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Synthesis of Versatile Carbon Quantum Dots for Targeted Detection of Nitro-Aromatic Explosives

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Abstract:

Nitroaromatics (NAs) are hazardous pollutants to aquatic life, with potential risks to human health, and the persistence of the environment. Therefore, their early sensing and detection in water bodies have become more crucial for environmental safety and pollution control. Carbon quantum dots (CQDs) have unique properties, such as high biocompatibility, excellent water dispersibility, and low toxicity, due to these properties, they gained remarkable attention in various applications, including bioimaging, photocatalysis, sensing, drug delivery, and other research fields. This study employed a solvothermal approach to synthesizing green-emissive carbon quantum dots (G-CQDs) using o-aminophenol (o-AP) and terephthalic acid (TPA) as precursors. G-CQDs were analyzed by using photoluminescence (PL) spectroscopy, ultraviolet-visible (UV-vis) spectroscopy, Fourier-transform infrared (FTIR), and X-ray photoelectron spectroscopy (XPS). The photophysical properties of G-CQDs displayed an emission wavelength of 499 nm with a 59% quantum yield at an excitation wavelength of 450 nm, whereas the observed emission wavelength was excitation-independent. Functional groups such as C=O, C-O, C=C, O-H, and N-H were evaluated by FTIR analysis. The XPS spectra displayed the presence of C1s, O1s, and N1s peaks, indicating nitrogen-containing groups were successful incorporated into the CQD. The G-CQDs show remarkable selectivity toward 2,4-DNPH, exhibiting a high quenching efficiency of 91% when compared to other potential interfering compounds, such as picric acid, 4-nitrobenzyl alcohol, 1,2-dinitrobenzene (DNB), 1,3-dinitrobenzene (DNB), 1,4-dinitrobenzene (DNB), and 2,4-dinitrotoluene (DNT). The experiments also shew that the G-CQDs have a calculated detection limit (LOD) of 30 nM to 2,4-DNPH. Furthermore, the CQDs exhibited reversible photoluminance behavior, revealing their potential as highly sensitive and selective probes for the detection of 2,4-DNPH.

Keywords:

Carbon quantum dots, sensing, 2,4-dinitrophenylhydrazine (2,4-DNPH), fluorescence quenching.