

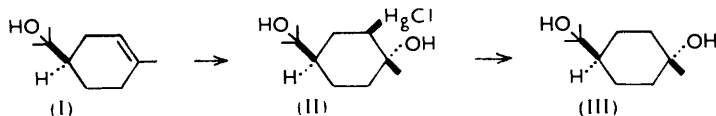
363 *Aspects of Stereochemistry. Part XIII.*<sup>1</sup> *The Reaction of (+)-Carvomenthene with Mercuric Acetate in Water.*

By H. B. HENBEST and R. S. McELHINNEY.

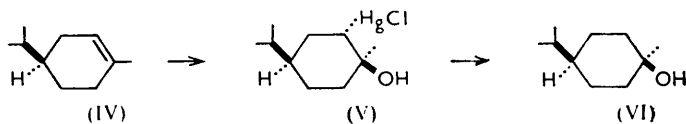
In the reaction of 1-methylcyclohexenes with mercuric acetate in water, replacement of a 4-(1-hydroxy-1-methylethyl) substituent (in  $\alpha$ -terpineol) by a 4-isopropyl substituent (in carvomethene) causes a reversal of the direction of perpendicular addition of HgX and OH groups. Mechanisms for the two reactions are discussed. Pure (+)-carvomenthene has been prepared from its hydroxy-chloromercuri-adduct, and the *cis*- and *trans*-isomers of  $\beta$ -terpineol and *p*-menthan-1-ol have been further characterised.

In a previous paper<sup>1</sup> on the reactions of unsymmetrical olefinic bonds with mercuric acetate in water or in methanol, it was shown that several cyclohexenes containing a Lewis-base substituent at the 4-position each yielded a single adduct, in which the new anionic substituent (OH or OMe) was placed in a *trans*-1:4-relation to the original Lewis-base substituent. It was also pointed out that the reaction of  $\alpha$ -terpineol (I; absolute configuration) apparently proceeds by the same mechanism (involving retention of the mercuri-group on the same side of the molecule as the Lewis-base group), as the resulting adduct (II) gives *cis*-terpin (III; discussion of stereochemistry below) on reductive removal of the

<sup>1</sup> Part XII, Henbest and Nicholls, *J.*, 1959, 227.

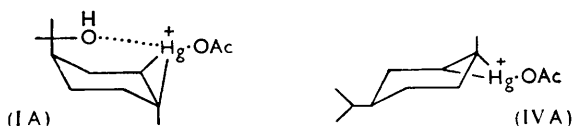


mercurial group. In order to determine the importance of the hydroxyl group in the side-chain of  $\alpha$ -terpineol in directing the formation of the adduct (II), we have now examined the reaction of its deoxy-analogue, (+)-carvomenthene (IV; absolute configuration), with mercuric acetate in water.



This reaction gave a single crystalline mercurial in at least 74% yield, after the acetoxymercuri-group in the initial reaction product had been converted into a chloromercuri-group by treatment with sodium chloride. The structure (V) for this adduct was established by its reduction with hydrazine<sup>2</sup> to *trans-p*-menthanol (VI; discussion of stereochemistry below). Carvomenthene was also formed in the reduction of the mercurial with hydrazine, and the olefin was obtained as the only product when sodium-ethanol was used as the reducing agent; in either case the elimination of the chloromercuri- and hydroxy-groups may be helped by their diaxial arrangement when the molecule is in the conformation with the *isopropyl* group equatorial.

The reactions of  $\alpha$ -terpineol (I) and carvomenthene (IV) with mercuric acetate in water differ, therefore, in the direction of attachment of the entering hydroxyl group, and hence in the direction of initial addition of the mercury electrophile. In the case of carvomenthene, the direction of addition conforms to the Markownikow rule and to the rule of diaxial addition to *cyclohexenes*, on the assumption that the molecule undergoes reaction in the conformation where the *isopropyl* group is equatorial (cf. mercurinium ion, IVA). The fact that the initial attack of the mercury electrophile is towards the less hindered side of the molecule (*trans* to the *isopropyl* group) may be an additional factor in causing the formation of the adduct (V). In  $\alpha$ -terpineol, the hydroxyl group on the



*isopropyl* side-chain can act as a Lewis base (cf. mercurinium ion, IA) to hold the mercury electrophile on to that side of the molecule,<sup>1</sup> and the direction of perpendicular addition of the HgX and OH groups is reversed.

*The  $\beta$ -Terpineols and p-Menthanols.*—The geometrical configurations of each of these pairs of compounds were uncertain until Pascual and Coll<sup>3</sup> established the structure of the "terpins." The lower-melting terpin, which forms a hydrate, has the structure (VII). It was called "*cis*-terpin" but, as Barnes<sup>4</sup> has pointed out, *trans*-terpin is a better name as it indicates the *trans*-arrangement of the alkyl groups. The isomeric higher-melting terpin, which does not form a hydrate, is best named *cis*-terpin (cf. III). In 1902, Stephan and Helle<sup>5</sup> isolated a " $\beta$ -terpineol," m. p. 32—33°, from a commercial terpineol mixture.

