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**SARS-CoV-2USA-CA1/2020**

**CLIENT: The PYURE Company Inc.**

**PROJECT: MDU/Rx™ Bioaerosol Test**

**PRODUCT: ODOROX® MDU/Rx™**

**FDA Registration: 510(k) Number K133800 (Class II Medical Device)**

**CAP LIC NO: 886029801**

**CLIA LIC NO: O5D0955926**

**STATE ID: CLF 00324630**

**CHALLENGE VIRUS: SARS-CoV-2 USA-CA1/2020**

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## **ABSTRACT: EFFICACY OF THE PYURE MDU/Rx™ DEVICE AGAINST AEROSOLIZED SARS-CoV-2**

**Background:** This in vitro study was designed to determine the efficacy of the MDU/Rx™ unit. The product is a commercially available mobile disinfection device manufactured by The PYURE Company (PYURE) out of Boynton Beach, Florida. The MDU/Rx™ unit is designed to be placed free standing in a room and decrease the concentration of pathogens in the air and on surfaces when it is operating, in order to sanitize enclosed spaces and their contents. For this challenge, the SARS-CoV-2-CA1/2020 pathogen was used. The CDC estimates more than 10,000,000 people in the United States have been infected by SARS-CoV2 leading to an estimated 240,000 deaths between 2019 and 2020. Coronavirus can be spread through the air and by touching contaminated surfaces. There is a demand for disinfectant devices that have a proven ability to reduce infectious pathogens in the air thereby reducing the risk of human infection and transmission. PYURE supplied a pre-packaged MDU/Rx™ free standing unit for testing purposes. For the testing, power was supplied through a power regulated 120v outlet with surge protector and backup battery system. Test procedures were followed using internal SOPs for aerosolized viral pathogen challenges and subsequent decontamination. All internal SOPs and processes follow GCLP guidelines and recommendations.

**Results:** When tested against SARS-CoV-2-CA1/2020 virus, the PYURE MDU/Rx™ unit showed a progressive reduction during the time it was operated resulting in significant destruction of the virus. In three identical trials, the average reduction of aerosolized virus was 99% at the 20-minute sampling point and a steady, further reduction to greater than 99.98% at the 80-minute sampling point, where the virus was no longer detectable due to the limit of quantification. The average reduction of inoculated surface samples was 99% at the 60-minute sampling point and steady, further reduction to greater than 99.999% at the 180-minute sampling point, where the virus was no longer detectable due to the limit of quantification.

### **EQUIPMENT PROVIDED:**

MANUFACTURER: The PYURE Company

MODEL: MDU/Rx™

SERIAL #: MDURXA0000069





**MDU/Rx™ EQUIPMENT:**

The equipment arrived at the laboratory pre-packaged from the manufacturer and was inspected for damage upon arrival. Two mercury vapor UV optics were provided by the manufacturer to install in the device upon arrival. The optics were installed, and the device was powered on to check for normal operations. Prior to starting the challenge, the PYURE MDU/Rx™ unit was operated for over 6 hours of dry runs in a sealed bioaerosol to confirm correct operation of the. Chamber was the same BSL3 chamber used for the viral challenge testing.

**VIRAL CHALLENGE TESTING CHAMBER:**

The testing chamber was a large, sealed air volume testing chamber consisting of metal walls and epoxy floor which complied with BSL3 requirements for containment of an aerosolized pathogen. The chamber was designed to be completely sealed from the outside environment to prevent any potential release of testing media into the atmosphere. The testing chamber was equipped with 4 sealed viewing windows and a lockable chamber door for entry and exit. The overall dimensions of the test chamber were approximately 8'x8'x20' with a displacement volume of 1280 cubic feet. Based on cubic foot volume the chamber had 36,245.56 liters of air.

