

2. Palladium(0)-Catalyzed Cyclizations of Simple 1-Aryl-1,7-octadien-3-yl Acetates

Preliminary Communication¹⁾

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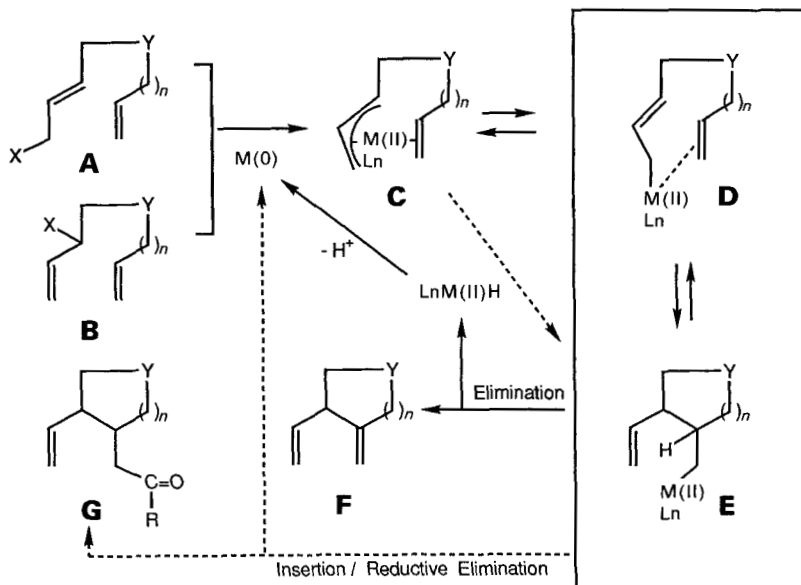
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Dienyl acetates **2** lacking a geminal disulfone or a malonate group cyclize selectively to (*E*)-1-methylidene-2-styrylcyclopentanes **4** in the presence of 7 mol-% of [Pd(PPh₃)₄].

Pd(0)-, [1], Pt(0)-, and Ni(0)-catalyzed [2] cyclizations of 1-acetoxy-, 1-tetrahydropyran-2-yl-, 1-bromo-, and 1-iodo-2,7-octadienes (or -2,8-nonadienes) **A** exemplify part of a new stereospecific methodology leading to an array of carbo- and heterocycles **F** (Scheme 1). Precursors **A** containing the allyl or the enophile unit as part of a ring gave

Scheme 1



X = AcO, OH, THPO, Br, I

Y = (SO₂Ar)₂C, (CO₂Me)₂C, RN, O

n = 1, 2

M = metal

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annulated ring systems. The experimental results are consistent with a *cis*-allylation of the alkene bond by a σ -allylmetal (**D**→**E**) or π -allylmetal unit²⁾ (**C**→**E**) and a β -elimination with subsequent regeneration of the metal(0) catalyst. CO insertion reactions into **E** afforded monocyclic esters **G** (**R** = MeO) and in some cases (*via* **G**, **R** = NiLn) bicyclic annulated cyclopentanones with 'concomitant' stereocontrolled formation of four C–C bonds [2]. However, all educts **A** described so far contained either a (SO₂Ar)₂C, malonate, N, or O functionality **Y** which (for entropic reasons) may assist the cyclization process. These functional groups also facilitate the preparation of the precursors **A** and can be readily removed [4] or modified; nevertheless, it remained to be clarified, whether they are essential for the cyclization **D** (**C**)→**E** or not.

We report here that 1,7-octadien-3-yl acetates **B** containing a simple C-bridge **Y** are very easily accessible and undergo smooth Pd(0)-catalyzed ring closures. Our results are summarized in *Scheme 2* and the *Table*.

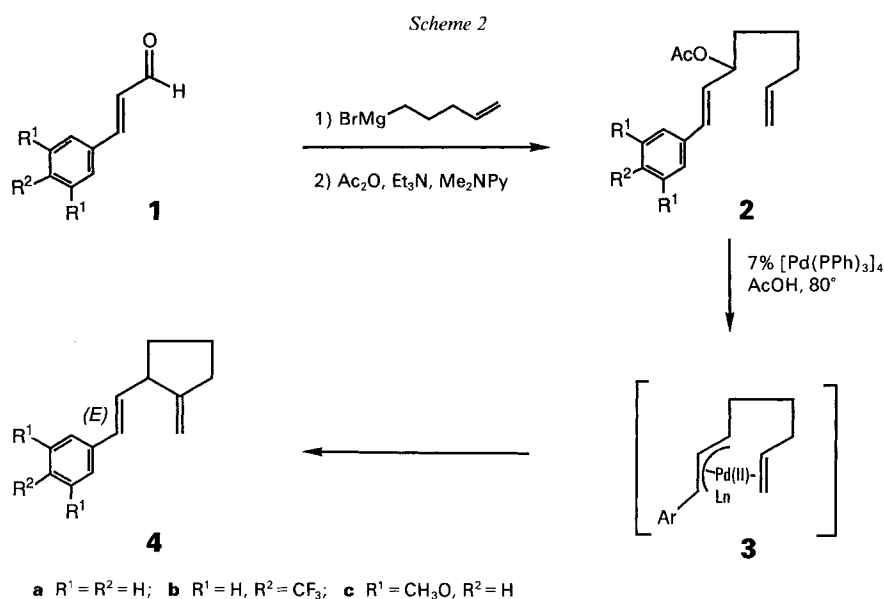


Table. 1,7-Octadien-3-yl Acetates **2** and their $[\text{Pd}(\text{PPh}_3)_4]$ -Catalyzed (7 mol-%, AcOH, 80°) Cyclization to **4**

