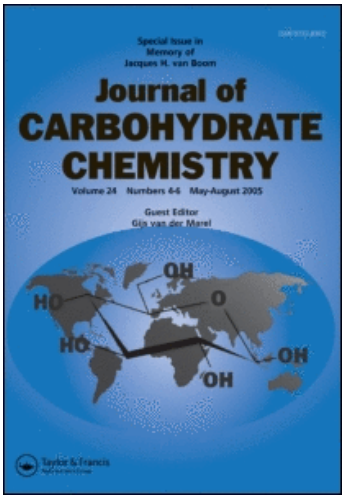

Journal of Carbohydrate Chemistry

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713617200

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To cite this Article Dekany, Gyula , Ward, Peter and Toth, Istvan(1995) 'Synthesis of Fully and Partially Protected Alkyl 1-Thio-β-l-fucopyranosides', Journal of Carbohydrate Chemistry, 14: 2, 227 — 236
To link to this Article: DOI: 10.1080/07328309508002065
URL: http://dx.doi.org/10.1080/07328309508002065

J. CARBOHYDRATE CHEMISTRY, 14(2), 227-236 (1995)

SYNTHESIS OF FULLY AND PARTIALLY PROTECTED ALKYL 1-THIO-ß-L-FUCOPYRANOSIDES

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Received April 8, 1994 - Final Form November 1, 1994

ABSTRACT

Fully acetylated (**1d**) and a mixture of partially acetylated (**1a**, **1b**, **1c**) ethyl 1-thio-ß-L-fucopyranosides have been prepared in high yields from peracetylated fucopyranosyl chloride (**1e**) with sodium ethanethiolate/ethanethiol in 1,2-dimethoxyethane. The same compounds were synthesised from peracetylated methyl 1-thio-ß-L-fucopyranoside (**1g**) with bromine and ethanethiolate. Selective hydrolysis of **1g** led to the removal of the 3-*O*-acetyl group, resulting in **1h**. Chemospecific and stereospecific α-fucosidation of the partially acetylated thioglycosides **1a**, **1b** and **1c** was achieved using benzyl-protected methyl 1-thio-ß-(**1i**) and α- (**1r**) L-fucopyranosides and DMTST promoter.

INTRODUCTION

Partially and fully protected alkyl 1-thio-fucopyranosides are important intermediates for the synthesis of oligosaccharides. The partially protected compounds are acceptors in glycosylation reactions, making it possible to synthesize glycosides containing 1-2', 1-3' or 1-4' O-glycosidic linkages. They are particularly important

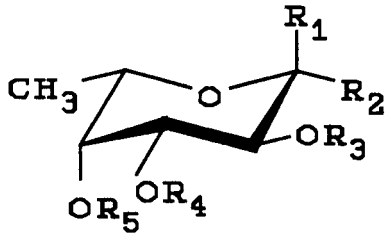
in the so called "armed - disarmed" strategy of oligosaccharide synthesis,[2] where they serve as "disarmed" acceptors.[2] The "disarmed" acceptors are valuable intermediates for the introduction of 1,2-*trans* linkages in a growing oligosaccharide chain. Veeneman and Van Boom reported[2] the principles of "armed - disarmed" type oligosaccharide synthesis, using iodonium dicollidine perchlorate (IDCP) and later iodonium dicollidine trifluoromethanesulphonate (IDCT)[3] as promoters. They found that the high chemospecificity of the thiophilic promoters (IDCP, IDCT) for "armed" thioglycosides was necessary to couple a "disarmed" thioglycoside directly with an "armed" thioglycoside, resulting in oligosaccharides containing predominantly α-glycosidic bonds.

