Preparation and characterization of highly blue emitting fluorescent carbon nano-dots using Pongamia pinnata fresh leaves

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Short Report

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Abstract

In this study, a simple environmental benign approach have been adopted for the preparation of highly luminescent (blue emitting) water soluble carbon nano-dots using *Pongammia pinnata* (Pp) leaves *via* hydrothermal technique. The prepared Pp-carbon nano-

dots were characterized using UV-vis spectroscopy, fluorescence spectroscopy, Fourier transform infrared (FT-IR) spectroscopy, transmission electron microscopy (TEM) and dynamic light scattering (DLS) measurements. The Pp-carbon nano-dots are spherical in shape with an average size of 32 nm.

Introduction

Carbon based nanoscale materials have recently came out as one of the most fascinating candidates to produce different photo-luminescent particles that do not comprise toxic materials such as heavy metals, semi-conducting quantum dots etc.[1, 2]. Recently, photo-luminescent carbon nano-dots one of the most attractive candidates are widely used in optical sensor [3], diagnosis [4], bio-sensor [5], heavy metal sensor [6], siRNA delivery [7] and bio-imaging probes [8, 9] empowered to provide size-dependent and excessive chemical strength. Many chemical methods are being steadily used to keep away from the use of high-energy systems, post-treatment processing, and expensive precursors [10, 11]. Therefore, simple, reasonable and effortless technique which uses natural sources to produce carbon nanomaterials with high efficiency and eco-friendly nature. Method of preparation of carbon nano-dots on a large-scale in a cost effective way is very convenient for various applications such as bio-medical, energy, sensor etc.,[12]. Though, there are reports on the preparation of fluorescent carbon nano-dots using glucose [11], sugar cane juice [9], food wastes [8], orange juice [13], banana juice [14] and coffee grounds [15] that have been some disadvantages such as expensive processing and low chemical strength. In the present work, preparation of carbon nano-dots using *Pongammia pinnata* (Pp) leaf waste through a simple environmental benign approach *via* hydrothermal technique and characterized by spectroscopic and microscopic tools.

Materials And Methods

Synthesis of carbon nano-dots from *Pongammia pinnata* leaf

Pongammia pinnata fresh leaves were collected from Sathyabama Institute of Science and Technology campus (12.8743° N, 80.2219° E) and used for preparation of carbon nano-dots. Preparation of carbon nano-dots via hydrothermal technique using *Pongammia pinnata* leaf extract as carbon source. Briefly, 10 g of fresh leaf was taken and extracted using 100 mL of distilled water. Further, extract was filtered using whatman filter paper and 70 mL of filtrates was mixed with 30 mL of ethanol and then transferred into 150 mL Teflon lined stainless steel autoclave. The autoclave was maintained at constant temperature (120 °C) for 3 h using a box furnace. The autoclave were carefully taken and allowed to cool under room temperature. The resulted solution was centrifuged at $10000 \times g$ for 20 min and supernatant were allowed under UV light (360 nm) for fluorescent emission. Further, the formation of carbon nano-dots confirmed by UV-vis and fluorescence spectroscopic analysis.

Characterization of carbon nano-dots

UV-vis spectroscopy was recorded using shimadzu 1600 UV-vis spectrophotometer. The fluorescence spectroscopy was measured using shimadzu IR-affinity spectrofluorometer. Fourier-transform infrared spectroscopy (FT-IR) spectra were recorded with a wave number ranging from $4000 - 400 \text{ cm}^{-1}$ on a Bruker alpha with ATR, Germany. The size and shape of the carbon nano-dots were examined using Transmission electron microscopy (TEM-JEOL 3010). DLS measurements (particles size) were carried out using Horiba SZ100, Japan.

Results And Discussion

Figure 1d depicts the UV-Vis absorption spectrum of Pp-carbon dots. The spectrum shows an absorption onset at around 270 nm which is mainly due to $\pi-\pi^*$ transitions of the functional groups. This result is in consistent with the previous reports [6, 13, 16, 17]. Figure 1e shows the PL spectrum of Pp-carbon dots which was recorded at an excitation wavelength, $\lambda_{\text{exc}} = 350 \text{ nm}$. From the PL spectrum, the broad emission band was observed at around 440 nm. This blue emission is mainly considered to be the versatile characteristic of Pp-carbon dots, which may be due to quantum confinement effects, small size distribution or the presence of emissive traps on the surface [6, 8, 13, 18]. FT-IR analysis is mainly utilized to study the functional groups which are present in the prepared Pp-carbon dots. Figure 1f shows the FT-IR spectrum of Pp-carbon dots. From the spectrum, the characteristic absorption broad band is observed at around 3333 cm^{-1} which is mainly due to O-H stretching vibration of hydroxyl group. Two sharp peaks were detected at around 1638 and 1016 cm^{-1} which corresponds to aromatic C = C (ring stretching) and CO stretching of alcoholic OH or C-O-C group [6, 13, 16]. The morphology, shape and average size of Pp-carbon nano-dots were studied using TEM and DLS analysis. From Fig. 2a&b, the TEM images of Pp-carbon nano-dots were spherical in shape with average size of 32 nm. Further, the particles sizes were confirmed using DLS measurement (Fig. 2c) with average hydrodynamic diameter of 31.5 nm.

Conclusions

In summary, we demonstrated simple, cost effective and environmental benign method for the preparation of highly fluorescent Pp-carbon nano-dots using *Pongamia pinnata* leaves extract as carbon source. The prepared Pp-carbon nano-dots exhibited bright blue color emission under UV light with average size of 32 nm. UV-Vis absorption spectrum shows an absorption onset at around 270 nm. PL spectrum of Pp-carbon dots display a broad blue emission band at around 440 nm. In future, these Pp-carbon nano-dots will use bio-imaging, bio-sensing and fluorescent probes.

Declarations

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Author Declarations

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Figures

Figure 1

shows a) Pongamia pinnata; b) Carbon dots solution; c) Carbon dots solution under UV light at 365 nm; d) UV-vis absorption spectrum; e) PL spectra and f) FT-IR spectrum of carbon dots

Figure 2

shows TEM images of carbon dots a) 100 nm; b) 50 nm and c) DLS measurement of carbon dots