

202. *Studies in the Polyene Series. Part XL.* Preparation and Properties of 2-Acetyl-1 : 3 : 3-trimethylcyclohexene.*

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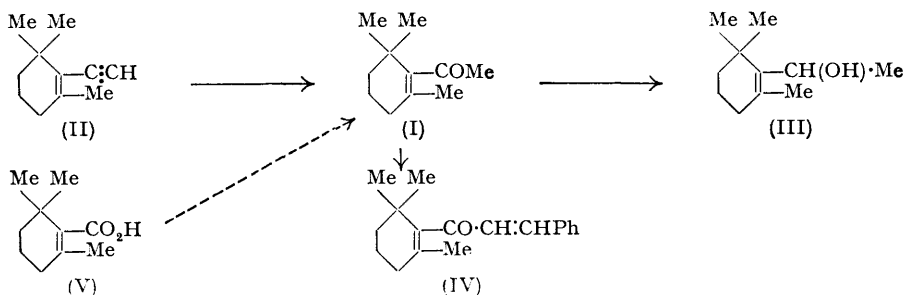
2-Acetyl-1 : 3 : 3-trimethylcyclohexene (I) has been prepared by hydration of 2-ethynyl-1 : 3 : 3-trimethylcyclohexene. This $\alpha\beta$ -unsaturated ketone exhibits unprecedentedly low-intensity light absorption in the 2400 Å region, and does not yield derivatives with the usual carbonyl reagents.

IN the course of an investigation concerned with the somewhat unusual light-absorption properties of β -ionone and its derivatives, Braude, Jones, Koch, Richardson, Sondheimer, and Toogood (*J.*, 1949, 1890) noted that the introduction of a methyl group into the 2-position in 1-acetylcyclohexene markedly decreases the intensity of light absorption in the 2400 Å. region (see Table), a finding that has been confirmed by Turner and Voitle (*J. Amer. Chem. Soc.*, 1951, **73**, 1403). Chanley (*ibid.*, 1948, **70**, 244) had earlier shown that replacement of the hydrogen atoms in the 6-position of 1-acetylcyclohexene by a *gem*-dimethyl grouping only very slightly lowered the absorption intensity relatively to that of the parent compound. It therefore seemed of interest to prepare and examine the properties of 2-acetyl-1 : 3 : 3-trimethylcyclohexene (I), a compound containing both of the above-mentioned structural features, as well as being the lower vinylogue of β -ionone.

A likely method for preparing this ketone seemed to be the hydration of 2-ethynyl-1 : 3 : 3-trimethylcyclohexene (II) (Sobotka and Chanley, *ibid.*, 1949, **71**, 4136). Treatment

* Part XXXIX, *J.*, 1951, 3099.

of the freshly purified hydrocarbon either with the methanol-boron trifluoride-mercuric oxide hydration catalyst described by Hennion and Zoss (*ibid.*, 1941, 63, 1151) or with hot formic acid gave the desired ketone (I), although the yield and quality were somewhat better in the former method. Careful fractional distillation of the product obtained by either method revealed that the main bulk was homogeneous—the product thus obtained giving correct analyses for a compound of structure (I).



The usual procedure for further purifying a carbonyl compound *via* a crystalline derivative could not be employed since the ketone did not react with semicarbazide, hydroxylamine, or 2 : 4-dinitrophenylhydrazine. However, the presence of a carbonyl group was established (a) by its infra-red absorption spectrum (determined by the late Dr. H. P. Koch), in which a carbonyl stretching band was readily discerned at 1693 cm^{-1} , (b) by lithium aluminium hydride reduction, which afforded the crystalline alcohol (III), which readily formed an acetate, and (c) by reaction with benzaldehyde in the presence of alkali, which gave the crystalline benzylidene compound (IV). The presence of one double bond was confirmed by perbenzoic acid titration of the alcohol (III), a band in the double-bond stretching frequency region also being detected in the infra-red spectrum of (I). The ketone (I) gave a negative iodoform test under the conditions given by Fuson and Tullock (*ibid.*, 1934, 56, 1638), a result that cannot be ascribed to steric hindrance alone, for 1-acetylcyclohexene itself is very reluctant to give iodoform under these conditions.

