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Development of Poly(3-hydroxybutyrate-co-3-hydroxyvalerate)/Poly(methyl acrylate) Hybrid Composites with Enhanced Electrical Conductivity through Graphene Nanoplatelet Incorporation and Optimization of Their Blend Ratio

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INTRODUCTION & AIM

In materials engineering, developing polymer composites with tailored electrical properties is crucial for applications in flexible electronics, development of biomedical devices and tissue engineering. Although polymers such as poly(methyl acrylate) (**PMA**) and poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (**PHBV**) offer flexibility, processability, and biodegradability, their intrinsic insulating nature limits functional performance.

Incorporating **conductive nanofillers**, such as graphene nanoplatelets (**GNPs**), can overcome this limitation by forming percolating networks, though effective dispersion and compatibility with the polymer matrix are critical. This study explores the development and physicochemical characterization of **PHBV/PMA blends reinforced with 10 wt% GNPs** to identify compositions that maximize conductivity without compromising morphology or thermal stability.

METHOD

Films of PHBV, PMA, and their blends (30/70, 20/80, 70/30, 80/20) were prepared via solvent casting using chloroform and toluene as solvents for PHBV and PMA, respectively. The PHBV/PMA 20/80 blend containing 10% wt. GNPs was selected for detailed analysis because of its superior homogeneity and conductivity. Samples were characterized by SEM, DSC, TGA, and electrical conductivity measurements.

