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APPENDIX A

The grafted natural rubber could be separated from the products of emulsion polymerization by the extraction with suitable solvent [16]. In this work, the extraction time of free polymer (e.g. S/MMA, ungrafted rubber) from grafted natural rubber was studied. Table A and Figure A show the time of extraction. The appropriate extraction time was 24 hours.

Table A. Extraction time of the free polymers.

Time (hr.)	Weight of sample (g) : extracted by LPE		Weight of sample (g) : extracted by acetone	
	No. 1	No. 2	No. 1	No. 2
	0	2.00	2.01	1.03
6	1.34	1.39	0.63	0.66
12	1.25	1.30	0.56	0.59
18	1.10	1.16	0.55	0.58
24	1.03	1.09	0.55	0.58
30	1.03	1.09	0.55	0.58

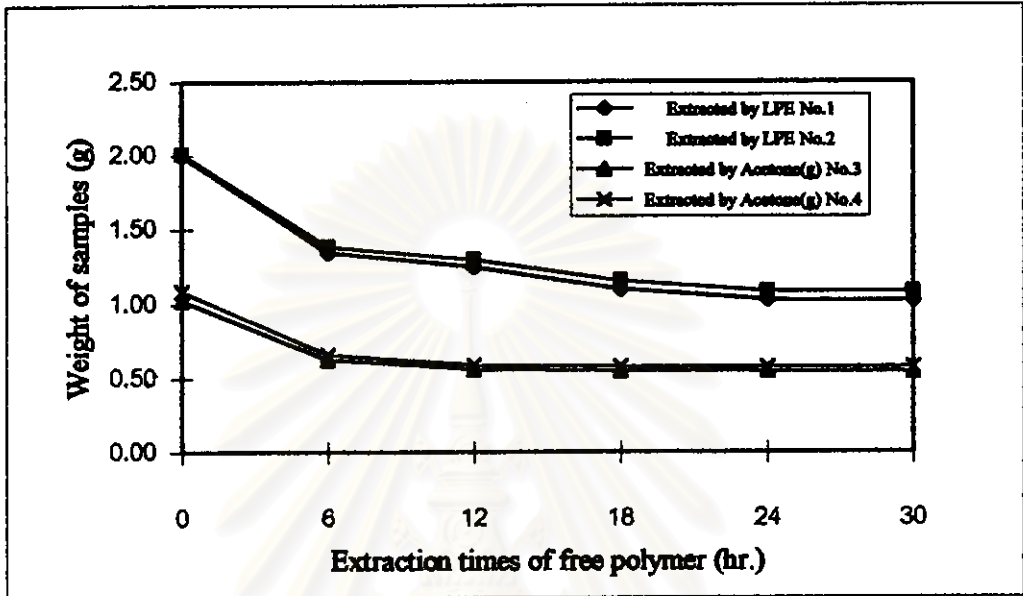


Figure A. Extraction time of the free polymer.

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APPENDIX B

Calculation of Monomers Conversion

The monomers conversion is defined as the mass of S/MMA formed (graft and free) divided by the initial mass of monomers [20]. The definition of conversion of monomers is

$$\text{conversion} = \frac{\text{S/MMA formed}}{\text{initial mass of monomers in sample}}$$

Calculation of Grafting Efficiency

The grafting efficiency is readily defined as the mass of the grafted S/MMA divided by the total S/MMA produced [20]. The definition of grafting efficiency is

$$\text{grafting efficiency} = \frac{\text{weight of grafted S/MMA}}{\text{weight of total S/MMA}}$$

Calculation of Graft Ratio

The graft ratio is defined as the mass of grafted S/MMA per unit mass of backbone polymer [20]. The definition of graft ratio is

$$\text{graft ratio} = \frac{\text{weight of grafted S/MMA}}{\text{weight of backbone } cis\text{-1,4-polyisoprene}}$$

Calculation of Graft Frequency

The graft frequency is the number of backbone polymer repeat units between two grafted chains. To obtain this value, we first calculate the number of graft chains per backbone chain [20]. For 41.99 g of grafted S/MMA at an \bar{M}_n of 121,907 (via Table BII) and 98.66 g of grafted *cis*-1,4-polyisoprene at an \bar{M}_n 116,991 (via Table BII), one chain of *cis*-1,4-polyisoprene has 1720.5 (116,991/68) repeat units. Hence the total number of grafted S/MMA chain is $(41.99/121,907) \times (\text{Avogadro's number})$ or $3.44 \times 10^{-4} \times (\text{Avogadro's number})$. The total number of grafted *cis*-1,4-polyisoprene chains is $(98.66/116,991) \times (\text{Avogadro's number})$ or $8.43 \times 10^{-4} \times (\text{Avogadro's number})$. The number of grafted chains per backbone chain is $(3.44/8.43) = 0.41$. The number of repeat units of rubber backbone per one of grafted chain is $(1720.5/0.41) = 4,212$.

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Table B1. Effect of emulsifier concentration, initiator concentration, and reaction temperature on the monomers conversion, the grafting efficiency, and the graft ratio. (Wt. of latex = 300 g; Wt. of monomer = 180 g)

Experiment	wt product (g)	%DRC	% conv.	sample (g)	wt. A*	wt. B*	%grafted NR	%free S/MMA	%free NR	total S/MMA	free S/MMA	graft S/MMA	graft ratio	%grafting efficiency
1	265.31	60.6	46.4	2.00	1.03	0.54	27.0	24.5	48.5	83.51	65.00	18.51	0.39	23.6
	271.42	60.6	49.8	2.01	1.09	0.58	28.9	25.4	45.8	89.62	68.87	20.75	0.37	23.4
2	313.06	60.6	72.9	2.04	1.61	1.18	57.8	21.1	21.1	131.26	65.99	65.27	0.76	48.9
	310.48	60.6	71.5	2.00	1.37	0.96	48.0	20.5	31.5	128.68	63.65	65.03	0.77	50.4
3	318.54	60.6	76.0	2.01	1.47	1.08	53.7	19.4	26.9	136.74	61.81	74.93	0.89	57.9
	314.72	60.6	73.8	2.06	1.46	1.06	51.5	19.4	29.1	132.92	61.11	71.81	0.88	56.2
4	320.01	60.7	76.6	2.02	1.48	1.03	51.0	22.3	26.7	137.91	71.29	66.62	0.81	52.5
	318.40	60.7	75.7	2.10	1.51	1.02	48.6	23.3	28.1	136.30	74.29	62.01	0.80	50.4
5	319.11	60.7	76.1	2.02	1.41	0.79	39.1	30.7	30.2	137.01	97.94	39.07	0.62	35.4
	321.69	60.7	77.6	2.08	1.49	0.87	41.8	29.8	28.4	139.59	95.89	43.70	0.64	37.8
6	272.53	60.7	50.2	2.06	1.17	0.62	30.1	26.7	43.2	90.43	72.76	17.67	0.26	18.4
	264.41	60.7	45.7	2.13	1.14	0.60	28.2	25.4	46.5	82.31	67.03	15.28	0.25	18.1
7	301.54	60.7	66.3	2.06	1.30	0.92	44.7	18.4	36.9	119.44	55.62	63.82	0.81	51.0
	298.43	60.7	64.7	2.00	1.25	0.85	42.5	20.0	37.5	116.33	59.69	56.64	0.80	48.3
8	318.54	60.6	76.0	2.01	1.47	1.08	53.7	19.4	26.9	136.74	61.81	74.93	0.89	57.9
	314.72	60.6	73.8	2.06	1.46	1.06	51.5	19.4	29.1	132.92	61.11	71.81	0.88	56.2
9	321.65	60.9	77.2	2.08	1.48	1.12	53.8	17.3	28.8	138.95	55.67	83.28	0.93	59.7
	324.92	60.9	79.0	2.11	1.51	1.14	54.0	17.5	28.4	142.22	56.98	85.24	0.95	60.1

DRC = dried rubber content.

Table B1. (Continued)

Experiment	wt. product (g)	%DRC	% conv.	sample (g)	wt. A*	wt. B*	%grafted NR	%free S/MMA	%free NR	total S/MMA	free S/MMA	graft S/MMA	graft ratio	%grafting efficiency
10	281.44	60.09	54.9	2.21	1.55	1.09	49.3	20.8	29.9	98.74	56.75	41.99	0.41	41.2
	278.80	60.09	53.4	2.04	1.39	0.98	48.0	20.1	31.9	96.10	56.66	39.44	0.41	41.0
11	318.54	60.6	76.0	2.01	1.47	1.08	53.7	19.4	26.9	136.74	61.55	75.19	0.89	57.9
	314.72	60.6	73.8	2.06	1.46	1.06	51.5	19.4	29.1	132.92	62.48	70.43	0.88	56.2
12	319.62	60.09	76.1	2.06	1.44	1.09	52.9	17.0	30.1	136.92	53.97	82.96	0.96	60.6
	320.43	60.09	76.5	2.05	1.44	1.10	53.7	16.6	29.8	137.73	53.20	84.53	0.97	61.4
13	326.02	60.09	79.6	2.16	1.58	1.25	57.9	15.3	26.9	143.32	49.76	93.55	0.99	65.6
	325.72	60.09	79.5	2.06	1.50	1.18	57.3	15.5	27.2	143.02	50.21	92.81	0.99	64.9

Experiment 1-5 : 0.5-2.5 parts by weight of emulsifier

Experiment 6-9 : 0.5-2.0 parts by weight of initiator

Experiment 10-13 : 40-60°C of reaction temperature

*wt. A : Graft product were extracted by light petroleum ether at 80°C for 24 hours.

*wt. B : Graft product were extracted by light petroleum ether at 80 °C for 24 hours and extracted by acetone at 55 °C for 24 hours

Table B2. Effect reaction temperature on graft frequency.

Experiment	wt. product (g)	total S/MMA	free S/MMA	graft S/MMA	graft NR	MW of S/MMA	MW of NR	repeat of NR	no of grafted S/MMA	no of NR	grafts per backbone	graft frequency	Avg. graft frequency
14	281.44	98.74	56.75	41.99	98.66	121,907	116,991	1,720.5	2.07E+20	5.08E+20	0.41	4,212	4,249
	278.80	96.10	56.66	39.44	94.28	121,907	116,991	1,720.5	1.95E+20	4.85E+20	0.40	4,285	
15	318.54	136.74	61.55	75.19	95.72	91,790	116,991	1,720.5	4.93E+20	4.93E+20	1.00	1,718	1,734
	314.72	132.92	62.48	70.43	91.29	91,790	116,991	1,720.5	4.62E+20	4.70E+20	0.98	1,749	
16	319.62	136.92	53.97	82.96	86.08	101,063	116,991	1,720.5	4.94E+20	4.43E+20	1.11	1,542	1,538
	320.43	137.73	53.20	84.53	87.22	101,063	116,991	1,720.5	5.04E+20	4.49E+20	1.12	1,533	
17	326.02	143.32	49.76	93.55	94.33	87,546	116,991	1,720.5	6.43E+20	4.85E+20	1.32	1,298	1,303
	325.72	143.02	50.21	92.81	94.28	87,546	116,991	1,720.5	6.38E+20	4.85E+20	1.31	1,307	

Experiment 14. : reaction temperature 40°C for 8 hours.

Experiment 15. : reaction temperature 50°C for 8 hours.

Experiment 16. : reaction temperature 60°C for 8 hours.

Experiment 17. : reaction temperature 70°C for 8 hours.

Table B3 The average degree of monomers conversion, %grafted NR, %free S/MMA, free NR, %grafting efficiency, and graft ratio.

Experiment	Avg. %conv.	Avg. %grafted NR	Avg. %free S/MMA	Avg. %free NR	Avg. %grafting efficiency	Avg. graft ratio
1	48.1	27.9	24.9	47.1	23.5	0.38
2	72.2	52.9	20.8	26.3	49.7	0.77
3	74.9	52.6	19.4	28.0	57.1	0.89
4	76.2	49.8	22.8	27.4	51.5	0.81
5	76.8	40.5	30.3	29.3	36.6	0.63
6	48.0	29.1	26.0	44.8	18.3	0.26
7	65.5	43.6	19.2	37.2	49.7	0.81
8	74.9	52.6	19.4	28.0	57.1	0.89
9	78.1	53.9	17.4	28.6	59.9	0.94
10	54.1	48.7	20.5	30.9	41.1	0.41
11	74.9	52.6	19.4	28.0	57.1	0.89
12	76.3	53.3	16.8	29.9	61.0	0.97
13	79.5	57.6	15.4	27.0	65.3	0.99

Experiment 1-5 : 0.5-2.5 parts by weight of emulsifier

Experiment 6-9 : 0.5-2.0 parts by weight of initiator

Experiment 10-13 : 40-60°C of reaction temperature

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APPENDIX C

In this research the GPC method was chosen for determination of the molecular weight of free S/MMA; in tetrahydrofuran at 35 °C. The details are as follows:

Detector 1 Calibration Report

METHOD NAME : DEMO METHOD 1
Calibration TYPE : Narrow Standards
Curve Type : 4th Order
Equation of Curve : $\log MW = +3.70E+01 - 1.60E+01 * R + 3.12E+00 * R^2 - 0.2763 * R^3 + 9.10E-03 * R^4$
Correlation Coef : $r^2 = 0.9978163$
Std Err of Estimate : 0.01649598
Calibration Points :

<u>Ret Time</u> <u>(min)</u>	<u>Specified</u> <u>Molecular Wt</u>	<u>Calculated</u> <u>Molecular Wt</u>	<u>Valid</u>
4.85	2890000	2867919	Yes
5.31	109000	1128873	Yes
5.65	706000	679435	Yes
6.20	355000	358079	Yes
6.88	190000	191123	Yes
7.65	96400	95992	Yes
8.62	37900	37928	Yes

