

## CHIROPTICAL PROPERTIES OF METHYL (4-METHYLPHENYLTHIO)HEXOSIDES: STEREOCHEMICAL APPROACH

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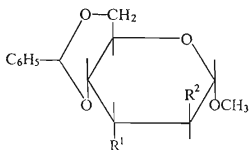
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Six isomeric methyl 4,6-O-benzylidene-2(or 3)-(4-methylphenylthio)hexosides were prepared by opening corresponding epoxides with 4-methylbenzenethiolate. They differ in the position of the arylthio group and in the configuration on the glycosidic carbon atom and C<sub>(4)</sub> (*i.e.* in the *cis*- or *trans*-junction of the benzylidenedioxy group). Their ORD and CD curves were measured. For correlation of Cotton effect signs with the relative position of arylthio substituent in the molecules a quadrant rule is examined.

The examination of chiroptical properties is a useful tool for the study of the spacial arrangement of various compounds. With aldoses this approach is seriously complicated by the fact that it is usually impossible to attain the region of anomalous dispersion, and plain dispersion curves must suffice. It is therefore reasonable to introduce a chromophoric substituent absorbing selectively at longer wave-lengths, *i.e.* in the region suitable for measurements<sup>1</sup>. In some instances such a modification of aldose molecule actually leads to the appearance of bands which reflect in a characteristic manner the spacial arrangement of the original molecule. An example of a successful procedure of this type is the study of molybdenum complexes of aldoses by means of circular dichroism and optical rotatory dispersion<sup>2</sup>. Generally, however, cases may occur when the relations between the sign of dichroitic bands of the introduced chromophore and geometry of the aldose molecule is not direct and when the Cotton effect reflects only the relative position of the substituent and the sugar moiety. Arylthio derivatives of a series of methylbenzylidene hexosides were found to be examples of this situation.

4-Methylphenylthio derivatives *Ia*, *Ib*, *IIa*, *IIb*, *IIIa* and *IIIb* were prepared by opening corresponding 2,3-anhydro-4,6-benzylidenehexosides (*V*, *VI*, *VIIa*, *VIIIa*, *VIIb*, *VIIIb*, respectively) with thiocresol. From the literature it is known that the anhydrohexosides *V*–*VIII* are opened with nucleophilic reagents stereoselectively. In the case of *allo*-epoxide<sup>3</sup> (*V*) and *gulo*-epoxides (*VIIa*)<sup>4</sup>, (*VIIb*)<sup>5</sup>, the nucleophilic particle attacks atom C<sub>(2)</sub>, while in the case of *manno*-epoxide<sup>6</sup> (*VI*) and *talo*-epoxide<sup>7</sup> (*VIIIa*), (*VIIIb*) (ref.<sup>8</sup>) opening at atom C<sub>(3)</sub> takes place; both processes are in agreement with the Fürst-Plattner rule. In our case the reaction with thiocresol also took place stereospecifically. In all instances studied, of two theoretically possible isomers only a single one was isolated in 80–85% yield (Table I). On the basis of

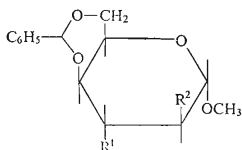
analogies from literature and on the basis of the mentioned rule, we assigned to the products of reaction of thiocresol with oxides *V*, *VI*, *VIIa*, *VIIIa*, *VIIb*, *VIIIb* the *trans*-diaxially disubstituted structures *Ia*, *Ib*, *IIa*, *IIb*, *IIIa*, *IIIb*, respectively.



