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METHOD AND GAS DISCHARGE VISUALIZATION TOOL FOR ANALYZING LIQUID-PHASE BIOLOGICAL OBJECTS

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***Abstract**: In the article are presented the results of researches that touch the problem of the reliability improvement of determining the impurities concentration in biological objects in liquid by using the method of gas discharge visualization. There is an improved analysis method for biological objects in liquid based on gas discharge visualization (GDV), proposed criteria approach towards the assessment of liquid bio object's composition applying this method, presented the assessment of the nature of liquid bio objects, which use the intensity of spectral components of its radiation has gotten during GDV. There is a developed and researched math model of ignition of a crown discharge and the dependency of spectrum intensity of radiation of liquid-phase biological object on its chemical composition proposed a conversion function for the assessment of the impurities concentration, together with the informative parameters of GDV images. All the results of the experimental researches of GDV and spectral composition of liquid-phase biological objects (LPBO) are presented in the article. The proposed approach lets specify the range of Mg concentrations in an oral fluid (OF) at various thyroid disorders obtained by the trilonometric method. It was found that the concentration of Mg in oral fluid of patients without thyroid disease is 12.73 ± 2.16 mg/l, patients with risk factors for thyroid disease have a concentration of 14.98 ± 1.92 mg/l, patients with sporadic goiter have a concentration of 26.65 ± 3.73 mg/l. Such data allow providing the patients with a better diagnosis of pathological disorders in glandular thyroids that are based on the concentration of Mg in oral fluid. It is confirmed that the concentration of Mg in oral fluid greater than 15 mg/l may indicate the presence of trilonometric pathology, including the focal thyroid gland.*

Keywords: gas discharge visualization, liquid-phase biological objects

METODA I NARZĘDZIE DO WIZUALIZACJI WYŁADOWAŃ GAZOWYCH DO ANALIZY OBIEKTÓW BIOLOGICZNYCH W FAZIE CIEKŁEJ

***Streszczenie**: W artykule przedstawiono wyniki badań poruszających problem poprawy wiarygodności oznaczania stężenia zanieczyszczeń w obiektach biologicznych w cieczy metodą wizualizacji wyładowań gazowych. Opracowano ulepszoną metodę analizy obiektów biologicznych w cieczy opartą na wizualizacji wyładowań gazowych (GDV), zaproponowano podejście kryterialne do oceny składu obiektów biologicznych w cieczy z zastosowaniem tej metody, przedstawiono ocenę charakteru obiektów biologicznych w cieczy wykorzystującą intensywność składowych spektralnych jej promieniowania uzyskanego podczas GDV.Opracowano i zbadano model matematyczny zapłonu wyładowania koronowego oraz zależność intensywności widma promieniowania obiektu biologicznego w fazie ciekłej od jego składu chemicznego, zaproponowano funkcję przeliczeniową do oceny koncentracji zanieczyszczeń wraz z parametrami informacyjnymi obrazów GDV. W artykule zostały przedstawione wszystkie wyniki badań eksperymentalnych GDV i składu spektralnego obiektów biologicznych w fazie ciekłej (LPBO).Proponowane podejście pozwala określić zakres stężeń Mg w płynie z ust, przy różnych schorzeniach tarczycy uzyskanych metodą trylonometryczną.Stwierdzono, że stężenie Mg w płynie z ust pacjentów bez chorób tarczycy wynosi 12,73 ± 2,16 mg/l, u pacjentów z czynnikami ryzyka chorób tarczycy stężenie wynosi 14,98 ± 1,92 mg/l, u pacjentów z wolem stężenie wynosi 26,65 ± 3,73 mg/l.Dane te pozwalają na zapewnienie pacjentom lepszej diagnostyki zaburzeń patologicznych w tyreocytach gruczołowych, które opierają się na stężeniu Mg w płynie ustnym.Potwierdza się, że stężenie Mg w płynie ustnym większe niż 15 mg/l może wskazywać na obecność patologii trylonometrycznej, w tym ogniska w tarczycy.*

Słowa kluczowe: wizualizacja wyładowań gazowych, obiekty biologiczne w fazie ciekłej

Introduction

Glándula tiroides (GT) is one of the important glands of inner secretion that is very sensitive toward the influence of outcomes of the many diseases caused by an environment state, a diet, an iodine deficit, inflectional diseases, and stresses. Bad environmental conditions in Ukraine, in particular, the Chernobyl accident, cause the number of patients with GT disorders increasing [2].

There are harmonic researches, medical ultrasound, biopsy, scintigraphy methods, thermography, X-rays, and other methods for the GT disorders diagnosis. But many of these methods very often need worthy and practically rare tools, can make a negative influence on a humane body, need significant time for implementation and the reliability of these methods on the first stage of a disease does not reach 91%. So, searching for new diagnosis methods are still actual today [3].

Any thyroid pathology (every enlargement of GT not depending on its functional state, morphological changes, and causes), in particular during focal pathology of GT (knotted struma, growth, cyst, thyroid) is followed by the growth of metal concentration (Al, Mg, Ca, Sc, Co, Cu, Zn, As, Zr, Ba) in its tissues. The concentrations of Mg and Ca is the biggest in this fluids and vividly correlate with each other because its correlation represents in-cell homeostasis and form antioxidant protection of cells, when the regulation of Ca-F-Mg change is provided, in many folds, by GT. In the first stage of thyroid diseases, the quantity of Mg in blood's plasma does not indicate the in-cell Mg deficit. So, it's worthy to use the probe of Mg rate in oral fluid for disease diagnosis on the first stage of health problems because of the strict similarity between oral liquid and in-cell liquid chemical specificities [8, 15].

