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APPENDICES

APPENDIX A

CALCULATION OF THE CRYSTALLITE SIZE

Calculation of the crystalline size by Debye-Scherrer equation

The crystalline size can be calculated from the width at half-height of the diffraction peak of XRD pattern using the Debye-Scherrer equation

From Scherrer equation

$$D = \frac{k\lambda}{\beta\cos\theta} \tag{A. 1}$$

where D = Crystallite size, Å

K = Crystalline-shape factor = 0.9

λ = X-ray wavelength, 1.5418 Å for CuKα

θ = Observed peak angle, degree

β = X-ray diffraction broadening, radian

The X-ray diffraction broadening (β) is the pure width of the powder diffraction, free of all broadening due to the experimental equipment. Standard α-alumina is used to observe the instrumental broadening since its crystallite size is larger than 2000Å. The X-ray diffraction broadening (β) can be obtained by using Warren's formula.

From Warren's formular:

$$\beta^2 = B_M^2 - B_S^2 \tag{A. 2}$$

$$\beta = \sqrt{B_M^2 - B_S^2}$$

Where B_M = Measured peak width in radians at half peak height

B_S = Corresponding width of a standard material

Example: calculation of the crystallite size of TiO_2

The half-height width of (101) diffraction peak = 1.0659°

= 0.018594 radian

The corresponding half-height width of peak of TiO_2 = 0.003836 radian

The pure width = $\sqrt{B_M^2 - B_S^2}$

= $\sqrt{0.018584^2 - 0.003836^2}$

= 0.0182 radian

β = 0.0182 radian

2θ = 25.55°

θ = 12.775°

λ = 1.5418 Å

The crystalline size = $\dfrac{0.9 \times 1.5418}{0.0182 \cos 12.775}$ = 78.18 Å = 7.82 nm

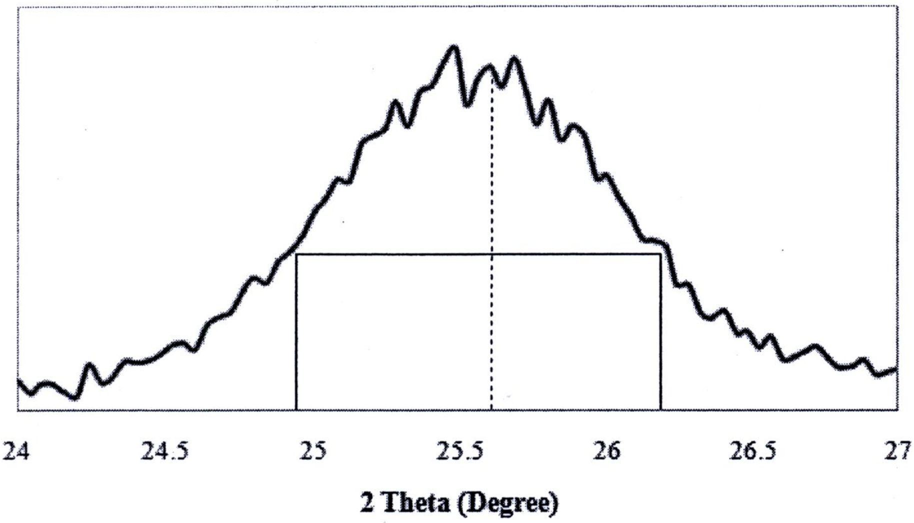

Figure A.1 The (101) diffraction peak of TiO_2 for calculation of the crystallite size

APPENDIX B

CALCULATION OF WEIGHT FRACTION OF ANATASE, RETILE AND BROOKITE PHASE

The phase content of a sable were determined by XRD which can be calculated from the integrated intensities at 2θ values of 25.32°, 27.44°, and 30.88° corresponded to the anatase, rutile and brookite phase, respectively.

The weight fraction of the phase content can be calculated by (Zhang, Banfield, 2000) as follows:

$$W_A = \frac{k_A A_A}{k_A A_R + A_R + k_B A_B}$$

$$W_A = \frac{A_R}{k_A A_R + A_R + k_B A_B}$$

$$W_B = \frac{k_B A_B}{k_A A_R + A_R + k_B A_B}$$

Where

W_A = weight fraction of anatase

W_R = weight fraction of rutile

W_B = weight fraction of brookite

A_A = the intensity of the anatase peak

A_R = the intensity of the rutile peak

A_B = the intensity of the brookite peak

k_A = the coefficients factor of anatase was 0.886

k_B = the coefficients factor of rutile was 2.721

Example: calculation of the phase contents of TiO_2 calcined 400°C

Where

The integrated intensities of anatase (A_A) = 444.47

The integrated intensities of rutile (A_R) = 122.25

The integrated intensities of brookite (A_B) = 41.83

The weight fraction of the phase content can be calculated by (Zhang, Banfield, 2000) as follows:

