BSU INP

Direct Determination of Volatile Compounds in Spirits Products

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Introduction

Over the world day-and-night according to the Official Methods the thousands accredited testing laboratories should determine the following 9 volatile compounds in spirit drinks: *acetaldehyde, methyl acetate, ethyl acetate, methanol, 2-propanol, 1-propanol, isobutyl alcohol, n-butanol, isoamyl alcohol*.

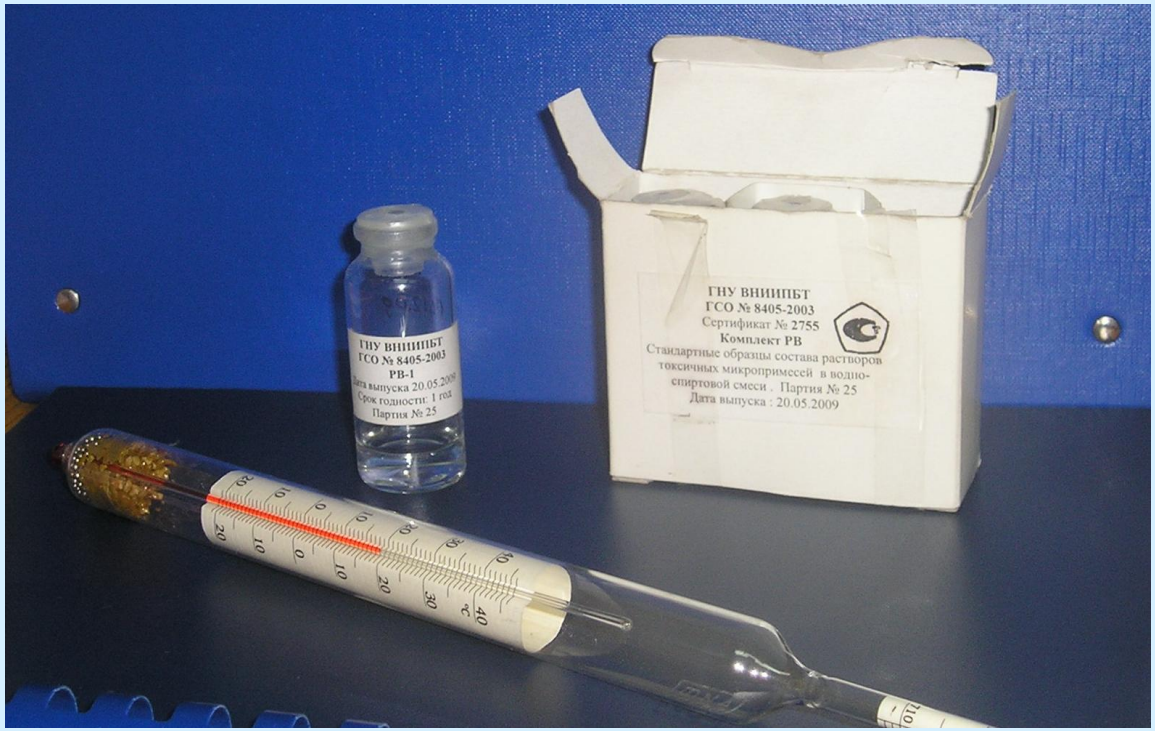
Concentrations of these compounds are expressed in milligrams per liter of absolute alcohol '**mg/L (AA)**'.

In accordance with "Compendium of international methods of wine and must analysis" Commission Regulation EC 2870-2000 and International Organisation of Vine and Wine **(**OIV, 2009, v. 1-2) for quantitation the Internal Standard (**IS**) method is used. These documents propose to use pental-3-ol as IS.

Researchers from formed Soviet States (NIS) make calculation by means of the External Standard (**ES**) method (GOST R 51698).

Finally, to get quantitative values of impurity concentrations in **mg/L (AA)** it is also required to measure alcohol strength (v/v ethanol concentration) of the analyzed sample.

Unsolved 2 problems. 1st



How to measure the volumetric content of ethanol (strength) in a brandy/cognac/whisky sample of less than 15 mL ?

Distillation of the sample must be at least 250 ml .

Unsolved 2 problems. 2nd

How to measure the volumetric content of ethanol (strength) in alcohol products with accuracy less 0,1% when concentration of impurities, for example iso-amilol, are more than 0,3% ?

Note: Concentration of iso-amilol in raw alcohol products often is more than 10 %.

Innovation

We propose the new methodical approach of using '**ethanol-as-IS'** in GC analysis of volatile compounds in spirit products in daily practice of analytical and testing laboratories**.**

This method is absolutely new, original, and innovative. **It improves the reliability of the measured data** as well as substantially **simplifies the total measurement procedure**.

Its substance thoroughly described in the recently published paper - Direct Determination of Volatile Compounds in Spirit Drinks by Gas Chromatography // Journal of Agricultural and Food Chemistry, 2013, 61 (12), 2950–2956 DOI:10.1021/jf3044956.

Method was repeatedly proven in our measuring practices and many times presented to the professional audience last time at:

- Association of Analytical Centers of Russia Annual Meeting, April, 15-17, 2013, Moscow, Russia;
- "In Vino Analytica Scientia", July, 2-5, 2013, Reims, France;
- The 1st International scientific conference "Reference materials in measurement and technology", September, 10-14, 2013, Ekaterinburg, Russia.

Innovation

This method provides direct determination of volatile compound concentrations in spirit drinks expressed directly in **mg/L (AA)** without measuring the alcohol content in the analyzed sample.

The analysis of the experimental results show possibility of developing;

- **New international standard of measurement procedure (to OIV),**
- **New approach to prepare certified references materials (CRF)**

of component composition of alcohol products.

These new methodical approaches will allow significantly increasing the data accuracy and considerably simplify the measurement procedure.

Theoretical background

In our case the GC calibration includes traditional measuring of relative detector response factors RRF_i for every analyzed compound relative to IS (**ethanol**).

RRF_i are calculated from the chromatographic data for standard solutions prepared by gravimetric method with known concentrations of analyzed compounds in **mg/L (AA)**. They may be expressed by the following equation:

$$RRF_i = RF_i / RF_{IS} = \frac{C_i^{st}(sol)}{A_i^{st}} / \frac{C_{IS}^{st}(sol)}{A_{IS}^{st}} = \frac{A_{IS}^{st} \cdot C_i^{st}(sol)}{A_i^{st} \cdot C_{IS}^{st}(sol)} = \frac{A_{IS}^{st} \cdot C_i^{st}}{A_i^{st} \cdot \rho_{Et}} \qquad (1)$$

where ρ_{Et} =789300 mg/L is the known density of ethanol.

