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## Eco-Friendly Manufacturing of High Performance Latex using Ultra Low Antigenic Protein Latex

In Association With



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I want to thank IRE 2011 conference organizers and the All India Rubber Industries Association for allowing us the opportunity to present here today. I would like to introduce Mr. Joseph John and Dr. Ranjit Matthan, KA Prevulcanised Latex, co-authors of this presentation. KAPVL represents Vystar in India and the SAARC region. Today I am going to highlight Vystar's multi-patented Vytex Natural Rubber Latex (NRL), the technology and performance attributes that differentiates Vytex NRL from standard centrifuged latex.



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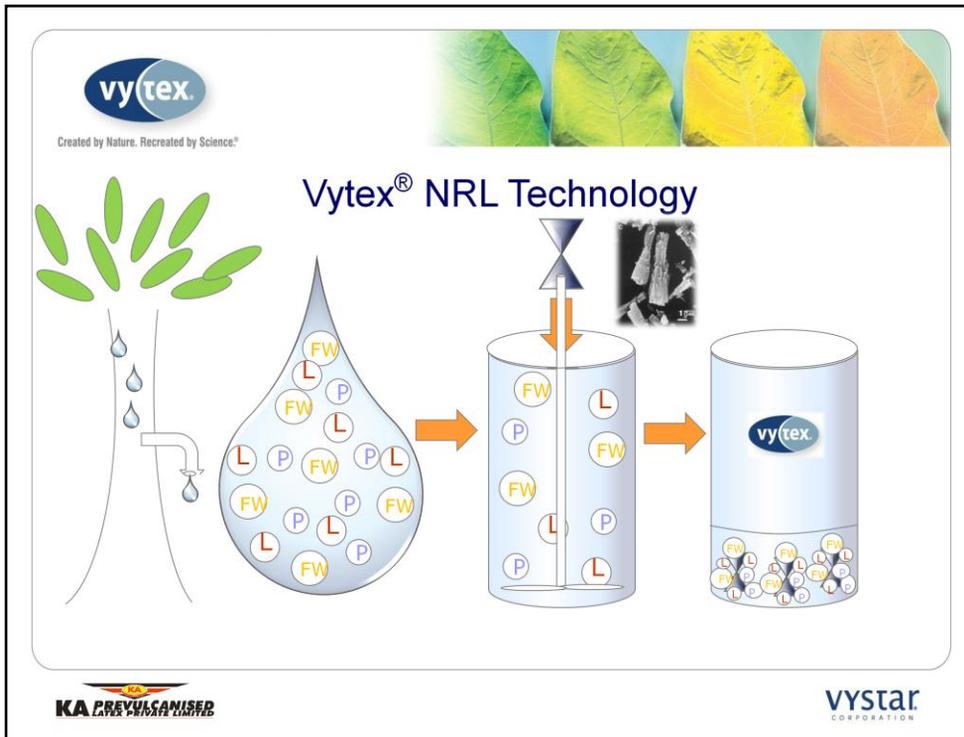


## What is Vytex® Natural Rubber Latex?

A fully commercialized, multi-patented source material, using a proprietary process to significantly reduce non-rubber components, including antigenic proteins, for a more consistent, stable and cleaner natural rubber latex



Vytex NRL is a standardized source material that can be easily integrated into the over 40,000 products produced with natural latex using green chemistry to reduce antigenic protein content to below detectable levels and provide a cleaner, whiter latex with ultra-low non-rubber content. Vytex NRL is an excellent eco-friendly alternative to synthetics.



Latex feedstock contains proteins and other non-rubbers including lutoids and Frey-Wyssling particles, shown in the middle water drop. The latex feedstock is introduced to a slurry of aluminum hydroxide  $\text{Al}(\text{OH})_3$ , represented by the dumbbell shape. The proteins and non-rubbers are adsorbed onto the reactive surface areas of the aluminum hydroxide, as depicted in picture (c) during centrifugation.

Note that adsorption is dependent on the physical and chemical characteristic of the protein as well as the conditions of adsorption, such as pH, temperature, particle size, etc.

