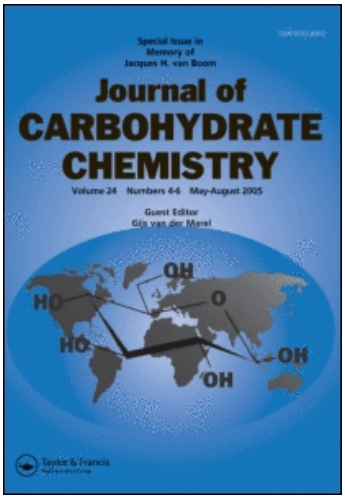

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Selective Monoesterification of Unprotected Mono and Disaccharides

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SELECTIVE MONOESTERIFICATION OF UNPROTECTED MONO AND DISACCHARIDES

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ABSTRACT

Under mild conditions, treatment of unprotected methyl-α-**D**-glucopyranoside, *N*-acetylglucosamine and maltose with triphenylphosphine, diethylazodicarboxylate and equimolar amount of various carboxylic acids allowed regioselective 6-*O*-esterifications (6'-*O* for maltose) of the carbohydrate without esterification of other hydroxyl groups. This reaction found an application in the synthesis of liposoluble, labelled sugars and hydrosoluble polymers.

INTRODUCTION

In spite of differences in the reactivity of the hydroxyl groups of a carbohydrate moiety,[1] a direct modification generally affords mixtures of products which can be avoided only by using protection-deprotection sequences. In connection with a program of synthesis of hydrosoluble polymers,[2] we decided to examine the scope and limitations of the Mitsunobu reaction[3] for the selective esterification of the primary hydroxyl group of unprotected mono- and disaccharides. At present, these 6-*O*-mono

esterified carbohydrates play an important role in different areas: non ionic surfactants,[4] labelled compounds for biological studies,[5] polymer precursors.[6]

Although enzymatic methods have been successfully employed in recent years for mono-esterification of simple glucosides,[7,8] usually efficient esterification of the primary hydroxyl group requires multi-step procedures.[9] Recently, the formation of 6-monoester from unprotected glycosides was reported but concomitant reaction with secondary hydroxyl groups was also observed.[10,11]

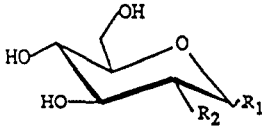
The Mitsunobu reaction has already been employed in carbohydrate chemistry. The regiospecific modification of the primary hydroxyl group of partially protected sugar was achieved[12], but in other cases mixtures were obtained.[11-13] Both primary hydroxyl groups of some disaccharides were simultaneously modified.[11-15] In a preliminary work,[16] we have demonstrated that high regioselectivity could be obtained in the esterification of unprotected carbohydrates by using a rigourously equimolar amount of the carbohydrate and the carboxylic acid.[16] We report herein full details of our work and extensions to different carboxylic acids.

RESULTS AND DISCUSSION

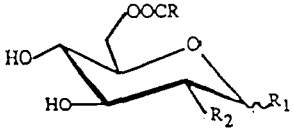
A solution of diethylazodicarboxylate (DEAD, 1.5 eq) and benzoic acid **5a** (1 eq) in anhydrous THF was slowly added, at room temperature, to a mixture of methyl α-**D**-glucopyranoside **1** and triphenylphosphine (Ph_3P, 1.5 eq) in THF. After stirring for 24 h at room temperature, TLC analysis indicated the formation of only one new glucidic product. After work-up (see experimental), **6a** was isolated in 46% yield by column chromatography. The structure of **6a** was determinated by ^1H NMR spectroscopy and by conversion into its peracetylated derivative **6'a** (SCHEME). By comparison, a complex mixture of five products was formed rapidly (1 h) when a solution of **1** in pyridine was treated with benzoyl chloride (1 eq) at 0 °C.