Finally the concentration C_i of the *i*-th sample compound relative to **absolute alcohol** has the following form

$$C_i = RRF_i \cdot \frac{A_i}{A_{Et}} \cdot \rho_{Et} = C_i^{st} \cdot \frac{A_{Et}^{st}}{A_i^{st}} \cdot \frac{A_i}{A_{Et}} \qquad (2)$$

The method does not require additional measurements volumetric content of ethanol in the sample

Validation. Standard solutions

Concentration: $$C_*^i(A) = \rho_{Et} \cdot \frac{C^i \cdot m_A^i + C^i(Et) \cdot m_A^{Et}}{C^{Et}(Et) \cdot m_A^{Et} + \sum_{j=1}^{9} C_j^{Et} \cdot m_A^j}, \quad i = 1,\ldots,9 \qquad (1)$$

Uncertainty:

$$u(C_*^i(A)) = \left[\left(\frac{\rho_{Et} \cdot C^i - C_*^i(A) \cdot C_i^{Et}}{Z(A)} \cdot u(m_A^i) \right)^2 + \left(\frac{\rho_{Et} \cdot m_A^i}{Z(A)} \cdot u(C^i) \right)^2 + \left(\frac{\rho_{Et} \cdot C^i(Et) - C_*^i(A) \cdot C^{Et}}{Z(A)} \cdot u(m_A^{Et}) \right)^2 + \left(\frac{\rho_{Et} \cdot m_A^{Et}}{Z(A)} \cdot u(C^i(Et)) \right)^2 + \right.$$

$$\left. + \left(\frac{C_*^i(A) \cdot m_A^{Et}}{Z(A)} \cdot u(C^{Et}) \right)^2 + \sum_{\substack{j=1 \\ j \neq i}}^{9} \left(\frac{C_*^i(A) \cdot C_j^{Et}}{Z(A)} \cdot u(m_A^j) \right)^2 + \sum_{j=1}^{9} \left(\frac{C_*^i(A) \cdot m_A^j}{Z(A)} \cdot u(C_j^{Et}) \right)^2 \right]^{1/2}, \qquad (2)$$

$$Z(A) = C^{Et}(Et) \cdot m_A^{Et} + \sum_{j=1}^{9} C_j^{Et} \cdot m_A^j \qquad u(C^i) = \left(\sum_{j=1(j \neq i)}^{9} u^2(C^j(i)) \right)^{1/2}$$

Method of measurement № 253.0169/01.00258/2013

Validation. Characteristics of standard solutions

Table 1. Concentrations of analyzed volatile compounds are expressed in **mg/L (AA)**. 1-pentanol was introduced as traditional **IS**.

Compound	Concentration, mg/L (AA)							Relative error, % (P=0,95)
	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	
acetaldehyde	4275	1096	111	56,2	11,2	2,22	1,13	± 3 %
methyl acetate	4397	1128	114	57,8	11,5	2,29	1,17	± 3 %
ethyl acetate	4173	1070	108	54,9	10,9	2,17	1,11	± 3 %
methanol	41995	10774	1092	555,5	113,3	24,96	14,3	± 3 %
2-propanol	3991	1025	105	54,1	12,1	3,69	2,70	± 3 %
1-propanol	4012	1029	104	52,8	10,5	2,08	1,06	± 3 %
isobutyl alcohol	3975	1020	103	52,3	10,4	2,06	1,05	± 3 %
n-butanol	4071	1044	106	53,5	10,7	2,11	1,08	± 3 %
isoamyl alcohol	4071	1044	106	53,5	10,7	2,11	1,08	± 3 %
1-pentanol (IS)	27,1	27,1	27,1	27,1	27,1	27,13	27,13	± 3 %

Validation. Standard solutions

Prototype of a novel CRM of component composition of alcohol products. Traditional 2 ml amber glass vials using sealed septa with crimped caps for liquid autosampler. One-off.

Validation. Traditional GC conditions

There were a traditional GC conditions:

GC equipped with FID, a split/splitless injector;

- liquid autosampler;
- Unichrom software;
- capillary column Rt-Wax, 60 m x 0.53 mm, phase thickness 1 μm;
- initial isotherm at 75 °C (9 min), raised to 155 °C at rate 7 °C/min;
- with final isotherm of 155 °C (2.6 min);
- carrier gas was nitrogen;
- gas flow was 2.44 mL/min;
- injector volume 0.5 μL and split ratio 1:20.

