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Polymer Nanocomposite Containing Silver Nanoparticles for Wound Healing

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Abstract : Hydrogels produced with polymers have been used in the development of dressings for wound treatment and tissue revitalization. Our study on polymer nanocomposites containing silver nanoparticles shows antimicrobial activity and applications in wound healing. The effects are linked with the slow oxidation and Ag^{+} liberation to the biological environment. Furthermore, bacterial cell membrane penetration and metabolic disruption through cell cycle disarrangement also contribute to microbial cell death. The silver antimicrobial activity has been known for many years, and previous reports show that low silver concentrations are safe for human use. This work aims to develop a hydrogel using natural polymers (sodium alginate and gelatin) combined with silver nanoparticles for wound healing and with antimicrobial properties in cutaneous lesions. The hydrogel development utilized different sodium alginate and gelatin proportions (20:80, 50:50 and 80:20). The silver nanoparticles incorporation was evaluated at the concentrations of 1.0, 2.0 and 4.0 mM. The physico-chemical properties of the formulation were evaluated using ultraviolet-visible (UV-Vis) absorption spectroscopy, Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC), and thermogravimetric (TG) analysis. The morphological characterization was made using transmission electron microscopy (TEM). Human fibroblast (L2929) viability assay was performed with a minimum inhibitory concentration (MIC) assessment as well as an in vivo cicatrizant test. The results suggested that sodium alginate and gelatin in the (80:20) proportion with 4 mM of $AgNO_3$ in the (UV-Vis) exhibited a better hydrogel formulation. The nanoparticle absorption spectra of this analysis showed a maximum band around 430 - 450 nm, which suggests a spheroidal form. The TG curve exhibited two weight loss events. DSC indicated one endothermic peak at 230-250 °C, due to sample fusion. The polymers acted as stabilizers of a nanoparticle, defining their size and shape. Human fibroblast viability assay L929 gave 105 % cell viability with a negative control, while gelatin presented 96% viability, alginate: gelatin (80:20) 96.66 %, and alginate 100.33 % viability. The sodium alginate:gelatin (80:20) exhibited significant antimicrobial activity, with minimal bacterial growth at a ratio of 1.06 $mg.mL^{-1}$ in Pseudomonas aeruginosa and 0.53 $mg.mL^{-1}$ in Staphylococcus aureus. The in vivo results showed a significant reduction in wound surface area. On the seventh day, the hydrogel-nanoparticle formulation reduced the total area of injury by 81.14 %, while control reached a 45.66 % reduction. The results suggest that silver-hydrogel nanoformulation exhibits potential for wound dressing therapeutics.

Keywords : nanocomposite, wound healing, hydrogel, silver nanoparticle
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