

**Doped and Functionalized Carbon Dots for  
Ultrasensitive and Highly Selective Toxic Metal Ions,  
Biothiols and Neurotransmitter Recognition**

**A Thesis**

**Submitted**

**by**

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**For the award of the degree of**

**Doctor of Philosophy (Ph.D.)**



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**September, 2016**

*To my Beloved Parents*



**Declaration by the Research Scholar**

This is to certify that the thesis entitled “**Doped and Functionalized Carbon Dots for Ultrasensitive and Highly Selective Toxic Metal Ions, Biothiols and Neurotransmitter Recognition**”, submitted by me to the School of Basic Sciences, Indian Institute of Technology Mandi, for the award of the degree of the Doctor of Philosophy is a bonafide record of research work carried out by me under the supervision of Dr. Chayan Kanti Nandi, and that it has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgements have been made wherever the work described is based on finding of other investigators.

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## Thesis Certificate

This is to certify that the thesis entitled “*Doped and Functionalized Carbon Dots for Ultrasensitive and Highly Selective Toxic Metal Ions, Biothiols and Neurotransmitter Recognition*” submitted by Mr. Abhishek Gupta to the Indian Institute of Technology, Mandi for the award of the degree of Doctor of Philosophy (Ph.D.) is a bonafide record of research work carried out by him under my supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma. In keeping with the general practice of reporting scientific observation, due acknowledgements have been made wherever the work described is based on the findings of other investigators.

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Signature:

## ACKNOWLEDGEMENTS

The work presented in this thesis would not have been possible without my close association with many people who were always there when I needed them the most. I take this opportunity to acknowledge them and extend my sincere gratitude for helping me make this Ph.D. thesis a possibility.

First of all, I would like to express my deep gratitude and profound indebtedness to my Ph.D. advisor Dr. Chayan Kanti Nandi for his dexterous guidance, invaluable suggestions and perceptive enthusiasm which enabled me to accomplish the task of undertaking the present study. He sets an example of a world-class researcher for his passion on research. His wide knowledge and logical way of thinking have been of great value for me. His inspirational, encouraging and personal guidance provided me a great platform for the presenting this thesis.

I express my sincere thanks to The Director, IIT Mandi for his support and encouragement. The research facility at Advanced Materials Research Center (AMRC), IIT Mandi is also gratefully acknowledged hereby.

I also like to express my deep gratitude to my D.C committee members, Dr. Abhimanew Dhir, Dr. Tulika P. Srivastava, Dr. Venkata Krishnan, and Dr. Satinder Kumar Sharma for their invaluable advice and encouragement during research work. My sincere thanks to all chemistry faculty members for motivations during my course work as well as research work.

I am also very much thankful to my research group members (Dr. Charu Dwivedi, Dr. Abhishek Chaudhary, Mr. Syamantak Khan, Mr. Navneet Chandra Verma, Ms. Chethana Rao) for their support and help during my research work.

I would like to thanks to all my friends for their continuous support and encouragement. My earnest thanks are due to AMRC staff for their assistance in lab.

I express profound sense of reverence to my parents for their untiring support and co-operation. I can never forget cooperation, endless tolerance and constant encouragement from all my family members during these happy moments of the journey.

Above all, all the praise is due to the Almighty God, the ultimate source of knowledge, a part of which He reveals to man and peace be upon all his Messengers throughout the world for success and guidance of mankind. I express my gratitude and indebtedness to the Almighty for countless blessings.

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## Abbreviations

Å	Angstrom
AA	Ascorbic Acid
AAS	Atomic Absorption Spectroscopy
AFM	Atomic Force Microscopy
As (III)	Arsenic Ions / Arsenate
Ca <sup>2+</sup>	Calcium Ions
CNDs	Carbon Nanodots / Carbon dots
CNTs	Carbon Nano Tubes
CV	Cyclic Voltametry
DA	Deionized Water
DL	Detection Limit
DLS	Dynamic Light Scattering
DNA	De Oxyribonucleic Acid
DTT	Di Thiothrietol
EDTA	Ethylene Di Amine Tetra Acetic Acid
EPA	Environmental Protection Agency
FBS	Fetal bovine Serum
FTIR	Fourier Transform Infrared Spectroscopy
GNPs	Gold Nano Particles
GO	Graphene Oxide
GQDs	Graphene Quantum Dots
GSH	Glutathione
Hg <sup>2+</sup>	Mercuric ion / Mercury
HRMS	High Resolution Mass Spectroscopy
ICPMS	Inductively Coupled Plasma Mass Spectrometry

kD	Kilo Dalton
kV	Kilo Volt
Lys	Lysine
mL	Mili Litre
MPA	3- Mercapto Propanoic Acid
MSA	3- Mercapto Succinic Acid
MTT	3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide
MWCNTs	Multi Walled Carbon Nano Tubes
NIR	Near Infrared
nM	Nano Molar
Pb <sup>2+</sup>	Lead Ions
PBS	Phosphate Buffer Saline
PDA	Potato Dextrose Agar
PEG	Poly Ethylene Glycol
pM	Pico Molar
ppb	Parts Per Billion
PVA	Poly Vinyl Alcohol
QDs	Quantum Dots
QY	Quantum Yield
rGO	Reduced Graphene Oxide
RhB	Rhodamine B
RNA	Ribose Nucleic Acid
rpm	Rotation Per Minute
S/N	Signal to Noise Ratio
SEM	Scanning Electron Microscopy
SERS	Surface Enhanced Raman Spectroscopy

SPR	Surface Plasmon Resonance
SWASV	Square Wave Anodic Stripping Voltammetry
SWCNTs	Single Walled Carbon Nano Tubes
TA	Tartaric Acid
TEM	Transmission Electron Microscopy
TRFS	Time Resolved Fluorescence Spectroscopy
$\mu\text{M}$	Micro Molar
$\mu\text{L}$	Microlitre
UV-vis	Ultraviolet-Visible spectroscopy
WHO	World Health Organization
XPS	X-Ray Photo Electron Spectroscopy
XRD	X-ray powder diffraction

# Thesis Abstract

## **Doped and Functionalized Carbon Dots for Ultrasensitive and Highly Selective Toxic Metal Ions, Biothiols and Neurotransmitter Recognition**

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Although the real structure is not known, however since its first discovery in 2004, carbon dots (CNDs), a new class of carbogenic nanomaterials has paid lots of attention to the nanomaterials research community. This is mainly due to their easy and low cost synthesis method, easy cell permeability, high photo stability, brightness and more over non toxicity for cellular bioimaging. Both the top down and bottom up approach have been used for the successful synthesis of CNDs. The present thesis deals with the bottom up approach for easy and fast microwave assisted synthesis of doped CNDs from different precursor molecules, its surface passivation or functionalization and its potential applications on the ultrasensitive and highly selective toxic heavy metal ions and small biomolecules detection, even in live cell. Several standard and advanced techniques were used for material characterization. For the analytical observation on sensing applications mainly steady state and time resolved fluorescence were used. Confocal microscopy along with several laser excitation sources were used for the live cell imaging and bio application of the CNDs.