

Contents

Preface	xv
Part 1: Fundamental Methodologies	1
1 Layered Double Hydroxides and the Environment: An Overview	3
<i>Amita Jaiswal, Ravindra Kumar Gautam and Mahesh Chandra Chattopadhyaya</i>	
1.1 Introduction	4
1.2 Structure of Layered Double Hydroxides	4
1.3 Properties of Layered Double Hydroxides	6
1.4 Synthesis of Layered Double Hydroxides	7
1.4.1 Co-precipitation Method	7
1.4.2 Hydrothermal Synthesis	8
1.4.3 Urea Hydrolysis Method	9
1.4.4 Sol-Gel Method	9
1.4.5 Ion-Exchange Method	9
1.4.6 Rehydration Method	10
1.4.7 Miscellaneous Methods	10
1.5 Characterization of Layered Double Hydroxides	11
1.5.1 X-ray Diffraction	11
1.5.2 Fourier Transform Infrared Spectroscopy	11
1.5.3 Thermogravimetric Analysis and Differential Thermal Analysis	12
1.5.4 Other Techniques	12
1.6 Applications of Layered Double Hydroxides	13
1.6.1 Catalytic Applications	14
1.6.2 Agricultural Applications	15
1.6.3 Pharmaceutical Applications	15
1.6.4 Industrial Applications	16

1.6.5	Environmental Applications	16
1.7	Conclusions	19
	Acknowledgements	19
	References	20
2	Improvement of the Corrosion Resistance of Aluminium Alloys	
	Applying Different Types of Silanes	27
	<i>Anca-Iulia Stoica, Norica Carmen Godja, Andje Stanković, Matthias Pözlner, Erich Kny and Christoph Kleber</i>	
2.1	Introduction	28
2.2	Silanes for Surface Treatment	31
2.2.1	Classification of Silanes	32
2.2.2	Surface Treatment and Silane Chemistry	34
2.2.3	Experimental Procedure	37
2.3	Materials, Methods and Experimentals	40
2.3.1	Materials	40
2.3.2	Preparation of Silane Solutions	41
2.3.3	Silane Treatment	41
2.4	Surface Analytics	42
2.5	Results and Discussion	43
2.5.1	Contact Angle	43
2.5.2	Characterization with SEM/EDX – FIB	46
2.5.3	Electrochemical Impedance Spectroscopy (EIS) Tests	50
2.5.4	Salt Spray Test	53
2.5.5	FTIR Spectroscopy	55
2.6	Conclusions	56
	Acknowledgements	57
	References	57
3	New Generation Material for the Removal of Arsenic from Water	61
	<i>Dinesh Kumar and Vaishali Tomar</i>	
3.1	Introduction	62
3.1.1	Properties of Arsenic [3–6]	62
3.1.2	World Health Organization Guidelines	63
3.1.3	Toxicity	63
3.1.4	Technologies	64
3.1.5	Adsorption Process	65
3.1.6	New Generation Materials	76

3.2	Arsenic Desorption/Sorbent Regeneration	76
3.2.1	Cost Evaluation	77
3.3	Conclusions	78
	Acknowledgement	79
	References	79
4	Prediction and Optimization of Heavy Clay Products Quality	87
	<i>Milica Arsenović, Lato Pezo, Lidija Mančić and Zagorka Radojević</i>	
4.1	Introduction	87
4.2	Materials and Methods	89
4.2.1	Raw Materials and Samples	89
4.2.2	Chemical and Technological Features	89
4.2.3	Second Order Polynomial Model and Analysis of Variance	90
4.2.4	Artificial Neural Network Modeling	91
4.2.5	Fuzzy Synthetic Optimization	93
4.3	Results and Discussions	94
4.3.1	Correlation Analysis	94
4.3.2	Analysis of Variance and SOP Models	97
4.3.3	Neurons in the ANN Hidden Layer	102
4.3.4	Simulation of the ANNs	103
4.3.5	Sensitivity Analysis	110
4.3.6	Fuzzy Synthetic Optimization	113
4.4	Conclusions	117
	Acknowledgement	118
	References	118
5	Enhancement of Physical and Mechanical Properties of Sugar Palm Fiber via Vacuum Resin Impregnation	121
	<i>M.R. Ishak, Z. Leman, S.M. Sapuan, M.Z.A. Rahman and U.M.K. Anwar</i>	
5.1	Introduction	122
5.2	Experimental	123
5.2.1	Materials	123
5.2.2	Methods	124
5.3	Results and Discussion	125
5.3.1	Physical Properties of Impregnated Fiber	125
5.3.2	Tensile Properties of Impregnated Fibre	132