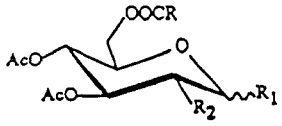
Although the mechanism of the Mitsunobu reaction has been the subject of controversies,[17-20] particularly about the initial steps, it is generally accepted that an SN_2 reaction is the key step. Hence the less hindered hydroxyl group is preferentially esterified. When an excess of all the reagents (1.2 eq per OH) was employed, inversion of C-3 configuration was observed besides the esterification of the primary hydroxyl group.[11]

$$\mathbf{ROH + R'COOH \xrightarrow[DEAD]{(Ph)_3P} (Ph)_3P^{+}\text{-}OR,\ R'\text{-}CO_2^{-} \xrightarrow{SN_2} R'COOR + (Ph)_3PO}$$



+ RCOOH





1 R_1= αOMe, R_2=OH

2 R_1= OH, R_2=NHAc

5 a-f

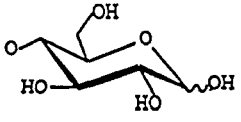
6 a-d R_1= αOMe, R_2=OH, R=a-d

7 b-d R_1=OH,R_2=NHAc, R=b-d

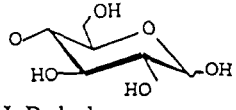
6'a-c R_1= αOMe, R_2=OAc, R=a-c

7'b R_1= OAc, R_2=NHAc, R=b

7'd R_1= OAc, R_2=NHAc, R=d

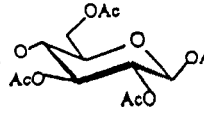
3 R_1=α  , R_2=OH

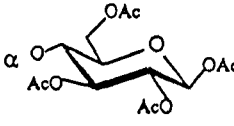
4 R_1= R_2= OH

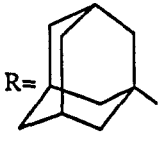
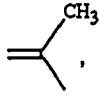
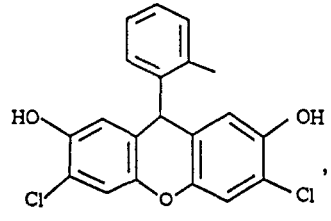
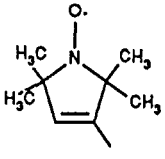
8 b-d R_1= α  R_2=OH, R=b-d

9 e R_1= αOMe, R_2=OH, R=e

10 f R_1=R_2=OH, R=f

8'b R_1= α  , R_2=OAc, R=b

8'd R_1= α  , R_2=OAc, R=d

a R=Ph- , b R=  , c R=  , d R=  , e R=  , f R=CH_3-$(CH_2)_9$-CH_2-

SCHEME

TABLE. Conditions for the monoesterification of sugars **1-4**

Entry	Starting Sugar	Starting acid	Obtained compound	PPh_3 and DEAD	Reaction time (h)	Reaction Solvant	Yield (%)
1	**1**	**5a**	**6a**	1.5	24	THF	46
2	**1**	**5b**	**6b**	1.5	24	DMF	26
3	**1**	**5c**	**6c**	1.5	24	DMF	55
4	**1**	**5d**	**6d**	1.5	24	DMF	39
5	**2**	**5b**	**7b**	1.5	24	DMF	38
6	**2**	**5c**	**7c**	1.5	12	DMF	48
7	**2**	**5d**	**7d**	1.5	24	DMF	34
8	**3**	**5b**	**8b**	1.5	24	DMF	28
9	**3**	**5c**	**8c**	3.0	48	DMF	20
10	**3**	**5d**	**8d**	1.5	24	THF	28
11	**1**	**5e**	**9e**	1.5	24	THF	59
12	**4**	**5f**	**10f**	2.0	24	THF	50

This esterification method was applied to a variety of carboxylic acids of biological interest. In this case, no reaction was observed in THF, and DMF was found to be the best solvent. So, a liposoluble carbohydrate derivative **6b** was obtained from **1** and adamantoic acid **5b**, a polymer precursor **6c** from **1** and methacrylic acid **5c** and a labelled sugar **6d** from **1** and 2',7'-dichlorofluoresceine **5d** (SCHEME). Esterification occurred only at C-6 as confirmed by MS and ^1H NMR of the acetylated derivatives **5'b** and **5'c**. In these cases, the obtained yields (TABLE, entries 2, 3, and 4) reflected the steric hindrance of the incoming group in agreement with the SN_2 nature of the key step.

Compounds **7b-d** (SCHEME) were synthesized by the same methodology from *N*-acetylglucosamine **2** in acceptable yields (TABLE, entries 5, 6, and 7). The structure of the products obtained was established by spectroscopic methods and by transformation into their acetylated derivatives **7'b** and **7'd**. The reducing character of **7b-d** was confirmed by a positive reaction with Fehling's reagent. This indicated that the anomeric hydroxyl was not esterified under the conditions employed.

