

# Modified Oil Bitumen with Polymer Waste for Oil Pipeline Application from Bitu

Shixaliyev Kerem<sup>1,\*</sup>

## Abstract

Protection of oil refining, oil production and gas pipeline equipment from corrosion is the most important problem today. Currently, anticorrosive materials are mainly used, resistant polymer compositions, epoxy resin, bitumen and other materials for coating metal parts of these equipment. But these anticorrosive materials do not always provide metals from corrosion at the metal-antioxidant boundary and do not provide high strength of the protective layer, so these anticorrosive materials do not always protect materials from corrosion in the long term. Based on this, we have created a new anticorrosive material based on polymer waste based on propylene and bitumen grade Baku 85/25. In this work, a composition based on polypropylene production waste and petroleum bitumen as an anticorrosive composition is determined. The manufactured composition based on polypropylene + bitumen as a result of pipeline insulation showed that the anticorrosive material offered by us provides metal from corrosion for a very long time and at the same time the cost is much lower than in the real antioxidants used. It was shown that the proposed composition on the upper layer of pipeline insulation should be 0.1-0.3 mm, the lower part of the pipe - 0.5-0.6 mm. These coatings should be prepared in the size of 2.5 meters long and 2.9 wide.

**Keywords:** insulation, corrosion, polymer-bitumen composition, modification

## INTRODUCTION

Oil and gas pipelines are inevitably subject to corrosion during operation. This is a process that lasts for years during operation. The main cause of pipe corrosion is pipe corrosion over a long period of time and as a result of oxidation. Many authors have tried to reduce pipeline corrosion. Although recently it has been suggested to replace metal pipes with polyurethane and polyethylene pipes, but the transportation of oil and oil products is very dangerous to transport through polymer-based pipes. The fight against corrosion was carried out in the following direction [1-5]:

1. Too resistant metal pipes and the hypocrisy of these pipes
2. Use various new technological processes
3. Use inhibitors
4. Make a bureau with constant high corrosion
5. Check its position without damaging the pipeline

### \*Author for Correspondence

Shixaliyev Kerem  
E-mail: [kerem\\_shixaliyev@mail.ru](mailto:kerem_shixaliyev@mail.ru)

<sup>1</sup>Professor, Department of Organic Substances and Technology of Macromolecular Compounds Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Received Date: April 30, 2025  
Accepted Date: July 08, 2025  
Published Date: August 07, 2025

**Citation:** Shixaliyev Kerem. Modified Oil Bitumen with Polymer Waste for Oil Pipeline Application from Bitu. Journal of Polymer & Composites. 2025; 13(Regular Issue 5): 101–109p.

The operating conditions of oil and gas pipelines are different, so the corrosion protection should be different. It should differ from the operating conditions.

Pipelines must be protected from corrosion. Polyethylene (low-density polyethylene) at high pressure,

In the USA it is widely used on the basis of epoxy resin to protect both the upper and lower surfaces of pipes. In this case, the composition based on epoxy

resin was used up to a thickness of 0.25 mm on the upper surface of the pipe and thus protects the pipes from corrosion [6-7]. The British company Pirin Chemical Services has developed the reagent Accomet PC, designed to protect pipelines from corrosion [8-10]. Before applying this coating, the metal surface is cleaned with chromium oxide to ensure better adhesion of the PC reagent [11]. Many authors have proposed insulating glass fabric materials for the protection of high-pressure and high-temperature pipelines, which significantly increases the strength and corrosion resistance of the coatings [12-18]. Glass fabric can mainly be used as an anti-corrosion material in pipelines that are underground [19-21]

Recently, the use of carbon anti-corrosion material made of coal has also been in the center of research. Wet soil, which means that there is a certain amount of moisture in the soil, which can negatively affect the metal elements of underground pipelines, and therefore, wet soil of a steel pipe is corrosive, reduces the process of servicing communications. In this regard, one of the most reliable and stable protective coatings for protecting pipes from corrosion is the research work of some authors to reduce this drawback. [22-23] The applied anti-corrosion materials do not provide operational requirements. Therefore, in this regard, the improvement and development of new, highly effective insulating materials and coatings based on them, including for pipelines of large (1020 - 1420 mm) diameters, the technology of their application in route conditions, ensuring a service life compatible with the amortization service life of the protected pipeline (at least 50 years), have become relevant. In this work, highly effective anti-corrosion material was obtained that meets all the requirements of operation [24-28]. Many authors have shown the possibility of solving the anti-corrosion problem, but the desired result has not yet been obtained [8,12,29-31]. In this work, this problem is partially solved.

