Esterifications of Linalol in Acidic Media.—Linalol (40 g., 0.26 mole) and acetic anhydride (30 g., 0.3 mole) were refluxed 10 hours (135°). The reaction mixture was worked up and the product fractionated. The fraction boiling at 55–60° (12 mm.) was assumed to be trienes with the formula $C_{10}H_{16}$ (13.5 g., 40% yield).

Geranyl acetate, b.p. 118° (12 mm.), $n^{25}D$ 1.4600 (18.5 g., 36% yield). Saponification equivalent: calculated, 196 g.; found, 198 g. Number of double bonds: calculated, 2; found, 1.91. Residue, about 10 ml.

Linalyl acetate (50 g., 0.25 mole), acetic acid (225 ml.) and phosphoric acid (1.5 ml. of 85%) were allowed to stand 66 hours at 25°. The products consisted of a fraction boiling at 56–60° (12 mm.), $n^{25}D$ 1.4726 (6.5 g.), and geranyl acetate, b.p. 116–121° (12 mm.), $n^{25}D$ 1.4610 (27 g., 54% yield); residue, 7.3 g.

Isomerization of Primary Allylic Acetates with Strong Acid.—γ,γ-Dimethylallyl acetate (16 g.), acetic anhydride (15 g.) and acetic acid (5 g.) were heated 116 hours at 95°. The primary acetate was recovered to the extent of 90%, b.p. 70.5° (40 mm). There was some residue but no tertiary acetate.

A solution of geranyl acetate (20 g.), glacial acetic acid (100 ml.) and 85% phosphoric acid (10 ml.) stood 9 days. The light brown solution yielded 1.3 g. with b.p. 57–60° (12 mm.), $n^{25}D$ 1.4779, and geranyl acetate, b.p. 115–116° (12 mm.), $n^{25}D$ 1.4610 (10.7 g., 54% recovery); residue, 4.5 g.

Esterification of Linalol in Basic Medium.—Linalol (34 g., 0.22 mole), acetic anhydride (28 g., 0.28 mole) and pyridine (24 g., 0.3 mole) were heated 110 hours at 95°. The black solution was diluted with ether, washed with water, dilute sulfuric acid, dilute alkali and dried over magnesium sulfate. Ether was evaporated and the residue fractionated. Linalyl acetate only was received, b.p. 96° (12 mm.), $n^{25}D$ 1.4480 (33 g., 75% yield).

α-Ethyl-α-methylallyl acetate was recovered unchanged (85% recovery) after being heated 11 days at 95° with acetic anhydride which had been previously freed of acetic acid by fractional distillation.

Rearrangement of α- and γ-Methylallyl Acetates.—A glacial acetic acid (82 g., reagent grade) solution, 3 moles per liter in crotyl acetate (38.5 g.) and 0.3 mole per liter in *p*-toluenesulfonic acid (6.0 g., crystalline), was heated at 60°. The volatile material, presumably butadiene, was determined by weighing the flask before and after the reaction period; there was no appreciable difference in weight in any experiment. The black reaction mixture was distilled at low pressure and the distillate poured onto ice. The acetic acid was neutralized with alkali, and the solution extracted repeatedly with ether. The ester mixture was analyzed with the three-foot modified Podbielniak fractionating column; results are shown in Table II. The amounts of residual material obtained in these experiments were not sufficient to account for the remainder of the yields. α-Methylallyl acetate, b.p. 112.5°, $n^{20}D$ 1.4048; γ-methylallyl acetate, b.p. 132–133°, $n^{20}D$ 1.4183.

Summary

1. The acylations of α,α-dimethylallyl alcohol, α-ethyl-α-methylallyl alcohol and linalol are reported.

2. In acidic media their acetates have been found to rearrange completely into the corresponding primary isomers, γ,γ-dimethylallyl acetate, γ-ethyl-γ-methylallyl acetate and geranyl acetate, respectively.

3. α-Methylallyl acetate and γ-methylallyl acetate have been found to rearrange in acetic acid at 60° under the influence of *p*-toluenesulfonic acid to mixtures of acetates which contain 35% of the secondary isomer and 65% of the primary isomer.

