Further Development of Vytex® Natural Rubber Latex Leads to Strong Niche Market Advances

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Biographical Note

Travis Honeycutt is the founder of Vystar Corporation and the inventor of Vytex Natural Rubber Latex (NRL). Mr. Honeycutt has founded a number of different companies, including Vystar, Isolyser, Climax Global Energy, and Safeharborseafood.com. Each of these companies include a product or process that he has patented. Mr. Honeycutt has a Bachelor of Science from North Carolina State University, a Masters Degree in Material Science and Engineering from the Georgia Institute of Technology, and an Honorary Doctorate in Physics for his work in microwave plasma physics from International Solomon University in Kiev.

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Abstract

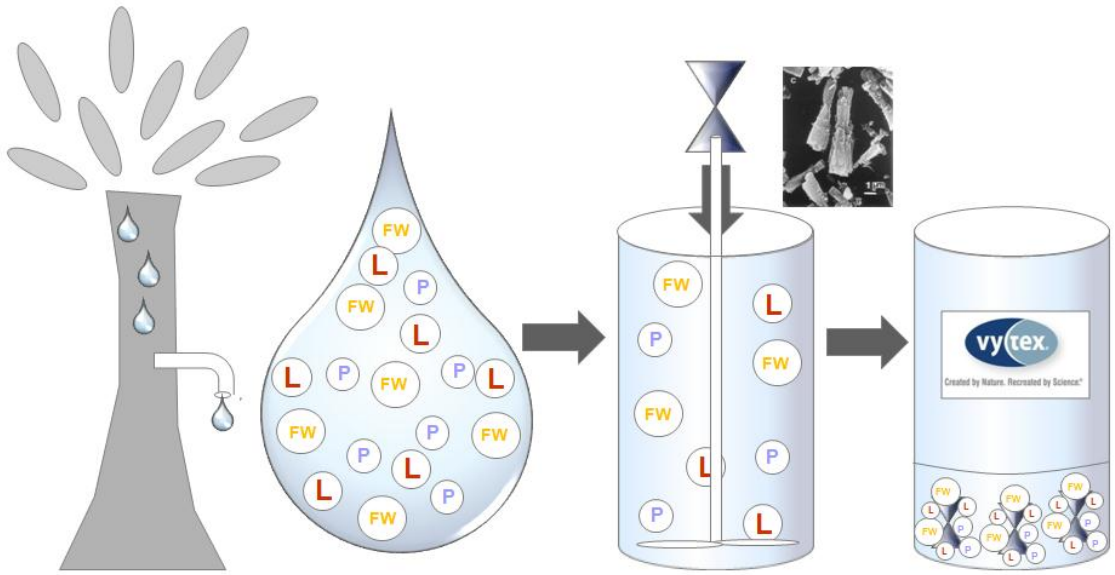
A major responsibility of manufacturing and/or marketing personnel is finding innovative techniques to differentiate their products vs. competition while driving down costs. Aluminum hydroxide-treated NRL, branded as Vytex NRL, was created to lessen the protein load in natural rubber latex for medical products, but has shown unique competitive advantages due to its versatility as a raw material regardless of end product application. The result of that extensive research led to, not only a nearly total protein reduction, but an overall 75% drop in non-rubber content, as noted by a recent ASTM categorization, which can now be targeted to all product manufacturers using NRL as a raw material. The aluminum hydroxide-treated NRL's multiple-patented process has shown an affinity for allowing a lower cost of production in various global industries and exhibits distinct improvements in product characteristics when compared to its untreated sibling, traditional natural rubber latex. While certain mainstream producers have already gravitated to the aluminum hydroxide-treated NRL, recently niche product producers have shown a keen interest in specific pre-compounded, further enhanced, specialty versions of aluminum hydroxide-treated NRL. This paper is designed to highlight the strong positive effects that such advances can have on future economic growth, the environment as we learn to use less toxic chemicals, and preservation of natural resources currently used to "clean" NRL.

Introduction

When Vytex NRL was originally invented, it was thought that the most compelling benefit to reducing latex protein in the *Hevea* latex raw material would be to reduce the risk of exposure to antigenic protein. It has generally been accepted that latex allergies can be developed through repeated exposure to the antigenic proteins that naturally occur in latex[1]. It is believed that by greatly reducing these antigenic proteins in the raw material, a person's risk of developing a latex allergy can be reduced. However, what has been learned over the past two years is that by removing the non-rubber components of latex along with the proteins, a cleaner and better form of latex is produced. This is advantageous in a number of different product applications[2].