## Method

To determine the protection against corrosion, we used samples of the pipe that is currently used to pump oil and oil products Baku-Ceyhan. These pipelines pass very difficult climatic conditions and for the protection of its metal part, an anti-corrosion material with high anti-corrosion properties is necessary. Because we want to offer for the protection of this pipeline new compositions that provide the pipeline from corrosion for a long time. Samples from the pipe that is in operation are shown in Figure 1

The polymer bitumen composition is obtained by mixing in a mixer at high temperatures (200-250°C), and the bitumen and polymer are mixed with each other.

We can consider the polymer-bitumen system as a three-component one, these components consist of bitumen, polymer and solvent (bitumen solvents). To consider such systems, the triangular diagram method is used.

Thus, the production of a polymer-bitumen composition in bitumen at a temperature of 200°C continues until a certain hardness of the polymer, and then it is divided into separate phases. Therefore, the amount of polymer in bitumen should not exceed 25%. The main properties of the bitumen used in the work are given in Table 1.



**Figure1.** The pipe used for being essential

**Table 1.** Main indicators of used oil bitumen.

| Name of indicators  | Type of bitumen   |             |               |
|---|-------------------|-------------|---------------|
|   | <i>Semi solid</i> | <i>hard</i> | <i>Liquid</i> |
| Softening temperature, °C   | 25 - 50           | 60 - 90     | -             |
| Penetration (the depth at which the needle penetrates the bitumen layer in 5 seconds as a result of the impact of 100 grams of load), 0.1mm | 4 - 20            | 0 - 5       | -             |
| Extension (25°C), cm  | 40 - 60           | 1 - 5       | 60            |

Properties that determine the quality of solid and semi-solid bitumen and separate them into brands are their viscosity, softening temperature.

The viscosity of bitumen characterizes its structure and mechanical properties, it depends on the temperature and group composition. Bitumen is selected, the density of the bitumen is determined, and the mixing temperature is found by determining its viscosity at different temperatures. The viscosity of bitumen was  $0.17 \pm 0.02$  Pa s), and the viscosity of bitumen at the compression temperature was 0.28 Pa s. Using a capillary viscometer, the following values of kinematic viscosity were determined. These values were determined at temperatures of 60, 135 and 159°C. The viscosity is  $2.8 \times 10$  cSt, 498 cSt and 219 cSt respectively.

Kinematic viscosity was found using the following equation:

$$\lg \eta = A - VTS \lg T$$

where:  $\eta$  - kinematic viscosity of bitumen, cSt; T - temperature, °C; VTS - viscosity sensitivity to temperature change ( $VTS=0.868$ ); A-parameter ( $A=2.28$ ).

The following optimal composition of the composition was selected;

Technological waste polypropylene 25 mass parts and bitumen 75 mass parts. To determine the physical and mechanical properties were used after the most modern research methods.

After preparing the composition and determining its physical and mechanical properties and to determine the adhesive strength of the polymer bitumen composition, ASTM D-429 was used, which is currently used to measure adhesion. As a result, we determined the adhesion of the polymer bitumen composition to the metal, i.e. its strength of the metal connection

This method is the adhesion between the core and the flexible shell of a large structure

The composition of the polymer-bitumen composition was studied and the obtained data are presented in Table 2.



**Figure. 2.** H-method metal- polymer bitumen device that determines the composition of adhesion.

**Table 2.** Composition and characteristics of the obtained polymer-bitumen composition based on bitumen grade "Baku 85/25" and polypropylene waste.

| "Baku 85/25" brand bitumen mass part | Bulk fraction of polpropylene waste | Temperature, °C |           | Penetration, 0.1m |         | Length, cm |         |
|--------------------------------------|-------------------------------------|-----------------|-----------|-------------------|---------|------------|---------|
|                                      |                                     | Softening       | fragility | At 0°C            | At 25°C | At 13°C    | At 25°C |
| 100                                  | –                                   | 51              | -5        | 16                | 65      | 14         | 60      |
| 95                                   | 3                                   | 49,5            | -5        | 15                | 60      | 12         | 70      |
| 90                                   | 6                                   | 49,5            | -9        | 13                | 59      | 8          | 85      |
| 85                                   | 8                                   | 49,5            | -12       | 12                | 59      | 8          | >100    |
| 80                                   | 15                                  | 41              | -12       | 8                 | 39      | 5          | >100    |

