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The Preparation of 4′,6′-Di- and 2′,4′,6′-Tri-*O*-acetates of Theophylline Nucleosides of 3′-Deoxy-3′-nitro-β-D-galacto-, gluco- and mannopyranose[1]

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7-(3′-Deoxy-3′-nitro-β-D-glucopyranosyl)theophylline (**1**) was treated with acetic anhydride in the presence of boron trifluoride, perchloric or phosphoric acid as a catalyst to afford the corresponding 2′,4′,6′-tri-*O*-acetate (**4**) in 87, 60 and 48% yields, respectively. With *galacto*-isomer (**2**), tri-*O*-acetate (**6**) was obtained in a high yield by the use of phosphoric acid or a large excess of perchloric acid as a catalyst, while 4′,6′-di-*O*-acetate (**5**) was selectively prepared in 82% yield when a trace of perchloric acid was used. The similar preparation of 4′,6′-di- and 2′,4′,6′-tri-*O*-acetates (**7** and **8**) of *manno*-isomer (**3**) was also carried out in the presence of boron trifluoride and phosphoric acid, respectively. The positions of the acetyl groups in the diacetates **5** and **7** were unequivocally deduced from NMR data.

On the acetylation of methyl 3-deoxy-3-nitro-hexopyranosides and their 4,6-*O*-benzylidene derivatives with acetic anhydride, Baer *et al*[2] pointed out the favorableness of boron trifluoride as a catalyst and mentioned the inadvisableness of acids such as sulfuric or perchloric acid, because these acids possess an inherent danger of acetolysis in the glycoside and benzylidene acetal structures. For the preparation of model compounds for our studies on aminations of nitro sugars,[3-5] we have examined the acid-catalysed acetylation of theophylline nucleosides of 3′-deoxy-3′-nitro-β-D-hexopyranoses (**1**—**3**) with boron trifluoride, perchloric or phosphoric acid and showed their merits, especially as a catalyst for a selective partial acetylation, and some limitations, as follows.

1) This paper was presented at the 23rd Annual Meeting of the Chemical Society of Japan, Tokyo, April, 1970.

2) H.H. Baer, F. Kienzle, and F. Rajabalee, *Can. J. Chem.*, **46**, 80 (1968).

3) T. Nakagawa, T. Sakakibara, and S. Kumazawa, *Tetrahedron Lett.*, **1970**, 1645.

4) T. Nakagawa, T. Sakakibara, and F. W. Lichtenthaler, This Bulletin, **43**, 3681 (1970).

5) T. Nakagawa, Y. Sato, T. Takamoto, F.W. Lichtenthaler, and N. Majer, *ibid.*, **43**, 3866 (1970).

Results and Discussion

Preparation of Acetates. When 7-(3′-deoxy-3′-nitro-β-D-glucopyranosyl)theophylline (**1**) was treated with acetic anhydride in the presence of boron trifluoride, the corresponding 2′,4′,6′-tri-*O*-acetate (**4**) was easily prepared in 87% yield, a favorable result over those in the case of perchloric or phosphoric acid (yields of **4**: 60 and 48%, respectively) as Baer *et al.* pointed out.[2]

The similar treatment of *galacto*-isomer **2** with boron trifluoride did not afford a single product but a mixture of two or more components including di- and tri-*O*-acetates of **2**. All attempts to isolate these components by a fractional recrystallisation were unsuccessful. When **2** was treated with acetic anhydride in the presence of a trace of perchloric acid, unexpected 4′,6′-di-*O*-acetate **5** was selectively prepared in 82% yield. If a large excess (*ca.* a molar amount) of this catalyst was used, only 2′,4′,6′-tri-*O*-acetate **6** precipitated in 89% yield. The triacetate **6** was also prepared in 60% yield by Fatiadi's method[6] using anhydrous phosphoric acid as a catalyst.

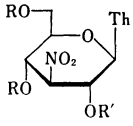
Similarly, the phosphoric acid-catalysed acetylation of *manno*-isomer **3** gave amorphous 2′,4′,6′-tri-*O*-acetate **8** in 45% yield, whereas 4′,6′-di-*O*-acetate **7** was exclusively obtained in 24% yield with boron trifluoride. Repeated trials of the perchloric acid-catalysed acetylation of **3** always produced a mixture of acetates containing both **7** and **8** at least on the basis of NMR spectra.

