Balancing Material Acquisition and Production Costs: Quantifying the True Cost of Aluminum Hydroxide Treated Natural Rubber Latex (NRL)

William R. Doyle (Speaker)[a], Matthew Clark[a], Ranjit K. Matthan, Ph.D. [b]

[a]Vystar® Corporation, 3235 Satellite Boulevard, Building 400, Suite 290, Duluth, GA 30096 USA
[b]KA Prevulcanised Latex P Ltd, Parvathipuram, Nagercoil 629 003, Tamil Nadu, India

William R. Doyle, Chairman of the Board, President and Chief Executive Officer

William Doyle was originally part of the Vystar Team as Senior Vice President of Sales and Marketing. His role expanded in November 2005 as he became company President and a member of the Board of Directors. Mr. Doyle assumed the role of Chairman of the Board and CEO in April 2008 when Travis Honeycutt retired.

Prior to joining Vystar, Mr. Doyle was Vice President of Marketing, Women's Health for Matria Healthcare, Inc. (now Alere) where he spearheaded the initial branding efforts and held responsibility for sales development, training, public relations, and marketing. He has worked in many aspects of healthcare for over twenty-five years encompassing manufacturing, sales, marketing, and advertising with such companies as Isolyser Company, Inc., McGaw, Inc., Lederle Laboratories (now Wyeth), and in an advertising capacity for Novartis Ophthalmics.

He has co-authored and presented numerous papers for Vystar globally since its inception, including the Japan Rubber Association and has served as section chair at latex conferences previously.

Mr. Doyle is a member of the Board of Directors of the Georgia Chapter of the March of Dimes where he is a past Chairman of the Prematurity Campaign. He holds a Bachelor of Science in Biochemistry from Penn State University and Master of Business Administration from Pepperdine University's Graziadio School of Business and Management.

Abstract

The true cost of manufacturing is measured as the sum of the total costs throughout the production cycle. Sometimes more can be less. Water and energy stress caused by the growing global population is expected to reach historic proportions, driving supply down and costs up, and directly affecting business operations according to a recent United Nations report.

Vytex® Natural Rubber Latex (NRL) addresses both of these burgeoning global environmental and manufacturing concerns. With its green beginnings, Vytex NRL is biodegradable and renewable unlike the petroleum-based synthetics in use today that can challenge acquisition, use, and disposal operations. Vystar® Corporation has developed a multi-patented technology using green chemistry to remove proteins and other non-rubber impurities from natural rubber latex, creating Vytex NRL (modified NRL). With its significantly reduced antigenic protein content, upgrading to modified NRL can eliminate the need for added processing steps to lower protein levels, saving energy, water, supply, and material handling costs while enhancing quality of the end product.

Introduction

The complex mechanical properties of natural rubber latex (NRL) allow its use in a broad range of applications. The availability, ease of production and performance of latex products make NRL a preferred raw material by product manufacturers and users around the globe. Its proven "green biodegradable behavior" makes it the material of choice in an increasingly environmentally conscious society. Manufacturers have utilized low-protein latices combined with improved leaching processes in an attempt to offer consumers safer latex products. The goal and mission of Vystar Corporation is to supplement these efforts through the offering of a new natural rubber latex source material branded Vytex NRL. This not only contains significantly fewer allergenic and total proteins but also has additional benefits that allow manufacturers to offer better NRL products with "Made with Vytex" as a cost-effective ingredient. Each end product discussed in this paper has its own unique compounding additive requirements as determined by the respective manufacturer. The benefits in removing specific non-rubber molecules leads to more stable, cleaner latex and can require less compounding additives for production.

Unlike most synthetic alternatives, aluminum hydroxide-treated NRL uses green chemistry to modify NRL. The modified NRL derived from rubber tree, *Hevea brasiliensis,* remains 100% natural. Bacteria and fungi are capable of degrading natural rubber latex.[1] An elegant experiment demonstrated that latex balloons degrade equally, if not faster than, oak leaves.[2] In contrast, many synthetic alternatives, such as PVC vinyl, styrene, nitrile, choloroprene and polyurethane, made from petro chemical derivatives, are neither biodegradable nor compostable. Incineration of these synthetic products can lead to the liberation of toxins and carcinogens, such as dioxin, cyanide, vinyl chlorides, and hydrogen chloride.[3] Unlike the synthetic alternatives the aluminum hydroxide-treated NRL has minimal impact on the environment.

The new revolutionary modified *Hevea brasiliensis* natural rubber latex is a standardized source material and is a multi-patent-protected process developed by Vystar Corporation for the production of natural rubber products. The treatment process removes specific non-rubber impurities from natural rubber latex (NRL) through directed application of aluminum hydroxide ($Al(OH)_3$). Aluminum hydroxide (Figure 1),[4] a commonly used absorbent, emulsifier, ion-exchanger, and antacid,[5] is used in the process of water purification. It forms a jelly-like structure suspending any unwanted materials in water, including bacteria.[6]

