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Eshmurodov Kh.E., Djalilov A.T.

Tashkent Research Institute of Chemical Technology. Tashkent, Uzbekistan

Turayev Kh.Kh.

Termez State University, Termez, Uzbekistan

E-mail: khurshideshmurodov@mail.com

OBTAINING ORGANOSILICON COMPOUNDS BASED ON SODIUM METASILICATE

Abstract: Organosilicon compounds are widely used in various industries due to their properties such as high thermal and chemical stability, elasticity and water resistance. This article is devoted to experiments on obtaining organosilicon compounds from the reaction of sodium metasilicate (Na_2SiO_3) with monochlorohydrin, dichlorohydrin and epichlorohydrin. The experimental results were analyzed using infrared (IR) spectroscopy to determine the composition and structure of the new compounds.

Keywords:organosilicon compound, sodium metasilicate, monochlorohydrin, dichlorohydrin, epichlorohydrin, IR spectroscopy.

Introduction. Organosilicon compounds are one of the important components of the modern chemical industry, which are characterized by unique properties such as high strength, heat resistance, hydrophobicity and electrical insulation. These compounds are widely used and are in high demand in the construction, automotive, electronics, medical and cosmetic industries. Various raw materials and synthesis methods are used to obtain them, one of which is the reaction of sodium metasilicate with organic halogen compounds.

Sodium metasilicate (Na2SiO3) is a cheap and widely used silicon raw material in industry, which is highly soluble in water and highly reactive. Organic halogen compounds, such as monochlorohydrin, dichlorohydrin, and epichlorohydrin, are important reagents in the synthesis of silicon compounds. The reactions of these compounds yield organosilicon compounds, which are considered to be an economically efficient and technologically feasible method for the production of silicon compounds.

When hydrins with epoxy and chlorine groups react with sodium metasilicate, polyfunctional organosilicon products are formed. These products are used as starting materials in chemical modification and the production of other high-value-added materials.

This research is devoted to the study of the process of obtaining organosilicon compounds through the reactions of sodium metasilicate with monochlorohydrin, dichlorohydrin and epichlorohydrin. This research contributes to the development of effective methods in the field of organosilicon chemistry and the creation of high-value-added products using local raw materials.

Scientific work in organosilicon chemistry shows that the reactions of sodium metasilicate with organic reagents to obtain silicon compounds have been widely studied. However, research is ongoing to improve the efficiency of this process and the quality of the product.

Sodium metasilicate is highly reactive due to its hydroxyl groups, and is used primarily as a building material, detergent, and chemical reagent. Its reaction with organic hydrins is a promising route for the synthesis of starting components for silicon-organic coatings and polymers [1-2].

Monochlorohydrin, dichlorohydrin, and epichlorohydrin are highly reactive due to their epoxide and chlorine groups. These compounds are particularly important in polymer production and the creation of new classes of compounds [3].

In recent years, a number of studies have been conducted on the production of silicon compounds using local raw materials. The main focus in this regard is on environmental safety and

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economic efficiency [4]. In particular, research is ongoing on the use of catalysts to make the reaction of sodium metasilicate with hydrins more efficient [5-6].

Organosilicon compounds based on sodium metasilicate and organic hydrins have thermal and chemical stability and are used in the production of high-quality coatings and adhesives [7-8]. Their water resistance and dielectric properties are also required in various industries.

Materials and methods.

Reagents: sodium metasilicate (Na_2SiO_3); monochlorohydrin (CH_2ClCH_2OH); dichlorohydrin ($C_3H_6Cl_2O$); epichlorohydrin (C_3H_5ClO); methanol and other solvents.

Research tools: water bath (60–90°C); mixer and reactor vessels; infrared spectroscope (FT-IR, 4000–400 cm^{-1}).

Experimental part.

To prepare the sodium metasilicate solution, 10 g of dry Na2SiO3 was slowly added to 100 ml of distilled water and stirred. The solution was maintained at 50–60°C.

