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Evaluation of Permanon as nano-surface protection coating and its potential to reduce the ability of microbes to adhere to surfaces.

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Abbreviations

S. aureus – Staphylococcus aureus

E. coli – Escherichia coli

P. aeruginosa – Pseudomonas aeruginosa (also spelled as *aruginosa*)

Cfu/ml – colony forming units /millilitre

OD- optical density

Introduction

Infection control, especially in operating rooms (ORs), is a major priority for hospitals. These areas are subject to strict cleaning procedures such as removal of contaminants, disinfection and sterilization from the air and contact surfaces (Mora et al., 2016). Since this is a costly endeavour; new methods or improvements on current practices to limit contamination caused by microbes is under constant investigation.

Most bacteria can adhere to material surfaces to form complex and heterogeneous microbial communities and biofilms (Valentini et al., 1992). Significant efforts are currently being directed to prevent bacterial adhesion and subsequent formation of biofilms. Many surface modification techniques have been used to examine inhibition of bacterial adhesion to surfaces. Among these methods chemical coating strategies are promising approaches for bacterial adherence reduction.

Physico-chemical properties such as surface potential, roughness and hydrophobicity affect the rate of bacterial adhesion (Pfeiffer et al., 2016). Surface hydrophobicity is reported as a key factor to govern bacterial cell attachment (Hogt et al., 1985) and the recent availability of nanomaterials (synthetic polymers) fit for this purpose has made its application both feasible and practical.

What is Permanon Platinum and how does it work

Permanon Platinum (MSDS 2449) is a polymerized siloxane coating substrate. The nano-engineered elemental Silicon (Si14) particles are bound electrostatically and fill microscopic pores and pits in solid materials. Therefore, making the surface less resistant to bacterial adhesion. The manufacturers of Permanon Platinum specialize in nanotechnology surface protection coatings since 1997 and markets in 36 countries. Permanon has been demonstrated to reduce the viability of *Escherichia coli* and *Staphylococcus aureus* on coated

surfaces (no survivors after 6 h). Permanon coated areas in wet or high humidity areas could also resist the growth of mould (Warriner et al., 2013). Permanon coating of stainless steel, polycarbonate, and soda-lime glass lowered bacterial adherence of aerobic nosocomial bacteria (*E. coli and S. epidermidis*) (Pfeiffer et al., 2016).

Safety information

Permanon Platinum is a 90% biodegradable surface active agent and is safe to use on solid surfaces including glass, paint, chrome, rubber, plastics and metal/metal alloys. It is neither flammable nor cytotoxic (Creamedix, 2013; Hiebl et al., 2013).

Expected outcomes:

To demonstrate the practical application of Permanon Platinum nano surface protection coating to reduce the ability of microbes to adhere to surfaces generally encountered in hospital environments.

Proposed benefits:

Preventative measure as an addition to current infection control practices without requiring extra effort from cleaning staff or changing current cleaning chemicals or chemical suppliers.

Aim of study

To demonstrate that nano surface protection coating is able reduce the ability of microbes to adhere to surfaces improving and aiding in conventional cleaning.

Materials and Methods

Bacterial strains used in this study:

The bacteria isolates used in this study are a) *Escherichia coli ATCC 11775*, b) *Staphylococcus aureus ATCC 26923* and c) *Pseudomonas aeruginosa.* The cultures were cultivated overnight in minimal broth media and grown up until an OD600nm = 0.8, which corresponds to a maximum of 300 cfu/ml and minimum 250 cfu/ml.

a) *Escherichia coli* (abbreviated as *E. coli*) are bacteria found in the environment, foods, and intestines of people and animals. *E. coli* are a large and diverse group of bacteria. For immune compromised individuals E. coli becomes an opportunistic pathogen causing symptoms such as diarrhea, urinary tract infections, and respiratory illnesses (www.cdc.gov/ecoli).

