A One-Pot Method for the Stereoselective Introduction of a Vinyl Group via an Atom-Transfer Radical-Cyclization Reaction with a Diphenylvinylsilyl Group as a Temporary Connecting Tether. Synthesis of 4′α-*C*-Vinylthymidine, a Potent Antiviral Nucleoside[1]

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A one-pot method for the stereoselective introduction of a vinyl group at the β-position of a hydroxyl group in halohydrins or α-phenylselenoalkanols via an atom-transfer radical-cyclization reaction was developed. When a solution of the diphenylvinylsilyl ether of (±)-*trans*-2-iodoindanol (**2a**) and $(Bu_3Sn)_2$ in benzene was irradiated with a high-pressure mercury lamp, the corresponding atom transfer 5-exo-cyclization product was produced, which in turn was treated with tetrabutylammonium fluoride to give *cis*-2-vinylindanol (**3**) in 82% yield from **2a**. Similar reactions with diphenylvinylsilyl ethers of (±)-*trans*-1-phenylselenoindan-2-ol (**4**), *trans*-2-iodocyclopentanol (**6**), and *trans*-2-iodocyclohexanol (**8**) gave the corresponding vinyl derivatives. Furthermore, this reaction was successfully applied to the synthesis of 4′α-*C*-vinylthymidine, a potent antiviral nucleoside.

Introduction

Radical cyclization is a highly versatile method for forming C−C bonds.[2] There has been growing interest in the use of silicon-containing tethers for intramolecular radical cyclization reactions.[3] These are very useful for the regio- and stereoselective introduction of a carbon substituent based on a temporary silicon connection.[3] We report here an efficient one-pot method for introducing a vinyl group via an atom-transfer[4] radical-cyclization reaction[5] with a diphenylvinylsilyl group as a temporary connecting tether followed by a fluoride ion-promoted elimination reaction.We have previously explored antitumor and/or antiviral branched-sugar nucleoside analogues[6] and found that 1-(2-*C*-cyano-2-deoxy-β−D-*arabino*-pentofuranosyl)cytosine (CNDAC)[7] and 1-(3-*C*-ethynyl-β−D-*ribo*-pentofuranosyl)cytosine (ECyd)[8] are potent antitumor nucleosides and are now under clinical and pre-clinical investigations, respectively. Most recently, we

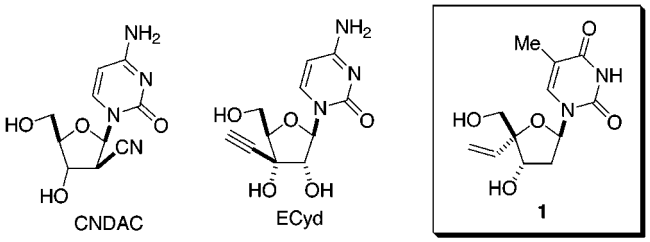

Figure 1.

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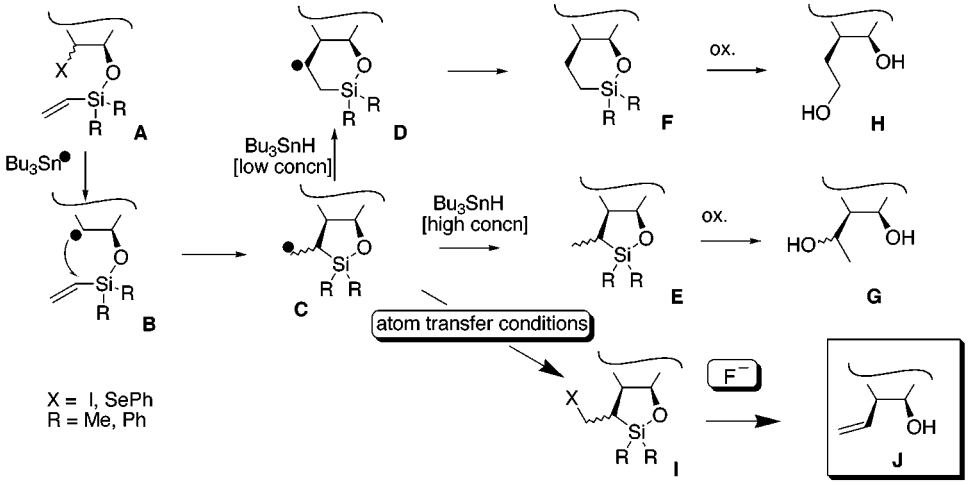
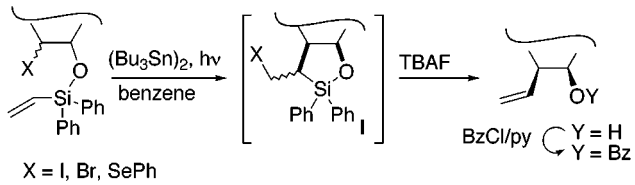
Scheme 1



