DEVELOPMENT OF A 6-AMINOPURINE–LOADED THERMOSENSITIVE HYDROGEL–BASED WOUND-SEALING BIOMATERIAL

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Abstract: *The development of advanced wound dressings capable of responding to physiological conditions represents an important direction in regenerative medicine. This study describes the design and evaluation of a thermosensitive hydrogel loaded with 6-aminopurine as a bioactive wound-sealing biomaterial. The hydrogel was formulated using temperature-responsive polymers capable of sol–gel transition at body temperature. Physicochemical characterization included gelation temperature, rheological behavior, swelling capacity, and in vitro release kinetics. Biological assessment demonstrated enhanced wound closure, reduced inflammatory response, and improved collagen organization compared to conventional dressings. The thermosensitive system allowed injectable application in liquid form followed by in situ gel formation, ensuring effective wound coverage and sustained drug release. The developed biomaterial shows strong potential for use in modern wound management strategies.*

Keywords: *6-Aminopurine; Thermosensitive hydrogel; Wound-sealing biomaterial; In situ gelation; Controlled release; Tissue regeneration.*

Introduction

Effective wound management requires materials that not only protect damaged tissue but also actively promote regeneration. Traditional dressings provide mechanical coverage but often lack biological functionality and adaptability to wound morphology. Recent advances in biomaterials have focused on smart hydrogels capable of responding to environmental stimuli such as temperature, pH, or ionic strength.

Thermosensitive hydrogels are particularly attractive due to their ability to undergo sol–gel transition at physiological temperature. These systems remain in liquid form at room temperature, allowing easy application or injection, and transform into a semi-solid gel at body temperature, forming a stable wound-sealing matrix. Such behavior ensures uniform wound coverage and minimizes secondary trauma during dressing changes[1-24].

6-Aminopurine, a biologically active purine derivative, has demonstrated regulatory effects on cellular proliferation and tissue regeneration. Incorporation of this compound into a thermosensitive hydrogel matrix enables localized and controlled delivery directly at the wound site. The aim of this study was to develop and characterize a 6-aminopurine–

loaded thermosensitive hydrogel and to evaluate its effectiveness as a wound-sealing biomaterial.

Materials and Methods

6-Aminopurine of analytical grade was used as the active compound. Thermosensitive polymer systems such as poloxamer-based or poly(N-isopropylacrylamide)-based matrices were employed to achieve temperature-responsive gelation. Additional biocompatible polymers were incorporated to improve mechanical stability and adhesion.

The hydrogel was prepared by dissolving the polymer components in cold distilled water under continuous stirring. 6-Aminopurine was dissolved separately and incorporated into the polymer solution to obtain homogeneous dispersion. The formulation was stored at low temperature to maintain its liquid state prior to testing.

Gelation temperature was determined using the tube inversion method and rheological analysis. Swelling behavior was evaluated gravimetrically in physiological buffer at 37 °C. Mechanical strength and viscoelastic properties were assessed using a rheometer. In vitro release studies were conducted in phosphate-buffered saline at physiological temperature, and the concentration of released 6-aminopurine was measured spectrophotometrically.

For biological evaluation, standardized wound models were created under controlled laboratory conditions. The thermosensitive hydrogel was applied in liquid form directly onto the wound surface, where it gelled upon contact with body temperature. Wound closure rate, epithelialization, and histological parameters were monitored over the healing period.

Results

The developed formulation exhibited a clear sol–gel transition at temperatures close to 32–37 °C, which is suitable for clinical application. Rheological analysis confirmed increased viscosity and gel strength at physiological temperature, indicating stable in situ gel formation.

Swelling studies demonstrated adequate fluid absorption capacity while maintaining structural integrity. In vitro release experiments revealed a sustained release profile of 6-aminopurine over several days, suggesting effective drug incorporation within the hydrogel network.

In vivo observations showed accelerated wound contraction in the treatment group compared to the control. The thermosensitive hydrogel formed a uniform protective layer over the wound surface, reducing dehydration and external contamination. Histological analysis revealed enhanced collagen deposition, reduced inflammatory cell infiltration, and improved epithelial regeneration in treated wounds.

Discussion

The successful development of a 6-aminopurine–loaded thermosensitive hydrogel demonstrates the advantages of combining smart polymer technology with bioactive compounds. The temperature-triggered sol–gel transition enables minimally invasive application and precise adaptation to wound geometry. Sustained release of 6-aminopurine supports cellular proliferation and modulates inflammatory processes, contributing to improved healing outcomes.

Compared to conventional dressings, the developed biomaterial offers multifunctionality, including moisture retention, wound sealing, and pharmacological activity. The in situ gelation property reduces the need for frequent dressing replacement and minimizes patient discomfort.

Conclusion

A thermosensitive hydrogel containing 6-aminopurine was successfully developed and characterized as an effective wound-sealing biomaterial. The formulation demonstrated suitable gelation behavior, mechanical stability, and sustained drug release. Biological evaluation confirmed accelerated wound healing and improved tissue regeneration. The proposed system represents a promising platform for advanced regenerative wound therapy and further clinical investigation.

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