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Letter to the editor

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We think that the paper "Mass transfer in fixed bed solid dissolution" published in Chemical Engineering Journal 69 (1998) 39–45 has not been justified properly. The items we are concerned about are as follows:

(1) Eq. (1) as follows cannot be a suitable form to define individual mass transfer coefficient.

$$\bar{v}_{\mathrm{D}} = k_1(C_A^* - C_A). \tag{1}$$

In this equation it is not clear that mean dissolution rate, $\bar{v}_{\mathrm{D}}$, (kg $\mathrm{m^{-2}s^{-1}}$) is based on which area whereas it could be either the cross-sectional area of the bed or interfacial area. It is obvious that cross-sectional area cannot be correct since mass transfer occurs around each solid particle. The real interface area for mass transfer between solid particles and solvent is less than the total surface area of particles because of dead area of contacts, i.e., k_1 depends on the number and size of particles.

(2) In Eq. (2),

$$v_{\mathrm{D}} = -\frac{\mathrm{d}m}{S\,\mathrm{d}t} \tag{2}$$

it is assumed that all particles are identical and during dissolution process have same dissolution rate. This assumption cannot be correct since the density of particles, 1335 kg $\mathrm{m^{-3}}$, makes them settle down and therefore, the outer particles in the bed have more dissolution rate than the inner ones. In other words, this assumption inevitably postulates the constancy of the number of particles during dissolution process. It is believed that, so far, no one has reported that during dissolution processes the number of particles remains constant.

(3) Eq. (6),

$$d_{\mathrm{p}} = d_{\mathrm{p}}^0\left[\frac{H}{H_0}\right]^{1/3} \tag{6}$$

is used by the authors to determine the dependency of particle diameter on time of dissolution and its results are presented in Figs. 3–8. These figures clearly show that:

(A) the dependency of particle diameter on time is not as simple as is described by Eq. (6) but it is dependent on some other variables as solvent flow rate.

(B) even in fixed solvent flow rate, this equation is not able to illustrate the dependency of particle diameter properly as different curves are not parallel.

(4) Eq. (4),

$$v_{\mathrm{D}} = \frac{-\rho_s}{2}\frac{\mathrm{d}d_{\mathrm{p}}}{\mathrm{d}t} \tag{4}$$

and Figs. 3–8 are used by authors to determine the particle dissolution rate. The applied method is not logical as the curves in these figures are not straight and their slopes are variable. A logical method to determine the particle dissolution rate is as follows:

$$-\frac{\mathrm{d}m}{\mathrm{d}t} = -\rho_s S\frac{\mathrm{d}h}{\mathrm{d}t} = kN\pi d_p^2(C_A^* - C_A), \tag{I}$$

where N is the number of particles and d_{p} represents diameter of each particle. Relationship between particle diameter and the fixed bed porosity can be shown by the following equation:

$$N\frac{\pi d_{\mathrm{p}}^3}{6} = S\cdot h(1-\varepsilon).$$

If it can be assumed that ε and N are constant, then

$$\left(\frac{d_0}{d}\right)^3 = \frac{h_0}{h}$$

or

$$d = d_0\left(\frac{h}{h_0}\right)^{1/3} \tag{II}$$

Substituting Eq. (II) in Eq. (I) gives:

$$kN\pi d_0^2\left(\frac{h}{h_0}\right)^{2/3}(C_A^* - C_A) = -\rho_s S\frac{\mathrm{d}h}{\mathrm{d}t}$$

$$\frac{kN\pi d_0^2}{\rho_s S}\left(\frac{1}{h_0}\right)^{2/3}(C_A^* - C_A) = -h^{-2/3}\frac{\mathrm{d}h}{\mathrm{d}t}$$

$$\alpha(C_A^* - C_A)\,\mathrm{d}t = -h^{-2/3}\,\mathrm{d}h, \tag{III}$$

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where in Eq. (III) α is equal to $kN\pi d_0^2/\rho_s S(1/h_0)^{2/3}$. Integrating Eq. (III) as follows gives:

$$\alpha \int_{t=0}^{t} (C_A^* - C_A)\,\mathrm{d}t = -\int_{h=h_0}^{h} h^{2/3}\,\mathrm{d}h$$

$$\alpha (C_A^* - C_A)_m t = -3h^{1/3}$$

or

$$\alpha' (C_A^* - C_A)_m t = -h^{1/3}. \tag{IV}$$

By taking logarithm from both sides of Eq. (IV) we will have:

$$\log h = -3\log t - 3\log \alpha' (C_A^* - C_A)_m \tag{V}$$

Eq. (V) shows that the mean individual mass transfer coefficient could be determined by plotting h versus t in log–log diagram and determining the intercept. As indicated by authors in the sixth page of their paper the experimental values obtained by them for mass transfer coefficient are smaller than other data reported in literature. The reason for this discrepancy is that they inherently assumed all particles are suspended in solvent and have equal interface with solvent whereas in practice the contacted area of each particle is not involved actively in mass transfer process.