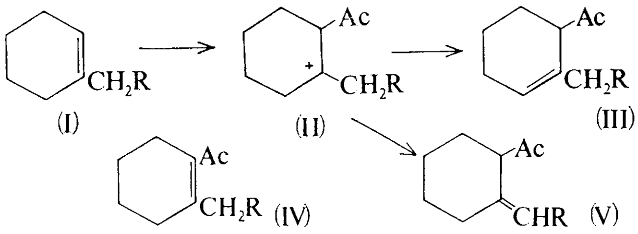
Aliphatic Friedel-Crafts Reactions. Part VI.[1] Preparation of βγ-Unsaturated Ketones by the Acetylation of Substituted Cyclohexenes

By **J. K. Groves** and **N. Jones,*** Chemistry and Metallurgy Department, Lanchester College of Technology Priory Street, Coventry

Reaction of 1-alkylcyclohexenes with zinc chloride–acetic anhydride produces 6-acetyl-1-alkylcyclohexenes in good yields, together with small amounts of the isomeric 1-acetyl-2-alkylidenecyclohexanes. Hydrogenation of of the unstaturated ketones readily affords 1-acetyl-2-alkylcyclohexanes.

INTERACTION of cyclohexene and zinc chloride–acetic anhydride has been shown to afford 1-acetylcyclohexene as the major product.[2,3] In contrast, Deno and Chafetz[4] found that acetylation of 1-methylcyclohexene under similar conditions provided the βγ-unsaturated ketone (III; R = H). This paper reports further examples of the zinc chloride-catalysed acetylation of 1-alkylcyclohexenes (I; R = Me, Et, Pr^n, or Bu^n) to provide the βγ-unsaturated ketones (III) in 50—70% yield and, unlike the acetylation of 1-methylcyclohexene, smaller amounts of the isomeric ketones (IV). In no instance was the αβ-unsaturated ketone (V) formed. The products have been quantitatively hydrogenated to the corresponding 1-acetyl-2-alkylcyclohexanes.



Nenitzescu[5] has reviewed the mechanisms proposed to account for the formation of βγ-unsaturated ketones in Friedel-Crafts acylation reactions. Such π-bond orientation may alternatively be accounted for by acylium ion attack from an axial direction followed by ejection of the quasi-axial γ-proton from the short-lived ion (II). Elimination of the quasi-axial proton is favoured by the efficient intermergence[6] of the disappearing sp^3- and *p*-orbitals on the γ- and β-carbons respectively when they form a π-bond.

The interaction of the alkyl-cyclohexenes with zinc chloride–acetic anhydride afforded mixtures of two ketones (*ca.* 4 : 1) which were isolated either by preparative g.l.c. or by regeneration from purified semicarbazones. The major component obtained from the acetylation of 1-ethylcyclohexene was assigned the structure (III; R = Me) on the basis of n.m.r. bands corresponding to a single olefinic proton, an acetyl group, and a methyl absorption split into a triplet by an adjacent methylene. The n.m.r. spectrum of the minor component differed in that the methyl absorption appeared as a doublet, consistent with structure (IV; R = Me). Confirmation of the above structural assignments was provided by hydrogenation of the mixture of the two ketones to a single compound, 1-acetyl-2-ethylcyclohexane. On a similar basis, structures (III) and (IV) are assigned to the ketone products obtained from the other alkyl-cyclohexenes reported in this paper.

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[1] Part V, N. Jones, E. J. Rudd, and H. T. Taylor, *J. Chem. Soc.*, 1963, 2354.

[2] O. C. Dermer and D. Simpson, *Chem. Abs.*, 1955, **49**, 8098.

[3] V. N. Belov, T. A. Rudolfi, and G. Z. Shekhtman, *Doklady Akad. Nauk S.S.S.R.*, 1953, **88**, 979.

[4] N. C. Deno and H. Chafetz, *J. Amer. Chem. Soc.*, 1952, **74**, 3940.

[5] C. D. Nenitzescu, 'Friedel-Crafts and Related Reactions,' ed. G. A. Olah, John Wiley, London, 1964, vol. III, pt. 2, p. 1038.

[6] D. V. Banthorpe, 'Elimination Reactions,' Elsevier, Amsterdam, 1965.

