

Enhanced Adsorption of Reactive Dye using Cationic Surfactant-Modified Banana Stem by Batch Studies

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Structured Abstract

Background: Researchers have discovered the exceptional efficacy of banana stems as adsorbent materials, particularly in removing heavy metals and dyes. This has led to a growing trend of reusing banana stems due to their abundant availability and effective removal of water-soluble pollutants. However, previous research has mainly focused on raw banana stems and other modification techniques, neglecting the potential benefits of modifying the banana stem surface using a cationic surfactant. Thus, this study aims to evaluate the effectiveness of banana stems treated with the cationic surfactant cetyltrimethylammonium bromide (CTAB) as an adsorbent for removing Reactive Orange 16 (RO16) dye from aqueous solutions. The objective is to enhance the adsorbent's capacity and performance compared to untreated banana stems.

Methods: In this study, the banana stem was chemically treated with CTAB, and the physical and chemical properties of the adsorbent were characterized using Scanning Electron Microscopy (SEM), Fourier transform infrared (FTIR), and pH meter. All experiments were conducted in a batch system under different conditions of pH, initial dye concentration, adsorbent dosage, and contact time. The desorption efficiency of the dye from surfactant-modified banana stems (SMBS) was also evaluated.

Results: Characterization confirmed the impregnation of CTAB onto the banana stem surface. The removal efficiency of RO16 increased with the rise in initial dye concentration, adsorbent dosage, and contact time. Adsorption was favorable under acidic conditions, with the maximum removal reaching 98% at pH 3. Dye-loaded SMBS demonstrated stability, with a desorption percentage of less than 5% in water. Isotherm studies revealed that the adsorption data correlated well with the Freundlich model. Kinetic studies indicated a good fit with the pseudo-second-order model. The maximum adsorption capacity, determined from the Langmuir isotherm, was 19.83 mg/g.

Conclusion: In brief, CTAB-treated banana stems exhibited promising potential as an effective and cost-efficient adsorbent for the removal of RO16 dye from aqueous solutions. This alternative method holds significant promise for treating dyed wastewater, given the abundance of banana stems and their ease of modification at a relatively low cost.

Keywords: surfactant-modified banana stem, adsorption, desorption, Reactive Orange 16

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