The current oral fluid researches are based on applying mass spectrometry, fluorescent, potentiometric measure, luminescent, interferometric, colorimetric, etc. research methods. Let's find out the chemical and biological composition of OF, but the needed tools are still large, worthy, or need a too big quantity of chemical agents, need a too long time for analyses. So, the development of new research methods and tools for a chemical express analysis of OF composition is still an important and an actual goal [13, 14].

One of the modern express methods of the research of liquid phase biological objects (LPBO) (together with OF) is gas discharge visualization (GDV), which happens during the influencing of a biological object (BO) by an alternative (a frequency more than 1000 Hz) electromagnetic field that has a huge voltage (20-25 kV per sm) when an object starts to radiate a shine caused by a gas discharge between BO and an electrode. BO is a part of an electric circuit, so it influences the shine specificity. So, analyzing of a discharge depiction can help to determine the state of BO [11, 16].

The LPBO method has found its domain in the medical procedures of the health conditions' screening and monitoring, the quantitative methods of an assessment of stress level, and readiness to fulfill complicated professional activities, researching the characters of fluids and materials. In its devices are researched the shine radiated by human's limbs or an LPBO. Currently, there is a bunch of researches that implement GDV of different objects and have a similar biophysical approach towards the storage of data gotten on the base of a fractal depiction analysis. It is the main difference between the GDV method and Kirlian photography because the additional computer processing and modern math methods applying are taken place. On the base of gotten data, further analysis or expert assessment is fulfilled. But in most cases, the results of researches have biases and do not present the quantitative assessment of the state of a human body.

The last decades are carried out the researches that let state the physical aspects of GDV and create the principally new classes of tools for BO and LPBO researches that apply in its works the last microelectronic and computer methods of image processing achievements. But the diagnosis potential of the GDV method is narrowed by the absence of standardization of work tools and image analysis. The similar experiments that are fulfilled by different researchers do not get the same meanings which cause the low probability of provided assessment. So, the development of a further approach of GDV implementation is still actual.

1. The main content of the work

The chemical and biological compositions of the oral fluids (OF) depend on the state of the oral space and the activities of the inner body's organs. Approximately 20% of all known proteins are residents simultaneously as in the saliva so in the blood. OF is secreted by a body with the intensity of 1.5 liters per day and, as a more dynamic organic fluid than blood, can distinctly represent all changes of a body's state. So, an analysis of OF composition by the means of the different methods lets found inappropriate states of body health and formulate a diagnosis (hepatitis, HIV, diabetes mellitus, caries, thyroid disease, etc). According to a proposed analysis of the known methods of a body's states and diseases diagnosis and on the base of the researches of the physical, chemical, and biological parameters of OF, the authors propose the classification of the known methods which are helpful in case of the diagnosis of a body's state and a healthy level and include the researches of the chemical, physical, biological parameters of OF [6]. The analysis of the biological fluids of the human body can identify approximately all diseases and the blood is a typical fluid for signalizing but the potential of oral fluids like a substance for lab testing is also very huge. It was stated that increasing of magnum concentration over 15 mg/l grade in adults' OF can be caused by the thyroid diseases or gastroduodenal illness, and it's decreasing to less than 2 mg/l grade can signify such heart diseases as an arrhythmia, tachycardia, etc. So, an analysis of OF allows put a diagnosis under the thyroid diseases, which are currently identified by the means of a palpation and an ultrasound diagnostic, and in this way hardly depends on the physicians' work experience.

So, the improvements of FBO analysis methods on the base of GDV is proposed, the criteria approach of LPBO composition assessment on the base of this method is started, the assessment of LPBO composition which applies the intensity of spectrum components of its radiation during the process of GDV is proposed, the math models of a streamer are developed, the function of impure's concentrations founding is gotten, describing the model of intensities of the central section of the normalized spectrum image together with a bunch of informative parameters of LPBO images is proposed by the authors.

The improved method of an LPBO analysis on the base of GDV uses the informative parameters of the sample LPBO and researched LPBO which are gotten simultaneously under the same internal and external conditions and in this way let's get the informative parameters for both LPBO that can be comprised without any additional corrections. The proposed method can be used as for the analysis of spectrum's compositions of LPBO radiations during possessing of GDV, so for the analysis of OF images which was gotten by the means of GDV.

The analysis of the spectrum's compositions of LPBO radiations in the case of GDV takes the researches of two LPBO samples that have concentration rates C_1 and C_2 using a GDV method under the conditions of constant parameters of the applied voltage (p, U, f) and typical frequency of the optical radiation ν_{ij}. The dependency of radiation intensity I_e on a dash concentration C in LPBO during using the typical frequency of radiation

$$I_e = (h\nu_{ij} A_{ij} a_{ij}(p, E, f))^b C^b, \quad (1)$$

where:
$h\nu_{ij}$ –photon energy, which is emitted during the quantum passing from energy state W_i to energy state W_j,
$a_{ij}(p,E,f)$ – the coefficient that indicates the number of atoms which have reached the state W_i when such work parameters as a gas pressure p, a voltage of electrical field E, a frequency of the applied voltage f are constant,
C – the initial concentration of neutral atoms,
b – reabsorbing coefficient.