found that 4′-α-*C*-vinylthymidine (**1**) significantly inhibited the growth of both human immunodeficiency virus type-1 (HIV-1) and herpes simplex virus type-1 (HSV-1) in vitro.[9] However, the preparation of **1** required relatively long reaction steps, and accordingly the overall yield was low.[9] Therefore, the development of a more straightforward method for synthesizing **1** is needed to examine its antiviral effect in detail.

We have also developed a regio- and stereoselective method for introducing a 1-hydroxyethyl or 2-hydroxyethyl group at the β-position of a hydroxyl group in halohydrins or α-phenylselenoalkanols by using an intramolecular radical cyclization reaction with a dimethyl or diphenylvinylsilyl group as a radical acceptor tether (Scheme 1).[10] The selective introduction of 1-hydroxyethyl and 2-hydroxyethyl groups is achieved via a 5-exo-cyclization product **E** or a 6-endo-cyclization product **F**, respectively, after oxidative ring cleavage by treating the cyclization products under Tamao oxidation conditions,[11] as shown in Scheme 1.[10] We have also demonstrated that the kinetically favored 5-exo-cyclized radical **C**, formed from radical **B**, was trapped when the concentration of Bu_3SnH was high enough to give **E**. At lower concentrations of Bu_3SnH and higher reaction temperatures, radical **C** rearranged into the more stable ring-enlarged 4-oxa-3-silacyclohexyl radical **D**, which was then trapped with Bu_3SnH to give **F**.[10a,b]

Scheme 2



We sought to develop a new efficient method for the stereoselective introduction of a vinyl group by adapting the above radical reaction via a radical atom-transfer reaction[4,5] and applying it to the synthesis of 4′α-*C*-vinylthymidine (**1**).

Results and Discussion

Our strategy is also shown in Scheme 1. We presumed that when the reaction is performed under radical atom-transfer conditions, 5-exo-cyclized radical **C** would be trapped with a halogeno or a seleno group to give **I**. If this indeed occurred, subsequent treatment of the radical atom transfer product **I** with fluoride ion would promote an elimination reaction to give the desired vinyl derivative **J**.

The atom-transfer reactions of various substrates were carried out with a high-pressure mercury lamp (300 W) in the presence of $(Bu_3Sn)_2$, and the products, without purification, were subsequently treated with tetrabutylammonium fluoride (TBAF). The results are summarized in Scheme 2 and Table 1.

We first performed the reaction with diphenylvinylsilyl ethers of (±)-*trans*-2-iodo, -bromo, and -phenylselenoindanol (**2a**−**c**). They were readily prepared by treating the corresponding alcohols with diphenylvinylchlorosilane, DMAP, and Et_3N at room temperature in toluene. When a solution of iodoindanol derivative **2a** and $(Bu_3Sn)_2$ (0.09 equiv) in benzene was irradiated with a high-pressure mercury lamp at room temperature under an argon atmosphere, the expected atom-transfer 5-exo-cyclization

