National Aeronautics and Space Administration

Johnson Space Center (JSC) / White Sands Test Facility (WSTF)

Spacecraft Lighting to Mitigate Microbial Growth

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Technology Area (TA): 6.1.1.4, 6.3.2.6, 6.4.4.

TRL: start 4 / current 6

ICA PROJECT OVERVIEW

- In this innovation project, we investigated the usage of narrow band violet light (408 nm) to attenuate the growth of bacteria typically found on ISS.
- Violet light is less hazardous than UV light and it can transmit through plastics, such as clear acrylics, making it possible to incorporate into large surface lamps and acrylic or polycarbonate based optical light guides.
- This study built a custom LED surface panel that was edge lit by an array of 408 nm violet LEDS. The optical light guide technology used in the lamp and the 408 nm violet LEDs are available on the market from multiple vendors.
- The application of the concept of using violet light driven LED panels and optical light guides is to integrate the paneling into spacecraft architectural surfaces for the automation of a light based microbial countermeasure that could enhance current cleaning methods used in areas on spacecraft prone to microbial growth.

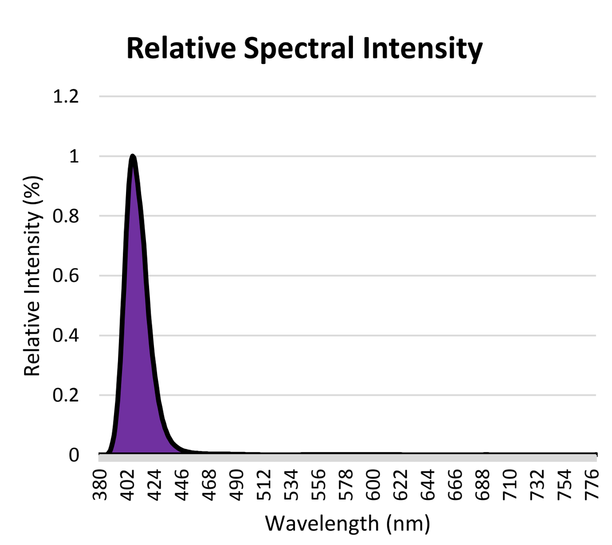
INNOVATION

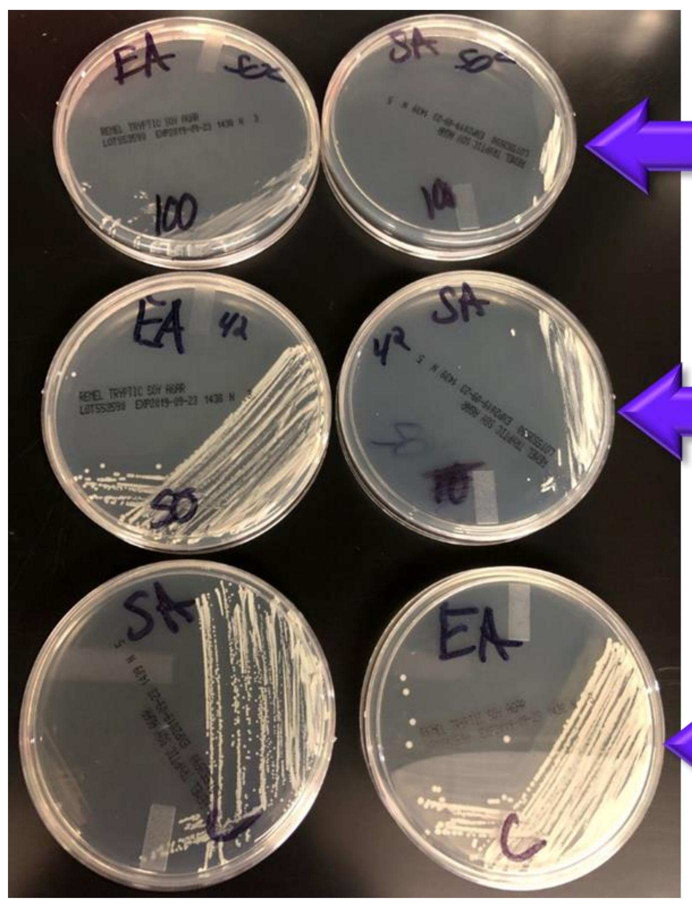
- Microbes such as bacteria tend to grow on surfaces, especially where there is moisture present.
- A typical small "lamp" housing, where the LED array is directly facing the aperture of the lamp, can emit light over a volume, with that light eventually striking a surface. Any objects in the way of the planned surface will block light to that surface. The inverse square law of light also causes a diminishing return on intensity the farther the intended surface is away from the lamp.
- New LED optical light guide technologies, allow for the realization of unique lamp configurations where the lamp can be the architectural surface to be treated while also providing beneficial light to irradiate objects within a volume.

