**Possibility of Obtaining Fire-Resistant Sealants on the Basis of Gossipol Resin and Inorganic Additives**

Shaxlo Aitovaa), Rasulbek Jabbiev, Maxsud Jumaniyazov, Ozoda Rajabova

*Urgench State University named after Abu Rayhan Biruni, Urgench, Uzbekistan*

*a)Corresponding author:* [*ximtex@rambler.ru*](mailto:ximtex@rambler.ru)

**Abstract:** This article presents the results of a study of the effects of mineral fillers such as talc, antimony (III) oxide Sb2O3 and aluminum alkaline Al(OH)₃ on the composition in order to increase the fire resistance of sealants prepared on the basis of gossipol resin. It has been found that the above inorganic additives significantly improve the thermal stability and flame resistance of the mastic matrix. The talc included in the compound has been found to act as a thermal barrier and structure stabilizer, surname (III) oxide as a smoke reduction and anti-fire synergist, and aluminum hydroxide as a component that releases water vapor during the endothermic decomposition process. Based on this, the sealant prepared was analyzed in the IQ (infrared) spectrum of the samples. The characteristic peaks in the obtained spectrum clearly express the interactions between organic and mineral components, bond types and structural changes. These developments reveal mechanisms for increasing the fire resistance and thermostability of sealants.

**Keywords:** gossipol resin,mastic, talc, survement (III) oxide, aluminum hydroxide, fire resistance, cracks, antipherene component.

**INTRODUCTION**

Bitumen-based sealants are widely used in road coverings, industrial polymer coatings and hydroinsulation systems, and in the production of anti-corrosion coatings. However, when using them in conditions requiring high temperatures, it is becoming increasingly difficult to resist fires. It becomes important to synthesize refractory sealants, which are free of these disadvantages.

Scientists of the world have published a lot of scientific works on products obtained on the basis of gossipol resin.

Maxsud Jumaniyazov and his associates studied the possibilities of producing oil production waste - gossipol resin and wrapped insulated materials on the basis of local resources. As a result of the research, it is possible to reduce heat effect of sealants made on the basis of gossipol resin by 94–97 ºC and reduce the water absorption index by 1.2–1.25%. The water permeability of the compound was 0.001 g in 72 h, and it maintained a coefficient of linear expansion at various temperatures. It is also found that the content is resistant to high temperatures, does not break at low temperatures (down to -20 ºC). It is found that the burning temperature is 315 ºС, the total corrosion resistance is 95%. The results obtained were compared with the indicators of international standards and compliance with the requirements was noted [1].

The researcher Rasulbek Jabbiev and others on the development of scientific foundations of non-oil bitumen production from unconventional raw materials – gossipol resin.

The influence of temperature and catalysts on the dehydration and thermal oxidation processes of Gosipol resin has been investigated. It was found that it was optimal to carry out the oxidation process in participation of catalysts Fe2O3 and H3PO4 at a temperature of 210–220°C. An increase in the reactive abilities of functional groups has been observed in thermally oxidized gosipolis smola. Since the process was conducted at temperatures of 200°C and 180°C, it was noted that the need to add 2.9% and 5.5% CaO respectively was emphasized. As a result of polymerization of gosipol resin at 220°C, when CaO content increased from 0.5% to 2.0%, it was observed that the softening temperature of product rose from 51°C to 62°C and the needle penetration depth (penetration) decreased from 62mm to 34mm [2].

This article provides information on the creation of rapid phosphating compounds as a result of the application of vermiculite. The following content was found to be optimal (as a percentage of weight relative to the absolute dried residue): C – 17.34, H – 6.43, O – 43.50, phenolic groups (–OH) – 5.06, methoxy (–OCH₃) – 3.06, carboxyl (–COOH) – 1.18, total acid groups – 6.24, sulphur (ash) – 4.12–2.74.

In addition, the physical and mechanical properties of the natural mineral vermiculite are improved in the composition, that is, its density is 70–180 kg / cu³, water absorption 400–530%, pH 6.8–7.0, mg content 10–14%, K 3–5%, Ca 1.2–2%, Mn 0.8–1%). The kinetic parameters derived from this study reveal the mechanisms underlying the rapid phosphating process. The results of this have important implications for creating environmentally friendly and highly durable protective coatings [3].

