Synchrotron X-ray And FE Modeling Of Flax Yarns For Technical Textile Applications

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Abstract

The textile industry is the third-largest global polluter, with synthetic fibres contributing heavily to microplastic contamination in marine environments. In response, the EU-funded UPWEARS project aims to replace synthetic fibres in technical textiles with sustainable, biosourced alternatives such as flax. To support this transition, we combine synchrotron X-ray microtomography and COMSOL Multiphysics®-based finite element (FE) modeling to investigate the mechanical behavior of flax yarns at the microscale.

High-resolution 3D imaging was performed on three grades of flax yarns to capture their complex internal structures. These images were directly meshed and imported into COMSOL to simulate their mechanical responses under load. The simulations revealed substantial variations in stiffness across the yarn grades, along with pronounced stress heterogeneity. These mechanical features are closely linked to both the anisotropic properties of the constituent fibres and the yarns' intricate geometries.

To validate the computational results, mechanical tests were conducted at the fibre and yarn levels, confirming the predicted trends. This integrated approach demonstrates the potential of combining advanced imaging with multiphysics modeling to guide the design of next-generation, eco-friendly technical textile.

Reference

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Figures used in the abstract

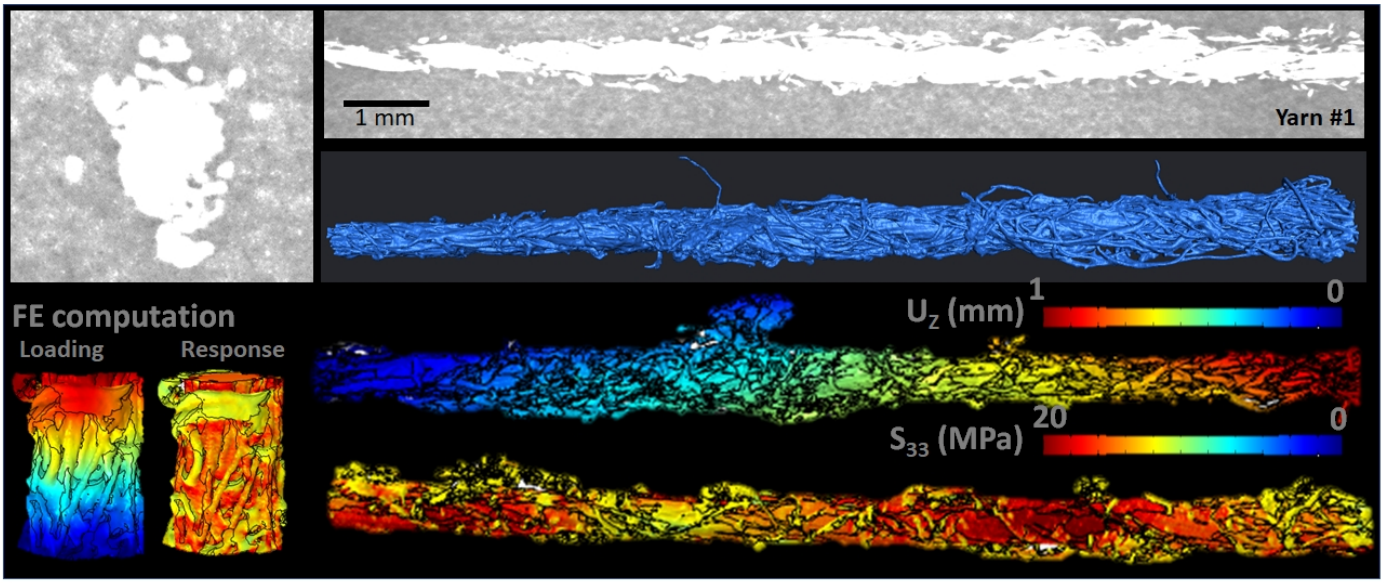

Figure 1 : Integration of synchrotron X-ray microtomography and finite element modeling: (a) 3D reconstruction of flax yarn microstructure from X-ray tomography, and (b) corresponding finite element simulation showing stress distribution under tensile loading.