

# Forms of Destruction on Wool and Cotton Fibers

Results reported by a Textile Testing Laboratory

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Whenever textile raw materials, half finished—or finished—materials have to be tested or passed by an expert, it will always be necessary that the material be subjected to a thorough inspection of its structure by means of a strong magnifying glass preferably of the binocular type, or still better by means of a microscope. In any case of a defect possible on textile materials, it is the first requirement to establish a true picture of the damage with the aid of a microscope. Even if the defect is of a chemical nature the microscopical investigation may lead to the cause, show the nature of the defect and may permit so to make some deductions. This is especially true in the case of wool as the morphologic-anatomical destructive forms allow certain conclusions on the value and general criticism of the material. Also in the case of cotton, though in a lesser degree, will the microscopical examination cast some light on the defects, whether of a mechanical or chemical nature: These visible marks can be further explained or augmented with microchemical reactions.

In a more detailed article<sup>1</sup> I have tried to compile the different forms of destruction on wool and cotton fibers met so often in the textile testing practice by practical examples and micro-photographs. The tested objects were mostly felt cloth, as used in the paper manufacturing plants, which became brittle and useless often after only a very short time of service (mostly due to strong acid or heat exposure). The general test consisted of three examinations:

1. A microscopical determination of the

exterior damages, such as slits, incrustations, holes, their size, form, and position.

2. A general chemical analysis.

3. A microscopical respectively microchemical examination of single hairs or fibers from different parts of the material.

## Chemical Analysis

The determination of the active acid concentration, which can be carried out by simple means and in a rather short time, has proven to be an effective method of chemical analysis. If always the same weights of fabric to be tested are taken and extracted in the same way with equal amounts of distilled water, which must be free from carbon-dioxide, well comparable values may be obtained for the pH concentration with the aid of a colorimeter in the manner as recommended for paper tests. If the hydrogen ion concentration (H) computed from the experimentally ascertained hydrogen ions, results are obtained, for instance, for a damaged drying felt, which was mended with a gray woolen yarn, indicating that the active acidity of the tested solution from the middle of the felt was 2.6 times as high as the acidity of the outer zone or 4.3 times as strong as the one contained in the gray darning yarn. This proves that there exist considerable differences in the active acid contents of the different felt parts, which may be made visible with litmus paper but can be quantitatively analyzed by taking the pH values.

Another very interesting case was found in a drying felt made of a mixture of wool and cotton, where the cotton warp threads were torn off in straight parallel lines inside a weft of naturally brown wool. The following values were found here:

<sup>1</sup>Forms of destruction on wool and cotton fibers from the results obtained in the textile testing practice. Reports of the German "Forschungs-Institut fuer Textil Stoffe" at Karlsruhe in Baden., edited by Prof. Dr. Ubelohde, 1928, pages 1-40 with 18 illustrations.

Distilled water :

$$\text{pH} = 7.0 - 7.1; [\text{H}] = 0$$

Outer zone undamaged :

$$\text{pH} = 6.4; [\text{H}] = 3.98 \times 10^{-7} = 0.0000004 \text{ g/l}$$

Felt center undamaged :

$$\text{pH} = 5.9; [\text{H}] = 1.3 \times 10^{-6} = 0.0000013 \text{ g/l}$$

Brown filling yarn, removed from the felt :

$$\text{pH} = 5.8; [\text{H}] = 1.6 \times 10^{-6} = 0.0000016 \text{ g/l}$$

drying felt having a badly damaged surface. Using the same testing methods I found the following :

Distilled water :

$$\text{pH} = 7.1; [\text{H}] = 0$$

Outer zone of the felt :

$$\text{pH} = 4.7; [\text{H}] = 2.0 \times 10^{-5} = 0.000020 \text{ g/l}$$

Middle of felt :

