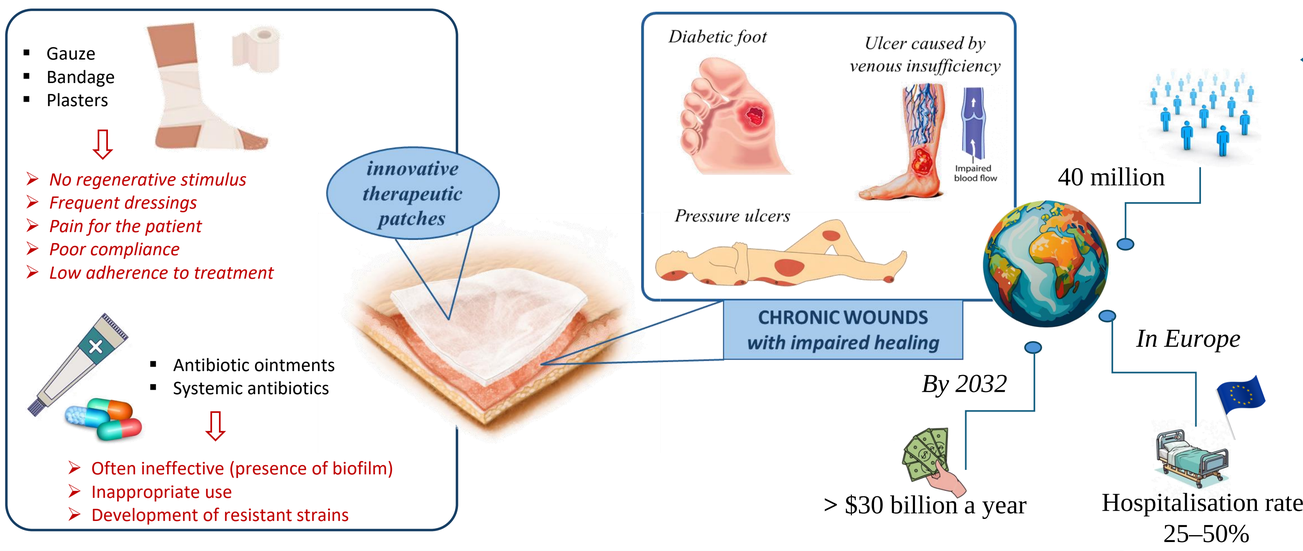
Biomimetic inks and 3D printing: from skin tissue regeneration to the engineering of in vitro models

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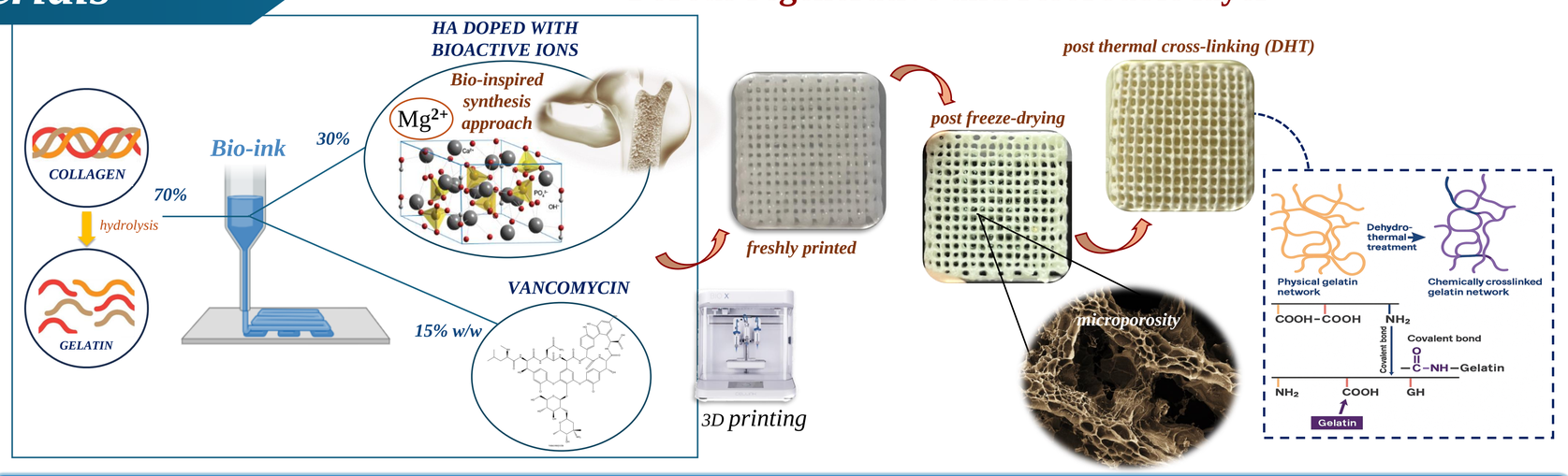
Introduction