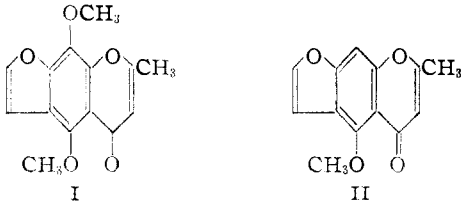
LOS ANGELES 24, CALIF. RECEIVED AUGUST 7, 1950

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA]

Chromones. II. The Synthesis of Visnaginone

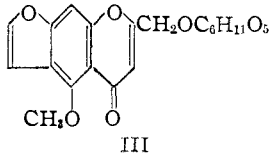
BY T. A. GEISSMAN AND ELLY HINREINER

The fruit of the umbelliferous plant *Ammi visnaga* contains the structurally related chromones khellin (I), visnagin (II) and khellol glucoside (III).

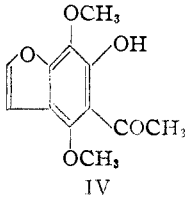


I

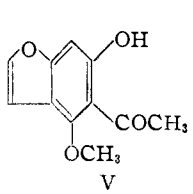
II



III



IV

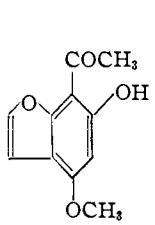


V

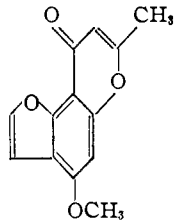
Upon alkaline degradation, khellin yields khellinone (IV)[1] and both visnagin and khellol glucoside yield visnaginone (V).[2] The partial,[1,3] from khellinone, and total[4,5,6,7] syntheses of khellin have been accomplished by several independent investigators. The total synthesis of visnaginone has recently been reported by Gruber and Horváth[8] in a preliminary note which became accessible after the completion of the work described in this paper.

While the synthesis of khellinone (from 2,5-dimethoxyresorcinol) involves no problems in the orientation of the furo- and chromone rings, that of visnaginone is not so straightforward so far as questions of orientation are concerned. Indeed, the initial attempts of Gruber and Robertson and their collaborators to prepare it led only to isovisnaginone (VI), from which isovisnagin (VII) was prepared.[9,10]

(1) Späth and Gruber, *Ber.*, **71B**, 106 (1938).
(2) Späth and Gruber, *ibid.*, **74B**, 1492 (1941).
(3) Geissman, THIS JOURNAL, **71**, 1498 (1949).
(4) Baxter, Ramage and Timson, *J. Chem. Soc.*, S30 (1949).
(5) Clarke and Robertson, *ibid.*, 302 (1949).
(6) Murti and Seshadri, *Proc. Indian Acad. Sci.*, **30**, 107 (1949).
(7) Geissman and Halsall, THIS JOURNAL, in preparation.
(8) Gruber and Horváth, *Monatsh.*, **80**, 874 (1949).
(9) Clarke, Glaser and Robertson, *J. Chem. Soc.*, 2261 (1948).
(10) Gruber and Horváth, *Monatsh.*, **80**, 563 (1949).

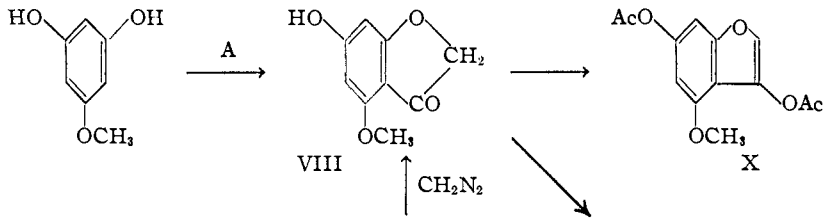


VI



VII

In the present work the first synthetic approach to visnaginone was through phloroglucinol monomethyl ether (route A). Acylation of this with chloroacetonitrile in the Hoesch reaction led (*via* the chloroketone) to a coumaranone for which the structure VIII was assumed by analogy with the