An appropriate amount of monochlorohydrin, dichlorohydrin, or epichlorohydrin (based on a molar ratio of 1:1) was added dropwise to the sodium metasilicate solution. The stirring speed was adjusted to 500 rpm during the dropwise addition. During the reaction, 10% NaOH solution was added to maintain the pH value in the range of 8–9.

The reaction with each hydrin type lasted for 3–4 hours. A water bath was used to maintain a constant temperature during the reaction. At the end of the reaction, the formed product was separated from the solution.

The resulting product was isolated by vacuum filtration. The solids were washed with methanol or distilled water to remove chemical residues. The washed products were dried at 60–80°C.

The dried products were analyzed by IR spectrum in the range of 4000–400 cm^{-1} after purification.

Results and discussion:

In the IR spectrum of the organosilicon compound obtained by reaction with dichlorohydrin, the following were noted: C–H stretching at 2850–2950 cm^{-1}, and the presence of Si–O–Si groups at 1000–1100 cm^{-1}.

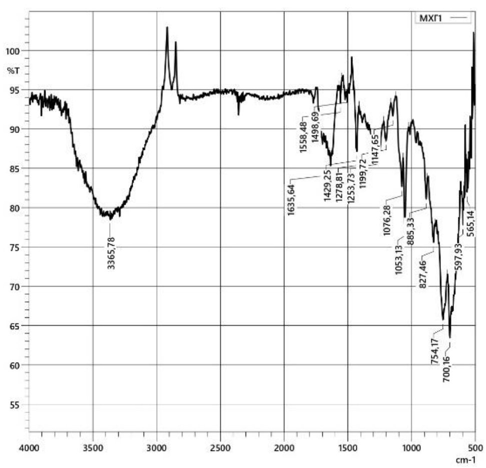

Figure 1. IR spectrum of monochlorohydrin

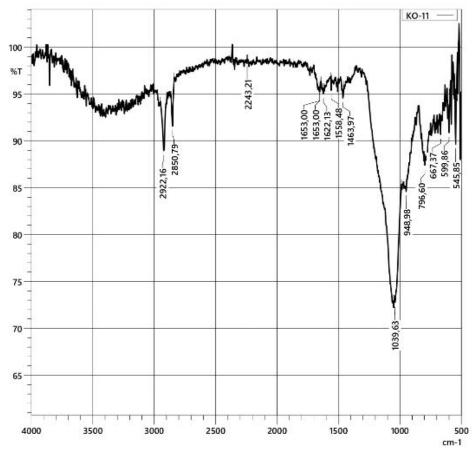

Figure 2. IR spectrum of KO-1

In the IR spectrum of the organosilicon compound (KO-2) obtained by reaction with monochlorohydrin: a broad OH group stretch absorption at 3400 cm^{-1} and a Si–O–Si bond stretch at 1000–1100 cm^{-1} were observed (Figure 4).

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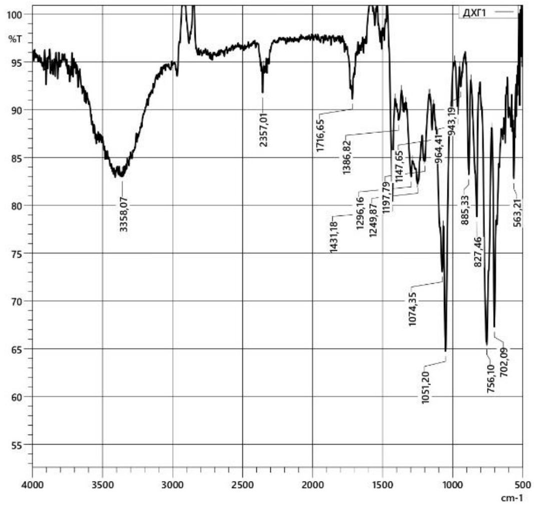

