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On the Chemistry of Wool.

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Although wool, and the closely related hair fabrics in general, play such an important part in our social and commercial economy, it is surprising to find that so little scientific work has been done by chemists in connection with the chemical constitution and properties of this important raw material which furnishes the basis of such a large number of industries. It is probably because wool is one of the commonplace materials of everyday life that the chemist passes it by and goes in search of some unheard of and unusable substance to which he may devote his labors of original research. We are, in fact, less acquainted, in a chemical sense, with some of the most commonplace substances of daily life than with many of the rare and less useful substances. The microscopic eye of the scientist is liable to pass by the large bodies near at hand and fix its attention on something far beyond the ken of common things.

In a study of the chemical constitution of the wool fibre, at the very outset a distinction must be drawn between the raw fibre as it occurs in the fleece and the purified fibre as it is used for purposes of manufacture. The fleece, as it comes from the back of the sheep, contains many other substances besides the fibre proper. In the first place, a considerable though varying amount of miscellaneous foreign matter and dirt is always associated with the fibre. This amount may vary from five to twenty-five per cent. of the weight of the fleece. Apart from this material, however, there is always associated with the fibre in a natural manner a large amount of grease, together with the residue resulting from the dried-up perspiration from the animal. The greasy matter, known as wool-fat, is a natural excretion from the sebaceous glands of the skin located around the hair-root of the fibre. The function of this greasy matter

is to prevent the fibres from becoming matted together in the fleece by surrounding them with a rather thick layer of soft fatty substance. In other words, the wool-fat is really a product closely related to the fibre itself, and is a physiological concomitant of its growth. This fat, however, does not in any sense form an integral part of the structure of the fibre, being merely an external coating on its surface and its removal therefrom, which takes place in the process of wool-scouring, does not in any manner affect the physical or chemical properties of the fibre. The dried-up perspiration, or so-called "suint," which also occurs in rather large amount in the wool fibre, differs from the wool-fat in that it is not in any special manner related physiologically with the growth of the fibre. It is merely derived from the perspiration naturally excreted by the sudorific glands in the skin, and which, by reason of the heavy layer of wool on the animal, has no chance of being removed except by evaporation, which of course, leaves within the fleece all the non-volatile solid constituents occurring in the perspiration. This dried-up residue is usually more or less mechanically held by the greasy matter coating the fibre, and is removed together with the latter in the scouring of the wool. The suint is distinguished from the wool-fat in that it is soluble in water, and consists for the most part of potassium salts of various organic acids. The wool-fat is chiefly composed of cholesterol (which is a monatomic alcohol having a high content of carbon atoms) and its related substances. The amount of actual grease present in the raw fleece of the sheep varies from eight to twelve per cent. while the amount of dried-up perspiration varies from fifteen to thirty per cent. The wide limits of variation in these substances are caused by difference in the breed of the sheep, difference in climatic conditons, manner in which the sheep are reared, etc. Taking all the materials existing in the raw fleece into consideration, we will find that the actual amount of fibre present varies from fifty to twenty per cent, with probably an average of thirty-five per cent. for the general grades of wool.

Coming now to a consideration of the fibre proper, we will discuss its general chemical behavior as at present determined. In the first place, wool belongs to the general class of proteoid substances, and is closely related, if not in fact almost identical

in composition with, the various skin tissues, including feathers, hair, horn, and leather. In other words, it is chemically related to gelatin and albumin. It is not, however, soluble in water, nor the ordinary solvents, although when heated for some time with water under pressure it is gradually decomposed and dissolved. In common with other albuminous substances, wool is evidently an amido-acid. The fact is deduced from many considerations: in the first place, ammonia is to be found among the products of the destructive distillation of wool; again, wool is rather easily hydrolysed by the action of dilute alkaline solutions; also, wool readily combines with acids, and even on boiling with dilute sulphuric acid it is possible to find considerable traces of ammonium sulphate in the solution. Further than this, the presence of an amido group in the wool fibre is strongly evidenced by the fact that on treating wool with an acid solution of nitrous acid and afterwards with a phenolic body, certain well defined colors are obtained analogous to the bodies produced by this same diazotising reaction on ordinary aromatic amines. This method of applying the diazo reaction to wool is interesting, and by the use of a variety of phenolic and amido bodies as developers for the diazo compound of the wool a variety of colors may be produced on the fabric. In such instances the wool acts as its own dyestuff, or rather, it acts as the material from which the dyestuff itself is made.

