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Editorial office Premier Publishing s.r.o.

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Section 1. Biology

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DETERMINATION OF THE EFFECTIVE DOSE OF "SUMAKH FRUIT EXTRACT" IN CORRECTING THE GENOTOXICITY OF CHEMICALS IN AN ARTIFICIALLY INDUCED MUTATION PROCESS

***Guliyev Mahir*[1], *Guliyeva Nigar*[1], *Huseynova Shahla*[1], *Israfilova Sabina*[1]**

[1] Department of Sitology, embryology and histology, Azerbaijan Medical University

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Abstract

This study explores the antimutagenic properties of sumakh fruit extract against the mutagen 4-nitroquinoline-1-oxide (4NQO) using human peripheral blood lymphocytes. The extract was tested in doses ranging from 0.001 to 10 μg/ml. Results showed that sumakh fruit extract significantly reduced sister chromatid exchanges, a marker of DNA damage, with optimal protection observed at 0.01 μg/ml. These findings highlight the extract's potential as a protective agent against mutagenic damage.

Keywords: *Sumakh fruit extract, Antimutagenic activity, Artificial mutagenesis, Natural antimutagenic substances*

The search for correctors of mutational processes of synthetic and natural origin, capable of resisting the harmful effects of mutagenic and carcinogenic substances, has been going on for almost a century. In this regard, the search for natural substances of plant origin, as well as artificial substances, is of particular interest.

In our research, to determine the effective dose as a modifier under conditions of artificial mutation, "**sumakh fruit extract**" containing a natural substance of plant origin was tested in a wide range.

To determine the effectiveness of genome protection, the maximum dose of antimutagenic activity of sumakh fruit extract was determined under the action of mutagenic substances that differ in nature, type, mechanism of interaction with hereditary substrates, as well as by the initial damage they cause in the DNA molecule.

Part of the research was conducted on "human peripheral blood lymphocytes". 4 NQO (4-nitroquinoline-1-oxide) was used as a mutagen. In this part of the experiments, test doses of the extract were administered to the subjects before the introduction of the mutagen.

As an experimental model for testing the sumakh fruit extract, a primary culture of

peripheral blood lymphocytes from healthy donors was used. For this purpose, the composition includes (1:3) heparinized plasma (0.1 ml of the ready-made Richter heparin solution + 10 ml of donor blood), blood precipitated with gelatin (1 ml of gelatin + + 10 ml of blood), a ready-made nutrient medium (medium No. 199–3 parts + lactalbumin hydrolysate – 1 part + bovine serum – – 1 part + phytohemagglutinin (PHA), a hemagglutination reaction agent (Welcome – 0.1 ml / 10 ml of the mixture). After maintaining the mixture prepared in this way at a temperature of 370 °C for 5 hours, doses from 0.001 to 10 μg/ml of the extract were added, and after 17 hours, 4NQO (2.5*10––7M) was added to the solution. The medium of the flasks with the experimental parts was added for 2 hours. An hour later, the medium of both variants was replaced with fresh standard medium. After 24 hours of culture development, 5-bromodeoxyuridine was added to all experimental and control flasks at a final dose of 10 μg/ml and placed in a thermostat. The frequency of sister chromatid exchange was analyzed in preparations prepared by differential staining of chromatids fixed at the 72 nd hour of cultivation.

In this part of the experiments, the spectrum of types of primary damage that they cause in the DNA molecule was taken into account when selecting model mutagens. Thus, the main types of damage created by 4NQO include cyclobutane-pyrimidine dimers, mutational monoadducts, and interstrand covalent crosslinks of the DNA molecule.

In experiments conducted on human peripheral blood lymphocytes obtained from a healthy donor, the extract obtained from sumakh fruits was tested in the environment of artificial mutation of 4-nitroquinoline-1-oxide (4NQO), which behaves like UV rays, for reparation, replication., as well as the ability to create artificial mutations, cell death. In quantitative analysis of alternative colored exchange in the cell, registration of sister chromatid exchange proves the antimutagenicity of the tested extract.

In experiments on the analysis of sister chromatid exchange in primary cultures of human peripheral blood lymphocytes using 4HQO, it was found that sumakh fruit extract prevented the formation of sister chromatid exchanges at doses from 0.001 to 1.0 μg/ml. The highest efficiency was demonstrated by a dose of 0.01 μg/ml.

Table 1. *Antimutagenic activity of sumakh fruit extract in primary human peripheral blood lymphocyte tissue*

Mutagens	Experience options	Extract dose, mcg/ml	Sister chromatid exchange SCE / according to the cell	td		P		AEF
				By control	By mutagen	By control	By mutagen	
	Control	0	5.17 ± 0.71	–	–	–	–	–
	4NQO	0	16.58 ± 1.97	5.46	–	<0.001		–
4NQO	Sumakh extract + 4NQO	0.001	9.16 ± 0.98	3.29	3.37	=0.001	<0.001	0.45
		0.01	8.23 ± 0.87	2.73	3.38	<0.01	<0.001	0.50
		0.1	9.34 ± 0.99	3.42	3.28	<0.05	<0.001	0.44
		1.0	11.55 ± 1.17	4.66	2.20	<0.01	<0.05	0.30
		10	12.73 ± 1.25	5.25	1.65	<0.051	<0.05	–

Calculation method:

$$M = \frac{n \cdot 100\%}{N};\ M = \sqrt{\frac{M \cdot (100 - M)}{N}};$$

$$td = \frac{M_2 - M_1}{\sqrt{m_1^2 + m_2^2}}$$

M – the frequency of mutations; M_2 – the frequency of mutations of the experimental variant; M_1 – the frequency of mutations of the control variant; M_1^2 – error of the control variant; M_2^2 – error of the experimental variant; AEF – $\frac{i-c}{i}$. Antimutagen effectiveness factor, i – primary (previous), c – subsequent

(determined by dividing the difference between the primary and modified mutation levels by the primary indicator), n = Sister chromatid exchange, N = all stadied cells.

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© Guliyev M., Guliyeva N., Huseynova Sh., Israfilova S.
Contact: israfilovi0506@mail.ru

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Section 2. Chemistry

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SYNTHESIS AND PROPERTIES OF DETERGENT REAGENT FOR CLEANING FROM ACCUMULATED MINERAL SALTS

G. T. Daniyarov [1], T. Mukhamedjanov [2], A. Sh. Huseinov [2], Kh. I. Kadirov [2]

[1] Yangier Branch of Tashkent chemical technology institute

[2] Tashkent Institute of Chemical Technology

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Abstract

In this work, the process of sulfomethylation of aniline, the optimal parameters of the sulfirovanie process are defined, the obtained products are tested and the quality of the steaming solution is otlogeny mineralnyx soley with the surface of the heat exchange apparatus.

Keywords: *aniline, sodium bisulfite, formaldehyde, monosulfomethyleneaniline, mechanism reaction, cleaning of steam boilers of mineralnyx otlogeny*

Introduction

The correct selection of “water-chemical reagent” standards for the water treatment system of thermal power stations, the main — turbine, condensers and secondary -compressors, pumps ensures efficient operation of the devices — prevents the accumulation of mineral salts, eliminates corrosion. For each type of circulating cooling systems, an individual approach to the selection of “water-chemical reagents” is required, and this is primarily related to the material of the components in the system and the type of reagents. Adding concentrated hydrochloric acid, sulfoamines, and phosphates to the environment is considered a traditional method and does not allow complete elimination of accumulated mineral salts and corrosion. Mineral salts collected on the surface of heat exchange devices affect vacuum weakening in technological systems, including heat exchange processes, which are considered the main economic indicator of energy devices. At the same time, special attention is being paid to the determination of effective components for “water-chemical reagent” correction-circulation cooling systems, production of competitive products based on organic synthesis from available raw materials, and determination of their properties.

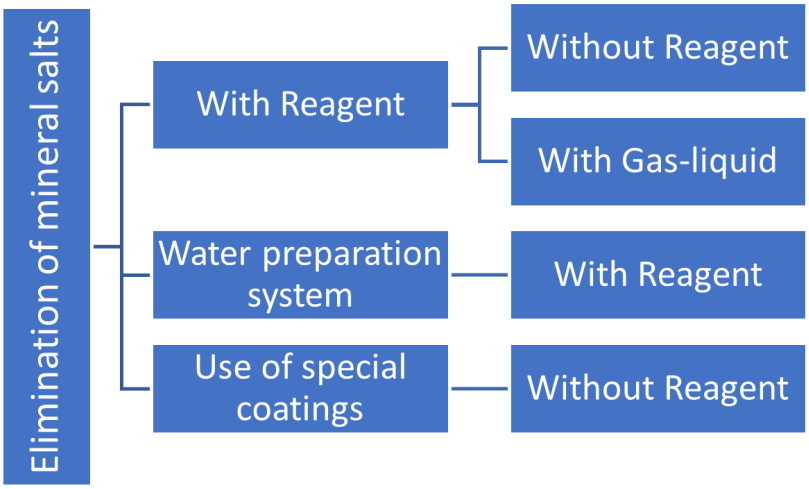
In practice, periodic cleaning of steam boilers is carried out on average once in

1–2 seasons. Boilers with a service life of 20 years (Levitin I. V., et al. 2011; Glazyrin A. I., Kostrikina E. Yu. 1987) are cleaned approximately 10–15 times before decommissioning.

The formation of salts is different due to the difference in mineral salts in the water, the method of its purification and the operating modes of the boilers. According to their chemical composition, salts can be divided into four main groups: 1) salts of alkaline earth metals — $SaSO_3$, $CaSO_4$, $CaSiO_3$, $5CaO\text{-}5SiO_2\text{-}H_2O$, $Mg(OH)_2$, etc.; 2) iron oxide and iron phosphate — FeO, Fe_2O_3, Fe_3O_4, $NaFePO_4$, $Fe_3(PO_4)_2$; 3) brass and 4) aluminum (RD 34.37.403–91; RD 34.20.591–97; Baranov V. N. 2013).

To clean boiler heating surfaces from salt deposits, reagent-based and reagent-free cleaning methods are applied depending on the structure of the contaminating layer, the degree of contamination of the heat exchange surface, and the type of boiler. The classification of methods to combat salt formation is shown in Figure 1, based on sources (Materials of OJSC 2014; Margulova T. Kh. 1969; GOST 24005–80). The choice of the method depends on the duration of the shutdown of the boiler, the availability of special equipment, chemical reagents, the flexibility of the technological scheme, and the availability of specialists and trained personnel.

Figure 1. *Classification of methods to combat salt formation*



It should be noted that the methods used may cause some negative phenomena, as a result of which the further operation of the boiler may be associated with a high rate of formation of salts or increased wear. For example, as a result of mechanical cleaning, the roughness of the surface increases and the oxide protective layer is destroyed, during chemical cleaning, partial melting of the oxide film and metal, hydromechanical wear of the surface, etc. may occur. The problem of effective cleaning of heating surfaces and increasing the wear resistance of the equipment is closely related to each other (Degremont, 2007).

The main advantage of the chemical cleaning method is that it does not require complete disassembly of the equipment being cleaned, and in some cases this salt is the only possible way to break up the sets.

Experimental part

Currently, chemical cleaning methods widely use organic acids (citric, adipic, maleic, oxalic, formic, acetic, and sulfamic), mineral acids (hydrochloric, sulfuric, sulfamic, and phosphoric), and chelating agents (such as disodium salt of ethylenediaminetetraacetic acid (Trilon B), hydroxyethane diphosphonic acid, and others) as well as compositions based on them. These methods are applied in open or closed cycles using forced circulation techniques or natural circulation of the solution.

The purpose of this article is to improve the efficiency of water supply systems by eliminating existing scale deposits and to develop affordable and effective compositions of reagents for removing accumulated mineral salts.

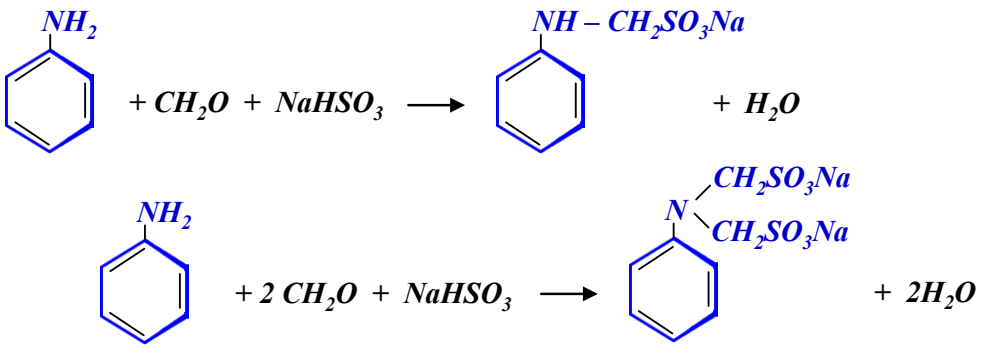
To achieve the goal, the process of sulfomethylation of aniline was studied to produce reagents for removing accumulated

mineral salts. A three-neck flask with a volume of 250 ml, equipped with a mechanical stirrer and a reflux condenser, was used. Into the flask, 10 ml of H_2O and 85 g of sodium metabisulfite ($Na_2S_2O_5$) were added. 80 mL of 37% formaldehyde solution was added with vigorous stirring. 5 ml of 50% caustic soda solution was poured there. After the formaldehyde odor dissipates, 47.5 ml of aniline is gradually added to the mixture while stirring intensively. The mixture is then heated at a temperature of 60–70 °C for 3 hours. After appropriate treatment and subsequent drying in a drying oven at a temperature of 100±5 °C for 5 hours, 80% of the final product is obtained in powder form. The authenticity of the substance was proven using IR spectroscopy and GC–MS methods and confirmed by elemental analysis.

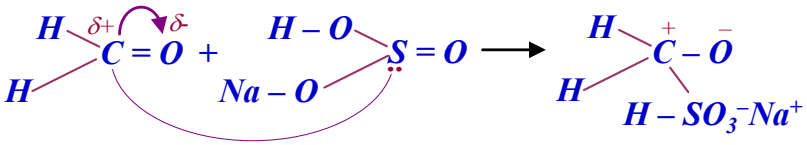
Analysis of results

This section examines the sulfomethylation process of aniline, systematically studies the factors affecting its yield, and evaluates the effectiveness of the obtained products both in their pure form and as an inhibited acidic formulation in removing accumulated mineral salts from boiler surfaces. The analysis of the resulting scientific findings is also provided.

For the sulfomethylation reaction of aniline, the initial raw materials aniline, formaldehyde, and sodium bisulfite condense in weakly acidic environments. The reaction proceeds according to the following scheme:

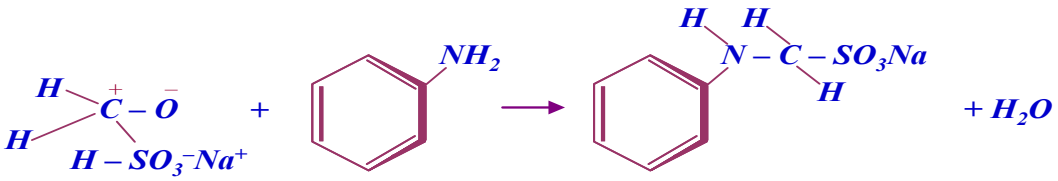


Studies on the dependence of the yields of mono- and disulfomethyl aniline on the ratio of initial raw materials show that the maximum yield of MSM (monosulfomethyl aniline) in its pure form is observed at a ratio of 1:1:0.5 at 70°C. With an increase in the amount of sodium bisulfite or temperature, the amount of DSM (disulfomethyl aniline) in the reaction mixture increases, reaching up to 57.4% at a 1:1:1 ratio at 90°C. The experimental results show that the condensation of aniline with formaldehyde in the presence of sodium bisulfite is independent of the amount of formaldehyde. This can be explained as follows: in the initial stage of the reaction, formaldehyde reacts with sodium bisulfite, which can be considered as a reaction where the hydrosulfite anion interacts with the nucleophile S.

