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Influence of Filler and Apprete on Composites Based on Polyolefylene, Filler and Apprete

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Abstract
The article shows the production of new generation composites in various proportions of components and the study of their properties based on high-density polyethylene (HDPE) and natural mineral rock from the village of "Demirchi Dam" in the Kelbajar region, Karabakh region. The influence of filler and sizing agent on a number of physical and mechanical 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 maleic anhydride and vinyl acetate, which differs in functionality, was taken as a coupling agent. It has been established that the properties of the resulting polymer composites depend on various factors; this depends on the structure of the polymer matrix, the amount of filler and its dispersion properties, as well as the influence of the sizing agent on the interfacial layer. Depending on the properties of new generation composites created as a result of research, their areas of application are expanding, and samples are considered as suitable materials in modern science.

Keywords: High-density polyethylene (HDPE), natural mineral rock "Demirchi Dam", maleic anhydride, vinyl acetate, copolymer, tensile strength (σ), elongation at break (ε), melt yield strength (MFL).

Introduction

One of the developed areas of chemical science in our time is the creation of new generation composites with complex performance properties by mixing polymers and including individual fillers in the resulting composites. Composite materials with high physical and mechanical properties are obtained as a result of the influence of a number of properties of fillers on polymer composites. 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.

Bio-polymer composites are emerging as a feasible substitute for conventional polymers in various major fields of applications. In the current research, the impact of hybridization of inter and intra-woven natural engineering fibers namely, brown flax, white flax, and jute of different amalgamations along with commingled SCF and novel nano IW filler has been studied. The composites are manufactured by hand layup process and physical and thermomechanical characteristics of the composites are experimentally studied. The composites mingled with IW filler demonstrated better dimensional stability and mechanical properties such as maximum tensile strength of 36.74 MPa, bending strength of 82.53 MPa, and hardness of 84.89 D compared to other composites. However, elastic and flexural modulus are maximum for composite without any filler. The composites mingled with SCF filler demonstrated the highest impact strength, energy absorption, and elongation. Thermogravimetric analysis and thermal conductivity study demonstrated that the composite with SCF filler exhibited better thermal stability and thermal resistance than the other hybrid composites (Bektashi & Jafarov, 2016; Babayeva et al., 2014; Kar et al., 2024).

The production of polymers and, consequently, the collection of products of various compositions in the form of waste in nature has a direct negative impact on the environment and leads to an imbalance in the ecological balance. This, in turn, means the emergence of a number of diseases at the next stage and the eventual destruction of the living world. Given this, it is necessary to conduct research towards the creation of a new generation of composites using various polyolefins and their products in order to obtain products suitable for use in a range of applications and gradually eliminate direct damage to the environment. Taking all this into account, high-density polyethylene (recycled) and materials have been developed that have positive properties due to the effects of various additives.

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 lead to an expansion of the areas of use of the resulting material (Ferrichio, 1981).

Minerals used as fillers are dispersed. In this case, the material playing the role of a binder (filler) can be either a liquid or a gas filler. When polymers are filled with gases, a polymer-foam composite is obtained, which makes it possible to reduce the density of materials or increase intramolecular pores. Filling polymers with liquid is a technologically complex process. Using liquid filling emulsions, you can obtain a solid and fairly durable material as the final product.

It is known from a number of literature sources that 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.

Research work in the direction of producing composites using natural rocks of various dispersions as fillers is sufficient. The use of nano-sized particles as fillers is one of the scientific studies that have achieved positive results in their use as modifiers because these fillers have adhesive properties and are surfactant particles. Since nanofillers are active particles, they are stabilized in certain polymer matrices. When metal oxide nanoparticles stabilized in a polymer matrix are used as a filler, various polymer composites with relatively high physicomechanical, thermophysical, rheological and thermal properties are obtained (Alimirzayeva, 2020).

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

One of the important areas of economic development is the problem of efficient use of natural resources and protection of the environmental balance. The basis of research carried out in this direction is the production of polymer composite materials with high performance through the use of intermediate products and waste generated during the production and processing of polymers.

Currently, one of the technologically and economically advantageous methods for the directed modification of thermoplastic polymers, including polyolefins, is the inclusion of natural mineral rocks in their composition. The main reason for the need for such modification is the unsatisfactory physical and mechanical characteristics of existing thermoplastic polymers. Thus, for many years, the use of powdered and fibrous minerals along with organic fillers has been considered a major factor in the preparation of polymer compositions. The strength, electrical, thermophysical, chemical and other properties of PCM obtained by adding selected fillers to the polymer can be achieved or adjusted within wide limits. Microscale volumetric dispersed fillers based on mineral fillers and polymers are known. Thus, the methods and properties of a number of polymer composite materials based on polyolefins (PE, PP) are studied below.