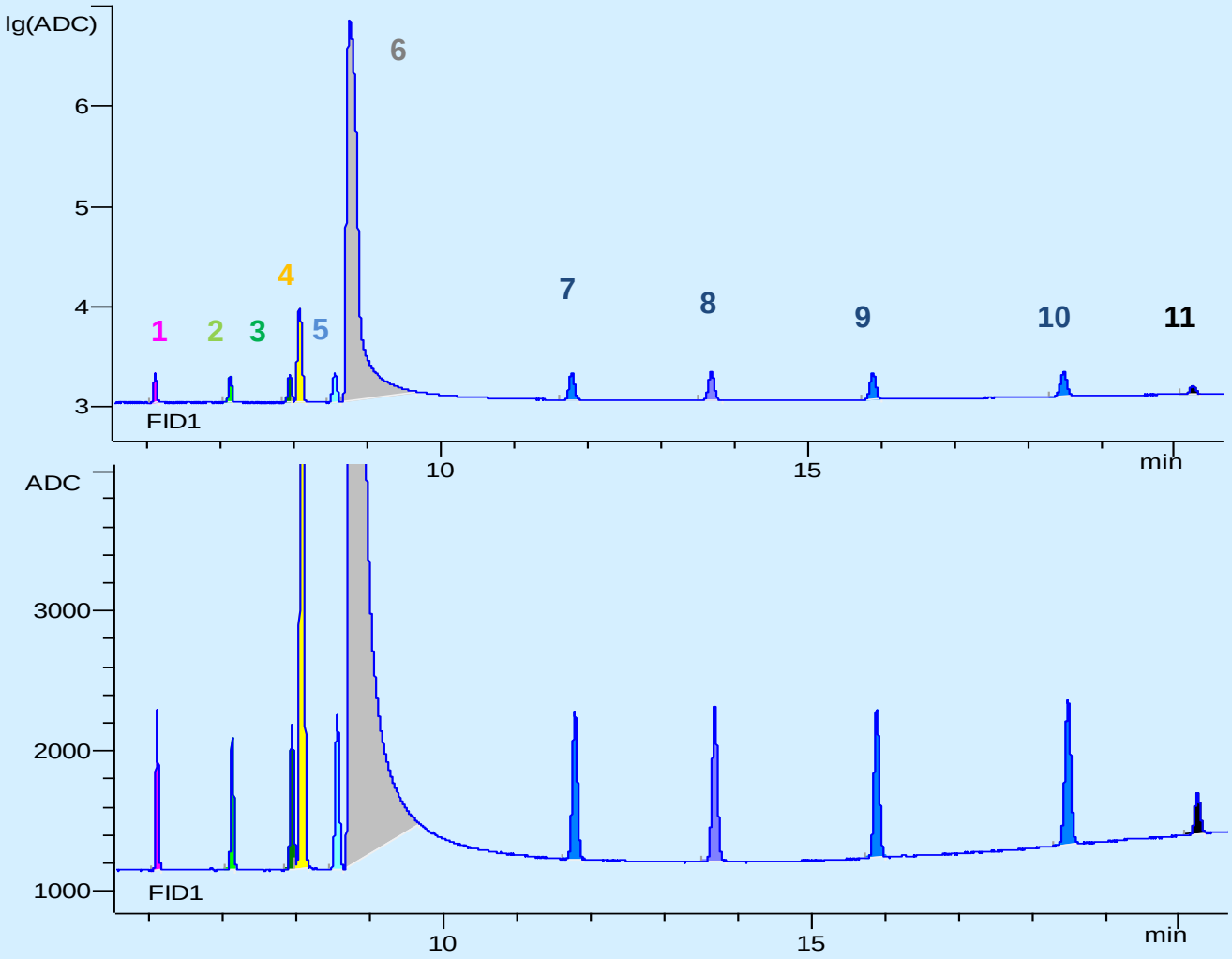
Validation. Standard solutions

In order to study accuracy of the proposed methodical approach in the case of large ranges of volatile compounds concentrations 6 – 20000 mg/L for methanol and 1 – 2000 mg/L for another 8 volatile compounds reference ethanol-water solutions were gravimetrically prepared with known concentrations of volatile compounds.

Validation of this method was been planed in accordance with ISO 5725.

Every reference solution was injected 30 (15 x 2) times.

Validation. Chromatograms



1 - acetaldehyde
2 - methyl acetate
3 - ethyl acetate
4 - methanol
5 - 2-propanol
6 - ethanol
7 - 1-propanol
8 - isobutyl alcohol
9 - n-butanol
10 - isoamyl alcohol
11 – 1-pentanol (IS)

Fig.1. Typical chromatogram of standard ethanol-water (40% vs 60 %) solutions. To show the dominant component ethanol and another compounds synchronously the logarithm scale of response signal is chosen.

Validation. Response factors

Table 2. Analytical characteristics of the obtained calibration graphs

Compound	1-pentanol as IS		ES		Ethanol as IS		LOD* (mg/L)
	RRF	Correlation coefficient, R^2	RF (mg/L)/ (pA*min)	Correlation coefficient, R^2	RRF	Correlation coefficient R^2	
acetaldehyde	2,396	0,9997	266,1	0,9997	1,710	0,9997	0,344
methyl acetate	2,491	0,9997	276,7	0,9996	1,779	0,9999	0,683
ethyl acetate	1,757	0,9997	195,1	0,9997	1,254	0,9999	0,322
methanol	2,133	0,9998	236,9	0,9997	1,523	0,9999	0,231
2-propanol	1,400	0,9998	155,5	0,9997	0,999	0,9999	0,119
ethanol	1,413	N/A	155,5	N/A	1	N/A	N/A
1-propanol	1,179	0,9997	130,9	0,9996	0,841	0,9999	0,222
isobutyl alcohol	1,018	0,9998	113,0	0,9997	0,727	0,9999	0,178
n-butanol	1,117	0,9999	124,1	0,9998	0,798	0,9999	0,189
isoamyl alcohol	1,030	0,9999	114,4	0,9998	0,735	0,9999	0,179
1-pentanol	1	N/A	110,1	N/A	0,708	N/A	0,271

* limit of detection (LOD)

Validation. Linearity for methanol

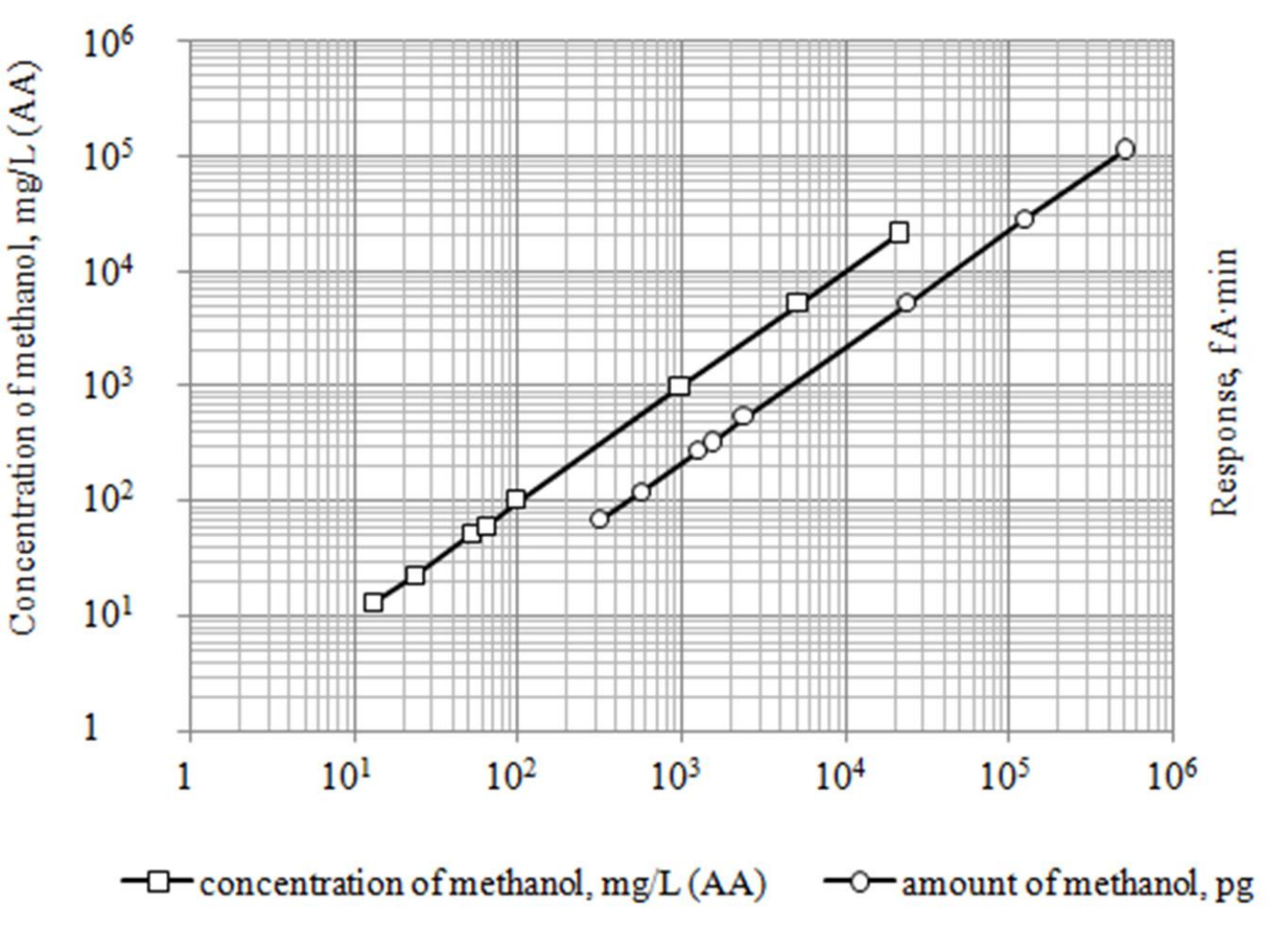


Fig. 2. Analytical characteristics of the obtained calibration graphs for **methanol**.

