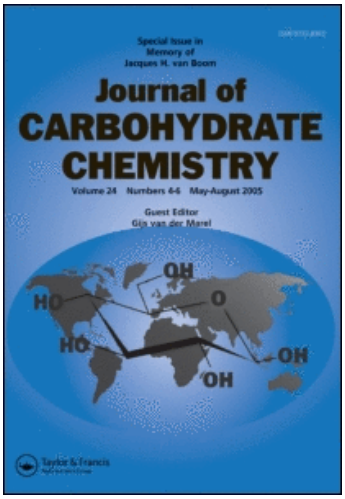

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C-Glycosylated Diphenylmethanes and Benzophenones: The Stille Coupling Reaction of *C*-Glycosylated Aryl Tins with Benzyl Bromides and Acid Chlorides

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C-GLYCOSYLATED DIPHENYLMETHANES AND BENZOPHENONES: THE STILLE COUPLING REACTION OF *C*-GLYCOSYLATED ARYL TINS WITH BENZYL BROMIDES AND ACID CHLORIDES

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ABSTRACT

C-glycosylated diphenylmethanes and *C*-glycosylated benzophenones were prepared by the palladium-catalyzed cross-coupling reaction of *C*-glycosylated aryl tins with various benzyl bromides or acid chlorides to provide physiologically stable glycomimetics of miscellaneous glycoepitopes.

INTRODUCTION

In the course of our studies on the synthesis of stable glycomimetics, *C*-glycosylated aryl tins were shown to be versatile synthetic intermediates[1] because of the palladium-mediated C-C bond forming reaction. In the preceding paper, we reported[2] the facile preparation of *C*-glycosylated biphenyls under the Stille coupling condition.[3]

Preparation of various *C*-glycosides on different classes of aromatic platforms may offer the possibility for the discovery of new lead compounds having novel biological activities and therapeutic value.

Here we wish to report the synthesis of *C*-glycosylated diphenylmethanes and *C*-glycosylated benzophenones readily prepared by coupling *C*-glycosylated aryl tins with various benzyl bromides or acid chlorides by the palladium-catalyzed cross-coupling reaction.

RESULTS AND DISCUSSION

The Stille coupling reaction[3] has been extensively studied and great efforts have been made to expand its application range. Now stannyl compounds are known to react with numerous electrophiles such as aryl halides,[2] benzyl halides,[4] and acid halides.[5]

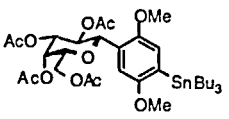
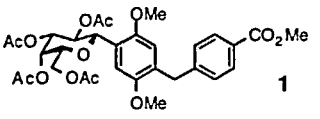
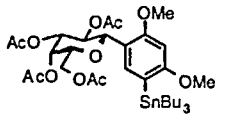
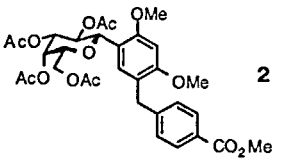
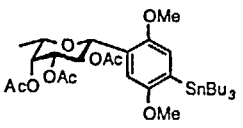
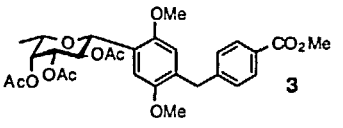
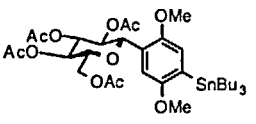
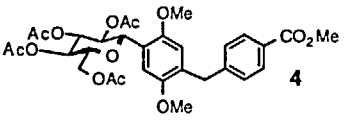
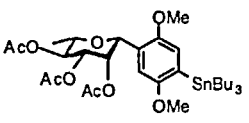
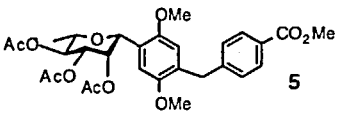
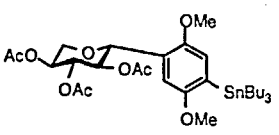
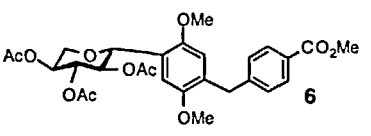
Several reported methods were first examined for the preparation of *C*-glycosylated diphenylmethanes using tri-*n*-butyl[2,5-dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)phenyl]stannane and methyl 4-(bromomethyl)benzoate as representative coupling partners. Among a number of reported procedures, including use of $Pd(PPh_3)_4$, PPh_3, CuBr and 2,6-di-*t*-butyl-*p*-cresol in refluxing DMF, which was effective for the preparation of the *C*-glycosylated biphenyls,[2] the combination of $PdCl_2$(dppe) and Na_2CO_3 in refluxing toluene was found to be the method of choice and afforded the *C*-galactosylated diphenylmethane, methyl 4-[2,5-dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzyl]benzoate (**1**) in 78% yield (Table 1, entry 1).

