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Air Disinfection against Coronavirus

Anatoly N. Verenchikov, MSC Ltd, Bar, Montenegro
Marina I. Mikheeva, Newcastle University, UK

ABSTRACT: To efficiently reduce the spread of Covid19 virus, the focus shall be on air disinfection in public admission spaces. Otherwise, 50 nm virus is airborne for several days before natural deactivation. While known UVC cleaners operate cyclically, we propose continuous air exchangers, which become possible due to the sufficient 200 J/m^2 dose of encapsulated UVC light and due to the ozone removing filters. The worldwide social demand is estimated as 1B devices at 100 m^2 productivity.

I. INTRODUCTION

Economic and social benefits of reducing the spread of Covid19 cannot be overestimated. As been well recognized, viral spreading primarily occurs at public admission spaces, like transportation, shops, restaurants, and hospitals. Currently, efforts have been primarily focused on wearing masks and sanitizing surfaces. However, Covid19 virus is mainly airborne transmissible and is too small to be completely filtered by masks. Thevirus size is estimated between 50 and 100 nanometres(Bar-On et al., 2020; Varga et al., 2020), while the High Efficiency Particulate Air (HEPA) filter has a cut off at 300 nm (Payet et al., 1992). In other words, the masks work primarily to stop sneezed and coughed droplets containing virus while providing a limited protection against inhaling virus (WHO, 2021). Thus, in addition to already taken efforts on sanitizingsurfaces, to slow down viral contingency the focus should be on the air disinfection.

Cleaning Air Vs Surfaces : The knowledge of the virus size allows us estimating how fast it may sediment on surfaces. Based on Stock's law (Stokes, G.G., 1851) the sedimentation speed of drops with water density in still air is equal to: **V**(cm/s) = 0.1* **r**^{2}(um)

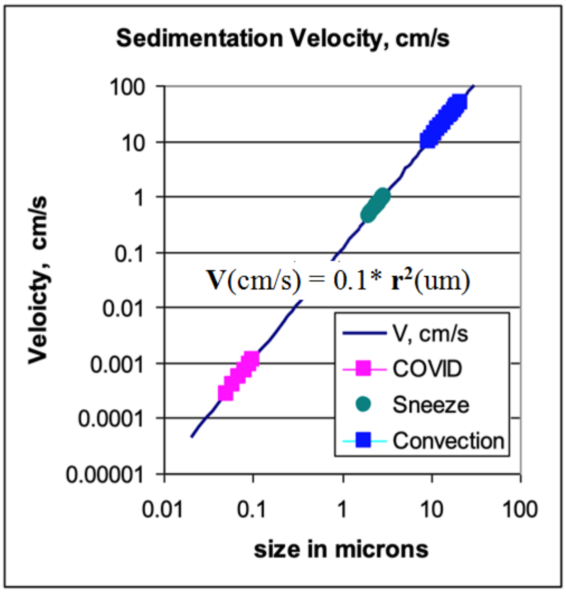

Fig.1

The relation is shown in **Fig.1**. Mind logarithmic scales.

The sedimentation velocities of both - 50 nm virus and minor sneezed droplets of micron size are way lower than velocities of air motion by thermal convection, by people stirring air, or by a ventilation. Thus, we conclude that both - virus and micrometre drops will not sediment onto surfaces, but will float in the business space forever, until they naturally deactivate within T=2-3days. This simple estimate allows formulating the new target - dramatic reduction of virus transmission may be achieved by disinfecting airborne virus within a much shorter time. Let us estimate if public admission spaces could be disinfected within one hour, this way reducing transmission speed by the factor of ~30.

II. CONCLUSION:

The focus shall be on disinfecting air to kill airborne virus

Existing Technologies : On the current market there are bacteria and virus killing devices using UVC germicidal technology. For example, the quartz lamps used to disinfect hospitals(Armellino et al., 2018). However, those devices work on the cycle basis, for people shall not be exposed neither to UVC, nor to the UVC produced ozone, taking 2 hours to deplete. The readily available UVC lamps could be efficient for a timed overnight cleaning of public spaces, but such long breaks in the daytime would be seriously disrupting social activities, and what is most important, are not acceptable in COVID19 clinics, where the risk of the contamination is highest.

