OPTICS & PHOTONICS NEWS

Research News

COVID-19: Putting UV-C to Work

Stewart Wills

Editor's note: *Exposure to UV-C light poses known threats to human health. While the research discussed in this story examined ways that UV-C might be broadly deployed to stem the spread of COVID-19, it is presented only as information about new research.* ***Readers are strongly cautioned not to experiment on their own with UV-C as an antimicrobial measure.***

COVID-19 has upended society and brought chaos to generous swaths of the global economy, as governments have "locked down" to prevent the spread of the virus. The pandemic has also boosted interest in a variety of technologies that might help in the coronavirus fight—including the use of ultraviolet light to sterilize scarce personal protective equipment (PPE) such as face masks, for reuse.

In recent papers, two research teams have now proposed approaches to take the use of UV-C much farther. The two groups lay out different schemes for using this high-energy light to scrub the pandemic virus from the air in occupied indoor spaces—while still keeping the occupants safe from the usual harmful long-term effects of exposure to UV radiation. The teams argue that the approaches they suggest, if widely adopted, could sharply reduce viral transmission in public indoor spaces, and thereby help the world resume something closer to normal economic activity.

Long-standing technology

The antimicrobial effects of UV-C light—which occupies the wavelength band from 200 to 280 nm—have long been known, and 254-nm mercury-vapor germicidal lamps are routinely used to disinfect empty hospital rooms, clean up tainted water, and otherwise cleanse surfaces and areas where bacteria and viruses may lurk. The problem is that the same light that hammers pathogenic airborne bacteria also wreaks havoc on human cells, with long-term impacts such as skin cancer and eye damage.

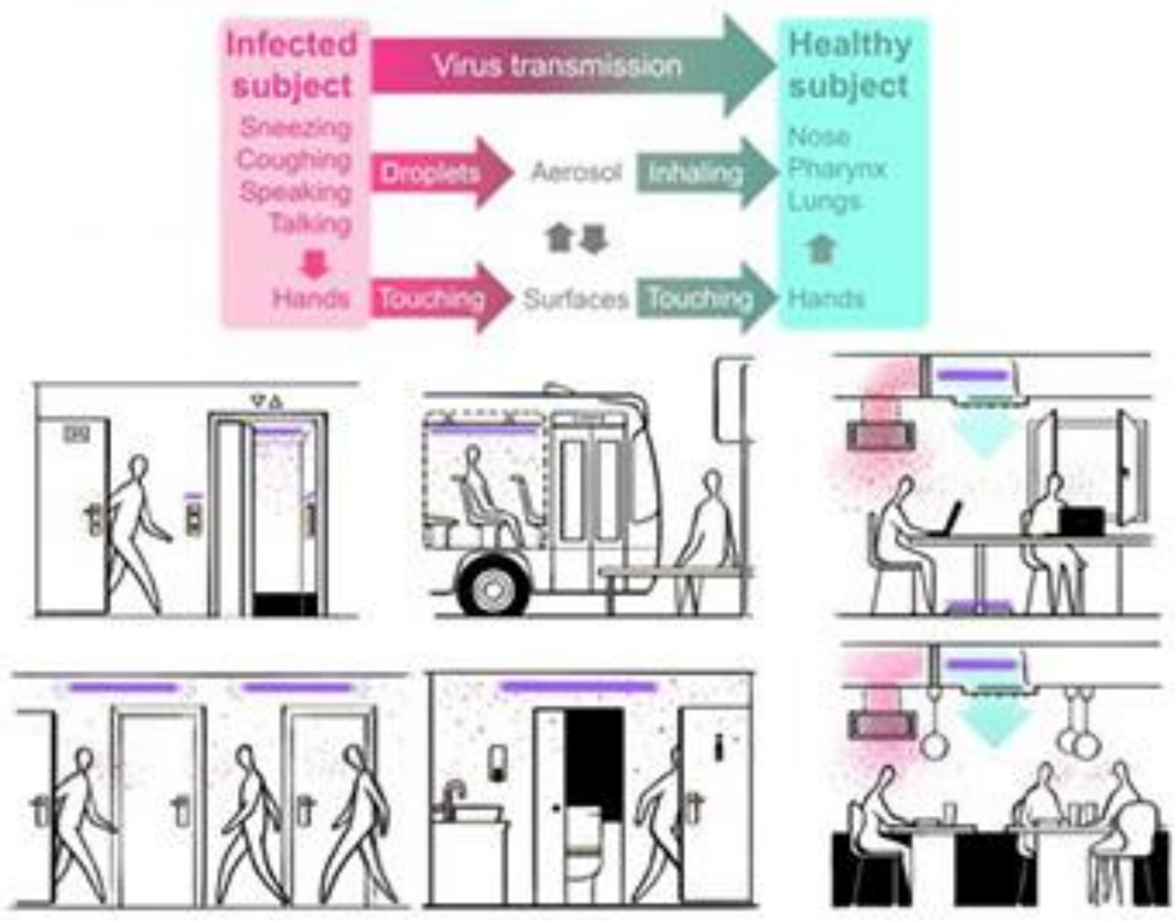
As a result, much of the recent interest in leveraging UV-C light against the COVID-19 virus, SARS-CoV-2, has centered around possible uses in disinfecting PPE for doctors, nurses and first responders. (One such effort, focusing on a low-cost system that can be used to disinfect scarce N95 face masks for reuse in resource-limited areas, is being pursued by an interdisciplinary team including OSA Fellow and past president Thomas Baer.)

