

THE YELLOWING OF BLEACHED JUTE

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THERE is good reason to believe that pure, undegraded cellulose (not holocelluloses) if stored in the dark in a vacuum at low temperatures would retain its whiteness almost indefinitely. At the other extreme, bleached cellulosic fibres containing a high proportion of non-cellulosic impurities are known to become brownish or yellowish fairly quickly during ordinary storage. Exposure to light, as in the case of partly bleached jute, may accelerate the process. Storage at a high temperature also hastens the discoloration. There are various intermediate conditions of purity and storage and the part played by all the factors cannot be said to be well understood for vegetable fibres in general, though in the case of cotton and linen a good deal of information is available. The present preliminary note is concerned with the yellowing of bleached jute on storage, particularly of jute bleached by means of sodium chlorite without thorough scouring.

In the case of cotton and linen the presence of degraded cellulose (oxycellulose or hydrocellulose) is known to cause a yellowish discoloration in storage. Moreover, it is known that linen which has not been well "bottomed" (well scoured with boiling alkaline solutions) is liable to lose its whiteness in storage. Here the hemicelluloses (of which flax, like jute, contains some 20 per cent.) remain in the bleached goods. The role of naturally occurring fats and waxes is less well-known, though experiments with cotton have shown that the effect of residual wax is negligible. The effect of so-called "chloramines" has not been quite clearly separated from other factors, but it is certain that partly bleached linen which has not been antichlored and contains substances, whatever they may be, which liberate iodine from acidified potassium iodide is liable to rather rapid yellowing.

It is obviously impossible to ascribe the yellowing of bleached vegetable fibres in general to any single cause. Fibres vary greatly in composition, for example, in cellulose content, lignin content, hemicellulose content, and the nature of the bleaching process is also subject to great variation, as in thoroughness of scouring, the chemical used for the oxidative treatment and its conditions of use (strength of liquor, reaction, duration, temperature); use of antichlors, thoroughness of washing and so on. Some of the views that have been held are illustrated by the following examples. Kuchinka,¹ studying the linen bleaching process, held the oxidation products of cellulose to be the cause of yellowing. A similar view is taken in a patent² of the Mathieson Alkali Works, it being claimed that the use of sodium chlorite ("Textone") produces less oxycellulose than the use of hypochlorites and gives a more permanent white. Ridge and Little³ suggest that the complete removal of lignin is necessary in order to obtain a white that does not yellow on exposure to light. Giertz,⁴ however, could

not trace the discoloration of bleached wood-pulps to any degradation product of lignin and considered that yellowing was due to the decomposition products of hemicelluloses. Elgin,⁵ in describing a patent, holds the natural pigments of lignified fibres to be responsible for yellowing and claims that their removal by organic solvents permits a brilliant permanent white to be obtained by bleaching with hydrogen peroxide, indicating that the process is applicable to jute.

Jute bleached by a process which includes thorough scouring with alkalis and careful treatment with hypochlorites will show a good, permanent white, but the natural cement which joins together the short ultimate fibres is removed in such treatments and the fibre has little or no strength, especially when wet, resembling in this respect papers made from wood-pulp. The problem is, therefore, to discover a means of removing the substances which are responsible for yellowing without removing the intercellular cement; any process that involves thorough scouring, or even mild hot alkaline treatments, must be avoided if good wet strength is to be obtained.

The observations to be described do not solve the problem, and the production of a really full permanent white on jute, if not impossible, is clearly a matter of great difficulty. Some light is, however, thrown on the matter and the result obtained when bleached jute was stored under alcohol seems to be of considerable importance in suggesting lines of attack.

The after-yellowing of jute bleached, or delignified, without scouring, by means of sodium chlorite has been examined in the course of our work during the past two or three years and the following observations are now recorded.

(1) Jute completely delignified by treatment with sodium chlorite develops a yellowish colour on exposure to light and air or on heating for a few hours in the dark and this occurs to approximately the same extent whether or not the fibre has previously been extracted with alcohol-benzene in a soxhlet. It may be concluded that the fats, waxes, etc., removable by alcohol-benzene are not responsible to a very important extent for the after-yellowing. Moreover, since it has been shown by Chatterjee and Sarkar⁶ that removal of lignin is complete by treatment with sodium chlorite under the conditions employed, the yellowing, observed on storage in diffused daylight for a few months or on heating to 105° C. for a few hours, is not due to presence of lignin itself. Of course, in jute bleached by treatments that leave part of the lignin in the fibre, the lignin may contribute to the yellowing that is observed. The most obvious possibilities that remain are that the yellowing is due to (a) small quantities of lignin decomposition products, (b) hemicelluloses or degraded hemicelluloses and (c) degraded cellulose, for

example, oxycellulose, and experiments have been made in an attempt to narrow down this field.

