Plastic greases based on few-layer graphene nanoflakes and their physical and chemical characteristics

GRAPHENE and RELATED STRUCTURES: GRS-2019 synthesis, production, and application

S. Yu. Kupreenko[1], R. V. Aziev[2], S. V. Savilov[1], N. V. Usol'tseva[3]
(1) Chemistry Department, M. V. Lomonosov Moscow State University, Moscow, Russia
(2) "INTESMO" LLC, Volgograd, Russia
(3) Nanomaterials Research Institute, Ivanovo State University, Ivanovo, Russia
e-mail: kupreenko@kge.msu.ru

One of the most effective way to enhance the performance of greases is adding of the solid fillers, which effectively reduce friction and improve wear resistance in the most difficult modes, and also prevent friction surfaces from scoring under shock loads.[1-2] However the scope of application of traditional solid fillers in greases, such as graphite and molybdenum disulfide, is usually limited to use only in low speed friction joints with low quality surfaces.

Carbon nanomaterials[1-4] might serve as an alternative solution. Their thermal stability, high thermal conductivity and the possibility of surface modification make them promising material for developing high performance greases.

Greases based on lithium stearate and complex thickener were modified using few-layer graphene nanoflakes (GNF)[5].

Based on a systematic physical and chemical study of the original lubricant compositions, it was shown that modification of lithium plastic greases by GNF (up to 5 % by weight) leads to a significant improvement of tribological characteristics:
- increase of wear scar diameter by 15 % (from 0.75 to 0.64 mm);
- increase of the welding load from 1568 to 2195 N;
- increase of scuffing index from 370 to 420.

