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SYNTHETIC STUDIES ON CELL SURFACE GLYCANS 3[a]
BRANCHING PENTASACCHARIDES OF GLYCOPROTEIN

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Abstract—Synthetic routes for the branching pentasaccharides **4** and **5** of glycoproteins are described in a regio- and stereo- controlled way.

With the increased understanding of the biochemistry of the glycan chains of glycoproteins present at cell surfaces and intercellular systems, many have been found to have branched chain structures[1] and to be linked to asparagine and these may be classified into three types. For example, oligosaccharide **1** isolated from calf thyroglobul in,[2] oligosaccharide **2** isolated from immunoglobulin glycopeptide,[3] and oligosaccharide **3** isolated from ovalbumin,[4] may respectively be classified as (i) high mannose type,[1,5] (ii) complex type,[1,5] and (iii) hybrid type[4] of the glycan chain, according to the kind of the monosaccharide residues involved. Not only their biological functions[6] as the recognition signals at cell surfaces for various phenomena such as cell-growth regulation, cell-recognition, invasion, metastasis, host immune surveillance, and differentiation, but also their unique, branched-chain structures have stimulated efforts directed toward their chemical synthesis. As part of a project on the chemical synthesis of glycan chains,[7] we describe here a synthesis of pentasaccharide units **4** and **5** of glycoprotein which may be classified as a high mannose type and a complex type respectively.

Regioselective eiectrophilic reactions on mannose residue

In planning the synthetic scheme of the branching oligo-mannosides **4** and **5**, a partially blocked monosaccharide synthon **11** was chosen as the proper glycosyl acceptor. The transformation of methyl α-D-mannopyranoside **6** into **11** was successfully achieved in 3 steps by employing stannyl method[8] which enhanced the

[a]Part 2; T. Ogawa, S. Nakabayashi, and S. Shibata, *Carbohydr. Res.* **86**, C7 (1980).

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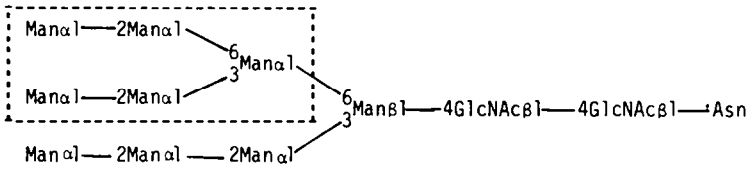

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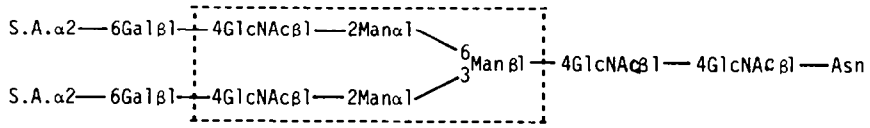

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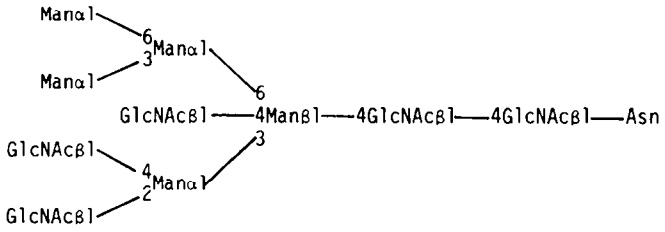

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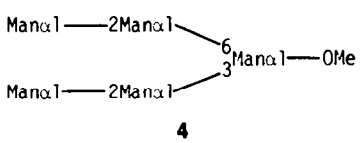

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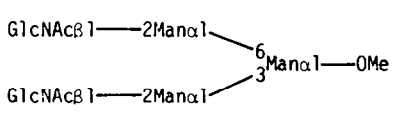

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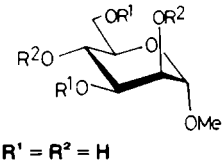
nucleophilicity of OH groups by tributylstannylation with high regioselectivity. Stannylation of **6** with 1.5 molar equivs of $(Bu_3Sn)_2O$ afforded methyl 3,6 - di - O - tributylstannyl - α - D - mannopyranoside **7** as an unstable oil which was directly transformed into methyl 3,6 - di - O - allyl - α - D - mannopyranoside **8**,[9] in 70.9% yield by heating in allyl bromide at 80°. The pattern of substitution of **8** was indicated by ^{13}C NMR data showing two deshielded signals[10] at δ 69.9 and 78.9 ppm for C-6 and C-3 C atoms respectively. As a minor product, the monoallyl derivative was also isolated in 12.7% yield and the structure was determined as 3 - O - allyl - derivative **9** by ^{13}C NMR data which showed the presence of a deshielded signal at δ 79.0 ppm for C-3 C atom. Benzylation of **8** afforded a 95.2% yield of methyl 3,6 - di - O - allyl - 2,4 - di - O - benzyl - α - D - mannopyranoside **10**. Deallylation[11] of **10** with 10% Pd–C in H_2O–EtOH–AcOH afforded methyl 2,4 - di - O - benzyl - α - D - mannopyranoside **11** in 75.3% yield. Deallylation could also be accomplished according to Gigg's procedure[12] with a similar yield. Thus, isomerization of diallyl ether **10** into enol ether and subsequent tretament of the enol ether with dilute acid afforded **11** in 67% yield. ^{13}C NMR data support the assigned structure **11** by showing two deshielded signals at δ 76.2 and 78.2 ppm for C-4 and C-2 C atoms, respectively. In order to prove the structure **11** firmly, chemical correlation of **11** with the dibenzoate **13** was performed. Benzoylation of **11** to methyl 3,6 - di - O - benzoyl - 2,4 - di - O - benzyl - α - D - mannopyranoside **12** and subsequent catalytic hydrogenolysis of **12** afforded an 81% yield of methyl 3,6 - di - O - benzoyl - α - D - mannopyranoside **13** which has been prepared in 62% yield from **6** by Williams and Richardson in 1967.[13] The same dibenzoate **13** was obtained in higher yield from **6** by the stannylation–acylation sequence. Thus, tributylstannylation of **6** and subsequent acylation afforded a 90.2% yield of **13**. The substitution pattern of two benzoyl groups in **13** was assigned according to ^1H NMR data which showed the presence of a deshielded signal for H-3 at δ 5.38 as a double doublet with J_{23} = 3Hz and J_{34} = 9 Hz. As no benzoyl group migration seems probable during the transformation of **12** into **13**, the regiochemistry of **8** and **11** could be correlated with that of **13** and hence was confirmed. Consequently, an efficient and an unambiguous route to the partially protected glycosyl acceptor **11** suitable for the synthesis of the branching oligomannosides **4** and **5** could be executed in 3 steps starting from commercially available methyl α-D-mannopyranoside **6** in 51% overall yield.

Synthesis of two disaccharide units

In order to study the method for the formation of glycosidic linkages between 2-OH of α-D-mannopyranoside residue as a glycosyl acceptor and α-D-mannopyranosyl or N-acetyl-β-D-glucopyranosyl residue as a glycosyl donor, two model disaccharides, methyl 2-O-(α-D-mannopyranosyl)-α-D-mannopyranoside **21** and methyl 2 - O - (2 - acetamido - 2 - deoxy - β - D - glucopyranosyl) - α - D - mannopyranoside **25** were chosen.