The dependency of the C_2 impurity concentration on the intensity of both sample and model LPBO under the condition of the same applied voltage and the known concentration of C_1 impurity in model LPBO has the next equation.

$$C_2 = C_1 \sqrt[b]{\frac{I_{e1}}{I_{e2}}} \quad (2)$$

where I_{e1} and I_{e2} are the intensities of the model and sample LPBO radiations on the typical frequency of radiation.

The streamer's image is a superposition of partial crown streamers on a one-half period of alternated voltage or the integral image of shining of alternating partial crown streamers. The normalized streamers image is an image that takes only one streamer, the central one of which comes together with the image's center, and the brightest part of the streamer is situated on the lower part of the image. The developed math model of the streamer lets define the dependency of the mean length of streamer $\overline{l}$ on the geometrical parameters of LPBO (Figure 1), its chemical compositions and the parameters of an applied voltage

$$\overline{l} = \frac{U\sigma}{2\pi r_\kappa heN_a \sum_{i=1}^{k} \frac{a_i m_i}{M_i}} t\left(1 + \frac{\omega\cos(\omega t)t}{\sqrt{2}}\right) \quad (3)$$

where:
r – a drop's radius;
σ – a drop's specific conduction;
h – the height of drop's edge;
e – an elementary charge;
α_i – a dissociation rate of i substance, which is a part of LPBO;
m_i – the mass of i substance, which is a part of LPBO;
M_i – molar mass of i substance, which is a part of LPBO;
N_a – the number of Avogadro;
t – the mean duration of electron avalanche's life;
U – the action significance of applied alternated voltage;
ω – the cyclical frequency of applied voltage [8].

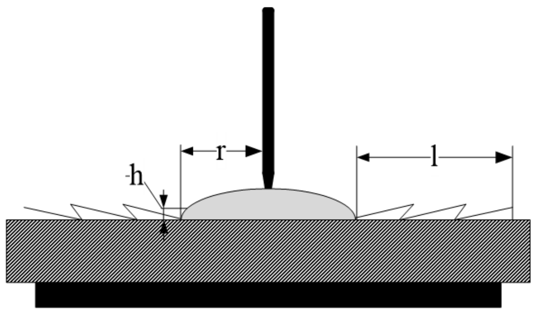


Fig. 1. The physic model of LPBO and its geometric parameters

In the graphs, 2–4 are presented the dependencies of streamer's length on the applied voltage's value, its frequency, and the molar concentration of impurities.

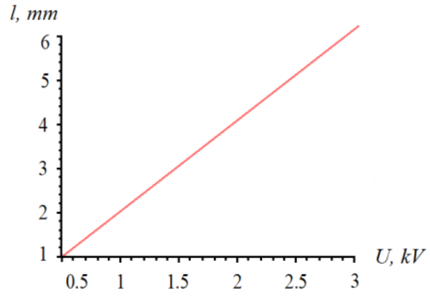


Fig. 2. The dependency of streamers length on applied voltage

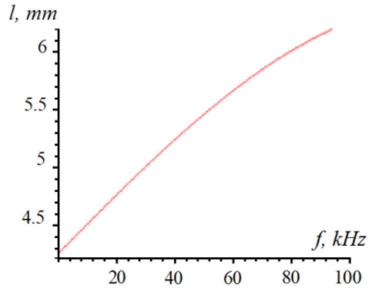


Fig. 3. The dependency of streamers length on the frequency

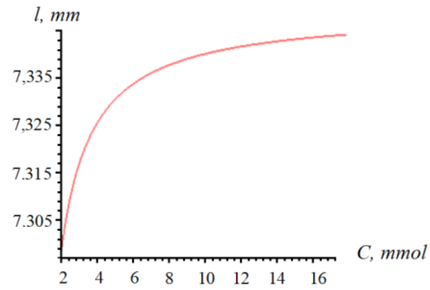


Fig. 4. The dependency of streamers length on NaCl concentration

As one can see in the graph, the dependency of a streamer's length on a voltage and frequency is linear and its dependency on a molar concentration of impurities is linear in the case of a small concentration rate [4].

As a result of experimental research works the next series of LPBO images, that have a clear picture of a streamer, is gotten by the means of GDV (figure 5).

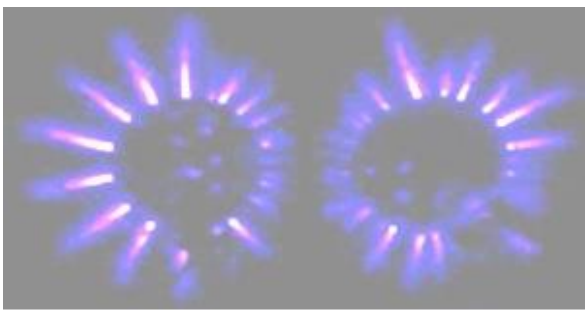


Fig. 5. The LPBO images are gotten by GDV implementing

The streamer's analysis shows that the brightness of the central section tends to increase or decrease according to an exponential low.

$$I = I_1 e^{k_1 x} \tag{4}$$

$$I = I_2 e^{k_2 x} \tag{5}$$

where I – a pixel's brightness; x – the number of a pixel from the end of the streamer (the pixel intensity of which a higher than a background), I_1 and I_2 – the optimal value of the maximal intensities of the central streamer's section for, in proportion, increasing and decreasing of streamers' brightness; k_1 and k_2 – the coefficients of increasing and decreasing of the brightness of streamer's central section.

