SYNTHESIS AND CHARACTERIZATIONOF pH SENSITIVE CARBON DOTS FROM TEA

Dissertation submitted in partial fulfillment of requirements ofthe Degree of Bachelor of Science in Chemistry,

University of Kerala

Submitted by

Anila Ajith	(23519101022)
Anjana Suvarnan	(23519101023)
Anusha Krishnan	(23519101024)

DEPARTMENT OF CHEMISTRY

BISHOP MOORE COLLEGE, MAVELIKKARA

CERTIFICATE

I certify that this is the bonafide record of the project work performed by Anila Ajith, Anjana Suvarnan and Anusha Krishnan in partial fulfillment of the requirement of Bachelor Degree in Chemistry of the Kerala University. This work is carried out under my guidance and that no part this work has been reported for any other degree.

Linda E Jacob
Department of Chemistry
Bishop Moore College
Mavelikkara

ACKNOWLEDGEMENT

We take this opportunity to express our sincere gratitude to Ms Linda E Jacob, Assistant Professor, Department of Chemistry, Bishop Moore College, Mavelikkara for her guidance and for arranging all the required facilities for this project. We are also grateful to Prof. Siji K Mary, Head of the Department of Chemistry and to other Professors of the department for their suggestions provided in the completion of this project. We are thankful to everyone who helped us in conducting this work. We are grateful to our parents, siblings and friends for their support which has enabled us to conduct and complete this work.

Anila Ajith

Anjana Suvarnan

Anusha Krishnan

DECLARATION

We hereby declare that this project work entitled "Synthesis and characterization of pH sensitive carbon dots from tea" submitted to Kerala Universityin partial fulfilment of Bachelor's Degree in Chemistry is bonafide record of the work carried out under the guidance of Assistant Professor Ms. Linda E Jacob and no partof it has been submitted for any other degree or diploma.

Anila Ajith

Anjana Suvarnan

Anusha Krishnan

CONTENTS

ABSTRACT

Carbon dots are new series of fluorescent nanomaterials that have drawn great attention in recent years owing to their unique properties. In this project, a simple green approach to synthesize carbon dots was developed by using tea powder as the carbon precursor. The synthesized carbon dots were further characterized using PL spectra. The effect of pH on the PL spectra of carbon dots was also analysed.. The alcoholic solution of as-prepared carbon dots were nearly transparent under visible light, while it displayed strong blue fluorescence under UV light (310nm). The PL spectra shows when excited at the maximum excitation wavelength of 375nm, the as-prepared carbon dots exhibited a strong PL peak at 470nm.In strong acidic condition, the emission wavelength shift to the 510nm wavelength, while it moved to 493nm wavelength in strong basic solution, implying that the as-prepared carbon dots were very sensitive to pH. So the carbon dots can be used as a promising material for sensing, bio imaging etc.

INTRODUCTION

1.1 Nanotechnology

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers .Physicist Richard Feynman, the father of nanotechnology. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across the other science fields, such as chemistry, biology, physics, material science, and engineering.The ideas and concepts behind nanoscience and nanotechnology started with a talk entitled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology (CalTech) on December 29, 1950,

Nanoscience and nanotechnology involve the ability to see and control individuals and molecules. Once scientists had the right tools, such as the Scanning Tunnelling Microscope (STM) and the Atomic Force Microscope (AFM), the age of nanotechnology was born. The confluence of these newly acquired capabilities, coupled with advances in imaging, bioinformatics, and systems biology, holds tremendous promise for answering some of biology's most challenging biochemicaland genetic questions. Although biology today a benefiting from a hat of technological developments, few may eventually have the paradigm-changing impact on basic research, drug development and clinical medicine as nanotechnology. By operating in the nanoscale realm, at the very scale of biomolecules, nanotechnology offers a wide range of tools and applications. Near-term applications include drug-delivery platforms enhanced image contrast agents, chip-based nano labs capable of monitoring and mandating individual cells, and nanoscale probes that can track the movements of cells and individual molecules they move about in environment Such an unprecedented ability to observe and influence the complex system in vivo and real-time provides detailed information about the fundamental mechanisms and signaling pathways involved in the progression of the disease and greatly extended the existing toolset for drug delivery and noninvasive drug monitoring

1.1.2Carbon dots

Carbon dots (CD) is defined as a quasi zero dimensional carbon based material witha size below 20 nm and fluorescent is their intrinsic property. There are materials derived from organic compounds and are stable in aqueous media which is extremely significant in terms of which is extremely significant in terms of biologicalpoint of view.

