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APPENDIX A

Mechanical properties

Table A1 Effect of DCP concentration on impact and tear strength of LLDPE/NR 90/10 and 50/50 at 3 and 7 % wt of MA.

Amount of DCP (% wt)	Impact strength (J/mm)		Tear strength (N/mm)	
	90/10	50/50	90/10	50/50
0	2.18±0.07	3.94±0.14	91.23±3.71	30.04±2.07
0.5	3.61±0.16	3.96±0.86	55.06±0.57	26.37±1.67
1	3.72±0.23	4.33±0.21	27.02±1.15	27.51±0.91
1.5	3.92±0.12	3.62±0.14	19.21±3.71	29.80±2.29

Table A2 Effect of MA concentration on impact and tear strength of LLDPE/NR 90/10 and 50/50 at 0.5 % wt of DCP.

Amount of MA (% wt)	Impact strength (J/mm)		Tear strength (N/mm)	
	90/10	50/50	90/10	50/50
1	3.47±0.16	2.05±0.55	45.71±1.78	24.82±1.99
3	3.61±0.16	2.08±0.02	55.06±0.57	24.75±3.36
5	3.91±0.12	2.67±0.08	63.2±2.94	25.01±0.52
7	3.33±0.11	3.96±0.86	74.71±6.73	26.37±1.67

Table A3 Effect of NR concentration on impact and tear strength of various compositions.

LLDPE/NR/MA/DCP (% wt)	Impact strength (J/mm)	Tear strength (N/mm)
40/60/7/1.5	3.68±0.12	14.48±0.45
50/50/7/1.5	3.62±0.14	28.42±2.29
80/20/3/0.5	3.7±0.18	47.64±2.14
90/10/3/0.5	3.61±0.16	55.06±0.57

Table A4 Displacement from creep test.

Time (h)	Displacement of LLDPE/NR/MA/DCP (mm)			
	90/10/3/0.5	90/10/3/0	50/50/7/1.5	50/50/7/0
0	0.17	0.18	0.54	2.1
0.017	0.19	0.21	0.78	3.58
0.1	0.21	0.26	1.04	7.28
0.2	0.21	0.3	1.12	8.39
0.5	0.21	0.3	1.12	9.74
1	0.27	0.4	1.12	11.03
2	0.27	0.4	1.28	12.57
5	0.31	0.5	1.28	14.39
20	0.31	0.75	1.28	20.68
50	0.31	0.76	1.28	24.84
100	0.32	0.76	1.29	25.74
200	0.32	0.76	1.29	26.06
300	0.32	0.76	1.81	26.06
400	0.32	0.97	2.46	26.06
500	0.32	1.1	2.67	26.95
600	0.32	1.1	2.84	26.95

Table A 5 Crack length (a) and maximum stress (σ_{max}) at each 500 cycles of 90/10/3 LLDPE/NR/MA with and without DCP from fatigue test.

90/10/3/0			90/10/3/0.5		
Cycle	a (mm)	σ_{max} (MPa)	Cycle	a (mm)	σ_{max} (MPa)
500	4.2	9.01	500	4.6	10.53
1000	4.4	8.95	1000	6	9.45
1500	4.7	8.88	1500	7.8	9.07
2000	5	8.85	2000	10	8.67
2500	5.5	8.79	2500	12.5	8.35
3000	6.1	8.69	3000	15.6	8.10
3500	6.9	8.68	3500	21.2	7.75
4000	8.4	8.62	3557	25	
4500	10.9	8.59			
5000	14.4	8.57			
5500	17.5	8.50			
6000	21.2	8.549			
6473	25				

The values of σ_{max} could not be observed when the samples were totally broken (crack length = 25 mm).

Table A 6 Crack growth rate (da/dN) and range of stress intensity factor (ΔK) of composition 90/10/3/0 and 90/10/3/0.5.

90/10/3/0		90/10/3/0.5	
da/dN (mm/cycle)	ΔK (MPa.m$^{1/2}$)	da/dN (mm/cycle)	ΔK (MPa.m$^{1/2}$)
0.0005	1.2022	0.0032	1.4824
0.0006	1.2328	0.004	1.6222
0.0008	1.2673	0.0047	1.7558
0.0011	1.3201	0.0056	1.8905
0.0014	1.3744	0.0087	2.0488
0.0023	1.4601	0.0146	2.2852
0.004	1.5999		
0.006	1.8162		
0.0066	2.0826		
0.0068	2.2771		
0.0077	2.5034		

For single-edge crack specimen

$$K = Q\,\sigma\,a^{1/2} \qquad (A.1)$$

where

$$Q = \left[1.99 - 0.41\left(\frac{a_0}{w}\right) + 18.7\left(\frac{a_0}{w}\right)^2 - 38.48\left(\frac{a_0}{w}\right)^3 + 53.85\left(\frac{a_0}{w}\right)^4\right]$$

σ = stress

a = crack length

a_0 = original crack length

w = width of specimen

The values of da/dN were calculated from slope of graph crack length versus number of cycle at each 500 cycles by using Sigma Plot program.

