DEVELOPMENT OF EQUIPMENT FOR COMPLEX MAN PROTECTION FROM ARTIFICIAL NON-IONIZING EMR

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Abstract: *The main factors that influence on the process of artificial non-ionizing electromagnetic radiation on the man were determined. The method of obtaining nanoparticles of metals directly in the structure of textile materials by impregnating them with solutions of metal salts was developed. Experimental equipment for obtaining nanoparticles of metals by the method of their sputtering by means of an electric arc in a liquid environment is developed. The experimental researches with the modification of textile materials by nanoparticles of metals were carried out and the mechanism of influence of copper nanoparticles on the structure of fabric was determined. The ways of further research for complex man protection are offered.*

Keywords: *textile materials, metal nanoparticles, non-ionizing EMR, fabric, protective properties, textile materials modification.*

1 INTRODUCTION

Today, scientific and technological progress is increasing day by day. We are surrounded by electronic devices, which have penetrated practically all areas of our business. However, the fee for their use is a permanent stay under the influence of electromagnetic fields which adversely affects on our health. The environment of human existence has always been under the influence of electromagnetic fields. These fields caused by nature are constant background radiation. There are natural and artificial sources of electromagnetic fields (EMF). Biological influence degree of electromagnetic fields on the human body depends on the frequency of oscillation, tension and intensity of the field, mode of its generation (pulse, continuous) and duration of influence. If the wavelength is shorter, then more energy it possesses. In our time, anthropogenic origin EMF significantly exceeds the natural background and it is the most unfavorable factor, which influence increases on the person from year to year. In essence, EMF sources can be any elements of electric circuit, through which passes the high-frequency current [1, 2]. The intensive development of electronics, radio and computer technology caused the pollution of the environment by electromagnetic radiation of different origins. EMF sources can be natural and technogene. The main sources generating EMF of anthropogenic origin are: television and radio broadcasting stations; radar and radio navigation equipment; high-voltage transmission lines; industrial equipment of high-frequency heating; devices providing mobile telephony; antennas and transformators.

Electromagnetic radiation of anthropogenic origin considered as one of the varieties of energy pollutants. They negatively affect on human body as well as on the other living organisms and have a harmful effect on the ecological systems of EMF. They also have energy and distributed in the form of electromagnetic waves. It is known that the main parameters of electromagnetic waves are the wavelength, frequency of oscillations and dissemination speed. The measure of pollution by electromagnetic fields is tension. Electromagnetic radiation by frequency divided into the following: low frequency radiation (LF): 0.003 - 30 kHz; high frequency (HF) radio waves: 30 kHz - 300 MHz; ultraviolet (UHF) radio waves: 30 - 300 MHz; ultrahigh-frequency microwave frequency: 300 MHz - 300 GHz. Such wide range of waves requires analysis and study of their effects on human and further possible protection from harmful radiation [3]. In last years, special attention of scientific community is attracted to the development of methods and means of protecting people from the harmful effects of electromagnetic fields (EMF). The degree of EMF biological effects on human body depends on many factors, especially frequency oscillations, tensions and modes of its generation (pulsed, continuous) and impact duration of exposure [4-6].

According to World Health Organization (WHO), the degree of exposure to EMF on human health exceeds the effects of radiation and therefore is particularly dangerous for the category of permanent users by electronic means. Among them, that especially dangerous, are children, young people (students). In this regard, greatest attention is devoted to development of protection against EMF, including personal protective clothing. An important role should be played a protective covers and other equipment for shielding the EMF sources by themselves [7-11].

With the development of nanotechnology in synthetic textile materials began to introduce different types of nanoparticles to obtain functionalized fibers with special properties. It is mainly inorganic, metal or metal oxides. The use of nanoparticles for the functionalization of textile materials provides the emergence of new properties, such as: protection against EMF, antibacterial activity, flame retardant property, super hydrophobicity and others [12-15]. Therefore, it is important to protect people who use modern electronic means from the influence of EMF by proper shielding clothes. Modern textile materials with applied nanoparticles have significant protective properties [16-20], so they are becoming more widespread. The purpose of the work is to develop equipment for the complex protection of people from artificial non-ionizing electromagnetic radiation (EMR).

