TABLE I

γ-KETO-β-METHYLGLUTACONIC ANHYDRIDE ARYLHYDRAZONES

Aryl group	Color	M.p., °C.	Yield, %	Recrystd.[a] from	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
Phenyl	Orange plates	175	70	C	62.60	62.66	4.38	4.60	12.17	12.38
m-Trifluoromethylphenyl	Yellow	182.3	65	C	52.40	52.47	3.04	3.12	9.40	9.53
o-Methoxyphenyl	Orange-brown needles	222	62	C	59.99	59.95	4.65	4.44	10.77	10.72
p-Methoxyphenyl	Rusty-orange needles	205	40	C	59.99	60.13	4.55	4.61	10.77	10.82
Sodium sulfophenyl	Yellow needles	>360	85	..	...	...	..	..	8.44[b]	8.50
2-Naphthyl	Red-orange needles	264	85	E	68.56	68.44	4.32	4.61	10.00	10.21
1-Naphthyl	Red-orange needles	218	85	E	68.56	68.52	4.32	4.51	10.00	10.29
p-Dimethylaminophenyl	Blue needles	211	72	E	61.53	61.73	5.53	6.37	15.38	15.34
p-Diethylaminophenyl	Blue cubes	171	71	E	63.77	63.88	6.36	6.20	13.95	14.28
o-Nitrophenyl	Orange plates	247	64	E	52.37	52.61	3.30	3.44	15.27	15.23
2,4-Dinitrophenyl	Orange-brown plates	230	69[c]	E	45.01	45.23	2.52	2.40	17.50	17.22
2,4-Dinitrophenyl	Yellow needles	230	69[c]	E	45.01	45.11	2.52	2.39	17.50	17.31

[a] C, carbon tetrachloride; E, ethyl acetate. [b] As monohydrate. *Anal.* Calcd. (as monohydrate): S, 9.64. Found: S, 9.35. [c] Combined yield of both products.

Anal. Calcd. for $C_{12}H_{10}O_3N_2$: C, 62.60; H, 4.38; neut. equiv., 230.2. Found: C, 62.42; H, 4.42; neut. equiv., 224.

1-(*o*-Methoxyphenyl)-3-carboxy-4-methyl-6-pyridazone (IV, Ar = *p*-$CH_3OC_6H_4$).—This compound was prepared by alkaline hydrolysis of 2.61 g. of γ-keto-β-methylglutaconic anhydride *o*-methoxyphenylhydrazone. There was obtained 1.4 g., 53% of the theoretical amount, of 1-(*o*-methoxyphenyl)-3-carboxy-4-methyl-6-pyridazone, m.p. 234° (cor.).

Anal. Calcd. for $C_{13}H_{12}O_4N_2$: C, 59.99; H, 4.65; N, 10.77; neut. equiv., 260.2. Found: C, 60.08; H, 4.62; N, 10.77; neut. equiv., 251.

1-Phenyl-4-methyl-6-pyridazone.—The pyridazinecarboxylic acid (2.3 g.) prepared as described above was decarboxylated by heating to 240° for five minutes. The residue was extracted with 12 *N* hydrochloric acid. The extracts were decolorized and made basic to precipitate the crude product. Additional product was obtained by ether extraction. Recrystallization from diethyl ether–petroleum ether at −20° gave 0.9 g., 50% of the theoretical amount, of 1-phenyl-4-methyl-6-pyridazone, hygroscopic needles, m.p. 84°, reported[9] m.p. 86°.

Anal. Calcd. for $C_{11}H_{10}N_2O$: N, 15.05. Found: N, 15.01.

