Reaction of Enamines with Benzylidene Ketones. Part II.[1]

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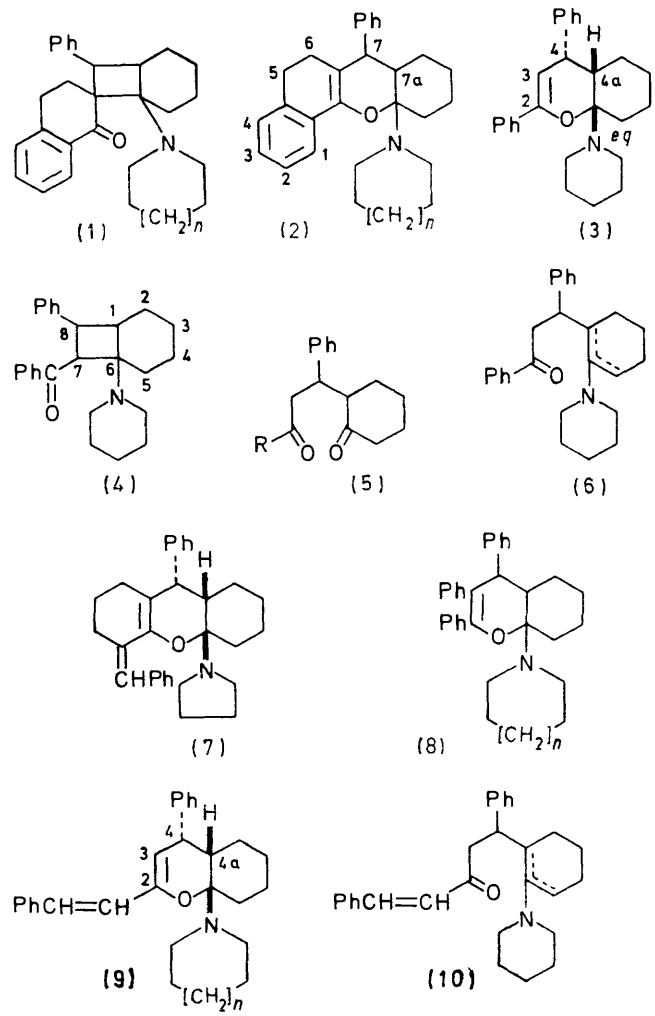
The reaction between cyclohexanone enamines and a variety of benzylidene ketones gives a dihydropyran derivative in each case. The benzopyrans from reactions of 1-piperidinocyclohexene with chalcone and with dibenzylideneacetone are unstable and on heating readily rearrange into isomeric enamino-ketones (6) and (10). Recyclisation of 2-phenyl-2-(2-piperidinocyclohex-2-enyl)ethyl styryl ketone (10) gives 1,4-diphenyl-7b-piperidinoperhydrocyclobuta[*de*]naphthalen-2-one (11).

In continuing our investigation of the reaction between enamines and benzylidene ketones [1,2] we have examined the products obtained from reactions of 2-benzylidene-1-tetralone, chalcone, benzylidenedeoxybenzoin, dibenzylideneacetone, and the monobenzylidene derivative of dimedone with cyclohexanone enamines.

The product from 2-benzylidene-1-tetralone and 1-pyrrolidin-1-ylcyclohexene has been briefly reported elsewhere.[2] A similar product was obtained from 2-benzylidene-1-tetralone and the piperidine enamine of cyclohexanone. These compounds were initially[3] assigned the spirocyclobutane structures (1; $n = 0$ or 1), but our interpretation of the spectral evidence[2] indicated that they should be formulated as dihydropyrans (2; $n = 0$ or 1). Positive chemical evidence in favour of structure (2) is difficult to obtain but it was hoped to obtain indirect evidence by investigation of the analogous reaction between chalcone and enamines. The possible dihydropyran and cyclobutane products [*e.g.* (3) and (4)] from this reaction were expected to be readily distinguishable by n.m.r.[4]

When chalcone and 1-pyrrolidin-1-yl-cyclohexene reacted in boiling ethanol, the only isolable compound produced was the known[5] diketone (5; R = Ph). Reaction between chalcone and 1-piperidinocyclohexene under the same conditions gave a crystalline 1 : 1 adduct, which was neither (3) nor (4) but had structure (6). It showed an i.r. carbonyl band at 1677 cm^{-1}; the n.m.r. spectrum contained a triplet (0·75H) at τ 5·18 which was slowly removed by exchange with D_2O and was therefore assigned to the olefinic proton of the enamine with the trisubstituted double bond, which must predominate in the ratio of approximately 3 : 1 over the isomer with the tetrasubstituted double bond. The formation of compound (6) suggested that the reaction was proceeding through an intermediate dihydropyran (3) or cyclobutane (4) which was very labile. This was confirmed by isolation of a different 1 : 1 adduct from the reaction of the piperidine enamine with chalcone at ambient temperature. The product showed an i.r. band at 1650 cm^{-1} suggesting a dihydropyran structure (3) rather than the alternative aromatic ketone formulation (4). Its n.m.r. spectrum showed a low-field doublet (J 2 Hz) at τ 4·81 attributable to the olefinic proton at C-3 in the dihydropyran (3) which is coupled to the adjacent benzylic proton at C-4. The alternative cyclobutane structure (4) might be expected to show a similar low-field doublet due to the proton at



