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ULPNR LATEX -A PLATFORM FOR SUSTAINABLE NR INTERMEDIATES, BIOELASTOPLASTICS AND PRODUCTS

INTERNATIONAL LATEX CONFERENCE 2019
AKRON

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PRESENTATION FORMAT

- NR LATEX INDUSTRY CURRENT TRENDS
- NR BIOELASTOPLASTS –A SUSTAINABLE CONCEPT?
- SPECIALITY NATURAL RUBBERS
  SOLID AND LATICES
- PRODUCT MODIFICATIONS AND DEVELOPMENTS
- THE FUTURE - CRYSTAL BALL GAZING

NR TOTAL / NR LATEX PRODUCTION AND CONSUMPTION (2018)[1]

	PRODUCTION		
YEAR	NR LATEX* [MT]	NR TOTAL [MT]	% SHARE
2018	1,667,400	13,869,000	12.02

	CONSUMPTION		
YEAR	NR LATEX [MT]	NR TOTAL [MT]	% Share
2018	1,626,000	13,780,000	11.8

Globally the latex industry constitutes **~12 %** of the rubber industry and is the **second largest** after tyre sector (60%)

NR/NR LATEX PRODUCTION TRENDS (2013-2018)[1]

YEAR	NR LATEX* [MT]	NR TOTAL [MT]	% SHARE
2013	1,258,000	12,282,000	10.24
2018	1,667,000	13,869,000	12.02
5-YEAR GROWTH (MT)	409,000	1,587,000	
5 YEAR GROWTH	32.51%	12.92%	
CAGR	5.79%	2.46%	YOY-5 YEARS

***Excludes West African Latex Production**

Natural Rubber production grew in spite of the adverse price trends for growers. Natural Rubber Latex production growth was more than double that of NR overall.

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NATURAL RUBBER/ LATEX CONSUMPTION TRENDS (2013-2018)[1]

YEAR	NR LATEX [MT]	NR TOTAL [MT]	% Share
2013	1,258,000	11,430,000	11.00
2018	1,626,000	13,813,000	11.77
GROWTH (MT)	368,000	2,383,000	
5 YEAR GROWTH	29.25%	20.85%	
CAGR %	5.27%	3.86%	

Despite the adverse economic environment for rubber in the period the Latex consumption growth trend has remained positive and better than the non latex (tyre and non tyre) segment growth

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ASIA NR LATEX PRODUCTION AND CONSUMPTION(2018)[1]

PRODUCTION YEAR	NR LATEX * (MTA)	ASIA LATEX TOTAL (MTA)	SHARE (%)
2018	1,573,3000	1,477,000	93.90

CONSUMPTION YEAR	NR LATEX [MT]	ASIA* TOTAL [MT]	SHARE (%)
2018	1,626,000	1,441,300	88.64

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ASIA NR LATEX CONSUMPTION TRENDS (2013-2018)[1]

YEAR	NR LATEX [MT]	ASIA TOTAL [MT]	Share (%)
2013	1,258,000	1,059,300	84.20
2018	1,626,000	1,441,300	88.47
GROWTH (MT)	368,000	382,000	
5 YEAR GROWTH	29.25%	36.1%	
CAGR %	**5.27%**	**6.35%**	

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PROJECTED SUPPLY-DEMAND (2023)

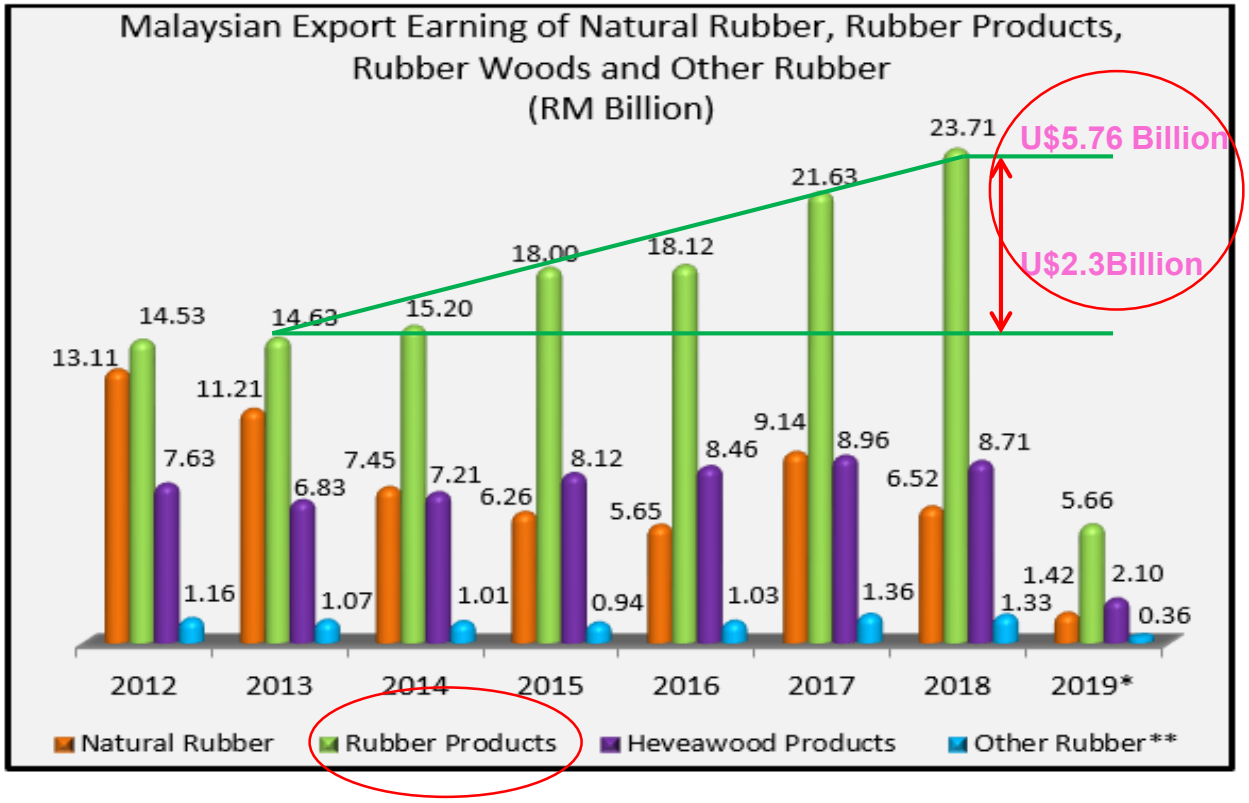
Sl No	PARTICULARS	2018 (MTA)		Estimated In 5 Years* 2023 (MTA)
1.	ASIA LATEX PRODUCTION	1,477,000	5.44	1,925,000
2.	GLOBAL NR LATEX PRODUCTION	1,626,000	5.79	2,154,000
3	ASIA LATEX CONSUMPTION	1,441,300	6.35	1,961,000
4.	GLOBAL NR LATEX CONSUMPTION	1,584,000	5.27	2,047,000
	ASIA SHARE OF			
	PRODUCTION			89.4%
	CONSUMPTION			95.8%

*Upper Estimate based on current CAGR Trends

ASIAN COUNTRIES LATEX CONSUMPTION TRENDS (2013-18)

SL.NO	COUNTRY	Latex Consumption in the Year				Growth	
		2013		2018		Change %	CAGR
		('000MTA)	% SHARE	('000MTA)	%SHARE	2013-2018	% per Annum
1	CHINA	294.8	27.8	467.5	32.4	4.6	9.66
2	MALAYSIA	379.2	35.8	452.6	31.5	4.3	3.6
3	THAILAND	130.4	12.3	205.7	14.5	2.2	9.54
4	INDONESIA	91.8	8.7	121.3	8.4	0.3	5.73
5	INDIA	77.8	7.3	91.7	6.4	0.9	3.34
6	VIETNAM	14.0 (E)	1.3	31.5	2.1	0.8	17.61
7	SRI LANKA	22.3	2.1	28.5	2.0	0.1	5.03
8	SOUTH KOREA	20.1	1.9	15.7	1.0	0.9	-4.82
9	JAPAN	9.8	0.9	4.4	0.3	0.6	-14.8
10	TAIWAN	4.4	0.4	3.7	0.2	0.2	-3.41
11	OTHERS*	14.63	1.5	18.7	1.2	0.3	5.03
	TOTAL	**1059.3**	**100.0**	**1441.3**			**6.35**
	* CAMBODIA, LAOS, PAKISTAN, BANGLADESH						

THE MALAYSIAN LATEX SECTOR
5-YEAR GROWTH SCENARIO



Note:

* January-March

** Other Rubber: Synthetic Rubber, Reclaimed Rubber, Waste Rubber, Compound Rubber and Unvulcanised Rubber (HS Code 4002-4006)

Natural Rubber figures including compounded rubber to China

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THE MALAYSIAN LATEX PRODUCT EXPORTS[2]

Malaysia's Exports of Selected Rubber Products, 2013-2018

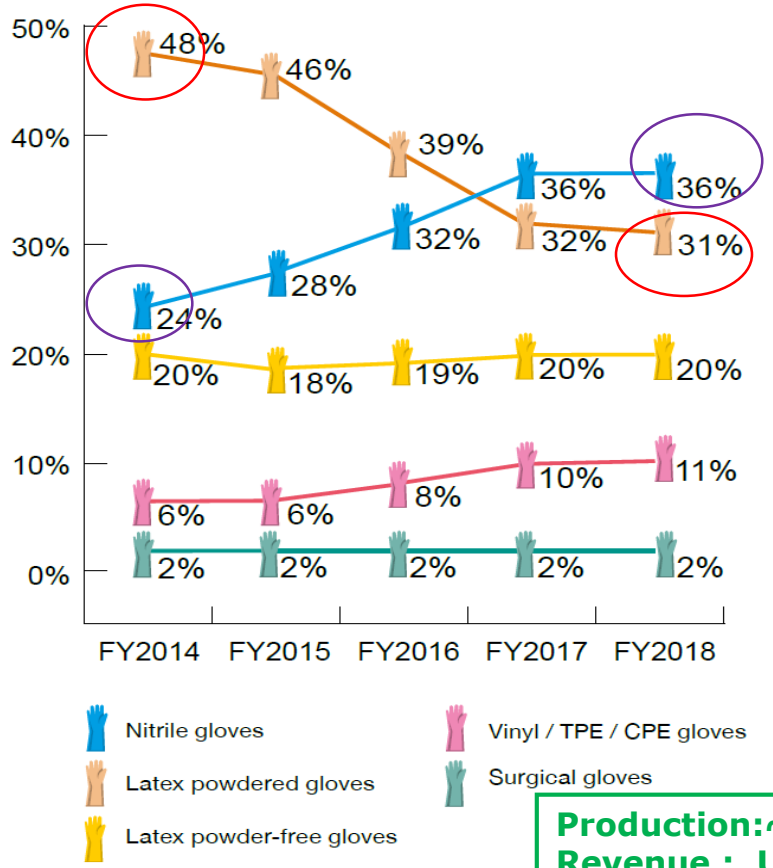
Rubber Product	Value (U$ X10^6)	Share	CAGR	Value (U$ X10^6)	Share
	2013	%	%	2018	%
Gloves, Other Than Surgical Gloves	1817.6	77.57	14.1	3516.5	81.45
Surgical Gloves	225.9	9.64	13.5	425.0	9.85
Vulcanized Rubber Thread and Cord	180.0	7.68	3.1	154.5	3.58
Sheath Contraceptives	64.9	2.77	12.2	115.3	2.67
Catheters	28.9	1.24	15.7	59.9	1.39
Foam Products	18.5	0.78	13.9	35.4	0.82
Finger Stalls	4.3	0.19	6.9	6.0	0.14
Teats & Soothers	2.8	0.13	9.0	4.3	1.10
TOTAL	**2342.9**	100.0	**13.0**	**4316.9**	100.0

91.3

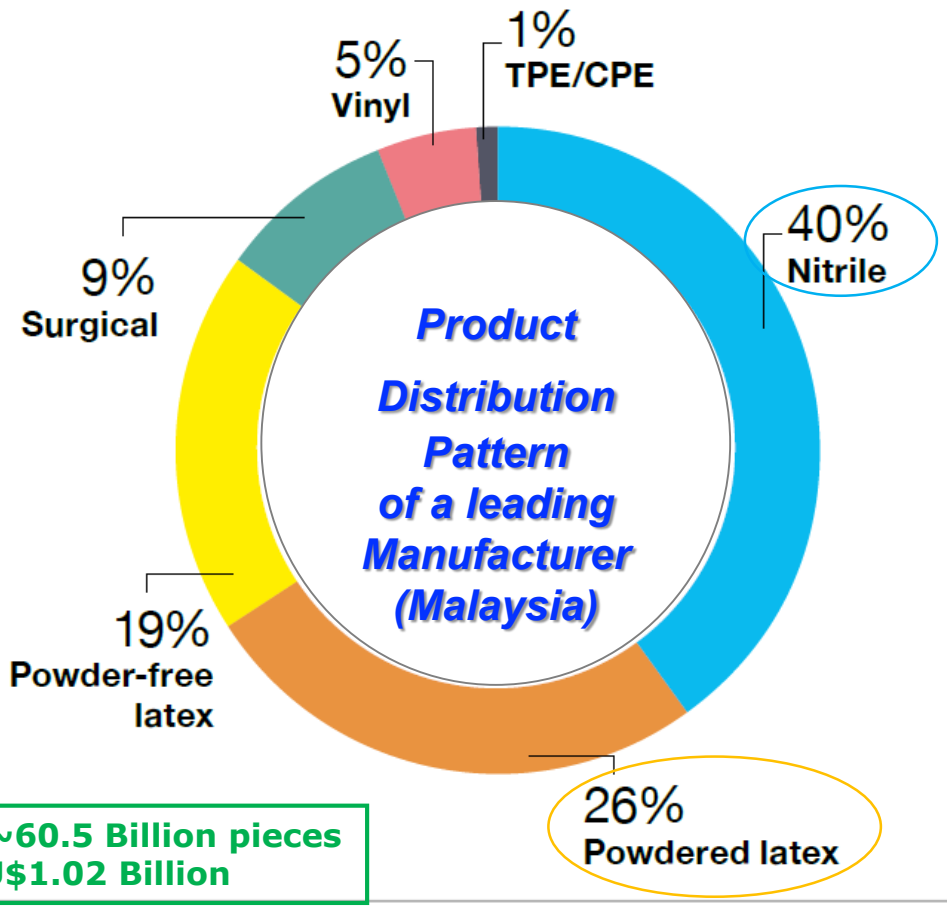
Global and Asian Latex consumption is expected to maintain a growth rate of between 4-6 % per annum. Value of goods used **domestically and exported** by Asian latex product manufacturers is estimated at around **US $ 13.75 billion** per annum (at cif prices) in 2018 and the market value estimated is **at least double**

PRODUCT MIX OF A LEADING GLOVE MANUFACTURE[3]

a) Product mix by Sales Volume from FY2014 to FY2018



b) Product mix by Sales Revenue for FY2018



Production:~60.5 Billion pieces
Revenue : U$1.02 Billion

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PRESENTATION FORMAT

NR LATEX INDUSTRY CURRENT TRENDS

BIOELASTOPLASTICS –A SUSTAINABLE CONCEPT

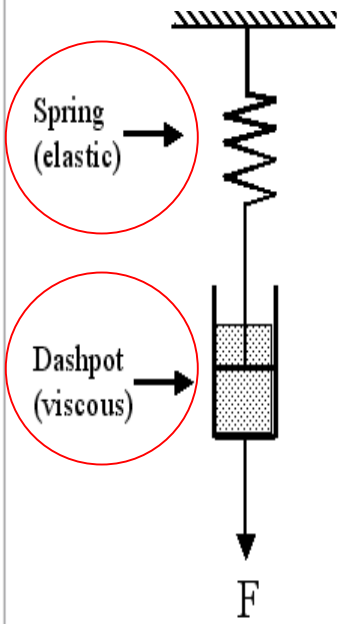
SPECIALITY NATURAL RUBBERS SOLID AND LATICES

PRODUCT MODIFICATIONS AND DEVELOPMENTS

THE FUTURE - CRYSTAL GAZING

VISCOELASTIC BEHAVIOUR MODELS FOR RUBBER

Rubber Bands



Maxwell Viscoelastic Model

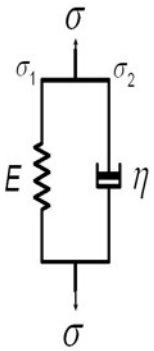
Elastomeric Bearings

Section 3 – Nonlinear Analysis
Module 4 – Viscoelastic Materials
Page 10

Kelvin Model

- The Kelvin model uses a spring and dashpot in parallel.
- The Kelvin model doesn't match relaxation data.
- It doesn't exhibit time dependent relaxation.

Derivation of Governing Equation



$$\sigma_1 = E\varepsilon$$

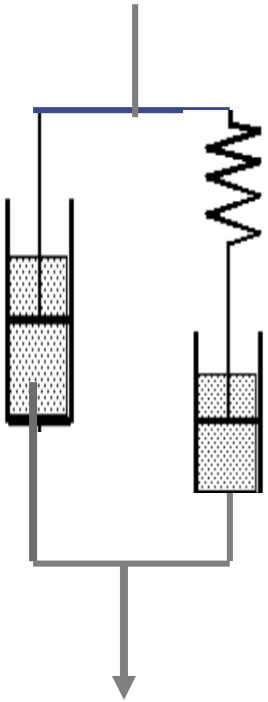
$$\sigma_2 = \eta\dot{\varepsilon}$$

$$\sigma = \sigma_1 + \sigma_2$$

$$\tau = \frac{\eta}{E}$$

$$\dot{\varepsilon} + \frac{1}{\tau}\varepsilon = \frac{\sigma}{\eta}$$

NR/BR Tyre Treads



PLASTICITY : VISCOSITY/RHEOLOGY/NON NEWTONIAN FLOW BEHAVIOUR
ELASTICITY: RESILIENCE /DAMPING/STRESS RELAXATION

DEVELOP STRUCTURED AMORPHOUS AND CRYSTALLINE REGIONS BY MOLECULAR MODIFICATIONS OF THE MAIN CHAINS (END GROUPS/EPOXIDATION/GRAFTING/ DEPOLYMERIZATION/HALOGENATION) AND/OR BLENDING & HOMOGENISATION TECHNIQUES.

