

# DEVELOPMENT OF SELECTIVE SENSORS FOR DETERMINATION OF ETHYL ALCOHOL VAPORS

**Ergashboy Abdurakhmanov**

Samarkand State University. Samarkand city. Doctor of Chemical Sciences, Professor of the Department of Analytical Chemistry.

[ergash50@yandex.ru](mailto:ergash50@yandex.ru)

**Zulfiya Begmuradovna Murodova**

Samarkand State University. Samarkand city. Candidate of Chemical Sciences, Associate Professor of the Department of Analytical Chemistry.

[ergash50@yandex.ru](mailto:ergash50@yandex.ru)

**Farrukh Fakhriddinovich Kholmurzaev**

Samarkand State University. Samarkand city. Master student of the Department of Analytical Chemistry. [fxolmurzayev@yandex.ru](mailto:fxolmurzayev@yandex.ru)

**Bakhtiyor Bakhodir ugli Akhmedov**

Samarkand State University. Samarkand city. Master student of the Department of Chemistry

*Abstract: The paper establishes the regularities of the oxidation of combustible substances in the presence of catalytic systems of different nature and on their basis the catalysts for measuring and compensation sensitive elements of a thermocatalytic ethanol vapor sensor are selected. The possibility of creating highly sensitive and selective sensors with the use of measuring and compensating thermosensitive elements of the sensor containing catalysts of different activity to the components of complex gas-air mixtures has been experimentally confirmed. The main metrological characteristics and operational parameters of the developed selective thermocatalytic ethanol sensors are estimated. The developed utensils allow the determination of ethyl alcohol vapors in wide ranges of its concentrations and have the best metrological characteristics and operational parameters.*

*Key words: Ethanol, thermocatalytic sensor, catalyst, selectivity, sensitive element, combustible gases, atmospheric air, process gases, cobalt oxide, copper oxide, bismuth oxide, molybdenum oxide.*

**Introduction.** Ethanol is a widespread fire and explosive air pollutant [1; p.87-90]. In many processes of chemical technology, the controlled parameter is the concentration of ethyl alcohol used as the main raw material and solvent [2; page 446-448, 3; page 342]. It is highly flammable, and even explodes when mixed with air, therefore, its presence in the air and closed ecological systems causes explosions and fires [1; page 87-90].

One of the most common psychotropic substances is ethyl alcohol overuse, which has no equal [4; page 21-25]. The amount of ethanol in the air exhaled by a person is the most important indicator and procedural rein in the examination of the state of intoxication in health care institutions and road patrol service [5; page 1-4]. In this regard, the control of its concentration in

gas-air systems is one of the most important tasks of safety, solving various environmental and medical problems [6; page 2459-2471,7; page 78-122]. Therefore, the task of creating a new generation of highly efficient sensors and gas analyzers, as well as the development of methods for monitoring ethyl alcohol in human exhaled air and process gases, is an urgent problem of modern analytical chemistry, ecology and medicine.

Of all the methods used in practice for monitoring the content of ethyl alcohol, the most widely used are chemical, gas chromatographic and thermocatalytic methods [8; page 13-15, 9; page 54-56]. In the practice of chemical control of ethyl alcohol in the gas exhaled by a person, indicator tubes "Sobriety control" are often used, containing potassium dichromate, reduced in an acidic medium to trivalent chromium salt. As a result, the yellow color of the solution turns into a yellow-green color [10; page 11-14, 11; page 5-10].

The highest accuracy in measuring the concentration of ethyl alcohol from a vapor-gas mixture is obtained by gas chromatography. However, this method requires rather cumbersome and expensive equipment as well as the training of a highly qualified specialist. The time required for such an analysis is very long, so this method can be recommended only as an exemplary measuring instrument. In addition, as is known, the analysis using the chromatographic method is quite time consuming and expensive.

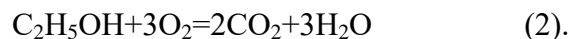
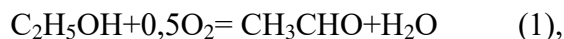
In the practice of controlling ethanol vapors, thermocatalytic methods are also widely used [12; page 25-37]. The advantages of the thermocatalytic method and the gas analyzer created on its basis are simplicity of exploitation, portability, significantly long service works, high sensitivity, accuracy and speed. The sensing element of a thermocatalytic sensor is a miniature microcalorimeter including a metal thermistor with a formed carrier ( $Al_2O_3$ ), on the surface layer of which a catalyst made of platinum group metals is installed [13; page 314, 14; page 30-32].

Along with the noted advantages of thermocatalytic sensors, it should also be noted that their disadvantages are not high selectivity of the catalysts themselves and on the basis of platinoids. In this regard, the development of highly selective thermocatalytic methods and the creation on their basis of accessible and highly sensitive units (sensors and automatic gas analyzers) for monitoring ethanol is a paramount and urgent problem of modern analytical chemistry and ecology.

