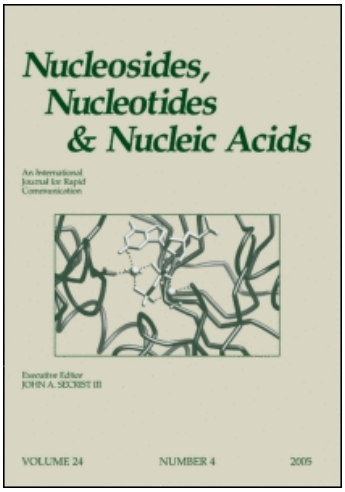

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Tokumi Maruyama[a]; Shigetada Kozai[a]; Kazuo Nakamura[b]; Masachika Irie[c]
[a] Tokushima Bunri University, Yamashiro-cho, Tokushima, Japan [b] School of Pharmaceutical Sciences, Showa University, Shinagawa-ku, Tokyo, Japan [c] Department of Microbiology, Hoshi College of Pharmacy, Shinagawa-ku, Tokyo, Japan

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SYNTHESIS OF 2′-DEOXY-2′-FLUOROGUANYL-(3′,5′)-GUANOSINE

Tokumi Maruyama,[1,*] Shigetada Kozai,[1] Kazuo Nakamura,[2] and Masachika Irie[3]

[1]Faculty of Pharmaceutical Sciences, Tokushima Bunri University, Yamashiro-cho, Tokushima 770-8514, Japan
[2]School of Pharmaceutical Sciences, Showa University, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142-8555, Japan
[3]Department of Microbiology, Hoshi College of Pharmacy, Ebara 2-4-41, Shinagawa-ku, Tokyo 142-8501, Japan

ABSTRACT

The protected analogue of 2-amnio-6-chloropurine arabinoside (**3b**) was subjected to reaction with diethylaminosulfur trifluoride (DAST) and subsequently treated with NaOAc in Ac_2O/AcOH to give $N^2, O^{3'}, O^{5'}$-triacetyl-2′-deoxy-2′-fluoroguanosine (**5a**). After deacetylation of the sugar moiety and protection of 5′-OH by a 4,4′-dimethoxytrityl group, this nucleoside component was converted to 2′-deoxy-2′-fluoroguanyl-(3′,5′)-guanosine (**6c**, GfpG).

Ribonucleases (RNases) are very important enzymes for RNA metabolism in almost all organisms; they include those that hydrolyze only single-stranded RNA, double-stranded RNA, and RNA hybridized with DNA. The mode of hydrolysis is thought to be via a 2′,3′-cyclic phosphated intermediate at the 3′-terminus of oligonucleotides, ultimately forming oligo- or mononucleotides with a terminal 3′-phosphated (transferase-type RNase). Recently, some