The proposed empirical model of the distribution of the intensity of the central section of a normalized streamer's is

$$I = \frac{B}{x^3\left(\exp\left(\frac{A}{x}\right)-1\right)} \tag{6}$$

where A, B – the energetic streamer's coefficients, which are defined on the base of an approximation of the values of the central section's brightness [2].

On the base of analyzing of experimental data in addition to such informative parameters as I_1, I_2, k_1, k_2, A and B, is proposed to apply the next important parameters: I_{max} – the maximal intensity rate of streamer's central section; L_i – the pixel's quantity beginning from the first one that is over the noise level to the one that has maximal intensity I_{max}; L_s – the number of pixels on which the intensity of central section of normalized streamer's image is alternating; S_s – the mean brightness of a streamer (divide the sum of brightness of the all pixels L_i on the number of such pixels); S_i – the mean brightness of an image (divide the sum of image pixel's brightness that is over the line of noise's brightness on its quantity). All parameters instead of S_s and S_i, are defined in a section that is drawn through the symmetry that has a pixel of maximal brightness I_{max} (Fig. 6).

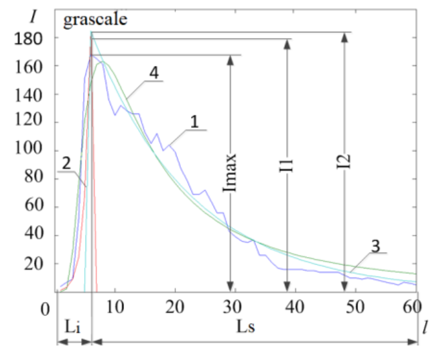


Fig. 6. The intensity distribution of central section of streamer's image and its parameters: 1 – the intensity distribution of central section: 2 – the intensity of increasing, 3 – the intensity of decreasing, 4 – the approximated characteristic

To estimate LPBO state, the complex criterion of purity is developed on the base of the proposed informative parameters

$$K = \frac{UI\tau k_1 T}{cm\Delta t k_2 AB} \tag{7}$$

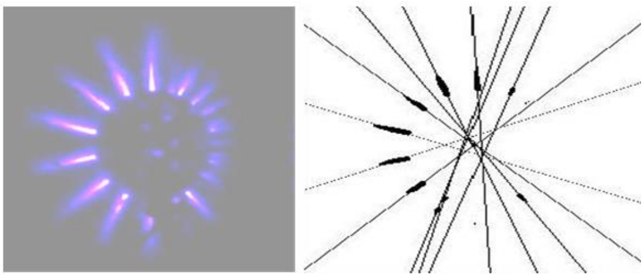
where U – a value of a voltage applied to LPBO; I – an electric current that goes through LPBO; τ – a time of voltage applying; c –specific heat of an object; m – a mass of an object; Δt – the change of LPBO temperature during a voltage applying.

The criteria access to the assessment of LPBO composition by the means of the improved method of analyzing of LPBO composition on the base of GDV using the parameters of the normalized streamers' images lets retrieve the informative parameters for both images of LPBO. Then, both can be compared without any previous correction.

To get the space distribution of streamer's brightness, the parameters of the LPBO image and the complex criteria the next method are developed and it includes the next sequence of steps:

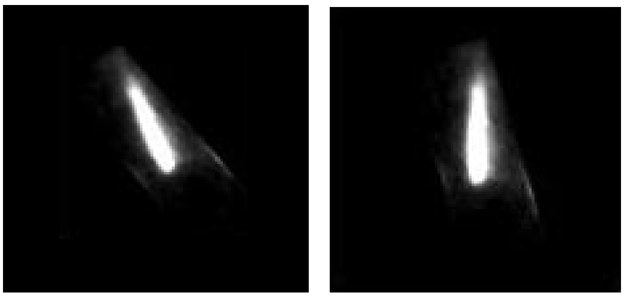
1) Preparing and setting a model and a sample LPBO in special cells of a GDV device.
2) Influencing of a charge on a model and a sample LPBO.
3) Getting of discharge image of a model and a sample LPBO by the means of GDV.

4) The division of LPBO depiction on a model and a sample images.
5) Uploading of a model LPBO image (Fig. 7a).
6) Execution of the image's threshold processing (Fig. 7b).
7) Execution the scanning of the image to find out the streamers.
8) Streamer finding.
9) Getting the equation of a line that comes through the streamer (Fig. 7b).
10) Getting an angle of a streamer's slop α according to image's.
11) Calculation of extreme coordinates to get the whole streamer inside the gotten square (Fig. 8a).
12) Setting the streamer in a vertical position (Fig. 8b).
13) Getting a data set of a streamer's intensity from the central image's section.
14) Finding the values of L_i and L_s in a section.
15) Finding the optimal value of the energetic coefficients A, B for a streamer, in which the mean square deviation has minimal value.
16) Finding the optimal value of an increasing coefficient k_1 for a section's part L_i, in which the mean square deviation has minimal value.
17) Finding the optimal value of a decreasing coefficient k_2 for a section's part L_s, in which the mean square deviation has minimal value.
18) Setting the calculated and gotten parameters in a file after which the program starts from a step 5 ad find an image of the next streamer.
19) Conduction of GDV image's analyzing by steps 4–17.
20) Getting the value of complex criterion and its comparative analysis.



a *b*

Fig. 7. The crown discharge around a drop of distilated water during the GDV: a – the income image; b – the prossessed image are gotten after the threshhold filtration and the lines that help to cut out and return the streamers



a *b*

Fig. 8. The image of a single streamer: a – the initial streamer's position; b – the streamer's position after rotation

The threshold processing of an image is carried out by the means of attribution of a zero value of intensity to pixels in which brightness is lower than zero level and attribution of a unity value of intensity to all other pixels. In that way, the binary image can be gotten. The separation of a streamer is carried out by the means of a filling function when its next extreme coordinates are defined as x_r, x_l, y_u, y_d.

