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Development of Antifrictional Coverings on the Basis of Aromatic Polyamide Phenylon Modified by Complex Connections Thioamides

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Abstract: **In given article process of development of antifriction coverings is considered on the basis of aromatic polyamide phenylon C-2. Thioamides and their copper compounds have been used as modifiers to obtain antifriction coatings based on aromatic polyamides. Friction and wear tests were realized at the friction machine with the lubrication with the industrial oil by the scheme shoe-disc. The dependence of the tribotechnical characteristics on the nature and concentration of the modifying additive of the elaborated polymer coatings was stated. The usage of d-addition at the amount of 1 mass % is optimal. It was shown that the friction and wear of the coating were influenced by the chemical structure of the compound materials based on thioamides. Thus, the best quality was registered in the coating containing the modifier with Cu^{3+} in its composition.**

Keywords: **Aromatic polyamides, phenylon, friction, wear, thioamides**

I INTRODUCTION

Aromatic polyamides have prospective application as the construction materials in engineering. The compositions based on aromatic polyamides possess good strength and wear-resistance, but high coefficient of friction (0.3 – 0.5), which limits the possible obtaining of the qualitative coatings of tribotechnical application on its basis [1].

Earlier [2] we investigated thioamides of displacement, as well as their copper compounds as wear-resistant and antifriction additives for industrial oils application. Good performance properties of such compositions in the systems of bronze-(oil I-40+additive)-steel is reached by the realization of the wear-free transfer effect.

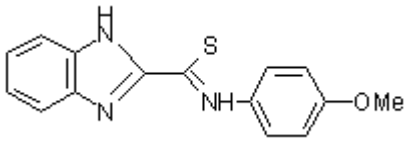
Taking this into consideration, it was a certain interest to use thioamides and their copper compounds as modifiers to obtain antifriction coatings based on aromatic polyamides [3].

II SUBJECTS AND METHODS OF INVESTIGATIONS

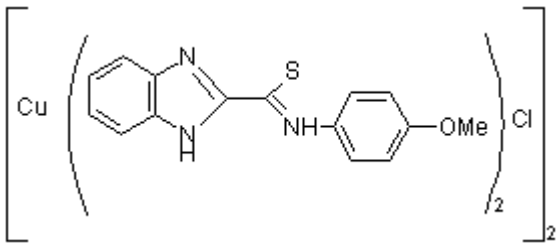
The initial materials were: aromatic polyamide phenylon C-2, porous bronze with the ordered pore depth (bottom layer), complex compound based on thioamides, and dimethylformamide as the solvent (DMFA).

Poly *m*-, *p*-, phenyleneisophthalamide is the linear aromatic co-polyamide known as phenylon C-2 (Russia). Phenylon is an amorphous polymer of white colour with the verification temperature of 545 K. Phenylon it decomposes heating to 610 – 630 K, its melting starts at 700K. It possesses good physico-mechanical properties, which justifydetermines its application as the construction material [4].

Coatings based on phenylon were modified by means of a compound additive that consists of the following chemical structures:



(1)



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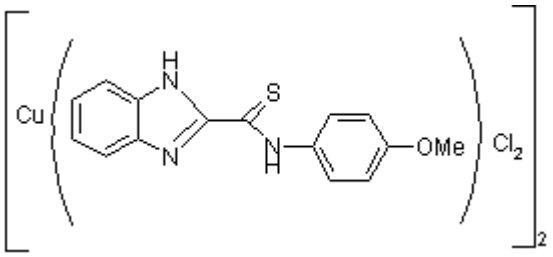

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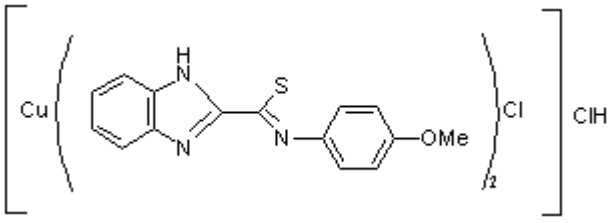