Field latex contains proteins and other non-rubbers including lutoids, cartenoids, and Frey-Wyssling particles (shown in the middle water droplet in figure 1). Field latex is introduced to a slurry of aluminum hydroxide $Al(OH_3)$ gel (at a basic pH), represented by the dumbbell in figure 1. The proteins and non-rubbers are absorbed onto the reactive surface areas of the aluminum hydroxide during mixing and stirring. A close study of the $Al(OH)_3$ molecule reveals nine possible sites for bonding – they are both electrostatic and electron ring sharing. This allows for an effective exchange of proteins from the field latex to the insoluble $Al(OH)_3$ forming a gel. Subsequent centrifugation easily removes the gel/non-rubber particles colloid.

Figure 1: Vytex® NRL Technology



Note that adsorption is dependent upon the physical and chemical properties of the protein and other non-rubbers as well as the conditions of adsorption, such as pH, mixing time, and temperature. Because $Al(OH)_3$ is a semi soluble gel it can be introduced into the liquid latex, but more importantly, it is removed along with the proteins and non-rubbers which have been adsorbed onto the outer surface in the bottom/skim layer and is removed and diverted into skim rubber. The remaining purified top layer is the aluminum hydroxide-treated NRL which is now ready to begin the traditional maturation process.

While the process to produce Vytex NRL is protected by several issued and pending domestic and international patents[3], the procedure itself integrates well into the current latex processing stages without the need for additional equipment or capital outlay. The simplicity of the process provides Vystar Corporation with flexibility allowing the company to manage supply chain issues by expanding processing alliances around the globe.

ASTM D1076-10: New Category 5 Classification

After years of testing and review, on October 10, 2010, ASTM approved a new latex category, recognizing the unique low non-rubber properties of a material like aluminum-treated NRL. In Category 5, the maximum non-rubber content is 0.5% compared to 2.0% for the other four categories of latex. Table 1 shows how the five different ASTM categories of latex compare in terms of solids, dry rubber content, and non-rubbers (total solids less dry rubber content). Manufacturers who have trialed Vytex have seen the benefits of working with cleaner source material. Dipped products are less yellow and more translucent, due to the removal of most of the cartenoids. Foams are more odor free due to lack of microbial food source. Balloons have more vibrant colors with fewer additives required and retain air better than similar balloons produced using regular latex, due, we believe, to tighter rubber particle integration (molecular matrix).

Table 1: ASTM D1076-10 - Some of the Requirements for Specified Latex Categories[4]

	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5
Total solids, min. %	61.3	66.0	61.3	44.0	61.3
Dry rubber content (DRC)[A], min. %	59.8	64.0	59.8	42.0	60.9
Total solids content minus dry rubber content, max. %	2.0	2.0	2.0	2.0	0.5

[A] Dry rubber content by definition and use is the acid coagulable portion of latex after washing and drying.

Impact of a Cleaner NRL Material on Various Applications

Reduced Leaching and Gloves

The original intent behind the development of Vytex NRL was to diminish the levels of antigenic protein in exam and surgical gloves by reducing the allergens in the raw material itself rather than relying on a costly, time-consuming, and resource-intensive leaching process of the finished product. But the question remained, by removing most of the antigenic protein from the raw material, could a glove producer reduce the number of leaches necessary to remove, not only the various compounding chemicals, but virtually all of the remaining proteins? One Malaysian glove producer ran a series of trials to help answer that question. The manufacturer found that by using aluminum hydroxide-treated NRL, they were able to realize a 50% reduction in leaching in the production of their clean room gloves. This reduced leaching not only decreased water and energy usage, but also reduced their glove rejection rate because of the reduced exposure of the gloves to the oxidizers and alkalines used in the leaching process[5].