5.4	Conclusions	138
	Acknowledgments	139
	References	139
6	Environmentally-Friendly Acrylates-Based Polymer Latices	145
	<i>Sweta Shukla and J.S.P. Rai</i>	
6.1	Introduction	146
6.1.1	Alkyds	146
6.1.2	Urethanes	147
6.1.3	Epoxies	147
6.1.4	Acrylics	148
6.2	Polymerization Techniques	154
6.2.1	Component of Emulsion Polymerization	155
6.2.2	Applications of Acrylic Polymers	168
	References	170
Part 2:	Inventive Nanotechnology	177
7	Nanoparticles for Trace Analysis of Toxins: Present and Future Scenario	179
	<i>Anupreet Kaur and Shivender Singh Saini</i>	
7.1	Introduction	179
7.2	Nanoremediation Using TiO ₂ Nanoparticles	180
7.3	Gold Nanoparticles for Nanoremediation	183
7.4	Zero-Valent Iron Nanoparticles	184
7.5	Silicon Oxide Nanoparticles for Nanoremediation	187
7.6	Other Materials for Nanoremediation	190
7.7	Conclusion	193
	References	193
8	Recent Developments in Gold Nanomaterial Catalysts for Oxidation Reaction through Green and Sustainable Routes	197
	<i>Biswajit Chowdhury, Chiranjit Santra, Sandip Mandal and Rawesh Kumar</i>	
8.1	Introduction	198
8.1.1	Quantum Size Effects	200
8.1.2	Charge Transfer between Gold and Metal Oxide Support	201
8.1.3	Formation of Reactive Gold–Metal Oxide Perimeter Interfaces	202

8.2	Propylene Epoxidation Reaction	202
8.3	Reaction Mechanism	211
8.4	Glucose Oxidation	214
8.5	Alcohol Oxidation	225
	8.5.1 Mechanism for Alcohol Oxidation Reaction	233
8.6	Conclusion	234
	References	234
9	Nanosized Metal Oxide-Based Adsorbents for Heavy Metal Removal: A Review	243
	<i>Deepak Pathania and Pardeep Singh</i>	
9.1	Introduction	244
9.2	Nanosized Metal Oxide	246
	9.2.1 Nano Ferric Oxides (NFeOs)	246
	9.2.2 Nano Manganese Oxides (NMnOs)	249
	9.2.3 Nano Titanium Oxides (NTOs)	250
	9.2.4 Nano Zinc Oxides (NZnOs)	251
	9.2.5 Nano Aluminum Oxides	252
9.3	Hybrid Adsorbents	253
	9.3.1 Bentonite-Based Hybrid Nano-Metal Oxide Nanocomposites (B-NMOs)	253
	9.3.2 Polymer-Supported Nano-Metal Oxide Nanocomposites (P-NMOs)	256
	9.3.3 Zeolites-Supported Nano Metal Oxide Nanocomposites (P-NMOs)	256
	9.3.4 Metal Oxides-Based Nanocomposites	257
9.4	Conclusion	258
	References	258
10	Future Prospects of Phytosynthesized Transition Metal Nanoparticles as Novel Functional Agents for Textiles	265
	<i>Shahid-ul-Islam, Mohammad Shahid and Faqeer Mohammad</i>	
10.1	Introduction	266
10.2	Synthesis of Transition Metal Nanoparticle Using Various Plant Parts	266
	10.2.1 Silver – Most Versatile Transition Metal Nanoparticle Synthesized by Using Plants	267
	10.2.2 Synthesis of Gold Nanoparticles	276
	10.2.3 Gold/Silver Bimetallic Nanoparticles	277
	10.2.4 Palladium Nanoparticles	278
	10.2.5 Synthesis of Other Transition Metal Nanoparticles	279

