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# CYANOSUGARS III[1]. THE REACTION OF TRIMETHYLSILYL CYANIDE WITH KETO, EPOXY AND ACETAL DERIVATIVES OF CARBOHYDRATES.

Federico G. De las Heras, Ana San Félix, Ana Calvo-Mateo and Piedad Fernández-Resa

Instituto de Química Médica, Juan de la Cierva 3, 28006-Madrid, Spain.

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Abstract - Reaction of methyl 2-acetamido-4,6-O-benzylidene-2-deoxy-α-D-*ribo*-hexopyranosid-3-ulose with $Me_3SiCN$ afforded methyl 2-acetamido-4,6-O-benzylidene-3-C-cyano-2-deoxy-3-O-trimethylsilyl-α-D-*allo*-hexopyranoside. Reaction of ethyl 4,6-di-O-acetyl-2,3-anhydro-α-D-mannopyranoside with $Me_3SiCN$ gave the corresponding ethyl 4,6-di-O-acetyl-2-C-cyano-2-deoxy-α-D-glucopyranoside. Reaction of methyl 4,6-O-benzylidene-2,3-anhydro-α-D-allopyranoside or methyl 4,6-O-benzylidene-2,3-di-O-tosyl-α-D-glucopyranoside with $Me_3SiCN$ at - 75° or - 50° gave the corresponding methyl 6-O-[(R)-cyano phenyl methyl]-α-D-glycopyranosides with high or total regio and stereoselectivity.

The cyano branched carbohydrates are useful intermediates for the synthesis of biologically important, naturally occurring branched chain sugars[3] such as D-vancosamine[4,5], L-evernitrose[4,6], D-kijanose[7], L-rubranitrose[8] and 3-amino-2,3,6-trideoxy-3-C-methyl-L-*xylo*-hexopyranose, a component of antibiotic A35512B[9], as well as for the synthesis of chiral synthons useful for the preparation of other biologically important non carbohydrate derivatives[10,11].

The main methods for the introduction of the cyano branch in sugars are the reaction of alkaline cyanide or hydrogen cyanide with keto sugars[4,5,6,12], which affords cyanohydrin derivatives; the reaction of buffered aqueous sodium cyanide[13], hydrogen cyanide-triethylaluminium[14] and diethylaluminium cyanide[11,15] with oxirane sugars to give *trans*-diaxial C-cyano hydroxy derivatives. In some cases, these reactions afforded complex mixtures[14] or byproducts lacking the CN branch[15]. Other important methods are the addition of hydrogen cyanide to nitroolefine[16,17] and cyanoolefine[18] sugars to give vicinal C-cyano-nitro and di-C-cyano carbohydrate derivatives, respectively; the $S_N2$ reaction of tetrabutyl ammonium cyanide with a sugar triflate[10]; the reaction of chlorosulfonyl isocyanate with glycals, which affords 2-C-cyano-2-deoxy-hex-1-enitol derivatives[19], and the transformation of deoxy-C-nitromethyl furanosides to the corresponding C-cyano branched chain sugars[20,21]. C-Cyano-gem-di-C-substituted carbohydrates have also been obtained by nucleophylic Michael-type additions of cyanide ion to 3-C-methylene derivatives[21].

Trimethylsilyl cyanide reacts readily with compounds having a variety of electrophilic carbon atoms[22,24]. In these reactions, the cyano group, acting as an anion stabilized by the adjacent Si atom, reacts with the electrophilic centers to give nitrile or isonitrile derivatives depending on the Lewis acid used as catalyst[25,26].