In work [18; pp.19-25], a method has been developed to ensure the selectivity of the TCS, which is based on the use of temperature-sensitive elements (measuring and compensation) containing catalysts with different activity to the components of the gas mixture. In this case, the output signal of the first (measuring) element is proportional to the total concentration of all combustible components of the analyzed mixture, the output signal of the second (compensation) element is proportional to the concentration of the mixture except for the component being determined, and the difference between the signals of the first and second elements is proportional to the content of the determined component in the mixture. According to this method, the primary objective of the research devoted to the development of an ammonia sensor is the creation of selective catalytic systems with increased operational parameters for sensitive elements.

In order to select a catalyst for the measuring and compensating sensitive element of a selective thermocatalytic sensor, the characteristics of catalysts based on mixtures of metal oxides were studied.

**Experimental methods.** The principle of operation of the developed thermocatalytic sensor (TCS) of ethanol (TCS-C<sub>2</sub>H<sub>5</sub>OH) is based on measuring the concentration of alcohol in the gas mixture by the amount of heat released during the chemical reaction of catalytic oxidation. Oxidation of alcohol on the catalyst surface proceeds mainly in two directions. The first of them is mild oxidation (1), which leads to the formation of carbonyl compounds, and the second is deep oxidation of alcohol to CO<sub>2</sub> and H<sub>2</sub>O (2):



It should be noted that the oxidation of ethanol on the surface of the TCS catalysts occurs mainly according to the second type with the formation of carbon dioxide and water vapor. This reaction is accompanied by a large thermal effect (1125 kJ) and is practically irreversible. The development of regimes for the manufacture of thermocatalytic ethanol sensors (TCS-C<sub>2</sub>H<sub>5</sub>OH) was carried out by us on the basis of the sensor developed in work [15; from. 19-25]. Structurally, TKS- C<sub>2</sub>H<sub>5</sub>OH is a pair of sensitive elements and a pair of resistors included in the bridge circuit. Both sensing elements are located in the reaction chamber. When alcohol enters the reaction chamber, it burns out on both sensitive elements, but on the element covered with a catalyst, combustion occurs at a higher rate, leading to a stronger heating of it, respectively, to a greater change in its resistance, resulting in an imbalance in the bridge circuit and the appearance analytical signal. The amount of heat released depends on the content of the test component (C<sub>2</sub>H<sub>5</sub>OH) involved in the reaction. Thus, the analytical signal is the output voltage proportional to the ethanol concentration in the analyzed mixture. Sensitive elements, depending on their purpose, are divided into measuring (R<sub>1</sub>) and compensation (R<sub>2</sub>) elements. Common in the design of both elements is a spiral made of platinum microwire in glass insulation, on which a layer of aluminum oxide in the form of a ball is applied.

In the measuring sensitive element, a catalytic coating of aluminum oxide is applied to the surface of the ball, which serves as a porous carrier for the catalyst. For the manufacture of sensitive elements of the ethanol sensor, as our experiments have shown, it is optimal to use a vitrified platinum microwire with a platinum core diameter of 0.01 mm. The number of convolutions of the vitrified microwire spiral, from which the measuring compensating element of the alcohol sensor was prepared, was 10-20 pcs, with the inner diameter of the spiral equal to 0.3 mm. The measuring and compensating temperature-sensitive elements are interconnected by a bridge circuit. Experiments on the selection of selective catalysts for thermocatalytic alcohol sensors were carried out in the presence of individual metal oxides (Cr, Mn, Fe, Co, Ni, Cu, Zn, Co, Sn, Bi, etc.) and their mixtures, which are the most active and selective catalysts of the process oxidation of combustible substances. Aluminum oxides are much less active in reconstructive oxidative reactions, and therefore we used aluminum oxide as a carrier.

The catalysts were prepared by impregnating the support with solutions of individual salts (nitrates, carbonates, or oxalates) followed by drying (for 3 hours at 120 °C) and calcining at the decomposition temperature of salts in a stream of air (for 3 hours). Platinum catalysts were prepared by impregnating the support with an aqueous solution of hydrochloric platinum, followed by drying for 3 hours at 120 °C and calcining at 500 °C in air for 3 hours.

The selection of the catalyst for the selective thermocatalytic ammonia sensor was carried out on a flow-through unit with a fixed catalyst layer. The oxidation state of the combustible component is controlled by taking a chromatogram of the mixture before and after passing through the catalyst layer. The completeness of oxidation of the analyte was chosen as the