Example of calculation ΔK

$$\Delta K = K_{max} - K_{min}$$

$$K_{min} = Q\,\sigma_{min}\,a^{1/2}$$

Sine $\sigma_{min} = 0$

$$K_{min} = 0$$

So $\Delta K = K_{max} = Q\,\sigma_{max}\,a^{1/2}$

$$a_0 = 1.5 \text{ mm}$$

$$w = 25 \text{ mm}$$

$$Q = \left[1.99 - 0.41\left(\frac{1.5}{25}\right) + 18.7\left(\frac{1.5}{25}\right)^2 - 38.48\left(\frac{1.5}{25}\right)^3 + 53.85\left(\frac{1.5}{25}\right)^4\right]$$

$$= 2.0251$$

ΔK of composition 90/10/3/0 at 1000 cycles with crack length = 4.4 mm and maximum stress = 8.95 MPa was shown.

$$\Delta K = 2.0251 \text{ x } 8.95 \text{ MPa x } (0.0044 \text{ m})^{1/2}$$

$$= 1.2022 \text{ MPa.m}^{1/2}$$

Table A7 Tensile properties of various compositions before and after weathering.

LLDPE/NR/MA/DCP (% wt)	Tensile strength (MPa)		Elongation at break (%)	
	Before	After	Before	After
90/10/3/0	19.57±1.11	12.1±1.15	1613.6±63.85	701.76±8.94
90/10/3/0.5	15.92±1.30	14.40±0.61	190.30±63.88	113.61±3.63
90/10/3/1.0	13.47±1.43	11.41±0.95	116.57±8.18	51.991±10.93
90/10/3/1.5	14.47±0.75	13.12±1.08	114.9±19.95	63.63±15.87
50/50/7/0	4.9±0.46	3.96±0.37	294.93±77.18	257.01±24.34
50/50/7/0.5	8.52±1.26	4.6±0.27	321.24±47.47	248.76±3.32
50/50/7/1.0	10.82±0.9	4.72±0.37	417.03±26.65	177.36±27.45
50/50/7/1.5	14.42±0.43	6.08±0.88	459.60±8.66	222.04±23.07
90/10/1/0.5	15.34±0.95	12.91±0.26	297.58±39.96	188.36±20.79
90/10/5/0.5	15.61±0.65	14.73±0.64	272.65±28.47	120.94±14.49
90/10/7/0.5	19.52±1.06	13.3±0.27	397.4±20	223.58±10.86
50/50/1/0.5	12.19±1.23	5.15±0.69	346.98±23.26	156.07±10.58
50/50/3/0.5	9.85±0.89	5.65±0.64	401.6±37.74	145.4±30.66
50/50/5/0.5	7.71±0.53	4.97±0.46	313.31±106.14	96.73±39.63
40/60/7/1.5	4.26±0.24	4.07±0.04	559.61±53.91	251.68±6.07
80/20/3/0.5	15.32±0.28	13.05±0.57	287.25±27.24	165.74±5.92

Appendix B

Calculation amount of materials for blending and graphs from Brabender mixer

Calculation amount of materials for blending

$$D_{total} = \frac{M_{total}}{V_{total}} \quad \text{(B.1)}$$

$$M_{total} = M_x + M_y + M_z + \ldots \quad \text{(B.2)}$$

$$V_{total} = \frac{M_x}{D_x} + \frac{M_y}{D_y} + \frac{M_z}{D_z} + \ldots \quad \text{(B.3)}$$

where D = Density of material (g/cm^3)

M = Weight of material (g)

V = Volume of material (cm^3)

Example of calculation

Calculation amounts of LLDPE, NR, MA, and DCP for composition 90/10/3/0.5 were shown.

$D_{LLDPE} = 0.718$ g/cm^3

$D_{NR} = 0.7$ g/cm^3

$D_{MA} = 1.2712$ g/cm^3

Density used in calculation was melt density which eqauled to bulk density minus two.

$$D_{total} = \frac{103}{\frac{90}{0.718} + \frac{10}{0.7} + \frac{3}{1.2712}}$$

$$= 0.725 \text{ g/cm}^3$$

Calculation of total density could ignore density of DCP since DCP was used in small amount for blending.

