*Syntheses of γ-Ionone Analogues. IV. An Attempted Approach to 4-(2′-Methylene-3′, 4′, 5′-trimethylcyclohexyl)-but-3-en-2-one from 6-Benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal, and Investigation on Some Derivatives Thereby**

By Atsuaki ARAI and Iwao ICHIKIZAKI

(Received May 15, 1961)

In the present work we have researched a synthetical route for the preparation of 4-(2′-methylene-3′, 4′, 5′-trimethylcyclohexyl)-but-3-en-2-one, an analogue of γ-ionone, from 6-benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal (IV). During the course of investigation we have studied on the hydrogenolysis products of 6-benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal ethylene acetal (V), and, moreover, investigated *p*-benzyloxybenzaldehyde as a new hydrogen acceptor for the modified Oppenauer oxidation.

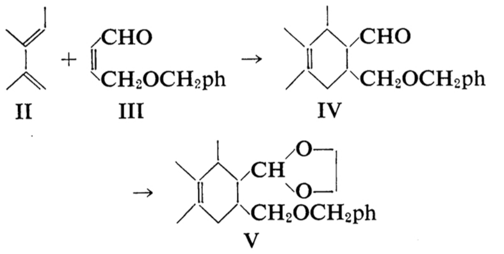
A diene mixture[1] containing 37.5% 3, 4-dimethyl-1, 3-pentadiene (I) and 62.5% 2, 3-dimethyl-1, 3-pentadiene (II) underwent the Diels-Alder reaction with 4-benzyloxy-2-buten-1-al (III). This resulted in the selective addition of III to II in the presence of a small amount of hydroquinone at 140 to 150°C to produce a pale yellow adduct, $C_{18}H_{24}O_2$, which was proved extremely homogeneous after careful redistillation. From the experimental result[1] with regard to the direction of addition of 4-benzyloxy-2-butyn-1-al, $C_6H_5CH_2OCH_2C\equiv CCHO$, or of crotonaldehyde to II, the structure IV was assigned for the adduct obtained above. This

---

* This paper involves the partial correction regarding a short communication reported by one of the authors in *J. Chem. Soc. Japan, Pure Chem. Sec.* (*Nippon Kagaku Zasshi*), **80**, 451 (1959).

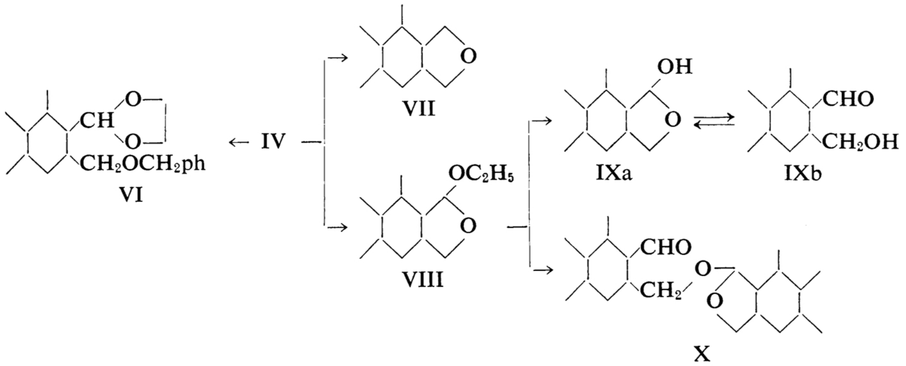
[1] A. Arai and I. Ichikizaki, This Bulletin, **35**, 45 (1962).

compound readily reacted with ethylene glycol in the presence of *p*-toluenesulfonic acid in benzene to afford its ethylene acetal V in an 80% yield. No elimination of benzyl alcohol was then observed, although in the analogous treatment of 2-benzyloxymethyl-4,5,6-trimethylcyclohexa-1, 4-dienylmethanal, a doubly unsaturated analogue of IV, a remarkable aromaticization with removal of benzyl alcohol had been observed[1].