The production and detailed study of the properties of composite materials based on high-density polyethylene (HDPE) and low-density polyethylene (LDPE) using glass fiber and its mixture with mineral powders as fillers has been the focus of researchers since the mid-2000s. last century. Thus, chopped HCO-6 glass fibers with a diameter of 6 microns and a length of 1.5-2.0 mm and chalk powder dispersed to a size of 0.1-0.4 microns were used as fillers. It is noted that the strength properties of filled PE depend on the length and grade of fibers, the degree of dispersion of the mineral filler, its shape and quantity. It has been established that the production of such PCMs with low hygroscopicity is technologically convenient and much cheaper (Lisichkin & Chernov, 2003).

Using HDPE and granulated aluminum hydroxide as a filler, reducing the size of its particles from 20-50 microns to 2-5 microns and increasing its amount to 10%, the fire resistance of PE was increased 4 times. It has been noted that a slight decrease in particle size makes it possible to create self-extinguishing PCM's (Jafarov & Efendiev, 2005).

Based on the results obtained by analyzing the micromechanism of the deformation process under uniaxial tension in dispersed-filled polyolefins (PE, PP), B.A. Topalgarayev and his colleagues substantiated the conditions for realizing the plastic properties of the material (Serenko et al., 2003).

Mineral fillers are also widely used in the production of PCM's with high electrical conductivity. One such method is the inclusion of conductive carbon black and graphite powder, carbon fibers, etc. into isotactic polypropylene as fillers. In this regard, it is of interest to study the shungite mineral in the development of new PCM's (Gorbunova & Kerber, 2001).

The composition of the rock obtained by crushing a carbonaceous rock mineral includes silicon dioxide with a metastable structure and a number of oxides of other metals. The amount of carbon in this rock reaches 2-98%. One of the distinctive features of the shungite mineral is its good mixing with polar and non-polar polymers. This is due to the fact that hydrophilic and hydrophobic groups in its composition and surface structure are prone to chemical modification. PCM was prepared by changing the volume content of shungite to 50%.

Plastics make up 7% of the world's chemical industry. The production of plastics is increasing every day. The main reason is their wide variety and the ability to be used for various purposes on the farm. Polyethylene, polyvinyl chloride, polystyrene and polypropylene account for two-thirds of the total plastic production volume. The most common areas of use are construction, packaging, mechanical engineering, electronics, transportation, etc. makes up. Low cost and relatively simple processing of these polymers are the main conditions for their widespread use.

The most widely used plasticized polymer is poly(vinyl chloride) (PVC) due to its excellent plasticizer compatibility characteristics. Traditionally, PVC plasticizers belong to the phthalate family; however, they have harmful effects on human health and the environment. In this work, we evaluated the effect of six types of plasticizers (dioctyl phthalate, dioctyl adipate, Lestarflex (a polymeric polyester plasticizer), polycaprolactone, polyester polyol, and 1,2,3-propanetriol triacetate) on the properties of PVC plastisol used in manufacturing shoes and toys. The mechanical properties (hardness, tensile strength, tear strength, and elongation at break) were evaluated before and after accelerated aging tests (in an ultraviolet oven and at 50°C). A thermal study was also carried out using differential scanning calorimetry and thermogravimetric analysis, while possible structural changes during deformation were investigated using the small-angle X-ray scattering technique. In general, the results have shown that in the plasticization and stabilization of PVC, the plasticizer dioctyl phthalate can be replaced by dioctyl adipate or Lestarflex without relevant changes in the final properties of the material, even after accelerated aging (Perito et al., 2022).

In the research work, high-pressure or low-density polyethylene HDPE or LDPE was used at a pressure of 150-300 MPa and a temperature of 150-3200C. The average molecular weight of HDPE is 8x104x105, the degree of crystallization is 50-60%. The high properties of PE, such as frost resistance and corrosion resistance, make it suitable for use in the production of pipes, electrical wires, etc. Although it is useful to use, it has some missing aspects in the former case.

Thus, pure polyethylene is subject to aging under the influence of sunlight, has relatively low mechanical strength, is flammable, etc. To eliminate these reasons, various chemical additives can be included (Kostenko & Teryaeva, 2010).

The creation of composite materials with electret properties based on PE is very economical. In another study, R. Yu. Deberdeev et al. found that the composition holding the filler has a higher electretity than pure PE in the electret state (Jafarov et al., 2013).