International Ultraviolet Association (IUVA)
[https://iuva.org/iuva-covid-19-faq] provides a list of 55DISINFECTION UV SYSTEMS currently applied in:

- ✓ Airports (35)
- ✓ Commercial Property (37)
- ✓ Drinking Water (27)
- ✓ Food & Beverage (31)
- ✓ Healthcare Facilities (39)
- ✓ Hotels & Restaurants (37)
- ✓ Optics for UV LEDs (9)
- ✓ Schools & Universities (38)
- ✓ Swimming Pools (18)
- ✓ Wastewater Reuse (18)

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Instead, we are proposing a line of air-disinfection devices which work continuously, disinfecting large spaces, and without harming humans. So how does it work?

The main principles are in continuous air exchange, disinfecting air by the sufficient dose UVC, enclosing UVC into shielded compartment, filtering out harmful ozone, and feeding clean air at a moderate velocity to avoid fast spreading of residual virus in not yet disinfection portion of the air.

UV Dose : Based on experimental data published on the International UV Association site (IUVA.org), the UV of choice is UVC (254 nm wavelength), and the sufficient UVC dose to kill 99.9% of viruses is 200 Joule per square metre if surfaces are exposed to the direct UVC light. Most appropriate are germicidal mercury lamps in a quartz body transmitting UVC. IUA site also provides a list of international UVC suppliers. Examples and parameters of mercury UVC lamps are well presented in Leybold Heraeus Site. Standard low pressure UVC lamps mostly produce 254 nm light at nearly 40% power efficiency. Their lifetime is 9,000 hours, meaning lamps would serve for 4.5 years at 8 hrs/day operation. Whilst 254 nm light produces only minor amount of ozone, approximately ~10% of the light is at 185 nm, which generates ozoneintensively. Humans and materials (except noncorrosive ones) shall not be exposed to ozone.

Conclusions: Required dose ~ 200 Joule/m^2 of Hg lamp UVC
Humans shall not be exposed to UVC and ozone

Proposed Air Disinfector

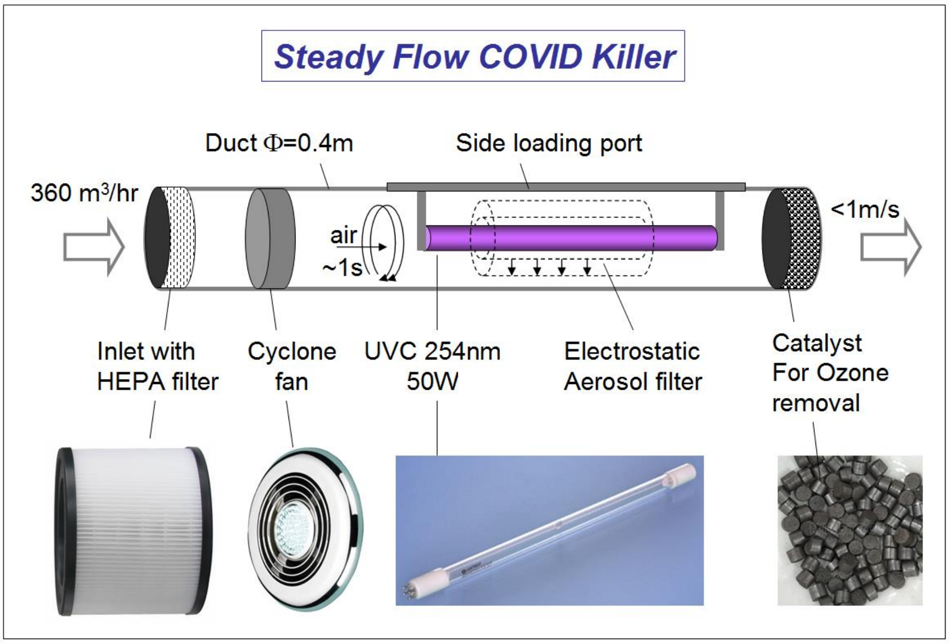

Fig.2

Fig.2 shows an exemplar schematic of the air cleaner. The device is designed to clean 360 m^3/hr air flux, which would exchange the air in 100m^2 space in less than an hour.

