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APPENDICES

Appendix A Adsorption Isotherms of SDS on Latex Particle at Various Pyrrole Concentration

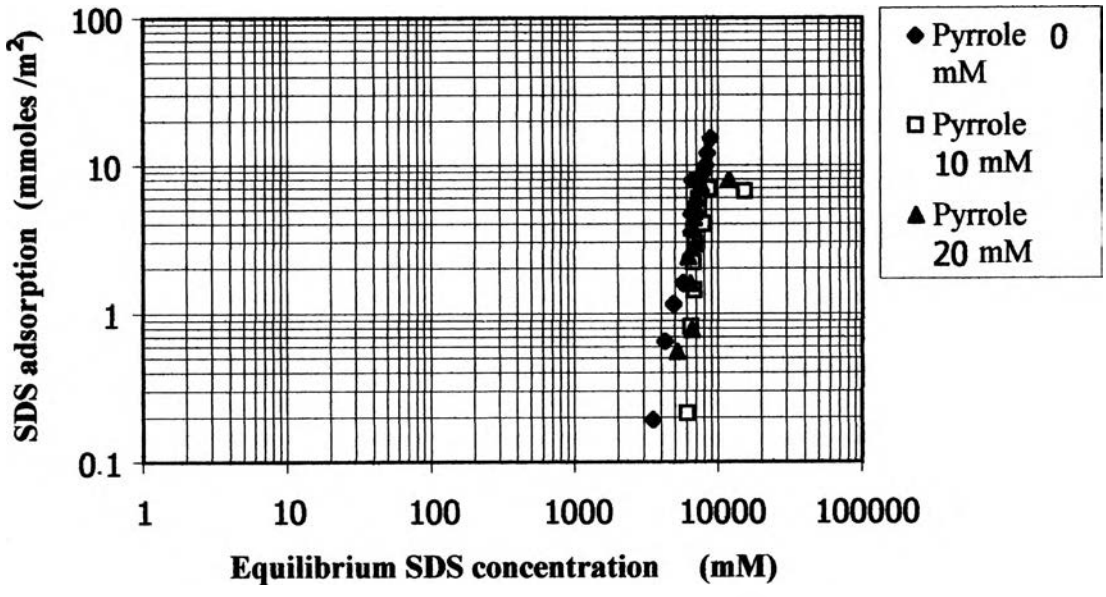

Figure A-1 Adsorption isotherms of SDS on latex particle at various pyrrole concentration. (obtained from the previous research work done by Bunsomsit, *et al.*, 2002)

Note

Pyrrole 10 mM condition made from latex 3.9 g

pyrrole 0.34 g = 5 mM

SDS 2.30 g = 8 mM

volume 13 ml

Pyrrole 20 mM condition made from latex 3.9 g

pyrrole 0.67 g = 10 mM

SDS 4.61g = 16 mM

volume 13 ml

Appendix B Raw Data of Mean Diameters From Centrifuged NR Latex

Table B-1 Mean diameters of centrifuged NR latex

Number	Mean diameters (mm)	Specific surface area* (m^2/g)
1	1.04	6.9721
2	1.08	6.8843
3	0.94	7.5895
4	0.98	7.0772
5	0.83	8.7563
Avg.	0.974	7.45588
Std.	0.0968504	0.776706477

* Density of NR particle assumed to be 1 g/cm^3.

Appendix C DTGA Thermograms of PPy under Different Atmospheres

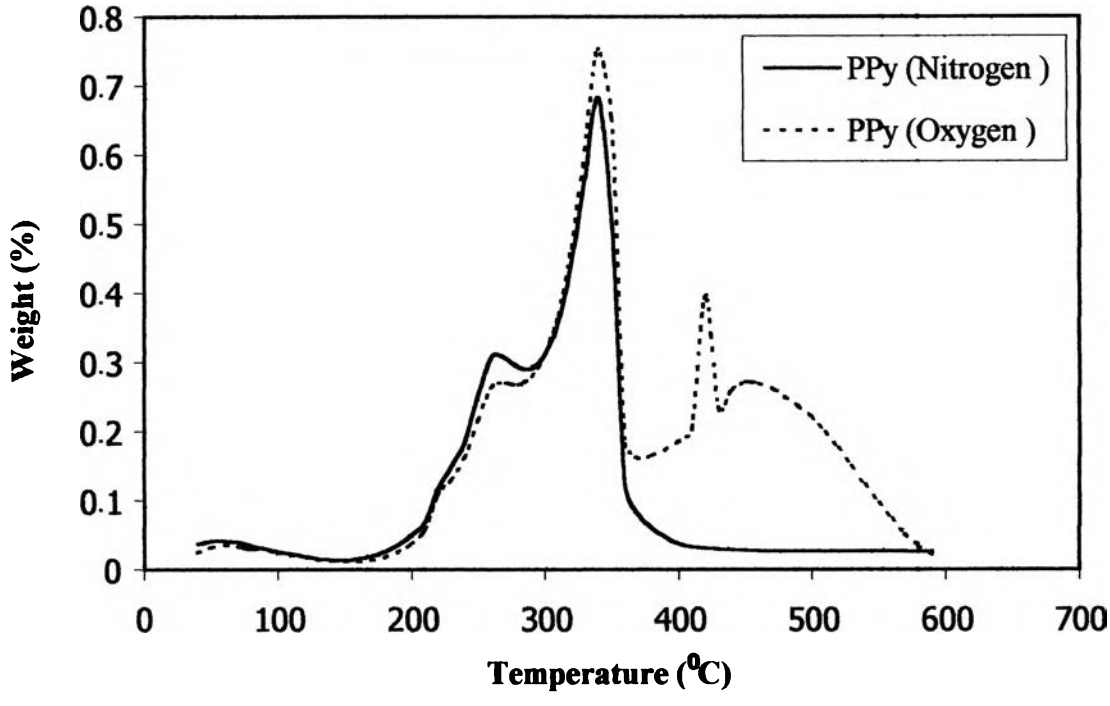

Figure C-1 DTGA Thermograms of PPy under different atmospheres.

