Synthesis of Functional Silk Fibroin/Chitosan Composite Hydrogel for Wound Healing

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INTRODUCTION & AIM

Biomaterials have emerged as a key component of modern regenerative medicine and are increasingly utilized in the development of advanced therapeutic technologies. Thus, wound healing research has been conducted extensively to develop new biomaterials, aiming to produce functional biomaterials that can provide multiple beneficial functions at the wound site. Among natural and synthetic materials, silk fibroin (a natural protein polymer) and chitosan (a natural polysaccharide polymer) have attracted considerable attention due to their effective properties of being biocompatible, biodegradable, and having injury healing properties.

Hydrogels are high-molecular-weight three-dimensional (3D) hydrophilic porous crosslinked network-based insoluble polymers, which can mimic some features of the extracellular matrix (ECM) in biological systems. Owing to these properties, hydrogels became an attractive material for wound healing applications. Moreover, dressing-based hydrogels provide a moist environment for wounds. Moist wound dressings are reported to enhance wound healing effectively compared with dry wound dressings.

Aims:

a) To produce a functional porous scaffold-based hydrogel for wound healing application.

b) To extract an aqueous solution of silk fibroin using Ajisawa's method and mix it with a solution of commercial chitosan to produce the target composite scaffold hydrogel.

d) To characterize chemical, swelling, and porosity properties of composite scaffold hydrogels.

METHOD

Porous SF-CS Scaffold Hydrogels Production via a Combined Method Involving Cyclic Freeze–Thawing and Freeze-Gelation Using NaOH.

