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Investigating Recycling Methods of End-of-Life Car Tires

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Abstract

In this research work, the amount of rubber dust formed as a result of the friction of the tires used on vehicles in a large city on the road was determined and it was shown that every day, approximately 5 grams of toxic rubber dust is swallowed by each of the city's population. This environmental disaster and its elimination ways of lifting have been investigated. Special compositions were prepared based on tires that were out of use and turned into waste. The optimal recipe was selected by using these compositions to prepare polymer asphalt concrete. tire recycling is of great economic importance. So, more than 80% of oil refinery products are used for their preparation, so by using them after use, we have solved both environmental and economic issues The study showed that if we add rubber scraps with 5 mass particles up to 1 mm to oil road bitumen, we can increase the main indicators of the obtained polymer bitumen composition by 2b time

Keywords: *Waste Tire, Polymer Waste, Modification, Oil-Road-Bitumen, Polymer Bitumen, Plasticizer, Viscosity, Penetration*

1. Introduction

Recycling of end-of-life tires is a pressing problem all over the world. So, its recycling is of both economic and ecological importance. Due to their non-biodegradability, used tires cause pollution of the environment for 100 years. When rubber products are burned, they cause several diseases in addition to pollution of the environment. For this reason, researchers continue to

Usually recycled raw material is a polymer material that has been subjected to exploitation lost its physical and mechanical properties and turned into waste.[1-4].

investigate ways of recycling polymer products that have become waste. although several authors have shown ways to recycle tires that have been turned into waste out of service, this problem has not been completely solved. therefore, recycling tires and acquiring valuable compositions based on them remains the most relevant research object today. The areas of use of rubber scrub are quite wide. Recently, important scientific research works have been carried out in the field of expanding the fields of use of RS [5-8] For the first time, the conducted research and obtained results showed the possibility of efficient use of production and household waste instead of traditional raw materials in various fields, which is of great importance for our country both in terms of expanding the range of raw materials and preserving resources, as well as economically and ecologically[9-11].

Investigation of non-traditional sources of raw materials has shown that a large amount of production and household waste with significant compounds is generated worldwide. The amount of these wastes and the concentration of important compounds in them allow for use as raw materials in various fields [12-17]**.**

2. Materials And Methods

This After car tires run for 90-110 km, their tread patterns are disintegrated, out of service, and turned into waste. Various methods of recycling tires have become waste.

The following products can be obtained by recycling used tires:- 1 mm rubber scrap (mainly used in the modification of road bitumen);- 1-10 mm rubber scrubber (used in the pyrolysis process)

- metalloid (used as metal scrap)- cord waste (used as raw material in the textile industry)

- 0.06-1.0 mm particles (mainly used to clean oil and oil residues from water bodies

