

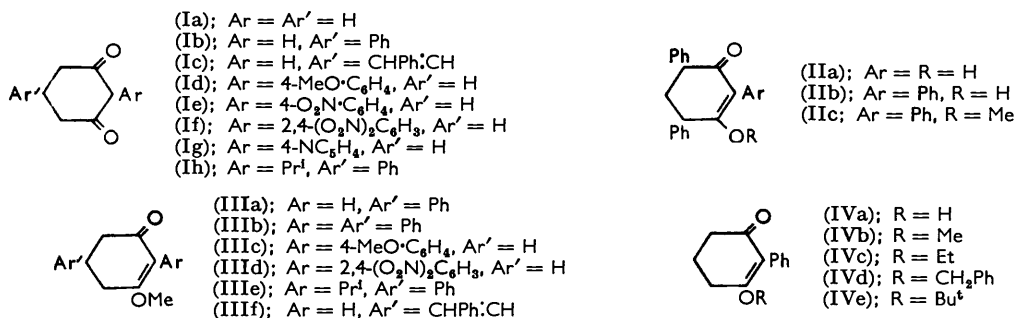
651. Cyclohexane-1,3-diones. Part VI.¹ Structural Requirements for the Displacement of the Alkoxy by the Cyano-group in the Enol Ethers of Cyclic β -Diketones.

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A series of β -diketones have been prepared and converted into the corresponding enol ethers. The replacement of the alkoxy group by a cyano-group by treatment with acetone cyanohydrin has been studied, and the reaction shown to be restricted to the alkyl enol ethers of 2-arylcycloalkane-1,3-diones.

THE structural requirements for the reaction of enol ethers of cyclohexane-1,3-diones with acetone cyanohydrin, reported in Parts II² and V,¹ have now been elucidated.

Cyclohexane-1,3-dione (Ia) and its 5-phenyl- (Ib),³ 4,6-diphenyl- (IIa),⁴ and 5-styryl- (Ic)⁵ derivatives were converted into the corresponding methyl enol ethers with diazomethane but all four enol ethers were recovered unchanged from attempted reactions with acetone cyanohydrin. When 3-methoxy-5-phenylcyclohex-2-en-1-one (IIIa) was used, a small quantity of 2,2,5,5-tetramethyl-4-oxazolidone^{6,7} was isolated as by-product. The inability of these enol ethers to undergo exchange, in contrast to 3-methoxy-2,5-diphenylcyclohex-2-en-1-one (IIIb), suggests that a phenyl group or possibly some other substituent in the 2-position is a prerequisite for reaction.



2-Phenylcyclohexane-1,3-dione (IVa) was converted into the methyl enol ether (IVb) by Born, Pappo, and Szmuskovicz's method.⁸ The ethyl enol ether (IVc) was obtained by treatment of the sodio-derivative of the dione (IVa) with ethyl iodide, since reaction of the dione with ethyl orthoformate gave unchanged material. The benzyl enol ether (IVd) was similarly prepared from the potassio-derivative and benzyl chloride. The dione (IVa) with phosphorus trichloride gave 3-chloro-2-phenylcyclohex-2-en-1-one (V), but an attempt to convert this into the t-butyl enol ether (IVe) by treatment with potassium t-butoxide gave an unidentified compound, C₂₄H₂₀O₂.

All three enol ethers (IVb), (IVc), and (IVd) underwent exchange with acetone cyanohydrin at room temperature to give 3-cyano-2-phenylcyclohex-2-en-1-one (VIa) in similar yield, thus showing the necessity for a 2-substituent and indicating that the nature of the alkoxy group had little if any effect on the displacement. Treatment of this cyano-ketone (VIa) with more acetone cyanohydrin at 90° afforded a small quantity of material which,

¹ Part V, *J.*, 1961, 1683.

² Part II, Ames and Davey, *J.*, 1957, 3480.

³ Vorlander, *Ber.*, 1894, **27**, 2053.

⁴ Ames and Davey, *J.*, 1958, 1794.

⁵ Vorlander, *Annalen*, 1896, **294**, 273.

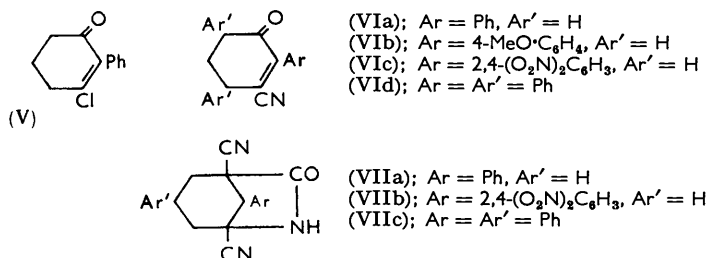
⁶ Ultee, *Rec. Trav. chim.*, 1909, **28**, 259.

⁷ Snyder and Elston, *J. Amer. Chem. Soc.*, 1954, **76**, 3039.

