the solvent, the oily residue was distilled to give 2.2 g of **4** as an oil with a camphor-like odor: bp 82–83° (19 mm); $n^{21.0}$D 1.4699; ir (neat) 895, 967, and 805 cm^{-1} (epoxide ring); nmr ($CDCl_3$) τ 7.17 (unsymmetrical double q, 1 H, X portion of an ABX pattern, HC–O–CH_2), 7.29–7.75 (complex m, 2 H, AB portion of an ABX pattern, HC–O–CH_2), 8.73 and 8.77 (each s, 3 H, CH_3), 9.18 (s, 3 H, CH_3), *ca.* 9.13 (d, *ca.* 1 H, J = *ca.* 7.0 Hz, partly overlapped with the signal at τ 9.18, an *endo* proton of C-6 methylene bridge), and 7.90–8.60 (broad m, *ca.* 6 H, other methylene and methine protons). Vpc analysis on a 2-m PG-6000 column at 150° revealed two close but separated peaks, indicating this epoxide to be a 55:45 mixture (estimated from relative peak area) of two isomers.

Anal. Calcd for $C_{10}H_{16}O$: C, 78.89; H, 10.59. Found: C, 78.68; H, 10.99.

Hydrolysis of 5,5-Dimethylbicyclo[2.1.1]hexane-1-epoxyethane (4).—A mixture of 4.0 g (0.0262 mol) of **4**, 1.0 ml of 5% sulfuric acid, and 30 ml of ether was refluxed for 11 days. The organic layer was washed with 10 ml of water and 10 ml of 5% aqueous sodium bicarbonate and dried (Na_2SO_4), and the solvent was removed to give 4.5 g of oily residue which was purified on a silica gel (Mallinckrodt, 100 Mesh) column (2 × 80 cm) by elution with dichloromethane, chloroform, and ethyl acetate, successively. From the first fraction, an oil was obtained after removal of the solvent, which amounted to 0.558 g (14.0%) and was identified as the recovered **4** on vpc (but with an isomer ratio of 32:68) and by the ir and nmr spectral comparisons.

From the second fraction, a volatile oil (0.30 g, 7.5%) of 3-(1,1-dimethyl-2-propenyl)cyclopentanone (**5**) was obtained.

Anal. Calcd for $C_{10}H_{16}O$: C, 78.89; H, 10.59. Found: C, 78.99; H, 10.55.

The third fraction afforded a sticky semicrystalline residue (3.46 g, 72.5%) after removal of the solvent *in vacuo*, which was assumed to be a glycol mixture from its ir spectrum (3440 and *ca.* 1110 cm^{-1}). Three recrystallizations from dichloromethane afforded colorless prisms (300 mg, 6.2%) of **6**, mp 114–115°.

Anal. Calcd for $C_{10}H_{18}O_2$: C, 70.54; H, 10.66. Found: C, 70.57; H, 10.88.

Di-*p*-nitrobenzoate of 6.—A mixture of 34 mg (0.187 mmol) of **6** and 90 mg (0.485 mmol) of *p*-nitrobenzoyl chloride in 5 ml of dry pyridine was stirred for 24 hr at room temperature. Addition of water to the reaction mixture resulted in precipitation. The precipitates were filtered, washed with water, and dissolved in 30 ml of benzene. Benzene solution was washed with 5% aqueous sodium bicarbonate and water and dried (Na_2SO_4). Removal of the solvent *in vacuo* afforded faintly yellowish needles which were recrystallized from dichloromethane–*n*-hexane to afford 70 mg (80%) of fine needles of the di-*p*-nitrobenzoate of **6**: mp 170–171°; ir (KBr) 1725 (C=O), 1610, and 728 cm^{-1} (phenyl); nmr ($CDCl_3$, 100 MHz) τ 1.60–1.98 (m, 8 H, phenyl protons), 4.15 and 4.20 (two overlapped t, 1 H, J = *ca.* 5.5 Hz, OCOCHCH$_2$OCO), 5.43 and 5.45 (2 H, two overlapped d, 2 H, J = *ca.* 5.5 Hz, OCOCHCH$_2$OCO), 7.89 and 8.23 (each broad s, 6 H, methine and methylene protons), 8.68 and 8.70 (two overlapped s, 3 H, CH_3), 9.08 and 9.21 (each s, 3 H, CH_3), and 8.90 and 8.95 (two overlapped d, 1 H, J = *ca.* 7.0 Hz, *endo* proton of C-6 methylene bridge). All of these signals could be explained by assuming that the product was a mixture of two stereoisomers (*ca.* 1:1 ratio estimated from relative signal height).