For the polymer composite materials we use, the main condition is the presence of a filler with the necessary properties. Research in the field of polymer composition is carried out on the basis of achievements in various fields of science (chemistry, physics, polymer mechanics, solid state physics). Currently, polymer composites are the basis of modern building materials. When processing polymers, the problem of filler with matrix is solved by adding a sizing agent. Appret acts on both the matrix and filler to improve adhesion (Zhazaeva et al., 2015).

One of the main issues in creating polymer composites is improving the effective interfacial adhesion interaction at the interface between the components. The most effective technological method for achieving this goal is appretion. Disciples are substances that determine the structure and properties between the filler and the polymer matrix. Students are of particular importance in the production of PCMs created on the basis of thermoplastic polymer matrices with low adhesive properties. The role of finishing in the formation of a number of polymer compositions is discussed below.

One of the ways to enhance the interfacial interaction between the polymer matrix and the filler in PCM is to introduce various modifiers or journeyman copolymers with low molecular weight into the system. Thus, increased adhesion between the polymer matrix and the filler is achieved by building functional groups on the surface of the matrix. Thus, there is a known study of the effect of sizing on the deformation properties of the material by introducing ethylene into the LDPE-elastic vinyl acetate copolymer filler system (Volonskiy & Bakeev, 2011).

The use of polymer mixtures to improve the performance properties of plastic materials is cost-effective and universal. However, during the preparation of these compositions, phase separation occurs due to the difficulty of mixing the polymers with each other. Reactive functional groups are introduced into the system to ensure mixing of the components that make up the polymer with each other. To obtain a functionalized polymer based on polyolefins, functional apparating monomers were added to the polymer chain and a peroxide-containing composition based on functional rosin-maleic and rosin-maleine-terpene resins was obtained (Gerasim et al., 2009).

Purchasing polymer electrets through ready-made fillers is considered cost-effective. In this regard, the relatively low cost and wider distribution of PE have increased the prospect of using it as an electret. When filling polymers, the formation of new structural elements with electric charge carriers is observed. Studies have shown that electret effects are observed in a PE matrix enriched with technical carbon. As a result of studying the influence of technical coal as a filler on the electret properties of PE compositions, it was shown that they can be used to obtain electrets with high stability (Kazangyan et al., 2012).

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. YTPE-based composites are considered to be a promising material in terms of low cost, high tensile strength, elongation at break and high temperature resistance.

Currently, a convenient way of introducing fillers into polymers that are compatible with polymer materials can create a “synergistic” effect. Therefore, attention is paid to the development of technology for the production of polymer composite materials in order to solve the required number of technical and environmental problems. 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 was introduced into the composition as a sizing agent.

Taking into account the above, composites with different ratios of components were obtained based on natural rocks (fillers) from local natural mineral deposits and HDPE. The properties of the resulting new generation 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 (Perito et al., 2022).

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 (Kar et al., 2024).

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

Solution

The presented work is devoted to the study of HDPE, a product of an ethylene-polyethylene plant produced in the Sumgayit region, and filled polymer composites based on recycled ones. Natural mineral rock from the village of "Demirchi Damba" in the Kelbajar region of the Republic of Azerbaijan was 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 economical, lightweight, durable and resistant to harsh environmental conditions, easily taking any shape and various synthetic materials. The rapid growth in the production of plastic products makes it necessary to carry out the recycling process by reusing waste plastic mass (Shıxaliev & Musaeva, 2012).

Employees of the laboratory "Processing and Ecology of Polymer Materials" of the Institute of Polymer Materials have been purchasing composite materials filled with polyolefins and natural minerals as fillers for many years, and use various copolymers synthesized by them as primers and various properties. the resulting composite samples, for example-physical and mechanical properties, fluidity of the alloy determine the indicator.

The results of computational and experimental research on the influence of electrically conductive carbon black (CB) on the elastic modulus of composites based on linear low-density polyethylene (LLDPE) were presented. The study was carried out at various structural levels of composites: a cell with a single filler particle, a cell with randomly distributed filler particles, a composite with randomly distributed agglomerates, and a macro level of a composite. The results show that the agglomeration of filler with a low local content reduces the elastic modulus of the composite, while the agglomeration of filler with a high local content increases it. In the LLDPE+CB composites, the filler has a complex influence on the elastic modulus of the composite. The values of elastic modulus of the composite were influenced by both single CB particles and an agglomerated filler with an increased local content in the matrix. As a result, the elastic modulus of the LLDPE+CB composites at the macroscale level increases nonlinearly with increasing filler content (Kropotin et al., 2025).

