PHYSICO-CHEMICAL ANALYSIS OF QUARTZ SAND AND TECHNOLOGICAL WASTE USED AS A MAIN RAW MATERIAL FOR GLASS PRODUCTION

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ABSTRACT

The composition and structure of Sherobod quartz sand and man-made waste were fully investigated using chemical, scanning electron microscope, X-ray, infrared spectroscopic and differential thermal analysis methods. It was found that the content of lead and manganese oxides in Handiza lead concentrate and manganese waste is 25 - 26 %, respectively, and silicon oxide in Sherabad quartz sand is more than 80 %. According to the results of chemical and physico-chemical analyzes of Sherabad quartz sand and man-made waste, it was found that they can be added as glass components by cleaning them from various additives.

Keywords: quartz sand, man-made waste, lead concentrate, chemical composition, physical-chemical analysis, X-ray, infrared light, spectrum, scanning electron microscope, differential thermal analysis.

INTRODUCTION

The production of glass products is an important branch of the national economy and is the main consumer of raw materials, energy and labor resources. In addition, glass products in many ways determine the level of development of the main sectors of the economy.

Glass products are processed by heat at high temperatures of raw materials such as quartz sand, calcined soda, dolomite, limestone, sodium sulfate, feldspar, alumina. Some of these raw materials are mined from the ground, while others are produced and used based on chemical methods. Among the listed raw materials, silica raw materials are considered one of the most important in the production of glass products, and their widely used representative is quartz sand.

Most of the natural raw materials cannot be used directly for glass production. For that they have been enriched and purified using special technological approaches.

Currently the creation of effective compositions and innovative technologies for obtaining demand-level glass and special materials based on local raw materials is one of the urgent problems in the field of construction and engineering. In this regard, it is important to conduct a comprehensive physical and chemical study of local raw materials and determine the prospects for their use [1].

When analyzing the development trend of the glass industry, it is important to study the state of the existing production capacities worldwide. A general analysis of the production of glass products in the world is given in the source [2].

The main purpose of the present research is to study the chemical composition and physico-chemical properties of quartz sand and man-made waste, which are the main feedsctock, and to determine the possibilities of obtaining transparent glass based on them.

EXPERIMENTAL

Materials

The following local raw materials and man-made waste were used as objects for glass production: Sherabad quartz sand, Khanjiza lead concentrate, and manganese waste, which was supplied from Uzmetkombinat enterprise. Each experiment was carried out triple and average result was accepted as a reliable date.

Methods

The surfaces of the initial and synthesized samples were studied using Fourier transform IR spectroscopy in a Nicolet 6700 setup in the ranges of 400 - 4000 cm^{-1}. Samples were tested up to Thermo Fisher Scientific 4 cm^{-1}. The materials were studied by the method of diffusion reflection, mixtures of the composition were prepared in the following ratio: 90 % KBr and 5 % of the studied material. For decryption, the OMNIC Spectra program was used [3 - 5].

The method of thermography studies endo-effect and exo-effect processes that occur during heating of inorganic substances and silicate materials. They are usually associated with heat release and heat absorption [5 - 7]. There are many types of thermography methods, one of the most important of which is the differential thermal analysis method (DTA) [8 - 13].

DTA and TG analyzes of the experimental samples were performed on a STA PT 1600 synchronous thermoanalyzer manufactured by Linseys, Germany, and the measurements were carried out in an oxidizing environment at a speed of 20°C min^{-1}.

Morphological studies of the surface of the samples were carried out using a SEM - EVO MA 10 (Zeiss, Germany) scanning electron microscope. The scanning electron microscope experiments were carried out as follows: in order to carry out the sample preparation process, in a circular holder made of metal alloy, an aluminum foil with a double-sided adhesive surface was glued on it, and the required amount of test samples was applied to it.

This sample preparation process was used to study the microstructure of the samples. During the measurement, an accelerating voltage of 20 kV (EHT - Extra High Tension) was applied, the working distance (WD-working distance) was 8.5 mm. Image taken using Smart SEM software at different scales.

