The Evolution of Charged Electrostatics

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Abstract:

Objective: The purpose of this experiment was to demonstrate the enhanced coverage achieved when using induction charged electrostatic sprayers as a delivery application tool compared to traditional hand sprayers and low pressure directional sprayers.

Method: Three delivery application systems were tested to find the efficiency of coverage from 0° to 180° of a curved, liquid sensitive paper using a traditional hand sprayer, a low pressure directional sprayer, and an induction charged electrostatic sprayer.

Results: Of the three application systems, the induction charged electrostatic sprayer yielded more consistent coverage of a liquid solution throughout the curved surface, compared to the traditional hand sprayer and low pressure directional sprayer. The surface sprayed with the electrostatic sprayer achieved >70% coverage through the 0-45° angle, compared to 30% and <10% with a low pressure directional sprayer and hand sprayer, respectively. The percent coverage of the low pressure directional sprayer and the traditional hand sprayer drops off significantly at greater angles. At the greatest angle from the sprayer, the electrostatic sprayer achieved approximately 30% coverage.

Conclusion: Induction charged electrostatic sprayers, paired with a disinfectant and a comprehensive protocol implementation will enhance compliance and improve surface coverage – especially to those surfaces often left untreated by traditional disinfection methodologies.

Introduction:

According to the Center for Disease Control and Prevention, one in every 25 hospital patients in the United States will contract a healthcare-associated infection (HAI) during their visit, and by 2050, drug-resistant bacteria are expected to responsible for the deaths of up to 10 million people (CDC, 2016). To combat the rising rates of infection, electrostatics engineers have developed a disinfectant delivery system that significantly reduces human error and improves compliance.

Electrostatic application originally emerged in the agricultural sector to achieve uniform distribution of pesticide throughout crop foliage. The charged particles repel one another, creating uniformly sized particles while increasing pesticide coverage under leaves. Electrostatic application allows for reduced spray drift because the electrostatic properties are attracted to the neutral surface of the leaves (The Center for Agriculture, Food, and the Environment, 2015, Gen et al., 2014).

Using a similar technique, the technology was carried into the automotive painting industry to provide superior coverage with high transfer efficiency. This method uses less paint while saving time and labor (Elliot Equipment Corporation, 2014).

Additional evidence of the benefits of using electrostatic is being published within the food-processing sector. Using electrostatics is beneficial from a business perspective, enabling companies such as potato chip manufacturers to achieve savings by reducing the amount of powder wastage, deliver a better end product to customers, and increasing efficiency of flavoring application. The technology allows exact control over minute quantities of powders and flavorings and delivers coverage, which means chips are evenly coated (Potato Pro, 2016). Today, electrostatic technology is an emerging infection control tool in hospitals, cruise lines, schools, gyms, and EMS agencies because of the superior surface coverage capability and the potential for significant labor savings (Patel, 2015).

Electrostatics + Disinfectant = Evolved Infection Control System

Using electrostatics as a delivery application tool is part of an revolutionary infection control program. Field studies show it is also the partnership between the delivery system and the chemistry that provides an effective solution (Ruch, 2016). The properties of the disinfectant will dictate the specific protocol, microbiological efficacy, surface compatibility, as well as the health and safety procedures required to produce exceptional results. Whether the system is used in healthcare, food processing, cruise lines or emergency management, the integration of the sprayer with the appropriate chemistry is key to the implementation of a successful infection control protocol that meets the changing needs of public health (Patel, 2015)

Induction Charged Electrostatics

As a unique discipline of electrostatics, induction charged sprayers generate charged droplets that repel each other but are attracted, and migrate to nearby oppositely charged or neutral surfaces (Patel, 2015, Gen et al., 2014). The combination of attraction to the surface and the repulsion between the droplets results in a more comprehensive deposition, or “wrap-around” effect. As a result, even those surfaces with complex geometries, including shaded and porous areas, achieve complete coverage (Gen et al., 2014).

