

TABLE OF CONTENTS

	Page No.
Abstract (3 pages)	i-iii
Preface (1 page)	v
List of Tables (1 page)	xiii
List of Schemes (4 pages)	xv-xviii
List of Figures (3 pages)	xix-xxi
List of Appendices (1 page)	xxiii
Appendix A: List of Research Publications (1 page)	xxv
Appendix B: Oral and Poster Presentations (1 page)	xxvii
Abbreviation (3 pages)	xxix-xxxi

CHAPTER I

Section A

	Carbonaceous Nanomaterials	1-17
I.A.1 Carbonaceous nanomaterials		3
I.A.2 The wonder material graphene: A breakthrough invention in nanoscience		5
I.A.2.1 Functionalization of graphenes		6
I.A.2.2 Covalent functionalization of graphene		7
I.A.2.3 Graphene oxide		10
I.A.2.4 Milestones in the synthesis of graphene oxide		11
I.A.2.4a Chlorate methods		11
I.A.2.4b Permanganate methods		12
I.A.2.4c Other methods		12
I.A.2.5 Structure of graphene oxide		13
I.A.2.6 Reduced graphene oxide (rGO)		16
I.A.2.7 Other graphene derivatives		17
I.A.2.8 Non-covalent functionalization of graphene		17
I.A.3 References		17

CHAPTER I

Section B

Graphene Oxide (GO) Promoted Direct C–H Sulfenylation of Aromatic Compounds 19-49

I.B.1	Introduction	21
I.B.2	Background and objectives	24
I.B.3	Present work: Results and discussions	28
	I.B.3.1 Optimization of reaction conditions	29
	I.B.3.2 Synthesis of 3-sulfenylindoles	30
	I.B.3.3 Sulfenylation of 2-naphthol, resorcinol and 2-naphthylamine	32
	I.B.3.4 Recyclability of graphene oxide	34
	I.B.3.5 Plausible mechanism for the sulfenylation of indoles	36
I.B.4	Conclusion	37
I.B.5	Experimental Section	37
	I.B.5.1 General Information	37
	I.B.5.2 Preparation of graphene oxide (GO)	38
	I.B.5.3 General procedure for the sulfenylation of aromatic compounds	38
	I.B.5.4 Characterization data of compounds listed in Table I.B.2-I.B.5	39
	I.B.5.5 Scanned copies of ^1H , ^{13}C NMR and HRMS spectra of 3-(pentylthio)-1 <i>H</i> -indole (3f)	48
I.B.6	References	49

CHAPTER I

Section C

Amine Functionalized Graphene Oxide Nanosheets (AFGONs): An Efficient Bifunctional Catalyst for the Synthesis of 1,4-Dihydropyridines 51-90

I.C.1	Introduction	53
I.C.2	Background and objectives	55
I.C.3	Present work: Results and discussions	59
	I.C.3.1 Preparation of the catalyst	60
	I.C.3.2 Characterization of AFGONs	61

I.C.3.3	Catalytic activity of AFGONs: Optimization of reaction conditions	63
I.C.3.4	Synthesis of 1,4-dihydropyridine derivatives	64
I.C.3.5	Synthesis of 1,8-dioxodecahydroacridine derivatives	67
I.C.3.6	Synthesis of polyhydroquinoline derivatives	68
I.C.3.7	Gram scale synthesis of 1,4-dihydropyridine (4a)	70
I.C.3.8	Recyclability of AFGONs	70
I.C.3.9	Control experiments	72
I.C.3.10	Plausible mechanism for the synthesis of 1,4-dihydropyridine	73
I.C.3.11	Comparison of AFGONs with previously reported catalytic systems	74
I.C.4	Conclusion	75
I.C.5	Experimental Section	75
I.C.5.1	General Information	75
I.C.5.2	Preparation of graphene oxide (GO)	76
I.C.5.3	Preparation of AFGONs	76
I.C.5.4	General procedure for the synthesis of 1,4-dihydropyridines (4a-q) using AFGONs	76
I.C.5.5	General procedure for the synthesis of 1,8-dioxodecahydroacridines (5a-j) using AFGONs	77
I.C.5.6	General procedure for the synthesis of polyhydroquinolines (6a-g) using AFGONs	77
I.C.5.7	Characterization data of compounds listed in Table I.C.2-I.C.4	77
I.C.5.8	Scanned copies of ^1H , ^{13}C NMR and HRMS spectra of a representative compound (6c)	89
I.C.6	References	90

CHAPTER I

Section D

Graphene Oxide (GO) Catalyzed Synthesis of Thioethers under Continuous Flow Mode	91-114	
I.D.1	Introduction	93
I.D.2	Background and objectives	98
I.D.3	Present work: Results and discussions	101
I.D.3.1	Optimization of reaction conditions	102
I.D.3.2	Synthesis of thioethers through flow reaction	104
I.D.3.3	Recyclability of the GO flow reaction bed	107