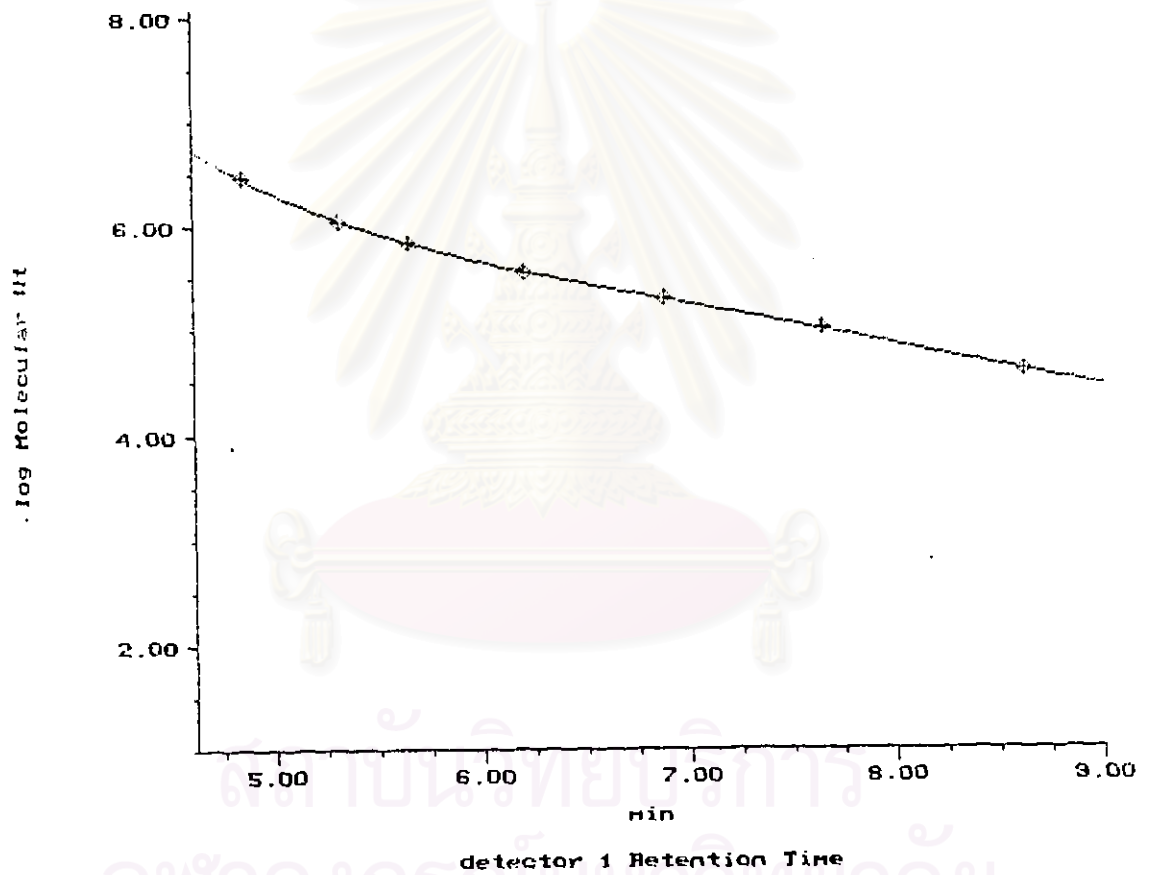
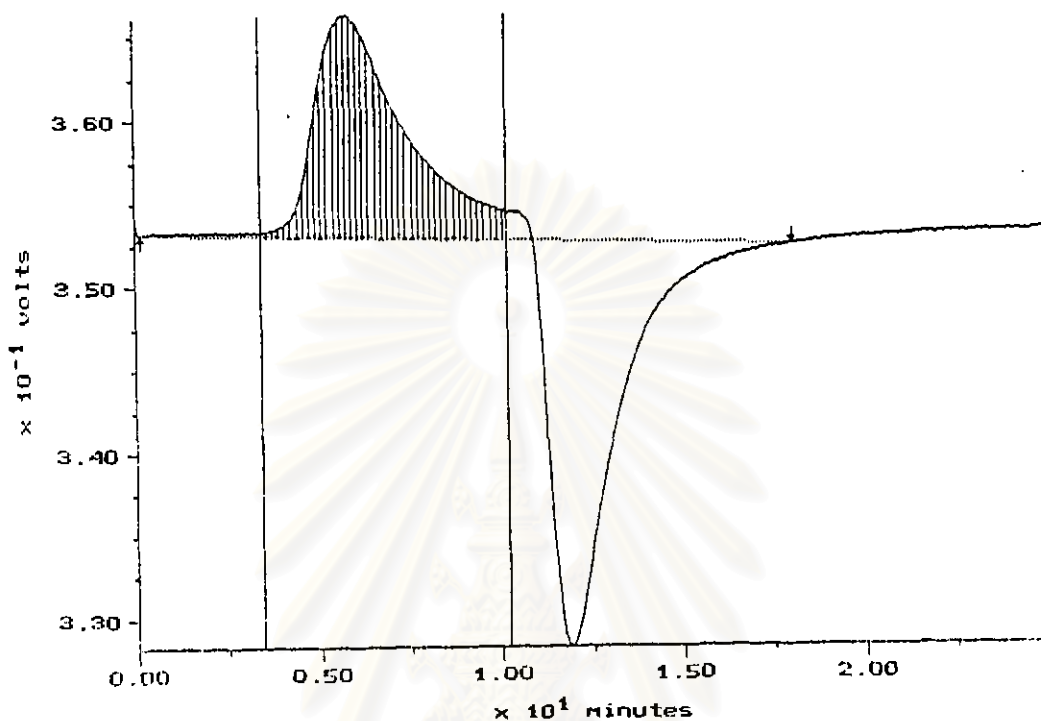


Figure C.1 The calibration curve, standard of polystyrene from GPC chromatograms.



SAMPLE: REVIEW

Method : DEMO METHOD 1
 Acquired : 21-MAY-1997 11:15
 Rate : 5.906 pcounts/sec
 Duration : 25.090 minutes
 Operator : DDV

Instrument : Instrument 1
 Filename : AD421D

ANALYSIS PARAMETERS:

Processing Start : 3.42 minutes
 Processing End : 10.17 minutes
 Number of Slices : 41
 Slice Width : 10 seconds

Baseline Start : 0.12 minutes
 Baseline End : 17.99 minutes

Calibration : Narrow Standards

DETECTOR: detector 1

Molecular Weight Distribution Averages (Area Normalization [W(t)]):

Number Average : 116991	Polydispersity : 5.725786
Weight Average : 669863	Intrinsic viscosity : 0.000000
Viscosity Average : 669863	S avg / Wt avg : 3.426414
Z Average : 2325628	S+1 avg / Wt avg : 4.578742
S+1 Average : 4405857	

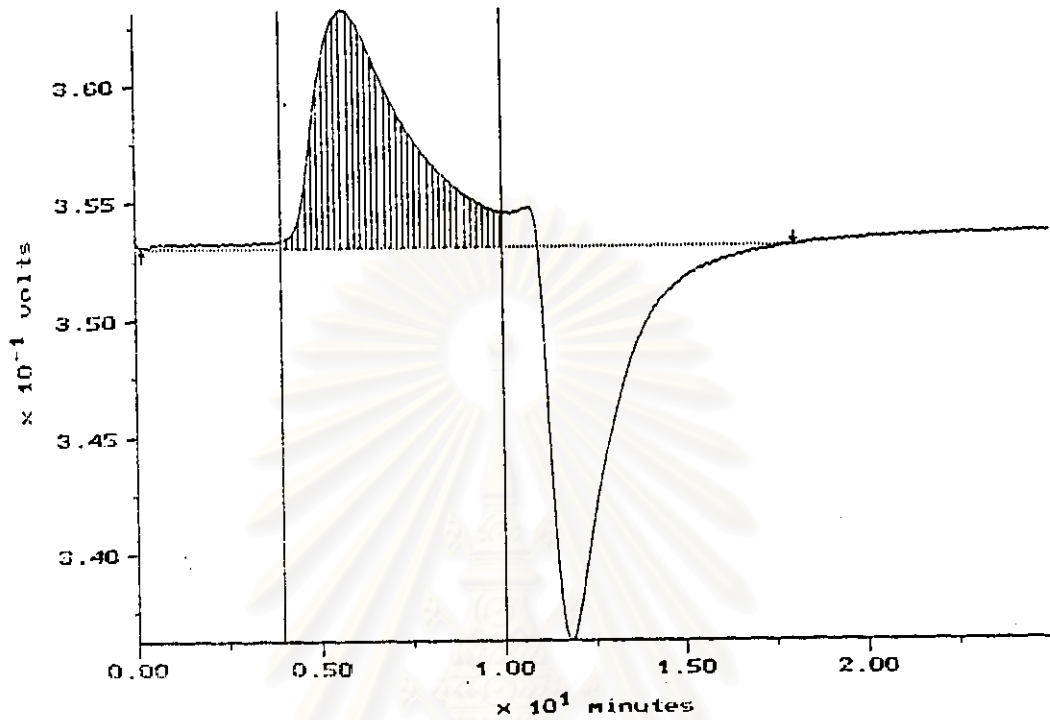
Molecular Weight Distribution Averages (Molecular Weight Normalization [W(t) / -d(log MW)/dC]):