This was also confirmed from the mass spectra of the acetylated derivatives. For example, the mass spectrum of **7b'** showed the fragment at m/z 450 (M - OAc) and no

ion corresponding to (M - OAd) fragmentation. Since the fragmentation at the anomeric carbon is characteristic of peracetylated sugar derivatives, this observation proves that the adamantoyl group is not at the anomeric carbon, which would have been the case by reaction of the anomeric hydroxyl in the Mitsunobu reaction. A similar procedure with maltose **3** and acids **5b-d** afforded monoesters **8b-d** (SCHEME). The deshielding of H-6'a, H-6'b, H-6a and H-6b between non-acetylated and acetylated maltose was 0.53, 0.22, 0.31 and 0.72 ppm respectively.[22] Introduction of the adamantoyl unit in maltose induced a shielding of the H-6'a (4.98 ppm) and H-6'b (4.85 ppm) signals in compound **8b**. However, in the compounds **8'b** signals of H-6a and H-6b (4.40 and 4.36 ppm, respectively) were not strongly modified by comparison with the signals of the same protons in acetylated maltose (4.40 and 4.23, respectively).[11] On the other hand, it is now well established that the C-6 position in maltose is considerably more hindered than C-6'.[27] Consequently it should be less reactive under Mitsunobu's conditions.[3] Again, mass spectrometry of the peracetylated derivative **8'b** provided confirmation of the regioselectivity by the presence of two peaks (m/z = 739 and m/z = 451 resulting respectively from fragmentation at C-1 (M-OAc) or C-1' (M-$C_{14}H_{19}O_{10}$).

In addition, to prove the generality of this method and to compare it with classical, or enzymatic methods, water soluble spin labelled glucose derivative **9e** (SCHEME) and the fatty acid ester of glucose **10f** were synthesized. These two esters, were obtained in 59% and 50% yields, respectively (TABLE, entries 11 and 12). By comparison, **9e** was previously elaborated in five steps[23] in about 20% yield, while **10f** was formed in the presence of lipase with a molar yield of about 35%.[7]

By contrast, selective formation of the 6-monoester of glucose involving acetylthiazolidine-2-thiones gave a significant formation of 2-*O*-acyl-D-glucopyranose[10] together with the 6-monoester.

EXPERIMENTAL

General methods. Melting points were determinated with a Thomas-Hoover apparatus and are uncorrected. Optical rotations were measured at 22 °C in a 10 cm cell with a Perkin-Elmer-141 polarimeter (for reducing carbohydrates solution was stabilized during 24 h). Analytical TLC was performed on Merck aluminium precoated plates of silica gel 60 F-254 with detection by UV and by spraying with 6M H_2SO_4 and heating about 2 min. at 300 °C. The following solvent systems were used: diethyl ether followed by 5:1 ethyl acetate-methanol, (A); diethyl ether followed by 7:3

chloroform-methanol, (B); 5:1 ethyl acetate-acetic acid followed by 7:3 chloroform-methanol, (C); diethyl ether followed by 7:2:1 2-propanol-ethyl acetate-water, (D); 4:1 ethyl acetate-methanol, (E); 2:1 diethyl ether-light petroleum ether, (F); ethyl acetate, (G); 4:1 ethyl acetate-light petroleum ether, (H). ^{1}H NMR were recorded at 250 MHz with a Brucker AM-250 spectrometer with tetramethylsilane as internal standard; the chemical shifts are given in ppm and coupling constants in Hz. Mass spectra were recorded with a R10-10B Nermag spectrometer (chemical ionisation with NH_3). Silica gel 60 (Merck, 230-400) was used for flash chromatography, and silica gel 60M (Merck) for PLC. Elemental analyses were performed at the Service de Microanalyse of the Université Pierre et Marie Curie.

