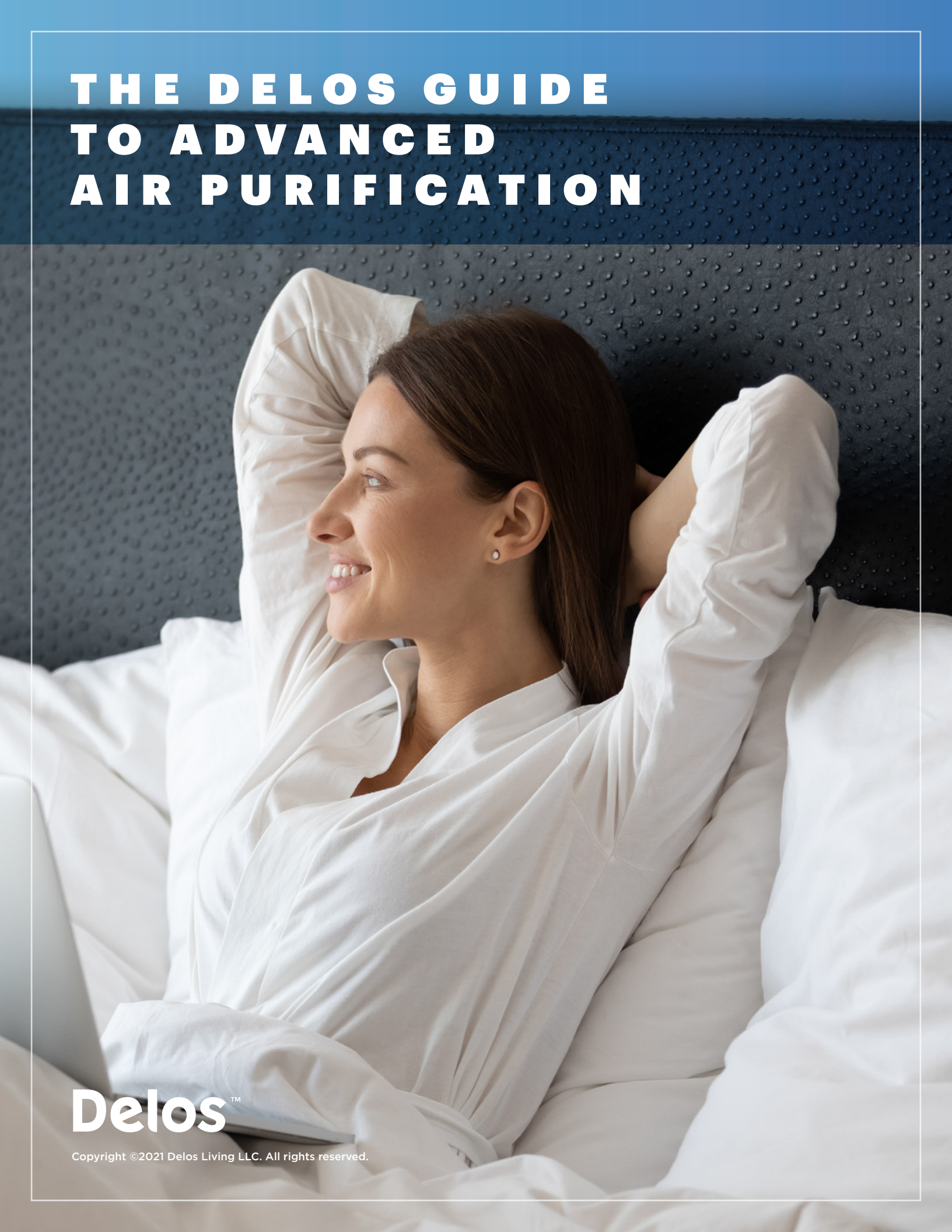
THE DELOS GUIDE TO ADVANCED AIR PURIFICATION



Delos™

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INTRODUCTION

Air pollution is estimated to contribute to nearly 6.7 million deaths per year

Clean air is essential for optimal health. Air pollution is a significant contributor to many noncommunicable diseases, and is considered one of the greatest killers of our generation. In addition, air can be the medium through which infectious diseases spread, as became evident during the Covid-19 pandemic. Globally, air pollution is estimated to contribute to nearly 6.7 million deaths per year, making it the fourth largest risk factor for mortality (after high blood pressure, tobacco, and dietary risks). In 2015, air pollution was responsible for 19% of all cardiovascular deaths, 24% of all deaths caused by ischemic heart disease, 21% of all stroke deaths, and 23% of all lung cancer deaths globally. And while most of the pollution is generated outdoors through both natural and man-made means, research suggests that concentrations of toxins, allergens and other pollutants can be two to five times higher indoors than they are outside.

Our homes, workplaces and schools are foundational to our well-being, providing space for learning, collaboration and socialization. We typically spend about 90% of our time indoors, primarily in our homes, followed by workplaces or schools. As the Covid-19 pandemic requires us to spend more time indoors, the quality of our indoor air has become more important than ever — both to help protect against the novel coronavirus, and to help promote overall health and well-being.

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We know that our indoor environments can play a significant role in safeguarding our health and well-being. We hope that in conjunction with current Covid-19 mitigation strategies these solutions will benefit everyone in every indoor space.

