Biocompatible polymeric nanoparticles for potential application in antimicrobial skin regeneration therapies

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INTRODUCTION

Severe skin injuries and burns compromise healing and increase the risk of infection, particularly by *Pseudomonas aeruginosa*, which remains a major limitation of bioengineered artificial skin substitutes (BASS). Conventional antimicrobial treatments may be toxic and contribute to resistance, highlighting the need for improved strategies. Polymeric NPs, such as chitosan (CS) and PLGA, enable controlled and targeted antibiotic delivery, enhancing efficacy while maintaining biocompatibility. Their combination with BASS represents a promising approach to improve wound healing and prevent infections.

OBJECTIVE

The aim of this study was to develop polymeric NPs (CS and PLGA) for antibiotic delivery and incorporate them into bioengineered skin substitutes to provide antimicrobial activity against *P. aeruginosa*.

METHODS

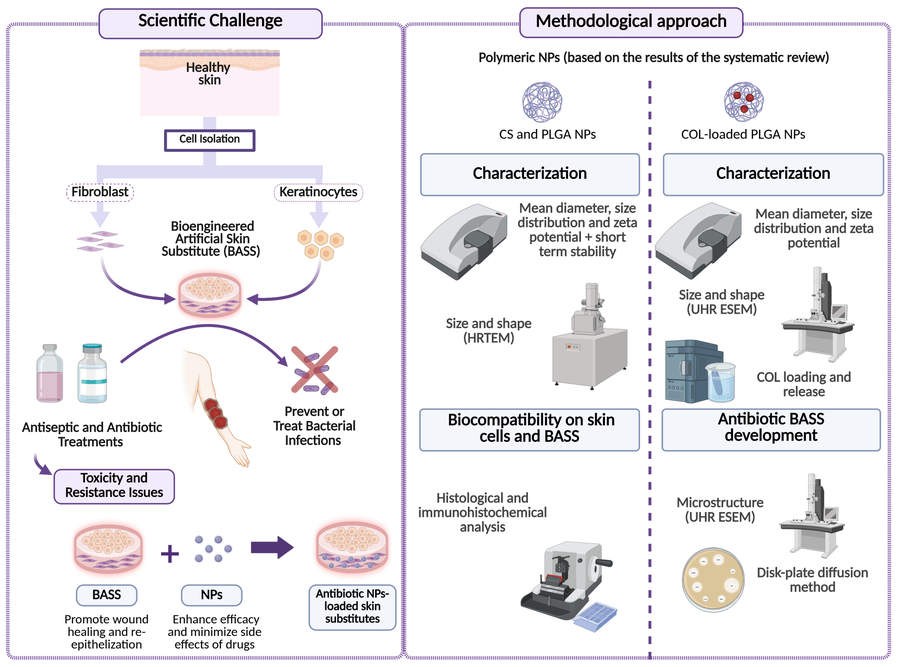


Figure 1. Overview of the scientific challenge and methodological approach used to assess the biocompatibility of polymeric NPs on skin cells and BASS and the development of antibiotic NPs-loaded BASS.

RESULTS

Polymeric NPs were successfully formulated with nanoscale sizes and homogeneous distributions, showing good biocompatibility in BASS. Only PLGA NPs efficiently encapsulated colistin (COL), achieving encapsulation efficiencies above 70%. COL release from PLGA NPs was sustained and pH-dependent, occurring under acidic conditions. When incorporated into BASS, these NPs were successfully distributed within the dermal matrix and produced a modest but significant inhibition of *P. aeruginosa* growth compared to controls.

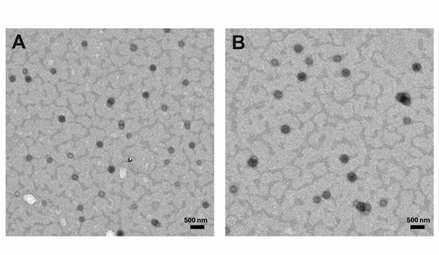


Figure 2. HRTEM photographs of: (A)PLGA NPs; and (B) CS NPs. Bar length: 500 nm. Mean diameter of the PLGA particles and CS particles were ≈180 nm and ≈290 nm, respectively.

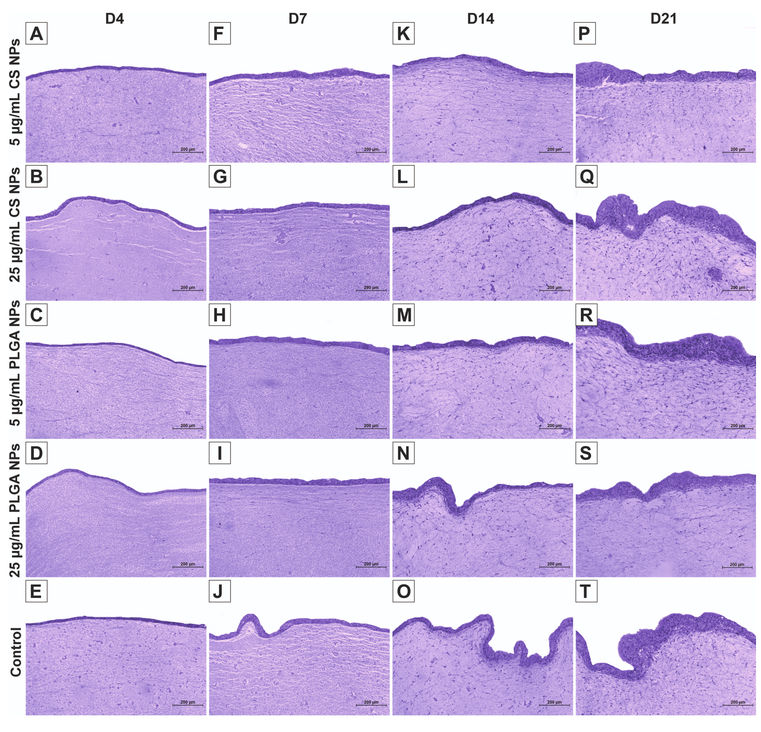


Figure 3. H&E staining of BASS after CS and PLGA NPs treatment and controls on days 4, 7, 10 and 21. All tested concentrations of CS and PLGA NPs allow for the development and stratification of the BASS epithelium.

