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Research Article

Economic way of synthesis of green fluorescent carbon nano particles from lemon juice as a new carbon source

Sumitha Tom*

Assistant Professor, Department of Chemistry, Catholicate College Pathanamthitta

*Corresponding author (*E-mail address*: sumivipin2011@gmail.com)

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Abstract

In the development of materials science, carbon-based materials are crucial. Carbon nanoparticles (CNPs) are one of the most interesting carbon-based nanomaterials which because of water insolubility formerly could not be employed in the biological fields. Recently, large efforts have been made to develop green routes in order to synthesize water soluble CNPs from economic sources. In this regard, in this study a simple ecofriendly economic method for the preparation water soluble green fluorescent Carbon Dots (CNPs) have been developed by microwave assisted method from lemon juice. The synthesized CNPs were characterized by UV-Visible absorption spectra, Fluorescence spectrophotometer as well as Fourier Transform Infrared Spectroscopy (FTIR). The results reveal that the as prepared CNPs emit bright green photo luminescence and the surface was rich in hydroxyl and carboxylic groups and shows excellent water solubility. The one-step economic green preparation process is simple and efficient and it is not necessary to use a strong acidic solvent or modify the surface of the reagent, which makes this approach very suitable for large-scale production, strong fluorescence and excellent biocompatibility.

Key words: Carbon nano particle, Microwave method, Lemon juice, Photo luminescence

1. Introduction

In recent years, nanotechnology has emerged as a promising area of research that spans multiple disciplines. It has found extensive applications in diverse sectors such as pharmaceuticals, agriculture, cosmetics, food preservation, electronics, biosensors, and bioimaging. In a general sense, it depends on altering the characteristics of basic materials to generate and control nanosized substances [1, 2]. Numerous types of inorganic and organic nanostructures have been examined and utilized due to their distinct physical, chemical, and biological attributes. These attributes include a diverse range of shapes and forms, a significant ratio of surface area to volume, reliability, uniformity in dispersion, and the ability to harm microorganisms or cancerous cells. One of the first nanomaterials ever created, carbon black is still widely used today. However, there has been growing interest in creating novel carbon materials with precise chemical functionality, controlled size, and shape [3, 4]. Fullerenes, carbon nanotubes, nanodiamonds, carbon nanoonions, graphene, graphene oxide, and carbon dots are among the novel carbon nanomaterials that have been created. Carbon nanomaterials have demonstrated promise in a variety of crucial research fields, including chemical catalysis,

photocatalysis, energy storage, fluorescence probe design for biological applications, and environmental remediation, as a result of their special physical and chemical properties [5].

Currently, a significant portion of the debate on nanotechnology perspectives is focused on nanostructures made of carbon. Fullerenes and nanotubes have received the most research to date, but other members of this family are starting to get more and more attention [6]. A new era in carbon materials started to emerge in the middle of the 1980s with the discovery of Buckminster fullerenes (also known as "buckyballs") and fullerene nanotubules (also known as "buckytubes") [5]. These materials have so far sparked a global research boom that seems to be continuing to grow. Because of their distinctive structure, electronic, mechanical, optical, and chemical characteristics, numerous carbon-based nanomaterials have drawn significant attention and have been thoroughly studied [7]. These materials have also been widely used in a variety of applications, including hydrogen storage, water filtration, electronics, energy applications, and biology [8-10]. Recently carbon nanoparticles utilized in the field of clinical diagnostic methods. Carbon nanoparticles (CNPs) are one of the most interesting carbon-based nanomaterials which are mostly composing graphite nanoparticles less than 10 nm in size [11,12]. CNPs are proposed to be promising alternates for the heavy metal- based nanoparticles [13]. Due to their high surface to area ratio and high abundance of interfacial edge sites, CNPs that resemble metal nanoparticles may be useful for electrochemical processes. [17-17].

To date, much effort has been put into creating environmentally friendly ways to synthesise new nanomaterials in order to substitute harmful substances, organic solvents, and techniques that are expensive and take a long time [18]. The limited solubility of CNPs has prevented their widespread usage in many fields, particularly biology, for many years. [19,20]. Finding affordable and suitable environmentally acceptable sources for the synthesis of CNPs is still needed. As a new environmentally friendly source, we created CNPs in our work by synthesising them from lemon juice under microwave irradiation. Lemon juice is one of the easiest drinks to make at home quickly. Lemon typically has a sour flavour. However, the flavour is enhanced with the addition of lime and sugar. Lemon juice is a refreshing summer beverage that satisfies thirst. It is the healthiest juice to drink in the summer and is simple to prepare. Lemon is very low in protein and fat. Its makeup is primarily made up of water and carbs. Lemon juice's carbohydrates often include fibre and sugars including sucrose, fructose, and glucose. According to the researchers, CNPs can be made from any carbohydrate that contains C, H, and O in the proportion of 1:2:1, as long as C and O are present in a form that enables dehydration when exposed to microwave radiation. The synthesis of CNPs from lemon juice involves the carbonization of its constituents. [21-25].