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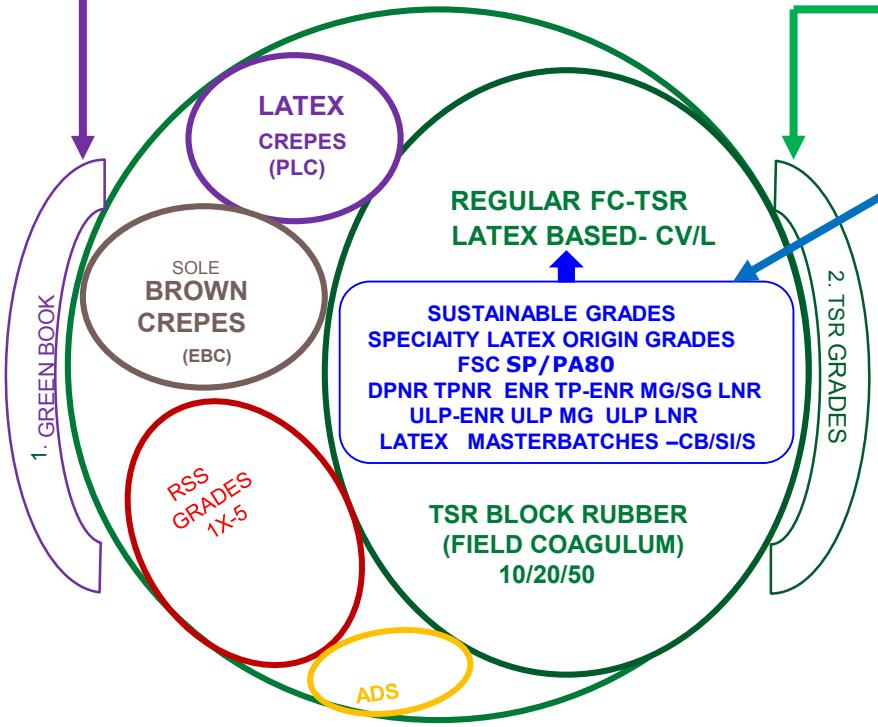
SUSTAINABLE NR DRY GRADES

FSC-ULTRA LOW PROTEIN –ENR-TPNR-GRAFTS –LIQUID FORMS



1. TRADITONAL GREEN BOOK VISUAL GRADES

2. TECHNICALLY SPECIFIED BLOCK RUBBER GRADES (TSR)
   - .1 TRADITIONAL [NORMAL/FSC]
   - .2 MODIFIED –CHEMICALLY & PHYSICALLY

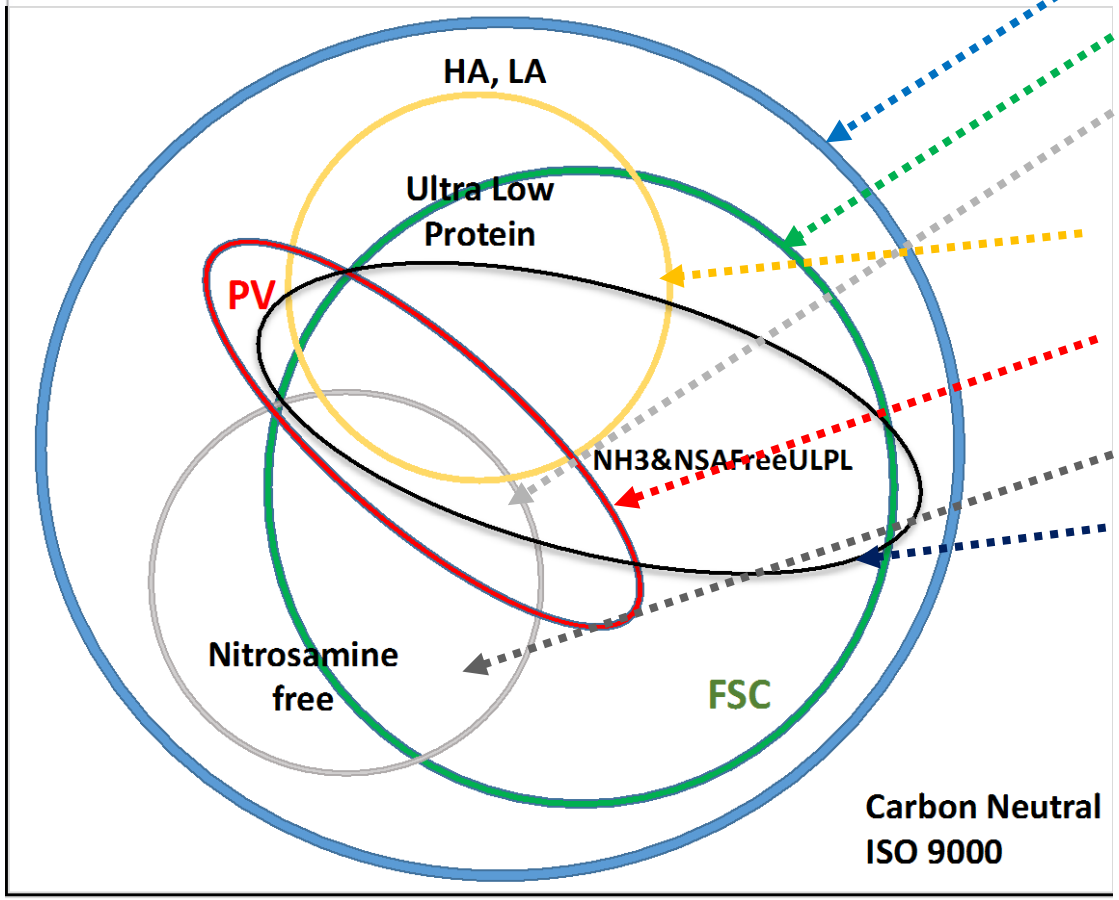
FSC/NON-FSC

- .1 SP/PA80
- .2 MG/SG –ULP
- .3 DPNR
- .4 ENR /ULP-ENR
- .5 LNR – ULP
- .6 TPNR TPENR
- .7 LATEX CARBON BLACK MB
- .8 LATEX SILICA MB

FSC –FOREST STEWARDSHIP COUNCIL

SUSTAINABLE LATEX GRADES

FSC-NITROSAMINE/AMMONIA FREE-ULTRA LOW PROTEIN – PV



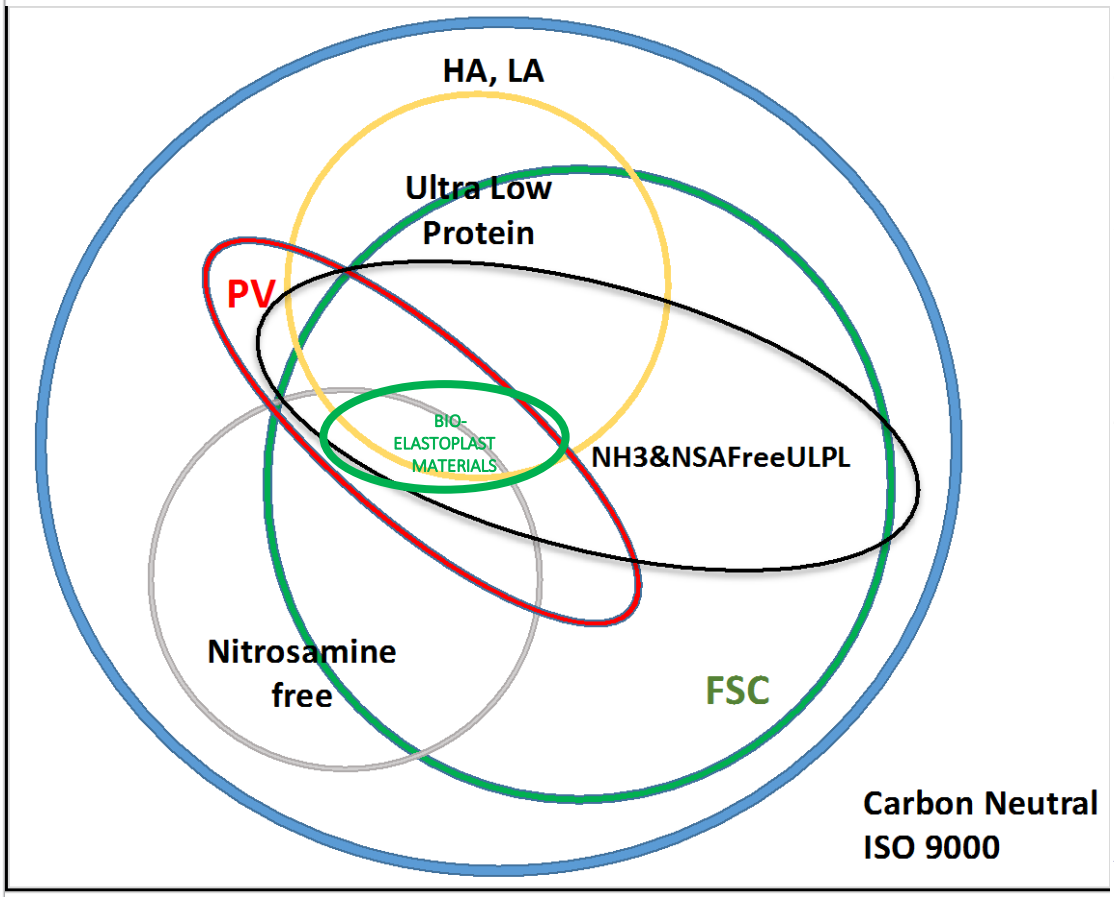
1. NORMAL HA & LA LATEX(HA/LA)
2. HA/LA-FSC LATEX
3. HA/LA-FSC- NF LATEX (TMTD NITROSAMINE FREE -NF)
4. HA/LA-FSC-ULP LATEX (UTRA LOW PROTEIN)
5. PREVULCANISED LATICES (FSC/ULP/NSF)
6. FSC–AF-NF LATEX
7. FSC –AF-NF-ULPLATEX

•ALL THESE GRADES ARE AVAILABLE FOR EVALUATION

ACRONYMS
FSC =FOREST STEWARDSHIP COUNCIL
AF = AMMONIA FREE
NF = NITROSAMINE FREE
ULP = ULTRA LOW PROTEIN

SUSTAINABLE LATEX GRADES

FSC-NITROSAMINE/AMMONIA FREE-ULTRA LOW PROTEIN – PV



BIOELASTOPLAST MATERIALS

A class of materials derived principally from Natural Rubber (Hevea Brasiliensis) which are physico-chemical modified at pre- or post centrifuged stage of latex processing, such that its modified viscoelastic behavior(i.e. elasticity and plasticity) enables it application in a wider range of static and dynamic mode applications.

