

Fabrication of Diabetic wound healing patch using bioactive silicate / GO composite.

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ABSTRACT

Background: Effective wound dressings should promote tissue regeneration while preventing infection. This study aimed to fabricate and evaluate a bioactive silicate/graphene oxide (SI-GO) composite wound healing patch.

Materials and Methods: The SI-GO composite was prepared by combining bioactive silicate and graphene oxide, followed by stirring, sonication, freezing, and freeze-drying to obtain a porous scaffold. The patch was evaluated for cytocompatibility, antibacterial activity, and surface morphology using cell viability assay, agar diffusion method, and scanning electron microscopy (SEM).

Results: The SI-GO composite showed good cytocompatibility (80–85% cell viability), effective antibacterial activity, and favorable cell attachment. SEM revealed a highly porous, interconnected structure suitable for cell adhesion, nutrient transport, and wound healing. Graphene oxide improved the scaffold's structural integrity and bioactivity.

Conclusion: The SI-GO composite demonstrated promising biocompatibility, antibacterial properties, and porous architecture, indicating its potential as an advanced wound healing biomaterial. Further in vivo studies are recommended..

AIM: Aim of the study is fabrication of wound healing patch using bioactive silicate/GO composite.

Keywords: Bioactive silicate; Graphene oxide; Wound healing patch; Tissue regeneration; Antibacterial activity..

INTRODUCTION

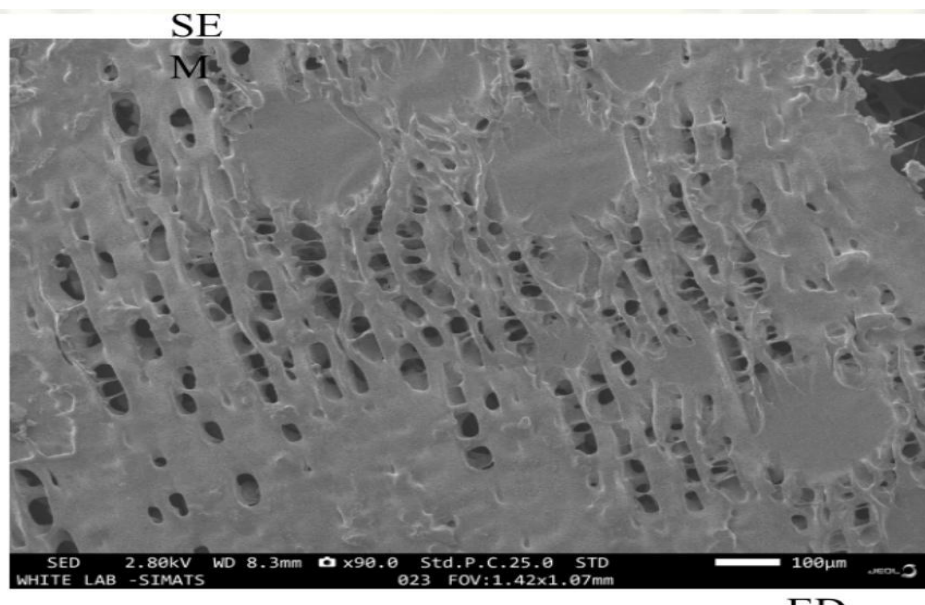
The challenge for treatment of severe cutaneous wounds poses an urgent clinical need for the development of biomaterials to promote skin regeneration. The fabrication of a wound healing patch using bioactive silicate/GO (Graphene Oxide) composite involves combining bioactive silicate, a material known for its tissue regeneration properties, with graphene oxide, which can enhance mechanical strength and bioactivity. (1) Bioactive silicate materials, such as bioactive glasses or silicate-based ceramics, possess properties that stimulate tissue regeneration, promote cell adhesion, and release bioactive ions (like silicon and calcium) crucial for bone and tissue repair. Incorporating bioactive silicates into the composite provides a biocompatible scaffold that aids in cellular growth and tissue regeneration. Utilising the composite material to form a patch or scaffold structure suitable for wound healing applications. (2) This could involve techniques such as solvent casting, freeze-drying, electrospinning, or other methodologies to create the desired patch shape and dimensions. In the past few decades, introduction of inorganic components into the material system has become a promising strategy for improving performances of biomaterials in the process of tissue repair. (3) Bioactive glasses are traditionally associated with bonding to bone through a hydroxycarbonate apatite (HCA) surface layer but the release of active ions is more important for bone regeneration. They are now being used to deliver ions for soft tissue applications, particularly wound healing..

