

## REFERENCES

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## APPENDIXES

## Appendix A

### 1. Total Solids (ASTM D 1076)

Calculate the percentage of total solids as follows:

$$\text{Total solids, \%} = \frac{\text{mass of dried sample}}{\text{mass of sample}} \times 100$$

No.	mass of sample(g)	mass of dried sample(g)	Total solids(%)
1	2.54	1.57	61.81
2	2.52	1.56	61.90

The average of two determinations was the result of total solids of 61.85%

### 2. Dry Rubber Content (ASTM D 1076)

Calculate the percentage of dry rubber content as follows:

$$\text{Dry rubber content, \%} = \frac{\text{mass of dried coagulum}}{\text{mass of sample}} \times 100$$

No.	mass of sample(g)	mass of dried coagulum(g)	Dry rubber content(%)
1	10.37	6.25	60.27
2	10.14	6.11	60.25

The average of two determinations was the result of dry rubber content of 60.26 %

## Appendix B

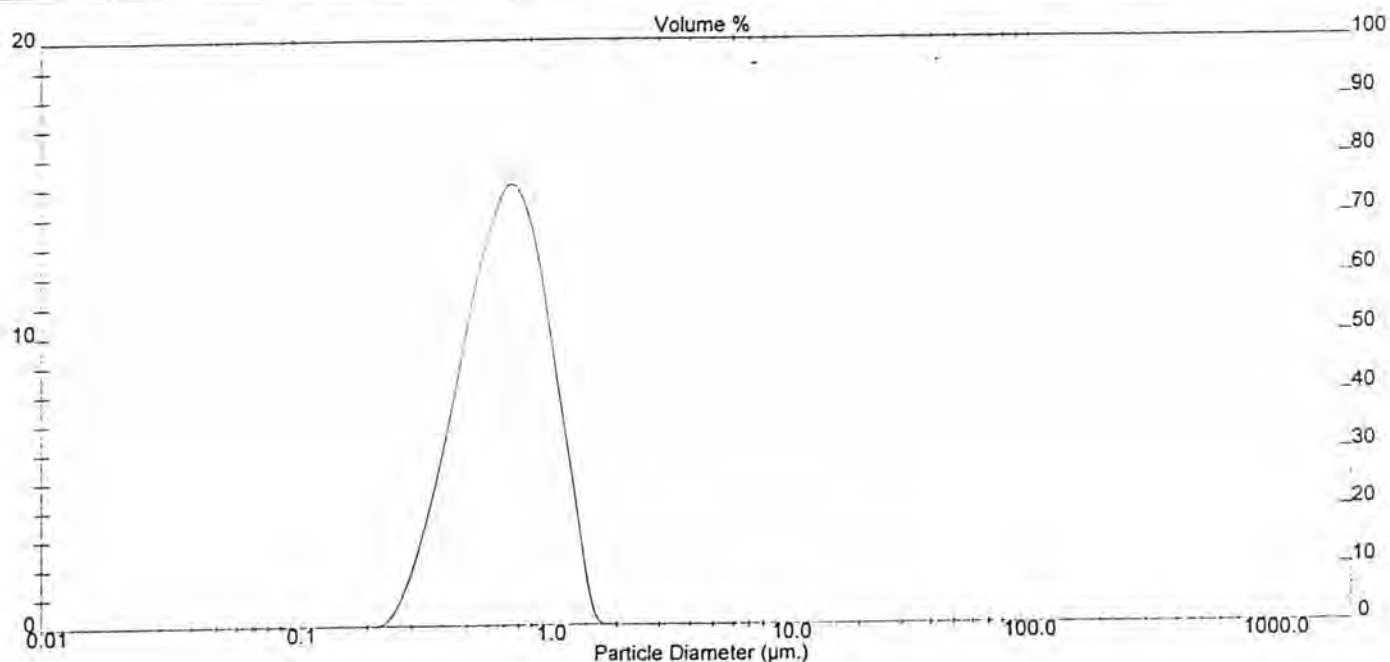
## Result: Analysis Report

Sample Details		Measurement Date: Thu, Aug 06, 1998 2.28PM
Sample ID: NR latex	Run Number: 1	Analysis Date: Thu, Aug 06, 1998 2.28PM
Sample File: RETICLE	Record Number: 32	Result Source: Analysed
Sample Path: A1		
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University Liquid medium : WATER		

System Details		Sampler: MS17	Obscuration: 25.3 %
Range Lens: 300RF mm	Beam Length: 2.40 mm		Residual: 0.889 %
Presentation: 30HD	[Particle R.I. = (1.5295, 0.1000); Dispersant R.I. = 1.3300]		
Analysis Model: Polydisperse			
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0044 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 9.2612 sq. m / g
Mean Diameters:	D (v, 0.1) = 0.42 $\mu$ m	D (v, 0.5) = 0.71 $\mu$ m	D (v, 0.9) = 1.13 $\mu$ m
D [4, 3] = 0.75 $\mu$ m	D [3, 2] = 0.65 $\mu$ m	Span = 1.007E+00	Uniformity = 3.095E-01

Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%	Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%
0.05	0.00	0.06	0.00	6.63	0.00	7.72	100.00
0.06	0.00	0.07	0.00	7.72	0.00	9.00	100.00
0.07	0.00	0.08	0.00	9.00	0.00	10.48	100.00
0.08	0.00	0.09	0.00	10.48	0.00	12.21	100.00
0.09	0.00	0.11	0.00	12.21	0.00	14.22	100.00
0.11	0.00	0.13	0.00	14.22	0.00	16.57	100.00
0.13	0.00	0.15	0.00	16.57	0.00	19.31	100.00
0.15	0.00	0.17	0.00	19.31	0.00	22.49	100.00
0.17	0.00	0.20	0.00	22.49	0.00	26.20	100.00
0.20	0.00	0.23	0.00	26.20	0.00	30.53	100.00
0.23	0.32	0.27	0.32	30.53	0.00	35.56	100.00
0.27	1.49	0.31	1.81	35.56	0.00	41.43	100.00
0.31	3.36	0.36	5.18	41.43	0.00	48.27	100.00
0.36	5.69	0.42	10.87	48.27	0.00	56.23	100.00
0.42	8.45	0.49	19.32	56.23	0.00	65.51	100.00
0.49	11.41	0.58	30.73	65.51	0.00	76.32	100.00
0.58	13.59	0.67	44.32	76.32	0.00	88.91	100.00
0.67	14.97	0.78	59.29	88.91	0.00	103.58	100.00
0.78	14.49	0.91	73.78	103.58	0.00	120.67	100.00
0.91	12.16	1.06	85.94	120.67	0.00	140.58	100.00
1.06	8.42	1.24	94.37	140.58	0.00	163.77	100.00
1.24	4.69	1.44	99.05	163.77	0.00	190.80	100.00
1.44	0.95	1.68	100.00	190.80	0.00	222.28	100.00
1.68	0.00	1.95	100.00	222.28	0.00	258.95	100.00
2.28	0.00	2.28	100.00	258.95	0.00	301.68	100.00
2.65	0.00	2.65	100.00	301.68	0.00	351.46	100.00
3.09	0.00	3.09	100.00	351.46	0.00	409.45	100.00
3.60	0.00	3.60	100.00	409.45	0.00	477.01	100.00
4.19	0.00	4.19	100.00	477.01	0.00	555.71	100.00
4.88	0.00	4.88	100.00	555.71	0.00	647.41	100.00
5.69	0.00	5.69	100.00	647.41	0.00	754.23	100.00
		6.63	100.00	754.23	0.00	878.67	100.00



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Figure B.1 Chart diagram showing the size distribution of rubber particles (run number 1)

Specific S.A. = 9.2612 sq. m/g

Diameter = 0.71  $\mu$ m

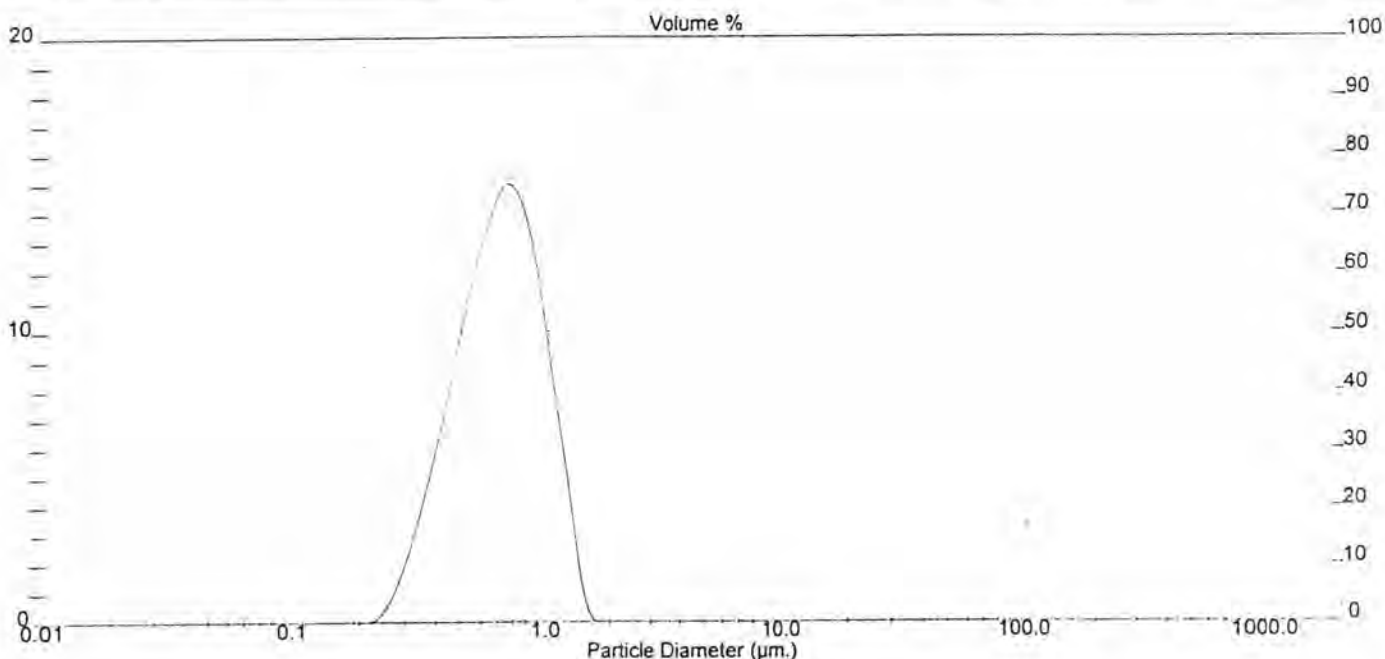
## Result: Analysis Report

Sample Details		
Sample ID: NR latex	Run Number: 2	Measurement Date: Thu, Aug 06, 1998 2:28PM
Sample File: RETICLE	Record Number: 33	Analysis Date: Thu, Aug 06, 1998 2:28PM
Sample Path: A\1		Result Source: Analysed
Sample Notes: Test by Pranee Scientific and Technological Research Equipment Centre Chulalongkorn University Liquid medium: WATER		

System Details			
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17	Obscuration: 25.7 %
Presentation: 30HD	[Particle R.I. = ( 1.5295, 0.1000), Dispersant R.I. = 1.3300]		Residual: 0.920 %
Analysis Model: Polydisperse			
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0045 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 9.2716 sq. m / g
Mean Diameters:	D (v, 0.1) = 0.41 $\mu$ m	D (v, 0.5) = 0.71 $\mu$ m	D (v, 0.9) = 1.13 $\mu$ m
D [4, 3] = 0.75 $\mu$ m	D [3, 2] = 0.65 $\mu$ m	Span = 1.013E+00	Uniformity = 3.115E-01

Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%	Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%
0.05	0.00	0.06	0.00	5.53	0.00	7.72	100.00
0.06	0.00	0.07	0.00	7.72	0.00	9.00	100.00
0.07	0.00	0.08	0.00	9.00	0.00	10.48	100.00
0.08	0.00	0.09	0.00	10.48	0.00	12.21	100.00
0.09	0.00	0.11	0.00	12.21	0.00	14.22	100.00
0.11	0.00	0.13	0.00	14.22	0.00	16.57	100.00
0.13	0.00	0.15	0.00	16.57	0.00	19.31	100.00
0.15	0.00	0.17	0.00	19.31	0.00	22.49	100.00
0.17	0.00	0.20	0.00	22.49	0.00	26.20	100.00
0.20	0.00	0.23	0.00	26.20	0.00	30.53	100.00
0.23	0.35	0.27	0.35	30.53	0.00	35.56	100.00
0.27	1.53	0.31	1.89	35.56	0.00	41.43	100.00
0.31	3.40	0.36	5.29	41.43	0.00	48.27	100.00
0.36	5.72	0.42	11.02	48.27	0.00	56.23	100.00
0.42	8.46	0.49	19.47	56.23	0.00	65.51	100.00
0.49	11.38	0.58	30.85	65.51	0.00	76.32	100.00
0.58	13.53	0.67	44.38	76.32	0.00	88.91	100.00
0.67	14.88	0.78	59.26	88.91	0.00	103.58	100.00
0.78	14.41	0.91	73.67	103.58	0.00	120.67	100.00
0.91	12.12	1.06	85.79	120.67	0.00	140.58	100.00
1.06	8.43	1.24	94.22	140.58	0.00	163.77	100.00
1.24	4.74	1.44	98.96	163.77	0.00	190.80	100.00
1.44	1.04	1.68	100.00	190.80	0.00	222.28	100.00
1.68	0.00	1.95	100.00	222.28	0.00	258.95	100.00
1.95	0.00	2.28	100.00	258.95	0.00	301.68	100.00
2.28	0.00	2.65	100.00	301.68	0.00	351.46	100.00
2.65	0.00	3.09	100.00	351.46	0.00	409.45	100.00
3.09	0.00	3.60	100.00	409.45	0.00	477.01	100.00
3.60	0.00	4.19	100.00	477.01	0.00	555.71	100.00
4.19	0.00	4.88	100.00	555.71	0.00	647.41	100.00
4.88	0.00	5.69	100.00	647.41	0.00	754.23	100.00
5.69	0.00	6.63	100.00	754.23	0.00	878.67	100.00



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Serial Number: 32734/42

Figure B.1 Chart diagram showing the size distribution of rubber particles (run number 2)

Specific S.A. = 9.2716 sq. m/g

Diameter = 0.71  $\mu$ m



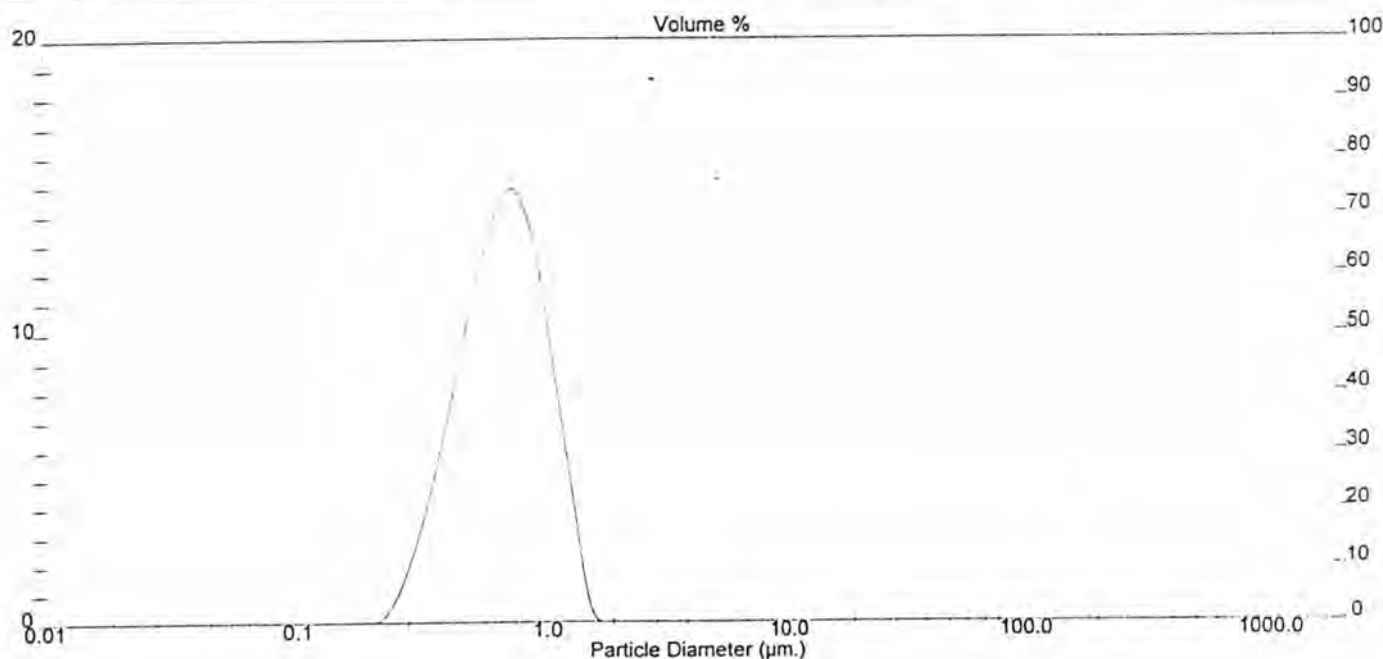
## Result: Analysis Report

Sample Details		
Sample ID: NR latex	Run Number: 3	Measurement Date: Thu, Aug 06, 1998 2:28PM
Sample File: RETICLE	Record Number: 34	Analysis Date: Thu, Aug 06, 1998 2:29PM
Sample Path: A\		Result Source: Analysed
Sample Notes: Test by Pranee Scientific and Technological Research Equipment Centre Chulalongkorn University Liquid medium: WATER		

System Details		
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17
Presentation: 3OHD	(Particle R.I. = ( 1.5295, 0.1000); Dispersant R.I. = 1.3300)	Obscuration: 25.4 %
Analysis Model: Polydisperse		Residual: 0.992 %
Modifications: None		

Result Statistics			
Distribution Type: Volume	Concentration = 0.0044 %Vol	Density = 1.000 g / cub cm	Specific S.A. = 9.2758 sq m / g
Mean Diameters:	D (v, 0.1) = 0.41 $\mu$ m	D (v, 0.5) = 0.71 $\mu$ m	D (v, 0.9) = 1.14 $\mu$ m
D [4, 3] = 0.75 $\mu$ m	D [3, 2] = 0.65 $\mu$ m	Span = 1.021E+00	Uniformity = 3.138E-01

Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%	Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%
0.05	0.00	0.06	0.00	5.63	0.00	7.72	100.00
0.06	0.00	0.07	0.00	7.72	0.00	9.00	100.00
0.07	0.00	0.08	0.00	9.00	0.00	10.48	100.00
0.08	0.00	0.09	0.00	10.48	0.00	12.21	100.00
0.09	0.00	0.11	0.00	12.21	0.00	14.22	100.00
0.11	0.00	0.13	0.00	14.22	0.00	16.57	100.00
0.13	0.00	0.15	0.00	16.57	0.00	19.31	100.00
0.15	0.00	0.17	0.00	19.31	0.00	22.49	100.00
0.17	0.00	0.20	0.00	22.49	0.00	26.20	100.00
0.20	0.00	0.23	0.00	26.20	0.00	30.53	100.00
0.23	0.36	0.27	0.36	30.53	0.00	35.56	100.00
0.27	1.56	0.31	1.93	35.56	0.00	41.43	100.00
0.31	3.44	0.36	5.37	41.43	0.00	48.27	100.00
0.36	5.76	0.42	11.13	48.27	0.00	56.23	100.00
0.42	8.47	0.49	19.60	56.23	0.00	65.51	100.00
0.49	11.35	0.58	30.96	65.51	0.00	76.32	100.00
0.58	13.47	0.67	44.42	76.32	0.00	88.91	100.00
0.67	14.78	0.78	59.21	88.91	0.00	103.58	100.00
0.78	14.32	0.91	73.52	103.58	0.00	120.67	100.00
0.91	12.06	1.06	85.59	120.67	0.00	140.58	100.00
1.06	8.43	1.24	94.02	140.58	0.00	163.77	100.00
1.24	4.80	1.44	98.82	163.77	0.00	190.80	100.00
1.44	1.18	1.68	100.00	190.80	0.00	222.28	100.00
1.68	0.00	1.95	100.00	222.28	0.00	258.95	100.00
1.95	0.00	2.28	100.00	258.95	0.00	301.68	100.00
2.28	0.00	2.65	100.00	301.68	0.00	351.46	100.00
2.65	0.00	3.09	100.00	351.46	0.00	409.45	100.00
3.09	0.00	3.60	100.00	409.45	0.00	477.01	100.00
3.60	0.00	4.19	100.00	477.01	0.00	555.71	100.00
4.19	0.00	4.88	100.00	555.71	0.00	647.41	100.00
4.88	0.00	5.69	100.00	647.41	0.00	754.23	100.00
5.69	0.00	6.63	100.00	754.23	0.00	878.67	100.00



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Serial Number: 32734/42

Figure B.1 Chart diagram showing the size distribution of rubber particles (run number 3)

Specific S.A. = 9.2758 sq. m/g

Diameter = 0.71  $\mu$ m

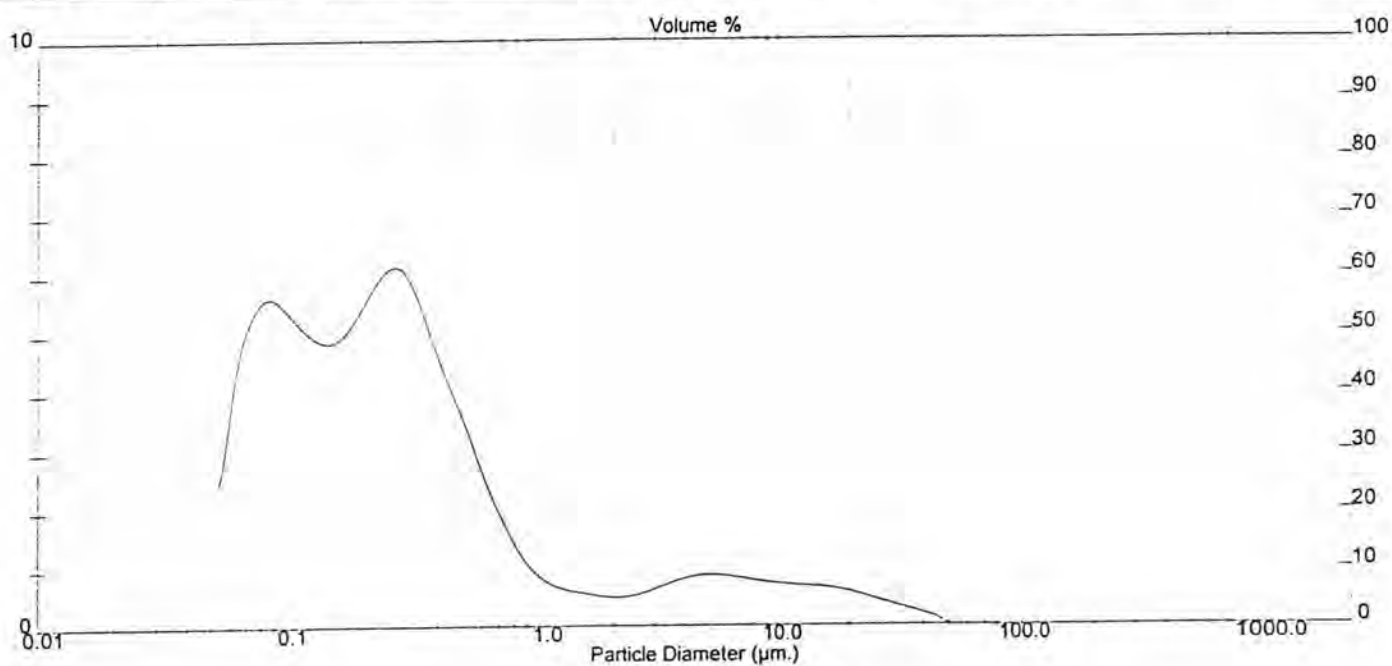
## Result: Analysis Report

Sample Details		
Sample ID: carbon black	Run Number: 1	Measurement Date: Thu, Aug 06, 1998 2:13PM
Sample File: RETICLE	Record Number: 29	Analysis Date: Thu, Aug 06, 1998 2:13PM
Sample Path: A.1		Result Source: Analysed
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University. Liquid medium : WATER		

System Details			
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler MS17	Obscuration: 26.7 %
Presentation: 30HD	[Particle R.I. = ( 1.5295, 0.1000);	Dispersant R.I. = 1.3300]	Residual: 0.899 %
Analysis Model: Polydisperse			
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0060 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 34.2379 sq. m / g
Mean Diameters:	D (v, 0.1) = 0.07 $\mu$ m	D (v, 0.5) = 0.24 $\mu$ m	D (v, 0.9) = 4.10 $\mu$ m
D [4, 3] = 1.69 $\mu$ m	D [3, 2] = 0.18 $\mu$ m	Span = 1.679E+01	Uniformity = 6.529E+00

Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%	Size_Low ( $\mu$ m)	In %	Size_High ( $\mu$ m)	Under%
0.05	2.43	0.06	2.43	6.53	0.83	7.72	93.57
0.06	4.22	0.07	6.66	7.72	0.78	9.00	94.35
0.07	5.25	0.08	11.91	9.00	0.74	10.48	95.09
0.08	5.58	0.09	17.49	10.48	0.71	12.21	95.80
0.09	5.43	0.11	22.92	12.21	0.69	14.22	96.50
0.11	5.12	0.13	28.04	14.22	0.67	16.57	97.17
0.13	4.88	0.15	32.92	16.57	0.64	19.31	97.80
0.15	4.86	0.17	37.79	19.31	0.58	22.49	98.38
0.17	5.11	0.20	42.90	22.49	0.49	26.20	98.87
0.20	5.57	0.23	48.47	26.20	0.41	30.53	99.28
0.23	6.02	0.27	54.49	30.53	0.32	35.56	99.61
0.27	6.08	0.31	60.56	35.56	0.24	41.43	99.85
0.31	5.54	0.36	66.11	41.43	0.15	48.27	100.00
0.36	4.72	0.42	70.83	48.27	0.00	56.23	100.00
0.42	3.99	0.49	74.82	56.23	0.00	65.51	100.00
0.49	3.29	0.58	78.10	65.51	0.00	76.32	100.00
0.58	2.48	0.67	80.58	76.32	0.00	88.91	100.00
0.67	1.82	0.78	82.39	88.91	0.00	103.58	100.00
0.78	1.26	0.91	83.66	103.58	0.00	120.67	100.00
0.91	0.91	1.06	84.57	120.67	0.00	140.58	100.00
1.06	0.71	1.24	85.28	140.58	0.00	163.77	100.00
1.24	0.62	1.44	85.89	163.77	0.00	190.80	100.00
1.44	0.56	1.68	86.46	190.80	0.00	222.28	100.00
1.68	0.52	1.95	86.98	222.28	0.00	258.95	100.00
1.95	0.50	2.28	87.48	258.95	0.00	301.68	100.00
2.28	0.53	2.65	88.01	301.68	0.00	351.46	100.00
2.65	0.61	3.09	88.62	351.46	0.00	409.45	100.00
3.09	0.71	3.60	89.32	409.45	0.00	477.01	100.00
3.60	0.80	4.19	90.12	477.01	0.00	555.71	100.00
4.19	0.87	4.88	90.99	555.71	0.00	647.41	100.00
4.88	0.89	5.69	91.88	647.41	0.00	754.23	100.00
5.69	0.87	6.53	92.74	754.23	0.00	878.67	100.00



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Serial Number: 32734/42

Figure B.2 Chart diagram showing the size distribution of the aqueous dispersions of the additives (run number 1)

