Reduced bacterial attachment on surface modified hydrophobic fabric surface: a possible approach for safety enhanced packaging material

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ABSTRACT

In the present study, three surface modified fabrics were investigated for their bacterial attachment properties using *Salmonella enterica* serovar Typhimurium (gram –ve) and *Staphylococcus aureus* (gram+ve) bacteria. The surface modified fabrics were nanometal oxide treated fabric (1163), nanometal oxide/hydrophobic coated fabric (1164), and superhydrophobic coated fabric (1165). The pristine cotton fabric (1166) was considered as control for all the experiments (n=6). A drop of 500µl, containing 1 X 10^5 colony forming units (cfu/ml) of gram –ve/ gram +ve bacteria was placed on each fabric and the fabric with bacteria were subsequently incubated for 1h at 37^0 C. The drop was absorbed on the fabric such as 1166 and 1163 whereas the drop was in a floating state on fabric 1164 and 1165.

Upon incubation, the drop was removed from the fabric surface and the bacterial recovery (if attached on the fabric) was performed using plate counting method using suitable dilutions. *Salmonella* Typhimurium count was reduced two folds for fabric 1163 and 1165 compared to fabric 1164 and 1166. On the other hand, *Staphylococcus aureus* count showed reduced bacterial count on fabric 1163 and 1164 and no count on paper 1165 compared to control 1166. Our results thus clearly indicate that surface modified fabric show reduced (1163 and 1164) or no (1165) bacterial attachment properties and therefore could be suitable of its application as a safety enhanced packaging material.

Keywords: Hydrophobic, Bacterial count, Bacterial attachment, Packaging material

1 INTRODUCTION

Food packaging is a very serious public health concern as packaged food is always at threat for being contaminated by pathogenic microorganisms during the manufacturing and packaging processes. Due to the biofilm forming bacterial species which are rapidly growing on the surface of packaging materials, development of safe packaging material is a challenge [1]. Bacteria often have a tendency to attach to the organic polymers exuded by the cells and such bacteria are difficult to remove and may require cumbersome efforts for their eradication. The bacterial biofilms are formed as initial reversible adsorption on the surface followed by adhesion of bacteria to the surface and lastly colony formation [2]. Hence, preventing the initial attachment of bacteria to the surface is a possible approach in order to prevent the process of biofilm formation [3].

Cellulose-based superhydrophobic papers have been shown a promising alternative to conventional superhydrophobic substrates that could have applications in a vast array of products, including fast food, microwavable food packages, and self-cleaning cartons [4-6]. Silane functionlized silica nanoparticles were used in water repellent finish of textile fabrics [7]. Previous research has shown nanotechnology field has several biomedical applications including the antibacterial phenomenon [8-13]. Therefore, the surface modification using nanopartilces which may impart hydrophobic nature to the fabric surface is a logical approach to reduce bacterial attachment and thereby develop a safety enhanced packaging material.

With this research in mind, present study demonstrated the reduced bacterial attachment to the nanomaterial treated fabric surfaces.

2 MATERIALS AND METHODS

2.1 Preparation of fabrics

Bleached and mercerized style 419W cotton (Testfabrics, Inc) fabric was used as the substrate for surface modified fabrics. Sample 1163 was prepared by spray coating of nano magnesium oxide particles dispersed in a spray adhesive (Loctite) solution (1163). Sample 1164 was prepared by spraying nano magnesium oxide with a silicone binder dispersed in hexane (1164), and superhydrophobic coated fabric (1165) was prepared by spray coating of fluorosilane-funtionalized silica nanoparticles.

2.2 Bacterial experiments

The surface modified fabrics were nanometal oxide treated fabric (1163), nanometal oxide/hydrophobic coated fabric (1164), and superhydrophobic coated fabric (1165). The pristine cotton fabric (1166) was considered as control for all the experiments (n=6). All the fabrics were cut into 1X 1cm^2 pieces for all the experiments. *Salmonella enterica* serovar Typhimurium and *Staphylococcus aureus* from **American Type Culture Collection** (ATCC®, VA USA) were grown at 37°C in Luria-Bertani (LB) broth (Difco, Sparks, MD, USA) with continuous shaking until the optical density (OD) was 0.6–0.8 (at 600 nm). A drop of 500µl, containing 1 X 10^5 colony forming units (cfu) /ml of gram –ve/ gram +ve bacteria was placed on each fabric and the fabric with bacteria were subsequently incubated for 1h at 37^0 C.

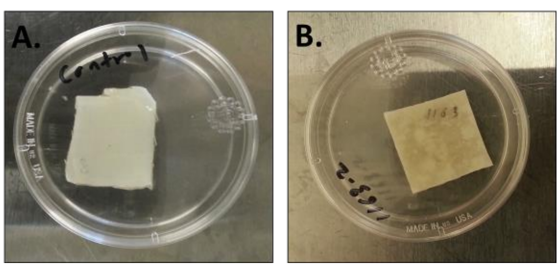

Figure 1: (A) control fabric 1166; (B) paper 1163

After incubation, the drop, if not absorbed, was removed from each fabric, and the fabrics were placed in 1 ml of sterile phosphate buffered saline (PBS, pH=7.00) and vortex to remove any attached bacteria to its surface. Upon vortexing, 1ml of PBS containing bacteria was collected, subjected to serial 10-fold dilutions in sterile PBS, if necessary, and then plated on plate count agar (PCA) to quantitate their cfu/ml.

