LETTERS TO THE EDITOR

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In a recent paper by Kulkarni and Doraiswamy (1975), the concept of the effectiveness factor was extended to gas-liquid reactions by defining a new parameter $\beta (= 1/a\delta)$, where a is the interfacial area and δ is the film thickness. They interpreted β as the ratio of the area per unit volume in the film $1/\delta$ to that in the liquid a.

It sounds more clearly if we explain β as the ratio of the total liquid volume ($= V =$ unity, in the original paper unit volume was chosen) to the liquid film volume ($= a\delta$). In a real gas-liquid system $V \geqq a\delta$, and therefore $\beta \geqq 1$. Although there is no mathematical problem to express $\beta \to 0$, the value of β should be, in reality, never smaller than unity. On this reason, it is suggested the curves of $\beta < 1$ on Figure 2 of the original paper be removed.

Literature Cited

Kulkarni, B. D., and L. K. Doraiswamy, "Effectiveness Factors in Gas-Liquid Reactions," *AIChE J.*, **21**, 501 (1975).

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TO THE EDITOR:

We refer to the letter by Ku-Yen Li regarding our paper "Effectiveness Factors in Gas-Liquid Reactions." It appears that there is some confusion about the definition of the new parameter $\beta [= 1/a\delta]$ where a is the area per unit volume of the bulk and δ is the film thickness. Conventionally a is defined as the area per unit total volume [film + bulk], but in anticipation of the difficulties explained in the paper, we have defined a here as mentioned above. In reality, the liquid film volume is negligible in comparison with the volume of the liquid bulk, so that the interfacial area a defined on the basis of unit volume of the bulk will almost be the same as that defined conventionally [on the basis of total volume]. Thus it can be seen that β will approach zero as the volume of the bulk approaches zero [which corresponds to gas-solid catalytic reactions].

The parameter β is defined in this way because, in the kinetic boundary condition [Equation 6 or 13] employed, the mass flux at the end of the film is equated to the amount consumed by reaction in the bulk:

$$-D_A \frac{\partial C_A}{\partial y}\bigg|_{y=\delta} = \frac{k_1 C_{A0}}{a}$$

If a is based on the total volume, this equation would not be valid because a would then include the film also, and the equation would have to be modified as

$$-D_A \frac{\partial C_A}{\partial y}\bigg|_{y=\delta} = \frac{k_1 C_{A0}}{a} - k_1 C_{A0}\delta$$

For the case of reaction complete in the bulk, Equation [9] of the paper will read as

$$\eta = \frac{1}{1 - m^2 [1 - \beta]}$$

For the limiting value of $\beta = 1$ [when a is based on total volume], $\eta = 1$ and this regime merges with the kinetic regime [there is no parallel to this regime in gas-solid catalytic reactions]. For the case of reaction in the film and rest in the bulk, the effectiveness factor will be given by

$$\eta = \frac{1}{\beta}\left[\frac{[\beta - 1]}{\cosh m} w_{A0} + \frac{\tanh m}{m}\right]$$

which for the limiting value of $\beta = 1$ also reduces to that for gas-solid reactions.

Thus, depending on the definition of the parameter β, different expressions can be obtained. If β is defined as in the original paper then the limiting value of β can be zero. On the contrary, if a is defined on the basis of total volume the limiting value of β will be unity; there is no need then to extend β to zero, since $\beta = 1$ will itself reduce the general equations to those for gas-solid systems as shown above.

Hence for the definition of β employed in the original paper Figure 2 should remain unchanged along with its curve for $\beta = 0$.

A relationship between the two definitions of β can be readily established. If β' is the parameter based on true interfacial area and β is that defined in the original paper, then

$$\beta' = \frac{1}{1 + \beta}$$

For the limiting value of $\beta = 0$ [as appears in Figure 2] the limiting value of β' [as suggested by Ku-Yen Li] will be unity.

It may be mentioned that Ku-Yen Li's remarks are based on a comparison of the volume V with the product $a\delta$. This does not appear to be correct since V has the dimensions of volume while $a\delta$ is dimensionless.

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