Materials are made available either in the latex or solid form.

The starting point for these are from deproteinsied (ultra low protein) field latex which is a leaner and purer latex

- ALL THESE GRADES ARE AVAILABLE FOR EVALUATION

FSC =FOREST STEWARDSHIP COUNCIL
AF = AMMONIA FREE
NF = NITROSAMINE FREE
ULP = ULTRA LOW PROTEIN

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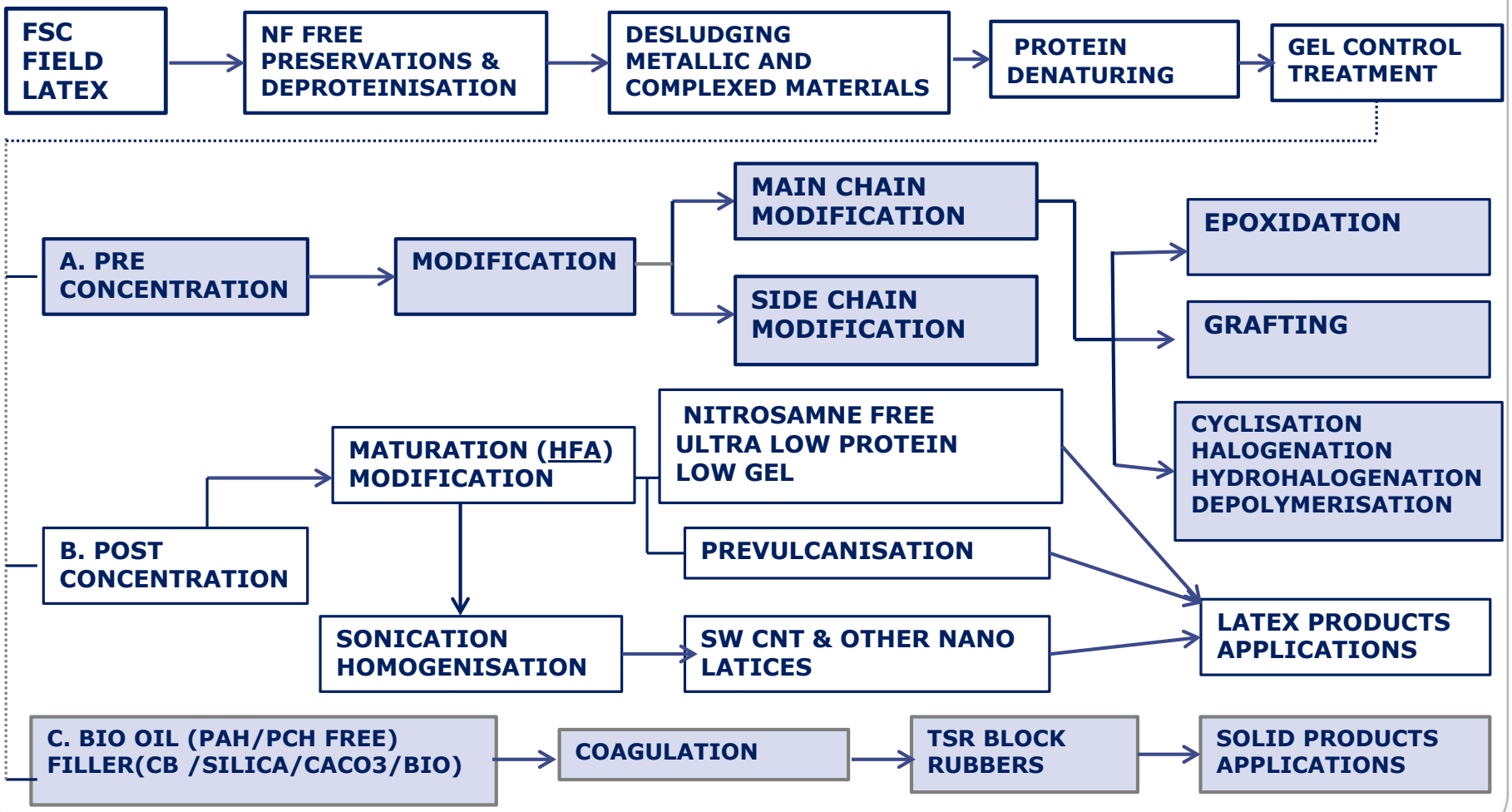
THE FUTURE - CRYSTAL GAZING

A HOLISTIC APPROACH TO NATURAL RUBBER BASED BIOELASTOPLAST MATERIALS



BIOELASTOPLAST MATERIALS

MODIFICATION OF THE VISCOELASTIC BEHAVIOUR THROUGH ONE OR MORE OF THE FOLLOWING PROCESSES

- Deproteinising of the field latex with denaturing of residual proteins(ULPFL)
  - Preparation of low gel content latices from ULPFL
    - Epoxidation of the ULPFL pre-concentration
      - Depolymerised and homogenised ULPFL latex with uniform particle size and molecular weight distribution
        - Custom grafted latices from ULPFL with various monomers in the range of 15-50% (mol ratio)
          - Custom compounded DPNR and ENR block rubbers with carbon black, silica/ENR/SWCNT incorporated in the post modified latex (ULPFL)stage

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NR GRAFT COPOLYMER. DEPOLYMERISED NR HALOGENATED / HYDROHALOGENATED NR CYCLISED NR RESIN

ULPL-NF-LOWGEL MG –SOLID & LIQUID

15/30/49-METHYLMETHACRYLATE GRAFTS
ADHESIVES/STIFFENERS/COMPATABILISERS
OTHER GRAFTS- VA/VP/STYRENE

ULPL –NF – LOWGEL DEPOLYMERISED NR - LATEX AND LIQUID

PLASTICISERS/ BINDERS/ MOL WT MODIFIERS

ULPL-NF-HALOGENATED NR- LATEX AND POWDER

MARINE PAINT & RUBBER-TO-METAL BONDING COMPONENT
IODINATED NR -CONDUCTIVE SHEETS
BROMINATED NR – GLOSSY SURFACE FINISHES

ULPL-NF-LOW GEL HYDROHALOGENATED NR LATEX

CLEAR THIN FILMS AND SHEETS- PRE-PVC- GOODYEAR PLIOFILMS

ULPL-NF-CYLCISED NR

RUBBER RESIN FOR BONDING AND STIFFENER APPLICATIONS

I .NON RUBBERS IN NORMAL CL60 POST CENTRIFUGING[6]

RUBBER PHASE – PROTEINS (0.25%*), LIPIDS,
HIGHER FATTY ACIDS, (0.36%)
NITROGENOUS BASES, METALS, CAROTENOIDS

SERUM PHASE – CHOLINE(0.6%), QUEBRACHITOL,
GLYCEROPHOSPHATE (0.04%), FREE PHOSPHATE (0.01%)
HIGHER FATTY ACIDS (0.4%), VOLATILE FATTY ACIDS 0.02%),
NITROGENOUS BASES(0.04%), OTHER ORGANIC ACIDS
(0.02%-OXALIC/CITRIC, TARTARIC, SUCCINIC,ETC)
PROTEINS (0.25%-BASIC, α-GLOBULIN),
FREE AMINO ACIDS (0.14%-ALANINE, ASPARTIC ACID,
ARGININE,CYSTINE,GLYCINE,GLUTAMIC ACID,ETC),
POLYPEPTIDES, METALS)

SLUDGE – $MgNH_4PO_4$, STEROL GLYCOSIDES

- ALL FIGURES INDICATE ~CONCENTRATION IN GM/100GM LATEX NON RUBBER SOLIDS ~2.0%
- KOH NUMBER DETERMINES ALL THE ACID RADICALS PRESENT- HIGHER FATTY ACIDS, ETC
- VFA DETERMINE THE VOLATILE FATTY ACIDS (ACETIC, FORMIC, PROPIONIC)
- NITROGEN CONTENT FROM PROTEINS, NITROGENOUS BASES, AMINO ACIDS,POLYPETIDES,

