Influence of mixing methods on wear rate and frictional properties of graphene nanoplatelet (GNP) reinforced polyethylene

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Although ultra-high molecular weight polyethylene (UHMWPE) has been the warhorse of total knee and hip replacements for several decades, its long-term response is heavily compromised by wear resistance [1]. In order to improve its tribological behaviour, graphene nanoplatelets (GNP) have been added as a reinforcement [2]. In this work, we introduced two different dry-processing methods for UHMWPE/GNPs composites: ball milling and blade mixing. GUR® 1050 UHMWPE (Celanese, USA) in powder form was mixed with AvanPLAT-40® (Avanzare, Spain) multilayer GNPs in different proportions (up to 3 wt%) by two different mixing methods: ball milling (400rpm, 8 h) and blade mixing. Tribological tests were performed on a ball-on-disk tribometer (CSM Instruments, Switzerland) at 37°C with the sample immersed in deionised water. The 5 N force was applied through a stationary alumina ball (6 mm in diameter, Ra = 0.050 ± 0.002 µm). The coefficient of friction (COF) was registered for 24 h with a total sliding distance of 4320 m. Worn tracks were measured using a confocal microscope SENSOFAR Plµ 2300.The wear response shows a strong dependence in wear factor (k) with processing method, as reflected in Figure 1, were a two times variation in k is shown for a wide range in wt% of GNP reinforcement. Additionally, k seems to be near constant for ball milling composites, opposing to blade mixing composites that where k significantly increases over 1.5 wt%. The presence of GNPs in the ball milled composites has a positive effect on COF, specially over 0.5 wt%. For instance, at 3 wt% of GNPs, a reduction of ~25% is achieved. For blade mixing processed composites, the results shows a similar trend, characterised by a minimum value of COF at 1.4 wt% (a 33% reduction). Accordingly with the results, a reduction in COF has been identified for both processing methods, considering filler percentages over 0.5 wt%.

REFERENCES

[1] Chih, A.; Anson-Casaos, A.; Puértolas, J.A.; Tribol Int 116 (2017) 295-302.
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FIGURES

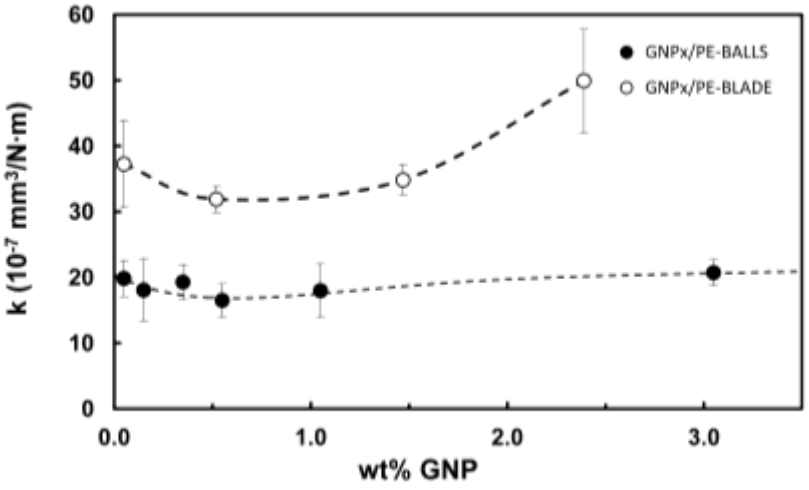

Figure 2: Wear rate vs GNP concentration for Ball Mill and Blade Mixer processed composites.