**Composite Materials and Engineering**, *Vol. 4, No. 1 (2022) 101-115*
https://doi.org/10.12989/cme.2022.4.1.101 

# Numerical study on viscoelastic behavior of particulate composites based on the mean-field based micromechanics model

Hangil You[1] and Gun Jin Yun*[1,2]

[1]*Department of Aerospace Engineering, Seoul National University, Gwanak-gu, Seoul, 08826, Korea*
[2]*Institute of Advanced Aerospace Technology, Seoul National University, 08826, Seoul, Korea*

*(Received August 6, 2021, Revised Fubruary 4, 2021, Accepted February 11, 2021)*

**Abstract.** This paper investigates the effects of constituents' properties (i.e., stiffness ratio, volume fraction, and interfacial stiffness) on the viscoelastic behavior through the mean-field-based micromechanics model. The stress prediction of the proposed micromechanics model for the viscoelastic composites is verified through the direct numerical simulation (DNS) using a finite element model with different volume fractions, materials properties, and interphase layers. The stress prediction accuracy is studied under cyclic loading conditions. The stress prediction accuracy is better when the volume fraction is lower and the interphase layer is modeled. Finally, the effects of the constituent's properties, volume fraction, and interfacial imperfection on the tangent delta and relaxation behavior of the composites are examined.

**Keywords:** homogenization; Mori-Tanaka method; micromechanics; particulate composites; viscoelastic behavior

## 1. Introduction

Polymers with rubber-like mechanical behavior have a wide range of engineering applications, including tires, structural bearing, and medical devices thanks to their viscoelastic characteristics (Khajehsaeid *et al.* 2014). The rubber compound for tires is a composite material of the reinforced elastomer. Adding fillers such as carbon black (CB) to rubber compounds can strengthen the mechanical property, increase the volume, improve tire stiffness, and adjust dynamic mechanical properties (Oleiwi *et al.* 2011, Li *et al.* 2015, Khadimallah *et al.* 2020, Patnaik *et al.* 2020). Moreover, tires are manufactured through complex procedures such as mixing, extrusion, calendaring, beading, building, and vulcanization. Also, various chemical fillers with strengthening effects are added with varying volume fractions and interfacial integrity during the manufacturing processes (Park *et al.* 2020).

Consequently, it is necessary to reliably predict the rubber compound's viscoelastic stiffness and dynamic mechanical properties under various possible conditions (Shao *et al.* 2018). However, the experimental evaluation of the tire composites' dynamic mechanical properties and effective

*Corresponding author, Professor, E-mail: gunjin.yun@snu.ac.kr


http://www.techno-press.org/?journal=cme&subpage=7 ISSN: 2671-4930 (Print), 2671-5120 (Online)