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SYNTHESIS FROM 10-UNDECENOIC ACID OF OCTADECA-2E,13Z-DIENYLACETATE, A COMPONENT OF THE SEX PHEROMONES OF *Synanthedon tipuliformis* AND *Zenzera pyrina*

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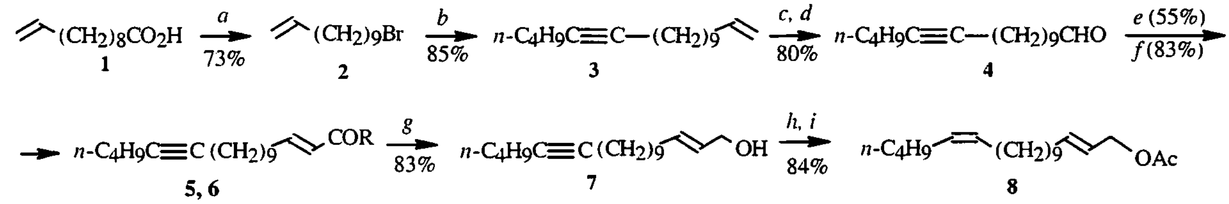
A new synthesis of octadeca-2E,13Z-dienylacetate from 10-undecenoic acid is developed by constructing the carbon framework of the pheromone in the key step and introducing the 2E double bond by Doebner condensation of hexadec-11-ynal and malonic acid.

Key words: pheromones, *Synanthedon tipuliformis*, *Zenzera pyrina*, 10-undecenoic acid, synthesis.

Several syntheses of octadeca-2E,13Z-dienylacetate (**8**), a pheromone component of the destructive clear-winged moth garden pests *Synanthedon tipuliformis* [1, 2] and *Zenzera pyrina* [3] have been reported. The *cis*-double bond is introduced by Wittig olefination [4] or through the corresponding acetylenic derivatives [5-9] whereas the *trans*-allyl alcohol group is introduced using E-stereospecific reduction of the propargyl compounds [4,6-9], the Wittig—Horner reaction of ethoxycarbonylmethylidenetriphenylphosphonium or the ethyl ester of diethylphosphoacetic acid with hexadec-11Z-enal [5], or modification of the carbon framework of the 2E-unsaturated telomer of butadiene and water [10].

We propose a new approach to the synthesis of **8** in which the starting compound is 10-undecenoic acid (**1**), which is available and widely used in the chemistry of insect pheromones [11-16].



R = OH (**5**), Cl(**6**)

a. see Ref [11]; *b*. n-$C_4H_9C{\equiv}CH/LiNH_2$; *c*. O_3/c-C_6H_{12}, MeOH; *d*. Me_2S; *e*. $CH_2(CO_2H)_2$/Py + Pyp;
f. $SOCl_2$; *g*. $LiAlH_4$; *h*. H_2/Ni-P2; *i*. AcCl/Py

The target molecule **8** was constructed using the following sequence of regio- and stereoselective transformations. Acid **1** was transformed into 1-bromoundec-10-ene (**2**) [11] by the method developed by us previously [17, 18] (an analogous communication appeared later [19]). Cross combination of **2** and lithium 1-hexynylide (reaction in liquid NH_3 and cosolvent THF and DMSO) gave heptadec-1-en-12-yne (**3**). Ozonolysis of **3** occurs selectively at the double bond owing to the low reactivity of ozone toward the acetylene compared with the vinyl [20]. Reduction of the peroxides with Me_2S gives hexadec-11-ynal (**4**) in high yield. The required carbon framework can be constructed and the 2E-double bond introduced through a Doebner reaction of **4**. The resulting octadec-2E-en-13-yn-1-oic acid (**5**) is converted to the corresponding chloroanhydride (**6**) and reduced with $LiAlH_4$ to octadec-2E-en-13-yn-1-ol (**7**). Hydrogenation of the triple bond of **7** in alcohol over Ni-P2 catalyst and subsequent acetylation completed the synthesis of **8** with 15.8% overall yield calculated for starting **1**. The content of the

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(E,Z)-isomer was 92% according to capillary GLC.

EXPERIMENTAL

IR spectra were recorded on a UR-20 spectrometer in thin layers. ^1H NMR spectra were obtained on a Tesla BS-567 (100 MHz) instrument in $CDCl_3$ relative to TMS. GLC was performed on a Chrom-5 chromatograph [1.2 m column, SE-30 (5%) silicone stationary phase on N-AW-DMCS chromaton (0.16-0.20 mm), working temperature 50-300°C] and on a Shimadzu GC-9A instrument (PEG-20M stationary phase, 25 m × 0.2 mm capillary column, working temperature 50-220°C) with He carrier gas.

Heptadec-1-en-12-yne (3). A suspension of lithium amide that was prepared from Li (1.04 g, 0.15 g-atom), $FeCl_3$ (0.05 g), and distilled liquid NH_3 (0.8 l) was treated with 1-hexyne (12.3 g, 0.15 mole), stirred (-33°C, 1 h), and treated with **2** bromide (23.3 g, 0.10 mole) in THF (absolute, 30 ml) and immediately after this with dry DMSO (30 ml). The reaction mixture was stirred until NH_3 completely evaporated (6-7 h). Water (100 ml) was added to the solid. The solution was extracted with hexane (4×200 ml). The combined extracts were washed with saturated NaCl solution (3×50 ml), dried over $MgSO_4$, and evaporated. Chromatography of the solid on silica gel (hexane eluent) gave **3**, 19.9 g (85%), $n_D^{20} = 1.4568$. IR and ^1H NMR parameters are identical to those in the literature [15].