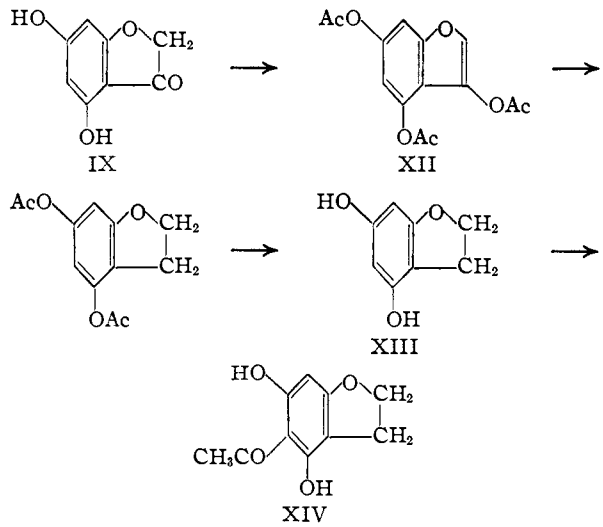
reaction product from phloroglucinol monomethyl ether and acetonitrile.[11] In an attempt to prepare what was expected would be the isomer of VIII (*viz.*, 4-hydroxy-6-methoxycoumaranone-3), 4,6-dihydroxycoumaranone-3 (IX)[12] was monomethylated with diazomethane (route B). The product of this reaction was found to be identical with VIII, to which the structure 4-methoxy-6-hydroxycoumaranone-3 was assigned on the basis of absorption spectra evidence (which was not entirely unequivocal), the fact that it did not give a color with ferric chloride, and the analogy cited above.[11]

This behavior of 4,6-dihydroxycoumaranone-3 (IX) toward ethereal diazomethane is noteworthy. The reluctance of hydroxyl groups ortho to carbonyl groups in such compounds as *o*-hydroxyacetophenone derivatives, 5-hydroxyflavones and 1-hydroxyanthraquinones to undergo diazomethylation under these conditions is well known[13] and is regarded as a consequence of the participation of the hydroxyl and carbonyl groups in hydrogen-bond chelation. It is apparent that in 4-hydroxycoumaranones this chelation is less effective, and that in IX the proximity of the 4-hydroxyl group to the carbonyl group augments its acidic character over that of the 6-hydroxyl group sufficiently to allow its preferential methylation.

After this part of the work had been completed and before the introduction of the acetyl group into the coumarane derived from VIII was attempted, a paper by Gruber and Horváth[10] appeared in which they described the preparation of VIII by route A. Despite a disparity in melting points for VIII (Gruber and Horvath, m.p. 267–269°; ours, 290–292°) the identity of the compounds was indicated by the melting point of the diacetate (X), which was found to be the same as that reported by Gruber and Horvath.[10] The conversion[10] of VIII into a hydroxymethoxyacetocoumarone (XI) isomeric with visnaginone substantiated the structure of VIII and showed the fruitlessness of this approach to the synthesis of visnaginone. Similar difficulties in the orientation of the entering acetyl group had been encountered by Clarke, *et al.*,[9] who found that the Hoesch reaction of ethyl 4-methoxy-6-hydroxycoumarone-2-carboxylate with acetonitrile led to the introduction of the acetyl group in the 7-position.

The introduction of the acetyl group in the desired 5-position was found to proceed smoothly when the Hoesch reaction was carried out with acetonitrile and 4,6-dihydroxycoumarane (XIII). This orientation is similar to that observed by Gruber and Traub[14] when they found that the formylation of 4-methyl-5-methoxyresorcinol yielded 3-methyl-4-methoxy-6-hydroxysalicylaldehyde. The 4,6-dihydroxycoumarane was prepared by the catalytic hydrogenation of 3,4,6-triacetoxycoumarone (XII). The structure of XIV as 4,6-dihydroxy-5-acetylcoumarane was established by the fact that its dimethyl ether was identical with the methyl ether of of dihydrovisnaginone prepared by the reduction of visnaginone derived from chellol glucoside.

The monomethylation of XIV with methyl iodide



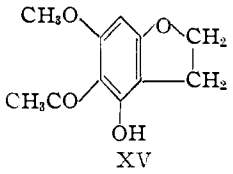
and potassium carbonate in acetone afforded a good yield of a mixture of the two isomeric methyl ethers XV and XVI. These were separated

(11) Zémplén, Bognar and Thiele, *Ber.*, **77B**, 446 (1944).

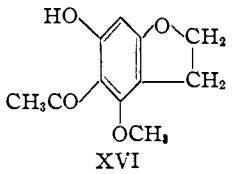
(12) Sonn, *ibid.*, **50**, 1272 (1917).

(13) See Schönberg and Mustafa, *J. Chem. Soc.*, 746 (1946), for a discussion of this matter.

(14) Gruber and Traub, *Monatsh.*, **77**, 414 (1947).



