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Abstract

Tuning the Sensing Properties of Carbon Dots for Colorimetric Detection of Heavy Metals in Water †

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Abstract: Carbon dots (CDs) have recently emerged as a new class of fluorescent nanomaterial that can be prepared and modified in order to determine sensitivity to a variety of chemical and biological analytes. This versatility originates from different strategies of synthesis, top–down or bottom–up, that provide the means to perform heteroatom doping and the modulation of surface- and edge-attached functional groups. In particular, their great affinity with heavy-metal ions in water has stimulated a great number of studies on the response to these toxic species. Although most investigations have exploited the fluorescent emission of CDs, much less has been reported on the variations in optical absorbance, which could be more suitable for colorimetric detection in simple and cheap visual-based devices. Previous studies on top–down undoped CDs have demonstrated how slight modifications in synthesis could turn simultaneous sensitivity to As(III), Cd (II), Cu(II), and Pb(II) into a selective response to Cr(VI), due to exposure of the functional groups on the surface and the formation of hydrogen bonds. In this study, we report on the sensitivity of bottom–up nitrogen-and-sulfur co-doped CDs (NS-CDs) prepared using a simple one-pot hydrothermal method. We show how tuning the pH of the sensing solution greatly reduced the interference effects of Fe(III) and enhanced sensitivity to Cu(II) through the emergence of a distinct absorption band at 660 nm. This was attributed to the formation of cuprammonium complexes through N-containing functional groups. The concurrent response to Co(II) in a different spectral region also suggests the possibility of dual-species multiple sensitivity. The NS-CDs were characterized using TEM, STEM-coupled EDX analysis, NMR, and IR spectroscopy. The response to Cu(II) was linear in the concentration range of 1–100 μM with a limit of detection of 100 nM. Interestingly, the present system neither requires any other reagents nor any previous assay treatment.

Keywords: carbon dots; optical sensing; water quality; heavy metals; colorimetry

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