ferent effects of the two structures on the chemical shift of the reference material. The results of the study are shown graphically in Fig. 1; no importance should be placed upon the absolute chemical shifts, since no attempt was made to set the instrument at zero.

Verification of the Compound Melting at 90–91° as 2-Methylpyrazine 1-Oxide (I).—In order to remove the confusion of this material with 2-methylpyrazine 4-oxide,[10] a 22.0 g. (0.20 mole) sample was treated with 58 ml. of acetic anhydride[4] in the manner described by Koelsch and Gumprecht.[2a] Their methods of isolation of the ester and its subsequent saponification were also used. In this way there was obtained 5.7 g. (26%) of pyrazinemethanol as a colorless oil, b.p. 59–60° at 0.23 mm. The n.m.r. and infrared spectra of the sample were indicative of a primary alcohol.

Anal. Calcd. for $C_5H_6N_2O$: C, 54.54; H, 5.49; N, 25.44. Found: C, 54.85; H, 5.45; N, 25.47.

Separation of 2-Methylpyrazine 4-Oxide (II) from the Eutectic Melting at 44–45°.—A mixture of 22.0 g. of the eutectic and 58 ml. of acetic anhydride was boiled under reflux for 1 hr. The resulting dark oil was allowed to stand at room temperature for 5 days. Evaporation of the excess acetic anhydride and acetic acid on a steam bath under reduced pressure left a viscous black oil which, when vacuum distilled, yielded 22.7 g. of a yellow, partially crystalline oil. The crystalline portion was separated by dissolving the mixture in ether at a concentration of 25%, cooling the solution, and decanting the mother liquor. Final purification was performed by recrystallization from ether at room temperature, giving 8.3 g. (73% assuming the eutectic was 52% the lower melting isomer, as indicated by vapor phase chromatography) of 2-methylpyrazine 4-oxide as white crystals, m.p. 69–70°.

Anal. Calcd. for $C_5H_6N_2O$: C, 54.54; H, 5.49; N, 25.44. Found: C, 54.56; H, 5.35; N, 25.51.

Terpenoids. XLV. Structure and Absolute Configuration of Canarone

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Contribution No. 574 from the National Chemical Laboratory, Poona, India

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During the course of separation of the constituents of the Black dammar resin (*Canarium strictum* Roxb.),[1] we isolated a small amount of a new monoethynoid sesquiterpene ketone, canarone, $C_{15}H_{24}O$. On the basis of the results described below, it can be represented by structure I and its absolute configuration by the stereoformula IX.

The infrared spectrum of canarone exhibited bands at 1700 cm.$^{-1}$ characteristic of a 2,2-dialkyl cyclohexanone[2] and at 1420 cm.$^{-1}$ due to a –CO–CH$_2$– grouping. Bands at 3080, 1640, and 890 cm.$^{-1}$ indicated the presence of terminal methylene group. Ultraviolet spectrum showed the absence of a conjugation.

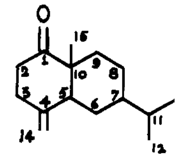
Canarone (I) on lithium aluminum hydride reduction gave canarol (IV), which on selenium dehydrogenation afforded eudalene (II). Canarone should therefore possess a eudalenic skeleton.

Hydrogenation of canarone (I) with Adams catalyst in acetic acid yielded a tetrahydro product, dihydrocanarol (VI), lacking the infrared bands due to ketone and terminal methylene groups, but instead showed an intense band at 3500 cm.$^{-1}$ due to a hydroxyl group.

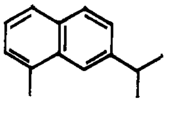
Hydrogenation of canarol (IV) in acetic acid over Adams catalyst also afforded dihydrocanarol (VI), showing the presence of one double bond in canarol (IV) and hence in canarone (I). In conformity with this, quantitative hydrogenation of canarone over palladium–charcoal catalyst in methanol furnished the saturated ketone, dihydrocanarone (III). Canarone therefore should be a bicyclic ketone.

The position of the carbonyl function at C-1 was fixed by reacting canarone with methyl magnesium iodide and dehydrogenating the resulting tertiary carbinol to furnish 4-methyl eudalene (VII).[3]

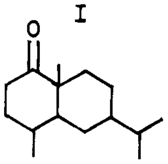
Ozonolysis of canarol (IV) yielded formaldehyde as the only volatile component. The nonvolatile portion consisted of the hydroxy norketone (V), which gave a negative iodoform test. In its infrared spectrum, it showed strong absorption bands at 3400 (hydroxyl), 1710 (six-membered ring ketone), 1420 (–CO–CH$_2$), 1360 and 1375 cm.$^{-1}$ (isopropyl). This locates the position of the ethylenic linkage between C-4–C-14 and not in the isopropyl side chain. In further support for this, canarone and all the products derived from it exhibited a doublet (between 1360 and 1380 cm.$^{-1}$) in the methyl bending region, indicating the presence of a isopropyl group[4] in the hydroxy norketone (V), and hence the location of the exocyclic methylene group at C-4 in canarone (I).



