

Regio- and Stereoselective Addition of Grignard and Organolithium Reagents to 4-Hydroxy-2-cyclopentenones

Aurelio G. Csáky,* Myriam Mba, and Joaquín Plumet*

Departamento de Química Orgánica I, Facultad de Química, Universidad Complutense, 28040 Madrid, Spain

csaky@quim.ucm.es

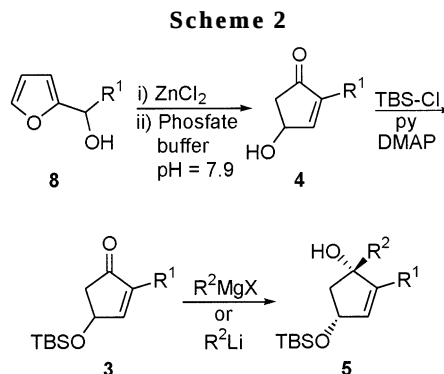
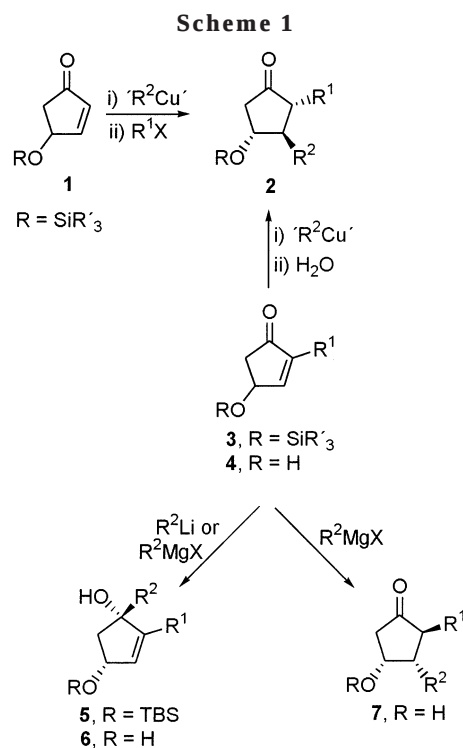
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4-Hydroxy-2-cyclopentenones and their *O*-silyl derivatives **1** constitute valuable synthetic intermediates. In particular, their regio- and stereocontrolled transformation into the 4,5-disubstituted 3-hydroxycyclopentanones **2** is a cornerstone in the synthetic approach to prostaglandins and related bioactive compounds.^{1,2} In this way, it is well-known that the additions of dialkylcuprates or Grignard reagents in the presence of copper(I) salts to compounds **1** proceed in a 1,4-anti fashion with respect to the bulky *O*-silyl substituent (Scheme 1).

Electrophilic capture of the intermediate enolates affords cyclopentanones **2** with a 3,4-anti-4,5-anti stereochemistry in a three-component coupling. Similar findings have been reported for the reaction of silyl-protected 2-substituted 4-hydroxy-2-cyclopentenones **3** with organocopper reagents. However, to increase the synthetic potential of compounds **1** and **3**, other stereochemical arrangements in the hydroxycyclopentanones **2** would be desirable. In this way, the concept of *ligand-assisted nucleophilic addition* first developed by Liotta et al.³ in the reaction of quinones with nucleophilic reagents can be an appealing possibility.

On the basis of this idea, in this paper we wish to account for the regio- and stereocontrolled transformation of cyclopentenones **3** and **4** into the 2,3-disubstituted 3,5-syn-dihydroxycyclopentenones **5** and **6** and into the 3,4-syn-4,5-anti-3-hydroxycyclopentanones **7** using organolithium or Grignard reagents (Scheme 1).