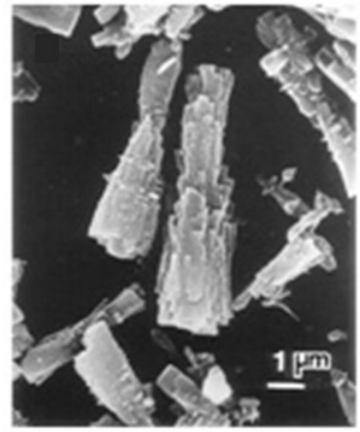
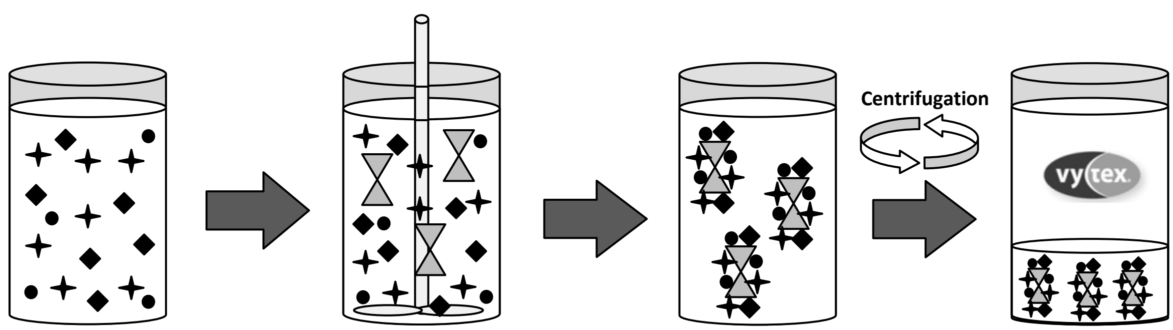


Figure 1: Scanning electron micrograph of an aluminum hydroxide crystal generated in water.[4]

Using traditional processing methods, a slurry of aluminum hydroxide is strategically added to the field latex (see Figure 2). Effective exchange/complexing of protein and other non-rubber impurities from the field latex emulsion to/with insoluble $Al(OH)_3$[7] occurs, with some of these non-rubber impurities adsorbed to the reactive surface of the aluminum hydroxide crystals.

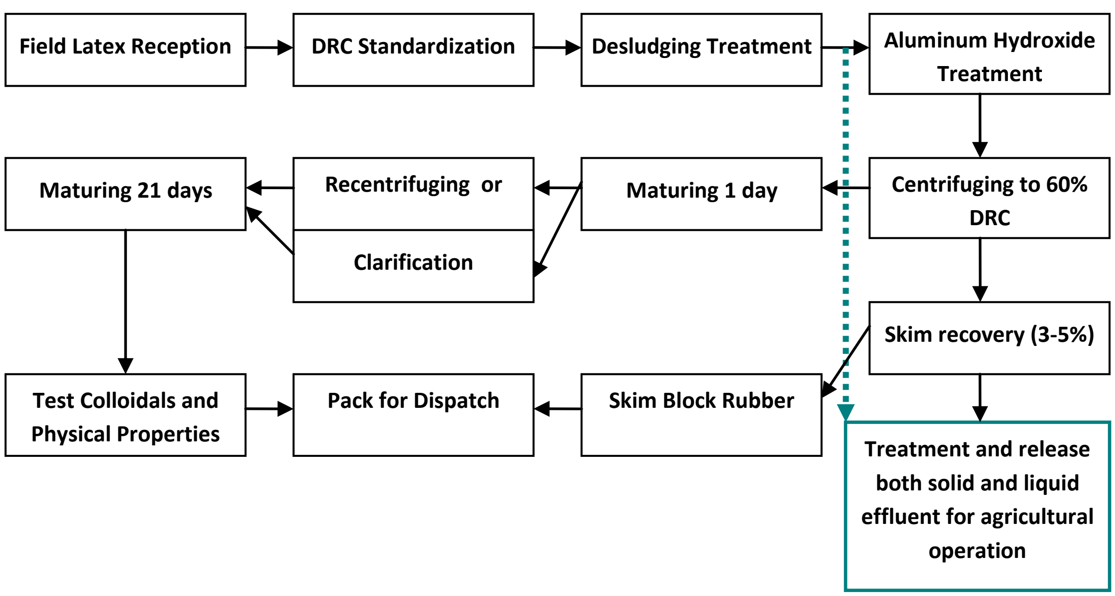
Figure 2: Schematic for Manufacture of Vytex NRL



With processing steps integrated into the manufacturing stages, there is no expense of capital equipment required. Reacted $Al(OH)_3$ complexes are removed by a combination of filtration and centrifugation. The remaining rubber particles retain the surrounding lipid layer, which during subsequent maturation improves the mechanical stability of the latex as the higher fatty acids (HFA) are formed. Notably, it has been observed that this process yields products exhibiting greater clarity and significantly reduced odor, in addition to low antigenic protein without sacrificing the properties that give NRL its enormous advantages over synthetic alternatives. Earlier industry efforts have produced low antigenic source latex through the treatment of raw latex with enzymes.[8] The products made with the aluminum hydroxide-treated source material will demonstrate parity compared to products made with non-treated NRL source materials exhibiting “drop in” characteristics. Results from field evaluations suggest that this new latex source material offers some improved performance characteristics believed to be due to the non-rubber impurity removal process. These benefits include color, stability, gel time, and air retention, which will be discussed in detail in this paper. The modified NRL is produced at latex processors in Southeast Asia, and is available as a standardized, consistent source material.

In the schematic for manufacture of the modified NRL (see Figure 3) the complete cycle of production and waste recovery and re-use highlights the ecologically friendly nature of the whole production process.

Figure 3: The Vytex Production and Recovery Cycle



Consistently, results from a glove manufacturer’s incoming quality control evaluation reveals that the extractable protein levels are significantly less with the aluminum hydroxide treatment (Table 1).

