Evaluation of the Efficacy of Fabric Face Masks on the Number of Wash During the Outbreak of Coronavirus (COVID-19)

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Background

The main objective of this study was to test the efficacy of common face masks worn by on-campus Mercer students after washing: nylon neck-gaiter, white cloth, and black Mercer-made mask. In March 2020, the outbreak of the coronavirus pandemic that has been spreading throughout most countries in the world has cost many innocent lives regardless of advanced medical technology. Wearing a mask has been proven to lower the chance of spreading the virus from the patient to be 1.5% (Lawrie, 2020). By providing the general population, especially the Mercer community, individuals will be able to make wise decisions to choose which face mask to wear along with social distancing practice to protect themselves from the virus during the COVID pandemic.

Figure 1. Face Masks in the Study: Nylon Neck-Gaiter, White Cloth, and Back Mercer.

Method and Analysis

The efficacy of face masks is described by (1) filtration efficiency - percentage of particles blocked by the face mask and (2) pressure drop - amount of air flow resistance that determines how hard it is to breathe. The face masks were clamped by a circular-shaped filter holder. Air runs through the mask to measure the pressure drop in cmH_2O by using a dual-port manometer (Fieldpiece SDMN5). The filtration efficiencies were tested using the laboratory set-up machine consisting of a Constant Output Atomizer (COA, TSI Aerosol Generator 3076), diffusion dryer, facemask sample holder, Wide-range Particle Spectrometer (WPS - 1000XP), flowmeter, and vacuum pump. This setup allowed the facemask sample material to work as a "filter" as it provides the barrier to the transport of aerosol particles made up of sodium. Concentrations of sodium particles in the air after passing through the face masks (filtered) and before the face masks (unfiltered) were measured using the WPS, which measures the concentration of particles in the range of total, nano, submicron, micron, and airborne sizes. The efficacy of three types of face masks was evaluated based on the pressure drop and the filtration efficiency (FE = ((filtered-unfiltered)/unfiltered)*100). After each measurement, face masks were washed and repeat these washings for seven times.

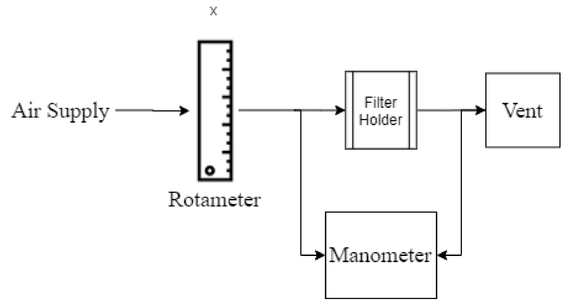

Figure 2. Pressure Drop Diagram.

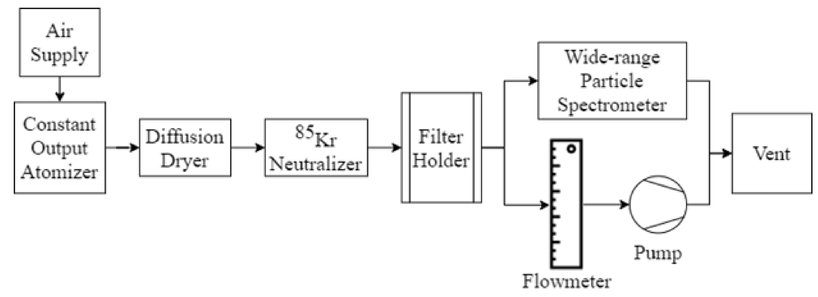

Figure 3. Filtration Efficiency Diagram.

Results

The white cloth mask has the overall highest pressure drop, and the nylon neck-gaiter has the overall lowest pressure drop. The pressure drop for each of the three types of face masks has an increasing trend after each wash. This is explained by the deterioration of the threads on the face masks that become hairy and fill the space gaps after each wash. In the FE evaluation, the white cloth mask has the overall highest FE in all total, nano, submicron, micron, and airborne sizes, whereas the nylon neck-gaiter has the overall lowest FE in all sizes, respectively. Since this study focuses on how face masks perform during the outbreak of coronavirus, the analysis mainly focuses on the FE in total and airborne sizes. The white cloth mask, again, has the highest FE (FE_{Total} and $FE_{Airborne}$ around 30%), then the black Mercer-made face mask (FE_{Total} and $FE_{Airborne}$ around 20%), and the nylon neck-gaiter has the lowest FE (FE_{Total} and $FE_{Airborne}$ around 0%). The durability of all three face masks after seven times of washing does not have an exact positive or negative slope relationship, and this could be affected by how the particles moved during washing. This suggests saving by washing and reusing the face masks.

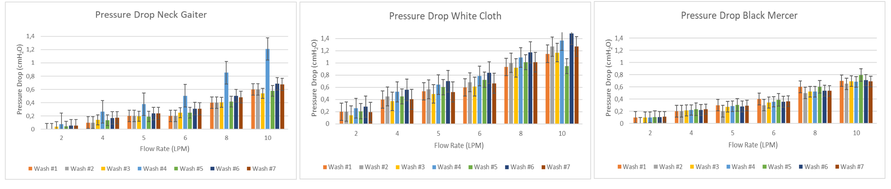

Figure 4. Pressure Drop Summary.

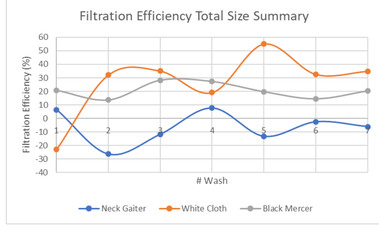

Figure 5. Filtration Efficacy in Total Size.

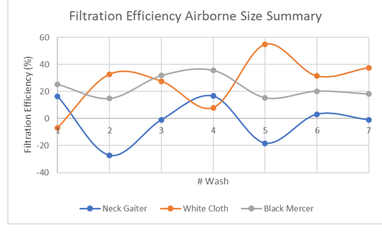

Figure 6. Filtration Efficacy in Airborne Size.

Conclusions

The current study results in a good indication of the efficacy and durability of the face mask materials. The findings will become extremely important for society, especially the Mercer University community. Faculty, staff, and students are recommended wearing appropriate face masks and practicing social distancing to enhance the prevention of community spreading of the coronavirus.

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References:

Lawrie, E. (2020, May 19). Coronavirus: Ryanair boss's face mask claim fact-checked. Retrieved from https://www.bbc.com/news/52707461