Hydrogenation of V in the presence of a palladium-on-charcoal catalyst in ethanol afforded in a 90% yield 6-benzyloxymethyl-2, 3, 4-trimethylcyclohexylmethanal ethylene acetal (VI), after a little more than one mole of hydrogen had been absorbed. In the presence of a more active catalyst, V afforded on hydrogenation a low-boiling oil, $C_{11}H_{20}O$, and a high-boiling liquid, $C_{13}H_{24}O_2$, in a 25.4 and 69% yield respectively, while ethylene glycol was then also obtained in a 86.5% yield. The low-boiling oil had a strong menthol-like odor, and has been proved to be 8, 9-*cis*-4, 5, 6-trimethyloctahydroisobenzofuran (VII), a full description on whose structure and some reactions will be given in a following paper. The infrared spectrum of the higher boiling oil clearly indicated the presence of a C–O–C–O–C group[2], while, the presence of neither carbonyl nor hydroxyl group was shown. On treatment with the Brady reagent, the oil gave a yellow 2,4-dinitrophenylhydrazone. This crystalline derivative was also obtained from the compound, $C_{11}H_{20}O_2$, which had been given by treating the oil with diluted sulfuric acid and showed a weak absorption band at 1721 cm^{-1} indicative of a carbonyl group in addition to marked absorption band characteristic of a hydroxyl and a C–O–C–O group in the infrared spectrum. From considering the fact[3,4] that α-alkoxytetrahydrofurans are readily converted with aqueous mineral acid into the corresponding γ-hydroxyaldehydes, which generally exist in an equilibrium between an acyclic and a cyclic form, we assigned 3-ethoxy-4, 5, 6-trimethyloctahydroisobenzofuran (VIII) and a tautomeric mixture of 6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethanal (IXb) and the cyclic hemiacetal IXa for the higher boiling oil and its hydrolyzed product respectively. By comparing the intensity at the carbonyl maximum in the infrared region of the equilibrium mixture with that of 4, 5-dimethyl-2-methoxymethylcyclohexylmethanal[5] which was adopted as a standard compound, it was suggested that the cyclic form IXa exists predominantly and the open free hydroxyaldehyde IXb in only 8.3%.

On hydrolysis of VIII a high-boiling viscous oil, $C_{22}H_{38}O_3$, besides IX was also obtained in a 12.4% yield. This compound reduced Tollens' reagent and its infrared spectrum showed the presence of a carbonyl group but no hydroxyl group, while almost all characteristic absorption bands in the finger print region, especially those at 1460 to 900 cm^{-1}, showed close resemblance to those of IX. With the Brady reagent this compound afforded the same 2, 4-dinitrophenylhydrazone as that from IX. It was obvious, therefore, that the ether linkage of this compound is readily cleaved by the action of acid to yield IX. Consequently, for this compound (3,4,5-trimethyl-2-formylcyclohexylmethyl - 4′, 5′, 6′ - trimethyloctahydroisobenzofuryl-3′)-ether (X) was assigned. It can be



---

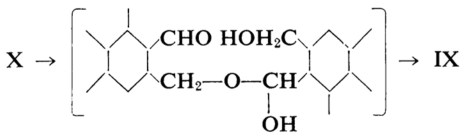
[2] M. Stoll and M. Hinder, *Helv. Chim. Acta*, **36**, 1948 (1953).

[3] L. E. Schniepp and H. H. Geller, *J. Am. Chem. Soc.*, **68**, 1646 (1946).

[4] C. D. Hurd and W. H. Saunders, Jr., ibid., **74**, 5324 (1952).

[5] A. Arai and I. Ichikizaki, This Bulletin, **34**, 1571 (1961).

considered that on hydrolysis this compound, through the fission of the tetrahydrofuran ring, was converted into IX via a temporary intermediate XI.


XI

On reductive alkylation of dimethylamine with IX in the presence of a Raney nickel catalyst in ethanol, *N*, *N*-dimethyl-6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethylamine (XII) was obtained in a yield of 66% accompanying by an appreciable amount of 1, 2-dihydroxymethyl-3, 4, 5-trimethylcyclohexane (XIII) which was proved identical with that prepared by hydrogenating the compound IV. In an attempt to prepare XII in one step, IV and dimethylamine were catalytically hydrogenated at 200°C and then was obtained the expected aminoalcohol XII in a 30% yield and a considerable amount of neutral product consisting mainly of XIII and a small amount of IX was also isolated. From the above results, it is presumed for sure that the initial addition of dimethylamine to a carbonyl group of the compound IV has been markedly hindered by a benzyloxymethyl group.

Oxidation of XII to the corresponding *N*-oxide XIV, followed by thermal decomposition of the latter in the same manner as described for *N*,*N*-dimethyl-2-hydroxymethyl-4,5-dimethylcyclohexylmethylamine[5] afforded in a 67% yield *N*, *N*-dimethylhydroxylamine which was characterized as hydrochloride and in a 58% yield 2-methylene-3, 4, 5-trimethylcyclohexylmethanol (XV), b. p. 122~124°C/14 mmHg, n_D^{15} 1.4925, whose infrared spectrum (Fig. 1) showed the presence of both hydroxyl (3333 and 1050 and exocyclic methylene group (3096, 1645 and 889 cm^{-1}). The compound XV was further characterized as allophanate, m. p. 152~153°C.

