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WEAR-RESISTANT COATINGS ON THE BASIS OF OLIGODIENES

The ways of increase of wear resistance of polymer protective layers under abrasive wear conditions are considered. The formulations of protective compositions tolerant to joint action of temperature and corrosive slurry are presented.

Keywords: oligodienes, wear-resistant coating, abrasive wear, slurry.

Introduction. At present polymers are not spoken of as being substitutes for other materials because their technical and economic efficiency is without a rival, and their proper application provides their irreplaceability. The potentials of new polymer synthesis and their modification are almost unbounded, which is why polymers are so attractive to material engineers, technologists, and designers.

Polymers can be used most efficiently, from the standpoint of economy and technology, in production of the following materials and products:

- materials and products for flooring;
- finishing and construction and finishing materials and products;
- shaped moulded products, including ones in the interfaces of large-panel construction, in the windows made of polyvinylchloride profiles;
- mastics and glues;
- heat-insulating and acoustic materials;
- waterproofing, roofing, and anticorrosive materials;
- paint and varnish, spackling, and plastering materials;

- pipes, shaped products, and sanitaryware equipment; elements and structures of buildings and facilities;
- glass and basalt-plastic reinforcement and flexible links on epoxy, vinyl ethereal, and hybrid binders;
- polymer fibres: fibres from polypropylene, polyamide etc for fibrous concrete production [1].

Solution of particular problems concerning improvement of physicochemical and mechanical is dictated by the technology needs. It is well-known that one of the most important technology problems is the problem of increase of operability of the materials on the basis of synthetic rubbers.

The most important directions of investigations which are of scientific interest due to the growth of consumption of synthetic rubbers in different industry branches are as follows:

- examination of structure, compositions and related properties of the rubbers;
- analysis of permolecular polymer structure;
- study on the processes of aging and stabilization of the composite on the basis of synthetic rubbers;
- development of theories of high-elasticity behavior, strength, and mechanical properties of rubber compositions;
- prevention of corrosion destruction of synthetic rubbers and compositions based on them;
- development of mechanochemistry of rubber compositions.

These directions are determined by the fact that rubber compositions are much more complex multicomponent systems in comparison with other polymer materials.

The pace of synthetic polymer production, progress in their synthesis and modification on a global scale allow us to state that synthetic polymer production will soon exceed production of ferrous and nonferrous metal.

Data on the use of polymer materials in different industry branches are shown in Fig. 1.

Specific properties of polymer compositions determined their place among building materials.

High chemical resistance in combination with regulated moduli of elasticity and strength make the polymers efficient means of corrosion prevention.

Corrosion is a destruction of solid bodies caused by chemical and electrochemical processes on the surface of the body during its interaction with the environment. The term “corrosion” is suitable for metals, concrete, certain plastics, and many other materials. Besides corrosion, metal (namely, building) designs undergo erosion, that is a destruction of material surface under mechanical action. Erosion is caused by rains, winds, sandy dust, and other nature factors. In this connection bridge arches, girder, and other structures should be protected fully. Hence, corrosion is a physicochemical interaction of structure material and environment which leads to the material destruction. As a result of corrosion, stable compounds are formed, such as salts, oxides, and other compounds. Institute of physical chemistry of Russian Academy of Science reports that one in six blast furnaces in Russia works in vain, because corrosion "eats" up to 10 % of produced metal.