Stroganov, I. V. and Khairullin, as a result of the influence of the processes of prevention of stratification, stability conditions, optimal ratio of fire-resistant additives with polymer matrices and rheology of hardening, the possibility of providing the required fire resistance and physical-mechanical properties for epoxide polymers was determined. The effects of aluminum and magnesium hydroxides and antimony (III) oxide as fire-resistant fillers have been studied. It has been revealed that the combined application of these substances has a positive effect not only on the technological processing capability of epoxide compositions, but also on the effectiveness of reducing the flammability of the polymer. This effect is mainly explained by a significant increase in the fire temperature of the polymer [4].

Truong, Cong Doanh, et al. successfully synthesized aluminum hydroxide nanoplates (nATH) from the Al(OH)₃ gel precursor with an average size of 350–450 nm and a thickness of 30 nm by Truong, Cong Doanh et al. Subsequently, these ATH nanoplates were supermodified with organic compounds and added to an intumescent (self-propagating fire-resistant epoxide) system that stored ammonium polyphosphate (APP@PEI) modified with polyethylenemine. Post-combustion remnants of samples were analyzed using Fure-infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM-EDX) equipped with energy-dispersion X-ray analysis to study the mechanisms of anti-inflammatory action. The results of the study showed that the formation of aluminum phosphates with high thermal stability plays an important role to improve the flame resistance during the condensation phase [5].

Piperopoulos, Ye. The purpose of the scientific work published by others was to develop and optimize fire-resistant coatings used in the marine industry. For this, Mg(OH)₂ and Al(OH)₃ fillers were added to the acrylic-based composition in order to increase fire resistance. It is also studied how the size of the alkali particles affects the fire resistance of coatings. The best results were observed in a sample filled with Mg(OH)₂, which indicates the potential of this product for further development and application in the marine sector [6].

A new type of phosphorus-containing fire-resistant epoxy resin has been synthesized by Iqbal, M. A., et al. by initial modification with phosphoric acid and subsequent treatment with aluminum alkali (ATH). This served to increase the fire resistance of modified epoxy resin. The effects of phosphorus-modified epoxy resin and ATH on the thermal and mechanical properties of epoxy resin were investigated and the effects of addition of alumina hydroxide on the thermal and mechanical properties of epoxy resin were investigated. The structure of modified fire-resistant epoxy resin was determined using Fure-infrared spectroscopy (FTIR) [7].

In the study conducted by Dzulkafli, H. H. and others, the effect of adding talc as an additive to the composition of intumescent (self-foaming) coatings on thermal insulation, decay and water resistance properties was investigated. Fire resistance tests were carried out according to ASTM-E119 standard to analyze the ability of coating samples to absorb heat. According to the results, the addition of 20% tolk improved thermal insulation, and it was observed that the sample temperature was 75°C after a fire test lasting 100 minutes [8].

This article presents the process of enrichment of raw materials at Zinelbulak talc-magnesite deposit in the Lower Amu Darya region of the Republic of Uzbekistan. First of all, the chemical composition of magnesite waste is studied. According to him, it was found that the content (weight percentage) contains 53.70% of magnesite – MgCO3, talc – 3MgO∙4SiO2∙H2O 27.20%, cammerite – 5MgO∙5FeO∙Al2(SiO3)3∙H2O10.01%,dolomite – MgCO3∙CaCO3 7.75% and calcite – CaCO3. To convert this compound into magnesium sulfate, treatment with sulfuric acid at different concentrations and at different temperatures has been studied. High-carbonate, low-quality Central Kyzylkum phosphorites were selected to neutralize the resulting pulp. As a result of numerous studies, it has been successfully carried out to obtain the total content of phosphorus pentaoxide, which is the main raw material components, containing 11.38%, the absorbable form 6.83%, and the water-soluble form of magnesium oxide 9.65% [9].

[A new type of flame-retardant epoxy resin containing phosphorus](https://www.researchgate.net/scientific-contributions/Muhammad-Ahsan-Iqbal-2144425666?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19)  by Mohammed Ahsan Iqbal and others was initially modified with phosphoric acid and then synthesized by adding alumina hydroxide (ATH). This method is aimed at improving the fire resistance of modified epoxy resin. By applying different mass ratios of phosphorus-modified epoxy resin and ATH, the effect of the addition of aluminum hydroxide on the thermal and mechanical properties of epoxy resin was investigated. The structure of modified fire-resistant epoxy resin was analyzed using Fure-Infrared Spectroscopy (FTIR), in which thermal decay properties and fire resistance levels were evaluated using thermogravimetric analysis (TGA) and UL-94 standard tests [10].

