Masks treated with HeiQ Viroblock NPJ03

Analysis of inhalation exposure potential

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Background

- The HeiQ Viroblock NPJ03 treatment is a formulation that contains silver-based active ingredients and fatty vesicle components.
- Face mask respirator (e.g. N95, FFP2 etc.) component textiles can be treated with HeiQ Viroblock NPJ03 to impart additional protection against viruses and bacteria.
- General duty face masks may also be constructed out of fabrics [1] and these materials may also be treated with HeiQ Viroblock NPJ03 to impart additional protection against viruses and bacteria.

- *This document addresses the question regarding the exposure potential for particle materials to break-off from the treated fabric surface and to subsequently find their way through the mask structure and be inhaled by the user*.

[1] Davies et.al. 2013. Testing the efficacy of homemade masks: would they protect in an influenza pandemic?. Disaster medicine and public health preparedness, 7(4), pp.413-418.

Mask construction

- Masks are generally constructed from multiple layers of textile materials
- The HeiQ Viroblock NPJ03 treatment may in principle be applied to the surface of any fabric layer however it is typically applied to external and/or middle layers.

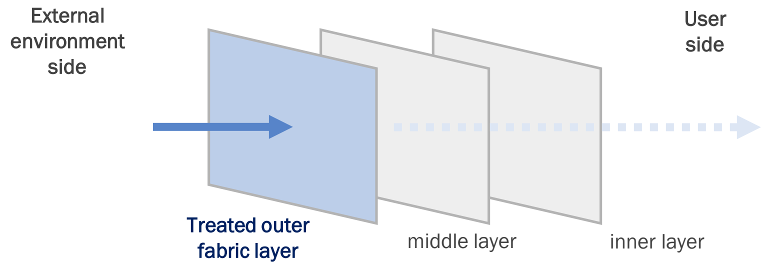


Figure 1. Example schematic showing an external fabric layer treated with HeiQ Viroblock NPJ03

Treatment process

- HeiQ Viroblock NPJ03 is a liquid formulation that can be applied to a range of textiles using standard continuous wet-processing methods (e.g. padding, kiss-roll etc.).
- The liquid formulation is directly compatible with conventional industrial processing systems and treatments can be implemented with standard industrial practices.
- The formulation is typically applied using a textile finishing process whereby the following steps are used:
  1. The formulated product is diluted in water (‘bath liquor’) to a target dosing level
  2. The fabric to be treated is dipped through the bath liquor and squeezed through rollers at a controlled pressure to impregnate the liquid throughout the fabric structure
  3. The wet fabric is carried through a hot oven system (‘stenter’) to dry the fabric (typically at 120 °C / 250 °F) leaving the solid components on the surfaces of the fibers within the textile structure
  4. The now ‘finished fabric’ is rolled-up and proceeds to cutting and construction phases of the mask production

Estimating shedding release from fabric

- For risk assessment purposes the potential for components of the treated textile to produce airborne particles that may subsequently be inhaled by the wearer is a key consideration.
- Abrasion of fabric components from fabric-to-fabric contact [1] is assumed to be the dominant path to generate airborne particulates from general use fabric masks.
- Airborne particulate generation from fabric-to-fabric abrasion has been characterized by Lamb et al. for untreated cotton fabrics and cotton fabrics treated with a textile finishing formulation [2] and serves as a useful model for estimating the potential for particle generation from mask fabrics treated with HeiQ Viroblock NPJ03.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1989. Studies of Fabric Wear: Part I: Attrition of Cotton Fabrics. Textile Research Journal, 59(2), pp.61-65.
[2] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

Estimating shedding release from fabric

- The Lamb et.al testing characterized the airborne number concentration of particles derived from reciprocal fabric-to-fabric contact abrasion of different fabrics [1,2].
- The experimental apparatus contacted fabrics through a belt drive system with controlled contact pressure and abraded area (Figure 1)
- The abrasion contact was conducted in an enclosed chamber with appended analytical systems to characterize particle number concentration for various size fractions (Figure 2)

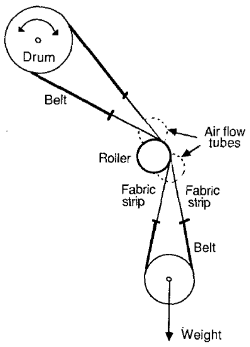


FIGURE 1. Arrangement of TRI fabric/fabric abrader.