Attacking sources of viral spread

The teams behind the two recent papers favor substantially broadening the use of UV-C against SARS-CoV-2. They suggest that, with the right precautions and setups, the light might be used as a prophylactic in occupied indoor spaces such as workplaces, schools, hospitals and other public areas, silently scrubbing the air of the coronavirus even as the occupants of the buildings go about their daily lives.

One of the studies was led by OSA Fellow Javier García de Abajo of the Institute of Photonic Sciences–ICFO, Spain, and tapped a multinational, interdisciplinary team of researchers in virology, aerosols, immunology and other areas (ACS Nano, doi: 10.1021/acsnano.0c04596). In the study, the researchers looked at how the judicious, strategic installation of UV-C sources might attack the most common routes of indoor viral transmission.

The team began by inventorying the indoor places and systems most likely to spread the virus. These, the researchers argue, include interior ventilation systems in a wide range of settings, which can spread airborne viruses; infrastructure items touched by many persons, such as elevator buttons, stair rails and public-transit handles; and common public facilities with repeated, periodic high use, such as public toilets, storerooms and other areas.



The ICFO-led team argues that antimicrobial UV-C light sources could be placed in a variety of locations associated with viral spread, such as ventilation systems and other areas. The lamps could then be operated without a direct optical path to humans, or while the rooms are not in use, to help reduce virus propagation without endangering human health. [Image: Sketches by Nacho Gaubert]

Targeted approach

The team then analyzed how a range of UV-C sources, including LEDs and conventional mercury-vapor lamps, could be safely deployed to attack coronavirus in these individual spread scenarios. For example, the team argues that lamps could be deployed *inside* ventilation systems, with no direct optical path to occupants in the building, and run continuously, to disinfect ambient air. In other settings such as public restrooms, high-intensity UV-C light could be applied during the periods in which the rooms are unoccupied. And frequently touched surfaces, such as elevator buttons, might be subjected to continuous, weak UV-C illumination for ongoing disinfection—as human interactions with these surfaces tend to be brief, and thus would involve only a very low dose of radiation.

The team acknowledges that putting such an approach into effect would require a massive new deployment of UV lighting, with a correspondingly huge required uptick in its production. Yet the cost, they argue, may not be excessive, given the scale of the problem humanity now confronts—not just in human mortality, but in the economic devastation that antiviral lockdowns have created.

The team estimates, in fact, that "disinfection with fluorescence lamps could be implemented at a cost of a few dollars per person with minimum changes in infrastructure." Thus, they argue, "a global capital investment of a few billion [U.S.] dollars could protect on the order of $\sim 10^9$ indoor workers worldwide." The authors add, however, that current manufacturers of UV-C sources "may have difficulty coping with the expected rise in demand originated by the SARS-CoV-2, pandemic," as "the global market for UV-C light barely reaches one billion dollars a year" at present.

A shorter-wavelength option?

Another team, based at Columbia University's Irving Medical Center, USA, took a different view of how UV-C might be used to fight coronavirus in occupied indoor settings (Sci. Reports, doi: 10.1038/s41598-020-67211-2). The team focused in particular on the specific wavelengths of UV-C light that might be used against the virus—stressing that not all UV-C light is necessarily the same in terms of its hazard to human health.

Conventional germicidal lamps operate at a wavelength of 254 nm, as that is one of the sweet spots for UV-C absorption by DNA or RNA molecules; the light thus scrambles and inactivates the pathogen's genetic machinery. It can also penetrate into the skin and eyes, causing similar genetic and other damage to living human cells.

The Columbia team points out, however, that light in the "far UV-C," between 207 and 222 nm, is also effective at killing microorganisms—yet "studies to date suggest that these wavelengths do not cause the human health issues" associated with the 254-nm radiation of germicidal lamps. The reason, according to the team, is that light in the far UV-C penetrates less than a few micrometers into biological materials. That's too short a distance to pierce the nonliving protective layers of the skin and eye into the living cells beneath. But it's more than sufficient to bore into tiny bacteria and viruses.

Continuous low dose

These considerations, the Columbia team argues, suggest that far-UV-C light should "have about the same anti-microbial properties as conventional germicidal UV light, but without producing the corresponding health effects." Thus, they conclude, continuous, low-dose application of light in the wavelength area of 222 nm might be used in occupied public areas to stem the spread of SARS-CoV-2, without posing other hazards to the occupants themselves.

To test the idea out, the team used a misting device to aerosolize two common coronaviruses that were structurally similar to SARS-CoV-2, and then flowed the aerosols through the air in front of a 222-nm UV-C lamp. The researchers found that, at very low doses, the far UV-C light killed more than 99.9% of the viral load. The team is now at work on tests using the actual SARS-CoV-2 pathogen—and says that preliminary data suggest that the far-UV-C light effectively kills that virus, too.

Putting these results together with the safety data, the team leader, David J. Brenner, asserted in a press release accompanying the work that far-UV-C at very low doses "could be used in combination with other measures, like wearing face masks and washing hands, to limit the transmission of SARS-CoV-2 and other viruses."

Publish Date: 26 June 2020