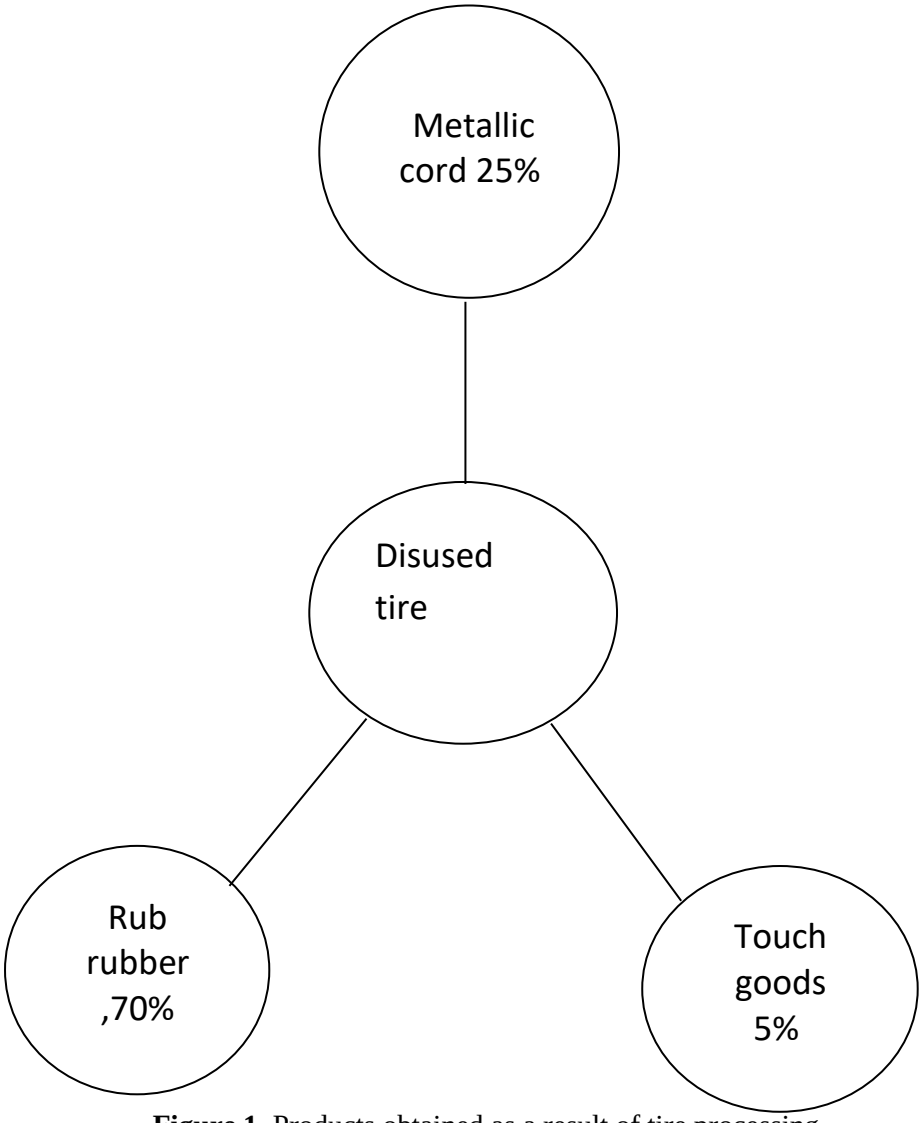

Figure 1. Products obtained as a result of tire processing

In addition, the non-recyclable residues are used in pyrolysis processes. These rubber fragments are decomposed in a pyrolysis unit at high temperature, in airtight conditions, and the following products are obtained: - gas (can be used as natural gas);

- light fractions of pyrolysis (are valuable chemical raw materials, suitable for use as liquid fuels);

After processing an old passenger car tire, we have listed its main components in Fig. 1. The raw materials shown in Fig. 1 are obtained.

Rub rubber

Table 1 lists the main areas of use of the rubber scrap obtained by processing on grinding wheels.

Table 1: The main areas of use of rubber scrub

Material	**Particle size, mm**	**1 ton Price in US dollars**	**Area of the use of rubber scrub**
1	2	3	4
Rub rubber	0,06 -1	28	- Rubber compound - waterproofing materials - Roof coverings
Rub rubber	1 – 2	33	sports fields Playgrounds -road covers

Rub rubber	2 – 3	35	In the preparation of some sports product
Rezin ovuntusunu	3 – 5	45	In the preparation of boxing gloves, In the preparation of parts of medical equipment
Rub rubber	4 – 8	51	Flooring, roofing, and sanitary equipment for livestock farms. Bio-component substances. insulation of gas pipelines. Rubber is used in the production of slates and rubber shoes

The method of preparation of bitumen modified with polymers, as a rule, involves the process at high temperature (150-200°C) and intensive mixing of the components. The decomposition temperature of most of the polymers (polyethylene, polypropylene, ethylene-propylene rubber, thermally elastic-plastic) used for bitumen modification is higher than the temperature of their compatibility with bitumen. Therefore, polymers' thermal and mechanical destructive reaction does not occur in the bitumen mass. If it does, it is very weak. When heated, bitumens soften, and thermoplastic polymers go into a viscous-flow state, regardless of whether they are crystalline or amorphous. High temperatures accelerate the swelling or dissolution of the polymer in the bitumen.

Dissolution of polymeric materials occurs in the swelling phase. The swelling process consists of dissolving the polymer in the solvent with an increase in volume and mass. The swelling process can be restricted or unrestricted. During limited swelling, the system goes into a gel state. This situation is explained by the limited solubility of the polymer in the given solution. In the case of limited swelling, the system consists of two phases in equilibrium:

• a saturated solution of a solvent in a polymer, that is, a gel;

• a saturated solution of the polymer in the solvent, usually of low concentration.

