Scientific article
UDC 667.621.2

DEVELOPMENT OF WATER-DISPERSION PAINT AND VARNISH MATERIAL FOR CREATING A DECORATIVE EFFECT USING THE "WASHED CONCRETE" TECHNOLOGY

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Keywords: *water-dispersion paint, concrete hardening inhibitor, rheological characteristics, "washed concrete", citric acid, sodium gluconate, penetration rate*

Abstract. *The article presents the formulation of water-dispersion paint and varnish material containing concrete hardening inhibitor. The authors investigated the rheological characteristics of the water phase, pigment paste, and paint. The paper determines the correlation of the penetration rate with the amount of inhibitor and concludes the selection of concrete hardening inhibitor.*

For citation:
Vargasova, S.V. & Tereshko, A.E. (2023) Development of water-dispersion paint and varnish material for creating a decorative effect using " the washed concrete" technology, *From Chemistry Towards Technology Step-By-Step*, 4(4), pp. 110-115 [online]. Available at: http://chemintech.ru/index.php/tor/2023-4-4

Introduction

Nowadays, the technology of manufacturing concrete products as "washed concrete" is becoming more and more popular. Therefore, it is possible to obtain products of a special decorative effect, which is unusual and phenomenal. Using this technology, it is possible to obtain unique textures, which will have no analogues.

Concrete hardening inhibitors [1-7] are used to give the surface of concrete products decorative properties during the formation of the products, which are used to treat the surface of the product. Then this uncured surface layeris washed off from the product. The resulting product surface has the texture of the filler, which was added to the cement mixture.

Nowadays special paints containing concrete hardening inhibitors are produced. However, such high quality materials are only imported and are not currently available on the Russian paint and varnish market. Also, these paints are organically dilutable, which negatively affects the environment, and require a special solvent for washing off the mould.

Main body

The purpose of this study is to develop a methodology and formulation for obtaining water-dispersion material used to create a decorative effect on the "washed concrete" technology. Since now there are no imported raw materials and materials, the necessity of creating a domestic paint from available raw materials is very acute.

We used citric acid (GOST 908-2004) and sodium gluconate (TU 6-09-3508-80) as concrete hardening inhibitors.

To obtain the dispersion medium we used ionogenic and non-ionogenic dispersants: natrasol, sodium tripolyphosphate (GOST 31638-2012), silicone-containing defoamer, diethylene glycol (GOST 10136-2019), and distilled water [8-10].

We obtained pigment paste with 70% filling by mixing pigment (titanium dioxide (GOST 9808-84) and filler (calcium carbonate (GOST 4530-76) with aqueous phase. Then we dispersed in a laboratory dissolver Homoge (Poland) with a volume of 250 cm^3, provided with a disc stirrer with a diameter of 40 mm with a maximum speed of 230 s^{-1}. To obtain the colour we combined the pigment paste with PVA polymer dispersion (TU 2385-002-18341150-98).

We added concrete curing inhibitors to the finished paint.

Table 1. Water phase component ratio

Substance	Mass content, %
Water	95.42
Sodium tripolyphosphate	0.76
Silicone-containing defoamer	0.19
Diethylene glycol	3.05
Nathrasol	0.38

Since water-dispersion systems due to the addition of electrolytes can lose their aggregative stability [11-14], we investigated the rheological properties of the materials and their components.

We performed rheological studies for the aqueous phase obtained from the formulation of Table 1 (Fig. 1).

