mp 256–258 °C (lit.[10] mp 257–259 °C); NMR (THF-d_8) δ 4.1–4.4 (m, 1, H_2), 5.4–5.6 (m, 1, H_1), 6.0–6.4 (m, 1, H_3), 6.67 (d, 1, H_4), 7.2–8.1 (m, 7, aromatic), 8.7–8.9 (m, 1, H_8), 8.83 (s, 1, H_{14}), 9.13 (s, 1, H_7).

For biochemical purposes **13b** was purified by HPLC in essentially the same way as described for **6b**.

Acknowledgment. This work was supported by a grant from the Council for Tobacco Research, Inc.

Registry No. **1**, 17750-93-5; **2**, 17573-23-8; **3a**, 79970-83-5; **5**, 79970-84-6; **6a**, 79970-85-7; **6b**, 58030-91-4; **7**, 72390-46-6; **8**, 153-39-9; **9a**, 79970-86-8; **9b**, 79970-87-9; **10**, 79970-88-0; **11**, 79970-89-1; **12**, 79970-90-4; **13a**, 79970-91-5; **13b**, 79301-84-1; 9,10-dihydrobenzo[*a*]pyran-7(8*H*)-one, 3331-46-2; silver benzoate, 532-31-0; dibenz[*a*,*h*]anthracene, 53-70-3; 14-acetoxy-1,2,3,4-tetrahydrodibenz[*a*,*h*]anthracene, 79970-92-6; 1,2,3,4-tetrahydro-7,14-dibenz[*a*,*h*]anthraquinone, 79970-93-7; 4-hydroxy-1,2,3,4-tetrahydrodibenz[*a*,*h*]anthracene, 79970-94-8.

Improved 3′-O-Phosphorylation of Guanosine Derivatives by O^6-Oxygen Protection

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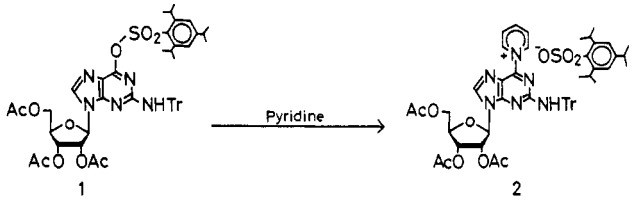
In oligonucleotide synthesis there have still remained some crucial problems during the elongation of oligonucleotide chains.[1] One of them is the side reaction of a condensing agent with the O^6 carbonyl oxygen of the guanosine moiety which occurs to an appreciable extent especially in the ribo series under the usual conditions. Reese[2] reported the reaction of arenesulfonyl azolides with the O^6-carbonyl group of guanosine derivatives to give O^6-azole-substituted guanosine derivatives via O^6-sulfonylated intermediates. On the other hand, we found that O^6-sulfonylated guanosine derivatives such as compound **1** were gradually converted in dry pyridine to pyridinium sulfonate derivatives like compound **2**. From



1 2

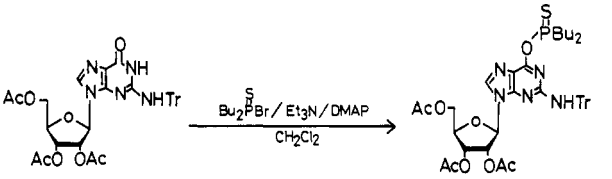
these results, we have felt the necessity of protecting the reactive O^6 position of the guanine moiety with an appropriate protecting group. In a previous paper,[3] we demonstrated the di-*n*-butylthioxophosphoranyl group as a possible blocking group of the O^6-carbonyl function since this group was relatively stable under the conditions where acetyl ester groups could be removed.

