Efficient Removal of Pb2+, Cd2+, and UO2+ from Water through Sustainable Nano Cellulose Coagulants Synthesized through One Step Modification of Raw Biomass

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Heavy metal pollution is a pressing global environmental threat and public health concern. In this study, sustainable nanofiber coagulants were synthesized to remove heavy metals lead, cadmium, and uranium from water. Raw biomass, jute fibers and spinifex grass, were treated with HNO2 and NaNO3 through a one-step modification to inexpensively and directly produce oxidized nanocellulose. The anionic carboxyl group, introduced to the cellulose nanofibers, enables adsorption of cationic heavy metals Cd2+, Pb2+, and UO2+. The anionic nanofibers coordinated with cationic metals form visible flocs, which a simple 1.0-micron filter can remove. SEM characterization revealed nucleation and precipitation of heavy metals on the nanofiber surface while FTIR characterization indicated shifts in functional groups corresponding to adsorption. Batch removal experiments, measured with ICP – MS and analyzed using Langmuir isotherm models, assess jute nanofiber's Pb2+ removal capacity as 2,270 mg/g and spinifex nanofiber's Cd2+ removal capacity as 2,550 mg/g. Based on this capacity, the nanofibers are the most effective adsorbent of Cd2+ and Pb2+ reported to date with efficiencies that are 15% higher than the most effective lead adsorbent and 70% higher than the most effective cadmium adsorbent. The nanofibers perform optimally at neutral pH, are recyclable, and cost effective enabling widespread use in impacted regions of developing countries. Sustainable, versatile, and efficient, the synthesized coagulants provide a pragmatic solution to the ubiquitous problem of heavy metal pollution.

Awards Won:

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