*Ia*;  $R^1 = \text{OH}$ ,  $R^2 = \text{SC}_6\text{H}_4\text{CH}_3$

*Ib*;  $R^1 = \text{SC}_6\text{H}_4\text{CH}_3$ ,  $R^2 = \text{OH}$

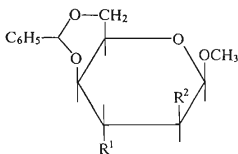
*Ic*;  $R^1 = R^2 = \text{OH}$



*IIa*;  $R^1 = \text{OH}$ ,  $R^2 = \text{SC}_6\text{H}_4\text{CH}_3$

*IIb*;  $R^1 = \text{SC}_6\text{H}_4\text{CH}_3$ ,  $R^2 = \text{OH}$

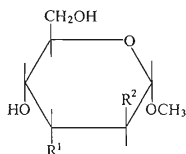
*IIc*;  $R^1 = R^2 = \text{OH}$



*IIIa*;  $R^1 = \text{OH}$ ,  $R^2 = \text{SC}_6\text{H}_4\text{CH}_3$

*IIIb*;  $R^1 = \text{SC}_6\text{H}_4\text{CH}_3$ ,  $R^2 = \text{OH}$

*IIIc*;  $R^1 = R^2 = \text{OH}$



*IVa*;  $R^1 = \text{OH}$ ,  $R^2 = \text{SC}_6\text{H}_4\text{CH}_3$

*IVb*;  $R^1 = \text{SC}_6\text{H}_4\text{CH}_3$ ,  $R^2 = \text{OH}$

*IVc*;  $R^1 = R^2 = \text{OH}$

TABLE I

Properties of 4-Methylphenylthio Derivatives Prepared

Pyranoside	Thio derivative	M.p. °C	[ $\alpha$ ] <sub>D</sub>	Found <sup>a</sup>		
				% C	% H	% S
<i>V</i>	<i>Ia</i>	84–86	+58	65.35	6.40	8.04
<i>VI</i>	<i>Ib</i>	154–155	–46.8	65.13	6.27	8.46
<i>VIIa</i>	<i>IIb</i>	100–103	+81.7	65.30	6.30	8.56
<i>VIIb</i>	<i>IIIb</i>	120–121	–9.6	64.88	6.46	8.55
<i>VIIIa</i>	<i>IIa</i>	95–97	–45.6	65.24	6.23	8.55
<i>VIIIb</i>	<i>IIIa</i>	108–117	–39.6	65.04	6.25	8.13

<sup>a</sup>For  $\text{C}_{21}\text{H}_{24}\text{O}_5\text{S}$  (388.5) calculated: 64.92% C, 6.23% H, 8.26% S.

In the case of 4-methylphenylthio derivatives *Ia*, *Ib* the position of 4-methylphenylthio group was also proved chemically by desulfuration with Raney nickel. Thus we obtained methyl 4,6-O-benzylidene-2-deoxy- $\alpha$ -D-altroside from *Ia* and methyl 4,6-O-benzylidene-3-deoxy- $\alpha$ -D-altroside from *Ib*. In compounds *IIa*, *IIIa*, *IIIb*, and *IVa* the structure also follows from their PMR spectra. Compounds *IVa*, *IVb*, and *IVc* were prepared by hydrolysis of corresponding benzylidene derivatives *Ia*, *Ib*, and *Ic* with 80% acetic acid. Benzylidene derivatives *Ic*, *IIC*, and *IIIc* were obtained by alkaline hydrolysis of epoxides *V*, *VIIIa*, and *VIIIb*, respectively.

In order to get an idea of the spacial arrangement of these substances we measured their ORD and CD curves (Table II). Substances without arylthio substituent display plain curves in the accessible part of the spectrum the sign of which is given by the configuration of the glycosidic carbon atom. For  $\alpha$ -glycosides it is positive (substances *IIC*, *Ic*, and *IVc*), for  $\beta$ -derivative *IIIc* it is negative. This picture is not affected substantially in the set of substances studied even when a benzylidene group is attached to them. The inherently chiral chromophoric grouping at  $C_{(1)}$  manifests itself also in the modelling of the background curves of substances with arylthio substituents<sup>9</sup>, its influence is non detectable only when it is superimposed in the long-wave part of the curve by a Cotton effect of the opposite sign. Thus, the pair *IIa* and *IIIa* deviates, according to  $[\alpha]_D$  values (in chloroform), from Hudson's rule (according to which the  $\beta$ -anomer should have a more negative rotation than the  $\alpha$ -anomer). In comparison with the pair of analogous anomers *IIC* and *IIIc* the cause of the deviation is necessarily the presence of the arylthio group. A more positive value