**Table 3.** The recipe of polymer bitumen to appreciate the surface.

| Names of components used to insulate the metal surface | The amount of components, mass p |     |     |     |     |     |     |     |     |
|--|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
|  | 1                                | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
| Rubber + polypropylene waste (3: 1)                    | -                                | 4   | 6   | 10  | 12  | 14  | 20  | 25  | 30  |
| Bitumen "Baku 85/25"                                   | 150                              | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Technical carbon                                       | 120                              | 120 | 120 | 120 | 200 | 150 | 150 | 150 | 150 |
| Epoxy resin  | 150                              | -   | -   | -   | 5   | 5   | 5   | 5   | 5   |
| Wood resin (kamed)                                     | -                                | -   | -   | -   | 8   | 8   | 8   | 8   | 8   |
| Mixing temperature in the mixer, °C                    | 130                              | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| During mixing, minutes                                 | 30                               | 30  | 30  | 30  | 30  | 30  | 30  | 30  | 30  |

**Table 4.** Physical-mechanical properties of a composition based on rubber dust.

| №  | Indicators                                       | Sample number |        |        |        |        |
|----|--|---------------|--------|--------|--------|--------|
|    |  | 1             | 2      | 3      | 4      | 5      |
| 1. | Penetration of the needle at 25 °C               | 38            | 72     | 100    | 71     | 96     |
| 2. | Softening temperature, °C.                       | 49            | 68     | 82     | 56     | 75     |
| 3. | Fragility temperature, ° C.                      | -10           | -10    | -26    | -8     | -20    |
| 4. | Stretching at 25, ° C                            | 40            | 60     | 70     | 55     | 60     |
| 5. | Density, g/cm 3                                  | 2,34          | 2,36   | 2,38   | 2,2    | 2,4    |
| 6. | Temperature changes at T = 65 ° C for 5 hours    | 7             | 6      | 6      | 6      | 6      |
| 7. | The strength of the strength at 20 ° Cat 50 ° C. | 2,40,9        | 3,01,0 | 3,51,2 | 3,11,1 | 3,41,3 |

## RESULTS AND DISCUSSIONS

We have adopted the following recipe to protect pipes from corrosion in various aggressive environments (Table 3).

The physical and mechanical properties of the composition based on the reception recipe are shown in Table 4

Different based on the rubber and polypropylene waste we use to modified

We have received the recipe given in Table 5 to prepare the binary system in quantities.

**Table 5.** The recipe for the polymer-bitumen.

| № | Indicators   | № 1  | № 2  | № 3  | № 4  | № 5  |
|---|--|------|------|------|------|------|
|   | Bitumen "Baku85 / 25" Rubber + polypropylene waste | 100- | 1003 | 1005 | 1007 | 1009 |

*Bitumen "Baku85 / 25" Rubber + PolpropLen waste binary system lirt-3*

**Table 6.** Butum "Baku85 / 25" Rubber + PolproROroplen waste binary system.

| №  | 130°C     |          |          |          | 150°C     |         |          |          |
|----|-----------|----------|----------|----------|-----------|---------|----------|----------|
|    | kilograms |          |          |          | kilograms |         |          |          |
|    | 11.75     | 20.85    | 26.1     | 32.6     | 11.75     | 20.85   | 26.1     | 32.6     |
| 1  | 250.81    | 56.70    | 33.18    | 18.75    | 82.18     | 20.65   | 11.56    | 6.12     |
| 2  | 91.62     | 26.51    | 18.17    | 7.95     | 40.65     | 10.98   | 6.75     | 3.12     |
| 3  | 80.17     | 22.63    | 15.65    | 6.17     | 29.63     | 8.65    | 5.12     | 2.65     |
| 4  | 70.78     | 19.73    | 14.02    | 5.12     | 21.62     | 7.12    | 3.98     | 2.03     |
| 5  | 60.12     | 17.14    | 12.85    | 3.75     | 17.18     | 5.95    | 2.12     | 1.04     |
| 6  | 91.62     | 26.51    | 18.17    | 7.95     | 40.65     | 10.98   | 6.75     | 3.12     |
| 7  | 80.17     | 22.63    | 15.65    | 6.17     | 29.63     | 8.65    | 5.12     | 2.65     |
| 8  | 70.78     | 19.73    | 14.02    | 5.12     | 21.62     | 7.12    | 3.98     | 2.03     |
| 9  | 60.12     | 17.14    | 12.85    | 3.75     | 17.18     | 5.95    | 2.12     | 1.04     |
|    | 170°C     |          |          |          | 185°C     |         |          |          |
| 10 | 40.25     | 11.13    | 7.82     | 5.75     | 31.18     | 6.75    | 4.85     | 2.98     |
| 11 | 19.30     | 6.32     | 3.16     | 2.04     | 30.07     | 5.6     | 3.72     | 2.03     |
| 12 | 17.816    | 5.604.70 | 2.901.98 | 1.681.68 | 27.928.65 | 4.95563 | 2.756.69 | 1.852.14 |

