Synthesis of sodium alginate composites and their application for methylene blue adsorption

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The industrial growth has resulted in the release of various pollutants in the environment and the treatment of effluents has become a challenging topic in environmental sciences [1]. Methylene blue is one of the most commonly dyestuff used for industrial applications. There are many different methods, such as degradation, flocculation–coagulation, oxidation, in order to remove dyestuffs from the industrial wastewaters [2]. Among these methods, adsorption by a low-cost adsorbent attracts attention as an economic and efficient method. In this respect, especially the synthesis of composite materials and their application of adsorption have become popular in recent times. In this study, activated carbon (AC)-sodium alginate (SA) and clay-sodium alginate composite spheres and films were synthesized and used for methylene blue (MB) adsorption. The optimization, equilibrium, kinetics, thermodynamic and adsorbent characterization studies were carried out for MB adsorption onto AC-SA and clay-SA spheres. Besides, at the optimum conditions; the adsorption capacities of composite materials and their constituent materials were compared to interpret the effectiveness of composite materials. The all adsorption experiments were conducted on a shaker at constant temperature with artificial wastewater in a batch mode and each experiment was repeated two times. Optimum initial pH, initial MB concentration, temperature and adsorbent concentration were determined to be 10, 1000 mg L^{-1}, 20 ^{o}C and 1.0 g L^{-1} for AC-SA spheres and 10, 1000 mg L^{-1}, 40 ^{o}C and 1.0 g L^{-1} for clay-SA spheres, respectively. The monolayer coverage capacities calculated from Langmuir isotherm model were found as 527 mg g^{-1} with high regression coefficient (R^2=0.9929) and low error value (ARE=10.13) for AC-SA spheres, 821 mg g^{-1} with high regression coefficient (R^2=0.9934) and low error value (ARE=9.98) for AC-SA spheres. The adsorption energies ($E_{AC-SA@20^oC}$=65.63 J $mole^{-1}$; $E_{clay-SA@40^oC}$=27.36 J $mole^{-1}$) calculated from Dubinin-Radushkevich were lower than 8 kJ $mole^{-1}$, which were indicating that the adsorption of MB onto AC-SA and clay-SA spheres proceeded through physical adsorption. Weber-Morris intraparticle diffusion model was applied to experimental data and it showed that both intraparticle and film diffusion were effective on the removal. Moreover, it was observed that composite films reached to equilibrium faster due to its lower intraparticle diffusion limitations than composite spheres. The studied adsorption processes were exothermic (ΔH_{AC-SA}=−25.98 kJ $mole^{-1}$, $\Delta H_{clay-SA}$=−14.41 kJ $mole^{-1}$), decreasing in randomness of adsorbed species (ΔS_{AC-SA}=−71.60 J $mole^{-1}$, $\Delta S_{clay-SA}$=−27.50 J $mole^{-1}$) and spontaneous ($\Delta G<0$ for both). The adsorbents were characterized with FT-IR analysis, and it corroborated that the studied processes were physical adsorption. Moreover, the adsorption capacities of SA, AC and clay were lower than composite materials, so it showed that the envisioned synergistic effect of HAp-SA composite materials could be obtained successfully. Consequently, the advanced adsorption properties were obtained by synthesizing AC-SA and clay-SA composite materials, which could be used effectively for MB adsorption.

References

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[2] Hassan, A. F., Abdel-Mohsen, A. M., and Fouda, M. M., Carbohydr Polym. 102 (2014): 192-198.