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DOI: doi.org/10.18372/38210
UDC: 502.175:[662.6/.9:629.7(045)

3.3 ANALYSIS OF THE ENVIRONMENTAL PROPERTIES OF THE COMPONENTS OF TRADITIONAL AND ALTERNATIVE AVIATION GASOLINE

Sergii Boichenko, Iryna Shkilniuk, Lesia Pavliukh, Kateryna Babikova, Anna Iakovlieva, Roza Vinetskaya

Millions of years under the Earth's surface, oil, did not cause toxic effects on the environment, but people removed it from the bowels of the earth and intensively use for their purposes [1]. Oil, with benefits to person, raises the question the existence not only of people, but every living thing on Earth [2].

The toxicity of petroleum products and gases emitted is determined mainly by the hydrocarbons that are part of their composition. Heavy oil is more toxic than light, and the mixture of hydrocarbons is more toxic through separate components. Significantly increases the toxicity of petroleum products during the processing of sulfuric oil. The most harmful to the human body is the combination of hydrocarbons and hydrogen sulfide, the central nervous system and the brain are attacked.

High regulations on the ecological quality of fuel and lubricants require effective and informative methods for their evaluation. Nowadays, the most environmentally hazardous bioactive polycyclic arenes (PA) – a group of compounds with fused benzene rings. The most carcinogenic include the highest number of PA rings from 4 to 7. These compounds are damaging the immune system of humans and animals, can cause infertility (mostly men), cancer and other serious diseases [3]. Investigated and obvious facts of products' toxicity of oil refining, make it necessary to further study the toxicity of gasoline components.

The purposeof this article is analysis of the environmental properties of components of traditional and alternative aviation gasoline.

Object: background of the optimal component composition of gasoline in the context of their environmental characteristics.

Subject: component composition of traditional and alternative aviation gasoline.

Chemicals have the most hazardous impact on the environment. This include gaseous and aerosol pollutants of municipal origin. It also has negative effect on the atmosphere of carbon dioxide accumulation, the amount of which, unfortunately, moreover increase. This could lead increasing of annual average temperature on Earth in the near future. Pollution of the oceans continue with oil and its derivatives, which covered already 1/5 of the entire surface of the ocean. Such a situation may cause a gas and water exchange disruption between the atmosphere and the hydrosphere. Soil pollution by pesticides and excess of acidity can lead to collapse of ecosystem. All these processes can cause negative changes in the biosphere [4].

The main raw material for gasoline is oil. It is combustible minerals, a complex mixture of hydrocarbons of various classes with a small amount of organic, oxygen, sulfur and nitrogen compounds, which is thick oily liquid [4]. Component (chemical) composition of gasoline – a set of elements from which this kind of gasoline is formed.

Modern aviation gasoline is prepared by compounding of various components, the quality and content of which depends on the brand of gasoline and on the general balance of petroleum products produced at the plant. In industry, the most commonly used are butane-butylene fraction (90 % of *n*-butane, 2–4 % of isobutane and 5–8 % of pentane), technical isopentane (2-methylbutane) and various gas gaselines [5].

There are more than 1000 individual organic substances in the oil content, with different toxicity [6].

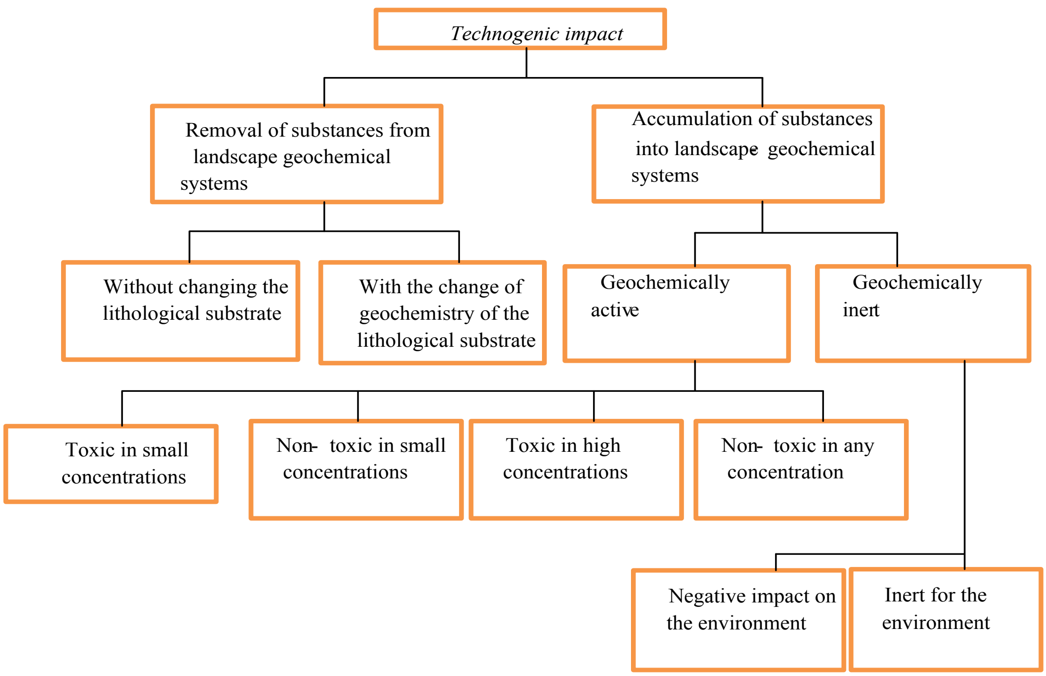


Fig. 1. Scheme of technogenic impact on the biosphere

Toxicity of petroleum products is determined by their hydrocarbon composition. Typically, the high-molcule-weight components are more toxic than low-molecule-weight, and the toxicity of a mixture of hydrocarbons is higher than the toxicity of its individual components. Most carcinogenic hydrocarbons are capable for bioaccumulation. Getting into the soil, the toxic components of oil can turn into even more toxic compounds, adsorb, concentrate and fall into the trophic chains, and get toxins into human body [7].

Light hydrocarbons have a local irritant effect, expressed neurotropic nature. Liquid carbohydrates with a number of hydrocarbon atoms from 5 to 16 have a narcotic and irritant effect, can cause prolonged excitation of the nervous system. When it exposed to the skin, oil causes dermatitis and eczema. All hydrocarbons have an effect on the cardiovascular system and on blood indices (lowering of hemoglobin and erythrocytes), as well as possible damage to the liver, disruption of the activity of the endocrine glands. Recognized carcinogenic action of a number of hydrocarbons [8].

One of the ways of getting gasoline is direct oil distillation [9].

In order to obtain high-quality gasoline, secondary (destructive) distillation of oil is carried out.

The main methods of destructive oil refining and the production of high-quality gasoline are:

– thermal cracking – processing of raw materials at temperatures of 450–500 °C and pressure of 2–5 MPa;

– catalytic cracking – flows at temperatures of 470–530 °C and a pressure of 70–370 MPa in the presence of a catalyst to produce the desired hydrocarbons;

– catalytic reforming is a process of upgrading low-quality gasoline by its catalytic processing under hydrogen pressure in the presence of a catalyst. As a result of catalytic reform, the high octane components of automotive gasoline are released;

– hydrocracking is a catalytic processing of petroleum fractions and residual products of distillation of oil (fuel oil, sludge) under hydrogen pressure to produce gasoline. The hydrocracking proceeds at a temperature of 260–450 °C and a pressure of 5–20 MPa in presence of catalysts;

– hydro-purification is carried out to improve the quality and stability of light distillates at a temperature of 250–420 °C and a pressure of 2–5 MPa in the presence of catalysts.