This study investigates the impact of heat treatment on the mechanical, morphological, and dimensional properties of polyethylene terephthalate glycol (PETG), a commonly used thermoplastic in 3D printing. Taguchi L25 orthogonal array (OA) was employed to optimize 3D printing parameters, considering factors such as infill percentage (ranging from 20% to 100%), layer height (0.12 mm to 0.28 mm), layer width (0.32 mm to 0.62 mm), and infill pattern. Following ASTM D638 type IV standards, mechanical testing revealed that the optimal printing conditions included a 100% infill percentage, a layer height of 0.16 mm, a layer width of 0.32 mm, and an infill pattern of 5. Specimen 22, produced under these conditions, exhibited a notable stress-bearing capacity of 46.43 ± 1.394 MPa (Kumar et al., 2024).

The review, presented as a continuation of a series of studies of literature reviews, reports on the influence of tantalum oxide nanoparticles on the structure and thermal properties of HDPE + Ta2O5 based polymer nanocomposites prepared by ex-situ solution casting method. XRD analysis confirmed the orthorhombic structure of Ta2O5 nanoparticles and an increase in the degree of crystallinity of HDPE/Ta2O5 based nanocomposites after the introduction of Ta2O5 into the HDPE matrix. SEM analysis showed that Ta2O5 nanoparticles were distributed over the surface of the sample in a spherical shape. FT-IR analysis confirmed the presence of Ta –O-Ta stretching vibration bands at 557 cm−1, 584 cm−1, 599 cm−1, 614 cm−1 and Ta-O bands at 824 cm−1, 828 cm−1 for HDPE/3-7 wt%Ta2O5 nanocomposites. The results indicate that small amounts of Ta2O5 nanoparticles (3–7 wt.%) introduced into HDPE act as nucleating agents, which enhance the thermal properties of the HDPE/Ta2O5 nanocomposite. Additionally, the properties of the polymer nanocomposite are influenced by both the structural changes in the polymer matrix and the interactions at the nanoparticle-polymer interface (Huseynova et al., 2024).

Due to the unique properties of modern nanomaterials, many companies design complex electronic devices that are used in the aviation and space spheres to assemble powerful computers, video equipment, help diagnose various diseases, as well as quickly transmit information. Such nanostructured materials are obtained by embedding nanoparticles into various polymer matrices. The effect of nickel oxide nanoparticles (NiONPs) stabilized by a matrix of high-pressure polyethylene (LDPE) obtained by the mechanochemical method on the structure and properties of nanocomposites based on high-pressure polyethylene (LDPE) containing multiwalled carbon nanotubes (MWCNT) has been studied. The physical-mechanical, thermophysical and thermal properties of the obtained composites were studied using DTA and AFM analysis methods. The optimal composition of components for obtaining nanocomposites with improved properties has been determined. Shown that small amounts of nanofillers introduced into the polymer play the role of structure formers - artificial crystallization nuclei, which contributes to the appearance of a fine spherulite structure in the polymer. AFM micrographs show the complex interweaving of nanoparticles with each other and the polymer matrix and the formation of a new fine-crystalline supramolecular structure related to the interfacial interaction of nickel-containing nanoparticles with multilayer carbon nanotubes, which contributes to the maximum increase in the physical-mechanical and thermal properties of the resulting nanocomposite (Kurbanova et al., 2024).

The presented research work provides for the production of new composites with complex performance properties in various mass. % ratios of components based on isotactic polypropylene and the natural mineral “Demirchi Dam” of the Karabakh region and the study of the effect of fillers on a number of their properties is reflected. In order to ensure and improve adhesion between the polymer matrix and the filler, as well as to obtain composites with higher physical and mechanical properties, a sizing agent is included in the system. Acrylic acid polymer synthesized in laboratory conditions was taken as a coupling agent. The complex and multifaceted properties of polymers greatly facilitate their use as a matrix in obtaining a homogeneous system using them as raw materials. The goal is to realize the possibility of obtaining and using both economically and environmentally competent products for various purposes. It has been established that a number of 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 in the interfacial layer. From this point of view, work is considered purposeful. Also, research conducted in this direction has yielded positive results. Scientific research culminates in the production of composites with complex performance properties and higher physical and mechanical properties. Guided by the researched literature, the work was carried out and the desired results were obtained (Jafarov et al., 2025).

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. A number of scientific research works produces a new generation of composites with different ratios of components based on lowdensity 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 (Jafarov et al., 2024).

