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Polysaccharides-clay composite beads as sustainable alternative porous adsorbents for purification of bio-oils: adsorption of α-tocopherols

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α-Tocopherols (vitamin E) present in bio-oils affect the trans-esterification and hydrodeoxgenation processes (conversion of bio-oils to biofuels) by poisoning the catalysts involved, owing to their antioxidant properties [1]. Basic anion exchange resins have conventionally been used for α-tocopherols removal [2], but fall short of eco-friendly attributes due to their synthetic polymeric nature, which during disposal may aggravate the microplastic menace. Polysaccharides-clay composite beads provide an environmentally benign alternative, by not only possessing bio-degradable components, but also disposal through burning to produce energy (high calorific values after adsorption of α-tocopherols) i.e. 3Rs (Remake, Reuse, and Recycle)

The project will entail composite material synthesis using 3 polysaccharides (chondroitin sulfate, hyaluronic acid, and alginate) either individually or as a combination, and clay particles (purchased and locally sourced). Porosity of the adsorbent will be controlled and tuned using acid (citric acid) base (calcium carbonate) reactions. The synthesized materials will be characterized for mechanical stability using thermal analysis i.e. Thermal Gravimetric Analysis (TGA) & Differential Thermal Analysis (DTA). The porosity and other textual properties (surface area) will be analyzed using 3D imaging techniques e.g. micro-Computerized Tomography (μ-CT) and 3D image analysis using Artificial Intelligence (AI)-driven software like Geodict & Dragonfly to measure pore connectivity & tortuosity. The effect of using one component and/or a combination of components for the composite materials will be studied to uncover correlations to adsorption performance and efficiency. Lastly, after successful composite material synthesis optimization and characterization, batch and fixed-bed adsorption studies will be done to test the performance of the composite materials. Basic anion exchange resins will be used for comparison tests.

The insights from this study will be geared to directly and/or indirectly provision of actionable contributions towards the achievement of Green Transition, Circular Economy (3Rs), and realization of Sustainable Development Goals (SDGs) No. 7 (Affordable & Clean Energy), Target 7.2 (Increase Global Percentage of Renewable Energy). Also, the use of AI-driven 3D image analysis software fits under SDG No. 9 (Industries, Innovation, and Infrastructure), Target 9.5 (Enhanced Scientific Research)

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[2] Yeromin, Lutz, Johannis B., Wilhelm, Gutsche, Bernhardt, Volkmar, Jordan, Vogatsk and Herbert. (https://patents.google.com/patent/JPH08500598A/en)