The skin you’re in

Skin is a fibrous material largely made up of collagen, a flexible protein found in the organs, as well as in hair, muscle, and bone. In its natural state, skin has a multilayer structure with a significant amount of water adsorbed to the material. This structure is preserved in leatherskin materials, albeit in a transformed way.

In rawhide, which is not chemically processed in any way, the fibrous layers of the skin collapse when dried (swell when wet). Other kinds of chemical processing such as tanning restrict this swelling behavior by cross-linking the chains or by replacing the water with another material, such as oil.

Water, water everywhere

As a proteinaceous material, collagen is very sensitive to water. If too much water is available to the system, it begins to disrupt the structure of the material and turn it into a disordered gel, which dries to a glassy solid. This process is known as denaturation. Denaturation is one of several major deterioration paths that affect leather. Leather may:

- Decay biologically
- Undergo red rot
- Become waterlogged
- Or denature.

Denaturation is most common in untaught and semi-tanned skin materials, which are more susceptible to water. Red rot is common in historic books and bindings, while most most archaeological leather is waterlogged and/or partially decayed.

Polyethylene glycol (PEG)

PEG is an organic consolidant typically used for waterlogged wood and leather. Short-chain PEG-400 is preferred for leather. PEG does not react with the treated material and is somewhat reversible.

Silicone coating (Dow 1248 fluid)

Silicones are inorganic polymers based on silicon dioxide, which react with or within the treated material to create an interpolating structure. They are controversial due to their irreversibility and non-retreatability.

Catechin (EtOH solution)

Catechin is a flavonoid found in green tea. If it reacts with collagen, it is a similar way to tannins. It creates crosslinks between collagen fibrils and is retretatable but not irreversible.

Experimental layout:

Coupons were cut from vegetable-tanned leather, oil-tanned leather, and rawhide, then kept in an oven at 80°C and 80% RH for 15 days to artificially denature them. Samples were also taken from a brain-tanned leather armband, which had already become partially denatured. All these samples were then treated with one of the three treatment materials. PEG was applied in a solution with ethanol, which was then evaporated off. Dow 1248 fluid was applied by brush, and the catechin solution was applied in a cellulose poultice. After treatment, the coupons were investigated with DSC (differential scanning calorimetry), FTIR, and FORS.

The figures below show the difference between the treated and untreated coupons.

Make a matcha marinade

An experiment was devised to compare the effect of a novel treatment, targeted at denaturation damage, with the effects of other treatments, which were developed for waterlogged organic materials. This novel treatment was chosen for its demonstrated ability to reduce water sensitivity in collagen by cross-linking the chains. In all, three treatment materials were tested.

Putting tea to the test

The samples were assessed with two questions in mind: how much did they change, and in what way? Chemically, the least possible change was desired, while physically, an increase in water resistance was needed. These properties translate closely to two analyses: TIR data describe the material’s chemical properties, while DSC data describe the material’s sensitivity to water and heat.

The table below summarizes the DSC findings. Τ indicates shrinkage temperature, which is inversely related to water sensitivity. The higher the Τ, the lower the water sensitivity. W indicates peak width, which describes how uniform the material’s response to water is. Although these results were somewhat contradictory, there are a few clear trends. PEG caused little to no change in the material, silicone caused mostly negative change in the material, and catechin caused mostly positive changes. FTIR data were transformed in several ways to show variations in chemical makeup. The spectra from treated samples were subtracted from the control spectrum for each material, and then compared with one another. Again, there are several distinct trends that developed. PEG caused the most material change, while catechin caused the least.

Figure: Sharphouse, John Henry. Leather technician’s handbook. Leather Producers’ Association, 1983.


Figure (above): Scott, J. “Molecules that keep you in shape.” New Scientist 111, no. 1518 (1986): 49.

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The problem is, there is no treatment in current use to address the effects of denaturation on collagenic materials, especially embrittlement.

Know how to treat them right

Although more research needs to be done before catechin can be used as a treatment, this experiment has very promising results. It establishes three points:

- Leather treatments in current use are not effective in treating denaturation.
- Of the treatments tested, catechin caused the least chemical change in the material.
- Of the treatments tested, catechin caused the most positive change in water sensitivity.

In addition to these quantifiable data, there were also qualitative changes in materials treated with catechin, such as increased flexibility. Hopefully, future research will be able to quantitatively test this property so the effects of catechin may be better understood.