JOC*Note*

Stereoselective Synthesis of 1′-*C*-Branched Arabinofuranosyl Nucleosides via Anomeric Radicals Generated by 1,2-Acyloxy Migration

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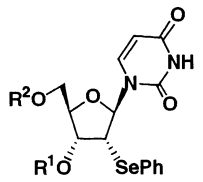
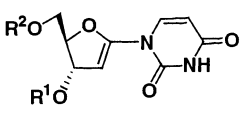
Abstract: Stereoselective C−C bond formation at the anomeric position of uracil and adenine nucleoside has been accomplished through reaction of the anomeric radical, generated by 1,2-acyloxy migration, with a radical acceptor. The present method consists of the following steps: (1) electrophilic addition (bromo-pivaloyloxylation) to 3′,5′-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-protected 1′,2′-unsaturated nucleoside, (2) tin radical-mediated reaction of the resulting adduct with a radical acceptor. The use of allyl(tributyl)tin gave the 1′-*C*-allylated uracil nucleoside **14** in 66% yield together with the unrearranged 2′-*C*-allylated product **15** (6%). Radical acceptors such as styryl(tributyl)tin and 3-bromo-2-methylacrylonitrile can also be used in the reaction of **5**, giving **16** (70%) and **17** (76%) without the formation of unrearranged product. The radical-mediated C−C bond formation of the adenine counterpart **12** was also investigated.

Free radical reaction processes are recognized as being increasingly important as a synthetic method in organic chemistry,[1] due to the mild and neutral reaction conditions that permit stereoselective entry to highly functionalized molecules such as natural products.[2] Glycosyl anomeric radicals have been used extensively for the synthesis of *C*-glycosides through reaction with acceptors such as alkenes and alkynes.[3] In the field of nucleoside chemistry, however, much effort regarding anomeric radicals has been devoted to the studies of DNA damage.[4] In this paper, we describe the stereoselective synthesis of arabinofuranosyl nucleosides branched at the anomeric position by way of reaction of the nucleoside anomeric radical, generated by 1,2-acyloxy migration,[5−7] with a radical acceptor.[8]

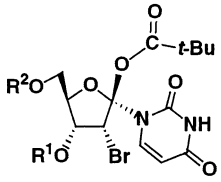
Substrates for 1,2-acyloxy migration were synthesized through bromo-pivaloyloxylation of 3′,5′-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl) (TIPDS)-protected **3** and 3′,5′-*O*-(di-*tert*-butylsilylene) (DTBS)-protected 1′,2′-unsaturated uracil nucleosides **4**, which were prepared by selenoxide *syn*-elimination of the corresponding 2′-phenylseleno derivatives **1** and **2**.[9] The bromo-pivaloyloxylation of **3** gave the α-*anti*-adduct **5** (52%) as the major product along with the isomeric **6** (26%). It was found that the α-*anti*-adduct **7** (67%) was the sole product in the reaction of **4**. The stereochemical assignments of **5** and **6** can be deduced from their $J_{2',3'}$ values (**5**, J = 4.8 Hz; **6**, J = 0.7 Hz), since the smaller J value corresponds to the dihedral angle close to 90° that is possible only for **6**. The stereochemistry of **7** was determined on the basis of X-ray crystallography.[6]



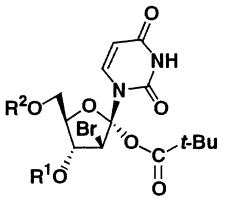
1: R^1 - R^2 = TIPDS
2: R^1 - R^2 = DTBS



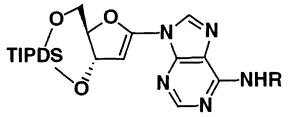
3: R^1 - R^2 = TIPDS
4: R^1 - R^2 = DTBS



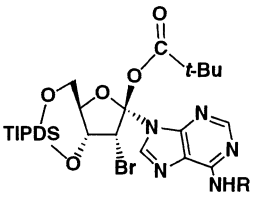
5: R^1 - R^2 = TIPDS
7: R^1 - R^2 = DTBS



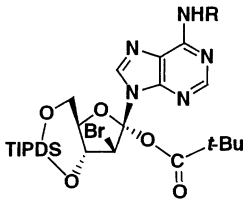
6: R^1 - R^2 = TIPDS



8: R = H
9: R = CO-*t*-Bu



10: R = H
12: R = CO-*t*-Bu



11: R = H
13: R = CO-*t*-Bu

(1) (a) Giese, B. *Radicals in Organic Synthesis: Formation of Carbon-Carbon Bonds*; Pergamon: Oxford, 1986. (b) Motherwell, W. B.; Crich, D. *Free Radical Chain Reactions in Organic Synthesis*; Academic Press: London, 1992. (c) Renaud, P.; Sibi, M. P. *Radicals in Organic Synthesis*; Wiley-VCH: Weinheim, Germany, 2001.