*Corresponding author. E-mail: maruyama@ph.bunri-u.ac.jp

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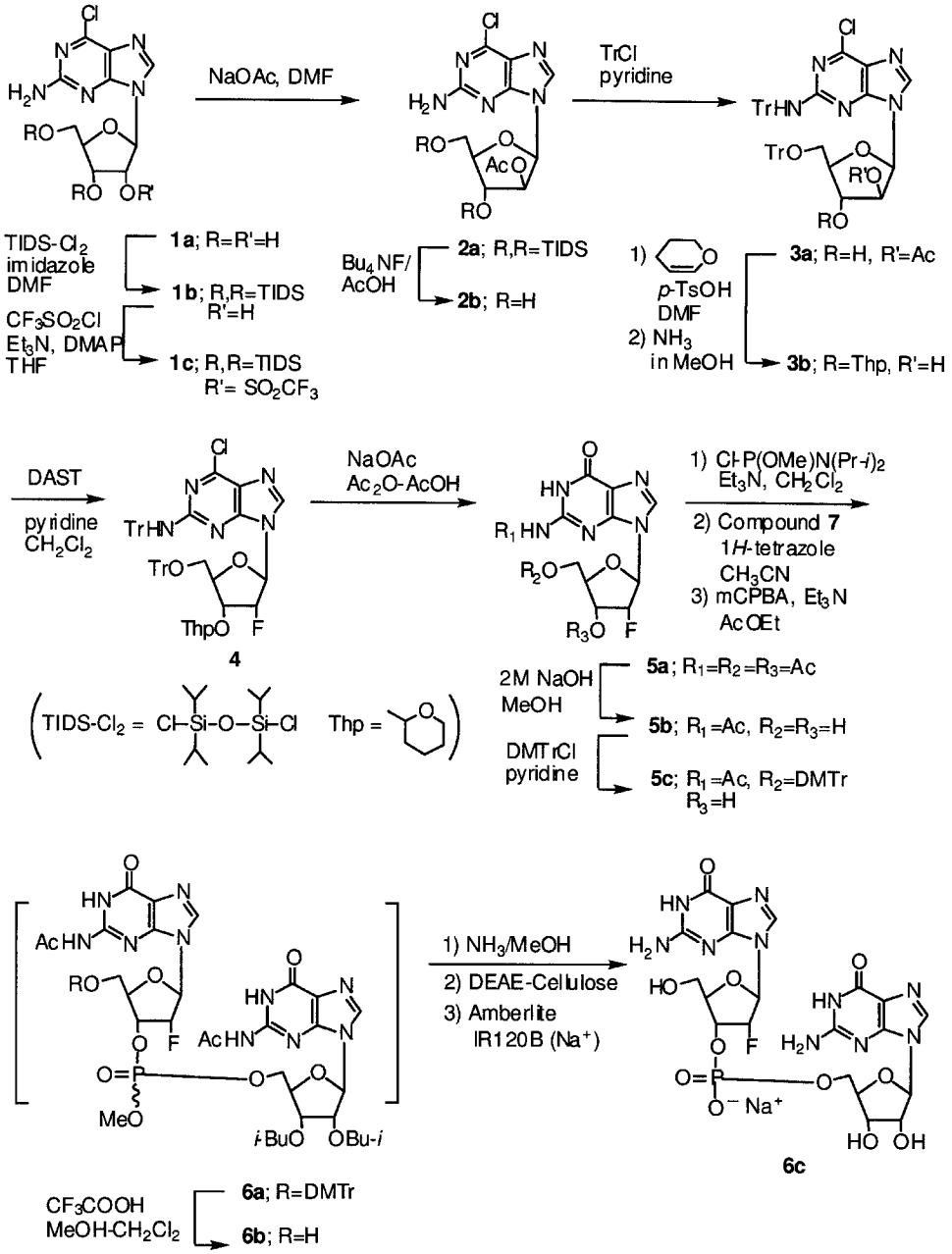
ribonucleases showed biological activity in addition to digestion of RNAs. RNase A was demonstrated to show toxicity to tumor cells, both in vitro[1] and in vivo.[2,3] Also, onconase, discovered from the Northern lieopard frog,[4] has emerged as a promising cancer chemotherapeutic agent. To elucidate the structure-function relationship of ribonucleases, X-ray crystallographic analysis of ribonucleases complexed with the analogues of dinucleoside monophosphate was achieved in many laboratories,[5–8] An especially important analogue is 2′-deoxy-2′-fluoroguanyl-(3′,5′)-cytidine (GfpC),[9] in which the 2′-hydroxyl group (2′-OH) of guanosine is replaced by a 2′-fluorine atom to prevent the transesterification step.

The synthesis of 2′-deoxy-2′-fluoronucleosides has been accomplished by several routes including nucleophilic displacement of 2′-*O*-trifluoromethanesulfonylarabinosides.[10,11] Recently, a method to introduce fluorine into the sugar moiety of guanine nucleosides using diethylaminosulfur trifluoride (DAST) has been developed.[12] However, problems still remain in respect of the yields and the analogues modified at the base moiety. This background prompted us to develop a new method to introduce fluorine at the downside of the 2′-carbon of guanosine. This paper reports a method for the synthesis of 2′-deoxy-2′-fluoroguanosine in which treatment of the protected 2-amino-6-chloropurine arabinoside with DAST was involved as a key step.