Table 2: Vytex NRL Protein Levels Under Different Leaching Processes for Gloves

Vytex NRL Trials Using Normal Established Parameters	Size	Powder-Free Modified Lowry ($\mu g/dm^2$) Spec.<50 $\mu g/dm^2$	Size	Powdered Modified Lowry ($\mu g/dm^2$) Spec.< 200 $\mu g/dm^2$
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

The glove manufacturer ran four Vytex NRL trials to compare the effect of different leaching processes on total extractable protein levels using ASTM D5712-10, modified Lowry testing methodology (see Table 2). In both powder-free and powdered versions, gloves made with aluminum hydroxide-treated NRL were significantly below industry (SMG/ASTM) specification of < 50 µg/dm² for powder free and <200 µg/dm² for powdered. Based on this trial, it is concluded that the manufacturer can reduce the number of processing steps, particularly for powder-free gloves and still meet internal and industry standards.

As seen above, clean room gloves represent a significant potential application for aluminum hydroxide-treated NRL because its low protein and non-rubber content has clear advantages for this market, which, by definition, needs low particle content products[6]. Theoretically, clean room gloves made from Vytex NRL could require less washing and leaching activities. The molecular matrix of Vytex NRL is very “tight” with reduced voids because of the removal of proteins and non-rubbers[7].

Reduced protein and non-rubbers should also lead to an improved dielectric property as hydration should be reduced. Conductivity testing of condoms produced using Vytex NRL compared to double centrifuged latex and regular high-ammonia latex condoms suggests a lower conductivity for Vytex NRL products[8]. (See Table 3). This feature along with having a "tight" molecular structure are important properties of electricians gloves as $Al(OH)_3$ treated NRL absorbs less H2O compared to both untreated regular and double centrifuged NRL.

Table 3: Comparison of Vytex NRL, Double Centrifuged, and High-Ammonia Latex – Conductivity

Characteristic	Vytex NRL	Double Centrifuged Latex	High Ammonia Latex
Conductivity @ 25°C (mS/cm)	1.93	2.29	3.0 – 5.0

Another manufacturer working on a process to incorporate a halogen based antimicrobial into latex compounds as a carrier to coat the compound onto readymade rubber articles, found Vytex NRL to be the best form of latex for this purpose because of its reduced antigenic properties. And while the compound's antimicrobial properties perform well when applied to a latex material the manufacturer found that when they mixed this antimicrobial into nitrile compounds for coating onto nitrile products, the antimicrobial properties were not retained. This is due to redox reactions between the nitrile particles and the halogens in the mixture. However, by using Vytex NRL as alternate carrier to nitrile latex, they were able to coat and develop products with both low in antigenic protein and had antimicrobial properties retained[9].

Nitrosamine Levels and Condom Production

The original Vytex NRL condom, allowed by the FDA in 2009, was the first latex condom to be permitted to make an antigenic protein claim (contains less than 2 µg/dm^2 of antigenic protein)[10]. Since allowance of the initial condom product, a number of additional condom manufacturers have been developing products made with aluminum hydroxide-treated NRL. Recently, regulation to limit nitrosamine contents in rubber articles, such as baby teats[11] and balloons[12], has been extended to the condom industry as well[13], especially in the European market. The nitrosamine content in rubber products is contributed by the choice of vulcanizing accelerators[14] with secondary amines and presence of TMTD, tetramethyl thiuram disulphide (preservative and accelerant), in latex.

Vytex NRL does not have any TMTD added in the manufacturing process, thus making it low nitrosamine concentrated latex. Moreover, during the production of Vytex NRL, a significant percentage of TMTD added to freshly tapped field latex is removed along with other non-rubbers. The Vytex NRL technology essentially identifies any TMTD as a non-rubber and flushes it out of the finished latex material. Development work to replace conventional accelerators for compounding purposes has been carried out with condom manufacturers. The initial results from the study indicate that condoms made with Vytex with conventional nitrosamine forming accelerators have a very low nitrosamine content, as low as 1ppb. However, the nitrosatable (pre-cursor to nitrosamine) results were high and reflect the addition of secondary amine accelerators. This is because the nitrosatables couldn't be converted to nitrosamines due to absence of nitrogenous non-rubbers (proteins).