criterion for the suitability of the catalyst for creating a sensitive element of a thermocatalytic sensor. Considering that the completeness of oxidation of combustible substances depends on its catalyst composition, process temperature, concentration of reactants, and the ratio of components in the gas mixture passed through the reactor, we also investigated the influence of these factors. Experiments to reveal the activity and selectivity of catalysts in the oxidation of alcohol were carried out in the presence of hydrogen, carbon monoxide, and methane. The selection of the catalyst and the optimal conditions for the oxidation of ethanol was carried out at a temperature of 100 - 300 °C, the feed rate of the gas-air mixture 10 l / h. The experiments were repeated five or more times. On all studied catalysts in the studied temperature range, the degree of conversion of ethanol is much lower than that of hydrogen and carbon monoxide. In the process of deep oxidation of ethanol, the most active and selective oxides were: MnO<sub>2</sub>, CuO, and SnO<sub>2</sub>. On these catalysts in the temperature range 100-200 °C, the degree of deep oxidation of ethanol ranges from 23-87%. On a catalyst based on MnO<sub>2</sub> at a temperature of 200 °C, the degree of conversion of hydrogen and carbon monoxide is in the range of 90-100%, which excludes the possibility of thermocatalytic determination of ethanol in the presence of hydrogen and carbon monoxide. It was found that hydrocarbons on these catalysts are practically not oxidized at 100 °C.

Thus, our studies show that the studied catalysts based on individual metal oxides do not provide selective thermocatalytic determination of ethanol in a mixture of hydrogen, carbon monoxide, and hydrocarbons, which are often found together in various natural and technological objects. The catalytic activity and selectivity of individual oxides in many catalytic processes can be changed to various degrees by adding other oxides to them, which form new chemical compounds or solid solutions with them.

Metal oxide catalysts have a less pronounced catalytic activity than their complex systems, because the latter, as experiments have shown, quite often have improved catalytic properties, and therefore further research was carried out with such systems. In this case, special attention is paid to the selectivity of the investigated catalytic systems. The characteristics of mixtures of the most active and selective metal oxides (cobalt, manganese, copper, etc.) obtained in their various ratios were studied experimentally. The results of studying the activity and selectivity of some binary systems in the oxidation of combustible gases are presented in Table 1.

Table 1.

Results of studying the activity of a mixture of metal oxides during the oxidation of combustible substances ( $C_{\text{alcohol}}=0.55$ ,  $H_2=1.25$ ,  $CO=1.45$ ,  $AI=93-0.50$ ,  $CH_4=1.50$ ).

№	Catalyst composition, wt. %	Oxidation degree ( $x \pm \Delta x$ ), %				
		ethanol	H <sub>2</sub>	CO	AI-93	CH <sub>4</sub>
Experiment temperature 100 °C						
3	CuO- MnO <sub>2</sub> (10-90)	43.6±0.2	46.0±0.6	34.0±0.5	13.0±0.4	2.0±0.1
4	CuO-MnO <sub>2</sub> (90-10)	69.5±0.5	28.0±0.5	18.0±0.5	11.0±0.5	
11	MnO <sub>2</sub> -SnO <sub>2</sub> (10-90)	41.3±0.3	66.0±0.4	71.0±0.8	16.0±0.4	-
12	MnO <sub>2</sub> -SnO <sub>2</sub> (90-10)	66.5±0.6	74.0±0.6	83.0±0.6	19.6±0.4	
Experiment temperature 200 °C						
15	CuO- MnO <sub>2</sub> (10-90)	96.5±0.6	76.0±0.4	72.0±0.6	20.0±0.2	5.0±0.1
16	CuO-MnO <sub>2</sub> (90-10)	90.5±0.6	71.0±0.7	67.0±0.4	27.0±0.3	10.0±0.1
23	MnO <sub>2</sub> -SnO <sub>2</sub> (10-90)	91.0±0.7	91.0±0.7	100±1.9	21.0±90.3	4.0±0.1

24	MnO <sub>2</sub> -SnO <sub>2</sub> (90-10)	90.5±0.6	100±0.9	100±2.0	27.0±0.2	9.6±0.1
Experimenttemperature 300 °C						
27	CuO- MnO <sub>2</sub> (10-90)	100.0±0.9	100±2.3	100±2.0	64.0±0.5	22.0±0.2
28	CuO-MnO <sub>2</sub> (90-10)	96.0±0.9	100±2.0	96.0±1.0	46.0±0.8	9.0±0.1
35	MnO <sub>2</sub> -SnO <sub>2</sub> (10-90)	94.5±0.6	100±0.9	100±0.9	36.0±0.5	6.0±0.1
36	MnO <sub>2</sub> -SnO <sub>2</sub> (90-10)	100.0±0.9	100±1.9	100±0.9	34.0±0.3	9.0±0.2

As follows from the data in the table, the relative activity of catalysts based on a mixture of metal oxides in the oxidation of combustible gases is in most cases higher than that of catalysts for individual oxides. Of the investigated catalytic systems in the oxidation of a mixture of hydrogen, carbon monoxide, and ethanol, the catalyst based on the binary mixtures CuO- MnO<sub>2</sub> (10-90) and MnO<sub>2</sub>-SnO<sub>2</sub>(90-10) has **shown** the highest activity. In the presence of these catalysts, a 100% oxidation degree of ethanol is observed at 400 °C. To obtain a low-temperature catalyst, we studied the activity of three component mixtures of oxides (MnO<sub>2</sub>, CuO and SnO<sub>2</sub>) in the oxidation of combustible substances. It was found that the highest degree of alcohol conversion was observed on catalysts (wt%): MnO<sub>2</sub>-CuO-SnO<sub>2</sub> (70-15-15); MnO<sub>2</sub>-CuO-SnO<sub>2</sub> (80-10-10) and MnO<sub>2</sub>-CuO-SnO<sub>2</sub> (90-5-5) at which the degree of ethanol conversion at a temperature of 200 °C reached 100%. The results of the study of the regularities of the oxidation of a mixture of some combustible substances on these catalysts in the temperature range 150-250 °C are shown in Table 2.