An attempt at the conversion of **1a** to the 2′-*O*-acetyl arabinoside (**2**) was made by application of the method of Fukukawa et al.[13] Thus, treatment of **1a** with 1,3-dichloro-1,1,3,3-tetraisopropyldisiloxane afforded the corresponding 3′,5′-*O*-(tetraisopropyldisiloxan-1,3-diyl) derivative **1b**.[14] Compound **1b** was allowed to react with trifluoromethanesulfonyl chloride in the presence of Et_3N and 4-dimethylaminopyridine in THF to give the 2′-*O*-triflate **1c**. An S_N2 displacement with the acetate anion at the 2′-position of **1c** was employed to obtain the 2′(*S*)(ara)-*O*-acetate **2a**. At this stage, the silyl protecting group should be changed to a group stable to the fluoride anion. Desilylation of **2a** with 2 equivalents of tetrabutylammonium fluoride in the presence of acetic acid at 0°C for 15 min afforded **2b**.[15] Since acyl protection causes neighboring group participation in the nucleophilic substitution, ethereal groups were chosen as a protecting group.[16] Reaction of **2b** with trityl chloride in pyridine gave a ditrityl derivative (**3a**), which was successively treated with 3,4-dihydro-2*H*-pyran and ammonia in methanol to give the N^2,$O^{5'}$-ditrityl-2-amino-6-chloro-[3-*O*-(tetrahydro-2-pyranyl)-9-β-D-arabinofuranosyl]-purine (**3b**). Then, **3b** was treated with DAST in the presence of pyridine in CH_2Cl_2 to afford the 2′-fluoride **4** in 60% yield, a key intermediate for the synthesis of base-modified analogues. No spot other than **4** was observed on TLC. When the DAST reaction was tried in the absence of pyridine, the protecting groups were removed from **3b** and **4** to give a complicated result. Reaction to convert the 6-chloro atom of **4** to 6-oxo was carried out by treatment with



Scheme 1.

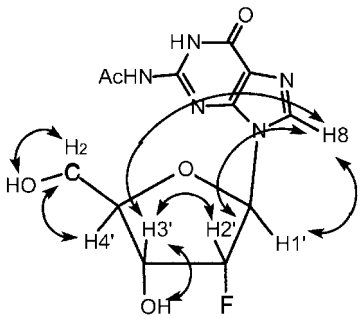


Figure 1. NOESY spectrum of **5b**.

NaOAc in Ac_2O-AcOH. Also, two trityl groups and the tetrahydro-2-pyranyl group were removed in acidic medium, followed by acetylation with Ac_2O to afford N^2,$O^{3'}$,$O^{5'}$-triacetyl-2′-deoxy-2′-fluoroguanosine (**5a**). Compound **5a** was subjected to partial deacylation with 2M NaOH in MeOH at 0°C to afford **5b**. The ^{1}H-NMR spectrum of **5b** indicated that the 2′-fluorine caused a downfield shift of the 2′-proton and a large H2′-C-F geminal coupling (52.7 Hz), and the nuclear Overhauser effect (NOE) was observed between H2′ and H3′ in the two-dimensional NOE (NOESY) spectrum of **5b** (Fig. 1). Therefore, the structure of **5b** was unequivocally determined. Then, a 4,4′-dimethoxytrityl group was introduced at 5′-OH of **5b** to give a nucleoside component **5c**.

