Oxidation of Hydroxyketone IX to Geronic Acid.—A solution of 20.0 g. of hydroxyketone in 175 ml. of acetic acid containing 85 ml. of 30% hydrogen peroxide was maintained at 60° for nine hours, after which time complete oxidation was indicated by complete solubility of a portion of the reaction mixture in saturated potassium carbonate solution. The cooled reaction mixture was poured into an aqueous solution of excess sodium carbonate which was extracted twice with ether, acidified with hydrochloric acid and then extracted four times with ether. The latter ether extract was dried over sodium sulfate and distilled to give 17.22 g. (78%) of geronic acid, b.p. 147–150° (3.3 mm.), $n^{25}D$ 1.4472–1.4477; semicarbazone, m.p. 164.5–165° (reported[20] m.p. 165°); 2,4-dinitrophenylhydrazone, recrystallized from ethyl acetate–hexane, m.p. 139.5–140° (reported[21] m.p. 135.5–137°).

Acknowledgment.—The authors wish to thank Dr. J. M. Vandenbelt, R. B. Scott and their associates at Parke, Davis and Co. for the ultraviolet and infrared spectral determinations.

[20] H. Rupe and C. Liechtenhan, *Ber.*, **41**, 1278 (1908).

[21] H. H. Strain, THIS JOURNAL, **57**, 758 (1935).

DETROIT 2, MICHIGAN

[CONTRIBUTION FROM THE PHARMACEUTICAL INSTITUTE, MEDICAL FACULTY, UNIVERSITY OF KYUSHU]

Thermal Behavior of *dl-trans-* and *dl-cis-*2-Iodo-N,N-dimethylcyclohexylamines[1]

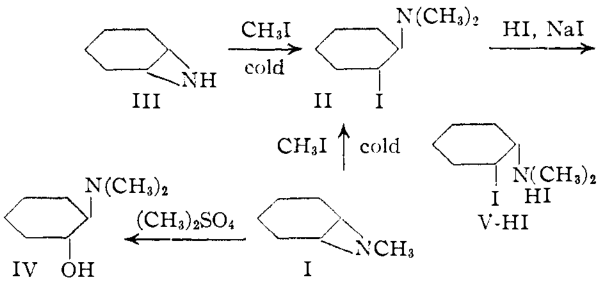
BY TANEZO TAGUCHI AND MORIFUSA ETO[2]

RECEIVED AUGUST 7, 1957

dl-trans-2-Iodo-N,N-dimethylcyclohexylamine (II) was obtained by the reaction of methyl iodide with either *meso-cis*-N-methylcyclohexenimine (I) or *meso-cis*-cyclohexenimine (III). The *cis* epimer V was prepared from II-hydroiodide. The configurations assigned to II and V were confirmed by a number of reactions on stereochemical grounds. Under pyrolytic conditions the *trans* epimer II gave cyclopentanecarboxaldehyde (VI) and cyclohexanone (VII), while the *cis* epimer V gave only cyclohexanone (VII). The thermal behavior was not governed by *cis* elimination, which is generally accepted for pyrolysis, but by heterolytic reaction rules. This was attributed to the reactivity of the dimethylamino group, since in the case of the *trans* epimer II hydrochloride destruction of the reactivity of the dimethylamino group by salt formation altered the reaction mechanism to *cis* elimination.

The reaction of *meso-cis*-N-methylcyclohexenimine (I) with methyl iodide at room temperature gave mainly *dl-trans*-2-iodo-N,N-dimethylcyclohexylamine (II) accompanied by a small amount of the methiodide of II; II was also prepared from *meso-cis*-cyclohexenimine (III) and excess methyl iodide. The configuration assigned to II is based on the known *trans* opening of the imine ring[3] and on the fact that treatment of the N-methylimine (I) with dimethyl sulfate gave *dl-trans*-2-dimethylaminocyclohexanol (IV) (see Scheme 1). The work of Winternitz and Mousseron,[4] who concluded that the reaction of I with methyl iodide with heat yields *dl-trans*-2-iodo-N,N,N-trimethylcyclohexylammonium iodide, supports this configuration for II. The following observations supply even stronger evidence for the configuration of II: boiling of the *trans* epimer hydroiodide II-HI with anhydrous sodium iodide in dry ethanol–acetone for many hours yielded the hydroiodide of *dl-cis*-2-iodo-N,N-dimethylcyclohexylamine (V), while all attempts to prepare V from esters of *dl-trans*-2-dimethylaminocyclohexanol failed.