The flow index of the mixture in the apparatus is 130 °C, 150 °C, 170oC, and 185 °C temperatures and variety, We have identified the effects of loads (Table 6)

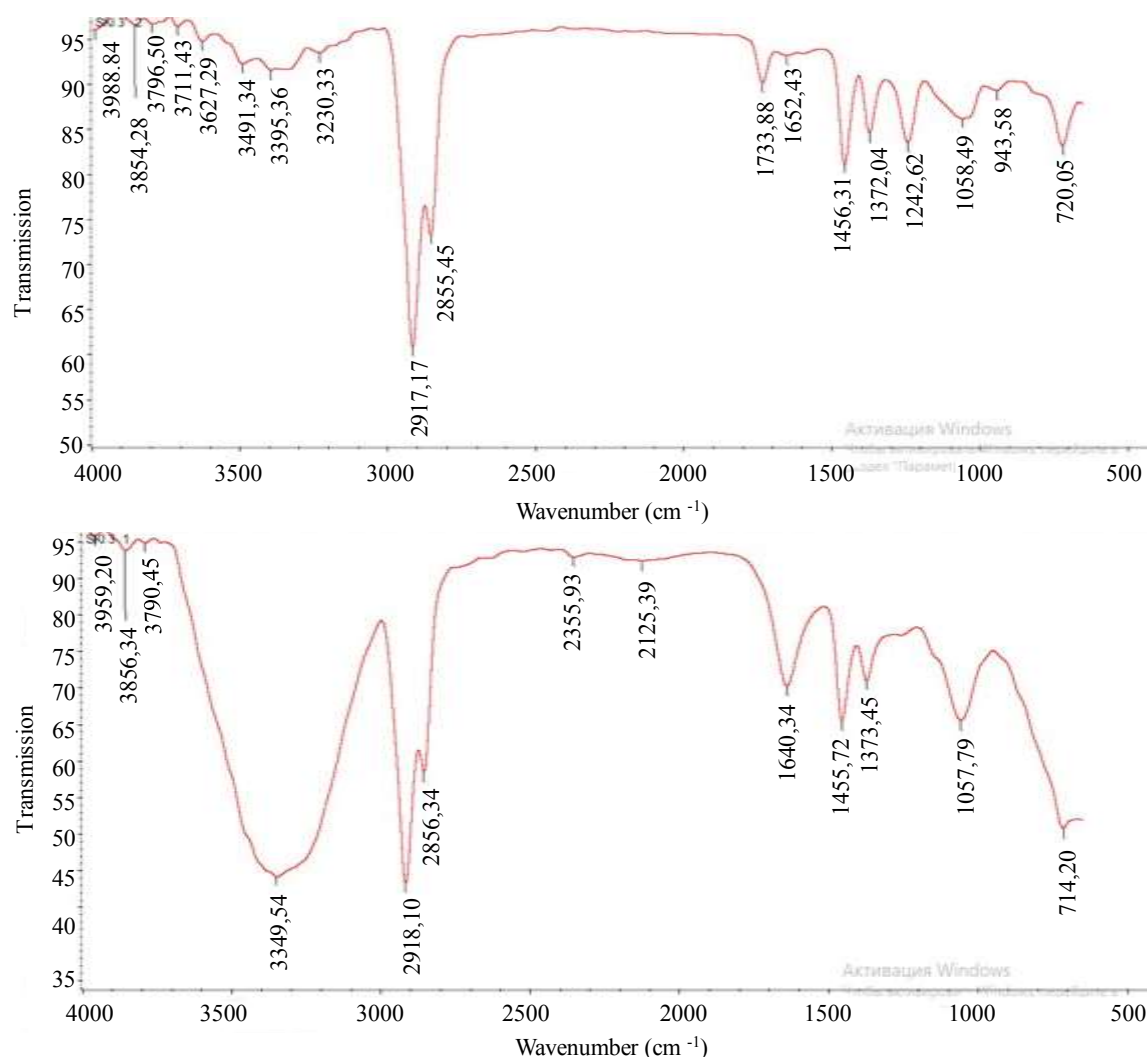
Capliyar's size  $S = 0.02$  mm, 10 minutes spent on the flow of alloys, 26.1 and 32.6 kg of cargo, creating the composition index of cargo, is given in Table 4. Looking at the schedule, we see that the system's flow index changes from 5 to 9 to 9 percent of the system.