RESULTS & DISCUSSION

Microstructure: uniform GNPs dispersion in PHBV/PMA blends

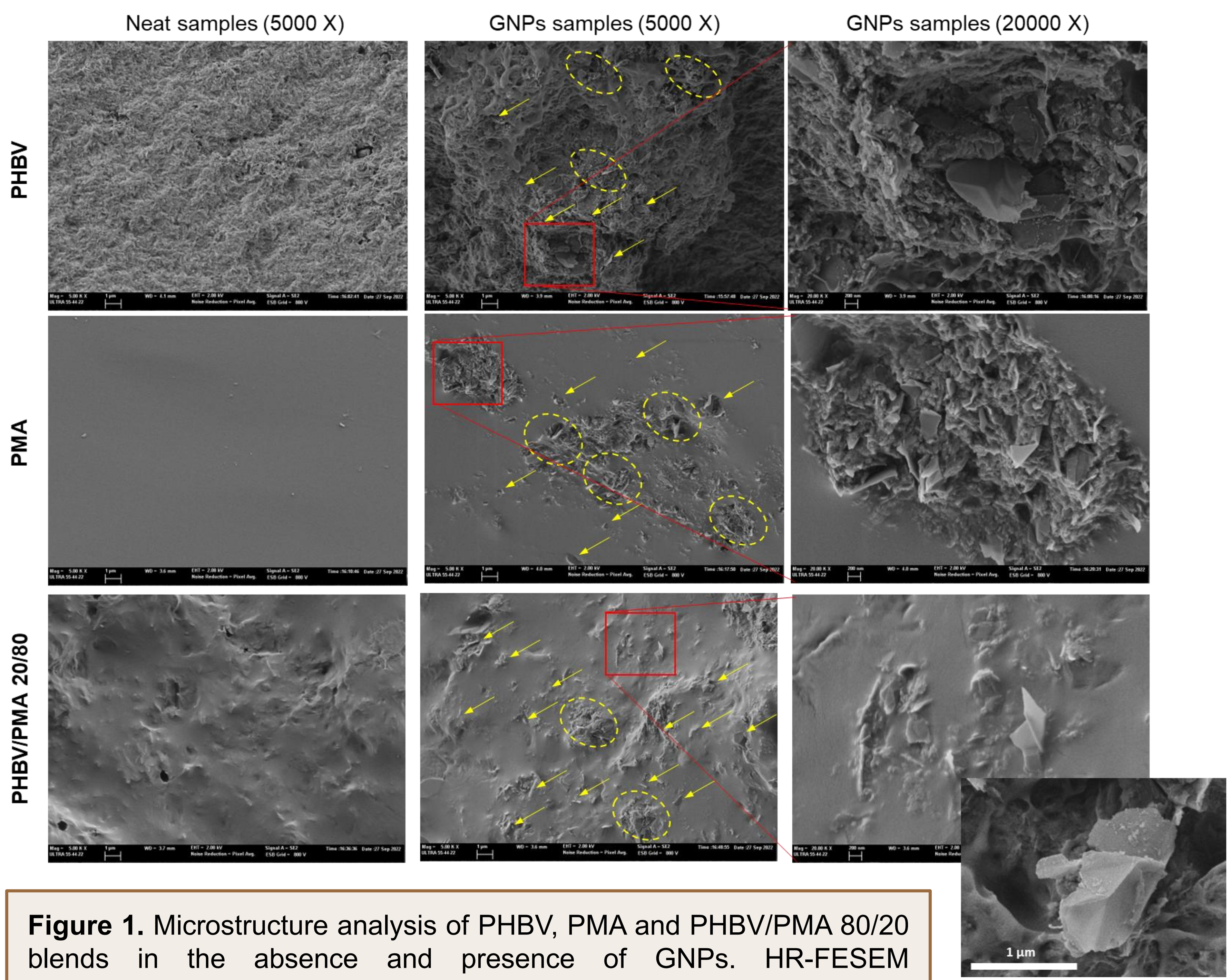


Figure 1. Microstructure analysis of PHBV, PMA and PHBV/PMA 80/20 blends in the absence and presence of GNPs. HR-FESEM photomicrographs reveal a uniform structure in the PHBV/PVA 80/20 blends. In contrast, GNPs form significant aggregates in both PHBS and PVA individual blends. However, the PHBV/PMA 20/80 blend exhibits a more stable structure with highly organized and well-distributed GNPs within the matrix.

