Creating customized 3D printing dressings with potential to deliver active compounds into the wound site

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Presenter profile

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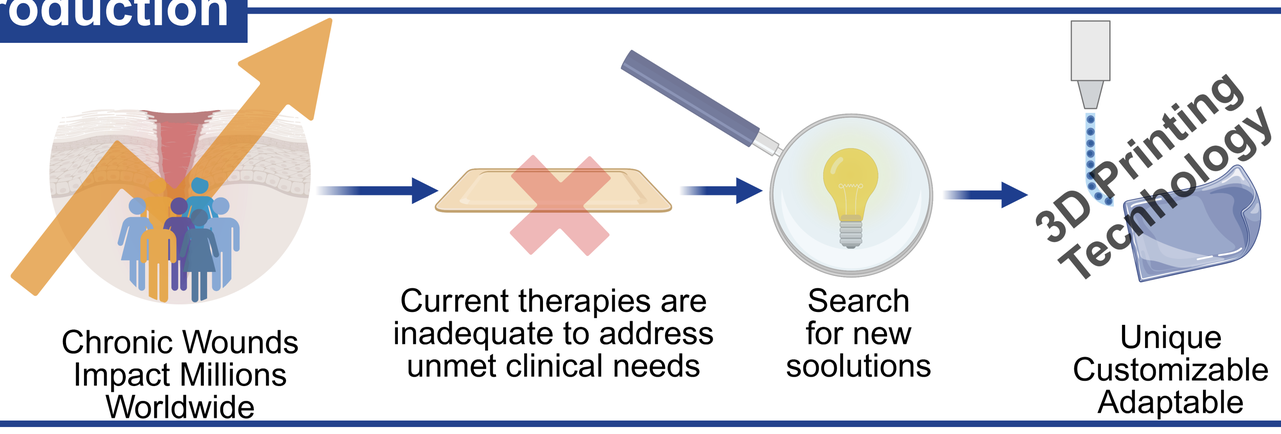
Introduction

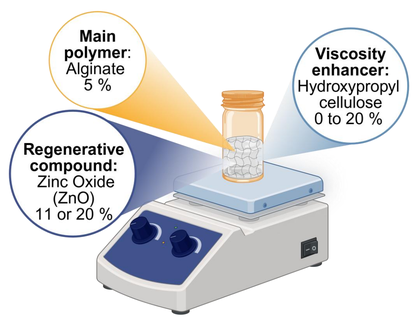


Aim

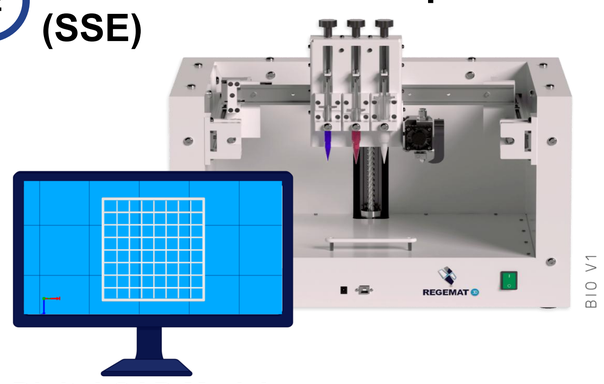
This study focuses on the development of **regenerative** porous **3D printing dressing** aiming to **deliver** active compounds with healing properties, such as **octenidine** (OCT).

