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ABSTRACT:

Multiscale Modeling and Simulation of the Mechanical Behavior of Polypropylene Composites via Integrated CT–FEA Methods

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This study presents an integrated methodology for modeling and simulating the mechanical and fracture behavior of microcellular glass fiber-reinforced polypropylene composite. The approach emphasizes the critical role of accurate modeling in multiphase materials consisting of a polymeric matrix, fiber reinforcements and cellular domains forming a solid-skin/foamed-core structure.

High-resolution computed tomography (CT) scan was employed to reconstruct highly detailed three-dimensional representations of the specimen internal structure. A segmentation procedure was applied to differentiate the polymer matrix, glass fibers, and cellular regions, enabling a detailed volumetric description of each phase. This structural data guided the creation of high-fidelity finite element (FEM) meshes, which preserved the key morphological features governing the material's mechanical response.

The numerical model incorporated the boundary conditions, matrix–fiber interfaces, and phase-specific material properties to replicate the physical experiments performed on the same materials [1]. Comparison between simulated and experimental results validated the proposed framework, enabling an in-depth analysis of how cellular morphology, fiber orientation, and spatial distribution influence local stress concentrations, stiffness variations and the resistance to crack initiation and propagation throughout the composite microstructure.

[1] J. Gómez-Monterde, M. Sánchez-Soto and M.Ll. Maspoch, Composites Part A, 104, 1-13 (2016).