Endo Mode Cyclization of 5,6-Epoxy-7-octyn-1-ol Derivatives

Chisato Mukai,* Sumie Yamaguchi, Yu-ichi Sugimoto, Naoki Miyakoshi, Eiji Kasamatsu, and Miyoji Hanaoka*

Faculty of Pharmaceutical Sciences, Kanazawa University, Takara-machi 13-1, Kanazawa 920-0934, Japan

cmukai@kenroku.kanazawa-u.ac.jp

Received March 24, 2000

Introduction

In previous papers,[1] we reported a new and efficient procedure for the construction of oxygen-atom containing heterocycles **2** (n = 1, 2) possessing the 2-ethynyl-3-hydroxy functionality as a common structural feature starting from the epoxy-alkyne derivatives **1**. Thus 3,4-epoxy-5-hexyn-1-ol and 4,5-epoxy-6-heptyn-1-ol derivatives **1** (n = 1, 2) have become suitable substrates for the endo mode cyclization to give, upon successive treatment with dicobaltoctacarbonyl [$Co_2(CO)_8$] and a catalytic amount of Lewis acid[2] such as boron trifluoride diethyl etherate (BF_3·OEt_2) at −78 °C, the corresponding oxacycles **2** (n = 1, 2) in a highly stereoselective manner after demetalation with cerium(IV) ammonium nitrate (CAN). The exo mode products [i.e., oxetane (n = 1) and tetrahydrofuran (n = 2) derivatives] could never be detected in this procedure. It should be mentioned that this procedure proceeded stereospecifically and stereocomplementarily to provide the oxacycles **2**; namely the *trans*-epoxide **1** afforded the corresponding **2** having a *cis*-2-ethynyl-3-hydroxy substituent, while *cis*-**1** furnished *trans*-2-ethynyl-3-hydroxy-**2**. In addition, this endo mode cyclization method could be applicable to the azacongener **3** (n = 2)[3] ending up with the stereoselective total synthesis of (±)-swainsonine, a representative indolizidine alkaloid.

The next phase of this program was to confirm whether this newly developed endo mode cyclization[4] could be applied to the construction of larger ring-sized oxacycles such as the seven-membered oxacycle **2** (n = 3) (oxepane ring system) and the eight-membered one **2** (n = 4) (oxocane ring system). Therefore, our efforts are directed toward investigating the $Co_2(CO)_8$-mediated[5] endo mode cyclization of 5,6-epoxy-7-octyn-1-ol species **1** (n = 3) leading to the corresponding oxepane derivatives with the 2-ethynyl-3-hydroxy functionality. This paper deals with the stereoselective but not the stereospecific construction of the oxepane derivatives.[6]

Results and Discussion

The required *trans*-epoxy and *cis*-epoxy compounds for the endo mode cyclization were prepared by conventional means (Scheme 2). The mono-*tert*-butyldimethylsilyl (TBDMS)-protected alcohol **4** was oxidized under Swern conditions to afford the labile aldehyde, which was subsequently exposed to the Horner−Emmons reaction with ethyl (diethylphosphono)acetate providing the (*E*)-ester **5** in 96% yield. Transformation of an ester moiety of **5** into the alkyne functionality was realizes as follows. The consecutive reduction of **5** with diisobutylaluminum hydride (DIBAL-H) and oxidation under Swern conditions produced the enal, which was then exposed to Corey's dibromoolefination and base treatment[7] to leave the enyne (*E*)-**6** in 62% overall yield. The introduction of the trimethylsilyl (TMS) group at the acetylenic terminus of (*E*)-**6** was followed by acidic hydrolysis to afford (*E*)-**7a** in 67% yield. The phenyl derivative (*E*)-**7b** was also derived from (*E*)-**6** under conventional conditions.[8] Epoxidation of (*E*)-**7a** with *m*-chloroperbenzoic acid (*m*CPBA) in methylene chloride gave *trans*-**8a** (*trans*:*cis* = 91:9). The other *trans*-enynes (*E*)-**7b** and (*E*)-**6** afforded *trans*-**8b** (*trans*:*cis* = 81:19) and *trans*-**8c** (*trans*:*cis* = 95:5), respectively, upon treatment with *m*CPBA and tetra-*n*-butylammonium fluoride (TBAF). The primary hydroxy group of these *trans*-epoxides **8** was silylated with TMS-imidazole to provide the *trans*-**9**. The *cis*-congeners **9** for endo mode cyclization were also prepared from the same starting material **4** as shown in Scheme 2 (see Experimental Section).

According to the procedure previously described for the transformation of the epoxy-alkyne derivatives **1** (n = 1, 2) to tetrahydrofuran and tetrahydropyran frameworks **2**,[1] *trans*-**8a** was treated with $Co_2(CO)_8$ in methylene chloride at room temperature to afford the corresponding cobalt complex, which was subsequently exposed to a catalytic amount of BF_3·OEt_2 (0.1 equiv) at −78 °C to furnish a mixture of *cis*-**11a** and *trans*-**11a** in 16% yield in a ratio of 54 to 46 (Scheme 3). Changing the Lewis acid from BF_3·OEt_2 to the other Lewis acids such as $SnCl_4$, $TiCl_4$, and BBr_3 were found to be fruitless. The organic acids such as CF_3CO_2H and CH_3SO_3H did not work well either. Our efforts were then focused on changing the amounts of the Lewis acid, anticipating improvement in the chemical yield. Thus increasing the amount of BF_3·OEt_2 from a catalytic to a stoichiometric

* To whom correspondence should be addressed. Chisato Mukai: tel: +81-76-234-4411, fax: +81-76-234-4410.

(1) (a) Mukai, C.; Ikeda, Y.; Sugimoto, Y.; Hanaoka, M. *Tetrahedron Lett.* **1994**, *35*, 2179. (b) Mukai, C.; Sugimoto, Y.; Ikeda, Y.; Hanaoka, M. *Tetrahedron Lett.* **1994**, *35*, 2183. (c) Mukai, C.; Sugimoto, Y. Ikeda, Y.; Hanaoka, M. *J. Chem. Soc., Chem. Commun.* **1994**, 1161. (d) Mukai, C.; Sugimoto, Y.; Ikeda, Y.; Hanaoka, M. *Tetrahedron* **1998**, *54*, 823.

(2) Nicholas, K. M. *Acc. Chem. Res.* **1987**, *20*, 207.

(3) Mukai, C.; Sugimoto, Y.; Miyazawa, K.; Yamaguchi, S.; Hanaoka, M. *J. Org. Chem.* **1998**, *63*, 6281.

(4) Endo mode cyclization for the preparation of seven-membered oxacycles: (a) Matsukura, H.; Morimoto, M.; Koshino, H.; Nakata, T. *Tetrahedron Lett.* **1997**, *38*, 5545. (b) Fujiwara, K.; Mishima, H.; Amano, A.; Tokiwano, T.; Murai, A. *Tetrahedron Lett.* **1998**, *39*, 393.

