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## Note

# The synthesis of derivatives of 3-*O*-(2-acetamido-2-deoxy-α-D-galactopyranosyl)-L-serine and -L-threonine*

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In the mucin-type glycoproteins, as well as in numerous other glycoproteins[1], including cell-membrane glycoproteins[1–4], blood-group substances[1,5], immunoglobulins[1,6] and the antifreeze glycoproteins[1,7], the carbohydrate-to-protein linkage involves a 3-*O*-(2-acetamido-2-deoxy-α-D-galactopyranosyl)-L-serine (or -L-threonine) residue. We report here the chemical synthesis of derivatives of 3-*O*-(2-acetamido-2-deoxy-α-D-galactopyranosyl)-L-serine and -L-threonine, which can serve as starting materials for the preparation of both types of glycopeptides. The synthesis of 3-*O*-(2-acetamido-2-deoxy-α-D-galactopyranosyl)-*N*-*p*-tolylsulfonyl-L-serine methyl ester from 2-deoxy-2-(2,4-dinitroanilino)-α-D-galactose has been reported[8]. However, it was deemed necessary to devise a more convenient synthesis for this type of compound.

By use of the experimental details kindly provided by Lemieux and Ratcliffe[9], the key intermediate 3,4,6-tri-*O*-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl chloride (**5**) was readily prepared. As expected from the synthesis of protected 2-azido-2-deoxy-α-glucopyranosides by Paulsen *et al.*[10], **5** is a useful intermediate for the preparation of 2-acetamido-2-deoxy-α-D-galactopyranosides, including the terminal trisaccharide unit of the A human blood-group determinant[11].

Treatment of readily available 1,5-anhydro-2-deoxy-D-*lyxo*-hex-1-enitol (**1**) in anhydrous acetonitrile with diammonium cerium hexanitrate in the presence of sodium azide, following Lemieux and Ratcliffe's procedure[9], afforded a mixture of 3,4,6-tri-*O*-acetyl-2-azido-2-deoxy-α- and -β-D-galactopyranosyl nitrate (**2** and **3**) in 60% yield. The n.m.r. spectrum also showed the presence of about 5% of the corresponding *talo* isomer. Column chromatography of this mixture on silica gel gave the pure α- and β-D-*galacto* anomers. The structure and configuration of **2** and **3** were based on the optical rotation, i.r., and n.m.r. data. Beside other characteristic signals, the n.m.r. spectrum showed an anomeric proton as a doublet at δ 6.35, $J_{1,2}$ 4.5 Hz for **2** and at δ 5.71, $J_{1,2}$ 9 Hz for **3**. The mixture of **2** and **3** in anhydrous acetonitrile was treated with

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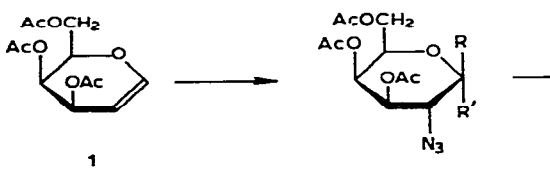
lithium iodide in the presence of molecular sieve. The n.m.r. spectrum of the reaction mixture showed no remaining starting material and contained signals corresponding to 3,4,6-tri-*O*-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl iodide (**4**) (δ 6.85, d, $J_{1,2}$ 4 Hz, H-1; 3.42, q, $J_{2,3}$ 10.5 Hz, H-2).

The iodide **4** was dissolved in anhydrous acetonitrile and immediately treated with tetraethylammonium chloride for a few minutes at room temperature to give the β-D-galactopyranosyl chloride **5** in 70% yield. When carefully monitored, the halogen exchange-reaction proceeded with a rather high degree of stereoselectivity, and only a very small proportion of α-chloride could be detected in the reaction mixture. The $^1$H-n.m.r. spectrum of **5** showed signals for H-1 (δ 5.15, d, $J_{1,2}$ 9.5 Hz) and H-2 (δ 3.88, q, $J_{2,3}$ 10.5 Hz).

