Corso di Dottorato di Ricerca in Scienze della Vita e dell'Ambiente - Ciclo XL

Optimizing G-hydrogels formulations for 3D bioprinting and historical heritage preservation

Rodrigo Fernandes de Almeida

Laboratorio biofisica molecolare, DiSVA Tutor: Paolo Mariani

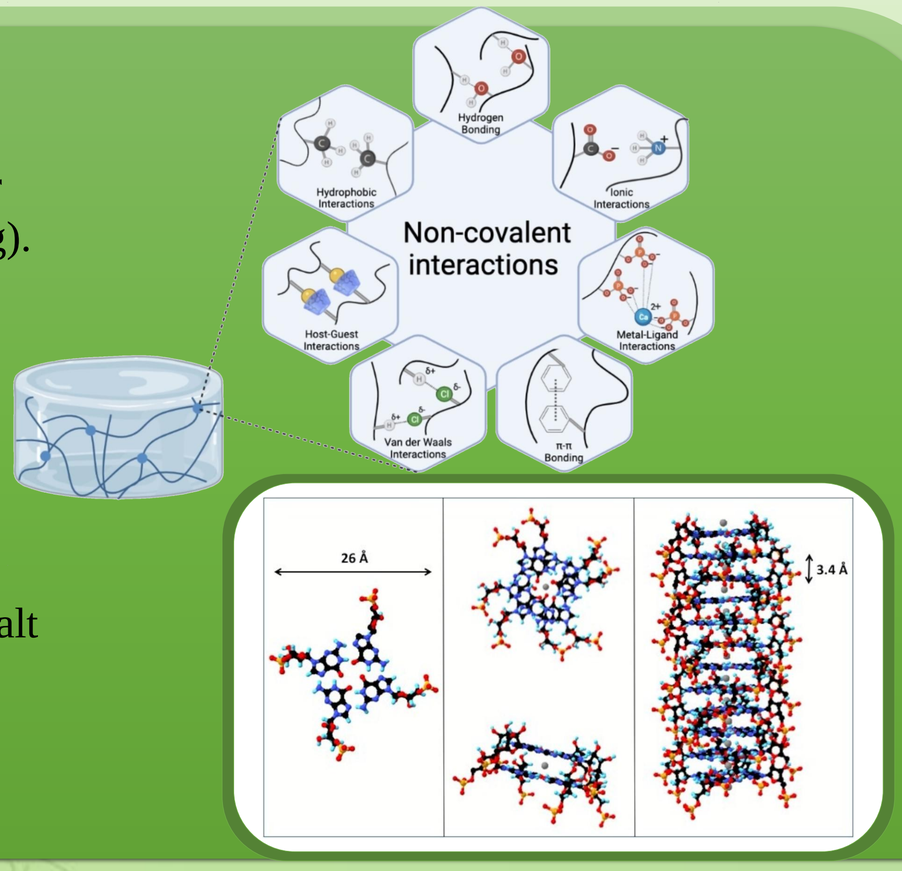
Introduction

Supramolecular gels exhibit diverse mechanical and swelling properties due to noncovalent interactions, making them a versatile tool for biological systems (extracellular matrix mimicking, drug delivery) and heritage preservation (matrix consolidation, cleaning).

Guanosine-5'-monophosphate (GMP) in water self-assembles into G-quartets that, with monovalent cations, form G-quadruplex tetrahelicoidal fibers through π-π stacking.

G-quadruplex matrix properties are primarily determined by their charge, which can be controlled by neutral guanosine (Gua) doping and salt additions.

This research aims to optimize G-hydrogels formulations for these distinct applications (3D-bioprinting and paper preservation) by adjusting hydration fraction, Gua:GMP ratio, salt content, addition of secondary gelation agents and promoting polymerization through the formation of phosphodiester bonds.



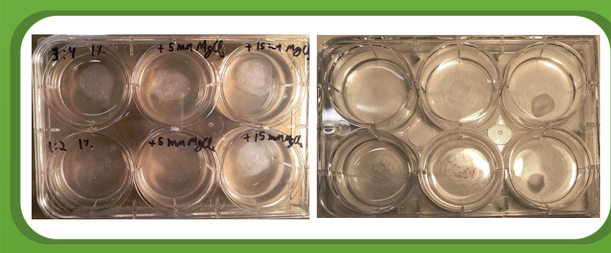
Optimization and Characterization of the G-hydrogels

Formulation

- **Gua:GMP molar ratio**
  (3:4 | 1:2 | 1:4)
- **Concentration**
  (15% | 10% | 5% w/v)
- **Addition of Gellan and Chitosan**
  Both used on cellular culture and historical heritage preservation
- **Covalent polymerization**
  Through phosphodiester bonds

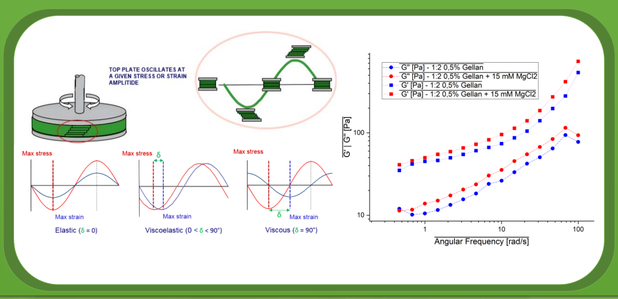
Stability

- **Erosion**
- **Swelling**
- **Gel-sol transition temp.**



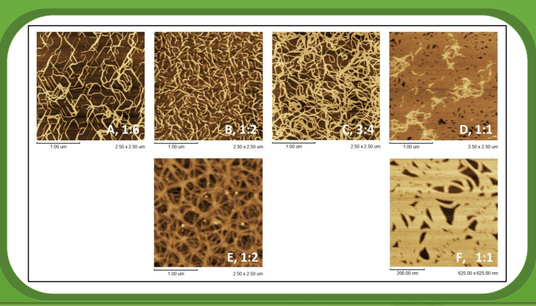
Rheology

- **Viscosity**
- **Thixotropy**
- **Creep recover**
- **Resistance to shear**
  (amplitude and frequency sweep)