Number Average : -72313	Polydispersity : N/A
Weight Average : 452088	Intrinsic viscosity : 0.000000
Viscosity Average : 452088	S avg / Wt avg : 2.565048
Z Average : 1668136	S+1 avg / Wt avg : 5.785396
S+1 Average : 3372585	

Peak Maximum:

Slice # : 15
 Molecular Wt : 536869

Figure C.2 GPC chromatogram of natural rubber



SAMPLE: REVIEW

Method : DEMO METHOD 1
 Acquired : 21-MAY-1997 11:58
 Rate : 5.000 points/sec
 Duration : 25.000 minutes
 Operator : DDV

Instrument : Instrument 1
 Filename : AG421A

ANALYSIS PARAMETERS:

Processing Start : 3.96 minutes
 Processing End : 9.99 minutes
 Number of Slices : 37
 Slice Width : 16 seconds

Baseline Start : 0.16 minutes
 Baseline End : 17.95 minutes

Calibration : Narrow Standards

DETECTOR: detector 1

Molecular Weight Distribution Averages (Area Normalization [W(t)]):

Number Average : 121987
 Weight Average : 677630
 Viscosity Average : 677630
 S Average : 2174182
 S±1 Average : 3869266

Polydispersity : 5.52595
 Intrinsic viscosity : 0.000000
 S avg / Wt avg : 3.208391
 S±1 avg / Wt avg : 5.709998

Molecular Weight Distribution Averages (Molecular Weight Normalization [W(t) / -d(log MW)/dt]):

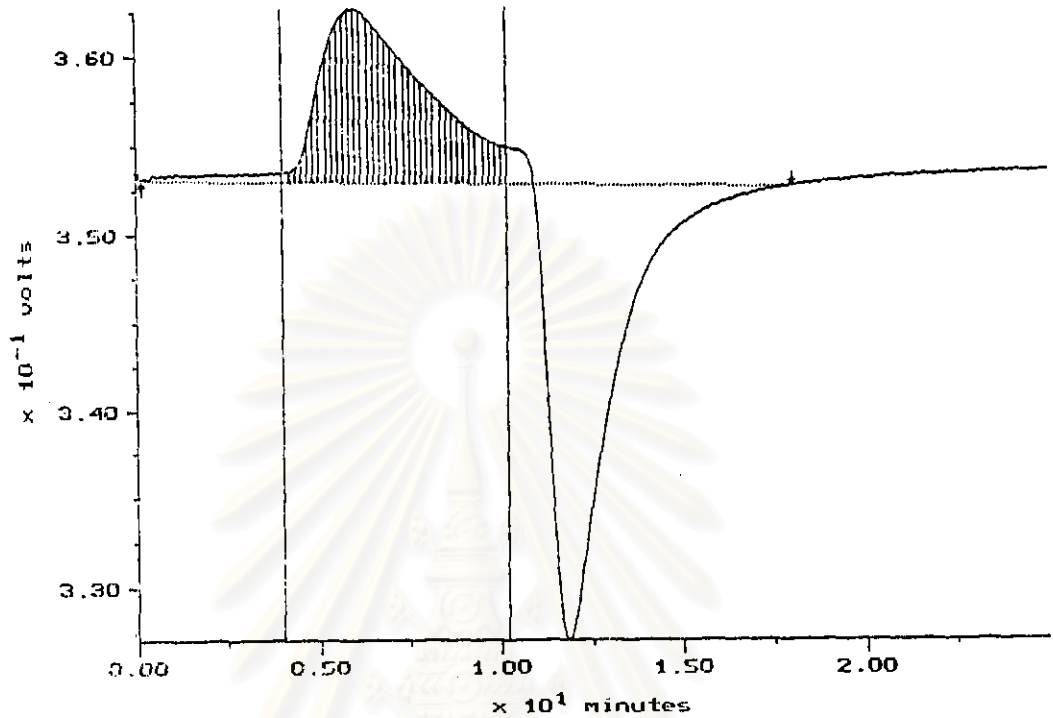
Number Average : 77565
 Weight Average : 425364
 Viscosity Average : 425364
 S Average : 1567662
 S±1 Average : 3341292

Polydispersity : 5.483982
 Intrinsic viscosity : 0.000000
 S avg / Wt avg : 3.685468
 S±1 avg / Wt avg : 7.855140

Peak Maxima:

Slice # : 11
 Molecular Wt : 629013

Figure C.3 GPC chromatogram of free S/MMA extracted from the products of graft copolymerization at 40 °C for 8 hours.



SAMPLE: REVIEW

Method : DEMO METHOD 1
 Acquired : 21-MAY-1997 16:07
 Rate : 5.000 points/sec
 Duration : 25.000 minutes
 Operator : DOV

Instrument : Instrument 1
 Filename : A04217

ANALYSIS PARAMETERS:

Processing Start : 4.04 minutes
 Processing End : 10.17 minutes
 Number of Slices : 37
 Slice Width : 10 seconds

Baseline Start : 0.16 minutes
 Baseline End : 17.99 minutes

Calibration : Narrow Standards

DETECTOR: detector 1

Molecular Weight Distribution Averages (Area Normalization [W(t)]):

Number Average : 91790
 Weight Average : 520691
 Viscosity Average : 520691
 Z Average : 2146770
 Z² Average : 4615937

Polydispersity : 5.672604
 Intrinsic viscosity : 0.000000
 Z avg / Wt avg : 4.127926
 Z² avg / Wt avg : 8.865828

Molecular Weight Distribution Averages (Molecular Weight Normalization [W(t) / -d(log MW)/dt]):

