

# Sorption-spectroscopic of Rhenium ion production of detection methods

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**Abstract.** In this research article, the sorption-spectroscopic of Rhenium ion production detection methods is presented. Various sorbent types were ascertained by the vismutol-2 reagent's immobilization levels and ideal operating conditions. The process of immobilizing the vismutol-2 reagent to the carrier was discovered, and the perfect circumstances for its convoluted formation using Rhenium (III) ions and metrological characteristics were established. A compassionate and selective sorption-spectroscopic approach is demonstrated for identifying the ions of Rhenium (III). The devised sorption spectroscopy was used on natural cakes, technological fluids, and industrial waste; mathematical statistics were used to interpret the results, and details regarding its application in the study were provided.

## 1 Introduction

The growing global demand for rare metals results in an annual decline in the amount of ore mined and a yearly reduction of all varieties of minerals. Sensitive techniques are now required since sewage effluent has a low rare metal content. Current physicochemical methods must be developed, improved, and widely applied to address this shortcoming.

The republic is putting a lot of effort into refining and introducing a novel process for extracting rare metals from organic reagents and synthetic sorbents. Some progress has been made in this direction. The method of improving the sector to a good level of quality, in-depth handling of indigenous materials, speeding up the manufacturing of finished goods, and enhancing the technology to acquire innovative types of products are outlined in a development approach for further growth of the Republic of Uzbekistan. Significant assignments intended to effectively use synthetic materials in the solution of various environmental protection-related problems, it is crucial to obtain synthesis materials from regional raw materials and to build novel sorts of sorption-spectroscopic components with improved qualities [1]. Around 4640.8 m<sup>3</sup> of ore are available in the Almalyk copper mine in Uzbekistan. The literature states that these ores include 371.27 MT of molybdenite with a molybdenum concentration of about 0.060 kg/t. Molybdenite and rhenium contents are 1350 g/t on average. Therefore, molybdenite contains 495 tons of rhenium reserves. One

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kilogram of Rhenium costs 1,500 USD; the remaining value is around \$742,500,000. It permits Uzbekistan to increase its output of the valuable metal [2].

Chalcogenides are the most stable rhenium compounds discovered in nature; rhenium metal disulfide has been shown to have physical and structural properties similar to those of molybdenum and tungsten disulfide. Rhenium is almost identical to molybdenum in terms of its chemical and physical properties, followed by the W, So, Su, V, Ni, and other elements [3-5].

Due to its scattered distribution, only some minerals contain Rhenium. One common mineral that is highly sought after is jezkazganite-SuReS<sub>4</sub>. The molybdenum and sulfur ores have been investigated. It is stated that Almalyk ores contain it in this mineral form. Minerals containing molybdenite and copper sulfide are the primary rhenium sources in scattered form.

Additionally, it is primarily present in the minerals bornite, chalcopyrite, and jezkazganite. As a result, research has been done on Rhenium's extraction and characteristics as satellites in copper and molybdenum technologies [6-8]. Decreasing rhenium sulphide by H at a temperature of 900 to 1000 °C until free metals residues [9] could detect Rhenium in its pure metallic state. The degree of destruction of those that combine with heptasulfide to generate volatile chemicals, including sulfur, arsenic, germanium, and selenium, has been explored in detecting Rhenium.

The effect of foreign ions was investigated, stoichiometric quantities were computed, spectral features were determined by utilizing the photometric reagents diketohydrindiamine for the measurement of Rhenium and molybdenum, and the photometric technique with the Sr-0.3 was created for pharmacology [10-12].

The ideal circumstances for rhenium 4 to form a complex with tetraphenylarsazole have been researched in the literature [8]. Based on these parameters, the complex formed a complex that remained stable for one day at a pH of 1 and in a medium containing 1 mg of hydrochloric acid. Rhenium was shown to be hampered by the presence of Mo (IV), Ag (I), Au (III) and Pd (II) ions in high quantity. Using nitron perrhenate adsorbed on a colourless polymethacrylate matrix, a method for determining Rhenium (III) was created; according to research, with rN = 1, 1 mg/l of Rhenium can be detected, with Sr = 0.03-0.05.

## 2 Materials and methods

Oxidation-reduction is the basis for the permanganometric method's experience in measuring the rhenium ion [13]. Hydrenium hydride is dissolved with amalgamated Zn and titrated with KMnO<sub>4</sub> to create Rhenium perrhenate. The rhenium oxidation state in this instance ranges from -1 to +7. This is accomplished by boiling 125 millilitres of concentrated H<sub>2</sub>SO<sub>4</sub> and up to 15 millilitres of a solution containing 500 milligrams of rhenium ion under a CO<sub>2</sub> stream to eliminate oxygen. In the same way, 150 mL of H<sub>2</sub>SO<sub>4</sub> was added after cooling it to 5 °C in a water bath. A Jones reducing column is used to pour 50 ml of a 0.1 N potassium permanganate solution into a 50 ml chilled sulphuric acid solution (1:19) of amalgamated zinc.

The analyzed mixture and remaining sulphuric acid are then added and titrated using 0.05 N permanganate reagent KMnO<sub>4</sub>. The test is conducted in a dry conical flask. As an alternative, 1.164 g of the KMnO<sub>4</sub> solution or 1 or 0.05 mg of the rhenium ions are used in the experiment. Procedure for the reaction: Two to three grams of calcium oxide, two grams of ammonium perrhenate, and 1 to 2 grams of potassium permanganate were added to a 0.2 to 2-gram sample and thoroughly mixed in a porcelain mortar. A muffle furnace (1000 °C SNOL) was then used to heat two to three grams of calcium oxide. Following a predetermined amount of time, the specimen was cooled, moved to a tiny crucible (4 DTS 9147-80), paired with 40 to 60 ml of boiling water in a flask, and allowed to boil for two

hours. Following cooling, a double filter was used to filter the solution. The residue left behind was then dissolved in the HCl solution and again filtered using a double filter. After cooling, the filtered solution was cleaned six to seven times using distilled water. After the mixture was moved to a 200 ml flask, the distilled water was poured to the volume to make it right [14-16].

The atomic absorption spectrometer (Optima-8300) was used in the analysis to determine the Rhenium (III) ion experimentally. Consequently, for the Rhenium (III) ion, the analyzed spectral lines correspond to the wavelengths of 221,426 nm.

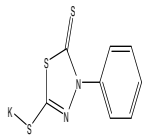
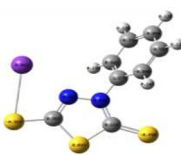
### 3 Results and Discussion

The sorption-spectroscopic approach was used to analyze organic materials' reactions and determine the various metal ions present.

It is known that reagents from different organic classes can detect trace levels of the metal ion under investigation [11-14]. We believed that the visual-2 solution was the best and most appropriate organic reagent for the rhenium ion [15-16]. It has been demonstrated that these reagents have excellent selectivity, sensitivity, and metrological qualities.

Vismutol-2 solution enables us to recognize it as a promising reaction for measuring the rhenium ion, given all the information on its employment in studying the discovered metal ion and its beneficial chemical and analytical features. Since there are several ways to detect the rhenium ion, we use the spectrophotometric characters of vismutol-2 substances for this purpose. After that, we investigated the reagent's structure and, based on initial research, determined that it was appropriate for the item being studied [17-19].

**Table 1.** Structural formula and designation of the studied reagent.

Structural structure	Gross structure	Quantum formula	Systematic nomenclature name	Total: 9.7342
	$C_8H_5S_3N_2K$		5-mercapto-3-phenyl-1,3,4-thiadiazolthione-2 potassium	Charges N- 0.528 -[N(1)] S-0.294 - [S(3)] C-0.085 - [C(4)] C-0.106 - [C(6)] K- 0.361 - [K(8)] S- 0.503- [S(9)] C- 0.126 - [C(10)]

Based on Table 2, we chose the bismutol-2 organic solution because of its excellent reactivity as a test reagent and analytical characteristics. Vismutol-2 was selected as an organic reagent due to its high sorption capability, and to prepare immobilized carriers, fibre sorbents were chosen and subjected to chlorination using the organic reagent 5-mercapto-3-phenyl-1,3,4-thiadiazolthione-2 (vismutol-2). On  $[H^+]$  sorbents, PAN GMDA, PPM-1, and PPA-1 were immobilized. Table 2 presents the best conditions for every immobilized fibre based on the acquired data.

**Table 2.** Choosing the optimal carrier ( $l=1$ ,  $t=25\pm 5$  °C).

Fibre	A - until immobilization (vismutol – 2)	A is immobilized after (vismutol – 2)	$\Delta A$
PPA-1 $[H^+]$	0.350	0.120	0.230
PPM-1		0.090	0.260
PAN-GMDA		0.190	0.160

The chart indicates that PPM-1 is the most effective immobilizing fibre, and additional research was conducted using this fibre. The immobilization technique: After adding 10 ml of 0.1% bismuth-2 solution to 10 L cups, 0.2 g of fibre was included and stirred for five to eight minutes with a glass rod. The fibre was then rinsed with clean water, and the quantity of reagent that settled on it was measured.

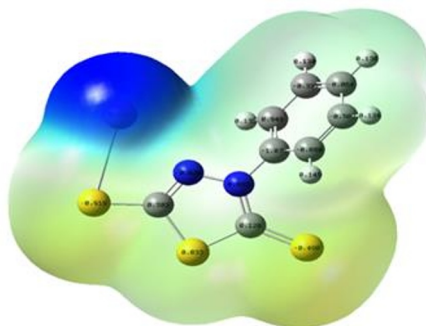
Fibre, reagent, buffer, and metal ions were added to 100 ml cups to determine the ideal conditions for visual-2 organic solution among the approaches above. The optical densities of each component were then calculated ( $\lambda_{max}$ -460, t-30 min, pH-4-5, universal buffer) and the results are displayed in Table 3.

**Table 3.** Casting procedure (t= 30 min, T=250C, pH=4-5 universal buffer, PPM-1).

Pouring order	Difference in the optical density - $\Delta A$
Reagent + Me + Fibre + Buffer	0.230
Reagent + Me + Buffer + Fiber	0.265
Fibre + Buffer + Me + Reagent	0.290
Fibre + Reagent + Buffer + Me	0.332
Reagent + Fibre +Buffer + Me	0.118
Me + Fibre + reagent + Buffer	0.105
Reagent + Buffer + Fibre +Me	0.126
Reagent + Me + Buffer + Fibre	0.113
Me + Fibre +Buffer + reagent	0.109

Table 4 shows that the 3<sup>rd</sup> injection strategy was applied after bismutol-2 reagents had been immobilized on PPM-1 fibre and Rhenium (III) ions were transported. This resulted in the highest analytical signal being seen. Using a spectrophotometer IV-ViS, the wavelength intensity, pH, solvent organic substance, buffer mixture, organic reagent concentration, and complex injection technique were investigated in developing a complicated mixture of rhenium ions with a reagent. The results of an investigation into the process of the analytical reactions between rhenium ions and bismutol-2 reagent are shown in Figure 1 and Table 4.

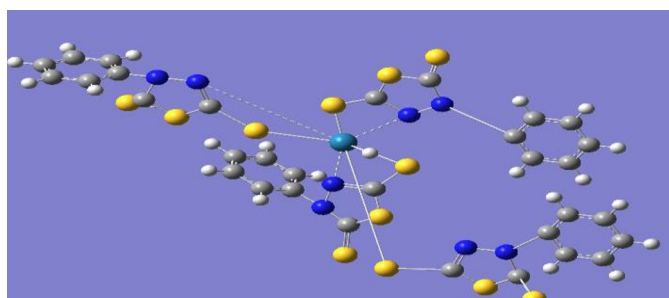
Quantum calculations for the reagent were performed in the Gaussian program with the 6-311+G (D, P) basis set, utilizing the RB3LYP analysis method. The findings demonstrated the highest optical density is reached at  $\lambda = 450$  nm when the vismutol-2 organic solution complexes with the Rhenium (III) ion. The likelihood of the metal atom attaching to the reagent was investigated chemically based on the computation results (result in Figure 2).



**Fig. 1.** Vismutol-2 reagent in the Gaussian program in quantum chemical methods, the structural formula of the reagent.

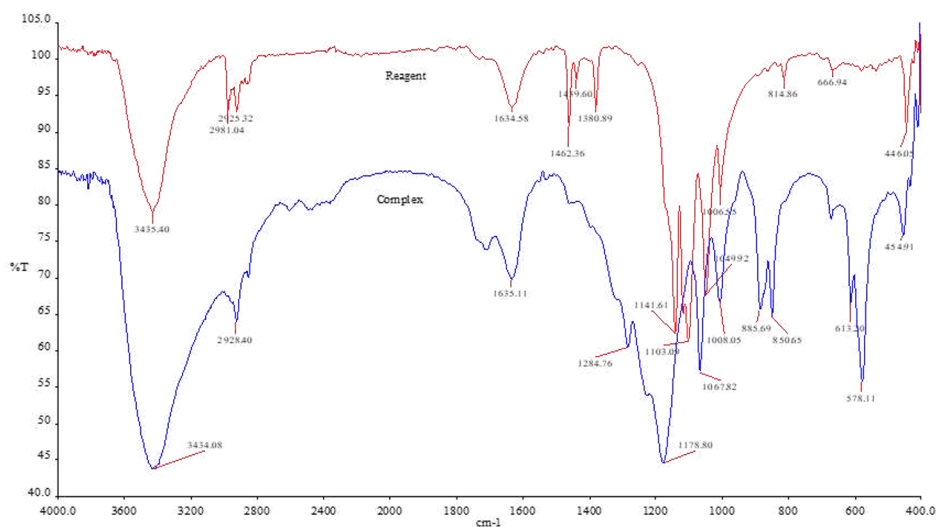
**Table 4.** Quantum-chemical calculations of vismutol-2 reagent in the Gaussian system.

Gaussian Summary- Calculation		
Method	RB3LYP	
Basis Set	6-311+G (D,P)	
Electronic Energy	-2212.1091	Hartree
	-60194.5860 eV	
	-1388119.7757 kkal/mol	(+) space
RMS Gradient Norm	$9 \times 10^{-6}$	Hartree or Bohr
Dipole Moment	12.4410	Debye



**Fig. 2.** Using Gauss View methods, the rhenium ion was determined in a state close to nitrogen and sulfur atoms.

In the first scenario, as illustrated in Figures 1 and 2, the rhenium ion and oxide are positioned close to the heteroring, and the system's configuration is optimized using the MOPAC program PM 7 and Gauss View techniques. The perrhenate anion and potassium cation move away from the reagent molecule. About rhenium oxide, it was found that the rhenium atom formed a coordination bond with the nitrogen and sulfur atoms by moving in their direction. To verify the outcome, the structural mechanism of the complex formed by the Rhenium (III) ion together with the bismutol-2 reagent was examined using I.R. spectroscopy (Figure 3).



**Fig. 3.** I.R. spectrum of the Rhenium (III) ion complex of vismutol-2 reagent.

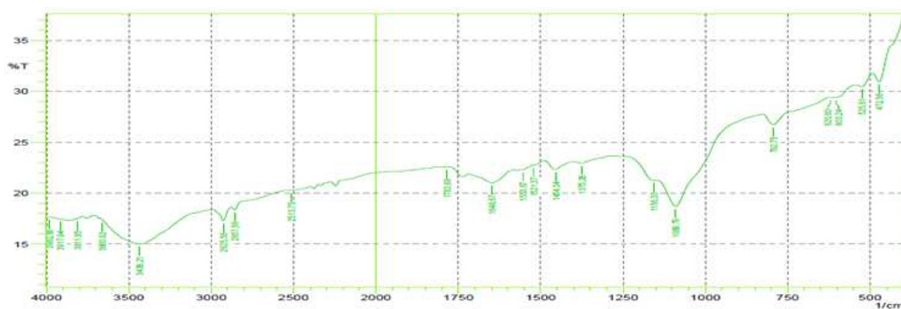
The chemistry of complex formation and the IR-spectral analysis is shown in Table 05. After it was established that the concentration was high, this reagent was employed in more research.

The main change in the metal ion's I.R. spectrum analysis is the presence of the following groups: 2246  $\text{cm}^{-1}$  from the  $-\text{C}\equiv\text{N}$  group and 1648–1651  $\text{cm}^{-1}$  from the  $-\text{N}=\text{N}=\text{N}$  group; 3424–3436  $\text{cm}^{-1}$  from the  $=\text{N}-\text{H}$  group; and  $\text{C}=\text{S}$  in the areas that belong to the group.

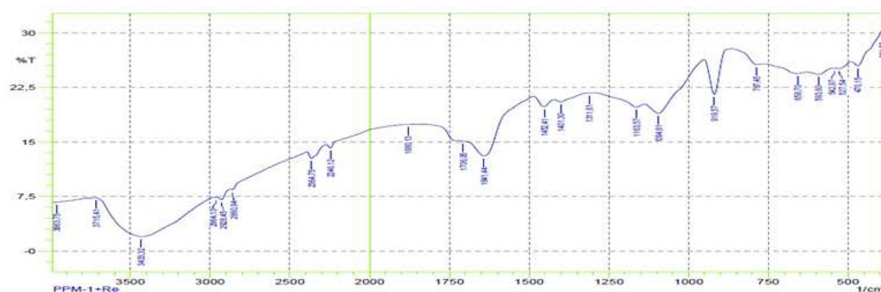
**Table 5.** Results of IR-spectra of organic reagent bismuth-2 immobilized on PPM-1 fibre and its complex with Rhenium (III) ion.

Fibre	$\text{C}\equiv\text{N}$	$\text{N}-\text{H}$	$-\text{N}=\text{N}=\text{N}$	$\text{CH}_2-$	Ar	$-\text{C}=\text{O}$	$\text{O}-\text{Me}$
PPM-1	2246 $\text{cm}^{-1}$ intensive	346 $\text{cm}^{-1}$	1648 $\text{cm}^{-1}$	2926 $\text{cm}^{-1}$	1090 $\text{cm}^{-1}$		
PPM-1+Me		3433 $\text{cm}^{-1}$ intensive	1648 $\text{cm}^{-1}$ little intensive	2928 $\text{cm}^{-1}$ little intensive	1094 $\text{cm}^{-1}$ intensive		592 $\text{cm}^{-1}$
PPM-1+Reagent+Me	2245 $\text{cm}^{-1}$ intensive	3424 $\text{cm}^{-1}$	1654-1651 $\text{cm}^{-1}$ intensive		1092 $\text{cm}^{-1}$ intensive	1730 $\text{cm}^{-1}$ intensive	469- 590 $\text{cm}^{-1}$

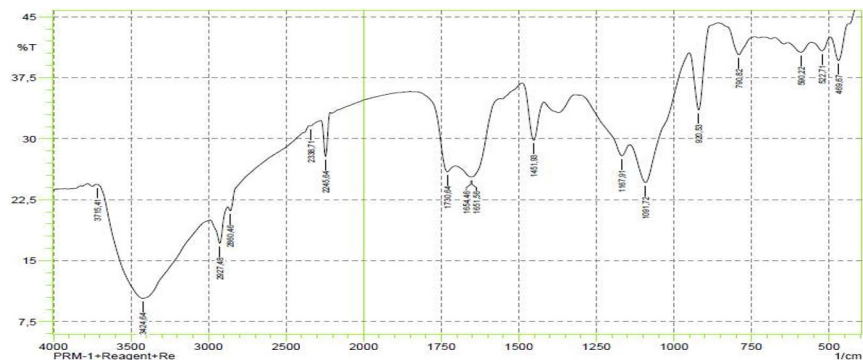
Results in Figures 1-3, and Table 5 demonstrate that the PPM-1 polymer sorbent complex immobilized with Rhenium (III) ions has a distinctive frequency of 469–590  $\text{cm}^{-1}$ , matching to  $\text{O}-\text{Re}$ .



**Fig. 4.** Experimental I.R. spectrum of PPM-1 fiber.



**Fig. 5.** I.R. spectrum obtained in the PPM-1 fibre and rhenium (III) ion complex experiment.



**Fig. 6.** Shows the I.R. spectrum of the complex formed with the Rhenium (III) ion on immobilized PPM-1 fibre using the bismutol-2 reagent.

## 4 Conclusion

The ideal circumstances were examined for the suggested reagent to compound with the rhenium ion in the solution. In an acidic environment with a pH of =4-5, the Rhenium (III) ion complexation was evaluated at various time intervals and  $20 \pm 5$  °C. The vismutol-2 reagent PPM-The duration of complete immobilization to 1 fibre was ascertained. Using  $\text{SnCl}_2$  to form the complex into a tablet, the mechanism of the complex formation created by the immobilized bismutol-2 reagent of Rhenium (III) ion was investigated by IR-spectroscopy (SHIMADZU) in the  $400\text{--}4000\text{ cm}^{-1}$  frequency range. Moreover, semi-empirical Gaussian, MOPAC 2016 software PM 7, and Gauss View approaches were utilized to ascertain the Rhenium (III) ion-free, sulfur approach state.

The method for determining Rhenium (III) ion employed immobilized organic reagents to boost selectivity and sensitivity. Vismutol-2, an organic reagent, was suggested to be immobilized on the PPM-1 carrier, and the ideal immobilization parameters were identified.

## References

1. J.H. Fendler, C.M. Fiona, *Advanced Materials*, **7**, 7 (1995)
2. M.M. Rustamjon, M.N. Kuchkarbaevna, *European Scholar Journal (ESJ)*, **3**, 9 (2022)
3. Y.D. Lampeka, L.V. Tsybmal, *Theoretical and Experimental Chemistry*, **51**, 141-162 (2015)
4. E.W. Thomas, D.F. Wood, *Analytical chemistry of molybdenum and tungsten: including the analysis of the metals and their alloys*, Elsevier, **47** (2013)
5. B. Abdullayev, N. Askarova, R. Toshkodiroya, M. Rifky, N. Ayakulov, B. Kurbanov, M. Samadiy, *Recent Developments in the Extraction of Lithium from Water Resources*, *Asian Journal of Chemistry*, **36**, 275-280 (2024).
6. S. Evgenii, *Physical metallurgy of refractory metals and alloys*, Springer Science & Business Media (2012)
7. L.A. Richard, *Molybdenum disulphide lubrication*, Elsevier (1999)
8. O. Ziyodullo, D. Absattorov, M. Rifky, S. Rakhimkulov, I. Usmanov, D. Ramazonova, Z. Matkarimov, M. Samadiy, *Research of bittern concentration processes lake Karaumbet and Barsakelmes*, *E3S Web of Conferences*, **411**, 02035 (2023)

9. S. Leiting, F. Tesfaye, X. Li, D. Lindberg, P. Taskinen, *Minerals Engineering*, **161**, 106719 (2021)
10. M.P. Volynets, F.M. Boris, *Critical Reviews in Analytical Chemistry*, **25**, 4 (1996)
11. G.H. Farrah, L.M. Melvin, *Analytical Chemistry*, **31**, 4 (1959)
12. K. Dissanayake, M. Rifky, J. Farmonov, Y. Boynazarova, A. Meyliyev, K. Zokirov, F. Narziyev, M. Samadiy, Impact of incorporating inorganic additives in processed meat production, *E3S Web of Conferences*, **510**, 01037 (2024)
13. G. Zaitseva, *Analytical chemistry, Part 2, Quantitative analysis* (2021).
14. J.R. Okalebo, W.G. Kenneth, L.W. Paul, *Laboratory methods of soil and plant analysis: a working manual second edition, Sacred Africa, Nairobi*, **21** (2002)
15. S. Hermann, K. Stalder, *Clinica chimica acta*, **18**, 2 (1967)
16. S. Israiljan, A. Kambarov, R. Najmiddinov, I. Rustamov, I. Usmanov, M. Samadiy. "Study of Physico-Chemical Properties of Phosphorate Solutions," In *E3S Web of Conferences*, **392**, 02036 (2023)
17. C. Julie, N. Fruh, A. Togni, *Chemical reviews*, **115**, 2 (2015)
18. X. Ju, J. Wang, F. Yuan, X. Pan, M. Samadiy, T. Deng, Y. Guo, "Volumetric properties of the binary aqueous system lithium metaborate from 283.15 to 363.15 K and 101 kPa: Experimental and thermodynamic model." *Journal of Molecular Liquids* **366**, 120174 (2022)
19. B. Abdullayev, M. Rifky, J. Makhmayorov, I. Usmanov, T. Deng, M. Samadiy, Adsorption Method and Adsorbents for the Recovery of Lithium Compounds from Water Sources, *International Journal of Engineering Trends and Technology*, **71**, 212-226 (2023)
20. M. Makhmudjon, A. Nimchik, O. Khodjiyev, M. Jesfar, K. Zokirov, S. Shamatov, K. Toshpulatov, A. Kambarov, Analyzing the chemical standards of the Fergana Mekhmash wastewater treatment plant and environmental processing, *E3S Web of Conferences*, **498**, 02016 (2024)
21. A. Nimchik, G. Pulatov, F. Yusupov, B. Haydarov, A. Kambarov, Use of acid gases in the production of sodium sulphide, *E3S Web of Conferences*, **494**, 02003 (2024)
22. D. Kasun, M. Rifky, M. Jesfar, J. Makhmayorov, S. Rakhimkulov, B. Abdullayev, Technology Development to Measure Chemical and Oxidative Stability of Edible Oils Using Fourier Transform-Infrared Spectroscopy, In *IOP Conference Series: Earth and Environmental Science*, **1275**, 012007 (2023)