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APPENDIX 1

1. Effect of deproteinization on the percent nitrogen reduction prepared from three different clones

Clones	Type	% N	% N reduction
RRIM 600	CV-NR	0.578	88.75
	CV-DPNR	0.065	
GT 1	CV-NR	0.599	81.64
	CV-DPNR	0.11	
PB 5/51	CV-NR	0.401	90.02
	CV-DPNR	0.04	

2. Effect of agitation speed on deproteinization

Agitation speed (rpm)	% N	%N reduction
no agitation	0.453	-
45	0.135	70.19
55	0.081	82.12
60	0.051	88.74
65	0.059	86.98
75	0.118	73.95

3. Effect of time on deproteinization

Time (hr)	% N at time intervals	% N reduction
0	0.4145	-
1	0.1545	62.73
2	0.1475	64.41
3	0.1404	66.13
4	0.1147	72.33
5	0.1146	72.35
6	0.1145	72.38
7	0.1144	72.40

1. Raw rubber properties

1.1 Raw rubber properties of CV-DPNR and its control produced from three different clones, RRIM 600, GT1 and PB 5/51

Properties	RRIM 600		GT1		PB 5/51	
	CV-NR	CV-DPNR	CV-NR	CV-DPNR	CV-NR	CV-DPNR
Nitrogen content (%)	0.578 ± 0.003	0.065 ± 0.004	0.599 ± 0.002	0.110 ± 0.005	0.401 ± 0.010	0.040 ± 0.001
Dirt content (%)	0.022 ± 0.002	0.006 ± 0.001	0.015 ± 0.005	0.002 ± 0.011	0.040 ± 0.001	0.009 ± 0
Ash content (%)	0.489 ± 0.038	0.201 ± 0.047	0.572 ± 0.049	0.280 ± 0.029	0.592 ± 0.025	0.184 ± 0.050
Volatile matter (%)	0.498 ± 0.019	0.067 ± 0.025	0.568 ± 0.015	0.239 ± 0.031	0.290 ± 0.019	0.035 ± 0.008
Po	40 ± 0.87	39 ± 0.79	48 ± 1.01	45.5 ± 0.56	63.5 ± 2.48	58 ± 1.59
PRI	87.5 ± 2.35	77.16 ± 1.51	88.54 ± 0.59	74.25 ± 1.11	86.21 ± 1.54	74.25 ± 1.58
Mooney viscosity	60.8 ± 1.41	57.0 ± 1.20	73.7 ± 0.91	69.2 ± 1.47	99.10 ± 0.48	97.85 ± 1.11
Colour	4.5-5	1.5-2	5.5-6	4.5-5	6-6.5	3.5-4

1.2 Raw rubber properties of CV-DP NR and its control produced from RRIM 600 by Papain and Alcalase

Properties	RRIM 600		
	Control rubber	Alcalase-treated rubber	Papain-treated rubber
Nitrogen content (%)	0.578 ± 0.003	0.126 ± 0.002	0.065 ± 0.004
Dirt content (%)	0.022 ± 0.002	0.002 ± 0.001	0.006 ± 0.001
Ash content (%)	0.489 ± 0.038	0.401 ± 0.047	0.201 ± 0.047
Volatile matter (%)	0.498 ± 0.019	0.430 ± 0.001	0.067 ± 0.025
Po	40 ± 0.87	37.5 ± 0.21	39 ± 0.79
PRI	87.5 ± 2.35	55.5 ± 3.50	77.16 ± 1.51
Mooney viscosity	60.8 ± 1.41	58.5 ± 0.40	57.0 ± 1.20
Colour	4.5-5	3-3.5	1.5-2

1.3 Raw rubber properties of CV-DPNR and its control produced from RRIM 600 by Papain at various agitation speed

1.3.1 At agitation speed 45 rpm

Properties	CONTROL	speed 45 rpm	
		CV-NR	CV-DPNR
Nitrogen content (%)	0.453 ± 0.003	0.454 ± 0.002	0.135 ± 0.001
Dirt content (%)	0.024 ± 0.004	0.025 ± 0.001	0.015 ± 0.01
Ash content (%)	0.448 ± 0.016	0.449 ± 0.021	0.169 ± 0.005
Volatile matter (%)	0.449 ± 0.007	0.450 ± 0.003	0.158 ± 0.025
Po	42 ± 0.02	42 ± 0.01	40 ± 0.12
PRI	85.5 ± 1.15	82.14 ± 1.10	43.75 ± 1.21
Mooney viscosity	60.8 ± 0.05	60.51 ± 0.05	59.1 ± 1.20
Colour	4.5-5	4.5-5	3.5-4



