A 3D PRINTED POLYMERIC DRUG-ELUTING IMPLANT

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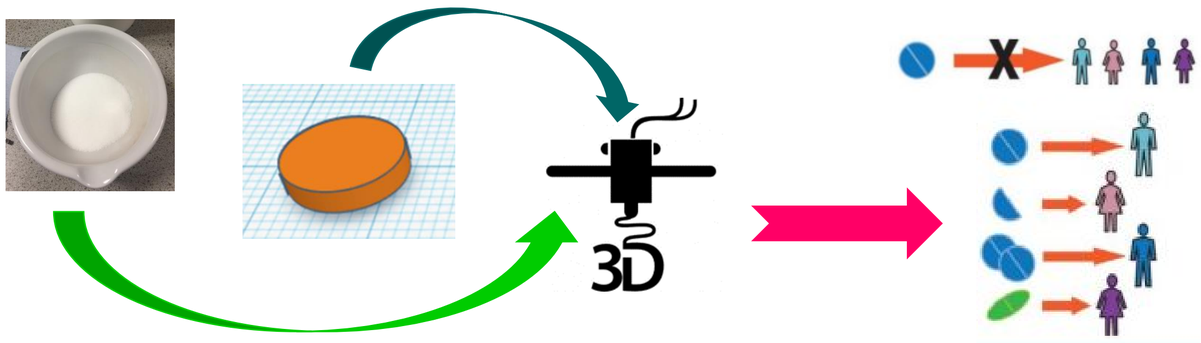
Introduction

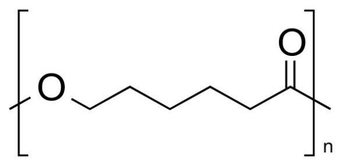
The often required frequent administration of multiple medicines to patients is sometimes inconvenient and their compliance can be compromised[1]. Personalized implants can offer a solution and 3D printing a novel method of manufacture of such systems[2].



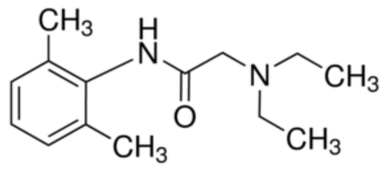
This work focuses on the fabrication of personalisable 3D printed lidocaine (LDC) loaded polycaprolactone (PCL) implants using an extrusion-based 3D printer. Here, the frequency of drug administrations could be decreased, as the implants could remain in the human body for long periods releasing the drug at a predetermined rate and profile.

Experimental Methods

3D printing of PCL-LDC 30% implants with different settings



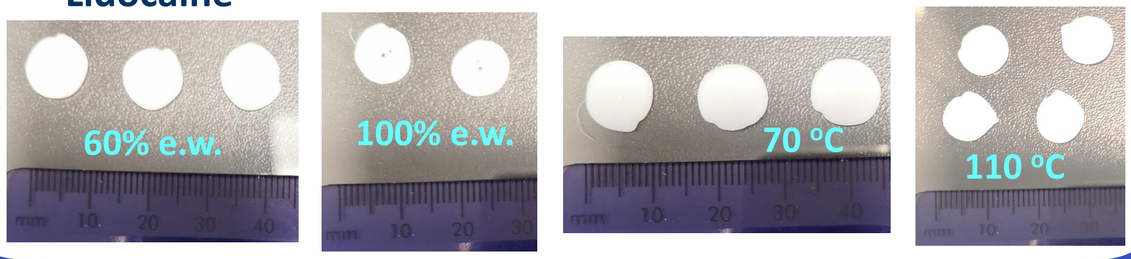
Polycaprolactone (MW 50 kDa)



Lidocaine

Disc-shaped implants were printed with different extrusion widths (e.w.) and print temperatures in order to optimise printing parameters.