TABLE

6-Acetyl-1-alkylcyclohexene semicarbazones

				Found (%)				Calc. (%)		
R	M.p.	$\lambda_{max.}$ (mμ)	ε	C	H	N	Formula	C	H	N
H	148—149° *	227	12,500	61·8	8·8	21·6	$C_{10}H_{17}N_3O$	61·6	8·7	21·5
Me	121—122	227	12,000	63·0	9·2	20·0	$C_{11}H_{19}N_3O$	63·2	9·1	20·1
Et	131—131·5	227	12,100	64·7	9·2		$C_{12}H_{21}N_3O$	64·6	9·4	
Pr^n	98—99	227	12,100	65·8	9·8		$C_{13}H_{23}N_3O$	65·8	9·7	

* Lit. values,[4,7,8] 153—155°, 160—162°, and 148—150° raised on admixture with $\alpha\beta$-unsaturated isomer.

1-Acetyl-2-alkylcyclohexane semicarbazones

		Found (%)				Calc. (%)		
R	M.p.	C	H	N	Formula	C	H	N
Me	174—174·5°	62·6	9·95	20·0	$C_{11}H_{21}N_3O$	62·6	9·95	19·9
Et	152—153	64·1	10·1	18·7	$C_{12}H_{23}N_3O$	64·0	10·2	18·7
Pr^n	122·5—123·5	65·2	10·5	17·7	$C_{13}H_{25}N_3O$	65·3	10·5	17·6
Bu^n	161·5—162	66·3	10·7		$C_{14}H_{27}N_3O$	66·4	10·7	

6-Acetyl-1-alkylcyclohexenes

	τ values				Found (%)			Calc. (%)	
R	C=C–H	$CH_3CO{\cdot}CH$	$CO{\cdot}CH_3$	CH_3	C	H	Formula	C	H
H	4·40m	7·02m	7·95s	8·40m	77·9	9·8	$C_9H_{14}O$	78·3	10·1
Me	4·40m	7·00m	7·95s	9·02t (*J* 8 c./sec.)	78·9	10·9	$C_{10}H_{16}O$	78·9	10·5
Et	4·40m	7·00m	7·95s	9·02t (*J* 7 c./sec.)	79·5	10·6	$C_{11}H_{18}O$	79·5	10·8
Pr^n	4·40m	6·98m	7·95s	9·10t (*J* 6 c./sec.)	79·6	11·1	$C_{12}H_{20}O$	80·0	11·1
Bu^n	4·40m	6·98m	7·95s	9·10t (*J* 6 c./sec.)	80·1	11·0	$C_{13}H_{22}O$	80·4	11·3

m = Multiplet, s = singlet, t = triplet.

EXPERIMENTAL

Spectroscopic Measurements.—N.m.r. spectra were determined for 5—10% solutions in carbon tetrachloride using a 60 Mc. Perkin-Elmer R10 spectrometer. Liquid films were used for i.r. spectra and u.v. absorptions were determined for methanol solutions.

Gas Chromatography.—Analytical g.l.c. of the products was carried out on a Pye Panchromatograph using a 9 ft. 10% silicone gum (SE 30) column at 140° and/or a 9 ft. 10% polyethylene–glycol adipate column at 180°. The purity of the cycloalkenes was confirmed using the former column at 80°. Preparative g.l.c. was carried out on a Wilkens Autoprep A700 with a 20 ft. column containing 10% diethylene glycol-adipate cross-linked with pentaerythritol (L.A.C.) operating at 165°.

Cycloalkenes.—Grignard reactions between cyclohexanone and alkylmagnesium bromides provided 1-alkylcyclohexanols in 45—75% yields. Dehydration of the alcohols with phosphoric acid and subsequent fractional distillation afforded pure 1-alkylcyclohexenes in 65—90% yields.

Reaction of Acetic Anhydride with Cycloalkenes.—Finely divided zinc chloride (0·11 mole) was added to a stirred solution of the cycloalkene (0·10 mole) in acetic anhydride (0·25 mole) during 20 min., the temperature being maintained at 0—3°. The cooled solution was stirred for a further 12 hr., poured into ice–water, and then ether extracted. The organic layer was washed with dilute sodium hydrogen carbonate solution and water, dried ($MgSO_4$), and the ether was removed. The residue was distilled under reduced pressure.

1-*Methylcyclohexene*.—The reaction carried out as above provided 6-acetyl-1-methylcyclohexene (11·0 g.), b.p. 66—69°/8 mm., n_D^{25} 1·4740, $\nu_{max.}$ 1706s (C=O stretching) and 1661w cm.$^{-1}$ (C=C stretching). A sample (1·00 g.) in ethanol absorbed hydrogen (155 ml. corr. to S.T.P. Calc. for $C_9H_{14}O$: 1 mole, 162 ml.) in the presence of palladium to provide 1-acetyl-2-methylcyclohexane; semicarbazone m.p. 182—183° (lit.,[9] 182—182·5°).