(2) Jasperse, C. P.; Curran, D. P.; Fevig, T. L. *Chem. Rev.* **1991**, *91*, 1237−1286.

(3) (a) Collins, P. M.; Ferrier, R. J. *Monosaccharides; Their Chemistry and Their Roles in Natural Products*; John Wiley & Sons: Chichester, U.K., 1995. (b) Postema, M. H. D. *C-GlycosideSynthesis*; CRC Press: Boca Raton, FL, 1995.

(4) 1′-*C*-Acylated derivatives of 2′-deoxyuridine were synthesized as anomeric radical precursors. (a) Greenberg, M. M.; Yoo, D. J.; Goodman, B. K. *Nucleosides Nucleotides* **1997**, *16*, 33−40. (b) Chatgilialoglu, C.; Gimisis, T. *Chem. Commun.* **1998**, 1249−1250. (c) Chatgilialoglu, C.; Ferreri, C.; Gimisis, T. *Tetrahedron Lett.* **1999**, *40*, 2837−2840.

(5) For a review, see: Beckwith, A. L.; Crich, D.; Duggan, P. J.; Yao, Q. *Chem. Rev.* **1997**, *97*, 3273−3312.

(6) Haraguchi, K.; Tanaka, H.; Matsumoto, K.; Nakamura, K. T.; Miyasaka, T. *Tetrahedron Lett.* **1995**, *36*, 3867−3870.

(7) Kinetic studies of the 1,2-acyloxy migaration have been reported: (a) Gimisis, T.; Ialongo, G.; Zamboni, M.; Chatgilialoglu, C. *Tetrahedron Lett.* **1995**, *36*, 6781−6784. (b) Gimisis, T.; Ialongo; Chatgilialoglu, C. *Tetrahedron* **1998**, *54*, 573−592. (c) Chatogilialoglu, C. *Nucleosides Nucleotides* **1999**, *18*, 547−553.

(8) Recently, intra- and intermolecular C−C bond formation of nucleoside-1-yl has been reported: (a) (Intramolecular reaction) Kodama, T.; Shuto, S.; Nomura, M.; Matsuda, A. *Chem. Eur. J.* **2001**, *7*, 2332−2340. (b) (Intermolecular reaction) Kumamoto, H.; Murasaki, M.; Haraguchi, K.; Anamura, A.; Tanaka, H. *J. Org. Chem.* **2002**, *67*, 6124−6130.

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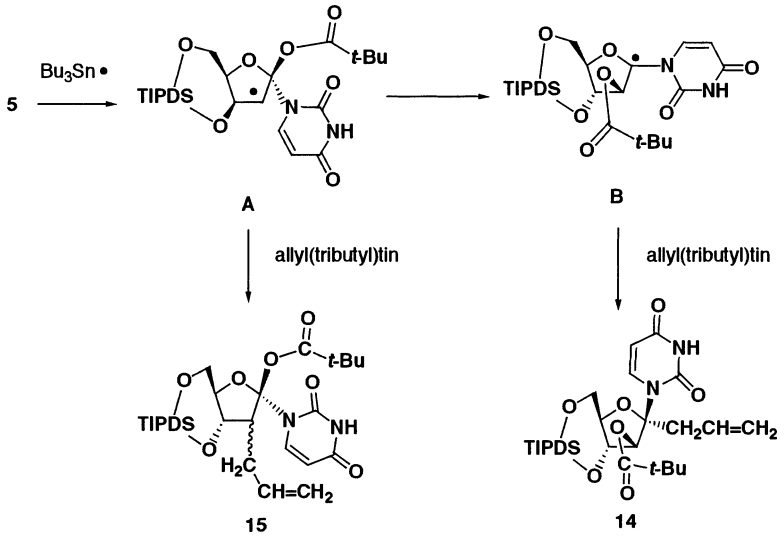
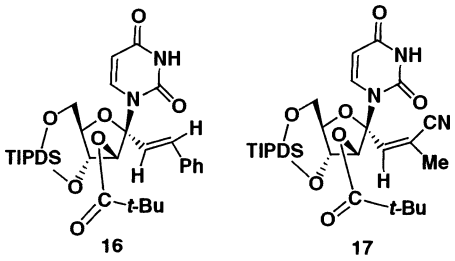
SCHEME 1



