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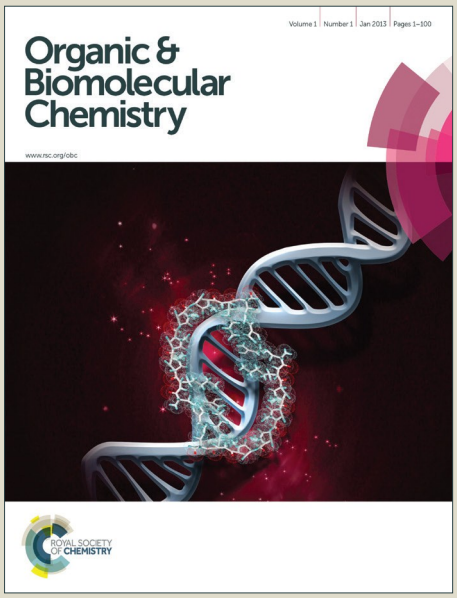

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Total Synthesis of Mangiferin, Homomangiferin, and Neomangiferin

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Total synthesis of mangiferin, homomangiferin, and neomangiferin, three *C*-glycosyl xanthone natural products with a wide spectrum of pharmacological effects, have been achieved starting from 2,3,4,6-tetra-*O*-benzyl-α/β-D-glucopyranose. The key steps involve a stereoselective Lewis acid promoted *C*-glycosylation of protected phloroglucinol with tetrabenzylglucopyranosyl acetate and a highly regioselective base-induced cyclization for the construction of the core xanthone skeleton.

Introduction

Aryl *C*-glycosides represent a unique class of natural products with *C*-*C* glycosidic bonds in their core skeleton.[1] Possessing remarkable stability toward both enzymatic and chemical hydrolysis,[2] these compounds usually exhibit a range of interesting biological properties and therefore are considered favorably as drug candidates.[3] Mangiferin (**1**, Figure 1), a representative *C*-glycosyl xanthonoid, was originally isolated as a colorant matter from the mango tree (*Mangifera Indica* L.) by Wiechowski and co-workers in 1908[4] and now has been found in many angiosperm plants and ferns.[5] Since its discovery, mangiferin has been shown to possess a wide spectrum of pharmacological activities, including antioxidant, antitumor, antiinflammatory, antidiabetic, lipolytic, antimicrobial, and antiallergic activities, and thus has been considered as a promising lead compound.[6] The structurally related xanthonoids homomangiferin (**2**) and neomangiferin (**3**),[7,8] typically coisolated with mangiferin but in a lesser amount, also display good antidiabetic properties.[9] In view of their impressive biological profile, we decide to undertake the total synthesis of these mangiferin xanthonoids.

Mangiferin was first obtained in about 0.1% yield via treatment of the aglycon 1,3,6,7-tetrahydroxyxanthone with a large excess of α-D-glucopyranosyl bromide in 1967.[10] It was not until 2010 when Yu and co-workers accomplished the first total synthesis of mangiferin, isomangiferin and homomangiferin, utilizing a highly stereoselective *C*-glycosylation between a xanthone derivative and tetrabenzylglucopyranosyl *N*-phenyltrifluoro acetimidate, but with a relatively low overall yield and poor regioselectivety.[11] Recently, our group reported an efficient semisynthesis of neomangiferin from naturally isolated mangiferin.[12] Nevertheless, the total synthesis of this molecule **3**, which bears both *O*- and *C*-glycosides, is still a challenge.

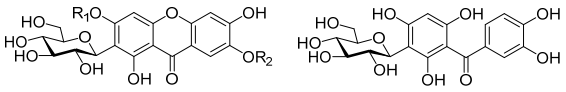

Figure 1. Structures of mangiferin (**1**), homomangiferin (**2**), neomangiferin (**3**) and the key biosynthetic intermediate (**4**).

In this work, we have based our synthetic studies on the biosynthetic pathway of mangiferin, in which benzophenone **4** acts as the key intermediate and the glucosylation takes place just prior to the construction of the core xanthone skeleton.[13] Herein, we provide our efficient synthetic approach to mangiferin (**1**) and homomangiferin (**2**), and we also report the first total synthesis of neomangiferin (**3**).

Result and discussion

Retrosynthetic analysis of mangiferin xanthonoids

Retrosynthetically, we envisioned that the key *C*-*C* glycosidic linkage between sugar and aromatic aglycon could be fashioned by a *O*-*C* rearrangement glycosylation (in which the *O*-glycoside intermediates was formed initially and then followed by Fries-type rearrangement to give the ortho *C*-glycoside) between 2,3,4,6-tetrabenzylglucose **5** and benzaldehyde **6**,[14] or by a Lewis acid promoted Friedel-Crafts type glycosylation between **5** and phloroglucinol derivative **7**.[15] Subsequent addition of aryl-metal **10** to the *C*-glycoside precursor **9,** followed by benzylic oxidation and selective deprotection would then provide the corresponding benzophenone **11**,[16] and the xanthone skeleton, which is the basic structure of the desired natural products (**1**-

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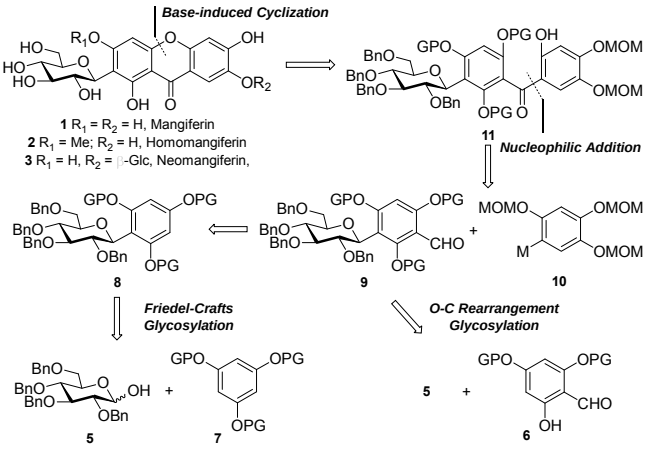
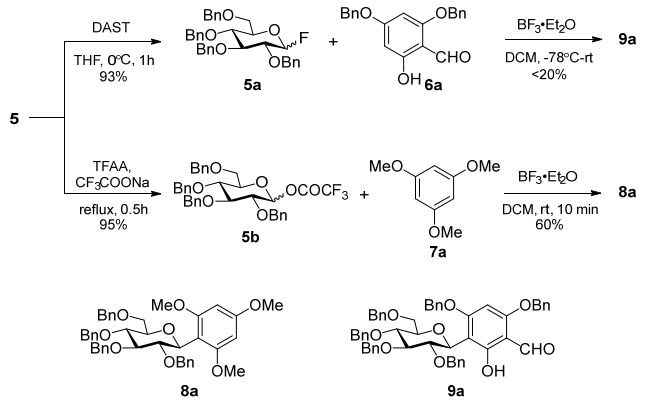
3), would be eventually constructed via a base-induced cyclization.[17] (Scheme 1)



Scheme 1. Retrosynthetic analysis of mangiferin xanthonoids.

Total synthesis of homomangiferin

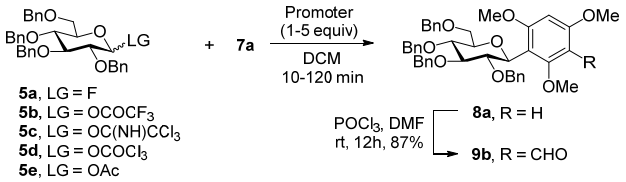
Our studies commenced by focusing on obtaining access to *C*-glycoside precursor **9** (Scheme 2). At the outset, a *O*-*C* rearrangement glycosylation using glycosyl fluoride **5a** (fluorinated from **5**) as the donor was attempted, expecting to introduce the sugar moiety directly onto the aromatic ring of benzaldehyde derivative **6a**.[14] However, due to the electron deficiency of acceptor **6a**, coupling between **5a** and **6a** gave only low yields of the desired *C*-glycoside product **9a**, regardless of the promoters, solvents and conditions we used. Thus, to remove the electron withdrawing effect of aldehyde group, a Friedel-Crafts type glycosylation[18] our group reported before was utilized instead. As anticipated, the glycosyl trifluoroacetate **5b**, easily esterified from **5**, reacted smoothly with trimethoxybenzene **7a** (2 equiv) in the presence of $BF_3{\cdot}Et_2O$ (1 equiv) as a Lewis acid promoter, providing *C*-aryl glycoside **8a** as a single *β*-anomer (H-1′: 4.12 ppm, d, *J* = 10.4 Hz) in 60% yield.



