Disposable decisions

PVC disposable gloves have been seen as an ideal glove alternative for avoiding latex allergies while offering the workforce suitable protection, but **Nick Gardiner** of Shield Scientific argues the choice is not so clear-cut

Polyvinyl chloride (PVC) or simply vinyl disposable gloves are often seen as the obvious latex-free alternative, especially in the micro-electronic industry. Their popularity seems to have grown as increasing concerns are being directed at the risk of natural rubber latex allergy, and it is recognised that vinyl disposable gloves are possibly the most economic alternative.

Against this backdrop, it may be appropriate to review the choice of this material in disposable gloves for use in the cleanroom.

In its natural state, PVC is hard and therefore to render the material soft and malleable, plasticisers are added. The most frequently encountered plasticisers are phthalates and in PVC products the following phthalates seem to be most frequently employed: DEHP (di-2-ethylhexyl phthalate) – CAS 117-81-7; DIDP (Diisodecyl phthalate) – CAS 26761-40-0; DINP (Diisononyl phthalate) – CAS 58033-90-2; DBP (Dibutyl phthalate) – CAS 84-74-2; BBP (Benzyl butyl phthalate) – CAS no: 85-68-7.

For many years, there have been concerns regarding the risk of plasticisers leaching out of the PVC materials. With regard to vinyl disposable gloves, the most commonly used plasticiser appears to be DEHP, while DINP is increasingly being employed. These plasticisers may represent between 22% and 44% of the total glove composition.[1]

More plasticisers

In the past, vinyl gloves were considered ill-fitting, stiff and with a cuff that was prone to slipping down the wrist. The newer generation of vinyl gloves are softer and more comfortable, but this is often achieved by use of high concentrations of plasticisers.

The danger of exposure to high concentrations of DEHP has long been recognised, with Arcadi et al reporting damage to kidney, liver and particularly testes.[2] For medical applications, there seems to be mounting evidence that DEHP may pose a reprotoxic risk to neonates.[3] A preliminary report from the SCENIHR appears to confirm the reproductive toxicity of DEHP,[4] while DINP is also cited as reprotoxin, but at doses 20 times higher.

Vinyl gloves undergoing a water test

To address this concern, all PVC medical devices that come into contact with the body and that contain phthalates will be classified as carcinogenic, mutagenic or reprotoxic (CMR). For PVC gloves that are registered as medical devices, this means that by 2010, it will be mandatory to label these gloves as "containing phthalates".

The profile of vinyl gloves as free of natural rubber latex and typically accelerator-free makes them appear very appealing. The assumption is that absence of natural rubber latex eliminates the risk of natural rubber latex allergy, and as PVC gloves do not contain accelerators this also removes a key component contributing to allergic contact dermatitis.

There is also often a misconception that vinyl does not cause the most commonly encountered dermal reaction — irritant contact dermatitis. However, research has shown that vinyl gloves can cause both irritant and allergic contact dermatitis.[5] Chemicals that may cause these conditions include plasticisers, colorants, antioxidants, fungicides and bactericides.

In Japan, where vinyl gloves have been used for many years and often for common household tasks, vinyl is reported to contribute to greater than 50% of glove-associated irritant and allergic contact dermatitis.[6] A similar finding came from a study of dentists in England and Wales, where 44.4% of people who routinely wore vinyl gloves reported dermatitis.[7]

Barrier properties

An inferiority of barrier performance for vinyl gloves is evident when subjected to in-use evaluation, as shown in table 1. These results contrast with the findings from tests on intact gloves prior to use, which suggest the barrier effectiveness between latex and vinyl is similar. The Klein study highlights ▶

Table 1: In use evaluation of vinyl gloves

DATE	% failure vinyl	% failure latex	Author	Additional comments
1999	up to 61%	2%	Rego[8]	Simulated in-use study on a range of standard and stretch vinyl gloves.
1993	43%	9%	Olsen[9]	Gloves tested after routine hospital procedures, where exposure to large number of pathogenic organisms anticipated.
1990	63%	7%	Korniewicz[10]	Gloves subjected to simulated in-use clinical practices, then viral penetration testing with ØX174 bacteriophage.
1990	22%[1] 56%[2]	<1%[1] <1%[2]	Klein[11]	Simulated in-use study. Tested in a solution containing lambda virus. In addition comparison made between before[1] and after[2] contact with 70% ethanol.
1989	53%	3%	Korniewicz[12]	Gloves dye tested after 15 mins. of simulated clinical activity.

another potential concern with vinyl regarding their relatively poor barrier properties to many commonly used chemicals such as ethanol or isopropyl alcohol. The high in-use failure rates of vinyl gloves may be because this material has a rigid inflexible molecular structure that is easily disrupted, creating structural breaks. Thus vinyl loses its barrier integrity quickly when subjected to rigorous procedures or exposed to pointed objects.