Since it is important to determine the dynamic viscosity of the composition system, the dynamic viscosity of the system is 60 °C, 170°C, and 185 °C assembly made it in the graphic image and given it in the graphic image.

The result of the analysis showed that the anticorrosive composition based on polymer bitumen is able to protect metal pipes from corrosion with a long-term property, and it has high adhesion of any metal pipes, since the polymer bitumen material does not biodegrade and can protect against corrosion for more than 50 years. All this is confirmed by our analysis, which we show the results of the study in Table 7

**Table 7.** Main indicators of the composition based on polymer bitumen.

| Indicators                                   | Rubber + polypropilenwaste, 3 mass parts | Rubber +polypropilenwaste, 7 mass parts | Rubber+polyprop.waste, 9 mass par. |
|--|--|---|------------------------------------|
| Conditional strength in case of rupture, MPa | 0,75                                     | 0,87                                    | 0,71                               |
| Relative lengthening, %                      | 960                                      | 700                                     | 680                                |
| Adhesion, MPa to steel                       | 1,20                                     | 1,34                                    | 1,35                               |
| Adhesion, MPa to concrete                    | 1,25                                     | 1,29                                    | 1,34                               |
| Heat resistance, °C.                         | 150                                      | 150                                     | 150                                |
| Frost resistance (I = 5 mm), ° C             | -60                                      | -60                                     | -60                                |
| Water, 20 ° C, 30 days- Strength, MPa        | 0,76                                     | 0,85                                    | 0,67                               |
| - relative lengthening, %                    | 576                                      | 630                                     | 641                                |
| - Water absorption, %                        | 0,84                                     | 0,65                                    | 0,72                               |
| Water, 80 °C, 15 days                        |  |   |                                    |
| - Strength, MPa                              | 3,12                                     | 2,95                                    | 2,50                               |
| - relative lengthening, %                    | 725                                      | 780                                     | 810                                |
| - Water absorption, %                        | 3,25                                     | 3,20                                    | 3,20                               |
| Air, 40 °C, 45 days- Strength, MPa           | 6,12                                     | 6,25                                    | 5,10                               |
| - relative lengthening, %                    | 240                                      | 255                                     | 320                                |



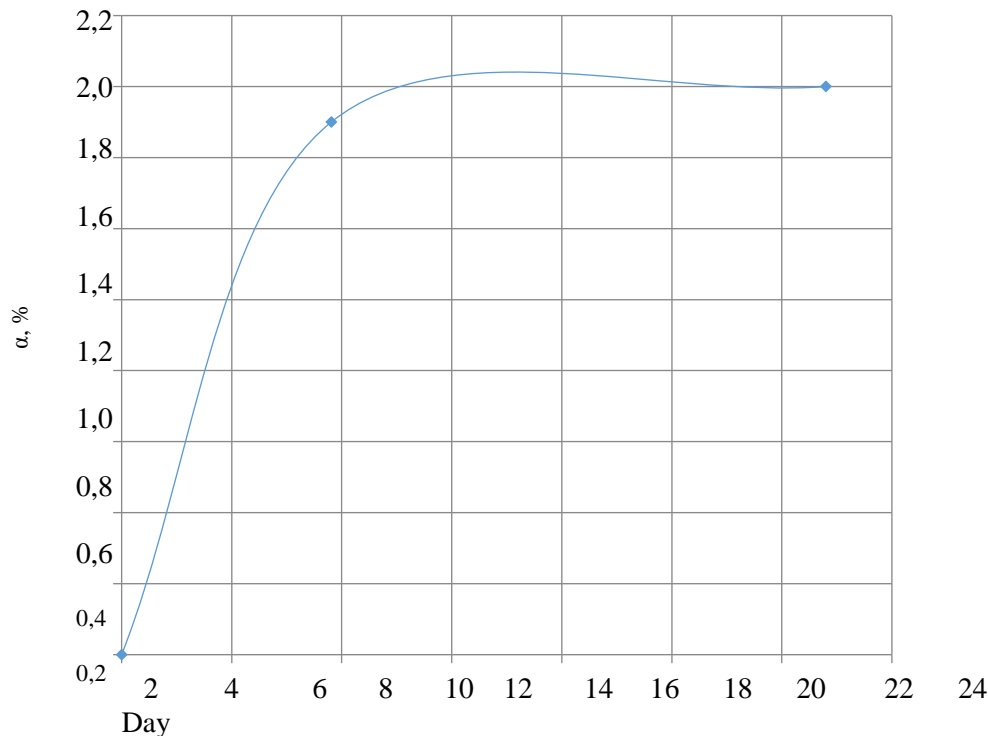
**Figure 3.** Ultra-red - spectra polymer waste + bitumen