Specific S.A. = 34.2379 sq. m/g

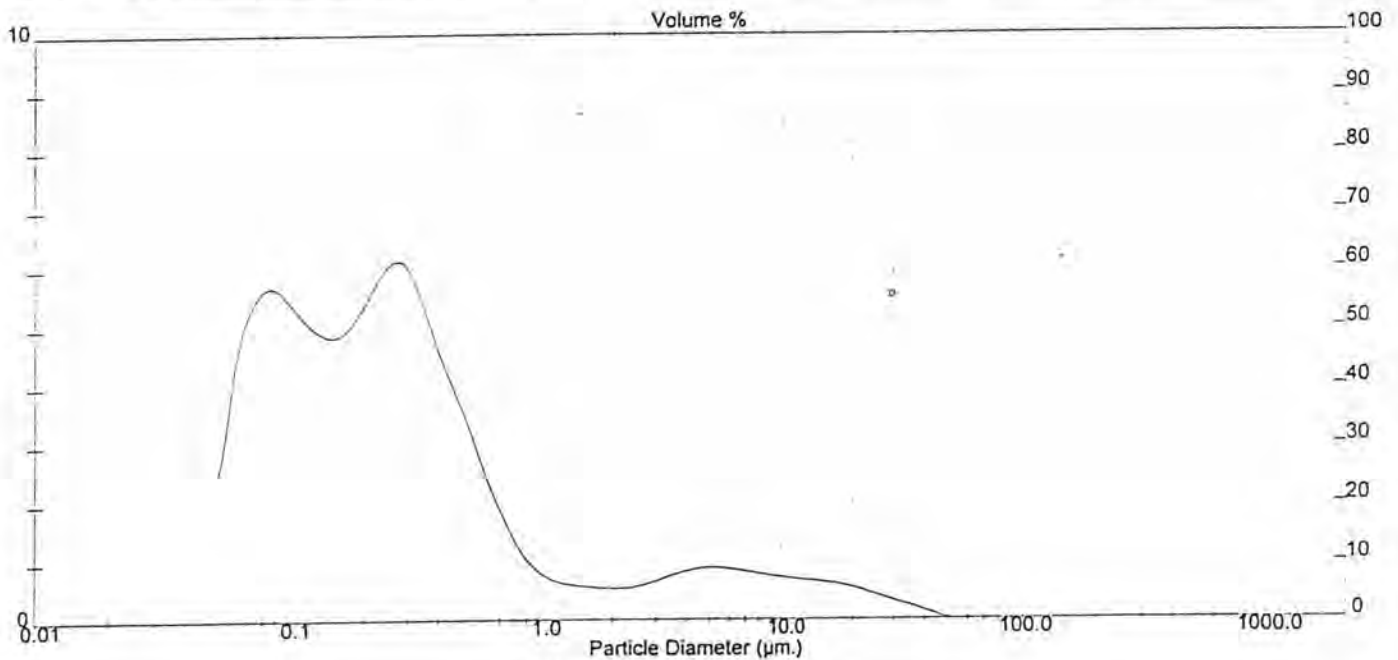
Diameter = 0.24  $\mu$ m

Sample Details		
Sample ID: carbon black	Run Number: 2	Measurement Date: Thu, Aug 06, 1998 2:13PM
Sample File: RETICLE	Record Number: 30	Analysis Date: Thu, Aug 06, 1998 2:13PM
Sample Path: A.1		Result Source: Analysed
Sample Notes: Test by Pranee : Scientific and Technological Research Equipment Centre Chulalongkorn University Liquid medium : WATER		

System Details			
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17	Obscuration: 26.6 %
Presentation: 30HD	(Particle R.I. = ( 1.5295, 0.1000);	Dispersant R.I. = 1.3300)	Residual: 0.937 %
Analysis Model: Polydisperse			
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0060 %Vol	Density = 1.000 g / cub. cm	Specific S.A. = 34 5276 sq. m / g
Mean Diameters:	D [v, 0.1] = 0.07 um	D [v, 0.5] = 0.24 um	D [v, 0.9] = 3.89 um
D [4, 3] = 1.60 um	D [3, 2] = 0.17 um	Span = 1.606E+01	Uniformity = 6.200E+00

Size_Low (um)	In %	Size_High (um)	Under%	Size_Low (um)	In %	Size_High (um)	Under%
0.05	2.49	0.06	2.49	6.63	0.83	7.72	93.91
0.06	4.31	0.07	6.80	7.72	0.78	9.00	94.69
0.07	5.34	0.08	12.15	9.00	0.74	10.48	95.43
0.08	5.66	0.09	17.80	10.48	0.71	12.21	96.13
0.09	5.48	0.11	23.29	12.21	0.68	14.22	96.81
0.11	5.14	0.13	28.43	14.22	0.65	16.57	97.47
0.13	4.89	0.15	33.32	16.57	0.61	19.31	98.08
0.15	4.86	0.17	38.18	19.31	0.54	22.49	98.62
0.17	5.10	0.20	43.28	22.49	0.45	26.20	99.08
0.20	5.56	0.23	48.84	26.20	0.37	30.53	99.44
0.23	6.01	0.27	54.86	30.53	0.28	35.56	99.72
0.27	6.07	0.31	60.92	35.56	0.19	41.43	99.90
0.31	5.52	0.36	66.45	41.43	0.10	48.27	100.00
0.36	4.69	0.42	71.14	48.27	0.00	56.23	100.00
0.42	3.95	0.49	75.09	56.23	0.00	65.51	100.00
0.49	3.25	0.58	78.34	65.51	0.00	76.32	100.00
0.58	2.44	0.67	80.78	76.32	0.00	88.91	100.00
0.67	1.77	0.78	82.55	88.91	0.00	103.58	100.00
0.78	1.23	0.91	83.78	103.58	0.00	120.67	100.00
0.91	0.88	1.06	84.65	120.67	0.00	140.58	100.00
1.06	0.69	1.24	85.34	140.58	0.00	163.77	100.00
1.24	0.62	1.44	85.96	163.77	0.00	190.80	100.00
1.44	0.58	1.68	86.54	190.80	0.00	222.28	100.00
1.68	0.55	1.95	87.09	222.28	0.00	258.95	100.00
1.95	0.54	2.28	87.64	258.95	0.00	301.68	100.00
2.28	0.57	2.65	88.21	301.68	0.00	351.46	100.00
2.65	0.64	3.09	88.85	351.46	0.00	409.45	100.00
3.09	0.74	3.60	89.59	409.45	0.00	477.01	100.00
3.60	0.83	4.19	90.42	477.01	0.00	555.71	100.00
4.19	0.88	4.88	91.30	555.71	0.00	647.41	100.00
4.88	0.90	5.69	92.20	647.41	0.00	754.23	100.00
5.69	0.87	6.63	93.08	754.23	0.00	878.67	100.00



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Serial Number: 32734/42

Figure B.2 Chart diagram showing the size distribution of the aqueous dispersions of the additives (run number 2)

Specific S.A. = 34.5276 sq. m/g

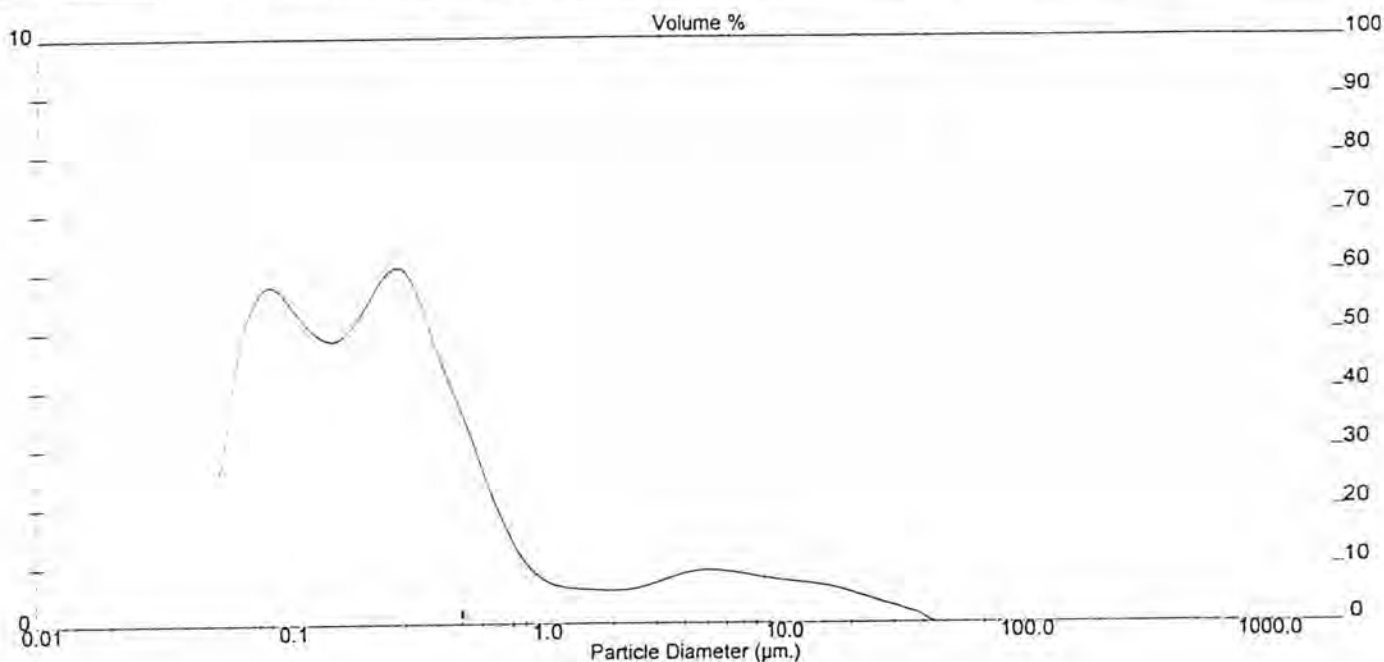
Diameter = 0.24 µm

Sample Details		
Sample ID: carbon black	Run Number: 3	Measurement Date: Thu, Aug 05, 1998 2:14PM
Sample File: RETICLE	Record Number: 31	Analysis Date: Thu, Aug 05, 1998 2:14PM
Sample Path: A:\		Result Source: Analysed
Sample Notes: Test by Pranee Scientific and Technological Research Equipment Centre Chulalongkorn University. Liquid medium: WATER		

System Details			
Range Lens: 300RF mm	Beam Length: 2.40 mm	Sampler: MS17	Obscuration: 25.6 %
Presentation: 30HD	[Particle RI = ( 1.5295, 0.1000), Dispersant RI = 1.3300]		Residual: 0.924 %
Analysis Model: Polydisperse			
Modifications: None			

Result Statistics			
Distribution Type: Volume	Concentration = 0.0060 %Vol	Density = 1.000 g / cub. cm	Specific S.A = 34.7844 sq. m / g
Mean Diameters:	D (v, 0.1) = 0.07 um	D (v, 0.5) = 0.24 um	D (v, 0.9) = 3.78 um
D [4, 3] = 1.52 um	D [3, 2] = 0.17 um	Span = 1.576E+01	Uniformity = 5.935E+00

Size_Low (um)	In %	Size_High (um)	Under%	Size_Low (um)	In %	Size_High (um)	Under%
0.05	2.54	0.06	2.54	6.63	0.84	7.72	94.12
0.06	4.40	0.07	6.94	7.72	0.79	9.00	94.91
0.07	5.43	0.08	12.37	9.00	0.75	10.48	95.66
0.08	5.73	0.09	18.10	10.48	0.72	12.21	96.38
0.09	5.54	0.11	23.64	12.21	0.69	14.22	97.08
0.11	5.18	0.13	28.82	14.22	0.65	16.57	97.73
0.13	4.90	0.15	33.72	16.57	0.59	19.31	98.33
0.15	4.85	0.17	38.57	19.31	0.51	22.49	98.83
0.17	5.08	0.20	43.66	22.49	0.42	26.20	99.25
0.20	5.53	0.23	49.19	26.20	0.33	30.53	99.59
0.23	5.98	0.27	55.17	30.53	0.25	35.56	99.84
0.27	6.02	0.31	61.19	35.56	0.16	41.43	100.00
0.31	5.48	0.36	66.67	41.43	0.00	48.27	100.00
0.36	4.65	0.42	71.32	48.27	0.00	56.23	100.00
0.42	3.91	0.49	75.23	56.23	0.00	65.51	100.00
0.49	3.21	0.58	78.44	65.51	0.00	76.32	100.00
0.58	2.40	0.67	80.84	76.32	0.00	88.91	100.00
0.67	1.74	0.78	82.58	88.91	0.00	103.58	100.00
0.78	1.20	0.91	83.79	103.58	0.00	120.67	100.00
0.91	0.86	1.06	84.64	120.67	0.00	140.58	100.00
1.06	0.68	1.24	85.32	140.58	0.00	163.77	100.00
1.24	0.62	1.44	85.94	163.77	0.00	190.80	100.00
1.44	0.59	1.68	86.53	190.80	0.00	222.28	100.00
1.68	0.58	1.95	87.11	222.28	0.00	258.95	100.00
1.95	0.57	2.28	87.68	258.95	0.00	301.68	100.00
2.28	0.61	2.65	88.29	301.68	0.00	351.46	100.00
2.65	0.67	3.09	88.97	351.46	0.00	409.45	100.00
3.09	0.77	3.60	89.73	409.45	0.00	477.01	100.00
3.60	0.85	4.19	90.58	477.01	0.00	555.71	100.00
4.19	0.90	4.88	91.48	555.71	0.00	647.41	100.00
4.88	0.91	5.69	92.39	647.41	0.00	754.23	100.00
5.69	0.88	6.63	93.28	754.23	0.00	878.67	100.00



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Serial Number: 32734/42

Figure B.2 Chart diagram showing the size distribution of the aqueous dispersions of the additives (run number 3)

Specific S.A. = 34.7844 sq. m/g

Diameter = 0.24 µm

### Rheometer data of compounded sheets containing carbon black type N330

**Test :** Rheometer

**Time Mode :** Time base

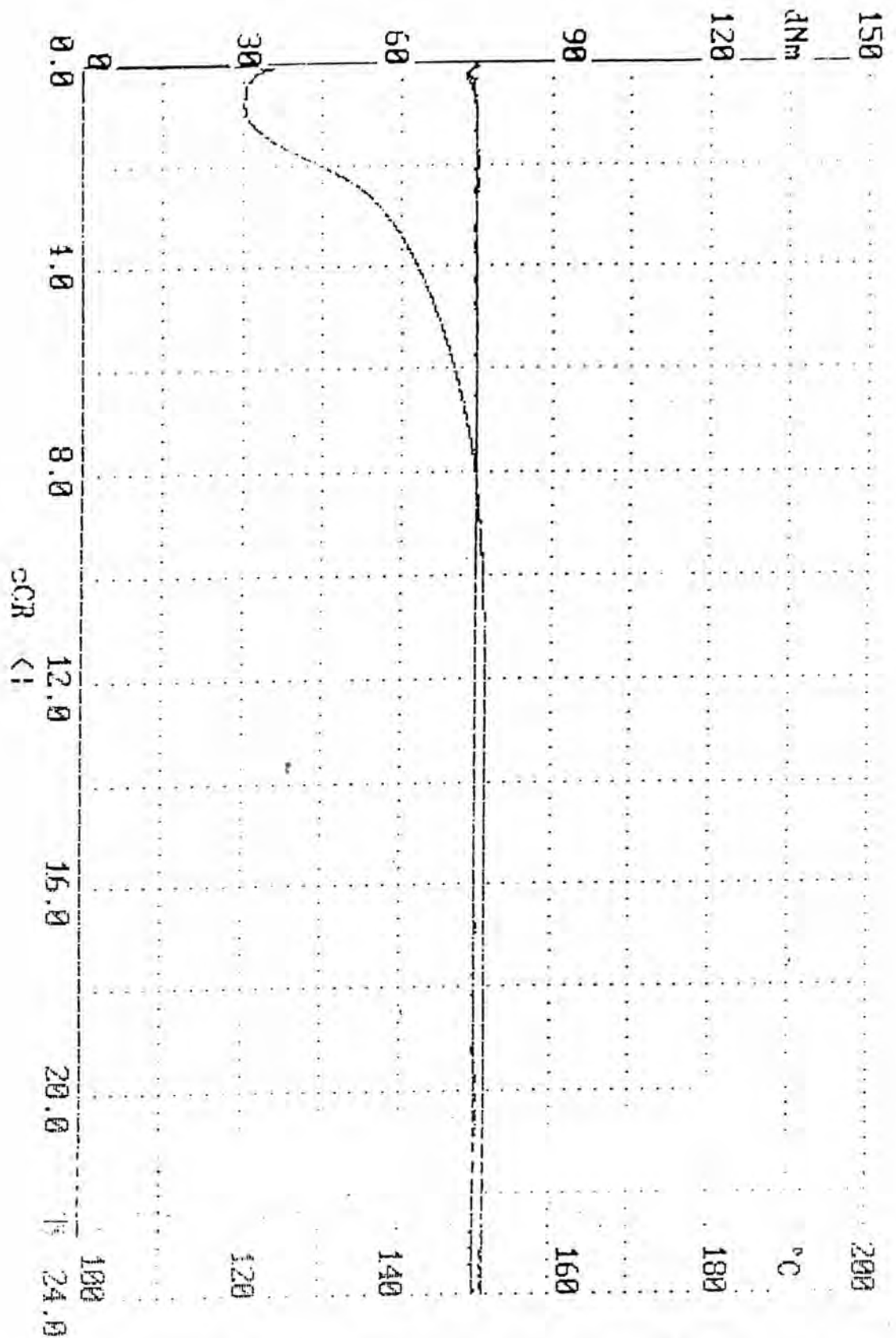
Curves	Torque	Temp. U	Temp. L
Units	dNm	°C	°C
Full Scale	150	100...200	100...200

**Arc Degree :** 3

**Temperature :** 150.0

**Testing Time :** 24

Rheometer Data	Results
$M_I$ – Initial Peak	35.7
$M_L$ – Minimum Torque	30.2
$t_{ML}$ – Time Min Torque	0.48
$t_{S1}$ – Scorch Time	1.07
$t_{S2}$ – Scorch Time	1.14
$t_{S05}$ – Scorch Time	1.30
$M_H$ – Max Torque	77.1
$t_{MH}$ – Time MH	14.44
Torque 90	72.4
$t_{90}$ – Time Torque 90	6.42
Torque 50	53.6
$t_X$ – Time Torque X	2.34
RH – Cure Speed	0.2
$t_{RH}$ – Time RH	1.42
$t_{R01}$ – Reversion Time	0.00



Client: WRAPGEN

Client: WRAPGEN

M ID: SAE00000

M ID: SAE00000

Date: 30-09-1999

Time: 10:29:37

Temp: 150.0 °C

Figure B.3 Cure curve of compounded sheet that used to determine the appropriate time of mixing

**Rheometer data of compounded sheets containing carbon black type N220**

**Test :** Rheometer

**Time Mode :** Time base

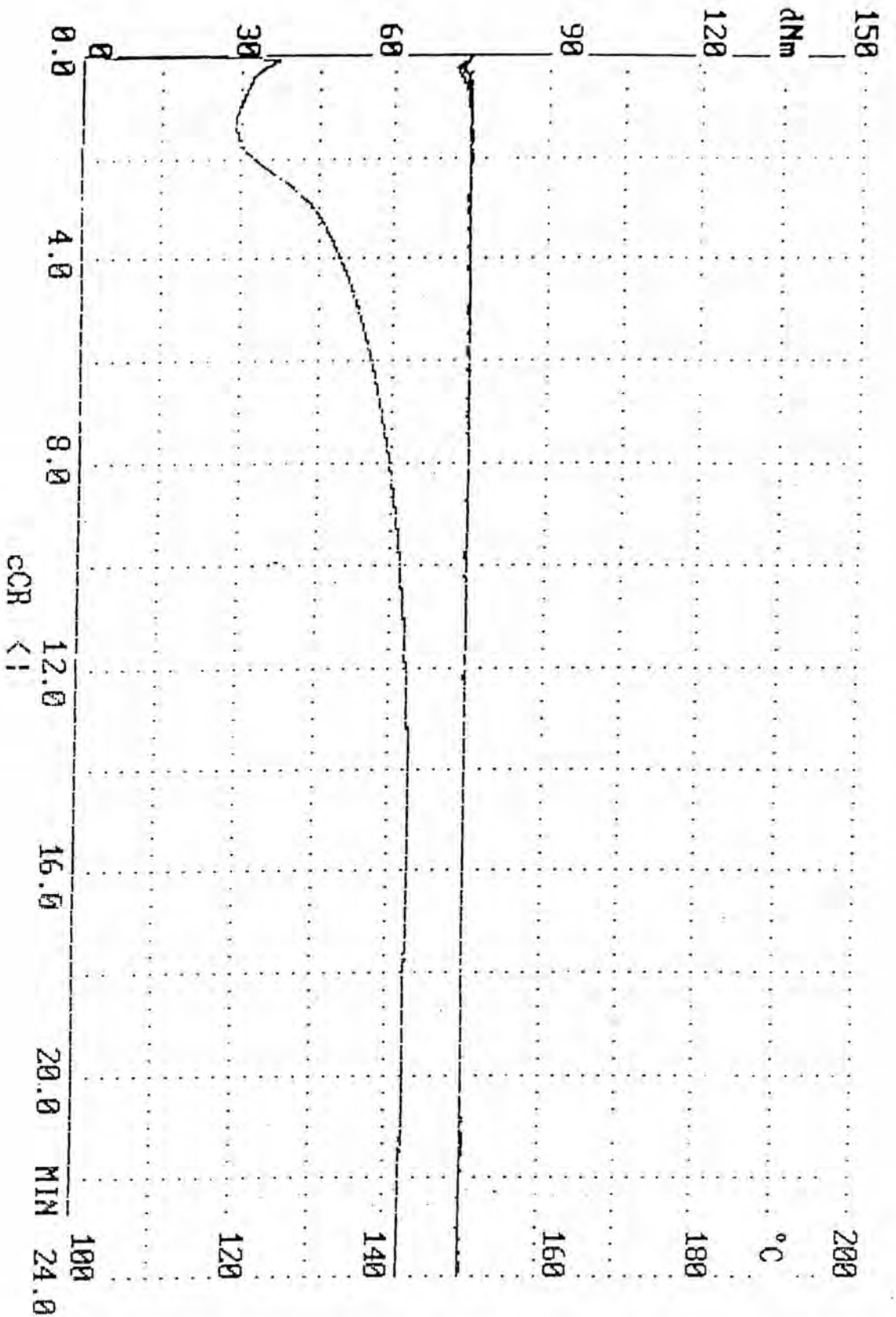
Curves	Torque	Temp. U	Temp. L
Units	dNm	°C	°C
Full Scale	150	100...200	100...200

**Arc Degree :** 3

**Temperature :** 150.0

**Testing Time :** 24

Rheometer Data	Results
M <sub>I</sub> – Initial Peak	37.1
M <sub>L</sub> – Minimum Torque	29.0
t <sub>ML</sub> – Time Min Torque	1.21
t <sub>S1</sub> – Scorch Time	1.42
t <sub>S2</sub> – Scorch Time	1.50
t <sub>S05</sub> – Scorch Time	2.08
M <sub>H</sub> – Max Torque	64.1
t <sub>MH</sub> – Time MH	15.32
Torque 90	60.6
t <sub>90</sub> – Time Torque 90	8.43
Torque 50	46.5
t <sub>X</sub> – Time Torque X	3.27
RH – Cure Speed	0.1
t <sub>RH</sub> – Time RH	2.23
t <sub>R01</sub> – Reversion Time	0.00



Company: RUBBER TECHNOLOGY DIVISION Client: VARAFORN

R\_ID SAEFN220 M\_ID SAE00000  
 Date: 30-06-1998 Time: 11:03:25 Temper: 150.0 °C

\*\*

Figure B.4 Cure curve of compounded sheet containing carbon black type N220



### Rheometer data of compounded sheets containing Tergitol NP9

Test : Rheometer

Time Mode : Time base

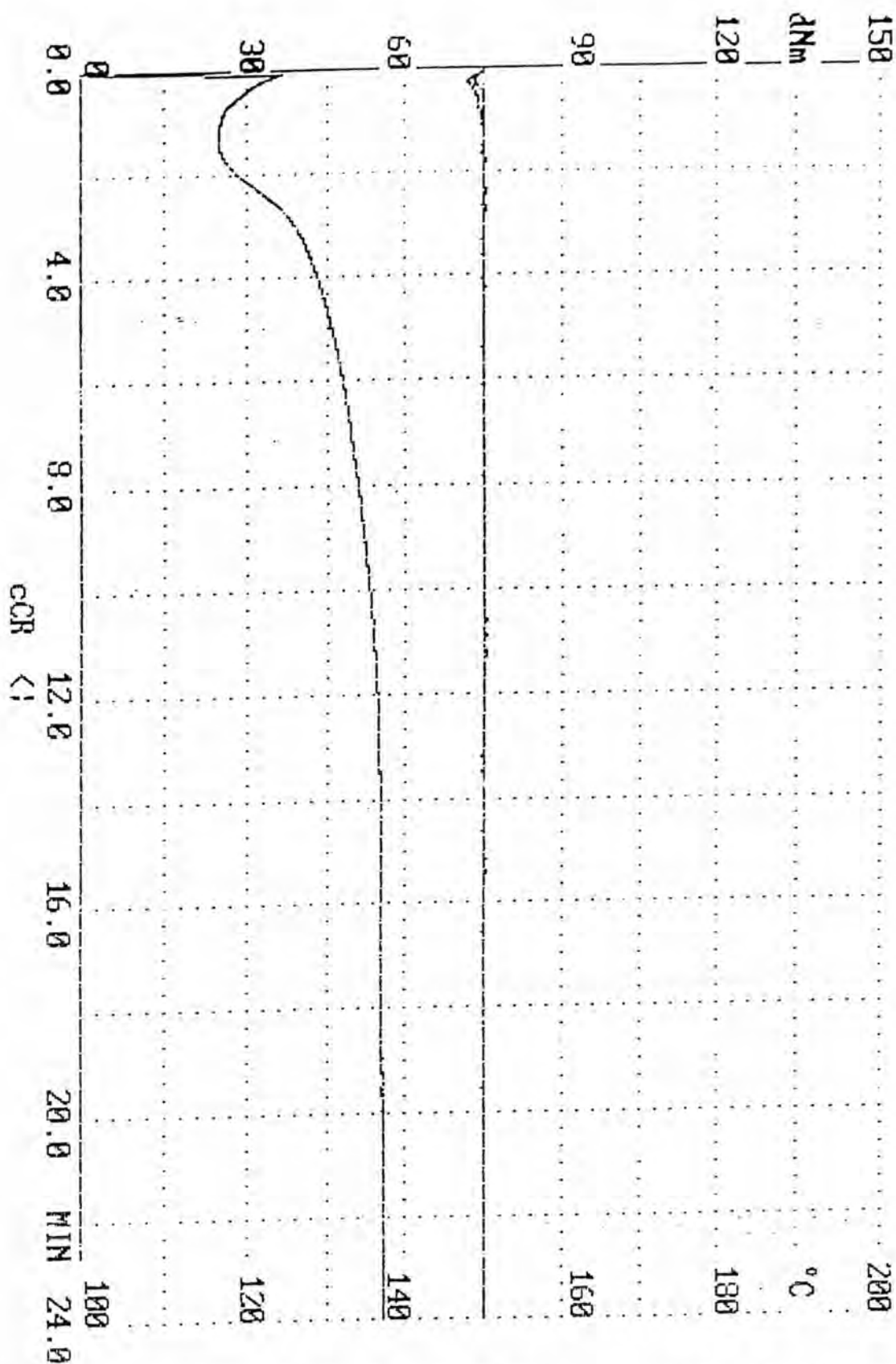
Curves	Torque	Temp. U	Temp. L
Units	dNm	°C	°C
Full Scale	150	100...200	100...200

Arc Degree : 3

Temperature : 150.0

Testing Time : 24

Rheometer Data	Results
M <sub>I</sub> – Initial Peak	36.4
M <sub>L</sub> – Minimum Torque	24.8
t <sub>ML</sub> – Time Min Torque	1.20
t <sub>S1</sub> – Scorch Time	1.41
t <sub>S2</sub> – Scorch Time	1.50
t <sub>S05</sub> – Scorch Time	2.08
M <sub>H</sub> – Max Torque	55.9
t <sub>MH</sub> – Time MH	23.33
Torque 90	52.8
t <sub>90</sub> – Time Torque 90	9.36
Torque 50	40.4
t <sub>X</sub> – Time Torque X	3.17
RH – Cure Speed	0.1
t <sub>RH</sub> – Time RH	2.28
t <sub>R01</sub> – Reversion Time	0.00