The study of a number of properties of composites obtained in the presence of various modifiers is also a large-scale scientific research area by our laboratory. For example, in the presented scientific research presents the creation of a new generation of high-performance composite materials using high-density polyethylene (HDPE) as a matrix and natural local mineral rocks as a filler. The goal is to obtain new generation composite materials with high physical and mechanical properties. Thus, carrying out research work towards the production of new generation composites with simple technology and low cost due to processing is considered relevant, economically and environmentally beneficial. To ensure conditions for the fusion of the polymer matrix and mineral rock with each other and achieve parameters characteristic of high performance indicators, a sizing agent synthesized in the laboratory is included in the composition of the filled system.

One of the advanced directions of modern science and technology is to obtain polymer composites with complex properties by mixing two or more polymers. The application of fillers to the acquired system and, as a result, the acquisition of a newer type of material is considered progressive. Currently, there is increasing interest in composite materials based on polymer matrix and small particles. Thus, they have the possibility of wide application in various fields, from catalysis to modern information technology, as well as chemistry, physics and material science. The development of scientific research on the study of particles with different natural mineral composition as a filler has led to the achievement of polymer composites with many characteristic physical-mechanical and operating properties. Such materials have properties such as high thermal and electrical conductivity, magnetization, shielding of ionizing rays (Jafarov et al., 2024).

Compositions based on polymer matrices and fillers have been developed at a number of scientific research facilities in our country. The regularities of the oxidation-chlorophosphorization reaction of divinyl rubber and the sorption processes with the obtained modifications were studied at Baku State University. At the Institute of Petrochemical Processes of ANAS, under the leadership of academician Akif Azizov, a method for obtaining Fe^-, Cu^-, Ni-containing nanocomposites with controlled thermophysical, magnetic, and electrical properties and high thermooxidation stability was developed based on polyethylene synthesized with the participation of a metalphenolate catalytic system (Alosmanov, 2013; Aliyeva, 2012).

Taking into account the above, current scientific research is being conducted in the direction of obtaining composites with new and different ratios of components and increasing their physical and mechanical properties by introducing individual binders (modifiers) into the resulting mixtures.

Practical Part

Polymer matrix – HDPE, filler – mine rock with natural mineral "Demirchi Dam". A copolymer of maleic anhydride and heptene-1 was synthesized and used as a primer.

The study was carried out on different filler dispersion, i.e. sizes 106 and 53 microns.

The mineralogical and chemical composition of the natural mineral rock taken as a filler was determined.

Table 1: Mineralogical composition, with-%

SiO_2 Quartz	Feldspar	$CaCO_3$ (Carbit)	Illit	Caolinit	Montmorillonit	Fe_2O_3	Volcanic ash
30	15	8	6	6	20	5	10

Table 2 : Chemical composition, with-%

Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	CT	YTİ
1.3	2.8	15.39	57.05	0.01	0.01	2.4	6.27	0.69	0.01	5.83	0.1	8.2

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

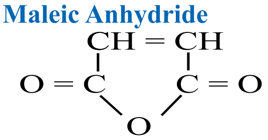
Looking at the composition of the mineral, you can see that it contains a lot of SiO_2 (quartz).

The demand for fillers is related to their dispersion, durability and portability, compatibility with the polymer matrix, low cost and availability, environmental friendliness and safety.

The coupling agent was added to the mixture to improve the properties of the composites and facilitate integration into the system. A copolymer of maleic anhydride and vinyl acetate (MA-VA), synthesized in laboratory conditions, was taken as a coupling agent. It is known that maleic anhydride is highly reactive towards donor monomers. Thus, MA forms copolymers with vinyl compounds and olefins.

The study used a copolymer of maleic anhydride (MA) and vinyl acetate (VA).

Maleic Anhydride



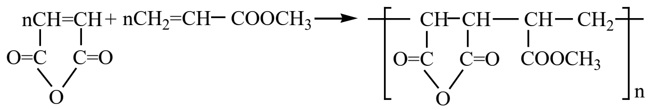
Molecular weight $Mr(C_4H_2O_3)$ = 98.06 g/mol.
Density d420 - 1.48 g/mol
Melting point Tp-52.86^0 C.
Boiling temperature Tb-202^0C
nD^{20} 1, 4429

Vinylacetate

CH_2=CH-$COOCH_3$
Molecular weight $Mr(C_4H6O2)$=86.09 g/mol
Density d420-0.934 g/mol
Boiling point Tb=72.70^0C.
nD^{20} 1.3853

Maleic anhydride was pre-crystallized and dried in preparation for the experiment. The dried maleic anhydride is dissolved in 200 ml of hot benzene and filtered. 0.5 mol (49 g) of the dissolved residue was taken and vinyl acetate was added dropwise. 0.1 g of benzoyl peroxide was added as an initiator. Benzoyl peroxide was synthesized in the laboratory using a known method The reaction is continued at a temperature of 780-800°C until a grayish precipitate is obtained. The resulting material is washed several times with hot benzene and dried in a vacuum oven at a temperature of 400-500C. A schematic diagram of copolymerization is presented below.