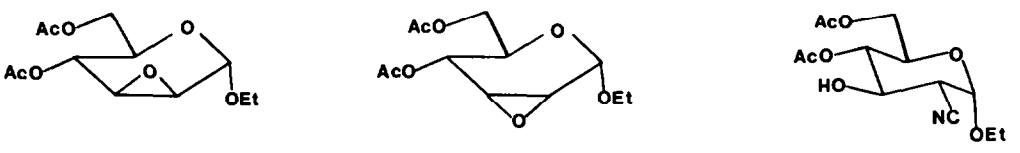
Following our studies on the application of $Me_3SiCN$ for the synthesis of cyanosugars[2,27] we report here the reactions of $Me_3SiCN$ with a variety of carbohydrate derivatives having ketone, oxirane, p-toluensulfonyl and benzylidene groups, which afford C-cyano branched chain sugars, by attack of $Me_3SiCN$ to ketone and oxirane electrophilic carbon atoms of the carbohydrate backbone, or mandelonitrile ethers, by opening of the 1,3-dioxane benzylidene ring with total or high regio and stereoselectivity.

## RESULTS AND DISCUSSION

Reaction of 4,6-O-benzylidene-hexopyranosid-3-ulose 1, with $Me_3SiCN$ in N,N-dimethylformamide in the presence of boron trifluoride etherate afforded the cyanohydrin trimethylsilyl ether 2 in 86% yield. The IR spectrum of 2 showed the absence of hydroxyl, ketone and isonitrile bands and, like many cyanosugars, the absence of a CN band[2,27]. The $^1H$ NMR spectrum showed bands characteristic of the benzylidene group. Owing to the steric hindrance of the axially oriented 1-OMe group, the attack of the cyano to the keto group of 1 should come from the less hindered upper side of the molecule to give the 3-C-cyano-allo-hexopyranoside 2. This hypothesis was confirmed by the small values of the coupling constants $J_{CN,H-2} \simeq J_{CN,H-4} = 1.5$ Hz measured on the CN band of the $^{13}C$ NMR spectrum of 2, which indicated the gauche relationship of the CN group with respect to H-2 and H-4 and, thus, its equatorial disposition[28,29].


1 2

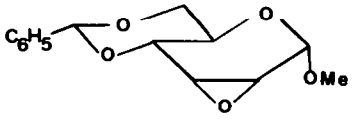
Reaction of the α-D-manno-oxirane 3 with $Me_3SiCN$ in nitromethane and in the presence of boron trifluoride etherate afforded the 2-C-cyano-glucopyranoside 5 in nearly quantitative yield. The gluco-trans-2,3-diequatorial stereochemistry of 5, contrary to the Fürst-Plattner rule[30] was confirmed by $^1H$ NMR. The signal of H-2, which appeared at δ 3.80, with values of $J_{1,2} = 5.4$ and $J_{2,3} = 7.6$ Hz, and the signal of H-3, which appeared at δ 4.37 with values of $J_{2,3} = J_{3,4} = 7.6$ Hz, indicated that the cyano group was attached to C-2 and that H-2 and H-3 had a trans-diaxial relationship. The regioselective attack of the cyano group to C-2, may be due to neighboring group participation of the 4-OAc group. Related participation of neighboring acyl groups in the opening of epoxides have been reported[31]. Reaction of α-D-allo-oxirane 4 with $Me_3SiCN$ in a variety of polar aprotic solvents (acetonitrile, nitromethane N,N-dimethylformamide) and in the presence of different Lewis acids as catalysts ($BF_3$, $SnCl_4$, $AlCl_3$) afforded complex mixtures. Ethyl α-D-manno and α-D-allo-2,3-anhydro-hexopyranoses 3 and 4 were obtained by reaction of ethyl 4,6-di-O-acetyl-α-D-erythro-hex-2-enopyranoside with hydrogen peroxide and benzonitrile, followed by reacetylation of the partially deprotected epoxides with acetic anhydride and pyridine. Structures of the ethyl 2,3-anhydro-hexopyranosides 3 and 4 were determined as reported for the known methyl 4,6-di-O-acetyl-2,3-anhydro-α-D-manno- and -allo-hexopyranosides[32].