XV



XVI

by passing a benzene solution of the mixture through an alumina column. The less readily eluted isomer (XVI) was shown to be identical with dihydrovisnaginone by mixed melting points of the compounds and their acetates and by absorption spectrum measurements in alcohol and in alkali.

The absorption spectra of dihydrovisnaginone and of the isomeric compound XV (which will be referred to as dihydroallovisnaginone), both in alcohol and in 0.03 *N* sodium hydroxide solution, are shown in Fig. 1. It is of interest to note that both

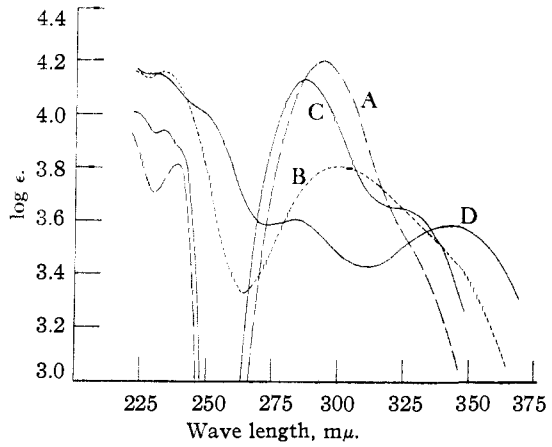
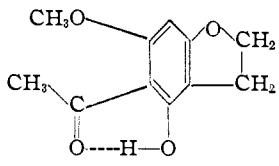


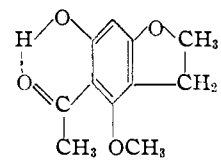
Fig. 1.—Absorption spectra of 4-hydroxy-5-acetyl-6-methoxycoumarane (A) in 95% ethanol; (B) in 0.03 *N* NaOH; and 4-methoxy-5-acetyl-6-hydroxycoumarane (C) in 95% ethanol and (D) in 0.03 *N* NaOH.

the spectra of these isomers and their behavior on the alumina column used in their chromatographic separation are consistent with the view that dihydroallovisnaginone has the more effective intramolecular hydrogen bond of the two. Its relatively less polar nature is indicated by the fact that it appears in the eluate from the alumina, while dihydrovisnaginone was removed by extraction of the extruded column. The greater wave length of the second absorption maximum and the smaller displacement of this band in alkali are in accord with this view. Comparison of the spectra of XV and XVI with those of *o*- and *p*-hydroxyacetophenone[15] are given in Table I.

The explanation for enhanced chelation in XV as compared with XVI must lie in the proximity of the number three carbon atom of the coumarane ring. The steric influence of this ring would favor the disposition of the 4-hydroxyl group in such a way as to enhance the contribution of a form XVII. No such influence operates in XVI, while in both the influence of the adjacent methoxyl group would tend to reinforce the chelation depicted in XVII and, by steric influence upon the methyl group of the acetyl grouping, adversely affect a form XVIII, derived from XVI.



XVII



XVIII

That the steric effect of such a 5-membered ring exists may be inferred from other studies,[16] although the exact degree to which a correspondence exists between a carbocyclic 5-ring and a coumarane ring is unknown. That the steric effect of the 5-ring is less important than that of a 6-ring is clear from the result of the diazomethylation of 4,6-dihydroxycoumaranone-3 referred to above, and from some related observations made in this Laboratory.[17]

The conversion of dihydrovisnaginone to visnaginone was most conveniently carried out by the use of N-bromosuccinimide.[7,18] The synthetic visnaginone was identical in all respects with the natural material (prepared from khellol glucoside).[2]

Experimental

4,6-Dihydroxycoumaranone-3 (IX).—This was prepared by a modification of the method of Shriner and Grosser.[19] Dry hydrogen chloride was passed for 3.5 hours into a stirred mixture of 73 g. of phloroglucinol, 45 g. of chloroacetonitrile, 20 g. of powdered anhydrous zinc chloride and 500 ml. of dry ether. A second phase, oily at first and later solid, separated. The mixture was allowed to stand overnight and the solid separated and washed with fresh ether. The chalky, yellow solid was dissolved in 400 ml. of ice-water and the solution heated under reflux for 1 hour. The solid which separated on cooling was boiled for 5 hours in a solution of 100 g. of potassium acetate in 2 l. of water. The hot solution was treated with decolorizing carbon and filtered. The product separated as tiny tan-yellow needles, m.p. 247–251° (dec.). The yield was 57 g. (59%). A sample purified by recrystallization from water melted at 250–256.5° (dec.).

