A COMPARISON OF THE GRIGNARD PURE ANTIMICROBIAL AIR TREATMENT TECHNOLOGY WITH ENHANCED VENTILATION AND FILTRATION STRATEGIES FOR REDUCING THE LEVELS OF AIRBORNE SARS-CoV-2 VIRUS PARTICLES

This paper addresses the use of the antimicrobial air treatment product, "Grignard Pure," as an additional measure for protecting against the transmission of the COVID-19 virus. It describes how the Grignard Pure product can be used in occupied, indoor spaces to quickly reduce by 99.5 % the level of airborne virus particles, such as SARS-CoV-2. It also compares the efficacy of the Grignard Pure technology with the ability of enhanced ventilation and air filtration systems to remove virus particles. Finally, the paper compares the practicality of using Grignard Pure with making changes to ventilation and air filtration systems.

Please note: The Grignard Pure system is not an antimicrobial "device." Rather, it is an aerosolized air treatment product that uses certified types of equipment to deliver the antimicrobial material into the air. As such, Grignard Pure is an antimicrobial "pesticide" – a type of product that cannot legally be sold without approval from the Environmental Protection Agency (EPA). EPA has reviewed Grignard Pure for safety and efficacy and approved its use on an emergency basis to reduce levels of the SARS-CoV-2 virus in the air. In contrast, EPA does not review, much less approve, the safety or efficacy claims made for, or the actual performance of, antimicrobial devices like many bipolar-ionization machines or Ultra-Violet lights. Thus, it would be technically inaccurate to refer to the Grignard Pure as a "device."

Finally, the Grignard Pure technology is not a competitive technology intended to replace the enhanced ventilation and filtration strategies recommended by ASHRAE and the Centers for Disease Control and Prevention (CDC). Grignard Pure is intended as an additional layer of protection for public health in the fight against the COVID-19 pandemic. The product's label will direct users to follow public health officials' advice, including the guidance for enhanced ventilation and filtration.

Introduction – What is Grignard Pure?

How it is used. Grignard Pure is an antimicrobial air treatment product that is dispersed into the air as aerosol, where it contacts and inactivates ("kills") airborne virus particles. It can be introduced into an indoor space either through application equipment installed in an HVAC system or by a free-standing dispersion unit. Engineering studies show that the aerosol quickly and evenly disperses throughout an indoor space and does so in both small and large spaces. Particle sensors can measure the level of aerosol in the space. In order to ensure a consistent, safe, and efficacious concentration of Grignard Pure in the air, proprietary software can use particle sensor measurements to automatically direct the dispersion equipment to add more Grignard Pure to maintain the concentration level of the product within the EPA approved concentration range once the target level is reached.

Safety. The active ingredient in Grignard Pure is triethylene glycol (TEG). The U. S. EPA's Office of Pesticide Programs has evaluated the numerous studies on the safety of TEG and determined that TEG does not cause systemic adverse effects at air concentrations below 1,000 mg/m^3. (https://archive.epa.gov/pesticides/reregistration/web/pdf/triethylene_glycol_red.pdf). Grignard Pure would be used in a manner that results in a level of TEG in the air of less than 3 mg/m^3. In addition to the extensive database on the biological effects of TEG, the safety of Grignard Pure is confirmed by the long history of use of a sister product as a lighting effects fluid. The sister product has the same formula and use pattern as Grignard Pure and has been used for over 20 years in film and TV production, at houses of worship, at live events such as concerts and sporting events, and in theaters and museums with no reported serious health effects.