Energy-dispersive X-ray spectroscopy (EDS) was carried out in the local area to determine the elemental composition, which was determined using an energy-dispersive elemental analyzer center - Oxford Instrument-Aztec Energy Advanced X-act SDD. Electronic photos with selected local areas, composition table and graphical spectrum were presented in obtaining data on elemental composition.

RESULTS AND DISCUSSION

The chemical composition of Sherabad quartz sand and man-made waste used for glass production are given in Table 1.

The amount of chemical elements in Kanjiza lead concentrate are tabulated in Table 2.

Table 1. Chemical composition of experimental samples.

№	Raw materials	Amount of oxides, wt., %											LOI, wt., %
		SiO_2	PbO	Al_2O_3	Fe_2O_3	Na_2O	K_2O	CaO	MgO	MnO	ZnO	SO_3	
1.	Sherabad quartz sand	80.30	-	3.94	0.48	0.32	0.97	5.13	1.07	-	-	1.81	5.98
2.	Lead concentrate	2.23	25.60	0.84	13.75	6.77	0.40	0.37	0.46	-	12.70	18.14	18.74
3.	Manganese waste	17.00	0.60	5.70	5.70	13.50	6.00	7.10	1.30	26.00	10.00	2.36	4.74

Table 2. Element composition of Khanjiza lead concentrate.

Amount of elements, wt., %								
Pb	Fe	Zn	S	O	C	Si	Al	Mg
28.6	17.6	14.7	12.4	11.5	11.1	2.4	1.2	0.6

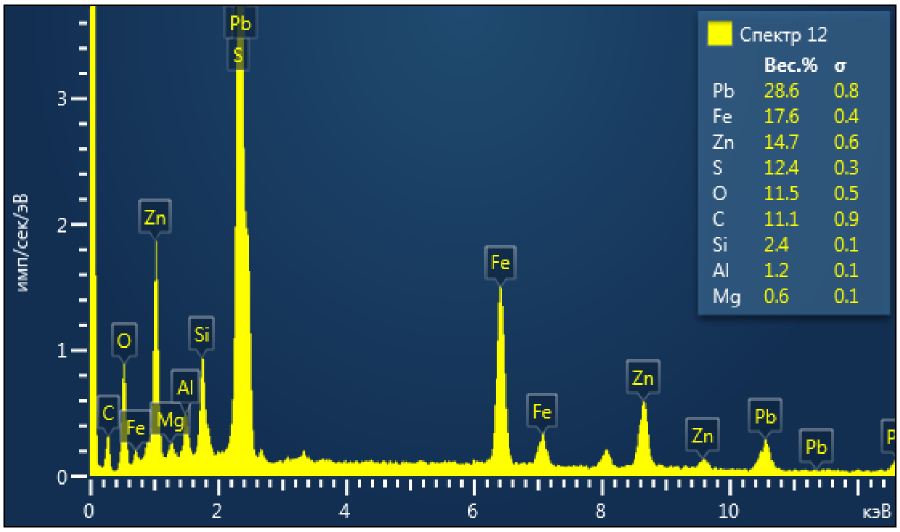

Fig. 1. The amount of elements in the spectrum diagram 12 of the sample of Khanjiza lead concentrate.

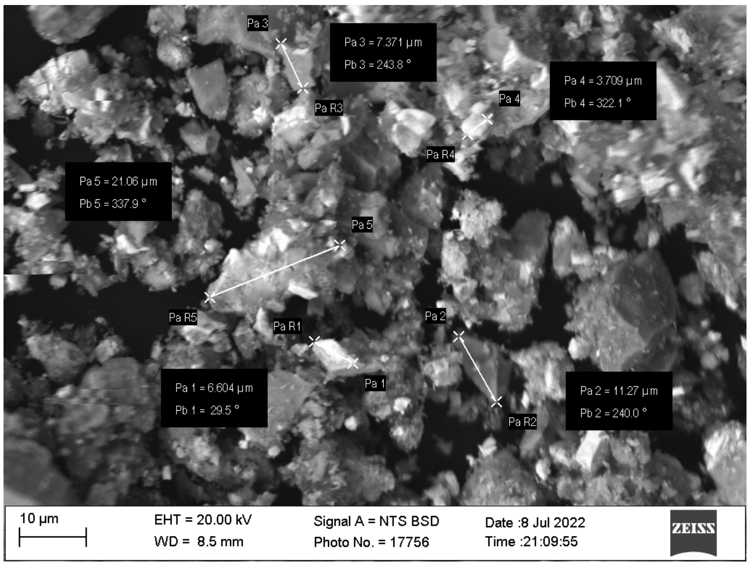

Fig. 2. Scanning electron microscopic image of the structure of Khanjiza lead concentrate.