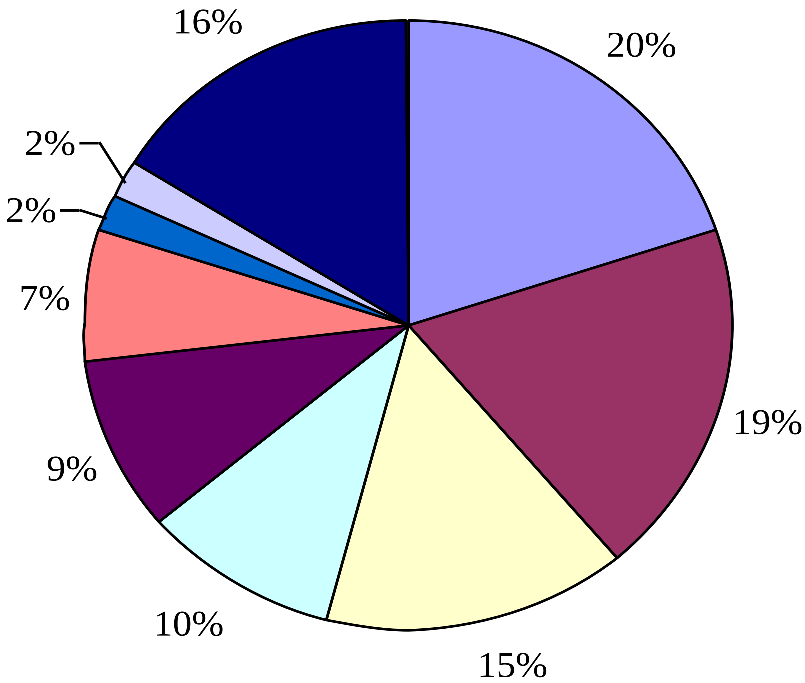


Fig. 1. Data on the use of polymer materials in different industry branches:
▫ Construction; ▪ Packaging materials; ▫ Transport; ▫ Consumer goods;
▪ Electrotechnics and radio electronics; ▪ Finish hardware;
▪ Machinery construction; ▫ Instrument engineering

About forty types of corrosion are distinguished depending on the type and properties of environment and process conditions, among which are atmospheric, gas, soil, sea, electronic, cavitation, acid, biological and other specific types of corrosion. As a rule, metal products and designs undergo many types of corrosion. In such cases combined corrosion takes place.

Corrosion damage involves not only metal mass loss but also deterioration of functional properties of products, decrease in their use value and durability. In this connection protection against corrosion is of importance in all branches of production. It is obviously that materials used for anticorrosion processing will be subject to the same negative actions as protected structures.

It should be noted that urgency of anticorrosion problem in construction is defined not only by huge financial losses but also by social importance of the problem because safe operation of buildings and is the necessary component of environmental safety provision.

Taking into consideration the fact that elimination of corrosion phenomenon is impossible, it is necessary to try to find more reasonable and efficient methods for prolongation of safe operation time of buildings, facilities, structures, and various products.

Currently, anticorrosion problem is solved in different ways. One of the most efficient ways is to develop highly efficient corrosion-resistant materials and products on the basis of polymers.

However, this way involves many serious problems.

The technology of production of various products on the basis of rubber becomes a stumbling block. This is so-called hot sulfur vulcanization which does not correspond to the traditional wear layer technologies such as spattering, gluing, etc. Compositions which are capable of cold hardenings, to say, without mobilization of additional energy inputs are in favour in this case.

Many researchers have been conducted on production of efficient polymer compositions by cold hardening, nevertheless traditional epoxy, polyether, and carbamide resins constitute the major portion of the polymers used nowadays. To design efficient compositions on the basis of rubber binders it is necessary to understand the processes of synthesis, filling, modification, and structurization of rubber composites.

As stated above, mechanochemical corrosion is attended with force action, together with действием corrosive medium action. This type of corrosion is often called corrosive wear.

In many industrial branches there is a high need in materials, predominantly on polymer basis, which protects steel structures and products from different types of wear. Material wear in abrasive flow is a peculiar type of wear. Polymer resistance to this type of wear is proportional to their elasticity. Systematized data on mechanisms of wear, or corrosion, of protective polymer layers, especially in the presence of chemically aggressive mediums, are almost unavailable.

The complication of technological processes and the advent of new methods of raw material processing are responsible for the need in efficient protective compositions tolerant to abrasion with simultaneous exposure of aggressive mediums.

Such materials are of great practical interest in the context of production of pipelines, pumps, containers for centrifugation, and other products which are operated in one or another aggressive medium. It is not clear how material will behave, for example, at elevated temperature (accompanied by increase in polymer, at increased concentration of aggressive medium and high intensity of mechanical exposure.

First of all, it should be noted that it is necessary to choose initial polymer to design efficient wear-resistant coatings.

In this connection we investigated the properties of polymer coating based on polydieneurethane with reaction-capable end groups reinforced by different components. The selection of components was conducted on the basis of analysis of its chemical stability to the proposed aggressive medium. Amount of introduced reinforcing component was restricted from the condition of attainment of maximum allowable technological viscosity. For the reason that reinforcing components were different in their chemical nature and oil absorption, elastic properties were different, too. We were interested, however, only in qualitative assessment of stability of developed compositions under aggressive slurry action.

