ABSTRACT

Understanding the common forces involved in the process of stabilization of collagen irrespective of tanning molecules used is of profound interest. In an attempt to define how skin attains stability when treated with tanning agents, issues related to the changes in thermal and enzymatic stability, chemical and physical properties of the skin protein have been addressed in the recent past and a unified theory of tanning has been proposed. In the present investigation, the role of water structure and hydration phenomena in the dimensional stability induced by tanning agents and ligands to skin and leather has been studied. Some novel experimental techniques have been deployed in this work for examining the role of water in influencing the dimensional stability of collagen and leather.

The transverse relaxation time, $T_2$ of water contained in skin and leather have been measured using NMR techniques with the objective of understanding the role played by the dynamic structure of water in processes leading to the stabilization of collagen. Some new correlations have been observed between transverse relaxation times, $T_2$ for water protons in tanned collagen in wet and dry conditions. Differences in the slopes for hydrolysable and irreversible tanning processes can be interpreted in terms of desolvation associated with tannin efficacies. For all the hydrolysable type of tanning, the slope of the correlation between $T_2$ in wet and dry conditions is $0.55 \pm 0.01$, whereas the corresponding slope for the more irreversible type of tanning
methodologies is $0.88 \pm 0.02$. Dielectric studies reveal the cooperative processes in organized molecular assembling of tanned collagen fibers. Thermoporometry technique, which enables measurements of sub-micro pore sizes based on freezing point of water contained in confined pore structures, has been deployed to probe the changes in sub-micro pore structures of skin lattices before and after tanning in this study. Thermoporometry offers signatures of desolvation and alterations in sub-micro pore structures of skin on tanning.

In the present investigation, experimental evidence has been presented to show that thermal shrinkage is associated with several changes in lattice levels and pore structures. The pores in the diameter range of 10-30 µm seem to be more seriously affected on thermal shrinkage whether tanned or otherwise. The final pore volume is reduced to about 9% for both untanned and chromium tanned specimen. Vegetable tanned leathers undergo more complete loss of pore structure than even chromium tanned leathers with increases in mean pore diameter on one side and final pore volume limiting to less than 1%.

Experimental evidence has now been provided demonstrating the utility of shear viscosity and elasticity profiles in exploring the role of surface entanglements in ordering of collagen and its cross-linked forms. The influence of tanning materials like Basic Chromium Sulfate (BCS), catechin, tannic acid and formaldehyde and a small ligand like curcumin on the three-dimensional ordering and kinetics of formation of collagen fibrils has been investigated. All the tanning materials seem to alter the auto-catalytic process
of fibril formation of collagen. The time required for the completion of the lag phase (involving the self-assembly of collagen) seems to be reduced in many cases. Curcumin does not seem to alter the auto-catalytic nature of kinetics of fibril formation. Efficacy of the ligand in wound healing may well arise from its control on the dynamics of formation of collagen fibrils.

The present investigation provides some tools and techniques to further improve the unified theory of tanning by including also the relevance of water structure in tanning.