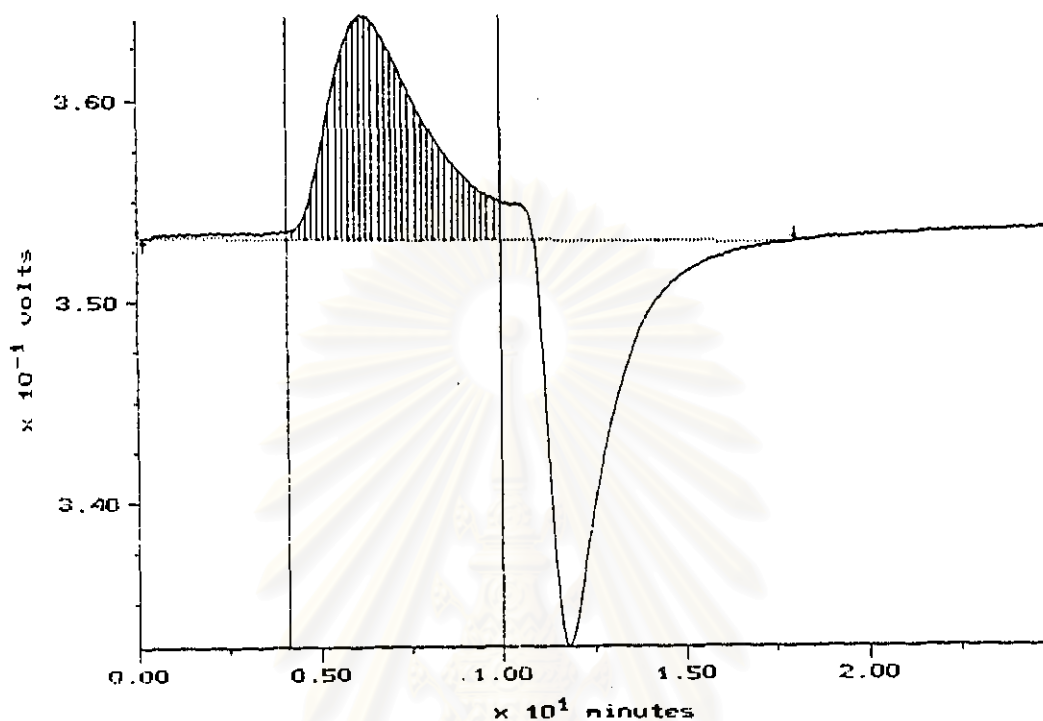
Number Average : 41560
 Weight Average : 267247
 Viscosity Average : 267247
 Z Average : 1415322
 Z² Average : 3816724

Polydispersity : 6.430308
 Intrinsic viscosity : 0.000000
 Z avg / Wt avg : 5.295937
 Z² avg / Wt avg : 21.719065

Peak Maxima:

Slice #: 12
 Molecular Wt: 464973

Figure C.4 GPC chromatogram of free S/MMA extracted from the products of graft copolymerization at 50 °C for 8 hours.



SAMPLE: REVIEW

Method : DEMO METHOD 1	Instrument : Instrument 1
Acquired : 21-MAI-1997 12:24	Filename : A04218
Rate : 5.000 points/sec	
Duration : 25.000 minutes	
Operator : DDV	

ANALYSIS PARAMETERS:

Processing Start : 4.14 minutes	Baseline Start : 0.10 minutes
Processing End : 9.99 minutes	Baseline End : 17.99 minutes
Number of Slices : 36	
Slice Width : 16 seconds	
Calibration : Narrow Standards	

DETECTOR: detector 1

Molecular Weight Distribution Averages (Area Normalization [W(t)]):

Number Average : 101063	Polydispersity : 4.344907
Weight Average : 439117	Intrinsic viscosity : 0.000000
Viscosity Average : 439117	\bar{M} avg / Wt avg : 3.529410
\bar{M} Average : 1548024	\bar{M} avg / Wt avg : 7.546791
\bar{M} Average : 3313925	

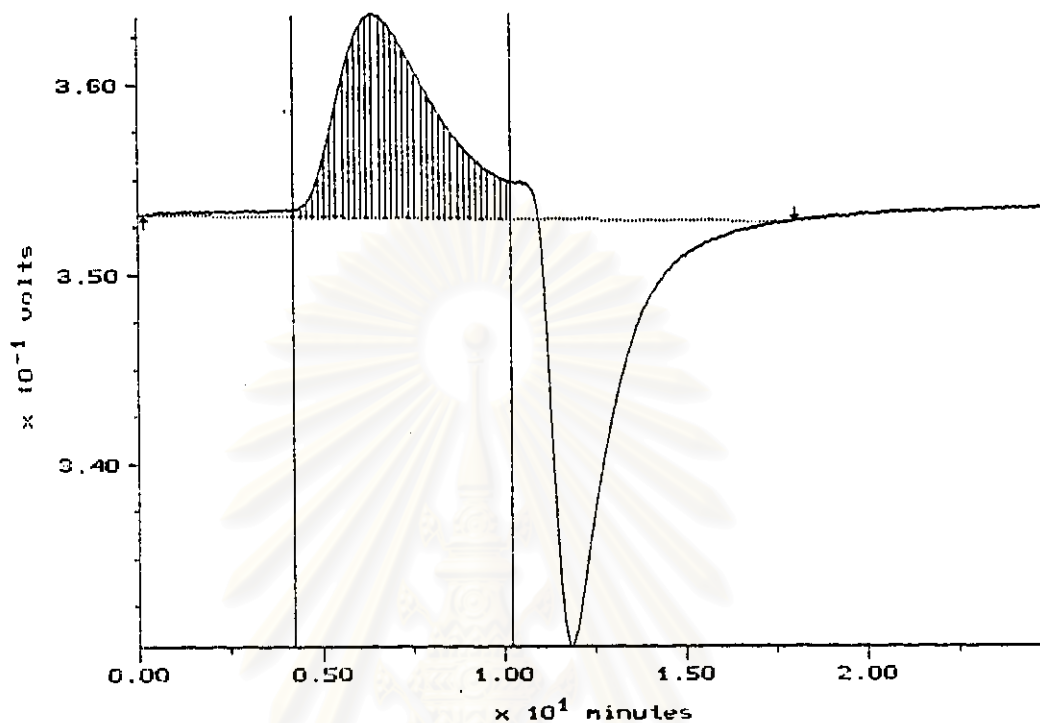
Molecular Weight Distribution Averages (Molecular Weight Normalization [W(t) / -d(log MW)/dt]):

Number Average : 65398	Polydispersity : 4.465799
Weight Average : 290745	Intrinsic viscosity : 0.000000
Viscosity Average : 290745	\bar{M} avg / Wt avg : 3.418797
\bar{M} Average : 1052140	\bar{M} avg / Wt avg : 9.277656
\bar{M} Average : 2497446	

Peak Maximum:

Slice # : 13
Molecular Wt : 351519

Figure C.5 GPC chromatogram of free S/MMA extracted from the products of graft copolymerization at 60 °C for 8 hours.



SAMPLE: REVIEW

Method : DEMO METHOD 1
 Acquired : 21-MAY-1997 13:41
 Rate : 5.000 points/sec
 Duration : 25.000 minutes
 Operator : DDV

Instrument : Instrument 1
 Filename : A6421E

ANALYSIS PARAMETERS:

Processing Start : 4.25 minutes
 Processing End : 10.17 minutes
 Number of Slices : 36
 Slice Width : 10 seconds

Baseline Start : 0.10 minutes
 Baseline End : 17.59 minutes

Calibration : Narrow Standards

DETECTOR: detector 1

Molecular Weight Distribution Averages (Area Normalization [V(t)]):

Number Average : 67546
 Weight Average : 370165
 Viscosity Average : 370165
 S Average : 1503207
 S+1 Average : 3025736

Polydispersity : 4.226229
 Intrinsic viscosity : 0.000000
 S avg / Wt avg : 4.060910
 S+1 avg / Wt avg : 10.335214

Molecular Weight Distribution Averages (Molecular Weight Normalization [W(t) / -(d(log MW)/dt)]):

Number Average : -30051
 Weight Average : 522613
 Viscosity Average : 522613
 S Average : 999050
 S+1 Average : 2993260

Polydispersity : N/A
 Intrinsic viscosity : 0.000000
 S avg / Wt avg : 1.913150
 S+1 avg / Wt avg : 5.727506

Peak Maxima:

Slice # : 13
 Molecular Wt : 315403

Figure C.6 GPC chromatogram of free S/MMA extracted from the products of graft copolymerization at 70 °C for 8 hours.