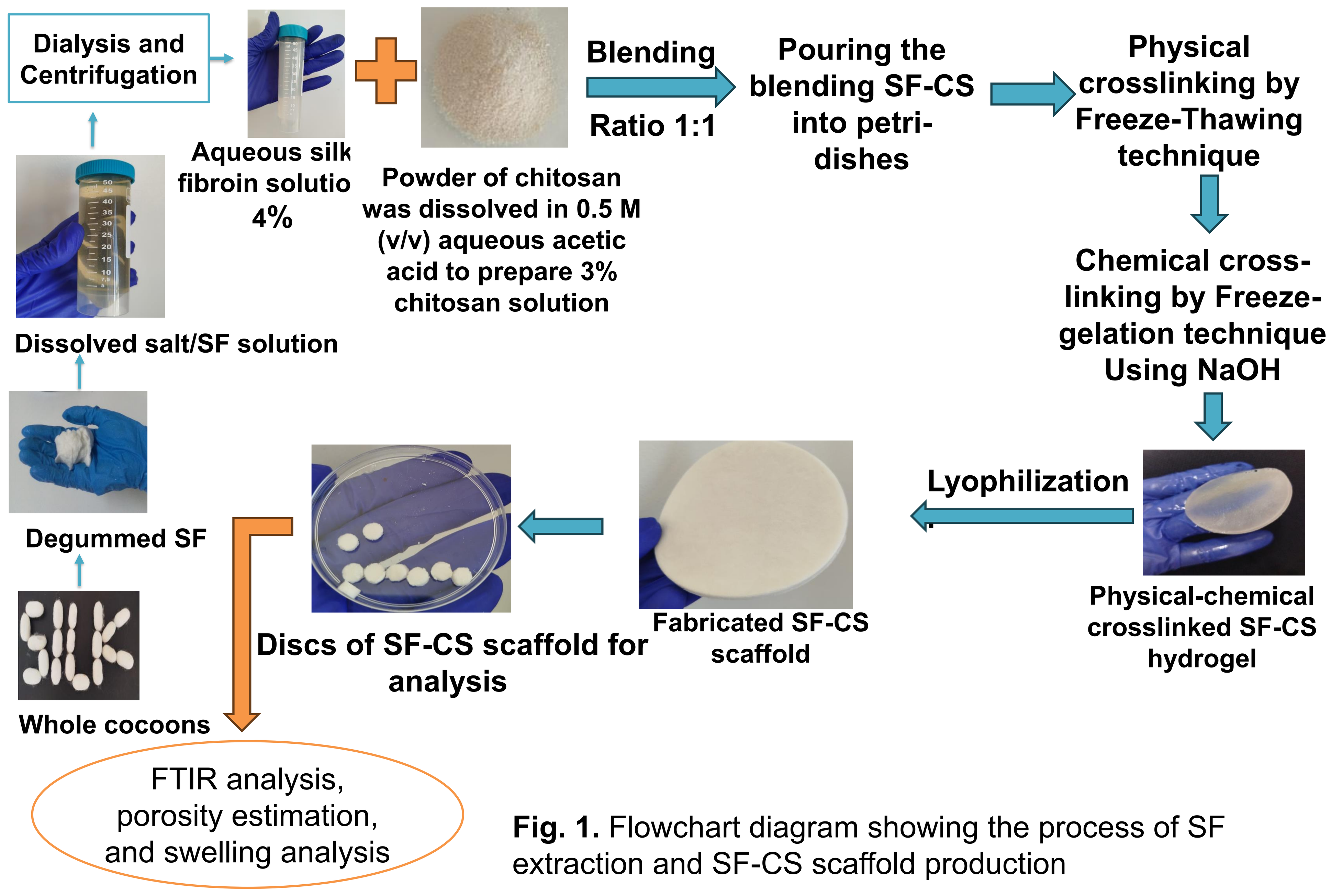

Fig. 1. Flowchart diagram showing the process of SF extraction and SF-CS scaffold production

RESULTS & DISCUSSION

Sample Codes: SF: Silk Fibroin, CS: Chitosan, and SF-CS: Silk Fibroin-Chitosan composite

