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Chemical and Biomedical Engineering _Vaporized Hydrogen Peroxide N95 Decontamination Summary

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Evaluation of Vaporized Hydrogen Peroxide for the Decontamination of N95 Filtering Facepiece Respirators

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The critical shortage of filtering facepiece respirators (FFRs) such as N95s due to the COVID-19 pandemic has resulted in the need for re-use of these devices in the medical community. Here, we review the evidence for the effectiveness of one decontamination method, vaporized hydrogen peroxide (VHP), with particular focus on its effectiveness against the novel human coronavirus (SARS-COV-2) and its effect on N95 structure and function.

VHP is effective against a SARS-COV surrogate on surfaces. VHP is a known and widely-used method for surface decontamination in hospital settings.[1] This method is usually considered to become effective at H2O2 concentrations above 80 ppm, with cycle times dependent on the size of the chamber, desired concentration, and delivery method.[2] Although already established as an effective decontamination method against both enveloped and nonenveloped viruses,[3] recent research has confirmed that HPV is virucidal (>4-log reduction) against transmissible gastroenteritis coronavirus of pigs, a surrogate for SARS-COV.[4] In this work, the virus was dried onto stainless steel disks then incubated for 2-3 h in a chamber filled with at least 125mL H_2O_2/m^3. Along with UV, VHP treatment was the centerpiece of OR surface decontamination procedures used in Singapore to successfully fight the COVID-19 outbreak.[5]

VHP does minimal damage to N95 FFRs. In 2009, Schaffer and colleagues at the National Institute for Occupational Safety and Health (NIOSH) examined various decontamination procedures, including VHP, for 6 different types of N95 FFRs. For VHP treatment, the samples were hung on string stretchin across the length of a room which was then treated with a Room Bio-Decontamination Service unit (Bioquell UK Ltd) with a vapor generator using 30% H_2O_2.[6] They found VHP ($8g/m^3$ for 125 min followed by overnight aeration) to be one of the most promising methods of decontamination, preserving low levels of filter aerosol penetration and proper airflow resistance.[7] However, they did notice that the nosebands in masks treated with VHP were slightly tarnished compared to untreated controls. In 2010, the group examined a 3-cycle decontamination treatment of the same set of N95s, showing that the filtration and airflow properties continued to be preserved.[6] These experiments also included examination of hydrogen peroxide gas plasma treatments (STERRAD 100S 55 min short cycle), which were shown to increase levels of aerosol penetration to >5%, particularly on those masks that were not stacked with others.

VHP inactivates an enveloped virus on N95 material. Recent work from the US EPA tested the efficacy of VHP against Phi6, an enveloped bacteriophage which is a recognized surrogate for the Ebola virus.[8] Using squares cut from N95s, they found that low concentrations of VHP (25 ppm) were effective at deactivating the viruses after 2h of exposure as long as there was no blood present on the surface. If blood was present, a higher concentration was required (>400 ppm) for a longer time (24-32 h) to achieve a 2-6 log reduction in the presence of phages. These results confirm that wherever possible, only visibly clean masks should be decontaminated and reused.

Limitations. There are no readily-available studies that I could find at this point using VHP to inactivate of virions that have been pulled through the N95 material via negative pressure (such as would occur during respiration). It is therefore difficult to say if VHP or any other sterilization technique would be adequate to inactivate virions within N95s as opposed to only on the surface. In addition, all studies on the deactivation of viruses via VHP as well as other techniques report a several-log reduction in viral load (decontamination). It should be noted, however, that this does not equate to perfect sterilization. At this point, the recommendation by experts is that while decontamination of FFR via various methods (such as VHP) has shown some promising results, more research is needed before the practice could be formally accepted.[9]

References

1. Andersen, B. M., Hochlin, K. & Daling, J. P. Cleaning and decontamination of reusable medical equipments, including the use of hydrogen peroxide gas decontamination. *J. Microb. Biochem. Technol.* **4**, 57–62 (2012).
2. Chou, S. F., Overfelt, R. A. & Gale, W. F. Effects of Hydrogen Peroxide on Common Aviation Textiles Federal Aviation Administration. (2009).
3. Zhang, X., Mirshahidi, S. & Chen, C.-S. Decontamination of Biobank Facilities. in 227–241 (Humana Press, New York, NY, 2019). doi:10.1007/978-1-4939-8935-5_20
4. Goyal, S. M., Chander, Y., Yezli, S. & Otter, J. A. Evaluating the virucidal efficacy of hydrogen peroxide vapour. *J. Hosp. Infect.* **86**, 255–259 (2014).
5. Wong, J. *et al.* Preparing for a COVID-19 pandemic: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. *Can. J. Anesth. Can. d'anesthésie* 1–14 (2020). doi:10.1007/s12630-020-01620-9
6. Bergman, M. S. *et al.* Evaluation of multiple (3-Cycle) decontamination processing for filtering facepiece respirators. *J. Eng. Fiber. Fabr.* **5**, 33–41 (2010).
7. Viscusi, D. J., Bergman, M. S., Eimer, B. C. & Shaffer, R. E. Evaluation of five decontamination methods for filtering facepiece respirators. *Ann. Occup. Hyg.* **53**, 815–827 (2009).
8. Wood, J. P. *et al.* Evaluating the Environmental Persistence and Inactivation of MS2 Bacteriophage and the Presumed Ebola Virus Surrogate Phi6 Using Low Concentration Hydrogen Peroxide Vapor. *Environ. Sci. Technol.* (2020). doi:10.1021/acs.est.9b06034
9. Fisher, E. M. & Shaffer, R. E. Considerations for recommending extended use and limited reuse of filtering facepiece respirators in health care settings. *J. Occup. Environ. Hyg.* **11**, (2014).