Filled factor in chamber mixer was 0.8 (80%) and volume of chamber mixer was 55 cm^3 so total weight in the chamber, M_c, was

$$M_c = 55 \times 0.8 \times 0.725$$
$$= 31.9 \text{ g}$$
$$M_{LLDPE} = 90 \times 31.9/103$$
$$= 27.87 \text{ g}$$
$$M_{NR} = 10 \times 31.9/103$$
$$= 3.1 \text{ g}$$
$$M_{MA} = 3 \times 31.9/103$$
$$= 0.93 \text{ g}$$
$$M_{DCP} = 0.5 \times 31.9/103$$
$$= 0.15 \text{ g}$$

Abbreviation list in graphs from Brabender mixer:

A = Loading peak

B = Minimum

G = Inflection point

X = Maximum

E = End

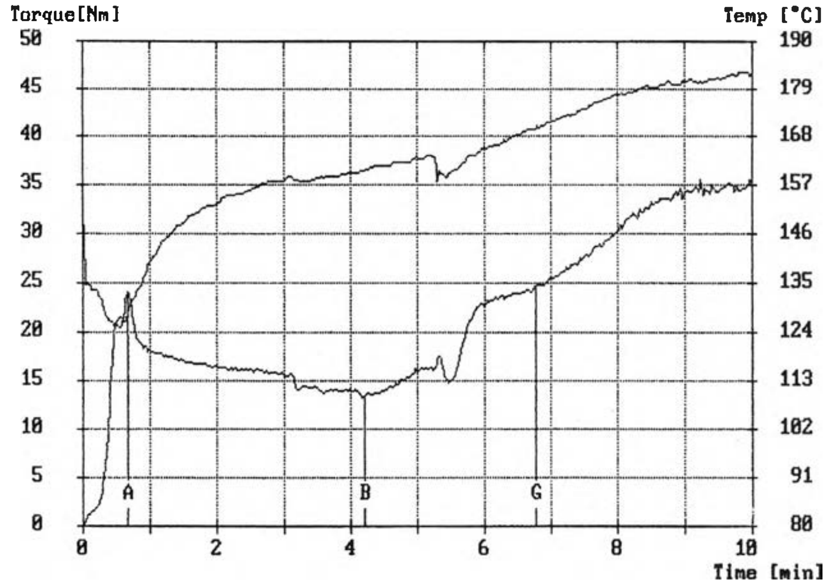

Figure B1 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/3/0.

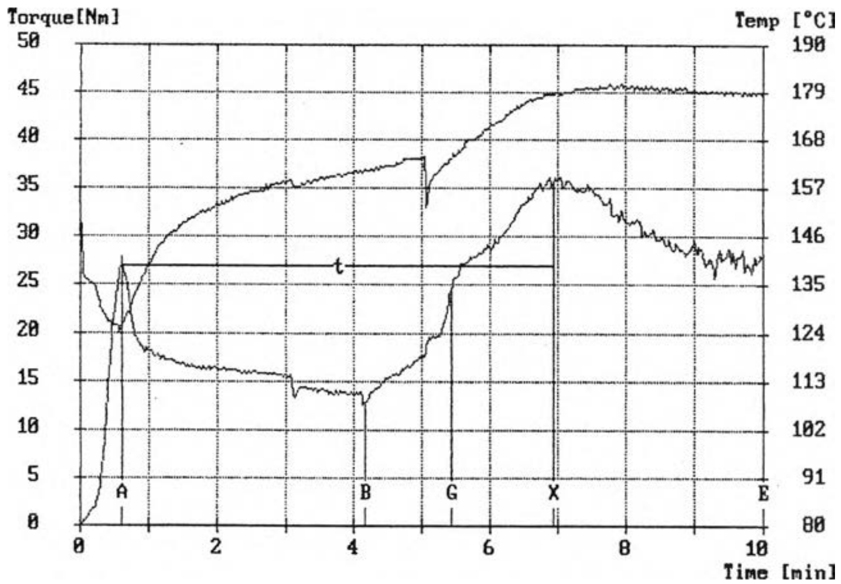

Figure B2 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/3/0.5.