The 4′,6′-*O*-benzylidene derivatives of **1**—**3** were prepared in the usual manner and then treated with acetic anhydride in the presence of boron trifluoride to yield the corresponding 2′-*O*-acetyl-4′,6′-benzylidene derivatives (**12**—**14**), which were submitted for NMR studies described below.

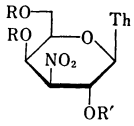
NMR Studies. Recently, Lichtenthaler *et al.*[7,8] summarized the relationship between chemical shifts of the methyl resonances of *O*- and *N*-acetyl groups and their conformations in a series of pyranose- and cyclitolpolyacetates: In deuteriochloroform ($CDCl_3$), axial *O*-acetyl groups of polyacetates of sugars and aminosugars appear generally in a region of τ 7.80—7.87, equatorial *N*-acetyl groups in a relatively higher field, τ 8.03—8.10 and equatorial *O*-acetyl (including 6-*O*-acetyl group of aldopyranose derivatives) and axial *N*-acetyl groups in a middle region, τ 7.87—8.02.[8] By changing the solvent to dimethylsulfoxide-d_6 (DMSO-d_6) a diamagnetical shift of the signals of *O*-acetyl groups is in general permissible (0.05 ppm), but that of *N*-acetyl groups appreciable (ordinarily 0.15 ppm).[8] In the case of fully acetylated hexopyranosyl nucleosides, the anisotropy of the bases causes a diamagnetical shift of the 2′-acetyl singnals, *i.e.* generally in pyrimidines 0.1 ppm; in purines 0.3 ppm.[8]

As seen in Fig. 1, all the equatorial *O*-acetyl groups on *C*-3′– *C*-6′ of *gluco*-isomer **4** and 7-(2′,3′,4′,6′-tetra-*O*-acetyl-β-D-glucopyranosyl)theophylline[9] resonate within the normal region, *i.e.* τ 7.88—7.98 in $CDCl_3$ and τ 7.91—7.99 in DMSO-d_6, but the equatorial 2′-*O*-acetyl groups of these acetates and **12** in higher field, τ 8.08—8.10 in $CDCl_3$ and τ 8.14—8.17 in DMSO-d_6 because of the anisotropy of the theophylline residue.[8,9]

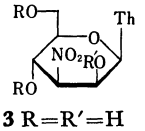
The lowest one of the three acetyl signals of *galacto*-isomer **6** (τ 7.82 in $CDCl_3$ and τ 7.86 in DMSO-d_6) is assigned to the axial 4′-*O*-acetyl group, the middle signal (τ 7.95 in $CDCl_3$ and τ 8.02 in DMSO-d_6) to the 6′-*O*-acetyl group, and the highest one (τ 8.11 in $CDCl_3$ and τ 8.18 in DMSO-d_6) to the equatorial 2′-*O*-acetyl group. These assignments are also confirmed by the facts that the 2′-*O*-acetyl signal of **13** appears at τ 8.11 in $CDCl_3$ and τ 8.20 in DMSO-d_6. The *galacto*-diacetate **5** has two acetyl signals at τ 7.82 and 7.94 in $CDCl_3$, and at τ 7.86 and 8.01 in DMSO-d_6, which are easily assigned to the 4′- and 6′-*O*-acetyl



1 R=R′=H
4 R=R′=Ac
9 RR=PhCH〈; R′=H
12 RR=PhCH〈; R′=Ac

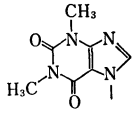


2 R=R′=H
5 R=Ac; R′=H
6 R=R′=Ac
10 RR=PhCH〈; R′=H
13 RR=PhCH〈; R′=Ac



3 R=R′=H
7 R=Ac; R′=H
8 R=R′=Ac
11 RR=PhCH〈; R′=H
14 RR=PhCH〈; R′=Ac

Th=



Acetates		Chemical shifts (τ) in $CDCl_3$ 7.80 7.90 8.00 8.10	in DMSO-d_6 7.90 8.00 8.10 8.20
gluco	4	2′	2′
	12	2′	2′
7-(2′,3′,4′,6′-Tetra-*O*-acetyl-β-D-glucopyranosyl) theophylline[b]		c) 2′	c) 2′
galacto	5		
	6	2′	2′
	13	2′	2′
manno	7		
	8	2′	d)
	14	2′	d)

Fig. 1. Acetyl resonances of the acetates of 3′-deoxy-3′-nitro-β-D-hexopyranosyl theophylline at 100 MHz[a]
a) TMS as an internal standard.
b) Values cited in Ref. 9 (at 60 MHz).
c) 6H-Intensity.
d) Decomposition and/or acetyl migration occurred in DMSO in a considerable extent and complex spectra were observed.

