

Contents

Contents		Page No.
TITLE OF THESIS		i
CERTIFICATE		ii
DECLARATION BY THE CANDIDATE & CERTIFICATE BY THE SUPERVISOR		iii
COPYRIGHT TRANSFER CERTIFICATE		iv
DEDICATION		v
ACKNOWLEDGMENT		vi-viii
CONTENTS		ix-xiii
LIST OF FIGURES		xiv-xvii
LIST OF TABLES		xviii
LIST OF SYMBOLS/ABBREVIATIONS		xix-xxi
PREFACE		xxii-xxv
Chapter 1: General Introduction		1-30
1.1	INTRODUCTION	2-3
1.2	Geometry of Prussian Blue	4-5
1.3	Color of Prussian Blue	5
1.4	Properties of Prussian Blue	5
	1.4.1 <i>Electrochemical</i>	<i>5-8</i>
	1.4.2 <i>Electrochromic</i>	<i>9-10</i>
	1.4.3 <i>Photo-physical</i>	<i>10-11</i>
	1.4.4 <i>Electromagnetic</i>	<i>11-12</i>

	1.4.5	<i>Characteristics of Charging and Discharging</i>	12-13
1.5	Prussian Blue and Its Analogs Modified Electrodes Application in Chemical Sensing		13-14
	1.5.1	<i>PB and PBA-Based Electrochemical Biosensors</i>	14-15
	1.5.2	<i>An Electrochemical Sensor for Non-Electroactive Cations</i>	15-16
	1.5.3	<i>Electrochemical Sensor for Oxidizable Compounds</i>	16-18
	1.5.4	<i>Advanced Transducer for Hydrogen Peroxide (H₂O₂)</i>	18-20
1.6	Contamination of Heavy Metals in Waste Water		20-21
1.7	Radioactive Materials in Waste Water		21-22
1.8	Adsorption		22
	1.8.1	<i>Electrochemical Adsorption</i>	22-23
	1.8.2	<i>Physical Adsorption</i>	23
	1.8.3	<i>Chemical Adsorption</i>	23-24
1.9	Challenges in Prussian Blue Synthesis and Its Analytical Chemistry		24-26
1.10	Origin of Present Research Work		26-27
1.11	Objectives		28-29
1.12	Work Plan		29-30
Chapter 2: Polyethylenimine (PEI), Tetrahydrofuran-Hydrogenperoxide (THF-H₂O₂), and 2-(3,4- Epoxycyclohexyl)-ethyltrimethoxysilane (EETMS) Mediated Synthesis of Nanocrystalline Prussian Blue Nanoparticles and Their Characterizations			31-54
2.1	Introduction		32-35
2.2	Experimental section		35

	2.2.1	<i>Materials</i>	35
	2.2.2	<i>Polyethylenimine (PEI) mediated synthesis of nanocrystalline (PBNP-1)</i>	35
	2.2.3	<i>THF-H₂O₂ mediated synthesis of nanocrystalline (PBNP-2)</i>	36
	2.2.4	<i>2-(3,4-Epoxy cyclohexyl)-ethyltrimethoxysilane (EETMS) and cyclohexanone mediated synthesis of nanocrystalline (PBNP-3)</i>	36
	2.2.5	<i>THF-H₂O₂ mediated synthetic incorporation of nanocrystalline (PBNP) within MSP and Mesoporous silica nanoparticles (MSNP) as potential Cesium ion Adsorbent:</i>	36-37
	2.2.6	<i>Preparation of Prussian blue nanoparticles modified screen-printed electrode</i>	37
	2.2.7	<i>Preparation of PBNP-modified graphite paste electrode</i>	37-38
2.3	Characterization of synthesized nanocrystalline PBNP		42
	2.3.1	<i>UV-Visible spectrophotometer</i>	43
	2.3.2	<i>Powder X-ray diffraction (XRD)</i>	44-45
	2.3.3	<i>SEM analysis of synthesized PBNP@MSN (Mesoporous silica nanoparticles)</i>	45-46
	2.3.4	<i>TEM analysis</i>	46-48
	2.3.5	<i>DLS Characterization of Nanoparticles</i>	48
	2.3.6	<i>Thermogravimetric (TGA) analysis</i>	49-50
	2.3.7	<i>BET analysis</i>	50
	2.3.8	<i>XPS of PBNP-1, PBNP-2 and PBNP-3</i>	51-54
Chapter 3: Sensing of Arsenic, Cesium ion, and catalytic activity of Hydrogen peroxide, and removal of Cesium ion through synthesized Prussian Blue Nanoparticles			55-88

3.1	Designing of PBNPs-Modified Electrochemical Electrodes		56
	3.1.1	<i>Fabrication of PB Nanoparticle-Modified Screen-Printed Electrodes</i>	56
	3.1.2	<i>Fabrication of PBNPs-modified graphite paste electrode designing</i>	57
3.2	Evaluation of PB Nanoparticle-Modified Electrodes		57
	3.2.1	<i>Electrochemical Sensing through Screen-Printed Electrode (SPE)</i>	58
	3.2.1.1	<i>Electrochemistry of PBNP-2 modified SPE in the presence of As(III) and Hydrogen Peroxide</i>	58-62
	3.2.1.2	<i>Electrochemistry of PBNP-2 modified SPE in the presence of Cs ion</i>	62-63
	3.2.2	Electrochemical Sensing of Cs ion through PBNP-modified Graphite Paste Electrode	64
	3.2.2.1	<i>Cyclic Voltammetry</i>	64-65
	3.2.2.2	<i>Differential Pulse Voltammetry</i>	66-67
	3.2.2.3	<i>Electrochemical Impedance Spectroscopy</i>	67-70
3.3	Sensing of cesium ions based on Magnetic Measurements		70-72
3.4	Fluorometric Sensing of Cesium ions-based PBNP mediated Fluorescence Quenching of Fluorescein		73-77
3.5	Measurement of ¹³⁷Cs radioactivity and determination of adsorption distribution coefficient (K_a) for cesium adsorption		77-78
3.6	Assessment of Electrochemical Adsorption		78-79
3.7	Prussian blue nanoparticles inserted biocompatible mesoporous silica for removal of cesium ion from contaminated water based on inductively coupled plasma resonance spectroscopy		79-80

3.8	Removal of Cesium ion	80
	3.8.1 <i>The Electrochemical Adsorption (EA) Performance of PB Nanoparticle-Modified SPE</i>	80-82
	3.8.2 <i>¹³⁷Cesium ion removal through PBNP-2 incorporated mesoporous silica</i>	83-88
Conclusion		89-90
Summary		91-93
Future Projection		94
References		95-127
List of Publications		128
List of Conferences		129