

Contents

About the author	xiii
Preface	xv
Acknowledgments	xvii
1. Introduction of photocatalysis and photocatalysts	1
<i>Mohammad Mansoob Khan</i>	
1.1 Introduction	1
1.1.1 Historical developments of photocatalysis	2
1.2 Photocatalysis	3
1.2.1 Photocatalysts	7
1.3 Importance of photocatalysis and photocatalysts	8
1.3.1 Photocatalysis	8
1.3.2 Photocatalysts	8
1.4 Future perspective	9
1.5 Summary	9
References	10
2. Fundamentals and principles of photocatalysis	15
<i>Mohammad Mansoob Khan</i>	
2.1 Introduction	15
2.2 Fundamentals of photocatalysis	15
2.2.1 Types of catalysis	17
2.2.2 Principles of photocatalysis	19
2.2.3 Mechanisms of the photocatalytic process	20
2.3 Effect of photocatalyst type, size, surface area, morphology, dose, light intensity, time, temperature, etc. on photocatalysis	22
2.3.1 Effect of the type of photocatalysts on photocatalysis	22
2.3.2 Effect of size and surface area of the photocatalyst on photocatalysis	23
2.3.3 Effect of the morphology of the photocatalyst on photocatalysis	24
2.3.4 Effect of the photocatalyst dose on photocatalysis	24
2.3.5 Effect of light intensity on photocatalysis	25
2.3.6 Effect of light irradiation time on photocatalysis	26
2.3.7 Effect of temperature on photocatalysis	26

2.3.8	Effect of pollutant's concentration and type on photocatalysis	27
2.4	Characteristics of good photocatalysts	29
2.5	Summary	29
	References	30
3.	Semiconductors as photocatalysts: UV light active materials	33
	<i>Mohammad Mansoob Khan</i>	
3.1	Introduction	33
3.2	Fundamentals of semiconductors	34
3.3	Semiconductors as photocatalysts	34
3.3.1	Intrinsic and extrinsic semiconductors	35
3.3.2	Band gap energy	41
3.3.3	Band edge positions	41
3.3.4	Ultraviolet light active semiconductors	42
3.3.5	Chalcogenides	45
3.3.6	Ternary semiconductors	46
3.4	Photocatalysis under ultraviolet light irradiation	46
3.5	Summary	48
	References	48
4.	Semiconductors as photocatalysts: visible-light active materials	53
	<i>Mohammad Mansoob Khan</i>	
4.1	Introduction	53
4.2	Visible-light active semiconductors	54
4.3	Metal-loaded or decorated semiconductors	55
4.4	Metal-doped semiconductors	57
4.5	Non-metal-doped semiconductors	60
4.6	Dye-sensitized semiconductors	61
4.6.1	Disadvantage of dye-sensitized semiconductors and dye-sensitized solar cell	63
4.7	Coupled semiconductors	64
4.8	Defective semiconductors	66
4.9	Chalcogenides	67
4.10	Ternary compounds	68
4.11	Quaternary compounds	69
4.12	Characteristics of visible-light active photocatalysts	70
4.13	Photocatalysis under visible-light irradiation	71
4.14	Parameters affecting the photocatalytic process	72
4.15	Summary	73
	References	73

5. Synthesis methods for photocatalytic materials	77
<i>Mohammad Mansoob Khan</i>	
5.1 Introduction	77
5.2 Sol–gel method	78
5.2.1 Advantages of the sol–gel method	81
5.3 Hydrothermal method	82
5.3.1 Advantages of the hydrothermal synthesis method	84
5.3.2 Disadvantages of the hydrothermal synthesis method	85
5.4 Solvothermal method	85
5.4.1 Advantages of the solvothermal synthesis method	87
5.4.2 Disadvantages of the solvothermal synthesis method	87
5.5 Sonochemical method	87
5.6 Microwave method	91
5.7 Chemical vapor deposition	96
5.8 Physical vapor deposition	101
5.8.1 Advantages of PVD coatings	103
5.8.2 Disadvantages of PVD coatings	104
5.9 Electrochemical deposition method	104
5.10 Green synthesis	107
5.10.1 Types of green synthesis	109
5.11 Summary	111
References	111
6. Common characterization techniques for photocatalytic materials	115
<i>Mohammad Mansoob Khan</i>	
6.1 Introduction	115
6.2 Spectroscopic characterization techniques	116
6.2.1 Absorption spectroscopy	117
6.2.2 Absorption spectroscopy for optical properties	118
6.2.3 Vibrational spectroscopy (Fourier transform infrared spectroscopy and Raman spectroscopy)	123
6.3 Emission spectroscopy for optical properties	129
6.4 Physiochemical characterization techniques	131
6.4.1 Structure and phase determination	131
6.4.2 Surface area and porosity measurements	134
6.4.3 Dynamic light scattering	136
6.4.4 Surface topography using atomic force microscopy	138
6.4.5 Scanning electron microscopy	139
6.4.6 Transmission electron microscopy	141
6.4.7 X-ray photoelectron spectroscopy for elemental composition	143
6.5 Electrochemical characterization technique	145
6.5.1 Thermodynamic properties using electrochemical techniques	145

6.5.2	Kinetic properties using electrochemical techniques	148
6.5.3	Photocatalytic efficiency using electrochemical techniques	150
6.6	Conclusion	152
	References	152
7.	Applications of photocatalytic materials	155
	<i>Mohammad Mansoob Khan</i>	
7.1	Introduction	155
7.2	Energy production using photocatalysis	157
7.3	Photocatalytic degradation of organic pollutants	161
7.4	Removal of inorganic pollutants from wastewater	162
7.4.1	Removal of toxic and heavy metals and metalloids using photocatalysis	162
7.4.2	Removal of cyanides using photocatalysis	165
7.5	Water disinfection and purification	166
7.5.1	Photocatalytic disinfection process	169
7.6	Photocatalytic self-cleaning glasses	169
7.7	Photocatalytic air purification	171
7.8	Photocatalytic decomposition and removal of oil spills	173
7.9	Photocatalytic paints	174
7.9.1	Mechanism behind photocatalytic paints	175
7.9.2	Factors affecting the efficiency of photocatalytic paints	177
7.10	Photocatalytic antibacterial disinfection	178
7.11	Photocatalytic chemical synthesis and/or conversions	180
7.12	Summary	183
	References	183
8.	Photocatalysis: laboratory to market	187
	<i>Mohammad Mansoob Khan</i>	
8.1	Introduction	187
8.2	Photocatalysis from laboratory to real life	189
8.3	Photocatalysis from laboratory to market	192
8.4	Photocatalytic self-cleaning and anti-fogging glass	194
8.5	Photocatalytic paints	196
8.6	Photocatalytic tiles	198
8.7	Photocatalytic air purifiers	200
8.8	Photocatalytic roads	202
8.9	Photocatalytic sterilization	203
8.10	Photocatalytic textiles	204
8.11	Sunscreens and cosmetics	205
8.12	Summary	207
	References	207

9. Future challenges for photocatalytic materials	213
<i>Mohammad Mansoob Khan</i>	
9.1 Introduction	213
9.2 Energy production using photocatalysis	215
9.3 Photocatalysis in environmental aspects	218
9.4 Water purification and disinfection using photocatalysis	222
9.5 Photocatalysis in biomedical aspects	224
9.6 Air purification using photocatalysis	227
9.7 Photocatalysis in the food-processing industry	230
9.8 Summary	232
References	233
Index	237