Company: RUBBER TECHNOLOGY DIVISION Client: VARAFORN

R ID SAEFONPG M ID SAE00000  
 Date: 30-06-1998 Time: 12:00:52 Temper: 150.0 °C

\*\*  
 Figure B.5 Cure curve of compounded sheets containing Tergitol NP9

### Rheometer data of compounded sheets containing SDS

**Test :** Rheometer

**Time Mode :** Time base

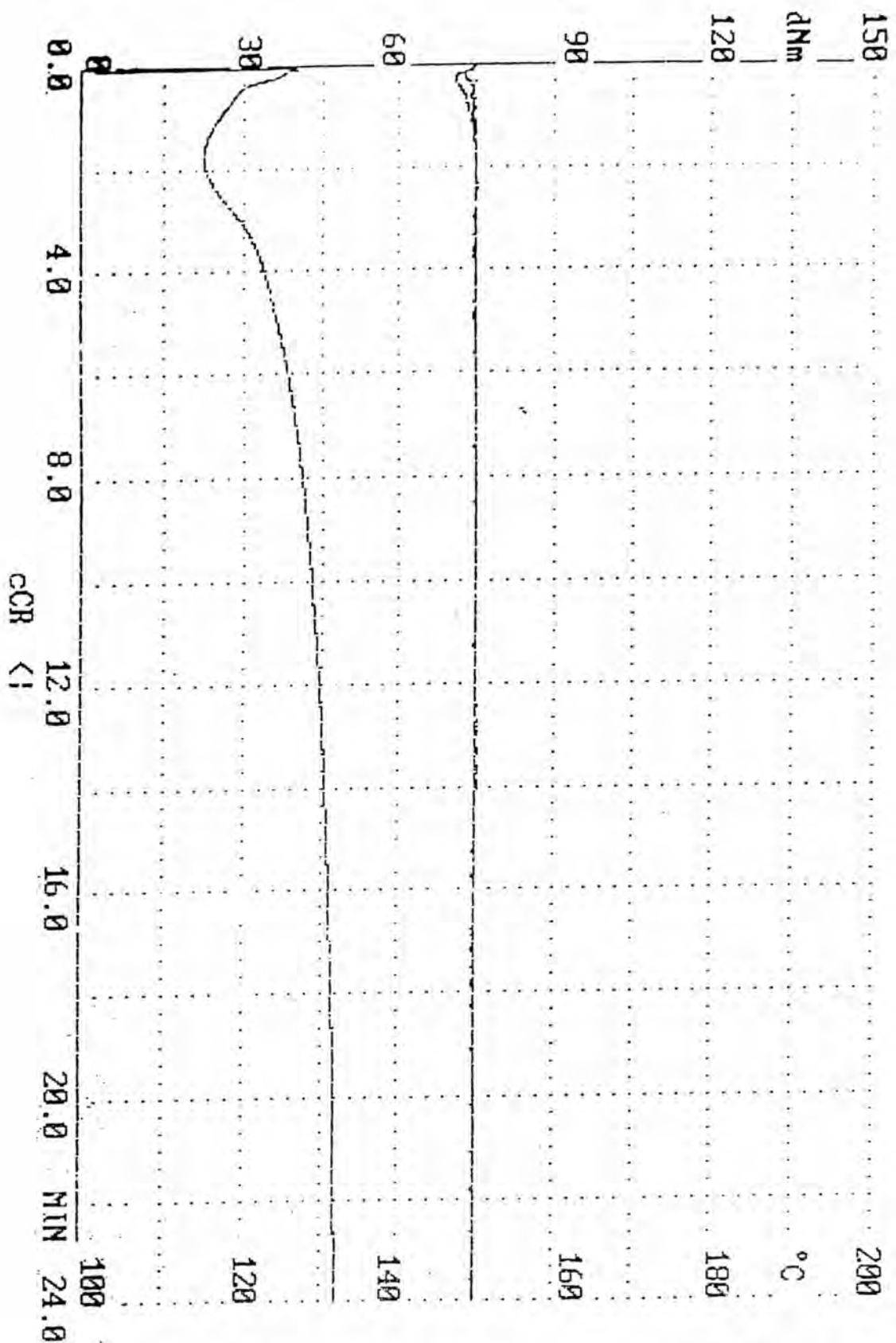
Curves	Torque	Temp. U	Temp. L
Units	dNm	°C	°C
Full Scale	150	100...200	100...200

**Arc Degree :** 3

**Temperature :** 150.0

**Testing Time :** 24

Rheometer Data	Results
M <sub>I</sub> – Initial Peak	40.1
M <sub>L</sub> – Minimum Torque	22.4
t <sub>ML</sub> – Time Min Torque	1.47
t <sub>S1</sub> – Scorch Time	2.10
t <sub>S2</sub> – Scorch Time	2.22
t <sub>S05</sub> – Scorch Time	2.46
M <sub>H</sub> – Max Torque	48.0
t <sub>MH</sub> – Time MH	23.37
Torque 90	45.4
t <sub>90</sub> – Time Torque 90	13.36
Torque 50	35.2
t <sub>X</sub> – Time Torque X	4.33
RH – Cure Speed	0.1
t <sub>RH</sub> – Time RH	2.54
t <sub>R01</sub> – Reversion Time	0.00



Company: RUBBER TECHNOLOGY DIVISION

Client: VARAFORN

R ID SAEPOSDS M ID SAE00000

Date: 30-06-1978 Time: 11:32:18 Temper: 150.0 °C

\*\*  
Figure B.6 Cure curve of compounded sheets containing SDS

## Appendix C

Assessment of carbon black dispersion- Rapid comparative methods (ISO 11345)

Method A : Visual microscopic or photographic/microscopic inspection

The dispersion level of carbon black is compared with a series of ten photographic stored standards and then rated numerically from 10 (excellent) to 1 (very poor). A state of dispersion are shown as follows:

Visual dispersion rating	Dispersion classification
9-10	excellent
8	good
7	acceptable
5-6	doubtful
3-4	poor
1-2	very poor

The photographic standards are shown in Figure C.1. The optical micrographs of carbon black dispersion of vulcanized sheets are shown in Figure C.2 .

A scanning electron microscope was also used to study the carbon black dispersion of some vulcanized sheets and scanning electron micrographs are shown in Figure C.3.

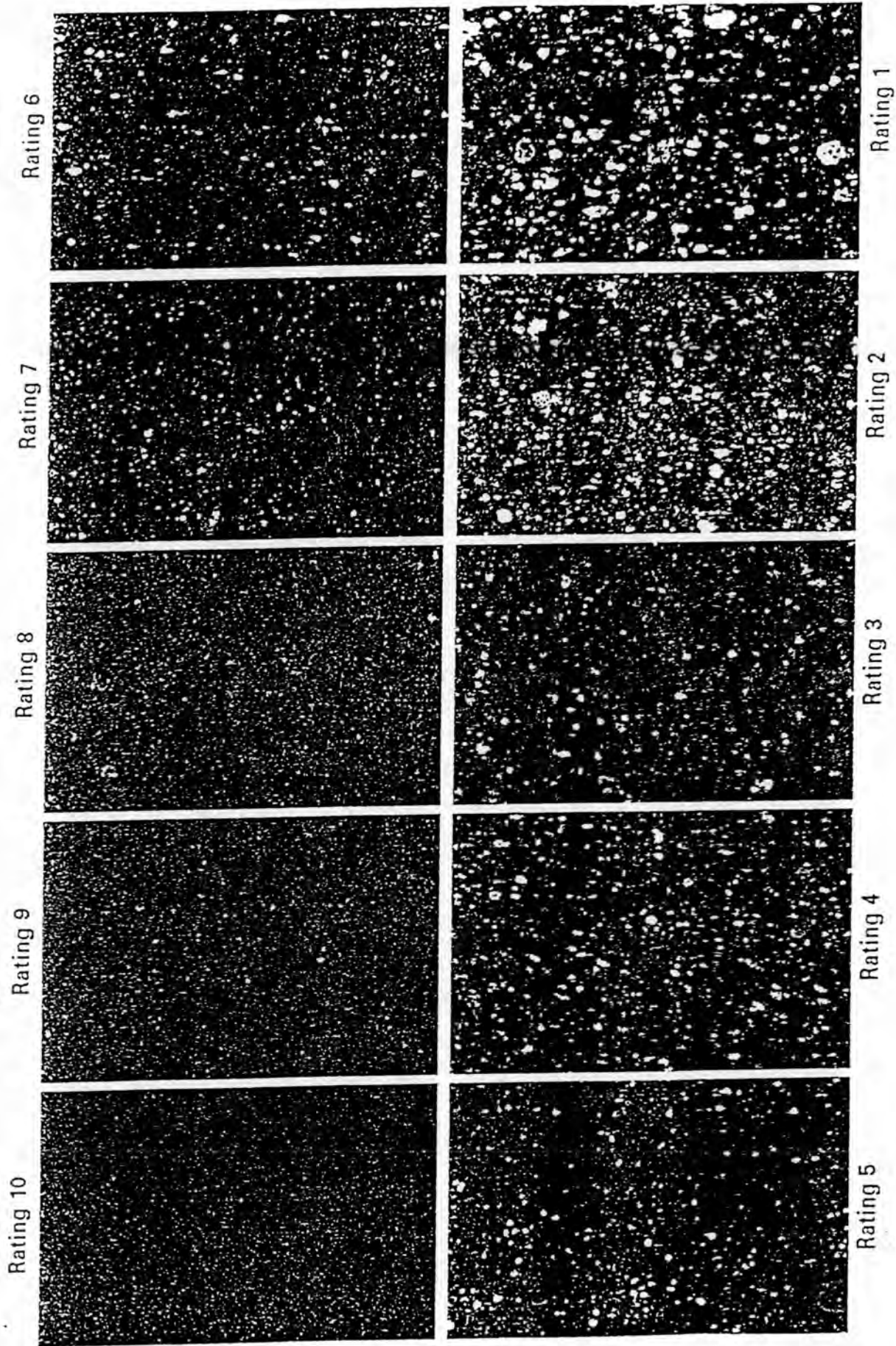


Figure C.1 Photographic standards



DR. = 4.5

Vulcanized sheet obtained from preparing aqueous dispersions of the additives 1 hr.



DR. = 4.5

Vulcanized sheet obtained from preparing aqueous dispersions of the additives 2 hr.

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets



DR. = 5.0

Vulcanized sheet obtained from preparing aqueous dispersions of the additives 3 hr.



DR. = 5.0

Vulcanized sheet obtained from preparing aqueous dispersions of the additives 4 hr.

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)





DR. = 5.0

Vulcanized sheet obtained from preparing aqueous dispersions of the additives 5 hr.



DR. = 4.5

Vulcanized sheet containing sulfur 1 phr

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 4.5

Vulcanized sheet containing sulfur 3 phr



DR. = 4.5

Vulcanized sheet containing sulfur 4 phr

Figure C.2 Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 4.5

Vulcanized sheet containing low amount of accelerator and accelerator activator



DR. = 4.5

Vulcanized sheet containing high amount of accelerator and accelerator activator

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 5.0

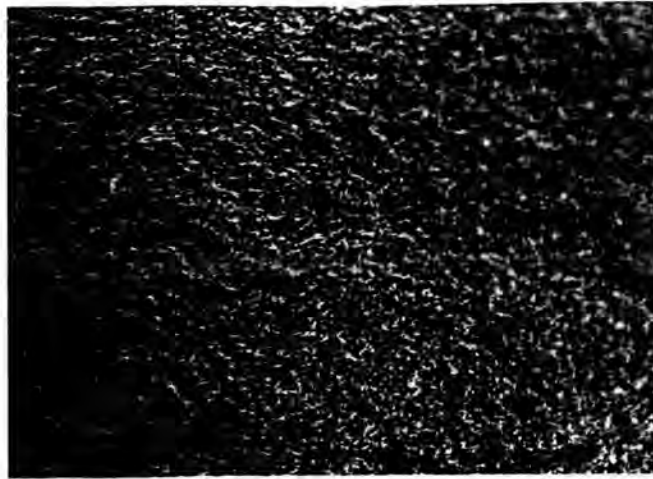
Vulcanized sheet containing carbon black type N220



DR. = 5.0

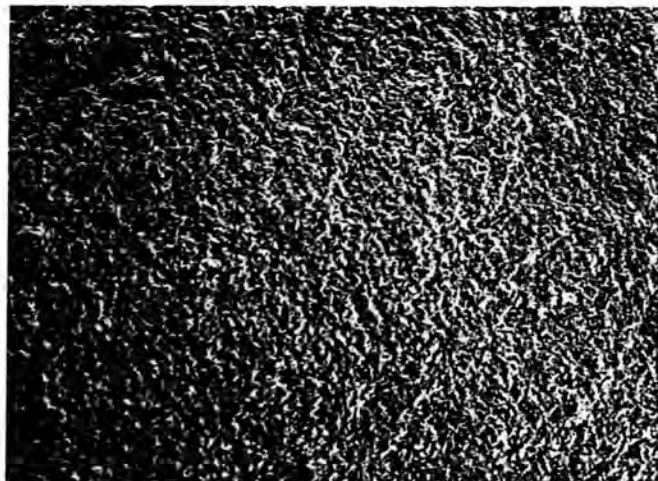
Vulcanized sheet containing Tergitol NP9 as surfactant

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 4.5

Vulcanized sheet containing SDS as surfactant



DR. = 5.5

Vulcanized sheet containing carbon black type N330 10 phr

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 5.0

Vulcanized sheet containing carbon black type N330 35 phr



DR. = 4.5

Vulcanized sheet containing carbon black type N330 45 phr

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



DR. = 6.5

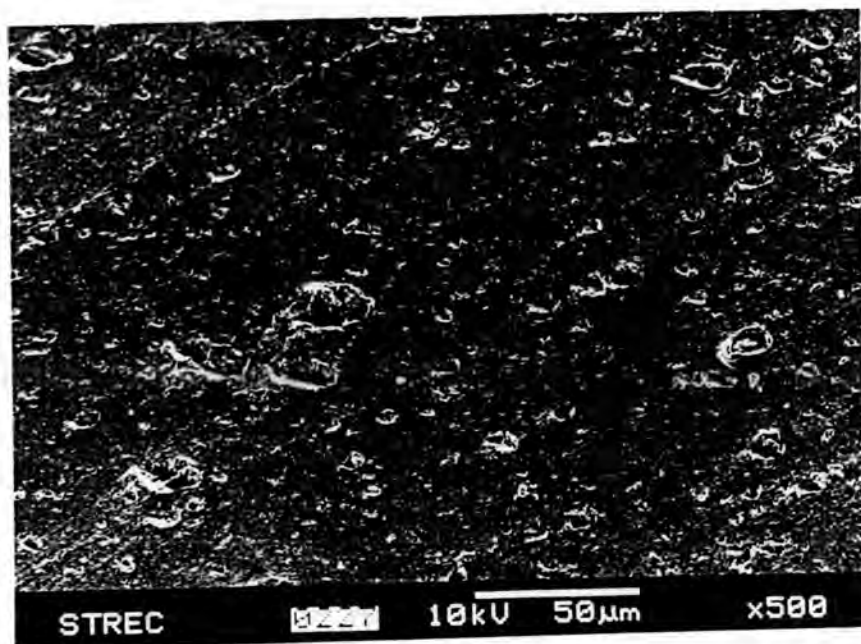
Vulcanized sheet that prepared by two-roll mills (raw rubber – smoked sheet rubber)



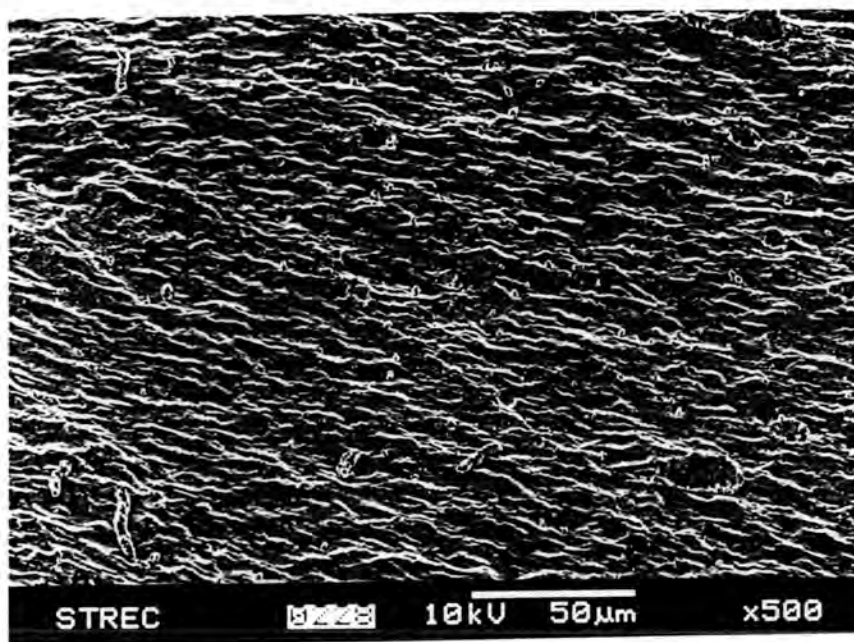
DR. = 6.5

Vulcanized sheet that prepared by two-roll mills (raw rubber – coagulate from concentrated natural rubber latex).

**Figure C.2** Optical micrographs of carbon black dispersion of vulcanized sheets (continued)



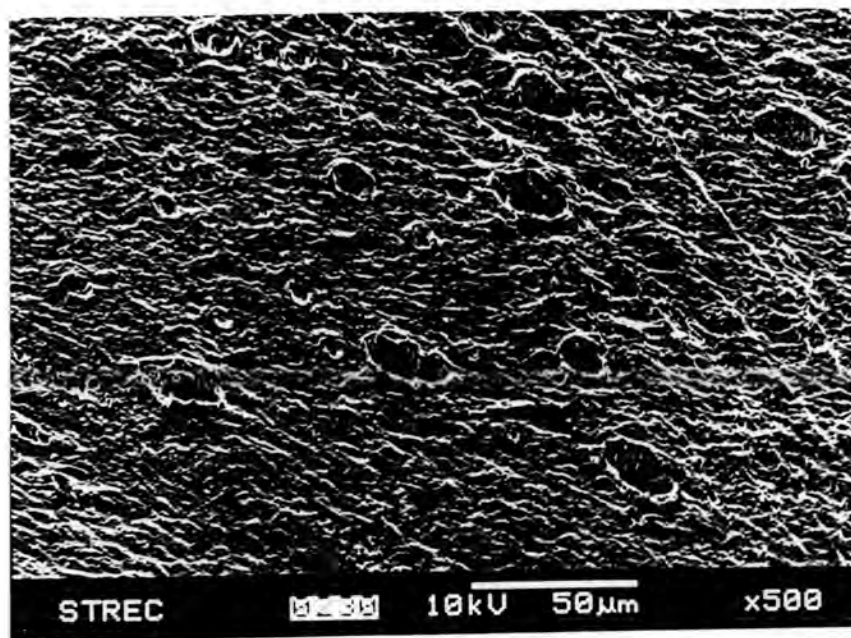
Scanning electron micrograph of vulcanized sheet containing sulfur 2 phr



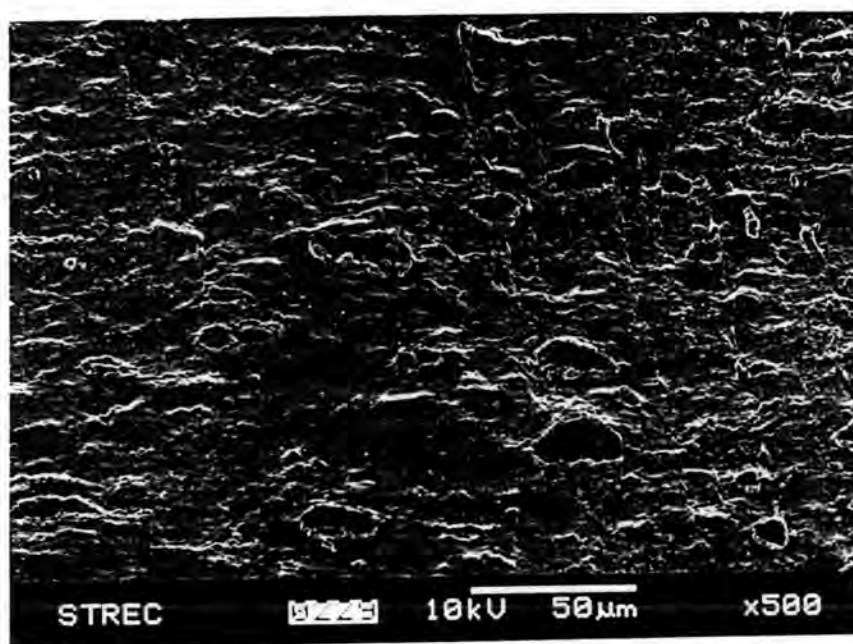
Scanning electron micrograph of vulcanized sheet containing carbon black type N220

**Figure C.3** Scanning electron micrographs of carbon black dispersion of vulcanized sheets



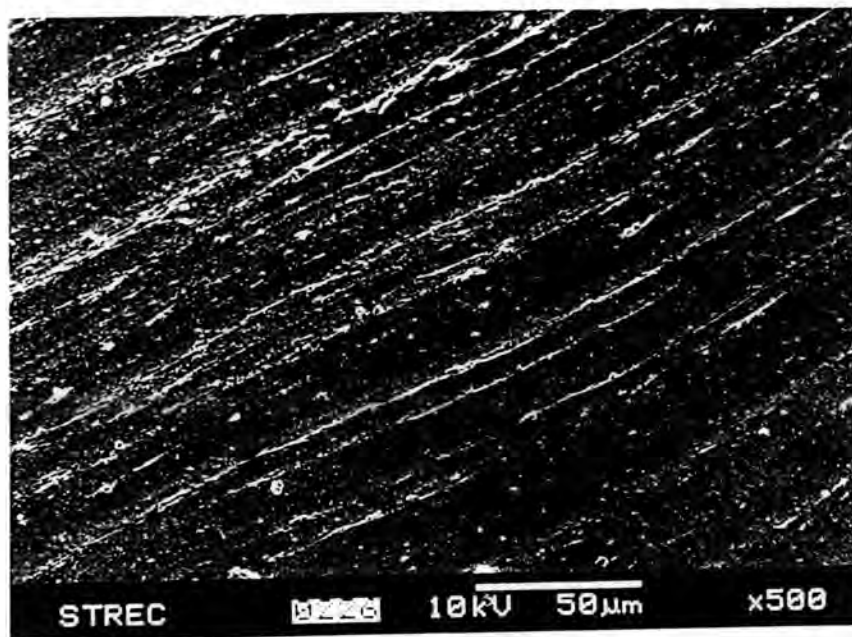


Scanning electron micrograph of vulcanized sheet containing Tergitol NP9 as surfactant

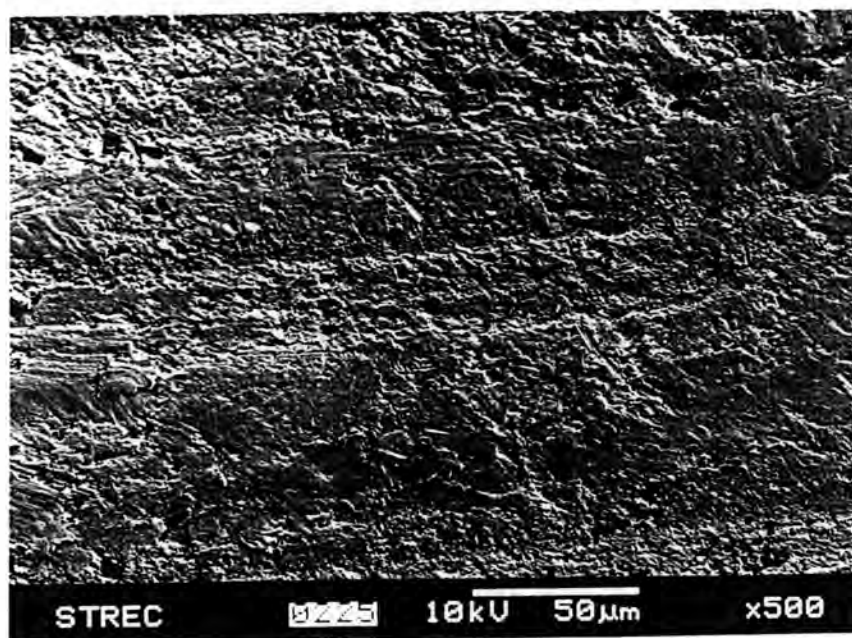


Scanning electron micrograph of vulcanized sheet containing SDS as surfactant

**Figure C.3** Scanning electron micrographs of carbon black dispersion of vulcanized sheets (continued)



Scanning electron micrograph of vulcanized sheet that prepared by two-roll mills (raw rubber – smoked sheet rubber)



Scanning electron micrograph of vulcanized sheet that prepared by two-roll mills (raw rubber – coagulate from concentrated natural rubber latex)

**Figure C.3** Scanning electron micrographs of carbon black dispersion of vulcanized sheets (continued)

## Appendix D

### 1. Tensile Strength of Vulcanized Sheets

**Table D.1** Tensile strength of vulcanized sheets at various time for preparing aqueous dispersions or mixing time

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
1	1	9.29	1	10.13	
	2	10.04	2	11.06	
	3	7.96	3	8.48	
	mean	9.10	mean	9.89	9.50
2	1	11.54	1	11.95	
	2	12.22	2	12.19	
	3	10.07	3	14.31	
	mean	11.28	mean	12.82	12.05
3	1	17.42	1	14.47	
	2	17.85	2	17.82	
	3	14.58	3	16.80	
	mean	16.62	mean	16.36	16.49
4	1	13.09	1	12.91	
	2	14.92	2	14.26	
	3	15.27	3	12.21	
	mean	14.43	mean	13.13	13.78

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
5	1	15.21	1	16.64	15.49
	2	14.43	2	14.94	
	3	15.67	3	16.05	
	mean	15.10	mean	15.88	

**Table D.2** Tensile strength of vulcanized sheets at various amount of sulfur

Amount of sulfur (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
1	1	8.90	1	11.12	10.81
	2	9.29	2	13.10	
	3	10.17	3	12.29	
	mean	9.45	mean	12.17	
2	The values are shown in Table D.1 at mixing time of 3 hr				
3	1	10.88	1	14.58	12.46
	2	10.27	2	12.75	
	3	12.15	3	14.10	
	mean	11.10	mean	13.81	
4	1	7.99	1	7.53	9.25
	2	8.93	2	11.24	
	3	10.53	3	9.27	
	mean	9.15	mean	9.35	

**Table D.3** Tensile strength of vulcanized sheets at various amount of accelerator and accelerator activator

Amount of Accelerator and accelerator activator	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
low	1	8.93	1	13.47	10.54
	2	8.21	2	10.91	
	3	10.56	3	11.16	
	mean	9.23	mean	11.85	
medium	The values are shown in Table D.1 at mixing time of 3 hr				
high	1	7.95	1	8.43	9.12
	2	8.71	2	9.77	
	3	8.31	3	11.54	
	mean	8.32	mean	9.91	

**Table D.4** Tensile strength of vulcanized sheets that change types of carbon black

Type of carbon black	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
N 220	1	10.90	1	13.81	11.74
	2	10.01	2	13.90	
	3	9.74	3	12.03	
	mean	10.22	mean	13.25	
N 330	The values are shown in Table D.1 at mixing time of 3 hr				

**Table D.5** Tensile strength of vulcanized sheets that change types of surfactant

Type of surfactant	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
Tergitol NP 9	1	10.06	1	12.50	13.08
	2	12.54	2	15.97	
	3	12.41	3	14.99	
	mean	11.67	mean	14.49	
Tergitol NP 10	The values are shown in Table D.1 at mixing time of 3 hr				
SDS	1	10.40	1	12.51	10.41
	2	8.87	2	10.34	
	3	8.36	3	11.95	
	mean	9.21	mean	11.60	

**Table D.6** Tensile strength of vulcanized sheets at various amount of carbon black

Amount of carbon black (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength (MPa)	specimen	Tensile strength (MPa)	
10	1	9.33	1	8.84	8.11
	2	8.98	2	6.64	
	3	7.98	3	6.89	
	mean	8.76	mean	7.46	
25	The values are shown in Table D.1 at mixing time of 3 hr				
35	1	13.73	1	12.05	12.47
	2	13.56	2	10.64	
	3	14.02	3	10.79	
	mean	13.77	mean	11.16	
45	1	10.18	1	13.99	11.10
	2	10.67	2	12.18	
	3	9.52	3	10.06	
	mean	10.12	mean	12.08	

**Table D.7** Tensile strength of vulcanized sheets that used Two-roll mill

Raw rubber	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tensile strength(MPa)	specimen	Tensile strength (MPa)	
Smoked sheet	1	12.57	1	11.17	
	2	13.15	2	12.07	
	3	15.20	3	10.38	
	mean	13.64	mean	11.21	12.43
Coagulate from conc.latex	1	7.94	1	7.68	
	2	9.39	2	7.20	
	3	8.82	3	7.52	
	mean	8.72	mean	7.47	8.10



## 2. Elongation of Vulcanized Sheets

Table D.8 Elongation of vulcanized sheets at various time for preparing aqueous dispersions or mixing time

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
1	1	1194	1	1161	1148
	2	1256	2	1234	
	3	1022	3	1022	
	mean	1157	mean	1139	
2	1	1361	1	1289	1358
	2	1389	2	1439	
	3	1161	3	1506	
	mean	1304	mean	1411	
3	1	1650	1	1339	1538
	2	1672	2	1611	
	3	1506	3	1450	
	mean	1609	mean	1467	
4	1	1287	1	1500	1459
	2	1485	2	1589	
	3	1471	3	1422	
	mean	1414	mean	1504	

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
5	1	1411	1	1583	1473
	2	1356	2	1478	
	3	1450	3	1556	
	mean	1406	mean	1539	

**Table D.9** Elongation of vulcanized sheets at various amount of sulfur

Amount of sulfur (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
1	1	1211	1	1039	1247
	2	1306	2	1445	
	3	1339	3	1139	
	mean	1285	mean	1208	
2	The values are shown in Table D.8 at mixing time of 3 hr				
3	1	1484	1	1417	1422
	2	1433	2	1289	
	3	1456	3	1450	
	mean	1458	mean	1385	
4	1	1022	1	805	1037
	2	1128	2	1044	
	3	1306	3	917	
	mean	1152	mean	922	

**Table D.10** Elongation of vulcanized sheets at various amount of accelerator and accelerator activator

Amount of Accelerator and accelerator activator	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
low	1	1258	1	1272	1256
	2	1195	2	1300	
	3	1297	3	1214	
	mean	1250	mean	1262	
medium	The values are shown in Table D.8 at mixing time of 3 hr				
high	1	927	1	956	999
	2	1011	2	1022	
	3	949	3	1130	
	mean	962	mean	1036	

**Table D.11** Elongation of vulcanized sheets that change type of carbon black

Type of carbon black	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
N 220	1	1484	1	1383	1267
	2	1201	2	1311	
	3	1156	3	1067	
	mean	1280	mean	1254	
N 330	The values are shown in Table D.8 at mixing time of 3 hr				

**Table D.12** Elongation of vulcanized sheets that change types of surfactant

Type of surfactant	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
Tergitol NP 9	1	1272	1	1183	1331
	2	1307	2	1508	
	3	1290	3	1422	
	mean	1290	mean	1371	
Tergitol NP 10	The values are shown in Table D.8 at mixing time of 3 hr				
SDS	1	1280	1	1350	1191
	2	1078	2	1217	
	3	1014	3	1206	
	mean	1124	mean	1258	

**Table D.13** Elongation of vulcanized sheets at various amount of carbon black

Amount of carbon black (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
10	1	1489	1	1237	1372
	2	1522	2	1283	
	3	1317	3	1384	
	mean	1443	mean	1301	
25	The values are shown in Table D.8 at mixing time of 3 hr				
35	1	1411	1	1247	1287
	2	1434	2	1061	
	3	1461	3	1105	
	mean	1435	mean	1138	
45	1	1106	1	1228	1106
	2	1161	2	1100	
	3	1100	3	939	
	mean	1122	mean	1089	

**Table D.14** Elongation of vulcanized sheets that used Two-roll mill

Raw rubber	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Elongation(%)	specimen	Elongation(%)	
Smoked sheet	1	1234	1	1072	1179
	2	1309	2	1072	
	3	1400	3	989	
	mean	1314	mean	1044	
Coagulate from conc.latex	1	844	1	878	914
	2	1028	2	895	
	3	944	3	894	
	mean	939	mean	889	

### 3. Modulus of Vulcanized Sheets

In this experiment, the modulus at 500% elongation were determine except the vulcanized sheet that used carbon black(N330) 10 phr. The datas were obtained from stress-strain curve. The curve was an average curve of three specimen in each vulcanized sheets.

