

Short-term adsorption of gold using self-flocculating microalga from wastewater and its regeneration potential by bio-flocculation

Supplementary material

Na Shen* and Evans M.N. Chirwa

Department of Chemical Engineering, University of Pretoria, Pretoria, 0028, South Africa

nashen2016@gmail.com

Adsorption isotherm

The Langmuir isotherm model (1918) essentially describes the monolayer type of adsorption and it is expressed as the following linearized Eq. (1):

$$\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{bq_m} \quad (1)$$

Where, q_e is the amount of metal ions absorbed at equilibrium (mg g^{-1}); C_e is the equilibrium concentration of metal ions remaining in the solution (mg L^{-1}); q_m represents the maximum adsorption capacity (mg g^{-1}) and b is a constant related to the energy of adsorption (L mg^{-1}).

The Freundlich isotherm (1906) is represented by the linearized equation as follows:

$$\ln q_e = \ln K_f + \frac{1}{n} \ln C_e \quad (2)$$

Where, K_f is the Freundlich constant related to adsorption capacity of biomass, and n is a constant indicative of biosorption intensity.

Adsorption kinetics

The linearized expression for the Pseudo-first-order is given by the following equation:

$$\ln(q_e - q_t) = \ln q_e - k_1 t \quad (3)$$

The expression for the Pseudo-second-order is given by the following linearized equation:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \quad (4)$$

Where, k_1 is the rate constant of Pseudo-first-order adsorption (min^{-1}) and k_2 is the rate constant of second-order adsorption ($\text{g mg}^{-1} \text{min}^{-1}$).

Thermodynamics of adsorption

Based on the thermodynamics, the relation between ΔG° and the equilibrium constant (K) is given by the equation (5):

$$\Delta G^\circ = - RT \ln (K) \quad (5)$$

Again, ΔH° and ΔS° of the reaction at constant temperature is related to the ΔG° according to the following equation:

$$\ln (K) = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{RT} \quad (6)$$

Where, K can be considered as the Langmuir constant, b if the system follows Langmuir isotherm and R is the universal gas constant ($8.314 \text{ J mol}^{-1} \text{ K}^{-1}$). The thermodynamic parameters determine the spontaneity of the reaction and randomness of the system during the sorption process. The ΔH° and ΔS° values of adsorption are measured from the slope and the intercept of the plot between $1/T$ versus $\ln (K)$.