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PHYSICOCHEMICAL FUNDAMENTALS OF USING BITUMEN AND PYROLYSIS DISTILLATE IN ANTI-CORROSION COATINGS

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Abstract. Bitumen is a high molecular weight, multi-component system with excellent moisture resistance, film-forming, and adhesive properties. Bitumen is characterized by the presence of asphaltenes, resins, and aromatic compounds, and it is their ratio that determines the coating‘s resistance to moisture, oxygen, and aggressive substances. A pyrolysis distillate, obtained by the thermal decomposition of hydrocarbon feedstock, contains fractions of aromatic, naphthenic, and oxygenated compounds that can alter the rheological properties of bitumen. Its application in anti-corrosion composite coatings improves heat resistance and adhesion. The introduction of a bitumen-distillate coating will significantly reduce (by 30–40%) the costs of corrosion protection through the use of raw materials, the utilization of recycled resources, and a reduction in the energy intensity of production.

Keywords. Bitumen, oxygen, aggressive substances, pyrolysis distillate, thermal decomposition, anti-corrosion, composite, resistance, adhesion.

Аннотация. Битум представляет собой высокомолекулярную многокомпонентную систему, обладающую превосходной влагостойкостью, пленкообразующими и адгезионными свойствами. Битум характеризуется наличием асфальтенов, смол и ароматических соединений, и именно их соотношение определяет устойчивость покрытия к воздействию влаги, кислорода и агрессивных веществ. Пиролизный дистиллят, полученный путем термического разложения углеводородного сырья, содержит фракции ароматических, нафтеновых и оксигенированных соединений, способных изменять реологические свойства битума. Его применение в антикоррозионных композиционных покрытиях улучшает термостойкость и адгезию. Внедрение битумно-дистиллятного покрытия позволит значительно (на 30–40 %) снизить затраты на антикоррозионную защиту за счет

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использования сырья, утилизации вторичного сырья и снижения энергоемкости производства.

Ключевые слова. Битум, кислород, агрессивные вещества, пиролизный дистиллят, термический разложение, антикоррозионная защита, композитный, стойкость, адгезия.

Annotatsiya. Bitum– bu yuqori molekulyar og‘irlikka ega, ko‘p komponentli tizim bo‘lib, namlikka chidamlilik, plyonka hosil qilish va yopishqoqlik xususiyatlariga ega. Bitum asfaltenlar, smolalar va aromatik birikmalar mavjudligi bilan tavsiflanadi va aynan ularning nisbati qoplamaning namlik, kislorod va agressiv moddalar ta'siriga chidamliligini belgilaydi. Gidrokarbon xomashyo materialining termik parchalash yo‘li bilan olingan piroliz distillati aromatik, naftenik va oksigenlangan birikmalar fraksiyalarini o‘z ichiga oladi, ular bitumning reologik xususiyatlarini o‘zgartira oladi. Uni koroziyaga qarshi kompozit qoplamalarda qo‘llash issiqlikka chidamlilik va yopishuvchanlikni yaxshilaydi. Bitumen-distillat qoplamasini joriy etish xomashyo sarfini, ikkilamchi xomashyoni qayta ishlash va ishlab chiqarish energiya intensivligini kamaytirish orqali koroziyaga qarshi himoya xarajatlarini sezilarli darajada (30–40% ga) kamaytiradi.

Kalit so‘zlar. Bitum, kislorod, korroziy moddalar, piroliz distillati, termal dekompozitsiya, korroziyaga qarshi himoya, kompozit, chidamlilik, adgeziya.

1. INTRODUCTION.

The reliability and durability of oil and gas pipelines are largely determined by the effectiveness of corrosion protection, since metal corrosion is one of the main causes of accidents, leaks and premature decommissioning of pipeline systems. The impact of aggressive factors of the external and internal environment - moisture, soil electrolytes, dissolved salts, hydrogen sulfide, carbon dioxide, as well as temperature and pressure drops - significantly accelerates corrosion processes and reduces the operating characteristics of pipes.

The purpose of these tests is to obtain objective and reproducible information on the protective effectiveness of anti-corrosion coatings, their compliance with the requirements of regulatory technical documentation and the possibility of use in the operating conditions of oil and gas pipelines. The test results allow optimizing coating compositions and technologies, increasing the reliability of pipeline systems and reducing the risks of accidents and economic losses. Many scientists have contributed to solving problems related to pipeline corrosion and modern protection methods.

According to some authors, the effectiveness of elastomeric composites as protective coatings is determined by their technical characteristics, high chemical resistance, and barrier properties. However, elastomeric composites are considered

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expensive materials and are imported into Uzbekistan from abroad. Cheaper local materials are required for the corrosion protection of main pipelines in our country. Such materials include bitumen, which are complex mixtures of aromatic, naphthenic, and paraffinic compounds, resins, and asphaltenes.