Carton dot were discovered accidentally in 2004 at the time of purification of single wall carbon nanotubes by Xu et al. Two years later, in 2006. Son et al First synthesized stable photo luminescent carbon nanoparticles of different sizes and named "Carbon quantum dots" (CCD)(1).CQDs have only sp hybridised carbon framework where CDs are composed of both sp^2 and sp^3 hybrid carbon network. Moreover, they can be easily functionalized with hydroxyl, carbonyl, amino and epoxy groups over their surface there by offering extra advantages for binding with both inorganic and organic moieties.The functionalities specifically allow the surfaces of CDs to espouse other with hydrophilic or with hydrophobic character which finally provide the necessary thermodynamic stabilities in different solvents Especially in water.(2) Carbon dots have emerged as new advancement a medicine and theranostics due to the exceptional biocompatibility typical optical properties, nontoxic precursors, high aqueous solubility and easy surface passivation, unlike semiconductor quantum dots such as CdTe and which possess some sort of toxicity another luscious property of carbon dot is their photoluminescence in near infrared region which assets the potential useof it for treatment of tumours by employing photothermal therapy. Moreover, they offer an interesting alternative to convention fluorescent materials and are currently touted to possess a tremendous potential for integration in a myriad of applications including displays, lighting, sensing both biological and chemical catalysis, solar cells, imaging and drug delivery among others (3) CDs can exhibit fluorescent properties that are excitation wavelength dependent, which implies that as the excitation wavelength is varied from high energy (UV) to lower energy [visible or nearinfrared), the emission is red-shifted and vice versa. Hence, a single CD system can possess multiple fluorescence possibilities. It is a so possible to design carbon dots with fluorescence properties that are excitation wavelength independent CDs are widely used in the area of bio imaging both in vitro and in vivo and in diagnosis purposes, photo thermal as well as photodynamic therapy and drug delivery carriers CDs could also been applied for the determination of cellular levels of biomolecules and ion (bio-sensor),such as Cu^{2+}, Hg, NO_3^-,etc

1.1.1 Synthesis

. Top-down formation

• Bottom-up formation.

Top-down synthesis

The top-down method involves cleaving or breaking of sheet or bulky carbon materials such as carbohydrates, carbon soot, carbon fiber activated carbon etc. Through laser ablation, are discharge and acidic ultrasonic chemical, hydrothermal and solvothermal exfoliations. The entire formation mechanism depends on the breakdown of the bond between the carbon atom. In the green synthesis of carbondots researchers usually use some carbon waste materials such as candle soot, natural gas soot as precursors. There large-sized carbon materials can be oxidised and broken into nano sized CDs by strong oxidising agents Such as $H_2SO_4$and HNO_3 limited raw materials, the top-down method is less applied in green synthesis

Arorea et al. indicated that arc discharge is the electricalbreakdown of a gas to generate plasma by using electric current with anode and cathode electrode. The anode is filled with carbon precursors and started to generate plasma with an arc current under a gas media at a high temperature of nearly 400K.The carbon vapour aggregated in the gas towards the cathode and cooled down **[4]**

Sun et al improved the CDs with strong photoluminescence effects Through laser ablation method of the carbon target as the mixture of graphite powder and cement. It involves three steps, (i)the carbon materials absorbs the high energy by the laser pulse (ii)electrons are stripped from the atoms through photoelectric and thermal emission and (iii) a high electric field produces a strong repulsive force between positive ions and solid material breaking down carbon dots**[5]**

Lu et al reported the use of an ultrasonic assisted, liquid phase exfoliation technique to prepare graphene carbon dots. Briefly graphite can be well dispersed in organic solvent and the graphite layers cleave apart and are exfoliated by the surface energyfor a Van der Waals forces of graphite layers under the ultrasonication process this study supported that sonication can enhance the exfoliation effects and dispersion in the organic solvent[6]

Bottom-up synthesis

The bottom-up synthesis involves the pyrolysis or carbonation of small organic molecules; generally, the organic molecules usually undergo four stages in the formation of CDs condensation polymerisation reactions such as amidation, aldol condensation, Schiff base condensation and radical reaction. Second, the intermediates are further polymerized or aggregated into polymer-like carbon dots with certain polymer like covalent, non covalent or other interactions. Third the polymer thin carbonizes to form the carbon core especially at high temperature finally the residual precursors as surface passivating agents can be modified on surface of carbon dots to improve luminescence efficiency

Zhu et al. reported that highest quantum as high as about 80% of carbon dots that is equal to fluorescent dyes [7]. They used citric acid and ethylenediamine as carbon and nitrogen sources to be utilized in the ionization to the condensation polymerisation and carbonization steps hydrothermal treatment at 150-300°C for 5 hours to prepare polymer like and carbonaceous carbon dots

Pyrolysis method for the synthesis of CDs from precursor molecules is also preferred by some researchers. Pyrolysis is an irreversible thermal decomposition reaction in which decomposition of organic materials take place in an inert atmosphere. It involves physical as well as chemical changes in organic materials resulting in solid residue containing carbon. Generally pyrolysis takes place at very high temperature and under controlled pressure. Bourlinos et al. synthesised Gd(lll)-doped CDs having diameter 3.2 nm with dual fluorescence via pyrolysis method 18]. They prepared a mixture of tris(hydroxymethyl) aminomethane (Tris base), gadopentetic acid, and betaine hydrochloride to fabricate Gd(lll)-CDs followed by the pyrolysis at 250 °C temperature