PAUL SCIALLA
Delos Founder and CEO

Air that is free of pathogens and chemical contaminants has always been essential to our health. During the Covid-19 pandemic, it has become even more important. Based on current scientific facts, we now know that buildings may influence the spread SARS-CoV-2 (the virus that causes Covid-19). It is also established that SARS-CoV-2 can be spread via airborne transmission. Furthermore, studies show that viral pathogens can travel further than the physical distancing recommendation of 6 feet. For example, if an infected person who is not wearing a mask sneezes, viral particles can travel up to 27 feet in some cases. While larger respiratory droplets quickly fall onto surfaces, smaller aerosolized particles containing SARS-CoV-2 can remain suspended in the air indoors for long periods of time (up to several hours), travel distances beyond 6 feet, and might be breathed in by others.

In addition, research shows that the severity of a Covid-19 infection is related to other parameters of air quality, namely fine particulate matter (PM2.5). People who live in areas with greater long-term ambient PM2.5 pollution have been found to have a greater risk of severe outcomes from Covid-19. Specifically, an increase of just 1 μg/m3 in long-term average PM2.5 exposure was associated with an 11% increase in Covid-19 mortality rate. For reference, the EPA's standard for public health protection is that PM2.5 levels in any area should not exceed 12 μg/m.

Delos Compact units capture ultrafine particles and can reduce particles that carry airborne bacteria and viruses

Recognizing the need for research-backed solutions across different sectors, Delos is collaborating with offices, hotels, and educational institutions around the globe to integrate air purification and other solutions in response to Covid-19. In fact, to-date Delos has provided over 100,000 Delos Powered by Healthway Compact air purification (Delos Compact) units to schools across the country, along with evidence-based recommendations on necessary measures for safer school reopening. Delos Compact units capture ultrafine particles and can reduce particles that carry airborne bacteria and viruses. Furthermore, the portable nature of these air purification units provides a scalable, implementable, and highly efficient solution, as they do not require heavy renovations or upgrades to aging buildings and existing HVAC systems.

DELOS POWERED BY HEALTHWAY COMPACT AIR PURIFICATION UNIT

There are two major types of air pollutants: gaseous pollutants and particulate matter. Viruses and bacteria, which have become a more central focus due to the Covid-19 pandemic, are bioaerosols, a type of particulate matter. Different air purification technologies are necessary to effectively target different types of pollutants.

The Delos Compact uses patented filtration technology to utilize the advantages of mechanical filters, sorbent filters, and bipolar ionization. This patented technology utilizes electrical charging processes combined with the means

of mechanical capture to enhance particle capture efficiency. There are two benefits of this technology:

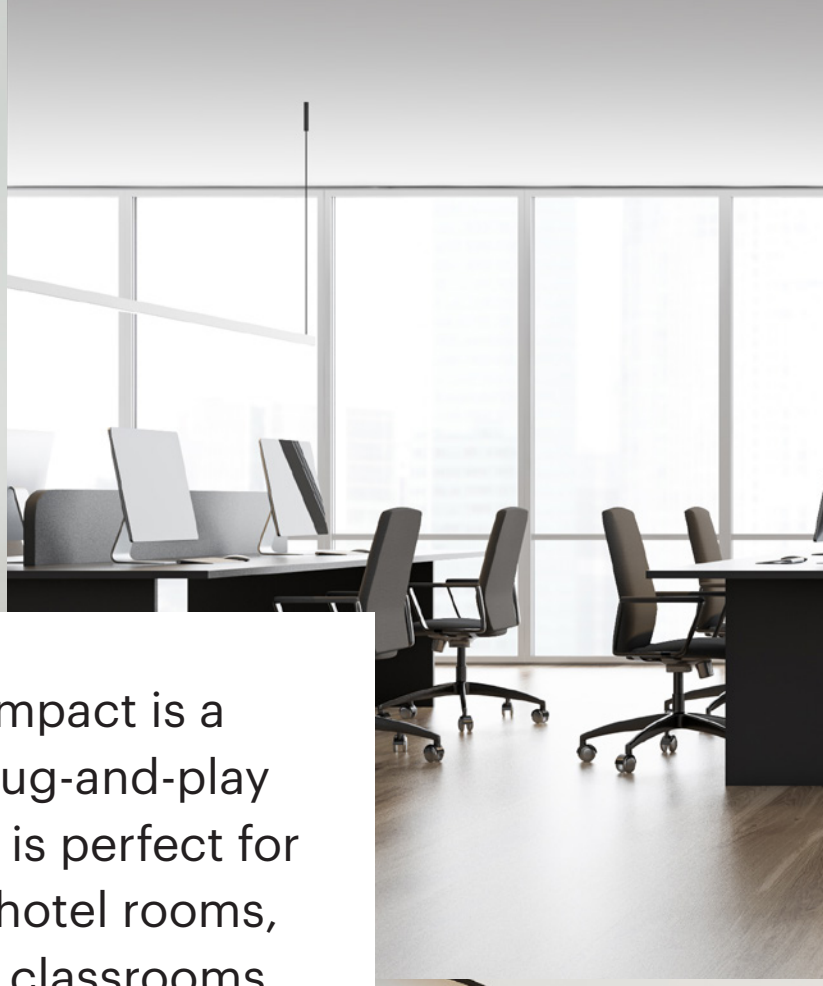
1. It forces particles to agglomerate (group with one another), creating larger particles which the mechanical filter may more easily capture.

2. The mechanical filter is charged oppositely of the agglomerated particles, forcing the particles to become attracted to, and subsequently captured by, the mechanical filter.

While many electronic air filters utilize an oppositely charged collection plate to capture particles or let the charged particles deposit on indoor surfaces freely, the Delos Compact charges the mechanical filter itself, enabling purification efficiency for a significantly longer period of time than comparable devices.

