SYNTHESIS AND CHARACTERIZATION OF CARBON DOTS FROM THULASI AND MINT EXTRACT

Dissertation submitted in partial fulfillment of the requirements of the Degree of Bachelor of Science in Chemistry in University of Kerala, Trivandrum

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ACKNOWLEDGMENT

We take this opportunity to express our sincere gratitude to **Dr.Abha.K**, Assistant Professor of Chemistry, Bishop Moore College for her guidance and supervision during the entire time of this project. We are also grateful to **Dr. Rekha Rose Koshy**, Head of the Department of Chemistry, Bishop Moore College for the suggestions and advice provided in the completion of this project. We are thankful to other teachers, lab assistants, friends and all those who have rendered their help and assistance for the timely completion of project. We are grateful to our parents who help us to complete this work.

DECLARATION

We hereby declare that the project work entitled '**Synthesis and Characterization of Carbon dots from Thulasi and Mint extract'** submitted to Kerala university in partial fulfillment of Bachelor's Degree in Chemistry is bonafide record of the work carried out by the supervision and guidance of Dr. Abha K Assistant professor, Post Graduate Department of Chemistry, Bishop Moore College, Mavelikara. We further declare that, the dissertation has not formed the basis award of any Degree, Diploma, Fellowship or Associate ship or similar title of any University or Institution.

CERTIFICATE

POST GRADUATE DEPARTMENT OF CHEMISTRY
BISHOP MOORE COLLEGE, MAVELIKARA

This is to certify that the report entitled "**Synthesis and Characterization of Carbon Dots from Thulasi and Mint extract'** submitted by **Anjali, Anantha Hari H and Jeevan V** is a bonafide record of the work carried out by them under my guidance and supervision in partial fulfillment of the requirements for the award of the degree of Bachelors of Science in Chemistry.

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CHAPTER 1

INTRODUCTION

NANOTECHNOLOGY AND NANOSCIENCE

The word nano means a billionth (1×10^{-9}). And the term Nanotechnology deals with various structures of matter having dimensions of the order of a billionth of a meter. Nanotechnology, sometimes shortened to nanotech refers to a field of applied science whose theme is the control of matter on an atomic and molecular scale. Generally, nanotechnology deals with structure 100 nm or smaller, and involves developing material or devices within that size. Normally, if the particle size is in 1 – 100 nm range they are generally called nano particles or materials. When characteristic structural features are intermediate between isolated atoms and bulk material in the range of approximately 1-100 nm, the objects often display physical attributes substantially different from those displayed by either atoms or bulk materials. The term "nanotechnology" is used as a reference for both nanoscience and nanotechnology, Nanoscience is a convergence of physics, chemistry, material science and biology which deals with the manipulation and characterization of matter on length scale between the molecular and the micron size. The idea and concept behind the nanotechnology started with a talk entitled" There is plenty of room at the Bottom" by Richard Feynmann.Nanotechnology offers numerous applications that revolutionized the way to detect and treat diseases, monitor, and protect the environment, produce and store energy, improve crop production and food quality and build complex structures as small as an electron.

1.1 CLASSIFICATION OF NANOMATERIALS

The carbon nanomaterials can be classified according to their dimensionality, which depends on their size in different dimensions, such as zero dimensional, one dimensional, two dimensional, three dimensional.

1.1.1 Zero Dimensional (0D)

Accordingly, in zero dimensional (0D) nano materials all the dimensions are measured within the nanoscale (no dimensions are larger than 100nm). Carbon – based nano materials are well explored in the area of nanoscience. Examples of carbon-based 0D nano materials are fullerenes and carbon dots.

1.1.2 One Dimensional (1D)

One dimensional nanostructures are those with a dimension within the range between 1 and 100nm. The morphologies, composition and structures cover a large variety including wires, rods, tubes, ribbons of metal/ semimetals, oxides, sulfides, halides, etc. The physical properties of one-dimensional structures have pointed these materials towards many potential applications from ultrasensitive sensors to nano electronics, as well as nanomaterials useful in drug delivery and biological systems.

1.1.3 Two Dimensional (2D)

Two dimensional (2D) nanomaterials are composed of thin layers that have a thickness of at least one atomic layer. Contrary to bulk materials, these nanomaterials have a high aspect ratio (surface area to volume ratio) and hence have many atoms on their surface. These atoms have a different function than internal atoms, and the increase in the number of surface atoms leads to change in the behavior of 2D nanomaterials.

1.1.4 Three Dimensional (3D)

These are the nanomaterials that are not confined to the nanoscale in any dimension. These materials have three arbitrary dimensions above 100 nm. With respect to the presence of features at the nanoscale, 3D nanomaterials contain dispersions of nanoparticles, bundles of nanowires and nanotubes as well as multi nanolayers (1). Bulk nanomaterials are materials that are not confined to the nanoscale in any dimension. These materials are thus characterized by having three arbitrarily dimensions above 100 nm. In terms of nanocrystalline structure, bulk nanomaterials can be composed of a multiple arrangement of nano size crystals most typically in different orientations.

