Phoseon™ TECHNOLOGY

Effectiveness of UV Light-Emitting Diodes for Inactivating Biomolecules and Microorganisms

UV LED delivers precisely controlled light intensity and dosage to provide various levels of inactivation

A Phoseon Technology White Paper

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Introduction

UV LED technology enables complete inactivation of contaminants in minutes compared to traditional methods.

UV-C light is known as “germicidal UV” for its effectiveness in decontamination and disinfection. While particular wavelengths affect different bonds within biological molecules, both nucleotides and proteins can be modified by deep ultraviolet light. Thus, both microorganisms and biological material can be inactivated with the right dose of light.

High intensity UV LED technology offers unmatched levels of deep UV irradiance, which enable significant process improvements, including faster analysis and operations, and increased capabilities for decontamination and disinfection applications that require low wavelengths. UV LED technology enables complete inactivation of contaminants in minutes compared to traditional methods.

This white paper makes the case for why UV LED technology deserves serious consideration by research labs and manufacturing facilities for inactivating biological molecules and microorganisms. It describes Phoseon’s research findings related to the different levels of inactivation.

Decontamination	Disinfection	Sterilization
Inactivation of biological molecules DNA, RNA, Enzymes	Inactivation of microorganisms Virus, Bacteria, Fungi	Inactivation of all mcroorganisms that reaches at least 6 log reduction
Current Techniques: Chemicals, Heat, Scrubbing, Rinsing	Current Techniques: Chemicals, Heat, Ethlene Oxide, Steam	Current Techniques: Chemicals, Heat, Ethlene Oxide, Steam
UV LEDs effectively inactivate hard-target biological molecules, even RNase A	UV LEDs effectively inactivate microorganisms such as Influenza A, Clostridium difficile spores, Aspergillis brasiliensis, and Staphylococus aereus	UV LEDs are on the verge of reaching sterilization levels or difficult and clinically-relevant pathogens

Decontamination:
Inactivation of Biomolecules

High-irradiance UV LEDs successfully inactivate biological molecules like DNA and RNA. Hard targets like RNase A can be completely inactivated with the right wavelength and intensity of ultraviolet light. Complete inactivation of laboratory contaminants can be accomplished by UV LED in under five minutes and at fraction of the cost of traditional methods.

UV LED successfully inactivates Influenza A, Clostridium difficile spores, Aspergillis brasiliensis, and Staphylococus aereus.

Disinfection:
Inactivation of Microorganisms

Ultraviolet Light-Emitting Diode technology provides a new method for inactivating microorganisms. UVC or germicidal UV light is effective for its disinfection properties, the perfect choice for sensitive surfaces of laboratory or equipment. UV LED inactivation of microorganisms assures that surfaces are disinfected without the chemicals and time-consuming rinsing.

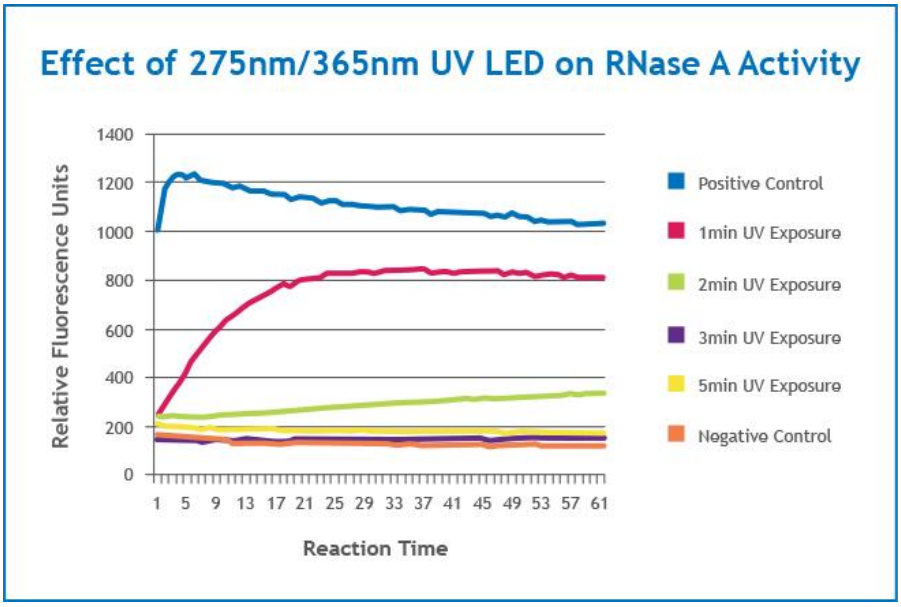
Microorganism	Dose (mJ/cm²)	Inactivation (log reduction)	Exposure Time
Influenza A	240	4.25	<5 sec
Clostridium difficile	1000	>5.79	30 sec
Aspergillis brasiliensis	36000	>4.95	180 sec
Staphylococcus aureus	52	5	<5 sec

Effectiveness of UV LED for Inactivating Ribonucleases (RNases)

High-intensity UV LED irradiation represents a novel, fast and convenient irreversible inactivation method for RNases on surfaces.