Next, we examined the effect of sugar moieties on the coupling yields using different *C*-glycosylated aryl tins and methyl 4-(bromomethyl)benzoate under the same conditions (Table 1). Table 1 shows that a 1,3-substituted *C*-galactosylated aryl tin also afforded the *C*-galactosylated diphenylmethane (**2**) in 66% yield (entry 2). L-Fucose-, D-glucose-, L-rhamnose- and D-xylose-derived *C*-glycosylated aryl tins were also suitable for this synthetic method and gave the *C*-glycosylated diphenylmethanes in good yields (entries 3-6).

Having established the conditions that afforded the various *C*-glycosylated benzyl benzoates in good yields, our attention was turned to benzyl bromides with other functional groups (Table 2). In the case of *C*-glycosylated biphenyls no substituent effect on the ring was observed, whereas for the coupling with benzyl bromides a severe effect was observed. In the case of *p*-bromomethylbenzonitrile and of *p*-nitrobenzyl bromide (entries 2 and 3), condition A afforded the products in yields of 33% and 37%, respectively.

Further examination of various reaction conditions using the *C*-galactosylated aryl tin and *p*-bromomethylbenzonitrile indicated that a combination of $Pd(PPh_3)_4$ and K_2CO_3 in refluxing 1,4-dioxane afforded the coupled product (**7**) in 81% yield (entry 2, condition B). Under condition B the *C*-galactosylated aryl tin reacted with not only electron-deficient benzyl bromides such as ones bearing a cyano or a nitro group, but also with methyl,

TABLE 1. Reaction of Various *C*-Glycosylated Aryl Tins with Methyl (4-Bromomethyl)benzoate[a]

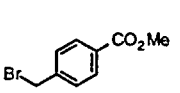
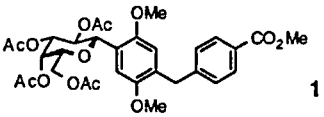
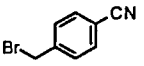
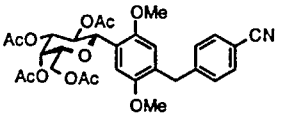
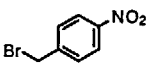
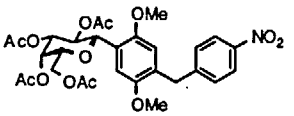
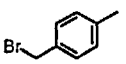
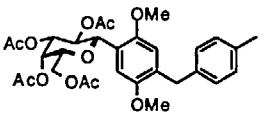
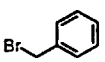
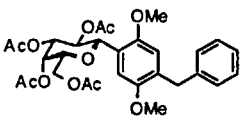
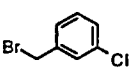
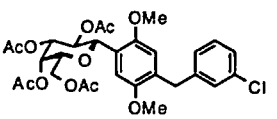
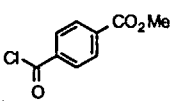
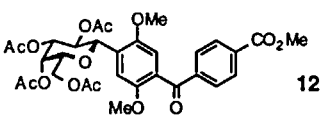
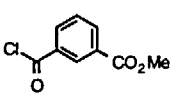
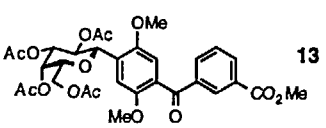
Entry	*C*-glycosylated aryl tins	Product	Yield
1			78%
2			66%
3			83%
4			80%
5			82%
6			52%

a. All reactions were carried out in refluxing toluene using *C*-glycosylated aryl tins, methyl (4-bromomethyl)benzoate, $PdCl_2$(dppe) and Na_2CO_3 under the following equivalency (1: 3: 0.1: 2).

hydrogen, or chloride substituted benzyl bromides to afford each *C*-glycosylated diphenylmethane in good yield (entries 3-6).