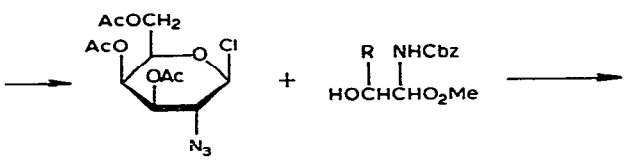
The condensation of **5** with the methyl ester of *N*-(benzyloxycarbonyl)-L-serine[12] (**6**) was performed in anhydrous nitromethane containing crushed molecular sieve, mercuric cyanide, and mercuric chloride. After the starting material could no longer be detected by t.l.c., an oily product was isolated and purified by column chromatography on silica gel giving 3-*O*-[3,4,6-tri-*O*-acetyl-2-azido-*N*-(benzyloxycarbonyl)-2-deoxy-α-D-galactopyranosyl]-L-serine methyl ester (**8**) as a white foam (yield 65%). No appreciable proportion of the β anomer could be detected. Compound **8** was characterized by its elemental analysis, and the n.m.r. spectrum showed the expected signals for both serine and the sugar component. Evidence for the α-D- configuration of **8** was based on n.m.r. signals at δ 4.98 (d, $J_{1,2}$ 3.5 Hz, H-1) and 3.6 (q, $J_{2,3}$ 11 Hz, H-2).




1

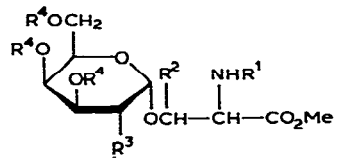
2 R = H, R′ = $ONO_2$
3 R = $ONO_2$, R′ = H

4




5

6 R = H
7 R = Me




8 $R^1$ = Cbz, $R^2$ = H, $R^3$ = $N_3$, $R^4$ = Ac
9 $R^1$ = Cbz, $R^2$ = H, $R^3$ = $NH_2$, $R^4$ = Ac
10 $R^1$ = Cbz, $R^2$ = H, $R^3$ = NHAc, $R^4$ = Ac
11 $R^1$ = Cbz, $R^2$ = H, $R^3$ = NHAc, $R^4$ = H
12 $R^1$ = $R^2$ = H, $R^3$ = NHAc, $R^4$ = Ac
13 $R^1$ = Z-Gly, $R^2$ = H, $R^3$ = NHAc, $R^4$ = Ac
14 $R^1$ = Cbz, $R^2$ = Me, $R^3$ = $N_3$, $R^4$ = Ac
15 $R^1$ = Cbz, $R^2$ = Me, $R^3$ = $NH_2$, $R^4$ = Ac
16 $R^1$ = Cbz, $R^2$ = Me, $R^3$ = NHAc, $R^4$ = Ac
17 $R^1$ = Cbz, $R^2$ = Me, $R^3$ = NHAc, $R^4$ = H

Hydrogenation of 8 in methanol in the presence of 5% palladium-on-charcoal as catalyst provided the 2-amino-2-deoxy derivative 9. According to the results of t.l.c. and the n.m.r. spectrum, no appreciable hydrogenolysis of the benzyloxycarbonyl protecting-group occurred. The product was acetylated without further purification to provide (in 96% yield, based on 8) 3-*O*-(3,4,6-tri-*O*-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-*N*-(benzyloxycarbonyl)-L-serine methyl ester (**10**). Quantitative removal of the benzyloxycarbonyl protecting-group was achieved by hydrogenation in the presence of 10% palladium-on-charcoal as catalyst in a mixture of cyclohexene and methanol[13,14]. The resulting 3-*O*-(3,4,6-tri-*O*-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-L-serine (**12**) was immediately condensed with the *o*-nitrophenyl ester of *N*-(benzyloxycarbonyl)glycine[15] to afford 3-*O*-(3,4,6-tri-*O*-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-*N*-(benzyloxycarbonylglycyl)-L-serine methyl ester (**13**).

The procedure just described was extended to L-threonine and 3-*O*-(3,4,6-tri-*O*-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl)-*N*-(benzyloxycarbonyl)-L-threonine methyl ester (**14**) was obtained in 45% yield and converted, as described earlier, into the 2-acetamido-2-deoxy derivative **16**. The yield of **16** was lower than that of the corresponding compound **10**. This seemed to be the result of a more extensive hydrogenolysis of the benzyloxycarbonyl protecting-group concomittant to the reduction of the azido group. *O*-Deacetylation of the D-galactopyranosyl residue was achieved by treatment of **10** and **15** with triethylamine—methanol, without an appreciable proportion of the carbohydrate residue being released *via* the well-known β-elimination mechanism, to provide **11** and **17**.