3 4 5

Reaction of α-D-allo-oxirane 6 with $Me_3SiCN$ at room temperature and using boron trifluoride etherate as catalyst gave 72% yield of a (2:1) mixture of the 6-O- and 4-O-(cyanophenylmethyl) regioisomers 7a and 9a formed by opening of the 1,3-dioxane benzylidene ring[33,34].

The regioselectivity of this reaction greatly increased at lower temperature. Thus, when the reaction was carried out at -45° it afforded 81% yield of a (15:2) mixture of 7a and 9a, and when the reaction temperature was -75°, an 83% yield of a (15:1) mixture of 7a and 9a, respectively, was obtained. The use of an excess of $Me_3SiCN$ did not afford the opening of the oxirane ring. The structures of 7a and 9a were determined by $^1H$ NMR, which showed at δ 3.49 - 3.56 ppm the bands of the oxirane H-2 and H-3 protons. Assignation of structures to the regioisomers 7a and 9a was carried out by acetylation with acetic anhydride in pyridine, which afforded the 4-O-acetyl and the 6-O-acetyl derivatives 8 and 10, respectively. In the $^1H$ NMR spectra, the H-4 proton of 8 and the two H-6 protons of 10 showed downfield chemical shifts of > 1 ppm and about 0.5 ppm, respectively, with respect to the same protons of 7a and 9a, which indicated at which positions the free OH groups were attached.



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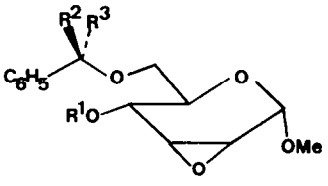
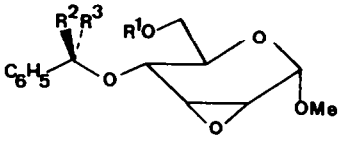
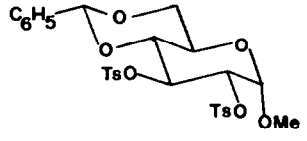


**7a**, $R^1$= H, $R^2$= H, $R^3$= CN
**7b**, $R^1$= H, $R^2$= CN, $R^3$= H
**8a**, $R^1$= Ac, $R^2$= H, $R^3$= CN
**8b**, $R^1$= Ac, $R^2$= CN, $R^3$= H



**9a**, $R^1$= H, $R^2$= CN, $R^3$= H
**9b**, $R^1$= H, $R^2$= H, $R^3$= CN
**10a**, $R^1$= Ac, $R^2$= CN, $R^3$= H
**10b**, $R^1$= Ac, $R^2$= H, $R^3$= CN



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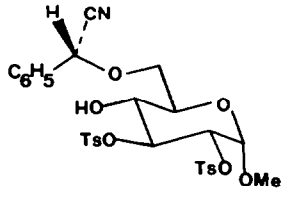

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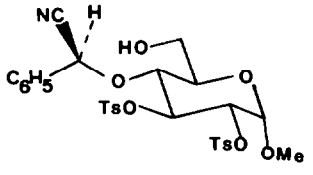

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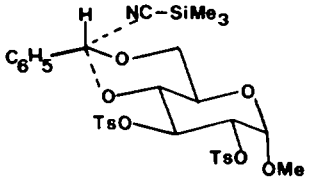

14

The basic conditions of acetylation of 7a and 9a and the acidity of the proton on the asymmetric carbon of the mandelonitrile residue produced the racemization of this carbon atom wich resulted in the formation of two diastereoisomeric 4-O-acetyl- (8a and 8b) and two 6-O-acetyl-2,3-anhydro-allopyranosides (10a and 10b). The $^1H$ NMR spectra of 8 and 10 showed two very close sets of signals of equal intensity, having very similar chemical shifts and almost identical coupling

constants, which indicated that no epimerisation (anomerisation) had taken place on the 2,3-anhydro-α-D-allopyranose skeleton. Thus, the isomerisation could only occur on the mandelonitrile ether residue. Treatment of 7a under similar basic conditions to those used for the acetylation, except that no acetic anhydride was added, also afforded a mixture of diastereoisomers 7a + 7b, the $^1$H NMR spectrum of which gave two closely related sets of signals in the $^1$H NMR spectrum and an optical rotation different from that of 7a. This demonstrated that 7a was a diastereoisomerically pure compound obtained by asymmetric addition of CNH to the chiral carbohydrate derivative.