6) A. J. Fatiadi, *Carbohyd. Res.*, **6**, 237 (1968).
7) F. W. Lichtenthaler and P. Emig, *Tetrahedron Lett.*, **1967**, 577; *Carbohyd. Res.*, **7**, 121 (1968).
8) F. W. Lichtenthaler, G. Bambach, and P. Emig, *Chem. Ber.*, **102**, 994 (1969).
9) F. W. Lichtenthaler and T. Nakagawa, *ibid.*, **100**, 1833 (1967).

TABLE 1. COMPARISON OF CHEMICAL SHIFTS OF THE RING PROTONS OF DIACETATES **5** AND **7** WITH THOSE OF TRIACETATES **6** AND **8**[a)]

Acetates	τ-Values in $CDCl_3$				τ-Values in DMSO-d_6			
	$H^{1'}$	$H^{2'}$	$H^{3'}$	$H^{4'}$	$H^{1'}$	$H^{2'}$	$H^{3'}$	$H^{4'}$
galacto **5**	3.94	(5.0—5.1)		3.98	4.06	4.99	4.53	4.28
6	3.71	3.77	4.84	3.95	(3.7—3.9)		4.08	4.14
$\Delta\tau$	0.23	1.2—1.3	0.2—0.3	0.03	0.2—0.4	1.1—1.3	0.45	0.14
manno **7**	3.79	(5.0—5.1)		*ca.* 4.1	3.67	5.36	4.30	3.70
8	3.58	3.84	4.48	4.13	———			[b)]
$\Delta\tau$	0.21	1.2—1.3	0.2—0.3	0.0				

a) Assignments of the spectra are based on a first-oder analysis.
b) See footnote d) in Fig. 1.

groups, respectively, and shows no diamagnetically shifted signal corresponding to the 2′-*O*-acetyl group (*cf.* Fig. 1). Therefore, the structure of **5** is unequivocally deduced to be 4′,6′-di-*O*-acetate.

On the other hand, the diamagnetically shifted axial 2′-*O*-acetyl signal of the *manno*-isomers appears at τ *ca.* 8.0 in $CDCl_3$ (*i. e.* compound **14**; τ 8.01: **8**; τ 8.02). From this reason, the two acetyl signals of *manno*-diacetate **7** (τ 7.89 and 7.90 in $CDCl_3$; τ 7.93 and 7.96 in DMSO-d_6) are assigned to the equatorial 4′- and 6′-*O*-acetyl groups and, therefore, the axial hydroxyl group on *C*-2′ is free, which indicates the structure of **7** also to be 4′,6′-di-*O*-acetate.

These structural elucidations of diacetates **5** and **7** are further confirmed by considerations on the spectra of their ring protons on *C*-2′:

a) Their signals, resonated in DMSO-d_6 at τ 4.99 and 5.36 in **5** and **7**, respectively, appear as diffused bands as a result of the coupling with the 2′-hydroxylic proton in the presence of a trace of water in the solvent[10] (*cf.* Figs. 2 and 3);

b) On acetylation (**5**→**6**; **7**→**8**) the chemical shift of the proton on *C*-2′ moves paramagnetically in a considerable extent, 1.1—1.3 ppm,[11] and this effect diminishes remarkably with the degree of the distance from the 2′-carbon atom along the C–C bond, *i. e.* 0.2—0.45 ppm for $H^{1'}$ and $H^{3'}$; 0.0—0.14 ppm for $H^{4'}$ (Table 1), all of which indicate clearly the 2′-hydroxyl group in **5** and **7** to be free.