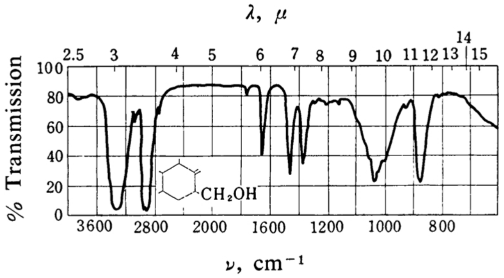
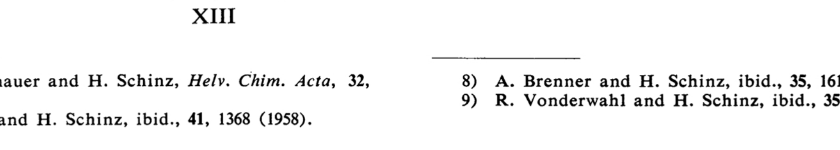


Fig. 1. Infrared spectrum of 2-methylene-3, 4, 5-trimethylcyclohexylmethanol (XV). (liquid film)

The amino alcohol XII was oxidized to yield *N*, *N*-dimethyl-2, 3, 4-trimethyl-6-formylcyclohexylmethylamine (XVI) in a yield of 88% by a modified Oppenauer procedure which involved *p*-benzyloxybenzaldehyde as the hydrogen accepter. For the oxidation of alicyclic primary alcohols to prepare the corresponding aldehydes some modified Oppenauer procedures have been employed successfully, in which cinnamaldehyde[6,7], anisaldehyde[6,8,9] and piperonal[6] as the hydrogen acceptors have hitherto been used. The use of these hydrogen acceptors is particularly advantageous when the desired aldehyde boils at below ca. 100°C/15 mmHg, because an efficient isolation of the resulted aldehyde by continuous distillation can be readily attained. However, in the case of high-boiling material no fruitful result can be expected on account of increasing hazardousness in separation. In this point of view, it was found that only *p*-benzyloxybenzaldehyde is a satisfactory hydrogen acceptor for the oxidation of XII, and that it can be superior in all respects for the case in which the resulted aldehyde boils at below ca. 110°C/1.0 mmHg.

Condensation of the amino aldehyde XVI with acetone in the presence of sodium hydride afforded in a 70% yield the amino ketone XVII, which was fully identified by the infrared absorption spectrum. Several attempts were made in an effort to obtain 4-(2′-methylene-3′, 4′, 5′-trimethylcyclohexyl)-but-3-en-2-one



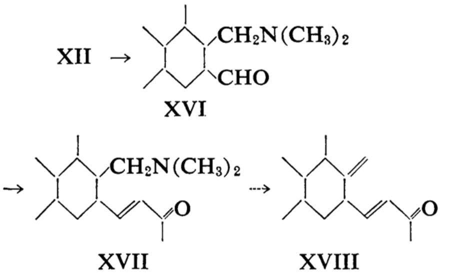
---

[6] A. Lachenauer and H. Schinz, *Helv. Chim. Acta*, **32**, 1265 (1949).

[7] H. Favre and H. Schinz, ibid., **41**, 1368 (1958).

[8] A. Brenner and H. Schinz, ibid., **35**, 1615 (1952).

[9] R. Vonderwahl and H. Schinz, ibid., **35**, 1997 (1952).



(XVIII) through the thermal decomposition of the *N*-oxide of XVII, however, a fruitful result has not yet been obtained.

Experimental[10]

Mixed Dimethyl-1, 3-pentadienes.—The same mixed diene (b. p. 107.5~108°C/753 mmHg, n_D^{20} 1.4664) which is a mixture of 37.5% 3, 4-dimethyl-1, 3-pentadiene (I) and 62.5% 2, 3-dimethyl-1, 3-pentadiene (II) as used in the previous paper[1] was employed.

4-Benzyloxy-2-buten-1-al (III).—4-Benzyloxy-2-buten-1-al (III) was prepared in the manner described previously[5] and had b. p. 122~123°C/2.8 mmHg and $n_D^{18.5}$ 1.5310.

6-Benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal (IV).—A mixture of III (27.5 g.), the mixed diene (16.5 g.) described above and benzene (35 ml.) was heated with a small amount of hydroquinone at 140~150°C for 14 hr. under nitrogen. The reaction product was fractionated through a short column to yield a pale yellow viscous oil (24.0 g.), b. p. 127~129°C/3×10^{-3} mmHg, n_D^{17} 1.5298. The analytical sample obtained by redistillation exhibited b. p. 129°C/3×10^{-3} mmHg and n_D^{17} 1.5299. $\nu_{\max}^{\text{film}}$ 1720 (C=O), 1098 (C-O-C), 3030, 1502, 742 and 704 cm^{-1} (mono-substituted phenyl group).