General procedure for the Mitsunobu reactions. A solution of carboxylic acid (1 mmol) and DEAD (1.5-3 mmol) in 1 mL of solvent was slowly added (30-180 min) at room temperature to a stirred mixture of sugar (1 mmol) and PPh_3 (1.5-3 mmol) in 3 mL of the same solvent (TABLE) under argon. The mixture was then stirred for 12-48 h. The solvent was removed and the residues were dissolved in ethanol and fractionated by flash chromatography with a mixture of chloroform-methanol of increasing polarity, except for **6d**, **7d** and **8d** which were isolated by PLC with eluents C, C and D, respectively. The detailed conditions and results are summarized in the TABLE.

General procedure for acetylation. Compounds **6a, 6b, 6c** and **7b** were acetylated with Ac_2O / pyridine.[24] **8b** and **8d** were acetylated with AcONa-Ac_2O.[25] After normal work-up, PLC (solvent F) afforded the acetylated compounds.

Methyl 6-*O*-Benzoyl-α-D-glucopyranoside (6a). Oil; $[\alpha]^{22}_D$ + 100° (*c* 1.7, $CHCl_3$) ; R_f 0.49 (solvent A); ^{1}H NMR ($CDCl_3$) δ 3.26 (s, 3H, CH_3O), 3.40 (dd, 1H, $J_{4,5}$ = 9.8 Hz, H-4), 3.73 (dd, 1H, $J_{2,3}$ = 9.8 Hz, H-2), 3.76 (dd, 1H, $J_{3,4}$ = 9.5, H-3), 4.2 (m, 1H, H-5), 4.46 (m, 2H, H-6a, and H-6b), 4.65 (d, 1H, $J_{1,2}$ = 4.8 Hz, H-1), 7.4 (m, 2H, Ar), 8.0 (m, 3H, Ar).

Anal. Calcd for $C_{14}H_{18}O_7$: C, 56.37; H, 6.08. Found: C, 56.28; H, 6.10.

Methyl 6-*O*-Adamantoyl-α-D-glucopyranoside (6b). Mp 86-90 °C (ether-methanol); $[\alpha]^{22}_D$ + 56°, (*c* 0.5, $CHCl_3$); R_f 0.52 (solvent A); ^{1}H NMR. ($CDCl_3$) δ 1.83 (m, 15H, Ad), 3.35 (s, 3H, CH_3O), 3.2-3.7 (m, 2H, H-2 and H-3), 3.41 (m, 1H, H-5), 3.95 (dd, 1H, $J_{4,5}$ = 9.5 Hz, H-4), 4.14 (dd, 1H, $J_{6a,6b}$ = 12 Hz, H-6a), 4.16 (dd, 1H, H-6b), 4.74 (d, 1H, $J_{1,2}$ = 4.0 Hz, H-1).

Anal. Calcd for $C_{18}H_{28}O_7$: C, 60.66; H, 7.92. Found: C, 60.59; H, 7.87.

Methyl 6-*O*-Methacryloyl-α-D-glucopyranoside (6c). Mp 68-72 °C (ether-methanol); $[\alpha]^{22}_D$ + 58° (*c* 2.4, $CHCl_3$) ; R_f 0.63 (solvent B) ; ^{1}H NMR ($CDCl_3$) δ 1.80 (s, 3H, CH_3O), 3.33 (m, 1H, H-4), 3.40 (s, 3H, CH_3O), 3.45 (m, 2H, H-2, H-3),

3.75 (m, 1H, H-5), 4.41 (m, 2H, H-6a, H-6b), 4.72 (d, 1H, $J_{1,2}$ = 3.5 Hz, H-1), 5.6 (br.s, 1H, H_2C=), 6.13 (s, 1H, H_2C=).

Anal. Calcd for $C_{11}H_{18}O_7$: C, 50.38; H, 6.92. Found: C, 50.50; H, 6.63.

Methyl 6-*O*-[2-(2,7-Dichloro-3,6-dihydroxyxanthen-9-yl) benzoyl]-α-D-gluco-pyranoside (6d). Mp 73-77 °C (ether-methanol); coloured orange; R_f 0.65 (solvent B); ^{1}H NMR (CD_3OD) δ 2.79 (dd, 1H, $J_{2,3}$= 9.6 Hz, H-2), 3.0 (s, 3H, CH_3O), 3.15 (m, 1H, H-5), 3.19 (dd, 1H, $J_{4,5}$= 9.6 Hz, H-4) 3.45 (dd, 1H, $J_{3,4}$ = 9.5 Hz, H-3), 4.04 (m, 2H, H-6a, H-6b), 4.19 (d, 1H, $J_{1,2}$ = 3.9 Hz, H-1), 6.43, 6.47, 6.87, 6.92, 7.05, 7.50, 7.95 (m, 8H, Ar).