C-7. However, the observed small splitting would be unprecedented for adjacent protons in a cyclobutane ring;[4] hence this structure can be rejected. The i.r. absorption of the dihydropyran (3) is very similar in frequency and intensity to that of the corresponding products (2; $n = 0$ or 1) from 2-benzylidene-1-tetralone

[1] Part I, J. W. Lewis, P. L. Myers, and M. J. Readhead, *J. Chem. Soc.* (*C*), 1970, 771.
[2] J. W. Lewis and P. L. Myers, *Chem. and Ind.*, 1970, 1625.
[3] R. Balaji Rao and G. V. Bhide, *Chem. and Ind.*, 1970, 653.
[4] I. Fleming and M. H. Karger, *J. Chem. Soc.* (*C*), 1967, 226.
[5] C. F. H. Allen and H. R. Sallans, *Canad. J. Res.*, 1933, **9**, 574.

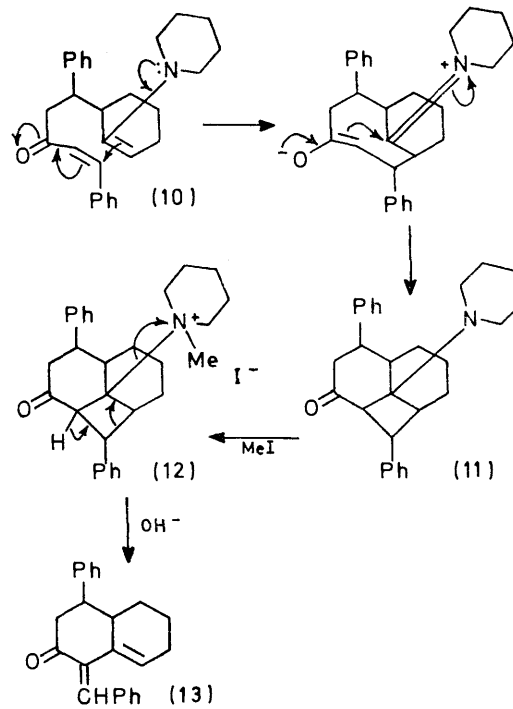
and enamines. The wavelength and intensity of the u.v. absorptions of compounds (3) and (2; $n = 0$ or 1) are also comparable.

Synthesis of an analogous dihydropyran adduct from chalcone and 1-morpholinocyclohexene has recently been reported [6] by Risaliti *et al.* These authors found that in boiling benzene the adduct underwent ring opening to give the enamino-ketone of type (6) in which the trisubstituted double bond enamine predominated over the tetrasubstituted isomer by a factor of 4 : 1.

In the n.m.r. spectrum of compound (3) the C-4 proton resonance appears as a double doublet, owing to strong coupling (J 8·5 Hz) with the C-4a ring junction proton and a much smaller coupling (J 2 Hz) with the olefinic proton at C-3 as already discussed. The size of these coupling constants does not enable the relative stereochemistry depicted in (3) to be deduced directly. However, since the dihydropyrans are formed by a two-stage process involving an intermediate zwitterion [6] it would be reasonable to suppose that the thermodynamically more stable *cis*-fused adduct (3) is obtained, in which the amine group can attain an equatorial configuration with respect to the cyclohexane ring. Risaliti *et al.*[6] have confirmed that the product from the reaction of phenyl vinyl ketone with the piperidine enamine of 4-t-butylcyclohexanone has a *cis*-fused ring junction. Of the structures with a *cis*-ring junction only the epimer (3) in which the dihedral angles between the proton at C-4 and those at C-4a and C-3 are approximately 25 and 60°, respectively, would be expected to exhibit the observed coupling constants.[7] Identical stereochemistry was tentatively assigned to the corresponding xanthen (7) from dibenzylidenecyclohexanone and 1-pyrrolidin-1-ylcyclohexene.[1]

Reactions of 1-piperidinocyclohexene and its pyrrolidine analogue with benzylidenedeoxybenzoin in boiling ethanol gave the benzopyrans (8; $n = 1$ or 0) in low yield. The presence of an additional phenyl group at C-3 in structures (8; $n = 0$ or 1) is reflected by a decrease in frequency of the enol ether i.r. absorption by 15—20 cm^{-1} in comparison with that of the chalcone adduct (3). When the same enamines reacted with dibenzylideneacetone, a variety of products were obtained, depending upon the reaction conditions. In ethanol at 0°, the dihydropyrans (9; $n = 1$ or 0) were isolated. The u.v. and i.r. spectra of these compounds showed enol ether absorption identical in wavelength and intensity to that previously observed for the xanthen (7). In both the n.m.r. spectra of compounds (9; $n = 1$ or 0) the C-4 proton signal appeared as a double doublet (J 3—3·5 and 9 and 10 Hz). The magnitudes of these splittings, which are analogous to those of compound (3), indicate that once again the relative stereochemistry is as shown.

The reaction of 1-piperidinocyclohexene with dibenzylideneacetone in boiling ethanol gave two crystalline products. One of these, which was formed after only 5 min, was the enamino-ketone (10). The n.m.r. spectrum revealed that the isomer with the trisubstituted



SCHEME 1

enamine double bond in structure (10) was present to the extent of 90%. Mild hydrolysis of compound (10) gave as expected the known [8] diketone (5; R = PhCH=CH). The product which was obtained after a longer reaction time (15 h) was shown by elemental analysis to be isomeric with (10). However, the n.m.r. showed no olefinic proton resonances and the i.r. spectrum showed a broad carbonyl band at 1700 cm^{-1}. A possible structure for this compound is (11), formed from the trisubstituted enamine isomer of (10) by the reaction sequence shown (Scheme 1). Treatment of compound (11) with methyl iodide–acetone gave the quaternary salt (12), which on heating with aqueous sodium hydroxide eliminated *N*-methylpiperidine. The major product was unambiguously identified as the benzylidene ketone (13) by its n.m.r. spectrum, which showed two olefinic proton signals, τ 3·25(s) and 3·97 (t, J 3·5 Hz). The formation of compound (13) is visualised as taking place by removal of the proton adjacent to the carbonyl function in structure (12) followed by fission of the cyclobutane ring (Scheme 1).

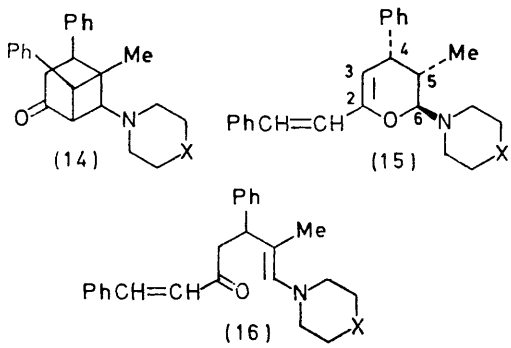
Attempts were made to synthesise the cyclobutylamines (14; X = CH_2 or O) from dibenzylideneacetone and the appropriate enamines of propionaldehyde. Reactions in boiling ethanol for 0·5 and 6 h, respectively, gave only the pyrans (15; X = CH_2 or O) in-

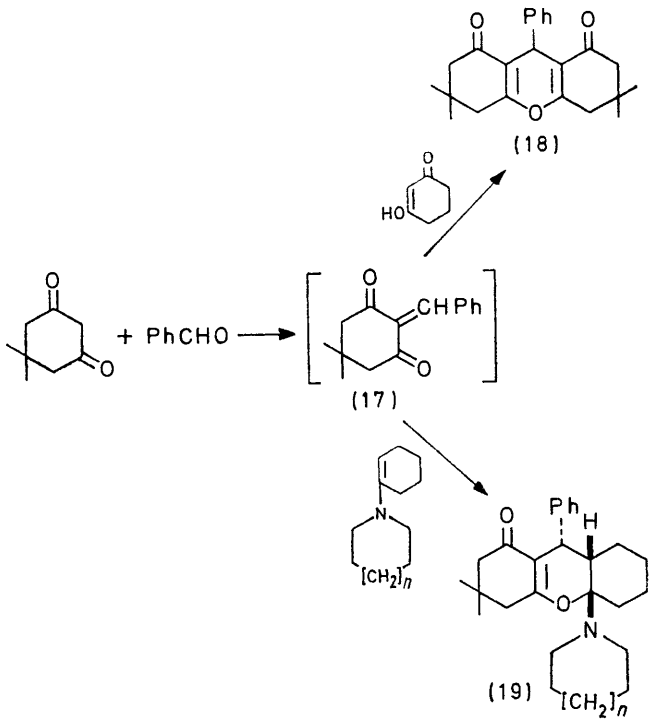
[6] P. F. Colonna, S. Tattuta, A. Risaliti, and C. Russo, *J. Chem. Soc.* (*C*), 1970, 2377.

[7] M. Karplus, *J. Amer. Chem. Soc.*, 1963, **85**, 2870 and references cited therein.

[8] H. A. P. de Jongh, F. J. Gerhatl, and H. Wynberg, *J. Org. Chem.*, 1965, **30**, 1409.

