AIR-TEK EFFICIENCY AGAINST SARS-COV2 AND SIMILAR VIRUSES

With a focus on HEPA14 and Photocatalysis Technologies

ABSTRACT

In this paper we analyze SARS-CoV 2 and the various known solutions to help prevent the spread, with a focus on the airborne aspect and its purification.

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What is SARS-CoV-2 (COVID-19)?

The SARS-CoV-2 coronavirus is a new type of coronavirus that can infect human beings and was first detected in December 2019 in the city of Wuhan, Hubei province, China. It is the causative agent of the COVID-19 disease, stemming from the same family as SARS (Severe Acute Respiratory Syndrome) a viral respiratory disease caused by the associated coronavirus. SARS-CoV was first identified in China back in 2003, where it fortunately only spread to 4 other countries.

The SARS-CoV-2 virus is spread through small particles expelled by an infected person through the mouth or nose when breathing, coughing, sneezing, talking or singing. These liquid particles have different sizes, from the largest respiratory droplets to the smallest, microdroplets, giving it similar transmission traits as the common cold or influenza[1]. It can also spread through people touching the same surface and then touching their nose or mouth[2].

The new coronavirus affects men, women and children with equal frequency. However, the consequences are very different. Age, sex as well as previous diseases play a decisive role in the development of the disease. SARS in general can affect children, adults, and seniors, with the last one being the highest risk age group. So far, the reported case fatality of people within the current W.H.O. case definition for probable and suspected cases of SARS is around 3%[1]. The time that elapses between exposure to COVID-19 and the time when symptoms begin can vary between 1 to 14 days. Asymptomatic patients have also been reported.

[1] https://www.who.int/es/news-room/q-a-detail/coronavirus-disease-covid-19-how-is-it-transmitted

[2] https://www.who.int/health-topics/severe-acute-respiratory-syndrome#tab=tab_1

SARS-CoV-2 Morphology

The CoV group of viruses (Coronavirus) constitute a wide group of viruses that are taxonomically situated in the Orthocoronaviri-nae subfamily, Nidoviral order. Four main types exist: Alphacoronavirus, Betacoronavirus, Gammacoronavirus, and Deltacoronavirus.

All of them are spherical in shape, ranging from 100 to 160 nm in diameter, and with a shell made up of a single strand of RNA with positive polarity (+ssRNA), with approximately 30,000 base pairs and between 26 and 32 kilobases[3].

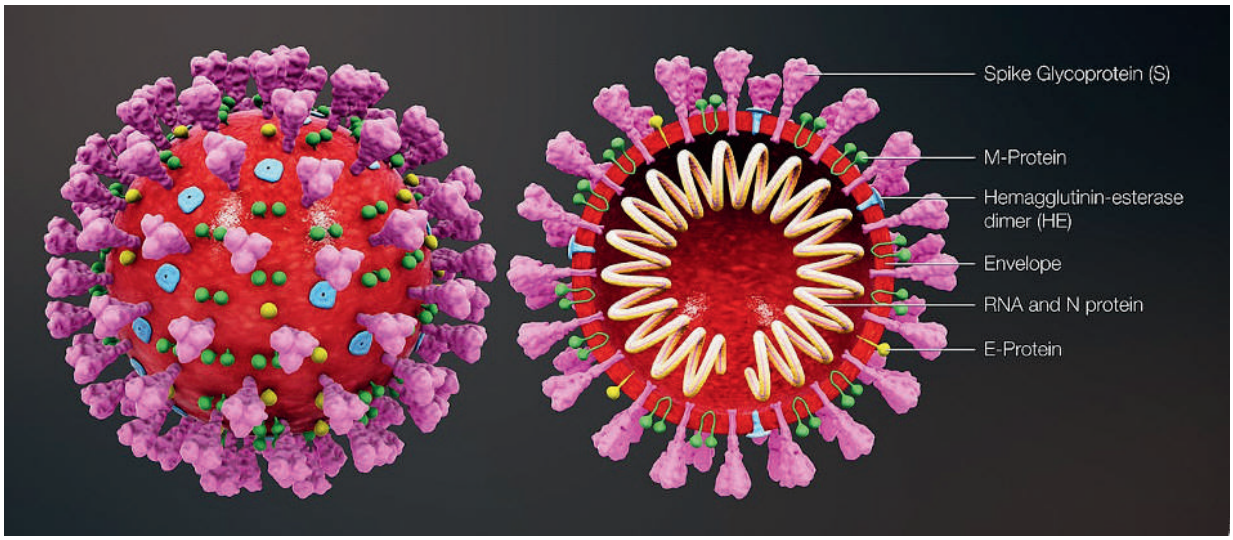

Figure 1 - Morphology
https://en.wikipedia.org/wiki/Coronavirus_diseases#/media/File:3D_medical_animation_coronavirus_structure.jpg

