

# **SYNTHESIS AND CHARACTERISATION OF CARBON DOTS FROM ROSE PETALS AND PASSION FRUIT 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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## DECLARATION

We hereby declare that the project work entitled '**Synthesis and Characterization of Carbon dots from Rose Petals and Passion Fruit 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 Rose Petals and Passion Fruit Extract**” submitted by **Nifana Kasim, Ragendu R, Sahla** 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

### 1.1 NANOSCIENCE AND NANOTECHNOLOGY

Nanoscience is the study of structures and materials on the nanoscale. It is an emerging area of science which includes the study of materials that have very small dimensions. It involves various fields such as chemistry, physics, biology, mathematics, cognitive science and life science. The results of nanoscience are realized in nanotechnology as new functional materials. It is defined as the study of phenomena, performance and manipulation of ultra small structures or materials at atomic and molecular scales, where properties differ significantly from those at large scale. Nanoparticles have large ratio of surface area to volume, size dependent properties such as absorption of light of a certain frequency due to onset of quantum effects at the nanometer scale etc. Nanoscience is simply the study of nanostructures and nanotechnology. The term nano is derived from the greek word means  $10^{-9}$  and hence a nanometer is one billionth of a meter  $10^{-9}$ . The idea of nanotechnology was highlighted by the Nobel laureate Richard Feynmann in his famous lecture at the California Institute of Technology. In his famous article 'There is plenty of rooms at the bottom', he discussed the idea of nanoparticles. The highlight in nano dimension is that the properties of particles are far different than bulk scale properties.

Nanotechnology is hailed as having the potential to increase the efficiency of energy consumption, help to clean the environment, and solve major health problems. The products of nanotechnology are smaller, cheaper, lighter yet more functional and requires less energy and fewer raw materials to manufacture.

## **1.2 CLASSIFICATION OF NANOMATERIALS**

Nanomaterials are classified into four types depending upon the number of dimensions of materials.

### **1.2.1 Zero dimensional nanomaterials**

Zero dimensional nanomaterials in all the dimensions are measured within the nanoscale. The most common representation of nanomaterials are nanoparticles. Nanoparticles are amorphous or crystalline. It is single crystalline or poly crystalline. It is composed of single or multi chemical elements. It exhibits various shape and forms [1] They exist individually or incorporated into a matrix. They are metallic., ceramic or polymeric which includes graphene quantum dots, carbon quantum dots, inorganic quantum dots etc. A major feature that discriminates various types of nanostructures is their dimensionality. A rich variety of physical and chemical methods have been developed for fabricating zero dimensional nanomaterials with well controlled dimensions. Recently zero dimensional nanomaterials such as uniform particle arrays, heterogeneous arrays, core shell quantum dots were synthesized by various methods.

### **1.2.2 One dimensional nanomaterials**

In this type of nanomaterial, one dimension is outside the nanoscale. This leads to needle like shaped nanomaterials. They includes nanotubes, nanorods and nanowires. They are amorphous or crystalline, single crystalline or polycrystalline [2]. They are metallic, ceramic or polymeric. The smallest possible crystalline wires with cross section as small as single atom can be engineered in cylindrical confinement. Carbon nanotubes, a natural semi-one dimensional nanostructures are as a template for synthesis. This class includes nanotubes, nanorods and nanowires.

### **1.2.3 Two dimensional nanomaterials**

The materials having two dimensions outside the nanoscale are known as two dimensional nanomaterials. This includes graphene, nanofilms, nanolayer and nanocoatings.. Various chemical compositions are used as a single layer or multilayer structures [3] metallic, ceramic or polymeric. The most important representative graphene was discovered in 2004.

### **1.2.4 Three dimensional nanomaterials**

Three dimensional nanomaterials are materials that are not confined to the nanoscale in any dimension. This class includes bulk powders, dispersion of nanoparticles, bundles of nanowires and nanotubes as well as multi-nanolayers. These materials are thus characterized by having three arbitrary dimensions above 100 nm. In terms of nanoscale structures, bulk nanomaterials are composed of a multiple arrangement of nanosized crystals, most typically in different orientation [4]. Three dimension nanomaterials are old classical shaped objects. They have a length, a width and a thickness that are relatively beyond a few nanometers. Three dimension nanomaterials are visible on every side like graphite.