6: $R^1 = R^2 = H$
7: $R^1 = SnBn_3$, $R^2 = H$
8: R^1 = allyl, $R^2 = H$
9: $O_6 - R^1 = H$, $O_3 - R^1$ = allyl, $R^2 = H$
10: R^1 = allyl, R^2 = Bn
11: $R^1 = H$, R^2 = Bn
12: R^1 = Bz, R^2 = Bn
13: R^1 = Bz, $R^2 = H$

The preparative route for the suitably blocked glycosly acceptor **17** was first studied. Tribenzyl orthoester **14**[14] obtainable from D-mannose in 4 steps was treated with $HgBr_2$[15] to afford methyl 2 - O - acetyl - 3,4,6 - tri - O - benzyl - α - D - mannopyranoside **15** and its β-anomer **16** in 66.7% and 4.2% yields respectively. Anomeric stereochemistry of **15** and **16** was determined by ^{13}C NMR data which showed signals for C-1 at δ 98.9 with $^1J_{CH}$ = 170.6Hz and 99.9 ppm with $^1J_{CH}$ = 155.9Hz respectively, in good agreement with the observation of Bock and Pedersen.[16] Saponification of **15** gave the desired glycosyl acceptor **17**.[14]

The glycosyl donor **18** could readily be prepared from **14** according to the condition of Newman and Olson.[17] Thus, treatment of **14** with small excess of chlorotrimethylsilane smoothly afforded α-chloride **18** quantitatively. Again α-configuration at C-1 was assigned by ^{13}C NMR data, showing a signal for C-1 C atom at δ 90.3 ppm with $^1J_{CH}$ = 183.8 Hz.

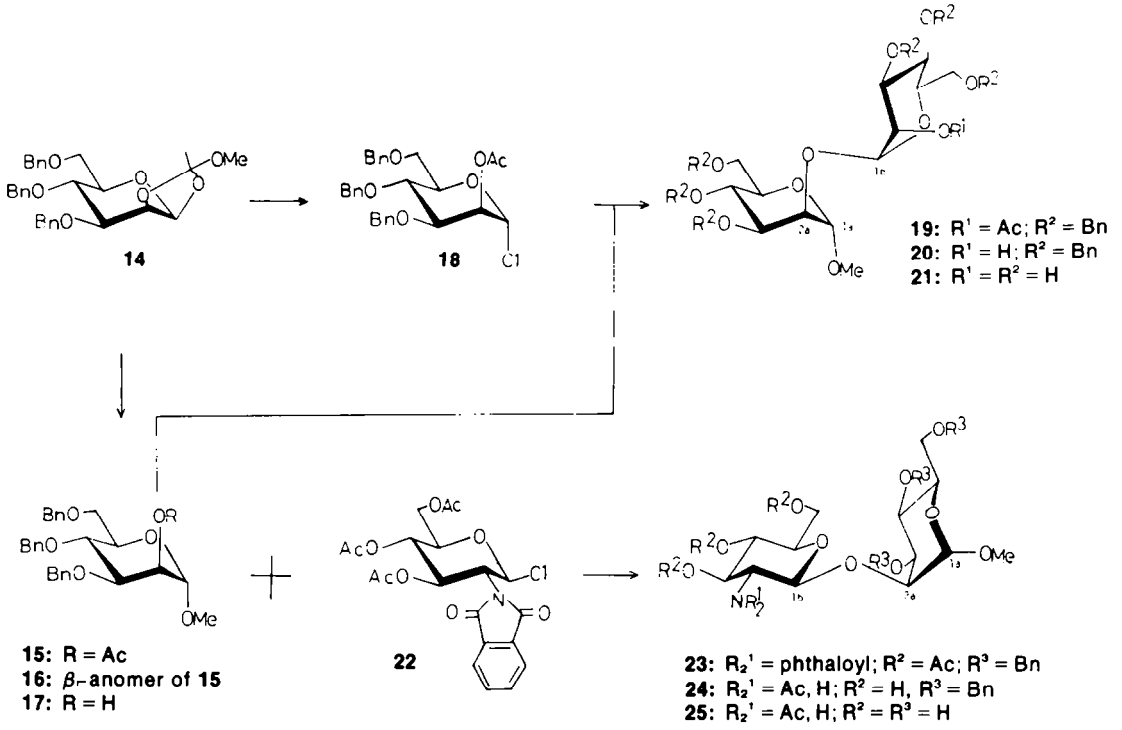
The glycosylation of **17** with **18** was carried out using the procedure of Hanessian and Banoub[18] to give a protected mannodioside **19** in 82% yield. Subsequent deacetylation of **19** to **20** and catalytic hydrogenolysis of **20** afforded a target molecule, Manα1–2Manα1–OMe, **21**. Anomeric stereochemistry of the newly introduced mannoside residue in **21** was determined to be α by the following ^{13}C NMR data; δ103.0, $^1J_{CH}$ = 170.4Hz for C-1b; 100.1, $^1J_{CH}$ = 171.9Hz for C-1a; and δ79.4 ppm for C-2a.

For the synthesis of another disaccharide, GlcNAcβ1–2Manα1–OMe **25**, 3,4,6 - tri - O - acetyl - 2 - deoxy - 2 - phthalimido - β - D - glucopyranosyl chloride **22**[19] was chosen as an efficient glycosyl donor to give 1,2-*trans*-glycosidic linkage according to the observation of Lemieux, *et al.*[20]. Glycosidation of **17** with **22**[20] afforded disaccharide derivative **23** in 90.6% yield. Removal of phthaloyl group of **23** and subsequent acetylation gave N-acetyl disaccharide **24** in 38.7% yield. Catalytic hydrogenolysis of **24** afforded the target molecule **25**. The following ^{13}C and ^1H NMR data are in good agreement with the assigned stereochemistry of **25**; δ_C 98.7 ($^1J_{CH}$ = 169.6Hz, for C-1a), 100.3 ($^1J_{CH}$ = 160.0Hz, for C-1b); δ_H4.47 (1H, d, J = 8Hz, for H-1b), 4.67 (1H, d, J = 2Hz, H-1a).

The above glycosidation at 2-OH of methyl α-D-mannopyranoside **6** with the glycosyl donors **18** and **22** which yielded correct anomeric configurations, strongly indicated the applicability of the same glycosyl donors **18** and **22** for the synthesis of larger glycan chains having such glycosidic linkages as **4** and **5**.

Synthesis of the branching trimannoside **32** *and its further transformation into pentasaccharides* **4** *and* **5**.

Since the reaction of Bu_3SnOR with tetra - O - acetyl - α - D - mannopyranosyl bromide **26** was reported to give a high yield of orthoester **27**,[21] a direct route to trimannoside **32** was planned: (i) the reaction of glycosyl halide **18** with selectively stannylated alchol **7** to give diorthoester **28** (ii) rearrangement of **28** into **32** or its synthetic equivalent. On the other hand, an indirect, but an unam-



biguous route to **32** should be based on the use of regioselectively protected methyl α-D-mannopyranoside **11**. These two routes for the synthesis of **32** were examined in order to develop an efficient route from the preparative point of view.

Treatment of **7** with **18** afforded a 34% yield of **28** and a 2.2% yield of a minor isomer, the structure of which was tentatively assigned as 4,6-di-orthoester. ^{1}H NMR data of **28** showed the presence of two singlets for two C-Me groups at δ1.76 and 1.83 ppm indicating the presence of two orthoester functions in **28**. The regiochemistry of **28** was expected to be as 3,6-di-O-branching mode from the result of the selective benzylation or benzoylation reaction of **7** and was actually proved by the chemical correlation in a following manner. Benzylation of **28** afforded a 77.3% yield of perbenzylated di-orthoester **29**. Rearangement of **29** into the protected trimannoside **30** was achieved in 27.3% yield by heating **29** in the presence of $HgBr_2$ without solvent. The same trimannoside was prepared using selectively protected methyl α-D-mannopyranoside **11** and the glycosyl donor **18**, and was identified with **30** by NMR data. Thus, **11** was treated with **18** in the presence of silver triflate and tetramethylurea to give a 78.6% yield of the protected trimannoside **30**. It is to be noted that when collidine was used as an acid trapping agent instead of $Me_2NCONMe_2$ in this reaction only mono orthoester **31** was isolated in 55% yield and **30** was not even detected by tlc examination. By the conventional orthoester approach, **30** could be obtained but in much lower yield; the reaction of **11** with **14** in the presence of $HgBr_2$ afforded only 24% yield of **30**.