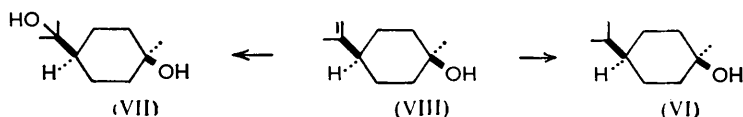
<sup>2</sup> Wright, *Canad. J. Chem.*, 1950, **30**, 268.

<sup>3</sup> Pascual and Coll, *Anal. real soc. españ. Fis. Quím.*, 1953, **49**, 547, 553.

<sup>4</sup> Barnes, *Austral. J. Chem.*, 1958, **11**, 134.

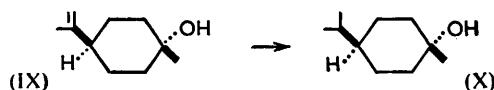
<sup>5</sup> Stephan and Helle, *Ber.*, 1902, **35**, 2148.

The fact that *trans*-terpin (VII) can be readily obtained<sup>6</sup> from this  $\beta$ -terpineol shows that the latter compound has the structure (VIII). The *p*-menthanol, obtained<sup>7</sup> by hydrogenation of  $\beta$ -terpineol, must therefore be the *trans*-compound (VI).<sup>4</sup> Repetition of this



hydrogenation gave *trans-p*-menthanol (VI) identical with the product obtained (above) by reduction of the mercurial from carvomenthene—hence the assignment of structure (II) to the mercurial.

Recently, an isomeric  $\beta$ -terpineol and the corresponding *p*-menthanol have been separated from the mixture obtained on autoxidation of limonene or carvomenthene followed by partial or complete reduction.<sup>8</sup> By exclusion, the new isomers must be the *cis*-compounds (IX and X). In these new isomers, the conformations with equatorial hydroxyl and *iso*-propenyl (or *isopropyl*) groups should predominate, whereas the hydroxyl groups in the corresponding old isomers (VIII and VI) will tend to be axial. In agreement, the new



isomers have the higher boiling points and are also more slowly eluted on vapour-phase chromatography. All four tertiary alcohols give crystalline phenylurethanes, and they can also be differentiated by differences in their absorption in the 900—1200  $\text{cm}^{-1}$  region of the infrared spectrum.

#### EXPERIMENTAL

M. p.s were determined on a Kofler hot stage. Optical rotations were determined by using dilute (1—2%) solutions in "AnalaR" benzene.

*Purification of (+)-Carvomenthene (IV).*—(+)-Limonene (27.2 g.) in ethanol (100 c.c.) was shaken with hydrogen at atmospheric pressure in the presence of pre-reduced Adams catalyst (0.272 g.). When one mol. had been absorbed (70 min.), the hydrocarbon was isolated with pentane. The crude carvomenthene (24.5 g.) had b. p. 52—53°/8 mm.,  $n_D^{25}$  1.4530,  $[\alpha]_D^{25} + 91^\circ$ ; it was used to prepare the mercurial (see below). A mixture of the pure mercurial (18.5 g.), 2N-sulphuric acid (200 c.c.), and light petroleum (b. p. 40—60°; 100 c.c.) was stirred vigorously at 20° for 6 hr. Filtration removed a yellow solid (3.6 g.), and then the carvomenthene was isolated from the petroleum layer. Distillation gave (+)-carvomenthene (5.06 g., 77%), b. p. 59°/11 mm.,  $n_D^{25}$  1.4544,  $[\alpha]_D^{25} + 114^\circ$ . The selective hydrogenation of limonene has recently been reported<sup>9</sup> to give carvomenthene with  $n_D^{23}$  1.4557,  $[\alpha]_D^{23} + 109^\circ$ .

*Reaction of (+)-Carvomenthene with Mercuric Acetate.*—Solutions of crude carvomenthene (9 g.) in dioxan (40 c.c.; distilled from sodium) and mercuric acetate (20.72 g.) in water (200 c.c.) were mixed and then stirred vigorously. 2N-Sodium hydroxide was added in portions to neutralise from time to time the acetic acid formed in the reaction. Some yellow mercuric oxide was precipitated if too large a portion of alkali was added, but this redissolved as more acetic acid was formed from the reaction. After 4 hr., one mol. of alkali (35 c.c.) had been added and addition of a further small portion gave no yellow precipitate. The cream-coloured emulsion was kept at 20° overnight, and then treated with 2N-sodium hydroxide (140 c.c.) to dissolve the mercurial. The solution was filtered and sodium chloride (7.61 g.) was dissolved in the filtrate into which carbon dioxide was then passed to neutralise the alkali and hence to precipitate the crude mercurial (19.45 g.; dried over  $\text{P}_2\text{O}_5$ ). Extraction with hot benzene

<sup>6</sup> Wallach, *Annalen*, 1906, **350**, 158.

<sup>7</sup> *Idem, ibid.*, 1911, **381**, 58.

<sup>8</sup> B.P. 761,686/1956.

<sup>9</sup> Newhall, *J. Org. Chem.*, 1953, **23**, 1274.

