Sustainable production of carbon nanodots with controlled properties via a green Maillard reaction approach

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Carbon nanodots (CNDs) are highly desirable due to their unique optical properties and diverse potential applications. However, conventional synthesis methods often rely on harsh chemicals and high temperatures, raising concerns about their sustainability and food safety risks. This study explores a novel green approach for CNDs synthesis using the Maillard reaction at low temperature (120oC) and long time (12 hours), a well-known natural process, and investigates the optimization of reaction conditions. The Maillard reaction was employed using various combinations of amino acids and sucrose as precursors, with reaction temperature and extraction solvent composition optimized for CNDs yield and fluorescence intensity. The synthesized CNDs (M-CNDs) were characterized using fluorescence, UV-Vis, Raman, and transmission electron microscopy (TEM). Glycine, combined with sucrose in a 1:1 molar ratio, resulted in the most effective formation of CNDs. Utilizing 40% ethanol as the extraction solvent significantly enhanced fluorescence intensity, while higher ethanol concentrations negatively impacted CND formation, likely due to hindered Schiff base formation. The purified M-CNDs exhibited desirable characteristics, confirming the success of the green synthesis approach, which was used as a standard to detect CNDs in bakery products. This study demonstrates a novel and sustainable method for synthesizing CNDs with tailored properties using the Maillard reaction under optimized conditions. Readily available precursors, green solvents, and low temperatures make this approach environmentally friendly and cost-effective. The findings pave the way for developing CNDs with various bioimaging, food, and environmental monitoring applications while promoting sustainable and safe nanomaterial development.

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