Unlimited swelling is characteristic of linear polymers. Constructed polymers swell in the solvent, but do not dissolve. During a change in the condition of the technological process (increase in temperature and pressure), limited swelling can change to unconfined swelling.

3. Results and Discussion

Polymer asphalt concrete based on oil refinery and rubber waste

preparation and application

The main properties of asphalt concrete prepared based on modified bitumen are manifested only during use. The tested polymer asphalt concrete fully met the parameters of DÜIST 28-97 bitumen under operational conditions. Compared to asphalt concrete, polymer asphalt concrete has high deformation, strength, water, and mine resistance.

One of the most important indicators is its tolerance to temperature changes. Physical and mechanical properties of polymer asphalt concrete n standard prepared based on bitumen modified with HRS were mainly determined and the obtained results are given in Table 2. The deformation of asphalt concrete and polymer asphalt concrete was studied under both static and dynamic loading modes.

Polymer asphalt concrete has been shown to have better deformation properties than asphalt concrete at 20ºC

In the mechanical process, Mu P-100 research conducted under dynamic conditions (piston travel speed 1200 mm/min) showed that the temperature at which the brittle disintegration of asphalt concrete takes place is indeed in the negative temperature region.

Table 2: Properties of polymer asphalt concrete

The name of the indicators	Time of impact of the load, sec	Temperature ºC	Used bitumens			
			Oil-road-bitumen	Bitumen modified with rubber rubbing.3%	Bitumen modified with rubber rubbing,5%	Bitumen modified with rubber rubbing8%
Balance module $E_m\left(\frac{kq\cdot s}{sm^2}\right)\cdot 10^{-3}$	-	+20	1,09	0,77	1,57	3,13
	-	-20	36,5	8,5	5,92	19,5

Deformation modulus $E\left(\frac{kq\cdot s}{sm^2}\right)\cdot 10^{-3}$	10 0,02	+20 -20 -20	0,24 18,3 133	0,16 4,7 32,2	0,36 3,4 22	0,96 9,4 50,5
Elasticity, P	- -	+20 -20	0,34 0,151	0,39 0,149	0,34 0,142	0,28 0,107
The highest viscosity of the conditional-dispersion structure $\eta_o^x\cdot 10^{-10}\,\frac{kqs\cdot s}{sm^2}$	- - -	+20 -20 -	11,6 488 42	7,6 270 35	15,6 340 22	31,2 1300 42
Aging factor α_0 - before aging α_1 - - - after aging	-	-20	1,76	1,73	1,39	-

In this case, the bending strength of polymer asphalt concrete is greater than that of asphalt concrete at a positive temperature.

polymer asphalt concrete prepared based on bitumen modified with rubber scrub has more deformation properties at negative temperatures and good brittleness and high dynamic resistance at positive temperatures confirmed.

To determine the aging of polymer asphalt concrete, we heated it and determined its acoustic indicators. As an indicator of aging, it is calculated according to the ratio of the attenuation coefficients of the sound waves in the sample before and after heating at 120ºC for 40 hours.

The elastic-viscous-plastic characteristics of polymer asphalt concrete samples at 50ºC were determined. The obtained results are given in Table 3.

Table 3. Polymer asphalt prepared based on bitumen modified with HRS indicators of brittle-viscous-plastic characteristics of concrete

Names of indicators	Oil-road-bitumen (Prototype)	Bitumen modified with rubber rubbing,5%
The highest plastic viscosity $\eta_o 10^{-4}$, Pa· sec	8,5	54,0
The lowest plastic viscosity $\eta_m 11^1$, Pa·sec	4,9	23,7
Dynamic displacement limit, $P_{1<2}$, Pa	4,4	24,0
modulus of elasticity of pressure Gm, $P < P_{1<2}$ a it was Pa	139	463
Voltage reaction cycle q· η_o /Gm· sec	611	1166

The analysis of the rheological characteristics shows that the viscosity and brittleness of polymer asphalt concrete prepared based on modified bitumen is 5-6 times higher than that of asphalt concrete.

