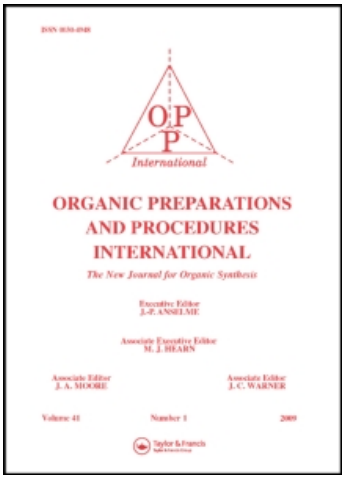

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AN IMPROVED SYNTHESIS OF (*E*)-9-DODECEN-1-YL ACETATE, THE SEX PHEROMONE OF *RHYACIONIA BUOLIANA*

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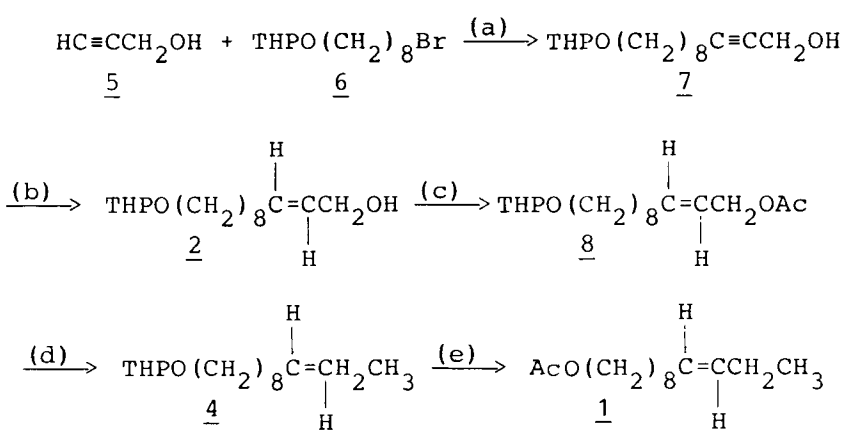
The European pine shoot moth (*Rhyacionia buoliana*), a major pest of pine trees, is widespread in the whole palearctic region. The main component of the sex pheromone of this insect is (*E*)-9-dodecenyl acetate (1).[1] (*Z*)-9-Dodecen-1-yl acetate diastereomer, on the other hand, is so potent an inhibitor of the attractive effect, that a synthetic *E/Z* mixture with more than 2% of (*Z*)-isomer is almost completely inactive.[1a] Since the separation of these geometrical isomers is difficult and expensive, 1 prepared for artificial lures should be synthesized by a highly stereoselective route excluding the formation of the corresponding (*Z*)-alkene. Conventional syntheses[2-4] of 1 are based on stereoselective reduction of 9-dodecyne-1-ol,[3] or a suitable derivative.[2,4] The procedures employed either prolonged heating with LAH at elevated temperature[5] or treatment with alkali metals in liquid ammonia.[6] Other preparations of 1 use multi-step procedures or sophisticated reagents.[7]

Recently, Vig *et al.* synthesized compound 1 from 10-un-

decen-1-ol through the intermediate (*E*)-12-tetrahydropyranyloxyundec-2-en-1-ol (2).[8] This alcohol (2) after mesylation and reaction with lithium dimethylcuprate (3) afforded (*E*)-12-tetrahydropyranyloxydodec-3-ene (4) which was converted to 1 by routine transformations. However, the key steps of this approach (e.g. cuprate coupling and the preparation of 3) proceeded in only moderate yields and no evidence of the high isomeric purity essential for our purpose was provided.[8]

Literature data[8] cited above prompted us to elaborate a simple method with higher overall yield and strict stereocontrol. The inexpensive propargyl alcohol (5) served as starting material in our synthetic pathway. The dianion generated from



(a) BuLi,HMPT,THF (70%)
(b) LAH,THF (83%)
(c) Ac_2O,Et_3N,DMAP,ether (94%)
(d) $LiCu(CH_3)_2$,ether
(e) Ac_2O,AcOH
(2 steps: 91%).

this precursor (5) was selectively alkylated[9] with the easily accessible bromoether 6[2,7d,9a,10] by a slightly modified literature procedure[9a] in fair yield. The resulting acetylenic compound (7)[9a,b] was then reduced under mild conditions with high stereoselectivity[9a,11] to the (*E*)-allylic alchol (2)[8a,9a]

isolated by non-acidic work-up.[12] A larger than usual[11] excess of lithium aluminium hydride was utilized to insure complete reduction, because any trace of remaining starting material (7) might result in contamination of pheromone 1;[13] under the conditions used, overreduction to 11-tetrahydropyranyloxyundecan-1-ol was not significant.[11b,14]

The transformation of (*E*)-alcohol 2 to (*E*)-olefin 4 was best accomplished by allowing the acetate 8 to react with cuprate 3 according to literature procedures.[2,15] The high reactivity of cuprates toward allylic esters,[2,15,16] the conservation of the geometry of the double bond and the minor amounts of rearranged and other by-products[2,15] in such alkylations with organometallics make acetate 8 the substrate of choice. On the other hand Henrick on the basis of a critical analysis of the literature suggested the use of lithium dialkylcuprates for the regio- and stereospecific nucleophilic substitution of the primary allylic acetates.[2] Thus alcohol 2 was acetylated under essentially neutral conditions[17] to afford ester 8 which was treated with an excess of lithium dimethylcuprate (3) in ether at low temperature.[15b,16a,18] The resulting crude tetrahydropyranyl ether (4) was directly subjected to acetic anhydride in acetic acid[19] to give 1 in high yield. The final product (1) was contaminated with 0.6-0.9% of (*Z*)-isomer as determined by capillary GC and NMR studies. Pheromone traps baited with this substance displayed high biological activity in field experiments.

This principle was utilized also in the preparation of (*E*)-11-tetradecen-1-yl acetate (9), the pheromone component of various economically important insect pests such as *Ostrinia*

nubilialis,[20] *Argyrotaenia velutiniana*,[20] *Archips podana*.[21]

EXPERIMENTAL SECTION

IR Spectra, determined as films, were measured with a Zeiss Specord-75 IR apparatus. NMR Spectra were recorded on a Varian XL-100 spectrometer at 100 MHz for ^{1}H and 25.2 MHz for ^{13}C nuclei ($CDCl_3$/TMS). Capillary GC-analyses were done by a Carlo Erba 2190 gas chromatograph (25 x 0.22 mm FSOT column coated with CP Wax 57 CB, carrier: 2.5 mL/min N_2, split 1:100, FID).

11-Tetrahydropyranyloxy-2-undecyn-2-ol (7).- The experiment was carried out under argon with stirring while the temperature of the reaction mixture was maintained at 4-6°. n-Butyllithium in hexane (13.75 mL, 1.6 M, 22.0 mmol) was added dropwise to a solution of propargyl alcohol (0.60 mL, 10 mmol) in anhydrous THF (8 mL) and HMPT (6 mL) over 0.5 hr. After 1 hr, bromoether 6 (2.93 g, 10 mmol) dissolved in dry HMPT (2 mL) was added over 0.5 hr; stirring was continued at room temperature overnight. The solution was poured into a 25% aqueous NH_4Cl solution. Usual extractive work up with hexane followed by flash chromatography (toluene/ethyl acetate 10:1) afforded 1.88 g (70%) oily product 7.

IR: 3450, 2250, 1140, 1090, 1030 cm^{-1}. ^{1}H-NMR: δ 1.2-2.0 (m, 18H, CH_2), 2.1-2.4 (m, 2H, $CH_2C{\equiv}C$), 3.2-4.1 (m, 5H, $2CH_2O$, OH), 4.23 (t, J = 2.5 Hz, 2H, $C{\equiv}CCH_2O$), 4.58 (m, 1H, O-CH-O). ^{13}C-NMR: δ 51.1 (C-1), 78.7+86.1 (C-2 + C-3), 18.8 (C-4), 26.2-29.7 (C-5 -C-10), 67.7 (C-11), THP: 98.8 (C-2'), 30.8 (C-3'), 19.7 (C-4'), 25.6 (C-5'), 62.3 (C-6').

