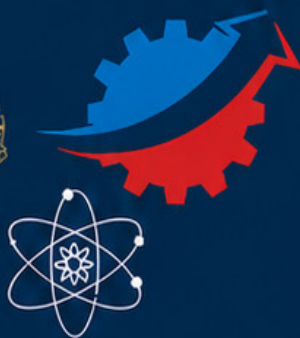


MUHANDISLIK

& IQTISODIYOT

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

2026-YIL
IYUL/7-SON, II-QISM



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- 05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
- 05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
- 05.01.03 – Informatikaning nazariy asoslari
- 05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
- 05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
- 05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
- 05.01.07 – Matematik modellash
- 05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
- 05.02.00 – Mashinasozlik va mashinashunoslik
- 05.02.08 – Yer usti majmualari va uchish apparatlari
- 05.03.02 – Metrologiya va metrologiya ta'minoti
- 05.04.01 – Telekommunikatsiya va kompyuter tizimlari, telekommunikatsiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
- 05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
- 05.05.05 – Issiqlik texnikasining nazariy asoslari
- 05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
- 05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
- 05.08.03 – Temir yo'l transportini ishlatish
- 05.08.06 – "G'ildirakli va gusenisali mashinalar va ularni ishlatish" (texnika fanlari)
- 05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
- 05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
- 10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
- 10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti
- 08.00.01 – Iqtisodiyot nazariyasi
- 08.00.02 – Makroiqtisodiyot
- 08.00.03 – Sanoat iqtisodiyoti
- 08.00.04 – Qishloq xo'jaligi iqtisodiyoti
- 08.00.05 – Xizmat ko'rsatish tarmoqlari iqtisodiyoti
- 08.00.06 – Ekonometrika va statistika
- 08.00.07 – Moliya, pul muomalasi va kredit
- 08.00.08 – Buxgalteriya hisobi, iqtisodiy tahlil va audit
- 08.00.09 – Jahon iqtisodiyoti
- 08.00.10 – Demografiya. Mehnat iqtisodiyoti
- 08.00.11 – Marketing
- 08.00.12 – Mintaqaviy iqtisodiyot
- 08.00.13 – Menejment
- 08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
- 08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
- 08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
- 08.00.17 – Turizm va mehmonxona faoliyati

Ma'lumot uchun, OAK
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COMPOSITION ANALYSIS OF DEMERCAPTANIZED RESIDUAL STREAMS AND GAS CONDENSATES AS RAW MATERIALS FOR THE SYNTHESIS OF MERCAPTAN-CONTAINED ODORANTS

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Abstract: This article describes the structural analysis of demercaptanization residual flows and gas condensates as raw materials for the synthesis of mercaptanic odorant. As a result of gas chromatographic analysis, it was established that the content of methyl-, ethyl-, propyl-, isopropyl-, isobutyl-, and n-butylmercaptans in gas condensate and demercaptanization residual streams is high, and they are promising as the primary raw material for obtaining odorant components. It is scientifically substantiated that during the alkaline extraction process, mercaptans react with NaOH and transition into the aqueous phase in the form of sodium mercaptide (RSNa); at a flow rate of 120 l/h and 5% NaOH, the concentration of RSN after extraction was 920 ppm, while at a flow rate of 70 l/h and 10% NaOH, this value decreased to 120 ppm, and the RSN concentration reached 6450 ppm. These results showed that an increase in alkali concentration and a decrease in flow velocity increase the transition of mercaptans into the alkaline phase.

Keywords: natural gas, sulfur, secondary flow, methylmercaptan, ethylmercaptan, isopropylmercaptan, odorant, condensate.

Annotatsiya: Ushbu maqolada merkaptanli odorant sintezi uchun xomashyo sifatida demerkaptanizatsiya qilingan qoldiq oqimlar va gaz kondensatlarining tarkibiy tahlili bayon etilgan. Gaz xromatografik tahlillar natijasida gaz kondensati va demerkaptanizatsiya qilingan qoldiq oqimlar tarkibida metil-, etil-, propil-, izopropil-, izobutil- va n-butilmerkaptanlar ulushi yuqori bo'lib, ular odorant komponentlari olish uchun asosiy xomashyo sifatida istiqbolli ekanligi asoslandi. Ishqoriy ekstraksiya jarayonida merkaptanlarning NaOH bilan reaksiyaga kirishib, natriy merkaptid (RSNa) shaklida suvli fazaga o'tishi ilmiy jihatdan asoslanib, 5 % NaOH va 120 l/soat oqim tezligida ekstraksiyadan keyingi RSH konsentratsiyasi 920 ppm ni tashkil etgan bo'lsa, 10 % NaOH va 70 l/soat oqim tezligida bu qiymat 120 ppm gacha kamaydi hamda RSNa konsentratsiyasi 6450 ppm ga yetdi. Ushbu natijalar ishqor konsentratsiyasining ortishi va oqim tezligining kamayishi merkaptanlarning ishqoriy fazaga o'tishini kuchaytirishini ko'rsatdi.

