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Production and Application of Hydrophobizing Polymer Compositions

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ABSTRACT: The article proposes a method of production hydrophobizing polymer composition. The possibilities of obtaining and using hydrophobic composite materials based on tetraethoxysilane, acrylic emulsion and polyvinylethynyltriethoxysilane for improving the hydrophobizing properties of materials have been studied.

KEY WORDS:vinyl ethynyltriethoxysilane, viscosity, hydrophobicity, density, tetraethoxysilane.

I. INTRODUCTION

It is known that in the conditions of a market economy, the qualitative indices of the output of industry are of paramount importance. In particular, they include building facade materials and cement. A very important criterion is an increase in water resistance and an increase in the operational properties of building materials. As is known, permeability of facade materials worsens the operational properties of products.

The purpose of this study is to improve the quality of hydrophobizing compositions, which improve the water-repellent properties of materials.

As is known, various factors lead to a deterioration in the properties of facade materials. These include the natural and man-made environment. To man-made aggressive substances can be attributed sulfur dioxide, which is formed when burning coal or peat, as well as in the production of a number of chemical products, and falling on different terrains in the form of acid rain. According to the corrosion activity, sulfur dioxide is in no way inferior to water-soluble chlorides, and surpasses them in a number of parameters.

II. THEORETICAL BASIS

Over the past decades, chemistry and technology of organosilicon compounds (OC) developed very rapidly. High thermal stability, hydrophobicity, electrical insulating and other properties of OC caused their wide application in industry. In silicone materials, high operational stability with selective adhesion properties is combined.

III. METHODOLOGY

Proceeding from the above, it follows that in order to ensure the long-term operation of building products, a surface protective barrier is required to protect materials from destruction. One possible solution is the surface treatment of materials with hydrophobizing composite fluids. During hydrophobization, the chemical reagent penetrates into the material relatively deep (by several tens of nanometers). Although the porous structure is preserved, the material acquires significant water-repellent properties. At present, in our Republic, siloxane liquids and sodium silicate are widely used for industrial hydrophobization. Siloxanes are insoluble in water and are usually used in the form of aqueous emulsions [1]. However, it should be noted that the use of organosilicon products is limited by their high cost.

Therefore, it became necessary to create a relatively inexpensive, but sufficiently effective, hydrophobizing composite.

A composition based on tetraethoxysilane (TEOS), acrylic emulsion (AE), polyvinylethynyl dihydroxychlorosilane (PVETP) and penetrator OP-10 was chosen for the studies. AE is a concomitant product at enterprises for the production of synthetic nitron fiber and is characterized by a relatively low cost, and PVETP was synthesized according to the procedure [2]. Studies of conventional viscosity, the mass fraction of volatile and nonvolatile substances, weather resistance, adhesion and hydrophobizing effect were carried out in accordance with generally accepted standards and methods (GOSTs: 9.045, 9.401, 9.403, 9.407, 9074, 6992, 19007, 15140, 8420).

As the studies have shown, TEOS, PVETES and AE are fully compatible with each other in all ratios. We made a theoretical assumption about the possibility of the formation of chemical bonds between these substances, due to the presence of reactive groups in TEOS and multiple bonds in AE and PVETP [3]. This assumption was confirmed by the studies of air-cured polymer films TEOS-AE-PVETES-OP-10 on a spectrophotometer "Spekord-75UR". The spectrograms clearly trace the band in the 900-700 cm^{-1} region, which corresponds to stretching vibrations of the Si-C bond and does not depend on the nature of the substituent groups. In addition, an indirect confirmation of the formation of a new modified product is a reduction in the weight loss of the TEOS-AE-PVETES-OP-10 composition during heat treatment in comparison with the initial components (Table 1).