RNases, specifically RNase A, are difficult to irreversibly inactivate in the absence of long-term heat treatment or harsh chemicals. Such methods may be incompatible with common laboratory materials or complicate subsequent biochemical reactions. Fast, complete, and irreversible inactivation of RNase A with mercury arc lamp sources have been difficult to achieve due to low power output at targeted wavelengths and the need to filter harmful wavelengths that do not contribute to the inactivation.

We report here the use of high irradiance UV LED light engines for enzyme inactivation. Results show that both irradiance (intensity) and radiant fluence (dose) contribute to rapid inactivation of the RNase A enzyme. UV light at 275 nm is thought to act on RNase A via an effect on the aromatic amino acids proximal to disulfide bonds. The 365 nm wavelength is targeted to the lysine side chain with the intent to destabilize the RNase A reaction pocket. These two wavelengths interact synergistically to inactivate RNase A. We conclude that high-intensity UV LED irradiation represents a novel, fast and convenient irreversible inactivation method for RNases on surfaces.



Effectiveness of UV LED for Inactivating Clostridium Difficile

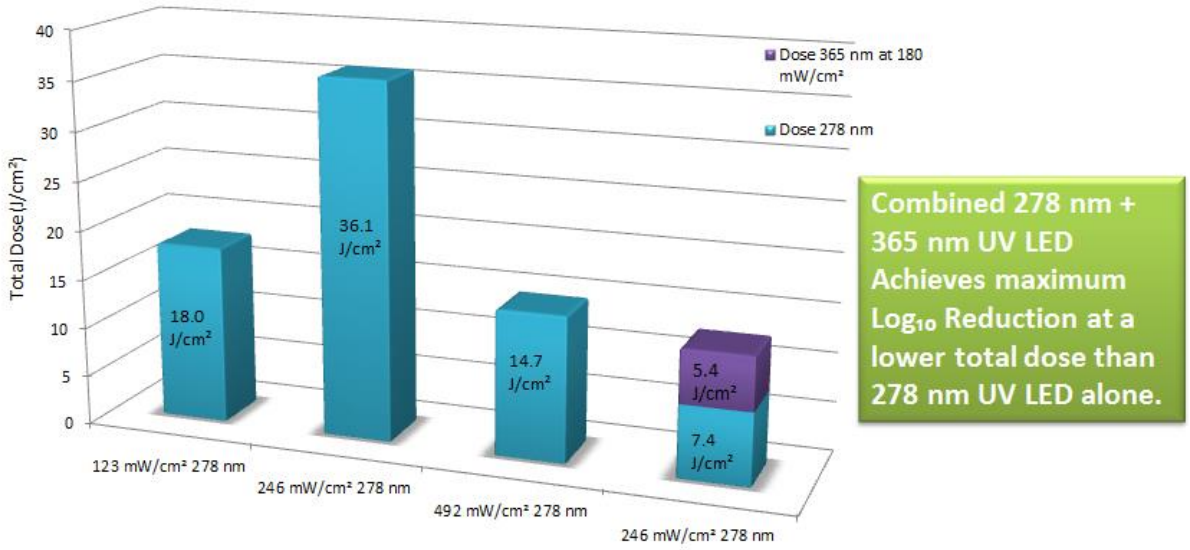
Clostridium difficile spore transmission from contaminated surfaces is a continuing problem for health care facilities. In a study from Phoseon, high-intensity UV LED was used to rapidly inactivate Clostridium difficile spores.

High-intensity UV LED was used to rapidly inactivate Clostridium difficile spores.

High-intensity UV LED 275 nm alone and 275 nm+365 nm combination, wavelengths targeted to protein disulfide functional groups, drive a greater than 5 log (5.79 log) CFU reduction of Clostridium difficile spores on a surface in less than 30 seconds. This is consistent with our results showing synergism between 275 nm and 365 nm high-intensity UV LED when irreversibly inactivating RNase A. Targeting protein stabilization and functional groups represents a new approach to spore inactivation.