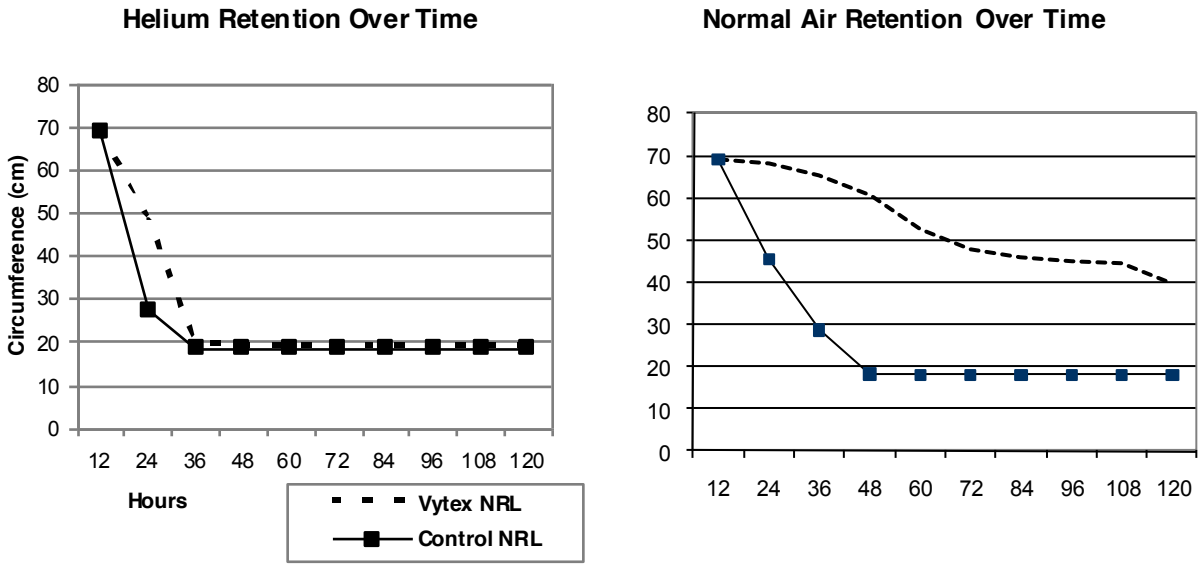
While one Malaysian condom manufacturer reported that Vytex NRL condoms contain 35% fewer nitrosamines than traditional latex condoms used as the control[15], the challenge is now to successfully develop a non-nitrosamine formulation for Vytex compounding using primary or tertiary amine accelerators. In theory, the condoms made will have very low level of nitrosamines and also nitrosatables compared to conventional natural rubbers. Moreover, the nitrosatables formed could not be converted to nitrosamines on storage due to absence of the proteins and other nitrogenous non-rubbers. Also, it is believed that, a "tight" molecular structure should improve barrier properties and enhance "bursting" test properties.

Brighter Colors and Better Air Retention in Balloons

One of the earliest successes for Vytex NRL was in balloons where the objective was to produce a higher quality balloon. Testing revealed several improvements over balloons produced using regular natural rubber latex. The first improvement was brighter and truer colors, and the second major benefit, observed , was that balloons retained normal air (N_2 and O_2) and helium (He) better than the manufacturer's regular latex balloons.

Independent testing confirmed our hypothesis that removal of a significant proportion of non-rubbers would lead to tighter rubber particle integration, resulting in better retention of normal air as well as better retention of the smaller helium gas molecules. Figure 2 demonstrates this point. Traditional latex balloons filled with regular air lost roughly 70% of their air within 48 hours, while the Vytex balloons still retained over 85% of volume at that point. Since helium is a very small molecule, both types of balloons lost their helium fairly quickly, but after 24 hours, the balloons made with aluminum hydroxide-treated NRL retained nearly 80% more helium compared to the latex control[2].

Figure 2



Better Flowing Adhesives

Because aluminum hydroxide-treated NRL contains up to 75% fewer non-rubber particles compared to standard NRL, it has significant advantages within adhesives, particularly in spray and coating applications. The absence of the non-rubbers provides for a cleaner spray with less clogging, documented by a U.S. adhesives manufacturer. Less clogging means less equipment downtime for nozzle head cleaning and a more consistent application of adhesive.

A U.S. manufacturer has developed and is marketing a new foam to 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 the new product has a 40% faster tack time than the standard latex used previously[16]. The faster tack time allows for increased unit output and increased line productivity.

