On the peculiar mechanical and tribological behavior of polymer nanocomposites with nanotubes of WS_2 and nanowires of $Mo_6S_2I_8$

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Abstract (Arial 10)
Inorganic tubular and wire-like nanomaterials based on WS_2 and MoSI are an interesting new alternative to carbon nanotubes [1, 2]. They show advantages such as easy synthetic access, good uniformity and solubility, and predefined electrical conductivity depending on the composition of the starting material. One of the most outstanding properties of both types of nanoparticles is their low inter-particle shear modulus, while having comparable tensile moduli to CNTs. This has the advantage that they are potentially much easier to disperse than carbon nanotubes. Also common to both types of nanoparticles (metal base W and Mo) is their excellent lubrication property. This makes them highly attractive as additives for friction reduction and wear protection of polymers [3]. They are therefore very promising candidates as active fillers for polymers for mechanical reinforcement, improvement of toughness, fracture toughness and fatigue behavior together with improving the tribological properties of the polymer host [4]. Hence, they hold the promise to give answers to these technological paramount property in polymers.

We report on the preparation and resulting mechanical and tribological properties of polymer nanocomposites (PNC) based on nanotubes of tungsten disulfide (WS_2) and nanowires of $Mo_6S_2I_8$ (MoSI) with both; a semicrystalline apolar and an amorphous polar thermoplastic polymer (i-PP, PC).

The PNCs were obtained by direct incorporation of the nanoparticles into the molten polymer using a lab-scale conical twin-screw extruder. We present the results of the mechanical and tribological properties of the PNC in function of NP-concentration and processing conditions.

Most, interesting is the fact that excellent reinforcement of both polymer matrices is obtained with both types of nanoparticle morphologies (wires and tubes). Up to 1.5 wt% nanoparticle concentration one observes a steady increase of Young's modulus. Higher concentrations mark a plateau, which is ca. 25% higher than the pure polymer matrix. Employing the fibre reinforcement model of Halpin and Tsai one obtains estimates of the fibre aspect ratio that are well beyond any physical sense, marking the limits of the Halpin-Tsai model and a significant higher reinforcement that predicted by commonly accepted and very often successfully employed models. We point out that the extremely high reinforcing effect cannot be attributed to the induction of crystallinity, because the effect occurs in the amorphous matrix as well.

Studies of the tribological properties of the i-PP composites revealed a reduction of the friction coefficient by ca. 25% at a concentration of 1.5wt%. Composites with WS_2-nanotubes performed better than nanowires of $Mo_6S_2I_8$. Likewise wear rate was reduced by ca. 25%, although here the nanowires of $Mo_6S_2I_8$ showed better results. It was observed that the pretreatment of nanoparticles before melt-mixing has a significant influence on the obtained reduction of friction coefficient but surprisingly not the wear rate.

References

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