Efficacy. Research by both EPA's Office of Research and Development (ORD) and by Microchem, an independent private laboratory, shows that once introduced into an indoor space, the product kills over 99.5% of airborne virus particles. Both research efforts used similar methodologies. Researchers nebulized a large amount of a surrogate virus, the MS2 bacteriophage, into a chamber and measured the concentration of the virus. Then, the Grignard Pure aerosol was introduced, and beginning 30 seconds later the researchers started to collect air samples to measure how much Grignard Pure reduced the concentration of the virus. To account for natural die-off and settling of the virus, researchers also performed a control run in which they measured the decline in concentrations of the virus in a chamber without Grignard Pure. The air samples in the control run were collected at the same time points as in the test run. Researchers calculated efficacy by comparing the virus levels measured in the test and control chambers. In the Microchem test, Grignard Pure reduced the virus concentration by 99.5% compared to the control during the first sampling interval –30 seconds to 10.5 minutes. A summary of the ORD research with Grignard Pure is available at: https://www.epa.gov/covid19-research/results-aerosol-treatment-technology-evaluation-grignard-pure, and a copy of the Microchem study, which was performed in accordance with EPA's Good Laboratory Practices rule, is available upon request.

It should be noted that the efficacy studies probably understate the extent to which Grignard Pure would inactivate the SARS-CoV-2 virus. First, the use pattern of Grignard Pure is to introduce the air treatment into spaces that will subsequently be occupied and to maintain an efficacious concentration continuously. This means that the product will begin working to inactivate virus particles at the instant that an infected individual releases the virus into a space protected by Grignard Pure. In addition, the surrogate virus, the MS2 bacteriophage, is a small, non-enveloped virus that is harder to inactivate than the large, enveloped SARS-CoV-2 virus. Thus, there are reasons to expect the Grignard Pure to perform more effectively than seen under the controlled laboratory conditions.

Efficacy of Grignard Pure and Enhanced Ventilation and Filtration at Reducing Virus Levels

A comparison of the efficacy of an antimicrobial air treatment and enhanced ventilation and filtration measure at reducing the level of pathogenic virus particles in the air should consider three criteria. First, the amount of reduction is important: **what percentage of the circulating virus particles is eliminated?** Second, the speed with which the measure works is important because an infected individual will continually release virus particles into an indoor space: **how quickly does the measure remove virus particles?** Finally, while both measures should be capable of reducing the level of airborne virus particles, the mechanism of action – removal vs. inactivation of the virus particles – should be considered: **how does the measure achieve its effect?**

Percentage reduction. As reported above, research shows that Grignard Pure reduces the level of airborne virus particles by over 99.5%. In addition, EPA's research shows that Grignard Pure also reduces the level of active virus particles that settle onto hard surfaces. (https://www.epa.gov/covid19-research/results-aerosol-treatment-technology-evaluation-grignard-pure). This compares favorably with enhanced ventilation and filtration strategies, which can vary considerably depending on the specific measures implemented.

- Ventilation, understood as the introduction of virus-free, outside, "fresh" air, depends on the HVAC system's settings, but is rarely more than 15% fresh air per air change. Historical ventilation requirements are for gases (CO_2 / VOCs), not for aerosols. The virus particles and their carriers function differently and require 2-3 times the ventilation rate to realize a meaningful reduction in airborne risk as determined by the Wells-Riley Equation. (Sze To and Chao, 2010, https://pubmed.ncbi.nlm.nih.gov/19874402/).

- Ventilation, understood as increasing the number of air changes per hour, helps by increasing mixing of indoor air, thereby reducing uneven concentration of virus particles. The elimination or reduction of "hotspots" may lessen the chance of transmission. At the same time, by itself, increasing ventilation is not enough to protect people from COVID-19. (https://www.epa.gov/coronavirus/ventilation-and-coronavirus-covid-19).

- Moreover, improper ventilation designs can direct higher concentrations of the virus emitted from an active shedder to other people in a space due to the air currents created. CDC and OSHA have specific guidelines in the meatpacking industry to design workstations such that air flows do not carry infection from one worker to another. (https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/meat-poultry-processing-workers-employers.html).