Scheme 2. *C*-glycosylation of carbohydrate **5a** and **5b**.

To further improve the relatively low yield of the coupling reaction, we performed a minor optimization study by varying the leaving groups on the glycosyl donor, as well as the corresponding promoters (Table 1). The results showed that, glycosyl acetate **5e**,[19] which was less reactive than **5b/5c/5d**, was a more suitable partner for the *C*-glycosylation reaction on the contrary, and accordingly, by treating donor **5e** with trimethoxybenzene **7a** (2 equiv) and TMSOTf (5 equiv) in a mixture solvent of CH_2Cl_2/THF at 0 °C for 1 h, the desired *C*-aryl precursor **8a** was obtained in a high 84% yield, with the anomeric stereoselectivity remaining unchanged (Table 1, Entry 5).

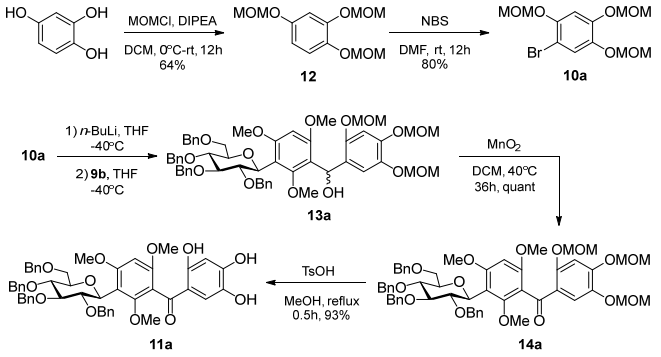
Table 1. Optimization of the *C*-glycosylation reaction



Entry	Donor	Promoter	T (°C)	Result[a]
1	**5a**	$BF_3{\cdot}Et_2O$ (2 eq)	0	Complex
2	**5b**	$BF_3{\cdot}Et_2O$ (1 eq)	rt	60%[b]
3	**5c**	TMSOTf (1 eq)	-30	[c]
4	**5d**	TMSOTf (2 eq)	rt	complex
5[d]	**5e**	TMSOTf (5 eq)	0	84%[b]

[a]Isolated yields were obtained using 2-3 equiv of **7a**. [b]Single *β*-anomer. [c]Inseparable mixture of *α*/*β* diastereomers. [d]Reaction was conducted in 2:1 DCM/THF.

The subsequent introduction of aldehyde moiety onto the aromatic ring was achieved successfully under the general Vilsmeier-formylation condition (DMF, $POCl_3$, rt),[20] affording glycosyl benzaldehyde **9b** as a pair of rotamers[21] (observed by ^{1}H NMR and ^{13}C NMR) in 87% yield. Nevertheless, attempted Friedel-Crafts acylation employing acetyl chloride/$AlCl_3$ or acetic anhydride/TFA all led to substrate decomposition, likely due to the sensitive nature of benzyl ether protecting groups to acidic conditions.[19] Therefore, it was not feasible to directly construct glycosyl benzophenone by Friedel-Crafts acylation with benzoyl chloride derivative.

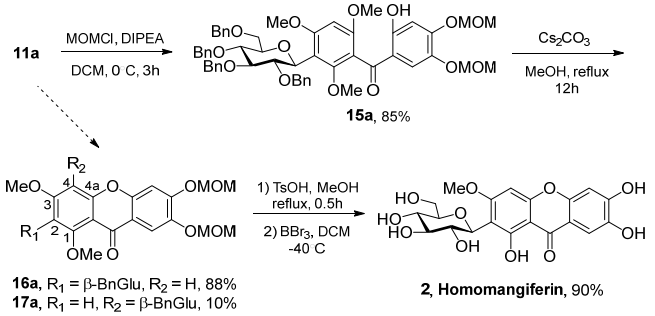


Scheme 3. Synthesis of cyclization precursor **11a**.

With *C*-glycoside **9b** in hand, we set out to investigate the construction of cyclization precursor **11a** (Scheme 3). The requisite bromobenzene **10a** for this procedure was initially fashioned from 1,2,4-benzenetriol by methoxymethylation (MOMCl, DIPEA) and bromination (NBS, DMF, rt). Lithiation of

10a with *n*-BuLi under low temerature (-40 °C), followed by trapping the generated anion with **9b** in THF gave rise to an inseparable mixture of diastereomeric aryl alcohols **13a** (86%).[16] Subsequent oxidation of **13a** with excess activated MnO_2 in CH_2Cl_2 provided **14a** smoothly, and deprotection of the MOM ether with catalytic amount of *p*-toluenesulfonic acid in refluxing methanol finally produced benzophenone **11a** in 93% yield for two steps.

Unfortunately, attempted cyclization of **11a** with cesium carbonate as a base in MeOH failed to give any desired products.[22] Instead, a large amount of unidentified byproducts was obtained. The catechol structure in **11a** was assumed to be the culprit. Thus, to tackle this problem, selective reprotection of **11a** was conducted again with chloromethylmethyl ether and *N, N*-diisopropylethylamine, providing monophenol **15a** (85%) with the stabilizing hydrogen bond remaining intact (Scheme 4).[23] To our delight, the following intramolecular cyclization proceeded smoothly on **15a**, leading to the major 2-*C*-glycoside **16a** and the minor 4-*C*-glycoside **17a** in 88% and 10% yield, respectively. Thus, HMBC correlations between signal of the anomeric proton H-1′ with those of C-1 (160.7 ppm), C-3 (163.8 ppm) were observed for **16a**, and the signal of the anomeric proton H-1′ with those of C-3 (163.7 ppm), C-4a (158.1 ppm) were observed for **17a**. Interestingly, due to the steric hindrance of the sugar subunit to the ortho-group, cyclization was more favored to form the 2-*C*-glycoside product, therefore adjustment of the base or solvent did not even affect the resulted good regioselectivity.

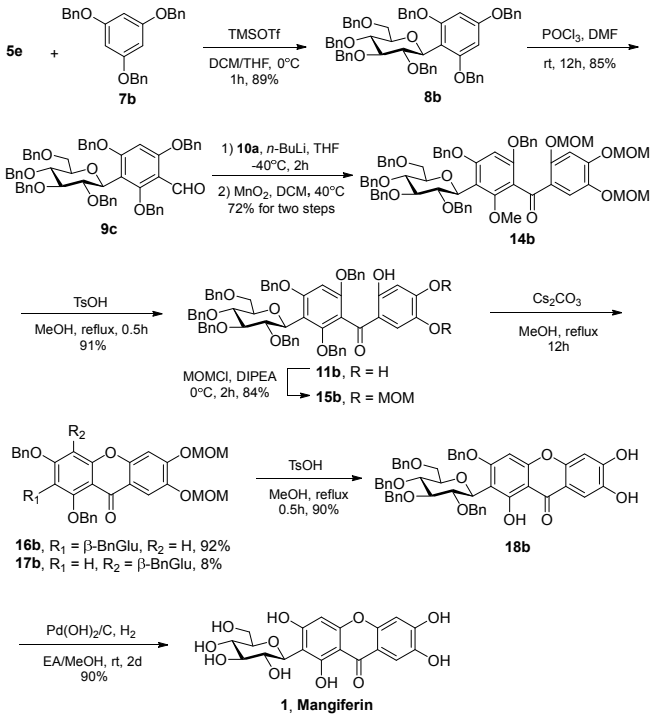


Scheme 4. Completion of the synthesis of homomangiferin

Finally, removal of methoxymethyl ether under acidic condition, followed by treatment with 1N BBr_3 in dichloromethane[11], gave homomangiferin (**2**) in 90% yield. Due to the restricted rotation of the glycosidic bond caused by 3-*O*-methyl group, a pair of rotamers were observed both in the ^1H NMR and ^{13}C NMR. The corresponding NMR signal (H-1′: 4.61/4.56 ppm, d, *J* = 9.6 Hz) for synthetic **2** was identical to that reported for the isolated natural product (H-1′: 4.57 ppm, d, *J* = 9.6 Hz),[7] and the 3-*O*-CH_3 group was assigned according to the HMBC correlation between its signal (3.87 and 3.84 ppm) with that of C-3 (165.7 and 164.5 ppm).

