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Synthesis of Quantum Dots from Algae-Derived Bio-Precursors

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Extended Abstract

Different types of alginates and carrageenans are among the most common biopolymers extracted from brown and red algae [1], with applications in the food, dental, and biomaterials industries [2], among many others. However, certain species of green seaweed remain underutilized, despite the potential to extract a variety of biopolymers from them. For example, green algae of the Ulvaceae family are largely untapped and do not find many industrial applications [3]. A biopolymer known as ulvan can be extracted from these algae [4] and can be used as a bioprecursor for the synthesis of carbon-based quantum dots [5]. This work reports on the synthesis of quantum dots from ulva-derived bioprecursors using a hydrothermal processing route. Dynamic light scattering (DLS) tests showed that the prepared quantum dots exhibited diameters ranging from 5 to 10 nm. The quantum dots were found to have an average particle size of 7.068 nm. The CQD solutions exhibited bright luminescence under UV lamp with excitation wavelength of 365 nm and the luminescence intensity shows blue color for the produced CQDs. Using UV-vis absorption and fluorescence (FL) spectroscopy, the optical properties were evaluated. Significant FL emission was observed at 490 nm at excitation wavelength of 396 nm. To further investigate the optical characteristics, stimulated emission spectra were obtained with different excitation wavelengths between 320 and 480 nm. The emission peaks gradually increase with increasing excited wavelength, suggesting that the emission wavelength could be changed by tuning the excitation wavelength. The tendency of the emission wavelength is red-shifted (right, towards longer wavelengths) as the excitation wavelength increases, indicating that the emission depends on the surface states and not only on the core of the CQDs [6, 7]. The emission intensity gradually decreases with increasing excitation wavelength. UV-Vis absorption spectra showed that peaks at wavelengths shorter than 200 nm (193-199 nm) may be related to $\pi \rightarrow \pi*$ electronic transitions of C=C or C=O bonds in aromatic or conjugated structures within the CQDs [8]. The peak at 284 nm is characteristic of $\pi \rightarrow \pi*$ transitions of aromatic or carbonyl functional groups [9]. It is common in CQDs and suggests the presence of groups such as ketones or quinones on the surface of the quantum dots [10]. It may also be due to organic residues of ulvan left in the structure of the CQDs. This study demonstrates that ulvan, a biopolymer derived from green algae, is a viable precursor material for the synthesis of CQDs by a hydrothermal process. The obtained CQDs present suitable sizes, controllable optical properties and a chemical structure compatible with their use in technological applications.

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