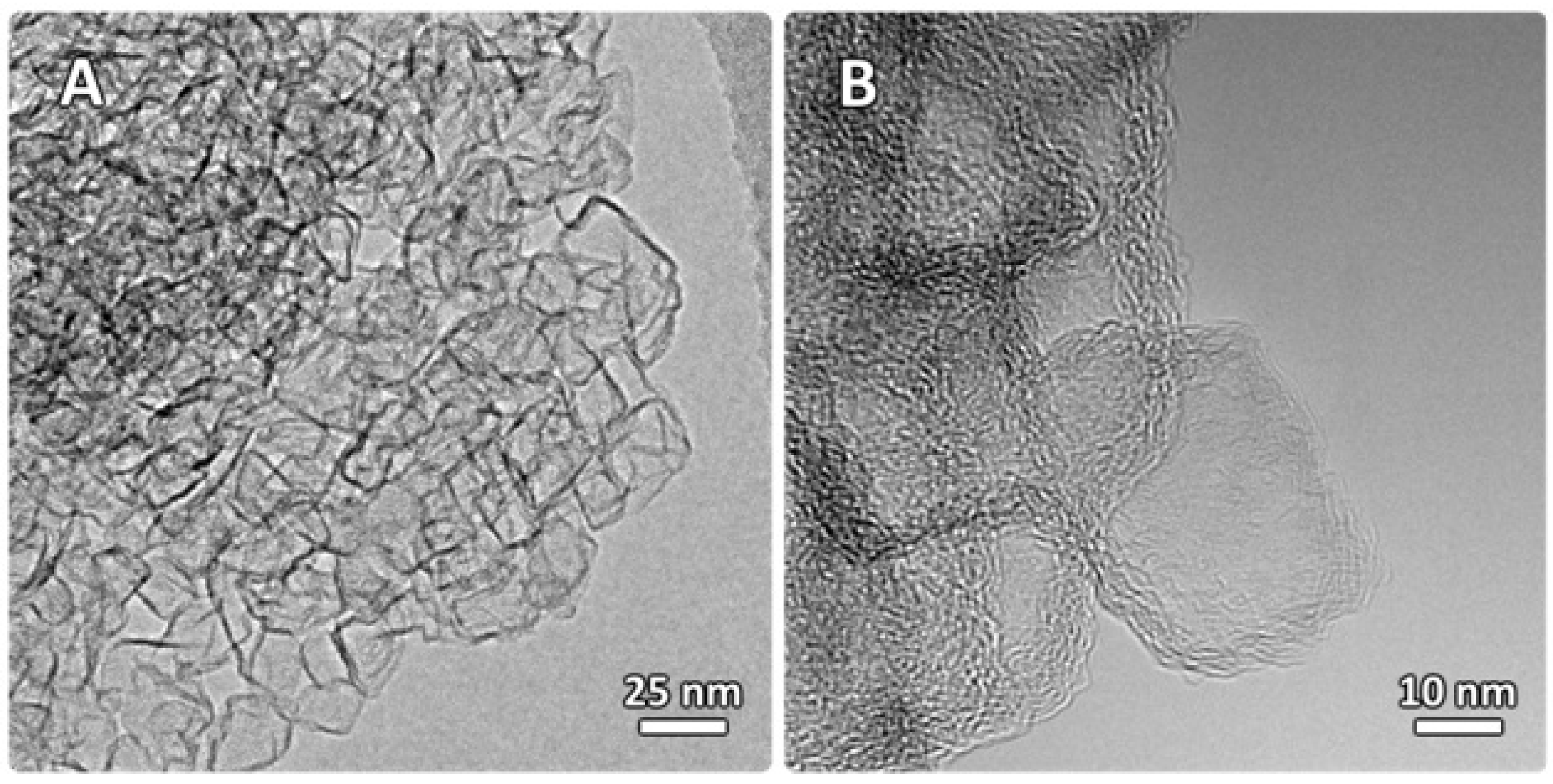

Fig. 1 HRTEM images of GNF.

The introduction of GNF (up to 5 % by weight) in the composition of lithium greases leads to an increase of thermal conductivity of the compositions up tp 60 % (from 0.32 to 0.52 W/m·K fro grease based on simple thickener and from 0.25 to 0.40 W/m·K for colmplex thickener), which significantly improves the ability of lubricant to remove heat from the friction surface without creating abnormal temperatures in the contact zone.

It was shown that the order of GNF introducing into the lubricant composition does not significantly affect on the volumentric-mechanical and operational properties of grease, which indicates that GNF is not involved in the formation of the thickener structure.

The XPS method revealed that during the lubricant operation in the friction unit, a significant change in the chemical state of the carbon nanostructures occurs, associated with the occurrence of a tribochemical reaction leading to the binding of lithium 12-oxystearate molecules to the surface of GNF.

Using current Russian and international standards, it was shown that GNF are corrosion-inactive and compatible with modern additive packages.

This work was financially supported by the RFBR grant 18-29-19150

Table 1 Element concentrations, component fractions and binding energies in the XPS spectra and the corresponding types of bonds for GNF before and after exploitation in the friction unit.

Spectrum	Binding energies, eV	Type of bond	Content, % at. GNF ref.	Content, % at. GNF 12 h.	Content, % at. GNF 24 h.
C1s	284.0	C–C (sp^2)	99.1	14.0	-
	285.0	C–C (sp^3)	-	64.2	74.5
	286.5	C–O	-	6.7	7.6
	288.9	O=C–O, ROO^-	-	4.0	4.4
O1s	531.9	O=C, ROO^-	-	6.2	8.0
	533.1	C–O–C	0.9	1.7	2.2
Li1s	55.5	Li^+	-	2.9	3.3

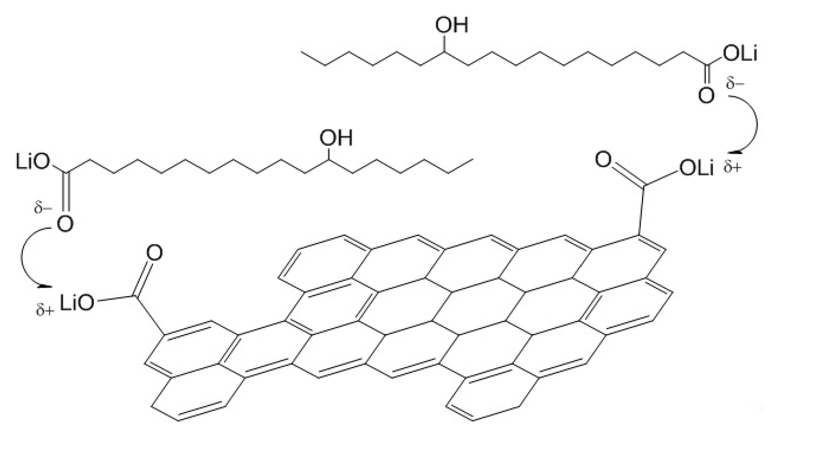

Fig. 4 The binding scheme of lithium 12-oxystearate molecules with GNF's surface.