2′-Deoxy-2′-fluoroguanyl-(3′,5′)-guanosine (**6c**) was prepared according to the established phosphite-triester method.[17] Thus, **5c** was treated with *N*,*N*-diisopropyl-methylphosphonamidic chloride in the presence of triethylamine in dry CH_2Cl_2. Monitoring the phosphitylating reaction by thin-layer chromatography (TLC) revealed the appearance of the 3′-*O*-(*N*,*N*-diisopropylamino)phosphramidites as a mixture of diastereomers. The products were converted to the monotetrazolides in situ and condensed with N^2-acetyl-2′,3′-di-*O*-isobutyrylguanosine (**7**) to form the dinucleotide phosphite triester. Mild oxidation and separation by silica gel chromatography furnished the full-protected phosphate triester **6a** as a caramel in 55% overall yield from **5c**. The product was deprotected successively with CF_3COOH in MeOH and ammonia in MeOH and separated by DEAE-cellulose chromatography using 0–0.12 M triethylammonium bicarbonate (TEAB) as eluent. After removal of the solution, the product was passed through a column of Amberlite IR120B (Na^+) to give 2′-deoxy-2′-fluoroguanyl-(3′,5′)-guanosine (**6c**, Na^+ salt) as a film in 34% overall yield from **5c**. The structure of the product was determined by the presence of two sets of sugar-protons in ^{1}H NMR and FAB mass spectroscopy (FAB-MS).

We are looking forward to obtaining the crystal structure of ribonuclease complexed with 2′-deoxy-2′-fluoroguanyl-(3′,5′)-guanosine.

EXPERIMENTAL

Melting points (mp) were determined using a Yanagimoto micro-melting point apparatus (hot stage type) and are uncorrected. UV spectra were recorded with a Shimadzu UV-190 digital spectrometer. Low-resolution mass spectra were obtained on a Shimadzu-LKB 9000B mass spectrometer in the direct-inlet mode. High-resolution mass spectra were obtained on a JMS AX-500 spectrometer in the direct-inlet mode. ^{1}H-NMR spectra were recorded on either Varian UNITY 200 (200 MHz) or Varian UNITY 600 (600 MHz) in $CDCl_3$ (or dimethyl sulfoxide (DMSO)-d_6) with tetramethylsilane as an internal standard. Merck Ark 5554 plates precoated with silica gel 60 containing fluorescent indicator F_{254} were used for thin-layer chromatography and silica gel 60 (Merck 7734, 60–200 mesh) was employed for column chromatography.

9-(2-*O*-Acetyl-3,5-*O*-tetraisopropyldisiloxan-1,3-diyl)-β-D-arabinofuranosyl)-2-amino-6-chloropurine (2a). 2-Amino-6-chloro-9-(3,5-*O*-tetraisopropyldisiloxan-1,3-diyl-β-D-ribofuranosyl)purine (**1b**) was prepared from 2-amino-6-chloro-purine riboside (**1a**) according to the published method.[14] To an ice-cooled solution of **1b** (19.4 g, 35.7 mmol), triethylamine (8.8 mL), and 4-dimethylaminopyridine (7.1 g, 58 mmol) in CH_2Cl_2 (300 mL) was added trifluoromethanesulfonyl chloride (7.1 mL, 66.7 mmol) and the solution was kept at room temperature for 10 min, then water (200 mL) was added. The organic layer was dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 25% AcOEt in hexane. Evaporation of the fraction gave **1c** as a caramel, which was immediately dissolved in DMF (150 mL) and sodium acetate (12 g, 146 mmol) was added. The solution was stirred at 50°C for 10 h, then partitioned between benzene (500 mL) and water (500 mL). The organic layer was washed with water twice (500 mL), dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 20–33% AcOEt in hexane. Evaporation of the fraction gave **2a** as a caramel (13.4 g, 64%). ^{1}H NMR ($CDCl_3$) δ 8.04 (1H, s, H8), 6.35 (1H, d, $J = 6.3$ Hz, H1′), 5.57 (1H, dd, $J = 6.3$, 8.2 Hz, H2′), 5.13 (2H, br s, NH_2), 4.69 (1H, dd, $J = 8.2$, 8.5 Hz, H3′), 4.03–4.18 (2H, m, H5′), 3.88–3.92 (1H, m, H4′), 1.78 (3H, s, Ac), 0.97–1.18 (28H, m, $(CH_3)_2$-CH x 4); UV λ_{max} (MeOH) nm: 249, 310; EI-MS m/z: 585, 587[M^+].