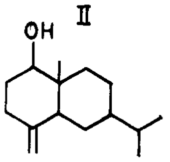
I



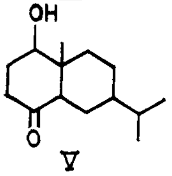
II



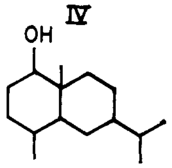
III



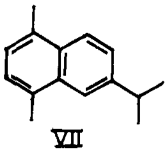
IV



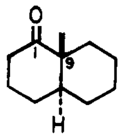
V



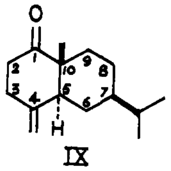
VI



VII



VIII



IX

The rotatory dispersion curve (Fig. 1A) of canarone (I) is the same type (+*ve* Cotton effect, *a* = +20), whereas the curve of the hydroxy norketone (V) (Fig. 1B)

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(1) Kirtikar and Basu, "Indian Medicinal Plants," Vol. 1, 1918, p. 287.

(2) E. J. Corey, T. H. Topie, and W. A. Wozhiak, *J. Am. Chem. Soc.*, **77**, 5415 (1955).

(3) G. Buchi, M. S. Wittenau, and D. M. White, *ibid.*, **81**, 1968 (1959).

(4) Infrared spectrum of canarone also showed the presence of bands at 1183 and 1160 cm.$^{-1}$, attributable to isopropyl group [*cf.* H. L. MacMurry and V. Thornton, *Anal. Chem.*, **24**, 318 (1952)].

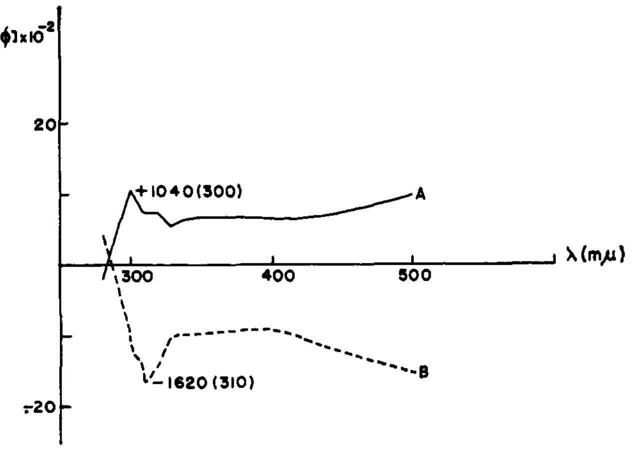

Fig. 1.-Optical rotatory dispersion curves of A, canarone (I); and B, keto alcohol V.

is the antipodal type (*−ve* Cotton effect, *a* = −30) compared to that shown by *trans*-9-methyl-1-decalone (VIII).[5] The molecular amplitude values, *a*, for compounds I and V are in better agreement with those reported[6] for *trans*-1-decalones from the eudesmanic group than from the eremophilane group. The ring fusion in canarone should therefore be *trans*, as shown in the formula of IX. Application of the octant rule[7] also points to a *trans* fusion of the ring.

The customary, β-equatorial configuration is assigned to the C-7 isopropyl side chain in analogy with other eudesmanic compounds. Canarone can therefore be represented by the stereoformula IX.

Experimental[8]

Isolation of Canarone (I).—From the petroleum ether (b.p. 60–80°) extract of the resin (7 kg.), pure ketone (1.8 g.) was isolated by column chromatography over alumina (grade II, 30-fold), followed by regeneration from its semicarbazone (oxalic acid, petroleum ether), b.p. 120–125° (bath) at 1 mm., n^{28}D 1.5020, [α]D +34.78° (*c* 3.45), d^{29}_{29} 0.9819; $\nu_{\max}^{\text{liq film}}$ 3080, 1700, 1640, 1420, 1360, 1375, 1225, 1260, 1183, 1160, and 890 cm.$^{-1}$.

Anal. Calcd. for $C_{15}H_{24}O$: C, 81.76; H, 10.98. Found: C, 81.00; H, 10.98.

The semicarbazone had m.p. 222–224°.

Anal. Calcd. for $C_{16}H_{27}N_3O$: N, 15.15. Found: N, 15.50.

Reduction of Canarone (I) and Dehydrogenation of Canarol (IV).—To a suspension of lithium aluminum hydride (0.9 g.) in dry ether (50 ml.) was added a solution of the ketone (1.03 g.) in dry ether (25 ml.). During addition, the temperature was maintained between 0 and 5° and the solution was then refluxed for 5 hr. The reaction mixture on decomposition in the usual way furnished the secondary alcohol canarol (IV), b.p. 110–115° (bath) at 0.2 mm., n^{28}D 1.5040, [α]D +23.81° (*c* 1.26, ethanol).

Anal. Calcd. for $C_{15}H_{26}O$: C, 81.04; H, 11.74. Found: C, 80.65; H, 11.58.

The secondary alcohol (0.4 g.) was heated with selenium (0.4 g.) at 280° for 7 hr. in a nitrogen atmosphere. The product obtained was filtered through alumina (grade I, 20 g.) and eluted with petroleum ether. The ultraviolet spectrum indicated more than 80% naphthalenic material. It was identified as eudalene (II) through its trinitrobenzene (TNB) derivative, m.p. and m.m.p. 110°, and through its infrared spectrum.