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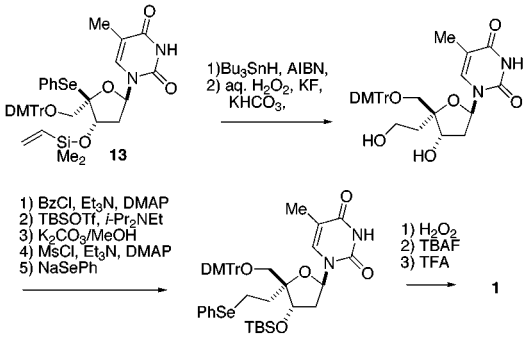

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Table 1. Introduction of a Vinyl Group via Atom-Transfer Radical-Cyclization Reaction

entry	substrate	product	yield (%)
1	**2a**: X = I	**3**	82
2	**2b**: X = Br		0
3	**2c**: X = SePh		0
4	**4**	**5**	53
5	**6**	**7**	58
6	**8**	**9**	52

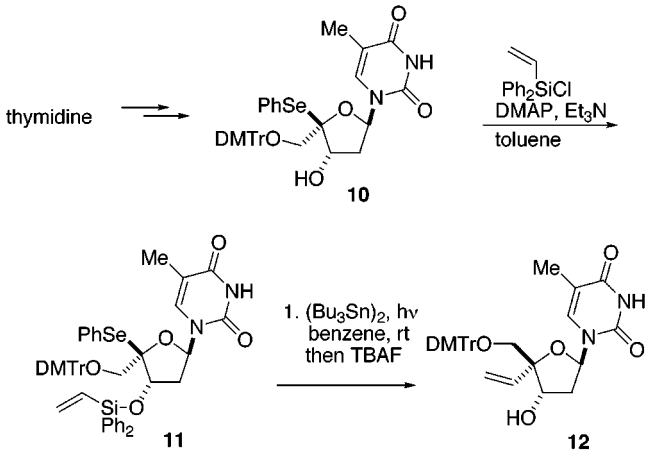
proceeded, and the product was detected on TLC. However, the product was too labile to be isolated, and therefore, after the radical reaction, TBAF was directly added to the reaction mixture to give the desired *cis*-2-vinylindanol (**3**)[12] in 82% yield from **2a**, after purification by silica gel column chromatography (entry 1). Similar treatment of the bromoindanol derivative **2b** and the phenylselenoindanol derivative **2c** did not give **3** (entries 2 and 3). In these cases, the radical reaction did not proceed at all, and the starting materials **2b** and **2c** were almost completely recovered. The Br−C and Se−C bonds in **2b** and **2c** may be too stable to be cleaved homolytically under these conditions. Accordingly, the iodo substituent seemed to be suitable for generating a radical in this reaction. On the other hand, the UV-irradiation reaction of another phenylselenoindanol derivative **4**, followed by treatment with TBAF, gave the corresponding vinylindanol **5**[12] in 53% yield (entry 4). This result suggested that the Se−C bond in **4** was readily cleaved homolytically, compared with that in **2c**, since a stable benzyl radical can be generated from **4**. The diphenylvinylsilyl ethers of *trans*-iodocyclopentanol and -hexanol (**6** and **8**, respectively) also functioned as substrates for the radical atom-transfer cyclization reaction to give the corresponding vinyl derivatives, which were isolated as benzoates, **7** and **9**,[13] respectively, after successively treating the cyclization products with TBAF in benzene and BzCl in pyridine.

These results showed that the vinylsilyl group is very useful as a temporary connecting radical acceptor tether, since it can be used for the regio- and stereoselective introduction of three kinds of C_2-substituents, including 1-hydroxyethyl, 2-hydroxyethyl, and vinyl groups, at the adjacent cis position of a hydroxyl group in halohydrins or α-phenylselenoalkanols, depending on the reaction procedures as shown in Scheme 1.

