

Contents

Title	Page No.
TITLE OF THESIS	i
CERTIFICATE	ii
DECLARATION BY THE CANDIDATE & CERTIFICATE BY THE SUPERVISOR	iii
COPYRIGHT TRANSFER CERTIFICATE	iv
Dedication	v
Acknowledgement	vi-vii
Contents	viii-xviii
List of Figures	xix-xxviii
List of Schemes	xxix-xxx
List of Tables	xxxi
List of Symbols/Abbreviations	xxxii-xxxiv
Preface	xxxv-xxxix
CHAPTER 1: Introduction and literature review	1-78
1.1 Introduction	1
1.1.1 Types of nanomaterials	2
1.1.1.1 Based on dimension	2
A. Zero-dimensional (0-D)	2
B. One-dimensional (1-D)	3
C. Two-dimensional (2-D)	3
D. Three-dimensional (3-D)	4
1.1.1.2 Based on core source material	4

A.	Carbon-based nanomaterials	4
B.	Metal oxide nanoparticles	5
C.	Metallic nanoparticles	6
1.2	Synthesis of nanoparticles	8
1.2.1	Top-down method	8
1.2.2	Bottom-up method	8
1.3	Overview of AgNPs and AuNPs	11
1.3.1	AgNPs	11
1.3.2	AuNPs	13
1.3.3	History of AgNPs and AuNPs	14
1.4	Green synthesis of AgNPs and AuNPs	17
1.4.1	Microbial route	18
1.4.1.1	Bacteria	20
1.4.1.2	Fungi	25
1.4.1.3	Algae	30
1.4.1.4	Actinomycetes and Yeast	36
1.4.2	Plants	38
1.4.2.1	Photoinduced synthesis	55
1.5	Properties of AgNPs and AuNPs	57
1.5.1	Tunable shape and size	57
1.5.2	Charged surface	60
1.5.3	Excellent stability	60
1.5.3.1	Electrostatic stabilization	60
1.5.3.2	Steric stabilization	61

1.5.4	Easy functionalization	63
1.5.5	Biocompatibility	64
1.5.6	Surface plasmon resonance (SPR)	65
1.6	Applications of AgNPs and AuNPs	66
1.6.1	Antibacterial	66
1.6.2	Antifungal	66
1.6.3	Antiviral	67
1.6.4	Anticancer	68
1.6.5	Catalytic	69
1.6.6	Biosensing	69
1.6.7	Drug delivery	70
1.6.8	Gene delivery	71
1.6.9	Wound healing	71
1.7	Selection of plant source	72
1.7.1	<i>Xanthium strumarium</i>	73
1.7.1.1	Scientific classification of <i>X. strumarium</i>	74
1.7.2	<i>Croton bonplandianum</i>	75
1.7.2.1	Scientific classification of <i>C. bonplandianum</i>	76
1.8	Research objectives	77
Chapter 2: Materials and Methods		79-110
2.1	Introduction	79
2.2	Materials	79
2.2.1	Bacterial strains	81
2.2.2	Cleaning solution	82

2.2.3 Sterilization	82
2.3 Methods	82
2.3.1 Preparation of leaf extracts	82
2.3.2 Confirmation and quantification of polyphenolic compounds	83
2.3.2.1 Ferric chloride test	83
2.3.2.2 Folin Ciocalteu's method	83
2.3.3 Preparation of standards	84
2.3.3.1 Preparation of standard solution of silver metal ion	84
2.3.3.2 Preparation of standard solution of gold metal ion	85
2.3.4 Green synthesis of AgNPs and AuNPs	85
2.3.4.1 Synthesis of AgNPs	85
2.3.4.2 Synthesis of AuNPs	86
2.3.5 Synthesis of graphene oxide (GO) and reduced graphene oxide (rGO)	87
2.3.6 Fabrication of AgNPs-rGO-PANI nanocomposite	88
2.3.7 Fabrication of AgNPs-rGO-PANI modified glassy carbon electrode	89
2.3.8 Fabrication of AgNPs-rGO nanocomposite	89
2.4 Characterization	89
2.4.1 UV-visible spectroscopy	90
2.4.2 Fourier transform infrared spectroscopy	92
2.4.3 X-Ray diffraction	94
2.4.4 Scanning electron microscopy	96

