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Synthesis and modification of silver-seeded PVC for use as anti-adherent materials to prevent ventilator-associated pneumonia

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SUMMARY

In this research, silver-seeded PVC was synthesised and modified to combat ventilator-associated pneumonia by preventing bacterial adherence. The silver-seeded PVC was synthesised by in situ deposition of silver particles, and the silver-seeded PVC was further modified by reacting with 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro-1-decanethiol to create a superhydrophobic surface with static water contact angle more than 150°. The silver-coated PVC and superhydrophobic silver-coated PVC both exhibited excellent anti-adherent activity against MRSA and *Pseudomonas aeruginosa*.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a type of hospital acquired infection with high mortality, ranging from 24-76% (Choudhuri A, 2013). When patients are mechanically ventilated, the presence of an endotracheal tube supresses the natural cough reflex, which allows secretions to accumulate in the trachea and enter into the lungs, leading to infection.

A variety of attempts have been made to modify PVC, a common material for an endotracheal tube, to reduce or eliminate bacterial colonization. Endotracheal tubes (ETTs) coated with silver has been reported to have the ability to delay the rate and extent of bacterial colonization(Rello J, 2006). Another strategy has been investigated was to directly attach 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro-1-decanethiol (HDFT) to PVC(McCoy CP, 2009). However, these methods fail to provide sufficient antimicrobial activity and can weaken the mechanical properties of PVC required for use as an ETT.

In this study, PVC was optimised by seeding silver particles on the surface and was further modified utilising HDFT to prevent bacterial adherence and ultimately reduce the incidence of VAP.

MATERIALS AND METHODS

PVC was treated with pyridine and tin chloride solution followed by deposition of silver particles using Tollens' reagent. Silver-seeded PVC samples were then immersed in HDFT solutions to prepare HDFT-modified-PVC. These modified PVC slices were characterised in terms of static contact angle. Anti-adherent effect of silver-seeded PVC and HDFT-modified PVC were evaluated by challenging the samples with inoculum of MRSA and *P. aeruginosa* at 10^6 cfu/mL for 4 hours and 24 hours.

RESULTS AND DISCUSSION

Static contact angle of PVC, silver-coated PVC and HDFT-modified PVC were determined, as shown in Table 1. After deposition of silver onto PVC surfaces, the static contact angle was 15°. After modification of HDFT, the surface became superhydrophobic, the static contact angle of which was about 158°.

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Table 1. *Static contact angle measurements of modified PVC samples and PVC control.*

Sample	Angle (°)
PVC	93.8±5.7
Silver-coated PVC	15.0±3.6
HDFT-modified-PVC	158.6±12.6

Log_{10} reductions in MRSA and *P. aeruginosa* adherence to silver-seeded PVC and HDFT-modified PVC were shown in Figure 1 and Figure 2, respectively. As shown in Figure 1, significant reductions in the viable adherence of MRSA to silver-seeded PVC and HDFT-modified PVC were observed at 4 h and 24 h compared to untreated PVC.

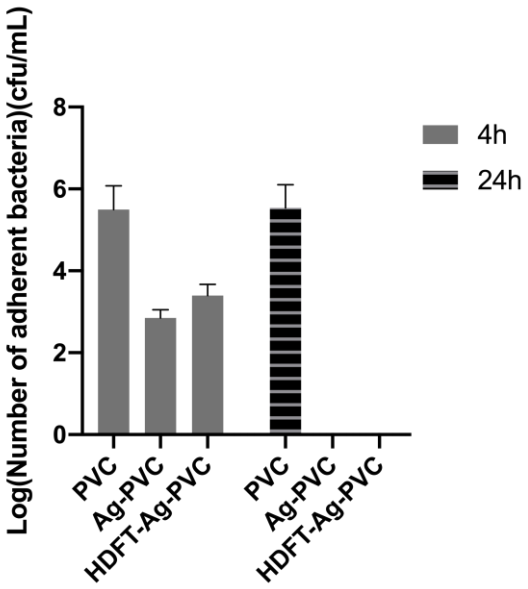

Fig. 1. *Log_{10} reduction in bacterial adherence of MRSA to Ag-PVC and HDFT-Ag-PVC relative to the PVC after 4 h and 24 h.*

As can be seen from Figure 2, after seeding silver on the PVC surface, the amount of detectable *P. aeruginosa* adhered to the surface decreased significantly after 4 and 24 hours. The HDFT-modified silver-seeded PVC samples also displayed good anti-adherent activity against *P. aeruginosa*.

CONCLUSIONS

This study developed a superhydrophobic silver coating on PVC that prevents or reduces bacterial adherence, indicating its potential for use in endotracheal tubes to prevent ventilator-associated pneumonia. Further studies will assess the mechanism of bacterial adhesion prevention and the biocompatibility of these modified surfaces.

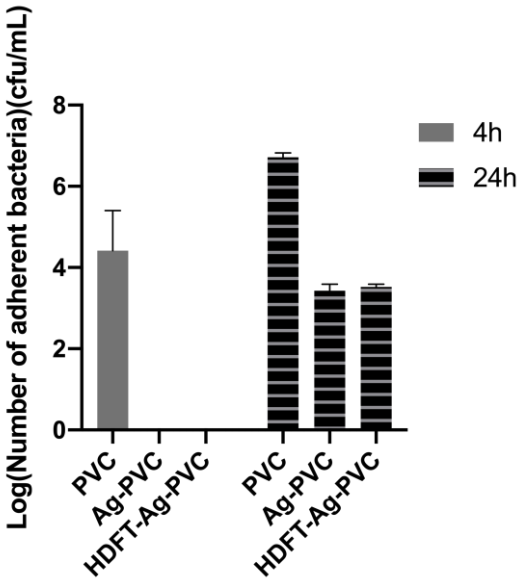

Fig. 2. *Log_{10} reduction in bacterial adherence of P. aeruginosa to Ag-PVC and HDFT-Ag-PVC relative to the PVC after 4 h and 24 h.*

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