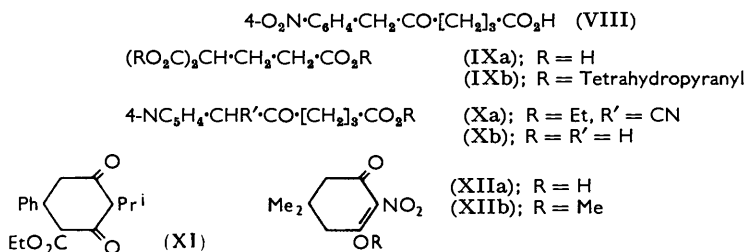
⁸ Born, Pappo, and Szmuskovicz, *J.*, 1953, 1779.

by analogy with the reactions of 3-methoxy-2,5-diphenylcyclohex-2-en-1-one (IIIb),¹ is considered to be 1,5-dicyano-8-phenyl-6-azabicyclo[3,2,1]octan-7-one (VIIa).

The effect of the substituent at position 2 was next investigated. 2-*p*-Methoxyphenylcyclohexane-1,3-dione (Id) was prepared as for the 2-phenyl-dione (IVa), but similar preparation of the 2-*p*-nitro-compound (Ie) was not possible since the initial condensation of *p*-nitrobenzyl cyanide with diethyl glutarate could not be achieved. An attempt to prepare the intermediate keto-acid (VIII) by conversion of propane-1,1,3-tricarboxylic acid (IXa)^{9,10} into the tetrahydropyranyl ester (IXb) by Bowman and Fordham's procedure,¹¹ followed by condensation of the sodio-derivative of this ester with *p*-nitrophenylacetyl chloride, gave only *p*-nitrophenylacetic acid. Attempts to prepare the dione (Id) by direct arylation¹² of cyclohexane-1,3-dione (Ia) with *p*-fluoronitrobenzene were also unsuccessful. Sodium ethoxide-catalysed reaction of cyclohexane-1,3-dione (Ia) with 1-fluoro-2,4-dinitrobenzene, however, gave 2-(2,4-dinitrophenyl)cyclohexane-1,3-dione



(If) in 25% yield. Preparation of 2-4'-pyridylcyclohexane-1,3-dione (Ig) as previously described⁸ required 4-cyanomethylpyridine as starting material. This nitrile was prepared¹³ from 4-chloromethylpyridinium chloride and potassium cyanide; Itai and Ogura's method¹⁴ gave only unchanged material. Condensation of this nitrile with diethyl glutarate furnished ethyl 6-cyano-5-oxo-6-4'-pyridylhexanoate (Xa), which could not be hydrolysed to the keto-acid (Xb). 2-Isopropyl-5-phenylcyclohexane-1,3-dione (Ih) was prepared by Michael condensation of diethyl malonate with 5-methyl-1-phenylhex-1-en-3-one (prepared by Cason's method¹⁵) and subsequent hydrolysis of the dioxo-ester (XI). 5,5-Dimethyl-2-nitrocyclohexane-1,3-dione (XIIa) was prepared as described by



Eistert, Elias, Kosch, and Wollheim.¹⁶ Sodium ethoxide-catalysed condensation of ethyl atropate¹⁷ with dibenzyl ketone afforded 2,4,6-triphenylcyclohexane-1,3-dione (IIb).

All these diones were converted into the corresponding methyl enol ethers with diazomethane and the exchange studied. 3-Methoxy-2-*p*-methoxyphenylcyclohex-2-en-1-one

⁹ Bischoff, *Annalen*, 1882, **214**, 53.

¹⁰ Fredga, *Arkiv Kemi, Min., Geol.*, 1946, **B**, **23**, No. 2, 5.

¹¹ Bowman and Fordham, *J.*, 1952, **3947**.

¹² Stetter, *Angew. Chem.*, 1955, **67**, 769.

¹³ Mosher and Tessieri, *J. Amer. Chem. Soc.*, 1951, **73**, 4925.

¹⁴ Itai and Ogura, *J. Pharm. Soc. Japan*, 1955, **75**, 296; *Chem. Abs.*, 1956, **50**, 1810.

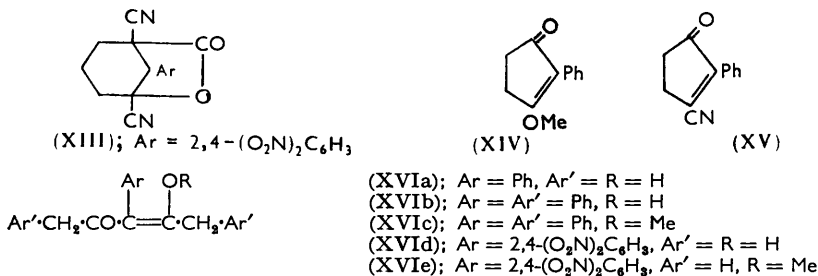
¹⁵ Cason, *J. Amer. Chem. Soc.*, 1946, **68**, 2078.

¹⁶ Eistert, Elias, Kosch, and Wollheim, *Chem. Ber.*, 1959, **92**, 130.

¹⁷ Schinz and Hinder, *Helv. Chim. Acta*, 1947, **30**, 1349.