4-Methoxy-6-hydroxycoumaranone-3 (VIII).—(A) To a cold solution of 8.3 g. of 4,6-dihydroxycoumaranone in 100 ml. of dioxane was added an ethereal solution of diazomethane (from 5 g. of nitrosomethylurea). An immediate reaction occurred and a precipitate began to form. After standing overnight the mixture was filtered and the cream-colored solid washed with ether and dried. The product (3.7 g.) crystallized from acetic acid as tiny needles, m.p. 290–292° (dec.). The compound gave no color with alcoholic ferric chloride.

TABLE I

	XV		XVI		*o*-Hydroxyacetophenone		*p*-Hydroxyacetophenone	
	Alcohol	NaOH	Alcohol	NaOH	Alcohol	NaOH	Alcohol	NaOH
1st λ_{max}, mμ	239	234	235	284	251.5	256.5	220.5	235
Log ε	3.82	4.16	4.00	3.59	3.97	3.75	4.03	3.81
2nd λ_{max}, mμ	294	300	288	343	327	359	276	325
Log ε	4.20	3.81	4.16	3.58	3.50	3.71	4.13	4.39

(15) Morton and Stubbs, *J. Chem. Soc.*, 1347 (1940).

(16) Arnold and Rondestvedt, THIS JOURNAL, **67**, 1265 (1945).

(17) Seikel and Geissman, *ibid.*, **72**, 5720 (1950).

(18) Horning and Reisner, *ibid.*, **72**, 1514 (1950), have described unsuccessful attempts to effect the dehydrogenation of dihydrofurocoumarins with this reagent.

(19) Shriner and Grosser, *ibid.*, **64**, 382 (1942).

Anal. Calcd. for $C_9H_8O_4$: C, 60.00; H, 4.48. Found: C, 60.09; H, 4.61.

(B) From Phloroglucinol Monomethyl Ether (*Cf.* Gruber and Horváth[10]).—Dry hydrogen chloride was passed into a solution of 8.5 g. of phloroglucinol monomethyl ether,[11] 4.5 g. of chloroacetonitrile and 4.5 g. of zinc chloride in 75 ml. of dry ether. The addition was continued for 2 hours, with stirring; a solid began to appear after an hour. After standing overnight the ether was decanted and the yellow solid washed with ether and boiled with 200 ml. of water for 10 minutes. The solid (8.8 g.) which separated on cooling was a mixture of coumaranone and chloroketone. Conversion into the coumaranone was completed by heating the solid for 5 hours with a solution of 10 g. of sodium acetate in 100 ml. of ethanol. The yield of crude coumaranone, which separated on cooling, was 7.0 g. (64%). Recrystallization from glacial acetic acid gave 5.4 g. of pink-tinged crystals, m.p. 289–290° (dec.). A mixture of this compound and the product of the diazomethylation described in (A) melted at 289–290° (dec.).

Anal. Calcd. for $C_9H_8O_4$: C, 60.00; H, 4.48. Found: C, 59.76; H, 4.66.

(C) The methylation of 4,6-dihydroxycoumaranone-3 (1.5 g.) with methyl iodide (3 g.) and potassium carbonate (3 g.) in acetone (50 ml.) yielded a product melting at 268–273.5° (dec.). A mixture of this and the m.p. 290–292° compound (A) melted at 268–277° (dec.).

6-Benzoyloxy-4-methoxycoumaranone.—The benzoates prepared (*cf.* Shriner and Grosser[19]) from 6-hydroxy-4-methoxycoumaranone prepared by routes A and B above were identical: m.p. and mixed m.p. 151–153°.

Anal. Calcd. for $C_{16}H_{12}O_5$: C, 67.60; H, 4.26. Found: C, 67.28; H, 4.63.

