# ATTRACTANT PHEROMONES OF COLEOPTERA.

## COMMUNICATION 1. SIMPLE SYNTHESIS OF EXO- AND ENDO-BREVICOMINS USING THE OXY-COPE REARRANGEMENT

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Two paths for the synthesis of 6,8-dioxabicyclo[3.2.1]octanes are known: via the δ,ε-dihydroxy or δ,ε-epoxy ketones and via 2-(1'-hydroxyalkyl)-2,3-dihydropyrans [1]. To prepare the (±)-forms of exo- (I) and endo-brevicomin (II), used as attractants against bark beetles of the genus *Dendroctonus*, the first path is applied [1-4] rather than the second [1, 5-7]. We proposed a preparatively convenient modified method for the synthesis of brevicomins by the first path, in which the oxy-Cope rearrangement is used to build the carbon skeleton of (I) and (II).

By a method previously described in [8], from acrolein and EtMgBr, 1-penten-1-ol (III) is obtained, which is then converted into 1-bromo-2-pentene (IV). In a Grignard reaction between (IV) and methyl vinyl ketone, a mixture of the erythro and threo isomers of 4-ethyl-3-methyl-1,5-hexadien-3-ol (Va, b) is obtained in a yield of 67%. An analysis of the mixture by GLC and PMR spectroscopic methods showed the absence of isomeric 3-methyl-1,5-octadien-3-ol. Since under kinetic control conditions, the Grignard reagent formed from (IV) (allylethylmagnesium bromide) corresponds to structure (VI), to obtain (Va, b), we can use allyl bromide (IV) with any ratio of E and Z isomers [9] (see reaction flowchart on next page.)

Thermolysis of a mixture of (Va, b) in N-methylpyrrolidone by the Fujita method [10] leads to a mixture of E and Z isomers of 6-nonen-2-one (VIIa, b) in a ratio of ≈65:35 (PMR spectrum of mixture at 250 MHz). The predominance of the E isomer (VIIa) in the rearrangement product agrees with the results observed for other erythro/threo isomeric 1,5-hexadien-3-ols (see [10, 11]).

Epoxidation of a mixture of enones (VIIa, b) by tert-butyl hydroperoxide (TBHP) in boiling benzene in the presence of molybdenyl acetylacetonate gives a mixture of (I) and (II) in a ratio of ≈40:60 in a 60% yield (GLC and PMR spectral data). The mixture is separated by preparative GLC into the individual racemates (I) and (II). It is clear that the ratio of (I) and (II) formed during a stereospecific thermal rearrangement [12] of the intermediately formed stereoisomeric epoxy ketones (VIIIa, b) depends on the ratio of the isomeric enones (VIIa, b) in the oxy-Cope rearrangement product.

The proposed scheme ensures a satisfactory overall yield of brevicomins (9% based on acrolein, 27% on methyl vinyl ketone) without chromatographic separations at intermediate stages.

## EXPERIMENTAL

The GLC was carried out on a Tsvet 467 apparatus, with a stainless steel column and a flame-ionization detector (5% XE-60 on Chromaton V-AW-DMCS, at thermostat temperatures of 60-90°C and evaporator temperatures of 120-150°C, excess $N_2$ pressure of 0.8-1.2 atm). The TLC was carried out on Silufol plates in hexane–ether systems (3:1 and 1:1). The IR spectra were run on a UR-10 spectrophotometer in $CCl_4$, and the PMR spectra on Tesla BS-467 (60 MHz) and Bruker-WM (250 MHz) spectrometers in $CCl_4$. The mass spectra were obtained on a Varian CH-6 spectrometer at a source temperature of 70-90°C.

1-Penten-3-ol (III). A 32.4-g portion (0.58 mole) of freshly distilled acrolein was added at −10°C, with vigorous stirring, to a Grignard reagent, prepared from 93.3 g (0.87 mole) of EtBr and 20.8 g of Mg in 300 ml of absolute ether. After 2 h, the mixture was de-