(12) It is well-known that cis selectivity is complete for formation of 5,5-ring fusions by radical-cyclization reactions (for example, see: Curran, D. P.; Porter, N. A.; Giese, B. *Stereochemistry of radical reactions*; VCH: Weinheim, 1996). The radical reactions with the vinylsilyl tether also give the corresponding cis products (ref 10). The cis stereochemistry of the product in this study was also confirmed from a rather large coupling constant between H-1 and H-2 ($J_{1,2}$ = 5.4 Hz) and NOE experiment (irradiated H-2, observed H-1, 2.0%) in ^{1}H NMR analysis with **5**.

(13) A small coupling constant between H-1 and 2 (J < 2.2 Hz) indicated the 1,2-cis stereochemistry of **9**.

Scheme 3



Finally, we tried to synthesize the target 4′α-*C*-vinylthymidine (Scheme 3). The 4′-phenylselenothymidine derivative **10**, prepared from thymidine by the method reported by Giese,[14] was treated according to the above-mentioned procedure to give the corresponding 3′-*O*-vinylsilyl derivative **11**, which is the substrate for the radical atom transfer reaction. When **11** was treated as in entry 1 in Table 1, the desired 4′α-*C*-vinylthymidine derivative **12** was successfully obtained in 61% yield, as expected.

In conclusion, we have developed an efficient one-pot method for introducing a vinyl group via an atom-transfer radical-cyclization reaction with a diphenylvinysilyl group as a temporary connecting tether followed by a F^--promoted elimination reaction. A potent antiviral 4′α-vinylthymidine was effectively synthesized using this reaction as a key step.

Experimental Section

Melting points are uncorrected. NMR spectra were recorded at 270, 400, or 500 MHz (^{1}H) and at 100 or 125 MHz (^{13}C) and are reported in ppm downfield from TMS. Mass spectra were obtained by electron ionization (EI) or the fast-atom bombardment (FAB) method. Thin-layer chromatography was performed on Merck coated plate 60F_{254}. Silica gel chromatography was performed with Merck silica gel 5715. Reactions were carried our under an argon atmosphere.

(±)-*trans*-1-Diphenylvinylsiloxy-2-iodoindan (2a). A solution of (±)-*trans*-2-iodoindanol[15] (520 mg, 2.00 mmol), Et_3N (0.42 mL, 3.0 mmol), DMAP (24 mg, 0.20 mmol), and diphenylvinylchlorosilane (0.67 mL, 3.0 mmol) in toluene (10 mL) was stirred at room temperature for 5 min. Et_2O and water were added, and the resulting mixture was partitioned. The organic layer was washed with brine, dried (Na_2SO_4), and evaporated. The residue was purified by silica gel column chromatography (Et_2O/hexane 1:100) to give **2a** (827 mg, 89%) as an oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67−7.15 (m 14 H), 6.60 (dd, 1 H, J = 20.3, 14.9 Hz), 6.34 (dd, 1 H, J = 14.9, 3.7 Hz), 5.92 (dd, 1 H, J = 20.3, 3.7 Hz), 5.55 (d, 1 H, J = 4.6 Hz), 4.36 (m, 1 H), 3.70 (dd, 1 H, J = 16.6, 6.8 Hz), 3.24 (dd, 1 H, J = 16.6, 5.9 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.2, 141.1, 137.8, 135.2, 133.8, 133.7, 133.6, 130.14, 130.11, 128.5, 127.9, 127.8, 127.1, 124.6, 124.4, 85.9, 42.9, 30.3; EI HRMS calcd for $C_{23}H_{21}IOSi$ 468.0406, found 468.0391 (M^+). Anal. Calcd for $C_{23}H_{21}IOSi$: C, 58.98; H, 4.52. Found: C, 59.10; H, 4.58.