(IIIc) with acetone cyanohydrin in the presence of triethylamine gave 70% of 3-cyano-2-*p*-methoxyphenylcyclohex-2-en-1-one (VIb) at room temperature and 76% of the same product at 90°. With methanolic potassium hydroxide as catalyst a 76% yield of the cyano-ketone (VIb) was isolated and 18% of the dione (Id) was recovered. With methanol as solvent the yield of (VIb) was only 20%. None of the expected cyano-ketone (VIc) could be isolated from reaction of 2-(2,4-dinitrophenyl)-3-methoxycyclohex-2-en-1-one (IIIId) with acetone cyanohydrin at room temperature or at 90° by using triethylamine or methanolic potassium hydroxide as catalyst. In all cases the product was 1,5-dicyano-8-(2,4-dinitrophenyl)-6-azabicyclo[3,2,1]octan-7-one (VIIb), an assignment supported by the infrared spectrum.¹⁸ Unlike the diphenylazabicyclo-octanone (VIIc),¹ this product was not converted into the corresponding cyano-ketone (VIc) by hydrochloric and acetic acids. The sole product was thought to have the structure (XIII). Both 2-isopropyl-3-methoxy-5-phenylcyclohex-2-en-1-one (IIIe) and 3-methoxy-5,5-dimethyl-2-nitrocyclohex-2-en-1-one (XIId) were unaffected by treatment with acetone cyanohydrin. The lack of reactivity of the nitro-enol ether (XIId), in contrast to that of the dinitrophenyl compound (IIIId), suggests that an electron-attracting group attached directly to the cyclohexane ring does not exert sufficient influence to facilitate the exchange. These results indicate that the 2-aryl group is essential for the reaction and that this effect is due mainly to electronic rather than steric factors. In spite of the steric hindrance expected from the additional phenyl groups, 3-methoxy-2,4,6-triphenylcyclohex-2-en-1-one (IIc) and acetone cyanohydrin reacted at room temperature to yield 70% of 3-cyano-2,4,6-triphenylcyclohex-2-en-1-one (VIId).

Attention was next turned to whether the exchange was restricted to cyclohexane derivatives. 3-Methoxy-2-phenylcyclopent-2-en-1-one (XIV) was prepared as for the corresponding cyclohexenone (IVb). Base-catalysed reaction with acetone cyanohydrin at room temperature or at 90° gave 3-cyano-2-phenylcyclopent-2-en-1-one (XV) as the sole product. 3-Phenylpentane-2,4-dione (XVIa) was prepared by acetylation of benzyl



methyl ketone¹⁹ as the Claisen condensation of this ketone with ethyl acetate²⁰ gave a negligible yield of the dione, and other methods failed. Condensation of ethyl phenylacetate with dibenzyl ketone afforded 1,3,5-triphenylpentane-2,4-dione (XVIb) which was converted into the enol ether (XVIc). This was recovered from treatment with acetone cyanohydrin. Arylation of pentane-2,4-dione with 1-fluoro-2,4-dinitrobenzene gave the required dione (XVIId) which, with diazomethane, afforded 3-(2,4-dinitrophenyl)-4-methoxypent-3-en-2-one (XVIe). From treatment with acetone cyanohydrin in boiling methanol, this enol ether (XVIe) was recovered but in the absence of methanol no crystalline material could be isolated. The failure of 2-methoxy-1,3,5-triphenyl- (XVIc) and 3-(2,4-dinitrophenyl)-4-methoxypent-3-en-2-one (XVIe) to exchange in contrast to the corresponding cyclic compounds (IIc) and (IIIId) suggests that a cyclic system is necessary.

¹⁸ Bellamy, "Infrared Spectra of Complex Molecules," Methuen, London, 1958, (a), p. 205, (b) p. 186.

¹⁹ Hauser and Manyik, *J. Org. Chem.*, 1953, **18**, 589.

²⁰ Morgan, Drew, and Porter, *Ber.*, 1925, **58**, 333.

To confirm that the exchange was restricted to enol ethers of β -diketones, the synthesis of 2-methoxy-1-phenylcyclohex-1-ene was attempted but could not be achieved. It was hoped that dehydrochlorination and etherification²¹ of 1,1-dichloro-2-phenylcyclohexane would afford the cyclohexene but reaction of 2-phenylcyclohexanone with phosphorus pentachloride yielded 2-phenylcyclohex-2-en-1-one. Also, although the action of phenylmagnesium bromide on 2-methoxycyclohexanone²² gave 2-methoxy-1-phenylcyclohexan-1-ol, yet attempted dehydration of this alcohol with phosphorus pentoxide gave 2-phenylcyclohexanone, and heating it with anhydrous copper sulphate in dry xylene gave a complex mixture of products.

From these results, it is apparent that the reaction of enol ethers of β -diketones with acetone cyanohydrin resulting in the displacement of an alkoxy group by a cyano-group is restricted to the alkyl enol ethers of 2-arylcycloalkane-1,3-diones.

It is noteworthy that those enol ethers (IVb), (IVc), (IVd), (IIIc), (IIId), and (IIc) which underwent exchange showed two absorption maxima at 228—230 and near 270 μ , the latter band being the stronger; enol ethers which did not react had only one absorption maximum in the 260- μ region.

EXPERIMENTAL

"Light petroleum" refers to the fraction, b. p. 60—80°.