Table I. Phosphorylation of 3 with 4 by Use of TPS

ratio of 4/3	ratio of TPS/3	time, h	% yield of 5
1.2	2.2	7	15
2.2	1.1	24	28
4.0	2.0	24	16

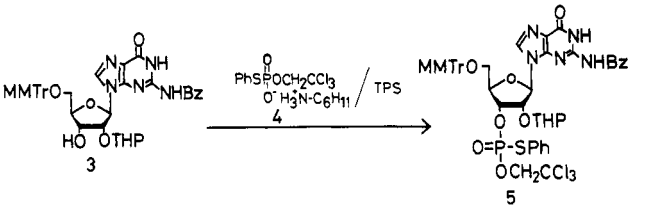
Table II. Phosphorylation of 6 with 4

ratio of 4/6	condensing agent	ratio of TPS or DMS/6	time, h	% yield 5	% yield 10	total % yield of 5 plus 10
1.2	TPS	2.4	72	36	34	70
1.5	TPS	3.0	12	50	33	83
4.0	TPS	2.0	5.5	35	48	83
1.2	DMS	2.4	45	52	39	91
4.0	DMS	2.0	24	55	33	88



In this paper, we report the importance of protecting the O^6-carbonyl group for phosphorylation of guanosine derivatives.

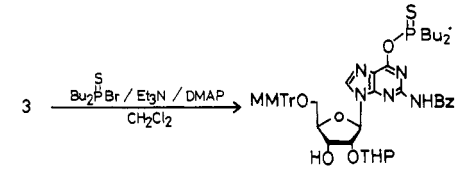
First, we chose N^2-benzoyl-2′-*O*-(tetrahydropyranyl)-5′-*O*-(methoxytrityl)guanosine (**3**) as a substrate for introducing a phosphoryl group onto the 3′-hydroxyl group. As a new phosphorylating agent, cyclohexylammonium 2,2,2-trichloroethyl *S*-phenyl phosphorothioate (**4**), was



3 5

employed. When **3** (0.5 mmol) was treated with **4** (0.6 mmol) in the presence of TPS (1.1 mmol) in dry pyridine (5 mL) for 7 h, the phosphorylated product **5** was isolated in only 15% yield after the usual workup (extraction, evaporation, and chromatography on silica gel). All attempts to improve the yield of **5** under various conditions were unsuccessful (see Table I).

In these reactions considerable amounts of byproducts were formed owing to the side reactions of **4** and TPS with the O^6-carbonyl group of **3** and **5**. Therefore, the di-*n*-butylthioxophosphoranyl group was introduced as a protecting group for the guanine residue to avoid such side reactions. When **3** (1 mmol) was treated with di-*n*-butylthioxophosphoranyl bromide[4] (1.5 mmol) and triethylamine (1.25 mmol) in the presence of 4-(dimethylamino)pyridine (DMAP, 0.04 mmol) in dry CH_2Cl_2 at room temperature for 4 h, the O^6-thioxophosphino derivative **6**



6

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(4) Furusawa, K.; Sekine, M.; Hata, T. *J. Chem. Soc., Perkin Trans. 1* **1976**, 1711.

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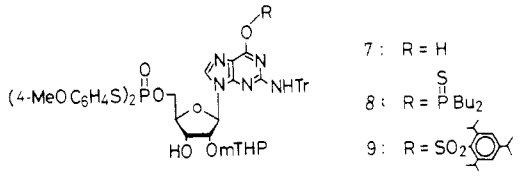
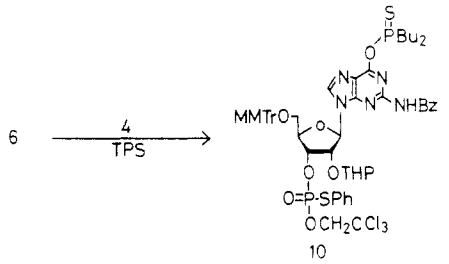
was isolated in an excellent yield of 96% after column chromatography on silica gel. Fortunately, the dibutylthioxophosphoranyl group was not introduced into the 3′-hydroxyl group. Similarly, guanosine derivative 7[5] reacted with the thioxophosphoranyl bromide to afford 8 in 62% yield. Once again, the 3′-*O*-thioxophosphino derivative was not formed. When 7 was allowed to react with TPS under similar conditions, the O^6-sulfonylated product 9 could be also isolated in 94% yield.