Table 1: Results of the Modified NRL (incoming control evaluation)

Modified NRL Protein (µg/ g)	Control NRL Protein (µg/ g)	% Change
44.81	441.65	91
47.97	436.58	89

Product Creation for a New Generation

There are over 40,000 types of products made from natural rubber latex; the most prominent are dipped goods encompassing nearly 50% of latex production (gloves, condoms, balloons, breather bags, tubing).[9] Other products made from latex include foam products (mattresses, pillows, and cushions), adhesives (pressure sensitive applications, footwear, and carpet backing), and elastic thread. The modified NRL promises to transform the various industries relying on natural rubber latices. The reduction in certain non-rubber constituents in the source material lends to the characteristic of being more stable and therefore having a longer shelf life compared to the standard natural rubber latex. Customer observations highlight the clean appearance and lack of odor in the expansive list of products made from the modified NRL.

Foam

Natural rubber latex foam is gaining increasing re-acceptance by consumers and retailers as a premium bedding component as well as recognition as a green recyclable material from a sustainable renewable natural resource. Due to the emphasis on the soundness of sleep and the increased education of consumers, one-sided, no-flip mattresses are becoming the industry standard. Latex's luxurious feel and controlled resilience separate it from synthetic foam source materials. However, being a natural product, there can be some variability with NRL properties and hence many manufacturers often do blend SBR and NRL for greater process uniformity. With consideration of product impact on the environment, there is an ongoing global effort to increase the blend to a higher percentage of NRL vs. SBR and meet the requirements of the EU Ecolabel. Manufacturers must consider the product life cycle and use sustainable materials, as well as limit the use of eco-toxic compounds and residues, while promoting a more durable product. The modified NRL being a stable sustainable raw material meets environmental initiatives and other regulatory requirements.

The foam manufacturing process requires compounded latex to undergo beating and whisking to generate foam with uniform air cell sizes. Therefore, the ability to withstand shear is a desirable property. The modified NRL is capable of withstanding mechanical shear as it is more stable than the standard NRL (see Table 2). The finished product has a cleaner appearance with a significant reduction of odor when compared to foam made from standard NRL. Treatment of field latex with $Al(OH)_3$ traps and removes proteins and other non-rubbers, reducing odor contributing bacteria[5] and the subsequent need of re-odorants.

Table 2: Colloidal Properties of Modified NRL - High and Low Ammonia

Property	Specifications (HA)	Typical Modified NRL (HA)	Specifications (LA)	Typical Modified NRL (LA)	ISO Standard No.
Viscosity cps (sp 2/60)	20-100	81	20-100	92	1652
TSC (%)	60.0-61.5	60.88	60.0-61.5	60.34	124
Alkalinity (%)	0.65-0.8	0.71	0.20-0.29	0.24	125
VFA no.	0.7 max.	0.018	0.07 max.	0.019	506
Mechanical Stability	650 seconds min.	1860	650 seconds min.	1870	35
Coagulum (mesh# 80) ppm	100 max.	23	100 max.	19	706
pH	10.5-11.5	10.87	9.5-10.5	9.89	976

The modified NRL foam with greater stability, cleaner appearance and significantly reduced odor meets the performance standards of standard NRL foam (see Table 3).

Table 3: Modified NRL Foam Physical Properties

Test	Details	Results		
Apparent Density		91.1 kg/m^{3*}		
Compressive Strength	50 mm/min 0.01N threshold	**Strain** 10% 25% 50%	**Stress (psi)** 0.12 ± 0.02 0.21 ± 0.04 0.50 ± 0.06	**Stress (kPa)** 0.8 ± 0.2 1.7 ± 0.3 3.4 ± 0.4
Indentation Force Deflection	Reduced size indentor (50.8 mm diameter)	**Mean Values ± Range (lb units)**		
		IFD-25% IFD-65% Support Factor	33 ± 2 99 ± 4 3.0	

*** Range from 85-175Kg/m^3**

NRL use is predicted to increase substantially due to the green nature as a natural product and a growing global movement. Manufacturers have been switching to natural rubber latex to produce foam and modified NRL is a good alternative material to switch to due to its stable nature, with the added cost benefit of reducing the amount of compounding additives, such as whitening agents and fragrances.

Adhesives

In 1845, the first rubber-based adhesive patent, US patent (number 3,965),[10] was issued to Henry Day.[11] NRL was the first polymer to be used to produce pressure sensitive adhesives (PSA). Interestingly, NRL is the only material that sticks to itself, making it ideal for cold seal adhesives. NRL has several key physical properties that are advantageous when used in pressure sensitive and contact adhesive formulations. Its low glass transition temperature (Tg), -70°C (vs. polychloroprene at -40°C) and low surface energy, enable NRL to effectively flow over surfaces. NRL can lose its tack and adhesion properties over time due to oxidative degradation and embrittlement that can be overcome with the use of antioxidants. Additionally, the proteins in NRL have the ability to cause an allergic reaction manifested as sensitized skin. Sensitization can be resolved with the use of a modified NRL[12] with no detectable carryover of proteins into the end product.

Using an industry-standard, air-assisted spray gun (Graco) with an air inlet pressure of 40 psi and spray orifice of 0.07-0.086, a comparison study between a standard low ammonia latex and the modified NRL (LA and HA) was performed to assess the overall spray ability. The latex spraying process gave no clogging of the spray head and the viscosity and stability were found to be acceptable. The tack of the latex samples was examined, using the rolling ball method and were found to be comparable (Figure 4). Notably, the modified NRL has greater reproducibility, error bars, than the control as it is a standardized source material. All films dried clear without any observable inclusions or irregularities.

