



Required UV Dose for Microbial Inactivation

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1. Evaluated Microorganisms

Various Fungi, Bacteria, and Viruses

2. Evaluation System

The figure to the right shows the system used for the evaluation detailed below.

The system's irradiation device contains multiple NCSU434B (U280) UV LEDs that were arranged to ensure the irradiance distribution uniformity on the surface of the Petri dish placed on the sample holder was $\geq 98\%$.

The irradiance was set to $1\text{mW}/\text{cm}^2$. Using this system, accurate UV dosing was achieved by controlling the irradiation duration with the timer unit.

Referenced Document:

Development of a standard evaluation method for microbial UV sensitivity using light-emitting diodes. Heliyon.

<https://doi.org/10.1016/j.heliyon.2024.e27456>

3. Evaluation Procedure for Inactivation of Microorganisms by UV Light

- Step 1:** Each of the test microorganisms was diluted to the predetermined concentration using Dulbecco's phosphate-buffered saline and dispensed into a Petri dish with a 35mm diameter.
- Step 2:** A test Petri dish was placed in the irradiation device as shown in Figure 2 and irradiated with UV LED light.
- Step 3:** The test solution was withdrawn from the Petri dish. Serial dilutions were made for the withdrawn solution, and cultures were prepared for each dilution factor.
- Step 4:** Colony counting was performed for both the non-irradiated sample (i.e. control sample) and each sample irradiated with the respective dose levels. The counts were used to determine the number of viable cells.

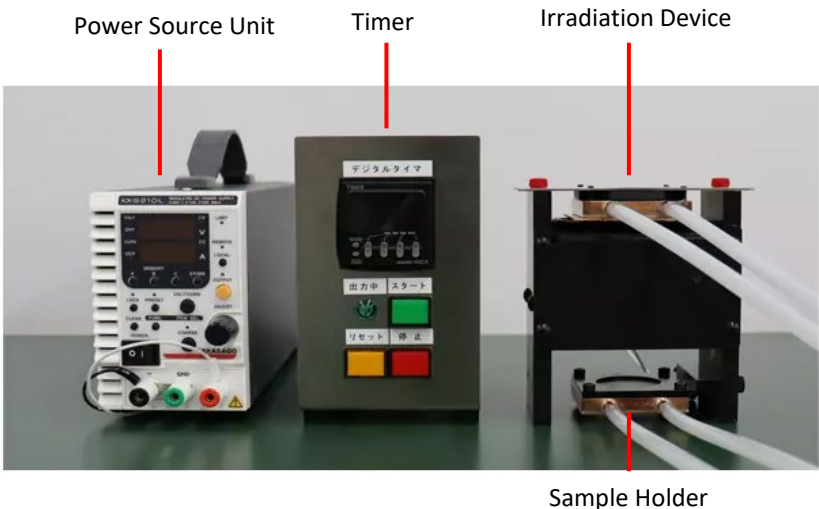


Figure 1. Evaluation System for the UV Sensitivity of Microorganisms

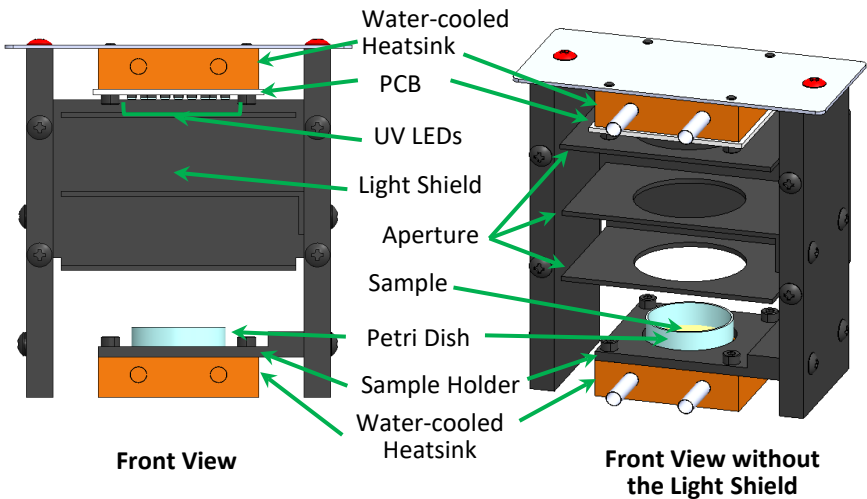


Figure 2. Structure of the Irradiation Device of the Evaluation System

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4. Evaluation Results for the Test Fungi (Test Wavelength: 280nm)

Six different fungi were evaluated; the results are provided in the table below.

