Advantages of Using Natural Rubber Latex to Manufacture Gloves and Unique Properties of Natural Rubber Gloves*

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There are several advantages of using natural rubber (NR) latex in the glove manufacturing process compared to that of synthetic latexes due to certain unique properties of NR latex which are not found in synthetic latexes. These include lower surfactant content, longer shelf life, much better wet gel strength and film formation properties than synthetic latexes. In addition, NR latex can be fully vulcanised in latex state, making it less susceptible to temperature fluctuation in the curing oven. Most rubber glove users like the performance properties of NR gloves because they are generally softer, more elastic than the synthetic gloves, which provide good comfort, low hand fatigue and good tactile sensitivity to the user. They are also more durable, have good resistance against polar solvents such as alcohol. The tear resistance of NR gloves is the highest among the common rubber glove materials. In addition, NR gloves also have the ability to reseal a small hole when punctured by a sharp object. NR gloves are generally cheaper than most synthetic gloves and are of low carbon foot-print products, and are biodegradable. Therefore, the use of NR gloves helps to reduce the impact of global climax change.

Keywords: Natural rubber, gloves, advantages, manufacturing, using

Profile of Eng Aik Hwee

Dr. Eng Aik Hwee graduated from University of Malaya, Kuala Lumpur with an upper second-class honours degree in chemistry in 1986 and Master's degree in natural rubber chemistry in 1989. In 1990, he was awarded the Mombugakusho scholarship by the Japanese Government to pursue his doctorate in functional material engineering at the Faculty of Engineering, Tokyo University of Agriculture and Technology and graduated in 1994. In the same year, he joined the Latex Science and Technology Unit of Rubber Research Institute of Malaysia (RRIM).

In 2001, Dr. Eng left RRIM to join the Science and Technology Department of Ansell, a multinational rubber glove company as a Module Director. He is an inventor of 5 patent applications of which 2 have been granted; co-authored review chapters of 4 books; and 35 journal articles.

Dr Eng left Ansell in 2016 and joined Malaysian Rubber Export Promotion Council (MREPC) in January 2017 as an independent advisor on part time basis. He left the company in December 2018 but continues the technical training for their industry members on assignment basis. In addition to the MREPC training programmes, Dr Eng has been conducting technical training for the Plastic Rubber Institute of Malaysia's members since 2012, University of Kuala Lumpur (UniKL) under the Professional Graduateship of Rubber Technology Programme, Universiti Sains Malaysia, Universiti Perlis Malaysia, and several private companies. He also frequently travels overseas to give educational talks on medical gloves and infection control under the MREPC's educational programmes.

Currently, Dr Eng is a committee member of the Malaysian Rubber Board's Academi Hevea Malaysia Training Programme Review Committee, a Fellow of Malaysian Institute of Chemistry, a Technical Committee Member of International Rubber Conference and Exhibition 2020

* Paper presented at International Rubber Conference, 4-6 September 2018, Kuala Lumpur, Malaysia

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INTRODUCTION

Materials for rubber glove applications must be able to form thin and flexible barrier films to provide the users the required good comfort and protection. Currently, the major rubber materials are NR, carboxylated acrylonitrile butadiene copolymer (nitrile rubber), polychloroprene (chloroprene rubber), polyvinyl chloride (vinyl), and polyethylene. Other rubber materials such as synthetic polyisoprene, styrene-isoprene block copolymer, polyurethane, butyl rubber, and other copolymers are also being used to manufacture rubber gloves. Despite the strong competitions from the synthetic rubbers, NR is still being widely used in the manufacturing of rubber gloves. This paper reviews some of the advantages of manufacturing and using NR gloves.

DISCUSSION

MANUFACTURING NR GLOVES

Long Shelf Life of Latex Concentrate

When a NR latex concentrate is well preserved with good stabilising systems, such as ammonia, the mechanical stability of the latex improves during storage even after a year. This is partly due to the hydrolysis of phospholipids to form hydrogen phosphate and free fatty acids as shown in the reaction scheme in Figure 1.

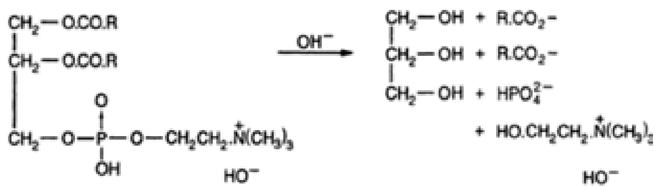

Figure 1: Hydrolysis of Phospholipid in natural rubber latex

Hydrogen phosphate is known to form precipitate with the magnesium ion in the latex to form insoluble magnesium hydrogen phosphate which then sinks to the bottom of the latex as sludge. Magnesium ion is one of the ions that is known to reduce the latex stability.1 The quantity of magnesium ion in NR latex is normally high because it is required in the biosynthesis of the rubber molecule in the rubber tree. The free fatty acids released from the hydrolysis of phospholipids could form fatty acid soaps with ammonium ion which further imparts stability to the latex.[2]

In addition to the latex stability, the presence of natural occurring antioxidants such as free and esterified tocotrienols helps to reduce the oxidative degradation of the rubber molecules.[3-5]

During the long term storage of NR latex, it must be regularly agitated to prevent the latex from creaming due to the lower density of the latex particles. The shelf life of synthetic latexes, on the other hand, is normally shorter, typically no more than six months.