Validation. Linearity for all other 8 compounds

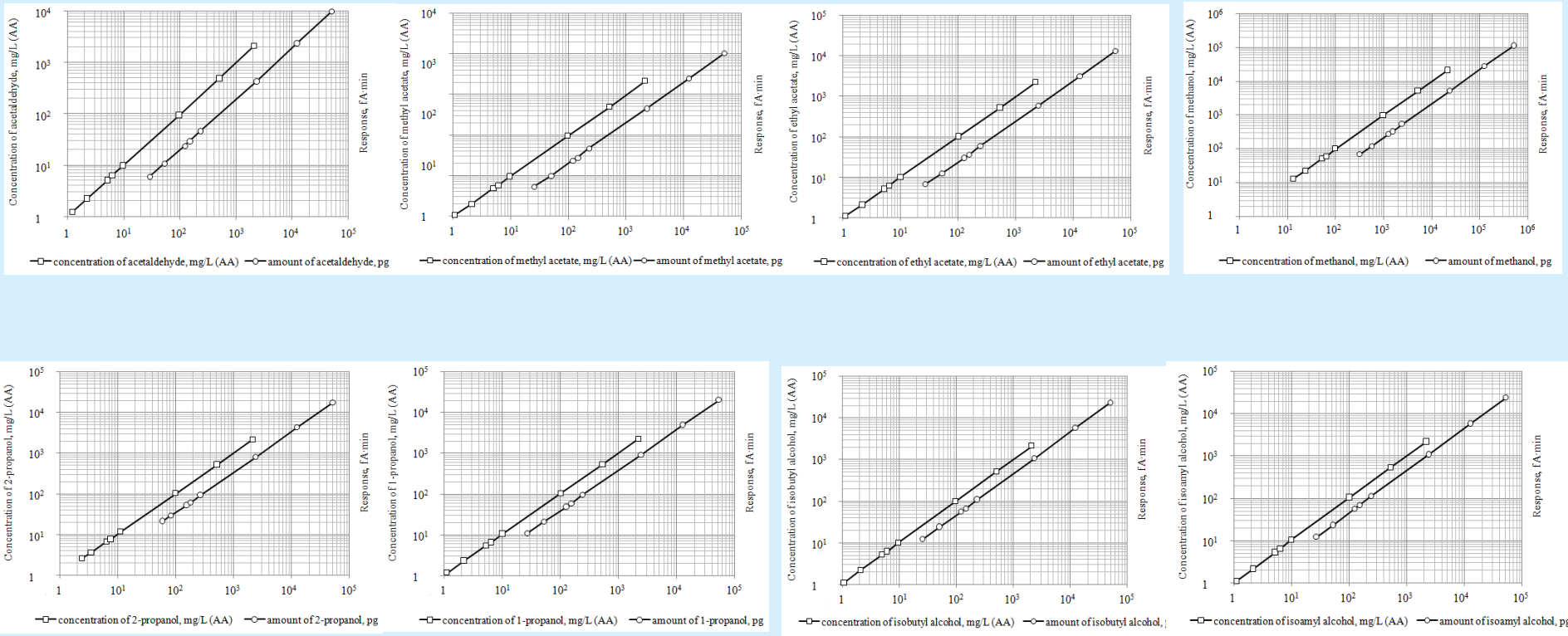


Fig. 3. Analytical characteristics of the obtained calibration graphs for **all other 8 compounds.**

Validation. Stability versus dilution

The standard ethanol-water (96:4) solution of volatile compounds: acetaldehyde, methyl acetate, ethyl acetate, methanol, 2-propanol, 1-propanol, isobutyl alcohol, n-butanol, isoamyl alcohol was analyzed after dilution with water in the ratios 1:1, 1:9, 1:99, 1:999, and 1:9999.