The authors conducted research on talc extraction from talc-magnesite minerals from the Zinelbulak deposits. Talc in the mineral – 3MgO·4SiO2· H2O – 60.97%, magnesite – MgCO3 – 27.74%, chlorite – 5MgO·5FeO· Al2(SiO3)3· H2O – 8.01%, dolomite – MgCO3· CaCO3 – 2.90% and calcite – CaCO3 – 0.38%. The results of IQ spectral analysis, X-ray fluorescence and X-ray phase analysis of the sample are also given. In the process of flotation of talc concentrate, the yield of talc concentrate was 33.43%. It has been proven that this talc can be used in the production of fire-resistant materials [11-13].

Studies have shown that the anti-spillage stability of aluminum and magnesium hydroxides, the dispersion of which is less than 10 μm, can be significantly achieved by 2–4 wt. of aluminum dioxide compositions with a dispersion of 6–8 μm. The fraction is provided by adding antimony (III) oxide. This technological method provides high fire resistance: the temperature of the fire reaches 400–410°C, and the physical and mechanical properties retain a high level of hydroxide of aluminum and magnesium and antimony (III) oxide in the ratio of 2.5:1 [12].

Based on the above, fire resistance, heat stagnation and rheological behavior of bitumen sealant developed on the basis of gossipolis resin have not yet been studied. Therefore, determining the synergistic effect of antimony (III) oxide and aluminum hydroxide modifiers on the composition is considered one of the important tasks in this study. The study employed laboratory methods based on AASHTO T 315, ASTM D7175, and EN 12697 series of standards. The obtained results form a new scientific and technological base for the development of environmentally friendly and sustainable road pavements.

**METHODS**

Natural gossipol resin was used as the main polymer base in the study. Various amounts of mineral additives were introduced to it - talc, antimony trioxide and aluminum hydroxide. In order to determine the effect of the supplement, they were examined separately and together at concentrations of 5%, 10% and 15%, respectively. The sealant samples were processed for 20 min in a mechanical mixer at 60–70°C until the mixture was homogeneous. Prepared samples were dried under natural conditions for 24 h, followed by 2h in an 80°C thermocooler.

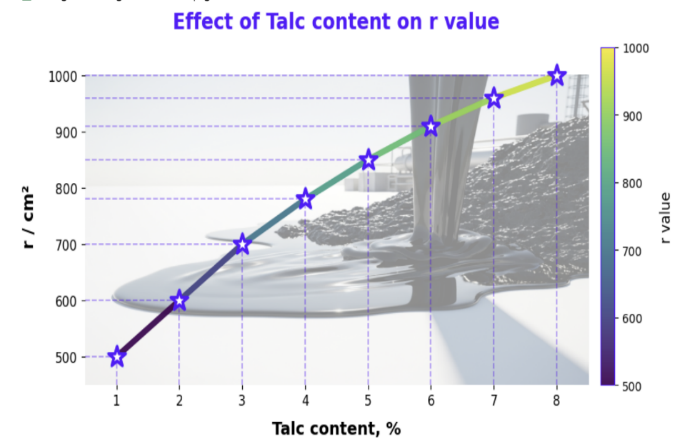
Fire resistance tests were carried out on special fire stands according to the standard GOST 12.1.044-89. The time of burning, the height of the flame, and the time of spontaneous extinction were determined.

IQ spectrum analyses were performed on the IRTracer-100 spectrometer at a range of 4000–400 cm⁻¹.

The calculated fire resistance index If was determined by the equation If=t1/t0. where: *t₁* is the fire resistance time (s) of the modified sealant, *t₀* is the fire resistance time (s) of the control sample. All experiments were repeated three times, the mean values of the results were determined with an error of ±5%.

**RESULTS AND DISCUSSION**

In order to improve fire resistance and operational properties of sealants based on Gossipol resin**, talc, antimony (Sb₂O₃)** and **aluminum alkali (Al(OH)₃)** were used as fillers. Each of these substances had a different effect on the physical-mechanical and thermal stability properties of sealants. The modifiers that we have chosen **are distinguished by a high-order lamellary (layered)** structure, and this feature serves to strengthen the internal structure of the mastics, which are modified with it. As a result of the introduction of talc into the composition of the mastic, there **was a clear change in its levels of elasticity, resistance to deformation**, and **structural stability**. According to the results of the studies, the elasticity properties of the mastics were at an optimal level when the talc content was **around 5%,** and it was observed that the consistency of the structure was maintained under the influence of temperature. This condition prevents the formation of cracks during fire and ensures the integrity of the fire-resistant layer. Although **some increase in fire resistance was noted with an increase** in talc content of more than 6%, a downward trend in the needle **insertion** depth and **softening temperature** of the mastics, respectively, was detected. This has been found to have a negative effect on the structure balance of higher complementary contents. The results are summarized in Figure 1 below.



