Alginate-Pectin Nanocomposite Powders Loaded with PLGA Nanoparticles for Wound Healing Applications

Chiara De Soricellis;Giovanni Falcone; Rosaria Margherita Rispoli; Chiara Amante; Paola Russo; Rita Patrizia Aquino; Stefania Marzocco; Pasquale Del Gaudio

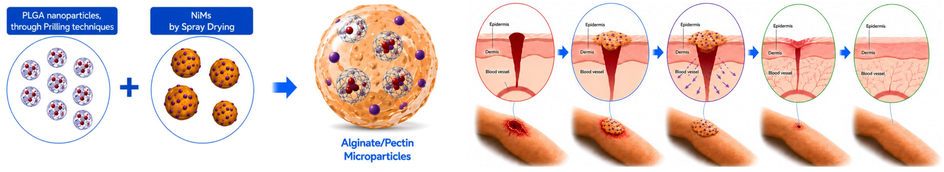
Department of Pharmacy, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy

Scientific Background

Wound is a disruption or break in the skin following physical or thermal injury or associated with a medical or physiological condition. The global wound care market is expanding, and various wound dressings have been developed to ensure adequate moisture absorption and retention, mechanical flexibility, and sufficient strength to guarantee easy applicability and removal, allowing proper hydration and gas exchange (1). Nanoparticles-in-microparticles matrices offer a promising strategy to enhance therapeutic efficacy (2).

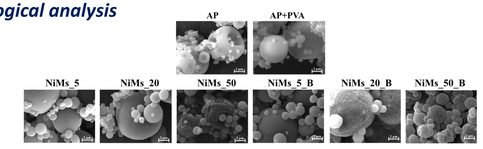
Aim

Development of alginate/pectin microparticles encapsulating PLGA nanoparticles for wound healing, filling in situ gel formation, and sustained drug release to enhance wound healing



Results

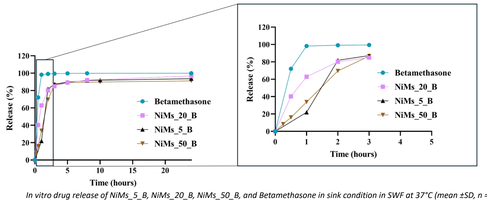
Morphological analysis



SEM microphotographs of powders produced by mini spray drying

- All drug-loaded NiMs showed satisfactory process yields (40–70%) and encapsulation efficiency (~60%)
- Increasing PLGA nanoparticle content leads to a transition from smooth, spherical particles to wrinkled and partially collapsed structures, likely due to hydrophobic–hydrophilic imbalance during formation and drying. Drug loading further increased surface corrugation.

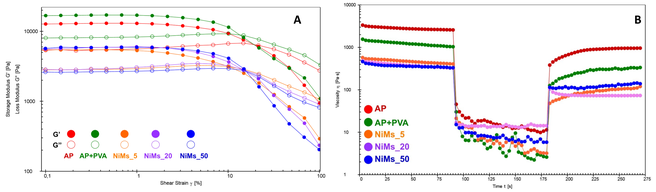
In vitro drug release



In vitro drug release of NiMs_5_B, NiMs_20_B, NiMs_50_B, and Betamethasone in sink condition in SWF at 37°C (mean ±SD, n = 3).

- Increasing PLGA nanoparticle content reduced the initial burst release, delaying 80% drug release from 2 to 3 h. All formulations then exhibited sustained release up to 24 h, likely driven by hydration, gel formation in SWF, and erosion–diffusion processes.

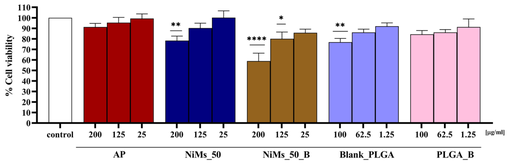
Rheological Studies



*Amplitude Sweep test of AP, AP+PVA, NiMs_5, NiMs_20, NiMs_50 (**A**) and time-dependent shear test (**B**)*

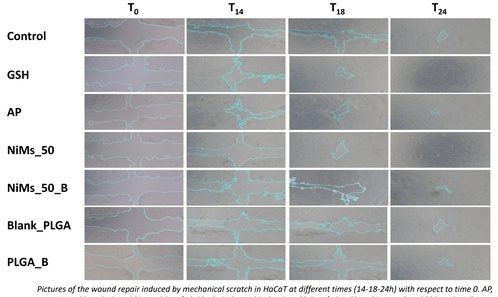
- Amplitude sweep tests indicated changes in the nanocomposite hydrogel consistency characterized by an initial reduction of entanglement strength due to nanoparticles incorporation, followed by matrix restructuring at higher nanoparticle concentrations.
- All NiMs exhibited thixotropic behavior, recovering viscosity after high shear stress. NiMs_50 showed the greatest recovery, comparable to AP, suggesting that higher nanoparticle loading improves gel structural resilience, supporting dressing integrity and retention at the wound site.

Biological evaluation



Antiproliferative activity assessed by MTT test on HaCaT cells after 24h of treatment with the compounds at different concentrations (25, 125, and 200 µg/mL for AP, NiMs_50, and NiMs_50_B and 1.25, 62.5, and 100 µg/mL for Blank_PLGA and PLGA_B).

- NiMs exhibited a mild dose-dependent decrease in viability, with a statistically significant reduction observed at 200 µg/mL, However, cell viability remained consistently above 50 %, indicating an absence of cytotoxicity



Pictures of the wound repair induced by mechanical scratch in HaCaT at different times (14-18-24h) with respect to time 0. AP, NiMs_50 and NiMs_50B at 125 µg/ml, Blank_PLGA and PLGA_B at 62.5 µg/ml. L-Glutathione reduced (GSH; 10 µM).

- NiMs_50 reaches approximately 80% wound closure after 18h and complete closure within 24h, compared to the other compounds. This effect may be attributed to the combined presence of PLGA nanoparticles and the alginate-pectin matrices

Conclusions

- Prilling–Spray-Drying enabled the reproducible production of powders with high yield and encapsulation efficiency.
- NiMs represent a versatile, ready-to-use platform for advanced wound dressings, providing controlled drug release, prolonged retention at the wound site, adaptability to the wound microenvironment, and enhanced wound closure

References

S. Kaya, S. Derman, PROPERTIES OF IDEAL WOUND DRESSING, J. Fac. Pharm. Ankar 47(3)1119-1131, (2023).
P. Pandey, H. Dureja, Nanoparticles-in-microparticles systems (NiMS): An overview, J. Innov. Bio-December 1(4) (2014) 195-199.

ACKNOWLEDGEMENTS

We acknowledge CRS Local Chapter Young Scientist Travel Grants which financed the congress registration
This study was funded by the Italian Ministry of University and Research (MUR) under the Grant No. FISA-2024-00200

For further information:
cdesoricellis@unisa.it