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APPENDIX

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THEORETICAL CURVES OF ELONGATION AT BREAK
AND TENSILE STRENGTH OF FILLED POLYMERS

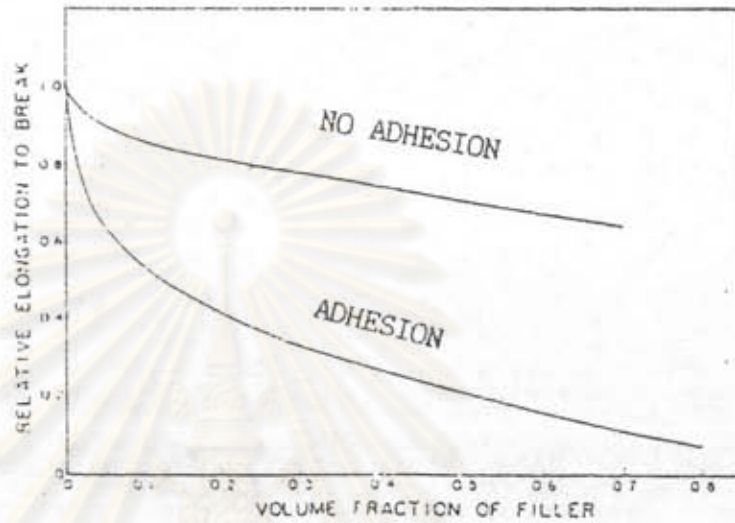


Figure A.1 Theoretical curves for the elongation at break for the case of perfect adhesion and no adhesion between the filler and polymer phases. (Nielsen, 1966.)

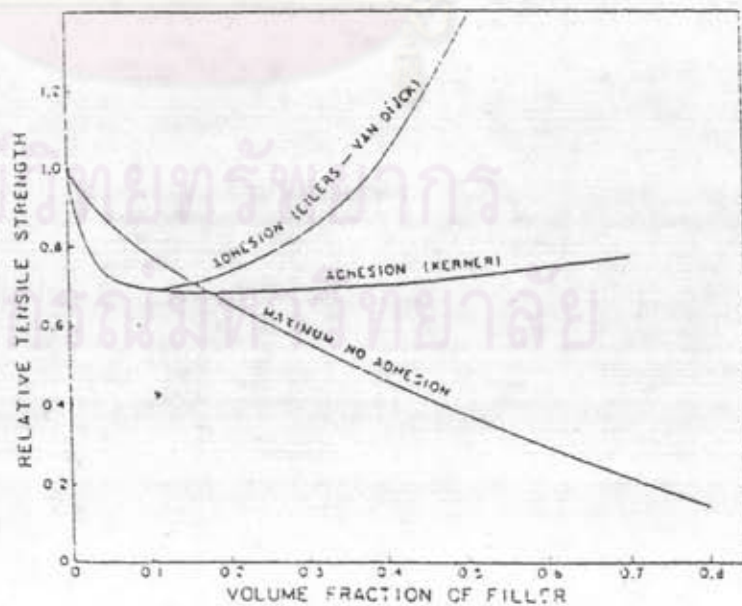


Figure A.2 Theoretical curves for the tensile strength of filled polymers. (Nielsen, 1966.)