Similarly, methyl 4,6-O-benzylidene-2,3-di-O-tosyl-α-D-glucopyranoside 11 reacted with $Me_3SiCN$ at -50°C to give 6-O-(cyanophenylmethyl)2,3-di-O-tosyl-α-D-glucopyranoside, 12, in 80% yield as the only product. As in case of 6, the use of higher reaction temperatures diminished the regioselectivity. Thus, the reaction of 11 with $Me_3SiCN$ at room temperature afforded a (2:1) mixture of 12 and its 4-O-(cyanophenylmethyl) regioisomer 13, by attack of the cyano group to the acetal moiety and not to C-2 and/or C-3 carbon atoms substituted with a good leaving group such as tosylate.

The absolute configuration of the newly developped chiral centers of 7a, 9a, 12 and 13, taking advantage of the asymmetry of the readily accesible benzylideneglycopyranoses as chiral templates was templatively assigned based on the suggested $S_N2$-like mechanism for this type of reaction[34]. The approach from the less hindered back side of the molecule, wich leads to the cleavage of the 4-O—$CHC_6H_5$ bond, as shown in 14 affords the mayor products 7a and 12 with a R absolute configuration in the mandelonitrile chiral carbon. The attack from the more hindered front side of the molecule affords the minor compounds 9a and 13 with a S absolute configuration for the same carbon atom. The fact that the regioselectivity obtained with 11, having a bulky substituent at C-3 is higher than that obtained with 6, is in support of this hipothesis.

In conclusion, $Me_3SiCN$ is a good reagent for the formation of glycosyl cyanides and branched chain cyanosugars, provided that reactive protecting groups, such as benzylidene acetals, are not present in the molecule. On the other hand, since $Me_3SiCN$, trimethylsilylazide[35], and eventually other trimethylsilyl anions, also react with acetals and ketone acetals, the use of the easily accesible benzylideneglycopyranosides, particularly those with bulky substituents at C-3, is a good approach for the enantioselective preparation of substituted phenylcarbinol derivatives.

## EXPERIMENTAL

M.ps were measured with a Kofler hot-stage apparatus. $^1$H NMR spectra were recorded with a Varian EM-390 or a Varian XL-300 spectrometer operating at 90 or 300 MHz, respectively, with $Me_4Si$ as internal standard. $^{13}$C NMR spectra were obtained with a Varian XL-300 spectrometer, with $Me_4Si$ as internal standard. IR spectra were recorded with a Perkin-Elmer 257 spectrophotometer. Optical rotations were determined with a perkin-Elmer 141 polarimeter. Analytical TLC was performed on aluminium sheets coated with a 0.2 mm layer of silica gel 60 $F_{254}$ (Merck), and preparative layer chromatography was performed on 20 x 20 cm glass plates coated with a 2 mm layer of silica gel $PF_{254}$ (Merck).

