SYNTHESIS OF METALS NANO-PARTICLES IN THE POROUS STRUCTURE OF TEXTILES FOR UV-SHIELDING

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Abstract: *The up-to-date numerous clinical and physiological studies show that ultraviolet radiation (UVR) has a negative impact on human organisms and provoke the dangerous diseases, such as cardiovascular, allergic, blood diseases, skin cancer, decreasing of immunity and so on. Nowadays the task of human protection against UVR has become very important and very urgent. That is why the development of new and effective methods and means for the human organism protection against UVR to acceptable levels persists to be one of the pressing challenges for people society and for researchers. Just the textiles and textile articles with especial protective properties may play the significant role in decision of this task. The aim of our work is investigation and elaboration of new reliable effective and rather simple method of textile modification with nano-metal particle. We propose to use the method of hydrometallurgy, namely, using textile impregnation in solution of soluble metal salts with following reduction of metal-ions in textile structure. We have done our work with Cu-sulfate solution and following Cu-ions reduction in porous structure of polyester textile and on surface of each fiber. The proposed method is simple, accessible and effective (cheap and accessible reagents, processing is possible on the equipment for dyeing); may be used for porous substrates of any chemical nature. It may be realized for soluble metal-salts.*

Keywords: *UV-shielding; textile modification; using of water soluble metal-compound.*

1 INTRODUCTION

The up-to-date numerous clinical and physiological studies show that UVR has a very negative impact on human organisms and provoke the different dangerous diseases (cardiovascular, allergic, blood diseases, skin cancer etc.). Also it may cause genetic changes, decreasing of immunity and so on [1-5]. So, nowadays the task of human protection against UVR is very important and urgent. That is why the development of modern effective methods and means for the human organism protection against UVR to acceptable level is one of the very pressing tasks for people society and for researchers. Just the especial protective textiles and textile articles are playing a significant role in decision of this task. The textiles used must be modified by suitable methods to have the sufficient protective properties against UV radiation. They must be conductive and have especially specific construction. Some methods are well known to provide UV-shielding by using of textile materials [6-9].

Treatment with UV absorbers, able to convert electronic excitation energy into thermal energy, acting as radical scavengers and singlet oxygen quenchers. To be effective UV absorbers have to absorb throughout the spectrum, to remain stable against UV radiation and to dissipate the absorbed energy to avoid degradation or loss in color. The main UV absorbers for modification of textile products are derivatives of o-hydroxy benzophenones, o-hydroxy phenyl triazines, o-hydroxy phenyl hydrazines and thus are rather toxic substances [10, 11]. It is known also combinations of UV absorbers with antioxidants and inorganic pigments (for example, with titanium dioxide, zinc oxide and ceramic materials) [12-14]. Metal oxide nano particles of TiO_2, ZnO and Fe_3O_4 that included into fibers structure or using for textiles as finishing agents have not sufficient effect on UV rays absorption; used in large quantities impair the textile properties and act as photocatalysts and degrade textiles. They are rather toxic for humans even if they are incorporated into fibers.

Dyeing with different types of dyes or pigments that absorb in UV range is increasing the Ultraviolet Protection Factor (UPF) of textiles [15]. The main problem in this case is that only darker colors (black, navy, dark red) absorb UVR much more strongly than the light pastel colors in general. But for the summer the pastel colors of fabrics are preferred. Moreover, the UPF could be low, if dark colors are applied on loosely textile structures. All these factors must be taken into account during elaboration of new processes of textiles modification.

The aim of our work is the investigation of the new, rather simple method of textile nano-modification. The proposed method involves the use of soluble metal salts. This method consists in impregnating of textile material in a solution of the soluble metal salt (in our work Cu-sulphate), followed by the reduction of metal ions in the structure and on the surface of the textile material. Technique and technology modification by this method can be carried out on modern equipment for dyeing and finishing.

2 EXPERIMENTAL PART

2.1 Setting the task

It is known that the processes of modification of textiles by nano-sized metal particles are time-consuming and expensive. At the same time, using the methods of hydrometallurgy, involving the reduction of metal ions in salt solutions, metal particles could be produced. So, it is possible to produce nano-metal-modified textiles by treating them in solutions of metal salts and reduction reaction of metal ions in textile structure. This technique can be used to obtain metals nano-particles from soluble salts metals of the first group, some salts of the second group metals (chlorides, bromides, iodides, nitrates and some others). This process is known as “hydrometallurgy” [16].

In our opinion, this technique can be used not only for textile materials, but also for any porous bodies. It is important that the chemical nature of the textiles and other materials in this case has not matter.

2.2 Samples preparation

Modification of the polyethylene terephthalate (PET) textile material with Cu nano-sized particles was carried out directly in the $CuSO_4$ solution. The essence of this method consists in textile sample impregnating in a solution of $CuSO_4$, followed by the chemical recovery of copper ions in the textile structure and on the surface of textile. As reducing agents polyhydric alcohols, carbohydrates, ascorbic acid, etc. may be used.

Copper sulphate was dissolved in glucose solution at a temperature of 30-50°C. The textile sample was impregnated in this solution and was constantly mixed. After a certain time the sample was immerse in glucose reducing solution, to complete the copper sulphate reduction process.

Transactions copper ions recovery process with using of glucose to copper nano-powder is carried out in air and atmospheric pressure. To maintain the pH between 8-9 sodium hydroxide was added gradually (in 5, 15, 25, 40 minutes).

