

Immobilized Enzyme on a Reactor Surface with Product Inhibition  
(Use MathCAD's equation solver for multiple equations.)

Instructor: Nam Sun Wang

---

Operating parameters:

$$F := 3 \cdot \text{cm}^3 \cdot \text{sec}^{-1} \quad \dots \text{volumetric flow rate}$$

$$A := 100 \cdot \text{cm}^2 \quad \dots \text{surface area of immobilized enzyme}$$

$$s_f := 10 \cdot \text{g} \cdot \text{liter}^{-1} \quad \dots \text{feed substrate concentration}$$

$$k_L := 0.01 \cdot \text{cm} \cdot \text{sec}^{-1} \quad \dots \text{mass transfer coefficient}$$

Reaction parameters:

$$v_m := 0.0001 \cdot \text{g} \cdot \text{sec}^{-1} \cdot \text{cm}^{-2} \quad \dots \text{maximum reaction rate}$$

$$K_m := 1 \cdot \text{g} \cdot \text{liter}^{-1} \quad \dots \text{Michaelis-Menten constant}$$

$$K_p := 1 \quad \dots \text{product inhibition constant}$$

$$v(s, p) := \frac{v_m \cdot s}{K_m + s + K_p \cdot p}$$

Material balance equations for the rate of conversion are given below:

$$r_1(s_b) := F \cdot (s_f - s_b)$$

$$r_2(p_b) := F \cdot p_b$$

$$r_3(s_b, s) := A \cdot k_L \cdot (s_b - s)$$

$$r_4(p_b, p) := A \cdot k_L \cdot (p - p_b)$$

$$r_5(s, p) := A \cdot v(s, p)$$

The above 5 equations can be solved simultaneously.

$$s_b := 0 \cdot \text{g} \cdot \text{liter}^{-1} \quad s := 0 \cdot \text{g} \cdot \text{liter}^{-1} \quad p_b := 0 \cdot \text{g} \cdot \text{liter}^{-1} \quad p := 0 \cdot \text{g} \cdot \text{liter}^{-1} \quad \dots \text{Initial guesses}$$

Given

$$r_1(s_b) = r_2(p_b)$$

$$r_2(p_b) = r_3(s_b, s)$$

$$r_3(s_b, s) = r_4(p_b, p)$$

$$r_4(p_b, p) = r_5(s, p)$$

$$\begin{bmatrix} s_b \\ s \\ p_b \\ p \end{bmatrix} := \text{Find}(s_b, s, p_b, p) \quad \begin{bmatrix} s_b \\ s \\ p_b \\ p \end{bmatrix} = \begin{bmatrix} 8.63 \\ 4.521 \\ 1.37 \\ 5.479 \end{bmatrix} \cdot \text{g} \cdot \text{liter}^{-1}$$