## **1.3 PROPERTIES OF NANOMATERIALS**

Nanomaterials have various properties such as

### **1.3.1 Optical Properties**

The colour of a material is determined by the wavelength of light absorbed and emitted by it. Carbon dots have strong absorption in the ultraviolet region, which can also extend to visible regions. Nanomaterials of different sizes have different electronic structures and different energy level separation [5]. Light induced transition between these levels determines the colour of the materials. Smaller nanoparticles are blue in colour and larger are red in colour. Thus nanoparticles are made to emit or absorb specific wavelengths of light merely by controlling their size. Nanomaterials having small particle sizes exhibit enhanced optical emission as well as



nonlinear optical properties due to the quantum confinement effect. Synthesis, characterisation and measurement of optical properties of nanomaterials with different anisotropic shapes have also drawn significant attention.

### **1.3.2 Electronic Properties**

Nanomaterials of different sizes have different electronic structures and different energy level separation. The electrical conductivity of nanotubes and nanorods are very high due to electron confinement to particular direction. Nanotechnology in electronics provides faster, smaller and enhanced handheld devices. It provides advanced display technologies with conductive nanomaterials, data storage, quantum computing, printable and flexible electronics and magnetic nanoparticles for data storage.

### **1.3.3 Mechanical Properties**

Mechanical strength, toughness and young's modulus of the nanomaterials are very high. Carbon nanotubes (CNTs) have attracted significant research attention in the field of nanomaterials ever since it was discovered. CNTs possess excellent mechanical qualities, specifically high mechanical strength. This has resulted in its diverse applications in the real world such as space elevators, better solar cells, faster computer chips, thinner electronic devices, faster flywheels etc. The excellent mechanical properties of CNTs are one of the major incentives for studying the mechanical properties of nanoscale materials [6]. Numerous studies have been undertaken to characterize the mechanical properties of CNTs. Laboratory experiments suggests that CNTs have highly strengthened elastic modulus. Young's modulus of CNTs are determined by directly measuring the thermal vibrations. It was found that the CNTs possess very high Young's modulus and excellent mechanical properties, which make them ideal for fabricating nanoscale fibres for light weight composites.

### **1.3.4 Magnetic Properties**

Symmetry and confinement of nanoparticles exhibits specific properties such as superparamagnetism due to the very small sizes and the fundamental change in the coordination of nanoparticles. Superparamagnetism is a unique feature of magnetic nanoparticles. It has great relevance to modern potential technologies. Superparamagnetism is found in ferromagnetic nanoparticles. Similar to paramagnets, an external magnetic field is able to magnetise the nanoparticles in superparamagnetic state. Superparamagnetic state is defined as in the absence of an external magnetic field, when the time used to measure the magnetisation of nanoparticles is longer than Neel relaxation time, their magnetisation appears to be zero. Neel relaxation time is the time between two flips. The magnetic susceptibility of superparamagnetic are much larger than the paramagnets.

## **1.4 METHODS OF SYNTHESIS OF NANOMATERIALS**

Two prevalent strategies adopted for the formation of nanoparticles are bottom-up and top-down. Nanomaterials are made by either cutting down macro structures to nanoscale (top-down approach) or by amassing structures from particles and atoms (bottom-up approach) [7]

### **A) Bottom-up approach**

The bottom up approach is an investment strategy that depends on the individual stocks. In this approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition[8]. Bottom up approach alludes to the built up of a material from the bottom, molecule by atom, atom by particle or cluster by cluster.

### **B) Top-down approach**

In the top-down approach, nano objects are contributed from larger entities. In this method, breaking up larger particles by the utilization of physical forms like pulverizing or grinding. This method creates smaller devices by using larger ones to direct their assembly. Many technologies

that descended from conventional solid state silicon methods for fabricating microprocessors are now capable of creating features smaller than 100nm.

