Silk fibroin nanofibers containing chondroitin sulfate and silver sulfadiazine for wound healing treatment

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Statement of Purpose: Applying the electrospinning technique for producing nanofibers from polymers with characteristics such as slow biodegradability, excellent mechanical properties, and biocompatibility have shown great potential in the tissue engineering field [1,3]. Here, polymeric nanofibers containing silk fibroin (SF), chondroitin sulfate (CS), and silver sulfadiazine (SSD) were made-up by electrospinning technique and characterized using several techniques. Methods: Poly(ethylene oxide) (PEO) was added to the solution used for electrospinning (SF, CS, and SSD in water, acid medium) to improve electrospinnability due to the low viscosity of SF solution. The materials were characterized through SEM images, FTIR-ATR spectra, EDS mappings, DSC curves and biological analysis. Results: The FTIR-ATR and DSC results showed that PEO was removed from the surface of the nanofibers by washing the as-spun fibers with absolute ethanol. Beyond this, FTIR-ATR and EDS results showed that CS and SSD remained in the nanofibers, without significantly altering their morphology. The quantification of Ag⁺ ions on the nanofibers showed that CS had a major influence on the remaining SSD content. Biological assays showed that the as-obtained nanofibers are not toxic to healthy Vero cells; beyond this, antibacterial activity tests showed that the concentration of CS significantly influenced the antibacterial activity of the samples. In vivo experiments with Wistar rats revealed that SF nanofibers containing CS and SSD had similar results to standard SSD cream treatment, but with the advantage of being applied only once to the patient avoiding discomfort and pain in dressing changes. Thus, CS played an important role as a stabilizing agent of electrospinning solutions to obtain homogeneous nanofibers and with an improved SSD-remaining, consequently, to enhance the antibacterial activity of nanofibers (SEM images in Fig. 1) against gram-positive and gram-negative bacteria through in vitro (histological images of analysis in Fig. 2).

Figure 1: SEM images of SF / PEO / CS / SSD nanofibers obtained at different concentrations before (left) and after (right) PEO removal with absolute ethanol.

Figure 2: Histological analysis of skin of Wistar rats after 5 days of the treatment. (A) G1 group: uninfected and untreated. (B) G2 group: infected with S. aureus and untreated. (C) G3 group: infected with P. aeruginosa and untreated. (D) G4 group: infected with S. aureus and treated with SSD cream. (E) G5 group: infected with P. aeruginosa and treated with SSD cream. (F) G6 group: infected with S. aureus and treated with nanofibers from SF. (G) G7 group: infected with P. aeruginosa and treated with nanofibers from SF. (H) G8 group: infected with S. aureus and treated SF nanofibers containing CS and SSD. (I) G9 group: infected with P. aeruginosa and treated SF nanofibers containing CS and SSD. Conclusions: Nanofibers containing SF, CS, and SSD were obtained by electrospinning. The production of nanofibers from these components intended to develop a new dressing [that has antibacterial activity and at the same time good characteristics for skin regeneration] to treat burns and skin wounds. In vivo experiments indicated that SF nanofibers composed by CS and SSD presented results similar to standard SSD cream treatment, but with the advantage of being applied only once to the patient avoiding discomfort and pain in dressing change and reaplication of treatment as occurs with SSD cream. The material produced in this work presents a great capability to be applied as a scaffold to cell growth allied to drug delivery to assist wound damaged tissues, mainly occasioned by burning.

References: