to that devised by Koelsch.[8] A mixture of 10 g. of triphenylvinyl bromide, 0.8 g. of magnesium and a small crystal of iodine was covered with 100 ml. of ether, and 0.05 ml. of ethyl bromide was added. The mixture, when heated under reflux to start the reaction, assumed a light green color. At the end of 10 minutes 5 ml. of *p*-(*t*-butyl)-benzoyl chloride, prepared from *p*-(*t*-butyl)-benzoic acid[9] by treatment with thionyl chloride,[10] was added. The mixture, which assumed a red color, was heated for 2 hours, and decomposed in the usual manner. Evaporation of the ether from the ether solution left a yellow oil, which crystallized when absolute ethanol was added, m.p. 193–199°. By repeated recrystallization from cyclohexane, the ketone was obtained as a colorless, micro-crystalline solid, m.p. 215.5°, yield 2.0 g. (16%).

Anal. Calcd. for $C_{31}H_{28}O$: C, 89.30; H, 6.78. Found: C, 89.06; H, 7.10.

The infrared absorption spectrum contains bands assignable to a conjugated carbonyl group (1670 cm.$^{-1}$), an aromatic system (1500, 1610 cm.$^{-1}$), a *para*-substituted phenyl radical (821 cm.$^{-1}$) and a *t*-butyl group (847 cm.$^{-1}$).

Alternate Synthesis of *p*-(*t*-(Butyl)-triphenylacrylophenone. 1. Benzyl *p*-(*t*-Butyl)-phenyl Ketone.—The method was similar to that employed for desoxybenzoin.[11] To a mixture of 67 g. of *t*-butylbenzene, prepared by the method of Huston, Fox and Binder,[12] 77.5 g. of phenylacetyl chloride and 400 ml. of carbon disulfide was added, with continuous stirring, 75 g. of anhydrous aluminum chloride. At the end of 20 hours the reaction mixture was poured into an ice–hydrochloric acid mixture. The ketone was isolated as a brown oil, which solidified when treated with methanol, m.p. 43–44°, yield 90 g. (71.3%).

Anal. Calcd. for $C_{18}H_{20}O$: C, 85.66; H, 7.99. Found: C, 85.93; H, 8.08.

2. **α,β-Diphenyl-β-chloro-*p*-(*t*-butyl)-propiophenone.**—From this point the synthesis was patterned after that of Kohler and Nygaard.[3] A solution of 51 g. of benzyl *p*-(*t*-butyl)-phenyl ketone in 23.3 g. of benzaldehyde was cooled in a freezing mixture and hydrogen chloride was passed into it for 7 hours. The solid cake that formed when the mixture was allowed to stand overnight was broken up under ethanol and recrystallized from this solvent, m.p. 196–197°, yield 48.8 g. (65%).

Anal. Calcd. for $C_{25}H_{25}OCl$: C, 79.67; H, 6.69. Found: C, 79.84; H, 6.79.

***p*-(*t*-Butyl)-α,β-diphenylacrylophenone.**—A mixture of 37.65 g. of α,β-diphenyl-β-chloro-*p*-(*t*-butyl)-propiophenone, 26.4 g. of fused potassium acetate, 8.48 g. of sodium carbonate and 300 ml. of methanol was boiled, with constant, vigorous stirring, for 3 hours, cooled and filtered. The solid was washed with sufficient water to remove inorganic salts completely and recrystallized repeatedly from ethanol; m.p. 98.5–100°, yield 24.5 g. (72.3%).

Anal. Calcd. for $C_{25}H_{24}O$: C, 88.19; H, 7.11. Found: C, 88.10; H, 6.97.

