

Research on the application of microwave synthesis to obtain aluminum-containing coagulant

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ABSTRACT

The extensive way of industrial development and the rate of population growth determine the increase in the amount of drinking water consumed and the requirements for water treatment. Known and applied technologies for the industrial production of aluminum oxychloride coagulant used in reagent water purification are based on high-temperature processes that require complex hardware design. The paper presents the results of studies on the production of basic aluminum chlorides by the microwave method. The experiments were carried out on a designed laboratory setup based on a microwave oven; data were obtained on the yield of aluminum polyoxychloride depending on the change in process parameters, duration, coefficient of efficiency, and 36% concentration of hydrochloric acid solution. Studies of the use of microwave technologies in inorganic synthesis have shown the effectiveness of such technologies, a decrease in the reaction time, an increase in the efficiency of the installation, and the absence of contact between the heating elements and the reaction mixture. The influence of sulfuric acid as a process activator substance, which positively affects the productivity of aluminum polyoxychlorides, has been established. The results of physicochemical studies of the synthesized samples and their coagulation properties are presented, which indicates the possibility of using microwave technologies in the inorganic synthesis of aluminum polyoxychloride coagulants.

Keywords: coagulant, aluminum polyoxychloride, microwave inorganic synthesis, aluminum hydroxide.

1. Introduction

Now, a lot of work is done in the Republic of Kazakhstan to provide the population with drinking water. As the population grows, and industrial production develops, the level of water consumption increases, and new water intake points, both surface and underground ones, are commissioned [1, 2]. Water taken from surface sources usually has a certain turbidity, especially significant during flood periods, and the practiced method of purifying natural waters from suspended substances and impurities of varying dispersity is the use of coagulants. Effective coagulants are salts of polyvalent metals, the most used are ferric chloride and aluminum-containing coagulants, including aluminum sulfate, aluminum oxychloride, sodium aluminate, and aluminum chloride. It is important how pH, temperature and other characteristics change. For every mg per ml of ferric chloride, the pH dropped by two units. Also,

with an increase in each mg per liter of polyaluminum chloride and iron sulfate for coagulants by approximately 0.04 and 0.06 °C, the temperature will decrease, respectively, and for aluminum sulfate and ferric chloride for coagulants by 0.015 and 0.03. The pH value increased with increasing dosages of polyacrylamide coagulants. In addition, TDS, EC and salt values did not change after the addition of a coagulant [3-8]. The modern coagulant aluminum polyoxychloride – $\text{Al}(\text{OH})_m\text{Cl}_{3n-m}$, has several advantages, does not corrode equipment, operates in a larger pH range, requires less coagulant dosage, effective for water treatment at low temperatures. The main issues to be solved in the coagulant production technology development are to reduce the product cost and to improve its quality, to simplify and speed up the process. Most methods intended to obtain aluminum polyoxychloride are based on the use as a source raw material – metal aluminum, aluminum oxides or hydroxides. At the same time industry

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has a significant amount of aluminum-containing waste that can serve as a source raw material for aluminum polyoxychloride production. It is possible to simplify the technology intended to obtain aluminum polyoxychloride, to reduce its cost with the use of waste but there are problems of stability of technological and qualitative characteristics of raw materials and the resulting product. Coagulant – Aqua-Aurat 30 which is in demand in the market and has stable characteristics, is produced by the interaction of metallic aluminum with hydrochloric acid. The reaction takes place at high temperatures and high pressure which requires appropriate equipment. A patented aluminum oxychloride production method with the use of the interaction of freshly precipitated aluminum hydroxide and hydrochloric acid of various concentrations is also known. Difficulties of this method are in the changing aluminum hydroxychloride reactivity, the so-called aging and changing the of $\text{Al}(\text{OH})_3$ aluminum hydroxide structure. Technical aluminum hydroxide is dried in a rotary kiln at 110-130 °C, purified in a pneumatic separator, and then undergoes thermal dehydration. The activated hydroxide is precipitated in a cyclone and then fed to a set of enameled reactors. Multistage technology implies quality compliance issues with the established parameters for each stage complicating the technology.

