$$
\begin{array}{ccccc}
E + S & \underset{}{\overset{K_m'}{\rightleftharpoons}} & ES & \xrightarrow{k_2} & E + P \\
 & & + & & \\
 & & S & & \\
 & & \Big\downarrow\!\!\Big\uparrow K_{S_1} & & \\
 & & ES_2 & &
\end{array}
\tag{3.32}
$$

With the definitions of

$$
K_{S_1} = \frac{[S][ES]}{[ES_2]}, \quad K_m' = \frac{[S][E]}{[ES]} \tag{3.33}
$$

the assumption of rapid equilibrium yields

$$
v = \frac{V_m[S]}{K_m' + [S] + \dfrac{[S]^2}{K_{S_1}}} \tag{3.34}
$$

A double-reciprocal plot describing substrate inhibition is given in Fig. 3.10.

At low substrate concentrations, $[S]^2/K_{S_1} << 1$, and inhibition effect is not observed. The rate is

$$
v = \frac{V_m}{\left[1 + \dfrac{K_m'}{[S]}\right]} \tag{3.35}
$$

or

$$
\frac{1}{v} = \frac{1}{V_m} + \frac{K_m'}{V_m}\frac{1}{[S]} \tag{3.36}
$$

A plot of $1/v$ versus $1/[S]$ results in a line of slope K_m'/V_m and intercept of $1/V_m$.

At high substrate concentrations, $K_m'/[S] << 1$, and inhibition is dominant. The rate in this case is

$$
v = \frac{V_m}{\left(1 + \dfrac{[S]}{K_{S_1}}\right)} \tag{3.37}
$$

or

$$
\frac{1}{v} = \frac{1}{V_m} + \frac{[S]}{K_{S_1}V_m} \tag{3.38}
$$

A plot of $1/v$ versus $[S]$ results in a line of slope $1/K_{s_1} \cdot V_m$ and intercept of $1/V_m$.