***p*-(*t*-Butyl)-α,β,β-triphenylacrylophenone.**—Seventeen grams of *p*-(*t*-butyl)-α,β-diphenylacrylophenone was added to a Grignard reagent made from 13 ml. of bromobenzene, 2.83 g. of magnesium and 50 ml. of ether. The solution was heated for 30 minutes and cooled in a freezing mixture while 17 g. of bromine was added, dropwise and with constant stirring. It was then poured into a mixture of ice and hydrochloric acid and the resulting mixture was shaken until solid began to separate. The ether layer was diluted with petroleum ether and the solid product was washed with water, with a mixture of ether and petroleum ether and finally with petroleum ether alone; m.p. 207–209°, yield 14 g. (56.5%).

The *p*-(*t*-butyl)-α-bromo-α,β,β-triphenylpropiophenone obtained in this way was difficult to purify, apparently because it loses hydrogen bromide readily. It was mixed with an equal weight (12 g.) of fused potassium acetate and 300 ml. of absolute ethanol, and the mixture was boiled for 2 hours with stirring sufficiently rapid to prevent bumping. When the reaction mixture was cooled, a mixture of the unsaturated ketone and potassium chloride separated. Additional amounts of product were obtained by concentration of the mother liquor. After being washed and dried, the compound was recrystallized from cyclohexane, m.p. 215–216°. The yield was very low.

A mixed melting point determination with the sample made by the method of Koelsch showed no depression. Also, the infrared spectra of the two samples were identical.

A slurry of 1.3 g. of the unsaturated ketone in 75 ml. of ether was added to a Grignard reagent made from 1.2 g. of magnesium, 7 ml. of *t*-butyl chloride and 50 ml. of ether and the mixture was stirred for 16 hours. Only starting material was isolated.

Urbana, Illinois

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[8] C. F. Koelsch, This Journal, **54**, 2045 (1932).

[9] This acid was kindly supplied by the Shell Chemical Corporation.

[10] R. C. Fuson and R. Tull, This Journal, **71**, 2543 (1949).

[11] C. F. H. Allen and W. E. Barker, "Organic Syntheses," Coll. Vol. 2, John Wiley and Sons, Inc., New York, N. Y., 1943, p. 156.

[12] R. C. Huston, W. B. Fox and M. N. Binder, *J. Org. Chem.*, **3**, 251 (1938).

[Contribution from the Department of Chemistry, Massachusetts Institute of Technology]

Diamines and Bicyclic Amines Derived from *cis*-2,5-Bis-(hydroxymethyl)-tetrahydrofuran

By Arthur C. Cope and Burton C. Anderson

Received August 25, 1954

Bicyclic tertiary amines (VII and VIII) are formed as the major products in the reaction of *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran ditosylate (I) with dimethylamine and diethylamine, with elimination of an alkyl group attached to nitrogen in the secondary amines. The expected diamines (VI and IX) also are formed but in smaller amounts. The reactions leading to the bicyclic amines are interpreted as proceeding by an intramolecular alkylation forming a bicyclic quaternary salt XII, a course that is favored as a six-membered ring closure leading to the 8-oxa-3-azabicyclo[3.2.1]octane ring system. The Gabriel phthalimide synthesis proceeded normally in this series, leading from I to 2,5-bis-(aminomethyl)-tetrahydrofuran (V).

The reaction of *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran ditosylate (I) with ammonia[1,2] or primary amines[3] results in closure of a six-membered heterocyclic ring by two displacement reactions on the same nitrogen atom, forming 8-oxa-3-azabicyclo[3.2.1]octane (II) or its N-alkyl derivatives (III). The bicyclic ring system of II and III formed so readily that diamines which might be obtained by reaction of the ditosylate I with two equivalents of ammonia or primary amines were not found as by-products, and must have been formed in small amount if at all.

In continuing the study of amines derived from *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran, the ditosylate I was treated with potassium phthalimide

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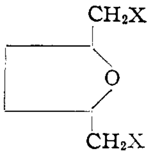
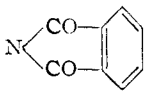
[1] F. H. Newth and L. F. Wiggins, *J. Chem. Soc.*, 155 (1948).