Study Objective

Three different delivery systems were evaluated for their effectiveness of liquid deposition on a curved surface. The purpose of this experiment was to demonstrate the enhanced coverage achieved when using induction charged spray compared to a traditional hand sprayer and a low pressure directional sprayer. Based on previous research, it was hypothesized that the electrostatic sprayer would yield the highest, most consistent coverage of liquid solution throughout the 180° of the test strip.

Methods:

In this study, each target surface was sprayed with either a traditional hand sprayer, a low pressure directional sprayer, or an induction charged electrostatic sprayer. The same volume of liquid was dispensed for each device. The target surfaces consisted of three liquid sensitive strips of paper angled against a semicircular shaped object (figure 1). A tripod with a fixed opening for a delivery system was positioned at a distance of 36 inches from the target surface, facing 0°. Each target surface was divided into four sections for data analysis. This design allows for quantity of solution to be quantified. The strips were measured for saturation and the percent area covered was calculated in each

45° section using ImageJ software (NIH).

Figure 1: Liquid sensitive paper angled against semicircular object. The paper is inserted at 0° (bottom of picture) and at 180° (top of picture) to form a semicircular shape. The sprayer makes initial contact with the liquid sensitive paper at 0°.

Results:

The induction charged electrostatic sprayer yielded significantly higher and more consistent coverage of a liquid solution throughout the curved surface. Additionally, the electrostatic sprayer was the only delivery system to effectively reach indirect surfaces around the target due to the attractive forces of induction charged technology (figure 2). Figure 2 demonstrates the coverage efficiencies of the three systems.

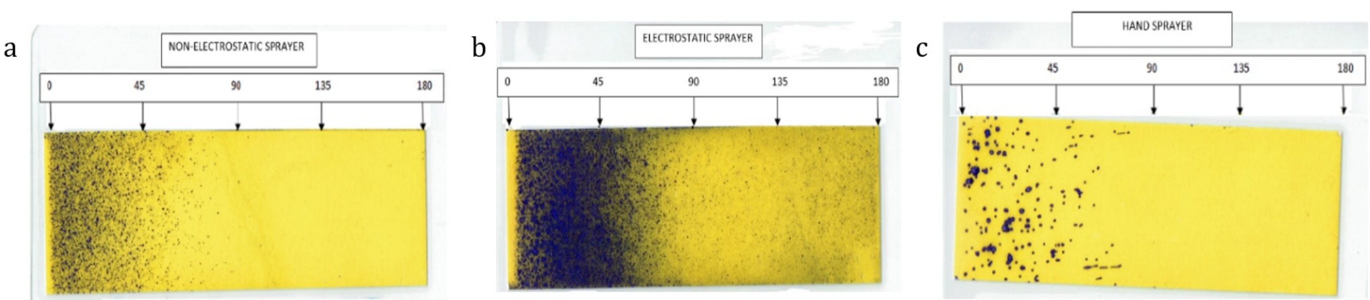

Figure 2: Percent area covered calculated in each 45° section of a) a low pressure directional sprayer, b) an induction charged electrostatic sprayer, and c) a traditional hand sprayer.

The surface sprayed with the electrostatic sprayer achieved >70% coverage through the 0-45° angle, compared to 30% and <10% with a low pressure directional sprayer and traditional hand sprayer, respectively (figure 3). The percent coverage of the low pressure directional sprayer and traditional hand sprayer drops off significantly at greater angles. However, at the 135-180° range, the electrostatic sprayer achieved approximately 30% coverage.