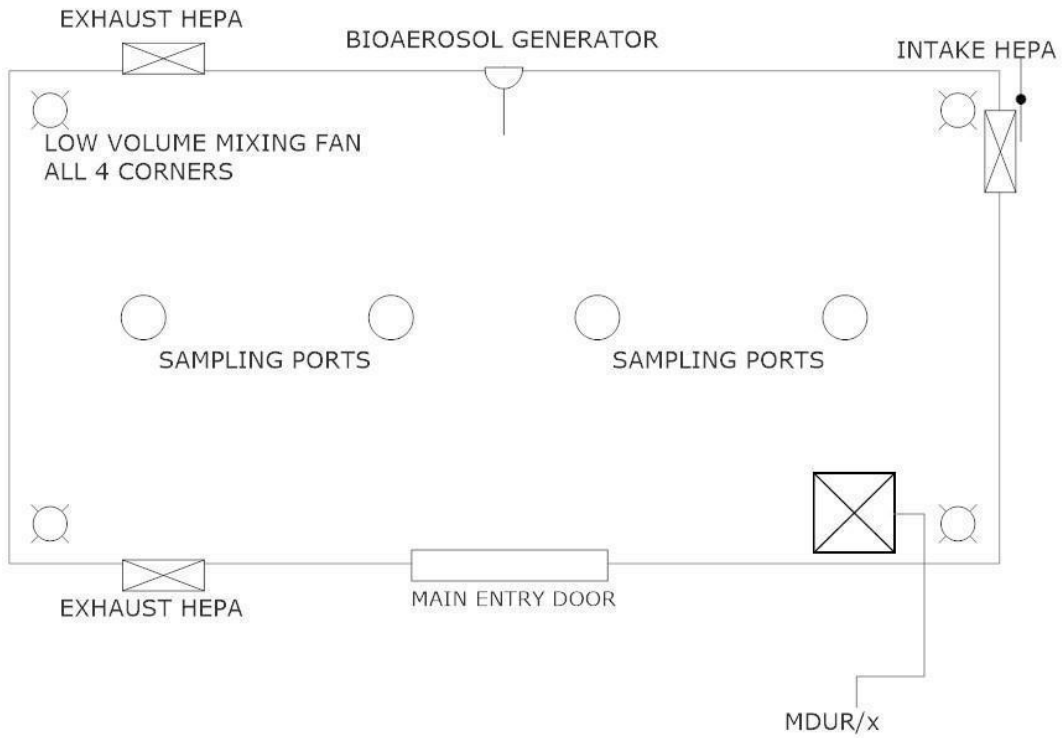
The testing chamber had HEPA filtered inlets and exhaust, coupled with an active UV-C system in all ducting lines. Humidity and temperature were monitored inside the chamber using a calibrated wireless device. For air sample testing, the chamber was equipped with 4 probes that were along the centerline of the room and protruded down from the ceiling 24". Each probe tube was connected to a Gilian 10i programmable system with sampling cassettes from lot # 18248 made by Sensidine. A single bioaerosol nebulizing port was in the center of the 20' wall opposite of the entry doors. The dissemination port protruded from the wall 24" and was connected to a programmable compressor nebulizer system.

Prior to testing, the chamber was pressure tested for leaks and visual inspections were made using a colored smoking device. All seals for the chamber were confirmed and all equipment used had a function test to confirm working conditions. For calibrated equipment, calibration records were checked to confirm operational status.

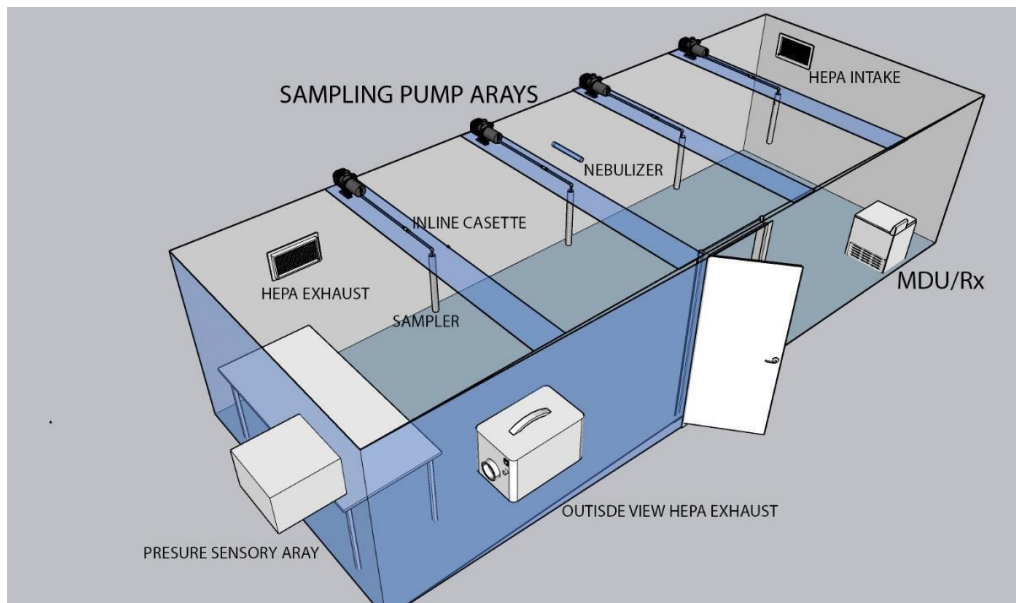
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## CHAMBER LAYOUT OVERHEAD 1:



## DESIGN LAYOUT 3D:





### **EXPERIMENTAL DESIGN**

- Prior to the initial control test and following each trial run the testing area was decontaminated and prepped per internal procedures.
- Temperature during all test runs was approximately 75F +/- 2F with a relative humidity of 43%.
- Relative humidity and temperature were taken in two sections of the chamber during all tests to confirm there was no more than a 3% deviation from each side.
- Air samplers were calibrated by the manufacturer on September 3, 2020 and set at a standard flow of 5.02L/min. Calibration records indicate a 0.20% tolerance.
- All sample collection volumes were set to 5-minute draws per time point.
- Low volume mixing fans were turned on prior to nebulization to confirm homogenous concentrations in the test chamber.
- Mixing fans remained on and positioned at a 45-degree angle to encourage bioaerosol suspension and reduce natural particle descent rates.
- Nebulization for control and viral test challenges were performed in the same manner.
- Sample cassettes were manually removed from the collection system and stored after each time point and replaced with new cassettes.
- Upon cassette removal at each time point, cassette sets were taken to an adjacent bio safety cabinet and pooled.
- Six total sample times were collected per bioaerosol challenge.
- 1 control was completed, and 3 viral challenges were completed using the same methodology.

### **BIOAEROSOL GENERATION:**

For the control and the viral challenges, the nebulizer was filled with the same amount of viral stock ( $4.02 \times 10^7$  TCID<sub>50</sub> per ml) and nebulized at a flow rate of 1ml/min. Nebulizer was driven by untreated local atmospheric air. The nebulizer's remaining viral stock volume was weighed after each completion to confirm the same amount of viral stock that was nebulized.

