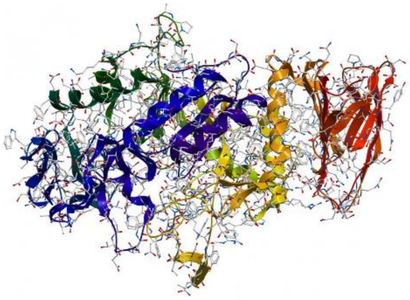
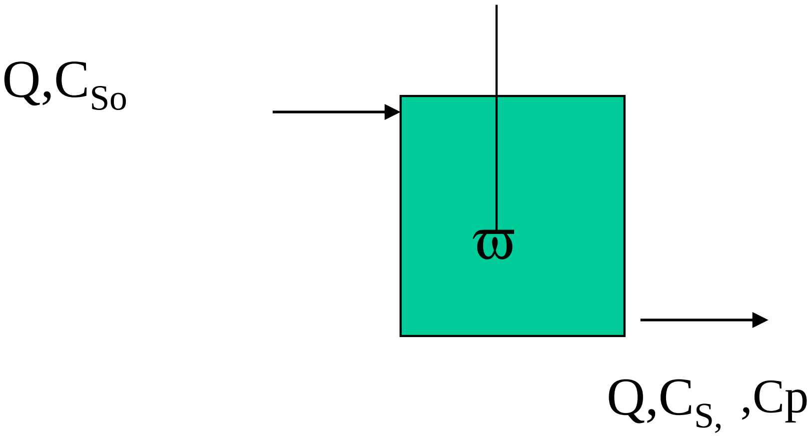


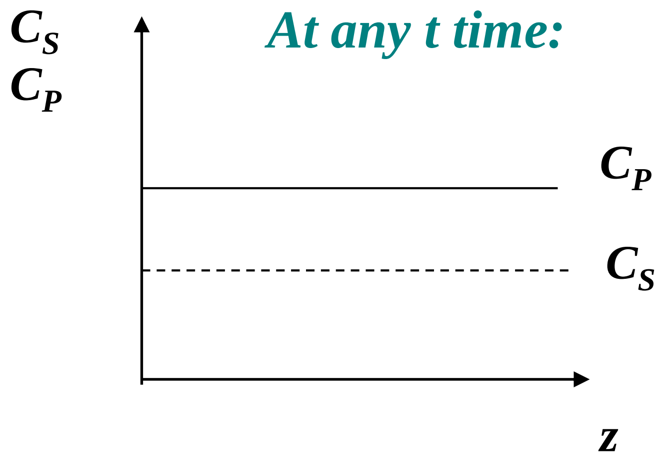
CEN-CHE 422
ENZYME ENGINEERING

ENZYME REACTORS-2

Continuus Stirred Tank Reactors

(Back-mixed Reactors)





No variations in C, T and r within the vessel

In the reactor: Low substrate and high product concentrations

i= component
J= reactor no
V= reactor volume
Q=besleme debisi
C=concentration
N=mole number

Mass Balance in an Ideal Continuous Stirred Tank Reactor

(for i component; for reactor j

moles/s

$$QC_i\Big|_{j-1} - QC_i\Big|_j + r_i V_J = \frac{d}{dt}(C_i V)_j$$

(steady state and liquid phase reaction)