CL60 VYTEX TREATMENT
POST CENTRIFUGING

RUBBER PHASE – PROTEINS (0.005%*), LIPIDS,
HIGHER FATTY ACIDS, (0.36%)
METALS (<0.005%)CAROTENOIDS

SERUM PHASE – CHOLINE(0.6%), QUEBRACHITOL,
GLYCEROPHOSPHATE (0.04%), FREE PHOSPHATE (0.01%)
HIGHER FATTY ACIDS (0.4%), VOLATILE FATTY ACIDS 0.02%),
OTHER ORGANIC ACIDS
(0.02%-OXALIC/CITRIC, TARTARIC, SUCCINIC,ETC),
METALS (<0.005%)

SLUDGE- 0.0007%

- ALL FIGURES INDICATE ~CONCENTRATION IN GM/100GM LATEX NON RUBBER SOLIDS ~1.2%
- KOH NUMBER DETERMINES ALL THE ACID RADICALS PRESENT- HIGHER FATTY ACIDS, ETC
- VFA DETERMINE THE VOLATILE FATTY ACIDS (ACETIC, FORMIC, PROPIONIC)
- NITROGEN CONTENT FROM PROTEINS, NITROGENOUS BASES, AMINO ACIDS,POLYPETIDES,

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SLUDGE CONTENT

SLUDGE CONTENT

Date of test : 19,/7/2019

No	LOT	GRADE	RESULT (% W/W, ON LATEX)
1	18	LA	0.0022
2			0.0022
3	28	HA	0.0015
4			0.0012
5	25	ULPL - LA	0.0005
6			0.0007
7	27	ULPL - HA	0.0007
8			0.0007

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ANTIGENIC PROTEINS IN ULPL

1. Older process EP<42 µg/g LOD)

GUATEMALA 1010

ACCREDITED Biological Testing Cert. No. 1438.01

GUTHRIE

7/11/2019

ASTM D6499-18 Inhibition ELISA

Report Number: 11369

Sample #	LTS#	Sample Identification	Sample Weight (g)	Extract Volume (ml PBS)	Inhibition Assay Conc. (µg/ml)	Surface Area dm^2	Antigenic Protein Concentration (µg/g)	Antigenic Protein Concentration ($\mu g/dm^2$)
1	44575	Natural ULPL Latex 500 mL	1.2	6.0	0.2	2.8	1.0	0.4

1000ng/g

2.Advanced process EP<42 µg/g (LOD)

BINH DUONG, VIETNAM
0084-650-3561487

ACCREDITED CERT #1438.01

GUTHRIE

1/31/2019

ASTM D6499-18 Inhibition ELISA

Report Number: 11254

Sample #	LTS#	Sample Identification	Sample Weight (g)	Extract Volume (ml PBS)	Inhibition Assay Conc. (µg/ml)	Surface Area dm^2	Antigenic Protein Concentration (µg/g)	Antigenic Protein Concentration ($\mu g/dm^2$)
1	44362	DT- ULPL (LA) LOT 07 = Ultra Low Protein Latex (Low Amoniac) (with 02 film/lot)	1.3	6.5	0.1	2.2	0.5	0.3

500ng/g

Innovative Technology Solutions across the Elastomer Industry Spectrum- Plantation to Products

INTERNATIONAL LATEX CONFERENCE

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NITROGEN CONTENT AND PROTEIN CONTENT

Lot	Type	Nitrogen content (%)
4	LA	0.25
5	LA	0.26
17	LA	0.26
22	LA	0.26
23	HA	0.27
28	HA	0.26
30	HA	0.27
31	HA	0.26

Lot	Type	Nitrogen content (%)	EP µg/g	AP µg/g
7	ULPLA	0.13	< 42	0.5
8	ULPLA	0.17	<42	0.5
24	ULPLA	0.16	<42	0.5
25	ULPLA	0.15	<42	0.5
26	ULPHA	0.19	<42	0.5
27	ULPHA	0.17	<42	<0.2

For Protein estimation from N_2 content does the 6.24 multiplication factor apply?

Name	Trivial Name	Physiologcal Role	Estimated level (ng/g)
Hev b 1	Rubber Elongation factor	Biosynthesis	210
Hev b 3	Small rubber particle protein	Biosynthesis	260
Hev b 5	Acidic Latex protein	?	5
Hev b 6.02	Hevein	Defence related protein	25
	TOTAL		500

III. ULTRA LOW PROTEIN SOLID NATURAL RUBBER PROPOSED STANDARD

Properties	Grade [a]						
	E-WFS	E-CV50	E-CV60	NE-WFS	NE-CV50	NE-CV60	Test method
Colour coding marker [b]	Green	Blueb	Blueb	Green	Blueb	Blueb	
Dirt retained on sieve maximum % (mass fraction)	0,03	0,03	0,03	0,03	0,03	0,03	ISO 249
Ash maximum % (mass fraction)	0,25	0,25	0,25	0,25	0,25	0,25	ISO 247-1, ISO 247-2
Nitrogen content % (mass fraction)	0,15	0,15	0,15	0,15	0,15	0,15	ISO 1656
Volatile matter content % (mass fraction)	0,5	0,5	0,5	0,5	0,5	0,5	ISO 248-1
Initial plasticity (P0) minimum	30	30	30	30	30	30	ISO 2007
Plasticity retention index (PRI) [c] minimum	60	60	60	60	60	60	ISO 2930
Mooney viscosity ML(1+4) at 100 °C	N/A	55±10 [c]	65±10 [c]	N/A	55±10 [c]	55±10 [c]	ISO 4660
Extractable protein Maximum (µg/g)	100	100	100	100	100	100	ASTM D5712 [d]
Antigenic protein Maximum (µg/g) [e]		10				10	ASTM D6499 [d]

[a] The raw material is given in Table 1.

[b] Suggested colours.

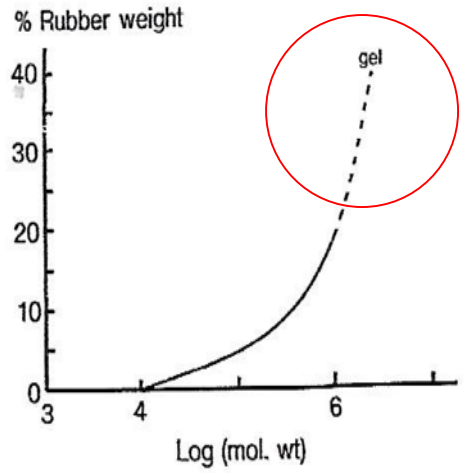
[c] Other viscosity levels may be agreed between interested parties. For specific applications, e.g. low viscosity CV40 for adhesives. In lieu of PRI the application of a maximum P of 12 units may also be agreed between interested parties.

[d] ASTM Standard in the absence of an equivalent ISO Standard

[e] Grade suitable for food and medical application

Proposed standard differentiates between the enzymatic and non enzymatic processes of deproteinisation

II. LOW GEL CONTENT LATICES



The molecular weight distribution of NR latex rubber (LA–TZ).

During Maturation. Storage and Transportation, the **gel content** of the rubber rises in 3 months to about **50%**,with consequent increase in the Mooney Viscosity(ML4) >100 and the Initial Plasticity (Wallace) of 80-100.This is akin to **Storage Hardening** in dry rubber, attributed to aldehyde groups .

Film forming properties are not affected, but, the effect is more significant in **Ultra thin films** that are finding increasing applications, e.g. ultrathin condoms, catheter balloons, etc.

The **removal of the proteins and reduction of the non rubber constitutents** has been found to inhibit the gel formation as the amino groups are significantly reduced .

Nitrogen content, gel content and ester content of HANR and DPNR.
Y. Yamamoto et al. / Polymer Degradation and Stability 156 (2018)

	N% (w/w%)	Gel% (w/w%)	Ester * (mmol/kg-rubber)
HANR	0.217	67.8	21.9
DPNR	**0.014**	**20.1****	**23.2**

*Fatty Acid.

** <10% IN DPNR CV

GEL AND MICROCOAGULUM

MICROGEL
TEST - SOLUTION. +
UHS CENTRIFUGING

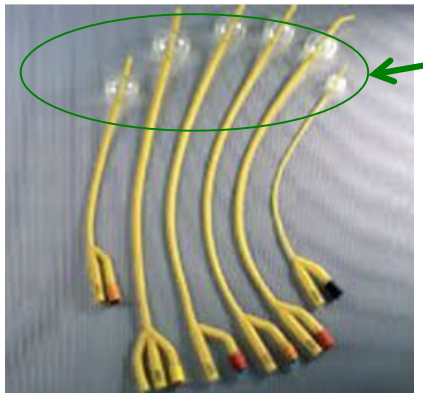
→

MACROGEL
TEST - SOLUTION +
HS CENRIFUGING

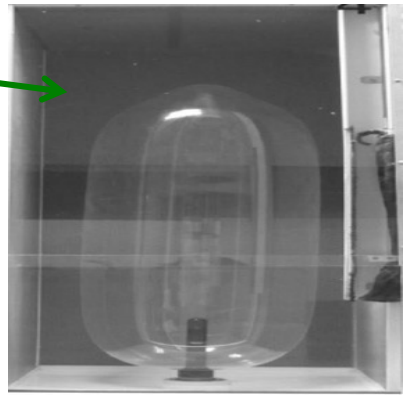
MACROCOAGULUM
100 MESH

→

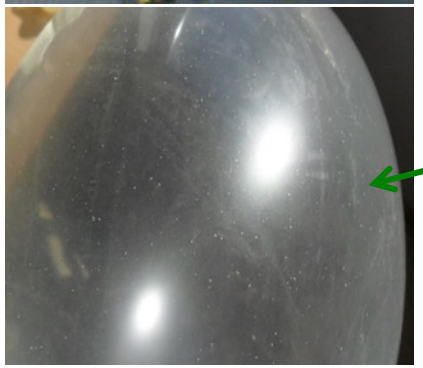
MICROCOAULUM
325 MESH



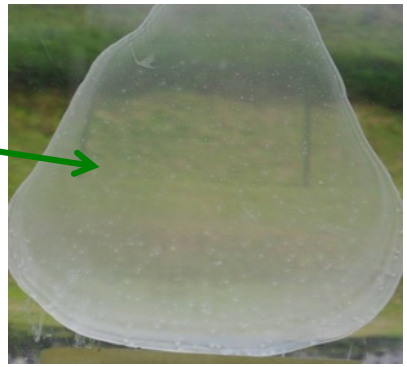
Ultra thin films



Microgel can be detected as spots and the vulcanisation in the neighbourhood is inconsistent with the total film properties.



