Universiteit Utrecht

Research Proposal: Aerosol adherence in face masks

The dynamics of capture and fate of exhaled COVID-19 loaded droplets in multi-layer porous materials. A combined experimental and simulation study into safety provided by face masks during daily use.

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Background Face masks are considered a vital asset to prevent the spreading of COVID-19. Face masks provide safety in two directions: The first is preventing exhaled droplets from COVID-19 positive individuals to be released into the air. Second, face masks filter inhaled air from fluid droplets containing COVID-19 viruses.

Face masks are specified by the percentage of blocked solid dust particles. However, the transport mechanisms of fluid droplets through a porous material is completely different from transport mechanisms of small solid particles. Understanding the dynamics is vital in evaluating the effectiveness of using face masks under various circumstances.

The capture mechanism of exhaled droplets (microdroplets and aerosols) is a combination of wetting properties and capillary action and determines the initial location of the droplet within the mask. Potentially worrying is the scenario that a gradual increase in saturation level of the face mask will drive COVID-19 containing fluid towards the exterior of the face mask. Even worse would be the generation of droplets (including aerosols) from the fluid, leaving the mask upon, for example, coughing through the mask. A solution to this would be replacing the face mask before certain saturation levels are achieved. In addition, the pore size distribution of the exterior could be designed such that only large droplets can be forcefully expelled, which would drop faster to the ground than aerosols.

Proposed work We have identified five key mechanisms to be characterized for a full safety assessment of face masks under various circumstances. We will study the individual mechanisms in detail through experiments and computer simulations before we combine the mechanisms into the full model. The individual mechanisms are:

1) The initial location of impinging droplets within the mask.

2) Pushing and pulling by breathing in and out and talking/singing/coughing.

3) Evaporation of the droplet humidity air.

4) Coalescence with additional droplets and subsequent redistribution across the porous material.

5) The potential for fluids to sputter from the other side and if sputtering occurs, in what form (droplet size) and what velocities.

Utrecht University The Environmental Hydrogeology group has a strong position in both experimental and computational work related to fluid dynamics in porous media. The 3D pore structure will be analyzed by advanced confocal scanning laser microscopy (CSLM) and electron microscopy, facilitating accurate computer models. CSLM will be used to study the dynamics validating computer simulations. Existing OpenFOAM simulations are already in place, ready to simulate the mechanisms occurring in the mask.