The effect of modified bitumen viscosity, the mineral part of the mixture on the properties of polymer asphalt concrete was studied by the requirements of standard 52056-2003. that. and the effect of viscosity and the granulomere composition of the mineral part is important for the preparation of the polymer asphalt concrete mixture. The obtained results were compared with the properties of asphalt concrete prepared based on standard BND 60/90 and BND 200/300 brand bitumen.

The results of the study of binders are shown in Table 4, and those of the mixture are shown in Table 5.

The obtained indicators allow us to say that the displacement resistance of polymer asphalt concrete is more durable than asphalt concrete. The sum of ΣR=R20+R50 is taken as strength. Because displacement can occur at 20ºC. We take P=2tg 4+c as the sum of displacement continuity

Polymer asphalt concrete prepared based on modified bitumen (type B) P_{25}=98 ΣR=5,61 MPa, from asphalt concrete type B prepared based on BND 60/90 (P_{25}=48) ΣR=6, 4 MPa is less, and P is corresponding - As much as 2.18 and 2.02. In this case, polymer asphalt concrete is more than asphalt concrete.

These indicators make it possible to reduce R_{50} and R_{20} norms for polymer asphalt concrete by 10% compared to asphalt concrete. Polymer asphalt concrete can maintain its basic properties even at

Figure 1 shows the limited swelling process of rubber particles in bitumen. In the 1st stage, light fractions of bitumen dissolve with rubber particles and its swelling occurs. In the 2nd stage, gel formation occurs. As a result, a resin-bitumen matrix is formed in the binder

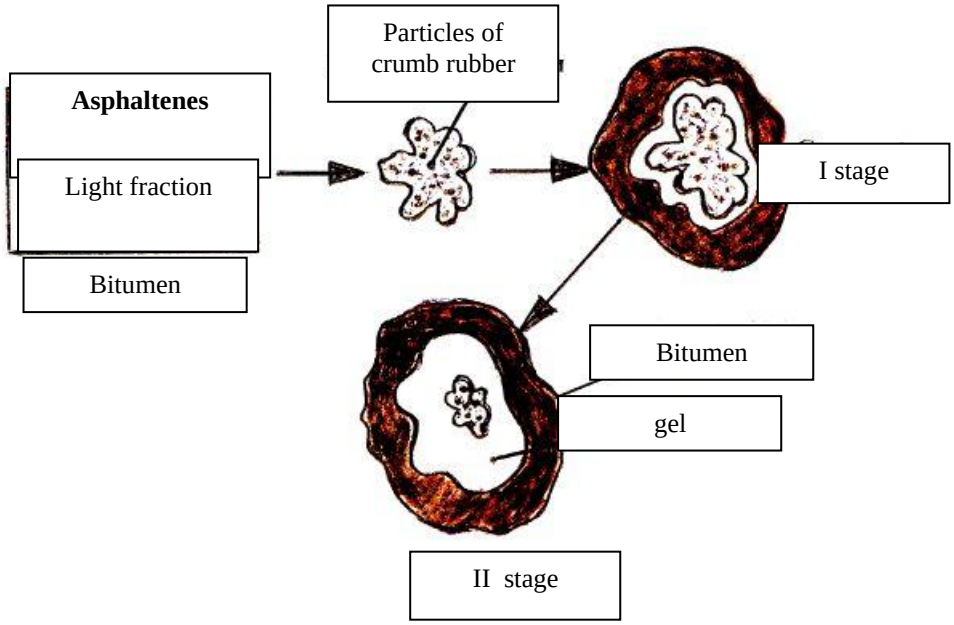

Figure 1 Stages of swelling of rubber particles in bitumen

Based on our many years of research, the following have been determined:

• unlike polymers with a complex branched structure, linear polymers mix more effectively with bitumen;

• the amount of aromatic and paraffinic-naphthenic hydrocarbons contained in the bitumen greatly affects the mixing process;

• the increase in the number of asphaltenes in bitumen makes it difficult to buy modified bitumen;

• the technology of mixing the polymer with bitumen, as well as the degree of dispersion of the polymer in the binder, play an important role

Investigating the effect of plasticizer and rubber scrub on the properties of polymer bitumen

The modification of bitumen with rubber scrub showed that the obtained results could be further improved. For this purpose, dibutyl phthalate was used as a plasticizer in the research work. The plasticizer increases the adhesion force between the components used, which significantly increases the mechanical strength of the composition.

