CCLXXIX. THE HEMICELLULOSES OF THE WOOD OF ENGLISH OAK.

II. THE COMPOSITION AND PROPERTIES OF HEMICELLULOSE A, ISOLATED FROM SAMPLES OF WOOD DRIED UNDER VARIOUS CONDITIONS.

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INTRODUCTION.

In a previous communication [O'Dwyer, 1931] it has been shown that the yields of hemicellulose A obtainable from oak wood are strictly related to the condition of the wood at the time of the initial alkaline extraction. Sapwood as a rule yields greater amounts of hemicellulose A than heartwood; with increasingly drastic conditions of drying of the original wood the yields in both cases show appreciable reductions. The suggestion was made that during drastic kiln-drying and oven-drying of oak wood at temperatures between 50° and 100° there is actual decomposition of the hemicelluloses. This suggestion has been followed up in the present work which has involved a study of the hydrolysis products of the various samples of hemicellulose A prepared under the conditions already described [O'Dwyer, 1931] as well as of certain other important properties of these substances.

EXPERIMENTAL.

The several dried samples of hemicellulose A prepared from green-, air-, kiln- and oven-dried (100°) sapwood and heartwood were purified by successive extraction for 6 hours with each of the following solvents: alcohol-benzene (1 : 2), absolute alcohol and dry ether. The impurities removed amounted on the average to about 2 % of the starting material, and the final products after extraction were almost white. Each preparation gave a colloidal solution with hot water and failed to reduce Fehling's solution. Without exception the preparations gave the Tollens naphthoresorcinol test for hexuronic acids and their anhydrides [Browne, 1912, p. 384].

Colour reactions with iodine.

In a previous study [O'Dwyer, 1926] it was observed that the hemicellulose A of beech wood gave a greenish coloration with iodine. With regard to the hemicellulose A of the present study it has been found that all the products obtained from sapwood, green and dried alike, gave the blue coloration with iodine-potassium iodide solution which is characteristic of starch. The test was applied by making a suspension of a small quantity of hemicellulose in hot water, cooling and adding a drop of iodine-potassium iodide solution containing 2 g. I and

6 g. KI in 100 ml. of H_2O . The blue coloration was discharged on heating and was regenerated on cooling. A greenish coloration was only obtained when the concentration of the hemicellulose suspension was too low. None of the heartwood products was found to give a colour reaction with iodine.

Effect of takadiastase on sapwood hemicellulose A.

A series of 0.3 g. samples of hemicellulose A taken from green and dried oak sapwood were exposed to the action of takadiastase as follows: 10 ml. of distilled water were added to each sample and raised to the boiling-point. After cooling to room temperature 0.3 g. of takadiastase was added to each and the series maintained at a temperature of 40° . A solution of soluble starch was used as a control. Whereas the starch solution failed to give a blue coloration with iodine-potassium iodide solution after 10 minutes' contact with takadiastase, the various preparations of hemicellulose A still gave a greenish blue coloration after 7 hours.

General analysis of the various samples of hemicellulose A.

The specific rotation of each sample was determined in 2 % sodium hydroxide solution ($c=0.8$ approx.). By means of the method described by Dickson *et al.* [1930] determinations were made of the amount of CO_2 given off by each sample on hydrolysis with 12 % HCl, the results being expressed, for reasons which will be apparent later, as uronic acid anhydride containing one methoxyl group. The only pentose sugar isolated from the hydrolysis products of hemicellulose A was xylose, so that xylan was estimated by the furfuraldehydephloroglucide method after the necessary correction had been applied for the phloroglucide arising from uronic acid residues. The furfuraldehydephloroglucide precipitate was insoluble in alcohol in every case, so that apparently no methylpentosan was present in any of the preparations.