SCHEME 1



The *trans* epimer II reacted with silver nitrate at room temperature to yield *dl-trans*-2-dimethylaminocyclohexanol (IV) and cyclopentanecarboxaldehyde[5] (VI), while the *cis* epimer V yielded only cyclohexanone (VII).[5] These results are stereochemically similar to those of Mousseron[4,6] obtained by analogous treatment of *dl-trans*-2-iodocyclohexylamine and *dl*-2-chlorocyclohexanols. Treatment of the epimers with water gave almost the same results. When II was warmed with water, *dl-trans*-2-dimethylaminocyclohexanol (IV) was obtained, and when it was heated with water at 140° in a sealed tube, IV and cyclopentanecarboxaldehyde (VI) were formed; V gave cyclohexanone (VII). Analogously, ethanolysis of II at 140–150° gave *dl-trans*-2-ethoxy-N,N-dimethylcyclohexylamine (IV′), a small amount of crude VII and a trace of crude VI, whereas V gave VII.

The similarity of these results suggests that the mechanism for the formation of a particular product is the same under all these conditions. For details see Scheme 2. One would expect that II in the preferred diequatorial conformation would yield VI *via* the N,N-dimethylcyclopentylmethylideneammonium (VIII), and that IV (or IV′) would be formed through the transition state with the migrating groups in axial positions followed by the formation of an intermediate, the *meso-cis*-N,N-dimethylcyclohexeniminium ion (IX).[7] With the *cis* epimer V, cyclohexanone would be expected

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[1] Studies in Stereochemistry. XVI.

[2] The Department of Agricultural Chemistry, Agricultural Faculty, University of Kyushu.

[3] (a) F. H. Dickey, W. Fickett and H. J. Lucas, THIS JOURNAL, **74**, 944 (1952); (b) R. Ghiradelli and H. J. Lucas, *ibid.*, **77**, 106 (1955); **79**, 734 (1957).

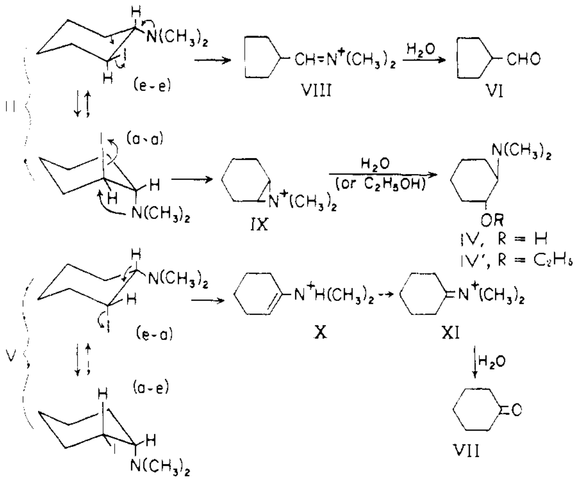
[4] F. Winternitz, M. Mousseron and R. Dennilauler, *Bull. soc. chim. France*, 382 (1956).

[5] G. E. McCasland obtained essentially the same rearrangement products from epimeric *dl*-2-aminocyclohexanols on treatment with nitrous acid in the cold; THIS JOURNAL, **73**, 2293 (1951).

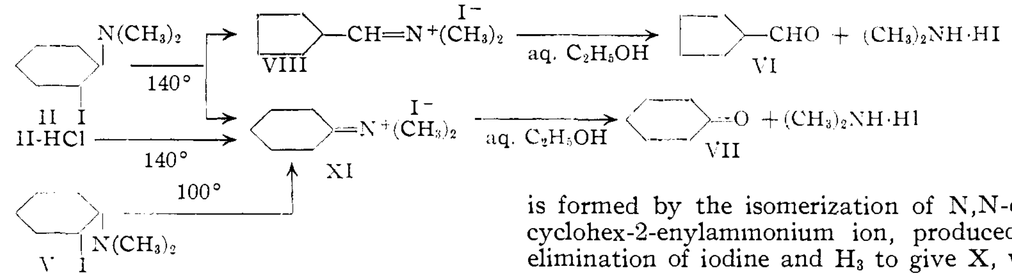
[6] M. Mousseron and R. Jaquier, *Compt. rend.*, **229**, 216 (1949).

[7] For details of the original mechanistic explanation adapted for this case, see D. Y. Curtin and S. Schmukler, THIS JOURNAL, **77**, 1105 (1955).

SCHEME 2



SCHEME 3



from the conformation which favors the *trans* elimination of H_1 and iodine, *i. e.*, from the structure in which the iodine is axial and the dimethylamino group is equatorial, *via* N,N-dimethylcyclohex-1-enylamine (X) and N,N-dimethylcyclohexylidenammonium ion (XI). If the reaction is interrupted by the immediate addition of aqueous sodium picrate to the clear solution obtained on warming of II in water, *meso-cis*-N,N-dimethylcyclohexeniminium picrate which corresponds to the intermediate IX can be isolated. Thus, reaction mechanisms consistent with the experimental results serve to confirm the configurations assigned to the two epimers II and V.