[2] D. J. C. Wood and L. F. Wiggins, *Nature*, **164**, 402 (1949).

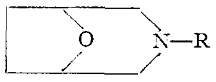
[3] A. C. Cope and W. N. Baxter, This Journal, **77**, 393 (1955).



I, X = $OSO_2C_6H_4CH_3$-*p*

IV, X =


V, X = NH_2
VI, X = $N(CH_3)_2$
IX, X = $N(C_2H_5)_2$
X, X = Cl



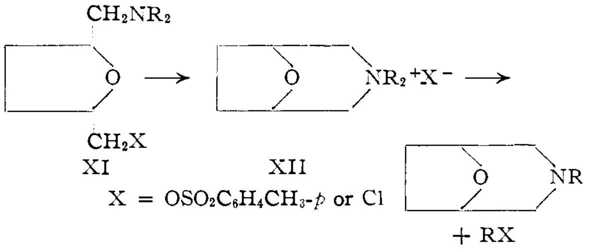
II, R = H
III, R = hydroxyalkyl
VII, R = CH_3
VIII, R = C_2H_5

in dimethylformamide. This reaction yielded 2,5-bis-(phthalimidomethyl)-tetrahydrofuran (45%) (IV, presumably the *cis* isomer). Cleavage of the phthalimido compound IV by hydrazine followed by hydrochloric acid yielded 2,5-bis-(aminomethyl)-tetrahydrofuran (V, presumably *cis*) (35%), identified as the crystalline dipicrate. Attempts to improve the yield in cleavage of IV to V with hydrazine or to hydrolyze IV with hydrochloric acid were unsuccessful. Methylation of V with formic acid and formaldehyde yielded 44% of 2,5-bis-(dimethylaminomethyl)-tetrahydrofuran (VI), which was characterized as the crystalline dimethiodide.

Investigation of a more direct synthesis of VI from the ditosylate I and dimethylamine led to surprising results. When these reactants were heated under pressure at 150° for sixteen hours with an excess of dimethylamine as the solvent, the product was a mixture from which 45% of the bicyclic amine, 3-methyl-8-oxa-3-azabicyclo[3.2.1]-octane (VII), and 28% of the expected diamine VI were separated by fractional distillation. Formation of the bicyclic amine VII was not due to the presence of methylamine as an impurity in the dimethylamine employed, for pure dimethylamine, prepared by alkaline hydrolysis of *p*-nitrosodimethylaniline, and the ditosylate I gave the same mixture of products. The structure of the bicyclic amine VII was established by preparation of an identical authentic sample from the ditosylate I and methylamine, and conversion of the two samples of VII into identical picrates and perchlorates. With a smaller excess of dimethylamine (four equivalents) and tetrahydrofuran as a solvent, reaction with the ditosylate I led only to the bicyclic amine VII (54%); none of the diamine VI was isolated.

The reaction of the ditosylate I with a large excess of diethylamine also formed a mixture of two amines. Fractional distillation of the product separated 38% of the bicyclic amine, 3-ethyl-8-oxa-3-azabicyclo[3.2.1]octane (VIII), from which the picrate was prepared, and 24% of the known diamine,[1] 2,5-bis-(diethylaminomethyl)-tetrahydrofuran (IX, presumably *cis*), which was characterized as the dipicrate and dimethiodide. Since Newth and Wiggins reported isolation of only the diamine IX from the reaction of *cis*-2,5-bis-(chloromethyl)-tetrahydrofuran (X) with diethylamine,[1] we repeated this reaction on a somewhat larger scale. A mixture of amines very similar to the one obtained from the ditosylate I and diethylamine was formed, from which 36% of the bicyclic amine VIII and 20% of the diamine IX were separated by fractional distillation.