Huijs et al., 2001 reported that annealing at 120 °C could destroy PPy by oxidation with oxygen such that the film developed higher resistance over time. Figure C-1 shows the decomposition of PPy and their derivatives in different atmospheres. The thermogram reveals that oxygen gas did not cause a strong effect of thermal resistance of PPy before 200°C.

Note Mass loss was calculated from TGA program. (Computer program)

Appendix D Admicelled Latex Recipe

Table D-1 Ingredients of the admicelled latices (one-step polymerization)

Sample	Pyrrole (ml)	Pyrrole (mM)	$(NH_4)_2S_2O_8$ (g)	SDS (ml)	NaCl (ml)	Make vol. to (ml)
Ctrl. 1	-	-	-	2.1	2.1	6.5
Ctrl. 2	-	-	-	2.1	-	6.5
N1	0.7	5	0.016	-	-	6.5
N2-1	0.7	5	0.016	2.1	-	6.5
N2-2	1.4	10	0.031	2.1	-	6.5
N2-3	3.4	20	0.078	2.6	-	10
N2-4	6.8	40	0.156	2.6	-	10
N2-5	28.2	60	0.645	7.2	-	40
N3-1	0.7	5	0.016	2.1	2.1	6.5
N3-2	1.4	10	0.031	2.1	2.1	6.5
N3-3	5.4	20	0.124	4.2	4.2	20
N3-4	34.8	40	0.795	13.4	13.5	80
N3-5	64.2	60	1.466	16.5	16.6	100
N2-2A9P1	Described below					

Note

All of the above mixtures were added with 3.9 grams of dry weight of NR latex particles. Stock solutions for each solution are 0.1 M Pyrrole, 0.052 M SDS, and 2M NaCl.

Preparation method (for N2-2A9P1)

Latex (N2-2) 18 g (dry weight content) + Pyrrole 1.4 ml (from stock solution) + Pyrrole (pure) 1.99 g + SDS 2.1 ml + Distilled water at the desired volume ---→ Put in shaker bath at 30^0C, 6 h ---→ Add $(NH_4)_2S_2O_8$ 2 g ---→ Polymerization for 4 h ---→ Dried in an air-oven at 70^0C

Table D-2 Calculation of pyrrole content in the admicelled latices in gram

Sample	Pyrrole (g)	Latex (g)	Pyrrole (wt%)	Latex (wt%)
N2-1, N3-1	0.0046	3.9	0.1167	99.8833
N2-2, N3-2	0.0091	3.9	0.2330	99.7670
N2-3	0.0229	3.9	0.5838	99.4162
N2-4	0.0458	3.9	0.1607	99.8393
N2-5	0.1895	3.9	4.6338	95.3662
N3-3	0.0363	3.9	0.9222	99.0778
N3-4	0.2337	3.9	5.6535	94.3465
N3-5	0.4310	3.9	9.9515	90.0485
N2-2A9P1	2	18	10	90

Table D-3 weight composition (%) of PPy mixed with admicelled latex (two-step polymerization)

Sample	Admicelled latex (wt%)	Pyrrole (wt%)	Admicelled latex (g)	Pyrrole (g)	Pyrrole (mole)	$(NH_4)_2S_2O_8$ (g)	$(NH_4)_2S_2O_8$ (mole)	Monomer :Initiator mole ratio
N2-1A1P9	10	90	2	18	0.268	18	0.079	3.4:1
N2-1A8P2	80	20	16	4	0.060	4	0.018	3.4:1
N2-1A4P6	40	60	8	12	0.179	12	0.053	3.4:1
N2-1A5P5	50	50	10	10	0.149	10	0.044	3.4:1
N2-1A9P1	90	10	18	2	0.030	0.030	0.088	3.4:1

Note

The other compositions were calculated similar to N2-1 system, the admicelled latex was only changed to N2-2, N3-1, and N3-2.

Calculation of PPy content in N2-2A9P1

Pyrrole from stock solution (1.4 ml = 0.01 g) + fresh distilled pyrrole (2-0.01 = 1.99 g). Therefore, whole pyrrole content = 2 g

Pyrrole (wt%) = [2/(18+2)] x 100 = 10%

Latex (wt%) = 100-10 = 90%

Calculation of mole of $(NH_4)_2S_2O_8$

Mole = gram / 228.20 g/mole (molecular weight of ammonium persulfate)

Calculation of PPy content in N2-1A1P9 (= PPy content in latex + PPy added)

[gram of admicelled latex x (0.1167/100)] + PPy added

= [2 x (0.1167/100)] + 18

= 18.0023 g

Mole of pyrrole = 18.0023 g / 67.09 g/mole

= 0.268 mole

Latex = 2x (99.8833/100)

