THE WALL STREET JOURNAL.

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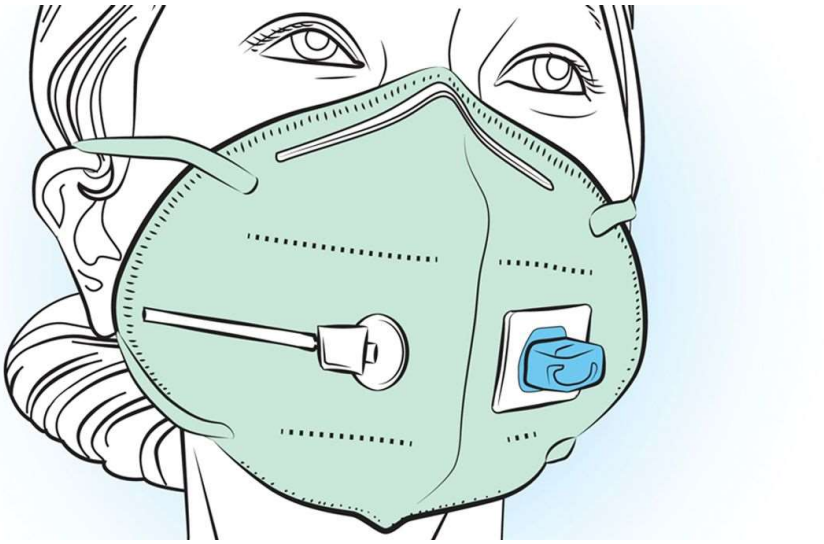
High-Tech Face Masks Aim to Step Up the Fight Against Covid-19

A new generation of coverings could last longer, diagnose Covid and actually kill viruses.



By Suzanne Oliver

The face mask is getting a high-tech upgrade.

Models now in testing do more than provide a physical barrier between the wearer and potential viruses. Materials scientists, chemists, biologists and engineers have created working prototypes of masks that include diagnostics, sensors and even the ability to kill viruses.

In the near future, if you're on a plane and the person next to you sneezes, you could be wearing a mask that sterilizes the air before you breathe it in.

Some of these new masks are designed for healthcare workers, while others will be

marketed to both healthcare workers and consumers. Masks and respirators marketed as medical devices or as worker protection must be approved for sale by the Food and Drug Administration or the National Institute for Occupational Safety and Health, or Niosh. (Respirators are masks that provide a tight seal to the face, such as the N95, and must be appropriately fit to provide their ideal protection.)

"I am excited by the attention being paid to masks," says Christopher Sulmonte, project administrator for the biocontainment unit at Johns Hopkins Medicine. The new ideas "have some scientific rigor to them," he says. "Once we see how they function, we will start to see which tools make the most sense."

Share Your Thoughts

What kind of masks would you like to see developed? Join the conversation below.

With all of the independent efforts to provide new and more effective protection against Covid-19, meanwhile, consumers might struggle to evaluate different products. "It has almost been like the Wild West," says Albert Ko, department chair and professor of epidemiology and medicine at the Yale School of Public Health. "There are no benchmarks. We need harmonizing standards so we can compare one mask to another."

Ana Rule, director of the Exposure Assessment Laboratories and an assistant professor at the Johns Hopkins Bloomberg School of Public Health, says, "We are seeing innovations that will make mask wearing safer and more environmentally friendly."

While Prof. Rule applauds greater reusability and the addition of diagnostics and sensors in masks, she is skeptical about one innovation: antimicrobial coatings. Better, she says, is simply to wear a tight-fitting N95 mask.

"If you have a coating on your mask and a gap around your nose or mouth, the virus particles are going to get in that way," says Prof. Rule, who is also a member of the Technical Advisory Group on Personal Protective Equipment at the World Health Organization. "The aerosol droplets take the path of least resistance," she says. "And the antimicrobial coatings may lead to additional antimicrobial resistance in the environment."

Here's a look at some of the masks in development.A smart, long-lasting N95 respiratorBecause of mask shortages, healthcare workers have been wearing masks for longer than is recommended, and reusing masks degraded by sterilizations with steam, hydrogen peroxide vapor and ultraviolet light. Over time, the sterilization degrades mask filtration and fit, and workers become less protected.

A new type of mask soon to be submitted for evaluation by Niosh remains effective for longer than many masks now being used because it stands up better to multiple sterilizations, including using such aggressive methods as boiling, but also sterilization by heat, UV treatment and isopropyl alcohol.

These transparent, silicon-rubber masks, which feature pop-out, disposable N95 filters, are the work of a team led by Giovanni Traverso, assistant professor of mechanical engineering at the Massachusetts Institute of Technology and a gastroenterologist at Brigham and Women's Hospital, Harvard Medical School. The masks have sensors that give feedback on fit and functionality. A heat-sensitive coating on the perimeter of the mask indicates a fit to the skin by changing color from black to pink. In testing at Brigham and Women's and at Massachusetts General Hospital, all wearers achieved a proper, protective fit, and only 5% said they preferred the standard, N95 hospital-supplied mask. Users said they also appreciated that the mask's transparency enabled them to communicate better through reading lips and facial expressions.

