The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Investigate the capability of microstructure based computational model to predict the inelastic properties of biopolymer aerogels

Rajesh Chandrasekaran[1], Markus Hillgärtner[1], Barbara Milow[2], Mikhail Itskov[1], and Ameya Rege[2]

[1] Department of Continuum Mechanics, RWTH Aachen University, Aachen,
chandrasekaran@km.rwth-aachen.de and https://www.km.rwth-aachen.de
[2] Institute of Material Research, German Aerospace Center, Cologne,
Ameya.Rege@dlr.de and https://dlr.de/wf

Key Words: *Biopolymer aerogels, Large strains, Cyclic loading, Inelasticity, Damage model, Finite element methods.*

Biopolymer aerogels are nanoporous open cellular solids characterised by a fibrillar morphology composed of an interconnected cellular network. They are used in tissue engineering, as scaffolds, due to their biocompatibility and biodegradability. For such applications, a detailed study on their pore-structure and mechanical properties is vital. The bulk mechanical response of such nanoporous materials is highly influenced by their microstructural properties which can be tailored during the synthesis process. The highly irregular pore-structure of biopolymer aerogels can be computationally reconstructed using a sphere packing and Laguerre-Voronoi tessellation [1]. The obtained Voronoi structure adheres well to the real pore-size distribution of biopolymer aerogels [1, 2]. The mechanical structure-property relationship is further investigated by means of finite element methods using periodic representative volume elements. The macroscopic stress-strain response of the computational model at low compressive strain shows very good agreement with the experimental data [1]. At high strain levels, open-porous cellular materials undergo pore collapse and hardening of the network resulting in a plateau and a densification regime in the stress-strain response, respectively [4]. Under cyclic loading, biopolymer-based aerogels show elastoplastic behaviour with large permanent set [5]. In this contribution, such inelastic responses at large compressive strain and cyclic loading are investigated using the developed computational model. Furthermore, the response of the model under tensile loading is discussed.

REFERENCES

[1] R. Chandrasekaran, M. Hillgärtner, K. Ganesan, B. Milow, M. Itskov and A. Rege, Computational design of biopolymer aerogels and predictive modelling of their nanostructure and mechanical behaviour. *Scientific reports*, 11(1), pp. 1-10, 2021.

[2] A. Rege, M. Hillgärtner and M. Itskov, Mechanics of biopolymer aerogels based on microstructures generated from 2-d Voronoi tessellations. *The Journal of Supercritical Fluids*, 151, pp. 24-29, 2019.

[3] A. Rege, Constitutive Modeling of the Densification Behavior in Open-Porous Cellular Solids. *Materials*, 14(11), pp. 2731, 2021.

[4] V. Santos-Rosales, G. Alvarez-Rivera, M. Hillgärtner, A. Cifuentes, M. Itskov, C. A. Garcia-González and A. Rege, Stability studies of starch aerogel formulations for biomedical applications. *Biomacromolecules*, 21(12), pp. 5336-44, 2020.