The thioxophosphoranylated derivative 6 was employed for phosphorylation with 4 and TPS under conditions similar to those employed in the case of 3. Consequently,



the yields of the phosphorylated products (10 and 5) were dramatically increased to 35% and 48%, respectively. The latter product 5 was formed during the workup since TLC showed that 10 was formed as the main product. The above fact means that the phosphorylation of the 3′-hydroxyl group of 6 could be performed in 83% (35% plus 48%) yield by the introduction of a thioxophosphoranyl group as the temporary protecting group.

When 4,6-dimethoxybenzene-1,3-disulfonyl chloride (DMS), which we have recently reported as a new promising condensing agent,[6] was employed for the phosphorylation, the optimum yield (91%) of the phosphorylated products 5 and 10 was obtained. In these phosphorylations DMS is converted after the usual workup to the disulfonic acid derivative, which can be easily removed by extraction. We conclude that protection of the guanine group with the new di-*n*-butylthioxophosphoranyl group avoids undesirable sulfonation and phosphorylation reactions which are frequently encountered during polynucleotide synthesis.

Experimental Section

NMR spectra were recorded at 100 M Hz on a JNM-PS-100 spectrometer. IR spectra were recorded on a Hitachi 260-50 spectrophotometer.

Reaction of 2′,3′,5′-Tri-*O*-acetyl-O^6-(2,4,6-triisopropylbenzenesulfonyl)-N^2-tritylguanosine (1) with Pyridine. Compound 1[5] (450 mg, 0.5 mmol) was dissolved in dry pyridine (10 mL). The solution was stirred continuously at room temperature. The reaction mixture turned gradually dark brown. After being stirred for 5 days, the mixture was evaporated and coevaporated with toluene (3 × 5 mL) for removal of the last traces of pyridine, and the residue was chromatographed on silica gel (1–4% methanol containing CH_2Cl_2) to give an unidentified purple compound (32 mg) and 225.2 mg (48%) of 2. The product was precipitated with *n*-hexane from its solution in acetone to give analytically pure sample: NMR ($CDCl_3$) δ 1.16 (m, 18 H, $(CH_3)_2C$), 2.03, 2.05, 2.12 (s, CH_3C=O), 2.83 (m, 1 H, CH of TPS) 3.95 (br s, 3 H, 2′,3′,4′-H), 4.51 (m, 2 H, CH of TPS), 5.63 (m, 1 H, 1′-H), 6.06 (m, 1 H, N^2H), 6.99 (s, 2 H, Ar H of TPS), 7.28 (m, 19 H, Ar H of Tr and 8-H), 8.37 (m, 3 H, Ar H of Py^+), 9.03 (m, 2 H, Ar H of Py^+). Anal. Calcd for $C_{55}H_{66}O_{13}N_6S\cdot 3H_2O$: C, 62.84; H, 6.33; N, 7.99. Found: C, 62.94; H, 6.19; N, 7.72.

5′-*O*-(Methoxytrityl)-2′-*O*-(tetrahydropyranyl)-N^2-benzoylguanosine (3). To a solution of 5.7 g (12 mmol) of 2′-*O*-(tetrahydropyranyl)-N^2-benzoylguanosine in pyridine (60 mL) was added 4.4 g (14.4 mmol) of monomethoxytrityl chloride (MMTrCl), and the mixture was stirred at room temperature in the dark for 1 day. To the solution was added an additional 4.4 g (14.4 mmol) of MMTrCl, and the mixture was continuously stirred. After 1 day, 4.4 g (14.4 mmol) of MMTrCl was added. After the mixture was stirred in the dark for 1 day, 500 mL of ethanol was added, and the resulting solution poured into 500 mL of water and extracted with CH_2Cl_2 (3 × 500 mL). The combined CH_2Cl_2 extracts were washed with water (3 × 500 mL), dried over Na_2SO_4, and evaporated. The residue was coevaporated with toluene (3 × 20 mL) and chromatographed on a silica gel column to give 8.3 g (93%) of 3: NMR ($CDCl_3$) δ 1.20–1.90 (m, 6 H, $(CH_2)_3$), 2.33 (s, 1 H, OH), 3.04–3.40 (m, 3 H, CH_2O of THP and 5′-H_a), 3.59 (m, 1 H, 5′-H_b), 4.26 (br s, 1 H, 4′-H), 4.56 (br s, 3′-H), 4.77 (br s, 2′-H), 5.27 (t, 1 H, J = 5.6 Hz, CH of THP), 5.98 (d, 1 H, J = 7 Hz, 1′-H), 6.73 (d, 2 H, J = 9 Hz, Ar H), 6.86–7.70 (m, 18 H, Ar H and N^1 H), 7.81 (s, 1 H, 8-H), 8.55 (br s, 1 H, HNC=O). Anal. Calcd for $C_{41}O_8N_5$: C, 67.82; H, 5.56; N, 9.41. Found: C, 68.09; H, 5.65; N, 9.26.