Figure 3. IR spectrum of dichlorohydrin

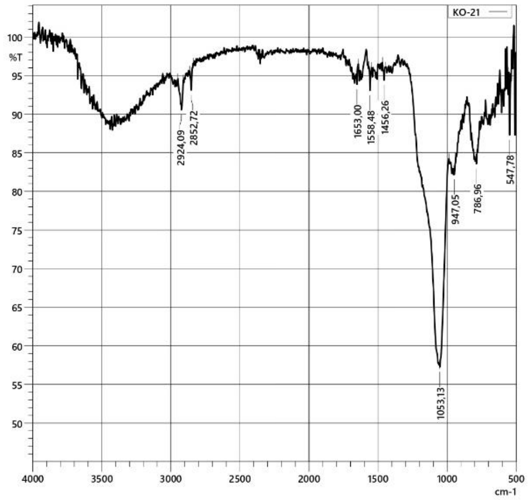

Figure 4. IR spectrum of KO-2

The IR spectrum of the organosilicon compound (KO-3) obtained by reaction with epichlorohydrin confirmed the presence of a Si–O–C bond at 800–1000 cm⁻¹ and a Si–O–Si system at 1100–1150 cm⁻¹ (Figure 6).

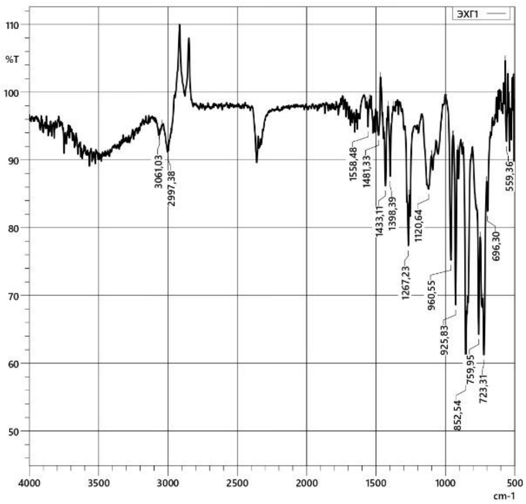

Figure 5. IR spectrum of epoxychlorohydrin

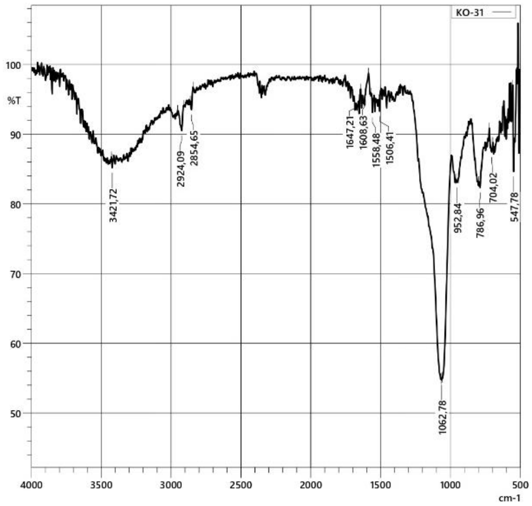

Figure 6. IR spectrum of KO-3

Reactions with monochlorohydrin, dichlorohydrin, and epichlorohydrin showed high efficiencies in the range of 80–90%. The composition and structure of the organosilicon compounds formed differed depending on the type of hydrin.

Based on the results of the IR spectrum, the bonding of silicon atoms to hydrin molecules confirmed the properties of the resulting compounds.

Discussion. Organosilicon compounds formed by the reaction of sodium metasilicate with various hydrins have been evaluated as potential materials for use in various industrial sectors. While Si–OH and Si–O–Si bonds predominate in the reaction with monochlorohydrin, the products formed with dichlorohydrin and epichlorohydrin have a more complex structure and are observed to have high thermal and chemical stability.

Conclusion. The results of this study showed that the reaction of sodium metasilicate with monochlorohydrin, dichlorohydrin, and epichlorohydrin successfully produced highly effective

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organosilicon compounds. These compounds are promising materials for use in the chemical, pharmaceutical, and building materials industries.

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