Schematic Diagram of the Reaction



Results and Discussion

A number of physical and mechanical properties of the obtained composite samples are given in Table 3.

Table 3: Physico-mechanical properties of composite samples

Without appret

№	Compound Composition, *with %*	Tensile force, σ, MPa	Elongation, ε, %	MFI, g/10min
1	HDPE-100	10.8	547.5	2.8
2	HDPE-70 Filler-30	9.4	40	2.0
3	HDPE-60 Filler-40	11.3	24	0.7
4	HDPE-50 Filler-50	13.1	28	0.6
5	HDPE-40 Filler-60	14.4	20	0.37
6	HDPE-30 Filler-70	16.5	8	-

The polymer matrix is high-density polyethylene (HDPE) grade-10803-020.
Filler: Karabakh mineral rock "Demirchi Dam". 106 mkm

From the data presented in Table 1, it is clear that with the ratio of the components included in the composite HDPE-30 and filler - 70 wt.% (HDPE/Fil.- 30/70%), the tensile strength reaches its value. the maximum value and σ=16.5 MPa. This is explained by an increase in the strength of the resulting composite as a result of an increase in the distribution power in the intermolecular layer as the amount of filler increases and thickness is created within the system. The relative elongation values of composite samples correspondingly decrease as the amount of filler increases.

During ice breakup, the relative elongation decreases to a minimum and becomes ε=8%.

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 30/70% by weight.

In continuation of the research and in order to ensure or increase 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 and vinyl acetate as a sizing agent. system.

Physico-mechanical properties of composite samples with appret

№	Compound Composition, *with %*	Tensile force, σ, MPa	Elongation, ε, %	MFI, g/10min
1	HDPE-100	10.8	547.5	2.8
2	HDPE-70 Filler-30 Appret-3	12.2	28	0.9
3	HDPE-60 Filler-40 Appret-3	14.1	22	0.7
4	HDPE-50 Filler-50 Appret-3	14.6	26	0.23
5	HDPE-40 Filler-60 Appret-3	15.4	23	0.007
6	HDPE-30 Filler-70 Appret-3	17.2	16	0.03

Filler: 106 mkm
Appret: – [MA-VA]

The coupling agent is included in the system in an amount of 3 mass%, regardless of the component ratio.

Looking at table 3. we see the values of physical and mechanical indicators. The tensile strength of the sample with 30/70 wt.% HDPE and filler by weight takes the maximum value (σ=17.2 MPa).

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 30/70% as a result of mixing the sizing agent in an amount of 3% by weight receives maximum value. In samples with a large amount of filler in the system, cases are sometimes observed when the strength decreases slightly and takes on small values. This is explained by the observation of brittleness due to the formation of microdefects within the composite. As can be seen from Table 2, the results in the case of the sizing agent are similar.

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

As a result of this study, composite samples corresponding to a filler size of 53 μm were obtained and their properties were studied.

Physico-mechanical properties of composite samples without appret

№	Compound Composition, *with %*	Tensile force, σ, MPa	Elongation, ε, %	MFI, g/10min
1	HDPE-100	10.8	547.5	2.8
2	HDPE-70 Filler-30	12.5	56	1.4
3	HDPE-60 Filler-40	13.1	27	1.3
4	HDPE-50 Filler-50	14.5	20	0.7
5	HDPE-40 Filler-60	15.3	13	-
6	HDPE-30 Filler-70	17.7	12	-

Filler:53 mkm
Interpreting the data in Table 3, it is clear that the maximum value of tensile strength is σ=17.7 MPa with the ratio of the components included in the HDPE/Nap composite being 30/70 wt.%. Accordingly, the relative elongation takes a minimum value (ε = 12%). However, fluidity in the alloy is not completely observed. This is explained by the increase in resistance of a homogeneous system as the strength of the system increases.

Similarly, in a composite system, a sizing agent is added to the mixture to increase adhesion between the polymer filler and improve properties.

