

Summary Review of EPA Office of Research and Development: Homeland Security Research, [COVID-19 Research: Ozone and Aerosol Treatment HSRP Webinar Series](#)

The Grignard Pure company prepared this document to summarize publicly available data from studies conducted by the Office of Research and Development (ORD) at the U. S. Environmental Protection Agency (EPA). *(The text appearing in italics and brackets represents the views of the Grignard Pure Company and do not necessarily reflect the conclusions of the EPA.)* The ORD studies, under the auspices of EPA's COVID-19 research program, evaluated the effectiveness of different technologies for reducing the level of virus particles in the air. ORD's studies have evaluated three different technologies: a Bipolar Ionization device, Grignard Pure, and the Knorr 3-stage system, which combines a fan to bring air into the device with three modules: an electrostatically charged physical filter, UVC radiation, and a Bipolar Ionization component.

[Independent efficacy testing data on technologies claiming to reduce the level of airborne virus particles is critically needed. Currently many products are appearing in the marketplace making extravagant claims to kill airborne viruses like the COVID-19 virus, SARS-CoV-2. The public is understandably eager to adopt products that promise to provide the needed protection that would allow people to resume indoor gatherings, where social distancing is not feasible. Using untested products may not provide the desired protection, and unjustified reliance on them could lead to the continued spread of COVID-19 illnesses.]

EPA's research goals were to assess the efficacy of air treatment products and devices at a real-world scale and develop reliable and standardizable methods for testing the efficacy of novel, untested air treatment technologies. The testing objective was to be able to obtain high enough recoveries of active virus in controlled conditions throughout testing to demonstrate a minimum efficacy of a $3 \log_{10}$ reduction, which is the equivalent of 99.9% reduction of active virus over the course of the test runs, which varied from 90 – 120 minutes.

Here briefly are the results of the EPA ORD efficacy studies with the three different antimicrobial air treatment technologies:

Technology	Efficacy at first sampling interval (15 minutes)	Highest level of efficacy, (time)
Bipolar ionization	Airborne: -44% (i.e., the virus levels were higher in test chamber than in control chamber)	Airborne: 86%, @ 60 min.
Bipolar ionization	Surface: 0%	Surface: 0%
Grignard Pure (GP)	Airborne: 99.5% (MS2 introduced into GP) 95.4% (GP introduced into MS2)	Airborne: 99.9% (MS2 into GP), @ 90 min. 99.5% (GP into MS2), @ 90 min.
Grignard Pure (GP)	Surface: 98.7% (MS2 introduced to GP) 96% (GP introduced to MS2)	Surface: 2 of 4 tests LOD (no active virus detected)

Knorr System – all modules	Airborne: ~96% (all modules, compared to control without an arrest filter)	99.7% (all modules, compared to control without an arrest filter), @ 90 min.
Knorr System – all modules	Surface: Data and testing not provided	Data not provided

EPA ORD evaluated all technologies for efficacy against the bacteriophage MS2, which is a non-enveloped virus that infects the host cell *Escherichia coli*. As a non-enveloped virus, MS2 is more resistant to chemical inactivation than enveloped viruses such as SARS-CoV-2. As you can see in Figure 1, the EPA Disinfectant hierarchy list, resistance increases from enveloped virus up to spores, in terms of increasing resistance to chemical inactivation.

To simulate a real-world scale testing method, EPA ORD utilized a specialized Aerosol Test Facility in Research Triangle, NC. The temperature- and humidity-controlled large air treatment test chamber measured 3,000 ft³ with mixing fans for consistent air flow. The mock HVAC system was made of galvanized steel duct materials and included a negative air machine which simulated cold air return with adjustable flow of approximately 7 air changes per hour. *[This is higher than average for a 3,000 cubic foot room.]* As depicted in Figure 2, the mock HVAC system was 25 feet in length with 6 branches from the main line, and each outlet was fitted with a 10-inch diffuser.