Ring opening⁴ of (2-furyl)carbinols **8** followed by *O*-silylation of the resulting 4-hydroxy-2-cyclopentenones **4** with TBS-Cl afforded the 2-alkyl- and 2-aryl-4-(*t*-butylsilyl)-2-cyclopentenones **3** (Scheme 2). The addition of either organolithium or Grignard reagents in THF solution and in the absence of Cu(I) salts or any added cosolvent to the *O*-TBS-cyclopentenones **3** afforded the



corresponding 1,2-addition products **5** (3,5-syn) in a highly regio- and stereoselective fashion.⁵ No traces of the diastereomeric 3,5-anti products were observed in the crude reaction mixture.⁶ The results are gathered in Table 1.

However, when the reactions with Grignard reagents were carried out starting from the *O*-unprotected cyclopentenones **4** in THF solution, the 1,4-addition products **7** (3,4-syn-4,5-anti) were obtained with high regioselectivity with no need of added Cu(I) salts or cosolvents⁷ and with 3,4-syn stereochemistry (Scheme 3). This stereoselectivity was found to be opposite⁸ to that observed

(1) For reviews, see: (a) Noyori, R.; Suzuki, M. *Angew. Chem., Int. Ed. Engl.* **1984**, *23*, 847–876. (b) Perlmutter, P. In *Conjugate Addition in Organic Synthesis*; Pergamon: Oxford, 1992. (c) Collins, P. W.; Djuric, S. W. *Chem. Rev.* **1993**, *93*, 1533–1564. (d) Nicolau, K. C.; Sorensen, E. J. In *Classics in Total Synthesis*; VCH: Weinheim, Germany, 1996.

(2) For leading recent references, see: (a) Myers, A. B.; Hammond, M.; Wu, Y.; Xiang, J.-N.; Harrington, P. M.; Kuo, E. Y. *J. Am. Chem. Soc.* **1996**, *118*, 10006–10007. (b) Kawata, S.; Yoshimura, F.; Irie, J.; Ehara, H.; Hirama, M. *Synlett* **1997**, 250–252. (c) Rodríguez, A.; Nomen, M.; Spur, B. W.; Godfroid, J.-J. *Eur. J. Org. Chem.* **1999**, 2655–2662 and references cited therein.

(3) Salomon, M.; Jamison, M. L.; McCormick, M.; Liotta, D.; Cherry, D. A.; Mills, J. E.; Shah, R. D.; Rodgers, J. D.; Maryanoff, C. A. *J. Am. Chem. Soc.* **1988**, *110*, 3702–3704. See also: Beak, P.; Meyers, A. I. *Acc. Chem. Res.* **1986**, *19*, 356.

(4) Piancatelli, G.; D'Auria, M.; D'Onofrio, F. *Synthesis* **1994**, 867–889 and references cited therein. See also: D'Auria, M. *Heterocycles* **2000**, *52*, 185–194.

(5) The 3,5-syn stereochemistry of compounds **5** has been assigned by NOE measurements. Thus, an increase of the H-5 signal (δ 4.64–4.56, m) of **7a** ($R^1 = \text{Ph}$, $R^2 = \text{Me}$) was observed upon irradiation of the CH_3 (δ 1.31, s).

(6) Determined on the ^1H NMR spectra (CDCl_3 , 300 MHz) of the crude reaction mixtures.

(7) Compare with the procedure described in ref 3.

(8) 3,4-Syn addition has been recently reported for the reaction of trialkylaluminum reagents to cyclopentenones **6** ($R^1 = \text{SO}_2\text{Ph}$ or CO_2Me). See: (a) Yakura, T.; Tanaka, K.; Iwamoto, M.; Nameki, M.; Ikeda, M. *Synlett* **1999**, 1313–1315. (b) Yakura, T.; Tanaka, K.; Kitano, T.; Uenishi, J.; Ikeda, M. *Tetrahedron* **2000**, *56*, 7715–7721.