Reported to be used as electrophiles in the Stille reaction, acid chlorides were also examined to afford the *C*-glycosylated benzophenones. In the case of methyl 4-chlorocarbonylbenzoate, condition A afforded the *C*-glycosylated benzophenone (**12**) in 72% yield (entry 7). Concurrently, the *C*-glycosylated biphenyl was also obtained in 28% yield as a result of carbon monoxide evolution from the Pd-complex, which comprised the

TABLE 2. Study with Various Benzyl Bromides and Acid Chlorides

Entry	Electrophile	Product	Yield Condition A[a]	Yield Condition B[b]
1		 **1**	78%	
2		 **7**	33%	81%
3		 **8**	37%	79%
4		 **9**		80%
5		 **10**		69%
6		 **11**		69%
7		 **12**	72%	
8		 **13**	91%	

a. Condition A: *C*-glycosylated aryl tin; electrophile; $PdCl_2(dppe)$; Na_2CO_3 = 1: 3: 0.1: 2 in refluxing toluene. b. Condition B: *C*-glycosylated aryl tin; electrophile; $Pd(PPh_3)_4$; K_2CO_3 = 1: 3: 0.1: 2 in refluxing 1,4-dioxane.

acid chloride and palladium catalyst.[6] However, the *C*-glycosylated benzophenone and the *C*-glycosylated biphenyl were separable by column chromatography. A reaction of methyl 3-chlorocarbonylbenzoate with the *C*-galactosylated aryl tin also afforded the *C*-glycosylated benzophenone (**13**) in 91% yield. In this case, the corresponding *C*-glycosylated biphenyl was not observed by TLC analysis (entry 8).

CONCLUSION

The *C*-glycosylated aryl tins were successfully combined with benzyl bromides and acid chlorides under the Stille reaction to provide various *C*-glycosylated diphenylmethanes and *C*-glycosylated benzophenones. All products are now being evaluated for their bioactivities. Reactions of *C*-glycosylated aryl tins with other electrophiles will be described elsewhere.

EXPERIMENTAL

General methods. Analytical TLC was done on E. Merck precoated (0.25 mm) silica gel 60 F254 plates. Column chromatography was conducted using silica gel 60 (E. Merck 9385, 230-400 mesh). Melting points were measured with a Yanaco MP-500D and were uncorrected. Infrared (IR) spectra were recorded on a JASCO FT-IR-8900 spectrometer. ^{1}H NMR spectra were measured on a JEOL-JNM-EX-270 (270 MHz) or a JEOL JNM-GX-270 (270 MHz) spectrometer. Chemical shifts from ^{1}H NMR spectra are reported relative to tetramethylsilane (δ 0). Splitting patterns are indicated as s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad. Mass spectra were recorded with a JEOL HX-100, a SX-102A or a JMS-AX-505H mass spectrometer. Optical rotation was measured on a Perkins-Elmer 241 polarimeter. All experiments were carried out under a nitrogen atmosphere. In experiments requiring dry solvents, dry toluene and 1,4-dioxane were purchased from Kanto Chemica. Other chemicals were used as purchased.

Methyl 4-[2,5-Dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzyl]benzoate (1). A suspended solution of tri-*n*-butyl[2,5-dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)phenyl]stannane (200.5 mg, 0.265 mmol), methyl (4-bromomethyl)benzoate (219.5 mg, 0.958 mmol), [1,2-bis(diphenylphosphino)-ethane]dichloropalladium (II) (14.9 mg, 0.0259 mmol), and Na_2CO_3 (57.6 mg, 0.543 mmol) in toluene was refluxed for 8 h under a nitrogen atmosphere. The resulting mixture was diluted with ethyl acetate, washed with a saturated aqueous KF solution, a saturated aqueous Na_2CO_3 solution, and brine, dried over $MgSO_4$, and concentrated under reduced pressure. A purification of the resulting residue by column chromatography with ethyl

acetate/hexane (1:3) provided the product (127.8 mg, 0.207 mmol) in 78% yield: mp 41-43 °C; TLC R_f 0.32 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.93 (d, 2H, J = 8.2 Hz, Ar), 7.23 (d, 2H, J = 8.2 Hz, Ar), 6.95 (s, 1H, Ar), 6.60 (s, 1H, Ar), 5.53 (d, 1H, J = 3.4 Hz, H_4), 5.53 (t, 1H, J = 10.0 Hz, H_2), 5.21 (dd, 1H, J = 10.0 Hz and 3.4 Hz, H_3), 4.91 (d, 1H, J = 10.0 Hz, H_1), 4.22-3.92 (m, 5H, H_5, H_6 and $ArCH_2Ar$), 3.90 (s, 3H, OMe), 3.79 (s, 3H, OMe), 3.72 (s, 3H, OMe), 2.21 (s, 3H, OAc), 2.03 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.79 (s, 3H, OAc); IR (KBr pellet) 2956, 2938, 2856, 1752, 1722 cm^{-1}; FABHRMS *m/z* 616.2155 (616.2156 Calcd for $C_{31}H_{36}O_{13}$ $[M]^+$); $[\alpha]_D^{23}$ -4.2° (*c* 0.83 CH_2Cl_2).

Methyl 4-[2,4-Dimethoxy-5-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzyl]benzoate (2). 66% yield; TLC R_f 0.48 (hexane/EtOAc 1:1); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.92 (d, 2H, J = 8.1 Hz, Ar), 7.24 (d, 2H, J = 8.1 Hz, Ar), 7.16 (s, 1H, Ar), 6.40 (s, 1H, Ar), 5.53 (t, 1H, J = 10.1 Hz, H_2), 5.49 (d, 1H, J = 2.7 Hz, H_4), 5.17 (dd, 1H, J = 10.1 Hz and 2.7 Hz, H_3), 4.80 (d, 1H, J = 10.1 Hz, H_1), 4.16-3.92 (m, 5H, H_5, H_6 and $ArCH_2Ar$), 3.88 (s, 3H, OMe), 3.85 (s, 3H, OMe), 3.76 (s, 3H, OMe), 2.18 (s, 3H, OAc), 2.02 (s, 3H, OAc), 1.98 (s, 3H, OAc), 1.75 (s, 3H, OAc); IR (KBr pellet) 3467, 2999, 2954, 2842, 1752, 1721, 1370 cm^{-1}; FABHRMS *m/z* 617.2241 (617.2234 Calcd for $C_{31}H_{37}O_{13}$ $[M+H]^+$); $[\alpha]_D^{23}$ +2.4° (*c* 0.42 CH_2Cl_2).

Methyl 4-[2,5-Dimethoxy-4-(2,3,4-tri-*O*-acetyl-β-L-fucopyranosyl)benzyl]benzoate (3). 83% yield; mp 49-50 °C; TLC R_f 0.40 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.92 (d, 2H, J = 8.2 Hz, Ar), 7.22 (d, 2H, J = 8.2 Hz, Ar), 6.97 (s, 1H, Ar), 6.60 (s, 1H, Ar), 5.53 (t, 1H, J = 10.0 Hz, H_2), 5.37 (d, 1H, J = 3.1 Hz, H_4), 5.30 (s, 2H, $ArCH_2Ar$), 5.21 (dd, 1H, J = 10.0 Hz and 3.1 Hz, H_3), 4.89 (d, 1H, J = 10.0 Hz, H_1), 3.97 (q, 1H, J = 6.0 Hz, H_5), 3.89 (s, 3H, OMe), 3.78 (s, 3H, OMe), 3.72 (s, 3H, OMe), 2.24 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.79 (s, 3H, OAc), 1.22 (d, 3H, J = 6.0 Hz, H_6); IR (KBr pellet) 2990, 2951, 2941, 2838, 1750, 1722, 1609, 1509 cm^{-1}; FABHRMS *m/z* 558.2095 (558.2101 Calcd for $C_{29}H_{34}O_{11}$ $[M]^+$); $[\alpha]_D^{23}$ +15.3° (*c* 1.22 CH_2Cl_2).