Total synthesis of mangiferin

Next, our attention focused on the synthesis of mangiferin **1**. Originally, it was envisioned that **1** could be achieved by further demethylation of its 3-*O*-methyl derivative **2**. However, any attempted removal of the remaining methyl group on **2** or on corresponding precursor **16a** proved to be problematic, which was also observed in Yu's work.[11] Therefore, to get rid of this dilemma, other protecting groups for the starting material **7** were tested, and accordingly, tribenzylphloroglucinol **7b** was prepared following previous literature for later use.[24]



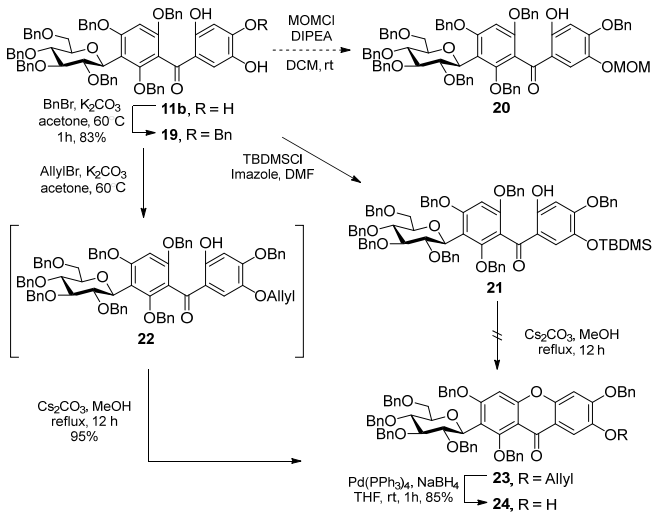
Scheme 5. Total synthesis of mangiferin.

The whole synthesis of mangiferin was accomplished in an analogous manner (Scheme 5). Glycosylation of **7b** with glycosyl acetate **5e**, followed by Vilsmeier formylation of **8b** led to the desired *β-C*-glycoside **9c** in 76% overall yield. Subsequent coupling with lithiated **10a** and immediate oxidation of **13b** then gave rise to benzophenone **14b** in 72% yield for two steps, which was later converted into **15b** by demethoxymethylation and selective reprotection (76% for two steps). Gratefully, the cyclization of **15b** proceeded successfully to afford the major 2-*C*-glycoside **16b** and the minor 4-*C*-glycoside **17b** in 92% and 8% yield, respectively. For **16b**, HMBC correlations between signal of the anomeric proton H-1′ with those of C-1 (159.4 ppm), C-3 (162.5 ppm) were observed, while for **17b**, the signal of the anomeric proton H-1′ with those of C-3 (162.6 ppm), C-4a (157.4 ppm) were observed instead. Eventually, deprotection of methoxymethyl and benzyl ether with toluenesulfonic acid and catalytic hydrogenolysis afforded mangiferin **1** in 81% yield from **16b.** And the analytical data of our synthetic mangiferin (H-1′: 4.59 ppm, d, *J* = 9.6 Hz) also matched that reported for the natural compound (H-1′: 4.59 ppm, d, *J* = 9.6 Hz).[7,25]

Total synthesis of neomangiferin

After completion of the total synthesis of mangiferin, we began to explore the construction of neomangiferin (Scheme 6 and 7).

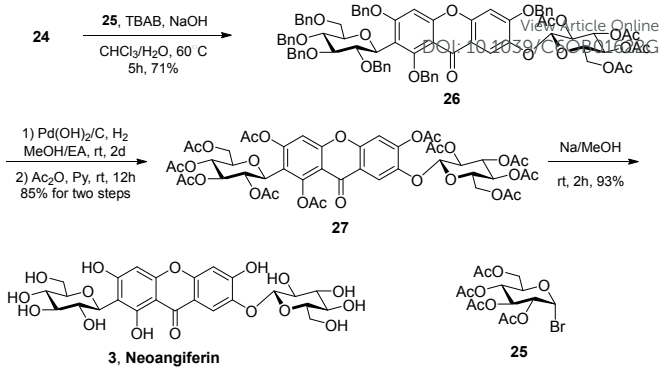
Structurally, neomangiferin, bearing both *O*- and *C*-glycosides, is the 7-*O*-glucosyl derivative of mangiferin, which means, to build this molecular, we first need to seek out an approach for regioselective protection of **1**, thereby providing an appropriate aglycon with free 7-OH for the required glycosylation. In view of simplicity, we assumed to complete this procedure by introducing orthogonal protecting groups onto **11b**, just before the intramolecular cyclization.



Scheme 6. Synthesis of glycosyl accepter **24**.

The most reactive hydroxyl group on **11b**, which located para to the carbonyl group, was selectively benzylated with 1.2 equiv of benzyl bromide in the presence of potassium carbonate, affording **19** in 83% yield. Afterwards, several diverse protecting groups were used to protect the meta-hydroxyl group, in order to leave the ortho- hydroxyl group free for the following cyclization (Scheme 6). As a result, neither MOM nor TBDPS ether would be suitable in our study; for the former, the deprotection of MOM would also destroy the 1-benzyloxy group, while for the latter, the TBDMS group could not stand the cyclization condition. We ultimately found, however, that the utilization of allyl ether (AllylBr, K_2CO_3, acetone)[26] could successfully lead to the desired orthogonal protection, and meanwhile, by further addition of cesium carbonate and methanol, the generated intermediate **22** could be converted directly into cyclization product **23** in an excellent yield (95% for two steps), with only trace of 4-*C*-glycoside detected. Gratefully, the removal of allyl ether went smoothly with $Pd(PPh_3)_4$ and $NaBH_4$,[27] and aglycon **24** was obtained in a good yield of 85%.

Glycosylation of **24** with *α*-D-glucopyranosyl bromide **25**, under the general phase-transfer catalysis (PTC) conditions (TBAB, 5% NaOH, CH_2Cl_2, reflux), gave rise to the expected 7-*O*-*β*-D-glucoside **26** in 71% yield,[12] which was then debenzylated through catalytic hydrogenolysis and acylated with acetic anhydride to afford xanthone **27** in 85% yield for two steps. At last, the cleavage of acetate ester was conducted with sodium methoxide in methanol, and neomangiferin **3** was thus afforded in 93% yield, with its structure confirmed by 1D and 2D NMR.[8]



Scheme 7. Completion of the synthesis of neomangiferin.

Conclusions

In summary, we have achieved the efficient total synthesis of the glycosyl xanthonoids mangiferin, homomangiferin and neomangiferin from tetrabenzylglucose **5**, phloroglucinol derivative **7a/b** and bromobenzene derivative **10a**. The whole synthesis proceeded in 10 or 13 steps with 33%, 40% and 18% overall yield, respectively, featuring a stereoselective Friedel-Crafts type of glycosylation and a regioselective base-induced cyclization. The high overall yield of the process, which was based on the biosynthetic pathway, makes the method one of the most practical alternatives for relevant structural modification. Further studies toward the structure-activity relationship are currently underway.

Experimental section

General Information

Unless otherwise noted, all the reagents were obtained from commercial suppliers and used without further purification. Melting points were uncorrected. Nuclear magnetic resonance spectra (NMR spectra) were recorded using 400 MHz equipments (400 MHz for ^{1}H; 100 MHz for ^{13}C). All spectra obtained in $CDCl_3$ were referenced to tetramethylsilane at 0.00 *ppm* for ^{1}H spectra and 77.16 *ppm* for 13C spectra. Spectra obtained in DMSO-d_6 were referenced to DMSO at 2.50 *ppm* for ^{1}H spectra and 39.52 *ppm* for 13C spectra. The following abbreviations are used for the multiplicities: s: singlet, d: doublet, t: triplet, q: quartet, m: multiplet, br s: broad singlet, br d: broad doublet. High resolution mass spectra (HRMS) data were performed with an ionization mode of ESI (electron spray ionization). Optical rotations were measured using sodium D line. Analytical thin layer chromatography (TLC) was performed on Silica gel 60 F_{254} precoated on aluminiumplates, with detection by fluorescence and (or) by staining with 5% concentrated sulfuric acid in ethanol. Flash column chromatography was performed using Silica gel (230~400 mesh) with solvents distilled prior to use.

Experimental procedures and characterization of products

Mangiferin: 1,3,6,7-Tetrahydroxy-2-*C*-β-D-glucopyranosylxanthone (1). To a solution of **18b** (50 mg, 0.057 mmol) in MeOH (2 mL) and DCM (2 mL) was added 10% $Pd(OH)_2/C$ (20 mg). After being stirred under 1 atm of H_2 for 2 d at room temperature, the suspension was filtrated through Celite to remove the solid catalyst. The filtrate was concentrated in vacuo, and the residue was purified by column chromatography on Sephadex LH-20 ($CHCl_3$-MeOH, 1:1) to afford mangiferin **1** (22 mg, 90%) as a yellow solid: mp over 250 °C (decomp.); ^{1}H NMR (400 MHz, DMSO-d_6) δ 13.75 (s, 1H), 10.53 (br s, 3H), 7.38 (s, 1H), 6.86 (s, 1H), 6.37 (s, 1H), 4.86 (br s, 2H), 4.59 (d, *J* = 9.6 Hz, 2H), 4.48 (br s, 1H), 4.04 (t, *J* = 8.8 Hz, 1H), 3.69 (d, *J* = 11.2 Hz, 1H), 3.40 (dd, *J* = 11.2, 5.6 Hz, 1H), 3.24 – 3.03 (m, 3H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) δ 179.4, 164.1, 162.1, 156.6, 154.2, 151.1, 143.9, 112.1, 108.4, 107.7, 103.0, 101.7, 93.8, 81.7, 79.3, 73.5, 70.9, 70.7, 61.8 ppm; HRMS (ESI-FT-ICR) *m*/*z* calcd for $C_{19}H_{19}O_{11}$ $[M + H]^+$ 423.0922, found 423.0930.

Homomangiferin： 1,6,7-Trihydroxy-2-*C*-β-D-glucopyranosyl-3-*O*-methylxanthone (2). To a solution of **16a** (20 mg, 0.02 mmol) in MeOH (1 mL) was added catalytic amount of *p*-toluenesulfonic acid (0.5 mg). After being stirred for 0.5 h at 80 °C, the reaction mixture was cooled to rt and evaporated under reduced pressure. The residue was diluted with DCM, and then washed with saturated $NaHCO_3$ (aq) and brine, dried over Na_2SO_4, and concentrated in vacuo to give the crude intermediate **18a**. The obtained **18a** was pre-treated to dryness and dissolved in anhydrous DCM (1 mL) under atmosphere of nitrogen. After being cooled to -40 °C, BBr_3 (1N in CH_2Cl_2, 1 mL) was added dropwise with an injector, and the reaction mixture was stirred for 0.5 h before warming to room temperature. Another 3 h later, appropriate amount of water was added in to quench the reaction, and the whole mixture was evaporated under reduced pressure. The residue was purified by column chromatography on Sephadex LH-20 ($CHCl_3$-MeOH, 1:1) to afford homomangiferin **2** (9 mg, 90%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: mp over 250 °C (decomp.); ^{1}H NMR (400 MHz, DMSO-d_6 + D_2O) δ 7.39 (s, 1H), 6.90 (s, 1H), 6.62 (s, 0.5H), 6.61 (s, 0.5H), 4.58 (dd, *J* = 16.8, 10.0 Hz, 1H), 4.17 (t, *J* = 9.2 Hz, 0.5H), 3.97 (t, *J* = 9.2 Hz, 0.5H), 3.87 (s, 1.5H), 3.84 (s, 1.5H), 3.67 (d, *J* = 6.0 Hz, 1H), 3.41 – 3.29 (m, 1H), 3.23 – 3.02 (m, 3H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6+D_2O) δ 179.7/179.4, 165.7/164.5, 161.3/160.6, 157.2/157.1, 154.4, 151.2, 144.1, 112.2, 108.6, 108.3, 102.9, 102.6/102.2, 91.0/90.2, 82.0/81.8, 79.1, 73.1/72.9, 71.0, 70.5/69.9, 61.8, 56.8/56.5 ppm; HRMS (ESI-FT-ICR) *m*/*z* calcd for $C_{20}H_{21}O_{11}$ $[M + H]^+$ 437.1078, found 437.1080.

Neomangiferin: 1,3,6-Trihydroxy-2-*C*-β-D-glucopyranosyl-7-*O*-β-D-glucopyranosylxanthane (3). To a solution of **27** (20.0 mg, 0.019 mmol) in methanol (2 mL) was added catalytic amount of sodium at room temperature. After being stirred for 2 h, the reaction mixture was neutralized with DOWEX 50WX8-400 resin (H^+ form), filtered, and evaporated in vacuo. The residue was purified by column chromatography on Sephadex LH-20 ($CHCl_3$-MeOH, 1:1) to afford neomangiferin **3** (18.5 mg, 93%) as a yellow solid: mp 226-227 °C; ^{1}H NMR (400 MHz, DMSO-d_6 + D_2O) *δ* 7.70 (s, 1H), 6.96 (s, 1H), 6.41 (s, 1H), 4.91 (d, *J* = 7.2 Hz, 1H), 4.59 (d, *J* = 9.6 Hz, 1H), 4.04 (t, *J* = 9.0 Hz, 1H), 3.81 – 3.05 (m, 11H, covered by the signal of H_2O) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) *δ* 179.2, 164.2, 161.7, 156.5, 155.0, 152.8, 143.7, 112.0, 110.5, 107.9, 103.4, 102.1, 101.5, 93.8, 81.7, 79.0, 77.3, 75.9, 73.4, 73.3, 70.7, 70.4, 69.7, 61.6, 60.7 ppm; HRMS (ESI-FT-ICR) *m*/*z* calcd for $C_{25}H_{29}O_{16}$ $[M + H]^+$ 585.1450, found 585.1447.

2,3,4,6-Tetra-*O*-benzyl-α/β-D-glucopyranosyl acetate (5e). To a solution of **5** (15.5 g, 28.7 mmol) in anhydrous pyridine (100 mL) was added acetic anhydride (20 mL) at room temperature. After being stirred overnight, the reaction mixture was quenched with methanol, and evaporated in vacuo. The residue was dissolved in DCM and washed with 1N HCl (aq), saturated $NaHCO_3$ (aq) and brine, and the combined organic layers were dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 5:1) to afford **5e** (16.5 g, 99%) as a colorless syrup: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.17 (m, 18H), 7.17 – 7.08 (m, 2H), 6.39 (d, *J* = 3.6 Hz, 0.8H), 5.64 (d, *J* = 8.0 Hz, 0.2H), 5.02 – 4.38 (m, 8H), 3.96 (t, *J* = 9.2 Hz, 0.8H), 3.92 – 3.85 (m, 0.8H), 3.80 – 3.51 (m, 4.4H), 2.06 (s, 2.4H), 1.97 (s, 0.6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.1/169.0, 138.5/138.3, 138.0/138.0 137.8 /137.7, 137.5, 128.3, 128.2, 128.0, 127.8, 127.7, 127.6, 127.6, 127.5, 127.5, 93.9/89.8, 84.6/81.5, 80.9/78.8, 77.1/76.8, 75.5/75.3, 75.1/74.8, 74.8, 73.3/73.3, 73.0, 72.7, 68.0, 20.9/20.8 ppm; HRMS (ESI-FT-ICR) *m*/*z* calcd for $C_{36}H_{42}NO_7$ $[M + NH_4]^+$ 600.2956, found 600.2972.

1,3,5-Tri-*O*-methyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)benzene (8a). Donor **5e** (4.11 g, 7.05 mmol) and acceptor **7a** (2.37 g, 14.09 mmol) were pre-treated to dryness and dissolved in anhydrous DCM/THF (26 mL/13 mL) under atmosphere of nitrogen. After being cooled to 0 °C, TMSOTf (6.4 mL, 0.44 mmol) was added dropwise with an injector, and the mixture was allowed to stir for 1 h before quenching with Et_3N. The residue was diluted with DCM and washed with saturated $NaHCO_3$ (aq) and brine, and the combined organic layers were dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 5:1) to afford **8a** (4.10 g, 84%) as a colorless syrup: $[\alpha]_D^{25}$ = +16.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.11 (m, 18H), 6.96 – 6.89 (m, 2H), 6.12 (dd, *J* = 24.0, 2.0 Hz, 2H), 5.00 – 4.85 (m, 4H), 4.75 (dd, *J* = 15.2, 11.6 Hz, 2H), 4.52 (dd, *J* = 11.2, 4.4 Hz, 2H), 4.39 (t, *J* = 9.2 Hz, 1H), 4.12 (d, *J* = 10.4 Hz, 1H), 3.94 – 3.83 (m, 2H), 3.82 – 3.71 (m, 8H), 3.68 (s, 3H), 3.57 (dd, *J* = 9.6, 2.0 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.4, 160.9, 159.9, 139.0, 138.9, 138.6, 138.5, 128.4, 128.4, 128.2, 128.2, 128.1, 128.0, 128.0, 127.6, 127.4, 127.2, 107.8, 91.8, 90.8, 87.6, 80.0, 79.7, 78.5, 75.8, 75.1, 74.5, 73.2, 72.7, 69.1, 56.1, 55.8, 55.3 ppm; HRMS (ESI-FT-ICR) *m*/*z* calcd for $C_{43}H_{50}NO_8$ $[M + NH_4]^+$ 708.3531, found 708.3543.

1,3,5-Tri-*O*-benzyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)benzene (8b). Glycoside **8b** was prepared from **5e** and **7b** following a procedure similar to that for **8a**. Donor **5e** (321 mg, 0.55 mmol), acceptor **7b** (655 mg, 1.65 mmol), and TMSOTf (0.50 mL, 2.75 mmol). The crude product was purified by flash column chromatography (PE-EtOAc, 5:1) to afford **8b** (450 mg, 89%) as a colorless syrup: $[\alpha]_D^{25}$ = +8.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (m, 2H), 7.39 – 7.07 (m, 31H), 6.93 (dd, *J* = 7.6, 1.6 Hz, 2H), 6.25 (s, 2H), 5.10 – 4.79 (m, 10H), 4.60 (dd, *J* = 11.2, 6.4 Hz, 2H), 4.48 (dd, *J* = 11.6, 3.2 Hz, 2H), 4.45

– 4.37 (t, *J* = 9.2 Hz,, 1H), 4.17 (d, *J* = 11.2 Hz, 1H), 3.82 – 3.66 (m, 4H), 3.60 – 3.50 (m, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.3, 160.1, 159.3, 139.2, 138.9, 138.6, 138.5, 137.3, 136.8, 128.7, 128.6, 128.4, 128.4, 128.4, 128.3, 128.1, 128.1, 128.1, 128.0, 128.0, 127.9, 127.8, 127.7, 127.6, 127.6, 127.5, 127.5, 127.3, 127.2, 127.2, 109.5, 94.9, 94.3, 87.8, 79.8, 79.5, 78.4, 75.4, 75.1, 74.1, 73.5, 73.4, 71.4, 70.8, 70.2, 69.5 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{61}H_{59}O_8$ $[M + H]^+$ 919.4205, found 919.4203.

2,4,6-Tri-*O*-methyl-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)benzaldehyde (9b). To a solution of glycoside **8a** (4.10 g, 5.90 mmol) in anhydrous DMF (30 mL) was added $POCl_3$ (3.40 mL, 35.6 mmol) under a nitrogen atmosphere. The reaction mixture was stirred overnight at room temperature, and then an additional $POCl_3$ (1.00 mL) was added for the complete consumption of substrate. After another 4 h, 1N NaOH (aq) was added carefully to quench the reaction, and the mixture was diluted with DCM, washed with saturated $NaHCO_3$ (aq), 1N HCl (aq) and brine. The combined organic layers were dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 3:2) to afford **9b** (3.7 g, 87%) as a yellow syrup, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.28 (s, 1H), 7.40 – 7.05 (m, 18H), 6.90 (m, 2H), 6.17 (s, 1H), 4.99 – 4.45 (m, 8H), 4.44 – 4.29 (m, 1H), 4.19 (d, *J* = 11.2 Hz, 1H), 3.96 – 3.68 (m, 13H), 3.57 (m, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 187.8/187.7, 165.3/165.2, 164.3/163.9, 163.9/163.7, 139.0/138.8, 138.7/138.5, 138.5/138.4, 138.2/ 138.2, 128.5, 128.4, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 127.9, 127.9, 127.7, 127.6, 127.6, 127.5, 127.5, 127.4, 127.3, 114.1/113.2, 113.1/112.3, 91.9/90.8, 87.9/ 87.4, 80.7/79.9, 79.0/78.8, 78.4/78.3, 75.9/75.5, 75.1/75.1, 74.8/74.5, 73.3/73.2, 72.3, 69.5/69.1, 65.5/64.4, 56.1, 56.0, 55.6 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{44}H_{47}O_9$ $[M + H]^+$ 719.3215, found 719.3240.

2,4,6-Tri-*O*-benzyl-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)benzaldehyde (9c). Benzaldehyde **9c** was prepared from **8b** following a procedure similar to that for **9b**. Thus, treatment of **8b** (3.09 g, 3.36 mmol) with $POCl_3$ (3 mL) in DMF (30 mL), after purification by flash column chromatography (PE-EtOAc, 5:1), gave **9c** (2.70 g, 85%) as a light yellow syrup, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +8.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.47 (s, 0.7H), 10.35 (s, 0.3H), 7.57 – 7.04 (m, 33H), 6.96 – 6.84 (m, 2H), 6.30 (s, 0.3H), 6.27 (s, 0.7H), 5.42 – 4.77 (m, 10H), 4.63 – 4.17 (m, 6H), 3.83 – 3.30 (m, 5H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 187.7/187.6, 164.1/163.4, 163.4/162.9, 162.6/162.1, 138.9/138.8, 138.7/138.3, 138.3/ 138.2, 137.9/137.5, 136.8, 136.0, 135.84, 128.8, 128.8, 128.7, 128.6, 128.6, 128.5, 128.4, 128.4, 128.3, 128.3, 128.3, 128.2, 128.2, 128.1, 128.1, 128.0, 128.0, 127.9, 127.8, 127.7, 127.6, 127.6, 127.5, 127.4, 127.2, 127.1, 127.0, 126.9, 115.0, 114.1, 113.2, 94.9/94.8, 87.9/87.6, 80.3/79.4, 79.3/79.2, 78.7/78.5, 78.3/78.2, 75.4/75.3, 75.1/75.0, 74.4/74.2, 73.7/73.5, 73.3/72.9, 71.0/70.9, 70.8/70.4, 69.4/69.2 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{62}H_{59}O_9$ $[M + H]^+$ 947.4154, found 947.4165.

1-Bromo-2,4,5-tris(methoxymethoxy)benzene (10a). To a solution of benzene **12** (17.5 g, 67.8 mmol) in DMF (50 mL) was added NBS solution (12.7 g in 50 mL DMF, 71.2 mmol) dropwise at room temperature. After being stirred overnight, the reaction mixture was quenched with water and then diluted with DCM. The organic layer was washed with brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 6:1) to afford **10a** (18.1 g, 80%) as a redish-brown liquid: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (s, 1H), 7.04 (s, 1H), 5.20 (s, 2H), 5.17 (s, 2H), 5.15 (s, 2H), 3.53 (s, 3H), 3.51 (s, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.0, 147.3, 142.7, 121.5, 106.7, 104.5, 96.0, 95.8, 95.6, 56.2, 56.1, 56.0 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{12}H_{18}BrO_6$ $[M + H]^+$ 337.0281, found 337.0291.

