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APPENDICES

APPENDIX A

CALCULATION OF THE CRYSTALLITE SIZE

CALCULATION OF THE CRYSTALLITE SIZE BY SCHERRER EQUATION

The crystallite size was calculated from the half-height width of the diffraction peak of XRD pattern using the Debye-Scherrer equation.

From Scherrer equation:

$$D = \frac{K\lambda}{\beta \cos \theta} \quad \text{(A.1)}$$

where D = Crystallite size, Å

K = Crystallite-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 a 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 2000 Å. The X-ray diffraction broadening (β) can be obtained by using Warren's formula.

From Warren's formula:

$$\beta^2 = B_M^2 - B_S^2 \quad \text{(A.2)}$$

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

Where B_M = The measured peak width in radians at half peak height.

B_S = The corresponding width of a standard material.

Example: Calculation of the crystallite size of Ni-modified Al_2O_3 (Ni/Al=0.5) prepared by sol-gel method

The half-height width of peak = 0.40^{o} (from Figure A1)

= $(2\pi \times 0.40)/360$

= 0.00692 radian

The corresponding half-height width of peak of α-alumina = 0.0041 radian

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

= $\sqrt{0.00692^2 - 0.0041^2}$

= 0.00553 radian

β = 0.00553 radian

2θ = 37.02^{o}

θ = 18.51^{o}

λ = 1.5418 Å

The crystallite size = $\dfrac{0.9 \times 1.5418}{0.00553 \cos 18.51}$ = 264.56 Å

= 26.5 nm

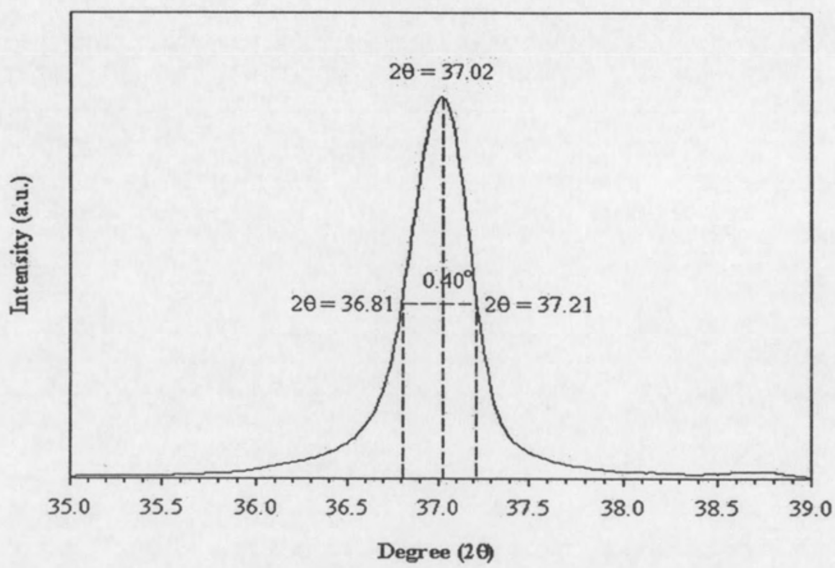
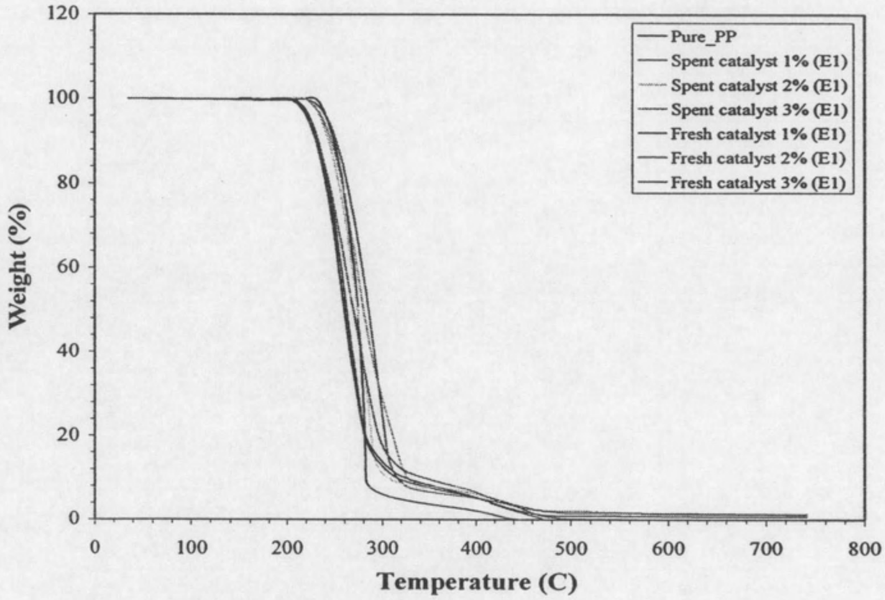