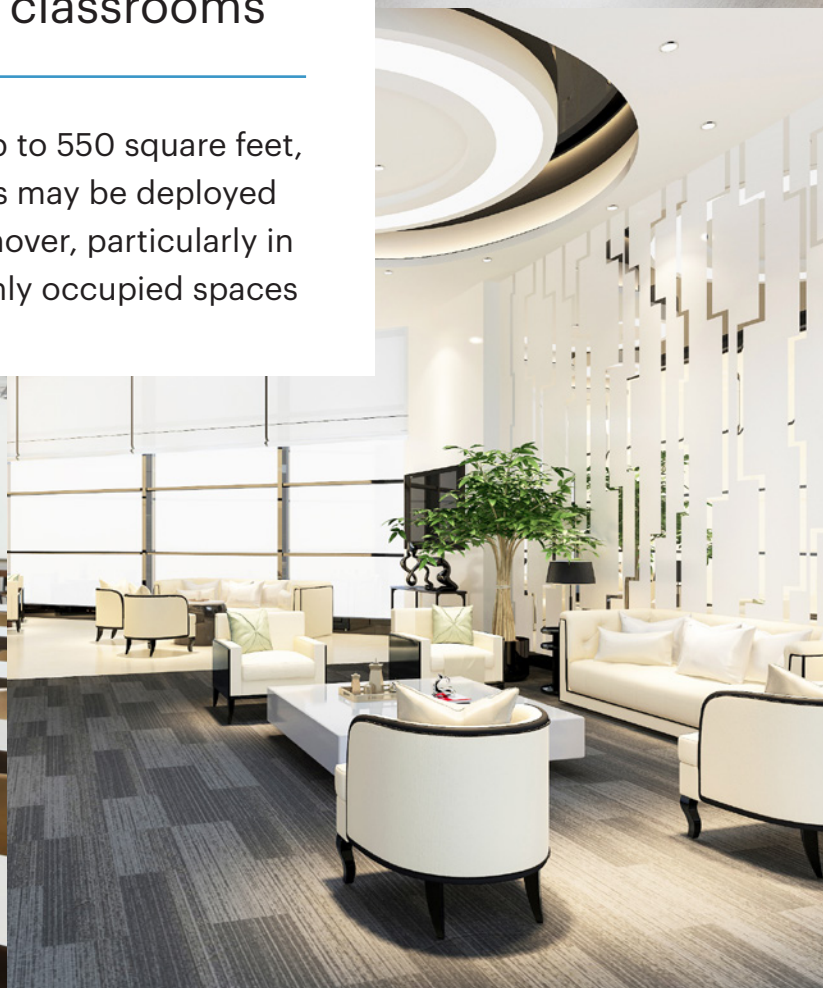
In addition to efficient system purification, the electrically charged filter creates a bacteriostatic environment. This means that microorganisms are unable to multiply inside the filter, which helps to prolong filter life.

The filtration process may produce ozone as a byproduct; however, third-party laboratory test results show the ozone emission concentration to be less than 0.050 parts per million (ppm), and the Delos Compact air purification system has been certified by the California Air Resources Board (CARB) as meeting their standards for ozone emission.



Delos Compact is a modular, plug-and-play solution that is perfect for bedrooms, hotel rooms, offices and classrooms

Each unit covers up to 550 square feet, and multiple units may be deployed to increase air turnover, particularly in larger or more highly occupied spaces



Ultrafine Particle Filtration Efficiency via Third-party Validation

A third-party analysis performed by the University of Buffalo Industry/University Center for Biosurfaces (IUCB) showed the purification efficiency of the technology utilized in the Delos Compact unit to be greater than 99.99% for aggregate removal of particles sized 0.007 microns and greater*, which is more efficient than traditional HEPA filter purification devices. For context, SARS-CoV-2 (the virus that causes Covid-19) particles range from 0.06 to 0.14 microns in size.

SARS-CoV-2 (the virus that causes Covid-19) particles range from 0.06 to 0.14 microns in size

Delos also retained LMS, a particle testing organization, to perform EN-1822 MPPS testing on the Delos Compact device to quantitatively define the efficiency of the device itself at HEPA particle testing standard of 0.3 microns. The EN-1822 test was modified to perform testing on the whole device versus just a filter media, which acknowledges the practical application of an entire purification device, tests at the highest fan speed of the device, and acknowledges any leakage and bypass which may occur when the filter is implemented in the device. The test results showed a 99.99% removal rate at 0.3 microns in size, proving that the Delos Compact device is more efficient than the minimum HEPA standard particle removal rate.

This testing shows the importance of understanding the actual capabilities of the device versus testing just a filter, which then gets installed into a device. Air velocity, production quality, leakage and bypass all play a critical role in device efficiency versus filter testing alone.

*Individual particle sizes and specific particle size ranges may have different filtration efficiency rates.

DELOS POWERED BY HEALTHWAY COMPACT AIR PURIFICATION UNIT VS. OTHER AIR PURIFICATION TECHNOLOGIES

Based on state-of-the-art research, performance standards, and market data, we compared a number of technical attributes of the Delos Compact system to other typical air purification technologies that are on the market today. The table below provides a detailed comparison.