The same way it is proposed to obtain aluminum oxychlorides by the interaction of aluminum sulfate or chloride with a lack of alkali in the solution. Sodium or potassium aluminate solutions are used as raw materials to increase the stability of the products. Difficulties in obtaining the product by this technology are in the low interaction rate of products and concentration heterogeneities of hydroxide ions. Solid basic aluminum chloride is obtained by periodic heating and cooling of AlCl_3 water solution, boiling aluminum chloride solutions for 2–4 h in a reflux condenser and then spray drying. This method produces basic aluminum chloride soluble in alcohol. The same basic aluminum chlorides are obtained by thermohydrolysis of concentrated aluminum chloride solutions (20–50%) in a spray dryer within the temperature range of 200–500 °C [9-13].

One of the developed directions in obtaining coagulants from aluminum polyoxychlorides is the processing of nepheline, bauxite and secondary aluminum smelting waste – salt slags. The technology is complex and power-consuming, the reaction takes place at temperatures up to 110–160 °C, the raw material is used when it is crushed to a fineness of less than 120 microns. The process is performed at

boiling point in heated tube reactors [14].

The proposed technology with the use of microwave inorganic synthesis has the advantage, as it is a one-stage technology for a high efficiency plant. The process time is significantly reduced, from 4–7 h to 15 min of the reaction, the aggressive medium is separated from the heating elements which implies a simple equipment design.

2. Methods and materials

The paper presents research on the development of a fundamentally new method for obtaining a reagent for water purification, aluminum polyoxychloride coagulant by microwave method with the use of technical aluminum hydroxide and hydrochloric acid.

Aluminum polyoxychloride was synthesized in a unit designed with a household microwave oven with a power range up to 1000 W and a volume of 20 liters and a reverse stirrer, thermometer and round bottom flask on a special plastic stand, refrigerator to condense the vapor and to return the condensate to the reaction mass, installed vertically and connected to cold water (Fig. 1).

Aluminum hydroxide $\text{Al}(\text{OH})_3$ and hydrochloric acid HCl with the concentration of were placed in a round bottom flask, the experiments were performed under constant stirring. This article presents data from experiments conducted with a concentration of hydrochloric acid of 36%.

The experiments were carried out: 1 series of experiments – at high heating intensity (1000 W), duration 2.5 minutes and with the addition of one percent of the activator substance, sulfuric acid of 93,6%; 2 series of experiments, with a reduced heating intensity (600 W), an even shorter heating period of 1 min, also with the addition of one percent sulfuric acid as an activator; Series 3 of experiments was carried out with a heating duration of fifteen minutes, at 800 W, without adding an activator. Besides, when samples of coagulants No. 1 and No. 2 were synthesized, concentrated sulfuric acid was added in an amount of one mass percent, as an activator substance. The synthesis results are presented in Table 1.

The elemental phase composition of the obtained synthesized samples was studied by physical and chemical research methods.

Chemical and physical-chemical analysis methods were used for study and analysis. Thermal analysis of samples was performed with the use of STA 449 F3 Jupiter, a synchronous thermal analysis device. Heating was performed at a rate of 100 °C/min. in an



Fig. 1. Laboratory setup for microwave synthesis.

atmosphere of highly purified argon. Results obtained with the STA 449 F3 Jupiter were processed using the NETZSCH Proteus software. The microstructure, quantitative and qualitative composition was studied with a ISM6610TV Scanning Electron Microscope D8 Advance X-ray Diffractometer (BRUKER) was used to study the phase composition of the samples, Cu-K α radiation, total morphological characteristics of the synthesized samples were taken by spectroscopic method, spectra were obtained using Avatar 370 CsI FTIR Spectrometer within spectral range of 4000–250 cm⁻¹ from products in the form of Vaseline oil suspension in KRS-5 windows. The vaseline oil spectrum was taken as a comparison spectrum. Experimental attachment: Transmission E.S.P. elemental analysis was performed by X-ray fluorescence method on the Axios Panalytical WDXRF.

Coagulation properties of synthesized samples were studied in comparison with coagulant - aluminum polyoxychloride Aqua Aurat 30, experiments were conducted with the use of natural waters taken from the Almaty water intake; the water turbidity was determined by GOST R 57164-2016 [15].

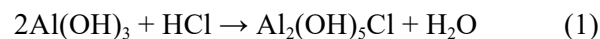
Solutions of samples of synthesized coagulant and Aqua Aurat 30 coagulant were prepared and studied for density and pH value in correlation with the data specified in the «Recommendations for the use of Aqua-Aurat 30».

Coagulant dosage for waters of different composition was set by trial coagulation of treated water under GOST 2919-45 [16,17].