Reducing non-rubbers, including antigenic proteins at the front end of the process, is important for adhesive applications since leaching is not an option for reduction in protein content. As you can see in table 4, Vytex

NRL achieved ultra low antigenic protein levels in two samples compared with control, which had wide variations between the two regular NRL control samples[17].

Table 4: Protein Test Results for a Foam to Foam Adhesive Spray

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

NRL is well known as an adhesive, and NRL adhesives are ubiquitous. Vytex NRL, with its unique properties, expands its uses into the adhesive market where clarity, cleanliness, and low allergy potential are desired. Aluminum hydroxide-treated NRL is an excellent film former which is the hallmark of a strong, lasting adhesive. Low proteins and non-rubbers also expand its utility into a variety of uses, such as medical and cosmetic products. Vystar, in cooperation with one of its adhesive customers, has developed an adhesive specifically for foam to foam adhesion to improve reliability, strength. and reduction of potential allergies and odors from biodegradation of non-rubbers.

Virtually Odor Free Foams

Vytex NRL reduced non-rubber content naturally provides for low odor foam which is useful in sleep products. Essentially, the Vytex NRL process removes the biodegradable materials (lutoids, proteins and cartenoids, and Frey-Wyssling particles), thereby reducing odor which would be caused by microbial actions on the non-rubber component of the material. Polyisoprene, the primary component of NRL, is not readily biodegradable, so removal of the non-rubber products is helpful in foams to be used as cushions, pillows, and mattresses. For foam manufacturers, the use of aluminum hydroxide-treated NRL can mean fewer leaching steps to achieve a low-odor product, and reduced dependence on costly fragrances, often used to mask odor.

Vytex NRL low-odor characteristics can be summarized in the following formula: K is a comprehensive constant which accounts for time, temperature, availability, etc.

$$K\,[R_1]^{x}{}_{D}\,[NR]_{Vytex} \leq K\,[R_2]^{Y}{}_{D}\,[NR]_{NRL}$$

Where R_1 is the rate of decomposition of non-rubbers in Vytex, and R_2 is the rate of decomposition of non-rubbers in natural rubber latex. As X < Y, then Vytex will emit less odor, then as the total concentrations of non-rubbers is 75% less than natural rubber latex then:

$$\Sigma\,[C_1{}^{NR}]_{Vytex} < \Sigma\,[C_2{}^{NR}]_{NRL}$$

Thus, as the concentration of non-rubbers in Vytex NRL is 75% lower than the concentration of non-rubbers in natural rubber latex, then the rate of degradation of Vytex is limited in rate by reduced concentration and bioavailability.

$$[R_1]^{x}{}_{D} \sim \Sigma\,[C_1NR]^{\text{limit X}}{}_{Vytex}$$

The non-rubbers are fatty acids, proteins, and carbohydrates and can quickly degrade to smelly ethanoic, propanoic, butyric, and small amines, all of which are smelly. To the contrary, isoprene itself degrades very slowly into CO_2, H_2O (and CH_4 in a reducing atmosphere), none of which have odor. If the latex is cross linked with sulfur, there will be a bit of SO_2 and H_2S both of which have their own unique odor.

Vystar is currently working with one foam manufacturer to test consumer response to foam pillows made with Vytex NRL. Participants will utilize the pillows over several months with participants providing feedback periodically on a number of different attributes including odor, comfort, and other features of the product.

Low Modulus/High Elongation in Elastic Threads

The majority of elastic thread used in the apparel industry is an elastic core of usually 100 gauge rubber or equivalent denier of spandex covered or wrapped with a 70 to 100 denier nylon filament yarn. This yarn can be "flat" (un-textured) or textured and is known as "single" covered yarn. The most used thread is a double covered yarn, where the single covered yarn is wrapped with an additional textured or un-textured yarn in the opposite direction. Double covered yarn is used in the top of socks to maintain position.

Elastic bands, such as those found across the top of men's underwear, can also be knitted or woven from this double covered yarn. Natural rubber latex is by far the best choice for these applications because of biodegradability (green), simple extrusion, elasticity, and high wet-gel strength. And, with its excellent physical properties, Vytex NRL may be the best form of latex for this use. Spandex used in this type of application tends to wear quickly and after, perhaps six washings, the bands lose their elastic recovery and exhibit "hysteresis" which manifests itself as a wavy, puckered band. Elasticity in polymers is due to coiling or folding of the polymers with uncoiling or unfolding under load. At load release, the polymers recoil to their original state.