Coronavirus are transmitted between both animals and humans. Alpha and Beta types can infect mammals, while Gamma and Delta are able to infect birds and are especially found in bats. In mammals the virus infects and affects principally the respiratory and gastrointestinal tracts. Many species of Coronavirus, that have yet to infect human beings, have not been studied in depth. As of the writing of this report, only 6 species of Coronavirus that can infect human beings and cause respiratory complications (HCoV) have been discovered. HCoV-229E, HCoV-OC43, HCoV-NL63 and HKU1 are usually found in winter and target the superior respiratory tract. Only in rare cases have of aggressive infections in younger children and seniors. These four species are endemic globally and currently account for around 10% to 30% of all upper respiratory tract infections in the adult population.

The most well-known species are the MERS-CoV and SARS-CoV because of their pathogenicity (high ability to cause disease). The newer SARS-CoV-2, pathogen that causes COVID-19, is a beta-coronavirus and maintains genetic similarities of 79% of its structure with SARS-CoV and exists in the same size range[2]. It is not yet clear the source of this virus, even though most studies point to bats.

[3] https://www.portalfarma.com/Profesionales/campanaspf/Asesoramiento-salud-publica/infeccion-coronavirus-2019-nCoV/Documents/Informe-tecnico-Coronavirus.pdf

Epidemiology

At the present there are three different ways of transmission known:

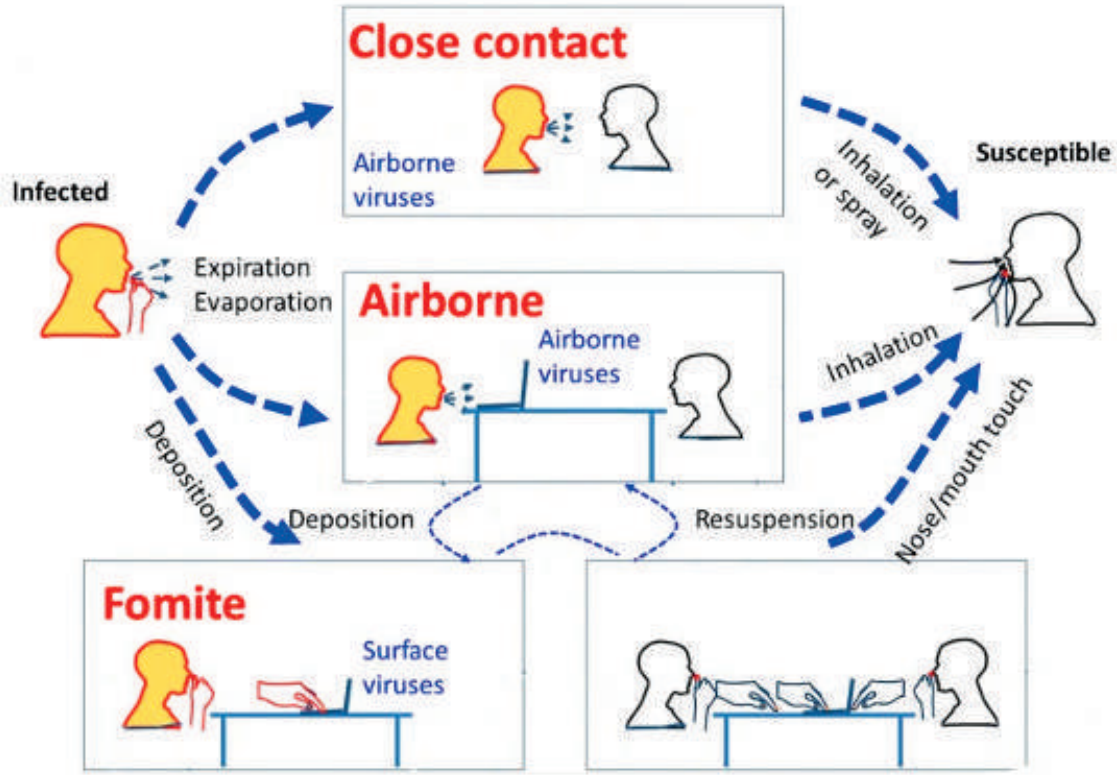

Figure 2 – Transmission
https://bmcinfectdis.biomedcentral.com/article s/10.1186/s12879-019-3707-y

- Exposure to the drops that the infected expulse when talking or coughing, this usually when at 2 meters or closer.
- Transmission through contact, direct or indirect, with an infected person or surface (Fomite).
- Airborne transmission through micro-droplets that can stay suspended in the air for long distances, over 2 meters, and for a few hours[4].