Found: C, 78.60; H, 8.87. Calcd. for $C_{18}H_{24}O_2$: C, 79.37; H, 8.88%.

The thiosemicarbazone crystallized from ethanol in needles, m. p. 127~127.5°C. $\lambda_{\max}^{\text{EtOH}}$ 271 mμ (ε, 37400).

Found: N, 12.13. Calcd. for $C_{19}H_{27}ON_3S$: N, 12.17%.

The phenylsemicarbazone crystallized from ethanol in needles, m. p. 145~146°C. $\lambda_{\max}^{\text{EtOH}}$ 248.5 mμ (ε, 29700).

Found: C, 74.18; H, 7.75. Calcd. for $C_{25}H_{31}\cdot O_2N_3$: C, 74.04; H, 7.71%.

The 2, 4-dinitrophenylhydrazone crystallized from ethanol in orange-yellow needles, m. p. 108~109°C.

Found: C, 63.68; H, 6.21. Calcd. for $C_{24}H_{28}O_5\cdot N_4$: C, 63.70; H, 6.24%.

6-Benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal Ethylene Acetal (V).—A mixture of the aldehyde IV (45 g.), ethylene glycol (22 g., 100% excess), benzene (50 ml.) and *p*-toluenesulfonic acid (70 mg.) was heated under reflux at a bath temperature of 120~130°C for 4.7 hr. with an azeotroper. The cooled reaction mixture was neutralized with a 5% aqueous sodium carbonate solution and the benzene layer was separated. The aqueous ethylene glycol layer was thoroughly extracted with benzene. The combianed benzene layers were washed with saturated aqueous salt solution and with water, dried over sodium sulfate and evaporated. Distillation of the residue gave the acetal V (42 g., 80%) as a pale yellow viscous oil, b. p. 132~135°C/3×10^{-3} mmHg, n_D^{16} 1.5281.

Found: C, 75.82; H, 9.01. Calcd. for $C_{20}H_{28}O_3$: C, 75.91; H, 8.92%.

6-Benzyloxymethyl-2, 3, 4-trimethylcyclohexylmethanal Ethylene Acetal (VI).—The unsaturated acetal V (20.0 g.) in ethanol (30 ml.) was hydrogenated in the presence of a palladium-on-charcoal catalyst (2.5% Pd, 0.8 g.) for 5.5 hr. at 130°C and 60 kg./cm^2 in a 100 ml. stainless steel autoclave. Removal of the catalyst and solvent, followed by distillation of the residue gave the acetal VI (18.3 g., 91%) as a colorless viscous oil, b. p. 167~170°C/1.0 mmHg, n_D^{21} 1.5150.

Found: C, 75.05; H, 9.70. Calcd. for $C_{20}H_{30}O_3$: C, 75.43; H, 9.50%.

Hydrogenation and Hydrogenolysis of 6-Benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal Ethylene Acetal (V). — The acetal V (40 g.) in ethanol (40 ml.) was hydrogenated in the presence of a palladium-on-charcoal catalyst (5% Pd, 3.0 g.) at 110 kg./cm^2. A vigorous absorption of hydrogen began at 60°C and the decrease of inner pressure was finished when the temperature reached to 122°C during 7 hr. After the catalyst was removed the filtrate was evaporated under reduced pressure through a 20 cm. Vigreux column to obtain two clear layers. The lower layer was extracted repeatedly with ether and the ether extracts were combined with the upper layer. The combined ethereal solution was washed with water, dried over sodium sulfate and evaporated. The remaining oil was fractionated through a 10 cm. Vigreux column to give two distinct fractions, b. p. 66~70°C/2.0 mmHg, n_D^{12} 1.4761 and b. p. 85~100°C/2.0 mmHg, n_D^{15} 1.4719. The former was redistilled through a short column to afford 8, 9-*cis*-4, 5, 6-trimethyloctahydroisobenzofuran (VII) (5.4 g., 25.4%) having a strong menthol-like odor, b. p. 67°C/2.0 mmHg, $n_D^{13.5}$ 1.4750. $\nu_{\max}^{\text{film}}$ 1457 (CH_2), 1383 (CH_3), 1053 (C-O-C), 1104, 905 and 886 cm^{-1} (tetrahydrofuran ring).

Found: C, 78.18; H, 11.43. Calcd. for $C_{11}H_{20}O$: C, 78.51; H, 11.98%.

The latter on redistillation gave 3-ethoxy-4, 5, 6-trimethyloctahydroisobenzofuran (VIII) (18.5 g., 69%), b. p. 90~100°C/2.0 mmHg, $n_D^{15.5}$ 1.4719, which showed the presence of a C-O-C-O-C group (1108, 995, 920 and 890 cm^{-1}), while the presence of neither carbonyl nor hydroxyl group was indicated in its infrared absorption spectrum.