(5) $Co_2(CO)_8$-mediated construction of seven-membered oxacycles: (a) Tanaka, S.; Isobe, M. *Tetrahedron Lett.* **1994**, *35*, 7801. (b) Hosokawa, S.; Isobe, M. *Synlett* **1995**, 1179. (c) Palazon, J. M.; Martin, V. S. *Tetrahedron Lett.* **1996**, *36*, 3549.

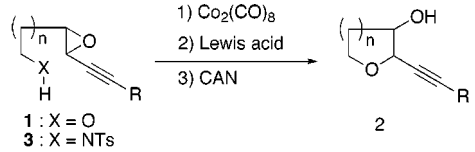
(6) Review for synthesis of of seven-membered oxacycles: (a) Boyd, D. R. *In Comprehensive Heterocyclic Chemistry*; Lwowski, W., Ed.; Pergamon: Oxford, 1984; Vol. 7, p 547. (b) Hassenruck, K.; Martin H. D. *Synthesis* **1988**, 569. (c) Moody, C. J.; Davies, M. J. *In Studies in Natural Products Chemistry*; Atta-ur-Rahman, Ed.; Elsevier: New York, 1992; Vol. 10, p 201. (d) Burns, C. J. *Contemp. Org. Synth.* **1994**, *1*, 23. (e) Wlliott, M. C. *Contemp. Org. Synth.* **1994**, *1*, 457. (f) Alvarez, E.; Candenas, M.-L.; Perez, R.; Ravelo, J. L.; Martin, J. D. *Chem. Rev.* **1995**, *95*, 1953. (g) Belen′kll, L. I. *In Comprehensive Heterocyclic Chemistry II*; Katritzky, A. R., Rees, C. W., Scriven, E. F., Eds.; Pergamon: Oxford, 1996; p 45. (h) Nicolaou, K. C. *Angew. Chem., Int. Ed. Engl.* **1996**, *35*, 589. (i) Hoberg, J. O. *Tetrahedron* **1998**, *54*, 12631, and references therein.

(7) Corey, E. J.; Fuchs, P. L. *Tetrahedron Lett.* **1972**, 3769.

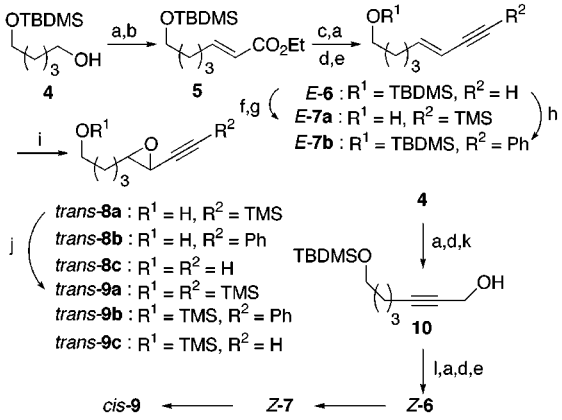
(8) Sonogashira, K.; Tohda, Y.; Hagihara, N. *Tetrahedron Lett.* **1975**, 4467.

10.1021/jo000450+ CCC: $19.00
Published on Web 09/07/2000

Scheme 1



Scheme 2



[a]Reaction conditions: (a) DMSO, $(COCl)_2$, Et_3N; (b) NaH, $(EtO)_2POCH_2CO_2Et$; (c) DIBAL-H; (d) PPh_3, CBr_4; (e) *n*-BuLi; (f) *n*-BuLi, TMSCl; (g) 1%HCl, EtOH; (h) $Pd(PPh_3)_2Cl_2$, CuI, C_6H_5I, $(^iPr)_2NH$; (i) *m*CPBA; (j) TMS-imidazole; (k) *n*-BuLi, $(CHO)_n$; (l) H_2, Pd-$CaCO_3$

Scheme 3

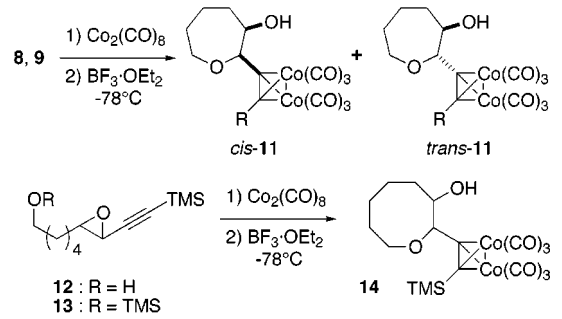


Table 1. Ring Closure of Epoxides 8, 9

entry	substrate	product	R	product ratio[a] *cis*:*trans*	yield[b] (%)
1	*trans*-**8a**[c]	**11a**	TMS	72:28	62
2	*trans*-**8b**[d]	**11b**	Ph	78:22	44
3	*trans*-**8c**[e]	–	H	–	0
4	*trans*-**9a**[c]	**11a**	TMS	70:30	75
5	*trans*-**9b**[f]	**11b**	Ph	78:22	62
6	*trans*-**9c**[g]	**11c**	H	68:32	20
7	*cis*-**9a**	**11a**	TMS	69:31	76
8	*cis*-**9b**[h]	**11b**	Ph	78:22	56
9	*cis*-**9c**[h]	**11c**	H	72:28	33

[a] Ratio of each isomer isolated by chromatography. [b] Isolated yields. [c] A mixture (*trans*:*cis* = 91:9) was used. [d] A mixture (*trans*:*cis* = 81:19) was used. [e] A mixture (*trans*:*cis* = 95:5) was used.[f] A mixture (*trans*:*cis* = 83:17) was used. [g] A mixture (*trans*:*cis* = 93:7) was used. [h] A mixture (*cis*:*trans* = 93:7) was used.

amount gave **11a** in 33% (*cis*-**11a**:*trans*-**11a** = 55:45). When 3.0 equiv of BF_3·OEt_2 was employed, the ring closed product **11a** was stereoselectively obtained in a higher yield (62%, *cis*-**11a**:*trans*-**11a** = 72:28) (Table 1, entry 1). This condition (3.0 equiv of BF_3·OEt_2) could be used for the ring closure of *trans*-**8b** having a phenyl substituent at the acetylenic terminus to yield the oxepane derivative **11b** in a rather lower yield (44%) in a *cis*-selective manner (*cis*-**11b**:*trans*-**11b** = 78:22) (entry 2). However, the *trans*-epoxy derivative **8c** without a substituent at the triple bond terminus gave only an intractable mixture for some unknown reason (entry 3).

It is known that the trimethylsiloxy group can serve as a surrogate for the free hydroxy functionality, for example, in the transformation of the carbonyl functionality into acetal species.[9] Therefore, we next attempted the ring closure of the TMS-derivatives, *trans*-**9**, hoping to improve the chemical yield as well as the stereoselectivity. The obtained results are presented in Table 1 (entries 4−6). The exposure of *trans*-**9a** under standard conditions [treatment with $Co_2(CO)_8$ and 3.0 equiv of BF_3·OEt_2] gave **11a** in 75% yield (entry 4), although the level of stereoselectivity was the same as that observed in the reaction of **8a** (entry 1). Similarly, *trans*-**9b** afforded **11b** in a higher yield (62%) compared to the case of **8b**. It would be noteworthy that *trans*-**9c** could be converted into the oxepane skeleton **11c**, although the chemical yield (20%) is far from being satisfactory (entry 6). This was not the case when *trans*-**8c** was exposed to the ring closure conditions leading to an intractable mixture (entry 3). Similar treatment of *cis*-**9** afforded the corresponding **11** in a *cis*-selective manner instead of in a *trans*-selective manner (entries 7−9).