3. Results and discussion

The following reagents – technical aluminum hydroxide Al(OH)₃ and hydrochloric acid HCl were chosen to study the microwave technology possibilities

in the synthesis of aluminum polyoxychlorides. When they are heated the reaction (1) proceeded with obtaining of aluminum polyoxychloride Al₂(OH)₅Cl and water. There were certain difficulties in the reaction, as a long heating process for the reaction mixture, up to boiling, and for several hours was required for the efficiency of the process according to the literature [18].



Microwave radiation can interact with substances in gaseous, liquid, or solid condition. Depending on the composition and morphology of the substance, the effects of radiation will vary, as shown in Fig. 1. Noticeable absorption of radiation observed during irradiation of many liquids and liquid solutions. Particularly strong absorption observed in the case of water and aqueous solutions. Microwave radiation technology has been successfully used in analytical chemistry and organic synthesis, direct absorption of electromagnetic energy by materials provides fast and uniform heating, the reaction and analysis time is significantly reduced, and the error of the result is reduced.

There is known experience in the use of microwave technologies in sample preparation, for acid decomposition, to transfer the sample into solution, both in closed microwave preparation systems and in open vessels. The results of studies on the synthesis of a substance that is used as a coagulant are shown in Table 1. Changing the reaction time and radiation power affect the result of the synthesis.

With the use of MV radiation, it is possible to synthesize such inorganic compounds as ZnTe, CuInS₂, CrC₃, WC₆, TiN, CrS, KVO₃, CuFe₂O₄, BaWO₄ rapidly [19-22].

In this study of the synthesis of a new coagulant, microwave technology is used by analogy, and considering experience in sample preparation in analytical chemistry. The change in the duration of the processes of sample dissolution in acids, evaporation, and ashing, from 2–11 h without the use of microwave units, to several minutes is indicative. Reactions with the use of conventional energy sources

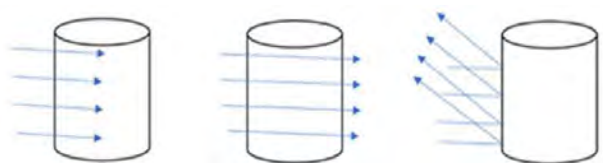


Fig. 2. Effects of microwaves on the sample.

Table 1. Conditions of microwave synthesis of polyaluminum chloride from aluminum hydroxide and hydrochloric acid 36%.

No	Radiation frequency W	Process duration min	Product yield %	Product color	H ₂ SO ₄ , 93,6%
1	1000	2.5	80	white	1%
2	600	1.0	78	gray	1%
3	800	15	91	white	

are mostly standardized, while microwave synthesis reactions depend on the reaction conditions and the substances used.

Processes with temperatures of over 1000 °C and above, with a high heating rate of over 100 deg/min can be used in inorganic synthesis to avoid uncontrolled changes in the composition of the initial reacting substances – charge and to obtain inorganic substances by uniform sintering throughout the initial charge volume. Oxides, sulfides, carbides, and some oxygen-containing salts capable to absorb microwave (MV) radiation intensively are used in these processes.

Both mixtures consisting of components capable to absorb microwave radiation and to be heated under its action, and mixtures where only one or some of the reagents absorbs microwave radiation are used during these syntheses. In some cases, chemically inert materials with different microwave absorption capacities are introduced into the charge to regulate the heating temperature. In the presented study, intense heating occurs due to the water contained in the mixture, due to an increase in the kinetic energy of dipole water molecules when exposed to microwave radiation.

Table 2. X-ray fluorescence analysis of samples

Analyte	Concentration, % MO 1	Concentration, %MO 2	Concentration, % MO 3
O	61.538	60.420	65.910
Na	0.138	0.152	0.203
Mg	-	0.021	0.043
Al	23.053	23.973	29.286
Si	0.024	0.038	0.025
S	2.813	2.438	0.003
Cl	6.073	6.369	1.359
Zn	-	-	0.010
Ga	0.004	0.004	0.002
Fe	0.011	0.018	0.006

Intensive heating occurs due to the water contained in the charge in the present research.

Absorption of microwave energy by the medium depends on the dielectric properties of the heated substance, that is, how strongly the medium prevents the passage of microwaves through it. Non-polar substances slightly interact with penetrating microwaves, and therefore are not heated, unlike polar substances, as shown in Fig. 2 [23].