= 1.9977 g

∴ Total weight = 18.0023 + 1.9977

= 20.0000 g

Appendix E Linear Viscoelastic Regime of Admicelled Latices

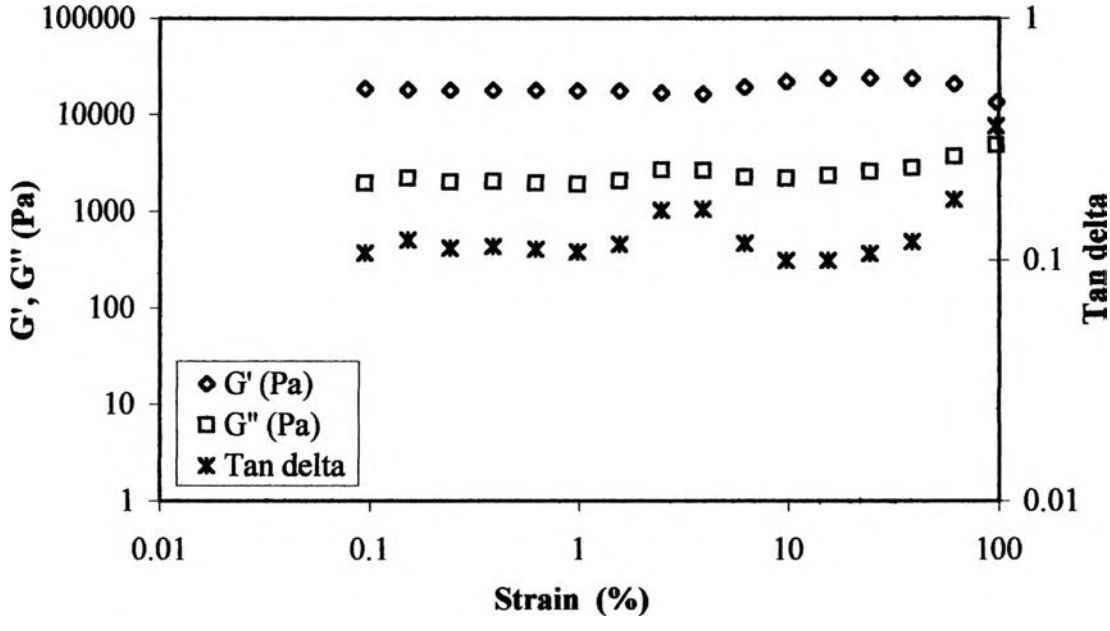

Figure E-1 Linear viscoelastic regime of NR latex film at 70^{0}C. (0.5% strain was selected)

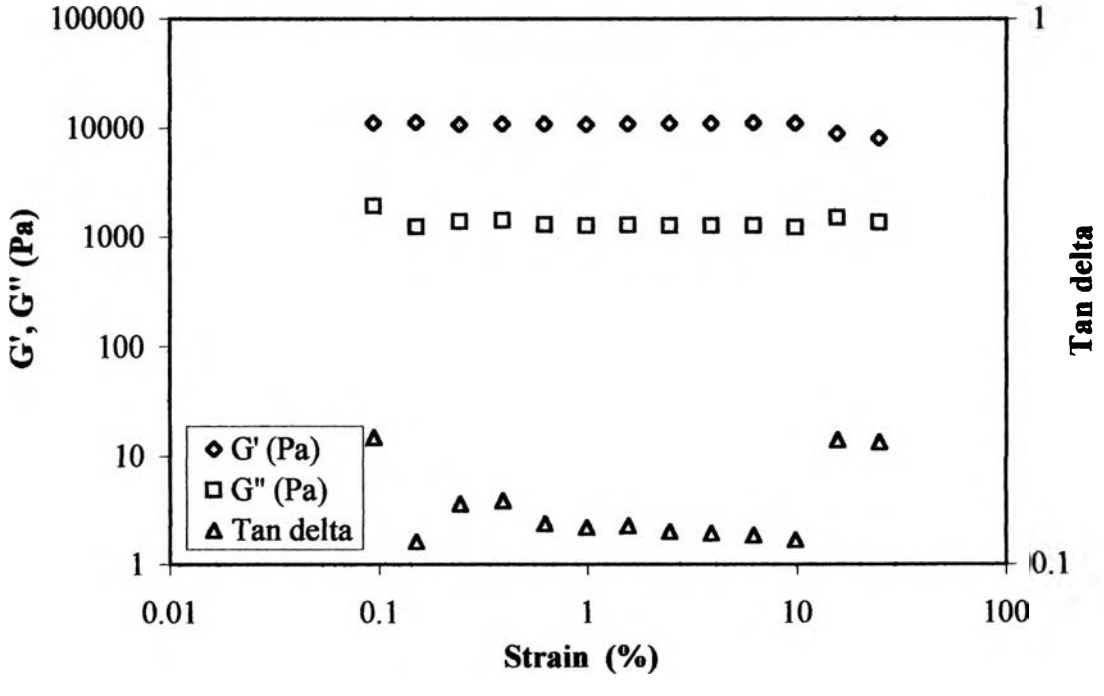

Figure E-2 Linear viscoelastic regime of N1 at 70^{0}C. (1% strain was selected)

