823. *A Novel Acetylation*

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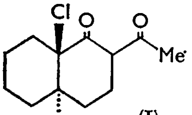
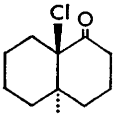
Boron fluoride-catalysed acetylation of 9-chloro-1-decalone furnishes two isomeric 6-methyl-*m*-dioxenones, incorporating, without rearrangement, all of the atoms of the starting material.

During work aimed at preparing model c/d ring systems of steroids, an attempted synthesis of 2-acetyl-9-chloro-1-decalone (I) from 9-chloro-1-decalone, (II) acetic anhydride, and boron trifluoride at 0° furnished two compounds, $C_{14}H_{19}O_3Cl$, m. p. 85° (polymorphic form, m. p. 71°), $\lambda_{max.}$ (in EtOH) 248 mμ ($\varepsilon = 6300$), and m. p. 105° (polymorphic form, m. p. 88°), $\lambda_{max.}$ (in EtOH) 251 mμ ($\varepsilon = 7400$). Both compounds absorbed strongly at 1727 and 1645 cm.$^{-1}$. On the basis of the ultraviolet spectra and chemical precedent [1] structures (III) and (IV) might be considered. However, the compounds were surprisingly stable to acid hydrolysis, and the infrared spectra did not bear a strong resemblance to the enol acetate prepared from 2-acetyl-1-decalone.

Attempts to hydrolyse these compounds to (I) yielded either tars or starting material. Nuclear magnetic resonance spectra of both compounds showed signals at 2·00 p.p.m. (doublet, $J = 0{\cdot}8$ c./sec.) and 5·17 p.p.m. (quartet, $J = 0{\cdot}8$, 1 proton). The signal at 2·00 p.p.m. appeared to be due to a methyl group. Unfortunately, interference from other protons prevented quantitative studies. This type of spectrum is similar to that observed for 2-methoxy-6-methyl-4-pyrone and 4-methoxy-6-methyl-2-pyrone. These two compounds have similar chemical shifts and also exhibit coupling constants of 0·8 c./sec. between the methyl group protons and the adjacent vinylic proton.


(I)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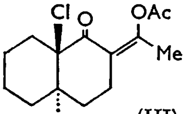
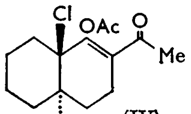

(III)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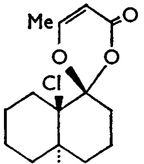
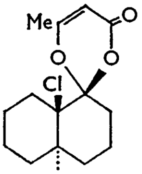
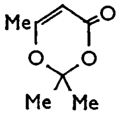

(V)


(VI)


(VII)

A mass spectrum showed major peaks at 150 and 68 mass units consistent with the presence of an octalone and a methacryloyl or crotonoyl unit. Treatment of either compound with 2,4-dinitrophenylhydrazine in ethanolic sulphuric acid furnished, after several hours, the 2,4-dinitrophenylhydrazone of Δ^9-octal-1-one. Upon treatment with the same reagent in acetic acid, 1 mole of acetone 2,4-dinitrophenylhydrazone was obtained.

Reduction with hydrogen at atmospheric pressure over 5% rhodium-on-alumina in ethyl acetate furnished two new dihydro-compounds which rapidly furnished Δ^9-octal-1-one derivatives but which no longer furnished acetone derivatives. Reduction of the dihydro-compound with sodium borohydride in methanol furnished 9-chloro-1-decalol in good yield. These observations lead us to suggest that the compounds are (V) and (VI). The compounds also furnish acetoacetanilide upon treatment with aniline in much the same manner as Carrol and Bader [2] observed for (VII). A comparison of the spectral properties of (VII) with compounds (V) and (VI) shows strong similarities throughout the range

[1] C. R. Hauser, F. W. Swamer, and J. T. Adams, " Organic Reactions," vol. 8, John Wiley and Sons, Inc., New York, 1954, p. 59.

[2] M. F. Carrol and A. R. Bader, *J. Amer. Chem. Soc.*, 1953, **75**, 5400.