	Ultra-violet			Infra-red (cm^{-1})	
	λ_{max} , Å	ϵ_{max}	Ref.	$\text{C}=\text{O}$	$\text{C}=\text{C}$
1-Acetylcyclohexene	2320 3080	12 500 } 50 J	1	1663	1638
2-Acetyl-1-methylcyclohexene	2450 2490	6 500 * 6 890 *	2 3	1686	1620
2-Acetyl-3 : 3-dimethylcyclohexene	2320	12 000 *	4	—	—
2-Acetyl-1 : 3 : 3-trimethylcyclohexene ...	2430 3050	1 400 } 90 J	5	1693	1650

* Only principal band given.

(1) Hamlet, Henbest, and Jones, *J.*, 1951, 2652. (2) Braude *et al.*, *loc. cit.* (3) Turner and Voitle, *loc. cit.* (the infra-red data for this compound are also from this paper). (4) Chanley, *loc. cit.* (5) This paper.

Before the ultra-violet light-absorption properties of (I) could be usefully compared with those of related compounds it was necessary to show that no appreciable amounts of impurities were present in the product obtained by distillation. The homogeneity on distillation indicated that the lower-boiling (ring) $\beta\gamma$ -unsaturated isomer was absent (some of the corresponding $\beta\gamma$ -isomer is always formed in the preparation of 1-acetyl-2-methylcyclohexene), and further evidence for the absence of any but small quantities of this isomer was obtained by examination of the infra-red absorption spectrum, in which bands that would be shown by the trisubstituted double bond were absent. The absence of the isomeric unsaturated aldehyde (see p. 1152), which might be formed to some extent by the reversal of the direction of hydration, had already been demonstrated by the negative 2 : 4-dinitrophenylhydrazine test and was further confirmed by a negative Schiff's test. The relatively

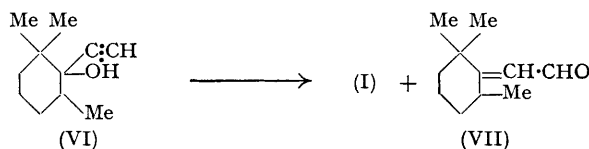
sharp melting point of the ketone (-8° to -4°) also suggested that impurities, if present, could only be there in quite small quantities.

An unsuccessful attempt was made to prepare the ketone (I) by the action of methyl-lithium on β -cyclogeranic acid (V). Prolonged reaction periods together with a large excess of organometallic reagent gave only unchanged (V). Conversion of an acid into the corresponding methyl ketone can be envisaged as taking place by addition of the reagent to the (potential) carbonyl group present in the initially formed lithium salt of the acid. In the present instance, the three methyl groups prevent the approach of the methyl-lithium, and thus another example is provided of the lack of carbonyl reactivity in this type of structure.

The ultra-violet absorption properties of 2-acetyl-1 : 3 : 3-trimethylcyclohexene are given in the table. The exceptionally low intensity of the main absorption band is, it is believed, unique for an $\alpha\beta$ -unsaturated carbonyl compound, and is clearly due to steric inhibition of resonance, the three (ring) methyl groups forcing the acetyl group out of the plane of the cyclohexene ring. Conjugation of the double bond with the carbonyl group is thus considerably restricted—this is also reflected in the value of the carbonyl stretching frequency in the infra-red, which approaches that of a saturated ketone ($\sim 1708\text{ cm.}^{-1}$ in methyl ketones), and to a lesser extent by the displacement to a shorter wave-length (3050 Å) of the R band in the ultra-violet absorption spectrum, compared with that of 1-acetylcyclohexene (3080 Å). The absence of appreciable amounts of $\beta\gamma$ -isomer in the hydration product (notably that from the formic acid treatment) can also be explained by the weakness of the conjugation, the activating influence of the carbonyl group not being transmitted by the double bond to the $C_{(3)}$ carbon atom carrying the hydrogen atom(s) potentially capable of undergoing prototropic rearrangement. The similarity between the ultra-violet absorption spectra of the benzylidene compound (IV) and benzylideneacetone (see Experimental) is another manifestation of the weakness of the conjugation in this system.

Much controversy surrounds the preferred geometrical configuration of 1-acetylcyclohexenes carrying an alkyl group in the 2-position (Braude *et al.*, *loc. cit.*; Turner and Voitle, *loc. cit.*), *i.e.*, whether such compounds exist predominantly in the *s-trans*- or *s-cis*-form. Examination of models of 2-acetyl-1 : 3 : 3-trimethylcyclohexene indicates that there is less hindrance in the *s-cis*-configuration; thus the acetyl group in (I) probably occupies a position somewhat twisted out of the plane of the ring from the *s-cis*-configuration.