$$Q(C_i\Big|_{j-1} - C_i\Big|_j) + r_i V_J = 0$$

τ (residence time)= *How long a unit reactor volume feed remains in the reactor*

$$\tau = \frac{1}{D} \qquad \tau = \frac{V}{Q}$$

$$\boxed{C_i\Big|_{j-1} - C_i\Big|_j + r_i \tau_J = 0}$$

MM expression is introduced in the equation

Example: For enzyme reaction with MM model

$$r = -r_S = \frac{r_{\max} C_S}{K_m + C_S}$$

$$Q(C_{So} - C_S) - \frac{r_{\max} C_S}{K_m + C_S} V = 0$$

$$\frac{(C_{So} - C_S)(K_m + C_S)}{C_S} = \frac{r_{\max} V}{Q}$$

$$x = \frac{C_{So} - C_S}{C_{S0}}$$

$$1 - x = \frac{C_S}{C_{S0}}$$

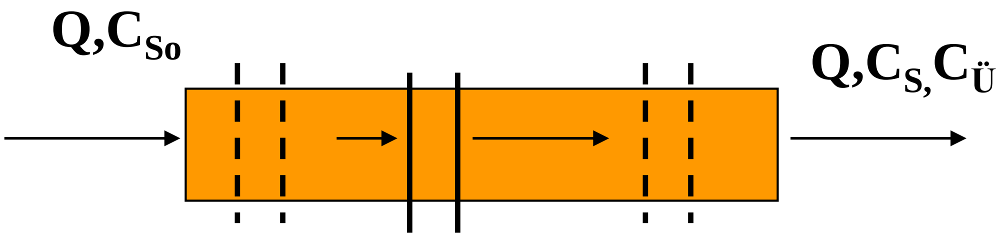
$$r_{\max}\tau = \frac{(C_{S0} - C_S)K_m}{C_S} \, C_{S0}\big/C_{S0} + \frac{(C_{So} - C_S)C_S}{C_S} \, C_{S0}\big/C_{S0}$$

$$r_{\max}\tau = \frac{xK_m}{1-x} + xC_{S0}$$

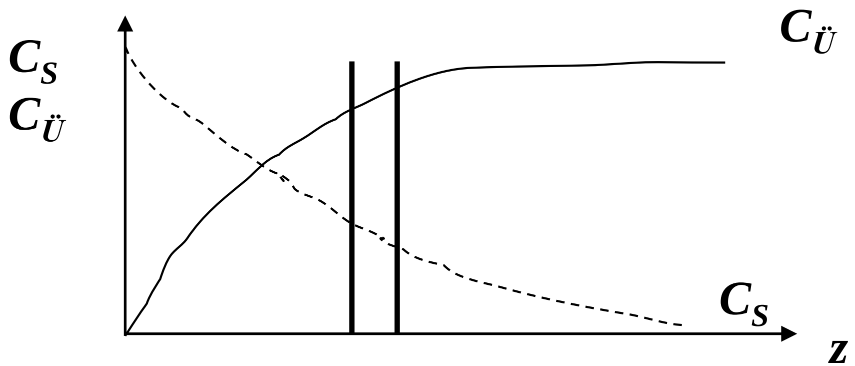
The relation between the residence time and conversion

$$\boxed{r_{\max}\tau = x\left[\frac{K_m}{1-x} + C_{S0}\right]}$$

Plug flow :



There is no axial interference (mixing); There is very good mixing in the radial direction



C, T and r change with length (z)

Mass Balance in an Ideal Plug Flow Reactor

(for i component, in (A∆z) volume element; ideal biyoreactor; A cross sectional area, z length)

$$QC_i\Big|_z - QC_i\Big|_{z+\Delta z} + r_i(A\Delta z) = \frac{d}{dt}(C_i A\Delta z)$$

Steady-state; *Q=vA*

$$vAC_i\Big|_z - vAC_i\Big|_{z+\Delta z} + r_i A\Delta z = 0$$

If divided by :

$$\frac{vC_i\Big|_{z+\Delta z} - vC_i\Big|_z}{\Delta z} = r_i$$

By taking limit :

$$\frac{d}{dz}(C_i v) = r_i$$

No chang of rate with z

$$C_i\frac{dv}{dz} + v\frac{dC_i}{dz} = r_i$$

$$v\frac{dC_i}{dz} = r_i$$

$$\tau = \frac{V}{Q} \quad \tau = \frac{V/A}{Q/A} = \frac{z}{v}$$

$$d\tau = \frac{dz}{v}$$

$$v\frac{dC_i}{dz} = r_i$$

$$\frac{dC_i}{d\tau} = r_i$$

MM expression is introduced in the equation

Example: For enzyme reaction with MM model

$$\frac{dC_S}{d\tau} = r_S \quad -r_S = \frac{r_{\max} C_S}{K_m + C_S} \quad -\frac{dC_S}{d\tau} = \frac{r_{\max} C_S}{K_m + C_S}$$

if integrated

The change in substrate concentration with residence time

$$\tau = \frac{K_m}{r_{\max}} \ln \frac{C_S}{C_{S0}} + \frac{C_S - C_{S0}}{r_{\max}}$$