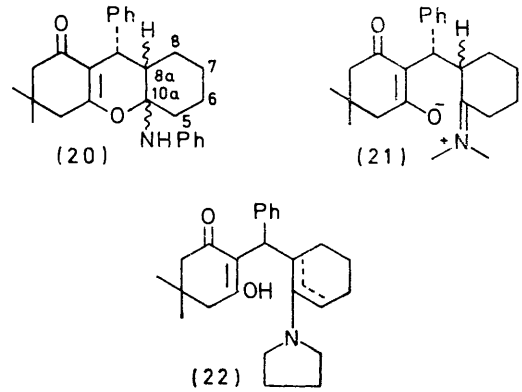
dicating that these compounds possess greater thermal stability than their enamino-ketone counterparts (16; X = CH_2 or O), which in this case would contain a tetrasubstituted enamine double bond. Further treatment of compounds (15; X = CH_2 or O) in ethanol failed to yield any of the desired cyclobutylamine (14; X = CH_2 or O). The n.m.r. spectra of compounds (15; X = CH_2 or O) showed the C-6 proton signal as a doublet (J 10 Hz). Dreiding models indicate that a splitting of this magnitude is only possible if the protons at C-5 and C-6 are *trans*-disposed, with the amine function in the more stable quasiequatorial configuration. Double irradiation experiments revealed that the coupling between the C-4 and C-5 protons was also 10 Hz, and this suggests that the relative stereochemistry is as depicted in (15), where the dihedral angle between these protons is *ca.* 0°. The coupling of the protons at C-3 and C-4 is small; this is also in good agreement with structure (15) in which the dihedral angle between them approaches 90°.





Scheme 2

The monobenzylidene derivative (17) of dimedone is not isolable from the simple reaction of benzaldehyde and dimedone under basic conditions since further condensation with another molecule of dimedone occurs.[9] When, however, this condensation was carried out in refluxing benzene solution in the presence of the enamine, the dihydropyran adduct (19; $n = 1$) was obtained (Scheme 2). The stereochemistry of (19; $n = 1$) was identical with that observed for the earlier dihydropyrans. The reaction of compound (19; $n = 1$) with pyrrolidine resulted in direct exchange of the tertiary amines, yielding compound (19; $n = 0$). On heating the latter with aniline a further exchange of amine functions occurred giving compound (20). The n.m.r. spectrum of this material indicated that it was an approximate 2 : 1 mixture of epimers; two distinct signals attributable to the proton at C-9 were observed. One of these (*ca.* 0·67H) was a doublet (J 9 Hz), assigned as before to the C-9 proton in [20; 10aβ-NHPh(*eq*), 8aβ-H]. The other was a broad singlet (*ca.* 0·33H) attributable only to the corresponding C-9 proton in [20; 10aα-NHPh(*eq*), 8aα-H], where negligible coupling between the protons at C-9 and C-8a would be expected. This suggests that the transamination reaction proceeds by formation of an intermediate zwitterion (21), followed by amine exchange and subsequent ring closure. In the case of compound (20), partial epimerisation must occur at C-8a and final ring closure must then proceed to give an α-NHPh group, thereby maintaining the more thermodynamically stable B/C *cis*-fused ring junction.



EXPERIMENTAL

General experimental methods have been previously described.[1]

5,6,7a,8,9,10,11,11a-*Octahydro*-7-*phenyl*-11a-*pyrrolidin*-1-*yl*-7H-*benzo*[c]*xanthen* (2; $n = 0$).—1-Pyrrolidin-1-ylcyclohexene (7·5 g) was added to a solution of 2-benzylidene-1-tetralone (9 g) in refluxing ethanol (40 ml). The solution immediately became deep red but on further refluxing for 1 h a colour change to yellow was observed. On cooling

[9] G. Swoboda and P. Schuster, *Monatsh.*, 1964, **95** (2), 398.

to −70° a solid precipitate was obtained which was rapidly filtered off and washed with cold light petroleum. The resulting powdery solid (13·2 g) was recrystallised from light petroleum to give the *xanthen* (2; $n = 0$) as prisms, m.p. 126—129° (Found: C, 84·0; H, 8·3; N, 3·6. $C_{27}H_{31}NO$ requires C, 84·1; H, 8·1; N, 3·6%); $\nu_{max.}$ 1650 (enol ether C=C) and 1599 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 230 (ε 13,400), 285 (10,820), and 292 nm (10,900); τ 7·78br (1H, d, *J* 10 Hz, 7a-H), 7·04 (4H, t, $CH_2{\cdot}N{\cdot}CH_2$), 6·50 (1H, d, *J* 10 Hz, PhC*H*), and 2·3—3·2 (9H, m, ArH).

