About a possibility of increasing the adhesion strength between mineral glass and polymeric binder under radio-frequency induction plasma treatment

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Abstract. The paper investigated influences of radio-frequency induction plasma treatment on the surface of sheet mineral glasses for household purpose. Discussion for casting the most suitable treatment modes and theirs substantiation is shown. During the investigation the most productive plasma treatment modes for applied binders have been found. It is shown that the durability of adhesive joints between mineral glass and polymeric binder under low-temperature plasma treatment increase to 65%.

1. The Introduction
One of the most important properties of glass materials is a possibility to change smoothly their features, depending on driven additives, in case of making, and a possibility of non-stoichiometric structure formation, what allow obtaining materials with properties different from properties of the crystalline material [1].

It may be noted that glasses have such properties as chemical and biological inertness, low adhesive durability of the surface, which can produce negative effect on the technical and operational properties of finished stock. For glasses are used as constituent element in composite, the activity of surface, adhesive properties, wettability will show the main role, as the processes which are proceeded on limit of the section of diverse materials are responsible for quality of the final product in the course of production [2].

It has been concluded that theory of durability of adhesive joints between mineral glass and polymeric binder lies in the diffusion of adhesive into substratum and bonding a strong connection. Theory specifications should be in the mechanical interaction: coupling of adhesive and substratum of having microcracks, roughnesses, hollows on the glass surface. Though, chemical theory of adhesion has been concluded that active formations on surface can form bonds with adhesive, while forming the reaction products.

The most common possible methods for increasing the adhesive durability include: chemical modifications of the glass surface, for example, by using salt of metakrilovy acid, hydrochloric acid [3], and hromoksilkhloridy, or another one chemical compound, which could interact in a complex with both: polymer and glass molecules, for example — four-chloride silicon or non-hardening epoxy [4]. Also, adhesive durability could increase by using the reagents which generate chemically bonded layer with glass surface, on which one further interaction with adhesive is followed [5].

However, chemical treatment can cause damage to the technical properties of glass and glass materials and produce negative effect on ecology.
Alternative method is high-frequency plasma treatment. The advantages of the method, such as speed, one-staging, nondestructive on the internal structure influence, ease of a variation of parameters, preservation of optical and strength properties of glasses, may to be noted.

2. Materials, methods and equipment
The objects of the investigation are samples of sheet silicate glasses. An influence of the radio-frequency induction plasma discharge on the adhesion value of the researched objects to road enamel KO-525 was considered. Glass processing was carried out in the experimental radio-frequency plasma equipment [6].

3. Results
Technical parameters of the radio-frequency plasma treatment are: ion energy $E_i = 15$–30 eV; ionic current density $J_i = 5$–23 A/m$^2$ (current intensity on the anode of a generating lamp $I_a = 1.0 - 2.5$ A); plasma-forming gas – Argon; gas rate 0.06 g/s; pressure in the working chamber $P = 40$–90 Pa; processing time $T = 300$ s. Samples were treated at various height over a plasmatron cut: 60, 50, 40, 30 mm. A series of experiments for different height and ion energy was conducted.

The adhesion strength was estimated by ISO 4624 by using Neurtek KN-10 equipment; the results of the measurements are shown in the table 1 and in the figure 1.

**Table 1. Average values of adhesion strength, kg/m$^2$**

| Ion energy, eV (Ia) | Samples height over a plasmatron cut, mm |
|---------------------|----------------------------------------|
|                     | 60          | 50          | 40          | 30          | The control sample |
| 15 (1.0 A)          | 140         | 473.9       | 599.2       | 941.6       | 577.8               |
| 20 (1.5 A)          | 310         | 371.3       | 834.6       | 663.4       |                     |
| 25 (2.0 A)          | 337.1       | 684.8       | 941.6       | 735.1       |                     |
| 30 (2.5 A)          | 627         | 642         | 863.5       | 613.1       |                     |

**Figure 1. Average values of adhesion strength, kg/m$^2$**
4. Conclusions
Thus, found results provide evidence for increasing the adhesion strength of glass to polymer binders under effect of the radio-frequency induction argon plasma discharge in cases with different height samples, lying over a plasmatron cut and different ion energy. At the same time, the most effective technical parameters are height over a plasmatron cut h=40 mm and h=30 mm. Presumably, the surface of sheet silicate glasses is exposed to microetching and regrouping of silicate network, can be ascribed to deep adhesive penetration into glass surface and its chemical bond with silicate groups.

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