Methyl 4-[2,5-Dimethoxy-4-(2,3,4-tri-*O*-acetyl-β-D-glucopyranosyl)benzyl]benzoate (4). 80% yield; mp 39-41 °C; TLC R_f 0.41 (hexane/EtOAc 1:1); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.93 (d, 2H, J = 8.1 Hz, Ar), 7.23 (d, 2H, J = 8.1 Hz, Ar), 6.89 (s, 1H, Ar), 6.59 (s, 1H, Ar), 5.37-5.20 (m, 3H, H_3, H_4 and H_2), 4.93 (d, 1H, J = 9.8 Hz, H_1), 4.26 (dd, 1H, J = 12.3 Hz and 4.7 Hz, H_6), 4.14 (dd, 1H, J = 12.3 Hz and 2.1 Hz, H_6), 4.04 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.92 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.89 (s, 3H, OMe), 3.87-3.82 (m, 1H, H_5), 3.77 (s, 3H, OMe), 3.71 (s, 3H, OMe), 2.07 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.01 (s, 3H, OAc), 1.78 (s, 3H, OAc); IR (KBr pellet) 3469, 3435, 2998, 2955, 2856, 1754, 1721, 1509 cm^{-1}; FABHRMS *m/z* 616.2160 (616.2156 Calcd for $C_{31}H_{36}O_{13}$ $[M]^+$); $[\alpha]_D^{23}$ -17° (*c* 0.41 CH_2Cl_2).

Methyl 4-[2,5-Dimethoxy-4-(2,3,4-tri-*O*-acetyl-β-L-rhamnopyranosyl)benzyl]benzoate (5). 82% yield; mp 63-64 °C; TLC R_f 0.49 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.91 (d, 2H, J = 8.2 Hz, Ar), 7.20 (d, 2H, J = 8.2 Hz, Ar), 7.02 (s, 1H, Ar), 6.55 (s, 1H, Ar), 5.55 (d, 1H, J = 3.2 Hz, H_2), 5.26 (dd, 1H, J = 9.6 Hz and 3.2 Hz, H_4), 5.15 (t, 1H, J = 9.6 Hz, H_3), 5.02 (s, 1H, H_1), 4.07 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.89 (s, 3H, OMe), 3.88 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.75 (s, 3H, OMe), 3.71 (s, 3H, OMe), 3.71-3.65 (m, 1H, H_5), 2.08 (s, 3H, OAc), 1.98 (s, 3H, OAc), 1.91 (s, 3H, OAc), 1.33 (d, 3H, J = 6.1 Hz, H_6); IR (KBr pellet) 3470, 2986, 2940, 2858, 1749, 1722, 1508 cm^{-1}; FABHRMS *m/z* 559.2155 (559.2179 Calcd for $C_{29}H_{35}O_{11}$ $[M+H]^+$); $[\alpha]_D^{23}$ +38° (*c* 0.45 CH_2Cl_2).

Methyl 4-[2,5-Dimethoxy-4-(2,3,4-tri-*O*-acetyl-β-D-xylopyranosyl)benzyl]benzoate (6). 52% yield; TLC R_f 0.51 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.92 (d, 2H, J = 8.2 Hz, Ar), 7.21 (d, 2H, J = 8.2 Hz, Ar), 6.89 (s, 1H, Ar), 6.58 (s, 1H, Ar), 5.36 (t, 1H, J = 9.4 Hz, H_2), 5.32 (t, 1H, J = 9.4 Hz, H_3), 5.20-5.11 (m, 1H, H_4), 4.83 (d, 1H, J = 9.4 Hz, H_1), 4.21 (dd, 1H, J = 11.0 Hz and 5.7 Hz, H_5), 4.05 (d, 1H, J = 15.4 Hz, $ArCH_2Ar$), 3.92 (d, 1H, J = 15.4 Hz, $ArCH_2Ar$), 3.89 (s, 3H, OMe), 3.76 (s, 3H, OMe), 3.71 (s, 3H, OMe), 3.47 (t, 1H, J = 11.0 Hz, H_5), 2.06 (s, 3H, OAc), 2.03 (s, 3H, OAc), 1.78 (s, 3H, OAc); IR (KBr pellet) 2999, 2953, 2858, 1755, 1721, 1609, 1509 cm^{-1}; FABHRMS *m/z* 567.1855 (567.1842 Calcd for $C_{28}H_{32}O_{11}Na$ $[M+Na]^+$); $[\alpha]_D^{23}$ -39° (*c* 0.51 CH_2Cl_2).

