Tribomechanical behaviour of gamma-irradiated Nomex® reinforced poly(vinyl alcohol)-based hydrogels for articular cartilage replacement

Francisco Santos [a], Andreia Sofia Oliveira [a,c], Célio Figueiredo-Pina[b,c], Ana Paula Serro [a,d]

[a] Centro de Química Estrutural (CQE), Institute of Molecular Sciences, Departamento de Engenharia Química, Instituto Superior Técnico, Universidade de Lisboa; [b] CDP2T, Escola Superior de Tecnologia de Setúbal, Instituto Politécnico de Setúbal; [c] CeFEMA, Instituto Superior Técnico, Universidade de Lisboa; [d] Centro de Investigação Interdisciplinar Egas Moniz (CiiEM), Instituto Universitário Egas Moniz

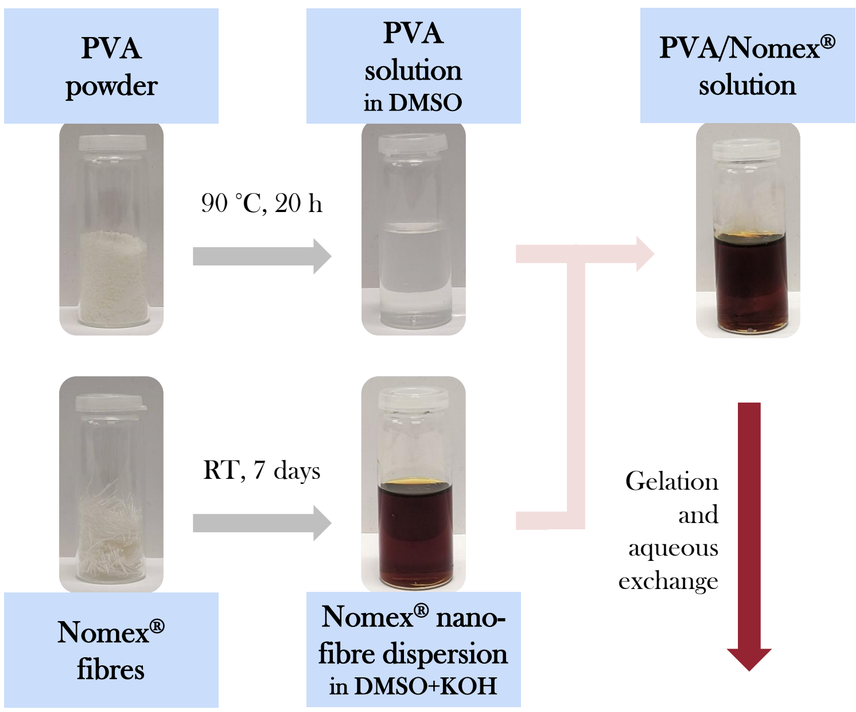
INTRODUCTION

Articular cartilage is a strong and durable tissue which provides shock absorption and a low friction and wear resistant surface within joints [1]. However, due to pathologies, such as osteoarthritis, this tissue can be damaged beyond the body's natural healing capacity, affecting the quality of life of millions worldwide [2].