According to a step 7, a line equation is composed by the means of two dots $A(x_1, y_1)$ and $B(x_2, y_2)$, through which the line is drowned (figure 7b). As a first streamer's dot the center of the closed bright area is taken, which coordinates are defined by the means of a next formula

$$x_c = \frac{\sum_{i=1}^{n} I_i x_i}{\sum_{i=1}^{n} I_i},\ y_c = \frac{\sum_{i=1}^{n} I_i y_i}{\sum_{i=1}^{n} I_i}, \tag{8}$$

where x_c, y_c – the coordinates of the center of the closed bright area, I_i – the value of brightness of a dot number i, x_i, y_i – the coordinates of i dot.

The other dot is the dot $B(x_2, y_2)$, which is situated on the maximal distance from the dot $A(x_1, y_1)$ in this closed area [6].

On the Figure 9 is shown the structural scheme of the experimental facilities for LPBO researching that lets simultaneously capture the images of a sample and a model LPBO under the equal external conditions and the parameters of experimental facilities. It is composed by two in-parallel connected core electrodes 1 and 2, that are put in cells which situated on a dielectric plate 3, and the last one in its turn is situated on the flat electrode 4, that contains a sample 5 and a model 6 LPBO in a form of a semi-sphere drops. The photo camera 7 is fixed over it and connected to the computer 8. Also, there is an in-parallel connected regulator of an impulses' quantity 9, the block of generation 10, increasing transformation 11, that is connected to electrodes 1, 2, and 4.

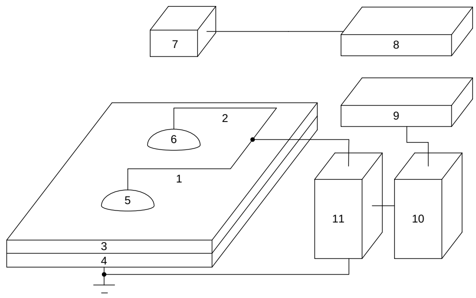


Fig. 9. The structural scheme of experimental facilities for LPBO researches based on GDV

The experimental device captures an image of a crown discharge that appears around LPBO during applying of high voltage and frequency current gotten from an increasing transformer. After this, the image comes to a computer where its main processing takes place.

During the experimental work had been defined as the next issues: the dependency of voltage's igniting of a crown discharge on its frequency and an impure's presence; the adequacy of the proposed model streamer is confirmed [5, 10].

On the Figure 10 is showed the structural scheme of the device for the spectral composition of LPBO radiation researching that works on the base of GDV and contains 1 – a high-voltage high-frequency current generator, 2 – a cell with a test LPBO, 3 – a cell with a model LPBO, 4 – an optical lens, 5 – many-channel light conductors, 6 – the outcomes of many-channel light conductors, 7 – light filters, 8 – a photodiode, 9 – amplifiers, 10 – an analog-digital converter, 11 – a digit indicator.

The device works in a next way: a test and a model LPBO are put in cells, the influence of high-voltage and high-frequency current is provided, the shine, as a result of this influence, is focused and accepted by many-channel light conductors (separately for a sample and a model object). Each channel of light conductors is ended by a light filter and after it, there is a photodiode that is connected to an amplifier and a signal from the last one go to an analog-digital converter. The digit data gotten from photodiodes are separately analyzed by the processing block for each LPBO, and then those data are compared and the results of this work are showed on the digital indicator [2].

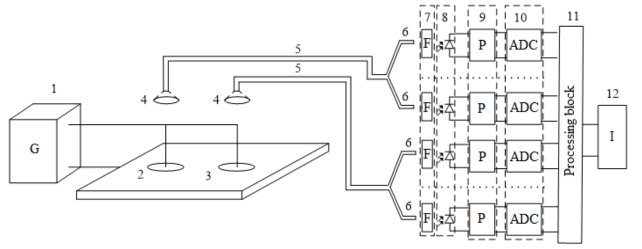


Fig. 10. The structural scheme of the device for a spectral composition of LPBO radiation researching on the base of GDV

On the figure 11 is showed the structural scheme of the experimental device for the spectral composition of LPBO radiation during GDV researching that is presented by two cells for a sample and a model LPBO, electrodes' pins 3, that is sunk in LPBO, a dielectric plate 4 between LPBO and a flat electrode 5, a frame 6, that provides a cover, a movable section 7, that lets put in a photoelectron multiplexor 10 for a test or a model LPBO, a frame for light filters fixing 9, a high-voltage high-frequency current generator 8, a section of a results' visualization 11.