- **Metal scanning**

Carbon dots have been extensively studied as nanosensors due to their ability to detect ions and molecules with great selectivity. Fluorescent carbon dots, due to their excellent optical properties chemical stability and good solubility in water in the field and chemical sensing under great attention are widely used in metal ion detection, anion detection etc. Carbon dots as a new fluorescent probe solution are easily quenched efficiently by electron acceptor and this can be effectively detect metal ions in solution and determine the concentration range to achieve the trace analysis of metal Hg is one of the most toxic heavy metal ions in environment, has received the attention of scientific researchers. Currently, based on CDs as sensors, scientists have developed a variety of methods to detect Hg^{2+}. Lu et al prepared a new type of CDs from grapefruit peel through hydrothermal method. As Hg^{2+} was developed the detection limit of 0.23Nm, and this method has been successfully applied to the detection of Hg in the rivers

Bio-imaging

Bio-imaging is an important, non invasive technique that permits the visualisation of intracellular compartments, cells and tissues, allowing for a better understandingof biological processes

CDs are potential candidates for bio-imaging application due to its unique fluorescent nature, photobleaching resistivity, less cytotoxicity and better aqueous solubility. The fluorescence bioimaging capacity of carbon dots was first reported by Sun et al. They attached PEG1800N on the surface of carbon dots and were amazed the possibility of usingthe surface modified CDs as optical labels. The PEG1500N attached carbon dots allowed the section of different emission wavelength with different excitation wavelength in the confocal microscopy imaging of E coli ATC G cells 25922 cells

Through several works demonstrated the huge potential of CDs as a superior universal fluorescent tags for cellular imaging, further optimization and improvement of several properties such as biocompatibility and the ability to absorb or emit in the long wavelengthare necessary in order apply them for the fluorescence imaging of HepG2 cells. The potential of carbon dots specific cellular imaging of various cell lines including Hela cell, human lung cancer, N,H-3T, fibroblast cells and fungus[9]

Catalysis

Pham-Truong Et al synthesised CDs using glucose and a mixture of glucose and glutaminein an ionic liquid. Base carbon dots using just glucose as a precursor were also produced asa control to evaluate the role of the nitrogen doping in the oxidation reductions. The two different mixture of precursors were then irradiated for different times and the product was purified by dialysis generating CDs that were = 12 nm in size

The presence of-COOH, -OCO, -CN and -NH_2, moieties on the surface of the CDs suggested the formation of N- doped dots in both cases, as expected with the presence of the imidazolene ring. The obtained material was used as a free catalyst for the selective production of hydrogen peroxide from the oxidation of oxygen molecules linear sweep voltammetry(LSV), performed to analyse the performance of the catalyst showed the presence of two reduction process suggesting that the oxidation reduction reaction occurred in two steps forming hydrogen peroxide as an intermediate. As from the result we get nitrogen atom had a significant effect on the mechanism. CDs are good reducing agents

• **Optronics**

CQDs possess the potential in serving as materials for dye synthesised solar cells, organic solar cells, supercapacitor, and light emitting devices. CQDs can be used as photosensitizers in dye-sensitised solar cells and the photoelectric conversion efficiency is significantly enhanced. CQD incorporated hybrid silica based sol can be used as transparent fluorescent paint

Drug or Gene delivery

Carbon dots can be used as a vehicle for drug /gene delivery due to them synthesize from cheap sources, facile surface functionalization, tiny size and high biocompatibliity. Drug delivery pathways are also tracked due to the intrinsic fluorescence nature of CDs. In order to deliver the anti-cancer drug doxorubicin (DOX) into cancer cells, Zhou et al. used fluorescent CD gated mesoporous silica nanoparticles (MSDs) as a pH response drug carrierand bio-imaging system. Its biocompatibility showed strong fluorescence both in vivo and in vitro. DOXs loaded CDs @MSPs entered into cancer cells via endocytosis showed a pH response drug delivery behaviour in mildly acidic condition and enhanced cyto-toxicity in Hela cells(10). Recently Kong and et al. fabricated a citric acid and ethylenediamine based CDs for drug delivery systems according to their results they observed that DOX could be quickly loaded on CDs through electrostatic interaction and the CDS/DOX complexes showed better cellular uptake and anti tumour efficiency on the breast cancer MCF-7 cells compared with free DOX **(11)**