Another potential route to the ketone (I) was by formic acid isomerisation of (VI). This type of reaction, which gives, for example, a good yield of 1-acetylcyclohexene from 1-ethynylcyclohexanol, is known to proceed by dehydration, followed by hydration of the triple bond (Hamlet, Henbest, and Jones, *loc. cit.*). Heating the carbinol (VI) with formic acid did not give a product homogeneous on distillation,



although the main bulk exhibited light absorption similar to that of the trimethyl ketone (I), but with slightly higher intensity. The presence of a second carbonyl compound was demonstrated by a positive Schiff's test and by the ready formation of a crystalline 2 : 4-dinitrophenylhydrazone, suitable treatment of the total product affording a 9% yield (based on VI) of this derivative. This compound, which displayed the typical light absorption of those derived from $\alpha\beta$ -unsaturated carbonyl compounds (Braude and Jones, *J.*, 1945, 498), was clearly the unsaturated aldehyde (VII), formed by 1 : 3-anionotropic shift of the hydroxyl group. Chanley (*loc. cit.*) isolated, by careful distillation, a 0.8% yield of cyclohexylideneacetaldehyde from formic acid-isomerised 1-ethynylcyclohexanol, and this competing reaction proceeded to the extent of 6% with 1-ethynyl-2 : 2-dimethylcyclohexanol (Chanley, *loc. cit.*), probably owing to the greater difficulty of dehydrating the more heavily methylated ethynylcarbinols (Hamlet, Henbest, and Jones, *loc. cit.*), rearrangement of the hydroxyl group thus being relatively facilitated. Even greater yields of unsaturated

aldehydes result from certain aromatic ethynylcarbinols in which dehydration cannot take place (Clapperton and MacGregor, *J. Amer. Chem. Soc.*, 1950, **72**, 2501). The physical properties of the unreacted material recovered from the 2 : 4-dinitrophenylhydrazine treatment of isomerised (VI) agreed closely with those of 2-acetyl-1 : 3 : 3-trimethylcyclohexene, which was thus the major product of the reaction.

EXPERIMENTAL

(M. p.s were determined on a Kofler block and are corrected; the light-absorption data were determined in ethanol solution with a Beckman spectrophotometer unless stated otherwise.)

2-Acetyl-1 : 3 : 3-trimethylcyclohexene (I).—(a) *Boron trifluoride method.* A catalyst solution, prepared by warming together mercuric oxide (0.5 g.), trichloroacetic acid (0.08 g.), and boron trifluoride-ether (0.5 c.c.) in methanol (1.75 c.c.), was added to freshly purified 1-ethynyl-2 : 6 : 6-trimethylcyclohexene (5.2 g.) (Sobotka and Chanley, *loc. cit.*) in methanol (90 c.c.). No apparent reaction was observed on warming the reaction mixture, which was heated under reflux for one hour and then kept at room temperature overnight. Potassium carbonate (5 g.) was added, and the solution filtered. The filtrate and ether washings were evaporated under reduced pressure to remove most of the methanol, and the product was then isolated with ether. Distillation gave the homogeneous ketone (3.0 g.), b. p. 87—89°/16 mm., n_D^{25} 1.4778 (Found: C, 79.3; H, 10.7. $C_{11}H_{18}O$ requires C, 79.5; H, 10.9%). Light absorption: see table.

(b) *Formic acid method.* Freshly-prepared 2-ethynyl-1 : 3 : 3-trimethylcyclohexene (5.2 g.) was heated under reflux with 90% formic acid (17.2 g.) for one hour, the solution becoming brown. Isolation with ether followed by distillation gave the ketone (2.9 g.), b. p. 86.5—89°/17 mm., n_D^{25} 1.4794.

