Core-shell PRP and Ag-nanoparticles airbrushing nanofiber patch with sustained release of growth factor and long-lasting antibacterial properties promotes second-degree burn wound healing

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Introduction

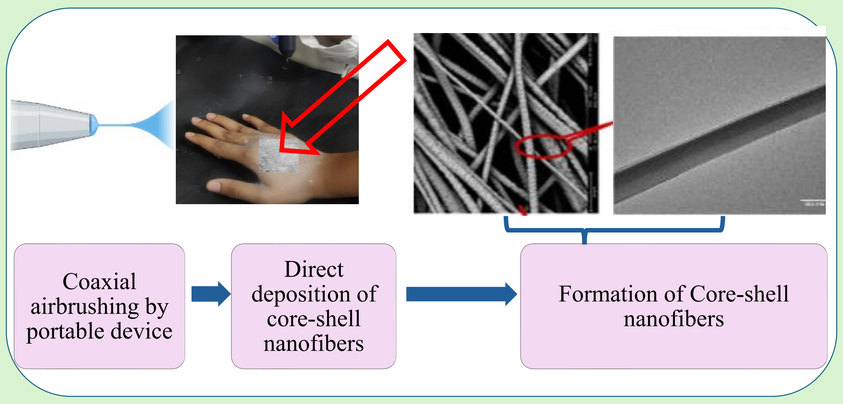
Burn injuries pose a significant global health challenge, causing about 300,000 deaths and affecting over six million people annually. Conventional silver sulfadiazine (SSD) treatments, which involve repeated dressing, offer limited antibacterial activity and regeneration of burn tissue.

Aim & Objective

This study develops a dual-functional nanofiber patch integrating silver nanoparticles (AgNPs) and platelet-rich plasma (PRP) for sustained growth factor release, prolonged antimicrobial action, and enhanced tissue regeneration through an ECM-mimicking nanofibrous scaffold.

- **Objective 1** Development of airbrushed nanofiber patch for burn wound dressing
- **Objective 2** Development of airbrushed advanced Nanofiber patch with antibiotics and bioactive molecules
- **Objective 3** In vitro evaluation of advanced nanofiber patch
- **Objective 4** In vivo validation advance nanofiber patch for burn wound healing efficacy

Material & Methods



Results

1. Size distribution of optimized nanofibers

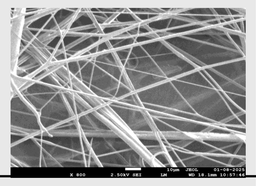
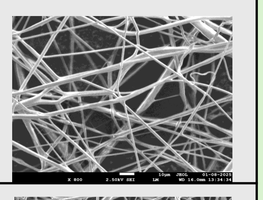
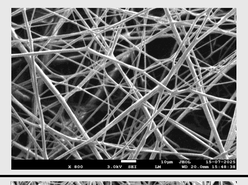
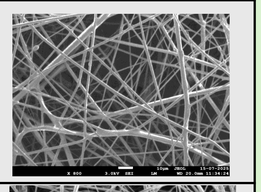
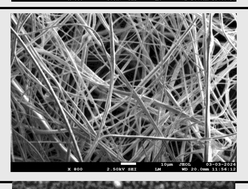
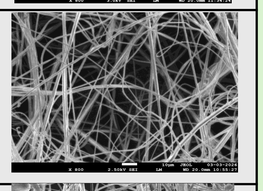
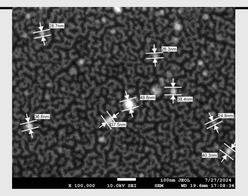
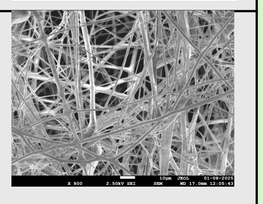
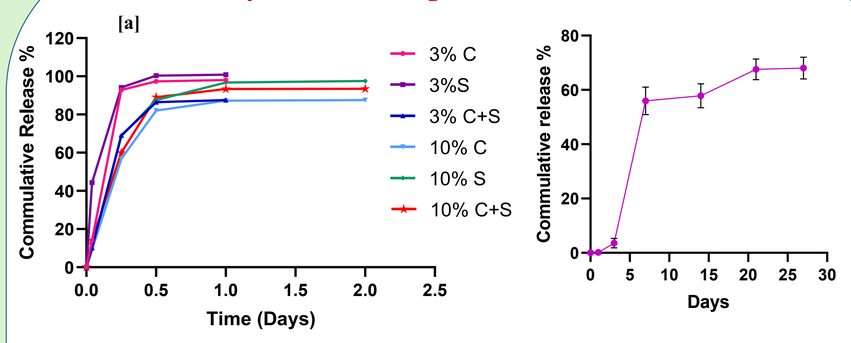
Formulations	SEM Images	Formulations	SEM Images
NF+3% SSD		NF+10% SSD	
NF+5% AgNPs		NF+10% AgNPs	
NF+ 5 PRP		NF+31 PRP	
AgNPs		NF+PRP +5%AgNPs	

