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Experimental and Analytical Model for the Electrical Conductivity of Polymer-Based Nanocomposites

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Abstract

In this research, an analytical formula has been developed to predict electrical conductivity of composites reinforced by conductive fillers such as polymer-based carbon composites. In this model, the percolation threshold phenomenon in the curve of electrical conductivity versus the filler volume fraction is represented by a sigmoidal equation. Moreover, four variables, consist of the filler electrical conductivity, filler aspect ratio, filler roundness, and wettability are included in the sigmoidal equation in specific sites. in this research in order to validation of model, some composites are provided by graphite, expanded graphite, and carbon fiber as reinforcement and phenolic resin as polymer. The manufacturing method is hot compaction. These composites plus several other composites derived from the literature are used to validate the model. The curve fitting is performed by MATLAB software. The composites are divided into two main categories: the first, nanofiller composites including graphene, carbon nanotube, expanded graphite, and carbon black; the second, microfiller composites including graphite and carbon fiber. In the paper, the effective factors on composite conductivity including the mixing methods, filler conductivity, filler aspect ratio, filler alignment, surface energy between filler and matrix, and matrix conductivity are comprehensively discussed. In addition, the filler volume fractions ascribed to percolation threshold in all samples is calculated and is compared together. The results show there is good agreement between the model and experimental data on both nanofiller and microfiber composites. In addition, it was specified that the aspect ratio and nanosizing of fillers are the most important factors effective on percolation threshold and jumping rate of sigmoidal curve.

Key words: Polymer-matrix composites, nano composites, Electrical conductivity, sigmoidal, analytical model