5,6,7a,8,9,10,11,11a-*Octahydro*-7-*phenyl*-11a-*piperidino*-7H-*benzo*[c]*xanthen* (2; $n = 1$).—1-Piperidinocyclohexene (5·5 g) was added to a solution of 2-benzylidene-1-tetralone (6 g) in refluxing ethanol (40 ml). The solution was refluxed for a further 18 h and the product was isolated as before. The *xanthen* (2; $n = 1$) (5·95 g) had m.p. 143—146° [from light petroleum (b.p. 40—60°)] (Found: C, 84·3; H, 8·1; N, 3·3. $C_{28}H_{33}NO$ requires C, 84·2; H, 8·3; N, 3·5%); $\nu_{max.}$ 1657 (enol ether C=C) and 1599 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 285 (ε 10,940) and 289 nm (11,100); τ 7·63br (1H, d, *J* 8 Hz, 7a-H), 6·57 (1H, d, *J* Hz, PhC*H*), and 2·4—3·2 (9H, m, ArH).

2-(2-*Benzoyl*-1-*phenylethyl*)*cyclohexanone* (5; R = Ph).—1-Pyrrolidin-1-ylcyclohexene (8 g) and chalcone (7·5 g) in ethanol (40 ml) were heated under reflux for 15 min. The solvent was removed to give an intractable gum, which was chromatographed on alumina (grade 1). Elution with light petroleum and ether–light petroleum (1 : 9) gave several gummy fractions which decomposed and slowly deposited crystals of the diketone (5; R = Ph). The solid was collected and washed with ether; it crystallised from ethanol in needles (1·75 g), m.p. 137·5—138·5° (lit.,[6] 141°; lit.,[5] 149°) (Found: C, 82·3; H, 7·1. Calc. for $C_{21}H_{22}O_2$: C, 82·3; H, 7·2%); $\nu_{max.}$ 1708 (cyclohexanone C=O), 1680 (PhC=O), and 1593 (Ar C=C) cm^{-1}.

The diketone (5; R = Ph) was more conveniently isolated from the reaction mixture as follows. 1-Pyrrolidin-1-ylcyclohexene (7 g) and chalcone (5 g) in ethanol (40 ml) were treated as before. Water was then added slowly to the hot solution until it became turbid. On cooling and addition of more water, the diketone (5; R = Ph) (6·2 g) crystallised. It was filtered off, washed with water and ether, and then dried (m.p. 137—138°).

2-(2-*Benzoyl*-1-*phenylethyl*)-1-*piperidinocyclohexene* (6).—1-Piperidinocyclohexene (6 g) and chalcone (5 g) in ethanol (30 ml) were heated under reflux for 0·5 h. The solution was cooled and the precipitated solid was filtered off, washed with cold ethanol, and dried. The *enamino-ketone* (6) (8·05 g) had m.p. 154—155° (decomp.) (from methyl ethyl ketone) (Found: C, 83·4; H, 8·2; N, 3·9. $C_{26}H_{31}NO$ requires C, 83·6; H, 8·4; N, 3·75%); $\nu_{max.}$ 1677 (PhC=O), 1638 (enamine C=C), and 1592 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 230 (ε 13,000) and 292 nm (4000); τ 5·18 (0·75H, t, *J* 4 Hz, olefinic H) and 1·9—3·0 (10H, m, 2 × Ph).

4a,5,6,7,8,8a-*Hexahydro*-2,4-*diphenyl*-8a-*piperidino*-4H-1-*benzopyran* (3).—A solution of 1-piperidinocyclohexene (5·6 g) and chalcone (5·2 g) in ethanol (30 ml) was stirred for 18 h at 0°. The chalcone gradually dissolved and the dihydropyran (3) (6·2 g) crystallised from the mixture; m.p. 121·5—122·5° (from light petroleum) (Found: C, 83·75; H, 8·5; N, 3·6. $C_{26}H_{31}NO$ requires C, 83·6; H, 8·4; N, 3·75%); $\nu_{max.}$ 1650 (enol ether C=C) and 1598 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 272 nm (ε 11,120); τ 7·80br (1H, d, *J* 8·5 Hz, 4a-H), 6·40 (1H, dd, *J* 2 and 8·5 Hz, PhC*H*), 4·81 (1H, d, *J* 2 Hz, olefinic 3-H), and 2·3—3·0 (10H, m, 2 × Ph). Irradiation at τ 6·40 caused the signal at τ 4·81 to collapse to a singlet.

4a,5,6,7,8,8a-*Hexahydro*-2,3,4-*triphenyl*-8a-*pyrrolidin*-1-*yl*-4H-1-*benzopyran* (8; $n = 0$).—1-Pyrrolidin-1-ylcyclohexene (2·2 g) was added to a warm solution of benzylidenedeoxybenzoin (3·6 g) in ethanol (25 ml) and the solution was heated under reflux for 2 h. On cooling, the *dihydropyran* (8; $n = 0$) (2·6 g) precipitated; m.p. 151—152° (from methyl ethyl ketone) (Found: C, 85·3; H, 7·4; N, 3·1. $C_{31}H_{33}NO$ requires C, 85·5; H, 7·6; N, 3·2%); $\nu_{max.}$ 1635 (enol ether C=C) and 1597 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 277 nm (ε 8800); τ 7·48br (1H, d, *J* 9 Hz, 4a-H), 7·00 (4H, t, $CH_2{\cdot}N{\cdot}CH_2$), 6·33 (1H, d, *J* 9 Hz, PhC*H*), and 2·6—3·6 (15H, m, 3 × Ph).