There are several features that should be pointed out: (i) Endo mode cyclization proceeded in acceptable yields, and the corresponding exo mode products could not be isolated from the reaction mixture. Complete control of the regioselectivity was thus realized as anticipated. (ii) Improvement of the chemical yields was made by introduction of the TMS group[10] on the primary hydroxy group of the epoxy-alcohol derivatives. (iii) Although stereoselective construction of the oxepane frameworks with a 2,3-*cis*-substituents were achieved from both the *trans*- and *cis*-epoxy derivatives **9** through the endo mode cyclization, the degree of stereoselectively was lower than those of **2** (n = 1, 2),[1] and no stereospecificity could be observed. Similar degree of *cis*-selectivity (*cis*:*trans* = ca. 70:30) recorded in all cases as well as nonstereospecificity might tentatively be interpreted in the terms of intermediacy of the common propynyl cation species.[11] The ring opening of the epoxy moiety of both *cis*- and *trans*-5,6-epoxy-7-octyn-1-ol derivatives **8** and **9** assisted by a Lewis acid would lead to the common cobalt-complexed carbenium ion intermediates,[11] which then collapse to the ring-closed product **11** in a *cis*-selective manner, although the reason for the preferential formation of *cis*-product over *trans*-one is uncertain.

To confirm the limitation of this endo mode cyclization, we next investigated the ring closure of the one carbon-elongated epoxides **12** and **13**[12] under the conditions described above. Thus the treatment of **12** and **13**, prepared from hexanediol according to the method depicted in Scheme 2, with $Co_2(CO)_8$ was followed by exposure to BF_3·OEt_2 resulting in an intractable mixture. Unfortunately the formation of the desired eight-membered oxacycle **14** could never be detected. On the basis

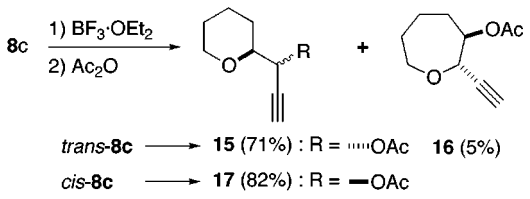
(9) Tsunoda, T.; Suzuki, M.; Noyori, R. *Tetrahedron Lett.* **1980**, *21*, 1357.

(10) The reason for the improvment of chemical yields by introduction of the TMS group is so far uncertain.

(11) (a) Schreiber, S. L.; Sammakia, T.; Crowe, W. E. *J. Am. Chem. Soc.* **1986**, *108*, 3128. (b) Schreiber, S. L.; Klimas, M. T.; Sammakia, T. *J. Am. Chem. Soc.* **1987**, *109*, 5749.

(12) Spectral data of **12** and **13** are presented in Supporting Information.

Scheme 4



of these experimental results in combination with the previous observation,[1] it would be concluded that the newly developed endo mode ring closure method can be successfully applied to the construction of five-, six-, and seven-membered oxygen atom-containing heterocycles, but not for that of medium-sized oxygen-containing heterocycles involving oxocane species (eight-membered oxacycles).

Upon direct exposure to a catalytic amount of $BF_3{\cdot}OEt_2$ (0.1 equiv) in methylene chloride at −78 °C, *trans*-**8c** gave a mixture of ring-closed products which was subsequently acetylated to furnish the exo mode product **15** in 71% yield with inverted stereochemistry at the homopropynyl position of **8c** in a highly stereoselective manner together with a small amount of the endo mode product **16** (5%) with inversion of configuration at the propynyl position (Scheme 4). The *cis*-congener, *cis*-**8c**, exclusively provided the exo mode product **17** in 82% yield as expected. These results in the control experiments were in good accordance with the prediction base on the previous works[1] and indicated that cobalt complexation of the epoxy-alcohol derivatives is mandatory for exclusive endo mode cyclization.

In summary, we have described a new procedure for the stereoselective synthesis of *cis*-3-hydroxy-2-ethynyloxepane derivatives from 5,6-epoxy-7-octyn-1-ols through the endo mode cyclization mediated by $Co_2(CO)_8$. This result, in combination with the previous studies, demonstrates that the $Co_2(CO)_8$-mediated endo mode cyclization can be applicable to the construction of tetrahydrofuran, tetrahydropyran, and oxepane skeletons possessing a 2-ethynyl-3-hydroxy substituent as a common structural feature.

Experimental Section

Melting points are uncorrected. IR spectra were measured in $CHCl_3$. ^1H NMR spectra were taken in $CDCl_3$. $CHCl_3$ (7.26 ppm) was used as an internal standard for silyl compounds. TMS was employed as an internal standard for other compounds. ^{13}C NMR spectra were recorded in $CDCl_3$ with $CHCl_3$ (77.00 ppm) as an internal standard. CH_2Cl_2 was freshly distilled from phosphorus pentaoxide, and THF was from sodium diphenyl ketyl, prior to use. All reactions were carried out under nitrogen atmosphere otherwise stated. Silica gel (silica gel 60, 230−400 mesh, Merck) was used for chromatography. Organic extracts were dried over anhydrous Na_2SO_4.

Ethyl 7-(*tert*-Butyldimethysiloxy)-2-heptenoic Acid (5). A solution of DMSO (7.10 mL, 100 mmol) in CH_2Cl_2 (15.0 mL) was added to a solution of oxalyl chloride (4.40 mL, 50.4 mmol) in CH_2Cl_2 (230 mL) at −78 °C over a period of 5 min. After the mixture was stirred for 15 min, a solution of the alcohol **4** (10.0 g, 45.8 mmol) was added to the CH_2Cl_2 solution, and the reaction mixture was stirred at the same temperature for an additional 1 h. Et_3N (32.0 mL, 229 mmol) was then added to the reaction mixture, which was gradually warmed to room temperature and diluted with CH_2Cl_2. The CH_2Cl_2 solution was washed with water and brine, dried, and concentrated to leave the crude aldehyde. The crude aldehyde was used directly for the next reaction. To a suspension of NaH (60% NaH in oil, 1.01 g, 50.4 mmol) in THF (100 mL) was added at 0 °C a solution of ethyl (diethylphosphono)acetate (10.0 mL, 50.4 mmol), and the mixture was stirred for 1 h. A solution of the crude aldehyde in THF (20.0 mL) was then added to a solution of the ylide thus adjusted in THF at 0 °C, and the mixture was stirred for 10 min at room temperature, quenched by addition of saturated aqueous NH_4Cl, and extracted with AcOEt. The extract was dried and concentrated to give a residue, which was chromatographed with hexane−AcOEt (15:1) to afford **5** (12.6 g, 96%) as a colorless oil: IR 1707, 1653 cm^{-1}; ^1H NMR δ 6.96 (dt, 1H, J = 15.6, 6.8 Hz), 5.18 (dt, 1H, J = 15.6, 1.5 Hz), 4.18 (q, 2H, J = 6.8 Hz), 3.61 (t, 2H, J = 5.9 Hz), 2.21 (qd, 2H, J = 6.8, 1.5 Hz), 1.58−1.51 (m, 4H), 1.28 (t, 3H, J = 6.8 Hz), 0.89 (s, 9H), 0.04 (s, 6H); ^{13}C NMR δ 166.70, 149.11, 121.40, 62.73, 60.11, 32.20, 31.92, 25.93, 24.37, 18.33, 14.27, −5.34; MS m/z 286 (M^+, 0.5). Anal. Calcd for $C_{15}H_{30}O_3Si$: C, 62.89; H, 10.55. Found: C, 62.53; H, 10.63.