This past year, the first sample yarns from Vytex NRL were produced with the elastic tapes made in Thailand. Our initial physical property tests were performed at the College of Textiles at North Carolina State University in Raleigh, NC. Table 5 demonstrates performance of Vytex NRL sample threads compared to similar natural rubber and spandex threads[18].

Table 5: Independent Test Results on Pilot Line Produced Vytex NRL Threads versus Regular NRL and Spandex Threads

Source	Physical Properties			
	% Strain[B]	Modulus[B] (g/denier)	Tenacity[B] (g/denier)	Antigenic Protein ELISA[C] (μg/dm^2)
Vytex® NRL	929.5 (± 48.4)	0.0088 (± 0.0007)	0.31 (± 0.02)	3.8
NRL Control	771.3 (± 90.1)	0.0144 (± 0.0016)	0.33 (± 0.02)	14.1
Spandex	755.7 (± 160.1)	0.0781 (± 0.0111)	0.87 (± 0.07)	n/a

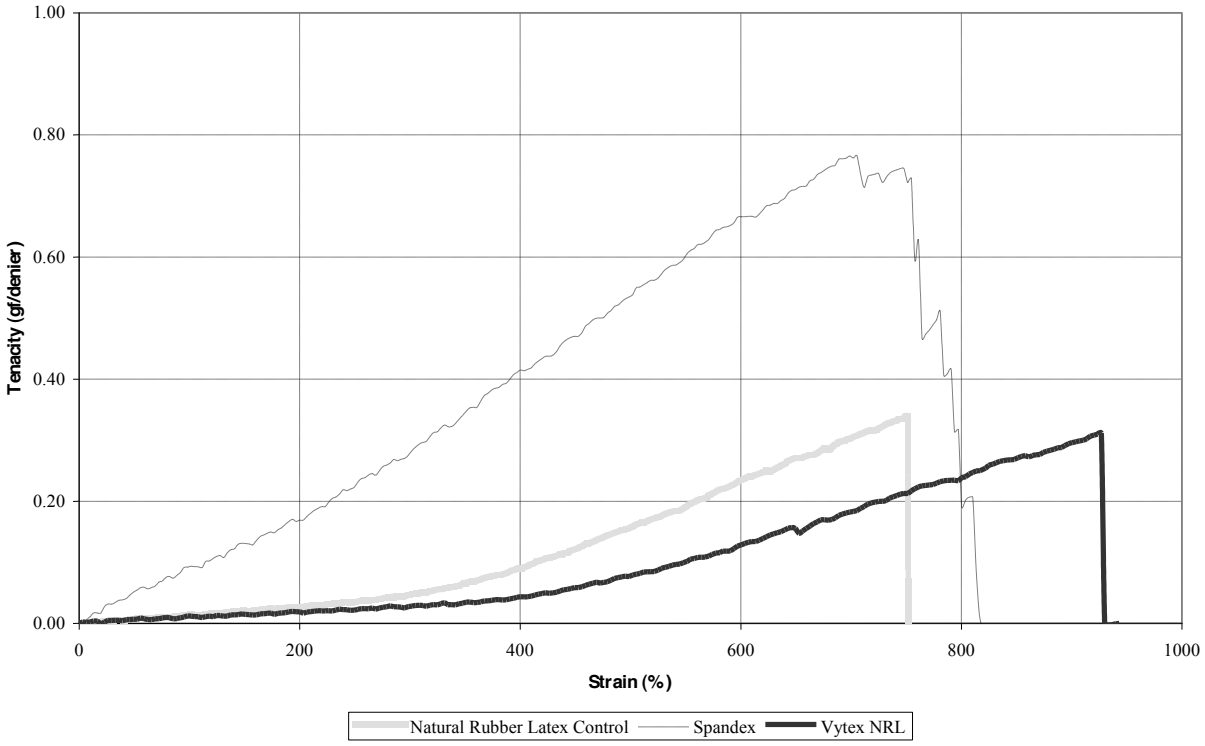
[B] Testing conducted by North Carolina State University, College of Textiles, Raleigh, NC USA
[C] Testing conducted by LEAP Testing Services, Sayre, PA USA

NRL has great utility in elastic threads for garments, such as socks, knit and woven fabrics and medical products. The physical properties of Vytex thread, as seen it this pilot run, are outstanding – low initial modulus with high elongation. These properties will make apparel made with Vytex thread easy to don and comfortable to wear without undue pressure. This property is particularly useful in medical garments, such as diabetic socks and burn bandages. One common complaint about synthetic polyurethane spandex is that it has too much compression for sustained comfort, particularly in products such as compression socks.

