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Научный журнал
Издается ежемесячно с декабря 2013 года
Является печатной версией сетевого журнала
Universum: технические науки

Выпуск: 10(127)

Октябрь 2024

Часть 8

Москва
2024

УДК 62/64+66/69
ББК 3
U55

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ISSN : 2311-5122

DOI: 10.32743/UniTech.2024.127.10

Учредитель и издатель: ООО «МЦНО»

ББК 3

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TECHNOLOGY OF MATERIALS AND PRODUCTS OF THE TEXTILE AND LIGHT INDUSTRY

DOI - 10.32743/UniTech.2024.127.10.18449

TECHNOLOGY AND TECHNOLOGY FOR EFFICIENT DRYING AND CLEANING OF COTTON WITH HIGH MOISTURE AND CONTAMINATION

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ТЕХНИКА И ТЕХНОЛОГИЯ ЭФФЕКТИВНОЙ СУШКИ И ОЧИСТКИ ХЛОПКА С ВЫСОКОЙ ВЛАЖНОСТЬЮ И ЗАГРЯЗНЕННОСТЬЮ

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ABSTRACT

After drying the 3rd grade cotton with the initial moisture content of 18%, the total amount of impurities of 17.6% and small impurities of 8.4% in a two-stage drying drum 2SB-10, the cotton moisture content was 11.6%, the total amount of impurities was 16.6%, and small foreign impurities were 7.35%. After drying and cleaning this cotton on the improved equipment 6A-12M in the technological system, the cotton moisture content was 10%, total contamination was 14.9%, and fine dirt was 2.7%, and compared to cotton produced by the existing design of the 6A-12M cleaner, the moisture decreased by 1.6 (abs)%, total dirt by 0.5 (abs)%, and fine dirt by 0.83 (abs)%. At the same time, the efficiency of cleaning the equipment for small impurities was on average 63.3%, which showed that it was on average 11 (abs)% higher than that of the existing 6A-12M cleaner.

Библиографическое описание: Ruzmetov R., Kuliyev T., Tuychiyev T.O. TECHNOLOGY AND TECHNOLOGY FOR EFFICIENT DRYING AND CLEANING OF COTTON WITH HIGH MOISTURE AND CONTAMINATION // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18449*

АННОТАЦИЯ

После сушки хлопка 3-го сорта с исходной влажностью 18%, общим количеством примесей 17,6% и мелкими примесями 8,4% в двухступенчатом сушильном барабане 2СБ-10 влажность хлопка составила 11,6%, общее количество примесей - 16,6%, мелкие сорные примеси составило 7,35%. После сушки и очистки данного хлопка на усовершенствованном оборудовании 6А-12М в технологическом системы влажность хлопка составила 10%, общая загрязненность - 14,9%, мелкая грязь - 2,7%, а по сравнению с хлопком произведенного существующей конструкцией очистителя 6А-12М, влага снизилась на 1,6 (абс) %, общая грязь на 0,5 (абс) %, мелкая грязь на 0,83 (абс) %. При этом эффективность очистки оборудования по мелким сорным примесям составила в среднем 63,3%, что показало, она в среднем на 11 (абс)% выше, чем у существующего очистителя 6А-12М.

Keywords: dryer-cleaner, technological system, saw gin, fiber cleaner, temperature, cotton, fiber, seeds, dirt, cleaning efficiency, quality.

Ключевые слова: сушилка-очиститель, технологическая система, пильный джин, очиститель волокна, температура, хлопок, волокно, семена, грязь, эффективность очистки, качество.

Introduction. Due to the fact that the drying and cleaning process of low-grade cottons with high humidity and dirt in the technological system and drying-cleaning equipment used in cotton-ginning enterprises is not sufficiently improved, the cleaning efficiency of the equipment is low, which has a negative effect on the quality of the produced fibre [1]. In order to improve the cotton drying and cleaning process, the 6A-12M equipment and, accordingly, the cotton drying and cleaning technological system in the initial processing were improved on the basis of theoretical and practical research (Fig. 1, 2).

Figure 1. Overview of cotton drying and cleaning equipment

In order to study the effectiveness of the improved 6A-12M drying-cleaning equipment and the corresponding drying-cleaning technological system, comparison-research was carried out with the existing 6A-12M cotton cleaning equipment from small impurities and the existing cotton drying-cleaning technological system in the initial processing. The research work was carried out at the cotton ginning enterprise of the Khorezm region, "KHOREZMTEX" LLC. Experiments were carried out on Khorezm-127 selective grade III grade 3 cotton with an initial moisture content of 18%, total dirtiness of 17.6%, and fine dirtiness of 8.14% [2, 3]. The results are presented in Figures 3-5.

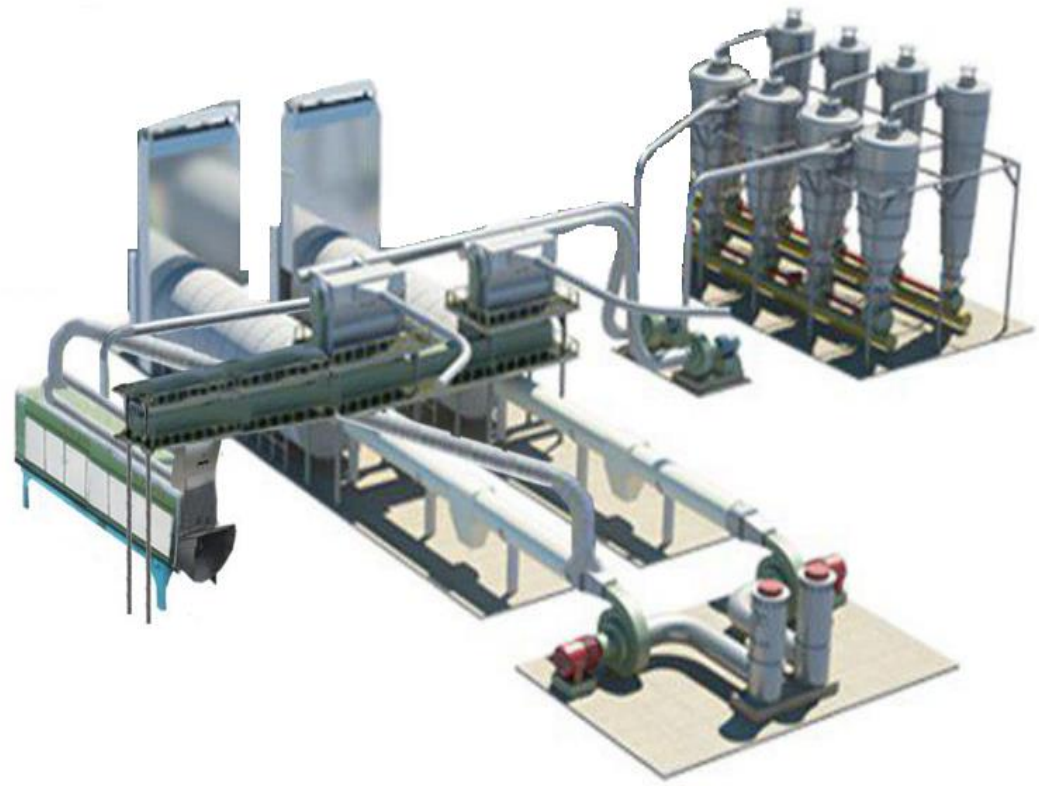
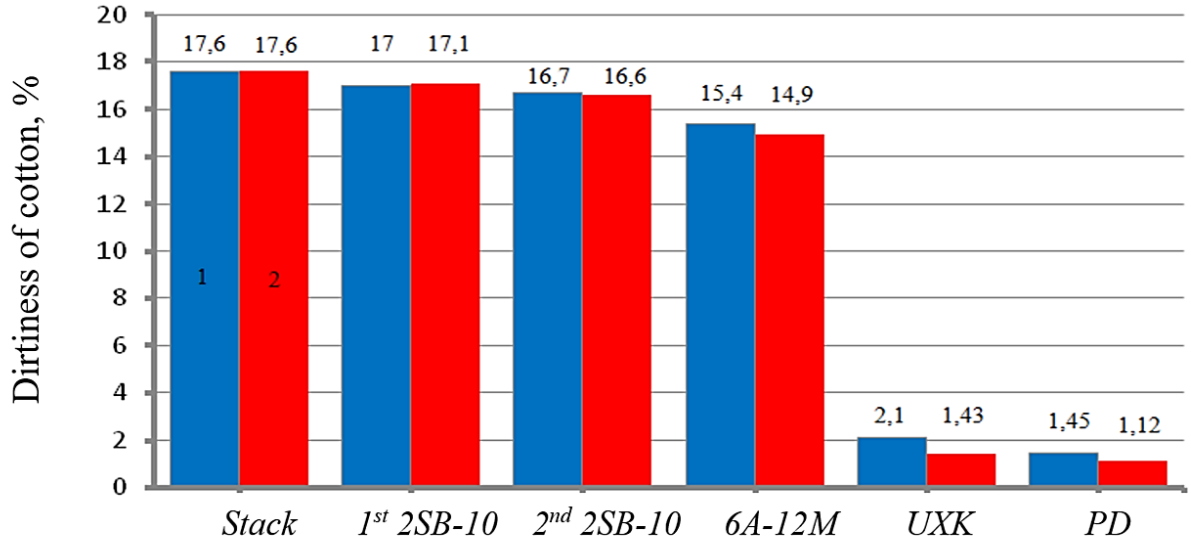


Figure 2. Scheme of the proposed technological process

Initially, research work was carried out with the current technology. 150 ^{0}C heat was given to the 1st stage 2SB-10 drying drum when processing Khorezm-127 selection III grade 3 cotton with an initial moisture content of 18%, total dirtiness of 17.6%, and fine dirtiness of 8.14% [4]. After drumming, the moisture content of the cotton was 14.6%, the total dirtiness was 17%, and the small dirtiness was 7.73%. After this cotton was heated to 140 ^{0}C in the drum in the 2nd stage and dried, the moisture content of the cotton was 11.8%, the total dirtiness was 16.7%, and the fine dirtiness was equal to 7.4% (Figure 3). Then, after the cotton is cleaned from small dirt cleaning equipment of the current 6A-12M model, the moisture content is 11.6%, the total dirt is 15.4%, and the small dirt is 3.53%, and the cleaning efficiency of the equipment for small dirt is 52.3% on average. was equal [5].



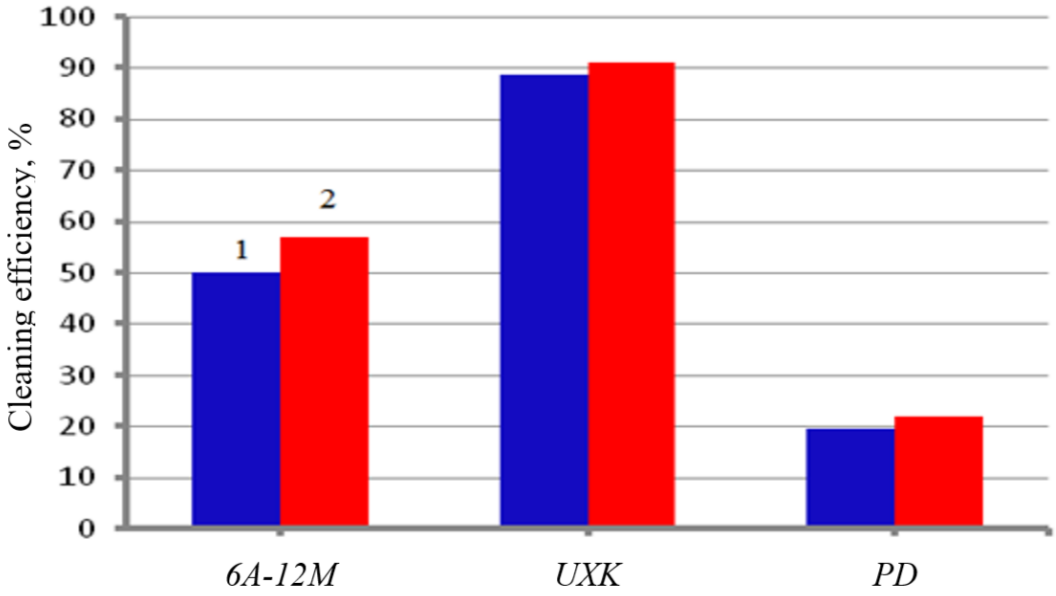
1- technological stage using the current 6A-12M type cleaner; 2- technological stage using the proposed 6A-12M type cleaner.

Figure 3. Changes in the content of impurities in cotton according to the current and proposed technological steps

This indicator is equal to 10.6% moisture and 2.1% dirtiness of cotton after UXK aggregate, and average cleaning efficiency of the aggregate was 86.4% (Fig. 4).

After the UXK aggregate, the cotton was sucked using the SS-15A type separator and given to PD by the 5DP-130 gin supplier in the technology [6, 7]. When the cotton was cleaned in the supplier and given to the gin working chamber, the moisture content and its dirt content was 1.45%. In this case, the efficiency of cleaning the supplier was equal to 19.5% on average. After the cotton was cleaned in the supplier, the ginning process was carried out [8]. The productivity of cotton ginning was 1196 kg/h on average. In cotton ginning, seed hairiness after ginning was equal to 11.6% and damage to 3.8% [9, 10]. The mass fraction of defective fibre and impurities in the post-ginning fibre was 3.88%. The fibre produced from gin was fed to a 1VPU-type fibre cleaner installed after gin using air through a nozzle and cleaned of impurities [11, 12].

The mass percentage of defective fibre and dirty impurities in the fibre after the cleaner is 2.47%, and the quality indicator belongs to grade III "Good" according to the state standard O‘zDst 632:2010. Then, in order to study the effectiveness of the proposed equipment and technological system, 1st-stage 2SB-10 type drying was carried out when processing Khorezm-127 selection III grade 3 cotton with an initial moisture content of 18%, total dirtiness of 17.6%, and fine dirtiness of 8.14%.



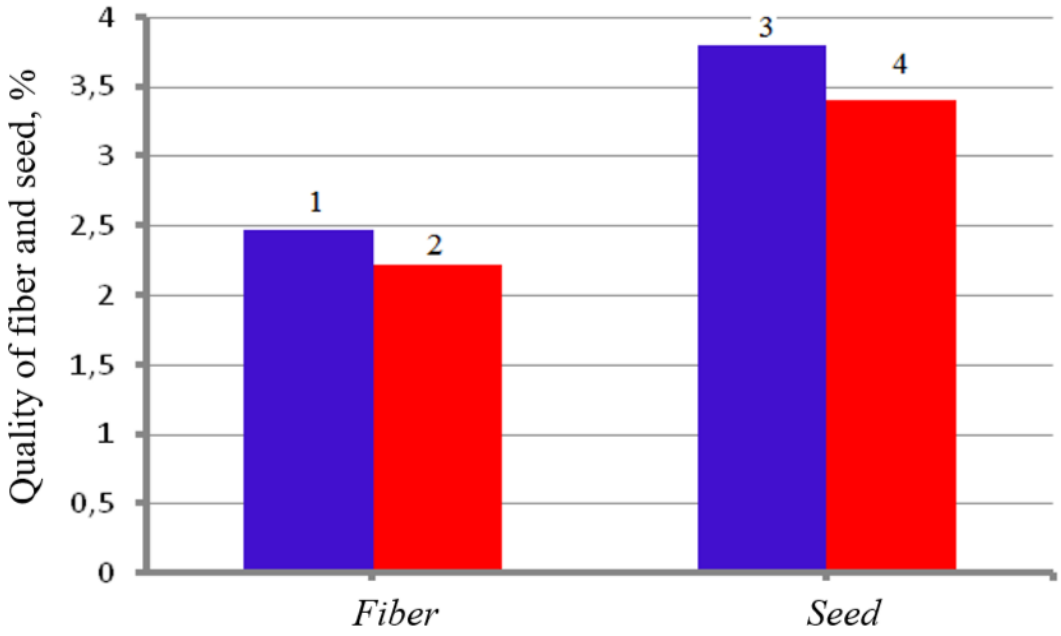
1- current technological stage, 2- proposed technological stage.

Figure 4. Cleaning effectiveness of current and proposed technological stages in the cleaning of Khorezm-127 selection III grade 3-class cotton

150 ^{0}C heat was given to the drum. After drumming, the moisture content of the cotton was 14.8%, the total dirtiness was 17.1%, and the small dirtiness was 7.72%. Since the moisture of the cotton dried from the 1st drum is higher than the moisture supplied to the cotton cleaning technology during the initial cotton processing, the cotton drying process was carried out in the 2nd drum [13].

Considering the moisture content of the cotton, the second drum was heated to 140 ^{0}C and the cotton was dried. After the drum, the moisture content of the cotton was 11.6%, the total dirtiness was 16.6%, and the small dirtiness was 7.35% [14]. Then, the improved 6A-12M drying-cleaning equipment was given a heat agent of 130 ^{0}C, and the cotton was dried and cleaned from small impurities at the same time. After cleaning, the moisture content of the cotton was 10%, the total dirtiness was 14.9%, and the fine dirtiness was 2.7%. In this case, the cleaning efficiency of the equipment in terms of small dirt was equal to 63.3% on average, which showed that it was on average 11 (abs)% higher than the existing 6A-12M cleaner. This indicator showed that the moisture content of cotton after UXK aggregate was 8.9% and the dirtiness was 1.43%, the cleaning efficiency of the aggregate was equal to 91% on average, and it showed that the cleaning efficiency of UXK aggregate in the current technology was on average 4.6 (abs)% higher.

After the UXK aggregate, the cotton was sucked using the SS-15A type separator and fed to the 5DP-130 gin supplier of the technology. In the feeder, the cotton was cleaned of small impurities. Then, cleaned cotton was fed from the feeder to the gin worker chamber. The moisture content of the supplied cotton was 8.6%, and its dirt content was 1.12%. In this case, the cleaning efficiency of the supplier was 22% on average, which was 2.5 (abs)% higher than the cleaning efficiency of the existing technology 5DP-130 gin supplier. After the cotton was cleaned in the supplier, the ginning process was carried out. In cotton ginning, the ginning process was carried out after the gin was cleaned in the work supplier. In cotton ginning, the ginning process was carried out after the gin was cleaned in the work supplier.



1, 3-current; 2, 4-in the proposed technological processes.

Figure 5. Khorezm-127 selection III variety 3rd grade cotton fibre and seed quality change depending on the technological process

The gin productivity in cotton ginning was 1235 kg/hour, which was 39 kg/hour higher than the productivity of the 5DP-130 gin in the current technology. After ginning, seed hairiness was 11.4%, damage was 3.4%, and seed quality improved by 0.4 (abs)% (Figure 5). The mass fraction of defective fiber and impurities in the post-ginning fiber was 3.54%. The ginned fiber was then cleaned in a 1VPU post-ginning fiber cleaner. The mass fraction of defective fiber and impurity in the cleaned fiber is 2.22% on average, and the quality indicator is improved by 0.25 (abs)% compared to the fiber produced from the 1VPU type fiber cleaner of the current technology, and according to the state standard O‘zDst 632:2010 III It was determined that the variety belongs to the "High" class [15].

Summary. The improved 6A-12M for drying and cleaning of cotton with high humidity and dirt and the correspondingly improved drying-cleaning technological system with the current equipment for cleaning cotton from small impurities 6A-12M and the corresponding drying-cleaning technological system in the current comparison - conducting research went It was studied that after drying cotton with initial moisture and dirtiness in the 1st and 2nd drying drums, the changes in moisture and dirtiness of cotton were close to each other in both options.

After the dried cotton was dried and cleaned from small impurities by applying a heat agent of 130 ^{0}C to the improved 6A-12M drying-cleaning equipment, the moisture content of the cotton was 10%, the total dirtiness was 14.9%, and the small dirtiness was 2.7%. In this case, the cleaning efficiency of the equipment in terms of small dirt was equal to 63.3% on average, which showed that it was on average 11 (abs)% higher than the existing 6A-12M cleaner. After this cotton was cleaned from small and large impurities in the UXK unit, the moisture content of the cotton was 8.9%, the dirt content was 1.43%, and the cleaning efficiency of the unit was equal to 91% on average, and compared to the cleaning efficiency of the UXK unit in the current technology, the average was 4.6 (abs), showing that it is higher by %. Then, when the cotton was ginned in a 5DP-130 saw ginner, the ginning efficiency of the ginner was 22%, which was 2.5 (abs)% higher than the current technology 5DP-130 ginning efficiency. When ginning cotton with a moisture content of 8.6% and impurity of 1.12% supplied from the supplier to the gin working chamber, the productivity of the gin was 1235 kg/h, and it was 39 kg/h higher than the productivity of the 5DP-130 gin of the current technology. After ginning, seed hairiness was 11.4%, damage was 3.4%, and seed quality improved by 0.4 (abs)%. After the ginseng fibre was cleaned in the 1VPU type fibre cleaner, the mass fraction of defective fibre and impurities in the fibre was on average 2.22%, and the quality index was improved by 0.25 (abs)% compared to the fibre produced by the 1VPU fibre cleaner of the current technology, and according to the state standard O‘zDst 632:2010, grade III belongs to the "High" class.

The result of the conducted test and comparison work is that the improvement of the 6A-12M cotton cleaning equipment and the corresponding cotton drying-cleaning technological system will improve the efficiency of the equipment in drying and cleaning low-grade cotton with high moisture and dirt, as well as the quality of fibre produced from low-grade cotton. improvement was achieved.