(3*E*)-8-(*tert*-Butyldimethylsiloxy)-3-octen-1-yne [(*E*)-6]. To a solution of **5** (6.08 g, 21.2 mmol) in dry hexane (100 mL) was gradually added DIBAL-H (1.0 M hexane solution; 47.0 mL, 47.0 mmol) at −78 °C. The reaction mixture was kept at the same temperature for 5 min, quenched with water and saturated aqueous Na_2SO_4, and filtrated by suction. The filtrate was extracted with AcOEt, which was washed with water and brine, dried, and concentrated to dryness. The residue was passed through a short pad of silica gel with hexane−AcOEt (8:1) to give the alcohol [4.94 g, 96%; IR 3613, 1669 cm^{-1}; ^1H NMR δ 5.69 (dt, 1H, J = 15.1, 6.4 Hz), 5.64 (dt, 1H, J = 15.1, 5.4 Hz), 4.08 (d, 2H, J = 5.4 Hz), 3.60 (2H, t, J = 6.4 Hz), 2.06 (q, 2H, J = 6.4 Hz), 1.55−1.50 (m, 2H), 1.46−1.39 (m, 2H), 1.35 (s, 1H), 0.89 (s, 9H), 0.04 (s, 6H)]. The crude alcohol thus prepared was oxidized under Swern conditions described for conversion of **4** to **5** to give the crude enal. To a solution of PPh_3 (23.4 g, 89.1 mol) in CH_2Cl_2 (100 mL) was added CBr_4 (1.48 g, 44.6 mmol) in CH_2Cl_2 (100 mL) and Et_3N (5.40 mL, 40.6 mmol) at 0 °C, and the reaction mixture was stirred for 30 min. A solution of the crude enal in CH_2Cl_2 (30 0.0 mL) was then added to a solution of the ylide in CH_2Cl_2 solution thus adjusted 0 °C, and stirring was continued for 2 h at room temperature. Hexane was added to the reaction mixture, and the resulting precipitates were filtered off. The filtrate was concentrated and diluted with hexane. After removal of the precipitates again, the filtrate was concentrated to give the crude dibromoolefin derivative. To a solution of the crude dibromoolefin derivative in THF (200 mL) was added *n*-BuLi in hexane (1.46 M, 29.7 mL, 43.4 mmol) at −78 °C, and the reaction mixture was stirred for 1 h at the same temperature and then at room temperature for an additional 1 h. The reaction mixture was quenched by addition of water, extracted with Et_2O, which was washed with water and brine, dried, and concentrated to dryness. Chromatography of the residue with hexane−AcOEt (50:1) afforded (*E*)-**6** (3.11 g, 62% overall yield from **5**) as a colorless oil: IR 3307, 2102 cm^{-1}; ^1H NMR δ 6.25 (dt, 1H, J = 16.1, 6.8 Hz), 5.46 (dq, 1H, J = 16.1, 2.0 Hz), 3.60 (t, 2H, J = 6.4 Hz), 2.78 (d, 1H, J = 2.0 Hz), 2.13 (qd, 2H, J = 6.8, 2.0 Hz), 1.55−1.50 (m, 2H), 1.48−1.42 (m, 2H), 0.89 (s, 9H), 0.04 (s, 6H); ^{13}C NMR δ 146.67, 108.63, 82.52, 75.62, 62.80, 32.76, 32.17, 25.95, 24.85, 18.33, −5.32; MS m/z 238 (M^+, 0.5). HRMS calcd for $C_{14}H_{26}OSi$ 238.1753, found 238.1751.

7-(*tert*-Butyldimethylsiloxy)-2-heptyn-1-ol (10). The alcohol **4** (1.00 g, 4.58 mmol) was successively oxidized under Swern conditions and exposed to Cory's dibromoolefination conditions as described for conversion of **5** to (*E*)-**6** to give the crude 1,1-dibromo-6-(*tert*-butyldimethylsiloxy)hex-1-ene. *n*-BuLi in hexane (1.52 M, 6.60 mL, 10.1 mmol) was added to a solution of the crude dibromo derivative in THF (46.0 mL) at −78 °C. After stirring for 1 h at the same temperature, the reaction was quenched by addition of paraformaldehyde (413 mg, 13.7 mmol). The reaction mixture was stirred for 3 h at room temperature, diluted with Et_2O, and washed with water. The organic layer was washed with brine, dried, and concentrated to dryness. Chromatography of the residue with hexane−AcOEt (5:1) afforded **10** (730 mg, 66%) as a colorless oil: IR 3609, 3425, 2224 cm^{-1}; ^1H NMR δ 4.25 (m, 2H), 3.62 (t, 2H, J = 6.3 Hz), 2.25−2.23 (m, 2H), 1.63−1.56 (m, 4H), 0.89 (s, 9H), 0.05 (s, 6H); ^{13}C NMR δ 86.22, 78.53, 62.63, 51.27, 31.86, 25.91, 25.00, 18.51, 18.30, −5.34; FABMS m/z 243 ($M^+ + 1$, 6.3). FABHRMS calcd for $C_{13}H_{27}O_2Si$ 243.1780, found 243.1767.

(3*Z*)-8-(*tert*-Butyldimethylsiloxy)-3-octen-1-yne [(*Z*)-6]. A solution of **10** (840 mg, 3.46 mmol) in MeOH (35.0 mL) was

hydrogenated for 15 h under hydrogen atmosphere in the presence of Pd−$CaCO_3$ (84.0 mg). The catalyst was filtered off, and the filtrate was concentrated to dryness. The crude (*Z*)-olefin derivative was successively exposed to Swern oxidation, dibromoolefination, and base treatment conditions as described for preparation of (*E*)-**6** to afford (*Z*)-**6** (545 mg, 66%) as a colorless oil: IR 3306, 2097 cm^{-1}; ^1H NMR δ 6.00 (dt, 1H, J = 10.7, 7.3 Hz), 5.46 (dd, 1H, J = 10.7, 2.0 Hz), 3.62 (t, 2H, J = 6.4 Hz), 3.07 (d, 1H, J = 2.0 Hz), 2.35 (q, 2H, J = 7.3 Hz), 1.58−1.53 (m, 2H), 1.50−1.44 (m, 2H), 0.89 (s, 9H), 0.05 (s, 6H); ^{13}C NMR δ 145.95, 108.19, 81.24, 80.50, 62.86, 32.26, 29.94, 25.97, 24.98, 18.35, −5.28; MS *m*/*z* 238 (M^+, 0.6). Anal. Calcd for $C_{14}H_{26}OSi$: C, 70.52; H, 10.99. Found: C, 70.13; H, 11.18.