RESULTS & DISCUSSION

DSC: GNPs act as nucleating agents, restoring semicrystalline behavior

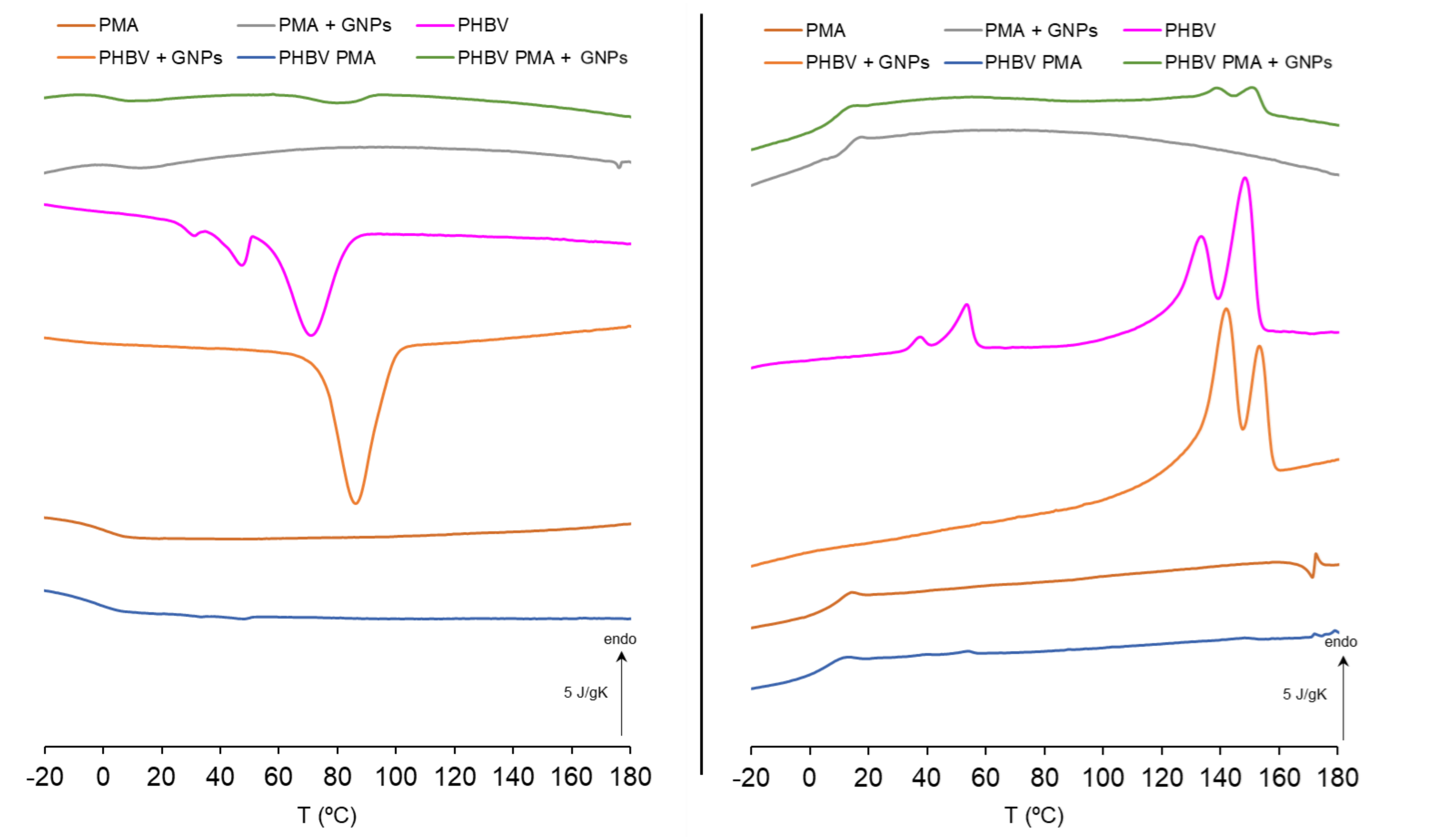


Figure 2. Differential scanning calorimetry (DSC) thermograms recorded at a heating/cooling rate of 20 ºC/min for neat PMA, PHBV, PHBV/PMA 20/80 blend, and their counterparts containing 10 wt% GNPs. Normalized heat flow are shown for both cooling and heating cycles. The PHBV/PMA blend suppressed PHBV crystallization, whereas the addition of GNPs acted as nucleating agent, restoring semicrystalline behavior.