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FOOD TECHNOLOGY

DOI - 10.32743/UniTech.2024.127.10.18321

THE IMPACT OF MINERAL FERTILIZER LEVELS ON THE BIOCHEMICAL COMPOSITION OF GRAPE VARIETIES

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ВЛИЯНИЕ НОРМЫ МИНЕРАЛЬНЫХ УДОБРЕНИЙ НА БИОХИМИЧЕСКИЙ СОСТАВ СОРТОВ ВИНОГРАДА

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ABSTRACT

This article describes the findings of a study conducted to investigate the effect of the mineral fertilizer standard on the biochemical content of the bunch of technical types of grapes. White grape varieties such as Bayan Shirey, Muscat Vengersky, Risling, Rkasiteli, and Kuldzhinsky, as well as black technical varieties such as Saperavi, Rangdor, Tavkveri, Aleatiko, and Kaberne Savinon, were used in the study. The cultivar vines were fed with $N_{160}P_{80}K_{30}$, $N_{180}P_{100}K_{40}$ (control), $N_{200}P_{120}K_{50}$ and $N_{220}P_{140}K_{60}$. Vine bushes have a canes of 80 buds, according to common recommendations. At the same time, the highest sugar content and total acidity were determined in the experimental version, fed in the norm $N_{200}P_{120}K_{50}$.

АННОТАЦИЯ

В данной статье приведены результаты исследований по изучению влияния норм внесения минеральных удобрений на биохимический состав ягод технических сортов винограда. В качестве объекта исследований служили бело ягодные технические сорта винограда Баян Ширей, Мускат Венгерский, Рислинг, Ркацители, Кульджинский и сорта с окрашенной ягодой Саперави, Рангдор, Тавквери, Алеатико и Каберне Савиньон. Виноградники изученных сортов подкармливали из расчета $N_{160}P_{80}K_{30}$, $N_{180}P_{100}K_{40}$ (контроль), $N_{200}P_{120}K_{50}$ и $N_{220}P_{140}K_{60}$. Нагрузка кустов глазками по общепринятым рекомендациям составляет 80 глазков. При этом наибольшая сахаристость и кислотность ягод определена в опытном варианте подкормки из расчета $N_{200}P_{120}K_{50}$.

Keywords: Vine, technical varieties of grape, fertilizer norm, nutrition, leave, biochemical composition, berry.

Ключевые слова: виноград, технический сорт, норма внесения удобрений, подкормка, нагрузка кустов, биохимический состав, ягода.

Introduction

The quality of grape products is directly proportional to the biological composition and technological qualities of the grape berries. From a technological standpoint, having detailed information about the chemical composition of each technical grape type pulp introduced into processing allows for proper organization of the subsequent steps of processing and lays the groundwork for producing high-quality wine [1; 6]. Sugar and organic acids play a key role in the chemical composition of berries. The sugar level of the pulp is determined

Библиографическое описание: Narkabulova N., Abduganiev U. THE IMPACT OF MINERAL FERTILIZER LEVELS ON THE BIOCHEMICAL COMPOSITION OF GRAPE VARIETIES // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18321*

by weather and soil conditions, cultivation method, care, grape variety, and degree of maturity, and can range from 12% to 30% [2; 5]. Data on the biochemical composition of the berries of technical grape varieties and the quality of the product obtained from them, the kind of soil in which this grape is cultivated, and the amount of nutrient elements in it. Scientists' study results [3] include V.S. Petrov, T.I. Guguchkina, G.Yu. Aleynikova, and others. Grape products such as wine and juices from natural grass-suppressed vines received the greatest organoleptic assessment among Vidvijenes and Bianca varieties. Because such soils are extremely high in both mineral nutrients and organic stuff. It is important to remember that these suggestions are meant for CIS and European countries. They might not work as intended when directly applied to the unique soil and climate of the Uzbekistan Republic. Taking this into account, we conducted a study to establish the influence of mineral nutrition on the quality of a pile of technological grape varietals under various norms.

Materials and methods

The study used white grape varieties such as Bayan Shirey, Hungarian Muscat, Riesling, Rkatsiteli, and Kuldzhinsky, as well as colored berry varietals Saperavi, Rangdor, Tavkveri, Aleatico, and Cabernet Sauvignon. The vine's planting pattern is 3 x 4 meters. The vines tested were fed at the following rates: $N_{160}P_{80}K_{30}$, $N_{180}P_{100}K_{40}$ (control), $N_{200}P_{120}K_{50}$ and $N_{220}P_{140}K_{60}$. According to common recommendations, vine bushes have an 80-bud load. When using mineral nutrition criteria, K.A. Serpukhovitina et al. [4] were consulted. The soluble dry matter in berry juice was determined using a Master-50H portable refractometer (Brix 0.0-50.0%; Atago Co., Tokyo, Japan) and expressed in degrees °Bx.

Results

The level of mineral nutrition had a substantial impact on the chemical makeup of the pulp of technical grape types. In this respect, the experimental examples with the highest concentration of soluble solids in berry juice were fed the amount of the examined variety vines $N_{200}P_{120}K_{50}$. The experimental example, in which the vines were fed in the $N_{220}P_{140}K_{60}$ quantity, was additionally shown to collect more soluble solids than both controls, but significantly less than the experimental example stated above (Table 1).

Table 1.

Effect of mineral nutrition on the chemical composition of grape juice from white technical varietals, 2021-2023 yy

Cane pruning length, buds	Total soluble solids (TSS), °Bx					Total acidity, g/l				
	Bayan Shirey	Hungarian Muscat	Riesling	Rkatsiteli	Kul-dzhinsky	Bayan Shirey	Hungarian Muscat	Riesling	Rkatsiteli	Kul dzhinsky
Not fertilised – absolut/ control	14,1	15,0	15,0	14,9	15,1	5,9	5,1	7,3	7,9	6,1
$N_{160}P_{80}K_{30}$	15,2	16,0	16,3	16,7	15,9	6,3	5,3	9,2	9,0	7,5
$N_{180}P_{100}K_{40}$ – control	16,3	18,9	18,0	17,2	16,4	6,6	5,4	10,1	9,5	8,1
$N_{200}P_{120}K_{50}$	17,8	18,5	18,4	17,8	17,1	6,7	5,5	10,4	9,8	8,1
$N_{220}P_{140}K_{60}$	17,2	18,3	18,3	17,7	16,5	6,7	5,5	10,2	9,9	8,0

The table data demonstrates that the minimum number of soluble solids is not fertilized - the absolute control option was selected. The $N_{160}P_{80}K_{30}$ norms fed, and the control ($N_{180}P_{100}K_{40}$) example took the following two slots, respectively.

The same tendency in the number of soluble solids was seen in the influence of mineral nutrition on the acidity of grape technical varieties' juice and pulp. The maximum quantity of acidity was found in the experimental example, where the vines were fed in the norm of $N_{200}P_{120}K_{50}$ and $N_{220}P_{140}K_{60}$, and the lowest acidity was not fertilized - in the absolute control option and in the experimental option fed in the norm of $N_{160}P_{80}K_{30}$. Mineral nutrition has had the same effect on the chemical composition of black and white grape varieties. In this situation, the experimental examples with vines fed at N200P120K50 and N220P140K60 had the maximum number of soluble solids in grape juice when compared to both controls. The lowest number of soluble solids was determined in both the non-fertilized absolute control version and the experimental forms fed in the $N_{160}P_{80}K_{30}$ norm (Table 2). Furthermore, even black grape varieties, mineral nutrition has had the same influence on fruit juice acidity as in white grape varieties. In this case, the experimental options in which the vines were fed in normal amounts $N_{200}P_{120}K_{50}$ and $N_{220}P_{140}K_{60}$ determined the highest amount of grape juice acidity in comparison to both controls, and the lowest acidity was not fertilized - in the absolute control option and in the experimental option fed in the norm $N_{160}P_{80}K_{30}$.

Table 2.

Effect of mineral nutrition on the chemical composition of grape juice from black technical varietals, 2021-2023 yy

Cane pruning length, buds	Total soluble solids (TSS), °Bx					Total acidity, g/l				
	Saperavi	Rangdor	Tavkveri	Aleatico	Cabernet Sauvignon	Saperavi	Rangdor	Tavkveri	Aleatico	Cabernet Sauvignon
Not fertilised – absolut/ control	17,3	19,1	16,2	17,8	15,9	5,5	5,0	5,1	5,0	7,3
$N_{160}P_{80}K_{30}$	20,1	23,2	20,0	21,8	18,7	6,5	5,9	5,6	5,0	9,1
$N_{180}P_{100}K_{40}$ – control	23,2	25,0	22,1	24,3	20,6	7,0	6,1	6,0	5,3	9,6
$N_{200}P_{120}K_{50}$	25,5	27,1	23,4	26,8	22,5	7,5	6,3	6,2	5,6	10,5
$N_{220}P_{140}K_{60}$	25,3	27,1	23,2	26,5	22,1	7,5	6,2	6,0	5,5	10,0

Conclusions

Overall, the chemical composition of the pulp of technical grape cultivars is greatly impacted by mineral nutrition standards. In this example, the experimental version fed had the highest sugar content and overall acidity in the norm $N_{200}P_{120}K_{50}$.

When the normal amount of mineral feeding is raised or decreased, the sugar content and overall acidity of the berries juice decrease substantially.

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THE IMPORTANCE OF INCREASING THE SHARE OF BIOLOGICALLY ACTIVE SUBSTANCES IN THE DIET OF THE POPULATION AND ITS CHARACTERISTICS

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ЗНАЧИМОСТЬ ПОВЫШЕНИЯ ДОЛИ БИОЛОГИЧЕСКИ АКТИВНЫХ ВЕЩЕСТВ В ПИТАНИИ НАСЕЛЕНИЯ И ЕГО ХАРАКТЕРИСТИКИ

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ABSTRACT

This paper examines the significance of increasing the share of biologically active substances (BAS) in the diet of the population and its impact on overall health and well-being. The study highlights the benefits of integrating BAS-rich foods into daily nutrition, including improved immune function, enhanced metabolic processes, and reduced inflammation. The paper also discusses current dietary trends and challenges in integrating these essential compounds into everyday nutrition.

АННОТАЦИЯ

В данной работе рассмотрено значение увеличения доли биологически активных веществ (БАВ) в рационе питания населения и его влияние на общее состояние здоровья и самочувствие. Исследование подчеркивает преимущества включения продуктов, богатых БАВ, в ежедневное питание, включая улучшение иммунной функции, усиление метаболических процессов и уменьшение воспаления. В статье также обсуждаются текущие тенденции в питании и проблемы интеграции этих незаменимых соединений в повседневное питание.

Keywords: Nutrition, Chronic Diseases, Public Health.
Ключевые слова: Питание, Хронические заболевания, Общественное здравоохранение.

Библиографическое описание: Sattorova K.A., Xolmurodov B.B., Rakhmanov E.K. THE IMPORTANCE OF INCREASING THE SHARE OF BIOLOGICALLY ACTIVE SUBSTANCES IN THE DIET OF THE POPULATION AND ITS CHARACTERISTICS // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18302*

Introduction

The link between diet and health has received significant attention in recent years, highlighting the critical role that nutrition plays in preventing disease and promoting overall well-being. Among the various components of a healthy diet, biologically active substances (BAS) have become fundamental elements that significantly contribute to human health. These substances, including vitamins, minerals, antioxidants and phytochemicals, are natural compounds that provide a range of health benefits, from boosting immune function to reducing inflammation and reducing the risk of chronic diseases such as diabetes, heart disease and some types of cancer [1].

Main part

According to nutritionist Elena Ivanova, including more biologically active substances in the diet is important for combating chronic diseases. Thus, increasing public awareness of these substances can lead to healthier lifestyles and improved overall health. The current global landscape is characterized by an alarming rise in lifestyle-related diseases, a phenomenon that is often linked to dietary patterns and nutritional deficiencies. According to culinary specialist Maria Smirnova, in my experience, many people do not know about the benefits of biologically active substances. Therefore, it is extremely important to not only promote these products, but also provide practical recipes and tips on how to incorporate them into your daily diet. BAS, which include vitamins, minerals, antioxidants and phytochemicals, play a vital role in various biological processes. Increasing their presence in the daily diet can help prevent chronic diseases, improve immune function and improve overall health [5, p. 48-60]. This article discusses the characteristics of biologically active substances, their importance in our diet and strategies for increasing their share in the population's diet [2, p. 71-88]. Alexey Petrov, a health advocate, says there is a clear correlation between taking dietary supplements and improving immunity. Thus, encouraging the consumption of foods rich in these substances should be a priority for public health initiatives.

Biologically active substances are natural compounds that have a significant effect on human health without necessarily providing energy [6, p. 578-580]. They play diverse roles, including antioxidant defense, immune modulation, anti-inflammatory effects, and contributions to cellular signaling pathways. The main categories of biologically active substances include:

1. Vitamins: Essential nutrients required for various metabolic processes. Examples include vitamin C (ascorbic acid), which promotes collagen synthesis and immune function, and B vitamins, which are critical for energy metabolism.

2. Minerals: inorganic elements vital to numerous biochemical reactions. Key minerals include calcium for bone health, iron for oxygen transport, and zinc for immune function [2].

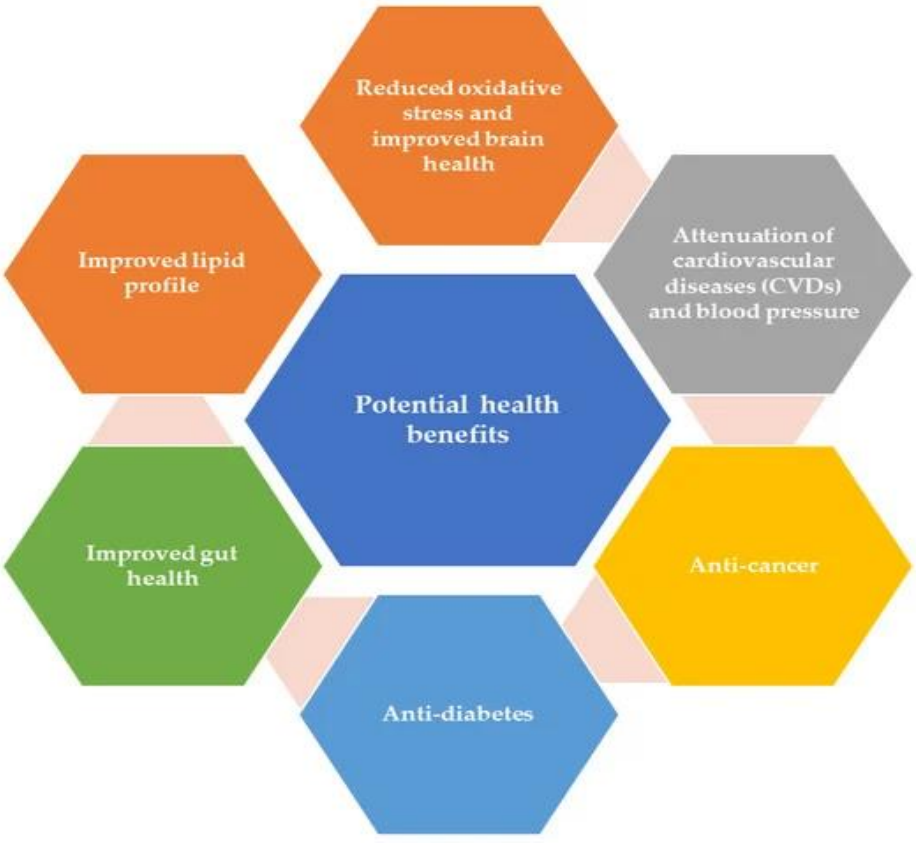

Figure 1. Potential Health Benefits of Plant Food-Derived Bioactive Components: An Overview

Numerous studies have shown that diets rich in dietary supplements can significantly reduce the risk of chronic diseases. For example, diets high in antioxidants and phytochemicals support cardiovascular health by reducing inflammation and improving endothelial function [3, p. 433]. Biologically active substances play a decisive role in maintaining the immune system. Vitamins A, C and E, as well as minerals such as zinc and selenium, are essential to maintain immune effectiveness. Regular consumption of foods rich in biologically active substances increases the body's ability to resist infections and reduces the severity and duration of diseases. New research suggests that a diet enriched with dietary supplements may play a role in protecting against cognitive decline and neurodegenerative diseases. Antioxidants and omega-3 fatty acids found in foods rich in dietary supplements are associated with improved brain health and function, potentially reducing the risk of conditions such as Alzheimer's disease. Dietary fiber, a key component of many sources of biologically active substances, is necessary to maintain the health of the digestive system [4, p. 543-597].

Trends in Consumption of Biologically Active Substances Over Time

Purpose: To illustrate changes in the consumption of biologically active substances over the last few decades.

- Type: Line graph
- Years on X-Axis: 2000 to 2023
- Y-Axis: Average daily intake (grams)
- Data Lines:
  - Line A: Fruits & Vegetables
  - Line B: Whole Grains
  - Line C: Fish

Figure: Behavioral Change Strategies for Increasing Intake

Purpose: To visually represent strategies to encourage the incorporation of more biologically active substances into diets.

- Type: Flowchart or infographic
  - Step 1: Education and awareness
  - Step 2: Community gardening programs
  - Step 3: Program for subsidizing healthy foods
  - Step 4: Policy changes to improve access

1. Table: Nutrient Deficiencies in Populations

Purpose: To summarize the prevalence of specific nutrient deficiencies in different demographic groups.

Nutrient	Age Group	Percentage Deficient (%)	Source of Data
Vitamin D	1-5 years	20%	Source: Health Organization
Iron	Women 18-49	25%	Source: Nutritional Survey
Omega-3 Fatty Acids	General	30%	Source: Dietary Study
Magnesium	Elderly	40%	Source: Health Agency

2. Graph: Dietary Sources of Biologically Active Substances

Purpose: To visually represent the contribution of various food groups to the intake of biologically active substances.

- Type: Pie chart
- Data Example:
  - Fruits: 30%
  - Vegetables: 25%
  - Nuts and Seeds: 15%
  - Fish: 10%
  - Whole Grains: 20%.

Conclusion

BAS help prevent chronic diseases, strengthen the immune system and improve the general condition of the body. Considering modern challenges, such as deteriorating nutrition quality and increasing morbidity, the importance of integrating biologically active substances into the diet becomes obvious. This requires a comprehensive approach, including educational programs and accessible guidance, to increase public awareness and promote healthier lifestyles.

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TECHNOLOGICAL CHARACTERISTICS OF KHORAKI GRAPES IN TERMS OF TRANSPORTABILITY AND DURABILITY

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ТЕХНОЛОГИЧЕСКИЕ ХАРАКТЕРИСТИКИ ВИНОГРАДА ХОРАКИ ПО ТРАНСПОРТИРОВКЕ И ЛЕТУЧЕСТИ

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ABSTRACT

The study focuses on the impact of climatic and agronomic factors on the storage quality and transportability of grapes. A correlation between the effective heat supply of the growing zone and the shelf life of grapes has been established. Rational fertilizer use and irrigation management were found to enhance disease resistance and reduce post-harvest losses. The research highlights advanced irrigation methods and vine formation techniques that improve yield and grape preservation. The use of progressive mechanization technologies also contributes to vineyard intensification and labor productivity.

АННОТАЦИЯ

Исследование посвящено влиянию климатических и агротехнических факторов на качество хранения и транспортабельность винограда. Установлена взаимосвязь между эффективным теплоснабжением зоны выращивания и сроком хранения винограда, выявлено, что рациональное применение удобрений и управление орошением повышают устойчивость к заболеваниям и снижают потери при хранении. Освещены перспективные методы орошения и формирования кустов, которые способствуют повышению урожайности и улучшению сохранности винограда. Применение прогрессивных технологий механизации также способствует интенсификации виноградарства и повышению производительности.

Keywords: grapes, storage, transportability, effective heat supply, fertilizers, irrigation, grape diseases, yield, mechanization, vine formation

Ключевые слова: виноград, хранение, транспортабельность, эффективное теплоснабжение, удобрения, орошение, болезни винограда, урожайность, механизация, формирование кустов

Introduction. Some scientists [46; 506-p], the most important conditions that determine the possibility of growing grapes for long-term storage in a certain area are the amount of heat and precipitation in a certain zone, the continentality of the climate, the growth of grapes and the storage of grapes. is the soil condition. He proposed a complex indicator called effective heat supply, taking the Shabash variety as an example, to characterize the zone and weather conditions of individual years of the growing season for the long-term storage suitability of the grapes grown here.

Methods. It was found that between the shelf life of grapes and the effective heat supply of the zone, the correlation ratio is close for the Shebash variety

Библиографическое описание: Shamshiev J., Shingisov A.U. TECHNOLOGICAL CHARACTERISTICS OF KHORAKI GRAPES IN TERMS OF TRANSPORTABILITY AND DURABILITY // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18480*

in Crimea - 0.84 +/- 0.09 and for the Agadai and Shaani black varieties in the Absheron zone of Azerbaijan - 0.79 +/- 0.81) there is a linear relationship. The areas where grapes are grown have a significant impact on its transportation. For example, depending on the farms of the supplier, the yield of standard grapes after processing was determined to be 95-97% to 76-86% for Sabash varieties, 95-98% to 77-86% for Chaush. Similar data were obtained for Tashli and Tavriz varieties [22; pp. 34-37].

Along with the soil, climate and weather conditions, the quality of its storage and transportability, as well as the agrotechnology of cultivation, are of great importance in the formation of the grape crop [23; p. 118-120]. Excessive use of nitrogen fertilizers delays growth processes, increases plant mass and yield, reduces sugar content, storage quality, vine ripening; potassium and phosphorus fertilizers increase the sugar content of grapes during storage and transportation and increase their shelf life.