Figure A1 The measured peak of Ni-modified Al_2O_3 (Ni/Al=0.5) prepared by sol-gel method to calculate the crystallite size.

APPENDIX B

TGA ANALYSIS OF POLYPROPYLENE COMPOSITES

(a)



(b)

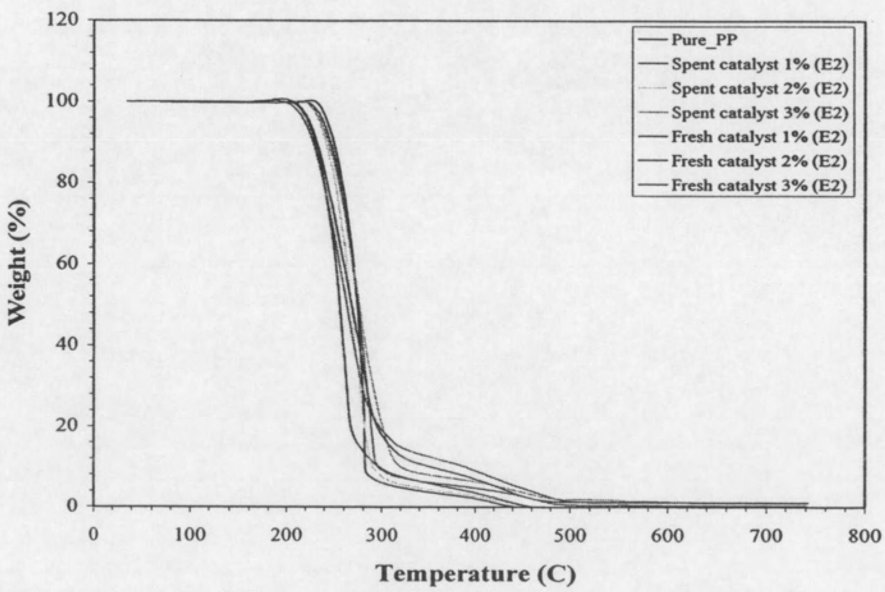


Figure B1 TGA analysis of pure PP, fresh catalyst/PP composite and spent catalyst/PP/PP composite under O_2 atmosphere using various time extrusion: (a) one time of extrusion and (b) two times of extruder.