1.2 APPLICATIONS OF NANOMATERIALS

Nanotechnology is used in various devices and materials. The common trait these technologies share is that the physical effects of the atoms at the nanoscale alter the materials properties. These technologies explore the benefits that nanotechnology offers.

1.2.1 Water filtration

Using chemical reactions, nanoparticles are being developed to clean industrial water pollutants in groundwater. Researchers are also designing magnetic water repellent nanoparticles that are used oil spills and be used to remove the oil from water by using magnets. Other than that, in nanotechnology nano membranes are used with the purpose of softening water and removal of contaminants such as physical, chemical, and biological contaminants and there are variety of techniques in nanotechnology which uses nanoparticles for providing safe drinking water with a high level of effectiveness

1.2.2 Medical tissue engineering

Nanotechnology for regenerative medicine, including bone and tissue engineering. Nanomaterials are engineered to mimic the crystal mineral structure of human bone or dental applications. Researchers are currently investigating how conductive graphene nanoribbons can be used to help repair spinal cord injuries.

1.2.3 Low Cost Flat Panel Displays

In the laptop computer industry, the demand for flat -panel display is high. The resolution of these display devices are significantly improved by synthesizing nanocrystalline phosphors, while considerably bringing down the manufacturing costs, Furthermore the flat panel displays manufactured using nanomaterials have far higher contrast and brightness compared to the traditional ones due to their improved magnetic and electrical properties.

1.2.4 Catalysis

Catalysis is one of the pioneer applications of nanoparticles. Various elements and materials like aluminum, iron, titanium dioxide, clay and silica all have been used as catalyst in nano scale for many years. The small metal particles in a range of 1-10 nm exhibit extraordinary catalytic activity. The high activity of nano catalysts is attributed to several important factors, including the high surface to volume ratio, surface geometric effect, the electronic effect as well as the quantum size effect. By using catalytic reagents one can reduce the temperature of transformation, reduce reagent based waste and enhance the selectivity of a reaction that potentially avoids the unwanted side reaction leading to a Green Technology. Thus by using catalyst manufacturing process protocols are made more economic, green and sustainable. In chemistry Carbon Nano Tubes (CNT) are also used as catalyst for partial oxidation of fuel cells.

1.2.5 Diagnosis

Diagnostic tests are a key components of successful strategies aimed at suppressing and emerging viral diseases and play an important role at all stages from early detection to final resolution. So, there is a need to develop new diagnostic platform that are accurate, specific, fast, and easy to use and to facilitate rapid screening. Currently, research dynamics have shifted towards rapid diagnostic based on nanomaterials. In this regard, nanotechnology based applications greatly improve the sensitivity of previously developed detection techniques, such as RT- PCR and immunoassays. Nanoparticles have the characteristics of high adsorption capacity, the quantum size effect and high reactivity. The large surface area of nanoparticles enhances the detection effectiveness, as it follows efficient interaction with target analytes. Therefore, through physical or chemical bonding, nanomaterial based diagnosis are developed to increase selectivity and specificity and reduce detection time.

1.3 CHARACTERIZATION METHOD OF NANOPARTICLES

1.3.1 X -Ray Diffraction

X–ray diffraction, or XRD is a technique used for analyzing the atomic or molecular structure of materials. It is non destructive, and works most effectively with materials that are wholly or partly crystalline. The technique is often known as X ray powder diffraction because the material being analyzed typically is a finely ground down to a uniform state. During preparation a few grams of the sample is taken and grinded it to a fine powder. Typically, this should be done in a fluid to minimize any extra surface energy, which might otherwise randomize the sample. The optimum size of the powder is less than 10 micrometers. Then place the ground powder into a sample surface, or within a holder. The x- ray diffractometer continuously records data during the process when both the source and detector rotates. Peak intensity occurs when d- spacing in the lattice planes of the mineral sample are appropriate to the value of the diffract x- rays. Results are presented as peak position and x- ray counts in a table.

1.3.2 Transmission electron microscopy (TEM)

Transmission Electron Microscopy (TEM) is a technique of imaging the internal structure of solids using a beam of high energy electrons transmitted through the solid, providing to much higher resolution than is possible with light based imaging technique(2). The transmission electron microscope uses high voltage beam which is simply the accelerated electron cloud to make an image. The electron gun is commonly associated with a tungsten filament cathode which acts as the electron source. The electron beams are emitted by this gun. The electron beam is accelerated by an anode focused by electromagnetic lenses and transmitted through the sample that is in partly transparent to the electrons. And the emerged electron beam carries the information such as structure of the sample which is enlarged by the objective lens system of microscope. Modern electron microscopes produce electron micro graphs using specialized digital cameras and frame grabbers to capture the images. Industrially, electron microscopes are often used for quality control and failure analysis.