Kalit so'zlar: tabiiy gaz, oltingugurt, ikkilamchi oqim, metilmerkaptan, etilmerkaptan, izopropilmerkaptan, odorant, kondensat.

Аннотация: В статье описан композиционный анализ демеркаптанизованных остаточных потоков и газовых конденсатов как сырья для синтеза меркаптановых одорантов. В результате газохроматографического анализа было доказано, что газовый конденсат и демеркаптанизованные остаточные потоки содержат высокую долю метил-, этил-, пропил-, изопропил-, изобутил- и н-бутилмеркаптанов, которые являются перспективным основным сырьем для производства одорантных компонентов. Научно доказано, что меркаптаны реагируют с NaOH в процессе щелочной экстракции и переходят в водную фазу в виде меркаптида натрия (RSNa), при этом при скорости потока 5% NaOH и 120 л/ч концентрация RSH после экстракции составляла 920 ppm, тогда как при скорости потока 10% NaOH и 70 л/ч это значение снижалось до 120 ppm, а концентрация RSNa достигала 6450 ppm. Полученные результаты показали, что увеличение концентрации щелочи и уменьшение скорости потока усиливают перенос меркаптанов в щелочную фазу.

Ключевые слова: природный газ, сера, вторичный поток, метилмеркаптан, этилмеркаптан, изопропилмеркаптан, одорант, конденсат.



INTRODUCTION

In our republic, significant results are being achieved in ensuring safety in gas supply systems, rapidly detecting gas leaks, and obtaining highly effective odorant substances. In the production of mercaptan odorants for gas systems, research is being conducted to improve their odor sensitivity, stability, and interphase distribution processes between components, increase the efficiency of extraction and regeneration stages, and develop scientific and technological foundations.

In this regard, it is of great importance to address urgent scientific, technical, and economic problems, such as determining the influence of component ratios in mercaptan mixtures based on gas condensate fractions and dimercaptization waste on their main technological and operational properties, as well as the mechanism of interphase transformation formation.

REVIEW OF LITERATURE ON THE SUBJECT

It is noted in the literature that in the early stages, simple sulfides and disulfides were used as odorants for natural gas. However, due to their insufficient stability and partly toxic effects, mercaptans (thiols) were later widely used. For example, the effectiveness of ethyl and methyl mercaptans in odorization was analyzed in the works of J. Davis (1962) and F. Schuler (1974).

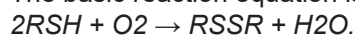
In recent decades, many scientists have been paying attention to the environmental safety of substances added to natural gas. In particular, the studies of A. Brunner (1998) and K. Schmidt (2005) studied the negative impact of organic sulfur compounds on air quality as a result of their release into the atmosphere. Therefore, work is underway in a number of European countries to develop alternative sulfur-free odorants.

Recent papers (Li et al., 2017; Zhang et al., 2020) have analyzed the ways to ensure the stable preservation of odorants in gas composition based on nanoencapsulation technology. Modern research has also been conducted on automation and monitoring systems for the odorization process.

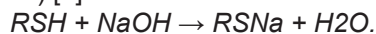
Currently, the first scientist in Uzbekistan to establish a local odorant production technology is Sharipov Kahramon Kandiyyorovich, a candidate of chemical sciences at Bukhara State Technical University. He localized the odorant substance added to natural gas in 2021.

The demercaptanization process is a chemical process aimed at neutralizing the most harmful sulfur-containing compounds in oil and gas condensates - mercaptans (thiol compounds). Mercaptans are represented by the general formula RSH and possess a pungent, unpleasant odor, which reduces the quality of fuel products and causes severe corrosion on metal surfaces. Therefore, the dimercaptanation process is used to convert them into stable, odorless compounds. Demercaptanization is essentially based on the catalytic oxidation of mercaptans to form disulfides (SSPs), in which the sulfur atoms change to a disulfide state during the process, but the hydrocarbon skeleton is preserved.[1]

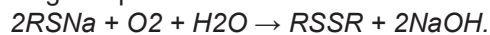
The basic reaction equation is expressed as follows:



Here, R is the hydrocarbon radical, and RSSR is the resulting disulfide compound. Disulfides are odorless, inert, and thermally stable, improving fuel quality and environmental indicators. The process is usually carried out in an alkaline medium, i.e., in a 6% NaOH solution, and in the presence of catalysts based on copper, cobalt, or manganese salts. The alkaline phase promotes the formation of mercaptans' sodium salts - mercaptides ($RSNa$):[1]



The resulting mercaptides are subsequently converted into disulfide compounds using air oxygen or other oxidizing components:



Catalysts play two main roles in the process: first, they accelerate the oxidation stage and activate the conversion of mercaptides into disulfides; second, they ensure the regeneration of NaOH and allow the process to be carried out continuously. Complexes containing Cu^{2+} , Co^{2+} , and Mn^{2+} cations are used as the most effective catalytic systems (Table 1). [1]

Table 1
Component composition of demercaptanized residual flows¹

No	Component name	Mass fraction, %
1.	Hydrogen sulfide (H_2S)	1,050

¹ Source: Developed by the author.

2.	Carbon dioxide	0.082
3.	Carbon monoxide (CO)	0.0041
4.	Carbon disulfide (CS ₂)	0.0005
Mercaptan Group		
5.	Methylmercaptan	0.180
6.	Ethylmercaptan	0.260
7.	i-Propylmercaptan	0.320
8.	n-Propylmercaptan	0.110
9.	2-methyl-2-propylmercaptan	0.045
10.	2-methyl-1-propylmercaptan	0.020
11.	1-methyl-1-propylmercaptan	0.250
Disulfide and other sulfur compounds		
12.	Dimethyl disulfide	0.0065
13.	Methyl ethyl sulfide	0.072
14.	Diethyl disulfide	0.028
15.	Methylethyltrisulfide	0.0062
16.	Ditrisulfide	0.0040
17.	2-ethylthiophen	0.0060

Furthermore, the presence of disulfide and trisulfide compounds allows for the production of additional mercaptan hydrocarbons through their reduction reaction, which may lead to an increase in the efficiency of the technology under development. Based on the results of the chromatographic analysis, it was established that the gas is a sufficiently rich raw material for extracting mercaptan compounds from a mixture of demercaptanized residual streams and creating a technology for producing odorants based on them.

RESEARCH METHODOLOGY

The research studied in detail the technology of obtaining mercaptan-type odorants from sulfur compounds, the physicochemical characteristics of the initial raw materials and reagents, the laboratory stages of mercaptan extraction and modern methods of their analysis. It was established that the process of obtaining mercaptan odorants in laboratory conditions is a complex technological system consisting of the stages of raw material preparation, alkaline extraction, intensification of extraction using promoters, phase separation, neutralization of mercaptide ions, transfer to the gas phase and product collection.

ANALYSIS AND RESULTS

During the alkaline extraction of mercaptans, the ionization of mercaptans (RSH) in an alkaline medium is accompanied by the formation of water-soluble mercaptide ions (RS⁻), but studies have shown that the alkaline extraction process is not always at a high level. Taking into account the drawbacks that arise during the extraction of these mercaptans, alkaline extraction was carried out with promoters and the effect on the efficiency of the process was investigated. The results obtained showed that the use of promoters significantly influenced the physicochemical and kinetic properties of the extraction process (Figure 1). [2]