1727 to 1040 cm.$^{-1}$. In addition, these authors also observed marked stability of (VII) to hydrolysis by acids.

The formation of (V) and (VI) appears to have resulted from formation of a *gem.*-diacetate and subsequent cyclisation. Acetylation of 1-decalone with boron trifluoride and acetic anhydride gave only 2-acetyl-1-decalone.[3] The difference in behaviour between (I) and 1-decalone appears to be due to the inductomeric effect of the chlorine. To the best of our knowledge this is the only example of an acid-catalysed acylation furnishing *meta*-dioxenones.

N.m.r. spectra were determined on a Varian A-60 spectrophotometer, tetramethylsilane being used as internal standard in deuterochloroform.

EXPERIMENTAL

Synthesis of Compounds (V) *and* (VI).—To a solution of 9-chloro-1-decalone (8·6 g.; 0·046 mole) (prepared by Warnhoff's method [4]) and acetic anhydride (67·2 g.; 0·66 mole; 13·5 mole excess) in dry methylene chloride (300 c.c.) was added with vigorous magnetic stirring gaseous boron trifluoride while the temperature was maintained between −5° and 5° (ice–brine) until the mixture was saturated (1·5—2·5 hr.). The mixture was thereafter stirred for ½ hr. When the temperature reached −10°, anhydrous sodium acetate (75 g.) in water (150 c.c.) were added and stirred overnight. The organic layer was separated and treated with water (500 c.c.) for 15 min. and then for 15 min. with saturated potassium hydrogen carbonate (750 c.c.). The organic layer was dried (Na_2SO_4) and concentrated at 20° in a rotatory evaporator to constant weight at 20 mm. pressure. The residual greenish-brown oil was evacuated overnight at 0·05 mm. The residue (13·2 g.) had $\lambda_{max.}$ (in EtOH) 251 m ($\varepsilon = 5650$) (on this basis the yield was between 82 and 97%). After chromatography on Florisil, the pure compounds (7·95 g.; 64%) were obtained, ranging from pure crystalline isomers to partially crystalline mixtures of the two. Chromatographic separation was accomplished on Florisil (2000 g.), washing with light petroleum (4 l.; b. p. 60—68°), 50 : 50 light petroleum–benzene (4 l.), 75 : 25 benzene–light petroleum (4 l.), and then collecting five 4-litre fractions eluted with ethyl ether. The ethyl ether fractions were concentrated to constant weight at 25°. The fractions were set aside for 14 days, then the noncrystalline material was washed away with ethanol. The isomers formed colourless monoclinic prisms (from ethanol), m. p. 84—85° (70—71°), $\lambda_{max.}$ 248 ($\varepsilon = 6300$) and m. p. 104—105° (86·7—87·6°), $\lambda_{max.}$ 251 ($\varepsilon = 7400$) [Found (m. p. 85°): C, 62·2; H, 7·0; Cl, 13·0. Found (m. p. 105°): C, 62·0; H, 6·9; Cl, 13·1. $C_{14}H_{19}O_3Cl$ requires C, 62·1; H, 7·1; Cl, 13·0%].

Δ^9-1-*Octalone* 2,4-*Dinitrophenylhydrazone from the m. p.* 105° (87°) *Compound*.—A solution of the compound (117 mg.), m. p. 103—105°, in ethanol (1 c.c.) upon treatment with 2,4-dinitrophenylhydrazine in ethanolic sulphuric acid (5 c.c.) was set aside for 3 days at room temperature. The precipitate was filtered off and washed with ice-cold ethyl ether (1 c.c.), and dried at 70°. The precipitate (79 mg.; 54%), had m. p. 257—258°, undepressed on admixture with authentic Δ^9-1-octalone-2,4-dinitrophenylhydrazone.