1.3.3 UV- Visible Absorption Spectroscopy

The principle of uv- visible spectroscopy is based on the absorption ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra. Ultraviolet and visible radiation interacts with matter which causes electronic transitions (promotion of electrons from the ground state to a high energy state). The ultraviolet region falls in the range between 190-380 nm, the visible region fall between 380-750 nm (3). A sample is placed between a light source the divided beams is passed through the sample solution and the other beam is passed through the reference solution. Although. the samples for recording spectra are most commonly liquids, but the absorbance of gases and even of solids can be measured. Both sample and reference solutions are placed in a transparent cell, known as cuvette. The cuvettes are rectangular in shape, and usually have an internal width of 1cm. A detector converts a light signal into an electrical signal. After the beams are passed through the sample under study, the intensities of the respective transmitted beams are then compared over the all wavelength range of the instrument. Generally, two photocells are used as detectors in uv spectrometer to record the spectra. One of the photocells receives the beam from sample cell and second detector receives the beam from the reference. The intensity of the radiation from the reference cell is stronger than the beam of sample cell. This results in the generation of pulsating or alternating currents in the photocells.

1.3.4 Photoluminescence Spectroscopy

Photoluminescence (PL) is a process in which a substance absorbs photons and then re-radiates photons. Quantum mechanically, this is described as an excitation to a higher energy state and then return to the lower energy state accompanied by the emission of a photon. If a light particle has an energy greater than the band gap energy, then it is absorbed and thereby raise an electron from the valence band up to the conduction band across the forbidden energy gap. In this process of photo excitation, the electron generally has excess energy which it loses before coming to rest at the lowest energy in the conduction band. At this point the electron energy eventually falls back down to the valence band. As this happens, the energy it loses is converted back into a luminescent photon which is emitted from the material. Thus, the energy of the emitted photon is a direct measure of the band gap energy.

1.4 PROPERTIES OF NANOMATERIALS

As the size is reduced to the nanometric scale, the exposed surface area increases and this favors the greater interaction between nearby atom and molecules, giving rise to greater interactions , attraction and repulsions that causes surface, electronic and quantum effects that affect to the optical, electric and magnetic behaviors of the materials.

1.4.1 Mechanical Properties

Mechanical properties such as the strength of metal can also be greatly improved by making them with nano scale grains. Several basic attributes of materials are involved in defining their mechanical properties. One is strength, which includes characteristics with more precise definitions but basically determines how much a material deforms in response to a force. Others are hardness, which is given by the amount another body such as a ball bearing or diamond is able to penetrate a material, and wear resistance, which is determined by the rate at which a material erode when in contact with another. These properties are dominated by the grain structure found in metals produced by normal processing.

1.4.2 Chemical Properties

Another size dependent property of nano particles is their chemical reactivity. This demonstrated most dramatically by gold, which in the bulk is the a typical inert material. It would therefore seem that gold, would be useless as a catalyst to speed up chemical reactions, but this is not so for gold nanoparticles. In fact, most catalyst are in the form of nanoparticles, especially when gold in the form of nanoparticles with diameters less than about 5 nm, it becomes powerful catalyst. There activity of gold nanoparticles appears to depend not only on their size but also on the material on which they are supported. But as a general rule the performance of all catalyst depends on the particle size. Because of the importance of catalyst to the chemical industry, the effect is the focus of large amount of research activity.

1.4.3 Optical Properties

One of the most fascinating and useful aspects of nanomaterials is their optical properties. The optical properties of nanomaterials depends on parameters such as feature size, shape, surface characteristics and other variables including doping and interaction with the surrounding environment or other nanostructures. Likewise, shapes have dramatic influence on optical properties of metal nano structures implies the difference in the optical properties of metal and semiconductor nanoparticles. With the CdSe semiconductor nanoparticles, a simple change in size alters the optical properties of the nanoparticles. When metal nanoparticles are enlarged, their optical properties changes slightly as observed for the different samples of gold nano spheres in. However, when an anisotropy is added to the nanoparticle, such as growth of nanorods , the optical properties of the nanoparticles change dramatically . Application based on optical properties of nanomaterials include optical detector, laser, sensor, Imaging, phosphor, display , solar cell ,photo catalysis, electrochemistry and biomedicine.

1.4.4 Magnetic Properties

Magnetic nanoparticles are nanomaterials consist of magnetic elements, such as Iron, Cobalt, Chromium, Manganese, Gadolinium, and their chemical compounds. Magnetic nanoparticles are super paramagnetic because of their nanoscale size, offering great potentials in a variety of applications in their bare form or coated with a surface coating and functional groups chosen for specific uses. The properties of magnetic nanoparticles depends on the synthesis method and chemical structure. In most cases, the magnetic nanoparticles range from 1 to 100 nm in size and displays superparamagnetism. Superparamagnetism is caused by thermal effects that the thermal fluctuations are strong enough to spontaneously demagnetize a previously saturated assembly; therefore, these particles have zero coactivity and have no hysteresis. In this, state an external magnetic field can magnetize the nanoparticles with much larger magnetic susceptibility (4). When the field is removed, magnetic nanoparticles exhibit no magnetization. This property is successfully used for controlled therapy and targeted drug delivery.

