Effect of RF plasma modification on electrical characteristics of collagen containing polymer materials surface

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Abstract. Artificial materials that used in the manufacture of textile industry products have increased static characteristic and electrical resistivity. The large electrical charge accumulated by them negatively affects the human body. The use of natural collagen containing polymer materials is the safest way to avoid unacceptable risk to human health. With the help of nonequilibrium low temperature plasma (NLTP) treatment of collagen materials under reduced pressure it is possible to achieve an additional reduction of the electric potential by scattering charges on the surface of genuine leather. Under certain conditions the main reason for the generation and accumulation of static electricity is the high hygroscopicity of the material. Hydrophobization of the surface of collagen containing materials is achieved through the use of a hydrophobizator and volumetric NLTP treatment. Plasma treatment of collagen containing polymer materials also increases their biological compatibility and antimicrobial properties, improving mechanical characteristics by changing the internal structure of the material.

1. Introduction
Capillary-porous collagen containing polymer materials which include genuine high molecular tanning materials are in a stable high demand for the production of textile, medicine, petrochemical and other industries products [1,2]. One of the main consumer properties of collagen containing polymer products which determine their value and competitiveness in the international market are reliability and safety in consumption. Reliability and safety of collagen-containing polymer materials are complex indicators of the first level. Reliability in turn is determined by such properties as reliability, durability, maintainability and storageability. Second level complex indicators of the afety of consumption are mechanical, electrical, chemical and biological safeties.

Electrical safety of textile industry products is associated with the use of artificial materials for its production. The large electric charge accumulated by such materials negatively affects the human body. Genuine collagen containing high molecular materials, unlike artificial materials, have significant advantages, because electrification of products made of genuine materials is much lower than that of products of other materials. With the help of nonequilibrium low temperature plasma (NLTP) processing of collagen materials under reduced pressure it is also possible to reduce the electrical potential by scattering charges on the surface of the material which will allow the use of products as special-purpose products in industries with increased danger.
2. Materials and Methods
The studies were carried out on experimental samples of collagen containing polymeric materials made using two technologies: nanostructured samples (genuine materials, which at the final stage of finishing production were treated with low pressure NLTP in a mode of $W_p = 1.5$ kW, $\tau = 7$ minutes), nanomodified samples (genuine materials, where a biocide agent, a solution of silver nanoparticles of 0.2%, was injected twice in the fattening stage with coating dyeing and at the stage of application of the coating film fixer; NLTP low pressure treatment in a mode of $W_p$ mode = 1.5 kW, $\tau = 7$ minutes was included within the finishing process).

Plasma torch with flat electrodes for obtaining a plasma flow of a capacitive type is represented by two water cooled copper plates with the following dimensions: 20x30 cm or 40 cm in diameter. The electrodes are placed in a vacuum block. A device for fixing the samples with the device for their rotation during processing is placed between the electrodes. The base of the vacuum unit is mounted in the form of a welded frame. There are two rotor pumps and a water cooling system of the units of the installation on the frame of the block [3-5].

Measurements of the zeta potential control samples of collagen containing polymeric materials, processed in NLTP and modified in NLTP with silver addition are performed with the help of the analyzer of electrophoretic mobility to evaluate the electrical properties of the material [6].

In dispersed systems a double electric layer appears on the surface of solids. The double electrical layer is a layer of ions formed on the surface of the particle as a result of the adsorption of ions from the solution or the dissociation of surface compounds. The surface of the particle acquires a layer of ions of a certain sign uniformly distributed over the surface and creating a surface charge on it. These ions are called potential determining ions. Ions of the opposite sign are attracted to the surface of the body from the liquid medium, they are called counter ions. Thus, the double electric layer consists of potential-determining ions and a layer of counter ions is located in the dispersion medium. The layer of counter ions consists of two layers:

- Adsorption layer (dense layer), adjacent directly to the interfacial surface. This layer is formed as a result of electrostatic interaction with potential determining ions and specific adsorption.
- Diffuse layer where counter ions are located. These counter ions are attracted to the particle due to electrostatic forces. The thickness of the diffuse layer depends on the properties of the system and can reach large values.

When the particle moves, the double electric layer breaks. The place of discontinuity when moving the solid and liquid phases with respect to each other is called the slip plane. The slip plane lies on the boundary between the diffuse and adsorption layers or in the diffuse layer near this boundary. The potential on the slip plane is called the electrokinetic or zeta potential (the $\zeta$ potential). In other words, the zeta potential is the difference between the potentials of the dispersion field and the fixed layer of fluid surrounding the body. The zeta potential is not equal to the adsorption potential or the surface potential in the double electric layer. However, the zeta potential is often the only available way to evaluate the properties of the double electrical layer.

3. Results and Discussion
The results of the measurements using the analyzer of the electrophoretic mobility of the zeta potential of control collagen containing polymer materials samples, treated in NLTP and modified in NLTP with silver addition are shown in Fig. 1.
Fig. 1. Zeta potential of control samples of collagen containing polymeric materials, processed in NLTP and modified in NLTP with silver addition.

Under certain conditions the main reason for the generation and accumulation of static electricity is the high hygroscopicity of the material. Hydrophobization of the leather surface, i.e. giving water-repellent properties, is achieved through the use of a hydrophobizator and volumetric NLTP treatment [7].

In turn, plasma processing of collagen containing materials also increases their biological compatibility and antimicrobial properties [8], mechanical properties [9,10] are improved without changing the chemical composition of the material. Processing of collagen-containing materials in NLTP allows to increase the operational indices of light industry products and prolong their service life.

4. Conclusions

On the basis of the conducted experiments it can be concluded that the NLTP treatment of collagen containing materials under reduced pressure leads to a decrease in the electric potential by scattering charges on the surface of the material. The magnitude of the zeta potential determines the degree and nature of the interaction between the particles of the system. The value of the zeta potential equal to 30 mV (positive or negative) can be considered as a characteristic value for the conditional separation of low-charged surfaces and high-charged surfaces. The more electrokinetic potential, the more stable the system. Thus, the potential of a sample subjected to a plasma modification by silver is much lower than a sample from a batch lot or processed in a NLTP, which determines the safety and reliability of the final products during operation.

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