As can be seen from the diagram Fig.1 below, according to the results of the scanning electron microscopic analysis of the lead concentrate, it contains Pb - 28.6 %; Fe - 17.6 %. The amount of Zn - 14.7 % and S - 12.4 % elements was found to be the main rock-forming element of the compound, and the remaining elements in small amounts as additives.

Fig. 2 shows a scanning electron microscopic image of the structure of the Khanjiza lead concentrate.

Fig. 3 and Fig. 4 show the DTA of Khanjiza lead concentrate and manganese waste of Uzmetkombinat enterprise.

In the differential thermal analysis of Khanjiza lead concentrate, 3 endo-effects at temperatures of 393.8°C, 587.3°C and 827.6°C and 2 exo-effects at temperatures of 541.8°C, 787.2°C were observed. Endo effects at temperatures of 393.8°C and 587.3°C are explained by decomposition of adsorbed and chemically bound water, respectively, and endo effect at 827.6°C is explained by release of SO_3 in the composition. Exo-effects at temperatures of 541.8°C and 787.2°C are explained by the early initiation of phase change processes due to low-temperature liquefied oxides in the lead concentrate (Fig. 3).

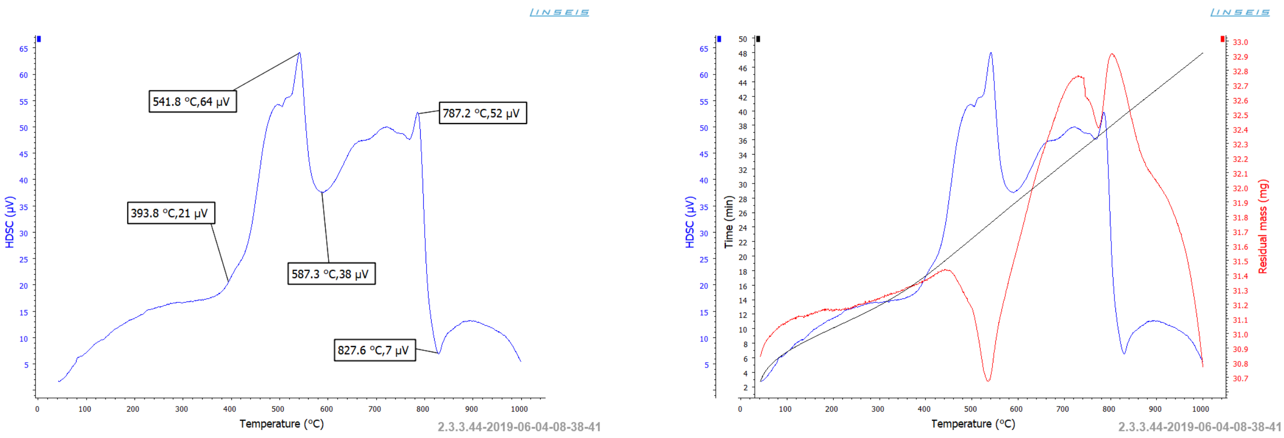

Fig. 3. Differential thermal analysis (DTA) of Khanjiza lead concentrate.