(c) *From 1-ethynyl-2 : 2 : 6-trimethylcyclohexanol.* A solution of this alcohol [5 g.; mixture of stereoisomers obtained from 2 : 2 : 6-trimethylcyclohexanone and sodium acetylide (cf. Sobotka and Chanley, *loc. cit.*)] in 90% formic acid was heated under reflux for one hour, the solution becoming dark green. Isolation with ether gave a product (3.8 g.), b. p. 85—90°/18 mm., n_D^{25} 1.4820. Light absorption: Maximum, 2360 Å; $\epsilon = 1950$. A portion (1 g.) of this product was added to 2 : 4-dinitrophenylhydrazine reagent [20 c.c. of a solution of the base (2 g.) in sulphuric acid (7 c.c.) and methanol (100 c.c.)], a red precipitate appearing after 20 minutes. After the mixture had been kept overnight, the precipitate was removed by filtration (see below), and the non-reacted product isolated with ether. Distillation gave almost pure trimethylketone (0.72 g.), b. p. 88—90°/20 mm., n_D^{25} 1.4775. Light absorption: Maximum, 2440 Å; $\epsilon = 1350$.

The above derivative was purified by chromatography on alumina; elution of the main band gave 2 : 2 : 6-trimethylcyclohexylideneacetaldehyde 2 : 4-dinitrophenylhydrazone (190 mg., 9%). Recrystallisation from ethyl acetate-chloroform gave vermilion needles, m. p. 214—215° (Found: N, 15.95. $C_{17}H_{22}O_4N_4$ requires N, 16.1%). Light absorption (in chloroform): Maxima, 2600 and 3800 Å; $\epsilon = 16\ 100$ and $31\ 500$, respectively.

1-Hydroxy-1-2' : 6' : 6'-trimethylcyclohex-1'-enylethane (III).—A solution of 2-acetyl-1 : 3 : 3-trimethylcyclohexene (540 mg.) in dry ether (25 ml.) was added to a solution of lithium aluminium hydride (300 mg.) in dry ether (15 c.c.), the mixture then being heated under reflux for 3 minutes. 2N-Sulphuric acid was added to the cooled mixture, and the product was isolated with ether. Distillation gave the carbinol (430 mg., 80%), b. p. ca. 100°/17 mm., n_D^{25} 1.4918. This product solidified after being kept for 2 days at -8° , and after three recrystallisations from *n*-pentane (with cooling to -60°) the carbinol was obtained as needles, m. p. 38—38.5° (Found: C, 78.35; H, 11.9. $C_{11}H_{20}O$ requires C, 78.5; H, 11.95%).

1-Acetoxy-1-2' : 6' : 6'-trimethylcyclohex-1'-enylethane.—The carbinol (130 mg.) was dissolved in dry pyridine (10 ml.) and acetic anhydride (5 ml.), and the solution kept at 20° overnight. The excess of anhydride was decomposed by shaking the solution with water, the temperature being kept below 20° by external cooling. The product was isolated with ether; distillation then gave the acetate (147 mg., 90%), n_D^{25} 1.4700 (Found: C, 73.15; H, 10.4. $C_{13}H_{22}O_2$ requires C, 72.6; H, 10.6%).

Condensation of 2-Acetyl-1 : 3 : 3-trimethylcyclohexene with Benzaldehyde.—The ketone (0.57 g.) and benzaldehyde (0.31 g., 0.93 mole) were dissolved in a mixture of ethanol (3 c.c.) and aqueous 2N-potassium hydroxide (1 c.c.), the solution then being warmed at 40° for 15 minutes. Isolation with ether followed by distillation gave unchanged ketone (0.23 g.) together with the crude benzylidene derivative (0.20 g.), b. p. 230—240°/0.001 mm., n_D^{25} 1.5521. This

product crystallised when kept at -8° overnight; recrystallisation from methanol-water (4 : 1) then gave the pure *benzylidene* compound (IV) as pale yellow needles (130 mg.), m. p. $49.5-51^{\circ}$ (Found : C, 85.0; H, 8.95. $C_{18}H_{22}O$ requires C, 85.0; H, 8.7%).

Light-absorption data.

	Benzylidene derivative (IV)		Benzylideneacetone *	
	λ , Å	ϵ	λ , Å	ϵ
Max.	2230	10 500	2200	12 000
Min.	2400	1 500	2370	1 600
Max.	2930	23 100	2870	22 700

* Wilds *et al.* (*J. Amer. Chem. Soc.*, 1947, **69**, 1985).

The authors thank Professor E. R. H. Jones, F.R.S., for his interest in the work described in this and the following paper, and to Dr. B. A. Hems of Glaxo Laboratories Ltd. for generous gifts of materials. One of them (G. W.) thanks the Ministry of Education for a F.E.T.S. Grant.

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[Received, November 14th, 1951.]