Extrusion-based 3D printer



Results and Discussion

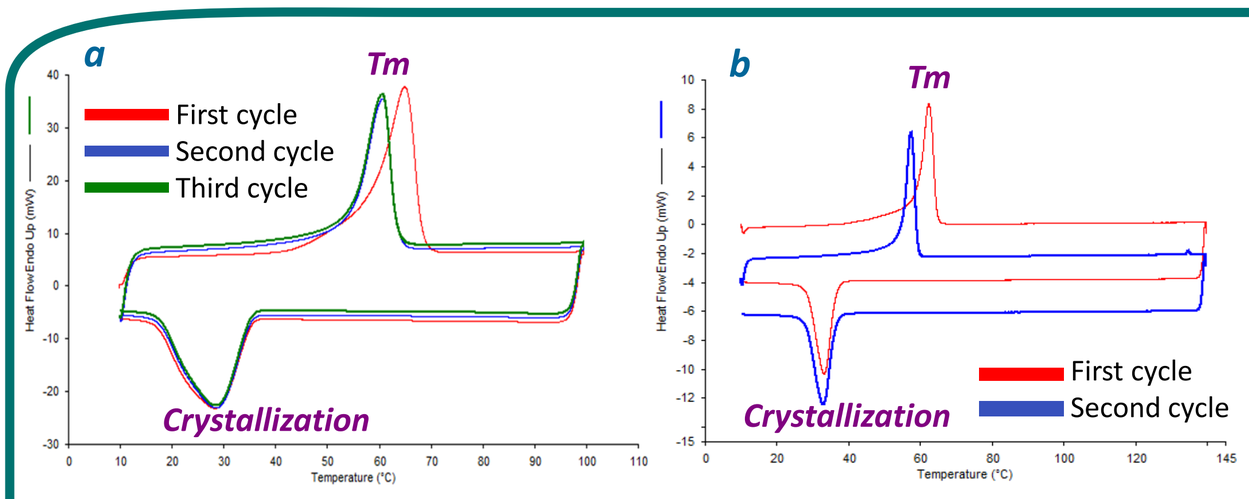


Figure 1: (a): DSC behaviour of PCL before 3D printing, ***(b):*** DSC behaviour of PCL after 3D printing at 70 °C with extrusion width 100%.

The temperature and the different extrusion widths applied during the 3D printing did not affect the thermal properties or the crystalline state of the polymer and the drug.

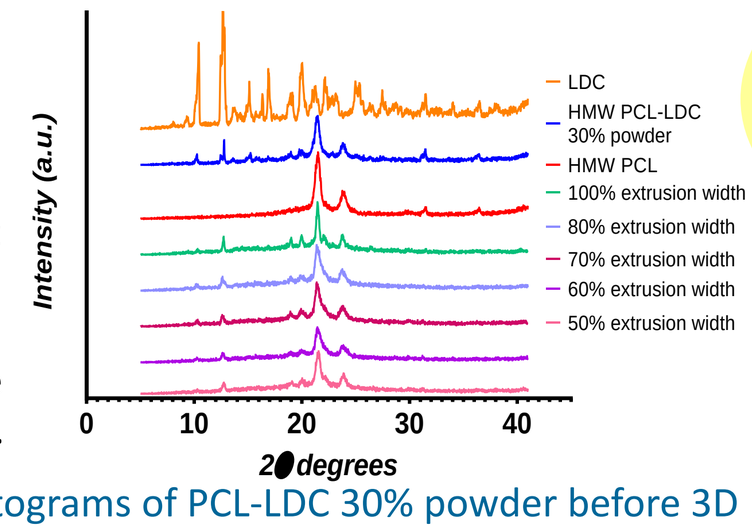
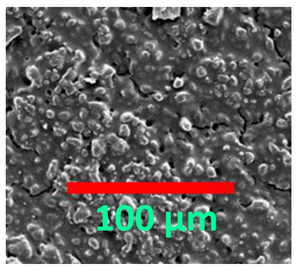


Figure 2: XRD diffractograms of PCL-LDC 30% powder before 3D printing and 3D printed implants with different extrusion width.

Characterizations of 3D printed PCL-LDC 30% implants

70 °C



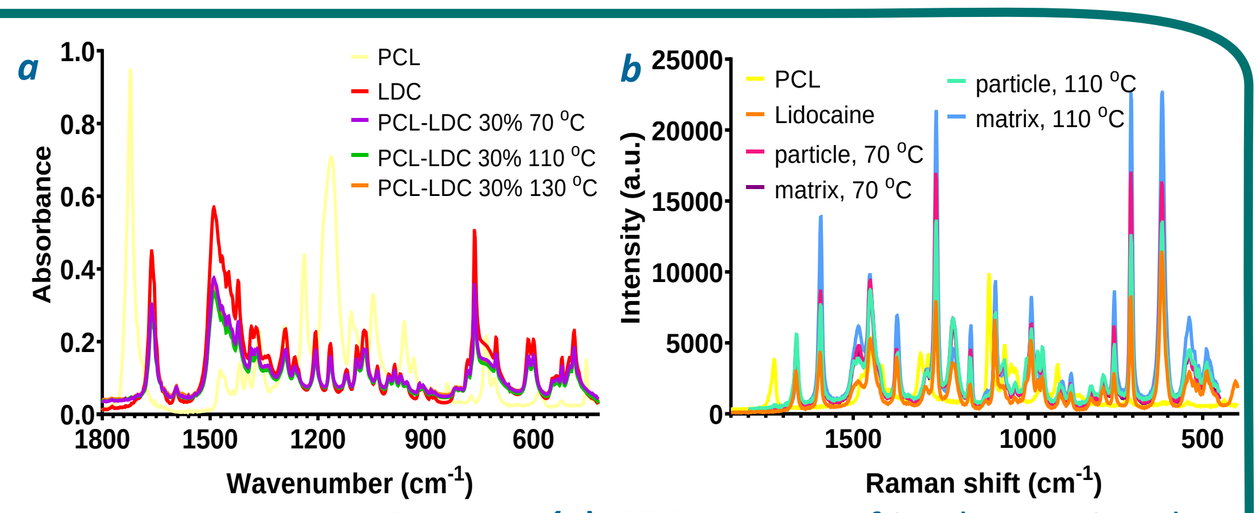
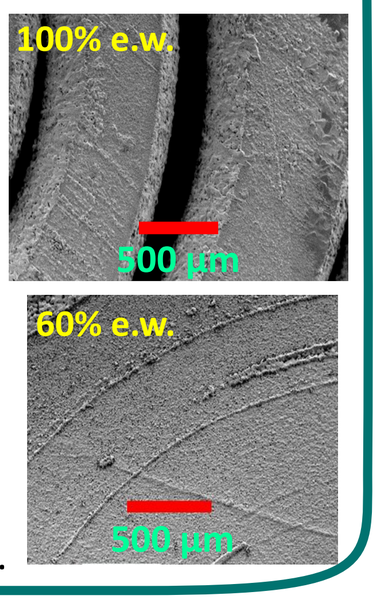