Because  $\text{Al}(\text{OH})_3$  is insoluble, it can be introduced into the liquid latex but more importantly, it is removed with the proteins adsorbed onto the outer surface in the bottom layer (skim layer) which can be recovered and recycled.

The remaining purified top layer is the Vytex® NRL.

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## Vystar® Corporation Expands Its Presence

○ Vytex Production

■ Sales/Technical Coverage

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While Vytex is patent protected, the process to create Vytex is simple and easy to replicate at the latex processing level without additional equipment or capital outlay. This ease of production positions Vystar ahead of any geographical shifts or trends in manufacturing since the start-up time to bring on additional Vytex processors can be significantly less than for the transitioning manufacturers. This flexibility also allows us to more effectively manage the supply chain, most times reducing lead times and transportation costs and protecting Vystar from unexpected political or economic situations.

Today Vytex NRL is manufactured in southern Malaysia by our toll manufacturer, Revertex Malaysia, in Guatemala by Pica de Naturale, a division of AgroIndustrialOccidente, and our newest producer KA Pre Vulcanised Latex, Tamil Nadu, India. KAPVL is India's largest concentrate processor and has exclusive rights to Vytex in India, Sri Lanka and the remaining SAARC countries. KAPVL is staffed by many of the most tenured latex scientists and will bring future innovation to meet the growing needs of our customers – several you will hear about today.



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## New Standard of Latex

Vytex® NRL Only Commercially Available Latex to Meet New ASTM D1076-10 Category 5 —

*“Centrifuged Hevea natural latex treated with aluminum hydroxide or by other means, preserved with ammonia.....containing less than 0.5 % non-rubber content.”*

Categories  
1 – 4  
Max. 2.0%




In October last year the ASTM D11 rubber subcommittee adopted a new category of latex within the current D1076 standard. The primary difference between the new category and the existing Categories 1-4 is the established maximum level of non-rubbers – 0.5% vs. 2.0% in the previous categories – a reduction of approximately 75% of the acceptable non-rubber content in Category 5.

ASTM recognized the need to establish a separate category for an ultra clean form of *Hevea* latex – to minimize the negative effect high non-rubber content has on latex performance - decreased stability, increased aging and potentially higher manufacturing costs caused by the breakdown of the microbial activity of the non-rubbers over time. By removing the food source, the non-rubbers, latex complying with Category 5 will exhibit a significant reduction in odor, which is of particular interest to foam and condom manufacturers, where there is strong customer resistance to odor.



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## Vytex® NRL Achievements: Specialty Gloves

### Clean Room and Specialty Gloves

- Clean room gloves made with Vytex® require ~ 50% less leaching to remove non-rubbers and chemical particles
  - Lower product rejection rates due to extensive alkaline washes
  - Decreased energy, water and waste usage
- Vytex® use with common antimicrobials is superior to NRL- will not react and de-stabilize



Vytex has been adopted by a leading glove manufacturer for use in specialty line of clean room gloves. Vytex, as substantiated in actual production runs, required 50% less leaching than traditional natural rubber latex. This reduction in leaching not only lowered the manufacturers rejection rates for the finished product that is typically caused by the repeated exposure of latex to the alkalines used in the leaching process but also decreased water and energy usage.

In addition, it has been reported by a Malaysian glove manufacturer that Vytex, when used with triosyn and other antimicrobials in gloves and catheters, unlike traditional latex, does not cause a reaction between the proteins and the antimicrobial chemicals which can de-stabilize traditional NRL.