2,4,6-Trimethoxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2',4',5'-trihydroxybenzophenone (11a). To a solution of **14a** (1.13 g, 1.16 mmol) in MeOH (20 mL) was added catalytic amount of *p*-toluenesulfonic acid (20 mg, 0.12 mmol). After being stirred for 0.5 h at 80 °C, the reaction mixture was cooled to rt and evaporated under reduced pressure. The residue was diluted with DCM, and then washed with saturated $NaHCO_3$ (aq) and brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-acetone, 2:1) to afford **11a** (0.91 g, 93%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +20.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.20 (s, 1H), 10.55 (br s, 1H), 8.80 (br s, 1H), 7.44 – 7.12 (m, 18H), 7.12 – 6.84 (m, 2H), 6.74 – 6.52 (m, 2H), 6.36 (s, 1H), 4.92 – 4.69 (m, 3.5H), 4.65 – 4.29 (m, 5.5H), 4.27 – 4.03 (m, 1H), 3.86 (s, 3H), 3.80 – 3.47 (m, 11H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) δ 197.4, 161.4/160.0, 158.1/157.4, 157.3/157.1, 155.4, 138.9/138.8, 138.5 138.4, 138.2/138.0, 128.2, 128.2, 128.1, 128.0, 127.9, 127.8, 127.7, 127.6, 127.5, 127.4, 127.4, 117.3, 116.0/114.9, 113.1/112.9, 112.8/112.2, 102.8, 93.3, 86.8/86.08, 80.3, 78.8, 78.3/78.0, 74.7/74.5, 74.1/74.1, 73.6/73.5, 72.9, 72.3/71.8, 69.1, 63.5, 56.4, 56.1, 56.0 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{50}H_{54}NO_{12}$ $[M + NH_4]^+$ 860.3641, found 860.3631.

2,4,6-Tribenzyloxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2',4',5'-trihydroxybenzophenone (11b). Benzophenone **11b** was prepared from **14b** following a procedure similar to that for **11a**. Thus, treatment of **14b** (1.61 g, 1.33 mmol) with catalytic amount of *p*-toluenesulfonic acid, after purification by flash column chromatography (PE-acetone, 2:1), gave **11b** (1.31 g, 91%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +12.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.17 (s, 1H), 10.50 (br s, 1H), 8.81 (br s, 1H), 7.68 – 6.64 (m, 37H), 6.37 (s, 1H), 5.41 – 4.23 (m, 15H), 4.14 (s, 1H), 3.73 – 3.48 (m, 5H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) δ 197.4, 160.3, 158.4, 156.5, 155.6, 138.9, 138.7, 138.3, 138.2, 138.0, 137.9, 136.9, 136.7, 136.6, 128.8, 128.7, 128.6, 128.6, 128.5, 128.4, 128.4, 128.3, 128.2, 128.1, 128.0, 127.9, 127.7, 127.6, 127.4, 127.3, 127.3, 116.1, 113.1, 102.9, 96.1, 86.8, 78.9, 78.2, 78.0, 74.5, 74.3, 73.7, 73.6, 72.7, 71.0, 70.2, 70.1, 69.2 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{68}H_{63}O_{12}$ $[M + H]^+$ 1071.4314, found 1071.4306.

1,2,4-Tris(methoxymethoxy)benzene (12). 1,2,4-Benzenetriol (2.5 g, 20 mmol) and DIPEA (15.8 mL, 90 mmol) were dissolved in DCM (100 mL) and cooled to 0 °C. Chloromethylmethyl ether (8.6 mL, 90 mmol) was then added dropwise with an injector

over 0.5 h. After being warmed to room temperature and stirred overnight, 2N NaOH (aq) (100 mL) was added, and the mixture was then extracted with large amount of DCM. The combined organic layer was washed with water and brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 6:1) to afford **12** (3.3 g, 64%) as a light yellow liquid: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.06 – 7.01 (m, 1H), 6.91 – 6.83 (m, 1H), 6.68 – 6.58 (m, 1H), 5.18 (s, 2H), 5.12 (s, 2H), 5.07 (s, 2H), 3.48 (s, 6H), 3.43 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.8, 148.1, 142.0, 118.1, 109.0, 106.2, 96.0, 95.2, 94.8, 55.9, 55.8, 55.6 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{12}H_{19}O_6$ $[M + H]^+$ 259.1176, found 259.1173.

2,4,6-Trimethoxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2',4',5'-tris(methoxymethoxy)benzophenone (14a). Bromobenzene **10a** (1.6 g, 4.75 mmol) was dissolved in anhydrous THF (15 mL) and cooled to -40 °C under a nitrogen atmosphere. A 2.5M solution of *n*-BuLi (1.9 mL, 4.75 mmol) was added dropwise and the solution was allowed to stir for 1h at -40 °C. The obtained mixture was then added dropwise into a solution of **9b** (1.14 g in 15 mL THF, 1.58 mmol), which was pre-cooled to -40 °C under atmosphere of nitrogen. After being stirred for another 1 h, appropriate amount of saturated NH_4Cl (aq) was added to quench the reaction, and the mixture was then diluted with DCM. The organic layer was washed with brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 1:1) to afford **13a** (1.44 g, 86%) as a yellow syrup. To a solution of **13a** (1.28 g, 1.3 mmol) in anhydrous DCM (25 mL) was added activated MnO_2 (2.28 g, 26.2 mmol) at room temperature. After being stirred for 36 h, the reaction mixture was filtrated through Celite to remove the solid oxidant, and the filtrate was concentrated in vacuo and purified directly by flash column chromatography (PE-EtOAc, 2:1) to afford **14a** (1.28 g, quant) as a yellow syrup, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +28.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.36 – 7.13 (m, 18H), 7.06 – 6.95 (m, 2H), 6.89 (s, 1H), 6.29 (s, 1H), 5.29 – 5.06 (m, 3H), 5.02 – 4.33 (m, 12H), 4.24 (d, *J* = 10.8 Hz, 1H), 3.90 – 3.62 (m, 13H), 3.58 – 3.48 (m, 4H), 3.48 – 3.35 (s, 3H), 3.21 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.0/191.6, 161.2/160.2, 159.6/158.6, 158.2, 153.8/153.4, 152.5/152.2, 141.6/1415, 139.1/138.8, 138.8/138.6, 138.4/138.4, 128.5, 128.4, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 128.0, 127.9, 127.8, 127.7, 127.7, 127.6, 127.5, 127.4, 124.2/123.3, 120.6/120.2, 120.2/120.1, 113.8/113.0, 105.7/104.7, 96.3/96.2, 96.0/95.5, 95.2, 92.8/91.2, 87.9/87.2, 80.9/79.8, 79.4/78.8, 78.6/78.3, 75.9/75.6, 75.1, 74.5/74.3, 73.8/73.3, 73.2/72.6, 69.6/69.2, 64.2/63.8, 56.6, 56.3, 56.2, 56.1, 56.1, 56.0, 56.0 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{56}H_{63}O_{15}$ $[M + H]^+$ 975.4162, found 975.4170.

2,4,6-Tribenzyloxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2',4',5'-tris(methoxymethoxy)benzophenone (14b). Benzophenone **14b** was prepared from **10a** and **9c** following a procedure similar to that for **14a**. Thus, treatment of **9c** (2.60 g, 2.75 mmol) with organolithium reagent and activated MnO_2, after purification by flash column chromatography (PE-EtOAc, 3:1), gave **14b** (2.38 g, 72% for two steps) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +16.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 (s, 0.7H), 7.42 – 6.88 (m, 35.3H), 6.81 (s, 0.7H), 6.76 (s, 0.3H), 6.27 (s, 0.3H), 6.25 (s, 0.7H), 5.30 – 5.08 (m, 2H), 5.02 – 4.29 (m, 19H), 4.24 (d, *J* = 11.2 Hz, 0.7H), 4.20 (d, *J* = 11.2 Hz, 0.3H), 3.68 – 3.16 (m, 11H), 3.01 (s, 2H), 3.00 (s, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.4/191.3, 160.1/159.3, 158.1/157.3, 157.2, 153.8/153.6, 152.2/152.2, 141.6/141.5, 139.1, 139.0/138.9, 138.4/138.4, 138.1/137.4, 136.8, 136.6/136.4, 128.7, 128.5, 128.5, 128.4, 128.4, 128.3, 128.3, 128.3, 128.2, 128.2, 128.1, 128.0, 128.0, 127.9, 127.9, 127.8, 127.7, 127.7, 127.6, 127.5, 127.5, 127.4, 127.3, 127.2, 127.1, 126.9/126.9, 123.9/123.7, 121.6/120.9, 120.2/119.8, 115.0/114.1, 105.0/104.5, 96.2/96.1, 95.9/95.7, 95.4, 95.2/95.1, 87.8/87.4, 80.3/79.4, 79.1/79.1, 78.4, 78.2/77.8, 75.4/75.2, 75.1/75.0, 74.2, 74.1/74.0, 73.4/73.4, 73.2, 71.4/70.8, 70.5/70.5, 69.6/69.4, 56.5, 56.3/56.2, 56.0/56.0 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{74}H_{75}O_{15}$ $[M + H]^+$ 1203.5101, found 1203.5090.

