Metal Coated Textile Testing with GDV Method: Raw Material Influence on the Parameters of GDV Electrograms

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Abstract **– The aim of the experiment under examination is to find out the effect of fibres and textile processing products separated in the textile washing process on the parameters of GDV electrograms, as well as the durability of metal coating, depending on the type of used textile material (polyester, viscose or wool). The obtained results have confirmed that the most sustainable copper nanoparticle coating is formed on the polyester fabric, but the lowest coating – on the viscose fabric. It has been concluded that the fibres and textile finishes separated from the fabric also influence the parameters of GDV electrograms.**

Keywords – copper, GDV electrography, nanotechnology, textile.

I. Introduction

Nanotechnology has gained a great deal of public interest due to the needs and applications of nanomaterials in many areas of human activities such as industry, agriculture, business, medicine, public health and so forth. Various metals are used in textile nanocoatings to obtain products with healing properties.

Copper has been used through the ages to alleviate a variety of health related problems, on all continents and throughout most cultures. The anti-bacterial and anti-fungal properties of copper have been recognized since ancient times. Copper is necessary for the formation of red blood cells and other components of the blood system, and for the healthy growth, development, and maintenance of bone, connective tissue, brain, heart, and many other body organs. Copper is involved in the formation, synthesis, and release of life-sustaining proteins and enzymes, which produce cellular energy, regulate body functions such as nerve transmission, blood clotting, oxygen transport, and stimulate the immune system to fight infections, repair injured tissues, and promote healing. Copper also functions to neutralize free-radicals, which are unstable oxygen by-products that are formed as a result of normal body processes or exposure to environmental pollutants and can cause severe damage to cells [1].

Current research shows that elevated levels of copper are found in the blood plasma of individuals suffering from a variety of diseased conditions, including arthritis, cancers, diabetes and cardiovascular diseases [2]. The same is true for patients suffering from wounds of various kinds. These findings suggest that the redistribution of copper within the body is a natural occurrence, playing a significant role in the body own healing response to diseased states and physiological stress. Based on these findings, it has now been suggested that copper complexes have additional medicinal properties that are fundamental to the healing process. Chelated copper complexes have been approved for a number of anti-inflammatory oral medications and copper metallo-organic complexes have been used successfully to treat arthritis and other chronic degenerative diseases [3].

Modern farming methods have depleted the soils of essential micronutrients, and food processing essentially eliminates any residual nutrients that may still be present. The human body cannot generate a copper by itself, it must be provided with water, food, skin contact or inhalation. It has now been recognized that copper deficiency is becoming a serious health concern in all countries and all age groups.

Symptoms of copper deficiency include general weakness, impaired respiration, skin sores, decreased immune function, elevated LDL cholesterol and reduced HDL cholesterol absorption. Copper deficiency may play a role in arteriosclerosis and aortic aneurysms; it affects the cardiovascular system, causing extensive damage to the heart and arteries and can cause early greying of the hair and loss of skin colour as the pigment melanin is copper-dependent [1].

Copper also provides protection against the geopathogenic zones and the electromagnetic radiation generated by the electrical devices (mobile phone, computer, etc.) [4].

Despite positive effects, the copper is a heavy metal required by living organisms in small amounts, but in large amounts it causes a lower or higher degree of poisoning and becomes pollution in sewage. The main risks of the use of metal coated textiles are related to the detaching of metal nanoparticles from the material during use. As a result of friction, nanoparticles can be detached from the product and thus end up in the air, pollute the environment, or inhaled get into the human or animal body. Nanoparticles can be detached from the textile during washing, thus polluting the water and causing harm to living organisms in it. Therefore, a simple, fast and effective method for metal coated textile testing is required.