Feature	Delos Compact	Mechanical Filtration	Sorbent Media Filtration	Bipolar Ionization	Ultraviolet Germicidal Irradiation (UVGI)
Deactivates Bacteria and Viruses (antimicrobial treatment)	Yes	No	No	Varies[1]	Yes[2]
Captures Bacteria	Yes	Yes, requires MERV 13 or higher rating	No	Varies[1,3]	No
Captures Viruses	Yes	Yes, requires HEPA filter	No	Varies[1,3]	No
Removes PM10 (particle size > 2.5 µg)	Yes	Yes	No	Yes	No
Removes PM2.5 (particle size between 0.1 and 2.5 µg)	Yes	Yes, requires MERV 13 or higher rating	No	Yes	No
Removes Ultrafine Particles (< 0.1 µg)	Yes	Yes, requires HEPA filter; testing is needed to determine efficacy	No	Varies[3]	No
Removes Volatile Organic Compounds (VOCs)	Yes	No	Yes	Yes	Yes
Meets Ozone Emission Standards[4]	Yes	Yes	Yes	Varies[5]	Varies[6]
Maintenance Requirement	Replace filters	Replace filters	Replace filters	Clean indoor surfaces that have PM deposition; Replace filters; Replace ionizers	Replace lights; Add additional air purification technology to remove PM
Filter Replacement Frequency	Every 12 months	Typically every 6 - 12 months	Typically every 3 - 6 months	Typically every 6 -12 months	Typically every 6 -12 months
Air Flow Resistance	Low	Medium	High	Low	Low
Energy Consumption under the same use case	Low	Medium	High	Low	Low

1. Laboratory and real-world efficacy testing would need to be evaluated to determine if they support claims of antimicrobial efficacy.
2. Deactivates microorganisms on-the-fly as they pass through the irradiated zone. However, due to limited exposure time, this process requires high doses of UV light. This makes the implementation of UV irradiation in the HVAC system complicated.
3. As a result of bipolar ionization, bacteria, viruses, and ultrafine particles may stick together, becoming larger particles, and fall from the air to surfaces more quickly. While this process may remove the particles from the air (which in effect is similar to particle capture), the particles may then still be transmittable if encountered on the surface).
4. Ozone generation/emission testing is required for air purifiers in order to satisfy applicable safety requirements (e.g., ozone safety limits required by CARB).
5. Different designs and modes of engineering of bipolar ionization technologies vary in ozone emissions. In addition, the ions released into the air can react with oxygen and other particles, leading to additional production of ozone, as well as generation of ultrafine particles.
6. UV-C technologies may generate ozone.

Mechanical Filtration

Mechanical filters use media with porous structures, containing fibers or stretched membrane materials in a variety of sizes, densities, and media extension configurations, that can remove particles from airstreams. There are four major types of filtering mechanisms:

- **Straining:** The mechanical filter strains airborne particles as the air flows through the openings in the filter membrane; air is able to get through because air molecules are smaller than the particles. Straining helps to remove **large coarse particles**.
- **Inertial impingement:** When the airflow hits the filter, **large or dense particles** cannot follow the airstream that goes around the filter fiber, due to their inertia. If the attraction between fiber and particles is strong enough, the particles remain on the fiber after making contact.
- **Interception: Medium-sized particles** follow the airstream close enough to the fiber that the particles come into contact with the fiber and remain there mainly due to van der Waals forces (i.e., weak intermolecular attractions between temporary dipoles).
- **Diffusion:** Due to the Brownian motion of gas molecules in the air, **small particles** run randomly within the airstream and produce an erratic path that brings the particles close enough to a media fiber to be captured by interception. The effects of diffusion increase with decreasing particle size and media velocity.

A filter with a higher MERV rating will perform better in filtering particles than a filter with a lower MERV rating; MERV16 filters have the best filtration performance

Minimum Efficiency Reporting Values (MERVs) are commonly used to report a mechanical filter's ability to capture particles between 0.3 and 10 microns. This value is helpful when comparing the performance of different filters. Most mechanical filters are MERV rated, in compliance with the ANSI/ASHRAE Standard 52.2-2017. MERV ratings range between 1 and 16. A filter with a higher MERV rating will perform better in filtering particles than a filter with a lower MERV rating; MERV16 filters have the best filtration performance in the MERV rating system. For a stricter filtration requirement, High Efficiency Particulate Air (HEPA) filters are also an option. HEPA is a special type of mechanical air filter that can theoretically remove at least 99.97% of particles 0.3 microns in diameter and larger.

Clean Air Delivery Rate (CADR) is a metric for evaluating the rate of particle removal in standalone and self-contained air purifiers. CADR is measured by multiplying the airflow rate and the contaminant removal efficiency. An air purifier with a higher CADR will clean the air faster. The methods to measure CADR may vary in different regions. Please refer to local guidance for more details about the CADR metric.*

ADVANTAGES AND DISADVANTAGES

Major benefits of the technology:

- Mechanical filters are a mature technology that has been widely implemented.
- The mechanism of the technology is simple.
- Mechanical filters can be installed in most HVAC systems or used in standalone air purifiers.
- Building managers can choose different grades (MERV ratings) of mechanical filters based on air purification needs in each building.
- The cost of mechanical filters is relatively low compared to other technologies when considering installation and maintenance.

*In the U.S., CADR is primarily tested using the protocol of the Association of Home Appliance Manufacturers (AHAM): ANSI/AHAM AC-1, The Method for Measuring Performance of Portable Household Electric Cord-Connected Room Air Cleaners for dust (0.09-1.0μm), tobacco smoke (0.5-3μm), and pollen (5-11μm). In China, GB/T 18801-2015 Air Cleaner Standard was adopted for testing the CADR for PM2.5.

Major disadvantages or performance concerns of the technology:

- Mechanical filters may cause an increased pressure drop across the filter, which can impact the performance of the HVAC system. Before installing a mechanical filter into an HVAC system, ensure that the HVAC system can handle filter upgrades without a negative impact on pressure differentials and/or air flow rates.
- Fans in the HVAC system may cause additional energy consumption.
- Filters need to be cleaned/replaced periodically to ensure high performance.

