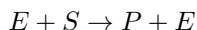
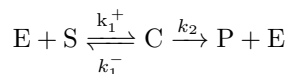


Enzyme kinetics

In our previous discussions, we determined that (under the Law of Mass Action) the model



does not fit empirical data very well. Michaelis and Menton developed the model



which fits experimental results much better. By performing equilibrium analysis, we concluded that the rate of the reaction is

$$V = \frac{dp}{dt} = \frac{V_{max} \cdot [S]}{K_D + [S]}$$

However, this still assumed that $\frac{d}{dt}[S] \approx 0$...which is a problem. If we assume that enzymes are primarily occupied with binding substrate, then instead we can set $\frac{d}{dt}[C] \approx 0$...that is, the concentration of the substrate/enzyme complex remains more or less consistent. From this, we can derive the following.

$$\frac{dc}{dt} = k_1^+[S][E] - (k_1^- + k_2)[C]$$

Since $\frac{dc}{dt} \approx 0$, we have

$$k_1^+[S][E] = (k_1^- + k_2)[C]$$

$$[C] = \frac{k_1^+}{k_1^- + k_2}[S][E]$$

We are interested in

$$V = \frac{dp}{dt} = k_2[C]$$

in terms of $[S]$.

$$[C] = \frac{k_1^+}{k_1^- + k_2}[S](e_0 - [C]) = \frac{e_0[S]}{\frac{k_1^+}{k_1^- + k_2} + [S]} = \frac{e_0[S]}{K_M + [S]}$$

Therefore,

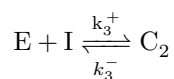
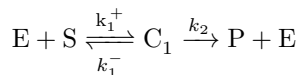
$$V = \frac{dp}{dt} = k_2 \frac{e_0[S]}{K_M + [S]} = \frac{V_{max} \cdot [S]}{K_M + [S]}$$

Inhibition

- competitive
- allosteric

You can distinguish these two by changing the substrate concentration and observing the maximum reaction velocity (rate).

Competitive inhibition



Let's assume $\frac{dc_1}{dt} \approx 0$ and $\frac{dc_2}{dt} \approx 0$.

$$[C_1] = \frac{k_i e_0 [S]}{K_M [I] + k_i [S] + K_m k_i}$$

$$[C_2] = \frac{K_m e_0 [I]}{K_M [I] + k_i [S] + K_m k_i}$$

$$k_i = \frac{k_3^-}{k_3^+} \quad (\text{dissociation constant of inhibitor})$$

$$k_m = \frac{k_2 + k_1^-}{k_1^+}$$

$$V = \frac{dp}{dt} = k_2 [C_1] \frac{k_2 e_0 [S] k_i}{k_m [I] + k_i [S] + k_m k_i} = \frac{[S] V_{max}}{[S] + k_m \left(1 + \frac{[I]}{k_i}\right)}$$

$$V = \frac{V_{max} \cdot [S]}{[S] + k_m \left(1 + \frac{[I]}{k_i}\right)}$$

If we saturate with substrate, we will still get maximum velocity eventually.

Allosteric inhibition

$$V = \frac{V_{max}}{1 + \frac{i}{k_i}} \cdot \frac{[S]}{k_m + [S]}$$

In allosteric inhibition, the maximum velocity is reduced.