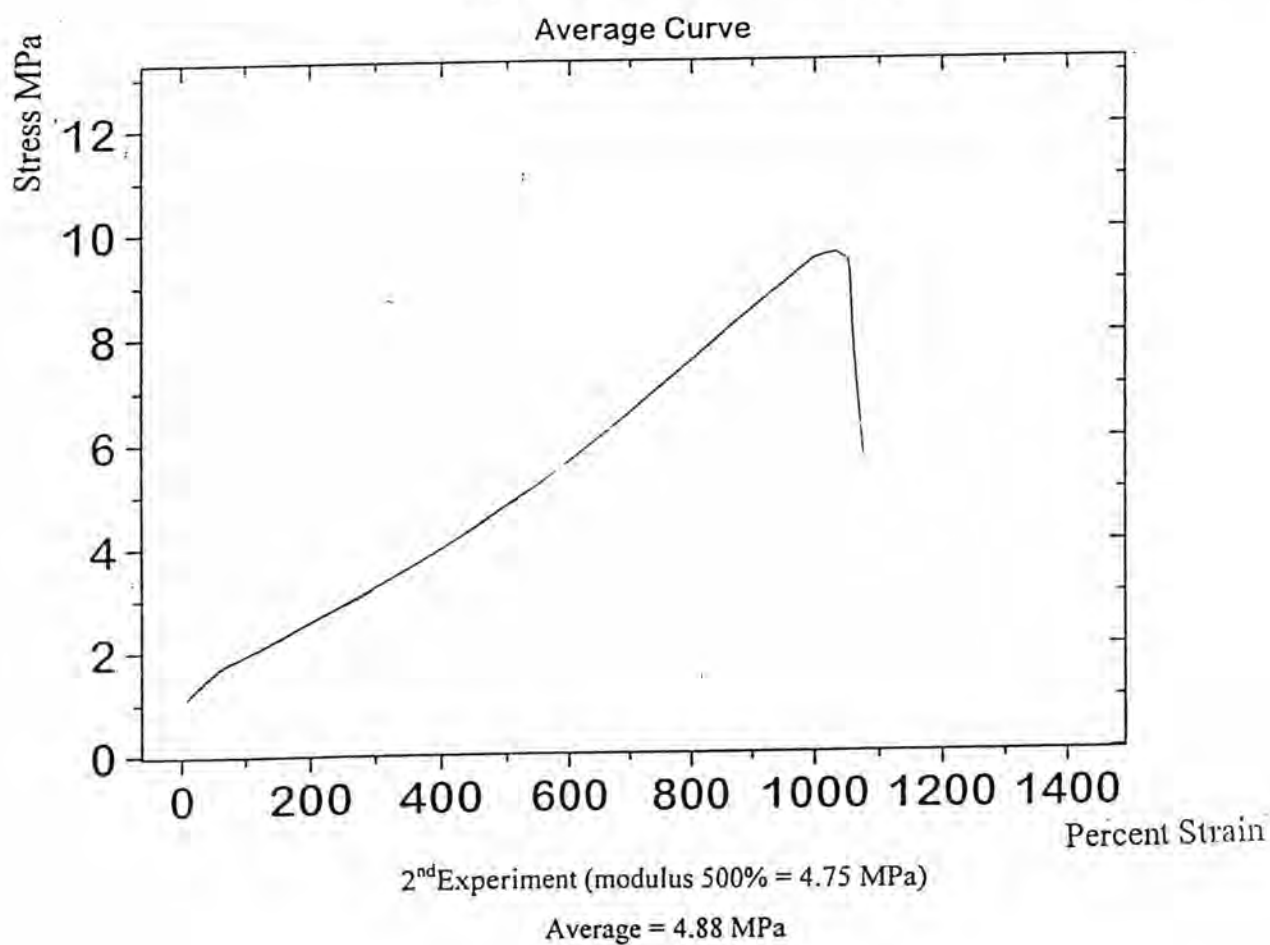
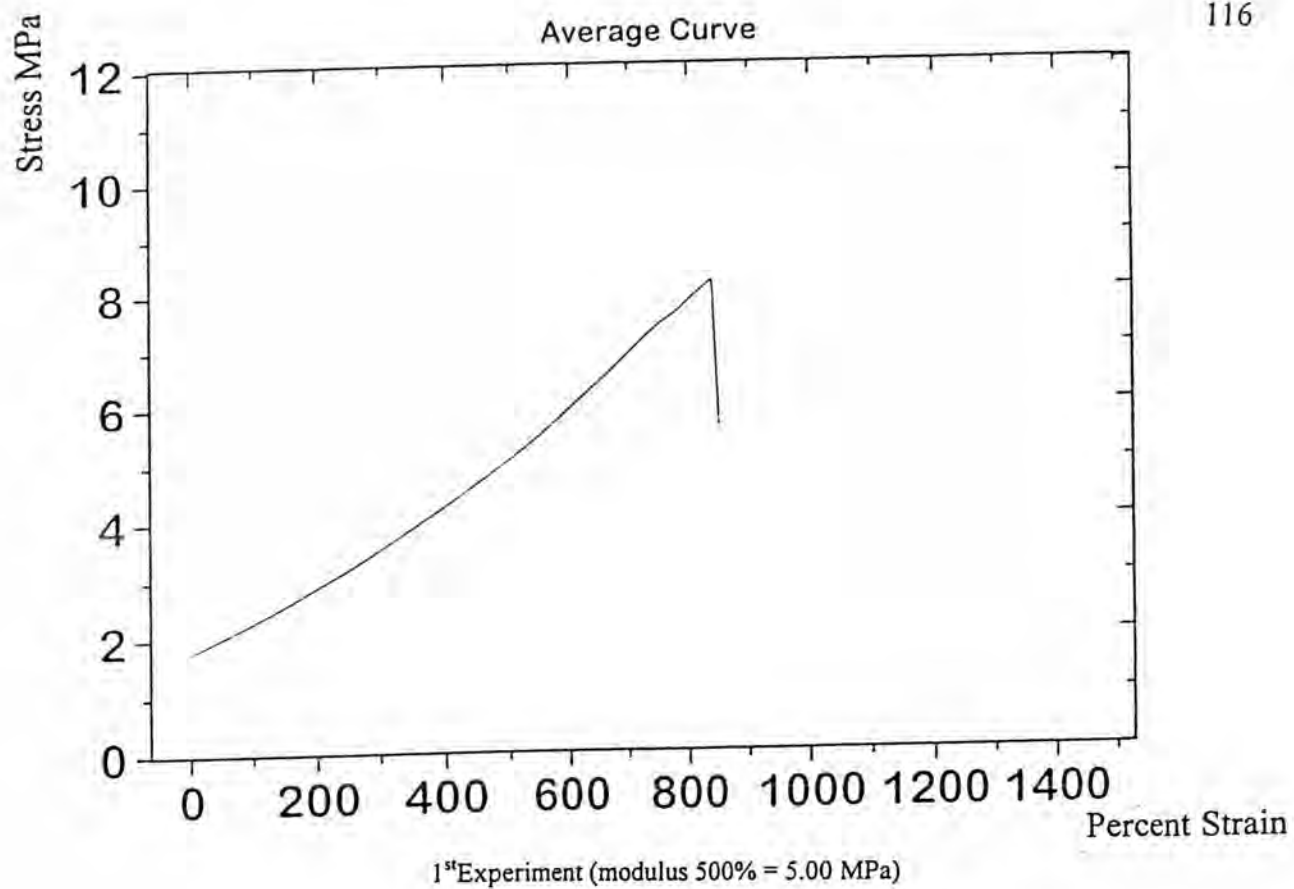


Figure D.1 Stress-strain curve of vulcanized sheets at mixing time of 1 hr

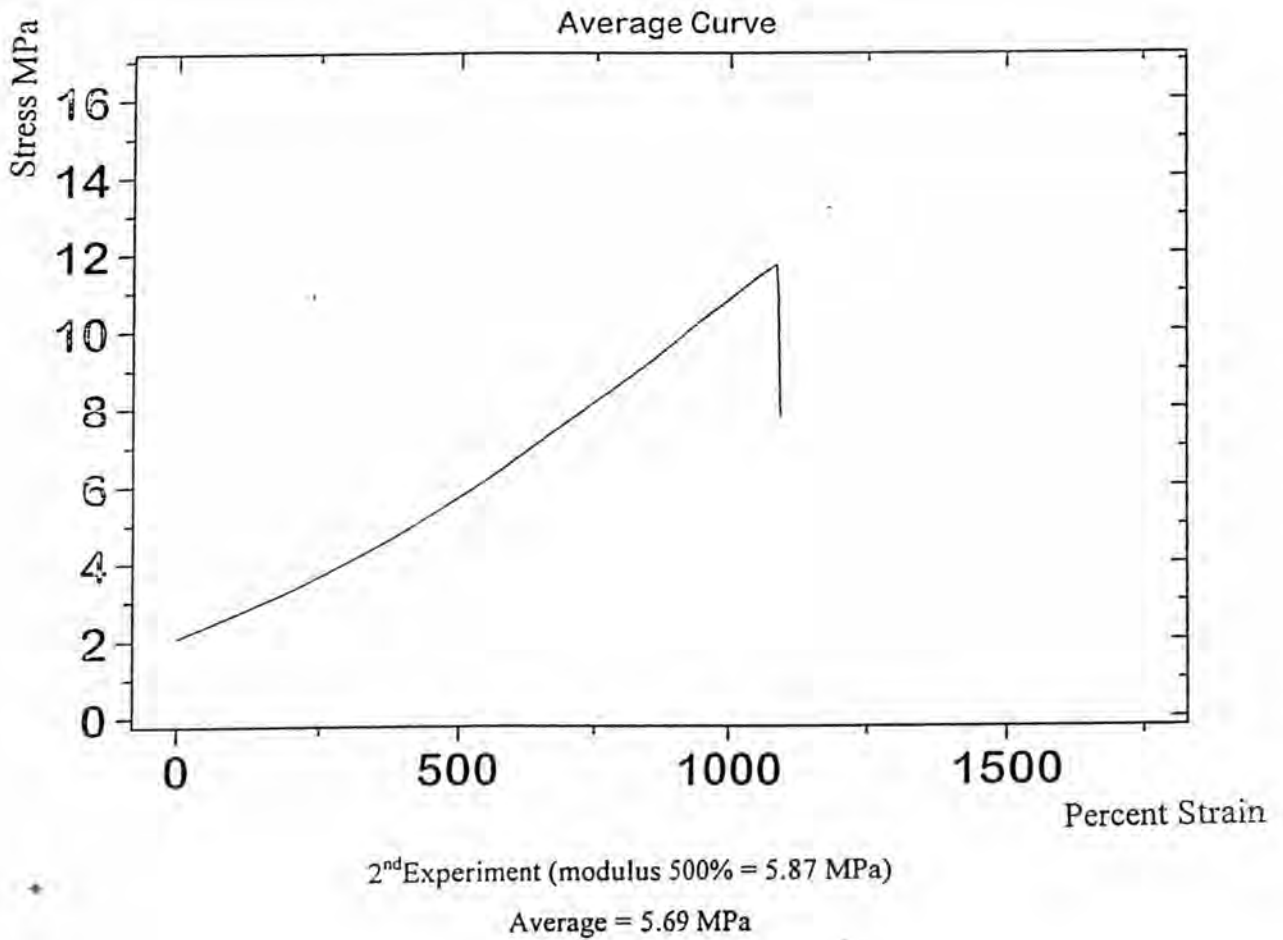
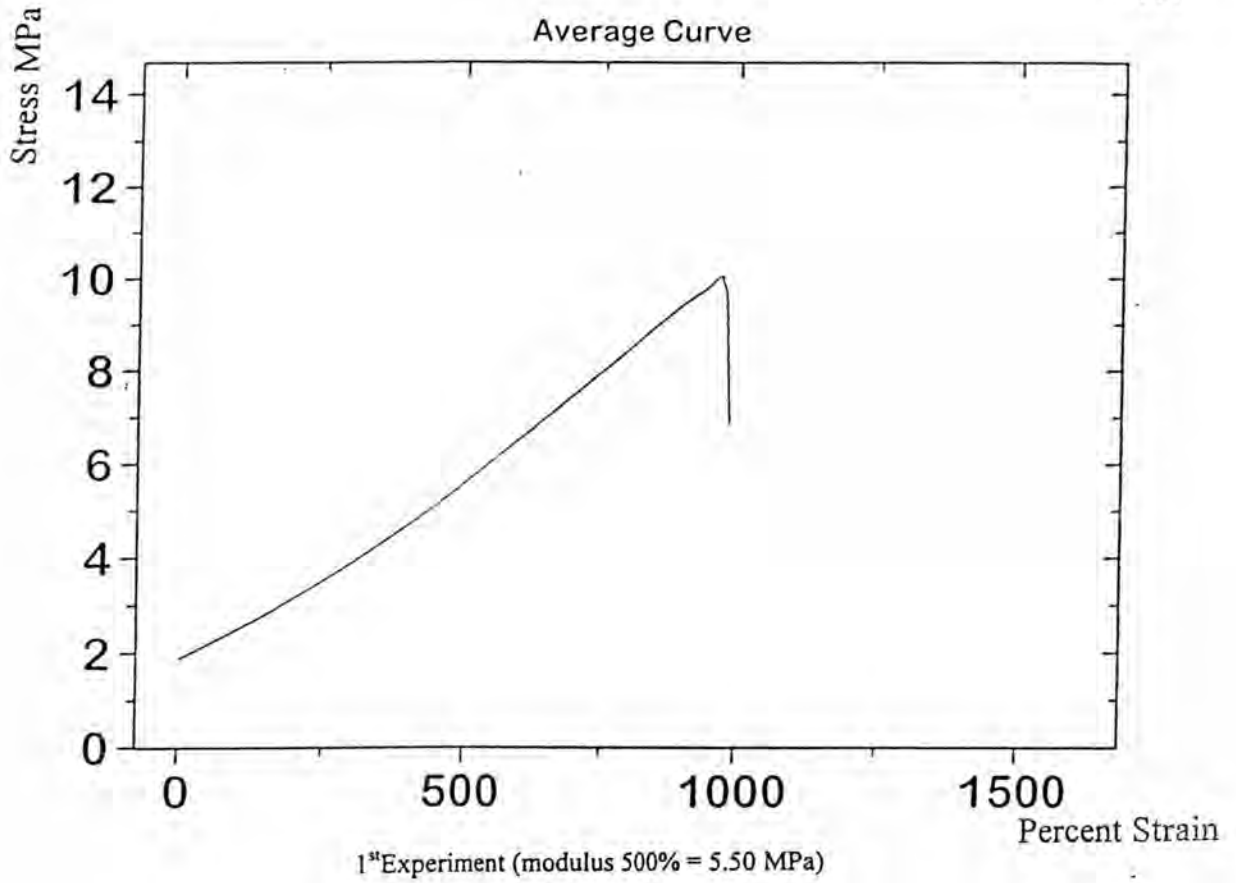


Figure D.2 Stress-strain curve of vulcanized sheets at mixing time of 2 hr



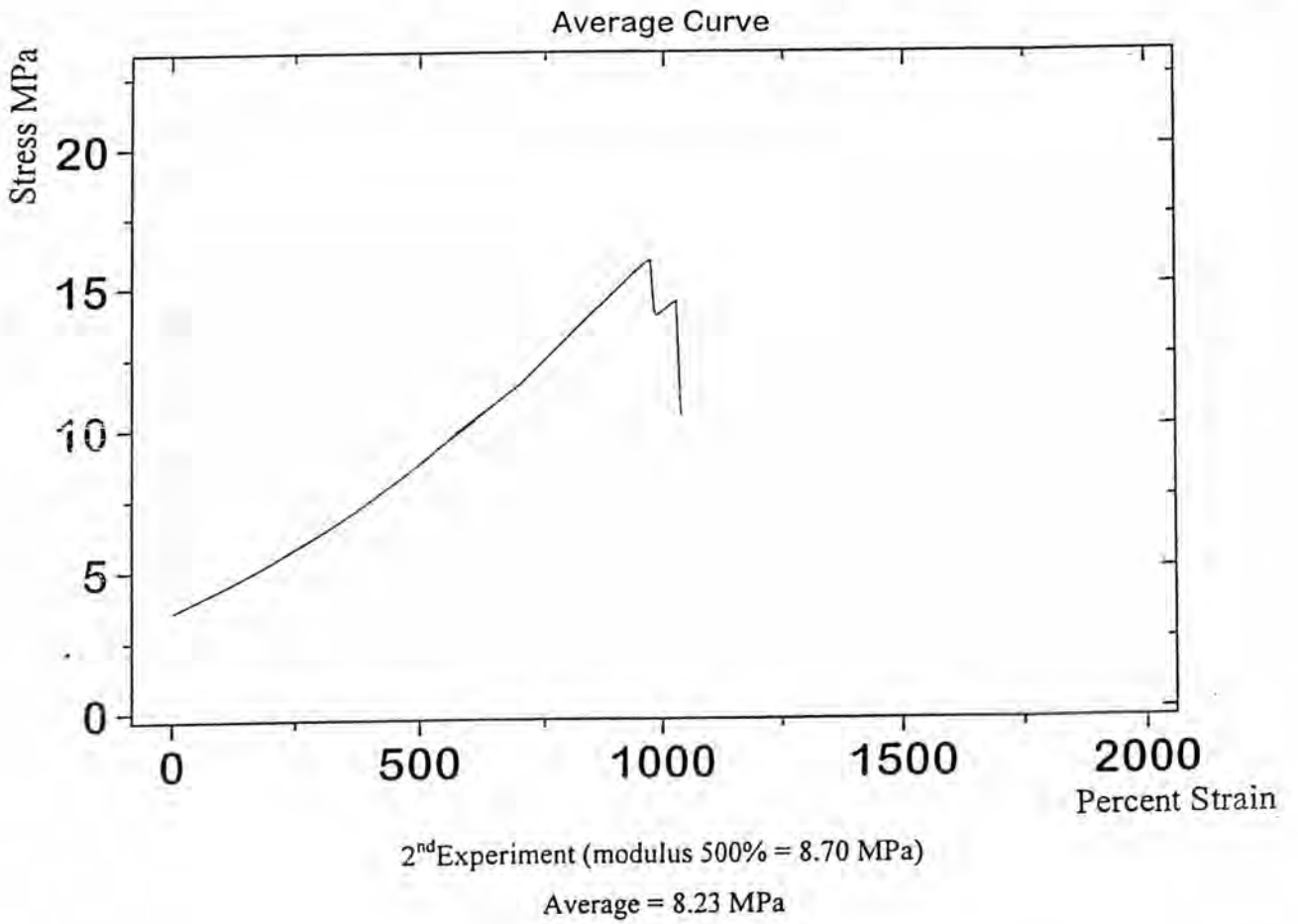
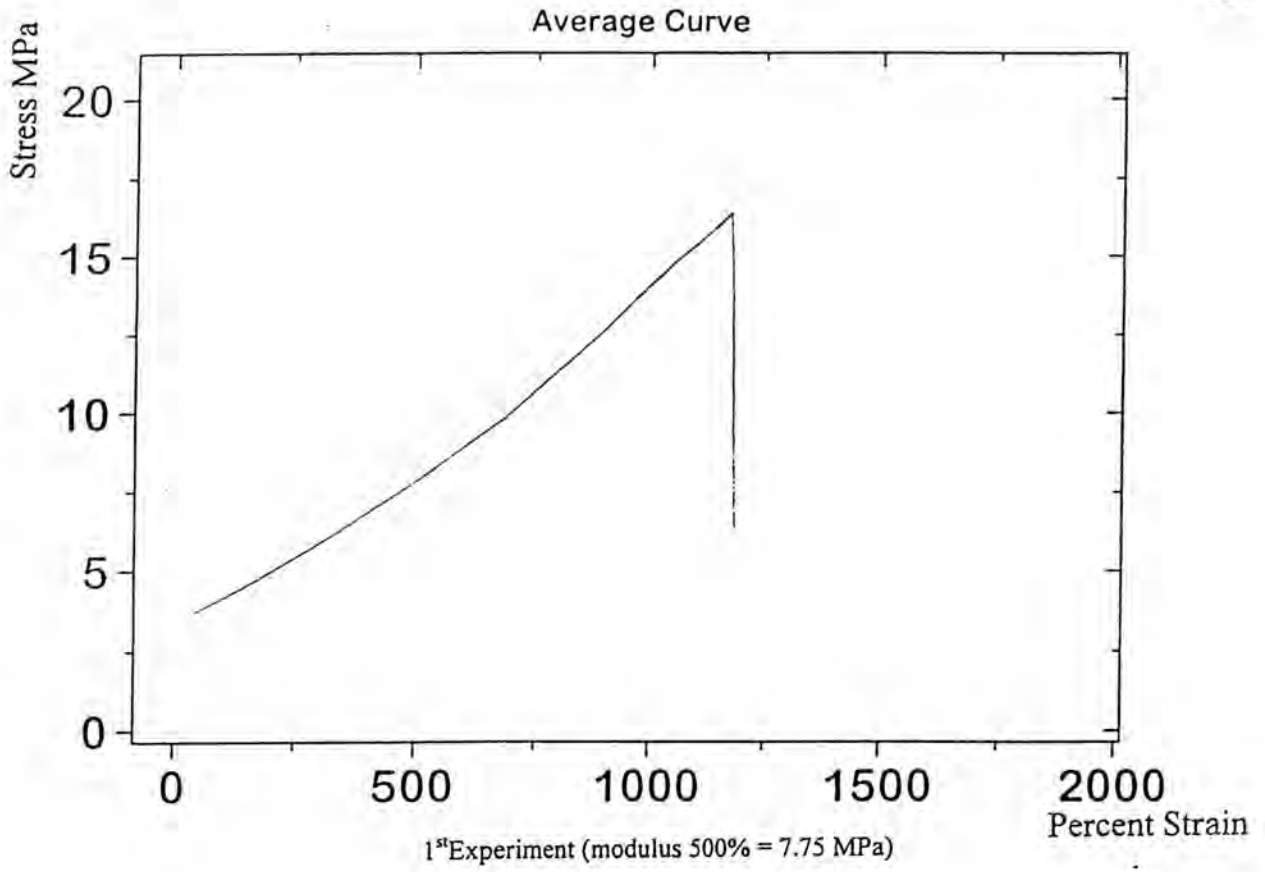
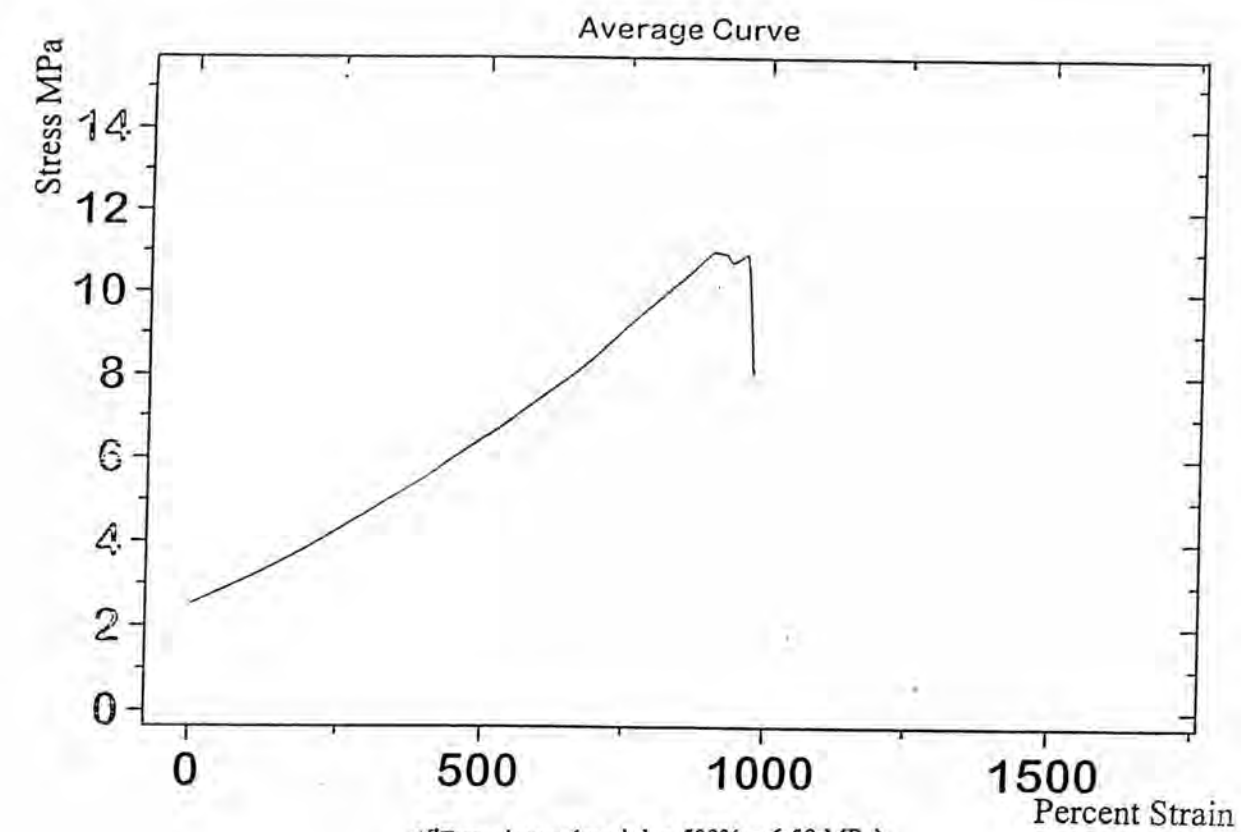
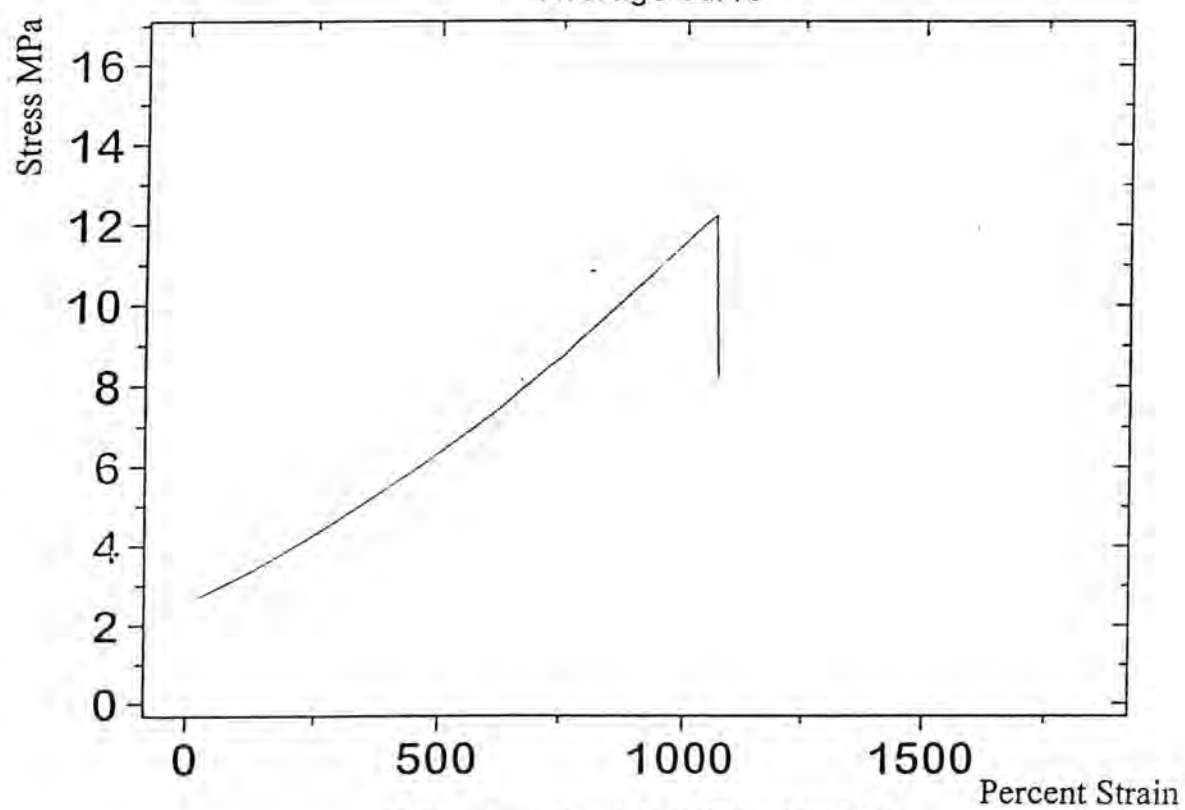