There are special cases when other hydrocarbon raw materials are used to produce gasoline. Possible flashing off gasoline fractions from semi-coking and coking resins (utilization of heavy residues of cracking in order to produce a distillate of a wide fractional composition) with additional purification. Gasolines are formed from synthesis-gas (coal gasification product, methane conversion) with the help of syntin-process method (Fischer-Tropsch synthesis).

Synthesis is used to produce individual hydrocarbons that have high anti-knock properties and are used as an additive to gasoline. The process is carried out in the presence of catalysts.

In gasoline, depending on the hydrocarbon composition of the raw materials and production technology, there can be more than 200 individual hydrocarbons of different structures [10].

Aviation fuels are middle-distilate oil fractions. They contain hydrocarbons of various classes, heteroatomic compounds and inorganic impurities.

Table 1

Basic classes of hydrocarbons that are part of aviation gasoline [11]

Class of hydrocarbons	Mass fraction of hydrocarbons, %
Alkanes (normal and isometric ctructure)	10–40
Cycloalkanes	20–60
Arenes	20–22

Table 1 continue

Class of hydrocarbons	Mass fraction of hydrocarbons, %
Monocyclic arenes	3–25
Bicyclic arenes	1–5

The most important properties of individual hydrocarbons, which determine their presence in the composition and the impact on the quality of gasoline, are boiling temperature and detonation stability (octane number). These properties, as well as density, maximum allowable concentrations (MAC), hazard class and flash temperature of some individual hydrocarbons of all classes that may be part of the gasoline components are presented in Table 2.

Environmental properties – combination of properties of fuel and lubricants appearing during interaction of the product with the environment and have a negative impact, namely during contact with the means of mechanization in conditions of storage, transportation, transfer and filtration, in contact with man, atmosphere, water, animal and plant world. Environmental characteristics (indicators) include toxicity, carcinogenic, fire hazard and explosion hazard, stability of product quality during storage, transportation, concentration of harmful substances in the exhaust gases of engines, MAC of harmful substances in the working area, the ability of the product to affect environmental pollution.

Flesh point is called the temperature to which it is necessary to heat the fuel, so that its vapor forms an explosive mixture with the air, flaring up when it is exposed to an open flame. The flash point, which is determined in a closed crucible, to some extent characterizes the degree of fuel fire hazard [10, 12]. Coefficient indicating the minimal temperature of a combustible substance, in which, under conditions of testing, a mixture of vapor or gases with air that can ignite in the air from the ignition source, but the velocity of their formation is still insufficient for subsequent combustion (in °C) is formed over its surface.

Table 2

Boiling temperature, octane number, density, maximum allowable concentrations, class of hazard and flash point of individual hydrocarbons that are in gasoline

Hydrocarbon	Hydrocarbon molecular structure	Boiling temperature °C [4,8]	Octane number		Density at a temperature of 20 °C, kg/m, [4, 8]	Maximum allowable concentrations, mg/m^3	Class of hazard	Flash point, °C
			Research method [1]	Motor method[2,3]				
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Paraffinic hydrocarbons								
Propane	C—C—C	-42	107,5	110	газ	200	-	472 (t of self ignition)
n-Butane	C—C—C—C	-0,6	93,6	92	600 (0 °C)	300	4	405 (t of self ignition)

Table 2 continue

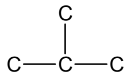
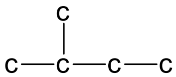
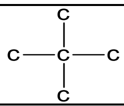
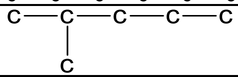
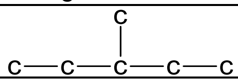
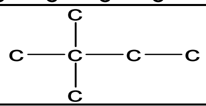
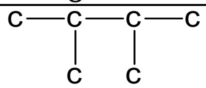
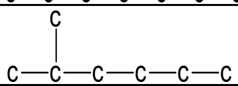
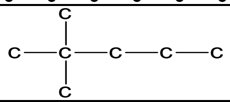
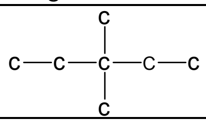
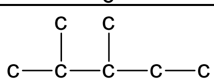
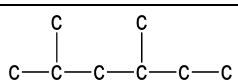
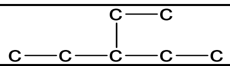
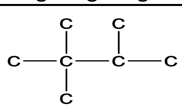
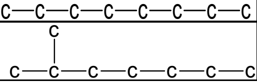
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2-Methylpropan (isobutane)		-11,7	101,1	99	600 (0 °C)	NA *	Com-bustion gas	
n-pentane	C—C—C—C—C	36	61,7	61	626	217	4	-49
2-Methylbutane (i-pentane)		28	92,3	89	620	NA *		<-51
2,2-Dimethylprop ane		9,5	85,5	83	591	NA *		Non use
n-Hexane	C—C—C—C—C—C	63,7	24,8	25	659	60	4	-22
2-Methylpentane		60,3	73,4	73	660	NA *		-32
3-Methylpentane		63,3	74,5	75	664	NA *		-6
2,2–Dimethylbutane (neohexane)		49,7	91,8	96	649	0,02	3	-21,6
2,3–Dimethylbutane (diisopropyl)		58,7	101,7	95	662	0,07	3	-29
n-Heptane	C—C—C—C—C—C—C	98,4	0	0	684	200	4	-4
2–Methylhexane		90,1	42,4	45	678	NA *		-18
2,2-Dimethylpent ane		79,2	92,8	94	674	0,06	2	-
3,3-Dimethylpen-tane		86,1	80,8	86	693	0,04	2	-
2,3-Dimethylpen-tane		89,1	91,1	89	695	0,00 8	1	-
2,4-Dimethylpen-tane		89,7	83,1	82	673	NA *		-
3-Ethylpentane		93,5	65,0	69	698	3	3	-32
2,2,3–Trimethyl-butane (triptane)		80,9	105,7	101	690	NA *		-
n-Octane	C—C—C—C—C—C—C—C	125,7	<0	-22	702	10	3	13
2-Methyl-heptane		117,6	21,7	24	698	NA *		-32

Table 2 continue

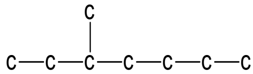
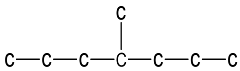
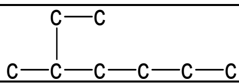
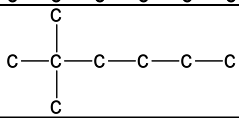
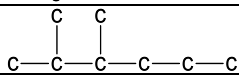
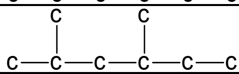
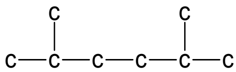
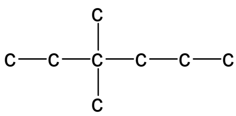
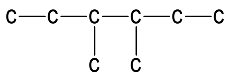
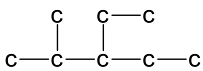
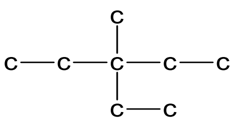
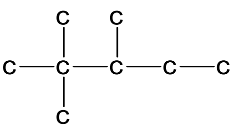
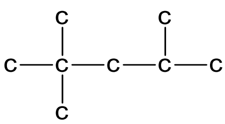
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
3-Methylheptane		118,9	26,8	35	706	NA *		<-20
4-Methylheptane		117,7	26,7	39	705	NA *		-
3-Ethylhexane		118,5	32,5	52	714	NA *		136
2,2-Dimethylhexane		106,8	72,5	77	695	NA *		-
2,3-Dimethylhexane		113,9	71,3	78	712	NA *		-
2,4-Dimethylhexane		117,7	65,2	70	719	NA *		22
2,5-Dimethylhexane		109,1	55,5	54	694	NA *		26
3,3-Dimethylhexane		112,0	75,5	83	710	NA *		-
3,4-Dimethylhexane		117,7	76,3	85	719	NA *		31, 6
2–Methyl–3-ethylpentane		115,6	87,3	88	719	NA *		-
3–Methyl–3-ethylpentane		118,3	80,8	90	727	NA *		
2,2,3-Trimethylpentane		109,8	104,5	101	716	NA *		
2,2,4–Trimethylpentane (isooctane)		99,3	100,0	100	692	NA *		