Preparation of β -Diketones.—2-Phenylcyclohexane-1,3-dione (IVa). The dione⁸ crystallised from benzene as the *hemihydrate*, plates, m. p. 158° (Found, after drying at 110°/0.1 mm.: C, 73.5; H, 6.3. $C_{12}H_{12}O_2 \cdot \frac{1}{2}H_2O$ requires C, 73.1; H, 6.6%). Born *et al.*⁸ report m. p. 160—161° for the anhydrous material.

2-p-Methoxyphenylcyclohexane-1,3-dione (Id). The dione was prepared from *p*-methoxybenzyl cyanide and diethyl glutarate by the procedure employed for the foregoing compound. Ethyl 6-cyano-6-*p*-methoxyphenyl-5-oxohexanoate (48%), obtained as a yellow oil, b. p. 190—191°/0.4 mm. (Found: C, 66.2; H, 6.8; N, 4.6. $C_{16}H_{19}NO_4$ requires C, 66.4; H, 6.6; N, 4.8%), was hydrolysed to 6-*p*-methoxyphenyl-5-oxohexanoic acid (85%), needles, m. p. 86°, from light petroleum (Found: C, 66.1; H, 7.1. $C_{15}H_{18}O_4$ requires C, 66.1; H, 6.8%). The corresponding *oxime* formed prisms, m. p. 122°, from ethyl acetate—light petroleum (Found: C, 61.9; H, 6.5; N, 5.7. $C_{15}H_{17}NO_4$ requires C, 62.1; H, 6.8; N, 5.6%). The *ethyl ester*, b. p. 158—160°/0.3 mm., which crystallised quantitatively from ether as plates, m. p. 43—44° (Found: C, 67.8; H, 7.5. $C_{15}H_{20}O_4$ requires C, 68.2; H, 7.6%), was cyclised to 2-*p*-methoxyphenylcyclohexane-1,3-dione (79%), plates, m. p. 175°, from benzene (Found: C, 71.2; H, 6.7. $C_{13}H_{14}O_3$ requires C, 71.5; H, 6.5%).

2-Phenylcyclopentane-1,3-dione. The dione was prepared from benzyl cyanide and diethyl succinate by the procedure used for the cyclohexane analogue. Ethyl 5-cyano-4-oxo-5-phenylpentanoate (47%), b. p. 160—162°/0.5 mm., m. p. 152° (from benzene—light petroleum) (Found: C, 69.1; H, 5.9; N, 5.4. $C_{14}H_{15}NO_3$ requires C, 68.6; H, 6.2; N, 5.7%), was converted into ethyl 4-oxo-5-phenylpentanoate (79%), b. p. 121—122°/0.3 mm. (Found: C, 70.5; H, 7.2. Calc. for $C_{13}H_{16}O_3$: C, 70.9; H, 7.3%) (Stefanova²³ gave b. p. 169—170°/20 mm.). Cyclisation of the latter ester gave the dione, needles, m. p. (inserted at 200°) 247°, from acetic acid (Found: C, 75.9; H, 5.7. Calc. for $C_{11}H_{10}O_2$: C, 75.8; H, 5.8%). Erskola²⁴ records m. p. 233—234°.

2-(2,4-Dinitrophenyl)cyclohexane-1,3-dione (If). Cyclohexane-1,3-dione (5.6 g.), followed by 1-fluoro-2,4-dinitrobenzene (10.2 g.), was added to a solution from sodium (1.1 g.) and dry ethanol (40 c.c.), and the mixture was refluxed for 3 hr., then poured into 2*N*-sodium hydroxide, washed with ether, acidified, and re-extracted with ether. Evaporation of the dried extract and crystallisation from ethyl acetate gave the required *dione* (25%), yellow plates, m. p. 252° (Found: C, 51.6; H, 3.8; N, 10.0. $C_{12}H_{10}N_2O_6$ requires C, 51.8; H, 3.9; N, 10.1%). Concentration of the original ether washings afforded 1-ethoxy-2,4-dinitrobenzene (1.9 g.), m. p. 85.5° (lit., m. p. 85—86°). When potassium hydroxide (2.8 g.) in methanol (12 c.c.) and water (8 c.c.) was used as the condensing agent, the yield of the required dione was only 9%, and

²¹ Markownikoff, *Annalen*, 1903, **327**, 69.

²² Bergmann and Gierrth, *Annalen*, 1926, **448**, 64.

²³ Stefanova, *Annuaire Univ. Sofia, Faculte phys.-maths.*, 1943—4, **40**, Livre 2, 147.

²⁴ Erskola, *Suomen Kem.*, 1938, **11**, B, 9; *Chem. Abs.*, 1938, **32**, 3359.

concentration of the mother-liquor furnished 2,4-dinitrophenol (6.8 g.), m. p. and mixed m. p. 114°, and unchanged cyclohexane-1,3-dione (0.9 g.), m. p. and mixed m. p. 104°.