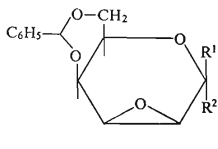
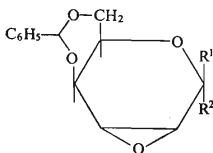
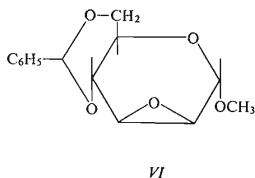
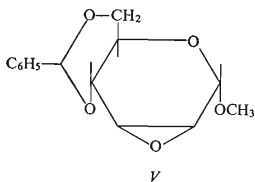


TABLE II  
Data of Optical Rotatory Dispersion ( $\lambda$ , nm;  $[\Phi]$ , deg cm<sup>2</sup> dmol<sup>-1</sup>) and Circular Dichroism ( $\lambda$ , nm;  $\Delta\epsilon$ ) of 4-Methylphenylthio Derivatives in Methanol

Com- pound	1st Cotton effect <sup>a</sup>	2nd Cotton effect <sup>a</sup>	$d^b$	End value
<i>Ia</i>	293 p	265 p (+ 800°)	247 tr (- 500°)	+ 23.0
<i>Ib</i>	—	267 tr (- 8 700°)	246 p (+ 1 050°)	- 97.5
<i>IIa</i>	289 tr	265 tr (- 4 150°)	242 p (+ 4 200°)	- 83.5
<i>IIb</i>	—	263 p (+ 7 900°)	252 tr (+ 7 600°)	+ 3.0
<i>IIIa</i>	290 tr	262 p (- 550°)	242 tr (- 4 250°)	+ 48.0
<i>IIIb</i>	—	263 p (+ 4 050°)	244 tr (+ 400°)	+ 36.5
<i>IVa</i>	298 tr	265 tr (- 150°)	245 p (+ 950°)	- 15.0
<i>IVb</i>	303 tr	263 p (+ 2 900°)	239 tr (+ 300°)	+ 26.0
<i>Ia</i>	284 (+ 0.18)	262.5 (+ 0.38)	243 (- 0.19),	220.5 (- 2.87)
<i>Ib</i>	285 (- 0.50)	254.5 (- 3.68)	231 (- 2.51) sh,	221.5 (0), 218 (- 4.26) e.v.
<i>IIb</i>	286.5 (- 0.27)	252.5 (+ 1.74)		215.0 (+ 15.6)
<i>IIIb</i>	—	252.5 (+ 1.35)		214 (+ 8.80)
<i>IVa</i>	287.5 (+ 0.075)	252 (- 0.495)		224.5 (- 2.24)

<sup>a</sup>Abbreviations: tr trough, p peak, sh shoulder, e.v. end value; <sup>b</sup>amplitude of the 2nd Cotton effect ( $[\Phi]_1 - [\Phi]_2/100$ ).

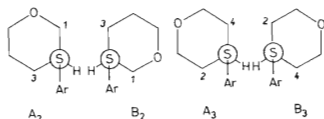
$[\alpha]_D$  for anomer  $\beta$  (*IIIa*) is explained by a positive dichroic band in the long wavelength spectral region of this substance, as opposed to a corresponding negative band in substance *Ia*.