Fully Prevulcanised Latex

NR latex concentrate can be fully prevulcanised in latex state. After prevulcanisation, the latex can be used to produce NR gloves without further vulcanisation. In commercial prevulcanised latex, the excess vulcanising agents are removed after prevulcanisation by low speed centrifugation. This gives the latex a longer shelf life and pot life because the latex will not undergo significant vulcanisation during storage or production of latex products. When the vulcanising agents are not removed, continuous vulcanisation in latex during production of rubber gloves would lead to different levels of pre-cured latex and eventually render the latex over-vulcanised or over-cured resulting in poor mechanical properties. As the prevulcanised latex is optimally vulcanised, the mechanical properties are less susceptible to variation in dipping time, and the fluctuation of oven temperature, leading to more consistent product quality. Therefore, it is possible to dry prevulcanised latex film with one oven temperature setting. Synthetic latexes, on the other hand, cannot be fully prevulcanised, have a shorter pot life, normally require multiple oven ozone for gradual drying and curing.

Good Wet Gel Strength

NR latex is known to have much better wet gel strength than synthetic latexes.[6] Wet-gel strength is the strength of a wet latex film after coagulant but before drying. Good wet gel strength is needed to prevent the latex wet film from tearing or cracking during processing such as wet gel leaching, beading and drying. A good wet gel strength property allows the latex film to be dried at a high speed without the film cracking issue. Rubber gloves with poor wet gel strength properties may crack during leaching or drying especially when the speed of production line or temperature is high. It may also tear easily during beading.

Low Surfactant

NR latex contains native stabilising agents such as proteins, phospholipids, fatty acid soaps. Therefore, additional surfactant required to stabilise the latex system is much lower than that of synthetic latexes. The low surfactant makes it easier to leach the latex film and helps in inter-particles integration. This also results in lower chemical oxygen demand (COD) value of the leaching water and effluent. The general observation that leaching could significantly improve the tensile properties of latex film indicates the advantage of NR latex having low surfactant content as shown by its good wet gel strength and high tensile properties with just moderate leaching process. High surfactant as in the case of synthetic latexes, will not only inhibit inter-particles integration and poor wet gel strength, it will also cause excessive foaming resulting in holes and pinholes formation in the gloves. High residual surfactant in the gloves will also increase the risk of skin reactions, such as irritant contact dermatitis.

Low shrinkage

Due to the broad particle size distribution (0.3 – 2μm),[7] the particles in NR latex film could be closely packed resulting in a lower shrinkage during drying compared to synthetic latex films. This is because the smaller particles could occupy the space in between the large particles. In addition, the lower surfactant content also contributes to the lower shrinkage of the latex film during drying. In the case of synthetic latexes such as nitrile latex (0.07 – 0.13 μm), the higher surfactant (5 – 8 phr, parts per hundred rubber) and homogeneous particle distribution lead to a high shrinkage ratio of the latex film during drying. A high shrinkage glove is expected to pose a higher risk in cracks formation.

Simple Procedure

NR latex has been used to produce latex products for a long time. In the case of natural rubber surgical glove, it was commercialised in 1964 by Ansell.[8] As such, the formulation, machine design, processing conditions are simple and have been well studied and published. The availability of commercial prevulcanised natural rubber latex further simplifies the glove manufacturing process. On the other hand, synthetic gloves, particularly medical gloves, were manufactured and marketed to replace natural rubber gloves about 30 years ago due to the latex protein allergy issues. Therefore, the information on synthetic rubber gloves manufacturing is less readily available in the literature.

USING NR GLOVES

Soft Products

Except for synthetic polyisoprene gloves, NR gloves are much softer than most of the synthetic rubber gloves, due to the low glass transition temperature. This is reflected in the low stress value at 300% or 500% elongation and the high elongation at break value which is generally above 800%. The highly stretchable property of NR gloves will result in lower hand fatigue, better fit and good comfort when the products are used for a long time. Because of these, most glove users prefer to use NR gloves in the healthcare settings.[9]

High tensile and Tear Strength

The tensile strength of NR gloves is normally higher than the synthetic gloves due to the ability of the rubber to undergo stretch-induced crystallisation. Because of this, the ASTM tensile requirements for NR examination and surgical gloves are significantly higher than those of synthetic rubber gloves. The tear strength of NR gloves is also better than most of the synthetic rubber gloves.[10-11] It is worth noting that synthetic polyisoprene gloves, although having the similar chemical structure as NR, have poorer tensile and tear strengths than NR gloves.[12] Glove tearing is one of the most common quality issue faced by the thin glove users. A glove having good tensile and tear strength such as NR gloves, will give a better protection to the glove users.