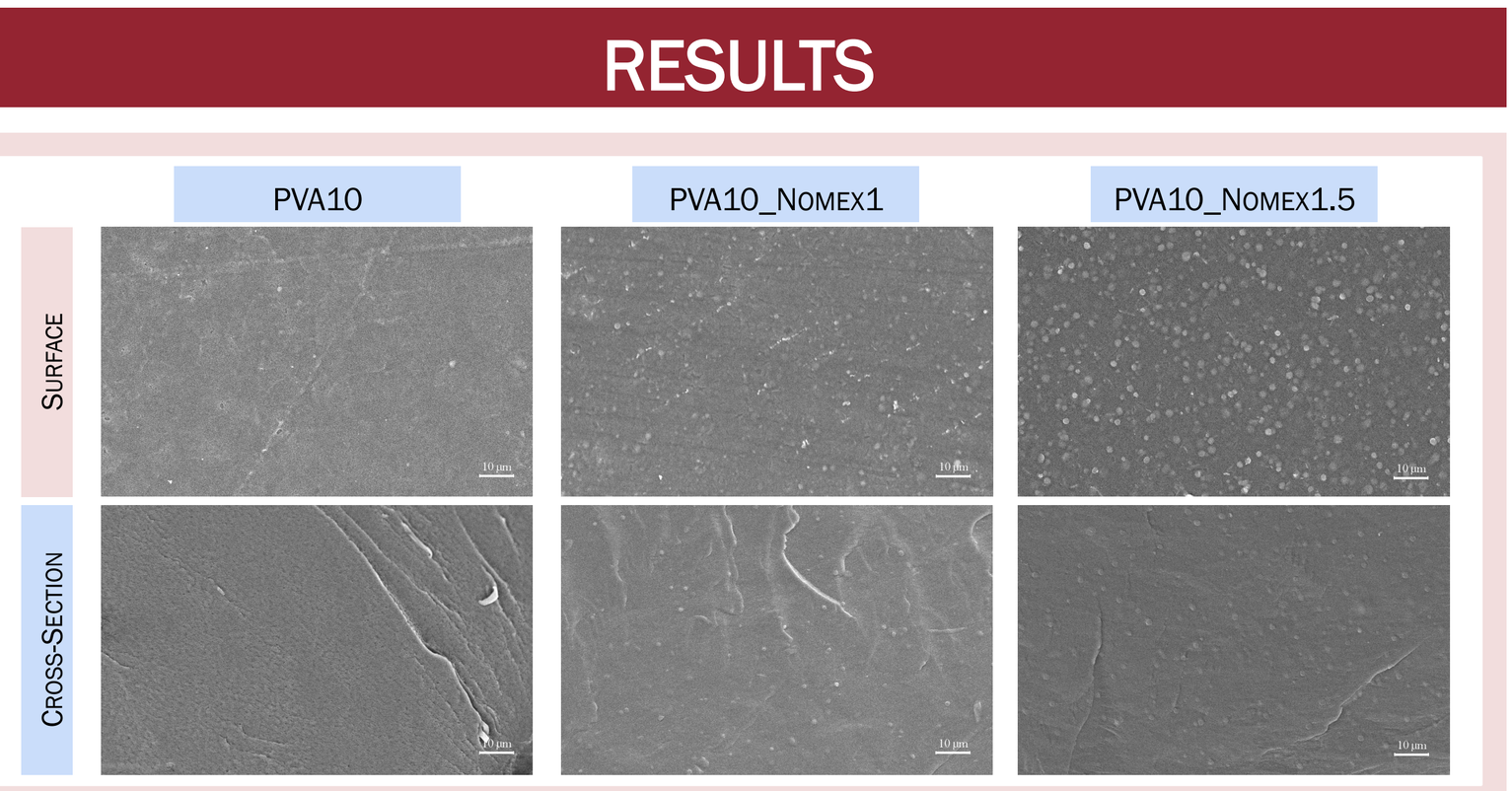
Due to the limitations of current therapies, **hydrogels**, particularly those based on **PVA**, have raised special interest given that they are biocompatible and have good biotribological performance. Still, their mechanical properties are not able to replicate those of native cartilage [3].