$$W_A = \frac{0.886(444.47)}{0.886(444.47)+(122.25)+2.721(41.83)} = 0.62$$

$$W_A = \frac{122.25}{0.886(444.47)+(122.25)+2.721(41.83)} = 0.19$$

$$W_A = \frac{2.721(41.83)}{0.886(444.47)+(122.25)+2.721(41.83)} = 0.18$$

APPENDIX C

DETERMINATION OF THE AMOUNT OF DYE ADSORBED ON TITANIA SURFACE

The amount of dye adsorbed was determined by UV-Visible Absorption Spectroscopy (UV-Vis) where measuring the concentration of dye desorbed on the titania film into a mixed solution of 0.1M NaOH and ethanol (1:1 in volume fraction).

The calibration curve of the concentration of dye with absorbance was illustrated in the following figure.

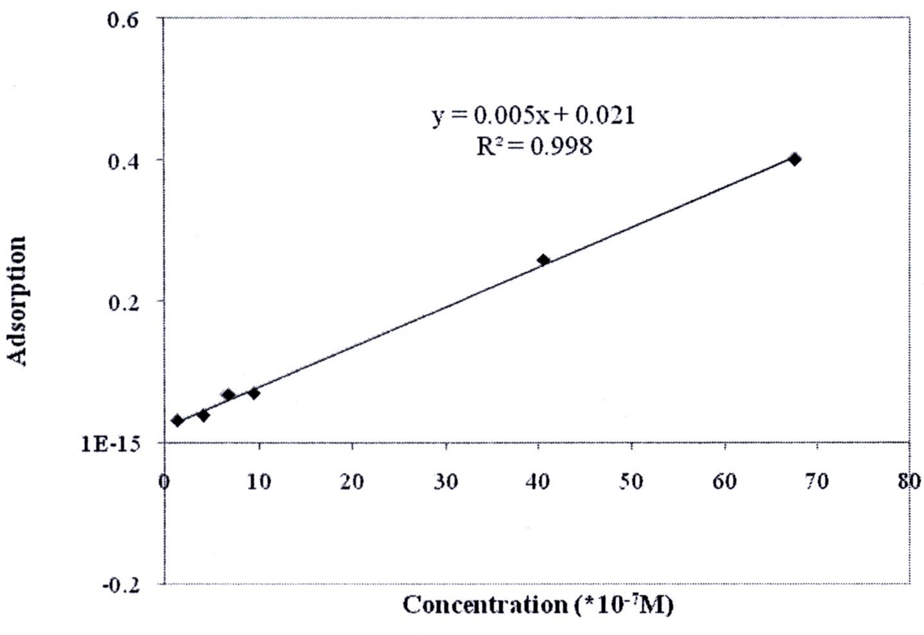

Figure C.1 The calibration curve of the concentration of dye adsorbed

APPENDIX D

CALCULATION OF RESULT OF ICP-OES

Calculation of ICP-OES results

The results from ICP-OES characterization were calculation the contents of metal in catalysts. The example of calculation is as following:

Example: calculation of the contents of 1.0 wt % of Al/Ti in Al_2O_3/TiO_2 powder.

For 1.0 wt % of Al/Ti powder, the initial weight of powder was 0.0126 g.

Hence, the calculation of the alumina contents the catalysts as follows:

The amounts of alumina in the catalyst were;

In 100 g of the Al_2O_3/TiO_2, had a alumina content was 1.0 %

In 0.0126 g of the Al_2O_3/TiO_2, had a alumina content was $\frac{0.0173 \times 1.0}{100}$

$= 0.126$ mg

For digest a samples were diluted to 10 cm^3 of volume

Therefore;

The sample had a concentration were $= \frac{0.126 \times 1000}{10} = 12.6$ ppm

From the result of ICP-OES, shown the contents of alumina was 10.46 ppm

Therefore;

The alumina contents in the catalysts were calculated by

The alumina concentrations were 12.6 ppm refer 1.0 wt % of alumina in catalyst.

The alumina concentrations were 10.46 ppm refer $\frac{10.46 \times 1.0}{12.6}$

$= 0.83$ wt % of alumina in the catalyst

APPENDIX E

THE ELECTROCHEMICAL PROPERTIES OF DYE SENSITIZED SOLAR CELL

The electrochemical properties of dye sensitized solar cell as a file thickness and sintering temperature of TiO_2 electrode by I-V tester. In this study three samples were used, and the efficiency of cell given is the average value follow by the standard derivation.