b) *Staphylococcus aureus* is a bacterial human pathogen causing a wide variety of clinical manifestations. Infections are common in community-acquired as well as hospital-acquired settings and treatment remains challenging to manage and due to the emergence of multi-drug resistant strains such as MRSA (Methicillin-Resistant *Staphylococcus aureus*). *S. aureus* does not normally cause infection on healthy skin; however, if it is allowed to enter the bloodstream or internal tissues, these bacteria may cause a variety of potentially serious infections (Taylor and Unakal, 2017).

c) Pseudomonas aeruginosa has emerged as an important pathogen. It causes between 10% and 20% of infections in most hospitals. Pseudomonas infection is especially prevalent among patients with burn wounds, cystic fibrosis, acute leukemia, organ transplants, and intravenous-drug addiction. P. aeruginosa is a common nosocomial contaminant, and epidemics have been traced to many items in the hospital environment. Patients who are hospitalized for extended periods are frequently colonized by this organism and are at increased risk of developing infection (Bodey *et al*, 1983)

Experimental design

A number of surfaces have been treated and contaminated with the mentioned bacterial isolates. The surfaces used in this study include the following; Hard Plastic, Stainless steel, PVA paint, and standard paint treated surfaces, Enamel, Grey (rough) and Brown (smooth) wood surfaces, Blue and Brown Vinyl surfaces, and Glass.

Initial experiments; Trial experiments

Initial experiments were conducted with stainless steel and plastic, the surfaces were contaminated with bacterial culture and surface contact, making use of contact plates were conducted at time intervals 0, 5, 30 minutes, 2 and 24 hours. After contact, at these time points, the surface was wiped and surface contact was redone at the respective time-intervals. Thus, data is given as wiped (W) and unwiped (UW). In addition, contact plates were also taken on non-contaminated surfaces treated only with Ethanol (control) and Permanon (control), these served as additional controls. This was done to eliminate any bacterial growth due to potential human errors or even environmental factors.

All experiments were performed in duplicate

Treatment of control surfaces

All surfaces were treated with 70% Ethanol, with a contact time of 20 minutes followed by rinsing the surfaces with dH_2O and allowing to dry. Once surfaces were dried, surfaces were

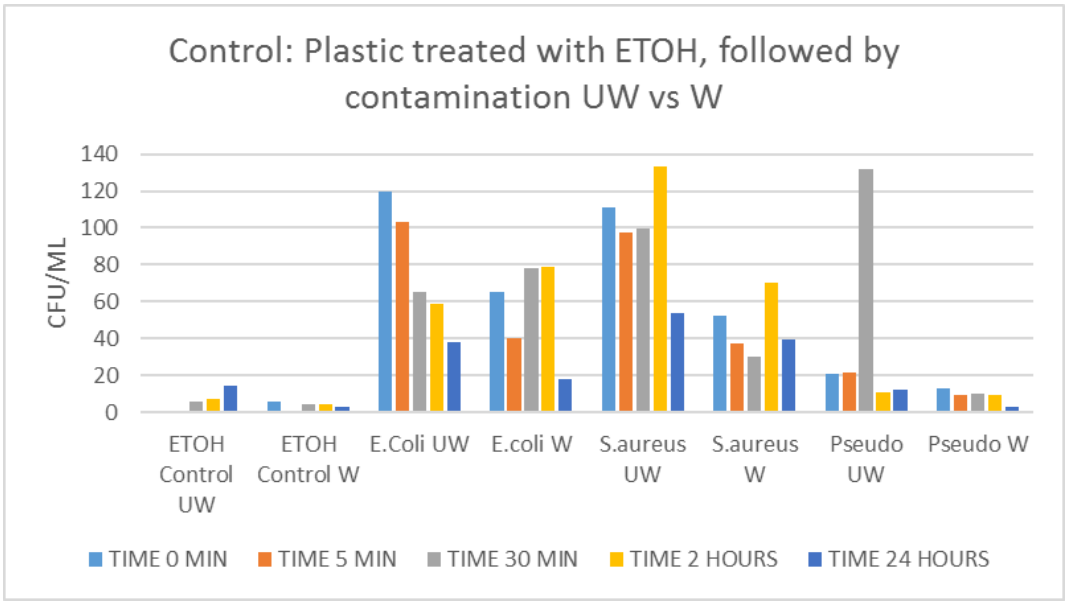
contaminated with separate bacterial cultures. The culture was allowed to dry, followed by surface contact, making use of contact plates at time intervals of 0, 5, 30 minutes, 4 and 24 hours. All experiments were performed in duplicate