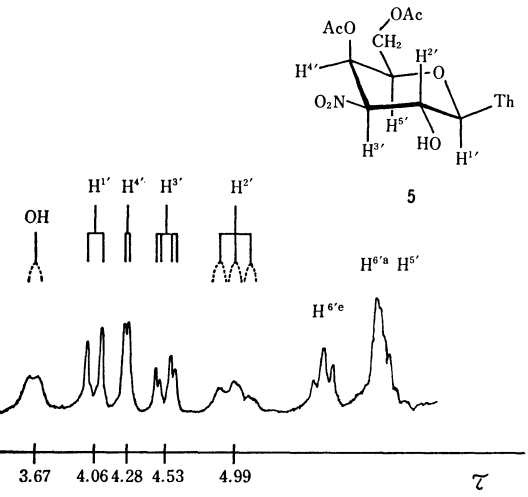


Fig. 2. NMR spectra of ring protons of *galacto*-diacetate **5** (100MHz; in DMSO-d_6).
$J_{1'2'}$: 9 Hz $J_{2'3'}$: 10 $J_{3'4'}$: 2.5 $J_{4'5'}$: ~0

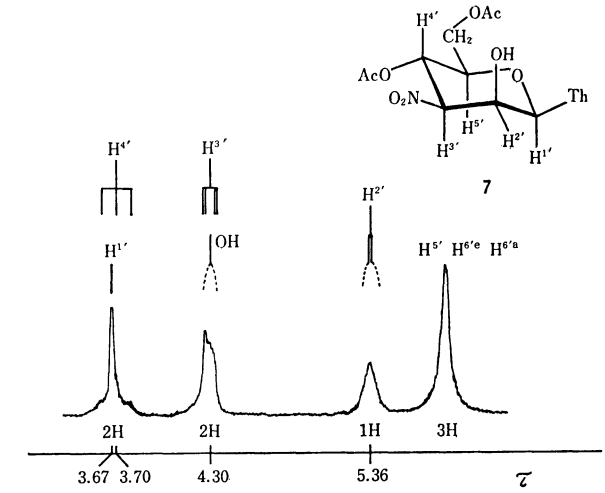


Fig. 3. NMR spectra of ring protons of *manno*-diacetate **7** (100 MHz; in DMSO-d_6).
$J_{1'2'}$: 1 (?) Hz $J_{2'3'}$: 2 (?) $J_{3'4'}=J_{4'5'}$: 10

Experimental

General. All melting points were determined in a capillary and uncorrected. Optical rotations were measured with a CARL ZEISS photoelectric polarimeter. NMR spectra were recorded at 100 MHz with a JEOL spectrometer (Type JNM-4H-100), using tetramethyl silane as an internal standard.

7-(2′,4′,6′-Tri-O-acetyl-3′-deoxy-3′-nitro-β-D-glucopyranosyl)-theophylline (4). a) Catalysed by Boron Trifluoride: To a stirred suspension of **1**[9] (3.0 g, 8.1 mmol) in acetic anhydride (7 ml) was added boron trifluoride etherate (*ca.* 0.3 ml) dropwise. After standing overnight at room temperature the mixture was poured into ice water (200 ml) with sitrring. The acetate separated in gel-like form while the excess anhydride decomposed, was collected by filtration, suspended again in

10) L. M. Jackman, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," Pergamon Press, London (1959), p. 26—28.

11) Acylation of secondary alcohols causes the chemical shift of the α-proton to move paramagnetically by 1.0—1.15 τ and this effect is the same for axial and equatorial protons in steroid molecules [Ref. 10, p. 55; J. N. Shoolery and M. T. Rogers, *J. Amer. Chem. Soc.*, **80**, 5121 (1958)].

water (50 m*l*) with vigorous stirring and then filtered. After thorough washing with water and drying *in vacuo* at 40—50°C, the resulting colorless powder (3.5 g, 87%) was analytically pure. All attempts to crystallize were unsuccessful. $[\alpha]_D^{20}$ −7.4° (*c* 1.0, $CHCl_3$). IR (KBr): 1750 cm^{-1} ($\nu_{C=O}$ of Ac). NMR ($CDCl_3$): 3.73 (1H-*d*, $J_{1'2'}=9$ Hz, H$^{1'}$); 4.93 τ (1H-*t*, $J_{2'3'}=J_{3'4'}=10$ Hz, H$^{3'}$).

Found: C, 45.72; H, 4.72; N, 14.26%. Calcd for $C_{19}H_{23}O_{11}N_5$: C, 45.85; H, 4.66; N, 14.08%.

b) Catalysed by Perchloric Acid: To a well stirred suspension of **1**[9] (1.0 g, 2.7 mmol) in acetic anhydride (4 m*l*) were added two drops of 70% perchloric acid. The mixture was stirred for additional 12 hr at room temperature and then worked up as described above to yield 0.80 g (60%) of colorless powder, which was identified with the product obtained above.

c) Catalysed by Phosphoric Acid: To a mixture of Fatiadi's catalyst[6] (1 m*l*) and acetic anhydride (4 m*l*) was added **1**[9] (0.50 g, 1.35 mmol) and warmed with stirring at 50°C for 1 hr. The mixture was then worked up as described under *a*): Yield 0.32 g (48%).