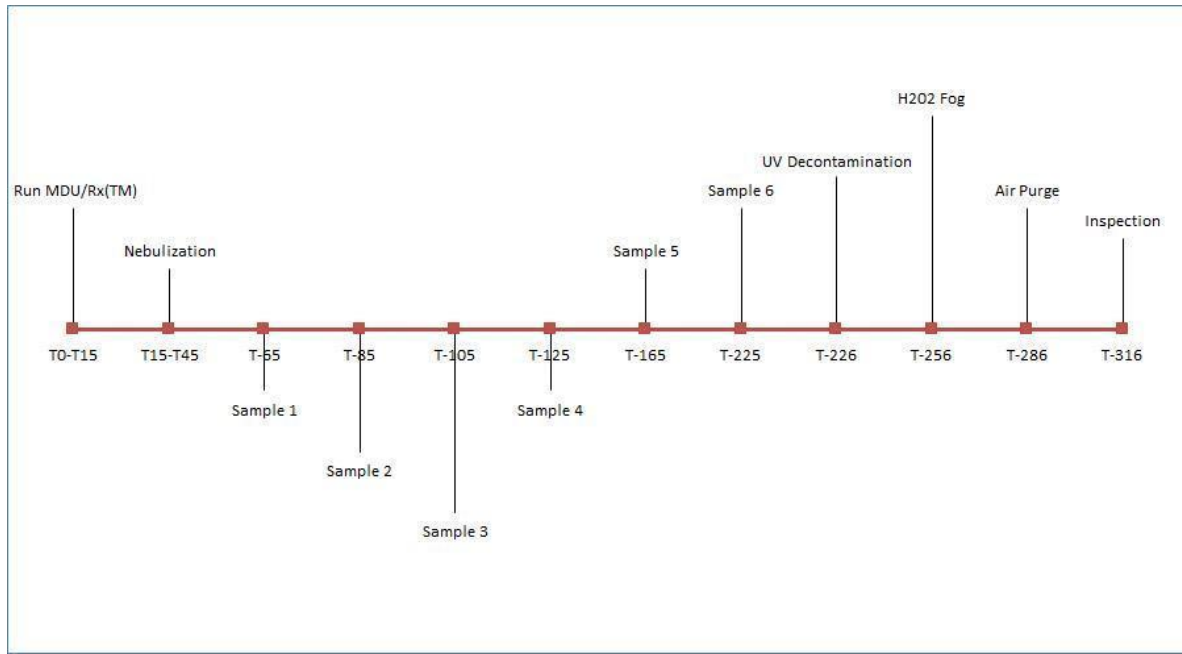
### **BIOAEROSOL SAMPLING:**

For air sampling, 4 different Gillian 10i programmable vacuum devices were used. Air samplers were calibrated by the manufacturer in September 2020 and certificates were inspected prior to use. Air sample volume collections were confirmed prior to use with a Gilian Gilibrator 2 SN- 200700-12 and a high flow bubble generator SN-2009012-H. Air samplers were operated in conjunction with removable sealed cassettes, which were manually removed after each sampling time point. Cassettes had a delicate internal filtration disc to collect viral samples.

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## SAMPLING POINT TIMELINE:



## VIRUS STRAIN BACKGROUND:

The following reagent was deposited by the Centers for Disease Control and Prevention and obtained through the BEI Resources, BIAID, NIH SARS-Related Coronavirus 2, Isolate USA-CA1/2020, NR-52382. This was the chosen pathogen strain because it was taken from a 38-year-old subject with severe acute respiratory syndrome in California as was part of the A lineage. This was a non-fatal case which represents most of the cases in the United State. The age group the patient belonged to was not elderly or juvenile, which was determined to be a good medium average.

## POST DECONTAMINATION:

At the conclusion of each viral challenge test the UV system inside the testing chamber was activated for 30 minutes. After 30 minutes of UV exposure the chamber was fogged with a Hydrogen Peroxide gas mixture followed by a 30-minute air purge. All test equipment was cleaned at the end of each day with a 70% alcohol solution. Collection lines were soaked in a bleach bath mixture for 30 minutes then rinsed repeatedly with DI water. Nebulizer and Vacuum collection pumps were decontaminated with Hydrogen Peroxide mixtures.



**TCID50 PROCEDURE:**

**Materials and Equipment:**

- Certified Biological Safety Cabinet
- Micropipette and sterile disposable aerosol resistant tips – 20uL, 200uL, 1000uL.
- Inverted Microscope
- Tubes for dilution
- Hemocytometer with cover slip
- Cell Media for infection
- Growth Media appropriate for cell line
- 0.4 % Trypan Blue Solution
- Lint Free Wipes saturated with 70% isopropyl alcohol
- CO<sub>2</sub> Incubator set at 37°C or 34°C or other temperature indicated.

**Procedure:**

1. One day prior to infection, prepare 96 well dishes by seeding each well with Vero E6 cells in DMEM plus 7.5 % fetal bovine serum, 4mM Glutamine, and antibiotics.
2. On the day of infection, make dilutions of virus sample in PBS.
3. Make a series of dilutions at 1:10 of the original virus sample. First tube with 2.0 mL PBS and subsequent tubes with 1.8mL
4. Vortex Viral samples, transfer 20 uL of virus to first tube, vortex, discard tip.
5. With new tip, serial dilute subsequent tips transferring 200 uL.

**Additions of virus dilutions to cells**

1. Label lid of 96 well dish by drawing grid lines to delineate quadruplicates and number each grid to correspond to the virus sample and label the rows of the plate for the dilution which will be plated.
2. Include 4 Negative wells on each plate which will not be infected.
3. Remove all but 0.1 mL of media from each well by vacuum aspiration.
4. Starting from the most dilute sample, add 0.1 mL of virus dilution to each of the quadruplicate wells for that dilution
5. Infect 4 wells per dilution, working backward.
6. Allow the virus to absorb to cells at 37°C for 2 hours.
7. After absorption, remove virus inoculum. Start with the most dilute and work backwards
8. Add 0.5 mL infection medium to each well being careful to not touch the wells with the pipette.