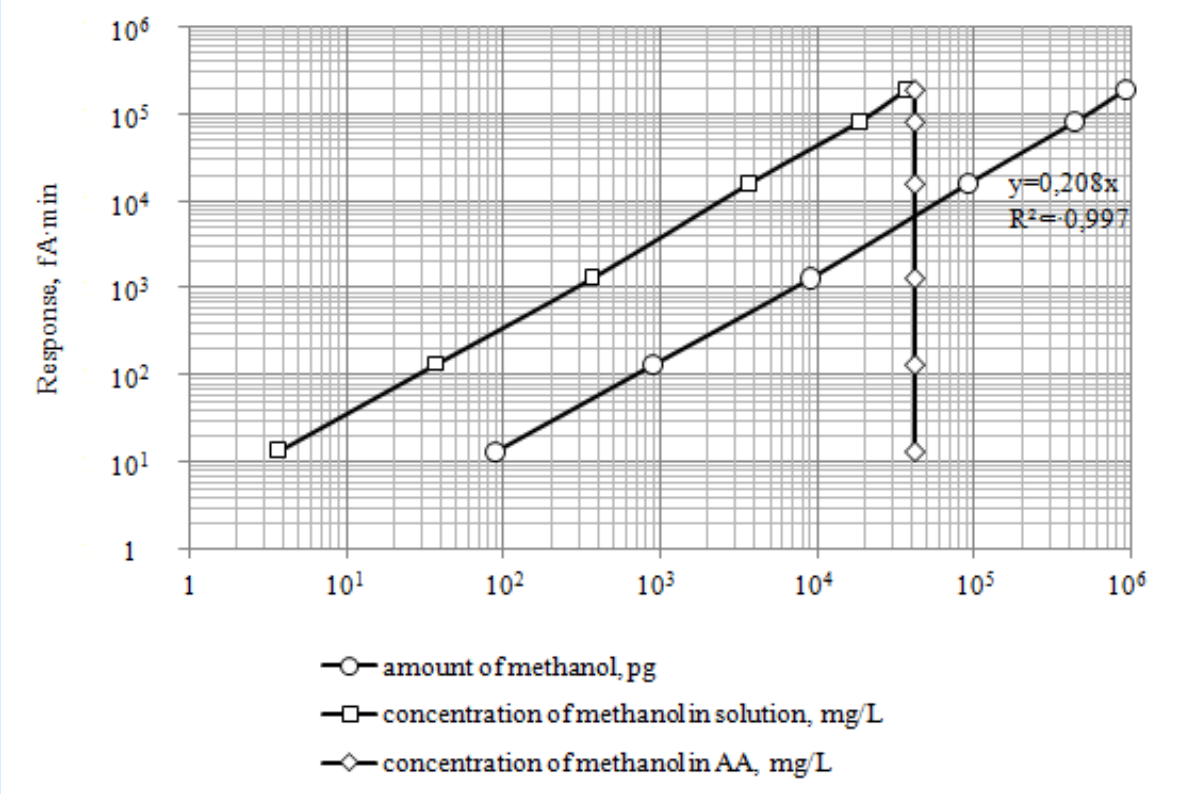


Fig. 4. The first line is the detector response versus the amount of the compound. The second and the third ones are the detector response versus the concentration of the compound, expressed in mg per litre of solution and in mg per litre of absolute alcohol. A corresponding linear dependence is added. Even after dilution with water in the ratio 1:999, the difference between the measured concentrations of all compounds and their values calculated using the gravimetric method does not exceed 7.7 %. .

Validation. Metrological characteristics of ‘ethanol-IS’ method

№ St Sol	acetaldehyde			methyl acetate			ethyl acetate			methanol			2-propanol			1-propanol			isobutyl alcohol			n-butanol			isoamyl alcohol		
	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %	C st, u(C), mg/l	C exp, S(TO), mg/l	Δ, u, %
1	1,23	1,23	-0,1	1,08	1,08	-0,5	1,13	1,10	-2,3	13,39	12,82	-4,2	2,45	2,55	4,0	1,13	1,15	1,8	1,08	1,08	-0,3	1,08	1,07	-0,7	1,12	1,08	-3,8
	0,024	0,07	6,1	0,001	0,04	3,5	0,002	0,05	5,2	0,376	0,22	5,4	0,20	0,07	9,6	0,001	0,07	6,3	0,001	0,05	4,4	0,001	0,07	6,3	0,001	0,06	7,0
2	2,25	2,26	0,2	2,11	1,99	-5,4	2,20	2,08	-5,8	23,72	22,29	-6,0	3,50	3,58	2,2	2,21	2,30	3,8	2,11	2,17	2,6	2,11	2,19	4,0	2,19	2,11	-3,5
	0,025	0,09	4,3	0,005	0,08	6,7	0,005	0,07	6,7	0,382	0,14	6,3	0,20	0,10	6,8	0,005	0,10	5,8	0,005	0,09	5,3	0,005	0,13	7,5	0,005	0,13	7,1
3	5,16	5,10	-1,0	5,04	4,90	-2,9	5,27	5,08	-3,5	53,15	51,28	-3,5	6,49	6,55	1,0	5,29	5,36	1,4	5,05	5,11	1,2	5,03	5,15	2,3	5,22	5,24	0,4
	0,03	0,10	2,2	0,01	0,08	3,3	0,01	0,11	4,1	0,38	0,19	3,6	0,20	0,08	3,5	0,01	0,13	2,9	0,01	0,10	2,3	0,01	0,11	3,3	0,01	0,17	3,4
4	6,44	6,25	-2,9	6,34	5,75	-9,2	6,62	6,16	-7,0	66,17	59,71	-9,8	7,81	7,53	-3,5	6,65	6,41	-3,6	6,34	6,12	-3,6	6,32	6,14	-2,9	6,57	6,30	-4,0
	0,03	0,11	3,4	0,01	0,11	9,4	0,01	0,07	7,0	0,38	1,01	9,9	0,20	0,08	4,5	0,01	0,16	4,3	0,01	0,09	3,9	0,01	0,12	3,5	0,01	0,19	5,0
5	9,75	9,81	0,7	9,68	9,56	-1,2	10,11	10,01	-1,0	99,70	99,78	0,1	11,21	11,50	2,7	10,15	10,51	3,5	9,69	9,98	3,1	9,66	10,07	4,3	10,03	10,38	3,5
	0,03	0,31	3,4	0,01	0,26	3,0	0,01	0,22	2,4	0,39	0,55	0,7	0,20	0,10	3,4	0,01	0,16	3,8	0,01	0,13	3,4	0,01	0,12	4,5	0,01	0,13	3,7
6	96,65	94,06	-2,7	97,38	95,68	-1,7	101,8	101,1	-0,7	980,5	990,3	1,0	100,5	101,2	0,7	102,2	103,3	1,1	97,47	98,97	1,5	97,18	99,28	2,2	100,9	103,6	2,7
	0,15	1,44	3,1	0,12	1,77	2,6	0,13	1,57	1,7	0,85	1,86	1,0	0,23	0,31	0,8	0,12	0,17	1,1	0,12	0,25	1,6	0,13	0,20	2,2	0,12	0,38	2,7
7	506,0	486,8	-3,8	510,5	491,6	-3,7	533,5	520,7	-2,4	5129	5124	-0,1	521,3	515,6	-1,1	535,6	530,8	-0,9	511,0	507,0	-0,8	509,5	506,0	-0,7	529,1	526,2	-0,5
	0,98	5,79	4,0	0,90	12,5	4,5	0,96	9,93	3,1	7,46	11,8	0,3	0,90	0,57	1,1	0,90	0,55	0,9	0,88	0,95	0,8	0,93	1,82	0,8	0,90	2,50	0,7
8	2085	2080	-0,2	2104	2113	0,4	2198	2202	0,2	21128	21130	0,0	2144	2139	-0,2	2207	2206	-0,1	2106	2107	0,1	2099	2104	0,2	2180	2187	0,3
	2,77	20,9	1,1	2,25	10,1	0,7	2,46	5,29	0,3	11,05	20,0	0,1	2,08	5,04	0,3	2,10	2,28	0,2	2,14	3,61	0,2	2,43	6,81	0,4	2,12	11,0	0,6

Table 3. The analysis of experimental data shows that the value of ***relative uncertainty*** ***u*** in the determination of the impurities concentration in experiments in the whole range of concentrations for all examined impurities ***does not exceed 10%***.