Table E.1 Electrochemical properties of dye sensitized solar cell of TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.51	5.29	1.27	3.40
2	0.65	7.43	0.70	3.36
3	0.68	7.95	0.69	3.74
Average	0.61±0.1	6.89±1.4	0.89±0.3	3.50±0.2

Table E.2 Electrochemical properties of dye sensitized solar cell of 0.25 wt % of Al_2O_3/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.74	7.39	0.71	3.92
2	0.73	8.03	0.70	4.07
3	0.73	7.82	0.71	4.03
Average	0.73±0.006	7.74±0.3	0.71±0.005	4.01±0.08

Table E.3 Electrochemical properties of dye sensitized solar cell of 1.0 wt % of Al_2O_3/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.82	7.10	0.90	5.28
2	0.75	8.93	0.72	4.83
3	0.83	7.52	0.81	5.02
Average	0.80±0.04	7.85±0.9	0.81±0.1	5.04±0.2

Table E.4 Electrochemical properties of dye sensitized solar cell of 2.0 wt % of Al_2O_3/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 µm

Number of cell	**V_{oc} (Volt)**	**J_{sc} (mA·cm^{-2})**	**Fill Factor**	**Efficiency (%)**
1	0.77	4.11	1.06	3.37
2	0.76	4.80	0.94	3.42
3	0.75	4.67	1.01	3.55
Average	0.76±0.01	4.53±0.4	1.00±0.06	3.45±0.09

Table E.5 Electrochemical properties of dye sensitized solar cell of 0.25 wt % of MgO/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 µm

Number of cell	**V_{oc} (Volt)**	**J_{sc} (mA·cm^{-2})**	**Fill Factor**	**Efficiency (%)**
1	0.78	4.46	0.81	2.81
2	0.77	5.81	0.61	2.72
3	0.77	4.43	0.83	2.86
Average	0.77±0.06	4.90±0.8	0.75±0.1	2.79±0.07

Table E.6 Electrochemical properties of dye sensitized solar cell of 1.0 wt % of MgO/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.71	3.42	0.93	2.25
2	0.76	3.44	0.84	2.19
3	0.74	4.53	0.70	2.38
Average	0.74±0.02	3.79±0.6	0.82±0.1	2.27±0.09

Table E.7 Electrochemical properties of dye sensitized solar cell of 2.0 wt % of MgO/TiO_2 electrode calcined at 400°C for 120 minutes, the thickness of TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.56	1.41	0.47	0.37
2	0.64	1.05	0.58	0.39
3	0.60	1.49	0.51	0.46
Average	0.60±0.04	1.32±0.2	0.52±0.05	0.41±0.05

Table E.8 Electrochemical properties of dye sensitized solar cell of double-layers electrode the thickness of Al_2O_3/TiO_2 film about 10.5 μm

Number of cell	V_{oc} (Volt)	J_{sc} ($mA \cdot cm^{-2}$)	Fill Factor	Efficiency (%)
1	0.74	7.76	0.89	5.10
2	0.73	8.53	0.82	5.12
3	0.73	8.13	0.86	5.10
4	0.74	9.88	0.84	6.08
5	0.73	9.41	0.88	6.04
Average	0.73±0.005	8.74±0.9	0.86±0.03	5.50±0.5

APPENDIX F

THE CRYSTALLITE SIZE AND SURFACE AREA OF 1.0 wt % Al_2O_3/TiO_2 POWDERS AT DIFFERENT CALCINATION TEMPERATURE AND TIME

Table F.1 Crystal size, surface area of 1.0 wt % of Al_2O_3/TiO_2 powders calcined for 30 minutes

Calcined Temperature (°C)	Calcined Time (minute)	Crystallite size (nm)	Surface area (m^2/g)
300	30	4.53	161.69
400	30	5.69	120.16
500	30	7.59	79.88

Table F.2 Crystal size, surface area of 1.0 wt % of Al_2O_3/TiO_2 powders calcined for 60 minutes

Calcined Temperature (°C)	Calcined Time (minute)	Crystallite size (nm)	Surface area (m^2/g)
300	60	5.12	146.72
400	60	5.95	110.30
500	60	7.37	80.85

Table F.3 Crystal size, surface area of 1.0 wt % of Al_2O_3/TiO_2 powders calcined for 120 minutes

Calcined Temperature (°C)	Calcined Time (minute)	Crystallite size (nm)	Surface area (m^2/g)
300	120	5.20	134.40
400	120	7.00	99.20
500	120	8.20	66.90

VITA

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