Found: C, 73.55; H, 11.28. Calcd. for $C_{13}H_{24}\cdot O_2$: C,73.53; H, 11.39%.

Treatment with the Brady reagent gave in an excellent yield 6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethanal 2, 4-dinitrophenylhydrazone which had m. p. 177°C after crystallization from methanol.

---

[10] All m. p. are uncorrected. The ultraviolet spectra were determined with a Hitachi model EPU-2A spectrophotometer and the infrared spectra were obtained with a Nippon Bunkō model IR-S and a Kōken model DS-301 recording spectrophotometers using sodium chloride prisms.

Found: C, 56.32; H, 6.50. Calcd. for $C_{17}H_{24}O_5 \cdot N_4$: C, 56.03; H, 6.64%.

From the residue leaving after being extracted the lower layer with ether, ethylene glycol (5.1 g., 86.5%) could be obtained.

Acid Hydrolysis of 3-Ethoxy-4, 5, 6-trimethyloctahydroisobenzofuran (VIII).—A mixture of VIII (18 g.), tetrahydrofuran (80 ml.) and 2 N sulfuric acid (80 ml.) was heated under reflux at 70~80°C for 7 hr. The resultant mixture was cooled and neutralized with a 10% aqueous sodium carbonate solution. After the bulk of the solvent was removed under reduced pressure, the remaining oil was extracted with ether and the ether extract was washed with a saturated aqueous salt solution and dried over sodium sulfate. Removal of the solvent, followed by distillation of the residue yielded a colorless oil (11 g.), b. p. 112~118°C/2.0 mmHg, n_D^{20} 1.4852 and a colorless viscous oil (2.6 g.), b. p. 188~195°C/2.5 mmHg, n_D^{16} 1.4977.

The former on redistillation gave the tautomeric mixture of 3-hydroxy-4, 5, 6-trimethyloctahydroisobenzofuran (IXa) and 6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethanal (IXb) (10.3 g., 64%), b. p. 113~116°C/2.0 mmHg, n_D^{17} 1.4875, whose infrared spectrum (liquid film) showed characteristic absorption bands at 3414, 1103 (OH), 998, 935, 910 cm^{-1} (C–O–C–O) and a weak band at 1721 cm^{-1} indicative of a carbonyl group. $\lambda_{max}^{70\%\ aq.\ dioxane}$ 224 mμ (ε, 102), 290 (9.6).

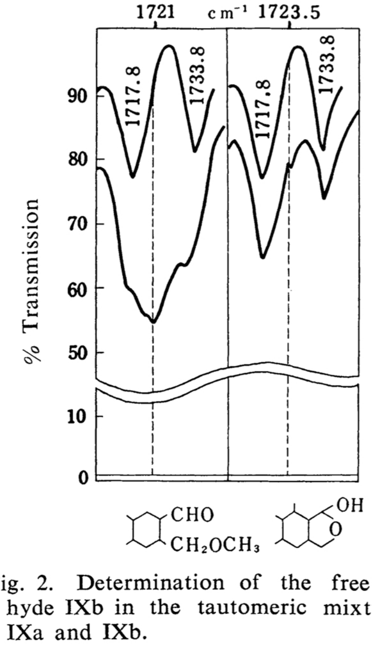


Fig. 2. Determination of the free aldehyde IXb in the tautomeric mixture of IXa and IXb.

(in carbon disulfide solution, 0.125 mm.)

c (mol./l.) :	0.0430	0.176
D :	0.2516	0.0853
ε :	5.85	0.485

Content of IXb: ca. 8.3%

(Perkin-Elmer model 112 spectrophotometer, NaCl prisms)

Found: C, 71.92; H, 10.98. Calcd. for $C_{11}H_{20} \cdot O_2$: C, 71.69; H, 10.94%.

The proportion of the free aldehyde IXb in the tautomeric mixture was ascertained, as shown in Fig. 2, by comparing the transmittance of the mixture at 1723.5 cm^{-1} with that of 4, 5-dimethyl-2-methoxymethylcyclohexylmethanal[5] at 1721 cm^{-1} in carbon disulfide at 20°C.

The 2, 4-dinitrophenylhydrazone prepared from the tautomeric mixture above was crystallized from ethanol to give yellow leaflets, m. p. 176~177°C, which was undepressed on admixture with that obtained directly from VIII.