Validation. Method was certificated in Rosstandart

001340

ФЕДЕРАЛЬНОЕ АГЕНТСТВО
ПО ТЕХНИЧЕСКОМУ РЕГУЛИРОВАНИЮ И МЕТРОЛОГИИ
(Росстандарт)
Федеральное государственное унитарное предприятие
«Уральский научно-исследовательский институт метрологии»
(ФГУП «УНИИМ»)
Государственный научный метрологический институт

СВИДЕТЕЛЬСТВО
об аттестации методики (метода) измерений

№ 253.0169/01.00258/2013

Методика измерений массовой концентрации летучих компонентов в водке и спирте (наименование методики, включая наименование измеряемой величины, и, при необходимости, объекта измерений, дополнительных параметров и реализуемый способ измерений) **этиловом методом газовой хроматографии**

предназначенная для измерений массовой концентрации летучих компонентов в водке и спирте этиловом методом газовой хроматографии (область использования) в лаборатории аналитических исследований НИИ ЯП БГУ.

разработанная Научно-исследовательским учреждением "Институт ядерных проблем" Белорусского Государственного Университета (НИИ ЯП БГУ). (наименование и адрес организации (предприятия), разработавшей методику)

220030 Беларусь, г. Минск, ул. Бобруйская, д. 11

и содержащаяся в документе "Определение летучих компонентов в водке и спирте этиловом методом газовой хроматографии. Методика измерений" (обозначение и наименование документа, содержащего методику, год утверждения, число страниц)

Методика аттестована в соответствии с ФЗ № 102 "Об обеспечении единства измерений" и ГОСТ Р 8.563-2009.

Аттестация осуществлена по результатам метрологической экспертизы материалов по (теоретических и (или) экспериментальных исследований) разработке методики измерений и экспериментальных исследований

В результате аттестации методики измерений установлено, что методика измерений (нормативно-правовой документ в области обеспечения единства измерений (при наличии) и ГОСТ Р 8.563) соответствует требованиям, предъявляемым ГОСТ Р 8.563-2009

Показатели точности измерений приведены в приложении на 2 л.

Зам. директора по качеству Ю.С.Бессонов

Зав. лабораторией Е.В. Осинцева

Дата выдачи 12.07.2013

Рекомендуемый срок пересмотра методики измерений: 12.07.2018

М.П.

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МЕТРОН

013400

Federal Agency
for Technical Regulation and Metrology
(Rosstandart)
The Federal State Unitary Enterprise
"Ural Scientific-Research Institute of Metrology"
(Federal State Unitary Enterprise "UNIIM")
State Scientific Institute of Metrology

CERTIFICATE
of certification procedure (method)

№ 253,0169/01.00258/2013

Method of measurement of the mass concentration of volatile compounds in alcohol drinks (name of method, including the name of the measured values and, if appropriate, measurement object,) **by Gas Chromatography** (additional parameters and implemented method for measuring) **designed for measuring** of the mass concentration of volatile components in alcohol drinks by (are of use) gas chromatography in the Laboratory of Analytical Research of INP BSU.

developed by the Research Institute "Institute of Nuclear Problems" of Belarusian State University (INP BSU) (name and address of the organization (enterprise) developed the method)

220030 Belarus, city of Minsk, Bobruiskaya Str., 11

and contained in the document "Determination of volatile compounds in alcohol drinks by gas chromatography" (designation and name of the document containing the method, year of approval, number of pages)

Method is certified in accordance with the Federal Law № 102 "On ensuring the uniformity of measurements" and GOST R 8.563-2009.

Certification carried out on the results of metrological examination of theoretical and experimental materials (development of measurement techniques and (or) experimental studies)

As a result of evaluation of the measurement procedure is established that the method meets the (legal document in the area of traceability (if available) and GOST R 8.563) requirements of GOST R 8.563-2009.

Performance measurement accuracy are given in Appendix on 2 pages.

Deputy Director — Yu.S.Bessonov

Head of Laboratory — E.V.Osintseva

Date of issue — 12.07.2013

Recommended for revision of the measurement procedure — 12.07.2018

Russia, 620000, City of Ekaterinburgh, Krasnoarmeiskaya Str., 4
Tel.: (343) 350-26-18, fax: (343) 350-20-39. E-mail: uniim@uniim.ru

Prospection

How to introduce this new method '**ethanol-as-IS**' in the daily practice ?

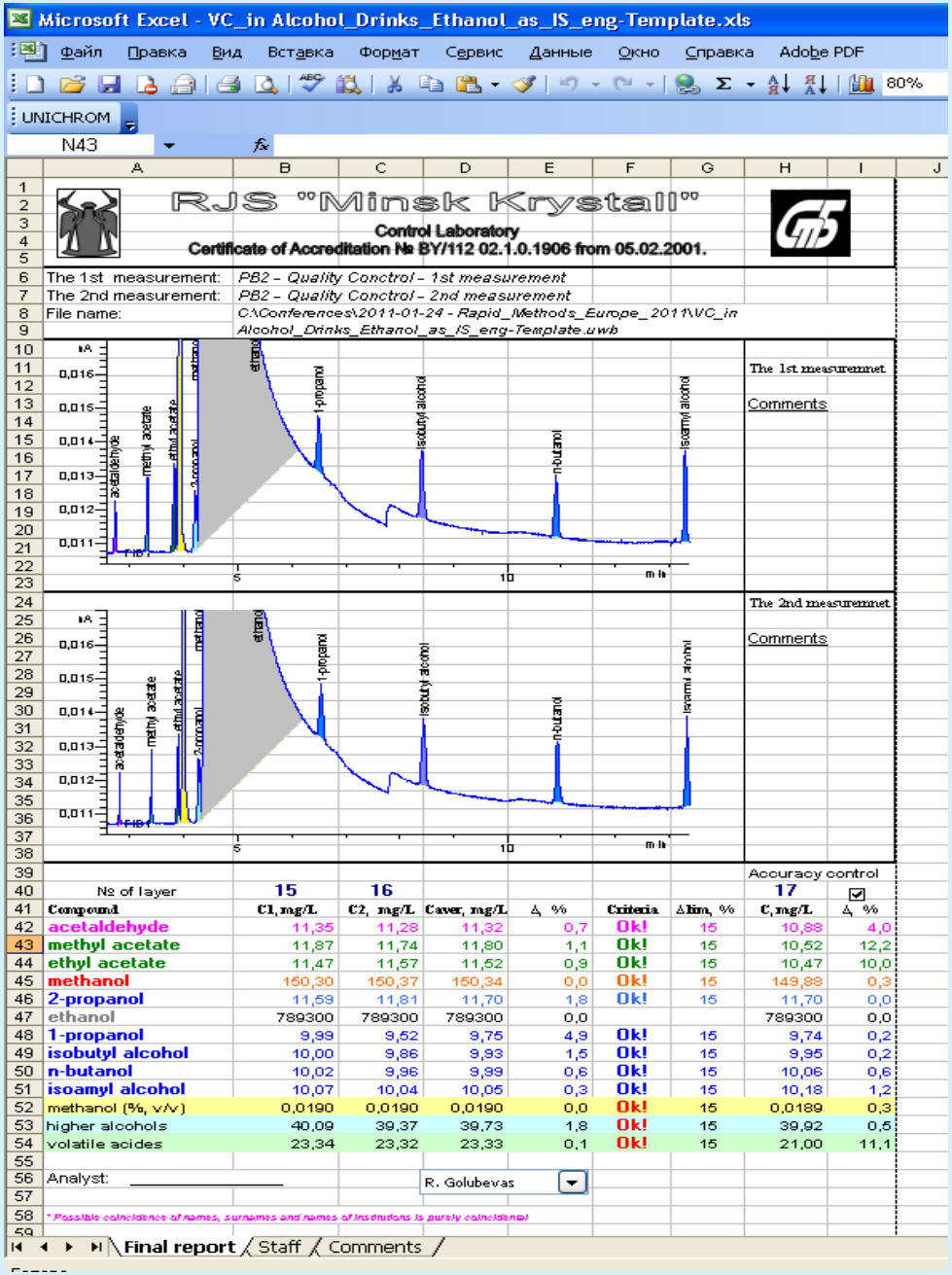
There is only one working way: to propose for customers more easy, attractive and effective way for laboratory business..

