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APPLICATION OF NANOPARTICLES FOR COLLAGEN MODIFICATION

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Abstract:

The modification of collagen with polymeric nanocomposites of plant origin was studied in the work. Studies have identified patterns in the reaction of polymers with collagen. The resulting polymer systems were used for leather tanning and a technology for obtaining modified collagen films was developed.

Keywords: Polymer, nanocomposite, modification, nanoparticles, nanomodification, nanochemistry, infrared spectra, SEM, laser abelation, assembler, collagen, nanotanning.

INTRODUCTION

The development of nanoscience in recent years is mainly associated with the development of new methods for obtaining, studying and modifying nanoparticles and nanostructures. The perspective and profound development of such problems is determined by nanochemistry [1].

In turn, nanochemistry itself has two important aspects. Modern methods of research in the nanochemistry of modification show that collagen molecules interact with active groups and the modifier form bonds in the area of those sections of the polypeptide chains of the disordered structure of collagen [1-3].

Features of the chemical properties and reactivity of nanoparticles consisting of a small number of atoms, the study of which lays new fundamental foundations for this science.

Another aspect is the use of nanochemistry to obtain, modify, stabilize isolated nanoparticles and direct their self-assembly into more complex nanostructures. In this case, the main attention should be paid to the change in the properties of the obtained structures as a result of adjusting the size and shape of the modifying nanoparticles for collagen.

In the world, there are different ways to modify the collagen of the dermis. Nanomodification of collagen and obtaining the desired properties of new materials, the study of the chemistry of these reactions has been little studied. The field of creating new nanotechnologies and the use of new nanomodifiers for collagen systems in the compositions of tanning agents will be quite promising.

In the production of leather, tanning processes are among the most important. The quality of the finished leather is largely dependent on the tanning process the modification of the dermis collagen.

The purpose of this work is the use of new modifying substances of polymers for the nanomodification of skin collagen in tanning processes. Determine theoretically and experimental conditions for the targeted production of modified collagen products with desired properties and the use of these drugs in production. As well as establishing the features of laser modification of collagen with tannin nanoparticles in the mode of double pulses in a wide range of input energies.

In our research, a new system based on a natural high-molecular compound was obtained by modifying it with vegetable tanning agents and we developed nanotechnologies for obtaining it. Used in the production of leather tanning processes. We have paid attention to the interaction of collagen with nanoparticles, as the researchers assumed that with the help of chemical nanomodifications, it is possible to elucidate the structural features of proteins, on which their properties depend.

It was clear that specific modification of collagen nanoparticles, such as monofunctional grafting, as well as reactions, would lead to cross-linking.

After the modification of collagen with nanoparticles, the process of skin ablation using a Co laser was studied in more detail. Nanomonofunctional interaction affects the physicochemical and other properties of collagen and thus disrupts the reactivity of individual functional groups. Maybe with the introduction of new groups into the protein molecule, there are opportunities for greater activity of individual functional groups present in collagen. Which nanoparticles of modifying substances are more accessible for penetration into them than the areas of the ordered structure of collagen. Composite modification occurs in two stages: the diffusion of elements to the active centers of collagen, their chemical binding to collagen fibers. The chemical composition includes elements of a vegetable tanned solution.

It should be pointed out that in the conditions of development, a special place is occupied by the creation of new modifying substances on their basis for the modification of skin collagen nanoparticles, which is a very urgent scientific and technological problem.

EXPERIMENTAL

Material preparation

Nanochemistry of the use of vegetable tanning composition, in the collagen of the dermis, gave their indicators. In the works it was determined that using a vegetable tanning composition instead of chrome tanning agents, it is possible to obtain genuine leather samples with good appearance and improved quality.

In continuation of the study, our colleagues from Bellorus of the Academy of Sciences (Bel AN) studied laser modification of natural leather after tannide tanning in the mode of double pulses in a wide range of input energies.

It should be noted that the scattering of laser radiation in the dermis of the skin also depends on the wavelength. The most important endogenous chromophores that absorb radiation are melanin, hemoglobin, and collagen. Approximately 5-7% of the radiation is reflected at the level of the stratum corneum. Laser radiation in the range of 600-1200 nm scatters less and penetrates deeper than l00 μm. The mechanisms of interaction between laser radiation and natural skin are largely determined by the properties of the irradiated object.