1-*Ethylcyclohexene*.—The reaction provided a liquid (8·5 g.), b.p. 98—102°/20 mm., consisting of two components in *ca.* 4 : 1 proportion (g.l.c.). Steam distillation of the semicarbazone of the major acetylation product with twice its weight of phthalic anhydride afforded pure 6-*acetyl*-1-*ethylcyclohexene*, n_D^{25} 1·4722, $\nu_{max.}$ 1705s and 1662w cm.$^{-1}$ (unspecified assignments here and below are as stated in the preceding paragraph).

The minor component, 1-*acetyl*-2-*ethylidenecyclohexane*, was isolated by preparative g.l.c. (Found: C, 79·3; H, 10·6. $C_{10}H_{16}O$ requires C, 79·5; H, 10·8%), n_D^{21} 1·4771, $\nu_{max.}$ 1707s and 1663w cm.$^{-1}$ N.m.r. bands at τ 4·40 (m, C=CH), 7·00 (AXY type quartet, $CH{-}CO{\cdot}CH_3$, J (H–H$_{eq}$) 7 c./sec. J (H–H$_{ax}$) 14 c./sec.), 8·00 (s, $CO{\cdot}CH_3$), and 8·90 (d, $C{=}CH{\cdot}CH_3$, J 8 c./sec.).

Hydrogenation of the mixed product as above afforded a single compound (g.l.c.).

1-*acetyl*-2-*ethylcyclohexane*, n_D^{25} 1·4561 (Found: C, 77·9; H, 11·7. $C_{10}H_{18}O$ requires C, 77·9; H, 11·7%), $\nu_{max.}$ 1706 cm.$^{-1}$. N.m.r. bands at τ 7·15 (m, $CH{-}CO{\cdot}CH_3$), 7·98 (s, $CO{\cdot}CH_3$), and 9·08 (t, CH_2CH_3, J 7 c./sec.).

1-*n*-*Propylcyclohexene*.—Reaction afforded a liquid (10·0 g.), b.p. 102—106°/11 mm., containing two components in

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[7] R. B. Turner and D. M. Voitle, *J. Amer. Chem. Soc.*, 1951, **73**, 1403.

[8] E. A. Braude, E. R. H. Jones, H. P. Koch, R. W. Richardson, F. Sondheimer, and J. B. Toogood, *J. Chem. Soc.*, 1949, 1890.

[9] R. B. Turner, *J. Amer. Chem. Soc.*, 1950, **72**, 879.

ca. 4 : 1 proportion (g.l.c.). The major product, 6-*acetyl*-1-*n-propylcyclohexene*, n_D^{20} 1·4708, $\nu_{max.}$ 1705s and 1660w cm.$^{-1}$, was regenerated from its semicarbazone as described above. The minor component, 1-*acetyl*-2-*propylidenecyclohexane*, was isolated by preparative g.l.c. (Found: C, 79·2; H, 10·6. $C_{11}H_{18}O$ requires C, 79·5; H, 10·8%), n_D^{25} 1·4702, $\nu_{max.}$ 1706s and 1665w cm.$^{-1}$. Hydrogenation of the mixed product as above afforded a single compound (g.l.c.), 1-*acetyl*-2-*n-propylcyclohexane*, n_D^{21} 1·4569, $\nu_{max.}$ 1706 cm.$^{-1}$.

1-*n-Butylcyclohexene*.—Reaction afforded a liquid (12·0 g.), b.p. 95—100°/6 mm. containing two components in *ca.* 4 : 1 proportion (g.l.c.). The major product, 6-*acetyl*-1-*n-butylcyclohexene*, was isolated by preparative g.l.c., n_D^{25} 1·4700, $\nu_{max.}$ 1705s and 1661w cm.$^{-1}$. Hydrogenation of the mixed product afforded a single compound, 1-*acetyl*-2-*n-butylcyclohexane*, n_D^{20} 1·4591, $\nu_{max.}$ 1705s cm.$^{-1}$.

1-*n-Pentylcyclohexene*.—Reaction afforded a liquid (15·9 g.), b.p. 128—130°/8 mm. containing two components in *ca.* 4 : 1 proportion (g.l.c.). The major component, 6-*acetyl*-1-*n-pentylcyclohexene*, was isolated by preparative g.l.c., n_D^{22} 1·4681, $\nu_{max.}$ 1705s and 1660 cm.$^{-1}$. Hydrogenation of the mixed product afforded 1-*acetyl*-2-*n-pentylcyclohexane*, n_D^{21} 1·4600, $\nu_{max.}$ 1706s cm.$^{-1}$.

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