According to M.I. Odinaev, the average weight of the grape heads is a feature of the variety, and in all the studied varieties, large grape heads characteristic of the large bunched grape varieties are formed. The size of the grape cluster is an important technological indicator. The weight of 100 bunches varies between varieties depending on the characteristics of the variety, that is, the size of one bunch [36; pp. 11-12].

According to G.L. Naumova [33; p. 33-37], the smallest losses of grapes of Nimrang and Taifi Rozovyy varieties during storage and transportation were a variant of increased potassium and nitrogen content from rotting and browning (3%). An increase in potassium nitrogen, as well as moderate doses of phosphorus, significantly reduces the resistance of grapes to microbiological and physiological diseases.

Results. Long-term studies have shown that calcium plays a very important physiological role in maintaining the natural resistance of grapes to fungal rot and physiological diseases, and increasing their calcium content increases their resistance to all diseases. Irrigation strongly affects the quality of grapes during storage and transportation [34; pp. 27-42].

In Nimrang, Taifi Rozovy, Terbash varieties, grapes have a higher indicator when watering is stopped 30 days earlier. The tension of the grapes is greatly reduced if watering is stopped before or after this period. It was found that the grapes of Asma and Shabash varieties grown without irrigation in conditions protected from moisture on the southern coast of Crimea are characterized by high quality of detergent [18; pp. 132-140].

According to V.A. Boyko [16; 10-11 p.], stopping irrigation 10 days before the harvest of grapes, stopping irrigation 30 days before the harvest increased the yield of the Nimrang variety, the average weight of the berries, and decreased the storage quality. During the months of storage, the loss from rotting increased by 10.82% and from blackening by 34.0%.

Table 1.

Storage and transportation of grapes, not based on the data provided, but consistent with the general topic

Factor	Impact on the quality of storage and transportability of grapes	Examples and technologies
Storage temperature	Optimum storage temperature prevents rotting, preserves the freshness and structure of berries	Use of refrigeration chambers with a temperature of +1…+3°C to prevent fermentation
Air humidity during storage	Humidity control reduces moisture loss, prevents drying out and spoilage of berries	Humidity level within 85-90% to preserve the natural moisture of berries
Transportation methods	The method of transportation is important: proper packaging and temperature prevent mechanical damage	Use of special containers with a controlled microclimate, cardboard or plastic boxes
Post-harvest processing	Reducing the number of pathogens on the surface of berries extends their shelf life	Use of mild disinfectant solutions, such as ozonation or hot water treatment

According to the researches of V.D. Volosovtsev, studying the effect of irrigation method on productivity in the Hisar Valley of Tajikistan, studying the quality of Rozovy grape "Taifi" variety, in comparison with drip irrigation, it was found that irrigation with furrows and without plow is the most effective. According to M.S. Dudarev, N.A. Basiy, V.I. Martovshuk, in-soil irrigation with ceramic humidifiers for Karaburnu vineyards helps to increase the yield, quality and preservation of grapes during storage. According to the authors, this progressive method of irrigation of vineyards should be more widespread [17; p. 3-7, 19; pp. 48-49].

Discussion. They found that one additional punching during the ripening stage of Nimrang grapes reduced the losses due to rotting during storage for one month. by 1.82, and by 58.0% from blackening compared to the control. It has been highlighted that the yield, quality, and preservation of grapes during storage and transportation largely depend on the formation of the bush [20; pp. 46-47].

In recent years, it has been found that favorable conditions have been created for the realization of growth potential not only in plantations formed in a special fence where rare bushes are planted, but also during compact planting, in the formation of stem plantations in the form of small cup-shaped bushes [18; p. 132-140].

As one of the promising directions in the intensification of the network, the wide-row high-standard system of growing vineyards is becoming widespread. Cultivation of vineyards It has been determined that a wide range of high-standard technology is fully compatible with the biology of the grape plant, and allows for a sharp increase in labor. gives productivity due to more complete mechanization of labor-intensive operations [21; pp. 82-83].

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CHEMICAL ENGINEERING

DOI - 10.32743/UniTech.2024.127.10.18421

CHLORINATION OF PHTHALIC ANHYDRIDE

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ABSTRACT

Currently, scientific research is being conducted to create a new generation of additional reagents used in oil and gas processing, as well as to improve production technology. In order to prevent wear and tear of chemical industry equipment and ensure the stability of its operation, special attention is paid to the production of competitive alternative products containing halogen-preserving organic compounds and meeting regulatory requirements for quality indicators. This article presents the results of research on obtaining a chlorine derivative of phthalic anhydride.

АННОТАЦИЯ

В настоящее время проводятся научные исследования по созданию нового поколения дополнительных реагентов, используемых при переработке нефти и газа, а также по совершенствованию технологии производства. В целях предотвращения износа оборудования химической промышленности и обеспечения устойчивости его работы особое внимание уделяется производству конкурентоспособной альтернативной продукции, содержащей галогенсохраняющие органические соединения и отвечающей нормативным требованиям по показателям качества. В данной статье представлены результаты исследований по получению хлорпроизводного фталевого ангидрида.

Keywords: halogenation, solvent, dimethyl sulfoxide (DMSO), dimethylformamide (DMFA), phthalic anhydride, chlorination, catalytic system

Ключевые слова: галогенирование, растворитель, диметилсульфоксид (ДМСО), диметилформамид (ДМФА), фталевый ангидрид, хлорирование, каталитическая система

Библиографическое описание: Rayimov Z.X., Ahmedov V., Kurbanov F.P. CHLORINATION OF PHTHALIC ANHYDRIDE // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18421*

Introduction. Since the coupling reaction of halogens to acid anhydrides has not been studied, it is important to obtain halogenated derivatives of these anhydrides. Such substances occupy an important place in the chemical industry and agriculture. The synthesis of halogenated derivatives of phthalic anhydride using solvent (DMSO) was investigated in our research. From the analysis of the studied literature, it can be seen that the solvent dissolves well in DMSO. This makes it possible to increase the yield of the chlorinated derivative of phthalic anhydride[1-3].

Phthalic anhydride is a weak acid. When phthalic anhydride reacts with chlorine gas under high pressure, a chlorine compound of phthalic anhydride is formed. As part of the research, the following experiments were carried out:

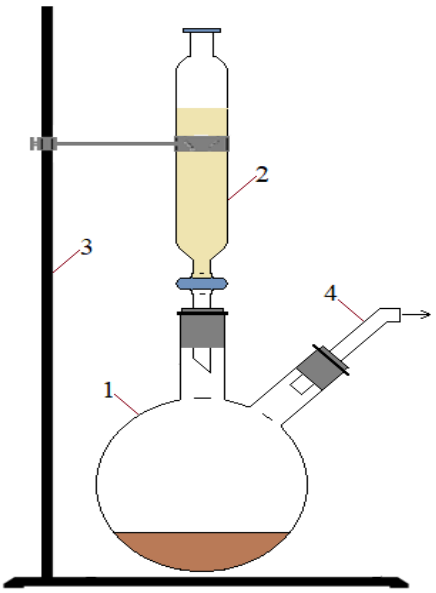
1. Chlorine gas was synthesized from hydrochloric acid.

2. Chlorine gas was passed through a solution of phthalic anhydride and dimethylsulfoxide (DMSO).

As part of the research, the halogenating agent chlorine was synthesized from hydrochloric acid. For this, potassium permanganate was treated with hydrochloric acid. The reaction proceeds as follows[4-6]:

$$2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$$

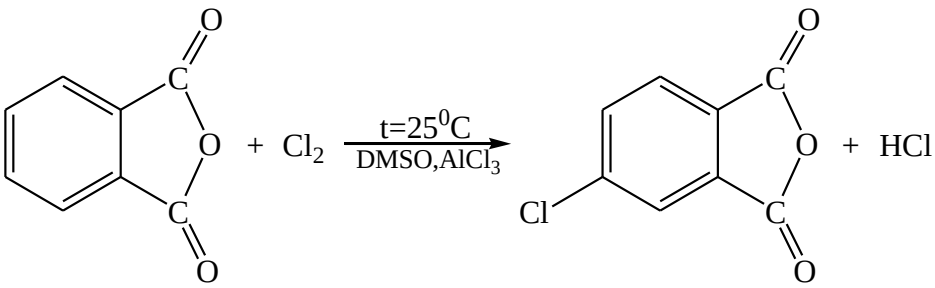
Materials and methods. The laboratory device for obtaining chlorine gas consists of a round bottom flask with two necks and a separating funnel installed in it (Fig. 1). First, 20 g of potassium permanganate was placed in a round-bottom flask with two necks. 30 ml of hydrochloric acid was added to the separatory funnel installed in the flask. The separator was filled drop wise with hydrochloric acid using a funnel separator. At this time, chlorine gas began to be released. The generated chlorine was directed to the next reaction stage using a gas discharge nozzle. The resulting chlorine gas was passed through a catalytic system consisting of phthalic anhydride, DMSO and $AlCl_3$. The introduction of a halogen atom into the aromatic ring is based on the Friedel-Crafts reaction, and the process proceeds in the electrophilic exchange mechanism. $AlCl_3$ acts as a catalyst in this reaction.



1-Double-necked round bottom flask, 2-Separating funnel, 3-Stand, 4-Gas outlet nozzle

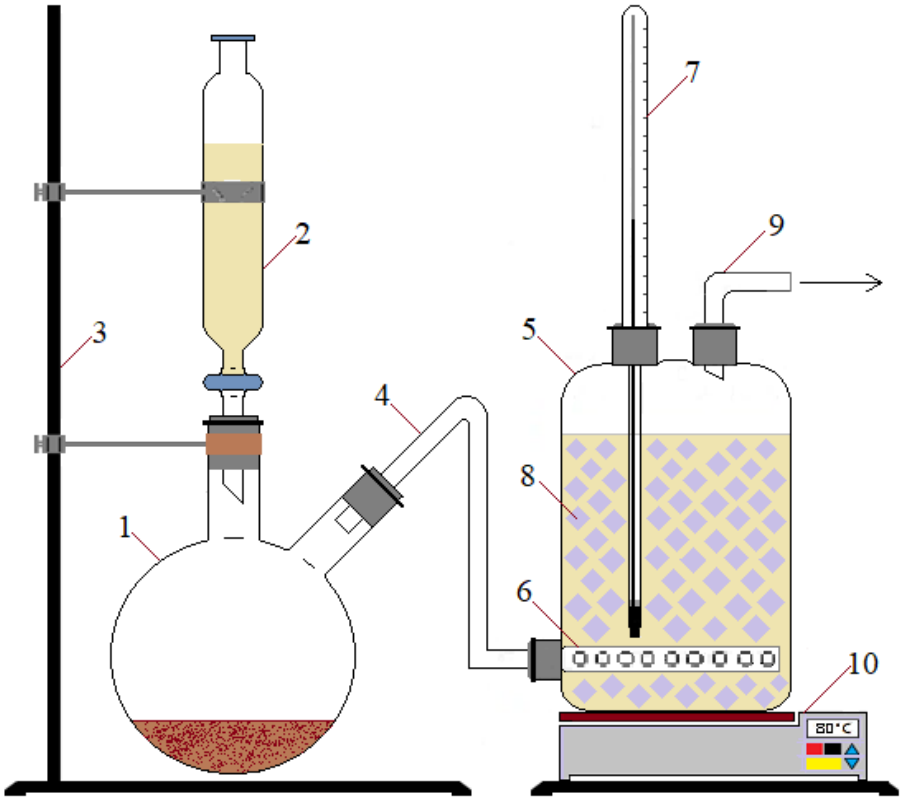
Figure 1. Chlorine gas extraction laboratory device

As a result of the reaction of the addition of a chlorine atom to phthalic anhydride, it was found that a monochlorinated compound of phthalic anhydride is formed. The reaction can be summarized as follows:



The interaction of phthalic anhydride and chlorine atom takes place in a heterogeneous system. The procedure was carried out in a laboratory device consisting of a specially equipped glass jar (Fig. 2).

This glass is equipped with a thermometer (7), a gas distributor (6) and nozzles (8) that evenly distribute chlorine gas in the form of small bubbles on the surface in order to increase the contact surface of the gas and liquid system.



1-Round-bottomed two-necked flask, 2-Separating funnel, 3-Separating funnel, 4-Gas transfer nozzle, 5-Beaker, 6-Gas distributor, 7-Thermometer, 8-Nozzle, 9-Gas discharge nozzle , 10-Electric oven

Figure 2. A laboratory device for obtaining a monochlorinated compound of phthalic anhydride

An electric heater (10) is installed under the glass. A large number of small gas bubbles supplied through the gas distributor also perform the function of forced convection of the heat coming from the heater and mixing of the multi-component system. The liquid reaction system was prepared as follows: 100 ml of DMSO and 7.5 g of $AlCl_3$ were added to a 300 ml conical flask and the mixture was stirred while heating at 40-45 °C. After complete dissolution of $AlCl_3$, 75 g of phthalic anhydride was added to the flask and stirred. After a homogeneous system was formed in the flask, the mixture was cooled to a temperature of 25 ℃ and placed in a glass (5). After that, in order to carry out the halogenation reaction, the liquid in the glass was heated to a temperature of 80 ℃ using an electric heater (10).

Chlorine gas synthesized in a round-bottomed two-necked flask (1) was transferred from the lower part of the 5th glass through the 6th gas distributor using the 4th gas transfer nozzle. After 3 hours, the synthesis process was stopped and the substances were cooled.

Results and discussion. The synthesized substance was analyzed by IR-spectroscopy. In order to identify the functional groups in 5-chloroisobenzofuran-1,3-dione, it was determined using IR spectroscopic analysis method. The following absorption areas can be seen in the IR spectrum of 5-chloroisobenzofuran-1,3-dione (Fig. 3).

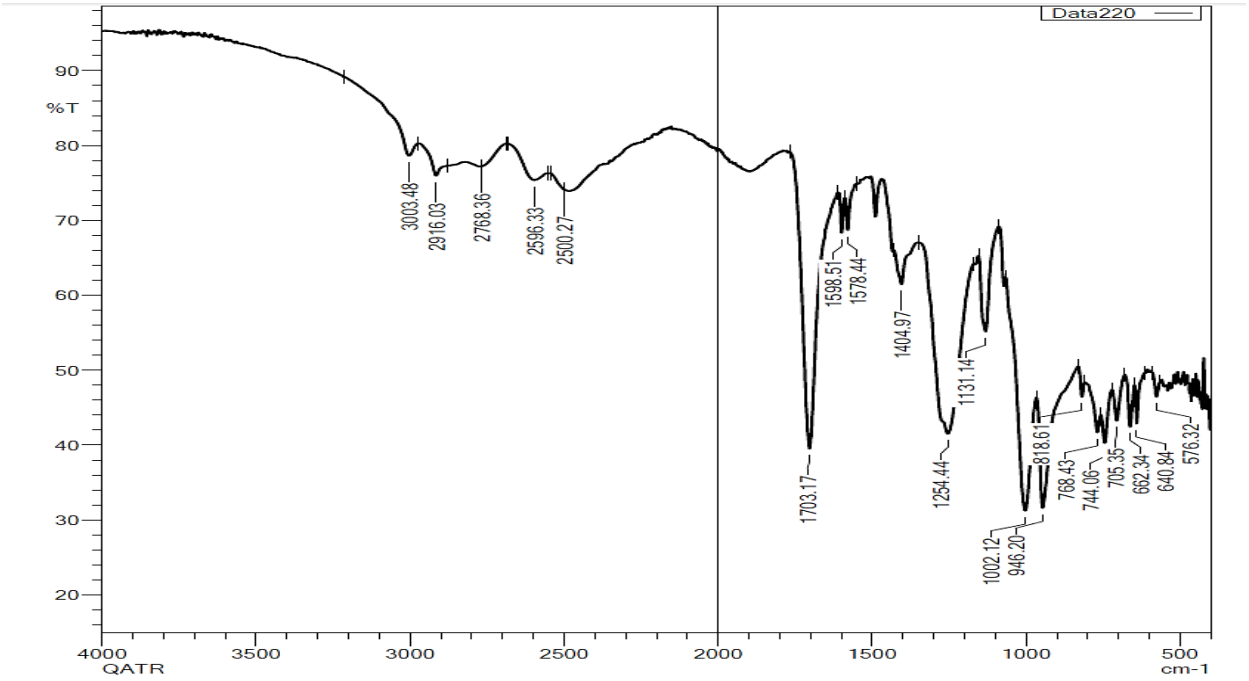


Figure 3. Results

1703.17 cm^{-1} −C=O carbonyl group valence vibrations, 1254.44 cm^{-1} carboxyl group valence vibrations, and 3003.48 symmetric vibrations for the C−H bond in the aromatic ring, 1254.44; Corresponds to deformational, symmetric vibrations of the chlorine bond in the aromatic ring in the 1131.14 and 1002.12 cm^{-1} fields. This means that it corresponds to the composition of the synthesized substance.

It is known that solvents are important in the course of chemical reactions. In this case, factors such as properties and nature of the solvent affect the yield of the product formed during the reaction. The reaction of chlorine gas with phthalic anhydride was carried out in the presence of various solvents. Solvents were analyzed depending on the yield of 5-chloroisobenzofuran-1,3-dione. Reactions were carried out for 3 hours. In the reactions, the catalyst $AlCl_3$ was 10% by mass of phthalic anhydride, and the temperature was 80 ℃.

In our research, we found that DMSO is the most important solvent. In our experiment, when DMSO was used as a solvent, the product yield was 40.3%. In order to study the effect of the nature of different solvents on the chemical reaction, it was 37% in the presence of DMFA at a temperature of 25 ℃. At the same time, it was 20% in water. Among the solvents used in the synthesis process, it was observed that the addition of chlorine gas to phthalic anhydride is more active than other solvents in DMSO.

When the temperature of the reactor in which the reaction is progressing is increased, the speed of movement of the particles of the reacting substances increases, and this situation increases the number of collisions between the particles. As a result, it causes an increase in product yield. Also, decomposition of organic substances is observed at extremely high temperatures. Therefore, it is important to find the optimal temperature value of the reaction under investigation.

Taking this into account, the effect of temperature on the exchange reaction of phthalic anhydride with chlorine gas was studied. Catalyst AlCl3 and solvent DMSO were used in the reaction. The temperature was carried out between 30-100℃ to obtain the monochloro derivative of the product phthalic anhydride. The obtained results were recorded in Table 1.

Table 1.

The effect of temperature on the reaction of phthalic anhydride with chlorine gas, the duration of the reaction is 3.5 hours

№	Temperature, ℃	Yield, %
1	30	12,4
2	40	18,6
3	50	24,3
4	60	29,8
5	70	35,7
6	80	40,3
7	90	36,8
8	100	29,6

As can be seen from Table 1, the reaction was carried out in 3.5 hours and the yield of 5-chloroisobenzofuran-1,3-dione was determined. The product yield was 12.4% when the reaction was carried out at 30℃. The maximum product yield was 40.3% when the reaction was carried out at 80℃. Product yield decreased when the temperature was raised above 80℃. This situation can be explained by the reduction of chlorine solubility, oxidation of phthalic anhydride or its destructive change.

Based on the data from the research results, a graph of temperature dependence of the yield of 2-5-chloroisobenzofuran-1,3-dione was drawn (Graph 1).

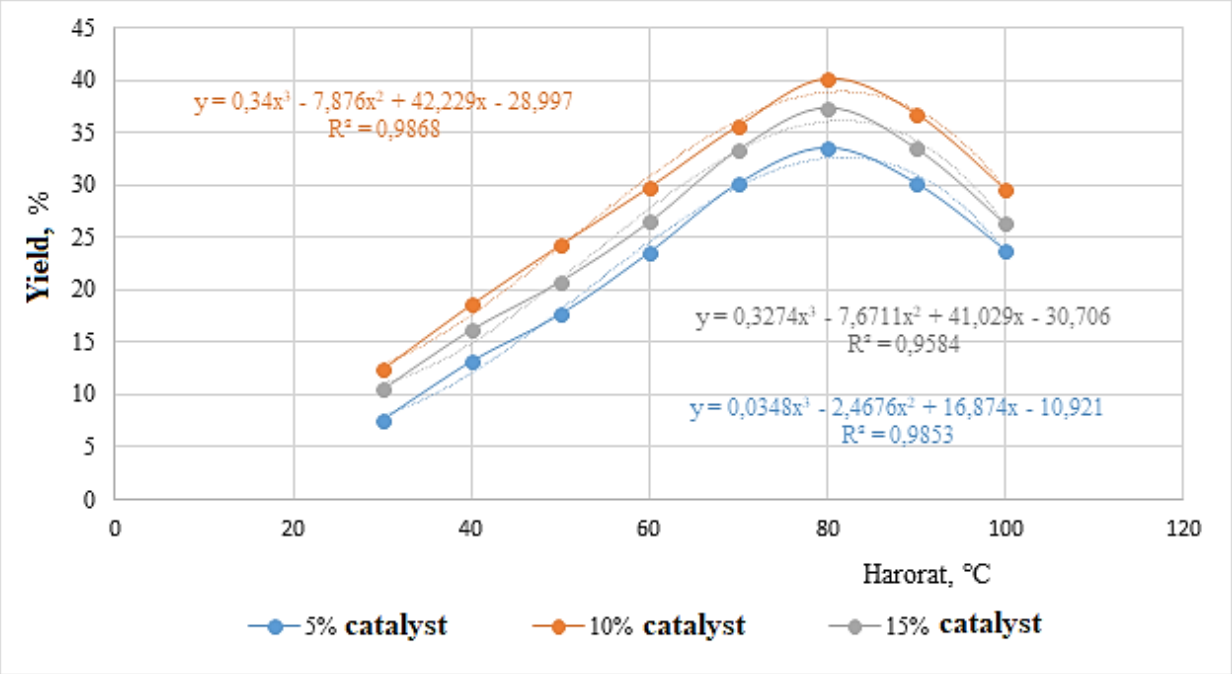


Figure. Temperature dependence of the yield of 5-chloroisobenzofuran-1,3-dione at different concentrations of the catalyst

Conclusion. In conclusion, it can be said that the solvent DMSO, the catalyst AlCl3, the reaction temperature 80°C and the duration of the reaction 3.5 hours were the solvent DMSO and the product yield was 40.3%. Based on the results of the conducted research, it was determined that the yield of 5-chloroisobenzofuran-1,3-dione has the highest value when the duration of the reaction is 3.5 hours. This phenomenon is explained by the saturation of a certain volume of DMSO solvent in 3.5 hours.