9-(2-*O*-Acetyl-β-D-arabinofuranosyl)-2-amino-6-chloropurine (2b). To a solution of **2a** (13.53 g, 23.1 mmol) and AcOH (2.86 mL, 50 mmol) in dry THF (50 mL) was added 1 M tetrabutylammonium fluoride (50 mL) and the solution was stirred at room temperature for 2 h, ten concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G with 0–17% EtOH in $CHCl_3$. Evaporation of the fraction gave a

caramel (7.36 g, 93%). ^{1}H NMR (DMSO-d_6) δ 8.25 (1H, s, H8), 7.02 (2H, br s, NH_2), 6.30 (1H, d, $J = 5.5$ Hz, H1′), 5.87 (1H, br s, 3′OH), 5.24 (1H, dd, $J = 5.5$, 5.8 Hz, H2′), 5.07 (1H, br s, 5′OH), 4.37 (1H, t, $J = 5.8$ Hz, H3′), 3.83–3.88 (1H, m, H4′), 3.61–3.74 (2H, m, H5′), 1.79 (3H, s, Ac); UV λ_{max} (MeOH) nm: 249, 310; EI-MS m/z: 343, 345 [M^+]. HR-MS m/z: 343.0689 (M^+, $C_{12}H_{14}ClN_5O_5$ requires 343.0684).

N^2,$O^{5'}$-Dityrityl-9-(2-*O*-acetyl-β-D-arabinofuranosyl)-2-amino-6-chloropurine (3a). To a solution of **2b** (9.16 g, 26.7 mmol), 4-dimethylaminopyridine (1.22 g, 10 mmol) and triethylamine (13.3 mL, 95 mmol) in dry DMF (220 mL) was added trityl chloride (27.8 g, 100 mmol). The solution was stirred at 50°C overnight, then MeOH (50 mL) was added and stirring was continued at room temperature for 1 h. The solvents were removed under reduced pressure and the residue was partitioned between $CHCl_3$ (300 mL) and water (100 mL). The organic layer was washed with water (100 mL), dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 25–50% AcOEt in hexane. Evaporation of the fraction gave a caramel (15.34 g, 69%). ^{1}H NMR ($CDCl_3$) δ 7.77 (1H, s, H8), 7.18–7.45 (ca. 30H, m, Tr × 2), 6.63 (1H, br s, H1′), 5.71 (1H,br s, N^2-H), 4.55 (1H, br s, 3′OH), 4.16–4.18 (1H, m, H3′), 3.98 (1H, q, $J = 4.9$ Hz, H4′), 3.35 (2H, d, $J = 4.9$ Hz, H5′), 2.72 (1H, d, $J = 2.7$ Hz, H2′), 1.73 (3H, s, Ac); UV λ_{max} (MeOH) nm: 259, 313; FAB-MS m/z: 828 [M^+], 850 [M^++Na].

N^2,$O^{5'}$-Dityrityl-2-amino-6-chloro-9-[3-*O*-(tetrahydro-2-phranyl)-β-D-arabinofuranosyl]purine (3b). To an ice-cooled solution of **3a** (8.28 g, 10 mmol) and 3,4-dihydro-2*H*-pyran (5 mL, 55 mmol) in dry DMF (50 mL) was added *p*-toluenesulfonic acid (800 mg, 4.2 mmol), and the solution was kept at 4°C overnight, then neutralized with triethylamine. The solvents were removed under reduced pressure and the residue was partitioned between benzene (300 mL) and water (300 mL). The organic layer was washed with water twice (300 mL), dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 17–25% AcOEt in hexane. Evaporation of the fraction gave a caramel, which was dissolved in CH_2Cl_2 (150 mL). To the solution was added ammonia in MeOH (100 mL), and the solution was kept at 4°C overnight. The solvents were removed under reduced pressure to give **3b** as a caramel (6.99 g, 80%). UV λ_{max} (MeOH) nm: 255, 313; FAB-MS m/z: 870, 872 [M^+], 892, 894 [M^++Na]. HR-MS m/z: 870.3436 (M^+, $C_{53}H_{48}ClN_5O_5$ requires 870.3420).