Compound V reacted with sodium ethoxide to give VII, probably through the formation of X (due to the elimination of iodine and H_1), followed by hydrolysis. Similar treatment of II with heat gave unidentifiable products, while in the cold it gave IV′, presumably *via* IX. In these cases *dl*-N,N-dimethylcyclohex-2-ene, which would have been produced by the elimination of H_3 and iodine. was not found.

Pyrolysis of II gave a solid mass which was washed with anhydrous ether and recrystallized from ethanol to give dimethylamine hydroiodide almost quantitatively. Compounds VI and VII were isolated as the 2,4-dinitrophenylhydrazones from the ethanolic solution. Similar treatment of V resulted in the formation of cyclohexanone (VII). Although the *cis* epimer V hydroiodide was stable, the free base V decomposed slowly at room temperature and rapidly at 100°. In these reactions, the formation of N,N-dimethylcyclopentylmethyldenammonium iodide (VIII) or *meso-cis*-N,N-dimethylcyclohexylidenammonium iodide (XI) as an intermediate is supported by the fact that the carbonyl compound (VI or VII) was not found in the washing ether, but in the aqueous ethanol from recrystallization; this suggests that they were formed by the hydrolysis of an intermediate; see Scheme 3.

The results of the thermal treatment of II and V have been interpreted as follows: In the preferred conformation of II in which the two substituents are equatorial, the coplanarity of C_6–C_1–C_2–I favored alkyl migration (*i. e.*, ring contraction) to give cyclopentanecarboxaldehyde (VI) *via* VIII. When the diequatorial form of II was converted to the diaxial conformation in the transition state, C_1-dimethylamino becomes coplanar with respect to C_2-iodine and in a favorable position for the participation to C_2; thus, cyclohexanone (VII) is formed *via* IX and XI. The possibility that VII is formed by the isomerization of N,N-dimethylcyclohex-2-enylammonium ion, produced by the elimination of iodine and H_3 to give X, was ruled out by the finding that the isomerization does not occur under these conditions. This fact also supports our contention that the formation of VII in pyrolysis proceeds from the elimination of iodine and H_1, rather than from iodine and H_3.

In the *cis* epimer V the dimethylamino group is equatorial and the iodine axial (e-a), or less probably *vice versa* (a-e). 1,3-Interaction in the *cis* epimer V in the e-a form, and even in the a-e form, would be stronger than in the *trans* epimer II in the e-e form. This steric compression might account for the relative instability of V. Presumably it is due to the same reason that VII was formed at a lower temperature from V than from II. Moreover, the formation of VII from V may have been furthered by the *trans* elimination of H_1 and iodine (which are coplanar in the e-a form), the molecule itself acting as a base which catalyzed E_2 elimination; for V-hydrohalide was much more stable to heat than V, a finding which suggests that in the case of the hydrohalide no catalysis was involved.

cis Elimination has been confirmed for the pyrolysis of a simple alicyclic chloride by Barton[8] and of alicyclic xanthates by several authors[9]; in these cases no appreciable rearrangement occurs. Our pyrolytic results, however, cannot all be explained in terms of *cis* elimination; for example, the ring contraction which occurred in the pyrolysis of II and the elimination of hydrogen iodide forming cyclohexanone faster from the *cis* epimer V

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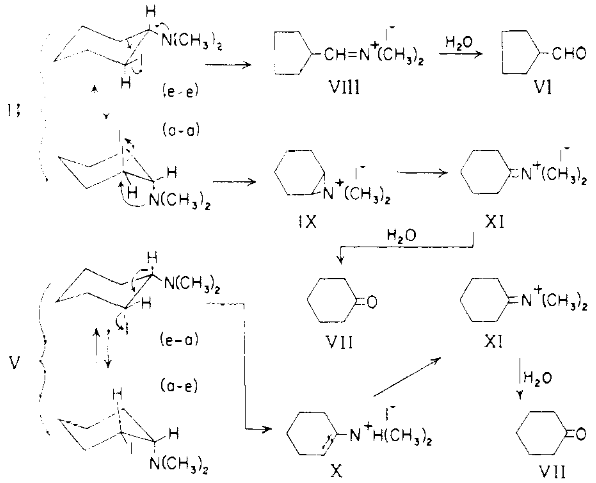
(8) D. H. R. Barton, A. J. Head and R. J. Williams, *J. Chem. Soc.*, 453 (1952).