Table 2.

Results of determination of deep oxidation of combustible substances on the catalyst  
MnO<sub>2</sub>-CuO- SnO<sub>2</sub>(n = 5, P = 0.95)

Component	Degree of deep oxidation of combustible substances, %								
	MnO <sub>2</sub> -CuO-SnO <sub>2</sub> (70-15-15)			MnO <sub>2</sub> -CuO-SnO <sub>2</sub> (80-10-10)			MnO <sub>2</sub> -CuO-SnO <sub>2</sub> (90-5-5)		
	Experimenttemperature, °C								
	150	200	250	150	200	250	150	200	250
H <sub>2</sub>	100	100	100	100	100	100	100	100	100
CO	96,1	100	100	100	100	100	100	100	100
Gasoline vapors	-	-	-	-	-	-	-	-	4,9
CH <sub>4</sub>	-	-	-	-	-	-	-	-	-
C <sub>2</sub> H <sub>5</sub> OH	97,0	100	100	100	100	100	100	100	100
CH <sub>3</sub> CHO	100	100	100	100	100	100	100	100	100

As follows from the data given in Table 2, at a temperature of 200 °C on the MnO<sub>2</sub>-CuO-SnO<sub>2</sub>(80-10-10) catalyst, 100% conversion of hydrogen, carbon monoxide, ethanol and acetaldehyde is observed. A decrease in MnO<sub>2</sub> and an increase in CuO-SnO<sub>2</sub> in the catalyst (catalyst: 70MnO<sub>2</sub>-15CuO-15SnO<sub>2</sub>) leads to a decrease in its activity. At a temperature of 150 °C, incomplete oxidation of carbon monoxide and ethanol is observed on this catalyst. An increase in the MnO<sub>2</sub> content in the catalyst (catalyst: 90MnO<sub>2</sub>-5CuO-5SnO<sub>2</sub>) similarly leads to an increase in the oxidation state of gasoline vapors at 250 °C.

Thus, as a result of the studies carried out to study the activity and selectivity of metal oxides, the composition and ratio of the catalyst components for the measuring sensitive element of the selective thermocatalytic ethanol sensor were selected. This catalyst (80MnO<sub>2</sub> - 10CuO - 10SnO<sub>2</sub>) at a temperature of 150-250 °C provides complete (100%) oxidation of ethanol,

hydrogen, carbon monoxide and acetaldehyde. The parallel simultaneous oxidation of carbon monoxide and hydrogen excludes the possibility of using this catalyst in the development of a thermocatalytic sensor for the selective determination of ethanol in the presence of these investigated substances.

The problem of selectivity is central to the thermocatalytic determination of organic compounds. Established [15; pages 19-25] that one of the possible methods of developing a selective thermocatalytic sensor is the use of temperature-sensitive elements (measuring and compensation) containing catalysts that have different, not the same activity to the components of the gas mixture. In this case, the output signal of the first element is proportional to the total concentration of the mixture of substances (except for the determined one, and the output signal of the second element is proportional to the concentration of the mixture of substances, including the determined component, and the difference between the signals of the first and second elements is proportional to the concentration of the determined component in the mixture. By our special experiments, we selected the composition and ratio of the components of the NiO-Cr<sub>2</sub>O<sub>3</sub> catalyst (70-30), which ensure the selective oxidation of CO and H<sub>2</sub> in the presence of ethanol in a wide temperature range. The results of studying the activity of the NiO-Cr<sub>2</sub>O<sub>3</sub>(70-30) catalyst during the oxidation of a mixture of combustible substances are shown in Table 3.

Table 3.

Results of determining the activity of the catalyst NiO- Cr<sub>2</sub>O<sub>3</sub>(70-30) in the oxidation of ethanol vapor (n = 5, P = 0.95)

Experiment temperature, °C	Conversion rate, %					
	H <sub>2</sub>		CO		Ethanol	
	$\bar{x} \pm \Delta x$	Sr·10 <sup>2</sup>	$\bar{x} \pm \Delta x$	Sr·10 <sup>2</sup>	$\bar{x} \pm \Delta x$	Sr·10 <sup>2</sup>
100	68.0±0.5	1.32	47.6±0.3	0.59	-	-
150	100±2.0	1.64	100±1.0	0.76	-	-
200	100±0.9	0.82	100±0.9	0.67	-	-
250	100±1.1	0.64	100±2.0	0.89	-	-
275	100±1.8	0.51	100±1.8	0.50	4.5±0.1	1.76