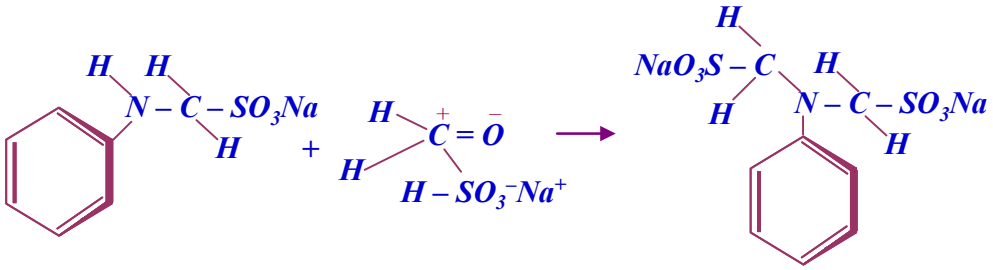


Since the carbonyl group of formaldehyde is a strongly polar group, it easily undergoes polarization. At the same time, the hydrosulfite, with its delocalized electrons, attacks the carbon of the carbonyl group, resulting in the formation of a new carbon-sulfur bond.

Since the resulting intermediate compound is highly unstable, the elimination of the hydroxyl group and the migration of the hydrogen from the hydrosulfite anion occur simultaneously. At the same time, the presence of aniline in the reaction environment leads to the interaction of the amino group with the hydroxyl groups of the ionized hydrogen, resulting in the formation of protonated water ions. As a result, monosulfomethyl aniline molecules are formed as the final product.



As the reaction progresses in this sequence, the concentration of monosulfomethyl aniline increases, which in turn leads to an increase in the amount of disulfomethyl aniline in the reaction mixture.



The reaction was carried out with various ratios of the initial raw materials. It was found that at a mole ratio of aniline: formaldehyde: sodium bisulfite of 1:1:0.5, the main product in the reaction mixture is monosulfomethyl aniline (MSMA). At a 1:1:1 ratio, disulfomethyl aniline (DSMA) is formed. The dependence of the yield of sulfomethyl aniline on the ratios of the initial reagents is presented in Table 1.

Table 1. *Dependence of the yield of mono- and disulfomethyl aniline on the ratio of initial raw materials, reaction duration: 3 hours*

C_6H_7N: CH_2O: $Na_2S_2O_7$ mol ratios	Temperature, °C	Productivity, %	
		MSMA	MSDA
1:1:0,5	30	26.4	4.8
1:2:1		7.8	18.0
1:1:0,5	50	47.3	7.8
1:2:1		16.2	25.5
1:1:0,5	**70**	**80.0**	**0.8**
1:2:1		24.6	49.8
1:1:0,5	90	78.1	1.9
1:2:1		22.2	57.4

The structure and composition of the obtained sulfomethyl aniline products were determined using elemental analysis, IR spectroscopy (Figure 2), and 1H NMR spectroscopy (Figure 3).

In the IR spectrum of the condensation products of aniline, formaldehyde, and sodium bisulfite in weakly acidic environments, the following characteristic absorption bands for sulfomethyl aniline can be identified:

1. A stretching vibration at 1190–1205 cm^{-1} corresponding to the -C–N bond,

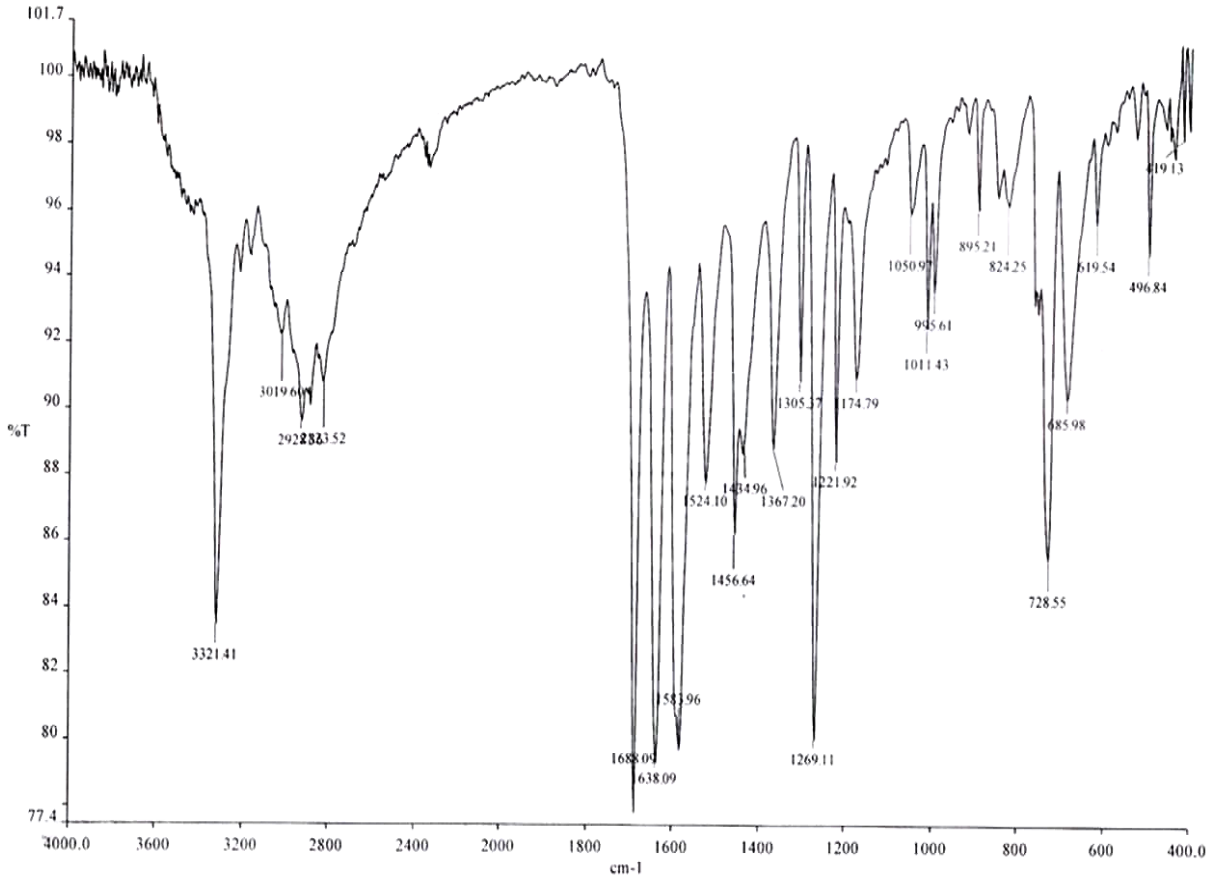
2. A stretching vibration at 1048–1075 cm^{-1} associated with the O=S=O group,

3. Absorptions at 3422–3448 cm^{-1} corresponding to the -N-H group in the aromatic ring,

4. A stretch at 1663.2 cm^{-1} for the C–C bond in the aromatic ring,

5. Deformation vibrations in the range of 1454–1472 cm^{-1}, characteristic of the methylene group.

Figure 2. *IR spectrum of the condensation products of aniline, formaldehyde, and sodium bisulfite in weakly acidic environments*



The rate of removal of accumulated mineral salts on the internal surface of the boiler was calculated using the gravimetric method (Antikain P. A., 1969) with the following formula:

$$W = \frac{\Delta m_{mt}}{S_t \cdot t} \qquad (1.1)$$

Where:

- W is the rate of removal of mineral salts (g/m²·h),
- m_{mt} is the mass of the dissolved accumulated mineral salts (g),
- S_t is the surface area being cleaned (m²),
- t is the time for the removal of the accumulated mineral salts (hours).

The effect of the reagents on metal corrosion during the washing process (Mk) was determined using the following formula:

$$K_M = \frac{\Delta m_{mt}}{S_t \cdot t} \qquad (1.2)$$

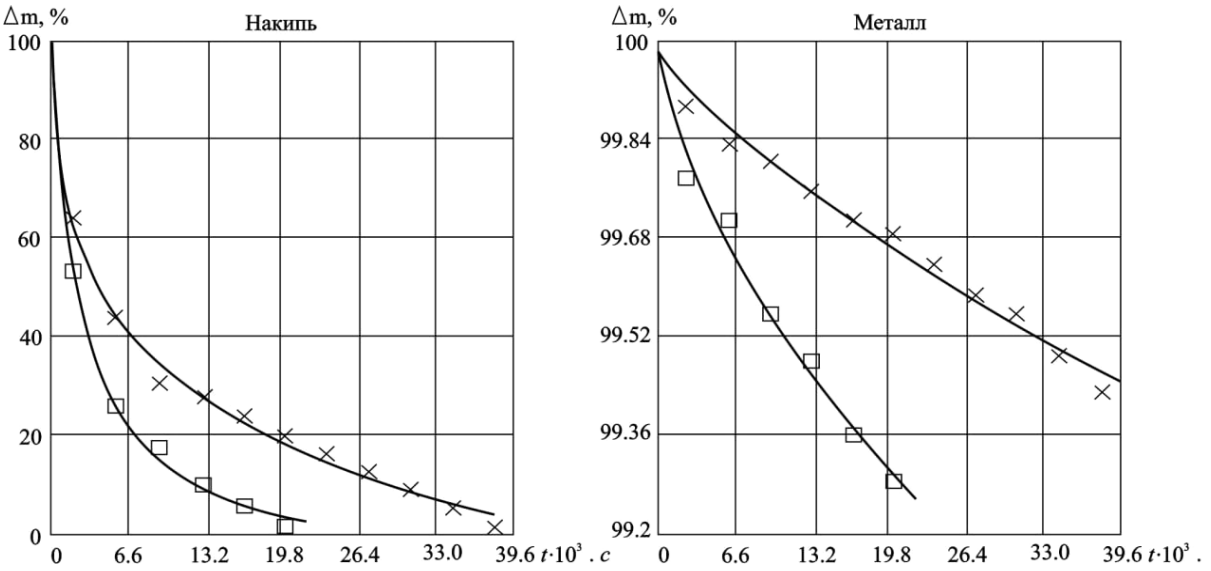
where – $\Delta m_M = (m_0 - m_m)$ mass of the metal initially and after the washing process, g; S_t – metal surface area, m²; t – washing time, hours.

Studies of the composition and structure of accumulated mineral salts in steam boilers under the conditions of the Syrdarya TPP, as well as numerous conducted experiments, indicate that the washing process consists of two main stages: The initial stage occurs rapidly (covering about a quarter of the total washing duration) and dissolves 75–85% of the mineral salts. The second stage involves dissolving the strongly adhered, hard-to-dissolve portion of accumulated mineral salts on the metal surface. This stage takes longer, encompassing 75–80% of the reaction duration and is considered the phase that determines the qualitative efficiency of the washing process.

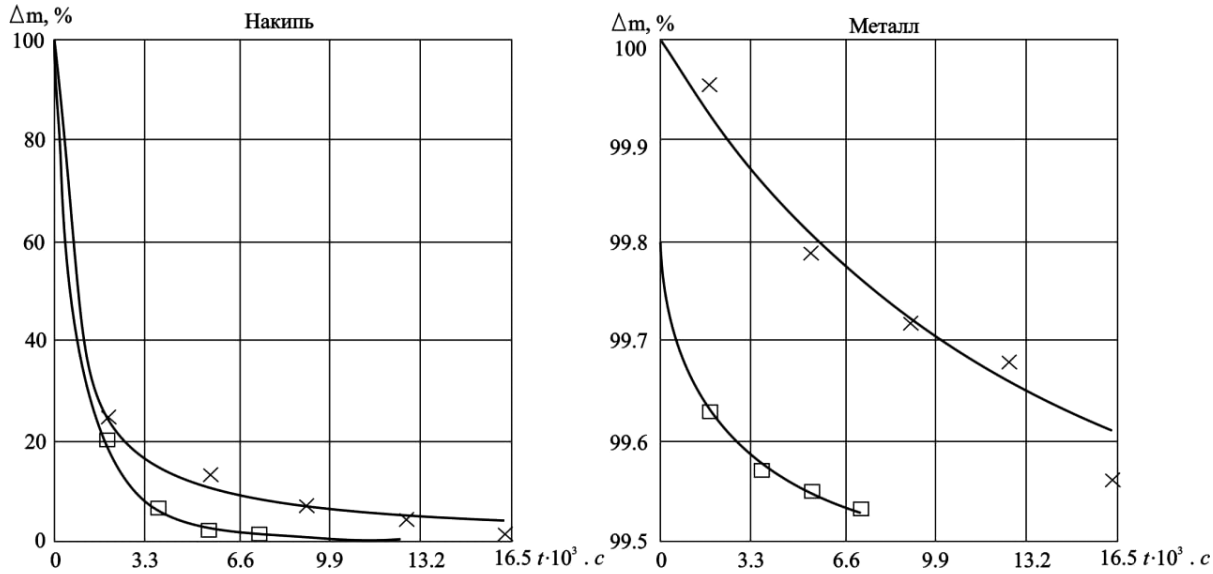
The upper layer of the accumulated mineral salts is relatively soft and mainly consists of carbonate compounds, while the layer closer to the metal surface contains a higher concentration of iron oxides.

Figure 4. *Concentration dependence of the dissolution process in washing (solution flow rate U=1 m/s): -×-washing reagent concentration 5%; -washing reagent concentration 8%; a) temperature t = 24°C; b) temperature t = 30°C*

a)

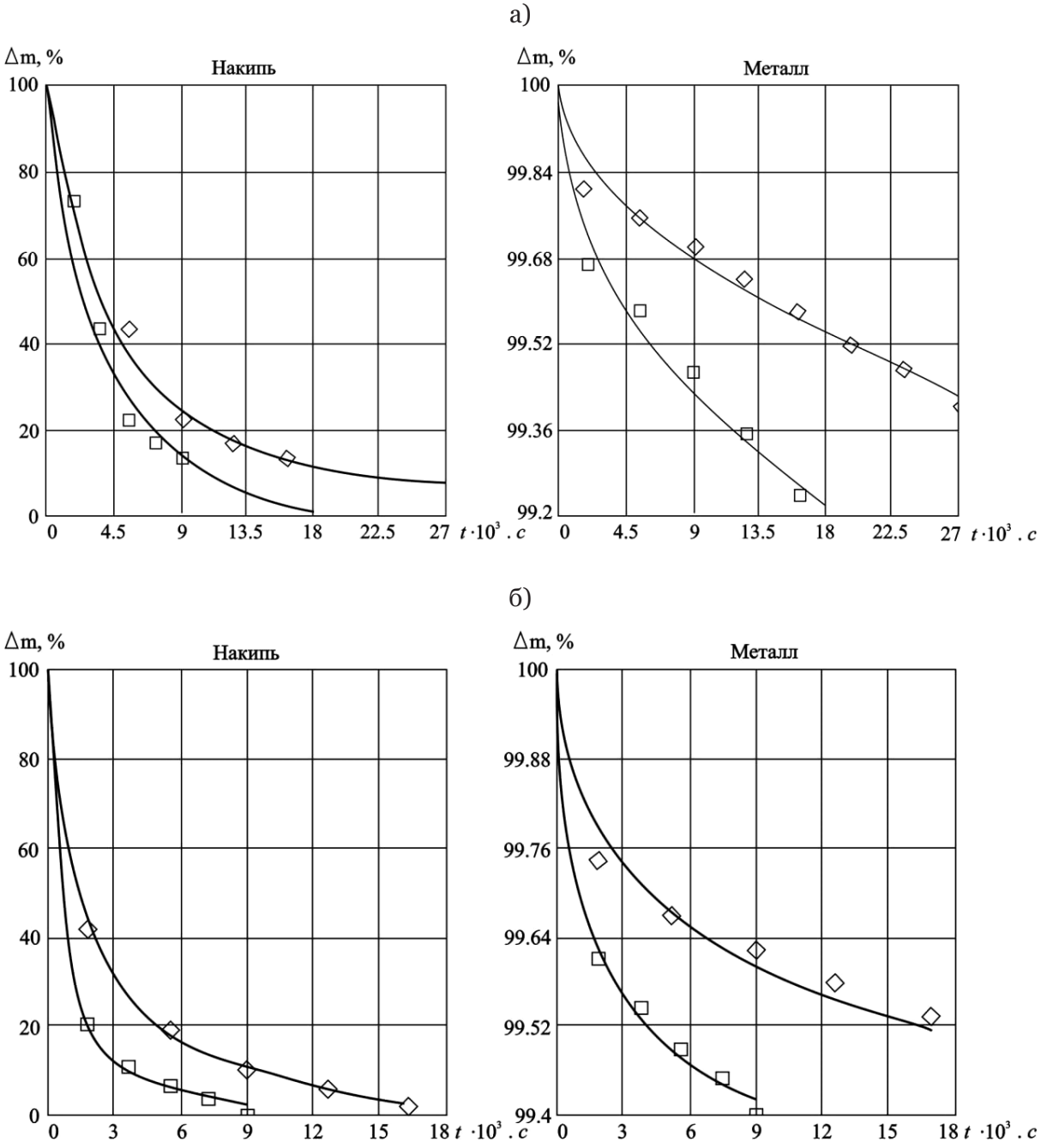


b)



From the comparative graphs of washing temperature and washing solution dosage, it is evident that temperature increase has a greater impact on cleaning duration than dosage increase. For instance: At a 5% dosage and a temperature of 20°C, the cleaning duration for metal surfaces is 39.6 × 10^3 seconds. Gradually increasing the temperature to 70°C at the same concentration reduces the cleaning duration to 16.5 × 10^3 seconds, shortening it by up to 2.4 times. Increasing the washing solution dosage to 10% at 20°C results in a cleaning duration of 19.8 × 10^3 seconds, reducing it by 2.1 times. This clearly demonstrates the aforementioned point.

