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A convergent synthesis of octadeca-2*E*,13*Z*-dienyl acetate, a pheromone component of *Synanthedon tipuliformis* C.

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A convergent synthesis of octadeca-2*E*,13*Z*-dienyl acetate, a pheromone component of *Synanthedon tipuliformis* C., has been developed. The synthesis is based on cross-coupling of 8-iodooct-2*E*-en-1-ol THP ether with dec-5*Z*-enyl bromide catalyzed by CuBr.

Key words: dec-5*Z*-enyl bromide, 8-iodo-1-(2-tetrahydropyranyloxy)oct-2*E*-ene, cross-coupling; octadeca-2*E*,13*Z*-dienyl acetate, pheromone.

In the known syntheses of octadeca-2*E*,13*Z*-dienyl acetate (**1**), the major component of the sex pheromone of *Synanthedon tipuliformis* C., the construction of the *cis*-double bond normally presents no substantial difficulties and is accomplished by Wittig olefination[1,2] or *via* the corresponding acetylene derivatives.[3,4] However, the *trans*-allylic alcoholic function can be introduced by only one method, *i.e.*, by *E*-stereoselective reduction of the corresponding propargylic compounds.[1—4]

We propose a new convergent pathway to the diene pheromone **1** based on a Wurtz-type coupling of two block synthons, namely, dec-5*Z*-enyl bromide (**2**) and 8-iodooct-2*E*-en-1-ol THP ether (**3**), serving as the sources of the 13*Z*- and 2*E*-double bonds, respectively (Scheme 1).

Ether **3** with a stereochemical purity of 90% was prepared from the telomer of butadiene and water (**4**) by hydroalumination—iodination reactions as has been described previously for the synthesis[5] of bombicol, the sex pheromone of the mulberry silkworm.

Unsaturated bromide **2** was synthesized from hex-1-yne (**5**) by the traditional "acetylene" method (**5**→**6**→**7**→**2**). The intermediate alkynol **6** was reduced to its *Z*-alkene analog **7** using a hydromagnesation reaction;[6] this allowed us to obtain the major stereoisomer bromide **2** (purity 98%) free of the corresponding saturated compound, which is normally formed as an impurity under conditions of catalytic hydrogenation. In addition, pure bromide **2** of only the *Z*-configuration was used for cross-coupling; this compound was synthesized by a procedure that we developed previously,[7] based on partial ozonolysis of cyclodeca-1*Z*,6*Z*-diene (**8**) resulting from isomerization of a co-oligomer of butadiene and ethylene.

When the final step of the construction of the carbon skeleton of pheromone **1** was catalyzed by Li_2CuCl_4 and CuI—bpy complexes, only traces of the reaction product, dienol **9**, were formed, whereas in the presence of CuBr its yield was 36%. Acetylation of alcohol **9** afforded the target dienyl acetate **1** containing ~90%

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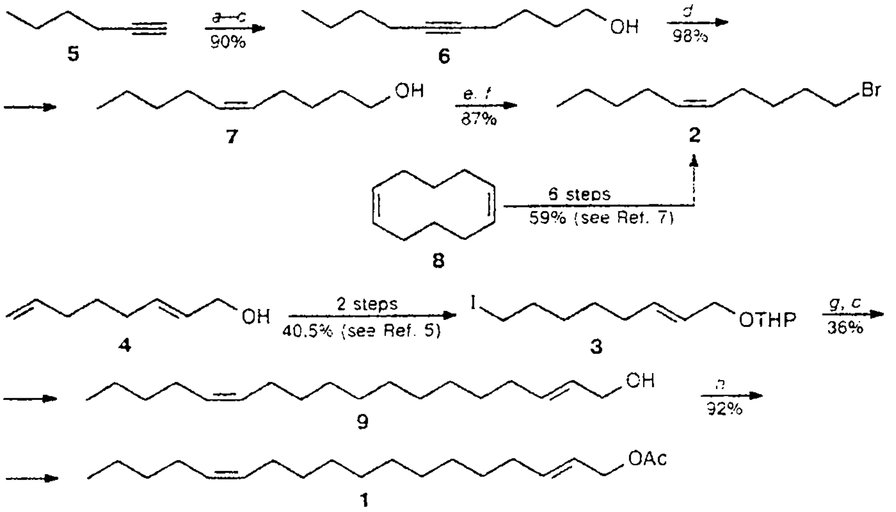
Scheme 1



Reagents: *a*. $LiNH_2$; *b*. $Br(CH_2)_4OTHP$; *c*. TsOH/MeOH—H_2O; *d*. Bu^{i}MgBr/Cp_2TiCl_2; *e*. TsCl/Py; *f*. LiBr; *g*. **2**/Mg/CuBr; *h*. Ac_2O/Py.