I.D.3.4	Control experiments	108
I.D.3.5	Plausible mechanism for the flow synthesis of thioethers	109
I.D.4	Conclusion	109
I.D.5	Experimental Section	110
I.D.5.1	General Information	110
I.D.5.2	Preparation of graphene oxide (GO)	110
I.D.5.3	Typical procedure for the synthesis of thioethers using flow reaction technique	110
I.D.5.4	Characterization data for various thioethers (3a-3l)	111
I.D.5.5	Scanned copies of ^1H and ^{13}C NMR spectra of (4-chlorophenyl)(4-methoxyphenyl)sulfane (3c)	114
I.D.6	References	114

CHAPTER II

Section A

Graphene-based Composites in Heterogeneous Catalysis	115-122	
II.A.1	Graphene-based nanocomposites	117
II.A.1.1	Graphene-zeolite composites	117
II.A.1.2	Graphene-silica composites	118
II.A.1.3	Graphene-metal composites	118
II.A.1.4	Graphene-metal oxide composites	121
II.A.2	Conclusion	122
II.A.3	References	122

CHAPTER II

Section B

Ni Decorated Reduced Graphene Oxide Zeolite Nanocomposite Catalyzed Synthesis of 1,2,3-Triazoles	123-154	
II.B.1	Introduction	125
II.B.2	Background and objectives	128
II.B.3	Present work: Results and discussions	134
II.B.3.1	Preparation of Ni-rGO-zeolite nanocomposite	135
II.B.3.2	Characterization of Ni-rGO-zeolite nanocomposite	135

II.B.3.3	Catalytic activity of Ni–rGO–zeolite: Optimization of reaction conditions	140
II.B.3.4	Synthesis of 1,4-disubstituted-1,2,3-triazoles	142
II.B.3.5	Recyclability of the catalyst	144
II.B.3.6	Plausible mechanism for the reaction	146
II.B.4	Conclusion	147
II.B.5	Experimental Section	147
II.B.5.1	General Information	147
II.B.5.2	Preparation of graphene oxide (GO)	148
II.B.5.3	Preparation of GO–zeolite nanocomposite	148
II.B.5.4	Preparation of Ni–rGO–zeolite nanocomposite	148
II.B.5.5	Preparation of Ni–zeolite catalyst	149
II.B.5.6	Preparation of Ni–rGO catalyst	149
II.B.5.7	Typical procedure for the synthesis of 1,2,3-triazoles	149
II.B.5.8	Characterization data of various 1,2,3-triazole derivatives	150
II.B.5.9	Scanned copies of ^1H and ^{13}C NMR spectra of 1-benzyl-4-phenyl-1 <i>H</i> -1,2,3-triazole (3a)	154
II.B.6	References	154

CHAPTER II

Section C

Cu@GO–SiO₂ Nanocomposite Catalyzed Diverse Cross-Coupling Reactions	155-182	
II.C.1	Introduction	157
II.C.2	Background and objectives	158
II.C.3	Present work: Results and discussions	160
II.C.3.1	Preparation of Cu@GO–SiO ₂ nanocomposite	160
II.C.3.2	Characterization of Cu@GO–SiO ₂ nanocomposite	160
II.C.3.3	Catalytic activity of Cu@GO–SiO ₂ nanocomposite	164
II.C.3.3a	Cu@GO–SiO ₂ nanocomposite catalyzed C–S cross-coupling	164
II.C.3.3b	Cu@GO–SiO ₂ nanocomposite catalyzed C–C cross-coupling reaction	167

II.C.3.3c	Cu@GO–SiO ₂ nanocomposite catalyzed cross-coupling reaction	169
II.C.3.3d	Cu@GO–SiO ₂ nanocomposite catalyzed C–N cross-coupling reaction	170
II.C.3.4	Recyclability of Cu@GO–SiO ₂ nanocomposite	172
II.C.4	Conclusion	173
II.C.5	Experimental section	173
II.C.5.1	General Information	173
II.C.5.2	Preparation of graphene oxide (GO)	174
II.C.5.3	Preparation of GO–SiO ₂ hybrid nanocomposite	174
II.C.5.4	Preparation of Cu@GO–SiO ₂ composite	174
II.C.5.5	Typical procedure for the cross-coupling reactions	175
II.C.5.6	Characterization data of various products listed in Table II.C.2, II.C.4, II.C.6 and II.C.8	175
II.C.5.7	Scanned copies of ¹ H and ¹³ C NMR spectra of 1-nitro-3-(<i>p</i> -tolyloxy)benzene (7c)	182
II.C.6	References	182

Bibliography

183-206

References for Chapter I, Section A	183
References for Chapter I, Section B	186
References for Chapter I, Section C	190
References for Chapter I, Section D	193
References for Chapter II, Section A	196
References for Chapter II, Section B	200
References for Chapter II, Section C	204

Index

207-208