To determine the modification of a new anticorrosive material based on polymer waste and bitumen, we produced binary systems and, using IR analysis, proved that the modification process was successful. The resulting spectra are shown in Figure 3

To determine the swelling capacity of the anticorrosive composition, honeycombs based on PP + bitumen + PVC were made and the composition contained the following ingredients per 100 parts by weight of the composition: technical stearin - 10, thiuram - 1.5, captax - 0.5, zinc oxide - 5.0, technical carbon P-324 - 50, sulfur - 2.0. The swelling of the bitumen polymer and various solvents was studied and the obtained data are presented. The obtained data are presented in Figure 4. It was determined that as a result of vulcanization, spatial networks are formed in the rubber macromolecule, which significantly increase the oil and fuel resistance of the anticorrosive composition.

The formulation of the composition based on PP+PVC is provided in Table 8, and the physical and mechanical properties of the vulcanizes of rubber compounds are given in Table 9.

Laboratory rollers were used to produce rubber mixtures. The mixing temperature was initially 90°C and after adding the remaining components the temperature rose to 160°C and the mixing duration was 12 minutes, it was at this time that a homogeneous and single-phase system was obtained. Sulfur was added only when the temperature of the mixture was 90°C so that vulcanization would not occur



**Figure 4.** Swelling of the polymer in bitumen.

**Table 8.** Formulation of composition and physical and mechanical properties of vulcanizates.

| № | Compound code components | 1   | 2   | 3   | 4   | 5    |
|---|--------------------------|-----|-----|-----|-----|------|
| 1 | PP+PVC(2\ 1)             | 100 | 100 | 100 | 100 | 100  |
| 2 | Bitumen                  | -   | 5   | 7.5 | 10  | 12.5 |
| 3 | Stearic Acid             | 1.0 | 1.0 | 1.0 | 1.0 | 1.0  |
| 4 | Atlax                    | 0.6 | 0.6 | 0.6 | 0.6 | 0.6  |
| 5 | NeoZone-D                | 3.0 | 3.0 | 3.0 | 3.0 | 3.0  |
| 6 | ZnO (Zinc Oxide)         | 5.0 | 5.0 | 5.0 | 5.0 | 5.0  |
| 7 | Technical Carbon PN-524  | 50  | 50  | 50  | 50  | 50   |
| 8 | Sulfur                   | 2   | 2   | 2   | 2   | 2    |

**Table 9.** Composition, physical and mechanical properties of vulcanizates.

| №  | Compound code indicators         | 1      | 2      | 3      | 4      | 5    |
|----|----------------------------------|--------|--------|--------|--------|------|
| 1  | Tensile Strength, MPa            | 20.7   | 21.2   | 22.1   | 21.8   | 20.9 |
| 2  | Conditional Stress at 300%, MPa  | 2.25   | 3.6    | 3.9    | 3.8    | 3.2  |
| 3  | Conditional Stress at 500%, MPa  | 5.25   | 5.95   | 6.1    | 6.21   | 5.8  |
| 4  | Elongation at Break, %           | 620    | 630    | 630    | 645    | 650  |
| 5  | Residual Elongation, %           | 14.8   | 14.9   | 14.8   | 14.5   | 14.9 |
| 6  | Separation Resistance, kN/m      | 34.8   | 35.7   | 36.8   | 37.1   | 36.3 |
| 7  | Hardness by TM-2, Arbitrary Unit | 44     | 44     | 44.1   | 45     | 44.9 |
| 8  | Rebound Elasticity, %            | 58.7   | 58.2   | 60     | 60.1   | 59.9 |
| 9  | Adhesion to Metals, MPa          | 3.9    | 4.0    | 4.2    | 4.1    | 41.8 |
|    | Load, kg                         | 11.75  | 11.75  | 11.75  | 11.75  |      |
|    | Temperature, °C                  | 100    | 130    | 150    | 170    |      |
| 10 |                                  | 0.0624 | 0.5774 | 0.2407 | 0.4376 |      |
| 11 |                                  | 0.2116 | 0.5774 | 1.4582 | 3.3284 |      |

---

**CONCLUSION**

1. An anticorrosive material was taken to protect metal from corrosion in various climatic conditions from minus 250C to 50C.
2. In this study, the proposed polymer-bitumen composite protects metal surfaces from corrosion, which has a long-term property of protection against corrosion in comparison with currently used anticorrosive materials.
3. The experimental results obtained allow us to use the anticorrosive composition manufactured by us for protection against corrosion of pipelines transported by oil and gas from corrosion for a long time.
4. The proposed composition, made on the basis of a polymer-bitumen composition, has high adhesion to metal and allows the use of this composition not only to protect the metal part of the pipeline that is in the open space and also, this composition can be used underground in soil conditions, since it has a biologically non-degradable polymer matrix.