1.2 Tea Powder

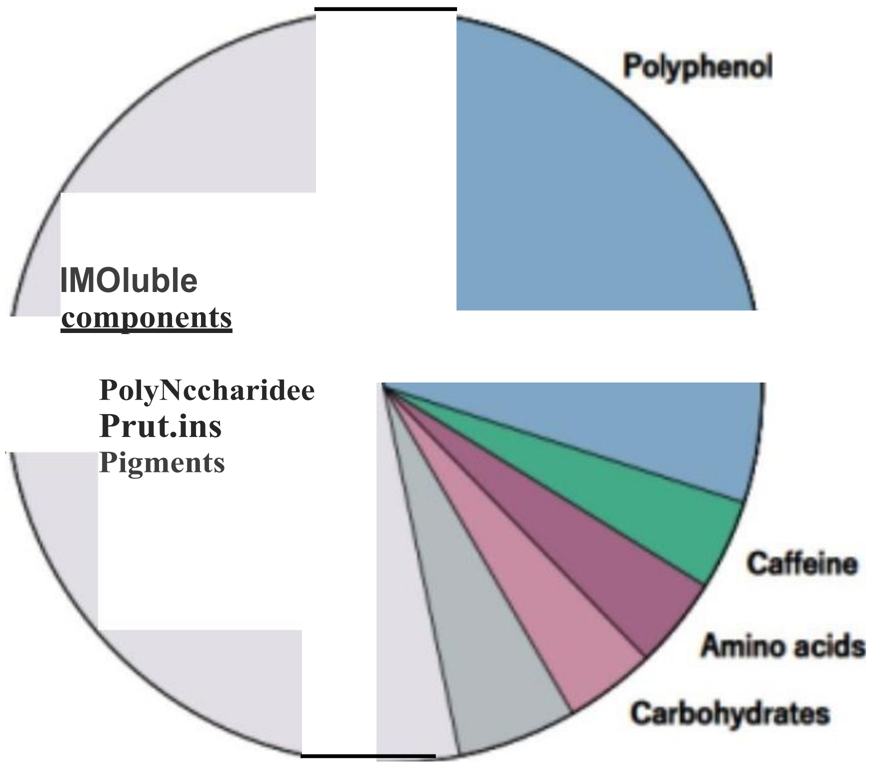
Tea chemistry is complex. Tea leaves contains thousands of chemical compounds. When tealeaves are processed, the chemical compounds within them break down, form complexes with one another and form new compounds. The most important compounds in fresh tea leaves are polyphenols, amino acids, enzymes, pigments, carbohydrates, methyl xanthines, minerals and many volatile flavor and aroma compounds. These components are responsible for producing teas with desirable appearance, aroma, and taste. There are several known categories within polyphenols. Flavonoids are arguably the most important category; they are the reason for many health claims surrounding tea because they containantioxidants.

Within the flavonoid group are flavanols, flavonols, flavones, isoflavones, and anthocyanins. Flavanols (short for flavan-3-ols) are the most prevalent and thus the most studied.

Flavanols are often referred to as tannins or catechins. The major flavanols in tea are: catechin (C), epicatechin (EC), epicatechin gallate (ECG), gallocatechin (GC), epigallocatechin (EGG), and epigallocatechin gallate (EGCG). EGCG is the most active of the catechins, and this flavanol is often the subject of studies regarding tea antioxidants.

Flavanols are converted to theaflavins and thearubigins during oxidation. They are the compounds responsible for the dark colour and robust flavors that are present in oxidized teas.

Composition of fresh tea leaves



1.3 Transmission electron microscopy

The transmission electron microscope is a very powerful tool for material science. A high energy beam of electrons is shown through a very thin sample, and the interactions between the electrons and the atoms can be used to observe features such as the crystal structure and features in the structure like dislocations and grain boundaries. Chemical analysis can also be performed. TEM can be used to study the growth of layers, their composition and defects in semiconductors. High resolution can be used to analyse the quality, shape, size and density of quantum wells, wires and dots.

The TEM operates on the same basic principles as the light microscope but uses electronsinstead of light. Because the wavelength of electrons is much smaller than that of light, the optimal resolution attainable for TEM images is many orders of magnitude better than that from a light microscope. Thus, TEMs can reveal the finest details of internal structure in some cases as small as individual atoms.**[12][13]**

1.4 Photoluminescence spectra

Photoluminescence is an important technology for measuring the purity and crystalline quality of semiconductors such as GaN and lnP and for quantification of the amount of disorder present in a system. Photoluminescence Spectroscopy, often referred to as PL, is when light energy, or photons, stimulate the emission of a photon, and stimulate the emission of a photon from any matter. In essence, light is directed onto a sample, where it is absorbed and where a process called photo- excitation can occur. Photoluminescence Spectra are recorded by measuring the intensity of emitted radiation as a function of either the excitation wavelength or the emission wavelength. An excitation spectrum is obtained by monitoring emission at a fixed wavelength while varying the excitation wavelength.

Forms of Photoluminescence:- Resonant radiation In resonant radiation, a photon of a particular wavelength is absorbed and an equivalent photon is immediately emitted, through which no
significant internal energy transitions of the chemical substrate between absorption and emission are involved and the process is usually of an order 10 nanoseconds.

Fluorescence: when the chemical substrate undergoes internal energy transitions before relaxing to its ground state by emitting photons, some of the absorbed energy is dissipated so that the emitted light photons are of lower energy than those adsorbed. One of such most familiar is fluorescence, which has a short lifetime.

Phosphorescence: Phosphorescence is a radiational transition, in which absorbed energy undergoes intersystem crossing into a state with a difference 9 in multiplicity. The lifetime of phosphorescence is much longer than that of fluorescence. Therefore, phosphorescence is even rarer than fluorescence. Since molecules in the triplet state have a good chance of undergoing intersystem crossing to ground state before phosphorescence can occur

CHAPTER 2

REVIEW OF LITERATURE

Carbon dots (CDs) are zero-dimensional carbon-based materia ls in the size range of a few tens of nanometers and can be doped with N, S, P, and B heteroatoms. They are chemically modifiable to enhance and render some additional functional properties. CDs possess many inherent assets such as tunable optoelectronic properties with high photoluminescence and/or fluorescence properties, good biocompatibility, and tunable and post modifiable functional groups with facile preparation methods. As the precursor materials and synthesis.methods greatly determine the applicability of CD materials in many fields. The approaches for CD synthesis, including the effects of source and doping as well as the reaction conditions such as temperature and time will be discussed. This will be followed by the application of CDs in bio imaging, cancer therapy, ge and drug delivery, sensors and biosensors, catalysts, and energy.