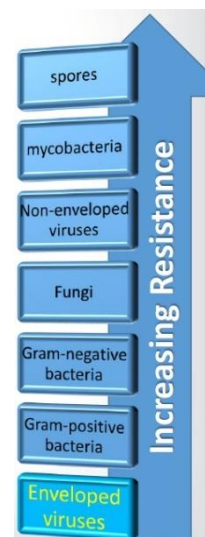


Figure 1: Disinfectant hierarchy list

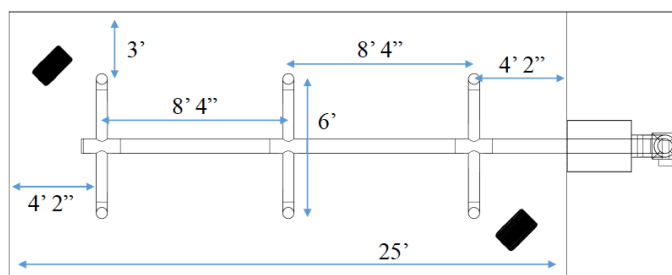


Figure 2: Mock HVAC system

Result Measurements: Efficacy in the EPA ORD studies was expressed as log₁₀ reductions. (The log reduction is a mathematical term used to express the relative number of living microbes eliminated by a technology, compared to the virus level in a control trial at the same time point. In this research, a 1 log₁₀ reduction, also commonly written as a 1-log reduction, corresponds to inactivating 90% of the MS2 with the count being reduced by a factor of 10. A 2 log₁₀ reduction is a 99% reduction.) The test objective of this research was to measure, for each technology studied, whether the technology produced a 3 log₁₀ (99.9%) reduction over the time interval studied.

Technology Type	Intended Use
Bipolar Ionization	Installed in-duct; intended for residential, commercial, industrial, education, health care settings
Grignard Pure (active ingredient: Triethylene Glycol)	Dispersed either in-room or in-duct; intended for use in indoor spaces for essential economic activities as determined by the state; e.g., health care, transportation, food processing
Knorr 3-Stage System: Electrostatic Filter, UVC, and Bipolar Ionization modules	3-stage air filtration and purification system designed to be installed (either new or as retrofit) in the HVAC system of rail transit vehicles; plan to evaluate components operating together & in isolation
Photocatalytic	General indoor use; transit vehicles
Filtration	For use in residential, commercial, transit settings

Figure 3: Technologies tested and intended use

Bipolar Ionization Devices and Research Results

Bipolar ionization generates charged ions that react with airborne contaminants, including viruses. Due to the increased weight, this causes contaminants to drop out of the air. The bipolar ionization device selected for evaluation was sized to treat a 2,000-4,000ft² living space. [The test chamber was approximately 300 ft² and hence the device chosen would normally treat spaces up to 13 times larger than the test chamber. This would appear to mean that the ion count was between 10- 13-fold higher than the ion count recommended to treat the 3,000 ft³ space.] Up to 30 to 90 minutes were allotted to build up the ions in the chamber prior to testing, resulting in an ion count of 1,000-6,000 ions/cm³ respectively. [Target density for bipolar ionization is 1,000 ions/cm³.] The highest log reduction was .85 at 60 mins, 86% efficacy in reduction of the MS2 virus in the air. The average recovery of MS2 from the inoculated coupons from the tests was 7.0 ± 0.1 log₁₀ PFU/coupon, and the average recovery from the control tests was 6.9 ± 0.1 log₁₀ PFU/coupon. No surface inactivation was observed.