$$\text{pH} = 3.5; [\text{H}] = 3.16 \times 10^{-4} = 0.000316 \text{ g/l}$$

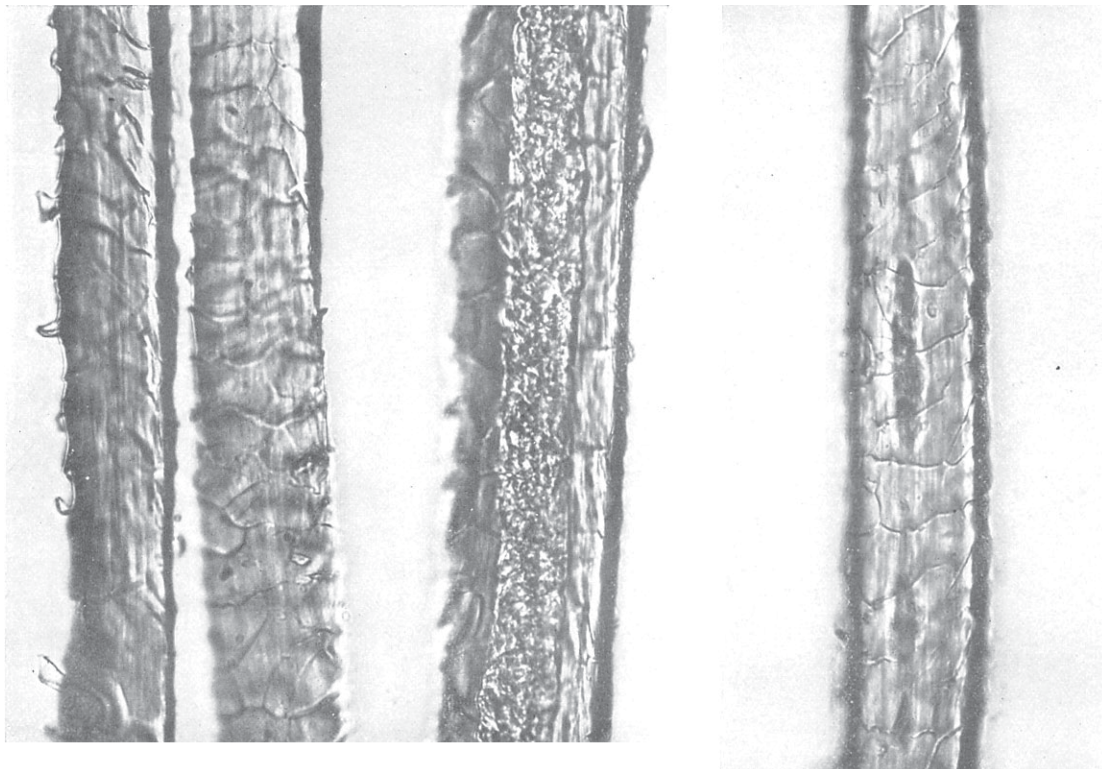


Illustration 1

Normal non-damaged wool hair of long staple. Microscopical adjustment for the upper scale layer; in the transparent depth four marrow islands. Weak longitudinal stripes of the fiber layer. 240 times enlarged.

Illustration 2

The same hair as Illustration 1 after treatment with diazo solution. Of the three wool hairs the middle one is intact, the left with a broad marrow canal is colored slightly red, the right stronger red. The latter shows stronger fiber stripes and damaged and partly loosened scales with typical curled forms. 240 times enlarged.

The H-ion concentrations in these three cases were, therefore, in the proportion of 4:13:16 or in other words: the acidity in the middle of the felt was three and one quarter times and in the brown filling yarn four times as great as the acidity of the outer zone of the felt.

These differences are rather small as compared with the results of a recently tested

The active acid concentration of the badly damaged felt center was, therefore, in this case almost 16 times the value of the outer zone, and in this part there were still  $2 \times 10^{-5}$  g hydrogen ions more per liter than in the perfectly neutral distilled water.

Microscopical Examination  
Accompanying these physical-chemical in-

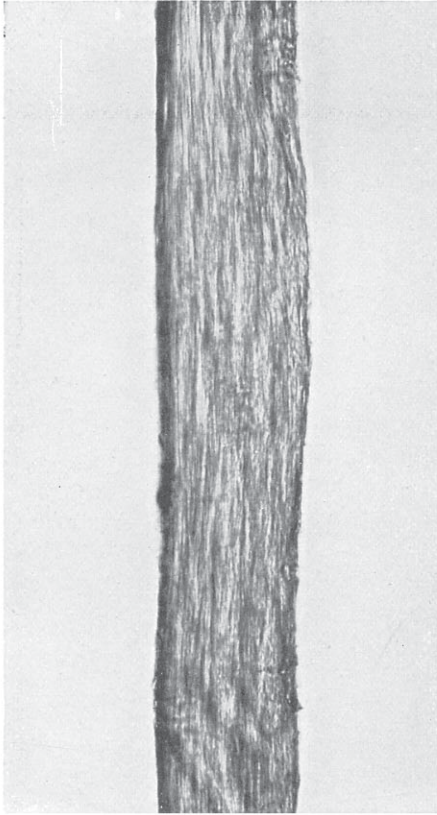


Illustration 3  
Wool perfectly free from scales with fiber splits colored dark red by diazo solution. 240 times enlarged.