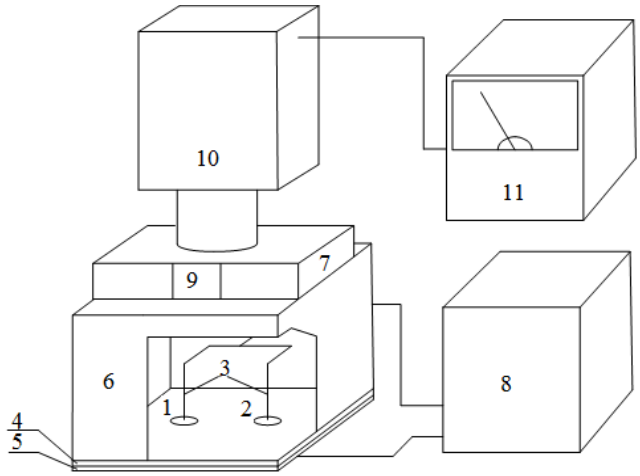


Fig. 11. The structural scheme of the experimental device for a spectral composition of LPBO radiation during GDV researching

The experimental device for a spectral composition of LPBO radiation during GDV researching works in a next way: the equal quantities of a sample and a model LPBO are put in the cells of the experimental device 1, 2; over the test LPBO photometer 7 is set by the means of a shifted section 7 and a light filter 9 ends up this construction's portion. After this, the system is ready for an influence of 3 kW 50 kHz voltages for 5 seconds. During this period the radiation intensity of LPBO is shown on an indicator 11. After this, by the means of a movable section, photometer 7 is focused on a model LPBO and the intensity of a radiation of a model LPBO is gotten in the same way. The change of light filters let's get linear spectrums of a sample and a model LPBO. The comparison of these two spectrums let's find out impure concentration in LPBO [2, 4].

On the Fig. 12 is showed the structural scheme of the GDV device for LPBO analyzing with the next new technological ideas: the use of two integral spheres that let's capture the all needed radiations from both a sample and a model LPBO and the implementing of two photodiodes for each LPBO. This new allows an increase in the preciseness of an impure concentration's assessment.

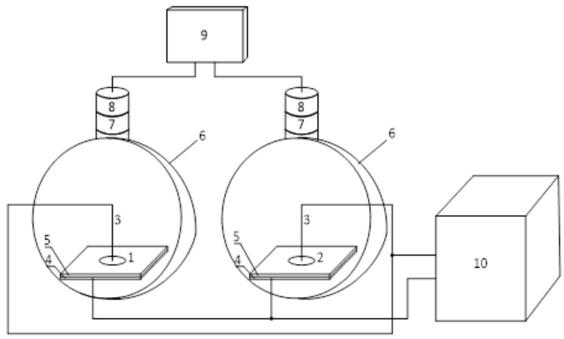


Fig. 12. The structural scheme of a device for an assessment of impure concentration in LPBO by the means of GDV principle

The device is composed by the next important elements: cells for a sample and a model LPBO– 1, 2; pin electrodes– 3, flat electrodes – 4, dielectric plates – 5, integral spheres – 6, light filters – 7, a photo acceptor – 8, processing and indicating section – 9, a generator of high-voltage high-frequency current 10.

The core element of a proposed GDV device for LPBO analysis is an integral sphere. The last one lets in the simplest way to solve the task of radiation capturing from the all body angle 4π [4].

The GDV devise for LPBO analyzing is showed on figure 13, where 1 – is a generator of a high-voltage high-frequency current, 2 – data processing and information indicating section, 3 – a photo multiplexor, 4 – an integral sphere. The scale preciseness of this device is 0.303%.

The device for identification of an impure's concentration in LPBO provides us with the spectrums of radiation of the chemical salt dissolves. Experiments are carried out in the next way: the equal quantities of a sample and a model LPBO are put in the cells; an appropriate light filter is put in; then 5 sec. influence of 3 kW 50 kHz voltage happens, during which the intensities of radiation of both LPBO samples are captured; the previous steps had been fulfilled for the other light filters. During the experimental work, 23 narrow-step light filters are used (the wide of a pass is 10 nm), which gradually covers the 457–675 nm range. On the base of gotten intensities, the linear spectrums of LPBO are formed. Such salts as NaCl, $MgSO_4$, KCl, $CaCl_2$, and FeSO4 are used during the experimental works. The distillate water is used as a model LPBO. The radiation spectrum, the spectrum of relative spectral lines of $MgSO_4$ dissolve, and distilled water are showed on Figure 14 and 15.

Fig. 13. GDV device for LPBO analyzing

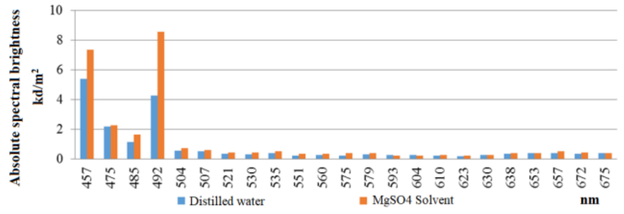


Fig. 14. The radiation spectrum of $MgSO_4$ dissolve and distillated water

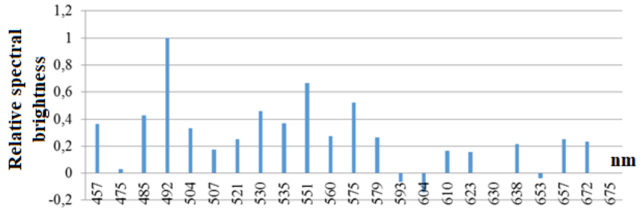


Fig. 15. The spectrum of relative spectral lines of $MgSO_4$ dissolve

On the spectrum of relative spectral lines of $MgSO_4$ dissolve the picks are presented at 492 nm, 530 nm, 551 nm, and 575 nm. The picks that are presented at 530 nm and 551 nm are caused by Mg^{2+} ions in LPBO. Analyzing the all experiments' results allows us to conclude that the maximal absolute intensities at 457 nm, 492 nm, and 485 nm waves are correlated with oxygen and hydrogen atoms. It has a maximal high because of the huge proportional quantity of water in any sample.