Scheme 3

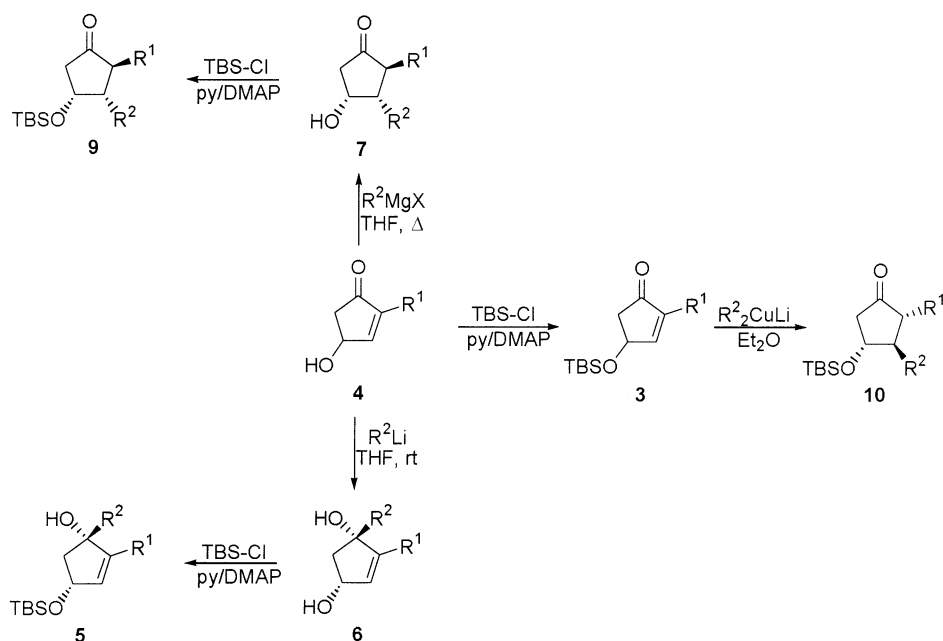


Table 1. Reaction of Cyclopentenones 3 with Organolithium or Grignard Reagents

no.	3	R ¹	R ² M ^a	5 (%) ^b
1	3a	Ph	MeLi	5a (70)
2	3a	Ph	MeMgI	5a (90)
3	3a	Ph	PhLi	5b (90)
4	3b	Me	PhLi	5c (50)
5	3b	Me	PhMgBr	5c (75)

^a THF was used as a solvent. Reactions with R²Li (1.1 equiv) were carried out from -78°C to room temperature, and reactions with R²MgX (1.1 equiv) were carried out at reflux temperature.
^b Isolated yields after silica gel chromatography (2:1 Hx–EtOAc).

Table 2. Reaction of Cyclopentenones 4 with Organolithium or Grignard Reagents

no.	4	R ¹	R ² M ^a	7:6 ^b (%) ^c
1	4a	Ph	MeMgI	7a:6a = 90:10 (7a, 60)
2	4a	Ph	EtMgBr	7b:6b = 95:05 (7b, 65)
3	4a	Ph	PhMgBr	7c:6c = 95:05 (7c, 70)
4	4a	Ph	<i>p</i> -F–C ₆ H ₅ –MgBr	7d:6d = 95:05 (7d, 65)
5	4b	Me	MeMgI	7e:6e = 90:10 (7e, 65)
6	4a	Ph	MeLi	7a:6a = 0:100 (6a, 65)
7	4b	Me	MeLi	7e:6e = 0:100 (6b, 70)

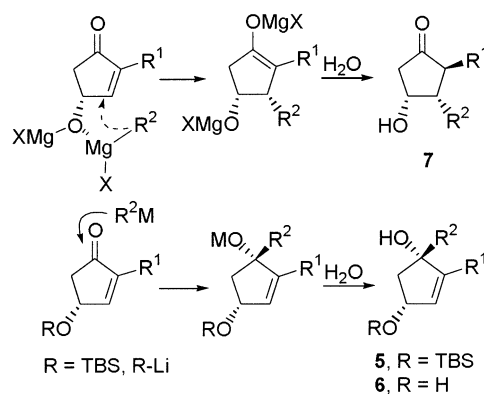
^a THF was used as a solvent. Reactions with R²Li (2.2 equiv) were carried out from -78°C to room temperature, and reactions with R²MgX (2.2 equiv) were carried out at reflux temperature.
^b Determined by integration of the ¹H NMR spectra (CDCl₃, 300 MHz) of the crude reaction mixtures. ^c Isolated yields after silica gel chromatography (2:1 Hx–EtOAc).