Methyl 2-acetamido-4,6-O-benzylidene-3-C-cyano-2-deoxy-3-O-trimethylsilyl-α-D-allo-hexopyranoside (2). To a solution of 1(0.321g, 1mmol) in DMF(5 mL), $Me_3SiCN$(0.19mL, 1.5mmol) and $BF_3$ (2 drops) were added. The mixture was stirred at room temperature for 15 minutes. The reaction mixture was concentrated under reduced pressure, and the residue dissolved in EtOAc was filtered and concentrated to dryness to give 0.36g (86%) of pure 2. An analytically pure sample of 2 was obtained by recrystallization from EtOAc-Hexane. M.p. 154-155°,$[\alpha]_D$+22°(c1, $CHCl_3$). $^1$H NMR($CDCl_3$, 300MHZ): δ 0.20(s, 9H, $Me_3Si$), 2.11(s, 3H, Ac), 3.35(s, 3H, OMe), 3.75(t, 1H, H-6a, $J_{6a,6e}$≃$J_{5,6a}$= 10.3Hz), 3.80(d, 1H, H-4, $J_{4,5}$=9.4Hz), 4.06(m, 1H, H-5), 4.36(dd, 1H, H-6e, $J_{5,6e}$=5.2Hz), 4.59(dd, 1H, H-2, $J_{1,2}$=4.4Hz, $J_{2,NH}$=9.8Hz), 4.65(d,1H,H-1),5.65(s, 1H, CH-$C_6H_5$), 6.0(d, 1H, NH), 7.37(m, 3H, $C_6H_5$), 7.50(m, 2H, $C_6H_5$). $^{13}$C NMR($CDCl_3$): δ 1.35($Me_3Si$), 22.32(Ac), 52.14, 55.34, 57.02, 67.55, 71.29, 78.97(C-2, C-3, C-4, C-5, C-6, OMe), 97.77, 100.77 (H-1, C-phenyl),118.00 (CN, $J_{CN,H-2}$=

= $J_{CN,H-4}$= 1.5Hz), 125.98, 127.83(phenyl C-2, C-3), 128.80(phenyl C-4), 136.7(phenyl C-1), 169.22 (CO). Anal. Calcd. for $C_{20}H_{27}N_2O_6Si$: C,57.28; H,6.44; N,6.68. Found: C,57.01; H,6.87; N,6.46.

Ethyl 4,6-di-O-acetyl-2,3-anhydro-α-D-manno and allo-hexopiranoside (3 and 4). To a solution of ethyl 4,6-di-O-acetyl-2,3-dideoxy-α-D-erythro-hex-2-enopyranoside (1g, 3.8mmol) in anhydrous EtOH(35mL), benzonitrile (12.6mL), 30% $H_2O_2$ (13.3mL) and $NaHCO_3$ (2g) were added. The mixture was stirred at room temperature for 3 days. Water (250mL) was added, and the resulting mixture was extracted with acetonitrile-$CH_2Cl_2$ (1:1). The organic phase was dried and concentrated. The benzamide wich precipitated was filtered. The filtrate was concentrated and the residue acetylated overnight with acetic anhydride (2mL) and pyridine (20mL). The reaction mixture was evaporated and the residue chromatographed on preparative TLC plates using EtOAc-hexane (1:3) as eluent. The faster running band afforded the manno-epoxide 3 (0.26g, 25%) as a pure syrup which chrystallized on standing, m.p. 35-36°, $[\alpha]_D$+68°(c1, $CHCl_3$). $^1H$ NMR($CDCl_3$, 90MHz): δ 1.26(t, 3H, $CH_3$-$CH_2$), 2.06, 2.12(2s, 6H, OAc), 3.04(dt, 1H, H-3, $J_{2,3}$=3.6, $J_{1,3}\simeq J_{3,4}\simeq$0.5Hz), 3.20(dd, 1H, H-2, $J_{1,2}$=0.5Hz), 3.47-4.30(m, 5H, H-5, H-6, $CH_2$-$CH_3$), 4.83(dd, 1H, H-4, $J_{4,5}$=9.5Hz), 5.00(bs, 1H, H-1). Anal. Calcd. for $C_{12}H_{18}O_7$: C,52.54; H,6.61. Found: C,52.75; H,6.72. The slower running band afforded allo-epoxide 4 (0.25g, 24%) as a syrup; $[\alpha]_D$+136°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 1.26(t, 3H, $CH_2$-$CH_3$), 2.08, 2.12(2s, 6H, OAc), 3.54(dd, 1H, H-2, $J_{1,2}$=2.6, $J_{2,3}$=4.2Hz), 3.57(dd, 1H, H-3, $J_{3,4}$= 1.5Hz), 3.55-3.89(m, 2H, $CH_2$-$CH_3$), 4.09-4.26(m, 3H, H-5, H-6), 5.05(d, 1H, H-1), 5.08(dd, 1H, H-4, $J_{4,5}$=9.8Hz). Anal. Calcd. for $C_{12}H_{18}O_7$: C,52.54; H,6.61. Found: C,52.66; H,6.52.