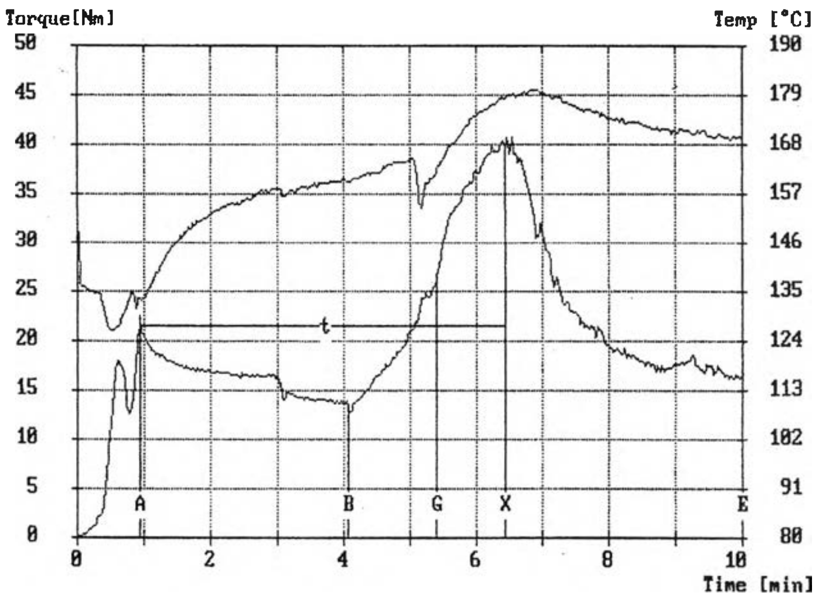

Figure B3 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/3/1.0.

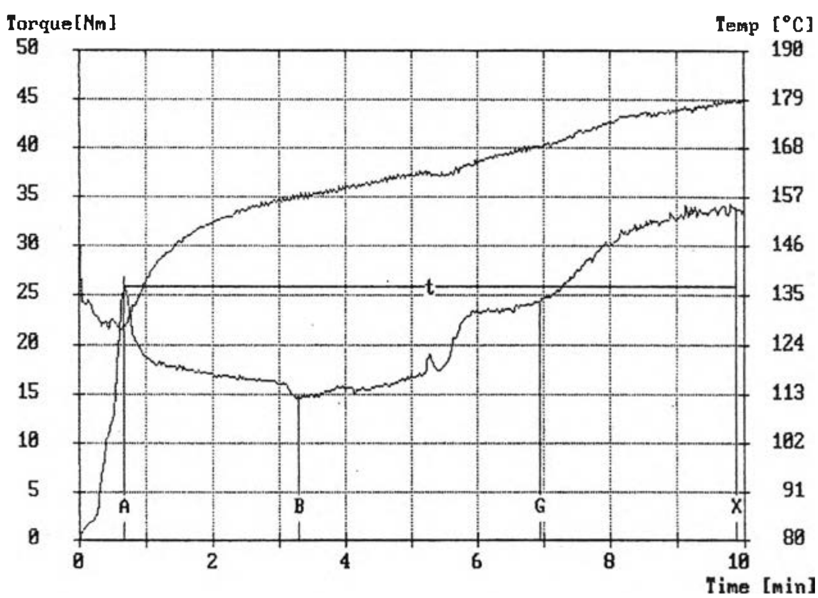

Figure B4 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/3/1.5.

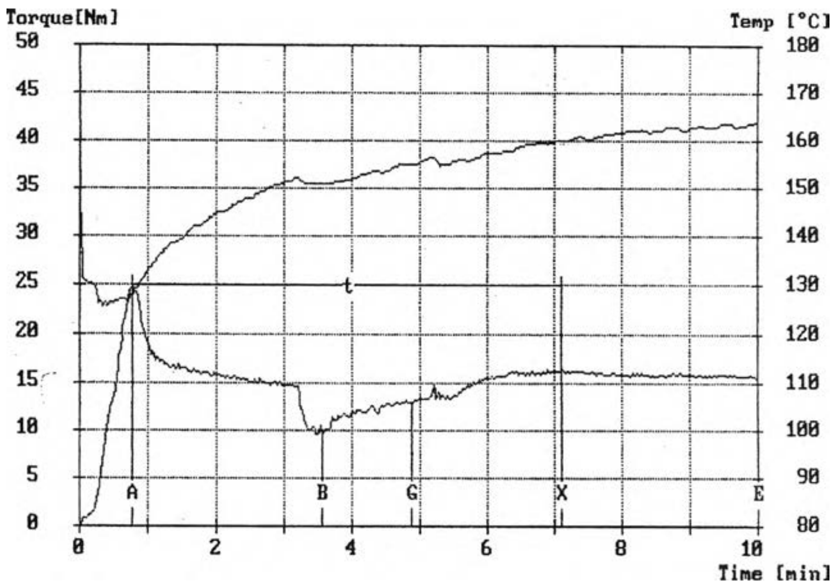

Figure B5 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/1/0.5.