Achyut Kanwar et al combined reduced graphene with tea carbon dots to produce an efficient conducting coating material for fabrication of an E-textile.The reduced graphene oxide (rGO) adsorbs some amount of tea-CDs on its surface and forms a very good dispersion in aqueous medium without the use of any other capping or stabilizing agents. Subsequently, the tea-CDs reduced graphene oxide (TCD-rGO) was used for fabrication of acotton-based conducting fabric with anticipated applicability in different electronic gadgets where high flexibility of the conducting material is required.Coating of cotton with TCD-rGO improved the thermostabi lity of the fabric.(14)

Datta B.Gunjal et al derived carbon dots from waste tea residue by simple reflux method.The fluorescence intensity of the CDs was diminished gradually with increasing concentrations of tetracycline drug owing to the inner filter effect (IFE) phenomenon.The developed fluorescent probe displayed a better linear range, excellent detection limit and interference free response to the tetracycline. This resulted in quantification of tetracycline in real sample which achieved almost 99% recoveries indicated excellent practical potential. Moreover, the CDs were used as fluorescent label for multicolour imaging of yeast cells which could open the doors for further research in biological fields.(15)

Zhixiong Hu et al, green tea leaf residue was recycled as carbon precursor for carbon dots. These were co-doped with S and N , and had fluorescence quantum yield of 14.8%.

It had stable fluorescence to the environmental pH, ionic strength and ultraviolet radiation .

The fluorescence of T-CDs was sensitive to temperature with switchable intensity .They findthat

T-CDs could be used as turn off sensor for the detection of gefitinib.(16)

Achyut Kanwar et al in their work reported novel chitosan-carbon dots nanocomposite hydrogel films. A new green source "tea" was used as precursor for carbon dots. The electrostatic interaction of positive charge on chitosan and negative charge on CDs prepared from tea was used for the successful preparation of a stable and robust chitosan-carbon dots nanocomposite hydrogel film. Carbon dots improve the strength,thermostability and wettability of chitosan hydrogen films(17)

Upama Baruh et al demonstrate carbon dots based sensor of catecholamine namely dopamine and ascorbic acid. Fluorescence of the carbon dots was found to be quenched in the presence of dopamine and ascorbic acid with greater sensitivity for dopamine. The minimum detectable limits were determined to be 33.+M and 98.+M for dopamine and ascorbic acid, respectively. The quenching constants determined from Stern-Volmer plot were determined to be 5×10^{-4} and 1×10^{-4} for dopamine and ascorbic acid, respectively (18)

Xiaofeng Lin et al prepared green carbon dots from natural resources, have received widespread attention due to their unique advantages, including wide sources, cost-effective, eco-friendly, etc Interestingly, the various properties of GCDs can be obtained from different synthetic methods, which including the hydrothermal synthesis, microwave-assisted synthesis, pyrolysis carbonization synthesis, chemical oxidation synthesis, and ultrasonic synthesis. In consideration of their unique properties, GCDs have shown tremendous potential in fluorescence sensors, colorimetric sensors, and electrochemical sensors(19)

Vinay sharma et al attempted to review the journey of green c-dots by means of the green sources of synthesis and their applications, with the major focus on various sensors and bioimaging probes.(20)

Umesh s Mott et al studied the effect of various aqueous extracting agents on fluorescence properties of waste tea residue-based carbon dots (WTR-CDs). WTR-CDs are firstly synthesized by utilizing kitchen waste-based carbonaceous biomass. They observed interesting blue shift fluorescence spectra in acidic medium for WTR-CDs-AA and polar protic solvents compared to polar aprotic medium. The solvatochromic behaviour of WTR-CDs-WT in model polar and non-polar solvent was also studied. The effect of cationic, anionic and non-anionic surfactants on the fluorescence of WTR-CDs-WT was also evaluated(21)

Jing Zhu et al explored the synthetic conditions, structures, and optical properties of CQDs derived from tea and peanut shell. Their unique characteristics of emitting strong and steady blue fluorescence under excitation of ultraviolet light and possessing of plenty of hydrophilic groups on a surface conferred CQD potentials in the field of biomarkers and analytical detection.(22)

Datta b Gungal et al approached with a waste utilization technology in which Sustainable carbon nanodots synthesised from kitchen derived waste tea residue for highly selective fluorimetric recognition of free chlorine in acidic water(23)

A.L,Himaja et al synthesised carbon dots from kitchen wastes and focused more on theconversion of waste to value added products.(24)

Gulli Ge et al successfully developed a green, economical and effective one-step hydrothermal method for the synthesis of fluorescent nitrogen-doped carbon dots (N- CDs) by utilizing fresh tea leaves and urea as the carbon and nitrogen sources, respectively.They used it for the Selective Fe^{3+} Ions Detection and Cellular lmaging(25)

CHAPTER3

OBJECTIVES

1.Synthesis of carbon dots from tea powder

2. Characterization of synthesised carbon dots usingPL

3.To study the effect of pH on the photoluminescence of as-prepared carbon dots.