Figure 4: Tack Analysis, Roller Ball Method

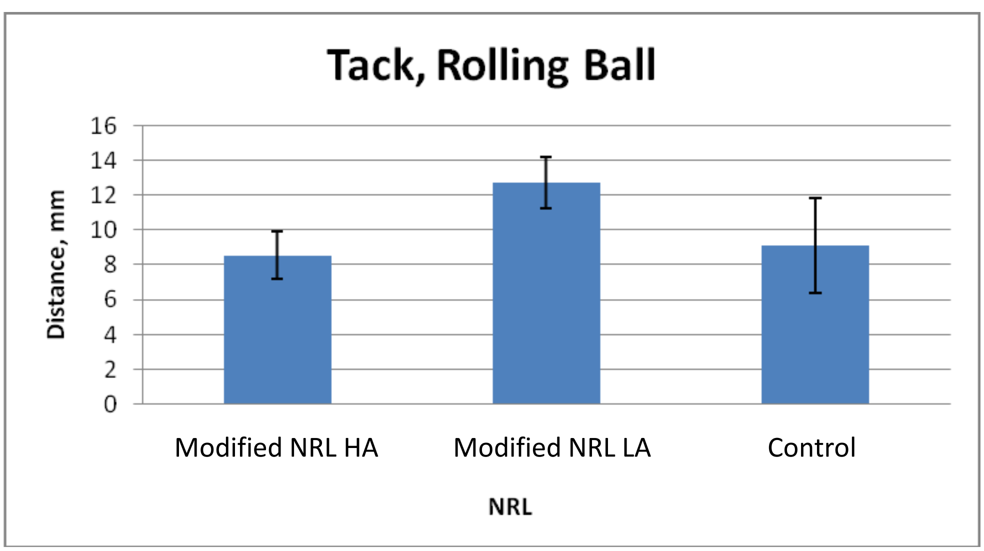


Table 4 illustrates that the removal of the non-rubber impurities does not affect the physical properties. The modified NRL and standard natural rubber latex were subjected to high shear stress. Specifically, the individual latices were placed in a high speed blender and evaluated for stability properties.

Table 4: Waring Blender Stability Test

	Waring Blender Stability Test (min)	
NRL	**Before spray**	**After spray**
C/LA	**5:49 gel**	**4:44 gel**
V/LA	**10:00 stable**	**10:00 stable**
V/HA	**10:00 stable**	**10:00 stable**

Significantly the modified NRL having ultra low protein content has exceptional high shear stability compared to standard natural rubber latex. Furthermore, gel times can be customized (through additives) to suit the particular application needs. Manufacturers have been pleased with the processing characteristics of the modified NRL in both spray and roll coating applications.

Many cohesive medical bandages use natural rubber latex as an adhesive, however if the standard latex is not modified, it can pose a potential risk of provoking a sensitive skin reaction. Table 5 demonstrates that bandages produced with modified NRL formulated adhesive have a 20-fold lower protein content than bandages made with adhesive containing standard NRL.

Cohesive Bandage

Table 5: Modified Lowry Protein Result μg/g

Modified NRL	NRL	% Reduction
50 μg/g	1000 μg/g	95

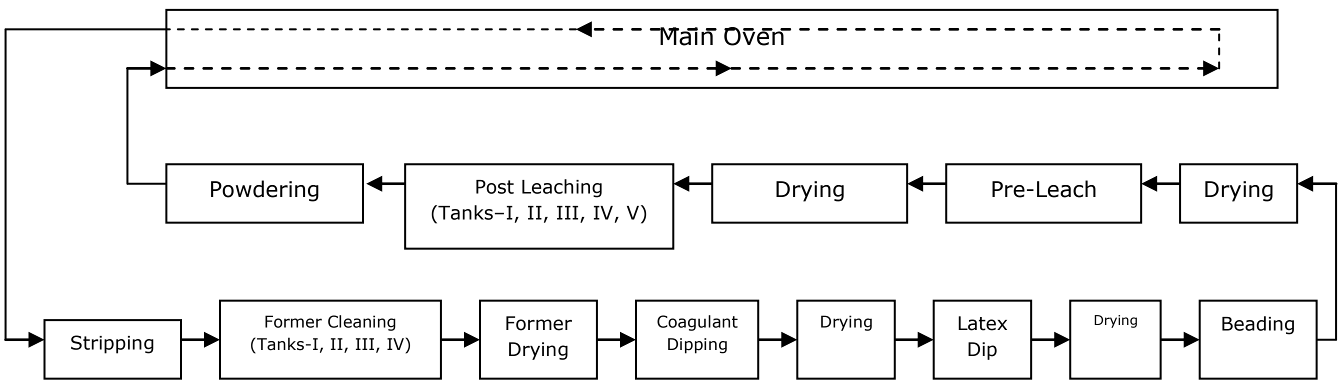
The modified NRL stands above the standard NRL demonstrating greater stability, while maintaining all the positive performance characteristics. A combination of greatly reduced protein, improved processing, and effective adhesion makes the modified NRL the next generation natural rubber latex adhesive.

Dipped goods

Water is not only important to human survival but also important to many sectors of the economy. The future of any society, people and business, depends on the preservation of water resources as part of the sustainable development process.[13] Companies need to think about how much water they are using and consuming in their processes.

Within the dipped goods industry increased efficiency has been demonstrated by reducing processes, such as excessive washing and leaching. This can significantly reduce the manufacturers' water and energy consumption, and by simultaneously reducing harmful leachates (e.g., zinc). The overall environmental impact is minimized resulting in an increase of production cost savings. The flow chart for a typical modern glove line is seen in Figure 5.

