FINAL REPORT

PROTOCOL
Efficacy Testing of a UV Light Device

PRODUCT TESTED
UV Lamp Device

EMSL ORDER NUMBER
152103084

TESTING LABORATORY
EMSL Analytical, Inc.
5950 Fairbanks North Houston Rd.
Houston TX 77040
Phone: (713) 686-3635
Web: www.emsl.com

SPONSOR
Cardinal Robotics Co.
2235 California Street
Mountain View, CA 94040

STUDY START DATE
April 29, 2021

STUDY COMPLETION DATE
May 24, 2021

Test Summary

ProjectTitle: Efficacy Testing of a UV Light Device

StudyMethods:ASTM E3135 Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil. (modified with no soiling)

ProductTested: UV Lamp Device

Sponsor: Cardinal Robotics Co.

TestConditions: Ambient room temperature

Challenge Organisms:
Methicillin-resistance *Staphylococcusaureus*(MRSA)- ATCC 33592
Enterococcusfaecium(VRE) – ATCC 700221
Pseudomonasaeruginosa(*P. aeruginosa*) - ATCC 27853
Escherichiacoli (*E. coli*) - ATCC 25922
Clostridioidesdifficile (*C. difficile*) - ATCC 43598

Study Dates and Facilities

All analytical testing was performed at EMSL Analytical, Inc. in Houston, Texas from date 04/29/2021 to 5/24/2021.

Record Retention

All raw data and a copy of the final report will be archived and stored by EMSL Analytical, Inc. for 5 years.

Objectives

To determine the antibacterial efficacy of a UV device against MRSA, VRE, *P. aeruginosa*, *E. coli* and *C. difficile* endospores (unsoiled) after UV exposure at 3 different time points and three distances away from the device.

Test Method

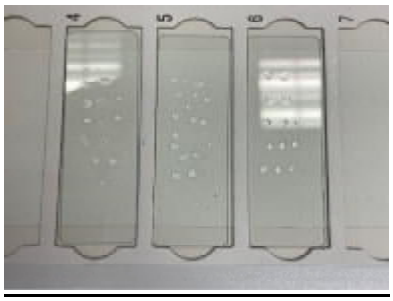
Inoculum Preparation

The test bacteria were taken from pure stock cultures and grown separately onto tryptic soy agar supplemented with 5% sheep blood (TSAB) and incubated at 35±1°C for 24 hours. *C. difficile* (ATCC 43598) spores were prepared according to EPA MLB SOP MB-28: Production and Storage of Spores of *Clostridiumdifficile* for Use in the Efficacy Evaluation of Antimicrobial Agents.

All cultures were used to harvest colonies which were suspended into 10 mL of PBS suspension (unsoiled).

Procedure

Sterile glass carriers were inoculated with 10 µL of the bacterial inoculum at room temperature inside a biosafety cabinet (Pic 1).