As follows from the data in the table, on the NiO-Cr<sub>2</sub>O<sub>3</sub> catalyst (70-30) in the temperature range, 100% oxidation of H<sub>2</sub> and CO is provided. At the same time, ethanol, methane and gasoline vapors are practically not oxidized on this catalyst. In the development of selective TCS of ethanol, based on the use of measuring and compensating elements containing catalysts with different activity to different components of the gas mixture. It has been established that MnO<sub>2</sub>-CuO-SnO<sub>2</sub> (80-10-10) and NiO-Cr<sub>2</sub>O<sub>3</sub>(70-30) can be used as a catalyst for measuring and comparative elements. In this case, the output signal of the first element (70NiO-30Cr<sub>2</sub>O<sub>3</sub>) is proportional to the total concentration of the mixture of H<sub>2</sub> and CO, and the output signal of the second element (80MnO<sub>2</sub> - 10CuO - 10SnO<sub>2</sub>) is proportional to the concentration of the mixture of substances, including the component to be determined (H<sub>2</sub>, CO, and ethanol), and the signal difference of the first and second elements is proportional to the concentration of the determined component of ethanol in the mixture. Special experiments have established that in the presence of these catalysts, gasoline vapors and methane are practically not oxidized on the first and second sensitive elements. Thus, using the developed method, the selectivity of the determination of ethyl alcohol in the presence of hydrogen, carbon monoxide, methane and gasoline vapors is ensured. Using the selected catalysts and optimized analysis conditions, a

thermocatalytic sensor for the selective determination of the ethanol content in the gas mixture was manufactured. Structurally, the sensor is a pair of sensing elements and the same number of resistors included in a bridge circuit. The manufactured sensors provide control of micro- (TSC- $\text{C}_2\text{H}_5\text{OH}$  1M) and macroconcentrations (TSC- $\text{C}_2\text{H}_5\text{OH}$  2M) ethanol in a gas mixture. The program for testing the sensor in the operating mode included special experiments related to the selection of the supply voltage value, the establishment of the instrument readiness time, dynamic and calibration characteristics, and also the identification of the degree of its selectivity. In the experiments, PGS was used with a  $\text{C}_2\text{H}_5\text{OH}$  content of  $700 \text{ mg} / \text{m}^3$  and 0.50% vol. the results obtained are shown in Figure 4.2.

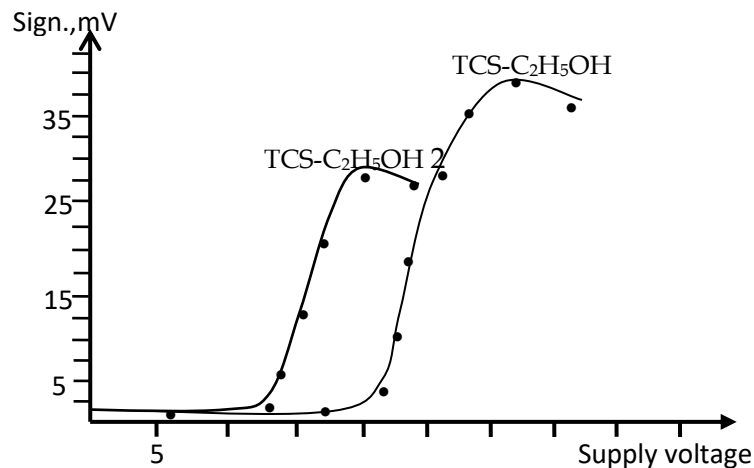


Figure 1. Dependence of the analytical signal thermochemical analyzer  $\text{C}_2\text{H}_5\text{OH}$  on the sensor supply voltage.

As follows from the data presented, the highest signals (of the TSC $\text{C}_2\text{H}_5\text{OH}$ 1M and TSC $\text{C}_2\text{H}_5\text{OH}$ 2M sensors are observed, respectively, at power values of 3.1 and 1.8 V. Therefore, all subsequent experiments to determine the micro- and macroconcentration of ethanol were carried out at these optimized sensor power values.

One of the main requirements for sensors of fire and explosive components is to ensure the rapidity of determining the component (i.e., a short transient time), established by studying their dynamic characteristics.

Checking the dynamic characteristics of the sensor was accompanied by a continuous recording of the transient process of the chart tape of the recorder, the speed of which was chosen such that the transient process schedule was adequate to State Standard 133220-81 "Gas analyzers, industrial automatic". The general technical parameters of the sensor fit on a segment of the chart strip, 15 cm long. The change in concentration at the sensor input was noted on the chart strip and was taken as the time reference. The results of determining the dynamic characteristics of the thermocatalytic sensor TSC $\text{C}_2\text{H}_5\text{OH}$  1M and TSC $\text{C}_2\text{H}_5\text{OH}$  2M are shown in Table 4.

