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A FOUR STEP SYNTHESIS FROM α-PINENE OF
7,7-DIMETHYLBICYCLO[4.1.1]OCTA-2,4-DIENE

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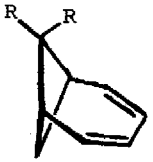
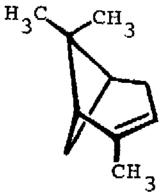
As part of our continuing experimental[1] and theoretical[2] studies of the chemical consequences of orbital interactions in molecules containing 1,3 bridged cyclobutane rings, we required a method for preparing reasonable quantities of bicyclo[4.1.1]octa-2,4-diene (**1**) or a simple derivative thereof. The literature contains a very limited number of entries into this ring system. Dibromocarbene has been added to α-pinene to yield a four to one mixture of exocyclic and endocyclic bromodienes, derived from the initially formed adduct by electrocyclic ring opening and loss of HBr.[3] Russell and coworkers[4a] have bis-homologated cis-1,3-cyclobutanedicarboxylic acid[4b] and used the acyloin reaction to cyclize the resulting diester. Although the product of the acyloin reaction is an obvious candidate for further transformation into the parent diene (**1**),[5] the total number of synthetic steps in this route, which starts from pentaerythritol,[4b] is quite large. Therefore, we sought a more convenient synthesis of a simple derivative of **1**.



1, R = H
2, R = CH_3



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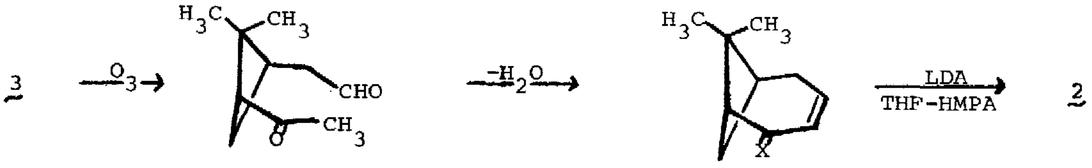
In designing such a synthesis, we noted that α-pinene (3), which is commercially available and inexpensive, contains the same number of carbons and the cis-1,3 disubstituted cyclobutane ring that is found in 7,7-dimethylbicyclo-[4.1.1]octadiene (2). We report herein a convenient transformation of α-pinene to 2 in four steps, the last of which is a vinylogous Shapiro reaction.

Ozonolysis of α-pinene in THF according to the published procedure[6] gave in 80% yield the ketoaldehyde (4), which was cyclized to the bicyclic enone in refluxing xylene containing piperidine and acetic acid. Bicyclo[4.1.1]oct-3-en-2-one (5) was isolated in 35% yield by distillation.[7] Its pmr spectrum ($CDCl_3$) showed: δ 0.98 (s,3H), 1.35 (s,3H), 1.85 (d,1H,J=10 Hz), 2.0-2.5 (m,2H), 2.5-2.9 (m,3H), 6.01 (d of q,1H,J =12 and 2 Hz), 6.51 (d of t,1H,J =12 and 4 Hz); uv (hexane): λ_{max} = 221 nm (log ε = 3.90). Although the enone (5) could be reduced to a single crystalline allylic alcohol, mp 57-58°, attempts to dehydrate this alcohol to 2 were uniformly disappointing. Therefore, another method was investigated for the transformation of 5 to 2.