Deacetylation of **30** afforded **32** in 84% yield. Three anomeric carbons of **32** could be observed in ^{13}C NMR at 98.1 ($^1J_{CH}$ = 170.8Hz), 99.6 ($^1J_{CH}$ = 170.1Hz) and 101.4 ppm ($^1J_{CH}$ = 172.8Hz) which indicate α-D-configuration of the two mannoside residues introduced at 0–3 and 0–6. And this was confirmed by the ^{13}C NMR data of free mannotrioside **33** obtained from **32** by catalytic hydrogenlysis which showed three signals at δ 100.1 ($^1J_{CH}$ = 170.9 Hz for C-1b), 101.8 ($^1J_{CH}$ = 171.9 Hz for C-1a) and 103.2 ($^1J_{CH}$ = 169.9 Hz for C-1c). It is to be noted that **32** can be regarded as a key intermediate for the synthesis of **4** and **5**, since **32** was protected in a proper manner for further elongation of glycan chain at 2-OH of the two mannose residues at non-reducing ends of the glycan chain. These experiments showed that the indirect approach is superior to the direct one from the view point of total overall yield for the preparation of the key intermediate **32**.

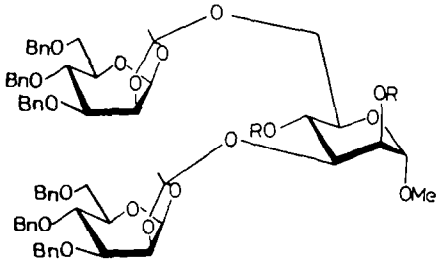
As regio- and stereochemistry of the key intermediate **32** was firmly established by the unambignous synthetic sequence and ^{13}C NMR data, further glycosidation of **32** was next studied.

Glycosidation of **32** with **18** under Hanessian-Banoub procedure afforded protected pentamannoside **34** in 78.8% yield. Saponification of **34** into **35** in 78.1% yield and subsequent hydrogenolysis of **35** afforded the target mannopentaoside **4** as an amorphous solid. Anomeric stereochemistry of five mannose residues in **4** was confirmed by the following ^{13}C NMR data; δ_C 98.7 ($^1J_{CH}$ = 172Hz for C-1b), 101.6 ($^1J_{CH}$ = 174Hz for C-1c), 101.7 ($^1J_{CH}$ = 174Hz for C-1a), and 103.0 ($^1J_{CH}$ = 172Hz for C-1d and C-1e). ^{1}H NMR spectra† also revealed the presence of five anomeric protons; δ_H: 4.70 (1H, s, H-1a), 5.01 (2H, s, H-1d and H-1e), 5.13 (1H, s, H-1b) and 5.32 ppm (1H, s, H-1c).

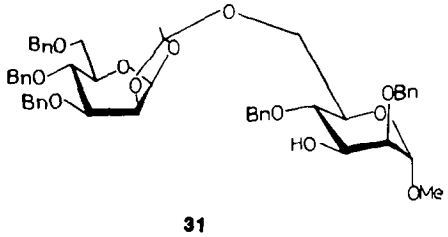
Selectively benzylated trimannoside **32** could also be transformed into pentasaccharide **5** in the following manner: Introduction of two β-D-glucosamine residues into **32** was achieved using **22** as the glycosyl donor in the presence of silver triflate and collidine, affording a

†The assignment of ^{13}C and ^{1}H NMR signals for these and related compounds will be discussed elsewhere separately.

26 **27**



28: R = H
29: R = Bn



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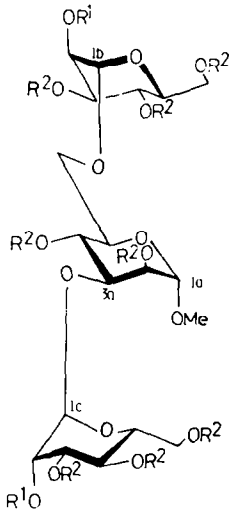
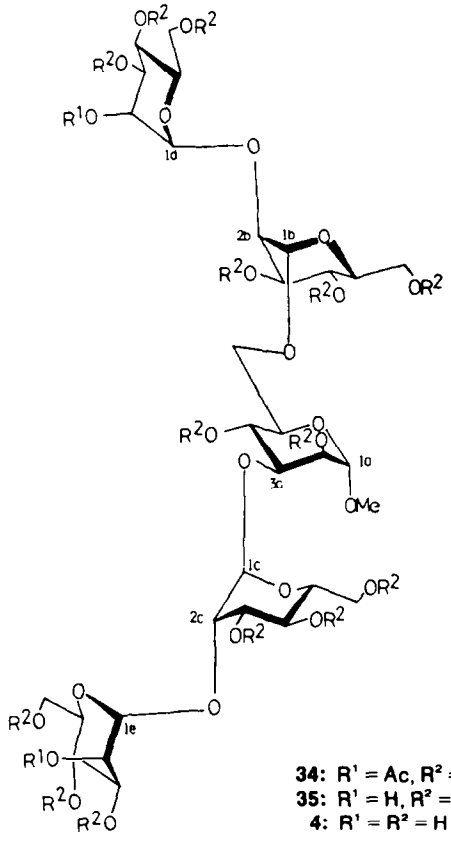
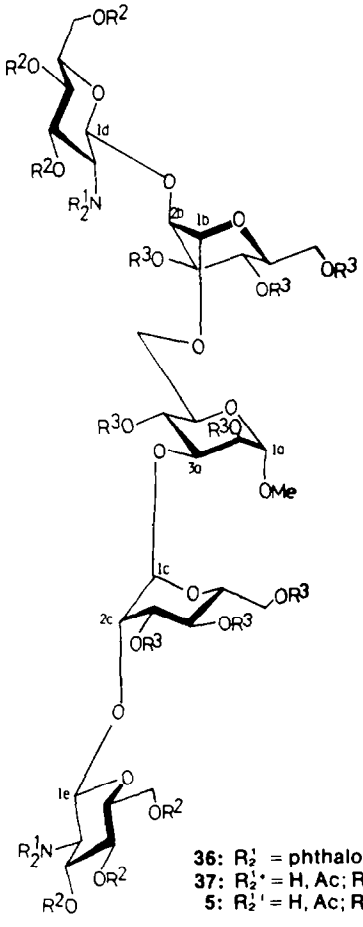


30: R^1 = Ac, R^2 = Bn
32: R^1 = H, R^2 = Bn
33: R^1 = R^2 = H



34: R^1 = Ac, R^2 = Bn
35: R^1 = H, R^2 = Bn
4: R^1 = R^2 = H



36: R_2^1 = phthaloyl, R^2 = Ac, R^3 = Bn
37: R_2^1 = H, Ac; R^2 = H; R^3 = Bn
5: R_2^1 = H, Ac; R^2 = R^3 = H

44% yield of protected pentasaccharide **36** along with a 27% yield of protected tetrasaccharide carrying only one β-D-glucosamine residue at either 0–2b or 0–2c of **32**. Subsequent removal of the phthaloyl group from **36** by $NH_2NH_2 \cdot H_2O$ and acetylation with Ac_2O–MeOH afforded N-acetyl derivative **37** in 45.8% yield. Hydrogenolysis of **37** gave the target pentasaccharide **5** as an amorphous solid. β-D-Configuration of two glucosamine residue in **5** was confirmed by ^1H and ^{13}C NMR data showing signals for two anomeric protons at δ4.5 ppm (2H, d, J = 8 Hz) and two anomeric carbons at δ100.4 ppm ($^1J_{CH}$ = 160.0Hz).