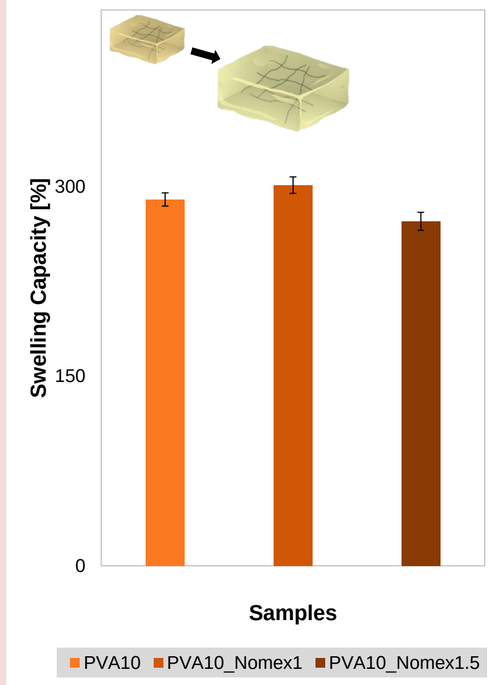
In this work, it was evaluated the possibility of reinforcing PVA hydrogels with Nomex®, a fibre known for its high mechanical toughness, flexibility, and resilience [4].

