

Table of Contents

Sr. No.	Content	Page No.
Chapter 1	Introduction, Aims and Objectives	
1.1	Introduction	1
1.1.1	History	1
1.1.2	What is the reason behind using biosensors as analytical devices?	3
1.1.3	Designing of Biosensors and the Underlying Principles	5
1.1.4	Characteristics of Biosensors	6
1.1.5	Types of biosensors	7
1.1.5.1	Types of Biosensors based on bioreceptors	7
1.1.5.1.1	Enzymatic biosensors	10
1.1.5.1.2	Antibody based biosensor	10
1.1.5.1.3	Nucleic acid/DNA based biosensor	11
1.1.5.1.4	Cell based biosensor	15
1.1.5.1.5	Biomimetic biosensor	17
1.1.5.2	Types of biosensors based on transducers	19
1.1.5.2.1	Electrochemical biosensor	19
1.1.5.2.2	Optical biosensor	23
1.1.5.2.3	Piezoelectric based biosensor	24
1.1.5.2.4	Calorimetric based biosensor	25
1.1.5.2.5	Magnetic biosensors	26
1.1.5.2.6	Resonant biosensors	26
1.1.6	Application of biosensors	27
1.1.6.1	Food monitoring and pathogen detection	27
1.1.6.2	Water and environmental monitoring	28
1.1.6.3	Infections and Disease detection	28
1.1.6.4	Toxin detection and defense use	29
1.1.7	Challenges	30
1.1.8	Future prospects	31
1.1.8.1	Miniaturization and wearable biosensors	31

1.1.8.2	Integration with Artificial Intelligence (AI)	31
1.1.8.3	Environmental Monitoring	31
1.1.8.4	Food Safety and Quality control	32
1.2	Nanomaterials	32
1.2.1	Introduction	32
1.2.2	Types of nano material	33
1.2.2.1	Metal nanoparticles	33
1.2.2.2	Magnetic nanoparticles	33
1.2.2.3	Carbon nanotubes (CNTs) and Carbon nanodots (CNDs)	34
1.2.2.4	Graphene and Graphene quantum dots (GQDs)	36
1.2.2.5	Quantum dots, Silica nanoparticles and Upconversion nanoparticles	37
1.2.3	Deposition techniques for Nanomaterials	37
1.2.3.1	Coating based deposition methods	38
1.2.3.1.1	Drop casting method	38
1.2.3.1.2	Dip coating method	39
1.2.3.1.3	Spin coating method	39
1.2.3.1.4	Blade coating method	40
1.2.3.2	Direct deposition methods	40
1.2.3.2.1	Vapor deposition method	40
1.2.3.2.2	Electrodeposition method	41
1.2.3.2.3	Electrospinning deposition	42
1.2.3.2.4	Electrospray deposition	42
1.2.3.3	Printing based deposition methods	43
1.2.3.3.1	Screen printed electrodes	44
1.2.3.3.2	Inkjet technology	44
1.2.3.3.3	Nozzle-jet printing	45
1.2.3.3.4	Laser Scribing	46
1.2.3.3.5	Direct growth deposition methods	47
1.3	Aims and Objectives	48

1.4	Brief introduction to chapters	50
Chapter 2	Novel Electrochemical biosensor based on immobilized fungal laccase for the detection of hydroquinone	
	Research highlights	55
	Graphical abstract	55
2.1	Introduction	56
2.2	Materials and Methods	58
2.2.1	Reagents and apparatus	58
2.2.2	Apparatus	58
2.2.3	Fabrication of Laccase/Glutaraldehyde/MWCNTs/PVA/SPE electrode	58
2.3	Result and discussion	59
2.3.1	Surface morphology studies	59
2.3.2	Electrochemical behavior of Laccase/Glutaraldehyde/MWCNTs/PVA/SPE electrode	61
2.3.3	Effect of pH on Laccase/Glutaraldehyde/MWCNTs/PVA/SPE:	63
2.3.4	Reproducibility and storage of the electrode	64
2.3.5	Cyclic voltammetric detection of hydroquinone	65
2.3.6	Interference study	67
2.3.7	Real sample detection	68
2.4.	Conclusion	68
Chapter 3	Development of lactose biosensor with immobilized β-Galactosidase and Galactose Oxidase with Multi-Walled Carbon Nanotubes and CuO-TiO₂	
	Research highlights	69
	Graphical abstract	69
3.1	Introduction	70
3.2	Materials and Methods	72
3.2.1	Reagents and Apparatus	72
3.2.2	Apparatus	73

3.2.3	Fabrication of electrochemical biosensor	73
3.3	Result and Discussion	74
3.3.1	Electrochemical behaviour of lactose electrode	74
3.3.2	Effect of pH on electrode	74
3.3.3	Calibration curve for lactose using cyclic voltammetry	78
3.4	Selectivity study	79
3.5	Real sample detection	80
3.8	Conclusion	81
Chapter 4	Development, fabrication and characterization of DNA biosensor for the detection of <i>Mycobacterium tuberculosis</i>	
	Research highlights	82
	Graphical abstract	82
4.1	Introduction	83
4.2	Materials and methods	86
4.2.1	Reagents and apparatus	86
4.2.2	Apparatus	87
4.2.3	Immobilization of ssDNA probe MWCNTs-COOH	87
4.2.4	Fabrication of ssDNA-modified electrode chip (ssDNA-MWCNTs/PVA/GA)	88
4.2.5	Hybridization	88
4.2.6	Conditions applied for Polynucleotide chain reaction (PCR)	88
4.2.7	Electrochemical characterization of hybridization reactions	89
4.2.8	Selectivity study	89
4.2.9	Replicability and regeneration of the electrode:	89
4.3	Result and discussion	90
4.3.1	Modification of MWCNTs-COOH with ssDNA probe	90
4.3.2	Characterization and replication of PuP chip (GA/ssDNA-MWCNTs-PVA/SPE electrode)	91
4.3.3	Analysis of <i>PupE</i> gene by PCR	92

4.3.4	Characterizing electrochemical response with varying complementary target concentrations	93
4.3.5	Hybridization selectivity of ssDNA probe of PupE and interference study	95
4.3.6	Regeneration of PupE chip	96
4.3.7	Real sample detection of PupE gene	97
4.4.	Conclusion	98
Chapter 5	Testing of Covid-19 real samples of Nsp3 gene of SARS-CoV-2 using DNA chip	
	Research highlights	99
	Graphical abstract	99
5.1	Introduction	100
5.2	Materials and methods	101
5.3	Results and Discussion	102
5.4	Conclusion	103
Chapter 6	Testing of triglyceride real samples using conductive Nano-PEI-lipase based biosensor	
	Research highlights	104
	Graphical abstract	104
6.1	Introduction	105
6.2	Material and methods	106
6.3	Results and discussion	106
6.4	Conclusion	109
Chapter 7	Electrochemical biosensor for breast cancer using DNA chip for cyclic voltammetric detection	
	Research highlights	110
	Graphical abstract	110
7.1	Introduction	111
7.2	Materials and methods	113
7.2.1	Reagents and apparatus	113

7.2.2	Apparatus	114
7.2.3	Immobilization of ssDNA probe MWCNTs-COOH	114
7.2.4	Fabrication of ssDNA-modified electrode (ssDNA-MWCNTs/PVA/GA)	114
7.2.5	Hybridization	115
7.2.6	Electrochemical characterization of hybridization effects	115
7.3	Results and discussion	116
7.3.1	Modification of MWCNTs-COOH with ssDNA probe	116
7.3.2	Characterization of BRCA1 chip (GA/ssDNA-MWCNTs-PVA/SPE electrode)	117
7.3.3	Characterizing electrochemical reaction with different Cs concentrations of BRCA1	118
7.4	Conclusion	120
Chapter 8	Summary and conclusions	121
	References	127
	List of publications, posters, achievements and conferences attended	