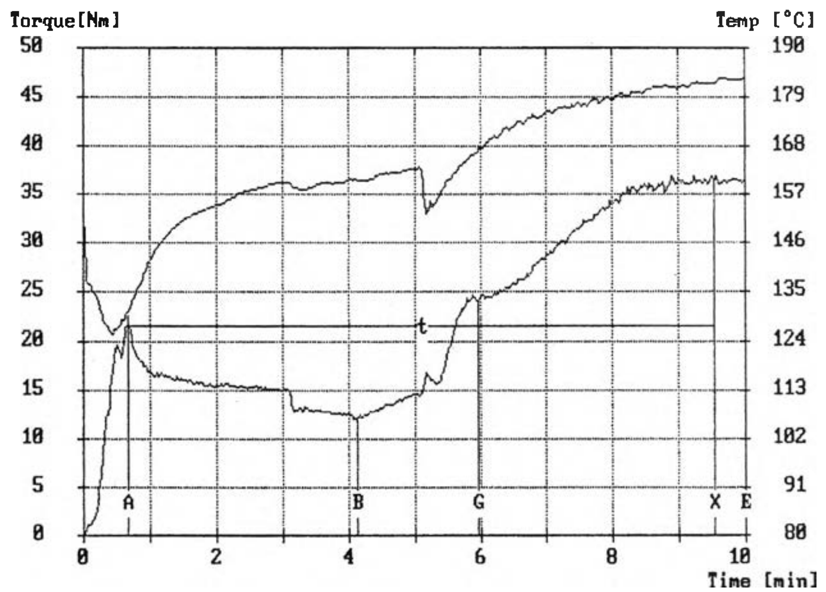

Figure B6 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/5/0.5.

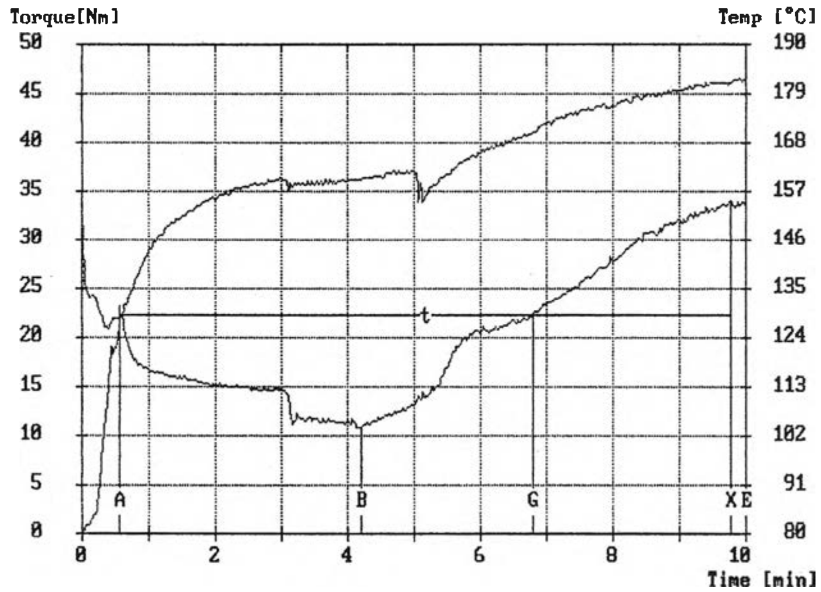

Figure B7 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 90/10/7/0.5.

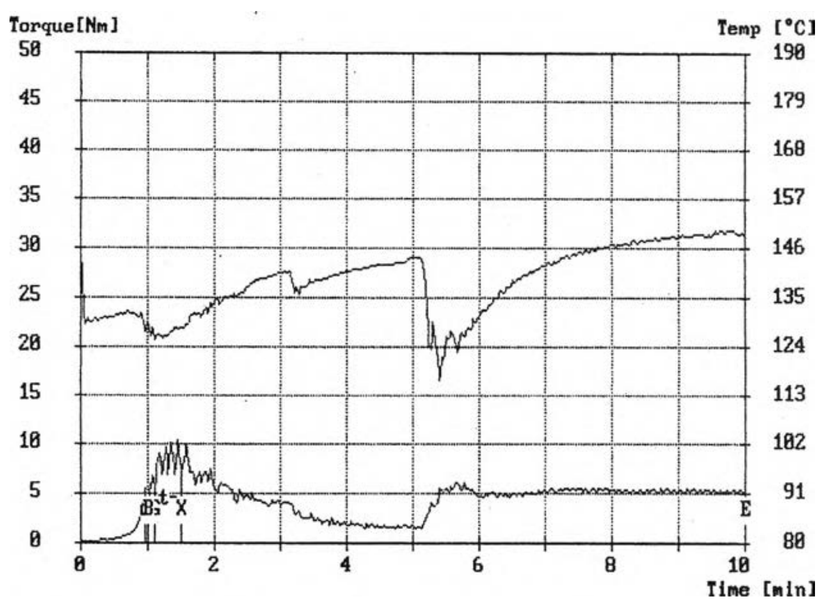

Figure B8 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/7/0.