[4] https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html

Exposure through contact has been deemed as the least dangerous by the European CDC and no cases, to the day of writing this report, have been reported to spread through contact transmission[5]. Transmission through larger drops in coughing or sneezing was thought to be the most effective way for the virus to spread. Now, after almost a year of battling COVID-19, the scientific world is coming to a consensus that the most dangerous and complicated type of exposure to control are the microdroplets that can stay in suspension for hours, released when we speak or breathe.

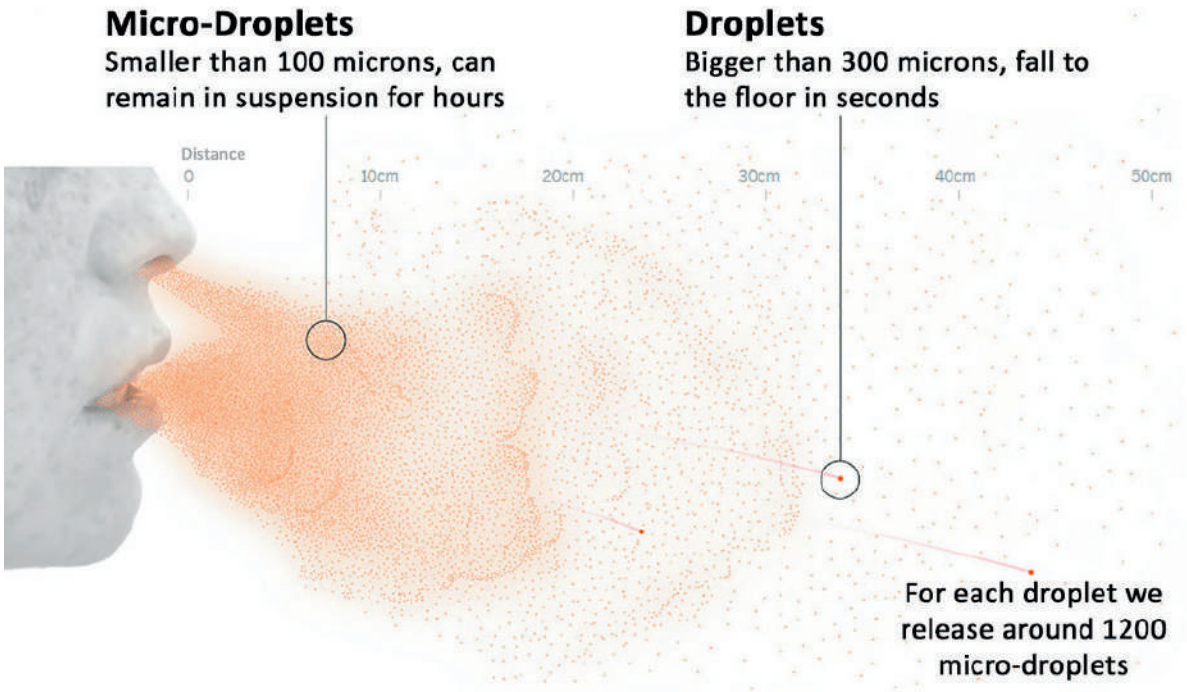

Figure 3 – Airborne Transmission
https://elpais.com/ciencia/2020-10-24/un-salon-un-bar-y-una-clase-asi-contagia-el-coronavirus-en-el-aire.html

To get an idea of this invisible concept we can take the example of a person smoking on the other side of a 5m x 5m room. Even though he is not right next to you, the smell of the smoke, and thus micro- particles carried by the aerosols released by the smoker's mouth, will reach you. Without ventilation or filtering, these micro-droplets can accumulate and remain in the room for hours. The UK government is, in fact, recommending a good ventilation or purification system for enclosed spaces and stating that "Research shows that being in a room with fresh air can reduce the risk of infection from particles by over 70%"[6].

[5] https://elpais.com/ciencia/2020-10-24/un-salon-un-bar-y-una-clase-asi-contagia-el-coronavirus-en-el-aire.html
[6] https://www.gov.uk/government/news/new-film-shows-importance-of-ventilation-to-reduce-spread-of-covid-19

Viral Charge

These micro-droplets, released through the air we expel from our respiratory tract, are thus important to control. When we speak, we release 50 times more particles than when silent. These airborne particles, if not filtered or ventilated, will keep raising the viral concentration in the room, increasing the risk of contamination. Studies have also shown that just by breathing, or talking with a loosely adjusted mask, the virus can travel for up to 5 meters and stay in suspension for various hours.

