Protective effect of treated cleanroom clothing against infectious droplets

A path to sustainable protective textiles for the healthcare sector

INTRODUCTION

OHB System AG, a subsidiary of European space and technology group OHB SE, has conducted a study to examine the protective effect of cleanroom clothing commonly used in cleanrooms for satellite production against surface interaction with potentially infectious droplets. The ultimate goal is to prevent potentially contagious aerosol droplets from sticking and penetrating the protective clothing. The study was carried out in cooperation with Dastex Reinraumzubehör GmbH & Co. KG, Krüss GmbH, the German Electron Synchrotron DESY, Helmholtz-Zentrum hereon, Volume Graphics GmbH, and Quality Analysis GmbH as well as ILL for neutron tomography. The combination of different methods showed a consistent picture on the repelling effect of the polytetrafluoroethylene (PTFE) treated textiles. The test results show as well the potential for quality control, further textile optimization and indicators for aging for example through washing. It was shown that the selected analytical methods provide quick and useful information to study the interaction of droplets and textiles, act as tool for systematic improvements and to check the quality and potential degradation. The know-how was then used to demonstrate the consistent repelling effect of PTFE modified reusable cleanroom textile after 120 washing cycles without any detectable performance degradation. In addition, the study provided insights into other aspects such as wearing comfort, eco balance and supply chain logistics.

CHALLENGE

Satellites are manufactured in a strictly controlled environment that may only be entered in special protective clothing to prevent contamination of sensitive components by humans. In view of the global coronavirus pandemic and the resulting shortage of suitable protective clothing for medical, nursing staff and caregivers, the aforementioned partners have been working together to investigate whether reusable, PTFE treated cleanroom clothing is also suitable for protecting frontline workers from harmful influences and especially from infectious droplets cross contamination. This case study focuses on the achievements to develop a scientific evaluation method for surface droplet interaction.

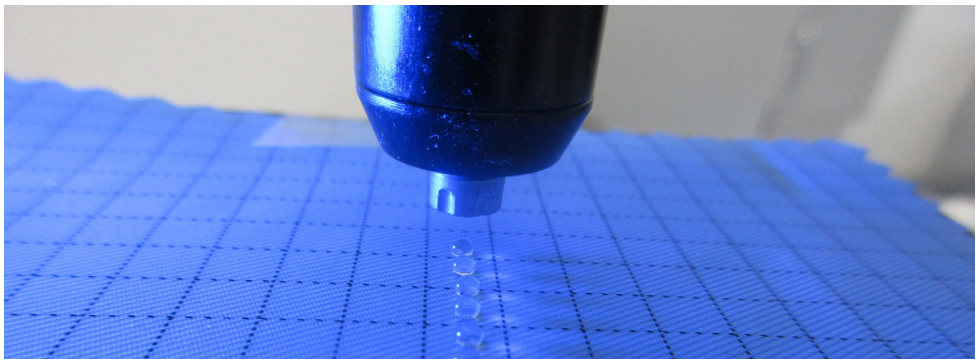
METHOD

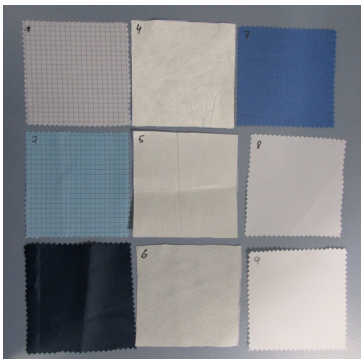
In order to show that cleanroom clothing offers protection against droplet infection and does not lose its protective properties even after 120 washing cycles, it was investigated how droplets emitted by humans behave on different textile surfaces. OHB, Dastex and Krüss received support in carrying out the measurements from Quality Analysis GmbH and the working group of the Helmholtz-Zentrum hereon at DESY, in Hamburg. Volume Graphics GmbH was responsible for the DESY data processing. As a substitute for real saliva drops, droplets of ultrapure water of appropriate size (100 µm) were used. These were applied to the different textile surfaces within controlled lab conditions and images with light, synchrotron and x-ray and neutron radiation were made.

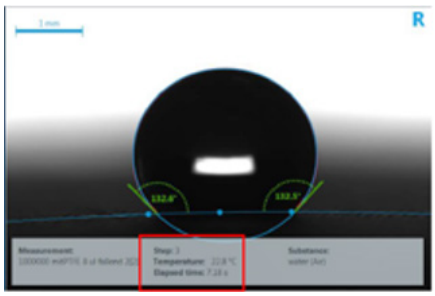
The shape of the droplet, the contact between droplet and textile and the droplet textile grid structure were the interesting parameters in static conditions and as function of time. Based on drop shape and saturation of the textile another key information is the lifetime of the droplet. In more detail the chemical interaction between the textile and the drop can be studied on the contact angle.

