Highly Segregated GNPs in UHMWPE Nanocomposites for Superior Barrier Properties

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Fluoropolymers like PTFEs and FKMs offer remarkable barrier properties in high-performance sealant applications. However, current health-related legislation in the UK and EU is banning most fluoropolymers. In this study, highly segregated ultrahigh molecular weight polyethylene (UHMWPE) and graphene nanoplatelets (GNP) nanocomposites with different GNP concentrations (between 0.5 and 10 wt.%) were manufactured as potential replacements for high-performance sealant applications. A comprehensive micro-CT analysis and AI-assisted segmentation of the scanning electron micrographs (SEM) was performed. The physical and chemical properties of the nanocomposites were studied through FTIR, DSC, and XRD. The mechanical performance was analyzed through DMA and tensile tests. The barrier properties were evaluated through toluene solvent uptake tests, and the gas permeability was investigated using CO2 in a custom low-pressure rig [1]. The results revealed that the mechanical and barrier properties strongly depended on the fractional GNP coverage of the UHMWPE particles rather than the actual concentration. In addition, the controlled dispersion of the GNPs onto the surface of polymer particles led to a substantial improvement in the properties of the nanocomposites, even at low GNP concentrations. For example, the diffusion coefficient for toluene uptake was reduced by 25%, and the CO2 permeability was dropped by around 30% with only 1 wt.% of GNPs. This improvement in the performance was primarily due to a very high GNP fractional coverage of UHMWPE particles. The results showed a great potential for these nanocomposites in sealant applications.

References

[1] Mufeng Liu et al., Composites Science and Technology, 249 (2024) 110483.

Figures

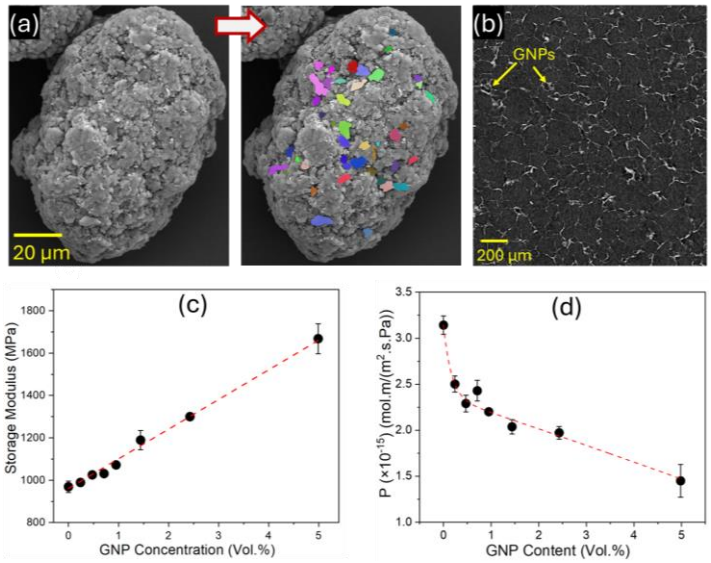

Figure 1: (a) SEM image showing segmentation of GNPs on UHMWPE particles, (b) Micro-CT radiograph showing the segregated network of GNPs, (c) storage modulus vs. GNP concentration, and (d) CO2 permeability vs. GNP concentration.