**FIGURE 1. Effect of talc concentration in gossipol resin-based mastic on fire resistance indicators**

At the next stage of the research, we determined the deformation indices of mechanical strength and combustion time when talc mineral 0–15% was introduced into gossipol slurry and compared it with the control sample. The results are presented in Table 1. It can be seen from the data that as the amount of talc in the compound increased, **the crack resistance and mechanical strength** of the sealant gradually improved compared to the control sample. Many large cracks were observed in the control sample (0% talc), which is explained by internal tension and uneven polymerization processes in the natural amount of gossipol resin. In this case, the sealant loses rigidity and during combustion a high deformation (70%) occurs.

**TABLE 1.** The effect of talc on **cracking** and mechanical strength of the composition   
of the mastic based on Gossipol resin

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **№** | **Amount of Talc, %** | **Number and characteristic of cracks** | **Mechanical strength (MPa)** | **Deformation during combustion** | **Residual mass after combustion, %** | **Note** |
| 1 | 0 (control) | Many, major cracks | 3,1 | High (70%) | 38 | Talc-free mastic is prone to cracking |
| 2 | 2,5 | Reduced, small cracks | 3,5 | 60% | 45 | Gomogen mass |
| 3 | 5 | Small cracks | 3,7 | 50 | 47 | Talc Mass Evenly Distributed |
| 4 | 7,5 | A small amount of cracks | 3,8 | 45 | 49 | Uniform mass |
| 5 | 10 | Minimal cracks, structure stable | 3,9 | 40% | 53 | Optimal concentration |
| 6 | 12,5 | The cracks multiplied again | 3,6 | 50% | 50 | Excess talk made the modification worse |

The addition of 5% of talc evened out the density in the mastic structure, reducing the number of cracks and increasing the mechanical strength from 3.1 MPa to 3.5 MPa. This process is related to the **dispersing effect** of talc particles which uniformly distribute the internal pressures within the polymer matrix.

It is clear from Table 1 that the results reach the highest when 10% talc is included in the mastic. At the same time, cracks were minimal, and the structure was kept in a stable state. The mechanical strength was increased to 3.9 MPa and the deformation at the time of combustion was reduced by 40%. At the same time, the post-combustion residual mass rose to 53%, indicating that talc **was acting as a thermal barrier**.

An excessive amount of talc (15%) on the contrary reduced the effectiveness of the effect. This condition is explained by the excessive accumulation of talc particles, leading to segregation of the polymer structure. This resulted in a decrease in mechanical consistency to 3.6 MPa, cracks reappeared, and a 3% decrease in residual mass was observed after combustion.

According to the results of the analysis, **it was determined that the optimal concentration of talc was 10%.**  Mastic based on gossipole resin in this amount showed high stability, low cracking, and high fire resistance.

It is also of great importance that talc reduces its **thermal conductivity as an additional physical effect**. When exposed to heat, talc particles limit the dissipation of internal energy, reducing the rate at which the combustion front propagates up. Thanks to this, the sealant retains its shape for a long time in the process of combustion. At the same time, the talc particles form a **physical barrier (barrier)** in the resin matrix, that is, preventing rapid destruction of polymer chains. This barer effect slows down the radical reactions in the polymer molecules, which in turn makes fire resistance more severe. By analyzing the results in Table 1, it can be concluded that the talc-added gossipol mastic is perfect not only mechanically, but also thermally and in terms of fire resistance. This modification method can be applied in the manufacturing of industrial insulating coatings, cable insulation materials and polymer-based fire-retardant sealants.

In our subsequent research, we investigated the introduction of surfalfa trioxide into tarkin in order to further increase the fire resistance of sealants based on gossipol resin.

The substance acts mainly through the phlegmatization mechanism in the gas phase, that is, it reacts with active radicals (H•, OH• and O•), which forms during the fire process, reducing their activity. Thanks to this, the chain reactions in the combustion process are disrupted, and the rate of combustion is drastically reduced.