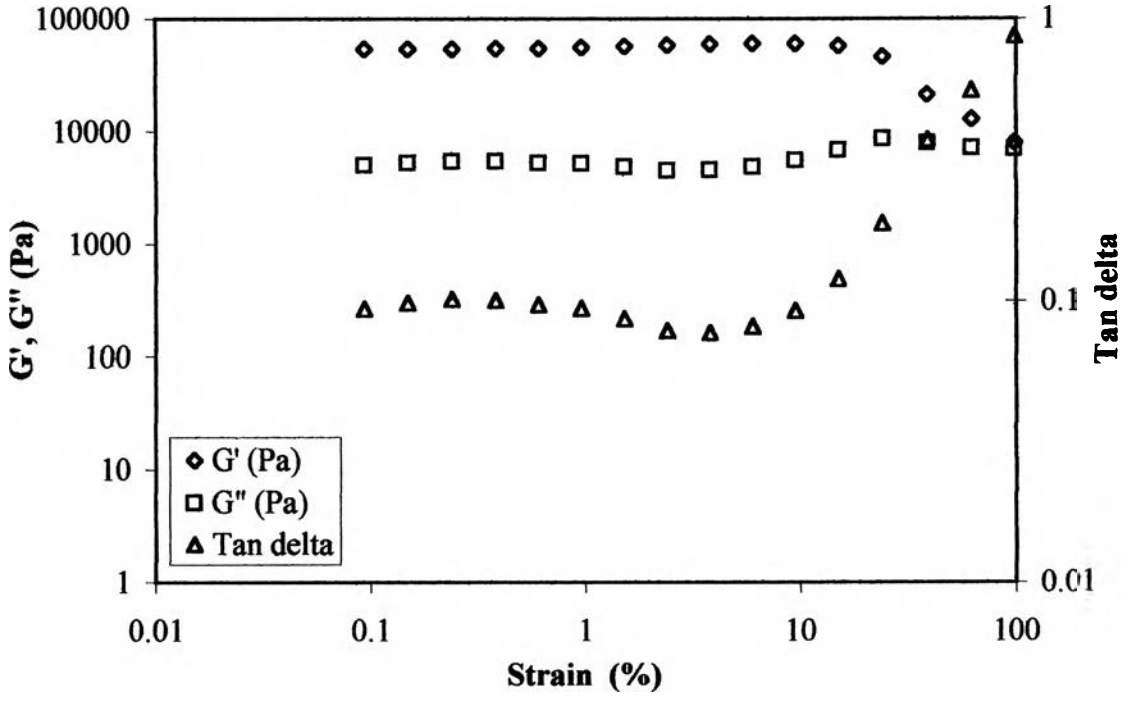

Figure E-3 Linear viscoelastic regime of N2-1 at 70^0C. (0.5% strain was selected)

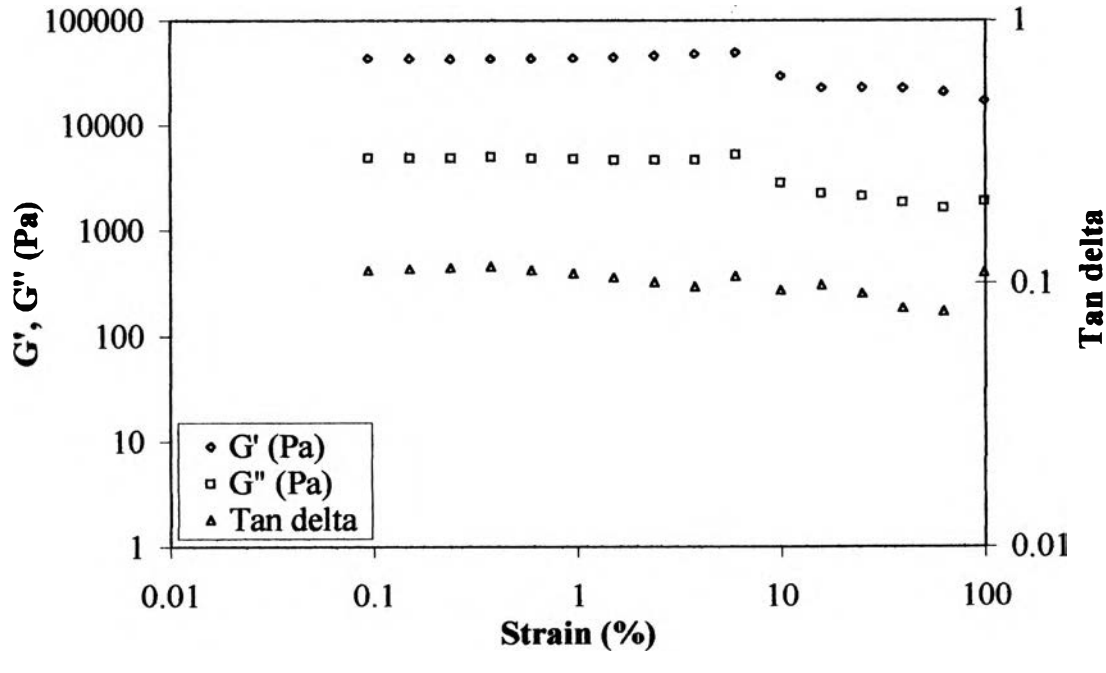

Figure E-4 Linear viscoelastic regime of N2-2 at 70^0C. (0.5% strain was selected)