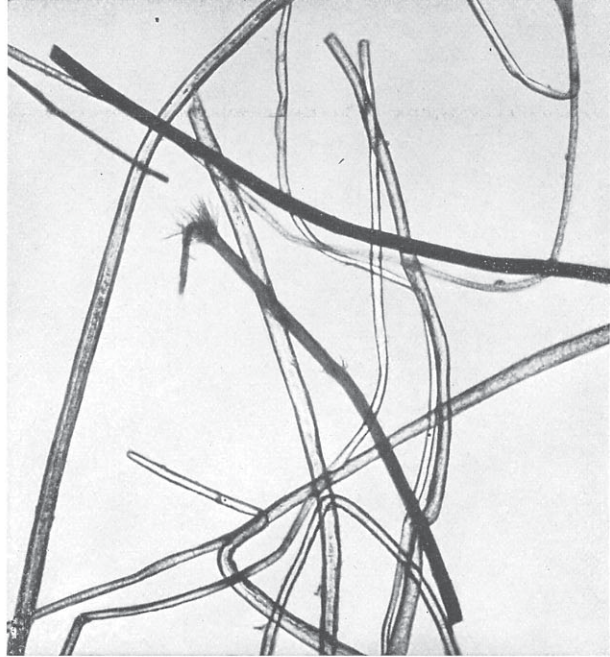


Illustration 4  
Breaks and splinters in light and dark colored hair. 29 times enlarged.

Illustration 5  
Bent of a wool hair with heavy splinters and partly loosened fiber cells. The hair colored dark red for stretches by diazo-solution, is, therefore, badly damaged. 91 times enlarged.

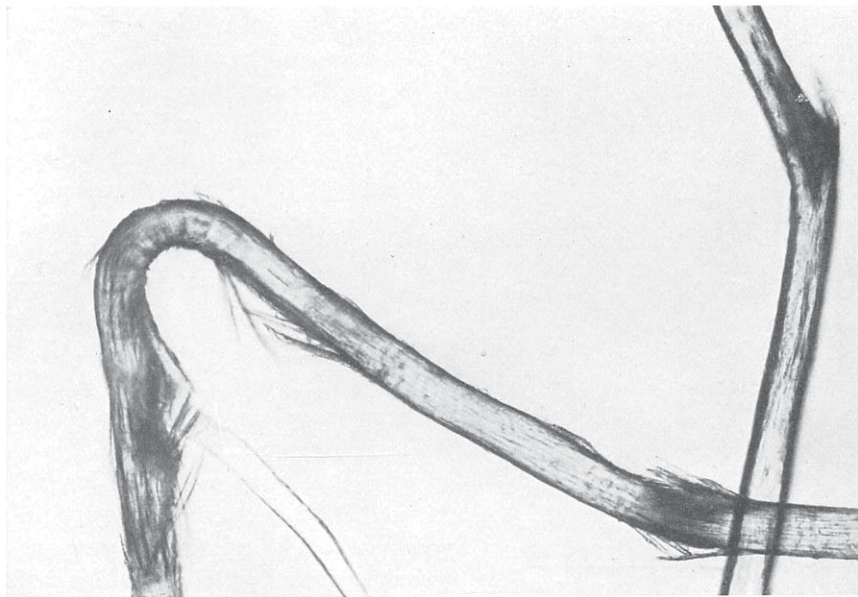


Illustration 5

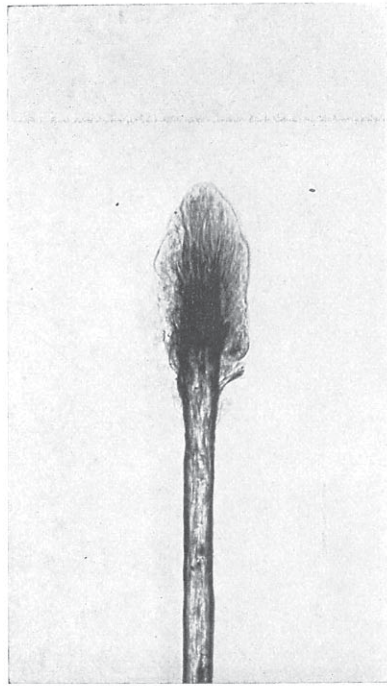


Illustration 6  
Brush end of an undyed hair with free protruding fiber cells. Scale layer of the lower part almost intact. 91 times enlarged.



