

Contents

	Page
Contents	vii
List of Tables	viii
List of Figures	ix
1. Introduction	1
1.1 Introduction	1
1.2 Review of Literatures	3
1.3 Objectives	33
2. Methods of Study	34
2.1 Materials	34
2.2 Instruments	34
2.3 Methods	35
2.3.1 Preparation of Immo-TiO ₂ films	35
2.3.2 Characterization of Immo-TiO ₂ films	37
2.3.3 Photocatalytic degradation of methylene blue (MB) by Immo-TiO ₂ films	37
3. Results	39
3.1 Syntheses and characterizations of Immo-TiO ₂ films	39
3.2 Photocatalytic degradation of methylene blue (MB) by Immo-TiO ₂ films	61
4. Discussions	112
4.1 Syntheses and characterizations of Immo-TiO ₂ films	112
4.2 Photocatalytic degradation of methylene blue (MB) by Immo-TiO ₂ films	116
5. Conclusions	134
References	136
Vitae	143

List of Figures

Figure	Page
1 The toxicity of wastewater with aquatic life	2
2 Crystal structures of TiO ₂ ; (a) Anatase, (b) Rutile, and (c) Brookite	4
3 TiO ₂ pigment manufactured by the sulfate process	5
4 TiO ₂ pigment manufactured by the chloride process	6
5 The heterogeneous photocatalytic oxidation processes of titanium dioxide photocatalyst	10
6 The structure of methylene blue	11
7 UV-Vis absorption spectrum of MB aqueous solution (solid line) and The relative emitted light intensity (dotted line) for 8W blacklight bulb	15
8 Photocatalytic degradation pathway of methylene blue	17
9 Flow chart of the preparation of Immo-TiO ₂ films	36
10 The photographs of Immo-TiO ₂ film samples (left: front view; right Back view)	39
11 Left: the photograph of commercial TiO ₂ anatase powder (0.1 g) and right: the SEM image of commercial TiO ₂ anatase powder	40
12 Left: the photograph of commercial TiO ₂ Degussa P25 powder (0.1 g) and right: the SEM image of commercial TiO ₂ Degussa P25 powder	40
13 SEM surface images of Immo-TiO ₂ anatase films	45
14 SEM cross section images of Immo-TiO ₂ anatase films	50
15 SEM surface images of Immo-TiO ₂ Degussa P25 thin films	54
16 SEM cross section images of Immo-TiO ₂ Degussa P25 thin films	58
17 Left: the SEM image of rubber substrate surface; Right: the SEM cross section of rubber substrate	59
18 XRD patterns of both commercial TiO ₂ powders; a) anatase (Carlo Eaba), b) Degussa P25, c) Immo-TiO ₂ anatase film, d) Immo-TiO ₂ Degussa P25 film, and e) rubber substrate	60

List of Figures (Continued)

Figure	Page
19 The photocatalytic degradation of methylene blue aqueous solution by Immo-TiO ₂ film under UV irradiation	61
20 The absorption spectra of methylene blue solution in the range of 2.5 x 10 ⁻⁶ M to 3.0 x 10 ⁻⁵ M	62
21 The standard calibration curve of methylene blue solution in the range of 2.5 x 10 ⁻⁶ M to 3.0 x 10 ⁻⁵ M	62
22 The absorption spectra of methylene blue solution alone under UV irradiation	63
23 The absorption spectra of methylene blue solution with the rubber substrate under UV irradiation	64
24 The UV-Vis spectral change of methylene blue with Immo-TiO ₂ anatase film samples under UV irradiation as a function of times	68
25 The UV-Vis spectral change of methylene blue with Immo-TiO ₂ Degussa P25 film samples under UV irradiation as a function of times	72
26 The UV-Vis spectral change of methylene blue by commercial TiO ₂ anatase powder (Carlo Erba) under UV irradiation as a function of times	73
27 The UV-Vis spectral change of methylene blue by commercial TiO ₂ Degussa P25 powder under UV irradiation as a function of times	73
28 The relative remained C/C ₀ of methylene blue by Immo-TiO ₂ anatase film samples prepared by varying amount of distilled water as a function of irradiation times	74
29 The relative remained C/C ₀ of methylene blue by Immo-TiO ₂ anatase film samples prepared by varying amount of latex as a function of irradiation times	75
30 The relative remained C/C ₀ of methylene blue by Immo-TiO ₂ anatase film samples prepared by varying amount of commercial TiO ₂ as a function of irradiation times	76

List of Figures (Continued)