#### **1.4.1 Microwave method**

Microwave radiation method (MWI) method provides simple and fast routes to the synthesis of nanomaterials since no high temperature and high pressure are needed. By using metal precursors that have large microwave absorption cross-sections relative to the solvent, very high effective reaction temperatures are achieved [9]. The material properties of nanomaterials are dependent on their size. Depending on the field of application, it is therefore essential to have the narrowest and most exact size distribution possible in order to obtain nanoparticles with defined properties. In recent years, microwave assisted synthesis has established itself as a modern way of producing different nanomaterials in order to effectively influence both size distribution and material properties.

#### **1.4.2 Co-precipitation**

This method is shown by the presence of precipitate normally soluble under normal conditions. Nanosized particles of iron oxide are mainly synthesized by this method. This method is mainly used to separate and concentrate trace elements of a very dilute solution. Co-precipitation yield is mainly depended on the amount of precipitate coexisting salt and ageing time of precipitation. This simple and low cost process is used for the synthesis of other nanoparticle having magnetic property

#### **1.4.3 Sol-gel process**

It involves the evolution of inorganic networks through the formation of a colloidal suspension (sol) and gelation of the sol to form a network in a continuous liquid phase. The process involves conversion of monomers into a colloidal solution (sol) that acts as a precursor for an integrated network (or gel) of either discrete particles or network polymers. Typical

precursors are metal alkoxides[10]. Sol-gel is used for the synthesis of various inorganic or organic hybrid materials. Typical precursors are metal alkoxides and metal chlorides, which undergo hydrolysis and polycondensation reactions to form a colloid.

#### **1.4.4 Hydrothermal synthesis**

Hydrothermal synthesis method involves using any of the techniques to crystallise substances. It is usually done at a high vapour pressure level and using a high temperature aqueous solution. A strong container within the hydrothermal reactor ‘autoclave’ is filled with a solution. The process requires constant maintenance of temperature difference between the opposing ends of the crystallizing compartment. Hydrothermal synthesis is one of the most commonly used methods of precipitation of nanomaterials. It is basically a solution reaction-based approach. Here, the formation of nanoparticles happens in a wide temperature range from room temperature to very high temperature. Hydrothermal synthesis can generate nanomaterials which are not stable at elevated temperatures. Nanomaterials with high vapour pressure are produced by hydrothermal methods with minimum loss of materials. The composition of nanomaterials to be synthesized are well controlled in hydrothermal synthesis through liquid phase or multiphase chemical reactions

### **1.5 CHARACTERIZATION METHODS**

#### **1.5.1. Ultraviolet Spectroscopy**

Ultraviolet/Visible/Infrared (UV/Vis/IR) spectroscopy is a technique used to quantify the light that is absorbed and scattered by a sample (a quantity known as the extinction, which is defined as the sum of absorbed and scattered light). Absorption of light in the UV/Visible part of the spectrum is 210 – 900 nm. In its simplest form, a sample was placed between a light source and a photodetector, and the intensity of a beam of light was measured before and after passing through the sample. These measurements are compared at each wavelength to quantify the sample’s wavelength dependent extinction spectrum [11]. The data was typically plotted as extinction as a function of wavelength. Each spectrum background is corrected using a “blank” –

a cuvette filled with only the dispersing medium, to guarantee the spectral features from the solvent that are not included in the sample extinction spectrum.

### **1.5.2 Photoluminescence Spectroscopy**

Photoluminescence spectra was recorded by measuring the intensity of emitted radiation as a function of either the excitation wavelength or the emission wavelength. In an emission spectrum a fixed wavelength is used to excite the sample and the intensity of emitted radiation is monitored as a function of wavelength. When corrected for variations in the source's intensity and the detector's response, a sample's excitation spectrum will be nearly identical to its absorbance spectrum. The excitation spectrum provides a convenient means for selecting the best excitation wavelength for a quantitative or qualitative analysis. In an emission spectrum a fixed wavelength was used to excite the sample and the intensity of emitted radiation was monitored as a function of wavelength [12].

### **1.5.3 Scanning Electron Microscopy**

SEM is similar to the optical stereo-binocular microscope to observe the morphology and shape of the specimen. It provides information about sample's elemental composition, structural variation and morphology. A beam of electrons are formed by the electron source and accelerated toward the specimen using a positive electrical potential. The electron beam was confined and focused using metal apertures and magnetic lenses into a thin, focused, monochromatic beam. Electrons in the beam interacts with the atoms of the specimen, producing signals that contains information about its surface topography, composition and other electrical properties [13]. These interactions and effects are detected and transformed into an image.