in the addition of cuprate reagents to cyclopentenones 3, as evidenced by the comparison of the spectroscopic data of compounds 9a and 10a (R¹ = Ph, R² = Me).

On the other hand, the reaction of organolithium reagents with cyclopentenones 4 took place in a 1,2-fashion to afford compounds 6 (3,5-syn), with the same stereoselectivity previously observed for the addition of organolithium and organomagnesium reagents to the TBS derivatives 3, as produced by the conversion of compounds 6 into the related O-TBS derivatives 5 (Scheme 3). The results are given in Table 2.

The stereochemical outcome of the addition reactions with organomagnesium reagents may be understood on the basis of an intramolecular chelation-directed delivery

Scheme 4



of the Grignard species to the β -vinyl carbon of the starting 4-hydroxycyclopentenones 4 (Scheme 4), which should take place in a syn fashion.^{3,9} Conversely, coordination of the organomagnesium species to the oxygen at carbon C-4 would not be possible in the presence of the bulky TBS group in compounds 3, and thus intermolecular addition would take place in a 1,2-fashion from the less encumbered diastereotopic face of the carbonyl group, with anti diastereoselectivity. On the other hand, organolithiums, which are harder nucleophiles than organomagnesium reagents, would always give 1,2-addition irrespective of the substitution at C-4 of the starting cyclopentenone. This addition takes place opposite to the bulky substituent at C-4 (TBSO or RLi–O complex), affording cyclopentenones 5 or 6 (3,5-syn).

In conclusion, a highly regio- and stereoselective method for the 1,2- or 1,4-addition reactions to 4-hydroxy-2-cyclopentenones has been devised, which makes use of readily available organolithium and Grignard reagents. This procedure allows for stereochemistry complementary to that observed in the 1,4-addition of organocuprates and makes possible the attachment of aromatic groups to carbons C-2 and C-3 of cyclopentenones 5 or 6

(9) For related models, see: Felkin, H.; Swierczewski, G.; Tambuté, A. *Tetrahedron Lett.* **1969**, 9, 707–710.

and carbons C-4 and C-5 of cyclopentanones **7**, which are of interest for further elaboration into biologically active targets.¹⁰

Experimental Section

Silica gel 60 F₂₅₄ was used for TLC, and the spots were detected with UV and vanillin solution. Flash column chromatography was carried out on silica gel 60. IR spectra have been recorded as CHCl₃ solutions. ¹H and ¹³C NMR spectra were recorded at 200 or 300 MHz and 50.5 or 75.5 MHz, respectively. MS was carried out at 70 eV. The 4-hydroxy-2-cyclopentenones **4** were prepared from furans **8** as previously reported.³

Synthesis of Cyclopentenones **3**: General Procedure.

To a solution of **4** (2.48 mmol) in pyridine (12.4 mL) were added TBS-Cl (748 mg, 4.96 mmol) and DMAP (60 mg, 0.49 mmol). The mixture was stirred for 24 h at room temperature. Filtration of the reaction mixture, rinsing with CH₂Cl₂ (2 × 5 mL), and evaporation of the solvent afforded an oil that was purified by chromatography (2:1 hexane–ethyl acetate).