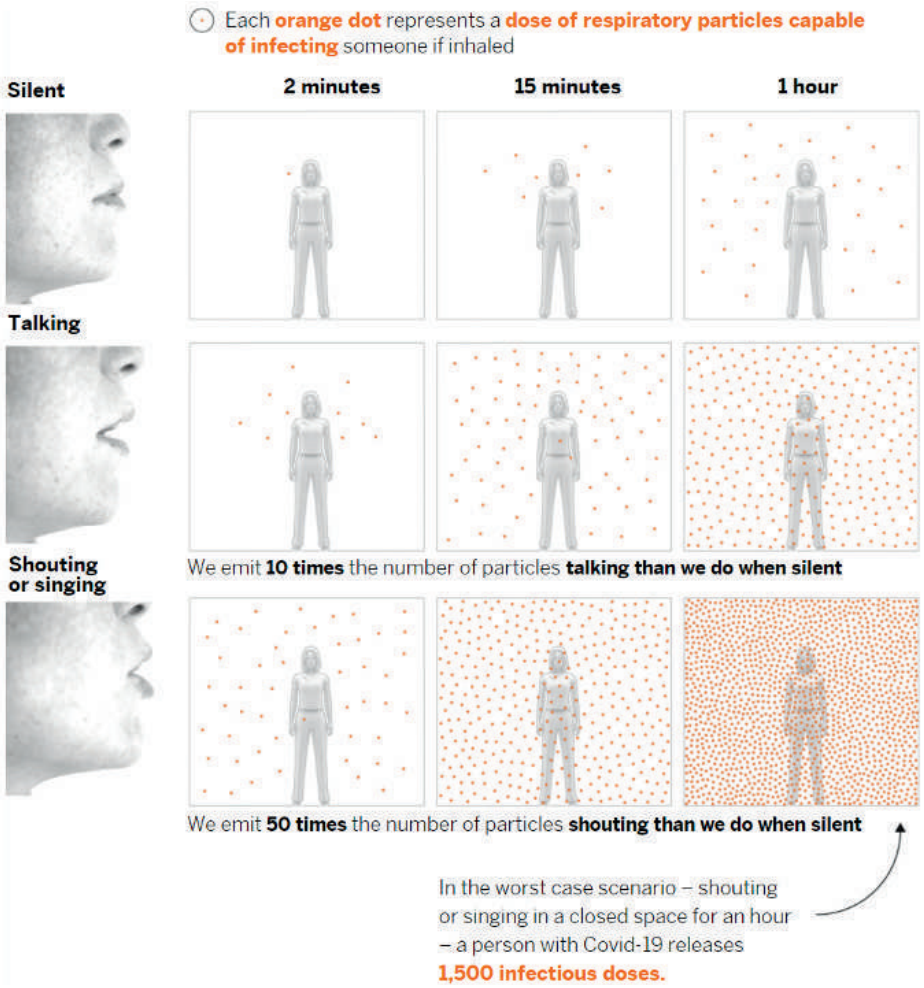

Figure 4 – Viral Charge Example

https://english.elpais.com/society/2020 -10-28/a-room-a-bar-and-a-class-how- the-coronavirus-is-spread-through-the- air.html

A study released in the International Journal of Infectious Diseases, in the November 2020 issue, also proved that:
"*Viable SARS-CoV-2 was isolated from air samples collected 2 to 4.8 m away from the patients. The genome sequence of the SARS-CoV-2 strain isolated from the material collected by the air samplers was identical to that isolated from the newly admitted patient. Estimates of viable viral concentrations ranged from 6 to 74 TCID50 units/L of air. Conclusions: Patients with respiratory manifestations of COVID-19 produce aerosols in the absence of aerosol-generating procedures that contain viable SARS-CoV-2, and these aerosols may serve as a source of transmission of the virus.*"[7]

So, now that we know how the virus can spread, how can we protect ourselves?

Best Practices for Protection Against COVID-19

To recapitulate, there are three kinds of transmission, all with different means of containment:

- Droplet transmission

  Can be contained thanks to masks and proper social distancing of over 2 meters. People should also cover coughs snezees[8].

- Contact transmission

  Can be contained thanks to frequent disinfection of surfaces and the washing/disinfection of hands with soap or a solution made up of minimum 60% alcohol concentration.[6]

- Airborne transmission

  Can be contained thanks to adequate ventilation or purification and filtration of the air.

[7] https://www.sciencedirect.com/science/article/pii/S1201971220307396

[8] https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html

This third kind of transmission is the focus for our paper, as it is proving to be the most dangerous kind with more studies coming out day to day showing the importance of controlling it due to the bad ventilation present in most buildings.