9. Place plates at 37°C and monitor CPE using the inverted microscope over a period of 1 to 4 weeks.
10. Record the number of positive and negative wells.

**CONTROL:**

One Control test was conducted without the PYURE MDU/Rx™ unit in the testing chamber. Control samples were taken at each of the corresponding sample times used for the three identical challenge trials (see sampling timeline above). Nebulization of viral media and collection methods were the same for the control as the viral challenge. Control testing was used for the comparative baseline to assess the viral reduction when the PYURE MDU/Rx™ device was operated in the challenge trials, to enable net reduction calculations to be made. During the control test, four low volume fans were operated in each corner of the testing chamber to ensure homogenous mixing of the air. An emergency O3 alarm was outfitted to the room and calibrated to 1ppm. During the control test no O3 alarms were observed. During the control temperature and relative humidity were monitored and recorded.

**VIRAL CHALLENGE:**

The challenge pathogen, SARS-CoV-2-USA-CA1/2020, was used for testing the efficacy of the PYURE MDU/Rx™ device. During the challenge tests the pressure in the challenge chamber was monitored to confirm no portion of the chamber was leaking. The bioaerosol efficacy challenge was completed in three distinct trials with the live pathogen to create a baseline of data. The PYURE MDU/Rx™ device was placed in the same position for each viral challenge and operated in the same manner. Prior to nebulizing the viral pathogen, the PYURE MDU/Rx™ device was turned on and allowed to run for 15 minutes to simulate a real-world environment and allow the device to reach standard operating conditions. Four low volume mixing fans were used throughout the entire control test and viral pathogen test. Sample times were as follows with T equal to minutes, T-20, T-40, T-60, T-80, T-120, T-180. Sampling occurred using 4 automatic air volume samplers that operated simultaneously for each collection. Samplers were pre-set to automatically shut off after 5 minutes of collection. Collections were made via the equipment utilizing viral media coated filters for maximum pathogen trapping and stability. Collection samples were provided to lab staff for pooling after each collection time point. An emergency O3 alarm was outfitted to the room and calibrated to 1ppm. During the challenge tests no O3 alarms were observed. Prior to running the viral challenges temperature and humidity were confirmed to be in relative range to the control +/- 5%.



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## TESTING PROCEDURE:

| TEST  | SPECIFICATIONS   | RESULTS   |
|---|--|---|
| Identification by Infectivity in Vero 6 cells   | Cell Rounding and Detachment   | Cell Rounding and Detachment  |
| Next Generation Sequencing (NGS) of complete genome using Illumina® iSeq™ 100 Platform<br><br>(Approx. 940 Nucleotides)   | ≥ 98% identity with SARS-CoV 2, isolate USA-CA1/2020<br>GenBank: MN994467.1<br><br>≥ 98% identity with SARS-CoV 2, strain FDAARGOS_983 isolate USA-CA1/2020<br>GenBank: MT246667.1 | 99.9% identity with SARS-CoV 2, isolate USA-CA1/2020<br>GenBank: MN994467.1<br><br>100% identity with SARS-CoV 2, strain FDAARGOS_983 isolate USA-CA1/2020<br>GenBank: MT246667.1 |
| Titer by TCID50 in Vero E6 Cells by Cytopathic effect   | Report Results   | 2.8 X 10 <sup>5</sup> TCID50 per mL in 5 days at 37°C and 5% CO <sub>2</sub>  |
| Sterility (21-Day Incubation)<br>Harpos HTYE Broth, aerobic<br>Trypticase Soy Broth, aerobic<br>Sabourad Broth, aerobic<br>Sheep Blood Agar, aerobic<br>Sheep Blood Agar, anaerobic<br>Thioglycollate Broth, anaerobic<br>DMEM with 10% FBS | No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth  | No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth   |
| Sterility (21-Day Incubation)<br>Harpos HTYE Broth, aerobic<br>Trypticase Soy Broth, aerobic<br>Sabourad Broth, aerobic<br>Sheep Blood Agar, aerobic<br>Sheep Blood Agar, anaerobic<br>Thioglycollate Broth, anaerobic<br>DMEM with 10% FBS | No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth  | No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth<br>No Growth   |
| Mycoplasma Contamination<br>Agar and Broth Culture<br>DNA Detection by PCR of extracted Test Article nucleic acid.  | None Detected<br>None Detected   | None Detected<br>None Detected  |

