



Studies on Chemical Properties of Carbon Dots Synthesized by Green Technique

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ABSTRACT

In this study, the carbon quantum dots (CQDs) are prepared by using 2 natural precursors namely Carica Papaya and Lemon by one step Micro wave assisted method. The sample emits green light due to its charming fluorescence property when it is kept under UV- illuminator. The energy gap and the Refractive Index of the synthesized sample is obtained by UV-Vis spectroscopy. The nature of the CQDs is confirmed by the X-RAY DIFFRACTION (XRD) Spectroscopy. The surface chemistry analysis is done by Raman and Fourier transform infrared spectroscopy (FT-IR).

1 Introduction

The rapidly growing area of science in recent times is nanotechnology. The discovery of Fluorescence CDs in 1985, sparked the growth of nanotechnology [1]. The semiconductor nanoparticles that emit particular color after illuminated by a light are called Quantum dots (QDs). The color and size of the QDs are corelated. Carbon Quantum dots (CQDs) were first discovered during purification process of single-walled carbon nanotubes in 2004. Initially they were indicated as carbon nano particles (CNP), later they were renamed as Carbon dots(C dots). The nano materials with size less than 10nm are known as Carbon Quantum Dots (CQDs) [2]. These CQDs have widespread application in light-emitting devices (LED), Bio imaging, Biosensor, Biocompatibility due to their unique and tunable optical properties, low cost, environmentally friendly fabrication and Low toxicity. Nowadays from the preparation of carbon dots to their application, the researchers have been working in green synthesis method through natural precursors [3].

So, in this work the CQDs are prepared using 2 natural precursors namely Carica papaya and Lemon by a one-step Microwave assisted method. Subsequently the fluorescence property of the sample is investigated.

2 Materials and Methods

2.1 Experimental Materials

The fresh Carica papaya and Lemon were purchased from a local market. Deionized water was purchased from amazon.1N Ammonium hydroxide (NH₄OH) was prepared in the laboratory.

2.2 Apparatus and Procedure



UV-Vis absorption spectra were examined by a spectrophotometer Shimadzu UV-2600, UV2700. Fluorescence images were carried out on UV-Illuminator Equiptronics Model Number EQ 785.

Centrifugation is done by using 20000 RPM Micro Refrigerated Centrifuge. Heating is done by using Hot Air Oven (Model Number KOMS.3. I.D.S.P, Temperature 2500⁰c, Volts 220/230AC) and Muffle Furnace (PFY900, 5SL62327RC, MCB, C32, ~415V). Raman Spectra of the sample were recorded with Lab RAM HR Evolution (HORIBA Scientific). Fourier-Transform Infrared Spectra (FT-IR) were recorded on a Perkin Elmer's new spectrumTM 3 FTIR spectrometers. Covers the near mid and far-IR ranges (11,000-30,000cm⁻¹).

2.3 Preparation of CQDS Liquid Sample

The fresh Caricapapaya and lemon were purchased from a local market and the outer layers of papaya peeled out. Then 30 ml of papaya and lemon Juice of each were extracted using a domestic mixer. To the above solution we need to add 16 ml deionized water and 23 ml of freshly prepared ammonium hydroxide (NH₄OH) [92.5ml of water + 7.5 ml of 25% NH₄OH = 100ml of 1N ammonia]. Later the mixture was transferred to a conical flask and it is heated in a domestic micro wave oven at 1700w for 5 minutes. After bringing it to the room temperature, it was placed in a muffle furnace at 162 °C for 2 hours, then after 2 days it was centrifuged for 3 hours at 6400 rpm. Then the solution is kept in freezer for further use [4].



Figure 1: Papaya and Lemon juice



Figure 2: *Solution after Heating*

2.4 Powder Sample

The fresh Caricapapaya and lemon were purchased from a local market and should peel out the outer layer of papaya. Then 100.0 ml of papaya and lemon juice each were extracted using a domestic mixer, To the above solution we need to add 53.3 ml of DI water and 76.6 ml freshly prepared ammonium hydroxide (N H₄OH) [92.5ml of water + 7.5 ml of 25% N H₄OH = 100ml of 1N ammonia]. Later the mixture was transferred to a beaker and it is heated in a domestic microwave oven at 1700w for 15 minutes. After bringing it to the room temperature the beaker was placed in a hot air oven at 242 °C for 54 hours 25 minutes.

Later the powder sample obtained are taken into crucible and allowed to heat in a muffle furnace at 400 °C for 5 hours. Then allowed to cool at room temperature, using mortar pestle the sample was crushed into a fine powder. Then the powder sample was ready for characterization.



Figure 3: *The powder sample after heating in a muffle furnace*

2.5 Fluorescence Images and UV-Vis Absorption Spectra

For long UV (320nm-400nm), mid UV (255nm-312nm), Short UV (100nm-254nm) and day light (500nm).

**Figure 4 : Long UV****Figure 5 : Mid UV****Figure 6 : Short UV****Figure 7 : Day Light**

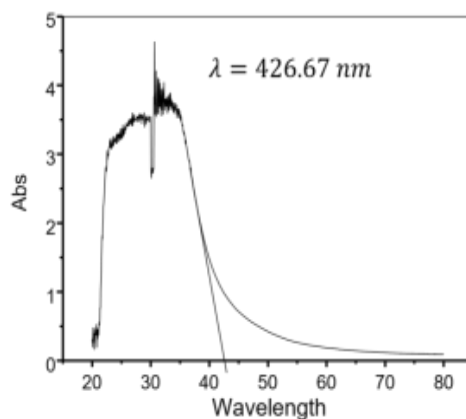
The Optical Properties of the sample were investigated by Fluorescence images and UV-Vis absorption spectra.