Table 1. Bacterial count

Fabric	*Salmonella* Typhimurium	*Staphylococcus aureus*
	Log_{10} cfu/ml	Log_{10} cfu/ml
1166	4.57 ± 4.25	4.54 ± 4.41
1163	2.94 ± 2.88	3.04 ± 3.20
1164	4.36 ± 4.00	4.36 ± 4.41
1165	3.10 ± 2.92	0 ± 0

3 RESULTS AND DISUCSSION

After one hour of incubation, it was observed that the drop was absorbed on the fabric such as 1166 and 1163 (Figure 1) whereas the drop was in a floating state on fabric 1164 and 1165 (Figure 2). This suggested that fabric 1164 and 1165 possessed hydrophobic surfaces.

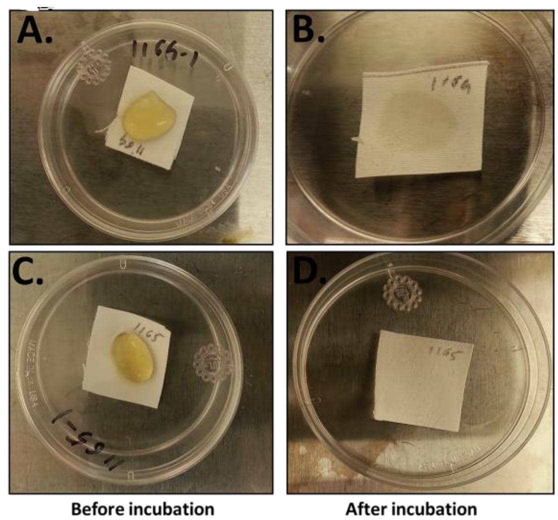

Figure 2: (A) & (B) fabric 1164; (C) & (D) fabric 1165.

Due to their hydrophobic nature, the drop was not able to attach to the surface of the fabric. It was also observed that the surface of fabric 1164 could be less hydrophobic than fabric 1165, as after 1h of incubation the surface of fabric 1164 appears to have absorbed the drop (Figure 2B, appear as a wet outline on the surface). Conversely, fabric 1165 did not exhibit this change. Further, bacteria were quantified using plate count method.

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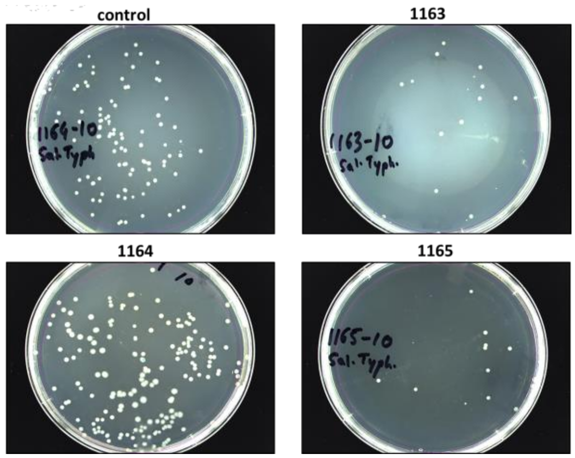

Figure 3: *Salmonella* Typhimurium count for each fabric

Salmonella Typhimurium count was reduced two folds for fabric 1163 and 1165 compared to fabric 1164 and 1166 (Table 1).

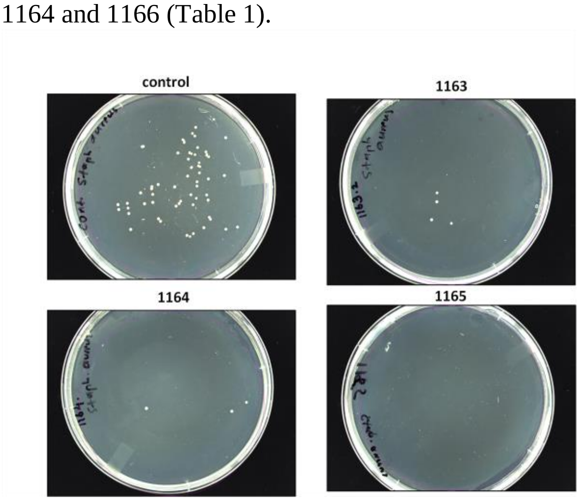

Figure 4: *Staphylocccus aureus* count for each fabric

On the other hand, *Staphylococcus aureus* count showed reduced bacterial count on fabric 1163 and 1164 and no count on paper 1165 compared to control 1166. As shown in Figure 3, fabric 1165 showed no recovery of *Staphylococcus aureus* whereas 1163 and 1164 showed reduced bacterial recovery. Similarly, fabric 1163 and 1165 showed lesser *Salmonella* Typhimurium recovery compared to fabric 1166 and 1164 (Figure 4). Overall, our results thus clearly indicate that surface modified fabric show reduced (1163 and 1164) or no (1165) bacterial attachment properties and therefore could be suitable of its application as a safety enhanced packaging material.

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