Standards, Metrology and Technology to Minimize Healthcare-Associated Infections: Novel approaches to measure efficacy[#]

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Healthcare-associated infections (HAIs) impose great burdens on public health, making HAIs the strongest contender as the most pressing healthcare problem in acute-care hospitalization. Ultraviolet-C illumination effectively decontaminate surfaces to reduce the population of many HAI-inducing microbes. Unfortunately, no industry-accepted standards exist for evaluating the decontamination efficacy, largely due to a paucity of measurements. Ideally, technology to detect microbial populations on surfaces will be sensitive, rapid, and efficient to maintain the high turnover required by hospitals. In this paper, we discuss some recent advances in UV-antimicrobial metrology focused on underpinning the development of standards through a collaborative effort involving NIST, the ultraviolet industry and the Yale School of Medicine.

Ultraviolet-C (UV-C) irradiation decontaminate surfaces by the photodegradation of of DNA and RNA through absorption of photons resulting in formation of pyrimidine dimers from thymine and cytosine, killing a variety bacterial species, including spores [1]. The killing efficacy is most commonly quantified using basic microbiology where the number of colony-forming units (CFUs) is determined from growth plate counts of a known CFU inoculum before and after UV-C exposure. Best practices for minimizing biological and technical error in plate counting have been established [2]. Current decontamination indicators include (i) biological indicators (BI) that directly determine survivability of the most resistant microorganisms (e.g., *Geobacillus stearothermophilus*), (ii) mechanical indicators (gauges and digital displays) and (iii) chemical indicators (e.g., autoclave tape) which do not ensure sterilization but indicate that autoclaving conditions have been met. Although none of these are rapid diagnostic techniques, they are they are currently the only available metrology for evaluating UV-C decontamination and establishing room disinfection protocols [3].

Dielectric spectroscopic investigations examine and explain different molecular dynamic processes of dielectric systems in response to rapidly changing magnetic fields. In this paper, we introduce a solid-state broadband dielectric spectroscopic (BDS, 10^{-5} -10^{10} Hz) method to rapidly and nondestructively indicate decontamination of DNA containing targets on inoculated surfaces (Figure 1A), and contrast it to the UV-C induced photodecomposition of pure protein (Figure 1B). The BDS technique is predicated on detecting photoinduced changes in the electrical properties (possibly due to a reduction of the

cytoplasm conductance and permittivity) of DNA containing moieties [4]. Mechanistically, the observed changes in electrical properties due to UV-C exposure are the result of an eventual disruption in the semipermeable cell membrane, allowing ions and molecules to leak out of the cytoplasm, as observed with membrane-potential fluorophores in bacteria [5] and yeast [6]. The loss of cellular integrity is measurable with microwave evanescent sensors. Indeed, the changes in the electrical properties may be independent of killing method. We expect our technique to detect and quantify bacterial populations on surfaces for rapid point-of-use diagnostics, and to provide a metrology for assessing the efficacy of decontamination processes [4].

References:

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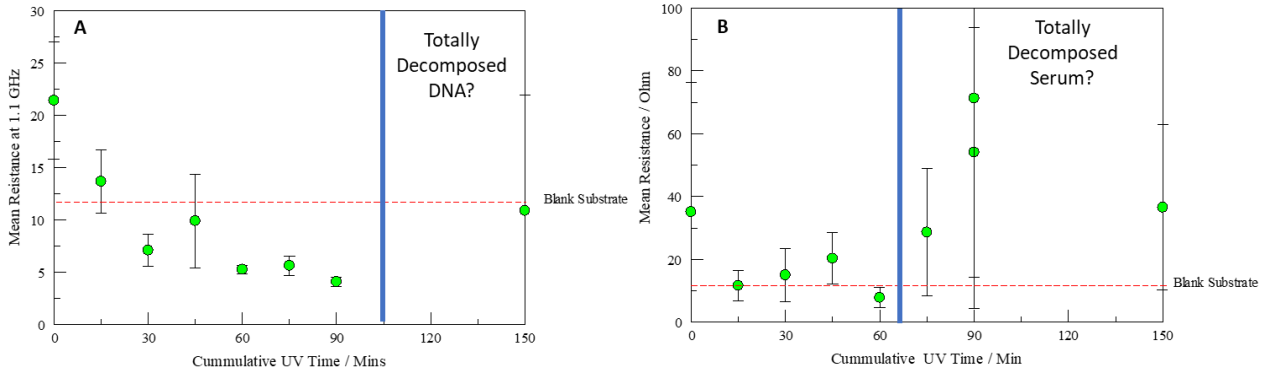

Figure 1. Side by side comparison of the evolution of the DC resistance of (A) double-stranded bacteriophage lambda and (B) fetal bovine serum (protein) thin films on glass during UV-C photolysis in open air.