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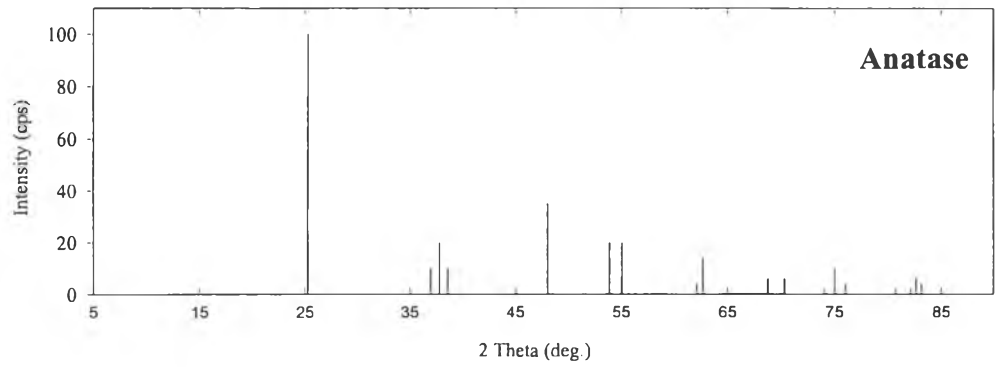
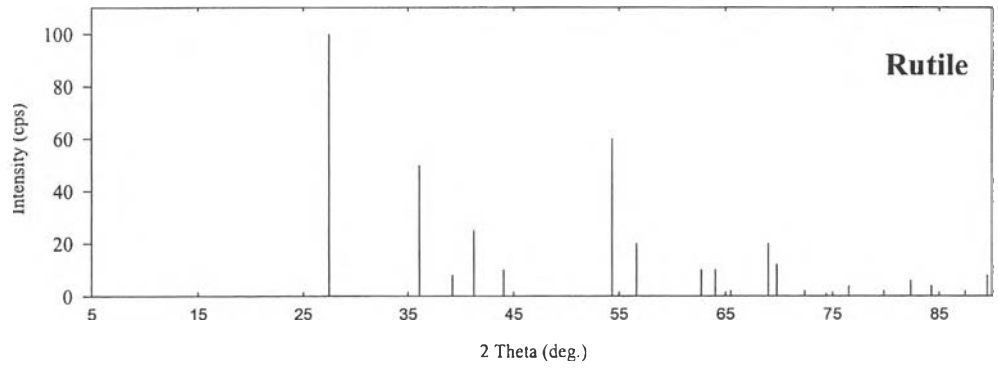
APPENDICES

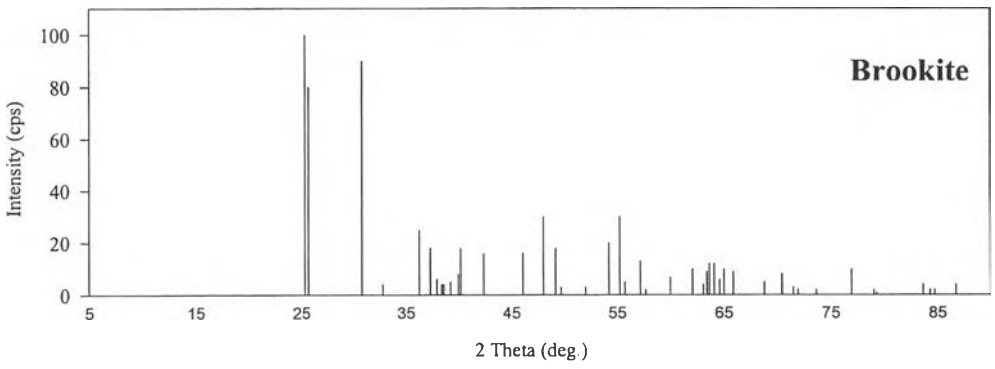
Appendix A

Standard TiO_2 XRD Patterns and Calculation of Crystalite Size of TiO_2 Catalysts

