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Modification of Frost-Resistant Plastic Lubricants Using Few- and Multi-Layered Graphene

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Extended Abstract

Plastic lubricants, consisting of a liquid base (dispersion medium), solid thickener (dispersed phase) and additives, are widely used in various machines and mechanisms to reduce wear and friction. Incorporating few- and multi-layered graphene into the lubricant composition is of particular interest nowadays due to the following reasons: 1) single-layered graphene can withstand about 6400 sliding cycles, maintaining a very low value of the coefficient of sliding friction, whereas three- or four-layered graphene withstands 47000 cycles [1]; 2) graphene not only reduces the coefficient of sliding friction 1.5-2-fold [2], but also increases the viscosity of the dispersion medium [3]; 3) the use of graphene is one of the promising ways of commercial production of environmentally friendly plastic lubricants [4].

In this regard, the present paper considers four options for modifying different plastic lubricants using graphene. These lubricants are based on low-viscosity petroleum oil and lithium stearate as a binder and can operate well at temperatures ranging from -60 to +90 ^{O}C.

In the first option, few-layered graphene (3-5 layers), produced by NanoTechCenter Ltd. (Tambov, Russia) [5], was used. First, a 9-10 wt.% graphene masterbatch was prepared, and then, it was mixed with the lubricant. The masterbatch concentration was 0.7-7 wt.%, which corresponded to the graphene concentration in the lubricant ranging from 0.05 up to 0.5 wt.%. The lubricant/graphene mixture was homogenized using a rotary mixer: the lubricant moved in a gap of 0.05-0.15 mm between the stationary housing and the rotating rotor. The rotor speed was 300-1500 rpm. The processing time was 0.16-0.66 cm^3 c^{-1}.

In the second option, the modification was carried out in the same manner, but multi-layered graphene (15-25 layers; NanoTechCenter Ltd.) with a concentration of 7-8 wt.% was employed.

In the third option, multi-layered graphene was obtained through mechanical graphite exfoliation using a rotor-stator mixer similar to the one employed elsewhere [6]. The rotor diameter and the height were 40 and 50 mm, respectively, and the radial clearance between the stator and the rotor was 0.05-0.15 mm. The rotor speed was 5000-15000 rpm.

In the fourth option, the masterbatch containing the multi-layered graphene was prepared using a rod drum mill [7], the rods of which do not rotate but slide relative to the rotating drum shell. In this case, graphite particles were exfoliated due to shear stresses. In the experiments, drums with diameters of 140 and 250 mm were used. The rotational speed was 5-60 rpm.

The tribological characteristics of the initial and modified lubricants were determined on a four-ball machine [4] and the device described elsewhere [2]. In all the options proposed, at the graphene concentrations exceeding 0.1 wt.%, the tribological properties of the lubricant were improved: *e.g.*, the friction coefficient was reduced 1.8-2-fold (for the first and second options) and 1.5-1.7-fold (for the third and fourth options), the wear spot diameter was decreased by 50 %, the load wear index was increased almost 2.2-3-fold, and the welding load was increased 3-3.8-fold (for the first and second options) and 2.5-3-fold (for the third and fourth options). However, we consider that the third and fourth lubricant modification options are preferred, since their cost is 10 times less than that of the first and second options.

Thus, the modification of lubricants employing graphene improves their tribological characteristics. Moreover, to reduce the cost of the lubricant modified, it is required to increase the efficiency of the graphite exfoliation in the liquid base used in the lubricant production.

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