INSECT PHEROMONES AND THEIR ANALOGS.

VII. SYNTHESIS OF THE SEX PHEROMONE OF THE FRUIT FLY *Ceratitis capitata*

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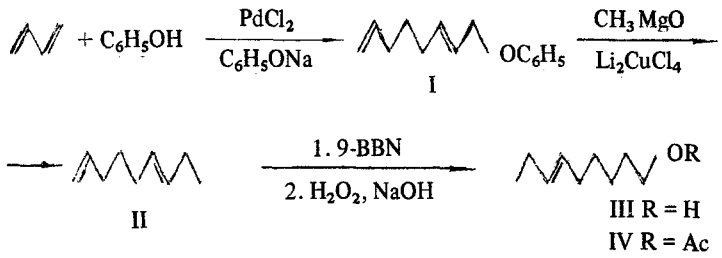
A new and simple route to the synthesis of non-6E-en-1-ol (I) — the pheromone of the fruit fly *Ceratitis capitata* Wiedemann — has been proposed on the basis of the readily available co-oligomer of butadiene and phenol, 1-phenoxyocta-2E,7-diene (II).

The sex pheromone of the fruit fly *Ceratitis capitata* Wiedemann, which has been identified as non-6E-en-1-ol [1], has been synthesized by the pyrolysis of the adduct of cyclohexa-1,3-diene with propionaldehyde [2], and also by multistage transformations of acrolein with the growth of the carbon skeleton [3]. The total yield of the required pheromone was less than 10%.

We propose a new simple route to the synthesis of this pheromone based on transformations of 1-phenoxyocta-2E,7-diene (I), a readily available co-oligomer of butadiene and phenol [4]. The replacement of the allyl phenoxy group by a methyl radical takes place smoothly under the action of methylmagnesium iodide in the presence of dilithium tetrachlorocuprate [5]. The selective hydroboration of the nona-1,6E-diene (II) with the aid of 9-borabicyclo[3.3.1]nonane (9-BBN) [6] or diborane [7] and oxidation of the organoboron compound by the action of an alkaline solution of 30% hydrogen peroxide led to the desired non-6E-en-1-ol (III) with a yield of about 60%.



It must be mentioned that the acetate (IV) of the alcohol (III) is the sex pheromone of the melon fly *Dacus cucurbitae* [8]. Lengthening the skeleton of the alcohol (III) via its bromide or tosylate to twelve or fourteen carbon atoms opens up a simple route to the synthesis of the sex pheromones of the grape moth *Sparganothis pilleriana* (Schiffermüller) [9] and the beet webworm *Loxostede sticticalis* [10].

EXPERIMENTAL

PMR spectra were recorded on a Tesla BS-487B instrument at a working frequency of 80 MHz, the solvent being CCl_4 or $CDCl_3$ (with HMDS as internal standard). IR spectra were recorded on a UR-20 instrument in a thin layer, GLC analysis was carried out on a Chrom-41 chromatograph with the stationary phase SE-30 (5%) on Chromaton N-AW-DMCS (0.16–0.20

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mm) at the working temperatures of 50–250°C (15 degrees/min), using helium as the carrier gas.

1-Phenoxyocta-2E,7-diene (I) was obtained with a yield of 87% by Smutny's method [4]; bp 85°C (1 mm), n_D^{20} 1.5195. IR spectrum (ν, cm^{-1}); 700 m, 760 m, 920 m, 980 m, 1000 m, 1020 m, 1040 m, 1180 m, 1220 and 1245 s, 1500 m, 1590 and 1600 m, 1645 w–m, 3030 m, 3080 m. PMR spectrum (δ, ppm): 1.25–1.65 (m; 1.3, 1.4, 1.5, 1.57; 1:2:2:1; 2 H, CH_2); 1.7–2.2 (m; 1.9, 2.02; 1:1; 4 H, 2 $CH_2C{=}C$); 4.31 (d, J = 4 Hz, 2 H, CH_2O); 4.7–6.0 (m; 4.79, 4.92, 4.99; 3 H, $CH{=}CH_2$); 5.6 (m, 2 H, CH=CH); and 6.6–7.25 (m; 6.66, 6.77, 7.0, 7.1, 7.22; 5 H, C_6H_5).

Nona-1,6E-diene (II). At 20°C in an atmosphere of argon, 10.1 g (0.05 mole) of the diene (I) was added to 150 ml of a 1 M solution of methylmagnesium iodide, obtained from 21.3 g (0.15 mole) of methyl iodide and 3.64 g (0.15 g-atom) of magnesium turnings in 150 ml of absolute diethyl ether, and then the reaction mixture was cooled to –20°C and 4.6 ml of a 0.5 M solution of Li_2CuCl_4 [solution prepared from 0.85 g (0.02 mole) of LiCl and 1.34 g (0.01 mole) of $CuCl_2$ in 20 ml of absolute THF] was gradually added. The mixture was stirred at –10°C for 2 h and then at 5°C for 3 h and it was left at room temperature for 15 h. After this, it was poured into 50 ml of 5% hydrochloric acid, the product was extracted with 300 ml of pentane, and the extract was washed with 20 ml of 40% caustic potash solution, dried over $MgSO_4$, and evaporated. The residue was distilled, giving 5.57 g (90%) of nona-1,6E-diene (II) with bp 144-145°C, n_D^{20} 1.4320 [5]. IR spectrum (ν, cm^{-1}); 920 s, 975 s, 1000 m, 1605 w, 1648 m, 3090 m. PMR spectrum (δ, ppm): 0.93 (t, J = 7 Hz; 3 H, CH_3); 1.25–1.63 (m; 1.3, 1.37, 1.48, 1.58; 1:2:2:1; 2 H, CH_2); 1.98 (m, 6 H, $CH_2C{=}C$); 4.75–6.0 (m; 4.8, 4.95, 5.02; 3 H, $HC{=}CH_2$); and 5.36 (m, 2 H, CH=CH).