APPENDIX B

FORCE AND EXTENSION CURVES OF FILLED COMPOUNDS

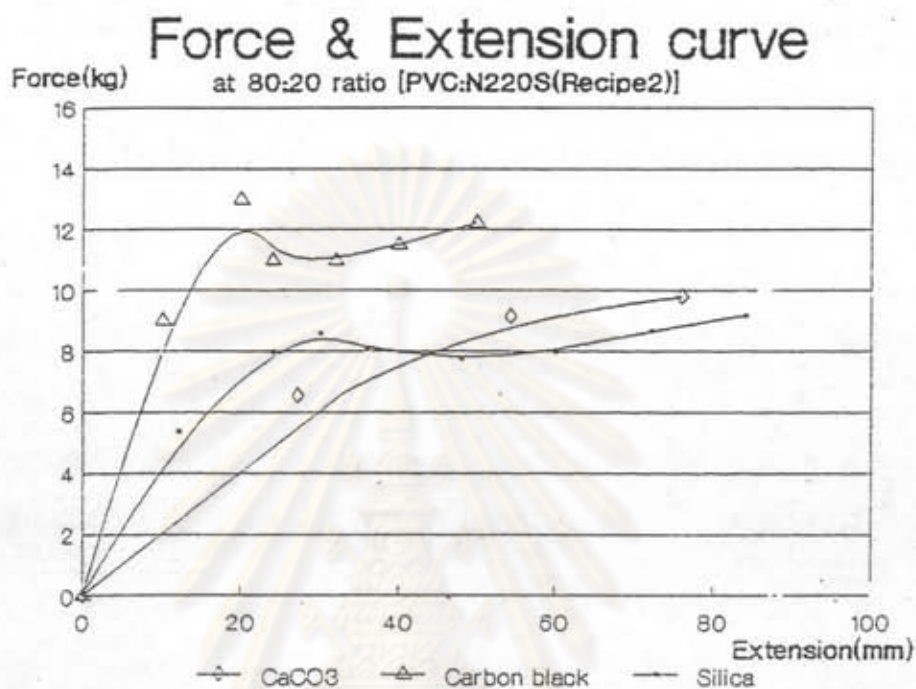


Figure B.1 Force & extension curve of filled compounds at 80:20 ratio (PVC/NBR)

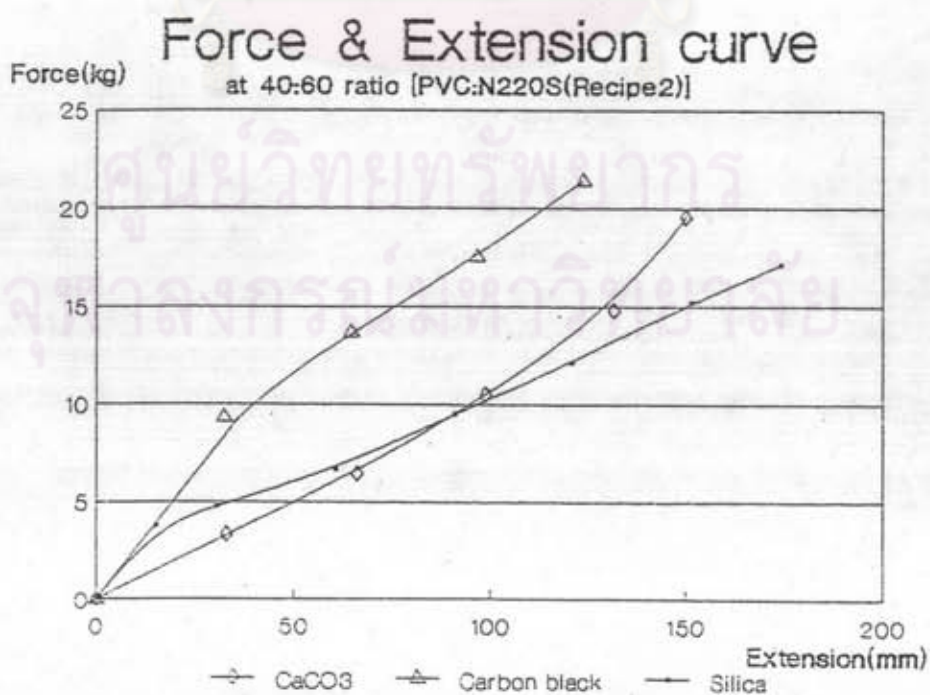


Figure B.2 Force & extension curve of filled compounds at 40:60 ratio (PVC/NBR)

APPENDIX C

AVERAGE VALUES AND STANDARD DEVIATIONS
OF PVC/NBR BLENDS

Table C.1 Average of hardness values and standard deviation (SD.) of unfilled compounds.

NBR types (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	76.6 (1.5354)	64.9 (1.0524)	53.2 (1.1906)	43.0 (0.9604)
N220S (SD.)	75.3 (1.3216)	61.2 (0.6423)	48.9 (0.3830)	37.8 (0.6799)
P83 (SD.)	82.0 (0.8300)	71.3 (0.3670)	61.7 (0.7542)	49.3 (0.7157)
Recipe 1 (SD.)	74.4 (0.4570)	62.2 (0.3771)	51.1 (0.7608)	48.7 (0.7431)
Recipe 2 (SD.)	76.3 (1.0160)	62.8 (0.6083)	52.6 (0.8699)	48.0 (0.4853)

Table C.2 Average of hardness values and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	79.1 ^d (0.9268) ^e	69.4 (0.7364)	59.9 (0.3145)	55.2 (0.2236)
Carbon black (SD.)	89.3 (0.5657)	86.6 (0.3399)	81.3 (0.4819)	- -
Silica (SD.)	89.0 (0.9781)	80.9 (0.6774)	76.8 (0.6191)	71.7 (0.7343)
Carbon black + silica (SD.)	89.6 (0.5260)	84.9 (1.2754)	79.5 (1.2512)	- -

$$^d \text{ Average value } (\bar{x}) = \sum_{i=1}^n x_i / n$$

$$^e \text{ Standard deviation (SD.)} = \sqrt{\left[\sum_{i=1}^n (x_i - \bar{x})^2 / n \right]}$$

Table C.3 Average of modulus values (MPa) at 100 % elongation and standard deviation (SD.) of unfilled compounds.

