Efficacy of silver/hydrophilic poly(*p*-xylylene) on preventing bacterial growth and biofilm formation in urinary catheters

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Catheter associated urinary tract infections (CAUTI), caused by several strains of bacteria, are a common complication for catheterized patients. This may eventually lead to a blockage of the catheter due to the formation of a crystalline or amorphous biofilm. Inhibiting bacteria should result in a longer application time free of complaints. This issue has been investigated using an innovative type of silver-coated catheter with a semipermeable cap layer to prevent CAUTI. In this work, two different types of silver catheters were investigated, both of which were capped with poly(*p*-xylylene) (PPX-N) and exhibited different surface properties that completely changed their wetting conduct with water. The contact angle of conventionally deposited PPX-N is approximately 80°. After O_2 plasma treatment, the contact angle drops to approximately 30°. These two systems, Ag/PPX-N and Ag/PPX-N-O_2, were tested in synthetic urine at a body temperature of 37 °C. First, the optical density and the inhibition zones of both bacteria strains (*Escherichia coli* and *Staphylococcus cohnii*) were examined to confirm the antibacterial effect of these silver-coated catheters. Afterward, the efficacy of silver catheters with different treatments of biofilm formed by *E. coli* and *S. cohnii* were tested with crystal violet staining assays. To estimate the life cycles of silver/PPX-catheters, the eluted amount of silver was assessed at several time intervals by anodic stripping voltammetry. The silver catheter with hydrophilic PPX-N coating limited bacterial growth in synthetic urine and prevented biofilm formation. The authors attribute the enhanced bacteriostatic effect to increased silver ion release detected under these conditions. With this extensive preparatory analytic work, the authors studied the ability of the two different cap layers (without silver), PPX-N and oxygen plasma treated PPX-N, to control the growth of a crystalline biofilm by measuring the concentrations of the Ca^{2+} and Mg^{2+} ions after exposure of the catheters to saturated urine for 24 h. The higher concentrations of Ca^{2+} and Mg^{2+} in the precipitates on the PPX-N catheters indicates that the hydrophilic PPX-N coating is superior to the simple PPX-N coating, with regard to the formation of a crystalline biofilm. Moreover, hydrophilic PPX-N as a cap layer may promote wettability and increase silver ion release rate and thus reduce the adhesion of suspended crystals to the catheter. Reduced bacterial growth and reduced adhesion may help to prevent CAUTI. [http://dx.doi.org/10.1116/1.4974197]

I. INTRODUCTION

With a share of 24%, urinary tract infections represent the most common nosocomial infection in hospital and home-care settings. Of these infections, 70%–80% are associated with use of an indwelling urethral catheter.[1] Indwelling urinary catheterization is grouped into short-term (<7 days) and long-term applications (>28–30 days). Approximately 10%–30% of patients undergoing short-term catheterization and virtually all patients with long-term catheterization develop catheter-associated bacteriuria.[2,3] In cases involving short-term catheterization, the most common infecting organism of catheter associated urinary tract infection (CAUTI) is *Escherichia coli*. Other common organisms are *Enterococci*, *Pseudomonas*, *Enterobacter*, *Staphylococcus aureus* or *epidermidis*, *Klebsiella*, *Staphylococcus cohnii* ssp. *urealyticus*, and *Serratia*.[4,5] In the long-term catheterization setting, common uropathogens include *E. coli*, *Pseudomonas aeruginosa*, and *Proteus mirabilis*.[4]

CAUTI often leads to the development of a biofilm on the long-term indwelling urethral catheter, which can shield the bacteria from antibiotics and promote further bacterial adhesion. The urease which is produced by bacteria reacts with urea to form ammonia and carbon dioxide. The resulting *p*H increase leads to precipitation of calcium or magnesium phosphate crystals on the catheter. Inorganic salts are colonized by bacteria, which may even block the catheter lumen.[6] To prevent morbidity and mortality associated with

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