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Electrical properties and electromagnetic shielding effectiveness of polycarbonate/acrylonitrile butadiene styrene/graphene nanoplatelets nanocomposites

In the current information age, the miniaturization of electronic systems and all the technical requirements for high technological applications are amplifying the complexity of developing electromagnetic interference (EMI) shielding materials for fully complying with electromagnetic compatibility (EMC) regulations [1, 2]. From an industrial perspective, the main challenge concerns the development of light cost-effective materials while combining other critical parameters such as easy processing, mechanical requirements, and esthetic factors. Electrically conductive polymer composites based on insulating polymer matrices and carbon particles have been shown to be the most promising materials for EMI shielding applications. Further, graphene-enhanced thermoplastics are showing to be more effective than the traditional carbon particles, such as carbon black and graphite [3].

In the present work, nanocomposites based on polycarbonate (PC), acrylonitrile butadiene styrene, and PC/ABS with different weight loadings of graphene nanoplatelets (GnP) were prepared in a twin screw extruder followed by compression molding for EMI shielding applications at NanoXplore Inc. As an attempt to improve the EMI shielding effectiveness (EMI-SE) with lower amounts of GnP, PC/ABS/GnP blends of 5 different morphologies with GnP content ≈ 15wt% were designed. The effect of the blend's morphology and, consequently, the distribution of GnP networks of different configurations on the electrical and EMI shielding properties were evaluated. Figure 1 shows a schematic representation of the 5 different blends.

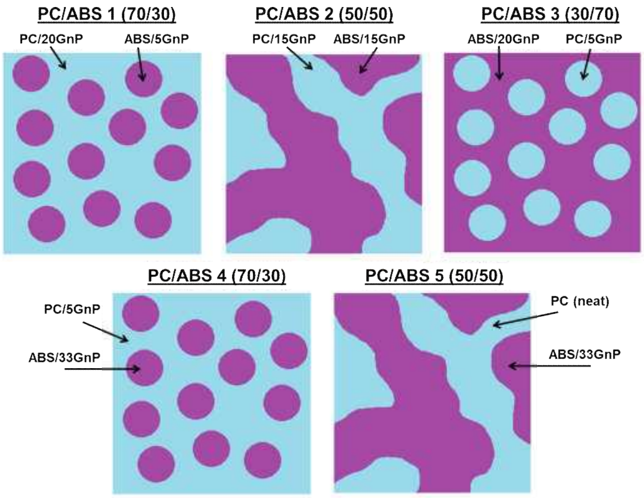

Figure 1: PC/ABS/GnP blends of different morphologies with ≈ 15wt% GnP loading. Blend 1: PC/ABS blend (70 wt% wt%/30 wt%) prepared from PC/20 wt% GnP and ABS/5 wt% GnP, Blend 2: PC/ABS blend (50wt%/50 wt%) prepared from PC/15 wt% GnP and ABS/15 wt% GnP, Blend 3: PC/ABS blend (30wt%/70 wt%) prepared from PC/5 wt% GnP and ABS/20 wt% GnP, Blend 4: PC/ABS blend (70 wt% wt%/30 wt%) prepared from PC/5 wt% GnP and ABS/33 wt% GnP, Blend 5: PC/ABS blend (50wt%/50 wt%) prepared from PC/0 wt% GnP and ABS/33 wt% GnP.

All 5 PC/ABS/GnP blends presented similar values of electrical conductivity which was very close to the one of ABS/GnP and PC/GnP nanocomposites with similar GnP concentration (≈ 5E-2 and 2E-1 S.m-1 for the compositions with 15 and 20wt% GnP loading, respectively). This behavior can be explained considering that at this concentration of GnP, the conductivity values are already in the plateau of conductivity after the electrical percolation threshold, and therefore the measurement is insensitive to changes regarding the morphology of the blends [3].
The EMI shielding properties were calculated from experimental data using suitable equations that can be found elsewhere [1, 4]. Figure 2 presents the EMI-SE of the different nanocomposites as a function of frequency.

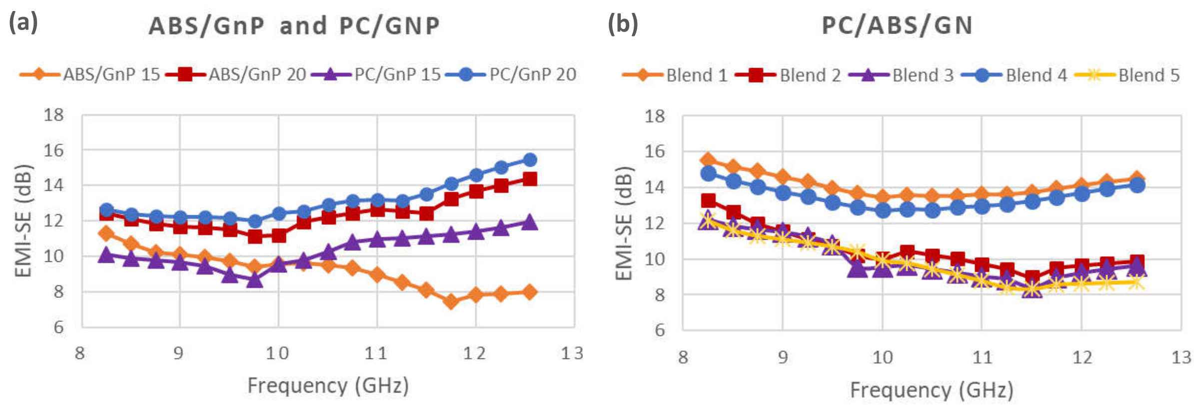

Figure 2: EMI-SE as a function of frequency of the a) PC/GnP and ABS/GnP nanocomposites and b) PC/ABS/GnP blends (≈ 2.5 mm thick)

As shown in the figure, PC/GnP presented higher EMI-SE than ABS/GnP. This result was already expected considering that PC has higher affinity with GnP than ABS according to thermodynamic predictions [5]. Further, differently than the results of electrical conductivity, the PC/ABS/GnP blends presented higher values of EMI-SE compared to the PC/GnP and ABS/GnP nanocomposites. For the PC/ABS (70 wt%/30 wt%) blends 1 and 4, where PC phase is continuous and the ABS phase is in form of droplets (with ≈ 15 wt% GnP loading), the EMI-SE of the blends were higher than the EMI-SE of PC/GnP and ABS/GnP nanocomposites with 20 wt% of GnP loading. These results can be explained considering the geometrical arrangement of the blends evaluated by rheological characterization (data not shown), where the domains of PC formed a close-packed conductive network (blend 1) and favored the formation of a highly GnP loading droplets network (blend 4) to interact with the electromagnetic radiation. Additionally, preliminary mechanical characterization (ongoing) showed a considerable increase of the mechanical properties of the PC/ABS/GnP blends compared to the PC/GnP nanocomposites.
As conclusion, it was possible to enhance the EMI-SE of the final material by controlling the morphology of the blends. PC/ABS/GnP blends of continuous PC phase showed to be potential candidates as EMI shielding materials for commercial applications.

References

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