Valorization of Orchid Waste for the Synthesis of Sulfur-Doped Carbon Quantum Dots for Paper-Based Fluorescent Sensors in Organophosphate Detection

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Abstract

The presence of organophosphate (OPs) residues in vegetables and fruits is a food safety issue that affects both human health and the environment. Therefore, the development of effective methods for detecting such residues is necessary. This project aimed to develop a paper-based sensor coated with carbon quantum dots (CQDs) derived from orchid flower waste for the detection of OPs. The effects of various hydrothermal synthesis conditions were investigated. The results showed that the optimal condition was 200 °C for 5 hours, which produced CQDs with a well-developed carbon core and the highest fluorescence intensity. Nitrogen and sulfur doping were studied, and the results indicated that sulfur-doped CQDs (S-CQDs) exhibited the highest performance in responding to OPs. Specificity tests against other pesticide types showed that S-CQDs responded most specifically to OPs. In addition, the fluorescence intensity of CQDs decreased significantly with increasing concentrations of OPs. Based on this finding, a paper-based sensor was further developed to enhance its suitability for field applications. The results showed that immersing the paper in 2.25% (w/v) S-CQDs for 40 minutes yielded the highest fluorescence intensity. Upon exposure to OPs, clear changes in RGB values were observed. These findings demonstrate that the developed paper-based sensor can be used as a material for the accurate and rapid detection of OPs and has potential for practical applications. Furthermore, it adds value to waste materials and supports food safety management at both community and industrial levels.

Keywords: Carbon quantum dots, Organophosphates, Pesticide residue, Orchid waste