(*E*)-11-Tetrahydropyranyloxy-2-undecen-1-ol (2).- Lithium aluminium hydride (2.28 g, 60 mmol) added portionwise to the stirred solution of alcohol 7 (3.22 g, 12.0 mmol) in 100 mL of

dry THF at -20° under argon. The resulting slurry was stirred at reflux for 10 hrs, then 40 mL of water was added cautiously with cooling followed by 200 ml of 25% aqueous solution of sodium potassium tartarate dihydrate which caused the dissolution of the precipitate on stirring. The mixture was extracted with ether, the organic layers were washed with water, dried (Na_2SO_4), stripped of solvent, and purified by flash chromatography (toluene/ethyl acetate 10:1.5) to yield 2.7 g (83%) of compound 2 as an oil. IR: 3450, 1660, 1100, 1025, 960 cm^{-1}. ^{1}H-NMR: δ 1.2-1.9 (m, 18H, CH_2), 1.9-2.2 (m, 2H, CH_2C=C), 3.2-3.9 (m, 4H, $2CH_2O$), 4.07 (dd, J = 5+1.5 Hz, 2H, $C\underline{H}_2OH$), 4.56 (m, 1H, O-CH-O), 5.67 (m, 2H, 2C=CH). ^{13}C-NMR: δ 63.3 (C-1), 132.6+129.3 (C-2 + C-3), 32.2 (C-4), 26.2-30.8 (C-5 - C-10), 67.6 (C-11), THP: 98.7 (C-2'), 30.8 (C-3'), 19.6 (C-4'), 25.5 (C-5'), 62.1 (C-6').

(*E*)-11-Tetrahydropyranyloxy-2-undecen-1-ol Acetate (8).- Acetic anhydride (0.64 mL, 6.6 mmol) was added to a solution of alcohol 2 (1.62 g, 6.0 mmol), 4-dimethylaminopyridine (37 mg, 0.3 mmol) and triethylamine (0.94 mL, 6.6 mmol) in 50 ml of dry ether. The reaction mixture was stirred under nitrogen for 2 hrs at room temperature, diluted with ether, extracted with 10% aqueous acetic acid (1x50 mL and 2x20 mL), water (10 mL), saturated aqueous $NaHCO_3$ solution (1x60 mL, 2x10 mL), brine (2x10 mL), dried (Na_2SO_4) and evaporated. Oily acetate 8 (1.76 g, 94%) was found to be homogeneous on TLC, and used without purification in the next reaction step. IR: 1760, 1240, 1140, 1090, 1040, 985 cm^{-1}. ^{1}H-NMR: δ 1.2-1.9 (m, 18H, CH_2), 2.0 (m, 2H, CH_2C=C), 2.04 (s, 3H, $COCH_3$), 3.2-4.0 (m, 4H, $2CH_2O$), 4.52 (dd, J = 5+1 Hz, 2H, C=CCH_2O), 4.58 (m, 1H,

O-CH-O), 5.7 (m, 2H, 2C=CH). ^{13}C-NMR: δ 65.2 (C-1), 136.5+123.9 (C-2 + C-3), 32.3 (C-4), 26.3-30.8 (C-5 - C-10), 67.6 (C-11), 21.0+170.7 (CH_3CO), THP: 98.8 (C-2'), 30.8 (C-3'), 19.7 (C-4'), 25.6 (C-5'), 65.2 (C-6').