Table 1.
Change in composition parameters during heat treatment:
Dependence of the weight loss of the composition on the time of heat treatment at 150 ° C

Contentofcomposition	Massloss,%		
	In 4 hour	In 8 hour	In 12 hour
TEOS	100	-	-
75 % TEOS - 20 % AE - 3 % PVETES - 2 % OP-10	41	45	47
50 % TEOS - 45 % AE - 3% PVETES - 2 % OP-10	21	29	32
10 % TEOS - 88 % AE - 2 % OP -10	24	32	34
100 % AE	84	96	100

The effect of hydrophobization was studied on standard samples. Hydrophobization was carried out by submerging the samples for two minutes in a 5% solution of the polymer composition under study and then holding them in air for 28 days. Figure 1 shows changes in the hydrophobic coating effect depending on the content of TEOS in the polymer composition. As expected, an increase in the TEOS content leads to an increase in the effect of hydrophobization. However, after increasing its concentration by more than 20%, the value of the effect of hydrophobization changes insignificantly, within a few percent.

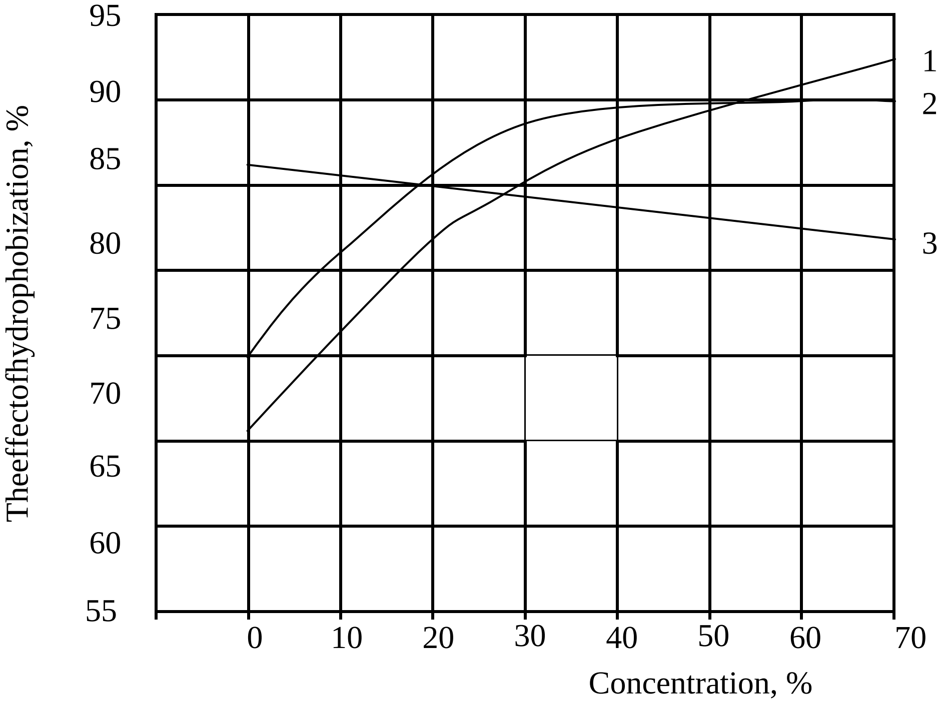

Fig.1. Dependence of the effect of hydrophobization on concentration 1-PVETES; 2-TEOS and 3 AE in the composition.

One of the conditions for the long-term preservation of the useful properties of hydrophobizing coatings is the presence of sufficient adhesion between the protective polymer film and the building material. However, it is extremely difficult to determine the adhesion characteristics directly on the hydrophobized sample due to the fact that the cementitious material has a porous structure and furthermore no continuous polymer film is present. Therefore, it was decided to further simulate the study of adhesion characteristics on materials with a minimum porosity - polyvinyl chloride.

To form a continuous film of sufficient thickness, a solution of a hydrophobizer with increased concentration was used. Adhesion characteristics were determined on an adhesometer "REM 250". The hydrophobizing composition in the form of a 15% solution in white spirits was applied to the substrate by means of a pneumatic sprayer. After drying the material for 72 hours, acrylic adhesive was coated with steel fungi and tests were carried out to determine the breaking strength.