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AROMATIZATION OF PROPANE AND ITS BASIC LAWS

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ABSTRACT

The article presents the results of studying some laws of the catalytic aromatization reaction of propane in the presence of a 2%Zr-2%Zn-7%Mo/MGS catalyst. Before the catalytic experiments, the samples were heated in a hydrogen stream (2500 h^{-1}) for 2 h. Then, the experiments were carried out according to the same procedure at a constant volumetric rate (V=500 h^{-1}). Also, the main parameters of the propane aromatization process in 2%Zr-2%Zn-7%Mo/MGS and 5%Zr-2%Zn-7%Mo/MGS catalyst, prepared by solid phase modification method with hydrogen pretreatment and The main parameters of the aromatization process of propane in the 2%Zr-2%Zn-7%Mo/MGS catalyst, propane production in the 5%Zr-2%Zn-7%Mo/MGS catalyst prepared by impregnation method without pretreatment with hydrogen and by soaking method the main parameters of the aromatization process were studied.

In this article of the work is to study the laws of the aromatization reaction of propane in 2%Zr-2%Zn-7%Mo/MGS and 5%Zr-2%Zn-7%Mo/MGS catalysts.

АННОТАЦИЯ

В статье представлены результаты исследования некоторых закономерностей каталитической реакции ароматизации пропана в присутствии катализатора 2%Zr-2%Zn-7%Mo/MGS. Перед каталитическими экспериментами образцы нагревали в токе водорода (2500 $ч^{-1}$) в течение 2 ч. Затем эксперименты проводили по той же методике с постоянной объемной скоростью (V=500 $ч^{-1}$). Также изучены основные параметры процесса ароматизации пропана на катализаторах 2%Zr-2%Zn-7%Mo/MGS и 5%Zr-2%Zn-7%Mo/MGS, приготовленных методом твердофазной модификации с предварительной обработкой водородом и Основные параметры процесса ароматизации пропана на катализаторе 2%Zr-2%Zn-7%Mo/MGS, получение пропана на катализаторе 5%Zr-2%Zn-7%Mo/MGS, приготовленном методом пропитки без предварительной обработки водородом и методом пропитки, основные параметры процесса ароматизации. В этой статье изучение закономерностей реакции ароматизации пропана на катализаторах 2%Zr-2%Zn-7%Mo/MGS и 5%Zr-2%Zn-7%Mo/MGS.

Библиографическое описание: Fayzullaev N., Hamidov D.R., Nomozova S.I. AROMATIZATION OF PROPANE AND ITS BASIC LAWS // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18406*

Keywords: propane, aromatization, temperature, reaction yield, selectivity, mesoporous sorbent.
Ключевые слова: пропан, ароматизация, температура, выход реакции, селективность, мезопористый сорбент.

Introduction

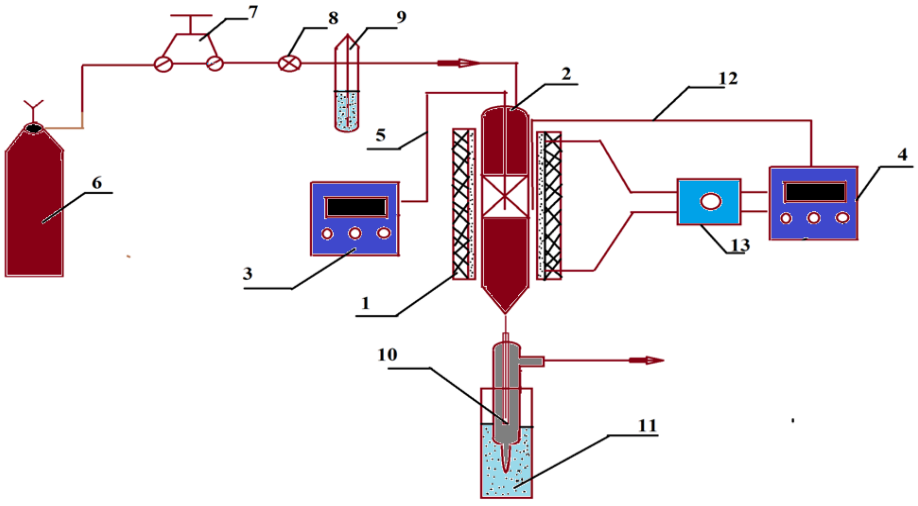
Aromatization of light alkanes (mainly propane and butane) has been widely studied for almost three decades due to its importance in economic and strategic fields. For propane aromatization process, ZSM-5 catalyst promoted by Zn, Pt and Ga was recognized as an effective bifunctional catalyst. Light alkane chain growth on a bifunctional catalyst involves dehydrogenation. The transformation of light hydrocarbons into aromatic compounds is one of the most important catalytic reactions both from a scientific point of view and from the point of view of industrial implementation. As a result of aromatization of lower alkanes, aromatic hydrocarbons (mainly benzene, toluene, and xylenes) are formed, which are valuable raw materials for the chemical and petrochemical industries. In addition, this reaction is of interest from the point of view of studying the mechanism of conversion of hydrocarbons. Aromatization of low molecular weight paraffinic hydrocarbons is a complex process, which includes not only reactions aimed at obtaining the target product, but also a number of side reactions. Therefore, selective conversion of lower alkanes to aromatic hydrocarbons is possible only in the presence of a highly selective catalyst. The published results of the study of the process of aromatization of $C_2 - C_4$ hydrocarbons confirm the effectiveness of the used bifunctional systems. They are characterized by the presence of acidic areas of the sorbent carrier and active metal-containing areas formed when dehydration promoters are introduced into the catalyst.

Experimental part

Propane - 99.9%, hydrogen - 99.9%, helium - 99.9%, nitrogen - 98.8% purity gases were used in the work. Catalysts were prepared in two ways: solid-phase modification (by mixing mesoporous sorbent powder with zirconium oxide for 2 hours) and soaking (the calculated amount of $ZrO(NO_3)_2 \cdot 8H_2O$ was dissolved in distilled water until the salt was completely dissolved). The resulting solution was added to a measured amount of sorbent and evaporated in a water bath with constant stirring, and then calcined in an oven at 200 °C for 3 h. A sample of zirconium aluminosilicate with a mesoporous sorbent (MGS) structure was obtained by hydrothermal synthesis at high pressure using a catalytic dehydroaromatization reaction mixture of aluminosilicate propane containing zirconium nitrate. Before the experiments, the catalyst powder was crushed and passed through a sieve with a size of 1-2 mm and pressed and made into tablets. To improve heat transfer, the catalyst was diluted 1:1 with quartz of the same particle size. All samples were treated at 550 °C in air or hydrogen flow for 2 h before catalytic experiments. Regeneration in hydrogen flow (1 l/h) was carried out according to the following scheme:

- maintaining the temperature from 25 to 350 °C at a heating rate of 4 °C/min and at a temperature of 350 °C for 1 hour;
- temperature rise from 350 to 550°C, heating rate 4°C/min and 550°C for 1 hour.

After activation, the catalyst was purged with helium for 15 min at experimental temperature to remove residual water. Catalytic experiments on the catalytic aromatization of propane were carried out in a bed-flow reactor with a stationary catalyst at atmospheric pressure. A schematic diagram of the laboratory device is shown in Figure 1.



1- quartz furnace, 2- quartz reactor, 3- relay RER-10, 4- thermocouple for temperature control, 6- gas cylinder, 7- reducer 8- valve, 9- rheometer, 10- collection of products of catalytic dehydroaromatization reaction of liquid propane holder for, 11- Liquid nitrogen container, 12 - thermocouple (temperature regulator), 13- Thermometer.

Figure 1. Schematic diagram of the experimental device

The laboratory equipment consists of a vertical quartz furnace (1) in the form of a hollow cylinder heated by nichrome wire with asbestos insulation. A quartz reactor (2) with an inner diameter of 21 mm is placed in the furnace. The heating rate and temperature were controlled by RES-10 (3) and TRM-1 (4) devices with an accuracy of ± 1°C. The temperature in the catalytic dehydroaromatization reaction zone of propane was varied in the range of 350-650 °C and was measured by a chrome-aluminum thermocouple (5) in a 1 mm diameter quartz housing. Propane, helium or hydrogen was supplied from cylinders (6) through a reducer (7). The gas flow rate is regulated by a valve (8) and measured using a rheometer (9) pre-calibrated for this gas. The volumetric rate of propane delivery is 500 h^{-1}. The duration of experiments is usually 2.5 hours. The products of the liquid propane catalytic dehydroaromatization reaction were taken into a liquid nitrogen (11)-cooled holder (10) twice for 40 min, degassed for 15-20 min at room temperature, and weighed and analyzed. Gaseous propane catalytic dehydroaromatization reaction products and propane catalytic dehydroaromatization reaction starting materials were collected in a gasometer for chromatographic determination of component concentrations. After each experiment, the catalyst was purged with helium for 15 min to remove the adsorbed propane catalytic dehydroaromatization reaction products. Helium was supplied from the cylinder at a rate of 5 l/h using a reducer, which was adjusted using a rheometer fine-adjustment valve. The catalyst was then regenerated with air at 550 °C for two hours.

Experimental results and their discussion

The reaction temperature of catalytic dehydroaromatization of propane at a constant volumetric rate (V = 500 h^{-1}) in MGSsorbent was changed (500-650°C). The main indicators of the process are presented in Table 1. Figure 2 shows the temperature dependence of the conversion, yield, and selectivity in the catalytic dehydroaromatization of propane for aromatic products. Aromatic hydrocarbons (ArU) formed in the catalytic aromatization of propane in the presence of a 2% Zr-2%Zn-7%Mo/MGS catalyst was 17.8% at 500°C. With a further increase in temperature, the yield of aromatic hydrocarbons formed during catalytic aromatization of propane in the presence of a 2%Zr-2%Zn-7%Mo/MGS catalyst increases and is 38.6% at 600°C. The propane conversion process is faster; with increasing temperature from 500 to 650°C, this indicator increased from 65.4 to 95.9%. The yield of catalytic aromatization products of gaseous propane is highly dependent on the reaction temperature of catalytic dehydroaromatization of propane. However, as shown in table 1, as the temperature increased from 500 to 650°C, the yield of methane increased by almost 50% (from 20.5 to 30.8%), and the yield of C_2 hydrocarbons increased from 21.8 to 27.4%.

Table 1.

The main parameters of the propane aromatization process in the MG'S catalyst

T, °C	KC_3H_8	Yield of products,%					
		CH_4	ΣC_2	C_3H_8	ΣC_4	ΣC_1-C_4	АрУ
500	65,4	20,6	21,8	1,7	2,8	46.9	17,8
550	79,4	25,4	23,4	2,2	1,8	52,5	27,8
600	94,6	30,8	25,6	2,5	1,7	60.6	38,6
650	95.9	31,9	27,4	2,8	0,0	62.1	40,6
T, °C	KC_3H_8	Product selectivity,%					
		CH_4	ΣC_2	C_3H_8	ΣC_4	ΣC_1-C_4	АрУ
500	62,4	32,9	33,4	2,4	3,9	72,4	27,6
550	79,4	31,7	29,4	2,8	1,9	65,4	35,4
600	96,6	31,8	25,6	2,5	1,4	61,4	39,4
650	99,4	31,2	25,8	2,4	0,4	59,42	40,8

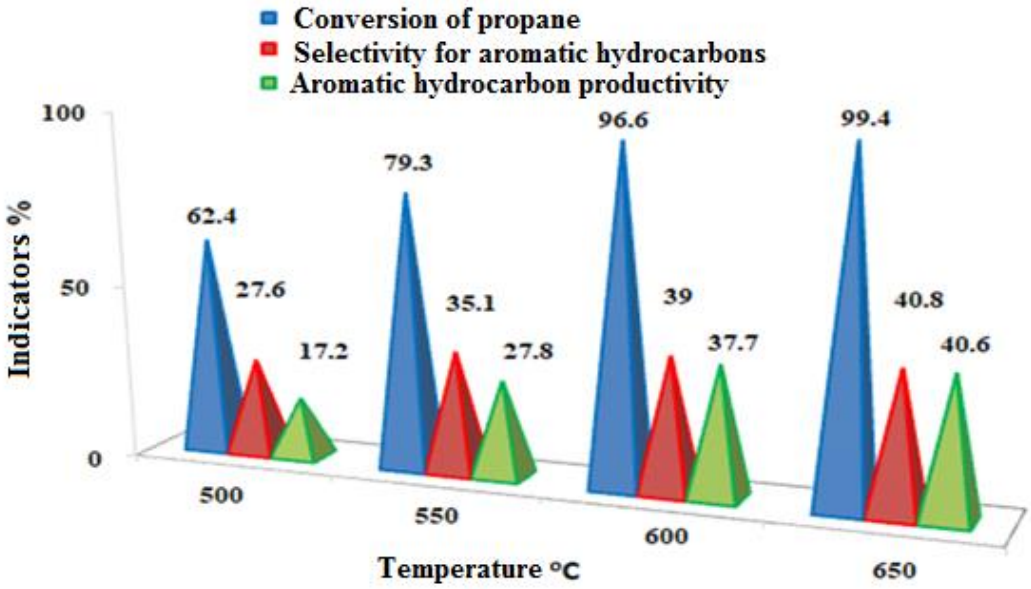


Figure 2. Temperature dependence of the main parameters of the process of propane aromatization in MGS catalyst Aromatization in 2%Zr-2%Zn-7%Mo/MGS catalyst.

Conclusion

Thus, the reaction temperature of catalytic dehydroaromatization of propane at a constant volume rate (V=500 h^{-1}) in MGSsorbent changed (500-650°C). The main indicators of the process are presented in Table 1. Figure 4 shows the temperature dependence of the conversion, efficiency and selectivity in the catalytic dehydroaromatization of propane for aromatic products. Aromatic hydrocarbons (ArU) formed during catalytic aromatization with propane 2%Zr-2%Zn-7%Mo/MGS catalyst was 17.8% at 500°C. With a further increase in temperature, the yield of aromatic hydrocarbons formed during catalytic aromatization of propane in the presence of a 2%Zr-2%Zn-7%Mo/MGS catalyst increases and is 38.6% at 600°C. The propane conversion process is faster; with increasing temperature from 500 to 650°C, this indicator increased from 65.4 to 95.9%.

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DOI - 10.32743/UniTech.2024.127.10.18410

SYNTHESIS OF THIOURETHANE OLIGOMER BASED ON ETHYLENE GLYCOL

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СИНТЕЗ ТИОРЕТАНОВОГО ОЛИГОМЕРА НА ОСНОВЕ ЭТИЛЕНГЛИКОЛЯ

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ABSTRACT

Thiourethane oligomers are essential materials in various industrial applications due to their excellent mechanical properties, chemical resistance, and unique functionalities. The synthesis of thiourethane oligomers involves the reaction of thiourea and polyols, such as ethylene glycol, with isocyanates. This article explores the synthesis process, characterization, and potential applications of thiourethane oligomers based on ethyleneglycol.

АННОТАЦИЯ

Тиоуретановые олигомеры являются важными материалами в различных промышленных применениях благодаря их отличным механическим свойствам, химической стойкости и уникальным функциональным характеристикам. Синтез тиоуретановых олигомеров включает реакцию тиомочевины и полиолов, таких как этиленгликоль, с изоцианатами. В этой статье рассматриваются процесс синтеза, характеристика и потенциальные применения тиоуретановых олигомеров на основе этиленгликоля.

Keywords: thiourethane, oligomers, ethyleneglycol, gel permeation chromatography, cryoscopic constant, product, polymer.

Ключевые слова: тиоуретан, олигомеры, этиленгликоль, гель-проникающая хроматография, криоскопическая постоянная, продукт, полимер.

Библиографическое описание: Murodov D.M., Akhmedov V.N., Niyozov A.K. SYNTHESIS OF THIOURETHANE OLIGOMER BASED ON ETHYLENE GLYCOL // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18410*

Introduction. The synthesis of thiourethane based on ethylene glycol, their molecular properties, and chemical reactions have been studied in numerous research papers in recent years. These thiourethanes are synthesized with the participation of ethylene glycol, formaldehyde, and thiourea. Thiourethanes are widely used in various fields, including polymer materials, coatings, and other specialty chemicals. Their main properties include high strength, chemical stability, and flexibility[1-3].

The synthesis of thiourethane oligomers based on ethylene glycol is a highly relevant topic in the field of polymer chemistry due to the unique properties and wide range of applications of these materials. Thiourethane oligomers exhibit exceptional mechanical properties, chemical resistance, and thermal stability, making them ideal for use in coatings, adhesives, sealants, and elastomers. The incorporation of ethylene glycol provides flexibility and enhances the polymer's ability to form strong, durable films [4-6]. Additionally, these oligomers can be tailored to possess specific functionalities, allowing for their use in advanced applications such as biomedical devices and high-performance materials. The process of synthesizing thiourethane oligomers involves reacting thiourea with ethylene glycol and isocyanates, leading to the formation of a robust polymer network. Research in this area is crucial for developing new materials with improved performance characteristics, meeting the increasing demands of various industries, including automotive, construction, and healthcare. The exploration of thiourethane oligomers not only advances scientific knowledge but also drives innovation in material science, making it a significant area of study [7-9].

Materials and methods. In the first step of oligomer synthesis involving urethane groups based on ethylene glycol, a chemical reaction is carried out between thiourea and ethylene glycol. The chemical reaction proceeds according to the following equation (Figure 1). The reaction results in ethylene glycol-based diurethane.

Figure 1

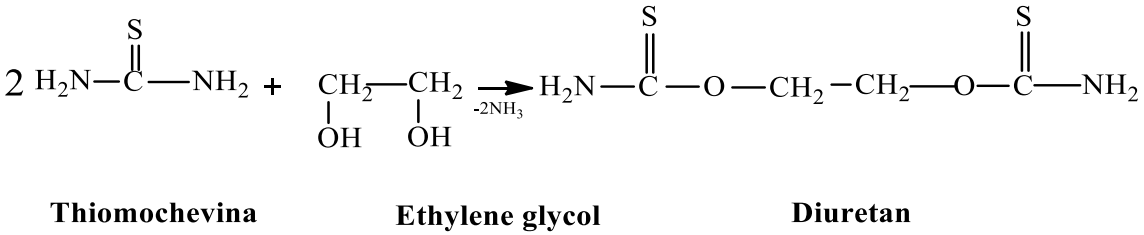

Figure. Results

- Reactants: Thiourea,Ethylene glycol
- Product: Diurethane based on ethylene glycol, Ammonia

In the second stage of synthesizing a urethane oligomer based on ethylene glycol, the previously obtained diurethane reacts with formaldehyde. The chemical condensation reaction of formaldehyde follows the scheme shown in Figure 2.

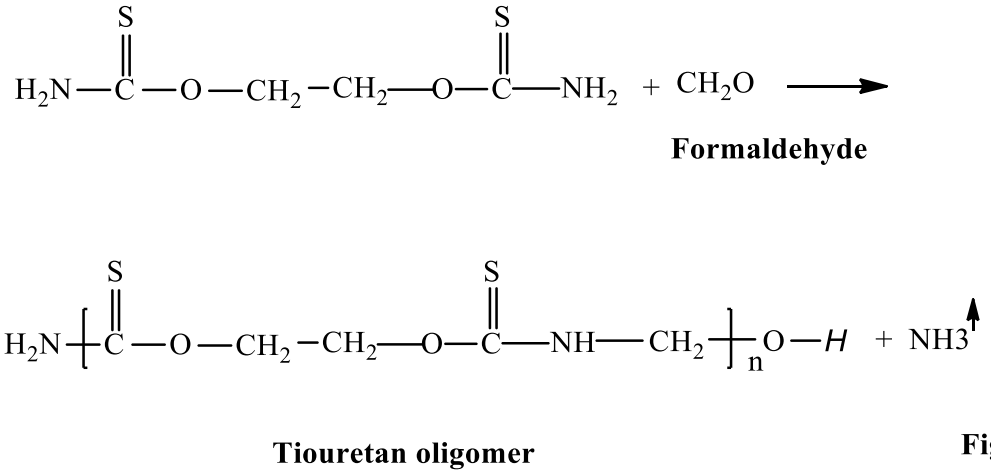

Figure 2

Figure 2. Formation reaction of thiouretan.