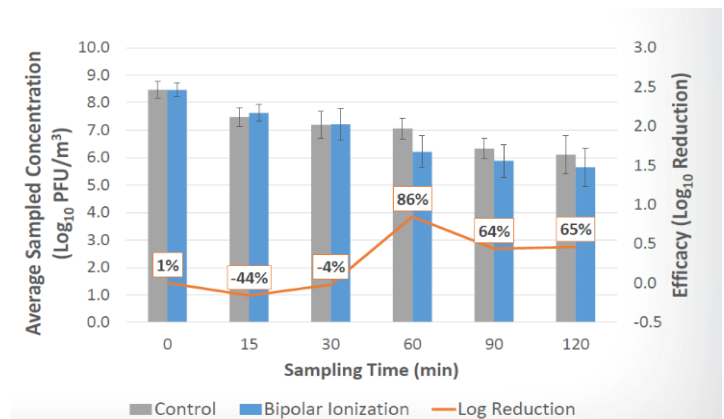


Figure 4: Bipolar Ionization study results

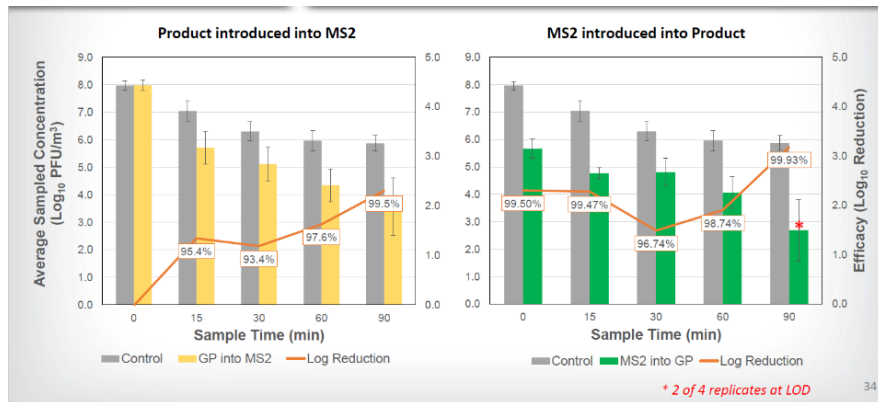
Grignard Pure Research Results

Grignard Pure is an antimicrobial air treatment approved by EPA under an Emergency Exception for indoor use in GA, MD, NV, PA, TN, and TX. The active ingredient, Triethylene glycol (TEG), is commonly used in theatrical fog machines and has historic publications on air disinfection dating all the way back to the 1940's. The concentration used for testing was 1.2- 1.5mg/m³. Grignard Pure was tested two ways.

The graph on the left in Figure 5 (with yellow bars) shows the efficacy of Grignard Pure when introduced to a chamber filled with MS2. The results range from 95.4% to 99.5% between sampling times of 15 min- 90 min.

Figure 5: Log reduction vs Sampling time

The graph on the right is testing Grignard Pure, as the product would be used. The chamber was treated with Grignard Pure and MS2 was introduced into the chamber. Results vary from 99.5% at time zero to 99.93% at 90 minutes. It is important to note that 2 of the 4 tests showed virus levels were below the Level of Detection (LOD), which means no MS2 was detected at 90 minutes for 2 of the 4 tests. A higher level of efficacy was achieved when the product was used as intended; Grignard Pure was introduced into the chamber and 1 minute later, MS2 was aerosolized for 10 minutes with the Grignard Pure in the air. Based on the results, there was over a 2 log₁₀ reduction at time zero and over a 3 log₁₀ reduction by 90 minutes.



In addition to air sampling, the EPA evaluated surface activity to see if the virus treated in the air was recovered on deposition coupons. (Coupons are simply plates used to test viral concentrations on the floor of the chamber.) The study showed reduced MS2 recoveries on these deposition coupons, which means the virus was inactivated in the air before falling to the floor of the chamber. In a second test, coupons inoculated with virus were placed on the floor to determine if Grignard Pure provided any inactivation of the virus on the coupons. Figure 6 shows the results of two inoculated surface tests – with Grignard Pure introduced to MS2 and a second test, MS2 introduced to a chamber already filled with Grignard Pure. The average log₁₀ reduction in MS2 recovered from inoculated coupons in the tests where Grignard Pure was introduced following the time = 0 sample relative to the control was 1.4 ± 0.3 PFU/coupon (96%), and it was 1.9 ± 0.3 PFU/coupon (98.7%) for the tests where the product was dispersed in the chamber prior to MS2 aerosolization. *Note some test replicates were at the Limit of Detection (LOD), meaning no virus was found on these tests. This means the results show 98.7% inactivation of the virus on surfaces when MS2 is introduced to a chamber of Grignard Pure, which is the intended use of Grignard Pure in real world applications.