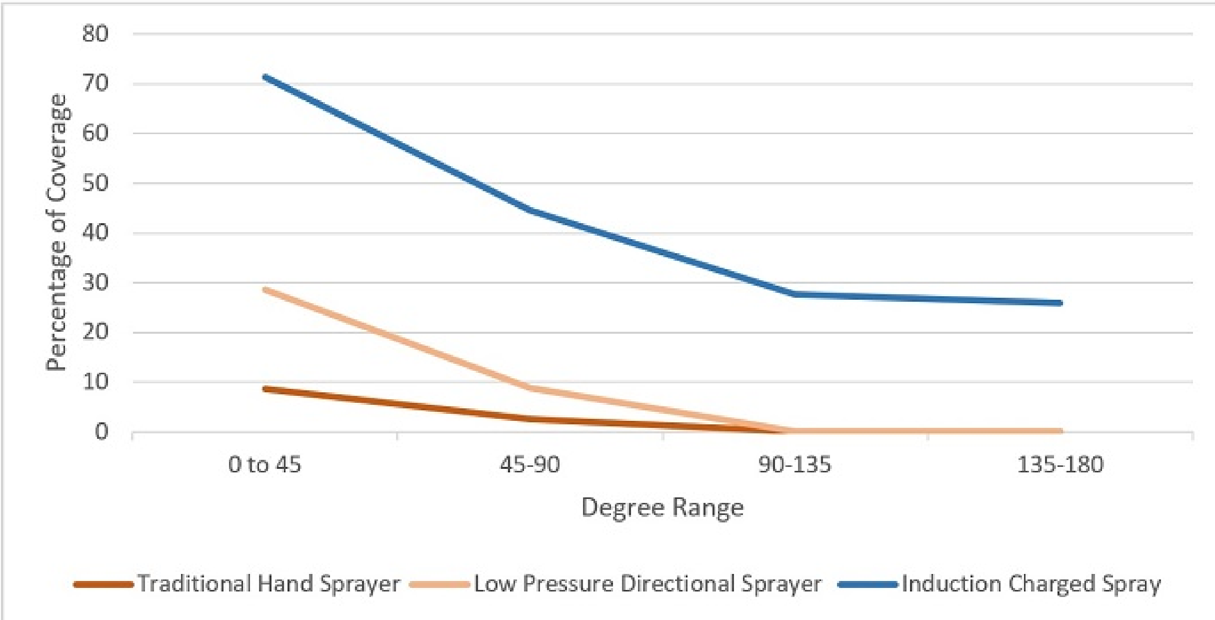

Figure 3: Coverage efficiency of delivery systems

Discussion:

Induction charged electrostatic sprayers demonstrated the most complete surface coverage on the liquid sensitive paper, especially when looking at surfaces that are not in the direct line of spray. These surfaces often go untreated when using less effective delivery application tools. Even at angles greater than 90°, the induction charged electrostatic sprayer continued to achieve approximately 30% coverage, compared to its competitors who showed a significant decrease at angles greater than 90°.

Interestingly, coverage of the samples was extremely limited even when the traditional hand sprayer and low pressure directional sprayer were in directly in front of the sample (0 to 45°). Unlike the ionized/charged spray, the traditional and lower pressure systems do not create a solution that is conducive to dispersal (Bailey 1998). In the electrostatic spray system, the negatively charged ions repel each other, increasing the surface area of dispersal (Bailey 1998). However, it should be noted a greater volume of the solution/disinfectant is applied to the areas that are reached by the spray of the traditional sprayers. This may correspond to more effective decontamination in those specific areas.

One main advantage of the electrostatic sprayer is the ability to apply a disinfectant to surfaces not directly aligned with the device (Beuershausen & Jarbath, 2016). Explained by Coulomb's law, the charged disinfectant ions seek out oppositely-charged or neutral surfaces (Robertson, 2016). This combined with the intermolecular repulsion described above, creates an environment where the disinfectant can effectively "wrap" around objects (Beuershausen & Jarbath, 2016). Traditional delivery systems do not include a method to improve dispersal of the solutions.

Conclusions:

Electrostatic sprayers, coupled with an Environmental Protection Agency (EPA) registered disinfectant and implemented protocol will enhance compliance and improve coverage even to those surfaces that are traditionally left untreated. With healthcare-associated infections on the rise, and the prevalence of antibiotic resistant bacteria, the electrostatic system can be a powerful infection control tool in preventing the spread of harmful pathogens.

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Updated October 31, 2016: a) The article's introduction was updated to reflect the published literature. b) Figure 2 wording was corrected as it was mislabeled.

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