FLEXIBLE CRYOSTRUCTURATED PVA-BASED HYDROGELS AS MATERIALS FOR ADVANCED SENSING APPLICATION

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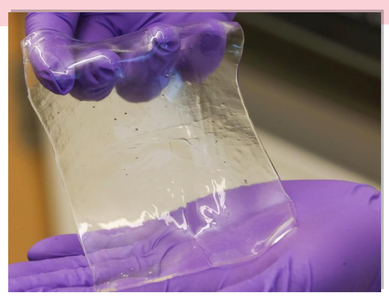
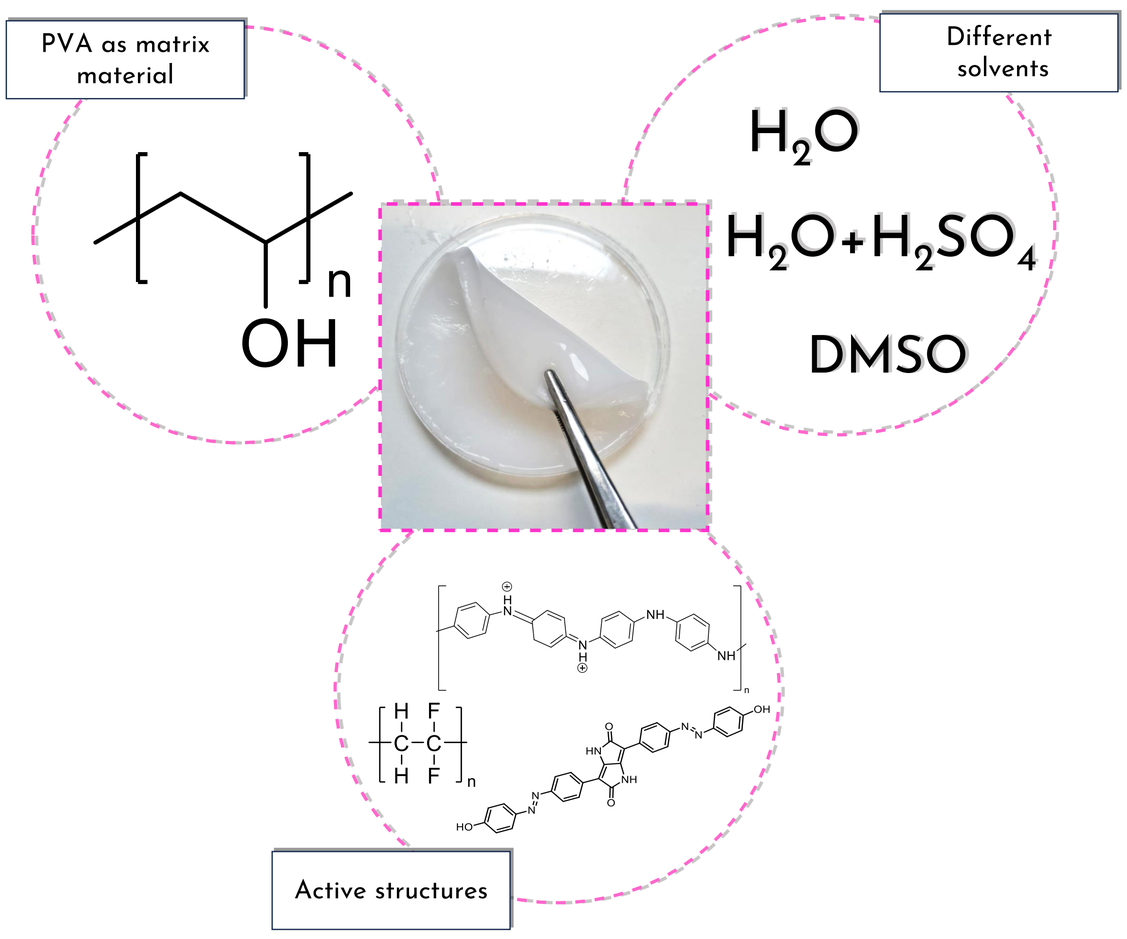
INTRODUCTION



Flexible polymeric materials have highlighted several advantages including low density, easy processing and excellent resistance under mechanical stimuli. Nowadays they have seen wide spread, thanks to their attractive properties that make them suitable for sensing in different fields (healthcare, security, environmental monitoring, food safety, agriculture) and for cutting-edge energy storage. Among them, PVA-based hydrogels, can be considered a promising material for their versatility and safety.[1]

In this work, physical cross-linked PVA hydrogels were cryo-structurated in acidic media by freezing-thawing (F-T) methodology. Different parameters (e.g. number of F-T cycles) have been investigated to evaluate the influence of the preparation method on the final material properties.[2] Moreover, their porous structure creates a preferred path for charges and external factors as vapours, gases and liquid solutions giving the possibility to be evaluated as a promising matrix for sensing applications studied by electrochemical measurements

