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Original Paper

Evaluation of the Impact of Iron on Structural deterioration of Chrome Leather in Buried Conditions, Based on Degradation Indices in FTIR Spectra

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Abstract

As leather production is an ancient industrial activity, historical leathers represent an important part of any society's cultural materials. However, since leather is made from collagen fibers that are susceptible to many degradation factors, leather artifacts have been remained less often than other historical materials. Wide variety application of leather, imposes a particular set of conditions, which can bring about deterioration in the leather. In general, deterioration of leather is a chemical process in which there are a great number of contributing factors. Iron and its corrosion products are among the effective factors in the degradation of leathers, especially in buried specimens. This factor, in combination with the leather and tanning chemistry, leads to very diverse and complex degradation mechanisms. Therefore, the aim of this study is to evaluate the effects of iron corrosion products on leather deterioration. Accordingly, a buried leather sample obtained from historic "Khosravi" Leather Factory, Tabriz Islamic Art University, was examined. Based on appearance, the leather was buried in the vicinity of the iron and its corrosion products. Different parts of leather show the possibility of penetration of different amounts of iron or its corrosion products. Structural evaluation of different parts of the leather and their deterioration was performed by spot test of iron (using potassium ferrocyanide), leather ash measurement, Micro x-ray fluorescence (μXRF), Ultraviolet–visible (UV-Vis) and Fourier-transform infrared (FTIR) spectroscopy and microscopic examination. FTIR spectra were also fitted to the Gaussian function. The results showed that this sample was tanned with chromium salts and, probably, lime was used for dehairing. Examination of leather showed that the amount of iron varied in different parts of leather. In other words, a part of the leather has been in direct contact with iron and, over time, corrosion products have penetrated the leather structure. This has led to differences in the amount of iron in different parts of leather. Structural changes in different parts of leather were investigated using degradation indices in FTIR spectra. The hydrolysis degree of the polypeptide chains can be semiquantified using the amide I/amide II band intensity ratio (I_{AI}/ I_{AII}), which is about 1.25 - 1.30 for new leathers and increases with deterioration. The triple helical structure integrity can be also evaluated by peak absorbance ratio of amide III and 1450 cm^{-1}, which is equal to or higher than 1 for the intact collagen triple helix and around 0.5 for denatured collagen. Moreover, the relative position of amide I and amide II bands ($\Delta\nu=\nu_{AI}-\nu_{AII}$) is corresponding to the collagen gelatinization process, and the value is around 90-100 cm-1 for new leathers. The carbonyl index at 1740cm^{-1} also shows the oxidation of collagen. Accordingly, examination of the structural properties of different parts of the leather showed that as the amount of iron in the leather

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increased, the integrity of triple-helical structure of collagen collapsed (decrease in I_{AIII}/I_{1450}) and its hydrolysis increased (increase in I_{AI}/I_{AII}). And it also has increased collagen oxidation (increase in I_{1740}/I_{AI}). However, the results did not show a significant change in the index of collagen gelatinization (Δν).

Keywords: Leather, Collagen, Chromium tanning, Degradation of leather, Iron, FTIR