4a,5,6,7,8,8a-*Hexahydro*-2,3,4-*triphenyl*-8a-*piperidino*-4H-1-*benzopyran* (8; $n = 1$).—1-Piperidinocyclohexene (2·8 g) was added to a warm solution of benzylidenedeoxybenzoin (2·6 g) in ethanol (20 ml) and the solution was heated under reflux for 18 h. On cooling the *dihydropyran* (8; $n = 1$) (0·5 g) crystallised; m.p. 157—158° (from methyl ethyl ketone) (Found: C, 85·4; H, 8·0; N, 2·8. $C_{32}H_{35}NO$ requires C, 85·8; H, 7·85; N, 3·1%); $\nu_{max.}$ 1633 (enol ether C=C) and 1597 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 277 nm (ε 8900); τ 6·23 (1H, d, *J* 7·5 Hz, PhC*H*) and 2·6—3·5 (3H, m, 3 × Ph).

4a,5,6,7,8,8a-*Hexahydro*-4-*phenyl*-8a-*pyrrolidin*-1-*yl*-2-*styryl*-4H-1-*benzopyran* (9; $n = 0$).—1-Pyrrolidin-1-ylcyclohexene (5 g) was added to a stirred suspension of dibenzylideneacetone (5 g) in ethanol (40 ml) at 0°. A clear red solution was obtained from which a semi-solid mass was deposited after 1—2 min. On cooling the mixture to −70°, the product completely solidified and was collected and washed with cold light petroleum. The *dihydropyran* (9; $n = 0$) (5·5 g) had m.p. 110—112·5° (from methyl ethyl ketone) (Found: C, 84·0; H, 7·8; N, 3·4. $C_{27}H_{31}NO$ requires C, 84·1; H, 8·1; N, 3·6%); $\nu_{max.}$ 1642 (enol ether C=C) and 1612 and 1596 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) (*ca.* 5°) 298 nm (ε 21,500); τ 7·98 (1H, m, *J* 10 Hz, 4a-H), 7·07 (4H, t, $CH_2{\cdot}N{\cdot}CH_2$), 6·38 (1H, dd, *J* 3 and 10 Hz, PhC*H*), 5·29 (1H, d, *J* 3 Hz, olefinic 3-H), 3·34 (2H, ABq, *J* 16 Hz, CH=CH), and 2·3—3·0 (10H, m, 2 × Ph).

4a,5,6,7,8,8a-*Hexahydro*-4-*phenyl*-8a-*piperidino*-2-*styryl*-4H-1-*benzopyran* (9; $n = 1$).—1-Piperidinocyclohexene (5·5 g) was added to a stirred suspension of dibenzylideneacetone (5 g) in ethanol (50 ml) at 0°. Stirring was continued for a further 1 h at 0° and then for 2 h at room temperature. The precipitated *dihydropyran* (9; $n = 1$) (7·7 g), washed with ethanol and dried, had m.p. 110·5—111·5° (Found: C, 84·0; H, 8·4; N, 3·4. $C_{28}H_{33}NO$ requires C, 84·2; H, 8·3; N, 3·5%); $\nu_{max.}$ 1642 (enol ether C=C) and 1611 and 1597 (Ar C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 298 nm (ε 22,800); τ 7·7 (1H, m, *J* 9 Hz, 4a-H), 6·37 (1H, dd, *J* 3·5 and 9 Hz, PhC*H*), 5·14 (1H, d, *J* 3·5 Hz, olefinic 3-H), 3·27 (2H, ABq, *J* 16 Hz, CH=CH), and 2·4—2·9 (10H, m, 2 × Ph).

2-*Phenyl*-2-(2-*piperidinocyclohex*-2-*enyl*)*ethyl Styryl Ketone* (10).—1-Piperidinocyclohexene (16·5 g) was added to a hot solution of dibenzylideneacetone (17·8 g) in ethanol (120 ml), and the solution was heated under reflux for 5 min. On cooling, the *enamino-ketone* (10) (22·5 g) crystallised as needles, m.p. 153—155° (from methyl ethyl ketone) (variable; decomp.) (Found: C, 84·3; H, 8·5; N, 3·7. $C_{28}H_{33}NO$ requires C, 84·2; H, 8·3; N, 3·5%); $\nu_{max.}$ 1650 and 1624 (CH=CH–C=O) and 1638 (enamine C=C) cm^{-1};

τ 5·13 (0·9H, dd, olefinic H) and 3·29 (2H, ABq, *J* 15 Hz, CH=CH).

