NR Latex Gloves - Superior Protective Medical Devices

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Introduction

The most important reason why a healthcare personnel wears a pair of gloves is to prevent transmission of microorganisms and infectious materials to and from the patient. With the onset of HIV and the fear among healthcare providers about cross contamination, the use of natural rubber latex (NR) gloves has proliferated. These gloves have been universally preferred over the years because of their excellent barrier performance, among other beneficial properties.

However, the emergence of the latex protein allergy problem has received a great deal of adverse attention during the past few years. There has, in fact, been considerable negative publicity concerning NR latex gloves in the consumer countries. Doubt has also been expressed by some regarding their effectiveness as a barrier. There has even been suggestion that they be replaced by the protein-free synthetic substitutes, the effectiveness of which as protective devices has generally been acknowledged to be less superior to that of NR latex gloves.

This paper therefore takes a look at some of the properties and performance of these gloves, pertaining to not only their effectiveness as protective medical devices, but also their impact on the environment, another important health-related issue. Comparison with those of non-NR alternatives is also discussed.

Characteristics Essential for Effective Protection

Barrier Properties

The most important criterion in glove selection is its barrier protection. Of late, there has been concern among healthcare personnel regarding the effectiveness of NR latex gloves as barrier against infectious diseases. The confusion and comments made by misinformed media have implied that these gloves failed because latex films were simply permeable to viruses. However, scientific evidence from studies using viruses has shown otherwise [1-5].

Viral penetration

It has been claimed that channels were detected in latex films under a scanning electron microscope[1]. Although there were counter arguments on the claim, which attributed the channels to artifacts of the microscopic technique[2], there has not been any direct experimental evidence to refute the existence of channels in latex films. The implications that channels exist in latex films and hence are porous to viruses can now be safely discounted. Recent studies have shown that properly produced intact latex films are actually impermeable to viruses. The effective barrier against HIV, HSV and Echo 9 viruses shown by well-manufactured gloves [3,6] strongly supports this. Viruses can however penetrate latex films through holes, such as those artificially introduced by laser drill or needle. The extent of penetration is reported to be a function of size and density of the holes as well as size and adsorbability of the virus on the latex films [7,8]. It is therefore evident that latex films leak or allow virus penetration only when there are holes in them, due to either occasional manufacturing defects or unfavorable conditions under which they are used or stored.

Although similar behavior has also been observed for intact non-NR films, but these films, especially those of vinyl, are 5 to 13 times more likely to leak under stress when compared to those of natural rubber latex[8]. Similarly high glove failure rate resulted in virus penetration has also been reported for polyethylene glove[9]. Hence, NR latex gloves are preferred to these gloves for more effective and durable barrier qualities [6,8-12]. As for the newer non-NR latex products, such as those of polychloroprene and nitrile, which claim to have improved properties [13,14], their gloves have however, not withstood the test of time as the NR gloves.

Barrier integrity

In order to maintain minimum damage to the barrier integrity of latex gloves, it is important that factors such as glove specifications, storage and handling are considered[7].

Specifications - Quality control parameters such as level for holes or other glove defects (tear, discoloration, dimension) are important. For effective barrier protection, the gloves should ideally adhere to the specifications of ASTM, CEN or other standards organizations.

Although the figures of acceptable quality level (AQL) of medical gloves may be subjected to revision from time to time, the water test is generally accepted to be adequate as a QC/QA measure to keep the risk of transfer of fluid between medical personnel and patient to a minimum[10].

Proper glove usage - proper usage of latex glove is also of importance. Gloves of the right size should be used as inappropriate fit on the users' hands may indirectly cause holes to form due to clumsy hand movements, especially during handling of sharp instruments.

Storage and handling - Regardless of the type of material, that is, whether they are NR or non-NR, proper storage and handling of latex gloves is essential to ensure that the barrier properties are not compromised.