Structurally, bitumen is a colloidal system in which asphaltenes are dispersed in an oil matrix (fine polar components and resins). This system determines the main physicochemical properties of bitumen: heat resistance, adhesion, and hydrophobicity. Intermolecular interactions occur between the components of bitumen and the surface of steel: - associations, chemisorption of oxygen groups, hydrogen bonds, as well as the formation of weak complexes with metal ions (Fe^{2+}, Fe^{3+}), which increases the adhesion energy and reduces the rate of electrochemical corrosion.

Another key point is that bitumen are best suited for saline soils, which are common in most regions of our country. Therefore, the aim of this study is to investigate the structure and composition of bitumen and its effect on the protective properties of the components of anti-corrosion coatings.

Bitumen are complex mixtures of aromatic, naphthenic, and paraffinic compounds, resins, and asphaltenes. Structurally, bitumen consists of a colloidal system in which asphaltenes are dispersed in an oil matrix (small polar components and resins). This system determines the main physicochemical properties of bitumen: heat resistance, adhesion, and hydrophobicity [1].

The main components of bitumen are: asphaltenes - polar, heavy molecules that form the structure; resins - amphoteric compounds that provide plasticity and adhesion; maltenes (oils) - light hydrocarbons that act as the dispersion medium. Typical characteristics of construction bitumen**:** softening point: 45-60 °C; fragility temperature: below -20 °C; penetration at 25 °C: 50-100 × 0.1 mm [2].

Bitumen are colloidal dispersions, such as “asphaltenes in a maltene matrix.” An important parameter describing the stability of such a system is the value of the Zeta potential (ζ), which influences the stability of the particles [3]:

$$\zeta = \frac{4\pi\varepsilon\varepsilon_0 * \mu}{\eta}$$

where:

ε ε - dielectric constant of the medium,

ε₀ ε₀ - permittivity of free space,

μ μ - electrophoretic mobility,

η η - viscosity of the dispersion medium.

1. Physicochemical Properties of Pyrolysis Distillate

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Pyrolysis distillate is a product of the thermal decomposition of hydrocarbon feedstock, which contains aromatic hydrocarbons, aliphatic compounds, neutral fractions, as well as oxygenated compounds. Pyrolysis distillates are characterized by the following [4]: high reactivity (due to the presence of multiple bonds); low viscosity; ability to modify polymer and bitumen systems; moderate toxicity (during initial stabilization); the presence of phenol and aldehyde groups that increase adhesion.

The IR spectra of the pyrolysis distillate show absorption bands [5]:

$\approx 2920\ cm^{-1}$ (C-H aliphatic);

$\approx 1600\ cm^{-1}$ (aromatic rings);

$\approx 1700\ cm^{-1}$ (carbonyl groups).

IR spectroscopy indicates the presence of functional groups active in the adhesive interaction [6,7]:

C = C (aroma) $\approx 1600\ cm^{-1}$ C = C (aroma) $\approx 1600\ cm^{-1}$

C = O (aldehydes/ketones) $\approx 1700\ cm^{-1}$ C = O (aldehydes/ketones) $\approx 1700\ cm^{-1}$

O-H (phenols) $\approx 3400\ cm^{-1}$ O-H (phenols) $\approx 3400\ cm^{-1}$

These groups participate in the formation of hydrogen bonds and donor-acceptor complexes with the metal surface or bitumen components [6].

2. METHODOLOGY

The study subjects in this work are selected: composite anticorrosive coatings (fillers, surface additives, stabilizers) developed on the basis of petroleum bitumen modified with fractions of pyrolysis distillate (PD) with the addition of functional additives; steel samples of pipe products used in trunk oil and gas pipelines (steel 20, steel 09G2S); aggressive media simulating operating conditions: water-salt solutions (NaCl, $MgCl_2$), hydrogen sulfide medium (H_2S), carbon acid medium (CO_2), as well as biocorrosion medium (sulfatizing bacteria) [7].

RESEARCH METHODS

Chemical and analytical methods: IR spectroscopy (FTIR) - for functional group analysis and approval of bitumen modification with pyrolysis products; gas chromatography (GX) and GX-Mass spectrometry (GX-MS) - for analysis of PD fraction composition; element analysis (CHNS/O) - to determine the composition of coatings and raw material elements; energy dispersion spectroscopy (EDS) - to determine the elements at the boundary of the metal coating.

Physicochemical and thermal methods: differential scanning calorimetry (DSC) and TGA (thermogravimetric analysis) - to assess the thermal stability and thermal stability of coatings; determination of viscosity and smoothing temperature

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per bag - for bitumen and modified compositions; contact angle (goniometry) - to assess the adhesion and interaction of the coating with the metal [8].

Mechanical tests: strength test of coating connection with metal as per GOST 15140; coating testing for flexibility and impact strength as per GOST 6806; melting and water absorption tests - as per GOST 9.403 and GOST 9.407. Electrophysical methods: determination of electrical insulation properties - breakdown voltage, specific volume and surface resistance; electrochemical tests (potentiodynamic polarization, impedance method) - to evaluate the corrosion resistance of coatings.

Microbiological tests: influence of sulfating bacteria (Desulfovibrio sp.) on coated and uncoated samples - in accordance with NACE TM0185 and GOST R 58167; assessment of biocorrosion by change in mass, surface morphology and degradation rate.