APPENDIX D

Table D1. The ratio of styrene and methyl methacrylate in grafted natural rubber (NR-*g*-S/MMA) calculated from the specific signal areas of NMR spectra.

Temp. (°C)	Signal area at			methyl methacrylate: isoprene : styrene
	3.6 ppm	5.2 ppm	7.0 ppm	
40	0.436	0.790	0.533	13.88 : 75.82 : 10.27
50	0.327	0.502	0.358	15.96 : 73.50 : 10.48
60	1.212	1.295	1.274	20.68 : 66.27 : 13.05
70	0.778	0.485	0.686	29.40 : 55.05 : 15.55

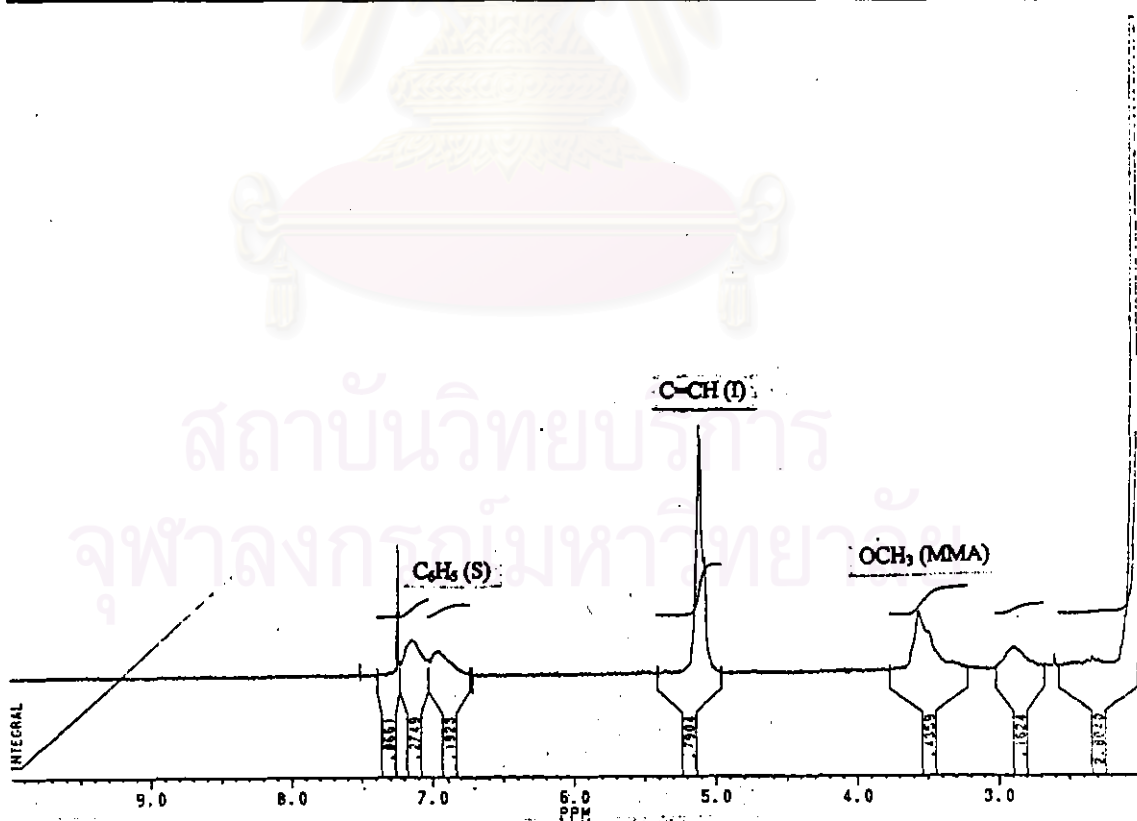


Figure D.1 NMR spectrum (CDCl_3) of grafted natural rubber extracted from the products of graft copolymerization at 40°C for 8 hours.

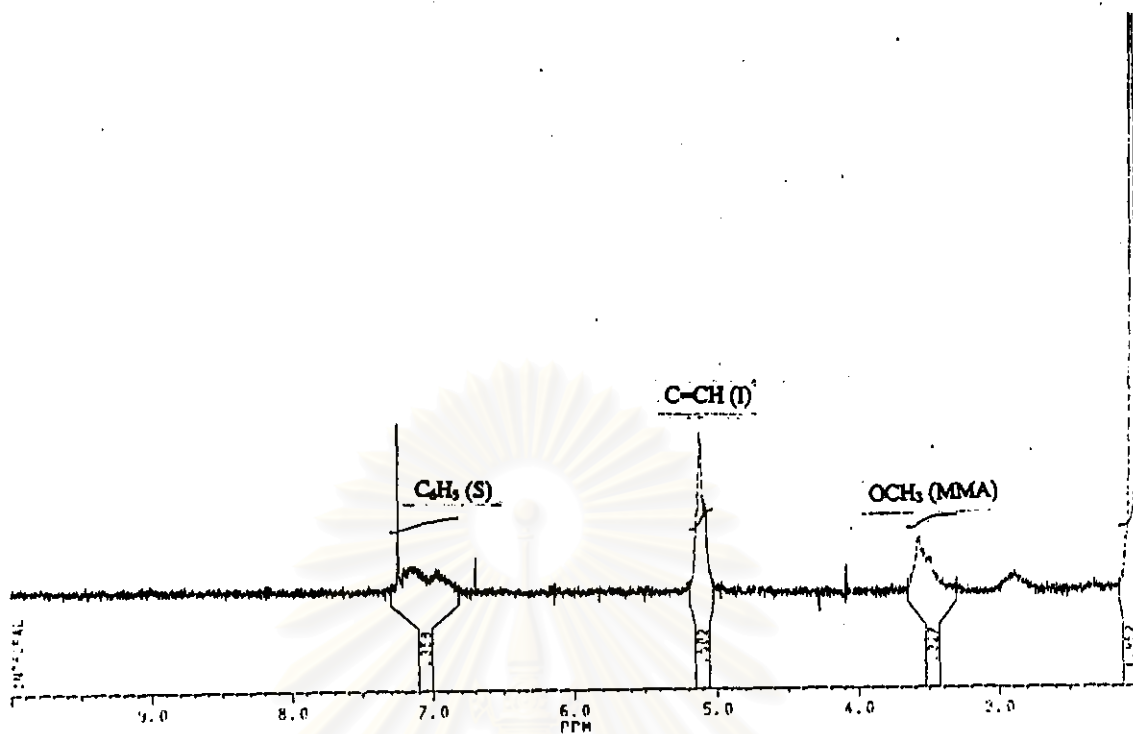


Figure D.2 NMR spectrum (CDCl_3) of grafted natural rubber extracted from the products of graft copolymerization at 50°C for 8 hours.