The simplest solution to combat airborne transmission, and thus an accumulation of viral loads in the different living spaces, is through natural ventilation. This is achieved by having windows open and a crossflow in the space, allowing for a constant exchange of air.

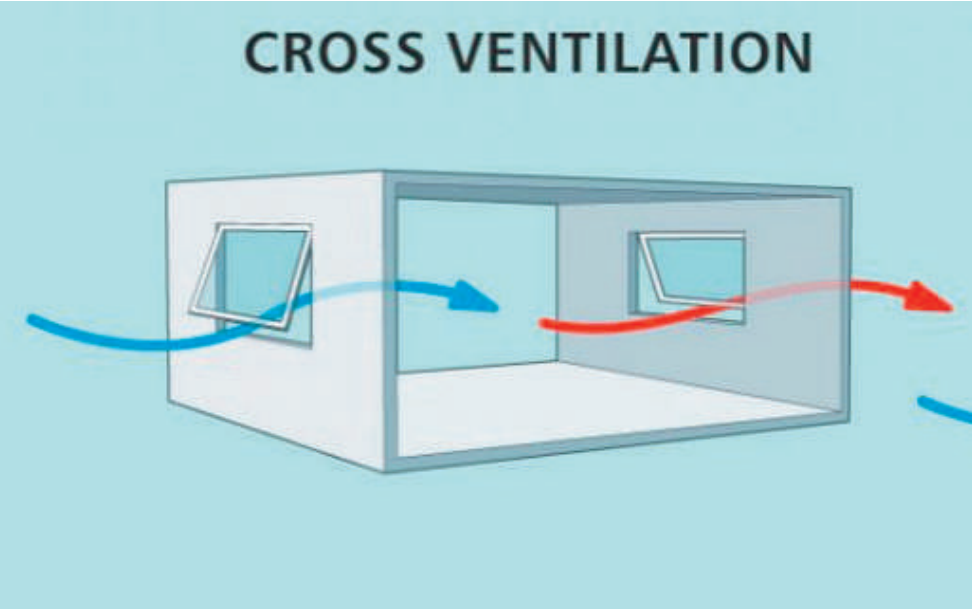

Figure 5 - Cross Ventilation
https://www.tealproducts.com/wp- content/uploads/2017/07/Natural-Ventilation.jpg

When this solution is not available, or in some cases not sufficient (i.e. public spaces with high agglomerations or insufficient inlets and outlets for air) then mechanical ventilation is the solution. This kind of ventilation can be achieved with just one intake and one exhaust fan for smaller spaces or highly sophisticated centralized ventilation systems with filters for larger spaces. If the space needs air conditioning for cooling or heating, then a thermal energy recovery system can ventilate and filter the air while upkeeping the thermal energy of the room, be it heating or cooling, for up to 90% recovery. This does not have to be confused with a centralized AC system, for example, that recycles the air instead of injecting fresh air and extracting used air.

HEPA Filtration

In cases where there is no possibility of an adequate ventilation, filtering the air and purifying it with HEPA filters and UV-C Photocatalysis, both technologies used in our Air-Tek products, is the best option. HEPA filters are known as a mean of mechanical filtration of air. They are made up of a fibrous material interleaved in multiple layers with fibers ranging from 2nm to 500 nm.

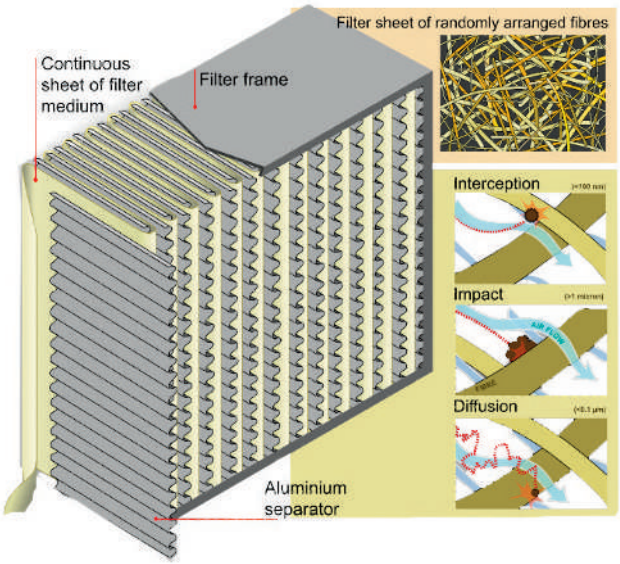

Figure 6 - HEPA Filter

https://en.wikipedia.org/wiki/HEPA#/media/File:HEPA_Filter_diagram_en.svg

This randomly interleaved pattern makes it so that these filters can catch microscopic airborne particles through one of three mechanisms[9].