- Filtration is more effective than ventilation, depending on the technology used to filter virus particles from the air. Filtration depends on the circulation of indoor air through an HVAC system in which either a physical filter or an antimicrobial device has been installed. Physical filters trap a percentage of particles that are in the air passing through the HVAC system. Filter efficiency varies according to the size of the particles; smaller particles are harder to trap. Also, filter efficiency depends on the construction of the filter. Merv 8 filters (industry standard for most current building design standards) ND% of particles in the SARS CoV 2 size range, 84.9% of particles in the 3-10 micron size range; Merv 14 filters trap 75-84% of particles in the 0.3 - 1.0 micron size range and greater than 90% in the 1.0 - 3.0 micron size range of particles. Note: SARS CoV 2 virus are estimated to be in the size range of 0.05-0.15 microns. (https://www.epa.gov/indoor-air-quality-iaq/what-hepa-filter-1).

- Generally, there is limited data on the percentage of virus particles removed by freestanding antimicrobial devices, and much of the research presented by device manufacturers has been questioned.[1]

[1] Independent academic researchers issued a public letter commenting on an article in the Washington Post describing antimicrobial device products claiming to reduce the level of SARS-CoV-2 in the air. See "FDA-approved air purifiers could help you breathe easy," May 17, 2021; available at: https://www.washingtonpost.com/technology/2021/05/11/fda-approved-air-purifiers-coronavirus/ The public letter states:

> The greatest risk of contracting COVID-19 is through breathing in small respiratory droplets expelled from an infected individual. No government agency has determined how much, or even whether, the products featured in the Post's May 17 article, reduce airborne levels of COVID-19. The public seeking protection against COVID should not rely on these or other products unless they have undergone relevant government review for safety and efficacy against the airborne virus.
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> The article gives a dangerously misleading picture of the efficacy of the featured products at removing COVID-19 virus particles from the air. The products mentioned in the story use a fan to pull air through filters that trap particulate matter and then use UV light to kill pathogens on the filters. The Molekule purifier captures over 95% of particulates ranging in size from 300 to 1000 nanometers. The COVID-19 virus, however, is only 50 - 140 nanometers. Moreover, the article's report that "the [Molekule] brand's technology reduced the virus's concentration by more than 99.999 percent," applies only to the virus trapped by the filter inside the purifier – not the level of virus in the air. These products are expensive but may not do much good.

- For example, EPA research on two antimicrobial devices showed reductions of -4% in 30 minutes (freestanding bipolar ionization device, 10x oversized), (https://www.epa.gov/covid19-research/results-aerosol-treatment-technology-evaluation-cold-plasma-bipolar-ionization) and 1.9 Log reduction in 30 minutes (device combining physical filtration (equivalent to 32 air exchanges per hour), UVC and bipolar ionization (high-ion concentration))). (https://www.epa.gov/covid19-research/results-aerosol-treatment-technology-evaluation-knorr-3-stage-air-filtration-and). Note: The above aforementioned technologies were either not tested against pathogens on surfaces and virus settling or showed zero efficacy.

- The performance of UVGI in HVAC systems is determined by the delivered UV dose (concentration x time). The elevated air velocities in many central duct systems make it difficult to deliver an effective UV dose in the treatment space typically available in a duct. It appears many products currently on the market claim performances substantially better than seems possible, given published air velocities and UV lamp performance. Improvements in the standardization of testing are needed.

Speed. Grignard Pure achieves 99.5% inactivation of airborne virus particles quickly. The Microchem study measured virus levels before Grignard Pure was introduced and then after collecting an air sample for ten minutes, starting 30 seconds after the Grignard Pure was introduced. (The ten-minute collection period was necessary in order to obtain a sample that had a measurable level of virus.) By comparison, the speed with which enhanced ventilation and filtration measures work will likely take considerably longer. Both filtration and ventilation depend on the rate of circulation of indoor air, expressed as air changes per hour (ACH), and in most buildings and other commercial indoor spaces, HVACs operate at 0.35 – 8 ACH (typical ACH is 2-4). (https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards). That means that a volume of air equal to the volume of the indoor space passes through the HVAC system every 15 – 30 minutes. It is notable that Grignard Pure would be immediately available in an indoor space where the virus is present, while ventilation and filtration work only as the air passes through the HVAC system. Thus, Grignard Pure operates at least as quickly and likely more rapidly than ventilation and filtration.