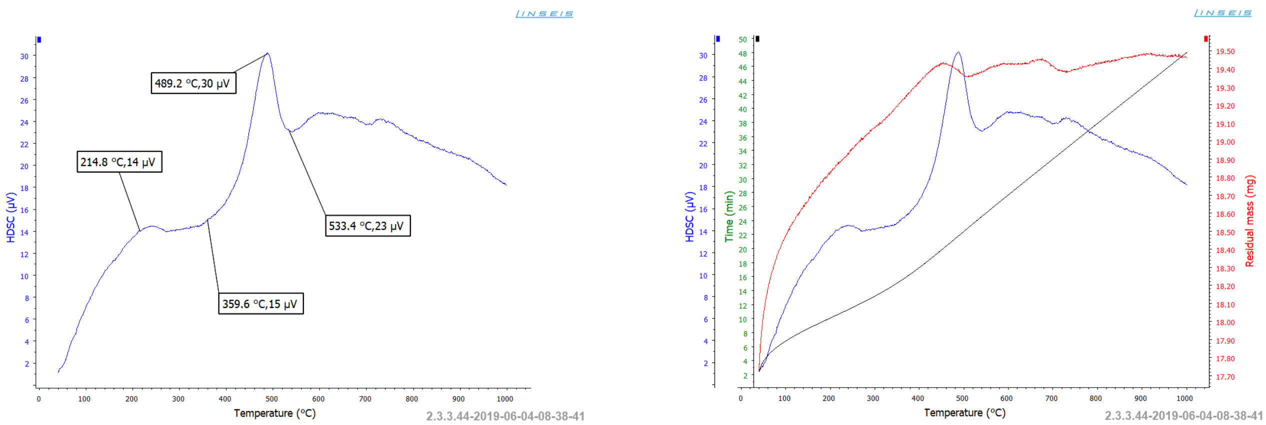

Fig. 4. Differential thermal analysis (DTA) of manganese waste of Uzmetkombinat enterprise.

In the differential thermal analysis of manganese waste of Uzmetkombinat enterprise, 2 endo-effects at temperatures of 359.6°C and 533.4°C and 2 exo-effects at temperatures of 214.8°C and 489.2°C were observed. Endo-effects at temperatures of 359.6°C and 533.4°C are explained by decomposition of adsorbed and chemically bound water, respectively, and exo-effects at temperatures of 214.8°C and 489.2°C are explained by separation of organic compounds accompanied by heat release in manganese waste.

When the mass of the sample was checked, from the initial temperature to 489.2°C, the mass increased due to the absorption of oxygen in the air. The exoeffect continued up to 489.2°C. From 489.2°C to 1000°C, the mass remained almost unchanged when the mass change was observed (Fig. 4).

From the analysis of the thermogram of Sherabad quartz sand (Fig. 5), it was found that there are 1 endo-effect and 2 exo-effects. In the thermogram, the endo effect at 82°C is related to the release of physically bound water, and the exo-effect at 573°C is related to the transition of α-quartz to β-quartz, and at 872°C, β-quartz to α-tridymite.

X-ray analysis of Sherabad quartz sand shows its composition: quartz - d = 0.420; 0.344; 0.222; 0.212; 0.197; 0.181; 0.166; 0.154; 0.138; 0.137 nm and anorthite - d = 0.322; 0.244; 0.226 nm (Fig. 6).

Infrared spectrum of a sample of Sherabad quartz sand is represented in Fig. 7.

The vibrational frequency of 3451.12 cm^{-1} in the infrared spectrum of Sherabad quartz sand corresponds to Al-OH valence vibrations, which are also called ON group vibrations. 1051.57 cm^{-1} corresponds to Si-O valence vibrations and O-H deformation vibrations.

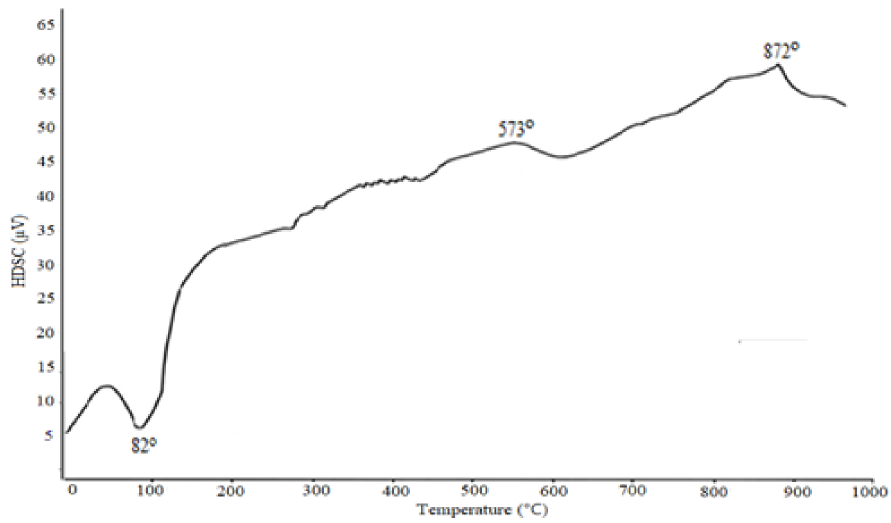

Fig. 5. Differential thermal analysis (DTA) of Sherabad quartz sand.