Figure 5. Dependence of the dissolution process in washing on the speed of solution movement (temperature t = 30 °C): -×-washing reagent flow rate 0.1 m/s; – washing reagent flow rate 1.0 m/s; a) washing reagent concentration 5%; b) washing reagent concentration 8%



Summary

Thus, the condensation products of aniline, formaldehyde, and sodium bisulfite in weakly acidic environments were studied using IR spectroscopy, elemental composition analysis, and PMR (proton magnetic resonance) spectroscopy. The synthesis of sulfomethyl aniline products aligns with the principles of organic chemistry theory, where it is based on the observation that with increased reaction time, sulfomethyl aniline produced in aqueous solutions undergoes hydrolysis, converting back to the initial products, which leads to a decrease in the reaction yield. The geometry and electronic structure of the obtained substances were studied using the semi-empirical

quantum chemical method with PMZ (probabilistic molecular zone) analysis.

The optimal standards for washing the mineral salts accumulated on the internal surfaces of steam boilers have been determined, and the effectiveness of the salt dissolution rate (W) was calculated using the gravimetric method. Studies on the composition and structure of the mineral salts accumulated in steam boilers under the conditions of the Syrdarya Thermal Power Plant (TPP) and numerous experiments showed that the washing process consists of two main stages: The initial stage – a rapid phase (covering about a quarter of the total washing duration) in which 75–85% of the mineral salts dissolve. The second stage – the dissolution of the strongly adhered, hard-to-dissolve portion of the accumulated mineral salts on the metal surface (this stage is prolonged, covering 75–80% of the reaction duration, and is considered the stage that determines the qualitative effectiveness of the washing process).

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© Daniyarov G. T., Mukhamedjanov T., Huseinov A. Sh., Kadirov Kh. I.
Contact: bmoxichexra@bk.ru

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OBTAINING CORROSION INHIBITORS IN THE PRESENCE OF OXYETHYLIDENE DIPHOSPHONIC ACIDS

Sh.B. Obidov [1], X.I. Kadirov [1], X.N. Raximov [1], S.M. Turabdjano [2], F.I. Xolmatova [1]

[1] Tashkent Institute of Chemical Technology Tashkent, Uzbekistan

[2] Tashkent State Technical University, Tashkent city, Republic of Uzbekistan

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Abstract

In this article the regularities of the urea condensation reaction with glyoxal are considered and studied. It is shown that during the condensation of carbamide with 1,2-dicarbonyl compound in the presence of OEDP as a catalyst the product based on tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 is synthesized with a yield of 80-85%. The obtained products in pure form and in composition with diethylamine, formaldehyde, carbamide and gossypol resin were tested as corrosion inhibitors. It was established that the compositions are effective corrosion inhibitors and protect steel from corrosion by more than 90%.

Keywords: *urea, dial, OEDP, tetrahydroimidazo -[4,5-d]- imidazoledione corrosion inhibitor, protection level*

Tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 - multifunctional compound, V which urea fragment, actually, defines properties molecules, conditioned presence two reactionary centers V structure: four donor NH groups And two acceptor C=O groups.

As a rule, synthesis tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 is carried out by condensation of 1, 2 - dicarbonyl connections With urea V presence aggressive mineral And organic acid (H_2SO_4, H Cl and CF3 COO H, HCOO H) and alkaline catalysts . Besides that, the main Part processes receipt glycolurils is being carried out V organic solvents (Kravshenko, A.N., 2018; Li, J.-T., 2010).

Relatively recently V in a row works (30-32, 108, 109) established, What 1-hydroxyethylidenediphosphonic acid (OEDF) showed myself V quality convenient catalyst V 3-x component reactions heterocyclization V water. IN reactions were used carbonyl connections With active methylene group, ureas And aldehydes.

So OEDF - five-base acid With constants dissociations rK_α: 1.7, 2.47, 7.28, 10.29 And 11.13 for five steps respectively, decomposes at temperature about 250 °C, A V water

solutions decomposes at 140 °C (Pansuriua, A.M. 2009). In natural reservoirs OEDF subject to rapid decay under action ultraviolet, A products disintegration are used V quality fertilizers (Vilapara, K.V., 2019). OEDF With grounds forms salts (Savant, M.M. 2009; Bakibaev, A., 2020; Panshina, S., 2020). Unique complexing properties OEDF, contributed synthesis sets new organophosphorus connections and creation on their basis practically valuable substances V quality regulators contents calcium V in the body a person, bactericidal funds, inhibitors corrosion, auxiliary substances V oil production And thermal power engineering And etc.

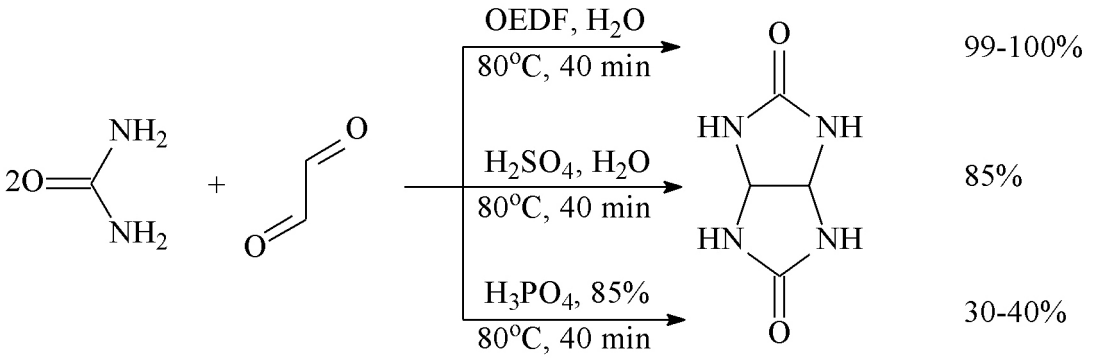
In molecule OEDF two phosphonyl atom O(H) at both atoms phosphorus, A Also deputies O H And With H_3 at atom WITH located By both sides from specified higher planes. This circumstance minimizes repulsion between atoms H(O), H(C) And phosphonic atoms oxygen. Two groups PO_3 in the structure OEDF have eclipsed conformation relative to axes P - P. By in the opinion of the authors (Belykh, S.I., 2018), obscured con formation molecules, conditioned by presence deputies HE And Me at atom carbon and responsible for weaker acidity V OEDF.

Taking into account the above, we carried out a condensation reaction of urea with 1,2-dicarbonyl compounds in the presence of OEDP as a catalyst in the synthesis of tetrahydroimidazo-[4,5-d]-imidazoledione-2,5.

It is known, What V industrial conditions tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 receive reaction condensation of glyoxal with urea in the presence of sulfuric acids with output 85% (Patent. 2439072).

Us for the first time carried out synthesis tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 reaction condensation ureas With glyoxal in water in the presence of OEDP as “green” catalyst (Mysheletti, G., 2013).

In the course conducted research, by us established, What synthesis tetrahydroimidazo- [4,5-d]-imidazoledione-2,5 With using OEDF leaks for 50-60 minutes With practically quantitative yield of the target product:



The relationships were established components and time reactions. On first stage research We used ratio 1:0.5 (urea: OEDF), Where reaction it was over already on 10 minute With exit glycoluril 44%. Dropped out product tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 at 10 minutes reactions was separated by filtering, A filtrate continued heat V flow 2 hours. By expiration time reactions general exit tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 amounted to 87% (Table 1).

Table 1. *Exit tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 at various ratio ureas and OEDF*

Time	Amount of OEDP, mol (ratios urea (urea , OEDF)			
	0.0005 (1:0.25)	0.001 (1:0.5)	0.002 (1:1)	0.004 (1:2)
10 minutes	35%	44%	61%	66%
120 minutes	79%	87%	99%	97%

Next at working off moths ratios quantities OEDF (table 2.1) was established, What the greatest exit tetrahydroimidazole-[4,5- d]-imidazoledione-2,5 (99%) V reactions bicyclization achieved at use relation 1: 1 urea to OEDF respectively.

At use 1 equivalent OEDF V synthesis tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 was established, what already on 40 minute was highlighted product tetrahydroimidazole- [4,5- d]-imidazoledione-2,5 With exit 99%, A at hourly duration tetrahydroimidazole-[4,5-d]-imidazole-2,5 dione process was received With quantitative yield (100%).

Was established, what at long-term heating reactionary masses synthesis tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 V presence OEDF (more 2 hours) finished product yield decreases. In this case, the analysis of the solution revealed that, together with OEDP, the filtrate contains products of a competitive reaction or rearrangement of tetrahydroimidazole- [4,5- d]-imidazole-2,5-dione.

Considering that the synthesis product and the initial reagents are corrosion inhibitors, the determination of the inhibitory properties was studied in a mixture without additional purification (Table 2). The effect of the concentration of tetrahydroimidazole-[4,5-d]-imidazoledione-2,5 (THID) in pure form and as a composition on the corrosion rate of grade Ct. 20 steel in 15% hydrochloric acid (t = 60 °C; τ = 42 hours).

Table 2. *The influence of TGID concentration on the corrosion rate of steel grade Ct. 20*

Concentration inhibitor, %	Corrosion rate g/ m² · hour	Degree protection, %
Without additives	13	–
0.2	6.5	95.0
0.4	4.7	96.4
0.6	4.1	96.8
0.8	2.0	99.0
1.0	1.4	99.6
1,2	2.4	97.6

The obtained inhibitor has limited solubility in gas condensate. When dissolved in a two-phase medium - gas condensate: water - an independent phase is released, which limits its use as an inhibitor of hydrogen sulfide corrosion.

TGID product was modified with the addition of diethylamine and was called TGID-SHO. Its effect on steel corrosion in hydrogen sulfide (Table 3) and carbon dioxide (Table 4) environments was studied.

Table 3. *The effect of TGID-SHO on the rate of steel corrosion in a hydrogen sulfide environment (strength grade D, T = 25-35 °C, hydrogen sulfide concentration – 2.5–3.0 g/l, gas condensate: water – 1:2, active substance – inhibitor 50%)*

Inhibitor	Concentration, mg /l	Time experience, hour	Corrosion rate, g/ m² hour	Degree protection, %
Without inhibitor	–	12	1.15	–
TGID-SHO	100	12	0.048	95.1
TGID-SHO	300	12	0.013	98.9
TGID-SHO	500	12	0.015	98.7
Without inhibitor	–	24	0.92	–
TGID-SHO	200	24	0.042	96.6
TGID-SHO	500	24	0.018	98.1
Dodikor (standard)	100	24	0.055	95.0
Without inhibitor	–	48	0.25	–
TGID-SHO	100	48	0.010	93.8
TGID-SHO	300	48	0.008	96.8
Dodikor (standard)	100	48	0.009	96.4

Table 4. *The effect of TGID-SHO on the rate of steel corrosion in a carbon dioxide environment (strength grade D, T – 25-40 °C, Pso $_2$ -1.0 MPa, stirring)*

Inhibitor	Concentration , mg /l	Time experience , hour	Corrosion rate, g/m²·hour	Degree protection , %
Without inhibitor	–	20	3.7	–
TGID-SHO	100	20	0.132	96.29
Without inhibitor	–	40	3.8	–
TGID-SHO	100	40	0.17	96.46
Without inhibitor	–	60	3.5	–
TGID-SHO	100	60	0.138	96.01
Without inhibitor	–	80	3.4	–
TGID-SHO	100	80	0.138	95,94
I-1-A	200	80	0.3	91.17

As can be seen from the data of Table 3, TGID-SHO is an effective corrosion inhibitor for 24 hours, at a concentration of 500 mg/l, with the corrosion rate being 0.018 and the degree of protection being 98.7%, for 48 hours of dosing at 300 mg/l, the corrosion rate is 0.008 and the degree of protection is 96.8%. Thus, the synthesized product is not inferior in terms of the degree of protection to the corrosion inhibitors imported from Russia "I-1-A" and from Germany "Dodicor".

The influence of TGID-SHO concentration on the corrosion rate depending on temperature was studied.

Tables 5. *The effect of TGID-SHO on the corrosion rate in different waters depending on temperature, the experiment time is 24 hours*

Solution, % mass.	Corrosion rate g/ m² h	Degree protection, %	Corrosion rate g/ m² h	Degree protection, %	Corrosion rate g/ m² h	Degree protection, %
	T=20 °C		T=40 °C		T=60 °C	
NaCl ÷ 25.0	0.042	–	0.99	–	25.80	–
NaCl+ TGID–SHO ÷ ÷ 25.0+0.5	0.0091	78.30	0.079	92.02	0.40	98.45
H_2SO_4 ÷ 20.0	15.7	–	7.7	–	31.20	–
H_2SO_4 + TGID–SHO ÷ ÷ 20.0+0.5	2.2	85.99	3.0	61.03	16.00	48.72
NaCl + H2S ÷ 25.0 + saturated solution	0.23	–	0.94	–	3.10	–
NaCl + H_2S + TGID– –SHO ÷25.0+ saturated p–p+1.0	0.02	91.30	0.072	92.34	0.099	96.81

As can be seen from the data in Table 5, TGID-SHO effectively protects steel from corrosion in aqueous solutions of NaCl and NaCl + H_2S, showing stability with an increase in temperature to 60 °C. At the same time, in a 20% aqueous solution of H_2SO_4, the efficiency decreases with an increase in temperature.

THID was also modified by adding formaldehyde, urea, gossypol resin, copper salts in the ratio: THID: formaldehyde: urea: gossypol resin = 0.6: 0.1: 0.29: 0.01 (the conventional name of this composition is THID – extra).

TGID and TGID - extra was studied ; the results for determining the volatility of the samples are presented in Table 6.

Table 6. *Results for determination of sample volatility*

Name samples	Load , g	Weight loss, g, after 5 hours.	Weight loss, g, after 25 hours
TGID	1.96	0.81 (41%)	0.97 (49.5%)
TGID -extra	2.6	0.29 (11%)	0.38 (14.6%)

Table 6 shows that the analyzed reagents (except for TGID - extra concentrate) have high volatility. Removal of the solvent from the reagent " TGID - extra " allowed us to obtain a homogeneous stable reagent, the volatility of which did not exceed 0.2%.

The studies of the inhibitory effect of "TGID - extra" were carried out by express determination on metal samples of steel grade St. 20. The inhibitor concentration was 400 mg/l. The study time was 24 hours, at room temperature in two-phase systems gas condensate - saline solution, oil - saline solution and in saline solution. The analyzed systems were saturated with hydrogen sulfide for 15 minutes.

The results of the inhibitory effect of the "TGID - extra" test on metal plates St.20 are presented in Tables 7 and 8.