## Dynamic characteristics of a thermocatalytic sensor for ethyl alcohol

№ o/n	Concentration alcohol, mg / m <sup>3</sup> (vol.%)	Sensordynamiccharacteristics *	Time, s.				
			TCS -1	TCS -2	TCS -3	TCS -4	TCS -5
TKC C <sub>2</sub> H <sub>5</sub> OH1 M, CC <sub>2</sub> H <sub>5</sub> OH, mg/m <sup>3</sup>							
1	300	t <sub>0,1</sub>	1	2	1	1	2
2	300	t <sub>0,65</sub>	4	3	5	5	4
3	300	t <sub>0,9</sub>	7	7	7	8	8
4	300	t <sub>π</sub>	9	10	10	10	9

\* t<sub>0,1</sub>- response start time, s; t<sub>0,65</sub> — constant time, s; t<sub>0,9</sub> - time of establishment of indications, s; t<sub>π</sub> - total total measurement time, s.

As can be seen from the data, for the developed sensors, the response start time (t<sub>0,1</sub>) is 1-2 s, the constant time (t<sub>0,65</sub>) is no more than 5 s, and the time for establishing readings (t<sub>0,9</sub>) reaches up to 8 s and the total measurement time (t<sub>π</sub>) 9-10s. The data presented show the possibility of express determination of ethanol by the developed sensors. The dependence of the useful analytical signal TKSC<sub>2</sub>H<sub>5</sub>OH on the alcohol concentration was established in a wide range of its concentration by passing a vapor-gas mixture of ethanol in air through the developed sensor. In the experiments carried out, each point of verification over the measurement range was characterized by six values: three for forward and three for reverse measurement cycles. The analytical signal of the sensors was monitored with a V7-35 voltmeter after establishing a constant value (for at least 1 min, after the standard mixture was fed into the device). The results of the experiments carried out to determine the calibration characteristics of thermocatalytic ethanol sensors are shown in figure 4.3.

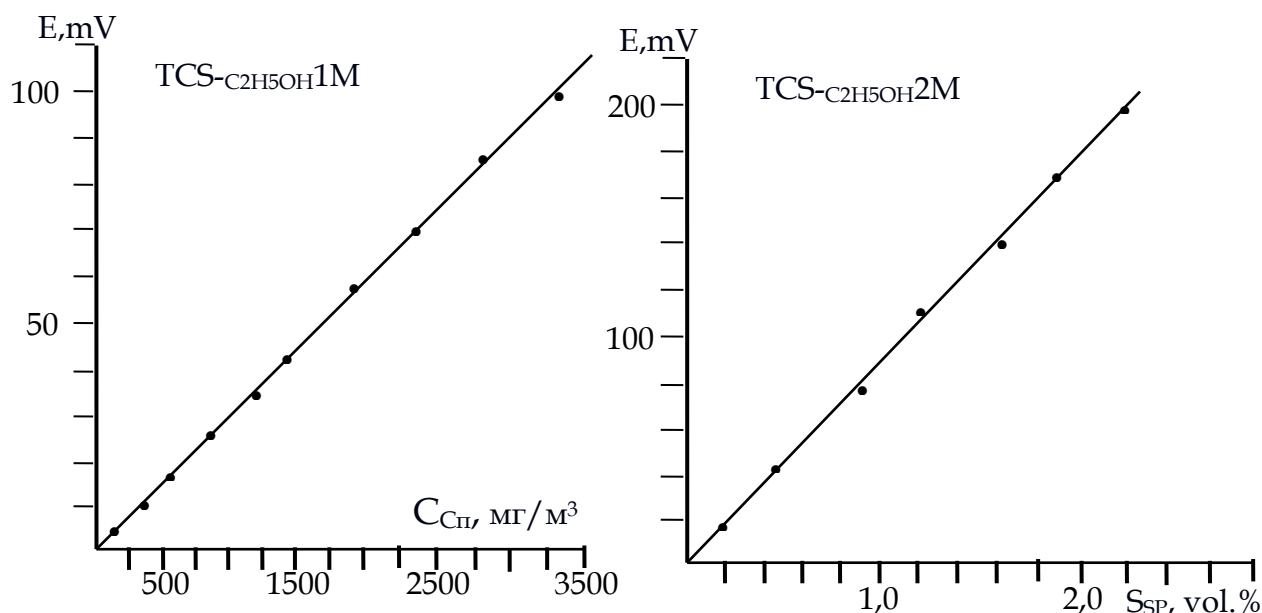


Figure 2. Dependence of the analytical signal of the sensor (E) on the amount of the determined component (S<sub>SP</sub>) in the PGS.



As follows from the data presented, in the studied interval, the dependence of the signal of the thermocatalytic sensors TCS<sub>C<sub>2</sub>H<sub>5</sub>OH</sub> 1M and TCS<sub>C<sub>2</sub>H<sub>5</sub>OH</sub> 2M on the ethanol concentration in the PGS has a linear character.

