INFLUENCE OF FILLER AND APPRETE ON THE PROPERTIES OF COMPOSITE BASED ON LOW DENSITY POLYETHYLENE AND MINERAL ROC “GIZIL ZOD”

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Abstract. The article produces a new generation of composites with different ratios of components based on low-density polyethylene (LDPE) and natural mineral from the village of Gızıl Zod in the Kelbajar region. The influence of the filler on the properties of the resulting composites was studied. In order to improve the adhesion between the polymer matrix and the filler and obtain composites with higher physical and mechanical properties, a sizing agent is included in the system. A copolymer of heptene-1 with maleic anhydride was taken as a coupling agent (apprete). It has been established that the properties of the resulting polymer composites directly depend on various factors: the structure of the polymer matrix, the amount and dispersion properties of fillers, and the properties of the sizing agent formed and acting on the interfacial layer.

Keywords: low-density polyethylene (LDPE), natural mineral "Gızıl Zod", copolymer of maleic anhydride and heptene-1, tensile strength (σ), elongation at break (ε), melt yield strength (MFL)

Introduction

One of the developed areas of chemistry in our time is the preparation of various composites by mixing polymers and including individual fillers in the resulting composites. As a result of the influence of a number of properties of fillers on polymer composites, new types of composite materials with high physical and mechanical properties have been obtained. Materials obtained by this method are considered necessary raw materials in various fields of technology - in radio engineering, electrical engineering, mechanical engineering, in the direction of purchasing various household materials.

Relatively high results can be obtained by determining the optimal proportions of the necessary components to obtain high-quality composites [1-3].

From the studies conducted, we can conclude that the composition, nature, quantity, and dispersion of the filler have a positive effect on the quality of the composite and thereby lead to an expansion of the areas of application of the resulting material [4].

The minerals used as fillers are solid. However, the material that plays the role of a modifier can be either a liquid or a gas aggregate. When polymers are filled with gases, a polymer-foam composite is obtained, thus it is possible to reduce the density of materials or increase intramolecular pores. Filling polymers with liquid is a technologically complex process. Using liquid filler emulsions, it is possible to obtain a solid and fairly durable material as the final product.

In a number of literature sources, polyolefins are used as a polymer matrix.

This is due to the fact that they have many positive characteristics. Thus, the positive properties of polyethylene, such as ease of production, low cost, environmental friendliness and safety, relatively low density and crystallinity, necessitate its use as a matrix.

There is quite a lot of scientific research in the direction of producing composites using materials of different sizes as modifiers. The use of nano-sized particles as a filler is among the research works with positive results. Since nanofillers are active particles, they are stabilized in certain polymer matrices. Using metal oxide nanoparticles stabilized in a polymer matrix as a filler, various polymer composites with improved physical-mechanical, thermophysical, rheological, and thermal properties were obtained [5].

Goal of the work

One of the most global problems of our time is environmental protection and ensuring the protection and integrity of natural resources. Environmental pollution from industrial and household waste leads to the spread of various diseases among people, weakened immunity and the emergence of a number of global problems. From this point of view, the production of environmentally friendly and safe materials obtained by simpler processing methods and the use of cheap raw materials is considered very important.

One of the important problems of economic development is the issue of efficient use of natural resources and maintaining environmental balance. The basis of the work carried out in this direction is the purchase of polymer composite materials with high performance indicators using intermediate products and waste generated during the production and processing of polymers [1].

Interest in polyethylene and composites based on it is due to their high physical and mechanical properties [1, 2]. In the chemistry and technology of polymers, the problem of creating a new generation of polymer composite materials with significantly improved properties comes to the fore. Low-density polyethylene (LDPE) composites are considered a promising material in terms of low cost, high tensile strength, elongation at break and high temperature resistance.

Currently, it is considered a very convenient way to introduce fillers into polymers that are compatible with polymer materials and capable of creating a synergistic effect. Therefore, to solve the required number of technical and environmental problems, much attention is paid to the development of technology for the production of polymer composite materials [3-4]. Sizing agents are suitable for processing a homogeneous mass, for example, vinyl acetate with maleic anhydride, hexene-1, heptene-1, etc. Copolymers have been synthesized. As a result, to obtain a composite, 3-5 wt.% of a sizing agent (apprete) was introduced into the composition as a sizing agent.