Modeling and forecasting: molecular modeling of the interaction of steel coating and surface components using the Materials Studio, Gaussian, Avogadro software packages; calculation of thermodynamic parameters of interaction and adhesion (Δ G, Δ H, Δ Ead); evaluation of barrier properties by multiphase diffusion modeling (COMSOL Multiphysics).

Thus, the complex of selected experimental and calculation methods allows to fully characterize the composition, structure and performance characteristics of composite coatings, as well as their behavior in aggressive conditions close to the actual operation of pipelines.

The following materials were used in this study:

BND 60/90 grade bitumen meeting the requirements of GOST 33133-2014 was used as base binding material. This bitumen is characterized by high adhesion of mineral materials, sufficient plasticity in use and resistance to aging. Its physicochemical parameters were used as a control for comparison with predefined and modified compositions.

Pyrolysis distiller is a secondary hydrocarbon product obtained as a result of thermal decomposition of hydrocarbon raw materials (for example, plastics, rubber waste, oil stacks, etc.). The distiller is a liquid fraction that boils at a temperature of 100 to 350 °C. It contains a significant number of aromatic, aliphatic and cycloalkanes, as well as heteroatomic compounds that modify the structure and properties of bitumen.

Compositions based on bitumen distillate and pyrolysis - within the framework of the study, composite binding materials were obtained by adding various amounts of pyrolysis distillate (from 5 to 30 t%) to the bitumen matrix. The mixing process was carried out at a temperature of 150-180 °C with vigorous

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mixing until homogeneous. The purpose of the modification is to improve low temperature properties, increase resistance to brittleness and aging.

The physicochemical characteristics of the starting components and the obtained compositions were studied in detail using the following complex methods: penetration, Kees softening temperature, moderate Fraas, IR spectroscopy, thermogravimetric analysis (TGA) and other analytical data presented in the following methods sections.

Complex tests, including climatic and electrochemical methods, were used to evaluate the anticorrosive effectiveness of bitumen compositions modified with pyrolysis distillate. The tests were carried out on samples of pipes coated with the test materials in order to duplicate the conditions of use in aggressive environments.

CONCLUSION

A comparative analysis with traditional protective systems (epoxy coatings and thermoplastic tapes) has shown that bitumen-distillate compositions are a cost-effective alternative with comparable strength characteristics, offering ease of application and the possibility of localized repairs. The introduction of bitumen-distillate coatings will significantly reduce (by 30–40%) the costs of corrosion protection through the use of raw materials, the use of recycled resources, and a reduction in the energy intensity of production. Bitumen-distillate compositions possess high corrosion resistance, retain their protective properties in aggressive environments, and exhibit good adhesion, i.e., they ensure strong bonding of the coating to the metal surface of the pipe and its resistance to peeling. The developed recommendations for adapting the coating composition to various climatic zones will ensure their effective application across a wide range of natural and climatic conditions, from northern territories to southern regions and coastal areas.

Based on the above, the commission concludes that bitumen-distillate coatings are a promising technical and economic solution for protecting trunk pipelines, ensuring their durability, maintainability and environmental safety, are in demand in modern conditions of import substitution and austerity

REFERENCES

1. Gladkykh I.F., Cherkasov N.M., Kraikin V.A., Sigaeva N.N., Ionova LA., Zaikov G.E., Monakov Yu. B. Heat- and thermostability of asphaltoresinous oligomers // Journal of the Balkan tribo logical association. -2001. -Vol. 7. -l3-4. -P-P. 147-155.

2. Cherkasov N., Kolosnitsin V., Gladkykh I., Monakov Yu. Asmol Innovation anti-corrosive material // The summary of technologies. Russian technological review. -2001. -Ns 2 (6). -P. 28-30.

ISSN 3030-3907

3. 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
4. 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. P. 136-148. DOI: 10.1016/B978-0-12-820352-1.00072-9.
5. Samimi A., Zarinabadi S. Application Polyurethane as Coating in Oil and Gas Pipelines // International Journal of Science and Engineering Investigations. 2012. Vol. 1, No. 8. P. 43-45.
6. 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. 241270. DOI: 10.5772/57420.
7. Shirazi M., Ayatollahi Sh., Ghotbi C. Damage evaluation of acid-oil emulsion and asphaltic sludge formation caused by acidizing of asphaltenic oil reservoir. Journal of Petroleum Science and Engineering. 2018, vol. 174, pp. 880-890. DOI: 10.1016/j.petrol.2018.11.051 29.
8. Straka P., Maxa D., Staš M. A novel method for the separation of high-molecular-weight saturates from paraffinic petroleum based samples. Organic Geochemistry. 2019, vol. 128, pp. 63-70. http://www.sciencedirect.com/science/article/pii/S0146638018302699.
9. Alexander I.V, Ragulin V.V., Telin A.G. Development and Introduction of Heavy Organic Compound Deposition Diagnostics, Prevention and Removing. SPE International Symposium on Oilfield Chemistry, 2005. DOI: 10.2118/93128-MS

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