The optoelectronics properties of CQDs significantly vary due to its shape and size. The Band Gap of the CQDs increases when the size of the particle decreases. Due to Fluorescence property of CQDs the green light is emitted when the sample is kept under UV-Illuminator. The sample is emitting green light then the size of the CQDs is said to be 2nm [6].



3 Results and Discussion

3.1 UV-Vis Spectra



$$E_g = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{426.67 \times 10^{-9}} = 4.658 \times 10^{-19}$$

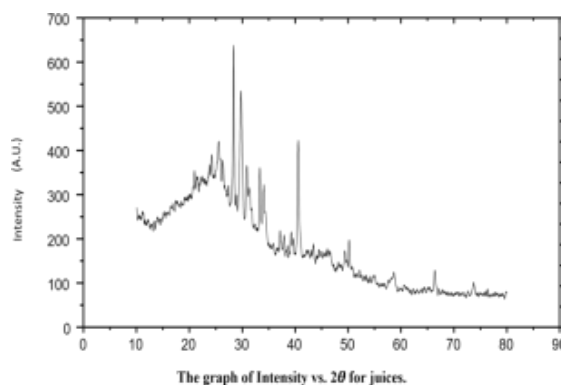
$$J = 2.911 \text{ eV.}$$

Refractive index, $n = 4.084 - 0.62 E_g = 4.084 - 0.62 \times 2.911$

$$n = 2.27918$$

From the above spectra of Abs vs. Wavelength we get to know the energy gap of the sample. The E_g of the above sample is about 2.911 eV, then it is said to be a Semiconductor. Using this Energy gap, Refractive Index can be determined. So, the RI of the sample is 2.27918 [5, 11].

3.2 Analysis of XRD



XRD graph is used to find the nature of the material. For sharp peak the material may be taken as crystalline. For broader peak it maybe polycrystalline, while in case where there is no peak, but some noisy pattern, then the material is said to have amorphous nature. So the above graph is having sharp peaks, then it indicates that the sample is of crystalline nature [7, 12, 13,].

3.3 Analysis of Raman Spectra

Intensity 500 450 400 350 300 250 200 150

2 juices trail 0 500 1000 1500 2000 2500 Raman shift / cm^{-1}



3.4 The graph of Intensity vs. Raman shift for 2 juices

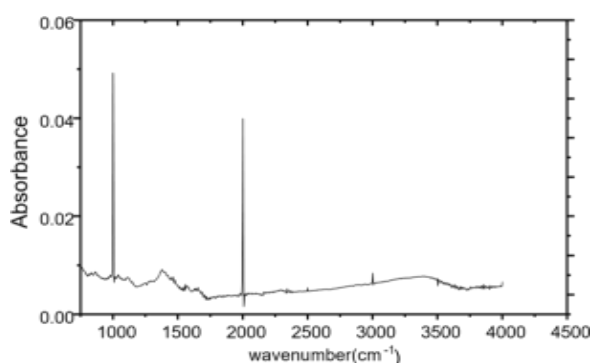
As per the above graph the region is around $1000\text{--}1250\text{ cm}^{-1}$, it having functional group $\delta(\text{CH}_3)$ asym and it is Raman medium and IR medium [8,12,13].

$\text{Y}(\text{C}=\text{S})$ and it is Raman strong and IR weak. Another region is around $1400\text{--}1470\text{ cm}^{-1}$ $\delta(\text{CH}_2)$

3.5 Analysis of Surface Chemistry

3.6 Absorption

2 juices lemon and papaya each 30ml, along with DI and NH_4OH kept in micro oven for 5 minutes



The graph of Absorbance vs. Wavenumber for 2 juices. From the above graph peaks are around 1000 and 2000 cm^{-1} , so as shown in the peak at 1000 cm^{-1} is in finger print region having single bond.

Transmittance

2 juices lemon and papaya each 30ml, along with DI and NH_4OH kept in micro-oven for 5 minutes.

The graph of Transmittance vs. Wavenumber for 2 juices. From the above graph peaks are around 1000 and 2000 cm^{-1} , so as shown the peak at 1000 cm^{-1} is in finger print region having single bond [9, 14, 15, and 16].

4 Conclusions

The Sample (Papaya + Lemon) successfully synthesized by Bottom – up Approach using green synthesis method. After the synthesis, the sample is kept under UV illuminator to check the fluorescence property. It also conforms the production of dots. Later, the sample is characterized for UV, XRD, RAMAN and FTIR characterizations successfully.

By UV-visible Characterization, Energy gap of the sample is found to be 2.911eV (Semiconductor). In this present study I-V characterization is done using powder sample. From this we get to know that the conductivity of the above sample is poor because as we had used high resistance. Because of high resistance, low size they are potential candidates for super capacitors. The fine powders of all the samples are studied for crystallinity using powder XRD. From XRD characterization nature of the sample is crystalline. For the powder sample Raman characterization is carried, it has been observed that Raman peaks around the regions for the



sample are $1000\text{--}1250\text{ cm}^{-1}$, having functional group $\nu(\text{C}=\text{S})$ and it is Raman strong and IR weak, $1400\text{--}1470\text{ cm}^{-1}$ $\delta(\text{CH}_2)$ $\delta(\text{CH}_3)$ asym and it is Raman medium and IR medium. There is a need for testing of suitability for device. Further properties should be studied like TEM (Transmission electron microscopy), SEM (Scanning electron microscopy) and Atomic Force Microscopy (AFM). Later the dopants can be added to the sample for forensic applications.

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