(9) (a) W. Hückel, W. Tappe and G. Legutke, *Ann.*, **543**, 191 (1940); (b) E. R. Alexander and A. Mudrak, THIS JOURNAL, **72**, 1810 (1950); **72**, 3194 (1950); **73**, 59 (1951).

than from the *trans* epimer II. In explaining the thermal behavior of these compounds, the influence of the dimethylamino group should not be neglected; presumably it is governed by antiparallel coplanarity rather than by cyclic coplanarity (*cis* elimination). The heterolytic elimination involved is made possible by the fact that the material undergoes fusion prior to decomposition.

SCHEME 4



If the reactivity of the dimethylamino group is destroyed, the pyrolysis should follow the general law of *cis* elimination. To test this supposition, the *trans* epimer II hydrochloride was treated at 140° to give, as expected, cyclohexanone (VII) as the only carbonyl compound; apparently it was produced by the elimination of H_1 and iodine in the *cis* direction. In contrast to the free *trans* epimer II, the nitrogen atom of II-hydrochloride, due to the salt formation, becomes positively charged; this furthers the release of H_1, and the nitrogen ceases to be anchimeric. Thus, the situation is favorable for *cis* elimination as in the case of the simple alicyclic halide studied by Barton.[8] In the pyrolysis of II-hydrochloride, *dl-cis*-2-chloro-N,N-dimethylcyclohexylamine (XII) also was obtained. XII-Hydroiodide, however, remained unchanged under these conditions, showing that the formation of cyclohexanone (VII) from II-hydrochloride did not proceed through XII-hydroiodide. Pyrolysis of V-hydrochloride, like that of the free base V, gave cyclohexanone (VII), although more drastic conditions were required.

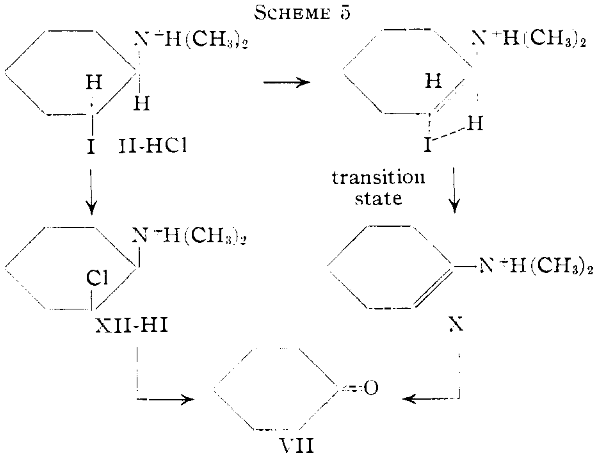
In the course of this study, the interconversion of ionic and non-ionic halogen was observed in II-hydrochloride; heating of II-hydrochloride in ethanol gave partially *dl-trans*-2-chloro-N,N-dimethylcyclohexylamine hydroiodide.

Experimental[10]

meso-cis-**N-Methylcyclohexenimine** (I) was prepared from 31 g. of *dl-trans*-2-methylaminocyclohexanol and 28.2 g. of chlorosulfonic acid by the procedure of Paris and Fanta[11] for the synthesis of *meso-cis*-cyclohexenimine; b.p. 65° (100 mm.), yield 10 g. The picrate was recrystallized from ethanol to give yellow needles, m.p. 128°.

Anal. Calcd. for $C_7H_{13}N\cdot C_6H_3N_3O_7$: C, 45.88; H, 4.72; N, 16.47. Found: C, 45.81; H, 4.81; N, 16.28.

SCHEME 5



***dl-trans*-2-Iodo-N,N-dimethylcyclohexylamine** (II). (a).—A mixture of 8 g. of *meso-cis*-N-methylcyclohexenimine (I) and 10.3 g. of methyl iodide in 25 ml. of absolute ether was kept for about 10 days at room temperature. The precipitate (yield 0.4 g.) was recrystallized from absolute ethanol as colorless needles, m.p. 107° dec.

Anal. Calcd. for $C_9H_{19}NI_2$ (iodomethylate of II): C, 27.35; H, 4.81; N, 3.54. Found: C, 27.78; H, 4.96; N, 3.53.

The picrate, m.p. 144° dec., gave a positive Beilstein test for halogen.

Anal. Calcd. for $C_9H_{19}NI\cdot C_6H_2N_3O_7$: C, 36.29; H, 4.23; N, 11.29. Found: C, 36.33; H, 4.15; N, 11.01.