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## Protein Results in Clean Room Gloves Using Comparative Leaching Processes

Vytex® NRL Trials Using Normal Established Parameters	Size	<u>Powder Free</u> Modified Lowry ( $\mu\text{g}/\text{dm}^2$ ) Spec: < 50 $\mu\text{g}/\text{dm}^2$	Size	<u>Powdered</u> Modified Lowry ( $\mu\text{g}/\text{dm}^2$ ) Spec: < 200 $\mu\text{g}/\text{dm}^2$
Trial #1 – Normal Process 2 pre-leach; 2 post-leach	L	17.87	XXXS	20.68
Trial #2 2 pre-leach; 1 post-leach	XL	19.32	L	43.29
Trial #3 2 pre-leach only	S	18.30	S	68.61
Trial #4 1 pre-leach only	XXXS	14.89	L	67.07
Trial #5 No post or pre-leach	L	15.46	S	142.57

Testing conducted by Malaysian Glove Manufacturer



The manufacturer ran four Vytex NRL trials to compare the effect of different leaching processes on total extractable protein levels using ASTM D5712 Modified Lowry testing methodology. In both powder-free and powdered versions, gloves made with Vytex NRL were significantly below the manufacturer's specification of less than 50  $\mu\text{g}/\text{dm}^2$  for powder-free and 200  $\mu\text{g}/\text{dm}^2$  for powdered and, as a result of the trials, able to reduce the number of processing steps and still meet internal specifications.



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## Vytex® NRL Achievements: Condoms

- Naturally whiter, more translucent condoms
- Condoms made with Vytex® NRL contained 35% fewer nitrosamines than traditional latex
- Significantly reduced odor compared to NRL
- US FDA protein claim “less than 2  $\mu\text{g}/\text{dm}^2$  antigenic protein”



Condoms made with Vytex NRL have several differentiable consumer benefits over traditional NRL; Vytex condoms exhibit a whiter, more translucent appearance and are significantly less odorous than NRL. A Malaysian condom manufacturer test results reveals Vytex condoms contained 35% fewer nitrosamines than the control NRL – a distinct benefit for those manufacturers serving the European markets where the issue of nitrosamines is top of mind.

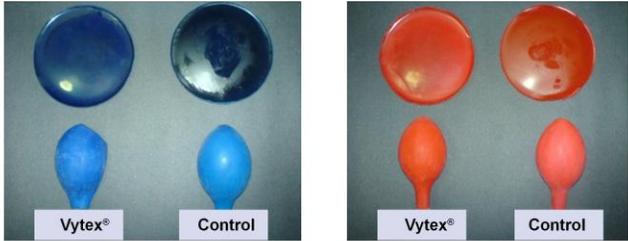
The US Food and Drug Administration gave a US manufacturer 510(k) clearance for the first protein claim for condoms – less than 2  $\mu\text{g}/\text{dm}^2$  of antigenic protein – potentially opening the door for other condom makers to make similar Vytex claims.



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## Vytex® NRL Achievements: Balloons

- Whiter, cleaner balloons for brighter, truer colors with less pigment usage
- Reduced usage of pigments and whiteners (TiO<sub>2</sub>)
- Better air and helium retention in balloons

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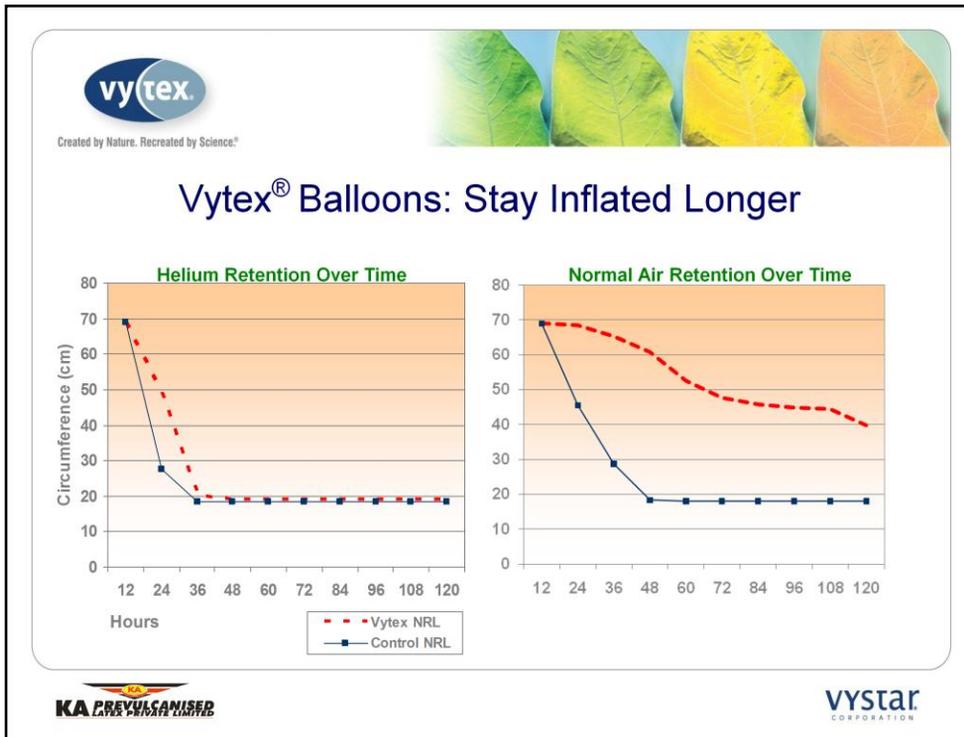
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This shows the color differences between Vytex NRL and standard NRL. When liquid latex is dried and cured, the film dries semi-transparent yellow as seen above. Whiteners such as titanium dioxide or calcium carbonate are often added to latex to express whiteness in a finished product.