HYDROGELS COMPONENTS



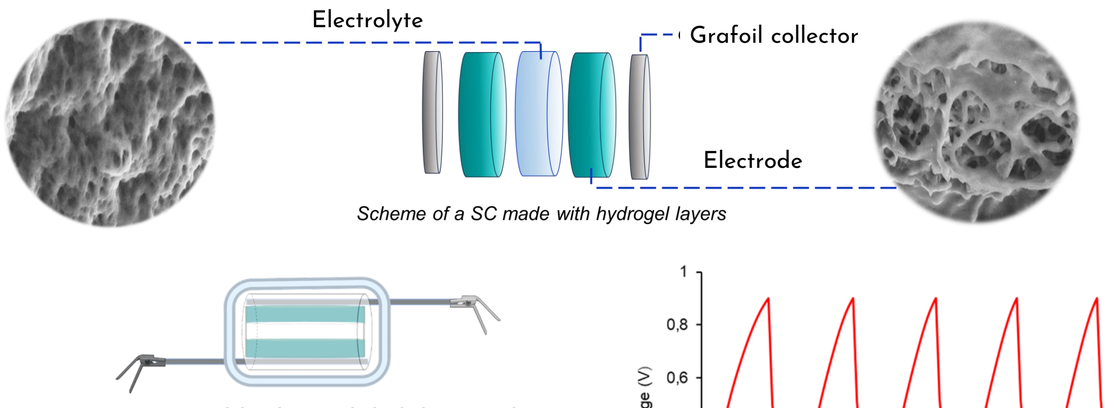
HYDROGELS PREPARATION

PVA dilssolution in a specific solvent → Solution sonication for bubbles remotion → Introduction of the solution in a Petri dish → Freezing-thawing cycles

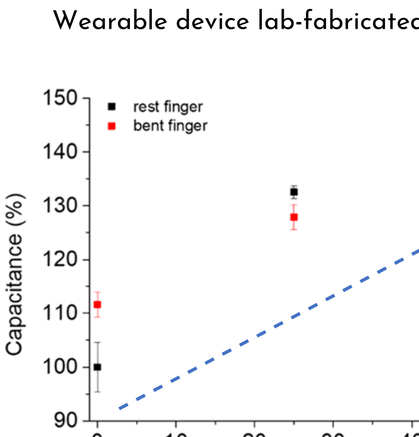
Freezing-thawing cross-linking method

During each cycle, the water freezes and expands, pushing the PVA chains into close contact with each other. This mechanism decreases the distance between the PVA chains, facilitating physical cross-links among the PVA chains via hydrogen bonding and formation of crystalline regions.

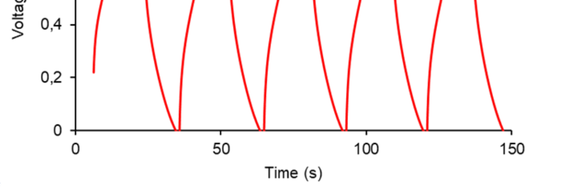
WEARABLE DEVICE FOR BIO-MEDICAL APPLICATIONS

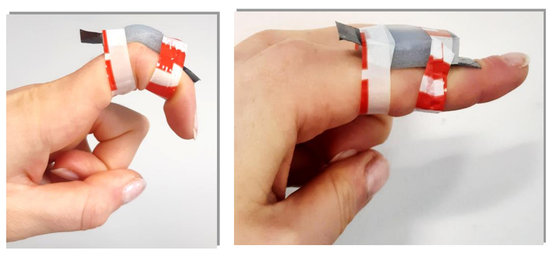


Scheme of a SC made with hydrogel layers



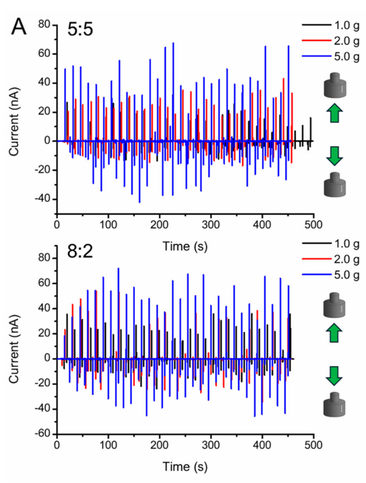
Wearable device lab-fabricated

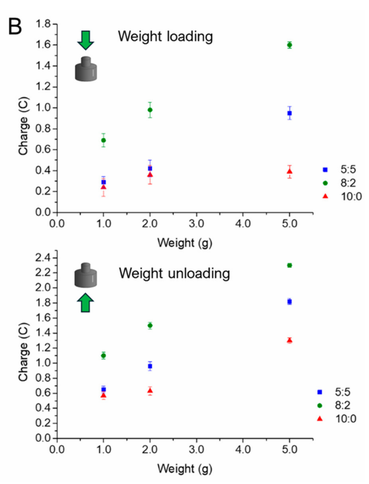




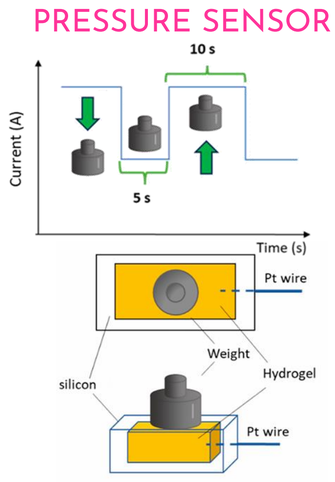
To investigate the device's performances under mechanical deformation in a relevant environment, the SC was encapsulated in a silicone shell and subsequentially evaluated in terms of capacitance while undergoing finger bending deformation and after 25 and 50 bending cycles.