A.1 XRD patterns of TiO_2 reference







A.2 Calculated crystallite size

X-ray diffraction patterns were used for the crystallite size (d) estimation. The crystallite sizes of the catalysts can be determined from the broadening of the anatase main peak by Debye-Scherrer equation:

$$d = k\lambda / b\cos\theta \qquad (3.1)$$

where

λ = the wave length (nm)

k = the Debye-Scherrer constant (assume equal to 1.0)

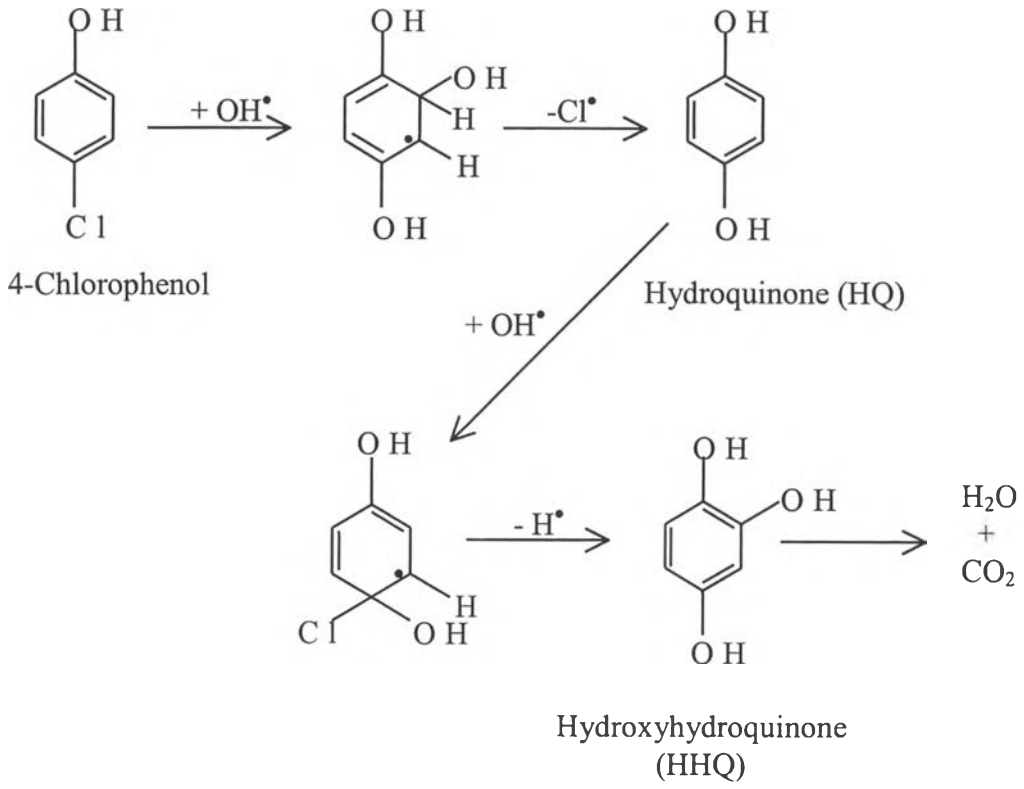
b = the full width at half maximum (FWHM) of the broadened peak

θ = the Bragg angle of the reflection (deg.)

d = the crystallite size (nm)

Catalyst	FWHM (deg.)	b	2θ (deg.)	cosθ	d (nm)
TiO_2 (Degussa P25)	0.329	0.0057	24.98	0.9971	26.90
TiO_2 (sol-gel)	0.259	0.0045	25.12	0.1000	34.07
0.05% Au/TiO_2	1.035	0.0181	25.30	0.9965	8.56
0.1% Au/TiO_2	0.847	0.0148	25.02	0.9984	10.43
1% Au/TiO_2	0.988	0.0172	25.00	0.9978	8.95
1.5% Au/TiO_2	0.447	0.0078	25.04	0.9989	19.76
0.05% Ag/TiO_2	1.153	0.0201	25.00	0.9978	7.67
0.1% Ag/TiO_2	1.012	0.0177	24.96	0.9963	8.75
1% Ag/TiO_2	1.153	0.0201	25.08	0.9997	7.66
1.5% Ag/TiO_2	0.988	0.0172	25.08	0.9997	8.93
0.1% Au-0.1%Ag/TiO_2	1.129	0.0197	25.18	0.9997	7.82
Immobilized TiO_2	0.306	0.0053	25.26	0.9980	28.89