1.3.2 At agitation speed 55 rpm

Properties	CONTROL	speed 55 rpm	
		CV-NR	CV-DPNR
Nitrogen content (%)	0.453 ± 0.003	0.449 ± 0.04	0.081 ± 0.06
Dirt content (%)	0.024 ± 0.004	0.028 ± 0.001	0.011 ± 0.009
Ash content (%)	0.448 ± 0.016	0.450 ± 0.04	0.171 ± 0.015
Volatile matter (%)	0.449 ± 0.007	0.481 ± 0.22	0.148 ± 0.008
Po	42 ± 0.02	43 ± 1.11	40 ± 0.07
PRI	85.5 ± 1.15	80.23 ± 0.12	76.25 ± 1.11
Mooney viscosity	60.8 ± 0.05	60.7 ± 0.91	58.2 ± 1.47
Colour	4.5-5	5-5.5	1.5-2

1.3.3 At agitation speed 60 rpm

Properties	CONTROL	speed 60 rpm	
		CV-NR	CV-DPNR
Nitrogen content (%)	0.453 \pm 0.003	0.451 \pm 0.002	0.051 \pm 0.004
Dirt content (%)	0.024 \pm 0.004	0.022 \pm 0.002	0.006 \pm 0.001
Ash content (%)	0.448 \pm 0.016	0.489 \pm 0.038	0.180 \pm 0.047
Volatile matter (%)	0.449 \pm 0.007	0.498 \pm 0.019	0.167 \pm 0.025
Po	42 \pm 0.02	40 \pm 0.87	39 \pm 0.79
PRI	85.5 \pm 1.15	87.5 \pm 2.35	77.16 \pm 1.51
Mooney viscosity	60.8 \pm 0.05	60.8 \pm 1.41	57.0 \pm 1.20
Colour	4.5-5	4.5-5	1.5-2

1.3.4 At agitation speed 65 rpm

Properties	CONTROL	speed 65 rpm	
		CV-NR	CV-DPNR
Nitrogen content (%)	0.453 \pm 0.003	0.451 \pm 0.001	0.059 \pm 0.004
Dirt content (%)	0.024 \pm 0.004	0.024 \pm 0.001	0.004 \pm 0.001
Ash content (%)	0.448 \pm 0.016	0.439 \pm 0.007	0.176 \pm 0.011
Volatile matter (%)	0.449 \pm 0.007	0.477 \pm 0.003	0.159 \pm 0.005
Po	42 \pm 0.02	41 \pm 0.05	40 \pm 0.01
PRI	85.5 \pm 1.15	89.27 \pm 1.11	77.5 \pm 1.51
Mooney viscosity	60.8 \pm 0.05	60.8 \pm 1.41	58.1 \pm 1.20
Colour	4.5-5	4.5-5	1.5-2

1.3.5 At agitation speed 75 rpm

Properties	CONTROL	speed 75 rpm	
		CV-NR	CV-DPNR
Nitrogen content (%)	0.453 ± 0.003	0.454 ± 0.005	0.118 ± 0.001
Dirt content (%)	0.024 ± 0.004	0.026 ± 0.001	0.009 ± 0.011
Ash content (%)	0.448 ± 0.016	0.459 ± 0.002	0.192 ± 0.029
Volatile matter (%)	0.449 ± 0.007	0.487 ± 0.001	0.178 ± 0.002
Po	42 ± 0.02	41 ± 0.02	39 ± 0.01
PRI	85.5 ± 1.15	87.8 ± 0.59	77.5 ± 1.11
Mooney viscosity	60.8 ± 0.05	68.7 ± 0.91	59.1 ± 1.47
Colour	4.5-5	4.5-5	4.5-5