Chronic wounds, such as diabetic ulcers, pressure ulcers and vascular lesions, are characterised by a reduced ability to heal, often associated with a high risk of infection [1]. They represent a major clinical and socio-economic challenge, as they affect a large proportion of the population, lead to frequent hospitalisations and entail high management costs, with a significant impact on healthcare systems and patients' quality of life. This condition is further aggravated by the use of traditional dressings, such as gauze and bandages, which primarily serve a protective function without actively promoting regenerative processes. In addition, their frequent replacement can cause pain and damage newly formed tissue. Another factor is the use of systemic antibiotics to treat infections, which are often not targeted at the site of the wound and are associated with an increase in antibiotic resistance [2].

Design and development of biomaterials

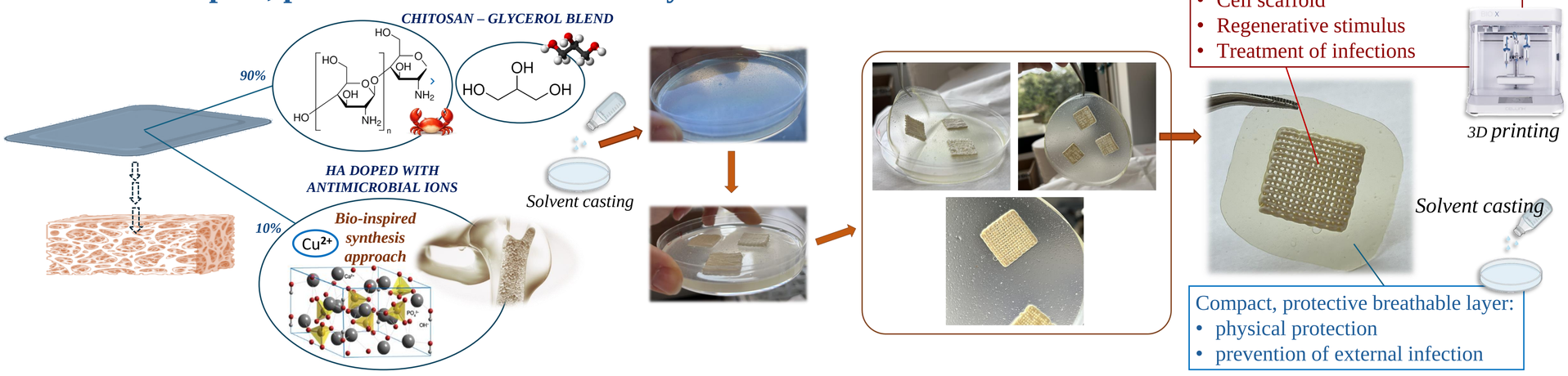
This work aims to overcome the limitations of current medications by designing a dual-layer multifunctional therapeutic patch combining protection, regeneration, and infection control. An internal regenerativee layer obtained by developing biomimetic injectable materials (bio-ink) for 3D printing. The bio-ink was formulated using medical-grade gelatin that was biomineralized with bioactive magnesium-doped hydroxyapatite (GelMgHA), dispersed in a gelatin-based matrix, and functionalized with vancomycin to enable localized antibiotic release. The 3D-printed constructs were freeze-dried to generate microporosity that is suitable for nutrient diffusion and cell migration. They were then thermally crosslinked to improve mechanical stability and control the degradation rate.

Porous regenerative and resorbable layer



To further optimize performance, the vancomycin-loaded 3D printed layer supporting tissue regeneration was combined with a compact, protective, breathable upper film obtained by solvent casting of chitosan and glycerol blend enriched with gelatine mineralized with copper-doped hydroxyapatite (GelCuHA). The controlled release of copper ions provides additional antibacterial protection against external contamination.