A.3 Reaction pathway for the photocatalytic degradation of 4-CP



Appendix B

Experimental Data from Photocatalytic Degradation of 4-CP

B.1 Photocatalytic degradation of 4-CP without catalyst

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5873	0.0000	0.0000	1.00	1.00
30	0.2278	0.1491	0.1163	0.39	0.92
60	0.1093	0.1969	0.1576	0.19	0.90
90	0.0561	0.2046	0.1843	0.10	0.88
120	0.0277	0.2183	0.2014	0.05	0.89
150	0.0000	0.2224	0.1948	0.00	0.88
180	0.0000	0.2075	0.1908	0.00	0.88
210	0.0000	0.1836	0.1850	0.00	0.87
240	0.0000	0.1594	0.1811	0.00	0.87
270	0.0000	0.1401	0.1743	0.00	0.86
300	0.0000	0.1193	0.1651	0.00	0.86
330	0.0000	0.1126	0.1631	0.00	0.86
360	0.0000	0.1057	0.1608	0.00	0.86

B.2 Photocatalytic degradation of 4-CP with TiO_2 (Degussa P25)

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.6084	0.0000	0.0000	1.00	1.00
30	0.2623	0.0612	0.0230	0.43	0.90
60	0.1353	0.0641	0.0627	0.22	0.78
90	0.0715	0.0579	0.0600	0.12	0.64
120	0.0295	0.0345	0.0753	0.05	0.53
150	0.0271	0.0299	0.0420	0.04	0.41
180	0.0000	0.0163	0.0355	0.00	0.30
210	0.0000	0.0000	0.0215	0.00	0.21
240	0.0000	0.0000	0.0118	0.00	0.14
270	0.0000	0.0000	0.0026	0.00	0.07
300	0.0000	0.0000	0.0000	0.00	0.06
330	0.0000	0.0000	0.0000	0.00	0.04
360	0.0000	0.0000	0.0000	0.00	0.03

B.3 Photocatalytic degradation of 4-CP with TiO_2 (sol-gel)

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.4678	0.0000	0.0000	1.00	1.00
30	0.1380	0.1259	0.0995	0.29	0.89
60	0.0517	0.1782	0.1437	0.11	0.86
90	0.0000	0.1773	0.1605	0.00	0.84
120	0.0000	0.1860	0.1639	0.00	0.82
150	0.0000	0.1484	0.1639	0.00	0.80
180	0.0000	0.1260	0.1597	0.00	0.77
210	0.0000	0.1062	0.1544	0.00	0.74
240	0.0000	0.0873	0.1480	0.00	0.71
270	0.0000	0.0684	0.1420	0.00	0.72
300	0.0000	0.0568	0.1309	0.00	0.66
330	0.0000	0.0457	0.1178	0.00	0.66
360	0.0000	0.0311	0.1006	0.00	0.62

B.4 Photocatalytic degradation of 4-CP with 0.05% Au/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5866	0.0000	0.0000	1.00	1.00
30	0.1820	0.1216	0.1759	0.31	0.90
60	0.0736	0.1707	0.2383	0.13	0.86
90	0.0000	0.1786	0.2807	0.00	0.86
120	0.0000	0.1820	0.3042	0.00	0.81
150	0.0000	0.1729	0.2996	0.00	0.81
180	0.0000	0.1512	0.2726	0.00	0.77
210	0.0000	0.1310	0.2789	0.00	0.79
240	0.0000	0.1163	0.2658	0.00	0.74
270	0.0000	0.0975	0.2591	0.00	0.72
300	0.0000	0.0809	0.2413	0.00	0.72
330	0.0000	0.0648	0.2263	0.00	0.69
360	0.0000	0.0514	0.2089	0.00	0.66