The methoxyl content of each sample was determined by Zeisel's method. Treatment with dilute sodium hydroxide solution under the conditions stated

Table I. *Comparative analyses of samples of hemicellulose A, isolated from the sapwood and heartwood of oak in the green and dried conditions.*

Source of hemicellulose A	[α] _D ²⁰ in 2 % NaOH (c = 0.8)	Ash %	Uronic acid anhy- dride	Xylan	Meth- oxyl	Total organic matter accounted for %
			% ash free			
Green sapwood	- 62°	1.5	10.16	82.5	1.9	94.16
Air-dried sapwood	- 65.2	1.0	9.8	83.0	2.0	94.80
Kiln-dried sapwood. Maximum kiln temperature 40.6°	- 63.4	0.98	9.8	82.5	2.0	94.60
Kiln-dried sapwood. Maximum kiln temperature 54.4°	- 50	1.2	9.0	83.8	1.82	94.62
Oven-dried sapwood	- 44	1.3	8.8	83.9	1.7	94.4
Green heartwood	- 82	1.5	10.71	84.5	2.23	97.24
Air-dried heartwood	- 81.8	1.8	10.0	84.9	2.15	97.05
Kiln-dried heartwood. Maximum kiln temperature 40.6°	- 83	0.8	10.71	85.0	2.2	97.91
Kiln-dried heartwood. Maximum kiln temperature 54.4°	- 85.1	1.7	10.25	84.7	2.0	96.95
Oven-dried heartwood	- 76	1.3	10.25	85.5	1.97	98.02
Theoretical molecule consisting of 11 anhydro-xyloses and 1 methoxy- hexuronic acid (+ 5 % other sub- stances)	—	—	10.02	82.64	1.77	—

in a previous communication [O'Dwyer, 1928] indicated that in every case the methoxyl groups were bound by an ether linkage. No acetyl groups were present in any of the preparations. The results are given in Table I.

Further evidence of the presence of uronic acid residues in hemicellulose A.

Further evidence that the carbon dioxide given off during the hydrolysis of hemicellulose A by 12 % hydrochloric acid originated from uronic acid residues was obtained as follows.

It has been established [Ehrlich and Rehorst, 1925; 1929; Niemann *et al.*, 1934; Link and Nedden, 1931] that the barium salts of the naturally occurring hexose uronic acids are of lower specific rotation than the equilibrium mixtures of the α - and β -acids from which they are derived. So far as it is possible to say at present from the scanty evidence available [Challinor *et al.*, 1931], the barium salts of the aldobionic acids are probably of higher specific rotation than the corresponding acids. It was accordingly decided to carry out a series of acid hydrolyses on the various preparations of hemicellulose A and to take rotations of the soluble products before and after neutralisation with barium carbonate. In general, the results (Table II) for the sapwood support the view

Table II. *Rotations obtained after hydrolysis of hemicellulose A with 1 % sulphuric acid.*

Source of hemicellulose A	Period of hydrolysis hours	Residue %	Specific rotation	
			In acid solution $[\alpha]_D^{20}$	In neutral solution $[\alpha]_D^{20}$
Green sapwood	3	1.7	+41.0°	+32.2°
	6	1.7	+39.4	+30.7
Air-dried sapwood	3	1.5	+41.1	+33.7
	6	1.5	+30.7	+28.0
Kiln-dried sapwood. Maximum kiln temperature 40.6°	3	1.5	+40.3	+33.6
	6	1.5	+30.6	+27.8
Kiln-dried sapwood. Maximum kiln temperature 54.4°	3	1.9	+37.6	+30.6
	6	1.9	+29.5	+28.0
Oven-dried sapwood	3	2.1	+36.6	+30.0
	6	2.1	+28.9	+28.0
Green heartwood	3	2.5	+30.6	+27.8
	6	2.5	+27.6	+47.0
Air-dried heartwood	3	2.1	+29.9	+25.8
	6	2.1	+24.0	+49.0
Kiln-dried heartwood. Maximum kiln temperature 40.6°	3	2.3	+30.0	+26.9
	6	2.3	+25.3	+48.5
Kiln-dried heartwood. Maximum kiln temperature 54.4°	3	2.5	+45.5	+20.1
	6	2.5	+20.5	+30.8
Oven-dried heartwood	3	2.5	+46.4	+28.2
	6	2.5	+23.8	+33.6
Kiln-dried heartwood. Maximum kiln temperature 40.6°	16	2.9	+25.1	+22.0
Ditto	40	3.0	+20.3	+19.5
Ditto with 4 % sulphuric acid	20	3.2	+23.8	+20.8

that the parent hemicellulose A contains uronic acid residues. In some cases after 6 hours' hydrolysis it will be observed that the rotations of the acid and neutral hydrolysis products are approximately the same. This must be taken