By changing the synthesis conditions, products were obtained – substances that have some differences in structure, color, and solubility, but a similar basic composition, including aluminum polyoxochlorides of various basicities, aluminum chloride and aluminum hydroxide. X-ray fluorescence analysis showed trace amounts of sulfur. According to the results of X-ray fluorescence analysis showed some sulfur in the samples, 2.8 and 2.4%. According to the results of X-ray fluorescence analysis, as can be seen from Table 2 for samples No. 1 and No. 2, sulfur passes into the composition of the samples during synthesis. The samples had a difference in color, sample No. 2 was characterized by a gray tint, and sample No. 3 had a maximum white color. Increasing the duration of synthesis resulted in an increase in product yield by 14%.

X-ray phase analysis was performed with a D8 Advance Diffractometer (BRUKER), radiation – Cu-K α .

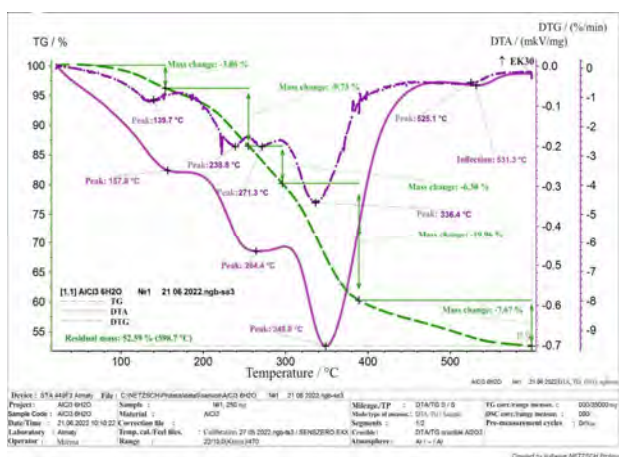
The presence of phases Al₉Cl₆ (OH)₂₁·18H₂O; Al₅Cl₃(OH)₁₂·7.5H₂O, which can be called polyoxichlorides, the total chemical formula of which Al₂(OH) NCL6-N we see them in the results of the X-ray analysis of synthesized coagulant samples presented in Table 3.

The mineral phase in the Aqua-Aurat 30 sample is 59.6%, the composition AlCl₃·6H₂O hydrated chloraluminum by 100% under the diffractogram analysis in Fig. 4.

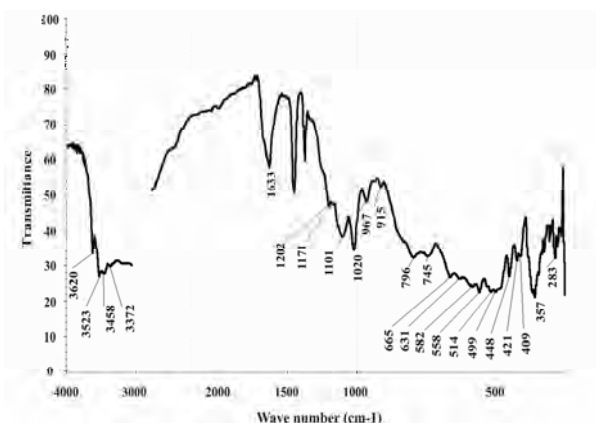
The elemental analysis results (X-ray fluorescence analysis) of synthesized samples No. 1, No. 2, No. 3 show the content of aluminum, oxygen, and chlorine. Sulfur contained in sulfuric acid, an activator of the reaction, practically does not pass into the sample during synthesis.

Based on the analyses results, it can be assumed that more chlorine passed into the composition of sample No. 2 during the synthesis.

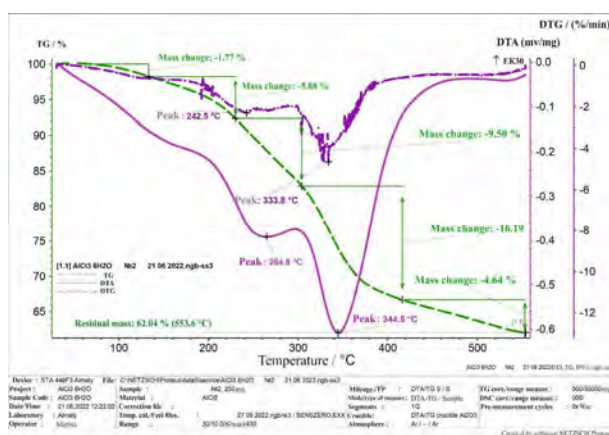
Thermal study of sample No. 1 is shown in Fig. 5. The DTA curve had endothermic effects of different intensity with maximum development at 157 °C, 264.4 °C, 348.8 °C. The bend at 531.3 °C can also be noted. All the above effects developed against the



