Work plan - ST7

Group B2
Sivert Ask and Håkon Ulvik

Supervisor: Junbo Yu

15. Oktober 2023

1 Introduction

In this experiment, the purpose is to look at membrane ultrafiltration as a separation technique. Here, a dead-end filtration process is conducted in an ultrafiltration cell in order to study the concepts of flux, the rejection coefficient and permeability. In order to achieve this, it is necessary to measure the mass change of the beaker and the conductivity of the solution. The experiment will give information about the instantaneous flux, the permeability with respect to the solvent and the reaction coefficient.

2 Theory

2.1 Membranes

Membranes are surfaces which have a structure so that only species of a size or smaller will get through to the other side of them. The smaller the species, the higher the rate of transfer through the membrane. The rate of transfer will also depend on the concentration and the pressure difference between the two sides of the membrane.
Membranes can be catecorized by molecular weight cut-off (MWCO). MWCO is defined as the lowest size of a molecule of which 90% will be separeted. Different membranes with the same MWCO can have different pore size distribution. Therefore, different membranes can remover different species to different extent.
Flux is one of the most important parameters, determining the characteristics of the membrane. The flux is given from eq. (2.1).

$$J_v = \frac{1}{A}\frac{\Delta V}{\Delta t} \tag{2.1}$$

A is the surface area of the membrane, Δ V if the filtration volume and Δ t is the filtration time.
The permeability with respect to the solvent is another important parameter, it is given by eq. (2.2). Where ΔP is the pressure driving force.

$$L_p = \frac{J_v}{\Delta P} \tag{2.2}$$

It is also necessary to know the sieving coefficients, this is given in eq. (2.3). R is the rejection coefficient, C_p is the permeate concentration and C_f is the feed concentration.

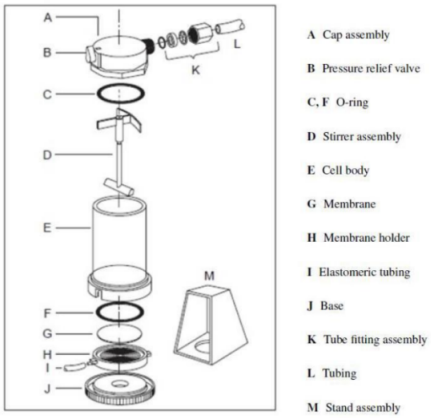
$$S_i = \frac{C_{pi}}{C_{fi}} = 1 - R \tag{2.3}$$

2.1.1 Ultrafiltration membranes

Ultra filtration membranes are membranes with pores that have a diameter of 10-100 nm.
Ultrafiltration is commonly used where there are a small volume being filtrated. This is do to the feed stream being directed at the membrane, and therefore the separation process being driven by pressure. This will separate the solute and the solvent from the larger molecules.
Problems that can occur when using ultrafiltration are concentration polarization and fouling. Both of these problem will lead to reduction of flux. Another reason that can be the reason of flux reduction is the clogging of pores.
Concentration polarization is when the concentration of the species removed is higher at the membrane surface than in the rest of the stream. This can lead to it being formed a boundary layer.

3 Experimental

3.1 Apparatus



Figur 1: Overview of the different parts in the experiment

In fig. 1 there is an overview of the ultrafiltration cell. When handling the membrane (G), it is important to wear gloves to avoid scratching or contaminating the membrane. Start by placing the membrane in the membrane holder (H), and make sure the shiny side is facing up. Place the O-ring on top of the membrane, and gently push it down to fit the membrane. Place the membrane holder on the bottom of the cell body (E), and fit the base (J) over the holder. To avoid air leakage When the cell is pressurized, screw the base firmly to the body. See to that the filtrate exit tubing (I) fits firmly onto the exit spout of the membrane holder. Place the stirrer assembly (D) into the cell body and pour the given feed into the cell. Take the cap assembly (A) and push it onto the cell body. It is necessary to make a twisting motion, and use some force at the same time. See to that the pressure relief value (B) is oriented in the same direction as the filter exit port. Place the cell body into the stand assembly (M) and turn the pressure relief value to the closed position. Fit the tubing of the gas pressure line (L) to the cap assembly and tighten the hexagonal nut (K). Place the beaker on the scale next to the ultrafiltration cell.

3.2 Procedure

1. Rinse the membrane.
2. Set transmembrane pressure to 1 bar.
3. Feed volume set to approximatly 100 mL
4. Stirrer must not overgo 100 rpm

3.2.1 Procedure with pure water

1. Do the filtration as described with DI-water.
2. Repeat 2-3 times, for 2 minuttes each round.
3. Note down temperature and conductivity before and after filtration.

3.2.2 Procedure with unknown sample

1. Do filtration as described with the unknown sample.
2. Note down temperature and conductivity before and after filtration.

3.2.3 Procedure for calibration curve

1. Prepare different solutions of known concentration (1-25 g/L)
2. Do filtration as described
3. Determine conductivity and temperature while filtrating.
4. Determine Concentration of feed and permeate.

4 HSE

There is no significant risk in this experiment.

Data collection

Sample	T_{before} [K]	T_{after} [K]	σ_{before} [μ S / cm	σ_{after} [μ S / cm
DI-water 1				
DI-water 2				
DI-water 3				
Unknown				

Tabell 1: Temperature and conductivity before and after

Sample	Δm [g]	ΔV [m^3]	Δt [s]	ΔP [bar]	J [$m^3/m^2 s$]	L_p [m/bar s]
DI-water 1						
DI-water 2						
DI-water 3						
Unknown						

Tabell 2: Raw data and calculated values

C [g/L]	T [K]	$\sigma[\mu S/cm]$

Tabell 3: .

Referanser