Vinyl gloves are allowed to be weaker than latex and other synthetic gloves. Durability is often determined by measuring physical attributes such as tensile strength and elongation (stretch). In terms of the standards associated with these properties, it may come as a surprise that less stringent standards apply to vinyl. The poorer performance of vinyl is clearly evident in the ASTM norms (as defined by the American Society for Testing and Materials) for exam gloves, shown in table 2.

The inherently weaker characteristics of vinyl mean that these gloves may break down within minutes of use, potentially exposing the process to human-borne contamination and the wearer to biohazards and liquids. This may also explain the divergence in equivalent barrier properties of unused latex and vinyl gloves versus significant disparities when comparing the results for used gloves.

In the face of mounting environmental concerns regarding waste, the high chlorine content in vinyl can pose an environmental challenge for manufacture and disposal.

Currently there are typically two options for disposal of vinyl gloves:

Table 2: A comparison of exam glove performance in the ASTM norms (as defined by the American Society for Testing and Materials)

Material	ASTM	Tensile strength	Elongation
Vinyl	D5250	11MPa	300%
Latex	D3578	14MPa	650%
Nitrile	D6319	14MPa	500%
Neoprene	D6977	14MPa	500%

a) Incineration — when subjected to incineration, vinyl breaks down to hydrochloric acid gas, residual chemicals and ash. If the incineration temperatures are not optimal, monomers of vinyl chloride may be released along with dioxin. The latter is highly toxic and a human carcinogen.

b) Landfill — vinyl is non-biodegradable and can present a risk of leaching into the groundwater of toxic chemicals, as well as contributing to toxic emissions. Additionally, phthalates may be released, especially when in contact with non-aqueous solvents.

Taking into account the well-publicised

Barrier standards are lower for vinyl gloves

low barrier properties of vinyl gloves, it is surprising that this material remains a popular choice among the micro-electronic industry. Similarly it has long been recognised that the plasticisers that keep vinyl gloves soft can cause "stiction".

For disk drive manufacturers this may mean interference of the disk lubricants, possibly resulting in hard drive failure. For the semiconductor industry the presence of plasticisers may impede the adhesion properties of films. An investigation by NASA into the non-volatile residues left by various glove materials led to the conclusion that to avoid critical surface contamination "vinyl gloves should never be used and should especially be avoided during solvent cleaning".[13]

For processes that are sensitive to particle contamination, vinyl again typically demonstrates particle levels four to six times higher than equivalent latex or nitrile gloves. This is especially evident when vinyl gloves are subjected to liquid particle testing (as opposed to dry particle testing with Helmke Drum). This difference can be accounted for by the fact that vinyl gloves undergo minimal post processing following dipping and drying.

Why, then, does the micro-electronic industry continues to use vinyl gloves? For procedures that are static sensitive, vinyl offers the most attractive electrostatic discharge (ESD) characteristics, especially when evaluated from the perspective of surface resistance. However, surface resistance does not reflect the path of dissipation for gloves and in-use resistance is more applicable. Here the differences between vinyl and nitrile are less significant.[14] Thus it is possible that ESD concerns that can contribute to losses of as much as 30%[15] may have overshadowed concerns regarding plasticiser and particle contamination from vinyl gloves.

When seeking a cost-effective solution that is free of natural rubber latex, vinyl gloves may be worth considering for less critical and rigorous procedures. However, while the reproductive toxicity of the phthalates used in vinyl gloves may currently only be a concern for medical applications, prudence may dictate that alternative materials could be preferable where there is prolonged usage of gloves. Similarly the disposal of vinyl does bring particular risks that could be avoided if alternatives were considered.

The combination of poor barrier properties and contamination concerns regarding phthalates plus particles would appear to indicate that vinyl gloves have a limited role in the more critical areas of the cleanroom. ■

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