MEASURING CONSUMER GRADE FACE MASKS DEGRADATION UPON STERILIZATION USING BRIGHT FIELD MICROSCOPY

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Abstract

Droplet transmission is the main route of spreading viruses such as COVID-19, wearing a mask serves as a crucial preventive measure to contain its spread [1]. Most of these masks are made of woven and non-woven fabrics [2], which are also meant to be re-used when properly sanitized [1]. The choice of materials varies from manufacturer to manufacturer as well as the number layers, affecting the mask filtration efficiency, breathability, and re-usability. Sanitizing a mask will extend its lifecycle and contribute to sustainability. Being aware on when a conventional facemask degrades (i.e. reduce its filtration properties after several uses and washing cycles) requires to be investigated aiming to reassure facemask consumers that the product continues to provide protection.

In this work, we propose the use of a bright field microscopy (BMF) system to measure the degradation of several fabrics after sterilization. We evaluate materials used in the production of consumer grade facemasks such as cotton, silk, flannel, bamboo, and metallic substrates. We identify changes in the pore size and associate this with particle penetration after sterilization.

Fabric pre-evaluation was carried out according to the EN 13274-7 standard. A 2% NaCl solution was aerosolised at 52 l/min through the fabric fixed inside the testing chamber. Upstream aerosol distribution was measured using a Palas U-SMPS. Filter efficiency over a 0.2-10µm particle range was measured using a Palas Promo 3000 spectrometer located downstream of the test filter. The fabrics were sterilized using an Eschmann SES3000B set for 32 min sterilization/drying @ 134 °C. The process was carried out for the different fabrics for a total of 5 cycles. Samples of the same pre-evaluated fabrics were mounted on microscope slides. Image J was used for image analysis. Ten images were averaged for each material and autoclave cycle. Thresholding was used to highlight the pore size distribution within the material. This was followed by using the Ferret's diameter to measure the longest distance between any two points along the pores identified within the fabric.

The pre-evaluation results carried out using our particle filtration testing system revealed a ~5% protection for cotton, silk, flannel and metallic fabrics while bamboo, a natural biodegradable material, presented a ~33% protection making it the best material due to its fibers random orientation. We measured the pore size increase at each autoclave cycle using our BMF system and associated this with the filtration data. The results showed an increasing pore size with a linear trend for flannel cotton silk, and bamboo fibers. The metallic fabrics did not show any signs of degradation having similar pore sizes after sterilization.

Given the high protection of bamboo fibers, its filtration properties were then correlated with the pores size. Additional pre-evaluation tests for up to five autoclave cycles were carried out. The bamboo pore size showed an increasing trend of ~1um for each autoclave cycle. We observed that during the first autoclaving cycle, the mask protection steeply reduces in the first two cycles followed by a moderate degradation on cycles 3 to 5 to a final value of 13.5%.

By pre-evaluating a batch of a given face mask fabric and relating this to its pore size, we can potentially use BFM system as an indicative tool to assess degradation without having to run particle filtration tests for each additional manufactured batch. This information can be used by the manufacturer to indicate the maximum number of washing cycles that face mask can tolerate still offering protection against viruses while contributing to its re-usability.

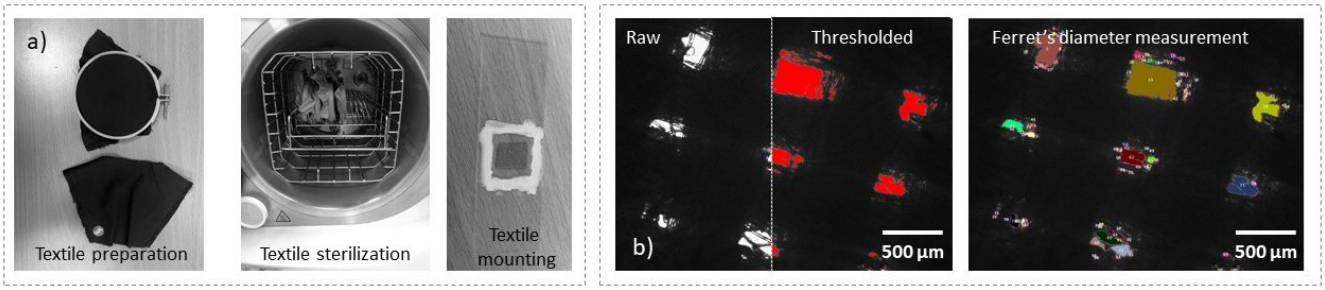

Fig 1. (a) Fabrics preparation for sterilization, b) Image analysis work flow for textiles pore measurement.

References

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