# SEPARATION OF WATER-OIL EMULSION BY USING MEMBRANE

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## ABSTRACT

Separation operation has to be done to get the crude oil, which is free of emulsion. Membranes are primarily used for separation and membrane processes are generally separation processes. Large-scale commercial uses of membrane separation have displaced conventional separation processes. Studies and testing had been performed on polysulphone flat sheet membrane crossflow ultrafiltration system. The effects of reject flowrate and feed pressure on the water-in-oil emulsion separation was observed. At constant flowrate, filtration rate and flux increase with pressure due to the effect of pressure difference across the membrane affects the presence of a higher strength to force the permeate to flow through the membrane. While at constant pressure, the higher the flowrate resulted in the higher filtration rate and flux due to the thinner cake layer build up on the membrane which decrease the resistance to the permeate stream to flow through the membrane. The purity of the permeate oil had been tested and has shown to be free of water.

**Keywords:** Emulsion separation , membrane, ultrafiltration

## INTRODUCTION

Membrane is initially used for separation processes. Since thirty years ago, these processes have been applied to different industries. Separation processes using membrane are relatively lower in cost and energy compared to other separation processes. The principle of crossflow filtration has been well establish in the related technology of reverse osmosis and ultrafiltration, which are concerned with the removal of soluble compounds from solutions. By using a ultrafiltration membrane as the separation medium, particles in the 0.1 to 10 μm range can be removed by crossflow filtration. The closed system resulting in yields of 95% to 98%.

## LITERATURE REVIEW

An emulsion is a system containing two liquid phases, one of which is dispersed as globules in the other. That liquid which is broken up into globules is termed the dispersed phase, whilst the liquid surrounding the globules is known as the continuous phase or dispersing medium. Surfactant films that protect the droplets from collision and rupture stabilize emulsions [1]. Water-in-oil emulsion system can be formed with less than 26 % of water and more than 76 % of oil. The w/o emulsion needs to be stabilized with appropriate emulsifier.

The selection of membrane separation processes is based on seven factors which are the separation goal, the nature of species retained (size of the species), the nature of species transported through membrane, electrolytic or volatile, the minor or major species of feed solution transported through membrane, the driving force, the mechanism for transport or selectivity and the phase of feed and permeate streams [2]. Based on the seven factors, ultrafiltration process is a suitable filtration process for water-in-oil emulsion separation.

Ultrafiltration completes the spectrum of the commonly used liquid-phase pressure-driven membrane processes. Ultrafiltration is often used in the 'dead-end' filtration mode, which results in cake accumulation on the membrane surface. However, tangential flow the term crossflow filtration is more appropriate. Compared to deadend filtration, in crossflow filtration pressure drives only part of the feed through the medium; the remaining feed flows tangentially along the surface of the medium, continuously sweeping particles from the medium's surface back into the feed. Generally, crossflow filters are operated as surface filters and have pores that are smaller than the particles to be removed. With crossflow filtration, in addition to the feed and the permeate, there is also the retentate, the no filtered effluent laden with suspended material. The relative flow rates of permeate and retentate are established by controlling the backpressure on the retentate to establish the pressure drop across the filtration membrane. To maintain a high liquid velocity parallel to the filtration surface, and thus prevent retained components from accumulating on the surface, the flow rate of process feed is significantly greater than that of the permeate. As a consequence, the retantate must usually be recirculated [2].

Crossflow filtration modules are available in a wide range of materials and geometries. The most common configurations of crossflow modules are the plate-and-frame, spiral, hollow-fibre and tubular types as shown in Figure 1.

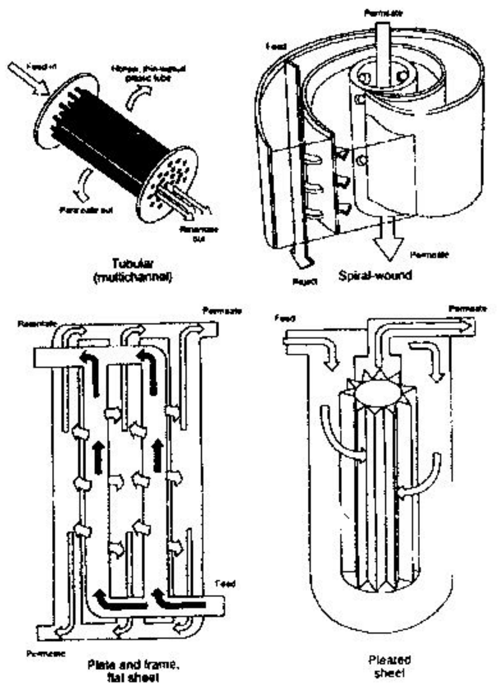


FIGURE 35-2. Microfilters can be configured in a variety of geometries (reprinted from Michaels 1989 with permission)