Treatment of experimental surfaces

All surfaces were treated with 10% Permanon, which was allowed to completely dry, followed by rinsing with dH_2O, allowing surfaces to dry Once surfaces were dried, surfaces were contaminated with separate bacterial cultures. The culture was allowed to dry, followed by surface contact, making use of contact plates at time intervals of 0, 5, 30 minutes, 4 and 24 hours. All experiments were performed in duplicate.

Results

All raw data are captured in Excel sheets. Given are the graphs that represents the average values taken of the duplicate experiments, both for Ethanol (control) and Permanon (Experimental) treated surfaces.



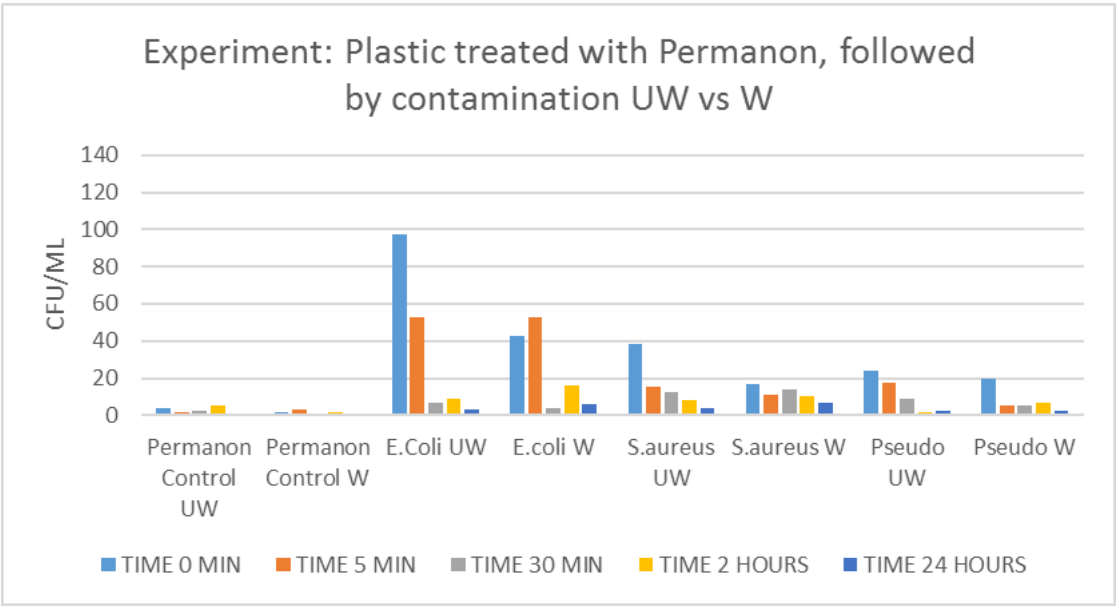


Figure 1: Plastic surfaces treated with Ethanol (control) and Permanon (experiment). Surfaces were contaminated with *E. coli*, *S. aureus* and *P. aeruginosa* (Pseudo), samples were taken at different time intervals, followed by wiping the surfaces with a clean paper towel, and contact samples were retaken at the respective time intervals. Reported is an approximate 32% bacterial load reduction when plastic surface was treated with Permanon, compared to Ethanol. No significant differences were seen for wiped samples, the reduction remained at an approximate 32%.