Figure 3: (a): FTIR spectra of implants printed at 70, 110, 130 °C, ***(b):*** Raman spectra of implants printed at 70 and 110 °C.

- The gap size between the printed lines of the 3D printed implants decreased towards zero as the extrusion width decreased.
- The size of the particles on the surface (matrix) of the 3D printed implants decreased as the print temperature increased.



In vitro drug release studies using a Flow-Through Cell Dissolution Apparatus (USP4)

110 °C, 35 ml/min

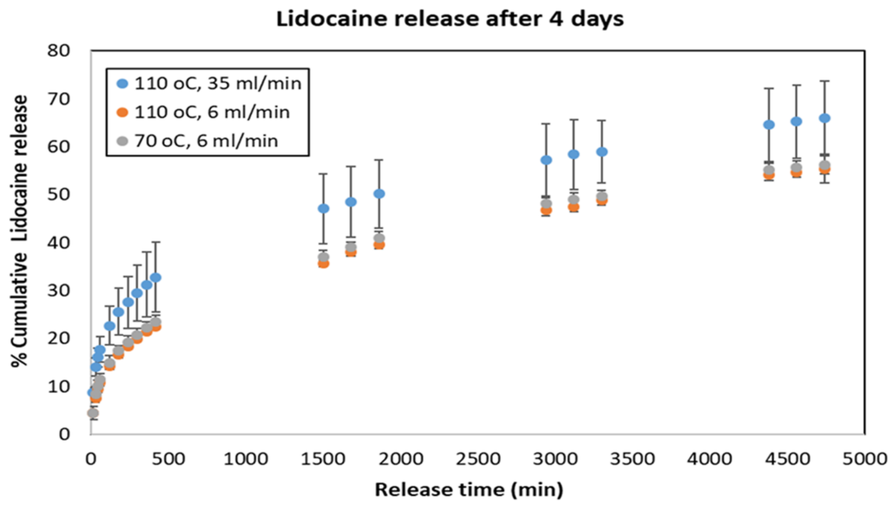
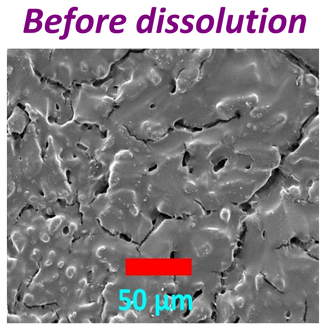


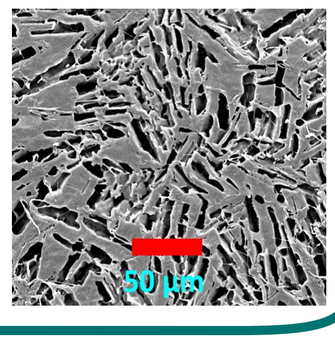
Figure 4: Release profiles of implants printed at 70 and 110 °C with different medium flow rates.

The holes on the implants matrix indicate that the drug release mechanism is diffusion related.

Before dissolution



After dissolution



Conclusions

- ❑ The manufacture of polymeric drug eluting implants using a solvent-free method, without the addition of excipients at a relatively low printing temperature with an extrusion-based 3D printer is feasible.
- ❑ PCL and LDC are in a largely crystalline state pre and post 3D printing.
- ❑ There is no chemical modification or interaction between the two compounds in the produced implants.
- ❑ Sustained drug release has been achieved with the 3D printed formulations.

References

1. Sandler, N. and Preis, M. (2016) 'Printed Drug-Delivery Systems for Improved Patient Treatment', Trends in Pharmacological Sciences. Elsevier Ltd, 37(12), pp. 1070–1080. doi: 10.1016/j.tips.2016.10.002.
2. Aquino, R. P. et al. (2018) 'Envisioning smart and sustainable healthcare: 3D Printing technologies for personalized medication', Futures. Elsevier Ltd, 103(March), pp. 35–50. doi: 10.1016/j.futures.2018.03.002.