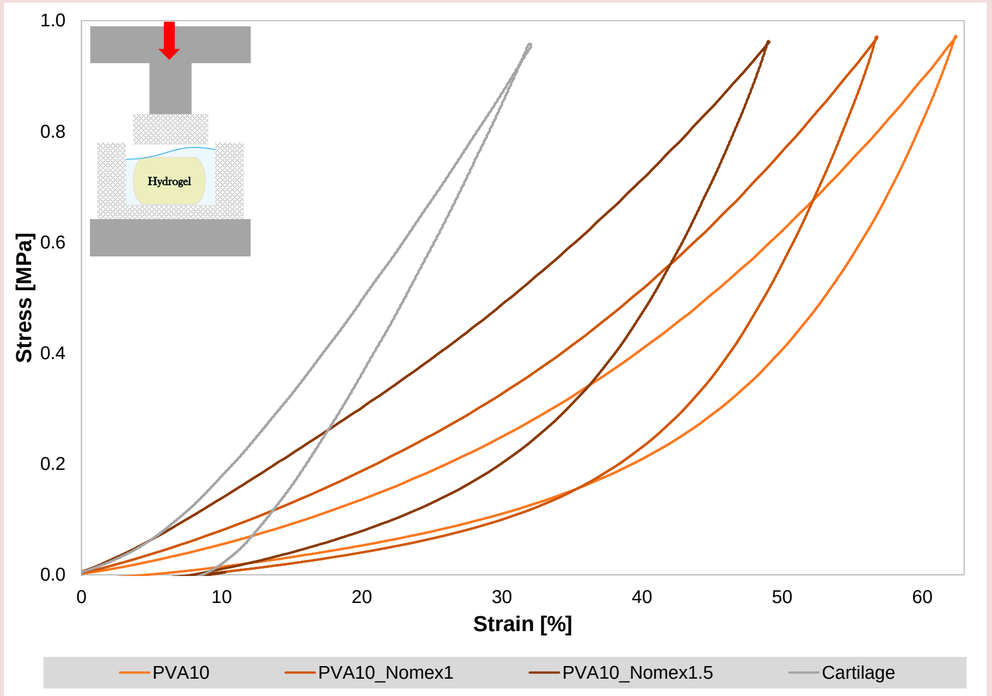
METHODS

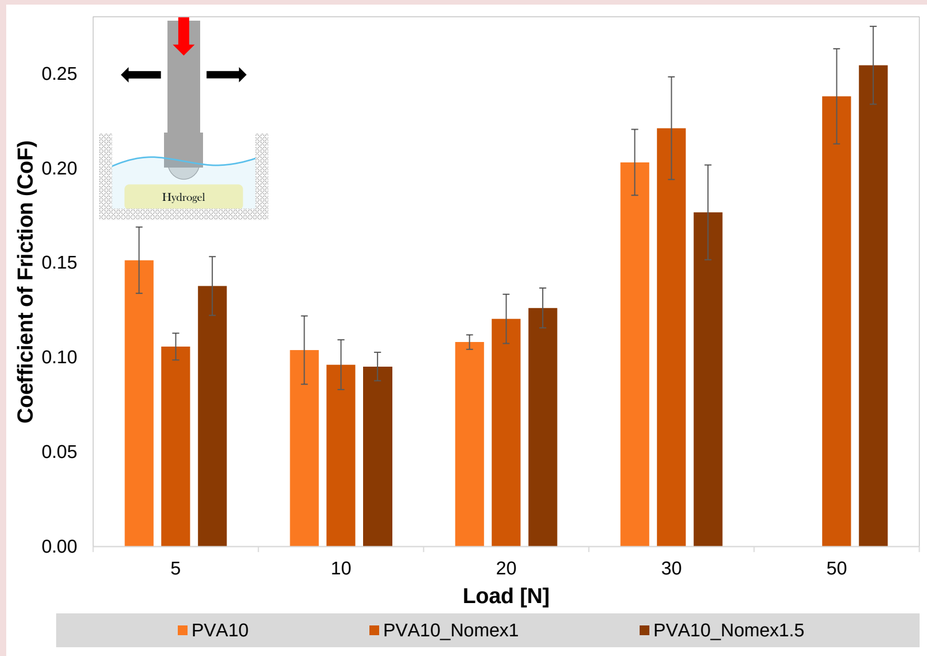


RESULTS









SEM images show the micro-structure of the samples, in which all the hydrogels present a smooth surface and compact structure.

The **SWELLING CAPACITY** of hydrogels is within the range of natural articular cartilage (~300%), with the **WATER CONTACT ANGLES** indicating that all the materials are hydrophilic (< 48°).

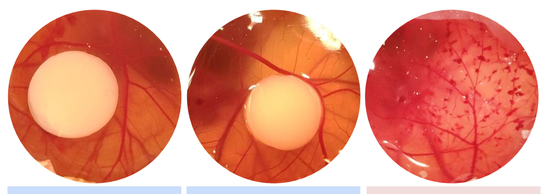
The increase in the Nomex® nanofibers content led to an increase of the **COMPRESSIVE** strength of the hydrogels, approaching the behaviour of human cartilage.

The **TRIBOLOGICAL** behaviour showed **larger CoF values with the increase of the normal load** applied, associated to the higher deformation of the hydrogels, that increases the contact area with the counterbody and promotes the adhesion between the surfaces.

The Nomex® nanofibers did not affect significantly the CoF observed at each load, but increased to force withstood.

The hydrogels' CoF are around half of that of natural articular cartilage measured under the same conditions, for load 10 N [1].

Materials are **BIOCOMPATIBLE** (cell viability > 70%) and **NON-IRRITATING** (HET-CAM test)



CONCLUSION

- It was possible to prepare PVA hydrogels reinforced with meta-aramid nanofibres obtained from Nomex® for the first time.
- The reinforcement of PVA hydrogels with 1.5% Nomex® nanofibres followed by sterilization with gamma-radiation allowed to obtain homogeneous hydrogels with a mechanical behaviour under compression significantly superior to PVA and friction coefficients lower than that observed for natural cartilage tested in the same conditions.

References

[1] A. S. Oliveira, O. Seidi, N. Ribeiro, et. al., "Tribomechanical Comparison between PVA Hydrogels Obtained Using Different Processing Conditions and Human Cartilage," Mater. 2019, Vol. 12, Page 3413, 2019; [2] M. Cross et al., "The global burden of hip and knee osteoarthritis: estimates from the Global Burden of Disease 2010 study," Ann. Rheum. Dis., vol. 73, no. 7, pp. 1323–1330, 2014; [3] A. S. Oliveira et al., "Tough and Low Friction Polyvinyl Alcohol Hydrogels Loaded with Anti-inflammatories for Cartilage Replacement," Lubr. 2020, Vol. 8, Page 36, 2020; [4] DuPont Technical guide for Nomex® fiber, 2019.

Acknowledgements

To Fundação para a Ciência e a Tecnologia (FCT) by funding through the research project PTDC/CTM-CTM/29593/2017 and the unit projects UID/QUI/00100/2019 (CQE), and UID/CTM/04540/2020 (CeFEMA).