***S*,*S*-Diphenyl 2,2,2-Trichloroethyl Phosphorodithioate.** To a stirred mixture of 6.19 g (23.2 mmol) of 2,2,2-trichloroethyl phosphorodichloridate and 4.76 mL (46.5 mmol) of thiophenol in 100 mL of dry ether at −20 °C was added dropwise 6.45 mL (46.5 mmol) of triethylamine over a period of 20 min. After being stirred at −20 °C for 10 min, the mixture was warmed to room temperature and stirred for an additional 1 h. To the mixture was added 50 mL of ether and 150 mL of water. The ethereal layer was washed with three 50-mL portions of water, dried over Na_2SO_4, and evaporated. The solid residue was recrystallized from 150 mL of *n*-hexane and 15 mL of THF to give 8.32 g (87%) of the title compound: mp 84–85.5 °C; IR (KBr) 1020, 1239, 1369, 1438, 1468, 1573, 2918, 3052 cm^{-1}; NMR ($CDCl_3$) δ 4.17 (d, 2 H, J = 7 Hz, CH_2OP), 7.10 (m, 10 H, Ar H). Anal. Calcd for $C_{14}H_{12}Cl_3O_2PS_2$: C, 40.65; H, 2.92. Found: C, 40.74; H, 2.85.

Cyclohexylammonium *S*-Phenyl 2,2,2-Trichloroethyl Phosphorothioate (4). To a solution of 8.27 g (20 mmol) of *S*,*S*-diphenyl 2,2,2-trichloroethyl phosphorodithioate in 160 mL of dioxane was added 160 mL of 0.2 N NaOH with stirring. The suspension was heated at 90 °C for 1 h, cooled to room temperature, and treated with 5 mL of concentrated HCl and 20 g of ice. The resulting solution was concentrated in vacuo to two-fifths of its original volume whereupon a white precipitate appeared. The heterogeneous solution was washed with *n*-hexane (3 × 20 mL). The washings were decanted and discarded. The aqueous solution and the remaining oil were further extracted with CH_2Cl_2 (80 mL and 2 × 40 mL). The combined CH_2Cl_2 extracts were dried over Na_2SO_4, evaporated, and dissolved in 100 mL of CH_2Cl_2. To the CH_2Cl_2 solution was added 2.29 mL (20 mmol) of cyclohexylamine. The solution was soon evaporated to dryness, and the solid residue was washed with 100 mL of *n*-hexane to give 5.93 g (71%) of the crude product (mp 155–159 °C). Recrystallization of the crude product from EtOH–water gave 5.13 g (61%) of analytically pure material: mp 165–166 °C; IR (KBr) 1103, 1220 (P=O), 1388, 1445, 1478, 1547, 1583, 1638, 1660, 2138, 2552, 2850, 2925, 3033 cm^{-1}; NMR ($CDCl_3$) δ 0.97–2.13 (m, 10 H, $(CH_2)_5$), 2.88 (m, 1 H, CHN), 4.40 (d, 2 H, J = 5 Hz, CH_2OP), 7.25 (m, 3 H, Ar H), 7.63 (m, 2 H, Ar H). Anal. Calcd for $C_{14}H_{21}Cl_3O_3NPS$: C, 39.97; H, 5.03; N, 3.33. Found: C, 40.39; H, 4.91; N, 3.31.