In conclusion, we developed an efficient route for the synthesis of branching pentasaccharides **4** and **5**, using regioselectively protected trimannoside **32** as a key intermediate, which in turn was prepared via regioseletive stannylation of methyl α-D-mannopyranoside **6** as a key reaction.

EXPERIMENTAL

M.ps were determined with a Yanagimoto micro m.p. apparatus and were uncorrected. Optical rotations were determined with a Parkin–Elmer Model 141 polarimeter for solns in $CHCl_3$ at 25°, unless otherwise noted. IR spectra were recorded with an EPI-G2 Hitachi Spectrophotometer, as KBr discs for the crystalline samples and as neat films for the liquid samples. ^1H-NMR spectra were recorded with a Varian HA-100 nmr spectrometer with TMS as internal standard. ^{13}C NMR spectra were recorded with a JNM-FX 100FT NMR spectrometer at 25.05 MHz. The values of δ_C and δ_H are expressed in ppm downward from the internal standard for the solns in $CDCl_3$ unless otherwise noted. Column chromatography was performed on columns of Silica Gel Merck (70-230 mesh; E. Merck, Darmstadt, Germany). Tlc was performed on precoated plates (0.25 mm; E. Merck, Darmstadt, Germany) of Silica Gel 60 F_{254}.

Methyl 3,6-*di*-O-allyl-α-D-*mannopyranoside* **8**

The mixture of **6** (3.84 g, 19.8 mmol) and $(Bu_3Sn)_2O$ (18 g, 30.1 mmol) in toluene (100 ml) was stirred under reflux for 1.5 hr with continuous azeotropic removal of water. After evaporation of toluene *in vacuo*, the residual oil was dissolved in allyl bromide (50 ml) and the soln was stirred for 7 days at 80° under N_2. Allyl bromide was evaporated *in vacuo* to give a residual oil which was chromatographed on SiO_2 (220 g). Elution with EtOAc–toluene (2:3, 1:1) gave **8** (3.85 g, 70.9%). Analytical sample was obtained by rechromatography of **8** on SiO_2 (CH_2Cl_2-Me_2CO, 5:1), R_f 0.5 in EtOAc–toluene (3:1). $[\alpha]_D$ +29.0° (*c* = 1.60). NMR δ_H: 3.39 (3H, s, OCH_3), 4.76 (1H, d, J = 2Hz, H-1). δ_C: 54.8 (OMe), 67.2 (C-2), 67.5 (C-4), 69.9 (C-6), 70.3 (C-5), 70.6 (C_3–O–CH_2–CH=), 72.4 (C_6–O–CH_2–CH=), 78.9 (C-3), 100.3 ($^1J_{CH}$ = 168.9, C-1), 117.0 (–CH=CH_2), 117.6 (–CH=CH_2), 134.1 (O–CH_2–CH=CH_2) (Found: C, 56.69; H, 8.08. $C_{13}H_{22}O_6$ requires: C, 56.92; H, 8.08%). Further elution with $CHCl_3$–MeOH (5:1, 1:1) gave **9** (587 mg, 12.7%), R_f 0.06 in EtOAc–toluene (3:1). $[\alpha]_D$ + 51.4° (*c* = 0.93). NMR δ_H: 3.36 (3H, s, OMe), 4.74 (1H, d, J = 2H, H-1). δ_C: 54.8 (OMe), 61.1 (C-6), 64.8 (C-4), 67.8 (C-2), 70.7 (C_3–O–CH_2–CH=), 72.1 (C-5), 79.0 (C-3), 100.5 ($^1J_{CH}$ = 169.9, C-1), 117.8 (–CH=CH_2), 134.1 (O-CH_2–CH=CH_2). (Found: C, 50.83; H, 7.65. $C_{10}H_{18}O_6$ requires: C, 51.27; H, 7.75%).

Methyl 3,6 - *di* - O - *allyl* - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **10**

To a soln of **8** (1.35 g, 5 mmol) in DMF (20 ml) was added portionwise NaH (50%, 700 mg, 15 mmol) and the mixture was stirred for 30 min at 25°. To this mixture was added dropwise benzyl bromide (1.8 ml, 15 mmol) during 15 min at −5° under N_2. The mixture was further stirred for 2 hr at 0° – 20°. Excess NaH was destroyed by carefully adding MeOH (2 ml). The mixture was diluted by H_2O and extracted with EtOAc. Organic layer was washed with H_2O, dried ($MgSO_4$) and evaporated to give an oil, which was chromatographed over SiO_2 (100 g, EtOAc–toluene, 10:1) to give **10** (2.132 g, 95.2%), R_f 0.62 in toluene–EtOAc (3:1). $[\alpha]_D$ +33.5° (*c* = 0.55) NMR δ_H: 3.32 (3H, s, OMe). (Found: C, 70.73; H, 7.40. $C_{27}H_{34}O_6$ requires: C, 71.34; H, 7.54%).

Methyl 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **11**

(A) A mixture of **10** (20 g, 44 mmol) and 10% Pd-C (10 g) in EtOH (800 ml)–H_2O (200 ml)-AcOH (40 ml) was stirred for 24 hr at 60°, when tlc (toluene–EtOAc 3:1) of the mixture showed the presence of a major product at R_f 0.20 and a minor product at R_f 0.30. To the mixture was added further 10% Pd-C (1 g) in EtOH (80 ml)–H_2O (20 ml)–AcOH (4 ml), and the mixture was stirred for 18 hr at 60°. Pd–C was filtered off through celite bed and the filtrate was evapoated *in vacuo* to give an oil which was chromatographed over SiO_2 (550 g, toluene–EtOAc 4:1) to afford **10** as a clear syrup (12.4 g, 75.3%).

(B) A soln of **10** (25 g, 55 mmol) in dry DMSO (100 ml) containing tBuOK (13.6 g, 121 mmol) was stirred for 30 min at 100° under Ar. DMSO was then distilled off in high vacuum to give a residual oil which was dissolved in dioxane (300 ml) and 1N HCl (125 ml). This soln was stirred for 1 hr at 80–90° and was evaporated *in vacuo* to give a residual oil which was chromatographed over SiO_2 (450 g, toluene-EtOAc 3:1) to give **11** (13.8 g, 67.0%), R_f 0.20 in toluene–EtOAc (3:1). $[\alpha]_D$ +23.5° (*c* = 0.77). NMR δ_H: 3.31 (3H, s, OMe); δ_C: 54.7 (OMe), 62.1 (C-6), 71.1 (C-3), 71.5 (C-5), 73.0 (OCH_2ph), 74.7 (OCH_2ph), 76.2 (C-4), 78.2 (C-2), 98.0 ($^1J_{CH}$ = 167.2, C-1). (Found: C, 67.39; H, 70.5. $C_{21}H_{26}O_6$ requires: C, 67.36; H, 7.00%).

Methyl 3,6 - *di* - O - *benzoyl* - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **12**

To **11** (25 mg) dissolved in pyridine (0.2 ml) and CH_2Cl_2 (0.5 ml) was added benzoyl chloride (0.1 ml). The mixture was stirred for 1 hr at 20° and H_2O (0.1 ml) was added to destroy excess benzoyl chloride. The mixture was further stirred for 30 min at 20°. Usual work-up and chromatography (SiO_2, toluene–EtOAc 10:1) gave **12** quantitatively, R_f 0.35 in toluene–EtOAc (10:1). $[\alpha]_D$ +7.2° (C = 1.79). NMR δ_H: 3.39 (3H, s, OMe), 4.78 (1H, d, J = 2 Hz, H-1), 5.33 (1H, dd, J_{23} = 3 Hz, J_{34} = 9 Hz, H-3). (Found: C, 72.76; H, 5.18. $C_{35}H_{34}O_8$ requires: C, 72.15; H, 5.88%).