In conclusion, we were able to prepare the 2-acetamido-2-deoxy-α-D-galactopyranosyl derivatives of both L-serine (**10**) and of L-threonine (**15**) in satisfactory yields (>50%). Moreover, it was shown by the preparation of the *N*-glycyl derivative **13** that **10** and **15** may be useful for the preparation of glycopeptides and related compounds.

## EXPERIMENTAL

*General methods.* — Melting points were determined with a Büchi instrument and are reported uncorrected. Optical rotations were determined at room temperature with a Roussel—Jouan polarimeter. Elemental analyses were made by the "Service Central de Microanalyse du C.N.R.S.", division of Montpellier. T.l.c. was performed on silica gel plates, sprayed with 10% sulfuric acid in ethanol followed by heating at 100°. N.m.r. spectra were recorded with either a Varian EM-390 or an HA-100 instrument; unless otherwise stated, chemical shifts are given in δ for solutions of ~10% in $CDCl_3$, with tetramethylsilane as the internal standard.

*Reaction of 1,5-anhydro-2-deoxy*-D-lyxo-*hex-1-enitol* (**1**) *with diceric diammonium hexanitrate in the presence of sodium azide.* — A solution of **1** (6.89 g, 25 mmol) in dry acetonitrile (137 mL), cooled to −30° under a nitrogen atmosphere, was added to a mixture of solid diammonium cerium hexanitrate (32.7 g, 60 mmol) and sodium azide (1.97 g, 60 mmol). The resulting suspension was vigorously stirred at −30° until t.l.c. showed the absence of **1** (30–40 h). At this time, cold ethyl ether (130 mL) was added, and the resulting mixture filtered to remove any solid. After the solids had been washed with ether (2 × 30 mL), the combined filtrates were poured into ice-cold water

(150 mL). The organic layer was washed with ice-cold water (3 X 100 mL), dried (sodium sulfate), filtered, and evaporated to give a yellow syrup (7.44 g), which was chromatographed on a silica gel column (120 g) with 9:1 (v/v) chloroform—ether as eluent. Compound **2** was obtained as a solid, m.p. 103–104°, $[\alpha]_D^{25}$ + 125° (*c* 1, chloroform); $\nu_{max}^{KBr}$ 2120 ($N_3$) and 1650 $cm^{-1}$ ($ONO_2$); n.m.r. ($CDCl_3$): δ 6.35 (d, $J_{1,2}$ 4.1 Hz, H-1), 5.49 (wd, $J_{3,4}$ 3.2 Hz, H-4), 5.24 (q, $J_{3,4}$ 3.2 Hz, H-3), and 4.12 (q, $J_{2,3}$ 11.5 Hz, H-2).

The β anomer was characterized by the following data: $\nu_{max}^{KBr}$ 2120 ($N_3$) and 1650 $cm^{-1}$ ($ONO_2$); partial n.m.r. spectrum ($CDCl_3$): δ 5.71 (d, $J_{1,2}$ 9.1 Hz, H-1) and 3.87 (q, $J_{2,3}$ 10.8 Hz, H-2).

*3,4,6-Tri*-O-*acetyl-2-azido-2-deoxy*-β-D-*galactopyranosyl chloride* (**5**). — A mixture of **2** and **3** (1.84 g, 4.89 mmol) was dissolved in anhydrous acetonitrile (7 mL) containing a small amount of 4-Å crushed molecular sieve, and stirred. After 30 min, anhydrous lithium iodide (4.39 g) was added, and the suspension was stirred in the dark for 25 min, at room temperature, poured into an ice-cold 1% aqueous solution of sodium thiosulfate (25 mL), and extracted with dichloromethane (25 mL). The organic layer was dried (sodium sulfate), filtered, and evaporated to give a white foam. The n.m.r. spectrum showed no remaining starting material, and contained signals corresponding to 3,4,6-tri-*O*-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl iodide (**4**); $^1$H-n.m.r.: δ 6.85 (d, $J_{1,2}$ 4.0 Hz, H-1), 5.18 (q, $J_{3,4}$ 3.2 Hz, H-3), and 3.42 (q, $J_{2,3}$ 10.5 Hz, H-2).