The device is arranged within sealed duct to confine the UVC light and ozone. The air is drawn by a fan and is filtered from large aerosol particles (dust, pollen, mould, and bigger bacteria) by a HEPA filter. The replaceable inlet filter prolongs the service cycle. The air flow is then exposed to a UVC germicidal lamp.Let us calculate the achievable UVC dose.
Dose = $W*t/2\pi RL$, t= $\pi R^2L/Flux$,
thus, **Dose = 2WR/Flux**
where W is the UV power, t - is virus residual time, R and L are the duct radius and length, and air Flux = 0.1m^3/s (360m^3/h).

For the chosen lamp power 50W and duct radius 0.2m (chosen to create an output air jet at less than 1m/s velocity), the least illuminated viruses near the duct wall will receive 200 J/m^2 dose (approximately 1 million photons per virus), which is sufficient for killing over 99.9% of the virus.The device may be further enhanced by using an electrostatic filter. In this example we propose a coaxial mesh electrode which would create radial electric field and deposit small aerosol particles onto walls in the UV exposed area, this way making UVC even more efficient.The exhaust employs the key feature of the device – a catalyst for an in-flow ozone removal. Metal oxide or active carbon ozone catalysts(Batakliev et al., 2014) appear highly efficient for an in-flow ozone removal. The materials shall support the device longevity. Aluminium is proposed for a duct material. Aluminium side port is used to install UVC lamp and electrostatic filter. The organic HEPA filter is on the air intake, and it is not exposed to UV or ozone. The fan blades shall be metallic (aluminium or stainless), for plastics would degrade rapidly. The catalyst is inorganic and would not degrade. Quick search of readily available components show that the device cost may be between the cost of air conditioner and refrigerator.Unlike existing products which require 2-4 hours break for the ozone natural disintegration, the proposed device works continuously. Therefore, it allows efficient disinfection without breaks or lockdowns, which is crucial for hospitals, and essential for commercial spaces like banks, grocery shops, pharmacies, offices, and transportation during the Covid pandemic.

Social Demand and Economy : The total office space in the US alone is around 10 billion m^2(Centre for Sustainable systems, 2021) per 350 million population. Global need is estimated at 0.5-1B of devicesat 100 m^2 productivity.Prompt implementation of the air disinfection requires multi-billion investment by large scale companies, ideally having strong experience in the medical equipment field. Competition is very welcome to produce most efficient, economic, and prompt solution. Government shall be assisting the development and expediting regulations and approvals. Producing consortiums shall include components manufacturers, and world-wide distributors.

The urgency of the market can be addressed rapidly as all the components are readily available. Besides killing viruses, the technology kills other harmful bacteria, eliminates smoke, microbes, and various allergens, creating an overall clean and healthy air.

The production and implementation of air disinfection devices can be either a government initiative or a large corporation product development. At mass production prices, the manufacturing of the whole number of needed devices is estimated at $50B and if priced at $1,000, the global revenue would amount to $500B. For comparison, $2,6 trillion were spent for the Coronavirus Aid, Relief, And economic Security Act in the US alone (USAspending.gov, 2020). Hence, investing around $10B in developing and distributing the air purification for the US market would have resulted in significant deceleration of the Covid contingency, expedite revival of social and economic activity and lesser impacts on inflation, due to the absence of such large budget spending ($10B is only 0.04% of the US budget, whereas the current Covid aid is 13%).

III. CONCLUSION

In conclusion, due to the size of the Covid-19 virus and it being mainly airborne transmissible, the additional disinfection focus shall be on purifying the air containing the virus. Whereas it can be done by the existing disinfection devices with the UVC germicidal technology, the device proposed in this article disinfects the air more efficiently. The main benefits of this device are: (1) continuous operation versus the existing products working on a cycle basis; (2) harmless for humans thanks to the in-built catalyst for the ozone disintegration; (3) advantageous for the economic activity revival as the need for imposing lockdowns is no longer; and finally (4) a relatively easy development and implementation as all components are readily available. Compared to the current policies aimedatfighting the Coronavirus, the proposed device is a relatively low-investment but very high-returns and effective solution for stopping the spread of the infection.

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