B.5 Photocatalytic degradation of 4-CP with 0.1% Au/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.4973	0.0000	0.0000	1.00	1.00
30	0.1745	0.0755	0.1277	0.35	0.88
60	0.0000	0.1546	0.2102	0.00	0.79
90	0.0000	0.1980	0.2485	0.00	0.78
120	0.0000	0.1871	0.2614	0.00	0.75
150	0.0000	0.1301	0.2618	0.00	0.75
180	0.0000	0.1326	0.2707	0.00	0.71
210	0.0000	0.1091	0.2681	0.00	0.70
240	0.0000	0.0837	0.2751	0.00	0.66
270	0.0000	0.0705	0.2622	0.00	0.67
300	0.0000	0.0429	0.2273	0.00	0.66
330	0.0000	0.0331	0.2196	0.00	0.64
360	0.0000	0.0039	0.1911	0.00	0.61

B.6 Photocatalytic degradation of 4-CP with 1% Au/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5974	0.0000	0.0000	1.00	1.00
30	0.1071	0.1501	0.1526	0.18	0.93
60	0.0603	0.2228	0.1742	0.10	0.86
90	0.0293	0.2402	0.1984	0.05	0.86
120	0.0000	0.2319	0.1875	0.00	0.83
150	0.0000	0.2123	0.1842	0.00	0.83
180	0.0000	0.1821	0.1788	0.00	0.82
210	0.0000	0.1494	0.1716	0.00	0.82
240	0.0000	0.1261	0.1654	0.00	0.80
270	0.0000	0.0883	0.1548	0.00	0.79
300	0.0000	0.0711	0.1477	0.00	0.77
330	0.0000	0.0554	0.1347	0.00	0.76
360	0.0000	0.0417	0.1219	0.00	0.74

B.7 Photocatalytic degradation of 4-CP with 1.5% Au/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5298	0.0000	0.0000	1.00	1.00
30	0.2636	0.1304	0.0656	0.50	0.95
60	0.1029	0.1961	0.1247	0.19	0.93
90	0.0512	0.2152	0.1529	0.10	0.92
120	0.0280	0.2379	0.1568	0.05	0.92
150	0.0000	0.1918	0.1591	0.00	0.89
180	0.0000	0.1689	0.1573	0.00	0.89
210	0.0000	0.1298	0.1538	0.00	0.88
240	0.0000	0.1137	0.1469	0.00	0.87
270	0.0000	0.0942	0.1418	0.00	0.84
300	0.0000	0.0799	0.1343	0.00	0.83
330	0.0000	0.0669	0.1227	0.00	0.82
360	0.0000	0.0530	0.1082	0.00	0.81

B.8 Photocatalytic degradation of 4-CP with 0.05% Ag/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5899	0.0000	0.0000	1.00	1.00
30	0.1620	0.1548	0.2148	0.27	0.86
60	0.0996	0.2011	0.2693	0.17	0.83
90	0.0000	0.2189	0.2993	0.00	0.79
120	0.0000	0.2172	0.3179	0.00	0.83
150	0.0000	0.2071	0.3267	0.00	0.79
180	0.0000	0.1745	0.3102	0.00	0.74
210	0.0000	0.1525	0.3020	0.00	0.71
240	0.0000	0.1318	0.2943	0.00	0.68
270	0.0000	0.1164	0.2780	0.00	0.66
300	0.0000	0.0993	0.2638	0.00	0.65
330	0.0000	0.0856	0.2540	0.00	0.65
360	0.0000	0.0722	0.2378	0.00	0.62