We belive that the formation of cyclic tertiary amines from the ditosylate I or the dichloride X and secondary amines, with elimination of one of the alkyl groups attached to nitrogen in the secondary amine, is best explained as follows. An expected intermediate in the reaction would be the monoalkylation product XI. This intermediate could react with another mole of the secondary amine to give the expected diamine, such as VI or IX. Alternately, it could form a cyclic quaternary salt XII, which could decompose forming an alkyl tosylate (or an olefin and toluenesulfonic acid if the alkyl group is larger than methyl) and a bicyclic tertiary amine, such as VII or VIII. The latter course of reaction appears to be favored by the steric proximity of the tosylate (or chlorine) and dialkylamino groups present in the intermediate XI, which results in more rapid intramolecular alkylation forming XII (and subsequently a bicyclic tertiary amine such as VII or VIII) rather than intermolecular alkylation of a second mole of the secondary amine, even when the secondary amine is present in high concentration as the solvent. This interpretation is consistent with the observed formation of the bicyclic amine VII in higher yield from the ditosylate I and a smaller excess of dimethylamine in tetrahydrofuran as an inert solvent. Evidence that the diamines such as VI or IX are stable under the conditions of the reaction of the ditosylate I with secondary amines and accordingly that they are not intermediates in the formation of the bicyclic amines VII and VIII was obtained by heating the diamine IX with *p*-toluenesulfonic acid in tetrahydrofuran. The diamine IX was recovered unchanged.



XI XII

X = $OSO_2C_6H_4CH_3$-*p* or Cl

Preliminary attempts to isolate the methyl *p*-toluenesulfonate, trimethylamine or tetramethylammonium tosylate expected as by-products from the reaction of the ditosylate I with dimethylamine according to the reaction path formulated above were unsuccessful.

Experimental[4]

Reaction of *cis*-2,5-Bis-(hydroxymethyl)-tetrahydrofuran Ditosylate with Dimethylamine.—In a 170-ml. stainless steel hydrogenation bomb, cooled well below 0° with Dry Ice, were placed 20 g. of 2,5-bis-(hydroxymethyl)-tetrahydrofuran ditosylate[3] and 15 g. of pure, dry dimethylamine, prepared by alkaline hydrolysis of *p*-nitrosodimethylaniline. The bomb was sealed and heated at 150° for 20 hours, with rocking to provide agitation. After cooling, the bomb was opened and the solution was poured into aqueous sodium hydroxide. The strongly basic solution

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[4] Melting points are corrected and boiling points are uncorrected. We are indebted to Dr. S. M. Nagy and his associates for analyses.

was extracted continuously with ether for 24 hours, and the extract was dried over potassium hydroxide and concentrated. Distillation of the residue through a semi-micro column separated the two products formed: (1) 2.74 g. (45%) of 3-methyl-8-oxa-3-azabicyclo[3.2.1]octane (VII), boiling below 60° (15 mm.); (2) 2.40 g. (28%) of 2,5-bis-(dimethylaminomethyl)-tetrahydrofuran (VI), b.p. 105° (15 mm.). Samples of these hygroscopic amines were prepared for analysis by drying them over metallic sodium followed by distillation through a column with a spinning band (30 × 0.5 cm.) rotated at approximately 1200 r.p.m. After the distillation, pure, dry nitrogen was admitted into the vacuum system and the vials containing the distillate were capped and placed in a desiccator over Ascarite. The compounds were analyzed soon after distillation.

3-Methyl-8-oxa-3-azabicyclo[3.2.1]octane (VII) had b.p. 55° (12 mm.), n^{25}D 1.4663, d_4^{25} 1.012.

Anal. Calcd. for $C_7H_{13}NO$: C, 66.10; H, 10.30; N, 11.01. Found: C, 66.21; H, 10.31; N, 10.91.

3-Methyl-8-oxa-3-azabicyclo[3.2.1]octane picrate was prepared by adding the amine to a saturated solution of picric acid in absolute ethanol. The yellow precipitate was separated and recrystallized from dry ethyl acetate to a constant melting point of 228.5–230° dec.