The first stage of synthesizing thiourethane based on ethylene glycol (process of synthesizing diurethane based on ethylene glycol). A flask equipped with a laboratory stirrer, a reflux condenser, a dropping funnel, and a thermometer is charged with 78 grams of thiourea. The flask is heated to 80 ºC and stirred at a speed of 120 revolutions per minute. While stirring the thiourea, 62 grams of ethylene glycol heated to 130-140 ºC is added. When the hot ethylene glycol is added, the temperature of the reaction mass rises to 125-130 ºC. The ethylene glycol must be added at such a rate that the temperature of the reaction mass remains between 120 ºC and 130 ºC. After adding the entire designated amount of ethylene glycol, the temperature of the reaction system is raised to 140 ºC. At this temperature, the chemical reaction is carried out for 90 minutes. During the chemical reaction, ammonia gas is observed to evolve from the reaction mass. The release of ammonia can be detected using moist litmus paper. At the end of the reaction between thiourea and ethylene glycol, the release of ammonia decreases. After the reaction is complete, the temperature is slowly lowered to 80 ºC and the light brown viscous liquid mass is held at 70 - 80 ºC for 25 – 30 minutes.

Results and discussion. The cryoscopic indicators of the solutions of the obtained diurethane based on ethylene glycol have been determined. Based on the results obtained from the cryoscopic method of study, Table 1 was compiled. The table shows the changes in the crystallization temperature of the solutions of the obtained diurethane based on ethylene glycol at concentrations of 2.5; 3, 3,5 and 4 as well as the molecular mass M. Based on the obtained data, a graph of the dependence of the molecular mass M on the concentrations of the corresponding solutions was constructed (Figure 3).

Table 1.

The results of calculations of the cryoscopic analysis method for the derivative reaction of the interaction of ethylene glycol with thiourea

m_1 (g)	m_2 (g)	C (%)	Tcr (°C)	Tc0 (°C)	ΔT (°C)	M (g/mol)
0.6	40	2.5	-0.12	0	-0.12	198
0.7	40	3	-0.158	0	-0.158	206
0.8	40	3.5	-0.212	0	-0.212	194
0.9	40	4	-0.315	0	-0.315	200

Designations: m_1– mass of the dissolved oligourethane, g; m_2– mass of the solvent, g; C– concentration of the solution, %; Tco– crystallization temperature of the solvent, °C; Tcr– crystallization temperature of the solution, °C; ΔT – temperature depression; M– molecular mass of the urethane-containing oligomer.

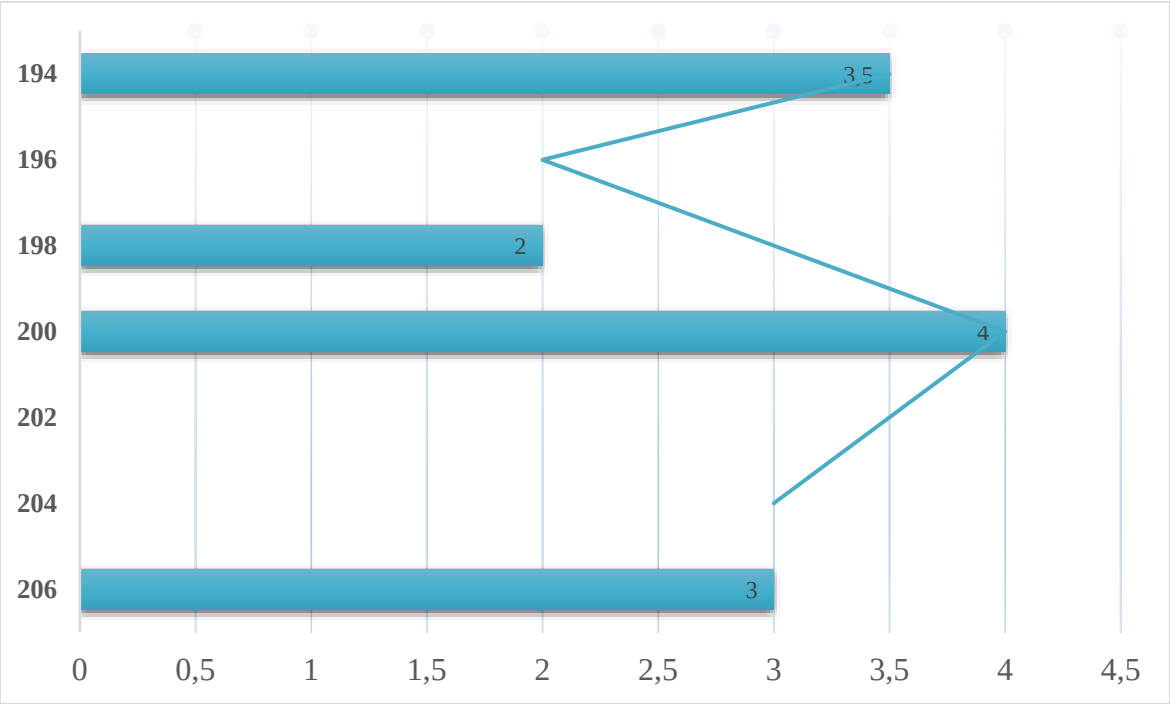

Figure 3. Diagram of the molecular weight dependence of the product of the interaction reaction between ethylene glycol and thiourea on the concentration of the solvent

Conclusion. Thus, based on the obtained results, it can be concluded that the developed isocyanate-free synthesis method for urethane oligomers based on ethyleneglycol allows obtaining oligourethanes with an average molecular weight of 900-1050. The optimal temperatures for the chemical reaction stages of the synthesis and the duration of each stage have been established.

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INCREASING THE EFFICIENCY OF THE GAS REFINING PROCESS THROUGH THE RECOVERY OF ALKANOLAMINES

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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ПРОЦЕССА ПЕРЕРАБОТКИ ГАЗА ЗА СЧЕТ ВОССТАНОВЛЕНИЯ АЛКАНОЛАМИНОВ

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ABSTRACT

in this article, the technology of gas purification from sour components by absorption method is aimed at achieving long-term use in the process of gas purification by determining the composition of used alkanolamine solutions and regenerating them. Using the ion exchange method: it is recommended to reduce the amount of active components in the solution, to compensate for this by adding new alkanolamine and piperazine; It is based on the fact that the composition additives affecting the operational properties of the used alkanolamines lead to a decrease in the amount of thermally stable salts, free elements, and heavy organic substances. With this, in turn, the physico-chemical properties of used alkanolamines, which affect the operational properties of viscosity and foaming, surface tension, were found to be in accordance with the norms, and it was recommended to reuse them.

АННОТАЦИЯ

В данной статье технология очистки газа от кислых компонентов методом абсорбции направлена на достижение длительного использования в процессе очистки газа путем определения состава отработанных растворов алканоламинов и их регенерации. С использованием метода ионного обмена: рекомендуется снизить количество активных компонентов в растворе, компенсировать это добавлением новых алканоламинов и пиперазина; Он основан на том, что добавки в составе, влияющие на эксплуатационные свойства используемых алканоламинов, приводят к снижению количества термостойких солей, свободных элементов и тяжелых органических веществ. При этом, в свою очередь, физико-химические свойства используемых алканоламинов, влияющие на эксплуатационные свойства вязкость и пенообразование, поверхностное натяжение, признаны соответствующими нормам, и рекомендовано их повторное использование.

Keywords: alkanolamine, monoethanolamine, diethanolamine, absorbent, desorption, ion exchange, filter, regeneration.
Ключевые слова: алканоламин, моноэтаноламин, диэтаноламин, абсорбент, десорбция, ионный обмен, фильтр, регенерация.

Introduction

Transition to low-waste and zero-waste technologies, in order to significantly reduce production waste, a number of actions are necessary, including modernization and improvement of existing technological processes in principle: use of waste in the technological system itself or in other industries; development and implementation of advanced methods of cleaning, processing and disposal of waste that cannot be used for technical or economic reasons. Only on the basis of evaluating the advantages and problems of waste disposal methods, it is possible to make a decision about the options for their future use [1].

Purification of DEA solutions by vacuum distillation has not been studied so far, therefore, studying the characteristics of working solution purification processes, developing a rational technological scheme and regimes of the process is an urgent scientific and practical problem, and the solution of this problem increases the performance of the natural gas purification process from hydrogen sulfide and carbon dioxide, as well as technical and leads to significant economic improvement [1].

Research and development of a complex technology for cleaning DEA working solutions, improving the quality of sorbents, increasing the productivity of amine gasification units, as well as providing a closed production

Библиографическое описание: Nematov K.I. INCREASING THE EFFICIENCY OF THE GAS REFINING PROCESS THROUGH THE RECOVERY OF ALKANOLAMINES // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18303*

cycle without waste as a result of the subsequent use of the generated waste [2].

Literature review

Researches recommended the use of ultrasonic radiation for the regeneration of absorbent - MEA aqueous solutions and the separation of absorbed components. The desorption rate of absorbed components was studied at 25 °C under 28 kHz ultrasonic radiation. The results showed that low concentration MEA (0.2 mol/ It is shown that the rate of desorption of absorbed components in solution l) is significantly higher under ultrasound irradiation than desorption by stirring at low temperature (25 °C). It is also observed that the desorption rate increases with a decrease in the concentration of MEA solutions [3].

Scientists have investigated the use of amine hydrogels (AlH) to separate CO_2 from a CH_4/CO_2 gas mixture. To this end, systematic experiments were conducted to analyze the performance of AlH particles, and an amine-saturated hydrogel was prepared by mixing MEA solution with dried hydrogel particles. The authors statement shows that AlH particles absorb CO_2 with high selectivity from CH_4/CO_2 gas mixture and have higher CO_2 absorption activity compared to MEA solution; CO_2 absorption kinetics were observed with temperature, mixing intensity changes, and addn. Mixing AlH particles with the gas mixture increases the absorption rate, which means that the absorption capacity depends on the properties of AlH. Also, the addition of decane and dodecyltrimethylammonium bromide (DTAB) to the absorbing composition leads to softening of coagulation between AlH particles, increasing the rate and yield of CO_2 absorption [4].

Methods

Based on the physico-chemical properties of the harmful additives contained in the 30% aqueous solution of DEA, a recommendation was made to use the immobilization method [5]. Natural river sand, activated charcoal, and Navbahor benthite were used to purify the spent ethanolamine solution. Quartz sand with a particle size of 0.34÷1.0 mm was used for the filter. At a rate of 1.5-2.1 l/h, the solution was passed through a sand filter, and activated carbon was used as an adsorbent for cleaning DEA solutions from tarry substances and other impurities. In this case, a solution was passed through a 100 cm3 layer of activated carbon at a speed of 1.5-2.1 l/h, and the resinous substances contained in it were filtered and retained [5].

The purification of bentonite from the amorphous crystalline part was carried out in the following sequence: the first step, the bentonite was washed three times in distilled water, then tindiralid and filtered; second step, washing 3 times in 0,1 normal hydrochloric acid and filtering again [5].

The diethanolamine solution, initially cleaned of mechanical impurities and tarry substances, is passed through previously prepared 100 cm3 sorbents (A-200 or A-400 anionites) at a specified speed (1.5-2.1 l/h) and is cleaned of various salts in the solution. When the absorbent solution was purified using the above filtration method, a reduction of mechanical impurities and resinous substances up to 75.0÷83.0% was achieved. When ethanolamine solutions were purified from salts using A-200 and A-400 anionite filters, the amount of salts in the absorbent was purified up to 85-90% [5, 6].

Results

Despite the variety of gas purification methods, the absorber must meet stable general requirements: the absorber must have a high absorption capacity of acidic components, despite their content in the gas being in a large interval; the partial pressure of the absorber should be low, because its loss in the process is reduced; for good contact with gas, the viscosity of the absorbent should be low; should be insoluble in hydrocarbons; should be neutral to hydrocarbons and inhibitors; low corrosion activity; resistant to oxidation and thermal decomposition; do not react with various compounds; stable to the formation of foam; the boiling point of the absorber should be lower than that of all components [7].

It should be noted that the presence of polyethylene polyamines in the composition of the used alkanolamines increases the viscosity and foaming properties of the solutions along with extinguishing the operational activity of absorbents. For this reason, it is necessary to separate the thermal degradation products of amine from the maximum solution composition [8].

During the research, the composition of the working solution used in the purification of natural gas was analyzed (Table 2) [9].

The data in the table shows that the amount of alkanolamines in the working solution is reduced to 70-75%, along with amino acids, glycolates, acetates, the amount of heat-resistant salts is 2,5 times higher, bicines (N, N-Bis(2-hydroxyethyl) glycine; diethylolglycine; diethanol glycine; dihydroxyethyl glycine) amount increases by 2,8 times, oxalates by 2 times, besides, the amount of iron increases by 24 times [9, 10].

Table 2.

Composition of components of ethanolamines used in natural gas purification

Composition of the used DEA solution	Unit of measure	Amount in solution, %	Reminder
Concentration DEA 30%			
Unreacted DEA	%	22,37	
Associated DEA	%	7,6	
Anions of heat-resistant salts	ppm	2553	2,5 times higher than the norm
Heat-stable amino salts	%	0,49	above the norm
Heat resistant salts	Mol/mol	0,0125	above the norm
Strong cations	ppm	67	above the norm
Amino acids	ppm	4233	dangerous level
Glycolates	ppm	627	1,3 times higher than the norm
Acetates	ppm	439	above the norm
Let them go	ppm	1648	2,8 times higher than the norm
Oxalate	ppm	498	2 times higher than the norm
Iron	ppm	118	24 times higher than the norm
Precipitated particles	mg/l	93	above the norm
H_2S	mg/m^3	15–17	norm
CO_2, %	%	2,1	norm

Based on the physico-chemical properties of the harmful additives contained in the 30% aqueous solution of DEA, studies were conducted on the method of immobilization [11].

Navbahor bentonite purified from amorphous part, activated carbon and A-200 or A-400 anionites were used to purify the used ethanolamine solution. It should be said that during research, a special method of cleaning the amorphous crystal part included in bentonite was recommended, and it was found that bentonite together with activated carbon can be one of the important components in absorbing tarry substances [12].

Quartz sand with particle sizes of 0,34÷1,0 mm was used for the filter. At a speed of 1,5-2,1 l/h, the solution was passed through a sand filter, and activated carbon was used as an adsorbent for cleaning DEA solutions from tarry substances and other impurities. For this, the working solution was passed through a 100 sm^3 layer of activated carbon, and the resinous substances contained in it were filtered and retained [13].

Diethanolamine solution purified from mechanical impurities and tarry substances is passed through pre-prepared 100 sm^3 sorbents (A-200 or A-400 anionites) at a specified speed of 1,5-2,1 l/h, and is cleaned of various salts in the solution. When the absorbent solution was purified using the above filtration method, a reduction of mechanical impurities and resinous substances up to 75,0÷83,0 % was achieved. Analysis shows that when ethanolamine solutions are purified from salts using A-200 and A-400 anionite filters, 85-90% of salts in the absorbent are lost. Tables 3 - 5 show the results of purification of DEA working solution according to the proposed system [13, 14].

Table 3.

3-step purification of the DEA working solution using the ionization method

Stage 1 pointers

The amount of the transferred working solution is 12 l, the degree of purification is 2 - 36%

Composition of the used DEA solution	Unit of measure	DEA working solution	Purified solution in activated charcoal
Unreacted DEA	%	23,06	23,1
Associated DEA	%	6,96	6,415
Anions of heat-resistant salts	%	5,14	4,84
Heat-stable amino salts	ppm	4229	3985
Heat resistant salts	ppm	629	586

Composition of the used DEA solution	Unit of measure	DEA working solution	Purified solution in activated charcoal
Strong cations	ppm	441	409
Amino acids	ppm	1649	1027
Glycolates	ppm	496	414
Acetates	mg/l	118	110
Let them go	mg/l	93	90
Oxalate	%	2,4-2,8	0,7-0,9
Iron	%	2,5-3,5	1,5-1,7
Precipitated particles	%	3,5-4,0	3,4-3,87
H_2S	mg/m^3	15-19	15-19
CO_2, %	%	2,2	2,2
Sodium (Na^+) salts,	mg/l	62,1	59,1
Potassium (K^+) salts,	mg/l	12,7	11,7
Ant acid, mg/l	mg/l	666,3	659,1

As can be seen from Table 4, working DEA solution passed through activated carbon reduces the amount of sulfur-containing organic compounds, as well as reduces the amount of heavy oxygen substances and tar compounds, such as bitcins [14].

Table 4.

3-step purification of the DEA working solution using the ionization method

Stage 2 pointers [14].

The amount of spent working solution is 12 l, the degree of purification is 56-63%

Composition of the used DEA solution	Unit of measure	DEA working solution	Refined solution in bentonite
Unreacted DEA	%	23,09	21,5
Associated DEA	%	6,94	0,48-0,69
Anions of heat-resistant salts	%	5,32	0,019-0,028
Heat-stable amino salts	ppm	4235	92,2-97,6
Heat resistant salts	ppm	629	81-86
Strong cations	ppm	436	73,1-79,2
Amino acids	ppm	1644	997,6
Glycolates	ppm	497	111,5-115,8
Acetates	mg/l	117	7,0-9,0
Let them go	mg/l	91	6,5
Oxalate	%	2,42-2,83	2,2-2,5
Iron	%	2,55-3,65	2,55-3,65
Precipitated particles	%	3,53-4,10	3,53-4,10
H_2S	mg/m^3	14-17	14-17
CO_2, %	%	2,13	2,134
Sodium (Na^+) salts,	mg/l	62,1	58,2
Potassium (K^+) salts,	mg/l	12,7	11,2
Ant acid, mg/l	mg/l	664,3	660,1

Table 5.

3-step purification of DEA working solution by ionization method

Stage 3 pointers[14].

The amount of the transferred working solution is 125 l, the degree of purification is 50-56%

Composition of the used DEA solution	Unit of measure	DEA working solution	Purified solution in anionites
Unreacted DEA	%	23,072	23,02
Associated DEA	%	6,96	0,54-0,72
Anions of heat-resistant salts	%	5,24	0,02-0,03
Amino acids	ppm	4236	92,2-97,4
Glycolates	ppm	628	81,1-86,3
Acetates	ppm	436	73,4-79,2
Let them go	ppm	1644	102,1-108,4
Oxalate	ppm	496	112,3-115,5
Ant acid, mg/l	mg/l	666,3	36,2-41,3
Precipitated particles	mg/l	92	6,9
Mechanical compounds	mg/m^3	778-1098	179,4-190
Sulfur preservatives	%	2,4-2,8	2,4-2,8
Resin compounds	%	2,5-3,5	2,5-3,5
Hydrates	%	3,5-4,0	3,5-4,0
H_2S	mg/m^3	15-17	15-17
CO_2	%	2,1	2,1
Metals:	mg/l		
Sodium		63,3	0,94
Manganese		90,8	0,023-0,032
Potassium		13,74	0,034-0,043
Calcium		83,2	26,2
Iron		119	7,2-9,1

Discussion

It is planned to clean the metal salts of the DEA working solution in anionites, and from the results of Table 5, it can be seen that the theoretical estimates have been proven in experiments, including the amount of sodium from 63,3 to 0,94 mg/l, manganese from 90,8 to 0,023-0,032 mg/l, we can see a decrease in the amount of potassium from -13,74 to 0,043 mg/l, Ca from 83,2 to 26,2 mg/l, Fe from 119 to 7,2-9,1 mg/l [15].

In the course of the research, a comparison was made in the main physico-chemical parameters of alkanolamines used in the purification of natural gas. The results of the comparison are presented in Table 6 [15].

Table 6.

Basic properties and physico-mechanical indicators of DEA working solution

Physical and mechanical properties	DEA 30% (pure) aqueous solution	DEA working solution
Ph	10,2	9,1
Viscosity (η) sPz	2,06	3,89
Density, g/sm^3	1,02	1,38
The surface tension (δ) 10^3, N/m	71,8	66,9
The thickness of the foam sm	1,45	2,52
Foam residence time, (τ) sek.	less 12–16	21–26

Studies of the physical and mechanical parameters of alkanolamines used in clean and natural gas purification show that the viscosity of the solution has almost doubled, and the density has increased from 1,023 to 1,39 g/sm^3, which means that with the increase in gas absorption resistance, the gas purification activity has decreased and natural gas components have become absorbent. with the increase in the period of being in the environment, it also causes the realization of additional chemical reactions [16]. Thus, the processes of formation of many products (complex ethers, carboxylic acids, anhydrides and chlorates of carboxylic acids) through chemical changes in the conditions of the amine system were proved, the realization of hydrolysis, hydrotation, heterocyclization reactions was substantiated, and the factors of change in element composition were proved [16].

Conclusion

The composition of working ethanolamine solutions used in the purification of natural gases from sour components using alkanolamines was determined.

Using the ion exchange method, the content additives affecting the operational properties of the used alkanolamines are based on the reduction of the amount of thermally stable salts, free elements, heavy organic substances, the physico-chemical properties affecting the operational properties of the purified alkanolamines, viscosity and foaming, surface tension are determined and reused.