2. Mooney viscosity of raw rubber before and after storage

2.1 Mooney viscosity of CV-DPNR and its control produced from three different clones, RRIM 600, GT1 and PB 5/51

Clones		1	2	3	4	5	6	7	8	9	10	11	12
RRIM 600	control	58.9 ± 0.1	60.8 ± 0.2	61.8 ± 0.3	62.7 ± 0.4	63.9 ± 0.1	64.9 ± 0.2	65.4 ± 0.1	66.2 ± 0.2	67.5 ± 0.1	66.8 ± 0.2	70.2 ± 0.2	71.6 ± 0.1
	DPNR	57.2 ± 0.1	57.5 ± 0.1	57.3 ± 0.2	57.9 ± 0.1	57.5 ± 0	57.6 ± 0.3	57.2 ± 0.2	57.9 ± 0.2	57.8 ± 0.1	58.4 ± 0.1	58.8 ± 0.2	60.2 ± 0
GT 1	control	70.7 ± 0.1	75.6 ± 0.2	79.5 ± 0.4	82.4 ± 0.1	85.6 ± 0.2	86.9 ± 0.1	87.1 ± 0.2	87.3 ± 0.1	87.8 ± 0.2	87.9 ± 0.1	88.1 ± 0.2	89.8 ± 0.3
	DPNR	69.2 ± 0.1	73.7 ± 0.1	75.5 ± 0.3	81.2 ± 0.5	81.5 ± 0.1	82.9 ± 0.1	84.5 ± 0	84.9 ± 0.1	85.7 ± 0.2	86.6 ± 0.3	86.9 ± 0.2	87 ± 0.1
PB 5/51	control	91.2 ± 0.2	93.5 ± 0.3	96.3 ± 0.2	100.9 ± 0.5	102.5 ± 0.7	103.7 ± 0.5	106.5 ± 0.1	109.8 ± 0.1	110.1 ± 0	110.5 ± 0.1	ND*	ND*
	DPNR	88.3 ± 0.1	90 ± 0.3	94.2 ± 0.4	96.2 ± 0.1	100.2 ± 0.4	102.5 ± 0	103.1 ± 0.1	103.5 ± 0.2	103.8 ± 0.1	104.1 ± 0.5	ND*	ND*

ND*- Not determined may be due to rubber was harden by cross-linking process

2.2 Mooney viscosity of CV-DPNR and its control produced from RRIM 600 by Papain at various agitation speeds

Agitation speed (rpm)	Type	%N	TIME (MONTHS)					
			1	2	3	4	5	6
0	CV-NR	0.453	60.8 ± 0.1	61.8 ± 0.3	62.7 ± 1.0	63.9 ± 0.2	64.9 ± 0.4	65.4 ± 0.1
45	CV-NR	0.454	60.5 ± 1.1	61.4 ± 0.2	62.5 ± 1.0	63.7 ± 0.3	64.2 ± 0.0	65.3 ± 0.1
	CV-DPNR	0.135	59.1 ± 0.9	59.9 ± 0.5	60.8 ± 0.1	63.8 ± 0.4	64.5 ± 1.0	67.2 ± 1.1
55	CV-NR	0.449	60.7 ± 1.1	61.0 ± 0.1	63.7 ± 0.3	64.8 ± 0.1	65.6 ± 1.1	66.7 ± 0.8
	CV-DPNR	0.081	58.2 ± 0.1	58.5 ± 0.2	58.7 ± 0.1	59.5 ± 0.1	59.9 ± 0.2	60.1 ± 0.5
60	CV-NR	0.451	60.8 ± 0.1	61.9 ± 0.0	62.6 ± 0.2	64.8 ± 0.2	66.2 ± 0.5	66.5 ± 0.1
	CV-DPNR	0.051	57.0 ± 1.1	57.3 ± 0.1	57.5 ± 0.5	57.7 ± 0.1	57.9 ± 0.0	58.1 ± 0.2
65	CV-NR	0.451	60.8 ± 0.1	61.8 ± 0.1	62.9 ± 0.8	65.9 ± 0.2	66.6 ± 0.1	67.5 ± 1.0
	CV-DPNR	0.059	58.1 ± 0.1	58.5 ± 0.0	58.9 ± 1.1	59.1 ± 0.1	59.4 ± 0.2	59.7 ± 1.1
75	CV-NR	0.454	68.7 ± 1.0	69.1 ± 0.1	70.5 ± 1.0	70.9 ± 0.5	71.1 ± 1.1	71.6 ± 0.1
	CV-DPNR	0.118	59.1 ± 1.1	59.7 ± 1.0	59.4 ± 0.1	62.5 ± 0.8	63.0 ± 0.1	65.8 ± 0.2

3. Cure characteristics of compound rubber

3.1 Cure characteristics of CV-DPNR and its control produced from three different clones, RRIM 600, GT1 and PB 5/51

Properties	RRIM 600		GT1		PB 5/51	
	CV-NR	CV-DPNR	CV-NR	CV-DPNR	CV-NR	CV-DPNR
Minimum torque (kg.cm)	9.56 ± 1.15	8.06 ± 1.01	8.75 ± 0.14	5.64 ± 0.03	8.52 ± 0.10	7.25 ± 0.09
Maximum torque (kg.cm)	31.10 ± 1.68	33.06 ± 0.01	30.29 ± 0.48	25.45 ± 0.12	30.06 ± 0.13	32.25 ± 0.04
Torque rise (kg.cm)	21.54 ± 1.50	24.99 ± 0.08	21.54 ± 0.003	19.81 ± 0.06	21.54 ± 0.007	24.99 ± 0.001
Scorch time (sec)	58.8 ± 0.04	61.8 ± 0.14	51.6 ± 0.16	57.6 ± 0.26	55.8 ± 0.33	57 ± 0.25
Cure time (sec)	208.8 ± 0.13	165.6 ± 0.86	136.8 ± 2.10	145.8 ± 0.13	141 ± 0.38	169.8 ± 0.33
Cure rate(sec)	150 ± 0.05	103.8 ± 0.15	85.02 ± 0.05	88.02 ± 0.04	85.02 ± 0.01	112.9 ± 0.02