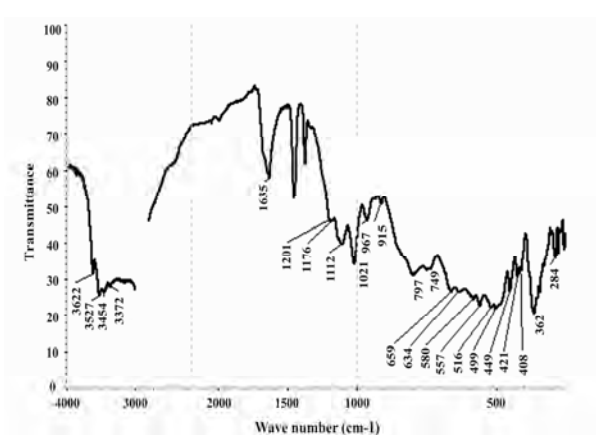
synthesized sample No. 1



Sample No. 1

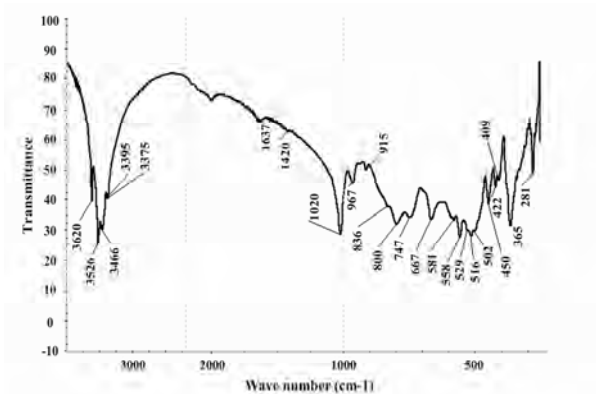


synthesized sample No. 2



Sample No. 2

Fig. 5. Thermogram of the synthesized samples.



Sample No. 3

Fig. 6. Infrared spectrum of sample No. 1; No. 2; No. 3.

The presence of an bischofite impurity – $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ is not excluded as in the analysis of sample No. 1. But it is less in Sample No. 2 than in Sample No.1. The presence of sulfate is assumed. Fig. 6. A comparative analysis of solid samples and aqueous solutions of synthesized Polyaluminum Chloride and Aqua Aurat 30 on the mass fraction of aluminum in terms of Al_2O_3 , basicity, solubility, density, and pH of solutions.

IR spectroscopic studies of Samples No. 1 and No. 2 of the synthesized oxychloride showed the presence of $\gamma\text{-Al}(\text{OH})_3$. The sample contains sulfates: SO_4^{2-} – 1201, 1176, 1112, 634 cm^{-1} . The band of deformation vibrations of water δHOH – 1635 cm^{-1} indicates the presence of crystalline hydrates.

The stripes are recorded in 362, 284 cm^{-1} in the long length of the spectrum, in the field of manifestation of vibrations – $\text{Me}-\text{Cl}$, $\text{Me}-\text{O}$. The studied sample No. 2 also contains stripes characterizing Gibbsite $\gamma\text{-Al}(\text{OH})_3$ are displayed in Table 6 and correspond to – 3620, 3523, 3458, 3372, 1020, 967, 915, 796, 745, 665, 582, 558, 514, 499, 448, 421, 409 cm^{-1} . The sample contains sulfates: SO_4^{2-} – 1202, 1171, 1101, 631 cm^{-1} .

The stripe of deformation vibrations of water δHOH – 1633 cm^{-1} indicates the presence of crystalline hydrates. The stripes at 357, 283 cm^{-1} are fixed in the long-wavelength part of the spectrum in the region of manifestation of $\text{Me}-\text{Cl}$, $\text{Me}-\text{O}$ vibrations. The intense stripes of valence νOH – 3415 cm^{-1} , δHOH – 1635 cm^{-1} deformation and νL H_2O libration vibrations with a maximum at a wave