POTENTIAL HEALTH RISKS AND CONCERNS

- Some filters have an electrical charge applied to the media to increase particle removal efficiency. This electrical charge may cause ozone generation. Exposure to ozone can lead to wheezing and shortness of breath, and potentially to more severe respiratory outcomes. For portable air purifiers with electrical charge, make sure that the ozone generated by the purifier does not exceed the requirements set by the California Air Resources Board (CARB), which is a commonly used guidance for regulating ozone generation of portable air purifiers.
- Mold and bacteria may grow on the filter. Exposure to mold can lead to upper respiratory tract symptoms, coughing, and wheezing, as well as asthma symptoms in people with asthma, while exposure to pathogens can cause various adverse health effects. Make sure to replace mechanical filters depending on the manufacturer's instructions in the user manual (which is usually every 6 to 12 months).
- When HEPA filters are used for biological safety purposes (e.g., in surgical rooms, healthcare facilities, or nuclear plants) but are not properly maintained, there is a risk of airborne pathogens being recirculated into the space due to filter damage or reduced filter efficiency.

Sorbent Media Filtration

Sorbent media filters use a special sorbent to remove gaseous pollutants in the air. There are typically two types of sorbent air filtration:

- **Physical adsorption (physisorption):** Physical adsorption is the process in which gaseous pollutants adhere to solid porous materials due to the physical forces between objects (van der Waals forces). The most commonly used adsorbent is activated carbon. Some other adsorbents include activated aluminas (aluminum oxides), natural and synthetic zeolites in granular form, oxides of silicon, molecular sieves, and various polymers.
- **Chemisorption:** Chemisorption involves both adsorption and instantaneous irreversible chemical reactions on the sorbent surface. Common adsorbents include activated alumina impregnated with potassium or sodium permanganate and activated carbons impregnated with acidic or basic compounds. One benefit of chemisorption is that once the targeted pollutant is adsorbed and chemically reacted by the sorbent, there will be no desorption of the pollutants (i.e., pollutants will not be released back into the air).

Air purification technologies (for removing gaseous pollutants) that are installed in the HVAC system can be tested using ANSI/ASHRAE Standard 145.2. However, there is no standardized testing method for evaluating the performance of standalone air purifiers in removing gaseous pollutants using a metric similar to CADR.

Air purification technologies (for removing gaseous pollutants) that are installed in the HVAC system can be tested using ANSI/ASHRAE Standard 145.2

ADVANTAGES AND DISADVANTAGES

Major benefits of the technology:

- Sorbent air filters are a mature technology that has been widely implemented.
- The mechanism of the technology is simple.
- Potential for high removal efficiency of many gaseous pollutants.
- No by-product formation.
- Pollutants are captured via chemisorption - an irreversible process - meaning that the pollutants are never released back into the air.

Major disadvantages or performance concerns of the technology:

- High pressure drop in some sorbent media filters can negatively impact the HVAC system.
- Fans in the HVAC system may cause additional energy consumption.
- Filters need to be regenerated/replaced periodically to ensure high performance.
- Effectiveness of many consumer-grade systems with small amounts of activated carbon is unknown.
- Different gases at different concentrations will have different removal efficiencies.

Bipolar Ionization

Bipolar ionization is a type of electronic air filter. Electronic air filters remove particles via an active electrostatic charging process that requires electricity to charge particles. These particles are attracted to oppositely charged plates (electrostatic precipitators) or other indoor surfaces (ionizers).

As a type of electronic air filter, bipolar ionization, also called ionizer, generates ions (mostly negative ions) by charging the molecules in the air through a high-voltage wire or carbon fiber brush. These negative ions then attach to airborne particles. Subsequently, the charged particles can attach to nearby surfaces such as walls or furniture. If there is a high-efficiency mechanical filter after the ionization process, the filtration is called electrically enhanced air filtration.

Ionization processes generate reactive oxygen species, including hydroxyl radicals, ozone, and superoxide, among others

Ionization processes also generate reactive oxygen species (ROS), including hydroxyl radical (OH•), ozone, superoxide (O2-), among others. The ROS are highly reactive with gases and biological particles. This reaction is also an oxidation reaction that can convert organic compounds into water vapor and carbon dioxide. This reaction is helpful for removing volatile organic compounds (VOCs) in the air and in deactivating bacteria and viruses.

ADVANTAGES AND DISADVANTAGES

Major benefits of the technology:

- Low pressure drop.
- Lower energy consumption compared to mechanical filtration systems.
- Can be implemented together with mechanical filters to enhance the performance of the overall filtration system.

Major disadvantages or performance concerns of the technology:

- The ionization process may generate ozone and other by-products due to the high-voltage charging. These by-products might be harmful to human health.
- For bipolar ionization ionizers that release ions to the indoor space, particles that have been charged are not physically removed by the filters. Instead, these particles deposit on indoor surfaces as dust. Occupants need to remove these deposited particles manually.

POTENTIAL HEALTH RISKS AND CONCERNS

Exposure to ozone can lead to wheezing and shortness of breath, and potentially to more severe respiratory oucomes

- All high-voltage devices can produce ozone. Exposure to ozone can lead to wheezing and shortness of breath, and potentially to more severe respiratory outcomes. The state of the science does not allow for a high degree of certainty regarding the relative harms of exposure between increased exposure to ozone and the exposure to ozone reaction by-products, vs. the reduced exposure to other contaminants that would be filtered. Ozone generation by a portable air purifier should not exceed the requirements set by the California Air Resources Board (CARB).
- By-products are generated from the incomplete process of ROS. These by-products might be more toxic and harmful than the original pollutants. Types of by-products and generation rates for each by-product are still being scientifically researched. Some well-known by-products include acetaldehyde, formaldehyde, acetone, and benzaldehyde.