Table 2 continue

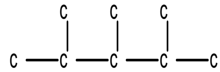
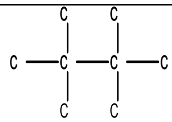
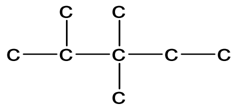
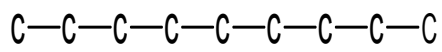
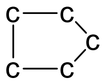
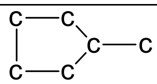
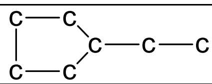
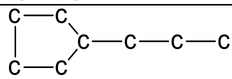
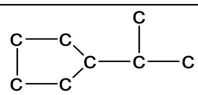
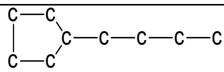
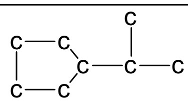
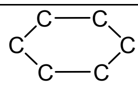
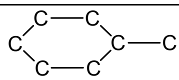
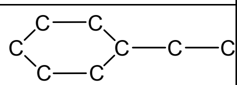
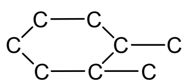
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2,3,4-Trimepentane		113,5	101,3	96	719	NA *		
2,2,3,3-Tetramethyl-butane		106,3	103	-	-	NA *		
2,3,3-Trimethyl-pentane		114,8	102,9	99	726	NA *		
n-Nonane		150,8	-	36	718	NA *		
Cyclopentane		49,3	-	84	744	0,1		-
Methylcyclo-pentane		71,8	91,3	81	728	NA *		
Ethylcyclo-pentane		103,5	67,2	62	766	NA *		
n-Propylcyclo-pentane		130,9	31,2	28	776	NA *		
Isopropyl-cyclopentane		126,4	-	76	776	NA *		
n-Butylcyclo-pentane		156,6	0	-1	785	NA *		-
Isobutylcyclo-pentane		154,4	33,4	28	-	NA *		-
Cyclohexane		81,4	83,0	77	718	100		-
Methylcyclo-hexane		100,9	74,8	71	769	3,9-1,8		-18
Ethylcyclo-hexane		131,8	46,5	41	788	NA *	-	-6
Cys-1,2-Dimethylcyclo-hexane trans-		129,7 123,4	80,9	79 79	796 776	NA *		-

Table 2 continue

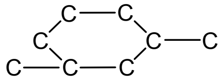
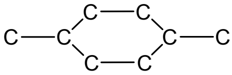
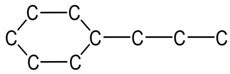
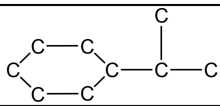
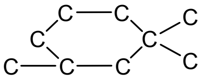
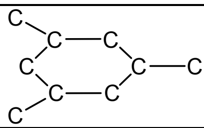
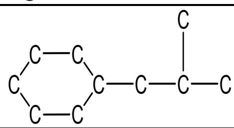
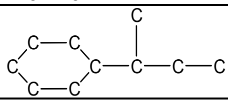
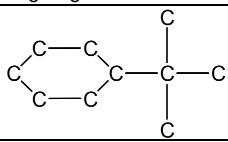
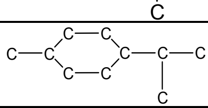
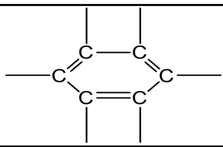
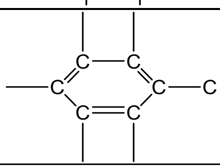
1	2	3	4	5	6	7	8	9
Cys-1,3-Dimethyl-cyclohexane trans-		120,1	69,3	71 64	766	NA *		9,4
Cys-1,4-Dimethyl-cyclohexane trans-		124,3	67,8	68 62	783	NA *		15,6
n-Propylcyclo-hexane		156,7	17,8	14	794	NA *		-
Isopropyl-cyclohexane		154,6	62,8	61	790	NA *		-
1,1,3–Trimethyl-cyclohexane		136,6	81,3	83	779	NA *		25,2
1,3,5–Trimethyl-cyclohexane		140,2	-	-	773	NA *		18,6
Isobutyl-cyclohexane		171,3	33,7	35	813	NA *		-
sec-Butyl cyclohexane		179,3	51,0	60	795	NA *		-
Tert-Butyl cyclohexane		171,6	98,5	91	810	NA *		40
1-Methyl 4-isopropyl cyclohexane		-	67,3	66	-	NA *		-
Aromatic hydrocarbons								
Benzol		80,1	113,0	108	879	15	2	-11
Toluene		110,6	115,7	102	867	50	3	4

Table 2 continue

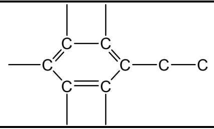
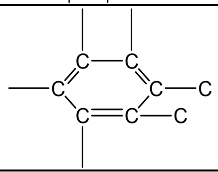
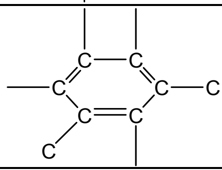
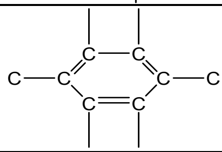
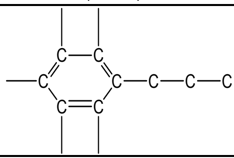
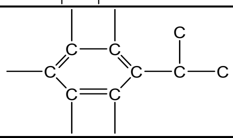
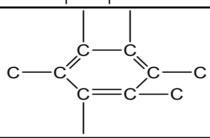
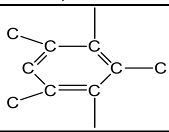
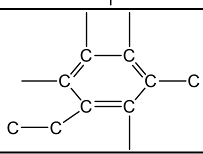
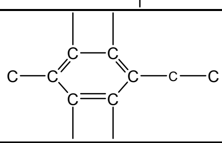
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Ethylbenzol		135,2	103,6	98	867	NA *		18
o-Xylol		144,4	-	100	880	NA *		32
m-Xylol		139,0	-	100	864	NA *		27
p-Xylol		138,3	-	100	861	NA *		27
n-Propylbenzene		159,0	105,1	99	862	Unidentified	-	23-60
Isopropylbenzene (Cumene)		152,4	108,0	99	862	0,014	4	31
1,2,4-Trimethyl-benzene		176,1	-	98	894	NA *		48
1,3,5,Trimethyl-benzene		164,7	-	114	865	NA *		50
1,3-Methyl-benzene		161,3	-	100	864	NA *		-
1,4,-Methyl-benzene		162,0	-	97	861	NA *		-