When viewing the Vytex NRL film on left compared to the control film on right, there is a marked difference in the degree of yellowing between the Vytex NRL and the control. Evidence from the films demonstrates that this addition could be eliminated or significantly reduced using Vytex NRL, an additional material cost savings for the manufacturer.

Below, these side by side pictures highlight a comparison between Vytex NRL and standard NRL in colored balloons conducted at an independent testing lab. The same amount of pigment was used for both the Vytex NRL and control NRL. Using typical industry practices, when the pigments are introduced, an oily yellowish tone was commonly observed with the blue and red in the regular latex. In contrast, the oily tone was absent on the pigmented balloons made with Vytex NRL as has now been verified by a major global balloon manufacturer. As the pictures above illustrate, balloons made with Vytex NRL produced much more vibrant colors. Additionally, it can be assumed that Vytex NRL would require less pigment to achieve the same color tone and intensity as the Standard NRL, yielding another area of cost savings that can be achieved with the use of Vytex NRL.

Further cost savings can be achieved through the partial replacement of titanium dioxide with fine particle calcium carbonate dispersions to boost the color vibrancy of the Vytex NRL for certain colors such as red and blue.



Independent testing was conducted to test our hypothesis that the removal of the non-rubbers from Vytex NRL would lead to tighter rubber particle integration, preventing the wicking loss of gas and air from within the balloon.

This chart on the left depicts the helium retention of Vytex NRL balloons compared to standard NRL. Balloons made with the Vytex NRL demonstrated approximately a 50% greater retention of helium after 36 hours compared to the standard NRL.

In same laboratory evaluation, when comparing air retention of Vytex NRL and standard NRL, balloons made with Vytex NRL maintained air retention at 60.6% on the fifth day compared to the standard NRL as seen in the chart on right.



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## Vytex<sup>®</sup> NRL Achievements: Adhesives

### Spray Adhesives

- Less non-rubber debris for cleaner spray
- Absence of non-rubber debris reduces spray-head clogging; decreased equipment/line downtime
- Cleaner adhesives flow easily; allow for gravity-fed system vs. pump system using propellants
- ~ 40% faster tack time in some formulations compared to traditional latex

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Because Vytex NRL contains 75% less non-rubbers over standard NRL, it has significant advantages within adhesives, particularly in spray and coating applications. The absence of the non-rubbers provide for a cleaner spray with less clogging documented by a US adhesive manufacturer. Less clogging means less equipment downtime for head cleaning and a more consistent final product.

A US manufacturer has developed and is marketing a new foam-foam spray adhesive made with Vytex NRL. The adhesive, used in the furniture and bedding industries, was the solution for manufacturers looking for a greener alternative to solvent based adhesives. The manufacturer has reported that the new product has a 40% faster tack time than the standard latex used previously. This faster tack time allows for increased unit output and line productivity.



