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INSECT PHEROMONES AND THEIR ANALOGS. LXI. SYNTHESIS OF 4E,10Z-TETRADECADIEN-1-YLACETATE, A COMPONENT OF THE *Lithocolettis ringoniella* SEX PHEROMONE

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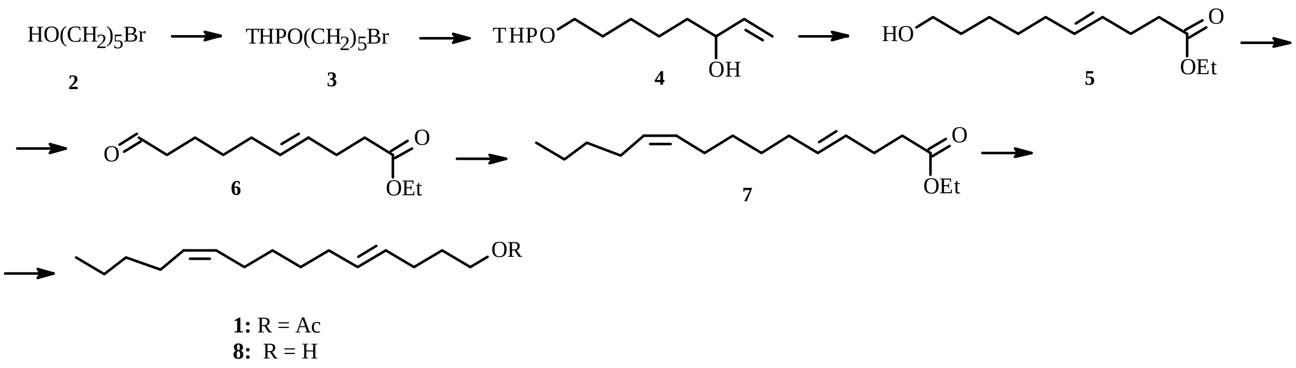
*A new scheme for synthesizing 4E,10Z-tetradecadien-1-ylacetate, the principal component of the apple leaf miner (*Lithocolettis ringoniella*) sex pheromone, is developed using a highly stereoselective Claisen rearrangement.*

Key words: *Lithocolettis ringoniella*, synthesis, sex pheromone, 4E,10Z-tetradecadien-1-ylacetate.

The principal component of the sex pheromone of the apple leaf miner (*Lithocolettis ringoniella*) is 4E,10Z-tetradecadien-1-ylacetate (**1**) [1]. A synthesis of **1** has been described in which the double bonds of E- and Z-configuration are introduced using the Wittig reaction [1].

We developed a synthesis of **1** that is based on a stereospecific thermal Claisen rearrangement that was used previously to synthesize pheromones of (E)-configuration [2-5].



The starting material is 5-bromopentan-1-ol (**2**). Reaction of its tetrahydropyranyl ether (**3**) in a Grignard reaction with acrolein gave the key synthon, alkenyl secondary alcohol **4**. The thermal Claisen rearrangement occurs smoothly on heating **4** with triethylorthoacetate in the presence of catalytic amounts of propionic acid. Acid hydrolysis gives the ethyl ester of 10-hydroxy-4E-decenoic acid (**5**). Formation of exclusively the E-configuration for the Δ^4-bond was confirmed by capillary GLC and IR and ^{1}H NMR spectroscopies. In particular, an absorption band for the C=C deformation is present at 965 cm^{-1} whereas the absorption at 780 cm^{-1} that is characteristic of a Z-double bond is absent.

Then alcohol **5** was oxidized by pyridinium chlorochromate to the corresponding aldehyde **6**, which underwent a Wittig reaction with the phosphorus ylide generated from butylbromide. Hydride reduction of the resulting ethyl ester of 4E,10Z-tetradecadienoic acid (**7**) gave 4E,10Z-tetradecadien-1-ol (**8**), acetylation of which gave the target compound **1**.

According to capillary GLC, **1** is at least 99% pure. The structure was confirmed by ^{1}H NMR and IR spectroscopies.