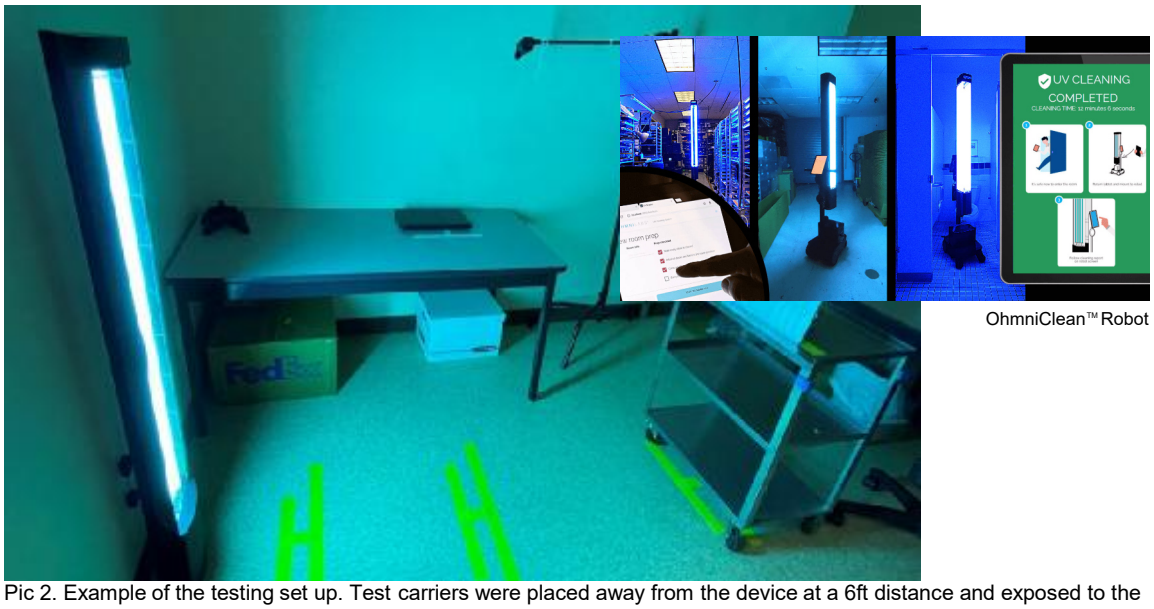


Pic1. Sterile glass carriers were inoculated with 10 µL of the test bacterial inoculums.

Inoculated test carriers were exposed to UV light set at different distances of either 1, 3 or 6 ft away according to Table 1 below.

Table 1. Testing parameters.

Organisms	UV Exposure	Distances (ft)	# Lamps in use	Exposure Time (minutes)
MRSA *VRE* *E. coli* *P. aeruginosa* *C. diff*	Treated	1, 3 & 5	4 Lamps	3, 5 & 10 mins



OhmniClean™ Robot

Pic 2. Example of the testing set up. Test carriers were placed away from the device at a 6ft distance and exposed to the UV light for 10 mins.

After the exposure, the test carriers were transferred into centrifuge tubes with 10 mL of PBS and vortexed for 60 seconds to recover any remaining microbes. For MRSA, VRE, *P. aeruginosa* and *E.coli*, the recovered microbes were serially diluted, plated onto Petrifilm AC plates and incubated for 24-48 hours at 35±1˚C.

For *C. difficile*, the recovered samples were serially diluted, plated onto Brain Heart Infusion Agar with Horse Blood and Taurocholate **(**BHIY**-**HT**)** and incubated anaerobically at 35°C for 72 hours. All tests were performed in triplicate including controls (untreated samples) to determine the starting microbial populations on the test materials.

Experimental Results:

Table 1. UV Device Efficacy at 3 distances and 3 exposure times against *E.coli.*

Test Conditions	Average CFU recovered from 3 trials	Percent Kill	Log Control	Log Treated	Log-Reduction
Control 3 min	12,500,000				
Control 5 min	13,500,000				
Control 10 min	8,900,000				
UV 1 ft 3 min	<10	>99.9999	7.10	1.00	**>6.10**
UV 1 ft 5 min	<10	>99.9999	7.13	1.00	**>6.13**
UV 1 ft 10 min	<10	>99.9999	6.95	1.00	**>5.95**
UV 3 ft 3 min	<10	>99.9999	7.10	1.00	**>6.10**
UV 3 ft 5 min	<10	>99.9999	7.13	1.00	**>6.13**
UV 3 ft 10 min	<10	>99.9999	6.95	1.00	**>5.95**
UV 6 ft 3 min	<10	>99.9999	7.10	1.00	**>6.10**
UV 6 ft 5 min	<10	>99.9999	7.13	1.00	**>6.13**
UV 6 ft 10 min	<10	>99.9999	6.95	1.00	**>5.95**

Detections limit = 10 CFU per carrier

Table 2. UV Device Efficacy at 3 distances and 3 exposure times against *C.diff.*

Test Conditions	Average CFU recovered from 3 trials	Percent Kill	Log Control	Log Treated	Log-Reduction
Control 3 min	1,200,000				
Control 5 min	1,100,000				
Control 10 min	1,000,000				
UV 1 ft 3 min	<100	>99.99	6.08	2.00	**>4.08**
UV 1 ft 5 min	<100	>99.99	6.04	2.00	**>4.04**
UV 1 ft 10 min	<100	>99.99	6.00	2.00	**>4.00**
UV 3 ft 3 min	3,367	99.7	6.08	3.53	**2.55**
UV 3 ft 5 min	<100	>99.99	6.04	2.00	**>4.04**
UV 3 ft 10 min	<100	>99.99	6.00	2.00	**>4.00**
UV 6 ft 3 min	3,733	99.6	6.08	3.57	**2.51**
UV 6 ft 5 min	1,567	99.8	6.04	3.19	**2.85**
UV 6 ft 10 min	367	99.96	6.00	2.56	**3.44**

Detections limit = 100 CFU per carrier

Table 3. UV Device Efficacy at 3 distances and 3 exposure times against MRSA.