3.2 Cure characteristics of CV-DPNR and its control produced from RRIM 600 by Papain and Alcalase

Properties	RRIM 600		
	Control rubber	Alcalase-treated rubber	Papain-treated rubber
Minimum torque (kg.cm)	9.56 ± 1.15	7.02 ± 0.02	8.06 ± 1.01
Maximum torque (kg.cm)	31.10 ± 1.68	26.24 ± 0.01	33.06 ± 0.01
Torque rise (kg.cm)	21.54 ± 1.50	19.21 ± 0.01	24.99 ± 0.08
Scorch time (sec)	58.8 ± 0.04	67.8 ± 0.15	61.8 ± 0.14
Cure time (sec)	208.8 ± 0.13	221.4 ± 0.02	165.6 ± 0.86
Cure rate (sec)	150 ± 0.05	153.6 ± 0.13	103.8 ± 0.15

3.3 Cure characteristics of CV-DPNR and its control produced from RRIM 600 by Papain at various agitation speed

3.3.1 At agitation speed 45 rpm

Properties	control CV -NR	control CV-NR speed 45 r.p.m	CV-DPNR speed 45 r.p.m
Minimum torque (kg.cm)	7.02 ± 0.4	7.37 ± 0.14	6.45 ± 0.10
Maximum torque (kg.cm)	27.64 ± 1.6	28.22 ± 0.01	29.49 ± 0.12
Torque rise (kg.cm)	20.62 ± 1.2	20.8 ± 0.13	23.04 ± 0.02
Scorch time (sec)	90 ± 0.15	90 ± 0.05	97.2 ± 0.33
Cure time (sec)	138 ± 0.14	141.6 ± 0.21	144 ± 0.34
Cure rate (sec)	51 ± 0.01	51.6 ± 0.16	46.8 ± 0.01

3.3.2 At agitation speed 55 rpm

Properties	control CV -NR	control CV-NR speed 55 r.p.m	CV-DPNR speed 55 r.p.m
Minimum torque (kg.cm)	7.02 ± 0.4	5.52 ± 0.09	6.10 ± 1.01
Maximum torque (kg.cm)	27.64 ± 1.6	24.19 ± 0.25	21.31 ± 0.12
Torque rise (kg.cm)	20.62 ± 1.2	18.66 ± 0.16	15.2 ± 0.89
Scorch time (sec)	90 ± 0.15	64.8 ± 0.48	96.6 ± 0.04
Cure time (sec)	138 ± 0.14	162 ± 0.01	147 ± 0.03
Cure rate (sec)	51 ± 0.01	97.2 ± 0.47	50.4 ± 0.01

3.3.3 At agitation speed 60 rpm

Properties	control CV -NR	control CV-NR speed 60 r.p.m	CV-DPNR speed 60 r.p.m
Minimum torque (kg.cm)	7.02 ± 0.4	5.18 ± 0.10	6.56 ± 0.14
Maximum torque (kg.cm)	27.64 ± 1.6	22.92 ± 0.27	20.96 ± 0.25
Torque rise (kg.cm)	20.62 ± 1.2	17.74 ± 0.17	14.4 ± 0.11
Scorch time (sec)	90.0 ± 0.15	66.6 ± 0.11	97.8 ± 0.16
Cure time (sec)	138.0 ± 0.14	158.4 ± 0.15	148.8 ± 0.10
Cure rate (sec)	51.0 ± 0.01	91.8 ± 0.04	51.0 ± 0.06

3.3.4 At agitation speed 65 rpm

Properties	control CV -NR	control CV-NR speed 65 r.p.m	CV-DPNR speed 65 r.p.m
Minimum torque (kg.cm).	7.02 ± 0.4	4.72 ± 0.10	6.22 ± 0.12
Maximum torque (kg.cm)	27.64 ± 1.6	26.03 ± 1.14	20.04 ± 0.11
Torque rise (kg.cm)	20.62 ± 1.2	21.31 ± 1.04	13.82 ± 0.01
Scorch time (sec)	90 ± 0.15	66 ± 1.00	99 ± 0.20
Cure time (sec)	138 ± 0.14	151.8 ± 0.10	148.8 ± 1.15
Cure rate (sec)	51 ± 0.01	85.8 ± 0.90	49.8 ± 0.95