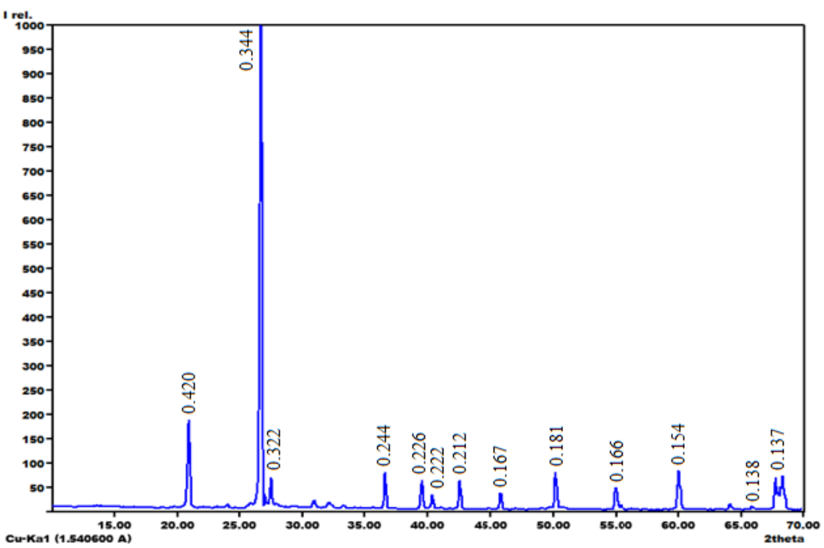

Fig. 6. X-ray of a sample of Sherabad quartz sand.

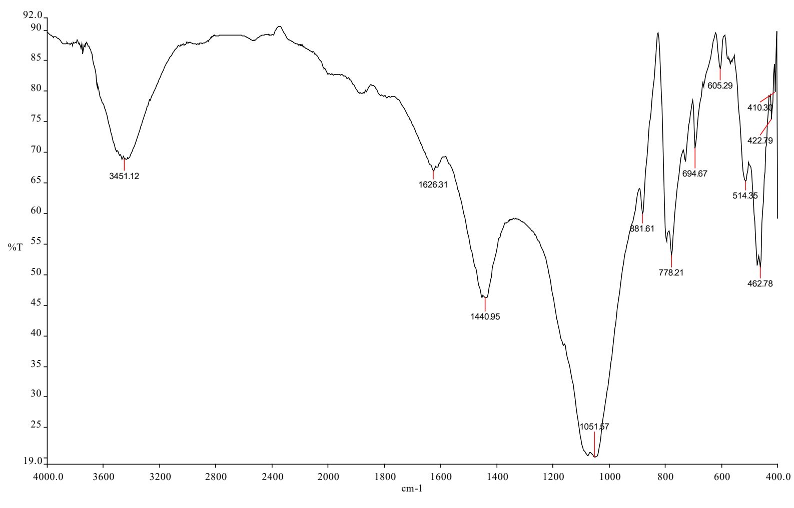

Fig. 7. Infrared spectrum of a sample of Sherabad quartz sand.

881.61 cm^{-1} and 778.21 cm^{-1} correspond to Si-O-Si valence vibrations by calculating the frequencies of residual complexes. 694.67 cm^{-1} to 462.78 cm^{-1} also correspond to O-Si-O stretching vibrations and Si-O-Si strain vibrations (Fig. 7).

CONCLUSIONS

In conclusion, according to the results of the physico-chemical analysis of Sherabad quartz sand and man-made waste, it was found that unenriched raw materials and waste can be added as glass components as a result of purification and enrichment from various additives, and their specific characteristics were analyzed and fully studied by physico-chemical methods.

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