(*E,Z*)-isomer (according to capillary GLC) in an overall yield of 25% based on the limiting starting alkyne 5.

Experimental

IR spectra were recorded on a UR-20 spectrometer in thin films. ^1H NMR spectra were obtained on a Tesla BS-567 instrument (100 MHz) in $CDCl_3$ using tetramethylsilane as the internal standard. GLC analysis was carried out on a Chrom-5 chromatograph (1.2-m column, SE-30 as the stationary phase, working temperature 50—300 °C) and a Shimadzu GC-9A instrument (PEG-20M as the stationary phase, a 25 m×0.2 mm capillary column, working temperature 50—200 °C) using helium as the carrier gas.

Dec-5-yn-1-ol (6). At −40 °C, hex-1-yne 5 (5.19 g, 63.3 mmol) was added to a solution of lithium amide prepared from Li (0.43 g, 61.4 mg.-at.) in dry NH_3 (580 mL) in the presence of $FeCl_3$ (0.014 g). The mixture was stirred for 1 h, 4-bromo-1-(2-tetrahydropyranyloxy)butane (10.0 g, 42.2 mmol) in anhydrous THF (43 mL) was added dropwise, and then dry DMSO (43 mL) was added. The mixture was stirred until the NH_3 completely evaporated and then was allowed to stand at -20 °C for 16 h; H_2O (50 mL) was added, and the product was extracted with Et_2O (3×100 mL). The solvent was evaporated, and the residue was dissolved in MeOH (208 mL). Water (86 mL) and TsOH (2.08 g, 13.4 mmol) were added, and the mixture was stirred for 24 h and concentrated. The residue was dissolved in CH_2Cl_2 (450 mL), and the solution was washed successively with saturated solutions of NaCl, $NaHCO_3$, and NaCl, dried with Na_2SO_4, and concentrated. The residue was chromatographed on a column (SiO_2, heptane—AcOEt, 10 : 1) to give 5.85 g (90%) of alcohol **6**, n_D^{20} 1.4576 (*cf.* Ref. 8). ^1H NMR ($CDCl_3$), δ: 0.86 (t, 3 H, Me, *J* = 7 Hz); 1.25—1.66 (m, 8 H, CH_2); 2.07—2.17 (m, 4 H, CH_2—C≡C); 2.62 (br.s, 1 H, OH); 3.61 (t, 2 H, CH_2O, *J* = 6 Hz).

Dec-5*Z*-en-1-ol (7). At 0 °C, a 1.4 *M* solution of Bu^{i}MgBr (21 mL) in Et_2O was added to a solution of alkynol **6** (0.92 g, 6 mmol) in anhydrous Et_2O (60 mL), and the mixture was stirred for 15 min and then heated to -20 °C. Cp_2TiCl_2 (0.09 g) was added, and the mixture was stirred until gas evolution ceased (1—1.5 h) and cooled to 0 °C. 10% HCl (30 mL) was added, and the mixture was stirred at 20 °C for 0.5 h. Ether (200 mL) was added to the reaction mixture, and the organic layer was separated, washed successively with saturated solutions of $NaHCO_3$ and NaCl, dried with Na_2SO_4, filtered through an Al_2O_3 layer (10 cm), and concentrated to give 0.91 g (98%) of compound **7**, n_D^{20} 1.4520. The IR and ^1H NMR spectra of the product were identical with those described previously.[7]