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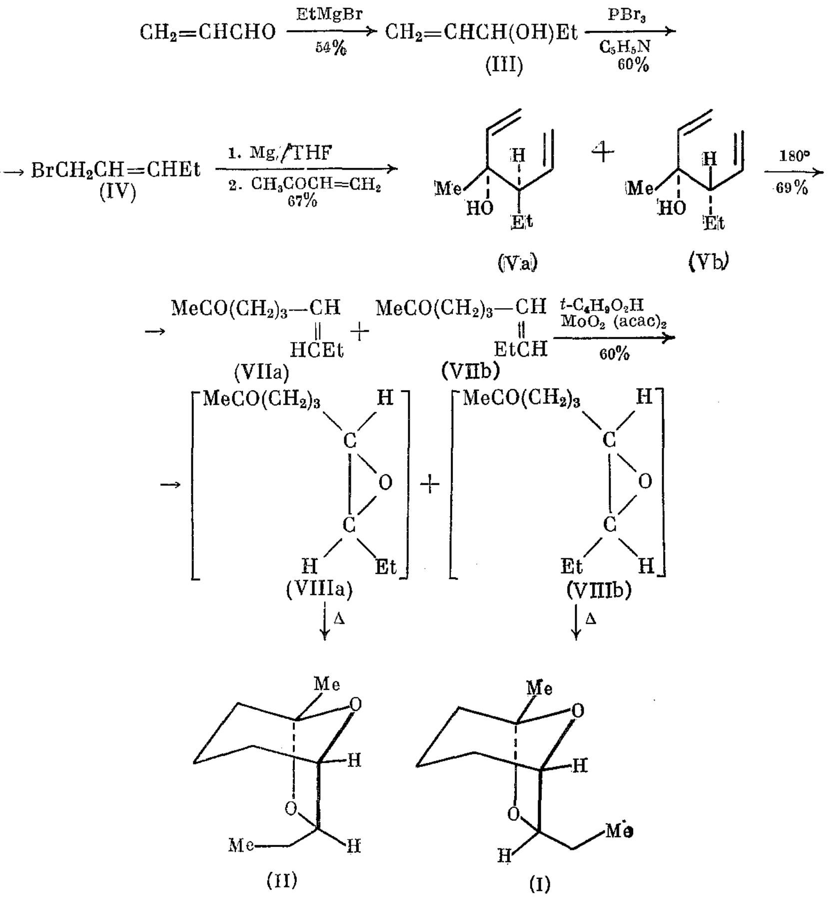

composed by ice water and neutralized by $NH_4Cl$. The ether layer was dried over $K_2CO_3$, the ether was coutiously evaporated through a dephlegmator, and the residue was distilled. Pure (III) was obtained, bp 54-55°C (50 mm), yield 27.1 g (54%). IR spectrum ($\nu$, $cm^{-1}$): 3300 and 920. PMR spectrum ($\delta$, ppm): 0.66 t (3H), 1.35 m (2H), 3.90 m (1H), and 4.90-5.95 m (3H, ABC system).

1-Bromo-2-pentene (IV). A 9.4-g portion (0.033 mole) of thoroughly purified $PBr_3$ was added to a solution of carbinol (III) (0.10 mole) and 2.63 g (0.034 mole) of dry Py in 20 ml of absolute ether, cooled to −20°C, and the mixture was allowed to stand for 2 h at −20 to 0°C. It was then washed with water and dried over $CaCl_2$. The ether was cautiously evaporated, and the residue was distilled at 72-78°C (135 mm). Compound (IV) was obtained, containing (according to GLC and PMR spectral data) $\sim$5-7% of isomeric 3-bromo-1-pentene, yield 9.0 g (60%). IR spectrum ($\nu$, $cm^{-1}$): 1650 and 580. PMR spectrum ($\delta$, ppm): 0.96 t ($\sim$3H), 1.70-21.5 m ($\sim$3H), 3.84 d ($\sim$2H), 5.55-5.80 m ($\sim$2H), and also weak signals at $\delta$ 4.20 m (<0.08H) and 5.00-6.00 (<0.08H, ABC).

