NANOTECHNOLOGY APPLICATION IN COMPOSITE REBAR PRODUCTION

PIETEIKUMU NANOTEHNOLOĢIJU RAŽOŠANAS KOMPOZĪTMATERIĀLU ARMATŪRAS

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Abstract. *The paper deals with the influence of metal/carbon nanocomposite additives on the physical properties of composite polymer reinforcement samples. Novel methods of composite rebar production have been suggested and tested. The overall positive effect of polymer composite material modification by selected additives has been found and analyzed.*

Keywords: *composite materials, polymers, composite rebar, modification, isomethyltetrahydrophthalic anhydride, metal/carbon nanocomposite.*

Introduction

Polymer composite materials with higher specific performance than the traditional high-strength structural materials based on steel, titanium and aluminium are considered to be the materials of the 21st century. Composite materials reinforced with continuous high strength high modulus glass or basalt fibers, in the form of rebar with diameter from 2 to 40 mm present the greatest interest as structural materials for the construction industry [1].

Structurally they are multicomponent materials consisting of polymer matrix reinforced with fillers, fibers, whiskers, particulate matter, etc. The main advantage of composite material is that by selection of the composition and properties of filler and matrix, their ratio, orientation of the filler it is possible to obtain materials with the required combination of operational and technological properties. The selection of key components is determined by the required functional requirements, operational reliability of the composites, and compatibility of components, adaptability of processing, availability and cost.

Materials and methods

Fiberglass performs a reinforcing function and ensures the necessary strength. Polymer binder, located in the interfiber space is used for distribution of mechanical stresses between the fibers, also partly takes these mechanical stresses and, very importantly, determines the solidity of the material, transfer and stress distribution in the filler, determines the heat-, moisture-, heat - and chemical resistance.

Currently a promising direction to enhance structural strength of fiberglass is the modification of polymer matrix by various nano-additives, or creation a matrix of nanostructures during the synthesis of the material. Updating is understood as the directed change of structure and properties of polymers when administered in the composition of macromolecules of the small number of nanoscale fragments of different nature [2]. The properties of the obtained multiphase nanocomposites are determined by two main factors: 1) the dispersion and distribution of nanoparticles in the polymer matrix, and 2) the interaction between polymer chains and nanoparticles.

The aim of this study is to increase the strength characteristics of fiberglass reinforcement by modification of epoxy resins by sapentia representing isomethyltetrahydrophthalic anhydride (ISO-MTHPA) with a concentration of metal/carbon nanocomposite (NC) Cu/C of 1.125% and the subsequent technological processing. The concrete result manifests itself in the peculiarities of the structure and the distribution of

http://dx.doi.org/10.17770/het2017.21.3589

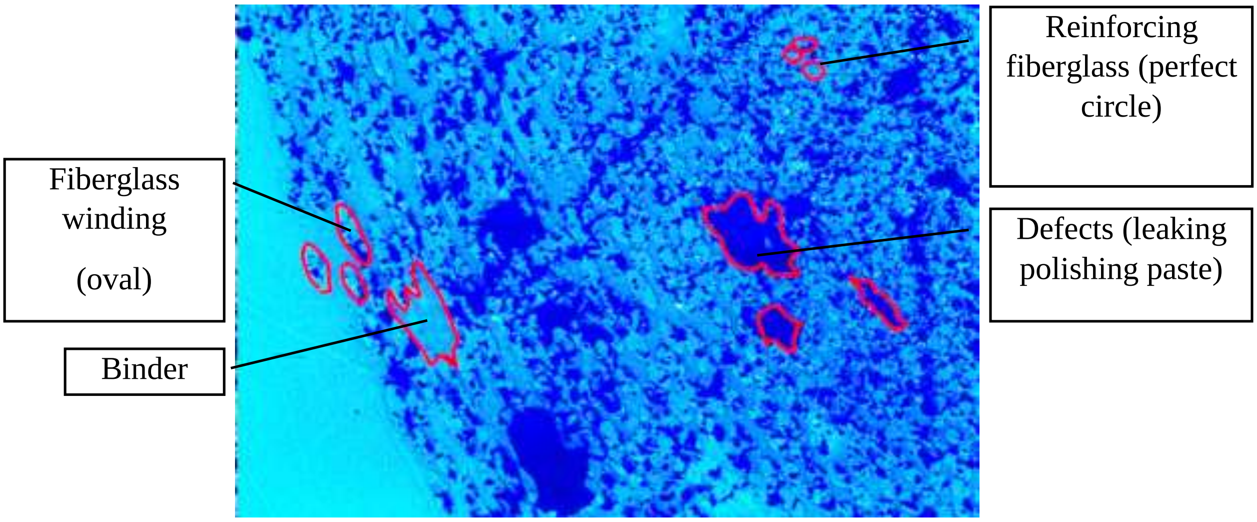
nanoparticles in the polymer matrix and interphase boundaries even at such small content of nanoparticles as 1-2 weight percent in the composite.

The technology of recovery metal compounds in the polymeric materials matrices consists of mechanochemical and thermochemical stages. This gives a durable nanocomplex metal with the carbon matrix. The amount of the nanoproduct depends on its nature and activity, and on the structure of the main composition. Modified nanocomposites have chemical-physical and mechanical properties, significantly exceeding those of the original [3].

Table 1

Results of physical-mechanical tests

Composition					**Heat mode (1) and (2)**		**Mechanical properties**		
	Epoxy resin ED-20, weight parts	**ISO-MTHPA, weight parts**	**UPR, weight parts**	**1,125% suspension NC, weight parts**	**T, ^{0}C (polymerization in the furnace)**	**t, min.**	**Tensile strength, MPa**	**Modulus of elasticity, MPa**	**Elongation, %**
Check sample	1000	1000	40	-	(1): 245, 240, 230, 200, 200, 190.	8	1110	51733	2,5
Sample 1 (FS Cu/C concentration 0,04%)	1000	964	40	36	(1): 245, 240, 230, 200, 200, 190	8	1158	51360	2,1
Sample 2 (FS Cu/C concentration 0,02%)	1000	980	40	18	(1): 245, 240, 230, 200, 200, 190	8	1150	50980	2,9
Sample 3 (FS Cu/C concentration 0,02%)	1000	980	40	18	(2): 245, 240, 230, 220, 210, 190	8	1196	49820	3,7
Sample 4 (FS Cu/C concentration 0,04%)	1000	964	40	36	(2): 245, 240, 230, 220, 210, 190	8	1224	50140	4,2



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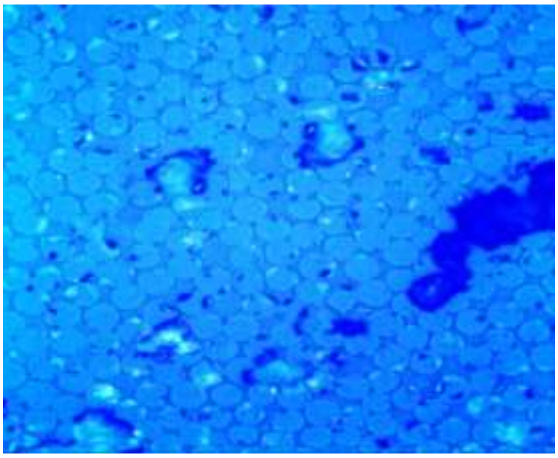

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Fig. 1. **Check sample (*a*: x100, *b*: x200)**