After two redistillations the latter, high-boiling fraction afforded (3, 4, 5-trimethyl-2-formylcyclohexylmethyl - 4′, 5′, 6′ - trimethyloctahydroisobenzofuryl-3′)-ether (X), an intermolecular dehydration product of IX, b. p. 171~172°C, n_D^{10} 1.5017 (1.9 g., 12.4%), which showed a positive Tollens' test. Its infrared spectrum showed a strong carbonyl band at 1721 cm^{-1}, but no hydroxyl band. Moreover, almost all absorption bands indicated in the region of 1460 to 900 cm^{-1} agreed closely with those of IX. $\lambda_{max}^{75\%\ aq.\ dioxane}$ 224 mμ (ε, 367), 295 (67).

Found: C, 75.48; H, 11.02. Calcd. for $C_{22}H_{38} \cdot O_3$: C, 75.38; H, 10.93%.

Treatment with the Brady reagent X gave in an excelient yield, a yellow 2, 4-dinitrophenylhydrazone which had m. p. 176~177°C after crystallization from ethanol and was identical with that prepared from IX. An attempt to prepare the semicarbazone of this compound in the usual manner has however been unsuccessful.

***N, N*-Dimethyl-6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethylamine (XII).** — *Reductive Condensation of Dimethylamine and 3-Hydroxy-4, 5, 6-trimethyloctahydroisobenzofuran (IX).*—A solution of IX (10.5 g.) and dimethylamine (4.3 g.) in ethanol (50 ml.) was hydrogenated with a Raney nickel catalyst (1.5 g.) for 2 hr. at 195~200°C and 109 kg./cm^2. After removal of the catalyst and solvent, the remaining colorless oil was dissolved in ether (80 ml.) and then extracted with 2 N hydrochloric acid (20 ml. × 3). The aqueous layer was made, after being washed once with ether, to strongly alkaline with a 10% aqueous sodium hydroxide solution under cooling. The regenerated organic base was taken up in ether and washed with water and dried over potassium carbonate. Removal of the solvent, followed by distillation of the residue yielded *N, N* - dimethyl-6-hydroxymethyl - 2, 3, 4-trimethylcyclohexylmethylamine (XII) (8.2 g., 67.5%) as a colorless oil, b. p. 96~97°C/0.6 mmHg, n_D^{12} 1.4880. ν_{max}^{film} 2842, 2790, 2748 (*tert*-amino group), 3380, 1040 (OH), 837 cm^{-1} (unassigned).

Found: C, 73.86; H, 12.67; N, 6.54. Calcd. for $C_{13}H_{27}ON$: C, 73.18; H, 12.76; N, 6.57%.

The methiodide crystallized from ethanol-ethyl acetate in leaflets, m. p. 204~206°C.

Found: C, 47.60; H, 8.33; N, 4.15. Calcd. for $C_{14}H_{30}ONI$: C, 47.30; H, 8.50; N, 3.95%.

The ether layer containing the neutral substance was washed with water, dried over sodium sulfate and evaporated. Distillation of the residue gave 1, 2 - dihydroxymethyl - 3, 4, 5 - trimethylcyclohexane (XIII) (1.7 g., 16%) as a viscous oil, b. p. 140~

141.5°C/2.0 mmHg, n_D^{29} 1.4874. ν_{max}^{film} 3320, 1058 cm^{-1} (OH).

Found: C, 71.38; H, 11.90. Calcd. for $C_{11}H_{22}\cdot O_2$: C, 70.92; H, 11.90%.

The bis-*p*-nitrobenzoate crystallized from methanol in prisms, m. p. 161~162°C, which gave no melting point depression on admixture with that obtained by the other routes as described below.

Reductive Condensation of Dimethylamine and 6-Benzyloxymethyl-2, 3, 4-trimethyl-3-cyclohexenylmethanal (IV).—A solution of IV (3.5 g.) and anhydrous dimethylamine (1.2 g.) in ethanol (30 ml.) was hydrogenated over Raney nickel (1.0 g.) for 5 hr. at 200°C and 150 kg./cm^2. On similar treatment of the hydrogenated products to the manner in a), the basic fraction (0.85 g.) which had b. p. 97~99°C/0.5 mmHg and showed identical infrared spectrum with XII and the neutral fraction (1.4 g.), b. p. 110~140°C/2.0 mmHg, which was indicated to be mainly the diol XIII contaminated with a small amount of IX by its infrared spectrum, were obtained.

The basic fraction wats treated with methyl iodide to give in a good yield the methiodide of XII as leaflets, m. p. 206~207°C, which gave no melting point depression on admixture with that of the authentic XII and an appreciable amount of what is believed to be the methiodide of *N*, *N*-dimethyl-6-hydroxy-methyl-2, 3, 4-trimethyl-3-cyclohexenylmethylamine, which exhibited m. p. 258°C (decomp.) after being crystallized from ethanol-ethyl acetate.

Found: C, 47.78; H, 8.20. Calcd. for $C_{14}H_{28}O\cdot NI$: C, 47.65; H, 8.01%.

