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SYNTHESIS OF THE AI COMPONENT OF THE FEMALE SEX PHEROMONE OF THE CALIFORNIA RED SCALE

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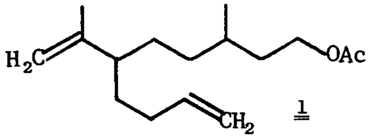
The female sex pheromone of the California Red Scale, Aonidiella aurantii (Maskell) has recently been shown to consist of two components.[1] We report here a short and efficient synthesis of the AI component (1) from readily available starting materials. The first and key step of this synthesis is the aluminum chloride catalyzed ene reaction[2] of methyl propiolate with citronellyl acetate which gives 2[3] in 55% yield as a ca. 1:1 mixture of diastereomers[4] (eqn. 1). The ene reaction introduces the isopropenyl group regiospecifically and provides appropriate functionality for conversion to 1. This aluminum chloride catalyzed ene reaction promises to be of general synthetic utility since functional groups such as acetate do not interfere with the reaction.



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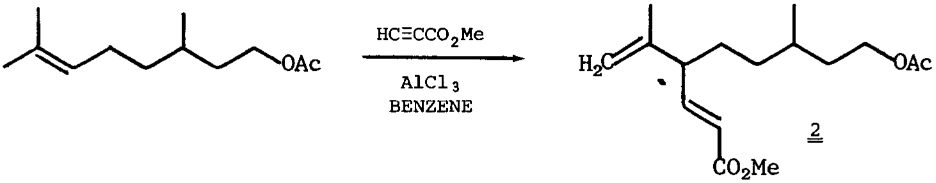

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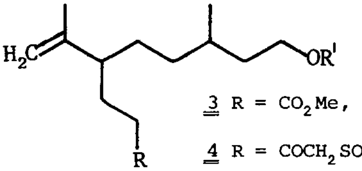
Utilization of 2 as an intermediate requires selective reduction of the conjugated double bond. Use of L-selectride, which has been reported to effect this transformation,[5] produces a mixture of saturated ester, allylic alcohol and starting material. Fortunately, reduction with 8 equiv of 2:1 iron pentacarbonyl:sodium hydroxide in 95:5 methanol:water[6] gives the saturated ester 3 in 80% yield. This is an attractive procedure since it is not sensitive to stoichiometry or to traces of water.

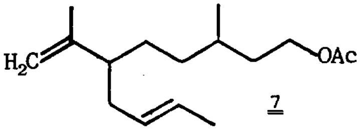


3 R = CO_2Me, R' = Ac

4 R = $COCH_2SO_2Ph$, R' = H

5 R = $CH(OH)CH_2SO_2Ph$, R' = H

6 R = $CH(OAc)CH_2SO_2Ph$, R' = Ac



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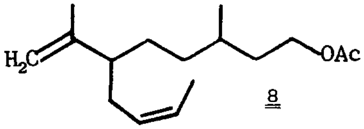

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The additional carbon needed for conversion of 3 to 1 is added by treatment of 3 with 4 equiv of phenylsulfonylmethyllithium to give 4 in 80% yield. Reduction of 4 with sodium borohydride in ethanol gives the hydroxysulphone 5 in 86% yield.[7] Acetylation of 5 to give 6, reduction[8] with a large excess of 6% sodium amalgam[9] in ethanol for 30 min. at 0°, and reacetylation gives 1 in 56% yield from 5 as a mixture of all 4 diastereomers. Bioassay indicates that this material has comparable activity to the natural material.[10]

Repetition of the synthesis of 1 with (R)-(+)- and (S)-(-)-citronellyl acetate[11] leads to 1 with controlled stereochemistry at C-3. Bioassay indicates that the 3-(S)-(-) isomer of 1 is four times as active as the 3-(R)-(+) isomer. Because the samples are not optically pure, one would expect a ten to one activity ratio if only the 3-(S) isomer is active. While the 3-(R) isomer is probably active also, the natural pheromone most likely has the 3-(S) configuration.

Reduction of 6 under more vigorous conditions (6% sodium amalgam in ethanol for several hours at 25°) gives partial isomerization of 1 to the internal olefins 7 and 8.[12] Bioassay indicates that a mixture of 1, 7 and 8 or pure 7 is inactive while pure 8 is weakly active.

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2. B. Snider, J. Org. Chem., 41, 3061 (1976).
3. All compounds have satisfactory nmr, ir and mass spectral data and are homogeneous by TLC and GC (except for diastereomeric mixtures).
4. The ^{13}C nmr spectrum of 3 consists of 4 singlets and 12 sets of closely spaces doublets indicating a 1:1 mixture of diastereomers.
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9. B.M. Trost, H.C. Arndt, P.E. Strege and T.R. Verhoeven, Tetrahedron Lett., 3477 (1976).
10. We wish to thank Professor Wendell Roelofs and Mary Gieselmann of the New York State Agricultural Experiment Station for performing the bioassays and providing spectra of natural pheromone.
11. We wish to thank Mr. B.J. Kane of Glidden-Durkee for a gift of (+)-citronellol ($[\alpha]_D$ = 4.54°, 84% ee, 92% (+)) and (-)-citronellol ($[\alpha]_D$ = 3.95°, 73% ee, 86.5% (-)). A value of 5.38° for the $[\alpha]_D$ of pure citronellol is used for the calculation of ee. See: D. Valentine, Jr., K.K. Chaw, C.G. Scott, K.K. Johnson, K. Toth and G. Saucy, J. Org. Chem., 41, 62 (1976).
12. Separation of 1, 7 and 8 can be accomplished by gas chromatography on an XF-1150 column.