Electrospun PVA-Chitosan Nanofiber composites: Molecular Weight-Dependent Antibacterial and Wound-Healing Performance

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Chronic wound management requires multifunctional biomaterials capable of both antimicrobial protection and tissue regeneration [1]. Chitosan (CS) is a commercial available bioactive biopolymer with potential applications in wound management, yet its relatively high molecular weight (>100 kDa) and poor water solubility limit its use[2] In this work, we report the microwave-assisted oxidative hydrolysis synthesis of low molecular weight CS (CS1 ~1.6 kDa and CS7 ~7.4 kDa) and its incorporation into electrospun poly(vinyl alcohol) (PVA) nanofibers (PVA@CS).

A set of composites with different CS content were produced and thoroughly characterized. The resulting PVA@CS nanofibers displayed tunable morphology, CS content, and bioactivity as a function of the molecular weight and the concentration of CS in the reaction solution. Notably, CS7 achieved an optimal balance between aqueous solubility and matrix-cell permeability, leading to enhanced bioactivity. In particular, PVA@CS7 fibers produced with the highest CS concentration (5% w/w in solution) exhibited strong antibacterial efficacy (>90% inhibition of *S. aureus*, *E. coli*, *P. aeruginosa*, and *C. albicans*, MIC = 3.2-7.5 mg/mL)[4–6] and markedly accelerated keratinocyte migration, with wound-closure rates of ~20 μm/h, nearly twice that of PVA or high-molecular weight CS systems.[7,8] Release experiments revealed an 99% release of CS after 24 hours in aqueous media at room temperature.

This work revealed a clear molecular-weight dependence of CS bioactivity, with the 7 kDa fraction being the most effective. The enhanced aqueous stability of low-molecular weight CS further enabled its incorporation into PVA nanofibers, producing antibacterial and wound-healing nanocomposites suitable as active layers in advanced wound dressings.

References

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Figures

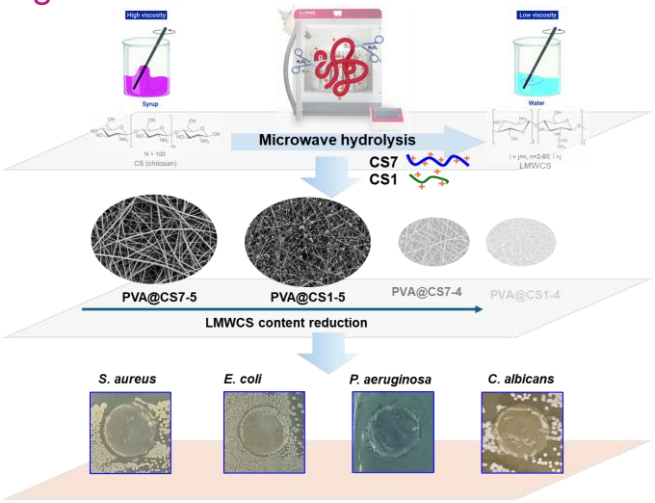

Figure 1. Synthesis of CS7 and CS1, along with SEM images of composite PVA@CS nanofibers and schematic diagram of the antibacterial effect of nanofibers

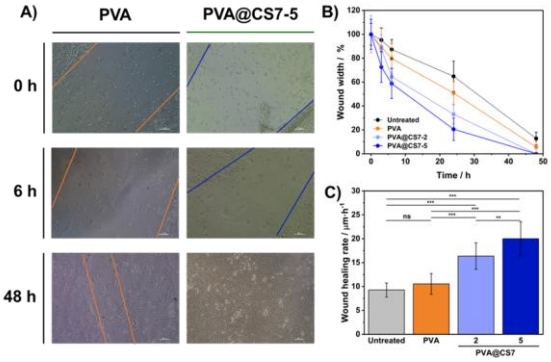

Figure 2. Representative images of HaCaT-ras A5 cell proliferation in the presence of the explored PVA and PVA@CS7-5 NFs (Scale bar = 100 μm). B) Quantification of the wound width over time and C) the estimated wound healing rate.