(4)

Preparation of specimens for testing the antifriction coating includes following stages:

- dissolving of phenylon and the modifying additive into DMFA;
- clearing and degreasing of the bottom layer in DMFA;
- putting the porous bronze specimens into the prepared solution into the vacuum barometric chamber. It provides removing the air from pores and creating vacuum inside. After taking down the pressure the pores are filled with the solution;

- drying of the treated specimens performed within the drying oven at the temperature of 420 K during 1.5 hours;
- the second layer of the polymer is directly covered realized with a brush or some other method;
- the specimen with the applied polymer surface layer is put into the drying oven and exposed to the temperature of 420 K for 2 hours.

Friction and wear tests were realized at the friction machine SMT – 2010 with the lubrication with the industrial oil I-40 (GOST 20799-88)) by the scheme shoe-disc. A disc with the diameter of 50 mm was made from steel 45 (GOST 1050-74*) and thermally treated (45...50 HRC, Ra = 0,4 mcm).

III DISCUSSION OF THE INVESTIGATION RESULTS

At the first stage the influence of modifiers' nature on friction with oil lubrication of the coatings at was studied. For the coatings from initial phenylon and coasting's modified with the compounds (1-4) the investigations were held at the specific load P = 10 MPa, and sliding velocity V = 1 m/sec. Compound (1) does not contain copper ions in its structure, compound (2) contains Cu (I), compound (3) – Cu (II), compound (4) – Cu (III) [4].

The analysis of the experimental results (fig. 1, 2) shows the improvement of the tribotechnical values. Here, the optimum is observed at the modifying veadditve concentration of 1 mass %. The efficacy of the modifying vesadditives is explained by the copper ions' transfer from the coating into the oil under the effect of self-cancellation system. The effect of self-cancellation system is characterized by physico-chemical processes within the friction zone with lubricate; this allows to maintain a very thin film on the counter-body and to exclude the phenomenon of its destruction.

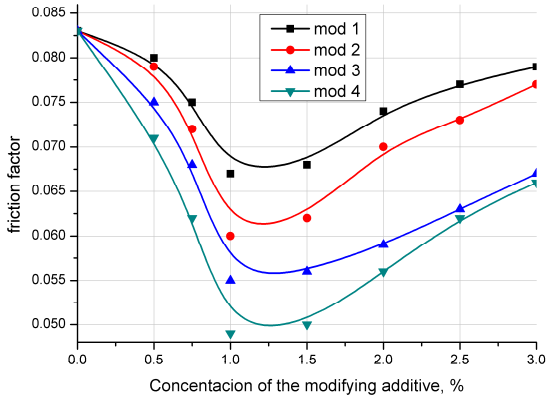

Fig. 1. Dependence of concentration of modifiers on factor of friction in a mode of friction with greasing ($P = 10^7$ Pa, V = 1 m/s)

The insufficient efficacy of modification at the additives concentration (~ 0.5 %) is explained by the low content of copper ions in the coating. In this case the coating does not provide for the necessary electrochemical interaction with the lubricate, which results in the fact that the formed film has local breaches, i.e. the process of the wear-free transfer is not realized to a complete extent.

At the second stage of investigations the influence of specific load on tribotechnical characteristics of polymer coatings was studied (fig. 3, 4).

Concerning the wear, in case of increasing the load from 5 to 10 MPa, it changes insignificantly, not more than by 5 %, but at the increase up to 20 MPa the wear grows rapidly, up to the catastrophic values.

The data of this stage confirm the initial supposition on the realization of the wear-free transfer effect within the system: phenylon- (Cu^{n+} - oil) -steel. As the oxidation-reduction reaction is realized here: $Cu^{n+} + Fe^0 = Fe^{n+} + Cu^0$, the efficacy of the modifiers should increase in the oxidation degree row $Cu^{3+} > Cu^{2+} > Cu^+$, which is observed. For example, as the coefficient of friction at P = 10 MPa: 0.054 (modif. 2) < 0.049 (modif. 3) < 0.044 (modif.4)).