### **1.5.4 Transmission Electron Microscopy**

TEM is the original form of electron microscopy and analogous to the optical microscope. Since the wavelength of electrons are much smaller than that of light, the optimal resolution attainable for TEM images was many orders of magnitude better than that from a light microscope (~0.1 nm). The beam of electrons passes through the specimen and analyzes the internal structure of the specimen in the form of images. The electrons have the poor penetrating capability and gets absorbed in the thick specimen [14]. Therefore, the thickness of the specimen should not be more than few hundred Angstroms (one angstroms  $10^{-10}$  m). However sometimes, slightly thickens samples were used in High Voltage Electron Microscope.

### **1.5.5 Dynamic Light Scattering**

Dynamic light scattering (DLS) is a technique that is used to determine the size distribution profile of small particles in suspension or polymers in solution [15]. In the scope of DLS, temporal fluctuations are usually analyzed by means of the intensity or photon auto-correlation function (also known as photon correlation spectroscopy or quasi-elastic light scattering). In the time domain analysis, the autocorrelation function (ACF) usually decays starting from zero delay time and faster dynamics due to smaller particles leads to faster decorrelation of scattered intensity traces. It has been shown that the intensity ACF was the Fourier transformation of the power spectrum and therefore the DLS measurements were equally well performed in the spectral domain.[16] DLS was also used to probe the behavior of complex fluids such as concentrated polymer solution.

## **1.6 APPLICATIONS OF NANO MATERIALS**

### **1.6.1 Chemical Sensing**

Fluorescent carbon dots, due to their excellent optical properties, chemical stability, and good solubility in water, in the field of chemical sensing are under great attention and are widely used

in metal ion detection, anion detection, small organic molecules, and biomolecules detection. Like the semiconductor quantum dots, CDs by the interaction with the analyte changes the efficiency of recombination between the surfaces of the electron-hole pairs, which occurred in the fluorescence enhancement and quenching treatment to achieve quantitative or qualitative analysis of the measured object.

### 1.6.2 Bio imaging

Carbon dots have awesome potential for fluorescent bio imaging, and multimodal bio imaging. The images were taken at various excitation wavelengths. Red and green represents the fluorescent signals of the CDs and the tissue auto fluorescence respectively. It was attractive to integrate the multi-imaging technology of one agent for comprehensive understanding of the state of the illness. Most popular nanostructured multimodal imaging probes are combinations of magnetic resonance imaging (MRI) and optical imaging modalities. MRI offers high spatial resolution and the capacity to simultaneously obtain physiological and anatomical information, whereas optical imaging allows the rapid screening. The Cdots were water-dispersible, displaying bright fluorescence in the visible range upon light excitation. Carbon dots own distinctive advantages marked by multicolor emission profile, small sizes, low cytotoxicity, prominent biocompatibility, and excellent photostability enabling them as an ideal candidate for fluorescence imaging.

### 1.6.3. Biosensor

CDs have been used as biosensor carriers due to their high solubility in water, flexibility in surface modification, nontoxicity, excitation-dependent multicolor emission, excellent biocompatibility, good cell permeability and high photostability. The CDs-based biosensors are used for visual monitoring of glucose, cellular copper, phosphate, iron, potassium and nucleic acid. CDs are used as an effective fluorescent sensing platform for nucleic acid detection with selectivity single-base mismatch. The general concept was based on the adsorption of the fluorescently labelled single-stranded DNA (ssDNA) probe by CD via  $\pi$ - $\pi$  interactions, which was accompanied by substantial fluorescence quenching, followed by specific hybridization with

its target to form double-stranded DNA (dsDNA). This results in desorption of the hybridized dsDNA from the CD surface accompanied with subsequent recovery of fluorescence, probing the target DNA

#### **1.6.4 Catalysis**

Carbon dots are efficiently used in photocatalysis. The flexibility of functionalization with the various groups of carbon dots make them possible to absorb light of different wavelengths. Carbondots serves as electron reservoir to improve the efficiency of suppression of electron hole pairs.