- Interception: happens when the contaminant directly hits one of the fibers and becomes entrapped in it.
- Inertial impaction: occurs thanks to the high velocity of the air, which can easily adapt to the many fibers of the HEPA filter, while the particulate carried by the air will tend to keep moving straight, coming into contact with the fibers and getting caught in them[10].

[9] https://www.entnet.org/sites/default/files/uploads/sedaghat3_hepa_filters_in_era_of_covid-19.pdf

[10] https://www.air-quality-eng.com/air-cleaners/filtration-mechanisms/

- Diffusion: smaller particles do not tend to stay in line with the air stream, but rather move around randomly and diffuse in it. By doing so they hit the filter's interleaved fibers and get captured.
- Adhesion: can occur through Van der Waals forces, capillary action, and electrostatic attraction where the particles simply are attracted and stick to the filter's fibers.

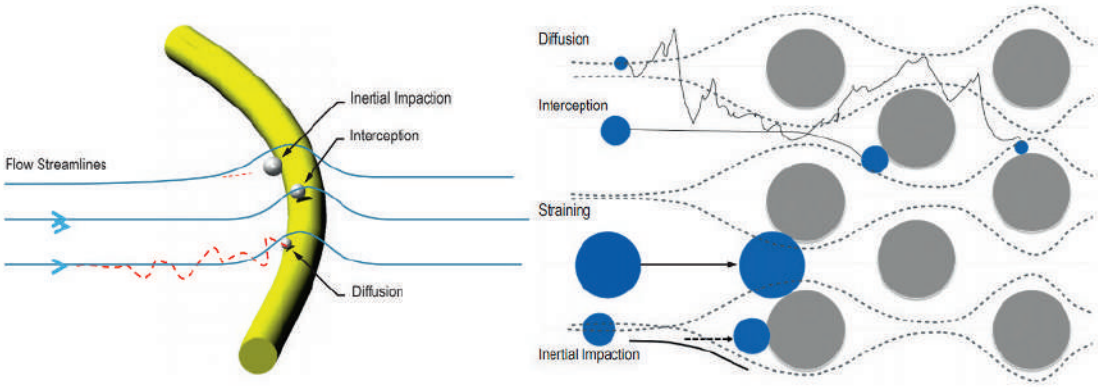

Figure 7 - Filtering Mechanisms
https://ntrs.nasa.gov/api/citations/20170005166/downloads/20170005166.pdf

It is important to note that, according to the U.S.A. EPA:
"*This type of air filter can theoretically remove at least 99.97% of dust, pollen, mold, bacteria, and any airborne particles with a size of 0.3 microns (µm). The diameter specification of 0.3 microns responds to the worst case; the most penetrating particle size (MPPS). Particles that are larger or smaller are trapped with even higher efficiency.*"[11]

As previously discussed, the newer SARS-CoV-2, pathogen that causes COVID-19, is a beta-coronavirus and maintains genetic similarities of 79% of its structure with SARS-CoV and the same size range[12]. This first kind was discovered in 2004 and has since then had extensive testing done, including with HEPA filters, which are currently recommended by the U.S.A. CDC as one of the main infection control measures. This means that with the particle having a similar structure and diameter as SARS-CoV-2 the same measures and filtration systems can be applied for COVID-19.

[11] https://www.epa.gov/indoor-air-quality-iaq/what-hepa-filter-1

[12] https://www.portalfarma.com/Profesionales/campanaspf/Asesoramiento-salud-publica/infeccion-coronavirus-2019- nCoV/Documents/Informe-tecnico-Coronavirus.pdf

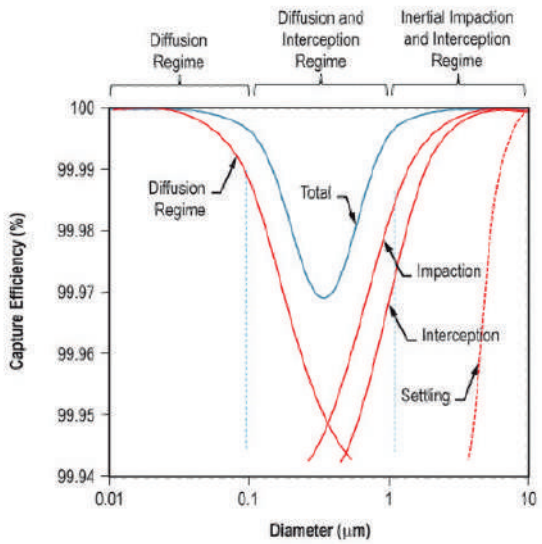

Figure 8 - HEPA Efficiency to Diameter Graph
https://ntrs.nasa.gov/api/citations/20170005166/downloads/20170005166.pdf