4-(‘Butyldimethylsilyloxy)-2-phenylcyclopent-2-enone (3a): 90%, white solid, mp 58–59 °C (MeOH); IR (CHCl₃) ν 1700 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.68–7.65 (2H, m), 7.51 (1H, d, ³J = 2.3 Hz), 7.38–7.33 (3H, m), 4.98 (1H, m), 2.91 (1H, B part of ABX system, ³J = 5.7 Hz, ³J = 18.0 Hz), 2.47 (1H, A part of ABX system, ³J = 2.4 Hz, ³J = 18.0 Hz), 0.91 (9H, s), 0.15 (3H, s), 0.13 (3H, s); ¹³C NMR (75.5 MHz, CDCl₃) δ 204.0, 157.3, 143.5, 130.6, 128.9, 128.4, 127.5, 68.3, 46.6, 25.7, 18.1. Anal. Calcd for C₁₇H₂₄O₂Si: C, 70.78; H, 8.39. Found: C, 70.99; H, 8.42.

4-(‘Butyldimethylsilyloxy)-2-methylcyclopent-2-enone (3b): 90%, colorless oil; IR (CHCl₃) ν 1715 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 6.98–6.94 (1H, m), 4.78–4.72 (1H, m), 2.59 (1H, B part of ABX system, ³J = 5.9 Hz, ³J = 18.3 Hz), 2.13 (1H, A part of ABX system, ³J = 2.1 Hz, ³J = 18.3 Hz), 1.16 (3H, d, ⁴J = 2.9 Hz), 0.78 (9H, s), 0.01 (3H, s), 0.00 (3H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 206.3, 157.4, 142.7, 68.8, 45.0, 25.6, 18.0, 9.7. Anal. Calcd for C₁₂H₂₂O₂Si: C, 63.67; H, 9.80. Found: C, 63.77; H, 9.70.

Reaction of Cyclopentenones **3 and **4** with Grignard Reagents: General Procedure.** To a solution of **3** or **4** (2.56 mmol) in THF (3.0 mL) at 0 °C was added dropwise a 1 M solution of R²MgX in THF (3.0 mL for compounds **3**, 6.0 mL for compounds **4**). The mixture was stirred at reflux temperature for 2 h, cooled to room temperature, and hydrolyzed with saturated NH₄Cl solution (3.0 mL). The organic layer was decanted and the aqueous layer extracted with Et₂O (3 × 10 mL). The combined organic layers were dried on MgSO₄. Filtration and elimination of the solvent under reduced pressure afforded an oil that was purified by chromatography (10:1 hexane–Et₂O).

Reaction of Cyclopentenones **3 and **4** with Organolithium Reagents: General Procedure.** To a solution of **3** (2.56 mmol) in THF (3.0 mL) at 0 °C was added dropwise a 1 M solution of MeLi in Et₂O (3.0 mL for compounds **3**, 6.0 mL for compounds **4**) or a 1.8 M solution of PhLi in cyclohexanes–Et₂O (1.67 mL for compounds **3**, 3.34 mL for compounds **4**). After the mixture was stirred for 2 h at room temperature, all operations were followed as above.

(1S*,4R*)-4-(‘Butyldimethylsilyloxy)-1-methyl-2-phenylcyclopent-2-enol (5a): white solid, mp 55–56 °C (hexane–ethyl acetate); IR (CHCl₃) ν 3400 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.55–7.49 (2H, m), 7.27–7.13 (3H, m), 5.87 (1H, d, ³J = 2.3 Hz), 4.60 (1H, m), 2.33 (1H, B part of ABX system, ³J = 6.3 Hz, ³J = 13.5 Hz), 1.89 (1H, A part of ABX system, ³J = 3.2 Hz, ³J = 13.5 Hz), 1.31 (3H, s), 0.79 (9H, s), 0.01 (3H, s), 0.00 (3H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 150.6, 134.8, 131.2, 128.2, 127.7, 127.5, 82.1, 73.1, 52.8, 25.9, 25.7, 18.1. Anal. Calcd for C₁₈H₂₈O₂Si: C, 71.00; H, 9.27. Found: C, 71.16; H, 9.32.