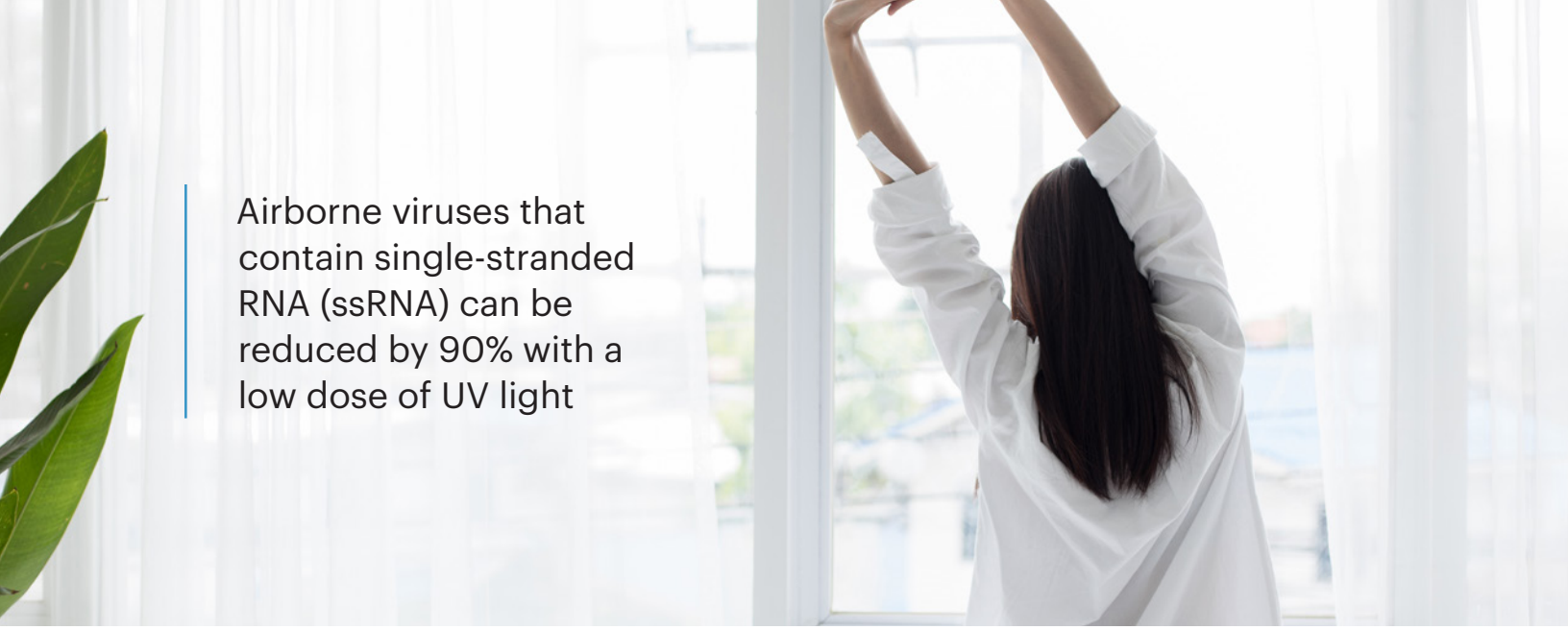
Ultraviolet Germicidal Irradiation

Ultraviolet Germicidal Irradiation (UVGI) is electromagnetic radiation that can destroy the ability of microorganisms to reproduce by causing photochemical changes in nucleic acids. There are two general types of nucleic acids: ribonucleic acid (RNA) and deoxyribonucleic acid (DNA). During UV irradiation and inactivation, the most sensitive target is the DNA of bacteria, the DNA of DNA viruses, the RNA of RNA viruses, and the DNA of fungi. UV wavelengths inactivate microorganisms by causing cross-links between constituent nucleic acids. The absorption of UV can result in the formation of intrastrand cyclobutyl-pyrimidine dimers in DNA, which can lead to mutations or cell death.

Wavelengths in the UV-C range are especially damaging to cells because they are absorbed by nucleic acids. The germicidal effectiveness of UV-C peaks at about 260–265 nm. This peak corresponds to the peak of UV absorption by bacterial DNA. The germicidal effectiveness of UV-C radiation can vary between species and the broader range wavelengths that include UV-B also make a small contribution to inactivation. Although all UV wavelengths cause some photochemical effects, wavelengths in the UV-C range are particularly damaging to cells because they are absorbed by proteins, RNA and DNA.

There are several common ways to integrate UVGI technology into the air purification system:

- **Upper-room UVGI (254 nm) systems.** Upper-room UVGI disinfection is typically used in healthcare facilities. Upper-room UVGI releases UV light directly into the indoor environment. UV exposure can adversely impact the health of the occupants (e.g., cause severe burns to the skin and lead to eye damage), and could potentially generate ozone which is harmful for our respiratory system. Upper-room UVGI should be used when disinfection requirements are very strict, such as in senior living care facilities, or in densely occupied spaces with high ceilings, such as waiting areas of train or bus stations.
- **Installing UVGI in HVAC systems.** The disinfection performance of an in-duct UVGI system highly depends on the design of the HVAC system. The minimum UV exposure time should be 0.25 seconds in order to achieve good air disinfection performance, which may be hard for many HVAC systems to achieve, as the air moves through the system too quickly.
- **Using a standalone air purifier with UVGI.** Standalone air purifiers with UVGI can be used in areas where the risk of transmission of infectious microorganisms is high. However, moving large volumes of air through any device is difficult, and limited by the clean-air delivery rate of portable air cleaners. Standalone air cleaners with UVGI may produce ozone, which is harmful for our respiratory system. Ozone generation by a portable air purifier should not exceed the requirements set by the California Air Resources Board (CARB).