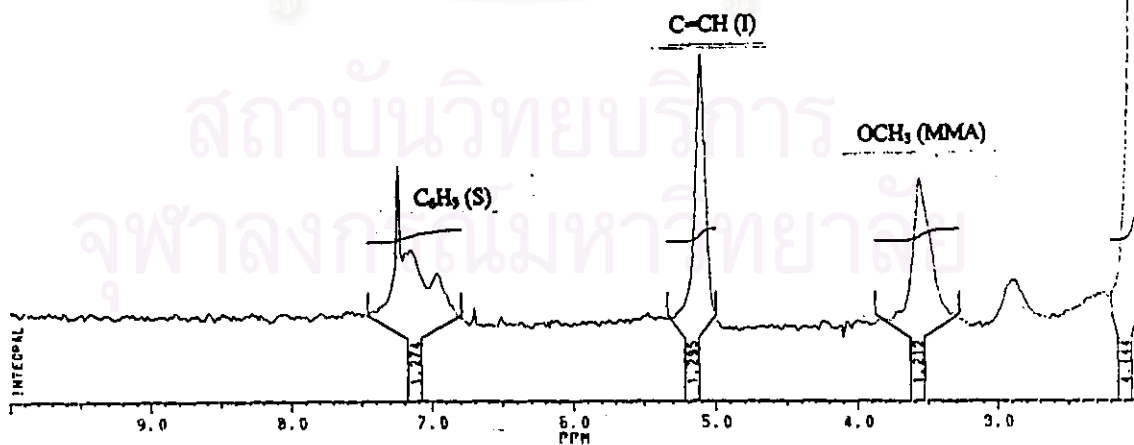


Figure D.3 NMR spectrum (CDCl_3) of grafted natural rubber extracted from the products of graft copolymerization at 60°C for 8 hours.

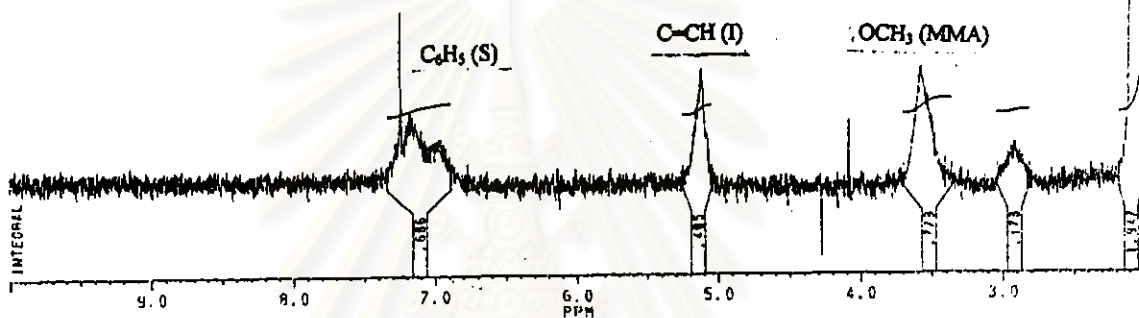


Figure D.4 NMR spectrum (CDCl_3) of grafted natural rubber extracted from the products of graft copolymerization at 70°C for 8 hours.

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APPENDIX E

Determination of Copolymer Composition of CHO method

Example of Calculation

For grafted natural rubber : from graft copolymerization at 40 °C

<u>Assume</u>	MMA : I : S	=	a : b : c	mole%
	(C ₄ H ₈ O ₂) Methyl methacrylate	=	a [C ₄ H ₈ O ₂]	
	(C ₅ H ₈) Isoprene	=	b [C ₅ H ₈]	
	(C ₈ H ₈) Styrene	=	c [C ₈ H ₈]	
	From CHO method C : H : O	=	83.096 : 10.846 : 5.940	
	Carbon	C = [4a + 5b + 8c] x 12	=	83.096 g (Eq. 1.1)
	Hydrogen	H = [8a + 8b + 8c] x 1	=	10.846 g (Eq. 1.2)
	Oxygen	O = [2a] x 16	=	5.940 g (Eq. 1.3)
From Eq. 1.3	∴ a	=	0.185	
From Eq. 1.1	0.740 + 5b + 8c	=	6.934	
From Eq. 1.2	1.480 + 8b + 8c	=	10.845	
	5b + 8c	=	6.194 (Eq. 1.4)	
	8b + 8c	=	9.365 (Eq. 1.5)	
	(1.4) x 8	40b + 64c	=	49.552 (Eq. 1.6)
	(1.5) x 5	40b + 40c	=	46.825 (Eq. 1.7)
	(1.6) - (1.7)	24c	=	2.727
		c	=	0.113
From Eq. 1.4	5b + 0.904	=	6.194	
	b	=	1.058	
a + b + c	=	0.185 + 1.058 + 0.113	=	1.356
	a : b : c	=	13.64 : 78.02 : 8.33 mole%	

Table E1. Analysis of CHO in grafted natural rubber extracted from grafted natural rubber.

Temp. (°C)	Sample No.	Grafted natural rubber		
		%C	%H	%O
40	1	83.030	10.783	6.187
	2	83.043	11.013	5.944
	3	83.569	10.741	5.690
	Mean	83.214	10.741	5.940
50	1	81.802	10.626	7.572
	2	82.066	10.098	7.836
	3	81.942	10.781	7.277
	Mean	81.937	10.502	7.562
60	1	80.809	10.510	8.681
	2	80.520	10.463	9.017
	3	80.298	10.167	9.535
	Mean	80.542	10.380	9.078
70	1	80.016	10.065	9.919
	2	80.064	10.076	9.860
	3	79.966	10.088	9.946
	Mean	80.015	10.076	9.908

APPENDIX F

Statistic of Mechanical Properties Data

The sampling distributions of mechanical properties data were calculated by standard deviation (SD) and t distribution [30].

$$SD = \frac{\sum (x_i - x_s)^2}{n-1}$$

where n is the number of sample.

x_i is the sample.

x_s is the sample mean.

The correct mechanical properties data was calculated by using the t distribution. The equations is as follows :

$$\mu = x_s \pm \frac{(t \times SD)}{\text{sqrt } n}$$

where μ is the correct data.

From the statistic table :

At 95% confidence, $n = 5$

$\therefore t = 2.132$

At 95% confidence, $n = 10$

$\therefore t = 1.833$

Table F1.1 Tensile strength of PVC blended with grafted NR product (MIS) and MBS

	MBS content (phr)					grafted NR product content (phr)			
	0	5	10	15	20	5	10	15	20
Tensile strength (MPa)	48.4	46.1	37.8	37.8	34.8	42.1	40.6	39.1	37.9
	48.8	45.9	38.0	37.8	35.7	42.4	40.6	39.1	37.5
	49.5	45.9	37.7	37.7	35.3	41.6	40.3	38.7	37.8
	48.9	46.3	38.1	37.3	35.1	41.8	40.2	38.5	37.4
	48.7	45.9	37.9	37.0	36.0	41.6	39.6	38.7	38.0
Mean	48.9	46.0	37.9	37.5	35.4	41.9	40.2	38.8	37.7
S.D.	0.41	0.18	0.16	0.35	0.46	0.33	0.38	0.26	0.23
t x S.D./sqrt n	0.39	0.17	0.15	0.34	0.44	0.32	0.36	0.25	0.22

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Table F1.2 Elongation at break of PVC blended with grafted NR product (MIS) and MBS

	MBS content (phr)					grafted NR product content (phr)			
	0	5	10	15	20	5	10	15	20
Elongation	61.2	64.9	73.0	91.9	113.0	68.5	71.8	88.3	98.0
at break (%)	61.1	65.1	73.4	92.7	113.9	68.8	71.5	87.9	97.6
	61.3	64.9	74.1	91.6	113.9	68.9	72.0	88.5	98.1
	61.4	65.5	74.0	92.4	113.1	69.0	72.1	88.0	97.6
	61.0	65.3	73.1	92.7	113.1	68.4	72.1	88.1	97.6
Mean	61.4	65.1	73.5	92.3	113.4	68.7	71.9	88.2	97.8
S.D.	0.42	0.25	0.50	0.47	0.46	0.28	0.25	0.25	0.25
t x S.D./sprt n	0.40	0.24	0.50	0.45	0.43	0.27	0.24	0.24	0.24