Studies have found that (0% talc) gossipol resin-based mastic begins to burn at a temperature of 290°C, emitting strong smoke for 30 seconds. This situation shows not only the fire resistance of mastic, but also the rapid course of active oxidation processes in the external environment. The introduction of suralfa trioxide at 5% of the total mass was reduced the smoke emission during combustion and temperature stability was increased by 320°C. and the burn time was shown to be 47 seconds. This indicates that the Sb2O3 molecules initiate the phlegmatization effect during combustion. At this stage, the surrogate trioxide blocked the radicals contained in the gossipol resin polymer, slowing the active radical turnovers in the combustion process.

Results are significantly improved when the amount of graft is increased to 10%. The combustion time lasted about 56 seconds, the temperature stability increased to 345°C, and the residual mass reached 52%. According to this result, the fire resistance of the sealant increased by about 1.7 times compared to the control sample. This case indicates that the surrogate trioxide in the amount of 10% interacts physically and chemically with the gossipole resin, forming an integrated flame retardant structure. At the same time, surround carbon molecules enclose with the resin phenolic fragments, limiting gas release and neutralizing combustion activating radicals.

However, at concentrations higher than 10% Sb2O3, i.e., in the 15% case, there was a slight increase in the combustion temperature (350°C), no significant preponderance was observed in the results. This condition is explained by the fact that oversliding particles agglomerate in the polymer matrix, breaking its uniform distribution. Even if in this case the thermal stability is maintained at a certain level, as a result of a violation of mechanical equilibrium, the effectiveness of the flame retardant decreases. Related to this is a 1% decrease in residual mass.

**TABLE 2.** Effect of surma trioxide on fire parameters of sealants prepared on the basis of gossipol resin

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **№** | **Amount of Sb₂O₃, %** | **Smoke emissions during combustion** | **Fire resistance, °C** | **Burning time (sec)** | **Residual mass, %** | **Note** |
| 1 | 0 (control) | Strong | 290 | 30 | 35 | It burns intensely. |
| 2 | 5 | Reduced | 320 | 47 | 48 | Rubbing reduces trioxide smoke |
| 3 | 10 | Significantly less | 345 | 56 | 52 | Fire resistance increased |
| 4 | 15 | A little smoke | 350 | 58 | 51 | Excess Quantity Is Inefficient |

The effect of the surrogate on the fire was realized in two stages:

1. Solid phase effect: As the temperature rises, the sealant formed a protective layer on its surface with the appearance of dense glass. This layer blocks the entry of heat and oxygen into the inner layers.
2. Gas phase effect: surfacing trioxide during combustion, breaks the reaction chain. Thus, cease to intensify fire fires. Based on the analysis of the data in Table 2, it can be concluded that the fire resistance of gossipol resin-based mastic at 10% Sb₂O₃ is the highest. In the process of burning this amount, smoke emission decreases sharply, and the temperature stability and indicators of residual mass reach the maximum. Also, Sb2O3 with its antipyrene property not only limits the process of combustion, but also slows down the thermal destruction of the resin.

At the same time, the sliding tip can have synergistic interactions with the organic components in the sealant. For example, when it is used together with aluminum hydroxide (Al(OH)₃) in a subsequent stage, the flame retardant effect is further increased, since the two substances simultaneously affect the gas phase through phlegmatization and heat absorption (dehydration) mechanisms.

To improve the fire resistance of Gossipol resin-based sealant, aluminum hydroxide (Al(OH)₃) was used as an important antipyrene additive. The substance acts mainly through endothermic reaction mechanism, i.e. under the action of heat, dehydration process takes place, from which the substance releases water vapor (H₂O) from its induction. This steam plays a key role in extinguishing the fire process by cooling and squeezing oxygen.

According to Table 3, the combustion temperature in the control sample (0%Al(OH)₃) was 290°C, the stability level was low, and the residual mass was only 34%. This case showed a rapid flammability of sealant without the addition of aluminum hydroxide and an active course of thermal destruction. Since at this stage there is no dehydration mechanism, the restrictive effect on the fire process will not be realized.

With the addition of aluminum alkali in an amount of 5%, the combustion temperature increased to 320°C, and the residual mass reached 47%. This result is explained by the cooling effect of water vapor released as a result of the reaction Al(OH)₃ → Al₂O₃ + 3H₂O. In this process, the decomposed steam lowers the temperature at the fire center and stops the polymer from undergoing rapid degradation. Due to this, the time of burning of the mastic is longer, and the smoke emission is reduced.

