Chapter 8

Improvement of RSM Prediction and Optimization by Using Box–Cox Transformation: Separation of Colloidal Contaminants From Mineral Processing Effluents via Electrocoagulation

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ABSTRACT

Electrocoagulation can be effectively used in the elimination of the colloids from the tailings of the mineral industries. Owing to the numerous operational parameters of this physicochemical process, the best engineering technique for the characterization of the process is RSM. In this chapter, a non-transformed quadratic model is firstly formed considering the supernatant turbidity of the electrocoagulation experiments as a function of temperature, pH, and electrical current. Then, the non-normality and the heteroscedasticity of this initial model was indicated. These drawbacks were improved by using the Box-Cox transformation with λ of -0.32 and a new model with a perfect normality and homoscedasticity was obtained. The R2 value increased from 81.60% to 99.48% and adjusted R2 increased from 48.48% to 99.22% upon the transformation. According to the confirmed optimization results of the Box-Cox transformed model, the maximum desirability was obtained at pH of 5, temperature of 85°C, and electrical current of 0.25A, and the supernatant turbidity decreased down to 2.25 NTU.

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INTRODUCTION TO THE REMOVAL OF THE COLLOIDAL CONTAMINANTS

The turbidity generating particles in natural waters and wastewaters stem from mineral dissolution, land erosion, the vegetation decay, and industrial waste discharges. Such contaminated waters may contain suspended and/or dissolved organic and/or inorganic materials, such as clay, quartz, hematite, pyrite, iron oxides and hydroxides etc. and various biological forms (Bratby, 2006). The main physical, chemical and physicochemical properties of these contaminants can significantly change due to the variation in different environmental parameters and natural conditions. For that reason, total solid content, zeta potential-surface charge, identification of solid crystals and their aqueous behavior, sedimentation characteristics, colloidal stability, EDL-Electrical Double Layer and other related parameters in solution and suspension should be clearly ascertained prior to the proper treatment of wastewater (Tchobanoglous, Burton, & Stensel, 2003).

In general, there are different wastewater processing techniques including biological processes for nitrification, denitrification, and phosphorus removal and physicochemical treatment processes for filtration, air stripping, adsorption, ion-exchange, chemical precipitation, oxidation, carbon adsorption, ultrafiltration, reverse osmosis, electrodialysis, volatilization, and gas stripping. The common physicochemical processes such as froth flotation, coagulation, and flocculation require the addition of chemicals. However, electrochemical processing techniques that include electrocoagulation (Ashraf, Sarfraz, Naureen, & Gharibreza, 2015), electroflotation, and electrodewatering do not require any chemical additions (Mollah, Schennach, Parga, & Cocke, 2001).

In mineral industry, wastewaters discharged from the processing plants are named as tailings. Mineral concentration processes like gravity separation, froth flotation, leaching etc. generally produce contaminated turbid tailings including suspended and colloidal particles, such as clays. Solid/liquid separation of clayey tailings is a crucial part of mining and mineral processing activities for the purpose of successful tailing management, recycling/recovering of clean water and sustainable production. For example, colloidal clay particles discharged from the hydrometallurgical processing of different ore bodies cause dewatering problems in effluent treatment and disposal of tailing material (McFarlane, Bremmell, & Addai-Mensah, 2006). This dewatering difficulty of the clayey tailings can be solved with the help of the conventional physicochemical techniques and gravity-assisted thickening (Mpofu, Addai-Mensah, & Ralston, 2005).

The colloidal particles in the tailings have a high degree of stability and stay suspended in water for a very long time, and thus lead pollution in water into which they are discharged or degrade re-circulation water in processing plants (Rubio, Souza, & Smith, 2002). The strong electrostatic repulsion among colloidal particles owing to the same sign of their zeta potential is the principal motivation for the stability of the suspension. It is difficult to separate these colloidal particles in gravitational sedimentation ponds or devices without any size enlargement processes. Agglomeration processes may involve destabilization of colloids or collision of particles to form larger aggregates. Destabilization can be applied to the tailings by either an increase in ionic strength of the solution or a neutralization of the surface charge of particles by the addition of coagulants or flocculants. These chemicals trigger different complex processes around the electrical double layer of particles. These processes embody the compression of electrical double layer, the increase in ionic strength in bulk solution, the formation and the absorption of specific aqua complexes as a function of pH, adsorption on the surface of colloidal particle compensating its former electrical charge, and heterocoagulation/heteroflocculation (Chen, Zhao, & Song, 2017; Lech, Marta, Michal, Harsha, & Krystyna, 2017; Liang, Wang, Nguyen, & Xie, 2017) due to the formation of