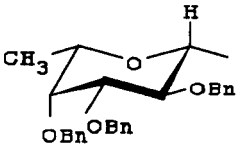
Several routes have been described for the preparation of fully protected alkyl 1-thio-fucopyranosides. Fully-acetylated ß-thio-fucopyranoside was prepared by mercaptolysis of per-*O*-acetyl-α- and ß-L-fucopyranose in the presence of $SnCl_4$.[3] Methyl 2,3,4-tri-*O*-acetyl-1-thio-ß-L-fucopyranoside was obtained from per-*O*-acetyl-L-fucopyranose by use of (methylthio)trimethylsilane in the presence of trimethylsilyl trifluoromethanesulphonate.[4] Per-*O*-acetyl-L-fucopyranose with ethyl mercaptane in the presence of BF_3-etherate[5] or $ZnCl_2$[6] or with Bu_3SnSMe in the presence of $SnCl_4$[7] resulted in the formation of alkyl 1-thio-L-fucopyranoside as an α/ß mixture. Preparations of alkyl 1-thio-glycosides were also obtained from bromo sugars with NaSEt[8] in aqueous solution or chloro sugars with KSAc[9,10] and *O*-ethyl-*S*-potassium dithiocarbonate.[11] The yields from the above methods were low and mixtures of α/ß-alkyl 1-thio-glycosides were obtained. There is little information in the literature on the synthesis of partially protected alkyl 1-thio-fucosides: 2- and 4-unprotected alkyl 1-thio-fucopyranosides have been reported[12,13] but not the 3-unprotected analogue.

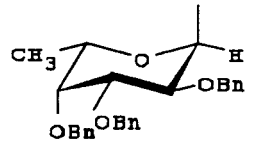
We report here some simple and economical syntheses of fully (**1d**) and partially (**1a**, **1b**, **1c** and **1h**) protected alkyl 1-thio-β-L-fucopyranosides. Furthermore, their use as acceptors will be described.

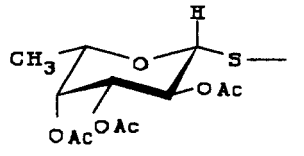
RESULTS AND DISCUSSION

The conversion of peracetylated α-L-fucopyranosyl chloride **1e** into **1d** with sodium ethanethiolate in ethanethiol[14] was only about 30 % even after a reaction time



X= 

Y= 

Z= 

1	R_1	R_2	R_3	R_4	R_5
a	H	SEt	H	Ac	Ac
b	H	SEt	Ac	H	Ac
c	H	SEt	Ac	Ac	H
d	H	SEt	Ac	Ac	Ac
e	Cl	H	Ac	Ac	Ac
f	Br	H	Ac	Ac	Ac
g	H	SMe	Ac	Ac	Ac
h	H	SMe	Ac	H	Ac
i	H	SMe	Bn	Bn	Bn
j	H	SEt	Y	Ac	Ac
k	H	SEt	X	Ac	Ac
l	H	SEt	Ac	Y	Ac
m	H	SEt	Ac	X	Ac
n	H	SEt	Ac	Ac	Y
o	H	SEt	Ac	Ac	X
p	H	Z	Ac	Ac	Ac
r	SMe	H	Bn	Bn	Bn

of 24 h. The same reaction in 1,2-dimethoxyethane was completed after 2 h affording **1a**, **1b** and **1c**. Compound **1d** was obtained in high yield with pyridine/acetic anhydride acylation of the partially deprotected compounds **1a**, **1b** and **1c** (compound **1p** was isolated as a side product). The method has many advantages: (i) compound

1e is stable, (ii) the reagents are inexpensive, (iii) the method can easily be scaled up, (iv) production of the fully protected **1d** is a "one pot" reaction and (v) the yields are high.

Furthermore, peracetylated methyl 1-thio-ß-L-fucopyranoside **1g** was converted *in situ* into the bromo-derivative **1f**. Treatment of the latter product with sodium ethanethiolate in 1,2-dimethoxyethane yielded the partially acetylated ethyl 1-thio-ß-L-glycosides **1a**, **1b** and **1c**, showing the exchange of the methylthio for ethylthio substituents.

For the preparation of partially acetylated alkyl 1-thio-fucopyranosides, acid catalysed hydrolysis of a fully acetylated alkyl 1-thio-fucospyranoside always gave us an inseparable mixture of products. Compound **1h** missing an *O*-acetyl group at C-3 could be prepared by a novel highly selective method from thioglycoside **1g**, using Amberlite IR-120 (H^+) ion-exchange resin in methanol-water solution (see Experimental).