NBR type (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	3.3912 (0.0870)	3.1662 (0.2272)	1.7071 (0.1610)	0.8226 (0.0965)
N220S (SD.)	6.2630 (0.1169)	3.3090 (0.0345)	1.7019 (0.0215)	0.6289 (0.1012)
P83 (SD.)	6.6049 (0.1611)	4.2861 (0.1103)	2.6995 (0.0676)	1.4208 (0.0265)
Recipe 1 (SD.)	5.7124 (0.0900)	3.0168 (0.2226)	1.7067 (0.0714)	1.1359 (0.1042)
Recipe 2 (SD.)	6.5345 (0.3430)	3.3153 (0.1904)	1.6889 (0.1087)	1.1076 (0.0156)

Table C.4 Average of modulus values (MPa) at 100 % elongation and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	5.9357 (0.4987)	3.3956 (0.1482)	2.0497 (0.0197)	1.3768 (0.0737)
Carbon black (SD.)	9.2713 (0.6102)	8.0697 (0.1095)	7.0692 (0.1586)	- -
Silica (SD.)	6.7625 (0.0370)	4.4843 (0.0975)	3.2724 (0.0593)	2.5116 (0.0091)
Carbon black + silica (SD.)	8.1918 (0.0725)	6.7951 (0.0902)	5.5233 (0.1657)	- -

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Table C.5 Average of modulus values(MPa) at 300 % elongation
and standard deviation (SD.) of unfilled compounds.

NBR type (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	7.6278 (0.1651)	5.1159 (0.2737)	2.4877 (0.2302)	1.1424 (0.1562)
N220S (SD.)	- -	5.6103 (0.0598)	2.6086 (0.0471)	0.9436 (0.1330)
P83 (SD.)	9.6125 (0.1711)	7.8778 (0.1767)	4.8691 (0.0995)	2.6348 (0.0333)
Recipe 1 (SD.)	- -	5.6612 (0.2692)	3.6288 (0.0063)	2.6841 (0.2648)
Recipe 2 (SD.)	11.0965 (0.4024)	6.0166 (0.2262)	3.4297 (0.0595)	2.5315 (0.0007)

Table C.6 Average of modulus values (MPa) at 300 % elongation and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	- -	5.8805 (0.4681)	3.7005 (0.0994)	2.6812 (0.1704)
Carbon black (SD.)	- -	9.2502 (0.0212)	11.9207 (0.2561)	- -
Silica (SD.)	7.0832 (0.0607)	5.1030 (0.0961)	4.5226 (0.0864)	4.6941 (0.0404)
Carbon black + silica (SD.)	- -	7.7991 (0.0737)	10.7005 (0.3157)	- -

Table C.7 Average of tensile strength values (MPa) and standard deviation (SD.) of unfilled compounds.

NBR type	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	8.2738 (0.0716)	5.8046 (0.2188)	4.2870 (0.3021)	2.2043 (0.2158)
N220S (SD.)	11.4777 (0.1413)	6.5923 (0.0697)	4.2085 (0.2148)	1.6579 (0.2099)
P83 (SD.)	12.9315 (0.7358)	12.1399 (0.5758)	9.9993 (1.0840)	5.6663 (0.5592)
Recipe 1 (SD.)	9.9699 (0.0579)	12.3312 (3.1000)	17.3441 (0.6847)	7.2005 (2.9087)
Recipe 2 (SD.)	11.2531 (0.6014)	13.2680 (0.5376)	16.1639 (1.3508)	11.7131 (0.0942)

Table C.8 Average of tensile strength values (MPa) and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	7.8627 (0.8770)	12.0359 (0.4258)	15.6960 (1.0605)	17.1577 (1.6265)
Carbon black (SD.)	10.1779 (0.0392)	10.8351 (1.8021)	17.6678 (0.7662)	- -
Silica (SD.)	7.3153 (0.1746)	7.7842 (0.3227)	14.2382 (0.3139)	18.7175 (0.5003)
Carbon black + silica (SD.)	7.9304 (0.1511)	10.6870 (0.3277)	16.8349 (0.4346)	- -

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Table C.9 Average of elongation at break values (%) and standard deviation (SD.) of unfilled compounds.