Table 7. *Results of the inhibitory effect of the TGID sample, inhibitor concentration 1% by weight*

No.	Terms and Conditions experience	Average loss mass, gr.	Average corrosion rate g/m² ·hour	Degree protection, %
1	Without inhibitor	0.0255	0.03310	
	Saline solution containing H2S + 70 ml gas condensate	0.004	0.00519	84.3
2	Without inhibitor	0.012	0.01557	–
	Saline solution containing H2S + 70 ml oil	0.0013	0.00143	89.2
3	Without inhibitor	0.0107	0.13889	–
	Saline solution containing H2S	0.0012	0.01493	89.3

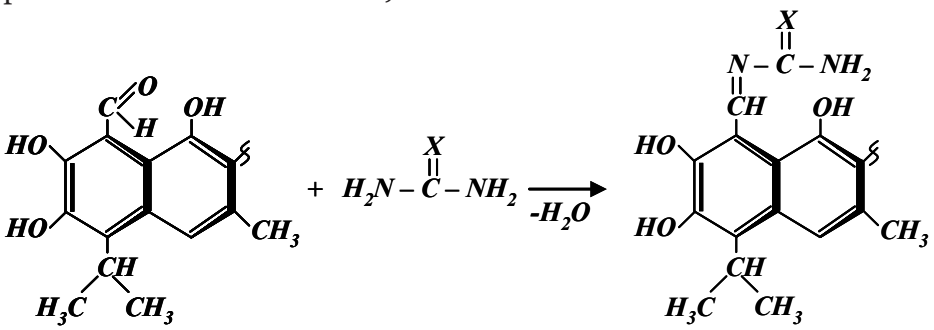
Table 8. *Results of the inhibitory effect of the "TGID - extra" sample, inhibitor concentration 1% by weight*

No.	Terms and Conditions experience	Average loss mass , gr .	Average corrosion rate g/m² · hour	Degree protection, %
1	Without inhibitor	0.0031	0.3952	
	Salt solution containing gas condensate: water 1:2 and H2S	0.0053	0.00365	90.7
2	Without inhibitor	0.0051	0.196	
	Salt solution containing gas condensate: water 1:2 and H2S + 70 ml of oil	0.0022	0.02791	85.8
3	Control	0.001	0.01298	
	Salt solution containing gas condensate: water 1:2 and H2S	0.0002	0.00128	90.1

In order to develop a universal hydrocarbon-soluble inhibitor, PKI-3 was improved by adding urotropine, gossypol resin, acrylic nitrile, formaldehyde, urea and copper salt in the ratios urotropine: gossypol resin: acrylic nitrile: formaldehyde: urea: copper salts = 0.5: 0.1: 0.09: 0.1: 0.2: 0.01 (the conventional name of this composition is "TGID - extra SHO").

The inhibitor components were selected based on the following considerations: formaldehyde reacts with urea to form mono-, di-, tri- and tetramethylol derivatives.

Urea reacts with gossypol, which is present in gossypol resin, according to the following scheme:



The inhibitor " TGID - extra SHO" has a weak characteristic odor. It dissolves well in gas condensate and hydrocarbons. The main indicators of the inhibitor " TGID - extra SHO" are given in Table 9.

Table 9. *Physicochemical parameters of the inhibitor " TGID - extra IIIO"*

No.	Name indicators	Meaning
1	Amine number, mg HC l per 1 g of inhibitor, not less than	45.0
2	Protective capacity in water-hydrocarbon environment containing hydrogen sulfide, % not less than	90.0
	Solubility:	
3	in gas condensate	soluble
	in the water	disperses
4	Freezing point, °C not higher	minus - 35
5	Kinematic viscosity at 20 °C mm^2 /s no more than	25
6	Dry residue , % not less	67
7	Density of inhibitor at 20 °C, g/cm^3 no more than	1.05

"TGID-extra SHO" was tested as a corrosion inhibitor in hydrogen sulfide, carbon dioxide and hydrochloric acid environments (Tables 10–12).

Table 10. *The effect of the inhibitor " TGID - extra SHO" on the corrosion of steel grade D in a carbon dioxide environment (PCO_2 = 1.0 MPa), room temperature*

Concentration inhibitor, mg /l	Time experience, hour	Corrosion rate, $g/m^2 h$	Degree protection, %
Without inhibitor	20	3.7	–
200	20	0.137	96.29
Without inhibitor	40	3.8	–
200	40	0.172	96.46
Without inhibitor	60	3.5	–

Concentration inhibitor, mg /l	Time experience, hour	Corrosion rate, g/m² h	Degree protection, %
200	60	0.138	96.0
Without inhibitor	80	3.4	–
200	80	0.135	95.94
I-1-A standard, 200	80	0.3	91.17
400	80	0.2	94.12

Table 11. *Protective action of the inhibitor " TGID - extra SHO" in a hydrogen sulfide environment. Temperature - room*

Concentration of H_2S in $_{gas}$ condensate g/l	Concentration inhibitor , mg /l	Corrosion rate g/m² hour	Degree protection , %
	Time 1 day		
2.5 – 2.7	Without inhibitor	3.9	-
	100	0.2	94.87
	250	0.31	92.05
	400	0.036	95.2
	Time 3 days		
2, 9 – 3 , 1	Without inhibitor	0.489	-
	100	0,013	97.3
	250	0,011	97.9
	400	0,014	97.0

Table 12. *Effect of temperature on the corrosion rate of C.3 in 15% hydrochloric acid. Concentration inhibitor 0.8% by weight*

Solution salt acids	Corrosion rate g/m² hour	Degree protection %
Temperature room temperature , τ = 24 hours		
Without inhibitor	5.2	–
With inhibitor	1.3	75.0
Temperature 40 °C, τ = 4 hours		
Without inhibitor	48	–
With inhibitor	0.6	99.0
Temperature 60 °C, τ = 4 hours		
Without inhibitor	13	–
With inhibitor	2.0	98.0
Temperature 80 °C, τ = 4 hours		
Without inhibitor	610	–
With inhibitor	2.0	99.6
Temperature 100 °C, τ = 1 hour		
Without inhibitor	1020	–
With inhibitor	4.3	99.5

As can be seen from the obtained data, the inhibitor "TGID - extra SHO" in all cases shows high protection against corrosion.

Thus, the regularities of the urea condensation reaction with glyoxal have been established. It has been shown that during the con-

densation of carbamide with 1,2-dicarbonyl compounds in the presence of OEDP as a catalyst, a product based on tetrahydroimidazo-[4,5-d]-imidazoledione-2,5 was synthesized with a yield of 80–85%. The products obtained in pure form and in combination with some secondary reagents of the chemical industry were tested as corrosion inhibitors.

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Contact: shoobidov@gmail.com

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THE INFLUENCE OF THE SUSPENSION SOLUTION (PULP) ENVIRONMENT ON THE SORBENT'S SORBENT SORBENCE

Sultonov Shavkat Abdullayevich [1], ***Narkulov Dilshod Axmatovich*** [1]

[1] Navoiy State Universitet

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Abstract

Today, one of the most effective methods of modifying clay powders is the effect of thermochemical processes. The main purpose of the article is to increase the sorption properties of specific sorbents for cleaning vegetable oils.

When processed by the thermochemical method, two-sided (temperature and acid) clays can be artificially modified. As a result, it was found that the size of the sorbent volume increased. The increase in the depth of the pores along with the surface area of the sorbent was analyzed and studied using the adsorption-isothermal analysis method. The most effective method for obtaining sorbents was determined using the thermochemical process. In addition, the sorption properties differ depending on the type of clay powder. It was found that the pH of the clay powders during the washing process is important for achieving a standard pH environment.

Keywords: *Palygorskite clay powder, porosity, sulfuric acid, grinding, bleaching, activation*

The urgency of the issue

Today, there are more than 100 types of clays that exhibit sorption properties in the world. Sorbents obtained by thermally activating the sorption properties of clay powders are used only for the purification of vegetable oils and drinking water, especially when small molecules are mixed with the product to be purified. There are also more than 10 types of clays for purifying cottonseed oil, and their activation processes have also been found to differ from each other. Depending on the method of processing clay powders and the type of clay powder, there are variations in the methods of carrying out activation processes, which differ from each other. According to the Lewis and Brønsted-Lowry theories, metals in sorbents play an auxiliary role in the sorption of organic substances that exhibit the properties of pollutants in dusty products.

The thermal method of processing clay powders produces pores of various sizes due to the reduction in the percentage of alkali and some alkaline earth metals. Therefore, depending on the quantitative ratio of elements with high metallicity in such clay powders, it is possible to increase the sorption properties. It was found that thermal activation leads to relatively similar results with chemical activation. A comparative analysis of the activation processes can be observed in Figure 1 below.

Figure 1. *Changes in sorption properties through chemical and temperature effects during the activation process*

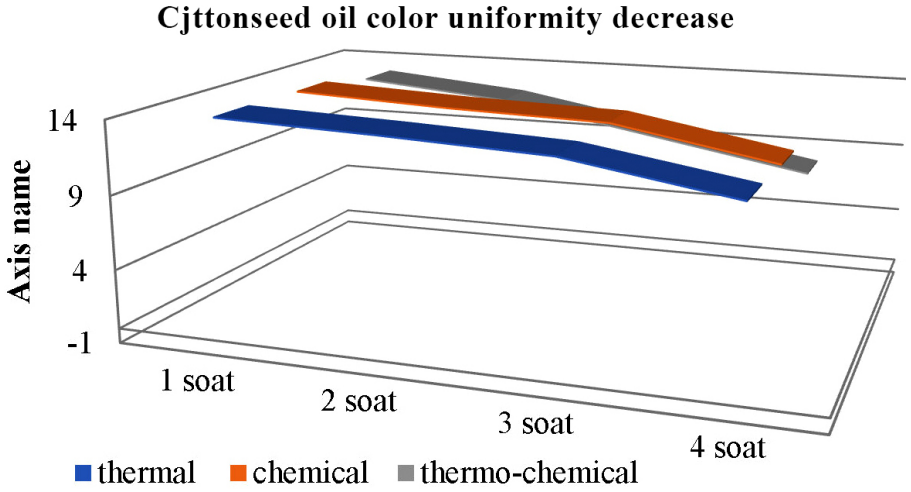
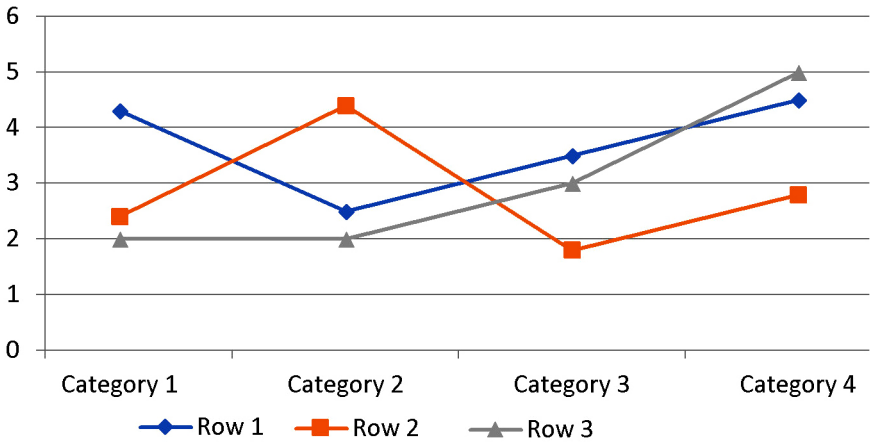


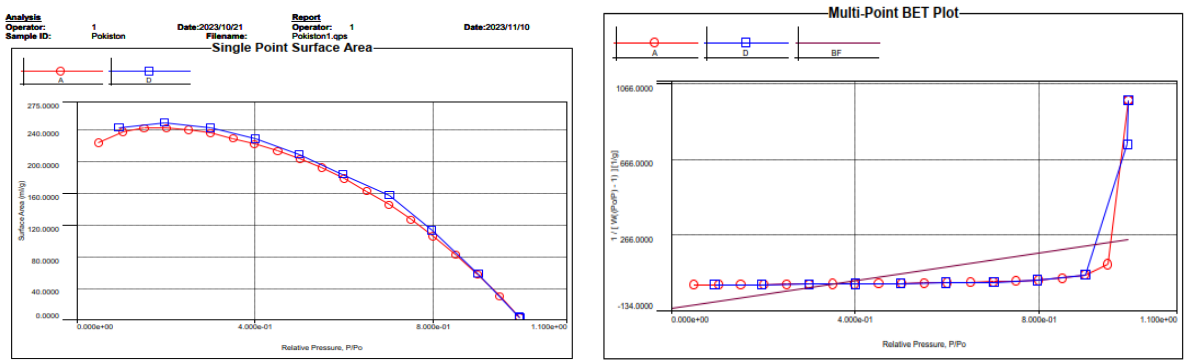
Figure 2. *As can be seen in the figure, thermochemical reactions achieve highly efficient results*



One of the effective methods for increasing the sorption properties of clay powders is thermochemical. When activated by this method, reactions occur as a result of two external influences (both temperature and acid). As a result, it was found that the sorption surface area increased. The results of adsorption-isothermal analysis show that the diameter and depth of the pores of the sorbent, along with the surface area, also increased, as can be seen in Figure 1 (a and b).

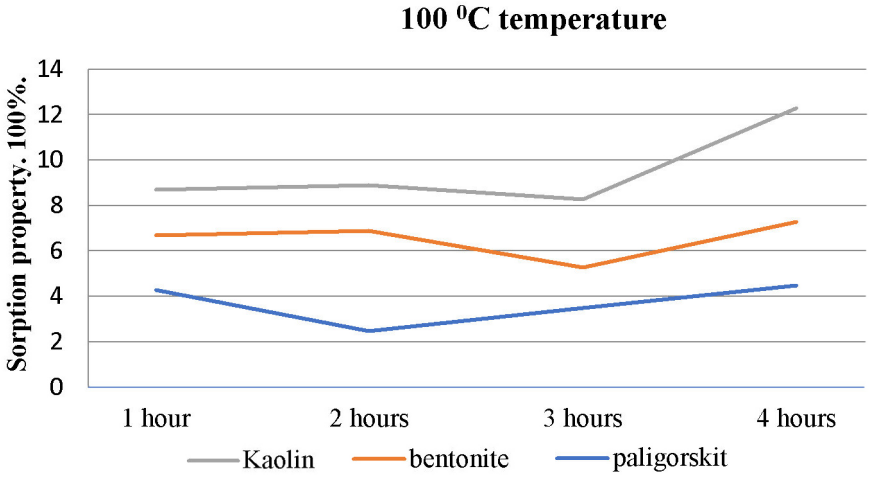
Figure 3.

a) b)



In the example of the most effective method of obtaining sorbents, the result of thermochemical processes was determined as the most optimal. In addition, the sorption properties of clay powders also differ depending on the type of clay powder. For example, in the process of activating palygorskite clay powders, the concentration of the acid solution and the acidic environment of the sorbent differ from those of kaolin and bentonite powders, as can be seen in Figure 2 below.

Figure 2. *Effect of activation time on clay powder types*



The figures and data presented in Figure 2 show that the concentration of the acid solution is lower when activating palygorskite clay powder and the sorption properties are higher.

A suspension solution (pulp) environment is also determined during the washing process at the final stages of obtaining sorbents. During the research, it was found that white or yellow palygorskite or clays that react violently with an acid solution have a sharp decrease in pH values during washing processes. The hardness of these clays, in particular, the difficulty of grinding, is explained by the strength of these inter-element interactions or bonds. The ability to react violently indicates that the clay consists of elements that exhibit strong metallic properties. In addition, from the results of the experiments, it can be concluded that if their electronegativity differs sharply from each other, the grinding properties of clays decrease.

If the pulp activated at high temperatures (from 100 ˚C to 300 ˚C) is dried until the pH value is equal to 3 during washing, the resulting sorbent is again observed to approach 5. This sharp decrease in the pH value is explained by the fact that the activation process also occurs during the drying process. It was also found that when activated twice without boiling (when the amount of water is small), but only as a result of drying, the pH value changes to 0.2.

Clay powders, which require a large amount of water during the reprocessing process, on the contrary, when dried in an acidic environment, the pH value increases to 1.5. It was observed that when activating such clays, if the quantitative ratio of acid is used less, the phenomenon of suffocation occurs. To determine the sorption properties of the resulting sorbent, a test was conducted by cleaning cottonseed oil. During the cleaning process, it was found that the sorbent darkened. This darkening is accompanied by sorption and partial saturation, as can be seen in Table 1 below.

From Table 1, it can be concluded that the higher the water content during activation, the greater the reduction in the occurrence of clogging. The optimal water content is 4 times higher than that of clay. At the same time, even if the water content is low, the optimal acid content is 1 time lower.

In both of the above activation methods, drying in an air dryer is required. It was found that the sorption properties of bentonite clays decreased sharply when dried by boiling in a reactor. In Figure 2 below, it can be seen that the pH of palygorskite clays decreased to the maximum as a result of drying.

Table 1. *Effect of different clay: water ratios on sorption properties during activation. At 150 0C, clay: acid ratio 1:0.5*

T/r	lay: water ratios	Volume of the sorbent relative to the sorbent	Sorption property	lay: water ratios	Volume of the sorbent relative to the sorbent	Sorption property
1	1:3	1.4	40	1:1	2	48
2	1:4	1.1	48	1:1.5	1.8	48
3	1:5	0.9	34	1:1.3	2	47
4	1:6	0.7	30	1:1.2	2.3	40

If the pH value is determined during the first washing (for the first time) and after filtering and drying, there is a sharp difference. It was found that the activation process does not change the pH value significantly when the drying process is carried out 2 or 3 times in a row. It was observed that the pH value decreases sharply when clay powders that require a lot of water during the activation process are dried. If the acid concentration is reduced in such clay powders, the activated powder exhibits a fouling property, and the fouling phenomenon is also observed in the purification of oils, and the filtration process is also sharply reduced or stopped. If the acidic environment is even higher, it turns the oil red. In the drying process without boiling, if all stages are carried out in air dryers, the sorption property is high. The effect of acid concentration and suspension solution medium on the sorption properties of clay powders is presented in Table 2 below.