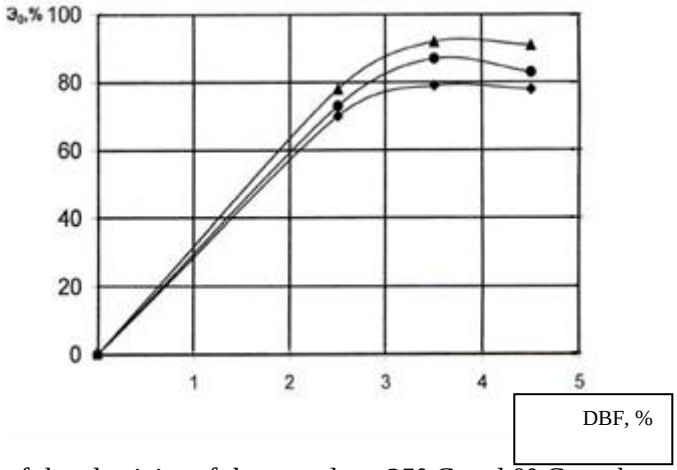

Figure 2. Dependence of the elasticity of the sample at 25° C and 0° C on the amount of rubber rub and DBF

• - 10% DBF; • - 2% rubber scrub▲ - 40% Rs

♦ - 10% DBF; ● - 2% RS; ▲ - 40% RS

Fig. 2 shows the dependence of the penetration depth of the needle into the sample and the embrittlement temperature, depending on the amount of rubber scrub and plasticizer. The amount of rubber scrub is between 3-5%, and the plasticizer dibutyl phthalate is between 0-20%. From the obtained results, it can be seen that the penetration depth of the needle into the sample, softening, and brittleness temperature of the rubber rub is more than 3 times higher than that of the dibutyl phthalate.

Studying the effect of the viscosity of the polymer bitumen composition prepared at different temperature ranges on its main properties, taking into account that this composition will be important on an industrial scale in the future, to determine how the plasticizer in the composition will affect the binder, the effect of the binder obtained by adding different mass parts of dibutyl phthalate to the polymer bitumen on the main properties of the composition at different temperatures was investigated in a wide range.

The dependence of the amount of RS and plasticizer, the penetration depth of the needle into the sample, and the brittleness temperature were studied and the obtained results are shown in Figure 3

Therefore, it is more convenient to use rubber scrub to get an environmentally friendly composition based on bitumen, and we have studied it more widely in our previous research [18-22ğ.].

From the obtained results, it can be seen that the penetration depth of the needle into the sample, softening, and brittleness temperature are more than 3 times compared to the DBF of the rubber rub. Therefore, it is more convenient to use rubber scrub to get an environmentally friendly composition based on bitumen [16-17,23].