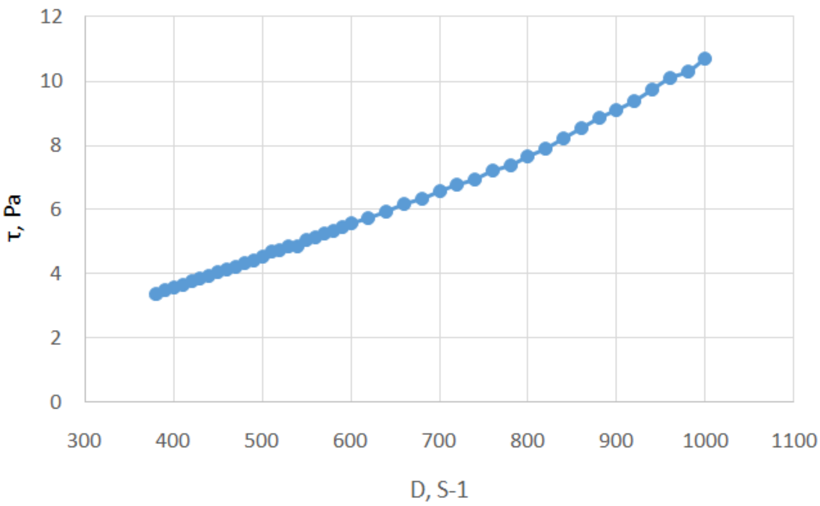
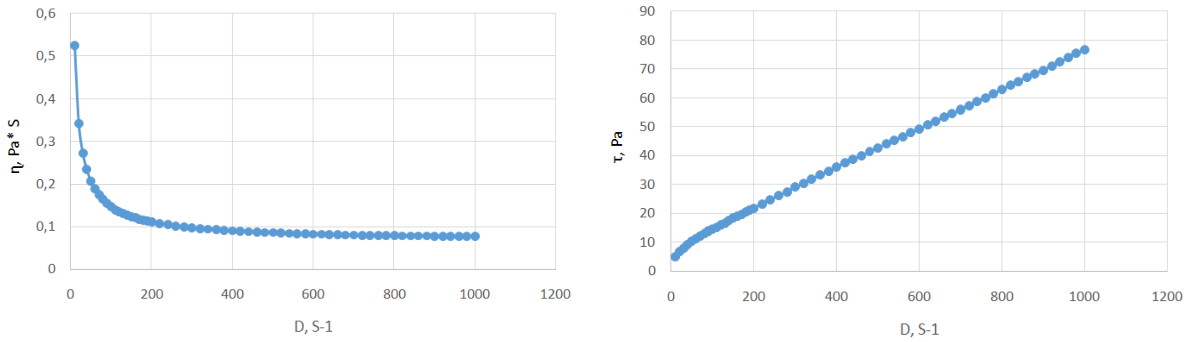


Fig. 1. Dependence of shear stress on shear rate for the aqueous phase

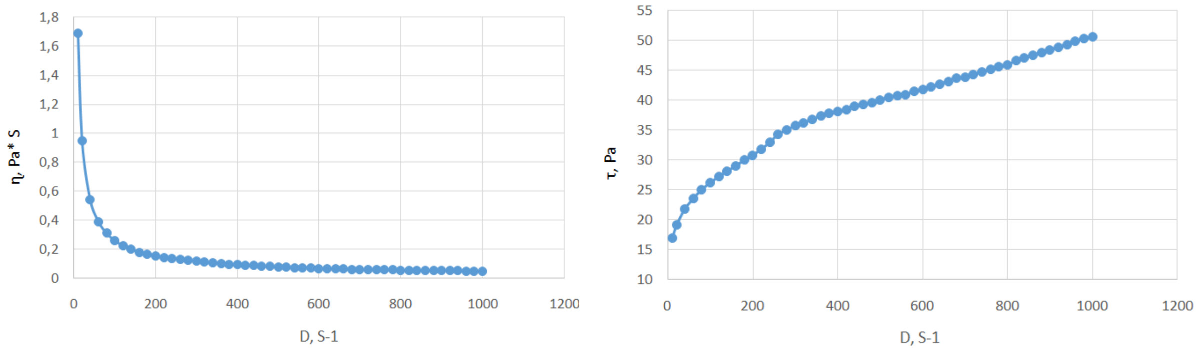
The graph on Fig. 1 for the obtained aqueous phase shows the increasing of the shear stress with shear rate. The graphs on Fig. 2 show a decrease in viscosity and an increase in shear stress with shear rate. It is characteristic of the thixotropic nature of the flow, probably due to the synergism of the surfactants used to produce the pigment paste.



a b

Fig. 2. Rheological properties of pigment paste: *a* - dependence of viscosity on shear rate; *b* - dependence of shear stress on shear rate

We observe similar rheological properties for the aqueous dispersion of PVA (Fig. 3). It is due to the emergence of reversible structures because of ionic atmospheres polarisation of dispersed particles under orienting flow action.



a b

Fig. 3. Rheological properties of PVA: *a* - dependence of viscosity on shear rate; *b* - dependence of shear stress on shear rate

The rheological properties of the obtained paint (Fig. 4) based on PVA dispersion are similar to those of the dispersion itself, indicating thermodynamic compatibility of the dispersion and pigment paste components.

The study results of the sodium gluconate effect on the rheological properties of the obtained paint are shown in Fig. 5.