Changes in sorption properties of different clays under the influence of temperature, acid concentration, and solution medium

Table 2.

T/r	Activated clays	Temperature (at ˚C)	Acid concentration	Suspended solution pH indicator	Sorption property (in %)
1	Palygorskite	200	10	2.5	80
				3.5	82
			20	2.5	90
				3.5	92
		300	10	2.5	86
				3.5	88
			20	2.5	96
				3.5	94
2	Bentonite	200	10	2.5	50
				3.5	76
			20	2.5	80
				3.5	78
		300	10	2.5	80
				3.5	80
			20	2.5	86
				3.5	84

T/r	Activated clays	Temperature (at ˚C)	Acid concentration	Suspended solution pH indicator	Sorption property (in %)
3	Kaolin	200	10	2.5	60
				3.5	62
			20	2.5	78
				3.5	82
4		300	10	2.5	82
				3.5	80
			20	2.5	86
				3.5	90

When sorbents are used for food purification and other purposes, it is necessary to compare their compliance with standard requirements and conduct various important analyzes. Even after activation, it is advisable for the researcher to check the effects of sorbents on the environment, the human body, the possibility of repeated use and in which other areas the used sorbent can be used, in particular, other properties. Analysis and comparison indicators, that is, combining theoretical, practical, laboratory work experiences, are written as experimental results.

To find out what the initial pH of the sorbent obtained by processing natural clay powder is, add 1 g of sorbent to 15 ml of water and mix for 1–2 minutes. If it is not mixed, an error is made in determining the acidity of the medium. It is also advisable to mix slowly during the determination. The active metals in the clay powder react and come out in the form of soluble salts. The metals are replaced by hydrogen cations, and since these cations are somewhat difficult to determine, they must be mixed. According to the Lewis theory, the hydrogen cation exhibits an electrophilic nature that accepts electrons from other metals in the clay. As the clay powder settles to the bottom of the solution, the acidity decreases in the upper part of the solution, which interferes with the analysis of the sorbent. The pH should be between 3.8–5, taking into account the areas of application of sorbents and the type of clays to be activated.

The density of sorbents also varies. After activation of clay powders, their density decreases. If the density of the processed sorbent is reduced by two or more compared to the initial clay powder, the expected result is achieved.

When using sorbents, it is also necessary to pay attention to the composition of the product. The properties of the product being cleaned are determined by the presence of similar properties in the sorbent, since these properties are explained by the ability of the sorbent to react.

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© Sultonov Sh. A., Narkulov D.A.
Contact: sshav85@bk.ru

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PRODUCTION OF SUPERPLASTICIZERS BASED ON THE PYROLYSIS PRODUCTS OF HEAVY RESINS

Safarov Toyir Tursunovich [1], ***Ziyadullaeva Kamola Xaitboevna*** [2], ***Ziyadullaev Anvar Egamberdievich*** [1], ***Eshpulatov Mukhammadi*** [1]

[1] Tashkent Chemical-Technological Institute of Republic of Uzbekistan, Uzbekistan

[2] University of Geological Sciences of the Republic of Uzbekistan, Uzbekistan

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Abstract

The process for obtaining naphthalene, indene, and phthalic anhydride through the distillation of liquid and solid fractions of heavy pyrolysis products has been implemented. The quantitative and qualitative composition of resin samples and the products derived from their fractions have been determined. Additionally, superplasticizer additives for cement were developed, and their strength, average particle density of the cement, the impact of the amount of superplasticizers, and their duration of action on the material properties were studied.

Keywords: pyrolytic heavy distillate, naphthalene, indene, phthalic anhydride, superplasticizer

Introduction:

The goal of pyrolysis processes, which are widely used in modern petrochemistry, is to produce lower olefins, primarily ethylene, a valuable raw material for synthesizing key petrochemical products (Pavlovich, L.B., Andreikov, E.I., 2013; Romanova, N.A., Leontyeva, V.S., Khrekina, A.S., 2018; Sahu, B.M., Bera, V.V., Kumar, R., Banik, B.K., Bora, P., 2020).

During pyrolysis, ethylene, propylene, butylene, and butadiene are generated, along with significant amounts of benzene and aromatic hydrocarbons such as toluene, xylene, indene, naphthalene, and anthracene. Ethylene obtained from pyrolysis is used to produce ethylene oxide, ethyl alcohol, polymers, styrene, plastics, and other products. The main applications of liquid pyrolysis products include the production of benzene and other aromatic hydrocarbons, oils from polymer resins, diesel fuel, coal, and high-quality coke (Sha, S., Wang, M., Cai, C., Shi, C., Xiao, Y., 2020; Ziyadullaeva, K.Kh., Nurmanov, S.E., Mukhidinov, B.F., Kodirov, O.Sh., Vapoев, Kh.M., 2020).

To improve the quality of cement compositions, it is essential to use highly effective plasticizing additives. In the construction industry, superplasticizers — chemical additives — are

employed to regulate the structural formation processes and rheological properties of concentrated suspensions, allowing for modifications in the flowability of raw materials and the properties of finished products. One of the pressing tasks today is to find new effective additives that can alter interfacial properties and rheological characteristics of dispersions (Batrakov, V.G., 1998; Gamaliy, E.A., 2009; Ibragimov, R.A., 2011; Ramachandran, V.S., 1988; Ramachandran, V.S., 1977).

Research Methods:

For the first time, catalysts of types VBS-33, VBS-44, VBS-55, and VBS-66 were created for the separation of naphthalene and indene fractions from secondary gas chemical products at various temperatures and for the production of plasticizers. The study employed methods such as UV spectroscopy, Raman spectroscopy, gas chromatography, mass spectrometry, and differential thermal analysis (DTA). Heavy pyrolysis oils from gas processing plants, naphthalene, indene and their homologues, plasticizers for concrete and cement, phthalic anhydride, and naphthalene were investigated.

Analysis of Results:

The primary direction of economic development in the Republic focuses on the development and utilization of natural resources, large-scale modernization of industrial production, technical and technological updates, the introduction of modern scientific achievements, and progressive innovative technologies in manufacturing. The creation of competitive import-substituting products with stable demand in the global market is essential.

The Ustyurt Gas Chemical Complex is one of the largest enterprises for the production of polymer products in Central Asia, based on the processing of natural gas in the Ustyurt region. The complex has an annual production capacity of 387,000 tons of polyethylene and 83,000 tons of polypropylene. More than 102,000 tons of pyrolysis distillates, 8,000 tons of pyrolysis oil, and 10,000 tons of resin are produced here. The pyrolysis distillates, pyrolysis oils, and resin products formed in this process are not currently processed. Pyrolysis distillates and oils, such as naphthalene and aromatic hydrocarbons, are now primary secondary raw materials for producing valuable chemical products essential for the industry.

The processing of heavy fractions from liquid pyrolysis products and the introduction of these products into practice are deemed relevant, allowing the production of costly and necessary products using modern technologies. Due to the lack of acceptable technologies for recycling pyrolysis waste to produce indene, naphthalene, and its homologues, phthalic anhydride is not produced in the country. Thus, research aimed at developing recycling technologies for gas chemical complex waste is a pressing issue that requires resolution.

Pyrolysis distillates, pyrolysis oil, and heavy fractions of liquid pyrolysis products are secondary raw materials with significant potential for producing naphthalene, aromatic hydrocarbons, indene, phthalic anhydride, and other valuable chemical products.

Currently, modern technologies enable the production of costly and necessary products. However, due to the absence of acceptable technologies for recycling pyrolysis waste to produce indene, naphthalene, and its homologues, phthalic anhydride is not manufactured in our country. Therefore, research aimed at developing an integrated technology for recycling waste from gas chemical complexes operating in the republic is a relevant task that needs addressing.

The process of thermal pyrolysis of hydrocarbon raw materials is the primary method for obtaining low-molecular unsaturated hydrocarbons — olefins (alkenes)—such as ethylene and propylene. The main applications of liquid pyrolysis products include the production of benzene and other aromatic hydrocarbons, naphthalene, oil polymers, gasoline, raw materials for producing high-quality coke, and more.

Currently, due to reduced oil production volumes in the petrochemical industry, the issue of expanding the raw material base for producing aromatic hydrocarbons and their various derivatives is becoming increasingly relevant. Heavy pyrolysis products, such as indene and naphthalene, along with their homologues, are of great interest as potential raw materials for producing petrochemical products.

Secondary gas chemical products were separated into naphthalene and indene fractions at various temperatures. Based on the obtained products, catalysts of various compositions (VBS-33, VBS-44, VBS-55, VBS-66) were developed (Ziyadullaeva, K.Kh., Nurmanov, S.E., Kurbanova, A.Dz., Akhmedova, N., 2021).

In Uzbekistan, ethane, propane-butane fractions, and gas condensates are prioritized as raw materials for the thermal pyrolysis of hydrocarbons. The study examined heavy fractions of liquid and solid pyrolysis products, secondary gas chemical products, and the chemical composition of pyrolysis distillate. The analysis showed that the secondary products isolated from heavy pyrolysis are liquids with a strong odor, appearing as dark brown, grease-like fluids, while the composition of the obtained pyrolysis feedstock is unstable.

To utilize liquid pyrolysis products as secondary raw materials and develop technology for their processing, work was conducted to study the chemical composition of pyrocondensate produced at the Ustyurt Gas Chemical Complex.

Table 1. *Chemical Composition of Pyrolysis Distillate*

Number of Carbon Atoms	Alkanes	Dienes	Olefins	Cycloalkanes	Arenes	Total
5	0.8	0.89	4.91	0.19	0	6.79
6	0.22	0.41	3.87	0.41	32.94	37.85
7	0.25	0.14	0.84	0.45	11.23	12.91
8	0.12	0.08	0.18	0.48	9.75	10.61
9	0.04	0.1	0.04	0.15	7.56	7.89
10	0.03	0.11	9.07	0.4	5.23	14.84
11	0.18	0.69	2.95	0	0.47	4.29
12	0	0.15	1.84	0	0	1.99
Total	1.64	2.57	23.7	2.08	67.18	97.17

The fractions of naphthalene and its homologues were isolated from heavy pyrolysis resins using dealkylation and rectification methods. The production of naphthalene is based on local raw materials, which positively impacts the overall efficiency of the heavy pyrolysis resin processing. However, the main challenge in effectively utilizing heavy pyrolysis products is related to the presence of asphaltenes and mechanical impurities in their composition.

The isolated products from heavy pyrolysis oils are odorless and depend on the composition of the original raw materials. Pyrocondensates from heavy pyrolysis products, containing indene and naphthalene, enable the synthesis of phthalic anhydride based on them (Kodirov, O.Sh., Ziyadullaeva, K.Kh., 2020).

Table 2. *Qualitative and Quantitative Composition of Heavy Pyrolysis Resin Samples*

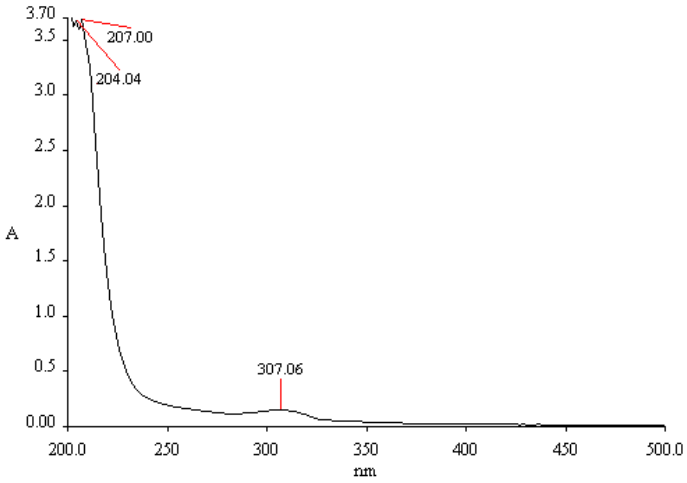
No.	Substance	Amount (%)	Degree of Correspondence	Retention Time (minutes)
1	Indene	9.33	93	12.30
2	1-Methylindene	8.96	96	14.72
3	Naphthalene	41.51	90	15.47
4	1-Methylnaphthalene	8.61	97	17.59
5	2-Methylnaphthalene	16.25	96	17.34
6	1-Ethylnaphthalene	1.77	90	18.78
7	1,6-Dimethylnaphthalene	1.71	95	19.18

The qualitative and quantitative composition of heavy pyrolysis resin samples was studied. The research was conducted using an Agilent 5977-A gas chromatograph equipped with a 30 m × 0.25 mm column, and the composition of the prepared sample was analyzed using gas chromatography-mass spectrometry (GC–MS). The results are presented in Table 2.

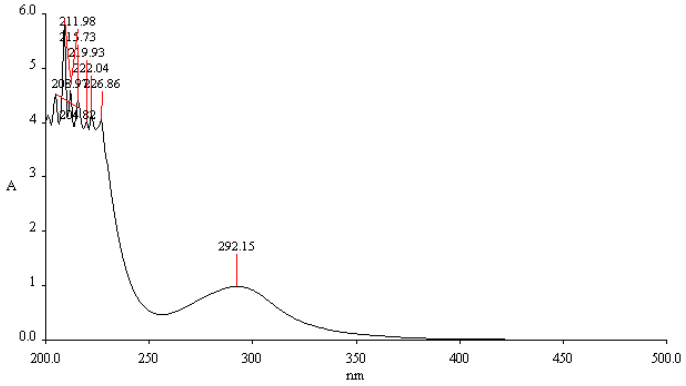
In the construction industry, superplasticizers are used to control the process and formation of structures, as well as the rheological properties of organic chemical additives — concentrated suspensions. This allows for targeted modifications of the flow properties of raw material mixtures and the properties of finished products.

Based on this, a superplasticizer was synthesized from naphthalene derived from secondary raw materials. The resulting hydrolyzed polyacrylonitrile, the synthesized superplasticizer, and the diluted superplasticizer were analyzed using UV spectroscopy (see Figure 1).

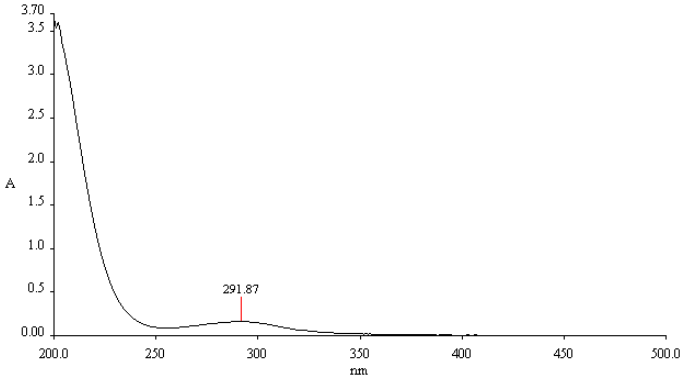
Figure 1.



A) Hydrolyzed Polyacrylonitrile



B) Synthesized Superplasticizer



C) Melted Superplasticizer

For the testing of superplasticizers, dry construction materials were selected: Portland cement grade PS400 D-20, gypsum, and cement with a high aluminum content. The influence of superplasticizers on the properties of these products was studied (see Table 3).

Table 3. *Test results for cement with synthesized superplasticizer*

No.	Mass of cement, g	Amount of additives by mass of cement, %	W/C (water-to-cement ratio)	Average density, g/cm³	Density after 28 days, MPa
1	100	–	0.31	2.065	25
2	100	0.05	0.30	2.05	25
3	100	0.2	0.29	2.142	27
4	100	0.5	0.28	2.12	28
5	100	0.8	0.27	2.15	30
6	100	1	0.27	2.192	31

Superplasticizers were added in an amount of up to 1% by weight of the binder. Adding superplasticizers in amounts greater than 1% generally led to a decrease in cement strength.