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## Antigenic Protein Results in Adhesives

### Vytex® NRL vs. Standard NRL

Source	ELISA D6499-07 (µg/g)	
	Sample 1	Sample 2
Vytex® NRL	1.6	2.4
Control A	624.5	76.3

Testing conducted by LEAP Testing Services, Sayre, PA, USA



Reducing non-rubbers, including antigenic proteins at the front-end of the process is critical for adhesive applications, where leaching is not an option for reduction of protein content. As you can see from this chart, Vytex achieved ultra low antigenic protein levels in two samples compared to the control in addition to a consistency between batches and lots not seen with the control, which had wide variations between the two samples.



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## Vytex® NRL Achievements: Foam Products

### Virtually Odor Free

- Reduce multiple leaching steps
- No fragrances required to mask or eliminate odor



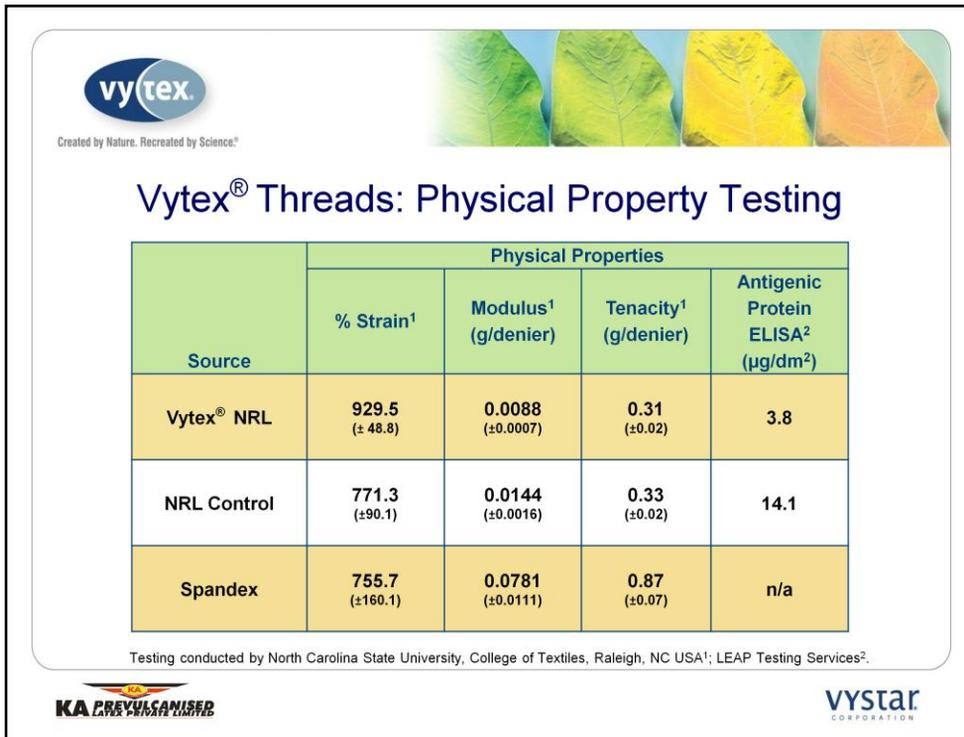
### Whiter, Cleaner Foams

### Greater Stability and Improved Aging

- Ultra low non-rubber content; more rubber for the money
- Vytex® process eliminates microbial food sources that break down to cause odor and accelerated aging



When it comes to foam products, the ultra low non-rubber content of Vytex provides significant advantages of particular importance to manufacturers in the bedding and accessory markets ; odor and whiteness.



This chart shows the differences in key physical properties between Vytex and a control NRL and the synthetic spandex/elastane as tested by the North Carolina State University, College of Textiles for Vytex threads produced by a leading Malaysian extruder. It is noteworthy that the threads were produced on a pilot line and future in-line production could yield even better results.

