Effect of coalescents on properties of protective styrene-acrylate latex coatings of oriented particle chipboards

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Abstract. It is necessary to note that in the production of finishing and protective materials for the surfaces of oriented chipboards, the most effective film former today is considered to be styrene-acrylate latex. However, the known styrene-acrylate dispersions have a minimum film formation temperature within 14 – 20 °C, which doesn’t satisfy mass construction works. In order to obtain high-quality films in a wide range of temperatures, it is necessary to use special additives - coalescents. It was decided to use methoxypropanol, ethylene glycol and butyl glycol as coalescents. Their main selection criterion was the homogeneity of the resulting film and the absence of external defects. Based on the studies conducted, it was determined that the butyl glycol additive in the composition leads to the reduction in the elastic modulus of film coatings, which, in its turn, invariably leads to the increase in the relative elongation at break. The butyl glycol additive also enhances the film-forming and adhesive properties of styrene-acrylate latexes. According to the results of the experiments a composition with 4% wt. butyl glycol content as a coalescent was selected for further research.

1. Introduction

Oriented-chipboards are relatively new in the construction market; they are made from natural wood with various additives: synthetic binder resins, fire retardant and biocidal compounds, etc. As a result, these products possess high operational characteristics and can be successfully used to perform certain construction tasks [1-7]. The appearance of wooden oriented chipboards on the construction market was caused by the necessity to obtain a building material that retains all the advantages of natural wood, but at the same time is devoid of its main disadvantages [8-10].

It is known [11-16] that in the natural environment wood changes its size and shape under the influence of temperature and humidity. Sharp removal of moisture (quick drying) generates stresses in the wood and its cracking. The wood is not fire resistant, subject to insects damage and decay. In addition, wood is characterized with a high degree of anisotropy, that is, a sharp change in characteristics depends on the direction of the fibers.

Oriented chipboards are practically devoid almost of all of these disadvantages. And at the same time oriented chipboards preserve the operational and environmental characteristics of natural wood. The production technology of the boards allows to produce them in various thicknesses and different sizes. Moreover, the cost of the oriented chipboards is more accessible than the cost of natural wood as
woodworking waste is often used in their production. At present, wood-based chipboards are widely used in the construction, and in many cases they are already considered indispensable for carrying out certain types of construction work [17-19].

Another disadvantage is low flammability resistance of wood which can be effectively reduced by the use of fire retardant intumescent water-dispersion paintwork materials [1-3].

Paintwork materials form coatings of small thickness on the surfaces of building constructions but it results in a slight weighing of these constructions; besides, they are easily restored after damage or at the end of their operational life span. The advantages of intumescent water-dispersion paintwork materials are obvious, since they are environmentally safe, weather-resistant, reveal good adhesion to the wooden construction surfaces. At the same time, fire retardant paint coatings, as a rule, are multifunctional: they protect wooden structures not only from fire but also from moisture and biological damage, strengthen the material and paint the products made of it [11-15].

Water-dispersion paintwork materials are becoming increasingly popular, since their production and use are not associated with the volatile solvents usage, which are known [8,11] to be toxic and flammable substances. Therefore, to study the influence of the of water-dispersion compositions of paintwork materials on the properties of the coatings formed by them appears to be rather actual.

2. Materials and methods issue
The hardness of paintwork films with water-dispersion compositions consisting of styrene-acrylate dispersion and butyl glycol with different percentages was determined with the help of a pendulum hardness tester “Constant MT-1”. The samples of the films were prepared with a frame applicator a groove height of which was 100 microns. The obtained coating was hardened on a flat horizontal surface. The values of the films hardness, cu, were received in 5, 7, 10, 15 and 20 days after the moment of casting.

To determine the water absorption of the compositions, the samples were poured into 3 round molds of 2 mm height and of 4.5 cm in diameter, 3 pcs and left to harden on a horizontal flat surface for 20 days. After hardening the films were immersed in distilled water, and after certain periods of time the determination of water absorption was carried out by evaluating the changes of the masses of the samples. The measurements were performed in 10, 30, 60 minutes and 24 hours after hardening.

3. Results and discussion
In the production of finishing and protective materials for the surfaces of oriented chipboards, the most effective film former today can be considered styrene-acrylate latex. It is explained by its high adhesion to wood, water and alkali resistance, resistance to UV radiation and other adverse atmospheric effects, as well as by its environmental friendliness and economic performance. The basic principles of the formulation of water-dispersion paintwork coatings are described in the sources [20-22]. The minimum temperature of film formation is seen as the main property of paintwork dispersions as it provides a film of good quality without any defects. It is known that styrene-acrylate latex dispersions have the minimum temperature of film formation in the range of 14–20 °C, which does not satisfy mass construction works. To obtain high-quality films within a wide range of temperatures, it is necessary to use special additives – coalescents, which lower the minimum temperature of film formation and promote uniform formation of a continuous film.