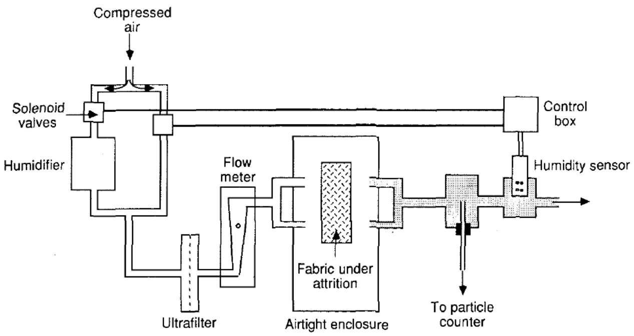
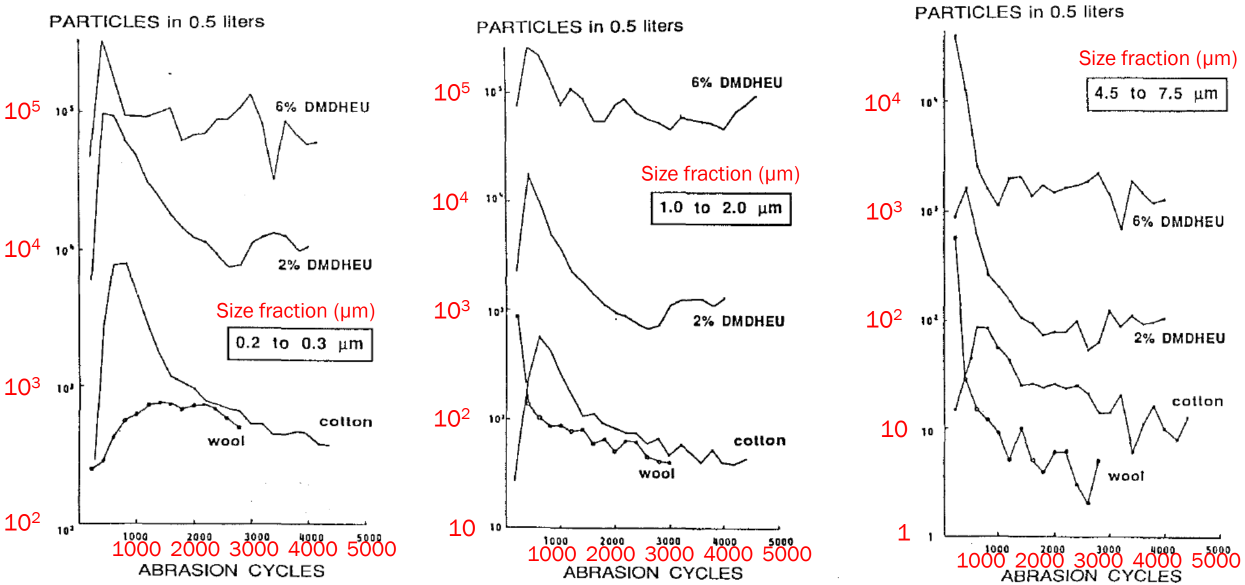


FIGURE 2. Apparatus for collection and sampling of airborne particles generated during fabric abrasion.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.
[2] Lamb, G.E., Kepka, S. and Miller, B., 1989. Studies of Fabric Wear: Part I: Attrition of Cotton Fabrics. Textile Research Journal, 59(2), pp.61-65.

Estimating shedding release from fabric

- Lamb et.al [1] report particle number concentration progression over a period of abrasion contact for different fabrics and treatments:



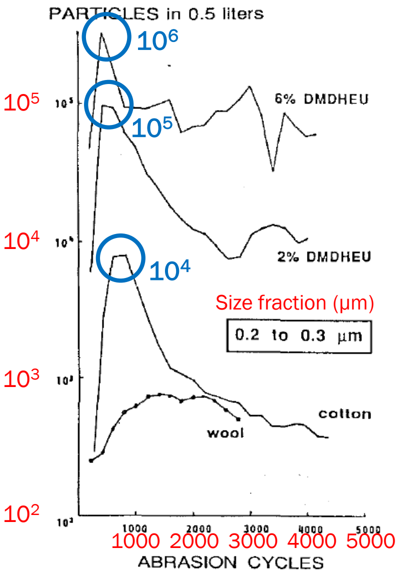
- The fabrics noted for further consideration are the cotton and cotton treated with 2% or 6% DMDHEU samples (DMDHEU is an ‘easy-care’, ‘durable press’ treatment).