Figure 1- Filtration module

Various crossflow operations can be distinguished and they are co-current, counter-current, crossflow with perfect permeate mixing and perfect mixing. As far as for the crossflow operations are concerned, counter-current flow gives the best results followed by crossflow and co-current flow. The worst results are obtained in the perfect-mixing case. In principal, two basic methods can be used in a single-stage or multi-stage process that is the single-pass system and the recirculation system. In the single-pass system the feed solution passes only once through the single or various modules, i.e., there is no recirculation. Hence, the volume of feed decreases with the path length. In a multi-stage single-pass design, arranging the modules in a 'tapered design' compensates this loss of volume. In this arrangement the crossflow velocity through the system remains virtually constant. The second system is the recirculation system. Here the feed is pressurized by a pump and allowed to pass several times through one stage, consisting of several modules. Each stage is fitted with a recirculation pump, which maximizes the hydrodynamic conditions, whereas the pressure drop over each single stage is low. The flow velocity and pressure can be adjusted in every stage.

The membrane can be defined essentially as a barrier, which separates two phases and restricts transport of various chemicals in a selective manner [3]. The membrane phase interposed between two bulk phases in membrane process. In the membrane separation process, the bulk phases are mixtures. Permeate is defined as the fluid that passed through the semi-permeable membrane while retentate or reject is the constituents that have been rejected by the membrane [4]. Solution-diffusion membrane is the most common commercial use membrane nowadays. The separation membrane material is mostly polymer glass. The separation process depends mainly on the size of the molecule. The mechanism of the separation process is as illustrated as Figure 2 below.

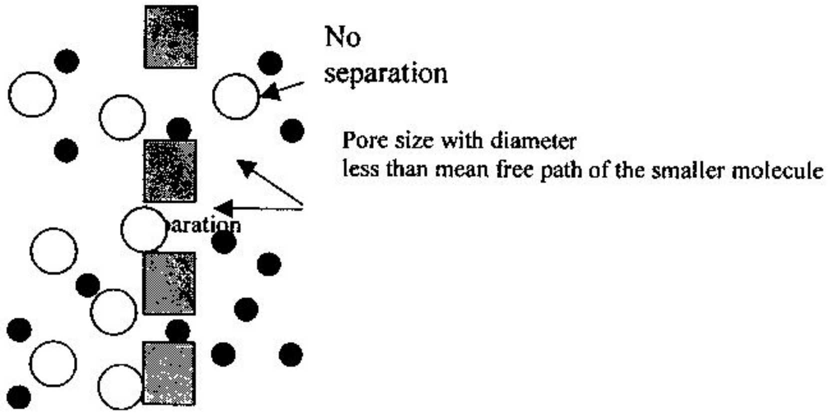


Figure 2 – Schematic of separation process

**EXPERIMENTS**

The system for the experiment was consist of pump for the feed emulsion, rotameter for measuring the flowrates, a cross flow membrane holder, valves and connection lines. The membrane used in the experiment was a newly developed polysulphone flat sheet ultrafiltration membrane. The area of the membrane is approximately 19.63 $cm^2$. The feed emulsion is introduced on the membrane holder and the permeate stream is collected at Channel 2. The operational configuration for the cross flow ultrafiltration is a batch concentration configuration. The water-oil emulsion used in the experiments was made up of 70 % oil and 30 % water by volume.

The measurement performed in the experiments include the pressures and flowrates of feed and reject stream, and the purity of the permeate stream. The operational variables used to obtain the experimental data are the feed pressure and reject flowrate.

**RESULTS AND DISCUSSION**

The results are displayed in Figure 3 and Figure 4 as a function of feed pressure and reject flow rate. According to Figure 4, the filtration rate and flux increase with pressure and by referring to Figure 4, the filtration rate and flux increase with flowrate.

