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Synergistic Effect of Hydrothermal Co-Carbonization (Co-HTC) of Sewage Sludge with Activated Hydrochar

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Structured Abstract

Background: The increasing generation of sewage sludge has raised environmental and disposal concerns. Hydrothermal carbonization (HTC) and co-hydrothermal carbonization (Co-HTC) offer a promising approach for converting wet biomass into hydrochar using mixed feedstocks. Microalgae, particularly *Chlorella vulgaris*, are suitable co-feedstocks with sewage sludge due to their high organic content. Therefore, this study focuses on activating hydrochar produced via Co-HTC of sewage sludge and microalgae and evaluating its physicochemical, morphological, and synergistic characteristics.

Methods: Hydrochar was produced via co-hydrothermal carbonization of sewage sludge and Chlorella vulgaris at a fixed feedstock ratio of 1:3 and at three temperatures: 180 °C, 200 °C, and 220 °C. The resulting hydrochar was chemically activated using phosphoric acid (H_3PO_4), followed by thermal activation at 600 °C. The activated hydrochar was characterized using proximate and ultimate analyses, Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). The synergistic effect of the mixed feedstock was evaluated using the Van Krevelen diagram based on H/C and O/C atomic ratios. The synergistic effect of the mixed feedstock was evaluated using the Van Krevelen diagram.

Results: The findings demonstrated that the yield of hydrochar rose at lower Co-HTC temperatures, reaching its maximum at 180 °C. After chemical activation, the hydrochar yield decreased significantly due to mass loss caused by acid treatment and repeated washing. After activation, proximate analysis showed an increase in ash content and a significant decrease in volatile matter. The reduction in O–H and C–H and the presence of phosphorus-containing functional groups by FTIR analysis confirmed the effect of chemical activation. SEM analysis of the activated hydrochar exhibited a rougher surface and a more porous structure compared to the non-activated hydrochar, indicating that the activation process was successful. Van Krevelen analysis demonstrated that the activated hydrochar was not suitable for fuel application, whereas hydrochar with a feedstock ratio of (1:3) exhibited a coal-like product.

Conclusion: Overall, the successful production of activated hydrochar resulted in modified surface characteristics, supporting its potential for adsorption and environmental applications rather than energy production.

Keywords: Co-hydrothermal Carbonization, Activated Hydrochar, Sewage Sludge, *Chlorella vulgaris*, Synergistic Effect

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