N^2,$O^{5'}$-Dityrityl-2-amino-6-chloro-9-[2-deoxy-2-fluoro-3-*O*-(tetrahydro-2-pyranyl)-β-D-ribofuranosyl]purine (4). To an ice-cooled solution of **3b** (13.52 g, 15.5 mmol) and pyridine (6.3 mL) in dry CH_2Cl_2 (200 mL) was added diethylaminosulfur trifluoride (3.3 mL, 25 mmol), and the solution was

stirred at 50°C for 6 h. The whole was added dropwise to 5% $NaHCO_3$ (500 mL) with stirring then the organic layer was diluted with CH_2Cl_2 (500 mL), washed water twice (500 mL), dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 15–40% AcOEt in hexane. Evaporation of the fraction gave white crystals (8.12 g, 60%). mp 201–201.5°C; UV λ_{max} (MeOH) nm: 260, 314; FAB-MS *m/z*: 872, 874 [M^+], 894, 896 [M^++Na]; *Anal* Calcd for $C_{53}H_{47}ClFN_5O_4$: C, 72.97; H, 5.42; N, 8.03. Found: C, 72.78; H, 5.52; N, 7.90.

N^2,$O^{3'}$,$O^{5'}$-Triacetyl-2′-deoxy-2′-fluoroguanosine (5a). A solution of **4** (4.73 g, 5.40 mmol) and sodium acetate (2.4 g, 30 mmol) in mixture of acetic anhydride (50 mL) and acetic acid (50 mL) was stirred at 120°C overnight. Then the solvents were removed under reduced pressure and the residue was dissolved in EtOH (30 mL). The solution was kept at room temperature for 3 hrs and concentrated to a small volume. The residue was partitioned between $CHCl_3$ (300 mL) and water (100 mL). The organic layer was washed with 5% $NaHCO_3$ (150 mL) and water (100 mL), dried over $MgSO_4$, and concentrated to a small volume. The residual solution was chromatographed over a column of silica gel G using 0–10% EtOH in $CHCl_3$. Evaporation of the fraction and crystallization from MeOH gave white crystals (1.79 g, 80%). Mp 108–108.5°C; ^{1}H NMR ($CDCl_3$) δ 12.08 (1H, s, N^1-H), 9.72 (1H, S, N^2-H), 7.78 (1H, s, H8), 6.04 (1H, m, H1′), 5.56–5.68 (2H, m, H2′, H3′), 4.70 (1H, dd, *J* = 4.7, 12.0 Hz, H5′a), 4.48–4.50 (1H, m, H4′), 4.25 (1H, dd, *J* = 5.5, 12.0 Hz, H5′b), 2.32 (3H, s, Ac), 2.18 (3H, s, Ac), 2.07 (3H, s, Ac); UV λ_{max} (MeOH) nm: 259, 280; EI-MS *m/z*: 411 [M^+]. HR-MS *m/z*: 411.1181 (M^+, $C_{16}H_{18}FN_5O_7$ requires 411.1203).

