X-ray micro-computed tomography for non-destructive analysis of thermoplastic (nano)composites processability and homogeneity

Eleni Gkartzou [1], Konstantinos Zafeiris [1], Christos Tsirogiannis [1], Artemis Kontiza [1], Tatjana Kosanovic Milickovic [1], and Costas Charitidis [1,*]

Research Lab of Advanced, Composites, Nanomaterials and Nanotechnology (R-NanoLab), Materials Science and Engineering Department, School of Chemical Engineering, National Technical University of Athens, 9 Heroon Polytechniou str., Zographou Campus, GR15780, Athens, Greece; egartzou@chemeng.ntua.gr (EG); kzafeiris@chemeng.ntua.gr (KZ); christsiro@chemeng.ntua.gr (CT); akontiza@chemeng.ntua.gr (AK); tkosanovic@chemeng.ntua.gr (TK)

* Correspondence: charitidis@chemeng.ntua.gr; Tel.: (+30-210-772-4046)

Abstract:

Thermoplastic (nano)composites, especially those incorporating fillers of various sizes and morphologies, are gaining prominence in various industrial applications due to their exceptional mechanical, thermal, and electrical properties, as well as ease of recyclability. However, ensuring their processability and homogeneity throughout the manufacturing process remains a critical challenge. Traditional methods of quality evaluation often involve destructive testing, while providing only partial insight on external/internal features dimensional accuracy, porosity, filler dispersion, orientation and spatial distribution. X-ray micro-computed tomography (micro-CT) has become an established method for non-destructive inspection of thermoplastic composites in recent years, offering the ability to visualize and quantify the internal structure and distribution of fillers and agglomerates within the polymer matrix, and thus enabling a comprehensive understanding of the composite's quality. While this non-destructive analysis method is gaining traction among both academia and industry, scan strategies and digital image processing protocols are still being developed to fully unravel its capabilities and establish time- and cost-effective ways to analyze various applications, from R&D up to industrial production. In the present work, a series of case studies of micro-CT analysis of thermoplastic (nano)composites at various stages of lab-scale processing chain (compounding, injection molding, extrusion-based Additive Manufacturing) are presented, aiming to capture critical factors affecting the material properties and performance. The acquired micro-CT datasets were further processed using image analysis techniques to extract qualitative and quantitative information on internal structure and morphology, degree of homogeneity, identification of defects, particle/agglomerate size and separation distance distribution, as well as comparison between nominal/actual geometry in AM structures. The findings of this study contribute to the advancement of quality control strategies and optimization of processing parameters, enabling the development of high-performance thermoplastic (nano)composites for various industrial applications.

Keywords: micro-CT; Additive Manufacturing; non-destructive analysis; thermoplastic (nano)composites

Acknowledgements: This work is funded by EU Horizon 2020 Research and Innovation Actions, entitled:
‘Digital method for imprOved Manufacturing of next-generation MultIfuNctIOnal airframe parts’ (DOMMINIO) under GA No 101007022;
‘Plastics Recycling from and for home appliances, toys and textile’ (PRecycling), under GA No. 101058670.
‘Recycling and Repurposing of Plastic Waste for Advanced 3D Printing Applications’ (Repair3D), under GA No. 814588.

Please indicate your preferred choice: oral presentation