Selenium Nanoparticle Coated Paper Towels Prevent Various Bacterial Growth

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Statement of Purpose: In the hospital environment, hand washing has been identified as the most significant manner towards preventing the spread of microbial infections[1], with hand drying as the critical last stage of the hand washing process. In some circumstances, such as for paper towels hanging in sink splash zones or those used to clean surfaces, they have been considered as potential sources of bacteria contamination.[2] In this study, for the first time, selenium nanoparticles were coated on normal paper towel surfaces through a quick precipitation method. In addition, their effectiveness at preventing biofilm formation was tested in bacterial assays involving various bacteria (for example, *Staphyloccocus aureus* and *Pseudomonas aeruginosa*). The results showed that the selenium coatings successfully introduced antibacterial properties to standard paper towels, revealing a promising selenium-based method to prevent bacterial infections on paper products.

Methods: Paper towels were coated with selenium nanoparticles through a simple and quick precipitation reaction involving glutathione (reduced form, GSH) and sodium selenite mixed at a 4:1 molar ratio. Bacteria cell lines of *S. aureus* and *P. aeruginosa* were obtained in freeze-dried form from the American Type Culture Collection. Selenium coated samples were placed into a 24-well plate, treated with the prepared bacterial solutions (10^6 bacteria/ml) and cultured for either 24, 48 or 72 hours in an incubator (37°C, humidified and 5% CO_2). For those samples that were cultured for 48 and 72 hours, the medium was changed with 1mL of sterile and fresh TSB (0.3mg/mL) every 24 hours. After treatment, the samples were rinsed with a phosphate buffered saline solution twice and placed into 1.5ml microfuge tubes with 1ml of PBS. These tubes were shaken at 3000 rpm for 15 minutes on a vortex mixer to release the bacteria attached onto the surface into the solution. Solutions with bacteria were spread on agar plates and bacteria colonies were counted after 18 hours of incubation. All experiments were completed in triplicate and were repeated three times. Data were collected and significant differences were assessed with the probability associated with a one-tailed Student's t-test.

Results: The results of the bacteria tests involving *S. aureus* and *P. aeruginosa* showed high effectiveness for the selenium coated paper towels at inhibiting bacteria growth on the paper towel surfaces, as shown in Figure 1. The selenium coatings significantly inhibited *S. aureus* growth by about 90% after 24, 48 or 72 hours and also successfully inhibited *P. aeruginosa* growth after 48 or 72 hours by 55% and 84%, respectively, on the surface of paper towels. Moreover, from the 24 hour culture time to the 48 hour culture time, there was an increase in bacteria numbers on uncoated paper towel samples, but was constant to the 72 hour culture time, implying that the uncoated paper towel was saturated by bacteria after 48 hours of treatment. In contrast, the bacteria numbers on the selenium coated paper towels remained at a lower level not increasing from 24 to 48 to 72 hours, indicating successful inhibition of bacterial growth.

Conclusions: In conclusion, the effectiveness of selenium coated paper towels towards inhibiting bacterial growth reached about 80-90% after 3 days compared with the uncoated paper towels. Importantly, this was accomplished without using antibiotics. This study suggests that selenium nanoparticle coatings could be used as an effective way to decrease bacterial spreading (specifically, *S. aureus* and *P. aeruginosa*) on paper products, which might have potentially important applications in the food packaging industry, medicine, and in clinical environments.

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References:

(1) McGuckin M. *LDI Issure Brief*. 2001;7:1-4.

(2) Hattula JL. *Clin Nurs Res*. 1997;6:363-74.

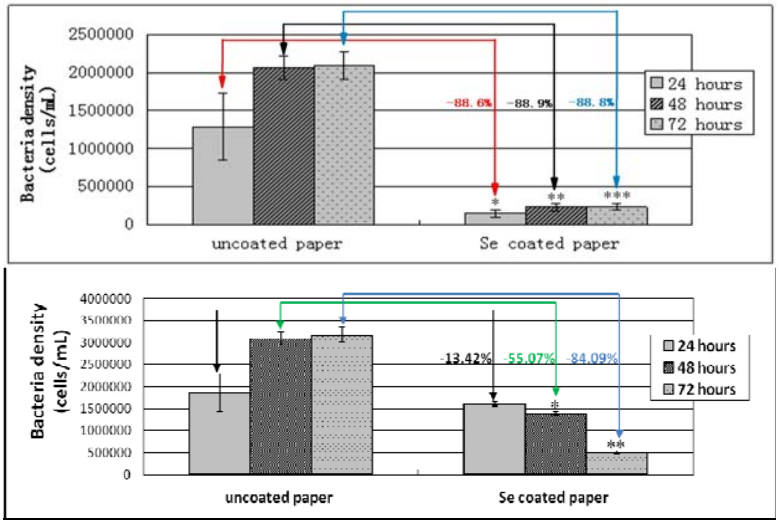

Figure 1. *Staphyloccocus aureus* (top graph) and *Pseudomonas aeruginosa* (bottom graph) growth on the surface of selenium coated and uncoated paper towels. Data is represented as mean ± standard deviation, n=3; *,**,***p<0.05 compared to the uncoated samples at the same time scale.