MATERIALS AND METHODS

The bioactive silicate/graphene oxide (GO) composite was prepared by dispersing 1 mg of bioactive silicate in deionized water, followed by the addition of 2 mg of GO. The mixture was stirred for 2 h and sonicated for 30 min to obtain a homogeneous suspension. The suspension was then frozen at –80°C for 12 h and freeze-dried to obtain a porous bioactive silicate/GO composite, which was subsequently used for the fabrication of the wound healing patch....

RESULTS:

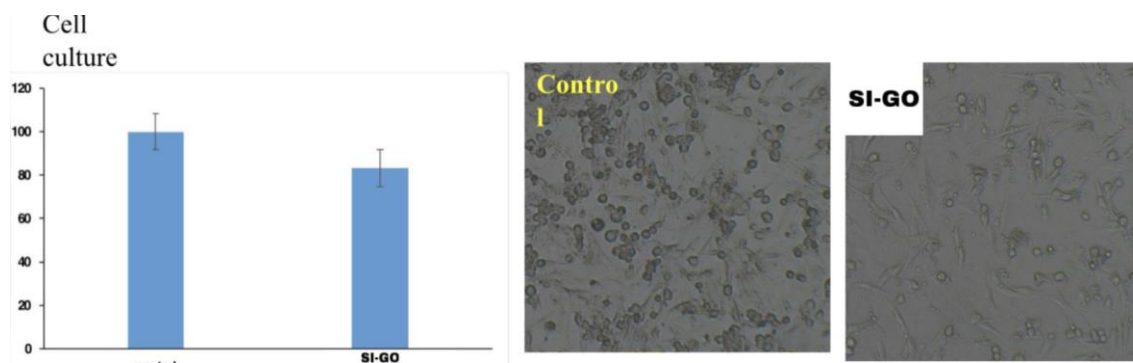
The bioactive silicate/graphene oxide (SI-GO) composite wound healing patch was successfully fabricated and characterized by cell culture, antibacterial, and morphological analyses. The cell viability assay demonstrated good cytocompatibility of the SI-GO composite, with approximately 80–85% cell viability compared to the control group (~100%), indicating that the composite supported cellular attachment and proliferation without significant cytotoxic effects. Microscopic observations further confirmed the presence of viable and well-spread cells on the SI-GO surface, suggesting a favorable environment for tissue regeneration. Antibacterial evaluation using the agar diffusion method showed a distinct inhibition zone around the SI-GO patch, demonstrating effective antibacterial activity against microbial growth. SEM analysis revealed a porous and interconnected surface morphology with uniformly distributed pores and rough microstructures, which are beneficial for cell adhesion, nutrient transport, and wound exudate absorption. The incorporation of graphene oxide within the bioactive silicate matrix enhanced the structural integrity and bioactivity of the scaffold. Overall, these findings indicate that the fabricated SI-GO composite patch possesses desirable biocompatibility, antibacterial properties, and surface characteristics, making it a promising candidate for wound healing applications.



Cell viability and morphological evaluation of the bioactive silicate/graphene oxide (SI-GO) composite.



Antibacterial activity of the bioactive silicate/graphene oxide (SI-GO) wound healing patch.



SEM micrograph of the fabricated bioactive silicate/graphene oxide (SI-GO) composite wound healing patch

DISCUSSION:

Recent studies have demonstrated that silicate bioceramics and bioglasses are one type of promising materials for the development of wound dressings, as they can actively accelerate wound healing by regulating endothelial cells, macrophages, and epidermal cells.(4) In particular, silicate-based biomaterials can be further functionalized by specific structural design or doping with functional components. In another study composite fibres containing new bioactive glass compositions delivered cobalt ions at a sustained rate, which could be mediated by the magnesium content of the glass(2). The dissolution products stabilised HIF-1 α and provoked a significantly higher expression of VEGF, suggesting the composites activated the HIF pathway to stimulate angiogenesis.