On the spectrum of relative spectral lines of $MgSO_4$ dissolve the pick are present at 492 nm, 530 nm, 551 nm, and 575 nm. The picks at 530 nm та 551 nm are caused by the presence of magnum ions Mg^{2+} in LPBO.

The results of conducted researches let state that identification of Na^{1+}, Cl^{1-}, Mg^{2+}, Fe^{3+}, Ca^{2+} ions in LPBO by the means of the proposed device is possible [6, 12].

It had been found out that a sample of LPBO should be situated in the middle of a flat electrode to provide the best condition for exploring LPBO specificity using a mean number of all streamers or using any parameters that are based on the streamer's quantity. In the moment of a voltage applying to the LPBO sample when a bowl is absent the process of LPBO's flowing has a start with a speed that is in proportion to an applied voltage. We had been found that it's better to explore the green and red channels of the RGB image of LPBO or transform it into the grayscale. The adequacy of the model that describes a central section of a streamer depiction is checked and informative parameters are calculated. When the applied voltage is constant, the width and length of streamers depend on the impure concentration level. This dependency lets develop a screening system of LPBO based on a principle 'norm – deflection'. It had been conducted 21 experimental works when a model LPBO is a 50 mg/l dissolve and a sample LPBO is a 100 mg/l Mg dissolve. In the GDV device, the light filter with the maximal transition at 551 nm was used. The captured data let found out the absorption coefficient *b* that is equal to 0.9272.

By the means of the GDV device, the exploration of dependency of LPBO radiation's intensity on Mg concentration in LPBO was carried out. The calculated results of intensities and gotten experimental data are shown in Fig. 16. As we can see the experimental results of radiation intensity are close to the theoretical one. On the base of experimental data, it had been calculated that the experimental value of radiation intensity of explored LPBO is similar to the theoretical value of 99.04%.

It had been conducted 89 experimental works to found out the possible similarities among gotten results. During the experimental work $MgSO_4$ dissolve of a concentration 150 mg/l, or 30 mg/l Mg dissolve, was used as a model LPBO and $MgSO_4$ dissolve of a concentration 75 mg/l, or 15 mg/l Mg dissolve was used as a sample LPBO. The dissolves were prepared by the use of a chemical scale and a 100 ml flask. The results of the experiments are shown on figure 17.

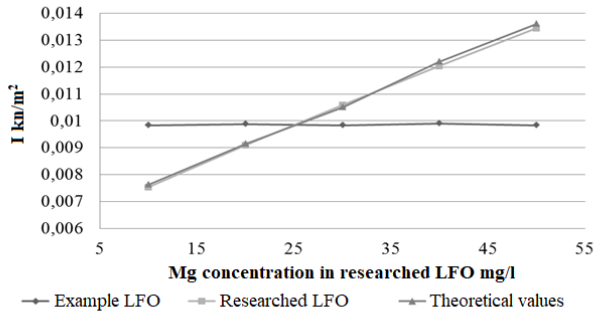


Fig. 16. The experimental specification of intensity of a test and a model LPBO together with a theoretical specification of a test LPBO

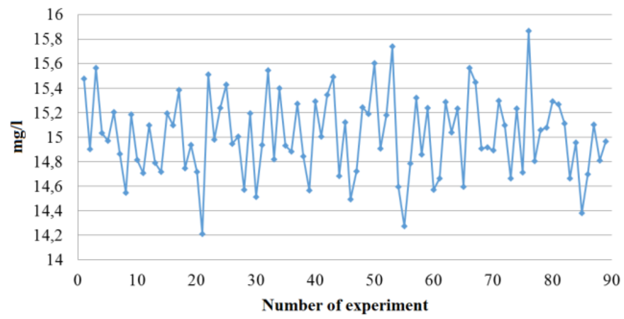


Fig. 17. Mg concentration in a sample LPBO (89 probes)

According to gotten data, the mean amount of radiation intensity of a model LPBO is 0.01058 cd/m^2, and in the case of a test LPBO, it is 0,00832 cd/m^2. Under such condition the mean value of Mg concentration in a test LPBO is 15.013 mg/l, the relative error is 1.81%.

So, the experimental assessment of the GDN device for LPBO analyzing let's conclude that the proposed technical tool matches the all previous requirements and its measurement error is lower than the measurement errors of other known tools.