Table 5 shows some of the physical property differences found in testing of Vytex NRL threads compared to NRL and spandex. The study was conducted at North Carolina State University, College of Textiles on behalf of Vystar. The first column, % strain or elongation, shows that Vytex stretches 20% further than NRL or spandex threads before break. When comparing modulus, again Vytex threads require less force to initiate the stretch than spandex, which is inherently a very stiff elastomer. Vytex NRL also performed better than

traditional untreated NRL, suggesting that garments made with Vytex NRL threads would be easier to don, an important feature for many hosiery products. When looking at 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 traditional untreated NRL. The area under the curve in figure 3 speaks to total energy expended to elongate the threads.

Figure 3: Tenacity vs. % Strain Curves for Representative Specimens



How Aluminum Hydroxide-Treated NRL Has Helped Solve Customer Product Development Challenges

Specialty Foams

The low protein content of the Vytex was very useful in evaluation of modulated recovery foams. This application requires the foams to be compressed and recover very slowly. This allows the foam product to be put in place while compressed and then slowly recover to fill any voids. Typically, natural rubber foams will have a fast recovery due to vulcanization to cross-link the latex particles. The vulcanization process will improve the compression set and indentation set. According to Carey and Rogers[19], typical values of compression set for natural rubber foams are 2.9%. But based on the evaluation of Vytex, the values improved to 3.7% which is close to polyurethane foam.

The challenge in this application was to make the latex particles compatible with low pH additives since Vytex NRL is similar to conventional natural rubber latex having pH as high as 11. The high pH stability of common natural latex is contributed mainly by the ammonia and the protein content[20]. Proteins will be anionic in the high pH medium causing the latex to be incompatible with low pH additives and coagulate. However, Vytex NRL being low antigenic protein latex can overcome the compatibility issues with a small modification to the nature of latex particles. The modification includes amphoteric nature of the aluminum hydroxide and addition of surfactants. This modification allows the low pH additives to be incorporated into

the Vytex successfully without any coagulation and the foams that are made recover after 30 seconds of being compressed.

Specialty Elasticized Fabrics for Personal Protection Products
Another successful development from the Vystar technical team would be disposable undergarments made from Vytex NRL-based material. These products encompass the range from diapers to cups for men to sanitary products for women. They are generally gender specific and come in several sizes and types such as pull-ups, panty liners of various designs, and adjustable diapers with tape-based closures. The styles are designed to meet the varying needs of patients, including those who are wheel-chair bound and those who are fully ambulatory. Vystar now sees interest in “pull-up” style undergarments that will provide protection for the mobile patient yet offer the more contoured profile associated with a traditional women’s panty or men’s brief.

Product made with Vytex NRL has very low antigenic protein and should provide improved protection from leakage, a softer feel, and be easier to don and comfortable while wearing due to lower modulus and higher elongation. As mentioned above, Vytex NRL is very low in antigenic protein and also has a very low non-rubber content latex. These attributes provide very tight cross-linking of latex particles after vulcanization since absence of non-rubbers will not interfere in between the latex particles which could eventually cause micro porous film formation. We have discussed above how Vytex NRL improves air retention in balloons due to absence of micro pores caused by non-rubbers. Just as air could not escape and is retained in the Vytex balloons, water and other fluids are also retained within the protective garment.

This application requires that the natural rubber film formed not be leached at the end of the process. Of course, without leaching, the non-rubbers and proteins from conventional natural rubber latex could not be removed. This challenge in the process was easily overcome by manufacturers with usage of Vytex NRL with low non-rubbers and proteins. Leaching not only removes non-rubbers and proteins but also removes the vulcanization chemicals to prevent Type IV allergy. Choice of chemicals with low dosage was recommended and implemented successfully in production. To summarize, Vytex NRL provided a clean natural rubber latex with tighter film integration and energy cost savings for this application.