The compounds containing a 4-methylphenylthio group give all anomalous dispersion curves with several Cotton effects, detectable more precisely in CD curves: 1. Cotton effect at 285 nm is very weak and detectable only with difficulty. In substance *IIIb* we were unable to prove its presence with circular dichroism either. 2. Cotton effect about 255 nm, of medium strength and easily detectable by both methods. 3. Cotton effects in the short-wave region, of which the band at 220–225 nm characteristic of substances with sulfur containing substituent in the position 2 is distinct; for substances with a substituent in the position 3 the band at 215 nm is prominent. The positions of these three Cotton effects agree with the positions of absorption bands in the UV spectra of substances *Ia*, *Ia*, *Ib* and also with the positions of the bands in spectra of alkyl aryl sulfides; for example, for methyl 4-methylphenyl sulfide bands at 282 and 256 nm are given<sup>10</sup>. Although the opinion on the electronic character of these absorption bands is not unambiguous<sup>11</sup>, it is undoubtedly true that they are connected with the electronic transitions of the 4-methylphenylthio group. In addition to the mentioned bands, the spectra of substances with a *trans*-junction of the benzylidenedioxy groups (*Ia*, *Ib*) contain another one, localised between the second and the third Cotton effect. A relatively large number of dichroic bands in the spectra of sulfides is not surprising; it was also observed in aliphatic sulfides<sup>12,13</sup>. For stereochemical interpretation the dichroic band at 255 nm comes primarily into consideration. The alternation of the sign of this band in single substances during the change of any of the structural parameters is remarkable. Among 2-thio ethers a positive effect is shown by *trans*-benzylidene isomer *Ia*, while the *cis*-benzylidene isomer with  $\alpha$ -configuration on the glycosidic carbon atom *Ia* gives a negative effect; however, the *cis*-isomer with  $\beta$ -configuration, *IIIa*, again gives a positive effect. On the contrary, in the case of 3-thio ethers the *trans*-isomer *Ib* gives a negative effect, the *cis*-isomer with  $\alpha$ -configuration, *Ib*, a positive, and the *cis*-isomer *IIIb* with  $\beta$ -configuration also a positive effect; only in the latter case this coincides with the effect given by the corresponding 2-thio ether. The properties of substances without a benzylidene group do not parallel the properties of benzylidene derivatives of the same configuration (pairs *IVa*, *IVb*, and *Ia*, *Ib*), but give effects of opposite signs.

The sign of the Cotton effects could be interpreted on the basis of varying conformation of the pyranose ring in single compounds. When substances *Ia* and *Ia* are compared, for example, then for the first one only a single conformation comes into consideration: the *CI* pyranose ring carrying the thio ether substituent at  $C_{(2)}$  in an axial position. In contrast to this, in *Ia* the *CI* conformation of the pyranose ring leads to appreciate 1,3-diaxial interactions of substituents at  $C_{(2)}$  and  $C_{(4)}$ . Therefore, the conformation of *IC* type, having both substituents in equatorial

positions, could be thermodynamically more stable, and the change of the sign of Cotton effect would be explicable by the change of the location of the arylthio group from the axial to the equatorial position. Analogous considerations could be also applied for other compounds. The PMR measurements carried out with compounds (*IIa*, *IIIa*, *IIIb*, and *IVa*), for which conformational analysis permitted both possible conformations of the pyranose ring, showed that all the compounds occur in the *CI* conformation.

The differences of chiroptical parameters do not follow from the differences of conformations of sugar moieties, but from the differences in spacial relationship of the arylthio group to the sugar residue. A similar problem was also studied by Paulsen<sup>14</sup> during interpretation of ORD and CD curves of sugar azides. For the application of the octant rule he chose as decisive a conformation in which the axial azide group protrudes from the center of the pyranose ring outward in a staggered conformation to the C—H bond on the same carbon atom. However, this conformation is unsuitable for the bulky arylthio group where hydrogen atoms in *ortho*-positions interfere with hydrogen atom on the carbon atom substituted by the thio group. For compounds under study only eclipsed positions of the arylthio substituent come into consideration as expressed by formulae  $A_2$ ,  $B_2$ ,  $A_3$ ,  $B_3$  Newman projection



in the direction of S—C<sub>(2)</sub> or S—C<sub>(3)</sub> bonds. The plane containing bonds linking the sulfur atom with both rings is the geometrical element defining the difference between approximately enantiomeric arrangements  $A_2$ ,  $B_2$ , or  $A_3$ ,  $B_3$ . The aromatic nucleus also lies in this plane which divides its  $\pi$ -electronic system and the orbitals of lone electron pairs on the sulfur atom into two prochiral parts. The projections  $A_2$ ,  $A_3$  (or  $B_2$ ,  $B_3$ ) are not interchangeable because the pyranose ring in *CI* conformation represents a chiral element by itself. A plane may be constructed in it which intersects the centers of all ring bonds. The cycloacetal oxygen atom is in cases  $A_2$  and  $B_2$  above this plane, while in cases  $A_3$  and  $B_3$  below it. Hence, the positions of the sulfur atom and the cycloacetal oxygen atom with respect to this plane are different. The application of the octant rule is impeded here because a part of the sugar moiety probably protrudes into the frontal octants. In view of the fact that we are unable to define the plane separating the frontal octants, a more detailed analysis is impossible. Therefore we made an attempt at interpretation of the data observed by means of a simple quadrant rule making use of the two above-mentioned planes

as nodal planes (Fig. 1). A condition for this is the ability to deduce probable conformations from models with sufficient reliability. According to our analysis this condition is to a certain extent fulfilled only in some of the substances studied: *IIa* ( $B_2$ ), *IIIa* ( $A_2$ ), *Ib* ( $A_3$ ), *IIb* ( $B_3$ ), *IVb* ( $B_3$ ); in substances *Ia*, *IIIb*, and *IVa* evaluation is impossible. The comparison of the signs of the Cotton effects with this geometrical arrangement leads to the conclusion that for structures in which the cycloacetal oxygen atom is located in the upper left or lower right quadrant in the projection shown in Fig. 1 the dichroic band at 252 nm is positive, if it is located in the remaining two quadrants it is negative. The localisation of the oxygen atom in some of the quadrants is only a formal device for the differentiation of both sides of the pyranose ring in *C1* conformation. It cannot be compared with the localisation of bonds and atoms in other sector rules<sup>15</sup>. The conformation on the bond linking the sulfur atom with the pyranose ring is, however, poorly fixed, and in solutions the coexistence of both types of conformations (*A* and *B*) must be reckoned with, the contributions of which compensate each other more or less. This is evident from the value of the dichroic absorption coefficient  $\Delta\epsilon$ . It is maximum for compound *Ib*, in which the conditions for fixation are best. In the case of other substances it assumes lower values, until in *Ia* and *IVa*, for which neither of the conformations can be considered as prevailing, it becomes very low.

We believe that the case discussed illustrates well the limitation of the utilisation of derivatives for conformational studies with sugars by means of chiroptic methods. In cases when the observed dichroic bands are due only to electronic transitions in the newly introduced chromophore, their sign is determined by the relative position of the new chromophore with respect to the rest of the molecule. The configuration and the conformation of the sugar moiety itself is manifest only

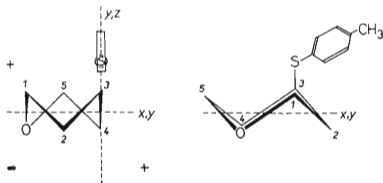


FIG. 1

#### Quadrant Scheme

The nodal plane  $x,y$  passes through the centers of six ring bonds of pyranose; the plane  $y,z$  comprises the bonds coming from the sulfur atom which is localised between the two upper quadrants. The molecule is oriented by the *p*-position of the arylthio group towards the observer. The molecule of substance *Ib* is represented in the drawing.

indirectly by enabling or, on the contrary, by preventing the new substituent from assuming some of the conformations. The interpretation of ORD and CD curves may lead, in a positive case, to the determination of the relative position of the new substituent with respect to the rest of the molecule as a whole, and from this only indirectly to the estimation of the sterical effect which produced this conformation.

## EXPERIMENTAL

The melting points were determined on a Kofler block and they are uncorrected. Optical rotations were measured in a cell 2 dm long in chloroform at concentration  $1.0 \pm 0.1$  g per 100 ml, unless stated otherwise.

### Methyl 4,6-O-benzylidene-4-methylphenylthio-D-glycopyranosides

To a suspension of 216 mg of sodium hydride in 5 ml of tetrahydrofuran *p*-thiocresol (719 mg; m.p. 43–44°C) in 10 ml of tetrahydrofuran was added dropwise, followed by 575 mg of methyl 2,3-anhydro-4,6-O-benzylidene-D-glycopyranoside *V–VIII* in 25 ml of tetrahydrofuran, and the mixture was refluxed for 4 h. After cooling it was decomposed with water and extracted with three 60 ml portions of ether. The combined extracts were evaporated, dried, and the residue chromatographed on a column of 130 mg of aluminum oxide. A fraction (93–97%) was obtained which after crystallisation from methanol or ethyl acetate and light petroleum gave 80–85% of pure corresponding 4-methylphenylthio derivative (Table I).

### Methyl 2-deoxy-2-(4-methylphenylthio)- $\alpha$ -D-altropyranoside (*IVa*)

Benzylidene derivative *Ia* (215 mg) dissolved in 50 ml of 80% acetic acid at 50°C was allowed to stand at room temperature for 40 h, the solvent was evaporated, and the residue was repeatedly dissolved in 50 ml of benzene and evaporated again. Chromatography of the residue on 40 g of silica gel CH gave 139 mg (84%) of altroside *IVa*, m.p. 112–112.5°C,  $[\alpha]_D +33.3^\circ$ . For  $C_{14}H_{20}O_5S$  (300.4) calculated: 55.98% C, 6.71% H, 10.68% S; found: 55.35% C, 6.71% H, 10.66% S.

### Methyl 3-deoxy-3-(4-methylphenylthio)- $\alpha$ -D-altropyranoside (*IVb*)

A solution of 439 mg of benzylidene derivative *Ib* in 50 ml of 80% acetic acid was allowed to stand at room temperature for 24 h and then evaporated. The residue was evaporated twice with 50 ml of benzene. Chromatography on silica gel CH (40 g) gave 249 mg (74%) of altroside *IVb*, m.p. 118–119°C,  $[\alpha]_D +96^\circ$ . For  $C_{14}H_{20}O_5S$  (300.4) calculated: 55.98% C, 6.71% H, 10.68% S; found: 55.80% C, 6.88% H, 10.64% S.

## Desulfuration

Thio derivative *Ia* (205 mg), m.p. 84–86°C, and 0.4 ml of Raney nickel in 830 ml of ethanol was refluxed for 2 h. Additional 0.4 ml of the catalyst were added and refluxed for another 4 h. The catalyst was filtered off and extracted several times with boiling ethanol. The combined ethanolic solutions were evaporated to dryness. The residue (approx. 100 mg) was chromatographed, giving 54 mg (38%) of methyl 4,6-O-benzyl-2-deoxy- $\alpha$ -D-altroside, m.p. 126–128°C, which was compared with an authentic preparation. From thio derivative *Ib* (m.p. 154–155°C) methyl 4,6-O-benzylidene-3-deoxy- $\alpha$ -D-altroside was obtained in the same manner, m.p. 110–111°C, in 35% yield.



## Standards

Methyl 4,6-O-benzylidene- $\alpha$ -D-altroside (*Ic*) was prepared by alkaline hydrolysis of anhydro derivative *V*, m.p. 169–171°C,  $[\alpha]_D +126.6^\circ$ , in agreement with the literature<sup>15</sup>. Methyl  $\alpha$ -D-altropyranoside (*IVc*) was obtained by hydrolysis of *Ic* in 80% acetic acid. M.p. 107°C,  $[\alpha]_D^{24} +126.5^\circ$  (water), in agreement with the literature<sup>16</sup>. Methyl 4,6-O-benzylidene- $\alpha$ -D-idoside (*IIC*) was obtained by alkaline hydrolysis of anhydro derivative *VIIa*, m.p. 147–149°C,  $[\alpha]_D +48.1$ , in agreement with the literature<sup>17</sup>. Methyl 4,6-O-benzylidene- $\beta$ -D-idoside (*IIIc*) was prepared in an analogous manner from anhydro derivative *VIIb*, m.p. 163°C,  $[\alpha]_D -88^\circ$ , in agreement with the literature<sup>18</sup>.

## Spectroscopic measurements

The ORD curves were measured on a Jasco UV/ORD-5 spectropolarimeter, the CD curves on a Jouan 185/II apparatus in methanol, concentration 0.10–0.25 g/100 ml. The results are summarised in Table II. For substances *Ic*–*IVc* plain curves were found with value  $[\phi]_{300}^0$ : for *Ic* +1700°, *IIC* +1050°, *IIIc* –1200°, *IVc* +1650°. The PMR spectra were measured on a Varian HA 100 spectrometer in deuteriochloroform, using tetramethylsilane as internal standard: The chemical shifts are given in  $\delta$ -values (p.p.m.), the coupling constants in Hz. Abbreviations, m multiplet, d doublet, s singlet. *Ila*: 7.30–7.70 complex m, 5 H, C<sub>6</sub>H<sub>5</sub>; 7.38 d and 7.09 d, 4 H, AA'BB' spectrum of *p*-disubstituted benzene derivative; 5.52 s, 1 H, O–CH–O; 5.03 broad s, 1 H, C<sub>(1)</sub>–H,  $J_{12} = 1.7$ ,  $J_{13} = 1.0$ ; 4.36 dd, 1 H, C<sub>(6')</sub>–H,  $J_{66'} = 12.5$ ,  $J_{65} = 1.5$ ; 4.11 dd, 1 H,  $J_{6'6} = 12.5$ ,  $J_{6'5} = 2.0$ ; 4.20 m, 1 H C<sub>(3)</sub>–H,  $J_{3,OH} = 9.5$ ,  $J_{32} = 2.9$ ,  $J_{34} = 3.0$ ,  $J_{31} = 1.0$ ; 4.035 m, 1 H, C<sub>(4)</sub>–H,  $J_{43} = 1.5$ ,  $J_{45} = 1.7$ ,  $J_{42} = 0.6$ ; 3.86 m, 1 H, C<sub>(5)</sub>–H,  $J_{56} = 1.5$ ,  $J_{56'} = 2.0$ ,  $J_{54} = 1.7$ ; 3.38 s, 3 H, CH<sub>3</sub>O; 3.71 d, 1 H, OH,  $J_{OH,3} = 9.5$ , after addition of deuterioacetic acid the signal disappears; 3.27 m, 1 H, C<sub>(2)</sub>–H,  $J_{21} = 1.7$ ,  $J_{23} = 2.9$ ,  $J_{24} = 0.6$ ; 2.31 s, 3 H, CH<sub>3</sub>–C. *IIla*: 7.20–7.60 m, 7 H, C<sub>6</sub>H<sub>5</sub> and protons in the positions 2 and 6 of the 4-methylphenyl group; 6.96 d, 2 H,  $J = 8.5$ , protons in the positions 3 and 5 of the 4-methylphenyl group; 5.28 s, 1 H, O–CH–O; 4.86 d, 1 H, C<sub>(1)</sub>–H,  $J_{12} = 2.0$ ; 4.35 unresolved m, 1 H, C<sub>(3)</sub>–H, after addition of deuterioacetic acid,  $J_{32} = 2.50$ ,  $J_{34} = 2.5$ ; 4.17 d and 3.85 d, 2 H, C<sub>(6)</sub>–H<sub>2</sub>,  $J_{66'} = 12.5$ ; 3.855 unresolved m, 1 H (C<sub>(5)</sub>–H); 3.61 s, 1 H C<sub>(4)</sub>–H; 3.44 s 3 H, CH<sub>3</sub>O; 2.24 s, 3 H, CH<sub>3</sub>C. *IIlb*: 7.25–7.55 complex m, 5 H, C<sub>6</sub>H<sub>5</sub>; 7.14 d and 7.34 d, 4 H, AA'BB' spectrum of *p*-disubstituted benzene derivative; 5.43 s, 1 H, O–CH–O; 4.78 d, 1 H, C<sub>(1)</sub>–H,  $J_{12} = 0.85$ ; 4.42 dd, 1 H, C<sub>(6)</sub>–H,  $J_{66'} = 12.5$ ,  $J_{65} = 1.5$ ; 4.06 dd, 1 H, C<sub>(6')</sub>–H,  $J_{66'} = 12.5$ ,  $J_{6'5} = 1.8$ ; 4.02 m, 1 H, C<sub>(4)</sub>–H,  $J_{43} = 2.5$ ,  $J_{45} = 1.0$ ,  $J_{42} = 0.8$ , 3.905 m, 1 H, C<sub>(5)</sub>–H,  $J_{56} = 1.5$ ,  $J_{56'} = 1.8$ ,  $J_{54} = 1.0$ ; 3.82 m, 1 H, C<sub>(2)</sub>–H,  $J_{21} = 0.85$ ,  $J_{23} = 2.5$ ,  $J_{24} = 0.8$ ; 3.735 m, 1 H, C<sub>(3)</sub>–H,  $J_{3,OH} = 11.5$ ,  $J_{32} = 2.5$ ,  $J_{34} = 2.5$ ; 3.61 s, 3 H, CH<sub>3</sub>O; 3.445 d, 1 H, OH,  $J_{OH,3} = 11.5$ , the signal disappears after addition of deuterioacetic acid; 2.33 s, 3 H, CH<sub>3</sub>–C. *IVa*: 7.10 and 7.33 d, 4 H, *p*-disubstituted benzene derivative; 4.89 broad s, 1 H, C<sub>(1)</sub>–H; 3.70–4.20 overlapping mm, 6 H, protons at C<sub>(3)</sub>, C<sub>(4)</sub>, C<sub>(5)</sub>, C<sub>(6)</sub> and OH; 3.53 dd, 1 H, C<sub>(2)</sub>–H,  $J_{21} = 1.1$ ,  $J_{23} = 2.6$ ; 3.39 s, 3 H, CH<sub>3</sub>O; 3.00 very broad signal, 1 H, OH; 2.68 very broad signal, 1 H, OH; 2.31 s, 3 H, CH<sub>3</sub>–C.

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## REFERENCES

1. Crabbé P.: *Optical Rotatory Dispersion and Circular Dichroism in Organic Chemistry*. Holden-Day, San Francisco 1965.
2. Voelter W., Kuhfittig G., Schneider G., Bayer E.: *Ann.* 734, 126 (1970).
3. Christensen J. E., Goodman L.: *J. Am. Chem. Soc.* 83, 3827 (1961).
4. Maehly A. C., Reichstein T.: *Helv. Chim. Acta* 30, 496 (1947).
5. Sorkin E., Reichstein T.: *Helv. Chim. Acta* 28, 1 (1945).
6. Bolliger H. R., Prins D. A.: *Helv. Chim. Acta* 29, 1061 (1946).
7. Gyr M., Reichstein T.: *Helv. Chim. Acta* 28, 226 (1945).
8. Gut M., Prins D. A., Reichstein T.: *Helv. Chim. Acta* 30, 743 (1947).
9. Verheyden J. P. H., Moffatt J. G.: *J. Org. Chem.* 34, 2643 (1969).
10. Fehnel E. A., Carmack M.: *J. Am. Chem. Soc.* 71, 84, 2889 (1949).
11. Jaffé H. H., Orchin M.: *Theory and Applications of Ultraviolet Spectroscopy*, p. 479. Wiley, New York 1962.
12. Salvadori P., Lardici L., Consiglio G., Pino P.: *Tetrahedron Letters* 1966, 5343.
13. Salvadori P.: *Chem. Commun.* 1968, 1203.
14. Paulsen H.: *Chem. Ber.* 101, 1571 (1968).
15. Capon B., Overend W. G., Sobell M.: *Tetrahedron* 16, 106 (1961).
16. Richtmyer N. K., Hudson C. S.: *J. Am. Chem. Soc.* 63, 1727 (1941).
17. Zobáčová A., Heřmánková V., Jarý J.: *This Journal* 36, 1860 (1971).
18. Sorkin E., Reichstein T.: *Helv. Chim. Acta* 28, 16 (1945).

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