3D printed Magnetically Deformable Hydrogels in a Granular Medium for Tissue Engineering applications

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1. Introduction

For the purpose of adding functionality to a 3D-printing ink, the application of external stimuli allows its deformation in a pre-programmed manner over time. With this new dimension, higher structural complexity of printed inks can be achieved without compromising their precision.
Within this PhD project, the response of a XG-Fe ink to a magnetic stimulation in the ambient air and in a granular gel supporting medium made by an "in-air microfluidics" process[3] will be explored.

2. Methods

1. Dispersion of Iron particles in Xanthan Gum hydrogel.
2. 3D printing of XG-Fe inks at different concentrations
3. Static and Dynamic magnetic pulling of XG-Fe inks
4. Image analysis by optical microscopy

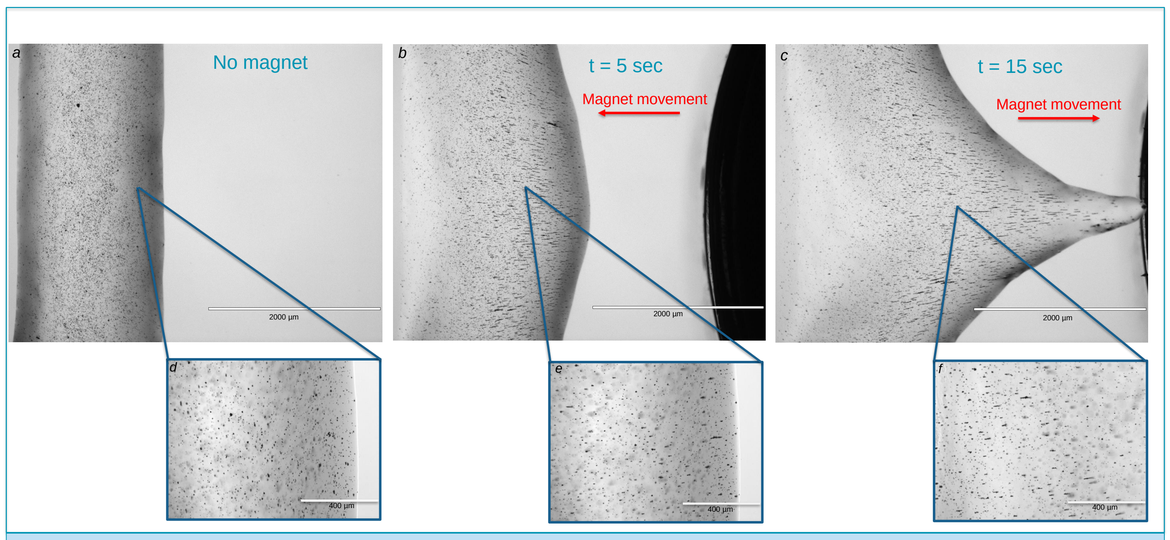

Figure 1. **Dynamic magnetic pulling** of $XG_{3\%}$-$Fe_{0.5\%}$ ink in ambient air: (a, d) Ink microstructure with no magnet around; Ink microstructure at (b, e) 5 secs and (c, f) 15 secs after placing a Neodymium magnet in movement at a few millimetres from the ink

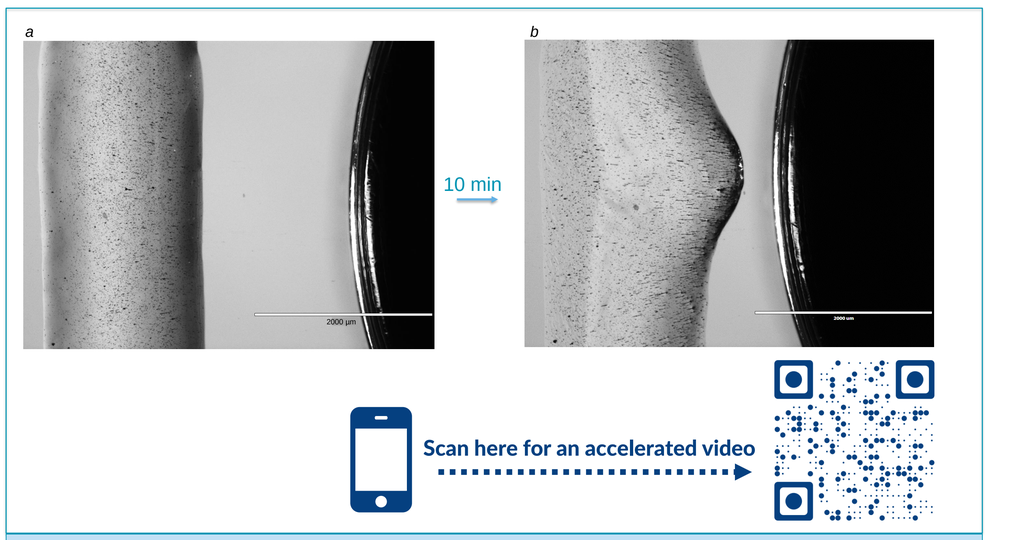

Figure 2. **Static magnetic pulling** of $XG_{3\%}$-$Fe_{0.5\%}$ ink in ambient air : Ink microstructure (a) before and (b) after placing a static Neodymium magnet at a few millimetres from the ink for 10 minutes. See the accelerated video by scanning the QR code.