Compound **4** was immediately dissolved in anhydrous acetonitrile in the presence of 4-Å molecular sieve and stirred for 30 min, before dry tetraethylammonium chloride (1.62 g, 9.84 mmol) was added. The mixture was stirred at room temperature (2 min), poured into ice-cold water (15 mL), and extracted with cold dichloromethane (25 mL). The organic layer was dried and evaporated to give a light yellow syrup. Crystallization from ether gave **5** (1.20 g, 70% yield), m.p. 106–108°; n.m.r. ($CDCl_3$): δ 5.15 (d, $J_{1,2}$ 9.0 Hz, H-1) and 4.86 (q, $J_{2,3}$ 10.5 Hz, H-3).

*3-O-(3,4 6-Tri-O-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-serine methyl ester* (**8**). — A solution of **5** (0.8 g, 2.28 mmol) in nitromethane (5 mL) was shaken for 30 min in the presence of 4-Å molecular sieve (3 g). Mercuric cyanide (0.27 g), mercuric chloride (0.15 g), and *N*-(benzyloxycarbonyl)-L-serine methyl ester (**6**, 1 g, 4 mmol) dissolved in nitromethane (2 mL) were then added, and the solution was stirred under a nitrogen atmosphere at 70° until t.l.c. showed no remaining starting material (12 h). Dichloromethane (35 mL) was added, and the reaction mixture treated with charcoal prior to being passed through a bed of Celite. Evaporation of the filtrate under 40° left a residue that was dissolved in chloroform (20 mL). This was cooled to 5° for 3 h, and the mercuric salts were removed by filtration. Evaporation gave a brown syrup (2.03 g). Column chromatography on silica gel with 9:1 (v/v) chloroform—diethyl ether as eluent gave **8** (851 mg, 1.52 mmol, 66% yield ) as a white foam; $^1$H-n.m.r.: δ 7.3 (s, Ph), 5.95 (d, *J* 8.5 Hz, NH of serine), 5.43 (d, $J_{3,4}$ 3 Hz, H-4), 5.28 (q, $J_{3,4}$ 3 Hz, H-3), 5.11 (s, $OCOCH_2$), 4.98 (d, $J_{1,2}$ 3.5 Hz, H-1), 3.75 (s, $OCH_3$), and 3.60 (q, $J_{2,3}$ 11 Hz, H-2).

*Anal.* Calc. for $C_{24}H_{30}N_4O_{12}$: C, 50.89; H, 5.34; N, 9.88. Found: C, 51.04; H, 5.54; N, 9.69.

*3-O-(3,4,6-Tri-O-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-serine methyl ester* (**10**). — Compound **8** (0.44 g, 0.76 mmol) in anhydrous

methanol (7 mL) was hydrogenated at atmospheric pressure in the presence of 5% palladium-on-charcoal catalyst (110 mg). After 3 h, t.l.c. analysis showed no remaining starting material. The catalyst was removed by filtration through Celite, which was thoroughly washed with methanol. The combined filtrates were evaporated to give a white syrup (**9**, 500 mg). Acetic anhydride (1 mL) was added to a cooled solution of this syrup in dry pyridine (30 mL). The solution was kept at room temperature (12 h) prior to evaporation *in vacuo* (0.05 mm Hg, 20°). Methanol was added to and evaporated from the residue, and this procedure was repeated 4 times. The residue was dissolved in dichloromethane (100 mL), and the solution was washed with ice-cold water (30 mL), dried (sodium sulfate), and evaporated to a yellow syrup (0.48 g), which was purified by passage through a column of silica gel (30 g) with ethyl acetate as eluent. Compound **10** was obtained as a white, foamy solid (0.43 g, 0.74 mmol, yield 97%), $[\alpha]_D^{25}$ +61 (*c* 1.0, chloroform); partial n.m.r.: δ 7.32 (s, 5 H, Ph), 6.30–6.20 (m, 2 H, NH), 5.37 (d, $J_{4,5}$ ≤0.5 Hz, H-4), 5.10 (s, $OCOCH_2$; and q, $J_{2,3}$ 11 Hz, $J_{3,4}$ 3 Hz, H-3), 4.88 (d, $J_{1,2}$ 3.7 Hz, H-1), 2.12 (s, 3 H), 2.0 (s, 6 H), and 1.94 (s, 3 H).

*3-O-(3,4,6-Tri-O-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-L-serine* (**12**). – To a solution of **10** (0.12 g) in anhydrous methanol (8 mL) and cyclohexane (5 mL) was added palladium-on-charcoal catalyst (60 mg). The suspension was boiled under reflux for 15 min, and the catalyst was filtered off and washed with methanol. Evaporation of the combined filtrated gave a syrup that crystallized from diethyl ether. Compound **12** reacted rapidly with atmospheric carbon dioxide and had to be used immediately or protected by formation of the hydrochloride salt.