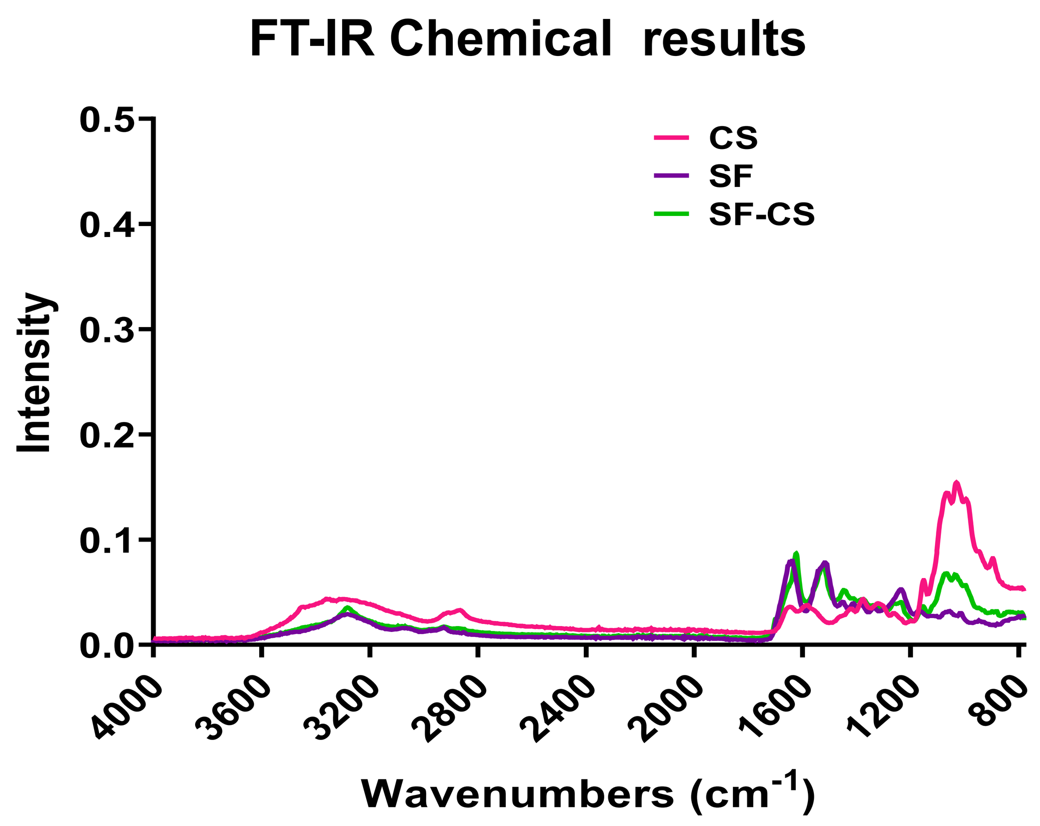

Fig. 2. ATR-FTR spectra of pure SF, pure CS, and fabricated SF-CS scaffold. FTIR analysis revealed that the band of SF with peaks at 1637 cm^{-1} (amide I) and 1515 cm^{-1} (amide II) remained the same in the synthesized composite hydrogel. However, a band of the synthesized SF-CS composite at 1445 cm^{-1} has appeared, confirming N-H bending. The peak of silk fibroin at 1234 cm^{-1} indicates that β-sheet structure (silk I) is shifted to a lower wave number, which suggests that the crosslinking process led to the conformation of silk I into silk II, the secondary structure. Meanwhile, the band of chitosan at 1028 cm^{-1} became lower in the fabricated composite. This confirms that the amino group (NH_2) of CS is included in the crosslinking reaction.

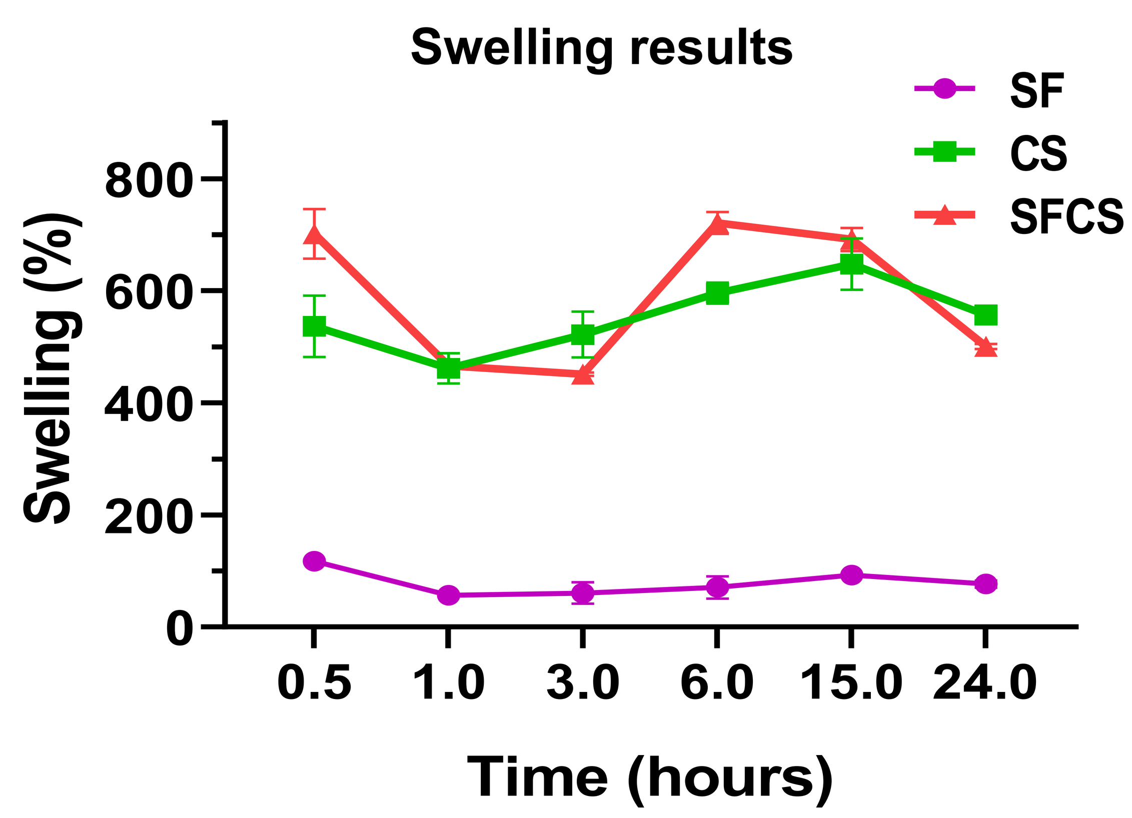

Fig. 3. The fluid uptake evaluation was conducted in PBS for 24 hours, and it confirmed that the synthesized composite hydrogel had a high capacity of solvent uptake, which was stabilized after 6h. This It is suggested that the ability of this composite to swell would allow the composite to absorb the wound exudate, which is an important property for modern wound dressings.