Anal. Calcd. for $C_{13}H_{16}N_4O_8$: C, 43.79; H, 4.53; N, 15.73. Found: C, 44.00; H, 4.73; N, 15.68.

3-Methyl-8-oxa-3-azabicyclo[3.2.1]octane perchlorate was prepared by adding a slight excess of 70% perchloric acid to a solution of the amine in dry ether, and was recrystallized to a constant melting point of 166.6–167.2° from dry ethyl acetate.

Anal. Calcd. for $C_7H_{14}ClNO_5$: C, 36.91; H, 6.20; Cl, 15.57. Found: C, 37.21; H, 6.40; Cl, 15.47.

2,5-Bis-(dimethylaminomethyl)-tetrahydrofuran VI had b.p. 105° (12 mm.), n^{25}D 1.4484, d_4^{25} 0.8243.

Anal. Calcd. for $C_{10}H_{22}N_2O$: C, 64.47; H, 11.90; N, 15.04. Found: C, 64.58; H, 12.02; N, 14.86.

2,5-Bis-(dimethylaminomethyl)-tetrahydrofuran dipicrate was prepared by the method described above for the picrate of VII and recrystallized from dry methanol, m.p. 214–214.7°.

Anal. Calcd. for $C_{22}H_{28}N_8O_{15}$: C, 41.00; H, 4.38; N, 17.39. Found: C, 40.90; H, 4.38; N, 17.21.

2,5-Bis-(dimethylaminomethyl)-tetrahydrofuran dimethiodide is described below.

3-Methyl-8-oxa-3-azabicyclo[3.2.1]octane (an authentic sample) was prepared by heating 20 g. of *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran ditosylate and 40 ml. of dry methylamine in a stainless steel pressure vessel at 140° for 20 hours. The amine was isolated by the procedure described above and distilled through the spinning band column; yield 3.51 g. (61%), b.p. 64° (20 mm.), n^{25}D 1.4660. The picrate, m.p. 228.5–230.5° dec., and perchlorate, m.p. 166.4–167.7°, of the amine prepared in this way were identical (mixed m.p.) with the corresponding derivatives described above, prepared from the amine VII obtained by reaction of the ditosylate I with dimethylamine.

Reaction of *cis*-2,5-Bis-(hydroxymethyl)-tetrahydrofuran Ditosylate with Dimethylamine in Tetrahydrofuran.—The ditosylate I (20 g.) and 46.7 g. of a solution of pure dimethylamine (from hydrolysis of *p*-nitrosodimethylaniline) in dry tetrahydrofuran containing 6.9 g. of the amine (by titration) were heated at 150° in a stainless steel pressure vessel for 21 hours. The product was isolated by the procedure described above, except that it was first dissolved in excess dilute hydrochloric acid and extracted continuously with ether for 23 hours to remove tetrahydrofuran, after which the solution was made strongly basic with sodium hydroxide and the product was extracted as before. The only product isolated was 3.13 g. (54%) of 3-methyl-8-oxa-3-azabicyclo[3.2.1]octane (VII), b.p. 55° (12 mm.), n^{25}D 1.4657. None of the higher boiling diamine VI remained after the distillation of VII.

Reaction of *cis*-2,5-Bis-(hydroxymethyl)-tetrahydrofuran Ditosylate with Diethylamine.—The ditosylate I (20 g.) and 25 g. of pure diethylamine were heated at 165° in a stainless steel pressure vessel for 8 hours. The products were separated and purified by a method similar to the one described above for the amines formed from I and dimethylamine, and were: (1) 2.39 g. (37%) of 3-ethyl-8-oxa-3-azabicyclo[3.2.1]octane (VIII), b.p. 69.5° (12 mm.), and (2) 2.70 g. (28%) of 2,5-bis-(diethylaminomethyl)-tetrahydrofuran (IX), b.p. 140° (12 mm.).