Anal. Calcd for. $C_{27}H_{22}Cl_2O_{10}$: C, 56.16; H, 3.84. Found: C, 56.81; H, 3.77.

2-Acetamido-6-*O*-adamantoyl-2-deoxy-D-glucopyranose (7b). Mp 92-93 °C (ether-methanol); $[\alpha]_D$ +20° (*c* 1, CH_3OH); R_f 0.44 (solvent A); ^{1}H NMR (D_2O) δ 2.O (s, 3H, CH_3CO), 2.06 (m, 15H, Ad), 3.56 (m, 1H, H-5), 3.48 (m, 2H, H-3, H-4), 4.06 (m, 1H, H-6a), 4.18 (m, 1H, H-6b), 5.14 (dd, 1H, $J_{2,3}$= 10.33 Hz , H-2), 6.2 (d, 1H, $J_{1,2}$ 9.5, H-1).

Anal. Calcd for $C_{19}H_{29}NO_7$ + 0.5 H_2O: C, 58.14; H, 7.70; N, 3.57. Found: C, 58.00; H, 7.86; N, 3.07.

2-Acetamido-2-deoxy-6-*O*-methacryloyl-D-glucopyranose (7c). Mp 128-130 °C (ether-methanol); $[\alpha]^{22}_D$ + 17° (*c* 0.5, CH_3OH); R_f 0.58 (solvent B) ; ^{1}H NMR (D_2O) δ 1.80 (s, 3H, CH_3C), 1.90 (s, 3H, CH_3CO), 3.33 (dd, 1H, $J_{2,3}$= 9.86 Hz, H-2), 3.49 (dd, 1H, $J_{4,5}$ = 9.57 Hz, H-4), 3.55 (dd, 1H, $J_{3,4}$ = 10.7 Hz, H-3), 3.68 (m, 1H, H-5), 4.40 (m, 2H, H-6a and H-6b), 5.19 (d, 1H, $J_{1,2}$= 3.14 Hz , H-1), 5.60 (br.s, 1H, H_2C=), 5.95 (s, 1H, H_2C=).

Anal. Calcd for $C_{12}H_{19}NO_7$: C, 49.82; H, 6.62; N, 4.84. Found: C, 49.65; H, 6.95; N, 4.19.

2-Acetamido-2-deoxy-6-*O*-[2-(2,7-dichloro-3,6-dihydroxyxanthen-9-yl)-benzoyl]-D-glucopyranose (7d). Mp 80-85 °C (ether-methanol); coloured orange; R_f 0.63 (solvent C); ^{1}H NMR (D_2O) δ 2.1 (s, 3H, CH_3CO), 3.25 (dd, 1H, $J_{2,3}$= 10.4 Hz, H-2), 3.35 (dd, 1H, $J_{3,4}$= 9.5 Hz, H-3), 3.5-4.4 (m, 4H, H-4, H-5, H-6a and H-6b), 5.0 (d, 1 H, $J_{1,2}$= 3.7 Hz, H-1), 6.50, 6.55, 6.75, 6.85, 7.20, 7.33, 8.2 (m, 8 H, Ar).

Anal. Calcd for $C_{28}H_{24}Cl_2NO_{10}$: C, 55.53; H, 3.71; N, 2.15. Found: C, 55.74; H, 3.45; N, 2.10.

4-*O*-(6-*O*-Adamantoyl-α-D-glucopyranosyl)-D-glucopyranose (8b). Mp 115-117 °C (ether-methanol); $[\alpha]^{22}_D$ + 40° (*c* 1, CH_3OH) ; R_f 0.39 (solvent B); ^{1}H NMR (CD_3OD) δ 2.0 (m, 15H, Ad), 3.13 (m, 1H, H-5), 3.28 (dd, 1H, $J_{2,3}$ = 9.47 Hz, H-2), 3.43 (m, 1H, H-5'), 3.56 (m, 2H, H-6a and H-6b), 3.67 (dd, 1H, $J_{2',3'}$= 9.67 Hz,

H-2'), 3.7-3.9 (m, 4H, H-3, H-4, H-3' and H-4'), 4.85 (m, 1H, H-6'b), 4.98 (m, 1H, H-6'a), 5.40 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 5.49 (d, 1 H, $J_{1',2'}$ = 3.84 Hz, H-1').