5-Methyl-1-phenylhex-1-en-3-one. Condensation of cinnamoyl chloride with di-isobutylcadmium according to Cason's method¹⁵ gave the hexenone (49%), b. p. 125—129°/2.0 mm., n_D^{20} 1.558 (Found: C, 82.4; H, 8.7. Calc. for $C_{13}H_{16}O$: C, 82.9; H, 8.6%). Gheorghiu and Arwentiew²⁵ record b. p. 179—183°/32 mm., n_D^{20} 1.557. The 2,4-dinitrophenylhydrazone, orange prisms from ethyl acetate, had m. p. 176° (Found: C, 62.2; H, 5.8; N, 14.8. $C_{19}H_{20}N_4O_4$ requires C, 61.9; H, 5.5; N, 15.2%). The semicarbazone formed needles, m. p. 167°, from ethanol (Found: C, 68.6; H, 7.8; N, 17.2. Calc. for $C_{14}H_{19}N_3O$: C, 68.6; H, 7.8; N, 17.1%). Gheorghiu and Arwentiew²⁵ give m. p. 167°.

Ethyl 3-isopropyl-2,4-dioxo-6-phenylcyclohexanecarboxylate. To sodium (1.2 g.) in dry ethanol (30 c.c.) was added diethyl malonate (8.5 g.) followed by 5-methyl-1-phenylhex-1-en-3-one (10.0 g.), and the mixture was refluxed for 3.5 hr. The ethanol was evaporated under reduced pressure, and the residue diluted with water. The aqueous suspension was washed with ether, acidified and then extracted with ether. Concentration of the dried extract afforded the *dioxo-ester* (12.0 g.), needles, m. p. 136°, from benzene-light petroleum (Found: C, 71.1; H, 7.2. $C_{16}H_{22}O_4$ requires C, 71.5; H, 7.3%).

2-Isopropyl-5-phenylcyclohexane-1,3-dione (Ih). The preceding ester (12.0 g.) was refluxed for 9 hr. with sodium carbonate (25.0 g.) in water (70 c.c.). The solution was acidified and then boiled to give a quantitative yield of the dione, needles, m. p. 191°, from ethanol. Desai²⁶ records m. p. 190°.

5,5-Dimethyl-2-nitrocyclohexane-1,3-dione (XIIa) was obtained as described by Eistert, Elias, Kosch, and Wollheim.¹⁶ It was essential to keep the reaction mixture below room temperature during the removal of the ether to avoid violent decomposition of the product.

2,4,6-Triphenylcyclohexane-1,3-dione (IIb). Dibenzyl ketone (21.0 g., 1 mol.) and ethyl atropate (18.0 g., 1 mol.)¹⁷ were successively added to sodium (4.6 g., 2 g.-atoms) in dry ethanol (100 c.c.), and the mixture was refluxed for 3 hr. The solution was diluted with water and washed with ether. Acidification of the aqueous fraction furnished 2,4,6-triphenylcyclohexane-1,3-dione (27%), needles, m. p. 215°, from methanol (Found: C, 84.5; H, 5.9. $C_{24}H_{20}O_2$ requires C, 84.7; H, 5.9%). If only 1 g.-atom of sodium was used the yield of dione was only 14%.

1,3,5-Triphenylpentane-2,4-dione (XVIb). Sodium (3.5 g.) was slowly added to dibenzyl ketone (31.5 g.) and ethyl phenylacetate (24.6 g.). When the initial reaction had subsided the mixture was stirred on a hot-water bath for 3.5 hr. and then dissolved in water and washed with ether. The sodium salt was decomposed by addition of solid carbon dioxide, and the *dione* (1.7 g.) thus obtained recrystallised from ethyl acetate-light petroleum as needles, m. p. 212° (Found: C, 84.2; H, 6.0. $C_{23}H_{20}O_2$ requires C, 84.1; H, 6.1%).

3-(2,4-Dinitrophenyl)pentane-2,4-dione (XVIId). The *dione*, prepared from pentane-2,4-dione and 1-fluoro-2,4-dinitrobenzene in the same manner as 2-(2,4-dinitrophenyl)cyclohexane-1,3-dione, crystallised as plates, m. p. 122°, from ethyl acetate-light petroleum (Found: C, 49.8; H, 3.9; N, 10.4. $C_{11}H_{10}N_2O_6$ requires C, 49.6; H, 3.8; N, 10.5%).

Enol Ethers.—The methyl enol ethers listed in Table 1 were obtained by treatment of a methanolic suspension of the appropriate dione with a slight excess of ethereal diazomethane, and were isolated by evaporation of the mixture.

3-Ethoxy-2-phenylcyclohex-2-en-1-one (IVc). To sodium (0.5 g.) in dry ethanol (20 c.c.) were added 2-phenylcyclohexane-1,3-dione (3.8 g.) and ethyl iodide (3.1 g.), and the mixture was refluxed for 2 hr., then concentrated, diluted with water, and extracted with ether. The extract was washed with 5% aqueous sodium hydroxide to remove any dione and then concentrated to yield 3-ethoxy-2-phenylcyclohex-2-en-1-one (2.9 g.), needles, m. p. 96°, from light petroleum (Found: C, 77.4; H, 7.3. Calc. for $C_{14}H_{16}O_2$: C, 77.7; H, 7.5%). Born *et al.*⁸ report m. p. 102°.

