

Modeling and optimization of dye removal process using response surface methodology: Kinetic and equilibrium studies

Narayana Saibaba K.V¹, P. King², R. Gopinadh¹ and Ravi Vital Kandisa¹

¹Department of Biotechnology, GIT, GITAM University, India

²Department of Chemical Engineering, Andhra University, India

Color is the primary pollutant in industrial effluent whose concentration is to be reduced within the permissible limit. The application of low-cost adsorbents obtained from plant wastes as a replacement for costly conventional methods of removing color from wastewater has been investigated in this paper. Activated carbon prepared from an agricultural waste was used as adsorbent. Physical characteristics of adsorbent were studied using Fourier transform infra-red (FTIR) and scanning electron microscopy (SEM). Crystal Violet was used as the model dye pollutant in this study. The adsorption experiments were conducted to study the effect of different parameters such as, initial dye concentration, adsorbent dose, temperature, equilibrium time and pH. All the experiments were done using Response Surface Methodology (RSM). Central Composite Design was used to develop the model. The developed model to estimate the removal efficiency of dye was tested for its reliability using ANOVA and regression analysis. All the results were statistically significant. Optimization of process variables is done using the model obtained from RSM studies.

Experiments were also conducted to know the kinetic behavior. The kinetic data obtained supports pseudo-second order model and intra-particle model but shows very poor fit for pseudo-first order model. Thermodynamic studies were also done to understand the feasibility of the adsorbent. Adsorption isotherms were obtained from conducting runs at different temperatures. These adsorption data were fitted well with both Langmuir and Freundlich isotherms. In addition, The thermodynamic parameters of the adsorption process such as Gibb's free energy ΔG^0 , enthalpy ΔH^0 , and entropy ΔS^0 were also calculated. The negative values of Gibb's free energy reflected the spontaneous nature of the adsorption. Based on the data of present investigation, one could conclude that the adsorbent prepared being a biocompatible, eco-friendly and low cost might be a suitable alternative for elimination of dyes from colored aqueous solutions.

Adsorption studies were made for the adsorption of CV from aqueous solutions onto a new green activated carbon prepared. The following conclusions can be made on the basis of experimental results obtained:

1. This adsorbent exhibited high adsorption capacities.
2. The adsorption capacity was affected by the changes in temperature, initial pH, contact time, adsorbent dosage and initial dye concentration of the solution.
3. Adsorption kinetics followed pseudo-first order and pseudo-second order kinetics.
4. High values of correlation coefficients indicated the best fit of experimental results with that of values obtained from modeling.
5. Optimization done by Response Surface method yielded good results.

All the results showed that the green carbon obtained was an efficient low-cost adsorbent for the removal of dye from waste aqueous solutions.

Biography

Narayana Saibaba K.V has completed his B.Tech in Chemical Engineering with Biotechnology as specialization from Andhra University and Masters in Chemical Engineering with Petroleum Refining Engineering as elective from Andhra University. He also completed MBA with dual specialization in HRM and Finance. He is currently pursuing his Ph.D under the guidance of Prof. P. King. He has published more than 15 papers in international journals of repute. His papers also published in the CHEMCON (top workshop for chemical engineers). Prof. P. King published more than 100 papers in reputed journals and serving as editorial board member of repute journals.

kvnsai@yahoo.com