

Table of Contents

	Page No.
<i>Abstract</i>	i–v
<i>Declaration</i>	vi
<i>Certificate from the Supervisor</i>	vii
<i>Certificate from the external examiner and ODEC</i>	viii
<i>Acknowledgements</i>	ix–xi
<i>Abbreviations and symbols used in this thesis</i>	xii–xv
<i>List of Figures</i>	xvi–xxiii
<i>List of Tables</i>	xxiv–xxv
<i>List of Schemes</i>	xxvi
Chapter 1: A general introduction to creatinine, its importance and its detection techniques	1.1–1.46
1.1 Introduction to creatinine: a significant metabolic waste product	1.1
1.2 Creatinine clearance and GFR: formulas, comparison and ranges	1.4
1.3 Creatinine determination methods used in clinical practices and their limitations	1.8
1.3.1 Jaffe method	1.9
1.3.2 Enzymatic method	1.10
1.3.3 Jaffe v/s Enzymatic: A comparison of the methods	1.14
1.4 Coordination with transition metal ions: the intrinsic property of creatinine	1.15
1.5 Development of new creatinine sensors	1.18
1.6 Importance of creatinine sensors in the future: a forecast	1.23
1.7 Aim and objectives of the work	1.24
1.8 Plan of work	1.24
References	1.26
Chapter 2: Materials and methods	2.1–2.17
2.1 Chemicals and reagents	2.1
2.2 Chemical structures	2.1

2.3 Instruments	2.2
2.4 Electrode cleaning, maintenance and connections	2.3
2.5 Methods	2.4
2.5.1 Electrochemical methods	2.4
2.5.1.1 Cyclic Voltammetry	2.4
2.5.1.2 Differential Pulse Voltammetry	2.7
2.5.1.3 Chronoamperometry	2.9
2.5.1.4 Chronopotentiometry	2.10
2.5.1.5 Electrochemical Impedance Spectroscopy	2.11
2.5.2 Other general methods	2.14
References	2.15
Chapter 3: A novel method for electrochemical determination of creatinine in human urine based on its reaction with 2-nitrobenzaldehyde using a glassy carbon electrode	3.1–3.29
<i>Highlights</i>	3.1
3.1 Introduction	3.2
3.2 Experimental	3.3
3.2.1 Chemicals, reagents and instruments	3.3
3.2.2 Solution preparation	3.4
3.2.3 Electrochemical and spectroscopic procedures	3.4
3.2.4 Optimization of the reaction parameters	3.4
3.2.5 Electrochemical determination of creatinine and LOD	3.5
calculation of the system	
3.2.6 Interference	3.5
3.2.7 Urine sample	3.6
3.3 Results and Discussion	3.6
3.3.1 Electrochemical behaviour	3.6
3.3.2 Kinetic model of the system	3.7
3.3.3 Selection of reagent parameters and validating 2-NBA	3.8
concentration	
3.3.4 pH optimization	3.9
3.3.5 Optimization of reaction time	3.11

3.3.6 Determination of the LOD	3.11
3.3.7 Interference study	3.13
3.3.8 Urine sample analysis	3.16
3.3.9 Discussion: a plausible mechanistic pathway of the reaction	3.18
3.3.9.1 Electrochemical perspective	3.18
3.3.9.2 Spectroscopic support	3.22
3.4 Conclusion	3.25
References	3.26
Chapter 4: Deciphering the complexation processes of creatinine-cobalt and creatinine-cobalt-2-nitrobenzaldehyde: Morphological, spectroscopic and electrochemical analysis	4.1–4.31
<i>Highlights</i>	4.1
4.1 Introduction	4.2
4.2 Experimental	4.3
4.2.1 Chemicals and reagents	4.3
4.2.2 Instrumentation	4.3
4.2.3 Synthesis of creatinine-cobalt complexes	4.4
4.2.3.1 In the absence of 2-NBA	4.4
4.2.3.2 In the presence of 2-NBA	4.4
4.2.4 Microscopic, spectroscopic and physiochemical characterizations	4.5
4.2.5 Electrochemical procedures	4.6
4.3 Results and Discussion	4.6
4.3.1 Preliminary observation	4.6
4.3.2 SEM and P-XRD analysis	4.7
4.3.3 Analysis of FTIR and Raman spectra	4.11
4.3.4 Analysis of DRS	4.16
4.3.5 Elemental compositions and molecular formulas of the complexes: EDX analysis	4.18
4.3.6 Electrochemical analysis	4.20
4.3.7 Yield and physiochemical properties: magnetism, conductivity and solubility	4.23

