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# Processing of the Content of Colored Glass Materials for Decorative Compositions and Researching their Main Properties

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**ABSTRACT**

The compositions of colored glasses in the PbO–SiO2 system for stained glass decorative compositions have been developed. Some physicochemical properties of the obtained glasses and their crystallization ability were studied.

**KEYWORDS:** colored glass, PbO–SiO2 system, decorative compositions, crystallization ability, temperature of crystallization.

The most striking and unusual decorations of windows and doors are stained glass or decorated windows [1–5]. Stained glass glass itself is a colored glass composition separated by a metal elongation [6]. IV century already began to be used to fill colored glass window openings. The most popular among buildings and structures, stained glass was used in decoration.

The peculiarity of the technology of making stained glass at that time was that they were made of colored glass blocks joined together. Stained glass windows are the most common of the decorative compositions. Below we give a definition of the word "stained glass" and the basics of their production technology [7–10].

What are stained glass windows called? Stained glass (from French vitrage, Latin vitrum glass) – a decorative or plot decorative composition (in the form of windows, doors, partitions, independent panels) made of glass or other light–transmitting material.

Stained glass windows are an artistic element in a separate interior, which is also a work of art. For example, the art–stained glass workshop produces classic art stained glass in all styles and directions, cleans glass with sand and produces decors using melting technology [11, 12].

In this study, the development of colored glass for stained glass was carried out in two directions based on the PbO – $SiO_2$ system, a series of two colored glass was welded and studied. In the first series, chromium, manganese, iron, and nickel oxides were used as colorants. They give the glass the color of the desired property. In the second series, oxides of rare metal elements $Y_2O_3$ , $Ce_2O_3$ , $Nd_2O_3$ and $Er_2O_3$ were used. It is considered necessary to use them as a component of glass.

Well–known methods of preparing samples from glass slag "pure for analysis" and "chemically pure" brand reactive materials were used (Tables 1 and 2). The mixing of the materials was carried out by the method of wetting with the use of ethyl alcohol. Preparation of bottles was carried out in electric furnaces heated on the basis of silica resistance. The compositions of the first series of bottles are given in Table 1.

**Table 1.** Compositions of the first series of bottles

| Bottle number | Amount of oxides, weight, % | | | | | | |
|---|---|---|---|---|---|---|---|
| | PbO | $SiO_2$ | $Cr_2O_3$ | $Mn_2O_3$ | $Fe_2O_3$ | $Ni_2O_3$ | Glass color |
| 1 | 77,72 | 20,92 | 1,36 | – | – | – | Dark green |
| 2 | 77,68 | 20,91 | – | 1,41 | – | – | Ink |
| 3 | 77,67 | 20,91 | – | – | 1,42 | – | Dark liver |
| 4 | 77,63 | 20,90 | – | – | – | 1,47 | Green |

PbO is synthesized on the basis of $SiO_2$ system. The maximum temperature of glass processing is 1000 – 1100 $^0$C. Retention at final temperature was 1h.

Colored bottles with the following physicochemical properties were obtained on the basis of slag mixtures:

The refractive index is – 1,906;

Density - 5,934 g/cm$^3$;

Chemical resistance, %;

Distilled $H_2O$ (pH = 7,0) relative to – 99,63;

$CH_3COOH$ (pH = 4,3) is 98,31;

With respect to NaOH (pH = 9,3) – 99,24;

The coefficient of thermal expansion is 10 $^{-7}$, grad$^{-1}$.

20 – 200 $^0$C each – 84,07

20 – 400 $^0$C each – 86,09

**Table 2.** The ability of experimental glass to crystallize

| Bottle number | The degree of crystallization is at room temperature | | | | | |
|---|---|---|---|---|---|---|
| | 550 | 600 | 650 | 700 | 750 | 800 |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |

no crystals;

formation of 0.1 mm thick crystalline film;

0,5 mm formation of a thick crystalline film;

surface crystallization;

complete crystallization.

The data obtained in Table 2 show the same property of crystallization of glass containing chromium, manganese, iron and nickel. Signs of crystallization in all cases – 625 ± 25 Starts at $^0$C and complete crystallization 800 Occurs at $^0$C.

In the second series as colour suppliers oxides of rare metal elements are selected. The compositions of the designed and synthesized bottles are given in Table 3.

**Table 3.** Compositions of designed and synthesized glass

| Bottle number | Amount of oxides, weight, % | | | | | | |
|---|---|---|---|---|---|---|---|
| | PbO | $SiO_2$ | $Y_2O_3$ | $Ce_2O_3$ | $Nd_2O_3$ | $Er_2O_3$ | Glass color |
| 5 | 78,00 | 21,00 | 1,00 | – | - | - | Light yellow |
| 6 | 77,65 | 20,90 | – | 1,45 | - | - | Yellow |
| 7 | 77,62 | 20,90 | – | - | 1,48 | - | Light green |
| 8 | 77,47 | 20,85 | – | - | - | 1,68 | Pink |

Corundum crucible 1000 – 1100 Bottles were baked at $^0$C;

Colored bottles with the following physicochemical properties were obtained on the basis of slag mixtures:

The refractive index is 1,914;

Density - 5,962 g/cm$^3$;

Chemical resistance, %;

Distilled $H_2O$ (pH = 7,0) relative to – 99,91;

$CH_3COOH$ (pH = 4,3) is 98,63;

With respect to NaOH (pH = 9,3) – 99,42;

The coefficient of thermal expansion is 10 $^{-7}$, grad$^{-1}$.

20 – 200 $^0$C each – 84,23

20 – 400 $^0$C each – 86,24.

In this study, glass crystal compositions with nucleated crystallization nuclei based on PbO – $TR_2O_3$ – $SiO_2$ structural glass were obtained. Oxides such as $Sr_2O_3$, $TiO_2$, $ZrO_2$ and $WO_3$ were selected as nucleators.

To determine the crystallization ability, the experimental vials were subjected to crystallization by the mass crystallization method. The crystallization of the bottles was carried out in an electric furnace with silicate heaters.

Allowed crystallization of four samples at the same time. The studied samples are kept at a certain temperature for 1 to 4 hours. The crystallization capacity of the experimental glass is given in table 4.

**Table 4.**The ability of experimental glass to crystallize

| Bottle number | The degree of crystallization is at room temperature | | | | | |
|---|---|---|---|---|---|---|
| | 500 | 550 | 600 | 650 | 700 | 750 |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |

no crystals;
formation of 0,1 mm thick crystalline film;
0,5 mm formation of a thick crystalline film;
surface crystallization;
complete crystallization.

The data obtained in Table 4 show the same property of crystallization of glass containing yttrium, series, neodymium and erbium. In all cases, signs of crystallization begin at 575 ± 25 $^0$C and complete crystallization occurs at 750 $^0$C.

Based on the data obtained, the crystallization ability of glass depends on many factors. Among the main ones, it is necessary to take into account the chemical composition of the glass, the type and amount of the crystallization core, the temperature regime of heat treatment and other conditions. In a certain case, an additional crystallization core is formed when $WO_3$ is added to the mixture in an amount of 1 to 9% to enhance the crystallization process.

The colored glass synthesized in this study crystallized at different temperature regimes and exposure modes – one and four hours. Increasing the heat treatment time from 1 hour to 4 hours helps the crystallization process.

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