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Friction and wear performance of PA1010 composites

Helena Ronkainen[1)*], Vuokko Heino[1)], Jani Pelto[1)]

[1)]VTT Technical Research Centre of Finland, Finland.
*Corresponding author: helena.ronkainen@vtt.fi

Polymers are used widely in different applications due to their lightweight. Often the wear resistance can be the limiting factor for the use of polymers in demanding applications. In this study, the tribological performance of PA1010 was improved by reducing the friction and particularly the wear with nanofillers and with a combination of micro- and nanoscale fillers. The tribolayer formation influenced both wear and friction performance of the polymer composites. In addition, the influence of test parameters was studied for selected PA composites.

Keywords (from 3 to 5 max): polymer, polyamide, wear, friction, nanocomposite

1. Introduction

Polyamide 1010 (PA1010) is plant derived bio-based aliphatic thermoplastic polymer that has mechanical properties comparable to the traditional aliphatic polyamides, such as PA6 and PA66. Similarly, to other polyamides, it has a high elastic modulus characteristic to engineering polymers, and high impact strength. Due to the beneficial mechanical properties and relatively low water absorption, PA1010 has also gained interest within tribology. In this study, PA1010 based nano-composites with the nanosilicas and graphene, and nano-micro composites with nanosilica/GO and glass flakes were developed.

2. Methods

PA1010 based nanocomposites were developed using graphene oxide nanosheets (GO), graphene nanoplatelets (NG), and fumed nanosilica (SiO_2) fillers with specific treatments to improve the dispersion of fillers and the adhesion between fillers and the polymer matrix. In addition, combination of micro- and nano-fillers were made with micro-scale glass flakes (GF). The composites were melt compounded and the samples were injection moulded to prepare the samples for tribological testing, microindentation measurements and for microscopy. The tribological performance was evaluated by sand abrasion and pin-on-disc sliding tests. In abrasion tests, two different loading levels were used and the sliding tests were carried out with a normal load of 30 N (representing 4.2 MPa), sliding speed of 0.6 m/s and sliding distance of 1000 m.

Table 1: Description of composites prepared.

Material	wt-%	Filler
PA	-	-
PA-0.5% GO	0.5	graphene oxide
PA-0.5% NG	0.5	graphene nanoplatelet
PA-20%GF-0.5% GO	20	glass flake
	0.5	graphene nanoplatelet
PA-20%GF-0.5% NG	20	glass flake
	0.5	graphene oxide
PA-20% GF-1.5%SiO_2	20	glass flake
	1.5	silicon oxide
PA-20% GF-3%SiO_2	20	glass flake
	1.5	silicon oxide
PA-3% SiO_2	3	silicon oxide

3. Results

According to sliding test, both friction and wear of PA1010 were increased by graphene based nanofillers alone, without the glass flakes. Nanosilica addition alone reduced friction but increased wear of PA. In contrast, the combination of micro-scale glass flakes and nano-scale fillers reduced both the friction and the wear of polymer in all cases, as presented in Figure 1.

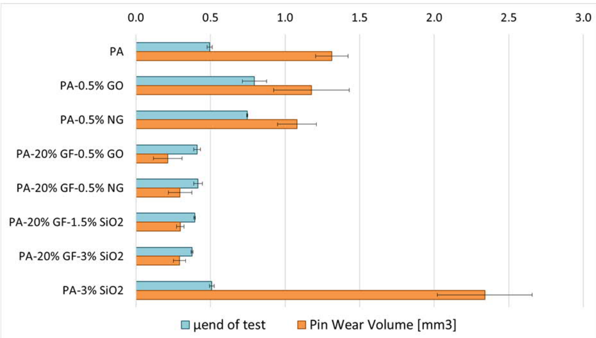

Figure 1: The friction coefficient and the wear volume in the end of the pin-on-disc tests of the polymer composites.

The abrasive wear performance was evaluated with sand abrasion tests, which showed that PA1010 itself has a rather good abrasive wear resistance. The abrasive wear of PA composites was in most cases higher compared to neat PA1010. Only the silica fillers could provide lower wear, and particularly in highly loaded abrasive conditions the wear of PA-3% SiO_2 composite was almost 40 % lower compared to neat PA1010. In contrast, in sliding tests, the composite experienced high wear.

4. Discussion

The PA composited developed showed improved tribological performance in sliding conditions when micro-and nano-scale fillers were used as combination. The micro-fillers seem to contribute beneficially to wear resistance, most likely by the significant mechanical reinforcement of the soft matrix polymer, and the concurrently increased thermomechanical stability. Hence, the micro-fillers facilitate the formation of beneficial sliding conditions where the nano-scale fillers may further provide low sliding friction, for example, by changing the surface hydrophilicity of the polymer, reducing the size of wear particles, and by the formation of more stable and/or lubricating tribolayers.