Biohydrogel 3D printing: a feasible circular economy strategy for eco-friendly cellulose obtention from olive waste and its application various fields

I. D. Perez*, F. J. Navas-Martos and M. D. La Rubia***

**Department of Chemical, Environmental and Materials Engineering, University of Jaén, Spain*
**University Institute for Research in Olive Grove and Olive Oil (INUO), University of Jaén, Spain*
(E-mail: idias@ujaen.es)
***Andaltec Technology Center, Martos, Jaén, Spain*

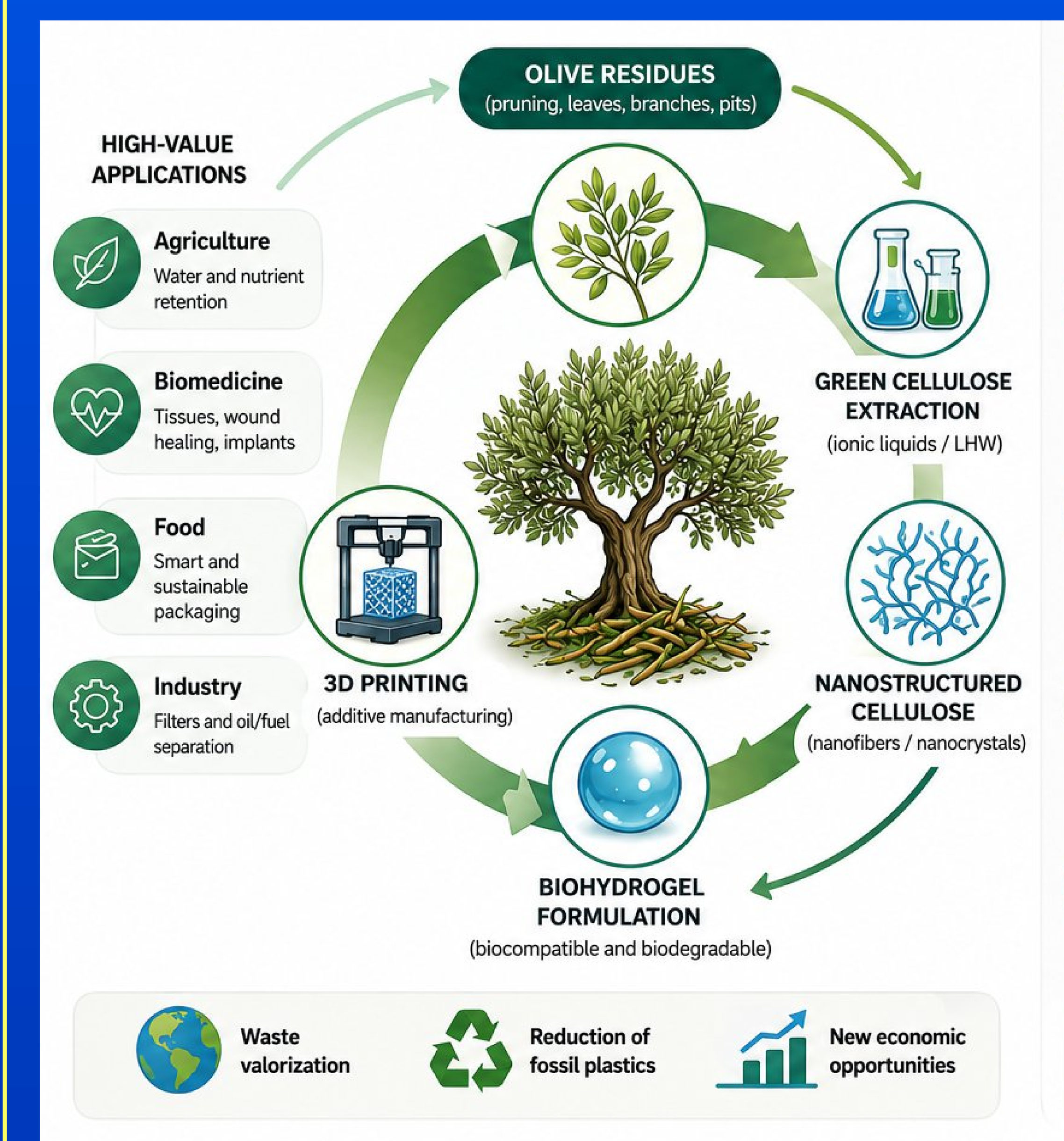

Figure 1: From olive residues to biohydrogel

Introduction

Agricultural waste is becoming an increasingly important issue, with Mediterranean countries that produce farm olives accounting for about 70 % of products, which end up unused, causing severe economic and environmental challenges.

Supported by the Marie Skłodowska-Curie Actions programme, the HYDROGEL0LIVE3D project will develop a solution for extracting cellulose from olive waste to produce valuable biohydrogels (BHGs), while also encouraging sustainable resource management and waste valorisation.