Methyl 3,6 - *di* - O - benzoyl - α - D - *mannopyranoside* **13**

(A) The mixture of **12** (75 mg) and 10% Pd–C (30 mg) in EtOH (2 ml) was stirred under H_2 for 10 hr at 50°. Filtration of the catalyst and evaporation of EtOH gave an oil which was crystallized from EtOAc–iPr_2O to afford **13** (42 mg, 81.1%).

(B) The mixture of finely powdered **6** (0.485 g, 2.5 mmol) and $(Bu_3Sn)_2O$ (2.25 g, 3.75 mmol) in toluene (20 ml) was refluxed for 4 hr with continuous azeotropic removal of H_2O. To the cooled soln was added benzoyl chloride (1.05 g, 7.5 mmol) at 0° The mixture was stirred for 3 hr at room temp. and was concentrated *in vacuo*. The residual oil was chromatographed (SiO_2 100 g, toluene-EtOAc 3:1) to give **12** (907 mg, 90.2%), which was crystallized from EtOAc-iPr_2O, m.p. 134–136°, R_f 0.5 in toluene-EtOAc (1:1). $[\alpha]_D$ +58.1° (*c* = 0.42). NMR δ_H: 3.42 (3H, s, OMe), 4.79 (1H, d, J = 2 Hz, H-1), 5.38 (1H, dd, J_{23} = 3 Hz, J_{34} = 9 Hz, H-3). (Found: c, 62.54; H, 5.54. $C_{21}H_{22}O_8$ requires: C, 62.68; H, 5.51%).

Methyl 2 - O - *acetyl* - 3,4,6 - *tri* - O - *benzyl* - α *and* β - D - *mannopyranoside* **15** *and* **16**

The mixture of **14** (5.06 g, 100 mmol) and $HgBr_2$ (1.4 g) was stirred for 1 hr at 140° (bath) under Ar. After cooling to room temp. the mixture was directly chromatographed over SiO_2 (500 g). Elution with toluene–EtOAc (5:1) afforded **15** (3.37 g, 66.6%), R_f 0.54 in toluene–EtOAc (5:1). $[\alpha]_D$ +23.2° (*c* = 1.15). NMR δ_H: 2.12 (3H, s, OAc), 3.34 (3H, s, OMe), 4.72 (1H, d, J = 2 Hz, H-1), 5.35 (1H, t, J_{12} = J_{23} = 2 Hz, H-2). δ_C: 21.1 (OAc), 54.9 (OMe), 68.6 (C-2), 68.9 (C-6), 71.2 (C-5), 71.7 (C_3–OCH_2Ph), 73.4 (C_6–OCH_2Ph), 74.3 (C-4), 75.1 (C_4–OCH_2Ph), 78.2 (C-3), 98.8 ($^1J_{CH}$ = 170.6 Hz, C-1). (Found: C, 70.14; H, 6.52 $C_{30}H_{34}O_7$ requires: C, 71.13; H, 6.77%). Further elution with toluene–EtOAc (5:1) gave **16** (0.219 g, 4.2%). $[\alpha]_D$ −38.5° (*c* = 0.85). MNR δ_H 2.18 (3H, s, OAc), 3.50 (3H, s, OMe), 5.61 (1H, bd, H-2). δ_C: 21.1 (OAc), 57.1 (OMe), 67.9 (C-2), 69.2 (C-6), 71.5 (C_3–OCH_2Ph), 73.5 (C_6–OCH_2Ph), 74.3 (C-5), 75.1 (C_4–OCH_2Ph), 75.5 (C-4), 80.3 (C-3), 99.9 ($^1J_{CH}$ = 155.9 Hz, C-1). (Found: C, 70.00; H, 6.73. $C_{30}H_{34}O_7$ requires: C, 71.13; H, 6.77%).

Methyl 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranoside* **17**

Acetate **15** (3.37 g) in MeOH (70 ml) and 2N NaOMe-MeOH (1 ml) was stirred for 16 hr at room temp. The mixture was neutralized by Amberlist 15 (H^+). After filtration of the resin and evaporation of the solvent and chromatography over SiO_2 (150 g, toluene–EtOAc 5:1) afforded **17** (2.572 g, 89.8%), R_f 0.25 in toluene–EtOAc (3:1). $[\alpha]_D$ +57.7° (*c* = 0.485). NMR δ_H: 3.34 (3H, s, OMe). δ_C: 54.8 (OMe), 68.2 (C-2), 68.9 (C-6) ,70.9 (C-5), 71.9 (C_3–OCH_2Ph), 73.4 (C_6–OCH_2Ph), 74.2 (C-4), 75.0 (C_4–OCH_2Ph), 80.1 (C-3), 100.3 ($^1J_{CH}$ = 169.1 Hz, C-1). (Found: C, 72.70, H, 6.95. $C_{28}H_{32}O_6$ requires: C, 72.39; H, 6.94%).

2 - O - *Acetyl* - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl chloride* **18**

The soln of **14** (405 mg, 0.8 mmol) and chlorotrimethylsilane (0.17 ml, 1.3 mmol) in CH_2Cl_2 (4 ml) was refluxed for 1.5 hr under N_2. The mixture was evaporated *in vacuo* to give crude **18** (4.12 mg, quantitative) which was enough pure for the next step. Analytical sample was obtained by chromatography over SiO_2 ($CHCl_3$–acetone 10:1), R_f 0.73 in $CHCl_3$–acetone (10:1). $[\alpha]_D$ +63.0° (*c* = 0.165). NMR δ_H: 7.05 (1H, d, J = 2 Hz, H-1), 6.45 (1H, dd, J_{12} = 2 Hz, J_{23} = 3 Hz, H-2), 2.13 (3H, s, OAc). δ_C: 21.0 (OAc), 67.9 (C-6), 70.9 (C-5), 72.1 (C_3–OCH_2Ph), 73.4 (C_6–OCH_2Ph and C-2), 74.2 (C-4), 75.3 (C_4–OCH_2Ph), 76.6 (C-3), 90.3 ($^1J_{CH}$ = 183.8, C-1). (Found: C, 68.12; H, 6.14. $C_{29}H_{31}ClO_6$ requires: C, 68.16; H, 6.12%).

Methyl 3,4,6 - *tri* - O - *benzyl* - 2 - O - (3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*) - α - D - *mannopyranoside* **20**

To the mixture of **17** (232 mg, 0.5 mmol), $AgSO_3CF_3$ (206 mg, 0.80 mmol), and $Me_2NCONMe_2$ (0.2 ml, 1.6 mmol) in CH_2Cl_2 (0.5 ml) was added 0.4 ml of the soln of **18** [prepared from **14** (380 mg, 0.75 mmol) in CH_2Cl_2 (0.7 ml)] during 2 min at −5° under N_2. After stirring for 2 hr at room temp., the remaining soln (0.3 ml) of **18** was added to the mixture and the stirring was continued overnight. Filtration through celite bed and evaporation of the filtrate gave a residual oil which was chromatographed over SiO_2 (80 g, toluene–EtOAc 10:1) to give **19** (385 mg, 82%), R_f 0.64 in toluene–EtOAc (4:1). NMR δ_H: 2.08 (3H, s, OAc), 3.23 (OMe), 5.08 (1H, d, J = 1.5 Hz, H-1b), 5.55 (1H, bs, H-2b). To a soln of **19** (289 mg, 0.31 mmol) in MeOH–THF (5:1, 6 ml) was added 0.1 N NaOMe in MeOH (0.5 ml). The mixture was stirred for 16 hr at room temp., diluted with MeOH, and was neutralized by Amberlist 15 (H^+). After filtration of the resin and concentration of the filtrate, the residual oil was chromatographed over SiO_2 (30 g, toluene–EtOAc 3:1) to give **20** (240 mg, 87%), R_f 0.4 in toluene–EtOAc (4:1). $[\alpha]_D$ +31.3° (*c* = 0.52). (Found: C, 73.58; H, 6.75. $C_{55}H_{60}O_{11}$ requires: C, 73.64; H, 6.74%).