TGA: stable thermal properties after GNPs addition

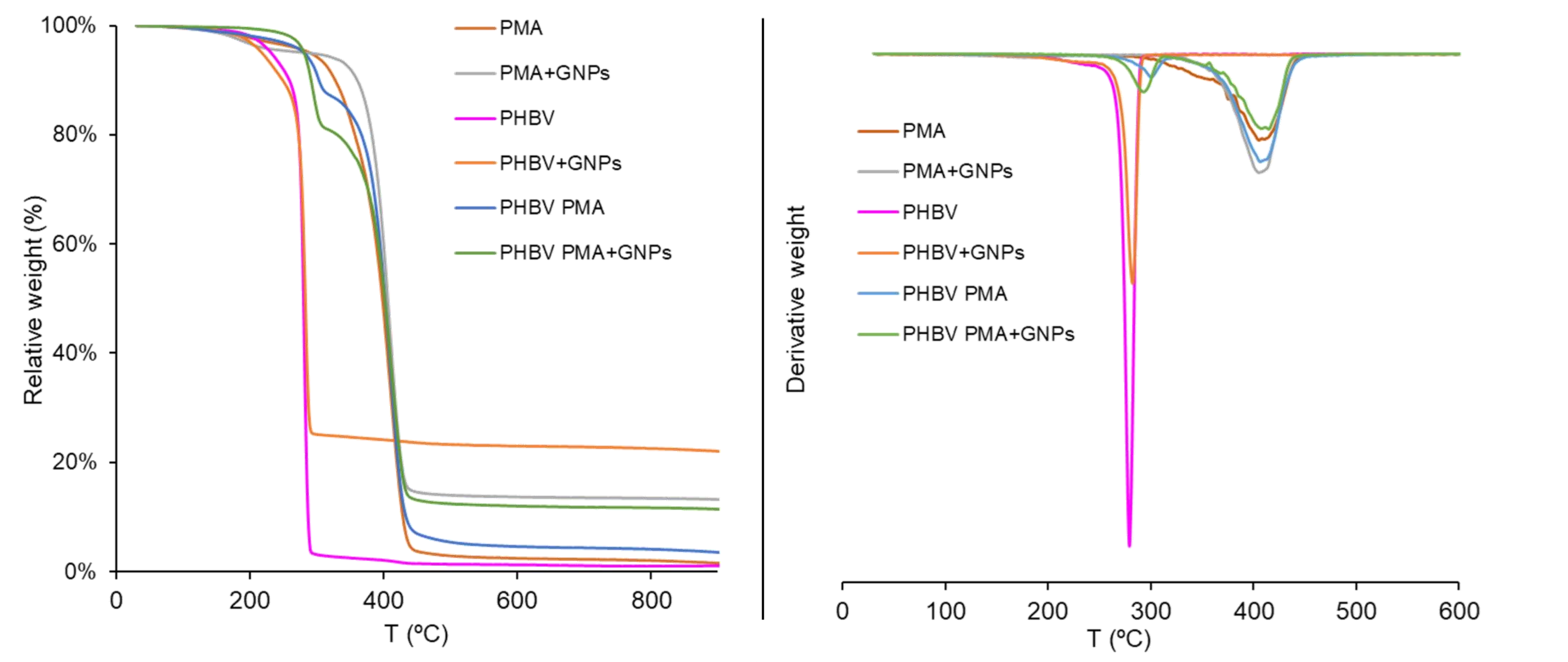
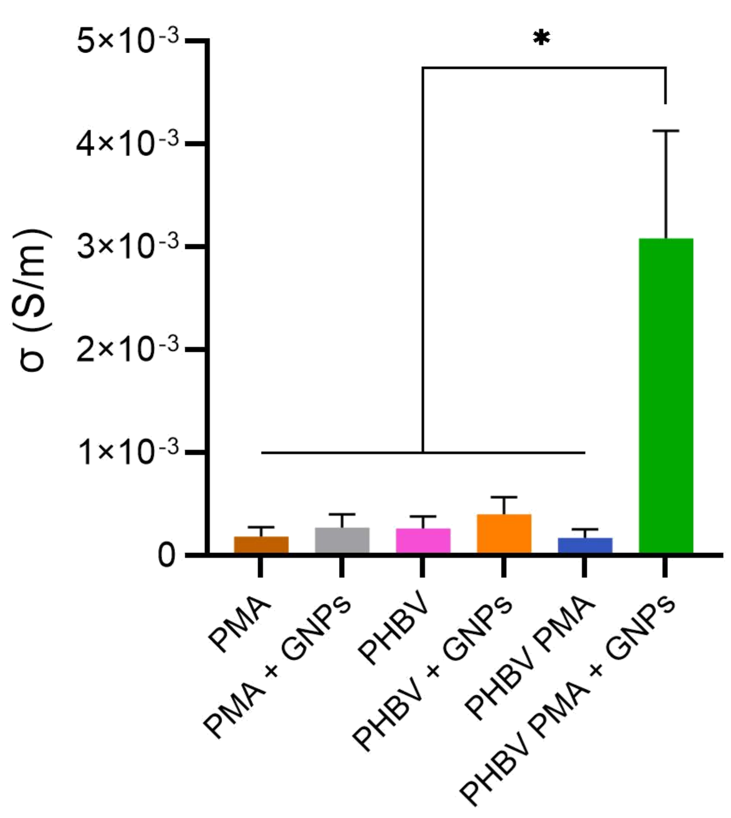


Figure 3. Thermogravimetric analysis (TGA) of neat PMA, PHBV, PHBV/PMA 20/80 blend, and their counterparts containing 10 wt% GNPs. Plots show relative weight loss and first derivative (DTG) as a function of temperature. The thermograms indicate that the thermal stability of the hybrid composite remained comparable to that of neat PMA, even after GNPs incorporation.



Enhanced electrical conductivity in the nanohybrid composite with GNPs

Figure 4. Surface electrical conductivity of neat PMA, PHBV, PHBV/PMA 20/80, and their counterparts containing 10 wt% GNPs. Electrical conductivity increased from 0.4 mS/m for the PHBV/PMA blend to 5 mS/m with GNPs incorporation, representing a more than 12-fold increase and indicating the formation of a conductive network.

CONCLUSION

The incorporation of graphene nanoplatelets (GNPs) into PHBV/PMA 20/80 blends resulted in a significant enhancement in electrical conductivity without compromising thermal stability or morphological uniformity. The uniform dispersion of GNPs and the pronounced increase in conductivity suggest the formation of a continuous, well-integrated conductive network within the hybrid composite. This approach offers a versatile pathway for developing functional materials for biomedical applications and flexible electronics, where maintaining an optimal balance between electrical performance and structural integrity is essential. Overall, these results highlight the strong potential of GNP-based conductive composites as a platform for next-generation multifunctional materials.