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EXPERIMENTAL

IR spectra were recorded on a Beckman Microlab 620 MX instrument as thin layers. ^{1}H NMR spectra were obtained on a Tesla BS-587A spectrometer (working frequency 80 MHz) in $(CD_3)_2CO$. Chemical shifts are given on the δ scale with HMDS internal standard. GLC analysis was performed on a Chrom-5 instrument with a flame-ionization detector, 3500×3 mm column, stationary phase of silicone SE-30 (5%) on chromaton N-AW-DMCS (0.16-0.20 mm), working temperature 50-250°C, and He carrier gas (30 mL/min). Compounds **1**, **5**, and **8** were analyzed on a Carbo Erba instrument with glass capillary column (20 m × 0.2 mm), working temperature 50-200°C. TLC was carried out on Silufol UV-254 plates with fixed SiO_2 layers.

1-(Tetrahydropyran-2-yl)oxy-5-bromopentane (3). A mixture of **2** (6.0 g, 35.9 mmole), TsOH (0.02 g), and diethylether (50 mL) was cooled (15°C), treated with dihydropyran (12.1 g), and stirred on a magnetic stirrer for 1 d (TLC monitoring). The reaction mixture was washed successively with saturated $NaHCO_3$ and NaCl solutions, dried over Na_2SO_4, and evaporated. Yield 7.2 g (80%) of **3**, bp 90-92°C (1 mm).

1-(Tetrahydropyran-2-yl)oxy-7-octen-6-ol (4). Grignard reagent prepared from **3** (7.0 g, 27.9 mmole) and Mg (0.73 g, 30 mmole) and dry diethylether (100 mL) was cooled, treated dropwise with acrolein (1.75 g, 28 mmole) in absolute diethylether (20 mL), stirred for 1 h, and treated with cold water (20 mL). The aqueous layer was separated and extracted with diethylether (3×20 mL). The combined organic layer was dried over Na_2SO_4. The solvent was evaporated. The residue was chromatographed over silica gel. Yield 5.02 g (79%) of **4**.

IR spectrum (ν_{max}, cm^{-1}): 3500 (OH), 1640 and 970 ($CH{=}CH_2$). PMR spectrum (δ, ppm, J/Hz): 1.2-1.6 (14H, m, CH_2), 3.6-4.2 (5H, m, CH_2–O, CH–O), 4.8 (1H, m, O–CH_2–O), 5.2-5.5 (2H, m, $CH_2{=}C$), 5.6-5.9 (1H, m, $CH{=}C$).

Ethyl Ester of 10-Hydroxy-4E-decenoic Acid (5). A mixture of **4** (4.12 g, 18.1 mmole), triethylorthoacetate (8.76 g, 54.2 mmole), and propionic acid (0.02 g) was heated on an oil bath at 138°C for 1 h. The ethanol formed was distilled through a condenser. The mixture was cooled, treated with diethylether (100 mL), washed with saturated $NaHCO_3$ and NaCl solutions, dried over Na_2SO_4, and evaporated. Unreacted triethylorthoacetate was vacuum distilled from the residue. The residue was dissolved in diethylether (100 mL), treated with TsOH (0.2 g), stirred at room temperature for 24 h (TLC monitoring), treated with saturated $NaHCO_3$ and NaCl solutions, dried over Na_2SO_4, and evaporated. The residue was chromatographed over silica gel. Yield 2.02 g (52%) of **5**.

IR spectrum (ν_{max}, cm^{-1}): 3500 (OH), 1740 (C=O), 1650 and 965 (E-CH=CH). PMR spectrum (δ, ppm, J/Hz): 1.12 (3H, t, J = 6, CH_3), 1.2-1.6 (6H, m, CH_2), 1.8-2.1 (6H, m, $CH_2C{=}CH_2$, CH_2COO), 3.7-4.1 (5H, m, CH_2–O, OH), 5.2-5.5 (2H, m, CH=CH).

