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Freeze-dried chitosan scaffolds incorporating polyvinylpyrrolidone/polyvinyl alcohol/curcumin (CS-PVP/PVA/Cur) and silicon dioxide nanoparticles (NPs-SiO_2)

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INTRODUCTION & AIM

Tissue engineering seeks to create structures that mimic or stimulate the regeneration of native tissues [1]. This study focuses on promoting cell regeneration using scaffolds composed of chitosan (CS), polyvinylpyrrolidone (PVP), polyvinyl alcohol (PVA), and silicon dioxide nanoparticles (NPs-SiO_2). Metal nanoparticles and polymers have been used in wound treatment. Key concepts can be derived and applied to the generation of new multifunctional polymeric devices, working with hydrogel scaffolds due to their high promise inha healing by providing an environment that promotes cell adhesion and growth. The goal is to design scaffolds with mechanical properties similar to bone, combining rigidity to withstand biomechanical loads and flexibility to allow cell migration [2][3]. This strategy offers a promising platform for effective and functional bone repair. In addition, curcumin-enhanced biodegradable scaffolds will offer improved tissue regeneration and protection against infection, inflammation, and oxidative damage [4][5].

METHOD

The preparation of PVP/PVA/Cur/CS/NPs-SiO_2 scaffolds at various final concentrations (w/v) (Table 1). These were then subjected to freeze-drying in an LC-FD-06H freeze dryer (Müller Scientific, Zhengzhou, China), where a vacuum was applied using a 2XZ4 rotary vane vacuum pump (East Vacuum, Beijing, China) until 5.5 Pa was reached for 72 hours, obtaining the PVA/PVP/Cur/CS/NPs-SiO_2 scaffolds.

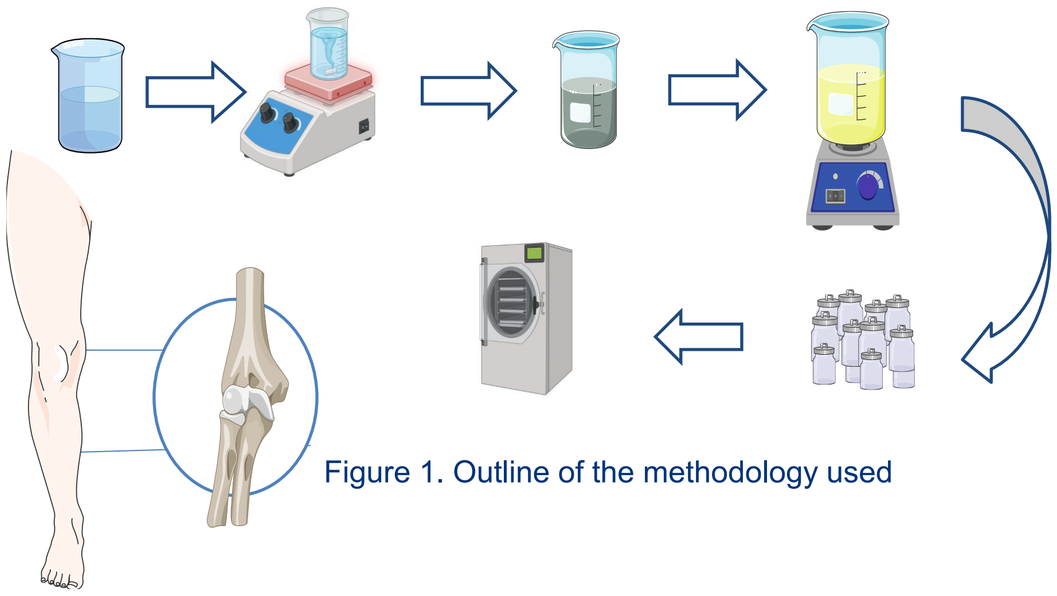

Figure 1. Outline of the methodology used

% (p/v)	(CS)	PVA	PVP	CUR	SiO_2
CS-PVP/PVA (F1)	40	20	40	0	0
CS-PVP/PVA/Cur/SiO_2 (F2)	40	18	40	1	1
CS-PVP/PVA/Cur/SiO_2 (F3)	40	16	40	2	2