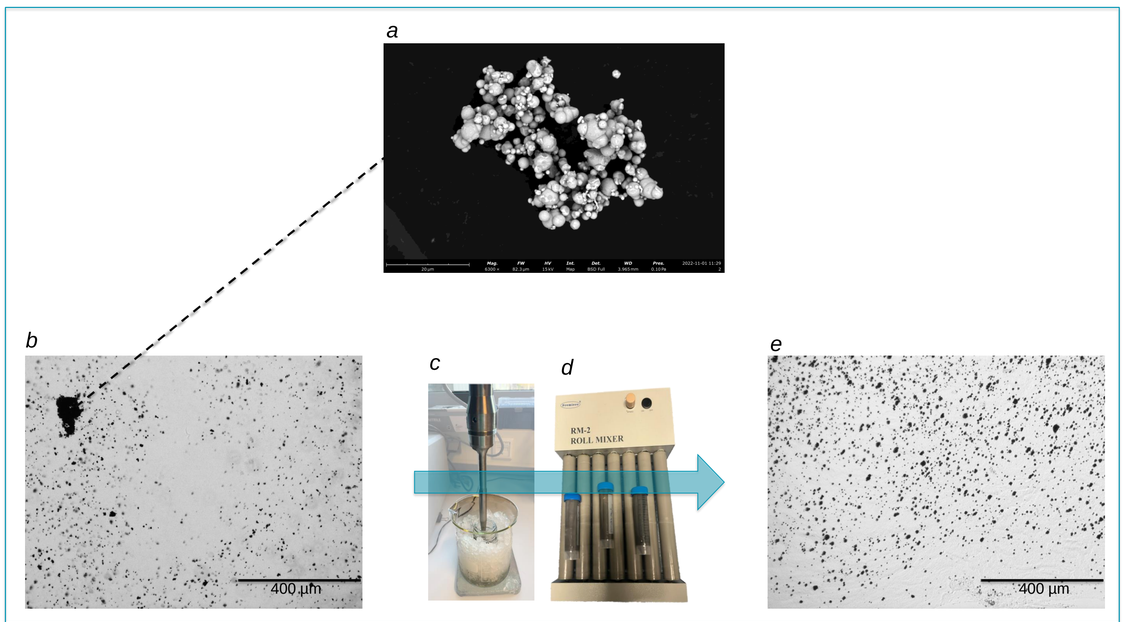

Figure 3. Preparation of Xanthan Gum/Iron inks. (a) SEM image of the iron particles in their initial state ; Ink microstructures seen by Optical Microscope highlights an (b) inhomogeneous and an (e) homogeneous dispersion of the Iron particles inside the Xanthan Gum hydrogel. The improved dispersion of the iron was done by using a (c) homogenizer and that of Xanthan Gum was done by using (d) the Roller Mixer.

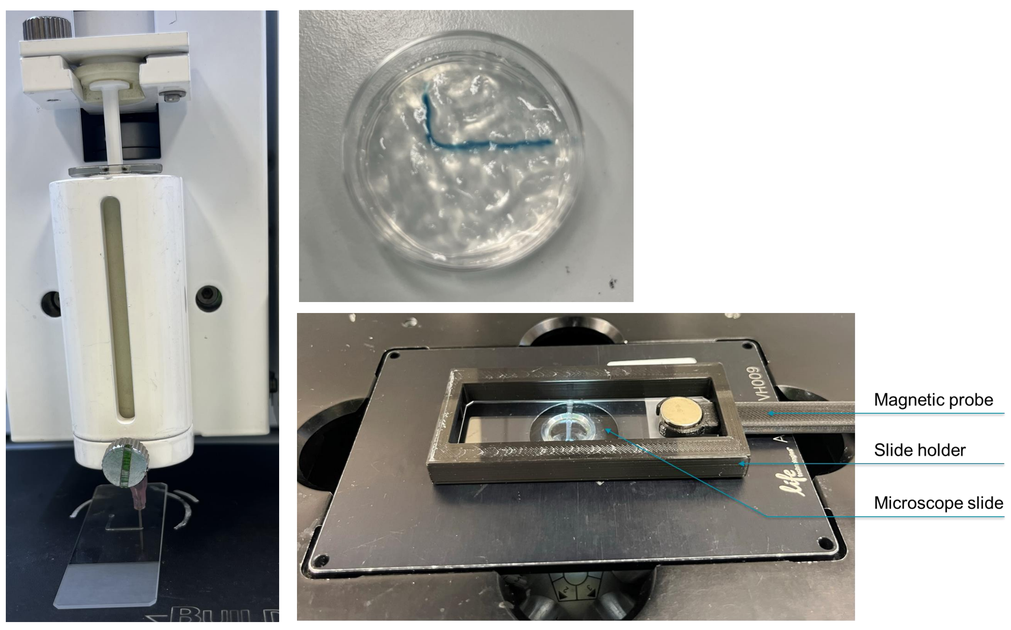

Figure 4. 3D printing of a Xanthan Gum/Iron ink in (on the left) ambient air and (on the top right) in a granular alginate medium made by the "in-air microfluidics" process. (on the bottom right) The 3D printed prototype used for the magnetic pulling of the XG-Fe ink printed in ambient air on a microscope slide using a Neodymium magnet.

3. Results

- Protocol for the creation of homogeneous XG-Fe 3D printing inks *(Figure 3)*
- Successful 3D printing of XG-Fe inks in ambient air and in the granular gel supporting medium *(Figure 4)*
- Preliminary results on the magnet manipulation steering of inks with 3% Xanthan Gum and 0.5% Iron in ambient air *(Figure 1 & 2)*

4. Discussion

- We notice a balance between magnetic pull (% Fe) and ink deformation (% XG)
- This balance will be further studied to figure out how to deform XG-Fe inks controllably in a granular medium.

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[3] In-air microfluidics enables rapid fabrication of emulsions, suspensions, and 3D modular (bio)materials | Science Advances