Tutorial 5: Chemostat & Kinetic parameters

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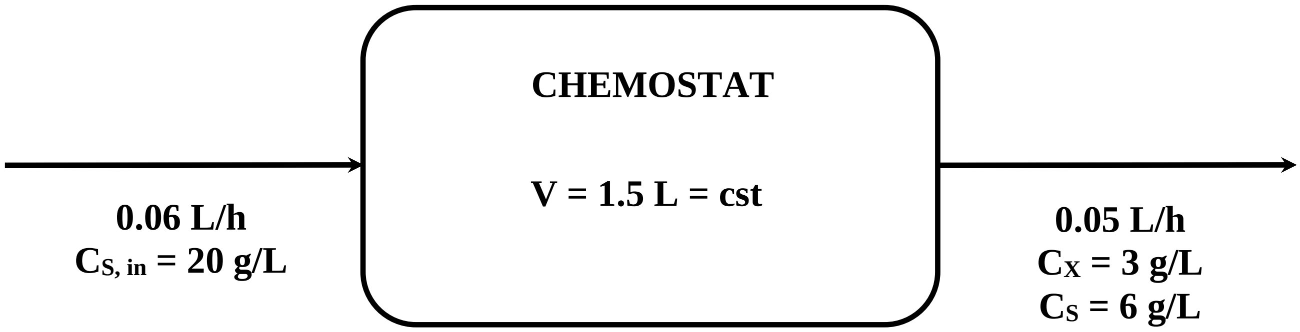
5.1. Chemostat study (8:1+3+2+2)

Considering a chemostat bioreactor running an aerobic heterotrophic growth at steady state:



1. What may cause the lower out-flow rate
2. Calculate **D, r_X, r_S, μ, q_S, $Y_{SX\ obs}$** (observed) and units (use mass balances and check μ in front of D)
3. **$C_{S,\ in}$** is changed from 20 g/l to 40 g/l at the same flow rate!
   A new steady state is achieved. What is the new **C_S**?
4. Calculate the new **C_X**. What are the new **μ (q_X), q_S, r_X, r_S, r_X, $Y_{SX\ obs}$**?

Note: In the present case, the residual substrate **C_S** is high enough to neglect maintenance in front of the growth.

5.2. Chemostat study of Saccharomyces cerevisiae (15: 4+2+4+5)

The yeast *Saccharomyces cerevisiae* is studied**.** A chemostat, V = 1.5 L, is fed with a glucose medium (with $C_{S,in}$= 20000 mg/L) at different flow rates.
It can be assumed that in- and out-flow are the same. The following concentrations of glucose (Substrates C_{Sin} & C_S), biomass (C_X) and ethanol (Product C_E) are found.

ϕ_L l/h	C_{Sin} mgS/L	C_S mgS/L	C_X gX/L	C_E gE/L
0.015	19780	1.2	5.0	0
0.060	20035	3	8.0	0
0.30	19990	16	9.5	0
0.33	20005	22	8.3	1.5
0.60	20120	180	5.3	5.3

a) Calculate Dilution rate **D**, the volumetric rates $\mathbf{r_i}$, the specific rates $\mathbf{q_i}$ and the yields for biomass observed yields $\mathbf{Y_{SX}}$, substrate and $\mathbf{Y_{SE}}$ product.
Note: Be aware of C_S unit.

ϕ_L	D	C_{Sin}	C_S	C_X	C_E	r_X	$-r_S$	r_E	μ	q_S	q_e	Y_{SX}	Y_{SE}
L/hr	1/hr	mgS/L	mgS/L	gX/L	gE/L	gX/ (L.hr)	gS /(L.hr)	gE/ (L.hr)	1/hr	gS/ (gX.hr)	gS/ (gX.hr)	g_X/g_S	g_E/g_S
0.015													
0.06													
0.3													
0.33													
0.6													

b) Plot these states variables C_X, C_S and C_{Eth}, volumetric rates $\mathbf{r_i}$, specific rates $\mathbf{q_i}$ on 3 charts vs D.

Notice that it seems that there are 2 regions of dilution rate which show 2 biokinetic behaviors according the applied dilution rate D which fix the substrate residual concentration C_S… Try understanding and explain the biomass behavior in each phase.

c) On the 3 first experimental data points, perform an estimation of the biological kinetic parameters:

- $\mathbf{Y_{SX}^{max}}$, $\mathbf{m_S}$ by using Herbert-Pirt Equation
- $\mathbf{q_S^{max}}$, $\mathbf{K_S}$ by using the Hanes-Wolf linearization

d) Determine Y_{SE}^{max} (yield of Ethanol production over Substrate) to fully reproduce observed q_s values with Herbert-Pirt Extended q_s expression.

Calculate q_s consumed susbtrate for Ethanol production, from TOTAL q_s consumption, MINUS consumption due to the biomass growth Herbert-Pirt Eq. (non catabolic) (with $\mathbf{Y_{SX}^{max}}$, $\mathbf{m_S}$). It allows to compute Y_{SEth}^{max} from $q_{SEth}=1/Y_{SE}^{max} \cdot q_E$

Plot Observed q_s and Extended Herbert-Pirt q_S values as your auto-checking.