We controlled the change in sample masses and the rate of the change. The tests were conducted at rates of collision of the polymer layer sample with the abrasive particle from 6 to 12 m/sec. Stationary rate of the wear served as the main characteristics of the process was attained in 20 minutes. Silica sand suspended at weak solutions of certain aggressive mediums was used as an abrasive. Compositions under investigation contained nature calcium silicate as a filler and reinforcing component, namely, alumina-borosilicate glass fibre. The tests were carried out at temperatures of 5 and 50 °C and were aimed at additional assessment of influence of aggressive medium temperature on elasticity of the tested samples.

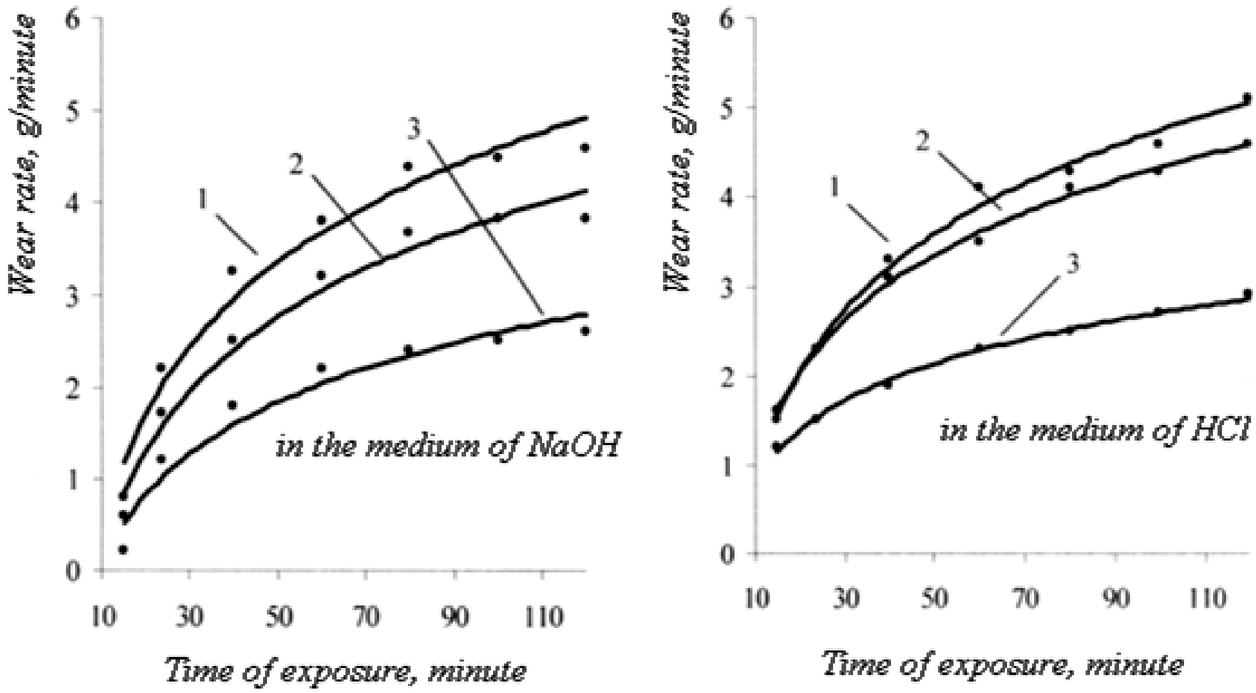
The results of experimental investigations are shown in Fig. 2 and 3.

The analysis of the data obtained allowed us to draw the following conclusions:

– elasticity of polymer layers affected their stability in aggressive slurries. In this connection the increase in aggressive medium temperature accompanied by the growth of elasticity led to the decrease of the wear. In some cases increase in concentration of aggressive medium caused the growth of polymer layer elasticity owing to swelling;
– at corrosion wear in aggressive slurry the stress was supplied to the polymer layer by short impulses, which caused particular regularities in this case.