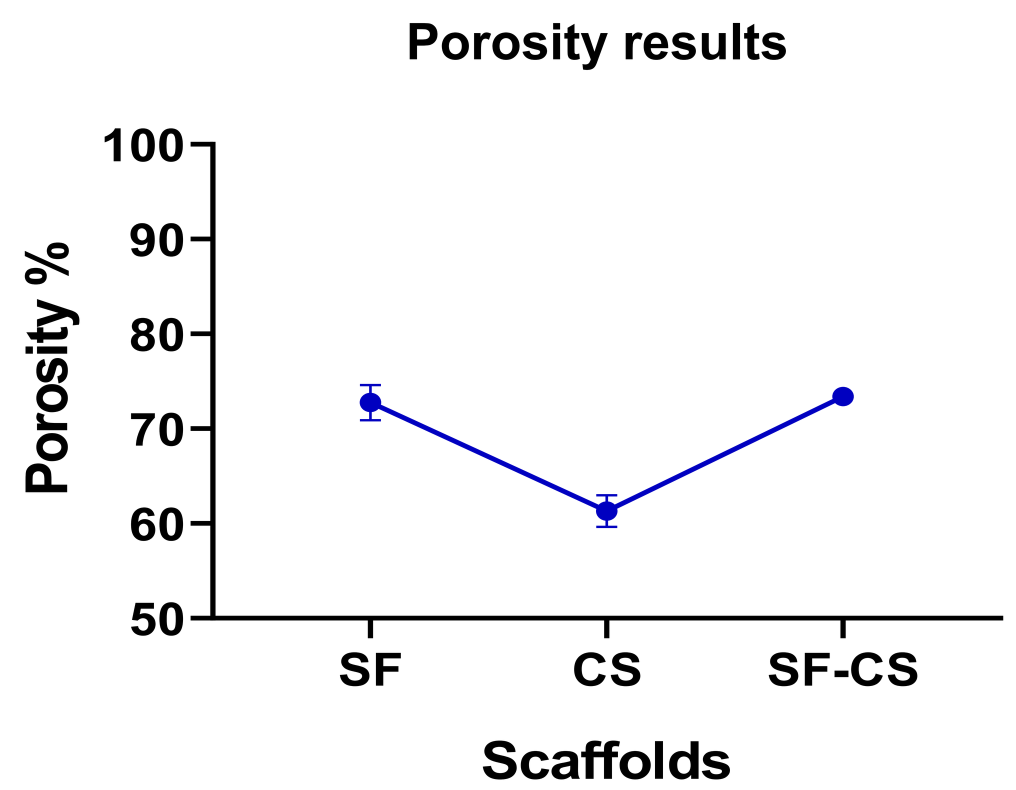

Fig. 4. Porosity evaluation showed that the synthesized composite hydrogel has 65-80% porosity. This aligns with Nosrati *et al.* (2020) that reported a scaffold-based hydrogels with porosity of 60-95% is most suitable for wound healing applications.

CONCLUSIONS

The synthesized functional composite-based hydrogel prepared using the combined method showed a porous structure and a high degree of swelling, indicating that it is a promising biomaterial with integrated drug delivery systems to prevent microbial infection, as well as optimizing epithelialization and pro-angiogenic activity during the wound healing process.

FUTURE WORK

Cytotoxicity assessment of the hydrogel scaffold will be conducted, and positive outcomes will be followed by cell proliferation and cell migration evaluations to investigate the behaviours of scaffold hydrogels with dermal fibroblast cells. Other characterisation analyses will also be performed, including SEM examination and biodegradation studies. In addition, antibiotics will be loaded into the scaffold, and their release will be analysed. Antimicrobial assays will be carried out to evaluate antibacterial activity. Moreover, a CAM assay with histological analysis will be conducted to investigate the ability of the composite to enhance vascularisation.

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