2-(2-*Cinnamoyl*-1-*phenylethyl*)*cyclohexanone* (5; R = PhCH=CH).—The enamino-ketone (10) (5·5 g) in chloroform (50 ml) was stirred with a buffer solution of sodium acetate (6 g) and acetic acid (12 ml) in water (40 ml) for 15 h. The organic layer was separated, washed with 2N-hydrochloric acid and water, and dried. Removal of solvent left the diketone (5; R = PhCH=CH), which crystallised from ethanol in needles (4·05 g), m.p. 132—134° (lit.,[8] 137°); $\nu_{max.}$ 1702 (cyclohexanone C=C) and 1650 and 1624 (CH=CH–C=O) cm^{-1}.

1,4-*Diphenyl*-7b-*piperidinoperhydrocyclobuta*[de]*naphthalen*-2-*one* (11).—1-Piperidinocyclohexene (5·5 g) was added to a hot solution of dibenzylideneacetone (5·9 g) in ethanol (50 ml). The solution was heated under reflux for 18 h and then the solvent was removed. The residue was triturated with ethanol to give the *amine* (11) (5·8 g), m.p. 173·5—174·5° (from ethanol) (Found: C, 84·2; H, 8·2; N, 3·65. $C_{28}H_{33}NO$ requires C, 84·2; H, 8·3; N, 3·5%); $\nu_{max.}$ 1700 (C=O) and 1598 (Ar C=C) cm^{-1}; no olefinic proton resonances were visible in the n.m.r. spectrum and the compound showed no u.v. absorption above 230 nm.

Reaction of the Quaternary Salt (12) *with Base*.—The cyclobutylamine (11) (10 g) and methyl iodide (10 g) in acetone (100 ml) were heated under reflux for 2 days. The solid was filtered off and washed with acetone, and the mother liquors were treated with more methyl iodide for 2 days. This procedure was repeated until a quantitative yield of the *quaternary salt* (12) was obtained; m.p. 217—218° (Found: C, 64·3; H, 6·7; N, 2·6. $C_{29}H_{36}INO$ requires C, 63·8; H, 6·65; N, 2·6%); $\nu_{max.}$ 1700 (C=O) cm^{-1}.

The quaternary salt (10 g) in 15% sodium hydroxide solution (100 ml) was heated on a steam-bath for 1 h. Extraction with ether gave a yellow solid (2·91 g), which crystallised from ethanol in yellow prisms of 1-*benzylidene*-3,4,4a,5,6,7-*hexahydro*-4-*phenylnaphthalen*-2(1H)-*one* (13), m.p. 111—114° (Found: C, 87·6; H, 7·0. $C_{23}H_{22}O$ requires C, 87·85; H, 7·05%); $\nu_{max.}$ 1687 (C=O) and 1619 (C=C) cm^{-1}; $\lambda_{max.}$ (EtOH) 298 nm (ε 9800); τ 3·97 (1H, t, *J* 3·5 Hz, =CH), 3·25 (1H, s, PhC*H*=), and 2·3—3·0 (10H, m, 2 × Ph).

2,3-*Dihydro*-3-*methyl*-4-*phenyl*-2-*piperidino*-6-*styryl*-4H-*pyran* (15; X = CH_2).—1-Piperidinopropene (15 g) was added to a hot solution of dibenzylideneacetone (15 g) in ethanol (100 ml) during 30 min. On cooling, the *dihydropyran* (15; X = CH_2) (14·1 g) precipitated. Recrystallisation from methyl ethyl ketone and acetone gave prisms, m.p. 142—143° (Found: C, 83·2; H, 8·1; N, 3·7. $C_{25}H_{29}NO$ requires C, 83·5; H, 8·1; N, 3·9%); $\nu_{max.}$ 1640 (enol ether C=C) and 1612 (Ar C=C) cm^{-1}; τ 9·15 (3H, d, *J* 6·5 Hz, Me), 6·77 (1H, dd, *J* 2 and 10 Hz, 4-H), 5·55 (1H, d, *J* 10 Hz, 6-H), 5·15 (1H, d, *J* 2 Hz, olefinic 3-H), 3·72 (2H, ABq, *J* 16 Hz, CH=CH), and 2·4—2·9 (10H, m, 2 × Ph). These assignments were verified by the appropriate double irradiation experiments which also revealed that the 5-H signal was at τ 7·9.

