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Size Effects on Antimicrobial Efficiency of DBD Plasma Coated Silver Nanoparticles on Textiles

Abstract

This work studies the surface characteristics, the antimicrobial activity and the aging effect, of plasma pre-treated polyamide 6,6 fabrics (PA66) coated with silver nanoparticles (AgNPs), with the aim to identify the optimum size of nanosilver exhibiting antibacterial properties suitable for manufacturing of hospital textiles. The release of bactericidal Ag^+ ions from the 10, 20, 40, 60 and 100 nm AgNPs-coated PA66 surface were function of the particles size, number and aging. Plasma pre-treatment promoted both ionic and covalent interactions between AgNPs and the formed oxygen species on the fibers (Figure 1), favoring the deposition of smaller in diameter AgNPs that consequently showed better immediate and durable antimicrobial effect against Gram-negative *Escherichia coli* and Gram-positive *Staphylococcus aureus* bacteria. Surprisingly, after 30 days of aging, a comparable bacterial growth inhibition was achieved for all the fibers treated with AgNPs of <100 nm in size. The Ag^+ in the coatings also favored the electrostatic stabilization of the plasma-induced functional groups on the PA66 surface, thereby retarding the aging process (Figure 2). At the same time, the size-related ratio Ag^+/Ag^0 of the AgNPs between 40 and 60 nm allowed for controlled release of Ag^+ rather than bulk silver. Overall, the results suggest that instead of reducing the AgNPs size, which is associated to higher toxicity, similar long-term effects can be achieved with larger NPs (40-60 nm), even in lower concentrations. Since the antimicrobial efficiency of AgNPs larger than 30 nm is mainly ruled by the release of Ag^+ over time and not by the size and number of the AgNPs, this parameter is crucial for the development of efficient antimicrobial coatings on plasma-treated surfaces, and contribution to the safety and durability of clothing used in clinical settings.

Figures

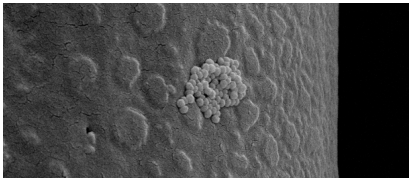

Figure 1 SEM images of plasma treated PA66 fibers loaded with 100 nm AgNPs with magnification of 50000X.

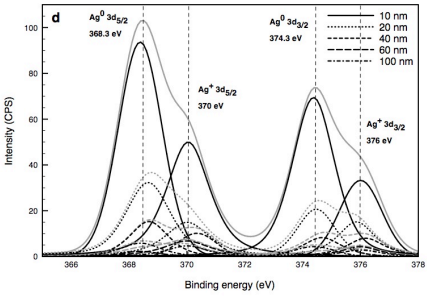

Figure 2: High-resolution deconvoluted XPS spectra of the Ag 3d binding energy region of plasma treated PA66 fibers after 30 days

References

[1] Zille A. et al., ACS Applied Materials & Interfaces, 2015, 7 (25), 13731-13744, DOI: 10.1021/acsami.5b04340