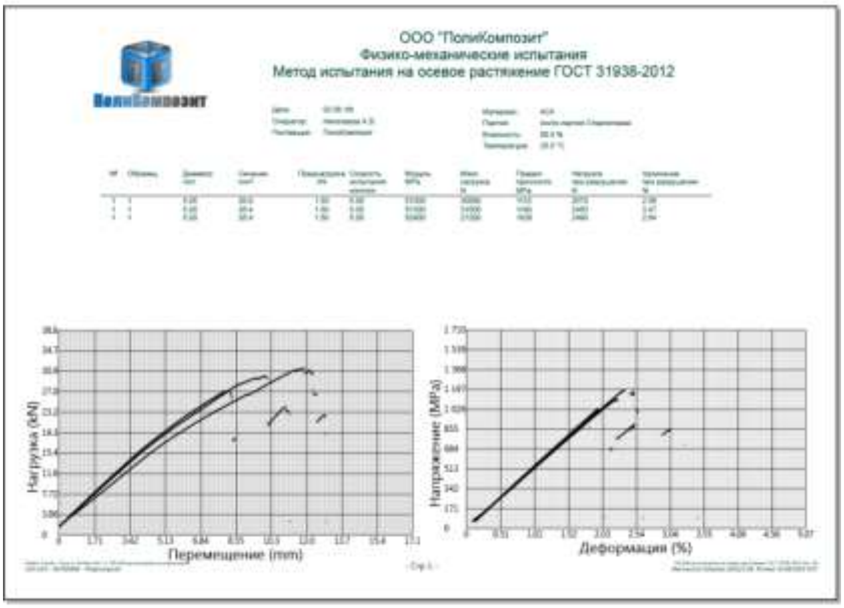
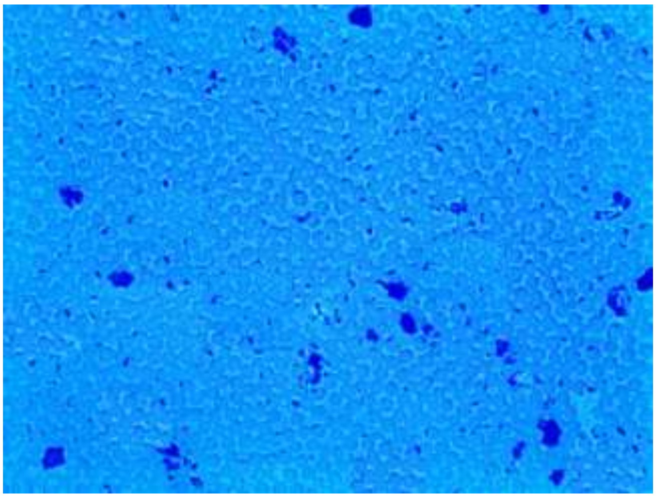


Fig. 2. **The tensile strength of 1110 MPa, Modulus of elasticity 51733 MPa**



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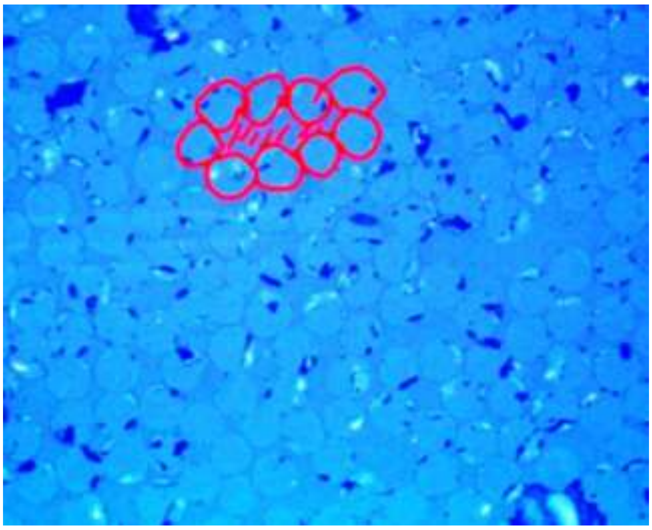

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Fig. 3. **Sample 1 (*a*: x100, *b*: x200)**

