R&D position paper: Aeration by Sea used in combatting airborne viruses in ventilation systems.

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This R&D position paper is a working paper, and hence it represents research in progress. This paper represents the opinion of TakeAir Labs and its associates and is the product of professional research.

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Chapter 1: The problem

Today, many rooms, schools or office buildings conduct extreme ventilation protocols. Physically regulating the ventilation of rooms decreases the level of pollutants or pathogens if this process happens with clean air. But the occupational density of people, their place and function in a room to the layout of the room and the incoming containments from outside still have the potential to increase airborne infection regardless of good ventilation practices (Amir et al., 2011). As the current protocols fits the situation of desperately seeking for solutions, a more pressing question comes to mind. Could we eliminate or inhibit airborne viruses before entering our working and living spaces? And when they are present in the ventilation cycle, how do we get them out? Single units with high efficiency show great promise but are limited to the room they are placed in. A complete adaptation of the system is not always possible or desirable, and keeping all people out of buildings and offices is not a good long-term vision. How do we deal with those organisms that have been making headlines for so many months now?

There are more advanced air filtration techniques that are used in hospitals and labs, but these are very energy-intensive, which means that this technology is unlikely or too complex to be used in offices or schools, for example. Existing ventilation systems are not dimensioned to replace conventional air filters with more advanced filter systems. As governmental agencies such as the CDC do not give a conclusive answer on the overall microbicidal effectiveness in combatting SARS-CoV-2, for example in portable high-tech purifiers (Christopherson et al., 2020). It is crucial that we keep on searching for the right strategy and actions in combatting future and current health crises.

In addition to effectiveness, there are also concerns about the survival of viruses on widely used filters. Research with viral surrogates (MS-2 coliphage), which are used in test laboratories for safety reasons but also for its characteristic features. The MS-2 virus, which is an undeveloped virus that lacks a lipid bilayer and appears to survive longer than an enveloped virus such as influenza or SARS-CoV-2 (Rengasamy et al., 2010; Rutala & Weber, 2004). Here, the MS-2 bacteriophage was able to maintain their viability of up to 7 days on filter surfaces and may indicate that other viruses could also survive (Mittal et al.,2011). Viruses cannot multiply outside the body of a host but can survive on a carrier for as long as they can. Crucial to depriving a virus of the chance to multiply within a host is the optimization of an antimicrobial environment in combination with carriers that inhibit spread and survival. Outbreaks of infection occurred on several occasions where entire floors get infected (Reuters, 2020; Park, S et al., 2020). Where two other outbreaks from China in January 2020 attribute air conditioning systems using a re-circulating mode as a probable aid to transmission (Shen Y et al., 2020).

The WHO but also the European Centre for Disease Control (ECDC) already concluded very early in the global pandemic that confined and enclosed spaces with poor ventilation increases the chances of infection. Where several studies have addressed the role of ventilation in COVID-19 outbreaks. The ECDC continues that It is possible for COVID-19 aerosols to spread through HVAC systems within a building or vehicle and stand-alone air-conditioning units if air is recirculated. They conclude that air flow generated by air-conditioning units may facilitate the spread of droplets excreted by infected people (EDCD, 2020). As further research is needed, we present a strong case in the following chapters that action is possible to eliminate sources of airborne contamination in ventilation systems and create a suitable environment for human consumption. Any transmission via ventilation systems can be spread more rapidly in coupled systems or have a heavier impact on a closed one. An optimized and personalized operation of our indoor air quality is imminent.

Chapter 2: Back to basics

Summarizing the problem, we are looking at two questions that need to be resolved: (i) is it possible to implement an anti-viral treatment in a ventilation system with the purpose in combatting airborne viruses. (ii) How do we counteract the survival and viability of airborne viruses and later remove them from the system, filter or matrix.

To make our story clear, we need to explain what aeration is. Aeration is a process where water (or small water particles) and air are brought into close contact to remove impurities. It is usually one of the first steps within large wastewater treatment plants. A very physical process removes impurities or unwanted particles from the chosen material. Once in contact with this process, the impurities can easily be removed by filtration. We translate the set-up back to our own setup: the element to be purified is air, the impurities to be removed are potential airborne viruses. Incoming air, recirculated air is therefore brought into contact with a specified carrier or matrix where an antiviral substance is embedded. This setup will inhibit and/or eliminate the airborne virus particles.

A new R&D line within TakeAir Labs is based on the application of marine polysaccharides (from now on called the biological compound). This biological compound showed promising antiviral characteristics in several scientific papers (Wang et al., 2012). We sent our biological compound to an independent scientific medical research institute, where measurements of the antiviral activity of these samples to the human coronavirus OC43 were made. All the results show that the tested solutions had an antiviral action against certain coronaviruses with EC50 values in the range of 20-100 µg/ml. Our anti-viral biological compound showed a satisfying and proven anti-viral effectiveness to further allocate resources to this program. In the next chapter we will explain how we will be removing the impurities and integrate the anti-viral biological compound into a ventilation system and therefore drastically address the viability of viral pathogens. This step in the ventilation process is what we call Aeration by Sea.

