World Conference on Technology, Innovation and Entrepreneurship

Antibacterial Polymer Based Transparent Coating for Elimination of Staphylococcus Aureus

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Abstract

A polymer antibacterial surface has been successfully developed. The coating system used silanes as binder and Ag nanoparticles (AgNPs) as antibacterial agent. One hindrance to wide application of the antibacterial coating is the complexity of its deposition process and technique (eg; sputtering, CVD, spin-coating etc). They are expensive, require special training and suitable only for small size sample. In this work, only sponge is required to apply the coating onto the intended surface. Ball-milling and ultrasonication stirring were used to mix the AgNPs and silanes. The surface properties were characterized by FESEM. The antibacterial properties of the coating were tested against \textit{Staphylococcus aureus} using JISZ 2801 method. This bacteria is known to cause nosocomial infections and have been posing problems in hospital all over the world. The need to provide bacteria-free environment is imminent especially in operation theatre (OT) and intensive care unit (ICU).

1. Introduction

Nosocomial infections are infections occurring within 48 hours of hospital admission, 3 days of discharge or 30 days of an operation (Inweregbu et al., 2005). \textit{Staphylococcus aureus} is among the most common cause of it. Although it may not cause harmful effects to healthy person but could pose serious illness and fatal infections to those with weak immunity. Patients in hospitals might get infection through air ventilation, walls, floors, equipments and etc. Therefore there is need to create a bacteria-free environment that can reduce the spread. Coating these surfaces with antibacterial layer could probably be the answer.

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Sol-gel is one of the many techniques used for polymer coating preparation. It has several advantages such as low operating temperatures and easy to fabricate. Owing to this simplicity, it has been used in numerous fields such as corrosion and coating, development of optoelectronics, membranes, sensors and catalysis. Silane as a binder has been widely used owing to its simplicity, durability, strength, and transparency. In this present study, an antibacterial coating based on polymer and silver nanoparticles (AgNPs) is presented. The effect of different amount of AgNPs to its antibacterial properties is discussed.

2. Methodology

2.1. Research Goal

In this present study, an antibacterial coating based on polymer and silver nanoparticles (AgNPs) is developed. The effect of different amount of AgNPs to its antibacterial properties is discussed.

2.2. Analyses and Results

Silver nanoparticles (AgNPs) were obtained from Sigma Aldrich Malaysia and used without further purification. The sol gel was prepared based on our previous work (Ali et al., 2014). Methyltrimethoxysilane (Si–CH3–(OCH3)3) and n-propanol were mixed (weight ratio of 1 : 1) in a beaker. Ag particles (0.5% wt) were added to the mixture and were vigorously stirred. Nitric acid was used as catalyst and added to the system by 10% wt and stirred. The sol-gel produced was then applied onto glass substrates using a sponge and allowed to dry at room temperature. FESEM was used to study the morphology and distribution of the Ag on the surface. The antibacterial testing for coatings was carried out according to Japanese International Standard, JISZ2801 (Association, 2000), by an accredited laboratory SIRIM Malaysia Sdn. Bhd.

The image (Fig. 1) viewed by FESEM shows that AgNPs are scattered all over the surface of samples. Size of the AgNPs is not even. The AgNPs are observed to be dispersed and exist as “clumps” (yellow circles) instead of continuous layer. Creating clumps instead of continuous layer of AgNPs would reduce the cost of excessive usage of AgNPs.

Table 1 shows result of the antibacterial test against Staphylococcus aureus bacteria. In this test, bacteria were allowed to breed on the Ag coated slides for 24 hours. Number of bacteria on the Ag coated slides at zero and after 24th hour was compared. As an antibacterial coating, the number of living bacteria cells at 24th hour must be lesser.
than the one at zero hour. This would indicate the reduction or elimination of the bacteria by the coated slides. Except for sample with 3.5 % wt of AgNPs which shows reduction from $1.6 \times 10^5$ to less than 10 in 24 hours, all the other samples does not exhibit any antibacterial properties against this bacteria. All of the control samples show increment in the number of bacteria after 24 hour.

Table 1: Antibacterial properties of different amount of AgNPs in the coated samples

<table>
<thead>
<tr>
<th>Amount of AgNPs in coated sample (%wt)</th>
<th>Coated Samples</th>
<th>Control Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0th h</td>
<td>24th h</td>
</tr>
<tr>
<td>0.5</td>
<td>$1.6 \times 10^5$</td>
<td>$2.2 \times 10^7$</td>
</tr>
<tr>
<td>1.5</td>
<td>$1.6 \times 10^5$</td>
<td>$5.6 \times 10^5$</td>
</tr>
<tr>
<td>2.5</td>
<td>$1.6 \times 10^5$</td>
<td>$3.6 \times 10^5$</td>
</tr>
<tr>
<td>3.5</td>
<td>$1.6 \times 10^5$</td>
<td>Less than 10</td>
</tr>
</tbody>
</table>

3. Conclusion

An antibacterial coating based on polymer has been succesfully developed. The coating requires minimum amount of 3.5 % wt of AgNPs to eliminate Staphylococcus aureus. The usage of sol-gel technique provides simplicity and flexibility for broader applications.

References