**Effects Of Pressure On Filtration Rate**

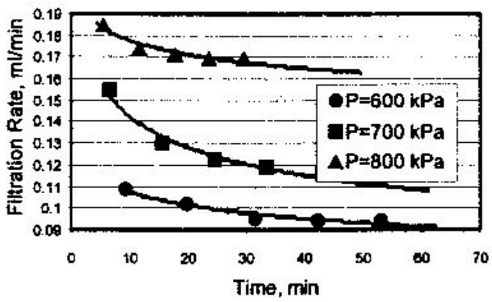


Figure 3 - Filtration rate versus time at constant flowrate

As shown in Figure 4, when the system is operating at a constant flow rate, which is 42 $cm^3$/min, increasing the feed pressure from 600 kPa to 800 kPa will increase the pressure difference across the membrane as well as the driving force for the separation process. Hence, more permeate oil filter through the membrane in a shorter time period and resulted in the filtration rate of the process increases. Although the thickness of the cake layer build up on the membrane increases with the pressure, the effects of this can be ignored. The filtration rate decreases with time for a single flow rate and pressure. This is due to the thickness of the deposited particles on the membrane increases with time and this resulted in the increase of the resistance to the permeate oil to flow through the membrane, that is a less effective filtration.

**Effects Of Flow Rate On Filtration Rate**

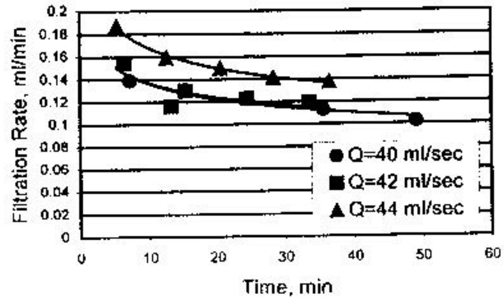


Figure 4 - Filtration rate versus time at constant pressure

As shown in Figure 5, the effects of the flow rate on the filtration rate is detectable when comparing the three each different flow rates. When the system was operating at a constant pressure, which is 700 kPa, the highest filtration rate was obtained at the highest flow rate. This is due to the reason that the deposited particles on the membrane were flushed away by a stronger flow and this resulted in the pore of the membrane did not block and thus, the permeate oil is able to flow through the membrane easier, that is a more effective filtration. However, the increase of the filtration rate will reach a stabilized point where the further increase of flow rate will not resulted in any increase in filtration rate. This phenomena happens when the forming of the dynamic particle layer on the membrane have reached its balance point. This balance point reaches when the rate for forming this dynamic layer is same with the rate of the total amount of particle deposited into the bulk flow due to the shear flow effects. The highest the shear force towards the cake layer, the thinnest the layer and thus, the resistance to the permeate flow decreases. Again for the case the filtration rate decreases with time for a single flow rate and pressure. This is also due to the thickness of the deposited particles on the membrane increases with time and this resulted in the increase of the resistance to the permeate oil to flow through the membrane, that is a less effective filtration.

**Effects Of Pressure On Flux**

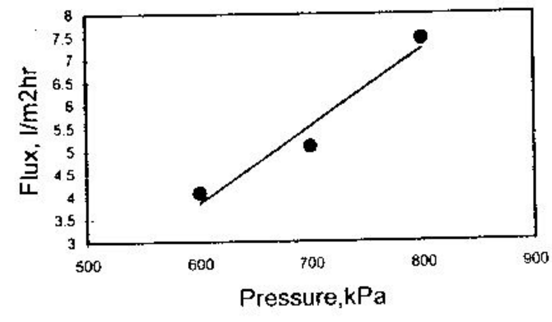


Figure 5 - Flux versus pressure

Flux was calculated by taking the area of the filtration membrane into account. By referring to Figure 5, flux is a linear function of pressure at a constant flow rate. The higher the pressure will result in the higher the flux.

**Effects Of Flow Rate On Flux**

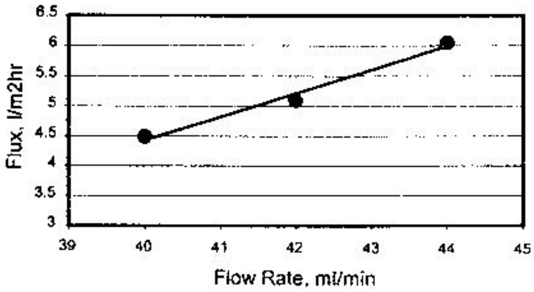


Figure 6 - Flux versus flow rate

By referring to Figure 6, the flux of the crossflow ultrafiltration process is a linear function of flow rate at a constant pressure. The higher the flow rate will result in the higher the flux.

## CONCLUSIONS

From this experiment, the purity of the permeate oil has proven to be free of any water. This shows that the membrane has a potential to be used in separating an emulsion. The crossflow ultrafiltration system depends highly on the pressure and flow rate of the operate system. The system must operate at a high pressure and flow rate to obtain the maximum volume of permeate.

## NOTATION

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| l | liter |
| ml/min | milliter per minute |
| hr | hour |
| m | meter |
| P | pressure |

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