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POLYTHERMAL SOLUBILITY OF THE NA_2SO_4·$MGSO_4$ - NACL-H_2O SYSTEM

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ПОЛИТЕРМИЧЕСКАЯ РАСТВОРИМОСТЬ СИСТЕМЫ NA_2SO_4·$MGSO_4$ - NACL-H_2O

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ABSTRACT

In this work, the solubility of the Na_2SO_4·$MgSO_4$ - NaCl-H_2O system was studied using a visual polythermal method. Based on the polytherms of binary systems and internal cross sections, polythermal solubility diagrams of the Na_2SO_4·$MgSO_4$ - NaCl-H_2O system were constructed in the temperature range from -25.2 to 41.0 °C. When studying the solubility of this system, polytherms were carried out in each temperature range of 10 ° C. On the polythermal solubility diagram the crystallization regions of ice, Na_2SO_4·$MgSO_4$, $MgSO_4$·$10H_2O$, NaCl, NaCl·H_2O, Na_2SO_4·$MgSO_4$·$2H_2O$, Na_2SO_4·$MgSO_4$·$4H_2O$ and compound of the composition $MgCl_2$ were delimited. Based on the results of the study, it was revealed that the Na_2SO_4·$MgSO_4$ - NaCl-H_2O system belongs to a complex eutonic type.

АННОТАЦИЯ

В этой работе было изучено растворимость системы Na_2SO_4·$MgSO_4$ - NaCl-H_2O с помощью визуального политермического метода. На основе политерм бинарных систем и внутренних сечений было построено политермические диаграммы растворимости системы Na_2SO_4·$MgSO_4$ - NaCl-H_2O в интервале температур от -25,2 до 41,0 °C. При изучении растворимости этой системы политермы проводились в каждом интервале температур 10 °C. На диаграмме политермической растворимости были выделены области кристаллизации льда, Na_2SO_4·$MgSO_4$, $MgSO_4$·$10H_2O$, NaCl, NaCl·H_2O, Na_2SO_4·$MgSO_4$·$2H_2O$, Na_2SO_4·$MgSO_4$·$4H_2O$ и соединения состава $MgCl_2$. На основе результатов исследования было выявлено что система Na_2SO_4·$MgSO_4$ - NaCl-H_2O относится к сложному эвтоническому типу.

Keywords: solubility, system, diagram, magnesium sulfate, sodium sulfate, sodium chloride, crystallization temperatures.

Ключевые слова: растворимость, система, схема, сульфат магния, сульфат натрия, хлорид натрия, температуры кристаллизации.

Библиографическое описание: Rakhmatzhanov U., Yorbobaev R., Mirzakulov K. POLYTHERMAL SOLUBILITY OF THE Na_2SO_4·$MgSO_4$ - NaCl-H_2O SYSTEM // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18435*

Introduction

One of the main directions of economic development in developing countries is the exploitation of natural raw materials, the production of competitive, import-substituting products based on local raw materials through its complex processing. Such chemical products include sodium and magnesium sulfates, as the need for these products increases every day with the development of industry and production [1-3].

The laws of solubility of salts and the equilibrium of liquid and solid phases are crucial in establishing the scientific basis for separating or purifying salts, especially those with complex compositions, for various applications [4-7]. Several scientists have conducted modern studies on salt systems to support the production of chemical products and the improvement of technologies [8-10]. In addition, several studies that have researched $MgSO_4$ and Na_2SO_4 as their objects are known from the literature.

Materials and methodology

The polythermal solubility of the $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system was studied by the visual polythermal method [11]. Liquid nitrogen was used as a freezing reagent in the study of solubility of solutions. In the quantitative chemical analysis of liquid and solid phases, the content of magnesium ions was determined by the complexometric method [12], sodium by flame photometry [13], chloride ions by the Mohr method [14].

Results and discussion

The binary system NaCl-H_2O was previously studied by the authors [15], this system is part of the system we are studying, and our data are in good agreement with the literature data.

The solubility of the $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system was studied using eight internal sections. Based on the results of the study of binary systems and internal sections, a complete polythermal diagram of this system was constructed in the temperature range from -25.2 to 41 °C. The crystallization fields of ice, $Na_2SO_4 \cdot MgSO_4$, $MgSO_4 \cdot 10H_2O$, NaCl, $NaCl \cdot H_2O$, $Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$, $Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O$ and a new compound of the system – magnesium chlorides are highlighted on the phase diagram of the solubility of the $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system. These fields converge at six triple nodal points of the system, for which the compositions of the equilibrium solution and their corresponding crystallization temperatures are determined, which are shown in Fig. 1.

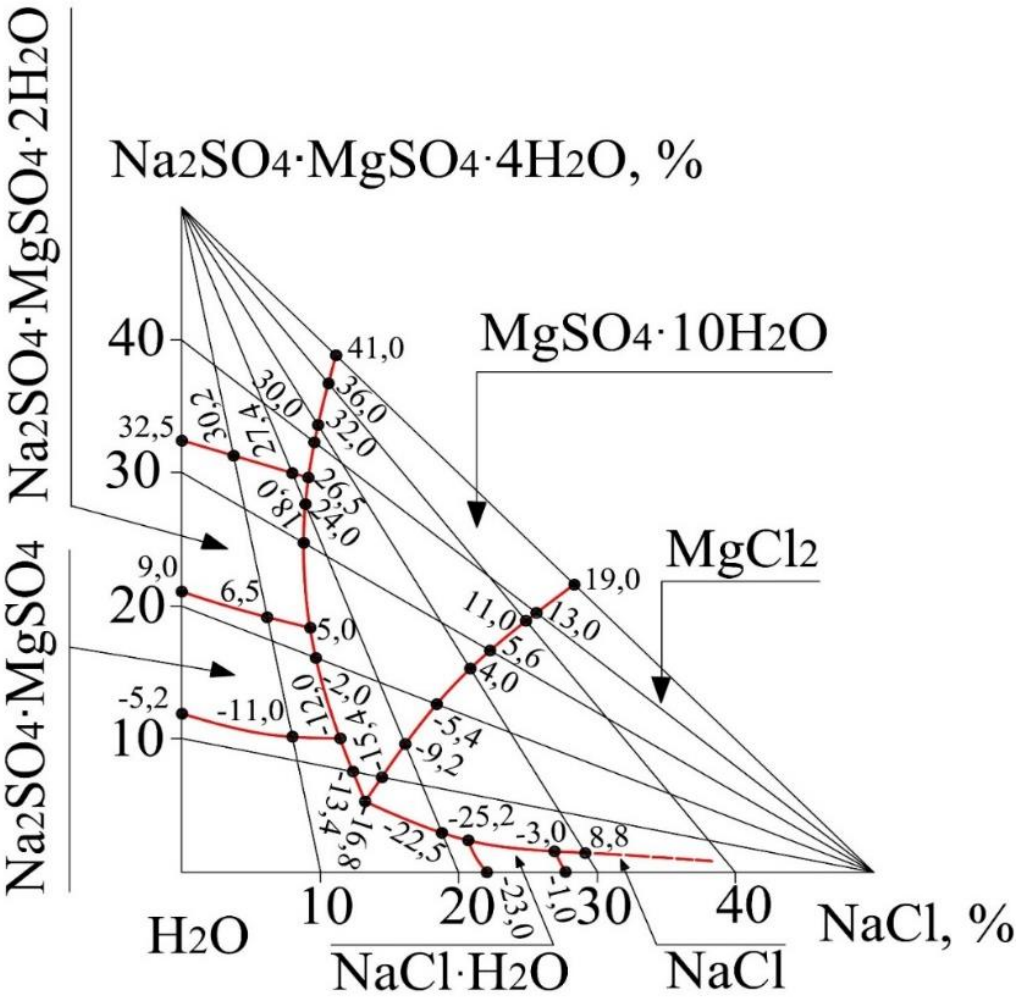

Figure 1. Polythermal diagram of the solubility of the $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system

On the polythermal diagram, the fields of the formed crystals of the system are highlighted in bold lines, and these fields are named accordingly. These fields arise at six triple nodal points of the system, for which the corresponding compositions of the equilibrium solution and crystallization temperatures are determined (Table 1).

Table 1.

Binary and ternary points of $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system

Composition of the liquid phase (wt.%)			Tc (°C)	Solid phase
NaCl	$Na_2SO_4 \cdot MgSO_4$	H_2O		
-	11.8	88.2	-5.2	Ice + $Na_2SO_4 \cdot MgSO_4$
9.0	10.1	80.9	-11.0	The same
11.5	10.1	78.4	-12.0	Ice + $Na_2SO_4 \cdot MgSO_4$ + $MgSO_4 \cdot 10H_2O$
11.8	8.2	80.0	-13.4	Ice + $MgSO_4 \cdot 10H_2O$
12.1	5.0	82.9	-16.8	Ice + $MgSO_4 \cdot 10H_2O$ + $MgCl_2$
19.6	2.4	78.0	-22.5	Ice + $MgCl_2$
20.4	2.0	77.6	-25.2	Ice + $MgCl_2$ + $NaCl \cdot H_2O$
21.2	-	78.8	-23.0	Ice + NaCl
28.2	1.2	70.6	-3.0	$NaCl \cdot H_2O$ + $MgCl_2$ + NaCl
28.6	-	71.4	-1.0	$NaCl \cdot H_2O$ + NaCl
28.8	1.0	70.2	-8.8	$MgCl_2$ + NaCl
12.4	8.0	79.6	-15.4	$MgSO_4 \cdot 10H_2O$ + $MgCl_2$
15.4	9.7	74.9	-9.2	The same
19.5	13.2	67.3	-5.4	-//-
20.5	16.3	63.2	4.0	-//-
21.2	17.7	61.1	5.6	-//-
25.0	19.3	55.7	11.0	-//-
25.3	19.8	54.9	13.0	-//-
28.7	21.0	50.3	19.0	-//-
9.8	16.4	73.8	-2.0	$Na_2SO_4 \cdot MgSO_4$ + $MgSO_4 \cdot 10H_2O$
9.6	19.6	70.8	5.0	$Na_2SO_4 \cdot MgSO_4$ + $Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$ + $MgSO_4 \cdot 10H_2O$
6.4	19.9	73.7	6.5	$Na_2SO_4 \cdot MgSO_4$ + $Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$
-	20.8	79.2	9.0	The same
9.4	25.0	65.6	18.0	$Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$ + $MgSO_4 \cdot 10H_2O$
9.5	28.0	62.5	24.0	The same
9.6	29.9	60.5	26.5	$Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$ + $Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O$ + $MgSO_4 \cdot 10H_2O$
8.8	30.0	61.2	27.4	$Na_2SO_4 \cdot MgSO_4 \cdot 2H_2O$ + $Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O$
4.3	31.3	64.4	30.2	The same
-	31.6	68.4	32.5	-//-
9.8	34.4	55.8	30.0	$Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O$ + $MgSO_4 \cdot 10H_2O$
9.9	35.0	55.1	32.0	The same
10.2	38.1	51.7	36.0	-//-
10.4	39.0	50.6	41.0	-//-

From the above data, it can be seen that there is no chemical interaction between the components of the system under study. The system belongs to a complex eutonic type.

Conclusion

Thus, the results of the study showed that during the study of the $Na_2SO_4 \cdot MgSO_4$ - NaCl-H_2O system, a new compound is formed as a result of the interaction of the components. This indicates that the system under study belongs to a complex eutonic type. And so, these results provide new scientific data to researchers studying graphical analysis of salt systems.

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DOI - 10.32743/UniTech.2024.127.10.18451

COMPARATIVE ANALYSIS OF THE EFFICIENCY OF OIL AND GAS CONDENSATE MIXTURE DISTILLATION IN PACKED VALVE AND VALVE COLUMNS

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СРАВНИТЕЛЬНЫЙ АНАЛИЗ ЭФФЕКТИВНОСТИ ПЕРЕГОНКИ НЕФТЕГАЗОКОНДЕНСАТНОЙ СМЕСИ В НАСАДОЧНО-КЛАПАННОЙ И КЛАПАННОЙ КОЛОННАХ

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ABSTRACT

The aim of this work is to conduct a comparative analysis of the efficiency of distillation of an oil and gas condensate mixture (30% oil + 70% gas condensate) in packed valve and valve columns. Distillation was carried out under various temperature regimes to determine the optimal conditions for separating light and heavy fractions. The study found that the packed valve column provides more efficient separation of light fractions at lower temperatures, which helps reduce energy consumption for distillation. Conversely, the valve column ensures a more uniform separation of the mixture components, which is preferable when precise control of the product composition is required. Analysis of the fractional composition of the mixture showed that light fractions begin to be released in the packed valve column at temperatures between 52-180°C, and the density and viscosity of the fractions depend on the distillation temperature.

АННОТАЦИЯ

Цель данной работы – провести сравнительный анализ эффективности перегонки нефтегазоконденсатной смеси (30% нефти + 70% газоконденсата) в насадочно-клапанной и клапанной колоннах. Перегонка проводилась при различных температурных режимах, чтобы определить оптимальные условия для выделения легких и тяжелых фракций. В ходе исследования установлено, что насадочно-клапанная колонна обеспечивает более эффективное выделение легких фракций при более низких температурах, что позволяет сократить энергозатраты на перегонку. Клапанная колонна, напротив, обеспечивает более равномерное разделение компонентов смеси, что предпочтительно при необходимости контроля состава продукта. Анализ фракционного состава смеси показал, что в насадочно-клапанной колонне легкие фракции начинают выделяться уже при температуре 52-180°C, а плотность и вязкость фракций зависят от температуры перегонки.

Keywords: oil and gas condensate mixture, packed valve column, valve column, distillation, fractions, physicochemical properties.

Ключевые слова: нефтегазоконденсатная смесь, насадочно-клапанная колонна, клапанная колонна, перегонка, фракции, физико-химические свойства.

Introduction. The efficiency of crude oil primary processing units (atmospheric distillation units, ADUs) is one of the key factors for enhancing the profitability of a refinery. This is due to the high energy consumption of the distillation process itself and the large throughput of feedstock in ADUs, making them the largest energy consumers at refineries [1].

Packed columns are widely used for mass transfer processes between gas and liquid in various areas of chemical and petrochemical technology [1-3]. The type of packing contact device determines the intensity of mass transfer and the overall efficiency of the apparatus [4-6]. Numerous studies have been devoted to improving the design of packing elements, with the goal of increasing the contact surface area of the phases [7], enhancing the mass transfer efficiency of the packing [8-10], and improving hydrodynamic characteristics [11-13].

The distillation of oil and gas condensate mixtures (OGCM) in different columns is an important step in the refining industry. Comparing the efficiency of packed valve and valve columns helps determine optimal conditions for fraction separation and improving the quality of the final product. Studies have shown [1, 2] that packed columns offer several advantages over tray

Библиографическое описание: Shomansurov F. COMPARATIVE ANALYSIS OF THE EFFICIENCY OF OIL AND GAS CONDENSATE MIXTURE DISTILLATION IN PACKED VALVE AND VALVE COLUMNS // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18451*

columns, including lower hydraulic resistance per unit of transfer height and the ability to operate under high gas and liquid loads.

Unlike tray columns, in which gas velocity is limited by increased liquid entrainment between trays and low overflow capacity, packed columns can operate at atmospheric pressure at gas velocities of up to 3.5 m/s. This allows a significant reduction in column diameter and an increase in their throughput. Additionally, packed columns have a simpler design and are highly resistant to fouling, reducing the risk of blockages and ensuring reliable operation [3, 4].

Valve columns, in turn, are characterized by more uniform separation of mixture components and stable control of product composition. However, their capacity and efficiency decrease at high gas-liquid flow rates [5]. Thus, the choice of the optimal column type for distillation of oil and gas condensate mixtures depends on the specific goals and conditions of the process.

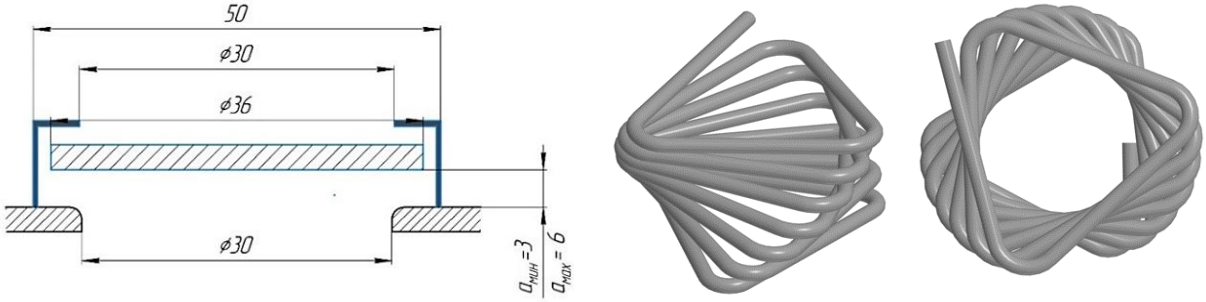


Figure 1. Comparative design of column elements: valve tray and 20x30 spiral-prismatic packing

Figure 1 shows a comparative design of elements of two types of columns used in the study. On the left, a valve tray is depicted, which is typically used to evenly distribute liquid and gas flow throughout the column, ensuring stable separation. On the right, a spiral-prismatic packing of size 20x30 mm is shown, designed to increase the contact surface between phases, significantly enhancing mass transfer efficiency and improving the separation of components during the distillation process.

Today, the development of new efficient packing for packed columns has enhanced their competitiveness and effectiveness in oil refining. This study aims to conduct a comparative analysis of the efficiency of distilling an oil and gas condensate mixture (OGCM) in packed valve and valve columns to determine the optimal conditions for the separation of light and heavy fractions.

The temperature range of the experiments was from 20 to 350°C. In each experiment, the yield of light fractions from the oil and gas condensate mixture was recorded, as well as the temperature at which component separation occurred. Standard methods for measuring boiling temperatures and determining fraction yields were used to monitor the distillation process. The equipment used ensured high precision in maintaining the set temperature conditions, while measuring instruments allowed for a detailed analysis of the composition of the obtained fractions.

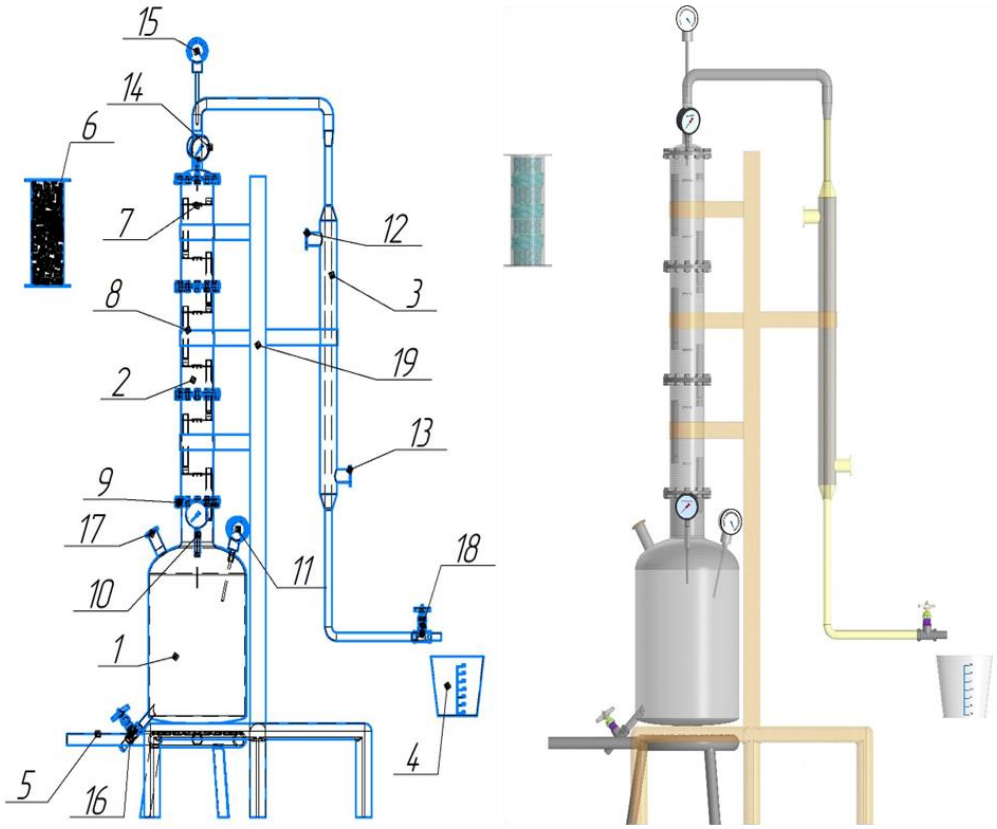
Methods and Materials. The study involved an oil and gas condensate mixture composed of 70% gas condensate and 30% oil, sourced from the Kokdumalak field. The experiments were conducted at the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan. In the "Processes and Apparatus of Chemical Technology" laboratory, an experimental setup was designed and installed, intended for the rectification of multicomponent mixtures under atmospheric and excess pressure conditions (Fig. 2).

The purpose of the experiment was to study the rectification process and investigate the physicochemical properties of the distillates obtained from the OGCM (30% oil and 70% gas condensate) [15].

An experimental setup was developed for processing hydrocarbon feedstock (Fig. 3), which includes an evaporative still (1), equipped with a gas burner (5) for heating the feedstock. The setup consists of three sections, including a packed section (6), connected by flanged joints (9). It also includes a condenser (3), a distillate receiver (4), and a control system with a manometer, thermometer, and regulating valves to ensure precise control of temperature regimes and pressures during the distillation process.

The experimental setup for processing hydrocarbon feedstock consists of a column with a diameter of 100 mm and a total height of 1380 mm, including a distillation pot with a capacity of 22 liters. During the study, two experiments were conducted: one using a valve column and the other with a packed-valve column. A mixture of oil and gas condensate (30% oil and 70% gas condensate) with a volume of 13.75 liters (10 kg) was heated in the column at temperatures ranging from 20 to 360°C, causing the lighter components of the mixture to evaporate according to their boiling points.

