

Antibacterial Chitosan–Carboxymethyl Cellulose Thin Films Loaded with S53P4 Bioactive Glass for Wound Dressing Applications in Soft Tissue Infection



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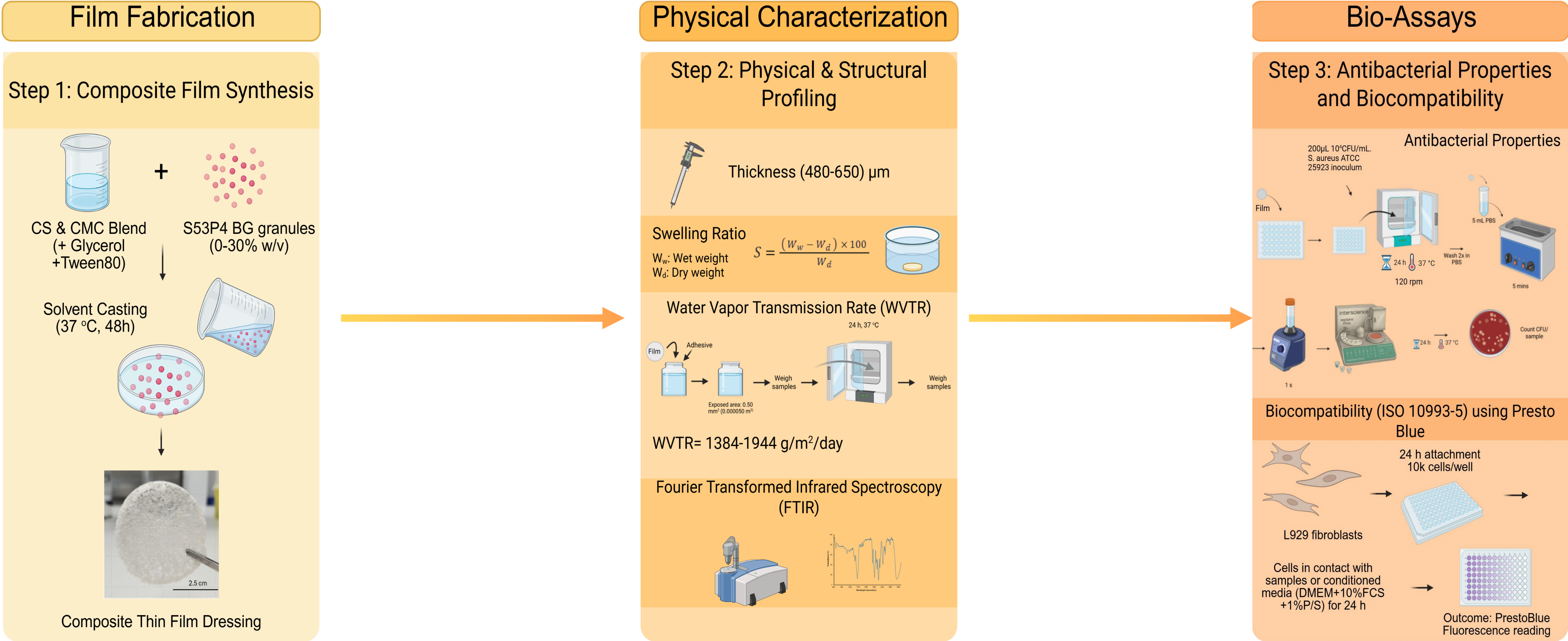
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Clinical Challenge: Soft-Tissue to Bone Progression



- High Infection Risk -> Chronic DFUs are prone to severe microbial colonization and persistent inflammation¹.
- Contiguous Osteomyelitis -> Untreated soft-tissue infections frequently spread contiguously into deeper fascia, joint capsules, and bone—driving the cascade toward Diabetic Foot Osteomyelitis (DFO) and lower-limb amputation².