Figure 5: Flow Chart for Glove Production



Notes

- Latex TSC. Range ~ 32%
- Coagulant => $CaCl_2 + Ca(NO_3)_2$ [~ 20%]
- Total No. Of Pre-Leach – 4 ; [Pre leach ranges 55 – 60 ^{o}C cooling down to 40 – 40 ^{o}C]
- Total No. Of Post Leach – 5 [Post Leach (I) ranges 55 – 60 ^{o}C and rising to 70 – 75 ^{o}C]

Line Sequence: Former Cleaning (Tanks-I, II, III, IV), Former Drying, Coagulant Dipping, Stripping, Drying, Latex Dip, Drying, Beading, Pre-Leach Tanks-I, II, III, IV, Drying, Post Leaching Tanks – I, II, III, IV, V, Powdering, Main Oven vulcanization, Stripping.

The modified NRL is slightly more expensive than traditional NRL, is priced comparable to, and in many cases less expensive than nitrile, chloroprene and other synthetic alternative materials, and provides significant cost value when compared to other synthetic latices. The increased price for the modified NRL can be offset by reducing the number of manufacturing steps required to achieve acceptable protein levels as demonstrated in Figure 6 and Figure 7.

Figure 6: Protein Results for Modified Lowry Test in Surgical Gloves (Glove Production Line)

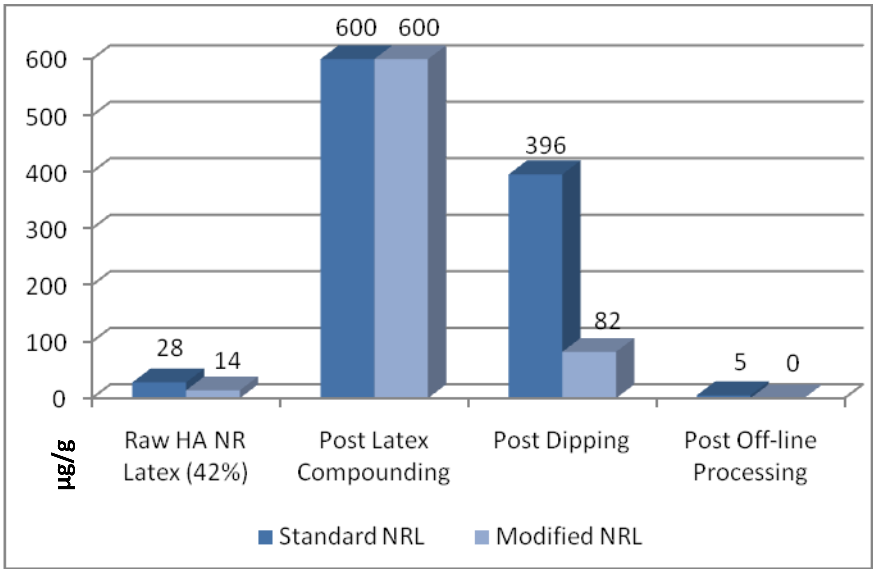
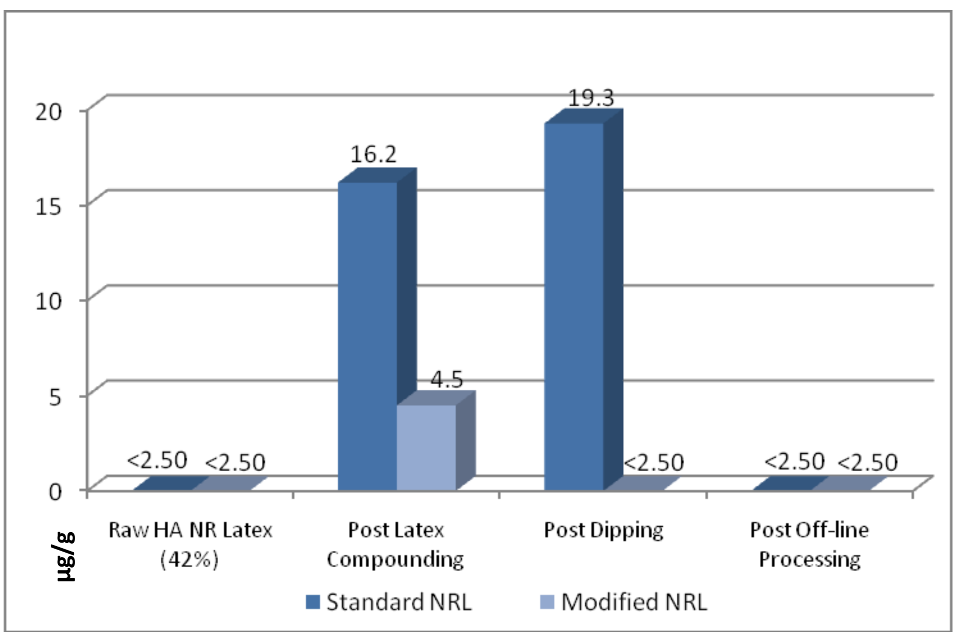


Figure 7: Protein Results for the ELISA Test in Surgical Gloves (Glove Production Line)



The production conditions for each trial were unique to the particular manufacturer. Variables included the compounding ingredients, leach time, water and vulcanization temperatures. Each of these variables can influence the finished glove protein values.

Both examination and surgical gloves made with modified NRL in all manufacturer trials contained significantly fewer proteins than *Hevea* control gloves. This indicates that glove manufacturers using the modified NRL as their raw feedstock can be within ASTM glove protein compliance with only pre-leaching. Hence, these glove manufacturers will offer gloves with acceptable protein levels and potentially reduce their production costs.