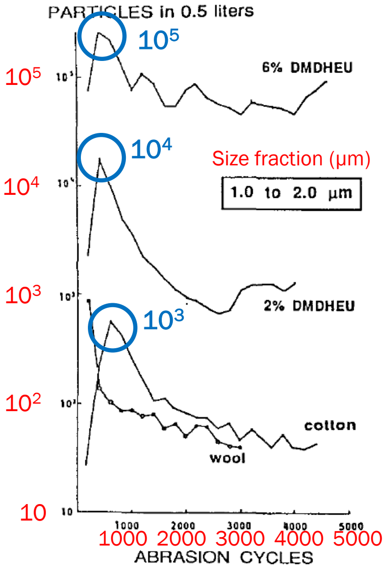
Red text added to above graphs for clarity.

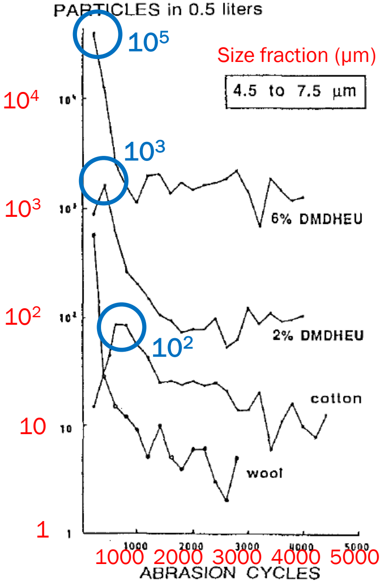
[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

Estimating shedding release from fabric

- The maximum release concentration derived from the Lamb et.al. [1] figures is used for estimation of the particle release potential for mask fabrics treated with HeiQ Viroblock NPJ03. The extracted peak release value (blue font below) is the conservative order of magnitude for the estimated release as follows:







[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

Estimating shedding release from fabric

- The maximum release concentration derived from the Lamb et.al. [1] figures is summarized as follows converted (*) to units of #/m^3:

Table A

Fabric	Particle concentration (#/m^3) by size range		
	0.2-0.3 um	1 - 2 um	4.5 - 7.5 um
6% DMDHEU	2.0×10^{9}	2.0×10^{8}	2.0×10^{8}
2% DMDHEU	2.0×10^{8}	2.0×10^{7}	2.0×10^{6}
Cotton	2.0×10^{7}	2.0×10^{6}	2.0×10^{5}

- The number concentration is converted to mass through assuming spherical particles at the midpoint size of each size fraction (**) and a conservatively high density of 1.2 g/cm^3:

Table B

Fabric	Particle concentration (mg/m^3) by size range		
	0.2-0.3 um	1 - 2 um	4.5 - 7.5 um
6% DMDHEU	2.0×10^{-2}	4.2×10^{-1}	2.7×10^{1}
2% DMDHEU	2.0×10^{-3}	4.2×10^{-2}	2.7×10^{-1}
Cotton	2.0×10^{-4}	4.2×10^{-3}	2.7×10^{-2}

* Values for peak release concentration are reported in the original figures as particle # per 0.5 Liters. These values are divided by 0.0005 to give units of #/m^3.

** For 0.25µm diameter the particle mass is approx. 9.82×10^{-12} mg/particle; for 1.5µm diameter approx. 2.12×10^{-9} mg/particle; for 6µm diameter approx. 2.12×10^{-7} mg/particle.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

Estimating shedding release from fabric

- The maximum release concentrations in the previous Table B are for the Lamb et.al. [2] experiment system which used a 70 cm^2 fabric-to-fabric contact area [1].
- For estimating the maximum release from the fabric mask material the concentration is scaled in proportion to the area of the face mask fabric (*) to give the following estimates:

Table C

Fabric	Estimated particle concentration (mg/m^3) by size range			TOTAL mg/m^3 (all sizes)	TOTAL mg/m^3 (<2µm respirable)
	0.2-0.3 um	1 - 2 um	4.5 - 7.5 um		
6% DMDHEU	0.0561	1.2118	77.5525	**78.8**	**1.3**
2% DMDHEU	0.0056	0.1212	0.7755	**0.90**	**0.13**
Cotton	0.0006	0.0121	0.0776	**0.09**	**0.01**