Table 2 continue

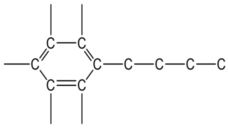
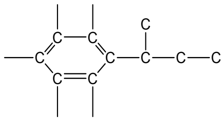
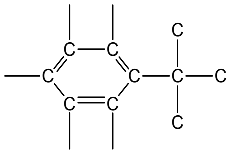
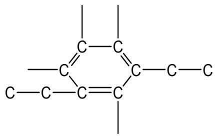
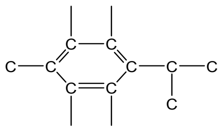
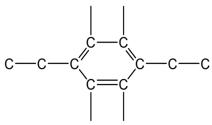
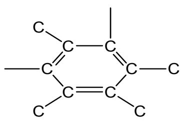
1	2	3	4	5	6	7	8	9
n-Butylbenzene		183,3	-	96	860	NA *		-
sec-Butylbenzene		173,3	-	96	862	NA *		52
Tert-Butylbenzene		169,1	-	106	866	NA *		44
1,3-Diethylbenzene		181,3	-	-	864	NA *		-
1,4-Methyl-isopropylbenzene		177,2	-	98	857	NA *		-
1,4-Diethylbenzene		183,8	-	96	862	NA *		-
1,2,3,5-Tetramethylbenzene		198,2	-	102	891	NA *	62	
Olefinic hydrocarbons								
Propylene	C═C—C	-47,7	101,4	85	gas	NA *		23-61
1-Butene	C═C—C—C	-6,2	97,4	82	618 (0°C)	NA *		Combustion gas
2-Butene	C—C═C—C	3,7	99,6	86	645 (4°C)	NA *		-

Table 2 continue

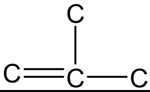
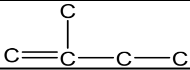
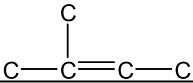
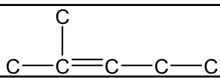
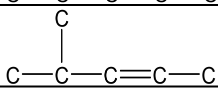
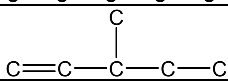
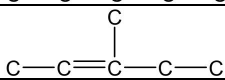
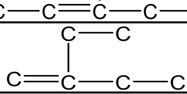
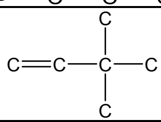
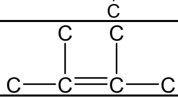
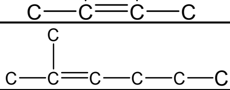
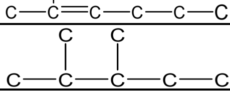
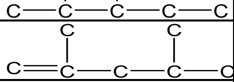
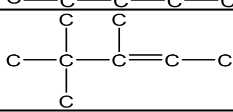
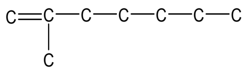
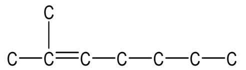
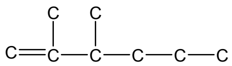
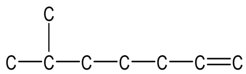
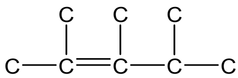
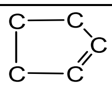
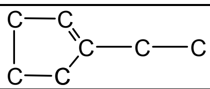
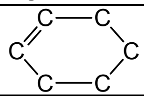
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2-Methylpropene		-7	101,5	88	gas	NA *		-76,1
1-Pentane	C=C—C—C—C	30,0	90,9	77	640	NA *		-49
2-Pentane	C—C=C—C—C	36,9	-	80	655	NA *		-49
2-methyl-1-butene		31,2	101,3	82	650	NA *		-48
2-methyl-2-butene		38,6	97,3	85	-	NA *		-45
1-Hexane	C=C—C—C—C—C	63,5	76,4	63	673	NA *		-
2-Hexane	C—C=C—C—C—C	68,8	92,7	81	687	NA *		-
3-Hexane	C—C—C=C—C—C	66,5	94,0	80	680	NA *		-
2-Methyl-2-pentene		67,3	97,8	83	686	NA *		-
2-Methyl-3-pentene		-	99,3	84	-	NA *		-
2-Methyl-1-pentene		54,2	96,0	81	667	NA *		-26
3-Methyl-3-pentene		70,4	-	79	698	NA *		30,2
2-Ethyl-1-butene		64,7	98,3	79	690	NA *		-
3,3-Dimethyl-1-butene		41,2	-	94	655	NA *		-17
3,3-Dimethyl-2-butene		73,2	97,4	80	708	NA *		-
2-Methyl-2-hezene		95,4	90,4	79	709	нд *		-6,6
2,3-Dimethyl-2-pentne		95,1	97,5	80	728	0,05	2	-
2,4-Dimethyl-2-pentene		81,6	100,0	85	694	NA *		-
2,2,3-Trimethyl-3-pentene		-	102,6	90	0	NA *		-
1-Octene	C=C—C—C—C—C—C—C	121,3	28,7	35	722	NA *		13

Table 2 continue

1	2	3	4	5	6	7	8	9
2-Octene	C—C═C—C—C—C—C—C	102	56,3	56	715	NA *		-
3-Octene	C—C—C═C—C—C—C—C	122,3	72,5	68	719	NA *		-
4-Octene	C—C—C—C═C—C—C—C	122,5	73,3	74	721	NA *		-
2-Methyl-1-heptene		119,2	70,2	66	720	NA *		-26,1
2-Methyl-2-heptene		122,6	75,9	71	724	NA *		-
2,3-Dimethyl-1-hexene		110,5	96,3	84	721	0,08	3	6,7
2-Methyl-6-heptene		113,2	63,8	66	712	NA *		-
2,3,4-Trimethyl-2-pentene		108,4	96,9	80	735	NA *		12,8
Cycloolefinic hydrocarbons								
Cyclopentane		44,2	-	70	772	NA *		lower 23
1-Ethylcyclopentene		103,5	-	72	766	NA *		-
Cyclohexene		83,0	-	63	811	NA *		-6

* - NA – nonavailable

The flash point characterizes the ignition of fuels, defines the safety conditions for the use of fuel in engines. It depends on the fractional fuel composition. The rate of flammability of fuels also characterizes their fire hazards, which is one of the environmental indicators.

Maximum allowable concentration (MAC) – indicator of the safe level of harmful substances content in the environment; maximum amount of harmful substance per unit of volume or mass in aqueous, air or soil environments, which almost does not affect human health [13].

By the degree of influence on the body of harmful substances are divided into four classes of toxicity and danger:

1st class – extremely toxic and extremely harmful;

2nd class – highly toxic and high-risk;

3rd class – moderately toxic and moderately dangerous;

4th class – low-toxic and low-dangerous [14].

On the figures 2–4 there are selected typical representatives of individual hydrocarbons.

The toxicity and carcinogenic of oil and synthetic combustible and lubricating materials in our time is estimated using biological tests on animals. Evaluation methods can be divided into short-term using a large dose of a substance to determine the potential hazard and long-term (from two weeks to three months) using smaller doses. Methods of the second group are useful for identifying the possible consequences of repeated contact with the substance. The most long-term methods – throughout the life of an animal – are used to assess the possibility of cancer and other diseases.