1.5 METHODS OF SYNTHESIS OF CARBON DOTS

1.5.1 Chemical Vapor Deposition (CVD)

The chemical vapor deposition (CVD) technique is one of the most suitable methods for the synthesis of carbon nanomaterials in terms of large scale production and its purity. The method is simple and economic for synthesizing at low temperature and ambient pressure. This method changes optical, electrical, and mechanical attributes as well as corrosion resistance of different substances (5). CVD reactions are strongly affected by the experimental parameters, such as reactor temperature, pressure, precursor composition catalyst and concentration. A minor modification in the experimental parameters causes a drastic change in the morphology and yield of the materials.

1.5.2 Hydrothermal Synthesis

Hydrothermal synthesis is defined as method of synthesis of single crystals that depends on the solubility of minerals in hot water under high pressure, and it is the most used methods for preparation of nanomaterials. It is basically a solution reaction based approach, the formation of nanomaterials happens in a wide temperature range from room temperature to very high temperatures. Many types of nanomaterials have been synthesized successfully by use of this approach. Nanomaterials with high vapors can be produced by the hydrothermal method with minimum loss of materials. Hydrothermal technique for nanoparticle synthesis needs using special instrumentation, called autoclave reactor (6).It is a specific style of strong vessel that is intended to face up to high temperature and better pressure level from within. In the technical part, a strong container within hydrothermal reactor autoclave fill with a solution. The process wants constant maintenance of temperature difference between the opposing ends of crystallizing compartment.

The end with higher temperature us wherever the solvent dissolved. While in the other end, which is comparatively cooler, where the nanoparticle growth takes place.

1.5.3 Solvothermal Synthesis

Solvothermal synthesis involves synthesis of nanomaterials using a solvent under elevated temperature usually 100 -1000°C and pressure 1-10,000 atm. Solvothermal synthesis is a method for preparing a variety of materials such as metals, semiconductors, ceramics, and polymers (7). The high temperature and pressure facilitate the interaction of precursors during synthesis. If water is used as the solvent the method is called “hydrothermal synthesis.” The process can be used to prepare many geometries including thin films, bulk powders, single crystals, and nanocrystals.

1.6 CARBON DOTS

Carbon dots are a type of carbon nanoparticles with particle size less than 10 nm. They were first discovered during the purification of single walled carbon nanotubes in 2004. The discovery of carbon dots got more attention due to their exceptional fluorescent, chemical and mechanical properties. Due to the unique structure and fascinating properties of carbon dots, they can be used in many fields such as biological sensing, drug delivery, photocatalysis, photodynamic therapy and in solar cells. Carbon dots are zero dimensional photoluminescent nanocarbon. Carbon dots are classified into four different types based on their surface functional groups, carbon core structure and their properties. Good biocompatibility, strong absorption, high quantum yield are some important physical properties of carbon dots. Carbon dots are also extracted from natural sources such as honey, caramel, sugar beet molasses, plants, food waste. They are synthesized using various methods. Some of the methods are combustion/ thermal MWA heating, laser ablation, electrochemical oxidation, hydrothermal synthesis, solvothermal synthesis and MWA synthesis. In these methods hydrothermal, solvothermal and MWA synthesis is more appropriate due to their inexpensive nature and simple operation steps.

1.7 CLASSIFICATION OF CARBON DOTS

There are four different types of carbon dots. The classification of carbon dots is based on their carbon core structure, surface functional groups and their properties. The four types of carbon dots are carbon quantum dots (CQDs), graphene quantum dots (GQDs), carbon nanodots (CNDs) and carbonized polymer dots (CPDs) (8). The CQDs are nanospheres having crystalline nature. They exhibit many chemical groups that impart the intrinsic state luminescence and quantum confinement effect of carbon dots. The GQDs are tiny fragments of graphene. They are anisotropic in nature and they constitute mono or multiple layers of graphene sheets with graphene networks in their configuration (9). The CNDs possess a high degree of carbonization with edge effect, but without disclosing the crystalline or polymeric structure. They lack in displaying the quantum confinement effect. CPDs are usually prepared from monomers of polymers or polymers by the process of condensation, cross linking, or slight carbonization. CPDs have unique characteristics, such as the bright emission, high yield, and high oxygen content ensuring excellent aqueous solubility.

1.8 PROPERTIES OF CARBON DOTS

1.8.1 Absorbance

CDs prepared from different precursors have different absorption spectra in different solvents. But they have some common UV- visible absorption phenomenon. Carbon dots absorb in short wavelength region due to π -π^* transition of c=c bonds. They show optical absorption in the UV region with a tail extending to the visible range. CDs reveal intense optical absorption from 260 to 320nm (10). The range of their absorbance may vary depending on the type of CD, due to the surface functional groups, as well as their surface passivation(11).

1.8.2 Photoluminescence study

Carbon dots typically show good PL quantum yields and present a characteristic shift in their emission spectrum with excitation wavelength. Longer excitation wavelength shifts the PL spectrum towards the red. The photoluminescence properties arise from quantum confinement effects. The PL quantum yield of bare C-dots is low due to emissive traps on the surface, it is typically lower than 10 %. In order to enhance the brightness of C-dots, surface passivation is necessary. Most of the carbon dots emit commonly in blue and green region. Undesirable for multi color imaging, most of CDs show broad emission spectra because of the large heterogeneity in the size and chemical composition.