Figure 4. COL loading and release from polymeric NPs. (A) EE and DL of COL-loaded CS NPs and PLGA NPs. ****p ≤ 0.0001. (B) Representative COL release profile from COL-loaded PLGA NPs at pH 5.5. (C) UHR ESEM of COL-loaded PLGA NPs magnification ×17000. Bar length 0.5 µm.

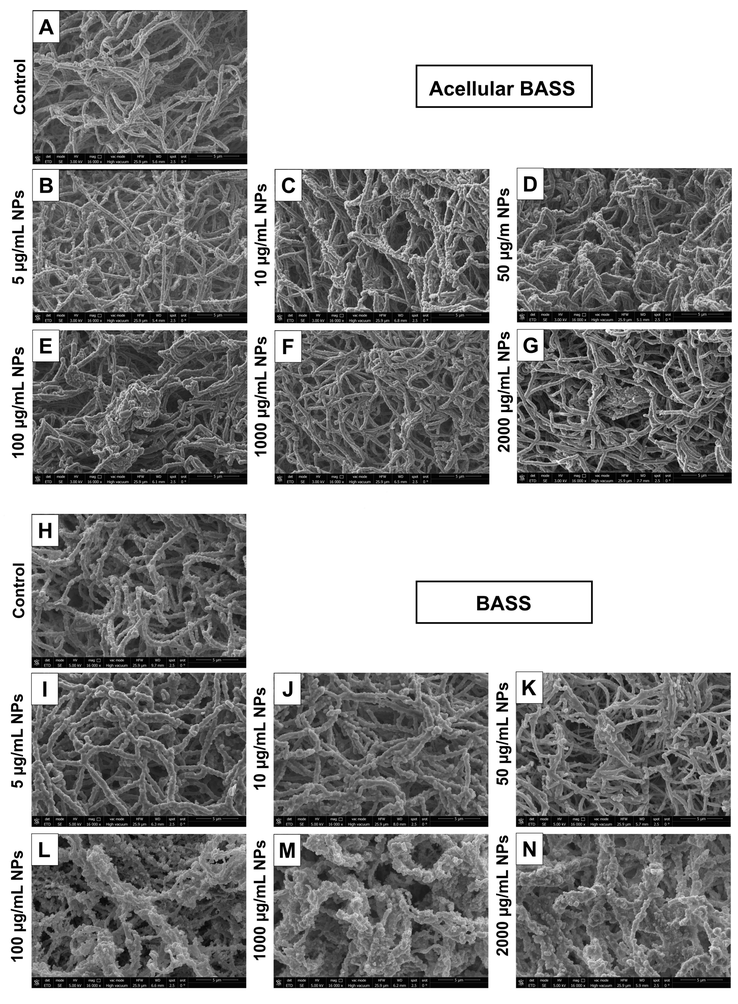


Figure 5. UHR ESEM images of COL-PLGA NPs loaded acellular BASS (A–G) and COL-PLGA NPs loaded BASS on day 14 of culture (H–N). Magnification ×16000 and bar length of 5 µm.

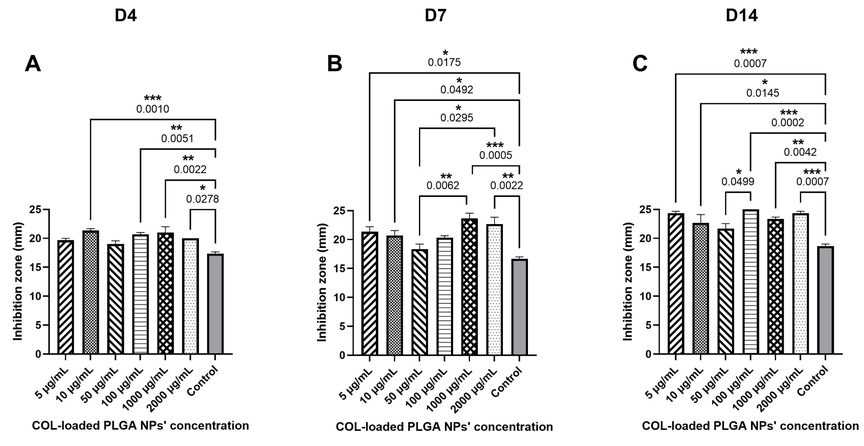


Figure 6. Antimicrobial efficacy of COL-PLGA NPs loaded BASS against *P. aeruginosa*.

CONCLUSION

Polymeric NPs, particularly PLGA, enabled effective antibiotic delivery within bioengineered skin substitutes, showing promising antimicrobial potential and representing a novel strategy for improving wound healing.

Quiñones-Vico, M. I., Mulero-Valle, I., Ubago-Rodríguez, A., Fernández-González, A., Fernández-Álvarez, F., Arias, J. L., ... & Arias-Santiago, S. (2025). Biocompatible polymeric nanoparticles for potential application in antimicrobial skin regeneration therapies. *Journal of Drug Delivery Science and Technology*, 107583.

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