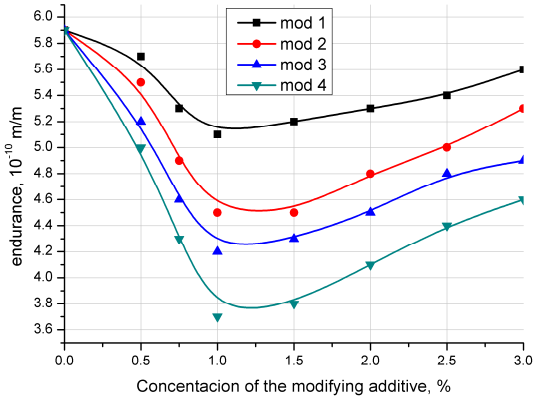

Fig. 2. Dependence of concentration of modifiers on wear resistance in a mode of friction with greasing ($P = 10^7$ Pa, V = 1 m/s)

The increase of the concentration of the modifying vesadditives up to 2 mass % and more, leads to the gradual growth of the wear and the coefficient of friction of the coating, which is characterized by quite strong chemical links of complex chemical compounds of thioamides in the polymer coating do not allowing the realization the wear-free transfer effect.

The analogous extreme dependency of the coefficient of friction and wear from the concentration of the modifying vesadditives was earlier obtained by A. S. Kuzharov for the system steel-oil-(fluoroplastic-copper) [6].

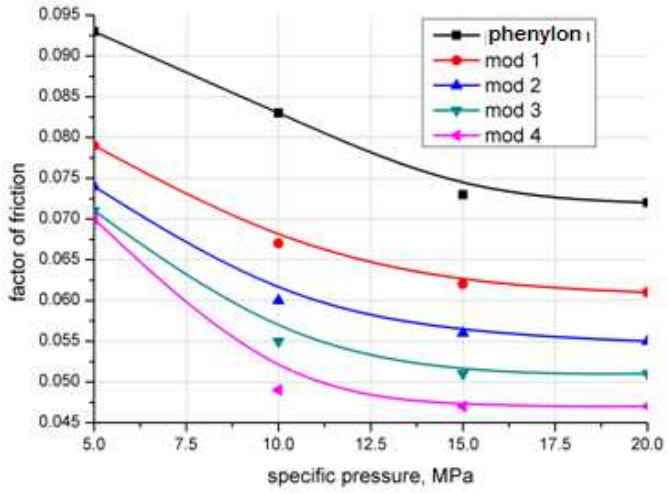

Fig. 3. Dependence of factor of friction on specific pressure at speed of sliding V = 1m/s and concentration of modifiers of 1 weights of %

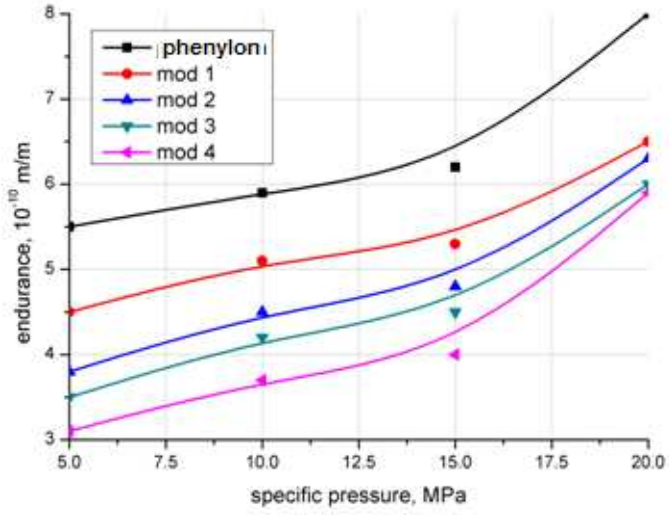

Fig. 4. Dependence of wear resistance on specific pressure at speed of sliding V = 1m/s and concentration of modifiers of 1 weights of %

Concerning the ligand environment of the central copper ion we can affirm that the structure of the investigated ligands does not have any visible influence on friction and especially on wear of the coating.