LOUISVILLE, KENTUCKY

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, CARNEGIE INSTITUTE OF TECHNOLOGY]

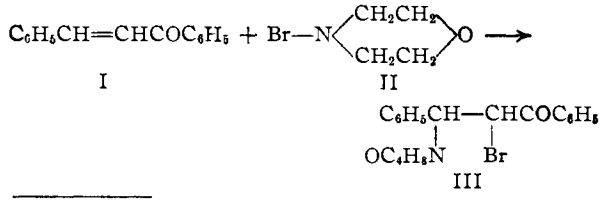
The Addition of N-Bromomorpholine to Benzalacetophenone

BY PHILIP L. SOUTHWICK AND WILLIAM L. WALSH[1]

RECEIVED JULY 22, 1954

The possibility of adding an N-haloamine to an unsaturated compound has been demonstrated; direct addition of the elements of N-bromomorpholine to *trans*-benzalacetophenone has produced a new form of α-bromo-β-morpholinobenzylacetophenone, the diastereoisomer of the previously known form. Hydrolysis and methanolysis of the new isomer proceeded readily, yielding, respectively, α-morpholino-β-hydroxybenzylacetophenone and a compound thought to be α-morpholino-β-methoxybenzylacetophenone. The stereochemical aspects of these reactions are discussed.

In the investigation to be described here it has been shown that the elements of N-bromomorpholine (II) can be added directly to the olefinic double bond of benzalacetophenone (I) to yield as the chief product a new diastereoisomeric form of α-bromo-β-morpholinobenzylacetophenone (III).[2]



I II III

This result establishes the possibility of N-haloamine addition to unsaturated compounds. It supports the opinion previously advanced that reactions of iodine–amine complexes with α,β-unsaturated carbonyl compounds proceed *via* an initial addition of the elements of an N-iodoamine.[3]

In benzene or ether solutions one mole of bromine reacts with one mole of morpholine with the formation of an orange precipitate which may be analogous to the iodine–morpholine complex.[3,4] However, unlike the iodine–morpholine complex, which can exist in the presence of considerable amounts of excess morpholine, the bromine–morpholine complex is immediately decomposed by the action of an additional mole of morpholine to give morpholine hydrobromide in a nearly quantitative yield. The white precipitate of morpholine hydrobromide may be filtered from the mixture to leave pale-yellow

(1) Institute Fellow in Organic Chemistry, 1952–1953. This paper is based on a portion of the Ph.D. Thesis of William L. Walsh, Carnegie Institute of Technology, June, 1953.

(2) N. H. Cromwell, THIS JOURNAL, 62, 2897 (1940), first described the other racemic form of this compound, which is produced by the addition of morpholine to α-bromobenzalacetophenone. Jordan, Lutz and Hinkley, ref. 7, recently showed that the same isomer is produced by the action of morpholine on either diastereoisomer of benzalacetophenone dibromide or on either geometric isomer of α-bromobenzalacetophenone.

(3) (a) P. L. Southwick, and D. R. Christman, THIS JOURNAL, 74, 1886 (1952); (b) P. L. Southwick and D. R. Christman, *ibid.*, 75, 629 (1953).

(4) R. V. Rice and G. D. Beal, U. S. Patent, 2,290,710 (July 21, 1943); *C. A.*, 37, 602 (1943).

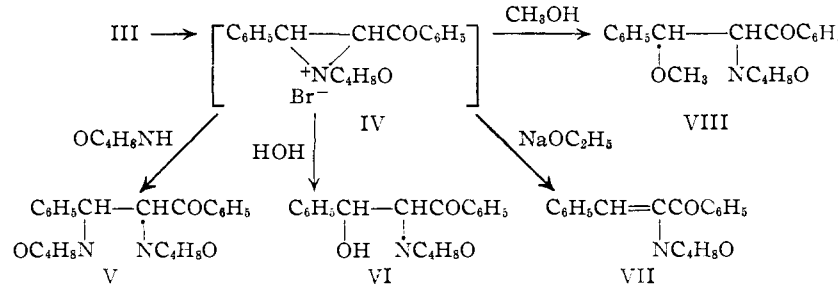
solutions containing a compound capable of liberating iodine from potassium iodide solutions. This latter observation and the apparent stoichiometry of the reaction between one mole of bromine and two of morpholine indicate that the product which remains in solution is N-bromomorpholine (II). Although removal of the solvent from such solutions and exposure of the light-yellow solid residue to the

$$2OC_4H_8NH + Br_2 \longrightarrow OC_4H_8NH_2^+Br^- + \underset{\text{II}}{OC_4H_8NBr}$$

air caused the compound to decompose, sometimes quite suddenly and vigorously, it was apparently stable for several days in solution.[5]