Thousands of testing laboratories over the world day-and-night carry out gas chromatographic analysis of volatile compounds in spirit drinks.

They may test and validate this new method in their real practice. It is important to note that there is no need to perform any additional measurements.

Everybody could test and validate '**ethanol-as-IS**' method while performing current measurements with existing instrumentation and calculations could be done in parallel according to the traditional way with addition of '**pental-3-ol**' as IS and using '**ethanol-as-IS**'.

Road map. Unification of final report generation



Generation of final report of any official documents with help of OLE Automation technology.

Road map. Traditional ‘1-pentanol-as-IS’ and ‘ethanol-as-IS’

Bobruisk Hydrolysis Plant
Control Laboratory
Certificate of Accreditation № BY/112 02.2.0.2948 to 29.12.2014.
Chekhova Str., 54, Bobruisk, 213827, Mogilev region, Belarus

The 1st mesurement: *SS-6 (1000 mg/L AA) - 1st measurement*
The 2nd measurement: *SS-6 (1000 mg/L AA) - 2nd measurement*
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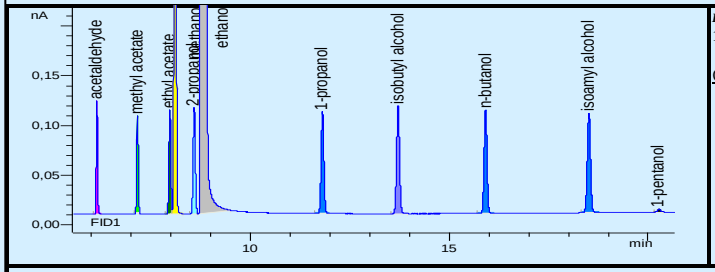
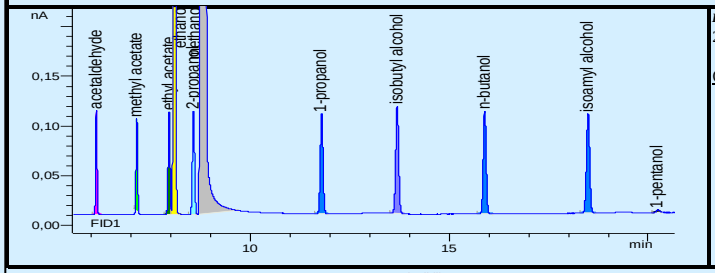


Ethanol_as_ISTD
1st measurement

Comments:



Ethanol_as_ISTD
2nd measurement

Comments:

			Reproducibility			Trueness			
No of layer	3	4				5			
Compoud	**C1, mg/L**	**C2, mg/L**	**Caver, mg/L**	**Δ, %**	**Criteria**	**Δ lim, %**	**C,mg/L**	**Δ, %**	**Criteria**	**Δ lim, %**
acetaldehyde	1163,04	1162,25	1162,64	0,1	Ok!	10	1096,40	6,0	Ok!	10
methyl acetate	1224,67	1122,11	1173,39	8,7	Ok!	10	1127,70	4,1	Ok!	10
ethyl acetate	1144,40	1142,64	1143,52	0,2	Ok!	10	1070,30	6,8	Ok!	10
methanol	11408,93	11382,99	11395,96	0,2	Ok!	10	10774,00	5,8	Ok!	10
2-propanol	1066,65	1064,46	1065,56	0,2	Ok!	10	1025,00	4,0	Ok!	10
ethanol	789300	789300	789300	0,0	Ok!		789300	0,0	Ok!	
1-propanol	1063,86	1063,16	1063,51	0,1	Ok!	10	1029,00	3,4	Ok!	10
isobutyl alcohol	1063,98	1059,30	1061,64	0,4	Ok!	10	1019,60	4,1	Ok!	10
n-butanol	1090,73	1092,01	1091,37	0,1	Ok!	10	1044,20	4,5	Ok!	10
isoamyl alcohol	1088,60	1092,13	1090,36	0,3	Ok!	10	1044,20	4,4	Ok!	10
methanol (%, v/v)	1,4391	1,4358	1,4374	0,2	Ok!	10	1,3590	5,8	Ok!	10
higher alcohols	5373,83	5371,05	5372,44	0,1	Ok!	10	5162,00	4,1	Ok!	10
volatile acides	2369,07	2264,76	2316,91	4,5	Ok!	10	2198,00	5,4	Ok!	10
1-pentanol	**28,27**	**28,15**	**28,21**	**0,4**	**Ok!**	**10**	**27,13**	**4,0**	**Ok!**	**10**

Analyst _____ *Makoed S.F*

Head of Lab _____ *Leskovets O.P.*

**All the mentioned names, surnames and organisations are accidental and not related with real persons and or insitutions.*

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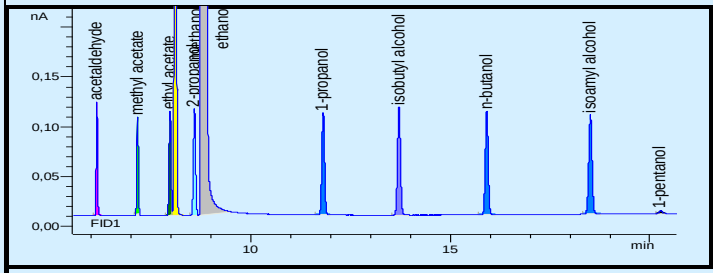
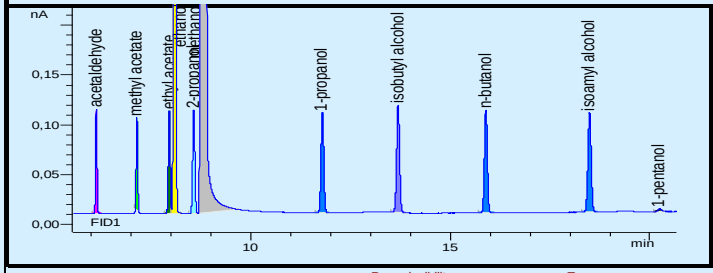
The 1st mesurement: *SS-6 (1000 mg/L AA) - 1st measurement*
The 2nd measurement: *SS-6 (1000 mg/L AA) - 2nd measurement*
File name: *\\Black\documents\IS_and_ES_and_Ethanol-as-ISTD_rus\IS_and_ES_and_Ethanol-as-ISTD.uwb*