Anal. Calcd for $C_{24}H_{24}O_8N_2$: C, 61.53; H, 5.16; N, 5.98. Found: C, 61.78; H, 5.08; N, 6.07.

Di-*p*-nitrobenzoate of 8.—A 2.39-g portion of the glycol mixture from the mother liquid of the third fraction as described above was treated with 5.5 g of *p*-nitrobenzoyl chloride in 20 ml of dry pyridine for 2 days at room temperature. After addition of water, the mixture was extracted with five 40-ml portions of chloroform and the combined chloroform extracts were washed successively with two 30-ml portions of 5% sulfuric acid, 30 ml of water, two 30-ml portions of 5% aqueous sodium bicarbonate, two 30-ml portions of water, and dried (Na_2SO_4). After removal of the solvent *in vacuo*, the crude product (3.5 g) was purified on a silica gel column (2 × 75 cm) by elution with benzene. From the first fraction, 1.07 g of faintly yellowish needles were obtained, mp 170–171° (dichloromethane–*n*-hexane), which was identified as the di-*p*-nitrobenzoate of **6** by mixture melting point determination and by the absolute superimposition of the ir spectrum on that of a specimen prepared directly from **6**. From the second fraction, 1.23 g of faintly yellowish prisms, mp 158–160° (dichloromethane–*n*-hexane) was obtained, which was characterized as a di-*p*-nitrobenzoate of **8**, though the stereochemistry of a hydroxymethyl group is uncertain: ir (KBr) 1725 (C=O), 1603, and 715 cm^{-1} (phenyl); nmr, see Figure 1.

Anal. Calcd for $C_{24}H_{24}O_8N_2$: C, 61.53; H, 5.10; N, 5.98. Found: C, 61.54; H, 5.15; N, 5.95.

Further fractions eluted with chloroform and ethyl acetate afforded *p*-nitrobenzoic acid and unidentified dark brown tar.

Lead Tetraacetate Oxidation of 1,2-Glycol 6.—Into a 50-ml, three-necked flask fitted with a dropping funnel and nitrogen inlet and outlet, which was immersed in a solution of 2,4-dinitrophenylhydrazine (2,4-DNP) reagent,[10] was placed 443 mg (1.0 mmol) of lead tetraacetate (commercial, used directly). After addition of 91 mg (0.5 mmol) of 1,2-glycol **6** in 20 ml of dry benzene, a slow stream of dry nitrogen was passed into the reaction mixture at *ca.* 60° for 1 hr. Precipitates in the 2,4-DNP solution were filtered and recrystallized from aqueous ethanol to give 40 mg (38%) of yellow needles, mp 166–168°,[11] which was identified as the 2,4-dinitrophenylhydrazone (2,4-DNP) of formaldehyde by mixture melting point and superposition of the ir spectrum on that of an authentic sample.

The reaction mixture in the flask was washed with water and treated with 2,4-DNP reagent to afford yellow precipitates, which were collected by filtration and dried. Purification on a silical gel column by elution with dichloromethane gave 50 mg (31.4%) of the 2,4-DNP of **7** as fine yellow needles, mp 171–172°, identified by mixture melting point and superposition of the ir spectrum on that of an authentic sample.[12] Although **7** has been described in the literature,[12] its 2,4-DNP is not reported. It was prepared as follows: 1.0 g of **3** in 100 ml of methanol was cooled at −70° and ozone was passed through the solution until **3** had disappeared on thin layer chromatography. Nitrogen was bubbled into the solution, for a short time, 1.0 ml of dimethyl sulfide was added, and the mixture was stirred for 5 hr at room temperature. Removal of the solvent and excess dimethyl sulfide afforded an oil, aldehyde **7**, a portion of which was treated with semicarbazine in the usual way to give the known semicarbazone of **7**, mp 193–194° (lit.[12] mp 192–193.2°). Another portion of the oily **7** was converted to its 2,4-DNP, mp 171–172° (aqueous ethanol).

