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3D Printing Blends of Sodium Alginate:Hydroxyapatite Structures for Controlled Release of Sulfanilamide

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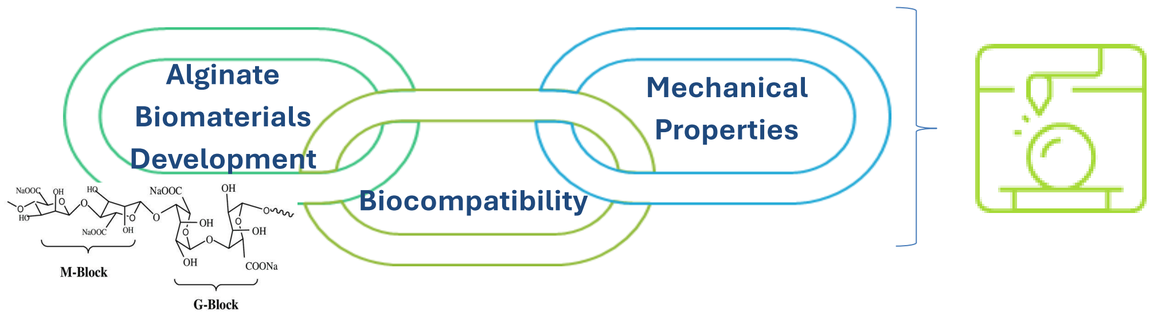
INTRODUCTION & AIM

Three-dimensional (3D) printing is an additive manufacturing process that enables the precise production of complex structures, layer by layer, with functional properties. The development of new biomaterials that could be used to produce 3D scaffolds for tissue regeneration and/or drug release systems, is nowadays a developing research field. [1,2] Biocompatibility and non-toxic properties are fundamental requirements to select the polymers to use as base matrices.



Scheme 1 – Global scheme for 3D printing of biocompatible structures.

As a strategy to improve both the structural and functional properties of the printed scaffolds, inorganic reinforcing compounds, as hydroxyapatite, can be applied to polymeric matrices

METHOD

In this research, an extrusion-based 3D printing was used, with a computer-controlled system, that enabled continuous deposition of the proposed bio blends, along the x-y-z axis. Using OpenSCAD, basic cube shape was created, and in Ultimaker Cura we were able to customize it. After several tests, some printing settings were defined (Figure 1).

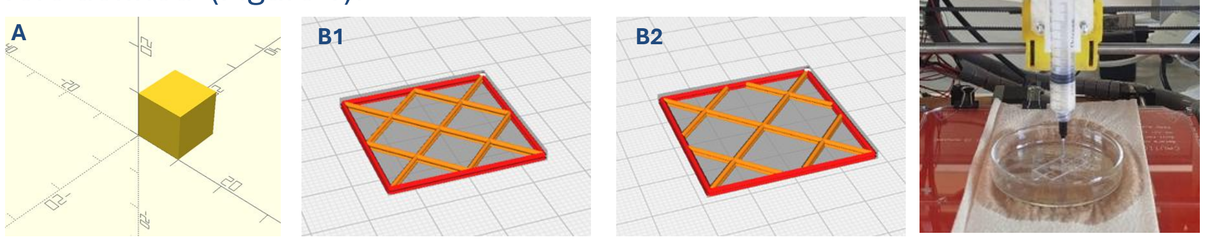


Figure 1 – A) Programmed cube; B1 and B2) Structures and C) Printing syringe.

Formulations consisted of sodium alginate (5, 7.5 and 10%):hydroxyapatite (0, 2.5 and 5%) (w/w) mixtures (Table 1), dopped with 0.1% sulfanilamide and the respective control. Crosslinking was performed by immersion in a 5% $CaCl_2$ aqueous solution.

Table 1 – Sodium alginate:Hydroxyapatite mixtures.

		Hydroxyapatite % (w/v) 0	2.5	5.0
Sodium Alginate % (w/v)	5	Sol. A	Sol. B	Sol. C
	7.5	Sol. D	Sol. E	Sol. F
	10	Sol. G	Sol. H	Sol. I

Figure 2 - Visual aspect of some of the prepared mixtures.

RESULTS & DISCUSSION

The solutions showed varying viscosities, with Group I being the least and Group III the most viscous. Group I solutions were too fluid for 3D printing, as their low viscosity prevented structural stability, and were therefore rejected. After defining the 3D printing parameters, printing was performed, and the produced structures were then reticulated (Figure 3).

