Exercise no. 5. **Building: A2, room 110**

Polymeric materials- laboratory

The method of preparation of polymer membranes and their application in proper water treatment processes

Prepared by Joanna Wolska

ULTRAFILTRATION

Introduction

Membrane separation processes play an import ant role in the field of wastewater purification and reuse. This technology is very interesting due to its low operation costs, conceptual simplicity, modularity, optimal quality of treated water, and being more ecological than conventional techniques [1].

Ultrafiltration (UF) is one of the pressure driven process which needs smaller transmembrane pressure than e.g. nanofiltration (NF). The pressure used in UF usually do not exceed 1 MPa so its operational cost is not so high. Ultrafiltration is using membranes with pore sizes in the range of 0.1 to 0.001 micron. The essence of UF is permeation through the membrane of the filtrate stream (permeate) containing water and substances which particle size is smaller than the pore size of membrane, and It has been shown that UF is efficient in the removal of larger molecular substances (polymers, colloids). Low molecular-weight organics and ions such as sodium, calcium, magnesium chloride, and sulfate are not removed by UF Membranes. Because only high-molecular weight species are removed, the osmotic pressure differential across the UF Membrane surface is negligible. Low applied pressures are therefore sufficient to achieve high flux rates from an Ultrafiltration membrane. Flux of a membrane is defined as the amount of permeate produced per unit area of membrane surface per unit time.

In the process of UF the polymer membranes are used for the asymmetric porous structure, with variable pore size of the cross section along the membrane. Such membranes consist of a very thin and dense layer of the skin of a thickness of 0.1 - 0.5 microns (with a small pore size), and much thicker about 50 - 500 microns of the porous support (with large pores). Membranes of this type are obtained by the phase inversion of the sol - gel. This involves the selection of a solvent miscible with each other and a non-solvent of the polymer selected. The polymer solution (with high viscosity) is formed on a glass plate polymeric film, and then the plate is immersed in a bath of non-solvent. As a result of displacement of the solvent by precipitating non-solvent of the polymer, and the polymer of a non-solvent filled pores. The pore size depends on the rate of precipitation of the polymer (polymer solution concentration control, sometimes the pre-evaporation of the solvent in air or changing the speed of the addition of precipitating agents). The characteristics of UF membranes used in the determination of the average pore size hydraulic flow method or by determining the molecular weight of the compound at which 90% of the stops (molecular weight cut-off - MWCO).

Experimental

1. Measurement of the water flux

a. From the polysulfone sheets of the membranes poured during exercise No. 4, cut the appropriate discs,
b. Put a membrane to the Amicon dead-cell (skin side up),
c. Fill the apparatus with the 100 mL of distillated water,
d. Turn on the compressor, regulating monostat pressure of 0.1 MPa,
e. Measure the flow time of three 10 mL of portions of water,
f. Turn the monostat and compressor off, pour the water from the cell without removing of membrane from the apparatus.

2. Measurement of the rejection coefficient in removing dyes

a. Fill the apparatus with the 100 mL of solution of dye,
b. Turn on the compressor, regulating monostat pressure of 0.1 MPa,
c. Measure the flow time of two 10 mL portion of filtrate,
d. Turn the monostat and compressor off, pour the solution from the cell without removing of membrane from the apparatus,
e. Fill the apparatus with the 100 mL of solution of the second dye,
f. Turn on the compressor, regulating monostat pressure of 0.1 MPa,
g. Measure the flow time of two 10 mL portion of filtrate,
h. Turn the monostat and compressor off, pour the solution from the cell,
i. Remove the membrane and measure the active surface and thickness of membrane
j. Determine the concentration of dye in the permeate (the second portion) using spectrophotometer UV/VIS (calibration curves).

Calculations

1. Permeation flux (***J***):

$$J = \frac{V}{S \times t}[\frac{cm^3}{cm^2 s}], \qquad (1),$$

where:
V – volume of filtrate, cm^3,
S – active surface of membrane, cm^2,
t – measurement time, s.

2. The rejection coefficient (***R***):

$$R = (1 - \frac{c_p}{c_o}) \cdot 100\%, \qquad (2),$$

where:

$\boldsymbol{c_o}$ – the initial concentration of dye, g/dm^3,
$\boldsymbol{c_p}$ – the concentration of dye in permeat, g/dm^3.

3. Porosity of membrane (***E***):

$$E = \frac{m_s - m_o}{m_s}, \qquad (4),$$

where:

m_s – weight of swollen membrane (wet), g,

m_o – weight of dry membrane, g (dried in the dryier at105°C).

4. The average pore size (r) from the Hagen-Poiseuille equation (equation 5):

$$r = \frac{8 \cdot J \cdot d \cdot \eta}{p \cdot E}, [nm], \quad (5),$$

where:

η – water viscosity, Ns/m^2,

d – thickness of membrane, cm, (average thickness from 10 measurements)

p – pressure, N/m^2.

[1] G. Pozniak, R. Pozniak, K. A. Wilk, *Chemical Engineering Transactions*, 17, (2009) 1693-1698.

Attention

The report should contain:

1. **The object of exercises,**
2. **short introduction,**
3. **the measurements results in the tables,**
4. **all calculations,**
5. **conclusions**

Issues

1. Definition of membrane processes, definition of membranes, division of membrane processes, division of membranes,
2. The advantages of a porous asymmetric membrane structure.
3. How is the skin formed in the asymmetrical membrane?
4. Where is UF used?