(120 c.c.) left a residue (2 g.) of inorganic material, and the yield of organomercurial was therefore 17.45 g. (69%). (By further working up of residues and mother-liquors, the yield of crude mercurial could be raised to 94%.) The cooled benzene solution gave the mercurial (14.3 g.) as needles, m. p. 134—136°. Recrystallisation from light petroleum (b. p. 80—100°) gave (80% recovery) pure 2 $\alpha$ -chloromercuri-1 $\alpha$ -methyl-4 $\beta$ -isopropylcyclohexan-1 $\beta$ -ol (V), m. p. 135—136°,  $[\alpha]_D^{25} + 27^\circ$  (Found: C, 30.9; H, 4.9. C<sub>10</sub>H<sub>19</sub>OClHg requires C, 30.7; H, 4.9%).

By starting with purified carvomenthene (above) the yield of mercurial (after the stage of extraction with benzene) was raised from 69 to 74%.

*Reduction of the Mercurial (V).*—A mixture of the pure mercurial (3.91 g.), 3% sodium hydroxide solution (40 c.c.), and 90% hydrazine hydrate (3.6 c.c.) was heated under reflux for 48 hr. The yield of mercury was 1.51 g. (75%) and subsequent study of the remainder of the products also indicated that reduction was not complete. The organic products were isolated with pentane, evaporation of which gave a residue which partially solidified owing to the presence of some organomercurial. Distillation at 0.4 mm. with a bath-temperature of 20—110° gave carvomenthene and *trans-p*-menthanol (0.68 g. combined), some of the former being collected in a cold trap. (The product obtained by raising the bath-temperature above 120° was partly ketonic and arose from the thermal decomposition of organomercurial still present.) The olefin-alcohol mixture was shown (by infrared and vapour-phase chromatographic analyses) to consist of carvomenthene (0.25 g., 18%) and *trans-p*-menthanol (VI) (0.43 g., 28%). The alcohol was isolated from the mixture by vapour-phase chromatography, and gave an infrared spectrum identical in all detail with that of *trans-p*-menthanol prepared by hydrogenation of *trans*- $\beta$ -terpineol (below). It also gave the same phenylurethane, m. p. and mixed m. p. 102—104°.

The mercurial (3.91 g.) was reduced with sodium amalgam (139.1 g.; 3% of Na) and water (25 c.c.) at 0°. The mixture was finally kept at 0° for two days and then the organic product was isolated with pentane. Distillation gave carvomenthene (0.83 g., 60%), b. p. 64—66°/17 mm.,  $n_D^{25} 1.4538$ , infrared spectrum identical with that of the authentic compound.

*cis- and trans-p-Menthanol (X and VI).*—*cis*- $\beta$ -Terpineol (IX) (m. p. 36°; 0.156 g.) and phenyl isocyanate (0.146 g.) were heated together in a sealed tube at 80° for 7 hr. The insoluble diphenylurea was left behind on extraction with light petroleum (b. p. 60—80°). Filtration of the extract through deactivated alumina gave the crude urethane (0.153 g.), m. p. 58—65°. Recrystallisation from aqueous methanol and from light petroleum (b. p. 40—60°) gave the *phenylurethane*, m. p. 69—70° (Found: C, 75.1; H, 8.4. C<sub>17</sub>H<sub>23</sub>O<sub>2</sub>N requires C, 74.7; H, 8.5%).

*cis*- $\beta$ -Terpineol (0.616 g.) in ethanol (10 c.c.) was shaken with hydrogen in the presence of Adams catalyst (31 mg.). Hydrogenation ceased (30 min.) when 83 c.c. had been absorbed (at 22°/767 mm.). Isolation with pentane gave *cis-p*-menthanol (X), m. p. 43—44°, which by the technique above gave a *phenylurethane*, m. p. 85° (from pentane) (Found: C, 74.3; H, 9.1. C<sub>17</sub>H<sub>25</sub>O<sub>2</sub>N requires C, 74.15; H, 9.15%).

*trans*- $\beta$ -Terpineol (VIII) gave a phenylurethane, m. p. 82—83° (lit., m. p. 85°). Hydrogenation of *trans*- $\beta$ -terpineol (as for the *cis*-compound) gave *trans-p*-menthanol (VI) (85%), b. p. 98—99°/19 mm.,  $n_D^{25} 1.4568$ . Its phenylurethane had m. p. 102—103° (lit., m. p. 101°).

*Spectra.*—The spectra (see Table) were determined with 5% solutions of the compounds in "AnalaR" carbon disulphide.

*Absorption bands in the 900—1200 cm.<sup>-1</sup> region for tertiary alcohols.*

<i>tert.</i> -Butyl alcohol .....	912			1140	1195
1-Methylcyclohexanol .....	914		972	1133	1175
<i>cis-p</i> -Menthanol (X) .....	915		981	1120	1150
<i>trans-p</i> -Menthanol (VI) .....	907	941	988	1000	1084
<i>cis</i> - $\beta$ -Terpineol (IX) .....	916		982		1110
<i>trans</i> - $\beta$ -Terpineol (VIII) .....	911	930	952	1000	1100

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