2 EXPERIMENTAL

2.1 Experimental equipment

The method of obtaining nanoparticles of metals directly in the structure of textile materials by impregnating them with solutions of metal salts is developed [18]. The essence of this method is the chemical renewal of metal ions to metals in the structure of textile material and on its surface. As a reducing agent are used: polyhydric alcohols, carbohydrates, ascorbic acid and others.

Developed experimental equipment for obtaining nanoparticles of metals by the method of their sputtering by means of an electric arc in a liquid environment is shown in Figure 1.

The glass cylinder 1 is filled with a dispersion environment. Electrodes 2 and 3 are connected through a rheostat to a DC power supply. The upper electrode is connected to the negative pole, the lower one is positive. The gap between the electrodes for the arc obtaining is controlled by the screw 4. The operating voltage on the electrodes is set in the range from 400 to 700 V with the help of power supply, depending on nature of dispersed material. Metal dispersion can be carried out in constant and pulse modes.

The presence of nanoparticles in a dispersion environment was controlled by appearance of opalescence and the "Tindal cone". The stability of dispersion system is achieved by the addition of surface active substance (SAS) OP-10 up to 0.1%. The size of nanoparticles in a dispersed environment did not exceed 200 nm (Figure 1).

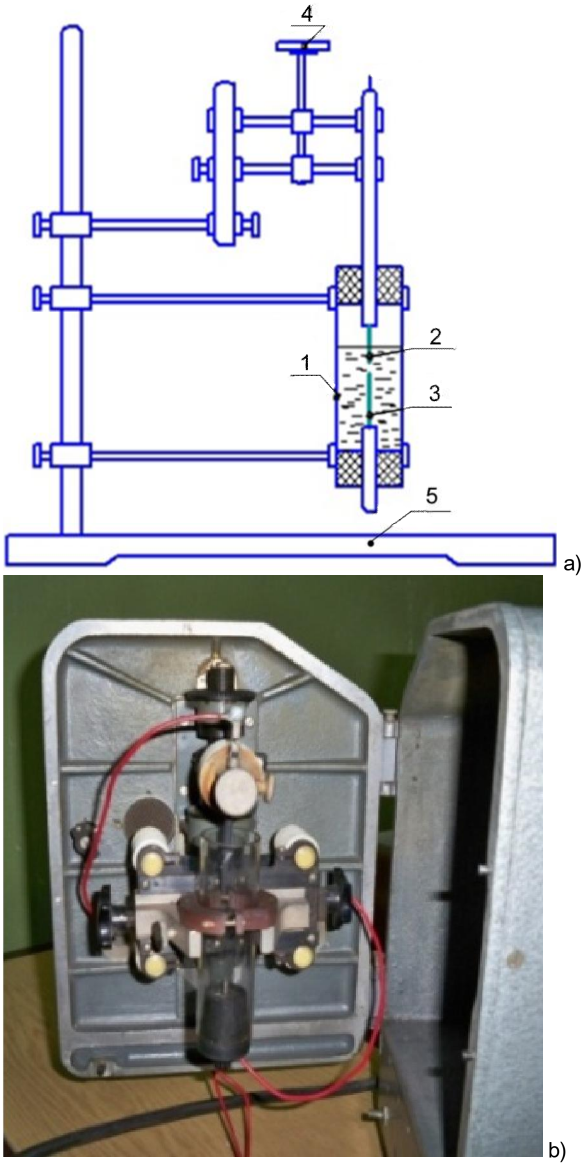


Figure 1 Experimental equipment for obtaining of nanoparticles of metals in a liquid environment using an electric arc: a) scheme; b) working node; 1 - glass cylinder; 2, 3 - electrodes; 4 - electrodes displacement screw; 5 - objective table

Such developed equipment allows perform all necessary experiments to identify the influence of environment with nanoparticles on the fabric.

2.2 Methodology

Nano systems were prepared by an electric arc method of dispersing metals in the form of lysols (dispersion environment – water, alcohol).

The peculiarity of lysols is that they can be stable only at fairly low concentrations (up to 1%). Increasing their concentration is accompanied by an intensive process of coagulation of particles.

