6 h, after which time TLC indicated absence of starting material.

The mixture was poured slowly into 50 mL of water, carefully acidified with 50 mL of 5% aqueous HCl, and extracted 3 times with 50 mL of methylene chloride. The combined organic extracts were washed with brine and dried (Na_2SO_4).

Solvent was removed in vacuo, giving 0.94 g (93%) of crude alcohols suitable for the next step. Spectral data: IR (neat) 3400, 1700, 1640 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.8–5.9 (2 m, ca. 60:40); ^{13}C NMR ($CDCl_3$) δ 81.0 (d), 79.6 (d); mass spectrum (70 eV), *m/e* (relative intensity) 264 (M, 10), 246 (15), 218 (25), 200 (20), 167 (30), 149 (B), 105 (45), 95 (60), 91 (65), 77 (52).

Anal. Calcd for $C_{16}H_{14}O_3$: 264.1725. Found: 264.1732.

Sodium hydride (0.19 g, 60% oil dispersion, 0.005 mol) was rinsed 3 times with 50 mL of dry tetrahydrofuran, and the oil free solid was suspended in 20 mL of the same solvent. The alcohol (0.94 g, 0.004 mol) was added in 10 mL of THF followed by 20 mg of imidazole. The solution was refluxed 1.0 h followed by the addition of 3 mL carbon disulfide in one portion. The solution was refluxed 30 min followed by the addition of 3 mL of iodomethane in one portion. The mixture was refluxed 30 min, cooled to room temperature, and partitioned between 50 mL of methylene chloride and 50 mL of water. The aqueous phase was extracted twice with 50 mL of methylene chloride, and the combined organic extracts were washed with brine and dried (Na_2SO_4).

Solvent was removed in vacuo and the residue filtered through silica to give 1.0 g (82%) of xanthates suitable for the next step.

Spectral data: IR (neat) 1700, 1220, 1050 cm^{-1}; ^1H NMR ($CDCl_3$) δ 2.6, 2.8 (s, 3 H), 5.8, 5.9 (m, ca. 60:40, 1 H); ^{13}C NMR ($CDCl_3$) δ 55.8 (q), double intensity, 90.5 (d), 92.5 (d).

To 1.0 g (0.0034 mol) of tri-*n*-butyltin hydride and 5 mg of AIBN in 30 mL of dry, degassed (N_2) toluene were added the xanthates (1.0 g, 0.003 mol) in 25 mL of the same solvent over a 10-min period. The mixture was warmed to reflux during addition, refluxed an additional 6 h after addition was complete, cooled to room temperature, and concentrated in vacuo.

The pure product was isolated by preparative TLC (2:8 CH_2Cl_2/hexanes, four to six elutions). The band corresponding to R_f 0.6 gave 662 mg (70%) of tricyclic ester **5** as one diasteromer.

5: IR (neat) 1710, 1620 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.94 (d, 3 H, J = 7 Hz), 1.1 (s, 3 H), 1.2 (t, 3 H, J = 7 Hz), 1.4–2.6 (m, 12 H), 4.1 (q, 2 H, J = 7 Hz), 6.6 (t, 1 H, J = 2 Hz); ^{13}C NMR ($CDCl_3$) δ 13.6 (q), 19.6 (q), 25.2 (q), 28.6 (t), 30.7 (t), 36.3 (t), 40.3 (t), 41.5 (d), 46.9 (t), 52.5 (s), 59.8 (d), 59.8 (t), 68.7 (s), 141.1 (d), 142.1 (s), 165.4 (s); mass spectrum (70 eV), *m/e* (relative intensity) 248 (M, 40), 202 (45), 174 (50), 118 (72), 104 (80), 90 (B), 78 (72), 54 (95).

Anal. Calcd for $C_{16}H_{24}O_2$: 248.1776. Found: 248.1777.

Acknowledgment. We are indebted to the Research Corporation (No. 9155) for the support of this work and to the Undergraduate Research Participation fellowship to R.P.S. (sponsored by the National Science Foundation). Heartfelt thanks are extended to Dr. J. Hudson (University of Texas, Austin) for the mass spectral measurements, and to Mr. Robert Brabetts, Professor Robert Gadwood, and Professor James Wilt for their generous assistance with the ozonolysis experiments.

Registry No. **5**, 80781-43-7; **11**, 89-82-7; **12**, 7712-68-7; **12** methyl ester, 30165-01-6; **13**, 80796-76-5; **14**, 80781-44-8; **15**, 80781-45-9; **16**, 80781-46-0; (*E*)-**17**, 80781-47-1; (*Z*)-**17**, 80796-77-6; **17** acid chloride, 80781-48-2; **18**, 80781-49-3; **19**, 80781-50-6; **20**, 80781-51-7; **20** alcohol, 80781-52-8; **20** xanthate, 80781-53-9; i, 80781-54-0; ii, 80781-55-1; ethyl bromoacetate, 105-36-2; diazoethane, 1117-96-0.

Synthesis and Carbon-13 Nuclear Magnetic Resonance Assignments of Xenognosin

Farouk S. El-Feraly* and Charles D. Hufford

Department of Pharmacognosy, School of Pharmacy, University of Mississippi, University, Mississippi 38677

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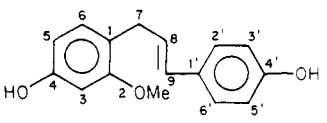
Xenognosin (**1**) is a modified flavonoid isolated from gum tragacanth, and it stands as the first natural host recognition substance for parasitic angiosperms. Xenognosin (**1**) was synthesized by converting umbelliferone (**2**) to the key aldehyde **6** which was treated with the aryllithium derived from **7**. The resulting alcohol **8** was heated in the presence of methyl sulfoxide to give **1**. In addition, a study of the ^{13}C NMR spectrum of **1** was undertaken.

Xenognosin (**1**) is a modified chalcone that was isolated[1] from gum tragacanth, and it stands as the first host recognition substance for parasitic angiosperms. Since xenognosin (**1**) was obtained in only microgram amounts, its structure elucidation was based solely on the study of its ^1H NMR and mass spectral data.



1

We herein report on an efficient synthetic scheme (Scheme I) for this biologically active compound that confirms its structure and also makes it available in sufficient amounts for further biological evaluations.

Xenognosin (**1**) was synthesized by first methoxymethylating umbelliferone (**2**) by treatment with methoxymethyl chloride in alkaline medium and in the presence of Adogen 464 as a phase-transfer catalyst.[2] The product, **3**, was hydrogenated in ethanol solution in the presence of 10% Pd/C to give the ethyl ester **4**, which was then methylated to **5** by using methyl iodide and anhydrous potassium carbonate. Diisobutylaluminum hydride reduction of **5** furnished **6** in about 75% yield. Unfortunately, the unreacted ester could not be easily separated from the product. As a result, **5** was alternatively reduced with lithium aluminum hydride to the corresponding alcohol which was then oxidized by using pyridinium chlorochromate to give the aldehyde **6** in an overall yield of 80% from **2**.

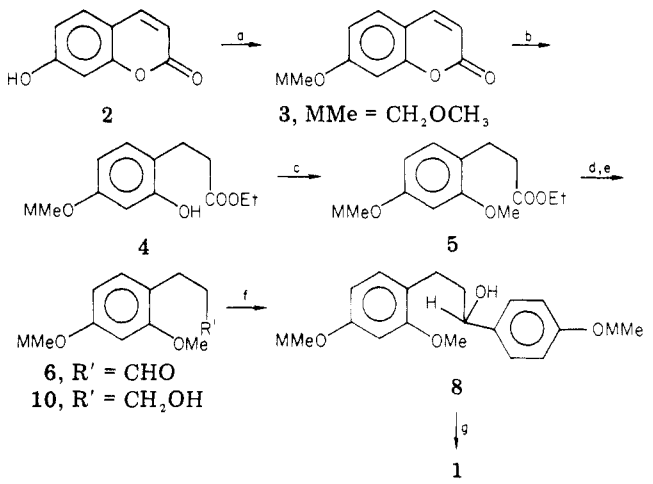
p-Bromophenol was then conveniently methoxymethylated by refluxing with dimethoxymethane[3] in the

(1) Lynn, D. G.; Steffens, J. C.; Kamut, V. S.; Graden, D. W.; Shabanowitz, J.; Riopel, J. L. *J. Am. Chem. Soc.* **1981**, *103*, 1868.

(2) Heerden, F. R.; Zyle, J. J.; Rall, J. H.; Brandt, E. V.; Roux, D. G. *Tetrahedron Lett.* **1978**, 661.

0022-3263/82/1947-1527$01.25/0

Scheme I[a]

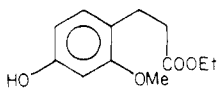


2 3, MMe = CH_2OCH_3 4 5 6, R' = CHO 10, R' = CH_2OH 8 1

[a] (a) Chloromethyl methyl ether, NaOH, Adogen 464; (b) H_2, 10% Pd/C in EtOH; (c) CH_3I/K_2CO_3; (d) $LiAlH_4$; (e) pyridinium chlorochromate; (e) (*p*-bromophenoxy)-methyl methyl ether (7), *sec*-BuLi, THF; (g) Me_2SO, heat at 160–165 °C.

presence of *p*-toluenesulfonic acid to give **7** in 85% yield. Treatment of **7** with *sec*-butyllithium partially generated the corresponding aryllithium which readily produced the benzylic alcohol **8** when added to the aldehyde **6**. By use of 1.7 equiv of **7**, a 91% yield of **8** was secured.

Xenognosin (**1**) was obtained from **8** by heating at 160–165 °C in the presence of methyl sulfoxide[5] followed by an aqueous workup. While only dehydration was expected at this stage, the cleavage of the methoxymethyl groups was a pleasant surprise. The mechanism of this cleavage is being further pursued. The product from this reaction was indistinguishable from a sample of xenognosin (**1**) isolated from gum tragacanth. Furthermore, the ^{13}C NMR signals (Table I) were in full agreement with the structure and were assigned by comparison with those of **8** and **9**. The latter was obtained by acid-catalyzed hydrolysis of **5**.



9

Experimental Section

All melting points were taken in capillaries on a Thomas-Hoover Uni-Melt apparatus and are uncorrected. IR spectra were determined on a Beckman IR-33 recording infrared spectrophotometer; ^1H NMR spectra were recorded on a Varian Model EM390 nuclear magnetic resonance spectrometer at 90 MHz operating at room temperature with $CDCl_3$ as the solvent unless otherwise stated and tetramethysilane as an internal standard with chemical shifts reported as δ values. ^{13}C NMR (15.03 MHz) spectra were recorded on a JEOL FX-60 instrument with a 45° pulse angle, repetition rates between 5 and 10 s, and 8K data points. PND spectra were obtained by broad-band (1 KHz) irradiation. SFORD spectra were conducted by centering the decoupling freguency 1100 Hz downfield from the signal for tetramethylsilane. The long-range selective proton decoupling (LSPD) experiment was conducted by centering the decoupler on the methoxyl proton resonances and recording the spectra at very low power levels. The integration was conducted on data obtained from a gated decoupling experiment (decoupler on only during data acquisition) with a pulse repetition of 50 s. Proton-noise-decoupled and/or off-resonance decoupled spectra were obtained with $CDCl_3$ as the solvent unless otherwise stated and Me_4Si as an internal standard. High- and low-resolution mass spectra were taken on a Finnigan 3200 mass spectrometer. Elemental analyses were done by Scandinavian Microanalytical Laboratory, Herlev, Denmark. Spot detection on TLC plates was acieved by spraying with 0.5% aqueous $KMnO_4$ or by viewing under ultraviolet light. The starting material, umbelliferone (**2**), and all reagents used were obtained from Aldrich Chemical Co.

(Methoxymethyl)umbelliferone (3). Umbelliferone (**2**; 4.10 g, 25.3 mmol) was stirred in CH_2Cl_2 solution (50 mL) with Adogen 464 (trade name for methyltrialkyl(C_8–C_{10})ammonium chloride; 2.30 g) and 20 mL of a 10% solution of NaOH in water. Chloromethyl methyl ether which was found to contain free HCl gas was added 1 mL at a time, keeping the solution basic at all times by the addition of more NaOH solution. A total of 10 mL of

Table I. ^{13}C NMR Spectral Data for **1**, **8**, and **9**[a]

	shift, δ		
carbon	1	8	9
1	121.1 s	124.0 s	120.7 s
2	159.3 s[b]	158.6 s[1]	159.6 s[1]
3	99.9 d	100.6 d	99.9 d
4	157.4 s[1]	157.1 s[1]	158.1 s[1]
5	107.7 d	107.7 d	107.7 d
6	131.0 d[c,d]	130.3 d	131.1 d
7	22.3 t	26.0 t	26.4 t
8	127.5 d[2,e]	39.4 t	35.7 t
9	130.7 d[2,e]	73.4 d	175.2 s
1′	131.0 s[d]	138.7 s	
2′	128.0 d[d]	127.3 d	
3′	116.1 d[d]	116.4 d	
4′	156.9 s[1]	156.8 s[1]	
5′	116.1 d[d]	116.4 d	
6′	128.0 d[d]	127.3 d	
OCH_3	55.7 q	55.9, 55.4 q	55.6 q
OCH_2CH_3			61.2 t
OCH_2CH_3			14.4 q
OCH_2O		95.0, 94.8 t	

[a] The data for **1** and **9** were obtained in methanol-d_4, while those for **8** were obtained in chloroform-*d*. Assignments are based on chemical shift theory and single-frequency off-resonance decoupling. Assignments bearing the same numerical superscript may be interchanged. [b] A long-range selective proton decoupling (LSPD) experiment (irradiation at δ 3.7) confirmed this assignment. The δ 159.3 signal showed a doublet in this experiment (with three-bond coupling to H-6). The δ 159.3 signal showed a multiplet in the proton-coupled spectrum while the signals for C-4 and C-4′ were essentially the same in the LSPD and proton-coupled spectrum. [c] The assignment of this signal was aided by the appearance of a signal in **9** at almost an identical chemical shift. [d] Double-intensity signals confirmed by integration. [e] Attempts to differentiate these signals from the proton-coupled spectrum were not successful due to overlap with the δ 128.0 and 131.7 signals. Likewise, attempts to use selective proton decouplings were not successful. It is likely that the most downfield signal can be assigned to C-9 on the basis of licarin A, a lignan with a similar propenyl side chain.[10]

(3) Yardley, J. P.; Fletcher, H. *Synthesis* **1976**, 244.

(4) The use of *n*-BuLi in ether resulted in no lithium exchange. Rather, *n*-BuLi is added to the aldehyde **6**, producing the corresponding secondary alcohol in about 60% yield. The use of THF as the solvent produced limited exchange as evidenced by the formation of some **8**, but again the addition product of *n*-BuLi to **6** was the major product.

(5) Traynelis, V. J.; Hergenrother, W. L.; Livingston, J. R.; Valicenti, J. A. *J. Org. Chem.* **1962**, *27*, 2377.

(6) Hydrogenation at a higher pressure (35 psi) resulted in partial hydrogenolysis of the methoxymethyl group, giving the corresponding diphenolic compounds as colorless needles (mp 91–92 °C) with spectral data in agreement with the structure. The same product was obtained as the sole product by hydrogenation of umbelliferone (**2**) itself under the same conditions.

chlorometyl methyl ether was added along with 50 mL of base. After stirring for 2 h, the mixture was worked up by dilution with more CH_2Cl_2 (200 mL) and then removal of the CH_2Cl_2 phase which was then washed with H_2O, dried (anhydrous Na_2SO_4), and evaporated. The residue (7.80 g) was chromatographed on a SiO_2 column (100 g) with $CHCl_3$ as the solvent, and the eluate containing the front-running material was evaporated. The residue was crystallized from ether–*n*-hexane to give 5.11 g of **3** (98%) which was obtained as colorless needles: mp 101–102 °C; IR ($CHCl_3$) 1720, 1612, 998, 836 cm^{-1}; ^1H NMR ($CDCl_3$) was similar to that of umbelliferone (**2**) with two additional singlets at δ 3.43 (OCH_3) and 5.16 (CH_2); ^{13}C NMR ($CDCl_3$) likewise exhibited two additional carbon signals at δ 94.70 (*t*) and 56.30 (*q*); mass spectrum, *m/z* (relative intensity) 206 (M^+, 100).

Anal. Calcd for $C_{11}H_{10}O_4$: C, 64.07; H, 4.89. Found: C, 64.12; H, 4.77.

Ethyl 3-[2-Hydroxy-4-(methoxymethoxy)phenyl]propanoate (4). Coumarin **3** (1.0 g) was suspended in 100 mL of absolute ethanol, and 0.308 g of 10% Pd/C was added to the mixture which was then hydrogenated in a Parr reaction vessel at 15 psi for 24 h. Filtration and evaporation of the filtrate provided 1.19 g (97%) of a colorless oil that was essentially pure **4** on TLC (SiO_2 plates with $CHCl_3$ as solvent gave an R_f value of 0.35 vs. an R_f value of 0.65 for **3**). Compound **4** exhibited the following: IR ($CHCl_3$) 3590, 3330, 1705, 1617 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.50 (1 H, s, exchangeable), 4.10 (2 H, q, J = 7.0 Hz, OCH_2CH_3), 1.20 (3 H, t, J = 7.0 Hz, CH_3); ^{13}C NMR ($CDCl_3$) δ 157.20 and 155.20 (aromatic C–O), 60.90 (t, OCH_2CH_3), 14.20 (q, CH_3); mass spectrum, *m/z* (rela tive intensity) 254 (M^+, 42), 167 (100).

Anal. Calcd for $C_{13}H_{18}O_5$: C, 61.40; H, 7.14. Found: C, 61.57; H, 7.24.

Ethyl 3-[2-Methoxy-4-(methoxymethoxy)phenyl]propanoate (5). Phenolic ester **4** (0.80 g) was dissolved in acetone (10.0 mL) and an excess of freshly distilled methyl iodide (3.0 mL), and the solution was refluxed with stirring in the presence of 5.0 g of anhydrous K_2CO_3. The reaction was complete after 5 h when the mixture was filtered, and upon eavaporation it yielded 0.81 g (96%) of a colorless oil that was almost pure **5** which was used for the next step without further purification. The IR ($CHCl_3$) had no OH absorption. The ^1H NMR ($CDCl_3$) was similar to that of **4**, but it showed an aromatic methoxyl signal at δ 3.75. The ^{13}C NMR spectrum, likewise, showed two methoxy signals at δ 55.80 and 55.30; one of them is due to the methoxymethyl group: mass spectrum, *m/z* (relative intensity) 268 (M^+, 28), 151 (100).

Anal. Calcd for $C_{14}H_{20}O_5$: C, 62.67; H, 7.51. Found: C, 62.77; H, 7.77.

3-[2-Methoxy-4-(methoxymethoxy)phenyl]propanal[7] (6). Compound **5** (1.40 g) was dissolved in ether (40 mL), and the solution was added gradually with stirring to 10.0 mL of a 1 M solution of $LiAlH_4$ in ether. The mixture was then refluxed for 4 h, and then the excess $LiAlH_4$ was decomposed by the addition of 70% ethanol followed by the addition of water and dilution with 100 mL of ether. The aqueous phase was acidified with 2 N HCl and extracted with 100 mL of ether. The combined ether extracts were washed with H_2O, dried (anhydrous Na_2SO_4), and evaporated, leaving 1.109 g (94%) of a colorless oil that was homogenous on TLC (SiO_2 plates with $CHCl_3$ as the solvent gave one spot, R_f 0.15) and was found to be pure **10**: IR ($CHCl_3$) 3610, 3480, 1607, 1500 cm^{-1}; ^1H NMR ($CDCl_3$) showed the absence of the ethoxy group and exhibited, instead, a two-proton triplet at δ 3.53 (J = 6.2 Hz, CH_2OH); ^{13}C NMR ($CDCl_3$) exhibited a signal at δ 62.1 (t, CH_2OH); mass spectrum, *m/z* (relative intensity) 226 (M^+, 43), 151 (100).

Anal. Calcd for $C_{12}H_{18}O_4$: C, 63.69; H, 8.02. Found: C, 63.89; H, 8.21.

(7) In another approach, **5** was reduced in toluene soltion with 1 equiv of a 25% solution of diisobutylaluminum hydride in the same solvent at −70 °C for 6 h. Examination of the ^1H NMR of the product revealed 75% conversion to **6**, but the separation of **6** from unreacted **5** by chromatography on Si gel proved to be difficult. Attempts of optimize the reaction were unsuccessful; e.g., while the use of 1.5 equiv of the reducing agent eliminated **5** completely, it produced substantial amounts of **10**. Consequently, this route was abandoned.

Alcohol **10** obtained above (1.20 g, 5.31 mmol) was oxidized by dissolving it in 30 mL of CH_2Cl_2 and stirring the solution with pyridinium chlorochromate (2.77 g, 12.8 mmol) for 2 h. The mixture was diluted with 200 mL of ether and filtered. Evaporation of the ether phase left a dark residue which was chromatographed on SiO_2 (15 g) with $CHCl_3$ as the eluent to give 1.09 g (92%) of **6** as colorless oil: IR ($CDCl_3$) 1717, 1608, 1587, 1500 cm^{-1}; ^1H NMR ($CDCl_3$) δ 9.77 (2 H, t, J = 1.5 Hz, CHO); ^{13}C NMR ($CDCl_3$) showed a signal at δ 202.1 (CHO); mass spectrum, *m/z* (relative intensity (M^+, 58), 168 (100).

Anal. Calcd for $C_{12}H_{16}O_4$: C, 64.27; H, 7.19. Found: C, 64.51; H, 7.35.

4-Bromo-1-(methoxymethoxy)benzene (7). *p*-Bromophenol (21.6 g) was dissolved in 500 mL of CH_2Cl_2 and 100 mL of dimethoxymethane. *p*-Toluenesulfonic acid (250 mg) was added to the solution which was refluxed in a Soxhlet extractor containing 150 g of type-3A molecular sieves. After 24 h, the molecular sieves were replaced by a fresh amount, and refluxing was continued for another 24 h. The reaction mixture was worked up by evaporation and dissolving the residue in ether which was washed with 10% aqueous NaOH and then H_2O. The dry (anhydrous Na_2SO_4) ether phase was evaporated to leave an orange residue that was dissolved in *n*-hexane and filtered over a short bed of SiO_2. Evaporation of *n*-hexane yielded 23.0 g (85%) of pure **7** as a colorless oil: IR ($CHCl_3$) showed no OH; ^1H NMR ($CDCl_3$) δ 5.10 (2 H, s, OCH_2O), 3.43 (3 H, s, OCH_3); ^{13}C NMR ($CDCl_3$) exhibited signals due to the methoxymethyl group at δ 94.50 (t) and 55.80 (q); mass spectrum, *m/z* (relative intensity) 116 (M^+, 100), 118 (M^+, 96).

Anal. Calcd for $C_8H_9O_2Br$: C, 44.26; H, 4.18. Found: C, 44.44; H, 4.08.

1-[4-(Methoxymethoxy)phenyl]-3-[2-methoxy-4-(methoxymethoxy)phenyl]propan-1-ol (8). Halide **7** (2.574 g, 11.86 mmol) was stirred with 20 mL of dry tetrahydrofura (THF), and the solution was cooled to −78 °C by using an ether–CO_2 bath. *sec*-Butyllithium (11.0 mL of a 1.3 N solution in *n*-hexane) was added over a period of 5 min, and the solution was then stirred for 30 min. A solution of the aldehyde **6** (1.560 g, 6.96 mmol) in 3.50 mL of THF was added to the reaction mixture over a period of 5 min, and the mixture was then stirred at −78 °C for 10 min, allowed to warm to room temperature, and stirred for an additional 10 min. The reaction mixture was worked up by dilution with 300 mL of ether and washing with saturated aqueous NH_4Cl solution and then with water. The dried (anhydrous Na_2SO_4) ether phase was evaporated to provide 3.80 g of a colorless oil. Thin-layer chromatographic analysis of this material on SiO_2 plates with ether–*n*-hexane (3:2) as the solvent and spraying with anisaldehyde[8] showed a major spot (dark violet spot) at R_f 0.40 corresponding to the product **8** with a trace of the unreacted aldehyde, R_f 0.70, in addition to the excess *p*-[(bromomethoxy)methyl]phenol which ran almost with the sovent front (observed under short-wavelength UV light as it did not give a colored spot with anisaldehyde reagent).

The product was purified by chromatographing the crude reaction mixture on 100 g of SiO_2 with ether–*n*-hexane (1:1) as the solvent, and the fractions containing **8** were pooled together and evaporated to leave 2.29 g (91%) of **8** as thick colorless oil: IR ($CHCl_3$) 3590, 3500, 1607, 1587 cm^{-1}; ^1H NMR ($CDCl_3$) δ 4.57 (1 H, t, J = 6.20, CHOH), 5.14 (4 H, s, $2CH_2$), 3.43 (6 H, s, $2OCH_3$); ^{13}C NMR ($CDCl_3$), Table I; mass spectrum, *m/z* (relative intensity) 362 (M^+, 6), 167 (100), 137 (100).

Xenognosin (1). Alcohol **8** (0.536 g, 1.48 mmol) was stirred under 1.130 g of methyl sulfoxide (14.48 mmol), and the solution was heated under nitrogen at 160–165 °C for 1.5 h.[9] The reaction

(8) This spray reagent was obtained by dissolving 0.5 mL of *p*-anisaldehyde in 10 mL of glacial acetic acid, 85 mL of CH_3OH, and 5 mL concentrated H_2SO_4, added in this order. The spots were visualized by spraying for 5 s and then heating at 110 °C for 10 min.

(9) While this reaction was reproducible, some runs took as long as 3 h to produce **1**. At the same time, excessive heating for a long period of time resulted in partial polymerization of the product. Consequently, the reaction was monitored by TLC every 0.5 h and was allowed to proceed until the spot due to **1** appeared to be the major spot.

(10) Wenkert, E.; Gottlieb, H. E.; Gottlieb, O. R.; Pereira, M. O.; Da, S.; Formiga, M. D. *Phytochemistry* **1976**, *15*, 1547. See also: El-Feraly, F. S.; Cheatham, S. F.; Hufford, C. D.; Li, Wen-Shyong, *Ibid.*, in press.

mixture was diluted with water and extracted with ether, which upon being washed with water, dried (anhydrous Na_2SO_4), and evaporated yielded 0.511 g of a gum that was flash chromatographed on SiO_2 with ether–*n*-hexane (1:1) to give 209 mg (55%) of a pale yellow thick oily residue that was identical with an authentic sample of xenognosin (1); same TLC mobility on SiO_2 identical ^1H NMR, IR, and mass spectra). The ^{13}C NMR spectrum ($CDCl_3$) is described in Table I.

Anal. Calcd for $C_{16}H_{16}O_3$: C, 74.98; H, 6.29. Found: C, 74.71; H, 6.41.

Ethyl 3-(4-Hydroxy-2-methoxyphenyl)propanoate (9). Ether **5** (0.335 g) was dissolved in absolute ethanol (2.0 mL) and the solution stirred for 5 h under N_2 with 0.30 mL of concentrated HCl. Evaporation of the solution yielded an oily residue that was dissolved in $CHCl_3$ and chromatographed over SiO_2 to give 260 mg (93%) of **9** in the form of a colorless oil that crystallized from ether–*n*-hexane to give colorless prisms: mp 56–57 °C; IR ($CHCl_3$) 3584, 3360, 1715, 1612 cm^{-1}; ^1H NMR ($CDCl_3$) δ 6.50 (1 H, br s, exchangeable); ^{13}C NMR ($CDCl_3$), Table I; mass spectrum, *m/z* (relative intensity) 224 (M^+, 24), 137 (100).

Anal. Calcd for $C_{12}H_{16}O_4$: C, 64.27; H, 7.19. Found: C, 64.31; H, 7.33.

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Registry No. **1**, 76907-79-4; **2**, 93-35-6; **3**, 80754-21-8; **4**, 80754-22-9; **5**, 80754-23-0; **6**, 80754-24-1; **7**, 25458-45-1; **8**, 80754-25-2; **9**, 80754-26-3; **10**, 80754-27-4.

Isomeric 1,2-Oxaphospholene 2-Oxides from the Reaction of Diacetone Alcohol and Methyl- or Phenylphosphonous Dichloride

Kurt Moedritzer* and Raymond E. Miller

Monsanto Agricultural Products Company, Research Department, St. Louis, Missouri 63166

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The reaction of methyl- or phenylphosphonous dichloride with diacetone alcohol produces, in addition to the previously described 1,2-oxaphosphol-4-ene 2-oxide derivatives, isomers of the latter, corresponding 1,2-oxaphosphol-3-ene 2-oxides. Both pairs of isomers were characterized by ^1H, ^{31}P, and ^{13}C NMR, IR, and mass spectroscopy, and a mechanism is proposed for the formation of the two isomers on the basis of the isolation of 3-chloro-1,2-oxaphospholane 2-oxide as an intermediate.

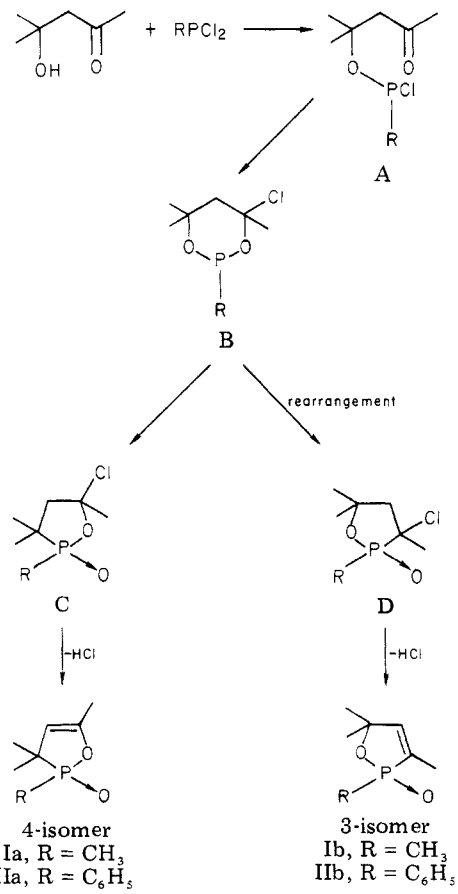
In the course of studies exploring various methods for the preparation of 1,2-oxaphospholene 2-oxides we were puzzled by the fact that in the cases of 2,3,3,5-tetramethyl-1,2-oxaphosphol-4-ene 2-oxide and the corresponding 2-phenyl drivative, prepared by the reaction of diacetone alcohol and methyl- or phenylphosphonous dichloride,[1] the ^{31}P NMR spectrum of distilled product samples showed an additional upfield resonance. This paper reports the isolation and characterization of the compounds corresponding to this upfield ^{31}P NMR resonance and their identification as isomeric 1,2-oxaphosphol-3-ene 2-oxides. The physical properties and characterization data of the two pairs of isomers are compared side by side, and a mechanism is presented rationalizing the formation of the pair of isomers on the basis of an isolated intermediate.

Results and Discussion

Earlier work[1] has shown that the reaction of phenylphosphonous dichloride with diacetone alcohol, which was reported to result in a 1,2-oxaphosphol-4-ene 2-oxide derivative as the final product, proceeds in several steps. The first step was assumed to be the alcoholysis of phenylphosphonous dichloride, with subsequent intermediates being phenylphosphinic acid, $C_6H_5P(O)(H)OH$, a β-keto phosphinic chloride, and a 5-chloro-1,2-oxaphospholane 2-oxide derivative, suggesting a five-step mechanism for this reaction.

We now report the unambiguous characterization of one of the key intermediates of the above-postulated sequence of reactions and on this basis suggest a mechanism for the formation of the observed two isomeric 1,2-oxaphospholene 2-oxides.

Scheme I



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