Methyl 2 - *O* - (α - D - *mannopyranosyl*) - α - D - *mannopyranoside* **21**

A mixture of **20** (185 mg, 0.21 mmol) and 10% Pd-C (100 mg) in EtOH (5 ml) was stirred under H_2 for 16 hr at 25°. Catalyst was filtered off through celite bed and the filtrate was concentrated *in vacuo* to give an amorphous solid (85 mg), R_f 0.49 in $CHCl_3$–MeOH–conc. NH_4OH (1:3:1). $[\alpha]_D$ +72.0° (*c* = 0.49, MeOH). NMR δ_H (D_2O): 3.36 (3H, s, OMe), 4.94 (1H, s, H-1a), 4.97 (1H, d, J = 2Hz, H-1b). δ_C (D_2O): 79.3 (C-2a), 100.1 ($^1J_{CH}$ = 171.9 Hz, C-1a), 103.0 ($^1J_{CH}$ = 170.4 Hz, C-1b). (Found: C, 40.48; H, 6.81. $C_{13}H_{24}O_{11}$ 3/2H_2O requires: C, 40.72; H, 7.10%).

Methyl 2 - O - (2 - *acetamido* - 2 - *deoxy* - β - D - *glucopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranoside* **24**

To the mixture of **17** (116 mg, 0.25 mmol), $AgSO_3CF_3$ (103 mg, 0.40 mmol) and 2,4,6-collidine (48 mg, 0.40 mmol) in CH_3NO_2 (0.5 ml) was added a soln of **22** (170 mg, 0.38 mmol) in CH_3NO_2 (1 ml) during 5 min at −5° and the mixture was stirred for 1.5 hr at 20°. The mixture was filtered through celite bed and the filtrate was evaporated to the residual foam which was chromatographed over SiO_2 (30 g, toluene–EtOAc 4:1) to give **23** (213 mg, 90.6%). NMR δ_H: 1.87 (3H, s, OAc), 2.04 (6H, s, OAc), 3.20 (3H, s, OMe), 5.20 (1H, t, J = 9.5 Hz, H-4b), 5.54 (1H, d, J = 8.5 Hz, H-1b), 5.83 (1H, t, J = 9.5 Hz, H-3b). A soln of **23** (315 mg, 0.36 mmol) in EtOH (5 ml) and 80% $NH_2NH_2 \cdot H_2O$ (1 ml) was stirred under reflux for 3 hr (Ar) and was evaporated *in vacuo* to give the residual oil which was dissolved in MeOH (10 ml)–Ac_2O (1 ml). After standing for 1.5 hr at 20°, the mixture was concentrated *in vacuo* (bath temp 30°) to give the residual oil which was chromatographed over SiO_2 (30 g, $CHCl_3$–MeOH 20:1) to afford **24** (92 mg, 38.7%), R_f 0.60 in $CHCl_3$–MeOH (5:1). $[\alpha]_D$ −5.7° (*c* = 0.30). NMR δ_H: 1.97 (3H, s, NAc), 3.25 (3H, s, OMe). (Found: C, 64.42; H, 6.84; N, 2.41. $C_{36}H_{45}O_{11}N$ requires: C, 64.75; H, 6.79; N, 2.10%).

Methyl 2 - O - (2 - *acetamido* - 2 - *deoxy* - β - D - *glucopyranosyl*) - α - D - *mannopyranoside* **25**

A mixture of **24** (80 mg, 0.12 mmol) and 10% Pd–C (40 mg) in EtOH–THF (2:1, 3 ml) was stirred under H_2 for 1 hr at 50°, when H_2O (1 ml) was added to the mixture. Further stirring under H_2 for 1 hr at 50°, filtration (celite), and evaporation of the filtrate gave an amorphous residue **25** (53 mg), R_f 0.56 in $CHCl_3$–MeOH–conc. NH_4OH (1:3:1). $[\alpha]_D$ −3.27° (*c* = 0.49, MeOH). NMR δ_H (D_2O): 2.02 (3H, s, NAc), 3.39 (3H, s, OMe), 4.47 (1H, d, J = 8 Hz, H-1b), 4.67 (1H, d, J = 2 Hz, H-1a). δ_C (D_2O): 77.0 (C-2b), 98.7 ($^1J_{CH}$ = 169.6 Hz, C-1a), 100.3 ($^1J_{CH}$ = 160.0 Hz, C-1b). (Found: C, 43.67; H, 6.92; N, 3.39. $C_{15}H_{24}O_{11} \cdot H_2O$ requires: C, 43.37; H, 7.03; N, 3.37%).

3,6-*Bisorthoester* **28**

Methyl α-D-mannopyranoside (1.94 g, 10 mmol) was stannylated with $(Bu_3Sn)_2O$ (8.93 g, 15 mmol) as described. Toluene soln of **7** was evaporated *in vacuo* and the residue was dissolved in CH_2ClCH_2Cl (50 ml). To this soln was added **18** [prepared from **14** (15.2 g, 30 mmol)] and the mixture was stirred for 16 hr at 85° under N_2. Concentration of the soln *in vacuo* and chromatography of the residue over SiO_2 (400 g, $CHCl_3$–CH_3COCH_3–Et_3N 90:10:1) gave **28** (3.9 g, 34%), R_f 0.48 in $CHCl_3$–CH_3COCH_3 (4:1). $[\alpha]_D$ +40.0° (*c* = 0.52). NMR δ_H: 1.76 (3H, s, C-Me), 1.83 (3H, s, C-Me), 3.40 (3H, s, OMe), 5.35 (1H, d, J = 2 Hz, H-1b or H-1c), 5.40 (1H, d, J = 1.5 Hz, H-1c or H-1b). δ_C: 97.3 ($^1J_{CH}$ = 173.3 Hz, C-1b and C-1c), 100.1 ($^1J_{CH}$ = 169.7 Hz, C-1a). (Found: C, 68.05; H, 6.56. $C_{65}H_{74}O_{18}$ requires: C, 68.28; H, 6.52%). Further elution by the same solvent afforded 4,6-bisorthoester (0.25 g, 2.2%): R_f 0.33 in $CHCl_3$–CH_3COCH_3 (4:1). $[\alpha]_D$ +38.5° (*c* = 0.46). NMR δ_H: 1.73 (3H, s, CMe), 1.82 (3H, s, CMe), 3.35 (3H, s, OMe), 5.29 (1H, d, J = 2.2 Hz, orthoester anomeric H), 5.40 (1H, d, J = 2 Hz, orthoester anomeric H). (Found: C, 68.73; H, 6.60. $C_{65}H_{74}O_{18}$ requires: C, 68.28; H, 6.52%).