to indicate that prolonged hydrolysis has resulted in the decomposition of the uronic acids. In the hydrolysis products of the heartwood preparations there would appear to be evidence of the presence of both uronic and aldobionic acids, for it will be observed in the majority of cases that, after 3 hours' hydrolysis, the specific rotation of the acid solution is higher than that of the neutralised solution, whereas after 6 or more hours' hydrolysis the situation is reversed. This may be taken to indicate that in the early stages of hydrolysis the presence of aldobionic acids is masked by that of uronic acids. During prolonged hydrolysis the uronic acids are decomposed, but the aldobionic acids, which are much more resistant, survive. This is confirmed by the fact that 40 hours' hydrolysis with 1 % sulphuric acid at 100° is required in order to reach the stage when no barium salt of an aldobionic acid is formed on adding barium carbonate. Sugar estimations on each of the hydrolysed preparations from both sapwood and heartwood gave values of from 88 to 93 % of reducing sugars reckoned as glucose. Goebel and Babers [1933] have shown, however, that the reducing power of uronic and aldobionic acids is similar to that of the monosaccharides.

Isolation and identification of the hydrolysis products of hemicellulose A.

10 g. of hemicellulose A prepared from oak sapwood kiln-dried at a temperature not exceeding 40-6° were incorporated with 350 ml. of 1 % sulphuric acid and maintained at 100° for 6 hours. The sample first formed a viscous solution in the acid but after heating for approximately an hour a brown flocculent precipitate began to form. At the end of the hydrolysis this was removed by filtration, washed free from acid with hot water and dried at 105°. It amounted to 1.5 % of the dry weight of the starting material and contained 15 % OMe. The clear filtrate was nearly neutralised with barium hydroxide solution, and solid barium carbonate was then added in slight excess. Prior to filtering, the material was treated according to the procedure laid down by Link and Nedden [1931]. The filtrate, which was almost colourless, was concentrated to 300 ml., decolorised with charcoal, filtered and further concentrated to 200 ml. On pouring into 4 vols. of 97 % ethyl alcohol a granular precipitate formed after stirring for some time. This was filtered off and after again concentrating to 200 ml. the filtrate was mixed with 4 vols. of alcohol when a second precipitation took place. As no further precipitation could be induced, the two precipitates were combined and reserved for examination. The final filtrate was now concentrated to a syrup, diluted to twice its volume with hot alcohol, decolorised with charcoal, filtered and cooled. After a short time the mass began to crystallise. The crystals were collected on a filter, washed with alcohol and dried to constant weight *in vacuo*. The yield, 6.63 g., represents 66.3 % of the starting material. After recrystallisation from alcohol, this material gave $[\alpha]_D^{20} + 24^\circ$ (in water: $c=4$); M.P. 120-130°. It was found to contain 2.3 % OMe and traces of barium. A trace of CO₂ was given off on hydrolysis with 12 % HCl, but the naphthoresorcinol test for uronic acids gave a negative result. *l*-Xylose was identified by means of the characteristic boat-shaped crystals of cadmium bromide-cadmium xylonate, but the substance gave neither a diphenylhydrazone nor mucic acid on oxidation with nitric acid. The specific rotation suggests that xylose was the principal sugar present but the presence of another sugar cannot be excluded. As the original hemicellulose gave the starch reaction with iodine it is suggested that the second sugar may have been glucose. This, however, could not be confirmed experimentally. There would appear to be little doubt that the crystalline xylose as isolated above contained traces of barium sulphate and other impurities

derived from the breaking down of uronic or aldobionic acids. It is suggested that the portion containing methoxyl groups arose from the hydrolysis of partly methylated glucuronic acid.

It can be seen from the results in Table II that hydrolysis of the sample of hemicellulose A with 1 % sulphuric acid at 100° for 6 hours must result in the decomposition of a considerable proportion of the inherent uronic acid residues. That these residues are broken down with ease by dilute mineral acids is already well known [O'Dwyer, 1926; Link and Niemann, 1930]. It has also been found, however, that aldobionic acids are relatively more resistant to hydrolysis, so that it is of interest to examine the barium salts obtained on neutralising the hydrolysis products in order to determine whether sapwood hemicellulose A contains aldobionic in addition to uronic acid residues.