Figure 1. Different optimized formulations with different concentrations of AgNPs, SSD and PRP. The average diameter of nanofibers (NF): 5% AgNPs and SSD shows 300-500nm, 10% AgNPs and SSD shows broad range of size distribution 400-800nm, AgNPs and NF+AgNPs+PRP shows 25nm-50nm and 500nm-700nm.

2. Release study of SSD and AgNPs



3. Antibacterial study of release samples of SSD and AgNPs

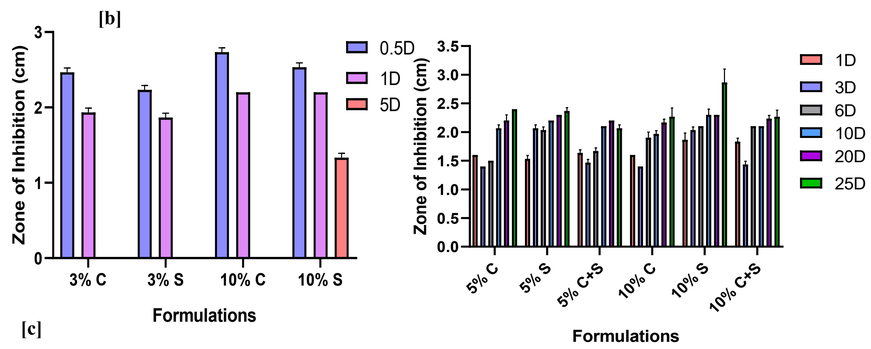


Figure 2, 3. [2a] Commulative release% of SSD and AgNPs through HPLC and ICP, [3b] Zone of inhibition release profile of SSD and AgNPs-encapsulated into core-shell nanofiber. [3c] Zone of inhibition of 5%w/w AgNPs-encapsulated into shell of nanofiber placed on the E.coli lawn. [2a], [3b,c] The SSD encapsulated nanofibers shows burst release while AgNPs nanofibers shows sustain release till day 30.