**VIRAL STOCK:** SARS-CoV-2 USA-CA1/2020 (BEI NR-52382)



### Aerosolization of Viral Media:

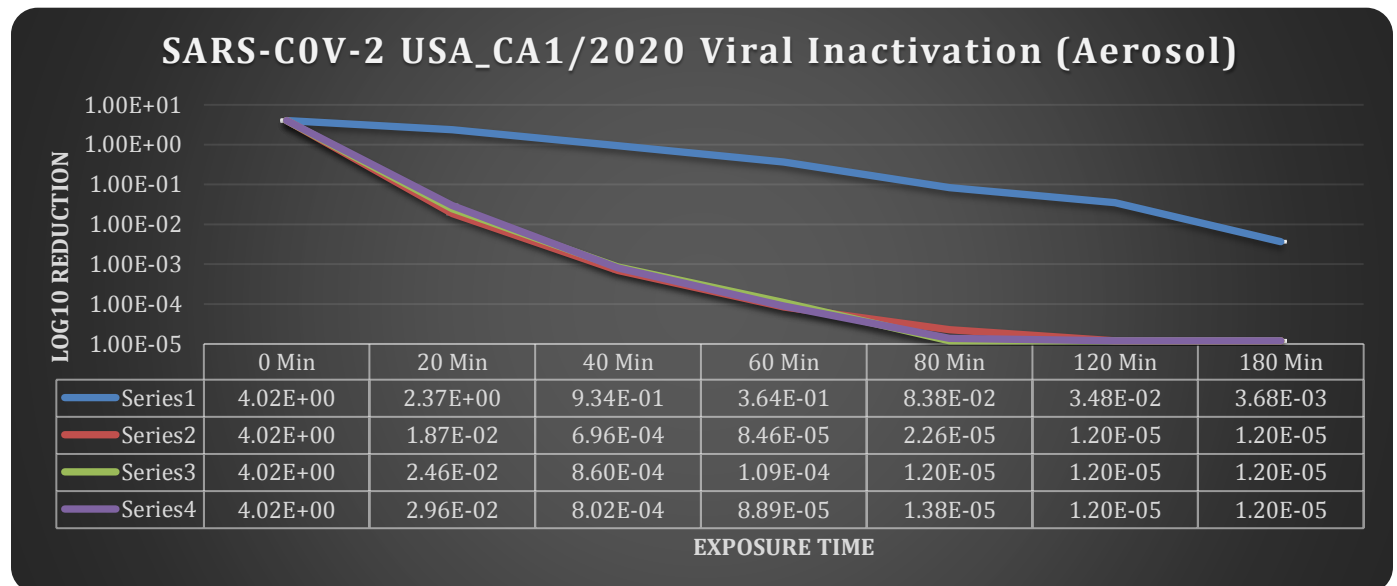
Controls samples were performed in the same manner as the viral test at the time-points and rate of collection. A viral stock of SARS-CoV-2USA\_CA1/2020 with a concentration of  $4.02 \times 10^7$  TCID50/mL was used for this experiment.

### Inoculation of Surface Samples

Surface inoculation consisted of applying exactly 1 ml of viral media to each coupon with a calibrated Eppendorf pipette utilizing filtered pipette tips. Coupons were standard sterile 25mm x 75mm slides. Once applied, the media was spread thin using a disposable spatula and allowed to dry for 10 minutes. The starting concentration of virus that was applied was  $4.02 \times 10^7$  TCID50/mL. After several tests for recovery, it was determined that the most efficient method of recovering viable virus would be a 2 mL rinse in viral media followed by a swab of the inoculated area. The maximum recovery achieved was 95.3% or  $3.83 \times 10^7$  TCID50/mL. This value was used as the "0 Minute" starting concentration for all surface testing to account for the recovery.