Table 6: Water and Energy Reduction

SL #	Particulars	Standard NRL Per Day	Modified NRL Per Day	Difference Per Day	Cost Per Unit $	TOTAL COST	
						Per Day $	Per Year $
1	Water Consumption (Kilolitres)	36KL	14.4KL	21.6KL/DAY	16.7/KL	360	108,000
2	Energy Consumption (Kcals/Kwh)	684,000 KCAL	288,000 KCAL	396,000 KCAL	0.12/KWH R	1,215	364,500
					TOTAL SAVINGS	**1,575**	**472,500**

1KW=861KCAL/HOUR THEREFORE 396,000KCALS/HR/861= 459.9KWH=~460KWH
460X24HRSX$0.11=1214.4=~1215/DAY
1215/DAYX300= 364,500

Therefore at a production rate of 110,000 pairs per day and using the data in Table 6, the cost saving per pair is $0.0143 with the benefits accruing:

(1) a significant reduction in the utilization of water;
(2) a significant reduction in energy cost;
(3) the Zn levels in the total discharges are reduced.

However, depending upon the particular plant line configurations, processing methodologies and the local costs of water and energy, the cost savings will differ accordingly.

Pigmenting

Raw, natural latex is a liquid. When dried and cured, the film dries semi-transparent yellow (Figure 8). Whitening agents, such as titanium dioxide or calcium carbonate, are added to the latex to express whiteness in the finished product or to provide a white background for which color pigments can be used. Significantly, the use of titanium dioxide can be expensive. Because the modified NRL is

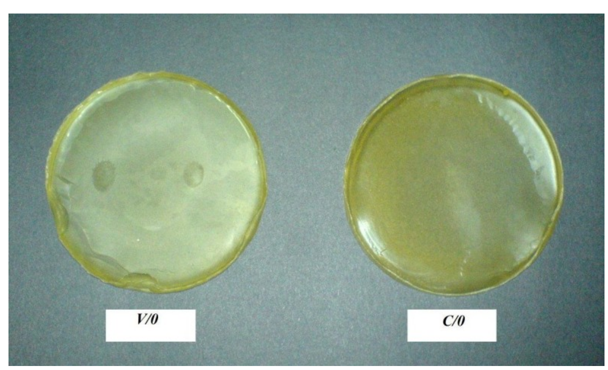


Figure 8. Uncompounded NRL films, V-Modified NRL, C-control standard NRL

characteristically white in appearance (See left film in Figure 8) this is an advantage by reducing the amount and cost of the base whitening agents. Interestingly, the standard NRL film contains a yellowish oily film on the surface. However, this yellowish oily film is absent on the modified NRL film.

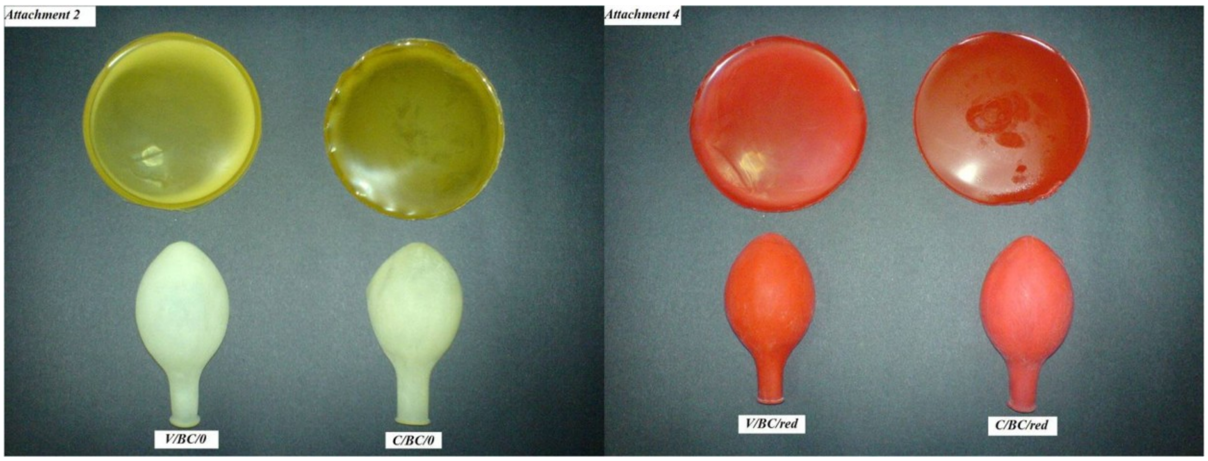
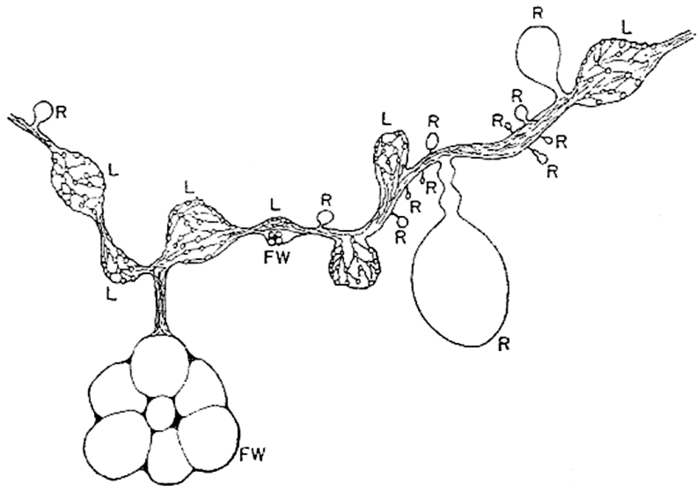