Methods



Results

Physical Properties and Moisture Control

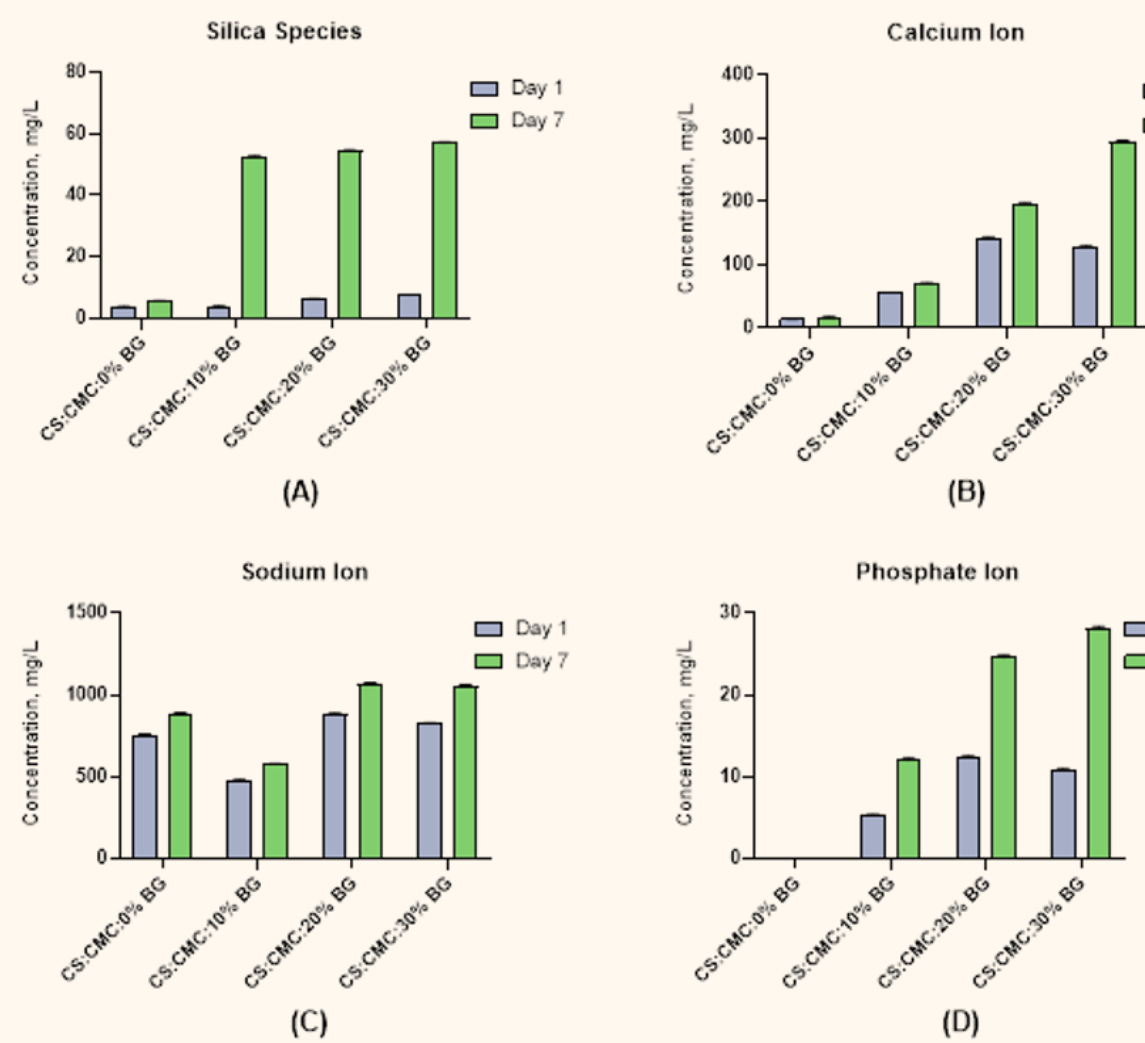


Figure 1. Cumulative ion release from composite films. Concentration of (A) silica species, (B) calcium ions, (C) sodium ions, and (D) phosphate ions released after 1 and 7 days.