Anal. Calcd for $C_{23}H_{36}O_{12}$: C, 54.75; H, 7.19. Found: C, 34.61; H, 4.51.

4-*O*-(6-*O*-Methacryloyl-α-D-glucopyranosyl)-D-glucopyranose (8c). Oil; $[\alpha]_D^{22}$ + 30° (*c* 0.5, CH_3OH) ; R_f 0.16 (solvent D); ^1H NMR (CD_3OD) δ 1.60 (s, 3H, CH_3), 3.30 (dd, 1H, $J_{2,3}$ = 9.3 Hz, H-2), 3.55 (dd, 1H, $J_{2',3'}$ = 9.5 Hz, H-2'), 3.58-3.70 (m, 8 H, H-3, H-3', H-4, H-4', H-5, H-5', H-6a and H-6b), 4.05 (m, 2H, H-6'a and H-6'b), 5.45 (d, 1H, $J_{1',2'}$= 4.05 Hz, H-1'), 5.50 (d, 1H, $J_{1,2}$ = 7.7 Hz, H-1), 5.6 (br.s, 1H, H_2C=), 6.05 (br.s, 1H, H_2C=).

Anal. Calcd for $C_{16}H_{26}O_{12}$: C, 46.82; H, 6.39. Found: C, 46.87; H, 6.83.

4-*O*-[6-*O*-[2-(2,7-Dichloro-3,6-dihydroxyanthen-9-yl)benzoyl]-α-D-glucopyranosyl]-D-glucopyranosyl (8d). Decomp- ; coloured orange ; R_f 0.63 (solvent D); ^1H NMR (D_2O) δ 3.22 (dd, 1H, $J_{2,3}$ = 9.41 Hz, H-2), 3.52 (dd, 1H, $J_{2',3'}$ = 9.0 Hz, H-2'), 3.60 (m, 1H, H-5), 3.64 (m, 1H, H-5'), 3.66 (m, 2H, H-6a and H-6b), 3.69 (dd, 1H, $J_{4,5}$ = 9.0 Hz, H-4), 3.72 (dd, 1H, $J_{4',5'}$ 10.9, H-4'), 3.80 (dd, 1H, $J_{3,4}$ = 8.8 Hz, H-3), 3.81 (dd, 1H, $J_{3',4'}$ 9.3 Hz, H-3'), 4.25 (m, 1H, H-6'a), 4.31 (m, 1H, H-6'b), 4.47 (d, 1H, $J_{1,2}$ = 7.98 Hz, H-1), 5.04 (d, 1H, $J_{1',2'}$ = 3.75 Hz, H-1'), 6.50, 6.55, 6.75, 6.85, 7.2, 7.33, 8.2 (m, 8 H, Ar).

Anal. Calcd for $C_{32}H_{30}Cl_2O_{15}$+ H_2O: C, 51.69; H, 4.34. Found: C, 51.66; H, 4.31.

Methyl 6-*O*-(2',2',5',5'-Tetramethyl-1'-oxyl-3'-pyrroline- 3'-carboxyl)-α-D-glucopyranoside (9). Mp 165-170 °C decomp-; $[\alpha]_D^{22}$ + 124° (*c* 1, $CHCl_3$); R_f 0.5 (solvent E). [Lit.[23] mp 169-172°C decomp-; $[\alpha]^{27}_D$ + 125.45° (*c* 1.1, $CHCl_3$)]. The starting **3-carboxy-2,2,5,5,-tetramethylpyrroline-1-oxyl (5e)** was synthesized following ref. 26.

6-*O*-Lauryl-D-glucopyranose (10f). Mp 124-126 °C, $[\alpha]_D^{22}$ + 56.2° (*c* 2, $CHCl_3$); R_f 0.47 (solvent A). [Lit.[7] mp 127 °C, $[\alpha]^{30}_D$ + 59.8° (*c* 0.5, pyridine)].