The ethereal mother liquor was evaporated to dryness and the residue distilled at 91° (5 mm.); yield 10 g. The addition of alcoholic hydrogen chloride to the distillate, which had been dissolved in ether, gave white cubes, m.p. 123–124°, which were not recrystallized as recrystallization caused the intramolecular interconversion of halogens; see below.

Anal. Calcd. for $C_8H_{16}NI\cdot HCl$ (II-hydrochloride): C, 33.16; H, 4.84; N, 5.87. Found: C, 33.27; H, 4.72; N, 5.89.

The picrate which was recrystallized as usual from ethanol gave a positive Beilstein test for halogen; m.p. 155–157°.

Anal. Calcd. for $C_8H_{16}NI\cdot C_6H_3N_3O_7$: C, 34.87; H, 3.94; N, 11.62. Found: C, 35.00; H, 3.84; N, 11.43.

(b).—A mixture of 2.5 g. of *meso-cis*-cyclohexenimine (III) and 3.6 g. of methyl iodide in 10 ml. of dry ether was kept for 24 hours at room temperature. The resulting precipitate was recrystallized from alcohol; m.p. 153–154°, yield 0.25 g.

Anal. Calcd. for $C_8H_{16}NI\cdot HI$ (II-hydroiodide): C, 25.17; H, 4.46; N, 3.67. Found: C, 25.01; H, 4.59; N, 3.51.

The ethereal filtrate was treated as described in (a). The picrate obtained from the distillate, m.p. 153–154°, was identical with that of II prepared by procedure (a).

***dl-trans*-2-Dimethylaminocyclohexanol (IV) from *meso-cis*-Cyclohexenimine (III).**—Dimethyl sulfate (6.53 g.) was added dropwise to a mixture of 4.5 g. of III and 5.3 g. of sodium carbonate in benzene. After the mixture had been warmed over a water-bath, water and sodium hydroxide were added. The benzene layer was dried over sodium hydroxide, evaporated to dryness and distilled at 80–110° (80 mm.). The picrate, m.p. 146–148°, was identified as that of IV by a mixed melting point determination.

Anal. Calcd. for $C_8H_{17}NO\cdot C_6H_3N_3O_7$: C, 45.16; H, 5.38; N, 15.06. Found: C, 45.40; H, 5.36; N, 14.99.

***dl-cis*-2-Iodo-N,N-dimethylcyclohexylamine (V).**—A mixture of 11 g. of the II-hydroiodide and 10 g. of dry sodium iodide in 50 ml. of dry ethanol and 100 ml. of dry acetone was refluxed for 30 hours on a water-bath. The mixture was evaporated under reduced pressure until the appearance of a precipitate while hot, and then cooled at room temperature; 3 g. of starting material which precipitated was recovered. To remove additional starting material the mother liquor was concentrated. This treatment was repeated three times until sodium iodide finally precipitated.

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[10] All melting points are uncorrected.

[11] O. E. Paris and P. E. Fanta, THIS JOURNAL, **74**, 3007 (1952).

A mixture of cubes and a small amount of needles, which separated from the refrigerated filtrate, was suspended in acetone, and the light needles were removed mechanically by decantation. The mechanical separation was repeated and the heavy crystals were recrystallized from acetone as thick hexagonal plates of V-HI, m.p. 123–124°, yield 3 g.

Anal. Calcd. for $C_8H_{16}NI \cdot HI$: C, 25.17; H, 4.46; N, 3.67. Found: C, 25.38; H, 4.47; N, 3.69.

A mixture of the picrate (152–153°) and the picrate of the *trans* epimer II melted at 142°.

Anal. Calcd. for $C_8H_{16}NI \cdot C_6H_3N_3O_7$ (V-picrate): C, 34.87; H, 3.94; N, 11.62. Found: C, 35.07; H, 4.26; N, 11.89.

The free base (V): Two equivalents of potassium carbonate was added to the cold, aqueous solution of the hydroiodide (V-HI) and the mixture extracted with ether. The ether extract which was evaporated to dryness in a vacuum desiccator gave crystals, m.p. 39.5–40.5°. The free base is so unstable that even in a desiccator at room temperature about 60% of it decomposed in two days.

Reaction of the *trans*-II and *cis* Epimer V with Silver Nitrate. (a).—To a solution of 450 mg. of II in ether was added an aqueous solution of 360 mg. of silver nitrate at room temperature. After shaking, the ether layer was separated and the aqueous layer was extracted three times with ether. The combined ether extract was evaporated to dryness. The residue, to which aqueous alcohol had been added, was distilled. The 2,4-dinitrophenylhydrazone (yield 24%) obtained from the distillate melted at 156–158° after one recrystallization; it was identified as cyclopentanecarboxaldehyde (VI) 2,4-dinitrophenylhydrazone by a mixed melting point determination. The aqueous layer was made alkaline and extracted with ether. The ether extract yielded a picrate (yield 76%) which melted at 142–145° alone and on admixture with *dl-trans*-2-dimethylaminocyclohexanol (IV).