Ethyl 4,6-di-O-acetyl-2-C-cyano-2-deoxy-α-D-glucopyranoside (5). To a solution of 3 (0.5g, 1.82mmol) in anhydrous nitromethane (8mL), $Me_3SiCN$ (0.7mL) was added dropwise. The mixture was stirred at room temperature for 20 min and $BF_3$ (3 drops) was added. The stirring continued until disappearance of the starting sugar. The reaction mixture was coevaporated several times with MeOH and purified by preparative TLC using EtOAc-Hexane (1:4) as eluent to give 5 (0.47g, 85%); m.p. 55-56° (from EtOAc); $[\alpha]_D$+4.2°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 1.24(t, 3H, $CH_3$-$CH_2$), 1.82, 2.12 (2s, 6H, OAc), 2.53(bs, 1H, OH), 3.57, 3.81(AB system, 2H, $CH_2$-$CH_3$, Jgem=9.6Hz) 3.80(m with signal at 3.81, 1H, H-2), 3.95(m, 1H, H-5, $J_{4,5}$=8.9Hz), 4.21(dd, 1H, H-6, $J_{6,6'}$=12.0 Hz), 4.34(dd, 1H, H-6'), 4.37(t, 1H, H-3, $J_{2,3}$=$J_{3,4}$=7.6Hz), 4.46(dd, 1H, H-4), 4.67(d, 1H, H-1, $J_{1,2}$=5.4Hz). Anal. Calcd. for $C_{13}H_{19}NO_7$: C,51.82; H,6.35; N,4.64. Found: C,51.80; H,6.65; N,4.41.

Reaction of Methyl 4,6-O-benzylidene-2,3-anhydro-α-D-allopyranoside 6 with $Me_3SiCN$.

a) At room temperature. A mixture of 6, (0.8g, 3mmol), anhydrous nitromethane (5mL) and $Me_3SiCN$ (1.5mL) was stirred at room temperature for 15 min and $BF_3$ (4 drops) was added. The stirring continued for 30 min. The solution was evaporated to dryness under reduced pressure and the residue purified by preparative TLC using $CHCl_3$-EtOH (15:1) as eluent to give two compounds. The faster running band gave methyl 2,3-anhydro-4-O-[(S)-cyanophenylmethyl]-α-D-allopyranoside (9a) as a syrup (0.15g, 27%), $[\alpha]_D$+104°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 1.95(bs, 1H, OH), 3.43(s, 3H, OMe), 3.51(dd, 1H, H-2, $J_{1,2}$= 2.9, $J_{2,3}$= 4.2Hz), 3.56(dd, 1H, H-3, $J_{3,4}$= 1.5Hz), 3.70-3.90(m, 3H, ABC System, H-5, H-6), 4.27(dd, 1H, H-4, $J_{4,5}$= 9.3Hz), 4.88(d, 1H, H-1), 5.53(s, 1H, CH-$C_6H_5$); Anal. Calcd. for $C_{15}H_{17}NO_5$: C,61.85; H,5.84; N,4.81. Found: C,61.91; H,6.06; N,4.76.