#### **1.6.5 Antimicrobial Activity**

Carbon dots (CDs) are one of the most recently developed, carbon-based nanomaterials (NMs). Owing to their multiple properties they are used in various applications. Recently, they were also examined for their antibacterial properties. In a few cases, CDs have inherent antibacterial properties, while in many cases, specific synthesis conditions or functionalization routes are followed, either in order to bestow antibacterial properties to CNDs or to enhance their performance[17]. Although much work has been done following this approach, an alternative option is to increase the antibacterial activity of CDs after irradiation at various wavelengths. For all the above cases, various mechanisms of action have been proposed to explain the observed antibacterial activity. C-dots conjugate showed enhanced antimicrobial activity against selective gram strain bacteria.

#### **1.6.6 Drug Delivery**

Drug delivery refers to the approaches, formulations, technologies, and systems for transporting a pharmaceutical compound in the body some time based on nanoparticles as needed to safely achieve its desired therapeutic effect. It involves scientific site-targeting within the body, or it might involve facilitating systemic pharmacokinetics; in any case, it was typically concerned with both quantity and duration of drug presence. Drug delivery was often approached



via a drug's chemical formulation, but it also involves medical devices or drug-device combination products.

## **1.7 CARBON DOTS**

Carbon dots were first discovered in 2004, during the purification of SWCNT. They are new class of fluorescent small nanomaterials with particle size less than 10 nm. The shape of carbon dots is circular or elliptical, even some have quadrate, triangular and hexagonal structure which has been confirmed by high resolution. TEM, SEM and X Ray diffraction pattern reveals that Carbon dots are also in hollow structured. They possess many unique physiochemical properties like biocompatibility, optical properties etc. The quantitative understanding of the physiochemical properties of carbon dots still remain a difficult challenge because of their complex structure. A paper published in 2019 showed that carbon dots resist temperature as high as 800 °C, paving way for application of carbon quantum dots in high temperature environments [18]. Carbon dots are synthesized from any carbon sources including plants, animals, food wastes etc. by top down or bottom up method. Carbon dots are extracted from natural products such as honey, caramel and sugar beet molasses. Bioimaging, biosensing, photocatalysis, drug delivery, etc. are some application of carbon dots.

## **1.8 CLASSIFICATION OF CARBON DOTS**

Carbon dots are classified into four types based on carbon core structure, surface functional groups and their properties. They are Carbon quantum dots (CQD), Graphene quantum dot (GQD), Carbon nano dots (CND), Carbonized polymer dot (CPD) [19].

Carbon quantum dots are nanospheres, crystalline in nature, and exhibit a large number of chemical groups that impart the intrinsic state luminescence and quantum confinement effect of carbon dots [20]. The graphene quantum dot are basically the tiny fragments of graphene,

anisotropic in nature and constitutes mono or multiple layers of graphene sheets with graphene networks in their configuration. GQDs have quantum confinement and edge effects because of the existence of various chemical functions on their edge or within their inter layer defect [21]. The CNDs possess a high degree of carbonization with edge effects, but without disclosing the crystalline or polymeric structures. Besides CNDs lack in displaying the quantum confinement effect [22]. The CPDs are ideally the cross linked nano hybrids of carbon and aggregated polymers with a central carbonized core enveloped by either the polymeric chains or functional groups [23].

## **1.9 PROPERTIES OF CARBON DOTS**

### **1.9.1 Absorbance**

C-dots absorb in short wavelength region due to  $\pi$ - $\pi$  transition of C=C bonds. They typically show strong optical absorption in the UV region (260-320 nm), with a tail extending into the visible range. Generally, C-dots are relatively more efficient in absorption of long wave-lengths. Their absorption characteristics differ from one C-dots to another depending upon surface passivation and functional groups attached on its surface.