N^2-Acetyl-2′-deoxy-2′-fluoroguanosine (5b). To an ice-cooled solution of **5a** (1.40 g, 3.4 mmol) in MeOH (80 mL) was added 1 M NaOH (15 mL), and the solution was stirred at 0°C for 10 min. Then the solution was neutralized with 1 M HCl and concentrated to a small volume. The residual solution was crystallized from water (10 mL) to give white crystals (970 mg, 87%). Mp 235.5–237°C; ^{1}H-NMR (DMSO-d_6) δ 12.08 (1H, s, N^1-H), 11.74 (1H, s, N^2-H), 8.27 (1H, s, H8), 6.11 (1H, DD, *J* = 2.5, 16.5 Hz, H1′), 5.71 (1H, d, *J* = 6.0 Hz, 3′OH), 5.30 (1H, ddd, *J* = 2.5, 4.1, 52.7 Hz, H2′), 5.18 (1H, t, *J* = 5.2 Hz, 5′OH), 4.38–4.44 (1H, m, H3′), 3.95–3.97 (1H, m, H4′), 3.75–3.78 (1H, m, H5′a), 3.59–3.63 (1H, m, H5′b), 2.19 (3H, s, Ac); UV λ_{max} (MeOH) nm: 259, 280; *Anal* Calcd for $C_{12}H_{14}FN_5O_5 \cdot 0.2H_2O$: C, 43.56; H, 4.38; N, 21.17. Found: C, 43.58; H, 3.95; N, 21.01.

N^2-Acetyl-5′-*O*-(4,4′-dimethoxytrityl)-2′-deoxy-2′-fluoroguanosine (5c). To a solution of **5b** (940 mg, 2.87 mmol) in pyridine (50 mL) was added

4,4′-dimethoxytrityl chloride (2.0 g, 6 mmol) and stirred at room temperature for 3 h. Water (5 mL) was added to the solution and concentrated to a small volume. The residue was partitioned between $CHCl_3$ (150 mL) and water (70 mL) and the organic layer was dried over $MgSO_4$, then concentrated to a small volume. The residue was evaporated azeotropically with toluene and chromatographed over a column of silica gel G using 0–10% EtOH in $CHCl_3$. Evaporation of the fraction and crystallization from benzene gave white crystals (1.39 g, 77%). Mp 164.5–165.5°C; ^{1}H NMR (DMSO-d_6) δ 12.08 (1H, s, N^1-H), 11.68 (1H, s, N^2-H), 8.12 (1H, s, H8), 6.77–7.37 (ca.13H, m, phenyl of DMTr), 6.20 (1H, dd, $J = 1.4$, 18.9 Hz, H1′), 5.68 (1H, d, $J = 7.1$ Hz, 3′OH), 5.41 (1H, ddd, $J = 1.4$, 4.4 52.5 Hz, H2′), 4.54–4.61 (1H, m, H3′), 4.11–4.13 (1H, m, H4′), 3.723 (3H, s, OCH_3), 3.719 (3H, s, OCH_3), 3.26–3.33 (2H, m, H5′), 2.18 (3H, s, Ac); UV λ_{max} (MeOH) nm: 237, 281; FAB-MS m/z: 630 [M^++H], 652 [M^++Na]. HR-MS m/z: 652.2178 (M^++Na,$C_{33}H_{32}FN_5O_7$ requires 652.2179).