4-[2,5-Dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzyl]benzonitrile (7). A suspended solution of tri-*n*-butyl[2,5-dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)phenyl]stannane (185.8 mg, 0.245 mmol), *p*-bromomethylbenzonitrile (148.5 mg, 0.757 mmol), tetrakis(triphenylphosphine)palladium (0) (28.6 mg, 0.0247 mmol), and K_2CO_3 (73.2 mg, 0.530 mmol) in 1,4-dioxane was refluxed for 8 h under a nitrogen atmosphere. The resulting mixture was extracted with ethyl acetate and washed with a saturated aqueous KF solution, a saturated aqueous Na_2CO_3 solution, and brine, dried over $MgSO_4$, and concentrated under reduced pressure. A purification of the resulting residue by column chromatography with ethyl acetate/hexane (1:3) provided the product (116.3 mg, 0.199 mmol) in 81% yield: mp 32-33 °C; TLC R_f 0.26 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.54 (d, 2H, J = 8.2 Hz, Ar), 7.27 (d, 2H, J = 8.2 Hz, Ar), 6.96 (s, 1H, Ar), 6.61 (s, 1H, Ar), 5.53 (d, 1H, J = 3.4 Hz, H_4), 5.51 (t, 1H, J = 9.9 Hz, H_2), 5.22 (dd, 1H, J = 9.9 Hz and 3.4 Hz, H_3), 4.91 (d, 1H, J = 9.9 Hz, H_1), 4.23-4.05 (m, 3H, H_5 and H_6), 4.05 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.91 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.78 (s, 3H, OMe), 3.75 (s, 3H, OMe), 2.21 (s, 3H, OMe), 2.03 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.80 (s, 3H, OAc); IR (KBr pellet) 3432, 2566, 2857, 2228, 1751, 1507 cm^{-1}; FABHRMS *m/z* 583.2059 (583.2054 Calcd for $C_{30}H_{33}O_{11}N$ $[M]^+$); $[\alpha]_D^{23}$ -3° (*c* 0.31 CH_2Cl_2).

1,4-Dimethoxy-2-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-5-(4-nitrobenzyl)benzene (8). 79% yield; mp 51-52 °C; TLC R_f 0.65 (hexane/EtOAc 1:1); ^{1}H NMR (270 MHz, $CDCl_3$) δ 8.11 (d, 2H, J = 8.6 Hz, Ar), 7.31 (d, 2H, J = 8.6 Hz, Ar), 6.97 (s, 1H, Ar), 6.63 (s, 1H, Ar), 5.53 (d, 1H, J = 3.5 Hz, H_4), 5.51 (t, 1H, J = 10.0 Hz, H_2), 5.22 (dd, 1H, J = 10.0 Hz and 3.5 Hz, H_3), 4.91 (d, 1H, J = 10.0 Hz, H_1), 4.22-4.07 (m, 3H, H_5 and H_6), 4.09 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.86 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.78 (s, 3H, OMe), 3.75 (s, 3H, OMe), 2.21 (s, 3H, OAc), 2.03 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.80 (s, 3H, OAc); IR (KBr pellet) 3470, 2940, 1751, 1598, 1520 cm^{-1}; FABHRMS *m/z* 603.1960 (603.1952 Calcd for $C_{29}H_{33}O_{13}N$ $[M]^+$); $[\alpha]_D^{23}$ -5.1° (*c* 0.70 CH_2Cl_2).