4. Release study of PRP and VEGF growth factor

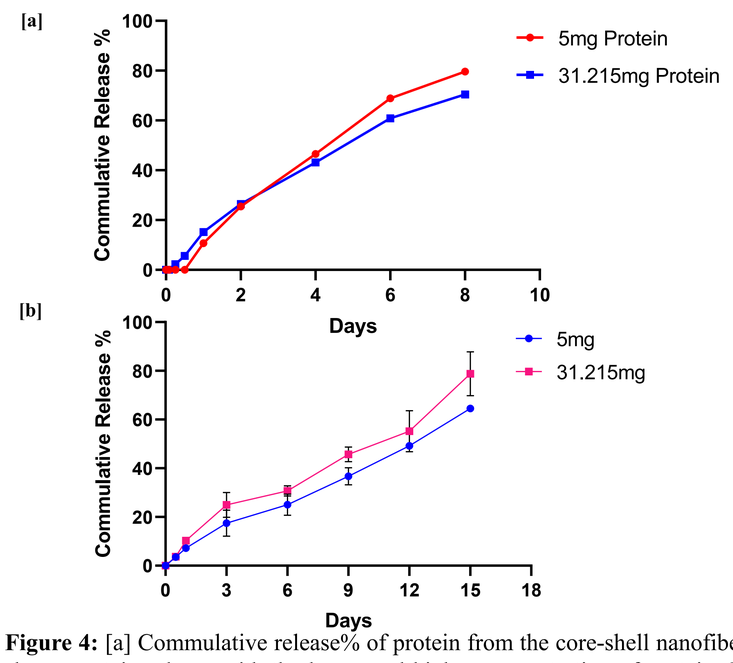


Figure 4: [a] Commulative release% of protein from the core-shell nanofibers shows sustain release with the lower and higher concentration of protein; [b] VEGF estimation from the PRP-encapsulated nanofibers shows sustain release of growth factor till day 15.

5. In-vitro study on HDF cells: Live dead assay

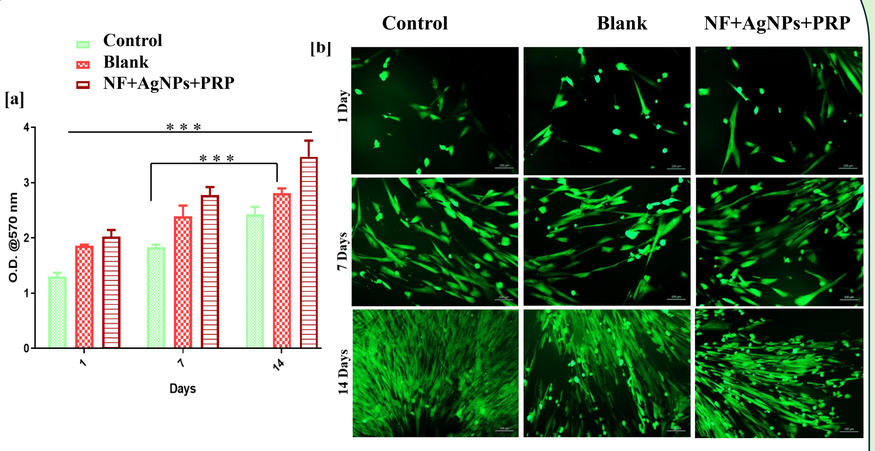


Figure 5. [a] Alamar blue result of HDFCs cell proliferation on core-shell nanofiber scaffold for 14 days; [b] Fluorescence imaging of HDFCs cultured up to 14 days on core-shell nanofibers. Results indicate that the cells seeded on the nanofibers mat showed higher proliferation than the control and it amplified significantly from day 1 to day 14.