The addition of the elements of N-bromomorpholine (II) to *trans*-benzalacetophenone (I) occurred when the α,β-unsaturated ketone was dissolved in benzene or ether solutions of the N-bromoamine prepared as described above, and the mixtures were allowed to stand either in a refrigerator or at room temperature for a period of several days to allow for completion of the reaction. Products which crystallized from the solution were removed from the mixture from time to time during the reaction period. The addition reaction appeared to proceed more readily in ether than in benzene. In addition to α-bromo-β-morpholinobenzylacetophenone (III), the major product, α,β-dimorpholinobenzylacetophenone (V) and morpholine hydrobromide were formed. The α-bromo-β-morpholinobenzylacetophenone (III) was produced in both of the possible racemic forms, but 90% of it consisted of the new diastereoisomer (m.p. 137–138°), which melted at nearly the same temperature as the known diastereoisomer, but depressed its melting point by more than 10°. The assignment of the positions of the bromine atom and the morpholino group in the new isomer is based upon the fact that the compound liberates iodine when treated with acidified potassium iodide solutions, a property employed by Cromwell and his co-workers[6] to distinguish α-bromo-β-amino ketones from β-bromo-α-amino ketones. In the Experimental section the new isomer will be referred to as form B the designation form A being reserved for the previously-known isomer produced by the addition of morpholine to α-bromobenzalacetophenone.[2]

The new form of α-bromo-β-morpholinobenzylacetophenone (III) is a very reactive substance. With morpholine it reacts to yield mainly the lower-melting, less basic form of α,β-dimorpholinobenzylacetophenone (V), the isomer B of Jordan, Lutz and Hinkley.[7] This is the same isomer formed as a by-product in the addition of N-bromomorpholine (II) to benzalacetophenone (I) and is the one produced by the action of morpholine and the iodine–morpholine complex on benzalacetophenone.[3] Like its diastereoisomer, the new form of III yields α-morpholinobenzalacetophenone (VII) when treated with sodium ethoxide in ethanol.[2] When heated with aqueous acetone, the compound is converted into α-morpholino-β-hydroxybenzylacetophenone (VI) as a result of a displacement of bromine (hydrolysis) and rearrangement, which, like the reactions previously mentioned, presumably involves an intermediate ethyleneimmonium salt (IV).[8] The positions to be assigned to the hydroxyl and morpholino groups in compound VI were first made evident by the fact that the substance decomposes slowly upon standing in a stoppered bottle with the formation of benzaldehyde, apparently as the result of a reverse aldol reaction. The assignment of the hydroxyl group to the β-position is also supported by the failure of VI to react with periodic acid in the manner of an α-hydroxy ketone such as benzoin.



The new form of α-bromo-β-morpholinobenzylacetophenone (III) also reacted readily with methanol to yield a compound to which the structure α-morpholino-β-methoxybenzylacetophenone (VIII) has been tentatively assigned on the basis of analogy to the reaction with water. It must be mentioned, however, that rearrangement does not always accompany displacement of the bromine in the other form of III; that isomer reacts with potassium acetate or triethylammonium acetate, for example, to yield α-acetoxy-β-morpholinobenzylacetophenone.[9]

If, as seems likely, the new form of III is an *erythro* form resulting from the *trans* addition of the elements of N-bromomorpholine to *trans*-benzalacetophenone,[10] then internal displacement with inversion should lead to a *trans* relationship of the phenyl and benzoyl groups in the intermediate ethyleneimmonium salt (IV) and, as a result of another inversion, to an *erythro* configuration for final displacement products such as V, VI and VIII.[11] However, it has been pointed out[7] that the form of V produced in these experiments shows

(5) R. A. Henry and W. M. Dehn, THIS JOURNAL, **72**, 2280 (1950), have described the preparation of N-bromomorpholine by means of the reaction of a sodium hypobromite solution with morpholine at 0°. Henry and Dehn reported that the material obtained by their method decomposed upon standing, the decomposition being complete within 10 hours. We have not as yet investigated the use of N-bromomorpholine prepared by their method.

(6) See N. H. Cromwell and J. A. Caughlin, THIS JOURNAL, **67**, 2235 (1945).