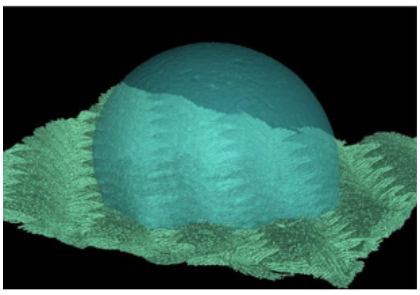
From the shape of the droplet, the contact angle and the onset of drop to surface plus mesh information of the textile protection aspects can be compared. This includes a study of the penetration and evaporation behavior available from the raw data.

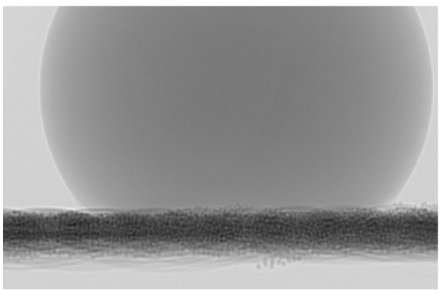
At the synchrotron light source PETRA III at DESY, the scientists from the Helmholtz-Centre hereon contributed to the measurement with high resolution data in 3D. By the means of the non-destructive, brilliant beam the textile structure became visible. This is essential for the data interpretation and subsequent optimization. The high-resolution computer tomographic data can validate even small droplets diffusing in and through the tissue samples. The tomography provided the three-dimensional information plus a detailed view on the textile structure.







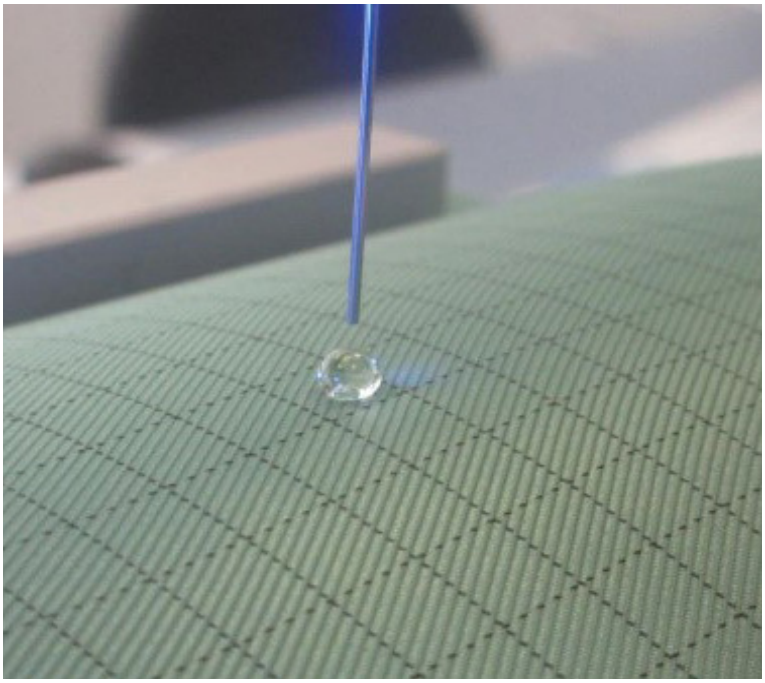




Imaging from the measurements: The drops remain spherical on the textile surface at a contact angle of 140° and hardly adhere to it (Images: research consortium)

KEY BENEFITS AT A GLANCE

- Modified cleanroom clothing can be an alternative to disposable protective clothing, not only for clean room research and production, but also for healthcare workers.
- Disposable protective clothing is largely produced in Asia, whereas reusable clothing is supplied throughout Europe and Germany. A disposable item is replaced by a reusable product and at the same time emissions caused by long supply chains can be reduced.



Sample preparation of textiles for cleanroom clothing (Image: research consortium)

INSIGHTS AND ANALYSIS

Normal cleanroom clothing is not water-repellent, which means that droplets penetrate it after a short time. However, the measurements showed that cleanroom clothing finished with PTFE can keep up with commercially available disposable protective clothing in terms of its water-repellent properties - not only when new, but also shows no measurable degradation even after 120 wash cycles. The drops remain spherical on the textile surface at a contact angle of 140° and hardly adhere to it, which speaks for a good protective effect.
Contact angle measurement can be used as a simple and quick alternative method for sampling textiles. This offers the advantage that the protective effect of textiles against infectious agents can also be investigated outside specialized laboratories. However, for a deeper understanding of the parameters influencing the contact angle, more sophisticated approaches, such as those that can be provided by DESY, are mandatory. Chemical and structural information are key parameters that need to be investigated. In this respect the scientific background can motivate pass fail criteria for product selection at purchase, quality or service laundry level. For further understanding of the parameters influencing the contact angle additional synchrotron measurements are mandatory. Chemical and structural information are key parameters to be investigated.

Experimental Setting of Beamline P05 at PETRA III, where the x-ray measuerments took place. (Image: hereon / C. Schmid)

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