This circumstance is apparently connected with the porosity of the structure of these materials, which probably led to overestimated results in determining the breaking strength. However, despite this, the tensile strength for a solid substrate reaches a significant value of 3.8 MPa, and for a polyvinyl chloride substrate this value is relatively smaller and amounts to 2.9 MPa, but on the whole is at a sufficiently high level.

The dependence of the tensile strength at detachment, regardless of the substrate material, is extreme. The maximum values of tensile strength at break-off are achieved at a TEOS concentration of 20-25%. To study the weather resistance of the hydrophobic coating, accelerated tests were carried out in the IP-3 climate chamber for 30 days as hydrophobized samples and coatings in the form of a film obtained similarly as in the case of determination of adhesion characteristics. The results of the tests are given in Table. 2.

Table 2.
Change in the properties of the hydrophobic coating with time

AE content,%	TEOS content,%	Coating state	Loss of hydrophobization effect ΔB,%
100	0	Peeling at day 14	22
88	10	Non-destructive	12
73	25	Non-destructive	7
48	50	Non-destructive, cloudiness of the coating	6

It is generally accepted that testing samples for 15 days in a climate chamber corresponds to one year of their stay in real atmospheric conditions. Adding 10% of the TEOS to the composition increases the resistance of the material to unfavorable technogenic conditions, and the modified coatings survive tests without destructions. As for the haze of coatings with a TEOS content of 50%, this can be explained by the complete hydrolysis of the excess organosilicon compound to colloidal silicon dioxide, which generally has no significant effect on the properties of the composition.

The loss of the hydrophobizing effect for compositions containing TEOS is extremely insignificant and, based on the results of the tests, it can be assumed that the shelf life of satisfactory hydrophobic properties in the operation of structures treated with these compositions will be at least five years in real conditions. This is comparable to such serially used water repellents as sodium silicates. According to preliminary calculations, the cost of the developed materials will be 10-15% lower in comparison with alkyl siliconates, which can lead to significant economic effect in conditions of their mass application [4].

Use for the preparation of a hydrophobizing composition of PVETES as an adhesion-hydrophobizing agent does not cause technological difficulties when it is dosed and mixed with other components. High miscibility and aggregative stability of the composition in the form of a mixture, in the environment of organic solvents, and not stratified during storage testifies to the effectiveness of the developed composition.

In Fig. 2. The principal technological scheme of obtaining a hydrophobizing composition on the basis of TEOS and PVETP is presented.

Hydrophobization of polymers leads to a long synthesis time, a decrease in the yield of the desired product (especially in shop conditions) and makes it difficult to transition to a continuous process. Particularly laborious is the filtering step, which leads, in particular, to more than a half-fold increase in the amount of solvent used. The large losses of volatile solvents during the separation of the target product in the shop environment lead to environmental contamination.

The hydrophobizing treatment developed by the compositions was carried out using a laboratory apparatus according to the following procedure.

The unit was poured in, the calculated amount of the developed hydrophobizing composition was thoroughly mixed. The concentration of the preparation obtained depended on the type of the processed material, for cement it was 6 g/l, in all other cases - 4.0 g/l. The impregnation of the samples was carried out with an LC = 8 for 8-10 minutes of rotation of the cement.

The sample was then slightly dried between sheets of filter paper by means of a padding and dried at a temperature of 50-60℃, for 40-50 minutes in a drying cabinet. The consumption of the hydrophobizing composition in all cases did not exceed 5.3 g/kg of the processed material.