3.3.5 At agitation speed 75 rpm

Properties	control CV -NR	control CV-NR speed 75 r.p.m	CV-DPNR speed 75 r.p.m
Minimum torque (kg.cm)	7.02 ± 0.4	7.48 ± 0.05	6.10 ± 0.03
Maximum torque (kg.cm)	27.64 ± 1.6	25.57 ± 0.04	29.83 ± 0.01
Torque rise (kg.cm)	20.62 ± 1.2	18.08 ± 0.01	23.73 ± 0.02
Scorch time (sec)	90 ± 0.15	61.2 ± 0.07	96 ± 0.10
Cure time (sec)	138 ± 0.14	150 ± 0.11	154.8 ± 0.10
Cure rate (sec)	51 ± 0.01	88.8 ± 0.04	58.2 ± 0.00

4. Physical properties of vulcanized rubber

4.1 Vulcanized properties of CV-DPNR and its control produced from three different clones, RRIM 600, GT1 and PB 5/51

Properties	RRIM 600		GT 1		PB 5/51	
	CV-NR	CV-DPNR	CV-NR	CV-DPNR	CV-NR	CV-DPNR
Tensile strength (MPa)	16.55 ± 1.38	20.15 ± 0.96	20.04 ± 0	21.1 ± 0.65	19.90 ± 0	22.62 ± 1.64
Tear strength (N/cm)	33.46 ± 4.97	30.45 ± 10.78	34.8 ± 6.05	32.88 ± 5.51	26.85 ± 7.26	30.22 ± 6.19
300 % Modulus (MPa)	3.29 ± 0.25	2.43 ± 0.93	5.19 ± 0	2.76 ± 0.27	3.66 ± 0	2.59 ± 0.98
Elongation at break (%)	666.1 ± 47.5	774.6 ± 23.1	580.0 ± 0	768.3 ± 28.6	660.0 ± 0	774.8 ± 20.1
Hardness (shore A)	58 ± 1.10	47 ± 1.10	47 ± 0.01	43 ± 1.00	41 ± 0.02	32 ± 0.01
Specific gravity	1.12 ± 0.01	1.09 ± 0.01	1.13 ± 0.02	1.11 ± 0.01	1.13 ± 0.01	1.12 ± 0.01

4.2 Vulcanized properties of CV-DPNR and its control produced from RRIM 600 by Papain and Alcalase

Properties	RRIM 600		
	Control rubber	Alcalase-treated rubber	Papain-treated rubber
Tensile strength (MPa)	16.55 ± 1.10	17.89 ± 1.08	20.15 ± 0.96
Tear strength (N/cm)	33.46 ± 2.48	35.22 ± 2.44	30.45 ± 5.39
300 % Modulus (MPa)	3.29 ± 0.25	3.32 ± 8.01	2.43 ± 0.93
Elongation at break (%)	666.1 ± 47.5	655.0 ± 25.1	774.6 ± 23.1
Hardness (shore A)	58 ± 1.10	53.0 ± 0	47.0 ± 1.00
Specific gravity	1.12 ± 0.01	1.12 ± 0.01	1.09 ± 0.01

4.3 Vulcanized properties of CV-DPNR and its control produced from RRIM 600 by Papain at various agitation speed

4.3.1 At agitation speed 45 rpm

Properties	CONTROL	speed 45 rpm	
		CV-NR	CV-DPNR
Tensile strength (MPa)	20.20 + 0.15	19.62 - 1.57	21.29 + 1.78
Tear strength (N/cm)	34.25 + 4.18	32.85 - 11.85	28.72 + 6.33
300 % Modulus (MPa)	3.64 + 0.51	4.37 - 0.09	2.52 + 0.26
Elongation at break (%)	684.35 + 25.2	665.8 - 17.1	718.0 + 34.9
Hardness (shore A)	44 + 0.1	39 - 0.01	39 + 0.01
Specific gravity	1.13 + 0.01	1.12 - 0.01	1.12 + 0.01