Identification of the barium salts. The combined precipitates obtained on adding excess of alcohol to the neutralised products of the hydrolysis were purified by solution in water and reprecipitation by excess of alcohol, washing with hot 97 % alcohol and then with ether. After drying to constant weight *in vacuo* the yield amounted to 0.939 g. or 9.39 % of the original hemicellulose. The analysis of this substance (Table III) revealed that it was apparently the

Table III. *Analysis of barium salts.*

Substance	Uronic acid %	Ba %	Free aldehyde %	Methoxyl %	Methoxyl groups per uronic acid %	Specific rotation $[\alpha]_D^{20}$ (in water)
Salt from hemicellulose A from sapwood	42.98	17.0	6.63	6.9	1.0 (approx.)	+69° (c=0.3)
Salt from hemicellulose A from heartwood	42.70	19.72	6.33	6.6	1.0 (approx.)	+60° (c=0.6)
Impure salt from hemicellulose A from heartwood (after treatment with 72 % sulphuric acid)	39.32	15.3	8.04	5.9	1.0 (approx.)	+50° (c=0.4)
Theoretical for barium salt of xylonomethoxyaldobionic acid	43.19	16.86	7.12	7.61	1.00	—

barium salt of a xylonomethoxyaldobionic acid. Obviously a considerable proportion of the uronic acid residues in the hemicellulose A must have been decomposed during the 6 hours' hydrolysis, since only about half of the amount originally present (Table I) was recovered in this barium salt.

The amount of salt obtained from hemicellulose A from sapwood after treatment with 72 % H₂SO₄ was too small for analysis.

The free aldehyde groups in the barium salts were estimated by Cajori's method [1922], 3 hours being required for the completion of the oxidation by iodine in alkaline solution. The barium was determined by Pregl's micro-method. All the salts gave the naphthoresorcinol test for hexuronic acids and reduced Fehling's solution strongly.

Hydrolysis of heartwood hemicellulose A.

8.26 g. of hemicellulose A prepared from oak heartwood, which latter had been dried under the same conditions as the sapwood mentioned above, were hydrolysed with 1 % sulphuric acid for 6 hours at 100°. As in the case of the sapwood product, a brown flocculent precipitate formed during the hydrolysis. This amounted to 2 % by weight of the starting material and contained 16 %

OMe. The soluble hydrolysis products were treated in precisely the same way as those obtained from the sapwood hemicellulose A with the result that a barium salt was obtained as before. The purified salt amounted to 2.22 g. or 26.87 % by weight of the original hemicellulose. The analysis of this product is given in Table III. The remainder of the soluble products was crystallised as before. The first crop of crystals contained a considerable proportion of the clear, thick, monoclinic crystals of *d*-glucurone. The mixture had m.p. 165–168° (which is too low for pure *d*-glucurone and too high for pure *l*-xylose) and $[\alpha]_D^{20} + 20^\circ$ in water ($c=3.5$). The glucurone was probably derived from glucuronic acid residues, and its presence among the hydrolysis products is an indication that the initial heating of the neutral hydrolysis products recommended by Link and Nedden [1931] had not been sufficiently prolonged. The main crop of crystals consisted of *l*-xylose, which was identified by means of the boat-shaped crystals of cadmium bromide-cadmium xylonate. The sugar had m.p. 145–148° and $[\alpha]_D^{20} + 19.5^\circ$ in water ($c=4$). When mixed with pure xylose no change in melting-point was observed. None of the crystalline matter in this case contained methoxyl groups and the total yield was 3.78 g. or 45.76 % by weight of the original hemicellulose. Unfortunately, a portion of the sugar syrup was lost prior to crystallisation so that the yield was low, but it can be seen from the data in Table I that this should have been of the order of 60 %.

The lignin-like residue formed during the hydrolysis of hemicellulose A.

It has previously been reported [O'Dwyer, 1932] that when wood hemicellulose is hydrolysed by means of 72 %, followed by 3 %, sulphuric acid according to the procedure followed in the estimation of lignin [Ost and Wilkening, 1910], a small percentage of a lignin-like residue is formed. There would appear to be good grounds for the conclusion that this residue is actually formed from the hemicellulose and is not present therein as an impurity. The residue contains methoxyl groups which may amount to 13 % of its dry weight. The following experiments were carried out in order to determine whether a greater proportion of hemicellulose A could be transformed into this substance in view of its apparent similarity to lignin.