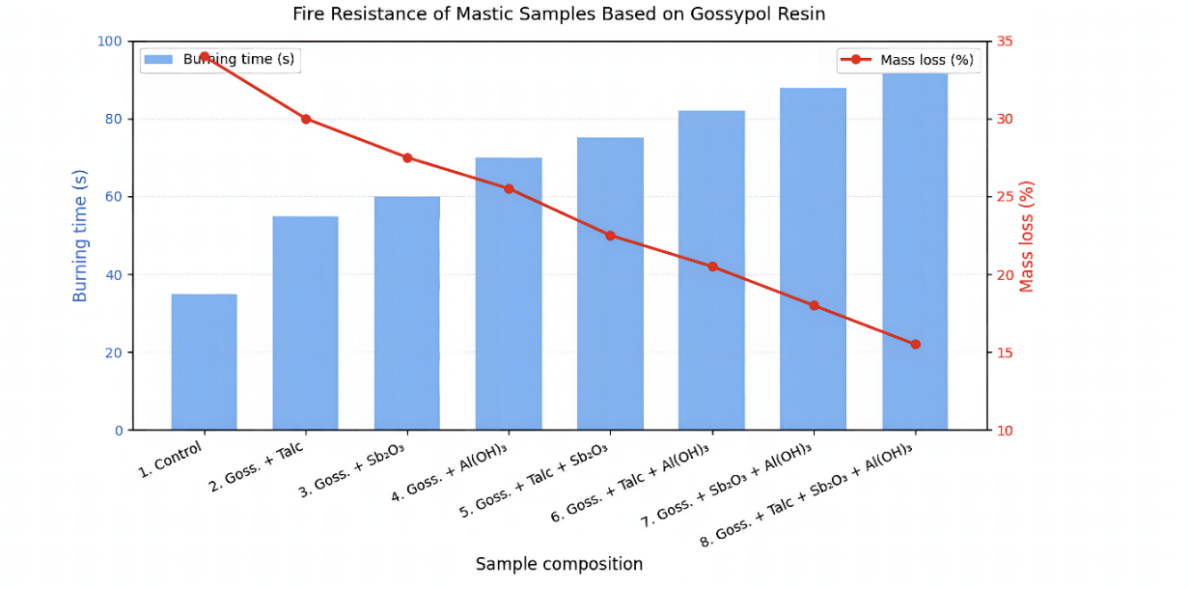
**TABLE 3.** The effect of aluminum hydroxide (Al(OH)₃)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **№** | **Al(OH)₃ content, %** | **Combustion temperature, °C** | **Dehydration initiation, °C** | **Degree of stability** | **Residual mass, %** | **Note** |
| 1 | 0 (control) | 290 | – | Past | 34 | The burning went quickly |
| 2 | 5 | 320 | 210 | Average | 47 | Cooling effect due to H₂O decay |
| 3 | 10 | 340 | 210 | High | 54 | Steady water output extinguished the fire |
| 4 | 15 | 335 | 205 | Average | 53 | The excess worsened the dispersion |

The highest result was recorded in the amount of 10% Al(OH)₃. In this case the combustion temperature is raised to 340°C, dehydration starts at 210°C and the stability degree is high. These results are related to the energy absorption of aluminum hydroxide in the water separation process (endoterm process). At this stage, Al(OH)₃ reduces the heat flux within the polymer matrix, protects the polymer chains from radical reactions, and forms an oxide layer (Al₂O₃) at the solid phase boundary. This layer acts as a thermal barrier and limits the entry of oxygen.

The decomposed steam in the process of dehydration not only absorbs heat, but also dissipates oxygen from the fire environment, which increases the phlegmatization effect. As a result, the main active radicals of the combustion process (H• and OH•) are slowed down and the fire front stops. This process took place in a synergistic coupling with the sliding spark effect in Table 2, resulting in a complex anti-fire effect.

When the concentration of aluminum hydroxide was increased to 15%, the combustion temperature decreased slightly (335°C), while the dehydration initiation temperature decreased to 205°C. This condition is explained by the ununiform dispersion in the polymer matrix due to agglomeration of excess Al(OH)₃ particles and deterioration of the dispersion. As a result, although the flame retardant effect is stable, the maximum effectiveness decreases.



