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Green Synthesis of Zinc Oxide Nanoparticles Embedded Microcrystalline Cellulose from Murusi Crown Leaves for Water Hardness Removal by Column Adsorption**Ashinshani, L.R.C.E., Jayathilaka, L.S., Thiripuranathar, G.****College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya, Sri Lanka***tgobika@ichemc.edu.lk***Abstract**

Pineapple crown is an abundant agricultural waste in Sri Lanka, usually discarded in landfills during harvesting or processing, despite being a source of lignocellulosic biomass and bioactive phytochemicals. These properties make it a promising resource to synthesize biogenic nanocomposite that acts as an effective adsorbent for removing water hardness, thereby enhancing drinking water quality and mitigating related health issues. This research focuses on the green synthesis of zinc oxide nanoparticles (ZnO NPs) embedded in microcrystalline cellulose (MCC) derived from Murusi pineapple crown leaves (MCL), for effective water hardness removal via column adsorption. The cellulose was extracted through alkaline and bleaching pretreatments, followed by MCC extraction from cellulose using acid hydrolysis under optimized conditions at 2.5 M HCl, 80 °C for one hour, yielding 32.3%. ZnO NPs were synthesized from MCL extract, under optimal conditions at a plant-to-metal ratio of 1:50, zinc acetate concentration 0.01 M, pH 12, and room temperature. UV-Visible spectroscopy demonstrated characteristic ZnO NPs absorption with a blue shift confirming nanoscale dimensions. Characterization by FTIR spectroscopy confirmed the removal of lignin and hemicellulose after chemical treatment and verified the presence of functional groups on ZnO NPs associated with phytochemical capping agents. SEM analysis showed MCC with an average diameter of about $2.50 \pm 0.54 \mu\text{m}$ and ZnO NPs with an average size of approximately $113.75 \pm 20 \text{ nm}$, exhibiting hexagonal and flower-like morphologies. The nanocomposite column embedding 10 mg ZnO NPs into 20 g MCC was compared with pure MCC and cellulose columns for filtering synthetic dolomite hard water (1,900 mg/L as CaCO_3) at 1.2 mL/min flow rate. All three columns, each with a bed height of 25 cm and a diameter of 2.5 cm were operated in duplicate. The ZnO-MCC composite outperformed, achieving breakthrough after filtering 60 mL, compared to 40 mL and 10 mL for MCC and cellulose, respectively. The ZnO-MCC also exhibited the highest saturation volume of 130 mL, surpassing MCC (120 mL) and cellulose (90 mL). Enhanced adsorption efficiency of ZnO-MCC (~99%) is attributed to synergistic effects of ZnO active adsorptive sites and MCC's high surface area with hydroxyl groups facilitating effective Ca^{2+} and Mg^{2+} binding. ZnO leaching was negligible, confirmed by no precipitate in centrifuged effluent. These findings highlight the sustainable ZnO-MCC nanocomposite synthesized via green methods as a low-cost solution for water treatment, leveraging agricultural waste valorization and environmentally benign synthesis techniques.

Keywords: *Pineapple, Microcrystalline cellulose, Nanocomposite, Hardness, Adsorption*