



## The study of the gossypol resin impact on adhesive properties of the intermediate layer of the pipeline three-layer rust protection coating



K.S. Nadirov, M.K. Zhantasov\*, B.A. Sakybayev, A.K. Orynbasarov, G.Zh. Bimbetova, A.S. Sadyrbayeva, A.S. Kolesnikov, H.A. Ashirbayev, D.M. Zhantasova, A.M. Tuleuov

M. Auezov South Kazakhstan State University, Shymkent, Republic of Kazakhstan

### ARTICLE INFO

#### Keywords:

Gossypol resin  
Adhesion  
Intermediate layer  
Three-layer polymeric coating  
Pipelines  
Rust protection

### ABSTRACT

The extrusion technique was used to obtain new compositions of the intermediate layer of the pipeline three-layer rust protection coating. Besides conventional low-density polyethylene and ethylene-vinyl acetate, the composition of the layer included various ratios of exfoliated vermiculite as mineral filler and gossypol resin. The optimal ratios of layer components were determined from the perspective of improvement of adhesion, impact strength, rest resistance, and exfoliation.

The developed compositions fully meet the requirements of current technical standards in this field. Their high technical characteristics are related to the synergistic effect between the gossypol resin and the exfoliated vermiculite. Gossypol resin stabilizes polyethylene and improves the mechanical characteristics of the composition and the mineral filler. Exfoliated vermiculite enhances the interaction of the polymer matrix with the steel.

As compared with the similar compositions, the content of the expensive component – ethylene-vinyl acetate – is reduced from 62–90 wt% to 7–9%. The new composition effectively protects pipelines that operate under high humidity. The developed composition uses cheap local raw materials (including waste, which has a negative impact on the environment) and improves the mechanical properties, rust resistance, and adhesion properties of the obtained coating.

### 1. Introduction

The need to improve and expand the range of adhesive compositions used in factory and gross rust protection insulation of steel pipelines is dictated by their growing use and the constantly increasing level of technical requirements. The polymeric adhesive underlayer (hot melt adhesive) serves as an intermediate layer in the three-layer coating structure for the rust protection of pipes. Its function is to provide coupling (adhesion) between the outer plastic layer and the inner epoxy layer.

In Kazakhstan, ethylene-vinyl acetate is the only available raw material for such hot melt adhesives. Given the previously obtained positive results [1–5] as regards to the use of mixed ethylene-vinyl acetate compositions as adhesives for metal and liquid epoxy primer, it would be interesting to study the possibility of using them as adhesives in a three-layer coating comprising the inner layer – primer.

When studying the properties of polymer composites, special attention should be paid to the assessment of the contribution of each mixture component to the structure and mechanical properties of composition materials [6]. Using simple mechanical polymer blends,

which consist of components with specific properties, is not enough to produce high-quality materials, which can be attributed to the lack of compatibility of most polymers due to the low entropy of their mixture and poor adhesion in the interphase area. The latter fact is one of the main reasons behind phase separation and downgrading of the strength characteristics of the composite materials.

Polyolefin compounds poorly combine not only with the polar polymers, but also with polymers of their own class. The improvement of their technological compatibility requires complex studies on the selection and use of specific compatibility optimizers. Various elastomers are widely used to modify the polyolefin compounds; this improves such properties as impact strength, crack resistance, elasticity and frost resistance [7,8]. The potential for improving the distortion and strengthening parameters of polyolefin mixtures is largely determined by the macromolecular characteristics and monomer composition of initial polymers. However, it is currently impossible to find the optimal values of these factors theoretically. Obviously, the requirements to the macromolecular characteristics and monomer composition of initial polymers providing the improved properties of the compositions cannot be universal; therefore, specifying these structural factors

\* Corresponding author.

E-mail address: [Manap.Zhantassov@hotmail.com](mailto:Manap.Zhantassov@hotmail.com) (M.K. Zhantasov).

with regard to the nature of polymers and their mixture ratios is a relevant problem.

The solidity of the composite material is achieved through adhesion. Such a feature of polymers as adhesion capability allows using them as film-forming materials, for instance, pressurizers, coatings or glues. This parameter also determines the possibility to obtain reinforced and filled polymeric materials. In order to create the adhesive joint, one of the materials should be supply, i.e. fluid (the one that will be adhesive) and the other – quite the opposite - solid (the one that would be the substrate). Adhesion of the substrate coating is the main parameter that determines the quality and reliability of the products [9]. Adhesion also affects the cost of manufactured products, since low adhesion strength is usually found only during the final manufacturing operations.

The main difficulty in choosing the optimal technology that would provide the required adhesion is the lack of objective quantitative criteria for evaluating certain parameters of application, for instance, the purity of the substrate surface and the degree of its activation. In practice, one is often forced to deal with complex systems of several films coming into adhesive contact. In this research, it is a three-layer pipe coating designed for pipelines. The adhesive strength of the system of bodies is determined by their weakest junction. It is worth noting that different junctions may be the weakest ones, depending on the separation conditions.

One of the main factors that determine the adhesiveness of a polymer is its chemical structure. This includes not only the existence and content of functional groups capable of interacting with the surface, but also the spatial structure of the polymer, the presence of side chains and groups, as well as the length and flexibility of the polymer chains or their segments in the netty structures.