Anal. Calcd for $C_{15}H_{18}O_4N_4$: C, 56.59; H, 5.70; N, 17.60. Found: C, 56.39; H, 5.53; N, 17.26.

Registry No.—**4**, 21990-90-9; **5**, 21990-91-0; **6**, 21990-92-1; di-*p*-nitrobenzoate of **6**, 21990-95-4; 2,4-DNP of **7**, 22037-79-2; di-*p*-nitrobenzoate of **8**, 22002-75-1.

Acknowledgment.—We are grateful to Dr. T. Nishida and Mr. I. Miura of Nippon Electric Varian, Ltd., for taking the nmr spectra.

(10) R. L. Shrine, R. C. Fuson, and D. Y. Curtin, "The Systematic Identification of Organic Compounds," 4th ed, John Wiley & Sons, Inc., New York, N. Y., 1956, p 219.

(11) Reference 10, p 283.

(12) K. Ebisu, L. B. Batty, J. M. Higaki, and H. O. Larson, *J. Amer. Chem. Soc.*, **88**, 1995 (1966).

A Stereospecific Synthesis of *trans*-3-(*exo*-5-*exo*-Isocamphyl)cyclohexanol

ROBERT T. DAHILL, JR., JULIAN DORSKY, AND WILLIAM EASTER

Givaudan Corporation, Clifton, New Jersey

Received June 18, 1969

Reports of the synthesis of substances possessing a sandalwood odor from terpenophenol ethers first appeared about 20 years ago.[1,2] Subsequently, Kheifits,

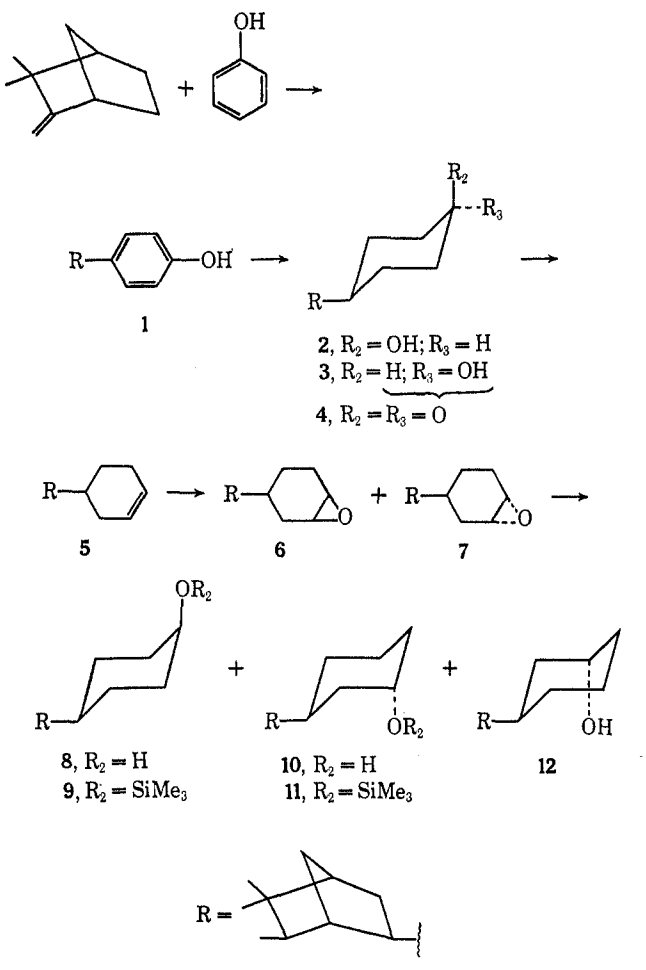
(1) J. R. Byers, *J. Amer. Perfumer*, **49**, 483 (1947).