### **1.9.2 Photoluminescence**

The most fascinating feature of C-dots is their tunable photoluminescence (PL) properties arising from quantum confinement effects. The PL quantum yield of bare C-dots is low (typically <10%) due to the emissive traps on the surface. In order to enhance the brightness of C-dots, surface passivation is necessary. C-dots with different colours have been synthesized, ranging from UV to red, but most of them emit commonly in blue and green region. Undesirable for multi-color imaging, most of the C-dots show broad emission spectra because of the large heterogeneity (in size and chemical composition) resulting from poorly controllable synthesis processes.

### 1.9.3 Chemiluminescence

Chemiluminescence (CL) is defined as the production of light through a chemical reaction. CL produces from the excitation of C-dots, after direct oxidation which is formed by electron and hole-injection. With proper reaction conditions in redox reaction, CL produced in aqueous phase system and unstable products are generated from intermediate radicals in the CL reaction process. It is produced by emitting species by direct oxidation of objective compounds or by indirectly enhancing inhibitory effects of certain luminescence compounds. It is also produced from the reaction of inorganic molecules but luminescence is weak and quantum yield is low. Therefore, in analytical applications the intensity CL should be enhanced.

## CHAPTER-2

### REVIEW

Bui Thi Ho et al. studied carbon dots emitting green luminescence with quantum yield in the range of 14.86 to 24.89% as a function of hydrothermal temperature. Firstly highly luminescent carbon dots were synthesized by the one pot method directly from lemon juices using different temperatures, time, ageing of precursors and diluted solvents to control the luminescence of C dots.[24] The obtained nanoparticles were characterized by HRTEM, X-Ray Photoelectron spectroscopy, FTIR spectroscopy, dynamic light scattering, U- V spectrophotometry and PL spectrophotometry.[25] Lu et al. prepared Carbon dots for the rapid assay of Hg<sup>2+</sup> ions with agreeable sensitivity and selectivity.[26] Zhan Lai and co-workers prepared fluorescent carbon dots from cherry tomatoes for highly effective detection of trifluralin herbicide in soil samples. [27] Amit Kumar and co-workers synthesised fluorescent carbon dots using the leaves of ocimum sanctum as a carbon source for the first time with a quantum yield of 9.3%.[28] The practical use of synthesized CDs for detection of Pb<sup>2+</sup> ions was demonstrated in triple negative breast cancer cells. Xiaohan Sun et al. prepared CDs using one pot hydrothermal treatment using Lycii fruits.[29] Optical and structural properties of the CDs are studied by XRD, TEM and HRTEM. The fluorescent quantum yield of the CDs was found to be 17%. Its broad fluorescence is between 415 and 545nm. The CDs exhibit captivating band selectivity towards Fe<sup>3+</sup> with a linear range of 0 to 30 micromolar and 21 nM is the detection limit. H.Muktha et al. prepared stable CDs from organic waste of pomegranate and watermelon peels. They are characterized by UV- Visible spectrophotometer, FTIR spectra, fluorescence spectroscopy, HRTEM and raman spectroscopy. They show antibacterial activity and were also used as a therapeutic agent.

## **CHAPTER-3**

### **OBJECTIVES OF THE WORK**

The important objectives of the work are

1. Synthesis of Carbon dots from Rose petal extract
2. Synthesis of Carbon dots from Passion fruit extract
3. Optical characterization of synthesized Carbon dots using Photoluminescence Spectroscopy

# **CHAPTER-4**

## **MATERIALS AND METHODS**

### **4.1 MATERIALS**

Rose petal extract

Passion fruit extract

Magnetic Stirrer

Beaker

Filter paper

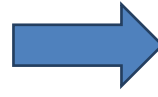
### **4.2 CHARACTERIZATION TECHNIQUES**

Photoluminescence Spectroscopy

### **4.3 EXPERIMENTAL TECHNIQUE**

#### **4.3.1 SYNTHESIS OF CARBON-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 Rose petals and Passion fruit extract is taken in separate vessel for the synthesis of C-dots. Then the vessel was placed on the hot magnetic stirrer and heated until a yellowish- brown colour is appeared in both samples . Then the vessels are cooled to room temperature and the resulting solution was centrifuged at 10,000 RPM (revolutions per minute) for 10 min to discard the large molecules.