Table 1. Scaffolding concentrations

RESULTS & DISCUSSION

These materials, selected for their complementary properties, offer significant advantages: chitosan (CS) provides biocompatibility and antimicrobial activity, while poly(N-vinyl-2-pyrrolidone) (PVP) improves the structural stability of composite polymers linked to steric balance, and poly(vinyl alcohol) (PVA) is a biodegradable synthetic polymer that exhibits remarkable mechanical stability, providing mechanical flexibility; while curcumin (CUR) is a non-flavonoid polyphenolic compound with antioxidant, anti-inflammatory, anti-apoptotic, and antibacterial properties. We also include SiO_2 nanoparticles to densify and optimize the microstructure, reducing porosity.

Sample	M. Elasticity (MPa)	Max. Stress (MPa)	Max. Deformation (%)
F1	0.24 ± 0.05	0.87 ± 0.11	87.16 ± 3.64
F2	0.77 ± 0.18	1.02 ± 0.01	86.37 ± 1.7
F3	0.33 ± 0.12	0.85 ± 0.16	87.85 ± 0.87

Table 2. Mechanical properties of scaffolding

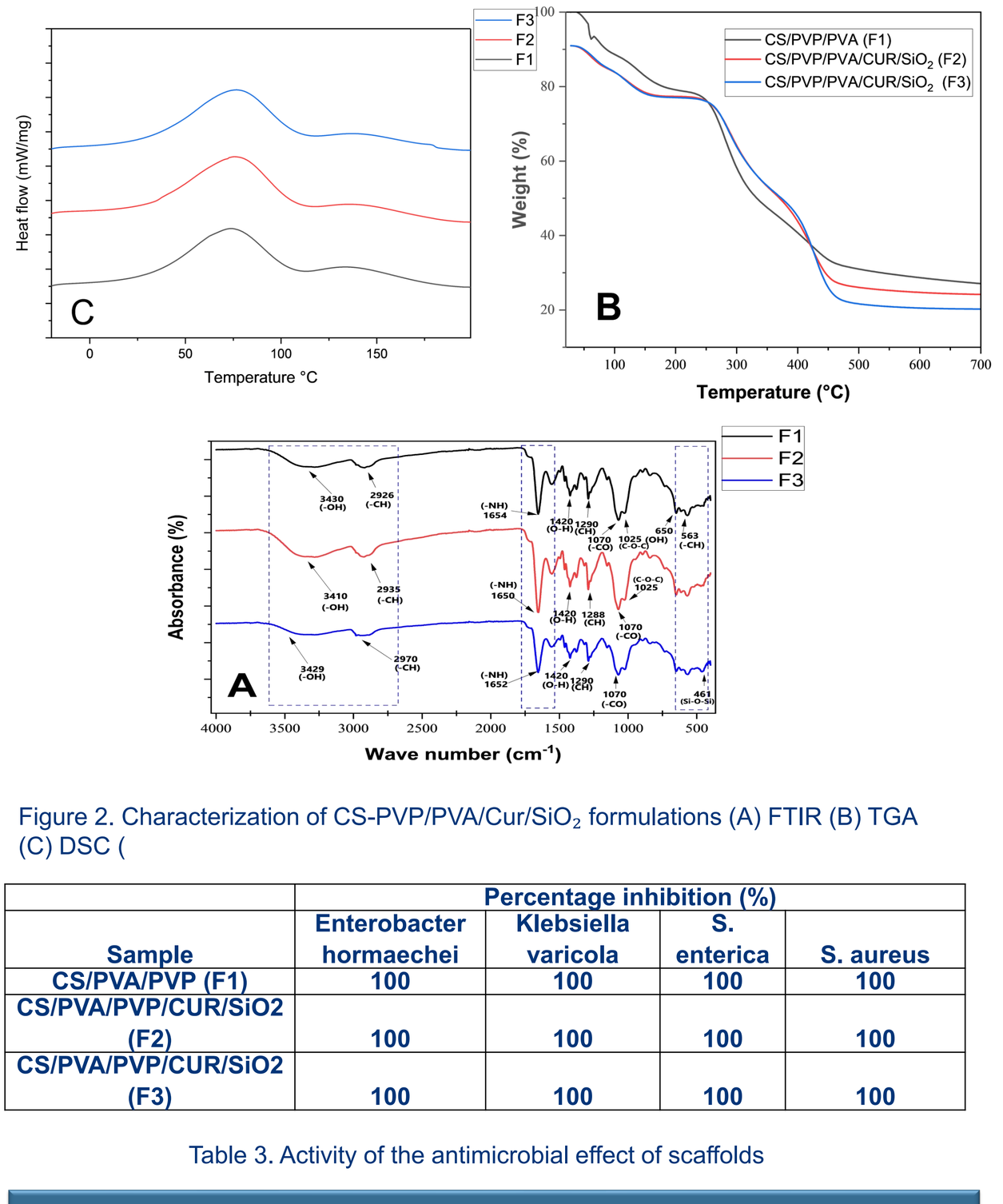

Figure 2. Characterization of CS-PVP/PVA/Cur/SiO_2 formulations (A) FTIR (B) TGA (C) DSC (

Sample	Percentage inhibition (%)			
	Enterobacter hormaechei	Klebsiella varicola	S. enterica	S. aureus
CS/PVA/PVP (F1)	100	100	100	100
CS/PVA/PVP/CUR/SiO2 (F2)	100	100	100	100
CS/PVA/PVP/CUR/SiO2 (F3)	100	100	100	100

Table 3. Activity of the antimicrobial effect of scaffolds

CONCLUSION

The mechanical properties are evaluated through the elastic modulus, maximum stress, and maximum strain. There is a clear difference in stiffness of approximately 2.3 in one formulation (F2) compared to the other two formulations, which is not only the most rigid but also the most resistant. Observing their notable differences in stiffness and resistance, the three types of scaffolds are highly deformable and elastic materials for biomedicine. We also see strong efficiency in the treatment with bacteria, the excess in pore numbers without being distributed