At steady state, the reaction rate is equal to the mass-transfer rate:

$$J_s = k_L\left([S_b]-[S_s]\right) = \frac{V_m'[S_s]}{K_m + [S_s]} \tag{3.53}$$

where V_m' is the maximum reaction rate per unit of external surface area and k_L is the liquid mass-transfer coefficient. This equation is quadratic in $[S_s]$, the substrate concentration at the surface. It can be solved analytically, but the solution is cumbersome. Furthermore, the value of $[S_s]$ is not amenable to direct experimental observation.

Equation 3.53 can be solved graphically as depicted in Fig. 3.18. Such a plot also makes it easy to visualize the effects of parameter changes such as stirring rate, changes in bulk substrate concentration, or enzyme loading.

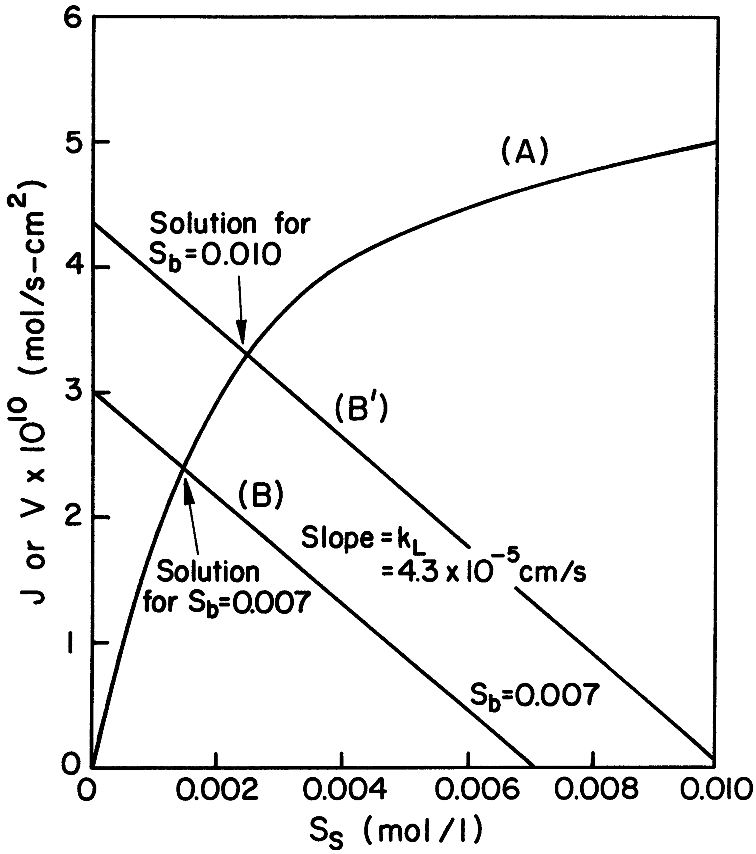

Figure 3.18. Graphical solution for amount of reaction per unit surface area for enzyme immobilized on a nonporous catalyst. Curve A results from a knowledge of the intrinsic solution-based kinetic parameters and the surface loading of enzyme (right side of eq. 3.53). Line B is the mass transfer equation (left side of eq. 3.53). The intersection of the two lines is the reaction rate, υ, that can be sustained in the system. The responses for two different bulk substrate concentrations are shown.