Phosphorylation of 3 with 4 by Use of TPS. Typical Procedure. Compound 4 (253 mg, 0.6 mmol) was dissolved in 5 mL of dry pyridine, and 333 mg (1.1 mmol) of TPS was added. The solution was stirred for 1 h, and 372 mg (0.5 mmol) of 3 in 9 mL of dry pyridine was added. The solution was concentrated to a ca. 5 mL and stirred for 7 h. TLC showed four trityl-con-

(5) For 7: NMR ($CDCl_3$) δ 1.60 (4 H, m), 2.71 (3 H, s), 3.58 (4 H, m), 3.71 (6 H, s), 4.11 (2 H, m), 4.22–4.58 (3 H, m), 5.37 (1 H, d), 6.78 (4 H, d), 7.08–7.52 (19 H, m). Anal. Calcd for $C_{49}H_{50}O_{10}N_5PS_2\cdot 2H_2O$: C, 58.85; H, 5.44; N, 7.00. Found: C, 58.69; H, 5.20; N, 6.94. The details of the synthesis of 7 will be reported soon elsewhere.

(6) Sekine, M.; Matsuzaki, J.; Hata, T. *Tetrahedron Lett.* **1981**, *22*, 3209.

taining spots other than the remaining 3. The mixture was diluted with 20 mL of CH_2Cl_2 and transfered into a separatory funnel, and 20 mL of water was added. After the mixture was shaken, the aqueous layer was further extracted with CH_2Cl_2 (3 × 20 mL). The combined organic layers were dried over Na_2SO_4 and evaporated, and the residue was treated with 10 mL of ethyl acetate. The insoluble solid was filtered and washed with ethyl acetate (2 × 3 mL). The filtrate was evaporated in vacuo, and after repeated coevaporation with toluene (3 × 5 mL) the residue was chromatographed on silica gel and eluted with CH_2Cl_2–MeOH to give 76 mg (15%) of **5**: NMR ($CDCl_3$) δ 1.20–1.85 (m, 6 H, $(CH_2)_3$), 3.02 (m, 1 H, 5′-H), 3.27 (m, 2 H, CH_2O of THP), 3.51 (m, 1 H, 5′-H), 3.67 (s, 3 H, CH_3O), 4.16 and 4.28 (br s, diastereomeric 4′-H), 4.34 (d, 1 H, J = 7 Hz, CH_2OP of one of diastereomers), 4.56 (dd, 1 H, J = 8 Hz, CH_2OP of the other diastereomer), 4.86 (br s, 1 H, 2′-H), 5.44–5.84 (m, 2 H, CH of THP and 3′-H), 5.92 (m, 1 H, 1′-H), 6.68 and 6.73 (d, 2 H, J = 8.8 Hz, Ar H), 6.98–7.75 (m, 23 H, Ar H and N^1H), 8.67 and 8.92 (s, 1 H, N^2 H). Anal. Calcd for $C_{50}H_{47}Cl_3O_{10}N_5PS$: C, 57.34; H, 4.52; N, 6.69; Cl, 10.16; S, 3.06. Found: C, 57.02; H, 4.79; N, 6.39; Cl, 10.15; S, 3.22.

5′-*O*-(Methoxytrityl)-2′-*O*-(tetrahydropyranyl)-*O*^{6}-(di-*n*-butylthioxophosphoranyl)-*N*^{2}-benzoylguanosine (6). To a solution of 744 mg (1 mmol) of **3** in 20 mL of dry CH_2Cl_2 were added 175 μL (1.25 mmol) of triethylamine, 5 mg (0.04 mmol) of DMAP, and 386 mg (1.5 mmol) of di-*n*-butylthioxophosphoranyl bromide. The mixture was stirred at room temperature for 4 h. The solvent was removed in vacuo, and the residue was chromatographed on silica gel and eluted with CH_2Cl_2–MeOH to give 884 mg (96%) of **6**: NMR ($CDCl_3$) δ 0.96 (t, 6 H, J = 1 Hz, CH_3C), 1.15–2.00 (m, 6 H, $(CH_2)_3$ of THP), 2.40–2.80 (m, 12 H, $(CH_2)_3$), 2.86 (br, 1 H, OH), 3.05–3.58 (m, 2 H, CH_2O of THP), 3.42 (m, 1 H, one of the 5′-Hs), 3.69 (s, 3 H, CH_3O), 3.72 (m, 1 H, one of the 5′-Hs), 4.23 (m, 1 H, 4′-H), 4.68 (m, 2 H, 2′- and 3′-H), 5.24 (t, 1 H, J = 5.5 Hz, CH of THP), 6.14 (d, 1 H, J = 6 Hz, 1′-H), 6.66 (d, 2 H, J = 9.2 Hz, Ar H), 7.00–7.58 (m, 17 H, Ar H), 8.03 (s, 1 H, 8-H), 8.31 (s, 1 H, NH). Anal. Calcd for $C_{50}H_{58}N_5O_8PS$: C, 65.28; H, 6.35; N, 7.61. Found: C, 64.79; H, 6.30; N, 7.37.