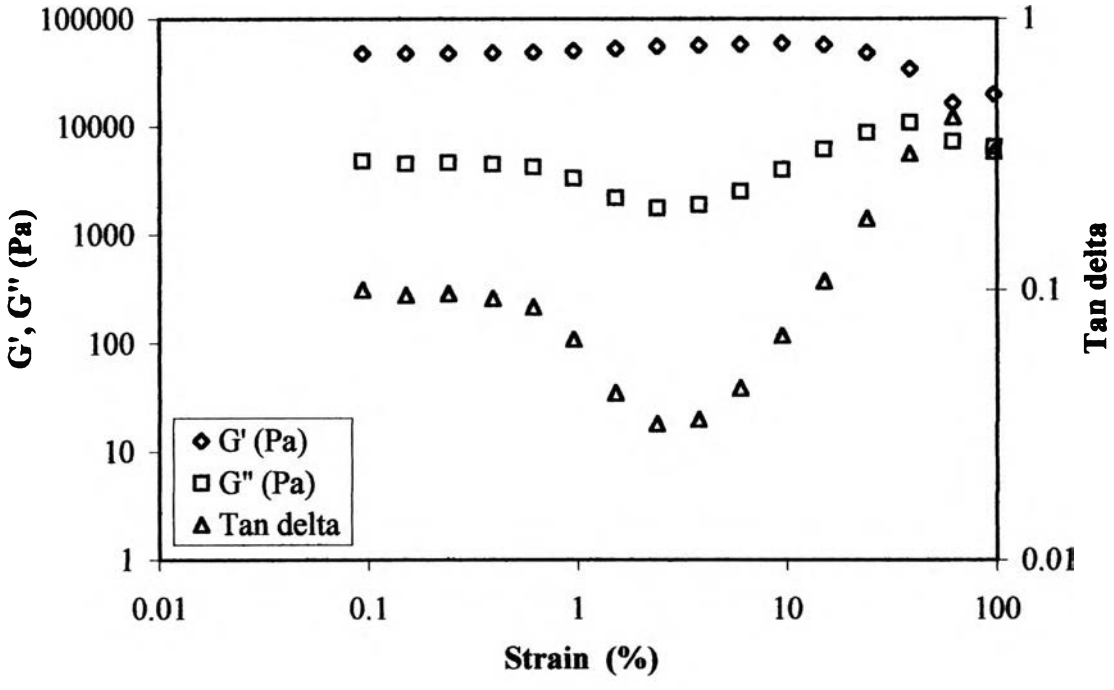

Figure E-5 Linear viscoelastic regime of N2-3 at 70^{0}C. (0.25% strain was selected)

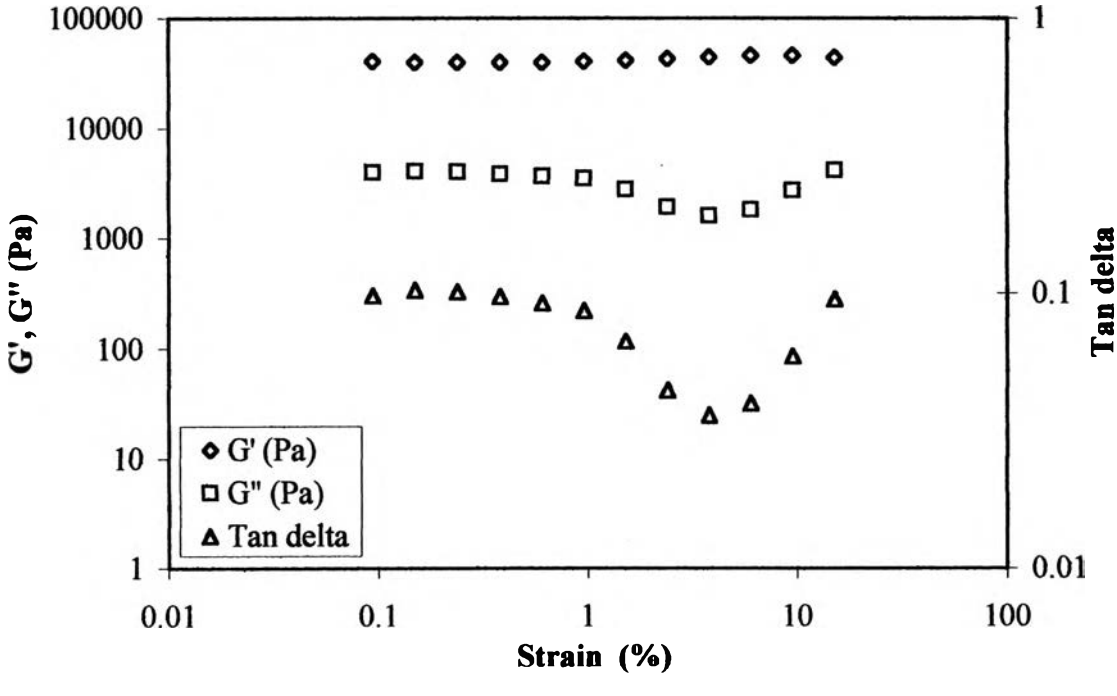

Figure E-6 Linear viscoelastic regime of N2-4 at 70^{0}C. (0.25% strain was selected)