(5*E*)-8-Trimethylsilyl-5-octen-7-yn-1-ol [(*E*)-7a]. To a solution of (*E*)-**6** (50.0 mg, 0.21 mmol) in THF (2.10 mL) was added *n*-BuLi in hexane (1.46 M, 0.17 mL, 0.25 mmol) at −78 °C. After stirring for 1 h, a solution of TMSCl (0.08 mL, 0.63 mmol) in THF (0.50 mL) was added to the reaction mixture, which was stirred at the same temperature for 30 min and then at room temperature for 12 h. The reaction mixture was quenched by addition of water and extracted with Et_2O. The extract was washed with water and brine, dried, and concentrated to dryness. The residue was taken up in EtOH (2.00 mL) to which 10% HCl solution (0.20 mL) was added at room temperature. The reaction mixture was stirred for 1 h, and EtOH was evaporated off to leave the residue which was diluted with water and extracted with AcOEt. The extract was washed with water and brine, dried, and concentrated to dryness. Chromatography of the residue with hexane−AcOEt (4:1) gave (*E*)-**7a** (27.6 mg, 67%) as a pale yellow oil: IR 3624, 3449 cm^{-1}; ^1H NMR δ 6.20 (dt, 1H, J = 16.1, 7.3 Hz), 5.51 (dt, 1H, J = 16.1, 1.5 Hz), 3.63 (t, 2H, J = 6.4 Hz), 2.13 (qd, 2H, J = 7.3, 1.5 Hz), 1.54 (quin, 2H, J = 6.4 Hz), 1.50−1.44 (m, 2H), 0.18 (s, 9H); ^{13}C NMR δ 145.61, 110.01, 103.97, 92.74, 62.61, 32.71, 32.06, 24.75, −0.07; MS *m*/*z* 196 (M^+, 17). HRMS calcd for $C_{11}H_{20}OSi$ 196.1283, found 196.1281.

(5*Z*)-8-Trimethylsilyl-5-octen-7-yn-1-ol [(*Z*)-7a]. According to the procedure described for the preparation of (*E*)-**7a**, (*Z*)-**7a** (22.1 mg, 56%) was obtained from (*Z*)-**6** (48.3 mg, 0.20 mmol) as a pale yellow oil: IR 3619, 2146 cm^{-1}; ^1H NMR δ 5.94 (dt, 1H, J = 10.7, 7.3 Hz), 5.50 (dt, 1H, J = 10.7, 1.5 Hz), 3.67 (t, 2H, J = 6.4 Hz), 2.36 (qd, 2H, J = 7.3, 1.5 Hz), 1.64−1.58 (m, 2H), 1.54−1.48 (m, 2H), 0.19 (s, 9H); ^{13}C NMR δ 144.87, 109.56, 102.00, 98.67, 62.55, 32.04, 29.83, 24.78, −0.07; MS *m*/*z* 196 (M^+, 22). HRMS calcd for $C_{11}H_{20}OSi$ 196.1283, found 196.1276.

(3*E*)-8-(*tert*-Butyldimethylsiloxy)-1-phenyl-3-octen-1-yne [(*E*)-7b]. To a solution of (*E*)-**6** (50.0 mg, 0.21 mmol) and iodobenzene (0.04 mL, 0.31 mmol) in THF (0.50 mL) were successively added $Pd(PPh_3)_2Cl_2$ (4.40 mg, 0.60×10^{-2} mmol), CuI (5.30 mg, 0.13×10^{-1} mmol), and diisopropylamine (1.60 mL) at room temperature. The reaction mixture was stirred for 1 h, and the precipitates were filtered off. The filtrate was concentrated to leave a residual oil, which was chromatographed with hexane−AcOEt (50:1) to afford (*E*)-**7b** (63.2 mg, 96%) as a pale yellow oil: IR 2201 cm^{-1}; ^1H NMR δ 7.42−7.40 (m, 2H), 7.32−7.27 (m, 3H), 6.24 (dt, 1H, J = 15.6, 7.3 Hz), 5.70 (dt, 1H, J = 15.6, 1.5 Hz), 3.62 (t, 2H, J = 6.3 Hz), 2.19 (qd, 2H, J = 7.3, 1.5 Hz), 1.57−1.53 (m, 2H), 1.52−1.47 (m, 2H), 0.90 (s, 9H), 0.05 (s, 6H); ^{13}C NMR δ 144.92, 131.41, 128.23, 127.85, 123.61, 109.69, 88.29, 87.93, 62.86, 32.98, 32.22, 25.97, 25.07, 18.35, −5.30; MS *m*/*z* 314 (M^+, 1.3). Anal. Calcd for $C_{20}H_{30}OSi$: C, 76.37; H, 9.61. Found: C, 76.09; H, 9.83.

(3*Z*)-8-(*tert*-Butyldimethylsiloxy)-1-phenyl-3-octen-1-yne [(*Z*)-7b]. According to the procedure described for the preparation of (*E*)-**7b**, (*Z*)-**7b** (111 mg, 84%) was obtained from (*Z*)-**6** (100 mg, 0.42 mmol) as a pale yellow oil: IR 2201 cm^{-1}; ^1H NMR δ 7.44−7.42 (m, 2H), 7.32−7.29 (m, 3H), 5.97 (dt, 1H, J = 10.7, 7.3 Hz), 5.69 (dt, 1H, J = 10.7, 1.5 Hz), 3.64 (t, 2H, J = 6.4 Hz), 2.42 (qd, 2H, J = 7.3, 1.5 Hz), 1.62−1.48 (m, 4H), 0.89 (s, 9H), 0.04 (s, 6H); ^{13}C NMR δ 144.01, 131.38, 128.25, 127.94, 123.67, 109.22, 93.48, 86.40, 62.93, 32.33, 30.07, 25.95, 25.11, 18.35, −5.30; MS *m*/*z* 314 (M^+, 3.4). Anal. Calcd for $C_{20}H_{30}OSi$: C, 76.37; H, 9.61. Found: C, 76.10; H, 9.91.

(5*R,6*S**)-5,6-Epoxy-8-trimethylsilyloct-7-yn-1-ol (*trans*-8a).** To a solution of (*E*)-**7a** (500 mg, 2.53 mmol) in CH_2Cl_2 (25.0 mL) were added Na_2HPO_4 (3.60 g, 25.5 mmol) and *m*CPBA (80% purity, 1.65 g, 7.70 mmol) at room temperature. The suspension was stirred at room temperature for 18 h and filtered. The filtrate was washed with saturated aqueous Na_2SO_3, water, and brine, dried, and concentrated to dryness. Chromatography of the residue with hexane−AcOEt (7:1) gave *trans*-**8a** (287 mg, 53%; *trans*:*cis* = 91:9) as a pale oil: IR 3620, 3448, 2179 cm^{-1}; selected data for ^1H NMR δ 3.66 (t, 2H, J = 6.4 Hz), 3.10 (m, 2H), 1.66−1.59 (m, 2H), 1.58−1.51 (m, 4H), 0.17 (s, 9H); ^{13}C NMR δ 101.82, 89.29, 62.54, 60.61, 45.43, 32.22, 31.41, 21.96, −0.34; MS *m*/*z* 212 (M^+, 1.6). HRMS calcd for $C_{11}H_{20}O_2Si$ 212.1233, found 212.1234.