Figure	Page
31 The relative remained C/C_0 of methylene blue by Immo-TiO ₂ Degussa P25 film samples prepared by varying amount of distilled water as a function of irradiation times	77
32 The relative remained C/C_0 of methylene blue by Immo-TiO ₂ Degussa P25 film samples prepared by varying amount of distilled water as a function of irradiation times	78
33 The relative remained C/C_0 of methylene blue by Immo-TiO ₂ Degussa P25 film samples prepared by varying amount of distilled water as a function of irradiation times	79
34 The relative remained C/C_0 of methylene blue by commercial TiO ₂ anatase powder (Carlo Erba) as a function of irradiation times	80
35 The relative remained C/C_0 of methylene blue by commercial TiO ₂ Degussa P25 powder as a function of irradiation times	81
36 The UV-Vis spectral change of methylene blue by Immo-TiO ₂ anatase film under various UV light intensity	86
37 The UV-Vis spectral change of methylene blue by Immo-TiO ₂ Degussa P25 film under various UV light intensity	87
38 The relative remained C/C_0 of methylene blue by Immo-TiO ₂ Anatase film under various UV light intensity as a function of irradiation times	88
39 The relative remained C/C_0 of methylene blue by Immo-TiO ₂ Degussa P25 film under various UV light intensity as a function of irradiation times	89
40 The UV-Vis spectral change of methylene blue by Immo-TiO ₂ Anatase film under various initial concentration of MB as a function of irradiation times	91

List of Figures (Continued)

Figure	Page
52 The photographs of Immo-TiO ₂ anatase film a) before second use b) after second use on the photocatalytic degradation of MB	107
53 The photographs of Immo-TiO ₂ anatase film a) before cleaning b) after cleaning	107
54 The UV-Vis spectral change of methylene blue by Immo-TiO ₂ anatase film in the repeated uses four times (with self-cleaning after use)	109
55 The relative remained C/C ₀ of methylene blue by Immo-TiO ₂ anatase film in the repeated uses four times (with self-cleaning after use)	110
56 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ anatase film samples prepared with varying amount of distilled water (including adsorption)	118
57 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ anatase film samples prepared with varying amount of latex (including adsorption)	119
58 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ anatase film samples prepared with varying amount of commercial TiO ₂ anatase (including adsorption)	120
59 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ Degussa P25 film samples prepared with varying amount of distilled water (including adsorption)	121
60 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ Degussa P25 film samples prepared with varying amount of latex (including adsorption)	122
61 The efficiencies of photocatalytic degradation of MB as a function of times of Immo-TiO ₂ Degussa P25 film samples prepared with varying amount of commercial TiO ₂ Degussa P25 (including adsorption)	123

List of Figures (Continued)

Figure		Page
62	The efficiencies of photocatalytic degradation of MB under irradiation times by Degussa P25, Anatase (Carlo Erba), Immo-TiO ₂ anatase film, and Immo-TiO ₂ Degussa P25 film (including adsorption)	124
63	The effect of UV light intensity on the photocatalytic efficiencies of Immo-TiO ₂ anatase film (including adsorption)	126
64	The effect of UV light intensity on the photocatalytic efficiencies of Immo-TiO ₂ Degussa P25 film (including adsorption)	127
65	The effect of initial concentration of MB on the photocatalytic efficiencies of Immo-TiO ₂ anatase film (including adsorption)	128
66	The effect of initial concentration of MB on the photocatalytic efficiencies of Immo-TiO ₂ Degussa P25 film (including adsorption)	129
67	The effect of pH of MB on the photocatalytic efficiencies of Immo-TiO ₂ anatase film (including adsorption)	130
68	The effect of pH of MB on the photocatalytic efficiencies of Immo-TiO ₂ Degussa P25 film (including adsorption)	131
69	The photocatalytic efficiencies of Immo-TiO ₂ anatase film from the four repeating uses (including adsorption)	132
70	The photocatalytic efficiencies of Immo-TiO ₂ anatase film on the repeated uses with self-cleaning (including adsorption)	133

List of Tables

Table	Page
1 Structure and UV-Vis absorption characteristics of methylene blue and its common reduced and oxidized forms	13
2 Photophysical properties of methylene blue	14
3 The percentage degradation of methylene blue (MB) by Immo-TiO ₂ anatase film samples as a function of irradiation times (including adsorption)	82
4 The percentage degradation of methylene blue (MB) by Immo-TiO ₂ Degussa P25 film samples as a function of irradiation times (including adsorption)	83
5 The percentage degradation of methylene blue (MB) by Immo-TiO ₂ anatase film under various UV light intensity, initial concentration of MB, and pH as a function of irradiation times (including adsorption)	101
6 The percentage degradation of methylene blue (MB) by Immo-TiO ₂ Degussa P25 film under various UV light intensity, initial concentration of MB, and pH as a function of irradiation times (including adsorption)	102
7 The percentage degradation of methylene blue (MB) by Immo-TiO ₂ anatase film under continuous use and cleaning before use as a function of irradiation times (including adsorption)	111