Compact, protective and breathable layer

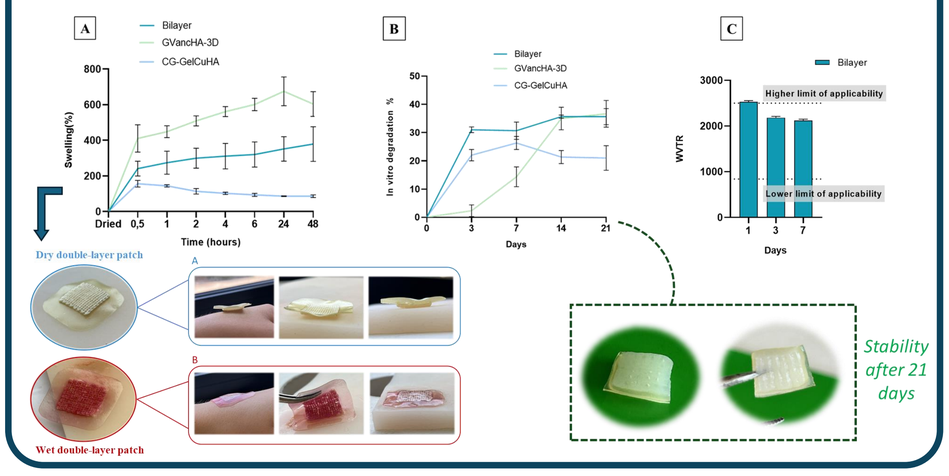


Three-in-one functions:

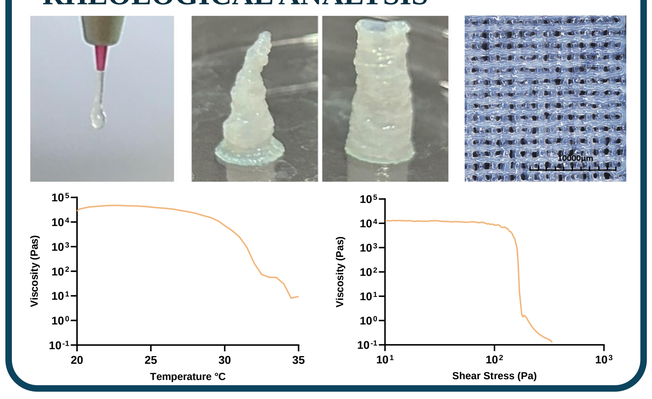
- WOUND PROTECTION
- REGENERATIVE STIMULUS
- PREVENTION AND TREATMENT OF INFECTIONS

