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Letter to the editor

Reply to 'Comments on ''An adsorption and kinetic study of lac dyeing on silk''' by Yuh-Shan Ho: Discussion on pseudo second order kinetic expression

In reaction to the comments by Dr. Y.S. Ho [1] on the work of Chairat et al. [2], we would like to address the following topics:

Firstly, we would like to point out that it is well known to the researchers in this area that pseudo first order kinetic expression was proposed by Lagergren [3]. The wide acceptability of models by the scientific community is the best means of providing credibility to such models [4]. Thus it is no longer necessary to mention original references to every published paper. Secondly, Ho commented to cite his papers for pseudo second order kinetics. We would like to point out that in 1984, Blanchard et al's [5] proposed a second order rate equation for the exchange reaction of divalent metallic ions onto NH_4^+ ions fixed zeolite particles. The linearized form of Blanchard et al. [5] second order kinetics was given by:

$$\frac{1}{q_e - q} - \alpha = kt \tag{1}$$

where q_e and q represent the amount of dye adsorbed at equilibrium and at any time t and are represented in terms of mg/g, k is the second order rate constant. The rate constant can be obtained from the slope of plot between $1/(q_e - q)$ vs. time t. Applying boundary conditions $q = 0$ for $t = 0$, it follows that $\alpha = 1/q_e$. Thus this model has an advantage to predict the equilibrium uptake capacity without the support of experimental data. The non-linearized form of Eq. (1) can be given by:

$$q = \frac{ktq_e + \alpha q_e - 1}{kt + \alpha} \tag{2}$$

Applying the value of α in Eq. (1) and rearranging, the non-linearized form of pseudo second order expression can be obtained as follows:

$$q = \frac{q_e^2 kt}{1 + kq_e t} \tag{3}$$

Eq. (3) can be linearized to different types as shown in Table 1. From Table 1, it was clear that pseudo second order kinetics can be linearized to at least four types: type 1, type 2, type 3 and type 4. Table 1 also shows the way to obtain the kinetic parameters from these linearized pseudo second order expressions. Out of the four linearized forms of pseudo second order expression shown in Table 1, type 1 was reported by Ho and McKay in 1998 for the sorption of dye ions onto peat particles. Thus it is evident that pseudo second order model for solid/liquid adsorption systems is not proposed by Ho but by Blanchard et al. [5] and only a linearized expression was proposed by Ho. In the adsorption field, Langmuir isotherm [6] has been the most widely used isotherm to represent the adsorption process at equilibrium conditions. In literatures, four linearized types of Langmuir isotherms have been reported [7–10]. Irrespective of the linearized expressions reported, it has been widely called the Langmuir isotherm. It is not right to bargain that the Langmuir model was derived or proposed by the other authors who had transformed the original Langmuir expression to a new linear expression. Thus we would

Table 1
Different linearized forms of pseudo second order expression

Type	Linear form	Plot	Parameters
Type 1	$\frac{t}{q} = \frac{1}{kq_e^2} + \frac{1}{q_e}t$	t/q_t vs. t	$q_e = 1/\text{slope}$ $K_2 = \text{slope}^2/\text{intercept}$ $h = 1/\text{intercept}$
Type 2	$\frac{1}{q} = \left(\frac{1}{kq_e^2}\right)\frac{1}{t} + \frac{1}{q_e}$	$1/q_t$ vs. $1/t$	$q_e = 1/\text{intercept}$ $K_2 = \text{intercept}^2/\text{slope}$ $R = 1/\text{slope}$
Type 3	$\frac{1}{t} = \frac{K_2 q_e^2}{q} - \frac{K_2 q_e^2}{q_e}$	$1/t$ vs. $1/q$	$q_e = -\text{slope}/\text{intercept}$ $K_2 = \text{intercept}^2/\text{slope}$ $R = \text{slope}$
Type 4	$\frac{q}{t} = K_2 q_e^2 - \frac{K_2 q_e^2 q}{q_e}$	q/t vs. q	$q_e = -\text{intercept}/\text{slope}$ $K_2 = \text{slope}^2/\text{intercept}$ $R = \text{intercept}$

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like to make a clear note to the readers that pseudo second order model was not proposed by Ho, it was originally reported by Blanchard et al. [5]. Ho has just used the original information of Blanchard et al. [5] with his own arguments. As mentioned by Ho [1] that ''poor referencing reflects on the article, the authors, and the journal itself'', we suggest the researchers in our field to cite the paper by Blanchard et al. [5] for pseudo second order kinetic model. In addition, we like to cite the paper of Blanchard et al. [5] for pseudo second order kinetic model for the citation error we had made in our paper that the paper by Blanchard et al. [5] should be read.

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