(±)-*trans*-1-Diphenylvinylsiloxy-2-bromoindan (2b). Compound **2b** (1.9 g, 96%) was obtained as an oil from (±)-

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(15) Moufid, N.; Renaud, P. *Helv. Chim. Acta* **1995**, *78*, 1001−1005.

trans-2-bromoindanol (Aldrich, 1.0 g, 4.7 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (AcOEt/hexane, 1:19): ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.68−7.14 (m, 14 H), 6.60 (dd, 1 H, J = 20.2, 15.0 Hz), 6.33 (dd, 1 H, J = 15.0, 3.8 Hz), 5.92 (dd, 1 H, J = 20.2, 3.8 Hz), 5.46 (d, 1 H, J = 4.7 Hz), 4.40 (ddd, 1 H, J = 6.5, 6.0, 4.7 Hz), 3.65 (dd, 1 H, J = 16.5 Hz, 6.5 Hz), 3.16 (dd, 1 H, J = 16.5, 6.0 Hz); EI MS m/z 420, 422 (M^+). Anal. Calcd for $C_{23}H_{21}BrOSi$: C, 65.55; H, 5.02; Br, 18.96. Found: C, 65.56; H, 5.20; Br, 18.61.

(±)-*trans*-1-Diphenylvinylsiloxy-2-phenylselenoindan (2c). Compound **2c** (0.25 g, quant) was obtained as an oil from (±)-*trans*-2-phenylselenoindanol[16] (0.15 g, 0.50 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (Et_2O/hexane 1:50): ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.72−7.11 (m, 19 H), 6.54 (dd, 1 H, J = 20.5, 15.2 Hz), 6.31 (dd, 1 H, J = 15.2, 4.0 Hz), 5.98 (dd, 1 H, J = 20.5, 4.0 Hz), 5.47 (d, 1 H, J = 5.9 Hz), 4.10 (dt, 1 H, J = 5.9, 5.3 Hz), 3.18 (d, 2 H, J = 5.3 Hz); EI HRMS calcd for $C_{29}H_{26}OSeSi$ 498.0916, found 498.0918 (M^+).

(±)-*trans*-2-Diphenylvinylsiloxy-1-phenylselenoindan (4). A mixture of NaH (60%, 0.24 g, 6.0 mmol) and (±)-*trans*-2-bromoindanol (Aldrich, 1.07 g, 5.02 mmol) in THF (25 mL) was stirred at room temperature for 2 h. To the resulting mixture was added a solution prepared from $(PhSe)_2$ (3.12 g, 10.0 mmol) and $NaBH_4$ (1.14 g, 30.1 mmol) in EtOH (25 mL), and the whole was stirred at room temperature for 10 min. Et_2O and aqueous saturated NH_4Cl were added, and the resulting mixture was partitioned. The aqueous layer was extracted with Et_2O, and the organic layer combined was washed with brine, dried (Na_2SO_4), and evaporated. The residue was purified by silica gel column chromatography (AcOEt/hexane 1:4) to give (±)-*trans*-1-phenylselenoindan-2-ol (1.42 g, 98%) as an oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53−7.21 (m, 9 H, aromatic), 4.66 (d, 1 H, H-1, $J_{1,2}$ = 1.7 Hz), 4.60 (m, 1 H, H-2), 3.30 (dd, 1 H, H-3$_a$, J = 16.6, 5.6 Hz), 2.82 (dd, 1 H, J = 16.6, 2.1 Hz), 1.85 (d, 1 H, 2-OH J = 5.9 Hz), the assignments were in agreement with H−H COSY spectrum; ^{13}C NMR (125 MHz, $CDCl_3$) δ 140.7, 140.6, 134.2, 129.4, 129.1, 128.0, 127.7, 127.1, 125.7, 125.3, 79.0, 53.9, 40.0; EI HRMS calcd for $C_{15}H_{14}OSe$ 290.0209, found 290.0195 (M^+). Anal. Calcd for $C_{15}H_{14}OSe$: C, 62.29; H, 4.88. Found: C, 62.18; H, 4.92.