Hydrogenation of the m. p. 85° (71°) *Compound*.—A solution containing 365 mg. (1·41 mmole) of the compound, m. p. 83—85°, in ethyl acetate (100 c.c.) was added to an equilibrated suspension of 5% rhodium-on-alumina catalyst (300 mg.) in solvent (10 c.c.), and reduced at atmospheric pressure. After 12 hr., 31 c.c. of hydrogen had been taken up (theoretical, 30·3 c.c.). After filtration the solvent was removed at 20° using a rotary evaporator. The crystalline residue was maintained for 14 hr. at room temperature and 0·05 mm.; 316 mg. of material was obtained, m. p. 113·5—115°. The material was extremely unstable towards recrystallisation (Found: C, 61·4; H, 7·7; Cl, 12·8. $C_{14}H_{21}O_3Cl$ requires C, 61·6; H, 7·8; Cl, 13·0%).

Treatment of a sample of this compound with a solution of 2,4-dinitrophenylhydrazine in ethanolic sulphuric acid instantaneously yielded the 2,4-dinitrophenylhydrazone of Δ^9-1-octalone 2,4-dinitrophenylhydrazone.

Hydrogenation of the m. p. 105° (88°) *Compound*.—A crystal of the compound, m. p. 104—105° (343 mg.; 1·28 mmole) on reduction as for the m. p. 71° compound, required 28·7 c.c. of hydrogen (theoretical, 28·5 c.c.). After concentration, the residual oil crystallised spontaneously.

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[3] J. J. Korst, Ph.D. Dissertation, University of Wisconsin, Madison, U.S.A., 1959.

[4] E. Warnhoff, Ph.D. Dissertation, University of Wisconsin, Madison, U.S.A., 1953.

This material, m. p. 103·5—105°, was unstable and was not recrystallised (Found: C, 61·2; H, 8·0; Cl, 12·8. $C_{14}H_{21}O_3Cl$ requires C, 61·6; H, 7·8; Cl, 13·0%).

The compound reacted instantaneously with a solution of 2,4-dinitrophenylhydrazine in ethanolic sulphuric acid to yield the 2,4-dinitrophenylhydrazone of Δ^9-1-octalone.

9-*Chloro*-1-*decalol from the m. p.* 115° *Dihydro-compound.*—To a cold solution of " dihydro-m. p. 85° compound " (220 mg.; 0·815 mmole), m. p. 113·5—115°, in methanol (10 c.c.) was added one drop of 5N-sodium hydroxide and sodium borohydride (198 mg.; 5·35 mmole). The mixture was kept at 2° for 12 hr. and then cold concentrated hydrochloric acid (2 c.c.) was added. The solution was diluted to 50 c.c. with methylene chloride and filtered. The organic layer was dried (Na_2SO_4), and after evaporation under a stream of nitrogen at room temperature yielded a light-yellow solid (131 mg.) which crystallised in clusters of needles, m. p. 63—69° [after sublimation, 73—74°; (lit.,[5] 64—69°), and after extensive purification 74—75°]. The infrared spectra of the material and of an authentic sample were superimposable.

Production of Acetoacetanalide from the m. p. 88° (105°) *Compound.*—To xylene (20 c.c.) was added the m. p. 87° compound (330 mg.; 1·22 mmole), m. p. 102—105°, aniline (0·25 c.c.) (Baker and Adamson Reagent), and diethanolamine (0·05 c.c.) (Matheson, Coleman and Bell, white label). The mixture was refluxed for 2 hr. under nitrogen, cooled, and extracted twice with 0·2N-sodium hydroxide (20 c.c.). The alkali extracts were combined and acidified with cold concentrated hydrochloric acid, and the resulting solution was extracted with methylene chloride (2 × 25 c.c.). The organic extracts were combined and dried (Na_2SO_4 and then decanted, and sparged to dryness under a stream of nitrogen at 35°. The crystalline material, dried at room temperature/0·05 mm. for 12 hr., weighed 67 mg. (34·2%), m. p. 80—83°, mixed m. p. 81—83° with an authentic sample (m. p. 82—83°). The material gave a very strong ferric chloride test, green in high dilution, wine-red in higher concentrations. The infrared spectrum was superimposable with that of an authentic sample.

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[5] Dr. V. J. Bauer, personal communication.