CHAPTER4

Materials and Methods

Materials

Chemicals used

•Tea powder

•Alcohol

•HCI

•NaOH

•Distilled water

Apparatus and instruments used

- Beaker
- Weighing bottle
- UV lamp
- Magnetic Stirrer
- Glass rod

EXPERIMENTAL METHODS

1. Synthesis of carbon dots from tea powder

Carbon dots were prepared by dissolving 2g of tea power in 50 ml of distilled water and strongly heated in flame, till the water get boiled and evaporated completely. After cooled down to room temperature the dark black powders were mechanically grind to fine powders. After that obtained powders were dispersed in water and alcohol .

Figure :Carbon dots prepared from tea

2. Characterization of synthesized carbon dots using PL

The optical properties of the as- synthesized carbon dots from tea were studied using Photoluminescence Spectroscopy (PL spectra). Photoluminscence (PL) of as prepared carbon dots were measured at room temperature using EDINBURGH FLS 1000 spectrometer

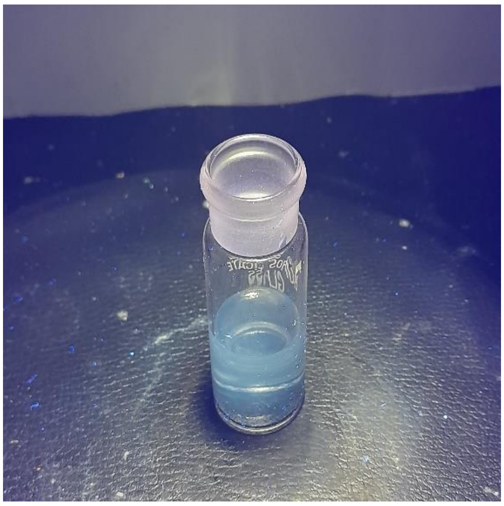
3. To study the effect of p on the PL of as-prepared carbon dots

The as-prepared carbon dots aqueous solutions were adjusted to the various target pH values by adding dil.HCl or NaOH solution, then the corresponding fluorescence spectra were measured upon excitation at 380nm separately

CHAPTER 5
RESULTS AND DISCUSSION

In the present work, a simple green approach to synthesize carbon dots was developed by using tea powder as the carbon precursor. The synthesized carbon dots were further characterized using PL spectra.The optical properties of the carbon dots were understood from PL spectra. The effect of pH on the PL spectra of carbon dots were also analysed

Optical properties of as- prepared carbon dots



A **B**

Fig: solution of carbon dots under UV light (a) alcohol (b) water

The as synthesized carbon dots were dissolved in two solvents namely water and alcohol. The carbon dots dissolved in ethanol shows good fluorescence while it shows no fluorescence when water is used. This difference in optical property may be due to the interaction of the functional groups on the carbon dots with the solvent used.

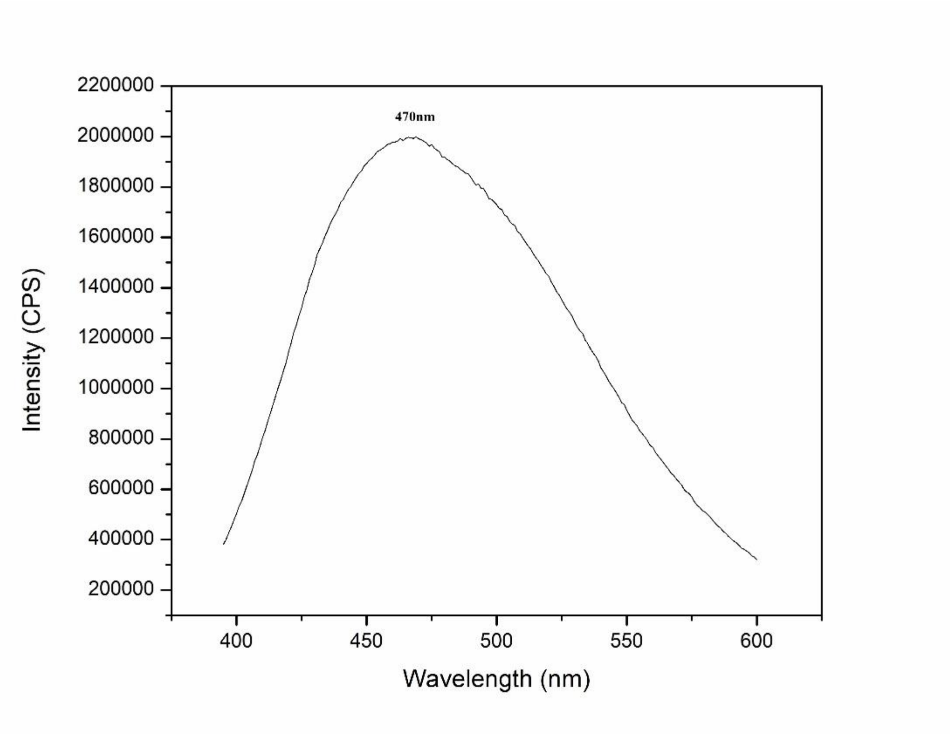


Fig: PL spectra of carbon dots

As shown in the PL spectra, when excited at the maximum excitation wavelength of 375nm, the as-prepared carbon dots exhibited a strong PL peak at 470nm. The aqueous solution of as-prepared carbon dots were nearly transparent under visible light, while it displayed strong blue fluorescence under UV light (310nm) excitation