The partially acetylated ethyl 1-thio-fucopyranosides **1a**, **1b** or **1c** were coupled with the "armed" perbenzylated methyl 1-thio-β-L-fucopyranoside **1i**[15,16] in the presence of one equivalent dimethyl(methylthio)sulphonium trifluoromethanesulphonate (DMTST)[17] as a thiophilic promoter. The reactions were completed in minutes and the α-linked disaccharide derivatives **1j**, **1l** and **1n** were formed almost quantitatively with high chemo- and stereospecificity; only a small amount of β-linked disaccharide derivatives **1k**, **1m**, **1o** were isolated as well (α:β=9:1, as determined by TLC and ^1H NMR). When the "disarmed" partially acetylated ethyl 1-thio-fucopyranosides **1a**, **1b** and **1c** were reacted with the "armed" perbenzylated methyl 1-thio-α-L-fucopyranoside **1r** (anomerised from **1i** with $SnCl_4$) the same chemo- and stereospecificity was achieved, showing that DMTST could be a suitable promoter in an "armed - disarmed" type glycosylation and the glycosidic configuration of the "armed" thioglycoside had no effect on the stereospecificity.

EXPERIMENTAL

Purification was achieved by flash chromatography on Sorbsil C60-H40/60, using mobile phases as stated. Reaction progress was monitored by thin layer

chromatography on Kieselgel 60 F_{254} using mobile phases as stated. Solvents were evaporated under reduced pressure with a rotary evaporator. ^1H NMR spectra were obtained with a Bruker AM 500 instrument operating at a field of 500 MHz. Chemical shifts are reported in ppm downfield from internal TMS. Mass spectra were run with a VG Analytical ZAB-SE instrument using fast atom bombardment (FAB) techniques -20 kV Cs^+ ion bombardment, with 2 μL of appropriate matrix, either 3-nitrobenzyl alcohol or thioglycerol with NaI (MeOH) solution added when necessary to produce natriated species when no protonated molecular ions were observed.

Syntheses of partially protected alkyl 1-thio-ß-L-fucopyranosides.

Method A. A mixture of **1e** (220 mg, 0.71 mmol), sodium ethanethiolate (66 mg, 0.79 mmol), ethanethiol (0.1 mL, 1.35 mmol) in 1,2-dimethoxyethane (5 mL) was stirred at room temperature for 2 h. The reaction mixture was neutralized with Amberlite IR-120 (H^+), filtered and concentrated. The residue was purified by flash chromatography using CH_2Cl_2/ether (1:1 v/v) as the mobile phase to give **ethyl 3,4-di-*O*-acetyl-1-thio-ß-L-fucopyranoside (1a)** (48 mg, 24 %): R_f 0.66 (CH_2Cl_2/ether 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.34 (d, 1H, H-4), 4.92 (dd, 1H, H-3), 4.39 (d, 1H, H-1, $J_{1,2}$ = 9.5 Hz), 3.81 (m, 1H, H-5), 3.78 (t, lH, H-2), 2.75 (m, 2H, CH_2S), 2.39 (bs, 1H, OH), 2.03 and 2.12 (2s, 6H, 2 Ac), 1.32 (t, 3H, CH_3), 1.19 (d, 3H, H-6); FAB-MS $C_{12}H_{20}O_6S$ (292.34) m/z (%) 315 $[M+Na]^+$ (100), **ethyl 2,3-di-*O*-acetyl-1-thio-ß-L-fucopyranoside (1c)** (42 mg, 21 %): R_f 0.55 (CH_2Cl_2/ether 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.24 (t, 1H, H-2), 4.97 (dd, 1H, H-3), 4.41 (d, 1H, H-1, $J_{1,2}$ = 10 Hz), 3.88 (d, 1H, H-4), 3.72 (m, 1H, H-5), 2.69 (m, 2H, CH_2S), 2.08 and 2.04 (2s, 6H, 2 Ac), 1.72 (bs, 1H, OH), 1.33 (d, 3H, H-6), 1.25 (t, 3H, CH_3); FAB MS $C_{12}H_{20}O_6S$ (292.34) m/z (%) 315 $[M+Na]^+$ (100), and **ethyl 2,4-di-*O*-acetyl-1-thio-ß-L-fucopyranoside (1b)** (56 mg, 28 %): R_f 0.46 (CH_2Cl_2/ether 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.20 (d, 1H, H-4), 4.98 (t, 1H, H-2), 4.40 (d, 1H, H-1, $J_{1,2}$ = 10 Hz), 3.82 (dd, 1H, H-3), 3.73 (m, 1H, H-5), 2.69 (m, 2H, CH_2S), 2.52 (bs, 1H, OH), 2.17 and 2.11 (2s, 6H, 2 Ac), 1.26 (t, 3H, CH_3), 1.19 (d, 3H, H-6); FAB MS $C_{12}H_{20}O_6S$ (292.34) m/z (%) 315 $[M+Na]^+$ (100).