The nanoparticles of metals were obtained by the method of erosive and explosive dispersion of metal granules by pulses of electric current in deionized water with pulse energies, which exceeds the sublimation energy of the dispersed metal. For this, the metal pellets were placed in a dielectric capacity with electrodes. Pulses of electric current with amplitude of current pulses in the range of 0.8-2 kA were passed through granules. Dispersion of granules took place in deionized water, which has a high specific resistance.

The concentration of nanoparticles in water environment is 10-100 mg/l. At the concentration of nanoparticles of metals less than 10 mg/l, the bactericidal activity of material is weakly expressed. At a concentration of more than 100 mg/l the stability of solution decreases and from it precipitate of nanoparticles of metals falls.

To conduct research from modifying materials and receiving packages, which can absorb the EMF, were used different textile materials, the characteristics of which are given in Table 1.

Table 1 Characteristics of textile materials used for modification and research

Textile material	Textile material characteristics		
	Textile material	Surface density [g/m^2]	Density [g/cm^3]
PET fabric with conductive thread	99% PET; 1.0% carbon thread	114	–
Bleached beard	100% cotton	140	–
Adhesive material "Sharnet"	100% copolymer of ethylene and vinyl acetate	14,0	–
Aerosil AM-300	99.3% silicon dioxide	–	2.36

Note: PET – polyethylene terephthalate

By method [19], were obtained Ag, Cu and Fe nanoparticles in water and alcohol dispersion environment. The main number of particles was small in size up to 200 nm. In the experiment, a water suspension of polyethylene glycol (PEG) and nanoparticles of metals was obtained. After removing a water environment received substance was added directly to the polymer. It is known that the addition of PEG to a fibrous polymer facilitates the formation. Therefore, it is advisable to introduce nanoparticles directly into the PEG. Subsequently, these colloidal solutions were added to the fiber forming polymer, stirred and dried. The technique for the introduction of nanoparticles directly into PEG was developed. The disperse system (PEG-water) was chosen. The metal was dispersed in a solution of PEG which, after removal of the dispersion environment, was added to the fiber forming polymer. PEG was placed in a porcelain device and heated to a temperature above 100°C, but not more than 130°C. Then, with a special device, in the received PEG substance was added water dispersion of metal, but in small portions.

3 RESULTS AND DISCUSSION

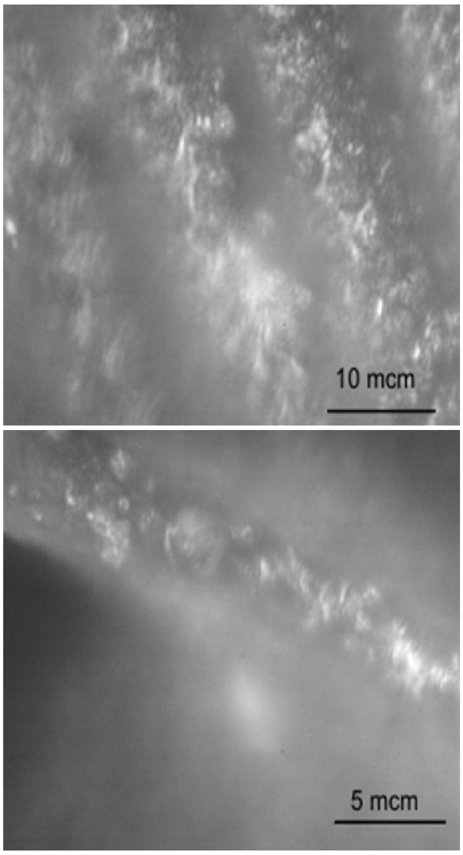
A series of studies on the modification of textile materials by copper nanoparticles was carried out to verify the effectiveness of proposed solutions. Copper sulphate was dissolved in glucose solution at a temperature of 30-50°C. The textile sample was soaked in this solution at constant stirring. To maintain pH 8-9, sodium hydroxide was added gradually (after 10, 20 and 30 minutes). As a result, copper nanoparticles were formed in the porous structure of the textile material and on its surface. Modification of the textile material was carried out directly in the reaction environment [20].

All operations of the process of copper sulphate reduction with glucose, with the formation of nano powder of copper, were carried out in air at atmospheric pressure.