(1S*,4R*)-4-(‘Butyldimethylsilyloxy)-1,2-diphenylcyclopent-2-enol (5b): white solid, mp 76–78 °C (hexane–ethyl acetate); IR (CHCl₃) ν 3415 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.31–7.02 (10H, m), 6.26 (1H, d, ³J = 2.3 Hz), 4.77 (1H, m), 2.53

(1H, B part of ABX system, ³J = 6.3 Hz, ³J = 13.5 Hz), 2.12 (1H, A part of ABX system, ³J = 3.7 Hz, ³J = 13.5 Hz), 0.80 (9H, s), 0.01 (6H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 149.3, 145.3, 133.9, 132.9, 128.5, 128.3, 127.9, 127.7, 126.8, 125.0, 86.2, 73.6, 56.1, 26.1, 18.4. Anal. Calcd for C₂₃H₃₀O₂Si: C, 75.36; H, 8.25. Found: C, 75.48; H, 8.44.

(1S*,4R*)-4-(‘Butyldimethylsilyloxy)-2-methyl-1-phenylcyclopent-2-enol (5c): colorless oil; IR (CHCl₃) ν 3425 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.29–7.15 (5H, m), 5.59 (1H, m), 4.69 (1H, m), 2.59 (1H, B part of ABX system, ³J = 6.6 Hz, ³J = 13.9 Hz), 1.99 (1H, A part of ABX system, ³J = 3.6 Hz, ³J = 13.9 Hz), 1.47 (3H, s), 0.83 (9H, s), 0.00 (6H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 147.8, 144.6, 131.2, 128.2, 126.6, 127.8, 85.8, 74.0, 54.1, 25.9, 18.1, 11.9. Anal. Calcd for C₁₈H₂₈O₂Si: C, 71.00; H, 9.27. Found: C, 71.25; H, 9.51.

(1S*,3R*)-1-Methyl-5-phenylcyclopent-4-ene-1,3-diol (6a): colorless oil; IR (CHCl₃) ν 3280 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.56–7.49 (2H, m), 7.27–7.19 (3H, m), 5.94 (1H, d, ³J = 2.3 Hz), 4.61 (1H, m), 2.44 (1H, B part of ABX system, ³J = 6.9 Hz, ³J = 14.2 Hz), 1.94 (1H, A part of ABX system, ³J = 2.9 Hz, ³J = 14.2 Hz), 1.32 (3H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 151.2, 134.4, 130.5, 128.2, 127.8, 127.5, 82.1, 72.7, 52.0, 26.5. Anal. Calcd for C₁₂H₁₄O₂: C, 75.76; H, 7.42. Found: C, 75.92; H, 7.61.

(1S*,3R*)-1,5-Dimethylcyclopent-4-ene-1,3-diol (6b): colorless oil; IR (CHCl₃) ν 3390 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 5.44 (1H, m), 4.48 (1H, m), 2.34 (1H, B part of ABX system, ³J = 6.9 Hz, ³J = 14.3 Hz), 1.78 (1H, A part of ABX system, ³J = 3.0 Hz, ³J = 14.3 Hz), 1.69 (3H, s), 1.21 (3H, s); ¹³C NMR (50.5 MHz, CDCl₃) δ 149.1, 128.9, 81.4, 73.0, 50.7, 25.6, 11.3. Anal. Calcd for C₇H₁₂O₂: C, 65.60; H, 9.44. Found: C, 65.75; H, 9.61.

(2R*,3S*,4R*)-4-Hydroxy-3-methyl-2-phenylcyclopentanone (7a): colorless oil; IR (CHCl₃) ν 3450, 1740 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.30–7.13 (3H, m), 7.02–6.98 (2H, m), 4.33 (1H, m), 3.20 (1H, d, ³J = 12.6 Hz), 2.48–2.46 (2H, m), 2.37–2.13 (1H, m), 1.04 (3H, d, ³J = 6.7 Hz); ¹³C NMR (50.5 MHz, CDCl₃) δ 216.7, 137.2, 128.5, 126.9, 70.0, 58.4, 48.3, 42.6, 12.9. Anal. Calcd for C₁₂H₁₄O₂: C, 75.76; H, 7.42. Found: C, 75.91; H, 7.66.