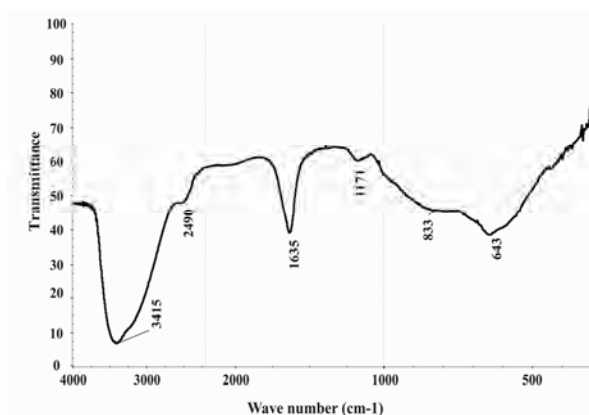


Fig. 7. Infrared spectrum of an Aqua Aurat 30 sample.

number of 643 cm^{-1} of vibrations of water molecules are observed in the spectrum of Aqua Aurate 30 in Fig. 7. The stripes with maxima at wavenumbers of 1171 , 833 cm^{-1} fall within the range of M–O–H deformation vibrations.

There are M–O–H deformation vibrations, and ν L H_2O liberation vibrations absent in Samples No. 1 and No. 2, and there are no spectra of Me – Cl, Me – O vibrations in the spectrum of AA 30 [24-25].

Scanning electron microscope study. Comparative characteristics of the obtained spectra of coagulant samples under study obtained with a scanning electron microscope, are presented in the Figs. 8-9 and in Table 3.

The aluminum content in the Aqua-Aurat 30 sample is 28.86% which corresponds to the claimed characteristics. The samples of synthesized coagulants have a close quantitative and qualitative composition as in Sample No. 3. Sample No. 2 has a different percentage composition both in terms of oxygen and aluminum content, and the formation of aluminum chloride AlCl_3 can be assumed. When the microstructure of the samples was studied, the difference in morphology was also shown. The aluminum content in the Aqua-Aurat 30 sample is 28.86% which corresponds to the

claimed characteristics. The samples of synthesized coagulants have a close quantitative and qualitative composition as in Sample No. 3. Sample No. 2 has a different percentage composition both in terms of oxygen and aluminum content, and the formation of aluminum chloride AlCl_3 can be assumed. When the microstructure of the samples was studied, the difference in morphology was also shown. It can be assumed that part of technical aluminum hydroxide did not react during the synthesis or changed its structure [26]. The difference in the textures of the samples was clearly visible when the pictures were taken with an increase of 10,000 times presented in Fig. 8.

The difference in the structure of samples is determined by the difference in technology for obtaining coagulants and the basicity of the reagent, presented in Fig. 9. Comparative analyzes of aqueous solutions of the synthesized POHA and AA-30 were carried out, as well as the solubility, density and pH of the solutions. When dissolved in water, the synthesized samples showed a significantly lower solubility, even when heated, than the AA-30 reagent, which can be explained by the formation of colloidal solutions and some content of aluminum hydroxide $\text{Al}(\text{OH})_3$, when heated, then the AA-30 reagent, which can be explained by the formation of colloidal solutions and some content of aluminum hydroxide $\text{Al}(\text{OH})_3$. Studies of aqueous solutions showed some differences in the values of the pH, and density, the values of synthesized samples on the acidity scale are approximately in the same range, pH 2.0; 2.3; 1.8, while the pH AA-30 value is – 1.5. The data is displayed in Table 4.

Samples obtained by evaporation of pre-dissolved coagulant have good solubility in water.

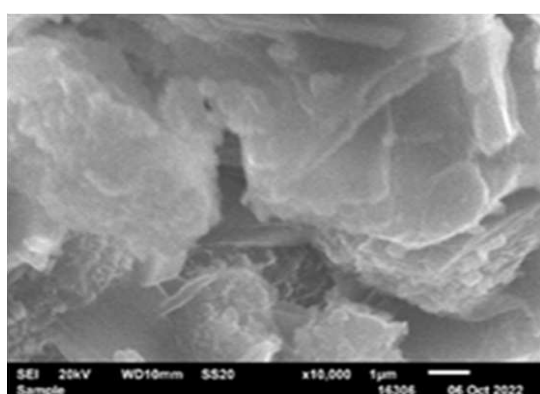
Determination of the optimal dose of coagulant depends on several factors, in particular, indicators of color and turbidity of water, temperature, pH and ionic composition of water, suspended solids content, concentration of colloidal particles and truly dissolved organic substances.

Table 3. Quantitative characteristics of samples of the studied coagulants

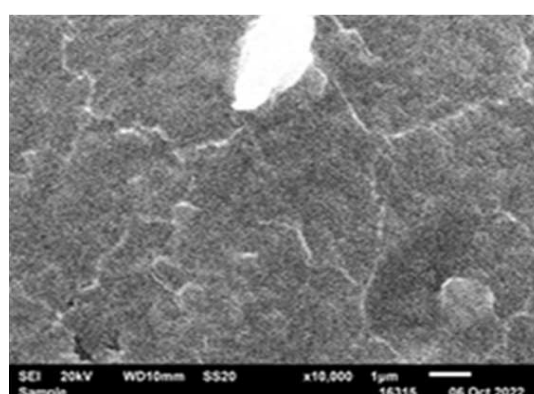
Spectrum	Content of O%	Content of Na%	Content of Al %	Content of Si %	Content of S %	Content of Cl %	Content of Fe%	Total %
Spectrum of AA	60.87	0.20	28.86	0.18	3.72	6.03	0.13	100.0
Spectrum of No. 1	45.74	0.25	16.20	0.12	0.00	35.98	0.16	100.0
Spectrum of No. 2	61.17	0.20	18.85	0.14	3.72	15.77	0.14	100.0
Spectrum of No.3	60.94	0.20	23.86	0.18	3.65	11.00	0.16	100.0

Table 4. Comparative characteristics of aqueous solutions of coagulants

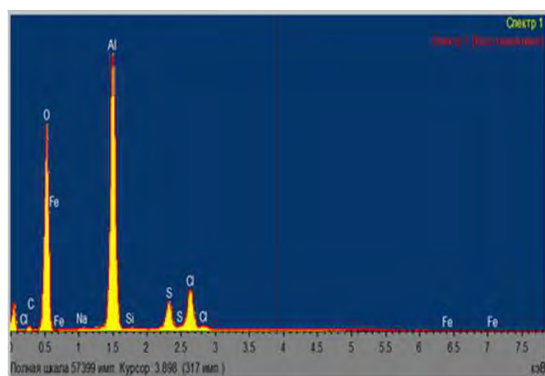
Coagulant	pH	Density	Solubility during agitation	Time to reach the transparency of the solution
Aqua Aurat 30 15% in terms of Al_2O_3	1.5	1.35	Good	0.1-0.2 h
Synthesized Polyaluminum Chloride No.1	2.0	1.43	Medium, colloidal solution is possible	8 h
Synthesized Polyaluminum Chloride No.2	2.3	1.45	Medium, colloidal solution is possible	5 h
Synthesized Polyaluminum Chloride No.3	1.8	1.6	Average, the suspension settles within 1 hour	2 h



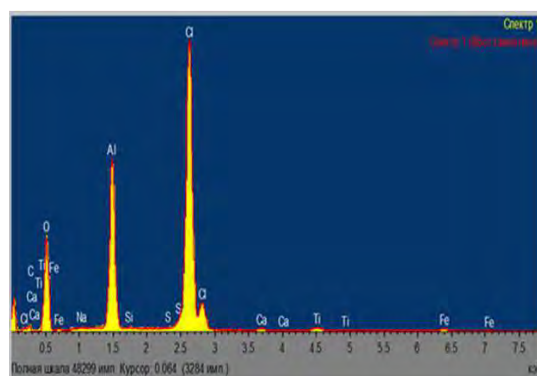
Sample No. 2.



Aqua Aurat 30

Fig. 8. Microstructure at 10,000x magnification. Sample No. 2 and sample Aqua-Aurat 30.

Sample No. 2.



Aqua Aurat 30

Fig. 9. Comparative characteristics of the quantitative analysis of Aqua-Aurat 30 coagulant sample and Sample No. 2.

4. Conclusion

The conducted studies have shown the possibility of using microwave technologies for the synthesis of aluminum polyoxychlorides from aluminum hydroxide and sulfuric acid. The preparation of the reagent was carried out by analogy with the reactions of acid decomposition of samples in analytical

chemistry, in a microwave setup for sample preparation. Microwave technologies significantly reduce the duration of the synthesis process, increase the efficiency of the installation, there is no contact between the heating elements and the aggressive environment. At this stage of the research, household microwave ovens were used, a laboratory pilot plant was designed, research was carried out on synthesis

with a change in process parameters. The elemental, phase compositions and morphology of samples of the synthesized reagents were studied in comparison with the widely used coagulant Aqua-Aurat 30. The role of sulfuric acid was revealed as an activator of the process, which increases the efficiency of synthesis, and practically does not pass into the synthesized sample. The yield of the synthesis product with the use of the activator was 78% at a duration of 1 minute. The synthesis carried out without an activator requires a longer process time for the completeness of the reaction; with an increase in power by 20% and the duration of synthesis by 15 times, the product yield increased only by 13%. It can be assumed that the synthesis of aluminum polyoxychlorides using 600 W microwave radiation and the addition of sulfuric acid is promising, since sample 2 showed more positive results.