(7) R. H. Jordan, R. E. Lutz and D. F. Hinkley, Jr., *J. Org. Chem.*, **16**, 1442 (1951).

(8) N. H. Cromwell and D. J. Cram, THIS JOURNAL, **65**, 301 (1943).

(9) N. H. Cromwell and F. W. Starks, *ibid.*, **72**, 4108 (1950).

(10) *trans* addition of the elements of an N-iodo primary amine seems necessary to account for the *trans* configuration of the ethylene imine ketones formed in reactions of *trans*-benzalacetophenone with iodine–primary amine complexes. See ref. 3b and N. H. Cromwell and M. A. Graff, *J. Org. Chem.*, **17**, 414 (1952).

(11) Compare (a) F. H. Dickey, W. Fickett and H. J. Lucas, THIS JOURNAL, **74**, 944 (1952); (b) N. H. Cromwell, G. V. Hudson, R. A. Wankel and P. J. Vanderhorst, *ibid.*, **75**, 5384 (1953).

properties which might seem to be in accord with those expected of a *threo* form, its melting point and basicity being lower and its solubility higher than the corresponding values for its diastereoisomer. Thus the configurations of these compounds remain uncertain.

Further work is in progress on N-haloamines, halogen–amine complexes and products formed in the addition reactions of these compounds.

Experimental[12,13]

Reaction of Bromine with Morpholine.—To a solution of 4 g. (0.025 mole) of bromine in 100 ml. of benzene 4.5 g. (0.054 mole) of morpholine was added with stirring. An orange-colored precipitate separated during the addition of the first half of the morpholine, but during the latter part of the addition the color of the precipitate gradually faded until it became white. Filtration of the solution yielded 4 g. (a 95% yield) of morpholine hydrobromide.

The light-yellow filtrate was concentrated by evaporation under reduced pressure to leave a light-yellow solid residue. A sample of this material liberated iodine from a potassium iodide solution. However, upon short exposure to air the substance decomposed vigorously with evolution of yellow fumes and formation of a black residue.

α-Bromo-β-morpholinobenzylacetophenone (III), Form B.—To a solution of 16 g. (0.10 mole) of bromine in 350 ml. of anhydrous ether 18 g. (0.217 mole) of morpholine was added with vigorous stirring. An initial orange precipitate faded to white during the latter part of the addition and the solution became light yellow. The solution was filtered to remove 17 g. of morpholine hydrobromide. To the filtrate was added a solution of 20 g. (0.096 mole) of *trans*-benzalacetophenone in 200 ml. of anhydrous ether. The mixture was allowed to stand overnight at room temperature, then was filtered to remove 3 g. of precipitate which proved to be almost entirely morpholine hydrobromide. The filtrate was concentrated to about $^2/_3$ of its original volume under reduced pressure, left overnight in a refrigerator, and filtered next day to collect 5 g. of precipitated products. Three more crops of crystals totaling 20 g. were collected by repetition of a procedure in which the filtrate was concentrated to about $^1/_2$ of its volume under reduced pressure, then kept in the refrigerator overnight to precipitate additional product.

Morpholine hydrobromide was removed from the different crops of mixed precipitates by water extraction, and the remaining materials were dissolved in ether. The ether solutions were then extracted repeatedly (usually 5 or 6 times) with dilute aqueous acid to remove α,β-dimorpholinobenzylacetophenone (V). (Hydrobromic acid rather than hydrochloric acid was used for the extractions in runs where analytical samples were sought so as to avoid any possibility of halide exchange.) Neutralization of the acid extracts precipitated the α,β-dimorpholinobenzylacetophenone (V). A total of 3 g. of this compound was obtained. When crystallized from petroleum ether (b.p. 65–110°) this product melted at 173–176° and was shown to be V, isomer B, by the mixed melting point test using an authentic sample.[7]