Anal. Calcd. for $C_{18}H_{32}O_4$: C, 69.20; H, 10.32

Found: C, 69.45; H, 10.39

(*E*)-9-Dodecen-1-yl Acetate (1).- Lithium dimethylcuprate (15 mmol) was prepared as follows. Cuprous iodide (2.86 g, 15 mmol) was added to a cooled solution of methyllithium in ether (30 mL, 1.0 M, 30 mmol) at -20° with stirring under argon; the mixture was stirred at the same temperature for 10 mins, at 0° for 1 hr, and then cooled to -78°. Ester 8 (937 mg, 3.0 mmol) dissolved in 15 mL of anhydrous ether was added dropwise and the stirring was kept on at -75° for 1 hr, at -20 - -30° for 1 hr, and finally poured into a stirred mixture of 25% aqueous NH_4Cl (100 mL) and 25% aqueous NH_3 (1 mL) solutions. The organic phase was separated, the water layer was extracted with ether (2x30 mL). The combined etheral solutions were washed with 25% aqueous NH_4Cl solution (2x20 mL) and brine (10 mL), dried (Na_2SO_4) and the ether was stripped off. The crude coupled product (4) was directly acetylated. Acetic acid (4 mL) and acetic anhydride (2 mL) was added, and the solution was strirred at 80° under argon overnight, cooled, poured into ice-water and extracted with ether (4x10 mL). The collected organic portions were washed with saturated aqueous $NaHCO_3$ solution (1x50 mL, 2x20 mL), brine (10 mL), dried ($MgSO_4$) and concentrated *in vacuo*. Purification by flash chromatography (benzene) resulted in 0.62 g (91%) of a colourless oil (1). IR: 1740, 1240, 1050, 965 cm^{-1}. ^{1}H-NMR: δ 0.96 (t, J = 7 Hz, 3H, $CH_2\underline{CH}_3$), 1.2-1.9 (m,

12H, CH_2), 2.0 (m, 4H, $2CH_2$=C), 2.02 (s, 3H, $COCH_3$), 4.06 (t, J = 6 Hz, 2H, OCH_2), 5.42 (m, 2H, 2C=CH). ^{13}C-NMR: δ 64.6 (C-1), 26.0-29.7 (C-2 - C-7), 32.6 (C-8), 129.3+132.0 (C-9 + C-10), 25.6 (C-11), 14.0 (C-12), 21.0+171.1 (CH_3CO). The spectral data were in agreement with those previously reported.[4c,7,8a,22a] GC analysis, carried out at 140°, revealed the presence of 0.6-0.9% of the corresponding (*Z*)-isomer (t_{ret} = 8.8 min) in the essentially pure product 1 (t_{ret} = 8.5 min).

(*E*)-11-Tetradecen-1-yl Acetate (9).- This substance was prepared in a way similar to the route described above for 1, starting from 10-bromo-1-(2-tetrahydropyranyloxy)-octane.[2,7d,10] Spectra of 9 showed characteristics in accord with literature.[7a,19,22b] IR: 1740, 1240, 1050, 965 cm^{-1}, ^{1}H-NMR: δ 0.95 (t, J = 7 Hz, 3H, CH_2CH_3), 1.1-1.9 (m, 16H, CH_2), 2.0 (m, 4H, $2CH_2C$=C), 2.01 (s, 3H, $COCH_3$), 4.05 (t, J = 6.5 Hz, 2H, OCH_2), 5.42 (m, 2H, 2C=CH). ^{13}C-NMR: δ 64.7 (C-1), 26.0-29.7 (C-2 - C-9), 32.6 (C-10), 129.4+131.9 (C-11 + C-12), 25.6 (C-13), 14.0 (C-14), 21.0+171.1 (CH_3CO). Compound 9 (t_r = 8.36 min) was contaminated with only a minor amount (0.8%) of (*Z*)-11-tetradecen-1-yl acetate (t_r = 8.82 min), determined by GC investigations (160°).

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REFERENCES

1. a) R. G. Smith, G. E. Daterman, G. D. Daves, K. D. McMurtrey and W. L. Roelofs, J. Insect Physiol., 20, 661 (1974); b) T. G. Gray, K. N. Slessor, R. F. Shepherd, G. G. Grant and J. F. Manville, Can. Entomol., 116, 1525 (1984).
2. C. A. Henrick, Tetrahedron, 33, 1845 (1977) and references therein.