The presence of an amido group in the wool fibre is also evidenced in the many ways in which wool exhibits its well-defined basic properties. In the first place, wool combines with and neutralizes a considerable amount of acid; for instance, if wool be boiled in a solution of sulphuric acid for some time, and then thoroughly washed until the wash waters are perfectly neutral, by a quantitative determination, the amount of acid neutralized by the wool may be readily ascertained. In this manner it is possible to obtain what may be termed the "coefficient of acidity" of wool. This is a number representing the amount of caustic potash, expressed in milligrams, neutralized by one gram of wool. This coefficient of acidity for wool, together with other related albuminoids, may be given as follows:

Wool = 57; Silk = 143; Albumin = 20.9; Gelatin = 28.4.

The basic nature of the wool fibre is furthermore evidenced

by the readiness with which it combines with acid dyestuffs, in which reaction it appears that there really exists some sort of chemical combination between the acid constituent of the dyestuff and some constituent in the wool.

In common with other amido acids, wool also exhibits in some degree the properties of an acid. It will absorb alkalies from solution and effect a partial neutralization of them. Owing to the fact, however, that it is not possible to determine with any degree of exactness the amount of alkali actually neutralized by the acid component of the fibre, it is not possible to furnish a coefficient of alkalinity for wool corresponding to the coefficient of acidity. This is caused by the fact that alkalies affect a decomposition of wool before the acid nature of the fibre is completely saturated. The fact, however, that when wool is treated in the cold with concentrated solutions of caustic potash there is a considerable absorption of the alkali by the fibre which cannot afterwards be removed completely by washing, would indicate a neutralization of the alkali by some acid component of the fibre. It has also been found that wool which has been thus treated has a lessened attraction for the general class of basic dyestuffs. In this connection, it may also be said, from the very fact that wool does exhibit in its normal condition, a considerable affinity for the basic colors, would be an indication of its containing an acid group in its constitution.

It is hardly probable that the wool fibre as a whole can be considered as a homogeneous chemical compound. I am led to this conclusion not only by a study of the varying chemical behavior of wool towards many reagents, but also by a consideration of its physical structure. In the latter respect the fibre is composed of three well-defined parts: an external sheath of flattened and hardened cells, an under layer of long fibrous cells which make up the major portion of the fibre, and finally a central layer of round medullary cells. From the very fact that these different portions of the fibre possess separate structures and functions, it would be reasonable to expect to find them possessing difference of chemical constitution. As it is an exceedingly difficult matter to satisfactorily separate from one another these different portions of the fibre for purposes of chemical analysis and study, it is not possible to state just what these chemical differences may be. I have found,

however, in the study of the action of alkalies on the wool fibre, that the external layer of cells, which furnishes the scales on the surface of the fibre, appears to be attacked in a somewhat different manner from the rest of the fibre; also in the action of the majority of dyestuffs on wool, I have found that these external cells are generally not dyed like the inner layers of cells. Although I am aware that these differences may be due more or less to differences in the physical structure of the cells, nevertheless, they are more likely to be due to the difference in chemical composition.

Another consideration which leads me to the conclusion that wool is not a homogeneous chemical compound is that by the action of alkalies a certain amount of one of its components, sulphur, may be removed without any apparent physical disintegration of the structure of the fibre. Also, in different qualities and kinds of wool, the percentage of sulphur present in the fibre is quite a varying factor. Whether this chemical difference is located in the substance of the different characters of cells to be met with in wool, or whether it is due to differences in the composition of the cell-wall as compared with the contents of the cells, we do not at present know, as it has not been possible as yet to satisfactorily separate the substance of the cell-wall from its contents. The chief hope of any scientific work in this direction lies in a study of the micro-chemical reactions of wool with various reagents.