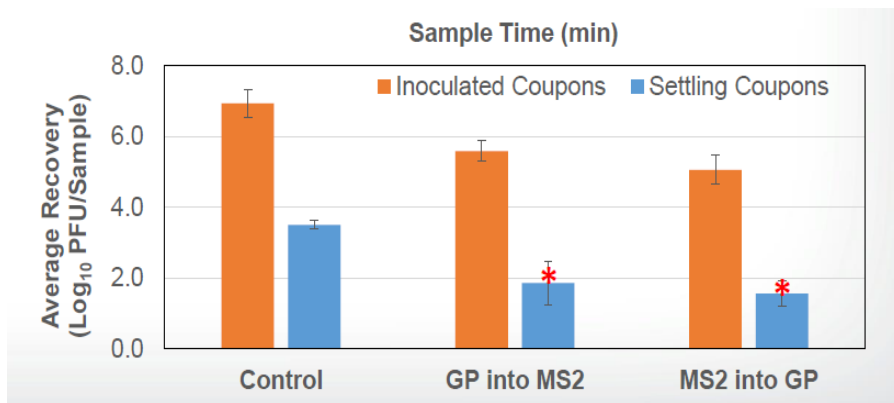


Figure 6: Showing LOG₁₀ reductions on Coupons

Knorr 3-Stage Air Filtration and Purification

The Knorr system, developed for transit vehicles, includes an electrostatically charged physical filter, a bipolar ionization component, and UV-C radiation. UV-C is the lowest wavelength of UV light radiation, which from the sun includes UV-A and UV-B. The test chamber included 7 air changes per hour (as with all previous tests). The Knorr blower circulates 25 air changes per hour through the device. *[Given the size of the test chamber, the Knorr system effectively was operating at 32 air changes per hour, a level of air exchange that might be difficult to maintain in indoor spaces with larger volumes.]* Testing was conducted on each individual module and combination of components and then compared to control runs with and without the physical filter while the device fan introduced air into the system.

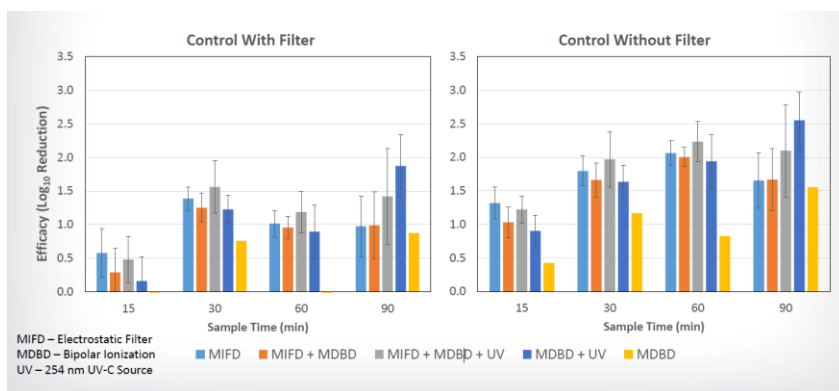


Figure 7: Knorr Testing

[It is notable that there was high variability across multiple trials with the Knorr system, (marked by the standard deviation black lines above each bar). The full report on the research has not been released, and so we are holding our remaining comments until results we receive full detailed results.]

EPA Links and Information:

- [EPA Grignard Pure Study](#)
- [EPA Bipolar ionization study](#)
- [EPA Knorr Study](#)