Although the 3′,5′-*O*-TIPDS-protected 1′,2′-unsaturated adenosine **8**, prepared according to a reported procedure,[10,11] showed a stereochemical trend similar to that of **3** in its bromo-pivaloyloxylation, the yield of the adducts was rather low (**10**, 39%; **11**, 3%) and their chromatographic separation from succinimide was difficult. The best results were obtained by employing the N^6-pivaloyl derivative **9** as a substrate and 1,3-dibromo-5,5-dimethylhydantoin (dibromatin) as a brominating agent. Thus, when **9** was reacted with dibromatin (4 equiv) in the presence of *t*-$BuCO_2H$ (10 equiv) and Et_3N (10 equiv) in CH_2Cl_2, the α-*anti*-adduct **12** was formed in 57% yield along with the *β*-*anti*-adduct **13** (12%).[12]

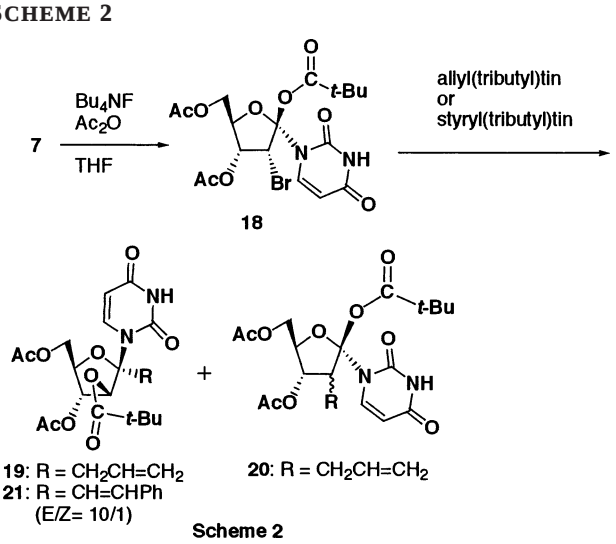
We first investigated the synthesis of 1′-*C*-branched uracil nucleosides. When **5** was treated with allyl(tributyl)tin (3.4 equiv)/AIBN (0.7 equiv) in refluxing benzene for 2 h, initially formed C-2′ radical **A** was transformed into nucleoside anomeric radical **B**[13] via 1,2-acyloxy migration, and subsequent reaction of **B** with allyltributyltin gave the *β*-anomer of 1′-*C*-allylarabinofuranosyl derivative **14**[14] in 52% yield stereoselectively, along with eliminated product **3** (11%) (Scheme 1). Under photochemically initiated conditions using $(Bu_3Sn)_2$ at room temperature in benzene, **14** was formed with an improved yield of 66% as well as the 2′-*C*-allylated byproduct **15** (6%, an isomeric mixture at C-2′) derived from **A**. The fact that **15** was isolated instead of **3** in this latter reaction indicates that the higher temperature employed in the former reaction caused the elimination pathway. Radical acceptors that react through an addition−elimination mechanism, such as styryl(tributyl)tin and 3-bromo-2-methylacrylonitrile, worked more efficiently in the reaction of **5** under the photochemical conditions to give the respective products uniformly in higher yields: **16**, 76%; **17**, 70%.[15]



The 3′,5′-*O*-DTBS derivative **7** was not a suitable substrate for 1,2-acyloxy migration due to its rigid conformation.[6] However, its ready accessibility from **4** as well as the right stereochemistry led us to replace the 3′,5′-*O*-protecting group of **7** with acetyl groups to make the molecule much more flexible. Compound **7** was treated with Bu_4NF in THF containing Ac_2O at room temperature for 2 h to give the 3′,5′-di-*O*-acetyl derivative **18** in 78% yield. When a benzene solution of **18** was irradiated in the presence of allyl(tributyl)tin/$(Bu_3Sn)_2$, the 1′-*C*-allylated product **19** was obtained in 62% yield along with **20** (10%) (Scheme 2). From the observed yield of **19**, which is comparable to that of **14**, it would be reasonable to say that the 3′,5′-*O*-TIPDS protection provides enough flexibility for the present 1,2-acyloxy migration. As was seen for **5**, styryl(tributyl)tin reacted with **18** more efficiently than allyl(tributyl)tin, giving **21** (a diastereomeric mixture, E/Z = 10/1) in 71% yield without forming the 2′-*C*-styrylated byproduct. This result may be a reflection of the difference in reactivity of these two radical acceptors. Namely, allyl(tributyl)tin