**FIGURE 2.** Changes in the fire resistance properties of gossypol resin-based mastic under the influence of talc, antimony trioxide, and aluminum hydroxide

According to the graphic data, **as a result of the addition of talc,** antimony trioxide **(Sb₂O₃)** and **aluminium** hydroxide **(Al(OH)₃) to the** composition **of gossipol resin-based mastic**, its fire resistance indicators have significantly improved. Under the action of antipyrenes, a slowdown in the thermomodestrusion of gossipol resin, which forms the mastic, occurred during combustion, heat absorption due to endothermic decomposition of aluminum hydroxide increased, and the surrogate extinguishes radical combustion chain reactions.

The IQ (infrared) spectrum of composite samples obtained by adding talc (Mg₃Si₄O₁₀(OH)₂), surround trioxide (Sb₂O₃) and aluminum alkali (Al(OH)₃) to the composition of the sealant prepared on the basis of gossipol resin was analyzed. The characteristic peaks in the obtained spectrum clearly express the interactions between organic and mineral components, bonding types and structural changes. These developments reveal the mechanisms for increasing fire resistance and thermostability of sealants.

In the spectrum, 8 main oscillation bands in the range of 4000–400 cm⁻¹ were detected. Each of them represents certain functional groups of mastics and states associated with mineral supplements. In the upper part of the range (3420–3450 cm⁻¹), a wide and strong peak was observed. This peak shows O–H oscillations of the gossipol resin concerning the phenol hydroxyl groups and the hydroxyls containing talc and aluminum alkali. The expansion and intensity of the peak indicate that strong hydrogen bonds have been formed by the effects of the additives. This case showed that a stable structure was formed in the organo-mineral medium, indicating an increase in thermal stability and fire resistance of the mastics. Between 3010–3080 cm⁻¹, aromatic C–H oscillations were detected. It belongs to the aromatic ring of gossipol resin, which confirms the conservation and structural stability of the organic matrix. At the same time, the weak peak around 2920 cm⁻¹ refers to the aliphatic C–H oscillations, their intensity decreasing under the action of additives. This means that the aliphatic bonds are partially dehydrogenated or oxidized, as a result of which the fire-fighting structure is strengthened. The strong peak in the range of 1650–1680 cm⁻¹ refers to the conjugated oscillations C=O and C=C, confirming the presence of aldehyde and quinone groups in the gossipole resin. This peak shifts slightly downward when additives are added, which indicates that hydrogen or covalent bonding is formed with metal hydroxides, and electron decalkalization is intensified. This indicates an increase in the energy absorption capacity of the structure In the range of 1420–1460 cm⁻¹, deformation oscillations C–C and O–H were detected. This is related to the bonding between peak phenol groups and aromatic rings. When aluminum hydroxide is introduced, the shape of the peak changes and a new peak is formed, indicating that a metal-organic transition phase has formed. This structure ensures the mechanical and thermochemical stability of the sealant.

The strong peak in the range of 1010–1040 cm⁻¹ consists of the Si–O–Si and Si–O–Mg oscillations characteristic of the talc mineral, confirming the integration between the gossipole resin matrix and the mineral phase. An increase in this range means that the silicate structures have stabilized, that is, the flame effect has increased. Oscillations of Si–O–M (M = Mg, Al) were recorded around 675–700 cm⁻¹. This indicates the bonds between the talc and aluminum alkali layers, establishing the mechanical stability of the composite structure. This peak increase means that the material's ability to retain shape when exposed to temperature and combustion is increased. At the lower end of the spectrum, in the range of 500–520 cm⁻¹, Sb–O oscillations corresponding to the surround tip were detected. This peak has a flame retardant effect, slowing down the combustion process by forming an active oxide layer during a fire, suffocating radicals. This provides spectroscopic confirmation of the fire-fighting function of the spark plug.

**CONCLUSION**

By introducing various inorganic additives to the mastic tart obtained from Gossipol resin, it was possible to increase its fire properties without weakening its physical-mechanical and chemical properties. In this place, the talc mineral actively acts as a heat barrier. It limits heat flow, forming a layer in the content. By introducing antimony (III) oxide into the composition of the sealant, radicals are slightly absorbed. Both have a synergistic effect, increasing fire resistance. Aluminum hydroxide provides cooling through an endothermic reaction. They absorb heat, emit water vapor and react to combustible gases. As a result, the flammability of the sealant decreases, thermal stability increases. Thanks to the combined effect of the above additives, a comprehensive fire protection is created. Synergetic mechanisms increase their effectiveness Such combination is important for sealant. The scientific data obtained make it possible to use a new type of refractory sealant based on gossipol resin in modern fire-resistant systems. This, in turn, paves the way for the use of this material in industrial areas where fire safety is required.

