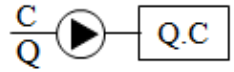
Transfer/Transport in bioreactors

1. Transport: FAST in ONE phase
Feeding, liquid pump, Aeration compressor
Mixing of stirred vessels or bubble columns



2. Transfer: SLOW between TWO phases
O_2 and CO_2 gas-liquid transfer in bioreactor
heat transfer in bioreactor

$K_L A(C^* - C)$

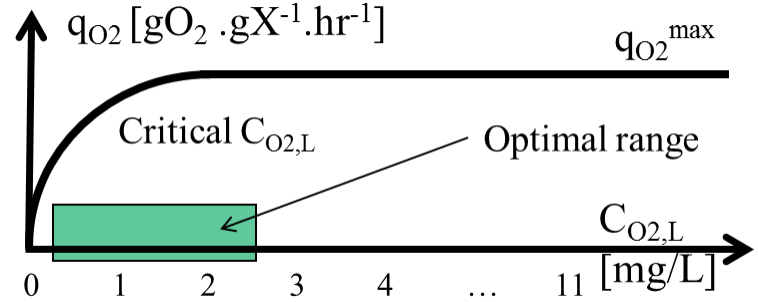
3. Transfer (Fick Diffusion) very SLOW in ONE phase
in biofilms
immobilized enzymes/organisms
in stagnant films at surfaces

$$-AD\frac{dC}{dX}$$

In bioreactor, at steady state

Biomass respiration $r_{O2} = q_{O2} \cdot X$ **[$gO_2 .m^{-3}.hr^{-1}$]**

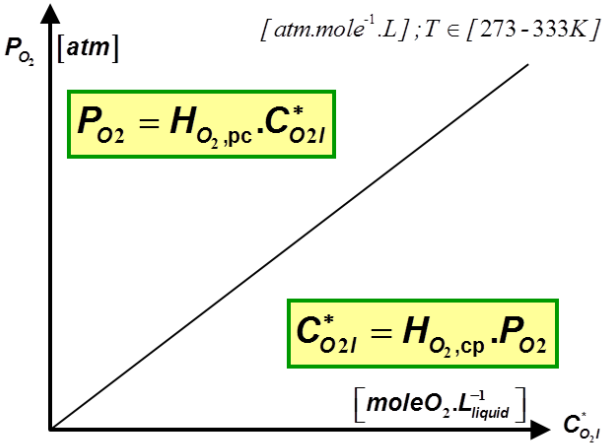
Oxygen transfer rate $OTR = k_L a\ (^*C_{O2} - C_{O2,l})$ **[$gO_2 .m^{-3}.hr^{-1}$]**



Henry's law H_{O2}

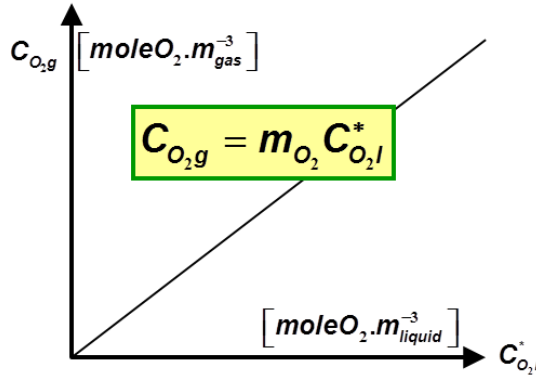
$$H_{O_2,pc} = exp(-8391.24/T - 23.24323 ln(T) + 167.2367)$$

$[atm.mole^{-1}.L]\ ; T \in [273-333K]$

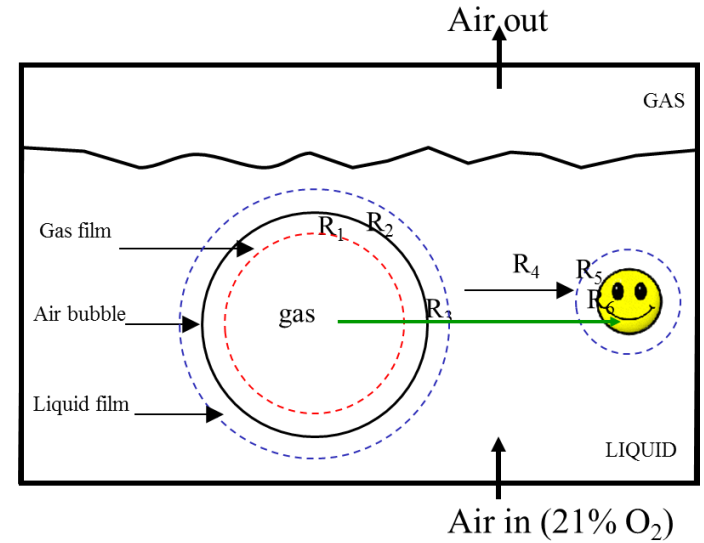


"**cp**" vs. "**pc**"
c: O_2 Concentration in liquid
p: O_2 partial Pressure in gas

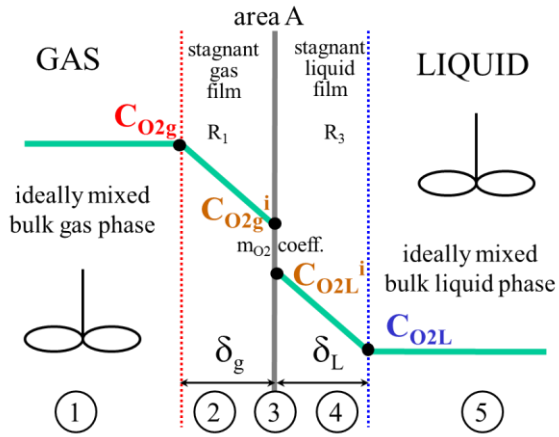
O_2 Gas-liquid partition



$$H_{O_2,pc} = m_{O_2} RT$$



Transfer/Transport in bioreactors



$$rate = Ak_g\left(C_{O_2g} - C^i_{O_2g}\right) = Ak_l\left(C^i_{O_2L} - C_{O_2L}\right) = K_L A\left(C^*_{O_2L} - C_{O_2L}\right) \quad with\ C^*_{O_2L} = m.C_{O_2g}$$

$$rate_{gas} = -\frac{AD_g}{\delta_g}\left(C^i_{O_2g} - C_{O_2g}\right) = Ak_g\left(C_{O_2g} - C^i_{O_2g}\right) \quad where\ k_g \overset{def}{=} \frac{D_g}{\delta_g}$$

$$rate_{liq.} = -\frac{AD_l}{\delta_l}\left(C_{O_2L} - C^i_{O_2L}\right) = Ak_l\left(C^i_{O_2L} - C_{O_2L}\right) \quad where\ k_l \overset{def}{=} \frac{D_l}{\delta_l}$$

$$C^i_{o_2g} = m.C^i_{o_2L}\ ;\ mO_2 = 32\ at\ 298K$$

$$\frac{1}{K_L} = \frac{1}{k_l} + \frac{1}{m.k_g}$$

$$K_L \approx k_L \overset{def}{=} \frac{D_l}{\delta_l} = \text{in order of } 10^{-4}\left[\text{m.s}^{-1}\right]$$

$$OTR = K_L.a\left(C^*_{O_2L} - C_{O_2L}\right)$$

$$K_L \approx 3-4\times10^{-4}\left[m.s^{-1}\right] \text{ then if a } \uparrow \Rightarrow K_La \uparrow$$

$$a = 6\frac{\varepsilon}{d_b}$$