(9) Haraguchi, K.; Tanaka, H.; Maeda, H.; Itoh, Y.; Miyasaka, T. *J. Org. Chem*. **1991**, *56*, 5401−5408.
(10) Fukukawa, K.; Ueda, T.; Hirao, T. *Chem. Pharm. Bull*. **1983**, *31*, 1582−1592.
(11) Robins, M. J.; Jones, R. A. *J. Org. Chem*. **1974**, *39*, 113−115.
(12) The stereochemistry of these adducts was determined on the basis of NOE experiments: **12**, H-2′/H-3′ and H-4′/H-8; **13**, H-2′/H-4′.
(13) Although **B** is depicted as an sp^2-hybridized radical, an alternative possibility is that **B** exists in equilibrium of two sp^3-hybridized species with opposite configurations. For examples of 2′-deoxyuridin-1-yl radical, see: Chatgilialoglu, C.; Ferreri, C.; Bazzanini, R.; Buerra, M.; Choi, S.-Y.; Emanuel, C. J.; Horner, J. H.; Newcomb, M. *J. Am. Chem. Soc*. **2000**, *122*, 9525−9533.
(14) The stereochemistry of **14** was confirmed on the basis of the observation of NOEs between H-3′/H-6 and H-2′/H-4′.
(15) Although styryl(tributyl)stannane and 3-bromo-2-methylacrylonitrile used were a mixture of geometric isomers, the respective products **16** and **17** appeared to consist of only the depicted isomer. The configurations about the 1′- and 2′-positions of these products were confirmed on the basis of the observation of NOE correlations between H-3′ and H-6 and H-2′ and H-4′, respectively.

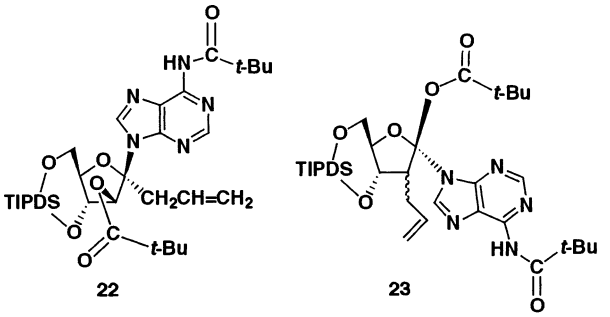
SCHEME 2



Scheme 2

could be more reactive than styryl(tributyl)tin, and therefore, allylation takes place before migration of the 1′-*C*-pivaloyloxy group.

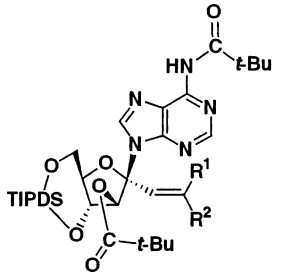
We next extended the radical-based C−C bond formation to the synthesis of 1′-*C*-branched arabinofuranosyl adenines by using the 3′,5′-*O*-TIPDS derivative **12**. When **12** was reacted with 5.0 equiv of allyl(tributyl)tin in benzene for 4 h under photochemical conditions as for the allylation reaction of TIPDS-protected uracil nucleoside **5**, unrearranged 2′-*C*-allylated byproduct **23** was formed in 24% yield and the yield of the desired product **22** was only 42%. This is a likely consequence of



the highly reactive nature of the allylating agent, as mentioned above. A simple solution would be, therefore, to reduce the amount of the reagent. In fact, by using 2.5 equiv of allyl(tributyl)tin, the yield of **22** was improved to 52% at the expense of **23** (11%). The best result was obtained by reducing the amount to 1.5 equiv: **22**, 60%; **23**, 5%.

On the basis of the results in the synthesis of **16** and **17**, one would anticipate that styryl(tributyl)tin and 3-bromo-2-methylacrylonitrile might react with the adenine nucleoside anomeric radical more efficiently. In fact, by using 5 equiv of these radical acceptors, the desired 1′-*C*-styryl(arabinofuranosyl)adenine **24** and 1′-*C*-acrylyl(arabinofuranosyl)adenine **25** compounds were obtained as a mixture of geometric isomers in 65% and 73% yield, respectively, without the formation of unrearranged product.