Compound **4** (2.20 g, 98%) was obtained as an oil from (±)-*trans*-1-phenylselenoindan-2-ol (1.30 g, 4.49 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (Et_2O/hexane 1:50): ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.49−7.14 (m, 19 H), 6.31 (dd, 1 H, J = 20.1, 14.9 Hz), 6.18 (dd, 1 H, J = 15.0, 3.8 Hz), 5.76 (dd, 1 H, J = 20.3, 3.9 Hz), 4.79 (m, 1 H), 4.76 (s, 1 H), 3.13 (dd, 1 H, J = 16.3, 5.3 Hz), 2.87 (dd, 1 H, J = 16.3, 1.4 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 141.3, 141.2, 137.3, 135.0, 134.7, 134.3, 134.2, 133.6, 130.0, 129.5, 128.9, 127.8, 127.7, 127.6, 126.8, 125.6, 125.0, 80.3, 54.6, 40.7; EI HRMS calcd for $C_{29}H_{26}OSeSi$ 498.0916, found 498.0912 (M^+). Anal. Calcd for $C_{29}H_{26}OSeSi$: C, 70.00; H, 5.27. Found: C, 70.03; H, 5.38.

(±)-*trans*-1-Diphenylvinylsiloxy-2-iodocyclopentane (6). Compound **6** (1.84 g, 94%) was obtained as an oil from (±)-*trans*-2-iodocyclopentanol[17] (987 mg, 4.66 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (Et_2O/hexane 1:100): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61−7.36 (m, 10 H), 6.49 (dd, 1 H, J = 20.3, 14.9 Hz), 6.30 (dd, 1 H, J = 14.9, 3.9 Hz), 5.88 (dd, 1 H, J = 20.3, 3.8 Hz), 4.61 (dt, 1 H, J = 5.9, 2.9 Hz), 4.13 (dt, 1 H, J = 2.9 Hz), 2.46−2.37 (m, 1 H), 2.14−1.99 (m, 2 H), 1.92−1.75 (m, 2 H), 1.73−1.65 (m, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.4, 134.9, 133.9, 133.4, 130.0, 127.8, 83.0, 35.8, 34.6, 32.2, 22.3; EI HRMS calcd for $C_{19}H_{21}IOSi$ 420.0406, found 420.0384 (M^+). Anal. Calcd for $C_{19}H_{21}IOSi$: C, 54.29; H, 5.04. Found: C, 54.17; H, 5.08.

(±)-*trans*-1-Diphenylvinylsiloxy-2-iodocyclohexane (8). Compound **8** (2.79 g, 91%) was obtained as an oil from (±)-*trans*-2-iodocyclohexanol[18] (1.60 g, 7.08 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (Et_2O/hexane 1:100): ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.68−7.30 (m, 10 H), 6.55 (dd, 1 H, J = 20.5, 15.2 Hz), 6.30 (dd, 1 H, J = 15.2, 4.0 Hz), 5.90 (dd, 1 H, J = 20.5, 4.0 Hz), 4.15 (ddd, 1 H, J = 9.9, 7.9, 4.0 Hz), 3.92 (ddd, 1 H, J = 8.6, 7.9, 4.0 Hz), 2.45−2.35 (m, 1 H), 2.05−1.85 (m, 2 H), 1.76−1.73 (m, 1 H), 1.52−1.28 (m, 4 H); EI HRMS calcd for $C_{20}H_{23}IOSi$ 434.0563, found 434.0593 (M^+).

(±)-*cis*-1-Hydroxy-2-vinylindane (3). A stirring solution of **2a** (103 mg, 0.220 mmol) and $(Bu_3Sn)_2$ (10 μL, 20 mmol) in benzene (2 mL) was irradiated with a high-pressure mercury lamp (300 W) for 1 h. To the resulting mixture was added TBAF (1 M in THF, 0.30 mL, 0.30 mmol), and the whole was stirred at room temperature for 20 min. The solvent was evaporated, and the residue was purified by silica gel column chromatography (AcOEt/hexane 1:5) to give **3** (29 mg, 82%) as an oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44−7.22 (m, 4 H), 5.97 (ddd, 1 H, J = 17.1, 10.5, 7.8 Hz), 5.30−5.25 (m, 2 H), 5.09 (m, 1 H), 3.17−3.10 (m, 1 H), 3.00 (d, 2 H, J = 7.3 Hz), 1.70 (d, 1 H, J = 5.1 Hz); EI HRMS calcd for $C_{11}H_{12}O$ 160.0888, found 160.0873.