Methyl 2,3,4-Tri-*O*-acetyl-6-*O*-benzoyl-α-D-glucopyranoside (6'a). Oil, $[\alpha]_D^{22}$ + 106° (*c* 0.75, $CHCl_3$) ; R_f 0.38 (solvent F); ^1H NMR ($CDCl_3$): δ 2.0 (s, 9H, CH_3CO), 3.39 (s, 3H, CH_3O), 4.07 (dd, 1H, $J_{6a,6b}$ = 12.5 Hz, H-6a), 4.13 (dd, 1H, $J_{6a,6b}$ = 12.6 Hz, H-6b) , 4.33 (d, 1H, $J_{1,2}$ = 4.79 Hz, H-1), 4.76 (dd, 1H, $J_{5,6'}$ = 5.5 Hz, H-5), 4.86 (dd, 1H, $J_{2,3}$ = 9.95 Hz, H-2), 5.15 (dd, 1H, $J_{4,5}$ = 9.84 Hz, H-4), 5.5 (dd, 1H, $J_{3,4}$ = 9.53 Hz, H-3), 7.4 and 8.04 (m, 5H, Ar); MS: m/z 442 ($M + NH_4^+$).

Anal. Calcd for $C_{20}H_{24}O_{10}$+ 0.5 H_2O(433.40): C,55.42; H, 5.81. Found: C, 55.61; H, 5.76.

Methyl 2,3,4-Tri-*O*-acetyl-6-*O*-adamantoyl-α-D-glucopyranoside (6'b). Mp 111 °C ; $[\alpha]_D^{22}$ + 90° (*c* 1, $CHCl_3$) ; R_f 0.42 (solvent F); ^1H NMR ($CDCl_3$) δ 1.2-2.0

(m, 15H, Ad), 2.3 (s, 9H, CH_3CO), 3.3 (s, 3H, CH_3 O), 3.96 (m, 1H, H-5), 4.03 (dd, 1H, $J_{6a,6b}$ = 12.4 Hz, H-6a), 4.20 (dd, 1H, $J_{6a,6b}$ = 12.4 Hz, H-6b), 4.45 (dd, 1H, $J_{2,3}$ = 9.2 Hz, H-2), 5.14 (dd, 1H, $J_{4,5}$ = 9.7 Hz , H-4), 5.63 (dd, 1H, $J_{3,4}$ = 9.6 Hz, H-3), 6.14 (d, 1 H, $J_{1,2}$ = 3.7 Hz, H-1); MS: m/z 500 ($M + NH_4^+$).

Anal. Calcd for $C_{24}H_{34}O_{10}$: C, 59.75; H, 7.05. Found: C, 59.64; H, 7.02.

Methyl 2,3,4-Tri-*O*-acetyl-6-*O*-methacryloyl-α-D-glucopyranoside (6'c). Oil; $[\alpha]^{22}_D$ + 82° (*c* 0.9, $CHCl_3$), R_f 0.44 (solvent F); ^1H NMR ($CDCl_3$) δ 1.9 (s, 3H, CH_3C), 2.2 (s, 9H, CH_3CO), 3.38 (s, 3H, CH_3O), 4.2 (m, 2H, H-6a and H-6b), 4.8 (m, 1H, H-5), 4.9 (d, 1H $J_{1,2}$ = 3.6 Hz, H-1), 5.0 (m, 1H, H-2), 5.58 (m, 1H, H-3); MS: m/z 406 ($M + NH_4^+$).

Anal. Calcd for $C_{17}H_{24}O_{10}$: C, 52.57; H, 6.18. Found: C, 52.50; H, 6.20.

2-Acetamido-1,3,4-tri-*O*-acetyl-6-*O*-adamantoyl-2-deoxy-α-D-glucoside (7'b). Mp 56 °C; $[\alpha]^{22}_D$ + 32° (*c* 0.9, $CHCl_3$) ; R_f 0.45 (solvent F); ^1H NMR ($CDCl_3$) δ 1.2-2.0 (m, 15H, Ad), 2.0 (s, 9H, CH_3CO),4.03 (m, 2H, H-6a, H-6b), 5.11 (m, 1H, H-4), 5.18 (m, 1H, H-5), 5.25 (m, 1H, H-3), 5.6 (m, 1H, H-2), 6.14 (d, 1H, $J_{1,2}$= 3.7 Hz, H-1) ; MS: m/z 527 ($M + NH_4^+$), and 450 (M - OAc).