2,3-*Dihydro*-3-*methyl*-2-*morpholino*-4-*phenyl*-6-*styryl*-4H-*pyran* (15; X = O).—1-Morpholinopropene (10 g) was added to a hot solution of dibenzylideneacetone (10 g) in ethanol (40 ml), and the solution was heated under reflux for 6 h. On cooling, the *dihydropyran* (15; X = O) (14·4 g) precipitated. Recrystallisation from ethanol gave prisms, m.p. 162—165° (Found: C, 79·65; H, 7·5; N, 3·65. $C_{24}H_{27}NO_2$ requires C, 79·7; H, 7·5; N, 3·9%); $\nu_{max.}$ 1642 (enol ether C=C) and 1612 (Ar C=C) cm^{-1}; τ 9·13 (3H, d, *J* 6·5 Hz, Me), 7·6—8·4 (1H, m, 5-H), 6·25 (4H, t, *J* 4·7 Hz, CH_2·O·CH_2), 5·60 (1H, d, *J* 2·3 Hz, olefinic 3-H), 3·24 (2H, ABq, *J* 16 Hz, CH=CH), and 2·4—2·9 (10H, m, 2 × Ph).

Attempted Conversion of Compounds (15; X = O or CH_2) *into the Corresponding Cyclobutylamines*.—The dihydropyran (15; X = O) was recovered virtually unchanged after refluxing in ethanol for 15 h. Under the same conditions compound (15; X = CH_2) gave a mixture of products which on chromatography did not yield any homogeneous material.

3,4,5,6,7,8,8a,10a-*Octahydro*-3,3-*dimethyl*-9-*phenyl*-10a-*piperidinoxanthen*-1(2H)-*one* (19; *n* = 1).—Dimedone (2·8 g), benzaldehyde (3·2 g), 1-piperidinocyclohexene (5 g), and piperidine (0·3 ml) in benzene (100 ml) were heated under reflux, with removal of water formed, for 15 h. The solvent was removed and the residue was triturated with light petroleum (b.p. 40—60°) to give the *xanthen* (19; *n* = 1) (5·5 g), m.p. 147—148° (from ethanol) (Found: C, 79·5; H, 9·1; N, 3·4. $C_{26}H_{35}NO_2$ requires C, 79·4; H, 9·0; N, 3·6%); $\nu_{max.}$ 1653 and 1625 cm^{-1}; $\lambda_{max.}$ (EtOH) 264 nm (ε 13,770); τ 8·88 (6H, s, 2 × Me), 6·30 (1H, d, *J* 7 Hz, PhC*H*), and 2·73 (5H, m, Ph).

Reaction of the Xanthenone (19; *n* = 1) *with Pyrrolidine*.—The xanthen (19; *n* = 1) (20 g), pyrrolidine (5 g), and a trace of toluene-*p*-sulphonic acid in toluene (120 ml) were heated under reflux for 18 h. Removal of toluene left the *xanthen* (19; *n* = 0) (13·0 g), which was washed with light petroleum (b.p. 40—60°) and recrystallised from the same solvent; yield 8·7 g, m.p. 139·5—140·5° [mixed m.p. depression with (19; *n* = 1)] (Found: C, 79·2; H, 8·95; N, 3·9. $C_{25}H_{33}NO_2$ requires C, 79·1; H, 8·8; N, 3·7%); $\nu_{max.}$ 1655 and 1625 cm^{-1} [the i.r. spectrum showed distinct differences from that of (19; *n* = 1) in the regions 780—900 and 1000—1150 cm^{-1}]; $\lambda_{max.}$ (EtOH) 267 nm (ε 14,850), $\lambda_{max.}$ (EtOH–NaOH) 290 nm [the bathochromic shift in alkali is presumably due to the establishment of an equilibrium with the enamino-ketone (22)]; τ 8·94 (6H, s, 2 × Me), 6·30 (1H, d, *J* 8·5 Hz, PhC*H*), and 2·83 (5H, s, Ph).

Reaction of the Xanthen (19; *n* = 0) *with Aniline*.—The xanthen (3 g), aniline (1·4 g), and a trace of toluene-*p*-sulphonic acid in toluene (120 ml) were heated under reflux for 72 h. Removal of toluene gave the *xanthen* (20) (1·3 g), which crystallised from benzene–light petroleum and then from methyl ethyl ketone to give needles (0·2 g), m.p. 214—216° (Found: C, 80·6; H, 7·8; N, 3·4. $C_{27}H_{31}NO_2$ requires C, 80·75; H, 7·8; N, 3·5%); $\nu_{max.}$ 3400 (NH), 1643, and 1618 cm^{-1}; $\lambda_{max.}$ (EtOH) 250 nm (ε 11,020), $\lambda_{max.}$ (EtOH–NaOH) 293 nm; τ 9·07 (*ca.* 2H) and 8·92 (*ca.* 4H) (2 × Me), 6·88 (d, *ca.* 0·67H, *J* 9 Hz, 9-H), 6·26br (*ca.* 0·33H, s, 9-H), and 2·6—3·6 (10H, m, 2 × Ph).

We thank Mr. G. Hancock for technical assistance.

[1/2121 *Received*, 11*th November*, 1971]