Dielectric Characteristics of Graphene-incorporated Composites

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For better dielectric characteristics of polymer-based dielectric composites, graphene and barium titanate ($BaTiO_3$, BTO) fillers were mixed within the polymer matrix by varying the mixing method and the degree of reduction of graphene. Four kinds of graphene incorporation with BTO were examined—graphene oxide (GO) mixing with BTO, reduced graphene oxide (rGO) mixing with BTO, GO encapsulation of BTO and subsequent mixing, and rGO encapsulation of BTO and subsequent mixing. Encapsulation was performed by the electrostatic interaction of the chemical reaction between the positively functionalized BTO and the negatively functionalized GO. rGO was obtained by chemical reduction of GO with hydrazine. [1-2] All four graphene-incorporated films showed 1.5~2.2 times higher values in the dielectric constants than the reference one, i.e., a polymer-based composite film with BTO fillers only, mainly due to the existence of graphene through the interfacial polarization or the micro-capacitor effects. An increment in the dielectric loss, which was difficult to avoid due to percolative connection among nanomaterials, here graphene, was successfully suppressed. Especially for the encapsulation cases, i.e., within an increment down to 23%. If not well suppressed, the dielectric loss would increase more than 330%, [2, 3] or even higher loss was obtained if the concentration of conducting nanomaterials exceeds the critical concentration of percolation. The best performance came from the rGO encapsulated mixing case, i.e., a 119% higher dielectric constant (201 from 92) and a decrease of 23% in the dielectric loss (0.037 from 0.048). Therefore, it is encapsulation by graphene that can enhance the dielectric performance, i.e., increase the dielectric constants and decrease the dielectric losses.

References

[1] S.-Y. Jun et al., Carbon 199 (2022) 23-32.
[2] S.-Y. Jun et al., Mater. Chem. Phys. 255 (2020) 123533.
[3] Y.-J. Wan et al., Compos. Sci. Technol. 141 (2017) 48-55.

Figures

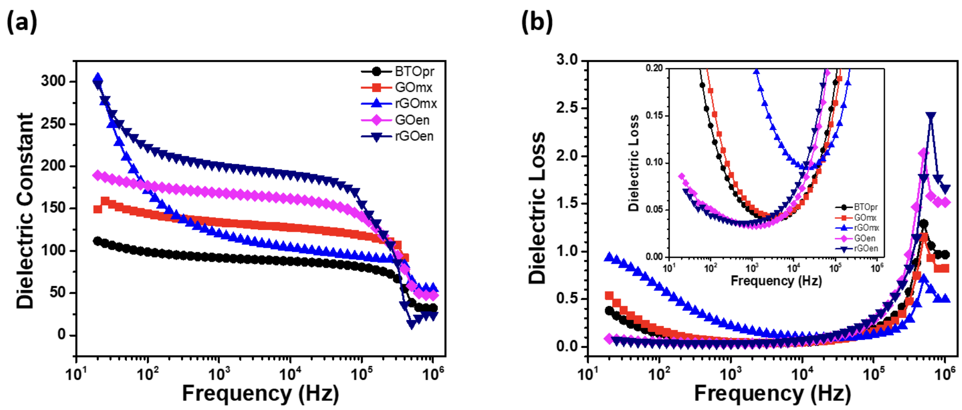

Figure 1: (a) The dielectric constants and (b) the dielectric losses as a function of the applied frequencies ranging from 20 Hz to 1 MHz at a fixed voltage of 0.1 V. The inset in (b) is the enlarged dielectric loss data to find out the minimum point behaviors easily.