4.3.2 At agitation speed 55 rpm

Properties	CONTROL	speed 55 rpm	
		CV-NR	CV-DPNR
Tensile strength (MPa)	20.20 + 0.15	17.28 - 1.39	20.42 + 1.33
Tear strength (N/cm)	34.25 + 4.18	31.23 + 4.64	28.72 + 6.33
300 % Modulus (MPa)	3.64 + 0.51	2.38 - 0.07	3.22 + 0.28
Elongation at break (%)	684.35 + 25.2	746.2 + 27.8	713.3 + 38.1
Hardness (shore A)	44 + 0.1	30 + 0.2	40 + 0.2
Specific gravity	1.13 + 0.01	1.11 + 0.01	1.12 + 0.01

4.3.3 At agitation speed 60 rpm

Properties	CONTROL	speed 60 rpm	
		CV-NR	CV-DPNR
Tensile strength (MPa)	20.20 + 0.15	16.59 + 1.35	20.15 + 0.96
Tear strength (N/cm)	34.25 + 4.18	33.46 + 2.48	30.45 + 5.39
300 % Modulus (MPa)	3.64 + 0.51	3.69 + 0.50	3.09 + 0.93
Elongation at break (%)	684.35 + 25.2	665.7 + 42.5	774.6 + 23.1
Hardness (shore A)	44 + 0.1	35 + 0.1	40 + 1.10
Specific gravity	1.13 + 0.01	1.12 + 0.01	1.09 + 0.01

4.3.4 At agitation speed 65 rpm

Properties	CONTROL	speed 65 rpm	
		CV-NR	CV-DPNR
Tensile strength (MPa)	20.20 + 0.15	18.31 + 1.32	17.15 + 1.78
Tear strength (N/cm)	34.25 + 4.18	34.38 + 4.97	28.90 + 2.37
300 % Modulus (MPa)	3.64 + 0.51	3.13 + 0.23	3.18 + 0.39
Elongation at break (%)	684.35 + 25.2	688.0 + 6.30	741.8 + 24.9
Hardness (shore A)	44 + 0.1	33 + 0.01	35 + 1.00
Specific gravity	1.13 + 0.01	1.13 + 0.01	1.13 + 0.01



4.3.5 At agitation speed 75 rpm

Properties	CONTROL	speed 75 rpm	
		CV-NR	CV-DPNR
Tensile strength (MPa)	20.20 + 0.15	18.60 + 1.34	18.98 + 1.38
Tear strength (N/cm)	34.25 + 4.18	27.87 - 7.27	28.01 + 3.03
300 % Modulus (MPa)	3.64 + 0.51	2.85 - 0.39	2.51 - 0.25
Elongation at break (%)	684.35 + 25.2	711.5 - 47.7	725.6 + 12.9
Hardness (shore A)	44 + 0.1	53 - 0.02	42 + 0.2
Specific gravity	1.13 + 0.01	1.08 - 0.01	1.12 + 0.01

5. Physical properties of vulcanized rubber before and after ageing

5.1.1 For RRIM 600 clone

Properties	control CV-NR		CV- DPNR	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	16.55 ± 1.38	16.44 ± 1.10	20.15 ± 0.96	20.48 ± 10.4
Tear strength (N/cm)	33.46 ± 4.97	37.65 ± 6.66	30.45 ± 10.78	35.31 ± 7.11
300 % Modulus (MPa)	3.29 ± 0.25	6.16 ± 0.32	2.43 ± 0.93	5.24 ± 0.26
Elongation at break (%)	666.1 ± 47.5	535.4 ± 25.6	774.6 ± 23.1	607.5 ± 15.2
Hardness (shore A)	58 ± 1.10	68 ± 1.10	47 ± 1.10	65 ± 1.0
Specific gravity	1.12 ± 0.01	1.12 ± 0.01	1.09 ± 0.01	1.09 ± 0.02

5.1.2 For GT 1 clone

Properties	control CV-NR		CV- DPNR	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	20.04 ± 0	17.89 ± 1.08	21.1 ± 0.65	19.27 ± 0.41
Tear strength (N/cm)	34.80 ± 6.05	37.76 ± 5.84	32.88 ± 5.51	36.86 ± 5.51
300 % Modulus (MPa)	5.19 ± 0	6.18 ± 0.34	2.76 ± 0.27	5.74 ± 0.17
Elongation at break (%)	580.0 ± 0	547.0 ± 0	768.3 ± 28.6	609.6 ± 19.0
Hardness (shore A)	47 ± 0.01	52 ± 1.10	43 ± 1.00	45 ± 1.0
Specific gravity	1.13 ± 0.02	1.13 ± 0.01	1.11 ± 0.01	1.11 ± 0.01