(2R*,3S*,4R*)-4-Hydroxy-3-ethyl-2-phenylcyclopentanone (7b): colorless oil; IR (CHCl₃) ν 3450, 1730 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.31–7.14 (3H, m), 7.03–6.97 (2H, m), 4.53 (1H, m), 3.26 (1H, d, ³J = 12.5 Hz), 2.49–2.47 (2H, m), 2.18–2.02 (1H, m), 1.69–1.39 (2H, m), 0.86 (3H, t, ³J = 7.4 Hz); ¹³C NMR (50.5 MHz, CDCl₃) δ 216.9, 138.0, 128.9, 128.8, 127.2, 67.8, 58.1, 51.8, 48.6, 21.0, 11.8. Anal. Calcd for C₁₃H₁₆O₂: C, 76.44; H, 7.90. Found: C, 76.61; H, 8.03.

(2R*,3R*,4R*)-4-Hydroxy-2,3-diphenylcyclopentanone (7c): white solid, mp 102–103 °C (hexanes–ethyl acetate); IR (CHCl₃) ν 3460, 1740 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.31–7.04 (10H, m), 4.50 (1H, m), 4.02 (1H, d, ³J = 13.1 Hz), 3.68 (1H, dd, ³J = 3.5 Hz, ³J = 13.1 Hz), 2.61 (2H, m); ¹³C NMR (50.5 MHz, CDCl₃) δ 214.5, 136.6, 136.2, 128.9, 128.5, 128.4, 128.3, 127.5, 127.0, 70.5, 54.6, 54.3, 46.9. Anal. Calcd for C₁₇H₁₆O₂: C, 80.93; H, 6.39. Found: C, 81.11; H, 6.50.

(2R*,3R*,4R*)-3-(4-Fluorophenyl)-4-hydroxy-2-phenylcyclopentanone (7d): white solid, mp 106–107 °C (hexane–ethyl acetate); IR (CHCl₃) ν 3460, 1740 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 7.35–7.21 (5H, m), 7.18–7.01 (4H, m), 4.54 (1H, m), 3.98 (1H, d, ³J = 13.2 Hz), 3.67 (1H, dd, ³J = 3.4 Hz, ³J = 13.1 Hz), 2.65 (2H, m); ¹³C NMR (50.5 MHz, CDCl₃) δ 214.2, 162.1 (d, ¹J_{CF} = 245 Hz), 138.0, 132.4 (d, ⁴J_{CF} = 3 Hz), 129.9 (d, ³J_{CF} = 3 Hz), 128.6, 128.4, 127.1, 115.9 (d, ²J_{CF} = 21 Hz), 70.5, 54.7, 53.9, 46.9. Anal. Calcd for C₁₇H₁₅FO₂: C, 75.54; H, 5.59. Found: C, 75.70; H, 5.71.

(2S*,3S*,4R*)-4-Hydroxy-2,3-dimethylcyclopentanone (7e): colorless oil; IR (CHCl₃) ν 3450, 1735 cm⁻¹; ¹H NMR (200 MHz, CDCl₃) δ 4.30 (1H, m), 2.34 (1H, m), 2.11–1.95 (1H, m), 1.79–1.61 (1H, m), 1.13 (3H, d, ³J = 7.5 Hz), 1.00 (3H, d, ³J = 7.0 Hz); ¹³C NMR (50.5 MHz, CDCl₃) δ 219.9, 70.6, 47.6, 46.5, 44.6, 13.2, 12.4. Anal. Calcd for C₇H₁₂O₂: C, 65.60; H, 9.44. Found: C, 65.73; H, 9.61.