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5, X = O
6, X = NNHTs

Ketones can be converted to olefins by treatment of the derived tosylhydrazones with methyllithium (Shapiro reaction).[8] When the tosylhydrazone of an α,β unsaturated ketone is treated with methyllithium, proton abstraction occurs from the α', rather than from the γ position, to give a diene in which the original double bond remains unshifted.[8,9] Since in **5** the α' position is at a bridgehead, we hoped that proton abstraction could be effected from the γ position.[10] In order to avoid possible addition of methyllithium to the double bond[10] of the tosylhydrazone (**6**)[11] derived from **5**, lithium diisopropylamide (LDA) was used as the base.[12] Vedejs has successfully used LDA in place of methyllithium in the Shapiro reaction,[13] and Schlessinger has employed 1:1 LDA-HMPA in THF to remove the γ proton from α,β unsaturated aldimines.[14] When the tosylhydrazone (**6**) was added to a THF solution of four equivalents of 1:1 LDA-HMPA at room temperature and the solution refluxed for 2 hr, a 34% yield of **2** was isolated after aqueous workup, passage through a short column of alumina, and distillation. An analytical sample[7] was obtained by preparative glc. Its pmr spectrum ($CDCl_3$) showed: δ 0.80 (s,3H), 1.0-1.1 (m,1H), 1.28 (s,3H), 2.1-2.8 (m,3H), 5.5-6.3 (m,4H); cmr ($CDCl_3$): δ 20.20, 22.40, 23.53, 28.32, 44.73, 125.29, 136.69; uv (hexane): λ_{max} = 270 nm (log ε = 3.38), 280 nm (log ε = 3.50), 292 nm (log ε = 3.47), 304 (log ε=3.19).[15]

Although the (unoptimized) yields in the second and last reactions of this four step synthesis of **2** from **3** are only fair, the commercial availability and low cost of the starting material make this route economical as well as convenient. Indeed, the ozonolysis of **3**, followed by the cyclization of **4** to **5**, represents a most attractive entry into the bicyclo[4.1.1]octane ring system. Finally, the transformation of **5** to **2** via the reaction of **6** with 1:1 LDA-HMPA is an extension of the Shapiro reaction that may prove generally useful for the preparation of dienes from α,β unsaturated carbonyl compounds that lack enolizable α' hydrogens.

References and Notes

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(2) W. L. Jorgensen and W. T. Borden, *J. Am. Chem. Soc.*, **95**, 6649 (1973); W. L. Jorgensen and W. T. Borden, *Tetrahedron Lett.*, 223 (1975).

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(4a) G. Russel, P. Whittle, and R. Keske, *J. Am. Chem. Soc.*, 93, 1467 (1971);
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(5) W. E. Volz and L. A. Paquette (private communication) have succeeded in transforming the acyloin product to **1** in five steps.

(6) H. E. Eschinazi, *J. Am. Chem. Soc.*, **81**, 2905 (1959). We found that substitution of THF for methanol-water averted acetal formation, which otherwise occurred.

(7) Satisfactory analytical data -- exact mass and/or elemental analysis -- were obtained for this compound.

(8) Review: R. H. Shapiro, *Org. Reactions*, **23**, 405 (1976).

(9) W. G. Dauben, M. E. Lorber, N. D. Vietmeyer, R. H. Shapiro, J. H. Duncan, and K. Tomer, *J. Am. Chem. Soc.*, **90**, 4762 (1968).

(10) Some precedent for such an event is found in the work of Y. Bessière-Chrétien and J.-P. Bras, *C. R. Acad. Sci.* Paris, *Ser. C.*, 2221 (1969). These authors treated verbenone tosylhydrazone with methyllithium and obtained an equal mixture of the diene resulting from γ hydrogen abstraction and the monolefin resulting from methyllithium addition to the double bond.

(11) Prepared as an equal mixture of *syn* and *anti* isomers by the procedure of reference 9.

(12) When **6** was treated with methyllithium in THF at 0°, in the presence or absence of TMEDA, on workup only unreacted starting material was recovered. At higher temperatures, reaction did occur; but no **2** was detectable among the otherwise uncharacterized products. We also found LDA alone to be less effective than 1:1 LDA-HMPA in transforming **6** into **2**.

(13) E. Vedejs and R. A. Shepherd, *J. Org. Chem.*, **41**, 742 (1976).

(14) G. R. Kieczykowski, R. H. Schlessinger, and R. B. Sulsky, *Tetrahedron Lett.*, 597 (1976).

(15) The spectral data for **2** are in good agreement with those obtained for the parent diene (**1**)[5]: R. Gleiter, P. Bischof, W. E. Volz, and L. A. Paquette, *J. Am. Chem. Soc.*, in press.

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