**REFERENCES**

1. Moller V.B., Dam-Johansen K., Frankær S.M.G., Kiil S. Acid-Resistant Organic Coatings for the Chemical Industry: a Review // *Journal of Coatings Technology and Research*. 2017. Vol. 14, No.2. P. 279-306. DOI: 10.1007/s11998-016-9905-2.
2. Chandrasekaran V.C. Rubber as a Construction Material for Corrosion Protection: A Comprehensive Guide for Process Equipment Designers. Scrivener Publishing LLC, 2010. RUR 321.
3. Webb R.N., Shaffer T.D., Tsou A.H. Butyl Rubber // *Kirk-Othmer Encyclopedia of Chemical Technology*: in Book. Hoboken: John Wiley and Sons, 2003. DOI: 10.1002/0471238961.0221202511180519.a01.pub2.
4. Visakh P.M., Sabu Thomas, Arup K. Chandra, Aji. P. Mathew. *Advances in Elastomers I*. Berlin: Springer, 2013. Vol. RUR 11,494 DOI: 10.1007/978-3-642-20925-3.
5. Khaladkar P.R. Using Plastics, Elastomers, and Composites for Corrosion Control // *Uhlig's Corrosion Handbook*: in Book. Hoboken: John Wiley and Sons, 2011, pp. 915-970.
6. Morton M. Elastomers, Synthetic, Survey // *Kirk-Othmer Encyclopedia of Chemical Technology*: in Book. Hoboken: John Wiley and Sons, 2009 pp. 1-20. DOI: 10.1002/0471238961.1921182213151820.a02.pub2.
7. De Leon A.C.C., da Silva I.G.M., Pangilinan K.D., Chen Q., Caldona E.B., Advincula R.C. High Performance Polymers for Oil and Gas Applications // *Reactive and Functional Polymers*. 2021. Vol. 162. Article No. 104878. DOI: 10.1016/j.reactfunctpolym.2021.104878.
8. Niu L., Cheng Y.F. Development of Innovative Coating Technology for Pipeline Operation Crossing the Permafrost Terrain // *Construction and Building Materials*. 2008. Vol. 22, Issue 4. P. 417-422. DOI: 10.1016/j.conbuildmat.2007.06.001.
9. Wong J.F., Hassan A., Chan J.X., Kabeb S.M. Plastics in Corrosion Resistant Applications // *Encyclopedia of Materials: Plastics and Polymers*. 2022. Vol. 4. R. 136-148. DOI: 10.1016/B978-0-12-820352-1.00072-9.
10. Samimi A., Zarinabadi S. Application of Polyurethane as Coating in Oil and Gas Pipelines // *International Journal of Science and Engineering Investigations*. 2012. Vol. 1, No. 8. P. 43-45.
11. Popoola A., Olorunniwo O.E., Ige O.O. Corrosion Resistance through the Application of Anti-Corrosion Coatings // *Developments in Corrosion Protection*: in Book. 2014. P. 241-270. DOI: 10.5772/57420.
12. Sukhareva K.V., Andriasyan Yu.O., Mikhailov I.A., Popov A.A. Protective Coatings Based on Synthetic Rubbers // *Plastics*. 2015. No. 11-12. P. 57-63. EDN: WJLCKZ.
13. Surovtsev I.S., Borisov Yu.M., Matreninsky S.I., Sapelkin R.I. Improving the technology of applying high-strength corrosion-resistant protective coatings based on low-molecular oligodiene // *Scientific Bulletin of the Voronezh State University of Architecture and Civil Engineering. Construction and Architecture*. 2010. No. 4 (20). P. 77-87. EDN: NBGDDD.