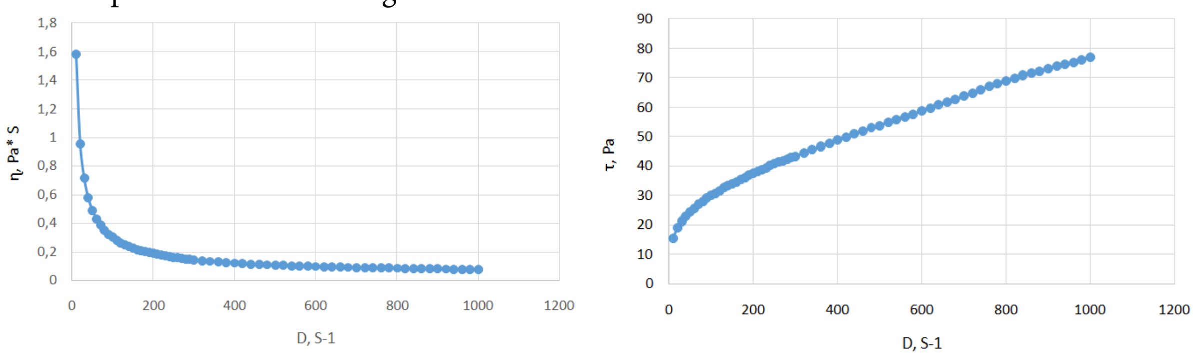


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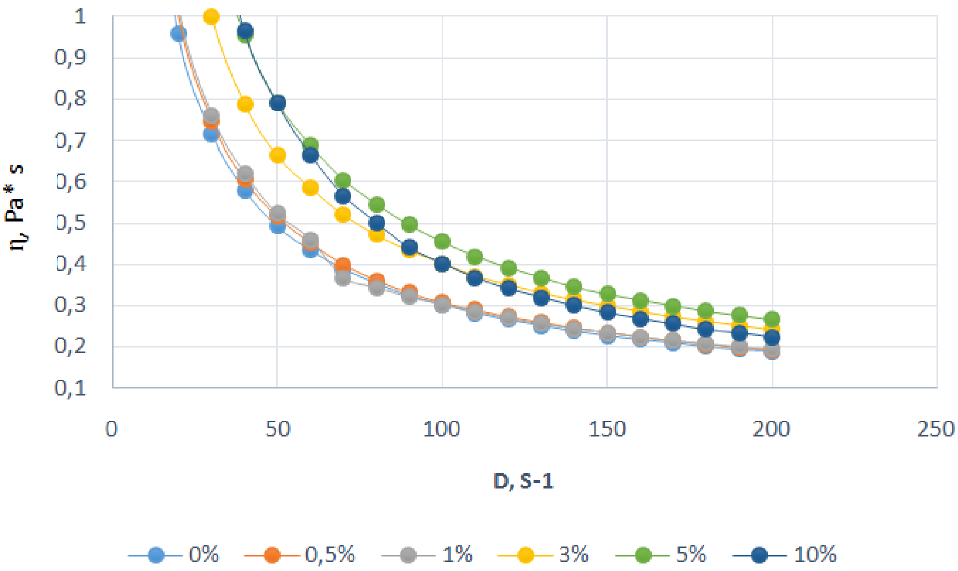
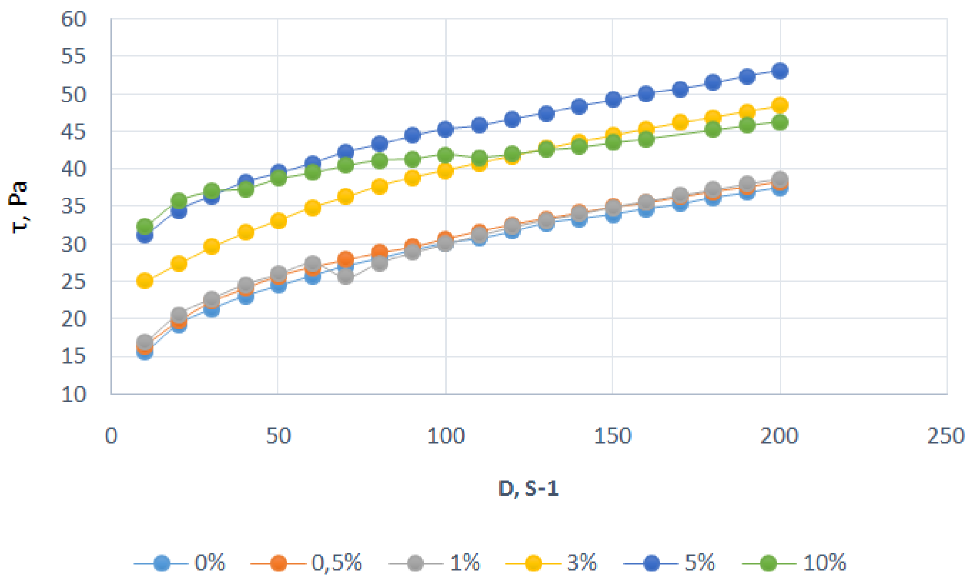
Fig. 4. Rheological properties of paint based on PVA dispersion: *a* - dependence of viscosity on shear rate; *b* - dependence of shear stress on shear rate



a



b

Fig. 5. Rheological properties of paint with different sodium gluconate content: *a* - dependence of viscosity on shear rate; *b* - dependence of shear stress on shear rate