Standard lignin determinations were carried out on samples of hemicellulose A prepared from oak sapwood and heartwood which had been kiln-dried at a temperature not exceeding 40.6°. In the case of the sapwood product 80 % of the starting material was lost, presumably as furfuraldehyde and carbon dioxide. 3.02 % was recovered as an insoluble methylated lignin-like residue (OMe=13.5 %) and the remaining 17 %, consisting of soluble products of the hydrolysis, was found, after neutralisation, to consist of sugars, principally xylose, and the barium salt of a uronic acid. It also contained methoxyl. As for the heartwood hemicellulose, the volatile products amounted to 65–75 %, and 3.02 % of a lignin-like residue (OMe=13.3 %) was obtained as before. In this case, however, the neutralised soluble hydrolysis products contained the barium salt of a methoxyaldobionic acid amounting to approximately 10 % of the dry weight of the original hemicellulose as well as a mixture containing methoxyl groups of the barium salt of a uronic acid and xylose. The total yield of soluble hydrolysis products amounted to 30–35 % of the original hemicellulose.

The effect on hemicellulose A of prolonged digestion with 72 % sulphuric acid.

1.89 g. of hemicellulose A prepared from green oak sapwood were digested at room temperature with 12.5 ml. of 72 % sulphuric acid for 48 hours. The acid was then diluted to approximately 3 % and the hydrolysis continued at

the boiling-point for 2 hours. 5.7 % of an insoluble residue containing 5 % OMe was obtained. A standard lignin determination on the same product gave 3.36 % residue containing 12.5 % OMe. 2.84 g. of hemicellulose A prepared from green heartwood were given a similar treatment to that applied to the sapwood product above. The insoluble residue amounted to 8.2 % of the starting material and contained 3.5 % OMe. A standard lignin determination on the same product gave 3.2 % of a residue containing 13.2 % OMe.

The effect of moderate heat on hemicellulose A.

1.01 g. hemicellulose A from green heartwood were exposed to dry heat in the presence of air at 135° for 66 hours. There was a loss in weight of 2.79 %. A standard lignin determination in the material after heating gave 13.04 % of a residue containing 2.63 % OMe.

3.53 g. of hemicellulose A from green sapwood were heated at 135° with 10 ml. of methyl alcohol in a sealed tube for 200 hours. The resulting products consisted of a pale brown amorphous solid and a substance, or substances, which had dissolved in the methyl alcohol to form a dark red solution. The solid portion amounted to 80 % of the starting material. It contained 2.6 % OMe and, on hydrolysis, yielded a sugar solution having $[\alpha]_D^{20} + 18.5^\circ$. The sugar preparation contained 2.5 % OMe and was presumably mainly xylose, so that the greater part of the hemicellulose must have been transformed into xylan during the heating process. A lignin determination on this substance gave a residue of 4.5 % containing 2.7 % OMe. The portion soluble in methyl alcohol was concentrated under reduced pressure, and a brown hygroscopic residue was obtained which smelt distinctly of caramel.

DISCUSSION.

From the foregoing considerations it is evident that, although drying of oak wood under ordinary conditions may have a pronounced effect on the yields of hemicellulose A obtainable therefrom, the general composition of the product is remarkably constant. Sapwood hemicellulose A suffers no appreciable degradation unless the parent wood substance be dried at temperatures exceeding 40° but, as is apparent from Table I, the heartwood product is more stable since the parent wood substance can be heated to 100° for several hours before any change in composition is detectable. Thus, although there is ample evidence that the same building units are present in hemicellulose A from both sapwood and heartwood, the greater stability towards heat of the heartwood product must be attributed either to its higher content of methoxyaldobionic acid residues or, alternatively, to different structural arrangements in the molecule. The relatively greater stability of heartwood hemicellulose A is further illustrated by the effect of concentrated sulphuric acid on the two substances. It has been shown that under exactly similar conditions of hydrolysis part of the methoxyaldobionic acid residues of heartwood hemicellulose A survive as the acids, while the corresponding residues in the sapwood product are completely broken up into smaller units. Taken in conjunction with the fact that sapwood hemicellulose A gives the starch reaction with iodine, whereas the heartwood product does not, this evidence all points to the conclusion that in oak wood the transition of sapwood into heartwood is marked by definite constitutional changes in the hemicelluloses. The fact that sapwood hemicellulose A gives the starch colour reaction with iodine is in itself interesting, since, so far as is known, this has not previously been established for any other wood hemicelluloses.

The analytical figures in Table I closely resemble those obtained for the hemicellulose A of mesquite wood by Sands and Gary [1933] and for the corresponding product from beech wood [O'Dwyer, 1926], so that the suggestion presents itself that hemicellulose A may be of similar composition in all hardwoods.

At this stage of the work it has been impossible, owing to the necessarily small amounts of material available, to identify the constituents of the aldobionic acid residues in the hemicelluloses. It is interesting to record, however, that Anderson and Otis [1930] have established the presence of *d*-glucuronic acid in a partly methylated aldobionic acid isolated from mesquite gum.

There is a certain amount of indirect evidence bearing on the constitution of the aldobionic acid from oak hemicellulose A which merits consideration. In the first place, the percentage of free aldehyde groups found in the barium salts (Table III) shows that, in common with compound uronic acids of a similar nature isolated from such natural products as gum arabic [Butler and Cretcher, 1929], gum tragacanth [Norman, 1931], mesquite gum [Anderson and Otis, 1930], mesquite wood [Sands and Gary, 1933] and quince seed mucilage [Renfrew and Cretcher, 1932], one part of the aldobionic acid is joined to the other by a glucosidic linkage, while in the other portion the aldehyde group is free. In all cases which have been examined it has been found that, on hydrolysis, the aldobionic acids split up into equimolecular proportions of a sugar and a uronic acid, except in the case of alginic acid [Cretcher and Nelson, 1928] which yields only uronic acids. In the case of the hemicellulose A from oak wood sufficient evidence would now appear to have been obtained to show that the aldobionic acid obtained on hydrolysis with dilute sulphuric acid could be split up into xylose and partly methylated glucuronic acid.

The point of attachment of the uronic acid molecule to that of the sugar in the aldobionic acid has not yet been determined. In the case of the aldobionic acid from gum arabic, Heidelberger and Kendall [1929] claim that their experiments eliminate all but carbon atoms 3 and 6 of the sugar molecule as the point of attachment. Challinor *et al.* [1931], however, state that it is abundantly clear that in this acid the 6-position of the galactose residue is joined in the biose type of linking with the reducing group of the glucuronic acid residue. The evidence given by these latter authors appears to be conclusive, and it may be that aldobionic acids in other plant products also conform to this type of structure. The conclusion would therefore appear to follow that the hemicellulose A of oak wood is largely composed of anhydroxylose residues combined with a proportion of uronic and methoxyaldobionic acid residues. The former acid residues predominate in the sapwood product and the latter in the heartwood product.

The lignin-like residue formed during the hydrolysis of hemicellulose.

It is still an open question as to whether the residue remaining after acid hydrolysis of hemicellulose A is, in reality, lignin, but there would appear to be little doubt that it is formed from a part of the hemicellulose complex. The most likely source of this material is the methoxyaldobionic acid residues. The numerous attempts recorded above to transform a greater proportion of hemicellulose A into this substance have been unsuccessful. Heating the hemicellulose at 135° for 66 hours gave a product from which 13.04 % of a residue insoluble in 72 % sulphuric acid was obtained, but the methoxyl content of this residue fell far short of that of the lignin normally isolated from wood.

SUMMARY.

1. Analyses of samples of hemicellulose A prepared from oak sapwood and heartwood in the green and dry conditions have revealed that although drying of the wood at moderate temperatures results in lower yields than are obtained from green wood the composition of the product is remarkably uniform.

2. Sapwood hemicellulose A suffers no appreciable degradation unless the parent wood substance be dried at temperatures exceeding 40°, but the heartwood product is apparently unchanged at temperatures up to 100°.

3. From a detailed examination of the hydrolysis products of hemicellulose A from oak wood it has been concluded that the transition from sapwood to heartwood is marked by definite constitutional changes in this component.

4. Anhydroxylose residues constitute the greater proportion of oak hemicellulose A, and these are combined with a proportion of uronic and methoxyaldobionic acid residues. The former acid residues predominate in the sapwood product and the latter in the heartwood product.

5. It has been established that hemicellulose A from oak sapwood gives the blue coloration with iodine which is characteristic of starch, so that the possibility of the presence of a small percentage of anhydro-glucose residues in the molecule cannot be excluded, although glucose was not identified among the hydrolysis products. None of the heartwood preparations of hemicellulose A gave the starch reaction with iodine.

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