Illustration 7  
Loose spindle cells (partly still in groups) and scale fragments. 91 times enlarged.

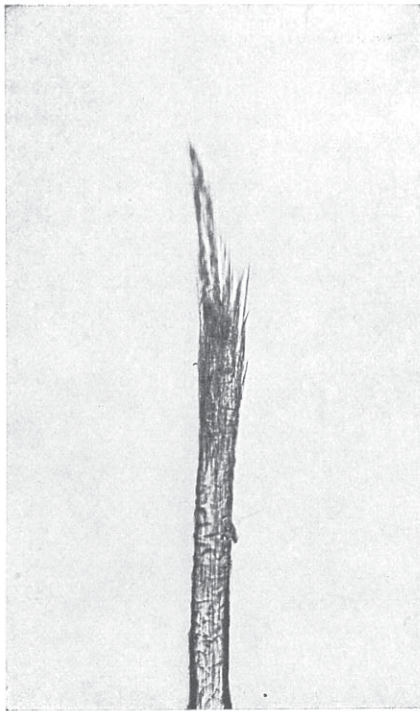


Illustration 8  
Hair root of a pulled not cut hair. 91 times enlarged.

vestigations the microscopical examination was conducted. In the case of the above mentioned drying felt with the brown filling yarn the wool hairs of the felt edge were almost perfectly intact. Also the wool in the middle of the felt was rather well preserved, which was also proven by the diazotizing test according to Pauly's method, or by the dyeing test with Cotton Red 10B as per Sieber's method. In the brown yarns, however, all steps of decomposition could be noticed along the rips next to the normal wool hair, for instance, damaged and often missing epithel scales, splitted hair ends (so-called brush ends), furthermore, in the length direction breaks and bad fractures, finely loose scale fragments and dead cells. Even the sample of unused brown wool yarn which had been requested from its manufacturer for a control test, showed already these defects as the micro-photographs below show, furthermore, hair damaged by moths and skinned wool with well preserved hair roots could

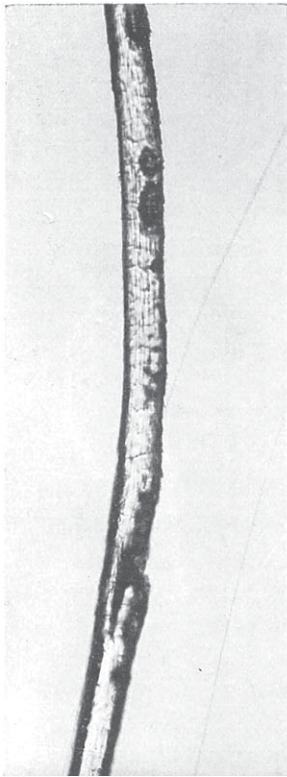


Illustration 9  
Moth damages on an otherwise fairly intact woolhair. 91 times enlarged.

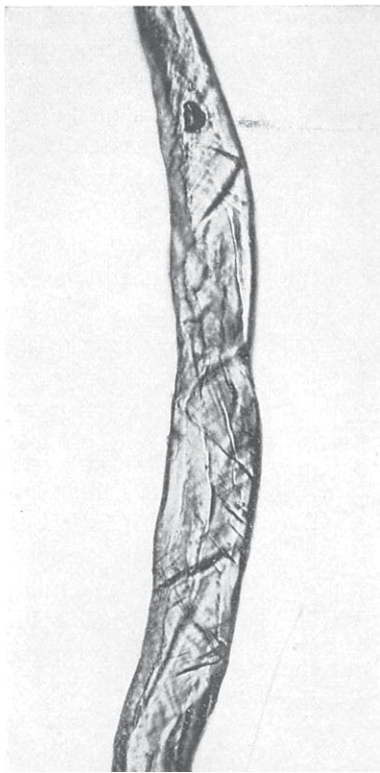


Illustration 10  
Cotton fiber with shrinking folds in the cuticle and parallel splits in the cell membrane. Adjusted to the upper half of the fiber, illumination on a slant. 240 times enlarged.