White Spots



Low gel latices
<2.0%

NITROSAMINE TEST RESULTS
LATEX AND BALLOONS

N-Nitrosamines and N-nitrosatable substances

Test Method
In accordance with: EN-71-12:2017
Migration 1 hour at 40 °C
Detection method: LC-MS/MS

NF Latex

	Abbrev	Unit	migratable N-nitrosamines	migratable, N-nitrosatable substances	Limits of quantification
Sample(s)			**180324655**	**180324655**	
N-Nitrosodimethylamine	NDMA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiethylamine	NDEA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiisopropylamine / N-Nitrosodipropylamine	NDiPA / NDPA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiisobutylamine / N-Nitrosodibutylamine	NDiBA / NDBA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosomorpholine	NMOR	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosopyrrolidine	NPYR	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosopiperidine	NPIP	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosoethylphenylamine	NEPhA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosomethylphenylamine	NMPhA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiisononylamine	NDiNA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodibenzylamine	NDBzA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiethanolamine	NDELA	mg/kg	< 0.01	< 0.01	< 0.01
Total			-	-	
Quantity allowed			max. 0.05	max. 1.0	
Conclusion			Pass	Pass	

NF Balloon

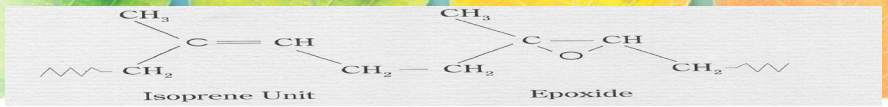
	Abbrev	Unit			
Sample(s)			**180324656**	**180324656**	
N-Nitrosodimethylamine	NDMA	mg/kg	< 0.01	**0.53**	< 0.01
N-Nitrosodiethylamine	NDEA	mg/kg	< 0.01	**0.12**	< 0.01
N-Nitrosodiisopropylamine / N-Nitrosodipropylamine	NDiPA / NDPA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiisobutylamine / N-Nitrosodibutylamine	NDiBA / NDBA	mg/kg	< 0.01	**0.02**	< 0.01
N-Nitrosomorpholine	NMOR	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosopyrrolidine	NPYR	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosopiperidine	NPIP	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosoethylphenylamine	NEPhA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosomethylphenylamine	NMPhA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiisononylamine	NDiNA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodibenzylamine	NDBzA	mg/kg	< 0.01	< 0.01	< 0.01
N-Nitrosodiethanolamine	NDELA	mg/kg	**0.02**	< 0.01	< 0.01
Total			**0.02**	**0.67**	
Quantity allowed			max. 0.05	max. 1.0	
Conclusion			Pass	Pass	

VAGARIES OF NITROSAMINE TESTING RESULTS

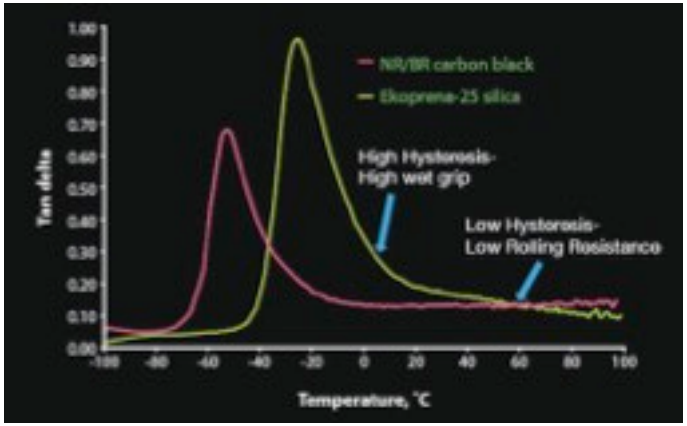
LABORATORY.	SAMPLE NOS.	AVERAGE mg/kg	Variation (%)
LAB01 (U.K)	1-3	0.46	8
LAB02 (GERMANY)	4-6	0.46	7
LAB03A (GERMANY)	7-9	0.50	27
LAB03B (DENMARK)	10-12	0.49	31
LAB0 4A (GERMANY)	13-15	0.39	41
LAB 5 (GERMANY)	16-18	0.42	13
LAB06(GERMANY)	19-21	0.47	27
LAB 07(GERMANY)	22-24	0.39	23
RANGE		0.39-0.50	8-40%

8 LAB X3 SAMPLES EACH
INDIVIDUAL RESULTS RANGE 0.32-0.56 mg/kg

IV. EPOXIDISED NATURAL RUBBER



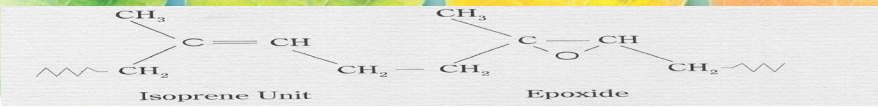
REF: EKOPRENA TECHNICAL BULLETIN–MRB



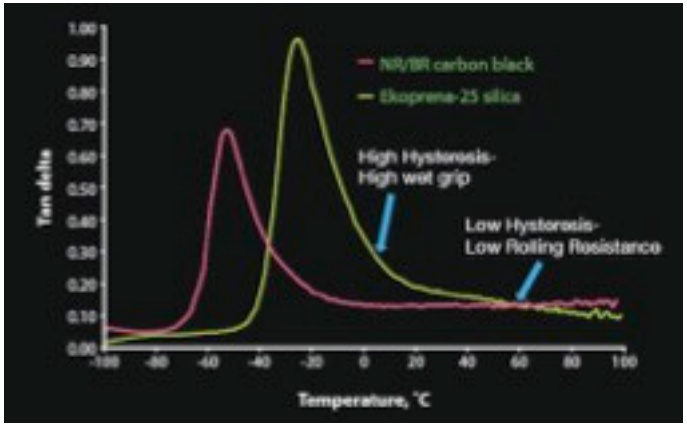
Feature	Application	Recommended ENR grade
Oil resistance	Hoses, seals, blow-out preventors,	ENR-50
	Milking inflation, connectors and tubes	ENR-50, ENR-25
Gas impermeability	Bladders, inner tubes and tyre liners	ENR-50[a]
Silica reinforcement	Where black is unacceptable and high reinforcement is required	ENR-25, ENR-50
Wet-grip/Rolling resistance	Tyre treads for motor cycles, racing cars and fork lift trucks	ENR-25
Damping	Anti-vibration mountings and other engineering applications	ENR-10[a]

Properties	Grades [a]			Test Method
	ENR10	ENR 25[b]	ENR 50[b]	
Colour coding Marker [b]	Yellow	Green	Blue	
Dirt retained on sieve maximum %(mass fraction)	0,03	0,03	0,03	ISO 249
Ash maximum % (mass fraction)	0,25	0,25	0,25	ISO 247
Nitrogen content %(mass fraction)	0,15	0,15	0,15	ISO 1656
Volatile matter content %(mass fraction)	0,5	0,5	0,5	ISO 248-1
Epoxidation level, %(mole fraction)[c]	10±0.5	25±1	50±2	
Density (Mg/m3)	0.94±0.01	0.97±0.01	1.02±0.01	ISO1183
Mooney Viscosity ML(1+4) at 100 ℃	70-90	70-110	90-140	ISO 289-1
Glass Transition temperature, ℃	-60±1	-45±2	-22±2	ISO22768:2017
Solubility Parameter[d] $(MpA)^{1/2}$	17..0±0.2	17.5±0.2	18.0±0.2	
Lovibond Colour	5.5	4.5	3.5	ISO 4660
Oil Resistance in				
ASTM Oil No.1 (IRM901)	10.0	1.2	0.1	ISO1817
ASTM Oil No.2 (IRM 902)	20.0	3.0	0.6	
ASTM Oil No.2(IERM903)	70.0	40.0	1.1	
Volume increase in rubber – after immersion for 4 days at 23 ℃				