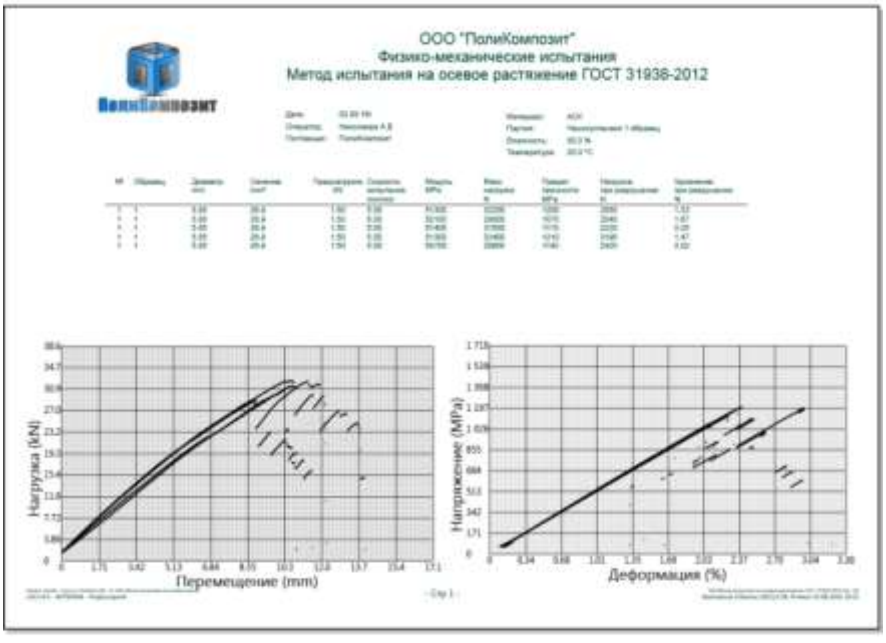
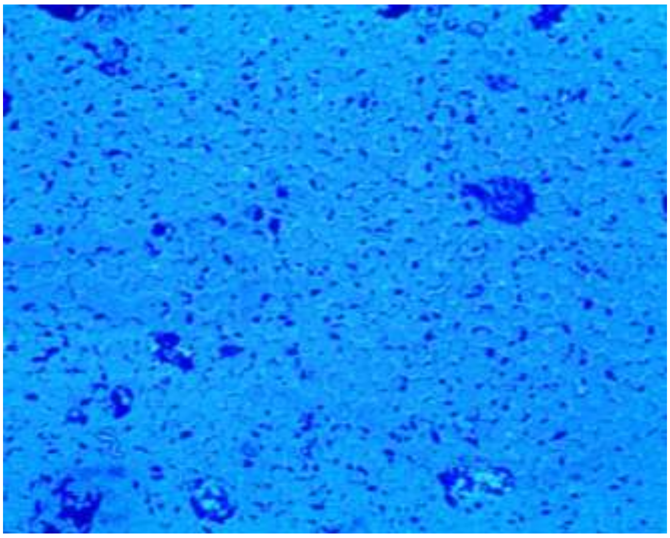


Fig. 4. **The tensile strength of 1158 MPa, Modulus of elasticity 51360 MPa**



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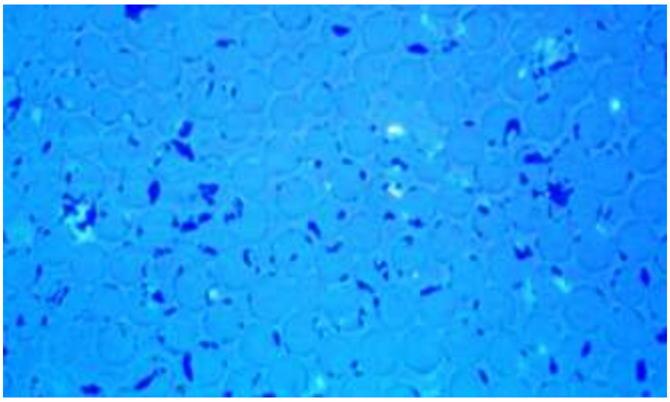

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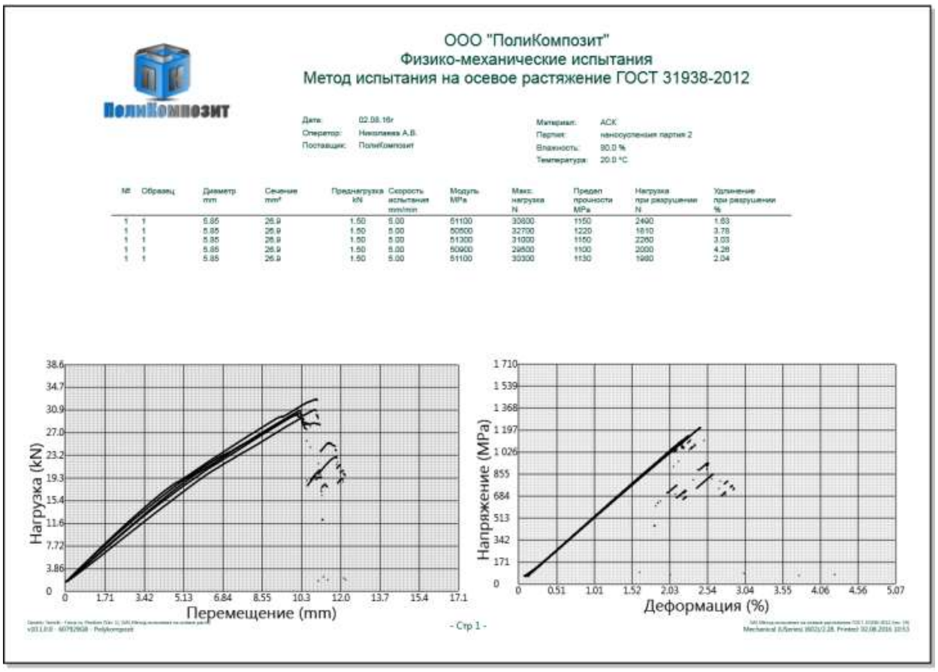
Fig. 5. **Sample 2 (*a*: x100, *b*: x200)**