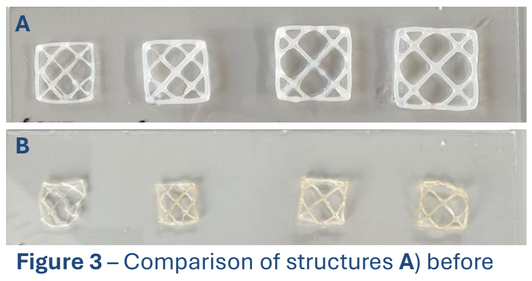


Figure 3 – Comparison of structures **A**) before and **B**) after chemical crosslinking

After crosslinking, the geometric shape was slightly altered, but the function remained unchanged (Figure 4).

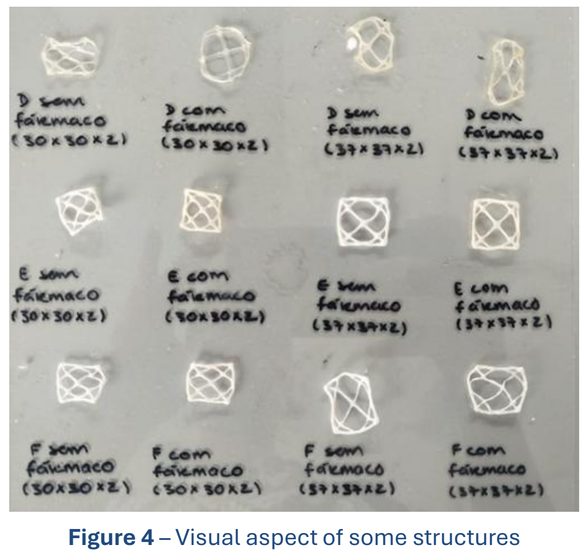


Figure 4 – Visual aspect of some structures after chemical crosslinking.

Preliminary drug release tests of sulfanilamide were performed for all doped structures, at 262 nm, for 24 h, in ethanol (Figure 5).

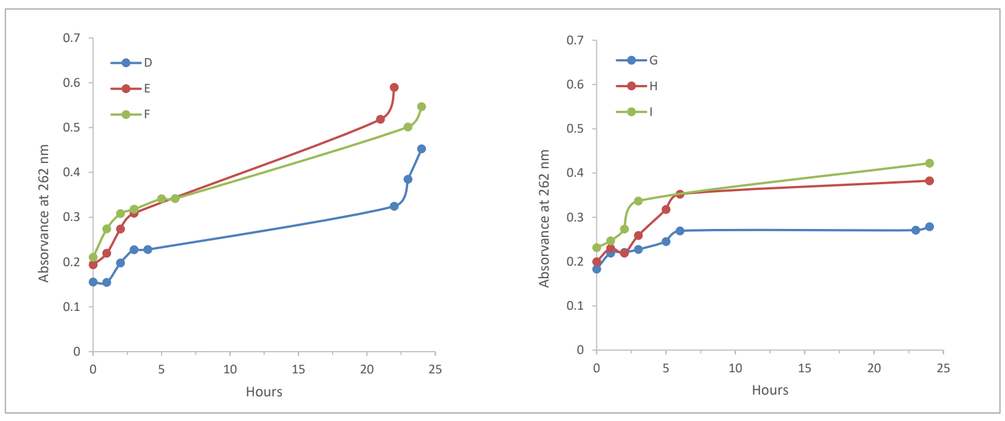


Figure 5 – Preliminary results of drug release tests of dopped structures of mixtures D, E, F, G, H and I

The results show that the incorporation of hydroxyapatite increased sulfanilamide release in both alginate-based mixtures. Formulations containing 7.5% alginate appear to release slightly more drug than those with 10% alginate. Further studies are needed to confirm this assumption.

CONCLUSION

This study demonstrated the feasibility of constructing a 3D printer capable of fabricating biocompatible mixtures of sodium alginate and hydroxyapatite, doped with sulfanilamide.

Results suggest that hydroxyapatite facilitates drug release, although excessive concentrations may hinder the process.

REFERENCES

[1] S. Nouri *et al.*, Polymers 2024, 311, 127523.
[2] A. Agrawal, C. M. Hussain, Gels 2023, 9(12), 960.

Acknowledges

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