2,4,6-Trimethoxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2'-hydroxy-4',5'-bis(methoxymethoxy)benzophenone (15a). To a solution of **11a** (100 mg, 0.12 mmol) in CH_2Cl_2 (1 mL) was added DIPEA (88 µl, 0.5 mmol) and MOMCl (38 µl, 0.5 mmol) in portions at 0 °C. The mixture was stirred for 3 h at 0 °C, and then diluted with DCM. The combined organic layer was washed with water and brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-acetone, 4:1) to afford **15a** (93 mg, 85%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +12.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.22 (s, 1H), 7.37 – 7.10 (m, 18H), 7.03 – 6.80 (m, 3H), 6.71 (s, 1H), 6.64 (s, 1H), 5.32 (d, *J* = 8.4 Hz, 2H), 4.90 – 4.32 (m, 11H), 4.26 – 3.98 (m, 1H), 3.86 (s, 3H), 3.80 – 3.48 (m, 11H), 3.39 (s, 3H), 3.19 (s, 3H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) δ 197.9/197.8, 161.8/160.4, 159.6/159.5, 158.4/157.6, 157.5/157.4, 155.5/155.5, 138.9/138.8, 138.6, 138.5, 138.4/138.3, 138.2/138.1, 128.2, 128.0, 127.8, 127.7, 127.6, 127.6, 127.5, 127.4, 127.3, 122.0/ 121.5, 115.4/114.2, 114.1/114.1, 113.3/112.3, 103.3, 96.0/95.9, 94.4, 93.2, 92.2/86.7, 86.0/80.4, 78.8/78.6, 78.3/78.0, 74.7/74.4, 74.1/74.0, 73.5/73.3, 72.9/72.3, 72.2/71.7, 69.1/69.0, 63.6, 56.3/56.2, 56.1, 56.0/56.0, 55.5 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{54}H_{59}O_{14}$ $[M + H]^+$ 931.3899, found 931.3932.

2,4,6-Tribenzyloxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2'-hydroxy-4',5'-bis(methoxymethoxy)benzophenone (15b). Benzophenone **15b** was prepared from **11b** following a procedure similar to that for **15a**. Thus, treatment of **11b** (1.02 g, 0.95 mmol) with DIPEA (695 µl, 3.98 mmol) and MOMCl (189 µl, 2.49 mmol) at 0 °C, after purification by flash column chromatography (PE-acetone, 4:1), gave **15b** (0.93 g, 84%) as a light yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +36.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.12 (s, 1H), 7.61 – 7.37 (m, 2H), 7.36 – 7.01 (m, 32H), 6.99 – 6.87 (m, 3H), 6.74 (s, 0.7H), 6.72 (s, 0.3H), 5.44 – 5.07 (m, 6H), 4.99 (d, *J* = 9.6 Hz, 0.3H), 4.90 (d, *J* = 10.4 Hz, 0.7H), 4.84 – 4.23 (m, 12H), 4.17 (d, *J* = 11.2 Hz, 0.7H), 4.09 (d, *J* = 10.4 Hz, 0.3H), 3.73 – 3.43 (m, 5H), 3.42 (s, 2H), 3.39 (s, 1H), 3.13 (s, 2H), 3.00 (s, 1H) ppm; ^{13}C NMR (100 MHz, DMSO-d_6) δ 197.50, 160.6/159.6, 159.5/159.4, 156.6,

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156.3, 155.6/155.3, 138.8/138.8, 138.7/ 138.7, 138.2, 138.1, 137.9/137.9, 137.2/136.7, 136.4, 136.4/136.3, 128.5, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 128.0, 127.9, 127.8, 127.8, 127.7, 127.6, 127.5, 127.5, 127.4, 127.3, 127.2, 127.0, 121.5, 115.2/114.5, 114.3, 113.2, 103.3, 95.8/95.7, 94.3, 86.7/86.3, 79.9/78.8, 78.4/78.1, 77.8/77.6, 74.3/74.2, 74.1/73.9, 73.4, 73.2, 72.4, 70.8, 70.0, 69.0, 56.16, 55.54 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{72}H_{71}O_{14}$ [M + H]$^+$ 1159.4838, found 1159.4835.

1,3-Di-*O*-methyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-6,7-di-*O*-methoxymethylxanthone (16a) and 1,3-Di-*O*-methyl-4-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-6,7-di-*O*-methoxymethylxanthone (17a). To a solution of **15a** (53 mg, 0.06 mmol) in MeOH (5 mL) was added Cs_2CO_3 (20 mg, 0.06 mmol) at room temperature. After being warmed to 80 °C and stirred overnight, the reaction mixture was cooled to rt and evaporated under reduced pressure. The residue was dissolved in DCM and filtrated to remove the undissolved substance, and the filtrate was concentrated and purified directly by flash column chromatography (PE-acetone, 4:1) to afford **16a** (45 mg, 88%) as a white solid and **17a** (5 mg, 10%) as a yellow solid respectively, with rotamers observed by ^{1}H NMR and ^{13}C NMR. Data for **16a**: $[\alpha]_D^{25}$ = +48.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (s, 1H), 7.38 – 7.00 (m, 19H), 6.92 – 6.77 (m, 2H), 6.58 (s, 1H), 5.42 – 5.24 (m, 4H), 5.01 – 4.83 (m, 4H), 4.75 – 4.32 (m, 5H), 4.17 (d, *J* = 11.2 Hz, 1H), 3.96 (s, 3H), 3.90 – 3.67 (m, 7H), 3.64 – 3.47 (m, 7H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.0/173.9, 163.8/162.8, 162.4/160.7, 159.5/159.4, 153.0/153.0, 151.5/151.4, 144.3/144.3, 139.1/138.9, 138.8/138.6, 138.5/ 138.4, 138.3/138.2, 128.6, 128.5, 128.5, 128.4, 128.3, 128.2, 128.1, 128.1, 128.0, 127.8, 127.8, 127.7, 127.6, 127.5, 127.5, 127.4, 127.3, 118.3/117.5, 117.2/117.1, 112.4, 110.7/110.0, 103.4/103.3, 96.3/95.9, 95.3/95.1, 88.0/87.5, 80.9/79.9, 79.0/78.9, 78.49/ 78.4, 76.0/75.6, 75.3/75.2, 75.0/74.4, 73.5/73.4, 73.2/72.5, 69.6/69.1, 64.5/63.5, 56.7/ 56.6, 56.5/56.5, 56.3/55.8 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{53}H_{55}O_{13}$ [M + H]$^+$ 899.3637, found 899.3623. Data for **17a**: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 0.5H), 7.93 (s, 0.5H), 7.42 – 6.90 (m, 19H), 6.86 – 6.70 (m, 2H), 6.34 (s, 0.5H), 6.25 (s, 0.5H), 5.47 – 4.90 (m, 8H), 4.79 – 4.46 (m, 4H), 4.42 (t, *J* = 9.2 Hz, 0.5H), 4.31 (t, *J* = 9.2 Hz, 0.5H), 4.21 (d, *J* = 11.2 Hz, 0.5H), 4.15 (d, *J* = 11.2 Hz, 0.5H), 4.03 (s, 1.5H), 4.00 (s, 1.5H), 3.96 – 3.60 (m, 8H), 3.58 – 3.40 (m, 6H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.2/175.0, 163.7/162.6, 162.4, 158.1/157.4, 153.0/152.9, 151.3/151.2, 144.2, 138.9/138.8, 138.8/ 138.7, 138.6/138.6, 138.1/137.8, 128.6, 128.6, 128.5, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 127.9, 127.9, 127.9, 127.8, 127.5, 127.5, 127.5, 127.4, 117.1/116.8, 112.6/112.4, 107.3/106.7, 106.5/106.4, 103.8/103.5, 96.1/95.3, 91.5/90.6, 88.0/87.9, 79.8/79.7, 79.6, 78.6/78.6, 76.1/75.3, 75.2/74.7, 73.4/73.3, 72.8/72.5, 69.2/69.1, 56.7/ 56.6, 56.5/56.5, 56.4, 55.9 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{53}H_{55}O_{13}$ [M + H]$^+$ 899.3637, found 899.3625.