The number of methods used in the testing of nanoparticles in water is not large; they are as follows: Microscopy methods, Photon Correlation Spectroscopy and Nanoparticle Tracking Analysis [5]. The methods vary in the measurements required, sample quantity, preparation techniques and the range of acquired parameters. Microscopy techniques require prior sample preparation, but required pre-treatment is problematic because the sample can react or decompose during preparation. For the photon correlation spectroscopy method, additional measurements are necessary to calculate any of the indicators. Most of the equipment cannot distinguish between individual nanoparticles and agglomerates of nanoparticles, which restricts their use because the toxicity of nanoparticles depends on their size (the decreasing size increases toxicity). Toxicity of the agglomerated nanoparticles and individual nanoparticles is higher than the toxicity of the whole substance of equivalent size. As a result of new testing methods, it will be possible to reduce textile technologist's work associated with the new material creation and testing.

Gas Discharge Visualization (GDV) electrography operating principle is based on the Kirlian effect. High-frequency (1.1 kHz) high-voltage (5 kV) current produced discharge or radiation around an object (human, animal body parts, plant, inanimate object or liquid) is detected by a digital camera. GDV electrograms represent complicated two-dimensional shapes, whose area and spectral parameters provide information about the structure and properties of the object. The resulting images are analyzed by the specialized software.

GDV camera is the most widely used in medical studies – allergy diagnosis [6], the diagnosis of autism [7], for the detection of changes in the characteristics of liquids like blood, energetic preparations, homeopathic remedies under influence of different factors [8]. GDV camera is widely used in sports medicine – for athletes' fitness and health determination [9]. In the light of the extensive use of GDV electrography, it is necessary to adapt the method for determination of textile nanometal coating durability.

II. METHODOLOGY

Nanometal coated textile durability testing has been performed by washing textiles in distilled water, and the acquired water samples have been tested by Gas Discharge Visualization camera (GDV camera Pro), using equipment from GDV Mini-Laboratory for the liquid analysis. The data has been recorded in "GDV Capture" software and processed in "GDV Scientific Laboratory" software. The analysis of the parameters has been performed in "Microsoft Office Excel" software.

"GDV Scientific Laboratory" software has calculated 12 parameters for each electrogram. The most significant parameters have been as follows: area, intensity, form coefficient and entropy. In this article, electrogram area and intensity have been analysed, because in the previous studies [10] it was concluded that the electrogram form coefficient and entropy did not represent changes in the concentration of metal nanoparticles in water. GDV electrogram area is assessed by the number of pixels in the image, but the intensity is the pixel brightness [11].

In the process of experiment, for each parameter the following indicators have been calculated: the arithmetical mean, variance, standard deviation, range and the average relative standard error.

The aim of the experiment has been to find out the effect of fibres, dyes, and other textile processing products separated in the textile washing process on the parameters of GDV electrograms, and how it affects the structure of potential testing methodology, as well as the durability of nanoparticles, depending on the type of textile material.

TABLE I
CHARACTERISTICS OF SAMPLES

Sample designation	Material	Coating	Particle size of the coating (nm)
7-1	100% polyester	-	-
7-1A	100% polyester	copper	60-70
7-1B	100% polyester	copper	60-70
7-2	100% viscose	-	-
7-2A	100% viscose	copper	60-70
7-2B	100% viscose	copper	60-70
7-3	100% wool	-	-
7-3A	100% wool	copper	60-70
7-3B	100% wool	copper	60-70

In the experiment, three different textile materials have bee used: polyester (PES), viscose and wool fabric. Characteristics of the samples are summarized in Table 1. To create a copper coating on the fabric, magnetron sputtering technology, which lasts for 60 seconds, has been used.

Each sample size is 70 x 90 mm, water for one sample washing is 60 ml. Samples without copper coating have been also washed, and Fig. 1 demonstrates the colour difference between pure distilled water and the washing water of samples 7-1, 7-2 and 7-3. It means that in the washing process different particles separate from the clothing. Water colour of samples changes, washing samples 7-2 and 7-3 (in particular 7-3); these samples are from natural fibres – viscose and wool.