Airborne viruses that contain single-stranded RNA (ssRNA) can be reduced by 90% with a low dose of UV light

ADVANTAGES AND DISADVANTAGES

Major benefits of the technology:

- With proper dosage, UVGI radiation can effectively inactivate microorganisms such as viruses, bacteria, and fungi.
- Airborne viruses that contain single-stranded RNA (ssRNA) can be reduced by 90% with a low dose of UV light. The UV dose requirement increases for ssRNA viruses found on surfaces., A previous study demonstrated that 10 minutes of UV-C light inactivated 99.999% of coronaviruses tested, including SARS-CoV and MERS-CoV, when the UV-C system was placed 4 ft (1.22 m) from the sample.
- UVGI within the UV-C range (200 nm–280 nm), primarily at 254 nm, has been used successfully and safely for over 70 years.
- UVGI technology has been widely used across the world in different climates for different types of buildings (such as hospitals, schools, offices, factories and storage facilities). It is used for air, water and surface disinfection in multiple forms of systems and equipment types, such as lamps/fixtures for upper room/induct air disinfection, and hand-held or small-scale devices for personal item disinfection.

Major disadvantages or performance concerns of the technology:

- **Inappropriate use of UVGI applications can:**
  - Present human health and safety issues (see the next section for details on potential health risks and concerns).
  - Lead to insufficient deactivation of infectious agents.
  - Release harmful chemicals if mercury lamps break.
- **Limitation of application in consumer products.** Concerns remain that consumers may use/handle UV products inappropriately (and therefore not achieve effective disinfection), or might mistakenly purchase a product that does not actually emit UV-C.
- **Potential generation of byproducts, such as ozone.** UV-C radiation below wavelengths of 240 nm interacts with oxygen in the air and may form ozone (low levels) or oxides of nitrogen.
- **UVGI has no effect on particles and VOCs, which are common air pollutants.**

UVGI has no effect on particles and VOCs, which are common air pollutants

POTENTIAL HEALTH RISKS AND CONCERNS

- UVGI may cause ozone generation. Exposure to ozone can lead to wheezing and shortness of breath, and potentially to more severe respiratory outcomes. The state of the science does not allow for a high degree of certainty regarding the relative harms of exposure between increased exposure to ozone and the exposure to ozone reaction by-products, vs. the reduced exposure to other contaminants that would be filtered. Ozone generation by a portable air purifier should not exceed the requirements set by the California Air Resources Board (CARB).
- Excessive UVGI may also adversely impact the skin and eyes (e.g., cause skin burns and eye damage).

CONCLUSION

The critical aspect of airborne viral transmission remains largely unaddressed, despite measures to address surface and behavioral viral load though extensive cleaning protocols, social distancing, and mask wearing, to name a few. Installing or retrofitting existing HVAC systems and/or renovating buildings for improved ventilation tend to be time-consuming and require significant resources. Portable air purification units are an effective and easily implementable solution to immediately start addressing airborne viral load with minimal disruption.

Through the Covid-19 pandemic, air purification systems have become recognized as a critical supplementary approach to reducing transmission rates by remediating airborne pollutants and contaminants. However, taking steps to improve air quality can have benefits that last long after the pandemic's end.

REFERENCES

Introduction

1. Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016;388(10053):1659-1724.
2. Landrigan PJ. Air pollution and health. The Lancet Public Health. 2017;2(1).
3. U.S. Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19) - Transmission. Published October 5, 2020. Accessed October 20, 2020. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html
4. Institute for Health Metrics and Evaluation (IHME). GBD Compare. 2019. Available at: http://ihmeuw.org/59m5
5. Wang H, Naghavi M, Allen C, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016;388(10053):1459-1544.
6. U.S. Environmental Protection Agency. Targeting Indoor Air Pollution EPA's Approach and Progress. 1993.
7. Klepeis NE, Nelson WC, Ott WR, et al. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. Journal of Exposure Science and Environmental Epidemiology. 2001;11(3):231.
8. U.S. Centers for Disease Control and Prevention. Scientific Brief: SARS-CoV-2 and Potential Airborne Transmission. Accessed October 20, 2020. https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html
9. Bourouiba L. Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19. JAMA. 2020;323(18):1837–1838. doi:10.1001/jama.2020.4756
10. World Health Organization. Transmission of SARS-CoV-2: implications for infection prevention precautions. Accessed September 25, 2020. https://www.who.int/publications/i/item/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations.
11. Allen JG, Marr LC. Recognizing and controlling airborne transmission of SARS-CoV-2 in indoor environments. Indoor Air. 2020;30(4):557-558. doi:10.1111/ina.12697
12. Morawska L, Milton DK. It is Time to Address Airborne Transmission of COVID-19 [published online ahead of print, 2020 Jul 6]. Clin Infect Dis.2020;ciaa939. doi:10.1093/cid/ciaa939
13. Lednicky JA, Lauzardo M, Hugh Fan Z, et al. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients [published online ahead of print, 2020 Sep 16]. Int J Infect Dis. 2020;S1201-9712(20)30739-6. doi:10.1016/j.ijid.2020.09.025
14. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). ASHRAE Position Document on Airborne Infectious Diseases.; 2020:22. https://www.ashrae.org/file%20library/about/ position%20documents/airborne-infectious- diseases.pdf
15. Wu X, Nethery RC, Sabath MB, Braun D, Dominici F. Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. Sci Adv. 2020;6(45). doi:10.1126/sciadv.abd4049
16. Wu X, Nethery RC, Sabath MB, Braun D, Dominici F. Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. Sci Adv. 2020;6(45). doi:10.1126/sciadv.abd4049