1.8.3 Chemiluminescence

The emission of light at ordinary temperature as a result of a chemical reaction is called chemiluminescence (CL). Carbon dots are one kind of emerging carbon nanomaterials for promising CL due to their unique luminescent properties. Carbon dots can take part in the CL reaction as oxidants, emitting species, energy acceptor of chemical reaction energy or even catalysis involving different CL systems (12). With proper reaction condition in redox reaction, CL produced in aqueous phase system and unstable products are generated from intermediate radicals in the CL reaction process. They are produced from the reaction of inorganic molecules but luminescence is weak because quantum yield is low. It was found that the increase in temperature has a positive effect on CL due to thermal equilibrium of electron distribution in the CDs. The CL properties can be designed by changing the surface groups.

1.8.4 Fluorescence

The fluorescence emission is one of the most fascinating features of carbon dots, which has been utilized in many fields (13). It is the phenomenon, where the excitation wavelength is larger than emission wavelength. CDs that are synthesized through ultrasonic treatment show up- conversion fluorescence property. Larger excitation wavelength results in the reduction of background auto fluorescence, which is significant for the bio imaging application.

1.9 APPLICATIONS OF CARBON DOTS

Carbon dots are carbon nanoparticles with size less than 10 nm. Carbon dots are extensively investigated due to their strong and tunable fluorescence emission properties, which enable their application in biomedicine, optronics, catalysis and sensing. One of the most promising application of CDs is in biomedicine. The CDs are safe for biomedical application. Biomedical applications of CDs include bioimaging, biosensing, phototherapy and nanomedicine.

1.9.1 Bioimaging

Bioimaging of carbon dots are due to its fluorescence emission and biocompatibility. It could be injected to human or animal bodies for medical diagnosis. Imaging utilizing traditional UV-absorbing and blue/green emitting CDs suffers from severe background interference due to the poor penetration of light in the biological tissues at short wavelength. So, it is very important to synthesis CDs with red infrared emission properties for bioimaging to ensure good light penetration depth and to minimize photo damage to biological tissues. CDs achieve diagnosis of various types of cancer as well as other diseases due to their compatibility to provide real time 3D photography and some significant information about the location, size and type of tumors in the human body. The difference in the structures and shapes of different cells or tissues have a particular response to the foreign substance like CDs.

1.9.2 Biosensing

Carbon dots are used as biosensor carriers for their high solubility in water, flexibility in surface modification, non-toxicity, excellent biocompatibility, good cell permeability and high photo stability. These biosensors are used for visual monitoring of glucose, cellular copper, phosphate, iron, pH and nucleic acid (14). The discriminating facts on applications recognized by the respective antibodies and fluorescence of carbon dots efficiently response pH local priority and presence of metal ions.

1.9.3 Catalysis

The catalytic application of carbon dots are due to their advantages such as low toxicity, strong and broad optical absorption, high chemical stability and rapid electron transfer properties. The flexibility of functionalization with various groups CDs makes them possible to absorb light of different wavelengths, which offers good opportunities for applications in photocatalysis (15). Metal free CQDs have been found to improve the kinetics of hydrogen evolution reaction, making CQDs a sustainable choice for catalysis (16).

1.9.4 Drug delivery

CDs are used as an innovative tool for drug delivery in brain tumors. Carbon dots have been used as drug delivery system to improve drug solubility, half-life, and accumulation at the tumorous site, reduce the drug side effects, and increase their bio availability and tolerance (17). CDs are promising nanocarriers for drug delivery due to their small size and rich surface chemistry that allows the bonding of receptors and chemotherapy drugs (18).

1.9.5 Optronics

Carbon dots are used in optronics. They have the potential in serving as materials for dye-sensitized solar cells, organic cells, super conductors, and light emitting devices (19). Carbon dots are used as photo sensitizer in dye sensitized solar cells and the photoelectric conversion efficiency is significantly enhanced. CDs hybridized with other carbon materials, polymers, or metal oxides are reported to improve the electrochemical performance of super conductors.