1-Bromodec-5*Z*-ene (2). At 0 °C, TsCl (1.22 g, 6.40 mmol) was added portionwise to a mixture of alkenol **7** (0.91 g, 5.83 mmol) and dry Py (1.8 mL). The mixture was stirred (0 °C, 15 h), diluted with 100 mL of Et_2O, washed successively with 10% HCl and with saturated solutions of $NaHCO_3$ and NaCl, dried with $MgSO_4$, and concentrated. The residue (1.81 g, IR, ν/cm^{-1}: 950, 1140, 1330 (S=O), 1600 (Ar)) was dissolved in 6 mL of dry acetone, LiBr (1.02 g, 11.7 mmol) was added, and the mixture was stirred at 40 °C for 3 h and filtered, and the solvent was evaporated to give 1.03 g (80%) of bromide **2**, n_D^{20} 1.4713. Its IR and ^1H NMR spectra were identical with those reported previously.[7]

Octadeca-2*E*,13*Z*-dien-1-ol (9). CuBr (0.15 g) was added to a solution of 8-iodo-1-(2-tetrahydropyranyloxy)oct-2*E*-ene **3** (1.12 g, 3.33 mmol) prepared from octa-2*E*,7-dien-1-ol (**4**) by a known procedure[5] in anhydrous THF (12 mL) (Ar), the mixture was cooled to −15 °C, and a solution of the Grignard reagent prepared from Mg (0.09 g, 3.97 mg-at.) and bromide **2** (0.80 g, 3.65 mmol) in 42 mL of anhydrous THF was added. The reaction mixture was stirred (10 °C, 0.5 h; 20 °C, 12 h); at −10 °C, 10% HCl (4 mL) was added, and the mixture was again stirred (20 °C, 5 h), diluted with Et_2O (200 mL), washed successively with saturated solutions of $NaHCO_3$ and NaCl, dried (Na_2SO_4), and concentrated. The residue was chromatographed (SiO_2, heptane—AcOEt, 10 : 1) to give 0.35 g (36%) of alcohol **9**; its IR and ^1H NMR spectra were identical with those reported previously.[1]

Octadeca-2*E*,13*Z*-dienyl acetate (1). Ac_2O (1.6 mL) was added to a stirred mixture of alcohol **9** (0.30 g, 1.1 mmol), Py (1.95 mL), and CH_2Cl_2 (3 mL). The mixture was stirred (20 °C, 24 h), diluted with 80 mL of CH_2Cl_2, washed successively with 10% HCl and with saturated solutions of $NaHCO_3$ and NaCl, dried ($MgSO_4$), and concentrated to give 0.32 g (92%) of acetate **1**, whose IR and ^1H NMR spectra were identical with those reported previously.[1]

References

1. A. M. Sorochinskaya and B. G. Kovalev, *Khim. Prir. Soedin.*, 1989, 264 [*Chem. Nat. Compd.*, 1989 (Engl. Transl.)].
2. A. M. Sorochinskaya, and B. G. Kovalev, *Zh. Org. Khim.*, 1991, **27**, 722 [*J. Org. Chem. USSR*, 1991, **27** (Engl. Transl.)].
3. M. Schwarz, J. Klun, B. A. Leonhardt, and D. T. Johnson, *Tetrahedron Lett.*, 1983, **24**, 722.
4. F. Ramiandrasoa, C. Descoins, Domaine de Brouessy, and Magny-les-Hameaux, *Synth. Commun.*, 1989, **19**, 2703.
5. V. N. Odinokov, G. Yu. Ishmuratov, I. M. Ladenkova, O. V. Sokol'skaya, R. R. Muslukhov, V. R. Akhmetova, E. V. Gorobets, A. V. Kuchin, and G. A. Tolstikov, *Khim. Prir. Soedin.*, 1993, 749 [*Chem. Nat. Compd.*, 1993 (Engl. Transl.)].
6. U. M. Dzhemilev, O. S. Vostrikova, R. M. Sultanova, and A. R. Gimaeva, *Izv. Akad. Nauk SSSR, Ser. Khim.*, 1988, 2156 [*Bull. Acad. Sci. USSR, Div. Chem. Sci.*, 1988, **37**, 1936 (Engl. Transl.)].
7. V. N. Odinokov, G. Yu. Ishmuratov, R. I. Galeeva, O. V. Sokol'skaya, Kh. F. Sagitdinova, and G. A. Tolstikov, *Zh. Org. Khim.*, 1990, **26**, 57 [*J. Org. Chem. USSR*, 1990, **26** (Engl. Transl.)].
8. G. Ohloff, C. Vial, F. Naf, and M. Pawlak, *Helv. Chim. Acta*, 1977, **60**, 1161.

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