(5*R,6*S**)-5,6-Epoxy-8-phenyloct-7-yn-1-ol (*trans*-8b).** According to the procedure described for the preparation of *trans*-**8a**, (*E*)-**7b** (200 mg, 0.64 mmol) was treated with *m*CPBA to give the epoxy derivative. To a solution of thus-prepared epoxy derivative in THF (6.40 mL) was added a solution of TBAF (1.0 M THF solution, 0.70 mL, 0.70 mmol) at room temperature. The reaction mixture was stirred for 1 h and diluted with Et_2O, which was washed with water and brined, dried, and concentrated to dryness. Chromatography of the residue with hexane−AcOEt (3:1) gave *trans*-**8b** (34.3 mg, 25%; *trans*:*cis* = 81:19) as a pale yellow oil: IR 3622, 3447, 2226 cm^{-1}; selected data for ^1H NMR δ 7.44 (dd, 2H, J = 7.3, 2.0 Hz), 7.34−7.29 (m, 3H), 3.68 (t, 2H, J = 5.9 Hz), 3.33 (d, 1H, J = 2.0 Hz), 3.20 (td, 1H, J = 5.9, 2.0 Hz), 1.83 (m, 1H), 1.72−1.56 (m, 5H); ^{13}C NMR δ 131.81, 128.68, 128.27, 121.98, 85.70, 83.52, 62.52, 60.76, 45.73, 32.20, 31.45, 21.96; MS *m*/*z* 216 (M^+, 6.7). HRMS calcd for $C_{14}H_{16}O_2$ 216.1150, found 216.1151.

(5*R,6*S**)-5,6-Epoxy-7-octyne-1-ol (*trans*-8c).** According to the procedure described for the preparation of *trans*-**8b**, *trans*-**8c** (32.5 mg, 28%; *trans*:*cis* = 95:5) was obtained from (*E*)-**6** (200 mg, 0.84 mmol) as pale yellow oil: IR 3622, 3472, 3307 cm^{-1}; selected data for ^1H NMR δ 3.67 (t, 2H, J = 6.4 Hz), 3.11 (m, 2H), 2.31 (d, 1H, J = 1.5 Hz), 1.66−1.53 (m, 6H); ^{13}C NMR δ 80.29, 71.84, 62.27, 60.15, 44.75, 32.06, 31.22, 21.82; MS *m*/*z* 140 (M^+, 7.0). HRMS calcd for $C_8H_{12}O_2$ 140.0837, found 140.0835.

(3*R,4*S**)-3,4-Epoxy-8-trimethysiloxy-1-trimethylsilyloct-1-yne (*trans*-9a).** A solution of *trans*-**8a** (100 mg, 0.47 mmol) and TMS-imidazole (0.10 mL, 0.71 mmol) was stirred for 30 min at room temperature and diluted with hexane. The resulting precipitates were filtered off, and the filtrate was concentrated to dryness. chromatography of the residue on silica gel (treated with hexane−AcOEt containing 3% Et_3N prior to use) with hexane−AcOEt (20:1) afforded *trans*-**9a** (103 mg, 77%; *trans*:*cis* = 91:9) as a pale yellow oil: IR 2179 cm^{-1}; selected data for ^1H NMR δ 3.58 (t, 2H, J = 6.4 Hz), 3.09 (m, 2H), 1.60−1.47 (m, 6H), 0.17 (s, 9H), 0.11 (s, 9H); ^{13}C NMR δ 101.94, 89.15, 62.21, 60.65, 45.45, 32.26, 31.50, 22.01, −0.34, −0.52; MS *m*/*z* 284 (M^+, 6.0). HRMS calcd for $C_{14}H_{28}O_2Si_2$ 284.1628, found 284.1631.

(3*R,4*S**)-3,4-Epoxy-8-trimethysiloxy-1-phenyloct-1-yne (*trans*-9b).** According to the procedure described for the preparation of *trans*-**9a**, *trans*-**9b** (132 mg, 52%; *trans*:*cis* = 83:17) was obtained from *trans*-**8b** (195 mg, 0.90 mmol) as a pale yellow oil: IR 2227 cm^{-1}; selected data for ^1H NMR δ 7.45−7.43 (m, 2H), 7.33−7.28 (m, 3H), 3.60 (t, 2H, J = 5.9 Hz), 3.26 (d, 1H, J = 2.4 Hz), 3.19 (td, 1H, J = 5.4, 2.4 Hz), 1.66−1.52 (m, 6H), 0.12 (s, 9H); ^{13}C NMR δ 131.77, 128.61, 128.21, 122.01, 85.82, 83.38, 62.16, 60.74, 45.66, 32.22, 31.52, 22.00, −0.57; MS *m*/*z* 288 (M^+, 12). Anal. Calcd for $C_{17}H_{24}O_2Si$: C, 70.79; H, 8.39. Found: C, 70.93; H, 8.41.

(3*R,4*S**)-3,4-Epoxy-8-trimethysiloxyoct-1-yne (*trans*-9c).** According to the procedure described for the preparation of *trans*-**9a**, *trans*-**9c** (126 mg, 84%; *trans*:*cis* = 93:7) was obtained from *trans*-**8c** (100 mg, 0.71 mmol) as a pale yellow oil: IR 3307, 2120 cm^{-1}; selected data for ^1H NMR δ 3.58 (t, 2H, J = 6.4 Hz), 3.10 (m, 2H), 2.30 (d, 1H, J = 1.5 Hz), 1.61−1.48 (m, 6H), 0.11 (s, 9H); ^{13}C NMR δ 80.49, 71.70, 62.14, 60.18, 44.76, 32.19, 31.38, 21.96, −0.56; FABMS *m*/*z* 213 ($M^+ + 1$, 4.5). Anal. Calcd for $C_{11}H_{20}O_2Si$: C, 62.21; H, 9.49. Found: C, 61.88; H, 9.55.

(3*R,4*R**)-3,4-Epoxy-8-trimethysiloxy-1-trimethylsilyloct-1-yne (*cis*-9a).** According to the procedure described for conversion of (*E*)-**7a** to *trans*-**9a**, *cis*-**9a** (177 mg, 25%) was obtained from (*Z*)-**7a** (500 mg, 2.53 mmol) as a pale yellow oil: IR 2176 cm^{-1}; ^1H NMR δ 3.61 (t, 2H, J = 6.4 Hz), 3.42 (d, 1H, J = 3.9 Hz), 3.02 (td, 1H, J = 6.4, 3.9 Hz), 1.79−1.50 (m, 6H), 0.18 (s, 9H), 0.11 (s, 9H); ^{13}C NMR δ 100.41, 91.03, 62.30, 58.10, 45.20, 32.42, 29.04, 22.21, −0.32, −0.52; MS *m*/*z* 284 (M^+, 7.0). HRMS calcd for $C_{14}H_{28}O_2Si_2$ 284.1628, found 284.1631.