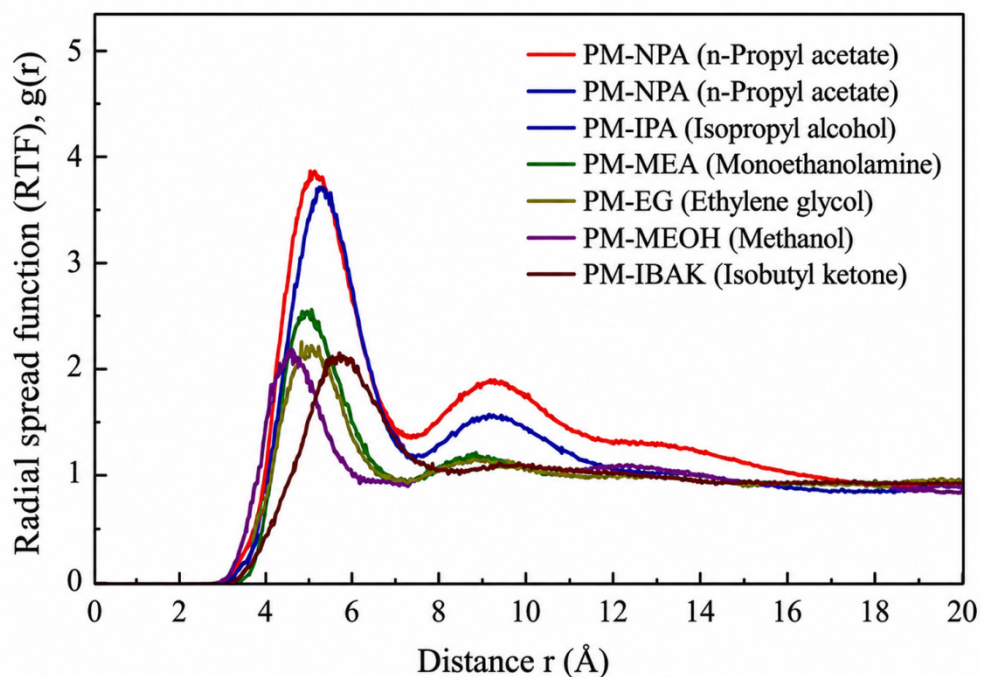


Figure 1. Changes in radial distribution functions (RDFs) between PM molecules under the influence of various solvents²

The RTF results showed that the maximum peak for all solvents is located in the range of 5–5.3 Å, indicating a significant interaction with mercaptan molecules, and the maximum peak height (Hfp) represents the strength of the solvent's interaction with mercaptan (Figure 2). [2]

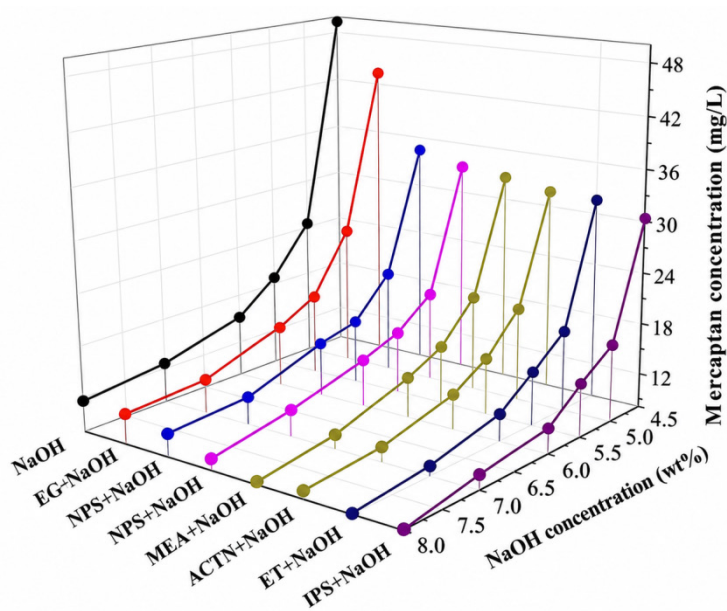


Figure 2. The extraction efficiency of alkaline solutions in the presence of IPA, NPA, ACTN, and other promoters during the separation of mercaptans from gas condensate (23 °C; 1:1 5-8 wt.%)³

The effectiveness of various hybrid solutions in extracting mercaptan impurities designated as PMs is presented (Figure 3). [2,5]

² Source: Developed by the author.

³ Source: Developed by the author.

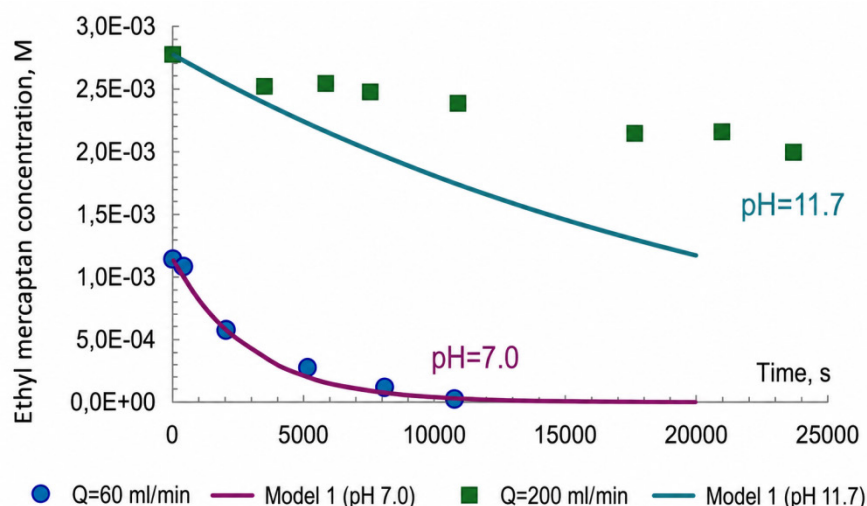


Figure 3. Process of releasing RSH from aqueous solutions into the gas phase

($T = 301$ K). Experimental points: $Q = 60$ mL/min, $V_L = 0.6$ L; $Q = 200$ mL/min, $V_L = 1.2$ L; (—) Results calculated according to model 1.⁴