### Test Results: Aerosolized Virus

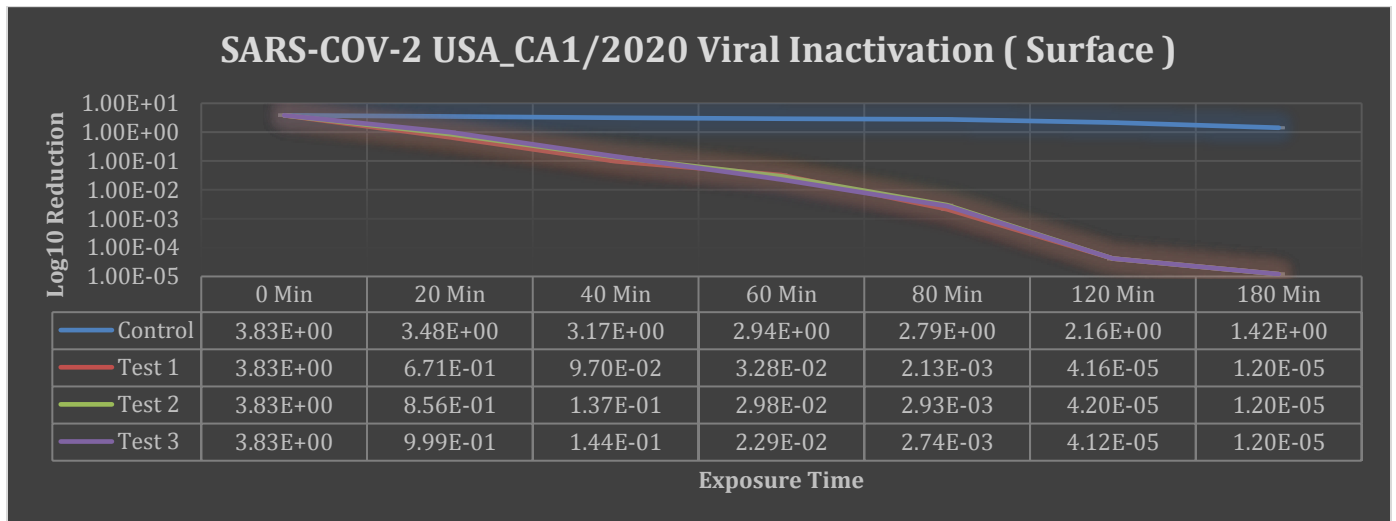
Performed in the same manner as the control testing, the following deactivation rates were observed for air samples collected for all 3 trials. Collection at each time point was done via the Gillian 10i air samplers. Samples were collected by a technician at specified time points inside the container and stored in a sealed refrigerated container until testing and recovery were complete. Technicians were wearing full hazmat coveralls and had no direct exposure to the pathogen at any time. The graph below represents the data for the three experiments and the control, as it pertains to surface inoculation.





### Test Results: Surface Inoculation

Performed in the same manner as the control testing, the following deactivation rates were observed for direct surface inoculation in the three challenge trials. Collection at each time point was done by swab and rinse of the coupon. Samples were collected by a technician at specified time points inside the container and stored in viral media until testing and recovery were complete. Technicians were wearing full hazmat coveralls and had no direct exposure to the pathogen at any time. The graph below represents the data for the three surface inoculation experiments and the control.



### Data Table for Aerosol Testing - Control Trial

| Time Point  | TCID50/mL              | Percent Reduction |
|-------------|------------------------|-------------------|
| 0 MINUTES   | 4.02 X 10 <sup>7</sup> | N/A               |
| 20 MINUTES  | 2.37 X 10 <sup>7</sup> | 41.04             |
| 40 MINUTES  | 9.34 X 10 <sup>6</sup> | 76.77             |
| 60 MINUTES  | 3.64 X 10 <sup>6</sup> | 90.95             |
| 80 MINUTES  | 8.38 X 10 <sup>5</sup> | 97.92             |
| 120 MINUTES | 3.48 X 10 <sup>5</sup> | 99.13             |
| 180 MINUTES | 3.68 X 10 <sup>4</sup> | 99.91             |

