Commentary

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1. What are carbon dots & what makes them special?

Carbon dots (CDs) are zero-dimensional carbonaceous nanostructures that are finely dispersed and are mostly less than 10 nm in diameter [1]. They are spherical nanoparticles with a carbon core that is frequently surface functionalized and contains sp^2 and sp^3 hybridized carbon entities that enable a variety of interactions with nearby molecules and electromagnetic waves [2]. Quantum confinement and unique features including photostability, quantum size effects, improved water solubility, biocompatibility and nontoxicity are all present in such a low-dimensional system [3,4]. It is noteworthy to highlight that in 2004, while purifying single-walled carbon nanotubes produced by arc discharge technology, researchers unintentionally discovered CDs for the first time. Sun et al. later gave these novel minerals their names in 2006. CDs can be divided into four groups according to their basic makeup: carbon nanodots with an amorphous core, graphene quantum dots with a 2D layered graphene core, carbon quantum dots (CQDs) with a spherical crystal core and carbonized polymer dots with a highly dehydrated crosslinking polymer frame or a slightly graphitized core. By using readily available carbon precursors or creating methods based on microreactors, researchers have been forced to reconsider fresh approaches to nanoparticle synthesis in light of the principles of green chemistry [5].

The easy synthesis, abundant functional groups, optical properties, biocompatibility and water solubility of CDs have garnered increasing attention. Numerous disciplines have made substantial use of these CDs, including drug determination, targeted drug administration, fluorescence probes, catalysis and cell imaging [6,7]. The optical feature and fluorescence quantum yields of CDs can be enhanced, particularly through element hybridization. As a result, a key method for drug detection is fluorescence measurement using doped CDs [7].

2. What are the different approaches for synthesis & characterization of CDs?

A salient characteristic that sets CDs apart from other nanomaterials is their synthesis, which is incredibly simple and adaptable. The plethora of synthesis techniques available for the manufacture of CDs can be broadly categorized into two groups: "top-down" and "bottom-up" approaches. A top-down approach describes synthetic processes that involve pulverizing bulky carbon structures using various means such as arc discharge, laser ablation, electrochemical treatments, acid oxidation and so on in order to synthesize CDs. Generally, these methods have poor photoluminescence (PL) quantum yields (QYs), a complicated purification process, and a laborious operation procedure. Owing to its adaptability and ease of use, the bottom-up method of synthesising CDs, which involves applying synthetic or natural organic small molecules as carbon precursors, has consequently gained popularity. Common methods including hydrothermal/solvothermal treatment, ultrasonic oscillation, pyrolysis, oxidative acid treatment and microwave irradiation can generally be used [2].

Determining the characteristics of CDs is crucial for ascertaining their size and form, stability, purity, optical qualities and surface composition. Accurately analyzing the gathered data aids in the prediction of action mechanisms as well. It offers a deeper comprehension of the factors affecting their behavior, which may aid in optimizing synthesis. Several characterization methods such as high-resolution transmission electron microscopy, x-ray photoelectron spectroscopy, Fourier transform infrared spectroscopy (FTIR), proton nuclear magnetic resonance, x-ray diffraction, ultraviolet-visible spectroscopy, Raman spectroscopy and fluorescence spectroscopy are utilized to determine their optical, catalytic, magnetic and structural properties [8,9].

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