The neutral fraction was fractionated through a short Vigreux column to give the diol XIII (1.1 g., 46%), b. p. 140~142.5°C/2.0 mmHg, n_D^{20} 1.4905, which afforded the bis-*p*-nitrobenzoate, m. p. 162°C, after crystallization from methanol, identified by mixed melting point with an authentic sample.

Preparation of 1, 2-Dihydroxymethyl-3, 4, 5-trimethylcyclohexane (XIII) by Hydrogenation of IV.—The aldehyde IV (3.5 g.) in ethanol (25 ml.) was hydrogenated over Raney nickel (3.5 g.) for 5 hr. at 210~225°C and 190 kg./cm^2. Removal of the catalyst and solvent, followed by distillation of the residue gave a small fore-run and the diol XIII (1.95 g., 81.5%), b. p. 137°C/1.8 mmHg, n_D^{30} 1.4900.

Found: C, 71.11; H, 11.95. Calcd. for $C_{11}H_{22}\cdot O_2$: C, 70.92; H, 11.90%.

The bis-*p*-nitrobenzoate crystallized from methanol in leaflets, m. p. 162°C.

Found: C, 61.92; H, 5.96. Calcd. for $C_{25}H_{28}O_8\cdot N_2$: C, 61.97; H, 5.83%.

2-Methylene-3, 4, 5-trimethylcyclohexylmethanol (XV).—A mixture of the amino alcohol XII (1.2 g.), methanol (6 ml.) and 30% aqueous hydrogen peroxide (3 ml.) was stirred for 24 hr. at room temperature and allowed to stand for additional 48 hr. with occasional stirring, at which time it gave a negative spot test for the amine with phenolphthalein. Excess hydrogen peroxide was decomposed by stirring the solution with a platinum foil (0.8 g.) for 2 days at room temperature. The solution, after being removed the platinum foil, was concentrated under reduced pressure at a bath temperature of 30~40°C and the residual syrup was diluted with absolute ethanol (7 ml.) and reconcentrated. After the process was repeated five times to remove as much water as possible, *N*, *N*-dimethyl-6-hydroxymethyl-2, 3, 4-trimethylcyclohexylmethylamine oxide (XIV) was obtained as a colorless syrup.

A 30 ml. Claisen flask fitted with a 10 cm. Vigreux column containing the *N*-oxide XIV prepared as above was connected to a condenser, which led to two receivers in series, first cooled in a freezing mixture and second in a liquid nitrogen respectively. Decomposition of the *N*-oxide and distillation of the product began at 130°C and was complete at 140°C after 1 hr., at which time practically no material remained in the flask. The distillate was dissolved in ether (40 ml.) and washed with cold 5% hydrochloric acid and with water and dried over magnesium sulfate. Removal of the solvent, followed by distillation of the residue under nitrogen afforded 2-methylene-3, 4, 5-tri-methylcyclohexylmethanol (XV) (0.55 g., 58% based on XII) as a colorless oil, b. p. 122~124°C/14 mmHg, n_D^{15} 1.4925. The infrared spectrum of this compound was shown in the theoretical part.

Found: C, 78.12; H, 11.60. Calcd. for $C_{11}H_{20}\cdot O$: C, 78.51; H, 11.98%.

The allophanate crystallized from methanol, m. p. 152~153°C.

Found: C, 61.60; H, 8.65. Calcd. for $C_{13}H_{22}\cdot O_3N_2$: C, 61.39; H, 8.72%.

The combined washings containing hydrochloric acid were evaporated to dryness. The residue was diluted with absolute ethanol, reconcentrated under reduced pressure and the process was repeated 4 times to remove as much water as possible. The crystalline solid that remained was crystallized from absolute ethanol, after treatment with active charcoal, to afford *N*, *N*-dimethylhydroxylamine hydrochloride (0.37 g., 67%) as colorless needles, m. p. 105°C, which gave no melting point depression on admixture with an authentic sample.

***p*-Benzyloxybenzaldehyde.**—A solution of *p*-hydroxybenzaldehyde (24.4 g.) in ethanol (40 ml.) was added with cooling to sodium ethylate (prepared from 4.6 g. of sodium) in ethanol (70 ml.). Benzylchloride (25.3 g.) was then added slowly and the mixture was heated in a 300 ml. glass bomb at 130~140°C for 1.5 hr. when sodium chloride was precipitated completely. The reaction mixture was filtered and the precipitate was washed with a small amount of hot benzene. The filtrates were combined and concentrated under reduced pressure. The orange residue was dissolved in a mixture of benzene (200 ml.) and ether (200 ml.), washed with 10% aqueous sodium carbonate and with water, dried over sodium sulfate and evaporated. The residue was distilled under nitrogen or, more conveniently, crystallized from ethanol to give *p*-benzyloxybenzaldehyde (38.0 g., 89.5%), b. p. 187~189°C/5 mmHg, b. p. 155~156°C/1.1 mmHg, m. p. 73.5~74°C (lit.[11] m. p. 72°C).