According to Figure 5, if the sodium gluconate content is up to 1% wt. %, the rheological properties of the paint are practically unchanged. When 3% wt. or more of sodium gluconate is added to the paint formulation, a slight increase in viscosity and shear stress is observed for the paint at low shear rates (up to 100 s^{-1}). Thus, the introduction of up to 10 wt% of sodium gluconate into the composition of water-dispersion paint based on PVA does not cause a decrease in the aggregative stability of the system.

The study results of the concrete hardening inhibitor penetration rate dependence on its content in the paint during the formation of concrete products are presented on Figs. 6-7. The inhibitor content in the paint varied between 0.5-10% wt.

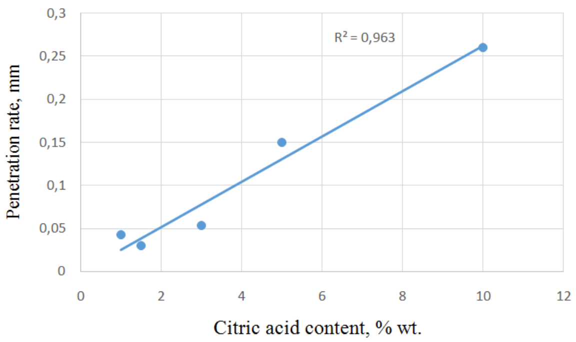


Fig. 6. Graph of penetration rate dependence on citric acid content in the paint

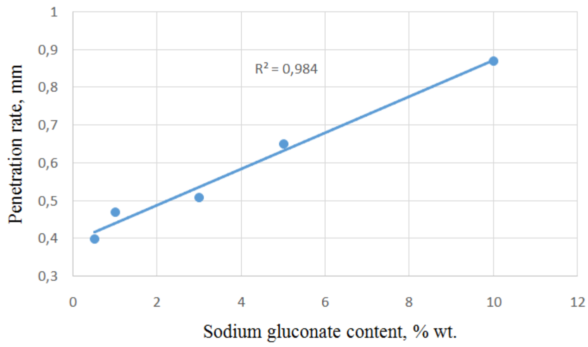


Fig. 7. Graph of penetration rate dependence on gluconate content in paint

The degree of inhibitor penetration from the colour into the concrete product was determined by the weight loss of the concrete specimen.

Figures 6 and 7 show a linear character with a high correlation coefficient (R^2) of the dependencies obtained. We've got the mathematical equations:

for paint containing citric acid $y = 0.0263x - 0.0006$;

for paint containing sodium gluconate $y = 0.0480x + 0.3929$.

These equations allow penetration rates to be predicted with high accuracy when formulating paints for washed concrete technology.

In addition, we have considered the possibility of creating a coloured paint material. The colour of the paint can serve as a marking to indicate the penetration rate of the concrete curing inhibitor. Namely, paint with different inhibitor content differs in colour. For this purpose, we have considered the use of ready-made water-based tinting pastes (Fig. 8). We used the following materials as tints: Palizh 29 colourant - ultramarine; LUXENS colourant - light green; PARADE colouring paste No. 201 - ochre, No. 204 - black, No. 207 - sun, No. 209 - scarlet, No. 215 - cherry. We introduced tint into the paint from 5 to 20% wt. All materials showed good compatibility with the paint. Hence, we found that the colour tinting paste had no effect on the penetration depth.

a

b

Fig. 8. Samples of coloured material for washed concrete technology: *a* - material applied to the surface of the product; *b* - paint in containers

Therefore, as a result of the conducted research the efficiency of using citric acid and sodium gluconate as concrete hardening inhibitors is shown. The authors have developed a formulation for obtaining aggregate-resistant water-dispersion paint for the "washed concrete" technology from raw materials available on the raw materials market of the Russian Federation. The authors determined the dependence of the inhibitor penetration degree into the concrete product on its content in the paint, and developed a range of coloured paints differing in their penetration ability.

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Received 10.11.2023
Approved 22.11.2023
Accepted 29.11.2023