



HAL
open science

3D FATIGUE-INDUCED STRUCTURE EVOLUTION OF EVA FOAMS REINFORCED WITH BIOBASED NANOFILLERS AND USED FOR RUNNING SHOES

Clara Aimar, Romain Bordage, Laurent Orgéas, Sabine Rolland Du Roscoat,
Lucie Bailly, Dimitri Ferré-Sentis, A Kayum, Olga Stamati

► **To cite this version:**

Clara Aimar, Romain Bordage, Laurent Orgéas, Sabine Rolland Du Roscoat, Lucie Bailly, et al..
3D FATIGUE-INDUCED STRUCTURE EVOLUTION OF EVA FOAMS REINFORCED WITH
BIOBASED NANOFILLERS AND USED FOR RUNNING SHOES. 5th International Conference
on Tomography of Materials and Structures (ICTMS) 2022, Jun 2022, Grenoble, France. pp.17.
hal-03851564

HAL Id: hal-03851564

<https://hal.science/hal-03851564>

Submitted on 14 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

3D FATIGUE-INDUCED STRUCTURE EVOLUTION OF EVA FOAMS REINFORCED WITH BIOBASED NANOFILLERS AND USED FOR RUNNING SHOES

Aimar C.^{1,2*}, Bordage R.¹, Rolland du Roscoat S.¹, Orgéas L.¹, Bailly L.¹, Ferré Sentis D.², Kayum A.², Stamati O.¹

¹ Univ. Grenoble Alpes, CNRS, Grenoble INP, 3SR, 38000 Grenoble, France

² Decathlon, Footwear, 59000 Lille, France

*clara.aimar@decathlon.com

1. Introduction

Nanofiller-reinforced Ethylene-Vinyl Acetate (EVA) foams are widely used in running shoes midsoles. Nanofillers (NFs) are used to reduce production costs and to ease manufacturing [1]. However, the role of NFs on the mechanical fatigue of EVA foams after hundreds of thousands cycles is still not elucidated. Indeed, the literature on elastomeric foams fatigue is rare, that dealing with the role of NFs even scarcer [2]. Some fatigue compression tests emphasized the consolidation of EVA foams upon cycling, where buckling patterns of cell walls illustrate creeping mechanisms [1]. However, results are limited to 2D qualitative observations of the foam structures. Therefore, a dedicated methodology combining macroscopic mechanical tests and 3D microstructural quantification is proposed to study fatigue mechanisms of NFs-EVA composite foams.

2. Materials and Methods

EVA-based foams were elaborated by injection moulding using various contents (from 0 to 20 wt. %) of rice husk ash NFs (silica particles, diameter 20 nm). The amount of blowing agent was tailored to produce plate samples with identical porosity $\phi \approx 0.77$. To mimic the midsole behaviour, 200000 compression cycles (1 Hz, maximal compression strain $|\epsilon_{max}| = 0.8$) were performed on cylindrical samples (diameter 2 mm, height 2 mm). The initial and aged foams microstructures were imaged with a laboratory μ -CT (voxel size $1 \mu\text{m}^3$, 2500 projections, 40 keV, 5 μA) and registered *via* semi-automatic image matching [3]. Microstructural characteristics such as the cell wall local thickness [4] and curvature, the pore volume and inertia anisotropy ratio were quantified on binarized images.

3. Results & conclusion

Increasing the NFs content induced an increase of the mean cell wall thickness and a decrease of the mean pore volume of the produced EVA foams (Fig 1a,c), the other structural descriptors remaining practically constant. In addition, upon cycling, samples exhibited

a rapid mechanical consolidation with a decrease of stress levels, an increase of the residual strain and a steady state stress-strain response above 1000 cycles. Moreover, increasing the NFs content yielded to an increase of the foam stiffness, stress levels and hysteresis, absorbed and dissipated energies. These trends were linked with the *post mortem* foam structures where the cell wall plastic deformation occurred without tears but rather with irreversible buckling deformations due to a progressive EVA creeping induced during cycling (Fig 1b,d). The higher the NFs content, the higher the cell wall curvature and pore anisotropy ratio, and the lower the volume of pores. For example, the two last descriptors exhibited an increase (resp. a decrease) of +3% and +19% (resp. -4% and -22%) when the NFs content increased from 0 to 20 wt. %. These results will provide guidelines to optimize the processing routes and induced microstructures of EVA foams, enhancing their mechanical properties according to the runner and its' program.

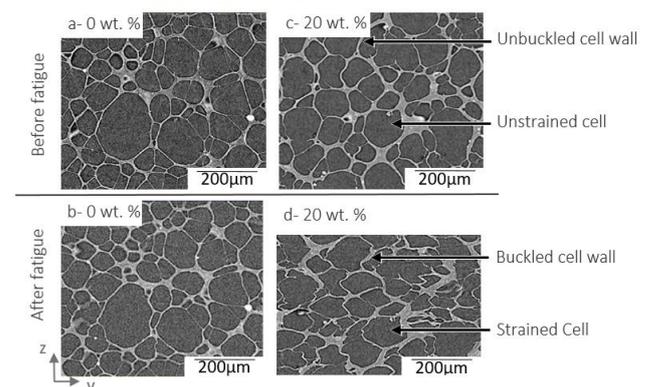


Figure 1. 2D slices in the (y, z) plane of EVA foams without NFs (a,b) or with (c,d, 20 wt. %), before (a,c) and after (b,d) compression fatigue along z direction.

4. Acknowledgements

The authors thank the ANRT for financial support.

5. References

- [1] Verdejo R. *et al.*, 2004, [10.1016/j.jbiomech.2003.12.022](https://doi.org/10.1016/j.jbiomech.2003.12.022)
- [2] Pardo-Alonso *et al.*, 2013, [10.1016/j.eurpolymj.2013.01.005](https://doi.org/10.1016/j.eurpolymj.2013.01.005)
- [3] Stamati O. *et al.*, 2020, [10.21105/joss.02286](https://doi.org/10.21105/joss.02286)
- [4] Doube M. *et al.*, 2010, [10.1016/j.bone.2010.08.023](https://doi.org/10.1016/j.bone.2010.08.023)