CHAPTER 2

REVIEW

Xu et al in 2004 accidently discovered C-dots as the new addition to the carbon family when using arc discharge to synthesis single walled carbon nanotubes (CNTs). Bui et al synthesized highly luminescent c-dots by the one pot simple hydrothermal method from lemon juice using different temperatures, time, aging of precursors of c-dots. These carbon dots were characterized by high resolution electron spectroscopy, X-ray photoelectron spectroscopy, FTIR spectroscopy, dynamic light scattering, U- V spectrophotometry and PL Spectrophotometry (20). Mao and coworkers fabricated for the first time fluorescent GQDs with different sizes from candle soot by using HNO_3 under a relatively low temperature in 2007. Peng et al prepared GQDs through a chemical exfoliation of carbon fibers by H_2SO_4 and HNO_3. The as prepared GQDs with different sizes ranges show yellow, green, and blue PL emission under different stirring temperatures. Amit Kumar and co-workers prepared fluorescent carbon dots using the leaves of Ocimum sanctum as a carbon source for the first time with a quantum yield of 9.3% (21). The practical use of synthesized CDs for detection of Pb^{2+} ions was demonstrated in triple negative breast cancer cells. Xiaohan Sun et al synthesized CDs using one Pot hydrothermal treatment using Lycii fruits (22). Optical and structural properties of the CDs have been studied by XRD, TEM and HRTEM. The fluorescent quantum yield of the CDs can reach to 17%. The CDs exhibit captivating band selectivity towards Fe^{3+} with a linear range of 0 to 30 micrometer and 21 nm is the detection limit. Johnsi et al reported the studies of fluorescent C-dots synthesized from tamarind towards antimicrobial activity and fungal stain. C-dots from tamarind successfully inhibited bacterial growth in a concentration dependent manner. Under confocal microscopy, fluorescent properties of C-dots were evaluated directly without any fluorescent tagging. Fungal cells only fluorescence when attached to the C-dots, while cells without C-dots do not have fluorescence properties. Jiji et al studied a simple hydrothermal process of citric acid and ethylene diamine to prepare amine functionalized c-dots and conjugated with ampicillin to produce C-dots–AMP nanostructures. The results showed the potential of CDs- AMP as an effective platform for the eradication of bacteria. The positively charged C-dots were found to have the most bacterial activity whereas the negatively charged and unchanged C-dots had almost no bacterial activity. H. Muktha et al. synthesized carbon dots from organic waste of pomegranate and watermelon peels. And they are characterized by UV- Visible spectrophotometer, FTIR spectra, fluorescent spectroscopy, HRTEM and Raman spectroscopy. The carbon dots show antibacterial activity and were also used as therapeutic agent. Zhan Lai and co-workers prepared water soluble carbon dots via hydrothermal treatment of fresh cherry tomatoes, and applied in the selective detection of trifluralin in soil samples. The synthesized CQDs exhibited excellent optical properties and high selectivity for trifluralin. Guili Ge and co-workers developed a green, economical, and effective one-step hydrothermal method for the synthesis of fluorescent nitrogen doped carbon dots by using fresh tea leaves and urea as the carbon and nitrogen sources respectively. The as prepared N-CDs were characterized by TEM, XPS and FTIR. These N-CDs are used for the selective Fe^{3+} ions detections and cellular imaging. The N-CDs exhibited bright blue fluorescence under ultraviolet illumination, with the maximum emission at 455nm. Song and co-workers prepared carbon dots from the aqueous dispersion of graphite and potassium sodium tartrate by ultrasonic assisted treatment. The obtained CDs were in the range of 1-5nm in diameter and showed blue luminescent emission. Sahu et al synthesized the carbon dots with size of 1.5-4.5nm from orange juice at 120-degree Celsius for 150 minutes in autoclave via one step hydrothermal method. These CDs shown tunable luminescence properties and good bio compatibility.

CHAPTER 3

OBJECTIVES OF THE WORK

The important objectives of the work are

1. Synthesis of carbon dots from Mint extract.

2. Synthesis of carbon dots from Thulasi extract

3. Optical characterization of synthesized Carbon dots using UV-Visible and Photoluminescence Spectroscopy

CHAPTER 4

MATERIALS AND METHODS

4.1 **MATERIALS**

- Mint Extract
- Thulasi Extract
- Magnetic Stirrer
- Glass wares
- Filter paper

4.2 **CHARACTERIZATION TECHNIQUES**

- UV – Visible spectroscopy
- Photoluminescence spectroscopy

4.3 **EXPERIMENTAL TECHNIQUES**

4.3.1 Synthesis of Carbon dots (C-dots)

The hydrothermal synthesis was performed using a thermal magnetic stirrer. Each reaction was carried out in a 100 ml glass vessel. A 50 ml solution of mint and thulasi extract was taken in a separate vessel for the synthesis of C-dots. Then the vessel was placed on the magnetic stirrer and heated until a yellow–brown color appeared in both.

