Technical Bulletin

Adenosine Triphosphate (ATP) Bioluminescence and its usefulness in monitoring the effectiveness of environmental cleaning and disinfection

Situation:

The importance of environmental surfaces as vehicles for healthcare-associated pathogens is supported by the fact that regular and proper cleaning and disinfection of high-touch environmental surfaces can reduce the spread of Healthcare-Associated Infections (HAIs). Therefore, there is now much emphasis on improving the techniques of environmental cleaning and disinfection while also identifying easy and field-relevant methods to validate cleanliness to provide meaningful and immediate feedback to housekeeping staff.

Historically, visual inspection and microbiological sampling were the main methods to validate the efficiency of environmental surface decontamination within the healthcare market. Visual inspections alone are inherently incapable of assessing the level of pathogen reduction on a given surface. While microbiological sampling of environmental surfaces can be a better indicator of reductions in microbial loads after cleaning and disinfection, the results may take too long for immediate feedback to train and educate the housekeeping staff.

The measurement of adenosine triphosphate (ATP) is among the means to rapidly assess the effectiveness of environmental surface cleaning and disinfection. This approach has been in use for years in the food and beverage industries, and potentially applicable within healthcare facilities.[1]

What is ATP?

ATP is present in many types of organic material including food, microbes, body fluids and other natural substances.[1,2] An enzymatic reaction with the ATP in bioburden results in bioluminescence (biological production and emission of light).[1,2] The intensity of bioluminescence generated is proportional to the amount of organic material present on the surface tested.[1] The luminescence is expressed in "relative light units" (RLU), providing a quantitative measurement.[1] However, it is important to reiterate that ATP measurements are non-specific meaning that they do not and cannot distinguish between microbial ATP and that from other sources such as food residues and mammalian cells. Further, ATP tests are unable to distinguish between viable and non-viable organisms as both living and recently killed organisms "spill" ATP onto surfaces.

Limitations with the use of ATP in Healthcare:

In spite of the increasing popularity of ATP measurements to assess environmental cleanliness in healthcare facilities, there are several limitations to this approach. First, the absence of standardization of the ATP technology from various manufacturers and RLU readings for use

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within healthcare makes cross-comparisons of readings and benchmarking problematic. Second, the lack of documented correlation between ATP readings and levels of microbial contamination on environmental surfaces makes meaningful interpretation of the data difficult and distinction between pathogenic and non-pathogenic microbes on the sampled surface virtually impossible. Also, ATP kits cannot detect or measure viral contamination because viruses possess no ATP. Third, and quite importantly, certain common surface disinfectant chemistries and cleaning tools may interfere to varying degrees with ATP measurements. Therefore, the use of ATP as a tool to determine the effectiveness of different cleaning practices or to compare the effectiveness of different cleaning and disinfectant chemistries remains a challenge.

Wider acceptance of ATP bioluminescence measurements in food processing plants became possible only after the food industry validated and agreed upon cleanliness standards.[3] In such settings, effectively cleaned surfaces normally yield readings of less than 250 - 300 RLUs, while the poorly cleaned ones give readings of more than 1000 RLUs.[1] Similar levels are being applied as indicators of cleanliness in healthcare facilities but without any agreement on their relevance in and acceptance by the healthcare industry.

Several studies have found no correlation between ATP readings and colony counts possibly due to the fact that colony counts detect only viable aerobic microorganisms on surfaces, whereas ATP bioluminescence assay detects all types of ATP-containing material.[2,4] As mentioned above, cleaning tools or cleaning chemistries can also interfere with ATP readings. For example, microfiber cloths can yield ATP readings even when clean and free of microbial contamination, possibly due to the presence of common plasticizers and trace levels of laundry detergents in eluates from them.[4]

The issue of different cleaning chemistries and their potential to enhance or quench ATP bioluminescence is especially significant here. Quats and anionic surfactants, for example, may give false positive results by enhancing RLU readings[5,7] by as much as 10%.[5,6] One study with Hydrogen Peroxide showed that concentrations of 0.1% did not have any enhancing or quenching effects on the RLU levels; at 0.5%, quenching effects of 3 - 5% were observed.[3] On the other hand, chlorine has been shown to have both enhancing and quenching effects. At concentrations of 100 ppm significantly enhanced RLU readings.[3,5] As concentrations increased to 500 ppm neither quenching or enhancing effects were observed[3,5], but as levels of chlorine increase to those (e.g., 1,000-5,000 ppm), routinely used for environmental surface disinfection in healthcare facilities there may be as much as a 40% deviation in quenching, thereby potentially giving false negatives![3,6] Consequently, Boyce et al[1] in their study on the use of ATP for monitoring the effectiveness of hospital cleaning, excluded all those rooms which were disinfected with a 5,000 ppm bleach solution.

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Conclusion:

Safe and effective disinfection of high-touch environmental surfaces is an important tool in reducing the spread of HAIs. Rapid and reliable means of monitoring the effectiveness of such practices are also crucial for training and quality control. Whereas there is increasing use of ATP measurement kits to assess the degree of cleanliness of cleaned and disinfected surfaces in healthcare settings, caution is advised in the interpretation of the results because several published studies have now documented the potential of cleaning tools and disinfectant chemistries to either enhance or suppress the levels of RLU. Therefore, using such an approach without a full understanding of its compatibility with the cleaning/disinfection regime at a given site, may lead to either an over-estimation or an under-estimation of the surface decontamination procedures in place.

Optimal deployment of ATP measurement kits in healthcare settings will require a thorough determination of baseline values of RLUs before and after surface decontamination using the specific combination of cleaning tools and disinfectant chemistry at a particular facility. In addition, standardisation is needed in the way ATP meters are built by different manufacturers and employed in healthcare settings for consistency, reliability and reproducibility of results.

References:

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