

Biochar from co-hydrothermal *Chlorella vulgaris*, Sewage Sludge and Coal: Activation and Characterization

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Structured Abstract

Background: Co-hydrothermal carbonization of mixed biomass of *Chlorella vulgaris*, sewage sludge and coal is a method to generate carbon-rich products such as biochar. Two feedstock ratios were used in this study: 1:1 (sewage sludge to *Chlorella vulgaris*, HC041) and 3:1 (sewage sludge to *Chlorella vulgaris*, HC044), with each combination containing 2g of coal. But the surface properties of the raw biochar are poor. Therefore, potassium hydroxide is also used for chemical activation to increase surface area and porosity. This research focuses on the production and activation of biochar for application in environmental and adsorption contexts.

Methods: Co-HTC of *Chlorella vulgaris*, sewage sludge, and coal was performed at 140°C to obtain crude biochar samples (HC041 and HC044). Activation was performed in two steps: KOH activation and pyrolysis, followed by chemical treatment with 1 M KOH (1:1 w/w) at 600°C and 500°C under a nitrogen atmosphere. Proximate analysis, higher heating value (HHV), elemental analysis (CHNS-O), FTIR, FESEM, EDX and XRD were used to assess the physicochemical properties of activated biochar.

Results: HC041 showed carbon (38.09%) and HHV (5.97 MJ/kg) values greater than those of HC044, with carbon (31.64%) and HHV (1.61 MJ/kg). Through chemical activation, it was clear that porosity increased significantly and HHV decreased due to the loss of volatile material. FTIR provided evidence of surface functionalities of -OH, C=O, and C-O groups. Activated HC041 exhibited well-developed pores, as demonstrated by FESEM images, and an amorphous carbon structure was confirmed by XRD to be suitable for adsorption. The existence of carbon and mineral-rich elements was corroborated by EDX analysis.

Conclusion: Co-HTC of *Chlorella vulgaris*, sewage sludge and coal and KOH activation is used to produce biochar with a better surface property. The results indicate that HC041 exhibits excellent energy properties and morphological features and may be an effective adsorption material for soil remediation.

Keywords: Co-hydrothermal Carbonization, Chemical Activation, *Chlorella vulgaris*, Sewage Sludge, Coal

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