Table 4. *Results of Testing Cement Pastes with Synthesized Superplasticizer and High Aluminum Content*

No.	Mass of cement, g	Amount of additives by mass of cement, %	W/C (water-to-cement ratio)	Average density, g/cm³	Density after 28 days, MPa QMQ310–2003
1	100	–	0.43	6	37
2	100	0.02	0.43	6	38
3	100	0.2	0.43	7	42
4	100	0.5	0.43	8	45
5	100	0.8	0.43	11	50
6	100	1	0.43	13	54
7	100	1	0.39	6	66

The analysis of the obtained results shows that the addition of superplasticizer to the mix, while maintaining a constant water-to-cement ratio, increases the strength of the product, and the average density of cement particles rises with the increased amount of superplasticizer. This indicates the strength of the cement mixture and improvements in its performance characteristics.

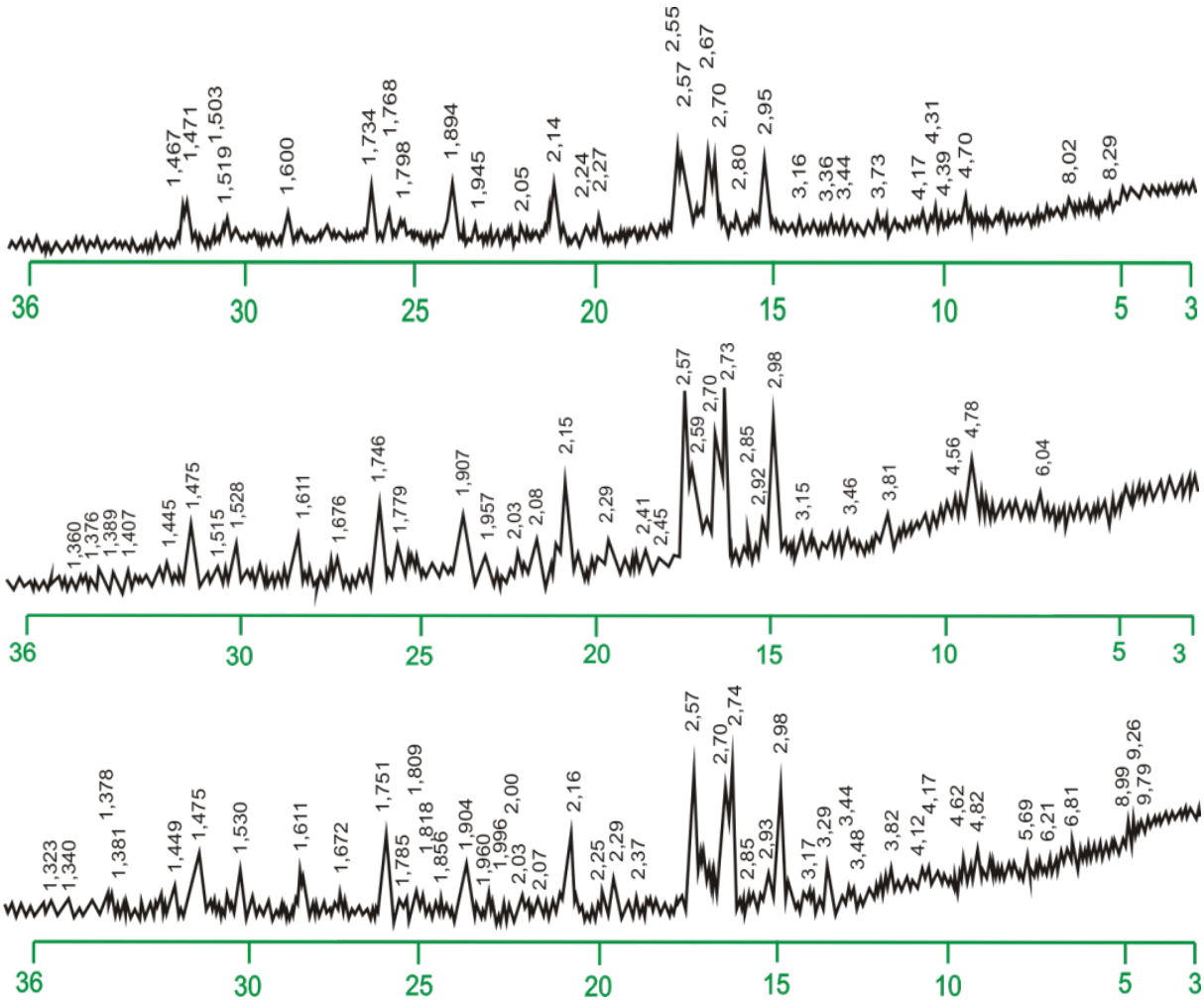
As seen in Table 4, the flowability of the cement with high aluminum content is 13 cm when a superplasticizer is added. Comparing these results with those of ordinary cement compositions showed an increase in plasticity. According to the literature, this is related to the high content of tricalcium aluminate. A study on the production of superplasticizers based on pyrocondensate-pyrolysis products was conducted, and cement mixtures with superplasticizers were investigated. Their results are presented in Table 5.

The analysis of the results revealed that a distinctive feature of the superplasticizer is that its use leads to normal setting of the cement mixture, resulting in the formation of a fine crystalline structure. Additionally, according to X-ray analysis of the binder samples, superplasticizers do not affect the composition of the hydrated phases on the surface of the cement.

Table 5. *Results of Testing Synthesized Superplasticizer and Gypsum Pastes*

No.	Mass of cement, g	Amount of additives by mass of cement, %	W/C (water-to-cement ratio)	Average density, g/cm³	Density after 28 days, MPa
1	100	–	0.5	8	11.6
2	100	0.03	0.5	8	16.1
3	100	0.2	0.5	9	15
4	100	0.5	0.5	10	13.3
5	100	0.8	0.5	11	12
6	100	1	0.5	13	11

Figure 1. *X-ray Spectrometer for Superplasticizers*



At the same time, the superplasticizer also exerts a moderate plasticizing effect. As the amount of superplasticizer increases, the density rises from 11.6 MPa to 16.1 MPa. Conversely, when the amount of additives relative to the mass of gypsum increases from 0.2% to 1%, the density of the mixture decreases from 15 MPa to 11 MPa.

Conclusions

The main content of the pyrolysis distillate consists of 67.18% arenes with carbon atom counts ranging from 6 to 12, and 23.7% olefins, allowing for the extraction of naphthalene and indene from the distillate. Naphthalene, indene, and their homologues were isolated from the heavy pyrolysis oils of

gas processing plants, leading to the development of plasticizers for concrete and cement.

Additionally, the influence of various catalyst compositions on superplasticizers during the extraction of indene and naphthalene from heavy pyrolysis products was investigated and analyzed. The chemical composition of the heavy pyrolysis distillate, as well as the qualitative and quantitative composition of the samples of heavy pyrolysis oils and the test results of cement with synthesized superplasticizer, were studied. The structure of the obtained substances and their physicochemical properties were confirmed using various methods.

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Contact: kamola ziyadullayev@mail.ru, safarov1968@rambler.ru, anvar_ziyadullayev@mail.ru, eshpulatovmuhammad018@gmail.com

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ON THE ISSUE OF RECHARGING THE BATTERY OF AN UNMANNED AERIAL VEHICLE

Rustamov Nasim Tulegenovich [1], ***Khusnutdinova Hamida Hafizovna*** [2], ***Babakhan Shokhrukh Abdilkasymuly*** [1], ***Pernebaev Kuanysh Orazbekuly*** [1]

[1] International Kazakh-Turkish University named after Khoja Ahmed Yasawi

[2] Tashkent State Transport University

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Abstract

This paper examines the issue related to recharging the battery of an unmanned aerial vehicle (UAV) in flight mode. By attaching a neodymium magnet with a propeller, a magnetic flux F is generated, which, crossing the coils of the coil wound on the beams of the unmanned aerial vehicle, generates an induction current. The work shows that it is with this induction current that it is possible to recharge the battery of an unmanned aerial vehicle.

Keywords: *Charging, magnet, propeller, magnetic flux, battery, induction current*

Introduction

UAV – is an abbreviation for “unmanned aerial vehicles”. These devices have been widely used by civilians relatively recently. They are used in many fields, including military, civilian and scientific. As is known, unmanned aerial vehicles are used to solve a wide range of civil and military tasks (monitoring, surveying and mapping the area for scientific or other purposes, delivery of mail and other goods, assistance in emergency situations) in various sectors of the economy (agriculture, construction, energy). The main advantage of an unmanned aerial vehicle is the significantly lower cost of their creation and operation.

The principle of operation of the drone is based on a combination of sensor systems, autopilot and software. Sensors such as cameras, radars, lidars and a navigation system collect information about the environment and the position of the device. This data is transmitted to the autopilot, which processes the information and makes decisions about the further movement and behavior of the drone, controlling the rotation of the engines and the deviation of the device from a given trajectory.

Today, the most vulnerable part of an unmanned aerial vehicle is recharging the battery in flight mode. The solution to this problem is relevant.

The aim of the work is to develop a system for recharging an unmanned aerial vehicle in flight mode.

The solution method. Today, there are many methods of charging the battery of an unmanned aerial vehicle (Zhukov D. R., Mikhailov V. A., 2024; Drone History Timeline From 1849, To 2019). Today, an unmanned aerial vehicle is a very practical and necessary device, but they have several main disadvantages: 1) fast battery discharge, 2) long charging, 3) constant human involvement when working with units. In the 21st century, humanity solved two out of three problems by creating a charging station for drones, and software for an unmanned aerial vehicle was written along with this. The high energy consumption of the engines of an unmanned aerial vehicle forces the use of batteries of rather large capacity, which most often have a lot of weight and do not allow you to spend a long time in flight. Thus, with an increase in the duration of flight missions, the use of a reliable and sufficiently distributed system of charging stations represents one of the main roles in ensuring autonomous operation of an unmanned aerial vehicle, the widespread use of unmanned aircraft is significantly limited by the need to charge batteries directly at the research facility, for which serial mobile power plants are used. In practice, there is an urgent problem of developing a reliable battery charging system for an unmanned aerial vehicle. Below is one of the possible solutions to this problem. The idea of the proposed method is as follows. A neodymium magnet is attached to the propellers of an unmanned aerial vehicle, preferably, under this magnet, an inductance coil is wrapped around the beams. When the propeller starts to rotate, a downward magnetic flux is generated. This flow, crossing the windings of the induction coil, creates an induction current I. This current is directed to the battery of the unmanned aerial vehicle (Rustamov N. T., Meirbekov A. T., Kibishev A. T.). In Fig. 1. A mock-up of the proposed battery charging system for an unmanned aerial vehicle is shown.

Figure 1. *A mock-up of an unmanned aerial vehicle that is being recharged.the charge from electromagnetic induction in coils*

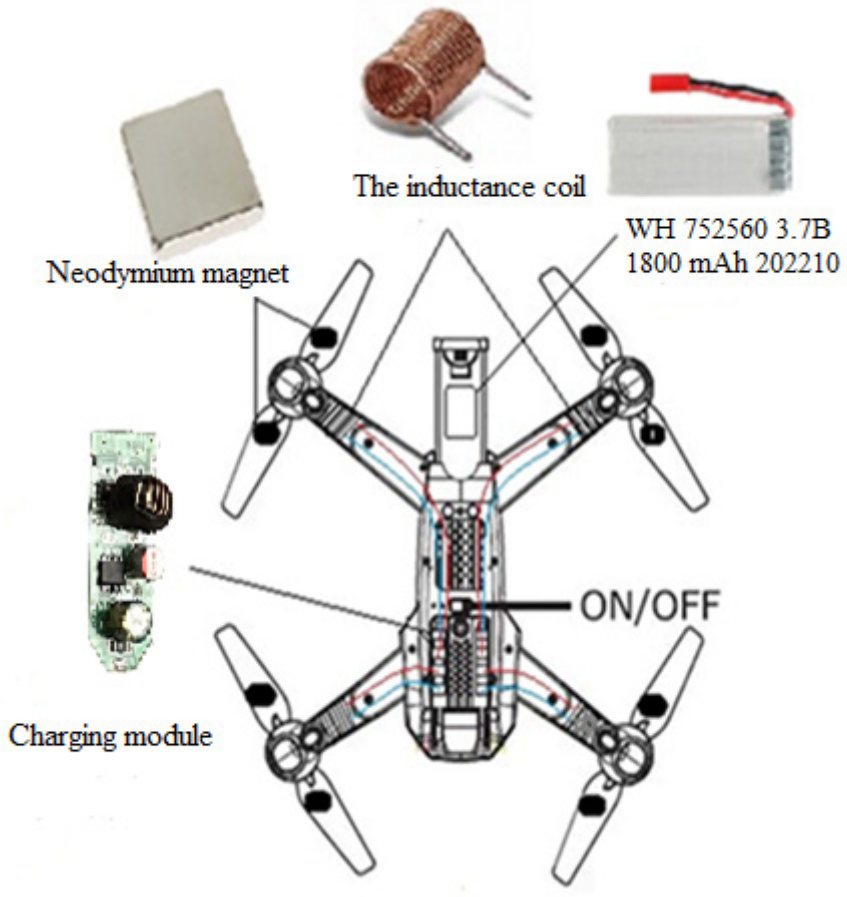


Figure 2. *Block diagram: additional power supply for recharging the drone's battery: 1–4 – motor generator; 5–8 – LED lamps; 9 – rechargeable battery; 10–13 – DC motors*

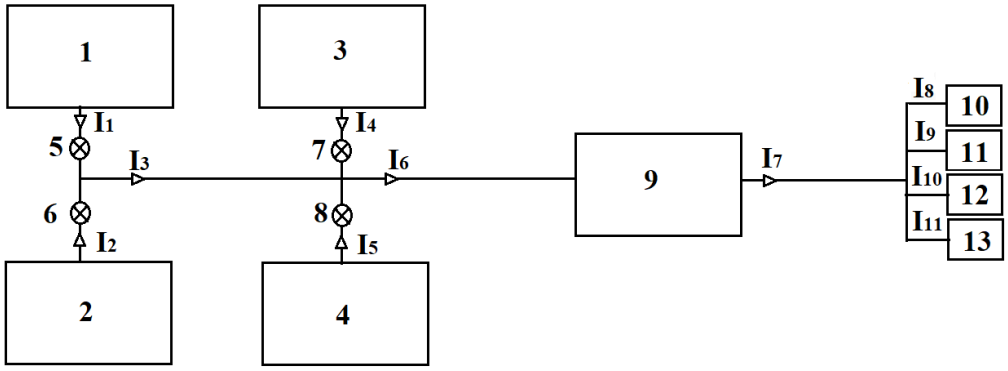
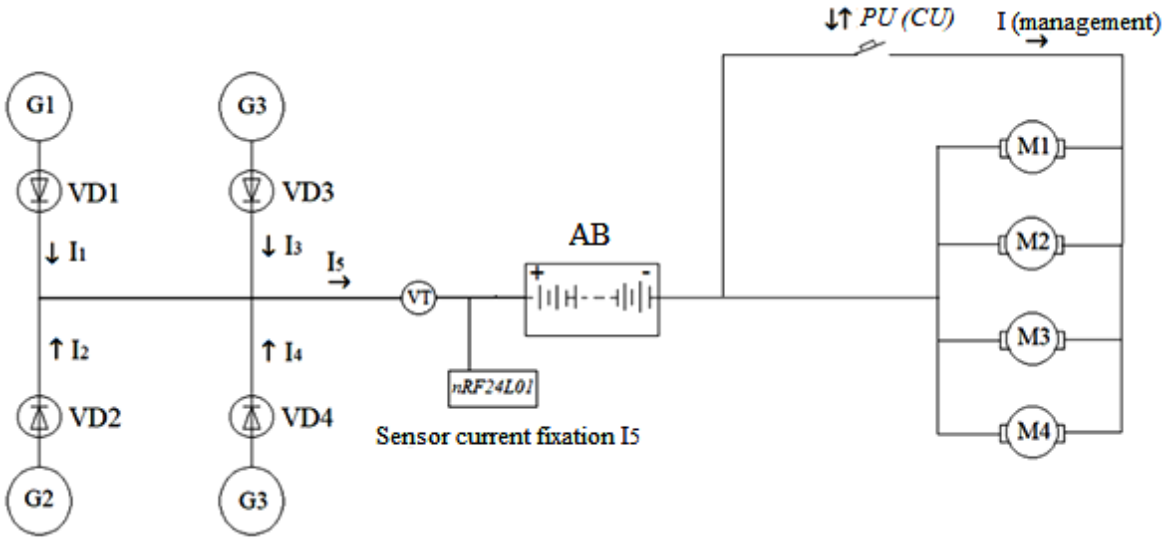


Figure 3. *Schematic diagram of the electrical circuit: The scheme of recharging the battery of an unmanned aerial vehicle; G1\G4 – engine generators (coil and neodymium magnet); VD1\VD4 – LED lamps; PU (CU) – engine control panel (key); SF – circuit breaker; AB – battery; M1\M4 – drone engines*



Initially, when the PU is turned on, after receiving a battery charge, high-speed M1\M4 DC drones begin to rotate. Due to the thrust, the air rises into space. Drone direction through the friction of air in the horizontal direction, the screws of the generators of the G1\G4 engine (coil and neodymium magnet) begin to rotate. They produce DC power and transfer it to the battery pack (AB). The battery begins to charge and constantly (continuously) transfers energy to the M1\M4 traction motors. Thus, receiving an additional charge from the generators of the G1\G4 unmanned battery in flight prolongs its operation. And the drone can fly longer and longer.

