil droplets size; MF membrane; two times repetitions

To further elucidate this point, visual inspections of inner membrane structure by SEM are currently in progress. Also, it was noted that oil removal by MF increased with filtration time. This increase might have been caused either by the filtration effect of the developing cake layer or by the consecutive blocking of the membranes internal structure. Although, no increase in oil removal rate over filtration time was observed in case of UF membranes, FEEM intensity scans of both feed and permeate showed that UF membranes had different retention efficiency for different oil components.

## Conclusion:

Oil droplet size distribution of oil/water emulsions has significant influences regarding the type of fouling of porous membranes. If droplets are allowed to penetrate into the membrane structure coalescence might occur inside the membrane causing higher fouling rates. Thus smaller pores sizes as in case of UF might be of advantage.

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