erythro- and threo-4-Ethyl-3-methyl-1,5-hexadien-3-ols (Va, b). A solution of 2.10 g (0.30 mole) of freshly distilled methyl vinyl ketone in 8 ml of THF was added, with vigorous stirring, to a Grignard reagent, prepared from 8.8 g (0.058 mole) of bromide (IV) and 4.08 g of Mg (threefold excess) in 50 ml of THF, while the temperature of the mixture was maintained at 30-35°C. The mixture was then allowed to stand for 1 h at 20-25°C. The mixture was decomposed by ice water and saturated with $NH_4Cl$ to stratification. The organic layer was separated, dried over $K_2CO_3$, and evaporated. Distillation of the residue *in vacuo* gave a mixture of (Va, b), bp 90-92°C (46 mm), yield 2.8 g (67%). IR spectrum ($\nu$, $cm^{-1}$): 3500, 1640, 920. PMR spectrum ($\delta$, ppm): 0.86 m (3H), 1.11 br s (3H), 1.65-1.95 m (3H), 4.85-6.0 (6H, two overlapping ABC systems). According to GLC data, the ratio of the stereoisomers with $R_t$ 20 and 22 min is $\approx$60:40.*

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*Under the GLC analysis conditions (evaporator, 150°C, thermostat, 90°C) no thermal rearrangement of (Va, b) into ketones (VIIa, b) was observed.

E- and Z-6-Nonen-2-ones (VIIa, b). A solution of 2 g of the stereoisomeric alcohols (Va, b) in 6 g of N-methylpyrrolidone was refluxed for 4 h at 180 ± 2°C in an argon atmosphere. The mixture was diluted by ice water (10 ml) and extracted by pentane (20 × 5 ml). The extract was dried over $K_2CO_3$, cautiously evaporated, and the residue was distilled. According to GLC, the product, bp 78-80°C (13 mm), is homogeneous, but the PMR spectrum (250 MHz) gives a double set of signals with a ratio of the integral intensities for (VIIa) and (VIIb) within 0.62-0.68:0.38-0.32. Yield, 1.38 g (69%). IR spectrum ($\nu$, $cm^{-1}$): 1715, 980. PMR spectrum ($\delta$, ppm): 0.93 < 0.95 t (3H), 1.62 m (2H), 1.93-2.07 m (4H), 2.15 s (3H), 2.45 and 2.47 q (2H), 5.25-5.52 m (2H); double resonance at $\delta$ 2.00 revealed a dominating multiplet signals in the form of an AB quartet with $\delta_A \approx 5.36$, $\delta_B \approx 5.44$ and $J_{AB}$ = 15 Hz, assigned to the E isomer (VIIa).

exo- and endo-Brevicomins (I), (II). A 0.1-g portion of $MoO_2$ acetylacetonate was added to a solution of 1.20 g (8.5 mmoles) of a mixture of enones (VIIa, b) and 1.56 g (17 mmoles) of freshly distilled TBHP in 10 ml of benzene. The mixture was boiled for 3 h, filtered, and washed with a saturated solution of $Na_2SO_3$, and then with 30% NaOH to complete removal of traces of TBHP and acetylacetone, and then dried over $Na_2SO_4$. Benzene was cautiously distilled with a dephlegmator, and the residue was distilled *in vacuo*. A mixture of (I) + (II) was obtained in a ratio of ≈40:60 ($R_t$ 29 and 24 min, respectively at 90°C and 0.4 atm $N_2$), bp 90-90.5°C (110), yield 0.78 g (60%). IR spectrum ($\nu$, $cm^{-1}$): 2940, 2850, 1470, 1390, 1380, 1360, 1265, 1250, 1200, 1180, 1140, 1040, 1035, 1020, 1010, 1085, 970, 860. PMR spectrum ($\delta$, ppm): 0.86 t (3H), 1.20 s, 1.31 s (3H), 1.40-1.98 m (6H), 3.77 t (1H, proton at $C^7$ in endo-brevicomin, J = 7, J' = 0 Hz), 3.83 m (1H, proton at $C^7$ in exobrevicomin), 4.0 (in sum of 1H, overlapping narrow multiplets of protons at $C^7$); m/z: 156 $M^+$.

The mixture was separated by preparative GLC on an all-glass column (10 m × 4.5 mm) with 5% XE-60 on Chromaton. N-AW-DMCS at 90°C. Pure samples of (I) and (II) were obtained with PMR spectra completely identical in form with those of (I) and (II) [13]. In the mass spectra of (I) and (II) there are characteristic ions with m/z 113, 98, and 43 (see [14]).

## CONCLUSIONS

A five-stage synthesis of exo- and endo-brevicomins was carried out from acrolein and methyl vinyl ketone, with an oxy-Cope rearrangement of 4-ethyl-3-methyl-1,5-hexadien-3-ol as the key stage.

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