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Polymeric Composite Materials Based on Polyethylene and Modifying Additives

Rosilov Mansur Sirgiyevich, Nomozova Sadoqat iskandar qizi, Tog'ayev Eldor Maxmanazarovich

Karshi Engineering and Economic Institute

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Annotation: The article presents the results of research on the development of polymer composite materials with improved strength and antifriction properties based on high-density polyethylene (HDPE), as well as low-density polyethylene (LDPE) and modifying additives - Azerbaijani clays and SAE5W30 motor oil. It has been established that the introduction of 5–25% nanosized clays and 1–3% of the above oil into the composition allows thermoplastic materials with sufficiently high antifriction and other properties.

Keywords: Komposition, polyethylene, polymer, motor oil, modifiers, clay, composition.

In technologies related to the development of filled polymer composite materials for various purposes, special attention is paid to the scientifically based selection of modifying additives to the polymer matrix, which eliminates the phenomenon of antagonism between them and ensures sufficiently high performance properties. [1].

In recent years, with the development of nanotechnologies, wide possibilities have opened up for varying the physicochemical and operational parameters of composite materials by impregnating various metals, their oxides, sulfides, montmorillonite, graphite, and other modifying substances in the structure of polymer matrices. [2–4].

The processes occurring during impregnation have been studied in detail on the effect of nanosized metal particles (NMPs) or their cluster particles on the properties of traditional polymers (PE, PVC, etc.). This is explained by the ability of particles to form ionic and coordination crosslinks limiting mobility of molecular chains or their segments, cohesive and adhesive interactions, and other reasons [3]. Often, in the compositions of compositions based on PE, PTFE, etc., along with inert fillers, reactive oligomers and co-oligomers are also used, which are involved in the process of crosslinking polymer chains, with the formation of a material with high strength and antifriction properties. Yes, in the patent [5] a new, curable composition is proposed, consisting of 1% PTFE (particles with a size of 0.1-0.4 microns), 57.5% reinforced carbon fiber fabric and 48.5% phenol-formaldehyde resin. The cured material can be used in dry friction conditions, in the absence of any lubrication. Thus, to impart the required additional properties to industrial polymers, various methods are used based on the inclusion of filler particles and other modified additives in the composition and their processing by any known suitable method.

This article presents the results of our research related to the development of new composite materials based on HDPE and LDPE, nanosized Azerbaijani clays (Gyzyl-Dare deposits of the Republic of Azerbaijan) and SAE5W30 motor oil intended for use in automobile gasoline engines.

Experimental part

The main characteristics used in the work as polyethylene matrices are given in **Таблица 1.**

Characteristics of polyethylenes.

Indicators	PENP	PEBP
Density at 20 °C, kg/m3	924	957
Melt flow index at 190 °C, g/10	7.0	8.6

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min		
Melting temperature	105–110	124–132
Tensile strength, MPa	26.0	31.0
Elongation at break, %	170	190
Water absorption (30 days, 20 °S)	0.020	0.005

Characteristics of modifying additives:

a) Nanoclay, which is a sedimentary rock dust-like in a dry state and plastic when moistened, consists of one or more materials of the kaolinite, montmorillonite or other layered aluminosilicates group. Composition, % wt.:SiO_2–47.0, Al_2O_3–39.0, H_2O –14.0.

b) SAE5W30 engine oil: kinematic viscosity at 100 °C ~10 mm2/C, flash point (in an open cup) 180–182 °C, pour point –33–34 °C. Compositions were made using LDPE (or HDPE) as matrices and various amounts of filler (clay) and SAE5W30 oil (acting as a structural plasticizer). Samples were prepared on hot rolls at a temperature of 180°C and a duration of 8–10 min.

First, the polymer matrix was melted on rollers, a filler (clay) was introduced into it in an amount of 5 to 25%, and then a plasticizing component of 1–3% SAE5W30 lubricating motor oil. Prepare samples without oil. The mass was mixed to a homogeneous mass and scraped off the rolls with the help of special knives. Next, the polymer composite (in an amount of 30 g) was placed in a mold and pressed under pressure. Samples for testing were cut out from the obtained plates.

The tensile stress and elongation (according to GOST 17370–71) and the coefficient of friction (according to GOST 11012–69) served as evaluation indicators.

Results and its discussion

In table. 2 shows the results of tests of filled composite materials obtained on the basis of polyethylene from nanoclay and motor oil (at their various mass ratios).

As can be seen from Table. 2, the inclusion of nanosized clays and motor oil (with a viscosity of ~10 ml/s) into the composition of the polyethylene matrix makes it possible to create a composite filled material with high strength and antifriction properties. When using only HDPE filler (clay) in the composition, it is not possible to achieve a sufficiently low value of the friction coefficient. So, when testing a cured composition consisting of 75% HDPE and 25% nanoclay, the friction coefficient is 0.42, then it is enough to introduce only 1% motor oil to reduce the friction coefficient to 0.24.

Table 2. Composition test results

The ratio of components, wt.%.	Breaking stress, MPa	Relative extension, %	Melt flow index, g/10min	Friction coefficient
HDPE: nanoclay: engine oil				
75:25:0	25.3	15.0	11.8	0.42
85:15:0	27.6	20.0	14.3	0.37
73:26:1	25.5	25.0	9.5	0.24
72:25:3	27.2	45.0	12.7	0.18
83:15:2	29.8	70.0	16.4	019
94:5:1	31.8	150190	9.7	032
LDPE: nanoclay: engine oil	12.5	20	7.2	0.24

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75:25:0	15.9	50	8.6	0.14
73:25:2	13.3	25	7.7	0.21
69:27:4	16.9	75	5.8	0.16
83:15:2	15.7	220?	2.2	0.22
95.5:4:0.5				

In the case of using LDPE (95.5%), nanoclay (4%) and only 0.5% oil as a matrix, to obtain a composite material with a friction coefficient of 0.22 and a tensile elongation of 220%. The composition consisting of 73% LDPE, 25% clay and 2% engine oil has the lowest wear rate: the friction coefficient is minimal 0.14. According to the values of the breaking stress of the sample, compiled on the basis of HDPE. surpass those obtained on the basis of LDPE.

Thus, by modifying the properties of industrial polyethylenes with cheap inorganic additives, it is possible to create composite materials with high strength and antifriction properties. The use of clay as a filler also increases their fire resistance.

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