To prove the dependency of Mg concentration in oral fluids on the thyroid gland's diseases the series of experiment had been conducted during the which the concentration of Mg in male oral fluid (age group 18–35 years, a sporadic goiter of 2nd stage and male group members of which have some risk factors of thyroid disease) was estimated by the means of GDV methods. The gotten data had been compared with Mg concentration in OF that was estimated by the means of the trylonometrical method. All patients were divided into three groups (20 humans in each): the first group comprises peoples with any thyroid disorders, the second group contains peoples with risk factors of thyroid disorders development and the third group was represented by the patients that have a sporadic goiter. Researching was conducted in a next way: in the morning, before feeding or teeth cleaning, every patient spits 5-10 ml of his oral fluid. After this, in the next hour, gotten samples were under researching by the means of the GDV device. As a model LPBO $MgSO_4$ dissolve of 60 mg/l concentration (or 15 mg/l Mg concentration) was used [9, 19].

Analyzing of the final results allow concluding that Mg concentration in OF of patients that do not have thyroid diseases is 12.73 ± 2.16 mg/l, an analogical indicator for the patients with risk factors is 14.98 ± 1.92 mg/l and for the third group those digits are 26.65 ± 3.73. So, in such a way the dependency of Mg concentration in OF on the thyroid diseases had been proved. Also, using GDV devices for LPBO analyzing the ranges of Mg concentration in OF of the patients from all three groups was specified [9].

The assumption that Mg concentration, that is more than 15 mg/l, can reveal the presence of thyroid pathologies (in particular, focal thyroid gland pathology – nodal goiter, tumors, cysts, and thyroiditis) had been proved. Comparing the results of the first and the third groups we had discovered that

21 patients (2 humans from first and 19 humans from third groups) had Mg concentration more than 15 mg/l, so the experiment's probability is 0.925. Gotten probability had been compared with analogical indicators of another GDV device [1, 7].

The probability of the proposed device is the highest among GDV devices and is no worse than the preciseness of other screening tools.

2. Conclusions

The work has been developed the means of GDV for LPBO that let increase the accuracy of the measurements in 1,5 times and the preciseness of impurities' concentration detection on 2.5%. It has been presented the short overlook on current GDV devices. It has been detected that during the implementation of those tools was not taken into account an influence of the atmospheric parameters (temperature, pressure, humidity) and the possible changes of in-system parameters that can make a significant influence on the gotten image. Also, the results of this researches in the many cases are biased and do not provide the quantitative assessment of a state of the human body and during the diagnosis, formation is very often used the ideas of east medical practice that do not have science confirmations. The main methods of GT are presented. The analysis of the main biological fluids of the human body is carried out and is proved that the most advanced method of diagnosis is the one based on the oral fluid analysis. It has been developed the main methods of diseases and body states diagnosis on the base of researches of physical, chemical, and biological parameters of oral fluids. The classification of methods for diseases and body states diagnosis on the base of researches of physical, chemical, and biological parameters of oral fluids are presented in the article. The worthiness of the GDV method implementation in oral fluids researches is proved. The main informative signs of LPBO images gotten by GDV implementation are presented. The methods of LPBO analyzing the base of GDV are improved by the means of simultaneous comparison researches of sample LPBO and unknown, researched LPBO, and also by the means of using a complex criterion of purity recognition of mineralization level of LPBO. It's proposed to use the intensity of spectral composition of LPBO radiation during GDV that let increase the preciseness of impurity concentration inside the researched LPBO. It has been developed the experimental facilities for LPBO researches using the GDV method and spectral intensities of LPBO radiation during GDV which are consist of two chambers for sample LPBO and unknown LPBO that let significantly compensate the possible influence of external conditions on the experiment's results preciseness. The adequacy of function between impurities concentration and the intensity of the LPBO spectral line during GDV is proved. The math model of a streamer is improved, which takes into account such parameters as a voltage, a molar concentration of LPBO impurities, a geometrical size, and conduction of LPBO. A bunch of informative parameters, which are taken from the streamer's image, is proposed and it let calculate the complex criterion of LPBO. On the base of the results of experimental researches, the empirical model of the intensity distribution of the central section of a normalized streamer's depiction is proposed. And it lets get the new informative parameters and an improved complex criterium of LPBO frequency ascertaining. The series of experiments is conducted; the dependencies of the LPBO radiation spectrum during GDV on the chemical composition of LPBO are ascertained. It is proposed to ascertain the concentration of LPBO impurities by the means of the radiation intensity of a specific spectral line of an impurity in a whole radiation spectrum of LPBO during GDV. It is established the possibility of NaCl, MgSO4, KCl, CaCl2, FeSO4 salt's ion, or its complex founding in one LPBO. The algorithm of a streamers' normalization which lets found out the streamers on the images and drives them to the stable view is proposed. It let automatically analyze streamers that accelerate the presses of informative parameters of GDV images getting and simplify further data processing and storage. The conducted experiments confirm the possibilities of an express diagnosis of GT diseases by the means of the GDV method for an LPBO analysis. It is ascertained that the intensity of researched GDV gotten by the means of LPBO impurity's concentration detector is similar to a theoretical intensity and the deviation is not more than 0.38%. The field experimental researches in a patient group, half of which has some GT disorders, are conducted using the GDV method for LPBO analysis. In this case, the probability of the research is 92.5%.

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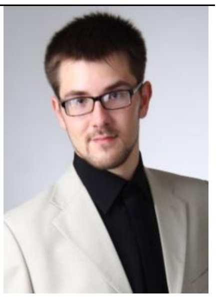

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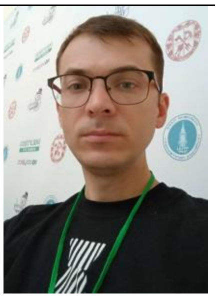

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