2′-Deoxy-2′-fluoroguanyl-(3′,5′)-guanosine (6, Na^+ salt). To a solution of **5c** (232 mg, 0.368 mmol) and triethylamine (0.1 mL) in CH_2Cl_2 (6 mL) was added *N*,*N*-diisopropylmethylphosphonamidic chloride (0.11 mL, 0.57 mmol) and the solution was stirred at room temperature under Ar atmosphere for 40 min, then concentrated to a small volume. The residue was partitioned between AcOEt (12 mL) and water (2 mL) and the organic layer was washed with water (2 mL), dried over $MgSO_4$, and evaporated. The residue was dissolved in CH_3CN (6 mL) and 1*H*-tetrazole (64 mg, 0.91 mmol) and N^2-acetyl-2′,3′-di-*O*-isobutyrylguanosine (343 mg, 0.74 mmol) was added successively to the solution. After stirring at room temperature overnight, the solution was evaporated and the residue was partitioned between AcOEt (15 mL) and water (1.5 mL). The organic layer was washed with water (1.5 mL), dried over $MgSO_4$, filtered to remove insoluble materials. To the filtrate was added 3-chloroperbenzoic acid (300 mg, 1.7 mmol) and triethylamine (0.15 mL), and the solution was stirred at room temperature for 3 h. Then the solvents were concentrated to a small volume and chromatographed over a column of silica gel G using 0–10% MeOH in AcOEt. Evaporation of the fraction gave full-protected GfpG **6a** as a caramel (237 mg, 55% from **5c**). UV λ_{max} (MeOH) nm: 254, 277; FAB-MS m/z: 1193 [M^++Na], 1209 [M^++K]. The product **6a** (212 mg, 0.178 mmol) was dissolved in a mixture of MeOH (6 mL) and CH_2Cl_2 (2 mL), then trifluoroacetic acid (0.1 mL) was added. The solution was stirred at room temperature for 3 h, and neutralized with triethylamine. The solvents was removed under reduced pressure, and the residue was chromatographed over a column of silica gel G using 0–10% EtOH in $CHCl_3$. Evaporation of the fraction gave the partially deprotected product as a white powder **6b** (112 mg, 72%). UV λ_{max} (MeOH) nm: 260, 277; FAB-MS m/z: 869 [M^++H], 891 [M^++Na]. A part of the product (80 mg, 92 μmol) was dissolved in MeOH (15 mL) and the solution was

saturated with ammonia at 0°C. The solution was stirred at room temperature overnight and concentrated to a small volume. The residue was chromatographed over a column of DEAD-cellulose (2 × 20 cm) using 0–0.12 M TEAB (1 L). The main fraction was evaporated under reduced pressure and the residue was evaporated azeotropically with water. The residue was dissolved in water (2 mL) and passed through the column of Amberlite IR 120 (Na^+ form, 10 mL). Evaporation of water (50 mL) gave 6 as a filmy substance (**6c**, 51 mg, 78.2 μmol, 85%). ^{1}H NMR (D_2O, a series; protons of 5′-Gf, b series; protons of G-3′) δ 7.94 (1H, s, H8), 7.85 (1H, s, H8), 6.10 (1H, dd, J = 3.0, 17.0 Hz, H1′a), 5.87 (1H, d, J = 5.5 Hz, H1′b), 5.48 (1H, ddd, J = 3.6, 4.1, 51.4 Hz, H2′a), 4.86–4.97 (1H, m, H3′a), 4.70 (1H, t, J = 5.2 Hz, H2′b), 4.49 (1H, dd, J = 4.7, 4.9 Hz, H3′b), 4.33 (1H, br s, H4′b), 4.28 (1H, br s, H4′a), 4.15–4.25 (2H, m, H5′b), 3.76–3.89 (2H, m, H5′a); UV λ_{max} (MeOH) nm: 252; FAB-MS m/z: 651 [M^+-H].

***N*^{2}-Acethyl-2′,3′-di-*O*-isobutyrylguanosine (7).** This compound was prepared from 5′-*O*-trityl-N^2-acetylguanosine by successive treatment with isobutyryl chloride and acid treatment in 76% yield. ^{1}H NMR ($CDCl_3$) δ 12.20 (1H, s, N^1-H), 9.54 (1H, s, N^2-H), 7.74 (1H, s, H8), 5.88–5.97 (2H, m, H1′, H2′), 5.67 (1H, dd, J = 2.7, 5.2 Hz, H3′), 4.26 (1H, d, J = 2.2 Hz, H4′), 3.95 (1H, dd, J = 2.2, 12.6 Hz, H5′a), 3.82 (1H, dd, J = 1.6, 12.6 Hz, H5′b), 2.47–2.68 (2H, m, CH x2), 2.33 (3H, s, Ac), 1.08–1.23 (12H, m, $CH_3 \times 4$); UV λ_{max} (MeOH) nm: 257, 280; EI-MS m/z: 465 [M^+].

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