2′-*O*-(Methoxytetrahydropyranyl)-*O*^{6}-(di-*n*-butylthioxophosphoranyl)-*N*^{2}-tritylguanosine 5′-(*S*,*S*-Bis(4-methoxyphenyl) Phosphorodithioate) (8). To a solution of 979 mg (0.985 mmol) of **7** in 20 mL of dry CH_2Cl_2 were added 0.233 mL (4.16 mmol) of triethylamine, 387 mg (1.5 mmol) of di-*n*-butylthioxophosphoranyl bromide, and 7.3 mg (0.06 mmol) of DMAP, and the mixture was stirred for 10 min. Then the solvent was removed, and the residue was chromatographed on silica gel to give 706 mg (62%) of **8**: NMR ($CDCl_3$) δ 0.09 (m, 6 H, CH_3C), 1.18–1.90 (m, 12 H, $(CH_2)_2$ and CH_2 of mTHP), 2.04 (m, 4 H, CH_2P), 2.71 (s, 3 H, CH_3O of mTHP), 2.75 (d, 1 H, J = 3 Hz, OH), 3.56 (m, 4 H, CH_2O), 3.80 (s, 6 H, CH_3O), 4.02–4.42 (m, 4 H, 3′-, 4′-, and 5′-H), 4.65 (t, 1 H, J = 6 Hz, 2′-H), 5.68 (d, 1 H, J = 6 Hz, 1′-H), 6.39 (s, 1 H, N^2 H), 6.83 (d, 4 H, J = 9 Hz, Ar H), 7.10–7.52 (m, 19 H, Ar H), 7.71 (s, 1 H, 8-H). Anal. Calcd for $C_{57}H_{67}O_{10}N_5P_2S_3$: C, 60.04; H, 5.92; N, 6.14. Found: C, 60.45; H, 6.34; N, 5.92.

2′-*O*-(Methoxytetrahydropyranyl)-*O*^{6}-(2,4,6-triisopropylbenzenesulfonyl)-*N*^{2}-tritylguanosine 5′-(*S*,*S*-Bis(4-methoxyphenyl) Phosphorodithioate) (9). To a solution of 199 mg (0.2 mmol) of **7** in 2 mL of dry CH_2Cl_2 were added 242 mg (0.8 mmol) of TPS, 0.12 mL (0.88 mmol) of triethylamine, and 8.5 mg (0.07 mmol) of DMAP, and the mixture was stirred for 18 h. The solvent was then removed in vacuo, and the residue was chromatographed on silica gel to give 247 mg (94%) of **9**: NMR ($CDCl_3$) δ 1.22 (d, 18 H, J = 6 Hz, $(CH_3)_2$), 1.50 (m, 4 H, CH_2), 2.56 (s, 3 H, CH_3O), 2.70 (m, 1 H, CH), 3.50 (m, 4 H, CH_2O), 3.72 (s, 3 H, CH_3O), 3.77 (m, 6 H, CH_3O), 3.70–4.55 (m, 5 H, 2′-, 3′-, 4′-, and 5′-H), 5.32 (d, 1 H, J = 6 Hz, 1′-H), 6.07 (s, 1 H, N^2 H), 6.56 (m, 4 H Ar H), 6.92–7.51 (m, 22 H, Ar H), 7.52 (s, 1 H, 8-H). Anal. Calcd for $C_{65}H_{74}N_5O_{13}PS_3 \cdot 3H_2O$: C, 59.39; H, 6.13; N, 5.33. Found: C, 59.35; H, 6.14; N, 5.13.