It may well be emphasized that NR latex gloves always have superior barrier properties. If protection against diseases fails, it is due to inferior quality of the glove, and /or due to the occurrence of damages in the gloves before or during use. It may also be of interest to note that the risk of virus-passage through small pin-holes (about 20µm in diameter), which are not detected by the water leak test, is insignificant as compared to that to larger holes caused by in-use damage[15].

Fit and Comfort

The second most important criteria are fit and comfort, being defined largely as the glove's ability to stretch, remain soft, and conform to the hand. The fit and comfort of a glove can have great influence on the user's ability to perform medical tasks. Poor fitting gloves can interfere with the optimal performance of the procedures, potentially putting the user at unnecessary risk.

NR latex gloves have always been known for their very good fit and comfort. Synthetic gloves [16,17] such as vinyl, on the other hand, have tensile only about half of that of typical latex gloves, and their elongation at break is also substantially lower (Table 1). This means that the chance of perforating a vinyl gloves is considerably greater than with a comparable latex glove. It is also less comfortable to wear and dexterity can be impaired. Although polyurethane gloves, another synthetic material, can have high tensile strength, higher than latex rubber, its modulus is also high. The latter, in combination with its lower elongation at break, tends to make polyurethane gloves uncomfortable to wear[16]. As for nitrile and polychloroprene gloves, their physical properties may be comparable to those of NR latex gloves, but their tensile strength tend to be lower and moduli higher[17]. Other non-NR gloves surfacing in the market now are those of styrene copolymers, which have been produced under various trade names such as Elastyren, Tactylite and Allergard. These gloves can have high strengths but they also often tend to have high permanent set, which means that their ability to revert to the original shape after repeated stretching is lower than that of a corresponding latex glove.

In short, natural rubber remains the material of choice where high strength properties are paramount despise attempts to duplicate these properties by synthetic rubber manufacturers.

"Green" Image

Over the years, owing to adverse effects of pollution, the public has become very environment conscious. There is now an increasing pressure for consumer goods to be made of green materials. Unlike its synthetic alternatives, NR latex gloves are made from an inherently environmentally friendly material.

Green house effect

Natural rubber itself is a sustainable and renewable resource. The rubber trees have been estimated to remove 363 million kilograms of carbon dioxide from the atmosphere annually, and replace it with life-saving oxygen[19]. This helps to combat the green house effect and the global warming, which are of great concern to the world ecologists.

The processes of manufacturing NRL gloves are also relatively safe, in contrast to those producing synthetic gloves, which often involve the use hazardous chemicals [16,20].

TABLE 1: COMPARISON OF PHYSICAL PROPERTIES OF NR LATEX, VINYL AND NTRILE GLOVES (UNAGED)[18]

Gloves	Tensile strength, Mpa	Modudus M300, Mpa	Elongation-at-break. %	Tear strength, N/mm
NR latex	29.7	1.4	860	22.0
Vinyl	10.9	6.4	420	4.2
Nitrile	26.9	3.0	650	3.9

Biodegradability

Natural rubber and natural rubber products can biodegrade by a combination of chemical and biological reactions [19,21-23]. Actinomycetes such as Nocardia have been widely documented as microorganisms responsible for the degradation of NR products. Other members of the Actinomycetes group such as Streptomycetes are also shown to attack rubber. Thin films from latex gloves have been shown to biodegrade rapidly, with a weight loss of 75% after 2 weeks of exposure to Nocardia. This has made NR products very environmentally friendly.

However, the same cannot be said for gloves of synthetic materials. This is evident by a study[24] on biodegradation of glove pieces in clayey and sandy soils over a period of 12 months. The extent of biodegradation as reflected in the amount of weight loss was insignificant for both nitrile and polychloroprene (Neoprene) as compared to that by NR latex which showed a dramatic loss of 94%. Only a small loss was noted in the case of vinyl (Figure 1).

An alternative way of disposing used non-NR gloves is therefore by burning or incineration. Unfortunately, the burning of many synthetic materials releases toxic and harmful substances, such as hydrogen cyanides, dioxins and hydrogen chlorides.