3-Ethyl-8-oxa-3-azabicyclo[3.2.1]octane (VIII) had b.p. 93° (43 mm.), n^{25}D 1.4630.

Anal. Calcd. for $C_8H_{15}NO$: C, 68.04; H, 10.71; N, 9.92. Found: C, 67.82; H, 10.67; N, 9.95.

3-Ethyl-8-oxa-3-azabicyclo[3.2.1]octane picrate was prepared in absolute ethanol and recrystallized from the same solvent, m.p. 180.7–181.9°.

Anal. Calcd. for $C_{14}H_{18}N_4O_8$: C, 45.40; H, 4.90; N, 15.13. Found: C, 45.71; H, 5.10; N, 15.08.

2,5-Bis-(diethylaminomethyl)-tetrahydrofuran (IX) formed a dimethiodide melting at 188–189.5°; Newth and Wiggins[1] report m.p. 187–188.5°. The diamine also was identified as the dipicrate, prepared in absolute ethanol and recrystallized from dry methanol, m.p. 129.5–130.5°.

Anal. Calcd. for $C_{26}H_{36}N_8O_{15}$: C, 44.60; H, 5.18; N, 16.01. Found: C, 44.70; H, 5.26; N, 16.22.

The stability of 2,5-bis-(diethylaminomethyl)-tetrahydrofuran (IX) under the conditions used for the reaction of the ditosylate I with diethylamine was determined by heating a mixture of 2.65 g. of the diamine IX, 40 ml. of diethylamine and 3.5 g. of *p*-toluenesulfonic acid monohydrate at 165° in a stainless steel pressure vessel for 23 hours. The only product isolated was 2.07 g. of the unchanged diamine IX.

***cis*-2,5-Bis-(chloromethyl)-tetrahydrofuran (X)** was prepared by the procedure previously described[1] from 13.5 g. of *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran and thionyl chloride in pyridine in a yield of 10.05 g. (58%), b.p. 45° (0.1 mm.), n^{25}D 1.4808, d_4^{25} 1.248. The compound was analyzed because the analysis reported previously showed a slightly high chlorine content (43.8%).

Anal. Calcd. for $C_6H_{10}Cl_2O$: C, 42.63; H, 5.96; Cl, 41.95. Found: C, 42.65; H, 6.16; Cl, 41.80.

Reaction of *cis*-2,5-Bis-(chloromethyl)-tetrahydrofuran with Diethylamine.—*cis*-2,5-Bis-(chloromethyl)-tetrahydrofuran (8.7 g.) and 25 ml. of diethylamine were heated at 165° for 15 hours in a 170-ml. stainless steel pressure vessel. The products were isolated in the same way as those formed from the ditosylate I and diethylamine. Fractionation through the spinning band column separated: (1) 2.6 g. (36%) of 3-ethyl-8-oxa-3-azabicyclo[3.2.1]octane (VIII), b.p. 60–61.5° (7 mm.), n^{25}D 1.4633–1.4640, identified as the picrate, m.p. 181.2–182.4°, identical by mixed m.p. with the picrate of VIII described above; (2) 2.52 g. (20%) of 2,5-bis-(diethylaminomethyl)-tetrahydrofuran (IX), b.p. 47–51.5° (0.04 mm.), n^{25}D 1.4531–1.4538.

2,5-Bis-(phthalimidomethyl)-tetrahydrofuran (IV).—A mixture of 11.0 g. of *cis*-2,5-bis-(hydroxymethyl)-tetrahydrofuran ditosylate, 10.0 g. of potassium phthalimide and 50 ml. of dimethylformamide was heated at 155–165° for 16 hours. After cooling, the solution was poured into a mixture of 100 ml. of chloroform and 150 ml. of water. The chloroform layer was separated, washed with 2 *N* sodium hydroxide and water, dried over sodium sulfate and concentrated to a small volume. The solid that separated amounted to 4.5 g. (45%) of 2,5-bis-(phthalimidomethyl)-tetrahydrofuran, which after recrystallization from ethanol melted at 228–229.5°.