Fig. 1. Pure distilled water (the first bowl from the left) and the washing water from samples 7-3, 7-2 and 7-1

By washing samples in distilled water for 5 minutes, copper coating partly separated from the samples, as indicated by both the sample coating changes (Fig. 2) and the water colour changes from clear, translucent to muddy pink. Judging by the pictures, it is likely that in the washing process nanoparticles mostly have separated from viscose fabric (Fig. 2 (d)), least of all – from polyester (Fig. 2 (b)).

For comparison pure distilled water has been used (designation – Control). Before GDV electrography session, a bowl with water has been shaken thoroughly to disperse the sludge. Prepared water (0.2 ml) has been drawn into a syringe and a syringe has been fixed on a stand above the GDV camera lens. From the same sample, 5 GDV static electrograms have been obtained. The experiment has been repeated eight times, resulting in 40 files with the same time interval (5 seconds) between electrogram fixing moments. Equipment testing results [12] have shown that for sufficiently reliable data it has been necessary to obtain at least 40 measurements per experimental subject.

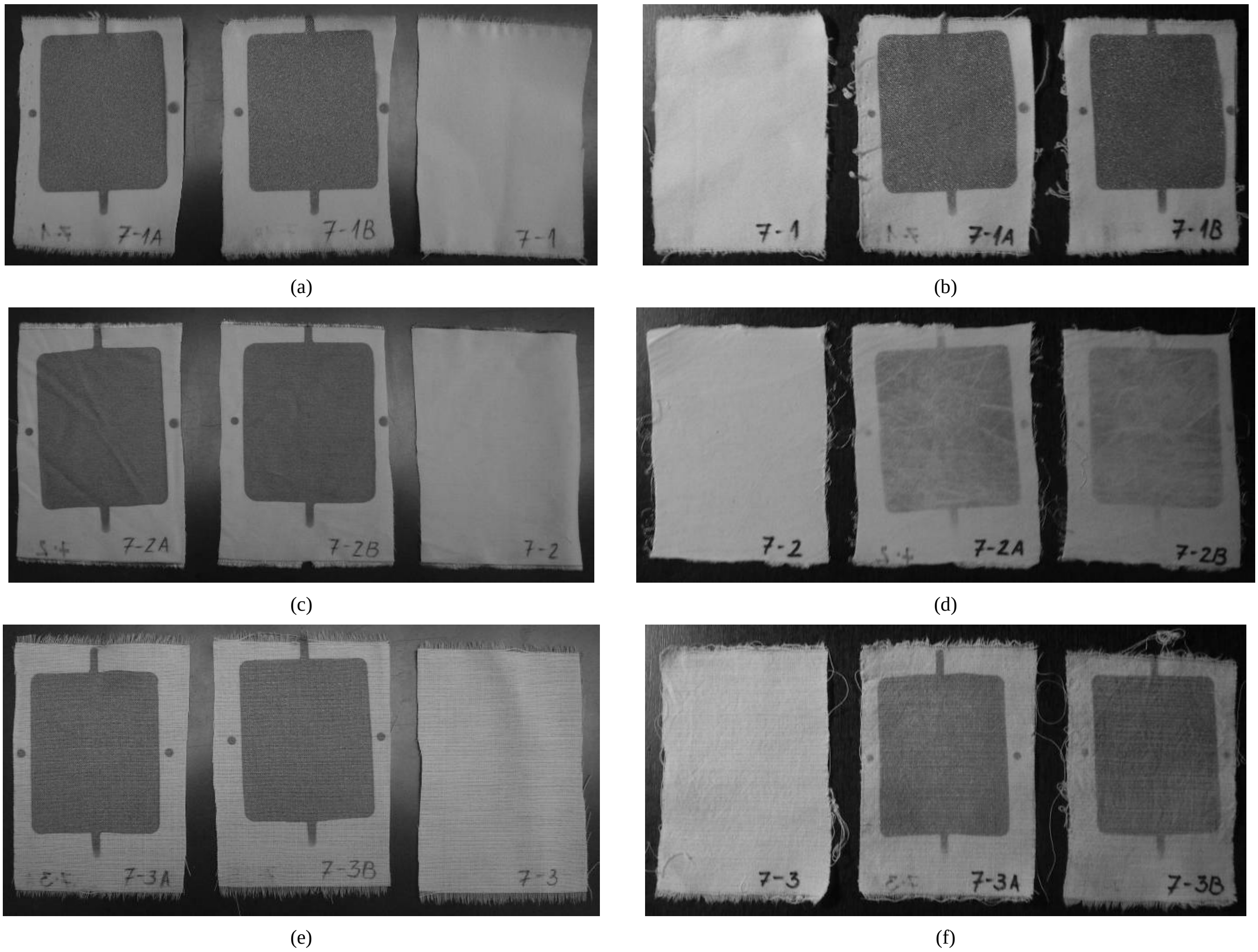

Fig. 2. Sample images: (a) the samples 7-1, 7-1A, 7-1B before washing; (b) the samples 7-1, 7-1A, 7-1B after washing; (c) the samples 7-2, 7-2A, 7-2B before washing; (d) the samples 7-2, 7-2A, 7-2B after washing; (e) the samples 7-3, 7-3A, 7-3B before washing; (f) the 7-3, 7-3A, 7-3B after washing.

III. Results

The main results of the experiment are summarized in Table 2. As you may see, the area results are appropriate – the smallest area is for control water, slightly higher results are for uncoated textile washing water (7-1, 7-2, 7-3), and the highest results are for textile materials coated with copper nanoparticles.

