Application Note

UVC decontamination of N95 masks: solving a multi-layer challenge[1]

T. L. Thompson PhD, C. Ortiz-Mateos

BENEFITS

- No touch
- Residue free
- Inactivation in complex materials
- Long lasting solution - lamps last upwards of 10,000 hours
- Applicable to biomolecules and microorganisms

KEYWORDS

UVC inactivation, enzyme activity, UV LED, N95 mask, Personal Protective Equipment, Pharmaceuticals, Manufacturing, RNase

PHOSEON

7425 NE Evergreen Pkwy, Hillsboro, OR 97124

https://phoseon.com/life-sciences/

Introduction

UVC light is an effective, fast, and no-touch solution against contaminants. In previous Phoseon studies, UVC decontamination of RNaseA and UVC disinfection of various microorganisms (Influenza A, Clostridium Difficile, and Staphylococcus Aureus) was accomplished in less than five minutes.[2,3]

Common challenges in UVC disinfection or decontamination are: (1) the susceptibility of different material types to ultraviolet light and (2) the direct line of sight required between the light source and contaminated object, increasing the difficulty of using UVC technology with complex shapes and structures. Previously, we compared two plastic materials with the same UVC treatment and showed that successful decontamination requires custom dosages based on material type.[4]

In this application note, we set out to decontaminate N-95 masks, a multi-layer material. RNase activity was used as a benchmark for N95 mask material decontamination. Previous RNase A studies showed synergistic and modulating enzyme effects between specific wavelengths.[5,6] Since IR can generally penetrate more deeply into materials; this study looks at the 278 nm UVC + 1640 nm IR combination for decontamination of mask material.

Methods

Material Treated:

- N95 mask

Equipment and reagents:

- Phoseon KeyPro Industrial Lamps
- RNase activity fluorescence/kinetics assay (RNaseAlert IDT)
- Fluorometer Gemini XPI (Mol. Devices)
- RNase-free foil
- RNase-free water
- RNase-free glass slides

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A N95 mask was worn for 8 hours during 2 consecutive days. The 3-layer (inner, middle, and outer) mask was cut into 1 cm² test samples. All three layers were retained in the treated samples with only the outer layer exposed to direct UVC, IR, or UVC + IR. Samples were placed on a glass slide over a black anodized aluminum plate for treatment.

UVC and IR treatment conditions

Wavelength	278 nm	1640 nm	278 nm + 1640 nm
Lamp Intensity	491.5 mW/cm²	8.7 mW/cm²	Both
Lamp Distance	25 mm		
Time	0, 3, 5, 17.5 hr		

Treated material was held in RNase-free foil until assayed. Material to be assayed was soaked for 1 hour in 500 µL RNase-free water. The supernatant was collected (80 µL) and used for each duplicate assay. Contamination was assayed as RNase Activity (IDT RNaseAlert) on a Gemini XPS fluorimeter (Molecular Devices) during a one-hour reaction time.

Results

As shown in Figure 1, the combination of 278 nm and 1640 nm exposure was more effective than either alone. At 17.5 hours the remaining RNase activity is significantly reduced and nearing the negative control level. Increasing exposure times (Figure 2) resulted in decreased RNase activity, and therefore contamination.

The 5-hour combined exposure showed a significant decrease in activity suggesting that an optimal decontamination time would be between 5 hours and 17.5 hours, or approximately a single work shift. At 17.5 hours we observed that the outer layer of mask material may show some faint yellowing.

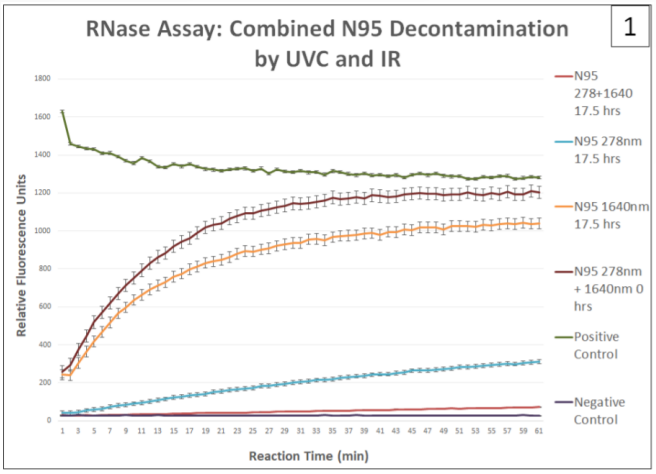

Figure 1. RNase Assay: Combined N95 Decontamination by UVC and IR. One cm² of contaminated N95 mask material was exposed to no UVC or IR, 278 nm alone, 1640 nm alone, or 278 nm +1640 nm combination of wavelengths for 17.5 hrs. Samples were soaked for 1 hour in RNase-free water, and supernatant recovered after vortexing and microfuge (5 min, 15 x g). Samples of the supernatant (80 µL) were assayed for RNase activity, allowing a 1 hour reaction time in a Gemini XPS. The graph shows the average of 3 experiments.

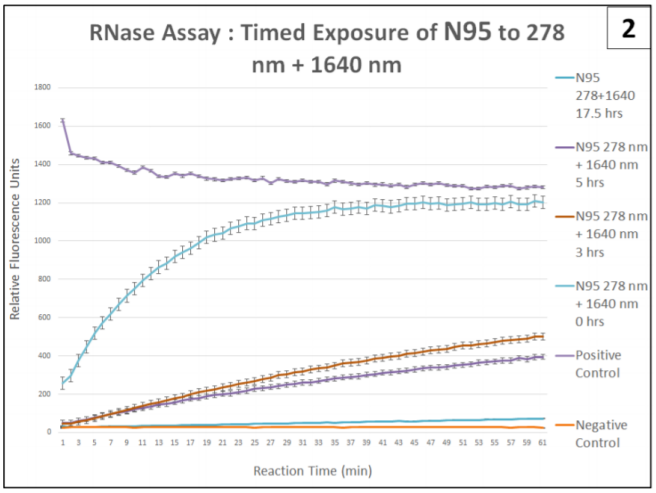

Figure 2. RNase Assay: Timed Exposure of N95 to 278 nm + 1640 nm. One cm² of contaminated N95 mask material was exposed to no UVC or IR, 278 nm alone, 1640 nm alone, or 278 nm +1640 nm combination of wavelengths for 17.5 hrs. RNase recovery and assessment was done as explained in Figure 1. The graph shows the average of 3 experiments.

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Conclusion

UVC and IR wavelengths appear to work synergistically to increase the germicidal effect in multi-layer materials such as N95 masks. The response to UVC + IR exposure increases with time/dose, and it is expected that higher lamp intensity can reduce inactivation time. Effects of a change to the ratio of 278nm:1640nm remain to be tested. This application note demonstrates that combined UVC and IR wavelengths can decontaminate materials without a direct line of sight, as shown by the middle and inner layers of the N95 mask. This finding is a major contribution to the disinfection field and proves that UVC and IR wavelengths at high enough dosages can treat complex structures. Optimal exposure dose for the combined LED sources was between 8.8 J/cm^2 278 nm + 0.15 J/cm^2 1640 nm and 30.9 J/cm^2 278 nm + 0.55 J/cm^2 1640 nm.

In addition, exposure to combined 278 nm UVC and 1640 nm IR may allow the reuse of N95 masks in reduced resource circumstances. This application, together with the decontamination of PCR test kits is part of Phoseon Technology's Covid-19 response.

Literature Cited

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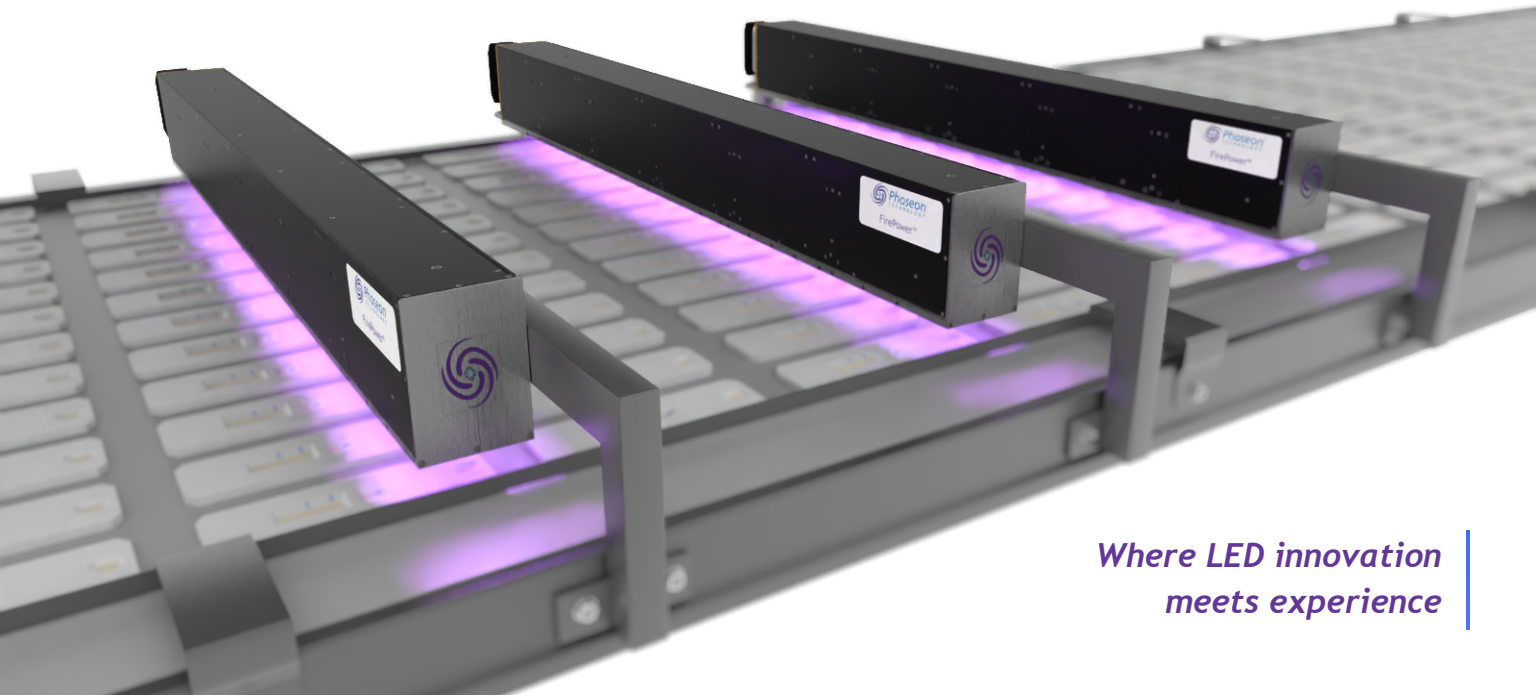
KeyPro™ UVC lamps



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