Materials and Methods

01 Hydrogels production

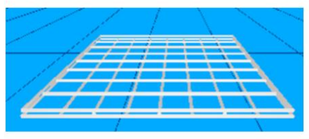


02 Semi-solid extrusion process (SSE)

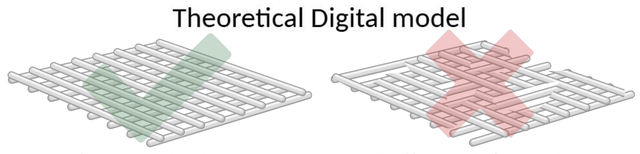


Digital CAD Model

03 3D dressings printability evaluation



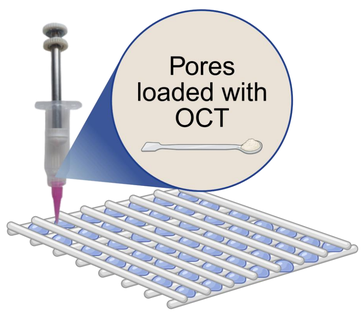
Theoretical Digital model



Similar to the theoretical CAD model

Different from the theoretical CAD model

04 Incorporation of Octenidine (OCT)-hydrogel



05 Dressings Characterization

Results

1. Ink's optimization

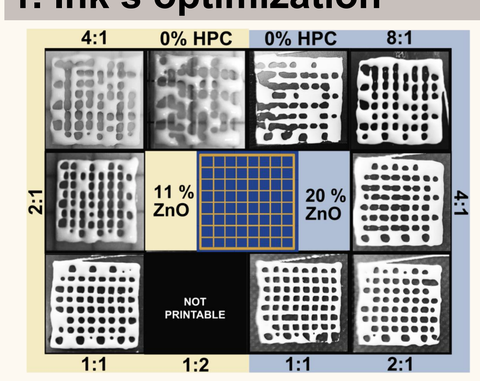


Fig. 1 3D printing optimization changing the ratio between ZnO and HPC.

2. Morphology and rheology evaluation

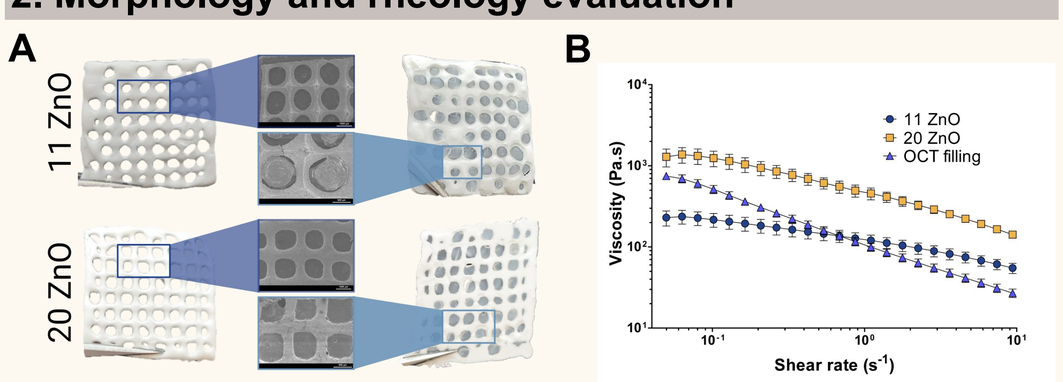


Fig. 2 (A) Morphology assessment though photographs and SEM images and **(B)** evaluation of the viscosity (Pa.s) as function of shear rate (s^{-1}) for 11 ZnO, 20 ZnO and OCT filling hydrogel.

- Adding **HPC** into the hydrogel ink improved the printability.
- The **best** formulations for both **ZnO** concentrations (**11** and **20** %) were **achieved**.
- All hydrogel matrices inks showed **shear-thinning** behavior.