10.3	Proposed Mechanisms	279
10.4	Transition Metal Nanoparticles as Novel Antimicrobial Agents for Textile Modifications	282
10.5	Concluding Remarks and Future Aspects	284
	References	285
11	Functionalized Magnetic Nanoparticles for Heavy Metal Removal from Aqueous Solutions: Kinetics and Equilibrium Modeling	291
	<i>Ravindra Kumar Gautam, Amita Jaiswal and Mahesh Chandra Chattopadhyaya</i>	
11.1	Introduction	291
11.2	Sources of Heavy Metals in the Environment	292
11.3	Toxicity to Human Health and Ecosystems	299
11.4	Magnetic Nanoparticles	303
	11.4.1 Properties of Magnetic Nanoparticles	303
11.5	Synthesis of Magnetic Nanoparticles	304
	11.5.1 Co-precipitation	305
	11.5.2 Hydrothermal Synthesis	307
	11.5.4 Thermal Decomposition	309
11.6	Magnetic Nanoparticles in Wastewater Treatment	310
	11.6.1 Magnetic Nanoparticles as Nanosorbents for Heavy Metals	310
11.7	Modeling of Adsorption: Kinetic and Isotherm Models	316
	11.7.1 Kinetic Studies in Adsorption of Heavy Metals	316
	11.7.2 Equilibrium Modeling of Adsorption	319
11.8	Thermodynamic Analysis	322
11.9	Metal Recovery and Regeneration of Magnetic Nanoparticles	323
11.10	Conclusions	324
	Acknowledgements	325
	References	325
12	Potential Application of Nanoparticles as Antipathogens	333
	<i>Pratima Chauhan, Mini Mishra and Deepika Gupta</i>	
12.1	Introduction	333
	12.1.1 Types of Pathogens	334
	12.1.2 Virulence	335
	12.1.3 Transmission	335
12.2	Applications of Nanoparticles	336

12.2.1	Nanoparticles in Drug Delivery	336
12.2.2	Role of Nanoparticles and Their Potential Application in Food Packaging	337
12.2.3	Nanoparticles Used in Agriculture	337
12.2.4	Nanotechnology for the Health Sector	338
12.2.5	Nanoparticles Applicable in the Area of Textile Fibers	339
12.2.6	Nanoparticles Used in Water Treatment	340
12.3	Nanoparticles in Biology	340
12.4	Uses and Advantages of Nanoparticles in Medicine	341
12.5	Antibacterial Properties of Nanomaterials	342
12.5.1	Gold Nanoparticles	343
12.5.2	Magnesium Oxide Nanoparticles	343
12.5.3	Copper Oxide Nanoparticles	343
12.5.4	Titanium Dioxide Nanoparticles	344
12.5.5	Zinc Oxide Nanoparticles	344
12.6	Antiviral properties of Nanoparticles	345
12.6.1	Silver	345
12.6.2	Selenium Nanoclusters	345
12.6.3	Metal Oxides	346
12.6.4	N-phenyl- and N-benzoylthiourea Derivatives	346
12.6.5	FeO ₄ /C ₁₂ Nanostructures and 2-((4-ethylphenoxy)methyl)-N-(substituted-phenyl carbamothioyl)-benzamides	347
12.6.6	Graphene Nanosheets	347
12.6.7	Photoactivated Carbon Nanotube–Porphyrin Conjugates	348
12.7	Antifungal Activity	348
12.7.1	Silver	348
12.8	Mechanism of Action of Nanoparticle inside the Body	349
12.9	Detecting the Antipathogenicity of Nanoparticles on Microorganisms in Vitro	350
12.10	Types of Nanoparticles	351
12.11	Synthesis of Nanoparticles by Conventional Methods	351
12.11.1	Top-down approach	351
12.11.2	Bottom-up approach	352
12.12	Biological Synthesis of Nanoparticles	353
12.12.1	Extraction of Nanoparticles	355
12.13	Characterizations of Nanoparticles	355
12.14	Biocompatibility of Nanoparticles	356