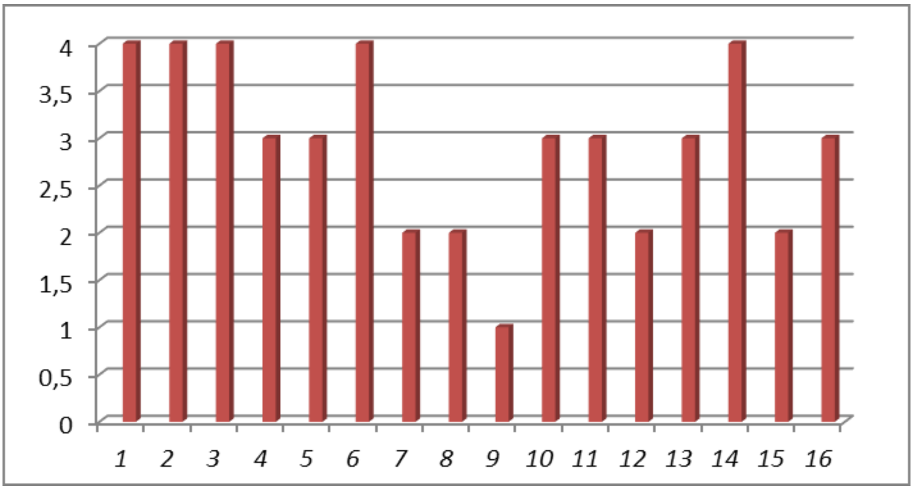


Fig. 2. Danger class of individual hydrocarbons that are in the gasoline component:
1 – *n*-Butene; *2* – *n*-Pentene; *3* – *n*-Hexene; *4* – 2,2-Dimethylbutene (neohexane); *5* – 2,3-Dimethylbutane (diisopropyl); *6* – *n*-Heptene; *7* – 2,2-Dimethylpentane; *8* – 3,3-Dimethylpentane; *9* – 2,3-Dimethylpentaneн; *10* – 3-Ethylpentane; *11* – *n*-Octane; *12* – Benzene; *13* – Toluene; *14* – Isopropylbenzene (Cumene); *15* – 2,3-Dimethyl-2-pentene; *16* – 2,3-Dimethyl-1-hexene

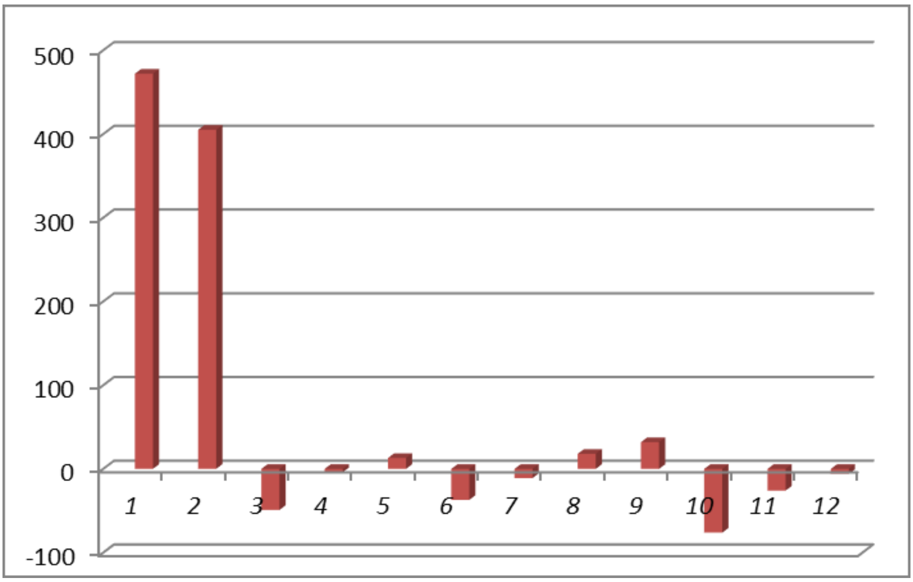


Fig. 3. Flash point of individual hydrocarbons that are in gasoline compound:
1 – Propane; *2* – *n*-Butene; *3* – *n*-Pentene; *4* – *n*-Heptene; *5* – *n*-Octane; *6* – Cyclopentene; *7* – Benzene; *8* – Ethylbenzene; *9* – o-Xylol; *10* – 2-Methylpropene; *11* – 2-Methyl-3-pentene; *12* – Cyclohexene

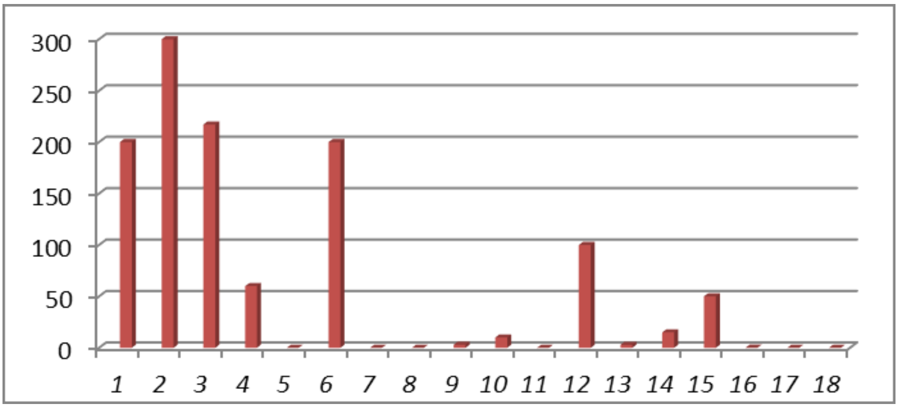


Fig. 4. Maximum allowable concentrations of individual hydrocarbons that are in gasoline compound: *1* – Propane; *2* – *n*-Butane; *3* – *n*-Hexane; *4* – 2,2-Dimethylbutane (neohexane); *5* – *n*-Heptane; *6* – 2,2-Dimethylpentane; *7* – 2,2-Dimethylpentane; *8* – 3,3-Dimethylpentane; *9* – 3-Ethylpentane; *10* – *n*-Octane; *11* – Cyclopentane; *12* – Cyclohexane; *13* – Methylcyclohexane; *14* – Benxene; *15* – Toluene; *16* – Isopropylbenzene (Cumene); *17* – Dimethyl-2-pentene; *18* – 2,3-Dimethyl-1-hexene

The toxicity of oil and its components increases due to the presence of sulfur. The oil, which has little aromatic hydrocarbons, acts like mixtures of paraffins and naphthenes – their pairs have a narcotic effect, often cause convulsive effects. Sulfur compounds of oil can cause acute and chronic poisoning. The most dangerous are hydrogen sulfide, especially dangerous for its connection with hydrocarbons [15].

Paraffin hydrocarbons have the smallest, except olefinic hydrocarbons, toxicity compared with hydrocarbons of other groups. They have a narcotic effect. When paraffin hydrocarbons poisoning appear, there are such symptoms as headache, drowsiness, dizziness, eye irritation and upper respiratory tract. Repeated and prolonged exposure of these products to skin causes dryness and can lead to dermatitis and eczema.

All paraffins belong to the 4-th class of low hazard substances. For hydrocarbons from methane to octane, the MAC of vapors in the working zone air is 300 mg/m^3, for isooctane – 100 mg/m^3. The maximum one-time MAC of butane, pentane and hexane vapors in the atmospheric air is 200, 100 and 60 mg/m^3 respectively.

Methane CH_4, as a source of poisoning, is small compared to its explosion hazard. Since CH_4 is lighter than air, when a person loses consciousness, a person enters the atmosphere with normal O_2 content, but the risk of poisoning still exists. CH_4 is a strong narcotic drug; therefore, certain precautions must be taken when using it.

