CH2110

Ping Pong Equation

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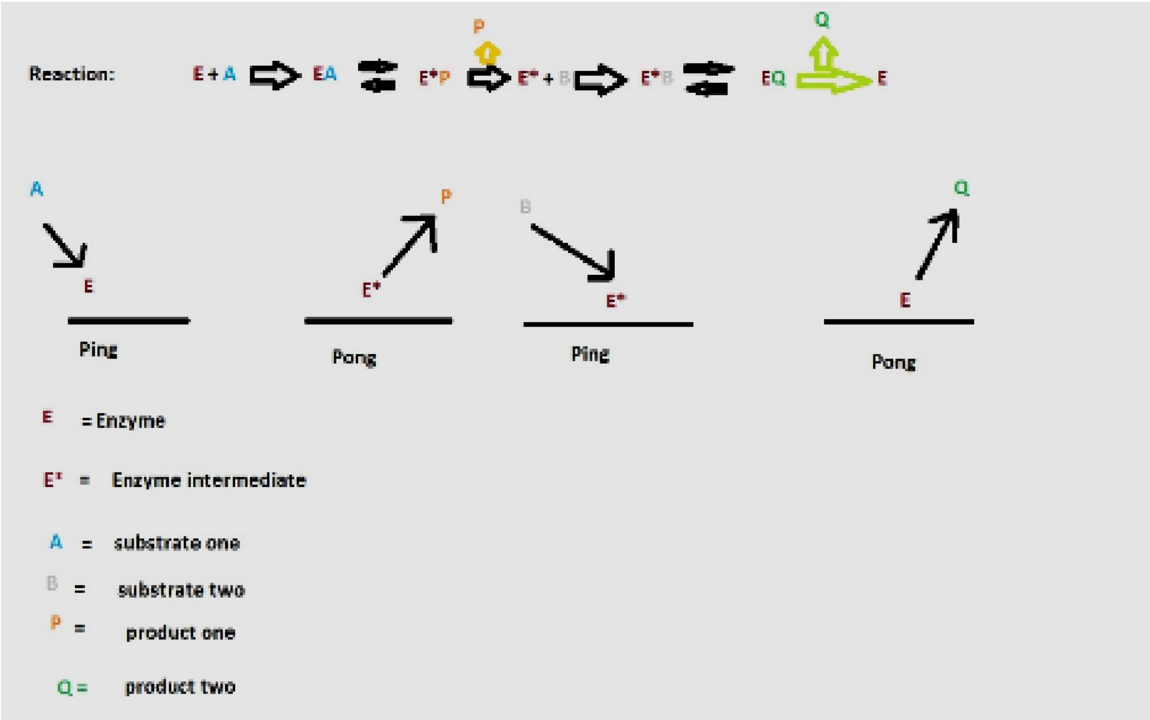
Ping Pong Equations

➢ MECHANISM

The ping pong reaction is a special multisubstrate reaction especially involving two-substrate,two-product system in which an enzyme reacts with one substrate to form a product and a modified enzyme.This modified enzyme upon reaction with second substrate forms a second,final end product and regenerates the original enzyme.Ping pong reaction is a typical example of non-sequential reaction,which don't require both the substrates to bind before releasing first product.This reaction is named as “ping-pong” equation because the enzyme bounces back and forth from an intermediate state to its standard state.The enzyme acts just like a ping-pong ball,bouncing back and forth from one state to another.

The ping-pong mechanism, also called the double-displacement reaction,involves changing of the enzyme into an intermediate form when the first substrate to product reaction occurs. The word intermediate, suggests that this type is only transient(temporary form). The enzyme should be located at the end of the reaction in its original state.A key characteristic of this reaction is that a product is formed and released before the second substrate binds. An enzyme is characterised by the fact that it participates and is not absorbed in the reaction.

Following is an illustration of ping-pong equation :



In the above reaction, substrate A binds to the enzyme(E) forming [EA](enzyme-substrate complex). This followed by the formation of E*, an intermediate state of enzyme.P is then released from E* and B gets bound to E*.B is then converted to Q, which is released as the second product. E* gets its original form i.e, E, and the process can be repeated. Sometimes, E* might contain a fragment of the original substrate A. This fragment when attached to B, can change the function of the enzyme or both.

Rate Constant Equations

→ The rate equation can be defined as:

$$V = K_{cat}[E_{AB}],$$

where $[E_{AB}]$ is the concentration of the A-B complex.

→ The total enzyme concentration,

$$E_0 = E + E_A + E_B + E_{AB}$$

→ The dissociation constants are:

$$K_{ia} = \frac{[E][A]}{[E_A]} \qquad K_{ib} = \frac{[E][B]}{[E_B]}$$

$$K_a = \frac{[E_B][A]}{[E_{AB}]} \qquad K_b = \frac{[E_A][B]}{[E_{AB}]}$$

Substituting these in the above equation we get,

→ Total enzyme concentration:

$$[E_0] = \frac{K_{ia} K_b [EAB]}{[A][B]} + \frac{K_b [EAB]}{[B]} + \frac{K_a [EAB]}{[A]} + [EAB]$$

→ And the rate equation becomes,

$$V = K_{cat} [EAB]$$

$$V = K_{cat} \cdot \frac{[E_0]}{\frac{K_{ia} K_b}{[A][B]} + \frac{K_b}{[B]} + \frac{K_a}{[A]} + 1}$$

→ We know Vmax i.e. $V_M = K_{cat} [E_0]$

Therefore,

$$\boxed{\frac{1}{V} = \frac{1}{V_M} \left(\frac{K_{ia} K_b}{[A][B]} + \frac{K_b}{[B]} + \frac{K_a}{[A]} + 1 \right)}$$

➢ EXAMPLES

1.Pyruvate Carboxylase :

Pyruvate Carboxylase is a biotin-containing enzyme that exhibits a Ping-pong mechanism. This enzyme catalyzes the addition of carbon dioxide to pyruvate to form oxaloacetate. This enzyme(E) binds with CO_2(A)and forms Carboxybiotin(EA). The biotin swings over towards pyruvate (E*P) and releases CO_2. Pyruvate (B),in the presence of CO_2, attacks the partial positive of Carbon in CO_2 (E*B) resulting in the formation of Oxaloacetate within the enzyme (EQ) and gets released (Q).During the attack, biotin gets back to its initial position, (E* --> E) and is ready to bind another CO_2.This process continues.

2.Chymotrypsin :

Chymotrypsin, when reacted with p-nitrophenyl acetate (A), two steps occur. In the first step, the substrate reacts extremely fast with the enzyme, leading to the formation of a small amount of p-nitrophenolate (P). In the second step, the substrate-enzyme interaction results in the formation of acetate ion (Q). This is a ping-pong reaction because the binding of the two substrates causes the enzyme to switch back and forth between two states.

References

1. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical engineering fundamentals*. New York: McGraw-Hill.

2. http://www.pasqualepetrilli.it/Didattica/Cinetica/BiblioCinet/Relaxation%20Methods.pdf

3. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000665/M018695/ET/1515662178CHE_P10_M32_etext.pdf

4. https://nptel.ac.in/content/storage2/courses/122101001/downloads/lec-27.pdf

5. https://www.slideserve.com/neena/determining-rate-constants-with-relaxation-method

6. https://chem.libretexts.org/Bookshelves/Biological_Chemistry/Supplemental_Modules_(Biological_Chemistry)/Enzymes/Enzymatic_Kinetics/Ping-pong_mechanisms