2.4.5	Transmission electron microscopy	98
2.4.6	Atomic force microscopy	99
2.4.7	Zeta potential	101
2.5	Environmental and biological applications	102
2.5.1	Antibacterial study	102
2.5.1.1	Determination of minimum inhibitory concentrations of AgNPs	102
2.5.1.2	Disc diffusion assay	103
2.5.1.3	Cell viability test	103
2.5.1.4	Evaluation of antibacterial mechanism of AgNPs	104
2.5.1.5	Cell morphology observation	105
2.5.2	Antileishmanial study	105
2.5.2.1	Parasites and culture conditions	105
2.5.2.2	<i>In vitro</i> antileishmanial activity	105
2.5.2.3	<i>In vitro</i> assay of cytotoxicity on J774A.1 macrophages	106
2.5.2.4	Giemsa staining	107
2.5.3	<i>In vitro</i> antioxidant assays	107
2.5.3.1	DPPH free radical scavenging assay	107
2.5.3.2	Hydrogen peroxide scavenging assay	108
2.5.4	Colorimetric detection of iron (Fe^{3+})	108
2.5.5	Electrochemical detection of H_2O_2	108
2.5.6	Peroxidase like catalytic activity of green synthesized AuNPs	109
2.5.6.1	Colorimetric detection of H_2O_2	109

2.5.6.2 Detection of glutathione	109
2.5.6.3 Detection of cholesterol	110
Chapter 3: Photo-induced rapid biosynthesis of silver nanoparticle using aqueous extract of <i>Xanthium strumarium</i> and its antibacterial and antileishmanial activity	111-137
3.1 Introduction	111
3.2 Materials and methods	113
3.2.1 Preparation of leaf extract	113
3.2.2 Biosynthesis of AgNPs	114
3.2.3 Experimental methodology	115
3.3 Results and discussion	115
3.3.1 Primary confirmation of AgNPs synthesis	115
3.3.2 Optimization	117
3.3.2.1 Sunlight exposure	117
3.3.2.2 AEX inoculum dose	119
3.3.2.3 AgNO ₃ concentration	121
3.3.3 Mechanism involving AgNPs formation	123
3.3.4 Characterization	125
3.4 Antimicrobial activity of AgNPs	131
3.4.1 Disk diffusion assay	132
3.4.2 Cell viability	132
3.4.3 Antibacterial mechanism of AgNPs	134
3.4.4 Cell morphology observation	134

3.5 Cytotoxicity assay	136
3.5.1 <i>In vitro</i> assay of cytotoxicity on J774A.1 macrophages	136
3.6 Conclusion	137
Chapter 4: Photo-mediated optimized synthesis of silver nanoparticles for the selective detection of Iron (III), antibacterial and antioxidant activity	138-176
4.1 Introduction	138
4.2 Materials and methods	141
4.2.1 Preparation of leaf extract	141
4.2.2 Synthesis of AgNPs	142
4.2.3 Experimental methodology	143
4.3 Results and discussion	144
4.3.1 Primary confirmation of synthesis of AgNPs	144
4.3.2 Optimization of process parameters	146
4.3.2.1 Sunlight duration	146
4.3.2.2 AEC inoculum dose	149
4.3.2.3 AgNO ₃ concentration	150
4.3.3 Mechanism involving AgNPs biosynthesis	152
4.3.4 Characterization of AgNPs	155
4.3.5 Stability of AgNPs	162
4.4 Colorimetric detection of iron (Fe ³⁺)	164
4.4.1 Mechanism of detection of Fe ³⁺	166
4.5 Antimicrobial activity of AgNPs	167
4.5.1 Cell viability	169