- Continuous therapeutic release of silica species (50–60 mg/L at Day 7) and calcium (70–300 mg/L) confirmed S53P4 function as an active inorganic reservoir
- High sodium concentrations were observed across all films due to native CMC counter-ions

Antibacterial Properties against *S. aureus*

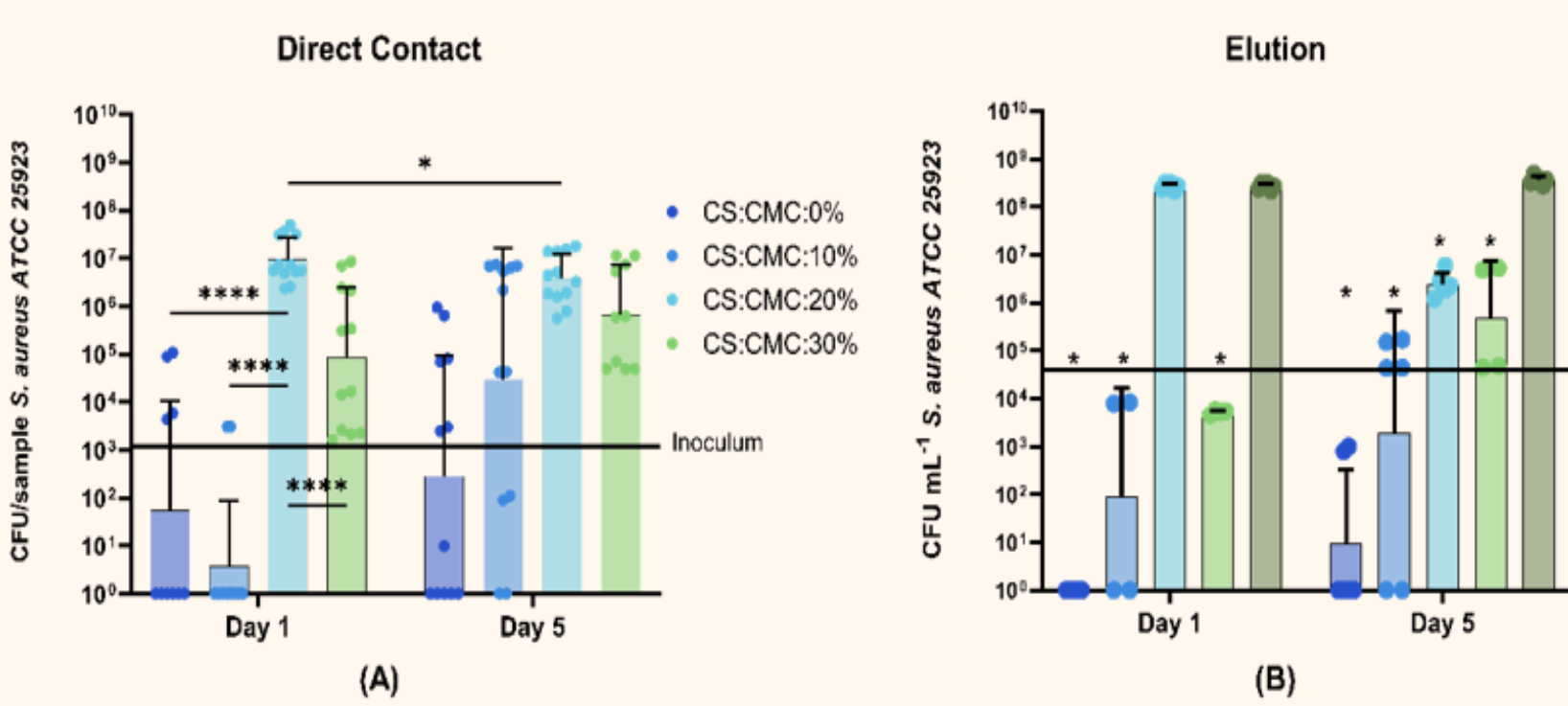


Figure 2. Antibacterial activity of films containing increasing percentages of S53P4 bioactive glass granules. The films were tested against *S. aureus* ATCC 25923. (A) Testing of direct contact killing. (B) Testing of the eluting antibacterial properties; * indicates a statistically significant difference with respect to the TSB control.

- 0% and 10% BG: Maintained bacterial counts below the initial inoculum threshold (10⁴ CFU/mL) during initial direct contact testing.
- Eluting Antibacterial Properties: The CS:CMC:10%BG film achieved a clinically relevant > 2 log reduction (2.5 log) at 24 h in elution assays.
- High BG Loadings (20%–30%): Failed to halt bacterial proliferation.