Method B. Compound **1g**[4] (1.0 g, 3.12 mmol) was dissolved in CH_2Cl_2 (20 mL) and bromine (0.58 g, 3.62 mmol) in CH_2Cl_2 (5 mL) was added. The mixture was

stirred at room temperature for 5 min and cyclohexene (0.5 mL) was added. The colourless solution was concentrated at 0 °C. The residue was dissolved in 1,2-dimethoxyethane (10 mL), and ethanethiol (0.4 mL, 5.93 mmol) and sodium ethanethiolate (290 mg, 3.47 mmol) were added. The reaction mixture was stirred at room temperature for 3 h, filtered, neutralized with Amberlite IR-120 (H^+) ion-exchange resin and concentrated. The residue was chromatographed with hexane/ether 1:1 v/v as the mobile phase, to give **1a** (200 mg, 22 %), **1c** (110 mg, 12 %), **1b** (520 mg, 57 %).

Method C. Methyl 2,4-di-*O*-acetyl-1-thio-ß-L-fucopyranoside (1h). Compound **1g** (1.0 g, 3.12 mmol) was dissolved in methanol/water 30:1 v/v (30 mL) and Amberlite IR-120 (H^+) (2.0 g) was added. The mixture was stirred overnight at 40 °C, filtered and concentrated. The residue was chromatographed with CH_2Cl_2/ether 1:1 v/v to give **1h** (683 mg, 75 %): R_f 0.46 (CH_2Cl_2/ether 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.25 (d, 1H, H-4), 5.05 (t, 1H, H-2), 4.33 (d, 1H, H-1, $J_{1,2}$ = 10 Hz), 3.82 (dd, 1H, H-3), 3.78 (m, 1H, H-5), 2.46 (bs, 1H, OH), 2.20, 2.17 and 2.14 (3s, 9H, 2 Ac, SCH_3), 1.22 (d, 3H, H-6); FAB MS $C_{11}H_{18}0_6S$ (278.34) m/z (%) 279 $[M+H]^+$ (20), 231 (60).

2,3,4-Tri-*O*-acetyl-α-L-fucopyranosyl chloride (1e). A mixture of α- and ß-L-fucopyranosyl tetraacetate (2.0 g, 6.50 mmol) was dissolved in acetyl chloride (40 mL) which was saturated with hydrogen chloride gas at -15 °C. The mixture was kept at room temperature for 24 h. Solvents were evaporated at 10 °C and coevaporated with toluene (3 x 10 mL). The residue was purified by flash chromatography using $CHCl_3$/ether 10:2 v/v as the mobile phase, to give **1e** (1.56 g, 84 %): R_f 0.62 (hexane/ethyl acetate 1:1 v/v); ^1H-NMR ($CDCl_3$) δ 6.35 (d, 1H, H-1, $J_{1,2}$ = 4.4 Hz), 5.42 (dd, 1H, H-2), 5.35 (dd, 1H, H-4), 5.23 (dd, 1H, H-3), 4.45 (m, 1H, H-5), 2.16, 2.09 and 1.98 (3s, 9H, 3 Ac), 1.18 (d, 3H, H-6); FAB MS $C_{12}H_{17}ClO_4$ (308.71) m/z (%) 331 $[M+Na]^+$ (35), 309 $[M+H]^+$ (8), 273 (98).