The process of skin ablation using a Co laser has been studied in more detail. Processes of skin structure changes under the action of a yttrium aluminum garnet laser with a wavelength of 1064 nm, which generates in a two-pulse mode, have practically not been studied.

The resulting skins have high physical and mechanical properties. The tanning method developed by us can also be used for leathers with a refined front surface.

SEM

Scanning electron microscope could be handy approach to govern the morphology and particle size of the samples. Samples studied by scanning electron microscope.

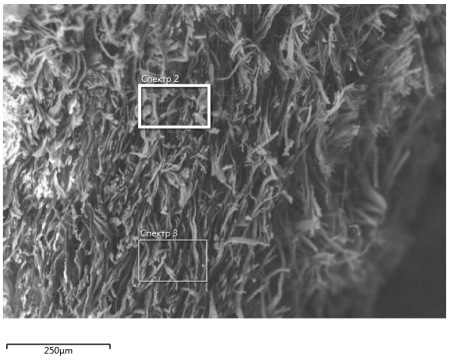

Fig 1. Cross section of tannin tanned leather

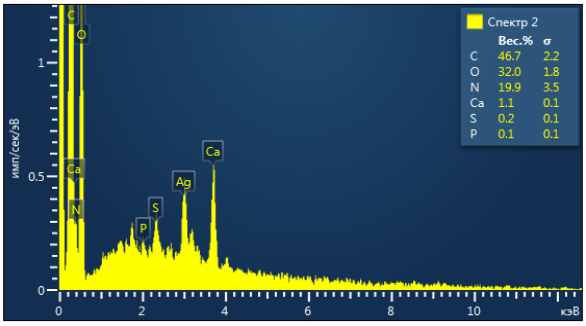

Fig 2. Elemental composition of modified skin collagen with tannins

The drawings show collagen bundles in a strict order. The elemental composition of the modified skin collagen shows the absence of chromium and chromium compounds. This indicates that collagen is modified with tannin nanoparticles.

The above results about the differing microstructures obviously indicate conformational differences in the collagen macromolecules of the dermis.

According to, under the influence of the first laser pulse, the substance evaporates, and a region with an increased temperature and a reduced density of air particles is formed in the near-surface layer, which leads to a more complete use of the energy of the second pulse for laser ablation.

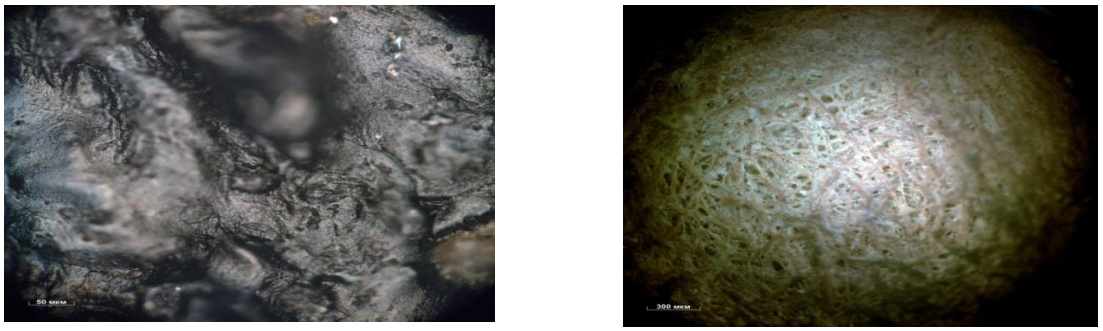

Fig.3 - Morphology of the surface of the front side of the skin after laser exposure: a - bright-field

illumination, b - dark-field illumination [3]

Under the influence of IR laser radiation in the process of ablation, an explosive evaporation of tissue water occurs together with fragments of tissue structures with the formation of an ablation crater.

Figure 3 shows the surface morphology of a natural leather sample in its original state. Figure 3 a, b shows collagen fibers and numerous holes from hair follicles (up to 15 or more per l mm2 surface). The hole size is from 80 to 250 microns. Figure 3 shows a hole from a hair bag with hair. In Figure 4, bundles of collagen fibers are clearly visible, which are of small thickness and densely randomly intertwined