3-Benzoyloxy-2-phenylcyclohex-2-en-1-one (IVd). 2-Phenylcyclohexane-1,3-dione (4.0 g.) and benzyl chloride (2.7 g.) were successively added to potassium (0.9 g.) in dry *t*-butyl alcohol (30 c.c.), and the mixture was refluxed for 6 hr., then concentrated, diluted with water, and extracted with ether. Distillation of the extract gave an oil which on trituration with ether afforded 3-benzoyloxy-2-phenylcyclohex-2-en-1-one (2.1 g., 36%), prisms, m. p. 70—71°, from light petroleum (Found: C, 81.7; H, 6.5. $C_{19}H_{18}O_2$ requires C, 82.0; H, 6.5%). When sodium

²⁵ Gheorghiu and Arwentiew, *J. prakt. Chem.*, 1928, **118**, 295.

²⁶ Desai, *J.*, 1932, 1079.

in ethanol was used in place of potassium in *t*-butyl alcohol the yield of the enol ether was only 17%.

Exchange Reactions with Acetone Cyanohydrin.—*General procedure.* (a) The enol ether was dissolved in the minimum volume of redistilled acetone cyanohydrin at room temperature, 13% methanolic potassium hydroxide (0.1 c.c./10 c.c. of acetone cyanohydrin) was added, and the

TABLE 1. *Methyl enol ethers.*

Com- pound	Form *	M. p.	Yield (%)	Formula	Found (%)				Required (%)			
					C	H	N	OMe	C	H	N	OMe
IIc	Plates ^d	171°	98	C ₂₅ H ₂₂ O ₂	84.2	6.4	—	10.2	84.7	6.3	—	8.8
IIIc	Plates	112	92	C ₁₄ H ₁₆ O ₃	71.9	7.0	—	—	72.4	6.9	—	—
IIId	Yellow prisms ^c	173	97	C ₁₃ H ₁₂ N ₂ O ₆	53.8	4.1	9.6	—	53.4	4.1	9.6	—
IIIe	Prisms ^a	73	67	C ₁₆ H ₂₀ O ₂	79.1	8.5	—	—	78.7	8.3	—	—
IIIf	Needles ^a	94	83	C ₁₅ H ₁₆ O ₂	79.1	7.1	—	—	79.0	7.1	—	—
IVb	Prisms ^b	122—123 †	87	C ₁₃ H ₁₄ O ₂	77.4	6.9	—	—	77.2	7.0	—	—
XIIb	Plates	130	65	C ₉ H ₁₃ NO ₄	54.3	6.6	7.0	—	54.3	6.6	7.0	—
XIV	Prisms	98	98	C ₁₂ H ₁₂ O ₂	76.6	6.4	—	—	76.6	6.4	—	—
XVIc	Needles	197—198	80	C ₂₄ H ₂₂ O ₂	84.0	6.3	—	9.3	84.2	6.5	—	9.1
XVIIc	Needles	100	90	C ₁₁ H ₁₀ N ₂ O ₆	51.7	4.3	9.8	—	51.4	4.3	10.0	—

* From benzene—light petroleum unless otherwise stated: ^a from light petroleum; ^b from benzene; ^c from ethyl acetate; ^d from MeOH.

† Born, Pappo, and Szmuskovicz ⁸ give m. p. 96—98°.

mixture set aside overnight. The solution was poured into water and acidified (Congo Red), and the product filtered off. (b) The procedure was the same as in (a) except that triethylamine (0.05 c.c./10 c.c. of acetone cyanohydrin) was used as catalyst. (c) Triethylamine (0.05 c.c./10 c.c. of acetone cyanohydrin) was added to a solution of the enol ether in the minimum volume of acetone cyanohydrin, and the mixture heated at 80—90° for 45 min., then cooled, poured into water, and acidified (Congo Red), and the product was filtered off. The products thus obtained are listed in Table 2.

TABLE 2. *Products from exchange reactions with acetone cyanohydrin*

Starting material *	Product	Yield (%)	Form †	M. p.	Formula	Found (%)			Required (%)		
						C	H	N	C	H	N
IVb ^{a,b}	VIa ⁴	37	Needles ^d	118°	C ₁₃ H ₁₁ NO	79.3	5.7	6.9	79.2	5.6	7.1
IVc ^{a,b}	VIa	30—37									
IVd ^{a,b}	VIa	30—40									
VIa ^c	VIIa	10	Needles	170	C ₁₆ H ₁₃ N ₃ O	71.3	5.3	16.7	71.7	5.2	16.7
IIIc ^a	VIIb ¹	76	Needles ^e	93	C ₁₄ H ₁₃ NO ₂	73.6	5.6	6.4	74.0	5.8	6.2
IIIc ^{b,c}	VIIb ^{2,3}	71—76									
IIId ^{a,b}	VIIb ⁵	25	Prisms	215	C ₁₈ H ₁₁ N ₅ O ₅	52.8	3.2	20.7	52.8	3.2	20.5
IIId ^c	VIIb	13									
XIV ^{a,b,c}	XV	76	Needles ^f	112	C ₁₂ H ₉ NO	78.2	5.0	7.7	78.7	5.0	7.6
IIc ^{a,b}	VIId	65	Prisms ^g	151	C ₂₅ H ₁₉ NO	85.9	5.7	3.8	85.9	5.5	4.0

* For method used see general procedures (a), (b), and (c).