Common Name	Scientific Name	UV Dose (mJ/cm ²) at Each Inactivation Rate		
		90%	99%	99.9%
Yeast	<i>Rhodotorula mucilaginosa</i> NBRC114835	63	84	100
Mold	<i>Cladosporium Halotolerans</i> NBRC113481(Mature Spores)	820	1450	2250
	<i>Cladosporium sphaerospermum</i> NBRC6348 (Mature Spores)	57	88	149
	<i>Penicillium roqueforti</i> NBRC5459	37	61	105
	<i>Aspergillus brasiliensis</i> NBRC9455	98	180	400
	<i>Botrytis cinerea Persoon</i> ATCC46522	104	128	187

Referenced Document:
Accumulated melanin in molds provides wavelength-dependent UV tolerance
<https://doi.org/10.1007/s43630-024-00632-4>

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5. Evaluation Results for the Test Bacteria (Test Wavelength: 280nm)

Eleven different bacteria were evaluated; the results are provided in the table below.

Common Name	Scientific Name	UV Dose (mJ/cm ²) at Each Inactivation Rate		
		90%	99%	99.9%
Bacteria	<i>Escherichia coli</i> ATCC25922	4.5	6.4	7.7
	<i>Staphylococcus aureus</i> ATCC29213	4.2	5.4	6.6
	<i>Vibrio parahaemolyticus</i> RIMD2210633	1.2	2.5	3.8
	<i>Enterococcus faecalis</i> ATCC7080	7.5	10.0	11.4
	<i>Pseudomonas aeruginosa</i> PAO-1 strain	1.8	3.0	4.4
	<i>Salmonella enterica</i> Enteritidis 171 strain	3.0	4.8	6.5
	<i>Legionella pneumophila</i> ATCC33152	3.0	4.5	6.2
	<i>Campylobacter jejuni</i> NCTC11168	2.1	3.7	5.2
	<i>Lactobacillus plantarum</i> ATCC8014	5.7	8.1	10.1
	<i>Bacillus subtilis</i> IFO3134 (trophozoite)	4.5	6.7	8.3
	<i>Bacillus subtilis</i> IFO3134 (spore)	36	48	61

Referenced Document:
Efficacy of ultraviolet-light emitting diodes in bacterial inactivation and DNA damage via sensitivity evaluation using multiple wavelengths and bacterial strains
<https://doi.org/10.1007/s00203-025-04324-0>

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6. Evaluation Results for the Test Viruses (Test Wavelength: 280nm)

Twelve different viruses were evaluated; the results are provided in the table below.

Common Name	Scientific Name	UV Dose (mJ/cm ²) at Each Inactivation Rate		
		90%	99%	99.9%
Virus	Influenza A virus H1N1 subtype PR8 strain	2	5	9.4
	Herpes simplex virus KOS strain	5	12	19
	Human coronavirus OC43 strain	2.7	5.2	7.7
	Human coronavirus 229E strain	3	5	9.7
	Feline calicivirus F9 strain	8.8	20.6	30
	Human adenovirus 5 strain	30	56	
	Human respiratory syncytial virus strain Long	1.6	2.6	3.9
	Human respiratory syncytial virus strain 18537	1.7	3.1	4.6
	Influenza A virus H5N1 subtype	3.5	7.7	12.6
	Human metapneumovirus strain TN/83-1211	3.8	5.4	7.1
	Severe acute respiratory syndrome coronavirus 2	2.5	5.4	7.6
	Escherichia coli phage MS2 NBRC102619	23.9	48.2	

Referenced Document:
Viral Inactivation by Light-Emitting Diodes: Action Spectra Reveal Genomic Damage as the Primary Mechanism
<https://doi.org/10.3390/v17081065>
Evaluation and Comparison of the UV-LED Action Spectra for Photochemical Disinfection of Coliphages and Human Pathogenic Viruses
<https://www.mdpi.com/2076-2607/13/12/2798>

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NICHIA CORPORATION
<http://www.nichia.co.jp> Phone: +81-884-22-2311 Fax: +81-884-21-0148
491 Oka, Kaminaka-Cho, Anan-Shi,
TOKUSHIMA 774-8601, JAPAN

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