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Carbon Dots and Their Synthetic Method

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ABSTRACT. *A new fascinating class of novel fluorescent carbon dots have garnered as an emphasis on their role in chemical and physical properties, because of their remarkable optical properties. In this article, we summarize their main synthetic method.*

KEYWORDS: *Carbon dots; Synthetic methods*

1. Introduction

In the last a few years, the carbon dots (CDs) is more and more popular, consisting is quasispherical nanoparticles with sizes below 10 nm.[1-3] The CDs have inspired extensive researches due to low cytotoxicity, high photo-stability, chemical inertness, good biocompatibility, other than that, having stable fluorescence properties. It is known that CDs could are suitable for various filed, such as, biomedical applications, optoelectronic devices .[4-6]

So far, consequently, in 2004, an advanced carbon material was discovered named carbon dots (CDs) by the arc discharge method, but after Sun et al. successfully synthesized it in 2006, it was prepared and studied by researchers. [7] CDs are used in many domains.[7-8] The size of a CDs is less than 10 nm.[10] The reported CDs were synthesized by two main groups, respectively the top-down and the bottom-up.[11] As a new nanomaterial, CDs show a huge application prospect, so the preparation of carbon quantum dots is particularly important. In this paper, we will discuss the preparation method of CDs.

2. Synthetic Methods

2.1 Top-Down Synthetic Route

In top-down technology, to peel off large chunks of carbon into CDs of varying sizes up to 10 nanometers. The main methods are electrochemical approach, laser ablation process laser ablation process.

2.1.1 Chemical Oxidation Process

Chemical oxidation process, no extra heat is needed, and it will obtain CDs with a low-cost and easy method. Herein, as shown in Figure 1, Meng et al. promoted chemical oxidation of coal pitch with formic acid and H_2O_2 as oxidation agent to a large of synthesize fluorescent CDs, by controlling the ratio of formic acid and H_2O_2, to adjust the emission wavelength of CDs, the fluorescent emission peaks gradually rangs from 630 to 400 nm, the size of the CDs decreases as the concentration decreases, is 3nm-5nm.[12] Yang et al. reported a CDs by one-pot chemical oxidation with strong acids by carbonizing galactose, it was heated in the ceramic crucible (300 ℃, 2 h).[13]

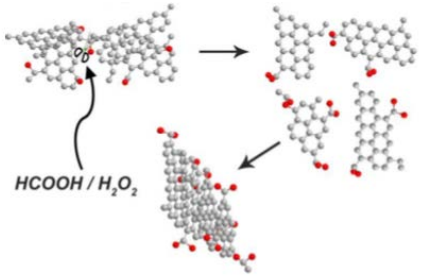

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Figure.1 The Formation Schematic of CDs by Treating Coal Pitch with the Mixture of Formic Acid and H_2O_2 .

2.1.2 Electrochemical Approach

Electrochemical approach is a simple and simple method to prepare CDs.[11,14] Hou's group described an electrochemical approach to prepare CDs,[15] sodium citrate and urea were added then inserted into platinum sheets that contained 1 h at 5V (DC), and will obtain the fluorescent CDs. The approach depicted is Figure 2.

Figure.2 The Formation of the CDs by Electrochemical Approach

2.1.3 Laser Ablation Process

Ren and co-workers produced N-doped micropore CDs via laser ablation from sustainable biomass. The cypress biomass fruits were dried in a vacuum drying chamber and carbonized at a 600◦ by nitrogen-equipped tube furnace keep 2 hours(Figure 3).[16] Samples of 0.5 g were then mixed with 1 g KOH and stirred with ultrasound for 30 minutes, and drying again in a vacuum chamber. a microporous carbon material was formed in 900◦C. in addition, the N-doped micropore CDs precursor were by pulsed laser ablation (20 mj, 3-6 ns) of the non-micropore carbon precursor target in formaide about 30 min, and obatained the a high quantum yield and dual wavelength N-doped micropore CDs.

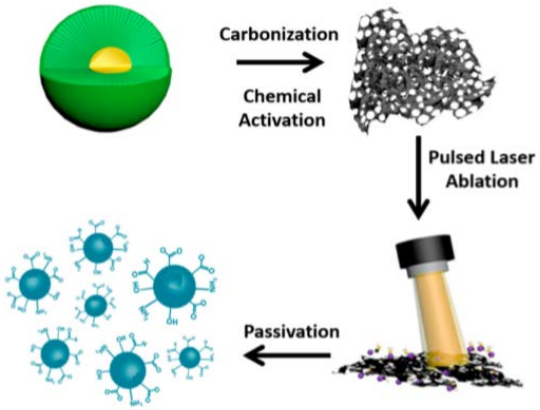

Figure.3 The Synthesis Process Scheme of n-Doped Micropore CDs Derived from Waste Platanus Biomass.

2.2 Bottom-Up Synthetic Route

Bottom-up method can control a lot of porperties about CDs, it includes sizes, shapes, surface states and others. The main methods are hydrothermal/solvothermal process and microwave irradiation process.

2.2.1 Hydrothermal/Solvothermal Process

Hydrothermal/solvothermal method is a is a low cost and nontoxic ways, and organic substance is usually required as a precursor, such as citric acid [17] and chitosan [18]. Herein, as shown in Figure 4, Wang's team reported a N-doped CDs by one-pot pyrolyzing method, [19] it based on the use of mixing ethanolamine and an

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ionic liquid of 1- carboxyethyl- 3methylimidazolium chloride as carbon precursors, then heat the mixture in a 220-240 ◦C keep 2 hours with oil bath under stirring. The CDs' quantum yield is 17.93% in water -solubility, the particle size is about 7.80 nm. Wang et al. promoted a solvothermal method of mixture ascorbic acid and adding $Cu(Ac)_2 \cdot H_2O$ by low temperature keep 5 h at 90℃ to synthesize fluorescent CDs, the size is about 3.2 nm with the emission wavelength is about 450 nm.[20]

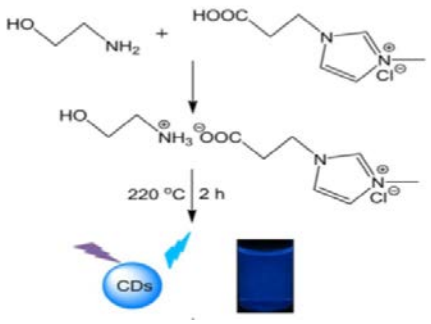

Figure.4 Schematic Representation of Synthesis Procedures of CDs.

2.2.2 Microwave Irradiation Process

The microwave irradiation method is an economical, green and fast heating method for prparing CDs. Liu et al. promoted Microwave irradiation of mixture solution with diethylene glycol, sucrose solution and H_2SO_4 to synthesize highly fluorescent CDs.[21]

3. Conclusion

Because of the CDs have many advantages applications in sensing, optical imaging, medical devices and composites, In this artical, we have described the synthetic method of CDs. Through these methods, we can produce CDs with better performance and apply them to future life.

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