(2) R. Hüttel and G. Keicher, German Patent 834,593 (1952); *Chem. Abstr.*, **47**, 5446*i* (1953).

et al., described an industrial method for the manufacture of these materials.[3] These early reports described the active-odor component as bornylhexahydroguaiacol. A Canadian patent filed in 1961 disclosed that the active components actually were terpenocyclohexanols devoid of the methoxyl group.[4] For a number of years this material has been used in perfumery for its sandalwood-like odor (Sandela Givaudan Corp.). It remained for Demole to isolate the active material, to establish its structure as *trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanol, and to accomplish its synthesis.[5] This synthesis is long and involved, requiring degradation of an aromatic ring to a carboxyl group and then the building up of a cyclohexanol ring again.

We report here a new stereospecific synthesis of *trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**10**). When camphene is condensed with phenol in the presence of a catalyst, there is produced a mixture of *o*- and *p*-(*exo*-5-*exo*-isocamphyl)phenol[6] from which the pure *para* isomer **1** was isolated by distillation and crystallization. The synthesis is outlined in Scheme I.

SCHEME I



Hydrogenation of this phenol resulted in a 1:1 mixture of two alcohols, **2** and **3**. That these alcohols were epimeric at the alcohol carbon atom was proven by oxidation to a single ketone, **4**. The mixture of alcohols was dehydrated in 90% yield with an acid catalyst. Epoxidation of the resulting olefin, **5**, with *m*-chloroperbenzoic acid resulted in a near-equal mixture of *cis* and *trans* oxides **6** and **7**. The properties of these two oxides were so similar that only very careful vapor phase chromatography effected a resolution. Preparative separation was not possible.

The mixture of epoxides **6** and **7** was reduced stereospecifically with lithium aluminum hydride–aluminum chloride to give axial alcohols **8** (same as **2**) and **10**.[7] That a mixture of alcohols **8** and **10** was present could not be readily ascertained by vapor phase chromatography, since they are both axial and very similar in physical properties. Upon conversion to the trimethylsilyl ethers **9** and **11** or trifluoroacetates, the two alcohols could be easily separated by vapor phase chromatography. The trimethylsilyl ethers **9** and **11** were also separable by distillation through a Nester-Faust Auto Annular Teflon spinning band column. *trans*-3-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (**10**) and *cis*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**8**) were obtained in a pure state by hydrolysis. *cis*-4-(*exo*-5-*exo*-Isocamphyl) cyclohexanol (**8**) was obtained as a crystalline material. *trans*-3-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (**10**) was a very viscous oil. After several weeks of storage, crystalline material was observed in the oil but recrystallization could not be accomplished. It is possible that two isomeric *trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanols are present (**10** and **12**).

Experimental Section[8]

***p*-(*exo*-5-*exo*-Isocamphyl)phenol (1).**—This compound was prepared by C alkylation of phenol with camphene catalyzed by Filtrol 20 at 125°. The crude product was fractionally distilled through a 4-ft Goodloe column and the fraction rich in **1** was crystallized twice from hexane. This is a modification of the procedure reported by Erman.[6]

***cis*- and *trans*-4-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (2 and 3).**—A mixture of 73 g (0.31 mol, mp 99–100°) of *p*-(*exo*-5-*exo*-isocamphyl)phenol (**1**), 100 ml of 2-butanol, 3 g of Raney nickel, and 3 g of 5% palladium on carbon was hydrogenated at 180–185° and 600 psi in a stainless-steel rocking autoclave until hydrogen absorption ceased. The product was filtered and the solvent was removed at 20 mm. There was produced 60 g (0.29 mol, 94%) of a 1:1 mixture (gas–liquid partition chromatography) of the *cis* and *trans* alcohols: mp 74–76°; ir (KBr) 2.95, 3.48, 6.80, 6.90, 7.22, 7.31, 7.37, 9.30, 9.50, 10.27, and 10.41 μ; nmr ($CDCl_3$) τ 5.80–6.10 (br, 0.5, CHOH), 6.25–6.65 (br, 0.5, CHOH), 7.90–8.80 (m, 18, CH and OH), 9.08 (s, 3, CCH_3), 9.13 (s, 3, CCH_3), and 9.1–9.3 (3, $CHCH_3$).