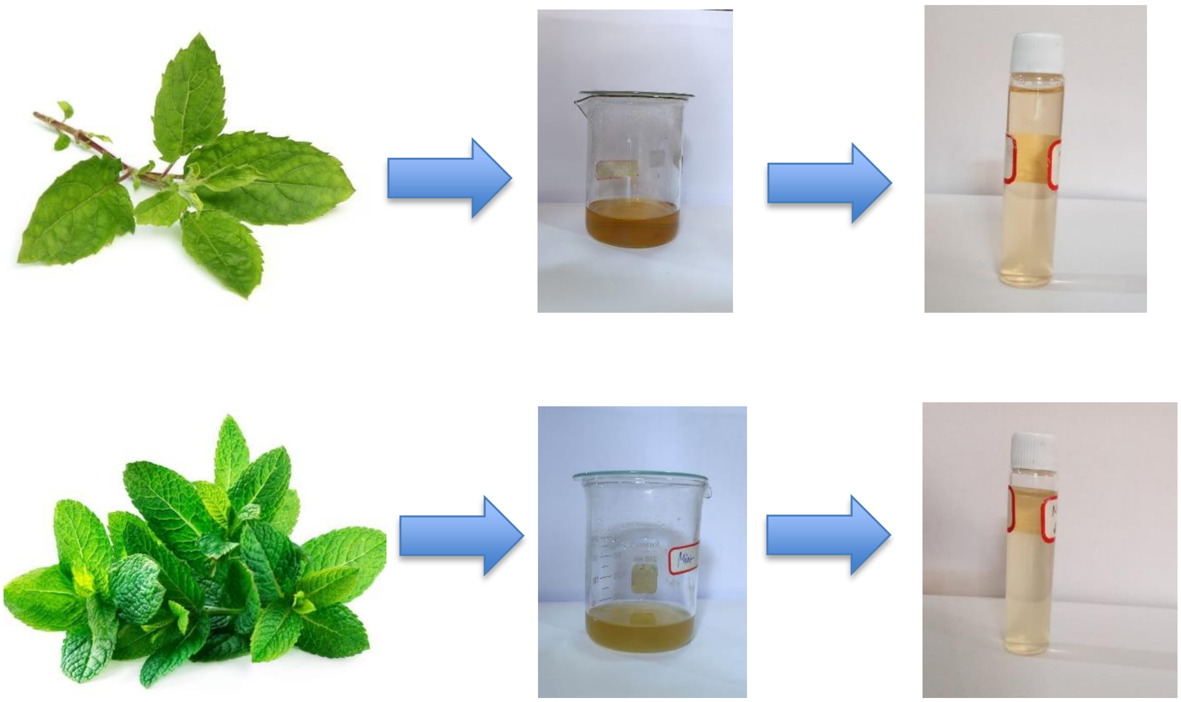

Figure 1: Scheme of Experiment

CHAPTER 5

RESULTS AND DISCUSSION

5.1 UV-VISIBLE ABSORPTION STUDIES

UV –Visible absorption studies of the synthesized carbon dots were plotted and depicted in **Figure 5.1& 5.2**. It was found that there was an absorption peak centered at 300nm in both samples. The absorption peak at 300 nm originates from the ***π-π*** *transition of Carbon dots.

