Antimicrobial properties of surgical sutures decorated with PtAu/Pd nanoparticles prepared by sputtering on liquids

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Abstract: colloidal suspensions of nanoparticles were produced by sequentially sputtering PtAu and Pd targets on polyethylene glycol liquid. Commercial suture wires were then immersed in the colloidal suspensions in an attempt to have them decorated with the trimetallic nanoparticles. The biocidal effect of the treated wires was tested against *Staphylococcus aureus and Escherichia coli.*

1. Introduction

Surgical site infection is one of the leading causes of mortality, morbidity, increased antibiotic use, prolonged hospital stays, and higher costs associated with surgical procedures. Among other factors, it can be caused by the material used for sutures. Reports show that incorporating active agents and antibiotics into sutures threads reduces the incidence of post-surgical infection in various types of surgeries [1,2]. An alternative to antibiotics could be nanoparticles (NPs) with antimicrobial action, prepared in colloidal suspensions. Amongst the different techniques available for preparing such suspensions, plasma sputtering onto liquids (SoL) enables the production of pure NPs without the need for reducing agents or stabilizers for creation of monodispersed suspensions. Here, it is explored the potential of suture wires decorated by trimetallic PtAuPd NPs previously obtained by sputtering onto polyethylene glycol (PEG) and their properties regarding the biocidal effect.

2. Methods

A magnetron system was used to prepare colloidal suspensions of trimetallic NPs in PEG. The process involved a two-step deposition: initially sputtering a PtAu target, followed by sputtering a Pd one under conditions of 100 W power, 1 Pa pressure and 5 cm distance. PEG was used as-received and after being activated (T-PEG) in O_2 (2.0 l/min) and He (2.0 l/min) atmospheric plasma (AP) treatment (15 kV, 150 mA, 5.5 kHz, 30 min). Commercial nylon threads were immersed in the colloidal suspensions for 2 hours. To enhance NP adhesion, the threads were pre-treated for 20 min using AP under the same conditions applied for PEG activation. NPs properties were analysed both in colloidal suspension (ultraviolet-visible spectroscopy and wide/small-angle X-ray scattering) and on the suture surfaces (X-ray photoelectron spectroscopy, high-resolution transmission electron microscopy, scanning electron microscopy, and energy-dispersive spectroscopy). Bacterial growth experiments were conducted *in vitro* to evaluate the biocidal effects of the colloidal suspension and decorated suture wires, using both Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria.

3. Results and Discussion

The colloidal suspension produced in PEG and T-PEG contained well-dispersed and separated PtAu and Pd NPs with a diameter of 1–3 nm. Biocidal effect was observed only for T-PEG suspension. Regarding the sutures, surface morphological alterations were observed after the thread activation in AP. NPs were observed to be adhered to the nylon surface. Microbiological results indicated no halo formation around the treated wires and no biofilm presence directly beneath them. The absence of a halo suggests that no harmful compounds or NPs were released from the sutures into the culture. The inhibition of biofilm growth in the area where the culture contacted the thread supports the biocidal effect observed in the colloidal suspension. The decorated threads exhibited a bacteriostatic effect (PEG) and a bactericidal effect (T-PEG) against the Gram-negative bacterium.

4. Conclusion

Colloidal suspensions of PtAu and Pd NPs were successfully prepared in PEG and plasma-treated PEG using SoL. T-PEG suspension exhibited biocidal effects against the Gram-negative bacteria. Immersion of surgical sutures in the colloidal suspensions resulted in NPs decoration without significantly altering their physicochemical properties and imparting a biocidal effect. The best results were achieved with sutures immersed in the T-PEG suspension.

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