5.1.3 For PB 5/51 clone

Properties	control CV-NR		CV- DPNR	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	19.90 ± 0	17.20 ± 0.42	22.62 ± 1.64	21.60 ± 2.84
Tear strength (N/cm)	26.85 ± 7.26	41.11 ± 1.93	30.22 ± 6.19	32.84 ± 5.31
300 % Modulus (MPa)	3.66 ± 0	6.17 ± 0.31	2.59 ± 0.98	5.86 ± 0.83
Elongation at break (%)	660.0 ± 0	537.0 ± 12.7	774.8 ± 20.1	609.4 ± 37.9
Hardness (shore A)	41 ± 0.02	51 ± 1.10	32 ± 0.01	50 ± 1.0
Specific gravity	1.13 ± 0.01	1.12 ± 0.01	1.12 ± 0.01	1.11 ± 0.01

5.2 Vulcanized properties of CV-DPNR and its control produced from RRIM 600 by Papain and Alcalase

Properties	Control rubber		Alcalase-treated rubber		Papain-treated rubber	
	Unaged	aged	Unaged	aged	Unaged	aged
Tensile strength (MPa)	16.55 ± 1.10	16.44 ± 1.10	17.89 ± 1.08	18.07 ± 1.33	20.15 ± 0.96	20.48 ± 1.04
Tear strength (N/cm)	33.46 ± 2.48	37.65 ± 6.66	35.22 ± 2.44	35.70 ± 1.91	30.45 ± 5.39	35.30 ± 0.64
300 % Modulus (MPa)	3.29 ± 0.25	6.16 ± 0.32	3.32 ± 8.01	6.40 ± 0.75	2.43 ± 0.93	5.24 ± 0.25
Elongation at break (%)	666.1 ± 47.5	535.4 ± 25.6	655.0 ± 25.1	504.98 ± 25.3	774.6 ± 23.1+	607.5 ± 15.2
Hardness (shore A)	58 ± 1.10	68 ± 1.10	53 ± 0	71.0 ± 1.0	47 ± 1.0	65 ± 1.0
Specific gravity	1.12 ± 0.01	1.12 ± 0.01	1.12 ± 0.01	1.12 ± 0.01	1.09 ± 0.01	1.12 ± 0.01

5.3 Vulcanized properties of CV-DPNR and its control produced from RRIM 600 by Papain at various agitation speeds

5.3.1 At agitation speed 0 rpm

Properties	Control	
	Unaged	Aged
Tensile strength (MPa)	20.20 + 0.15	20.86 + 0.45
Tear strength (N/cm)	34.25 ± 4.18	42.05 ± 1.49
300 % Modulus (MPa)	3.64 ± 0.51	5.49 ± 0.37
Elongation at break (%)	684.35 ± 25.2	633.60 ± 16.90
Hardness (shore A)	44 ± 0.1	52 ± 0.1
Specific gravity	1.13 ± 0.01	1.13 ± 0.01

5.3.2 At agitation speed 45 rpm

Properties	Control speed 45 r.p.m		DPNR speed 45 r.p.m	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	19.62 ± 1.57	20.68 ± 1.94	21.29 ± 1.78	23.01 ± 0.90
Tear strength (N/cm)	32.85 ± 11.85	42.32 ± 4.63	28.72 ± 6.33	41.90 ± 1.90
300 % Modulus (MPa)	4.37 ± 0.09	5.30 ± 0.40	2.52 ± 0.26	4.37 ± 0.09
Elongation at break (%)	665.8 ± 17.1	644.52 ± 24.0	718 ± 34.9	695.4 ± 12.4
Hardness (shore A)	39 ± 0.1	42 ± 0.1	39 ± 0.1	43 ± 0.1
Specific gravity	1.12 ± 0.01	1.12 ± 0.01	1.12 ± 0.01	1.11 ± 0.01

5.3.3 At agitation speed 55 rpm

Properties	Control speed 55 r.p.m		DPNR speed 55 r.p.m	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	17.28 ± 1.39	18.72 ± 1.94	20.42 ± 1.33	20.09 ± 1.30
Tear strength (N/cm)	31.23 ± 4.64	43.53 ± 7.70	28.72 ± 6.33	39.04 ± 5.04
300 % Modulus (MPa)	2.38 ± 0.07	6.35 ± 0.85	3.22 ± 0.28	5.27 ± 0.21
Elongation at break (%)	746.2 ± 27.8	561.7 ± 23.2	713.3 ± 38.1	675.7 ± 35.3
Hardness (shore A)	30 ± 0.2	35 ± 0.1	40 ± 0.2	45 ± 0.1
Specific gravity	1.11 ± 0.01	1.12 ± 0.01	1.12 ± 0.01	1.10 ± 0.01