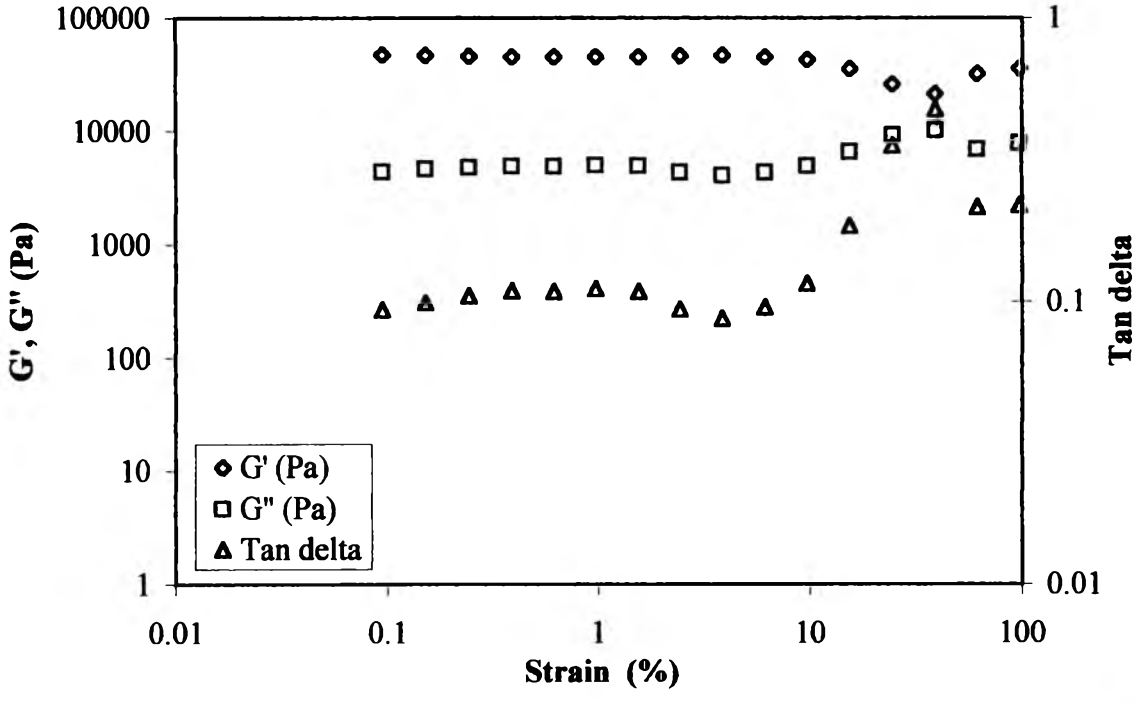

Figure E-7 Linear viscoelastic regime of N3-1 at 70^{0}C. (0.75% strain was selected)

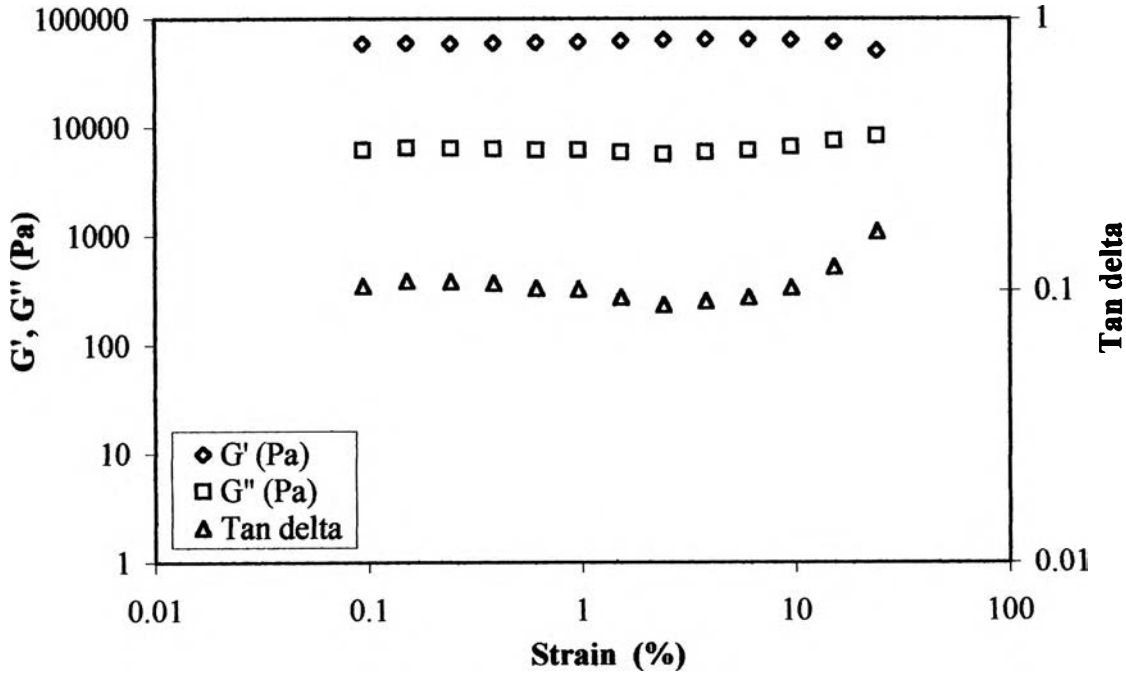

Figure E-8 Linear viscoelastic regime of N3-2 at 70^{0}C. (0.25% strain was selected)