Taking all this into account, composites with different ratios of components were obtained based on natural rocks (fillers) from local mineral deposits and low-density polyethylene (LDPE).

Formulation of the problem

The properties of the resulting new type of composites are determined by the fact that the polymer matrix is mixed with filler and located in the interfacial layers.

Also, the inclusion of natural mineral fillers of various compositions into polymers as modifiers leads to the production of composites with relatively better fire-resistant properties [1].

The mechanism of consolidation of composites is a difficult process to understand. In this regard, many researchers have conducted their research by adding rubber to the system in order to increase the hardness of the polymer composite. The fact that elastomers have an amorphous structure and thus form domains in the system due to the disruption of adhesion leads to an increase in the thermal strength of the composite [2].

Natural mineral fillers increase the viscosity and processing temperature of the polymer. The hardness of the outer surface of the resulting material increases and the difference from the original shape disappears.

Solution to the problem

The presented work is devoted to the study of filled polymer composites based on LDPE produced by the ethylene-polyethylene plant of the Sumgayit Industrial Park. Republic of Azerbaijan, Kelbajar region Natural minerals “Gyzyl Zod” were used as a filler.

Since the beginning of the 20th century, special attention has been paid to replacing metal, wood, fabric and other natural materials with more cost-effective, lightweight, durable and resistant to harsh environmental conditions, easily taking any shape and various synthetic materials. [6-7].

The rapid growth in the production of plastic products causes the need to recycle plastic waste [8-9].

For many years, employees of the laboratory “Recycling and Ecology of Polymer Materials” of the Institute of Polymer Materials have been purchasing composite materials filled with natural minerals, such as polyolefins and fillers, and using various copolymers synthesized by them as coupling agents, as well as various properties of the resulting composite samples, for example, - physical and mechanical properties, determine the fluidity index of the alloy [10].

Taking all this into account, current scientific research is being conducted in the direction of obtaining new composites with various components and increasing their physical and mechanical properties by applying various modifiers to the resulting mixtures.

The polymer matrix is low-density polyethylene (LDPE), the filler is rock with the natural mineral “Golden Zod”. A copolymer of maleic anhydride and heptene-1 was taken as a coupling agent.

The mine rock used as filler has the following mineralogical composition.

Table 1

Mineralogical composition, %

Conventional name of samples	$(Mg,Al)_3((Si,Fe)_2O_5)(OH)_4$ Alisardite	$MgFe_2O_4$ magnesium ferlite	Other mixtures
№1 “Gyzyl Zod”	88	10	2
№ 2			
№3 Waste mining	87	13	2

The chemical composition of the natural mineral included as a filler in polymer composites is given in the table below.

Table 2

Chemical composition of the presented samples, %.

Conventional name of samples	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO
№1 “Gyzyl Zod”	0,01	36,94	0,57	36,54	0,01	0,28	0,01	0,21
№2	0,14	9,48	12,93	40,24	0,12	0,13	0,02	26,37
№3 Waste mining	0,01	34,91	0,53	37,14	0,01	0,11	0,01	0,30

TiO_2	MnO	Fe_2O_3	NiO	Cr_2O_3	Cl^-	YTİ
0,01	0,12	11,00	0,45	0,40	0,07	13,34
0,98	0,05	5,01	0,02	0,03	0,01	4,46
0,01	0,14	12,52	0,61	0,53	0,10	13,06

Note: YTI – 950^0C indicates the amount of volatile components.

In addition to SiO2, the natural mineral that we take as a filler contains a number of other compounds in mass fractions.

The physical and mechanical properties of the resulting composites are given in Table 3.

Table 3

Physico-mechanical properties of the resulting compositions
Without Apprete

№	Components w. %	Stretching force, σ, MPa	Relative elongation, ε,%	MFR
1.	LDPE-100	11.0	45	5.9
2.	LDPE-70 Filler-30	29.6	16	5.4
3.	LDPE-60 Filler-40	30.6	8	4.5
4.	LDPE-50 Filler-50	32.7	4	3.8
5.	LDPE-40 Filler-60	25.0	4	1.4
6.	LDPE-30 Filler-70	19.0	4	0.4

From the data presented in Table 3, it is clear that the tensile strength takes its maximum value when the ratio of the components included in the composite, LDPE-50 and filler is 50 wt.%. σ=32.7 MPa. This is explained by an increase in the strength of the resulting composite with an increase in the amount of filler. However, with a subsequent increase in the amount of filler, the value of the tensile strength of the sample decreases and, as a result, it takes on a minimum value (σ = 19.0 MPa) with a component ratio of LDPE-30 and filler of 70 wt.%. This is explained by an increase in brittleness due to microdefects that can occur within the composite.

