Manufacturing, Mechanical Characterization and Modeling of Functionalized Graphene Epoxy Nanocomposites

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Abstract

Statement of the Problem: The focus of this work is the manufacturing of graphene-epoxy nanocomposites for optimum enhancement in the mechanical properties, wide range of mechanical characterization and modeling of mechanical behaviors. Optimum enhancement in the mechanical properties can be achieved when filler material is uniformly dispersed in the matrix material. To provide uniform dispersion, among the several techniques such as ultrasonic methods, three roll milling (3RM), high and low shear mixing, 3RM is selected. In addition, to improve the interfacial bonding between graphene nano flakes (GNF) and epoxy matrix, GNFs are functionalized using Triton X-100 as a surfactant.

Since in the design of polymer or polymer based materials, all viscoelastic – viscoplastic behaviors need to be investigated, a wide range of mechanical characterization of functionalized graphene (f-GNF)-epoxy nanocomposites are performed. In the mechanical characterization, rate dependency, viscoelastic and viscoplastic indications, temperature dependency are investigated.

Following the manufacturing and characterization of f-GNF-epoxy nanocomposites, its viscoelastic and viscoplastic behaviors are modeled by using cooperative-viscoplasticity theory based on overstress (VBO) model for nanocomposites. Storage modulus of f-GNF-epoxy nanocomposite is modeled using the temperature and strain rate dependent elasticity modulus formulation. In order to define modulus values as a function of graphene fraction, the Mori Tanaka scheme is used. Storage modulus versus time, stress-strain behaviors under compression test and relaxation behaviors of f-GNF-epoxy nanocomposites are simulated and compared with experimental data.

Development of material models for different materials is needed for structural analysis. Due to the viscoelastic and viscoplastic properties of polymers, it is still a challenge modeling polymer nanocomposites. Another important point in the material modeling is finding out material parameters in the model and verifying the modeling effort. For that purpose, a detailed material characterization is needed. This work consist of all these needs: manufacturing, characterization and modeling f-GNF-epoxy nanocomposites.

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Recent Publications (minimum 5):

O. Bakbak, B.E. Birkan, A. Acar, O. Colak ,Mechanical characterization of Araldite LY 564 epoxy: creep, relaxation, quasi-static compression and high strain rate behaviors, Polymer Bulletin, 2021, 1-17

O. Colak, D. Uzunsoy, N. Bahlouli, C. Francart, Experimental investigation of oligo cyclic compression behavior of pure epoxy and graphene-epoxy nanocomposites, Polymer Bulletin, 2020, 1-18.

O Colak, N. Bahlouli, D. Uzunsoy, C. Francart. High strain rate behavior of graphene-epoxy nanocomposite, Polymer Testing, 2020, 81, 106219.

O. Colak and Y. Cakir, Material model parameter estimation with genetic algorithm optimization method and modeling of strain and temperature dependent behavior of epoxy resin with cooperative-VBO model, Mechanics of Materials, 2019, 135, 57-66.

A. Acar, O. Colak, J. Correia, S. Ahzi, Cooperatve-VBO model for polymer/graphene nanocomposites, Mechanics of Materials, 2018, 125, 1-13.

Conclusion & Significance:



Biography

Ozgen Colak received her bachelor's and MSc degrees in the Department of Mechanical Engineering from Yıldız Technical University, She got her Ph.D from Rensselaer Polytechnic Institute in USA. She was visiting professor in Strasbourg University during 2018-2019. She has been working as full professor in Yildiz Technical University since 2010. Her research interests include development of material models for metal, polymers and nanocomposites, viscoelasticity, viscoplasticity, manufacturing and characterization of nanocomposites.

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Notes/Comments: