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Mini Review

Utilization of Morinda coreia Fruit-Derived Green-Emissive Nitrogen-Doped Carbon Quantum Dots for the Discriminative and Responsive Detection of Ferric Ions in Aqueous Environments

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ABSTRACT

The utilization of carbon quantum dots (CQDs) derived from Morinda coreia fruits has garnered attention for their potential in sensing applications, particularly in the detection of ferric ions (Fe^3+) in aqueous environments. This study focuses on the synthesis, characterization, and application of Morinda coreia fruit-derived green-emissive nitrogen-doped carbon quantum dots for the discriminative and responsive detection of ferric ions. The synthesis involves a facile and eco-friendly approach, resulting in CQDs with enhanced optical properties and surface functionalities. Characterization techniques including transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and Fourier-transform infrared spectroscopy (FTIR) elucidate the morphology, composition, and surface chemistry of the CQDs. The nitrogen doping induces energy levels within the carbon matrix, leading to strong green-emission under ultraviolet (UV) excitation. The selective detection of ferric ions is achieved through the quenching of green emission upon interaction with surface functional groups, demonstrating sub-nanomolar detection limits and high selectivity. Moreover, the responsive behavior of the CQDs enables real-time monitoring and dynamic sensing of ferric ions, enhancing their utility in environmental monitoring and analytical chemistry. This work highlights the potential of Morinda coreia fruit-derived CQDs as versatile platforms for sensitive and selective detection in aqueous environments, with implications for various applications in environmental remediation and biomedical diagnostics.

Keywords: Morinda coreia; Fruit-derived carbon quantum dots; Nitrogen-doped; Green-emissive; Ferric ions detection, Aqueous environments

INTRODUCTION

In recent years, the development of novel materials for sensing applications has garnered significant attention, particularly in environmental monitoring and healthcare sectors. Among these materials, carbon quantum dots (CQDs) have emerged as promising candidates due to their unique optical and chemical properties. In this context, Morinda coreia fruit-derived green-emissive nitrogen-doped carbon quantum dots have shown remarkable potential for the selective and sensitive detection of ferric ions (Fe^3+) in aqueous environments [1]. This article explores the synthesis, characterization, and application of these innovative nanomaterials in ferric ion detection. Morinda coreia, commonly known as East Indian Mulberry or Indian Mulberry, is a tropical fruit native to Southeast Asia. This fruit has gained attention not only for its nutritional value but also for its potential in various medicinal and industrial applications [2,3]. In recent studies, Morinda coreia has been explored as a source for the synthesis of carbon quantum dots due to its abundance, low cost, and environmentally sustainable characteristics. The resulting carbon quantum dots derived from Morinda coreia exhibit unique optical properties, making them promising candidates for sensing applications.

Among the numerous applications of carbon quantum dots, the selective and sensitive detection of metal ions in aqueous environments holds particular importance due to its relevance in environmental monitoring, water quality assessment, and biomedical diagnostics [4]. In this context, ferric ions (Fe^3+) stand out as crucial targets due to their ubiquitous presence and environmental significance. The development of effective sensing platforms for ferric ions detection is imperative for addressing environmental concerns and ensuring public health safety.

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This article focuses on the utilization of Morinda coreia fruit-derived green-emissive nitrogen-doped carbon quantum dots for the discriminative and responsive detection of ferric ions in aqueous environments. We present a comprehensive investigation into the synthesis, characterization, and application of these innovative nanomaterials, highlighting their potential impact on environmental monitoring, analytical chemistry, and beyond [5,6].

Synthesis and Characterization

The synthesis of Morinda coreia fruit-derived carbon quantum dots involves a facile and environmentally friendly approach, typically employing a hydrothermal or microwave-assisted method. During synthesis, the nitrogen-doping process enhances the quantum yield and imparts specific functional groups on the surface, contributing to the unique optical properties and surface chemistry of the carbon quantum dots [7]. Characterization techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and Fourier-transform infrared spectroscopy (FTIR) are employed to elucidate the morphology, elemental composition, and surface functionalization of the synthesized carbon quantum dots [8].

Optical Properties

The Morinda coreia fruit-derived carbon quantum dots exhibit strong green-emission under ultraviolet (UV) excitation, attributed to their quantum confinement effect and surface functionalization. The nitrogen doping induces energy levels within the carbon matrix, leading to enhanced photoluminescence properties. Moreover, the emission wavelength can be tuned by adjusting the synthesis parameters, offering versatility in optical sensing applications.

Selective Detection of Ferric Ions

One of the key applications of Morinda coreia fruit-derived carbon quantum dots is the selective detection of ferric ions in aqueous environments. The surface functional groups, such as carboxyl, amino, and hydroxyl moieties, facilitate the chelation and coordination of ferric ions, resulting in quenching of the green emission. This quenching phenomenon is utilized for the sensitive and selective detection of ferric ions, with detection limits reaching sub-nanomolar concentrations. The selectivity of the detection method is demonstrated through control experiments and real sample analysis, highlighting its applicability in environmental monitoring and analytical chemistry [9,10].

CONCLUSION

Morinda coreia fruit-derived green-emissive nitrogen-doped carbon quantum dots represent a promising platform for the selective and sensitive detection of ferric ions in aqueous environments. Their facile synthesis, tunable optical properties, and responsive behavior make them attractive candidates for various sensing applications. Future research directions may focus on enhancing the selectivity, sensitivity, and stability of these carbon quantum dots, as well as exploring their potential in other analytical and biomedical applications. The facile and eco-friendly synthesis method employed in producing these carbon quantum dots underscores their potential for large-scale production and widespread application. The introduction of nitrogen doping enhances their optical properties, enabling strong green-emission under ultraviolet excitation, which is pivotal for sensitive detection purposes. Furthermore, the selective interaction between the surface functional groups of the carbon quantum dots and ferric ions allows for the specific detection of Fe^3+ with high sensitivity and selectivity. The quenching of green emission upon interaction with ferric ions provides a reliable signal for the quantification of Fe^3+ ions, with detection limits reaching sub-nanomolar concentrations. Moreover, the responsive behavior of these carbon quantum dots enables real-time monitoring and dynamic sensing of ferric ions, offering practical implications for environmental monitoring, water quality assessment, and biomedical diagnostics.

DISCUSSION

The utilization of Morinda coreia fruit-derived green-emissive nitrogen-doped carbon quantum dots (N-CQDs) for the discriminative and responsive detection of ferric ions (Fe^3+) in aqueous environments presents a significant advancement in sensing technology. In this discussion, we delve into the key findings, implications, limitations, and future directions of this study.

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