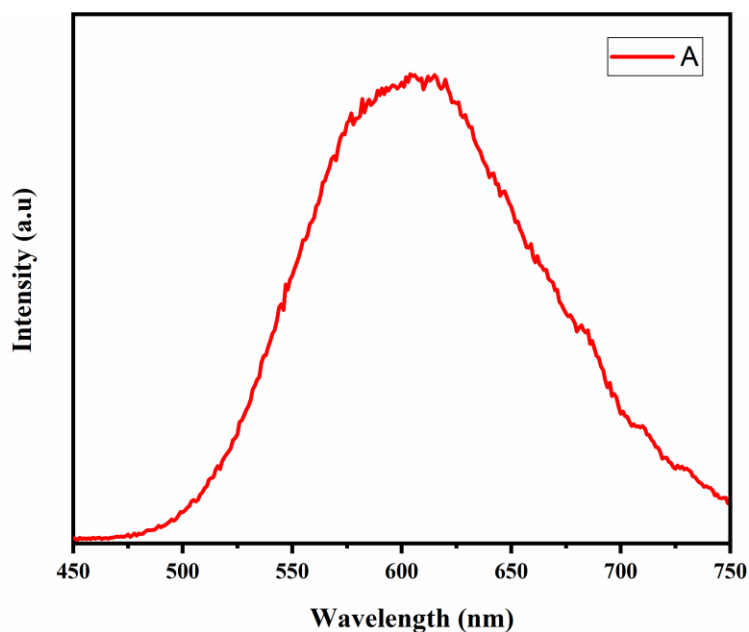
**Schematic representation of synthesis of carbon dots from rose petals and passion fruit.**

# CHAPTER-5

## RESULTS AND DISCUSSION

### 5.1 PHOTOLUMINESCENCE SPECTROSCOPY

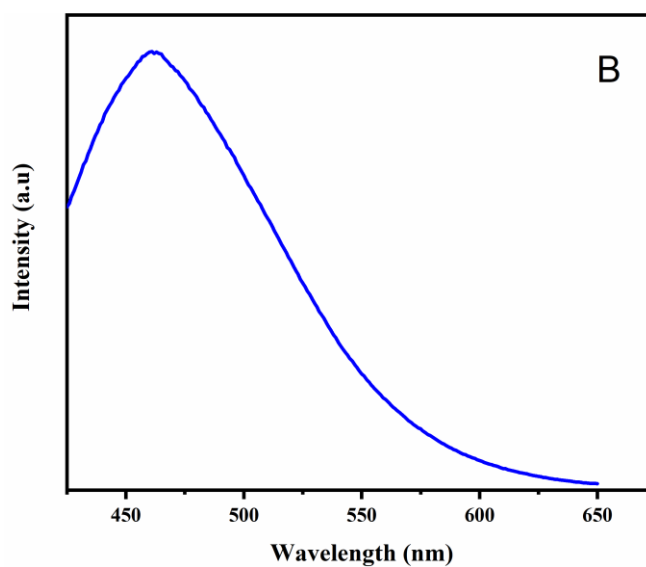
The luminescence property of the synthesized carbon dots was studied by photoluminescence spectroscopy. The intensity of the PL depends on the number of particles excited at a particular wavelength. The highest PL intensity was observed at an excitation wavelength of 380 nm. From the data, it was found that the synthesized carbon dots from both samples (from rose petal and passion fruit extract) show considerable photoluminescence properties.



**Figure 5.1 The photoluminescence spectra of carbon dots from passion fruit extract at excitation wavelength 380nm**



A strong emission band centered at around 610 nm for carbon dots from passion fruit extract and 460 nm for carbon dots from rose petals extract were obtained as depicted in **Figure 5.1** and **Figure 5.2** respectively. The emission band corresponds to the  $n \rightarrow \pi^*$  transition of carbon dots from different sources.



**Figure 5.2** The photoluminescence spectra of carbon dots from rose petals extract at excitation wavelength 380nm

## **CHAPTER-6**

### **CONCLUSION**

Carbon dots were successfully synthesized from natural sources like rose petals extract and passion fruit extract. A room temperature hydrothermal method was employed for the synthesis of carbon dots. The synthesized carbon dots were optically characterized using 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 bioimaging 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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