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Hyaluronic acid/ Spider silk based antimicrobial hydrogels for biomedical applications

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Hydrogels are advanced hydrophilic polymeric networks that can uptake considerable amounts of fluid compared to their dry weight. The involvement of hydrogels is extensively expanded in diverse industries due to their remarkable physical, chemical, and biological properties.[1] Hydrogel characteristics and properties mainly depend on their polymeric components, crosslinking methodology, and synthesis process. According to polymer and synthetic researchers, natural polymer-based hydrogels are promising materials for different applications since their natural origin and natural decomposition.[2] Besides, the biocompatibility, biodegradability, and low immunogenicity of natural polymer-based hydrogels allow the applicability in a wide range of biomedical applications. Hyaluronic acid is a glycosaminoglycan commonly found in epithelial and neural tissues as a component in the extracellular matrix.[3] Spider silk is one of the best biopolymers with extraordinary biological properties yet to be discovered.[5] Initially, the hyaluronic acid/ spider silk-based hydrogels were prepared using EDC (1-ethyl-3-(3-dimethyl aminopropyl) carbodiimide (EDC)/N-hydroxysuccinimide (NHS) mediated chemical crosslinking method. Silk solution was prepared by dissolving separated spider silk fibers in Trifluoroacetic acid before performing dialysis leading to obtaining spider silk protein-water solution. General characterization of the hydrogels was performed using Scanning Electron Microscopic (SEM) imaging, Fourier-transform infrared spectroscopy (FTIR), and contact angle measurements. Scanning Electron Microscopic (SEM) imaging confirmed the success of the crosslinking process of hyaluronic acid and spider silk proteins with the confirmation of the hydrogel's fibrilar structure. The exact compositions of the hydrogels were assured by Fourier-transform infrared spectroscopy (FTIR), while the contact angle measurements present unique hydrophilic properties of hydrogels. Further characterizations of the hydrogels were executed with the observations of swelling degree of hydrogels, shrinking ability of hydrogels in physiological conditions, the conductivity of hydrogels, the viscosity of hydrogels, and enzymatic degradability of hydrogels. Excellent swelling abilities and the optimum shrinking abilities of the hydrogels demonstrate more favorable potentials to be applied in drug loading and drug release studies. The conductivity of the hydrogels revealed the dielectric properties of the hydrogels to be applied in electrophoretic drug delivery systems. The shear-thinning viscosity of the hydrogels indicates the applicability of hydrogels as a material for 3D printing. Trypsin and Chymosine degradability studies present that hydrogels are partially degradable in different enzymes in variable degradability efficacy. Considering the observations of Hyaluronic acid/ Spider silk-based hydrogels' baseline characterizations, the drug uptake and drug delivery studies were performed with the anti-inflammatory drug Ibuprofen. The drug loading capacity of the hydrogels is optimum to use as an anti-inflammatory drug carrier for local (external) use with the superlative drug entrapment efficiency. Moreover, the hydrogels exhibit a magnificent drug (Ibuprofen) release rate, which exceeds 80% of the accumulated drug within the hydrogels. Furthermore, hyaluronic acid/ spider silk hydrogels show tremendous anti-microbial properties on both gram-positive (Micrococcus sulfuricum) and gram-negative (Escherichia coli) bacteria.

Hyaluronic acid predominantly contributes to the anti-microbial properties due to its concentration-dependent bacteriostatic inhibitory effects.[4] Besides, Spider silk assists with the slight properties of concentration-dependent anti-adhesion of bacteria. Human Postnatal Fibroblast (HPF) cells were cultivated on the surface of hydrogels over 72 hours of duration. The hydrogels do not show drastic toxic effects on Human Postnatal Fibroblast (HPF) cells, confirming the applicability of hydrogels in skin contact applications (external use). In conclusion, hyaluronic acid/ spider silk-based hydrogels can be involved in multiple aspects of biomedical applications. Predominantly, the hydrogels can be applied as an anti-inflammatory drug delivery material with collaborated antibacterial and bacterial inhibition properties for external use. Thus, the hydrogels can be used as wound dressing material together with anti-microbial and anti-inflammatory properties. In addition, the hyaluronic acid spider silk-based hydrogels can be used as a material for 3D printing of anti-microbial constructs such as anti-microbial surgical meshes.

References

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