In a strongly alkaline medium ($pH = 11.7$), the initial concentration of ethyl mercaptan is $\approx (2.7-2.8) \times 10^{-3}$ M, and its decrease over time is significantly lower; at 5000 seconds, the concentration remains around $\approx 2.5 \times 10^{-3}$ M, at 10000 seconds $\approx 2.4 \times 10^{-3}$ M, and at 20000 seconds $\approx (2.0-2.1) \times 10^{-3}$ M. This means that even over a long period of time, the bulk of mercaptan remains in the liquid phase, and its transition to the gas phase is significantly reduced (Figure 4). [3]

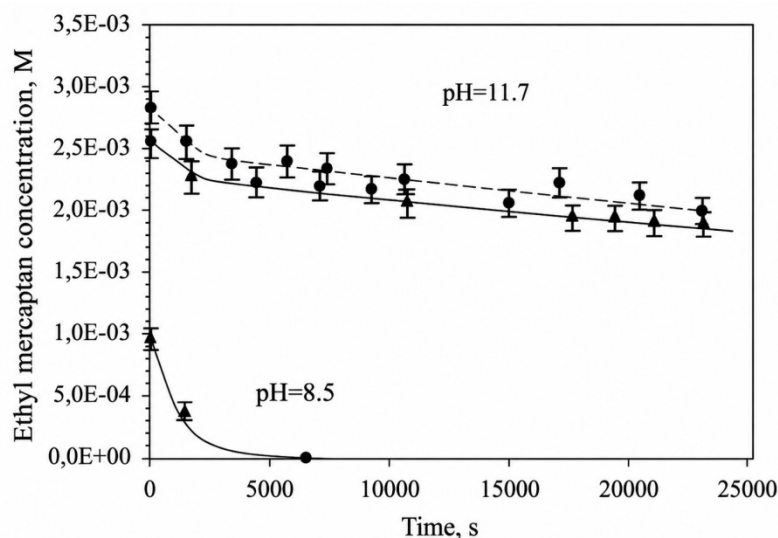


Figure 4. The process of removing RSH from aqueous solutions to the gas phase at a temperature of 301 K:

(—) Results calculated using model 2. Experimental points: $Q = 200$ mL/min, $V_L = 1.0$ L, $CRSH_o = 0.93$ mM; $Q = 400$ mL/min, $V_L = 1.2$ L, $CRSH_{2O} = 2.78$ mM; $Q = 320$ mL/min, $V_L = 1.2$ L, $CRSH_{2O} = 2.52$ mM.⁵

Since the resulting mercaptide ions ($C_2H_5S^-$) are non-volatile, they do not pass into the gas phase and remain in the solution, slowing down the desorption process. The accuracy of the mathematical model is confirmed by the fact that the experimental points obtained on the graph under various gas flow ($Q = 200, 320$, and 400 mL/min) and volume conditions coincide with the model calculations. [4]

⁴ Source: Developed by the author.

⁵ Source: Developed by the author.



CONCLUSIONS AND SUGGESTIONS

The conducted research has scientifically and practically proven that gas condensate and demercaptanized residual streams are promising raw materials for obtaining mercaptan odorants; the selection of optimal technological parameters during alkaline extraction allows for the efficient extraction of mercaptans and significantly increases the extraction efficiency of hybrid solvent systems based on organic promoters, especially IPS and ACTN. The physicochemical regularities of the process of ethyl mercaptan extraction from mercaptan mixtures have been studied in depth, mathematical models for the extraction and desorption stages have been developed, and the influence of the ionization process of mercaptans, gas-liquid balance, mass transfer, and kinetic factors on process efficiency has been theoretically and experimentally substantiated during the research.

The influence of pH value on the equilibrium between the RSH and RS⁻ forms of ethyl mercaptan was determined, and it was scientifically substantiated that under pH < 8-9, mercaptan exists mainly in a neutral (RSH) form and easily transitions into the gas phase due to its high volatility, while under pH ≥ 11, ethyl mercaptan is almost completely ionized, transitions into the form of mercaptide ions (RS⁻), and is retained in the liquid phase.

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