Ethan C_2H_6 has a narcotic effect on humans.

Known acute human poisoning by steam of propane C_3H_8. Symptoms of poisoning: excitement, deafness, narrowing of the pupils, slow pulse, vomiting, long sleep. On the second day, a slight increase in temperature, a decrease in blood pressure. In case of severe poisoning with prolonged anesthesia, memory loss and pneumonia may be present. C_3H_8 is a strong drug, but because of its meager blood solubility it was dangerous. In chronic poisoning, C_3H_8 does not cause severe organic changes.

Butane C_4H_{10} has narcotic properties. Maximum allowable concentration of C_4H_{10} in air of populated areas is 200 mg/m^3. A person feels the smell of C_4H_{10} in the air when it concentration is 328 mg/m^3. Known cases of people poisoning with gas leakage.

Pentane C_5H_{12}. The smell of pentane is felt at a concentration of vapor 217 mg/m^3. Concentration 14900 mg/m^3 at inhalation for 10 minutes. Does not cause clinical signs of poisoning. Maximum permissible concentration of C_5H_{12} in air of inhabited places is 100 mg/m^3.

Pentane slightly irritates the respiratory tract. There have been cases where C_5H_{12} caused headache, drowsiness, dizziness.

Hexane C_6H_{14} has narcotic properties. Described cases of polyneuritis development in systematic contact with hexane vapor. When in contact with the skin it causes dryness. The highest concentration of C_6H_{14} vapor, which is carried over 8 hours by most people, is 1900 mg/m^3.

Heptane C_7H_{16} in comparison with hexane has a stronger narcotic effect. At a concentration of 0,1 %, insignificant dizziness appears after 6 minutes.

Octane C_8H_{18} with normal conditions – colorless liquid. Slightly soluble in water. Octane is a strong drug that irritates the respiratory tract. With chronic effects, octane does not cause severe poisoning.

C_8H_{18} under normal conditions is a colorless liquid with a specific odor. Drug action of isooctane is poorly expressed. The isooctant pains cause slight irritation of the eyes and upper respiratory tract.

Olefinic hydrocarbons act on the human body as strong drugs, although somewhat weaker than paraffins. Narcotic action increases with increasing number of hydrocarbon atoms in the molecule. The highest members of a number of olefins have, along with narcotics, a pronounced convulsive effect (hexene, heptene), as well as irritating effects on the airways. Hexane pairs act narcotically with the same force as hexane pairs; vapors of hepten are weaker than vapors of heptane.

Naphthenic hydrocarbons. Total toxic effect of naphthenic hydrocarbons is similar to the action of paraffine. The narcotic effect of naphthenic is higher than the corresponding paraffines. The derivative of cyclohexane acts more strongly than derivatives of cyclopentane with the same number of hydrocarbon atoms in a molecule. According to toxicity, naphthenes occupy an intermediate position between paraffinic and aromatic hydrocarbons.

Cyclohexane C_6H_{12} has narcotic properties that irritate the skin. The MAC of cyclohexane vapors in the air of the working zone is 100 mg/m^3.

Methylcyclohexane C_7H_{14} under normal conditions is a colorless liquid with a smell of gasoline. The smell of C_7H_{14} is perceived at a concentration of 3,9–1,8 mg/m^3. Its vapors strongly irritate the mucous membrane, when it hits the skin itching. When chronic poisoning is marked by changes in blood, similar to poisoning with benzene. Poisoning by C_7H_{14} vapor can be, as a rule, only with faulty equipment, poor ventilation of the room; in other cases the risk of poisoning is small.

Light aromatic hydrocarbons in comparison with hydrocarbons of other homologous groups have increased toxicity.

Benzene C_6H_6 under normal conditions is a colorless, easily movable liquid with a characteristic smell. Has an increased narcotic effect. The toxicity of benzene vapor is much higher than that of petrol vapor. Chronic inhalation of benzene vapors, even at low concentrations, can lead to serious illness. In accordance with GOST 12.1.005, benzene belongs to the 2nd class of highly hazardous substances; physiologically very active. In large concentrations of steam, damage to the central nervous system can also cause fatty degeneration of the vascular walls of the internal organs and severe damage to the blood forming organs (bone marrow), decreased blood coagulation, subcutaneous hemorrhage and bleeding.

Toluene C_7H_8 under normal conditions is a colorless, mobile fluid. The MAC of toluene vapors in the working zone air is 50 mg/m^3. The threshold of odor of toluene is 1,8 mg/m^3. MAC in the air of inhabited places – 0,6 mg/m^3, in water – 0,5 mg/dm^3. Toluene vapor at high concentrations has narcotic effect, as well as affect the nervous system, have irritant effects on the skin and the mucous membrane of the nose, eyes and throat. When acute poisoning with toluene appears headache, nausea, loss of consciousness.

Propylbenzene C_9H_{12} under normal conditions is a liquid. MAC has not been established, only the study of the toxic properties of C_9H_{12} on animals (white mice) when introducing propylbenzene into the stomach. There was arousal, quickly transient into oppression, death for 1–4 days. With a long-term supply of C_9H_{12} in the stomach (0,25 g/kg), a tendency towards leukocytosis appears.

Isopropylbenzene (cumene) C_9H_{12} under normal conditions – a liquid with non-diffident odor. Poorly dissolved in water, mixed with organic solvents. The concentration of 0,025–0,1 mg/m^3, which is minimal in smell, is tangible. In acute poisoning acts more strongly than benzene and toluene, anesthesia occurs more slowly, but continues longer, during inhalation causes acute and chronic lesions of blood forming organs (bone marrow, spleen). MAC in air – 0,014 mg/m^3, in water in the reservoir – 0,1 mg/dm^3 [16].

Emissions of harmful substances into the atmosphere continue to grow. Assimilation of harmful substances by the natural process does not have time for their receipt. There is accumulation of these substances in the atmosphere, soil, water. There is a threat to the development of the greenhouse effect, the destruction of the ozone layer of the Earth, the accumulation of carcinogenic and mutagenic products, sometimes falls acid rain. All this has negative effect on the environment, on agricultural production, on public health [17].

In the combustion products liquid fuels derived from petroleum, in addition to the final combustion products, CO_2 and H_2O, usually there are still CO, $SO_x \cdot NO_x$, without burning down and again forming numerous carbonaceous C_nH_m, soot and other products.

Alkanes, saturated hydrocarbons (paraffines) – saturated acyclic hydrocarbons having general formula C_nH_{2n+2}, they are also called paraffines. Most of their chemical reactions with different reagents begin with the breakdown of C–H, whereas their decomposition at high temperatures is primarily due to the C–C bond.

Alkanes form a significant part of hydrocarbons, oil and natural gas. All alkanes of normal structure, from methane to tritriacontane ($C_{33}H_{68}$) inclusive, are isolated from oil and combustible gases. Since alkanes contain the highest possible amount of hydrogen in a molecule, they are characterized by the greatest mass heat of combustion (energy intensity), and with increasing number of atoms, the mass heat of combustion of alkanes decreases (in methane 50207 kJ/kg). Due to low density, the volumetric heat of combustion of alkanes is less than that of hydrocarbons of another structure with the same amount of carbon atoms in the molecule. By aggregate composition, alkanes are divided into gaseous (C_1–C_4), liquid (C_5–C_{17}) and solid (starting with C_{18}), which crystallize at 200 °C.