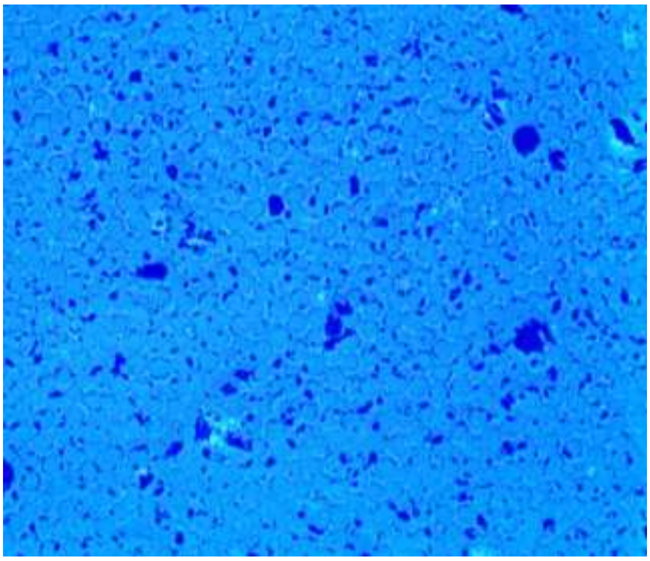
ООО "ПолиКомпозит"
Физико-механические испытания
Метод испытания на осевое растяжение ГОСТ 31938-2012

Дата: 02.08.16г
Оператор: Николаева А.В.
Поставщик: ПолиКомпозит

Материал: АСК
Партия: наноусиленая партия 2
Влажность: 90.0 %
Температура: 20.0 °C

№	Образец	Диаметр mm	Сечение mm²	Преднагрузка kN	Скорость испытания mm/min	Модуль MPa	Макс. нагрузка N	Предел прочности MPa	Нагрузка при разрушении N	Удлинение при разрушении %
1	1	5.85	26.9	1.50	5.00	51100	30800	1150	2490	1.63
1	1	5.85	26.9	1.50	5.00	50600	32700	1220	1810	3.78
1	1	5.85	26.9	1.50	5.00	51300	31000	1150	2260	3.03
1	1	5.85	26.9	1.50	5.00	50900	29600	1100	2000	4.28
1	1	5.85	26.9	1.50	5.00	51100	30300	1130	1980	2.04

Fig. 6. **The tensile strength of 1150 MPa, Modulus of elasticity 50980 MPa**



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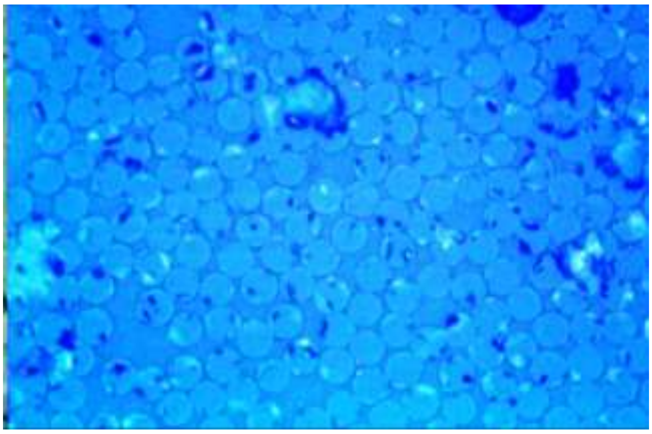

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Fig. 7. **Sample 3 (*a*: x100, *b*: x200)**