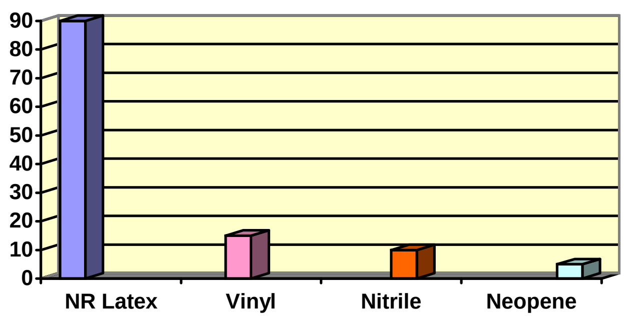

Figure 1. Weight loss of glove pieces due to biodegradation in clayey and sandy soils over a period of 12 months

Presence of *sulphur*

It may be mentioned that the presence of sulphur in latex gloves could pose a problem for their disposal by incineration. Both NR and synthetic gloves encounter this problem. However, it is possible to overcome this pollution problem by the use of radiation or peroxide prevulcanized latices.

Low energy requirement

Among the attributes of natural rubber *vis-a-vis* synthetics is the amount of energy needed to produce these materials. While it requires only 16 GJ/ton in the case of NR, the energy consumption ranges from 108 and 174 GJ/ton for the synthetics [25,26]. Although it may be argued that some extra energy is required to process NR latex to gloves, this is insignificant as compared to the total energy inputs needed for the synthetics. Therefore, NR is clearly greener in energy term than the synthetics.

Risk to Allergy

The awareness of latex protein allergy affecting sensitive individual via the use of some latex products has caused concern among the glove users. There has been considerable over-reaction due to the lack of correct information concerning the problem, which has subsequently resulted in the proposed bills for banning the use of NR latex powdered gloves in some States in USA. This has also been accompanied by the call for change to non-NR gloves, which are protein-free.

It may be of interest to note that synthetic products are not free from allergy problems. The cause of this is often due to the use of relatively high overall levels of chemical additives in their processing. These constitute a potential source of hazard. Cases of allergic eczema and urticarial reaction have been reported for the use of vinyl gloves [27,28]. Additives in the products were found to be the cause of the allergy in these cases. There have also been reports of contact dermatitis to polyurethane and polychloroprene products [29,30]. Although styrene in the styrene copolymer products is not considered to be very toxic, but several incidents of immediate asthmatic responses to styrene inhalation have been reported [31,32]. Similar allergic reaction in the form of contact urticaria has also been reported for the use of nitrile gloves [33]. These latter reactions indicate that molecules other than proteins in gloves may also elicit Type I allergy reaction.

Cost

Costs of NR latex products are well known to be relatively expensive, compared to the synthetic ones. Some indications can be seen in the Table below.

TABLE 2: COST OF SYNTHETIC OPTIONS AS COMPARED TO THE NR LATEX GLOVES.

Type of glove	**Cost**
Vinyl (polyvinyl chloride)	Comparable
Nitrile (butadiene co-polymer)	2X-4X
Neoprene(polychloprene polymer)	6X
Styrene butadiene block polymer	5X
Styrene ethylene butadiene copolymer	10X
Polyurethane (thermoplastic elastomers)	>10X

Conclusion

It is evident that NR latex gloves are effective protective medical devices. They have many inherent superior properties, such as the unparalleled barrier performance, excellent comfort and fit due to high wet-gel, tensile and tear strengths, high elasticity and extreme softness, as well as being made from a "green" material and low cost. None of the synthetic rubber latex gloves available in the market today could match the natural rubber latex gloves *in full* of the fore-said properties.

The use of the poorly manufactured protein-rich powdered latex gloves may have been associated with latex protein allergy; improved NR latex gloves with low-protein and low-powder contents that are much reduced risk are now available. It is important that the immense beneficial qualities of NR latex gloves should not be overlooked. It is these superior properties of the latex gloves that have prevented the loss of many precious lives.

However, for the latex sensitive minority who has to practise latex avoidance, their choice of gloves should be that of the non-NR substitutes.

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