*7-(2′,4′,6′-Tri-O-acetyl-3′-deoxy-3′-nitro-β-D-galactopyranosyl)-theophylline (**6**).* *a) In the Presence of a Large Excess of Perchloric Acid*: To a well stirred suspension of **2**[9] (2.0 g, 5.4 mmol) in acetic anhydride (8 m*l*) was added 70% perchloric acid (4.6 m*l*, 5.4 mmol) dropwise. The mixture became immediately a clear solution and then the acetate precipitated in crystalline form, which was filtered after stirring for 1 hr and washed well with ether. Additional crystals were deposited by further addition of 70% perchloric acid (3.0 m*l*) into the filtrate, filtered and washed with ether. The combined crystals were suspended in cold water (30 m*l*) with vigorous stirring for 1 hr, filtered, washed with water and then dried *in vacuo* at 50°C: 2.4 g (89%) of analytically almost pure, colorless needles, mp 191—193°C (decomp.).

Found: C, 45.95; H, 5.13; N, 14.02%. Calcd for $C_{19}H_{23}O_{11}N_5$: C, 45.85; H, 4.66; N, 14.08%.

Recrystallization from ethanol gave needles with lowered mp: 188—189°C (decomp.); $[\alpha]_D^{20}$ −1.8° (*c* 1.1, $CHCl_3$). (IR) (KBr): 1760 cm^{-1} ($\nu_{C=O}$ of Ac). NMR ($CDCl_3$): 3.71 (1H-*d*, $J_{1'2'}=9$ Hz, H$^{1'}$); 4.84 τ (1H-*q*, $J_{2'3'}=10$, $J_{3'4'}=3$ Hz, H$^{3'}$). Found: C, 45.75; H, 4.50; N, 14.17%.

b) Catalysed by Phosphoric Acid: To a mixture of Fatiadi's catalyst[6] (5 m*l*) and acetic anhydride (20 m*l*) was added **2**[9] (2.5 g, 6.7 mmol) and warmed with stirring at 50°C for 1.5 hr. The reaction mixture was poured into ice water with stirring and the resulting precipitates were filtered. Recrystallisation from ethanol gave 2.0 g (60%) of colorless needles, which were identified with the product obtained above.

*7-(2′,4′,6′-Tri-O-acetyl-3′-deoxy-3′-nitro-β-D-mannopyranosyl)-theophylline (**8**).* To a mixture of Fatiadi's catalyst[6] (2 m*l*) and acetic anhydride (8 m*l*) was added **3**[9] (1.0 g, 2.7 mmol) and stirred at room temperature for 1 hr. The reaction mixture was poured into ice water (100 m*l*) and stirred vigorously for 0.5 hr. The water layer was removed by decantation and the remnant was stirred with new cold water again. This operation was repeated three times more to afford colorless powder, which was collected by filtration and dried *in vacuo* at room temperature over phosphorous pentoxide: Yield 0.60 g (45%). The product obtained was analyticallly pure, but all attempts to crystallize were unsuccessful. $[\alpha]_D^{20}$ +108.6°C (*c* 1.0, $CHCl_3$). IR (KBr): 1750 cm^{-1} ($\nu_{C=O}$ of Ac). NMR ($CDCl_3$): 3.58 (1H-*d*, $J_{1'2'}=1.5$ Hz, H$^{1'}$); 4.84 τ (1H-*q*, $J_{2'3'}=3.5$, $J_{3'4'}=10.5$ Hz, H$^{3'}$).

Found: C, 45.56; H, 4.44; N, 14.38%. Calcd for $C_{19}H_{23}O_{11}N_5$: C, 45.85; H, 4.66; N, 14.08%.

*7-(4′,6′-Di-O-acetyl-3′-deoxy-3′-nitro-β-D-galactopyranosyl)theophylline (**5**).* To a suspension of **2**[9] (1.0 g, 2.7 mmol) in acetic anhydride (7 m*l*) was added a drop of perchloric acid and stirred at room temperature for 10 hr. To the reaction mixture was added 30 m*l* of ice water with vigorous stirring and the resulting precipitates were separated, washed well with water and dried *in vacuo* at 50°C to afford analytically pure, colorless needles (1.01 g, 82%) of mp 170—171°C (decomp.). Even after recrystallisation from ethanol/petroleum ether, the melting point did not change. $[\alpha]_D^{20}$ −19.2° (*c* 0.57, dioxane). IR (KBr): 3400 (ν_{OH}); 1750 and 1730 cm^{-1} ($\nu_{C=O}$ of Ac).