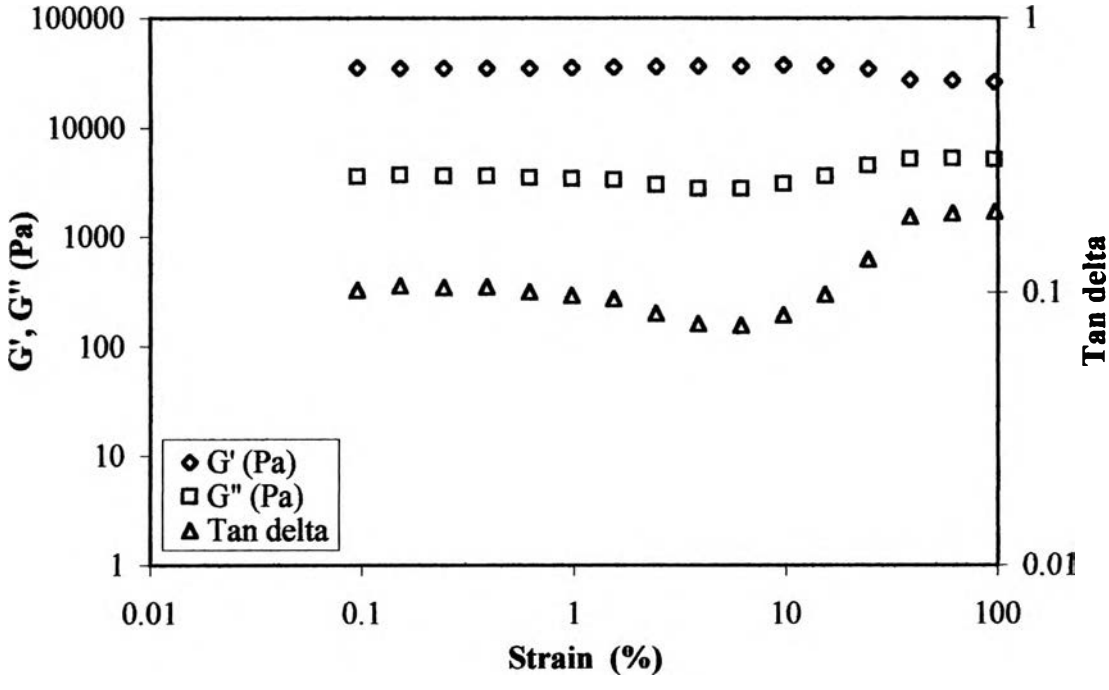

Figure E-9 Linear viscoelastic regime of N3-3 at 70^0C. (0.5% strain was selected)

Appendix F Calculation of Tensile Properties

Results obtained from Lloyd Universal Testing Machine are maximum load and extension at break in percentage. Tensile modulus, tensile strength, and secant modulus at 50% strain were calculated from the following equations.

Tensile modulus (E) = stress (σ) /strain (ε)

Stress (σ) = Load (N)/ Cross-sectional area of the specimen (mm^2)

$$\%\text{Strain } (\varepsilon) = \frac{\text{Crosshead extension (mm)}}{\text{Grip separation (mm)}} \times 100$$

$$50\%\text{ secant modulus } (E_{50\%}) = \frac{\text{Stress at 50\% strain}}{\text{Strain at 50\%}}$$

Tensile strength (MPa)

= Maximum load (N)/ Cross-sectional area of the specimen (mm^2)

Table F-1 Raw data of tensile properties calculation

Sample	Thickness (mm)	Max. Load (N)	Extension @ break (%)	Strain (%)	Stress (MPa)
Pure Latex					
1	1.01	13.60	784.5	816.67	0.53
2	1.18	14.10	862.9	850.00	0.47
3	0.97	14.3	842.9	833.33	0.58
4	0.82	15.90	987.9	966.67	0.76
5	0.73	9.80	734.5	733.33	0.53
Avg.	0.94	13.54	842.54	840.00	0.57
Std.	0.17	2.26	95.64	83.83	0.11
Ctrl. 1					
1	0.74	3.1	659.6	675.00	0.60
2	0.74	4.4	906.2	900.00	0.85
3	0.74	2.6	496.2	566.67	0.50
4	0.75	2.6	412.9	416.67	0.49
5	0.74	2.9	524.6	525.00	0.56
Avg.	0.74	3.12	599.9	616.67	0.60
Std.	0.01	0.75	192.86	183.43	0.15
Ctrl. 2					
1	0.64	2.3	376.2	383.33	0.51
2	0.65	2.2	526.2	533.33	0.48
3	0.66	2.4	332.9	341.67	0.52
4	0.65	5.2	1081.0	1075.00	1.14
5	0.65	4.7	1068.0	1066.67	1.04
Avg.	0.65	3.36	676.86	680.00	0.74
Std.	0.01	1.46	370.04	363.84	0.32

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Thickness (mm)	Max. Load (N)	Extension @ break (%)	Strain (%)	Stress (MPa)
N1					
1	0.64	3.7	819.6	816.67	0.83
2	0.61	5.4	1008.0	1000.0	1.26
3	0.75	3.0	577.9	575.0	0.57
4	0.59	2.4	529.4	516.67	0.58
5	0.67	2.8	614.6	600.0	0.59
Avg.	0.65	3.46	709.9	701.67	0.77
Std.	0.06	1.18	200.0	201.76	0.30
N2-1					
1	0.71	8.6	1111.0	1100.0	1.74
2	0.73	9.2	1125.0	1110.8	1.80
3	0.73	7.9	1065.0	1058.3	1.55
4	0.77	8.0	1055.0	1050.0	1.48
5	0.66	8.1	1090.0	1083.3	1.76
Avg.	0.72	8.36	1089.2	1080.5	1.66
Std.	0.04	0.54	29.63	26.12	0.14
N2-2					
1	0.63	9.7	1155	1133.3	2.20
2	0.58	8.8	1111	1133.3	2.15
3	0.61	7.8	1025	1041.67	1.82
4	0.74	8.6	1046	1033.3	1.67
5	0.67	9.4	1116	1108.3	2.00
Avg.	0.65	8.86	1090.6	1090.0	1.97
Std.	0.06	0.74	53.62	49.09	0.23

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Thickness (mm)	Max. Load (N)	Extension @ break (%)	Strain (%)	Stress (MPa)
N2-3					
1	0.53	13.7	1282	1266.67	1.02
2	0.49	20.2	1285	1266.67	1.62
3	0.51	25.3	1148	1133.33	1.95
4	0.55	34.7	1108	1100.00	2.48
5	0.66	34.4	1286	1133.33	2.05
Avg.	0.55	25.66	1221.8	1180.00	1.83
Std.	0.07	9.10	86.80	80.278	0.55
N2-4					
1	0.59	8.9	1056	1050.0	2.15
2	0.62	9.3	1103	1100.0	2.12
3	0.60	9.1	1080	1066.67	2.17
4	0.61	8.6	1050	1066.67	2.02
5	0.64	10.3	1171	1158.33	2.32
Avg.	0.61	9.24	1092	1088.33	2.16
Std.	0.02	0.65	48.90	43.14	0.11
N3-1					
1	0.64	8.5	1085	1090.0	1.89
2	0.66	8.7	1098	1143.3	1.88
3	0.67	9.8	1176	1173.3	2.09
4	0.63	8.9	1180	1200.0	2.03
5	0.62	9.3	1143	1150.0	2.15
Avg.	0.64	9.04	1136.4	1151.3	2.01
Std.	0.02	0.52	43.67	40.87	0.1