3,4,6-Triacetoxycoumarone was prepared according to Späth, Wessely and Kubiczek.[20]

4,6-Diacetoxycoumarone (*cf.* Gruber and Horváth[10]).—A mixture of 17.5 g. of 3,4,6-triacetoxycoumarone and 3.0 g. of Adams catalyst in 250 ml. of glacial acetic acid was hydrogenated at ordinary temperature and pressure. The initially rapid absorption became slow after 4 hr., 1430 ml. of hydrogen having been absorbed. The platinum was replaced by 1.0 g. of fresh catalyst; in 12 minutes 740 ml. of hydrogen was absorbed (total, 2170 ml.; calcd. 2162 ml.). The absorption of hydrogen was continuing, but the reaction was interrupted at this point. The solvent was removed and the residue distilled under reduced pressure. The distillate (12.4 g.) was redistilled to yield 11.6 g. (83%) of a water-white oil which could not be crystallized.

4,6-Diacetoxycoumarane.—While 4,6-diacetoxycoumarone could be further reduced to the coumarane, the best results were obtained by carrying out the reduction of 3,4,6-triacetoxycoumarone in such a way as to hydrogenolyze the 3-acetoxy group and to obtain the coumarane directly.

A suspension of 68 g. of 3,4,6-triacetoxycoumarone and 5.8 g. of Adams catalyst in 500 ml. of absolute ethanol was hydrogenated in two batches at room temperature and a pressure of from 45–20 p.s.i.g. After about 2.5 hours the rate of hydrogen uptake became negligible and slightly more than the required two moles of hydrogen had been used. The combined filtrates from the two runs were freed of solvent and the residue distilled under reduced pressure. The product distilling at 176° (5 mm.) was a colorless oil (51 g., 92%) which slowly crystallized. A portion of the material was recrystallized from ether–petroleum ether; m.p. 68.5–70°.

Anal. Calcd. for $C_{12}H_{12}O_5$: C, 61.01; H, 5.12. Found: C, 60.83; H, 5.30.

4,6-Dihydroxycoumarane was obtained by saponification of the diacetate (51 g.) with 500 ml. of 20% aqueous sodium hydroxide containing 0.5 g. of detergent (5 hr., reflux). The product (24 g.) isolated in the usual manner, boiled at 189° (3 mm.). A portion was induced to crystallize from ether by cooling in solid carbon dioxide–acetone, but it was not characterized further but used directly in the next step. Its identity was shown by its ready reconversion to the crystalline diacetate, m.p. 68.5–70°. It gave a brown color with ferric chloride.

5-Acetyl-4,6-dihydroxycoumarane.—Dry hydrogen chloride was passed for 2 hours into an ice–salt-cooled mixture of 23 g. of 4,6-dihydroxycoumarane, 13 g. of acetonitrile and 23 g. of anhydrous, powdered zinc chloride in 450 ml. of absolute ether. The mixture was allowed to stand overnight, treated with hydrogen chloride for a further 3 hours, and allowed to stand in a cold-room for 3 days. The ether was decanted and the residue washed with two 50-ml. portions of dry ether. The gummy solid was treated with 75 ml. of water, causing yellow needles to form. These were collected and dissolved in 150 ml. of water and the solution boiled for 40 minutes. Yellow-tan needles separated during the heating and, after cooling, were collected. The yield was 13.8 g. (47%) of a product which after a recrystallization from water formed buff crystals, m.p. 192–194°. The compound gives a red-purple color with alcoholic ferric chloride. An analytical sample melted at 193–195°.

Anal. Calcd. for $C_{10}H_{10}O_4$: C, 61.85; H, 5.19. Found: C, 61.85; H, 5.45.

Dihydrovisnaginone (XVI).—A warm solution of 4.9 g. of visnagimone in 150 ml. of methanol was reduced at an initial hydrogen pressure of 40 p.s.i.g. and 50–55° in the presence of 0.5 g. of Adams catalyst. After the calculated amount of hydrogen had been taken up the catalyst was removed and the nearly colorless filtrate concentrated on the steam-bath. Crystallization of the residue from dilute methanol afforded 4.0 g. (81%) of white needles, m.p. 98.5–100.5°. The compound gives a deep wine-red color with ferric chloride (visnaginone gives a clear grass-green color).

5-Acetyl-4,6-dimethoxycoumaranone.—A solution of 0.5 g. of 5-acetyl-4,6-dihydroxycoumaranone in 15 ml. of boiling methanol was treated with 3.6 ml. of methyl sulfate and 2.1 ml. of 50% potassium hydroxide, and then alternately with five 1.4-ml. portions of methyl sulfate and five 1.7-ml. portions of the alkali. The solution was diluted with water (40 ml.) and allowed to stand. The oil which separated crystallized after several days. After recrystallization from methanol (0.33 g.) it melted at 95.5–97°.

