Biomimetic Scaffold Using Graphene Quantum Dots-Hybrid Hydrogel for Diabetic Wound Healing

Introduction

To address diabetic wound healing challenges, we developed a biomimetic scaffold for wound healing with minimal inflammation using graphene quantum dot (GQD)-polyacrylic acid (PAA) hybrid hydrogel, leveraging unique properties of GQDs and the versatility of PAA.

Methods

The GQD-PAA hybrid hydrogel was synthesized via aqueous homopolymerization of acrylic acid using APS and TEMED as accelerator and initiator. Comprehensive characterization techniques, cytotoxicity assays, wound healing rates in diabetic rats along with an assessment of inflammatory cytokines were performed to analyse the structure, biocompatibility and wound-healing process.

Results

The average pore size of the hybrid hydrogel after swelling was about 120 μm. The incorporation of GQDs led to a strong interaction with the inherent functional groups of the hydrogel. It facilitated the preferential stacking and rolling of GQD sheets during polymerization. Cytotoxic studies demonstrated cell viabilities of over 95%, indicating high biocompatibility and complete wound healing on the 13^{th} day in diabetic wounds treated with 0.05–0.1% GQD-PAA hybrid hydrogel, indicative of expedited rate of reepithelialization and accelerated wound healing process. Moreover, the expression of IL-10 (around 210 pg/ml) was highest in 0.05% and 0.1% GQD-PAA hydrogel composites, further supporting their role in promoting a favorable wound healing environment.

Conclusions

Incorporating 0-D GQD into PAA hydrogel for a biomimetic scaffold enhances diabetic wound healing in rat models resulting in complete diabetic wound closure by day 13, accompanied by favorable pro- and anti-inflammatory responses. The GQD-PAA hybrid hydrogel emerges as a promising band-aid by promoting expedited angiogenesis and maintaining a moist environment.