Development of UVC Measurement Tools at NIST to Combat Healthcare-Associated Infections (HAIs)

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In the United States (U.S.), healthcare-associated infections (HAIs) infect one in every 25 hospital patients, account for more than 99,000 deaths and increase medical costs by more than $35 billion, each year. Ultraviolet-C (UV-C) antimicrobial devices are shown to reduce the incidence of many of these HAIs by 35% or more. The adoption of UV-C technology by the healthcare industry has been sporadic largely due to the lack of measures for efficacy. NIST has leveraged our new UV scale realizations to provide multiple calibration facilities for a variety of source technologies through the implementation of straylight corrected spectroradiometers calibrated against UV standard detectors.

HEALTHCARE PROBLEM

HAIs are one of the leading causes of death in the U.S. HAI statistics are difficult to obtained. HAI are not as newsworthy as other causes of death, until a facility is closed for sanitation reasons. Nationwide, HAIs infect about one in every 25 hospital patients.[1] Each year this translates to approximately 1.7 million HAIs occurring in U.S. hospitals, resulting in approximately 100,000 or more unnecessary deaths and an estimated $20 billion in U.S. dollars in healthcare costs. [2] The overall costs due to operational or occupational losses of productivity are estimated at more than $100+ billion.

Comparing these economic data to information obtained from the U.S. Centers for Disease Control and Prevention shown in Figure 1, the deaths from HAIs place HAI deaths nearly at the level of those attributed to Alzheimer's disease and above the seventh leading cause of death in the U.S., that is, above diabetes. [3] In 2015, diabetes claimed 79,535 deaths, which is only about three-quarters of the deaths attributed to HAIs. The U.S. currently recognizes an "Opioid Crisis" where in 2016, about 63,000 drug overdose deaths in the US were reported, while terrible is lower than those attributed to HAIs.

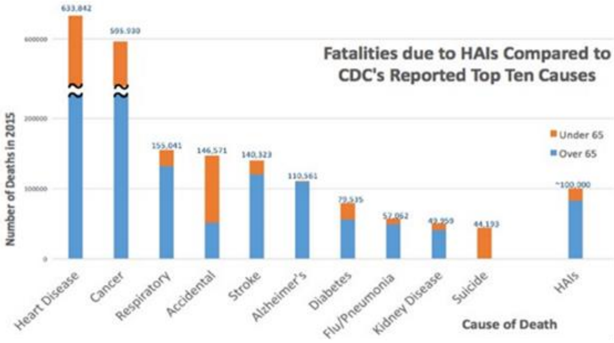

Figure 1 - CDC reported top ten causes of death in 2015 (CDC 2018) compared to the reported number of HAI fatalities (SRT&SOCS 2014)

NIST'S ROLE

Multiple UV-C light source technologies and disinfection mechanisms at multiple wavelengths (Hg lamps, Xe lamps, LED, excimer) contribute to the confusion and difficulty in comparing devices. Levelling of the playing field with scientifically certifiable data of the efficacy of antimicrobial devices will help facilitate science-based decision making.

NIST has developed three new facilities and working with the International Ultraviolet Association (IUVA) and Illuminating Engineering Society (IES) on several standard methods to support the UV-C measurement community. The first facility is a 25 cm integrating sphere system for the measurement of UV-C LEDs. The second facility is a small frame goniometer coupled to the new NIST photometric bench used for measuring radiant intensity distributions of UV-C LEDs. The third facility is 1.5 m sphere that has been recoated with a PTFE film which is highly reflective down to 200 nm.

UV-C LED SPHERE SYSTEM

The UV-C LED Sphere System is composed of a 25 cm sphere that is coupled to CCD based array spectroradiometer and a halogen/deuterium source via two fibers. The port entrance is 25 mm in diameter with a mounted precision aperture mounted. The system is calibrated for spectral irradiance using a pulsed laser-based system that is directly compared to silicon single element and trap detectors calibrated on the NIST cryogenic radiometer. [4] Calibration by this method creates a stray-light correction matrix for the system. [5] The UV-C LED Sphere System has a fiber coupled halogen/deuterium lamp system that holds the calibration scale. On days when the system is used the fiber coupled lamp validates the calibration.

As completion of the calibration loop, deuterium lamps calibrated at the NIST Synchrotron Ultraviolet Radiation Facility (SURF) described in another abstract submitted to NEWRAD2020 are compared using the detector-based UV-C LED Sphere System. The results of the source-based scale to the detector-based scale will be presented.

UV-C LED GONIOMETER SYSTEM

The UV-C LED Goniometer System is a compact goniometer that acts as a source on the new NIST Photometric Bench, shown in Fig. 2. The goniometer is a Type-D goniometer according to LM-75 capable of positioning thermal electrical temperature-controlled LEDs. [6]

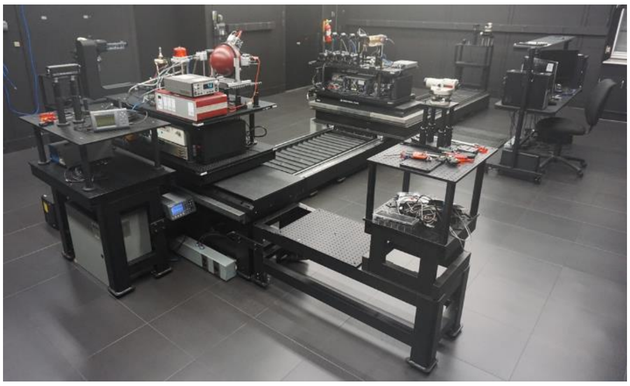

Figure 2 – New NIST Photometric Bench. UV-C LED Goniometer is to the left on the source table.

Using the NIST Photometric Bench and the alignment techniques developed at NIST using microscopes, the angular dependent radiant intensity of the LEDs can be measured and verified at various distances. The total radiant flux using the UV-C LED Goniometer System will be presented compared to the UV-C LED Sphere System.

IES DOCUMENT DEVELOPMENT

NIST along with the Illuminating Engineering Society (IES) and the International Ultraviolet Association (IUVA) are supporting the UV-C disinfection community by leveraging the standards developed to support the infrastructure of the general lighting community. Four topics have been identified as areas of need for documentary test measurement standards: Total radiant flux and radiant intensity distribution measurement of discharge sources; Total radiant flux and radiant intensity distribution measurement of LED chips and arrays; Total radiant flux and radiant intensity distribution of complete UV devices; and the Application distance radiometry of UVC devices.

SUMMARY

NIST is taking an active role by improving UV measurement scales and UV measurement facilities to support the application of the documentary standards for the UV-C disinfection community.

REFERENCES

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