mixture was refluxed for eight hours. The ether was distilled, leaving a gummy residue which, on recrystallization from nitrobenzene and then from dioxane, yielded a white, crystalline product, m. p. 217.1–217.6°, soluble in carbon disulfide, chloroform, carbon tetrachloride, ether and alcohol. The silicon content was determined gravimetrically as described in the article above referred to.

Anal. Calcd. for $(C_6H_{11}O)_6Si_2O$: C, 64.9; H, 9.91; Si, 8.55. Found: C, 64.8, 64.4; H, 10.0, 9.93; Si, 8.55.

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CAMBRIDGE, MASS. WALTER C. SCHUMB
DONALD F. HOLLOWAY

RECEIVED AUGUST 18, 1941

COMMUNICATIONS TO THE EDITOR

THE FORMATION OF FIBERS FROM NON-FIBROUS NATIVE PROTEINS

Sir:

Proteins have been classified[1] into two structurally distinct groups, namely, the fibrous proteins such as silk, wool, and hair, and the non-fibrous proteins tending toward corpuscular structure and crystallizability.

The non-fibrous native proteins are characteristically susceptible to dissociation and denaturation as a result of environmental effects on intermolecular forces.[2] In several widely different native, non-fibrous proteins dissociation and denaturation have been shown to follow a preliminary unfolding of the molecule characterized by a single, sharp, slower sedimenting boundary in the ultracentrifuge. This unfolded or so-called α-form is labile and is not present long enough to be detected under usual conditions.[3]

Experiments in this Laboratory indicate that the unfolded configuration corresponds with the intermediate fibrous state of non-fibrous proteins which Astbury, *et al.*, have demonstrated with edestin and excelsin using X-ray diffraction patterns.[4] Further confirmation of the fibrous state was found by them in the formation of fibers from urea dispersions of edestin, casein and other proteins.

With the use of detergents it has been found possible to control the transformation of the native forms into the unfolded configuration of all the non-fibrous proteins so far tested in this Laboratory. This change was followed in two ways: by the ability to draw fibers from the precipitated protein; and by the corresponding viscosity changes in the system protein–detergent. Elastic and highly double-refracting fibers were obtained in this manner from the following proteins: crystalline egg albumin, purified preparations of hog thyroglobulin, wheat glutenin, casein, and commercial preparations of zein and blood albumin.

Detergents appear to be superior to other reagents which have been investigated although some, including pyrogallic acid and guanidine hydrochloride, were found to behave somewhat similarly. The conditions favorable for the drawing of fibers appear to vary with the protein, the nature and concentration of the reagent, the temperature and the *p*H of the system. Thirty-nine detergents have been tested so far. The following example illustrates one technique used for the formation of fibers from aqueous solutions of crystalline egg albumin and an alkyl aryl sulfonate: to 4 ml. of a solution of dialyzed egg albumin (4%) at 25° was added 10 ml. of 5%-salt-free "Nacconol N. R. S. F." (trade name for a detergent of the sodium alkyl aryl sulfonate type) at the same temperature and *p*H (7.5). After one-half minute 2 ml. of saturated ammonium sulfate was added to precipitate the protein which then could be drawn into long silky filaments. After three minutes the precipitate became tough and it was no longer possible to form fibers.

Relatively low concentrations of the detergents suffice, and the treatment is not likely to cause as drastic alterations in the protein structure as many of the customary alkaline dispersion procedures now used for the production of artificial protein fibers. The possibility is foreseen that more satisfactory commercial products can be produced from protein molecules which have themselves been permanently transformed into a

(1) Astbury, *Compt. rend. trav. lab. Carlsberg, Ser. Chim.*, **22**, 45 (1937).
(2) Lundgren, *Nature*, **138**, 122 (1936); **143**, 896 (1939).
(3) Lundgren and Williams, *J. Phys. Chem.*, **43**, 989 (1939).
(4) Astbury, Dickinson and Bailey, *Biochem. J.*, **29**, 2351 (1935).

fibrous configuration than are at present available as protein fibers in which the molecules are not so oriented.

Studies on the fixing and tanning of fibers formed in the fashion described are also in progress.

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ALBANY, CALIFORNIA HAROLD P. LUNDGREN

RECEIVED SEPTEMBER 13, 1941

AN INTERMEDIATE IN THE ALCOHOLIC FERMENTATION OF CARBOHYDRATES BY FUSARIUM LINI BOLLEY (FlB.)[1]

Sir:

Among the few microörganisms which degrade carbohydrates to give rise to carbon dioxide and ethyl alcohol in a ratio comparable to that obtained in fermentations with ordinary yeasts are the *Fusaria*. They have been designated as "...the alcohol former par excellence" of the lower fungi.[2] In spite of accumulated data on enzymic effects of *Fusaria*,[3] the most important transitory stage in the phase sequence between carbohydrate and alcohol has been so far unknown.

We have been successful in isolating pyruvic acid which accumulates transiently during the course of fermentations of glucose, fructose, mannose, galactose, and xylose effected by FlB. The synthetic nutrient media consisted of the usual inorganic salts and carbohydrate (*p*H 4.5). That this accumulation is not a characteristic of our strain alone, as used in corresponding work,[4] was shown by the following. Another culture of FlB, obtained through the courtesy of the North Dakota Agricultural Experiment Station, and cultures of *Fusarium oxysporum*, *Fusarium graminearum* Schwabe, and *Fusarium lycopersici*, all yielded the self-same result since pyruvic acid accumulated as an intermediate during the fermentations. It was identified in every case as its 2,4-dinitrophenylhydrazone in the usual way.

TABLE I

Day of experiment	Glucose fermented, g. (per 100 cc.)	Pyruvic acid found, mg. (per 100 cc.)
0	0.00	0
4	1.73	158
6	3.47	171
8	4.09	155

TABLE II

Day of experiment	Xylose fermented, g. (per 100 cc.)	Pyruvic acid found, mg. (per 100 cc.)
0	0	0
5	1.60	15
6	2.51	24

This accumulation of pyruvic acid, which occurred in complete absence of any interceptor, in transformations caused by an alcoholic fermenting system, could be very likely attributed to a deficiency, with respect to some components, of the decarboxylating system. That this consideration is correct was shown by experiments in which vitamin B_1 was added to the nutrient medium.[5] Under these conditions, the ratio between the pyruvic acid found in the vitamin containing media (24 mg./100 cc.) and pyruvic acid accumulating in the control (171 mg./100 cc.) was about one to seven, at the time when the absolute amounts of pyruvic acid were at a maximum in both cases.

In view of numerous findings in the sphere of enzymic carbohydrate degradations, these experiments lend additional support to the view[3] that conclusions drawn from a comparison of living systems may prove more justifiable in the study of the mechanism of the enzymic conversion of a given compound than those arrived at from the application of artificial or disorganized enzyme preparations.

Details of the experiments, with hexoses as well as with pentoses, and a discussion of their significance, will be presented later.

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RECEIVED SEPTEMBER 18, 1941

(1) This investigation was supported in part by a grant from the Rockefeller Foundation, and was presented at the centenary celebration of Fordham University on September 16, 1941.

(2) J. H. Birkinshaw, *Biol. Rev.*, **12**, 369 (1937).

(3) F. F. Nord, *Chem. Rev.*, **26**, 423 (1940).

(4) George J. Goepfert, *J. Biol. Chem.*, **140**, 525 (1941).

(5) E. Dammann, O. T. Rotini and F. F. Nord, *Biochem. Z.*, **297**, 184 (1938).