2. Materials and Methods

2.1 Materials

Commercially available sugar -2.5g, Concentrated H_2SO_4 – 1ml, Distilled water -50ml, Lemon juice-5ml.

2.2.Synthesis of CNPs

In order to synthesize CNPs the commercially available sugar (2.5g) was dissolved in 45ml of distilled water and then 5ml of lemon juice was added. 0.5ml of concentrated H2SO4

was added dropwise to speed up the dehydration and carbonization process, and it was agitated for 10 minutes. The solution was then subjected to microwave irradiation for 10 minutes to obtain a brownish yellow solution. The brownish yellow solution was centrifuged at a speed of 5000 rpm for 15 minutes to obtain CNPs and is used for further analysis.

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3. Characterization of CNPs

To analyse the optical features of synthesized CNPs, 1ml of CNPs was dissolved in 10ml of distilled water and analysed. The FTIR spectra were recorded using the JASCO FTIR 4100 Spectrometer in the 400-4000 cm^{-1} range. The absorbance spectra of samples were recorded in JASCO V-550 UV-Vis spectrophotometer. Fluorescence measurements were conducted with a Cary Eclipse fluorescence spectrophotometer.

4. Results and Discussion

4.1. Optical characterization

The prepared CNPs have good aqueous solubility and exhibit Brownish yellow colour under daylight and green colour under UV lamp. It indicates the prepared CNP emit a green fluorescence as shown in (Figure 1). The UV-Visible spectrum (Figure 2) shows a strong absorption at 250 nm which is because of the n-л* transition of C=O and л -л* transitions, which are characteristics of the CNPs synthesized.

The excitation and emission spectra of synthesized Carbon nano particles were initially recorded as 380 nm and 460 nm (Figure 3 & Figure 4) respectively. The Carbon nano particles aqueous solution emitted obvious green fluorescence under UV light while appearing as brownish yellow colour under daylight.