The sequence of stages of copper ion recovery process in glucose solution may be represented by the scheme:

$$CuSO_4 + (C_6H_{12}O_6 + NaOH) \rightarrow Cu_2O$$

$$Cu_2O + NaOH \rightarrow Cu$$

Under these conditions the reduction of copper oxide Cu_2O to copper Cu was ended after 60-70 minutes. Then the textile samples were dried in air without pressing.

2.3 Investigation technique

Optical microscopy shows that impregnation of textile materials in a metal salt solution with subsequent reduction of metal ions provides the formation of metal nanoparticles in the structure of the textile material and on its surface (see Figure 1). We can see Cu particles on fiber sized about 100 nm.

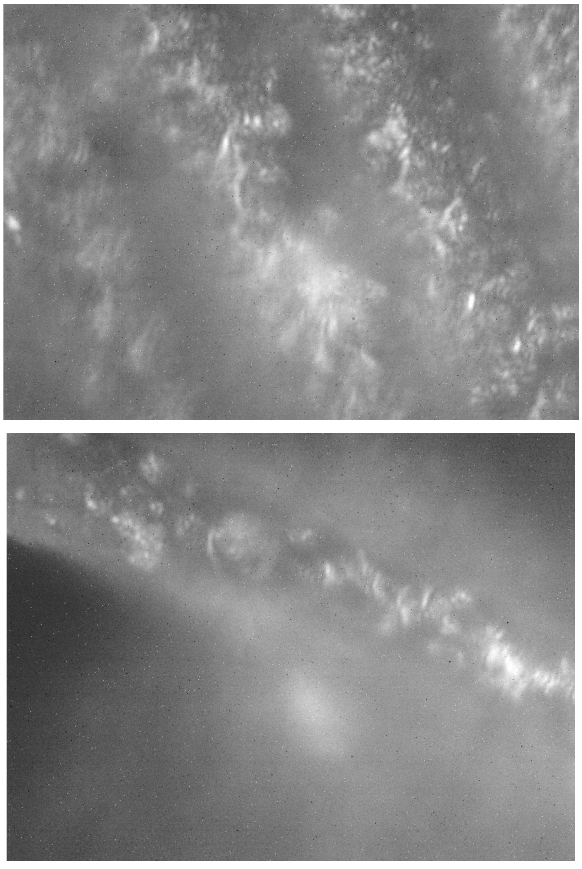

Figure 1 Optical image of cotton fabric bleached, modified by Cu: a) fabric; b) separate fiber

Testing the efficiency of copper nanoparticles coated materials for UV-light absorption was carried out in the Test-Laboratory of our University on the device FADOMETR mark LE-1 (model KT7035). The source of UV radiation is arc Xenon Lamp OSRAM XENON SHORT ARC DISPLAY/OPTIC LAMP XBO® XTREME LIFE; filter - a triangular prism, in the middle of which there is an arc Xenon Lamp. The radiation intensity is measured by the UV-Radiometer “Tenzor-71”.

Table 1 The degree of ultraviolet light absorption by Cu modified textile at wavelengths A (315-400 nm) and B (315-280 nm)

№ specimen	Characteristics of the sample	Power light, [W/m^2] (range A)		The degree of absorption in the range A [%]	Power light [W/m^2] (range B)		The degree of absorption in the range B [%]
		before sample	*behind sample*		*before sample*	*behind sample*	
1.1	PET fabric unmodified	51.1	4.2	91.8	8.9	0.5	94.4
1.2	PET fabric modified by Cu		0.2	99.6		0.3	96.6
2.1	Cotton fabric unmodified	51.1	7.5	85.3	8.9	5.1	42.7
2.2	Cotton fabric modified by Cu		3.4	93.3		0.7	92.1

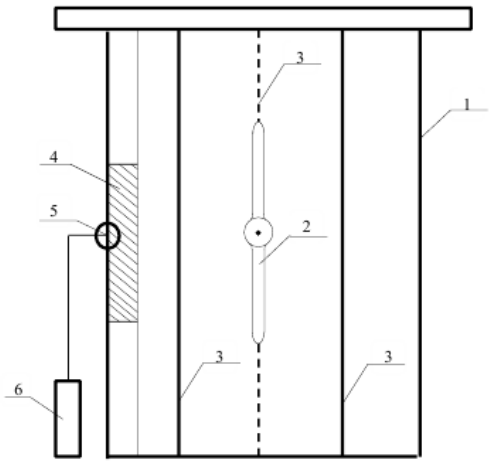

Figure 2 Scheme of FADOMETR: 1 - frame for placing of textile samples; 2 - arc Xenon Lamp type; 3 - triangular prism - filter in which a Xenon Lamp is placed; 4 - sample of textile material; 5 - UV-radiometer "Tensor-71"; 6 - the electronic block with the screen of the UV-radiometer

3 RESULTS OF RESEARCH

The results of UV-light absorption testing are summarized in Table 1. As we can see the modification by nano Cu-particles enhanced the protection properties both in A and in B range of UVR.

4 CONCLUSION

It was investigated the new method of nano-metal textile modification by impregnation in the metal-salt solution and subsequent reduction of metal ions in structure and on surface of textile material (by the example of a solution of Cu-salt).

This technique, in principle, can be used to obtain metals nano-particles from soluble salts metals of the first group; some salts of the second group metals (chlorides, bromides, iodides, nitrates) and some others.

The proposed method is simple, accessible and effective (cheap and accessible reagents, processing is possible on the equipment for dyeing); may be used for porous substrates of any chemical nature.

UV-shielding by using of textile materials modification by nano Cu-particles with using of $CuSo_4$ solution enhanced the protection properties both in A and in B range of UVR.

***ACKNOWLEDGEMENT**: This work was carried out with the support of the Ukraine Ministry of Science and Education.*

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