(±)-*cis*-2-Hydroxy-1-vinylindane (5). Compound **5** (17 mg, 53%) was obtained as an oil from **4** (100 mg, 0.201 mmol) as described above for the synthesis of **3**, after purification by silica gel column chromatography (AcOEt/hexane 1:5): ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28−7.17 (m, 4 H, aromatic), 6.02 (ddd, 1 H, C*H*=CH$_2$, J = 17.7, 10.4, 8.4 Hz), 5.39 (dd, 1 H, CH=C*H*$_2$, J = 10.4, 1.7, Hz), 5.34 (dd, 1 H, CH=C*H*$_2$, J = 17.7, 1.7 Hz), 4.60 (ddd, 1 H, H-2, $J_{1,2}$ = 5.4 Hz, $J_{2,3a}$ = 5.4 Hz, $J_{2,3b}$ = 3.0 Hz,), 3.82 (dd, 1 H, H-1, $J_{1,1'}$ = 8.4 Hz, $J_{1,2}$ = 5.4 Hz), 3.15 (dd, 1 H H-3$_a$, J = 16.1, 5.4 Hz), 2.96 (dd, 1 H, H-3$_b$, J = 16.1, 3.0 Hz), 1.69 (d, 1 H, 2-OH, J = 5.2 Hz), the assignments were in agreement with H−H COSY spectrum; NOE ($CDCl_3$, 400 MHz) irradiated H-2, observed H-1 (2.0%); ^{13}C NMR (125 MHz, $CDCl_3$) δ 142.6, 140.9, 135.1, 127.1, 126.7, 125.1, 124.9, 119.2, 75.4, 54.8, 41.0; EI HRMS calcd for $C_{11}H_{12}O$ 160.0888, found 160.0897. Anal. Calcd for $C_{11}H_{12}O$: C, 82.46; H, 7.55. Found: C, 82.19; H, 7.32.

(±)-*cis*-1-Benzoyloxy-2-vinylcyclopentane (7). A stirring solution of **6** (210 mg, 0.500 mmol) and (*n*-$Bu_3Sn)_2$ (25 μL, 49 μmol) in benzene (2.5 mL) was irradiated with high-pressure mercury lamp (300 W) for 30 min. To the resulting mixture was added TBAF (1 M in THF, 0.30 mL, 0.30 mmol)), and the whole was stirred at room temperature for 20 h. After the solvent was evaporated, the residue and BzCl (0.60 mL, 5.2 mmol) were dissolved in pyridine (2 mL), and the resulting mixture was stirred at room temperature for 2 h. Et_2O and water were added, and the resulting mixture was partitioned. The organic layer was washed with brine, dried (Na_2SO_4), and evaporated. The residue was purified by silica gel column chromatography (Et_2O/hexane 1:100) to give **7** (62 mg, 58%) as an oil: ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02−7.42 (m, 5 H), 5.93 (ddd, 1 H, J = 17.1, 10.5, 7.6 Hz), 5.43 (ddd, 1 H, J = 5.1, 1.7 Hz), 5.12 (ddd, 1 H, J = 17.1, 1.7, 1.5 Hz), 5.03 (dd, 1 H, J = 10.5, 1.5 Hz), 2.72−2.65 (m, 1 H), 2.13−2.06 (m, 1 H), 1.95−1.78 (m, 4 H), 1.74−1.66 (m, 1 H);^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 137.0, 132.6, 130.7, 129.4, 128.2, 115.7, 79.0, 48.5, 32.4, 29.5, 22.3; EI HRMS calcd for $C_{14}H_{16}O_2$ 216.1150, found 216.1146 (M^+). Anal. Calcd for $C_{14}H_{16}O_2$: C, 77.75; H, 7.46. Found: C, 77.75; H,7.58.