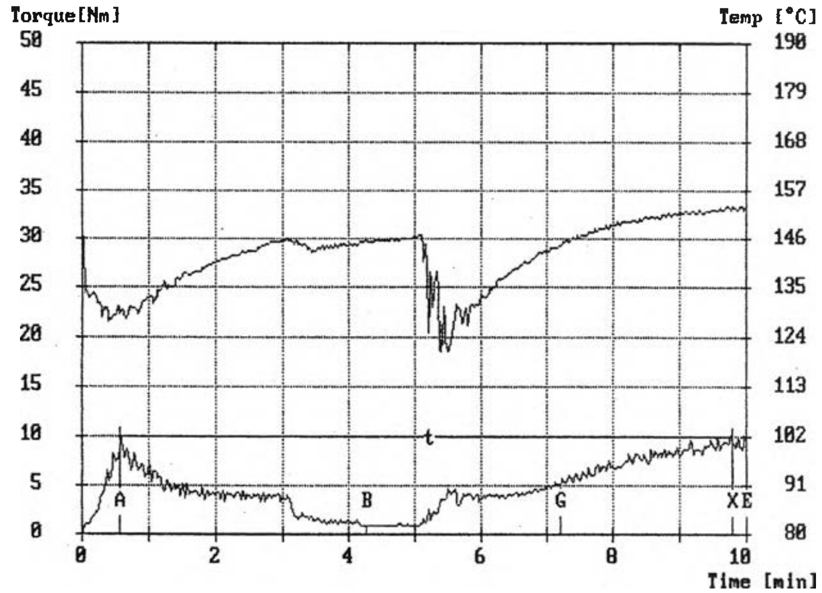

Figure B9 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/7/0.5.

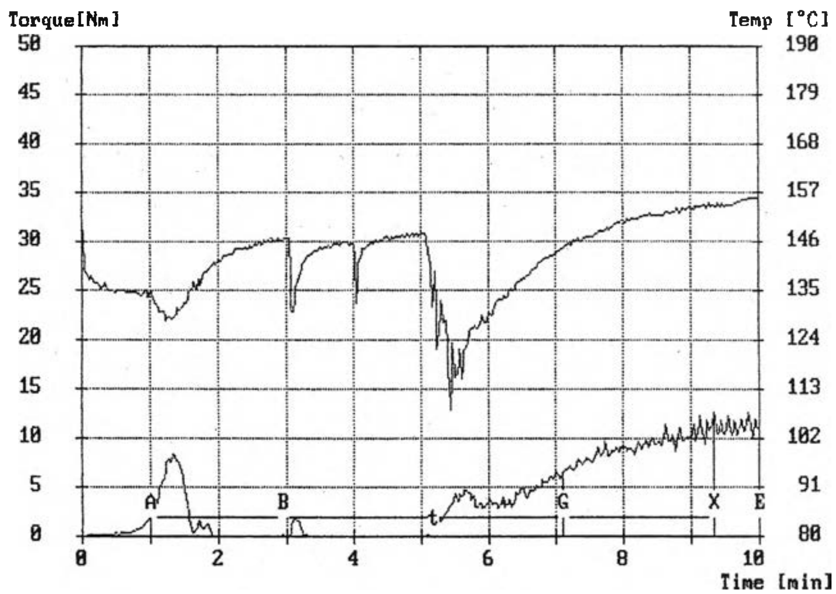

Figure B10 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/7/1.0.

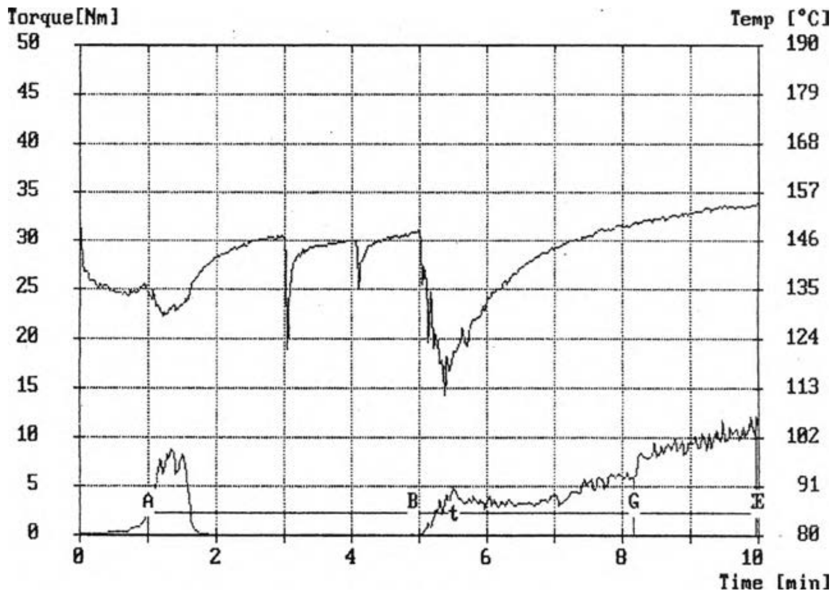

Figure B11 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/7/1.5.