Synthesis of 10. Typical Procedure. A mixture of 138 mg (0.15 mmol) of **6** and 95 mg (0.23 mmol) of **4** was rendered anhydrous by repeated coevaporation with dry pyridine (3 × 2 mL) and dissolved in 3 mL of dry pyridine. To the solution was added 145 mg (0.45 mmol) of TPS. After being stirred for 12 h, the mixture was poured into 20 mL of CH_2Cl_2, transfered into a separatory funnel, and shaken with 20 mL of water. The CH_2Cl_2 layer was collected, and the aqueous layer was further extracted with CH_2Cl_2 (3 × 10 mL). The combined extracts were dried over Na_2SO_4, evaporated in vacuo, and treated with 10 mL of ethyl acetate. The insoluble solid was filtered and washed with ethyl acetate (2 × 3 mL). The filtrate was evaporated in vacuo and coevaporated with toluene three times. The residue was chromatographed on silica gel and eluted with CH_2Cl_2–MeOH to give 51 mg (33%) of **5** and 92 mg (50%) of **10** as ca. 1:1 diastereomeric mixture. For **10**: NMR ($CDCl_3$) δ 0.95 (m, 6 H, CH_3), 1.10–2.10 (m, 14 H, CH_2), 2.62 (m, 4 H, CH_2P), 3.00–3.54 (m, 4 H, CH_2O of THP and 5′-H), 3.70 (s, 3 H, CH_3O), 4.13 and 4.12 (br s, 1 H, diastereomeric 4′-H), 4.52 (m, 2 H, CH_2OP), 4.77 (br s, 1 H, 2′-H), 5.25–5.70 (m, 2 H, CH of THP and 3′-H), 6.07 (m, 1 H, 1′-H), 6.66 and 6.70 (d, 2 H, J = 9.2 Hz, Ar H), 8.06 (s, 1 H, 8-H), 8.35 and 8.41 (s, 1 H, diastereomeric NH). Anal. Calcd for $C_{58}H_{64}Cl_3N_5O_{10}P_2S_2$: C, 56.93; H, 5.27; N, 5.72. Found: C, 56.70; H, 5.39; N, 5.74.

Registry No. 1, 77001-23-1; 2, 79970-26-6; 3, 79970-27-7; 4, 79970-29-9; 5 (isomer 1), 79970-30-2; 5 (isomer 2), 79970-31-3; 6, 79970-32-4; 7, 79970-33-5; 8, 79970-34-6; 9, 79970-35-7; 10 (isomer 1), 79970-36-8; 10 (isomer 2), 79970-37-9; 2′-*O*-(tetrahydropyranyl)-*N*^{2}-benzoylguanosine, 60324-96-1; *S*,*S*-diphenyl 2,2,2-trichloroethyl phosphorodithioate, 79970-38-0; di-*n*-butylthioxophosphoranyl bromide, 55656-88-7; MMTrCl, 14470-28-1.

Fluorination with Xenon Difluoride. 27. The Effect of Catalyst on Fluorination of 1,3-Diketones and Enol Acetates

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Xenon difluoride is a mild fluorinating agent for fluorination of alkenes, acetylenes, aromatic, and heteroaromatic molecules; this topic has recently been reviewed.[1] It is known that the course of fluorination strongly depends on the following factors: the structure of the organic molecule, the catalyst used, and solvent polarity and temperature. The importance of the correct selection of catalyst for successful fluorination has been shown in fluorination of several alkenes, and so far, the catalysts which have been found to be effective are hydrogen fluoride,[2] hydrogen fluoride–pyridine,[3] boron trifluoride,[4] boron trifluoride etherate,[5] pentafluorothiophenol,[6] trifluoroacetic acid,[7] and bromine.[8]

Fluorination of 1,3-diketones has received much less attention than reactions involving other halogens. Reaction with perchlorylfluoride in the presence of base resulted in the formation of mono-[9] and difluoro[10] products, the

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