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SYNTHESIS OF NEW ARYLTETRALIN LIGNANS

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Abstract - Cyclization with CF_3CO_2H of the dibenzyllactone compounds 3 and 4 afforded the aryltetralin derivatives 6a and 6b, epimers at the carbon α to the lactonic carbonyl group, in which the aryl substituent group is in the α-axial position. ^1H NMR data assignments of the compounds obtained are also given.

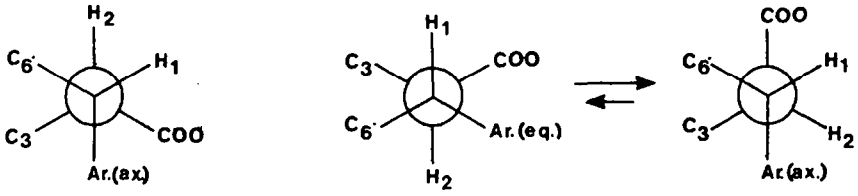
Almost all the works carried out in order to obtain aryltetralin lignans led to compounds in which the aryl substituent group had a β-equatorial configuration, as opposed to that of the naturally occurring compounds. In the present work we wish to report on the isolation of an aryltetralin lignan with the aryl group in the α-axial position. This aryl group has a single substituting group in the para position.

A synthetic scheme similar to that previously employed by us[1] was followed. Condensation of the adduct 1 with the aldehyde 2 afforded, after separation by chromatography, compounds 3 and 4 (yield 87%, 3:7). Their IR, MS and NMR spectra indicated that they must be the epimers in the carrier carbon of the hydroxyl group, since the trans configuration of the lactone for this type of condensation is well known.[2] This assumption was confirmed by oxidation of 3 and 4 by pyridine dichromate, a single product 9 (98%) being formed in both reactions; the isomers are therefore erythro and threo. The assignment of configurations to these isomers was based on the study of the coupling constants found between protons 1 and 2 in their ^1H NMR spectra. The said value was determined by the most stable conformation in each product, due to the presence of a hydrogen bridge between the hydroxyl proton and the lactone carbonyl.

Proton 1 of the isomer 3 was centred at δ 5.02 ($J_{1,2}$ = 2.7 Hz) while that of 4 was found at δ 4.83 ($J_{1,2}$ = 5.5 Hz). By calculation of the angle corresponding to the couplings, using a modified Karplus equation,[3] a value of 62° was obtained between protons 1 and 2 for compound 3, while the angle was 132° for those of compound 4. This assignment also agrees with the values of the shifts and with those of the coupling constants of the above-mentioned protons in some analogous erythro-threo pairs described in the literature.[4]

Cyclization of these compounds with trifluoracetic acid dissolved in benzene saturated with water gave compound 5a (with a yield of 71.5%) that underwent the loss of the methoxy-methoxy shield group (IR: 3380 cm^{-1}). This compound, insoluble in the usual solvents, was acetylated in order to study its NMR spectrum; acetate 5b could not be dissolved, and therefore could not be studied spectroscopically, but its IR, MS and UV spectra are as expected for this product.

The dithiane group was then eliminated to give compound 6, which can be compared with other analogous ketones, isomers of podophyllotoxone. The unshielding of 5b ($HgO/BF_3(Et_2O)$) afforded a mixture (yield 50%) from which a very insoluble crystalline product, m/z 338, was separated. Acetylation of this compound followed by chromatography gave two isomeric products, 6a and 6b (4:6), the IR spectra of which show the absence of hydroxyl groups and have M^+ 380. These compounds are stereoisomers on the asymmetric carbons of the central ring. Their configuration can be deduced from the study of their NMR spectra. Compound 6a presents the signal of the proton at C-2 as a double doublet centred at δ 3.30 that is decoupled, on irradiating proton 1, to a doublet of $J_{2,3}$ = 15.6 Hz, implying a trans configuration for the lactonic protons 2 and 3.[2] The coupling constant between protons 1 and 2 is 4.3 Hz, giving an angle of 55°, calculated by the modified Karplus equation mentioned above, indicating an axial-equatorial interaction between protons 1 and 2, as seen in Figure A.



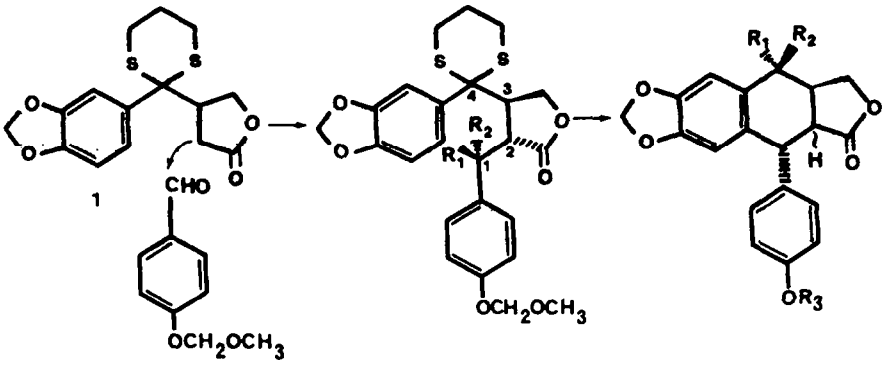
A B C

These values of the chemical shifts, coupling constants and angles coincide with those given by Dewick and Ayres[5,6] for podophyllotoxone 8a, suggesting that this compound must have an analogous configuration, with the aryl substituent in an α position and the lactone in trans.

In the second isomer 6b, protons 2 and 3 have a coupling at 7.9 Hz, indicating that the lactone must be in a cis position. The couplings of protons 1 and 2 ($J_{1,2}$ = 1.5 Hz) and those of the 3 and α protons ($J_{3,\alpha}$ = 0 Hz) can be compared with those of picropodophyllotoxone 8b.[6] Moreover, the angle of 69° calculated for 6b between protons 1 and 2 coincides with Ayres' hypothesis that of the two possible conformers existing in picropodophyllotoxone (Figs. B and C), the equilibrium is found to be almost totally shifted towards the conformer having an axial aryl group (C), an angle of 70° being calculated for protons 1 and 2 in picropodophyllotoxone,[6] in perfect agreement with the data obtained for our compound 6b, that must therefore be the analogue of picropodophyllotoxone. This conclusion is supported by the value of 5.5 Hz found for the coupling constant between protons 1 and 2 of isopicropodophyllotoxone, epimer at C-1 of picropodophyllotoxone.[7]

In order to support these conclusions, compounds 6a and 6b were jointly reduced with $Zn(BH_4)_2$, a reagent previously employed for the transformation of picro- and podophyllotoxone into picro- and podophyllotoxin, respectively;[8] this allowed a comparison to be made of our products with these well known compounds The above-mentioned reduction was carried out with $Zn(BH_4)_2$ in glyme to afford a mixture (yield 73%) from which, after extraction, a crystalline mass (M^+ 340, IR: 3470, 3210 cm^{-1})[7] was separated. The mixture resulting from the acetylation of these crystals was separated by chromatography to give three products, 7a, 7b and 7c (2:5:3), that must be isomers on the asymmetric carbons of ring C (M^+ 424).

Reduction of podophyllotoxone with $Zn(BH_4)_2$ afforded podophyllotoxin 8c, with the hydroxyl group in an α position.[9,10] Similarly, reduction of 6a should give 7a, a compound with a structure identical with that of podophyllotoxin, as can be

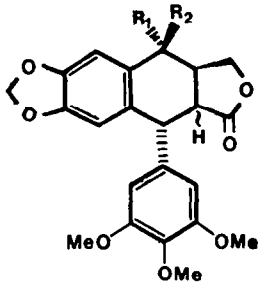


1

2

3: R_1 = OH, R_2 = H
4: R_1 = H, R_2 = OH
9: $R_{1,2}$ = O

5a: $R_{1,2}$ = $S(CH_2)_3S$, R_3 = H
5b: $R_{1,2}$ = $S(CH_2)_3S$, R_3 = Ac
6 : $R_{1,2}$ = O, R_3 = H
6a: $R_{1,2}$ = O, R_3 = Ac, Hβ
6b: $R_{1,2}$ = O, R_3 = Ac, Hα
7a: R_1 = OAc, R_2 = H, R_3 = Ac, Hβ
7b: R_1 = OAc, R_2 = H, R_3 = Ac, Hα
7c: R_1 = H, R_2 = OAc, R_3 = Ac, Hα



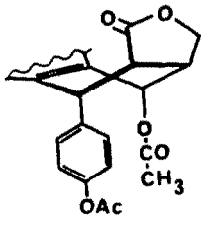
8a: $R_{1,2}$ = O, Hβ
8b: $R_{1,2}$ = O, Hα
8c: R_1 = OH, R_2 = H, Hβ
8d: R_1 = H, R_2 = OAc, Hβ
8e: R_1 = OAc, R_2 = H, Hα
8f: R_1 = OAc, R_2 = H, 6,7 dimethoxy, Hα

deduced from its spectroscopic data: the coupling between protons 2 and 3 ($J_{2,3}$ = 14.5 Hz) and between 1 and 2 ($J_{1,2}$ = 4.6 Hz) indicate a transdiaxial interaction for the former and an axial-equatorial interaction for the latter, although the angles are slightly distorted due to the tension of the ring. The coupling $J_{3,4}$ = 9.1 Hz clearly indicates a transdiaxial, although impure, configuration, with a value similar to those found in analogous products, such as podophyllotoxin acetate ($J_{3,4}$ = 8 Hz), and quite different from that of epipodophyllotoxin acetate 8d with a markedly smaller constant ($J_{3,4}$ = 3.5 Hz).[6]

Ketone 6b, with a cis lactone, may be found in two conformations, although that with the axial aryl group is favoured, the magnitude of the equilibrium depending on factors such as solvent and temperature. Reduction of analogous ketones with $Zn(BH_4)_2$ has already been described,[9,10] a single compound being obtained with the hydroxyl group in the α position, although this has not been unequivocally confirmed.[10] Our work thus reports on the fact that reduction of 6b with $Zn(BH_4)_2$

afforded two different compounds that must be C-4 epimers.

In principle, it can be expected that the coupling between protons 3 and 4 may throw some light on the respective configurations, but the couplings found ($J_{3,4}$ = 3.8 Hz and $J_{3,4}$ = 4.4 Hz for 7b and 7c, respectively) do not permit the structures to be assigned. However, the shift of the methyl of the acetate group over C-4 of compound 7b that appears at δ 1.83 is significant. This led us to consider a possible shielding effect of the aryl substituent group in the isomer that has both the acetate and aryl groups in the α-axial position in close proximity to each other, as can be seen in the Figure.



The values obtained by other authors for similar compounds[3b,6,11] confirm these assignments. Thus, for example, the methyls of picropodophyllotoxin acetate 8e and picrosikkimotoxin acetate 8f appear at δ 1.99 and δ 1.93, respectively, while both their C-4 epimers appear at δ 2.13. It can therefore be affirmed that compound 7b has the acetate group in the α position, while compound 7c is the C-4 epimer.

The greater shielding of the methyl of the acetate group in 7b with respect to picropodophyllotoxin may be due to a greater proportion of compound in the conformation with the aryl group in an axial position. The proportion of the said conformer for picropodophyllotoxin acetate was calculated by Ayres,[6a] taking this to have a value of $J_{1,2}$ = 1.5 Hz in the conformation with the axial aryl group (analogous to C), and a value of 9.5 Hz for the other conformer (B). The constant found for this acetate ($J_{1,2}$ = 3.75 Hz) implies a contribution of the first conformer of 70%. Analogous calculations applied to compound 7b, with $J_{1,2}$ = 2.8 Hz, give a value of 84% for the contribution of the axial aryl group which might account for the greater shielding of the methyl group.

We therefore concluded that structures 7b and 7c are analogous to those of picro- and epipicropodophyllotoxin acetates.

EXPERIMENTAL

Melting points were determined on a Kofler block and are uncorrected. Infrared spectra were recorded on a Perkin-Elmer 681 spectrophotometer. Ultraviolet spectra were recorded on a Perkin-Elmer 550 spectrophotometer. ^{1}H NMR spectra were obtained on Bruker WP 200 and WM 360 spectrometers, chemical shifts are reported relative to Me_4Si (δ0) and coupling constants are given in hertz. ^{13}C NMR spectra were obtained on a Bruker WP 200 spectrometer and the chemical shifts are reported relative to Me_4Si (δ0). Low and high resolution mass spectra were obtained from a VG Micromass ZAB-2F instrument. Column chromatography was performed on silica gel G, all Merck products. The TLC plates were developed by spraying with 6N-sulphuric acid and heating. All solvents were purified by standard techniques. Anhydrous sodium sulphate was used for drying solutions.

4-Methoxymethoxybenzaldehyde 2. - To p-hydroxybenzaldehyde (1 g) dissolved in chloroform (40 ml) and dimethoxymethane (methylal) (10 ml) was added phosphorus pentoxide (2.5 g) at room temperature and the reaction was left for 48 hours. The reaction mixture was washed with sodium carbonate; the organic layer was concentrated to afford an oil (0.8 g, 59%) that could not be crystallized. m/z : 166 M^+; ν_{max}^{NaCl} cm^{-1} : 2960, 1700, 1602, 840; λ_{max}^{MeOH} nm : 216, 269; δ ($CDCl_3$) : 9.90 (1H, s), 8.00-7.70 (2H, d, J= 8.7 Hz, arom. H 2.6), 7.30-7.10 (2H, d, J= 8.7 Hz, arom. H 3.5), 5.23 (2H, s, CH_2O_2), 3.46 (3H, s, CH_3O).

2-(4-Methoxymethoxybenzyl)-6-hydroxy-5-(1,3-dithian)-3-(3,4-methylenedioxybensyl)-butyrolactone 3,4. - To a solution in THF (8.28 ml) of diisopropylamine (1.8 M) in dry THF (80 ml) under argon and cooled to -78°C was added n-BuLi (30 ml). The mixture was left to react for 8 hours, the adduct (11.8 g) dissolved in THF (200 ml) was added and the mixture left for a further hour. Compound 2 (8 g) dissolved in THF (60 ml) was then added. The mixture was left to react for 48 hours at the same temperature, acetic acid (5 ml) was added and the mixture was allowed to reach room temperature. Extraction with AcOEt gave, after concentration, an amorphous solid (15.5 g, 87%) that upon purification by column chromatography on silica gel afforded two compounds (30:70) that were separated as follows: the less polar compound, 3 (4.6 g), crystallized from AcOEt-n-hexane: m.p. 168-168.5°C. m/z : 490.1140 M^+ ($C_{24}H_{25}O_7S_2$ requires 490.1119), 472, 428, 239; ν_{max}^{KBr} cm^{-1} : 3440, 2890, 1745, 815; λ_{max}^{EtOH} nm : 218, 228, 298; δ ($CDCl_3$) : 7.17 (1H, dd, J= 8.2, 2.0 Hz, H6'), 6.99 (1H, d, J= 2.0 Hz, H2'), 6.94 (2H, d, J= 8.8 Hz, H3",5"), 6.81 (2H, d, J= 8.8 Hz, H2",6"), 5.90-5.96 (AB, 2H, methylenedioxy), 5.11 (2H, d, J= 1.4 Hz, CH_2O_2), 5.02 (1H, m, H1), 4.74 (1H, dd, J= 2.2 and 9.4 Hz, Hα), 4.23 (1H, dd, J= 8.0 and 9.4 Hz, Hβ), 3.43 (3H, s, CH_3O), 2.98 (1H, d, J= 4.2 Hz, OH), 2.93 (1H, dd, J= 2.7 and 2.7 Hz, H2), 2.66 (1H, m, H3), 2.43-2.56 (4H, m, CH_2), 1.78-1.82 (2H, m, CH_2).

The more polar compound, 4 (10.9 g), was an amorphous solid that could not be crystallized. m/z : 490.1063 M^+ ($C_{24}H_{26}O_7S_2$ requires 490.1119), 324, 239, 165; $\nu_{max}^{CHCl_3}$ cm^{-1} : 3600, 2920, 1765, 1480; λ_{max}^{EtOH} nm : 212, 224, 297; δ $CDCl_3$): 7.41 (1H, dd, J= 8.3 and 1.9 Hz, H6'), 7.31 (1H, d, J= 1.8 Hz, H2'), 7.14 (2H, d, J= 8.6 Hz, H3",5"), 6.94 (2H, d, J= 8.6 Hz, H2",6"), 6.78 (1H, d, J= 8.3 Hz, H5'), 6.01 (AB, 2H, methylene dioxy), 5.16 (AB, 2H, CH_2O_2), 4.82 (1H, dd, J= 5.5 and 2.6 Hz, H1), 4.57 (1H, dd, J= 9.8 and 8.4 Hz, Hα), 3.78 (1H, dd, J= 8.4 and 2.6 Hz, Hβ), 3.25 (1H, dd, J= 5.5 and 2.9 Hz, H2), 2.51-2.79 (6H, m, OH, H3, CH_2), 1.87-1.94 (2H, m, CH_2).

2-(4-Methoxymethoxybenzyl)-6-keto-5-(1,3-dithian)-3-(3,4-methylenedioxybenzyl)-butyrolactone 9. - Compound 3 or 4 (110 mg) dissolved in methylene chloride (50 ml) and pyridine trifluoracetate (60 mg) was treated with pyridine dichromate (500 mg) and left to react with stirring for 1.5 hours. Dry ether (60 ml) was then added and the mixture filtered through Celite 545. The compound was purified on a silica gel column and crystallized from AcOEt-diisopropylic ether-hexane as colourless needles (100 mg, 98%), m.p. 125.5-128.5°C. m/z : 488.0969 M^+ ($C_{24}H_{24}O_7S_2$ requires 488.0963), 457, 239; $\nu_{max}^{CHCl_3}$ cm^{-1} : 2865, 1778, 1680, 1607; λ_{max}^{EtOH} nm : 209, 275, 292; δ ($CDCl_3$): 8.06-6.70 (7H, m, arom. H), 6.05-5.49 (2H, m, methylenedioxy), 5.35 (2H, s, CH_2O_2), 5.35-4.95 (1H, m, H2), 4.67-4.33 (2H, m, Hα,Hβ), 4.00-4.65 (1H, m, H3), 3.50 (3H, s, CH_3O), 2.80-2.50 (4H, m, CH_2), 2.20-1.74 (2H, m, CH_2).

1-(4-Hydroxyphenyl)-3-hydroxy,ethyl-4-(1,3-dithian)-6,7-methylenedioxy-2-naphthoic acid lactone 5a. - To a mixture of 3 and 4 (0.52 g) dissolved in benzene (30 ml) saturated with water was added dropwise and with shaking trifluoracetic acid (1.26 ml) in benzene (20 ml) and at 0°C. The mixture was kept with shaking for 2 hours at the same temperature and was then extracted in the usual manner with AcOEt. The compound was purified by chromatography with silica gel to yield white crystals (0.33 g, 71.5%) from acetone, that decomposed above 247°C. m/z : 428.0697 M^+ ($C_{22}H_{20}O_5S_2$ requires 428.0752), 353, 107; ν_{max}^{KBr} cm^{-1} : 3380, 2880, 1770, 934; λ_{max}^{EtOH} nm : 217, 302.

Acetylation of this product was performed in the usual manner with acetic anhydride and pyridine. After extraction in the usual way, compound 5b crystallized from AcOEt-hexane. m.p. 283-286°C. m/z : 470.0848 M^+ ($C_{24}H_{22}O_6S_2$ requires 470.0857), 428; ν_{max}^{KBr} cm^{-1} : 2900, 1770, 1485, 913; λ_{max}^{Diox} nm : 234, 236, 242, 254, 261, 265, 298; δ ($CDCl_3$) : 6.30-7.66 (6H, m, arom. H), 5.90 (2H, m, methylenedioxy), 2.70-3.30 (4H, m, CH_2), 1.50-1.80 (2H, m, CH_2), 2.20 (3H, s, CH_3CO).

1-(4-Hydroxyphenyl)-3-hydroxymethyl-4-keto-1,2,3,4-tetrahydro-6,7-methylenedioxy-2-naphthoic acid lactone 6. - To the cyclized compound 5a (1.12 g) dissolved in THF/H_2O (85:15) were added H_2O (red) (1.5 g) and Et_2OBF_3 (0.9 ml) and the mixture was left at room temperature for 5 hours, after which was added $CHCl_3$ (100 ml). The mixture was washed with sodium bicarbonate and extracted to yield a compound (0.44 g, 50%), m/z : 338.0784 M^+ ($C_{19}H_{14}O_6$ requires 338.0790) 293; λ_{max}^{EtOH} nm : 216, 223, 303, 333; $\nu_{max}^{CHCl_3}$ cm^{-1} : 3580, 3000, 1760.

Compound 6 was acetylated with Ac_2O and pyridine, washed and extracted in the usual manner, affording two products (40:60) that were separated by column chromatography. The less polar, 6a, crystallized from benzene-hexane with m.p. 125-128°C. m/z : 380.0891 M^+ ($C_{21}H_{16}O_7$ requires 380.0896), 338; λ_{max}^{MeOH} nm : 216, 236, 280, 320; ν_{max}^{Nujol} cm^{-1} : 1781, 1758, 1687, 1612, 1184; δ ($CDCl_3$) : 7.55 (1H, s, H2'), 7.18 (2H, d, J= 8.6 Hz, H3",5"), 7.01 (2H, d, J= 8.6 Hz, H2",6"), 6.65 (1H, s, H5'), 6.07 (2H, s, methylenedioxy), 4.88 (1H, d, J= 4.3 Hz, H1), 4.55 (1H, dd, J= 7.5 and 9.4 Hz, Hα), 4.37 (1H, dd, J= 9.5 and 9.4 Hz, Hβ), 3.48 (1H, dt, J= 9.5, 7.5 and 15.6 Hz, H3), 3.30 (1H, dd, J= 4.3 and 15.6 Hz, H2), 2.29 (3H, s, CH_3CO).

The more polar, 6b, crystallized from diisopropyl ether, m.p. 159-162°C. m/z : 380.0504 M^+ ($C_{21}H_{16}O_7$ requires 380.0896), 338; ν_{max}^{KBr} cm^{-1} : 2900, 1768, 1662, 1610, 1471; λ_{max}^{EtOH} nm : 214, 241, 336; δ ($CDCl_3$) : 7.50 (1H, s, H2'), 7.00-7.07 (4H, m, H2",3",5",6"), 6.65 (1H, s, H5'), 6.03 (AB, 2H, methylenedioxy), 4.75-4.77 (2H, m, H1, Hα), 4.33 (1H, dd, J= 5.6 and 9.1 Hz, Hβ), 3.29 (1H, dd, J= 7.9 and 1.5 Hz, H2), 3.26 (1H, m, H3), 2.24 (3H, s, CH_3CO).

1-(4-Hydroxyphenyl)-3-hydroxymethyl-4-hydroxy-1,2,3,4-tetrahydro-6,7-methylenedioxy-2-naphthoic acid lactones 7a,b,c. - To compound 6 (930 mg) dissolved in dry glyme (60 ml) a solution of $(BH_4)_2Zn$ (150 ml, 0.15 M) in ethyl ether was added with stirring and at room temperature under inert atmosphere. The mixture was left to react for 20 hours, after which water (40 ml) was added. The organic phase was separated, washed with sodium bicarbonate and dried over sodium sulfate. The residue (83 mg, 73%) was acetylated with acetic anhydride and pyridine, washed and extracted in the usual manner (850 mg) and then chromatographed on a column of silica gel, to give three compounds (20:50:30). The least polar compound, 7a (170 mg) crystallized from acetone-diisopropyl ether, m.p. 211-214°C. m/z : 424.1204 M^+ ($C_{23}H_{20}O_8$ requires 424.1158), 382, 340, 322; λ_{max}^{EtOH} nm : 194, 275, 313; $\nu_{max}^{CHCl_3}$ cm^{-1}: 3010, 2900, 1765, 1500, 1480; δ ($CDCl_3$) : 7.14 (2H, d, J= 8.5 Hz, H3",5"), 6.94 (2H, d, J= 8.5 Hz, H2",6"), 6.75 (1H, s, H2'), 6.45 (1H, s, H5'), 5.94 (AB, 2H, methylenedioxy), 5.86 (1H, d, J= 9.1 Hz, H4), 4.61 (1H, d, J= 4.6 Hz, H1), 4.33 (1H, dd, J= 7.0 and 9.3 Hz, Hα), 4.18 (1H, dd, J= 9.6 and 9.3 Hz, Hβ), 2.29 (1H, dd, J= 4.6 and 14.6 Hz, H2), 2.80 (1H, m, H3), 2.25 (3H, s, CH_3CO), 2.18 (3H, s, CH_3CO).

The next compound in polarity, 7b (425 mg), also crystallized from acetone-diisopropyl ether as needles, m.p. 214-217°C. m/z : 424.1117 M^+ ($C_{23}H_{20}O_8$ requires 424.1158), 365, 339, 107; λ_{max}^{EtOH} nm : 218, 291; ν_{max}^{KBr} cm^{-1} : 2920, 1750, 910; δ ($CDCl_3$) : 7.16 (2H, d, J= 8.7 Hz, H3",5"), 7.02 (2H, d, J= 8.7 Hz, H2",6"), 6.82 (1H, s, H2'), 6.62 (1H, s, H5'), 5.97 (2H, s, methylenedioxy), 5.66 (1H, d, J= 3.8 Hz, H4), 4.54 (1H, d, J= 2.8 Hz, H1), 4.45 (1H, dd, J= 7.7 and 9.6 Hz, Hα), 4.14 (1H, dd, J= 3.7 and 9.6 Hz, Hβ), 3.39 (1H, dd, J= 2.8 and 9.6 Hz, H2), 3.06 (1H, m, H3), 2.29 (3H, s, CH_3CO), 1.84 (3H, s, CH_3CO).

The most polar compound, 7c (255 mg), could not be crystallized, remaining as an amorphous solid, m/z : 424.1145 M^+ ($C_{23}H_{20}O_8$ requires 424.1158), 382, 364, 322; λ_{max}^{EtOH} nm : 219, 293; $\nu_{max}^{CHCl_3}$ cm^{-1} : 3010, 1750, 1500, 1480; δ ($CDCl_3$) : 7.22 (2H, d, J= 8.6 Hz, H3",5"), 7.08 (2H, d, J= 8.6 Hz, H2",6"), 6.87 (1H, s, H2'), 6.50 (1H, s, H5'), 5.95 (AB, 2H, methylenedioxy), 5.90 (1H, d, J= 4.4 Hz, H4), 4.47 (1H, d, J= 4.1 Hz, H1), 4.37 (1H, dd, J= 7.7 and 9.8 Hz, Hα), 4.25 (1H, dd, J= 2.9 and 9.8 Hz, Hβ), 3.36 (1H, dd, J= 4.1 and 10.7 Hz, H2), 3.25 (1H, m, H3), 2.30 (3H, s, CH_3CO), 2.11 (3H, s, CH_3CO).

REFERENCES

1 A. G. González, J. P. Pérez and J. M. Trujillo, Tetrahedron 34, 1000 (1978).

2 D. C. Ayres, Chem. Lignans 123 (1978).

3 a) L. G. Vorontsova and A. F. Bochov, Org. Mag. Res. 6, 654 (1974); b) C. F. Brewer, J. D. Loike, S. B. Horwitz, H. Sternlicht and W. J. Gensler, J. Med. Chem. 22, 3, 21b (1979); c) J. R. Cavanaugh and B. P. Dailey J. Chem. Phys. 34, 4, 1099 (1961); d) B. P. Dailey and J. N. S. Shoolery, J. Am. Chem. Soc. 77, 3977 (1955).

4 a) F. E. Ziegler and J. A. Schwartz, J. Org. Chem. 43, 985 (1978); b) M. Kuhn, A. von Wartburg, Helv. Chim. Acta 161, 1547 (1967); c) D. A. Widdowson, G. H. Wiebecke and D. J. Williams, Tetrahedron Lett. 23, 41, 4285 (1982).

5 D. E. Jackson and P.M. Dewick, Phytochemistry 23, 1147 (1984).

6 a) D. C. Ayres, J. A. Harris, P. N. Jenkins and L. Phillips, J. Chem. Soc., Perkin Trans. 1 1343 (1972); D. C. Ayres and J. A. Harris, Chem. Comm. 1135 (1969).

7 P. M. Dewick and D. E. Jackson, Phytochemistry 20, 2277 (1981).

8 T. Nakata and T. Oishi, Tetrahedron Lett. 1641 (1980).

9 V. N. Aiyar and F. C. Chang, J. Org. Chem. 40, 2384 (1975).

10 V. N. Aiyar and F. C. Chang, J. Org. Chem. 42, 246 (1977).

11 E. Schreier, Helv. Chim. Acta 46, 75 (1963).