Figure 3.3. Effect of substrate concentration on the rate of an enzyme-catalyzed reaction.

It is assumed that the ES complex is established rather rapidly and the rate of the reverse reaction of the second step is negligible. The assumption of an irreversible second reaction often holds only when product accumulation is negligible at the beginning of the reaction. Two major approaches used in developing a rate expression for the enzyme-catalyzed reactions are (1) rapid-equilibrium approach and (2) quasi-steady-state approach.

3.3.2. Mechanistic Models for Simple Enzyme Kinetics

Both the quasi-steady-state approximation and the assumption of rapid equilibrium share the same few initial steps in deriving a rate expression for the mechanism in eq. 3.1, where the rate of product formation is

$$v = \frac{d[P]}{dt} = k_2[ES] \tag{3.2}$$

where v is the rate of product formation or substrate consumption in moles/l-s.

The rate constant k_2 is often denoted as k_{cat} in the biological literature. The rate of variation of the ES complex is

$$\frac{d[ES]}{dt} = k_1[E][S] - k_{-1}[ES] - k_2[ES] \tag{3.3}$$

Since the enzyme is not consumed, the conservation equation on the enzyme yields

$$[E] = [E_0] - [ES] \tag{3.4}$$

At this point, an assumption is required to achieve an analytical solution.

3.3.2.1. The rapid equilibrium assumption. Henri and Michaelis and Menten used essentially this approach. Assuming a rapid equilibrium between the enzyme and