Evaluation of Leather ageing using DMA and DETA techniques in a controlled humidity environment.

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Many artists' materials, particularly substrates, are sensitive to moisture content. A means of exploring the effects of substrate ageing or the efficacy of conservation treatments is sought. A simple DMA or dielectric measurement carried out under ambient room temperature and humidity conditions may only reveal a small percentage change in properties such as storage modulus, E' or relative permittivity, ε'. However when the same properties are measured with varying conditions of temperature and humidity, much greater effects are observed.

Recent studies have employed moisture uptake to magnify the effect of changes within the structure caused by ageing and conservation treatments. Data presented here show the effects of thermal ageing on leather material, as used in book bindings, to simulate real ageing effects over long periods of time.

Samples measured were a Sumac material, which is a vegetable tanned calf leather. Strips of material were taken for Dynamic Mechanical, DMA measurements and were mounted in a tension geometry. Small discs (10mm dia) were taken for dielectric analysis, DETA. For each technique samples were subjected to a controlled ramp of relative humidity at room temperature (23°C) from 20 to 80% RH at 1% RH / min.

One parameter was extracted from each analysis. The rate of extension as a function of relative humidity in the range of 25 to 40 %RH was used from DMA measurements. Plots of displacement (%) vs relative humidity yielded a straight line, whose slope was the rate of extension as a function of RH. The conductivity (sometimes called ionic conductivity) values were taken from DETA measurements. This value was taken one half hour after reaching 80%RH. This did not coincide with the time to reach equilibrium at 80%RH but was selected so that a comparison between samples could be made within the time scale of the experiment.. The conductivity value was calculated from the slope of loss permittivity, ε" measurements made at multiple frequencies. Care was taken to use only those frequencies that yielded a linear plot of ε" vs 1 / (2πf), indicating a purely conductive response.

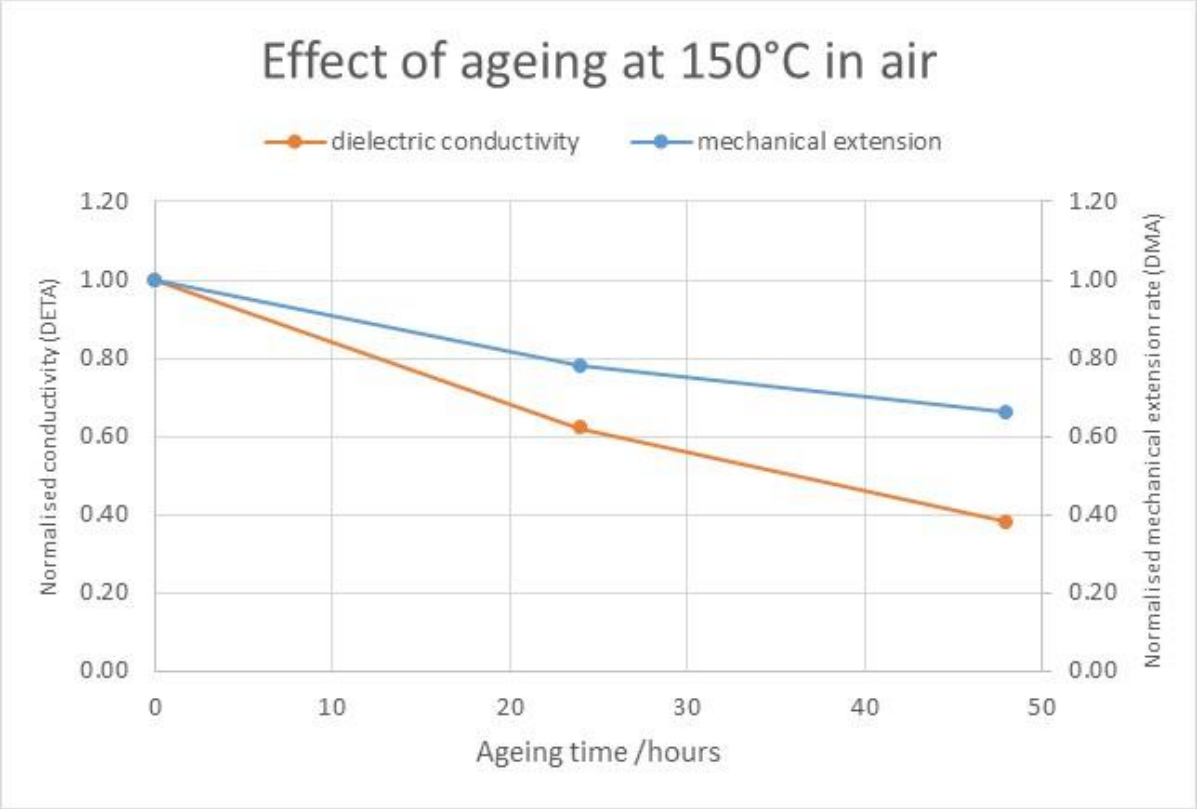

Fig 1 Effect of thermal ageing at 150°C in air for Sumac leather, as measured by the normalised conductivity and normalised mechanical extension rate. Normalised with respect to untreated, unaged sample. Samples were subjected to a controlled humidity environment (see text for details).

Fig 1 shows how both parameters decease as a function of accelerated ageing time. The 150°C ageing temperature is quite severe, since it is known that denaturation in leather occurs above 120°C. Evidence of structural breakdown has been observed using AFM by the decrease in D-banding periodicity of the collagen fibrils. It is thought that the ageing process involves loss of the triple helix structure of the collagen material and its transformation into gelatin. This is accompanied by fibre shrinkage which reduces its mobility as would be expected in a tighter structure. This is borne out by both the decrease in the rate of mechanical extension as a function of RH (and moisture content) and also the decreased conductivity seen in DETA measurements.

Further work shall demonstrate the effectiveness of conservation treatments on typical substrate materials such as canvas, leather and parchment.

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