JOURNAL OF APPLIED POLYMER SCIENCE VOL. IV, ISSUE NO. 11, PAGES 179–180 (1960)

X-Ray Diffraction by Hairs and Feathers. Part II

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INTRODUCTION

In this investigation the tail hairs of various mammals discussed in Part I of this series[1] were treated with different chemicals for different times and their x-ray diffraction photographs taken. The chemical treatment was intended mainly for the study of buffalo hair because of the peculiar pattern it exhibits, and for comparison a few other hairs were also subjected to the same treatment and their diffraction patterns obtained.

EXPERIMENTAL

The treated fiber was exposed under the same conditions as have been described previously. The treatment falls broadly under two heads (*1*) in organic acids and (*2*) in inorganic salt solutions. Under the former category comes treatment with acetic, formic, butyric, and propionic acids; the latter consists of treatment with nickel nitrate, potassium iodide, and calcium chloride solutions. Saturated solutions at 30°C. were used.

Treatments

Acetic acid treatments were carried out for various lengths of time on the various hairs as shown in Table I.

Formic acid treatment for 48 hr. was given to buffalo, sheep, ass, ox, and cow hair.

The buffalo hair only was treated for 48 hr. with propionic and *n*-butyric acid.

Treatment with potassium iodide solution for 48 hr. was given buffalo, ass, ox, and cow hair.

TABLE I

Hair	Acetic acid treatment time, hr.
Buffalo	5, 10, 15, 24, 48
Sheep	5, 10, 24, 48
Ass	5, 10, 20, 24, 48
Cow	5, 10, 15, 24, 48
Ox	5, 10, 15, 24, 48
Elephant	24, 48

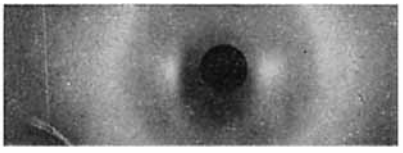
The buffalo hair only was treated with nickel nitrate, $Ni(NO_3)_2$ solution, for 5, 24, 48, and 130 hr. and with calcium chloride solution for 3, 5, 10, 20, and 24 hr.

RESULTS AND DISCUSSION

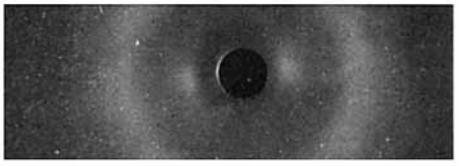
Action of Organic Acids

As the time of treatment increased it was observed that there was a gradual fading of intensity of the additional powder rings obtained in the pattern of buffalo hair. Treatment for 48 hr. in acetic and formic acids was sufficient for the complete disappearance of the additional rings. Propionic and butyric acids were not so active, and even after the same time of treatment, the rings, though weak, continued to appear. The characteristic pattern of α-keratin remained practically unaffected, except for a very small decrease in intensity. This was the case with all the other hairs experimented with. Some of the patterns obtained for treated tail hairs are reproduced in Figure 1.

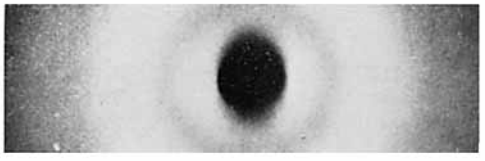
In Part I of this series[1] the fact that the additional powder rings may be attributed to the presence in the protein of an additional amino acid whose existence was established by chromatography was discussed. This exists as crystallites with random orientation about the fiber axis. When the hair is treated in the organic acid (either acetic or formic) for sufficient time, the molecules gradually gain entry into the inner parts of the fiber and shatter the crystalline arrangement; hence the rings disappear. The conclusion is strengthened by Meyer and Mark's[2] observation on the action of formic acid on silk. The exceptional reactivity shown by acetic and formic acids on the one hand and comparatively slow action of propionic and butyric on the other may be due to the fact that the former molecules are sufficiently small in size to penetrate the hair. This observation is in conformity with that of Speakman[3] in the case of wool.



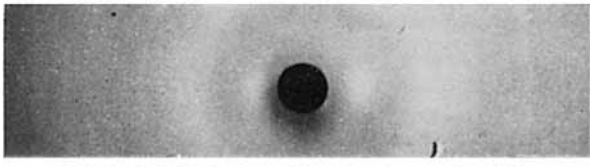
(*a*) buffalo hair treated 48 hr. in formic acid



(*b*) buffalo hair treated 48 hr. in propionic acid



(*c*) elephant hair treated 48 hr. in acetic acid



(*d*) buffalo hair treated 15 hr. in acetic acid

Fig. 1. Patterns of treated hairs.

Another conclusion we arrive at is that the new amino acid is only loosely bound to the main polypeptide chain. This is illustrated by the fact that the characteristic pattern remains practically unaffected, while the additional rings alone disappear, after chemical treatment.

Inorganic Salt Solutions

These treatments are adopted from Santhanam's[4] work on collagen. The usual treatment of 48 hr. was not sufficient to make the rings disappear. A treatment of 130 hr. in nickel nitrate solution made the rings disappear. It may be postulated that any particular liquid might fail to react with the fiber for one of two reasons,[5] either that the compound is inherently incapable of reaction on chemical grounds or because it is unable to penetrate the fine capillary structure of the fiber. We have seen that organic reagents with hydroxyl groups in the molecule were able to modify the crystal structure. Other reagents are comparatively inert, and this may be the reason why very long treatments are necessary in the case of nickel nitrate solution.

CONCLUSIONS

From the investigations presented here the following conclusions may be drawn:

(*1*) Organic reagents are more effective in destroying the crystalline arrangement in the buffalo hair than inorganic solutions.

(*2*) The acetic and formic acids have a specific action on the micelles of the hair fiber. Since these molecules are small in size they easily enter the inner parts of the fiber and destroy the crystalline arrangement. The butyric and propionic acids are comparatively less effective.

(*3*) Since the rings disappear after certain treatments, the new amino acid present in the buffalo hair may be only loosely attached to the polypeptide chain.

(*4*) The structure of α-keratin, the main constituent of hairs, has not been modified by any of the above treatments.

References

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Synopsis

The tail hairs of various mammals were subjected to different chemical treatments for different times and their x-ray diffraction photographs obtained. The powder rings recorded in the case of buffalo hair disappeared after the fiber was treated in acetic or formic acid for 48 hr. On the other hand, inorganic salt solutions were practically inert.

Résumé

Les poils de la queue de différents mammiféres ont été soumis ä différents traitements chimiques pendant des durées variables; on en a déterminé la photographie par diffraction aux rayons x. Les anneaux obtenus dans le cas des poils de buffle disparaissent aprés traitement de la fibre pendant 48 heures par l'acide acétique ou formique. D'autre part les solutions de sels inorganiques sont pratiquement inertes.

Zusammenfassung

Die Schwanzhaare verschiedener Säugetiere wurden in verschiedener Weise und für verschiedene Versuchsdauern chemisch behandelt und Röntgenbeugungsaufnahmen gemacht. Die Pulverringe, die im Falle von Büffelhaaren erhalten wurden, verschwanden nach Behandlung der Faser in Essig- oder Ameisensäure während 48 Stunden. Andrerseits erwiesen sich anorganische Salzlösungen als unwirksam.

Received April 18, 1960