Test the filtration efficiency of N95 masks recovered using an electrostatic charging device

Gabriela Ornelas & Rowan Carroll. Faculty Advisor: Dr. Liangcheng Yang
Department of Health Sciences Environmental Health and Sustainability Program, Illinois State University

Background

N95 respirators are crucial in protecting frontline workers at high risk for coronavirus disease. This COVID-19 pandemic has caused a shortage of N95 respirators, resulting in users relying on decontamination methods to combat supply scarcity. Decontamination, environmental factors, and repeated use of the respirators can reduce the N95 performance. The electrostatic charge of the fibers within the N95 respirator is what permits the facepiece to achieve a high filtration level for viruses and small size particles. This study aimed to improve the N95 respirator filtrating ability by using a high-voltage recharger to increase electrostatic charges.

Conclusions

- Recharging the N95 respirators increased the filtration efficiency of small size particles, which can aid in the shortage of N95 respirators.
- The use of electrostatic rechargers may allow for increased protection, efficiency, and reuse of N95 respirators.

Future work

A proposal has been submitted to the NIH SBIR Phase 1 program to further develop this technology.

References

E. Hossain, S. Bhadr, H. Jain, S. Das, A. Bhattacharya, S. Ghosh, D. Levine, Recharging and rejuvenation of decontaminated N95 masks, Physics of Fluids, 32 (2020) 093304.

S. Rengasamy, A. Miller, E. Vo, B. Eime, Filter performance degradation of electrostatic N95 and P100 filtering facepiece respirators by dioctyl phthalate aerosol loading, Journal of Engineered Fibers and Fabrics, 8 (2013) 62-69.

Acknowledgement

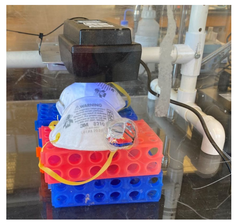
This project was sponsored by F.N. Smith.

Methods

Step 1: Mimic mask use
Masks were submerged into artificial saliva solution for 10 minutes.

Step 2: Decontamination methods

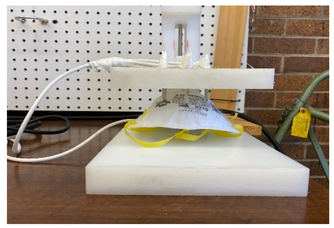
Cooking: sets of 3 masks cooked for 30 minutes at 149F, with the cover on (CDC recommended).



UV: irradiated 3" under a UV lamp with 254 nm for 30 min. Intensity: 5600 μW/cm².

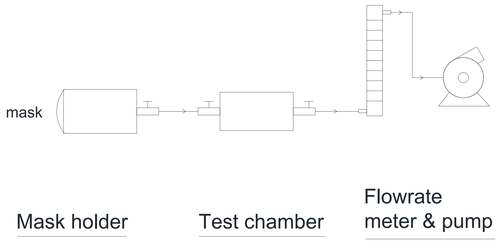
Step 3: Air drying
Air dry in a hood for overnight.

Step 4: Charging



Recharger design: made of ultra-high molecular weight polyethylene, with four adjustable electrodes
Charging: electrodes touch the mask. Charging for 5-min, with a power supply of 1,000 volts and 0.5 milliamps .

Step 5: Filtration tests



The N95 masks were fitted to a mask holder made of PVC. The vacuum pump flowrate was 10 L/min. Particle concentration of the air after filtration was measured using a particle counter. Each sample takes 45 seconds. The mask pressure drop was measured.

Results

- Figure 1: Charging of new masks increased the average filtration efficiency from 93.1% to 97% for 0.3 micrometer particles.
- Figure 2: Charging of used-and-UV decontaminated masks increased the average filtration efficiency from 92.8% to 94.3% for 0.3 micrometer particles.
- Figure 3: Filtration efficiency didn't decrease after going through the reuse-decontamination (cooking)-charging cycle twice (97% for 0.3 micrometer particles), but slightly decreased after the third time (93.6%).
- Pressure drop cross the mask was minimal in all tests.

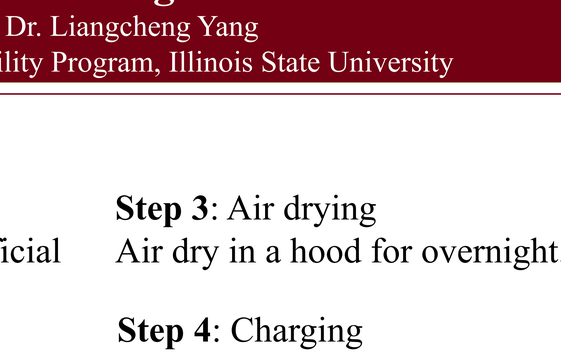


Figure 1

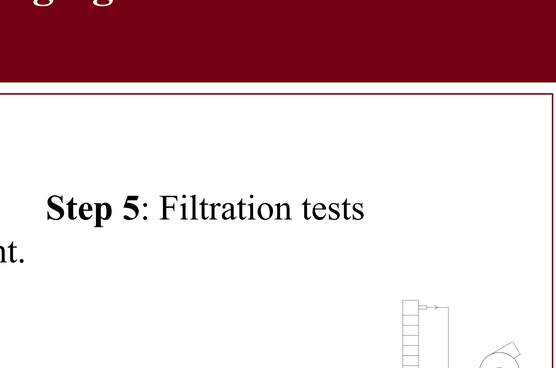


Figure 2

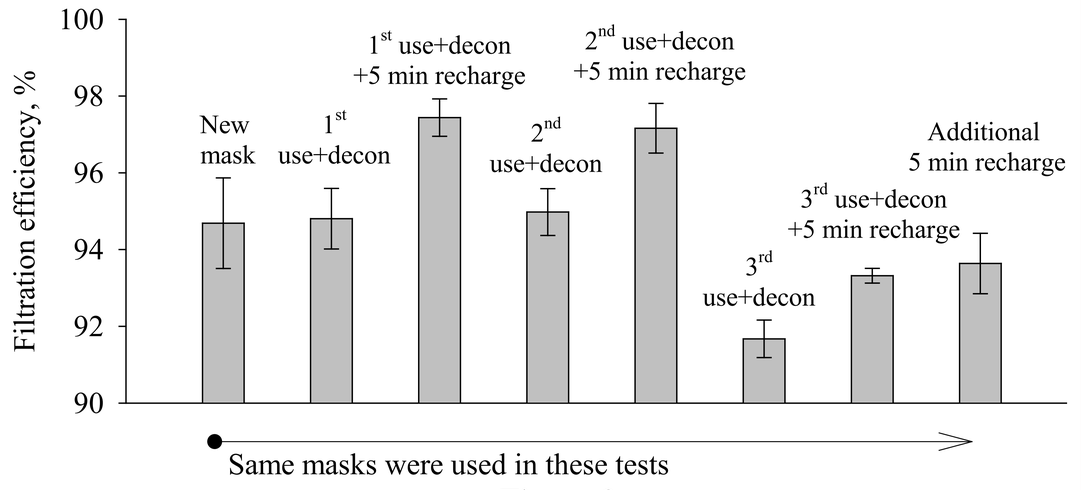


Figure 3