Ethyl 2,3,4-tri-*O*-acetyl-1-thio-ß-L-fucopyranoside (1d) and 2,3,4-tri-*O*-acetyl-β-L-fucopyranosyl 2,3,4-tri-*O*-acetyl-1-thio-β-L-fucopyranoside (1p). A mixture of chloride **1e** (220 mg, 0.71 mmol), sodium ethanethiolate (66 mg, 0.79 mmol) and ethanethiol (0.1 mL, 1.35 mmol) in 1,2-dimethoxyethane (5 mL) was stirred at room temperature for 2 h, dry ice was added, and the solution was

evaporated. The residue was dissolved in dry pyridine (2 mL) and acetic anhydride (1.4 mL, 14.8 mmol) was added. The mixture was then stirred for 15 h and concentrated. Toluene (5 mL) was added to the residue, evaporated, and the residue was chromatographed using CH_2Cl_2/ether 4:1 v/v as the mobile phase, to give **1d** (190 mg, 80 %): R_f 0.76 (CH_2Cl_2/hexane 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.24 (d, 1H, H-4), 5.18 (t, 1H, H-2), 5.01 (dd, 1H, H-3), 4.43 (d, 1H, H-1, $J_{1,2}$ = 10.0 Hz), 3.79 (m, 1H, H-5), 2.70 (m, 2H, CH_2S), 2.14, 2.03 and 1.95 (3s, 9H, 3 Ac), 1.24 (t, 3H, CH_3), 1.19 (d, 3H, H-6); FAB MS $C_{14}H_{22}O_7S$ (334.38) m/z (%) 357 $[M+Na]^+$ (100), 273 (14), and **1p** (32 mg, 8 %): R_f 0.62 (CH_2Cl_2/hexane 1:1 v/v); ^1H NMR ($CDCl_3$) δ 5.25 (d, 2H, H-4, H-4'), 5.18 (t, 2H, H-2, H-2'), 5.05 (dd, 2H, H-3, H-3'), 4.76 (d, 2H, H-1, H-1', $J_{1,2}$ = $J_{1',2'}$ = 10.0 Hz), 3.79 (m, 2H, H-5, H-5'), 2.16, 2.03 and 1.96 (3s, 18H, 6 Ac), 1.20 (d, 6H, H-6, H-6'); FAB MS $C_{24}H_{34}O_{14}S$ (578.57) m/z (%) 601 $[M+Na]^+$ (100), 273 (14).

Ethyl *O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→2)-3,4-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1j) and ethyl *O*-(2,3,4-tri-*O*-benzyl-β-L-fucopyranosyl)-(1→2)-3,4-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1k). A mixture of **1i** or **1r** (95 mg, 0.02 mmol), **1a** (60 mg, 0.02 mmol) and molecular sieves 4A (1.0 g) in CH_2Cl_2 (5 mL) was stirred, and DMTST (53 mg, 0.02 mmol) was added. The mixture was stirred at room temperature for 10 min and neutralized with triethylamine (0.05 mL). The suspension was diluted with CH_2Cl_2 (10 mL), dried and filtered. The filtrate was washed with water (3 x 2 mL) and concentrated. The residue was chromatographed using hexane/ether/methanol 7:7:1 v/v/v as the mobile phase, to give **1j** (110 mg, 76 %): R_f 0.42 (hexane/ether/methanol 7:7:1 v/v/v; ^1H NMR ($CDCl_3$) δ 7.48-7.23 (m, 15H, 15 Ar-H), 5.61 (d, 1H, H-1', $J_{1',2'}$ = 3.1 Hz), 5.27 (m, 1H, H-4), 5.00 (dd, 1H, H-3), 4.96-4.62 (m, 6H, 3 CH_2Ar), 4.57 (d, 1H, H-1, $J_{1,2}$ = 10.1 Hz), 4.07 (m, 1H, H-2), 4.00 (m, 2H, H-2', H-5), 3.87 (dd, 1H, H-3'), 3.77 (m, 1H, H-5'), 3.59 (d, 1H, H-4'), 2.74 (m, 2H, SCH_2), 2.14 and 1.91 (2s, 6H, 2 Ac), 1.25 (t, 3H, CH_3), 1.18 and 1.11 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (42), 647 (26), 557 (48), 417 (26), 91 (100), and **1k** (8 mg, 6 %): R_f 0.35 (hexane/ether/methanol 7:7:1 v/v/v); ^1H NMR ($CDCl_3$) δ 7.46-7.22 (m, 15H, 15 Ar-H), 5.28 (m, 1H, H-4), 5.18 (dd, 1H, H-3), 4.97-4.62 (m, 6H, 3 CH_2Ar), 4.56 (d, 1H, H-1,