Adhesives for Personal Care Products

Vytex NRL may be the best, water-based latex adhesive material for food and skin contact since there is no leaching step in adhesive manufacturing[21]. The principal advantages of using natural rubber latex for water-based adhesives over synthetics are cost, the possibility of formulating for a wide range of total solids content and viscosities, high molecular mass and superior resistance to deterioration during ageing, and tendencies of adhesives to wet and penetrate porous substrates. When conventional natural rubber latex is considered, Vytex NRL performs better in terms of higher adhesive and cohesive strength due to non-restricted inter-particle coalescence with absence of non-rubbers. This attribute also gives advantage to Vytex NRL in view of the fact that no leaching step is done in adhesives.

Skin contact adhesives’ application varies with the type of materials bonded to the skin. Paper, textile, metal, hair extensions, and many more products fit into this application. Usage of Vytex NRL provides low antigenic protein latex adhesives to help prevent Type I allergy and other contaminations of the non-rubbers to the substrates. After drying, it also gives superior water-resistance due to the tight particle integration and electrical resistance properties as a result of the absence of charged non-rubbers, especially proteins[22].

The most distinctive advantage of Vytex NRL-based adhesives is ability to use mineral oil instead of solvents or heat during removal of the adherents. This approach is more user-friendly and simple. Moreover, the adhesive residues after removal can be washed off with normal soap or shampoo.

Opportunities for Further Enhancements to Aluminum Hydroxide-Treated NRL

Vystar Corporation continues to work on process improvements designed to produce Vytex NRL products that are low in protein and offer cost-effective alternatives to untreated natural rubber latex. The company continues to pursue numerous specialized formulations, such as no ammonia Vytex, as well as custom blends designed to help customers meet their unique needs.

No Ammonia Alternative
Currently, latex is used in a variety of skin contact applications, including body paints and skin adhesives. A cosmetics manufacturer seeking a better and safer adhesive was attracted to Vytex for its low protein feature, but also wanted a formulation that eliminated ammonia to further improve its safety profile. The technical team was successful in developing a formulation that is clear and stable and has good strength with no ammonia.

A no-ammonia formulation of Vytex NRL could be a replacement for ordinary natural latex in all types of cosmetics, particularly mascara, skin adhesive, face and body paint, hair extensions, and other theatrical makeup applications around the face. With low proteins, low non-rubber content, no nitrosamine (cancerous mutagens), and no ammonia, Vytex NRL could be a safer alternative to typical natural latex alternatives.

Nano Fillers
Nano is from the Greek word, nănο, nannos – an extremely small, little old man, 10^{-3} µm or 10^{-9} meter particle size. As an angstrom is only 1/10 of a nanometer, nano $CaCO_3$ is only a few molecules thick in each particle. Vytex NRL with its reduced polarity matrix (by virtue of protein and non-rubber particles removal) has particular compatibility with nano fillers. The role of traditional fillers in lattices includes cost cutting, bulking, viscosity enhancing, and increased modulus. This last property can be a problem for most applications because fillers generally provide for a very steep initial modulus curve. However, it appears that Vytex NRL, with its reduced polarity molecular matrix at light loads of nano fillers (up to 5% w/w) is minimally impacted as far as physical properties are concerned. The nano filler may even provide for molecular chain lubricity to improve physical properties.

Conclusion

Vystar Corporation's patented aluminum hydroxide-treated NRL, Vytex NRL, has proven to be a versatile material offering numerous advantages across a broad variety of applications from balloons that are brighter and retain air better, to low-odor foams, smoother applying adhesives, and low-protein condoms and gloves that have received FDA 510(k) clearance. The low non-rubber properties comply with the new ASTM D1076-10 category 5 classification, and as a result of the cleaner material properties, use of Vytex NRL can help dipped goods producers increase their product quality as well as reduce water and energy consumption by reducing the need for additional leaching steps to reduce protein levels.

Work continues in a number of different areas as part of the Vystar Corporation's product development plan. Many of the new projects come directly from helping our customers meet their product challenges, while others are pursued to help reduce costs while optimizing product characteristics.

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