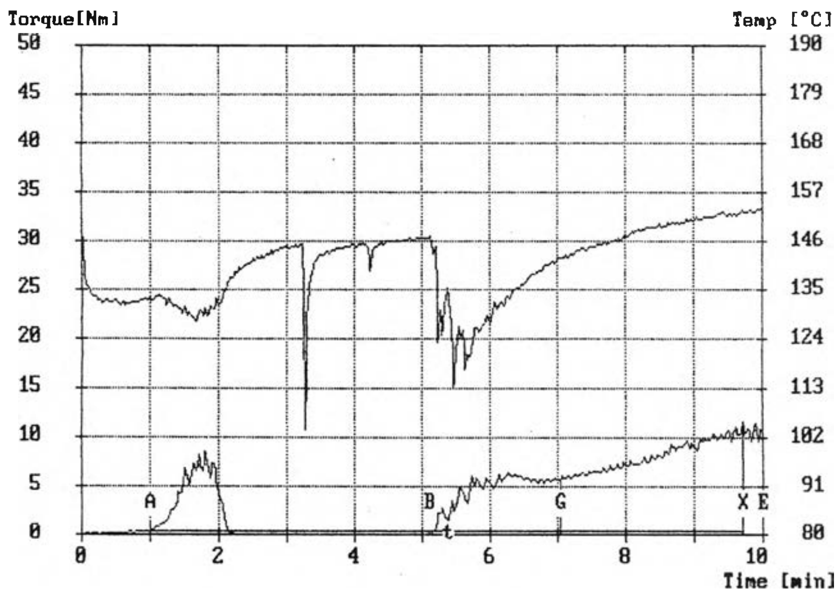

Figure B12 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/1/0.5.

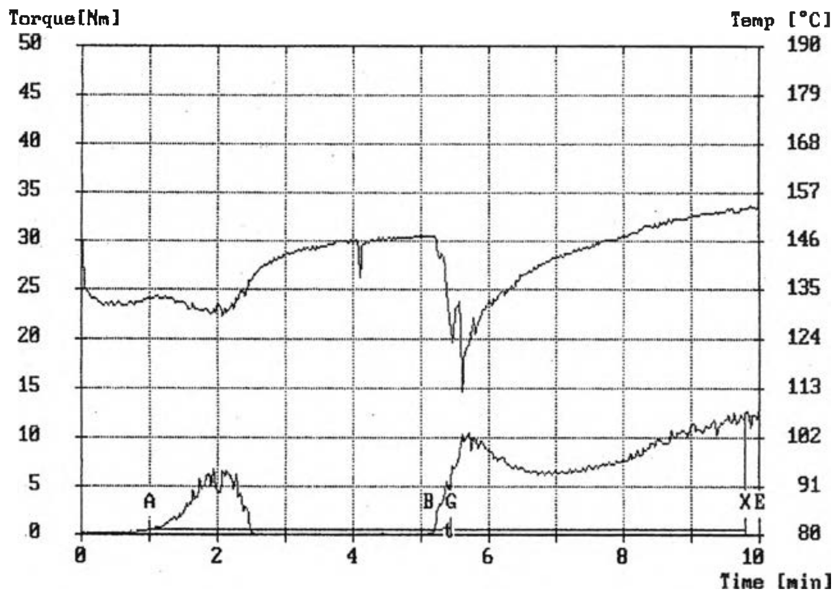

Figure B13 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/3/0.5.

