Nano-$BaSO_4$ as a Novel Agent to Yield Antimicrobial Thermoplastics for Medical Tubing

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Statement of Purpose: Hospital acquired infections remain a major costly problem. Each year there are approximately 2 million hospital acquired infections, 90,000 of which are fatal [1]. More than half of these infections can be attributed to contamination of life sustaining medical devices such as endotracheal tubes, bladder catheters, central venous catheters, as well as other medical implants [2]. These infections can prolong hospital stay, increase medical costs, and result in the death of the patient [3]. Pellethane is a common thermoplastic that is commonly used in various medical tubing applications. This study seeks to understand how incorporating nano-barium sulfate into pellethane composites affect the physical properties and antimicrobial nature of the resulting polymers. The results of this study showed that the incorporation of nano-barium sulfate into pellethane polymers yielded polymers which had enhanced antimicrobial properties, yet had similar hydrodynamic properties and were still radiopaque. **Methods: Sample preparation:** Pellethane pellets were mixed with various weight percentages of standard $BaSO_4$ powder and nano- $BaSO_4$. Seven different sample groups were made (0% $BaSO_4$, 20% nano- $BaSO_4$, 30% nano-$BaSO_4$, 40% nano-$BaSO_4$, 20% $BaSO_4$, 30% $BaSO_4$, and 40% $BaSO_4$). These mixtures were mixed, melted, and extruded into tapes. Tapes were then cut into disks, approximately 22mm in diameter, and sterilized for contact angle and bacteria growth trials. For all other trials, sections of the tapes were used without sterilization. **Contact angle tests:** Contact angle measurements were made on a Krüss Easy Drop contact angle instrument (Krüss, Germany) connected to an image analysis program (Drop Shape Analysis (Version 1.8)). The Krüss Easy Drop apparatus was used to measure the contact angles that resulted when a 10µL drop of either H_2O, glycerol, or ethylene glycol was placed on the surface of a sample disk [4]. **Radiopacity Trials:** Polymer samples were labeled and X-rays taken using an infinity XMA HF-30AP, set to Manual mode with an exposure time of 0.016 seconds and MAS@6.1 and 70KV. Images were taken of each sample individually and s-values, the numerical value of exposure received by the receptors in the digital system, were recorded [5]. **Bacteria culture:** Stock solutions of *Staphylococcus aureus* (*S. aureus*) (ATCC# 25923) and *Pseudomonas aeruginosa (Schroeter) Migula* (*P. aeruginosa*) (ATCC# 27853) were diluted and frozen. Bacteria from stock solutions were streaked out for isolation on agar plates. Approximately 3mLs of sterile tryptic soy broth (TSB) (Sigma Aldrich) inoculated with one colony of desired bacteria were then incubated at 37°C while on a shaker set to 200rpm. These solutions were incubated for 18 hours to reach stationary phase and were then diluted to a density of 1×10^7 bacteria/mL (as estimated by the McFarland scale which corresponded to an optical density of 0.52 at 562 nm and was then further diluted at a ratio of 1:100) [6]. **Bacteria growth trials:** All bacterial growth trials with polymer samples were done in 12 well plates tissue culture plates. For trials, polymer samples were placed in separate labeled wells of a 12 well tissue culture plate. They were then covered in 1ml of the bacteria solution. The plates were then sealed with parafilm and incubated at 37°C while shaking at 200rpm for 1.5 hours. Next, 10µL samples of each solution were added to separate 990µL of fresh sterile TSB in a micro-centrifuge tube, creating a 1:100 dilution. The tubes were then vortexed and 100 µL was removed from each tube and added to 900 µL of sterile TSB in a micro-centrifuge tube, creating a 1:1000 dilution. To quantify the colony forming units 5 separate 20 µL were plated in TSB-Agar plates, and were allowed to incubate overnight. In addition to experimental trials, a set of control growth trials were conducted where bacteria grown under similar conditions to the experimental samples, but without the polymer disk, were diluted and plated at 15 minute intervals to track the bacteria growth rate at room temperature. The next day the colony forming units were counted and this count was used to calculate the total colony forming units in each solution. **Results:** No significant differences were seen in contact angles between the two polymer samples. However, these trials indicated that the nano-$BaSO_4$ embedded in the polymer samples were still able to make the samples radiopaque. In the case of *S. aureus* significant decreases were observed when 20% and 40% nano $BaSO_4$ polymers were used (see figure 1). In the case of *P. aeruginosa* significant decreases were observed when 0% $BaSO_4$ as well as 30%, and 40% nano $BaSO_4$ polymers were used (data not shown). Additionally the 40% nano $BaSO_4$ lead to a significant decrease in *P. aeruginosa* compared to the 40% $BaSO_4$ polymer (data not shown).

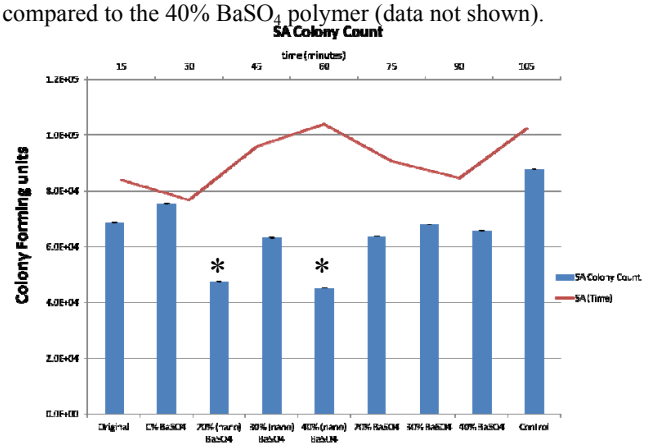

Figure 1. *S. aureus* colony count after 1.5 hours of contact with pellethane polymers. Data = mean +/- SEM (the red line indicates a growth curve of S. *aureus* grown at room temperature under similar conditions to the experimental trial) {*indicates a significant decrease when the marked sample is compared to the samples of 0% $BaSO_4$ as well as the empty well control samples containing no polymer sample, as determined by $p<0.05$}

Conclusions: These trials indicate that although the nano-$BaSO_4$ did not change the hydrodynamic nature of the samples there was a significant decrease in bacteria function when nano- $BaSO_4$ was present in the polymer. Further trials need to be done to better characterize the polymers as well as understand bacteria growth on samples over prolonged periods of time as well as investigating other possible sources of biofouling.

References:

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