The evaporating components passed through the valve sections of the column, where the vapor interacted with the condensing liquid flowing down to the lower plates through feed pipes. The hydrocarbon vapors were then cooled in the condenser and collected in a measuring receiver. Temperature and pressure were monitored at all stages using manometers and thermometers to ensure precise process control.



1 - Column pot (boiler); 2 - Valve section of the column; 3 - Condenser (cooler); 4 - Distillate collector; 5 - Gas burner; 6 - Packing section of the column; 7 - Valve tray; 8 - Feed pipe; 9 - Flanged connections; 10, 14 - Pressure gauge; 11, 15 - Thermometer; 12 - Inlet pipe for cold water; 13 - Outlet pipe for water; 16, 18 - Valve.

Figure 2. Setup for studying the rectification process of multicomponent hydrocarbon mixtures

In the second experiment, the upper section of the column was replaced with a packed section, which increased the contact surface between the vapor and the liquid, improving the heat and mass transfer processes. As a result of the distillation of the oil and gas condensate mixture in both types of columns, parameters such as temperature and mass fraction of the output fractions were recorded. The results of the experiment were plotted to compare the efficiency of the valve column and the packed-valve column. Special attention was given to the degree of fraction separation and the quality of the obtained products.

The main parameters measured during the study included the initial boiling temperature, the degree of separation of light and heavy fractions, and the fractional composition. Standard analytical methods in accordance with ISO 12185 and GOST 33-2000 were used to determine the density and viscosity of the fractions.

The water content in the oil-gas condensate mixture and distillates was determined by the Dean and Stark method in accordance with GOST 2477-65. Mechanical impurities were identified using a Soxhlet extraction apparatus following GOST 6370-2018.

The cloud point, freezing point, and the limit temperature of oil and gas condensate mixture were determined using the OPLCM "CRYSTAL" setup according to ISO 9001 standards.

The sulfur content in gasoline fuel was measured using the Spectroscan S equipment following the methods of GOST R 51947-2002 and ASTM D 4294-98. To ensure the reliability of the analysis, deviation determination methods in accordance with GOST were used. The mean of two parallel measurements was employed as the calibration standard. This average was calculated considering accuracy and adherence to the established confidence level of 95%, in accordance with state standard requirements.

Results and Discussion. In this study, the main physicochemical properties and the composition of hydrocarbons of the oil and gas condensate mixture (30% oil and 70% gas condensate), as well as gasoline fractions obtained from the Kukdumalak field, were determined.

The fractional composition of the mixture was determined using an experimental setup, in accordance with ASTM 2892 and ASTM 5236 methodologies, with the construction of a true boiling point (TBP) curve. Figure 3 shows the atmospheric distillation graph of oil up to 350 °C.

Valve Column (Curve 1): In the valve column, a higher initial temperature for the onset of fraction distillation is observed, with a gradual temperature increase up to 350 °C. This indicates that the evaporation of light components occurs gradually, allowing for a stable separation of heavy and light fractions.

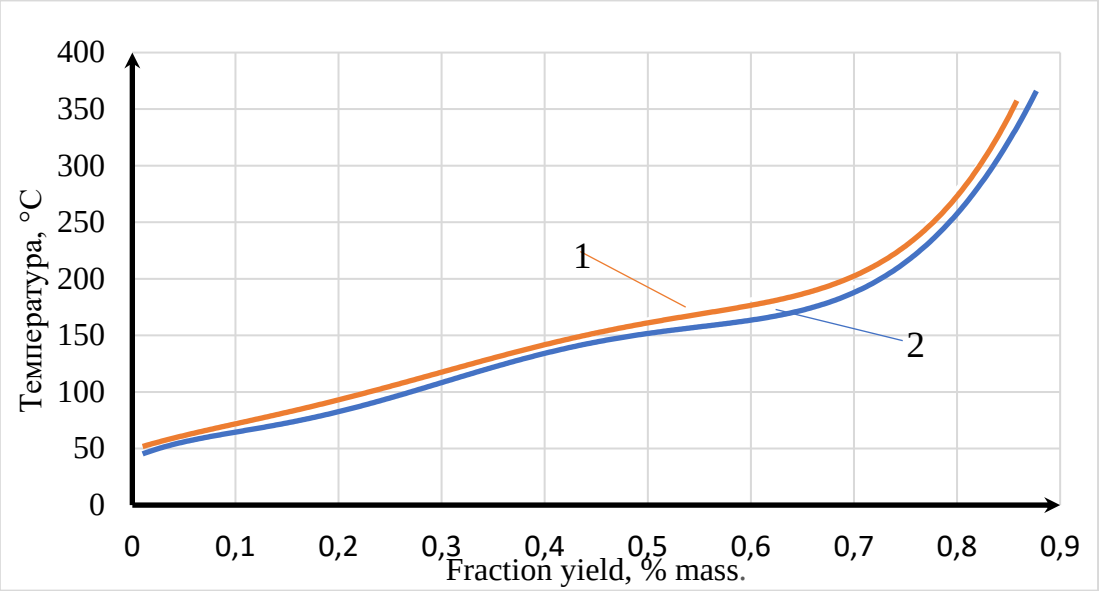


Figure 3. Results of experiments on the study of the fractional composition of the oil and gas condensate mixture (30% oil and 70% gas condensate), carried out using the packed-valve column (2) and valve column (1)

Packed-Valve Column (Curve 2): The onset of distillation in the packed-valve column occurs at a lower temperature compared to the valve column. The curve demonstrates a sharp rise in temperature after achieving 60% of the fraction yield, indicating a more active evaporation of light components. The packed-valve column shows higher efficiency in separating light fractions at lower temperatures, which enables energy savings. On the other hand, the valve column ensures a more uniform distribution, which may be preferable when strict control over the final product composition is required.

Based on the analysis, it can be concluded that the packed-valve column is more suitable for the rapid and energy-efficient separation of light components. Subsequently, a study was conducted on the physicochemical characteristics of distillate fractions obtained from the oil and gas condensate mixture (30% oil and 70% gas condensate) during distillation in the packed-valve column [15]. The results of the measurements of the physicochemical properties of the mixture are presented in Table 1.

Table 1

Primary Properties of the Oil and Gas Condensate Mixture (30% Oil, 70% Gas Condensate) from Kukdumlok Field

Parameters	**Samples of Oil-Gas Condensate from the Kokdumalak Field**			
Wells	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Density at 20°C, kg/m³	760	763	767,5	770,8
Kinematic Viscosity at 20°C, mm²/s	1,415	1,421	1,432	1,448
Pour Point, °C	17	17	18	19
Mass Fraction of Water, % (max)	0,075	0,08	0,09	0,095
Mechanical Impurities Content, % (max)	0.037	0.030	0.032	0.035
Volume, % mass:				
- Sulfur	3,5	3,53	3,53	3,57
- Nitrogen	0,11	-	-	-
- Silicate Resins	3,5	4,9	4,6	2,7
- Asphaltenes	0,5	0,59	0,51	0,35
- Paraffins	1,95	2,6	3,87	2,1
Paraffin Pour Point, °C	45	46	47	48
Coking Ability, %	1.12	1.3	1.4	1.2
Ash Content, %	0.22	0.21	0.23	0.30
Acid Number, mg KOH/g	0.13	0.11	0.12	0.15
Fraction Yield, % mass:				
- Up to 200°C	74,2	72,5	71,4	69,2
- Up to 350°C	87,7	84.9	84.3	88.1

Table 1 was identified as the most promising for further processing due to its relatively low density (760 kg/m³) and kinematic viscosity (1.415 mm²/s at 20°C), indicating high fluidity and lightness. Additionally, the low water content (0.075%) and minimal mechanical impurities (0.037%) reflect its high purity. These properties make Sample 1 the most favorable candidate for further processing among all analyzed samples.

The oil and gas condensate mixture from the Kukdumlok field falls under the naphthenic-paraffinic group of hydrocarbons. According to the national standard ЎзДСт 3031:2015, this mixture is classified as 2.0.1.0, indicating its hydrocarbon profile. The analyses revealed that the mixture contains significant quantities of gasoline and kerosene fractions, classifying it as light oil. The density of the mixture ranges from 760 to 770.8 kg/m³, with viscosity between 1.415 and 1.448 mm²/s at 20°C.

The pour point of the mixture is between 17 and 19°C, which, combined with low levels of water and mechanical impurities, confirms its high quality. The paraffinic components have a pour point within 45–48°C. The fractional composition of the mixture indicates a broad temperature range, with a distillation yield of up to 87.7% for fractions boiling between 70 and 350°C. The mixture is also characterized by minimal resin content (2.7–4.9%) and asphaltenes (0.35–0.59%) (Table 1). To conduct a more in-depth analysis of distillates, physicochemical parameters of gasoline and oil distillates obtained from Well No. 1 were examined. The results of the gasoline properties are presented in Table 2 and Figure 4.

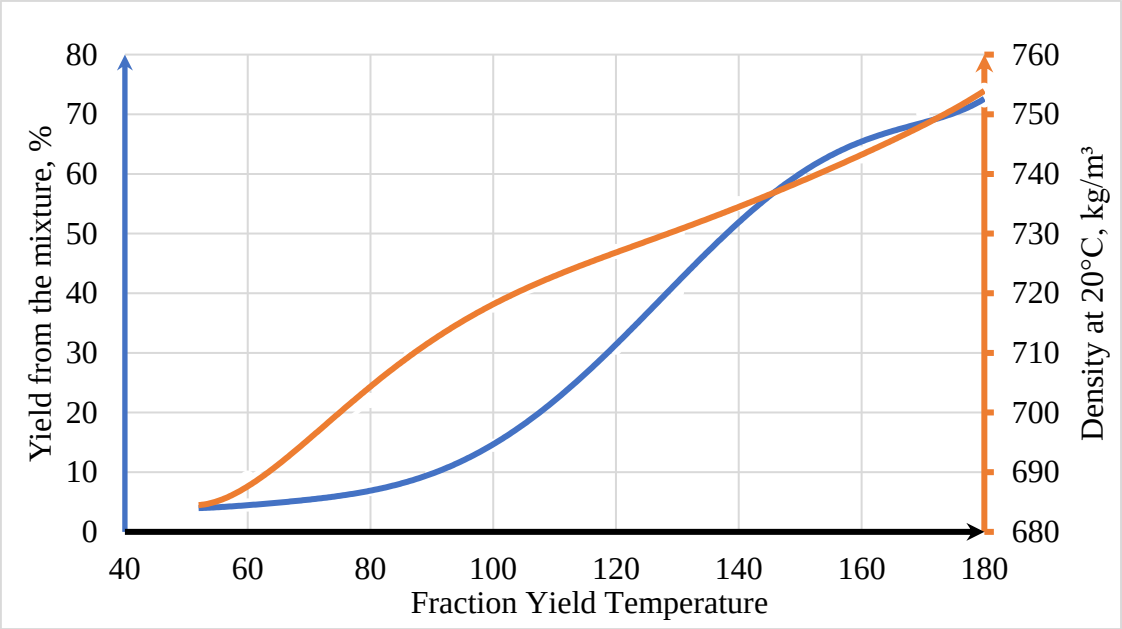


Figure 4. Dependence of Yield and Density of Gasoline Fraction on Temperature

Figure 4 illustrates the relationship between the density of the gasoline fraction at 20°C and the yield of fractions as a function of distillation temperature from an oil and gas condensate mixture (30% oil + 70% gas condensate) from the Kukdumlok field, obtained using a packed valve column.

Blue Line (Left Y-Axis, Fraction Yield, %):

- The blue line demonstrates the change in the yield of fractions as the distillation temperature increases. Initially, at a temperature of 52°C, the yield is about 4%. As the temperature rises to 180°C, the yield of light hydrocarbons also increases, reaching 72.25%. This trend indicates an effective separation of light hydrocarbons in the packed valve column, resulting in a higher yield of gasoline fractions.

Orange Line (Right Y-Axis, Density at 20°C, kg/m³):

- The orange line shows the variation in density with increasing temperature. The initial density at 52°C is 684 kg/m³, which reflects the predominance of light hydrocarbons. As the temperature increases, the density rises, reaching 754 kg/m³ at 180°C. This indicates a gradual transition to heavier hydrocarbons, which is characteristic of gasoline fractions.

Table 2.

Physicochemical Properties of the Gasoline Fraction (200–180°C) of the Oil and Gas Condensate Mixture (30% Oil + 70% Gas Condensate) from the Kukdumlok Field

Temperature of Fraction Collection, °C (Initial Boiling Point)	Fractional Composition, °C				Sulfur Content, wt.%
	Initial Boiling Point	10%	50%	90%	
До 52	-	-	-	-	1.55
60	-	-	-	-	
70	-	-	-	-	
80	43	67	72	76	
90	48	72	84	88	
100	52	75	89	95	
110	57	78	92	105	
120	60	81	107	113	
130	63	84	112	121	
140	67	87	117	129	
150	70	90	121	138	
160	72	92	126	148	
170	73	94	131	162	
180	78	96	136	171	

The physicochemical characteristics of the gasoline fraction from the oil and gas condensate mixture obtained from the Kukdumlok field are presented in Table 2. These data include temperature indicators of the fractional composition as well as sulfur content, reflecting the properties of the raw material and its suitability for further processing.

The sulfur content in the gasoline fraction is 1.55% by mass, which remains constant across the entire temperature range from 52°C to 180°C. This indicates the necessity for further purification to remove unwanted sulfur compounds, as elevated sulfur levels can negatively impact the fuel's operational properties and increase its corrosive activity.

The temperature data for the fractional composition also illustrate how different components of the mixture evaporate at various points during distillation. For each temperature, initial boiling point, as well as temperatures at which 10%, 50%, and 90% of the fraction evaporate, are provided. For instance, at a distillation temperature of 80°C, the initial boiling point is 43°C, with 10% of the fraction evaporating at 67°C, 50% at 72°C, and 90% at 76°C. This data shows a transition from lighter hydrocarbons to heavier components, which begin evaporating at higher temperatures.

As the temperature increases, the complete evaporation of heavier hydrocarbon components becomes evident, as seen at temperatures ranging from 120°C to 180°C. The boiling points for initial, 10%, 50%, and 90% evaporation also increase, indicating the complexity of the hydrocarbon structure and the gradual transition to heavier fractions.

Overall, the data from Table 2 indicate that the gasoline fraction of the oil and gas condensate mixture has a wide temperature range for evaporation and stable sulfur content, suggesting the need for additional processing to improve fuel quality and enhance operational characteristics.

The results of the study showed that the packed valve column provides more active extraction of light fractions at relatively low distillation temperatures. The initial boiling point in this column was lower compared to the valve column. The temperature profile indicated a sharper increase after reaching 60% of fraction yield, indicating efficient separation of light fractions.

The valve column is characterized by a smoother increase in temperature up to 350°C. This distillation profile contributes to a more stable separation of heavy and light fractions, allowing for the production of a product with the desired fractional composition.

A comparative analysis of the efficiency of the packed valve and valve columns demonstrated that the former method enables more active extraction of light fractions at lower distillation temperatures, contributing to the production of high-quality products.

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DOI - 10.32743/UniTech.2024.127.10.18422

TECHNOLOGY OF COMPLEX PRODUCTION OF CORROSION INHIBITOR FOR OIL AND GAS WELLS

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ТЕХНОЛОГИЯ КОМПЛЕКСНОГО ПРОИЗВОДСТВА ИНГИБИТОРА КОРРОЗИИ ДЛЯ НЕФТЯНЫХ И ГАЗОВЫХ СКВАЖИН

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ABSTRACT

This article provides information on the technological possibilities of obtaining a corrosion inhibitor with complex-forming free electron pairs. Also, in the technological process, the synthesis process is carried out in a jacketed reactor for neutralization of raw materials, and then the product is sent to the reactor. The products produced in the reactor are sent to the second jacketed reactor. The products coming out of the reactor are cleaned, passed through a cooler and sent to packaging. The parameters of the time, temperature and pressure required to obtain the finished product are given. The regimes of all processes were studied and the material balance was developed.

АННОТАЦИЯ

В данной статье приведены сведения о технологических возможностях получения ингибитора коррозии с комплексообразующими свободными электронными парами. Также в технологическом процессе процесс синтеза осуществляется в реакторе с рубашкой для нейтрализации сырья, а затем продукт направляется в реактор. Продукты, полученные в реакторе, направляются во второй реактор с рубашкой. Продукты, выходящие из реактора, очищаются, проходят через охладитель и направляются на упаковку. Приведены параметры времени, температуры и давления, необходимые для получения готового продукта. Изучены режимы всех процессов и разработан материальный баланс.

Keywords: jacketed reactor, capacity, YJB corrosion inhibitor, propane, sodium hydrosulfide, hydrogen chloride, dryer, raw materials.

Ключевые слова: реактор с рубашкой, производительность, ингибитор коррозии YJB, пропан, гидросульфид натрия, хлористый водород, сушилка, сырье.

Introduction. In the world, derivatives of compounds with different functional groups, which have free electron pairs, are widely used in the fields of economy, pharmaceuticals, chemical industry, textiles, paint and oil and gas chemistry[1-4]. As a result of the development of the oil and gas industry in the world, targeted scientific research is being carried out on the creation of effective corrosion inhibitors to prevent corrosion of metal structures used in the industry under the influence of various aggressive environments. In this regard, special attention is being paid to the creation of a new generation of highly effective inhibitors based on common natural

Библиографическое описание: Yuldoshev J., Ahmedov V. TECHNOLOGY OF COMPLEX PRODUCTION OF CORROSION INHIBITOR FOR OIL AND GAS WELLS // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18422*

resources, the synthesis of new corrosion inhibitors, the determination of their properties, and the development of technology for the creation of effective and import-substituting inhibitors based on them[5-8].

Materials and methods. The structure of the synthesized corrosion inhibitor was analyzed by IR spectroscopy (figure 1). It is distinguished by the presence of corresponding absorption peaks characteristic of the structure of the corrosion inhibitor.

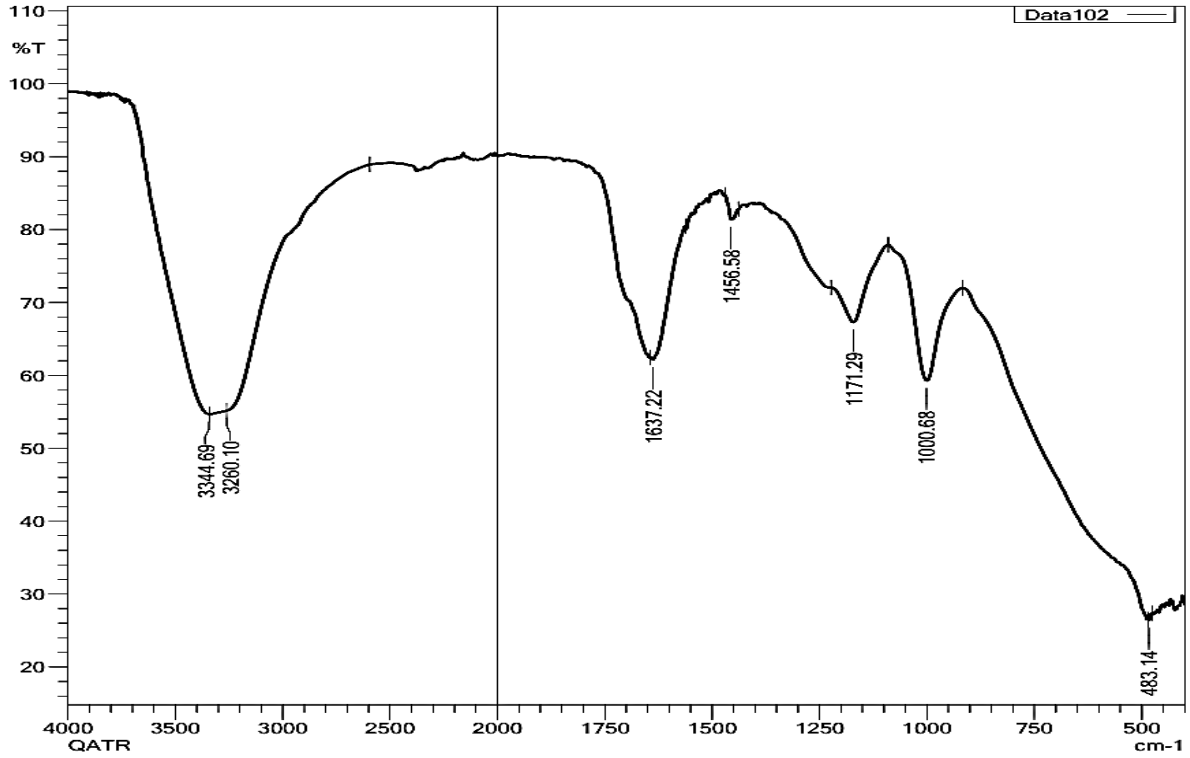
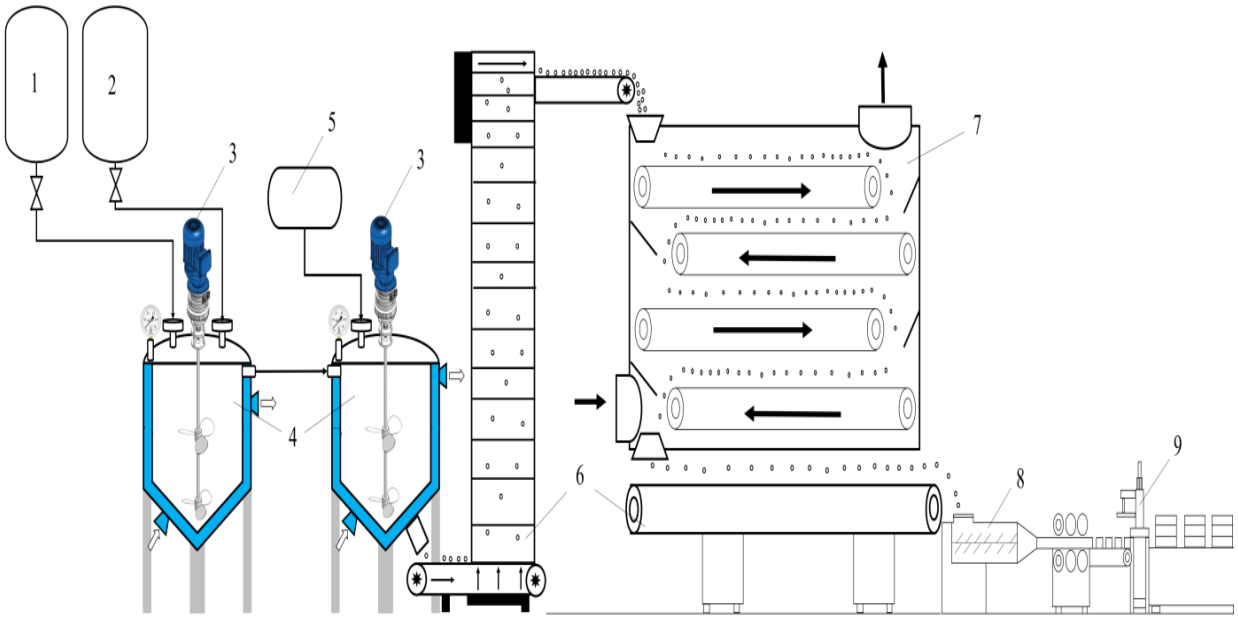


Figure 1. IR spectrum image of synthesized YJB corrosion inhibitor

The characteristic absorption areas in the IR spectrum of YJB are as follows: 3300 cm^{-1} $(R)_2$-NH, ≡C-H 3310-3200 cm^{-1}, -N=N- 1600 cm^{-1}, RHC=CH_2 1645 cm^{-1}, -CH_2 - 1480-1440 cm^{-1}, -CH_3- 1470-1435 cm^{-1}, $(R)_3P$=O 1175 cm^{-1}, $(R)_2S$=O 1050 cm^{-1}, observed in the field.