Anal. Calcd for $C_{25}H_{35}NO_{10}$: C, 58.92; H, 6.92; N, 2.74. Found: C, 59.67; H, 7.09; N, 2.31.

2-Acetamido-1,3,4-tri-*O*-acetyl-6-*O*-[2-(2,7-dichloro-3,6-dihydroxyxanthen-9-yl)benzoyl]-2-deoxy-α-D-glucopyranose (7'd). Mp 77-79 °C; coloured orange; R_f 0.50 (solvent F); ^1H NMR ($CDCl_3$) δ 2.0 (s, 9H , CH_3CO), 2.1 (s, 3H, CH_3CON), 3.24 (m, 1H, H-4), 3.70 (m, 1H, H-3), 4.02 (m, 2H, H-6a, H-6b), 4.21 (m, 1H, H-5), 4.39 (m, 1H, H-2), 5.80 (d, 1 H, $J_{1,2}$ = 4.0 Hz, H-1), 6.50, 6.55, 6.75, 6.85, 7.20, 7.33, 8.20 (m, 8 H, Ar); MS: m/z 719 ($M + NH_4^+$), and 642(M - OAc).

Anal. Calcd for $C_{36}H_{31}Cl_2NO_{14}$: C, 61.62; H, 4.45; N, 1.99. Found: C, 61.49; H, 4.54; N, 1.68.

4-*O*-(2,3,4-Tri-*O*-acetyl-6-*O*-adamantoyl)-α-D-glucopyranosyl(1,2,3,6-tetra-*O*-acetyl)-β-D-glucopyranose (8'b). Oil; $[\alpha]^{22}_D$ + 50° (*c* 1, $CHCl_3$); R_f 0.47 (solvent F); ^1H NMR ($CDCl_3$) δ 1.9 (m, 15H, Ad), 2.1 (m, 21H, CH_3CO), 3.99 (m, 2H, H-5 and H-5'), 4.07 (m, 2H, H-4'and H-4), 4.31 (m, 1H, H-6'b), 4.36 (m, 1H, H-6b), 4.40 (m, 1H, H-6a), 4.42 (m, 1H, H-6'a), 4.87 (m, 1H, H-2'), 4.94 (m, 1H, H-2), 5.31 (m, 1H, H-3'), 5.34 (m, 1H, H-3) 5.70 (d, 1H, $J_{1,2}$ = 8.0 Hz, H-1), 6.21 (d, 1H, $J_{1',2'}$ = 4.0 Hz, H'-1); MS: m/z 816 ($M + NH_4^+$) and 739 (M - OAc).

Anal. Calcd for $C_{37}H_{50}O_{19}$: C, 55.63 ; H, 6.31. Found: C, 55.80; H, 6.47.

4-*O*-[2,3,4-Tri-*O*-acetyl-6-*O*-[2-(2,7-dichloro-3,6-dihydroxyanthen-9-yl) benzoyl]-α-D-glucopyranosyl](1,2,3,6-tetra-*O*-acetyl)-β-D-glucopyranose (8'd).

Oil; coloured orange ; R_f 0.64 (solvent H); ^1H NMR ($CDCl_3$): δ 2.1 (m, 21H, CH_3 CO), 3.77 (m, 1H, H-5), 3.90 (m, 1H, H-3), 3.93 (m, 1H, H-6b), 3.97 (m, 2H, H-6'b), 3.99 (m, 1 H, H-6a), 4.13 (m, 1H, H-6'a), 4.18 (m, 1H, H-5'), 4.77 (m, 1H, H-4), 4.85 (m, 1H, H-3'), 4.96 (m, 1H, H-4'), 5.24 (m, 1H, H-2), 5.67 (d, 1H, $J_{1,2}$ = 8.1 Hz, H-1), 6.18 (d, 1H, $J_{1',2'}$ = 3.6 Hz, H'-1), 6.50, 6.55, 6.75, 6.85, 7.2, 7.33, 8.2 (m, 8H, Ar); MS: m/z 1079 ($M + NH_4^+$) .

Anal. Calcd for $C_{48}H_{46}Cl_2O_{23}$ + 3 H_2O: C, 51.65; H, 5.02. Found: C, 51.81; H, 5.44.

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