1,4-Dimethoxy-2-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-5-(4-methylbenzyl)benzene (9). 80% yield; mp 40-41 °C; TLC R_f 0.54 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.06 (s, 4H, Ar), 6.93 (s, 1H, Ar), 6.61 (s, 1H, Ar), 5.54 (t, 1H, J = 10.0 Hz, H_2), 5.52 (d, 1H, J = 3.4 Hz, H_4), 5.21 (dd, 1H, J = 10.0 Hz and 3.4 Hz, H_3), 4.90 (d, 1H, J = 10.0 Hz, H_1), 4.23-4.01 (m, 3H, H_5 and H_6), 3.96 (d, 1H, J = 15.2 Hz, $ArCH_2Ar$), 3.84 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.80 (s, 3H, OMe), 3.71 (s, 3H, OMe), 2.31 (s, 3H, OAc), 2.21 (s, 3H, OAc), 2.03 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.79 (s, 3H, OAc); IR (KBr pellet) 3456, 3000, 2938, 2860, 1752, 1509 cm^{-1}; FABHRMS *m/z* 572.2269 (572.2258 Calcd for $C_{30}H_{36}O_{11}$ $[M]^+$); $[\alpha]_D^{23}$ -3.5° (*c* 0.10 CH_2Cl_2).

1,4-Dimethoxy-2-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-5-benzylbenzene (10). 69% yield; mp 33-35 °C; TLC R_f 0.44 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.29-7.16 (m, 5H, Ar), 6.94 (s, 1H, Ar), 6.61 (s, 1H, Ar), 5.54 (t, 1H, J = 10.0 Hz, H_2), 5.52 (d, 1H, J = 3.5 Hz, H_4), 5.21 (dd, 1H, J = 10.0 Hz and 3.5 Hz, H_3), 4.91 (d, 1H, J = 10.0 Hz, H_1), 4.21-4.07 (m, 3H, H_5 and H_6), 4.01 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.88 (d, 1H, J = 15.3 Hz, $ArCH_2Ar$), 3.80 (s, 3H, OMe), 3.71 (s, 3H, OMe), 2.21 (s, 3H, OAc), 2.02 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.79 (s, 3H, OAc); IR (KBr pellet) 2939, 1751, 1509, 1370, 1220 cm^{-1}; FABHRMS *m/z* 581.1973 (581.1999 Calcd for $C_{29}H_{34}O_{11}Na$ $[M+Na]^+$); $[\alpha]_D^{23}$ -4.7° (*c* 0.38 CH_2Cl_2).

1,4-Dimethoxy-2-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-5-(3-chrolobenzyl)benzene (11). 69% yield; mp 29-30 °C; TLC R_f 0.47 (hexane/EtOAc 3:2); ^{1}H NMR (270 MHz, $CDCl_3$) δ 7.25-7.14 (m, 2H, Ar), 7.10-7.04 (m, 2H, Ar), 6.96 (s, 1H, Ar), 6.61 (s, 1H, Ar), 5.53 (t, 1H, J = 9.9 Hz, H_2), 5.52 (d, 1H, J = 3.4 Hz, H_4), 5.22 (dd, 1H, J = 9.9 Hz and 3.4 Hz, H_3), 4.91 (d, 1H, J = 9.9 Hz, H_1), 4.24-4.05 (m, 3H, H_5 and H_6), 3.98 (d, 1H, J = 15.1 Hz, $ArCH_2Ar$), 3.82 (d, 1H, J = 15.1 Hz, $ArCH_2Ar$), 3.79 (s, 3H, OMe), 3.74 (s, 3H, OMe), 2.21 (s, 3H, OAc), 2.03 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.80 (s, 3H, OAc); IR (KBr pellet) 2939, 1751,

1509, 1370 cm^{-1}; FABHRMS *m/z* 592.1721 (592.1730 Calcd for $C_{29}H_{33}O_{11}{}^{35}Cl$ $[M]^+$); $[\alpha]_D{}^{23}$ -36° (*c* 0.45 CH_2Cl_2).