Pentanol_as_ISTD
1st measurement

Comments:

Ethanol, % (v/v)
96



Pentanol_as_ISTD
2nd measurement

Comments:

Ethanol, % (v/v)
96

			Reproducibility			Trueness			
No of layer	3	4				5			
Compoud	**C1, mg/L**	**C2, mg/L**	**Caver, mg/L**	**Δ, %**	**Criteria**	**Δ lim, %**	**C,mg/L**	**Δ, %**	**Criteria**	**Δ lim, %**
acetaldehyde	1152,69	1156,53	1154,61	0,3	Ok!	10	1096,40	5,3	Ok!	10
methyl acetate	1213,60	1116,43	1165,02	8,3	Ok!	10	1127,70	3,3	Ok!	10
ethyl acetate	1133,99	1136,79	1135,39	0,2	Ok!	10	1070,30	6,1	Ok!	10
methanol	11305,46	11324,98	11315,22	0,2	Ok!	10	10774,00	5,0	Ok!	10
2-propanol	1014,75	1059,09	1036,92	4,3	Ok!	10	1025,00	1,2	Ok!	10
ethanol	#ССЫЛКА!	789300	#ССЫЛКА!	########	#ССЫЛКА!		789300	#ССЫЛКА!	#ССЫЛКА!	
1-propanol	1011,99	1057,68	1034,84	4,4	Ok!	10	1029,00	0,6	Ok!	10
isobutyl alcohol	1012,14	1011,73	1011,94	0,0	Ok!	10	1019,60	-0,8	Ok!	10
n-butanol	1037,69	1086,53	1062,11	4,6	Ok!	10	1044,20	1,7	Ok!	10
isoamyl alcohol	1035,71	1086,69	1061,20	4,8	Ok!	10	1044,20	1,6	Ok!	10
methanol (%, v/v)	1,4260	1,4285	1,4272	0,2	Ok!	10	1,3590	5,0	Ok!	10
higher alcohols	5112,28	5301,73	5207,01	3,6	Ok!	10	5162,00	0,9	Ok!	15
volatile acides	2347,60	2253,23	2300,41	4,1	Ok!	10	2198,00	4,7	Ok!	15
1-pentanol	27,13	27,13	27,13	0,0	Ok!	10	27,13	0,0	Ok!	10

Analyst _____ *Makoed S.F*

Head of Lab _____ *Leskovets O.P.*

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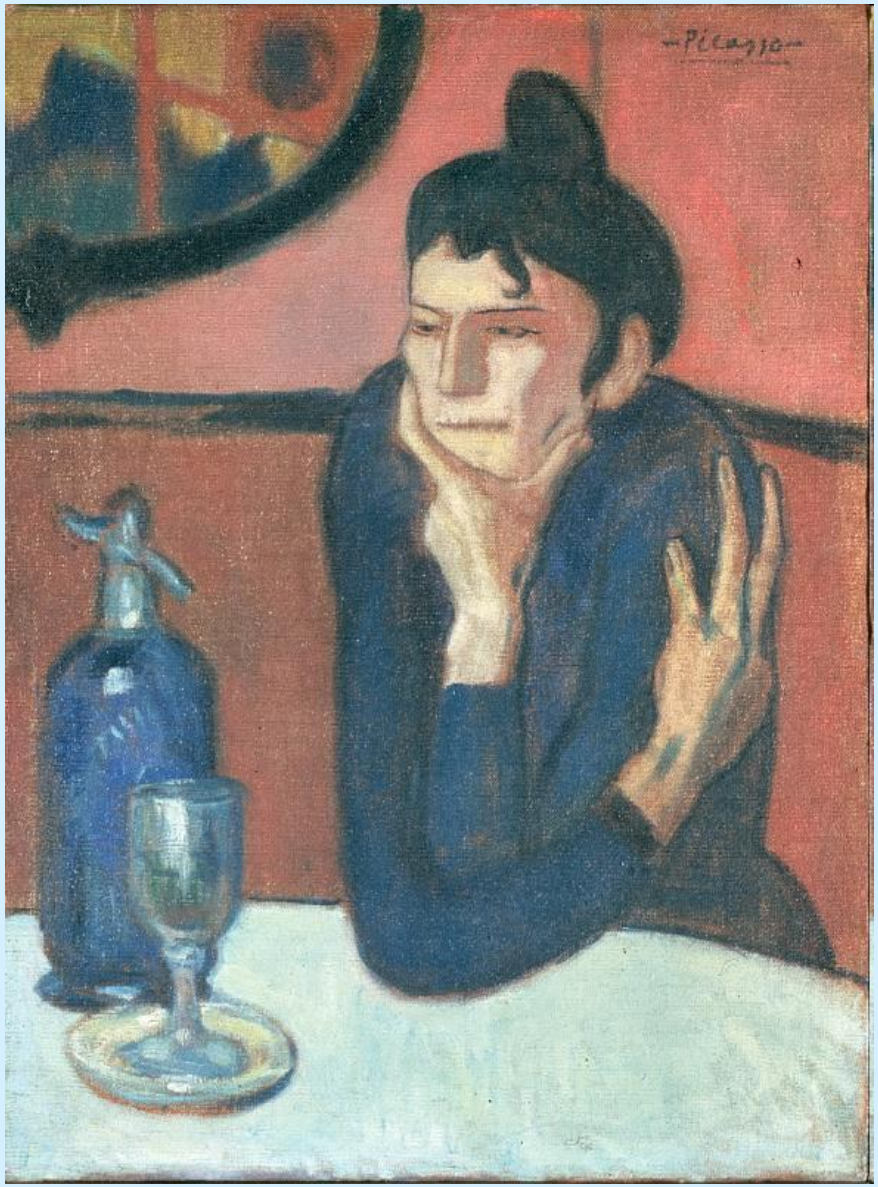
Generation in parallel two reports: traditional ‘**1-pentanol-as-IS**’ and ‘**ethanol-as-IS**’

Thanks You for attention !



I have a dream…

…ethanol should be the ISTD !