Microorganism inactivation with experimental dose response and projected time to log 6 reduction at 275 nm and 4W/cm² irradiance.

Clostri*dium difficile*: 5.79 Log_{10} Reduction - Synergism of 278 nm and 365 nm LED



Effectiveness of UV LED for Inactivating Staphylococcus Aureus

Reproducible Inactivation of Staphylococcus aureus on a Surface Using UV LED.

Staphylococcus aureus contamination of food processing and contact surfaces is a source for foodborne infection for consumers of meat and meat products. In this study from Phoseon, surfaces contaminated with high loads of Staphylococcus aureus were exposed to 265 nm UV-C LED to assess the effects of multiple doses and irradiances.

One-inch square stainless steel targets inoculated with S. aureus were exposed to a UV-C LED (265 nm) array light source (Phoseon Technology) at 1.3, 1.5, 2.0, 2.5 and 3.0 mW/cm^2 (at the target) from a distance of 15 mm. Doses ranged from 26 mJ/cm^2 through 150 mJ/cm^2 . Surviving bacteria were plated and colony forming units (CFU) assessed. Log reduction was calculated as the difference in the log of geometric means between the unexposed control and the exposed test samples. Each test sample included four independent exposures at each condition.

Irradiances of 1.3 and 1.5 mW/cm^2 resulted in four to five-log reduction of Staphylococcus aureus CFU on exposed targets. This corresponded to doses of between 20 and 52 mJ/cm^2. Increasing the irradiance to 2, 2.5, and 3.0 mW/cm^2 to deliver a dose of 150 mJ/cm^2 resulted in a five-log reduction in all cases.

Short 265 nm UV-C exposures of ≤60 seconds were sufficient to result in a four-log reduction of Staphylococcus aureus. Treatment of food products by 265 nm UV-C LEDs represents a viable investigation path for decreasing food-borne Staphylococcus aureus infections in consumers.

Conclusion

UV light has been recognized for decades for its ability to inactivate biological molecules. However, complete inactivation of difficult targets like enzymes and spore-forming microorganisms has been out of reach for traditional light sources. By targeting specific molecular bonds, UV LED technology exhibits higher efficacy with lower total power consumption than broad-band sources such as mercury. UV LED technology is enabling new methods and discoveries by research labs.

Phoseon Technology is the first to develop a UV LED system that surpasses 5 W/cm² at 275nm, significantly higher than the levels reached previously by other LED systems, and surpassing many other technologies in the market by an order of magnitude. This milestone development enables users to utilize UV LED systems where they were prohibited in the past. Phoseon is trailblazing a new path by building high-performance UV LED systems that bring improved disinfection capability to various processes. LEDs are on the verge of reaching sterilization levels for difficult and clinically-relevant pathogens.

In addition to high performance decontamination and disinfection systems, exciting research is on the way in other applications as well. Preliminary data indicate that high-intensity ultraviolet light can be tuned to partially or completely inactivate viruses without damaging recognition features. Retaining recognition features is challenging with existing methods of virus inactivation. Stay tuned to see what the future will hold.

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References

1. Rapid inactivation of RNase A by high irradiance UV LEDs; Thompson T, Eliason G, Pasquantonio J; American Society of Cell Biology/European Molecular Biology Organization Scientific Sessions 2017 https://phoseon.com/wp-content/uploads/2019/06/ASCB-EMBO-poster_Tabloid_v2.pdf

2. Theresa L. Thompson and Jay Pasquantonio "High-intensity UV LED inactivation of Clostridium difficile spores", Proc. SPIE 10863, Photonic Diagnosis and Treatment of Infections and Inflammatory Diseases II, 1086314 (7 March 2019); doi: 10.1117/12.2507993; https://doi.org/10.1117/12.2507993

3. P2-61: Reproducible Inactivation of Staphylococcus aureus on a Surface Using UV LED https://iafp.confex.com/iafp/2019/meetingapp.cgi/Paper/21498

4. Breakthrough UV-C LED Performance Enables New Life Science Applications https://phoseon.com/wp-content/uploads/2019/02/2018-02-05-Phoseon-Life-Sciences-PR-High-Power-275nm-FINAL.pdf

About Phoseon Technology

The world leader since 2002, Phoseon Technology pioneered the use of LED technology for Life Science and Industrial Curing applications. Phoseon delivers innovative, highly engineered, patented LED solutions. The company is focused 100% on LED technology and provides worldwide support.

Contacts

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