Based on the proposed technology (Fig. 2), a mixture of reagents (HCl and 10% hypan) required for the composition is sent to the jacketed reactor (4) for neutralization through tanks (1; 2) in a ratio of 1:10. A white gel product is formed in this reactor (4) at a temperature of 25ºC-35 ºC, a pressure of 1 atm, a frequency of 100-125 rpm and a duration of 30 minutes. The resulting product is sent to the second jacketed reactor (4). A mixture of ($NaHSO_3$) with a ratio of 35-40% relative to the carbonyl group is sent to the second jacketed reactor (4) through the capacity (5). In this reactor (4) at a temperature of 65 ºC -75 ºC, a pressure of 1 atm, a frequency of 200-250 rpm and a duration of 60 minutes, a red-brown thick mass with a high viscosity is formed. This product is fed to the belt using the elevator (6), and the product is sent to the dryer (7) through the belt. The dryer (7) is supplied with air from the lower part and discharged from the upper part to improve the drying process. The product is dried at a temperature of 85ºC -95ºC for 30 minutes. The belt dryer is designed for continuous drying of non-toxic, dispersible (granular, granular, fibrous) products with an initial moisture content of up to 75% at atmospheric pressure with hot air. a belt dryer looks like a rectangular box, which is divided into several sections (from 3 to 10) in length, and divided into two corridors in width.



1-2-5 capacity, 3-mixer, 6-elevator, 7-dryer 8- extractor, 9-packing

Figure 2. Technological scheme of production of complex forming corrosion inhibitor for oil and gas wells

A continuous transport conveyor (belt) is placed inside the corridor on the right (by product movement). The product to be dried moves on the tape. Steam radiators are placed in the corridor on the left side. The width of the tape is 1.2 or 2 m, its working surface is from 7.2 to 40 m^2, and the required power can vary from 22 to 137 kW. The efficiency of the belt dryers of different models varies from 35 to 600 kg/h. The dried raw material is sent to the extractor (8) for separation into extractions. After the extractor (8), the finished product divided into extractions is sent to the packaging device (9) for packaging.

Table 1.

Cost of raw materials

№	Raw materials	Product addition ratio
1	HCl	1:10
2	10%li HYPAN	1:10
3	$NaHSO_3$	With respect to the functional group-14-16 %

Conclusion. Based on the proposed technology, a continuous corrosion inhibitor production technology with 87% efficiency has been developed and the process control is available. By using the YJB substance created from this technological production scheme as a corrosion inhibitor, it will be cheaper than analogues imported from abroad, and the efficiency will be higher.

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POWER, METALLURGICAL AND CHEMICAL ENGINEERING

DOI - 10.32743/UniTech.2024.127.10.18433

OPTIMIZATION OF ANODIZED ALUMINUM OXIDE TEMPLATES FOR ENHANCED HYDROGEN EVOLUTION REACTION EFFICIENCY

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ОПТИМИЗАЦИЯ ШАБЛОНОВ ИЗ АНОДИРОВАННОГО ОКСИДА АЛЮМИНИЯ ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ РЕАКЦИИ ВЫДЕЛЕНИЯ ВОДОРОДА

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ABSTRACT

Anodized Aluminum Oxide (AAO) has emerged as a multifunctional material with significant potential in energy conversion applications, particularly in enhancing the efficiency of hydrogen evolution reactions (HER). This study explores the fabrication and optimization of AAO templates through a two-step electrochemical anodization process, highlighting the impact of barrier layer modification on catalytic performance. The initial anodization in 0.3 M oxalic acid at 50 V resulted in a porous alumina structure, which was subsequently refined through chemical etching using a phosphoric and chromic acid solution to remove the barrier layer. Our findings reveal that the barrier layer obstructs ion and gas diffusion, thereby hindering HER efficiency. Techniques including chemical etching and laser ablation were examined for barrier layer removal, with chemical etching demonstrating effective results. The optimized AAO templates, characterized by an average pore diameter of approximately 100 nm, facilitate the potential creation of high-performance 3D metal nanowires for HER applications. Scanning Electron Microscopy (SEM) analysis confirmed the successful removal of the barrier layer, showing clean hexagonal cell boundaries after 45 minutes of treatment. This research underscores the importance of barrier layer optimization in AAO templates as a crucial step toward the development of efficient catalysts for sustainable hydrogen production technologies.

Библиографическое описание: Hoshimov F.X., Butanov X.T. OPTIMIZATION OF ANODIZED ALUMINUM OXIDE TEMPLATES FOR ENHANCED HYDROGEN EVOLUTION REACTION EFFICIENCY // Universum: технические науки : электрон. научн. журн. 2024. 10(127). URL: *https://7universum.com/ru/tech/archive/item/18433*

АННОТАЦИЯ

Анодированный оксид алюминия (АОА) стал многофункциональным материалом, обладающим значительным потенциалом в применении при преобразовании энергии, в частности, в повышении эффективности реакций водородной эволюции (ВЭР). В данном исследовании исследуется изготовление и оптимизация шаблонов AAO путем двухэтапного процесса электрохимической анодизации, выделяется влияние модификации барьерного слоя на каталитические показатели. Первоначальная анодизация в 0,3 М щавелевой кислоте при 50 В привела к образованию пористой алюминиевой структуры, которая в последующем была отшлифована путем химического выщелачивания с использованием раствора фосфорной и хромовой кислот для удаления барьерного слоя. Наши результаты показывают, что барьерный слой препятствует диффузии ионов и газов, тем самым препятствуя их эффективности. Для удаления барьерного слоя были изучены методы, включающие химическую резьбу и лазерную резьбу, при этом химическая резьба показала эффективные результаты. Оптимизированные шаблоны AAO, характеризующиеся средним диаметром пор порядка 100 нм, способствуют созданию потенциальных высокопроизводительных 3D-металлических нанопроводов для применения HER. Анализ сканирующей электронной микроскопии (СЭМ) подтвердил успешное удаление барьерного слоя, который после 45 минут обработки показал чистые гексагональные границы клеток. В данном исследовании подчеркивается важность оптимизации барьерного слоя в образцах AAO как важного шага к разработке эффективных катализаторов для устойчивых технологий производства водорода.

Keywords: AAO template, hydrogen catalyst, barrier layer removal, hydrogen evolution reaction, nanoscale fabrication.

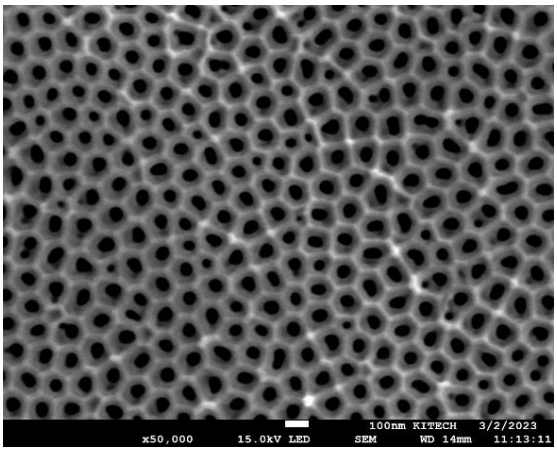
Ключевые слова: шаблон AAO, катализатор водорода, удаление барьерного слоя, реакция водородной эволюции, наномасштабное изготовление.

Introduction. Anodized Aluminum Oxide (AAO) has garnered significant attention as a multifunctional material due to its highly ordered, porous structure and its versatile applications across various fields, including nanofabrication, sensing, filtration, and energy storage. Over the years, researchers have exploited the unique properties of AAO in numerous applications, taking advantage of its tunable pore size, high surface area, and chemical stability [1]. More recently, AAO has emerged as a promising platform for applications in energy conversion, particularly in enhancing the efficiency of hydrogen evolution reactions (HER). The precise control over AAO's porous structure makes it highly suitable as a template for catalysts, a critical feature for advancing energy-related technologies like hydrogen generation [2]. One of the most critical factors that determine the performance of AAO as a catalyst support for HER is the modification and optimization of its structure. In its unmodified form, AAO possesses a barrier layer that is a byproduct of the anodization process. This barrier layer, while structurally important in certain applications, acts as a significant obstacle in hydrogen evolution reactions [3]. The presence of this insulating layer hampers the free diffusion of ions and gases through the AAO's pores, limiting the active surface area available for catalysis. Consequently, the removal or thinning of the barrier layer has become a key focus for researchers seeking to maximize the performance of AAO as a catalytic template [4]. The process of forming AAO involves the anodization of aluminum in acidic electrolytes, resulting in a porous structure with a hexagonal arrangement of nanopores [5]. The top layer, known as the porous layer, is essential for applications that rely on the AAO's high surface area and permeability. However, beneath this porous layer, a barrier layer is formed, consisting of a non-porous, dielectric alumina layer that is several nanometers thick. This barrier layer poses a challenge in applications involving electrochemical reactions, such as HER, where the free flow of ions is crucial for the efficient generation of hydrogen [6]. Therefore, removing or sufficiently thinning this barrier layer is essential to optimize AAO's performance as a template for hydrogen catalysts [7]. Several methods have been explored to address this challenge. Techniques such as chemical etching, voltage-controlled anodization, and stepwise anodization have been employed to remove or reduce the thickness of the barrier layer [8]. The goal is to produce an AAO template with an open, continuous channel structure that facilitates ion and gas diffusion, enhancing the overall catalytic activity for HER. Moreover, the ease of functionalizing AAO surfaces with various catalytic materials, such as platinum, nickel, or molybdenum, further underscores its potential as a versatile material in hydrogen energy applications [9]. In addition to improving the hydrogen evolution reaction, AAO's unique properties enable the development of low-cost, scalable methods for producing high-performance catalysts. Its high thermal and mechanical stability, combined with the tunability of its pore structure, allows researchers to design AAO-based systems tailored for specific electrochemical processes [10]. By focusing on optimizing the barrier layer removal, researchers are working to unlock the full potential of AAO as a key component in the drive toward more efficient and sustainable hydrogen production technologies [11, 12, 13, 14, 15]. In this study, we synthesized an anodized aluminum oxide (AAO) template to create three-dimensional metal nanowires for hydrogen evolution reactions (HERs). AAO has gained significant attention in recent years as a versatile template for various nanoscale applications. A critical aspect of optimizing AAO templates for HER is the removal of the barrier layer, which is essential for developing efficient hydrogen catalysts. This article explores the key methods and techniques used to remove the barrier

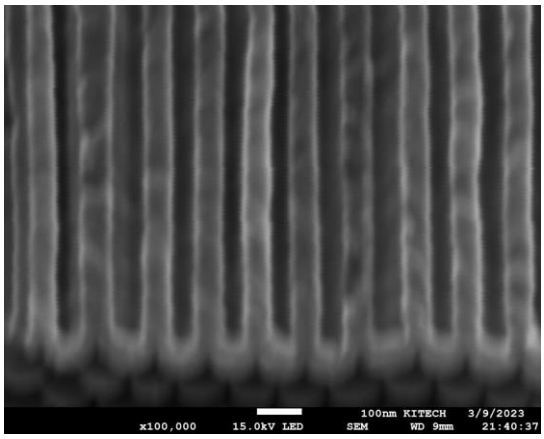
layer, emphasizing its significance and discussing the implications for catalytic applications.

Method for synthesizing AAO nanopores. The AAO template was fabricated using a two-step electrochemical anodization process on high-purity aluminum foil. The first anodization step was carried out in a 0.3 M oxalic acid electrolyte solution at a temperature of 5°C and a DC voltage of 50 V for 15 minutes. The resulting anodic alumina layer was then removed by chemical etching in a mixture of diluted phosphoric acid (6 wt.% H_3PO_4) and chromic acid solution (1.8 wt.% CrO_3) for 5 hours at 60°C.

The second anodization step was carried out under the same conditions as the first step, with different time durations of 4, 8, 16, and 24 hours. The resulting AAO templates examined using field emission scanning electron microscopy.(Figure 1) It shows the longer anodization time led to the formation of distorted pores in some areas and the creation of new smaller nanopores within the previously formed nanopores. The average pore diameter of the AAO template was observed to be approximately 100 nm. This AAO template can potentially be used for the creation of 3D metal nanowires for HERs by depositing metal ions into the pores of the AAO template and then reducing them to form metallic nanowires. The highly ordered and uniform pore structure of the AAO template can facilitate the creation of nanocatalysts with high catalytic activity and stability. Overall, this study demonstrates a promising method for the synthesis of AAO templates for the creation of 3D metal nanowires as a catalyst for HERs.



a)



b)

Figure 1. SEM micrograph of AAO a) SEM image of the membrane surface b) SEM image of the cross section of the membrane

Methods of Barrier Layer Removal: Chemical Etching: Chemical etching is one of the most common methods used to remove the barrier layer. Acidic or alkaline solutions are employed to dissolve the aluminum oxide, selectively leaving behind a porous structure without the barrier layer. The choice of etching solution and conditions can be tailored to obtain specific pore sizes and structures, enhancing the AAO's catalytic performance.

Electrochemical Methods: Electrochemical techniques involve applying an electric field to the AAO template, which can facilitate the controlled removal of the barrier layer. Anodic or cathodic dissolution methods can be employed to tailor the pore diameter and distribution in the AAO template, making it suitable for hydrogen catalyst applications.

Laser Ablation: Laser ablation is a precise and efficient technique for removing the barrier layer in AAO templates. High-energy laser pulses are focused on the AAO surface, vaporizing the barrier layer and creating well-defined pores for improved catalytic performance.

Significance in Hydrogen Catalyst Applications: The removal of the barrier layer in AAO templates is crucial for hydrogen catalyst applications due to its direct impact on the efficiency of hydrogen evolution reactions. The absence of the barrier layer allows for enhanced mass transport of ions and gases, improving the kinetics of the catalytic reaction. This results in reduced overpotentials and higher catalytic activity, making AAO templates an attractive choice for green hydrogen production and storage.

In this work, we used a chemical method to remove the barrier layer. It was done by applying 10 wt% $H3PO_4$ to open the barrier layer. As depicted in the SEM micrographs, the bottom surface of the prepared AAO is characterized by hexagonal close-packed arrays of hemispherical domes. According to the results presented in the paper, the barrier oxide was gradually etched away from the entire surface of each dome, revealing relatively clean hexagonal cell boundaries. The removal of the barrier layer of AAO was carried out at different times. The opening of the barrier layer occurs in the very center of the hemispherical dome. The barrier oxide layer was completely removed after wet chemical treatment for 45 minutes. (Figure 2)

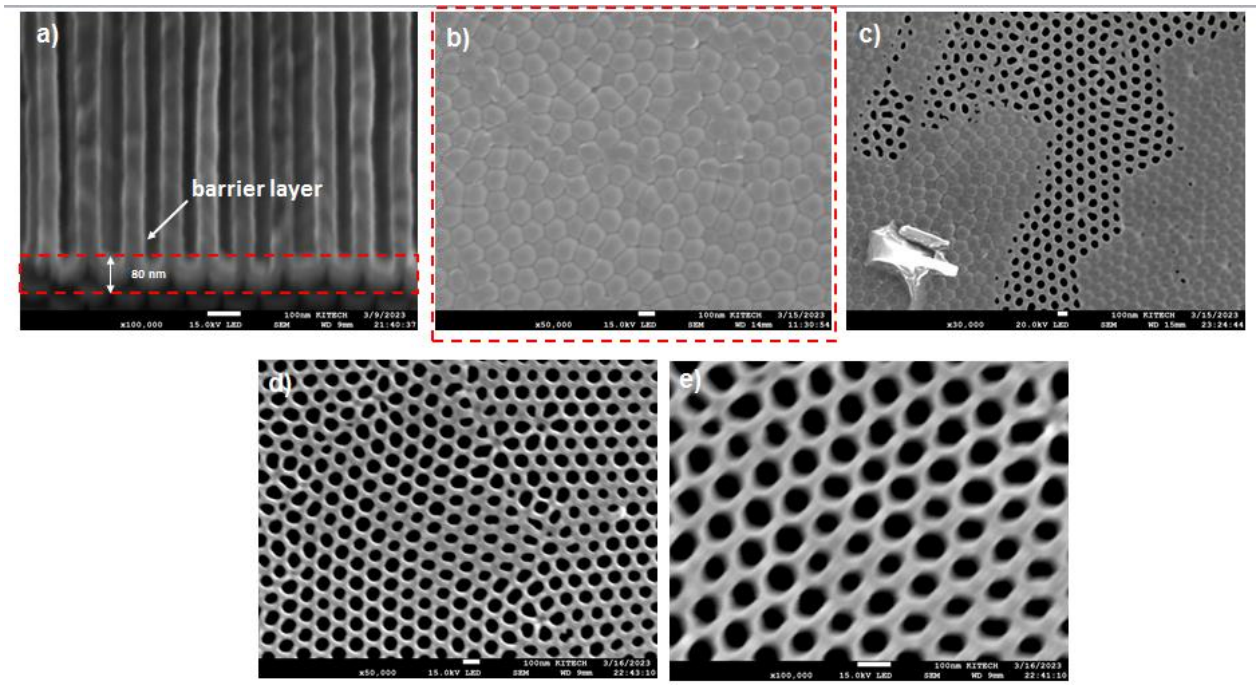


Figure 2. SEM images of remove the barrier layer of AAO. a) Cross-sectional SEM images of AAO, b) bottom view before chemical etching, c) bottom view at 5 minutes, d) bottom view at 30 minutes, e) bottom view at 40 minutes, (process performed in 10% H_3PO_4 solution)

Conclusion. This study demonstrates the significant potential of Anodized Aluminum Oxide (AAO) as a versatile template for enhancing the efficiency of hydrogen evolution reactions (HER). Through a systematic two-step electrochemical anodization process and subsequent barrier layer removal using chemical etching, we have successfully optimized the structure of AAO to maximize its catalytic performance. The removal of the insulating barrier layer is essential for improving ion and gas diffusion, which directly impacts the kinetics of the catalytic reaction and overall hydrogen production efficiency. The resulting AAO templates, characterized by well-defined nanopore structures and high surface areas, present exciting opportunities for the development of 3D metal nanowires as advanced catalysts for HER applications. Furthermore, the findings highlight the importance of tailoring fabrication techniques and conditions to achieve specific pore sizes and distributions, thus enhancing the AAO's applicability in energy-related technologies. Future work should focus on further refining the AAO templates and exploring alternative methods for barrier layer removal to further enhance catalytic performance. Overall, this research contributes to the growing body of knowledge on AAO and its role in advancing sustainable hydrogen production technologies, paving the way for innovative solutions in the field of energy conversion and storage.

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ДЛЯ ЗАМЕТОК

Научный журнал

UNIVERSUM:
ТЕХНИЧЕСКИЕ НАУКИ

№ 10(127)
Октябрь 2024

Часть 8

Свидетельство о регистрации СМИ: ЭЛ № ФС 77 – 54434 от 17.06.2013

Издательство «МЦНО»
123098, г. Москва, улица Маршала Василевского, дом 5, корпус 1, к. 74
E-mail: *mail@7universum.com*
www.7universum.com

Отпечатано в полном соответствии с качеством предоставленного оригинал-макета в типографии «Allprint»
630004, г. Новосибирск, Вокзальная магистраль, 1
16+