(b) To an ethereal solution of V, which was freshly prepared from its hydroiodide, was added an aqueous solution containing 100 mg. of silver nitrate. After vigorous shaking, the silver iodide was removed by filtration. The separated ether layer yielded a 2,4-dinitrophenylhydrazone (m.p. 155°, yield 82%) which was identical with that of cyclohexanone. The only picrate obtained from the aqueous layer was that of dimethylamine.

Treatment of II with Water. (a) The Formation of IV.—A suspension of 200 mg. of II in 2 ml. of water was heated in a water-bath until a clear solution was obtained (*ca.* 3 min.); then it was cooled with ice and washed with ether. Neither picrate nor 2,4-dinitrophenylhydrazone was obtained from the ether layer. The aqueous layer was made alkaline with sodium hydroxide and after two days extracted with ether. This ether extract gave the picrate of *trans*-2-dimethylaminocyclohexanol (IV); yield 66%, m.p. 142–143°; m.p. of the pure compound 146–148°.

Anal. Calcd. for $C_8H_{17}NO \cdot C_6H_3N_3O_7$: C, 45.16; H, 5.38; N, 15.06. Found: C, 45.45; H, 5.29; N, 14.94.

(b) **The Formation of *meso-cis*-N,N-Dimethylcyclohexeniminium Salt (IX).**—As soon as treatment of 0.3 g. of II as described under (a) gave a clear aqueous solution, an aqueous solution of sodium picrate was added gradually. At first there appeared an orange-yellow precipitate which was followed by pale yellow needles. The picrate was fractionally filtered. The first precipitate was recrystallized three times from acetone solution by the addition of ether (heating should be avoided) to give short needles, m.p. 153–154° dec. It showed a slight depression of melting point on admixture with an authentic sample of dimethylaminocyclohex-2-ene[12] picrate, the structural isomer which melts at 170° without decomposition.

Anal. Calcd. for $C_8H_{16}N \cdot C_6H_3N_3O_7$ (XI-picrate): C, 47.32; H, 5.08; N, 15.77. Found: C, 47.75; H, 5.20; N, 16.03.

The second precipitate (yield 300 mg.) has not been characterized.

Anal. Found: C, 38.45; H, 3.52; N, 15.49.

(c) **The Formation of IV and VI.**—A sealed tube containing 200 mg. of II suspended in 2 ml. of water was heated at 140° in an oil-bath for 10 minutes. The resulting clear solution was cooled and aqueous sodium picrate added. The picrate of IV was obtained, m.p. 146–147°, yield 51%. When 2,4-dinitrophenylhydrazine was added to the solution, cyclopentanecarboxaldehyde 2,4-dinitrophenylhydrazone was obtained, m.p. 149–151°.

Treatment of V with Water. The Formation of VII.—An aqueous suspension of the free base V, freshly prepared from 150 mg. of the hydroiodide, was boiled for 4 minutes. The resulting clear solution, after cooling, was extracted with ether, and the extract was evaporated to dryness. The residual oil was distilled three times with aqueous alcohol. The distillate gave a 2,4-dinitrophenylhydrazone (m.p. 155–156°, yield 64%), which was identical with the cyclohexanone derivative.

The Ethanolysis of II. The Formation of Crude VI, Crude VII and IV′.—A solution of 2.5 g. of II in 20 ml. of absolute ethanol was heated in a sealed tube at 140–150° for 30 minutes. After evaporation to dryness, water was added to the residue and the solution extracted with ether. The ether extract was distilled with alcohol. The distillate gave a 2,4-dinitrophenylhydrazone (m.p. 123–128°, yield 5%), which melted at 130–134° after repeated recrystallization. Further purification seemed hopeless. This dinitrophenylhydrazone gave a mixed m.p. of 125° with the 2,4-dinitrophenylhydrazone of cyclohexanone (VII) and a mixed m.p. of 137–147° with the cyclopentanecarboxaldehyde (VI) derivative.

The precipitate, resulting from the addition of water to the recrystallization filtrate, melted at 120° alone and at 124° with the cyclohexanone derivative. The aqueous layer, after saturation with sodium hydroxide, was extracted with ether and dried over sodium hydroxide. After evaporation of the ether, the residue boiled at 94.5–95.5° (27 mm.), yield 58%. The picrate, m.p. 125°, was identical with *dl-trans*-2-ethoxy-N,N-dimethylcyclohexylamine picrate prepared by the action of sodium ethoxide on II as mentioned below.