The source of works of a gas analyzer is closely related to the stability of its signal. As it is known thermocatalytic sensors are characterized by high signal stability. Checking the constancy of the values of the input signals over time was monitored in continuous operation for 2000 hours. When processing the test results, casual single ejection of the output signal were not taken into account with the duration of each surge not exceeding 10 s. Experiments to study the stability of the ethanol sensor were carried out under normal conditions of  $740 \pm 20$  mm Hg. In the experiments, we used PGS with an ethanol content of  $680 \text{ mg / m}^3$  and 1.60 vol%.

Table 5.

Results of determining the stability of TCS-C<sub>2</sub>H<sub>5</sub>OH (n = 5, P = 0.95)

№ o/n	Time, hour	TCS-C <sub>2</sub> H <sub>5</sub> OH 1M C <sub>C<sub>2</sub>H<sub>5</sub>OH</sub> =680mg/m <sup>3</sup>			TCS-C <sub>2</sub> H <sub>5</sub> OH 2M C <sub>C<sub>2</sub>H<sub>5</sub>OH</sub> =1.60vol.%		
		$\bar{x} \pm \Delta x$	S	Sr·10 <sup>2</sup>	$\bar{x} \pm \Delta x$	S	Sr·10 <sup>2</sup>
1	1	19.6±0.1	0.080	0.41	115.5±1.8	1.447	1.25
2	24	19.0±0.2	0.161	0.85	113.9±1.8	1.447	1.27
3	220	20.0±0.3	0.241	1.21	115.1±0.8	0.643	0.56
4	450	19.8±0.4	0.322	1.62	113.8±2.1	1.688	1.48
5	850	19.8±0.4	0.322	1.62	114.4±1.6	1.286	1.12
6	1000	19.0±0.2	0.161	0.85	113.8±2.1	1.367	1.48
7	1400	19.2±0.3	0.241	1.26	115.3±1.8	0.608	0.42
8	1800	19.0±0.3	0.241	1.27	113.9±0.9	0.863	0.75
9	2000	19.8±0.3	0.241	1.22	114.4±1.6	1.286	1.12

The results of the 2000-hour experiment are presented in Table 6., from which it follows that the output signal TCS-C<sub>2</sub>H<sub>5</sub>OH remains stable during the regulated time interval.

Table 6

Results obtained when determining the maximum discrepancy of the alcohol sensor

Sensor	U <sub>max</sub> , mV	U <sub>min</sub> , mV	Δt <sub>g</sub>	GOST tolerance
C <sub>C<sub>2</sub>H<sub>5</sub>OH</sub> =0.33 vol.%	25.1	23.0	2.1	5.0
C <sub>C<sub>2</sub>H<sub>5</sub>OH</sub> =1.60 vol.%	115.5	113.0	2.5	5.0

The change in the value of the output signal for a specified time interval was estimated by the maximum discrepancy of the sensor signal:

$$\Delta t_g = (U_{p_{\max}} - U_{p_{\min}}) 100 / U_{sd} \quad (3),$$

where Δt<sub>g</sub> is the limit of the permissible change in the output signal for a regulated time interval; U<sub>p<sub>max</sub></sub> and U<sub>p<sub>min</sub></sub> - maximum and minimum signal discrepancies; U<sub>sd</sub> - scale of the device (KSP 0-50 mV).

Our calculations show that the value of Δt<sub>g</sub> for a regulated time interval is 2.5% (Table 6.).

In objects where control of ethanol content is required, in addition to alcohol vapors, a number of combustible and non-combustible substances are also contained. The influence of non-combustible components (CO<sub>2</sub>, H<sub>2</sub>O, etc.) contained in controlled gases is excluded when

determining ethanol vapors, which is due to their chemical properties and the capabilities of the method itself, since non-combustible components on the catalyst surface of a sensitive element cannot be oxidized and a thermocatalytic sensor, excluding their influence does not react to them at all. Therefore, the selectivity works of the ethanol vapor sensor was determined in the presence of only combustible components (carbon monoxide, hydrogen and gasoline vapor). The results obtained when establishing the selectivity of the developed ethanol sensors are presented in Table 7.

Table 7.

Results of establishing selectivity in the determination of ethanol (n = 5, P = 0.95)

№ o/n	Introduced gas mixture, vol.% (mg / m <sup>3</sup> )	Found alcohol, vol.% (mg / m <sup>3</sup> )		
		$\bar{x} \pm \Delta x$	S	Sr·10 <sup>2</sup>
TKC <sub>C<sub>2</sub>H<sub>5</sub>OH</sub> 1 MS <sub>alcohol</sub> , mg / m <sup>3</sup>				
1	C <sub>2</sub> H <sub>5</sub> OH 1250+CO 1000+air	1242±7.4	4.985	0.44
2	C <sub>2</sub> H <sub>5</sub> OH 1250+CH <sub>4</sub> 1000+air	1253±9.6	4.663	0.37
3	C <sub>2</sub> H <sub>5</sub> OH 1250+H <sub>2</sub> 1000+air	1245±7.8	6.754	0.54
4	C <sub>2</sub> H <sub>5</sub> OH 1250+CO <sub>2</sub> 1000+air	1252±8.7	5.789	0.46
TKCC <sub>2</sub> H <sub>5</sub> OH1 MS <sub>alcohol</sub> , mg / m <sup>3</sup>				
5	C <sub>2</sub> H <sub>5</sub> OH 0.52+CO 0.50+ air	0.50±0.02	0.016	3.22
6	C <sub>2</sub> H <sub>5</sub> OH 0.52+CH <sub>4</sub> 0.50+ air	0.51±0.01	0.008	1.58
7	C <sub>2</sub> H <sub>5</sub> OH 0.52+H <sub>2</sub> 0.50+ air	0.52±0.02	0.016	3.09
8	C <sub>2</sub> H <sub>5</sub> OH 0.52+бeH <sub>3</sub> . 0,50+ air	0.51±0.01	0.008	1.58