Delos Powered by Healthway Compact Air Purification Unit

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Delos Powered by Healthway Compact Air Purification Unit vs. Other Air Purification Technologies

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24. ASHRAE Position Document on Filtration and Air Cleaning, https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf
25. In the U.S., CADR is primarily tested using the protocol of the Association of Home Appliance Manufacturers (AHAM): ANSI/AHAM AC-1, The Method for Measuring Performance of Portable Household Electric Cord-Connected Room Air Cleaners for dust (0.09-1.0μm), tobacco smoke (0.5-3μm), and pollen (5-11μm). In China, GB/T 18801-2015 Air Cleaner Standard was adopted for testing the CADR for PM2.5.
26. U.S. Environmental Protection Agency. Health Effects of Ozone Pollution. US EPA. Published June 5, 2015. Accessed May 28, 2020. https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
27. Centers for Disease Control and Prevention. Basic Facts about Mold and Dampness. Published December 17, 2019. Accessed May 28, 2020. https://www.cdc.gov/mold/faqs.htm
28. The American National Standards Institute (ANSI) webstore. ANSI/ASHRAE Standard 145.2-2016 Laboratory Test Method For Assessing The Performance Of Gas-Phase Air-Cleaning Systems: Air-Cleaning Devices. Accessed November 12, 2020. https://webstore.ansi.org/standards/ashrae/ansiashraestandard1452016

29. ASHRAE, ASHRAE Handbook 2019 - HVAC Applications, Chapter 47, Air Cleaner for Gaseous Contaminants
30. ASHRAE, ASHRAE Handbook 2016 - HVAC Systems and Equipment, Chapter 29, Air Cleaners for Particulate Contaminants.
31. U.S. Environmental Protection Agency. Health Effects of Ozone Pollution. US EPA. Published June 5, 2015. Accessed May 28, 2020. https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
32. ASHRAE, ASHRAE Position Document on FIltration and Air Cleaning.
33. Mo, J., Zhang, Y., Xu, Q., Lamson, J. J., & Zhao, R. (2009). Photocatalytic purification of volatile organic compounds in indoor air: A literature review. Atmospheric Environment, 43(14), 2229–2246. doi:10.1016/j.atmosenv.2009.01.034
34. Harm W. 1980. Biological Effects of Ultraviolet Radiation. New York: Cambridge University Press.
35. Koller LR. 1952. Ultraviolet Radiation. New York: John Wiley & Sons.
36. Kuluncsics Z, Perdiz D, Brulay E, Muel B, Sage E. 1999. Wavelength dependence of ultraviolet induced DNA damage distribution: Involvement of direct or indirect mechanisms and possible artefacts. J Photochem Photobiol 49(1):71–80.
37. Webb RB, Tuveson TW. 1982. Differential sensitivity to inactivation of NUR and NUR$_s$ strains of Escherichia coli at six selected wavelengths in the UVA, UVB, and UV-C ranges. Photochem Photobiol 36:525–530.
38. Bolton JR, Cotton CA. 2008. Ultraviolet Disinfection Handbook.American Water Works Association. Denver, CO.
39. Rauth AM. 1965. The physical state of viral nucleic acid and the sensitivity of viruses to ultraviolet light. Biophys J 5:257–273.
40. U.S Food and Drug Administration. Ultraviolet (UV) Radiation. Accessed January 20, 2021. https://www.fda.gov/radiation-emitting-products/tanning/ultraviolet-uv-radiation#UVCrisks
41. Kowalski, W. (2010). Ultraviolet germicidal irradiation handbook: UVGI for air and surface disinfection. Springer science & business media. Ultraviolet Germicidal Irradiation Handbook - UVGI for Air and Surface Disinfection. 2009
42. Tseng CC, Li CS. Inactivation of viruses on surfaces by ultraviolet germicidal irradiation. J Occup Environ Hyg. 2007;4(6):400-405. doi:10.1080/15459620701329012
43. Tseng C-C, Li C-S. 2007. Inactivation of viruses on surfaces by ultraviolet germicidal irradiation. J Occup Environ Hyg 4:400–405.
44. Lytle CD, Sagripanti J-L. 2005. Predicted inactivation of viruses of relevance to biodefense by solar radiation. J Virol 79:14244 –14252.
45. Bedell K, Buchaklian AH, Perlman S. 2016. Efficacy of an automated multiple emitter whole-room ultraviolet-C disinfection system against coronaviruses MHV and MERS-CoV. Infect Control Hosp Epidemiol 37: 598–599.
46. CIE Position Statement on Ultraviolet (UV) Radiation to Manage the Risk of COVID-19 Transmission. 2020
47. CIE Position Statement on Ultraviolet (UV) Radiation to Manage the Risk of COVID-19 Transmission. 2020
48. U.S. Environmental Protection Agency. Health Effects of Ozone Pollution. US EPA. Published June 5, 2015. Accessed May 28, 2020. https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
49. ASHRAE, ASHRAE Position Document on FIltration and Air Cleaning.
50. U.S Food and Drug Administration. Ultraviolet (UV) Radiation. Accessed January 20, 2021. https://www.fda.gov/radiation-emitting-products/tanning/ultraviolet-uv-radiation#UVCrisks

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