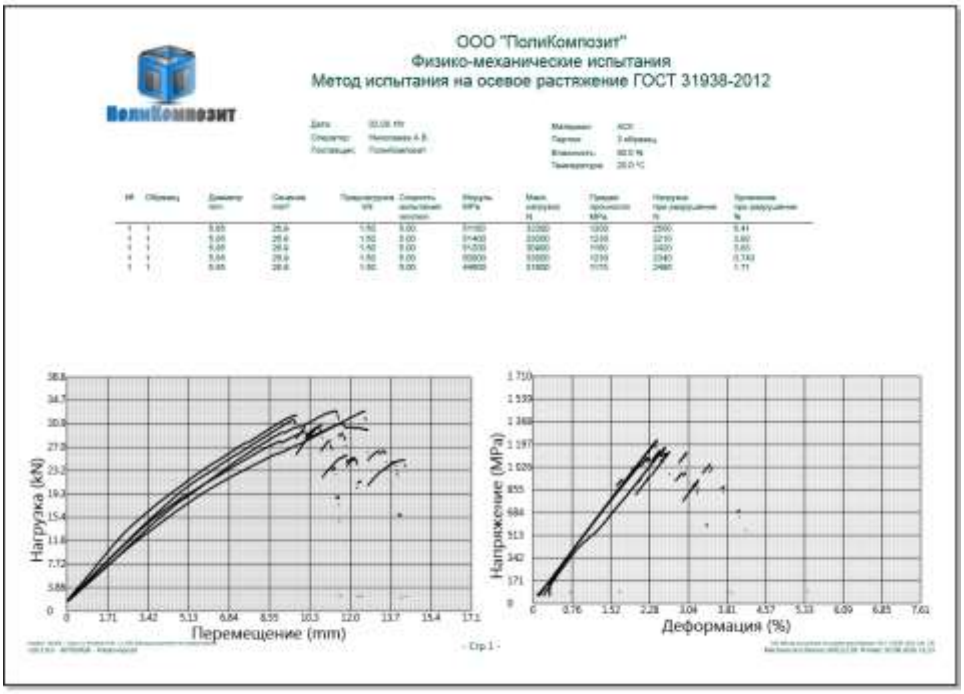
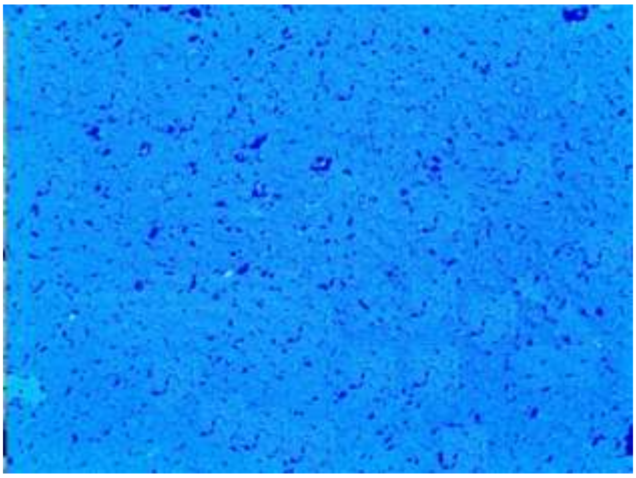


*Fig. 8.***The tensile strength of 1196 MPa, Modulus of elasticity 49820 MPa**



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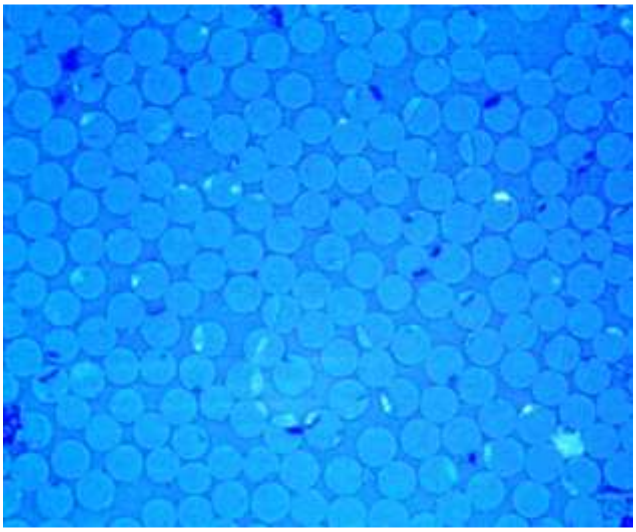