Anal. Calcd. for $C_{12}H_{14}O_4$: C, 64.85; H, 6.35. Found: C, 64.83; H, 6.51.

A sample of dihydrovisnagimone (from visnaginone) was methylated in the same way. The product, m.p. 95–96°, did not depress the melting point of the sample prepared from the dihydroxy compound.

Anal. Found: C, 64.50; H, 6.7.

Monomethylation of 5-Acetyl-4,6-dihydroxycoumarane.—A mixture of 1.0 g. of 5-acetyl-4,6-dihydroxycoumarane, 2 ml. of methyl iodide, 2 g. of anhydrous potassium carbonate and 50 ml. of dry acetone was refluxed for 1.5 hours. The mixture was filtered and the residue left after evaporation of the filtrate recrystallized from dilute methanol. The product (0.7 g.) melted over the range 67–97°, and repeated recrystallization did not change this range. The melting-point range of a mixture of this mixture and authentic dihydrovisnagimone was 67–95°. The material gave a wine-red color with ferric chloride in alcohol.

Anal. Calcd. for $C_{11}H_{12}O_4$: C, 63.45; H, 5.81. Found: C, 63.37; H, 6.17.

Chromatographic Separation of the Monomethyl Ethers of 5-Acetyl-4,6-dihydroxycoumarane.—A solution of 1.7 g. of the mixture of monomethyl ethers, m.p. 67–97°, in 25 ml. of dry benzene was poured onto an alumina column previously wet with the solvent. Fresh benzene was added at the top of the column and the following fractions taken

Fraction	Vol., ml.	Wt. of residue, mg.	M.p., °C.
1	20	16	.....
2	10	515	s.65, 82–102
3	10	608	s.65, 69–86
4	10	115	s.64, 69–82[a]
5	10	49	.....
6	10	25	.....

[a] Mixed with dihydrovisnaginone, s.74°, m.p. 70–85°.

The column was extruded and the adsorbent extracted with methanol. Evaporation of this eluate yielded 171 mg. of a crystalline residue. Recrystallization from aqueous methanol gave 97 mg. of colorless needles, m.p. 98–100°. One more recrystallization raised the m.p. to 98.5–101°. When mixed with dihydrovisnaginone (from visnaginone) the

(20) Späth, Wessely and Kubiczek, *Ber.*, **70**, 243 (1937).

m.p. was unchanged (98.5–101°). Acetylation of the synthetic material yielded an acetate (see below) identical with that of dihydrovisnagimone: m.p. and mixed m.p. 98–100°.

Absorption spectra of synthetic and "natural" dihydrovisnaginone were determined in approximately 2.5×10^{-5} *M* solutions in (a) 95% ethanol and (b) 0.032 *N* sodium hydroxide solution. The absorption spectrum of dihydroallovisnaginone was measured at the same time and in the same way. A Beckman model DU ultraviolet spectrophotometer was used.

The isomeric 4-hydroxy-6-methoxy-5-acetylcoumarane (dihydroallovisnaginone) was isolated from fractions 2 and 3 from the chromatographic separation described above. These were rechromatographed in the same way; the first 40 ml. of eluate yielded 300 mg. of m.p. 100–105°. Mixed with dihydrovisnaginone, the m.p. was depressed to 74–85°. After recrystallization from aqueous methanol the near colorless, centimeter-long needles melted at 106–108°.

Anal. Calcd. for $C_{11}H_{12}O_4$: C, 63.45; H, 5.81. Found: C, 63.18; H, 5.94.

Dihydrovisnaginone Acetate.—A mixture of 4.0 g. of dihydrovisnaginone, 4 g. of anhydrous sodium acetate and 40 ml. of acetic anhydride was refluxed for 5 min. and then heated on the steam-bath for an hour. The reaction mixture was cooled and poured onto ice and the resulting colorless needles collected and recrystallized from aqueous methanol. The product (2.25 g.) melted at 98–100°.

Anal. Calcd. for $C_{13}H_{14}O_5$: C, 62.39; N, 5.64. Found: C, 62.13; H, 5.60.