Characterisations and results

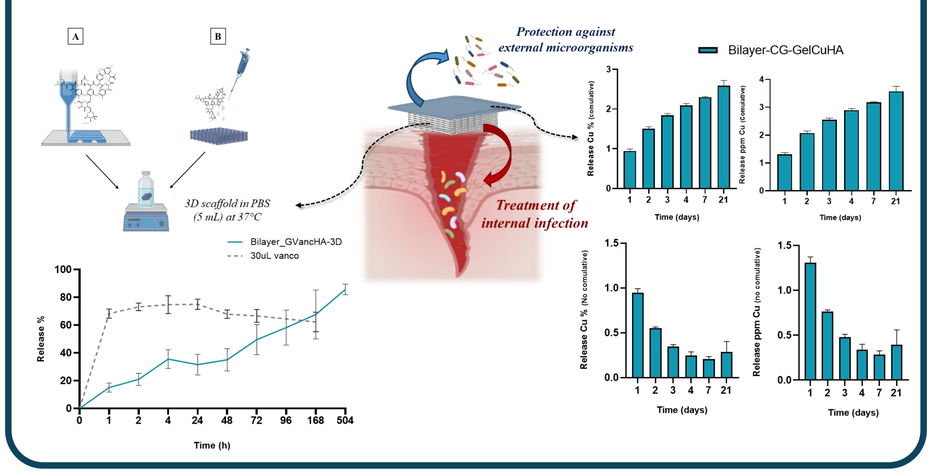
PHYSICAL ANALYSIS



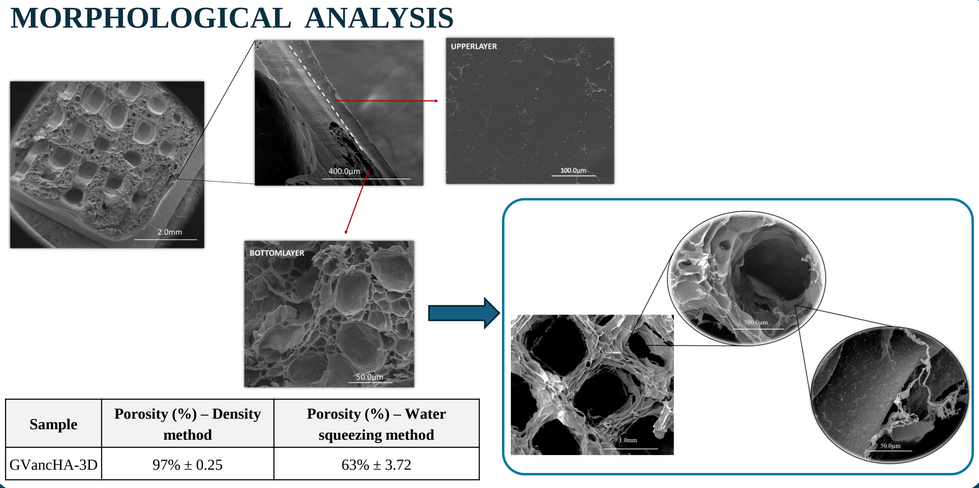
RHEOLOGICAL ANALYSIS



VANCOMYCIN AND COPPER RELEASE

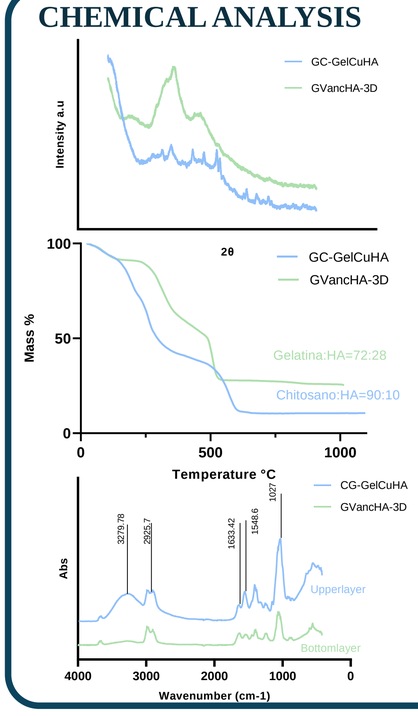


MORPHOLOGICAL ANALYSIS



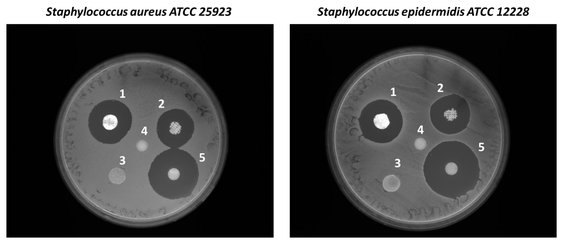
Sample	Porosity (%) – Density method	Porosity (%) – Water squeezing method
GVancHA-3D	97% ± 0.25	63% ± 3.72

CHEMICAL ANALYSIS



MICROBIOLOGICAL ANALYSES

KIRBY-BAUER

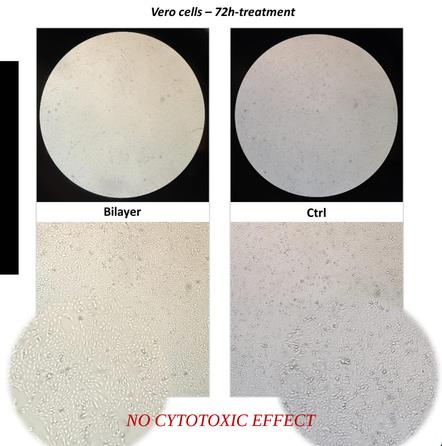


	S. aureus	S. epidermidis
1. Bilayer	22-23 mm	20-21 mm
2. Layer GVancHA-3D	21-22 mm	19-20 mm
3. Layer CG-GelCuHA	0	0
4. Floppy disc (no vanco)	0	0
5. Floppy disc 30 µL vanco (Ctrl pos)	25-26 mm	28-29 mm

INHIBITION OF BACTERIAL GROWTH FOR SAMPLES CONTAINING VANCOMYCIN

CELL VIABILITY

Vero cells – 72h-treatment



NO CYTOTOXIC EFFECT

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References

[1] R. Laurano et al, Jun 2022, Doi: 10.1016/j.engreg.2022.04.002.

[2] S. Dhivya et al, Nov 2024, Doi: 10.37796/2211-8039.1526.