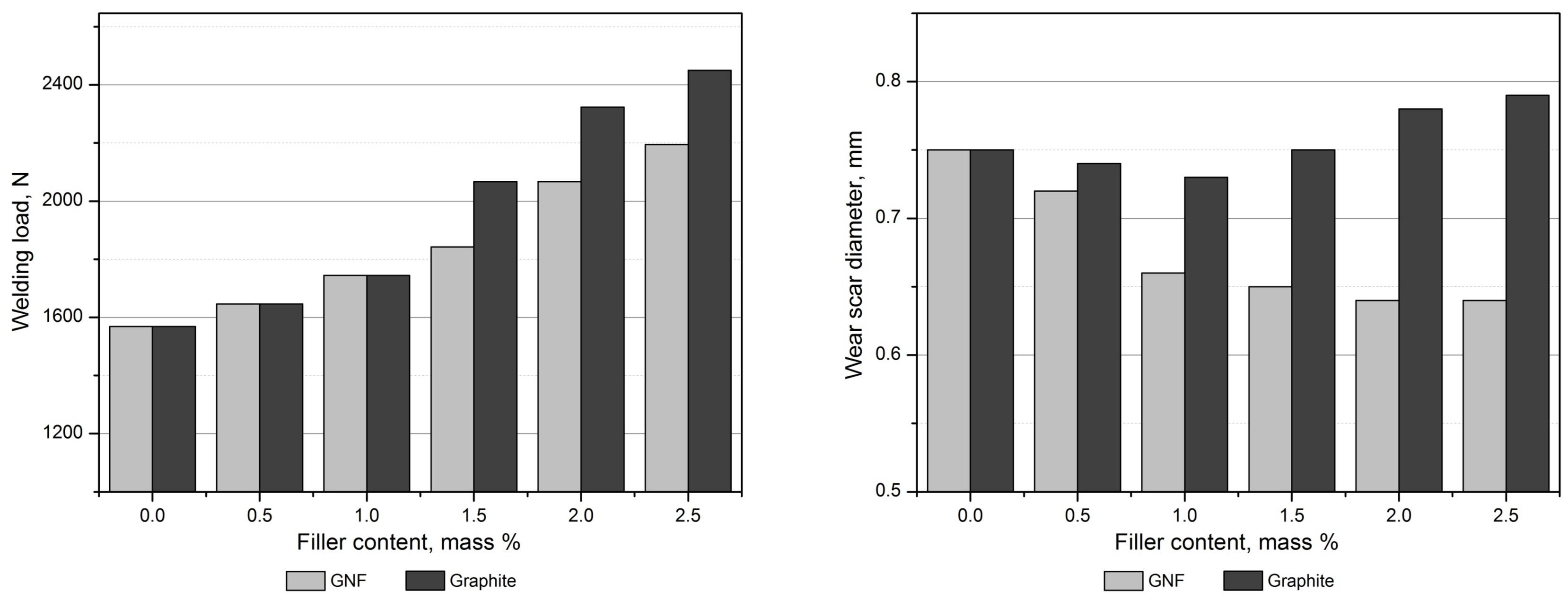

Fig. 2 The effect of GNF and graphite content on the welding load and wear scar diameter of the lithium grease.

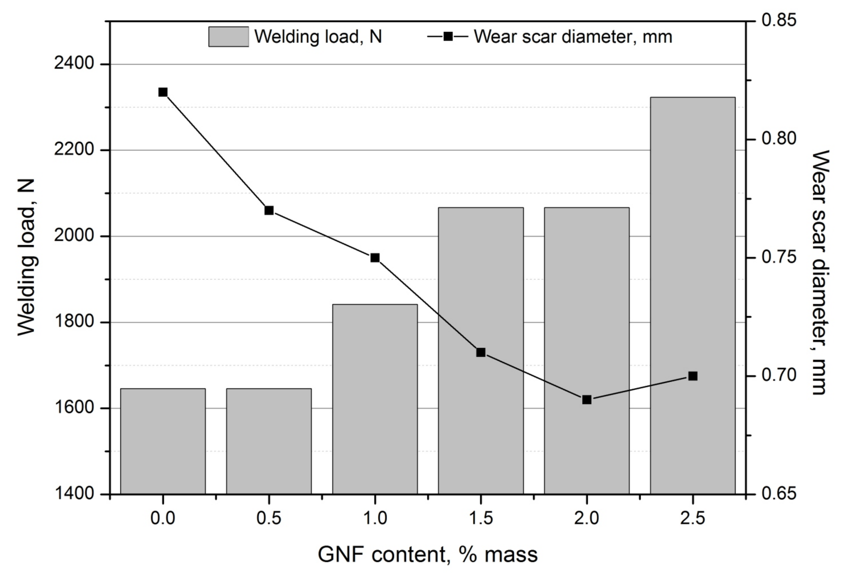

Fig. 3 Effect of GNF content on the welding load and wear scar diameter of the coplex lithium grease.

Table 2 Effect of additives on lithium grease properties

	Without additives	2% GNF	2% GNF 5% DF-11K	2% GNF 2.5% Anglomol-99
Wear scar diameter, mm	0.75	0.62	0.53	0.45
Welding load, N	1568	2450	2607	3685
Copper strip corrosion, ASTM D 4048	1a	1b	1b	1b

Fig. 5 Test template for standard method of corrosivity determining.

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