Quantitative Determination of Unsaturation.—Canarone (I, 30 mg.) was hydrogenated in methanol in the presence of palladium on charcoal (5%, 30 mg.); the absorption of hydrogen (3.5 ml., 24°, 710 mm.) amounted to one double bond; $\nu_{\max}^{\text{liq film}}$ 1704, 1420, 1383, and 1366 cm.$^{-1}$.

Hydrogenation of Canarone (I) to Dihydrocanarol (VI).—Canarone (130 mg.) was hydrogenated in acetic acid (20 ml.) using platinum oxide (50 mg.) catalyst. The hydrogenation stopped after absorption corresponding to 2 moles of hydrogen. After removal of the catalyst, the filtrate afforded after the usual processing 90 mg. of dihydrocanarol (VI), b.p. 105–110° (bath) at 0.3 mm., n^{28}D 1.4940, [α]D +8.43° (*c* 1.78); $\nu_{\max}^{\text{liq film}}$ 3450, 1380, and 1370 cm.$^{-1}$.

Anal. Calcd. for $C_{15}H_{28}O$: C, 80.29; H, 12.56. Found: C, 80.52; H, 12.81.

Hydrogenation of Canarol (IV) to Dihydrocanarol. (VI)—A solution of canarol (100 mg.) in acetic acid (20 ml.) was hydrogenated over prereduced Adams' catalyst (50 mg.). The absorption corresponded to 1 mole of hydrogen. The infrared spectrum of the purified product was superimposable with the infrared spectrum of the product obtained by direct hydrogenation of canarone over Adams catalyst, and had identical properties.

Ozonolysis of Canarol (IV) to the Keto Alcohol (V).—Canarol (0.12 g.) in chloroform (10 ml.) was ozonized at −5° to completion. The chloroform was removed *in vacuo* and the ozonide was decomposed with water. The volatile component was identified as formaldehyde by its dimedone derivative, m.p. and m.m p. 189°. The trap water did not give a test for acetone. The nonvolatile product (60 mg.), purified by filtering through a short column of alumina (grade III), did not give a test for methyl ketone, b.p. 135° (6 mm.); $\nu_{\max}^{\text{liq film}}$ 3400, 1701, 1425, 1375, 1360, 1180, and 1065 cm.$^{-1}$.

Anal. Calcd for $C_{14}H_{24}O_2$: C, 75.04; H, 10.78. Found: C, 76.80; H, 10.6.

Due to the paucity of material a better analysis could not be obtained.

Grignard Reaction on Canarone (I) and Isolation of 4-Methyleudalene (VII) by Dehydrogenation.—The ketone (0.50 g.) in dry ether (20 ml.) was added dropwise to the solution of methyl magnesium iodide (prepared from 0.40 g. magnesium and 2.5 ml. of methyl iodide) in dry ether (50 ml.), and the reaction mixture was refluxed for 12 hr. The product was worked up in the usual way and the derived tertiary alcohol was separated from traces of unchanged ketone by chromatography. The crude tertiary alcohol (0.25 g.) was heated with selenium (0.3 g.) at 290° for 6 hr. The reaction product was extracted with ether and filtered through alumina (grade I, 10 g.). The ultraviolet spectrum of the dehydrogenated product indicated 90% naphthalenic product. It was identified as 1,4-dimethyl-7-isopropylnaphthalene (VII) by its TNB derivative, m.p. 102–103°, lit. m.p. 103–104°.[9]

Anal. Calcd. for $C_{15}H_{18} \cdot C_6H_3N_3O_6$. N, 10.21. Found: N, 10.3.

The parent hydrocarbon regenerated from its TNB complex gave a picrate, m.p. 112–113°, lit. m.p. 113–114°.[3]

Acknowledgment.—We are grateful to Professor W. Klyne of Westfield College, University of London, for optical rotatory dispersion measurements and helpful discussions.

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[5] C. Djerassi, R. Riniker, and B. Riniker, *J. Am. Chem. Soc.*, **78**, 6362 (1956).

[6] C. Djerassi and W. Klyne, *J. Chem. Soc.*, 4929 (1962).

[7] C. Djerassi, "Optical Rotatory Dispersion," McGraw-Hill Book Co., Inc., New York, N. Y., 1960, p. 181.

[8] Melting points are uncorrected. Rotations were determined in chloroform solution unless otherwise stated. Infrared spectra were taken by H. Gopinath using a Perkin-Elmer Model 137b spectrophotometer. Ultraviolet spectra were measured in ethanol solution by Miss Prabhu with a DK-2 Beckman spectrophotometer. Analyses were carried out by Mr. Pansare and colleagues.

[9] G. S. K. Rao and S. Dev, *J. Indian Chem. Soc.*, **33**, 561 (1956).

Reactions of Derivatives of 2-Formyl-1-tetralone

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In the course of the preparation of 1-substituted 3,4-dihydronaphthalenes, we had occasion to investigate the reaction of the acetal II with phenylmagnesium bromide.