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Thickness (mm)	Max. Load (N)	Extension @ break (%)	Strain (%)	Stress (MPa)
N3-2					
1	0.79	6.5	926.2	926.67	1.180
2	0.72	7.5	1020.0	403.33	1.49
3	0.67	8.1	1053.0	1056.67	1.72
4	0.68	8.7	1058.0	1060.00	1.82
5	0.69	9.5	1123.0	1130.00	1.96
Avg.	0.71	8.06	1036.04	915.33	1.63
Std.	0.05	1.14	71.86	295.49	0.31
N3-3					
1	0.58	8.4	1083	1100.00	2.08
2	0.58	8.8	1098	1108.33	2.17
3	0.58	8.5	1085	1083.33	2.10
4	0.62	8.9	1068	1066.67	2.06
5	0.59	8.2	1070	1075.0	1.98
Avg.	0.59	8.56	1080.8	1086.67	2.08
Std.	0.02	0.29	12.24	17.28	0.07
N2-2A9P1-1					
1	0.56	9.3	886.2	900.00	0.65
2	0.55	15.8	1090.0	1066.67	1.13
3	0.50	10.5	1003.0	1000.00	0.83
4	0.48	9.8	958.0	933.33	0.80
5	0.55	15.9	995.0	1033.33	1.14
Avg.	0.53	12.3	986.44	986.67	0.91
Std.	0.04	3.30	74.04	69.12	0.21

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Tensile Modulus (N)	Tensile Strength (MPa)	50% secant modulus (N)
Pure Latex			
1	0.065	0.530	0.161
2	0.055	0.470	0.484
3	0.070	0.580	0.426
4	0.079	0.763	0.516
5	0.072	0.529	0.526
Avg.	0.068	0.575	0.423
Std.	0.009	0.113	0.151
Ctrl. 1			
1	0.089	0.600	0.872
2	0.095	0.852	0.774
3	0.088	0.501	0.627
4	0.118	0.493	0.616
5	0.107	0.561	0.870
Avg.	0.099	0.601	0.752
Std.	0.013	0.147	0.125
Ctrl. 2			
1	0.134	0.482	0.767
2	0.090	0.482	0.712
3	0.153	0.522	0.762
4	0.106	1.1423	0.604
5	0.097	1.035	0.661
Avg.	0.116	0.733	0.701
Std.	0.026	0.328	0.069

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Tensile Modulus (N)	Tensile Strength (MPa)	50% secant modulus (N)
N1			
1	0.101	0.826	0.754
2	0.127	1.264	0.790
3	0.010	0.574	0.790
4	0.113	0.58	0.485
5	0.099	0.594	0.636
Avg.	0.108	0.768	0.691
Std.	0.012	0.296	0.131
N2-1			
1	0.158	1.738	0.909
2	0.162	1.798	0.782
3	0.146	1.545	0.782
4	0.141	1.481	0.694
5	0.163	1.763	0.816
Avg.	0.154	1.665	0.797
Std.	0.010	0.142	0.077
N2-2			
1	0.194	2.202	0.880
2	0.190	2.155	0.857
3	0.174	1.816	0.698
4	0.161	1.668	0.824
5	0.181	2.001	0.984
Avg.	0.180	1.968	0.849
Std.	0.013	0.226	0.103

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Tensile Modulus (N)	Tensile Strength (MPa)	50% secant modulus (N)
N2-3			
1	0.188	1.976	0.857
2	0.163	2.080	0.877
3	0.159	2.024	0.893
4	0.157	1.991	0.878
5	0.176	2.241	0.985
Avg.	0.169	2.062	0.898
Std.	0.013	0.108	0.050
N2-4			
1	0.205	2.154	0.666
2	0.193	2.119	0.854
3	0.204	2.173	0.866
4	0.189	2.019	0.939
5	0.200	2.315	0.983
Avg.	0.198	2.156	0.862
Std.	0.007	0.107	0.122
N3-1			
1	0.174	1.895	0.669
2	0.164	1.880	0.864
3	0.178	2.086	0.639
4	0.169	2.027	0.683
5	0.187	2.153	0.868
Avg.	0.174	2.008	0.745
Std.	0.009	0.119	0.112

Table F-1 Raw data of tensile properties calculation (Continued)

Sample	Tensile Modulus (N)	Tensile Strength (MPa)	50% secant modulus (N)
N3-2			
1	0.127	1.1808	0.7267
2	0.369	1.489	0.893
3	0.163	1.724	0.851
4	0.171	1.818	0.627
5	0.173	1.957	0.798
Avg.	0.201	1.634	0.779
Std.	0.096	0.305	0.1056
N3-3			
1	0.189	2.083	0.868
2	0.196	2.173	0.988
3	0.194	2.097	0.864
4	0.193	2.063	0.985
5	0.184	1.975	0.964
Avg.	0.191	2.078	0.934
Std.	0.005	0.071	0.063
N2-2A9P1-1			
1	0.073	0.654	0.562
2	0.106	1.131	0.573
3	0.083	0.827	0.630
4	0.086	0.804	0.656
5	0.110	1.134	0.573
Avg.	0.092	0.911	0.599
Std.	0.016	0.215	0.042

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