IV. EPOXIDISED NATURAL RUBBER



REF: EKOPRENA TECHNICAL BULLETIN–MRB



Feature	Application	Recommended ENR grade
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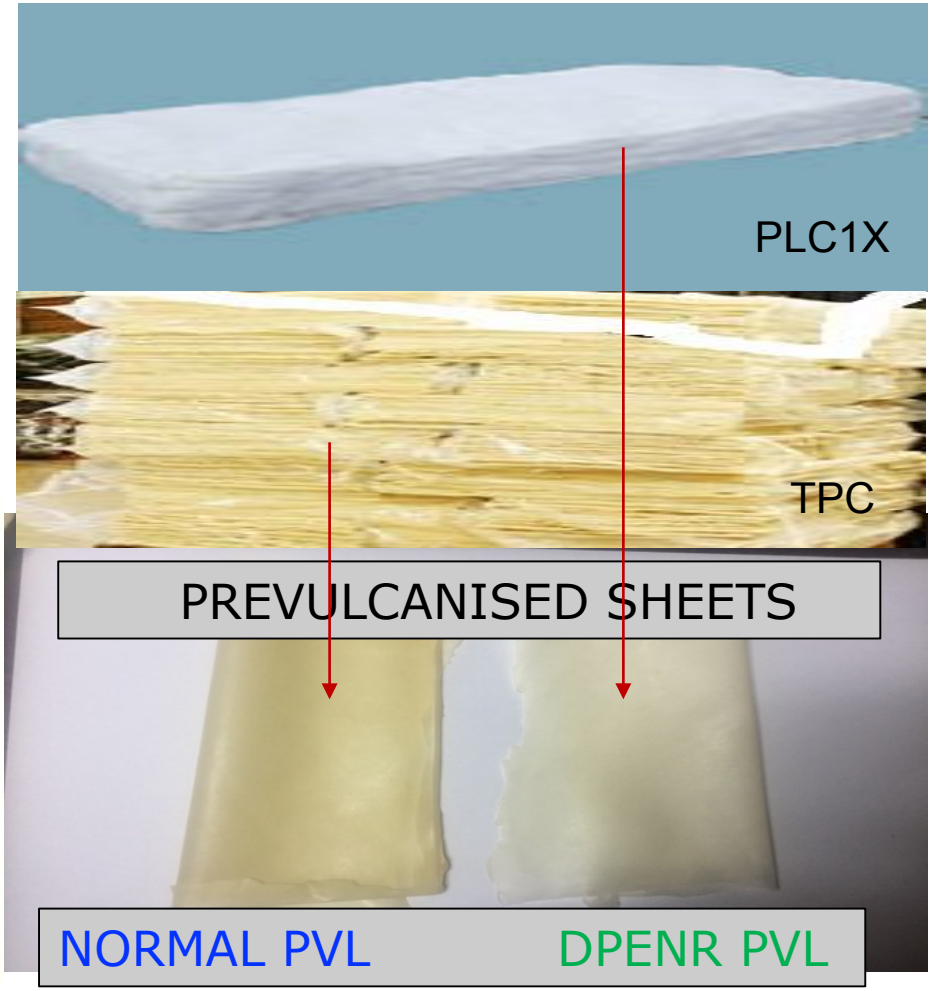
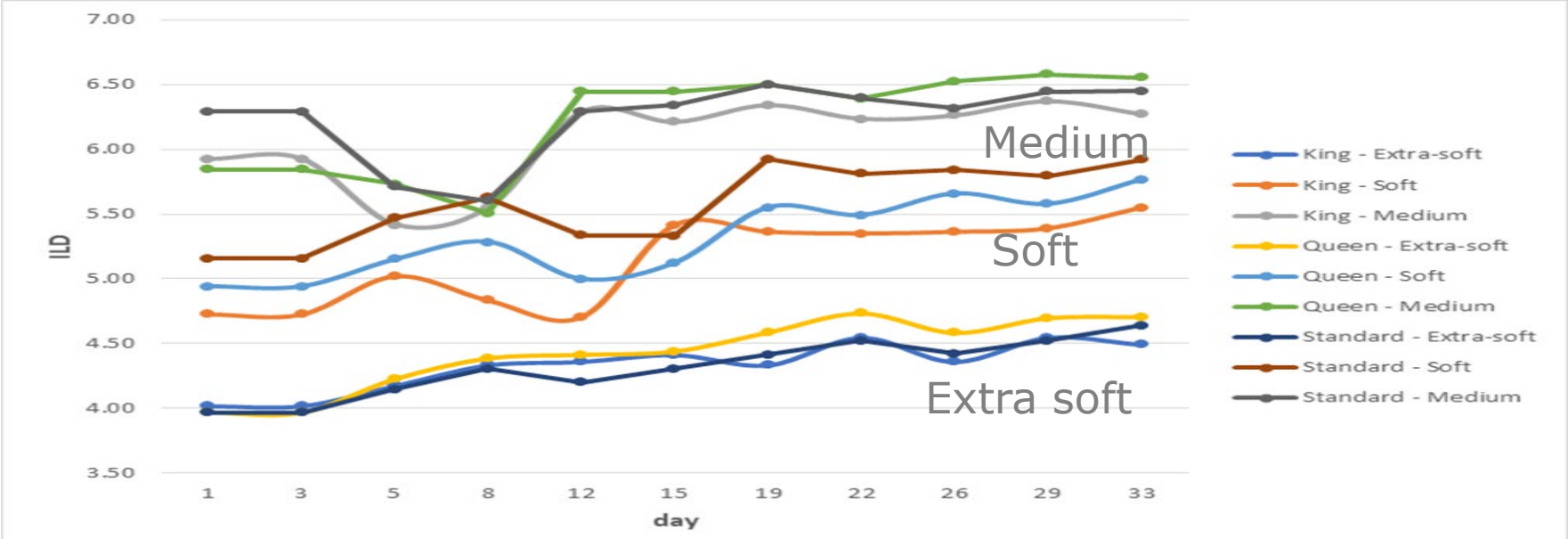
	Milking inflation, connectors and tubes	ENR-50, ENR-25
Gas impermeability	Bladders, inner tubes and tyre liners	ENR-50[a]
Silica reinforcement	Where black is unacceptable and high reinforcement is required	ENR-25, ENR-50
Wet-grip/Rolling resistance	Tyre treads for motor cycles, racing cars and fork lift trucks	ENR-25
Damping	Anti-vibration mountings and other engineering applications	ENR-10[a]



INDENTATION LOAD HARDNESS ON DIFFERENT VYTEX FOAMS



Indentation Load to compress foam to 25% of original height (under a 50sq.in platen).

SLOW COMPRESSION RECOVERY FOAMS

LATEX FOAMTESTED FOR HARMFUL SUBSTANCES

OEKO-TEX® Certification– Confidence In Textile Products

Report No. 19.0.61779 21. May 2019 Product Tested -100 % natural latex (rubber) foam in colour raw white used for pillows and mattresses (Certified as passed=Standard 100)

Product Groups (I) Children (upto36 months) in this context are all articles, basic materials and accessories (II) Direct contact to skin are those which are worn with a large part of their surface in direct contact with the skin (e.g. Blouses, shirts,etc)

NOT DETECTED:

Formaldehyde, Quinoline, OrganoTin Compounds, Phenol and Chlorinated Phenols, Phalates (Plasticisers), Bispehol A, TCEP, Azodicarbonimde (ADCA),Per/Poly Fluorinated compounds (PFC)

2. DETECTED: All within the permissible limits Ffor the product

Nitrosatables NDEA (0.03ppm)/NDMA(2.51ppm)

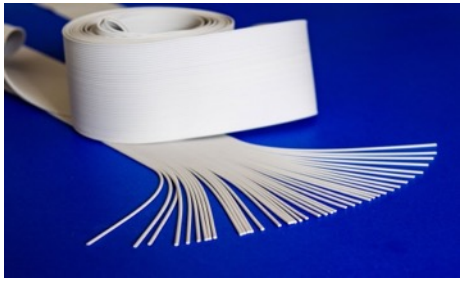
Volatile emissions (7 tested-0.08ppm)

Polycyclic Aromatic hydrocarbons (PAH –Naphthalene 0.27ppm)

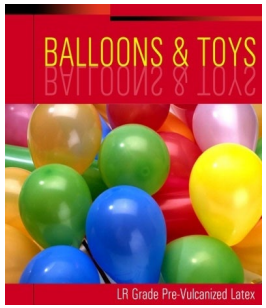
Surfactants (25.9ppm), Acidity (pH-7.2)

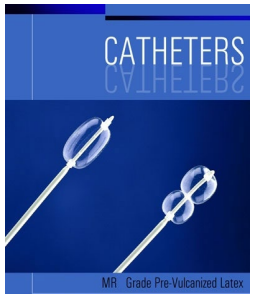
Heavy Metals(Extracted and Digested tests){Sb&Cu <4ppm},{As,Pb, Cr,Co,Ni <0.1ppm}, Cd(<0.05ppm), Hg(<0.01ppm)