The team's research was published in ACS Pharmacology and Translational Science in November.

Jason Troutner, president of Teal Bio, which plans to manufacture the respirators in the U.S., says that he anticipates the product will be available to purchase this year at a price that is competitive with disposable N95s.

Virus-killing masksCurrent masks function as barriers to virus particles. Michael Strano, a professor of chemical engineering at MIT, is developing a mask designed to actually kill virus. "Filtering has its place, but so does just destroying the virus," says Prof. Strano.The mask design incorporates a copper mesh heated to about 160 degrees that traps and deactivates the virus. Neoprene insulation and a thermoelectric cooler will ensure the inhaled air is comfortable to breathe. "You actually breathe medically sterile air," says Prof. Strano.The mask, which also kills bacteria and mold, can be run on a 9-volt battery. Prof. Strano and his team are still building and testing mask prototypes, and their current research has been accepted for publication by AIChE Journal, a chemical-engineering publication.

Prof. Strano expects each reusable mask to weigh about a half-pound, to cost just a few dollars and, if approved by regulators, to be available in two models—a slightly larger version for use by healthcare personnel and first responders, and a smaller version for the consumer market.

A mask from U.K.-based Medi-Immune Ltd. takes a different approach to killing virus. It

uses UVC light to sterilize air that is drawn into a small chamber that can be worn on a belt or in a backpack. A hose from the chamber goes to the mask, and a fan maintains positive pressure in the mask to ensure any possible leakage is outward. Exhaled air passes through filters on the sides of the mask.

In animal tests performed by Public Health England in 2017, the mask was as effective as a vaccine in preventing influenza, says Nigel Silman, visiting chair of infectious diseases at the University of the West of England who was involved with the research.

U.K.-based Mackwell Health, which has partnered with Medi-Immune to make the device, is currently seeking device certification from the British Standards Institute and plans to seek Niosh approval in the U.S. The rechargeable, battery-powered mask is expected to cost near $500, and will be marketed to healthcare workers.

Diagnostic masksMasks collect evidence of infection in each wearer's exhalations, so, why not use them to test for Covid-19?

Researchers at Harvard University's Wyss Institute for Biologically Inspired Engineering have figured out how to integrate a freeze-dried diagnostic Covid-19 test into a face mask. The test reacts with exhaled particles and gives a diagnosis in 90 minutes or less.The tests and a tiny blister pack of water can be mounted on any mask. After the mask has been worn for at least 30 minutes, a person punctures the blister pack to release the water needed to rehydrate and run the reactions. The test result is indicated by one or two lines, similar to a pregnancy test."Think of our diagnostic reactions as ramen soup," says Peter Nguyen, a Wyss Institute research scientist and co-first author on the research. "We have taken these diagnostic assays and, keeping with our analogy, separated the water from the noodles. We just mix them back together when you want those reactions to occur."

The researchers tested their technology by putting their masks on a breathing simulator that exhaled a snippet of SARS-CoV-2 RNA in aerosols similar to those generated by humans. The researchers found that their test performed as well as FDA-approved Covid-19 RT-PCR tests. "We can match the current technology for detecting the virus," says Dr. Nguyen, who has a Ph.D. in biochemistry. The paper detailing their research is currently being reviewed for publication. The mask is subject to FDA approval.

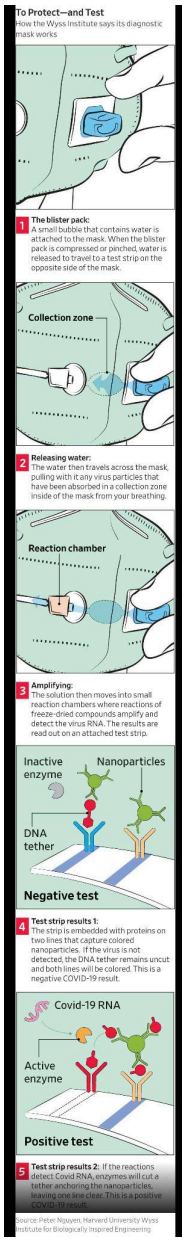
The Wyss team, led by James J. Collins, core faculty member of the Wyss Institute, Termeer professor of medical engineering and science at Massachusetts Institute of Technology, and a member of the Harvard-MIT Health Sciences & Technology faculty, expects the product to cost about $5. The technology can be targeted to identify other viruses and variants as well.

A team led by Jesse Jokerst, an associate professor of nano-engineering at the University of California, San Diego, is also working on a mask-mounted Covid-19 test. This test is contained in a sticker that can be applied to any mask. Unlike the Wyss Institute test, which identifies SARS-CoV-2 RNA, the UC San Diego test identifies the presence of a protease produced in the body during a Covid-19 infection.

Prof. Jokerst and his team, whose work is part of the National Institutes of Health's Rapid Acceleration of Diagnostics Program to address gaps in Covid-19 testing and surveillance, have tested their technology with human saliva samples and are preparing to test in humans.

The professor believes the cost of the sticker will be just a few cents each.

Ms. Oliver is a writer in New York. She can be reached at reports@wsj.com.



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