Found: C, 44.84; H, 4.68; N, 15.12%. Calcd for $C_{17}H_{21}O_{10}N_5$: C, 44.84; H, 4.65; N, 15.38%.

*7-(4′,6′-Di-O-acetyl-3′-deoxy-3′-nitro-β-D-mannopyranosyl)theophylline (**7**).* To a well stirred suspension of **3**[9] (0.50 g, 1.35 mmol) in acetic anhydride (10 m*l*) was added a few drops of boron trifluoride etherate and stirred for 3.5 hr at room temperature. To the reaction mixture was added ice water (30 m*l*) and vigorously stirred for 30 min. After extraction with methylene chloride (20 m*l*×4), washing with water and drying over sodium sulfate, the organic solvent was evaporated *in vacuo* at 40°C to dryness. The remained sirup was dissolved in chloroform (2 m*l*) and then allowed to stand overnight. The acetate deposited was collected by filtration and recrystallized from methanol: 0.15 g (24%) of colorless needles; mp 203—204°C (decomp.); $[\alpha]_D^{20}$ +73.4° (*c* 1.0, dioxane). IR (KBr): 3400 (ν_{OH}), 1741 cm^{-1} ($\nu_{C=O}$ of Ac).

Found: C, 44.93; H, 4.29; N, 15.48%. Calcd for $C_{17}H_{21}O_{10}N_5$: C, 44.84; H, 4.65; N, 15.38%.

*7-(4′,6′-O-Benzylidene-3′-deoxy-3′-nitro-β-D-glucopyranosyl)theophylline (**9**).* A mixture of **1**[9] (2.5 g, 6.7 mmol) and zinc chloride (2.5 g) in freshly distilled benzaldehyde (30 m*l*) was stirred for 2 days and then poured into ice water with stirring. The precipitates were collected by filtration washed well with water and petroleum ether, and then recrystallized from ethyl acetate to afford 1.95 g (63%) of colorless crystals; mp 255°C (decomp.); $[\alpha]_D^{20}$ −64.4° (*c* 1.23, dioxane). NMR (DMSO-d_6): 2.61 (5H-nallow *m*, phenyl); 3.52 (1H-*d*, J=6 Hz, OH); 4.07 (1H-*d*, $J_{1'2'}=8$ Hz, H$^{1'}$); 4.24 (1H-*s*, PhCH⟨); 4.71 (1H-*t*, $J_{2'3'}=J_{3'4'}=10$ Hz, H$^{3'}$); 4.95 τ (1H-*m*, H$^{2'}$).

Found: C, 52.57; H, 4.53; N, 15.44%. Calcd for $C_{20}H_{21}O_8N_5$: C, 52.28; H, 4.61; N, 15.25%.

*7-(4′,6′-O-Benzylidene-3′-deoxy-3′-nitro-β-D-galactopyranosyl)-theophylline (**10**).* **2**[9] (1.0 g, 2.7 mmol) was treated with freshly distilled benzaldehyde (15 m*l*) in the presence of zinc chloride (1 g) in the same manner described above and then recrystallized from ethanol/petroleum ether to yield 0.78 g (63%) of **10**; mp 224—226°C (decomp.); $[\alpha]_D^{20}$ −86.0° (*c* 1.04, dioxane). NMR (DMSO-d_6): 2.61 (5H-*m*, phenyl); 3.78 (1H-*d*, J=6 Hz, OH); 4.04 (1H-*d*, $J_{1'2'}=9$ Hz, H$^{1'}$); 4.32 (1H-*s*, PhCH⟨); 4.61 (1H-*q*, $J_{2'3'}=10$, $J_{3'4'}=3.5$ Hz, H$^{3'}$); 4.90 τ (1H-*m*, H$^{2'}$).

Found: C, 52.42; H, 4.35; N, 15.36%. Calcd for $C_{20}H_{21}O_8N_5$: C, 52.28; H, 4.61; N, 15.25%.