Reaction with Sodium Ethoxide. (a) The Formation of *dl-trans*-2-Ethoxy-N,N-dimethylcyclohexylamine (IV′) from II.—To a solution of 130 mg. of II in 1 ml. of absolute ethanol was added sodium ethoxide prepared from 40 mg. of sodium metal and 0.7 ml. of ethanol. After standing for 3 hours at room temperature,[13] the mixture was evaporated almost to dryness. Water and ether were added to the residue. The ether layer yielded a picrate which after three recrystallizations melted at 124–125°. The analytical data indicate that this product is *dl-trans*-2-ethoxy-N,N-dimethylcyclohexylamine (IV′) picrate.

Anal. Calcd. for $C_{10}H_{21}NO \cdot C_6H_3N_3O_7$: C, 48.00; H, 6.00; N, 14.00. Found: C, 48.15; H, 6.11; N, 13.95.

(b) **The Formation of VII from V.**—A mixture of the free base, freshly prepared from 200 mg. of V-hydroiodide, and 2 ml. of alcoholic sodium ethoxide solution (40 mg. of metallic sodium) was allowed to stand for 1.5 hours at room temperature; 2 ml. of water and 5 ml. of ether were added with shaking. The ether layer gave no picrate except that of the unchanged starting material. The ether solution after the removal of V-picrate was distilled with alcohol. The distillate gave a 2,4-dinitrophenylhydrazone (m.p. 154–155°, yield 68%) which was identical with the cyclohexanone derivative.

Pyrolysis. (a) The Formation of VI and VII from II.—One gram of the *trans* epimer II, which had been dried *in vacuo* over phosphorus pentoxide at room temperature for a week was heated at 140–145° in a sealed tube. The material first fused and then decomposed after 4 minutes of heating; it crystallized upon cooling. Washing with dry ether gave 0.94 g. of yellow powder. The powder was distilled with alcohol (dried over sodium once) and this treatment was repeated. The distillate gave 260 mg. of a 2,4-dinitrophenylhydrazone,[13] m.p. 125–128°, which after three recrystallizations from alcohol yielded orange plates, m.p. 154–155° alone and on admixture with the cyclopentanecarboxaldehyde derivative.

Anal. Calcd. for $C_{12}H_{14}N_4O_4$: C, 51.79; H, 5.07; N, 20.13. Found: C, 52.00; H, 5.03; N, 20.47.

The distillation residue was recrystallized from alcohol and ether. The recrystallization filtrate gave 300 mg. of a 2,4-dinitrophenylhydrazone,[14] m.p. 126–129°, which after

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(12) R. Willstätter and D. Hatt, *Ber.*, **45**, 1464 (1912).

(13) Heating should be avoided.

(14) This is probably a mixture of the derivatives of VI and VII, as the m.p. is low; these values, therefore, do not indicate the proportion of the ketone to the aldehyde.

repeated recrystallization from alcohol gave orange plates, melting at 152–154° alone and on admixture with the cyclohexanone derivative.

Anal. Calcd. for $C_{12}H_{14}N_4O_4$: C, 51.79; H, 5.07; N, 20.13. Found: C, 51.88; H, 4.89; N, 20.23.

The recrystallized distillation residue was again recrystallized from alcohol to give colorless prisms of dimethylamine hydroiodide, m.p. 147–150°.

Anal. Calcd. for $C_2H_7N\cdot HI$: C, 13.87; H, 4.62; N, 8.08. Found: C, 13.60; H, 4.41; N, 8.21.

(b) **The Formation of VII from V.**—When 130 mg. of the freshly prepared free base V was heated in a sealed tube at 100°, the material first fused and then decomposed after 30 seconds. The resulting solid mass was washed with dry ether and distilled with aqueous alcohol. The distillate gave a 2,4-dinitrophenylhydrazone (yield 100%, m.p. 155–156°) which was identified as the cyclohexanone derivative by a mixed m.p. determination.

(c) **The Formation of VII and *dl-cis*-2-Chloro-N,N-dimethylcyclohexylamine (XII) from II-Hydrochloride.**—Dried II-hydrochloride (1.04 g.) in a sealed tube was heated in boiling xylene. It melted at once and then decomposed after about 7 minutes to give a solid mass, which was treated as described under (b). The 2,4-dinitrophenylhydrazone of cyclohexanone was obtained; yield 56%, m.p. and mixed m.p. 150°.

The distillation residue was dissolved in water. The oily layer which apeared on the addition of alkali was extracted with ether. The ether layer yielded a picrate (yield 24%, m.p. 145–150°) which was repeatedly recrystallized from ethyl acetate to give needles, m.p. 178°, which were identified as *dl-cis*-2-chloro-N,N-dimethylcyclohexylamine (XII) picrate by a mixed m.p. determination.