Figure 9. Balloon Compounded Latices **V = Modified NRL C = Standard NRL**

The toy balloon industry, a dipped goods process, highlights the case for pigmenting. Latex balloons come in a multitude of colors. A comparison of modified NRL and standard NRL in balloons, where TSC was adjusted to 55%, and coagulation strength reported at 16%, pigmentation is seen in Figure 9. Balloons were leached for 15 min at 50°C, dried for 45 min at 70°C, followed by release agent. Viscosity was assessed on the black pigmented latices. Modified NRL demonstrated a viscosity of 68.5 cps and standard NRL exhibited 62.0 cps. In Figure 8, the uncompounded modified NRL produced a cleaner film sheet compared to standard NRL. Following industry standards for balloon compounding, the unpigmented modified NRL film sheet is more transparent and less yellowish than the standard NRL (Figure 9).

Moreover, when modified NRL is used to produce a balloon the balloon is whiter and therefore cleaner in appearance than the balloon produced from the standard NRL. Notably when pigments are introduced, an oily yellowish tone was commonly observed on the blue, red or yellow film sheets made from the standard NRL. In contrast, this oily tone was absent on the pigmented modified NRL film sheet (Figure 9). No significant differences between the modified NRL and standard NRL were detected of black pigmented films. Taken together, when the modified NRL is compared to the standard NRL, modified NRL is noticeably more white, suggesting that compounding modified NRL for applications, such as toy balloons, tubing and breather bags, has reduced requirement for whiteners, such as titanium dioxide or calcium carbonate. Additionally, the modified NRL most likely will require less pigment to achieve the same color tone and intensity as the standard NRL.

Figure 10: Latex Vessel Depiction: Rubber Particles (R), Lutoids (L), and Frey-Wyssling (FW) Particles[14]



The cleaner appearance of the modified NRL is probably due to the removal of molecules, such as lutoid and Frey-Wyssling particles (Figure 10), which are present in freshly tapped latex.[15, 16] The yellow appearance of latex is due to the presence of carotenoid pigments from the Frey-Wyssling particles. The frequency of Frey-Wyssling particle occurrence can vary between clones. There have been studies employing the use of aluminum hydroxide gels to characterize carotenoids.[17] The efficient separation of carotenoids from saponified plant extracts on aluminum hydroxide loaded cellulose papers has been reported.[18] These provide evidence that carotenoid pigments can be adsorbed to the surface of aluminum hydroxide, and thus support the contention that the carotenoids associated with both lutoid and Frey-Wyssling particles are removed with the aluminum hydroxide.

In addition to assessing the pigmentation on the modified NRL balloon, gas retention was also studied. Using either helium gas or normal air balloons made of either modified NRL or the standard NRL, balloons were inflated to a specified circumference with gas. The circumferences were measured at intervals of 6 hours. The modified NRL demonstrated about a 50% greater retention of helium as compared to the standard NRL. Additionally, modified NRL maintained air retention at 60.6% on the fifth day as compared to standard NRL which completely deflated on the second day. The authors believe that the removal of the non-rubbers may lead to the tighter rubber particle integration, preventing the ‘wicking’ loss of gas from within the balloons. It should be noted that the modified NRL balloons weighed 13.9% heavier than the control standard NRL balloons (Table 7).

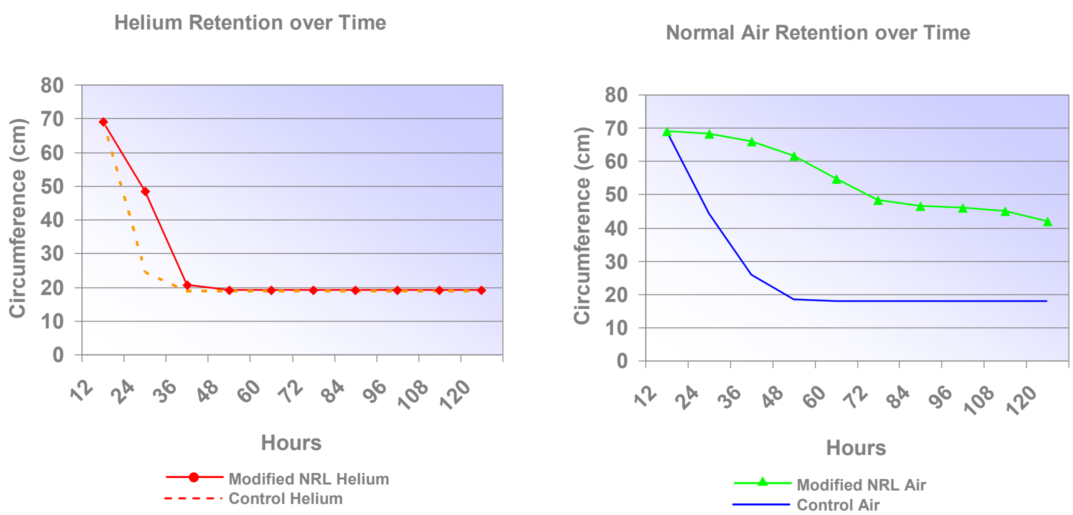
Table 7: Gas Retention of Modified NRL vs Standard NRL