Figure D.3 Stress-strain curve of vulcanized sheets at mixing time of 3 hr



1<sup>st</sup>Experiment (modulus 500% = 6.50 MPa)

Average Curve



2<sup>nd</sup>Experiment (modulus 500% = 6.33 MPa)

Average = 6.42 MPa

Figure D.4 Stress-strain curve of vulcanized sheets at mixing time of 4 hr

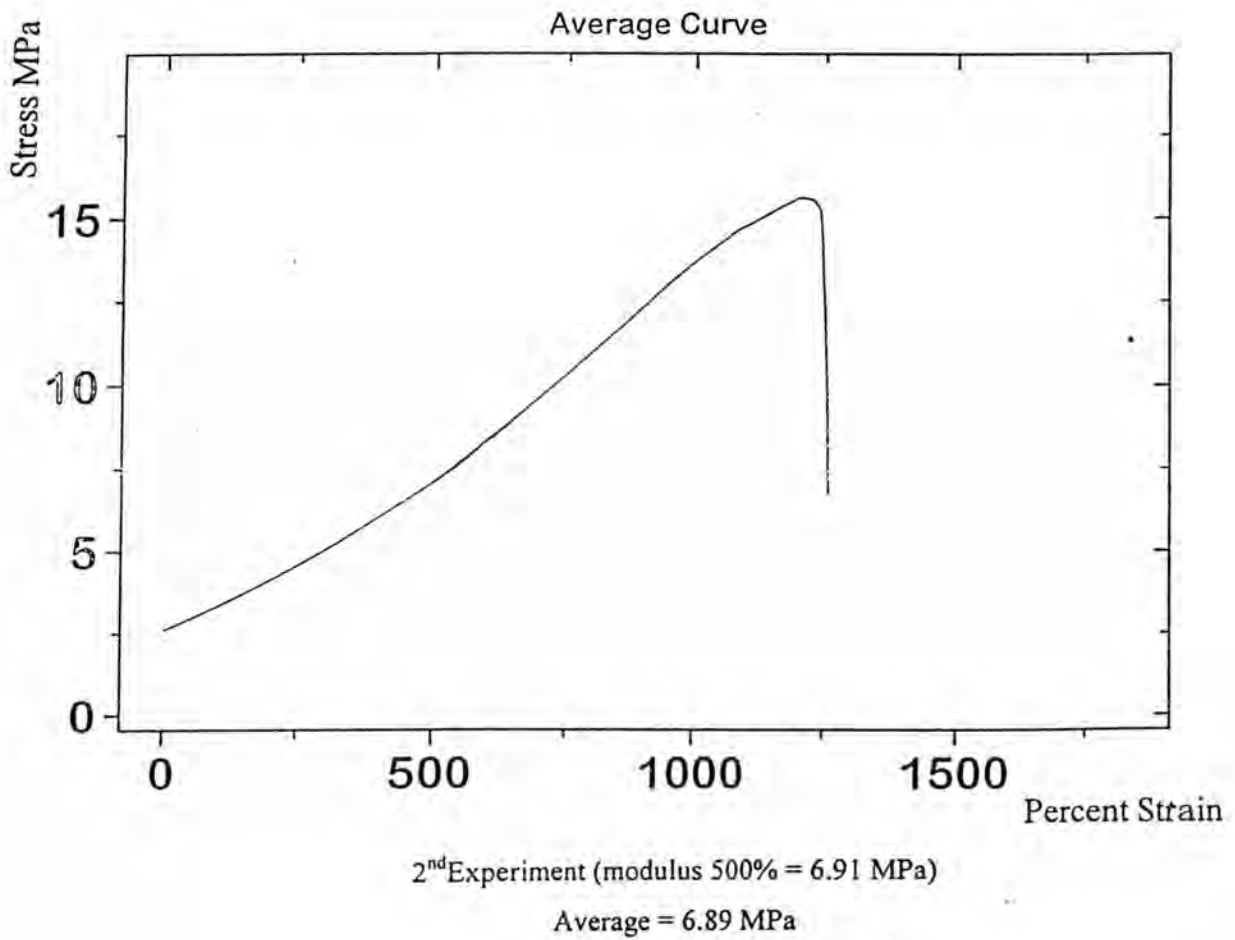
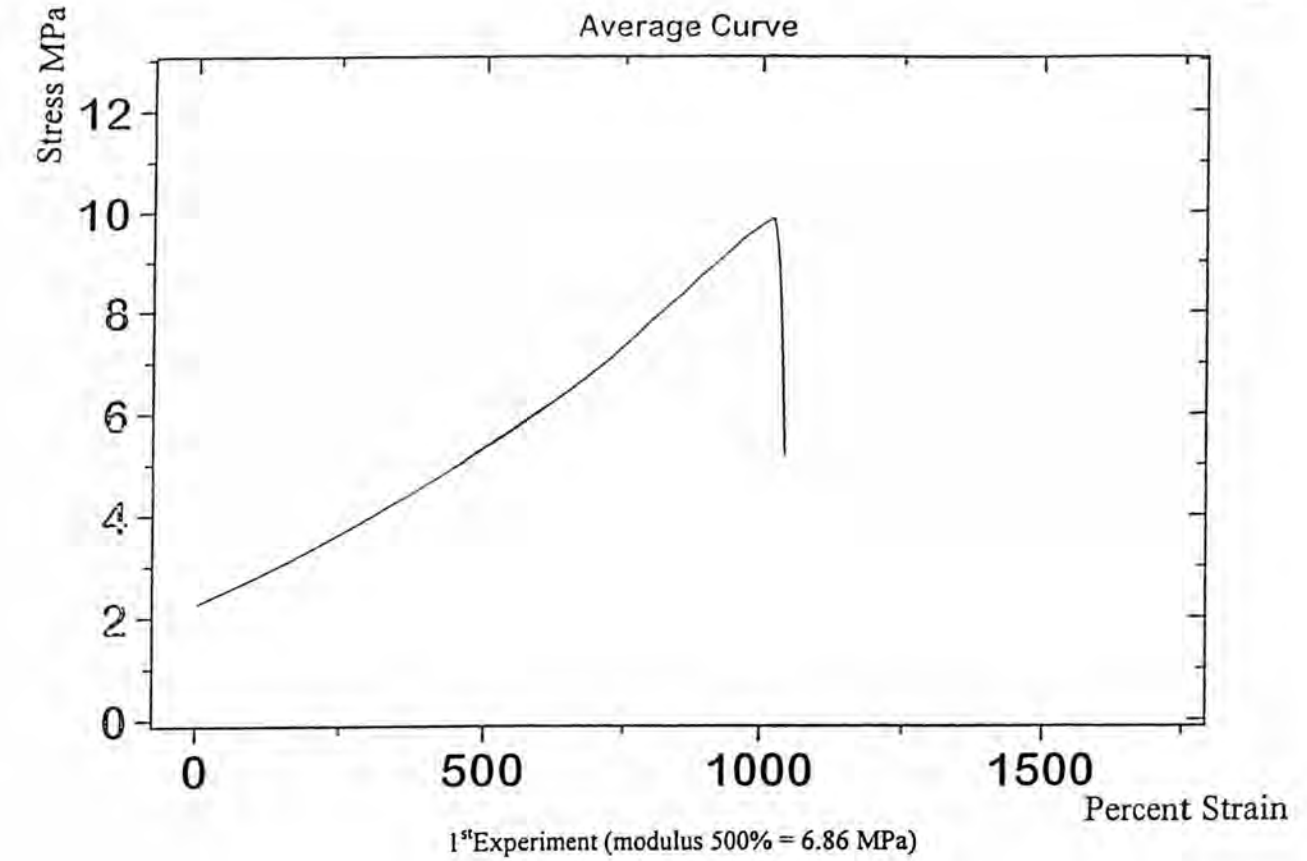


Figure D.5 Stress-strain curve of vulcanized sheets at mixing time of 5 hr

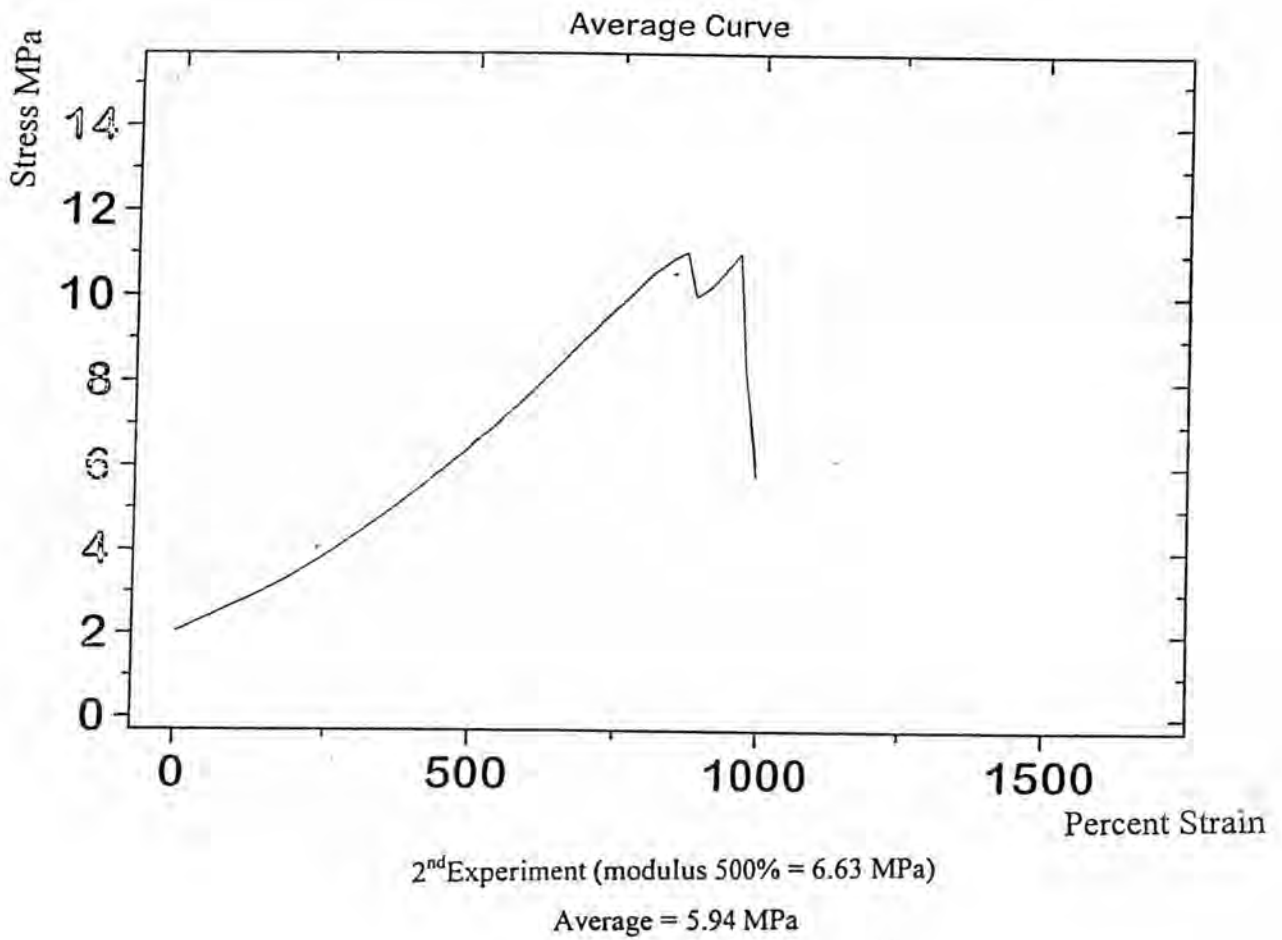
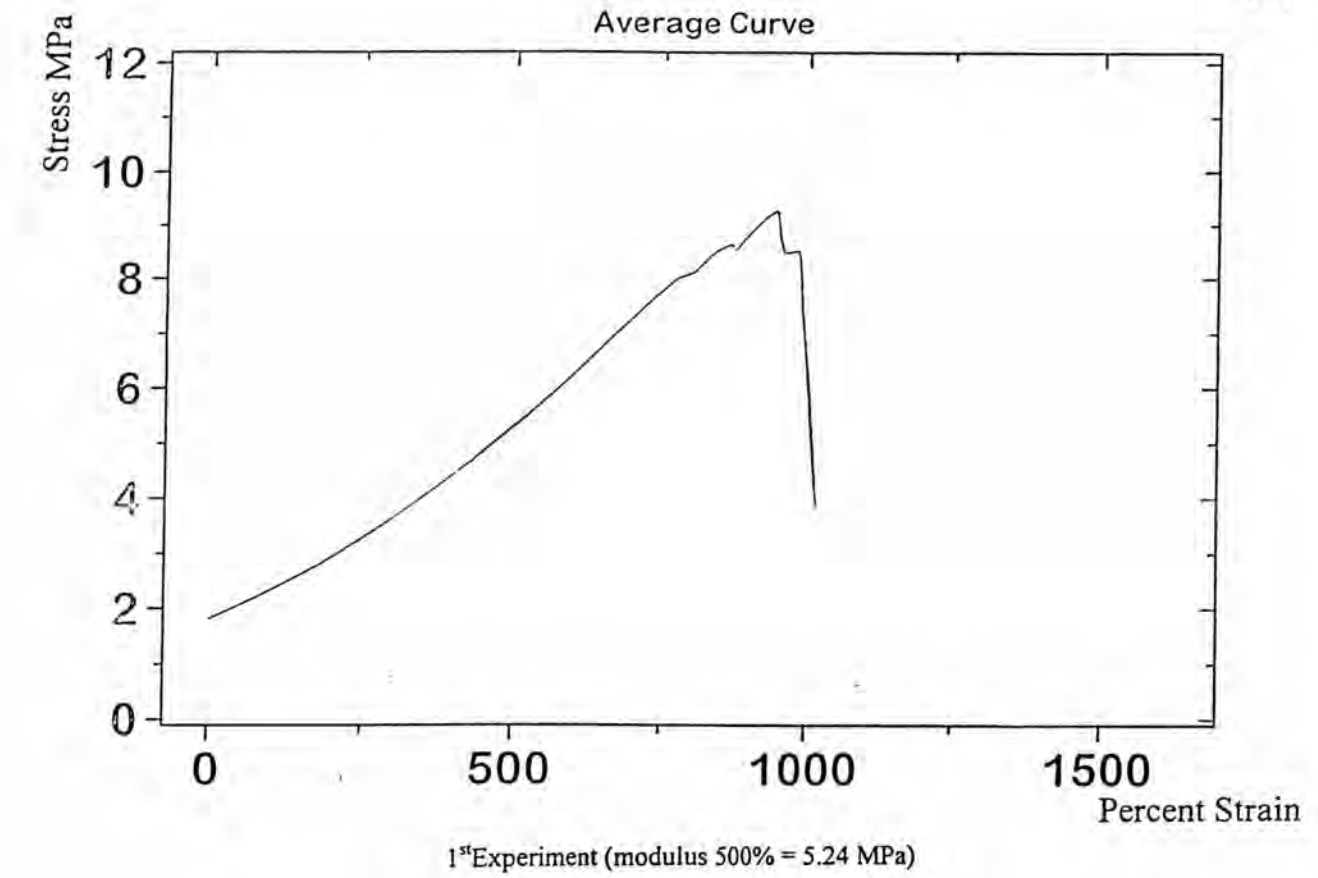
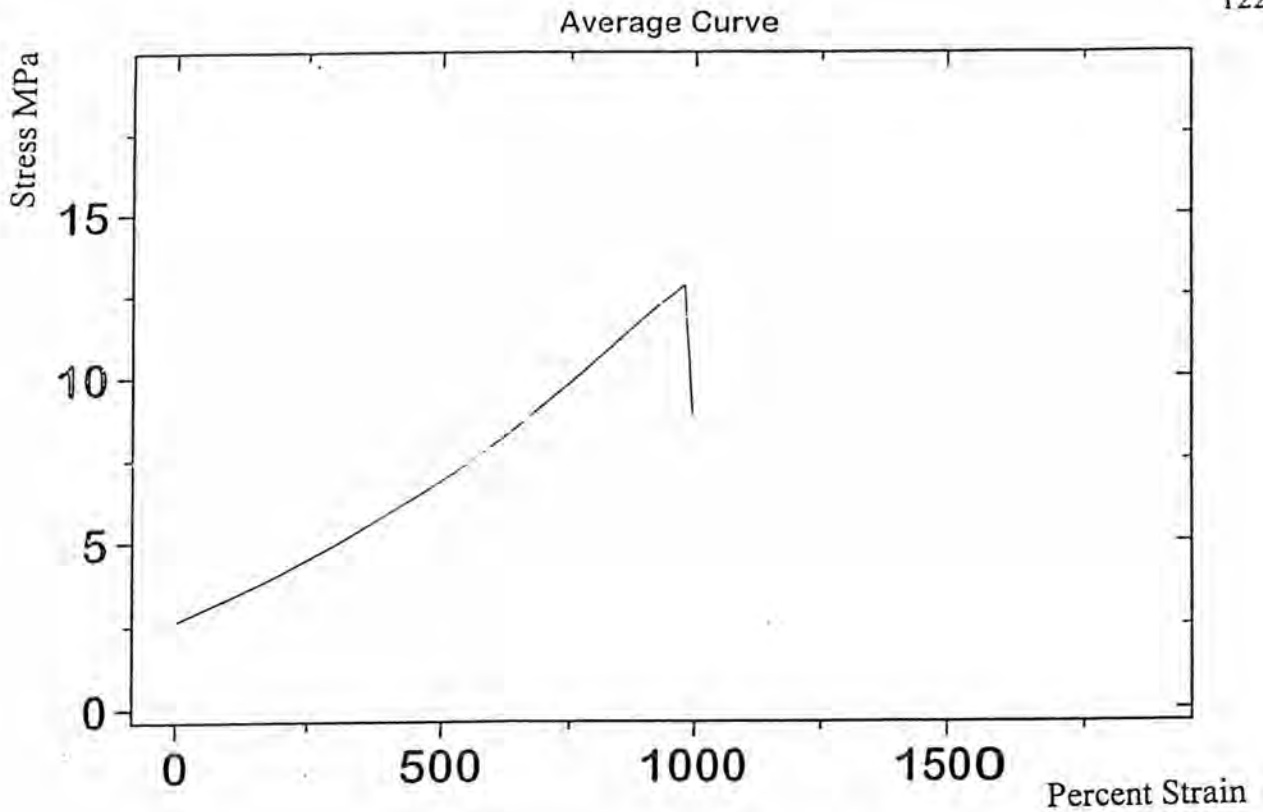
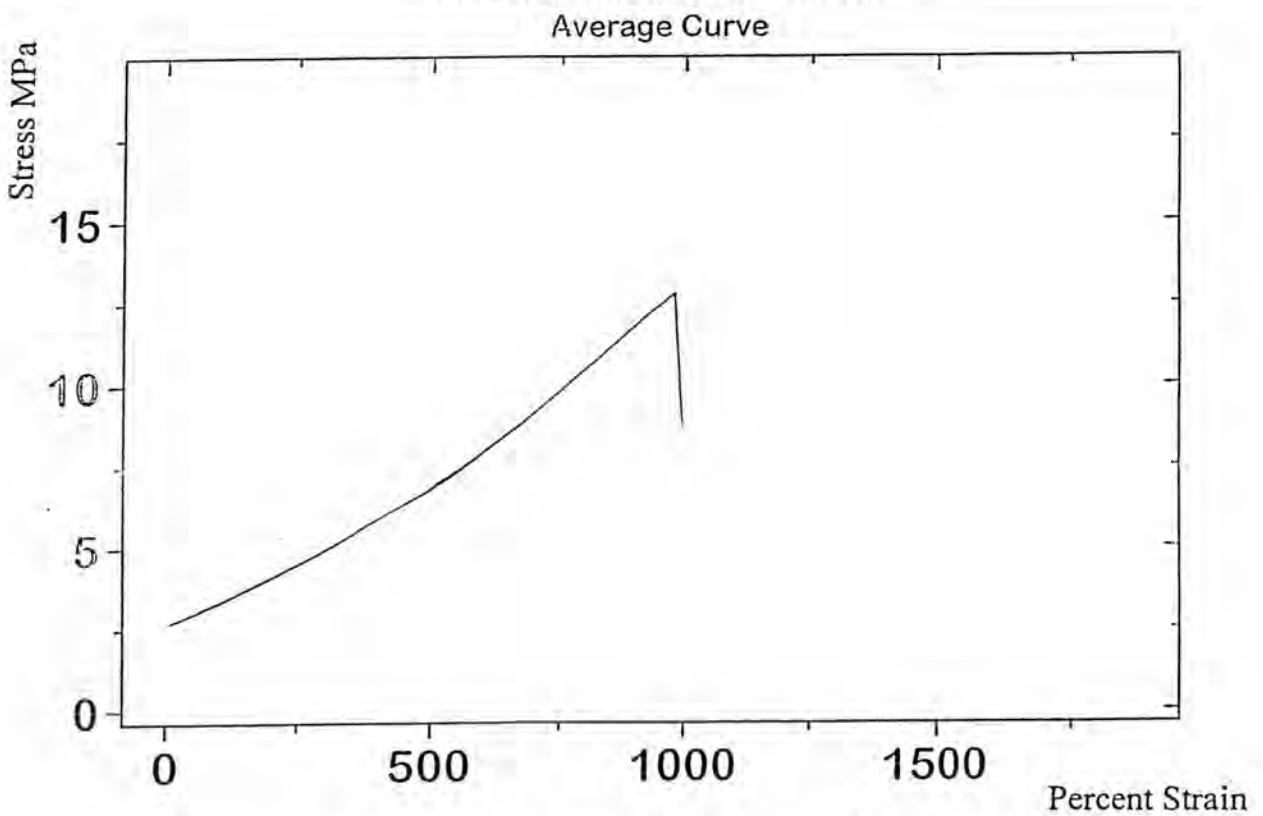


Figure D.6 Stress-strain curve of vulcanized sheets containing sulfur 1 phr



1<sup>st</sup>Experiment (modulus 500% = 5.26 MPa)



2<sup>nd</sup>Experiment (modulus 500% = 6.86 MPa)

