Effects of silica on mechanical and rheological properties of EPDM-based magnetorheological elastomers

Rusila Zamani Abd Rashid[1], Norhasnidawani Johari[1], Saiful Amri Mazlan[1], Siti Aishah Abdul Aziz[1], Nur Azmah Nordin[1], Nurhazimah Nazmi[1], S N Aqida[2] and Mohd Aidy Faizal Johari[1]

[1] Engineering Materials and Structures (eMast) ikohza, Malaysia–Japan International Institute of Technology (MJIIT), Universiti Teknologi Malaysia, Kuala Lumpur 54100, Malaysia

[2] College of Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

ABSTRACT

Magnetorheological elastomers (MREs) are a kind of emerged smart material, where its responsive moduli in terms of mechanical and rheological properties are largely influenced by the presence of an external magnetic field. However, the incompatibility on the surface properties of its raw materials (fillers and matrix) may deteriorate the required properties of MREs. Therefore, in this study, the innovation of MRE by embedding silica nanoparticles as an additive has been experimentally investigated to strengthen the interactions between filler and matrix, thus resulted in enhancement of mechanical and rheological properties of MRE. The ethylene propylene diene monomer (EPDM)-based MREs were fabricated by mixing the EPDM with carbonyl iron particles (CIPs) as the main filler and different contents of silica nanoparticles (0 wt%–11 wt%) as an additive. The microstructures, magnetic properties and tensile properties of isotropic EPDM-based MREs were observed by using field emission scanning electron microscopy, vibrating sample magnetometer and Instron Universal Testing Machine, respectively. Meanwhile, the rheological properties were examined under oscillatory loadings in the absence and presence of magnetic field using rotational rheometer. The experimental results showed that the silica nanoparticles play a significant role in improving the properties of EPDM-based MREs. The adhesiveness of silica into CIPs has amended the interfacial interactions between CIPs and matrix by occupying the gaps between distributed CIPs within the MRE. Consequently, the addition of 11 wt% silica has not only improved the tensile properties (tensile strength and elongation at break), but also enhanced the MR effect compared to EPDM-based MREs without silica. Thus, incorporation of silica nanoparticles as an additive in EPDM-based MRE has the potential to be further explored and compromised to bring new innovation in real engineering applications.

KEYWORDS

Ethylene propylene diene monomer; Magnetorheological elastomer; Mechanical; Rheology; Silica

REFERENCES

1. Morillas, J.R., De Vicente, J.
   Magnetorheology: a review
   (2020) *Soft Matter*, 16 (42), pp. 9614-9642. Morillas, J.R., De Vicente, J.

2. Ubaidillah, Sutrisno, J., Purwanto, A., Mazlan, S.A.
   Recent progress on magnetorheological solids: Materials, fabrication, testing, and applications
   (2015) *Advanced Engineering Materials*, 17 (5), pp. 563-597.

3. Chen, D., Yu, M., Zhu, M., Qi, S., Fu, J.
   Carbonyl iron powder surface modification of magnetorheological elastomers for vibration absorbing application
   (2016) *Smart Materials and Structures*, 25 (11), art. no. 115005.

4. Jung, H.S., Kwon, S.H., Choi, H.J., Jung, J.H., Kim, Y.G.
   Magnetic carbonyl iron/natural rubber composite elastomer and its magnetorheology
   (2016) *Composite Structures*, 136, pp. 106-112.

5. Wang, Y., Hu, Y., Deng, H., Gong, X., Zhang, P., Jiang, W., ZuyaoChen
   Magnetorheological elastomers based on isobutylene-isoprene rubber
   (2006) *Polymer Engineering and Science*, 46 (3), pp. 264-268.