Visnaginone (V).—A trace of benzoyl peroxide was added to a mixture of 920 mg. of dihydrovisnaginone acetate and 694 mg. of N-bromosuccinimide in 40 ml. of carbon tetrachloride. The mixture was heated; after about a minute of refluxing a red-brown color appeared and after another half-minute the solution was again colorless and hydrogen bromide began to appear at the condenser outlet. Refluxing was continued for 50 minutes by which time hydrogen bromide evolution had ceased. The mixture was cooled and filtered and the filtrate evaporated in an air stream. The nearly colorless oil which remained (1.34 g.) was heated for 3 hours with 15 ml. of freshly distilled dimethylaniline in a metal-bath held at 195–200°. The brown solution was cooled, diluted with ether and washed with three 30-ml. portions of 3 *N* sulfuric acid. Removal of the ether left a brown oil which was heated on the steam-bath for 30 minutes with a solution of 1.5 g. of potassium hydroxide in 20 ml. of aqueous (1:1) methanol. The solution was diluted with water, acidified and extracted with ether. The ether solution was washed with dilute acid and water, dried and evaporated. The residue was a yellow crystalline material weighing 634 mg. Recrystallization from dilute methanol afforded 444 ml. of bright yellow needles, m.p. 108–109°, not depressed upon admixture with authentic visnaginone. The compound gave a clear green color with alcoholic ferric chloride, identical with that given by visnaginone in a parallel test.

Visnaginone Acetate.—Acetylation of visnaginone with acetic anhydride–sodium acetate yielded the colorless acetate: white needles, m.p. 64.5–65.5°.

Anal. Calcd. for $C_{13}H_{12}O_5$: C, 62.90; H, 4.87. Found: C, 63.07; H, 5.12.

Both the synthetic and natural samples of visnaginone yielded the same acetate (m.p. and mixed m.p.).

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Analyses were performed by Mrs. Beatrice Kent (U.C.L.A.) and the Clark Microanalytical Laboratories, Urbana, Illinois.

Summary

The total synthesis of visnaginone has been accomplished, starting from phloroglucinol.

A new procedure for the conversion of a coumarane into a coumarone, employing N-bromosuccinimide, has been described.

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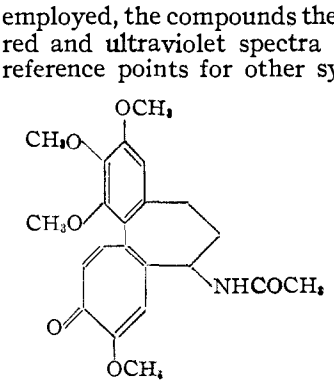
[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, WASHINGTON UNIVERSITY]

The Synthesis, Stereochemistry, and Infrared and Ultraviolet Spectra of Several Tricyclic Ketones Homologous with Ketoöctahydrophenanthrene[1]

BY C. DAVID GUTSCHE

As part of a program concerned with the synthesis of colchicine (I) and related compounds several tricyclic ketones of the general structure II have been made in the hope that the methods employed, the compounds themselves, and the infrared and ultraviolet spectra might serve as useful reference points for other syntheses in this series.



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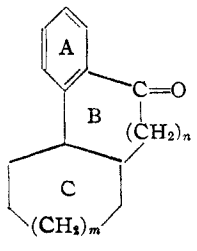

II

(1) This research was supported in part by a grant from the National Cancer Institute, U. S. Public Health Service.

Series A [Ring C Six-membered (m = 1); Ring B Five-, Six- and Seven-membered (n = 0, 1, 2)].—The ketones of series A were prepared by cyclization of *cis*-2-phenylcyclohexanecarboxylic (IIIa), -acetic (IVa), and -propionic (Va) acids and *trans*-2-phenylcyclohexanecarboxylic (IIIb), -acetic (IVb) and -propionic (Vb) acids, the preparation and stereochemistry of which have previously been described.[2]

Interesting differences in the ease of cyclization of the various acids were noted. Under the influence of anhydrous hydrogen fluoride only three of the six acids formed cyclic ketones. *cis*-2-Phenylcyclohexanecarboxylic acid (IIIa) formed 1,2,3,4,4a,9a-hexahydro-9-ketofluorene (VIa),[3] previously described by Cook and Hewett[4] and by

(2) Gutsche, THIS JOURNAL, **70**, 4150 (1948).

(3) We are indebted to Dr. Leonard T. Capell of *Chemical Abstracts* for advice concerning the nomenclature of the tricyclic ketones discussed in this paper.

(4) Cook and Hewett, *J. Chem. Soc.*, 62 (1936).