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EFFICIENT SYNTHESES OF INSECT SEX PHEROMONES EMITTED BY THE BOLL WEEVIL AND THE RED BOLLWORM MOTH

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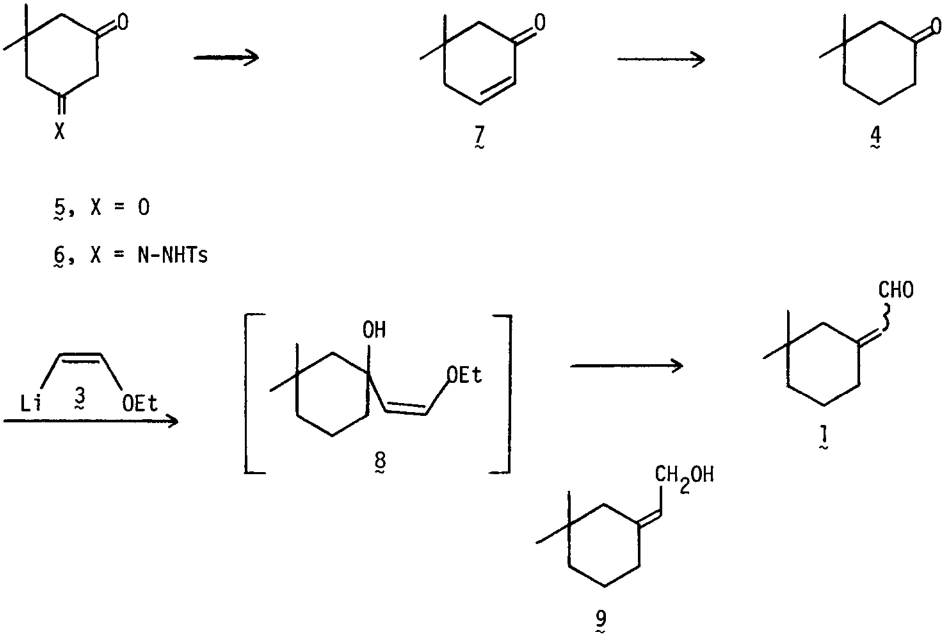
The use of pesticides for insect control has been the focus for considerable criticism,[1] especially owing to their harmful effects on wildlife and the human health hazards associated with pesticide residues found in our food. As a result, there has been considerable interest in the understanding of the chemicals responsible for sensory communications among insects.[2] These remarkably active,[3] generally nontoxic, and insect specific attractants (*e.g.* sex pheromones, aggregation pheromones, food lures, and oviposition lures) can be used in pest control in three major ways: (1) in sampling or monitoring specific pest populations, (2) in attracting insects to traps or poison baits isolated from food crops, and (3) in distracting or confusing insects from their normal mating, aggregation, feeding, or oviposition behavior.

Two pests responsible for major destruction of cotton crop are the boll weevil (*Anthonomus grandis* Boheman) and the red bollworm moth (*Diparopsis castanea* Hampson). This letter describes facile syntheses of two of the four terpenoid compounds emitted by male boll weevils (stereoisomers corresponding to 1) and also a potent sex pheromone produced by the virgin female red bollworm moth (2). The routes described use in key steps our recently developed nucleophilic acetaldehyde equivalent, (Z)-2-ethoxyvinyllithium (3).[4]

The two aldehyde constituents of the boll weevil pheromone complex, (E)- and (Z)-3,3-dimethyl-$\Delta^{1,\alpha}$-cyclohexaneacetaldehyde (1), were synthesized as illustrated in Scheme I.[5] Thus, 3,3-dimethylcyclohexanone (4) was conveniently prepared from commercially available 5,5-dimethylcyclohexane-1,3-dione (5, dimedone) by heating the corresponding crude monotosylhydrazone (6) in aqueous potassium carbonate solution[6] followed by hydrogenation of the resulting enone 7 (1 atm H_2 with 10% Pd/C in EtOH; 48 h; 47% yield from 5).[7] Reaction of ketone 4 with