While the results of intensity are not stable and adequate, for example, washing water of polyester and wool fabrics coated with copper (7-1B and 7-3B) has shown lower results than uncoated samples.

In general, the differences between the results of the intensity are relatively small; 3 units provide the highest results (between samples 7-2 and 7-2A, 7-2B; also between 7-3 and 7-3A). Since the differences are so small, it is comparatively difficult to get persistent results, because the smallest inaccuracy in the experiment may cause inconsistent results.

TABLE II

Results of the Experiment

Material	Designation	Area	Intensity
-	Control	1 038	79
Polyester	7-1	1463	81
	7-1A	1767	81
	7-1B	1520	79
Viscose	7-2	2035	84
	7-2A	2486	87
	7-2B	2359	87
Wool	7-3	2248	85
	7-3A	2628	88
	7-3B	2568	84

For all of the analysed data blocks, the mean relative standard error has been calculated. For any data complexes the mean relative standard error does not exceed 1.52%.

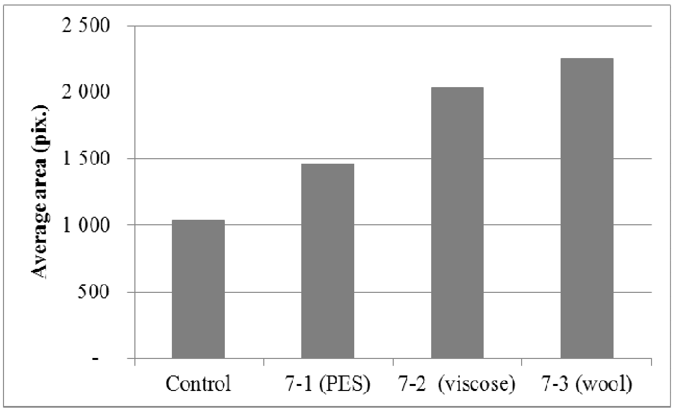

Fig. 3. Differences between the mean areas of control water and water after untreated fabric samples washing

Figure 3 summarizes the results for individual objects of experiment: all the water samples, in which textile free of copper nanoparticles has been washed (7-1, 7-2, 7-3), have a greater area than the control water. It means that when washing fabrics in distilled water, not only nanoparticles of metal coating separate but also other particles, which affect the GDV electrogramm parameters. It confirms both the observed water colour changes (Fig. 1) and the obtained results. Hence, it follows that developing the textile metal coating durability testing methodology, it is necessary to choose water (as Control water), in which the textile sample without metal nanoparticle coating was washed, than pure distilled water.