3. Microbial and *in vitro* release drug evaluation

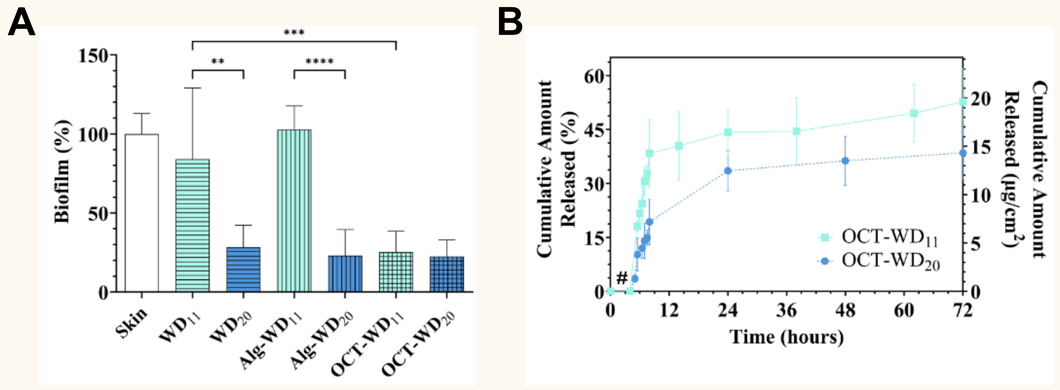


Fig. 3 (A) Antibiofilm activity against *Staphylococcus aureus* and **(B)** OCT release from wound dressings.
WD_{11}/WD_{20} - unloaded dressings at 11 and 20 % ZnO. OCT-WD_{11}/OCT-WD_{20} - OCT loaded dressings with 11 and 20 % ZnO. Alg-WD_{11}/Alg-WD_{20} – Alg drug free loaded dressings with 11 and 20 % ZnO (filling control).

- Drug free 20 % ZnO dressings and all OCT loaded dressings presented **antimicrobial** and **antibiofilm** activity.
- **OCT** loaded **dressings** enabled **similar activity** in drug free **11** % **ZnO** dressings.
- The 11 % ZnO matrix provided a superior OCT release.

3. Healing potential and biocompatibility evaluation

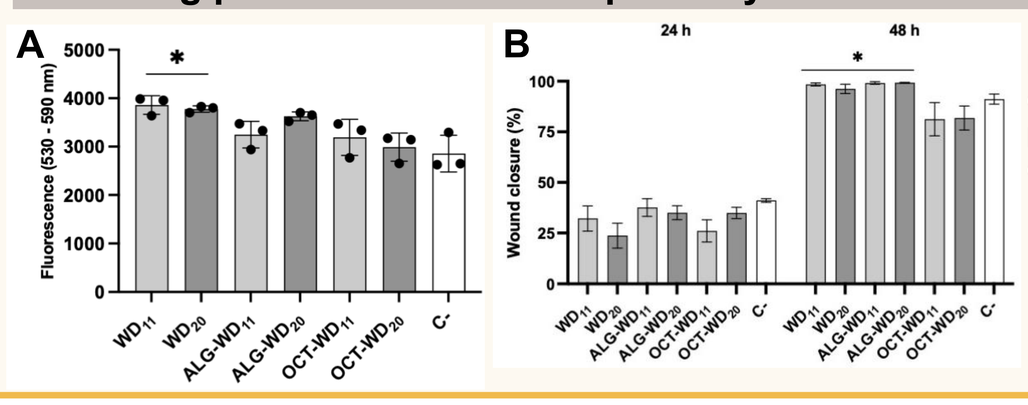


Fig. 4 (A) *In vitro* cytocompatibility by evaluation of the metabolic activity and **(B)** regenerative potential of the wound dressings in human dermal fibroblast cultures (AG22719).

- All dressings were cytocompatible and presented an adequate regenerative potential.

Conclusions

- **A novel ink was achieved by combining Alg:ZnO:HPC resulted in suitable printing and healing properties.**
- The addition of **OCT** provided **antimicrobial** properties against ***S. aureus*** in the **11 % ZnO**.
- The **matrix's pores** were suitable for the **incorporation** and **delivery** of **active compounds**.

References

1. Norahan MH, Pedroza-González SC, Sánchez-Salazar MG, Álvarez MM, Trujillo de Santiago G. Bioact Mater. 2023;24:197-235.
2. Rajabifar N, Alemi MH, Rostami A, et al. Adv Colloid Interface Sci. 2025;344:103602

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