STUDY OF THE MINERALOGICAL COMPOSITION OF GLASS-CERAMIC MATERIAL SYNTHESIZED ON THE BASIS OF BASALT

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Abstract: There is a sizable market for glass-ceramic items made by melting and heating rocks, which are a great substitute for conventional materials. Because of their strong resistance to abrasion wear, they may be applied as a coating and are frequently used in civil construction projects for things like cladding panels and pavement.

The basic ideas behind creating glass-ceramic materials, along with an outline of their characteristics and uses, will all be covered in this article. Following that, a presentation will be made on the glass ceramics derived from basaltic rocks, including their possible applications, ways of processing, and uses.

Keywords: basalt, glass-ceramic, applications, synthesis, crystallization, properties, amorphous.

ИЗУЧЕНИЕ МИНЕРАЛОГИЧЕСКОГО СОСТАВА СТЕКЛОКЕРАМИЧЕСКОГО МАТЕРИАЛА, СИНТЕЗИРОВАННОГО НА ОСНОВЕ БАЗАЛЬТА

Аннотация: Существует значительный рынок изделий из стеклокерамики, изготовленных путем плавления и нагревания горных пород, которые являются прекрасной заменой традиционным материалам. Из-за их высокой устойчивости к истиранию их можно наносить в качестве покрытия и часто использовать в проектах гражданского строительства для таких вещей, как облицовочные панели и тротуары.

В этой статье будут рассмотрены основные идеи создания стеклокерамических материалов, а также описание их характеристик и использования. После этого будет сделана презентация стеклокерамики из базальтовых пород, ее возможного применения, способов обработки и использования.

Ключевые слова: базальт, стеклокерамика, применение, синтез, кристаллизация, свойства, аморфность.

INTRODUCTION

In general, materials can be categorized as crystalline or amorphous based on how their atoms are dispersed in respect to their structure. Crystalline materials exhibit long-range structural order because their atoms are arranged in a periodic pattern throughout their structure. On the other hand, atoms in amorphous materials are dispersed randomly over space and lack long-range organization [1,2]. Glasses are a common example of an amorphous material. W.H. Zachariasen presented a list of criteria in 1932 that are met when a substance creates glass. According to the requirements, there must be a three-dimensional network with no long-range order in the atomic [3].

Glass-ceramic materials are formed by a combination of the two types of the structure presented (amorphous and crystalline) and can be defined as ceramic materials, in which the crystalline phases are formed by nucleation and controlled crystallization of glass. Efficient nucleation allows the formation of randomly oriented fine-grained crystals in a glass matrix [4,5]. The microstructure of a glass-ceramic is generally composed of 50–95% by volume of the crystalline phase. When the glass is heat-treated, one or more crystalline phases may be formed. Both the composition of the formed phases and the residual glass will differ from the composition of the original glass [6].

Most glass-ceramic materials with a structure that contains over 90% crystalline phase and crystal sizes between 0.5 and 1 m are considered to offer the greatest properties [7]. The ultimate qualities of the product will be greatly influenced by both surface polish and residual porosity because it is a ceramic material.

George H. Beall and Hermann L. Rittler filed the first patent for a glass-ceramic material made from basaltic rock in 1971. It was named "Process for forming a basaltic glass-ceramic product" [8]. The process of the invention involves melting basalt under oxidizing circumstances, quickly cooling the resulting glass, and then applying heat treatment to the glass matrix to create uniformly distributed crystals.

The use of natural raw materials to produce glass-ceramics is of great economic, technological, and scientific importance. With an adequate chemical composition, different types of rocks can be used to obtain glass-ceramics, resulting in varied microstructures and a wide range of technological properties [9].

MATERIALS AND METHODS

For the synthesis of glass-ceramic samples, local raw materials available in Uzbekistan: Osmonsoy basalt, Samarkand quartz sand and Kungirot technical soda were used.

Chemical analysis of the synthesized glasses was determined on an energy-dispersive X-ray fluorescence spectrometer Rigaku NEX CG (USA).

Glass was melted in 200 g corundum crucibles using injection burners in a gas furnace. The temperature was raised at a pace of 270–300 °C per hour and held at a maximum of 1450 °C for one hour. Crystallization process of glass samples was carried out for 1 hour at intermediate temperatures of 800-1000 °C.

Phase analysis of the samples was carried out on the basis of diffraction patterns, which were recorded on an XRD-6100 apparatus (Shimadzu, Japan), using CuK. - radiation (β - filter, Ni, 1.54178 tube current and voltage mode 30 mA, 30 kV) and a constant detector rotation speed of 4 degrees/min with a step of 0.02 degrees, and the scanning angle varied from 4 to 80 °.

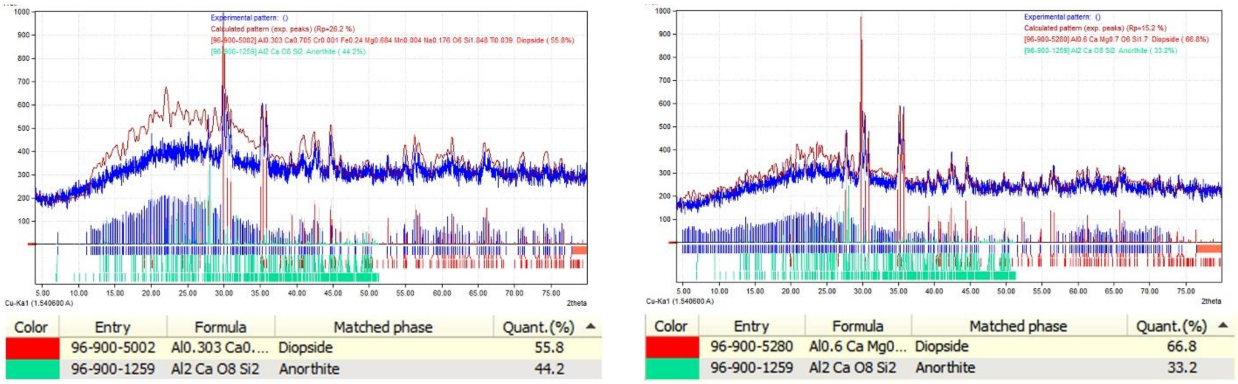
RESULTS

Glass samples were synthesized at a temperature of 1450 °C, and the compositions were made based on the available raw materials. The chemical composition of the synthesized glass samples was analyzed.