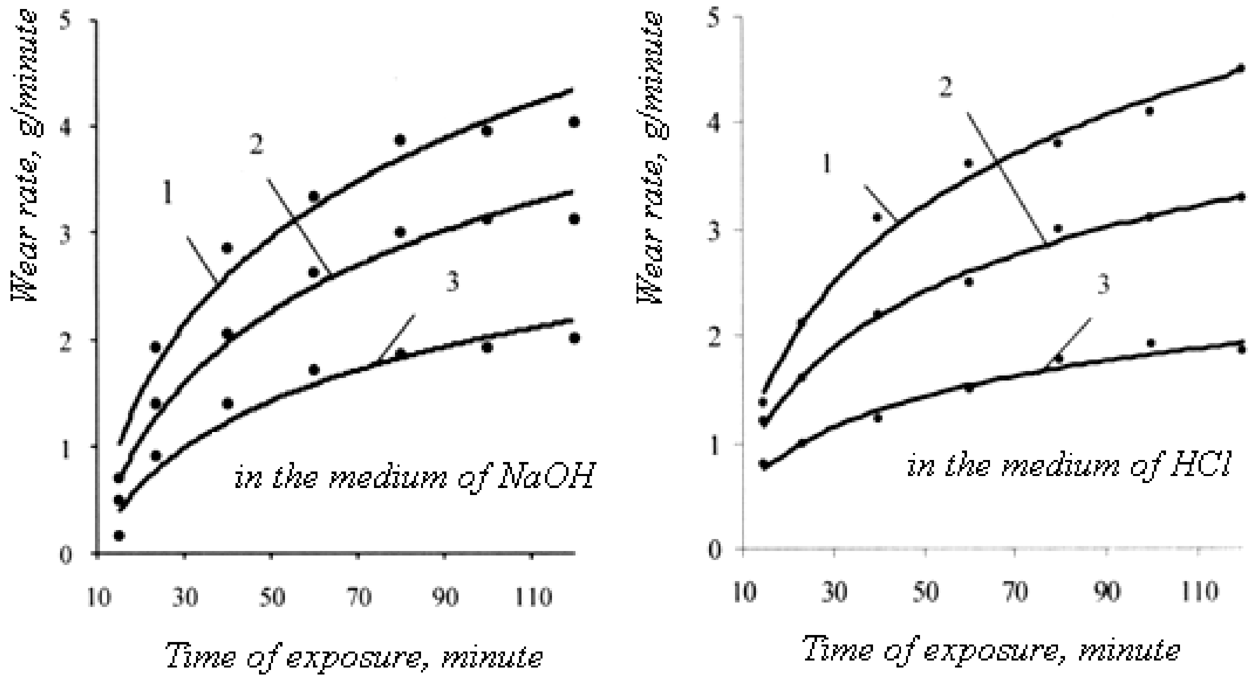
At static fatigue relative role of aggressive medium decreased with an increase in intensity of mechanical exposure, but at corrosion wear the role increased. The higher the rate and concentration in the solid phase and the larger the particle size, the larger the difference in the action of the low-activity and the aggressive medium. Mechanical stresses activated chemical processes in the composites under investigation.

This activating action usually overlapped by strengthening effect of orientation developed under deformation [2].



Rate of abrasive supply, m/sec: 1-12, 2-9, 3-6

Fig. 2. Change in wear rate depending on time of exposure and type of aggressive medium at temperature of +5 ºC



Rate of abrasive supply, m/sec: 1-12, 2-9, 3-6

Fig. 3. Change in wear rate depending on time of exposure and type of aggressive medium at temperature of +50 ºC

The increase in intensity of mechanical exposure resulted in relative increase in the role of aggressive medium [3].

Simultaneous progress of the two processes stated above hinders the development of criterion assessment of the composite wear. However, we attempted to determine characteristic dependence of wear rate only in some aggressive mediums, though their list is very broad.

It was established that wear rate change was adequately described by logarithmic equation. Coefficients of these equations reflected the influence of the test temperature, rate of abrasive supply, and type of aggressive medium. The analytical dependences obtained are tabulated.

Table

Coefficients of approximate equations

Temperature of the tests, ºC (aggressive medium)	Rate of abrasive supply *x*, m/sec		
	12	9	6
5 (NaOH)	1.8027ln(x)–3.7005	1.58ln(x)–3.428	1.09891ln(x)–2.4656
5 (HCl)	1.6831ln(x)–2.9942	1.4264ln(x)–2.2318	0.8187ln(x)–1.0648
50 (NaOH)	1.5864ln(x)–3.2565	1.2956ln(x)–2.8109	0.8571ln (x)–1.9232
50 (HCl)	1.4479 ln(x)–2.448	1.02781ln(x)–1.6127	0.5681ln(x)–0.7883

Summary

Establishment of quantitative dependence of polymer layer stability to the exposure of abrasive slurries makes it possible to design efficient protective compositions and to determine the thickness of the layers efficiently protecting the substrate.

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