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:

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

(a)By fitting the biomass data to the logistic equation, determine the carrying-capacity coefficient *k*.

(b)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 g/l, K_S = 1 g/l, I = 0.05 g/l, $Y_{X/S}$ = 0.1 g cells/g substrate

X_0 = 0 g/l, K_I = 0.01 g/l, μ_m = 0.05 h^{-1}, k_d = 0

(a) Determine X and S as a function of D when I=0

(b) With inhibitor added to the chemostat, determine the effluent substrate concentration and X as a function of D

(c) 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 kg kg^{-1} 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:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

(a) From stoichiometry, what is the maximum theoretical yield of ethanol from glucose?

(b) *S. cerevisiae* and *Z. mobilis* are cultured in batch fermenters. Predict the observed product yield from substrate for the two cultures.

(c) 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.

(d) 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:

(a) Active transport with example
(b) Passive diffusion
(c) Adenylate Energy Charge
(d) Enzyme level regulation with schematic

Marks: 2+1+1+2=6