*7-(4′,6′-O-Benzylidene-3′-deoxy-3′-nitro-β-D-mannopyranosyl)-theophylline (**11**).* **3**[9] (2.0 g, 5.4 mmol) was treated with freshly distilled benzaldehyde (30 m*l*) in the presence of zinc chloride (2.5 g) in the same manner for preparing of **9** and recrystallized from methanol: 2.0 g (81%) of colorless crystals; mp 264—266°C (decomp.); $[\alpha]_D^{20}$ +94.8° (*c* 0.65, dioxane). NMR (DMSO-d_6): 2.61 (5H-*s*, phenyl); 3.62 (1H-nallow *d*, $J_{1'2'}=1.5$ Hz, H$^{1'}$); 3.66 (1H-*d*, J= 7 Hz, OH); 4.16 (1H-*s*, PhCH⟨); 4.39 τ (1H-*q*, $J_{2'3'}=3.5$, $J_{3'4'}=10$ Hz, H$^{3'}$).

Found: C, 52.14; H, 4.39; N, 15.28%. Calcd for $C_{20}H_{21}O_8N_5$: C, 52.28; H, 4.61; N, 15.25%.

*7-(2′-O-Acetyl-4′,6′-O-benzylidene-3′-deoxy-3′-nitro-β-D-glucopyranosyl)theophylline (**12**).* To a suspension of **9** (1.0 g, 2.2 mmol) in acetic anhydride (5 m*l*) was added a few drops

of boron trifluoride etherate and stirred for 1 hr at room temperature. The reaction mixture was poured into ice water with vigorous stirring and the resulting precipitates were collected by filtration, washed well with water and recrystallized from ethyl acetate/petroleum ether to yield fine, colorless needles (0.91 g, 81%); mp 209—211°C (decomp.); $[\alpha]_D^{20}$ (decomp.); −59.1° (*c* 0.6, $CHCl_3$). IR (KBr): 1750 cm^{-1} ($\nu_{c=o}$ of Ac). NMR ($CDCl_3$): 2.61 (5H-nallow *m*, phenyl); 4.37 (1H-*s*, PhCH〈); 4.96 τ (1H-*t*, $J_{2'3'}=J_{3'4'}=10$ Hz, $H^{3'}$).

Found: C, 51.91; H, 4.48; N, 13.78%. Calcd for $C_{22}H_{23}O_9N_5 \cdot 1/2H_2O$: C, 51.78; H, 4.73; N, 13.73%.

*7-(2'-O-Acetyl-4',6'-O-benzylidene-3'-deoxy-3'-nitro-β-D-galactopyranosyl)theophylline (**13**).* **10** (0.46 g, 1.0 mmol) was acetylated in the similar manner described above and then recrystallized from ethyl acetate/ethanol to afford colorless crystals (0.31 g, 60%); mp 202—204°C (decomp.); $[\alpha]_D^{20}$ −22.6° (*c* 0.40, $CHCl_3$). IR (KBr): 1750 cm^{-1} ($\nu_{c=o}$ of Ac). NMR ($CDCl_3$): 2.58 (5H-nallow *m*, phenyl); 4.39 τ (1H-*s*, PhCH〈).

Found: C, 52.43; H, 4.39; N, 14.05%. Calcd for $C_{22}H_{23}O_9N_5$: C, 52.69; H, 4.62; N, 13.97%.

*7-(2'-O-Acetyl-4',6'-O-benzylidene-3'-deoxy-3'-nitro-β-D-mannopyranosyl)theophylline (**14**).* **11** (1.0 g, 2.2 mmol) was acetylated in the similar manner for preparing of **12** and recrystallized from ethyl acetate to give colorless prisms (0.75 g, 68%); mp 238°C (decomp.); $[\alpha]_D^{20}$ +108° (*c* 0.32, $CHCl_3$). IR (KBr): 1765 cm^{-1} ($\nu_{c=o}$ of Ac). NMR ($CDCl_3$): 2.60 (5H-nallow *m*, phenyl); 3.52 (1H-*d*, $J_{1'2'}=1.5$ Hz, $H^{1'}$); 4.26 (1H-*s*, PhCH〈); 4.87 τ (1H-*q*, $J_{2'3'}=3.5$, $J_{3'4'}=10.5$ Hz, $H^{3'}$).

Found: C, 52.66; H, 4.41; N, 14.21%. Calcd for $C_{22}H_{23}O_9N_5$: C, 52.69; H, 4.62; N, 13.97%.

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