Days	Hours	Circumference Measurement of Balloons at Intervals (cm)							
		Helium Retention				Normal Air Retention			
		V/Black	*V/Black*	C/Black	C/Black	*V/Black*	*V/Black*	C/Black	C/Black
1	**12**	***69.0***	***69.0***	69.0	69.0	***69.0***	***69.0***	69.0	69.0
	24	***47.8***	***48.9***	20.8	27.5	***68.0***	***68.4***	45.5	42.7
2	**36**	***21.0***	***20.2***	18.7	18.5	***66.7***	***65.3***	28.7	22.9
	48	***19.5***	***18.9***	18.6	18.5	***62.4***	***60.7***	18.3	18.4
3	**60**	***19.2***	***18.9***	18.6	18.5	***57.0***	***52.6***	18.0	17.8
	72	***19.2***	***18.9***	18.6	18.5	***48.9***	***47.6***	18.0	17.8
4	**84**	***19.2***	***18.9***	18.6	18.4	***47.1***	***45.8***	18.0	17.8
	96	***19.2***	***18.9***	18.6	18.4	***46.9***	***44.9***	18.0	17.8
5	**108**	***19.2***	***18.9***	18.6	18.4	***45.6***	***44.4***	18.0	17.8
	120	***19.2***	***18.9***	18.6	18.4	***43.8***	***39.8***	18.0	17.8

V = Modified NRL   C = Standard NRL

The helium molecules being lighter and smaller are able to permeate out faster than normal air molecules of nitrogen and oxygen.

Figure 11: Air Retention for Helium and Air



Pick up from the dipping process of modified and standard NRL was assessed on the weight of the balloons made from each. Thickness was done using standard thickness gauge (Wallace, S4/14 00005), and the weight was determined using an analytical balance (ACU High precision balance, HJ-6004). Modified NRL balloons were 13.9% heavier than standard NRL. This suggests that the dipping times can be reduced to achieve the same weight parameters.

Table 8: Thickness of Modified NRL vs Standard NRL

Balloon Sample	**Weight (g)**	
	Reading	**Average**
V/Yellow 1	***2.83***	***2.823***
V/Yellow 2	***2.76***	
V/Yellow 3	***2.88***	
C/Yellow 1	2.48	2.477
C/Yellow 2	2.54	
C/Yellow 3	2.41	

V = Modified NRL   C = Standard NRL

Additionally, the gel time of balloon compounds was assessed for both modified NRL and standard NRL. Modified NRL compound demonstrated, on average, a gel time 7 seconds quicker than standard NRL. A reduced gel time can translate into a reduction of drying temperature and time.

Table 9: Gel Time of Modified NRL vs Standard NRL

Balloon PV Compound Sample Made From	**Gelling Time Reading (sec)**			
	1	**2**	**3**	**Average**
Modified NRL	***24.36***	***23.97***	***22.88***	***23.74***
Standard NRL	31.65	30.86	30.17	30.89

Collectively, these results suggest that manufacturers can achieve savings in energy and material costs when using the modified NRL. Further, decreased pigmenting is an added cost benefit for such dipped good industries as breather bags and rubber tubings.

Table 10: Potential Impact of using Modified NRL on Manufacturer Cost Structure

	Gloves	Adhesives	Foam	Balloons
Raw Material				
▪ NRL/Synthetic	↔	↔	↔	↔
▪ Vytex NRL	↑	↑	↑	↑
Additives				
▪ Compounding Chemicals	↓		↓	↓
▪ Pigmenting Chemicals				↓
▪ Other Raw Materials (Acrylics etc.)		↔		
Production				
▪ Dipping	↔			↓
▪ Foaming/Blowing			↔	
▪ Spraying		↓		
Production: Finishing Steps				
▪ Rinsing/leaching	↔		↔	↔
▪ Drying	↔		↔	↔
▪ Rinsing/leaching	↓		↓	↓
▪ Drying				
▪ Rinsing/leaching	↓		↓	↓
▪ Drying				
Packaging	↔	↔	↔	↔

↔ No impact on cost of this step as a result of using modified NRL
↑ Modified NRL cost is higher than alternative ingredient
↓ Use of modified NRL reduces cost of this step

Conclusions

Manufacturers continue to see more value in modified natural rubber latex allowing them to increase production efficiency and also improve their brand by including "Made with Vytex NRL" as a cost effective ingredient. Recognizing the need and importance of natural products that minimize the environmental impact while maximizing economic, health and safety benefits are critical to the sustainability of the latex industry. Vystar has addressed this need by commercializing a revolutionary process by modifying natural rubber latex while enhancing the attributes and performance made from this modified latex. The process using aluminum hydroxide eliminates a significant portion of proteins and other non-rubber composition in latex. This allows manufacturers to offer notably enhanced pigmented products, as demonstrated in the balloon comparisons. Additional benefits include superior gas and air retention, heavier pick up during the dipping process, and a reduced gel time translating into a reduction of drying time and temperature.

Foam made with modified latex contains significantly less odor and is much whiter in appearance compared to foam made from standard latex. The increased stability of modified latex allows foam manufacturers the ability to increase their blend of a natural product, addressing a growing global initiative. Stable, modified latex performed well in spraying applications for adhesives without compromising tack properties. Dipped goods manufacturers, users of large amounts of water and energy required to achieve acceptable protein levels, benefit from using modified latex since low protein status is achieved during the latex modification process. Additionally, the modified latex compound can require less additives such as stabilizers and whitening agents, also contributed to the latex modification process.

Modified latex is a logical upgrade for manufacturers currently using standard latex across a broad scope of industries. The overall performance benefits and attributes of using modified latex offer a unique value proposition to manufacturers allowing them to capitalize on the “green” movement while addressing health and safety concerns. Production cost saving opportunities using modified latex makes this the obvious material of choice for future generations. Balancing material acquisition and production costs manufacturers quantify the true cost of aluminum hydroxide treated natural rubber latex.

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