The first column % strain, (or elongation) you can see that Vytex stretches greater than 20% further than NRL and Spandex when submitted to comparable force .

When comparing modulus, again Vytex threads require significantly less force to initiate stretch than Spandex, which is inherently a very stiff elastomer, and better than traditional NRL, making garments made with Vytex NRL easier to don, particularly in hosiery.

When looking @ tenacity (or peak load), the measure of comfort and durability, the results show that Vytex requires significantly less load to stretch when compared to spandex, which takes nearly three times the load to stretch than either Vytex or NRL.

You will note how tight the Standard Deviations (in parenthesis) were for Vytex relative to the other two materials; In this test the Vytex material was more consistent than either the NRL or Spandex threads that were tested.

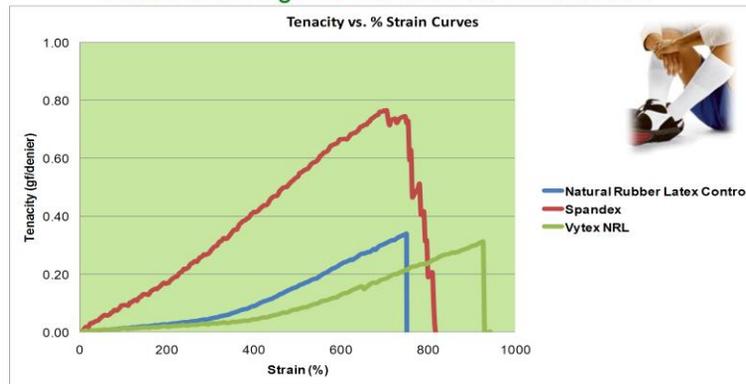
When comparing antigenic proteins levels of Vytex and traditional NRL, Vytex showed nearly a 4-fold decrease in the levels of antigenic proteins.



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## Vytex® Threads: Lower Modulus/Higher Elongation Easier Donning and Greater Wearer Comfort



Testing conducted by North Carolina State University, College of Textiles



Tests conducted at the University of North Carolina State University, School of Textiles revealed that Vytex threads exhibit a lower modulus and higher elongation over NRL and spandex. This chart depicts the amount of force required to stretch sample thread before break – the more horizontal the line the easier the garment is to don and provides more comfort for the wearer.

The spandex thread, shown in red, requires considerable more force depicted by the steep vertical rise, than standard NRL and specifically Vytex. Vytex, in green, exhibited a lower modulus and greater elongation before break over both spandex and standard NRL. These physical attributes, coupled with the significant reduction in proteins, makes Vytex the next generation of thread material.



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## Conclusions



### Vytex® NRL Multi-patented Process

- Physically removes non-rubbers from liquid latex
- Differentiated within industry standards (D1076 Category 5)

### Products Made with Vytex® NRL

- Availability of existing FDA 510(k)s
- Cleaner and whiter
- Exhibit significantly less odor
- Offer truer colors with fewer color additives
- Can reduce manufacturing processes/steps
- Minimize the environmental impact – potential for reduced water and energy consumption
- Now available through KAPVL – SAARC region





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"Eco-friendly Manufacture of High  
Performance Latex Products using  
Ultralow Antigenic Protein Latex including  
'No Ammonia' Latex"

**Joseph John, KA Pre vulcanised Latex Pvt. Ltd.**



## KAPVL Developmental Work

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Ammonia Preserved CL 60 has been the Industry Standard for Years

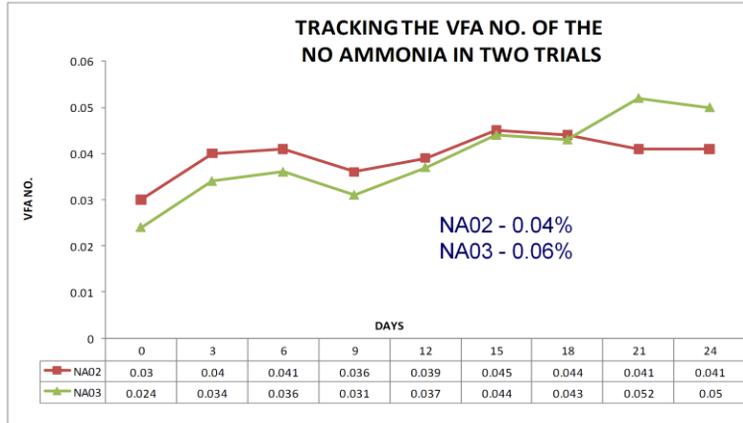
- Only significant change: low ammonia levels reduced from 0.70% to 0.35%
- TMTD is retained as preservative and therefore CL60 is not Nitrosamine-free