NPsSiO_2 and Cur. This reduces intermolecular attractions in the polymer matrix, generating scaffolds with greater porosity and pores with more regular shapes and smaller diameters. Next, we have that the thermal properties of the compositions include stable degradation for biomedical functions with an emphasis on bone regeneration.

FUTURE WORK / REFERENCES

Express our deep gratitude to all the people and institutions that contributed to the creation of this poster, to Dr. Carlos Grande Tovar, Dr. Paula Zapata, and collaborators, colleagues from the seedbed of functional properties of natural species. For the future, we seek to conduct live and in vitro tests to preliminarily determine the feasibility of implementation.

[1] Zhang, Y.; Poon, K.; Masonsong, G. S. P.; Ramaswamy, Y.; Singh, G. Sustainable Nanomaterials for Biomedical Applications. Pharmaceutics 2023, 15(3), 1–20. doi:10.3390/pharmaceutics15030922.

[2] Sánchez-Téllez, D. A.; Baltierra-Uribe, S. L.; Vidales-Hurtado, M. A.; Valdivia-Flores, A.; García-Pérez, B. E.; Téllez-Jurado, L. Novel PVA–Hyaluronan–Siloxane Hybrid Nanofiber Mats for Bone Tissue Engineering. Polymers 2024, 16(4). doi:10.3390/polym16040497.

[3] Grande-Tovar, C. D.; Castro Castro, J. I.; Barba-Rosado, L. V.; Zapata, P. A.; Insuasty, D.; Valencia-Llano, C. H. Histology Assessment of Chitosan–Polyvinyl Alcohol Scaffolds Incorporated with CaO Nanoparticles. Molecules 2025, 30(2), 1–17. doi:10.3390/molecules30020276.

[4] Ganesh, S. S.; Anushikaa, R.; Swetha Victoria, V. S.; Lavanya, K.; Shanmugavadivu, A.; Selvamurugan, N. Recent Advancements in Electrospun Chitin and Chitosan Nanofibers for Bone Tissue Engineering Applications. Journal of Functional Biomaterials 2023, 14(5). doi:10.3390/jfb14050288.

[5] Sanz, D.; Claramunt, R. M.; Alkorta, I. Curcumin and curcuminoids: Chemistry, structural studies and biological properties New inhibitors of Plasmodium falciparum View project. 2015.