(3*R,4*R**)-3,4-Epoxy-8-trimethysiloxy-1-phenyloct-1-yne (*cis*-9b).** According to the procedure described for conversion of (*E*)-**7b** to *trans*-**9b**, *cis*-**9b** (23.9 mg, 29%; *cis*:*trans* = 93:7) was obtained from (*Z*)-**7b** (90.0 mg, 0.29 mmol) as a pale yellow oil: IR 2230 cm^{-1}; selected data for ^1H NMR δ 7.44 (dd, 2H, J = 7.3, 1.5 Hz), 7.33−7.29 (m, 3H), 3.65 (d, 1H, J = 3.9 Hz), 3.62 (t, 2H, J = 6.4 Hz), 3.14 (td, 1H, J = 5.9, 3.9 Hz), 1.87−1.74 (m, 2H), 1.68−1.56 (m, 4H), 0.10 (s, 9H); ^{13}C NMR δ 131.88, 128.70, 128.30, 122.16, 85.25, 84.22, 62.32, 58.46, 45.59, 32.40, 29.26, 22.36, −0.50; MS *m*/*z* 288 (M^+, 20). Anal. Calcd for $C_{17}H_{24}O_2Si$: C, 70.79; H, 8.39. Found: C, 70.51; H, 8.42.

(3*R,4*R**)-3,4-Epoxy-8-trimethysiloxyoct-1-yne (*cis*-9c).** According to the procedure described for conversion of (*E*)-**6** to *trans*-**9c**, *cis*-**9c** (28.6 mg, 75%; *cis*:*trans* = 93:7) was obtained from (*Z*)-**6** (24.6 mg, 0.18 mmol) as a pale yellow oil: IR 3307, 2124 cm^{-1}; selected data for ^1H NMR δ 3.60 (t, 2H, J = 6.4 Hz), 3.42 (dd, 1H, J = 3.9, 2.0 Hz), 3.04 (td, 1H, J = 6.4, 3.9 Hz), 2.34 (d, 1H, J = 2.0 Hz), 1.79−1.67 (m, 2H), 1.65−1.53 (m, 4H), 0.11 (s, 9H); ^{13}C NMR δ 78.89, 73.59, 62.27, 57.76, 44.69, 32.31, 28.97, 22.27, −0.52; CIMS *m*/*z* 213 (M^+ + 1, 100). Anal. Calcd for $C_{11}H_{20}O_2Si$: C, 62.21; H, 9.49. Found: C, 61.91; H, 9.63.

General Procedure for $Co_2(CO)_8$-Mediated Endo Mode Ring Closure. To a solution of the epoxide **8**, **9** (1.00 mmol) in CH_2Cl_2 (30.0 mL) was added $Co_2(CO)_8$ (1.10 mmol) at room temperature. After being stirred for 20−30 min (consumption of the starting material was monitored by TLC), the reaction mixture was cooled to −78 °C and held at the same temperature for 30 min. A solution of $BF_3{\cdot}OEt_2$ in CH_2Cl_2 (1.0 M solution; 3.00 mmol) was added to the reaction mixture, which was further stirred at −78 °C for 30 min. The reaction was quenched by addition of water and gradually warmed to room temperature. The CH_2Cl_2 layer was separated, washed with water and brine, dried, and concentrated to dryness. Chromatography with hexane−AcOEt (20:1) afforded **11**. Chemical yields and ratio between *trans* and *cis* isomers are summarized in Table 1.

Hexacarbonyl-μ-[η^4-(2*R,3*S**)-3-hydroxy-2-(2-trimethylsily)ethynyloxepane]dicobalt(Co−Co) (*cis*-11a).** A reddish brown oil: IR 3605, 2089, 2050, 2022 cm^{-1}; ^1H NMR δ 4.56 (s, 1H), 3.95 (dt, 1H, J = 10.7, 3.4 Hz), 3.90−3.79 (m, 2H), 2.67 (d, 1H, J = 10.3 Hz, OH), 2.04−1.93 (m, 2H), 1.77−1.68 (m, 2H), 1.60−1.54 (m, 2H), 0.31 (s, 9H); ^{13}C NMR δ 200.27, 109.20, 79.89, 78.65, 73.21, 68.70, 37.52, 29.56, 19.18, 0.76; MS *m*/*z* 470 (M^+ − CO, 10). Anal. Calcd for $C_{17}H_{20}Co_2O_8Si$: C, 40.98; H, 4.05. Found: C, 40.83; H, 4.02.

Hexacarbonyl-μ-[η^4-(2*R,3*R**)-3-hydroxy-2-(2-trimethylsilyl)ethynyloxepane]dicobalt(Co−Co) (*trans*-11a).** A reddish brown oil: IR 3600, 2087, 2048, 2009 cm^{-1}; ^1H NMR δ 4.30 (d, 1H, J = 7.8 Hz), 4.07 (dt, 1H, J = 12.2, 4.9 Hz), 3.72−3.64 (m, 2H), 2.09 (m, 1H), 1.84−1.66 (m, 5H), 1.46 (d, 1H, J = 4.4 Hz, OH), 0.31 (s, 9H); ^{13}C NMR δ 200.59, 128.32, 111.43, 85.61, 78.71, 71.32, 36.64, 30.78, 20.78, 0.69; MS *m*/*z* 470 (M^+ − CO, 11). Anal. Calcd for $C_{17}H_{20}Co_2O_8Si$: C, 40.98; H, 4.05. Found: C, 40.98; H, 4.06.

Hexacarbonyl-μ-[η^4-(2*R,3*S**)-3-hydroxy-2-(2-phenyl)-ethynyloxepane]dicobalt(Co−Co) (*cis*-11b).** A reddish brown oil: IR 3580, 2092, 2055, 2027 cm^{-1}; ^1H NMR δ 7.55 (dd, 2H, J = 6.8, 1.5 Hz), 7.36−7.28 (m, 3H), 4.77 (s, 1H), 4.11 (dt, 1H, J = 10.7, 3.4 Hz), 3.98−3.89 (m, 2H), 2.67 (d, 1H, J = 10.3 Hz, OH), 2.07−1.98 (m, 2H), 1.83−1.62 (m, 4H); ^{13}C NMR δ 199.42, 138.06, 129.58, 128.77, 127.60, 95.78, 91.12, 79.80, 72.89, 69.04, 37.49, 29.72, 19.32; MS *m*/*z* 474 (M^+ − CO, 21). Anal. Calcd for $C_{20}H_{16}Co_2O_8$: C, 47.83; H, 3.21. Found: C, 47.77; H, 3.19.