The project will use expertise in 3D printing technologies, agriculture, waste valorisation, and green materials science, combining these fields to develop functional and sustainable materials from agricultural waste and progress the farm sector's transition into a circular economy (Figure 1).

Methodology

Two hydrogel formulations were synthesised, differing according to the cellulose source, and their performance was preliminarily assessed through swelling behavior (Figure 2).

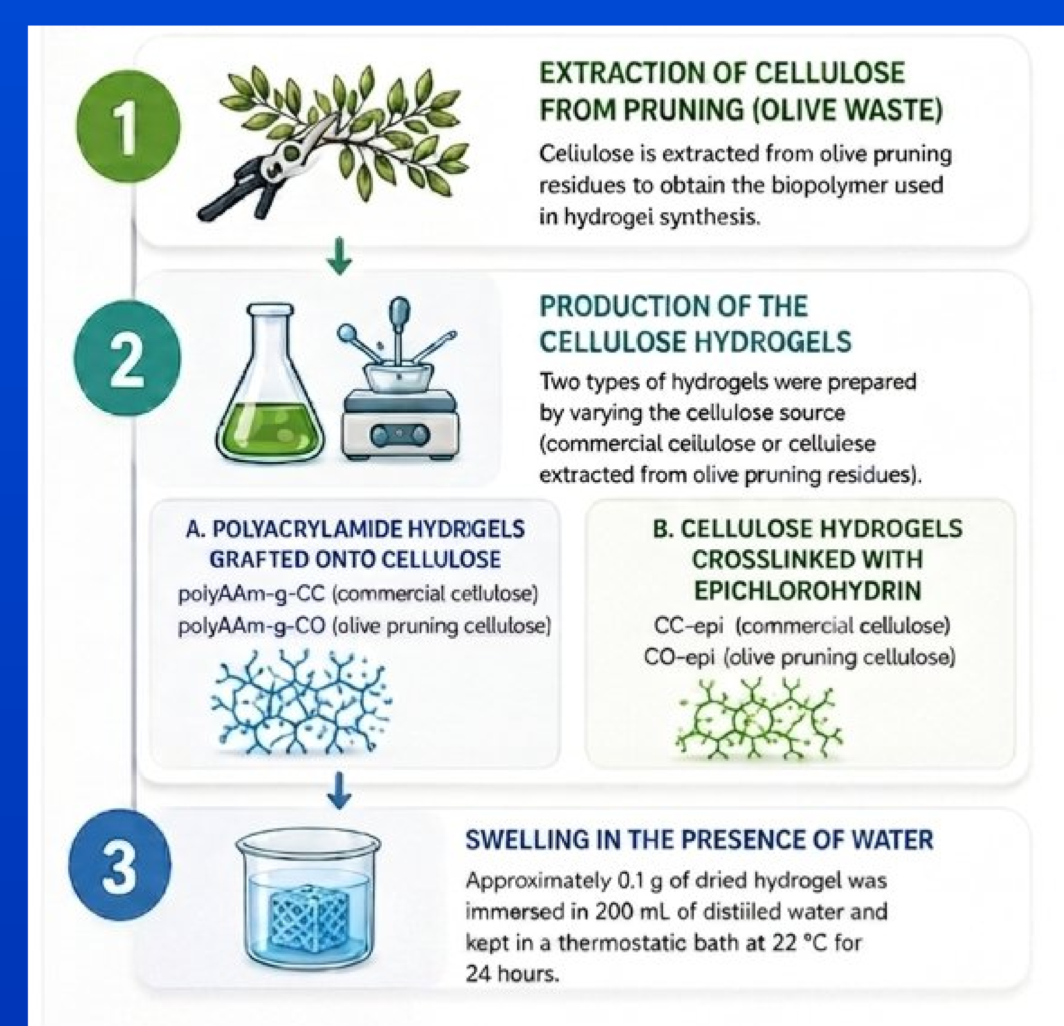

Figure 2: Methodology in 3 steps

Results & Discussion

- The swelling degrees were:
  - 10.07 $g.g^{-1}$ for polyAAm-g-CO
  - 9.80 $g.g^{-1}$ for polyAAm-g-CC
  - 6.36 $g.g^{-1}$ for CO-epi
  - 3.74 $g.g^{-1}$ for CC-epi
- Acrylamide Dominance: Acrylamide-based hydrogels achieve the highest swelling degrees due to their highly hydrophilic nature and flexible polymer chains.
- Cellulose Influence: The source of cellulose is secondary in hybrid systems but becomes critical in pure cellulose hydrogels, where it dictates the final network structure.
- Crosslinking Effects: Epichlorohydrin creates denser, more rigid ether-linked networks, which significantly limits water diffusion and swelling capacity.
- Mass vs. Dimension: Gravimetric swelling (water mass) does not always correlate with physical expansion; structural response depends on internal water distribution (Figure 3).
- Sustainability Goal: Cellulose extracted from olive pruning waste is a viable, high-performance renewable precursor for sustainable bio-based materials.