In conclusion, we have developed a novel method for the stereoselective synthesis of 1′-*C*-carbon-substituted



***trans*-24**: R^1 = H, R^2 = Ph
***cis*-24**: R^1 = Ph, R^2 = H
***trans*-25**: R^1 = Me, R^2 = CN
***cis*-25**: R^1 = CN, R^2 = Me

(arabinofuranosyl)uracil and -adenine nucleosides based on a combination of bromo-pivaloyloxylation to 1′,2′-unsaturated nucleoside and C−C bond formation of the nucleoside anomeric radical resulting from 1,2-acyloxy migration. The present radical migration (from C-2′ to the anomeric position) is unique in that it is the reverse pathway to that observed in carbohydrate systems (from the anomeric position to C-2). Reaction of the nucleoside anomeric radical with radical acceptors proceeded stereoselectively, due to the steric repulsion exerted by the 2′-"up"-pivaloyloxy group (the *anti*-rule).[16] It is noteworthy that a radical acceptor, which reacts through an addition−elimination mechanism such as styryl(tributyl)tin and 3-bromo-2-methylacrylonitrile, is a suitable choice of reagent for this tandem 1,2-acyloxy migration/intermolecular C−C bond formation methodology. Since the compounds synthesized in this study are medicinally interesting arabinofuranosyl nucleosides, we are currently evaluating their biological activities.

Experimental Section

Melting points are uncorrected. ^{1}H NMR was measured at 400 or 500 MHz. Chemical shifts are reported relative to that of Me_4Si for ^{1}H NMR. Mass spectroscopy (MS) was done in FAB mode (*m*-nitrobenzyl alcohol as a matrix). Column chromatography was carried out on silica gel (silica gel 60). Thin-layer chromatography (TLC) was performed on silica gel (precoated silica gel plate F_{254}). HPLC was carried out on a Shimadzu LC-6AD with a shim-pack PREP-SIL(H)·KIT column (2 × 25 cm).

1-[2-*O*-Pivaloyl-1-*C*-*(E)*-styryl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]uracil (16). A benzene solution (15 mL) of **5** (117.7 mg, 0.18 mmol), $Bu_3SnCH{=}CHPh$ (0.36 mL, 0.90 mmol), and $(Bu_3Sn)_2$ (98 μL, 0.18 mmol) was irradiated with a high-pressure mercury lamp under an Ar atmosphere at rt for 4 h. Column chromatography of the reaction mixture (hexane/AcOEt = 5/1) gave **16** (85.3 mg, 70%) as a syrup: UV (MeOH) λ_{max} 255 (ϵ 23700), λ_{min} 225 (ϵ 6800); ^{1}H NMR ($CDCl_3$) δ 1.05−1.06 (28H, m), 1.12 (9H, s), 3.90 (1H, dd, J = 8.4 and 11.4 Hz), 4.19 (1H, dd, J = 3.7 and 11.4 Hz) δ 4.04−4.08 (1H, m), 4.38−4.41 (1H, m), 5.68 (1H, d, J = 8.4 Hz), 5.74 (1H, d, J = 2.6 Hz), 6.79 and 6.88 (2H, each as d, J = 16.1 Hz), 7.27−7.34 and 7.42−7.53 (6H, each as m), 7.84 (1H, d, J = 8.4 Hz), 8.51 (1H, br); FAB-MS *m*/*z* 695 (M^+ + Na), 673 (M^+ + H). Anal. Calcd for $C_{34}H_{52}N_2O_8Si_2$: C, 60.68; H, 7.79; N, 4.16. Found: C, 60.58; H, 7.94; N, 4.13.

1-[1-*C*-Methacrylyl-2-*O*-pivaloyl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]uracil (17). A benzene solution (10 mL) of **5** (69.8 mg, 0.11 mmol), $BrCH{=}C(CH_3)CN$ (53.0 μL, 0.55 mmol), and $(Bu_3Sn)_2$ (0.30 mL, 0.55 mmol) was irradiated with a high-pressure mercury lamp under an Ar atmosphere at rt for 4 h. Purification of the reaction mixture by preparative TCL (hexane/AcOEt = 4/1) gave **17** (52.9 mg, 76%) as a syrup: UV (MeOH) λ_{max} 261 (ϵ 10400), λ_{min} 236 (ϵ

(16) Renaud, P. Stereoselectivity of Radical Reactions: Cyclic Systems. In *Radicals in Organic Synthesis*; Renaud, P., Sibi, M. P., Eds.; Wiley-VCH: Weinheim, Germany, 2001; Vol. 1, pp 400−415.