We can also see, as illustrated in Figure 10, that HEPA filters have an efficiency in the 1 to 1.6 microns range (size of the COVID-19 virus) of around 99.99%.
Another study from the International Journal of Infectious Diseases, previously mentioned in this paper, also proved in an experiment that SARS-CoV-2 (COVID-19) was successfully retained through HEPA filtration:

"*SARS-CoV-2 genomic RNA (vRNA) was detected by real-time reverse transcriptase quantitative polymerase chain reaction (rRT-qPCR) in material collected by air samplings 1-1, 1-3, 2-1, and 2-3, which had been performed without a HEPA filter covering the inlet tube. In contrast, in the presence of a HEPA filter, no SARS-CoV-2 genomes were detected in air samplings 1-2 and 2-2*".[13]

Please note that due to the highly efficient way in which HEPA filters capture viruses and bacteria the maintenance or replacement must always be carried out using protective tools such as a mask, gloves and, if possible, goggles and be placed in a dedicated plastic bag, following the local regulations for its proper disposal.

[13] https://www.sciencedirect.com/science/article/pii/S1201971220307396

UV-C Activated Titanium Dioxide Photocatalysis

As a part of the purification system UV-C activated titanium dioxide photocatalysis can be used to aid in the purification process. This system uses a UV-C lamp (200nm to 300nm), that is known for being able to break down organisms by interfering with their DNA and RNA sequences, as well as their proteins. The absorption of this high energy light by proteins leads to the rupture of the cell walls and thus the subsequent death of the organism.

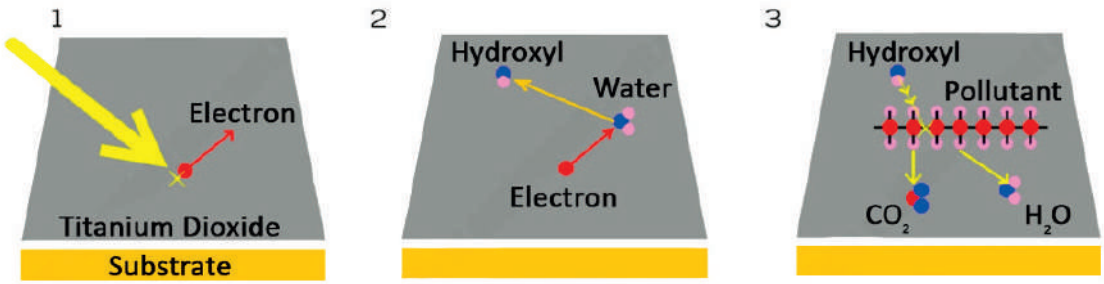

Figure 9 – Photocatalysis Process
https://www.explainthatstuff.com/how-photocatalytic-air-purifiers-work.html

When it meets DNA or RNA it damages and disables the double helix strands through the formation of thymine dimers, which disrupt the DNA replication process, and thus inhibit the organism from reproducing[14].
To futher enhance this technology, a thin sheet of titanium dioxide is exposed to the UV-C radiation, which releases electrons that interact with H_2O in the air, splitting them up into hydroxyl radicals (OH·), highly reactive and short lived forms of hydroxide ions (OH-).

These highly reactive radicals attack organic, carbon based, pollutant molecules, such as virus and bacteria, breaking apart their chemical bonds and, as a result, turning them into harmless substances like carbon dioxide (CO_2) and water (H_2O) (Oxidation)[15].

A study conducted in collaboration with the University of Milan and at the laboratory specialized in virus testing at the “Luigi Sacco” Hospital in Milan has also proven that the photocatalysis technology is able to eliminate SARS-CoV-2 (Annex 1):

[14] https://www.klaran.com/klaran-university/about-uvc

[15] https://www.explainthatstuff.com/how-photocatalytic-air-purifiers-work.html

"From the experimentation conducted within the Department of Biomedical and Clinical Sciences "Luigi Sacco" it is clear that the Dust-Free FC UNIT 3 technology has shown the ability to break down the viral load of SARS-CoV-2 inoculated in liquid form both on a hard surface and on a tissue.
The abatement verified on the inoculated petri dish of SARS-CoV-2, exposed to treated air for 20 minutes in a volume of 2.13 m^3, showed a reduction of 1.0 log (90.0%) greater than the natural decay of the virus verified in the control test, performed under equal conditions, but without Dust-Free technology. The abatement verified on the cloth consisting of 45% polyether and 55% cellulose, inoculated with SARS-CoV-2, exposed to the treated air for 20 minutes in a volume of 2.13 m^3, showed a
reduction of 2.5 log (99.7%) greater than the natural decay of the virus verified in the control test, performed under the same conditions, but without Dust Free technology.
The fan used has an air flow rate of 35 m^3/h."