- The estimated maximum released particle concentration (all sizes) ranges from ca. 0.1 mg/m^3 for cotton through to 0.9 to 79 mg/m^3 for the treated fabrics. However, the larger size fraction (4.5 to 7.5 µm) would have limited potential for subsequent passage through a fabric material and so the sizes less than 2 µm are considered as the respirable relevant fraction that could have potential for passage through the fabric and subsequent inhalation.
- **For the size fraction < 2 µm the maximum concentration is estimated as 0.01 to 1.3 mg/m^3.**

* The fabric mask material area is 200 cm^2, and the Lamb et.al. data is for a 70 cm^2 contact area. The values in Table B are multiplied by 200/7 = 2.86.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.
[2] Lamb, G.E., Kepka, S. and Miller, B., 1989. Studies of Fabric Wear: Part I: Attrition of Cotton Fabrics. Textile Research Journal, 59(2), pp.61-65.

Estimating shedding release from fabric

- The preceeding analysis used experimental data [1] for untreated cotton and cotton treated with a DMDHEU textile treatment. This analysis gave an estimated range for maximum released particle concentration due to fabric-to-fabric contact abrasion.
  - For the size fraction < 2 μm the maximum concentration is estimated as 0.01 to 1.3 mg/m^3.
- This range represents the estimated source magnitude for particles however the extent to which released particles may pass through the fabric mask material and be available for inhalation also needs consideration of the filtration efficiency of the fabric material.
- A study by Davies et.al [2] examined the filtration efficiency of various fabrics against microorganisms. Cotton and linen fabrics gave a filtration efficiency values greater than ca.60%.
- **Applying a 60% filtration efficiency to the total fraction < 2 μm, the estimated maximum concentration range is 0.005 to 0.51 mg/m^3.**

* The assumed typical fabric mask material area is 200 cm^2, and the Lamb et.al. data is for a 70 cm^2 contact area. The values in Table B are multiplied by 200/7 = 2.86.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

[2] Davies, A., Thompson, K.A., Giri, K., Kafatos, G., Walker, J. and Bennett, A., 2013. Testing the efficacy of homemade masks: would they protect in an influenza pandemic?. *Disaster medicine and public health preparedness*, 7(4), pp.413-418.

Summary

- The maximum release concentration of debris particles due to fabric-to-fabric wear for fabrics treated with HeiQ Viroblock NPJ03 is estimated to be **between 0.005 and 0.51 mg/m^3**

- This estimated concentration range is at least a magnitude lower than the **OSHA PEL of 5 mg/m^3 for respirable PNOR** (particles not otherwise regulated) [#]

- *The estimated range indicates that the level of respirable particulate material being released through fabric-to-fabric abrasion and subsequent passage through the fabric material and inhalation is likely to be at significantly lower levels than exposure limit thresholds.*

[#] PNOR -- Particulates not otherwise regulated, https://www.cdc.gov/niosh/npg/npgd0480.html

Comments to assumptions

- The analysis presented is based on a number of assumptions that are considered to lead to higher release concentration estimates than what would be expected for the HeiQ Viroblock treatment.

1. Treatment basis: The DMDHEU treatment is prone to resin fragments breaking off the fabric surface under abrasion [1]. The loss through abrasion is likely higher for the DMDHEU treatment basis than what would be expected for HeiQ Viroblock NPJ03.
2. Fabric type: The Lamb et al study showed that synthetic fabrics yield significantly lower particle release potential under abrasion than cotton fabrics.
3. Density: The density assumption of 1.2 g/m^3 for material abraded off the fabric is conservatively high and components of the HeiQ Viroblock NPJ03 treatment would be expected to have densities closer to 1 g/cm^3 i.e. a similar density to water and polymers.
4. Abrasion damage: The fabric-to-fabric abrasion profile used in the Lamb et.al. study simulates wear of apparel layers. This level of abrasion would be significantly higher than what would be expected for fabric masks due to the smaller size, mass and overall lower level of pressure between fabric layers that would be associated with face mask articles.

[1] Lamb, G.E., Kepka, S. and Miller, B., 1990. Particle release from fabrics during wear. Aerosol Science and Technology, 13(1), pp.1-7.

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