† From ethyl acetate unless otherwise stated: ^d from benzene—light petroleum; ^e from ethyl acetate—light petroleum; ^f from light petroleum.

¹ 18% of the dione (Id), m. p. and mixed m. p. 175°, was also isolated. ² The derived *oxime* formed needles, m. p. 212°, from ethanol (Found: C, 69.1; H, 6.2; N, 11.4. C₁₄H₁₃N₃O₂ requires C 69.4; H, 5.8; N, 11.6%). ³ Addition of methanol as solvent reduced the yield to 20%. ⁴ Infrared spectrum (KBr disc), bands at 2210 (conjugated C=N), 1675 ($\alpha\beta$ -unsaturated C=O), 765 and 702 cm.⁻¹ (phenyl system). ⁵ Infrared spectrum (KBr disc), bands at 3303 (NH), 2247 (C=N), 1721 (C=O, fused ring γ -lactam), 1538 and 1358 cm.⁻¹ (NO₂).

Treatment of 1,5-Dicyano-8-(2,4-dinitrophenyl)-6-azabicyclo[3,2,1]octan-7-one (VIIb) with Acid.—The azabicyclo-octanone (1.4 g.) in acetic acid (50 c.c.), concentrated hydrochloric acid (4 c.c.), and water (4 c.c.) was refluxed for 12 hr. The solvents were evaporated *in vacuo* and the residue was diluted with water. The solid was filtered off and recrystallised from ethyl acetate to give a *substance*, prisms, m. p. 244° [Found: C, 52.0; H, 3.1; N, 15.5; M (Rast), 306. C₁₅H₁₀N₄O₆, $\frac{1}{2}$ H₂O requires C, 51.3; H, 3.2; N, 15.9%; M, 351].

3-Cyano-2,4,6-triphenylcyclohex-2-en-1-ol.—Potassium borohydride (0.8 g.) in water (5 c.c.) was added to 3-cyano-2,4,6-triphenylcyclohex-2-en-1-one (1.3 g.) in methanol (50 c.c.). After 5 hr. at room temperature the solution was poured into water, and the solid collected. The

required *cyclohexenol* (0.7 g.), needles, m. p. 124°, crystallised from ethyl acetate–light petroleum (Found: C, 85.0; H, 6.0; N, 4.4. $C_{22}H_{21}NO$ requires C, 85.4; H, 6.0; N, 4.0%).

Reaction of 3-Methoxy-5-phenylcyclohex-2-en-1-one with Acetone Cyanohydrin.—The enol ether (4.0 g.) was treated with acetone cyanohydrin (60 c.c.) containing methanolic potassium hydroxide as described in procedure (a). The resultant aqueous mixture was extracted with ethyl acetate. Distillation of the dried extract afforded a fraction, b. p. 160–162°/1.0 mm. (2.7 g.), consisting of unchanged enol ether and a substance which crystallised in the condenser. The latter was purified by resublimation *in vacuo*, followed by recrystallisation from light petroleum, to yield 2,2,5,5-tetramethyl-4-oxazolidone (0.3 g.), needles, m. p. 163° (Found: C, 58.2; H, 8.9; N, 10.2. Calc. for $C_7H_{13}NO_2$: C, 58.7; H, 9.1; N, 9.8%). Admixture with authentic material, m. p. 167°, prepared as described by Snyder and Elston,⁷ did not depress the m. p.

3-Chloro-2-phenylcyclohex-2-en-1-one (V).—2-Phenylcyclohexane-1,3-dione (2.4 g.) in dry chloroform (10 c.c.) was refluxed with phosphorus trichloride (1.0 c.c.) for 3 hr. Crushed ice, ether, and aqueous sodium hydrogen carbonate were successively added, and the organic layer was separated, washed with 2*N*-sodium hydroxide, dried ($MgSO_4$), and evaporated. 3-Chloro-2-phenylcyclohex-2-en-1-one (1.8 g.) crystallised from light petroleum as needles, m. p. 92° (Found: C, 69.3; H, 4.9; Cl, 17.5. $C_{12}H_{11}ClO$ requires C, 69.7; H, 5.4; Cl, 17.2%). This chloro-ketone (4.7 g.) was refluxed with potassium (0.7 g.) in dry *t*-butyl alcohol (80 c.c.) for 3.5 hr., then poured into water and extracted with ether. Concentration of the extract furnished a substance $C_{24}H_{20}O_2$, prisms, m. p. 206°, from ethyl acetate [Found: C, 84.4; H, 6.3; *M* (Rast), 353. $C_{24}H_{20}O_2$ requires C, 84.7; H, 5.9%; *M*, 340], which gave an *oxime sesquihydrate*, needles, m. p. 260°, from ethyl acetate (Found: C, 75.6; H, 6.1; N, 3.4. $C_{24}H_{21}NO_2 \cdot 1.5H_2O$ requires C, 75.4; H, 6.3; N, 3.7%).