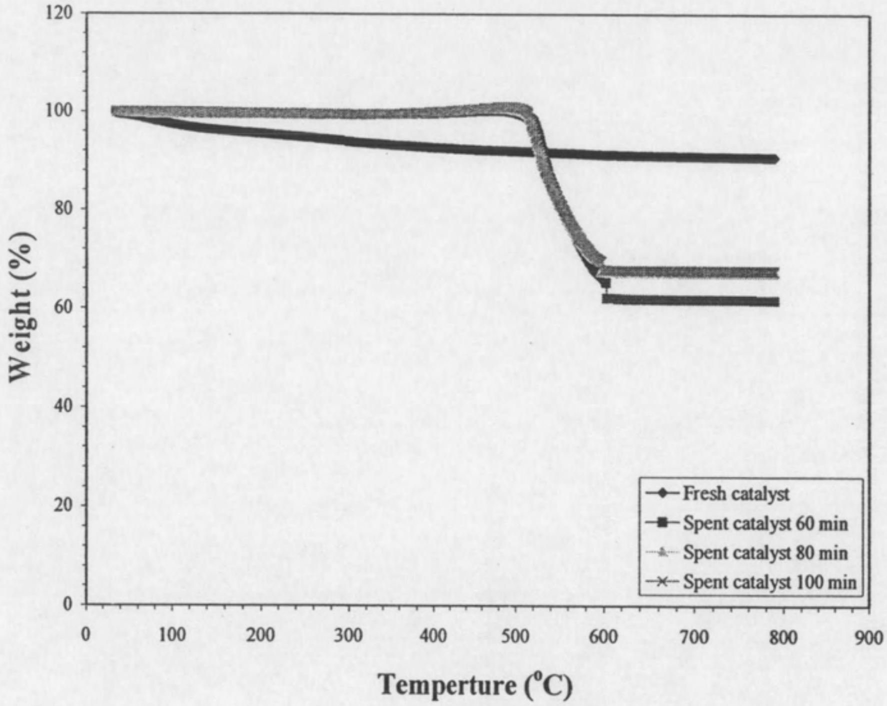


Figure B2 TGA analysis of fresh catalyst and spent catalyst/PP/PP composite at various reaction time.

APPENDIX C

MECHANICAL PROPERTIES

Table C1 Mechanical properties of pure polypropylene

PP Pure	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	27.1	1026.9	5.3	117.5
2	30.2	1283.0	4.8	113.2
3	30.0	1190.7	5.3	105.3
4	27.2	1085.6	4.5	87.3
5	29.6	1214.3	4.9	111.9
Average	28.8	1160.1	5.0	107.0
Standard deviation	1.6	102.8	0.3	11.9

Table C2 Mechanical properties of PP-Spent catalyst 1 wt% at one cycle extrusion

PP-Spent catalyst 1% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	28.7	1202.2	4.4	86.1
2	28.5	1128.9	3.9	78.8
3	27.8	1259.3	4.0	74.1
4	31.0	1210.0	5.3	128.2
5	29.2	1275.7	4.3	86.7
Average	29.0	1215.2	4.4	90.8
Standard deviation	1.2	57.5	0.6	21.6

Table C3 Mechanical properties of PP-Spent catalyst 2 wt% at one cycle extrusion

PP-Spent catalyst 2% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	30.3	1406.4	4.0	83.2
2	30.7	1339.0	3.8	85.7
3	29.8	1330.4	4.0	109.3
4	30.0	1332.1	4.1	96.4
5	29.7	1404.5	3.8	80.7
Average	30.1	1362.5	3.9	91.1
Standard deviation	0.4	39.3	0.1	11.8

Table C4 Mechanical properties of PP-Spent catalyst 3 wt% at one cycle extrusion

PP-Spent catalyst 3% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	27.5	1274.0	3.7	77.9
2	30.4	1427.6	3.8	87.2
3	30.2	1484.0	3.8	92.7
4	28.4	1324.9	3.3	65.8
5	29.7	1417.8	3.6	71.5
Average	29.2	1385.6	3.6	79.0
Standard deviation	1.2	84.6	0.2	11.0

Table C5 Mechanical properties of PP-Fresh catalyst 1 wt% at one cycle extrusion

PP-Fresh catalyst 1% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	30.2	1303.3	4.4	92.0
2	28.6	1163.4	4.4	87.6
3	27.2	1148.7	5.0	110.9
4	29.1	1388.7	4.0	74.5
5	29.8	1430.8	3.8	69.5
Average	29.0	1287.0	4.3	86.9
Standard deviation	1.2	128.1	0.5	16.3