Ethyl Ester of 10-Oxo-4E-decenoic Acid (6). A suspension of pyridinium chlorochromate (14.9 g, 8.34 mmole) in dry $CHCl_3$ (100 mL) was treated dropwise with **5** (1.54 g, 7.12 mmole), stirred for another 30 min, diluted with diethylether (100 mL), and pased over a silica-gel column (15 cm layer). The resulting solution was washed successively with $NaHCO_3$ and NaCl solutions, dried over Na_2SO_4, and evaporated. The residue was chromatographed over silica gel. Yield 1.13 g (64%) of **6**.

IR spectrum (ν_{max}, cm^{-1}): 1740 (C=O), 1650 and 965 (E-CH=CH). PMR spectrum (δ, ppm, J/Hz): 1.12 (3H, t, J = 6, CH_3), 1.25-1.5 (4H, m, CH_2), 1.8-2.2 (8H, m, $CH_2C{=}CCH_2$, $CH_2C{=}O$, CH_2COO), 3.7-4.1 (2H, m, CH_2O), 5.2-5.5 (2H, m, CH=CH), 9.27 (1H, s, CH=O).

Ethyl Ester of 4E,10Z-Tetradecadienoic Acid (7). Butylbromide (0.59 g, 4.34 mmole) and PPh_3 (1.14 g, 4.34 mmole) were heated under Ar at 160°C for 8 h, cooled to -20°C, treated with absolute THF (50 mL) and carefully with *t*-BuOK (0.49 g, 4.34 mmole), stirred for 30 min, cooled to -70°C, treated with **6** (0.92 g, 4.34 mmole), again stirred at -70°C for 2 h, left overnight, diluted with hexane (50 mL), filtered to remove Ph_3PO, evaporated, and chromatographed over a silica gel column. Yield 0.69 g (62%) of **7**.

IR spectrum (ν_{max}, cm^{-1}): 1740 (C=O), 1650 and 965 (E-CH=CH), 780 (Z-CH=CH). PMR spectrum (δ, ppm, J/Hz): 0.88 (3H, t, J = 6, CH_3), 1.12 (3H, t, J = 6, $\mathbf{CH_3}CH_2O$), 1.25-1.5 (6H, m, CH_2), 1.8-2.3 (10H, m, $H_2CC{=}C$, CH_2COO), 3.7-3.9 (2H, q, J = 6, CH_2–O), 5.2-5.5 (4H, m, CH=CH).

4E,10Z-Tetradecadien-1-ol (8). A mixture of $LiAlH_4$ (0.08 g, 2.1 mmole) and absolute diethylether (20 mL) under Ar was treated dropwise with **7** (0.43 g, 1.68 mmole), stirred for 2 h, cooled to 0°C, and treated dropwise below 5°C with water (5 mL). The organic layer was separated. The aqueous layer was extracted with ether. The combined organic layer was dried over Na_2SO_4 and evaporated. Yield 0.27 g (71%) of **8**.

IR spectrum (ν_{max}, cm^{-1}): 3500 (OH), 1650 and 965 (E-CH=CH), 780 (Z-CH=CH). PMR spectrum (δ, ppm, J/Hz): 0.88

(3H, t, J = 6, CH_3), 1.2-1.5 (8H, m, CH_2), 1.8-2.1 (8H, m, $H_2CC{=}C$), 3.7-4.0 (3H, m, CH_2–O, OH), 5.2-5.5 (4H, m, HC=CH).

4E,10Z-Tetradecadien-1-ylacetate (1). A mixture of **8** (0.08 g, 0.38 mmole), absolute pyridine (1 mL), and Ac_2O (0.35 mL) was held at room temperature for 24 h, diluted with diethylether (10 mL), washed with HCl (5 mL, 10%) and saturated NaCl solutions, dried over Na_2SO_4, evaporated, and chromatographed over silica gel. Yield 0.06 g (86%) of **1**.

IR spectrum (ν_{max}, cm^{-1}): 1740 (C=O), 1640 and 965 (E-CH=CH), 780 (Z-CH=CH). PMR spectrum (δ, ppm, J/Hz): 0.88 (3H, t, J = 6, CH_3), 1.2-1.5 (8H, m, CH_2), 1.8-2.1 (11H, m, $H_2CC{=}C$, CH_3COO), 3.6-3.8 (2H, m, CH_2–O), 5.2-5.5 (4H, m, HC=CH).

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