Anal. Calcd. for $C_{22}H_{18}N_2O_5$: C, 67.68; H, 4.65; N, 7.18. Found: C, 67.88; H, 4.85; N, 7.31.

2,5-Bis-(aminomethyl)-tetrahydrofuran (V).—A solution of 15.3 g. of 2,5-bis-(phthalimidomethyl)-tetrahydrofuran and 5.0 ml. of 85% hydrazine hydrate in 100 ml. of methanol was heated under reflux for 2 hours. The mixture was cooled, 50 ml. of water was added, and the methanol was distilled under reduced pressure. Concentrated hydrochloric acid (50 ml.) was added to the residue and the mixture was heated under reflux for 1 hour. After cooling, the solid precipitate was separated and the filtrate was concentrated under reduced pressure. The residual solution was made basic with 2 *N* sodium hydroxide and extracted continuously with ether for 2 days. The extract was dried over potassium hydroxide, concentrated, and the residue was fractionated through a semi-micro column, yielding 1.76 g. (35%) of V, b.p. 56° (0.26 mm.), n^{25}D 1.4832. Analysis indicated that this hygroscopic diamine contained a small amount of water; it was converted to the dipicrate described below for analysis.

2,5-Bis-(aminomethyl)-tetrahydrofuran dipicrate was prepared from the diamine and picric acid in ethanol and recrystallized from ethanol to a constant melting point of 211.5–212.5° dec.

Anal. Calcd. for $C_{18}H_{20}N_8O_{15}$: C, 36.74; H, 3.43; N, 19.04. Found: C, 36.55; H, 3.49; N, 18.62.

2,5-Bis-(dimethylaminomethyl)-tetrahydrofuran (VI).—A mixture of 0.70 g. of 2,5-bis-(aminomethyl)-tetrahydrofuran (V), 5 ml. of 87% formic acid and 3.0 g. of 37% formalin was heated under reflux for 24 hours. After addition of 5 ml. of concentrated hydrochloric acid, the solution was concentrated to a small volume under reduced pressure, made basic with 25 ml. of 6 *N* sodium hydroxide, and extracted continuously with ether for 18 hours. The extract was dried over sodium sulfate, concentrated, and the residue was distilled by heating in a short-path still at 1 mm. The diamine VI was obtained in a yield of 0.45 g. (44%), n^{25}_{D} 1.4500; it formed a dipicrate melting at 214.1–214.8° which was identical by mixed m.p. with the dipicrate of VI described above, prepared from I and dimethylamine.

2,5-Bis-(dimethylaminomethyl)-tetrahydrofuran dimethiodide was prepared by heating a solution of 0.45 g. of VI (prepared from V by the route described above) and 2 ml. of methyl iodide in 60 ml. of dry methanol under reflux for 2 hours. The dimethiodide that separated on cooling amounted to 0.82 g. (72%). An analytical sample that was recrystallized from methanol melted at 317.5–318.5° dec.

Anal. Calcd. for $C_{12}H_{28}I_2N_2O$: C, 30.61; H, 5.99; I, 53.91. Found: C, 30.46; H, 5.93; I, 54.19.

A sample of the dimethiodide prepared in 88% yield from the diamine VI obtained from the ditosylate I and dimethylamine had the same melting point and a mixed melting point with the sample described above was not depressed.