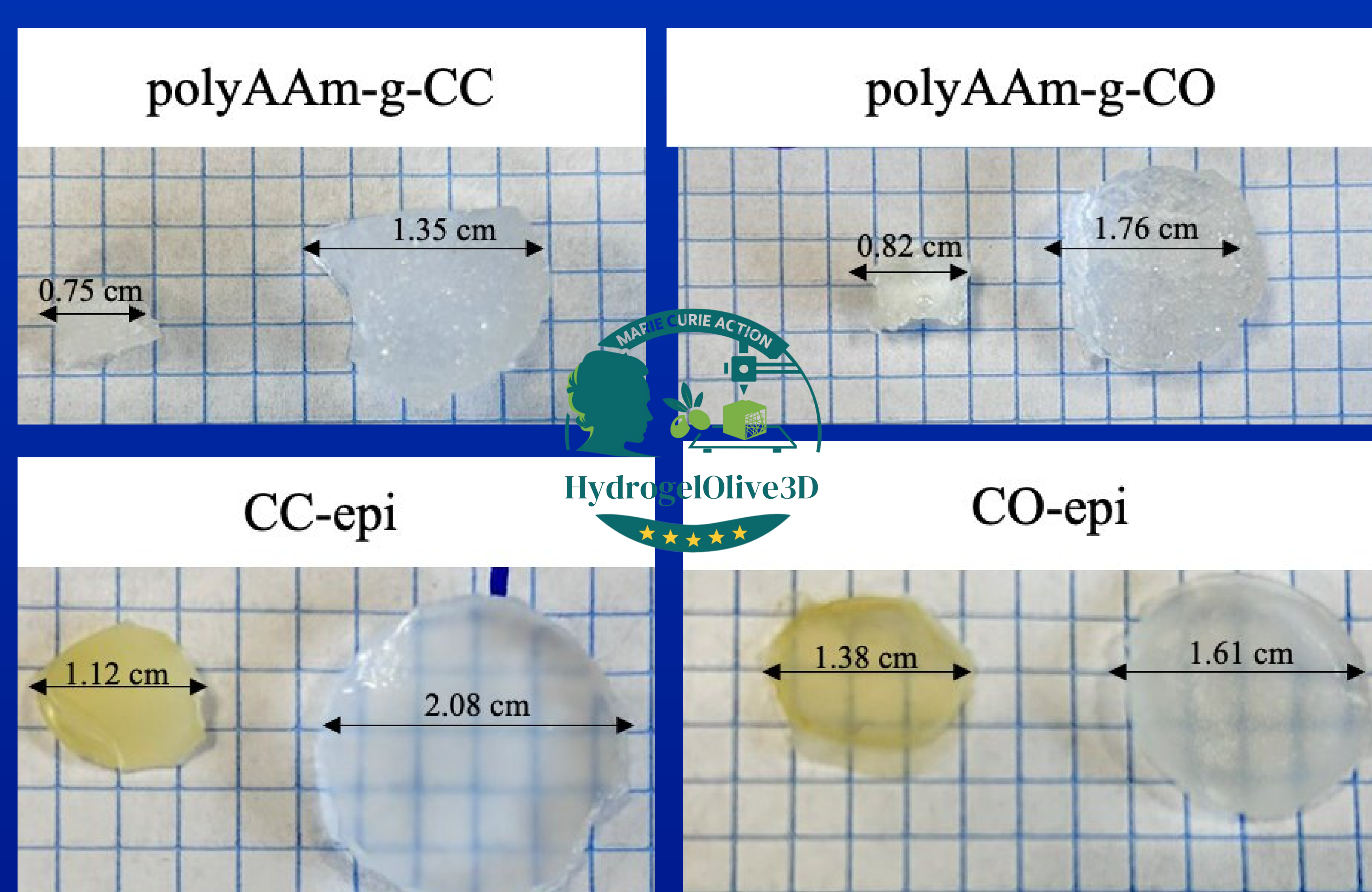

Figure 3: Comparison of cellulose-based hydrogels in the dried state and after 24 h of swelling

Conclusions

These preliminary results highlight the potential of olive pruning-derived cellulose as a sustainable biomaterial within a circular economy framework. The extracted cellulose showed promising gravimetric swelling, demonstrating its suitability as a renewable precursor for hydrogel production. As a first step toward 3D hydrogel fabrication, further structural, thermal, morphological, and mechanical analyses will be conducted to better understand the network structure, explain the swelling behavior, and evaluate the material's properties and potential applications.

Acknowledgement

This paper is part of the HYDROGEL0LIVE3D project that has received funding from the European Union's Horizon Europe research and innovation program under the Marie Skłodowska-Curie Actions (MSCA) grant agreement No 101209650.

Instituto Universitario de Investigación en Olivar y Aceites de Oliva

UJA. Universidad de Jaén

Funded by the European Union

andaltec