Perbenzylated 3,6-*bisorthoester* **29**

To a soln of **28** (3.7 g, 3.2 mmol) in DMF (50 ml) was added NaH (60%, 700 mg, 17.5 mmol) with ice-cooling. After stirring for 1 hr at 20°, benzyl bromide (1.8 ml) was added and the mixture was stirred for 3 hr at 20°. After the addition of MeOH (2 ml), DMF was evaporated *in vacuo*. The residue was partitioned between EtOAc and H_2O. EtOAc layer was washed with H_2O, dried ($MgSO_4$), and concentrated *in vacuo* to afford an oily product which was chromatographed over SiO_2 (200 g, toluene–EtOAc–Et_3N 50:10:0.6) to give **29** (3.31 g, 77.3%), R_f 0.86 in toluene–EtOAc (2:1). $[\alpha]_D$ +45.5° (*c* = 0.44). NMR δ_H: 1.74 (3H, s, CMe), 1.86 (3H, s, CMe), 3.31 (3H, s, OMe), 5.17 (1H, d, J = 2.2 Hz, H-1b or H-1c), 5.38 (1H, J = 2 Hz, H-1c or H-1b). (Found: C, 71.73; H, 6.58. $C_{79}H_{86}O_{18}$ requires: C, 71.69; H, 6.55%).

Methyl 3,6 - *di* - O - (2 - O - *acetyl* - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*) - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **30**

(A) **29** (2.9 g, 2.19 mmol) and $HgBr_2$ (500 mg, 1.39 mmol) was stirred for 2 hr at 120° (bath) under N_2 without solvent. After cooling to room temp, the product was chromatographed over SiO_2 (200 g, toluene–EtOAc 4:1) to give **30** (793 mg, 27.3%).

(B) To a mixture of **11** (374 mg, 1 mmol), $AgSO_3CF_3$ (771 mg, 3 mmol), $Me_2NCONMe_2$ (0.72 ml, 6 mmol) in CH_2Cl_2 (2 ml) was added a soln of **18** (from **14**, 1.52 g, 3 mmol) in CH_2Cl_2 (8 ml) during 5 min at −5° under N_2. The mixture was stirred for 2 days at 20° and was filtered (celite). The filtrate was concentrated to a syrup which was chromatographed over SiO_2 (100 g, toluene–

EtOAc 4:1) to give **30** (1.03 g, 78.6%), R_F 0.36 in toluene–EtOAc (4:1). $[\alpha]_D$ +41.7° (*c* = 0.59). NMR δ_H: 2.06 (3H, s, Ac), 2.13 (3H, s, Ac), 5.17 (1H, bd, J = 2 Hz, anomeric H), 5.42–5.53 (2H, bs, H-2b and H-2c). (Found: C, 71.65; H, 6.59. $C_{79}H_{86}O_{18}$ requires: C, 71.69; H, 6.55%).

(C) To a mixture of **11** (150 mg, 0.40 mmol), $AgSO_3CF_3$ (230 mg, 0.895 mmol) and collidine (0.14 ml, 1.07 mmol) in CH_2ClCH_2Cl (2 ml) was added a solun of **18** (prepared from **14**, 450 mg, 0.89 mmol) in CH_2ClCH_2Cl (2 ml) during 5 min at −20–−30° under N_2. The mixture was stirred under N_2 for 1 hr at −20° and 4 hr at 20°, and was filtered (celite). The filtrate was concentrated to an oily product which was chromatographed over SiO_2 (60 g, toluene–EtOAc 3:1) to give 6-O-*mono-orthoester derivative* **31** (186 mg, 54.8%), R_f 0.3 in toluene–EtOAc (4:1). $[\alpha]_D$ +27.5° (*c* = 0.51). NMR δ_H: 1.76 (3H, s, CMe), 3.32 (3H, s, OMe), 4.37 (1H, q, J = 3 and 4 Hz, H-2b), 5.24 (1H, d, J = 3 Hz, H-1b). (Found: C, 70.33; H, 6.49. $C_{50}H_{56}O_{12}$ requires: C, 70.73; H, 6.65%).

Methyl 2,4 - *di* - O - *benzyl* - 3,6 - *di* - O - (3,4,6 - tri - O - *benzyl* - α - D - *mannopyranosyl*) - α - D - *mannopyranoside* **32**

To a soln of **30** (1.67 g, 1.26 mmol) in MeOH–THF (2:1, 30 ml) was added 0.1N NaOMe–MeOH (5 ml). The mixture was stirred for 16 hr at 20° and was neutralized by Amberlist 15 (H^+). Usual work-up and chromatography over SiO_2 (100 g, toluene–EtOAc 2:1) afforded **32** (1.31 g, 83.8%), R_f 0.37 in toluene–EtOAc (2:1). $[\alpha]_D$ +53.8° (*c* = 0.47). NMR δ_H: 3.22 (3H, s, OMe), 5.17 (1H, bd, J = 1 Hz, anomeric H), 5.21 (1H, bs, anomeric H). δ_C: 98.1 ($^1J_{CH}$ = 170.8 Hz), 99.6 ($^1J_{CH}$ = 170.1 Hz), 101.4 ($^1J_{CH}$ = 172.8 Hz), for three anomeric carbons.

Methyl 3,6 - *di* - O - (α - D - *mannopyranosyl*) - α - D - *mannopyranoside* **33**

A mixture of **32** (63 mg, 0.05 mmol) and 10% Pd-C (40 mg) in EtOH (2 ml) was stirred under H_2 for 7 hr at 50°. After cooling to room temp, the mixture was filtered (celite) and the filtrate was evaporated *in vacuo* to give amorphous **33**, R_f 0.2 in $CHCl_3$–MeOH–conc NH_4OH (1:3:1). $[\alpha]_D$ +96.7° (*c* = 0.45, MeOH). NMR δ_H (CD_3OD): 3.36 (3H, s, OMe), 4.60 (1H, d, J = 1.5 Hz, H-1a), 4.83 (1H, d, J = 1.5 Hz, H-1b), 5.06 (1H, d, J = 1.5 Hz, H-1c). δ_H (D_2O, at 60°): 3.40 (3H, s, OMe), 4.73 (1H, s, H-1a), 4.91 (1H, s, H-1b), 5.11 (1H, s, H-1c). δ_C (D_2O): 79.4 (C-3a), 100.1 ($^1J_{CH}$ = 170.9, C-1b), 101.8 ($^1J_{CH}$ = 171.9 Hz, C-1a), 103.2 ($^1J_{CH}$ = 169.9 Hz, C-1c). (Found: C, 43.91; H, 6.77. $C_{19}H_{34}O_{16}$ requires: C, 44.01; H, 6.61%).

Methyl 3,6 - *di* - O - [2 - O - (2 - O - *acetyl* - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*] - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **34**

To a mixture of **32** (1.86 g, 1.50 mmol), $AgSO_3CF_3$ (1.2 g, 4.67 mmol) and $Me_2NCONMe_2$ (1.2 ml, 10 mmol) in CH_2Cl_2 (3 ml) was added a soln (3 ml) of **18** (prepared from **14**, 2.28 g, 4.51 mmol and dissolved in CH_2Cl_2 4.5 ml) during 5 min at −5° under N_2. After 2 hr of stirring at 20°, remaining soln of **18** in CH_2Cl_2 (1.5 ml) was added to the mixture which was further stirred for 16 hr at 20° under N_2. Usual work-up and chromatography over SiO_2 (400 g, toluene–THF 20:1) gave **34** (2.59 g, 78.8%), R_f 0.67 in toluene–EtOAc (4:1). $[\alpha]_D$ +34.7° (*c* = 0.51). NMR δ_H: 2.12 (6H, s, OAc × 2), 3.18 (3H, S, OMe). (Found: C, 73.05; H, 6.56. $C_{113}H_{142}O_{28}$ requires: C, 72.99; H, 6.54%).