Entry	R ¹	R ²	Yield [%] of 2 from 1	Cyclization time [h]	Yield [%] of 4 from 2
a	H	H	68	8	49
b	H	CF ₃	70	2	67
c	MeO	H	64	3	94

Addition of (*E*)-cinnamaldehydes **1** to pent-4-enylmagnesium bromide (1.1 mol-equiv., THF, 0°→r.t., 4 h; aq. workup) followed by 4-(dimethylamino)pyridine-catalyzed acetylation (1.5 mol-equiv. Ac₂O/Et₃N, 0.02 mol-equiv. Me₂NPy, THF, r.t., 4–18 h)

²⁾ For the formation and other reactions of allylpalladium intermediates, see [3].

furnished dienyl acetates **2** in good yields. Heating the phenyl-substituted acetate **2a**³⁾ in AcOH in the presence of 7 mol-% of [Pd(PPh₃)₄] at 80° for 8 h followed by aq. workup and flash chromatography (SiO₂, pentane) gave **4a**³⁾ in 49% yield. No other product could be found in the reaction mixture. We then subjected the less volatile dienyl acetates **2b**³⁾ and **2c**³⁾ which carry electron-withdrawing or electron-donating aryl substituents, respectively, to similar cyclization conditions. Indeed, the expected 1-methylidene-2-styryl-cyclopentanes **4b**³⁾ and **4c**³⁾ were isolated in 67 and 94% yield, respectively. In all three cases, *only* the (*E*)-product **4** (assigned *via* the ¹H-NMR coupling constant $J_{AB} = 16$ Hz) was observed. This indicates that among the rapidly equilibrating *anti*- and *syn*-allylpalladium intermediates²⁾, it was the latter (*i.e.* **3** or the corresponding σ -allyl complex) which cyclized and determined kinetically the (*E*)-configuration of **4**. In support of this argument it was found that methyl oleate and (*Z*)-1-phenylhept-1-ene did not isomerize to their (*E*)-isomers on heating with [Pd(PPh₃)₄] (7 mol-%) at 80° in AcOH for 16 h.

The scope and implications of these results are being further explored in our laboratories.

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REFERENCES

- [1] a) W. Oppolzer, J.-M. Gaudin, *Helv. Chim. Acta* **1987**, 70, 1477; b) W. Oppolzer, *Pure Appl. Chem.* **1988**, 60, 39; c) W. Oppolzer, *Chimia* **1988**, 42, 212; d) W. Oppolzer, J.-M. Gaudin, T. N. Birkinshaw, *Tetrahedron Lett.* **1988**, 29, 4705; e) W. Oppolzer, J.-M. Gaudin, M. Bedoya-Zurita, J. Hueso-Rodriguez, T. M. Raynham, C. Robyr, *ibid.* **1988**, 29, 4709; f) W. Oppolzer, R. E. Swenson, J.-M. Gaudin, *ibid.* **1988**, 29, 5529; g) W. Oppolzer, *Angew. Chem.* **1989**, 101, in press; *ibid. Int. Ed.* **1989**, 28, in press.
- [2] W. Oppolzer, M. Bedoya-Zurita, C. Y. Switzer, *Tetrahedron Lett.* **1988**, 29, 6433.
- [3] J. Tsuji, *Pure Appl. Chem.* **1981**, 53, 371; B. M. Trost, T. R. Verhoeven, 'Comprehensive Organometallic Chemistry', Eds. G. Wilkinson, F. G. A. Stone, and E. W. Abel, Pergamon Press, Oxford, 1982, Vol. 8, p. 799; J. Tsuji, *Tetrahedron* **1986**, 42, 4361; 'Principles and Applications of Organotransition Metal Chemistry', Eds. J. P. Collman, L. S. Hege, J. R. Norton, and R. G. Finke, University Science Books, Mill Valley, California, 1987, p. 881.
- [4] D. Ferroud, J.-M. Gaudin, J. P. Genet, *Tetrahedron Lett.* **1986**, 27, 845.

³⁾ Characterized by IR, ¹H-NMR (360 MHz), ¹³C-NMR, and MS. The 4-(trifluoromethyl)benzaldehyde obtained from 4-(trifluoromethyl)benzyl alcohol (pyridinium chlorochromate, CH₂Cl₂, r.t., 2.5 h) was treated with (formylmethylidene)triphenylphosphorane (1.1 mol-equiv., toluene, 80°, 22 h) to give **1b**. Using identical conditions, **1c** was prepared from 3,5-dimethoxybenzaldehyde.