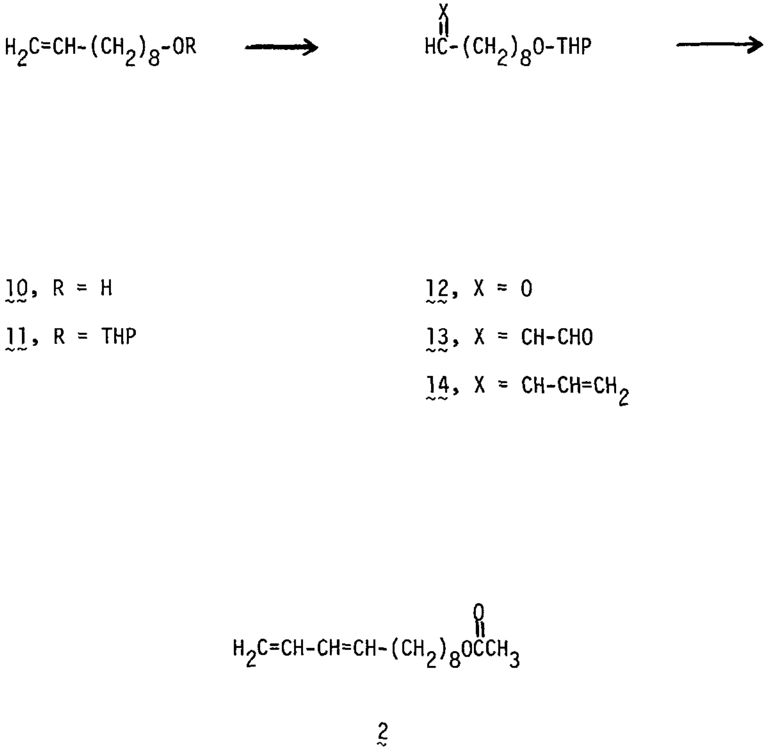
1.1 equiv of (Z)-2-ethoxyvinyllithium (3) in THF for 1 h at -78°C gave the labile enol ether 8. Rearrangement of 8 proceeded smoothly during column chromatography (silica gel) of the crude reaction mixture producing an equal mixture of α,β-unsaturated aldehydes 1 in 94% yield. The Z allylic alcohol 9 is also a constituent of the boll weevil pheromone complex and has previously been prepared by sodium borohydride reduction of 1.[5a] The aldehydes 1 (ratio 1:1) were thus prepared in 44% overall yield from dimedone (5).

Scheme I



The red bollworm moth pheromone 2 was conveniently prepared from commercially available 9-decen-1-ol (10) as illustrated in Scheme II.[8] Thus, treatment of the tetrahydropyranyl ether 11, prepared from alcohol 10 in 98% isolated yield, with osmium tetroxide-sodium metaperiodate effected fission of the double bond forming aldehyde 12 in 72% yield. Reaction of 12 with 1.4 equiv of the vinyllithium reagent 3 in THF for 2 h at -78°C followed by dilute acid (0.01N HCl; 20 min) catalyzed rearrangement of the intermediate γ-hydroxy enol ether[9] gave stereospecifically[10] the (E)-α,β-unsaturated aldehyde 13 in 64% yield (after chromatography). Wittig condensation of 13 with methylenetriphenylphosphorane gave diene 14.[11] Deprotection (cat. p-TsOH, CH_3OH, 3 h) of crude 14 followed by acetylation (Ac_2O, 2 equiv pyridine, 0.1 equiv 4-dimethylaminopyridine; CH_2Cl_2) formed 9,11-dodecadien-1-yl acetate (2) in 80% isolated yield from aldehyde 13. The diene 2 was thus prepared in 36% overall yield from 9-decen-1-ol (10).

Scheme II



$H_2C{=}CH{-}(CH_2)_8{-}OR \longrightarrow H\overset{X}{\overset{\|}{C}}{-}(CH_2)_8O{-}THP \longrightarrow$

10, R = H

11, R = THP

12, X = O

13, X = CH-CHO

14, X = CH-CH=CH_2

$H_2C{=}CH{-}CH{=}CH{-}(CH_2)_8O\overset{O}{\overset{\|}{C}}CH_3$

2

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References and Notes

1. R. Carson, "Silent Spring," Houghton Miflin, Boston, Mass., 1962.

2. See, *inter alia*: H. C. Coppel and J. W. Mertins, "Biological Insect Pest Suppression," Springer-Verlag, New York, 1977; W. Roelofs, "Insecticides of the Future," M. Jacobson (Ed.), Marcel Dekker, New York, 1975, pp. 41-59; M. Shepard (Ed.), "Insect Pest Management: Readings," MSS Information Corporation, New York, 1973.

3. See, for example, R. J. Marks, *Bull. ent. Res.* **66**, 219 (1976); **66**, 427 (1976).

4. R. H. Wollenberg, K. F. Albizati, and R. Peries, *J. Am. Chem. Soc.*, **99**, 7365 (1977).

5. For previous syntheses of **1** see, (a) J. P. de Souza and A. M. R. Goncalves, *J. Org. Chem.*, **43**, 2068 (1978) and (b) references cited therein.

6. G. A. Hiegel and P. Burk, *J. Org. Chem.*, **38**, 3637 (1973).

7. All compounds reported herein were fully characterized by pmr, ir, and mass spectral analysis on chromatographically homogeneous samples.

8. For previous syntheses of **2** see, (a) J. H. Babler and M. J. Martin, *J. Org. Chem.*, **42**, 1799 (1977) and (b) references cited therein.

9. The γ-hydroxy enol ethers derived from addition of vinyllithium reagent **3** with simple aldehydes undergo rearrangement to α,β-unsaturated aldehydes on silica gel less smoothly than those adducts prepared from ketones.

10. This was determined by examination of the pmr spectrum (*cf.* ref 8a) which showed a single aldehydic proton.

11. The Wittig condensation is reported to proceed without appreciable isomerization of the α,β-unsaturated carbonyl system [ref 8a].

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