5.3.4 At agitation speed 60 rpm

Properties	Control speed 60 r.p.m		DPNR speed 60 r.p.m	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	16.59 ± 1.35	16.45 ± 1.05	20.15 ± 0.96	23.01 ± 0.90
Tear strength (N/cm)	33.46 ± 2.48	37.75 ± 6.55	30.45 ± 5.39	35.75 ± 6.05
300 % Modulus (MPa)	3.69 ± 0.50	7.56 ± 1.03	3.09 ± 0.93	5.56 ± 1.42
Elongation at break (%)	665.7 ± 42.5	533.5 ± 40.2	774.6 ± 23.1	607.5 ± 15.2
Hardness (shore A)	35 ± 0.1	42 ± 0.1	40 ± 1.10	45 ± 1.0
Specific gravity	1.12 ± 0.01	1.12 ± 0.01	1.09 ± 0.01	1.09 ± 0.01

5.3.5 At agitation speed 65 rpm

Properties	Control speed 65 r.p.m		DPNR speed 65 r.p.m	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	18.31 ± 1.32	17.55 ± 1.00	17.15 ± 1.78	19.80 ± 2.08
Tear strength (N/cm)	34.38 ± 4.97	37.74 ± 3.63	28.90 ± 2.37	36.19 ± 4.76
300 % Modulus (MPa)	3.13 ± 0.23	7.47 ± 0.44	3.18 ± 0.39	5.84 ± 0.57
Elongation at break (%)	688.0 ± 6.30	507.8 ± 10.9	741.8 ± 24.9	566.0 ± 23.0
Hardness (shore A)	33 ± 0.1	55 ± 0.1	35 ± 0.1	45 ± 0.2
Specific gravity	1.13 ± 0.01	1.13 ± 0.01	1.13 ± 0.01	1.10 ± 0.01

5.3.6 At agitation speed 75 rpm

Properties	Control speed 75 r.p.m		DPNR speed 75 r.p.m	
	Unaged	Aged	Unaged	Aged
Tensile strength (MPa)	18.60 ± 1.34	18.75 ± 0.76	18.98 ± 1.38	17.45 ± 1.77
Tear strength (N/cm)	27.87 ± 7.27	27.05 ± 5.19	28.01 ± 3.03	33.81 ± 4.59
300 % Modulus (MPa)	2.85 ± 0.39	6.43 ± 0.32	2.51 ± 0.25	4.96 ± 0.25
Elongation at break (%)	711.5 ± 47.7	549.7 ± 19.9	725.6 ± 12.9	581.4 ± 40.7
Hardness (shore A)	53 ± 0.1	65 ± 0.1	42 ± 0.2	53 ± 0.1
Specific gravity	1.08 ± 0.01	1.08 ± 0.01	1.12 ± 0.01	1.12 ± 0.02

APPENDIX 3

1. Calculation of % nitrogen reduction

Correlation between the protein with the nitrogen content is described by:

$$\text{the protein content} = 6.25 \times \%N$$

Time (hr)	% N content	% N reduction
0	0.4145	-
1	0.1545	62.73
2	0.1475	64.41
3	0.1404	66.13
4	0.1147	72.33
5	0.1146	72.35
6	0.1145	72.38
7	0.1144	72.40

The % nitrogen reduction is calculated as follows:

$$\begin{aligned} \text{\% nitrogen reduction at 4 hrs} &= \\ &= \frac{(\text{initial nitrogen content} - \text{nitrogen content at 4 hrs})}{\text{initial nitrogen content}} \times 100 \end{aligned}$$

$$= \frac{(0.4145 - 0.1147)}{0.4145} \times 100$$

$$= 72.33 \%$$

2. Calculation of intensity factor (θ)

Agitation speed (rpm)	Re	intensity factor, θ	%N reduction
45	939	47.46	70.19
55	1149	53.04	82.12
60	1253	55.62	88.74
65	1358	58.14	86.98
75	1566	62.88	73.95

2.1 Calculated the Reynolds Number, Re from

$$Re = (\rho N L^2) / \mu$$

ρ = density of latex 25% DRC at pH 7.5

μ = viscosity of latex 25% DRC at pH 7.5, 50°C

N = agitation speed

L = Impeller diameter

$$Re \text{ (at 60 rpm)} = \frac{(0.975 \text{ g/cm}^3) (60 \text{ rpm}) (1/60 \text{ sec}) (28 \text{ cm})^2}{(61 \times 10^{-2} \text{ g cm}^{-1} \text{ sec}^{-1})}$$

$$= 1253$$

2.2 Calculated the intensity factor, θ at each speed

$$\theta = 1.1 \text{ Re}^{0.55}$$

$$\theta = 1.1 (1253)^{0.55}$$

$$= 55.62$$



VITA

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