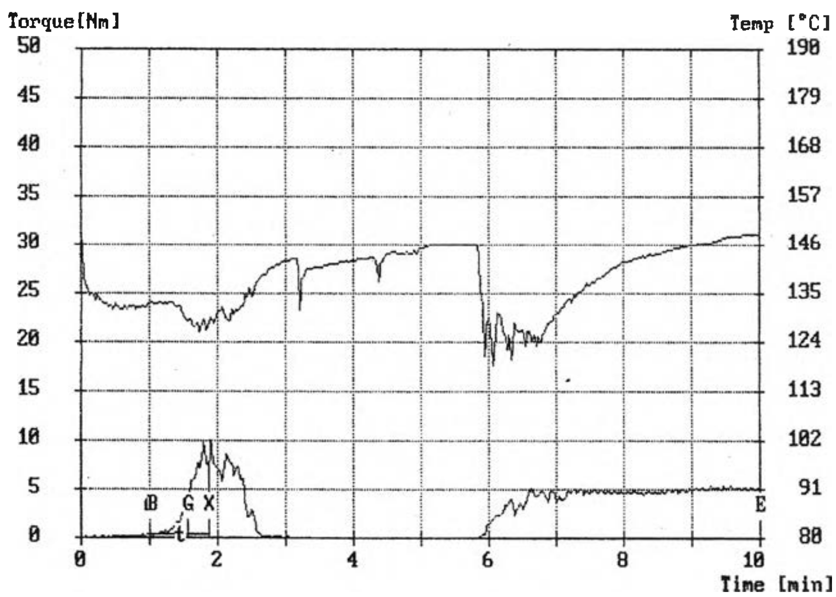

Figure B14 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 50/50/5/0.5.

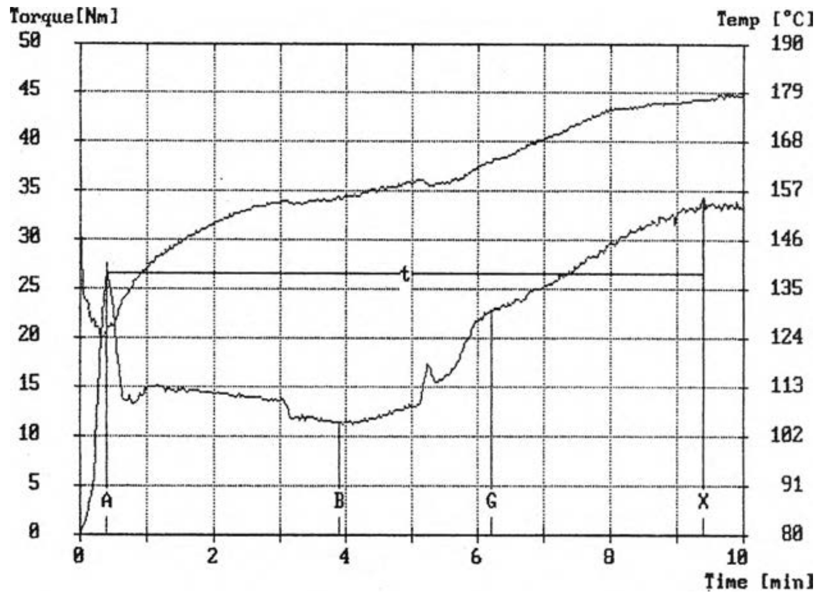

Figure B15 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 80/20/3/0.5.

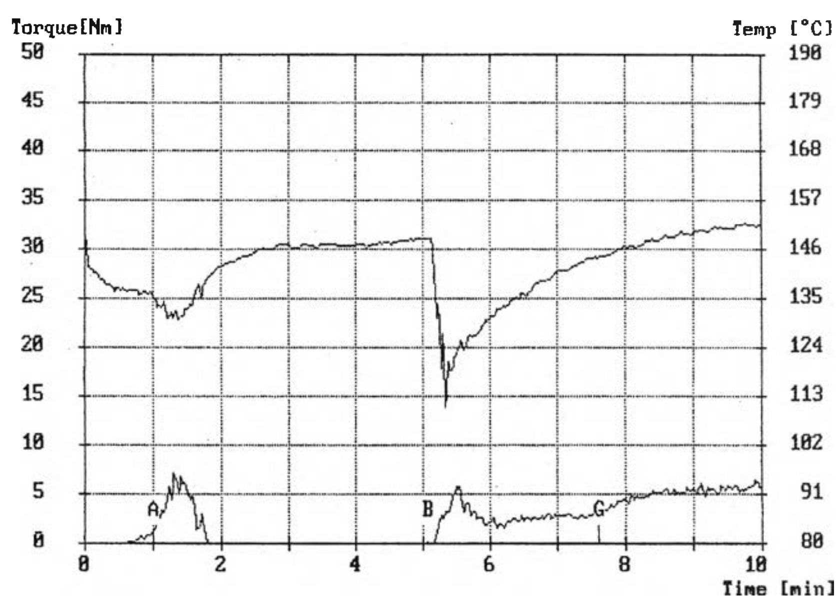

Figure B16 Time Temperature and Torque Relationship of LLDPE/NR/MA/DCP blend composition 40/60/7/1.5.

CURRICULUM VITAE

Name:	Buchanee Chan-ngam
Date of Birth:	23th of December, 1975
Nationality:	Thai
University Education:	
1994-1998	Bachelor degree of Science in Industrial Chemistry, King Mongkut Institute of Technology Ladkrabang, Bangkok, Thailand.