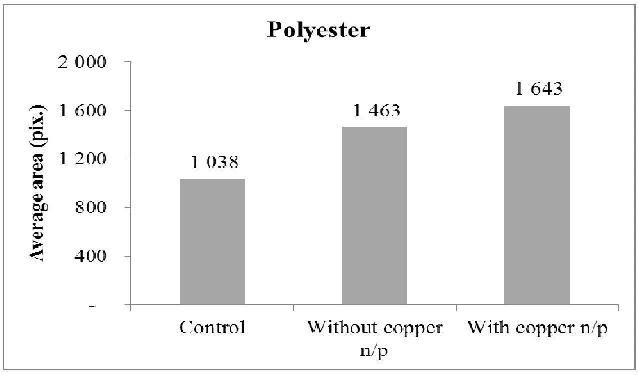

Fig. 4. Washing water of polyester fabric compared to Control

To compare the area results of the samples with and without the presence of copper nanoparticles, the arithmetical mean of the samples 7-1A and 7-1B; 7-2A and 7-2B; 7-3A and 7-3B has been calculated. Fig. 4 shows the relationship between the Control and washing water of polyester fabric: the difference between the Control and the water, in which the fabric without metal coating has been washed, is 425 pixels, but the difference between the uncoated and coated textile washing water is 180 pixels.

Fig. 5 shows a similar comparison for viscose fabric samples: the difference between the Control and sample without copper nanoparticle coating is 997 pixels, but the difference between washing water of bare and coated viscose fabric samples is 388 pixels. Thus, more nanoparticles have separated from the viscose fabric, because between the coated and uncoated fabric a greater difference has been in comparison with polyester.

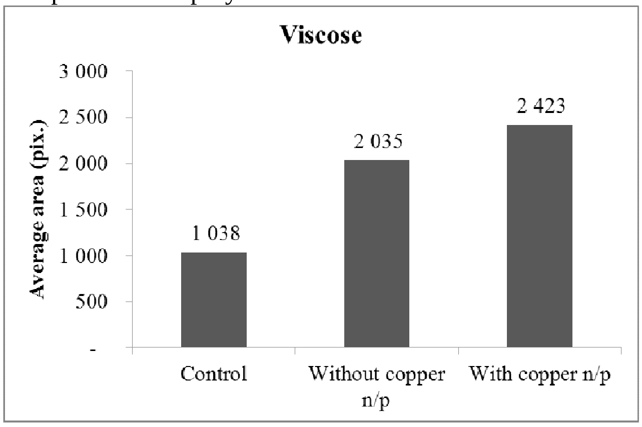

Fig. 5. Difference between the mean areas of control water and water after copper treated viscose fabric sample washing.

Figure 6 shows the comparison of washing water of wool fabric and Control; as a result of the comparison it has been found that between Control and fabric without copper nanoparticles there is difference in 1209 pixels, but between the bare and coated fabrics the difference in the number of pixel is 350. Thus, fewer nanoparticles have detached from the wool fabric than from viscose.

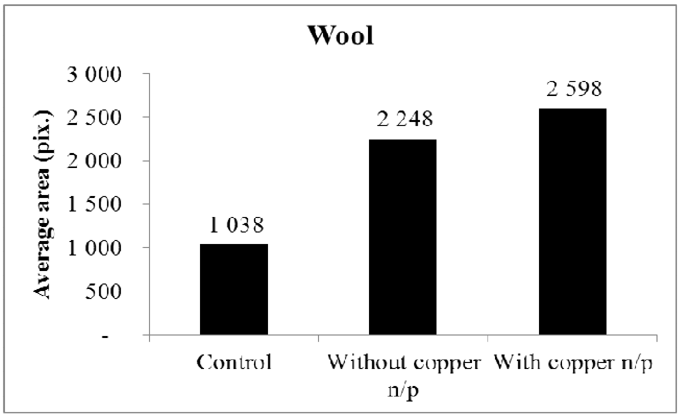

Fig. 6. Difference between the mean areas of control water and water after copper treated wool fabric sample washing

Figures 4, 5 and 6 display the data, which confirms the hypothesis expressed by analysing Fig. 2: nanoparticles mostly have detached from the viscose fabric, but least of all – from polyester.