Before making the modification of the textile material the apreat and surface-active substances were removed (washing at a temperature of 50-60°C, concentration of non-ionic detergent 2-3 g/l). Modification of textile materials by nano-dispersed copper particles was carried out in solution of pentavalent copper sulphate and glucose at a molar ratio of glucose to five-water copper sulphate (1.0-2.5)-1.0. Copper sulphate (17.0-42.5 g) was dissolved in a 10-40% solution of glucose at a temperature of 50-60°C. Into the prepared solution immerses dusted water samples of textile material (bath module 1:10). Gradually, the temperature of the reaction mixture was raised to 70°C. The samples were kept in isothermal conditions for 20-30 minutes. In the reaction mixture with samples of textile material 0.25-5.00 g of sodium hydroxide was added in several techniques. As a result of the reaction, the environment was heated to a temperature of 75-90°C and a monovalent copper oxide was formed. During the reaction, the pH of the environment was constantly decreasing, therefore, at some time intervals, several more portions of sodium hydroxide were added additionally to 0.25-5.00 g to maintain the pH of the solution, preferably 8-9.

Copper nanoparticles of 30-45 nm in size were obtained. The reaction ended after 60-70 minutes, depending on the concentration of reagents and pH of the environment. Copper nanoparticles were formed on surface and in the structure of textile material. Textile samples were dried in air.

The samples of unmodified and nanomodified fibrous materials: cotton fabric impregnated with silver iodide salt colloidal solution (Figure 2a) and polypropylene non-woven fabric modified by silver nanoparticles (Figure 2b), were selected for research



a)
b)

Figure 2 Optical image of fibrous materials bleached and modified by Cu: a) fabric; b) non-woven fiber

Modified research samples were obtained. 24.3 g of 5-water copper sulphate was dissolved in 100 ml of a 30% solution of glucose (in air at atmospheric pressure) at a temperature of 60°C (molar ratio of $C_6H_{12}O_6$:$CuSO_4 \cdot 5H_2O$ = 1.75). In this solution, specimens of textile material pre-moistened in distilled water were immersed and the temperature increased to 70±2°C. The samples were kept at this temperature for up to 30 minutes and then the first portion of 2.5 g of sodium hydroxide was injected.

As a result of the reaction, the mixture was heated to 90°C. In the process of reaction, the pH of reaction environment decreases, so every three 15-minute intervals, three servings of 2.5 g of sodium hydroxide were injected. The reaction time was 60-70 minutes.

As a result, monovalent copper oxide was formed, which with the addition of the next three portions of sodium hydroxide was reduced to copper. At the end of the reaction, samples of textile materials were washed and dried in air without spin in the strained state.

Optical microscopy shows that the impregnation of textile materials in the solution of metal salts with the subsequent restoration of metal ions ensures the formation of nanoparticles of metals in the structure of the textile material and on its surface. Thus, a new method for modifying the nanoparticle of metals by impregnation in a salt solution with the subsequent restoration of metal ions in the structure and on the surface of the textile material was proposed and investigated. The equipment of complex man protection from artificial non-ionizing EMR was developed. Such equipment is characterized by spraying nanoparticles of metal on the fabric, which ensures their further impregnation. As a disadvantage, it can be noted that such equipment is experimental nature. So, it is necessary to improve the construction of equipment in further research. This will ensure high-quality research with greater accuracy.

It should also be noted that the study was conducted only with copper particles, which limits the scope of research. Therefore, it is important to conduct further research on the developed equipment using the developed method for a significant number of nanoparticles of various metals. Application of nanoparticles of various metals will allow to establish the most effective material for complex man protection from ionizing radiation.

4 CONCLUSION

The analytical researches from the definition of influence of artificial non-ionizing EMR on the man were conducted. The main factors influencing on this process were determined.

The method of obtaining nanoparticles of metals directly in the structure of textile materials by impregnating them with solutions of metal salts was developed.

The experimental equipment for obtaining nanoparticles of metals by the method of their sputtering by means of an electric arc in a liquid environment was developed

Experimental researches with the modification of textile materials by nanoparticles of metals were carried out. The mechanism of influence of copper nanoparticles on the structure of fabric was determined.

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