IV CONCLUSION

1. The dependence of the tribotechnical characteristics on the nature and concentration of the modifying additive of the elaborated polymer coatings was stated. The usage of d-addition at the amount of 1 mass % is optimal.
2. It was shown that the friction and wear of the coating were influenced by the chemical structure of the compound materials based on thioamides. Thus, the best quality was registered in the coating containing the modifier with Cu^{3+} in its composition.

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Vladimirs Sytars, Aleksandrs Stowpnyk. Antifrikcijas pārklājumu izstrāde uz modificētu aromātisko poliamīda fenilonu bāzes.
Rakstā apskatīta jauna augstas kvalitātes pārklājuma izstrāde, kurš paredzēts antifrikcijas konstrukcijas materiāliem uz aromātiskā poliamīda fenilona C-2 bāzes, kas pēc savas uzbūves ir lineārais aromātiskais kopoliamīds - poli *m*-, *p*-, fenilēna izoftalamīds. Antifrikcijas pārklājumu pētījumos uz aromātisko poliamīdu bāzes, kā sistēmas modifikatori tiek izmantoti kompleksie heterocikliskie savienojumi uz tioamīdu pamata un to vara savienojumi. Berzes un nodiluma pārbaudes tika realizētas berzes iekārtā ar rūpnieciskās eļļas pielietojumu kā smēri. Ir noteiktas triboloģiskās īpašības atkarībā no iegūtā polimēru pārklājuma sastāva un modifikatora koncentrācijas. Nodilumizturības un berzes koeficienta vērtību izmaiņas atkarībā no modifikatora koncentrācijas noteiktas pie nemainīgas slodzes un iedarbības ātruma V = 1m/s. Modifikatora koncentrācijas ietekme uz berzes koeficientu un nodilumizturību ir noteikta berzes eksperimentā ar smēres pielietojumu. Tika pierādīts, ka berzes koeficientu un pārklājuma nodilumu ietekmē polimēru pārklājuma veidojošo tioamīdu un modifikatoru ķīmiska struktūra un daudzums. Antifrikcijas sistēmas ar visoptimālākajām īpašībām ir novērotas pie modifikatora piedevas koncentrācijas ap 1 masas %. Visaugstākās antifrikcijas īpašības tika reģistrētas pārklājumiem, kuri satur Cu^{3+} jonu modifikatorus.

Владимир Ситар, Александр Стовпник. Разработка антифрикционных покрытий на основе модифицированных ароматических полиамидных фенилонов.
В данной статье рассматривается процесс разработки антифрикционных покрытий для конструкционных материалов на основе ароматического полиамида фенилона С-2, который является линейным ароматическим сополимером полиамида – поли *m*-, *p*-,

фениленизофталамид. Показаны результаты исследований триботехнических значений покрытий в которых, как модификаторы, использовались сложные гетероциклические соединения тиоамида и производных соединений тиоамида с медью. Испытания на трение и истирание были осуществлены на экспериментальной установке проверки трения с применением промышленных смазочных материалов. Трибологические свойства определены в зависимости от состава полимерного покрытия. Зависимость устойчивости к истиранию и коэффициента трения от концентрации модификатора определяли при постоянной нагрузке и скорости эксперимента V = 1 м/с. Выяснено влияние концентрации модификатора на коэффициент трения и износостойкость покрытия при проведении эксперимента на трение с использованием смазки. Было показано, что трение и износ покрытия зависят от химической структуры и процентуального количества тиоамида и добавки модификатора. Оптимальные антифрикционные свойства исследуемых систем были обнаружены при концентрации модификатора 1 % по массе. Самые высокие антифрикционные свойства были зарегистрированы для покрытий содержащих модификаторы с Cu^{3+} ионами.