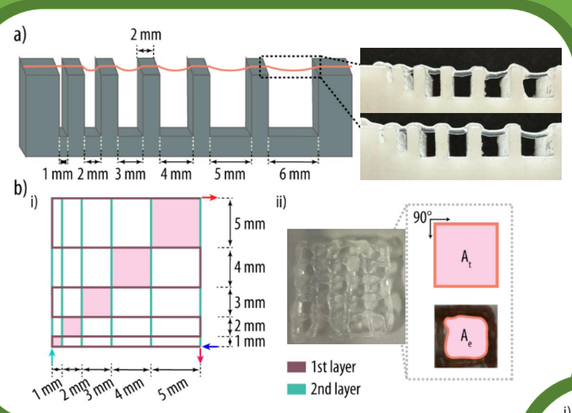


Structure

- **X Ray, neutron and light scattering**
- **FRAP**
- **FTIR and RAMAN**
- **AFM**

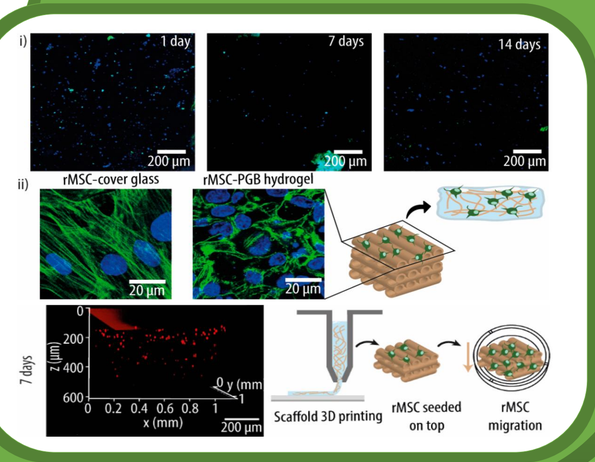


3D Bioprinting



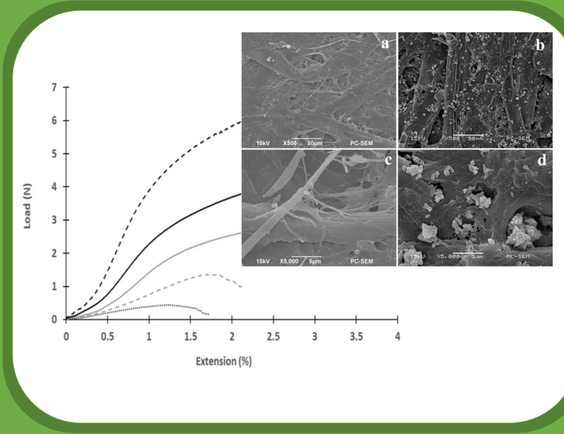
Printability:
Verify the capability of printed hydrogels of retain its shape over time and in aqueous media, as far as access the printing resolution and definition.

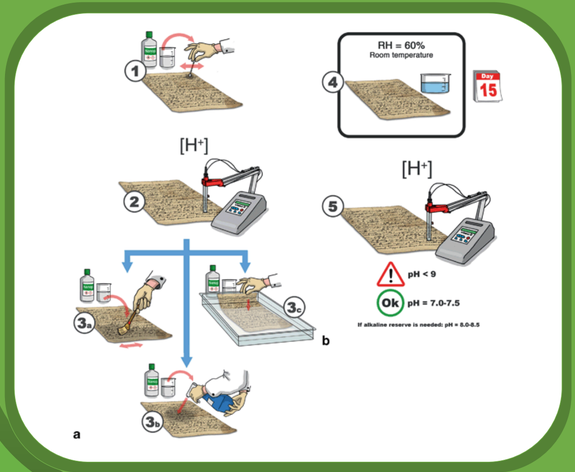
Cellular viability:
In order to use the hydrogels as bioink, biocompatibility is essential, but other factors such as enabling cellular adhesion and promoting cellular migration and propagation are also fundamental.



Paper preservation

Consolidation:
Aims to stabilize and reinforce the paper structure by adding the gelation agents solutions to paper to use the gel fibers as a scaffold to sustain the paper fibers. Other additives can also prevent oxidation and acidification





Conservation:
Use the hydrogel as a release system of surfactants, alkalizing and antioxidant agents to clean and stabilize the paper, preventing the degradation process caused by acidification and oxidation of the cellulose fibers.

Ref.: **[1]** F. Carducci, J. S. Yoneda, R. Itri, and P. Mariani, "On the structural stability of guanosine-based supramolecular hydrogels," Soft Matter, vol. 14, no. 15, pp. 2938–2948, 2018 **[2]** S. Li, J. Tang, L. Jiang, and L. Jiao, "Conservation of aged paper using reduced cellulose nanofibrils/aminopropyltriethoxysilane modified CaCO3 particles coating," International Journal of Biological Macromolecules, vol. 255, p. 128254, Jan. 2024
[3] M. Merino-Gómez, J. Gil, R. A. Perez, and M. Godoy-Gallardo, "Polydopamine Incorporation Enhances Cell Differentiation and Antibacterial Properties of 3D-Printed Guanosine-Borate Hydrogels for Functional Tissue Regeneration," IJMS, vol. 24, no. 4, p. 4224, Feb. 2023