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List of Abbreviations and Symbols

DNA	Deoxyribonucleic Acid
RNA	Ribonucleic Acid
α	Alpha
β	Beta
BSA	Bovine Serum Albumin
CQDs	Carbon Quantum Dots
CNTs	Carbon Nanotubes
D	Dimensional
LEDs	Light Emitting Diodes
LASER	Light Amplification By Stimulated Emission Of Radiation
GQDs	Graphene Quantum Dots
CNDs	Carbon Nanodots
PDs	Polymer Dots
PL	Photoluminescence
UV	Ultraviolet
nm	Nanometer
FCNs	Fluorescent Carbon Nanodots
HOMO	Highest Occupied Molecular Orbital
LUMO	Lowest Occupied Molecular Orbital
IC_{50}	Half Maximum Inhibitory Concentration
UCPL	Up Conversion Photoluminescence
SAM	Self-assembled Monolayer
QY	Quantum Yield
QD	Quantum Dots
PEG	Polyethylene Glycol
PEI	Polyethylenimine
PAA	Polyacrylic Acid
DAPI	4',6-Diamidino-2-Phenylindole
ROS	Reactive Oxygen Species
NaCl	Sodium Chloride
HAuCl4	Tetrachloroauric Acid
-COOH	Carboxylic
C=O, C-O	Carboxyl, Carbonyl
C-H, C=C	Carbon Bonds
GLU	B-Glucuronidase
CdSe	Cadmium Selenide
ZnSe	Zinc Selenide
M	Molar
DOX	Doxorubicin
BBB	Blood-Brain Barrier
TJ	Tight Junction
PtNPs	Platinum Nanoparticles
GO	Grapheme Oxide

TE	Tissue Engineering
PBH	Protein Based Hydrogels
PPy- PEI	Polypyrrole-Polyethyleneimine
PACG	Poly(N-Acryloyl 2-Glycine)
Mel	Melatonin
MW	Molecular Weight
Da	Dalton
TiO_2	Titanium Oxide
UA	Uric Acid
AA	Ascorbic Acid
HX	Hypoxthenene
DD	Double Distilled
MTT	3-(4, 5-Dimethylthiazolyl-2)-2,5-Diphenyltetrazolium Bromide
PNDs	Protein Nanodots
GCE	Glassy Carbon Electrode
CV	Cyclic Voltammetry
SWV	Square Wave Voltammetry
Hz	Hertz
mM	Milimolar
μM	Micromolar
DI	Deionized water
MPNDs	Melatonin Loaded Protein Nanodots
QS	Quinine Sulfate
DMEM	Dulbecco's Modified Eagle Medium
MEM	Minimum Essential Medium
NEAA	Non-Essential Amino Acid
ANOVA	One-Way Analysis Of Variance
CMOS	Complementary Metal Oxide Semiconductor
NIR	Near Infra-Red
Vis	Visible
PMT	Photomultiplier Tube
FTIR	Fourier Transform Infrared Spectroscopy
KBr	Potassium Bromide
HeNe	Helium-Neon
MCT	Multiple Cathode Tubes
NIBS	Non-Invasive Back Scatter
XPS	X-Ray Photoelectron Spectroscopy
eV	Electron Volt
ESCA	Electron Spectroscopy For Chemical Analysis
Al	Aluminum
Mg	Magnesium
SAXS	Small Angle X-Ray Scattering
A^0	Angstrom
TEM	Tunneling Electron Microscope
λ	Wavelength
E	Energy
mo	Mass of Electron
c	Speed Of Light
LaB_6	Lanthanum Hexaboride

CCD	Charge Coupled Device
SEM	Scanning Electron Microscope
EDX	Energy Dispersive X-Ray Analysis
%	Percentage
^{0}C	Degree Celsius
Rad	Radian
AgCl2	Silver Chloride
KCl	Potassium Chloride
ZnO	Zinc Oxide
H2O2	Hydrogen Peroxide
G′	Storage Modulus
G″	Viscous Modulus
SC	Stratum Corneum
Tep	Epidermis
Ed	Perivascular Edema
pM	Picomolor
C	Carbon
N	Nitrogen
O	Oxygen
AuNPs	Gold Nanoparticles
PLL	Poly-L-Lysine
ITO	Indium Titanium Oxide
f	Frequency
LOD	Limit Of Detection
RSD	Relative Standard deviation