4500); ^{1}H NMR ($CDCl_3$) δ 0.97−1.10 (28 H, m), 1.11 (9H, s), 2.03 (3H, d, J = 1.8 Hz), 3.88 (1H, dd, J = 7.0 and 11.7 Hz), 4.17 (1H, dd, J = 3.7 and 11.7 Hz), 4.05−4.08 (1H, m), 4.31 (1H, dd, J = 3.7 and 4.9 Hz), 5.63 (1H, d, J = 3.7 Hz), 5.74 (1H, d, J = 8.4 Hz), 6.94 (1H, d, J = 1.8 Hz), 7.99 (1H, d, J = 8.4 Hz), 8.37 (1H, br); FAB-MS m/z 658 (M^+ + Na), 636 (M^+ + H). Anal. Calcd for $C_{30}H_{49}N_3O_8Si_2$: C, 56.66; H, 7.77; N, 6.61. Found: C, 56.82; H, 7.90; N, 6.43.

1-[3,5-Di-*O*-acetyl-1-*C*-(*E* and *Z*)-styryl-2-*O*-pivaloyl-*β*-D-arabinofuranosyl]uracil (21). A benzene (15 mL)/THF (0.2 mL) solution of **18** (155.8 mg, 0.32 mmol), $Bu_3SnCH{=}CHPh$ (623.2 mg, 1.59 mmol), and $(Bu_3Sn)_2$ (31 μL, 0.06 mmol) was irradiated with a high-pressure mercury lamp under an argon atmosphere at rt for 4 h. Column chromatography of the reaction mixture (hexane/AcOEt = 2/1) gave **21** (115.8 mg, E/Z = 10/1, 71%) as a syrup: UV (MeOH) λ_{max} 255 (ϵ 20100) and 225 (ϵ 11200), λ_{min} 226 (ϵ 5600); ^{1}H NMR ($CDCl_3$) δ (*E*-isomer) 1.13 (9 H, s), 1.99 and 2.14 (6H, each as s), 4.32−4.36 (2H, m), 4.47 (1H, dd, J = 7.4 and 14.2 Hz), 4.90 (1H, d, J = 2.1 Hz), 5.73 (1H, dd, J = 1.9 and 8.2 Hz), 5.84 (1H, s), 6.71 and 6.87 (2H, each as d, J = 16.2 Hz), 7.31−7.36, 7.41−7.44 (5H, each as m), 7.84 (1H, d, J = 8.2 Hz); (*Z*-isomer/selected data) 1.06 (1H, s), 2.04 and 2.19 (6H, each as s), 5.71 (1H, s), 6.21 (1H, d, J = 12.2 Hz); FAB-MS m/z 515 (M^+ + H). Anal. Calcd for $C_{26}H_{30}N_2O_9 \cdot {}^1/_4H_2O$: C, 60.17; H, 5.92; N, 5.44. Found: C, 60.07; H, 5.98; N, 5.21.

1-[1-*C*-Allyl-2-*O*-pivaloyl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]-*N*^{6}-pivaloyladenine (22) and 1-[2-*C*-Allyl-2-deoxy-1-pivaloyloxy-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-α-D-ribofuranosyl]-*N*^{6}-pivaloyladenine (23). A benzene solution (7 mL) of **12** (88.0 mg, 0.12 mmol), $Bu_3SnCH_2CH{=}CH_2$ (57 μL, 0.18 mmol), and $(Bu_3Sn)_2$ (60 μL, 0.12 mmol) was irradiated with a high-pressure mercury lamp under an Ar atmosphere at rt for 4 h. Purification of the reaction mixture by preparative TCL (hexane/AcOEt = 2/1) gave **22** (51.1 mg, 60%, syrup) and **23** (4.3 mg, 5%, syrup, a mixture of diastereomers).