Physico-mechanical properties of composite samples With appret

№	Compound Composition, *with %*	Tensile force, σ, MPa	Elongation, ε, %	MFI, g/10min
1	HDPE-100	10.8	547.5	2.8
2	HDPE-70 Filler-30 Appret-3	14.1	36	1.7
3	HDPE-60 Filler-40 Appret-3	14.8	41	1.5
4	HDPE-50 Filler-50 Appret-3	15.2	26	0.5
5	HDPE-40 Filler-60 Appret-3	16.4	20	0.07
6	HDPE-30 Filler-70 Appret-3	18.02	12	-

Filler: 53 mkm
Appret:– [MA-VA]
Let us interpret the data in Table 4. With a ratio of mass% polymer/filler of 30/70 mass%, like other results, the tensile strength reaches a maximum and takes the value σ=18.02 MPa. In this case, the elongation at break is ε=12%. The flow rate of the alloy decreases with increasing amount of filler and does not give any result at an amount corresponding to 70 wt.% filler. This is explained by the increase in tensile strength corresponding to the excess amount of filler.

Conclusion

Based on high-density polyethylene and a natural mineral filler selected in an appropriate dispersion, composites were obtained in the ratio of individual components and the effect of the filler and sizing agent on the system was studied. Composite samples were obtained in various mass ratios, and to increase the compatibility of the matrix and filler and obtain composites with better physical and mechanical properties, a size synthesized in the laboratory was introduced into the system.

As a result of the research, it was established that the sample with the highest physical and mechanical properties among the samples without sizing and with sizing is the sample corresponding to the component ratio of 30/70%.

The production and study of composites, which are the target products, show that scientific research carried out in this direction gives satisfactory results, and the resulting polymer composites with high properties can be used in various fields.

The created polymer composites can be used to produce structural materials for various purposes in relevant fields of technology.

The presented research work is considered to be economically and environmentally feasible.

References

1. Bektashi, N. R., & Jafarov, V. J. (2016). Systems filled based on recycling of new composition LDPE, IPM-50. Sumgayit, p.83.
2. Babayeva, G. R., Veliyev, I. V., Bektashi, S. A., & Jafarov, V. J. (2014). Compositions based on low-density polyethylene. Researches of the Institute of Polymer Materials of ANAS (Collection of Scientific Works). Sumgayit, 154-160.
3. Kar, S., Pattnaik, S., & Sutar, M. K. (2024). Influence of nano industrial waste and short coir fiber filler on hybrid inter and intra yarn bio fiber composites. *Elastomers and Plastics, 56*(8), pp.958-983. DOI: https://doi.org/10.1177/00952443241289539
4. Ferrichio, T. H. (1981). Osnovnıye principy vybora i ispolzovaniya dispersnyh napolniteley. In M., Himiya (Eds.), s 30.
5. Alimirzayeva, N. A. (2020). Metal-Containing Nanocomposites On The Basis Of Isotactic Polypropylene And Ethylene-Propylene-Diene Rubber. *Az. Chem. J., 2020*(1), 41-45. DOI: https://doi.org/10.32737/0005-2531-2020-1-41-45
6. Lisichkin, G. V. & Chernov, N. N. (2003). Man and his environment. Reader. Moscow, Mir, p. 460.
7. Jafarov, V. D., & Efendiev, A. N. (2005). Macromolecules with anhydride links - finishing components in filled polyethylene. Reports of ANAS, 50-58
8. Serenko, O. A., Avinkin, V. S., Bazhenov, S. L. & Budnitsky, Yu. M. (2003). Properties of composites with dispersed and elastic filler, Plastics, 1, 18-21. https://www.researchgate.net/publication/297321240_Properties_of_composite_materials_with_dispersed_elastic_filler
9. Gorbunova, I. Yu., & Kerber, M. L. (2001). Modification of crystallizing polymers, *International Polymer Science and Technology, 28*(4), pp. 7-10. DOI: https://doi.org/10.1177/0307174X0102800411
10. Perito, E. D., Guerra, N. B., Giovanela, M., Machado, G. & Crespo, J-da S. (2022). Chemical, thermal and mechanical evaluation of poly(vinyl chloride) plastisol with different plasticizers, *Journal of Elastomers and Plastics, 54*(8), pp. 1277-1294. DOI: https://doi.org/10.1177/00952443221135001
11. Kostenko, O. V., & Teryaeva, T. N. (2010). Influence of thermal treatment of mineral filler on the properties of polymer composites. Plastics, 4, 34-36.
12. Jafarov, V. D., Babaeva, G. R., Akperova, E. G., & Veliev, I. V. (2013). Polymer wastes - the problem of ecological balance. Plastic masses, 11, 61-63.
13. Zhazaeva, E. M., Al-Khawlani, Ya. F. M., Tkhakova, R. B., & Shomakhov, A. V. (2015). Morphology and strength of composites based on isoprene elastomer and polyethylene modified with fillers of various nature, Plastics, pp. 35-39.