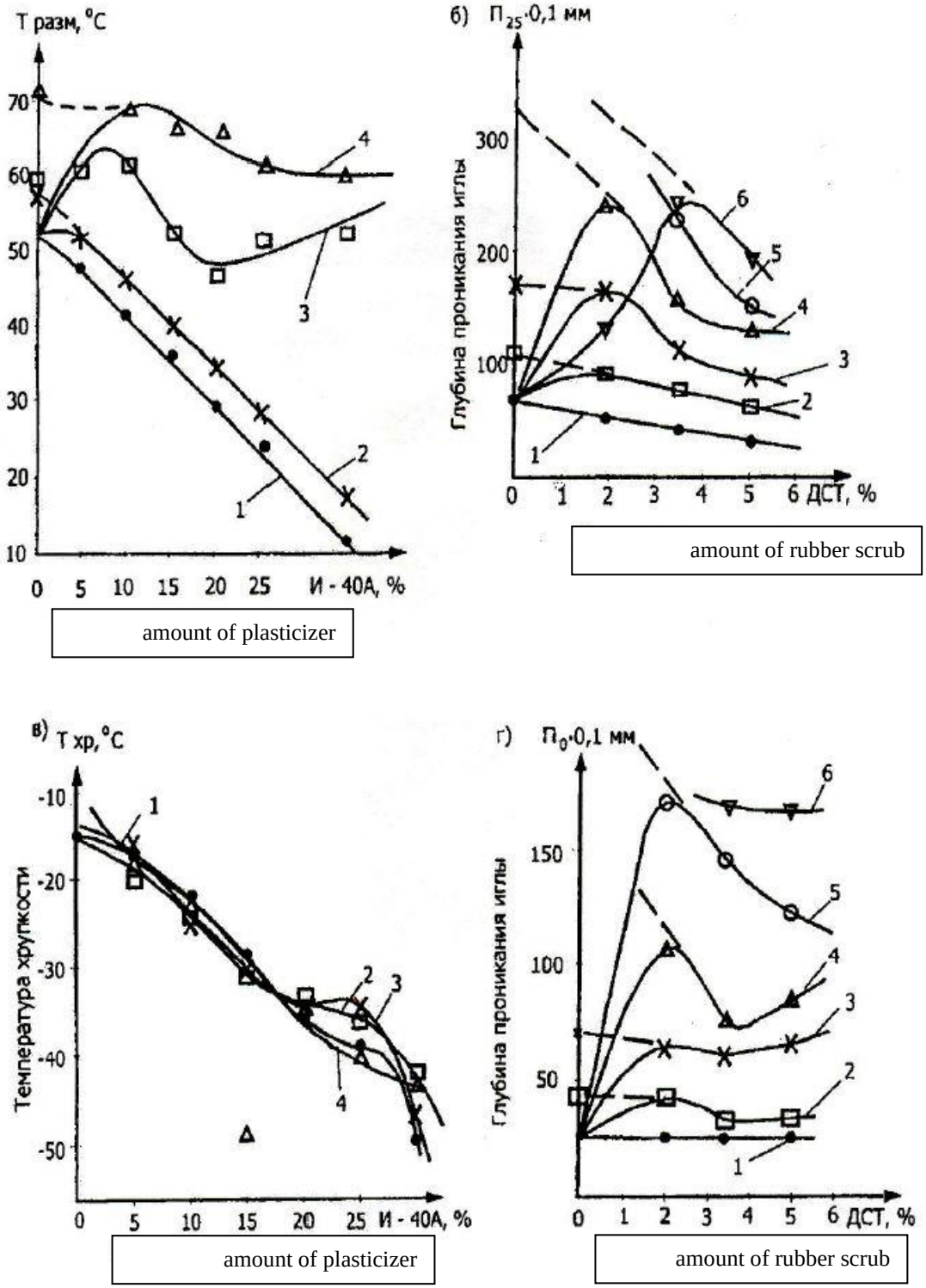

Figure 3. Dependence of the amount of RS and plasticizer, the penetration depth of the needle into the sample, and the brittleness temperature.

4. Conclusion

We have modified oil-road-bitumen with rubber coating. As a result, we received a high-quality polymer-bitumen composition. By adding polymer waste to bitumen, it was possible to increase its viscosity by 2 times and its strength by 4 times. After modifying the bitumen with polymer waste, we studied the properties of the obtained composition. The obtained results show that the penetration of the prepared sample is 1.4 times higher than the standard, and its elasticity is 4 times higher. The destruction of the rubber coating mainly occurs as a result of high temperatures. As a result, the molecular mass of RS decreases. When studying this in an oxygenated and non-oxygenated environment, the maximum stability of RS is observed in the temperature interval of 180°C. Therefore, we adopted the temperature of 180°C to modify road oil bitumen with RO waste. Since the physical and chemical properties of bitumen are very low, the asphalt-concrete road surfaces made of them soften

in the summer months and release toxic chemicals into the atmosphere. To prevent all this, we managed to obtain ecologically clean bitumen by modifying road oil bitumen with polymer-based waste. It has been proven by the results of our scientific research that the eco-friendly bitumen we offer is 4 times more flexible than the bitumen currently produced on an industrial scale, and it is possible to increase its heat resistance up to 120°C, which creates fertile conditions for its application in the industry.

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