12.15	Toxic Effects of Nanoparticles	356
12.15.1	Respiratory System	357
12.15.2	Translocation of nanoparticle to the Blood Stream and Central Nervous System	358
12.15.3	Gastrointestinal Tract and Skin	358
12.16	Conclusion	359
	References	360
13	Gas Barrier Properties of Biopolymer-based Nanocomposites: Application in Food Packaging	369
	<i>Sarat Kumar Swain</i>	
13.1	Introduction	370
13.2	Experimental	372
13.3	Objective	372
13.4	Background of Food Packaging	373
13.4.1	Oxygen Penetration	373
13.4.2	Antimicrobial Systems	374
13.4.3	Detection of Gases Produced by Food Spoilage	375
13.4.4	Different Fillers for Nanocomposites	376
13.5	Conclusion	382
	References	382
14	Application of Zero-valent Iron Nanoparticles for Environmental Clean Up	385
	<i>Ritu Singh and Virendra Misra</i>	
14.1	Introduction	386
14.2	Zero-Valent Iron Nanoparticles: A Versatile Tool for Environmental Clean Up	388
14.2.1	Iron Chemistry	388
14.2.2	Synthesis	389
14.2.3	Structure	390
14.2.4	Environmental Application	390
14.3	Reduction Mechanisms and Pathways	406
14.4	Pilot- and Field-Scale Studies	408
14.5	Transport of nFe ⁰ in Environment	410
14.6	Integrated Approach	411
14.7	Challenges Ahead	412
14.7.1	Toxicity	412
14.7.2	Fate and Behavior in Environment	413
14.8	Concluding Remarks	413
	References	414

15 Typical Synthesis and Environmental Application of Novel TiO₂ Nanoparticles	421
<i>Tanmay Kumar Ghorai</i>	
15.1 Introduction	421
15.2 Use of Different Dyes	424
15.2.1 Methyl Orange Degradation (MO)	424
15.2.2 Rhodamine B (RB)	425
15.2.3 Thymol Blue (TB)	425
15.2.4 Bromocresol Green (BG)	426
15.3 Synthetic Methods for Novel Titania Photocatalysts	427
15.3.1 Photocatalytic Reactor	429
15.3.2 Sol-Gel Method	430
15.4 Novel Chemical Synthesis Routes	438
15.4.1 Fe(III)-Doped TiO ₂ Nanophotocatalyst	439
15.4.2 Metal Molybdate Incorporated Titanium Dioxide Photocatalyst	441
15.4.3 Metal Molybdate Doped Bismuth Titanate (NMBT) Nanocomposites	441
References	445
16 Zinc Oxide Nanowire Films: Solution Growth, Defect States and Electrical Conductivity	453
<i>Ajay Kushwaha and M. Aslam</i>	
16.1 Introduction	453
16.2 Solution Growth of ZnO Nanowire Films	456
16.2.1 Low Temperature Hydrothermal Growth	457
16.2.2 Alternative Solution Growth Methods	463
16.3 Defects and Photoluminescence Properties of ZnO	465
16.3.1 Defects in ZnO	465
16.3.2 Photoluminescence of ZnO Nanowire	467
16.4 Role of Defect States in Electrical Conductivity of ZnO	469
16.4.1 Defect States Responsible for N-Type Conductivity	469
16.4.2 Defect States Responsible for P-Type Conductivity	471
16.5 Defects and Electrical Conductivity of ZnO Nanowire Films	471
16.5.1 Electrical Conductivity of Nanowire Film in Dark	474
16.5.2 Defect-Induced Photoconductivity in Nanowire Films	476

16.5.3	Surface Modification and Optoelectrical Properties of ZnO Nanowires	477
16.6	ZnO Nanowires for Energy Conversion Devices	478
16.6.1	Photovoltaic Applications	479
16.6.2	Water Splitting/Solar Hydrogen Generation	480
16.6.3	Piezoelectric Nanogenerators	481
	References	483
	Index	493