Anal. Calcd. for $C_8H_{16}NCl\cdot C_6H_3N_3O_7$: N, 14.35. Found: N, 14.47.

(d) **The Formation of VII and Crude *dl-trans*-2-Chloro-N,N-dimethylcyclohexylamine from V-Hydrochloride.**—V-Hydrochloride (40 mg.) was heated in a sealed tube at 125°. When the decomposed material was treated as described in (b), the 2,4-dinitrophenylhydrazone of cyclohexanone was obtained, m.p. and mixed m.p. 152–154°. When the decomposed material was dissolved in water and extracted with ether after the addition of potassium carbonate, the extract gave a picrate which contained halogen; yield 45%, m.p. 138–142°. This picrate showed no depression of melting point on admixture with an authentic sample of *dl-trans*-2-chloro-N,N-dimethylcyclohexylamine picrate and a depression of melting point on admixture with its *cis* epimer.

***dl-cis*-2-Chloro-N,N-dimethylcyclohexylamine (XII)** was prepared by the Mousseron procedure[15]; b.p. 100° (25 mm.). The hydroiodide, which melted at 168–169° after recrystallization from acetone–ether, was unchanged when heated in a sealed tube at 140°.

Anal. Calcd. for $C_8H_{16}NCl\cdot HI$: C, 33.16; H, 5.87; N, 4.83. Found: C, 33.28; H, 5.90; N, 4.65.

Intramolecular Interconversion of Halogen.—A solution of 1.07 g. of II-hydrochloride in 10 ml. of absolute ethanol was refluxed for 5 minutes and then kept at room temperature for 3 days. Ether (15 ml.) was added and the mixture kept for 50 days. During this interval colorless needles appeared (m.p. 150–155°, yield 520 mg.) which after three recrystallizations from ethanol melted at 156–157° alone and on admixture with the hydroiodide of II. The picrate was also identical with the picrate of II-HI.

Anal. Calcd. for $C_8H_{16}NI\cdot HI$: C, 25.17; H, 4.46. Found: C, 25.47; H, 4.58.

After 50 days different needles appeared (yield 120 mg.) which were recrystallized from ethanol as cubes, m.p. 184–185°.

Anal. Calcd. for $C_8H_{16}NCl\cdot HI$ (*dl-trans*-2-chloro-N,N-dimethylcyclohexylamine hydroiodide): N, 5.84. Found: N, 5.78.

The picrate (m.p. 166–168°) gave a positive Beilstein test for halogen, but contained no iodine. Since the melting point of the picrate was depressed on admixture with authentic *dl-cis*-2-chloro-N,N-dimethylcyclohexylamine (XII) picrate (m.p. 178°), it is probably the *trans* epimer.

Anal. Calcd. for $C_8H_{16}NCl\cdot C_6H_3N_4O_7$ (*dl-trans*-2-chloro-N,N-dimethylcyclohexylamine picrate): C, 43.02; H, 4.86; N, 14.35. Found: C, 43.25; H, 4.94; N, 13.95.

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KATAKASU, FUKUOKA, JAPAN

[CONTRIBUTION FROM THE RESEARCH DEPARTMENT, UNION CARBIDE CHEMICALS CO.]

Synthesis of Lactones[1]

BY PAUL S. STARCHER AND BENJAMIN PHILLIPS

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The use of peracetic acid in an inert solvent was investigated in the Baeyer–Villiger synthesis of lactones from cyclic ketones. Side reactions were minor with cyclopentanone and various cyclohexanones, and it was possible to isolate by distillation the corresponding δ-valerolactone and ϵ-caprolactones in high yield as stable monomeric compounds. Several previously unreported alkyl-substituted ϵ-caprolactones were prepared by this method. Extension of the reaction to cycloheptanone and cyclooctanone resulted in extensive ring cleavage to the corresponding dibasic acids.

A previous contribution[2] from this Laboratory described a new synthesis of peracetic acid—one which gave the product as a solution in an inert solvent. The present paper deals with the use of this reagent for the preparation of lactones by reaction with cyclic ketones.

The limitations which have made the Baeyer–Villiger reaction[3] and its various modifications unsatisfactory in the past for the preparation of many acid-sensitive products, such as δ-valerolactone and ϵ-caprolactone, have been noted.[4] High yields of these products were obtained in the present study, and this was attributed to the type of peracetic acid solution used. The absence of inor-

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(1) Presented in part at the Atlantic City Meeting of the American Chemical Society, September 1956.

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