The relative elongation values of composite samples correspondingly decrease as the amount of filler increases. The alloy flow index values obtain lower values as the mass % of the filler increases. This is explained by a decrease in fluidity depending on the nature of the filler. Summarizing the results of the presented studies, we can conclude that the content of a composite filler polymer with excellent deformation resistance properties is 50/50% by weight.

In continuation of the research and in order to ensure or improve the compatibility of the polymer matrix with the filler, as well as to obtain composites with high-quality physical and mechanical properties, an analysis of the properties was carried out by adding a copolymer of maleic anhydride with heptene-1 in the form of a coupling system.

Polymer matrix - low density polyethylene (LDPE). brand-10803-020.

Filler - mining rock "Kyzyl Zod".

The coupling agent (apprete)- is a copolymer of maleic anhydride with heptene-1.

Apprete is included in the system in an amount of 3 mass%, regardless of the ratio of the components.

Looking at Table 4, we see the values of physical and mechanical indicators. Tensile strength of a sample with 50/50 wt. % LDPE and filler by weight takes the maximum value (σ=33.3). It is observed that the strength gradually decreases with a subsequent increase in the amount of filler.

When studying the effect of adding a sizing agent to the system, we see that the strength of a sample with a component ratio of 50/50% receives its maximum value as a result of mixing the sizing agent in an amount of 3% by weight. With a further increase in the amount of filler, the tensile strength value gradually decreases, as in the case of samples without sizing. As a result, the minimum price for a LDPE-filler-sizing sample becomes relevant at a component ratio of 30/70/3 wt.%. In samples with a large amount of filler in the system, the decrease in strength and low values are explained by the observation of brittleness due to the formation of microdefects inside the composite. As can be seen from Table 4, the results in the case of the sizing agent are similar.

Table 4

Physico-mechanical properties of composite samples
With apprete

№	Components, %	Stretching force, σ, MPa	Relative elongation, ε,%	MFR
1.	LDPE-70 Filler-30 Apprete-3	28.4	16	3.5
2.	LDPE-60 Filler-40 Apprete-3	29.7	12	2.9
3.	LDPE-50 Filler-50 Apprete-3	33.3	8	2.4
4.	LDPE-40 Filler-60 Apprete-3	23.6	4	1.2
5.	LDPE-30 Filler-70 Apprete-3	19.4	4	0.4

The melt flow index values decrease with increasing filler amount. The same results are observed when adding a sizing agent to the system.

In order to increase the adhesion of the polymer matrix to the filler and achieve higher physical and mechanical properties when obtaining composite samples in various mass% ratios by adding a sizing agent to the system, the maximum value of the tensile strength is set higher than the results of samples without sizing agent. σ=32.7 MPa for LDPE/Dol.-50/50% without sizing agent and σ=33.3 MPa for LDPE/Nap./Ap.-50/50/3% with sizing agent. From this we can conclude that the influence of the primer on a homogeneous system containing a filler polymer is undeniable.

Conclusion

Based on low-density polyethylene and natural mineral fillers, polymer composites with different ratios of components were obtained and the influence of the filler and primer on the system was studied. Composite samples with different mass% ratios were obtained, and to increase the compatibility of the matrix with the filler and obtain composites with better physical and mechanical properties, a copolymer synthesized in the laboratory was introduced into the system.

As a result of the research, it was concluded that the sample with the highest physical and mechanical properties among the samples without sizing and with sizing has a component ratio of 50/50%.

The acquisition and study of polymer composites of various compositions shows that scientific research in this direction gives very good results, and the resulting polymer composites with high properties can be used in various fields.

The resulting polymer composites can be used in various fields of technology as structural materials for technical purposes.

Therefore, the presented research work is considered to be economically and environmentally beneficial.

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Accepted: 30.10.2024