(2) In order to remove lignin decomposition products that may remain in small amounts after treatment with sodium chlorite, the delignified jute was extracted at room temperature with dilute solutions of (a) sodium bisulphite, (b) sodium sulphite, (c) sodium thiosulphate, (d) sodium bicarbonate, (e) ferrous ammonium sulphate, (f) caustic soda, (g) calcium hydroxide. The fibre still showed considerable yellowing in all cases when heated to 105° C. for three days, but it was less than in samples that had not received the subsequent treatment, particularly in the treatments with caustic soda and calcium hydroxide. Extraction of the delignified fibre with alcohol, acetone, chloroform or benzene did not prevent after-yellowing. We have not yet attempted to ascertain to what extent the treatments with sodium sulphite, etc., actually remove lignin decomposition products that might be present or to determine to what extent there was a simultaneous removal of hemicelluloses, degraded hemicellulose, or degraded cellulose but it is likely that sodium sulphite, for example, is effective in removing lignin decomposition products and the fact that considerable yellowing still occurred points to the conclusion that hemicelluloses, of which at least 20 per cent. occur in the raw fibre, play an important part in the yellowing. Delignification by means of sodium chlorite under the conditions employed leaves the hemicelluloses practically intact.⁶ It is known, too, that jute partially bleached by the use of mild alkaline treatments in conjunction with hypochlorite treatments is subject to considerable after-yellowing. In such treatments it is clear from the loss in weight (say 8 to 15 per cent.) that much of the hemicelluloses remain. Sodium chlorite is known to be mild in its action on cellulose and an important contribution to the yellowing by oxycellulose produced during delignification is unlikely. Further evidence of the part played by hemicelluloses in the yellowing is given by the following observations.

(3) Cellulose prepared from jute by Cross and Bevan's method is entirely free from lignin but retains some of the hemicelluloses.⁶ It shows some yellowing on prolonged storage in diffused light, though much less than the holocellulose obtained by the chlorite treatment of defatted jute. This is regarded as partly due to the presence of oxycellulose and partly to the presence of residual hemicelluloses, though the importance of each is not easy to assess.

(4) As shown by Chatterjee and Sarkar (*loc. cit.*) partial removal of hemicelluloses by treatment with dilute (half per cent.) caustic soda at about 31° C., prior to delignification with sodium chlorite, materially diminishes the tendency to yellowing on heating at 105° C. The effects of other preliminary alkaline treatments were also examined and it was found that the more severe the treatment, the less is the tendency towards after-yellowing in the delignified fibre. It appears, therefore, that the lower hemicelluloses—those removable by the milder alkaline treatments—play an important part in the yellowing. Cross and Bevan's cellu-

lose and Norman and Jenkins's cellulose have lost the lower hemicelluloses and show a small tendency to yellowing, comparable with that shown by the sodium chlorite cellulose that has received a mild preliminary alkaline treatment.

(5) Cellulose prepared by treatment with moist chlorine dioxide becomes yellow very quickly on storage or on heating; the yellowing is much more rapid than with chlorite cellulose. This is attributed to the combined effect of the practically complete retention of hemicelluloses and of the degradation of both cellulose and hemicelluloses, the latter condition being indicated by the high copper number (Chatterjee and Sarkar, *loc. cit.*)

(6) Jute extracted with alcohol-benzene and then delignified with sodium chlorite did not become yellow even in fifteen months when stored immersed in alcohol, in a large boiling-tube, in diffuse day-light. This is presumably due to the virtual exclusion of oxygen from the holocellulose, the alcohol being preferentially oxidised by any oxygen that passes into it. Both reducing and acidic products were detected in the alcohol. A sample of delignified jute stored under benzene is being kept under observation, but it is too early to report results.

(7) By treatment with dilute alkali at room temperature the dull yellow colour of delignified jute, developed during storage, can be removed almost completely. It is yet to be seen whether the treated samples again turn yellow during storage, though, as stated in Section (2) above, an improvement has already been found after treatment with dilute caustic soda.

Conclusion: The foregoing observations are consistent with the view that the hemicelluloses of the jute fibre, which form at least 20 per cent. of its bone dry weight and are retained in delignification by means of sodium chlorite, are largely responsible for yellowing during storage. They may suffer some degradation during the chlorite treatment and further degradation in storage by light and oxygen would explain the results observed. Yellowing of the hemicelluloses, or degraded hemicelluloses is not, of course, regarded as the sole cause of yellowing of bleached jute. If, in addition to hemicelluloses, the bleached fibre contains residual lignin, or lignin degradation products or a considerable proportion of degraded cellulose (e.g., oxycellulose) yellowing may be expected, and other non-cellulosic impurities may play a part. The practical bearing of the matter lies in the fact that if, as it appears, hemicelluloses play a major role in yellowing, it becomes very important to study the possibilities of removing hemicelluloses, or that portion of them which is mainly responsible for the yellowing, without unduly detracting from the strength of the fibre, particularly its wet strength. It is known that even mild alkaline treatments, before or after treatment with chlorite or hypochlorites, may very considerably reduce the wet strength; the problem is, therefore, a difficult one. Lignin cannot in practice be removed without some oxidative treatment (as with hypochlorites, chlorites, peroxides, permanganates) and such treatments cannot be given without producing some oxycellulose. Treatments to remove oxycellulose