The material under study was styrene-acrylate latex dispersion with the minimum temperature of film formation of + 19°C. The coalescent selection was carried out by adding it to the latex in an amount of 2 to 5% wt. The used coalescents were methoxypropanol, ethylene glycol and butyl glycol. The main selection criterion was the homogeneity of the resulting film and the absence of external defects. The criterion of the optimal number of coalescents was determined by the absence of cracks during the film coatings formation under the average room conditions. The data of the coalescents effect on film homogeneity are shown in Table 1.
Table 1. The coalescents effect on the uniformity of latex films.

| Coalescent content, % wt | Methoxypropanol | Ethylene glycol | Butyl glycol |
|-------------------------|-----------------|-----------------|--------------|
| 2                       | Film formation an hour later, after a while cracks appeared | Film formation an hour later, after a while cracks appeared | Film formation an hour later, in 1.5 hours cracks appeared |
| 3                       | Film formation an hour later, in 1.5 hours cracks appeared | Film formation an hour later, in 1.5 hours cracks appeared | Film formation an hour later, in 24 hours no cracks were found |
| 4                       | Film formation 40 minutes later, cracks appeared in 1.5 hours | Film formation 40 minutes later, cracks appeared in 2 hours | Film formation 30 minutes later, in 24 hours no cracks were found |
| 5                       | Film formation 40 minutes later, cracks appeared in 2 hours | Film formation 40 minutes later, cracks appeared in 2 hours | Film formation 30 minutes later, in 24 hours no cracks were detected |

Based on the experiments performed, it can be concluded that butyl glycol is advisable to use as a coalescent for this latex. This is confirmed by the results of the visual inspection (Figure 1).

The result can be explained by the fact that the molecular weight of butyl glycol is higher compared to those of ethylene glycol and methoxypropanol, so added to the latex composition it can enhance a more uniform film formation.

The aim of the further studies was testing the film samples for hardness and water absorption. Data measurements of the latex films hardness containing butyl glycol with different percentages are shown in Table 2.

Table 2. The effect of butyl glycol content on the latex films hardness.

| Film hardening duration, 24 hours | The content of butyl glycol, wt.% and the films hardness, cu |
|-----------------------------------|------------------------------------------------------------|
| 5                                 | 0,32 0,24 0,21                                            |
| 7                                 | 0,29 0,20 0,21                                            |
| 10                                | 0,34 0,28 0,27                                            |
| 15                                | 0,35 0,28 0,28                                            |
| 20                                | 0,35 0,31 0,29                                            |
Analyzing the data of Table 2, it becomes evident that 3% butyl glycol content provides the hardness of the highest degree, but the hardness provided by 5% butyl glycol content is of the lowest one. Thus, the introduction of butyl glycol into the film increases the elasticity of the initial paintwork composition.

The effects of butyl glycol on the water absorption of latex films with different exposure times are presented in Table 3.

| Exposure time, hour | The content of butyl glycol, wt.% | and water absorption, % |
|---------------------|----------------------------------|-------------------------|
| 0,2                 | 1,1                              | 1,2                     | 1,0                     |
| 0,5                 | 1,6                              | 1,9                     | 2,2                     |
| 1                   | 3,5                              | 2,8                     | 2,9                     |
| 24                  | 14,3                             | 14,2                    | 12,8                    |

The sample with 5% wt butyl glycol showed the lowest water absorption value 24 hours later; at the same time the hardness value of this composition and the 4% wt butyl glycol composition are practically the same but significantly less compared to the 3% wt butyl glycol composition. The water absorption values of the 3% wt and 4% wt butyl glycol samples are practically the same, however the hardness value of the 4% wt butyl glycol sample is slightly lower compared to 3% wt butyl glycol composition.

4. Conclusion:
The results of the experiment show that butyl glycol coalescent added to the styrene-acrylate latex reduces the elastic modulus of the films coatings, which in its turn, invariably increases the relative elongation at break. Besides, butyl glycol addition enhances the film-forming and adhesive properties of styrene-acrylate latexes. Thus, on the basis of the results of the experiments, a composition with 4% wt. butyl glycol content as a coalescent was chosen for further research.

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Acknowledgments
The work is realized in the framework of the Program of flagship university development on the base of the Belgorod State Technological University named after V.G. Shukhov, using equipment of High Technology Center at BSTU named after V.G. Shukhov.