Average = 6.06 MPa

Figure D.7 Stress-strain curve of vulcanized sheets containing sulfur 3 phr

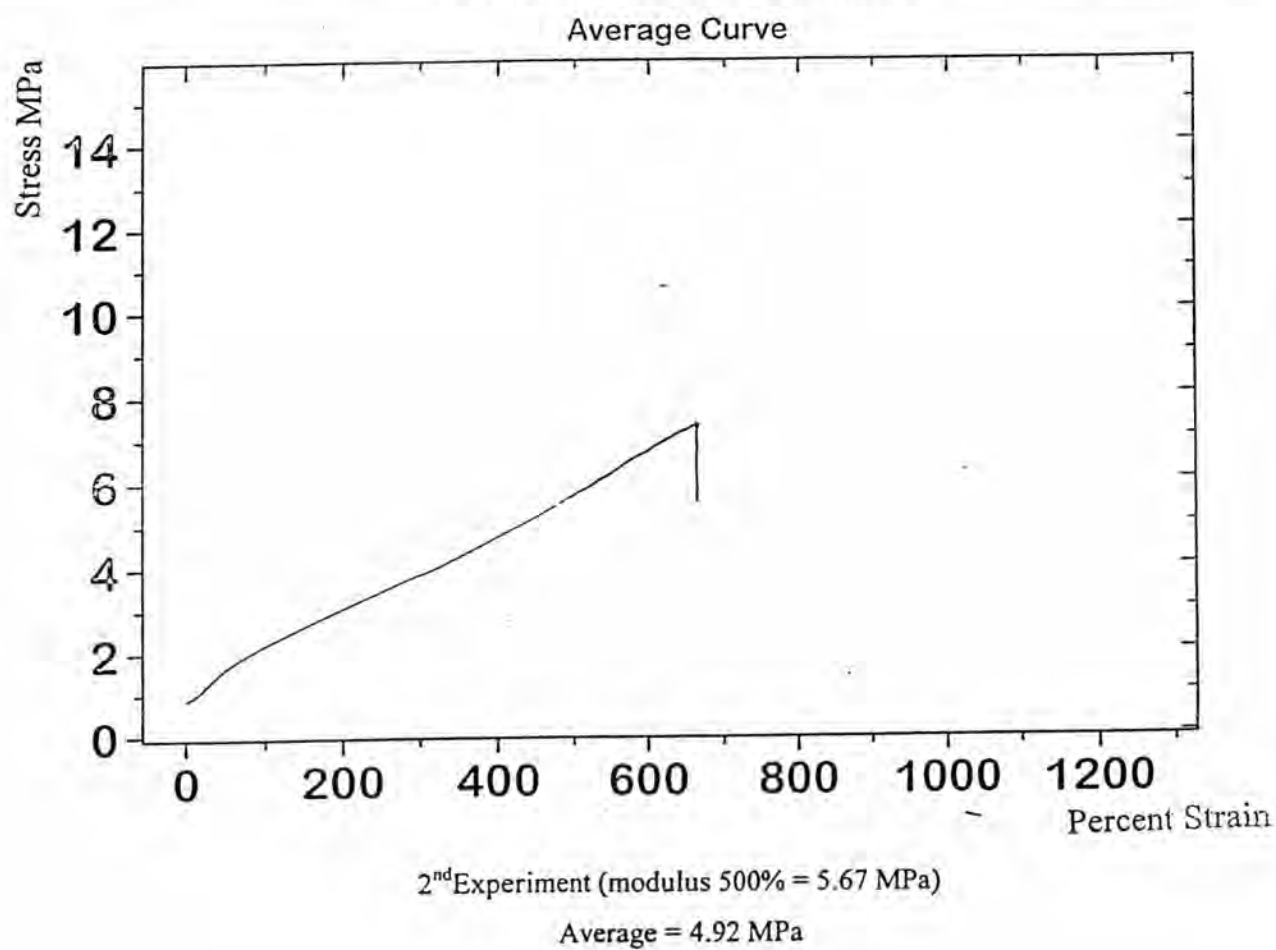
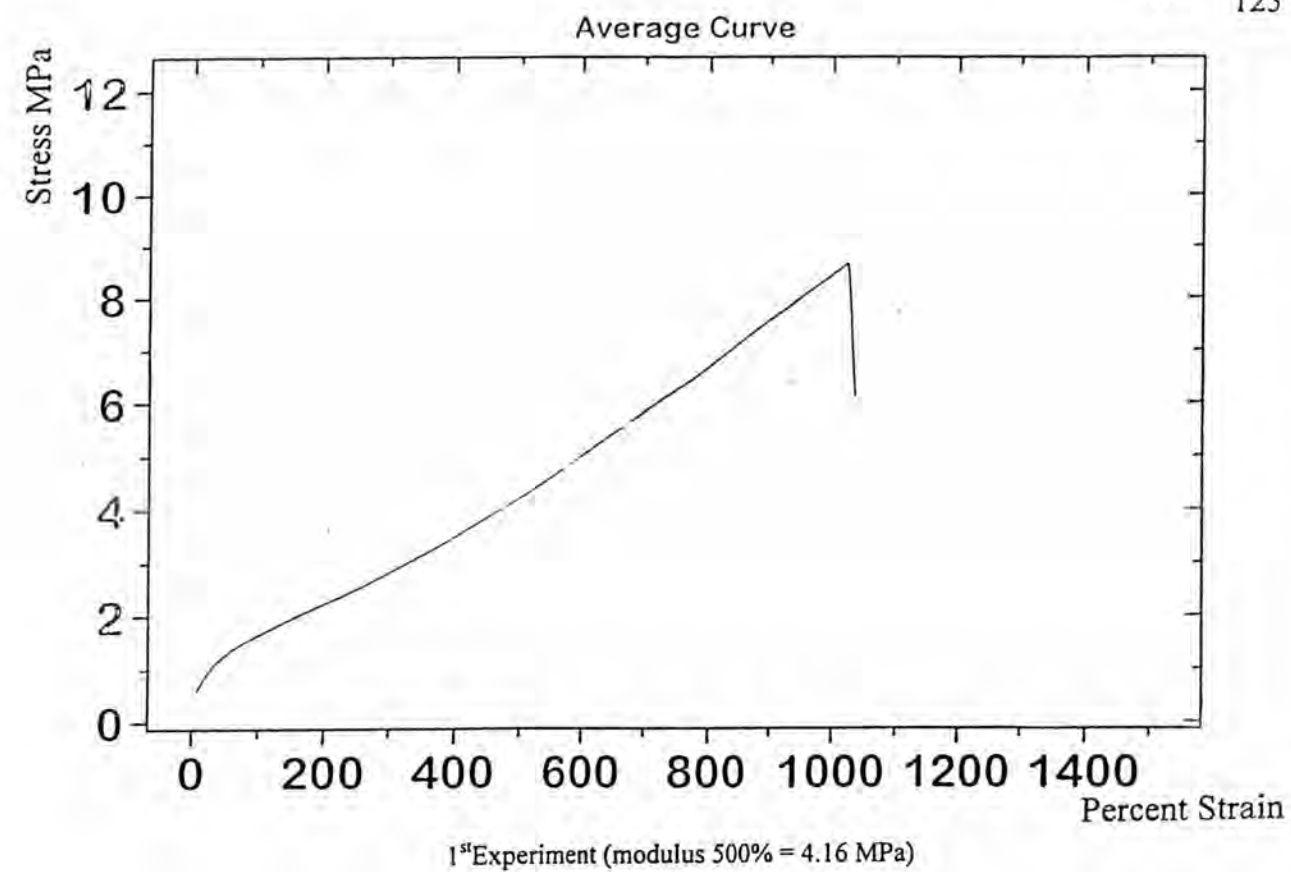
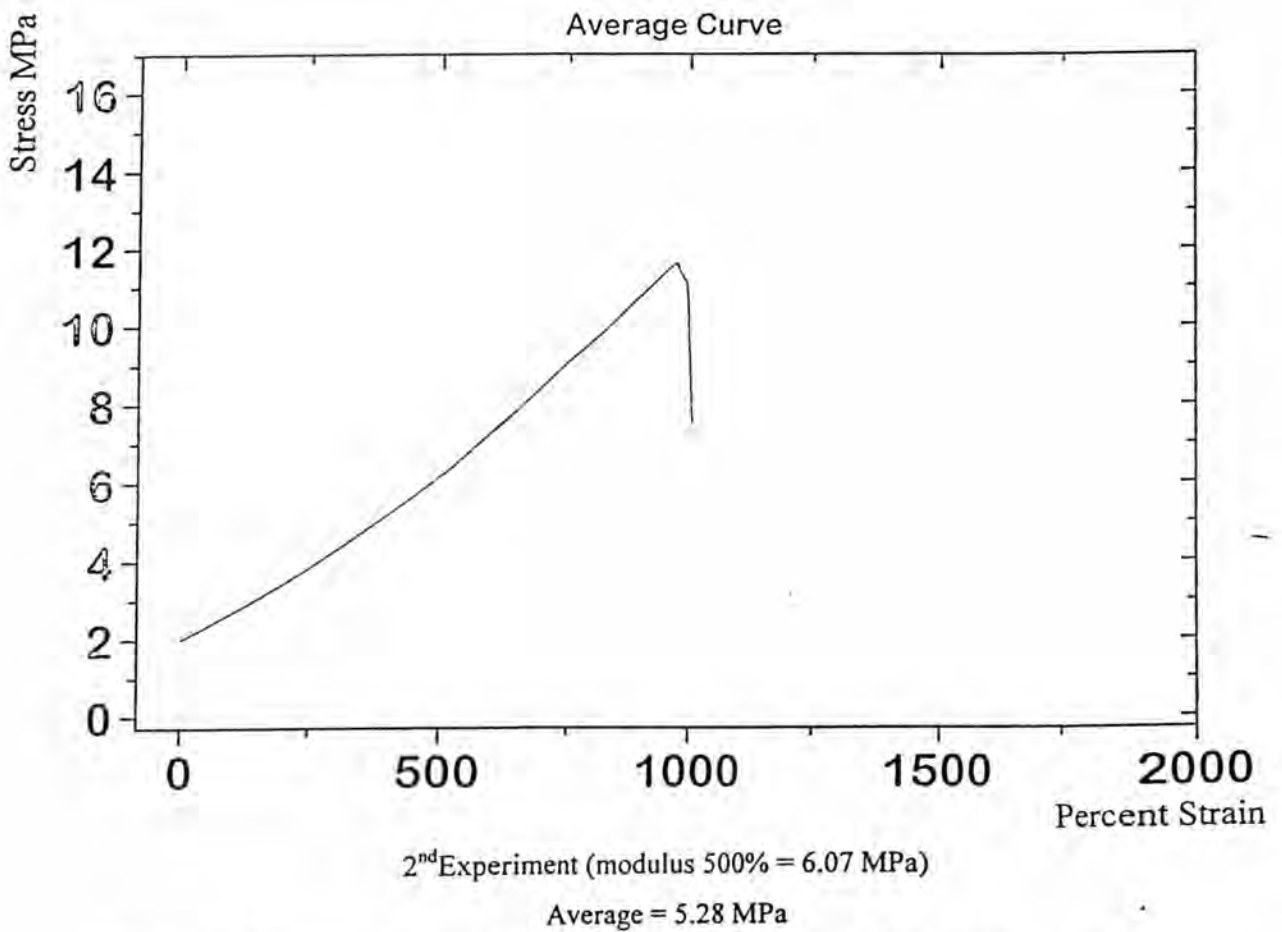
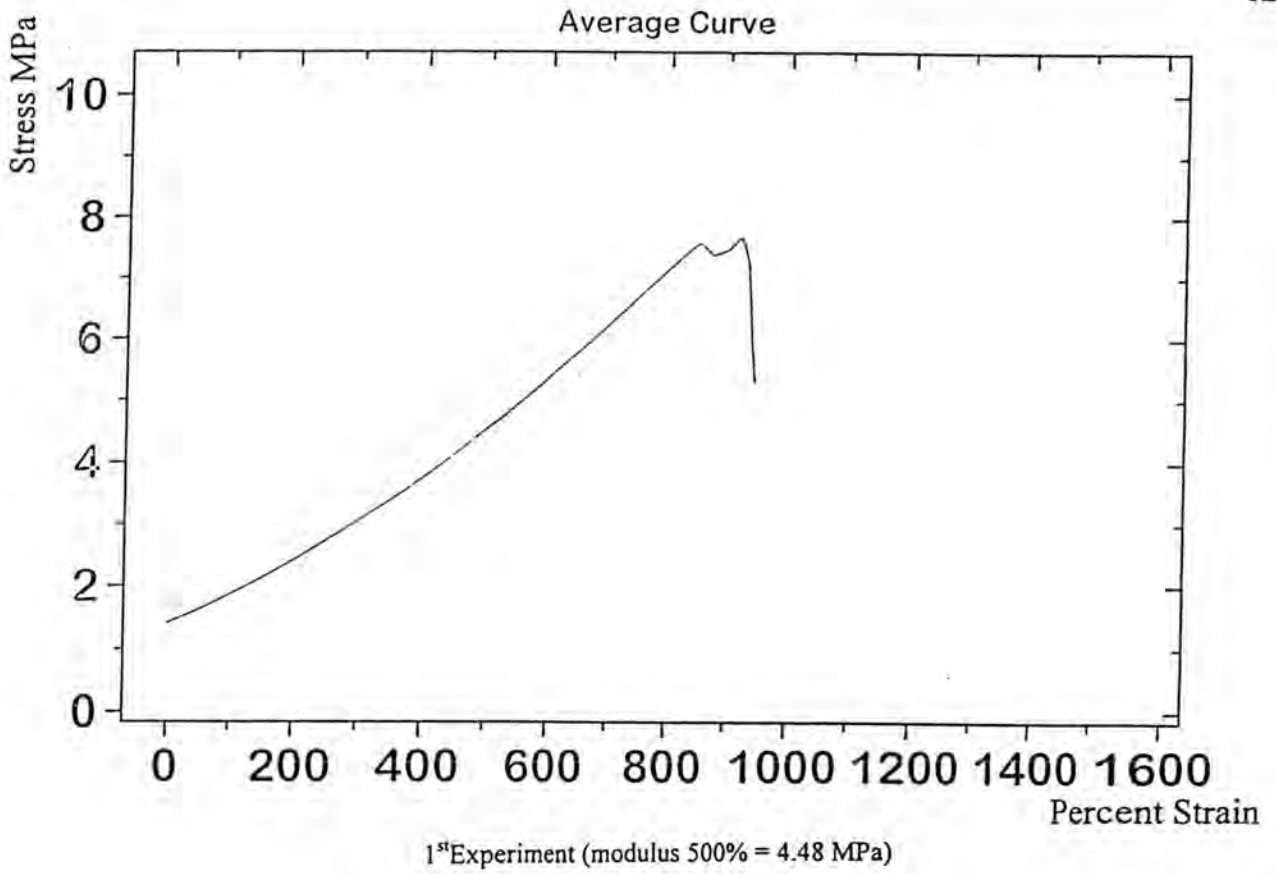
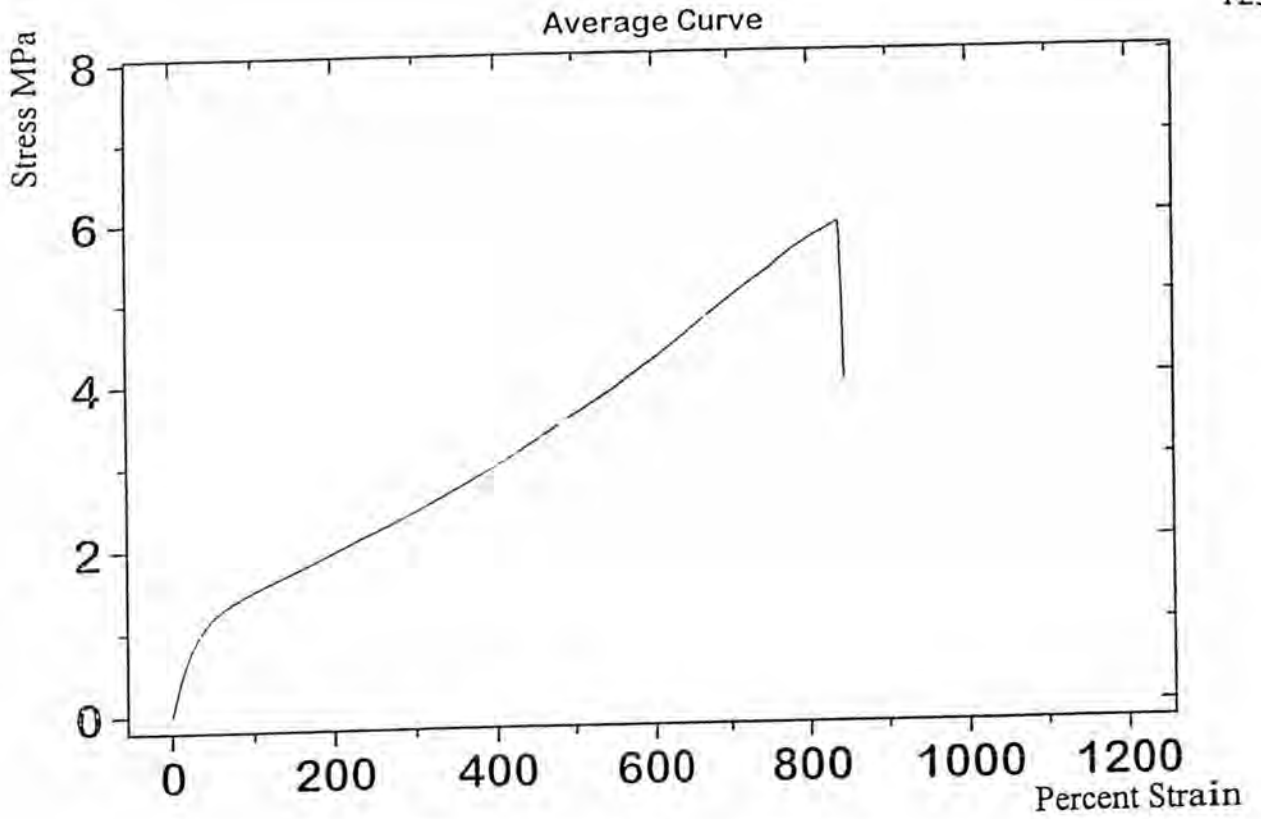


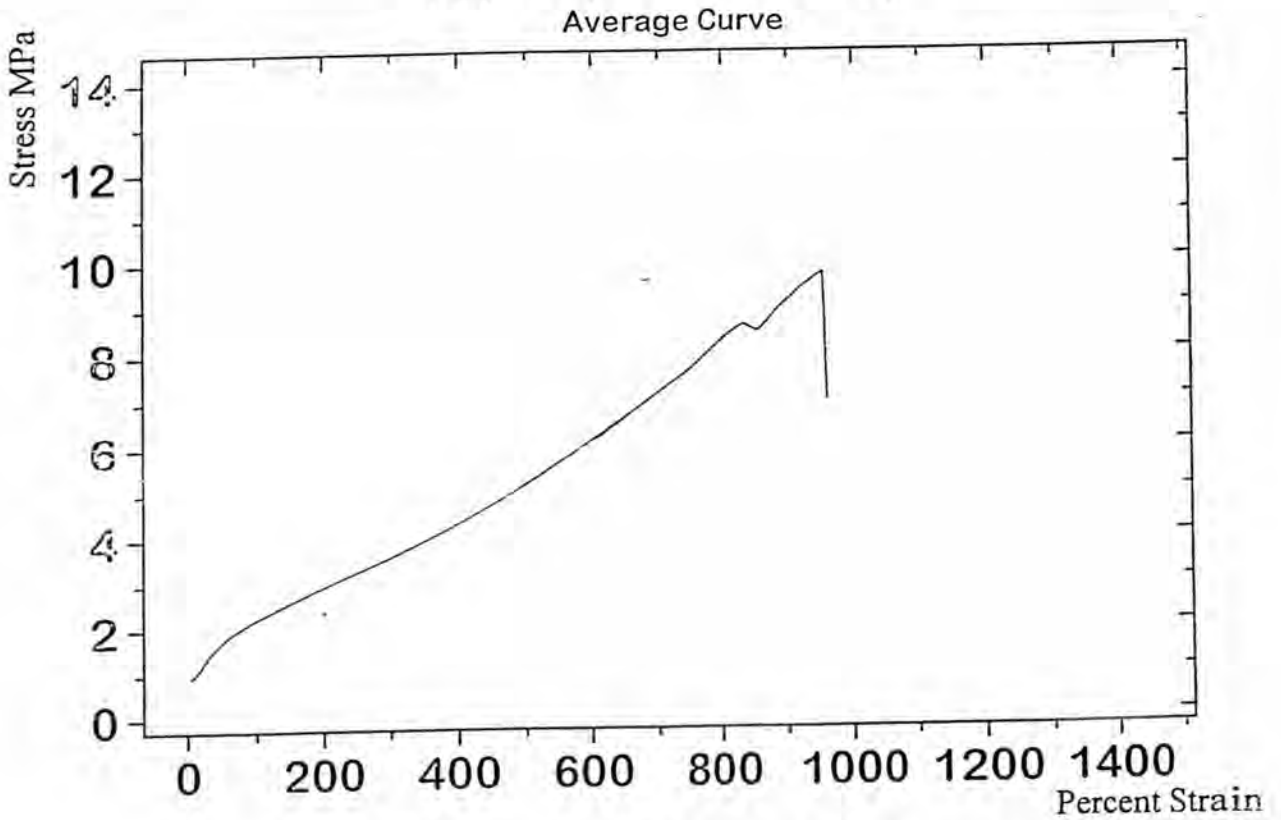
Figure D.8 Stress-strain curve of vulcanized sheets containing sulfur 4 phr



**Figure D.9** Stress-strain curve of vulcanized sheets containing low amount of accelerator and accelerator activator



1<sup>st</sup>Experiment (modulus 500% = 3.55 MPa)

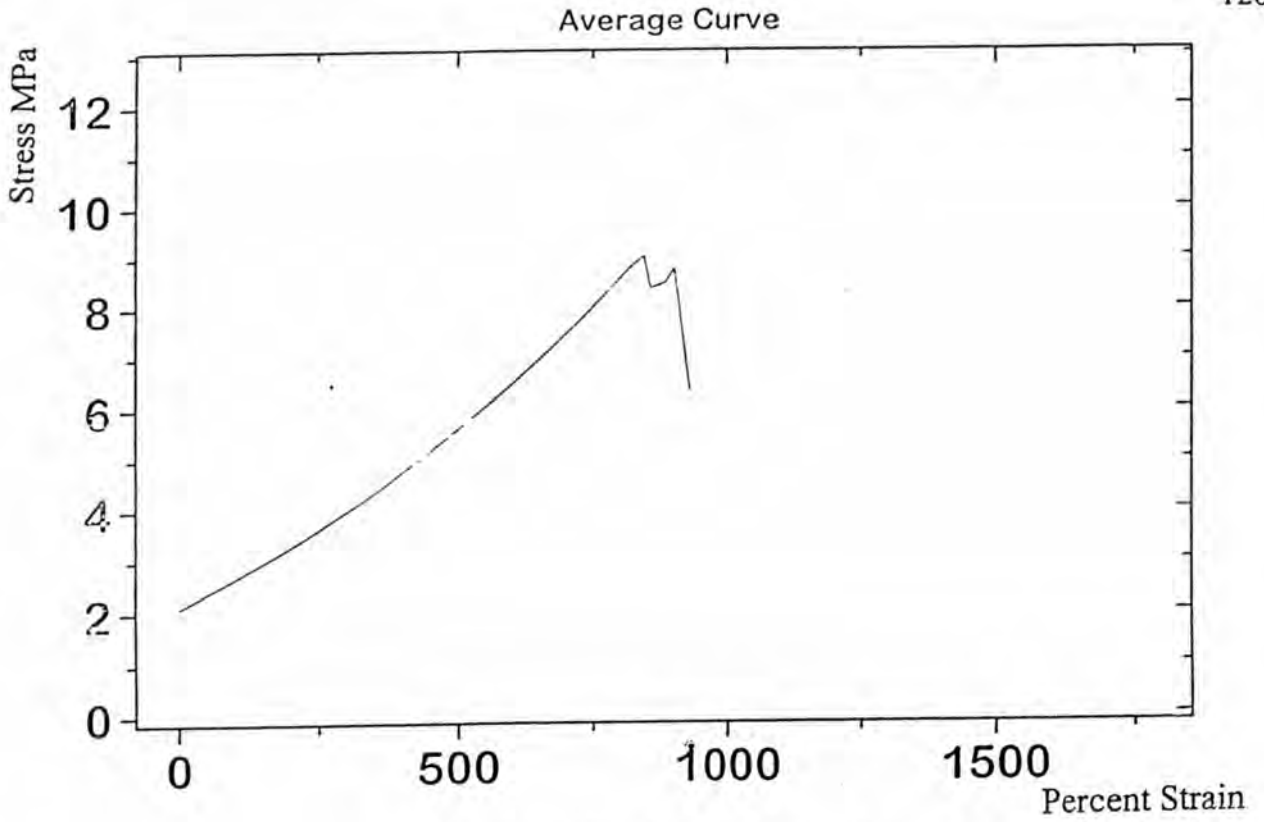


2<sup>nd</sup>Experiment (modulus 500% = 4.12 MPa)

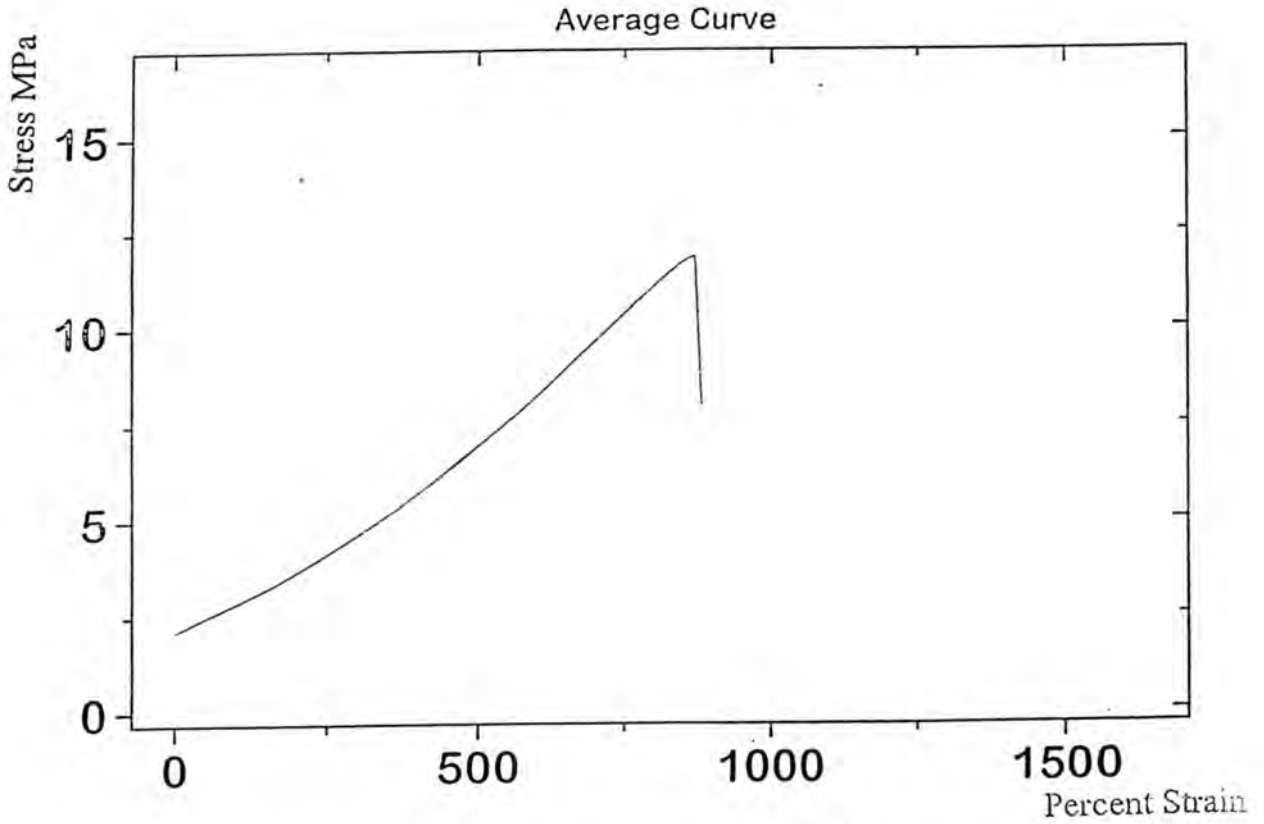
Average = 3.84 MPa

**Figure D.10** Stress-strain curve of vulcanized sheets containing high amount of accelerator and accelerator activator





1<sup>st</sup>Experiment (modulus 500% = 5.58 MPa)



2<sup>nd</sup>Experiment (modulus 500% = 6.88 MPa)

Average = 6.23 MPa

Figure D.11 Stress-strain curve of vulcanized sheets containing carbon black type N220