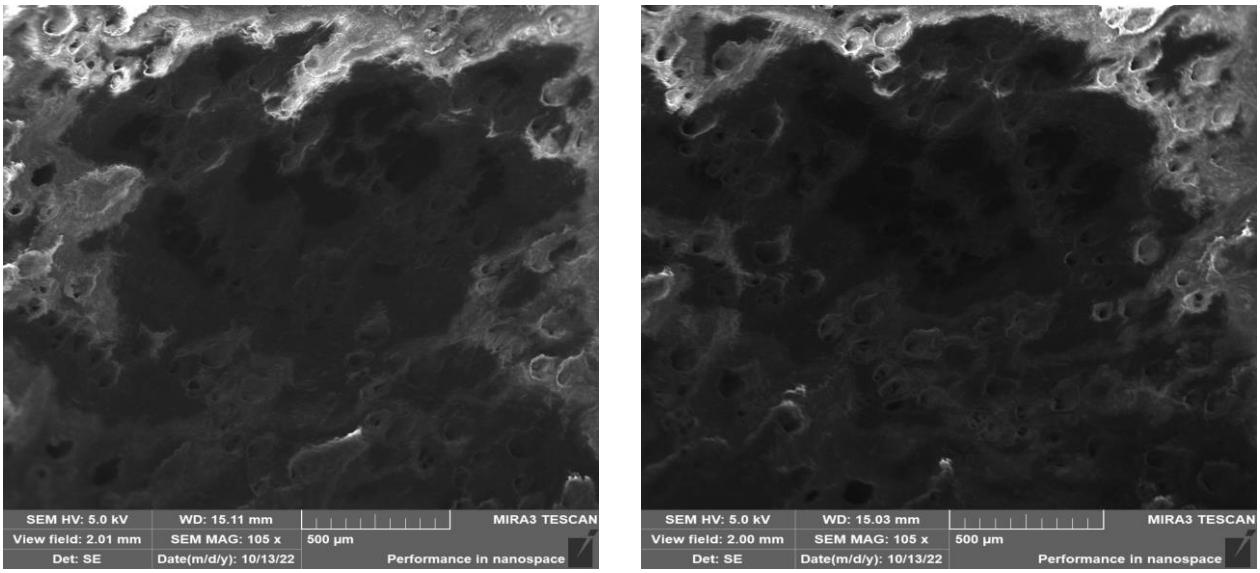

Fig. 4 - Morphology of the surface of the front side of the skin after laser exposure at various magnifications: a, b - center and edge of the laser spot, respectively; wet energy 10 J; exposure time 10 s.

Figure 4 shows the mode of "soft" (10-30J) impact on the surface of the measure. This figure shows the polishing of natural skin and slight delamination of collagen fibers. These results show the possibility of changing the structure of natural skin due to conformational changes.

The process of skin ablation using a Co laser has been studied in more detail. Processes of skin structure changes under the action of a yttrium aluminum garnet laser with a wavelength of 1064 nm, which generates in a two-pulse mode, have practically not been studied.

Based on the results achieved, it can be assumed that the study of the polymer-composite composition and collagen makes it possible to obtain high-strength leathers with high performance. The developed method of modification with a polymer-composite composition can also be used for leathers with a refined front surface.

CONCLUSION

Based on the results of laser abelation, it can be concluded that it is expedient to replace traditional methods, including the used tanning agents. These products, as micro-heterogeneous systems, can be used for tanning hides from small ruminants.

Based on the results achieved, it can be assumed that collagen skin tanning makes it possible to obtain natural leather coatings with high performance.

By the method of optical microscopy , the surface morphology of a sample of natural lamb skin was stufied under laser exposure. The leather has been pre-treated with natural tannins.

Modification of the skin surface was carried out using a laser generating in a two-pulse mode (pulses are separated by a time interval of 3 µs, pulse duration of 10 µs) with a wavelength of 1064 nm in a wide range of applied energies from to, wich lead to, both skin surface resultacing and its perforation. The possibility of changing the structure due to conformational changes has been shown.

ACKNOWLEDGEMENT

These nanoparticles, as microheterogeneous systems, can be used for tanning leather from the skins of small cattle. It should be noted that at present the tanning of leather with tannins provides waste-free production and is an environmentally friendly technology.

The Bellorusian colleagues of the Academy of Sciences (Bel AN) and I studied natural leather after modification with polymer-composite materials in the mode of double laser modification pulses in a wide range of input energies.

The resulting skins with a refined front surface have high physical and mechanical properties. The tanning method developed by us can also be used for leather with a refined front surface. These nanoparticles, as an assembler of the system, can be used for tanning leather from the skins of small cattle.

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