The ether solutions containing the α-bromo-β-morpholino benzylacetophenone (III) were evaporated under reduced pressure. The resulting light-yellow crystalline residues contained form B contaminated with a small amount of form A. The diastereoisomers were separated by means of two different procedures. From the residues obtained by evaporation of the ether solutions it was sometimes possible to separate the large granular crystals of form B from the light, flaky crystals of form A by adding water, stirring the resulting suspension and decanting the floating crystals of form A. Crystallization from petroleum ether (b.p. 65–110°) also served to separate the isomers if the crystallization flask was removed from the refrigerator after separation of the light-yellow granules of form B seemed complete, and the supernatant solution was removed quickly by decantation or rapid filtration. The separation of form A was then induced by scratching the walls of the flask. The separated isomers were purified by crystallization from petroleum ether. The yield of form B was 9 g. (25.2%), m.p. 133–136°; the yield of form A was 1 g. (2.8%), m.p. 130–131°. Further recrystallization of form B from petroleum ether gave an analytical sample as very pale yellow prisms, m.p. 137–138°. Melting occurred without obvious signs of decomposition but melted samples did not resolidify.

Anal. Calcd. for $C_{19}H_{20}O_2NBr$: C, 60.97; H, 5.39; N, 3.74. Found: C, 61.38; H, 5.48; N, 3.56.

An authentic sample of form A, m.p. 137–138°,[14] prepared by the addition of morpholine to α-bromobenzalacetophenone[2] caused a depression of the melting point to 122–125° when mixed with a sample of form B. When the authentic sample of form A was mixed with the somewhat impure sample of form A, m.p. 130–131°, described in the paragraph above, the m.p. was 132–134°.

When a sample of form B was treated with an acidified potassium iodide solution according to the directions of Cromwell and Caughlin,[6] 76% of the calculated amount of iodine was released, as determined by titration with sodium thiosulfate. Form A is reported to release 79% of the calculated amount of iodine under these conditions.[6]

Reaction of α-Bromo-β-morpholinobenzylacetophenone (III), Form B, with Morpholine.—To a solution of 1 g. (0.0027 mole) of α-bromo-β-morpholinobenzylacetophenone (III), form B, in 10 ml. of benzene 0.5 g. (0.006 mole) of morpholine was added and the mixture was allowed to stand overnight. The precipitated morpholine hydrobromide was filtered out and the solvent was removed under reduced pressure. The residual solid was recrystallized from petroleum ether (b.p. 65–110°) to yield 0.5 g. (49% yield) of light-yellow crystals of α,β-dimorpholinobenzylacetophenone (V), m.p., 164–166°. A second recrystallization raised the melting point to 167–169°. No depression of the melting point was observed when this product was mixed with an authentic sample of V, isomer B.[7]

Reaction of α-Bromo-β-morpholinobenzylacetophenone (III), Form B, with Sodium Ethoxide.—Three grams (0.0081 mole) of α-bromo-β-morpholinobenzylacetophenone (III), form B, was added slowly to a refluxing mixture prepared by dissolving 0.27 g. (0.012 atom) of sodium in 10 ml. of absolute ethanol. The orange-colored mixture was refluxed for 20 minutes, then cooled to 0° and diluted by gradual addition of water. The orange-colored plates of α-morpholinobenzalacetophenone which precipitated (2 g., 84% yield) melted at 89–91°. Several recrystallizations from ethanol–water mixtures raised the m.p. to 92–94°. There was no depression of the melting point when the compound was mixed with an authentic sample of α-morpholinobenzalacetophenone.[2]

α-Morpholino-β-hydroxybenzylacetophenone (VI).—A solution of 2 g. (0.0054 mole) of α-bromo-β-morpholinobenzylacetophenone (III), form B, in 25 ml. of acetone was heated on a steam-cone while 0.2 g. of water was added slowly from a dropper. (Rapid addition causes precipitation of starting material.) After the water had been added the mixture was refluxed for 20 minutes. The hot solution was filtered to remove a small amount of insoluble material, and the filtrate was neutralized with sodium bicarbonate. Scratching the walls of the flask containing the cooled and filtered solution caused crystallization of a white product, which was removed by filtration and recrystallized from petroleum ether (b.p. 65–110°) to yield 1 g. (60% yield) of a product melting at 103–105°. Two further recrystallizations from petroleum ether gave white plates, m.p. 106–107°.

Anal. Calcd. for $C_{19}H_{21}O_3N$: C, 73.29; H, 6.80; N, 4.50. Found: C, 73.00; H, 6.82; N, 4.23.