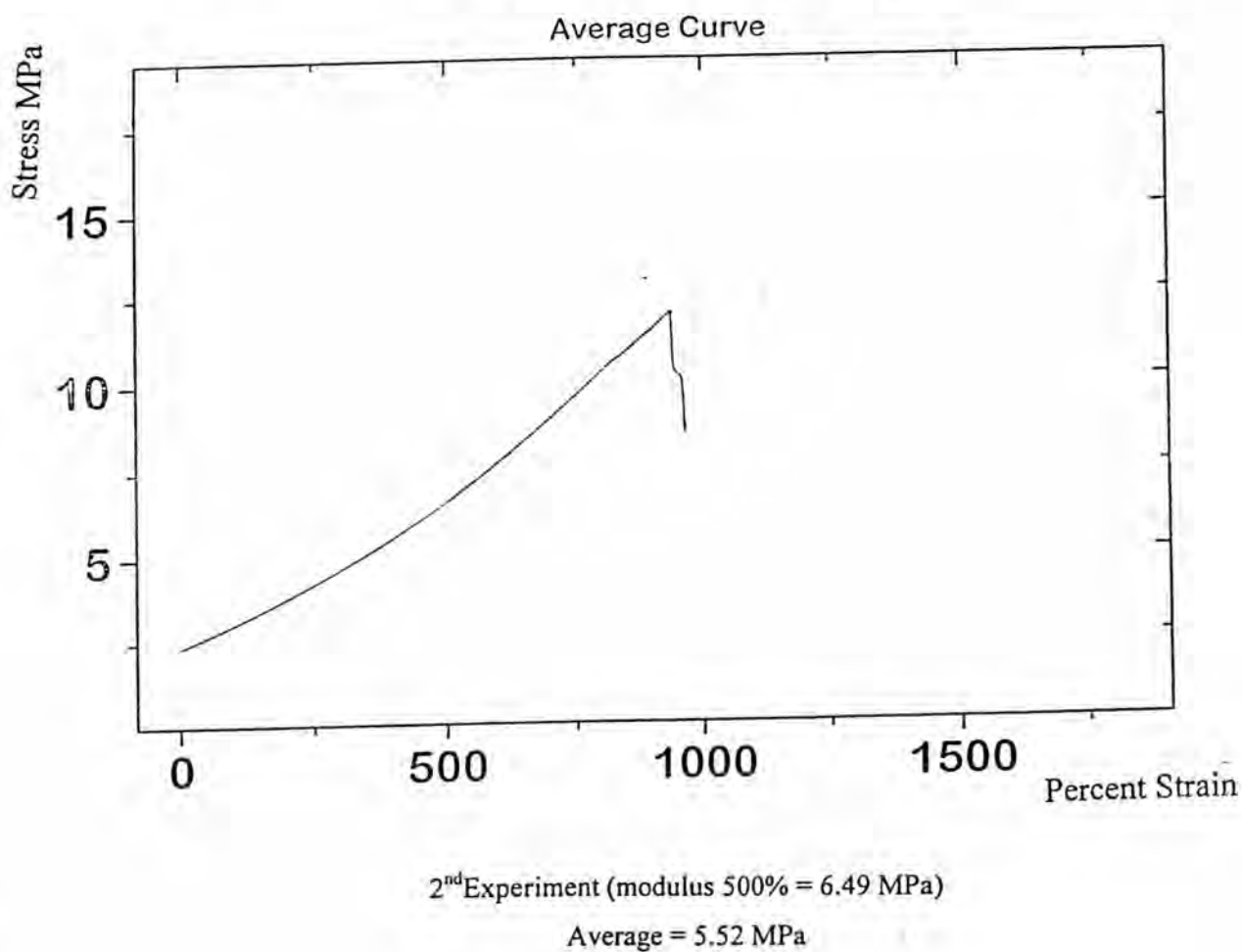
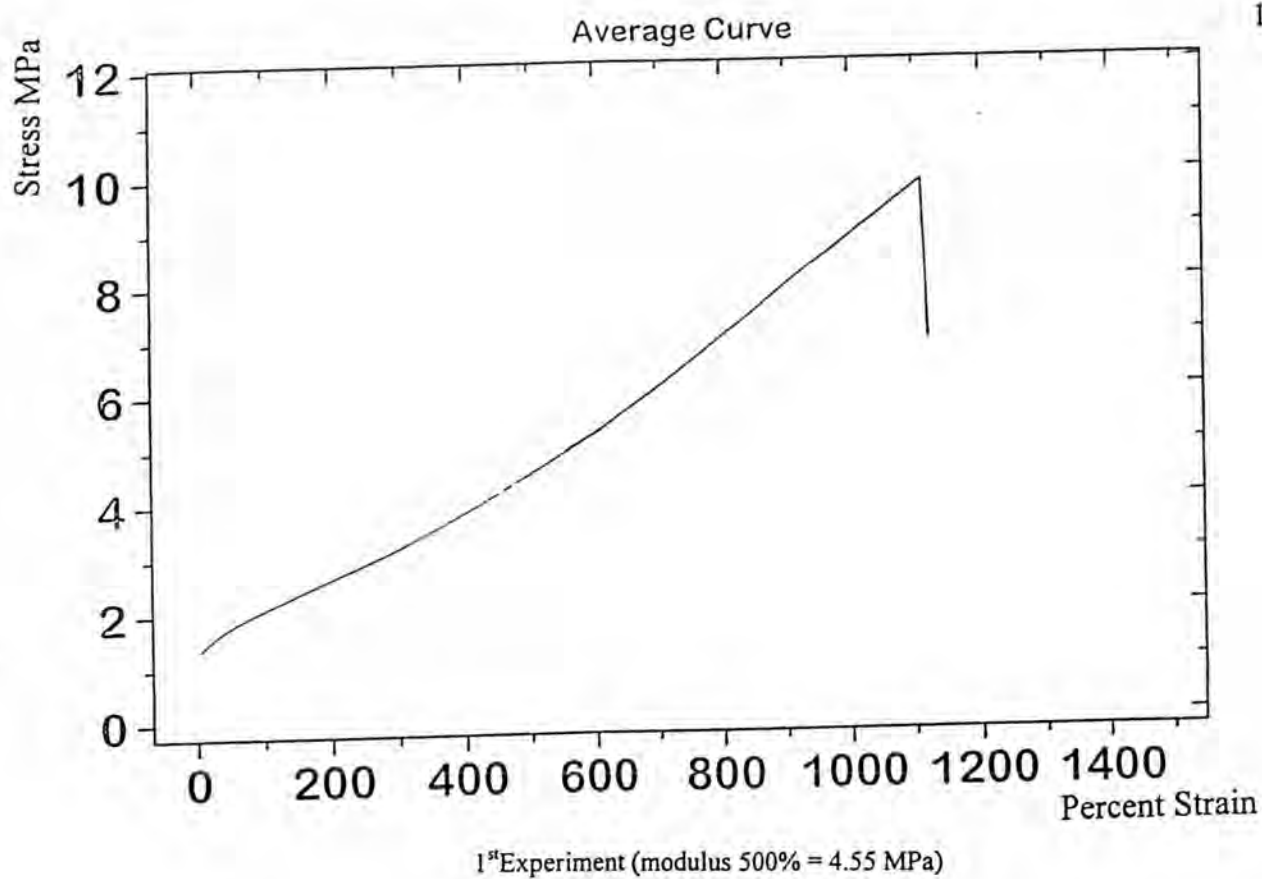
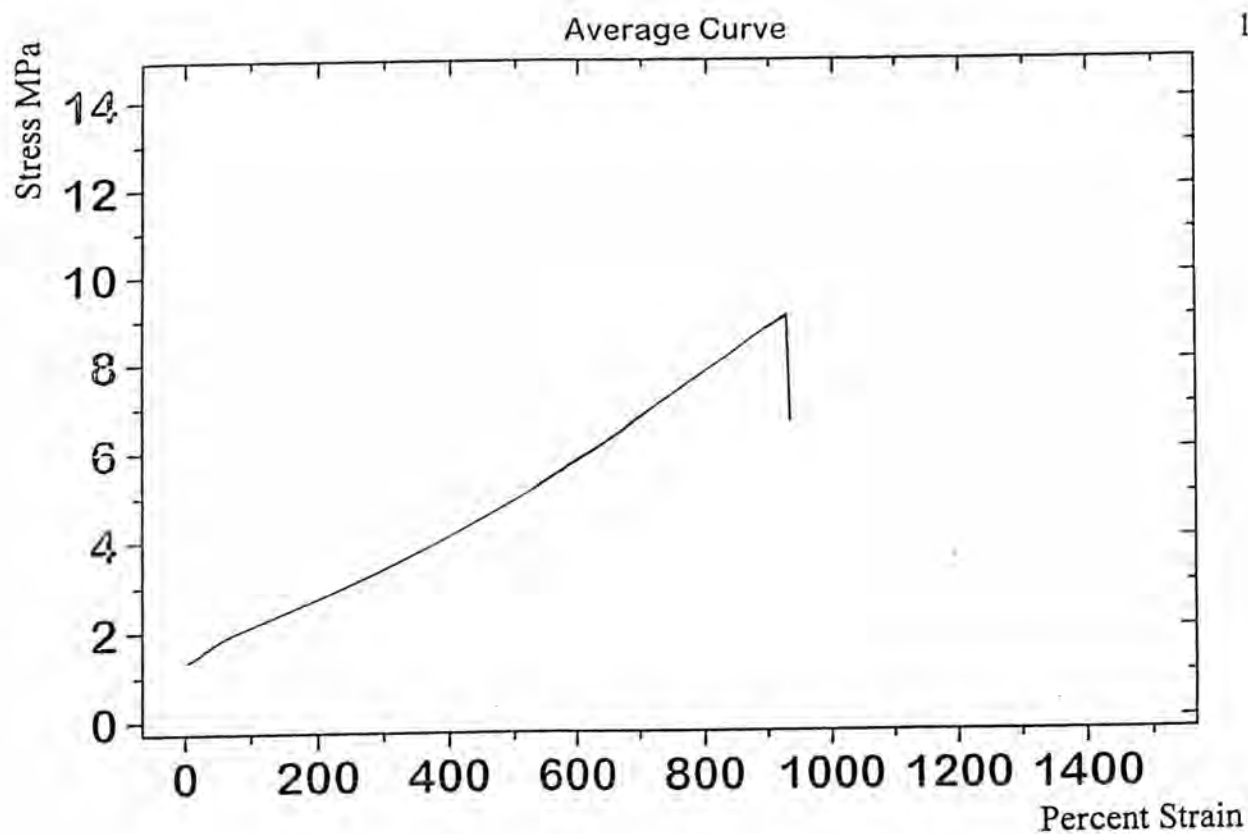
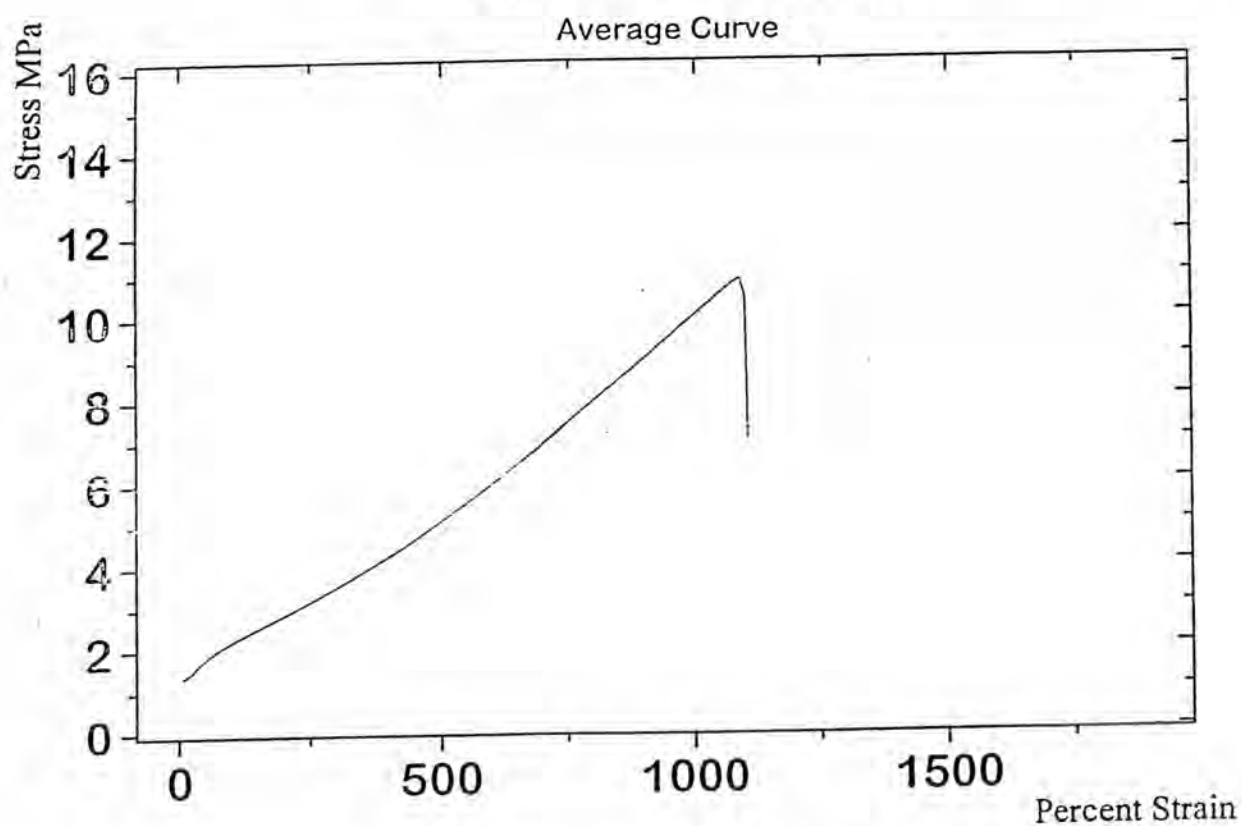


Figure D.12 Stress-strain curve of vulcanized sheets containing Tergitol NP9 as surfactant



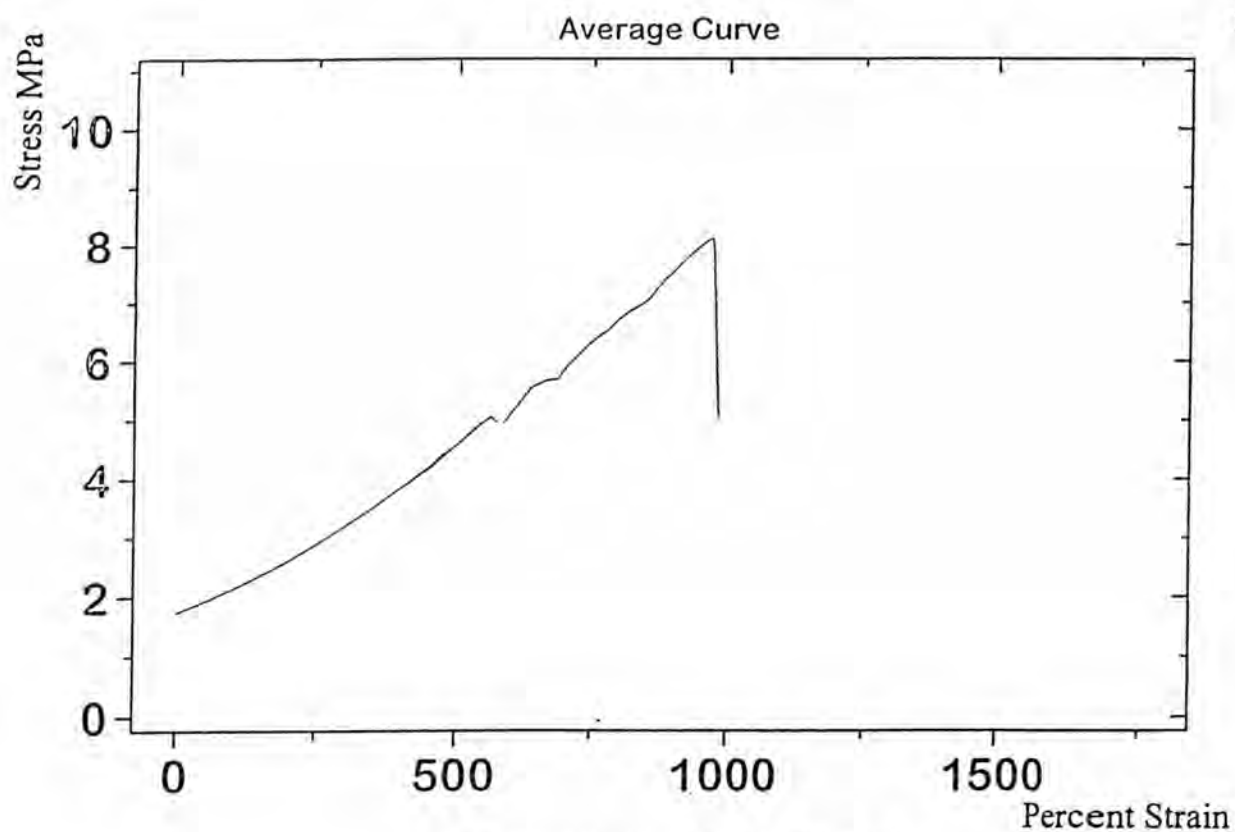
1<sup>st</sup>Experiment (modulus 500% = 4.82 MPa)



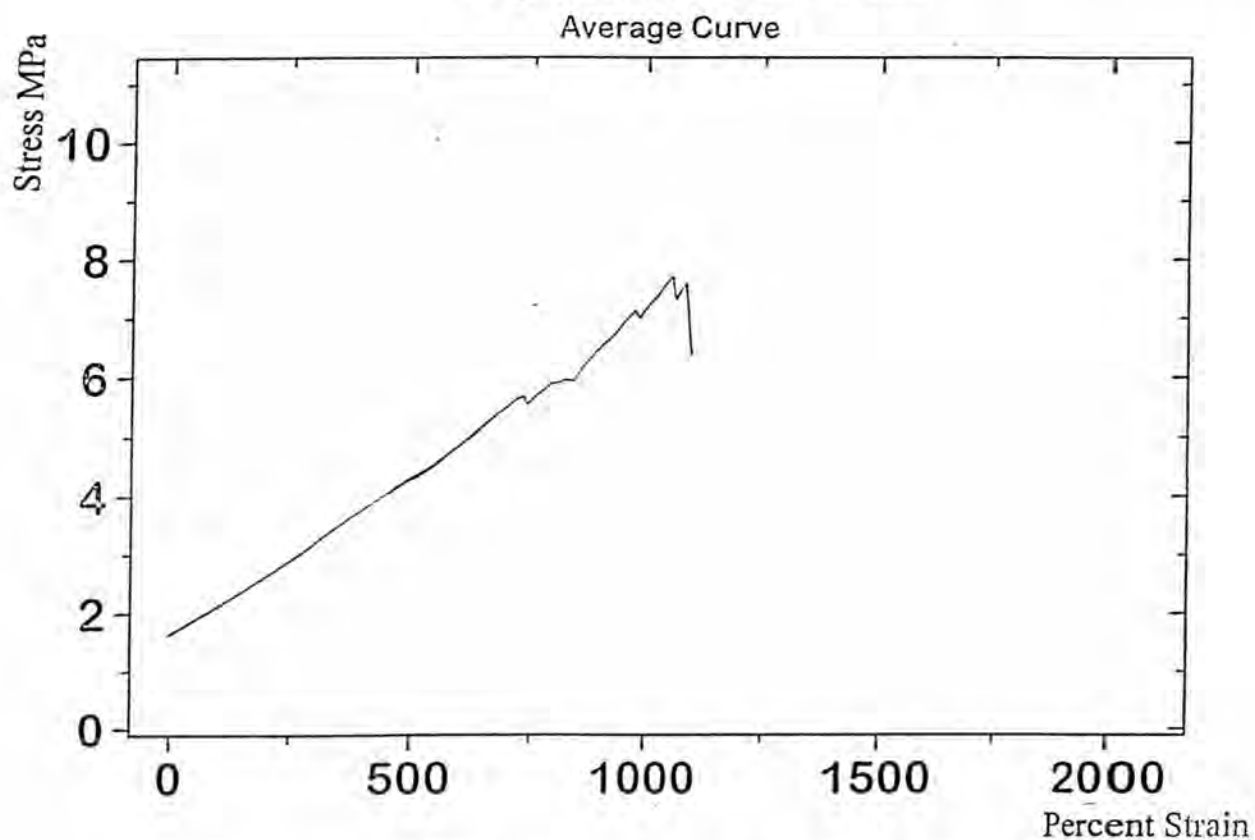
2<sup>nd</sup>Experiment (modulus 500% = 5.03 MPa)

Average = 4.93 MPa

Figure D.13 Stress-strain curve of vulcanized sheets containing SDS as surfactant



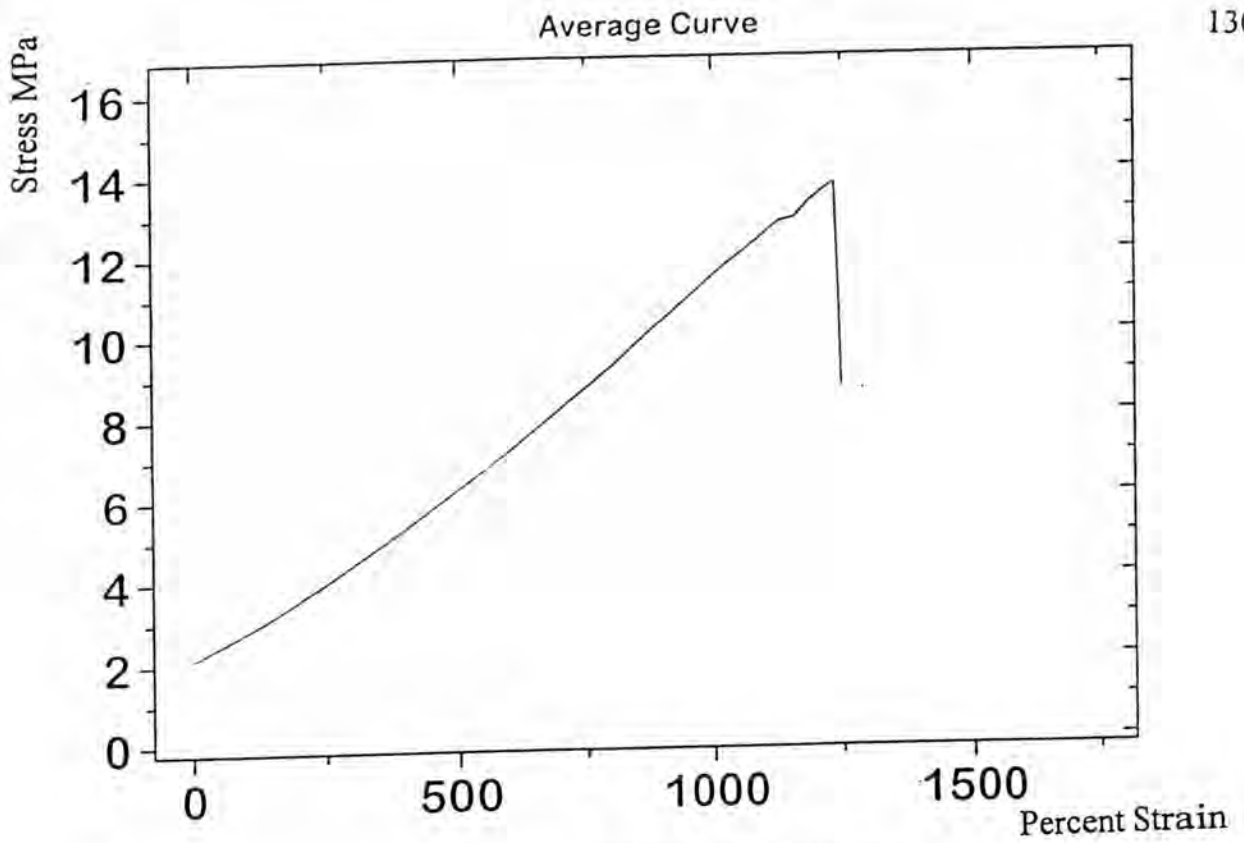
1<sup>st</sup> Experiment (modulus 200% = 2.55 MPa)



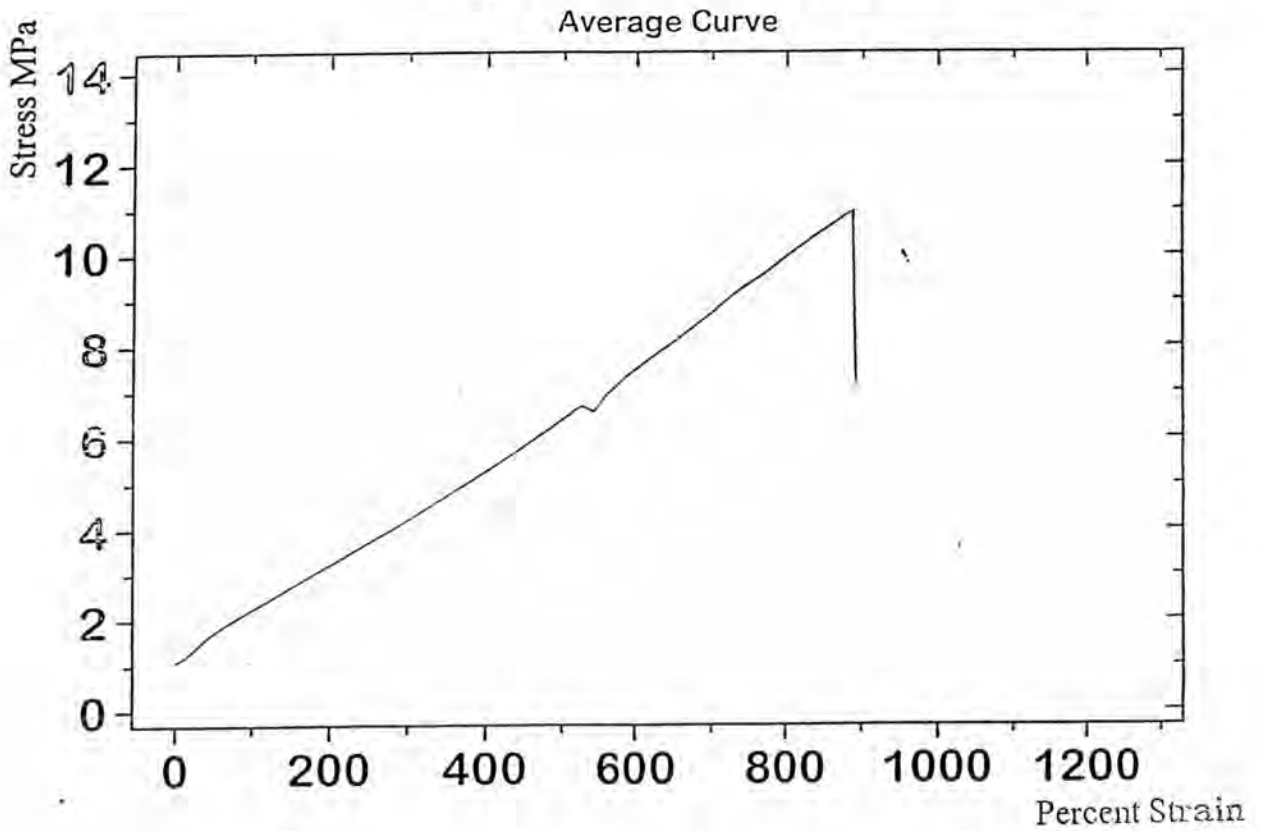
2<sup>nd</sup> Experiment (modulus 200% = 2.64 MPa)

Average = 2.60 MPa

**Figure D.14** Stress-strain curve of vulcanized sheets containing carbon black type N330 10 phr



1<sup>st</sup>Experiment (modulus 500% = 6.20 MPa)



2<sup>nd</sup>Experiment (modulus 500% = 6.35 MPa)

Average = 6.28 MPa

Figure D.15 Stress-strain curve of vulcanized sheets containing carbon black type N330 35 phr