4-Pyridylmethyl Cyanide.—4-Chloromethylpyridinium chloride (45.0 g.)¹⁸ and potassium cyanide (45.0 g.) in methanol (400 c.c.) and water (200 c.c.) were refluxed for 2 hr. The solution was then concentrated, diluted with water, and extracted with ether. Distillation of the extract afforded a single fraction, b. p. 115–119°/3.5 mm., which crystallised when set aside for 1 hr. Redistillation furnished 4-pyridylmethyl cyanide (13.0 g.), b. p. 92°/0.5 mm., m. p. 36° (Found: C, 69.4; H, 5.1; N, 22.7. $C_7H_8N_2$ requires C, 71.2; H, 5.1; N, 23.7%). This nitrile decomposed within a few days. Treatment with dry hydrogen chloride furnished the *hydrochloride*, needles, m. p. 270–272° (decomp.), from ethanol (Found: C, 54.5; H, 4.9; N, 17.7; Cl, 23.0. $C_7H_8N_2 \cdot HCl$ requires C, 54.4; H, 4.6; N, 18.1; Cl, 22.9%).

Ethyl 6-Cyano-5-oxo-6-4'-pyridylhexanoate (X).—4-Pyridylmethyl cyanide (14.7 g.) and diethyl glutarate (35.2 g.) were successively added to a solution of sodium (3.7 g.) in dry ethanol (80 c.c.), and the mixture was refluxed for 2 hr., set aside overnight, then concentrated, diluted with water, and washed with ether. Acidification of the aqueous fraction yielded *ethyl 6-cyano-5-oxo-6-4'-pyridylhexanoate* (19%), which recrystallised from benzene as prisms, m. p. 142° (Found: C, 64.7; H, 6.3; N, 10.6. $C_{14}H_{16}N_2O_3$ requires C, 64.6; H, 6.2; N, 10.8%).

Reaction of 2-Phenylcyclohexanone with Phosphorus Pentachloride.—The ketone (6.0 g.) was refluxed with phosphorus pentachloride (7.0 g.) in dry benzene (30 c.c.) for 2 hr. The resulting solution was poured on ice, neutralised with sodium hydrogen carbonate, and extracted with ether. Distillation of this extract gave a fraction, b. p. 132–138°/1.0 mm., which crystallised from light petroleum to give 2-phenylcyclohex-2-en-1-one (2.4 g.), needles, m. p. 94–95° (Found: C, 83.3; H, 6.8. Calc. for $C_{12}H_{12}O$: C, 83.7; H, 7.0%), undepressed on admixture with an authentic sample kindly supplied by Prof. D. Ginsberg.

2-Methoxy-1-phenylcyclohexan-1-ol.—2-Methoxycyclohexanone (1.9 g.)²⁴ in dry ether (10 c.c.) was added to phenylmagnesium bromide (from 2.4 g. of bromobenzene and 0.4 g. of magnesium) in dry ether and the mixture was refluxed for 1 hr. The complex was decomposed with ammonium chloride solution and extracted with ether. Distillation of the extract gave 2-methoxy-1-phenylcyclohexan-1-ol (1.6 g.), b. p. 95–97°/0.5 mm., n_D^{20} 1.5370 (Found: C, 76.1; H, 8.8. $C_{13}H_{18}O_2$ requires C, 75.6; H, 8.8%). This alcohol was unchanged by treatment with benzoyl chloride in dry pyridine. The alcohol (3.0 g.) and phosphorus pentoxide (5.0 g.) in dry benzene (30 c.c.) were refluxed for 1 hr. The solution was filtered and distilled to give 2-phenylcyclohexanone (1.2 g.), m. p. and mixed m. p. 58° (from light petroleum).

Ultraviolet Spectra.—The ultraviolet absorption spectra of most of the compounds described are given in Table 3, for 96% ethanolic solutions, determined with a Unicam S.P. 500 Spectrophotometer. Italicised wavelengths denote an inflexion.

TABLE 3

Com- pound	λ_{\max} (m μ)	ϵ	Com- pound	λ_{\max} (m μ)	ϵ	Com- pound	λ_{\max} (m μ)	ϵ
(a) <i>Diones</i>								
(IVa)	229	4,450	(If)	255	18,850	(IIb)	231	8,800
	279	9,800	(Ih)	265	14,100		282	12,900
(Id)	239	15,550		298	3,800	(XVIIb)	260	10,700
	274	10,050	(XIIa)	264	15,700		271	12,100
						(XVIId)	269	14,350
(b) <i>Derived enol ethers</i>								
(IVb)	232	8,900	(IIIc)	237	11,350	(XIV)	248	15,450
	269	13,850		280	10,750		258	14,950
(IVc)	232	9,300	(IIId)	256	23,000		268	13,750
	271	14,000	(IIIe)	268	16,050	(XVIc)	229	10,700
(IVd)	231	8,650	(XIIb)	258	15,200		243	8,300
	271	13,800	(IIc)	230	11,800		274	12,400
				273	14,200	(XVIe)	259	21,400
(c) <i>Exchange reaction products</i>								
(VIa)	235	10,550	(VIIb)	241	21,700	(VIId)	216	21,800
	292	4,300		247	20,900		237	12,600
(VIb)	232	19,450	(XIII)	234	14,300		296	6,400
	335	4,000		240	13,950	(XV)	224	13,200
							292	7,600

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