The slower running band afforded methyl 2,3-anhydro-6-O-[(R)-cyanophenylmethyl]-α-D-allopyranoside (7a) as a syrup (0.3g, 45%) $[\alpha]_D$+167°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 3.43(s, 3H, OMe), 3.49(dd, 1H, H-3, $J_{2,3}$= 4.2, $J_{3,4}$= 1.8Hz), 3.58(dd, 1H, H-2, $J_{1,2}$= 3.1Hz), 3.77-4.01(m, 5H, H-4, H-5, H-6, OH), 4.92(d, 1H, H-1), 5.39(s, 1, CH-$C_6H_5$); Anal. Calcd. for $C_{15}H_{17}NO_5$: C,61.85; H, 5.84; N,4.81. Found: C,61.45; H,6.04; N,4.50.

b) At -45°. A solution of 6 (0.05g, 0.19mmol), acetonitrile (2mL) and $Me_3SiCN$ (0.3mL) was stirred at -45° for 15 min and $BF_3$ (2 drops) was added. The stirring continued for 45 min and the solution was worked up as before to give 81% of a (15:2) mixture of 7a and 9a.

c) At -75°. A similar mixture of 6 (0.05g, 0.19mmol), DMF(2mL) $Me_3SiCN$(0.3mL) and $BF_3$(2 drops) reacted for 60 min to give 80% of a (15:1) mixture of 7a and 9a respectively. In the two latter reactions, the regioisomers ratio was estimated by $^1H$ NMR.

Isomerisation of 7a. A solution of 7a (0.1g, 0.38mmol) in dry pyridine (3mL) was stirred at room temperature overnight. The reaction mixture was worked up as indicated for 8 to give a (1:1)

mixture of 7a and 7b (0.1g, 100%). $[\alpha]_D$+59.3°(c1 $CHCl_3$); $^1H$ NMR($CDCl_3$, 90MHz): δ3.41, 3.43(2s, 6H, 2 OMe), 3.40-3.63(m, 4H, 2H-2, 2H-3), 3.70-4.20(m, 8H, 2H-4, 2H-5, 4H-6), 4.86(d, 1H, H-1, $J_{1,2}$= 2.5Hz), 4.88(d, 1H, H-1, $J_{1,2}$=2.5Hz), 5.52, 5.53(2s, 2H, 2CH-$C_6H_5$).

Methyl 4-O-acetyl-2,3-anhydro-6-O-[(R)-cyanophenylmethyl]-α-D-allopyranoside (8). A solution of 7a(0.25g, 0.86mmol), dry pyridine (5mL) and acetic anhydride (0.5mL) was stirred at room temperature overnight. The mixture was evaporated under reduced pressure and the residue, dissolved in chloroform, was washed with diluted sulfuric acid, sodium bicarbonate and water. The organic layer was dried over sodium sulfate, filtered and evaporated to dryness to give a (1:1) mixture of 8a and 8b as a syrup (0.26mg, 91%). An analytically pure sample was obtained after preparative TLC chromatography using EtOAc-hexane (3:2) as eluent, $[\alpha]_D$+119°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 2.02, 2.09(2s, 6H, 2 OAc), 3.43, 3.47(2s, 6H, 2 OMe), 3.51-3.57(m, 4H, 2H-2, 2H-3), 3.61(dd, 1H, H-6), 3.75-3.79(m, 3H, 3H-6), 4.05(m, 2H, 2H-5), 4.93(d, 2H, 2H-1, $J_{1,2}$=3.0Hz), 5.18(dd, 1H, H-4, $J_{3,4}$=1.5, $J_{4,5}$=9.9Hz), 5.19(dd, 1H, H-4, $J_{3,4}$=2.0, $J_{4,5}$=9.7Hz), 5.37(2s, 2H, 2CH-$C_6H_5$). Anal. Calcd. for $C_{17}H_{19}NO_6$: C,61.26; H,5.71; N,4.20. Found: C,60.86; H,5.81; N,4.26.