Non-6E-en-1-ol (III). A. At 20°C, a solution of 3.1 g (0.025 mole) of nona-1,6E-diene (II) in 15 ml of THF was added to 50 ml of a 0.5 M solution of 9-BBN in THF, obtained as described by Brown et al. [6], and the mixture was stirred at 25°C for 2 h. Then 5 ml of 6 N NaOH and 10 ml of 30% H_2O_2 were added successively to the reaction mixture. This was heated at 50°C for 2 h and was then cooled to room temperature and was saturated with K_2CO_3, after which the organic layer was separated off and dried over K_2CO_3. The solvent was evaporated off and the residue was distilled in vacuum. This gave 2.06 g (58%) of the alcohol (III) with bp 76–84°C (0.2 mm Hg), n_D^{25} 1.4471 [1, 8]. IR spectrum (ν, cm^{-1}): 975 s, 1060 m, 3350 br.s. PMR spectrum (δ, ppm): 0.87 (t, J = 7 Hz, 3 H, CH_3); 1.32 (m, 6 H, 3 CH_2); 1.65–2.15 (m, 4 H, 2 $CH_2C{=}C$); 3.54 (t, J = 6 Hz, 2 H, CH_2O); and 5.35 (m, 2 H, CH=CH).

Non-6E-en-1-ol acetate (IV), bp 65–70°C (0.3 mm Hg), n_D^{25} 1.4343 [8]. IR spectrum (ν, cm^{-1}): 980 m, 1248 s, 1370 m, 1745 s. PMR spectrum (δ, ppm): 0.85 (t, J = 7 Hz, 3 H, CH_3); 1.3 (m, 6 H, 2 CH_2); 1.85 (m, 4 H, 2 $CH_2C{=}C$); 3.97 (t, J = 6 Hz, 2 H, CH_2O); and 5.33 (m, 2 H, CH=CH).

B. At 20°C, the B_2H_6 obtained from 2.5 g of $BF_3O(C_2H_5)_2$ and 0.4 g of $NaBH_4$ in 10 ml of absolute diglyme [7] was bubbled through a solution of 3.1 g (0.025 mole) of nona-1,6E-diene (II) in 60 ml of absolute diglyme for 2 h. Then 5 ml of 6 N NaOH and 10 ml of 30% H_2O_2 were added successively to the reaction mixture. This was heated at 50°C for 2 h and was then cooled to room temperature and extracted with ether (3 × 150 ml). The combined ethereal solution was washed with water, dried over Na_2SO_4 and evaporated. The residue (1.85 g) contained, according to GLC analysis, 80% of the alcohol (III), 8% of non-6E-en-2-ol, and 12% of diols. Vacuum distillation yielded 1.28 g (36%) of the alcohol (III), with bp 76–84°C (0.2 mm Hg), n_D^{25} 1.4471. The IR and PMR spectra were identical with those of the alcohol (III) obtained in experiment A.

SUMMARY

A new and effective two-stage route to the synthesis of the sex pheromone of the fruit fly *Ceratitis capitata* Wiedermann has been proposed which is based on simple transformations

of 1-phenoxy-octa-2E,7-diene — a readily accessible co-oligomer of butadiene and phenol.

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IDENTIFICATION OF CATIONS IN THE ACTIVE CENTERS OF THE CARBOXYPEPTIDASE OF *Streptomyces griseus* AND THE AMINOPEPTIDASE OF *Aspergillus oryzae*

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It has been shown by atomic adsorption spectroscopy that the active center of the molecule of the carboxypeptidase of *Streptomyces griseus* contains 1 zinc atom and that of the aminopeptidase of *Aspergillus oryzae* 1 cobalt atom. The latter was also confirmed by the ESR method. In addition to the cobalt, 0.3 g-atom of strongly bound zinc, upon the pressure of which the enzymatic activity does not depend, has been found in the aminopeptidase.

As a rule, the activity of peptidases depends on the presence of bound metals — magnesium, cobalt, calcium, zinc, manganese, etc. Their roles in enzymatic reactions of peptidases are extremely diverse [1—3]. The metal present in the active center performs the function of a "bridge" binding the substrate with the enzyme in the formation of the intermediate complex, acts on the substrate, and creates or stabilizes a definite conformation of the molecule that is necessary for catalysis.

We give the results of a determination of the amounts of metal ions in the active centers of the carboxypeptidase of *Streptomyces griseus* and the aminopeptidase of *Aspergillus oryzae*.

The enzyme preparations were additionally purified by dialysis against double-distilled water at +4°C. To obtain the apoenzymes, o-phenanthroline was added to the enzyme solution before dialysis. After 3 h, the enzyme had lost its activity completely, while in a control the activity was almost completely retained. The excess of complex-forming agent and the metal cations bound to it were eliminated from the solution of the apoenzyme by dialysis. The apoenzyme obtained was analyzed in a similar manner to the initial preparation. In a native preparation of the carboxypeptidase of *Streptomyces griseus*, 1.15 atoms of zinc

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