The transfer function of induction coils.

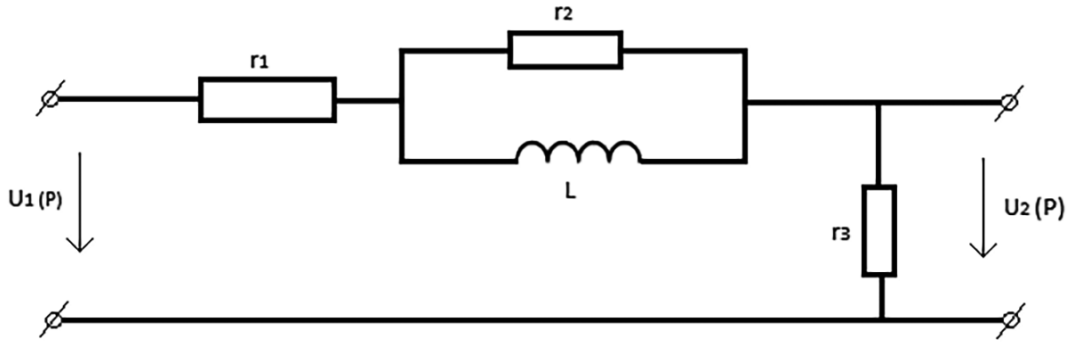
First, let's build a transfer function for one coil, since an unmanned aerial vehicle has four such coils, the transfer function of each coil is limited.

The procedure for constructing the transfer function of one induction coil will be shown by an example for the replacement shown in Fig. 4, for data:

$$r_1 = 1 Ohm, r_2 = 1 Ohm; r_3 = 2 Ohm; L = 3 H.$$

1. Here, the output valuey $= U_2(p)$ corresponds to the electrical energy of the generated coil, the input effect – $U_1(p)$ corresponds to the energy of the wind flow (Babakhan Shokhrukh, Kokanbay Yernar, Pernebaev Kuanysh. 2023).

Figure 4. *The replacement electrical circuit of the induction coil*



2. In this case, the equivalent resistance is: $Z_1(p)=r_1,\ Z_3(p)=r_3,\ Z_L(p)=pLZ_2(p)$ when the elements are connected in parallel:

$$\frac{1}{Z_2}=\frac{1}{r_2}+\frac{1}{pL}=\frac{r_2+pL}{r_2pL}=\frac{r_2pL}{r_2+pL} \quad (1)$$

Here $Z_{общ}(p)$ will be the resistance in the circuit, then $Z_1(p),Z_2(p),Z_3(p)$ we know:

$$Z_{общ}(p)=Z_1(p)+Z_2(p)+Z_3(p)=$$
$$=r_1+\frac{r_2pL}{r_2+pL}+r_3= \quad (2)$$
$$=\frac{r_1r_2+r_1pL+r_2pL+r_2r_3+r_3pL}{r_2+pL}$$

The current before branching according to Ohm's law is equal to:

$$I(p)=\frac{U_1(p)}{Z(p)}=$$
$$=U_1(p)\cdot\frac{r_2+pL}{r_1r_2+r_1pL+r_2pL+r_2r_3+r_3pL} \quad (3)$$

Then the voltage in the circuit will be equal to:

$$U_2(p)=I(p)\cdot Z_3(p)=U_1(p)\times$$
$$\times\frac{r_2+pL}{r_1r_2+r_1pL+r_2pL+r_2r_3+r_3pL}\times r_3= \quad (4)$$
$$=U_1(p)\cdot\frac{r_2r_3+r_3pL}{r_1r_2+r_1pL+r_2pL+r_2r_3+r_3pL}$$

3. Write down the final transfer function as the ratio of input to output and open the brackets in the denominator:

$$\frac{U_2(p)}{U_1(p)}=\frac{r_2r_3+r_3pL}{r_1r_2+r_1pL+r_2pL+r_2r_3+r_3pL} \quad (5)$$

$$\frac{U_2(p)}{U_1(p)}=\frac{r_2r_3\left(1+\frac{r_3pL}{r_2r_3}\right)}{r_2r_3\left(\frac{r_1r_2}{r_2r_3}+\frac{r_1pL}{r_2r_3}+\frac{r_2pL}{r_2r_3}+1+\frac{r_3pL}{r_2r_3}\right)} \quad (6)$$

$$\frac{U_2(p)}{U_1(p)}=\frac{1+\frac{pL}{r_2}}{\frac{r_1}{r_3}+\frac{r_1pL}{r_2r_3}+\frac{pL}{r_3}+1+\frac{pL}{r_2}} \quad (7)$$

We have found the ratio of the output voltage to the input voltage. We have fulfilled all the specified conditions. But we have one more point that needs to be taken into account, and it is necessary to switch to a constant time chain.

$$[\tau]=[\frac{Гн}{Ом}].\quad \frac{L}{r_2}=\tau_1,\quad \frac{L}{r_3}=\tau_2.$$
$$\frac{U_2(p)}{U_1(p)}=\frac{1+p\tau_1}{\frac{r_1}{r_3}+\frac{r_1}{r_2}p\tau_2+p\tau_2+1+p\tau_1} \quad (8)$$

4. Substituting numerical values, we get:

$$W(\kappa)=\frac{U_2(p)}{U_1(p)}=$$
$$=\frac{1+\frac{pL}{r_2}}{\frac{r_1}{r_3}+\frac{r_1pL}{r_2r_3}+\frac{pL}{r_3}+1+\frac{pL}{r_2}}=\frac{2+3p}{3+12p} \quad (9)$$

The image shown in Fig. 5 is a single module charging system for an unmanned aerial vehicle created in Matlab Simulink.

Figure 5. *The model of the induction coil in the Simulink application of the Matlab program*

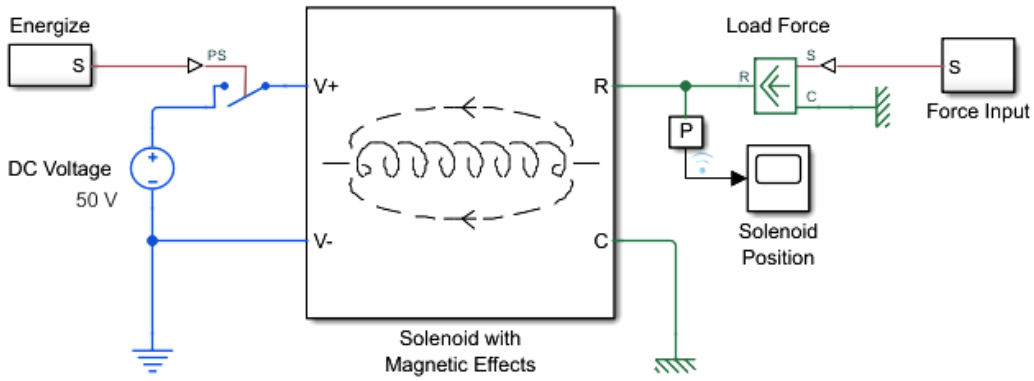
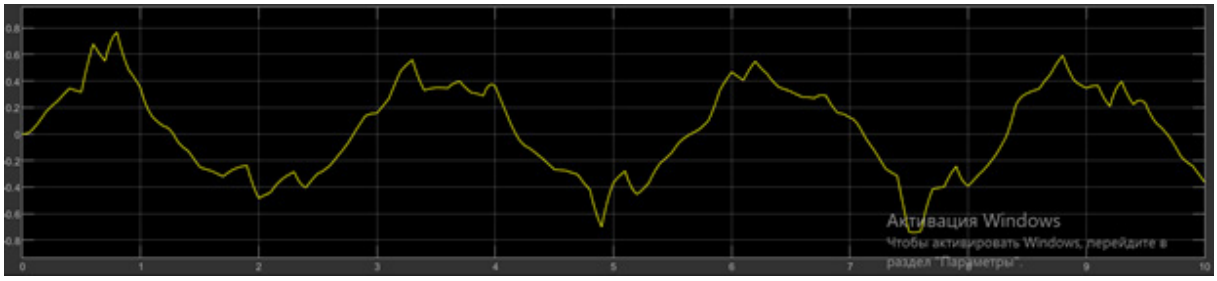


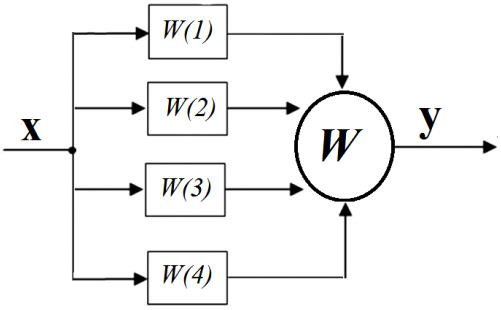
Figure 6 shows the production of an induction current of one coil

Figure 6. *Simulation results of the voltage at the output of the induction coil*



The transfer function of the accumulator battery charging system of an unmanned aerial vehicle is shown in Fig. 7:

Figure 7. *Transfer function of the battery charging system of an unmanned aerial vehicle*



From this scheme, you can write the transfer function of a magnetic coil mounted in an unmanned aerial vehicle.

$$W = W(1) + W(2) + W(3) + W(4) =$$

$$= \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} + \frac{2+3p}{3+12p} = \frac{8+12p}{3+12p}$$

$$W = \frac{12p+8}{12p+3} \qquad (10)$$

Thus, the mathematical model of the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program is shown in Fig. 8.

Figure 8. *Model of the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program*

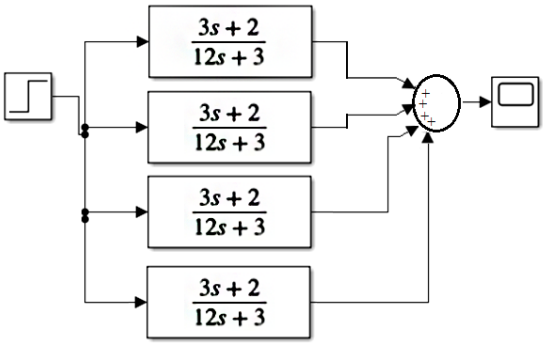
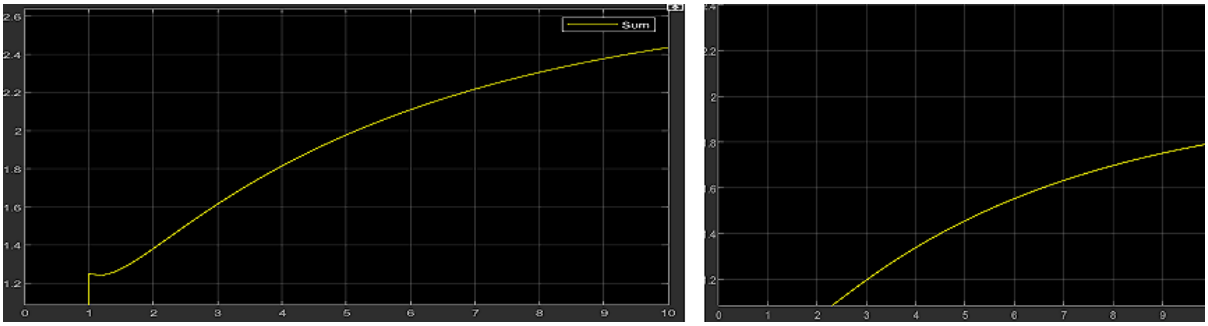


Figure 9 shows the output from the battery charging system of an unmanned aerial vehicle

Figure 9. *View of the output induction current from the battery charging system of an unmanned aerial vehicle in the Simulink application of the Matlab program*



Conclusions

The unmanned aerial vehicle is undergoing a period of active development, and its application is becoming more widespread and diverse. At the same time, there is a need to extend the flight mode of an unmanned aerial vehicle. On the other hand, this problem has become in demand today. The proposed method of recharging the battery of an unmanned aerial vehicle is one of the possible solutions to this problem, the advantage of the proposed method of recharging the accumulator battery is its prostate in design and efficiency in operation. The proposed method is patented (Patent of the Republic of Kazakhstan for invention No. 36987)

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© Rustamov N. T., Khusnutdinova H. H., Babakhan Sh. A., Pernebaev K. O.
Contact: babakhan.shokhrukh@ayu.edu.kz

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Section 4. Biology. Applied research

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BREED-SPECIFIC COAT CHARACTERISTICS IN DOGS AS A BASIS FOR SELECTING GROOMING TECHNIQUES AND ACCEPTABLE METHODS

Valeriia Sevriukova [1]

[1] Independent Researcher, Dubai, United Arab Emirates

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Abstract

This article examines the morphofunctional and breed-specific features of the canine coat that determine the choice of grooming techniques and methods. It analyzes the structure and growth of hair, differences in coat structure among individual breeds, and the main methods of professional coat care. Particular attention is given to the rationale for clipping, hand stripping, brushing, and other procedures according to coat type. The article considers criteria for deciding whether a grooming procedure is acceptable, potential risks of damage to the skin and coat, and factors that affect procedural safety. Drawing on the scientific literature and professional guidelines, it systematizes approaches to choosing grooming methods for the individual dog, with the aim of maintaining skin health, preserving coat structure, and safeguarding animal welfare.

Keywords: *dogs, breed characteristics, coat, hair morphology, coat structure, grooming, grooming techniques, hand stripping, clipping, coat care, grooming safety, animal welfare*

Background

Grooming techniques and methods should be chosen on a scientific basis that takes into account the breed-specific features of the canine coat. The coat provides protection and thermoregulation, and its length, density, structure, and growth pattern vary considerably among breeds. These features shape the care requirements of each dog and limit the use of one-size-fits-all grooming methods.

Research has shown that coat characteristics in dogs are largely determined by genetic factors (Shearin & Ostrander, 2010; Whitaker & Ostrander, 2019). At the same time, poorly chosen coat-handling methods can damage the hair and irritate the skin, whereas insufficient care contributes to matting and poorer skin condition. Clipping, brushing, removal of dead hair, and drying should therefore be chosen according to the morphological features of the coat and the condition of the individual animal.

The topic therefore calls for a systematic review of the evidence on breed-specific

coat features in dogs, criteria for deciding which grooming methods are acceptable, and well-grounded recommendations for their use. This work has practical value for maintaining healthy skin, a normal coat, and animal welfare.

Objective

This study aims to provide a scientific rationale for selecting grooming techniques and acceptable grooming methods for dogs on the basis of the morphofunctional and breed-specific features of the coat, while ensuring procedural safety and protecting the animal's health.

Materials and methods

The study drew on published research in veterinary dermatology and in the morphology and physiology of the canine coat, the breed standards of the Fédération Cynologique Internationale (FCI), and the recommendations of veterinary and kennel organizations.