Hexacarbonyl-μ-[η^4-(2*R,3*R**)-3-hydroxy-2-(2-phenyl)-ethynyloxepane]dicobalt(Co−Co) (*trans*-11b).** A reddish brown oil: IR 3580, 2091, 2054, 2028 cm^{-1}; ^1H NMR δ 7.63−7.61 (m, 2H), 7.35−7.28 (m, 3H), 4.56 (d, 1H, J = 7.3 Hz), 4.15 (dt, 1H, J = 12.7, 4.4 Hz), 3.89 (m, 1H), 3.73 (m, 1H), 2.14−2.09 (m, 2H), 1.89−1.70 (m, 5H); ^{13}C NMR δ 199.68, 137.95, 129.83, 128.90, 127.71, 98.15, 91.09, 85.43, 71.84, 67.96, 36.41, 30.95, 20.70; MS *m*/*z* 474 (M^+ − CO, 21). Anal. Calcd for $C_{20}H_{16}Co_2O_8$: C, 47.83; H, 3.21. Found: C, 48.12; H, 3.22.

Hexacarbonyl-μ-[η^4-(2*R,3*S**)-3-hydroxy-2-ethynyl-oxepane]dicobalt(Co−Co) (*cis*-11c).** A reddish brown oil: IR 3580, 2095, 2056, 2029 cm^{-1}; ^1H NMR δ 6.07 (s, 1H), 4.55 (s, 1H), 3.92 (dt, 1H, J = 10.3, 3.4 Hz), 3.85−3.82 (m, 2H), 2.61 (d, 1H, J = 10.3 Hz, OH), 2.04−1.93 (m, 2H), 1.77−1.57 (m, 4H); ^{13}C NMR δ 199.61, 94.02, 79.73, 73.21, 72.24, 68.88, 37.34, 29.65, 19.23; FABMS *m*/*z* 427 (M^+ + 1, 4.4). Anal. Calcd for $C_{14}H_{12}Co_2O_8$: C, 39.46; H, 2.84. Found: C, 39.09; H, 3.16.

Hexacarbonyl-μ-[η^4-(2*R,3*R**)-3-hydroxy-2-ethynyl-oxepane]dicobalt(Co−Co) (*trans*-11c).** A reddish brown oil: IR 3580, 2095, 2054, 2031 cm^{-1}; ^1H NMR δ 6.08 (s, 1H), 4.30 (d, 1H, J = 8.3 Hz), 4.03 (m, 1H), 3.70 (m, 1H), 3.61 (m, 1H), 2.10 (m, 1H), 1.85−1.63 (m, 5H); ^{13}C NMR δ 199.84, 96.03, 84.85, 71.66, 70.51, 65.84, 36.48, 30.50, 20.85; FABMS *m*/*z* 427 (M^+ + 1, 1.9). Anal. Calcd for $C_{14}H_{12}Co_2O_8$: C, 39.46; H, 2.84. Found: C, 39.15; H, 3.00.

Direct Ring opening of *trans*-8c and *cis*-8c. A solution of $BF_3{\cdot}OEt_2$ in CH_2Cl_2 (0.10 M solution; 0.14 mL, 0.14×10^{-1} mmol) was added to a solution of *trans*-**8c** (20.0 mg, 0.14 mmol) in CH_2Cl_2 (4.80 mL) at −78 °C. The reaction mixture was stirred at the same temperature for 10 min, gradually warmed to 0 °C, and then quenched by addition of water. The CH_2Cl_2 layer was separated, washed with brine, dried, and concentrated to dryness. The residue was dissolved in CH_2Cl_2 (4.00 mL) to which Ac_2O (21.5 mg, 0.21 mmol) and Et_3N (21.3 mg, 0.21 mmol) were added. The reaction mixture was allowed to stand for 1 h, diluted with CH_2Cl_2, which was washed with water and brine, dried, and concentrated to dryness. Chromatography of the residue with hexane-AcOEt (10:1) afforded (1′*R**,2*S**)-2-(1′-acetoxy-2′-propyn-1′-yl)tetrahydropyrane (**15**; 18.0 mg, 71%) and (2**R*,3*S**)-3-acetoxy-2-ethynyloxepane (**16**; 1.20 mg, 5%). Compound **15** was a pale yellow oil: IR 3307, 2128, 1740 cm^{-1}; ^1H NMR δ 5.37 (dd, 1H, J = 3.4, 2.4 Hz), 4.08 (m, 1H), 3.53 (m, 1H), 3.47 (td, 1H, J = 11.2, 2.0 Hz), 2.33 (d, 1H, J = 2.4 Hz), 2.13 (s, 3H), 1.91 (m, 1H), 1.70−1.50 (m, 5H); ^{13}C NMR δ 169.86, 78.46, 77.90, 74.54, 68.81, 66.25, 26.65, 25.55, 22.88, 20.95; CIMS *m*/*z* 183 (M^+ + 1, 100). Anal. Calcd for $C_{10}H_{14}O_3$: C, 65.92; H, 7.74. Found: C, 65.73; H, 7.98. Compound **16** was a colorless oil: IR 3306, 2124, 1733 cm^{-1}; ^1H NMR δ 5.08 (td, 1H, J = 6.6, 3.3 Hz), 4.36 (dd, 1H, J = 6.6, 2.3 Hz), 3.98 (m, 1H), 3.70 (m, 1H), 2.48 (d, 1H, J = 2.3 Hz), 2.08 (s, 3H), 1.96−1.59 (m, 6H); ^{13}C NMR δ 169.95, 81.13, 74.32, 71.74, 68.61, 30.91, 30.17, 21.33, 21.17; MS *m*/*z* 182 (M^+, 1.1). HRMS calcd for $C_{10}H_{14}O_3$ 182.0942, found 182.0939. Similar treatment of *cis*-**8c** (20.0 mg, 0.14 mmol) gave (1′*R**,2*R**)-2-(1′-acetoxy-2′-propyn-1′-yl)tetrahydropyran (**17**; 20.9 mg, 82%) as a pale yellow oil: IR 3307, 2128, 1741 cm^{-1}; ^1H NMR δ 5.38 (dd, 1H, J = 6.4, 2.4 Hz), 4.04 (m, 1H), 3.51 (ddd, 1H, J = 10.8, 6.4, 2.0 Hz), 3.44 (td, 1H, J = 11.2, 2.0 Hz), 2.48 (d, 1H, J = 2.4 Hz), 2.13 (s, 3H), 1.92 (m, 1H), 1.80 (m, 1H), 1.62−1.41 (m, 4H); ^{13}C NMR δ 169.78, 78.71, 77.56, 74.68, 68.64, 66.06, 27.10, 25.54, 22.75, 20.95; CIMS *m*/*z* 183 (M^+ + 1, 100). Anal. Calcd for $C_{10}H_{14}O_3$: C, 65.92; H, 7.74. Found: C, 65.40; H, 7.85.

Supporting Information Available: Spectral data of compound **12** and **13**, ^1H and ^{13}C NMR spectra for compounds (*E*)-**6**, (*E*)-**7a**, (*Z*)-**7a**, *trans*-**8a**,**b**,**c**, *trans*-**9a**, *cis*-**9a**, **10, 12**, **13**, and **16**,^1H NMR spectra for compounds **11**. This material is available free of charge via the Internet at http://pubs.acs.org.

JO000450+