Simultaneous Production of Highly Porous Hydrochar and Carbon Dots Derived from Waste Biomass Via Hydrothermal Treatment

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Abstract:

Hydrochar, a carbon-rich solid derived from biomass via hydrothermal carbonization, features low energy consumption and ash content, alongside high fixed carbon (40%-60%) and energy content (15-30 MJ/Kg). With rich surface functionality and a porous structure, hydrochar serves multiple purposes: it functions as a renewable solid fuel, an adsorbent for pollutants in wastewater treatment, a soil amendment to boost fertility, an electrode material for energy storage, and aids in carbon sequestration to mitigate greenhouse gas emissions. While carbon dots are nanoparticles under 10 nm in size that exhibit excellent optical and electrical properties due to their surface functional groups. Composed of sp^2 and sp^3 carbon in varying structures, they are stable in water, non-toxic, biodegradable, and can be produced inexpensively from waste biomass. Their high thermal and optical photostability makes them suitable alternatives to toxic metal-based materials. Applications include drug delivery, medical diagnostics, fluorescence imaging, optical sensors, optoelectronics, biosensors, and energy storage solutions.This study addresses limitations in traditional hydrochar and carbon-dots production methods, such as biomass segregation, negligible carbon-dots generation, and low carbon efficiency. It systematically varied key parameters—reaction temperature, time, and biomass dosage—to optimize hydrochar yield and carbon dots quality. The results showed that hydrothermal treatment produced a carbon-rich solid (hydrochar), an organic aqueous phase (carbon dots), and minor gaseous byproducts, primarily CO2. Overall, the study demonstrates the potential of hydrothermal conversion as a promising route for sustainable biomass utilization, offering a versatile platform for energy and environmental applications.

Keywords:

Hydrothermal Treatment, Hydrochar, Carbon-dots, Waste Management, Fluorescence.