The compound did not react with periodic acid under conditions[15] which produced a strong positive test from benzoin. When a sample was stored in a stoppered bottle for several weeks it decomposed to a mixture smelling strongly of benzaldehyde.

In an experiment in which α-bromo-β-morpholinobenzylacetophenone (III), form B, was hydrolyzed in a way similar

(12) Melting points are corrected.

(13) Microanalyses by Micro Tech Laboratories, Skokie, Illinois.

(14) This compound melts with decomposition and the m.p. varies somewhat with the rate of heating. See ref. 2 and ref. 7. In the present work it was the common practice to use a bath preheated to 15 or 20° below the m.p. of the compound to be melted and to raise the temperature fairly rapidly (*ca.* 5°/min.)

(15) R. L. Shriner and R. C. Fuson, "The Systematic Identification of Organic Compounds," 3rd ed., John Wiley and Sons, Inc., New York, N. Y., 1948, p. 115.

to that described above, but with a longer period of heating and removal of the acetone by distillation from the steam-cone, the product isolated was a colorless oily base which formed a hydrochloride agreeing in melting point (m.p. 220–222°) with the hydrochloride of ω-morpholinoacetophenone (m.p. 222–223°).[16]

α-Morpholino-β-methoxybenzylacetophenone (VIII).—A solution of 1.5 g. (0.0046 mole) of α-bromo-β-morpholino-benzylacetophenone (III), form B, in 10 ml. of methanol was heated on a steam-cone for 20 minutes. Distilled water was added to precipitate the product, which was removed by filtration, treated with an aqueous sodium bicarbonate solution, collected again by filtration and dried to yield 1 g. (77% yield) of a white solid. After two recrystallizations from petroleum ether (b.p. 65–110°) the compound was obtained as white plates, m.p. 116–117°.

Anal. Calcd. for $C_{20}H_{23}O_3N$: C, 73.82; H, 7.12; N, 4.30. Found: C, 73.67; H, 7.17; N, 4.35.

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(16) N. Ruben and A. R. Day, *J. Org. Chem.*, **5**, 54 (1940).

[CONTRIBUTION FROM THE ORGANIC CHEMISTRY LABORATORY OF THE COLLEGE OF ENGINEERING AND TECHNOLOGY, BENGAL]

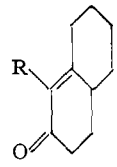
Synthesis of 1-Methyl-*trans*-2-decalone and 2,3,4,4a,4b,5,6,7,8,8a,9,10-Dodecahydro-2-phenanthrone

BY D. K. BANERJEE,[1] S. CHATTERJEE AND S. P. BHATTACHARYA[2]

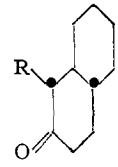
RECEIVED JUNE 7, 1954

1-Methyl-*trans*-2-decalone (IIa) and *trans*-2-decalone (IIb) have been prepared by the metal–amine reduction of 1-methyl-$\Delta^{1,9}$-2-octalone (Ia) and $\Delta^{1,9}$-2-octalone (Ib), respectively. 2,3,4,4a,4b,5,6,7,8,8a,9,10-Dodecahydro-2-phenanthrone has been prepared from *trans*-2-decalone.

1-Methyl-*trans*-2-decalone (IIa) was obtained first by English and Cavaglieri[3] from decalone, and later by Pinder and Robinson[4] from *trans*-2-decalone. The present synthesis, which is simpler, depends upon the *trans* reduction of 1-methyl-$\Delta^{1,9}$-2-octalone (Ia).