A study published in the Journal of Colloid and Interface Science proved that viruses like the influenza and H1N1, for example, were eliminated with an exposure of 5 to 7 minutes of TiO_2 Photocatalysis, the same technology included in the Air-Tek PRO lineup[16]. These same results were replicated and documented by Shiraki et al., Aerosol and Air Quality Research where 99% of influenza RNA was destroyed in the first 3 minutes, and no viral RNA was able to be detected after 7 minutes of exposure to the photocatalysis system[17].
As the Photocatalytic system will attack any organic, carbon based, pollutant molecule, it works in the same manner for COVID-19 as it does for Influenza and H1N1 viruses.
This technology not only attacks airborne pollutant particles, but also ones the Hydroxil Radicals encounter on surfaces in the room the air purifier is in. This has also been proven thanks to a study backed up by the FDA on a product with same technologies (HEPA 14 and UV-C Photocatalysis) as our Air-Tek PROs, where it was shown that it "can remove SARS-CoV-2 from surfaces. Within three hours its 94.5% gone, within seven hours its 99.97% removed and that's been independent lab tested, it's gone through the FDA"[18].

[16] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7361121/pdf/main.pdf

[17] https://aaqr.org/articles/aaqr-17-06-oa-0220.pdf

[18] https://www.fox21news.com/top-stories/fda-confirms-air-purification-machine-kills-99-97-of-sars-cov-2-virus-particles/

Air-Tek PRO. An integral solution

The Air-Tek PRO lineup was created as a result of VORTICE's concern with the COVID- 19 outbreak and interest to help in the reopening of businesses and returning to a normal day to day, with the protocols and devices necessary to have safe conditions.

Thanks to the Group's experience of designing and manufacturing air purifiers since 1969, we have focused on the above data, and included highly effective and scientifically backed technologies into an integral solution.

Figure 10 - Resturant Use Exemple

https://english.elpais.com/society/2020-10-28/a-room-a-bar-and-a-class- how-the-coronavirus-is-spread- through-the-air.html

The HEPA H14 filters and TiO_2 photocatalysis system are able to capture and eliminate viruses like SARS-COV, SARS-COV2 (COVID-19), Influenza and H1N1, among others, with up to 99.99% efficiency. The combination of the high durability material and design of the purifier's body, as well as its heavy duty wheels, make it the best, most versatile option even for high transit places. With the bigger model covering up to 125m^2, the Air-Tek PRO can be used in a variety of spaces ranging from offices, warehouses, commercial buildings and more.

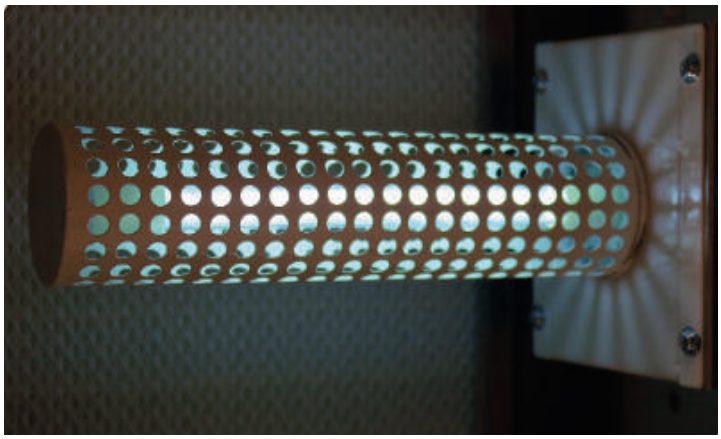

Figure 11 – UV-C Photocatalysis Technology in the Air-Tek PRO

We know the filter is an integral piece at the heart of the product, so we included HEPA H14 filters with 99.995% efficiency and European certification EN1822. This means that each filter is assessed and certified for its efficiency, seal, and integral efficacy of the filtering element. Furthermore, each Air-Tek PRO HEPA filter is efficiency tested and comes with its own lab test report displaying its performance.

Thanks to all the facts discussed throughout this paper we can understand the dangerousness of how the virus is transmitted easily through micro-droplets/aerosols in the air, and thus the importance to include Air-Tek PRO, a professional air filtering solution with certified filters, to complement the rest of the practices used to protect against COVID-19 and provide the safest environment possible.

Figure 12 - Clinic use case

Figure 13
Odonntologist use case

Please note:
The contents of this document are of general nature and contain information reported by articles or websites of leading institutes or specialized technicians whose sources are clearly cited throughout.