Droplet by Droplet

Scientists test the protective effect of different materials for face masks against the virus

In Southeast Asia they have become the norm. In Europe, the wearing of simple face masks, whether surgical masks or self-stitched, is under discussion. Opinions on what protection these masks actually offer still differ widely, even within the scientific community. It will be some time before there are really comprehensive and internationally confirmed scientific studies on this subject. "But in my opinion, we as a society cannot afford to wait until this data is available before making a decision," says Prof. Dr. Oliver Paschereit, head of the Department of Fluid Mechanics at the TU Berlin, who is now conducting scientific tests on the protective effect of face masks as part of a newly applied for project. The idea for the project was born during a telephone conversation with his group leader, Dr. Sebastian Schimek: "Couldn't our scientific expertise in the field of fluid mechanics contribute to enriching the discussion about the wearing of masks with scientific facts? It was during this telephone call that we developed the basic outlines of the project."

The air that an infected person breathes out or that is released when they sneeze contains viruses. The single SARS-CoV-2 virus is only between 60 and 140 nanometers in size. The risk of infection increases with the number of inhaled viruses. It is currently assumed that individual viruses play a subordinate role in the air we breathe in and that the risk of infection is mainly caused by droplets in the air we breathe in. The larger the droplet, the more viruses it can contain. However, the smaller a droplet, the slower it sinks to the ground - small droplets can therefore spread more easily and further.

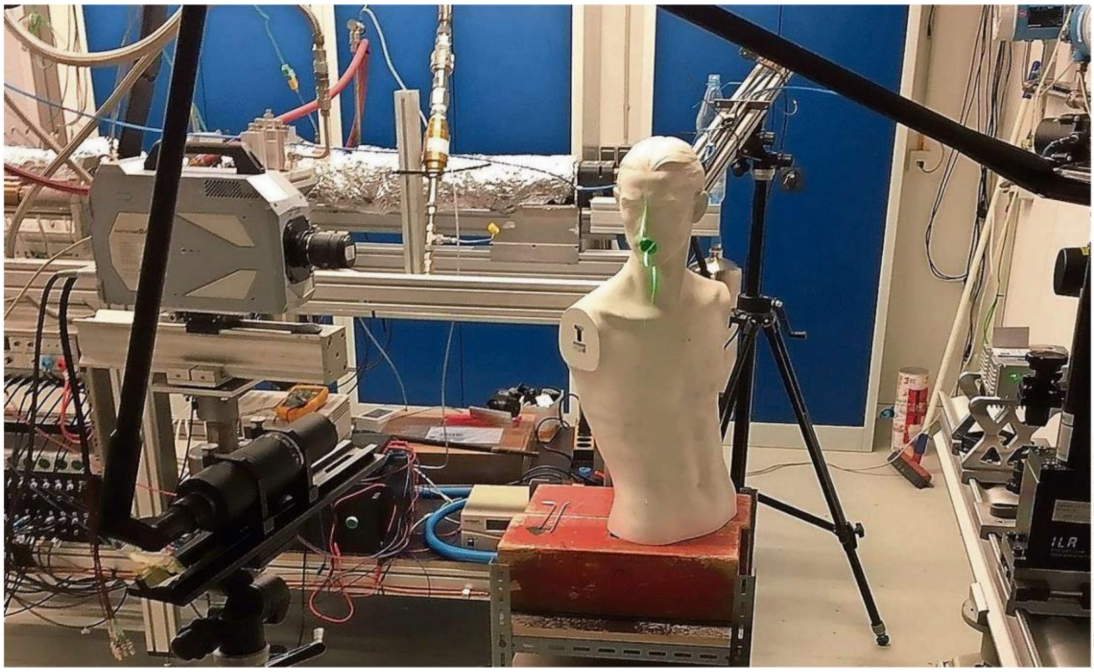
"We have focused our investigations on particle mists, so-called aerosols, with droplet sizes in the range of five to fifty micrometers, which correspond to those in exhaled air. We can generate these aerosols artificially in the laboratory," explains Oliver Paschereit. Two different experiments are used to investigate coughing and sneezing processes as well as the inhalation of aerosols.

"We use a model of a head that looks a little like a mannequin. The aerosol is introduced into the model through a nozzle and then expelled through the mouth at a typical speed, droplet load and droplet size. The sneezing or coughing process is simulated by a quickly opening solenoid valve," explained the scientist. The process of coughing and sneezing can be visualised and measured by illuminating the inhaled or exhaled aerosol with a laser beam or a powerful LED lamp. Images are captured using the Photron FASTCAM SA-Z high-speed camera and the distribution of the drops is determined. The advantage of this experimental setup is that it enables completely comparable and reproducible conditions. "A comparison of the droplet distribution for a "coughing" model with and without a mask allows us to assess which masks prevent or at least make it more difficult for certain droplet sizes to spread," says Sebastian Schimek.

Initial results show that there are significant differences in the filter effect of different masks. Some of the masks investigated in the experiment retained only about 75 percent of the liquid volume. Conversely, this means that 25 percent of the potentially infectious liquid passed through the mask and was released into the room. With other masks however, almost no droplets could be detected after the mask. "We were very surprised by the extreme deviations in the filter properties. Of course, every type of mask helps to reduce the spread of droplets when breathing, coughing or sneezing, but with widely varying efficiency. Above all, the mask must fit well so that air does not escape unfiltered," says Oliver Paschereit. "This makes it all the more important to consistently adhere to the rules of distancing and other recommendations for hygiene despite the mask. Relying solely on the protective effect of self-sewn masks would be absolutely disastrous".

During the tests regarding the protection against the inhalation of aerosols, the engineers create a corresponding aerosol in a room and suck in the air through the mouth and nose of the model - comparable to the process of inhalation. Measuring the particle distribution in the transparent suction tube behind the mask allows the droplet size and quantity of the inhaled aerosol to be measured. The setup simulates realistic conditions, since it takes into account that the masks usually do not completely seal the mouth and nose, but allow air to flow in and out at the sides. Pressure and volume flow measurements show how much unfiltered air can enter and exit the sides of the mask.

Until now, Oliver Paschereit’s team has investigated a small number of commercial and self-made masks. Among them were those sewn at TU Berlin through the initiative of Dr. Josephine Barbe, researcher in the Department of Economic Education and Sustainable Consumption, and a team of tutors. "These masks, some of which use a special filtering material, show very good retention properties in initial experiments. In further experiments, however, we will test the suitability of masks from other institutional partners as well as various materials," says Oliver Paschereit. These simple masks cannot prevent every infection from SARS-CoV-2. "But we will be happy if our investigations contribute to a better evaluation of the protective measures they afford," says the scientist.



Fotos: FG Experimentelle Strömungsmechanik (2), TU Berlin/ Dominic Simon

Tests with a model of a head in the laboratory for fluid mechanics. The mouth opening is illuminated by the laser light. A Photron FASTCAM SA-Z high-speed camera records the intensity of the reflected light as it "exhales".

Breathing under illumination. The droplets "exhaled" by the head model become visible in the laser light.

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