Anal. Calcd for $C_{16}H_{28}O$: C, 81.29; H, 11.94. Found: C, 80.93; H, 11.91.

4-(*exo*-5-*exo*-Isocamphyl)cyclohexanone (4).—To a solution of 0.46 g (1.56 mmol) of potassium dichromate in 3.5 ml of water was added 1.00 g (0.425 mmol) of *cis*- and *trans*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol dissolved in 5 ml of hexane. To this mixture was added 0.41 ml of concentrated sulfuric acid. The mixture was stirred at room temperature for 3 hr, taken up in ether, washed well with water, and dried ($MgSO_4$). The ether was removed, producing 0.875 g (0.37 mmol, 87%, purity 100% by vapor phase chromatography) of 4-(*exo*-5-*exo*-isocamphyl)-

(3) L. A. Kheifits, *et al.*, *Maslob-Zhir. Prom.*, **23**, No. 6, 35 (1957); *Chem. Abstr.*, **51**, 17107*d* (1957).
(4) Canadian Patent 688,543 (1964).
(5) E. Demole, *Helv. Chim. Acta*, **47**, 319, 1766 (1964).
(6) W. F. Erman, *J. Amer. Chem. Soc.*, **86**, 2887 (1964).
(7) B. Richborn *et al.*, *J. Org. Chem.*, **29**, 3185 (1964); **32**, 537 (1967).
(8) The infrared spectra were taken neat unless otherwise noted on a Perkin-Elmer Model 137 spectrophotometer. Proton nmr spectra were obtained on a Varian Associates A-60-A spectrometer with $Si(CH_3)_4$ as an internal standard. The vapor phase chromatography was done on a F & M Model 720 using, unless otherwise stated, a 4 ft × 0.25 in. column packed with 25% SE-30 on Gas-Chromosorb P at a temperature of 175–225°. The spinning-band distillation utilized the NFA-100 Nester-Faust Auto Annular Teflon spinning band column. The mass spectra were determined on a Consolidated Electrodynamics Corp. mass spectrometer, Model 110.

cyclohexanone: ir 3.41, 5.86, 6.82, 6.96, 7.28, 7.36, 7.40, 7.50, and 8.50 μ; nmr ($CDCl_3$) τ 7.68 (m, 4, CH_2CO, 7.80–9.00 (m, 13, CH), 9.07 (s, 3, CH_3), 9.13 (s, 3, CH_3), and 9.05–9.22 (3, $CHCH_3$).

This material crystallized upon standing and was recrystallized from hexane; mp 48.5–49.5°.

Anal. Calcd for $C_{16}H_{26}O$: C, 81.99; H, 11.18. Found: C, 81.60; H, 11.34.

4-(*exo*-5-*exo*-Isocamphyl)cyclohexene (5).—A mixture of 59 g (0.25 mol) of *cis*- and *trans*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**2** and **3**), 300 ml of *p*-menthane, and 0.5 g of 85% phosphoric acid was refluxed with a Dean–Stark water separator until no more water was produced. An additional 0.5 g of 85% phosphoric acid was added, and refluxing was continued until no more water was produced and the theoretical amount had been collected (12 hr). The mixture was washed with water, 10% sodium carbonate, and again with water. The solvent was removed at 20 mm. The product was distilled through a 37-cm column packed with glass helices. The yield was 49 g (0.224 mol, 90%) of 4-(*exo*-5-*exo*-isocamphyl)cyclohexene (**5**), homogeneous by vapor phase chromatography: bp 83° (0.2 mm); $n^{20}D$ 1.5003; ir 3.38, 3.50, 6.10, 6.87, 6.98, 7.05, 7.30, 7.39, 7.42, 7.52, 7.70, 8.05, 8.48, 8.80, 9.10, 9.71, 10.10, and 13.70 μ; nmr ($CDCl_3$) τ 5.40 (d, 2, J = 3.5 cps, *cis* HC=CH), 7.95–9.05 (br, 15, CH), 9.10 (s, 3, CCH_3), 9.17 (s, 3, CCH_3), and 9.05–9.35 (3, $CHCH_3$).

Anal. Calcd for $C_{16}H_{26}$: C, 88.00; H, 12.00. Found: C, 87.97; H, 11.96.