Alkanes form the main part of hydrocarbons in oil of all deposits and natural combustible gases. The total content of alkanes in the petroleum is mainly 25–30 % (without dissolved gases), taking into account dissolved hydrocarbons, their content increases to 40–50 %, and in some oil – up to 50–70 %, although there is oil with an alkane content of 10–15 %. With increasing average molecular weight of oil fractions, the content of alkanes in them tends to decrease.

Cycloalkanes (naphtenes) are hydrocarbons with one or more carbon cycles. The general formula C_nH_{2n} or $(CH_2)n$.

In general, cycloalkanes are similar in physical properties to the corresponding alkanes, but have a slightly higher melting and boiling point, more density. These properties they have due to stronger London forces, because the cyclic form contributes to the greater surface of intermolecular contacts. Cycloalkanes exhibit virtually the same chemical passivity as alkanes (containing stable C–C and C–H bonds). However, cyclic stress can contribute increasing reactivity.

Alkenes (olefins), unsaturated acyclic hydrocarbons having general formula C_nH_{2n}. Light alkenes, for example, ethylene and propylene, are gases that are obtained from fractions when oil is cracked. Alkenes have one double bond between carbon atoms, so they are called unsaturated. Another name of the series is olefinys (but this term also refers to polyenes).

Olefines are widely used for polymers production, as well as for the synthesis of olefines derivatives: dichloroethane, ethylene glycol, isopropyl alcohol, acetone, acrylic acid nitride and many other compounds of great importance.

The first three members of the series of olefines are gases, followed by liquids that do not mix with water; higher olefines are solids. With increasing molecular mass, the melting and boiling temperatures increase. Alkenes of a normal structure are boiling at a higher temperature than their isomers having an isometric structure. The boiling point of cis-isomers is higher than trans-isomers, and the melting point is the opposite.

Arenes (aromatic hydrocarbons) are organic compounds belonging to the class of carbocyclic compounds. As part of the aromatic hydrocarbon molecule, there is one or more groups of 6 carbon atoms (Carbon) connected in the ring (benzene nucleus) by closed system of conjugate pi-bonds. According to modern notions, Carbon atoms in the benzene nucleus are connected by electrons of two types: some electrons are contained in the plane of the molecule, others are perpendicular to it.

Monocyclic (single-ring: benzene, toluene) arenes – colorless liquids with specific odor, volatile, flammable, lighter than water, do not dissolve in it. Well soluble in organic solvents, are solvents for many organic substances.

Oxygenates – general name of lower alcohols and ethers, high octane components of motor fuels. Usage of oxygenates expands the resources of fuels and can often improve their quality. Oxygenated gasolines are characterized by improved washing properties, combustion characteristics, and during combustion, they form less carbon monoxide and hydrocarbons.

Recommended concentration of oxygenates in gasolines is 3–15 % (volume) [18] is selected so that the oxygen content in the fuel does not exceed 2,7 %. This quantity of oxygenates, despite their lower calorific value in comparison with gasoline, does not have negative effect on the strength characteristics of the engines.

Oxygenates, as components of gasoline, are characterized primarily by octane mixing numbers, saturated vapor pressure, and heat-generating capacity.

Water-absorbing capacity of oxygenates affects the phase stability of fuel mixtures containing oxygenates, which manifests itself as turbidity of fuels at reduced temperatures.

There are used alcohols, ethers, mixtures and alcohol-based wastes from food and petrochemical industries.

Octane numbers of alcohols are reduced by increasing the length of the hydrocarbon chemical group. (Methanol – Ethanol – Isopropanol – Isobutanol).

As additives to gasoline methanol is used infrequently. This is hampered by its toxicity, poor solubility in hydrocarbons and high water-absorbing capacity. It has negative affects on materials of sealants and hot spot according to non-ferrous metals.

As additives to fuels, ethanol has larger interest than methanol, since it is better dissolved in hydrocarbons and has less water-absorbing capacity. It is widely known to use a gasohol (a mixture of gasoline with 10–20 % of ethanol) in the USA and Brazil, which has vast resources of sugar produced from sugar cane. Ethanol is interesting as an additive to fuel in countries rich in plant resources. Adding 5 % of ethanol to gasoline does not lead to deterioration of engine performance and does not require pre-regulation of the carburetor. At the same time there is a significant decrease in emissions of CO and small – hydrocarbons.

Catastrophic pollution of the environment by products of combustion of fuels, the emergence of the greenhouse effect led to the formation of requirements for engine emissions of toxic products.

One of the most important events in the field of environmental policy was the 21st World Climate Summit (COP 21), carried in Paris in November–December 2015. As a result of work COP 21 signed a final agreement, which obliges all countries to take measures to limit the increase in the average temperature of the planet no more than 2 °C in relation to the average temperature before the industrial era (before 1990). This agreement will substitute the existing Kyoto Protocol, which is limited by 2020.

limit increasing of temperature at 2°C, as well as make every effort to limit the temperature increase to 1,5 °C	increase climate resistance and take measures to reduce CO_2 emissions, while not increasing the problem of food shortages (it is a question of gradually stopping the use of crops as raw materials for biofuels)	direct financial flows to stimulate the development of environmentally sustainable development and technology support, which allows to reduce CO_2 emissions

Fig. 5. The main ideas of Paris Agreement

According to Agreement, each country must develop and adopt a series of measures aimed at solving the tasks, as well as enhance multilateral interaction and cooperation.

The toxic properties of hydrocarbons are very different. However, by this time the issue of toxicity of hydrocarbons is not sufficiently studied and the rationing of their content in the exhaust gases are carried out in total. Air control of the working area during operation with gasoline is carried out in the presence of hydrocarbon vapors (MAC=300 mg/m^3, 4th hazard class in accordance with GOST 12.1.005), gasoline (MAC=100 mg/m^3, 4th hazard class in accordance with GOST 12.1. 005), carbon monoxide (MAC = 20 mg/m^3, 4th hazard class according to GOST 12.1.005).

Toxicity is determined by the chemical and fractional composition of fuels.

For prevebtion of harmful substances contamination and defend environment have been established maximum allowable concentrations (MAC). MAC of harmful substances in the atmosphere – maximum concentration of harmful substances, which belongs to a certain period of averaging: 30 minutes, 24 hours, month, year, without causing, under the regulated probability of its occurrence, no direct or indirect effect on the human body, without reducing human activity and not worsening its health state [19].

Toxicity and fire hazards of petroleum fuels are classified in 4 hazard classes in accordance with GOST 12.1007–76 for the degree of exposure to the body. The hazard class of harmful substances is determined according to standards and standards indicators.

The most dangerous is the poisoning of a couple of fuels through the respiratory system with air. The vapor easily passes through the alveolus of lungs and gets directly into the blood circulation circle bypassing the liver, which plays an important role in delaying and neutralizing toxic substances.

Ecological properties of fuel and lubricants are detected in the interaction of products with the environment, that is, when in contact with the means of mechanization in conditions of storage, transportation, transfer and filtration, as well as in contact with the atmosphere, water, man, animals and the plant world. The quality of the fuel and lubricants depends on the reliability of the engines and machines in general, and, consequently, the cost of their maintenance and repair.

The force of toxicity of fuels and oils depends on the properties of the product, its concentration and duration of exposure, as well as on the ways of penetration into the body, external conditions, in which the work is performed, and individual characteristics of man. Fuel and oil can enter the human body through the respiratory tract, skin, digestive organs and mucous membranes of the eyes. The most dangerous is when fuel vapor or oil passes through the respiratory tract, since poisonous substances come from the lungs easily into the bloodstream. In this case, the poison enters the large circle of blood circulation, passing the hepatic barrier, and operates in 20 times faster.