$J_{1,2}$ = 10.3 Hz), 4.49 (d, 1H, H-1', $J_{1',2'}$ = 9.9 Hz), 4.09 (m, 1H, H-2), 4.01 (m, 2H, H-2', H-5), 3.92 (dd, 1H, H-3'), 3.77 (m, 1H, H-5'), 3.61 (d, 1H, H-4'), 2.75 (m, 2H, SCH_2), 2.05 and 1.89 (2s, 6H, 2 Ac), 1.26 (t, 3H, CH_3), 1.16 and 1.08 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (47), 647 (31), 557 (42), 417 (29), 91 (100).

Ethyl *O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-2,4-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1l) and ethyl *O*-(2,3,4-tri-*O*-benzyl-β-L-fucopyranosyl)-(1→3)-2,4-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1m). A mixture of **1i** or **1r** (95 mg, 0.02 mmol), **1b** (60 mg, 0.02 mmol) and molecular sieves 4A (1.0 g) in CH_2Cl_2 (5 mL) was stirred, and DMTST (53 mg, 0.02 mmol) was added. The mixture was stirred at room temperature for 10 min, neutralized with triethylamine (0.05 mL), the suspension was diluted with CH_2Cl_2 (10 mL) and filtered. The filtrate was washed with water (3 x 2 mL), dried and concentrated. The residue was chromatographed using hexane/ether/methanol 7:7:1 v/v/v as the mobile phase, to give **1l** (122 mg, 84 %): R_f 0.40 (hexane/ether/methanol 7:7:1 v/v/v); ^1H NMR ($CDCl_3$) δ 7.42-7.23 (m, 15H, 15 Ar-H), 5.35 (m, 1H, H-4), 5.22 (dd, 1H, H-2), 5.01 (d, 1H, H-1', $J_{1',2'}$ = 3.8 Hz), 4.97-4.62 (m, 6H, 3 CH_2Ar), 4.24 (d, 1H, H-1, $J_{1,2}$ = 9.6 Hz), 4.00 (m, 1H, H-3), 3.83 (m, 1H, H-5), 3.80 (dd, 1H, H-2'), 3.77 (dd, 1H, H-3'), 3.65 (m, 1H, H-5'), 3.51 (d, 1H, H-4'), 2.72 (m, 2H, SCH_2), 1.96 and 1.90 (2s, 6H, 2 Ac), 1.26 (t, 3H, CH_3), 1.17 and 1.09 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (35), 647 (26), 557 (37), 417 (23), 91(100) and **1m** (7 mg, 5 %): R_f 0.35 (hexane/ether/methanol 7:7:1 v/v/v); ^1H NMR ($CDCl_3$) δ 7.41-7.22 (m, 15H, 15 Ar-H), 5.36 (m, 2H, H-4, H-2), 4.95-4.62 (m, 6H, 3 CH_2Ar), 4.42 (d, 1H, H-1', $J_{1',2'}$ = 8.2 Hz), 4.27 (d, 1H, H-1, $J_{1,2}$ = 10.0 Hz), 3.94 (dd, 1H, H-3), 3.75 (m, 1H, H-5), 3.72 (dd, 1H, H-2'), 3.68 (dd, 1H, H-3'), 3.53 (d, 1H, H-4'), 3.42 (m, 1H, H-5'), 2.70 (m, 2H, SCH_2), 2.11 and 1.88 (2s, 6H, 2 Ac), 1.26 (t, 3H, CH_3), 1.22 and 1.17 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (40), 647 (29), 557 (42), 417 (27), 91(100).