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Table F1.3 Modulus of PVC blended with grafted NR product (MIS) and MBS

	MBS content (phr)					grafted NR product content (phr)			
	0	5	10	15	20	5	10	15	20
Modulus (MPa)	20857.7	17447.9	14283.0	11757.3	7779.2	15098.2	13459.7	10238.0	6789.7
	20861.0	17436.2	14286.4	11755.7	7775.4	15096.2	13451.4	10235.3	6781.3
	20850.1	17448.3	14282.5	11758.7	7771.9	15093.8	13450.1	10232.0	6783.9
	20863.1	17445.1	14289.7	11756.7	7774.4	15095.6	13458.4	10240.0	6788.8
	20849.0	17439.6	14283.4	11751.1	7776.0	15099.5	13457.7	10237.2	6781.6
Mean	20856.2	17443.4	14285.0	11755.9	7775.4	15096.7	13455.5	10236.5	6783.2
S.D.	6.37	5.2	3.02	2.90	2.64	2.21	4.37	3.00	3.33
t x S.D./sqrt n	6.07	5.08	2.88	2.76	2.52	2.11	4.16	2.87	3.18

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Table F2 Impact strength of PVC blended with grafted NR product (MIS) and MBS

	MBS content (phr)					grafted NR product content (phr)			
	0	5	10	15	20	5	10	15	20
Impact	270.0	278.7	422.2	445.6	454.9	288.9	303.1	373.0	426.5
strength (kJ/m²)	271.2	280.6	422.2	446.2	455.2	288.9	303.3	372.6	427.0
	268.9	279.5	422.0	447.5	454.9	289.2	303.1	373.7	427.7
	270.3	277.8	422.5	446.5	454.7	288.6	303.6	373.7	427.4
	269.2	278.7	422.9	446.5	456.7	288.6	302.8	375.0	427.7
	271.2	278.7	424.8	446.5	455.0	288.6	304.8	374.3	426.8
	270.0	279.5	424.1	446.6	455.5	289.2	304.8	373.7	427.4
	271.2	278.7	423.9	446.7	455.8	288.9	305.1	374.5	427.4
	270.0	278.9	423.2	447.0	455.5	288.6	303.3	374.3	427.7
	270.3	278.7	423.6	446.7	456.2	288.9	305.1	374.8	427.5
Mean	270.2	279.0	423.1	446.6	455.4	288.8	303.9	374.0	427.3
S.D.	0.78	0.74	0.94	0.51	0.63	0.24	0.92	0.76	0.41
t x S.D./sqrt n	0.17	0.15	0.13	0.07	0.08	0.05	0.18	0.12	0.06

Table F3 Hardness of PVC blended with grafted NR product (MIS) and MBS

	MBS content (phr)					grafted NR product content (phr)			
	0	5	10	15	20	5	10	15	20
Hardness (N)	37.8	36.9	36.0	35.1	34.7	36.9	36.0	35.3	34.2
	37.8	36.7	36.0	35.1	34.7	36.9	35.8	35.1	34.2
	37.8	36.9	36.0	34.9	34.7	36.9	36.0	35.1	33.8
	37.3	36.7	36.5	35.1	34.7	36.9	36.0	35.3	34.2
	37.8	36.7	36.0	35.1	34.2	36.5	36.0	35.3	34.2
Mean	37.7	36.8	36.1	35.1	34.6	36.8	36.0	35.3	34.1
S.D.	0.20	0.12	0.20	0.10	0.20	0.20	0.10	0.12	0.20

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APPENDIX G

Testing of Oven Heat Stability

The oven heat stability of the PVC/grafted NR product blends and PVC/MBS blends were measured by ASTM D2115: Standard test method for oven heat stability of poly(vinyl chloride) composition. The test specimens were prepared by compounding on a laboratory two-roll mill. Adjust the rolls to give a 0.816 ± 0.08 mm thick sheet after banding. The specimens not less than 25.4 by 25.4 mm. Place the specimens in the oven at $177 \pm 1.0^\circ\text{C}$. Remove one of specimens at selected periodic intervals over an exposure range to discoloration, preferably blackening.

In Figure G., the testing of oven heat stability of the PVC/grafted NR product blends and PVC/MBS blends at 177°C for 120 min. The more grafted NR product and MBS content quickly turn brown and black. This can be explained that the residual unsaturation in poly(isoprene) and poly(butadiene) promotes oxidative degradation readily. Therefore impact modifiers containing unsaturated components weather poorly and can undergo spontaneous thermal degradation if not properly stabilized with antioxidants during manufacture.

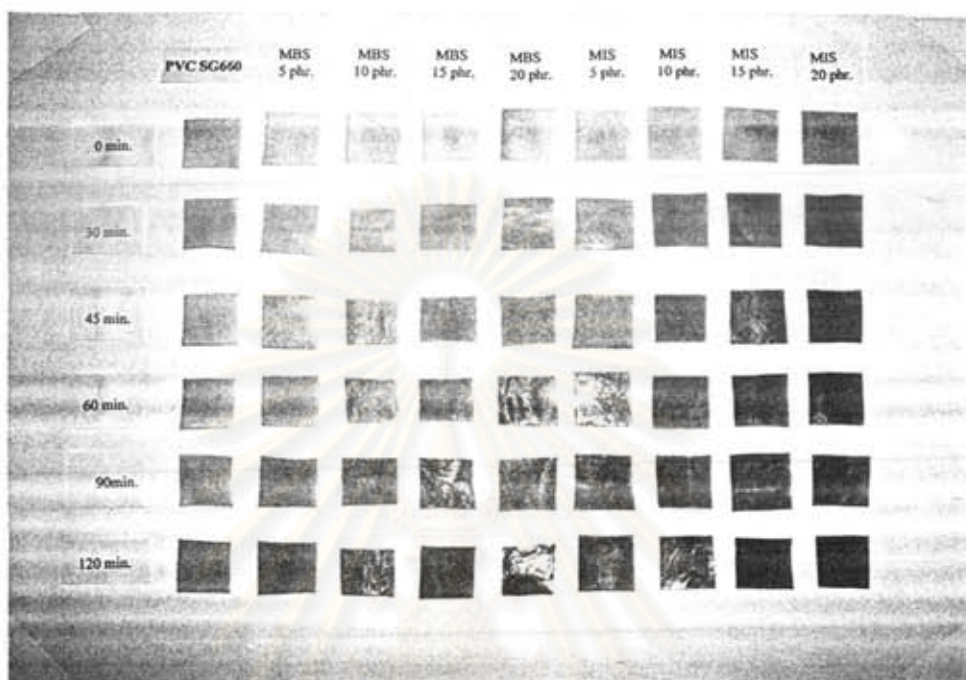


Figure G. The testing of oven heat stability of the PVC/grafted NR product and PVC/MBS blends at 177°C for 120 min.

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VITA

Kitikorn charmondusit was born on June 12, 1973, in Bangkok, Thailand. He received the Bachelor's Degree in Industrial Chemistry from the Faculty of Applied Science, King Mongkut's Institute of Technology North Bangkok in 1995. He has been a graduate student in the Program of Petrochemistry and Polymer Science, Graduate School, Chulalongkorn University since 1995.



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