Methyl 4-[2,5-Dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzoyl]benzoate (12). 72% yield; TLC R_f 0.25 (hexane/EtOAc 3:2); ^1H NMR (270 MHz, $CDCl_3$) δ 8.19 (d, 2H, *J* = 8.4 Hz, Ar), 7.81 (d, 2H, *J* = 8.4 Hz, Ar), 7.11 (s, 1H, Ar), 6.97 (s, 1H, Ar), 5.55 (d, 1H, *J* = 3.6 Hz, H_4), 5.50 (t, 1H, *J* = 9.9 Hz, H_2), 5.25 (dd, 1H, *J* = 9.9 Hz and 3.4 Hz, H_3), 4.99 (d, 1H, *J* = 9.9 Hz, H_1), 4.23-4.11 (m, 3H, H_5 and H_6), 3.95 (s, 3H, OMe), 3.83 (s, 3H, OMe), 3.65 (s, 3H, OMe), 2.22 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.00 (s, 3H, OAc), 1.85 (s, 3H, OAc); IR (KBr pellet) 3440, 3000, 2955, 1753, 1727, 1672 cm^{-1}; FABHRMS *m/z* 653.1838 (653.1846 Calcd for $C_{31}H_{34}O_{14}Na$ $[M+Na]^+$); $[\alpha]_D{}^{23}$ -30° (*c* 0.39 CH_2Cl_2).

Methyl 3-[2,5-Dimethoxy-4-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)benzoyl]benzoate (13). 91% yield; TLC R_f 0.33 (hexane/EtOAc 1:1); ^1H NMR (270 MHz, $CDCl_3$) δ 8.41 (s, 1H, Ar), 8.22 (d, 1H, *J* = 7.8 Hz, Ar), 7.97 (d, 1H, *J* = 7.8 Hz, Ar), 7.53 (t, 1H, *J* = 7.8 Hz, Ar), 7.12 (s, 1H, Ar), 6.97 (s, 1H, Ar), 5.56 (d, 1H, *J* = 3.4 Hz, H_4), 5.53 (t, 1H, *J* = 9.9 Hz, H_2), 5.26 (dd, 1H, *J* = 9.9 Hz and 3.4 Hz, H_3), 5.01 (d, 1H, *J* = 9.9 Hz, H_1), 4.26-4.08 (m, 3H, H_5 and H_6), 3.93 (s, 3H, OMe), 3.83 (s, 3H, OMe), 3.66 (s, 3H, OMe), 2.22 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.01 (s, 3H, OAc), 1.85 (s, 3H, OAc); IR (KBr pellet) 3434, 2956, 2857, 1752, 1728, 1674, 1401 cm^{-1}; FABHRMS *m/z* 631.1999 (631.2027 calcd for $C_{31}H_{35}O_{14}$ $[M+H]^+$); $[\alpha]_D{}^{23}$ -26.2° (*c* 0.707 CH_2Cl_2).

REFERENCES AND NOTES

1. T. Kuribayashi, Y. Mizuno, S. Gohya and S. Satoh, *J. Carbohydr. Chem.*, preceding paper in this issue.
2. T. Kuribayashi, S. Gohya, Y. Mizuno and S. Satoh, *J. Carbohydr. Chem.*, preceding paper in this issue.
3. (a) J. Tsuji, *Palladium Reagents and Catalysts: Innovations in Organic Synthesis*; Wiley: New York, 1995, p 228; (b) J. K. Stille, *Angew. Chem. Int. Ed. Engl.*, **25**, 508 (1986); (c) T. N. Mitchell, *Synthesis*, 803 (1992); (d) V. Farina, V. Krishnamurthy and W. J. Scott, in *Organic Reactions*; L. A. Paquette, Ed.; Wiley: New York, 1997, p 1.
4. (a) D. Milstein and J. K. Stille, *J. Am. Chem. Soc.*, **101**, 4992 (1979); (b) S. S. Labadie and E. Teng, *J. Org. Chem.*, **59**, 4250 (1994).
5. (a) D. Milstein and J. K. Stille, *J. Org. Chem.*, **44**, 1613 (1979); (b) B. Jousseaume, H. A. Kwon, J. -B. Verlhac, F. Denat and J. Dubac, *Synlett*, 117 (1993).
6. J. Tsuji and K. Ohno, *J. Am. Chem. Soc.*, **90**, 94 (1968).