Ethyl *O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→4)-2,3-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1n) and ethyl *O*-(2,3,4-tri-*O*-benzyl-β-L-fucopyranosyl)-

(1→4)-2,3-di-*O*-acetyl-1-thio-β-L-fucopyranoside (1o). A mixture of **1i** or **1r** (95 mg, 0.02 mmol), **1c** (60 mg, 0.02 mmol) and molecular sieves 4A (1.0 g) in CH_2Cl_2 (5 mL) was stirred and DMTST (53 mg, 0.02 mmol) was added. The mixture was stirred at room temperature for 10 min and neutralized with triethylamine (0.05 mL). The suspension was diluted with CH_2Cl_2 (10 mL) and filtered. The filtrate was washed with water (3 x 2 mL), dried over $MgSO_4$ and concentrated. The residue was chromatographed using hexane/ether/methanol 7:7:1 v/v/v was the mobile phase, to give the product **1n** (125 mg, 86 %): R_f 0.45 (hexane/ether/methanol 7:7:1 v/v/v); ^1H NMR ($CDCl_3$) δ 7.50-7.18 (m, 15H, 15 Ar-H), 5.17 (dd, 1H, H-2), 5.15 (dd, 1H, H-3), 5.09 (d, 1H, H-1', $J_{1',2'}$ = 3.5 Hz), 5.02-4.70 (m, 6H, 3 CH_2Ar), 4.22 (d, 1H, H-1, $J_{1,2}$ = 9.6 Hz), 4.16 (d, 1H, H-4), 4.08 (m, 1H, H-5), 3.98 (dd, 1H, H-2'), 3.88 (dd, 1H, H-3'), 3.80 (m, 1H, H-5'), 3.56 (d, 1H, H-4'), 2,72 (m, 2H, SCH_2), 1.97 and 1.91 (2s, 6H, 2 Ac), 1.27 (t, 3H, CH_3), 1.15 and 1.11 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (41), 647 (30), 557 (51), 417 (28), and **1o** (5 mg, 4 %): R_f 0.39 (hexane/ether/methanol 7:7:1 v/v/v); ^1H NMR ($CDCl_3$) δ 7.49-7.17 (m, 15H, 15 Ar-H), 5.19 (dd, 1H, H-2), 5.16 (dd, 1H, H-3), 5.04-4.71 (m, 6H, 3 CH_2Ar), 4.36 (d, 1H, H-1', $J_{1',2'}$ = 9.3 Hz), 4.22 (d, 1H, H-1, $J_{1,2}$ = 9.6 Hz), 4.11 (d, 1H, H-4), 3.86 (m, 1H, H-5), 3.82 (dd, 1H, H-2'), 3.77 (dd, 1H, H-3'), 3.66 (m, 1H, H-5'), 3.56 (d, 1H, H-4'), 2.76 (m, 2H, SCH_2), 2.11 and 1.93 (2s, 6H, 2 Ac), 1.25 (t, 3H, CH_3), 1.13 and 1.09 (2d, 6H, H-6, H-6'); FAB MS $C_{39}H_{48}O_{10}S$ (708.84) m/z (%) 731 $[M+Na]^+$ (36), 647 (25), 557 (59), 417 (26).

Methyl 2,3,4-tri-*O*-benzyl-1-thio-α-L-fucopyranoside (1r). Compound **1i** (300 mg, 0.64 mmol) was dissolved in CH_2Cl_2 (5 mL) and $SnCl_4$ added. The reaction mixture was stirred for 10 min, diluted with CH_2Cl_2 (10 mL), washed with saturated $NaHCO_3$ solution (2 mL), then with water (2 mL), dried over $MgSO_4$ and concentrated. The residue was chromatographed with hexane/ether 1:1 v/v as the mobile phase, to give **1r** (273 mg, 91 %): R_f 0.66 (hexane/ether 1:1 v/v); ^1H NMR ($CDCl_3$) δ 7.35-7.20 (m, 15H, 15 Ar-H), 5.56 (d, 1H, H-1, $J_{1,2}$ = 3.9 Hz), 4.94-4.59 (6d, 6H, 3 CH_2Ar), 4.23 (dd, 1H, H-2), 4.07 (m, 1H, H-5), 3.75 (dd, 1H, H-3), 3.75 (d, 1H, H-4); FAB MS $C_{27}H_{29}O_4$ (464.47) m/z (%) 487 $[M+Na]^+$ (42), 91 (100).

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