4.5.2 Antimicrobial mechanism of AgNPs	170
4.5.3 Cell morphology observation	171
4.6 Antioxidant activity	173
4.6.1 DPPH assay	173
4.6.2 Measurement of H ₂ O ₂ scavenging assay	174
4.7 Conclusion	175
Chapter 5: Green synthesis of gold nanoparticles and its mimetic activity for the colorimetric detection of hydrogen peroxide	177-206
5.1 Introduction	177
5.2 Materials and methods	179
5.2.1 Preparation of leaf extract	179
5.2.2 Biosynthesis of NC-AuNPs	179
5.2.3 Experimental methodology	180
5.3 Results and discussion	180
5.3.1 Optimization of process parameters	182
5.3.1.1 Sunlight exposure	182
5.3.1.2 AEX inoculum dose	184
5.3.1.3 HAuCl ₄ .xH ₂ O concentration	185
5.3.2 Mechanism involving NC-AuNPs formation	187
5.3.3 Characterization	189
5.3.4 Peroxidase-like activity of NC-AuNPs	197
5.3.5 Optimization of factors affecting the peroxidase-like activity	198

5.3.6 Detection of H ₂ O ₂	203
5.3.7 Selectivity	204
5.4 Conclusion	205
Chapter 6:	207-239
Size-dependent green synthesis of gold nanoparticles and its peroxidase-like mimetic activity for the detection of glutathione from human blood serums	
6.1 Introduction	207
6.2 Materials and methods	209
6.2.1 Preparation of leaf extract	209
6.2.2 Biosynthesis of AuNPs	209
6.2.3 Experimental methodology	210
6.3 Results and discussion	211
6.3.1 Primary confirmation of AuNPs synthesis	211
6.3.2 Optimization of the process parameters	212
6.3.2.1 Sunlight exposure	212
6.3.2.2 AEC inoculum dose	214
6.3.2.3 HAuCl ₄ .xH ₂ O concentration	215
6.4 Mechanism involving AuNPs formation	218
6.5 Characterization	220
6.6 Peroxidase-like catalytic activity of green synthesized AuNPs	229
6.6.1 Optimization of factors affecting peroxidase-like activity	231
6.6.2 Detection of GSH	234
6.6.3 Detection of GSH in real samples	237
6.7 Conclusion	238

Chapter 7: Enhanced electron transfer mediated detection of hydrogen peroxide using silver nanoparticles-reduced graphene oxide-polyaniline fabricated electrochemical sensor	240-263
7.1 Introduction	240
7.2 Materials and methods	242
7.2.1 Experimental methodology	242
7.3 Results and discussion	244
7.3.1 Characterization	244
7.3.2 Electrochemical detection of hydrogen peroxide (H_2O_2)	254
7.3.3 Electrochemical characterization of AgNPs-rGO-PANI-GCE	255
7.3.3.1 Cyclic voltammograms (CV)	255
7.3.3.2 Effect of scan rate	258
7.3.3.3 Electrochemical impedance spectroscopy of AgNPs-rGO-GCE and AgNPs-rGO-PANI-GCE	259
7.3.3.4 Amperometric determination of H_2O_2	260
7.3.3.5 Interference study	262
7.4 Conclusion	263
Chapter 8: Peroxidase-like mimetic activity of AuNPs@rGO nanocomposite for the colorimetric detection of cholesterol	264-283
8.1 Introduction	264
8.2 Materials and methods	266
8.2.1 Fabrication of AuNPs@rGO nanocomposite	266
8.2.2 Experimental methodology	266
8.3 Results and discussion	267
8.3.1 Characterization	267

8.3.2 Peroxidase-like activity	273
8.3.2.1 Optimization of the factors affecting peroxidase-like activity	276
8.3.2.2 Detection of cholesterol	279
8.3.2.3 Selectivity	281
8.4 Conclusion	283
Summary	284-289
Future Recommendations	290
References	291-317
List of Publications	318-321