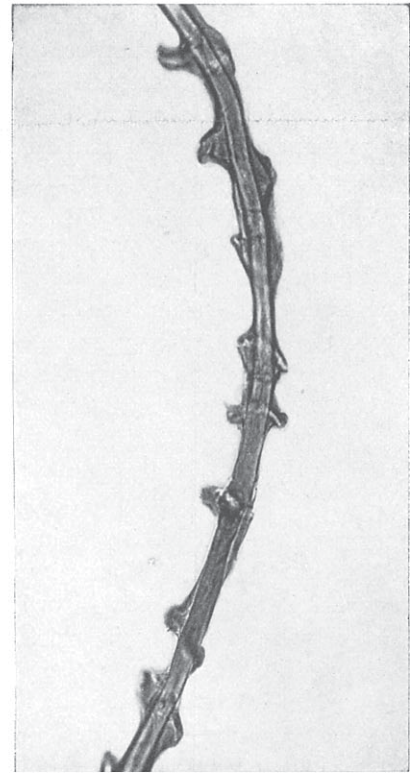


Illustration 12  
Amyloid jags and edges over a chemically unchanged cellulose interior of mercerized cotton fiber. Zinc-chloride iodine coloration. 240 times enlarged.



Illustration 11  
Slightly parchmented cotton fibers from yarn of a transparent fabric. Zinc-chloride-iodine coloration. 91 times enlarged.

be discovered. (See illustrations 1-9) Therefore, already the raw wool contained wool fibers qualitatively inferior. The close structure of the felt obtained in the scouring process perhaps might have rendered these damages inconspicuous. But in the course of running this felt over the hot drying cylinders of a paper machine a local acid concentration took place due to physical circumstance in the dark filling yarn to finally effect a 105 cm long rip in the felt after only one month's service. Further details regarding this case may be found in the above mentioned publication.

### New Physical and Chemical Testing Methods

The damages done by acid concentration gave occasion to introduce new physical and chemical testing methods in order to explain the conditions existing in wool drying felts. Starting with the theory of Donnan about the equilibrium of membranes and the gelatine swelling experiments by Procter and Wilson the colloidal-chemical investigations on albuminous bodies by J. Loeb are discussed. These researches were checked and augmented through the important investigations carried out by E. Elod and his co-workers, which have been of value for the technique of the acid dyeing process for wool, the one bath tanning process for animal skins and the weighting of silk with tin-tetrachloride. They also have confirmed and furthered the theoretical calculations regarding the physical and chemical reactions in the dyeing process as laid down by K. H. Meyer, who came to similar results about the absorption of acid by wool without Donnan's theory.

The second part of this publication deals with the forms of destruction of cotton, also drawing the conclusions from damaged samples obtained by practical tests. Mentioned are the well known splitting processes of vegetable fibers caused by improper washing as well as the fiber forms occurring on paper raw materials due to the beating process.

A cotton drying felt which appeared very brittle on account of the formation of hydro-cellulose showed some striking and characteristic splits on the most damaged parts of the surface. (See illustration 10.) These diagonal rips showed a direct relation to the natural fiber structure of the cotton fiber and should not be taken as the longitudinal shrinking folds of the membrane, which are formed after the drying out of the semen hair as a consequence of the opening of the cotton capsule.

### Results of Practical Tests

Furthermore, the results of practical tests to improve the quality of fine threaded cotton fabrics (Swiss "Transparent" — "Opal" weaves) by acid treatment have proven that the short reaction of concentrated mineral acids causes a swelling of the fiber and an amyloidation of its surface, and finally an incrustation of the fibers and yarns forming parchment-like films. The cellulose is partly destroyed on its surface by amyloid formation, which shows a blue coloration with iodine. Blue edges after the treatment with iodine also indicate a weak parchment formation of the fiber, and sample fibers obtained from the yarns of a transparent material under the microscope showed very characteristic jagged formation on their surface, their form and size depending on the concentration and duration of the acid effect. (See illustrations 11 and 12.) The nature of this acid swelling is entirely different from the final effect of lye mercerization although similar in its appearance which is due to the fine structure of the cellulose fiber. The chemical and physical researches by K. H. Meyer\* and H. Mark during the last few years have brought light into the nature of the micellae structure of the cellulose fiber as well as into the mechanism of the effect of swelling agents which will bring further enlightenment for other practical finishing processes of vegetable fibers and products made of them.

\*See THE MELLIAND, April issue, page 76.