Given tha data above predetermine the need to find ways to reduce emissions of harmful substances into the atmosphere. The most widely used devices on management and neutralization of harmful substances.

The most important decision of environmental problems in the chemotology of fuel and lubricants should be considered improvement of the quality of commodity products, development of new, environmentally nonhazardous fuels and lubricants [20].

Nowadays, there is developed aviation gasoline containe ethanol. Because it is the most massive product among aliphatic alcohols. Ethanol is best suited for use in practice at the expense of high production and low toxicity. Compared to methanol, it is better dissolved in hydrocarbons. Thanks to ethanol, gasoline is enriched with oxygen and contributes to more complete fuels combustion. Today, biobutanol have great actuality as additive among aliphatic alcohols. During literature analysis revealed that it is the least aggressive to the structural details of the engine, it has the greatest stabilization effect in relation to alcohol-gas mixtures, has octane-enhancing properties and reduces the amount of toxic emissions.

Usage of biofuels leads to improvement environmental characteristics of internal combustion engines: with the increasing of ethanol content in the fuel, the concentration of toxic substances (CO, NO_2, SO_2, CH_2O) in the exhaust gases is reduced.

The composition of the fuel includes hydrocarbon and non-hydrocarbon (heteroatomic) compounds of various classes that determine the physical, chemical and operational properties of fuels (Table 3).

Table 3

Characteristics of physical-chemical properties of traditional and alternative gasolines

Characteristics	Aviation gasoline B91/115	Motor gasoline	Methanol	Ethanol	Butanol	Hydrogen
Density at temperature 20 °C, kg/m^3	Not rated	740–760	792	789,3	810	70
Boiling temperature,°C	40–180	35–200	64,5	78,4	117,5	minus 253
Chilling point, °C	minus 60	minus 60	minus 98	minus 114,1	minus 90,2	minus 259
Mass content of oxygen, %	-	-	50	34,7	21,6	-
Combustion heat, kJ/kg	42947	41000–44000	24000	26945	35520	11820
Evaporation heat, kJ/kg	Not rated	200	1115	839,3	591,2	48
Saturated vapour pressure, kPa	29,3–47,9	45–80 (in summer time)	-	17	8,4	-
Water solubilityat temperature 20 °C, %	Insoluble	Insoluble	No limits	No limits	7,9	-
Octane number: - reaserch method - motor method	Not rated 91	80–98 -	111 94	108 92	99,6 94	30–40 Not rated
Viscosity at temperature 20 °C, mm^2/sec	Not rated	0,5–0,7	-	1,52	3,64	-
Percentage limits in gasoline according EN 228:2000	-	-	3 %	5 %	7–10 %	-

Adding aliphatic alcohols to fuel changes their properties: increase octane number, it allows to reduce the content of aromatic hydrocarbons. The results indicate that 25 % of the concentration of ethanol C_2H_5OH is optimal for use in internal combustion engines.

We find that with the increasing of octane number, the concentration of toxic gases in the exhaust decreases, which improves the ecological properties.

Thus, ensuring the ecological purity of traditional and alternative aviation gasoline will increase the climate sustainability, reduce CO_2 emissions, aimed at fulfilling the basic provisions of the Paris Agreement. After analyzing the environmental properties of the components of traditional and alternative aviation gasoline, it can be concluded that with the reducing aromatic hydrocarbons in the gasoline, saturated it with oxygenates, it is possible to improve the composition of aviation gasoline, thereby reducing the formation of carbon monoxide and hydrocarbons during combustion. The most powerful influence is aromatic and olefinic hydrocarbons, oxygen-containing compounds have a lowering effect of fuel deposits and carbon laydown on the details of fuel equipment and combustion chamber.

In turn, the established direction, encourage the continuation of the scientific and applied research direction: the analysis of the environmental properties of components of traditional and alternative aviation gasoline and their component composition.

РЕФЕРАТ

Сергій Бойченко, Ірина Шкільнюк, Леся Павлюх, Катерина Бабікова, Анна Яковлєва, Роза Вінецька
Національний авіаційний університет, chemmotology@ukr.net

АНАЛІЗ ЕКОЛОГІЧНИХ ВЛАСТИВОСТЕЙ КОМПОНЕНТІВ ТРАДИЦІЙНОГО ТА АЛЬТЕРНАТИВНОГО АВІАЦІЙНОГО БЕНЗИНУ

У статті проаналізовано екологічні властивості компонентів традиційних і альтернативних авіаційних бензинів. Встановлено, що зі зменшенням ароматичних вуглеводнів у складі бензинів, насичуючи їх оксигенатами, можна покращити склад авіаційних бензинів, у такий спосіб зменшити утворення оксиду вуглецю і вуглеводнів під час згорання. Зі збільшенням октанового числа концентрація токсичних газів у вихлопі зменшується, завдяки чому поліпшуються екологічні властивості. Використання біопалива веде до покращення екологічних характеристик.

Ключові слова: екологічні властивості, альтернативний бензин, токсичність, біоактивні поліциклічні арени (ПА), компонентний склад, вуглеводні, температура спалаху, гранично допустима концентрація (ГДК), викиди, біопаливо.

РЕФЕРАТ

Сергей Бойченко, Ирина Шкильнюк, Леся Павлюх, Екатерина Бабикова, Анна Яковлева, Роза Винецкая
Национальный авиационный университет, chemmotology@ukr.net

АНАЛИЗ ЭКОЛОГИЧЕСКИХ СВОЙСТВ КОМПОНЕНТОВ ТРАДИЦИОННОГО И АЛЬТЕРНАТИВНОГО АВИАЦИОННОГО БЕНЗИНА

В статье проанализированы экологические свойства компонентов традиционных и альтернативных авиационных бензинов. Установлено, что с уменьшением ароматических углеводородов в составе бензинов, насыщая их оксигенатами, можно улучшить состав авиационных бензинов, тем самым уменьшить образование оксида углерода и углеводородов при сгорании. С увеличением октанового числа концентрация токсичных газов в выхлопе уменьшается, благодаря чему улучшаются экологические свойства. Использование биотоплива ведет к улучшению экологических характеристик.

Ключевые слова: экологические свойства, альтернативный бензин, токсичность, биоактивные полициклические арены (ПА), компонентный состав, углеводороды, температура вспышки, предельно допустимая концентрация (ПДК), выбросы, биотопливо.

ABSTRACT

Sergii Boichenko, Iryna Shkilniuk, Lesia Pavliukh, Kateryna Babikova, Anna Iakovlieva, Roza Vinetskaya
National Aviation University, chemmotology@ukr.net

ANALYSIS OF THE ENVIRONMENTAL PROPERTIES OF THE COMPONENTS OF TRADITIONAL AND ALTERNATIVE AVIATION GASOLINE

In this article have been analyzed ecological properties of traditional and alternative aviation gasoline. We determine that with reducing of aromatic hydrocarbons in gasoline, saturated with oxygenates; it is possible to improve the composition of aviation gasoline, thereby reducing the formation of carbon monoxide

and hydrocarbons during combustion. With increasing octane number, the concentration of toxic gases in the exhaust decreases, that improves the ecological properties. Using biofuels leads to improve environmental characteristics.

Key words: ecological properties, alternative gasoline, toxicity, bioactive polycyclic arenes (PA), component composition, hydrocarbons, flesh point, maximum allowable concentration (MAC), emissions, biofuels.

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