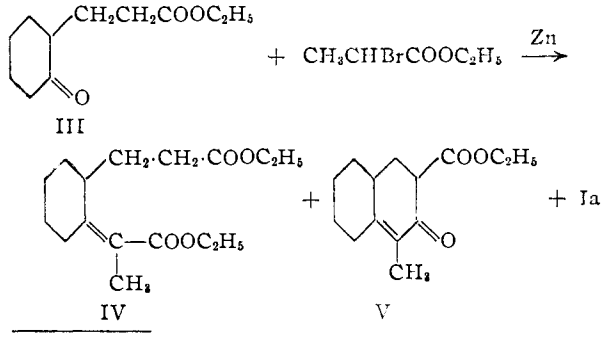
Ia, R = CH_3; Ib, R = H



IIa, R = CH_3; IIb, R = H

Catalytic reduction of polycyclic α,β-unsaturated ketones of type I generally leads to formation of the *cis* isomers of the saturated ketones[5]; however, there are cases in which the *trans* isomer[6] or a mixture of *cis* and *trans* isomers[7] of the reduced ketones has been obtained. Chemical reductions of similar type of compounds, however, have been reported to yield *trans* isomers,[8] the ketones being invariably reduced to secondary alcohols. Recently Djerassi and co-workers[9] reduced a steroidal α,β-unsaturated ketone of the $\Delta^{9,10}$-octalone type to the *trans* isomer without affecting the carbonyl group. They used lithium–amine in the absence of alcohol; in the presence of alcohol the keto group is reduced to a saturated alcohol. With a slight modification of this procedure, Ib and Ia were reduced to IIb and IIa, respectively; the identity of both reduction products was confirmed by comparison with derivatives of authentic specimens. Reduction of Ib by the same method in the presence of alcohol gave *trans*-2-decalol which was oxidized with chromic acid to *trans*-2-decalone. Whereas we obtained only the stable form of the two possible isomers of IIa, Pinder and Robinson[4] obtained a mixture of isomers which on treatment with alkali yielded the homogeneous stable form. According to Barton's conformation rule[10] IIa should represent the configuration of the more stable form in which the C_1-methyl group is equatorial. Catalytic (PtO_2) hydrogenation of IIa in ethanol gave the *cis* isomer, previously prepared by Robinson and Weygand[11] by a different method.

1-Methyl-$\Delta^{1,9}$-2-octalone (Ia) was prepared by condensation[12] of ethyl cyclohexanone-2β-propionate (III) with ethyl α-bromopropionate followed by treatment of the crude condensation product with aqueous alkali. The Reformatsky condensation product, prior to treatment with alkali, consisted of



(1) Organic Chemistry Department, Indian Institute of Science, Bangalore 3, India

(2) Indebted to East India Pharmaceutical Works, Ltd., Calcutta, for the award of a fellowship.

(3) J. English, Jr., and G. Cavaglieri, THIS JOURNAL, **65**, 1085 (1943).

(4) A. R. Pinder and R. Robinson, *J. Chem. Soc.*, 1224 (1952).

(5) (a) E. C. du Feu, F. J. McQuillin and R. Robinson, *ibid.*, 53 (1937); (b) J. W. Cornforth and R. Robinson, *ibid.*, 1855 (1949); (c) H. Grasshof, *Z. physiol. Chem.*, **223**, 249 (1934).

(6) A. Butenandt, K. Tschernig and G. Hanisch, *Ber.*, **68**, 2097 (1935).

(7) A. Butenandt and G. Fleischer, *ibid.*, **68**, 2094 (1935).

(8) (a) W. B. Renfrow and J. W. Cornforth, THIS JOURNAL, **75**, 1347 (1953); (b) W. S. Johnson, B. Bannister, B. M. Bloom, A. D. Kemp, R. Pappo, E. R. Rogier and J. Szmuszkovicz, *ibid.*, **75**, 2275 (1953).

(9) (a) C. Djerassi, G. Rosenkranz, O. Mancera and F. Sondheimer, *ibid.*, **75**, 1282 (1953); (b) F. Sondheimer, O. Mancera, G. Rosenkranz and C. Djerassi, *ibid.*, **74**, 2696 (1952); (c) C. Djerassi, W. Frick, G. Rosenkranz and F. Sondheimer, *ibid.*, **75**, 3496 (1953).

(10) D. H. R. Barton, *Experientia*, **6**, 316 (1950); D. H. R. Barton and W. J. Rosenfelder, *J. Chem. Soc.*, 1048 (1951).

(11) R. Robinson and F. Weygand, *ibid.*, 386 (1941).

(12) P. S. Adamson, F. C. McQuillin, R. Robinson and J. L. Simonsen, *ibid.*, 1576 (1937).