6. Cell morphology

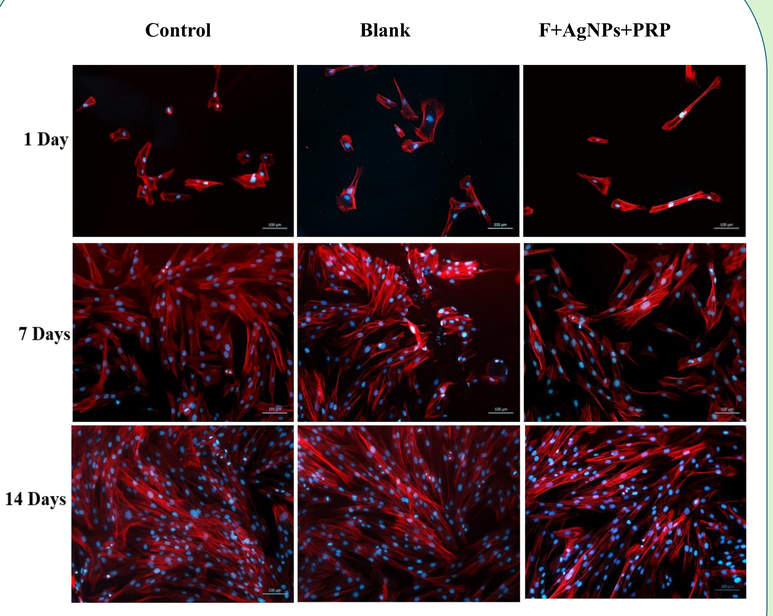


Figure 6. Actin filaments and nucleus were stained using Alexa-tagged phall*oi*din (Red) and DAPI (blue). Red fluorescence with defined boundaries, and the nucleus stained with DAPI showed an intact nucleus of blue fluorescence.

7. In-vivo study on rat burn wound model

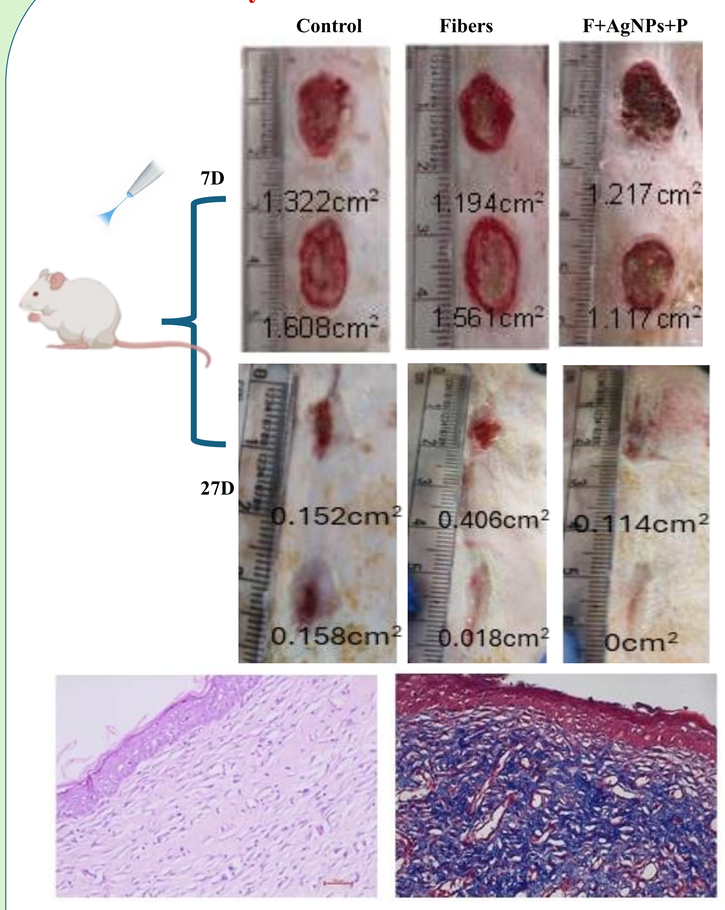


Figure 7. Effect of different scaffolds in healing of burn wound in rat burn wound model after 7days and 27 days, display a complete wound healing of the group treated with AgNPs and PRP encapsulated nanofibers Histopathology (H&E staining and Masson's Trichome) was performed after 27 days, results in fully formation of epidermis layer, appearance of hair follicles and sebaceous glands.

Conclusion

- Co-axial air-brushing to make core-shell fiber mat is a novel technique where core can be loaded with antibiotics/drugs and bioactive molecules for inherent protection burn wound infection and help in skin tissue regeneration.
- PRP helps shorten inflammation, boosts granulation tissue formation, epithelialization, and skin remodeling.
- These nanofibers enhance cell proliferation, antibacterial effects, and dermal fibroblast migration.
- The nanofiber patch can serve as an advanced wound dressing for various injuries.

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