Cambridge, Massachusetts

[Contribution from the Baker Laboratory of Chemistry at Cornell University]

Many-membered Carbon Rings. VIII. *cis-trans* Isomers of 1,3-Cyclodecadiene[1]

By A. T. Blomquist and Albert Goldstein[2]

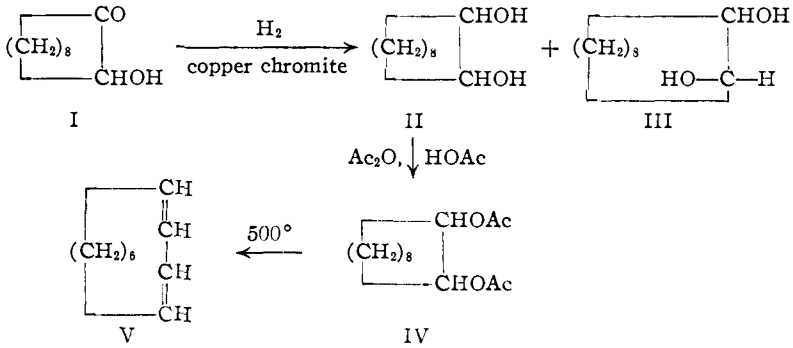
Received July 23, 1954

The ten-membered carbocycles *cis–cis*-1,3-cyclodecadiene and *cis–trans*-1,3-cyclodecadiene have been synthesized. Pyrolysis of *cis*-1,2-cyclodecanediol diacetate, obtained from 2-hydroxycyclodecanone, gave *cis–cis*-1,3-cyclodecadiene. Treatment of *cis*-1,2-cyclodecanediol with phosphorus tribromide afforded 3-bromo-*cis*-cyclodecene. Aminolysis of the latter with trimethylamine followed by a Hofmann degradation of the base derived from the resulting quaternary ammonium bromide produced *cis–trans*-1,3-cyclodecadiene. Chemical and physical properties, including infrared and ultraviolet spectra, of these isomeric hydrocarbons indicate that they possess a fairly rigid structure. The *cis–trans* isomer appears to be strained.

The development of the acyloin condensation for the formation of carbocyclic compounds[3,4a,5] has greatly facilitated study of the chemistry of many-membered carbon rings of intermediate size. As part of the general study, much of the work reported by Prelog,[4] Ziegler,[6] Cope[7] and this Laboratory[8] has been concerned with investigating the effect of ring size on various properties of 8-, 9- and 10-membered carbocycles.

In an effort to gain further insight into the behavior of these systems, study of the *cis–trans* isomers of 1,3-cyclodecadiene was undertaken. For this the cyclic acyloin sebacoin, 2-hydroxycyclodecanone (I), was used as the starting material.[4a,8b]

***cis–cis*-1,3-Cyclodecadiene (V).**—Synthesis of this diene V from I was achieved as indicated in the diagram which follows.



Sebacoin (I) was reduced to a separable mixture of *cis*- and *trans*-1,2-cyclodecanediol (II and III) by high pressure hydrogenation using a copper chromite catalyst. Pyrolysis of the *cis*-diacetate IV, derived from II, at 500° gave the diene V in 27–40% yield, m.p. 19–22°, b.p. 190.3–191.2° (744 mm.), n^{20}_{D} 1.4928. This diene showed no marked tendency to polymerize on distillation or on standing.

Upon quantitative catalytic hydrogenation, V absorbed 100% of 2 molar equivalents of hydrogen and gave cyclodecane. Oxidation of the hydrocarbon with aqueous potassium permanganate gave a 57% yield of suberic acid. The isolable products obtained upon ozonolysis of V were

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[1] For the preceding paper in this series see A. T. Blomquist and L. H. Liu, This Journal, **75**, 2153 (1953).

[2] Taken from the dissertation of A. Goldstein presented to the Graduate School of Cornell University in September, 1954, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[3] V. L. Hansley, U. S. Patent 2,228,268, Jan., 1941; *C. A.*, **35**, 2534 (1941).

[4] (a) V. Prelog, K. Schenker and H. H. Günthard, *Helv. Chim. Acta*, **35**, 1598 (1952); (b) V. Prelog and K. Schenker, *ibid.*, **35**, 2044 (1952); (c) V. Prelog, K. Schenker and W. Küng, *ibid.*, **36**, 471 (1953).

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