14. Borisov Yu.M., Matreninsky S.I., Sapelkin R.I. High-strength corrosion-resistant coating for effective protection of steel pipelines operated in the Far North // Scientific Bulletin of the Voronezh State University of Architecture and Civil Engineering. Series: Physical and Chemical Problems of Construction Materials Science. 2008. No. 1. P. 75-77. EDN: PVARJH.
15. Lichman N.V., Pukhareno Yu.V. Effective protective coatings based on sulfur compositions // Bulletin of civil engineers. 2012. No. 2 (31). P. 162-166. EDN: PAQQGL.
16. Schwartz A.G., Dinsburg B.N. Combination of rubbers with plastics and synthetic resins. Moscow: Chemistry, 1972. 224 p.
17. Tagasheva R.G., Faizrakhmanov I.R., Brusko V.V., Bukharov S.V. Obtaining anti-corrosion compounds based on phenolic resin and cyclohexylamine // Bulletin of the Technological University. 2015. Vol. 18, No.18. P. 65-67. EDN: UYYUJH.
18. Trofimov A.N., Kosolapov A.F. Anti-corrosion coating for the protection of pipelines and engineering structures // Delovaya Slava Rossii. 2013. No. 5 (43). P. 38-42. EDN: TFMCEH.
19. Shatilo S.P., Kolesnik S.V., Emelianov V.V. Anti-corrosion materials for the protection of pipelines and test results under the conditions of the field of OAO Samotlorneftegaz // Experience, current problems and prospects for the development of the oil and gas complex: Proc. V regional. scientific-practical. conf. of students of higher education, postgraduate students and scientists. Tyumen: Publishing house of Tyumen University, 2015. P. 311-324. EDN: UISWTR.
20. Pham H.Q., Marks M.J. Epoxy Resins // Ullmann's Encyclopedia of Industrial Chemistry: in Book. Weinheim: Wiley-VCH, 2003. P. 155-244. DOI: 10.1002/14356007.a09\_547.pub2.
21. Morozova Z.V., Salnikov A.V. Development of a protective coating for structures with increased corrosion resistance and icing resistance // Resources of the European North. Technologies and economics of development. 2018. No. 3 (13). P. 18-30. EDN: VREWWQ.
22. Special Paints and Varnishes LLC. URL: <http://www.skraski.ru> (date of access: 22.06.2023). Paint and varnish coatings for anti-corrosion protection of oil and gas industry facilities // Novax. URL: <https://www.novax.ru/products/neftegazovaya-promyshlennost/> (date of access: 22.06.2023).
23. Medvedeva M.L. Fundamentals of electrochemical corrosion and protection of equipment during transportation and storage of oil and gas. - M.: Russian State University of Oil and Gas named after I.M. Gubkin, 2004. -145 p.
24. Protasov V.N. Quality of engineering products at various stages of their life cycle. - M.: OOO "Izdatelskiy dom Nedra, 2012.-231 p.
25. Protasov V.N. Physicochemical mechanics of materials of equipment and structures of the oil and gas industry. - M.: Nedra, 2011. - 200 p.
26. Kosachev V.B., Gulidov A.P. Corrosion of metals // News of heat supply. 2002. No.1 (17). P. 34-3927.
27. Torres A., Amaya Suárez J., Remesal E.R., Márquez A.M., Fernández Sanz J., Rincón Cañibano C. Adsorption of Prototypical Asphaltenes on Silica: First-Principles DFT Simulations Including Dispersion Corrections // Journal of Physical Chemistry B. – 2018. – V. 122, No. 2. – P. 618
28. Kerem Shixaliyev. Properties of the Composition Based on Modified Polyethylenes. International Journal of Innovative Technology and Exploring Engineering. Volume-9 issue- / January 2020.pp2484-2493, SCOPUS <https://www.ijitee.org/download/volume-9-issue-7/>
29. Kerem Shixaliyev. Modification of Polymer Wastes and Obtaining Composites Based on Them Annotation. International Journal of Innovative Technology and Exploring Engineering (IJITEE). Volume-9 Issue-5, March 2020 pp. 1072-1076. Number-E2156039520 | 2020 © BEIESP <https://www.ijitee.org/instructions-for-authors/>
30. Kerem Shixaliyev. Paint and Varnish Materials Based on Epoxy Novolac oligomers Jour of Adv Research in Dynamical & Control Systems. Vol. 12, Special Issue-02, 2020.pp351-358
31. Kerem Shixaliyev Sefi..DETERMINATION OF COMPATIBILITY OF POLYMER SYSTEMS, SKEP, PU, KhKPE, and CHEMICAL FEATURES OF THEIR MIXTURES. Journal of Adv Research in Dynamical & Control Systems. Vol. 12, Special Issue-02, 2020.pp359-370