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APPLICATION OF SILYLCUPRATION OF ALKYNES TO STEREO- AND REGIOSPECIFIC FORMATION OF TRISUBSTITUTED ALKENES. A SHORT SYNTHESIS OF YELLOW SCALE PHEROMONE

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SUMMARY. Silylcupration of a sterically hindered terminal alkyne, and alkylation, gave trisubstituted, β,γ-unsaturated alkene **4** stereo- and regiospecifically. Conditions are described for iodinolysis of **4**, and subsequent Pd^0-catalyzed elaboration to yellow scale pheromone.

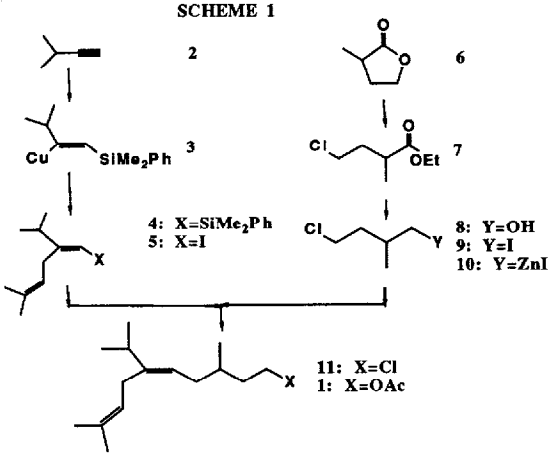
In conjunction with a field program examining yellow scale distribution, we required yellow scale sex pheromone **1**. Several syntheses of this compound have been published, but published routes to date do not allow the stereospecific placement of the double bond[1a] or are somewhat lengthly[1b-d]. Development of a short, stereoselective synthesis seemed feasible, given the considerable volume of recent literature on stereoselective synthesis of trisubstituted alkenes[2].

Examination of the structure revealed two complicating factors. First, a reaction such as carbocupration of an alkyne precursor is prohibited due to the steric hindrance afforded by the allylic methyl group[3a]. Second, allylmetallation of alkynes may be difficult (eg. for Cu and Al)[3b], or may lead to the undesired or mixed regiochemistry (eg. bimetallic reagents)[1c,d]. Consequently, a slightly more indirect route via silylcupration[4] was investigated. This reaction gives cis addition to the alkyne and steric hindrance by the bulky silyl ligand places the copper regio- and stereospecifically on the more substituted carbon, in contrast to addition of most organometallics to terminal alkynes. To our knowledge, there have been no examples reported of silylcupration of 1-alkynes with substitution at the propargyl position; however, the extra steric hindrance afforded by a propargyl substituent was expected to reinforce rather than hinder the regiochemical bias.

In practice[5], vinylsilane **4** was readily prepared by addition of 3-methyl-1-butyne to a cooled (0^o) THF solution of the higher order cuprate from $PhMe_2SiLi$ (2 equiv) and CuCN (1 equiv)[4]; the solution of intermediate **3** was cooled to -78^o, and excess 1-bromo-3-methyl-2-butene was added, giving **4** (77%, bp 81-$84^{0.15}$), admixed with 16% of the S_N2' product. Silane **4** proved intractable to the usual iodinolysis conditions (I_2, CH_2Cl_2, -35^o)[6]. After considerable experimentation, a moderate yield (51%) of unstable iodide **5** was obtained by addition of the silane to a slurry of I_2 in CH_3CN (-35-0^o), rapid quenching with ice-cold 5% aq. $Na_2S_2O_3$, and flash chromatography on silica (hexanes).

The second segment was prepared in straightforward fashion from α-methyl-γ-butyrolactone **6** (Aldrich) by the sequence: a) Transesterification (EtOH/HCl, 0-20^o,) to the chloroester **7** (98%), b) Reduction of the crude ester **7** to alcohol **8** ($LiAlH_4$ in ether, 0-20^o; 77%, Kugelrohr bp ~125^{80}), c) Iodination of alcohol **8** (Ph_3P, I_2, imidazole, in CH_3CN:ether, 1:3; 69%, Kugelrohr bp ~$75^{.7}$)[7].

SCHEME 1



The synthesis was completed by the sequence a) conversion of 9 to 10 (1.25 equiv activated Zn granules, THF, 20-35°)[8]; b) addition of iodide 5 (1 equiv) to a slurry of 10 (2 equiv) and $(Ph_3P)_4Pd$ (.05 equiv) in THF (0-20°)[9]; c) stirring the crude chloride 11 with NaOAc (6 equiv) in HMPA (75°), giving racemic 1 as a single alkene stereoisomer after flash chromatography (42% from 5). This route can easily be extended to the synthesis of either enantiomer of 1 by making chiral 9, eg from commercially available 3-hydroxy-2-methyl-propionic acid methyl ester enantiomers (Sigma).

This route also involves fewer steps and is more general than a very recently reported route[10] to trisubstituted alkenes, via epoxidation of vinylsilanes, reaction with organocuprates, and elimination of silanol.

REFERENCES

1. a) R.J. Anderson and C.A. Henrick, J. Chem. Ecol., 1979, 5, 773. b) T. Suguro, W.L. Roelofs, and K. Mori, Agric. Biol. Chem., 1981, 45, 2509. c) S. Masuda, S. Kuwahara, T. Suguro, and K. Mori, Agric. Biol. Chem., 1981, 45, 2515. d) K. Mori and S. Kuwahara, Tetrahedron, 1982, 38, 521.
2. a) B.H. Lipschutz, R.S. Wilhelm, and J.A. Kozlowski, Tetrahedron, 1984, 40, 5005. b) S. Sharma and A.C. Oehlschlager, Tetrahedron Lett., 1986, 27, 6161, and refs therein. c) S. Sharma and A.C. Oehlschlager, Tetrahedron Lett., 1988, 29, 261, and refs. therein.
3. a) J.F. Normant and A. Alexakis, Synthesis, 1981, 841. b). E. Negishi and J.A. Miller, J. Am. Chem. Soc., 1983, 105, 6761.
4. I. Fleming, T.W. Newton, and F. Roessler, J. Chem. Soc. Perkin I, 1981, 2527.
5. All compounds were completely characterized by NMR, IR, and mass spectrometry.
6. T.C. Chan, Synthesis, 1979, 761.
7. E.J. Corey, S.G. Pyne, and W. Su, Tetrahedron Lett., 1983, 24, 4883.
8. P. Knochel, M.C.P. Yeh, S.C. Berk, and J. Talbert, J. Org. Chem., 1988, 53, 2392.
9. E. Piers, M. Jean, and P.S. Marrs, Tetrahedron Lett., 1987, 28, 5075.
10. S.-S.P. Chou, H.-L. Kuo, C.-J. Wang, C.-Y. Tsai, and C.-M. Sun, J. Org. Chem., 1989, 54, 868.

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