Laboratory 3

Characterisation of an Ultrfiltration Module

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Ultrafiltration is a membrane separation process used for removing large solutes (macromolecules) and particulates e.g. virus, bacteria, from solutions, usually water. Membranes are usually asymmetric polymers, which are rated in terms of a nominal molecular weight cut-off (MWCO).

The separation is a pressure driven process, the flowrate of liquid through the membrane (permeate) is determined by the membrane permeability of the solvent liquid K_m. In the absence of dissolved solutes the solve flux, J_{solv} is given by

$$J_{solv} = \frac{\Delta P}{t_m / K_{solv}}$$

where ΔP is the transmembrane pressure difference and t_m is the effective thickness of the membrane.

In the presence of dissolved solutes, additional resistances arise at the membrane surface due to the effect of concentration polarisation and, with some feeds, the formation of a gel layer.

When concentration polarisation occurs the flux rate decreases with the logarithm of solute concentration.

In the case of a gel layer, the fluxrate is given by

$$J_{solv} = \frac{\Delta P}{\frac{t_m}{K_{solv}} + \frac{t_g}{K_g}}$$

Where t_g and permeability K_g are the gel layer thickness and permeability.

Experimental Equipment

The equipment is a commercial hollow fibre module operated in a batch recycle mode. Feed is introduced in cross flow across the module at a set pressure and permeate is collected continuously, the flow rate of which is measured either volumetrically or gravimetrically.

Note that the pressure gauges are both on the feed side and thus are used to give the average trans-membrane pressure differential.

There are two hollow fibre modules of different characteristics available for the test, although you are only required to use one of these.

Objective

1. To characterise the membrane module flux; pressure drop behaviour and thereby determine the membrane permeability.
2. To determine the effect of dissolved solutes on the flux, pressure drop behaviour.

Experimental procedure

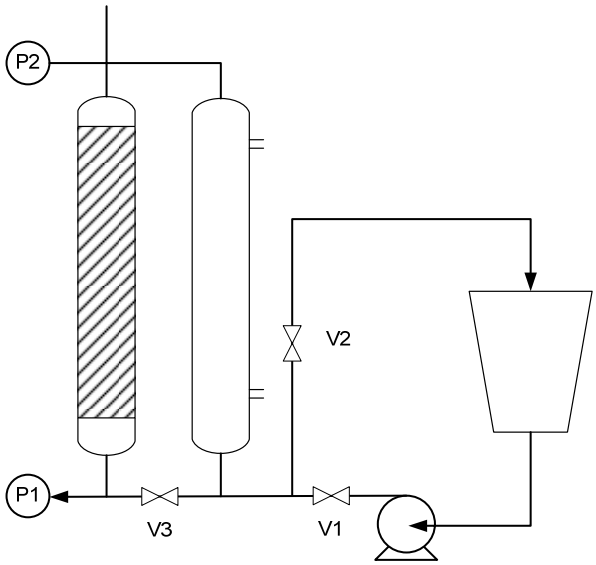

Fig.1 Schematic diagram of the ultrafiltration experiment setup

After becoming familiar with the equipment first recirculate distilled water through the module (5 minutes) to give it an initial clean.

Then a suggested range of experiments are:

1. Measure the variation of fluxrate through the membrane with applied pressure difference across the membrane at a fixed flow rate using a new batch of distilled water. These measurements will enable the membrane permeability to be characterised. Make sure that V1 and V2 are fully open and use V3 to change flowrate.

2. Repeat part 1 using a 1% solution orange juice (or apple or glycerol) in tap water and determine the effect of membrane pressure differential on flux rate. Try to keep the flow through the membrane module (cross-flow velocity) constant if possible.

3. Repeat part 2, using 2% and 5% solutions of orange juice (or apple or glycerol) in tap water and determine the effect of pressure differential on flux rate.

4. Clean the hollow fibre module by recirculating a surfactant solution through the module for approximately 10 minutes. Measure the membrane fluxrate at different transmembrane pressure using a fresh batch of distilled water.

Note: You will need at least 3 readings of each run. Hence use three different pressures for each fluid.