OUTCOME

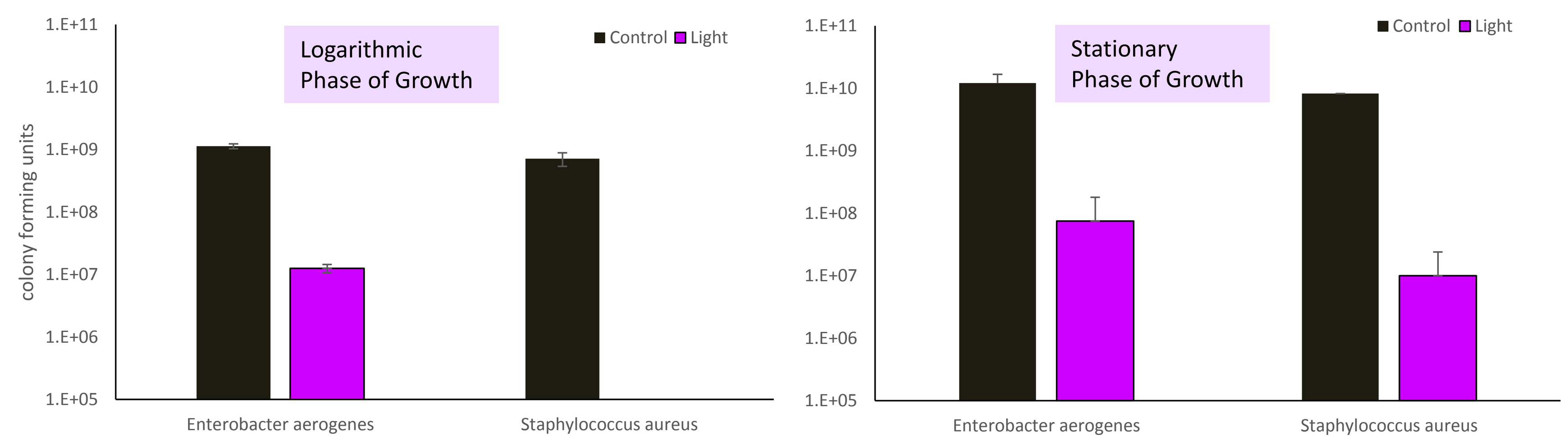
- *Enterobacter aerogenes* is less susceptible to violet light when compared to Staphylococcus aureus. *Staphylococcus aureus* is sensitive to violet light disinfection.
- Bacteria growth is still impacted but appear to be more resistant to violet light when in stationary growth phase as compared to logarithmic phase.
- Initial testing shows much potential for the technology.
- Successful application of this potential technology requires planning on targeted zones for a microbial countermeasure, determination on required irradiance levels, and development of practical exposure times that accommodate both crew activities and effective light-dosage.

	LOG Dimmer Setting	LINEAR Dimmer Setting
Dimmer Setting (% ON)	Irradiance (watts/m^2) @ 407nm	Irradiance (watts/m^2) @ 407nm
100	0.616650105	0.618251979
90	0.513876259	0.553633928
80	0.41501689	0.496556014
70	0.325845122	0.433516979
60	0.248668224	0.370118678
50	0.179880083	0.306409627
40	0.122767307	0.245538756
30	0.074601203	0.182887971
20	0.037911151	0.122212842
10	0.012393613	0.060458016





Results from 3 Hours of Testing at 100% Intensity Setting



INFUSION SPACE / EARTH

The consumer and commercial health industry are actively looking for novel ways to help improve health and control contagions. With the practice of health experts steering consumers away from the usage of anti-bacterial chemicals, due to increasing bacterial resistance, novel ways of making an environment "hazardous" to unwanted microbes is desired. NASA has a vested interest in using lightweight and non-frangible materials, such as polycarbonates and acrylics, instead of glass. As exploration missions become more complex, NASA will also need novel ways to maintain crew health while minimizing crew time dedicated to maintenance and cleaning. Realization of a low-cost, low-weight, non-frangible, microbial countermeasure would benefit both space and earth.

FUTURE WORK

- The initial findings from testing and analysis performed for this Innovation Charge Account project has shown that usage of violet light to curb the bacteria tested does make an impact.
- Future larger studies need to be performed on more complicated light emitting surfaces and optical light guide implementations.
- Future testing at different exposure levels and a larger range of microbes (other bacteria, fungus, and virus species) should be run to determine the extent of the usability of the countermeasure.
- Conceptual architectural and end-item lamp design concepts and analysis needs to performed to determine effective implementation and design requirements.