The present study successfully fabricated a bioactive silicate/graphene oxide (SI-GO) composite wound healing patch and demonstrated its potential for wound management through favorable biocompatibility, antibacterial activity, and structural characteristics. The combination of bioactive silicate and graphene oxide was designed to exploit the regenerative properties of silicate-based biomaterials and the unique physicochemical properties of graphene oxide, thereby creating a multifunctional wound dressing.

The cell viability results indicated that the SI-GO composite maintained approximately 80–85% viability compared with the control group, suggesting good cytocompatibility. According to ISO 10993-5 standards, cell viability above 70% is generally considered non-cytotoxic. The observed cellular response may be attributed to the release of bioactive silicon ions, which have been reported to stimulate cell proliferation, angiogenesis, and extracellular matrix formation during tissue repair (Hench, 2006). Similar findings were reported by Jones (2013)(5), who demonstrated that bioactive silicate-based materials promote cellular attachment and tissue regeneration through ionic dissolution products.

Microscopic observations further confirmed the attachment and spreading of cells on the SI-GO composite surface. The rough and porous architecture observed through SEM analysis likely contributed to enhanced cell-material interactions. Previous studies have shown that porous scaffolds provide a favorable microenvironment for cell migration, nutrient diffusion, and tissue ingrowth, all of which are essential for effective wound healing (Liu et al., 2017). Furthermore, graphene oxide has been reported to improve cell adhesion due to its high surface area and abundance of oxygen-containing functional groups (Bitounis et al., 2013).(6)

The antibacterial assay demonstrated a visible inhibition zone surrounding the SI-GO composite, indicating effective antimicrobial activity against the tested microorganism. This finding is consistent with previous reports describing the antibacterial properties of graphene oxide. The sharp edges and oxidative stress-inducing characteristics of graphene oxide can disrupt bacterial cell membranes, resulting in reduced microbial viability (7). Additionally, graphene-based materials have been shown to inhibit bacterial adhesion and biofilm formation, making them attractive candidates for wound dressing applications (7,8). The incorporation of bioactive silicate may further enhance antibacterial performance through local ionic effects and environmental changes that are unfavorable for bacterial growth.

SEM analysis revealed an interconnected porous network within the SI-GO composite. Such morphology is particularly advantageous for wound dressings because it facilitates oxygen transport, moisture retention, and absorption of wound exudates while providing sufficient mechanical support for tissue regeneration. Similar porous structures have been reported to accelerate wound closure and improve tissue remodeling in chronic wound environments (9).

Overall, the results demonstrate that the synergistic combination of bioactive silicate and graphene oxide produces a multifunctional wound healing patch with desirable biological and antibacterial properties. The observed cytocompatibility, antimicrobial activity, and porous morphology suggest that the fabricated SI-GO composite could serve as a promising biomaterial for advanced wound care applications. Future studies should focus on in vivo wound healing assessment, mechanical characterization, and long-term biocompatibility evaluation to further establish its clinical potential.

CONCLUSION:

The bioactive silicate/graphene oxide (SI-GO) composite wound healing patch was successfully fabricated and demonstrated favorable properties for wound care applications. The composite exhibited good biocompatibility, effective antibacterial activity, and a porous surface morphology that supports cell attachment and tissue regeneration. These findings suggest that the SI-GO patch has significant potential as an advanced wound dressing material, warranting further investigation through in vivo studies to evaluate its wound healing efficacy.

Future scope: Future studies should focus on tensile strength of the patch, in vivo wound healing evaluation, long-term biocompatibility, and mechanical property assessment of the bioactive silicate/graphene oxide (SI-GO) patch. Additionally, incorporating therapeutic agents such as antibiotics or growth factors may further enhance its effectiveness for advanced wound care applications....

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