Now

- There is growing demand for improved latices:
  - Low VOCs for use in **enclosed factory** spaces
  - Specialty **end use** applications such as body paints, adhesives, etc
  - Without ammonia or TMTD used at any stage of preservation



## Introducing No Ammonia Latex



## Properties of No Ammonia Latex (NAFL0612)

Properties		NA02	NA03
Total Alkalinity as Ammonia	%	0.14	0.14
VFA No:		0.04	0.05
pH		10.13	9.52
Coagulum Content	%	0.0004	0.0005
Micro Coagulum Content	%	0.0006	0.0003
Mg	%	0.014	0.014

## Preservative

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The preservative is a proprietary preparation of:

**KA PREVULCANISED LATEX PVT. LTD, NAGERCOIL**

Source	Code No.	Form	Recommended Dosage
<b>Field Latex</b>	NAFL0612	Liquid	4 kg per 100 kg field latex
<b>CL60</b>	NACL0312	Liquid	1.10 kg per 100 kg CL 60



## Colloidal Properties (Location 1)

	Test Parameters	Ammonia-Free & Nitrosamines-Free Concentrate				Spec @ 21 Days Age
		1 Week (Fresh)	After Heat Maturation 50° C @ 4 Days	After 21 Days @ Room Temp	After 3 Months Storage @ Room Temp	
1	Total Solids Contents (%)	60.19	60.17	60.47	60.77	
2	Dry Rubber Content (%)	58.93	NT*	NT	NT	60.0 Min
3	Non Rubber Content (%)	1.09	NT	NT	NT	2.0 Max
4	Volatile Fatty Acids No	0.013	0.012	0.006	0.008	0.03 Max
5	KOH No	0.487	0.501	0.499	0.502	0.65 Max
6	Viscosity, F/Cup #3 (sec)	30.34	33.9	28.97	29.95	N/A
7	Brookfield Viscosity LVT (2/60) , Cps	78.5	114.5	75.5	81	N/A
8	Mechanical Stability Time (sec)	>3600	3240	>3600	>3600	750-1500
9	Coagulum ( 80/325 mesh), ppm	16/49	27/84	41/99	41/99	100/250 max
10	pH	9.95	9.93	10	9.73	N/A
11	Free Magnesium ( %)	NIL	NT	NT	NT	TRACE
*NT – Not Retested						

## Colloidal Properties (Location 2)

Properties	1 <sup>st</sup> Day	10 <sup>th</sup> Day
DRC (%)	59.09	59.09
TSC (%)	61.46	61.46
Total Alkalinity as Ammonia (%)	0.14	0.16
pH	10.57	10.72
VFA No.	0.035	0.028
KOH No.	0.48	0.46
MST (sec)	140	716
Coagulum Content (%)	0.001	0.0005
Micro Coagulum Content (%)	0.0015	0.0008
Mg (%)	0.0058	0.0039
FC#3 @ Actual TSC, 27°C	30.65	30.79
BF (cps), @ 60% TSC, 23°C	60.5	52.5
ZOV <sub>5</sub> min (%)	4.13	-9.52
ZOV <sub>60</sub> min (%)	4.96	-9.52
ZST (sec)	117	328
ZHST (sec)	1162	1196

## Further Developments Under Large Scale Evaluation

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- Vytex® No Ammonia
- Vytex® No Ammonia Pre vulcanised
- No Ammonia Pre vulcanised Latex



Go Green



**Thank You**

