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Assessment of derivative spectrophotometry for analyzing competitive adsorption of brilliant green and methylene blue using multiple coated graphite oxide/sand composite

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Wastewater from industrial sectors such as paint production and textile processing are often contaminated with multiple dye pollutants. The simultaneous presence of multiple dyes like Brilliant Green (BG) and Methylene Blue (MB) poses significant challenges for treatment technologies. These dyes not only contribute to environmental degradation but also pose significant health risks, including allergic reactions and cancer due to their toxicity and persistence in ecosystems. A major challenge in treating dye mixtures is the accurate identification and quantification of multiple dyes due to overlapping absorption spectra. This research aims to enhance the resolution of spectral data using derivative spectrophotometry, enabling more distinct identification of overlapping dye components. In this study, the competitive adsorption of MB and BG onto multiple coated graphite oxide/sand (M-GO/S) composite was examined. The determination of dye concentrations was carried out using first order derivative (¹D) spectrophotometry. Kinetic and isotherm evaluations were conducted under optimal conditions: pH 7.0, 0.09 g of M-GO/S, and a contact time of 20 minutes in binary dye systems. The 20-minute contact time was sufficient to reach equilibrium, as extended durations showed no significant change in adsorption results from preliminary experiments. The experiment was triplicated. The equilibrium adsorption of MB and BG dyes onto M-GO/S showed an inverse relationship with their initial concentrations, signifying the competitive adsorption dynamics where the dyes compete for the available adsorption sites. In a binary mixture of 10 mg/L BG and MB, significant peak overlap at 625 nm and 664 nm hinders precise concentration measurement using zero-order spectra. First-order derivative spectrophotometry resolves this by identifying the adsorption peaks of MB at 625.6, and 503 nm, and BG at 443.2, 445.6, 525.6 and 664.2 nm. Simultaneous determination of BG and MB was achieved at 443.2 nm (¹D_{443.2}) (R²=0.9982) and 625.6 nm (¹D_{625.6}) (R²=0.9958), respectively. The characteristic parameters of regression equation for the ¹D method and obtained coefficient of determination for individual BG and MB were also studied. Therefore, the application of derivative spectrophotometry has proven to be an effective method for quantification of simultaneous adsorptions of BG and MB onto multiple coated graphite oxide adsorbent. This technique allows for precise differentiation and quantification of each dye in the presence of the other, enhancing the understanding of their adsorption dynamics. The results demonstrate that derivative spectrophotometry can improve the accuracy and efficiency of multipollutant adsorption studies.

Keywords: Adsorbent, Competitive adsorption, Derivative spectrophotometry, Graphite oxide, Isotherm