Green Carbon Dots: Advanced Material For Renewable Energy Sources

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Abstract: Fluorescent carbon dots (CDs) are an emerging category of nanomaterials in the carbon family. There are different inexpensive and renewable resources that can be used to synthesize green CDs, which include received immense consideration from researchers because of their improved aqueous solubility, high biocompatibility, and eco-friendly nature compared with chemically derived CDs. Additional surface passivation is not necessary as heteroatoms be present on the surface of green CDs in the form of amine, hydroxyl, carboxyl, or thiol functional groups, which be able to improve their physicochemical properties, quantum yield, and the probability of visible light absorption. Green CDs boast potential applications in the fields of bioimaging, drug/gene delivery systems, catalysis, and sensing. While their discovery, there have been several review articles that describe the synthesis of green CDs and some of their applications. Nevertheless, there are no review articles describing the synthesis and complete applications of green CDs. Here, we provide detailed information concerning their synthesis and applications based on the available literature. In addition, we discuss a number of the less explored applications of green CDs and the challenges that continue to be overcome.

Keywords: carbon dots; nanomaterials; green; energy; renewable sources

1. Introduction

Nanomaterials are colloidal particles among sizes in the range between 1 and 100 nm. They comprise remarkable physicochemical and optoelectronic properties that differ from individuals of their bulk structures. The multi functionality of those nanoparticles makes them appropriate for use in numerous biomedical [1] and chemical applications such as bio-imaging [2], gene delivery, drug delivery [3], cell differentiation [4], sensing [5-8], and catalysis [9]. Carbon is the most abundant element on Earth, with different allotropes. Carbon nanofibers, nanotubes, fullerenes, graphenes, and carbon dots (CDs) compose the family of carbon nanomaterials. However, CDs are the most promising applicant for apply in several applications because of their outstanding features. CDs are a class of quantum dots that can be synthesized from several carbon precursors. The carbon nanoparticle was accidentally exposed by Xu et al. 2004 [10], and a single-walled carbon nanotube be purified via electrophoresis by his group. The name CDs was coined by Sun et al [11]. two years later while synthesizing fluorescent carbon particles with dimensions of less than 10 nm. CDs are fascinating because of their unique properties, such as wavelength-pitched color production, low toxicity, high water solubility, and high biocompatibility. In addition, the optical, physical, and chemical properties of CDs can be improved by surface doping. CDs are too

considered an active photocatalyst because they can act as an electron acceptor and a donor leading doping among several heteroatoms, metal ions, and assorted functional groups [12-15]. Green CDs are carbon nanomaterials that are formed from green sources. The term green refers to materials that are natural or harvest of natural renewable sources. Green sources grant outstanding properties, such as low cost, high yield, high availability, high biocompatibility, and high renewability.

In this review, we discuss different applications of green CDs, such as bioimaging [13], catalysis, biosensing [11, 12], gene delivery, drug delivery, and chemical sensing [12, 16]. Among these applications, bioimaging is the mainly studied application of green CDs.

2. Formation mechanisms for carbon dots (CDs)

CDs preserve be synthesized through top-down or bottom-up approaches. The top-down process refers to the contravention of larger particles into smaller ones on the nanometer scale via physical, chemical, or electrochemical methods [5-6]. Carbon materials are generally broken through oxide cutting methods, i.e., cutting of bulky carbon precursors into small pieces using oxidizing agents, such as HNO_3 or HNO_3/H_2SO_4 mixture, and the surface of those small carbon pieces are modified by oxygen-based functional groups. This oxide cutting method for the synthesis of graphene quantum dots (GQDs) generally consists of two steps. The first stage is to translate graphite-based materials into graphene oxide (GO) sheets by the Hummer method. In the second stage, GQDs are obtained through cutting of GO sheets using various methods, such as metal-graphite intercalation, electrochemical, hydrothermal/solvothermal/special oxidation, and physical route such as laser ablation, arc discharge, and nanolithography [9, 10].
In the bottom-up approach, small molecules go through pyrolysis or carbonization to form nanoparticles with the preferred size range. Researchers mostly use the bottom-up approach to synthesize green CDs because of its low cost, precise control over precursors, and simplicity of use [11-16]. Moreover, most renewable sources surround small bioactive molecules that can be carbonized to appearance CDs. Organic molecules generally undergo more than a few stages during CD synthesis, including condensation, polymerization, carbonization, and passivation [12].

3. Green synthesis of carbon dots (CDs)

The synthesis of CDs was controlled to the use of carbonaceous materials after its primary discovery. However, these CDs obsessed a limited aqueous solubility and low quantum yield. The solubility and quantum yield can be improved by surface passivation of the CDs. However, in the last decade, green syntheses of CDs have increasingly been reported.

To attain cost-effective, simple, and environmentally compassionate synthetic methods with remarkable optical and electronic properties, various green precursors have been investigated. Based on the different synthetic methodologies, we have classified these CDs into different groups.

At this point, we discuss the various methods and sources used to synthesize green CDs for the source of green comprise fruits, juices, beverages, bakery products, vegetables, human derivatives, plants, and plant petals.

Conclusion

CDs are a class of quantum dots that can be synthesized from several carbon precursors. The carbon nanoparticle was accidentally exposed as a single-walled carbon nanotube be purified via electrophoresis by his group. The name CDs was synthesizing fluorescent carbon particles with dimensions of less than 10 nm. CDs are fascinating because of their unique properties, such as wavelength-pitched color production, low toxicity, high water solubility, and high biocompatibility. In addition, the optical, physical, and chemical properties of CDs can be improved by surface doping. CDs are too considered an active photocatalyst because they can act as an electron acceptor and a donor leading doping among several heteroatoms, metal ions, and assorted functional groups. Green CDs are carbon nanomaterials that are formed from green sources of green comprise fruits, juices, beverages, bakery products, vegetables, human derivatives, plants, and plant petals.

4. References

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