Chapter 3: Aeration by Sea

As most systems rely on filters in cleaning pollutants and impurities from the air the question still stands how they affect the viability of viral pathogens on these carriers and matrices. Through scientific research and several test set-ups, we further enhanced our biological compound to be applied on a special matrix. The material and matrix were then tested under laboratory conditions to evaluate the effectiveness of virus capture in a ventilation system.

Assays with bacteriophages, viruses that infect a specific bacterium ('host' bacterium), offer a safe alternative to investigate antiviral effects of chemical components. Within the test setup, we use the MS2 phage with E. coli as host. The choice for the MS2 phage is because it is harmless to humans and is more difficult to kill than SARS-CoV-2 (Prussin et al,. 2018), and less susceptible to environmental stressors such as temperature and osmotic pressure. It has also proven itself in recent months in a joint study by Boeing and the University of Arizona, regarding safe air travel (Aisha et al., 2020).

By first conducting directional tests with MS2, we have been able to test a large number of potentially effective formulations and multiple contact times. Within the different concepts carried out in confined spaces where the dispersion of the phages in the air was done by aeration of a phage suspension (creation of aerosols) and where an internal airflow was created by a fan. We were able to conclude that there was a capture of phages in the airflow by our specified matrix. By adding our antiviral product to the matrix, the retained phages on the matrix can be killed by a combination of dehydration and the action of our biological compound. After a lot of research, a test procedure is developed to obtain the capturing of phages from the air stream utilizing a treated filter, placed in the ventilation tube. Eventually we were able to experimentally demonstrate the antiviral effect and a decrease in viability of viruses on our matrix, with the possibility in further developing this set-up to an existing ventilation system

Conclusion:

In this position paper, we wanted to describe our latest research findings for ventilation systems to create an anti-viral treatment in combatting airborne pathogens such as SARS-CoV-2. By creating a specified matrix that captures the airborne pathogens we counteract the survival and viability of viral airborne pathogens as we imbed the matrix with an anti-viral biological compound. This gives us the possibility to later remove airborne pathogens from the matrix and system. As the first experimental set-up was successful, we continue building on these results towards a viable system to be implemented in real-life building.

Bibliography

Amir A. Aliabadi, Steven N. Rogak, Karen H. Bartlett, Sheldon I. Green, "Preventing Airborne Disease Transmission: Review of Methods for Ventilation Design in Health Care Facilities", Advances in Preventive Medicine, vol. 2011, Article ID 124064, 21 pages, 2011. https://doi.org/10.4061/2011/124064

Christopherson DA, Yao WC, Lu M, Vijayakumar R, Sedaghat AR. High-Efficiency Particulate Air Filters in the Era of COVID-19: Function and Efficacy. Otolaryngology–Head and Neck Surgery. July 2020. doi:10.1177/0194599820941838

Rengasamy, S., Fisher, E., & Shaffer, R. E. (2010). Evaluation of the survivability of MS-2 viral aerosols deposited on filtering face piece respirator samples incorporating antimicrobial technologies. American Journal of Infection Control, 38(1), 9-17.

Rutala, W. A., & Weber, D. J. (2004). Registration of disinfectants based on relative microbicidal activity. Infection Control and Hospital Epidemiology, 25, 333-341.

Mittal H, Parks SR, Pottage T, Walker JT, Bennett AM. Survival of Microorganisms on HEPA Filters. Applied Biosafety. 2011;16(3):163-166. doi:10.1177/153567601101600305

Shen Y, Li C, Dong H, Wang Z, Martinez L, Sun Z, et al. Airborne transmission of COVID-19: epidemiologic evidence from two outbreak investigations. 2020 [18 May 2020]. Available from: https://www.researchgate.net/publication/340418430_Airborne_transmission_of_COVID19_epidemiologic_evidence_from_two_outbreak_investigations

Reuters . (2020, September 15). JPMorgan sends some traders home after worker contracts COVID-19: Bloomberg News. Reuters.

Park, S., Kim, Y., Yi, S., Lee, S., Na, B., Kim, C....Jeong, E. (2020). Coronavirus Disease Outbreak in Call Center, South Korea. Emerging Infectious Diseases, 26(8), 1666-1670. https://dx.doi.org/10.3201/eid2608.201274.

Wang, W.; Wang, S.-X.; Guan, H.-S. The Antiviral Activities and Mechanisms of Marine Polysaccharides: An Overview. Mar. Drugs 2012, 10, 2795-2816.

Prussin et al. 2018 (10.1128/AEM.00551-18); silverman & Boehm 2020 (10.1021/acs.estlett.0c00313); Fedorenka et al. 2020 (10.1101/2020.06.15.152983)

Aisha N Khatib, MD, Anna-Maria Carvalho, MD, Robert Primavesi, MDCM, Kent To, MDCM, Vincent Poirier, MDCM, Navigating the Risks of Flying During COVID-19: A Review for Safe Air Travel, Journal of Travel Medicine, , taaa212, https://doi.org/10.1093/jtm/taaa212

European Centre for Disease prevention and Control (ECDC), 22 June 2020; Heating, ventilation and air-conditioning systems in the context of COVID-19