Methyl 6-O-acetyl-2,3-anhydro-4-O-[(S)-cyanophenylmethyl]-α-D-allopyranoside (10). Compound 9a (0.25g, 0.86mmol) was acetylated and worked up, as indicated above for 7a, to give a (1:1) mixture of 10a and 10b (0.25g, 88%) as a solid m.p. 90-92° (from EtOAc-hexane); $[\alpha]_D$+ 95°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 300MHz): δ 2.08, 2.09(2s, 6H, 2 OAc), 3.44, 3.45(2s, 6H, 2 OMe), 3.44(dd, 1H, H-3), 3.50 (dd, 1H, H-2, $J_{1,2}$=3.0, $J_{2,3}$=4.2Hz) 3.60(dd, 1H, H-2, $J_{1,2}$=2.8, $J_{2,3}$=4.2Hz), 3.63(dd, 1H, H-3, $J_{3,4}$=1.5Hz), 3.97, 4.03(m, 2H, 2H-5), 4.08(dd, 1H, H-4, $J_{4,5}$= 9.5Hz), 4.19-4.33(m, 5H, 4H-6, H-4), 4.87(d, 1H, H-1), 4.93(d, 1H, H-1), 5.48, 5.58(2s, 2H, 2CH-$C_6H_5$); Anal. Calcd. for $C_{17}H_{19}NO_6$: C, 61.26; H,5.71; N,4.20. Found: C,61.24; H,5,82; N,4.53.

Reaction of methyl 4,6-O-benzylidene-2,3-di-O-tosyl-α-D-glucopyranoside 11 with $Me_3SiCN$.

a) At room temperature. a solution of 11 (0.3g, 0.5mmol), anhydrous nitromethane (4mL) and $Me_3SiCN$(0.2mL) was stirred at room temperature for 15 min and $BF_3$ (2 drops) was added. The stirring continued for 45 min and the solution was evaporated to dryness under reduced pressure. The residue was purified by preparative TLC using EtOAc-hexane (2:3) as eluent to give two compounds. The faster running band gave methyl 6-O-[(R)-cyanophenylmethyl]-2,3-di-O-tosyl-α-D-glucopyranoside (12) as an amorphous solid (0.16g, 51%); $[\alpha]_D$+59°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 90MHz): δ 2.15(bs, 1H, OH), 2.42(s, 6H, $2CH_3$-tosyl), 3.20(s, 3H, OMe), 3.70(m, 1H, H-5, $J_{4,5}$= 9.5Hz), 3.94(m, 2H, H-6), 4.05 (t, 1H, H-4, $J_{3,4}$=9.5Hz), 4.20(dd, 1H, H-2, $J_{2,3}$= 10Hz, $J_{1,2}$= 3.5Hz), 4.68(d, 1H, H-1), 5.30(dd, 1H, H-3), 5.96(s, 1H, CH-$C_6H_5$); Anal. Calcd. for $C_{29}H_{31}NO_{10}S_2$: C,56.40; H,5.02; N,2.27; S,10.37. Found: C,56.27; H,5.10; N,2.61; S,10.08.

The slower running band afforded methyl 4-O-[(S)-cyanophenylmethyl]-2,3-di-O-tosyl-α-D-glucopyranoside (13) as an amorphous solid (0.091g, 27%); $[\alpha]_D$+42°(c1, $CHCl_3$); $^1H$ NMR($CDCl_3$, 90MHz): δ 1.75(bs, 1H, OH), 2.36, 2.42(2s, 6H, $2CH_3$-tosyl), 3.23(s, 3H, OMe), 3.48-4.03(m, 4H, H-4, H-5, H-6), 4.31(dd, 1H, H-2, $J_{2,3}$= 9.5, $J_{1,2}$= 3.5Hz), 4.83(d, 1H, H-1), 5.18(dd, 1H, H-3, $J_{3,4}$= 10Hz), 5.45 (s, 1H, CH-$C_6H_5$). Anal. Calcd. for $C_{29}H_{31}NO_{10}S_2$: C,56.40; H,5.02; N,2,27; S,10.37. Found: C,56.46; H,5.15; N,2,53; S,10.30.

b) At -50°. A solution of 11 (50mg, 0.085mmol), acetonitrile (2mL) and $Me_3SiCN$ (0.3mL) was stirred at -50° for 15 min and $BF_3$ (2 drops) was added. The stirring continued for 60 min and the solution was worked up as before to give 12 (80%).

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