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Synthesis of Carboxymethylated Cellulose from Pineapple (*Ananas Comosus*) Leaf Fiber and its Application for Heavy Metal Ions Adsorption in Industrial Wastewater

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Background: The significant volume of post-harvest pineapple leaf residues in agricultural operations presents a sustainable opportunity to develop value-added materials for environmental applications such as heavy metal removal from water.

Objective: This study aimed to synthesize carboxymethyl-modified cellulose from pineapple leaf fiber and evaluate its efficiency in removing lead (Pb²⁺) and cadmium (Cd²⁺) ions from aqueous solutions.

Methods: Here, cellulose fibers were isolated from pineapple leaves via alkaline extraction and bleaching processes, followed by chemical functionalization with carboxymethyl groups to yield carboxymethyl cellulose (Cell-CM). The modified cellulose was then evaluated as an adsorbent for heavy metals. Batch adsorption tests employed aqueous solutions of lead (Pb²⁺) and cadmium (Cd²⁺) ions at an initial concentration of 100 mg L⁻¹, over a pH range of 1 to 7 at ambient temperature.

Results: Analysis of dried pineapple leaves (PAL) in this study showed notable variation from conventional composition data, particularly highlighting an elevated α -cellulose content of 38.57%, surpassing the hemicellulose fraction of 19.5%. This compositional profile suggests promising potential for adsorbent synthesis. Results of batch adsorption demonstrated that Cell-CM exhibited markedly superior adsorption performance compared to unmodified cellulose, achieving maximum uptake capacities of 62.03 mg g⁻¹ for Pb²⁺ and 26.25 mg g⁻¹ for Cd²⁺ at pH 6. Notably, equilibrium was attained more rapidly for Pb²⁺ (30 minutes) than for Cd²⁺ (45 minutes). The adsorption isotherms fitted well with the Langmuir model, suggesting monolayer chemisorption on a homogeneous adsorbent surface. Regeneration studies using 1 M HCl indicated that the Cell-CM adsorbent could be recycled more efficiently for Cd²⁺ than Pb²⁺ ions.

Conclusion: Overall, this work establishes pineapple leaf-derived Cell-CM as an efficient, eco-friendly, and cost-effective adsorbent for heavy metal removal from contaminated water, thereby offering a sustainable approach to valorizing agricultural waste while addressing environmental pollution challenges.

Keywords: Adsorption, Cell-CM, PAL