**Data Table for Aerosol Testing - Averages of Three Challenge Trials.**

| TIME POINT  | TCID50/mL           | Percent Reduction |
|-------------|---------------------|-------------------|
| 0 MINUTES   | $4.02 \times 10^7$  | N/A               |
| 20 MINUTES  | $2.43 \times 10^5$  | 99.40             |
| 40 MINUTES  | $7.86 \times 10^3$  | 99.98             |
| 60 MINUTES  | $9.43 \times 10^2$  | 99.99             |
| 80 MINUTES  | $< 1.2 \times 10^2$ | >99.999           |
| 120 MINUTES | $< 1.2 \times 10^2$ | >99.999           |
| 180 MINUTES | $< 1.2 \times 10^2$ | >99.999           |

**Data Table for Surface Testing - Control Trial**

| Time Point  | TCID50/mL          | Percent Reduction |
|-------------|--------------------|-------------------|
| 0 MINUTES   | $3.83 \times 10^7$ | 4.72              |
| 20 MINUTES  | $3.48 \times 10^7$ | 9.14              |
| 40 MINUTES  | $3.17 \times 10^7$ | 17.23             |
| 60 MINUTES  | $2.94 \times 10^7$ | 23.23             |
| 80 MINUTES  | $2.79 \times 10^7$ | 27.15             |
| 120 MINUTES | $2.16 \times 10^7$ | 43.60             |
| 180 MINUTES | $1.42 \times 10^7$ | 62.92             |

**Data Table for Surface Testing – Averages of Three Challenge Trials**

| Time Point | TCID50/mL            | Percent Reduction |
|------------|----------------------|-------------------|
| 0 Min      | $3.83 \times 10^7$   | 4.72              |
| 20 Min     | $8.43 \times 10^6$   | 77.99             |
| 40 Min     | $1.26 \times 10^6$   | 96.71             |
| 60 Min     | $2.85 \times 10^5$   | 99.26             |
| 80 Min     | $2.60 \times 10^4$   | 99.93             |
| 120 Min    | $4.16 \times 10^2$   | 99.999            |
| 180 Min    | $< 1.20 \times 10^2$ | >99.999           |



## **CONCLUSIONS:**

The PYURE MDU/Rx™ device performed to manufacturer specifications and demonstrated a progressive and dramatic reduction of live virus after 80 minutes of exposure in aerosol form and 180 minutes of exposure in surface testing. The live SARS-CoV-2 virus was not detectable at these timepoints (levels were below the 120 TCID50 / ml limit of quantification).

Every effort was made to simulate a real-life environment in the chamber while taking into consideration the special precautions needed when working with a Biosafety Level 3 Pathogen. Taking into consideration the high starting concentration of active SARS-CoV-2 virus, the volume aerosolized, and the volume inoculated, one could assume that the likelihood of entering an environment with this quantity of pathogen in a real-life circumstance to be unlikely.

When aerosolizing pathogens and collecting said pathogens, there are variables that cannot be fully accounted for, namely, placement of pathogen, collection volume, collection points, drop rate, surface saturation, viral destruction on collection, viral destruction on nebulization, and possibly others. Every effort was made to address these constraints with the design and execution of the trials. These efforts are reflected in the meaningful recovery of live virus in the control tests.

Taking these variables into account, there was a high rate of virus destruction achieved by the MDU/Rx™ device. The reduction in air and on surfaces was significant and consistent with the manufacturer's claims that the organic oxidants produced by the MDU/Rx™ device diffuse into a treated space and destroy the virus in air and on surfaces. Overall, the MDU/Rx™ device showed substantial efficacy in the destruction of SARS-CoV-2USA\_CA1/2020 in air and on surfaces.

## **DISCLAIMER:**

The Innovative BioAnalysis, LLC. ("Innovative BioAnalysis") laboratory is not certified or licensed by the United States Environmental Protection Agency and makes no equipment emissions claims pertaining to ozone, hydrogen peroxide gas, reactive oxygen species, volatile organic compounds, or byproduct of any MDU/RX™ device. Innovative BioAnalysis makes no claims to the overall efficacy of any MDU/RX™. The experiment results are solely applicable to the device used in the trial, serial number: MDURXA0000069. The results are only representative of the experiment design described in this report. Innovative BioAnalysis makes no claims as to the reproducibility of the experiment results given the possible variation of experiment results even with an identical test environment, viral strain, collection method, inoculation, nebulization, viral media, cell type, and culture procedure. Innovative BioAnalysis makes no claims to third parties and takes no responsibility for any consequences arising out of the use of, or reliance on, the experiment results by third parties.

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