Preface

Functional nanomaterials have gained tremendous interest in the scientific community due to their application in health, energy, and the environment. In the last few decades, excellent research work has been done on nanomaterials in different aspects due to their exceptional properties compared to bulk materials. Researchers have worked on various precursor materials to get facile synthesis routes and advance nanomaterial's physicochemical properties in which carbon-based material is the first choice. Biomolecules are a class of carbon-based materials vital for life, and essential components for organisms to grow, sustain, and reproduce. They are building blocks for organisms, from single-cell growth to complex living beings like humans. Protein, carbohydrate, lipids, and nucleic acids are four classes of biomolecules with different molecular compositions, shapes, and structures, leading to diverse functions. In recent years biomolecules have captured massive interest within the scientific community as a functional material due to their unique designs, processes, interactions, and applications in health, energy, and the environment. Studies show that these biomolecules can arrange themselves via self-assembly and form higher-order functional materials at optimal environmental conditions like temperature, pH, and salinity. In this thesis, I have worked on self-assembled nanomaterials of biomolecules and used them for different biomedical applications. Protein nanodots, gold nanoparticles, and Hydrogels were synthesized by facile hydrothermal and electrochemical polymerization/ reduction methods. The fluorescent nanomaterials named protein nanodots show the characteristic properties of carbon quantum dots with high fluorescence intensity and minimal cell toxicity. Lysozyme and bovine serum albumin were used to synthesize novel protein nanodots under physiological conditions and used for drug delivery and sensing of melatonin. For the first time, BSA hydrogels were synthesized using the hydrothermal method without any crosslinker and used for skin protection against UVB. CQDs have gained tremendous attention due to their extraordinary chemical and physical properties, such as tunable photoluminescence with high quantum yields, low cytotoxicity, photo-stability, and simple synthetic routes. These properties provide an actual application in biomedicine, sensing, and catalysis. Similarly, hydrogels are soft materials with distinct properties such as controllable swelling behavior, high water content, and biocompatibility, making them attractive for biomedical applications. This thesis comprises six chapters followed by references and a list of publications. A brief description of each chapter is given below.

Chapter 1 gives an overview of the self-assembled nanomaterial synthesized from biomolecules and their biomedical application. This chapter illustrates the motivation behind work, background, and recent fluorescent carbon-based nanomaterial developments. Different synthesis methods and applications of carbon quantum dots and hydrogels were discussed in detail to give a glance at the importance of the research work included in the thesis.

Chapter 2 discusses the materials, methods, and instrumentations used during the experiments. The synthesis methods and assays, such as MTT and cell culturing, are discussed in detail. This section also includes the full description of physical and optical characterization instruments such as UV-Vis spectrophotometer, Photoluminescence spectrophotometer, scanning, and tunneling electron microscope, zeta-sizer pro, and X-ray electron photometer used during the characterization of the materials.

Chapter 3 describes the various self-assembled phases of BSA protein. In this study, bovine serum albumin (BSA) has been used as a precursor to synthesize temperature and pressure-dependent phase transition from sol (globular aggregates) - gel (hydrogels) - sol (protein nanodots) using a single-step hydrothermal method with an objective to develop an efficient and effective UVB blocker. The synthesized hydrogels exhibit UV - attenuation, self-fluorescence, and high biocompatibility properties that make them suitable for UV-blocker or sunscreen material. The biological efficacy of the hydrogels was studied through cytotoxicity studies. Also, UVB blocking efficiency of developed hydrogel in primary mice skin cell culture as well as *in vivo* in mice model were investigated. *In vivo* study on mice further demonstrated prominent thickening of stratum corneum and epidermis with perivascular edema in the dermis after 5 days of UVB exposure. Hence, this suggests that hydrogel could be a potential candidate for protecting skin from UVB exposure and reducing the threat of skin cancer.

Chapter 4 shows the fabrication of a PNDs conjugated AuNPs, poly-lysine bio-interface for selective detection of melatonin in pharmaceutical and food samples using electrochemical sensing. This work used bovine serum albumin to derive PNDs decorated with active functional groups. The functional groups were further exploited to modify and tailor the surface with AuNP-poly Lysine thin film to achieve the facilitated charge transfer. The fabricated surface's detailed topographical and chemical characterization was done using FTIR, XPS, UV-Vis, HR-SEM, and HRTEM. The ability of the developed sensor to estimate melatonin was probed using Cyclic and Square Wave Voltammetry. The fabricated bio-interface manifested a ~ 2.5-fold magnification in peak current of Mel oxidation with a potential shift of ~ 60 mV towards a lower potential compared to the unmodified electrode. The tailored bio-interface demonstrated appreciable stability and reproducibility and outperformed previously reported sensors in terms of cost-effectiveness, sensitivity, bio-compatibility, and selectivity.

Chapter 5 shows another application of PNDs as a bioimaging tool and drug delivery carrier for melatonin in the breast cancer cell. In this study, green-emitting protein nanodot (PND) was synthesized by a one-step hydrothermal method for loading melatonin. The Physicochemical characterization of both PNDs showed similar morphological and functional activities. Further, the biological efficacy of melatonin-loaded PND (MPND) was evaluated in breast cancer cells line (MDA-MB-231) for live-cell imaging and enhanced nano-drug delivery efficacy. Results showed that MPND causes enhanced bioavailability, better cellular uptake, and inhibition of migration of breast cancer cells as compared to drug alone. Besides, synthesized MPND showed no sign of fluorescence quenching even at high melatonin concentrations, making it an ideal nanocarrier for bioimaging and drug delivery.

Chapter 6 concludes the outcomes of the research work included in this thesis and the future scope of the work.