Acknowledgments

The authors of the article express their gratitude to the staff of the National Scientific Collective Use Laboratory on the priority «Technologies for the hydrocarbon and mining and metallurgical sectors and related service industries.»

The Program BR11765599 “Development and improvement of technologies for purifying natural waters and improving the quality of drinking water in the regions of Kazakhstan 2022-2023.” Agreement No. 04-57 dated April 29, 2022 JSC ImiO: «Development of technology for producing aluminum polyoxychloride coagulant for natural water purification» Head: Kenzhaliev B.K. Was performed with the support of the Ministry of Science and Education of the Republic of Kazakhstan.

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Исследование по применению микроволнового синтеза для получения алюминий содержащего коагулянта

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АННОТАЦИЯ

Экстенсивный путь развития промышленности и темпы роста численности народонаселения определяет увеличение количества потребляемой питьевой воды и требования к водоподготовке. Известные и применяемые технологии промышленного получения коагулянта оксихлорида алюминия, используемого в реагентной очистке воды, основаны на высокотемпературных процессах, требующих сложного аппаратного оформления. В работе представлены результаты исследований по получению основных хлоридов алюминия микроволновым способом. Эксперименты проведены на сконструированной лабораторной установке на основе микроволновой печи, получены данные по выходу полиоксихлорида алюминия в зависимости от изменения параметров процесса, продолжительности опытов, отношении Ж:Т и концентрации раствора соляной кислоты. Исследования применения микроволновых технологий в неорганическом синтезе показали эффективность подобных технологий, снижение времени реакции, увеличение КПД установки, отсутствия контакта нагревательных элементов с реакционной смесью. Установлено влияние серной кислоты, как вещества активатора процесса, положительно влияющего на выход полиоксихлоридов алюминия. Представлены результаты физико-химических исследований синтезированных образцов и их коагуляционных свойств, что указывает на возможность использования микроволновых технологий в неорганическом синтезе коагулянтов полиоксихлорида алюминия.

Ключевые слова: коагулянт, полиоксихлорид алюминия, микроволновый неорганический синтез, гидроксид алюминия.

Микротолқынды синтезді қолдана отырып, алюминий құрамды коагулянттың алынуын зерттеу

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АННОТАЦИЯ

Өнеркәсіпті дамыту мен халық санының өсу қарқындылығының экстенсивті жолы, тұтынылатын ауыз су мөлшері және суды дайындауға қойылатын талаптардың ұлғаюымен айқындайды. Өнеркәсіпте белгілі және суды тазарту реагенті ретінде қолданылатын алюминий оксихлоридінің коагулянттың алудың технологиясы күрделі аппаратты қажет ететін, жоғары температуралық үрдістермен негізделген. Жұмыста, микротолқынды әдіспен алюминий хлоридің алудың

негізгі көрсеткіштері зерттелінді. Тәжірибелер, микротолқынды пеш негізімен құрастырылған зертханалық қондырғыда жүргізілді, үрдістегі көрсеткіштердің, соның ішінде Қ.З:С қатынасы, ұзақтығы және концентрленген тұз қышқылының ерітіндісінің өзгеруіне сай алюминий полиоксихлоридінің шығымы бойынша көрсеткіштер алынды. Бейорганикалық синтезге микротолқынды технологияларды қолданғандағы әрі осыған ұқсас тиімді технологиялардың зерттеулермен, реакция уақытының баяулауы, КПД қондырғысының артуы, қыздыру элементтерінің реакция қоспасымен байланысының болмайтындығы көрсетілді. Синтезделген үлгілердің және олардың коагуляциялық қасиеттерінің физикалы-химиялық зерттеулерінің нәтижелерімен, бейорганикалық синтезбен алюминий полиоксихлорид коагулянттарының микротолқынды технологиясын қолданғудағы мүмкіндіктері көрсетілді.

Түйін сөздер: коагулянт, алюминий полиоксихлориді, микротолқынды бейорганикалық синтез, алюминий гидроксиді.