Biocompatibility ISO-10093-5

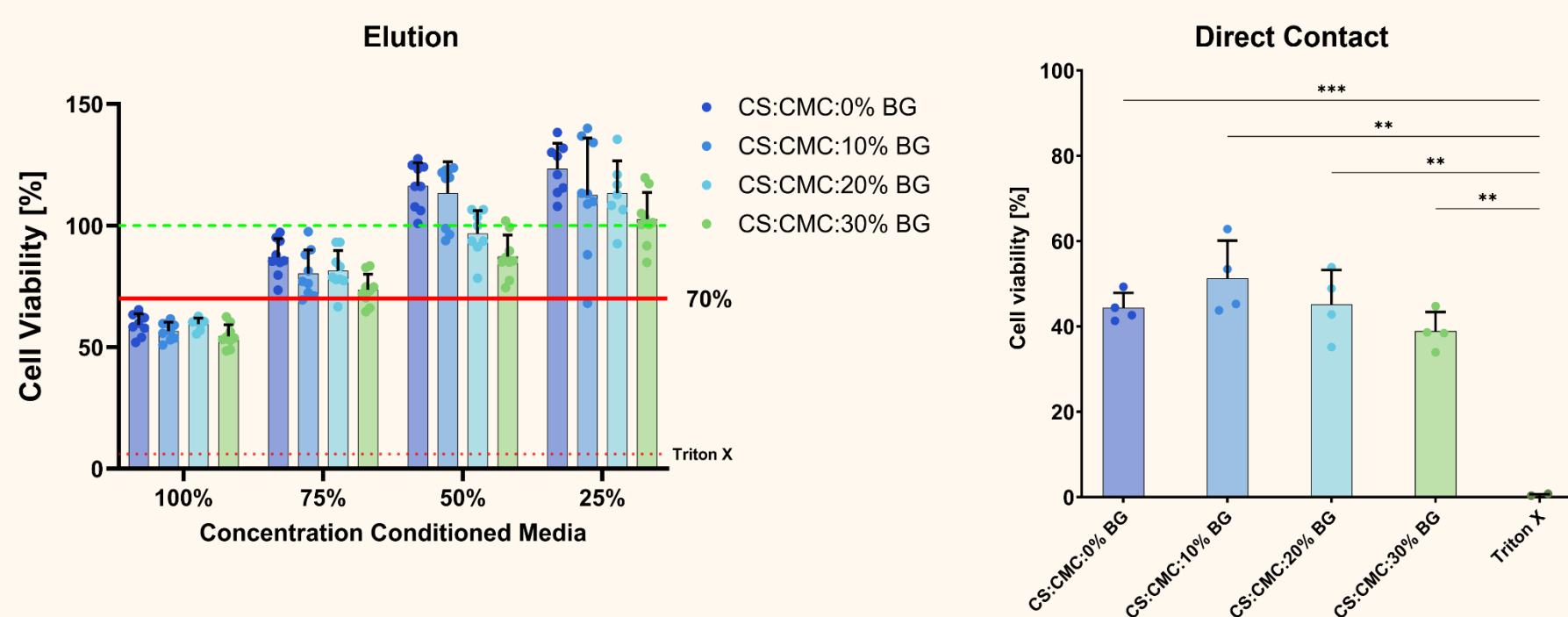


Figure 3. Cell viability of L929 mouse fibroblasts. Viability percentages are normalized to the untreated positive control (cells cultured on a standard tissue culture plate). Triton X-100 serves as the negative control (100% cell death). (A) Cell viability evaluated using conditioned culture media (indirect contact). (B) Cell viability evaluated via direct contact of the films over a confluent L929 cell monolayer. Significant differences are indicated by $p < 0.01$ and $***p < 0.001$.

- Direct Contact: Exhibited reduced viability (< 70%), primarily attributed to physical mechanical loading and diffusion barriers over the monolayer rather than chemical toxicity.
- Conditioned Media: Viability remained non-cytotoxic (> 70% up to > 100%) across all formulations when diluted to ≤ 75% concentration.

Conclusions

The CS:CMC:10%BG composite films achieved the best therapeutic balance, with therapeutic ion release over 7 days and potent early bactericidal activity. Future studies should focus on optimizing film formulation by exploring bilayer architectures to prevent functional interference between chitosan-mediated contact killing and S53P4 bioactive glass ion release

Acknowledgements

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References

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