*3-O-(2-Acetamido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-serine methyl ester* (**11**). – A solution of **10** (175 mg) in anhydrous methanol (10 mL) containing anhydrous triethylamine (0.9 mL) was kept in the dark for about 3 h, and the reaction monitored by t.l.c. The reaction mixture was evaporated in a rotary evaporator and the remaining triethylamine removed by azeotropic distillation with methanol, to leave a slightly yellow, solid material containing small amounts of triethylammonium salts. Pure crystalline material was readily obtained by passing this mixture through a silica gel column. Elution with 4:1 (v/v) dichloromethane–methanol gave **11** (125 mg, yield 90%), m.p. 159–162°, $[\alpha]_D^{25}$ + 117.0° (*c* 1.0, methanol); n.m.r. ($CD_3OD$): δ 7.33 (s, 5 H, Ph), 5.10 (s, 2 H, $COCH_2$), 4.78 (d, *J* 3.6 Hz, H-1), 4.21 (q, *J* 10.6 Hz, H-2), 3.7 (s, 3 H, OMe), and 1.94 (s, 3 H, NAc).

*Anal.* Calc. for $C_{20}H_{28}O_{10}N_2 \cdot H_2O$: C, 50.63; H, 6.37; N, 5.90. Found: C, 50.93; H, 6.12; N, 5.99.

*3-O-(3,4,6-Tri-O-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonylglycyl)-L-serine methyl ester* (**13**). – A solution of **12** (130 mg, 0.31 mmol) and *N*-(benzyloxycarbonyl)-glycine *o*-nitrophenyl ester (150 mg, 0.45 mmol) in anhydrous dimethylformamide (20 mL) was stirred for 3 h under a nitrogen atmosphere; constant pH (pH 9) was maintained by addition of triethylamine. Hydroxybenzotriazole (50 mg) was added during the reaction. The solution was poured into ice-cold water (200 mL) and extracted with ethyl acetate (250 mL). The organic layer was washed with M hydrochloric acid (100 mL), ice-cold water (100 mL), dried (sodium sulfate), filtered, and evaporated to give a yellow syrup (280 mg) which was purified by passage through a column of silica gel (12 g) with ethyl acetate as eluent. Compound **13** was obtained

pure as white crystals (190 mg, 95%), m.p. 68–70°, $[\alpha]_D^{25}$ +85.6 (*c* 1, chloroform); $^1$H-n.m.r. ($CDCl_3$): δ 7.4 (d, *J* 8.5 Hz, NH of Ser), 7.33 (s, Ph), 6.2 (d, *J* 9 Hz, NHAc), 5.9 (t, *J* 5.4 Hz, NH of Gly), 5.36 (d, $J_{4,5}$ ≤0.5 Hz, H-4), 5.11 (s, $OCOCH_2$), 5.1 (q, $J_{3,4}$ 3.0 Hz, H-3), 4.86 (d, $J_{1,2}$ 3.6 Hz, H-1), 4.5. (dd, $J_{2,3}$ 11.4 Hz, H-2), 3.9 (d, *J* 5.4 Hz, $CH_2$ of Gly), 3.75 (s, 3H, $OCH_3$), 1.94 (s, 3H, NHAc), 2.02 (s, 6H), and 2.13 (s, 3H).

*Anal.* Calc. for $C_{28}H_{37}N_3O_{14}$: C, 52.58; H, 5.83; N, 6.56. Found: C, 52.68; H, 5.84; N, 6.37.