(±)-*cis*-1-Benzoyloxy-2-vinylcyclohexane (9). Compound **9** (60 mg, 52%) was obtained as an oil from **8** (217 mg, 0.500 mmol) as described above for the synthesis of **7**, after purification by silica gel column chromatography (Et_2O/hexane 1:100): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08−7.42 (m, 5 H, aromatic), 5.89 (ddd, 1 H, C*H*=CH$_2$, J = 17.3, 10.5, 6.8 Hz), 5.29 (m, 1 H, H-1, $J_{1,2}$ < 2.2 Hz), 5.06 (ddd, 1 H, CH=C*H*$_2$, J = 17.3, 1.5, 1.5 Hz), 5.01 (ddd, 1 H, CH=C*H*$_2$, J = 10.5, 1.5,

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1.2 Hz), 2.41 (m, 1 H, H-2), 2.05−1.39 (m, 8 H, H-3,4,5,6), the assignments were in agreement with H−H COSY spectrum; EI HRMS calcd for $C_{15}H_{18}O_2$ 230.1307, found 230.1326 (M^+).

1-(5-*O*-Dimethoxytrityl-3-*O*-diphenylvinylsilyl-4-*C*-phenylseleno-2-deoxy-α-L-*erythro*-pento-1,4-furanosyl)thymine (11). Compound **11** (14.5 g, 92%) was obtained as a foam from **10**[14] (12.1 g, 17.4 mmol) as described above for the synthesis of **2a**, after purification by silica gel column chromatography (AcOEt/hexane 3:2): ^{1}H NMR (270 MHz, $CDCl_3$) δ 8.11 (br s, 1 H), 7.47−6.71 (m, 29 H), 6.59 (dd, 1 H, J = 6.6, 7.3 Hz), 6.13−5.56 (m, 3 H), 4.56 (dd, 1 H, J = 4.0, 5.3 Hz), 3.80 (d, 1 H, J = 10.6 Hz), 3.77 (s, 6 H), 3.12 (d, 1 H, J = 10.56), 2.44 (ddd, 1 H, J = 13.9, 6.6, 5.3 Hz), 2.32 (ddd, 1 H, J = 13.9, 7.3, 5.3 Hz), 1.89 (s, 3 H); FAB HRMS calcd for $C_{51}H_{49}N_2O_7SeSi$ 909.2474, found 909.2465 (MH^+).

5′-*O*-Dimethoxytrityl-4′α-*C*-vinylthymidine (12). Compound **12** (35 mg, 61%) was obtained as a foam from **11** (91 mg, 0.10 mmol) as described above for the synthesis of **3**, after purification by silica gel column chromatography (AcOEt/hexane 3:1): ^{1}H NMR (270 MHz, $CDCl_3$) δ 8.21 (br s, 1 H), 7.61 (s, 1 H), 7.42−6.83 (m, 13 H), 6.32 (t, 1 H, J = 5.9 Hz), 5.86 (dd, 1 H, J = 17.2, 10.6 Hz), 5.53 (dd, 1 H, J = 17.2, 1.3 Hz), 5.36 (dd, 1 H, J = 10.6, 1.3 Hz), 4.64 (m, 1 H), 3.79 (s, 6 H), 3.34 (d, 1 H, J = 10.6 Hz), 3.28 (d, 1 H, J = 10.6 Hz), 2.45−2.29 (m, 2 H), 1.77 (d, 1 H, J = 4.6 Hz), 1.47 (s, 3 H); FAB HRMS calcd for $C_{33}H_{35}N_2O_7$ 571.2444, found 571.2448 (MH^+).

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Supporting Information Available: ^{1}H NMR spectral charts of **2c**, **3**, **8**, **9**, **11**, and **12**. Ordering information is given on any current masthead page. This material is available free of charge via the Internet at http://pubs.acs.org.

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