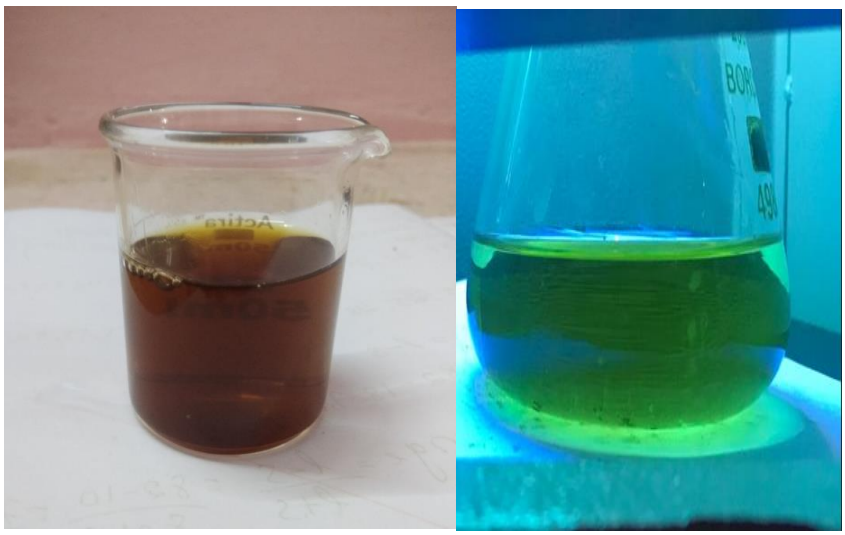

Figure 1: Carbon nanoparticle under day and UV light

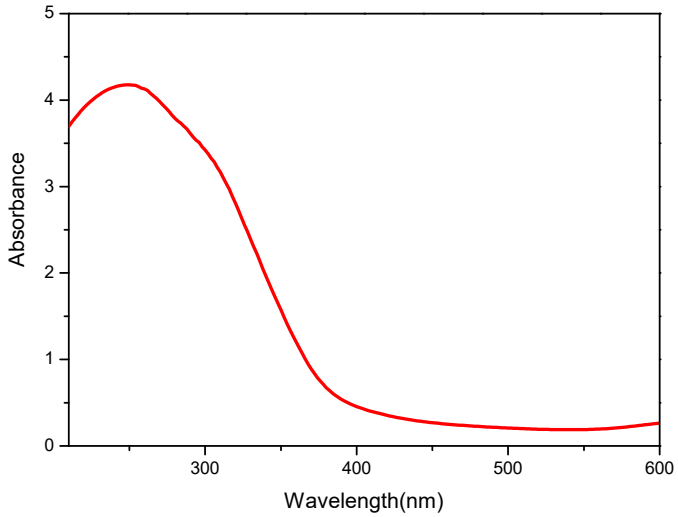

Figure 2: UV-visible absorption spectrum of carbon nanoparticles

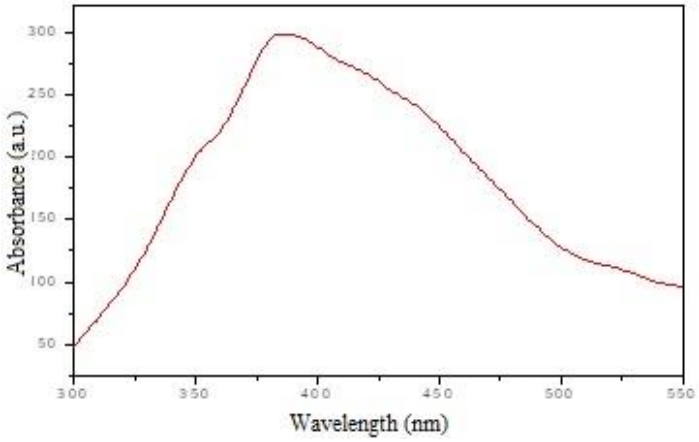

Figure 3: Fluorescence excitation spectrum of carbon nanoparticles

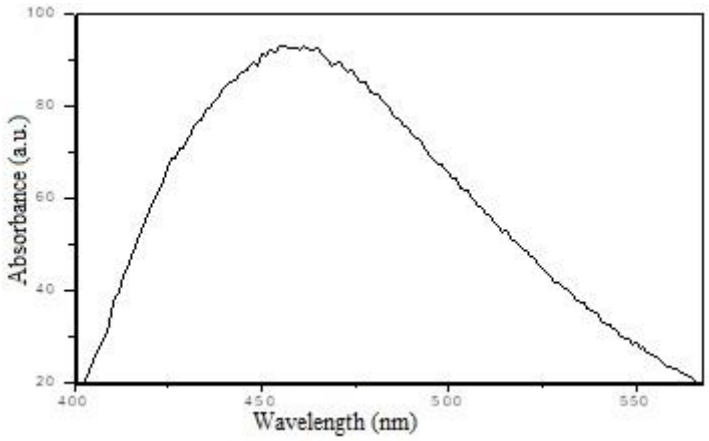

Figure 4: Fluorescence emission spectrum of carbon nanoparticles

4.2.FTIR Analysis

The CNPs were characterized for their functional groups by FTIR spectroscopy. FTIR spectrum was obtained on a JASCO FTIR 4100 Spectrometer by KBr pellet method which is shown in the figure Figure 5. The most prominent peak at around 3406cm^{-1} was attributed

hydroxyl stretching vibrations. The band at 2936 cm^{-1} was assigned to C-H stretching vibrations. The peak at 1644 cm^{-1} and 1468 cm^{-1} may be caused by asymmetric and symmetric stretching vibrations of COO^- respectively. The peak at 1070 is assigned to the characteristic absorption band of C-O stretching vibration mode. These results declare that synthesized CNPs are probably carbonaceous material with large number of hydroxyl and carboxylic groups on the surface. The produced CNPs present excellent water solubility because of the presence of these functional groups.

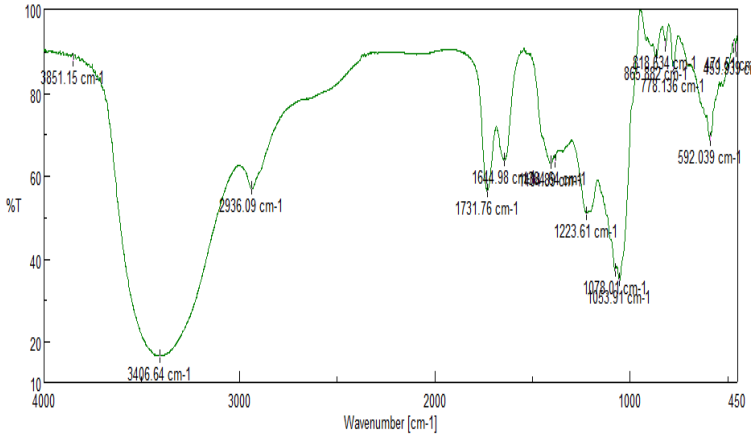

Figure 5: FTIR spectrum of carbon nanoparticles

5. Conclusion

In the present study the water soluble green fluorescent CNPs were synthesized from lemon juice by green economic method. The obtained CNPs showed stable optical properties and small enough to show strong fluorescence peak. The characterization of the synthesized CNPs confirmed the capability of CNPs to be used in the biological aspects due to the low toxicity and presence of carboxylic and hydroxyl group on the surface of CNPs.

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