Effect of pH on the PL of as prepared carbon dots

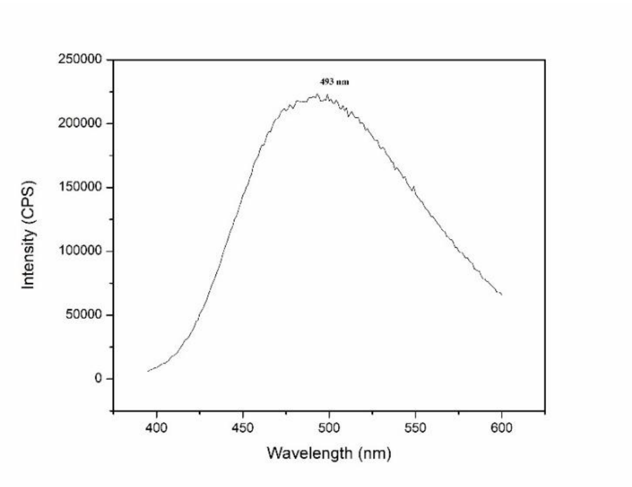


Fig: PL spectra of carbon dots in alkaline medium

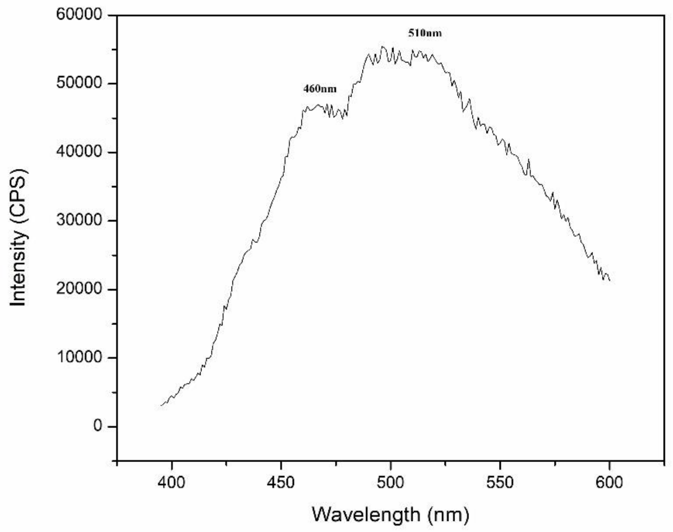


Fig: PL spectra of carbon dots in acid medium

In strong acidic condition, the emission wavelength shift to the longer wavelength 510nm, while it moved to wavelength 493nm in strong basic solution, implying that the as-prepared carbon dots were very sensitive to pH. These tunable fluorescence emission properties of as-prepared carbon dots were particular attractive for sensing, in vivo bio imaging and synthesizing novel photocatalysts etc.

CHAPTER 6

CONCLUSION

This study reports a green, cheap and convenient process for the synthesis of carbon dots from tea powder as the carbon precursor. The alcoholic solution of the as synthesized carbon dots exhibit bright luminescence and their optical properties are pH dependent. These tunable properties of as synthesized carbon dots can be utilized for sensing, invivo bio imaging and synthesis of photo catalysts etc.

CHAPTER 7

REFERENCES

1. Y.-P. Sun, B. Zhou, Y. Lin et al., "Quantum-sized carbon dots for bright and Colourful photoluminescence," Journal of American Chemical Society, 2006, vol. 128, pp.7756-7757

2. V. Georgakilas, J. A. Perman, J. Tucek, and R. Zboril, "Broad family of carbon nano allotropes: classification, chemistry, and applications of fullerenes, carbon dots, nanotubes, graphene, nanodiamonds, and combined superstructures," Chemical Reviews, 2015., vol. 115, no. 11, pp.4744-4822

3.M. Farshbaf, S. Davaran, F. Rahimi, N. Annabi, R. Salehi, andA.Akbarzadeh, "Carbon quantum dots: recent progresses on synthesis, surface modification and applications," ArtificialCells Nanomedicine, and Biotechnology, 2018,vol. 46, no. 7, pp. 1331-1348

4.Arora N, Sharma NN “Arc discharge synthesis of carbon nanotubes comprehensive review”, Diamond and related materials, 2014, vol 50,pp.135-150

5.Xiao J,Liu P, Wang CX, Yang GW, “External field-assisted laser ablation in liquid an efficiency strategy for nanocrystal synthesis and nanostructure assembly”, Diamond and related materials,2017,vol 87,pp.140-2201

6.Lu L, Zhu Y, Shi C, Pei YT, "Large scale synthesis of defect-selective graphene quantum dots by ultrasonic assisted liquid phase exfoliation", Carbon,2016, vol103, 373-83

7.Zhu S,Meng q, Wang L, Zhang J, "Highly photoluminescent carbon dots for multicolor patterning sensors and bioimaging" Angewandte Chemi.,2013,vol 52,pp.1-6