A distinctive preparation process involving freezing-thawing and solvent replacement was optimized to prepare PVA/PVDF composite hydrogels as materials with promising properties for bio-medical applications.

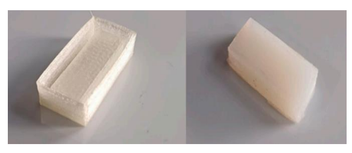


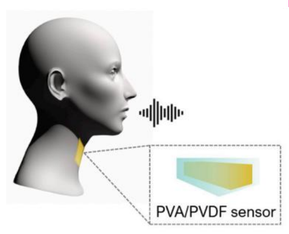


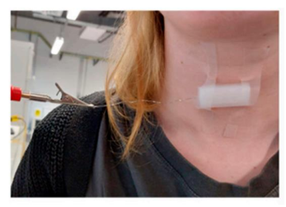
PRESSURE SENSOR

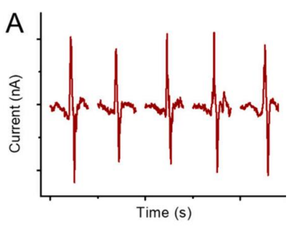


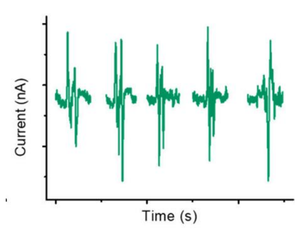
HUMAN VOICE SENSOR

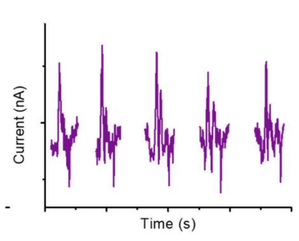






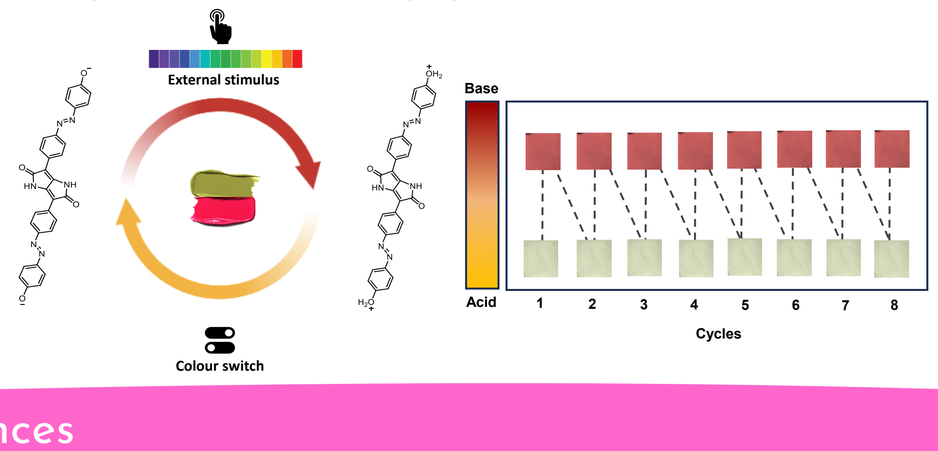






pH-RESPONSIVE HYDROGELS

A pH-responsive dye based on azobenzene-substituted iso-diketopyrrolpyrroles (i-DPP) was integrated in hydrogel matrix before the freezing-thawing cycles and subsequently cryostructured. The final functional hydrogels were applied as acid-base switchable probe for colorimetric polymeric sensor.



CONCLUSIONS

The integration of active molecules into PVA-based hydrogel matrices has demonstrated promising results for the development of innovative sensing systems. The obtained materials exhibit favorable properties—such as responsiveness, and stability—that make them suitable for a wide range of sensing applications, including biomedical diagnostics and environmental monitoring. These preliminary outcomes pave the way for further optimization and functionalization of the hydrogel systems, with the potential to enable advanced, versatile platforms for real-time and selective detection in diverse fields.

The encouraging preliminary results highlight the versatility of the hydrogel platform and open new perspectives for its further functionalization and adaptation.

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References

[1] Li, L.; Han, L.; Hu, H.; Zhang, R.; A review on polymers and their composites for flexible electronics. Mater. Adv. 2023, 4, 726-746. *DOI: 10.1039/D2MA00940D*

[2] Giovagnoli, A.; et al.; Multi-Layer PVA-PANI Conductive Hydrogel for Symmetrical Supercapacitors: Preparation and Characterization, GELS, 2024, 10 (7), 458. *DOI: https://dx.doi.org/10.3390/gels10070458*