B.9 Photocatalytic degradation of 4-CP with 0.1% Ag/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5428	0.0000	0.0000	1.00	1.00
30	0.0840	0.1374	0.1574	0.15	0.90
60	0.0000	0.1802	0.2239	0.00	0.79
90	0.0000	0.1982	0.2493	0.00	0.77
120	0.0000	0.1932	0.2348	0.00	0.75
150	0.0000	0.1804	0.2663	0.00	0.74
180	0.0000	0.1410	0.2646	0.00	0.67
210	0.0000	0.1176	0.2807	0.00	0.61
240	0.0000	0.0952	0.2877	0.00	0.64
270	0.0000	0.0700	0.2526	0.00	0.51
300	0.0000	0.0567	0.2482	0.00	0.53
330	0.0000	0.0430	0.2231	0.00	0.49
360	0.0000	0.0257	0.1998	0.00	0.48

B.10 Photocatalytic degradation of 4-CP with 1% Ag/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5939	0.0000	0.0000	1.00	1.00
30	0.1151	0.0990	0.1575	0.19	0.91
60	0.0857	0.1287	0.2184	0.14	0.89
90	0.0000	0.1355	0.2709	0.00	0.84
120	0.0000	0.1264	0.2687	0.00	0.84
150	0.0000	0.1837	0.2956	0.00	0.80
180	0.0000	0.1691	0.2831	0.00	0.81
210	0.0000	0.1464	0.2909	0.00	0.77
240	0.0000	0.1196	0.2683	0.00	0.75
270	0.0000	0.1027	0.2773	0.00	0.70
300	0.0000	0.0831	0.2623	0.00	0.70
330	0.0000	0.0618	0.2479	0.00	0.68
360	0.0000	0.0412	0.2254	0.00	0.65

B.11 Photocatalytic degradation of 4-CP with 1.5% Ag/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.4927	0.0000	0.0000	1.00	1.00
30	0.1971	0.0876	0.2142	0.40	0.89
60	0.0898	0.1611	0.2895	0.18	0.85
90	0.0000	0.2054	0.3266	0.00	0.85
120	0.0000	0.2200	0.3184	0.00	0.82
150	0.0000	0.2139	0.3245	0.00	0.80
180	0.0000	0.2005	0.3139	0.00	0.79
210	0.0000	0.1825	0.3072	0.00	0.78
240	0.0000	0.1476	0.2873	0.00	0.75
270	0.0000	0.1063	0.2822	0.00	0.74
300	0.0000	0.0877	0.2668	0.00	0.71
330	0.0000	0.0732	0.2627	0.00	0.70
360	0.0000	0.0597	0.2354	0.00	0.66

B.12 Photocatalytic degradation of 4-CP with 0.1% Au-0.1% Ag/TiO_2

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.5013	0.0000	0.0000	1.00	1.00
30	0.2213	0.1007	0.1722	0.44	0.88
60	0.1303	0.1622	0.2484	0.26	0.79
90	0.0000	0.1790	0.2466	0.00	0.73
120	0.0000	0.1788	0.2545	0.00	0.72
150	0.0000	0.1811	0.2713	0.00	0.70
180	0.0000	0.1662	0.2558	0.00	0.66
210	0.0000	0.1511	0.2593	0.00	0.66
240	0.0000	0.1353	0.2481	0.00	0.65
270	0.0000	0.1144	0.2386	0.00	0.61
300	0.0000	0.0914	0.2281	0.00	0.60
330	0.0000	0.0785	0.2159	0.00	0.56
360	0.0000	0.0615	0.1971	0.00	0.48

B.13 Photocatalytic degradation of 4-CP with TiO_2 (sol-gel) immobilized

Time (min)	Concentration (mM)			Remaining fraction	
	4-CP	HQ	HHQ	4-CP	TOC
0	0.4052	0.0000	0.0000	1.00	1.00
60	0.1207	0.1570	0.0785	0.30	0.90
120	0.0401	0.1992	0.1262	0.10	0.76
180	0.0198	0.1725	0.1323	0.05	0.73
240	0.0198	0.1270	0.1253	0.05	0.68
300	0.0198	0.1292	0.1240	0.05	0.67
360	0.0198	0.1166	0.1100	0.05	0.66

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