***cis*- and *trans*-1,2-Epoxy-4-(*exo*-5-*exo*-isocamphyl)cyclohexane (6 and 7).**—To a solution of 9.00 g (41.2 mmol) of 4-(*exo*-5-*exo* isocamphyl)cyclohexene (**5**) in 90 ml of methylene chloride was added at room temperature in small quantities 8.8 g (43.2 mmol, 85% pure) of *m*-chloroperbenzoic acid with constant stirring. After the addition was complete, the mixture was stirred for 60 hr at room temperature. The resulting mixture was filtered and the solvent was removed under reduced pressure. The residue was taken up in ether, washed with 3% sodium hydroxide and water, and dried ($MgSO_4$). The ether was removed, producing 8.21 g of product which was 88.5% pure by vapor phase chromatography (0.035 mol, 85%). This mixture had a woody, sandalwood odor. A Versamide column (225°) showed two components (*cis* and *trans* isomers) in a 1:1 ratio, but preparative separation was not possible. The product was distilled through an 8-in. Vigreux column: bp 123° (1.3 mm); $n^{20}D$ 1.5032; ir 3.40, 6.80, 6.90, 7.00, 7.22, 7.30, 7.33, 7.45, 7.90, 8.50, 10.30, 11.70, 12.30, 12.60, and 13.50 μ; nmr τ 6.92–7.17 (br, 2, HCOCH), 7.90–9.00 (br, 15, CH), 9.17 (s, 3, CCH_3), 9.21 (s, 3, CCH_3), and 9.03–9.23 (3, $HCCH_3$).

Anal. Calcd for $C_{16}H_{26}O$: C, 81.99; H, 11.18. Found: C, 81.54; H, 10.77.

***trans*-3-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (10) and *cis*-4-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (8).**—To a solution of 70.0 g of lithium aluminum hydride in 2100 ml of dry ether was added, dropwise with cooling, 322 ml of a solution of 93.25 g of anhydrous aluminum chloride in 700 ml of dry ether.[7] A mixture of 54.5 g (0.25 mol) of *cis*- and *trans*-1,2-epoxy-4-(*exo*-5-*exo*-isocamphyl)cyclohexane (*ca.* 1:1) dissolved in 1000 ml of dry ether was added dropwise with stirring and cooling to room temperature to the above solution. After the addition was complete, the mixture was allowed to stand at room temperature for 0.5 hr. The excess hydride was decomposed by the dropwise addition of isopropyl alcohol followed by wet ether. The organic phase was separated, the water layer was extracted several times with ether and dried ($MgSO_4$), and the solvent was removed under atmospheric conditions. There was produced 54.1 g (0.23 mol, 92%) of a mixture of *trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**10**) and *cis*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**8**). The two axial alcohols **8** and **10** could not be separated by vapor phase chromatography, but the trimethylsilyl ethers and trifluoroacetic esters could be separated. The mixture of **8** and **10** had ir 3.15, 3.50, 6.95, 7.36, 8.00, 8.45, 8.80, 9.50, 10.35, 11.35, 12.35, and 12.95 μ; nmr ($CDCl_3$) τ 5.78–6.10 (br, 1, CHO), 8.10–9.05 (br, 18, CH and OH), 9.12 (s, 3, CCH_3), 9.19 (s, 3, CCH_3), and 9.05–9.20 (3, $CHCH_3$).

Anal. Calcd for $C_{16}H_{28}O$: C, 81.29; H, 11.94. Found: C, 80.65; H, 12.00.

