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Influence of argon ion sputtering on electric and mechanical surface properties of graphene/polyethylene composites

A. Ansón-Casaos[1], E. Aylon[1], R. Ríos[2], J.A. Puértolas*[2]

[1]Universidad de Zaragoza, Spain, [2]Instituto de Carboquímica ICB-CSIC, Spain

The exposure of polymers and graphene to Ar^+ ion bombardment has been widely studied independently. The goal of this work is assessing the microstructural effect of Ar^+ sputtering on graphene/polyethylene composites and the influence of the induced interaction mechanisms between both components on the mechanical and electrical surface properties of the composites.

Composites of ultra-high molecular weight polyethylene (UHMWPE) and 4 wt% multi-layered nanoplatelet graphene (GNP) were thermo-compressed [1]. An ESCAPlus Omicron spectrometer was utilized for both Ar^+ treatments and XPS measurements at different ion energies in the range of 500 to 5000 eV.

The Ar^+ irradiation in the unfilled polyethylene causes changes in the XPS C 1s peak position and shape profile with a narrow transition around 3000 eV related to the conversion of tetrahedral sp^3 into planar sp^2 carbon. Trans-vinylene groups, C=C bonds and oxygen groups were also detected by IR and Raman spectroscopy. In the composites, this graphitization effect is reduced by the presence of graphene, in spite of the low values of GNP concentration. Thermogravimetric measurements also point to the free radical trapping effect of the graphene [2], which can be related to the former behaviour.

Nanoindentation and Vickers hardness indicate that ion bombardment increases the elastic modulus and hardness by 50-100 % in both raw polyethylene and composites. More relevant is the behaviour of the surface electrical resistance. For the polyethylene, it decreases from 10^{15} to 10^8 Ω by sputtering with energies higher than 3000 eV. However, an abrupt transition from insulating (10^{15} Ω) to conducting (10^4 Ω) appears when the composite is irradiated above 3000 eV. Apparently, the irradiation effect is enough to link an electrical network in the composite.

[1] A. Chich et al. Tribol. Int. 116 (2017) 295-302.

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