Table 1. **Chemical compositions of synthesized glasses**

Index glass	Amount of percentage, %												
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	Cr_2O_3	ZnO	MnO	CuO	SO_3
1	49,8	12,8	6,84	7,62	3,10	17,0	0,598	1,71	0,0099	0,0078	0,099	0,0057	0,126
2	50,9	13,2	8,53	9,61	3,33	10,8	0,693	2,14	0,0113	0,0121	0,116	0,0064	0,151
3	52,5	10,5	7,11	6,23	2,81	17,6	0,81	1,74	0,0131	0,0081	0,0967	0,0059	0,0738

The crystallization process was carried out in the synthesized glass samples at temperatures of 800 °C, 900 °C and 1000°C. X-ray analysis process was carried out to determine the mineralogical composition of crystallized glass-ceramic samples

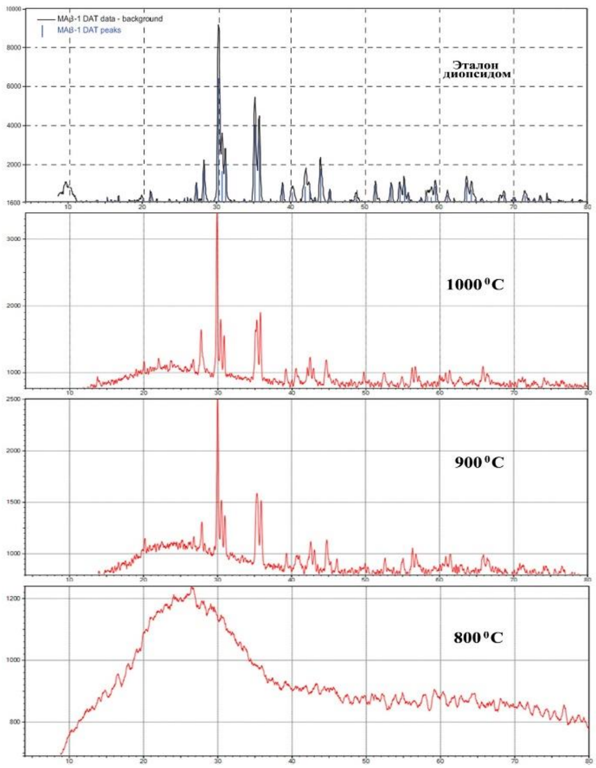


Picture 1. X-ray pattern of sample 3 at temperatures of 900 and 1000 °C

X-ray analysis was carried out to study the phase composition of crystallized composition-3, the analysis revealed the presence of diopside and anorthite minerals, the amount of diopside mineral increased and that of anorthite decreased at a high temperature of 1000 °C, and the X-ray images were compared to the diopside standard. The amount of minerals was determined in the MATCH computer application. The results of the analysis are presented in the following table 2.

Table 2. **Mineralogical composition of the glass-ceramic sample 3**

Minerals.	**Amount of percentage, %**		
	800^0C	900^0C	1000^0C
Diopside	Amorphous	55,8	66,8
Anorthite	Amorphous	44,2	33,2



Picture 2. X-ray pattern of sample 3 compared to the diopside standard.

DISCUSSION

Osmonsoy basalt, Samarkand sand, Kunhirot soda were used as local raw materials for the synthesis of glass ceramic samples.

It was found that it is possible to synthesize glass samples of different colors on the basis of basalt, in addition to glass-ceramic materials

The chemical composition of the synthesized glass samples was determined. Crystallization process was carried out on glass samples at different temperatures.

Glass crystal materials were developed according to glass technology. Glass firing temperature is 1400-1450 °C, crystallization temperature 1st stage 800 °C (1st hour), 2nd stage 900-1000 °C (2nd hour).

It was determined from the results of the analysis that the mineralogical composition of sample 3 and the diopside mineral standard are similar to each other.

CONCLUSION

Rock-derived glass-ceramic products are highly marketable and a great substitute for conventional materials. The characteristics of basaltic rocks are fine grain, dark coloring, and high hardness. Basalt is utilized as a raw material in its natural state for the building of sidewalks, pavements, and walls due to its strong chemical resistance and wear resistance. It is also widely used as an inexpensive raw material to manufacture aggregates for civil construction.

However, basalt can be used to produce glass-ceramics with a wide range of microstructures and properties through cycles of heat treatments and chemical composition variations. This enables the application of these materials in the most diverse areas, from fibers and fabrics to corrosion- and wear-resistant coatings and paving. More specialized uses are also being investigated, such as the manufacturing of semiconductors, insulators, and fuel cells.

The opportunity to convert basalt, a cheap, readily available, and naturally occurring raw material, into a glass-ceramic material with superior qualities, a high added value, and a wide range of uses was therefore highlighted in this research.

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