As follows from the above data, the developed sensor allows selective determination of alcohol vapors in human exhaled air and process gases in the presence of carbon monoxide, hydrogen and gasoline vapors. The sensor error in determining the components of the gas mixture does not exceed 1.5%.

### Conclusions

The rmocatalytic techniques with improved metrological characteristics have been developed, and on their basis sensors have been created for monitoring ethanol vapors in human exhaled air and process gases. The developed sensors make it possible to selectively control the content of ethyl alcohol in the presence of CO, CO<sub>2</sub>, hydrogen, methane, acetaldehyde, gasoline and water vapors in wide ranges of their concentrations. The basic metrological characteristics and operational parameters of the developed selective thermocatalytic sensors are estimated.

### References:

1. Muravyova S.I. Handbook on the control of harmful substances in the air.- M .: Chemistry, 1988.- Pages 87-90.
2. Nakamura H., Karube I. Current research activity in biosensors // Anal. Bioanal. Chem. 2003.- V. 377.- № 3.- Pages 446-468.
3. Zefirov N. S. Chemical encyclopedia.- M .: Great Russian encyclopedia. 1995. Vol. 5 - page 783.
4. Medical examination to establish the fact of alcohol consumption and intoxication // Methodical instructions (as amended by the Order of the Ministry of Health of the Russian Federation dated from August 12, 2003 № 399) .- Moscow: 2003: Based on materials from the

site <http://gai.net.ru>

5. On the organization of chemical and toxicological studies in the analytical diagnosis of the presence in the human body of alcohol, narcotic drugs, psychotropic and other toxic substances: Method. directions. Registered in the Ministry of Health of the Russian Federation. - Moscow 2.6.2006: Based on materials from the site <http://gai.net.ru>
6. Rotariu Lucian, BalaCamelia. New type of ethanol microbial biosensor based on a highly sensitive amperometric oxygen electrode and yeast cells // (Laboratory of Quality Control and Process Monitoring, Department of Analytical Chemistry, Faculty of Chemistry, University of Bucharest, Bucharest, Romania) Anal. Lett .. 2003. V.36.-№ 11.- Pages 2459-2471.
7. Bushuev E.S., Babakhanyan R.V., Isakov V.D. Determination of ethyl alcohol in exhaled air and biological fluids: Reference and inform. manual.-SPb .: Juridical Center Press, 2008.- №. 1.- Pages 78-122.
8. Medical provision of road safety. Organization and procedure for conducting pre-trip medical examinations of vehicle drivers // Methodical recommendations. Ministry of Transport of the Russian Federation, 2002.- pages 13-15.
9. Rogozhin, V.V. and Rogozhina, T.V., The use of alcohol dehydrogenase to determine the ethanol content in biological material, Tez. report VII conf. "Analytics of Siberia and the Far East". - 2004.- pages 54-56.
10. Indicator of ethanol vapors in exhaled air with automatic control IPE – "Shark" // Instructions for use of the device. LLC "ERA-COMPANY", 2002.- Pages 11-15.
11. Indicator strip for the qualitative and semi-quantitative determination of alcohol in saliva (ALCO-SKRIN) // Instructions for use of the device of Progressive Bio-Medical Technologies LLC, 2006.- Pages 5-10.
12. Baran S.V. Portable gas analyzers of combustible gases // Safety technology. T.9.-№ 2.- 2005.- pages 25-37.
13. Abdurakhmanov E., Abdurakhmanov B.M., Normuradov Z.N., Gevorgyan A.M. Selectivity of some oxides and sulfides in the process of thermocatalytic monitoring of hydrogen sulfide // Chemical Industry.- SPb. № 6, 2008.- pages 314-319.
14. Abdurakhmanov E., Daminov G.N., Sultanov M.M., Tillayev S.U. Ensuring the selectivity of the thermocatalytic sensor of exhaust gas components // Ecological systems and devices. - Moscow, 2008. - № 5.-pages 30-32.
15. Abdurakhmanov E., Ruziev E.A. Selective thermocatalytic sensors in the ecoanalytical monitoring of gaseous emissions // Chemical Industry. - 2003. - № 9. – Pages 19-25.