Physical data for **22:** UV (MeOH) λ_{max} 264 (ϵ 14000), λ_{min} 230 (ϵ 2900); ^{1}H NMR ($CDCl_3$) δ 0.73 and 1.41 (18 H, each as s), 0.98−1.34 (28H, m), 3.37 (1H, dd, J = 7.0 and 14.8 Hz), 3.52 (1H, dd, J = 7.3 and 14.8 Hz), 3.98−4.02 (1H, m), 4.14−4.18 (2H, m), 4.57 (1H, t, J = 7.3 Hz)), 5.09 (1H, dd, J = 1.4 and 10.3 Hz), 5.16 (1H, J = 1.4 and 17.2 Hz), 5.69 (1H, d, J = 7.3 Hz), 5.64−5.75 (1H, m), 8.41 and 8.71 (2H, each as s), 8.64 (1H, br); FAB-MS m/z 718 (M^+ + H). Anal. Calcd for $C_{35}H_{59}N_5O_7Si_2$: C, 58.54; H, 8.28; N, 9.75. Found: C, 58.81; H, 8.25; N, 9.92.

Physical data for **23:** UV (MeOH) λ_{max} 259 (ϵ 13900), λ_{min} 227 (ϵ 2800); ^{1}H NMR ($CDCl_3$) δ (major isomer) 1.02−1.16 (28H, m), 1.08 (9H, s), 1.41 (9H, s), 1.81−1.94 (1H, m), 3.12−3.15 (1H, m), 3.42−3.46 (1H, m), 4.14 (1H, dd, J = 3.3 and 11.9 Hz), 4.18 (1H, dd, J = 3.7 and 11.9 Hz), 4.29−4.33 (1H, m), 4.44 (1H, dd, J = 1.5 and 15.9 Hz), 4.51−4.57 (2H, m), 5.43−5.54 (1H, m), 8.30 (1H, s), 8.60 (1H, br), 8.75 (1H, s); (minor isomer/selected data) 1.21 (9H, s), 1.40 (9H, s), 2.17−2.24 (1H, m), 2.48−2.53 (1H, m), 2.87−2.92 (1H, m), 3.88 (1H, dd, J = 8.1 and 12.0 Hz), 3.98 (1H, dd, J = 7.3 and 12.0 Hz), 4.42−4.46 (1H, m), 4.91−4.99 (2H, m), 5.09 (1H, dd, J = 1.5 and 17.2 Hz), 5.63−5.70 (1H, m), 8.17 (1H, s), 8.54 (1H, br), 8.71 (1H, s); FAB-MS m/z 718 (M^+ + H), 616 (M^+ − *t*-BuCOO). Anal. Calcd for $C_{35}H_{59}N_5O_7Si_2$: C,58.54; H, 8.28; N, 9.75. Found: C, 58.69; H, 8.11; N, 10.09.

1-[2-*O*-Pivaloyl-1-*C*-(*E*)-styryl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]-*N*^{6}-pivaloyladenine (*trans*-24) and 1-[2-*O*-Pivaloyl-1-*C*-(*Z*)-styryl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]-*N*^{6}-pivaloyladenine (*cis*-24). A benzene solution (7 mL) of **12** (50.9 mg, 0.07 mmol), $Bu_3SnCH{=}CHPh$ (131.7 mg, 0.34 mmol), and $(Bu_3Sn)_2$ (84.6 μL, 0.17 mmol) was irradiated with a high-pressure mercury lamp under an argon atmosphere at rt for 4 h. Purification of the reaction mixture by preparative TCL (hexane/AcOEt = 2/1) gave *trans*-**24** (23.8 mg, 46%, syrup) and *cis*-**24** (10.4 mg, 19%, syrup).

Physical data for *trans*-**24**: UV (MeOH) λ_{max} 273 (ϵ 19000), λ_{min} 233 (ϵ 9600); ^{1}H NMR ($CDCl_3$) δ 0.70 and 1.39 (18H, each as s), 0.91−1.26 (28H, m), 3.99−4.03 (1H, m), 4.18 (1H, dd, J = 1.5 and 12.5 Hz), 4.32 (1H, dd, J = 5.2 and 12.5 Hz), 5.29 (1H, dd, J = 6.4 and 7.6 Hz), 5.57 (1H, d, J = 6.4 Hz), 7.09 (1H, d, J = 15.9 Hz), 7.31 (1H, d, J = 15.9 Hz), 7.36−7.39 and 7.52−7.54 (5H, each as m); FAB-MS m/z 561 (M^+ + H). Anal. Calcd for $C_{40}H_{61}N_5O_7Si_2 \cdot {}^3/_4CH_3CO_2C_2H_5$: C, 61.03; H, 7.98; N, 8.28. Found: C, 60.66; H, 8.15; N, 8.14.