**REFERENCES**

## Jumaniyazov, M., Kurambayev, S., Atashev, E., Jumaniyozov, A., & Buranova, M. (2025). Determination of the composition of the Zinelbulak talc-magnesite deposit rock using modern physicochemical methods. E3S Web of Conferences, 633, 06002. <https://doi.org/10.1051/e3sconf/202563306002>

1. Masharipova, S., Jumaniyazov, M., Turkmenbaeva, M., & Kabulova, L. (2025). Study of physicochemical properties of hydrophobic calcite based on sugar factory defecates. E3S Web of Conferences, 633, 01003. <https://doi.org/10.1051/e3sconf/202563301003>
2. Jumaniyazov, M., Masharipova, S., Bekchanov, B., Masharipova, Z., & Kudiyarova, K. (2025). Obtaining the composition of ceramic bricks based on the color characteristics of the original sample. AIP Conference Proceedings, 3304, 040046. <https://doi.org/10.1063/5.0269042>
3. Stroganov, I. V., & Khairullin, R. Z. (2025, May 22). *Fire-resistant yepoxy anhydride and yepoxy amine compositions*. Polymer Science Series D, 18(2), 210–219. <https://doi.org/10.1134/S1995421225020076>
4. Doanh, T. C., Thi, N. H., Nguyen, H. T., Oanh, H. T., Doan, T. D., Tuyen, N. D., Vu, M., & Hoang, M. H. (2025). Preparation and synergistic effect of aluminum hydroxide nanoplates on the fire resistance and thermal stability of the intumescent flame retardant epoxy composite. RSC Advances, 15(21), 16814–16825. <https://doi.org/10.1039/d5ra00231a>
5. Santana, I., Félix, M., Guerrero, A., & Bengoechea, C. (2022). Processing and Characterization of Bioplastics from the Invasive Seaweed Rugulopteryx okamurae. Polymers, 14(2), 355. <https://doi.org/10.3390/polym14020355>
6. Matchonov, S. K., Ruzmetova, A. S., Yakubov, Y. K., & Kurbanov, D. S. (2023). Khodzhakul kaolins of Uzbekistan: composition, physical and chemical properties, and processing methods. Obogashchenie Rud, 5, 31–36. <https://doi.org/10.17580/or.2023.05.06>
7. Dzulkafli, H. H., Ahmad, F., Ullah, S., Hussain, P., Mamat, O., & Megat-Yusoff, P. S. (2017). Effects of talc on fire retarding, thermal degradation and water resistance of intumescent coating. Applied Clay Science, 146, 350–361. <https://doi.org/10.1016/j.clay.2017.06.013>

# Jumaniyazov, M., Kurambayev, S., Atashev, E., Aitova, S., & Pirnapasova, H. (2025). The extraction of talc from Zinelbulak talc-magnesite raw materials. AIP Conference Proceedings, 3304, 040043. <https://doi.org/10.1063/5.0269064>

1. Iqbal, M. A., Iqbal, M. A., & Fedel, M. (2018). Fire retardancy of aluminum hydroxide reinforced flame retardant modified epoxy resin composite. Russian Journal of Applied Chemistry, 91(4), 680–686. <https://doi.org/10.1134/s1070427218040225>
2. Mamutov, B., Butkov, E., Hamzayev, A., Sherkuziev, D., Aripov, K., Ergasheva, F., & Ismoilova, K. (2021). Application of mineral fertilizers to increasing soil moisture and growth of forest seedlings for creation forest crops in Western Tien-Shan. E3S Web of Conferences, 304, 03007. <https://doi.org/10.1051/e3sconf/202130403007>
3. Deveci, S., Antony, N., Nugroho, S., & Eryigit, B. (2019). Effect of carbon black distribution on the properties of polyethylene pipes part 2: Degradation of butt fusion joint integrity. Polymer Degradation and Stability, 162, 138–147. <https://doi.org/10.1016/j.polymdegradstab.2019.02.015>
4. Masharipova, S., Jumaniyazov, M., & Aitova, S. (2025). Improvement of the technology of obtaining mineral binders from loess-like rocks using mechanoactivation. E3S Web of Conferences, 633, 08004. <https://doi.org/10.1051/e3sconf/202563308004>