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Fig. 9. **Sample 4 (*a*: x100, *b*: x200)**

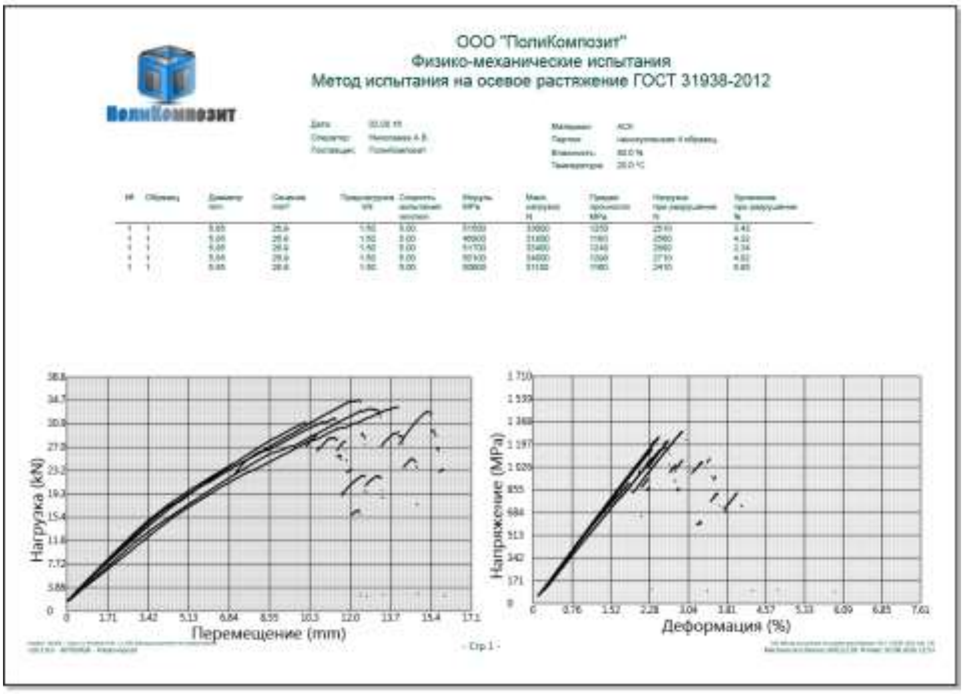

*Fig. 10.***The tensile strength of 1224 MPa, Modulus of elasticity 50140 MPa**

Results

To enable the interaction of components in the suspension, before the experiment on a production line “Polikom-5” “OOO Polikompozit” in the production of fiberglass reinforcement with the method of nightrose, fine suspension (FS) Cu/C NC was subjected to ultrasonic treatment for 20 min. Then FS Cu/C NC was injected into the epoxy binder (resin ED-20 + hardener ISO-MTGFA), processing system in ultrasonic bath for 20 minutes, for uniform distribution of ultrafine particles in the polymer. The optimal NC concentrations (0.02 and 0.04%) were chosen empirically. Further modified compound was poured into a bath of impregnation of the glass strands on the line. The binder composition of fiberglass reinforcement samples (Ø6mm) obtained in the experiment is shown in Table 1.

Some samples were studied optically using their thin sections (Figures 1 – 5) and tested for axial tension according to GOST 31938-2012 "Composite polymer reinforcement for concrete structures reinforcement. General technical conditions".

As a result of epoxy binder modification using a FS Cu/C NC, improvement of glass fiber wettability was visually observed for all samples, which is consistent with the optical study of micro-sections (according to the images of micro-sections, the packing density in these samples is higher than that in the check sample, demonstrating the highest defects content and consequently the lowest limit strength). However, with the introduction of nano-modifier, a decrease in the elastic modulus takes place, which is probably caused by a decrease in plasticity of the binder.

Conclusions

When analyzing data of physical-mechanical tests it was found that the thermal mode "2" increases the tensile strength to 10% as well as the ductility of the epoxy binder. The tensile strength growth in samples 1-4 may be caused by an increase in adhesive interaction between glass and epoxy binder.

Thus, the application of modifying additives makes it possible to control the composite rebar properties in accordance with operational requirements. The overall positive effect of composite rebar modification by selected additives extends the application area of such materials.

Bibliography

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