Methyl 3,6 - *di* - O - [2 - O - (3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*] - 2,4, - *di* - O - *benzyl* - α - D - *mannopyranoside* **35**

A soln of **34** (1.93 g, 0.88 mmol) in MeOH–THF (4:1, 50 ml) and 0.1 N NaOMe-MeOH (2.5 ml) was stirred for 16 hr at 20° Further 0.1N NaOMe-MeOH (1 ml) was added and the mixture was stirred for 2 hr at 20°. After dilution of the mixture with MeOH (20 ml), it was neutralized by Amberlist 15 (H^+). Further processing and chromatography over SiO_2 (150 g, toluene–THF 7:1) afforded **35** (1.45 g, 78.1%), R_f 0.26 in toluene–EtOAc (4:1). $[\alpha]_D$ +45.9° (*c* = 0.70). NMR δ_H: 3.16 (3H, s, OMe). (Found: C, 74.00; H, 6.67. $C_{129}H_{138}O_{26}$ requires: C, 73.62; H, 6.61%).

Methyl 3,6 - *di* - O - [2 - O - (α - D - *mannopyranosyl*) - α - D - *mannopyranosyl*] - α - *mannopyranoside* **4**.

A mixture of **35** (182 mg) and 10% Pd-C (100 mg) in EtOH–THF (3:1, 4 ml) was stirred under H_2 for 9 hr at 50° with occasional additions of EtOH (2 ml, after 3 hr) and H_2O (1 ml, after 6 hr). Catalyst was filtered off (celite) and the filtrate was evaporated *in vacuo* to give an amorphous **4** (71 mg), R_f 0.18 in MeOH–conc. NH_4OH (3:1). $[\alpha]_D$ +89.5° (*c* = 0.51, MeOH). NMR δ_H (D_2O, at 60°): 3.39 (3H, s, OMe), 4.70 (1H, s, H-1a), 5.01 (2H, s, H-1d and H-1e), 5.13 (1H, s, H-1b), 5.32 (1H, s, H-1c). δ_C (D_2O, at 60°): 79.4 (C-3a, C-2b and C-2c), 98.7 ($^1J_{CH}$ = 172 Hz, C-1b), 101.6 ($^1J_{CH}$ = 174 Hz, C-1c), 101.7 ($^1J_{CH}$ = 174 Hz, C-1a), 103.0 ($^1J_{CH}$ = 172 Hz, C-1d and C-1e). (Found: C, 43.22; H, 7.07. $C_{31}H_{54}O_{26}$ requires: C, 44.18; H, 6.46%).

Methyl 3,6 - *di* - O - [2 - O - [3,4,6 - *tri* - O - acetyl - 2 - deoxy - 2 - *phthalimido* - β - D - *glucopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*] - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **36**

To a mixture of **32** (1.86 g, 1.50 mmol), $AgSO_3CF_3$ (1.2 g, 4.67 mmol) and 2,4,6-collidine (0.65 ml, 4.9 mmol) in CH_3NO_2 (6 ml) was added 2/3 of the soln of **22** (2.04 g, 4.50 mmol) in CH_3NO_2 (4.5 ml) during 5 min at −5° (bath) under N_2. After stirring for 2 hr at −5°, remaining 1.5 ml of the soln of **22** in CH_3NO_2 was added to the mixture at −5°, which was stirred for further 16 hr at 20°. Filtration of the mixture (celite) and evaporation of the filtrate *in vacuo* gave a foam which was chromatographed over SiO_2 (400 g, toluene-THF 5:1) yielded **36** (1.36 g, 43.7%), R_f 0.4 in toluene–EtOAc (2:1). $[\alpha]_D$ +12.0° (*c* = 0.59). NMR δ_H: 1.83 (3H, s, Ac), 1.84 (3H, s, Ac), 1.94 (3H, s, Ac), 1.99 (3H, s, Ac), 2.02 (6H, s, Ac × 2), 3.25 (3H, s, OMe). (Found: C, 67.61; H, 5.94; N, 1.30. $C_{115}H_{120}O_{34}N_2 \cdot C_6H_5CH_3$ requires: C, 67.63; H, 5.96; N, 1.29%). Further elution with the same solvent gave *methyl* 6(3) - O - [2 - O - (3,4,6 - *tri* - O - *acetyl* - 2 - *deoxy* - 2 - *phthalimido* - β - D - *glucopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*] - 3(6) - O - (3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*) - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* (0.66 g, 26.5%), R_f 0.3 in toluene–EtOAc (2:1). $[\alpha]_D$ +25.1° (*c* = 0.76). NMR δ_H: 1.85 (3H, s, Ac), 1.99 (3H, s, Ac), 2.02 (3H, s, Ac), 3.26 (3H, s, OMe). (Found: C, 68.52; H, 6.25; N, 1.19. $C_{95}H_{101}O_{25}N$ requires: C, 68.87; H, 6.15; N, 0.85%).

Methyl 3,6 - *di* - O - [2 - O - (2 - *acetamido* - 2 - *deoxy* - β - D - *glucopyranosyl*) - 3,4,6 - *tri* - O - *benzyl* - α - D - *mannopyranosyl*] - 2,4 - *di* - O - *benzyl* - α - D - *mannopyranoside* **37**

A soln of **36** (542 mg, 0.26 mmol) in EtOH (10 ml) and 80% $NH_2NH_2 \cdot H_2O$ (2 ml) was stirred under reflux for 1.5 hr (Ar). After evaporation of EtOH and 80% $NH_2NH_2 \cdot H_2O$ *in vacuo*, the residue was redissolved in EtOH (5 ml) and was filtered. The filtrate was concentrated *in vacuo* to give the residual oil which was dissolved in MeOH (10 ml). To this soln was added Ac_2O (1 ml) at −5°–0°. The mixture was stirred for 1 hr at 0° and evaporated *in vacuo* below 30° (bath). The residue was dissolved in $CHCl_3$ and $CHCl_3$ layer was washed with H_2O, dried ($MgSO_4$) and evaporated to give an oily product, which was chromatographed over SiO_2 (30 g, $CHCl_3$–MeOH 10:1) to afford **37** (197 mg, 45.8%), R_f 0.43 in $CHCl_3$–MeOH (4:1). $[\alpha]_D$ +21.3° (*c* = 0.47). (Found: C, 65.63; H, 6.53; N, 1.65. $C_{91}H_{108}O_{26}N_2 \cdot H_2O$ requires: C, 65.69; H, 6.66; N, 1.68%).

Methyl 3,6 - *di* - O - [2 - O - (2 - *acetamido* - 2 - *deoxy* - β - D - *glucopyranosyl*) - α - D - *mannopyranosyl*] - α - D - *mannopyranoside* **5**

A mixture of **37** (190 mg, 0.12 mmol) and 10% Pd–C (100 mg) in EtOH (5 ml) was stirred under H_2 for 1 hr at 50°, when H_2O (2 ml) was added to the mixture. And the mixture was further stirred under H_2 for 2 hr at 50°. Usual work-up and evaporation of the solvent afforded **5** as an amorphous solid (113 mg), R_f 0.27 in MeOH–conc.NH_4OH (4:1). $[\alpha]_D$ +44.2° (*c* = 0.51, MeOH). NMR δ_H (D_2O, at 60°): 2.04 (6H, s, NAc), 3.39 (3H, s, OMe), 4.50 (2H, d, J = 8Hz, H-1d and H-1e), 4.71 (1H, s, H-1a), 4.89 (1H, s, H-1b), 5.09 (1H, s, H-1c). δ_C (D_2O, at 60°): 77.2 (C-2b), 77.4 (C-2c), 79.4 (C-3a), 97.5 ($^1J_{CH}$ = 169.9 Hz, C-1b), 100.4 ($^1J_{CH}$ = 160.0 Hz, C-1d and C-1e), 100.4 ($^1J_{CH}$ = 168.0 Hz, C-1c), 101.8 ($^1J_{CH}$ =

172.9 Hz, C-1a). (Found: C, 42.88; H, 6.28; N, 2.97. $C_{35}H_{60}O_{26}N_2 \cdot 2.5\,H_2O$ requires: C, 43.34, H, 6.75; N, 2.89%).

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