Currently, there are a lot of adhesive compositions based on ethylene-vinyl acetate [10–12]. Their disadvantage is the insufficiently high adhesion strength to metals during shift and exfoliation, as well as high concentration of various expensive resins (35–55 wt%).

The purpose of this research is to develop an intermediate layer composition with increased adhesive capacity. Using this layer in the coating composition allows increasing the shifting tension during separation of the adhesive composition of the intermediate layer from the inner primer layer on the one hand and from the developed composite layer forming the outer layer with low surface energy on the other hand.

## 2. Materials and methods

The suggested new adhesion composition includes four main components: low-density polyethylene (LDPE), ethylene-vinyl acetate (EVA), gossypol resin (GR), and exfoliated vermiculite (EV) as mineral filler.

This research used cheap LDPE with low molecular weight without the stabilizer, since the improving the properties of this polythene is the most relevant task.

Vermiculite is a mineral from the hydromica group; it has a layered structure conducive to many physical and chemical interactions. It is biologically resistant – whereas it is not subject to decay and rot under the influence of microorganisms, it is not a favorable environment for insects and rodents, as well as it is a chemically inert substance – neutral to alkalis and acids.

The new elements in the suggested composition is gossypol resin [13,14]. Gossypol resin is a waste product of cottonseed oil production (tar of fatty acids distillation), a homogeneous viscous mass colored dark brown to black. Gossypol resin contains 52–64% of crude fatty acids and their derivatives. The fat fraction of gossypol resin (FFGS) is dark brown and is a mixture of 11 fatty acids. The specific weight of FFGS is 0.981 t/m<sup>3</sup>; its acid number of –112.8 mg KOH/g; saponification value – 228.3 mg KOH/g; ester number – 155.43 mg KOH/g; iodine number – 1.44 g I<sub>2</sub>/100 g; solidification temperature – 57 °C. Seven unsaturated acids dominate the compositions (86.8% of total

**Table 1**  
Content of studied compositions, when compared to the prototype, wt%.

Composition No	LDPE	EVA	EV	GR	FFGS	Talc	APE-silane	Rosin	Mica
1		62–90				1–10	1–5	5–20	1–3
2	78	7		15					
3	78	15	7						
4	78	7	5	10					
5	78	7	5		10				
6	78	7			10	5			
7	73	8	6	13					
8	69	9	7	15					
9	60	11	12	17					
10	85	5	2	8					

weight), with the largest mass being that of linoleic (30.5%) and oleic acid (26.5%).

The rest are products of gossypol condensation and polymerization generated during oil extraction, especially in the process of distillation of acids from soap stocks. Gossypol resin is used mainly in road construction and as a reagent for removing solid paraffin deposits in oil wells.

The content of the main components in the study of adhesion compositions is presented in Table 1. Hereinafter, all concentrations are expressed in wt%. An adhesion composition based on EVA (composition 1 in Table 1) was used as a prototype for comparison with the developed materials. Such compositions usually contain 62–90% of EVA, 1–10% of talc, 5–20% of rosin, 1–3% of mica, and 1–5% of  $\gamma$ -aminopropyletoxysilan (APE-silane). The other compositions in Table 1, numbered 2–10, offered for study are based on various combinations of LDPE, EVA, GR, and EV. In particular, the concentration of LDPE in the suggested compositions ranges from 69% to 78%, EVA – 7–9%, EV – 5–7%, GR – 10–15%.

A technique for preparing the adhesive layer composition using extrusion was developed. Using extrusion gives important advantages, namely, the possibility to combine several processes in a single extruder: dispersing, mixing, homogenizing, thermal treatment, etc. along with the continuous and highly productive process.

Polymer compositions were prepared by melt mixing in a laboratory desktop multifunction twin-screw extruder UR-TC (England). Its operating principle is fully consistent with the technological process in the production line. The entire rig includes the extruder with dispensers, the cooling bath, and granulator.

Compositions are mixed in an extruder with heating up to 110–120 °C. First, the melted polyethylene and EVA are supplied. Then the exfoliated vermiculite and gossypol resin are added. As the composition moves to the discharge area of the extruder, it is mixed and heated. After a homogeneous mixture is obtained, it is discharged from the extruder at a temperature of 130–140 °C.

The developed compositions' characteristics of adhesion to steel were determined at temperatures of 20 ± 5 °C and 60 ± 3 °C in accordance with standard procedures [15]. Construction low-alloy steel for welded structures ST17G1S (K-52), which is similar to the S355 J0 steel by European classification or 1522 steel by US AISI-SAE classification, was used as the underlayer.

The impact strength was determined by Izod impact testing. The exfoliation area of protective coatings under cathode polarization, the transition electric resistance of the insulating coating was also determined in accordance with standard procedures [16]. The crack resistance of adhesive coatings was studied in a strongly acidic medium at a temperature of 50 °C according to the method described in [17].

The measured properties of tested adhesion layers were compared to the maximum permissible levels according to the standard for protective coatings of steel pipes with a diameter of 820 mm [16]. The rust resistance of the adhesion layer (bloating in groundwater) was measured in the original state after 60-days holding.

Download English Version:

<https://daneshyari.com/en/article/5014781>

Download Persian Version:

<https://daneshyari.com/article/5014781>

[Daneshyari.com](https://daneshyari.com)