Excellent Barrier Protection

Due to the good wet gel strength and film formation properties, NR gloves generally have a lower defect rate than synthetic gloves. In addition, NR gloves have also been found to have the unique ability to reseal when punctured by needles. This provides additional barrier protection against transmission of infectious pathogens. This is well-demonstrated by two studies that reported significant viral and bacterial leaks in synthetic gloves such as vinyl, chloroprene and nitrile gloves when punctured with an injection needle. NR gloves, on the other hand, could “self-reseal” resulting in significantly less viral and bacterial penetrations as observed during the laboratory tests.[11,13]

Alcohol Resistance

NR is a non-polar material. As such, the alcohol resistance of NR gloves is much better than some polar rubber gloves such as nitrile gloves. Alcohol resistance is an important properties of medical gloves because the use of alcohol in medical settings is very common. CDC guidance recommends the disinfection of gloved hands by multiple applications of alcohol-based hand rub (ABHR) following the care of a patient with Ebola, before glove doffing.[14] It is therefore important for medical gloves to remain intact in the presence of alcohol. Any degradation of glove during the disinfection by alcohol may expose glove user to pathogens in the healthcare settings.

Sustainable Material and Low Carbon Foot Print

NR gloves are made from NR latex which is produced by the Hevea brasiliensis tree. As such, NR latex a sustainable material and the carbon foot print of NR gloves is much lower than that of synthetic rubber gloves.

CONCLUSION

NR gloves have been used for protection against biological and chemical contaminants for many years. They have been reported to possess many superior properties that synthetic glove manufacturers are trying to replicate. Although synthetic polyisoprene can provide the similar fit and feel, the material cost is very much higher than that of NR, making the polyisoprene gloves unaffordable to many users. Moreover, the tear resistance of synthetic polyisoprene gloves is still very much inferior to that of NR gloves.[7] As more users consider sustainability of material as an important factor when choosing a product, NR gloves which are made of a plant based material, will remain relevant in the glove industry for many years to come.

REFERENCES

1. Malahom N., Jarujamrus P., Meelapsom R., Siripinyanond A., Amatatongchai M., Chairam S. (2017) Simple test kit based on colorimetry for quantification of magnesium content in natural rubber latex by miniaturized complexometric titration without using masking agent. Polym. Test., 59 , 160-167

2. Chen S.F., Ng S.S. (1984) The Natural Higher Fatty Acid Soaps in Natural Rubber Latex and Their Effect on the Mechanical Stability of the Latex. Rubb. Chem. Technol., 57, 243-253.

3. Whittle K.J., Dunphy P.J., Pennock J.F. (1966) The Isolation and Properties of δ-Tocotrienol from Hevea Latex. J. Biochem, 100, 138-145, phospholipids, proteins and amino acids

4. Yacob A. R., A. Bakar N. A., Said N (2012) Vitamin E Isomers from Latex Timber Clone Rubber Tree Characterized by Ultra Violet and High Performance Liquid Chromatography. APCBEE Procedia, 4, 228-234.

5. Abad L.V, Relleve L.S., Aranilla C.T., Aliganga A.K., San Diego C.M., dela Rosa A.M. (2002) Polymer Degradation and Stability, 76, 275-279.

6. Dik L., Krutzer B., and van Dijk N. (2013) Wet-Gel Strength Improvement. Kraton Innovation Center Amsterdam. http://www.kraton.com/products/pdf/Cariflex%20IR%20latex%20-%20Wet%20Gel%20Strength.pdf

7. Lim H.M., Misni M. (2016) Colloidal and Rheological Properties of Natural Rubber Latex Concentrate. Appl. Rheol. 26, 15659. Page 1 – 10.),

8. https://en.wikipedia.org/wiki/Medical_glove

9. Mylon P., Lewis R., Carre M.J., Martin N., Brown S. (2014) A study of clinicians' views on medical gloves and their effect on manual performance. Am. J. Infect. Control, 42, 48-54.

10. Walsh D.L., Schwerin M.R., Kisielewski R.W., Kotz R.M., Chaput M.P., Varney G.W., To T.M. (2004) Abrasion Resistance of Medical Glove Materials. J. Biomed. Mater. Res. Part B: Appl. Biomater., 68B, 81–87.

11. Hasma H., Othman A.B. and Fauzi M.S. (2003) Barrier Integrity of Punctured Gloves: NR Superior to Vinyl and Nitrile. J. Rubb. Res., 6, 231-240.

12. Nakamura Y., Ishizu O., Aihara S. (2017) Latex for molding use, composition for dip molding use, and dip-molded article. US Patent 9546239.

13. Bardorf M.H., Jäger B., Boeckmans E., Kramer A., Assadian O. (2016) Influence of material properties on gloves' bacterial barrier efficacy in the presence of microperforation. Am J Infect Control., 44, 1645-1649.

14. Centers for Disease Control and Prevention (2015) Guidance on Personal Protective Equipment (PPE) To Be Used By Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola who are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE. https://www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html