When percentage kill and speed are considered together, it is apparent that using Grignard Pure is more effective than enhanced ventilation and filtration measures. As noted, Grignard Pure lowers the level of airborne virus particles by 99.5% in less than10 minutes. By contrast, CDC estimates that it would take about 90-180 minutes for an air filtration system to remove an equivalent amount of virus without an active shedder in the space. (https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html).

Another way of looking at this: Air movement through a space is an imperfect mixing process and it is generally held that a minimum of 6 changes of room air with a nearly 100% effective removal rate via ventilation, filtration or UV treatment must be completed to fully rid a space of a subject contaminant. Air change rates in typical occupied spaces range from 2-4 Air Changes per Hour resulting in a period of 90-180 minutes to complete 6 changes of room air. Grignard Pure has been tested to provide a 99.5% reduction in airborne virus concentrations in a period of less than 10 minutes accomplishing a 99% reduction in airborne concentrations 9 to 18 times faster than central ventilation, HEPA filtration or UV treatment alone. Confusion among the general population leads some people to believe that a 99% efficient filtration rating means that 99% of the airborne Covid has been removed from the occupied space, this can be far from the truth when equipment is improperly deployed.

Mode of action. Grignard Pure inactivates virus particles in the air of an indoor space. By contrast, ventilation and filtration remove particles, without necessarily inactivating them. Replacing virus-laden air with fresh air lowers the level of virus particles but filtration using physical means simply traps the virus in the filtration medium. Finally, filtration and ventilation are effective at removing viruses and bacteria from the space but may do little for respiratory droplets which carry these pathogens; filtration and ventilation do not address the pathogens that may reach a hard surface.

Practicality of Grignard Pure and Enhanced Ventilation and Filtration Measures

As noted above, Grignard Pure works when used in both freestanding devices and dispersion equipment installed in HVAC systems. Because it readily and rapidly dispersed throughout indoor spaces, it is a scalable approach to protection in indoor spaces of any size.

In contrast, engineering considerations limit the extent to which various ventilation and filtration measures can be employed. Some of the challenges of relying on improved ventilation and filtration strategies are detailed below:

- Prior to making any enhancements to ventilation and/or filtration, a meaningful engineering assessment of each specific space would have to been done to evaluate the feasibility of making any change to the air handling system's performance or operation. Special training and equipment are required for this work, and the labor pool is limited. Unfortunately, however, the country does not have the resources to conduct such needed assessments in many indoor spaces in a reasonable period of time.
- It is not feasible to make a meaningful upgrade to the ventilation rates of many indoor locations due to limitations on critical elements of the building infrastructure and geometry. For example, ceiling cavities and vertical duct shafts do not allow space for the larger ducts required to deliver elevated air change rates.
- Increasing the amount of outside, fresh air introduced will increase operating costs as the introduced air will need to be conditioned – heated, cooled, and/or dehumidified – prior to circulating inside.
- Increasing the efficiency of filtration in HVAC equipment is likely to reduce the air flow rate through the equipment. Many of the new ventilation guidelines for filtration and ventilation for large spaces like malls and older venues cannot be readily accommodated with existing installed equipment because the equipment lacks sufficient power to maintain an adequate ACH level. Even if the equipment can meet the power requirements, operating costs will increase, and the amount of carbon emissions is also likely to rise.
- Because of the presence of potentially active virus particles, removing a filter could be hazardous. Very specific procedures must be established prior to filter changes to allow the virus to become inactive to avoid PPE use during filter changes.

In conclusion, compared to enhanced ventilation and filtration measures, Grignard Pure is an effective, safe, practical, and quicker way to reduce airborne concentrations of virus particles. While Grignard Pure offers advantages compared to enhanced ventilation and filtration measures, it is not intended to replace the use of those measures wherever feasible. Instead, Grignard Pure should be used as an added layer of protection in conjunction with other measures recommended by public health officials. Using Grignard Pure, together with the suite of other public health actions, could dramatically reduce the level of circulating virus in locations where large groups of people gather and where risk of continued transmission is still high.

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