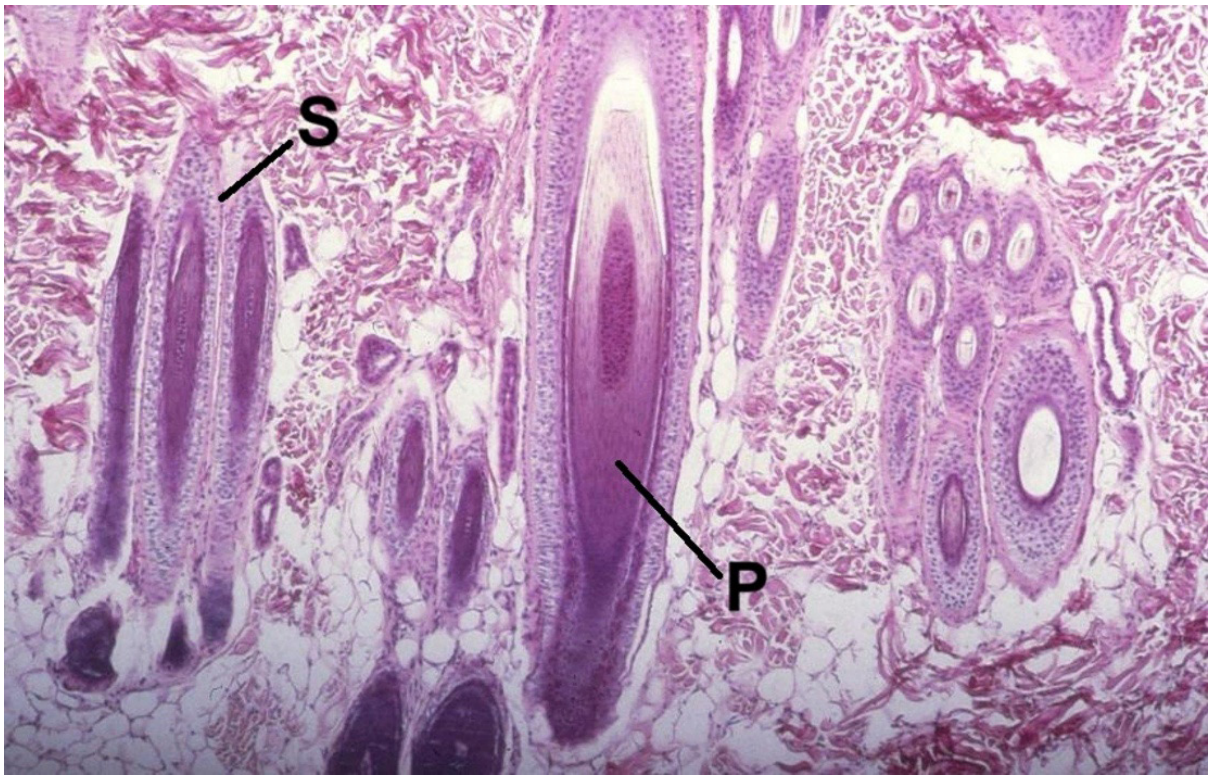
The methods included analysis and synthesis of the literature, comparative analysis, and classification and systematization of data. Coat features were compared with grooming techniques using the Siberian Husky, the Wire Fox Terrier, and the Poodle as examples. The conditions for applying individual procedures, their potential risks, and the criteria for their acceptability were examined.

Results

The canine coat consists of hairs that grow from hair follicles in the skin. Dogs have compound hair follicles, in which several hairs emerge through a common opening. These follicles contain larger primary hairs, which form the outer coat, and fine secondary hairs, which make up the undercoat. According to the Merck Veterinary Manual, a single primary hair in such a follicle may be surrounded by 3–15 secondary hairs (Moriello, 2018). The ratio between these hairs affects the density, volume, and appearance of the coat.

Figure 1 shows a compound hair follicle in a dog

Figure 1. Compound hair follicle in a dog: P, primary hairs; S, secondary hairs (Moriello, n.d.)



Each hair consists of a root, which lies within the follicle, and a shaft, which projects above the skin surface. The hair shaft comprises the cuticle, the cortex, and the medulla,

although the medulla is not present in every hair. The cuticle forms the outer layer, the cortex contains keratin structures and pigment, and the medulla, when present, occupies the center of the hair. Morphological differences in these structures are associated with the thickness, strength, and other physical properties of the coat (Roudebush & Schoenherr, 2010).

Hair grows in cycles comprising anagen (the active growth phase), catagen (the transitional phase), and telogen (the resting phase). The phases differ in duration, which depends on the individual animal. Coat renewal is also influenced by hormonal status, nutrition, season, and day length.

Breed differences are most evident in hair length and shape, coarseness, density, and how well developed the undercoat is. The official breed descriptions set out in breed standards can be used for comparison (Table 1).

Table 1. Coat characteristics of selected dog breeds

Breed	Coat characteristics	Structure and distribution of the coat
Siberian Husky	The coat is double and medium in length, consisting of straight guard hairs and a soft, dense undercoat. The guard hairs lie flat against the body and are not excessively harsh. The coat is short enough to preserve the natural outline of the body.	The undercoat is long enough to support the guard hairs. Seasonal shedding is typical, and the undercoat may be temporarily absent during this period. The hair between the toes and around the feet differs from the body coat in placement and length.
Wire Fox Terrier	The coat is dense and very wiry, lying close to the body. The undercoat consists of shorter, softer hairs. The guard hairs are distinctly harsh and vary in length over different parts of the body.	The coat is about 2 cm long on the shoulders and up to 4 cm on the withers, back, ribs, and hindquarters. The coat on the back and hindquarters is harsher than on the sides. The hair on the jaws is fairly long and harsh; on the legs it is dense and crisp.
Poodle	The coat is dense and profuse, with fine hairs of a characteristic curly texture. There are two coat varieties: curly and corded. The curly coat is springy and dense and forms even curls.	The curly coat is uniform in length and holds its curls well. The corded variety consists of dense, fine-textured hair that forms distinct cords. Cords must be at least 20 cm long.

Source: American Fox Terrier Club, 1991; Fédération Cynologique Internationale, 2022, 2024.

Breed-specific features also appear in how the coat is distributed over the body. In the Wire Fox Terrier, the hair on the back and hindquarters is harsher than on the sides. In the Siberian Husky, the undercoat may be temporarily absent during seasonal shedding; the breed standard allows for this, and it is not in itself regarded as a fault. The Poodle standard describes two coat forms: curly, which forms even curls, and corded, which forms characteristic cords. These differences show that coat organization can vary even within a single breed.

The choice of grooming technique depends primarily on how the coat grows and renews itself, how prone it is to matting, and whether its natural structure needs to be preserved. For dogs with continuously growing coats, regular brushing and periodic clipping are important for keeping the coat at an optimal length and preventing mats. In breeds with pronounced seasonal shedding, the focus is on removing dead undercoat in good time while keeping the guard hairs intact and protective.

Table 2 summarizes how grooming techniques are chosen according to coat type.

Table 2. Grooming techniques by coat type

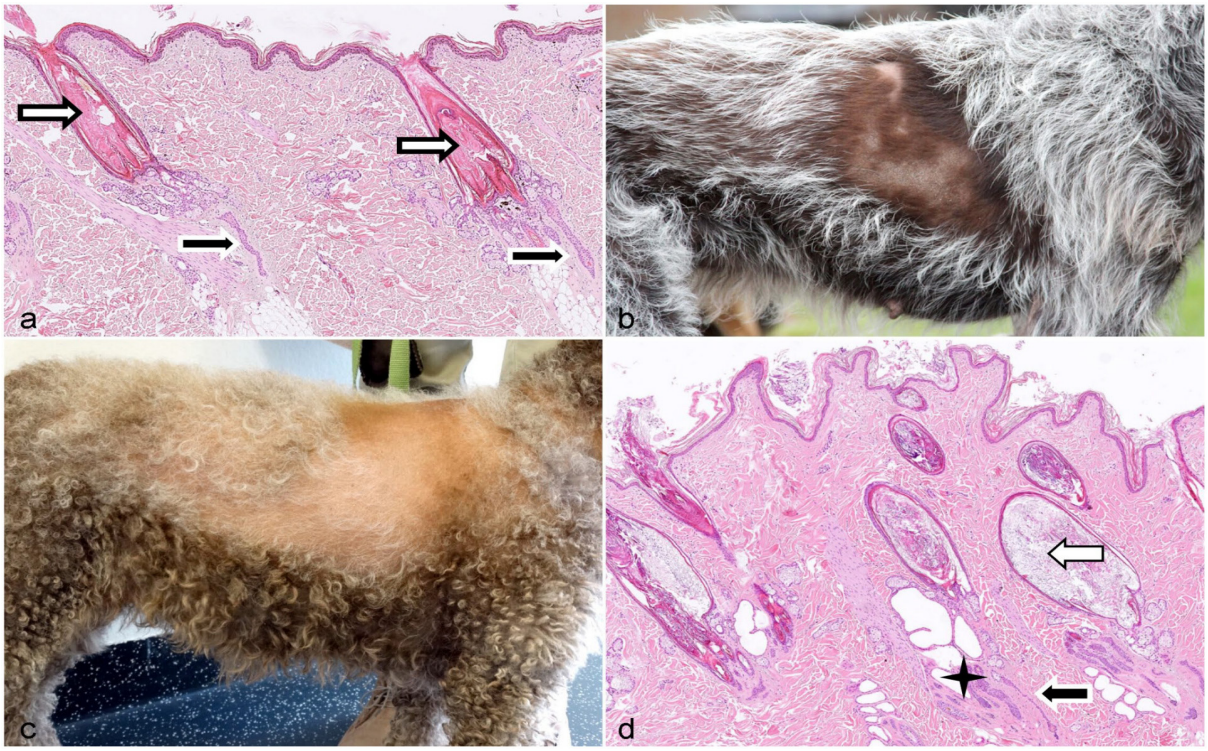
Breed	Main techniques and tools	Application notes
Siberian Husky	Brushing out with a metal-toothed brush and a comb; removal of shed undercoat	More intensive brushing during shedding; guard hairs are preserved; routine clipping of the body is not needed
Wire Fox Terrier	Hand stripping, stripping knife, comb; clipper for a pet trim	Ripe hairs are removed in the direction of growth; hand stripping is chosen when the show texture of the coat must be preserved
Poodle	Slicker brush, metal comb, clipper, straight and thinning shears	Thorough brushing down to the base of the hair; periodic clipping; coat length chosen according to whether regular maintenance is feasible

Source: compiled from AKC recommendations (American Kennel Club, n.d.-a, n.d.-b; Kearl, n.d.).

Regardless of breed, the order of procedures should take into account the condition of the coat before bathing. Veterinary professionals recommend dealing with tangles beforehand, because mats can be harder to work out once wet. Small mats may be carefully teased apart with a comb, whereas dense mats require a clipper or professional help. Using scissors close to the skin increases the risk of accidental cuts.

Whether a grooming procedure is acceptable depends on the condition of the animal's skin, the nature of the intended procedure, and whether it can be performed without injury or marked stress. Before starting, the skin should be examined for redness, scratches, crusts, wounds, and other abnormalities. Any suspicious changes warrant a veterinary consultation, because grooming is no substitute for the diagnosis and treatment of skin disease.

Figure 2. Example of uneven coat regrowth after clipping (Welle, 2023)



Mechanical injury can result from excessive pulling on the hair, the use of sharp tools, and contact between the skin and hot clipper blades. Grooming products that are not completely rinsed out pose an additional hazard, as they can cause local irritation. Equipment should therefore be checked, sensitive areas handled with care, and cosmetic products rinsed out thoroughly (Dunn, 2011).

Delayed coat regrowth after short clipping deserves particular attention (Welle, 2023). Post-clipping alopecia is a condition in which hair regrowth is delayed after the coat has been clipped (Figure 2). Such cases are reported more often in dogs with a dense undercoat, including Siberian Huskies. However, the mechanism of this condition has not been fully established, and clipping does not always disrupt hair growth.

Safety assessment should also take into account how dogs respond behaviorally. Ferreira et al. (2022) analyzed 55 grooming sessions. The most noticeable changes in the animals' behavior and physiological parameters occurred on arrival at the salon and during drying. These findings indicate that the dog's reactions to equipment noise, restraint, and the length of the procedure need to be monitored.

Table 3 lists the criteria for the acceptability of grooming procedures and the associated risks.

Table 3. Criteria for the acceptability of grooming procedures and associated risks

Assessment criterion	Potential risk	Condition for acceptability
Skin condition	Irritation and aggravation of existing lesions	Examination before the procedure; referral to a veterinarian if disease is suspected
Mechanical action	Abrasions, cuts, hair damage	Well-maintained tools; no excessive pressure or pulling
Equipment temperature	Overheating and local skin injury	Monitoring the temperature of cutting blades and exposure to hot air
Use of cosmetic products	Skin irritation from incomplete rinsing	Use of products as directed; thorough rinsing
Short clipping	Possible delayed coat regrowth	Consideration of breed predisposition and whether the procedure is justified
Behavioral response	Stress, resistance, risk of injury	Monitoring the animal; breaks or stopping the procedure if the dog is markedly distressed

Source: compiled from Ferreira et al. (2022).

In practice, grooming methods should be chosen on the basis of a comprehensive assessment of the animal's condition, its coat type, and the purpose of the procedure. An individual care plan should take into account the dog's age, coat condition, living conditions, tolerance of procedures, and whether regular grooming at home is feasible.

Puppies should be gradually accustomed to being touched, brushed, and handled with grooming equipment. In older dogs, general physical condition, mobility, and the ability to hold a position for a long time need to be considered. Dogs with limited mobility require particular attention, because prolonged restraint may cause them discomfort.

The frequency and scope of grooming should be determined individually, taking into account how quickly the coat gets dirty, its tendency to mat, the intensity of shedding, and the dog's living conditions. If the owner cannot brush a long coat regularly, a simpler care routine suited to the particular dog is advisable. When dense mats are present, the

priority is to remove them safely rather than to preserve the original coat length.

Grooming must also take the animal's behavior into account. If the dog is markedly anxious, individual procedures should be shortened, breaks provided, and excessive restraint avoided. Restraint methods should keep both the dog and the groomer safe.

To make grooming more effective, the outcome of each session should be recorded, noting coat condition, any matted areas, the animal's response, and any difficulties encountered. Comparing these records over subsequent visits makes it possible to adjust the frequency and content of grooming to the dog's individual needs.

A differentiated choice of grooming methods thus involves an individual care plan that accounts not only for breed but also for the animal's age, health, behavior, and living conditions. The main criterion of the plan's effectiveness is keeping the skin and coat in good condition with minimal risk of discomfort or injury.

Conclusions

The analysis showed that breed-specific coat features are of considerable importance in choosing grooming techniques and methods for dogs. Differences in hair structure, density, length, and growth pattern call for a differentiated approach to coat care. The findings indicate that the choice of procedures should be determined not only by breed but also by the condition of the skin and coat, the dog's age and individual characteristics, and how well it tolerates handling. Applying grooming methods without regard to these factors increases the risk of damage to the skin and coat. Professional grooming should therefore be based on a prior assessment of the animal, a reasoned selection of procedures, and adherence to safety requirements. This approach helps preserve the natural properties of the coat, prevent adverse effects of grooming, and maintain the welfare of dogs.

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© Sevriukova, V.
Contact: valeria.vishn@icloud.com

Contents

Section 1. Biology

Guliyev Mahir, Guliyeva Nigar, Huseynova Shahla, Israfilova Sabina
DETERMINATION OF THE EFFECTIVE DOSE OF "SUMAKH FRUIT EXTRACT" IN CORRECTING THE GENOTOXICITY OF CHEMICALS IN AN ARTIFICIALLY INDUCED MUTATION PROCESS. 3

Section 2. Chemistry

G. T. Daniyarov, T. Mukhamedjanov, A. Sh. Huseinov, Kh. I. Kadirov
SYNTHESIS AND PROPERTIES OF DETERGENT REAGENT FOR CLEANING FROM ACCUMULATED MINERAL SALTS. 6

Sh. B. Obidov, X. I. Kadirov, X. N. Raximov, S. M. Turabdjano, F. I. Xolmatova
OBTAINING CORROSION INHIBITORS IN THE PRESENCE OF OXYETHYLIDENE DIPHOSPHONIC ACIDS 14

Sultonov Shavkat Abdullayevich, Narkulov Dilshod Axmatovich
THE INFLUENCE OF THE SUSPENSION SOLUTION (PULP) ENVIRONMENT ON THE SORBENT'S SORBENT SORBENCE 22

Safarov Toyir Tursunovich, Ziyadullaeva Kamola Xaitboevna, Ziyadullaev Anvar Egamberdievich, Eshpulatov Mukhammadi
PRODUCTION OF SUPERPLASTICIZERS BASED ON THE PYROLYSIS PRODUCTS OF HEAVY RESINS. 28

Section 3. Electrical engineering

Rustamov Nasim Tulegenovich, Khusnutdinova Hamida Hafizovna, Babakhan Shokhrukh Abdilkasymuly, Pernebaev Kuanysh Orazbekuly
ON THE ISSUE OF RECHARGING THE BATTERY OF AN UNMANNED AERIAL VEHICLE. 35

Section 4. Biology. Applied research

Valeriia Sevriukova
BREED-SPECIFIC COAT CHARACTERISTICS IN DOGS AS A BASIS FOR SELECTING GROOMING TECHNIQUES AND ACCEPTABLE METHODS 41