Found: C, 79.36; H, 5.96. Calcd. for $C_{14}H_{12}\cdot O_2$: C, 79.22; H, 5.70%.

---

11) E. Wörner, *Ber.*, **29**, 142 (1896).

When the reaction was carried out at a temperature of 150~160°C, yield of the product decreased to ca. 60~70%.

p-Benzyloxybenzaldehyde is stable even when it was heated for several hours at 240~250°C under a nitrogen atomosphere.

The semicarbazone crystallized from ethanol in needles, m. p. 201~202°C.

Found: N, 15.75. Calcd. for $C_{15}H_{15}O_2N_3$: N, 15.61%.

The 2, 4-dinitrophenylhydrazone crystallized from ethanol-ethyl acetate in orange needles, m. p. 231 ~232°C.

Found: N, 14.05. Calcd. for $C_{20}H_{16}O_5N_4$: N, 14.28%.

***N*, *N* - Dimethyl-6-formyl - 2, 3, 4 - trimethylcyclohexylmethylamine (XVI).**—Aluminum isopropoxide (1.3 g., 120%) was added to the amino alcohol XII (3.4 g.) in a 15 ml. pear-shaped Claisen flask equipped with a 10 cm. Vigreux column. The isopropanol formed was removed over the course of 1.5 hr. at a bath temperature of 70~80°C and 10~12 mmHg pressure. To the XII-aluminate was then added *p*-benzyloxybenzaldehyde (5.6 g., 160%) in one portion, and the mixture was warmed at 80°C for a few minutes to make it homogeneous and distilled slowly by raising the bath temperature from 120 to 180°C. (1.0 mmHg pressure) during 40 min. under nitrogen. Fractionation of the distillate afforded the amino aldehyde XVI (2.95 g., 88%), b. p. 90~92°C/1.2 mmHg, n_D^{18} 1.4833, whose infrared spectrum indicated the presence of a carbonyl (1706) and a *tert*-amino group (2840, 2800 and 2745 cm^{-1}), but no hydroxyl group.

Found: C, 73.86; H, 11.95; N, 6.96. Calcd. for $C_{13}H_{25}ON$: C, 73.88; H, 11.92; N, 6.63%.

An attempt to prepare the 2, 4-dinitrophenylhydrazone of XVI using the Brady reagent gave instead the sulfate of the desiredder ivative. Basifying an aqueous solution of this salt with 10% aqueous sodium hydroxide yielded the free 2,4-dinitrophenylhydrazone, which was chromatographed from benzene-petroleum ether (1 : 1) on alumina and crystallized from methanol to give orange-yellow needles, m. p. 189~190°C.

Found: N, 17.30. Calcd. for $C_{19}H_{29}O_4N_5$: N, 17.89%.

4-(2′ - *N*, *N* - Dimethylaminomethyl - 3′, 4′, 5′ - trimethylcyclohexyl)-but-3-en-2-one (XVII). — The amino aldehyde XVI (2.8 g.) in acetone (15 ml.) was added to a solution of sodium hydride (100 mg.) in acetone (25 ml., freshly distilled after being treated with potassium permanganate) and the stirring was continued for 4.5 hr. at room temperature under nitrogen. After removal of the solvent, the residual oil was dissolved in ether and extracted with 10% hydrochloric acid. The aqueous layer was washed once with petroleum ether, basified with 10% aqueous sodium hydroxide and the free base regenerated was taken up in ether. The combined ether extracts were washed with water, dried over sodium sulfate and evaporated. Distillation of the residue gave the amino ketone XVII (2.4 g., 70%) as a pale yellow oil, b. p. 122~123°C/0.6 mmHg, $n_D^{25.5}$ 1.4898. ν_{max}^{film} 1678 (C=O, conju.), 1620 (C=C, conju.), 983 (-CH=CH-, trans), 2836, 2790, 2750 (*tert*-amino group), 1256 (=CH-CO-), 1380 (CH_3), 1361 cm^{-1} (CH_3CO).

Found C, 75.00; H, 11.89. Calcd. for $C_{16}H_{29}ON$: C, 76.44; H, 11.63%.

We wish to thank Dr. Asaji Kondo of the Tokyo Institute of Technology for microanalyses and Dr. Kenji Kuratani of the Aeronautical Institute of the University of Tokyo and Dr. Tadashi Satō of the Waseda University for infrared spectroscopy.

Laboratory of Organic Chemistry
Kobayasi Institute of Physical Research
Kokubunji, Tokyo