Test Conditions	Average CFU recovered from 3 trials	Percent Kill	Log Control	Log Treated	Log-Reduction
Control 3 min	124,300,000				
Control 5 min	156,333,000				
Control 10 min	103,700,000				
UV 1 ft 3 min	83	99.99993	8.09	1.92	**6.17**
UV 1 ft 5 min	<10	>99.99999	8.19	1.00	**>7.19**
UV 1 ft 10 min	<10	>99.99999	8.02	1.00	**>7.02**
UV 3 ft 3 min	<10	>99.99999	8.09	1.00	**>7.09**
UV 3 ft 5 min	<10	>99.99999	8.19	1.00	**>7.19**
UV 3 ft 10 min	<10	>99.99999	8.02	1.00	**>7.02**
UV 6 ft 3 min	<10	>99.99999	8.09	1.00	**>7.09**
UV 6 ft 5 min	33	99.99997	8.19	1.52	**6.67**
UV 6 ft 10 min	<10	99.99999	8.02	1.00	**>7.02**

Detections limit = 10 CFU per carrier

Table 4. UV Device Efficacy at 3 distances and 3 exposure times against VRE.

Test Conditions	Average CFU recovered from 3 trials	Percent Kill	Log Control	Log Treated	Log-Reduction
Control 3 min	22,500,000				
Control 5 min	20,133,000				
Control 10 min	23,000,000				
UV 1 ft 3 min	<10	>99.99996	7.35	1.00	**>6.35**
UV 1 ft 5 min	<10	>99.99996	7.30	1.00	**>6.30**
UV 1 ft 10 min	<10	>99.99996	7.36	1.00	**>6.36**
UV 3 ft 3 min	<10	>99.99995	7.35	1.00	**>6.35**
UV 3 ft 5 min	<10	>99.99995	7.30	1.00	**>6.30**
UV 3 ft 10 min	<10	>99.99995	7.36	1.00	**>6.36**
UV 6 ft 3 min	<10	>99.99996	7.35	1.00	**>6.35**
UV 6 ft 5 min	<10	>99.99996	7.30	1.00	**>6.30**
UV 6 ft 10 min	<10	>99.99996	7.36	1.00	**>6.36**

Detections limit = 10 CFU per carrier

Table 5. UV Device Efficacy at 3 distances and 3 exposure times against *P. aeruginosa*.

Test Conditions	Average CFU recovered from 3 trials	Percent Kill	Log Control	Log Treated	Log-Reduction
Control 3 min	77,900,000				
Control 5 min	73,800,000				
Control 10 min	67,600,000				
UV 1 ft 3 min	<10	>99.99999	7.89	1.00	**>6.89**
UV 1 ft 5 min	<10	>99.99999	7.87	1.00	**>6.87**
UV 1 ft 10 min	<10	>99.99999	7.83	1.00	**>6.83**
UV 3 ft 3 min	<10	>99.99999	7.89	1.00	**>6.89**
UV 3 ft 5 min	<10	>99.99999	7.87	1.00	**>6.87**
UV 3 ft 10 min	<10	>99.99999	7.83	1.00	**>6.83**
UV 6 ft 3 min	23	99.99997	7.89	1.37	**6.52**
UV 6 ft 5 min	10	99.99999	7.87	1.00	**6.87**
UV 6 ft 10 min	17	99.99998	7.83	1.22	**6.61**

Detections limit = 10 CFU per carrier

References:

ASTM E3135 Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil.

EPA MLB SOP MB-28: Procedure for the Production and Storage of Spores of *Clostridium difficile* for Use in the Efficacy Evaluation of Antimicrobial Agents, December 2017, Docket Number: EPA-HQ-OPP-2016-0753

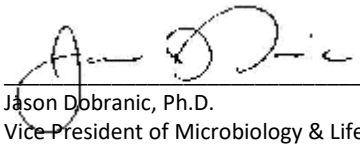
Signatures

Study Performed by:

Mona Ramadi, Ph.D.
Microbiologist

5/24/2021
Date

Report Issued by:



Jason Dobranic, Ph.D.
Vice President of Microbiology & Life Sciences
Study Director

5/24/2021
Date