Department of Biochemical Engineering & Biotechnology
BBL445: Membrane Applications in Biotechnology
Major Test

9 May 2018
M.M.: 40
Time: 2 hour

1. (i) Draw a typical sketch obtained for microfiltration membrane integrity test between applied pressure vs time. Describe briefly integrity test using this sketch. (2+1)

(ii) Calculate the water flux through a XM100A (MWCO = 100,000) membrane with a mean pore diameter of 6.1 nm, pore density of 1.3×10^{11} pores/cm^2 and skin thickness of 0.2 μm at an applied pressure of 100 kPa at 20°C. Water viscosity is 1 cp = 0.01g/cm.sec. Provide your answer in standard LMH units. (2)

2. For a low flux UF membrane using a high cross flow velocity, the protein rejection coefficient is measured as a function of volumetric flux as given below:

Rejection coefficient (%)	22	35	63	71	72	74	78
Flux (LMH)	1	2	10	20	25	33	50

Explain the data by making appropriate assumptions to K-K model and calculate the relevant parameters. (6)

3. The 1000 liter of cheese whey obtained from the milk of an Indian cow has the composition as given below. The protein content of this whey is on the low side but is considered to be of a superior quality. Therefore, it needs to be purified to high purity level so that it can be mixed with baby milk food. Protein purification is to be carried out by combination of concentration by ultrafiltration (UF) followed by continuous diafiltration (CD) using the concept of **minimum process time**. The gel concentration of the protein is assumed to be 217 g/l. The rejection coefficient of each component for this membrane is also given below.

PROTEIN: 0.1% (w/v), R = 1.0
NPN: 0.1% (w/v), R = 0.10
LACTOSE: 4.0% (w/v), R=0.05
ASH: 0.5% (w/v), R=0.0

(a) How much concentration of cheese whey is needed before continuous diafiltration (CD) for minimizing process time. (2)

(b) What is the volume of cheese whey after concentrating it to the concentration as found in step (a). (2)

(c) Estimate the purity of protein if three times the volume of pure water is used for continuous diafiltration (CD) after initial concentration. (4)

4. Calculate the surface area required to produce a fivefold concentration of skim milk in a hollow fiber UF module in a batch operation at the rate of 1000 liter/h. The cross flow velocity for each hollow fiber UF module is to be maintained at the cross flow rate of 1.1m/s. The flux through the hollow fiber UF module for the specified cross flow can be approximated by the equation J (l/m^2 h) = 35 – 15 $\log_{10}$ (VCR). Where VCR is volume concentration ratio. **(2)**

The each hollow fiber UF module has surface area of $1.4m^2$ and each fiber has a channel diameter of 1.4mm and it is one meter long. (i) How many hollow fibers are there in each module? (ii) How many modules are required to obtain retentate at the rate of 1000liter/h. The pressure drop across each module is 0.9 kg/cm^2. Calculate the energy required to carry out concentration of milk in terms of (iii) per unit permeate volume basis and (iv) per unit membrane area basis. Assume pump efficiency of 75%. **(1+2 +2+2)**

5. For a MF membrane, pure water flux for 1 bar pressure at 25^0C is 5000 LMH. This MF membrane is used to filter skim milk at 50^0C in a tubular module at a high cross flow velocity. Skim milk is known to foul MF membrane extensively. How will volumetric flux of skim milk appear as a function of time if it is filtered in a) normal conventional mode, b) Co-current permeate flow (CPF)/UTP mode. Make these sketches if average TMP is 1 bar. **(3)**

Critical flux for this system was found to be around 300 LMH and it was decided to carry out MF below critical flux. If TMP of 0.05 bar was chosen, make the sketches of the flux as a function of time for conventional mode as well as UTP mode. **(3)**

Make suitable assumptions to draw the sketches. Show representative flux value on y-axis and time in minute on x-axis.

6A. Microfiltration is commonly used for processing of raw milk, write about the salient features of this processing. Microfiltration is also used before ultrafiltration of cheese whey, how its role is found useful? **(4+2)**

or

6B. What is **lignin** recovery after biomass pretreatment process? To recover **lignin** what are the major considerations for a successful membrane operation? What kind of membrane can be used for it? **(6)**

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