Green-Nanocarbon from Waste: Sustainable Materials for Advanced Sensing Applications

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Abstract:

The conversion of sustainable raw materials, such as biomass, plant residues, and organic waste, represents a promising strategy for producing carbon-based nanomaterials due to their widespread availability, eco-compatibility, and alignment with the Sustainable Development Goals (SDGs)[1]. Carbon nanomaterials possess remarkable characteristics, including high solubility in water, structural robustness, large surface area, and excellent electro-catalytic performance, enabling their application across various technological fields [2]. Biomass-derived carbon structures can be efficiently synthesized via thermochemical methods like hydrothermal carbonization (HTC) and microwave irradiation, providing solutions to environmental and energy-related challenges. HTC is a water-based thermochemical process conducted under autogenous pressure at moderate temperatures (150-300 °C), particularly suited for wet lignocellulosic waste valorization. During this transformation, biomass undergoes dehydration, yielding solid, liquid, and gaseous fractions. The carbonaceous solid derived from citrus waste, known as hydrochar, is rich in oxygen-containing functional groups, making it a valuable material for applications such as pollutant adsorption, soil remediation, energy storage, and electrochemical devices [3]. Additionally, the bio-oil fraction recovered from the HTC aqueous phase contains high-value compounds with potential use in biofuel production and as platform chemicals. Although the utility of bio-derived carbon materials has been widely acknowledged, further opportunities exist for their integration into advanced technologies, including sensing applications. This study highlights the potential of HTC for biomass transformation, focusing on bio-nanocarbon and bio-oil production, while discussing key aspects related to process optimization and scalability. Furthermore, these materials have been successfully employed in cutting-edge sensor technologies, including voltammetric detection of organic and inorganic pollutants at trace levels. The exploration of this efficient hydrothermal method offers a sustainable route for repurposing wet organic waste, contributing to the development of high-value products while mitigating environmental burdens associated with citrus waste management.