Synthesis of (2R*,3S*,4R*)-4-(‘Butyldimethylsilyloxy)-3-methyl-2-phenylcyclopentanone (9a). To a solution of **7a** (471 mg, 2.48 mmol) in pyridine (12.4 mL) were added TBS-Cl (748 mg, 4.96 mmol) and DMAP (60 mg, 0.49 mmol). The mixture was stirred for 24 h at room temperature. Filtration of

(10) For example benzoprostacyclins, see: Larock, R. C.; Lee, N. H. *J. Org. Chem.* **1991**, *56*, 6253–6254 and references cited therein.

the reaction mixture, rinsing with CH_2Cl_2 (2×5 mL), and evaporation of the solvent afforded an oil that was purified by chromatography (2:1 hexane–ethyl acetate): 90%, white solid, mp 56–57 °C (hexane–ethyl acetate); IR (CHCl_3) ν 1745 cm^{-1} ; ^1H NMR (200 MHz, CDCl_3) δ 7.27–7.10 (3H, m), 7.01–6.96 (2H, m), 4.31 (1H, m), 3.13 (1H, d, $^3J = 12.5$ Hz), 2.42–2.39 (2H, m), 2.30–2.17 (1H, m), 0.98 (3H, d, $^3J = 6.7$ Hz), 0.80 (3H, s), 0.02 (3H, s), 0.01 (3H, s), 18.0, 13.5. Anal. Calcd for $\text{C}_{18}\text{H}_{28}\text{O}_2\text{Si}$: C, 71.00; H, 9.27. Found: C, 71.25; H, 9.39.

Synthesis of (2*R,3*S**,4*S**)-4-(*n*-Butyldimethylsilyloxy)-3-methyl-2-phenyl-cyclopentanone (10a).** To a solution of CuI (145 mg, 0.76 mmol) in Et_2O (5.0 mL) at 0 °C was added dropwise a 1.6 M solution of MeLi in Et_2O (0.95 mL, 1.52 mmol). After the mixture was stirred for 10 min, a solution of **3a** (199 mg, 0.69 mmol) in Et_2O (5 mL) was added. The mixture was stirred at 0 °C for 2 h and hydrolyzed with saturated NH_4Cl solution (3.0 mL). The organic layer was decanted and the aqueous layer extracted with Et_2O (3×10 mL). The combined organic layers were dried on MgSO_4 . Filtration and elimination of the solvent under reduced pressure afforded a pale yellow oil that was purified by chromatography (10:1 hexane– Et_2O): 85%,

colorless oil; IR (CHCl_3) ν 1745 cm^{-1} ; ^1H NMR (200 MHz, CDCl_3) δ 7.29–7.12 (3H, m), 7.09–6.99 (2H, m), 3.97–3.85 (1H, m), 2.81 (1H, d, $^3J = 12.7$ Hz), 2.69 (1H, B part of ABX system, $^3J = 7.2$ Hz, $^3J = 18.5$ Hz), 2.26 (1H, A part of ABX system, $^3J = 9.0$ Hz, $^3J = 18.5$ Hz), 2.30–2.10 (1H, m), 1.04 (3H, d, $^3J = 6.4$ Hz), 0.80 (3H, s), 0.02 (3H, s), 0.01 (3H, s); ^{13}C NMR (50.5 MHz, CDCl_3) δ 213.1, 136.5, 128.6, 128.5, 127.0, 62.9, 47.8, 47.5, 25.6, 17.9, 15.9. Anal. Calcd for $\text{C}_{18}\text{H}_{28}\text{O}_2\text{Si}$: C, 71.00; H, 9.27. Found: C, 71.21; H, 9.50.

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Supporting Information Available: ^1H and ^{13}C NMR of compounds **3**, **5–7**, **9**, and **10**. This material is available free of charge via the Internet at <http://pubs.acs.org>.

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