Heterogeneous Structure of Rayon. V. Effect of Stretching on the Heterogeneous Structure (2)

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In the preceding report the effect of the stretching of a rayon fiber in the second bath upon its heterogeneous structure was studied making use of a series of viscose rayons. Now the same experiment was repeated on another series of rayons which were spun by one-bath process but stretched to various degrees.

Experiment

(1) Sample of Rayons.—The spinning was also carried out in the laboratory of Teikoku Jinken Co. by one-bath process using an ordinary factory viscose. A constant volume of viscose was extruded through spinnerets of various orifice sizes and collected with an equal velocity so that the denier of the filament was kept constant. The peripheral velocity of the first godet was so controlled as to equalize it to the extrusion velocity of the viscose so that an equal drafting is given to every filaments. The details of the spinning condition and some of the properties of the yarns obtained are tabulated below.

TABLE I

No.	Diam of orifice, mm.	Stretch	Denier	Dry		Wet	
				Strength, g./den	Elong., %	Strength, g./den	Elong., %
IIIa	0.08	1.06	119.4	1.43	26.2	0.64	35.7
IIIb	0.085	1.20	120.3	1.69	20.5	0.74	29.9
IIIc	0.09	1.35	120.2	2.14	15.9	0.91	20.3
IIId	0.095	1.50	119.7	2.10	12.6	1.06	16.2

Collection velocity: 86.48 m./min.; Number of holes of a spinneret: 25; Bath composition: H_2SO_4 120 g./l, Zn 10 g./l besides Na_2SO_4, sp. gr. 1.25; Bath temperature: 50°C.

In this spinning the spinnerets with uniform holes were prepared with special precautions in order to keep the standard deviation of the denier as small as possible. And the actual standard deviations of the single filaments relative to the mean deniers were 5.8, 6.4, 7.3 and 7.6% in the order from IIIa to IIId.

The other operations were similar to those of the previous experiment, except that one bath-process was adopted in the present spinning.

The acetylation temperature was also controlled but it fluctuates so much that the discussion of the rate of acetylation is abandoned.

Experimental Results

(1) The Structure of the Skin and Core.—The relation between the loss during the acetylation (L_1/W) and the acetic acid content (A) is also similar to that of the previous report (Fig. 1). The weight percentages of the outermost skins IIIa—IIId are 4.6, 4.2, 4.2, and 4.4% respectively, or nearly constant irrespective of the stretching and the mean depth of the outermost skin is estimated to be 2.2% of the total radius. The slope of the line of the skin part, OK, is also nearly constant, but that of the inner structure decreases as the stretching increases. This means that the outermost skin is of nearly equal structure

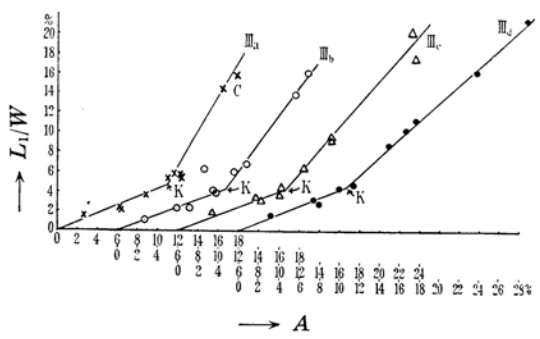

Fig. 1.

in each yarn but the structure within the skin becomes the more difficult to disperse as the filament is stretched the higher.

It is described in the previous paper that the origin of the outer most skin is related to the production of the Zn-xanthate. The constancy of this skin can be explained from this point of view as follows. If the diameter of an orifice is D, then the sectional area of each filament on the first godet will be k_1D^2. Of course the attenuation of a filament occurs due to some complex factors, such as drafting, gelling, dehydration, etc., and the cross section can not be circular. k_1 implies these complex changes of the sectional area and of the form but it is nearly constant and independent on the value of D in the range of the present spinning condition. Now the

thickness d of the Zn-xanthate layer formed is in proportion to the square root of the immersion time t, during which the yarn stays in the bath, so that d is given by

$$d=k_2t=k_3L^{1/2}D,$$

where L is the immersion length and k_2 and k_3 are numerical constants. Therefore d/D is independent on the orifice diameter D.

As the thickness of the outermost skin, which is derived from this Zn-xanthate layer is also proportional to d, and the further shrinkage of the cross section due to the regeneration, stretching and drying occurs uniformly the percentage of the outermost skin, P_r, must always be independent of D as shown above.

(2) Orientation.—The radial distribution of the intrinsic double refraction Γ is given in Fig. 2. The highly stretched filament has larger Γ.

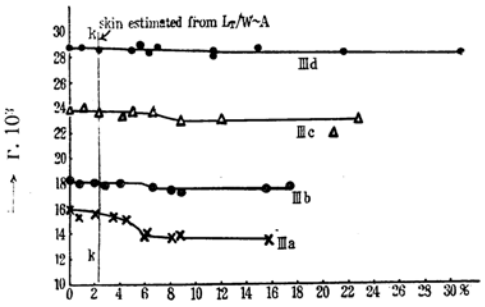

Fig. 2.

On the curves of Γ—P_r three parts of the structure are seen as already pointed out in the second paper of this study. The outermost skin indicated on these curves grows thicker in the order from IIIa to IIId and the last one appears to be of all skin types. But the skin which appears during the acetylation is a part of it as is indicated by a line k-k, in Fig. 2. So the outermost skin optically indicated as one layer is not simple but is composed of two layers. The inside layer may be caused as follows.

Because the viscose or xanthate close to the Zn-xanthate skin is dehydrated so much by osmotic diffusion and gelates, the flow property of that part is so similar to that of the Zn-xanthate layer, that the orientation of this layer is fixed during the stretching of the filament and the regeneration of cellulose as effectively as in the true outermost skin. The dehydration and syneresis of this layer is further enhanced by the stretching, so the apparent outermost skin thickens with the degree of stretching. For the same reason the destruction of the structure due to the gas evolution within the outermost skin is suppressed in the same order as actually observed in the acetylation.

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