Hexadec-11-ynal (4). An ozone—oxygen mixture (2 wt. % O_3) was passed at 5 l/h until 0.075 mole of O_3 had been absorbed through a solution of **3** (17.55 g, 0.075 mole) in distilled cyclohexane (200 ml) at 5°C containing MeOH (7.5 ml, absolute). The reaction mixture was purged with Ar, diluted with THF (100 ml), treated at 5°C with Me_2S (25 ml), stirred for 6 h, held at room temperature until the peroxide disappeared (monitored with acidified aqueous KI), and evaporated. The solid was dissolved in Et_2O (300 ml), washed with H_2O (3×50 ml), dried over Na_2SO_4, and evaporated. Chromatography of the solid on silica gel (hexane—Et_2O eluent, 4:1) gave **4**, 14.2 g (80%). IR and ^1H NMR parameters are identical to those in the literature [21]. IR spectrum: 1725 (C=O), 2242 (C≡C), 2730 (C–H).

Octadec-2E-en-13-yn-1-oic Acid (5). A solution of **4** (12.51 g, 0.053 mole), malonic acid (7.20 g, 0.069 mole), dry pyridine (35 ml), and piperidine (1.7 ml) was heated (22°C, 17 h; 30°C, 6 h; 120°C, 1.5 h), cooled, and treated with Et_2O (250 ml). The reaction mixture was successively washed with HCl (15%, 3×50 ml) and saturated NaCl solution (2×50 ml). The organic layer was treated with saturated $NaHCO_3$ solution (200 ml) until the pH was 8-9. The aqueous layer was separated, acidified with conc. HCl until the pH was 2, and extracted with Et_2O (5×100 ml). The extract was dried over Na_2SO_4 and evaporated. Yield of **5**, 8.10 g (55%) of oil. IR spectrum (ν, cm^{-1}): 995, 1660, 1700, 3025 (E-CH=CH–C=O), 2240 (C≡C). PMR spectrum (100 MHz, $CDCl_3$, ppm, J, Hz): 0.88 (3H, m, H-18), 1.27 (18H, br. s, CH_2), 1.95-2.3 (6H, m, H-4, H-12, H-15), 5.80 (1H, d, J = 15.4, H-2), 7.08 (1H, dt, $J_1 = 15.4$, $J_2 = 6.8$, H-3), 10.5 (1H, br. s, CO_2H). Found (%): C 77.74, H 10.91. $C_{18}H_{30}O_2$. Calc. (%): C 77.65, H 10.86. M 278.43.

Octadec-2E-en-11-yn-1-ol (7). A mixture of **5** (1.60 g, 6 mmole) and $SOCl_2$ (1.43 g, 12 mmole) was heated for 1 h at 60°C (TLC monitoring). The excess of $SOCl_2$ was removed under vacuum. Yield of octadec-2E-en-13-yn-1-oic acid chloride (**6**) 1.42 g (83%). IR spectrum (ν, cm^{-1}): 980, 1675, 1755 (E-CH=CH–C=O), 2245 (C≡C). A part of **6** (0.94 g) was dissolved in Et_2O (absolute, 20 ml), treated at -20°C under Ar with a suspension of $LiAlH_4$ (0.15 g, 4 mmole) in Et_2O (5 ml), held for 1 h at -20°C and 1 h at -16°C, left overnight at room temperature, treated with ethylacetate (40 ml), acidified with 2 N H_2SO_4 until the pH was 5-6, and extracted with ethylacetate (3×50 ml). The combined extracts were dried over Na_2SO_4 and evaporated. Yield of **7**, 0.66 g (83%). The IR and ^1H NMR parameters are identical to those in the literature [8].

Octa-2E,13Z-dienylacetate (8). A suspension of $Ni(OAc)_2 \cdot 4H_2O$ (0.049 g) in EtOH (1 ml, 96%) was stirred on a magnetic stirrer and treated with $NaBH_4$ (0.012 g) in EtOH (0.3 ml). The resulting catalytic mixture was stirred until H_2 was no longer evolved, treated successively with ethylenediamine (0.025 ml) and **7** (0.53 g, 2 mmole) in EtOH (0.5 ml), and stirred under an atmosphere of H_2 until 43 ml had been absorbed. The solvent was distilled off. The solid was dissolved in Et_2O (20 ml), successively washed with HCl (5%) and saturated NaCl solution, dried over Na_2SO_4, and evaporated. The solid (0.48 g) was successively treated with pyridine (0.15 g) in benzene (absolute, 20 ml) and acetylchloride (0.17 g) in benzene (3 ml). After the reaction was finished (TLC monitoring) the mixture was diluted with H_2O (13 ml). The benzene layer was separated, washed with H_2O, and dried over Na_2SO_4. The solvent was removed. The solid was chromatographed on silica gel (Et_2O—hexane eluent, 1:5). Yield of **8**, 0.52 g (84%), $n_D^{20} = 1.4598$. IR and ^1H NMR parameters are identical to those in the literature [5].

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