IV. Conclusions

Comparing data, obtained from three different textile materials, it is concluded that the most sustainable copper nanoparticle coating is formed on the polyester fabric, but the lowest resistance of the copper coating is on the viscose fabric. On the wool, a relatively resistant coating of copper nanoparticles also forms, using the magnetron sputtering technology. From the acquired results it can be concluded that the synthetic textiles provide better adhesion of metal nanoparticles to the material.

Analysing the information obtained in the course of the experiment, it is concluded that not only the metal nanoparticles that detach during the washing, but also the fibres and textile finishes separated from the fabric affect GDV electrogram parameters. It means that creating a methodology for testing metal coating durability on the textile, it is necessary to choose distilled water (as Control), in which the textile without metal coating was washed, than pure distilled water. Table 3 displays the calculations required for testing methodology: from the obtained measurements of similar samples the arithmetic mean is calculated, from which measurements of the samples without the nanoparticle coating are subtracted. The resulting difference is the number of nanoparticles really existing in the water, expressed in the area pixels.

TABLE III

GDV electrogram area

Polyester		Viscose		Wool	
	Area, pix		Area, pix		Area, pix
7-1A	1 767	7-2A	2 486	7-3A	2 628
7-1B	1 520	7-2B	2 359	7-3B	2 568
Average	**1 644**	Average	**2 423**	Average	**2 598**
7-1	**1 463**	7-2	**2 035**	7-3	**2 248**
Difference	**181**	**Difference**	**388**	**Difference**	**350**

To determine the number of weight units corresponding to the number of pixels in the electrogram, it is necessary to add powder of copper nanoparticles to distilled water in defined quantities, which in turn will be made in subsequent phases of the methodology development. The result will be a set of nomographs, where concrete weight of metal nanoparticles corresponds to the particular number of pixels.

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Eva Trumsiņa, Silvija Kukle, Gunta Zommere. Metālpārklātu tekstilmateriālu testēšana ar GDV metodi: izejmateriāla ietekme uz GDV elektrogrammu parametriem.

