An exponential kinetic model for adsorption at solid/solution interface

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HIGHLIGHTS

- ► A new kinetic model was proposed for adsorption at solid/solution interface.
- ► The exponential kinetic model can be applied for homo- and heterogeneous surfaces.
- ► Driving force of new model is a combination of PFO and PSO models driving forces.

GRAPHICAL ABSTRACT
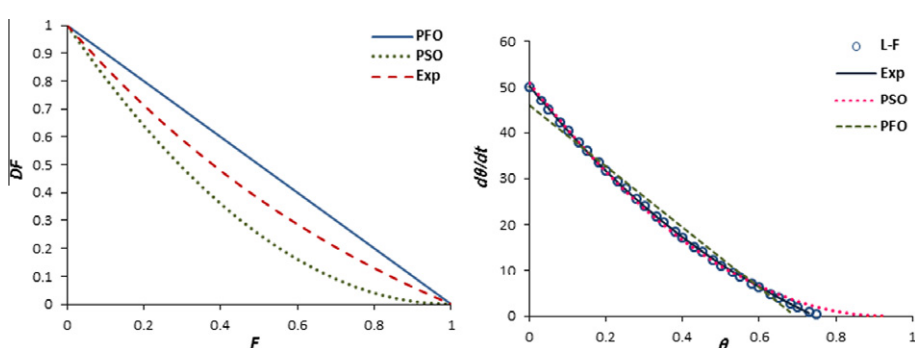
ABSTRACT

An exponential kinetic model has been proposed for modeling of adsorption kinetics at the solid/solution interface. This new equation was compared with pseudo first-order (PFO) and pseudo second-order (PSO) equations as the well-known two parametric models. Based on numerically generated data points (t,q) by using of statistical rate theory equation for homogeneous surfaces, it has been shown that we can use the new model for homogeneous solid surfaces as well as the pseudo second-order model. Moreover, the driving force of new model is a combination of driving forces of PFO and PSO equations. However, using Langmuir–Freundlich equation to generate kinetic data for heterogeneous surfaces, it has been shown that the kinetic data can be described by PFO model when the adsorption rate coefficient is smaller than the desorption rate coefficient; but, when the adsorption rate coefficient is bigger than the desorption rate coefficient, which is more favorite for practical application, the new exponential model shows better agreement with kinetic data. The main advantage of using the new model for heterogeneous systems is its simplicity in comparison with Langmuir–Freundlich kinetic model which there is no analytical solution for it. Finally, the results of fitting to the experimental data represent that exponential model can describe kinetics of adsorption for both homo- and heterogeneous systems very well.

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1. Introduction

For many years, adsorption has been used extensively for gas separation and wastewater treatment. Because of facility and high economical efficiency of this process, predicting the rate of adsorption is one of the most essential factors for the effective sorption system design.

There are several models for adsorption kinetics at the solid/solution interface. The most popular and simple equation is Langmuir kinetic model [1] which is related to an ideal energetically homogeneous solid surface. Integrated kinetic Langmuir equation (IKL) [2] is a complete analytical solution of the Langmuir kinetic model that it is necessary to consider some limitations for using this equation. On the other hand, Langmuir–Freundlich rate equation [3] is a model to consider the heterogeneity effects but there is no analytical solution for this model. Another kinetic model is statistical rate theory (SRT) [4,5] which is based on theoretical concepts of quantum mechanics and thermodynamics [6,7]. However, there is no analytical solution for this equation. Pseudo first-order (PFO) [8] and pseudo second-order (PSO) [9] are popular

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