14. Volonskiy, A. V., & Bakeev, A. F. (2011). New approach to creation of nanocomposites with polymer matrix. High-molecular compound, Series C, 53(7), pp. 1203-1216.
15. Gerasim, V. A., Guseva, M. A., Rebrov, A. V., Korolev, Yu. M., & Antipov, E. M. (2009). Influence of physical and mechanical characteristics of the polymer matrix and the structure of the filler on the deformation behavior of polymer-montmorillonite nanocomposites. High-Molecular Compounds, Series A, 51(3), pp. 454-468.
16. Kazangyan, A. E., Osipchik, V. S., Chalaya, N. M., & Kikel, V. A., (2012). Modification of the properties of chemically cross-linked polyethylene with thermoplastics. Plastics, 1, 3-7.
17. Shıxaliev, C. S., & Musaeva, A. Y. (2012). Vliyanie mineralnıx napolniteley hna pererabativaimost fiziko-mexaniçeskie svoystva modifisirovannoqo polietilena, Plastmassı, 4, s. 40-42.
18. Kropotin, O. V., Rogachev, E. A., & Kalenchuk, A. A. (2025). Influence of Carbon Black on the Elastic Modulus of Composite Materials Based on Linear Low Density Polyethylene at Various Structural Levels. *Mechanics of Composite Materials, 61*(11), 67–78.
DOI: http://dx.doi.org/10.1007/s11029-025-10262-1
19. Kumar, S., Singh, I., Kumar, D., Mago, J., & Koloor, S. S. R. (2024). Mechanical, morphological, and dimensional properties of heat-treated fused deposition modeling printed polymeric matrix of polyethylene terephthalate glycol. Progress in Rubber, Plastics and Recycling Technology, 40(2), 68-190.
DOI: https://doi.org/10.1177/14777606231218354
20. Huseynova, A. S., Rzayev, R. M., & Hajiyeva, F. V. (2024). Investigation on the structure and thermal properties of HDPE/Ta2O5-based nanocomposites. *Elastomers and Plastics, 56*(8), 929-941.
DOI: https://doi.org/10.1177/00952443241289560
21. Kurbanova, N. I., Mirzoeva, N. A., Zeynalov, E. B., Huseynov, A. B., Hajiyeva, F. V. & Muradov, M. B. (2024). The effect of nickel oxide nanoparticles on the structure and properties of nanocomposites based on high-pressure polyethylene containing multiwalled carbon nanotubes. *Journal of Elastomers and Plastics, 56*(6), 732-744.
DOI: https://doi.org/10.1177/00952443241263608
22. Jafarov, V. J., Alimirzaeva, N. A., Manafov, M. A., Bektashi, S. A., Radzhabova, M. J., Khalilova, S. M. & Musayeva, G. Kh. (2025). Influence of apprete on composites based on isotactic polypropylene. *Processes of Petrochemistry and Oil Refining, 26*(2), 511-523.
DOI: https://doi.org/10.62972/1726-4685.2025.2.511
23. Jafarov, V.J ., Alimirzaeva, N. A., Musaeva, G. H., Khalilova, S. M. & Rajabova, M. C. (2024). Influence of filler and apprete on the properties of composite based on low density polyethylene and mineral roc “Gizil Zod”. *Elmi Əsərlər, 3*(2), 98-103.
DOI: http://dx.doi.org/10.61413/VJRF3682
24. Jafarov, V. J., Alimirzaeva, N. A., Musaeva, G. H., Manafov, M. A., Khalilova, S. M., & Rajabova, M. J. (2024). Production of new generation composite materials based on high- density polyethylene and “Artesian clay” and the effect of appret. Sumgayit State University - “Scientific News” - *Department of Natural and Technical Sciences, 24*(3), 31-37.
25. Alosmanov, R. M. (2013). Regularities of the oxidation-chlorophosphorization reaction of divinyl rubber and the sorption processes with the obtained modifications. Abstract of the dissertation of Doctor of Sciences in Chemistry, Baku, 46.
26. Aliyeva, R. V. (2012). New complex catalytic and initiator systems for the synthesis of (co)polyolefins, nanometal composites and sulfocationites based on the obtained polymers. Abstract of the dissertation of Doctor of Chemical Sciences, Baku, 47.