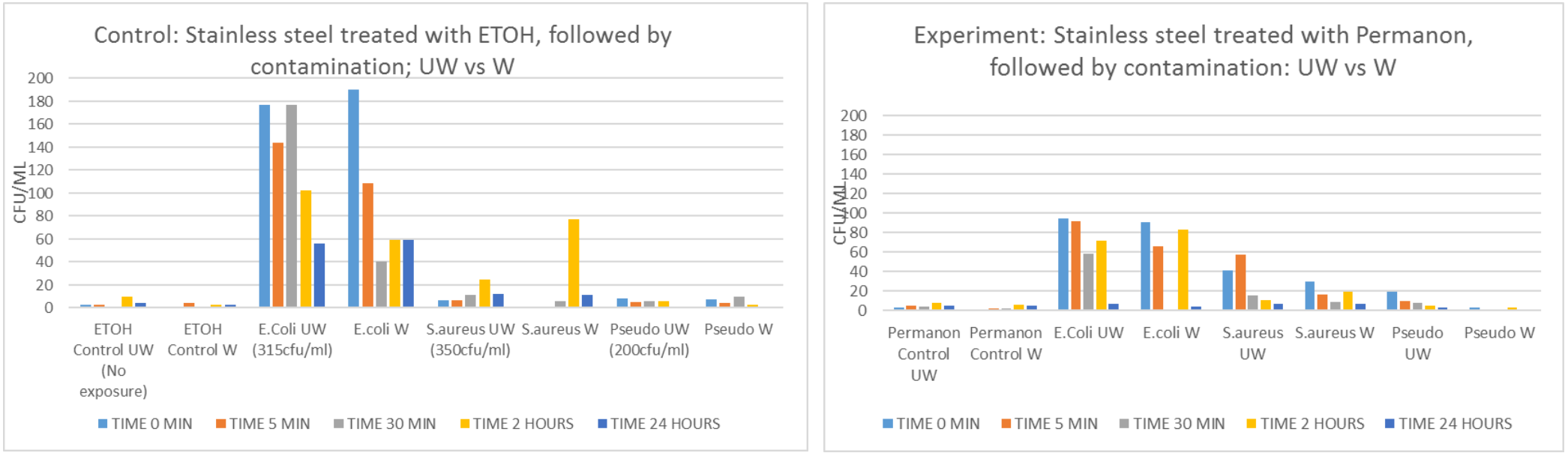


Figure 2: Stainless steel surfaces treated with Ethanol (control) and Permanon (experiment). Surfaces were contaminated with *E. coli*, *S. aureus* and *P. aeruginosa* (Pseudo), samples were taken at different time intervals, followed by wiping the surfaces with a clean paper towel, and contact samples were retaken at the respective time intervals. Reported is an approximate 64% bacterial load reduction when plastic surface was treated with Permanon, compared to Ethanol. No significant differences were seen for wiped samples, the reduction remained at an approximate 64%.

Figure 3: Various surfaces pre-treated with Ethanol (control) and Permanon (experiment). Surfaces were contaminated with *E. coli*, *S. aureus* and *P. aeruginosa* (*P. aruginosa*), samples were taken at different time intervals, 0, 5, 30 minutes, 4 and 24 hours. No significant differences were seen with both control and Permanon surfaces that were contaminated with E. coli (1st row of graphs).

Significant differences were seen between Ethanol and Permanon treated for most surfaces contaminated with *S. aureus* except with PVA and standard painted wood surfaces. There was a significant reduction, with almost no growth reported for surfaces pre-treated with Permanon (2nd row of graphs).

Significant differences were seen between Ethanol and Permanon treated for Grey (rough) wood, Blue and Brown vinyl surfaces contaminated with *P. aruginosa* There was a significant reduction, with almost no growth reported for surfaces pre-treated with Permanon (3rd row of graphs). The remaining surfaces (PVA, Enamel, standard painted (White wood) and Glass) had comparable results, however, Permanon treated surfaces still reported lower bacterial loads.

Conclusions

It is clear from the experiments conducted on the various surfaces that were pre-treated / pre-coated with Permanon, upon bacterial contamination lower bacterial loads were recovered, this could be due to Permanon interfering with the ability of the bacteria to attach to these surfaces, but this cannot be conclusively stated. However, from our studies a reduction of between 32%-64% bacterial growth was reported for surfaces pre-coated with Permanon compared to Ethanol treated surfaces.

References

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