PRODUCTS MANUFACTURED FROM SPECIALITY LATICES



SOOTHERS





ELECTRICAL GLOVES

PRODUCTS MANUFACTURED FROM SPECIALITY SOLID RUBBERS

MEDICAL GRADE

ANTISTATIC

PRODUCTS FROM LGM DURAPRENA

vytex®

PRESENTATION FORMAT

NR LATEX INDUSTRY CURRENT TRENDS

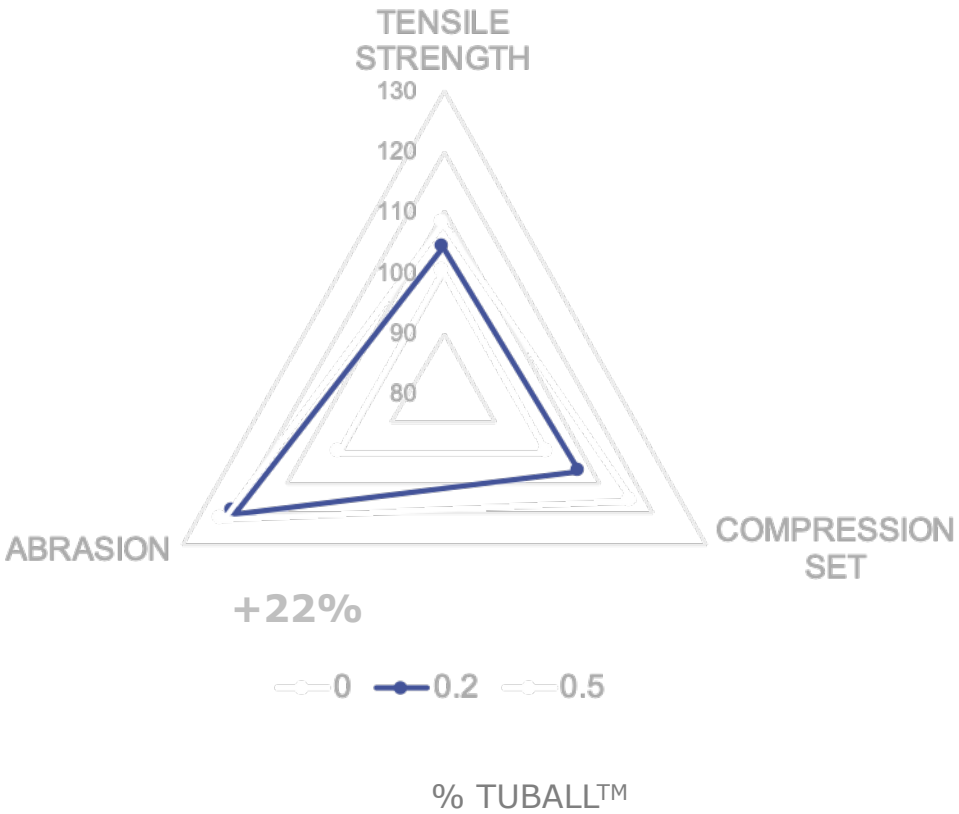
BIOELASTOPLASTS –A SUSTAINABLE CONCEPT

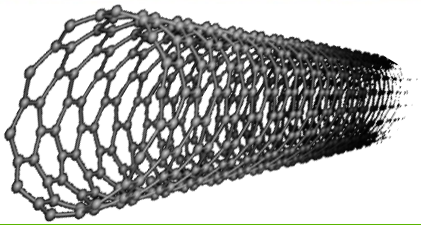
SPECIALITY NATURAL RUBBERS SOLID AND LATICES

PRODUCT MODIFICATIONS AND DEVELOPMENTS

THE FUTURE - CRYSTAL GAZING

NANOMATERIALS RESULTS NR-SWCNT COMPOUND
(SINGLE WALLED CARBON NANOTUBES TUBALL™)





Diameter	1.6 nm
Length	> 5 µm
Wall thickness	1 atom

SIGNIFICANTLY IMPROVED
Higher Conductivity/
Lower S&V Resistivity
Improved Gas Impermeability
Enhances. Filler Reinforcement
Lower Heat Build Up
(Tyre Treads)

LATEX INCORPORATED SWCNTs BRING AN UNUSUAL PERFORMANCE SPACE EXPANSION (separate presentation on this subject)[7]

NEW HORIZONS?

- HYDROGENATED NR.–$(CH_2.CH{:}CH.CH_2)$- $\xrightarrow[\text{(IN SITU)}]{H_2}$ -$(CH_2.CH_2.CH.CH_2)$-

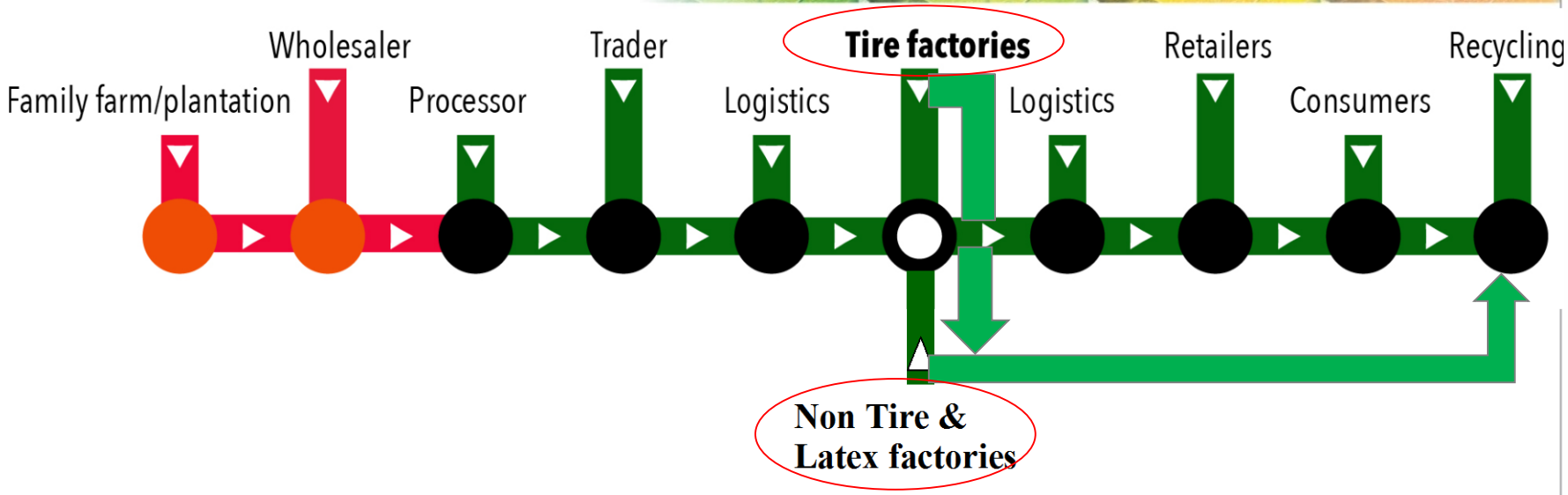
  CH_3 → CH_3

THERMOPLASTIC ETHYLENE PROPYLENE NR

NO UNSATURATION OR RETAIN LOW LEVEL OF UNSATURATION FOR COSSLINKING SIMILAR TO EPDM

- FLUORINATED AND HYDROFLUORINATED NR FOR HIGH TEMPERATURE APPLICATIONS

THE NATURAL RUBBER VALUE CHAIN
CIRCULAR ECONOMY AND BIODEGRADABILITY



In the context of the **circular economy concept and life cycle analysis**, the role carbon positive sustainable NR materials in achieving the overall objective of an neutral carbon rubber industry is of crucial importance.

Biodegradability of NR: Biodegradation rates or rubber and rubber products are still lower than desired. Research studies are in progress to enhance rates in the end-of-life cycle using various degradation methodologies.
All Rubber Products - Gloves-to-Tyres are already recyclable

THE NATURAL RUBBER JOURNEY
AN EVOLVING SCENARIO

SUPERIORITY <1950s	NR PREDOMINATES(>50%)
SURVIVABILITY 1960-1980's	NR:SR BLENDS (<50%)
SYMBIOSIS 1980-2010	NR (40%)
SUSTAINABILITY 2010-2025	NR REJUVENATION (>45%)
SECURITY >2025	NR STABILISES POSITION (~50%)

	2013.	2018
NR:SR CONSUMPTION RATIOS[1]	42.6:56.4	47.4:52.6

A NEW PARTNERSHIP FOR LATEX AND SOLID BIO MATERIALS R&D

VYSTAR+IRMRA+END USER A WIN-WIN PARTNERSHIP

Indian Rubber Manufacturers Research Association
Under Dept. of Promotion for Industry & Internal Trade (DPIIT) formerly known as DIPP
Ministry of Commerce & Industry, Govt. of India

MATERIALS AND PRODUCTS
RESEARCH AND DEVELOPMENT
BIOOILS/BIOFILLERS/BIOELASTOPLAS
TESTING
TYRE & NONTYRE
FORSENSIC ENGINEERING
EDUCATION & TRAINING
RSDC /MSc-University of Bombay)

vytex®

NATURAL RUBBER
A SUSTAINABLE ECOFRIENDLY BIOELASTOMER

References & Acknowledgements

References:

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2. LGM WEBSITE www.lgm.gov.my
3. MARGMA 9th International Rubber Conference 2018 www.margma.co.in
4. W.J.S.NAUNTON Applied Science f Rubber

5 MRB BULLETIN – EKOPRENA & DURAPRENA

6.Therml degradation of deprotinised natural rubber – Yoshimasa Yamamoto et al. National Institute of Technology ,Tokyo College, Tokyo 193-0997 Japan

7. OCSiAl Nano Augmented Materials Summit, Luxembourg, November 2017

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Mr. Joseph John – PCS P Ltd Kochi India
Dr Rajkumar – IRMRA www.irmra.org Thane, India