*3-O-(3,4,6-Tri-O-acetyl-2-azido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-threonine methyl ester* (**14**). — Compound **5** (0.7 g, 2 mmol) and *N*-(benzyloxycarbonyl)-L-threonine methyl ester (**7**, 1.46 g, 5.5 mmol) in nitromethane (15 mL) were shaken under a nitrogen atmosphere with dry mercuric cyanide (0.36 g) and mercuric chloride (0.2 g) for 24 h at 70°. The mixture was diluted with dichloromethane (40 mL), treated with a small amount of charcoal, and filtered, and the filtrate evaporated. The residue was taken up with chloroform (25 mL), the suspension kept for 3 h at 0°, and the crystalline mercuric salts filtered off. Solvent removal left a brown syrup (3.0 g) that was passed through a column of silica gel (120 g) with 9:1 (v/v) chloroform–ether as eluent to give amorphous **14** (0.55 g, 0.95 mmol, 45% yield), n.m.r. ($CDCl_3$): δ 7.32, (s, 5 H, COBzl), 5.61 (d, *J* 9.5 Hz, NH-Cbz), 5.42 (d, $J_{4,5}$ ≤0.5 Hz, H-4), 5.22 (q, $J_{3,4}$ 3 Hz, H-3), 5.14 (s, 2 H), 5.01 (d, $J_{1,2}$ 3.5 Hz, H-1), 3.76 (s, 3 H, OMe), 3.61 (q, $J_{2,3}$ 11 Hz, H-2), and 1.33 (d, 3 H, *J* 6.2 Hz, $CH_3$ of Thr).

*Anal.* Calc. for $C_{25}H_{32}N_4O_{12}$: C, 51.72; H, 5.55; N, 9.65. Found: C, 51.82; H, 5.53; N, 9.55.

*3-O-(3,4,6-Tri-O-acetyl-2-acetamido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-threonine methyl ester* (**16**). — A solution of **14** (0.4 g, 0.69 mmol) in anhydrous methanol (7 mL) containing 5% palladium-on-charcoal catalyst (38 mg) was hydrogenated at atmospheric pressure. T.l.c. analysis showed no starting material after 7 h, but the presence of 2 spots corresponding to the 2-amino-2-deoxy-*N*-(benzyloxycarbonyl) derivative and the 2-amino-2-deoxy free amine methyl ester. The catalyst was removed by filtration on a bed of Celite, the catalyst was washed abundantly with methanol, and the combined filtrates were evaporated. Acetic anhydride (1 mL) and dry pyridine (25 mL) were added to the residue. The mixture was kept for 12 h at room temperature, and then processed as described for **10**. The resulting yellow syrup (0.450 g) (three spots in t.l.c.) was passed through a column of silica gel and eluted with ethyl acetate to give **16** (0.22 g, 0.37 mmol, 54% yield) as a colorless syrup; n.m.r. ($CDCl_3$): δ 7.33 (s, 5 H, Ph), 6.04 (d, *J* 9.5 Hz, NH), 5.35 (broad d, $J_{4,5}$ ≤0.5 Hz, H-4), 5.12 (s, 2 H, $OCOCH_2$), 5.07 (q, $J_{2,3}$ 11 Hz, $J_{3,4}$ 2.6 Hz, H-3), 4.88 (d, *J* 3.5 Hz, H-1), 4.82 (d, *J* 4.6 Hz, NH), 3.72 (s, 3 H, OMe), and 1.32 (d, 3 H, *J* 6.0 Hz, $CH_3$ of Thr).

*Anal.* Calc. for $C_{27}H_{36}N_2O_{13}$: C, 54.36; H, 6.04; N, 4.70. Found: C, 55.02; H, 5.95; N, 4.67.

*3-O-(2-Acetamido-2-deoxy-α-D-galactopyranosyl)-N-(benzyloxycarbonyl)-L-threonine methyl ester* (**17**). — The same procedure as for the preparation of **11** was applied to **16** (110 mg) dissolved in anhydrous methanol (5 mL) containing anhydrous triethylamine (0.6 mL). The compound obtained after removal of the solvents was immediately purified by column chromatography on silica gel with 4:1 (v/v) dichloromethane–methanol as eluent. Pure **17** (85 mg, yield 87%) was obtained as a white crystalline

material, m.p. 140–142°, $[\alpha]_D^{25}$ + 114.6° (*c* 1.06, methanol); partial n.m.r. ($CD_3OD$): δ 7.33 (s, 5 H, $C_6H_5$), 5.12 (s, 2 H, $OCOCH_2$), 4.75 (d, partially superimposed with DOH signal, H-1), 4.18 (q, $J_{1,2}$ 3.75 Hz, $J_{2,3}$ 10.5 Hz, H-2), 1.97 (s, 3 H, $COCH_3$), and 1.26 (d, 3 H, *J* 6.0 Hz, $CH_3$ of Thr).

*Anal.* Calc. for $C_{21}H_{30}O_{10}N_2 \cdot H_2O$: C, 51.63; H, 6.60; N, 5.73. Found: C, 51.30; H, 6.37; N, 5.60.

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