Separation of *trans*-3-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (10) and *cis*-4-(*exo*-5-*exo*-Isocamphyl)cyclohexanol (8) *via* Trimethylsilyl Ether Derivatives.—To a solution of 20 g (85 mmol) of *trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**10**) and *cis*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol (**8**) in 1 l. of dry pyridine was added 200 ml of hexamethyldisilazane followed by 80 ml of trimethylchlorosilane at room temperature. After the addition was complete the mixture was stirred at room temperature for 1 hr. The solvent and unreacted starting materials were removed under water pump vacuum. The last traces of solvent were removed by heating to 100° at 1 mm. The crude product weighed 22.7 g (74 mmol, 87%). The product was distilled as follows through a Teflon spinning band column. The crude material weighed 22.4 g and was composed of 41.8% **9** and 58.2% **11**. The fraction with bp 98–100° (0.028–0.035 mm) contained 4.8 g of the trimethylsilyl ether of *trans*-3-(*exo*-5-*exo*-isocamphyl)-cyclohexanol. The fraction with bp 100–202° (0.029–0.038 mm) contained 2.2 g of the trimethylsilyl ether of *cis*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol. Each of the above pure isomers was refluxed for 8 hr with 5% water in methanol (500 ml). The pure alcohols were obtained by evaporation of the methanol and removal of the water in theoretical yield.

The pure ***trans*-3-(*exo*-5-*exo*-isocamphyl)cyclohexanol (10)** was obtained as a colorless, viscous oil which, after several weeks storage, started to crystallize. Even after many months, it failed to solidify completely. Attempts at recrystallization from a variety of solvents were unsuccessful. Except for this behavior on crystallization, **10** appeared to be homogeneous (ir, nmr, vpc on several columns). We believe that our product is a mixture of isomers **10** and **12**. It analyzed as follows: $n^{20}D$ 1.5001; ir 2.99, 3.42, 6.90, 7.20, 7.25, 7.30, 7.90, 8.80, 9.05, 9.50, 10.05, and 10.30 μ; nmr ($CDCl_3$) τ 5.94 (centered, br, 1, CHO), 8.20–9.03 (br, 18, CH and OH), 9.11 (s, 3, CH_3), 9.28 (s, 3, CCH_3), and 9.00–9.20 (3, $CHCH_3$); mass spectrum m/e 236 (M^+).

Anal. Calcd for $C_{16}H_{28}O$: C, 81.29; H, 11.94. Found: C, 81.03; H, 12.02.

This alcohol has a strong sandalwood odor. The proton on the carbon atom bearing the hydroxyl group appears at τ 5.94, which is consistent with an equatorial proton and therefore an axial alcohol. The 10.3-μ band in the ir, characteristic of axial alcohols, confirms the structure.[5]

The pure ***cis*-4-(*exo*-5-*exo*-isocamphyl)cyclohexanol (8)** was obtained as a colorless crystalline material which could be recrystallized from hexane: mp 88–89°; ir 2.98, 3.45, 6.88, 7.22, 7.30, 7.34, 7.92, 8.77, 9.42, 9.70, 9.87, 10.30, 10.50, 11.10, 11.25, 11.55, 12.30, and 12.50 μ; nmr τ 6.05 (centered, br, 1, CHO), 8.20–9.00 (br, 18, CH and OH), 9.08 (s, 3, CCH_3), 9.16 (s, 3, CCH_3), and 9.00–9.20 (3, $HCCH_3$); mass spectrum m/e 236 (M^+).

Anal. Calcd for $C_{16}H_{28}O$: C, 81.29; H, 11.94. Found: C, 80.93; H, 12.01.

This alcohol was odorless. The proton on the carbon atom bearing the hydroxyl group appears at τ 6.05, which is consistent with an equatorial proton and therefore an axial alcohol. The 10.3-μ band in the ir, characteristic of axial alcohols, confirms the structure.[5]

Registry No.—**2**, 22242-60-0; **3**, 22242-61-1; **4**, 22242-62-2; **5**, 22242-67-7; **6**, 22242-63-3; **7**, 22242-64-4; **9**, 22297-77-4; **10**, 22242-65-5; **11**, 22242-66-6.

Conformations of Cyclic Peptides. Stability of Folded Conformations of *para*-Substituted 3-Benzylpiperazine-2,5-diones[1]

ZIAUDDIN AND KENNETH D. KOPPLE

Department of Chemistry, Illinois Institute of Technology, Chicago, Illinois 60616

Received June 12, 1969

Cyclic dipeptides bearing an arylmethyl side chain, *e.g.*, 3-benzylpiperazine-2,5-dione (cycloglycylphenyl-

(1) This work was supported by a research grant (GM 14069) from the National Institute of General Medical Sciences, U. S. Public Health Service.