Vara ārstnieciskās īpašības ir zināmas visās kultūrās, tā antibakteriālā un antifungicīdā iedarbība tiek izmantota kopš seniem laikiem. Neskatoties uz pozitīvajām ietekmēm, tomēr jāatceras, ka varš ir smagais metāls, kas dzīviem organismiem nepieciešams mazos daudzumos, bet lielos daudzumos izsauc mazākas vai lielākas pakāpes saindēšanos, nonāk kā piesārņojums notekūdeņos. Lai tas nenotiktu, ir nepieciešama vienkārša, ātra un efektīva metodika tekstilmateriālu metālu pārklājumu testēšanai. Rakstā analizētā eksperimenta mērķis ir noskaidrot, kādu ietekmi uz GDV elektrogrammu parametriem atstāj mazgāšanas laikā no materiāla atdalījušās šķiedras, krāsvielas, smites un citi tekstilmateriālu apstrādes līdzekļi un kā tas ietekmē potenciālās testēšanas metodikas struktūru, kā arī, vara nanodaļiņu noturība atkarībā no pielietotā tekstilmateriāla veida. Eksperimentā izmantoti trīs atšķirīgu izejvielu tekstilmateriāli – poliestera (PES), viskozes un vilnas audums. Vara pārklājuma izveidošanai uz tekstilmateriāla lietota magnetrona uzputināšanas tehnoloģija, kas ilgst 2 sekundes. Salīdzinot datus, kas iegūti no trim atšķirīgu izejvielu tekstilmateriāliem, secināts, ka visnoturīgākais vara nanodaļiņu pārklājums veidojas uz poliestera auduma, bet viszemākā noturība ir uz viskozes auduma. Pēc šī brīža rezultātiem var spriest, ka sintētiski tekstilmateriāli nodrošina labāku metāla nanodaļiņu pielipšanu pie materiāla. Analizējot eksperimenta gaitā iegūto informāciju, secināts, ka GDV elektrogrammu parametrus ietekmē ne tikai metāla nanodaļiņas, kas atdalījušās mazgāšanas laikā, bet arī no tekstilmateriāla atdalījušās šķiedras un apdares materiāli. Tas nozīmē, ka, veidojot metodiku metālpārklātu tekstilmateriālu pārklājuma noturības testēšanai, par kontroli jāizvēlas nevis tīrs destilēts ūdens, bet destilēts ūdens, kurā mazgāts attiecīgais tekstilmateriāls bez metāla nanodaļiņu pārklājuma. Lai noteiktu, cik lielai svara vienībai atbilst konkrētais pikseļu skaits attēlā, nepieciešams pievienot vara nanodaļiņu pulveri destilētam ūdenim noteiktos daudzumos, kas savukārt tiks veikts turpmākos metodikas izstrādes etapos. Rezultātā tiks izveidotas nomogrammas, kur noteiktam GDV elektrogrammu laukuma pikseļu skaitam atbilst konkrēts metāla nanodaļiņu svars.

Эва Трумсиня, Силвия Кукле, Гунта Зоммере. Тестирование текстиля, покрытого металлом, методам ГРВ: влияние исходного материала на параметры ГРВ электрограмм.

Антибактериальный и антифунгицидый эффект меди использовался с древних времен. Несмотря на позитивное воздействие, следует помнить что медь - металл тяжелый, в которой живые организмы нуждаются в небольших количествах, в больших количествах он может стать причиной отравления или загрязнения стоков. По этой причине нужен простой, быстрый и эффективный метод испытания текстиля с покрытием из нанометалла. Цель статьи - выяснить с помощью эксперимента, какое воздействие на параметры ГРВ электрограмм оказывают волокна и продукты обработки текстильного материала, отделившийся во время мытья материала, и как это влияет на структуру потенциальной методологии тестирования, а также устойчивость наночастиц в зависимости от типа текстильного материала. В эксперименте использовались три текстильных материала из различного сырья: полиэфир, вискоза и шерстяная ткань. Для создания покрытия меди на материал использовалась технология магнетронного распыления, которая длится 2 секунды. Сравнивая данные, полученные из трех различных текстильных материалов, сделан вывод, что наиболее надежные покрытия медных наночастиц можно получить на полиэфирной ткани, но самая низкая устойчивость - на вискозной ткани. По данным результатам можно судить, что синтетические ткани обеспечивают высочайшее качество прилипания металлических наночастиц к материалу. Анализируя информацию, полученную в ходе эксперимента, сделан вывод, что на параметры ГРВ электограмм влияют не только металлические наночастицы, которые отделялись во время стирки, но также волокна и другие средства для обработки текстиля. Это означает, что при создании методологии для тестирования металлопокрытого текстиля, в качестве контрольной воды нужно выбрать дистиллированную воду, в которой вымывался текстиль без покрытия металлическими наночастицами, вместо чистой дистиллированной воды. Чтобы определить, какой вес наночастиц соответствует конкретному количеству пикселей в электрограмме, необходимо добавить порошок медных наночастиц в дистиллированную воду в определенных количествах, а это в свою очередь будет производиться на следующих этапах разработки методологии. В результате будет создан набор номограмм, где конкретному количеству пикселей соответствует определённый вес металлических наночастиц.