3. G. K. Roshka, A. M. Sorochinskaya and G. B. Kovalev, Nov. Metody v Zashchite Rast., Kishinev, 4, 14 (1982); C. A., 99, 121775j (1983).
4. a) B. F. Nesbitt, P. S. Beevor, R. A. Cole, R. Lester and R. G. Poppi, J. Insect Physiol., 21, 1091 (1975); b) L. Kalvoda and J. Vrkoc, Czech. Patent CS 207,179 (1984); C. A., 101, 130227u (1984); c) E. Korblova and M. Romanuk, Coll. Czech. Chem. Commun., 50, 2284 (1985).
5. R. Rossi and A. Carpita, Synthesis, 561 (1977).
6. a) D. Wharten and M. Jacobson, J. Med. Chem., 11, 373 (1968); b) J. D. Wharten and M. Jacobson, Synthesis, 616 (1973).
7. a) C. Canevet, T. Röder, O. Vostrowsky and H. J. Bestmann, Chem. Ber., 113, 1115 (1980); b) L. I. Zakharkin and E. A. Petrushkina, Zh. Org. Khim., 18, 1623 (1982); c) N. Popovici, A. A. Botar, A. Barabás, I. Oprean and F. Hodosan, J. prakt. Chem., 325, 17 (1983); d) V. Fiandanese, G. Marchese, F. Naso and L. Ronzini, J. Chem. Soc., Perkin Trans. 1, 1115 (1985).
8. O. P. Vig, M. L. Sharma, N. K. Verma and N. Malik, Indian J. Chem., 19B, 692 (1980); the preparation of the related (*E*)-11-tetradecen-1-ol has been reported [*Idem.*, *ibid.*, 19B, 581 (1980)].
9. a) M. Ochiai, T. Ukita and E. Fujita, Chem. Pharm. Bull. Jpn., 31, 1641 (1983); b) H. Suemune, N. Hayashi, K. Funakoshi, H. Akita, T. Oishi and K. Sakai, *ibid.*, 33, 2168 (1985); c) G. Casy, M. Furber, K. A. Richardson, G. R. Stephenson and R. J. K. Taylor, Tetrahedron, 42, 5849 (1986).
10. S.-K. Kang, W.-S. Kim and B.-H. Moon, Synthesis, 1161 (1985).
11. a) R. A. Raphael and F. Sondheimer, J. Chem. Soc., 3185 (1950); b) W. T. Borden, J. Am. Chem. Soc., 90, 2197 (1968); 92, 4898 (1970).
12. A. S. Dreiding and J. A. Hartman, *ibid.*, 75, 939 (1953).
13. P. Rona and P. Crabbe, *ibid.*, 90, 4733 (1968); 91, 3289 (1969).
14. a) F. A. Hochstein and W. G. Brown, *ibid.*, 70, 3284 (1948); b) J. Gore and R. Baudoy, Tetrahedron Lett., 3743 (1974) and references therein.
15. a) G. Fouquet and M. Schlosser, Angew. Chem., 86, 50 (1974);

b) J. H. Babler and W. J. Buttner, Tetrahedron Lett., 239 (1976); c) D. Samain, C. Descoins and A. Commercon, Synthesis, 388 (1978).

16. a) E. J. Corey and J. Mann, J. Am. Chem. Soc., 95, 6832 (1973); b) T.-L. Ho, Synth. Commun., 8, 15 (1978).
17. S. R. Wilson and M. F. Price, J. Am. Chem. Soc., 104, 1124 (1982); E. F. V. Scriven, Chem. Soc. Rev., 12, 129 (1983) and references therein.
18. G. L. Mourik and H. J. J. Pabon, Tetrahedron Lett., 2705 (1978).
19. R. Rossi, A. Carpita, L. Gaudenzi and M. G. Quirici, Gazz. Chim. Ital., 110, 237 (1980).
20. J. A. Klun, O. L. Chapman, K. C. Mattes, P. W. Wojtkowski, M. Beroza and P. E. Sonnet, Science, 181, 661 (1973) and references therein.
21. C. J. Persoons, A. K. Minks, S. Voerman, W. L. Roelofs and F. J. Ritter, J. Insect Physiol., 20, 1181 (1974).
22. a) A. Barabás, A. A. Botar, A. Gocan, N. Popovici and F. Hodosan, Tetrahedron, 34, 2191 (1978); b) A. A. Botar, A. Barabás, I. Oprean, J. Csonka—Horvai and F. Hodosan, Rev. Roum. Chim., 28, 741 (1983).

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