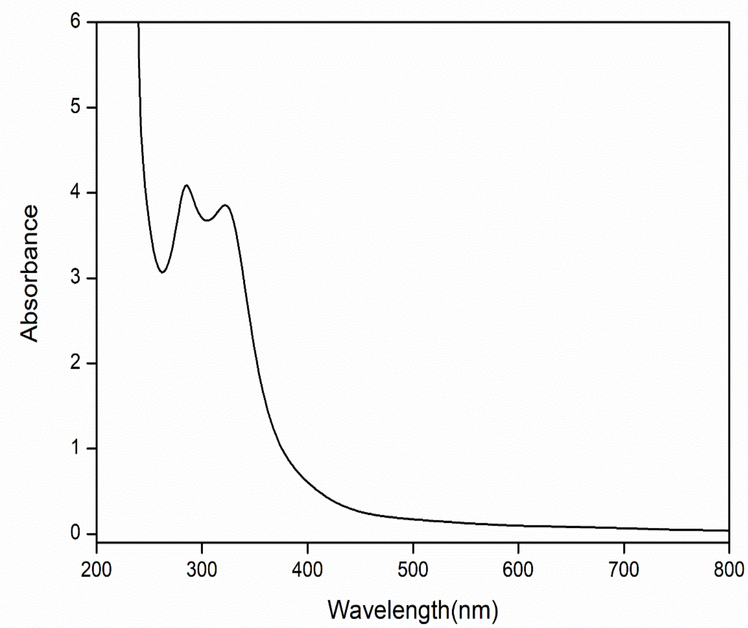

Figure 5.1: UV-Visible Spectrum of Carbon dots from Mint Extract

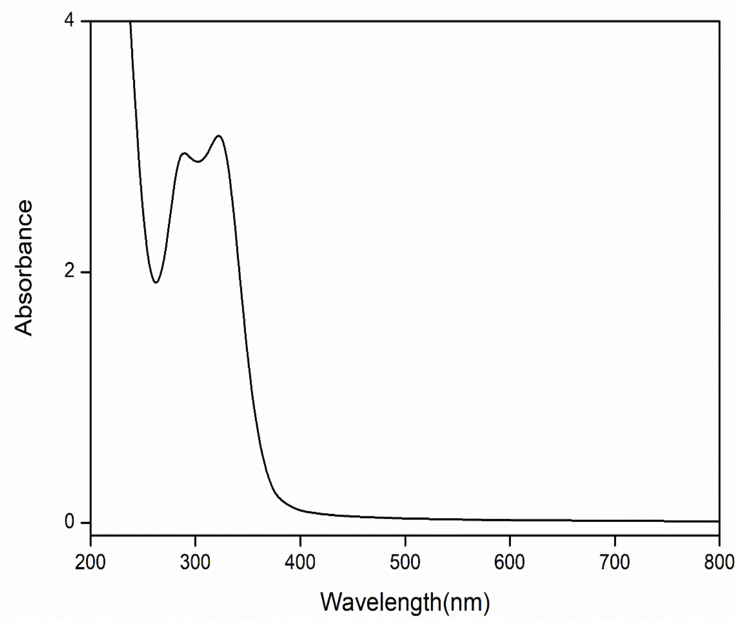

Figure 5.2: UV-Visible Spectrum of Carbon dots from Thulasi Extract

5.2 PHOTOLUMINESCENCE STUDIES

The luminescene property of the synthesized carbon dots was studied by photo luminescence spectroscopy. The intensity of the PL depends on the number of particles excited at a particular wavelength. The highest PL intensity was observed at an excitation wavelength of 480 nm, From the data, it was found that the synthesized carbon dots from for both samples (from mint and thulasi extract) shows considerable photoluminescence properties.

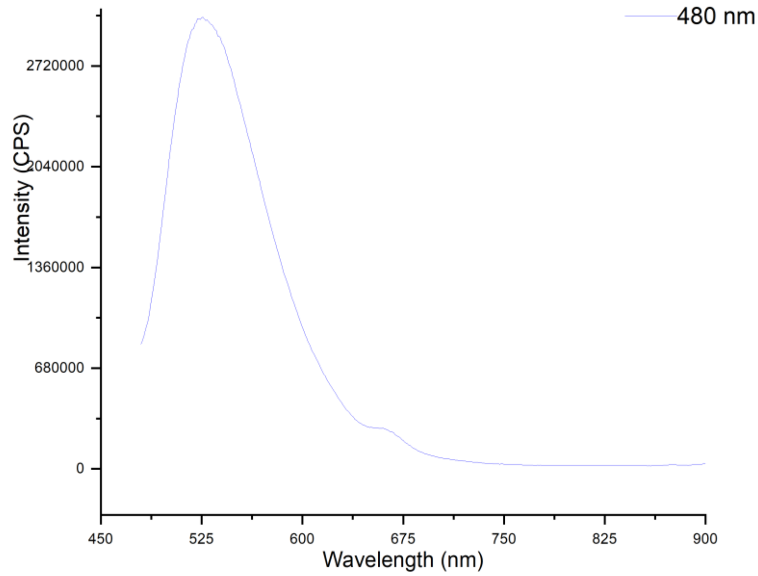

Figure 5.3: Emission spectrum of Carbon dots from Mint Extract

A strong emission band centered at around 525 nm for carbon dots from mint extract and 505 nm for carbon dots from thulasi extract were obtained as depicted in **Figure 5.3** and **Figure 5.4** respectively. The emission band corresponds to the n $\rightarrow\pi^*$ transition of carbon dots from different sources.

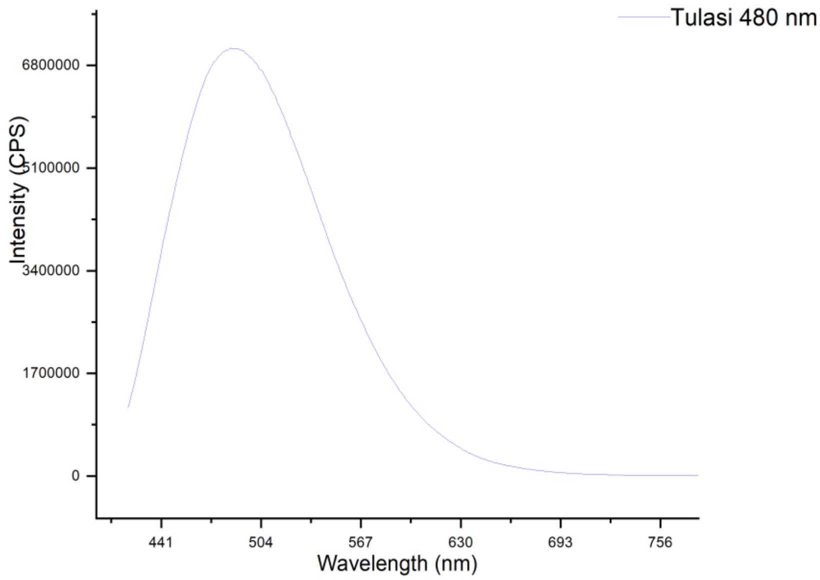

Figure 5.4: Emission Spectrum of Carbon dots from Thulasi Extract

CHAPTER 6

CONCLUSION

Carbon dots were successfully synthesized from natural sources like mint extract and tulasi extract. A room temperature hydrothermal method was employed for the synthesis of carbon dots. The synthesized carbon dots were optically characterized using UV-Visible spectroscopy and Photoluminescence Spectroscopy. The carbon dots exhibited strong luminescence property due to their $n \rightarrow \pi^*$ transitions which can be effectively utilized for various future sensing and bio imaging applications. Hence strong luminescent and stable carbon dots were successfully synthesized using a simple and cost effective method from easily available natural sources.

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