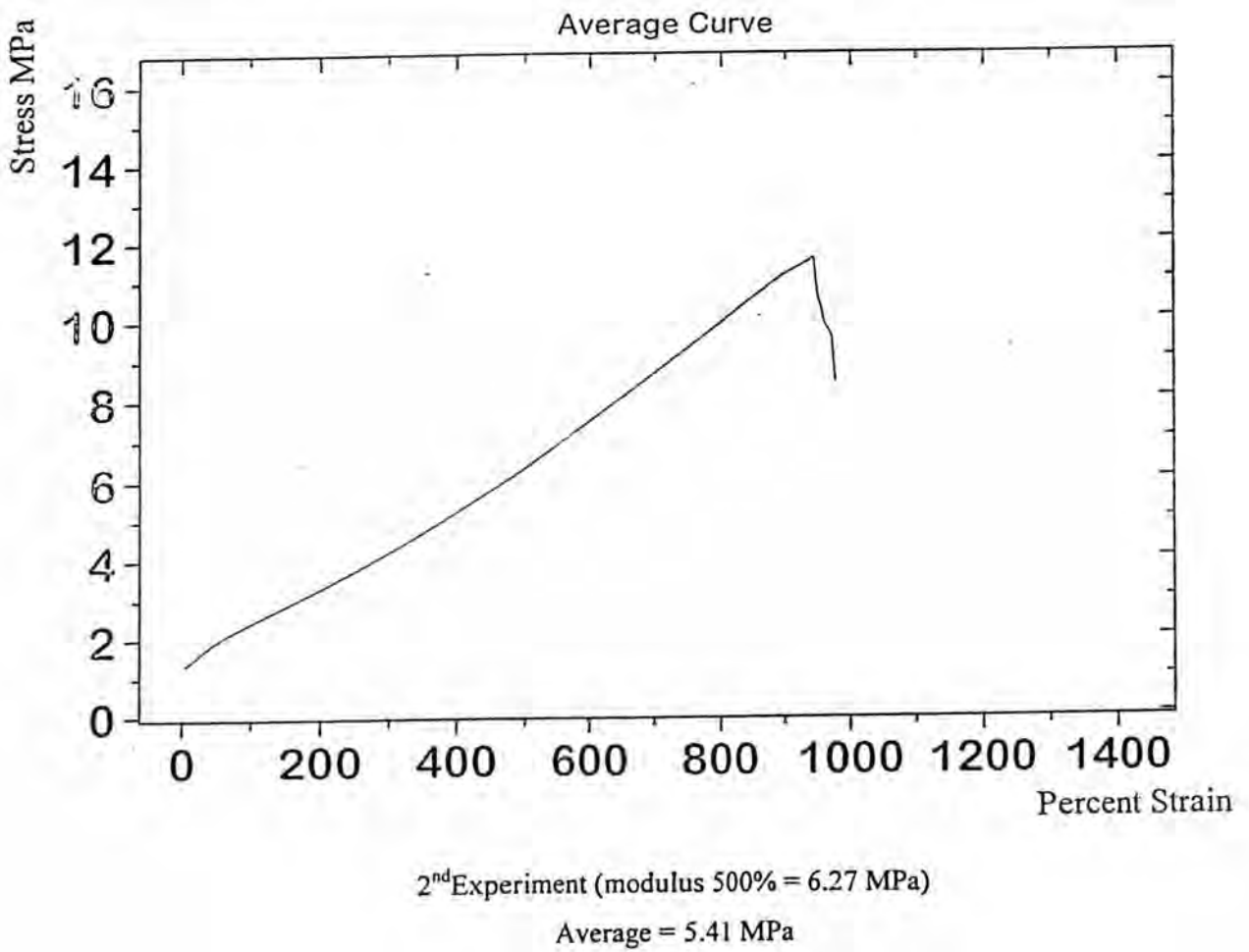
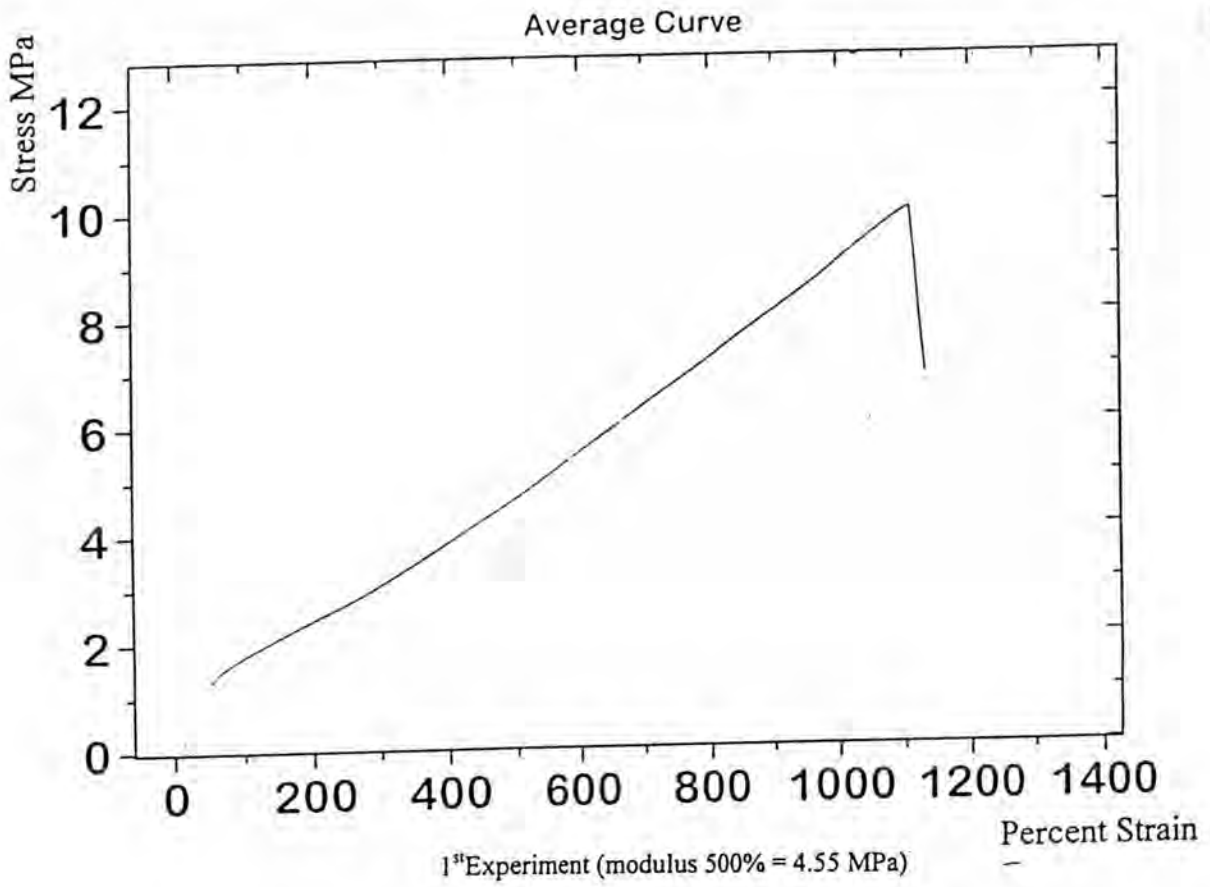
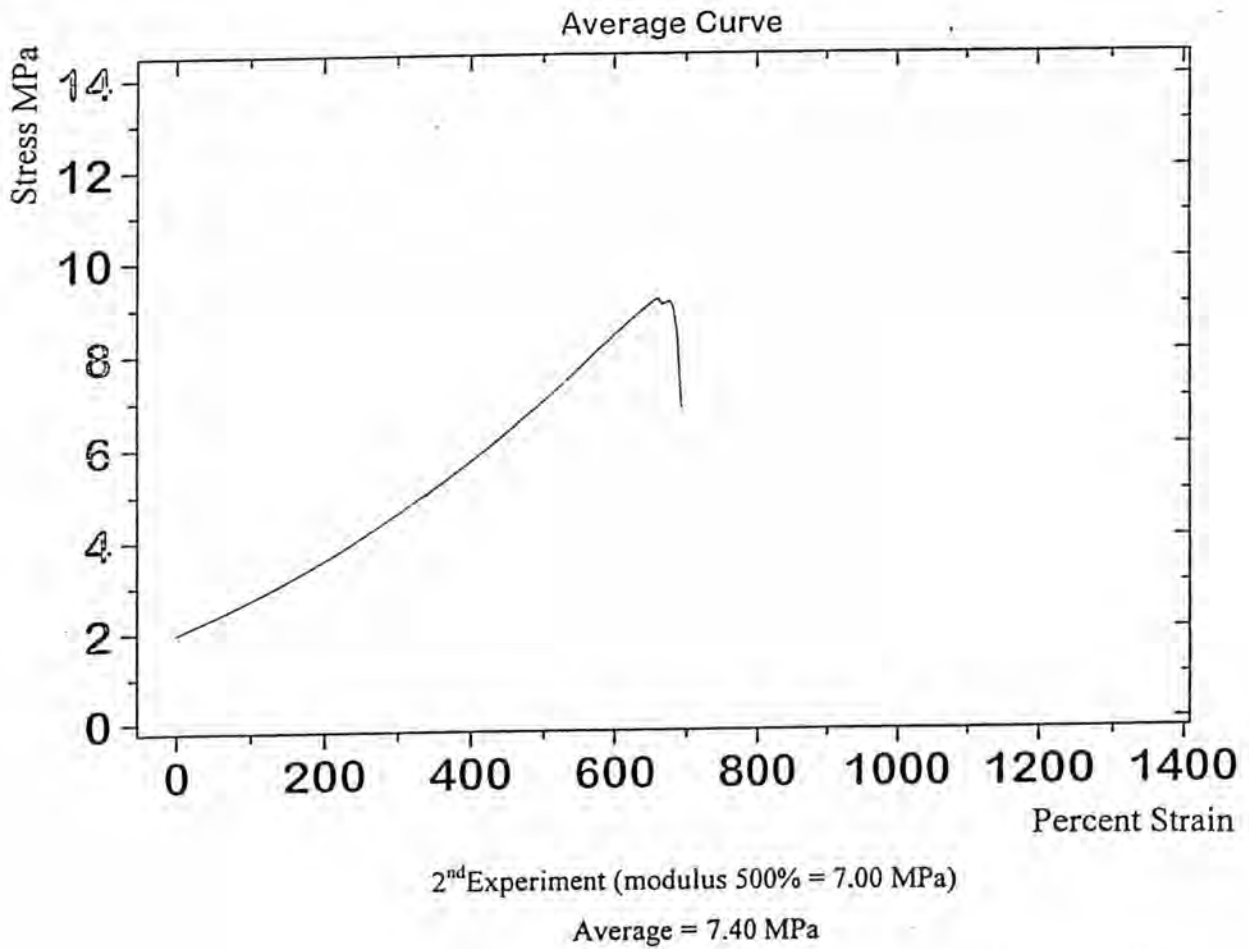
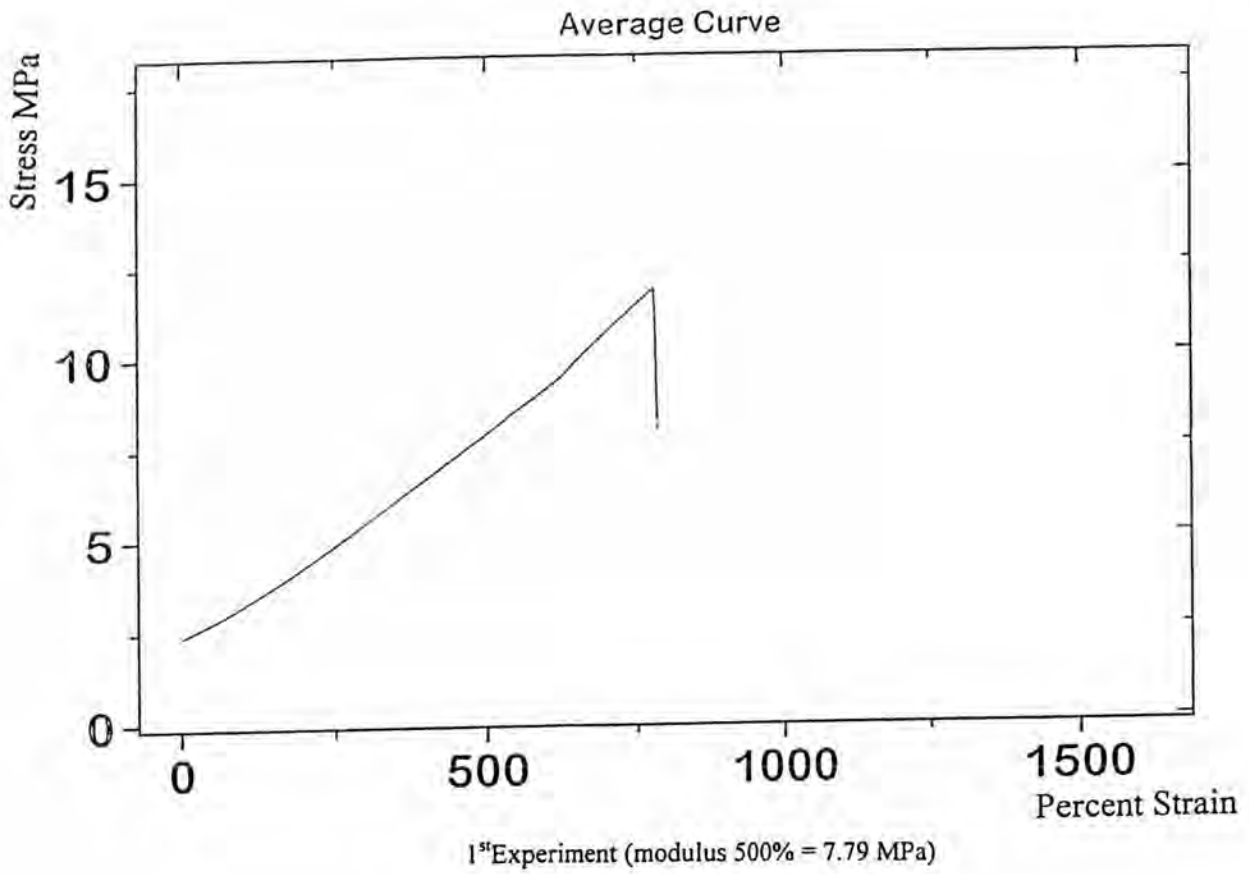
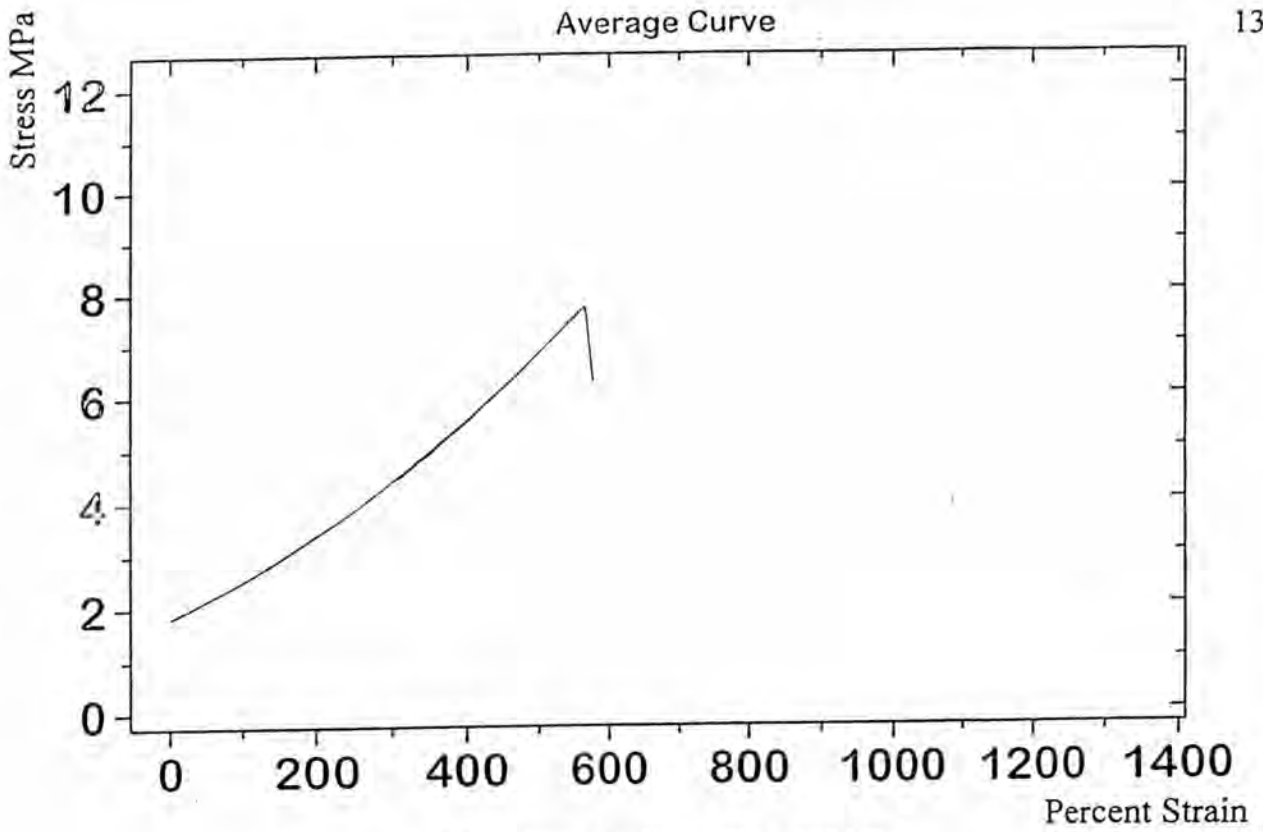


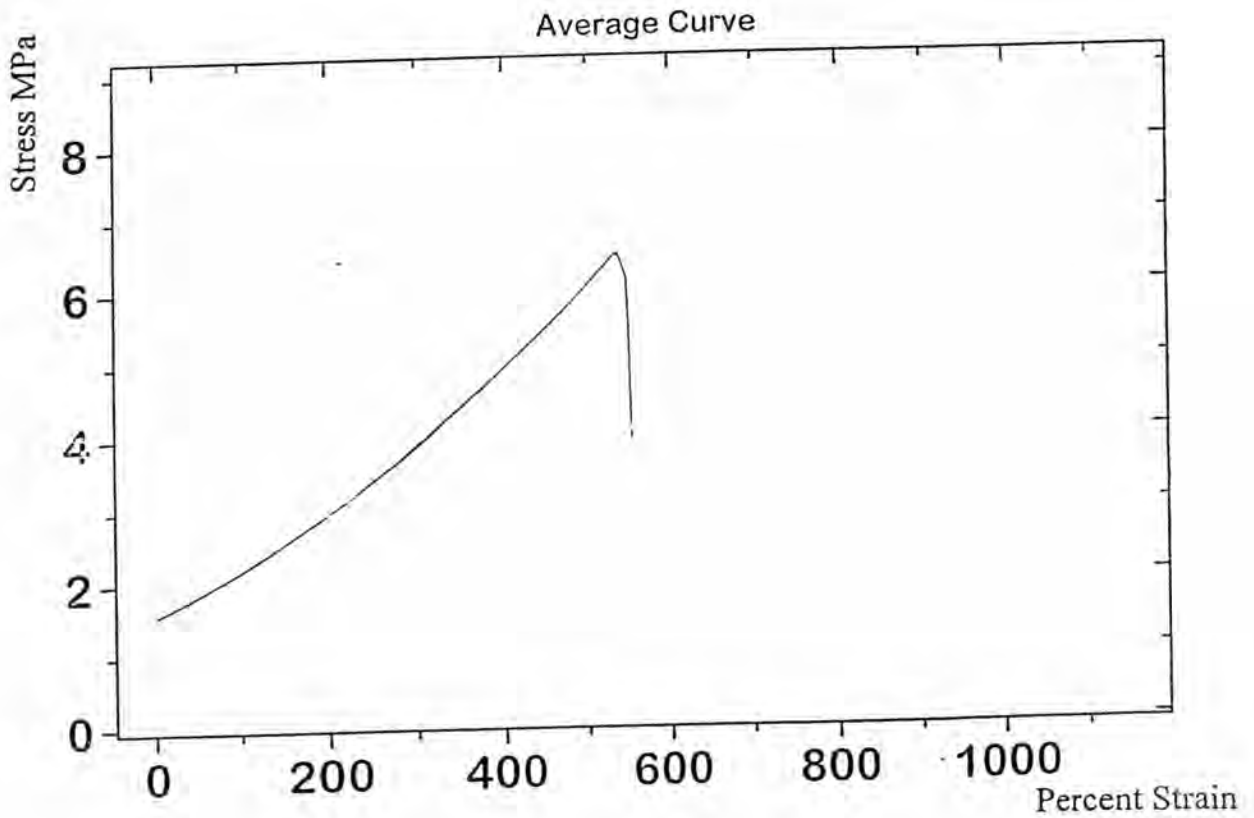
Figure D.16 Stress-strain curve of vulcanized sheets containing carbon black type N330 45 phr



**Figure D.17** Stress-strain curve of vulcanized sheets that prepared by two-roll mills (raw rubber – smoked sheet rubber)



1<sup>st</sup>Experiment (modulus 500% = 6.80 MPa)



2<sup>nd</sup>Experiment (modulus 500% = 6.11 MPa)

Average = 6.46 MPa

Figure D.18 Stress-strain curve of vulcanized sheets that prepared by two-roll mills (raw rubber – coagulate from concentrated latex)



#### 4. Hardness of Vulcanized Sheets

**Table D.15** Hardness of vulcanized sheets at various time for preparing aqueous dispersions or mixing time

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
1	1	60	1	59	59.0
	2	62	2	58	
	3	58	3	57	
	4	58	4	58	
	5	61	5	59	
	mean	59.8	mean	58.2	
2	1	59	1	58	59.2
	2	60	2	60	
	3	58	3	60	
	4	57	4	60	
	5	60	5	60	
	mean	58.8	mean	59.6	
3	1	60	1	60	60.4
	2	62	2	60	
	3	60	3	60	
	4	60	4	59	
	5	63	5	60	
	mean	61.0	mean	59.8	

Mixing time (hr.)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
4	1	60	1	60	60.2
	2	61	2	60	
	3	61	3	60	
	4	60	4	60	
	5	60	5	60	
	mean	60.4	mean	60.0	
5	1	60	1	60	60.9
	2	62	2	60	
	3	61	3	60	
	4	63	4	60	
	5	63	5	60	
	mean	61.8	mean	60.0	

**Table D.16** Hardness of vulcanized sheets at various amount of sulfur

Amount of sulfur (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
1	1	55	1	56	55.6
	2	56	2	55	
	3	55	3	55	
	4	56	4	56	
	5	56	5	56	
	mean	55.6	mean	55.6	
2 The values are shown in Table D.15 at mixing time of 3 hr					
3	1	60	1	59	59.4
	2	59	2	59	
	3	60	3	59	
	4	60	4	59	
	5	60	5	59	
	mean	59.8	mean	59.0	
4	1	61	1	62	61.2
	2	60	2	60	
	3	61	3	62	
	4	63	4	60	
	5	61	5	62	
	mean	61.2	mean	61.2	

**Table D.17** Hardness of vulcanized sheets at various amount of accelerator and accelerator activator

Amount of Accelerator and accelerator activator	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
low	1	50	1	50	51.1
	2	52	2	52	
	3	50	3	50	
	4	52	4	52	
	5	52	5	51	
	mean	51.2	mean	51.0	
medium	The values are shown in Table D.15 at mixing time of 3 hr				
high	1	65	1	65	65.4
	2	67	2	65	
	3	67	3	65	
	4	65	4	65	
	5	65	5	65	
	mean	65.8	mean	65.0	

**Table D.18** Hardness of vulcanized sheets that change types of carbon black

Type of carbon black	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
N 220	1	60	1	60	60.3
	2	60	2	60	
	3	62	3	60	
	4	61	4	60	
	5	60	5	60	
	mean	60.6	mean	60.0	
N 330	The values are shown in Table D.15 at mixing time of 3 hr				

**Table D.19** Hardness of vulcanized sheets that change types of surfactant

Type of surfactant	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
Tergitol NP 9	1	60	1	59	60.1
	2	60	2	60	
	3	60	3	60	
	4	62	4	60	
	5	60	5	60	
	mean	60.4	mean	59.8	
Tergitol NP 10	The values are shown in Table D.15 at mixing time of 3 hr				

Type of surfactant	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
SDS	1	60	1	63	
	2	63	2	62	
	3	61	3	62	
	4	64	4	60	
	5	64	5	63	
	mean	62.4	mean	62.0	

**Table D.20** Hardness of vulcanized sheets at various amount of carbon black

Amount of carbon black (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
10	1	44	1	43	
	2	45	2	40	
	3	44	3	40	
	4	45	4	42	
	5	46	5	41	
	mean	44.8	mean	41.2	
25	The values are shown in Table D.15 at mixing time of 3 hr				
35	1	63	1	62	
	2	65	2	60	
	3	60	3	60	
	4	59	4	62	
	5	64	5	61	
	mean	62.2	mean	61.0	

Amount of carbon black (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
45	1	66	1	63	65.2
	2	69	2	65	
	3	65	3	64	
	4	68	4	63	
	5	65	5	64	
	mean	66.6	mean	63.8	

Table D.21 Hardness of vulcanized sheets that used Two-roll mill

Raw rubber	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	positions	Hardness (shore A)	positions	Hardness (shore A)	
Smoked sheet	1	55	1	54	54.9
	2	56	2	55	
	3	57	3	54	
	4	55	4	55	
	5	55	5	53	
	mean	55.6	mean	54.2	
Coagulate from conc.latex	1	54	1	55	54.4
	2	56	2	53	
	3	55	3	55	
	4	55	4	54	
	5	54	5	53	
	mean	54.8	mean	54.0	

## 5. Tear Strength of Vulcanized Sheets

**Table D.22** Tear strength of vulcanized sheets at various amount of sulfur

Amount of sulfur (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
1	1	31.42	1	36.02	36.47
	2	32.78	2	42.88	
	3	35.88	3	39.81	
	mean	33.36	mean	39.57	
2	1	58.05	1	52.08	57.15
	2	59.51	2	64.14	
	3	48.60	3	60.47	
	mean	55.39	mean	58.90	
3	1	38.38	1	44.68	42.37
	2	36.25	2	45.30	
	3	44.41	3	45.18	
	mean	39.68	mean	45.05	
4	1	28.19	1	29.36	33.38
	2	31.51	2	38.34	
	3	37.17	3	35.70	
	mean	32.29	mean	34.47	



**Table D.23** Tear strength of vulcanized sheets at various amount of accelerator and accelerator activator

Amount of Accelerator and accelerator activator	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
low	1	32.50	1	40.94	
	2	30.12	2	33.13	
	3	38.39	3	38.88	
	mean	33.67	mean	37.65	35.66
medium	The values are shown in Table D.22 at the amount of sulfur 2 phr				
high	1	29.65	1	31.84	
	2	35.05	2	36.89	
	3	30.95	3	39.34	
	mean	31.88	mean	36.02	33.95

**Table D.24** Tear strength of vulcanized sheets that change type of carbon black

Type of carbon black	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
N 220	1	38.48	1	45.63	
	2	35.78	2	43.41	
	3	37.91	3	41.32	
	mean	37.39	mean	43.45	40.42

Type of carbon black	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
N 330	The values are shown in Table D.22 at the amount of sulfur 2 phr				

**Table D.25** Tear strength of vulcanized sheets that change types of surfactant

Type of surfactant	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
Tergitol NP 9	1	36.68	1	44.32	
	2	44.69	2	50.89	
	3	46.84	3	48.87	
	mean	42.74	mean	48.03	45.39
Tergitol NP 10 The values are shown in Table D.22 at the amount of sulfur 2 phr					
SDS	1	35.53	1	37.41	
	2	29.59	2	35.27	
	3	29.06	3	36.45	
	mean	31.39	mean	36.38	33.89

**Table D.26** Tear strength of vulcanized sheets at various amount of carbon black

Amount of carbon black (phr)	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
10	1	29.02	1	28.47	27.51
	2	27.93	2	26.43	
	3	25.13	3	28.07	
	mean	27.36	mean	27.66	
25	The values are shown in Table D.22 at the amount of sulfur 2 phr				
35	1	48.47	1	46.69	45.45
	2	47.85	2	39.78	
	3	49.48	3	40.42	
	mean	48.60	mean	42.30	
45	1	35.92	1	37.60	36.76
	2	37.65	2	41.41	
	3	33.58	3	34.39	
	mean	35.72	mean	37.80	

**Table D.27** Tear strength of vulcanized sheets that used Two-roll mill

Raw rubber	1 <sup>st</sup> Experiment		2 <sup>nd</sup> Experiment		Average
	specimen	Tear strength (kN/m)	specimen	Tear strength (kN/m)	
Smoked sheet	1	42.44	1	34.77	39.73
	2	41.46	2	36.38	
	3	39.44	3	43.88	
	mean	41.11	mean	38.34	
Coagulate from conc.latex	1	30.17	1	29.19	30.75
	2	35.70	2	27.35	
	3	35.52	3	28.58	
	mean	33.13	mean	28.37	

## 6. Solvent Swelling of Vulcanized Sheets

**Table D.28** Solvent swelling of vulcanized sheets at various amount of sulfur

Amount of sulfur (phr)	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
1	0.24	0.97	304	0.23	0.91	296	293
	0.23	0.90	291	0.22	0.90	309	
	0.24	0.89	271	0.22	0.85	286	
		mean	289		mean	297	

Amount of sulfur (phr)	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
2	0.25	0.90	260	0.22	0.75	241	
	0.23	0.79	243	0.22	0.81	268	
	0.23	0.85	270	0.22	0.70	218	
		mean	258		mean	242	250
3	0.24	0.84	250	0.23	0.77	235	
	0.21	0.75	257	0.23	0.80	248	
	0.24	0.79	229	0.24	0.79	229	
		mean	245		mean	237	241
4	0.26	0.84	223	0.24	0.69	188	
	0.22	0.74	236	0.23	0.73	217	
	0.22	0.69	214	0.23	0.70	204	
		mean	224		mean	203	214

**Table D.29** Solvent swelling of vulcanized sheets at various amount of accelerator and accelerator activator

Amount of accelerator and accelerator activator	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
low	0.23	0.87	278	0.23	0.80	248	
	0.23	0.90	291	0.22	0.83	277	
	0.24	0.81	238	0.22	0.79	259	
		mean	269		mean	261	265
medium	The values are shown in Table D.28 at the amount of sulfur 2 phr						
high	0.23	0.71	209	0.20	0.63	215	
	0.23	0.69	200	0.21	0.65	209	
	0.22	0.65	195	0.22	0.70	218	
		mean	201		mean	214	208

**Table D.30** Solvent swelling of vulcanized sheets that change types of carbon black

Type of carbon black	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
N220	0.23	0.80	248	0.23	0.79	243	
	0.23	0.85	270	0.22	0.80	264	
	0.23	0.82	257	0.22	0.73	232	
		mean	258		mean	246	252
N 330 The values are shown in Table D.28 at the amount of sulfur 2 phr							

**Table D.31** Solvent swelling of vulcanized sheets that change types of surfactant

Type of surfactant	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
Tergitol NP 9	0.26	0.88	238	0.25	0.86	244	
	0.24	0.79	229	0.25	0.90	260	
	0.24	0.80	233	0.23	0.75	226	
		mean	233		mean	243	238
Tergitol NP10 The values are shown in Table D.28 at the amount of sulfur 2 phr							
SDS	0.22	0.77	250	0.23	0.82	257	
	0.22	0.80	263	0.23	0.80	249	
	0.22	0.69	214	0.22	0.79	259	
		mean	242		mean	255	249

**Table D.32** Solvent swelling of vulcanized sheets at various amount of carbon black

Amount of carbon black (phr)	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample weight(g)	swelling weight(g)	%	sample weight(g)	swelling weight(g)	%	
10	0.22	0.98	345	0.22	0.93	323	
	0.22	0.94	327	0.23	1.01	339	
	0.22	0.99	350	0.23	0.95	313	
		mean	341		mean	325	333
25 The values are shown in Table D.28 at the amount of sulfur 2 phr							
35	0.21	0.69	229	0.23	0.70	204	
	0.22	0.67	205	0.25	0.75	200	
	0.22	0.71	223	0.24	0.77	221	
		mean	219		mean	208	214
45	0.25	0.76	204	0.24	0.71	196	
	0.24	0.70	192	0.24	0.73	204	
	0.24	0.75	213	0.23	0.68	196	
		mean	203		mean	199	201



Table D.33 Solvent swelling of vulcanized sheets that used Two-roll mill

Raw rubber	1 <sup>st</sup> Experiment			2 <sup>nd</sup> Experiment			Average
	sample	swelling	%	sample	swelling	%	
	weight(g)	weight(g)		weight(g)	weight(g)		
Smoked sheet	0.24	1.14	375	0.22	1.13	414	
	0.23	1.15	400	0.23	1.15	400	
	0.24	1.04	333	0.23	1.24	439	
		mean	369		mean	418	394
Coagulate from conc.latex	0.22	1.14	418	0.22	1.05	377	
	0.23	1.03	348	0.22	1.11	405	
	0.25	1.15	360	0.22	1.09	395	
		mean	375		mean	392	384

## VITA

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