Table C6 Mechanical properties of PP-Fresh catalyst 2 wt% at one cycle extrusion

PP-Fresh catalyst 2% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	28.7	1306.4	4.5	93.4
2	26.9	1383.3	3.8	67.8
3	30.3	1321.0	4.0	85.4
5	29.7	1094.3	4.5	95.8
6	29.5	1337.0	3.5	63.6
Average	29.0	1288.4	4.1	81.2
Standard deviation	1.3	112.3	0.4	14.7

Table C7 Mechanical properties of PP-Fresh catalyst 3 wt% at one cycle extrusion

PP-Fresh catalyst 3% (E1)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	26.2	1130.3	3.3	50.3
2	30.1	1284.8	3.8	75.2
3	24.5	1448.0	2.4	32.6
4	25.6	1161.6	3.3	47.7
5	29.9	1279.3	3.9	72.8
Average	27.3	1260.8	3.3	55.7
Standard deviation	2.6	125.3	0.6	18.0

Table C8 Mechanical properties of PP-Spent catalyst 1 wt% at two cycle extrusion

PP-Spent catalyst 1% (E2)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	28.9	1264.8	4.5	105.2
2	28.8	1247.3	4.8	95.8
3	29.3	1218.5	4.3	92.4
5	31.2	1345.7	4.2	95.2
6	30.5	1215.6	4.7	106.8
Average	29.7	1258.4	4.5	99.1
Standard deviation	1.1	52.9	0.3	6.5

Table C9 Mechanical properties of PP-Spent catalyst 2 wt% at two cycle extrusion

PP-Spent catalyst 2% (E2)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	27.8	1171.6	3.5	72.8
2	29.0	1266.1	3.6	77.2
3	27.3	1257.4	3.4	63.1
4	29.7	1229.5	4.0	86.5
5	29.7	1241.3	4.2	89.6
Average	28.7	1233.2	3.7	77.8
Standard deviation	1.1	37.2	0.3	10.7

Table C10 Mechanical properties of PP-Spent catalyst 3 wt% at two cycle extrusion

PP-Spent catalyst 3% (E2)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	29.2	1189.4	4.2	86.3
2	30.9	1384.9	4.0	87.3
4	30.3	1183.3	4.3	95.0
5	28.7	1123.4	4.2	92.4
6	31.1	1440.2	3.8	91.3
Average	30.0	1264.2	4.1	90.5
Standard deviation	1.0	139.2	0.2	3.6

Table C11 Mechanical properties of PP-Fresh catalyst 1 wt% at two cycle extrusion

PP-Fresh catalyst 1% (E2)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
2	32.7	1384.2	5.1	134.3
3	30.5	1360.8	4.3	95.5
4	30.1	1143.6	4.6	103.0
5	30.9	1326.4	4.8	108.4
6	29.5	1162.5	4.3	91.3
Average	30.7	1275.5	4.6	106.5
Standard deviation	1.2	113.8	0.3	16.9

Table C12 Mechanical properties of PP-Fresh catalyst 2 wt% at two cycle extrusion

PP-Fresh catalyst 2% (E2)	Tensile strength (MPa)	Young's modulus (MPa)	Elongation at break (%)	Areas under tensile stress-strain curves (MPa)
1	29.2	1062.8	4.5	92.1
2	32.0	1415.0	4.3	94.0
3	30.3	1160.4	4.6	102.6
4	28.9	1117.3	4.2	82.4
5	29.6	1261.3	4.2	82.8
Average	30.0	1203.3	4.3	90.8
Standard deviation	1.2	138.9	0.2	8.5

VITA

Miss Kingkan Muangmaithong was born on October 7, 1980 in Petchaburi, Thailand. She received the Bachelor's Degree in Chemical Engineering from Department of Chemical Engineering, Faculty of Engineering, Rangsit University in March 2005, She entered the Master of Engineering in Chemical Engineering at Chulalongkorn University in June, 2005.