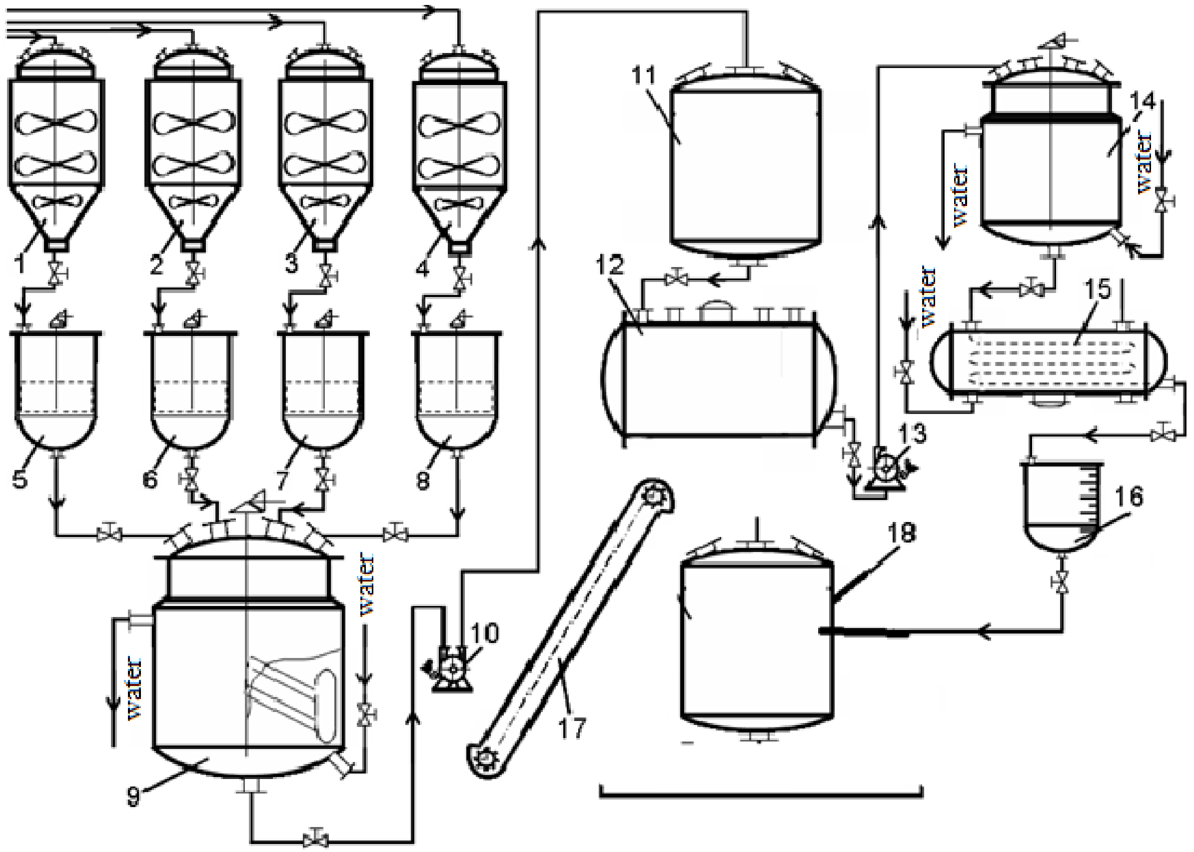

Figure 2. Principal technological scheme for obtaining a hydrophobizing composition based on TEOS and PVETP. 1-4-mixer; 5-8-measure; 9-reactor for producing a hydrophobizing polymer composition; 10-plunger pump; 11-cube for storing the hydrophobizing mixture; 12-way valve; 13-pump; 14-mixer for the hydrophobizing mixture; 15-heat exchanger for a water-repellent mixture; 16-measure; 17-elevator for the supply of chemicals and materials; 18-reactor for material processing.

IV. CONCLUSION

The use of this composition ensures the improvement of the quality of the materials, by increasing the water-repellent properties, without deterioration as a result of hydrophobization of their other parameters.
Thus, as a result of the studies, the possibility of using the composition as a hydrophobizing material for surface treatment of building materials was shown to be principally possible and the tendency of developing new hydrophobizators with a non-traditional chemical structure was revealed.

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