

BT-303 (Biochemical Engineering)

Mid-Sem Examination

Date: 19.09.2024

Total Marks: 30

Q1: Ethanol formation from glucose is accomplished in a batch culture of *Saccharomyces cerevisiae*, and the following data were obtained.

Time (h)	Glucose (S), g/L	Biomass (X), g/L	Ethanol (P), g/L
0	100	0.5	0.0
2	95	1.0	2.5
5	85	2.1	7.5
10	58	4.8	20.0
15	30	7.7	34.0
20	12	9.6	43.0
25	5	10.4	47.5
30	2	10.7	49.0

The growth of the organism is characterized by the logistic equation as follows:

$$\frac{dx}{dt} = kX \left(1 - \frac{\bar{X}}{X_{max}} \right); \text{ where } \bar{X} \text{ is average biomass concentration during } \Delta t$$

- By fitting the biomass data to the logistic equation, determine the carrying-capacity coefficient k .
- Determine yield coefficients $Y_{P/S}$ and $Y_{X/S}$.

Marks: 4+4 = 8

Q2: The specific growth rate for inhibited growth due to substrate inhibition in a chemostat is given by the following equation:

$$\mu_g = \frac{\mu_m S}{K_s + S + \frac{IK_s}{K_I}}$$

Where, $S_0 = 10 \text{ g/l}$, $K_s = 1 \text{ g/l}$, $I = 0.05 \text{ g/l}$, $Y_{X/S} = 0.1 \text{ g cells/g substrate}$

$X_0 = 0 \text{ g/l}$, $K_I = 0.01 \text{ g/l}$, $\mu_m = 0.05 \text{ h}^{-1}$, $k_d = 0$

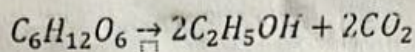
- Determine X and S as a function of D when $I=0$
- With inhibitor added to the chemostat, determine the effluent substrate concentration and X as a function of D
- Determine the cell productivity, as a function of dilution rate.

Marks: 3+3+2 = 8

Q3: Ethanol is produced by anaerobic fermentation of glucose by *Saccharomyces cerevisiae*. For the particular strain of *S. cerevisiae* employed, the maintenance coefficient is 0.18 kg kg^{-1}

h^{-1} , Y_{XS} is 0.11 kg kg^{-1} , Y_{PX} is 3.9 kg kg^{-1} and μ_{\max} is 0.4 h^{-1} . It is decided to investigate the possibility of using *Zymomonas mobilis* bacteria instead of yeast for making ethanol. *Z. mobilis* is known to produce ethanol under anaerobic conditions using a different metabolic pathway to that employed by yeast. Typical values of Y_{XS} are lower than for yeast at about 0.06 kg kg^{-1} ; on the other hand, the maintenance coefficient is higher at $2.2 \text{ kg kg}^{-1} \text{ h}^{-1}$. Y_{PX} for *Z. mobilis* is 7.7 kg kg^{-1} ; μ_{\max} is 0.3 h^{-1} .

Equation for formation of ethanol from glucose:



- From stoichiometry, what is the maximum theoretical yield of ethanol from glucose?
- S. cerevisiae* and *Z. mobilis* are cultured in batch fermenters. Predict the observed product yield from substrate for the two cultures.
- What is the efficiency (observed product yield/theoretical product yield) of ethanol production by the two organisms? Efficiency is defined as the observed product yield from substrate divided by the maximum or theoretical product yield.
- How does the specific rate of ethanol production by *Z. mobilis* compare with that by *S. cerevisiae*?

Marks: 2+2+2+2 = 8

Q4: Define following:

- Active transport with example
- Passive diffusion
- Adenylate Energy Charge
- Enzyme level regulation with schematic

Marks: 2+1+1+2=6