8. Bourlinous AB Trivizer G, "Green and simple route boron doped carbon dot with significant enhanced nonlinear optical properties", Carbon ,vol 83, pp:173-179

9.A. Dehghani, S. M. Ardekani, M. Hassan and V. G. Gomes , "Collagen derived carbon quantum dots for cell imaging in 3D scaffolds via two-photon spectroscopy",Carbon, 2018 ,vol 131, pp.238-245

10.Zhue L, Liz, Liu Z, Ren J, Qu X, "Luminescent carbon dot -gated nano vehicle for pH triggered intracellular controlled release and imaging", Langmuir ,2013,Vol 29,pp.6396-403

11. Kong T,Hao L, Wei Y, Cai X, Zhu B, "Doxorubicin conjugated carbon dots as a drug delivery system for human breast cancer therapy" ,Cell proliferation,2018,vol 51,pp 4888-4893

12. David B. Williams and C. Barry Carter, Transmission electron microscopy Plenum, 1996

13. Peter Hirsch, Electron microscopy of thin crystals, Butterworths, 1965.

14. Achyut Konwar, Upama Baruah, Manash J. Deka, Amreen A. Hussain, Sultana R. Haque, Arup R. Pal, and Devasish Chowdhury,'"Tea-CarbonDots-Reduced Graphene Oxide: An Efficient Conducting Coating Material for Fabrication of an E-Textile"ACS Sustainable Chem. Eng. 2017, vol 5, pp.11645-11651

15. Datta B.Gunjal,Yogesh M.Gurava,Anil H.Gorec,Vaibhav M.Naika,Ravindra,D.Waghmarea,ChandrashekharS.Patila,DaewonSohnd,Prashant V.Anbhulea ,Rajendra V.Shejwa lb,Govind B.Ko lekarad"Nitrogen doped waste tea residue derived carbon dots for selective quantification of tetracycline in urine and pharmaceutical samples and yeast cell imaging application", Optical Materials, 2019, vol 98, pp.109484

16. Zhixiong Hu,Xin-Yue,Jiao,Li Xu,"The N,S co-doped carbon dots with excellent luminescent properties from green tea leaf residue and its sensing of gefitinib"Microchemical Journal,2020,vol154,pp. 104588

17. AchyutKanwar,NeelamGogoi,GitanjaIiMajumdar,DevasishChowdhury ,"Green chitosan-carbon dots nanocomposite hydrogel film with superior properties"CarbohydratePolymers,2015,vol 115, 22,pp.238-245

18. Upama Baruah,Neelam Gogoi,Achyut Konwar, Manash Jyoti Deka,

Devasish Chowdhury, and Gitanjali Majumdar,"Carbon Dot Based Sensing of Dopamine and Ascorbic Acid", Journal of Nanoparticles,2014,vol 2014,pp.1-8

19. Xiaofenglina,MogaoXiong,JingwenZhang,ChenHe,Xiaoming,Ma,HuifangZhang,YingKu a ng,MinYang,QitongHuang,"Carbon dots based on natural resources: Synthesis and applications in sensors",Microchemical Journal,2021,vol160, pp. 105604

20. Vinay Sharma, Pranav Tiwari and Shaikh M. Mobin,"Sustainable carbon-dots: recent advances in green carbon dots for sensing and bioimaging",Journal of Materials ChemistryB,2017.vol 45,pp.202-209

21. Umesh S. Mote,Anil H. Gore,Sumit Kumar Panja,Govind B. Kolekar,"Effect of various aqueous extracting agents on fluorescence properties of waste tea residue derived carbon dots (WTR-CDs): Comparative spectroscopic analysis",Luminesence,2022,vol37, pp. 440-447

22. Jing Zhu, Fengyuan Zhu, Xiaona Yue,,Peirong Chen, Yue Sun,Liang Zhang, Dongdong Mu and Fei Ke,"Waste Utilization of Synthetic Carbon Quantum Dots Based on Tea and Peanut Shell" Journal of Nanomaterials,2019, vol. 2019,1-7

23. Datta B.Gunjal,Vaibhav M.Naik, Ravindra D.Waghmar Chandrashekhar S.Patil,Rajendra V.Shejwal,A ni l H.Gorea ,Govind B.Ko lekara ,"Sustainab le carbon nanodots synthesised from kitchen derived

waste tea residue for highly selective fluorimetric recognition of free chlorine in acidic water: A waste utilization approach"Journal of the Taiwan Institute of Chemical Engineers,2019,vol 95, February 2019,pp.147-154

24. Himaja, A L., Karthik, P.S., Sreedhar, B. et al” Synthesis of Carbon Dots from Kitchen Waste: Conversion of Waste to Value Added Product”. Journal of Fluorescence,2014,vol 24, pp.1767-1773

25.Ge G, Li L, Chen M, Wu X, Yang Y, Wang D, Zuo S, Zeng Z, Xiong W, Guo C." Green Synthesis of Nitrogen-Doped Carbon Dots from Fresh Tea Leaves for Selective Fe^{3+} Ions Detection and Cellular Imaging’’. Nanomaterials. 2022; vol12,pp.9 -18

25.86.