4.3.8 Brown filtrate analysis	4.26
4.4 Conclusion	4.26
References	4.27
Chapter 5: A highly selective method for electrochemical determination of creatinine in human serum based on its coordination reaction with Co^{3+} in the presence of 2-nitrobenzaldehyde	5.1–5.26
<i>Highlights</i>	5.1
5.1 Introduction	5.2
5.2 Experimental	5.2
5.2.1 Chemicals, reagents and instruments	5.2
5.2.2 Solution preparation	5.3
5.2.3 Electrochemical and spectroscopic procedures	5.3
5.2.4 Optimization of reaction parameters	5.4
5.2.5 Electrochemical determination of creatinine and LOD calculation	5.4
5.2.6 Interference	5.4
5.2.7 Serum sample collection and deproteinization	5.5
5.3 Results and Discussion	5.6
5.3.1 Electrochemical behaviour	5.6
5.3.2 Optimization of the reaction time and concentration of the reagents	5.7
5.3.3 LOD determination	5.10
5.3.4 Interference study	5.12
5.3.5 Human blood serum (HBS) sample analysis and analytical performance of this method	5.14
5.3.6 Plausible mechanistic pathway: a discussion	5.18
5.3.6.1 From the electrochemical perspective	5.18
5.3.6.2 From the spectroscopic perspective	5.22
5.4 Conclusion	5.23
References	5.24

Chapter 6: Insight into the creatinine-copper interaction through electrochemical, UV-vis spectrometric and impedimetric study and feasibility of molecularly imprinted creatinine sensor design 6.1–6.31

<i>Highlights</i>	6.1
6.1 Introduction	6.2
6.2 Experimental	6.4
6.2.1 Chemicals, reagents and instruments	6.4
6.2.2 Electrochemical studies with bare electrode	6.5
6.2.3 Electrode modifications and electrochemical studies	6.5
6.2.3.1 Cu ⁰ /Pt electrode	6.5
6.2.3.2 MIP electrode	6.6
6.2.4 Spectroscopic analysis	6.6
6. 3 Results and Discussion	6.7
6.3.1 Electrochemical response of copper sulphate solution and the influence of the potential sweep direction	6.7
6.3.2 PEIS analysis of the copper sulphate solution	6.11
6.3.3 Electrochemical study of creatinine-copper interaction in the aqueous medium	6.12
6.3.4 Spectroscopic analysis of creatinine-copper interaction	6.14
6.3.5 Chronoamperometry response to fabricate the Cu ⁰ /Pt electrode	6.16
6.3.6 Electrochemical (DPV) analysis with Cu ⁰ /Pt electrode and the effect of consecutive DPV runs	6.16
6.3.7 Chronopotentiometry response for fabrication of TIP/Pt	6.19
6.3.8 Spectroscopic analysis of creatinine-pyrrole interaction	6.21
6.3.8.1 UV-vis analysis	6.22
6.3.8.2 FTIR analysis	6.22
6.3.9 CIP/Pt formation and validation	6.23
6.4 Conclusion	6.27
References	6.28

Chapter 7: Conclusions and Future Scope 7.1–7.6

7.1 Overall conclusions	7.1
7.1.1 Chapter 1	7.1
7.1.2 Chapter 2	7.1
7.1.3 Chapter 3	7.1
7.1.4 Chapter 4	7.2
7.1.5 Chapter 5	7.3
7.1.6 Chapter 6	7.3
7.2 Significance	7.4
7.3 Drawbacks	7.4
7.4 Future Scopes	7.5
<i>Appendix</i>	Ai–Aii