NBR type	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	330 (0.00)	365 (12.75)	726 (19.80)	1650 (150.00)
N220S (SD.)	275 (0.00)	378 (4.71)	713 (16.50)	2000 (145.77)
P83 (SD.)	305 (18.03)	424 (10.83)	531 (20.73)	592 (42.49)
Recipe 1 (SD.)	278 (2.36)	500 (35.36)	652 (2.36)	491 (65.51)
Recipe 2 (SD.)	305 (22.73)	553 (15.46)	700 (8.17)	652 (39.23)

Table C.10 Average of elongation at break values (%) and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	280 (21.60)	557 (30.91)	660 (10.80)	708 (11.79)
Carbon black (SD.)	150 (54.01)	362 (115.21)	533 (23.57)	- -
Silica (SD.)	322 (15.46)	580 (30.00)	758 (11.79)	733 (7.50)
Carbon black + silica (SD.)	133 (22.48)	500 (20.41)	508 (11.79)	- -

Table C.11 Average of tear strength values (N/mm) and standard deviation (SD.) of unfilled compounds.

NBR type	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220SH (SD.)	70.7529 (5.0307)	55.9823 (3.2210)	38.3758 (0.2117)	23.7013 (0.4643)
N220S (SD.)	78.9412 (4.2017)	59.7886 (3.0863)	36.3661 (0.4050)	19.0814 (0.1958)
P83 (SD.)	71.2740 (3.0749)	54.6401 (1.1745)	40.8461 (1.3764)	30.1708 (0.1897)
Recipe 1 (SD.)	72.5653 (1.6112)	53.8602 (1.8557)	39.0954 (0.6294)	23.0851 (1.2936)
Recipe 2 (SD.)	60.1003 (1.9304)	48.8852 (1.2936)	39.0180 (1.2855)	27.9914 (0.7837)

Table C.12 Average of tear strength values (N/mm) and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	59.1688 (0.7088)	51.2568 (0.7298)	45.4929 (1.0430)	31.5467 (0.8794)
Carbon black (SD.)	80.5185 (0.8962)	88.0963 (1.3657)	92.3994 (3.4311)	- -
Silica (SD.)	60.9109 (2.0465)	61.8161 (1.9450)	66.2324 (1.6698)	65.1168 (2.4956)
Carbon black + silica (SD.)	76.3728 (1.5557)	79.9614 (1.9017)	84.5194 (1.9056)	- -

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Table C.13 Average of oil swell values (%) and standard deviation (SD.) of unfilled compounds.

NBR type	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220S (SD.)	0.44 (0.1695)	15.11 (1.1840)	30.77 (0.1096)	41.40 (0.1080)
P83 (SD.)	2.77 (0.1327)	12.71 (0.2740)	27.44 (0.1247)	44.98 (0.0855)
Recipe 1 (SD.)	0.78 (0.0252)	11.52 (0.1479)	17.17 (0.0592)	28.09 (0.0437)
Recipe 2 (SD.)	1.40 (0.0529)	16.72 (0.1731)	19.56 (0.1553)	28.21 (3.3802)

Table C.14 Average of oil swell values (%) and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	13.45 (0.2214)	19.85 (0.2594)	21.03 (0.1039)	25.02 (0.0609)
Carbon black (SD.)	0.63 (0.2484)	8.55 (0.6692)	15.79 (0.2879)	- -
Silica (SD.)	0.05 (0.0350)	5.46 (0.0533)	13.93 (0.0298)	20.53 (0.2772)
Carbon black + silica (SD.)	3.62 (1.2022)	9.01 (0.0026)	13.88 (0.2745)	- -

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Table C.15 Average of volume loss values (mm^3) and standard deviation (SD.) of unfilled compounds.

NBR type	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
N220S (SD.)	114.78 (4.1815)	111.47 (2.6043)	148.44 (0.6290)	478.67 (86.1841)
P83 (SD.)	110.57 (1.1302)	84.01 (0.4655)	75.23 (2.3864)	88.20 (2.4834)
Recipe 1 (SD.)	111.51 (2.8324)	80.22 (9.9975)	50.16 (1.9365)	51.65 (9.2341)
Recipe 2 (SD.)	101.22 (2.8274)	80.81 (0.9462)	77.45 (1.0691)	72.30 (2.0165)

Table C.16 Average of volume loss values (mm^3) and standard deviation (SD.) of filled compounds.

Filler types (+ Recipe 2) (SD.)	PVC:NBR ratios			
	80:20	60:40	40:60	20:80
CaCO ₃ (SD.)	241.05 (9.9314)	226.41 (5.8403)	192.79 (4.6141)	187.17 (4.7796)
Carbon black (SD.)	126.00 (4.2998)	114.17 (3.3600)	98.63 (1.6548)	- -
Silica (SD.)	171.27 (2.7987)	142.50 (1.1309)	138.26 (7.7401)	132.05 (1.8043)
Carbon black + silica (SD.)	147.39 (1.0558)	125.93 (1.4174)	103.14 (0.7513)	- -

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Mr.Paiboon Tepumnoysuk was born on February 25, 1967 in Bangkok. He recieved a Bachelor's Degree of Science in Chemical Engineering from Chulalongkorn University in 1989.



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