Physical data for *cis*-**24**: UV (MeOH) λ_{max} 263 (ϵ 17200), λ_{min} 232 (ϵ 7800); ^{1}H NMR ($CDCl_3$) δ 0.71 and 1.40 (18H, each as s), 0.91−1.15 (28H, m), 3.72−3.75 (1H, m), 3.88−3.89 (2H, m), 4.86 (1H, t, J = 6.5 Hz), 5.66 (1H, d, J = 6.5 Hz), 6.66 (1H, d, J = 12.5 Hz), 6.90 (1H, d, J = 12.5 Hz), 7.02−7.04, 7.09−7.10 (5H, each as m), 8.22 (1H, s), 8.71 (1H, s), 8.44 (1H, br); FAB-MS m/z 561 (M^+ + H). Anal. Calcd for $C_{40}H_{61}N_5O_7Si_2 \cdot {}^2/_3H_2O$: C, 59.52; H, 7.99; N, 8.68. Found: C, 59.49; H, 8.04; N, 8.42.

1-[1-*C*-(*E*)-Methacrylyl-2-*O*-pivaloyl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]-*N*^{6}-pivaloyladenine (*trans*-25) and 1-[1-*C*-(*Z*)-Methacrylyl-2-*O*-pivaloyl-3,5-*O*-(1,1,3,3-tetraisopropyldisiloxane-1,3-diyl)-*β*-D-arabinofuranosyl]-*N*^{6}-pivaloyladenine (*cis*-25). A benzene solution (7 mL) of **12** (53.2 mg, 0.07 mmol), $BrCH{=}CH(CH_3)CN$ (34.0 μL, 0.35 mmol), and $(Bu_3Sn)_2$ (0.19 mL, 0.35 mmol) was irradiated with a high-pressure mercury lamp under an argon atmosphere at rt for 4 h. Purification of the reaction mixture by preparative TCL (hexane/AcOEt = 2/1) gave a mixture of *trans*-**25** (14.1 mg, 28%, syrup) and *cis*-**25** (23.1 mg, 45%, syrup).

Physical data for *trans*-**25**: UV (MeOH) λ_{max} 271 (ϵ 16800), λ_{min} 236 (ϵ 5500); ^{1}H NMR ($CDCl_3$) δ 0.73 and 1.40 (18H, each as s), 0.91−1.11 (28H, m), 1.89 (3H, d, J = 1.8 Hz), 3.96−3.99 (1H, J = 3.4 and 12.7 Hz), 4.14 (1H, dd, J = 3.4 and 12.7 Hz), 4.22 (1H, dd, J = 4.3 and 12.7 Hz), 4.92 (1H, t), 5.58 (1H, d, J = 7.0 Hz), 7.36 (1H, q, J = 1.8 Hz), 8.23 (1H, s), 8.50 (1H, br), 8.70 (1H, s); FAB-MS m/z 781 (M^+ + K). Anal. Calcd for $C_{36}H_{58}N_6O_7Si_2 \cdot {}^1/_2$AcOEt: C, 57.98; H, 7.94; N, 10.67. Found: C, 58.02; H, 8.00; N, 10.88.

Physical data for *cis*-**25**: UV (MeOH) λ_{max} 271 (ϵ 15900) λ_{min} 261 (ϵ 10000); ^{1}H NMR ($CDCl_3$) δ 0.77 and 1.41 (18H, each as s), 0.91−1.16 (28H, m), 2.13 (3H, d, J = 1.5 Hz), 4.18 (1H, dd, J = 3.1 and 13.1 Hz), 4.21−4.23 (1H, m), 4.31 (1H, dd, J = 2.8 and 13.1 Hz), 4.74 (1H, t, J = 7.8 Hz), 5.57 (1H, d, J = 7.8 Hz), 7.65 (1H, d, J = 1.5 Hz), 8.45 (1H, s), 8.58 (1H, br), 8.70 (1H, s); FAB-MS m/z 781 (M^+ + K). Anal. Calcd for $C_{36}H_{58}N_6O_7Si_2 \cdot {}^1/_2$AcOEt: C, 57.98; H, 7.94; N, 10.67. Found: C, 57.68; H, 8.08; N, 10.81.

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Supporting Information Available: Detailed description of the experimental procedures and compound characterization of **1**−**15** and **18**−**20**. This material is available free of charge via the Internet at http://pubs.acs.org.

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