1,3-Di-*O*-benzyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-6,7-di-*O*-methoxymethylxanthone (16b) and 1,3-Di-*O*-benzyl-4-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-6,7-di-*O*-methoxymethylxanthone (17b). Glycosyl xanthone **16b** and **17b** were prepared from **15b** following a procedure similar to that for **16a** and **17a**. Thus, treatment of **15b** (52 mg, 0.045 mmol) with Cs_2CO_3 (44 mg, 0.135 mmol) at 80 °C in MeOH (5 mL), after purification by flash column chromatography (PE-EtOAc, 4:1), gave **16b** (45 mg, 92%) as a white solid and **17b** (4 mg, 8%) as a yellow solid respectively, with rotamers observed by ^{1}H NMR and ^{13}C NMR. Data for **16b**: $[\alpha]_D^{25}$ = +28.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (s, 0.7H), 7.80 (s, 0.3H), 7.66 – 7.49 (m, 2H), 7.42 – 6.84 (m, 27H), 6.83 – 6.67 (m, 2H), 6.49 (s, 0.3H), 6.47 (s, 0.7H), 5.38 – 4.59 (m, 12H), 4.55 – 4.19 (m, 5H), 4.14 (d, *J* = 11.6 Hz, 0.7H), 4.08 (d, *J* = 11.6 Hz, 0.7H), 3.69 – 3.13 (m, 11H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.7, 162.5/161.8, 160.6/159.4, 159.1/159.0, 152.8/152.7, 151.2/151.0, 144.2/144.1, 138.9/ 138.7, 138.6, 138.5/138.3, 138.2/138.1, 137.9/137.4, 135.7/135.7, 128.9, 128.6, 128.4, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 127.9, 127.9, 127.8, 127.7, 127.6, 127.6, 127.4, 127.4, 127.3, 127.2, 127.1, 127.0, 126.9, 118.6/117.7, 117.0/116.9, 112.2/ 112.0, 110.9/110.1, 103.2/103.1, 97.2/96.8, 95.6/95.6, 95.0, 87.8/87.5, 80.3/79.3, 78.3/78.2, 75.2/75.0, 74.9/74.8, 74.3/74.0, 73.8/73.3, 73.2/73.0, 70.8/70.3, 69.5/69.0, 56.4/56.3, 56.3/56.2 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{65}H_{63}O_{13}$ [M + H]$^+$ 1051.4263, found 1051.4265. Data for **17b**: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (s, 0.6H), 7.96 (s, 0.4H), 7.67 – 7.53 (m, 2H), 7.49 – 6.89 (m, 27H), 6.88 – 6.61 (m, 2H), 6.38 (s, 0.4H), 6.35 (s, 0.6H), 5.42 – 4.86 (m, 11H), 4.83 (d, *J* = 10.8 Hz, 0.6H), 4.73 (d, *J* = 10.8 Hz, 0.4H), 4.68 – 4.22 (m, 5H), 4.16 (dd, *J* = 11.2, 3.2 Hz, 1H), 3.98 – 3.59 (m, 5H), 3.59 – 3.47 (m, 5H), 3.44 (s, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.0/174.9, 162.6/161.6, 161.0/160.8, 158.1/157.4, 152.9/152.9, 151.3/151.2, 144.3/144.3, 139.0/138.8, 138.7/ 138.6, 138.4, 138.1/138.1, 136.5, 136.3/136.1, 128.9, 128.8, 128.7, 128.6, 128.6, 128.5, 128.5, 128.4, 128.3, 128.3, 128.2, 128.1, 128.1, 128.0, 127.9, 127.9, 127.8, 127.7, 127.6, 127.5, 127.5, 127.4, 127.3, 127.2, 127.0, 127.0, 117.1/116.9, 112.4/ 112.2, 108.0/107.4, 107.4/107.3, 103.8/103.5, 96.0, 95.3/95.3, 95.0/94.8, 88.0/87.9, 79.8/79.6, 79.5/79.2, 78.6/78.5, 76.0/75.6, 75.3/75.0, 74.5/74.4, 73.6/73.2, 73.0/72.8, 71.3/71.1, 70.8, 69.5/69.1, 56.7/56.6, 56.5/56.5 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{65}H_{63}O_{13}$ [M + H]$^+$ 1051.4263, found 1051.4265.

1,6,7-Trihydroxy-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-3-*O*-benzylxanthone (18b). Glycosyl xanthone **18b** was prepared from **16b** following a procedure similar to that for **11a**. Thus, treatment of **16b** (626 mg, 0.60 mmol) with catalytic amount of *p*-toluenesulfonic acid, after purification by flash column chromatography (PE-EtOAc, 1:1), gave **18b** (466 mg, 90%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +32.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 13.51 (s, 0.5H), 13.40 (s, 0.5H), 8.03 (br s, 1H), 7.42 – 6.72 (m, 27H), 6.55 (s, 0.5H), 6.37 (s, 0.5H), 6.04 (s, 0.5H), 6.02 (s, 0.5H), 5.08 – 4.63 (m, 6.5H), 4.60 – 4.10 (m, 5.5H), 3.80 – 3.47 (m, 4H), 3.32 (t, *J* = 8.8 Hz, 0.5H), 3.15 (t, *J* = 9.2 Hz, 0.5H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 179.3/179.1, 163.8/163.3, 161.7/161.4, 157.7/157.5, 154.1/152.8, 151.7/151.4, 142.2/141.3, 138.7/ 138.6, 138.4/137.9, 137.8/137.8, 136.4, 136.1/136.0, 128.7, 128.6, 128.5, 128.5, 128.5, 128.4, 128.4, 128.2, 128.1, 127.9, 127.9, 127.7, 127.3, 127.2, 113.0/112.6,

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111.9/ 109.9, 106.2/106.2, 103.5/102.6, 102.4/102.3, 91.1/90.9, 87.8/87.3, 78.7/78.5, 78.4, 78.3/78.2, 75.5, 75.2/74.9, 74.3/74.1, 73.7/73.5, 72.9/72.2, 70.9/70.8, 69.8/69.1 ppm. HRMS (ESI-FT-ICR) *m/z* calcd for $C_{54}H_{49}O_{11}$ [M + H]$^+$ 873.3269, found 873.3250.

2,4,4',6-Tetrabenzyloxy-3-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-2',5'-hydroxybenzophenone (19). To a solution of **11b** (50 mg, 0.047 mmol) in acetone (2 mL) was added K_2CO_3 (26 mg, 0.187 mmol) and BnBr (7 µL, 0.056 mmol) at room temperature. After being warmed to 60 °C and stirred for 1 h, the reaction mixture was cooled to rt and filtrated to remove the solid reagent. The combined filtrate was concentrated in vacuo, and purified directly by flash column chromatography (PE-acetone, 4:1) to afford **19** (45 mg, 83%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.48 (s, 0.7H), 12.35 (s, 0.3H), 7.53 – 6.85 (m, 42H), 6.69 – 6.27 (m, 2H), 5.49 – 4.17 (m, 18H), 3.89 – 3.35 (m, 5H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.8, 160.8/160.0, 159.2/159.0, 157.8/156.7, 153.3/153.2, 139.1/139.0, 139.0, 138.4/138.3, 138.0/137.8, 136.7/136.4, 136.3/135.2, 128.9, 128.8, 128.7, 128.6, 128.6, 128.6, 128.5, 128.4, 128.4, 128.3, 128.1, 128.1, 128.0, 127.9, 127.83, 127.8, 127.7, 127.7, 127.5, 127.4, 127.3, 127.2, 127.1, 127.0, 126.9, 117.9, 116.9, 116.2, 115.2, 114.7, 114.6/114.3, 100.6, 96.1, 87.9/87.6, 80.7, 79.6/79.3, 78.7, 78.3/78.2, 75.4, 75.1/75.0, 74.4/74.2, 73.6/73.5, 73.2, 71.5, 71.2/71.0, 70.6, 69.4/69.2 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{75}H_{69}O_{12}$ [M + H]$^+$ 1161.4784, found 1161.4810.

1,3,6-Tri-*O*-benzyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-7-*O*-allylxanthone (23). To a solution of **19** (166 mg, 0.143 mmol) in acetone (5 mL) was added K_2CO_3 (79 mg, 0.572 mmol) and allyl bromide (20 µl, 0.224 mmol) at room temperature. After being warmed to 60 °C and stirred for 2 h, the reaction mixture was cooled to rt and filtrated to remove the solid reagent. The combined filtrate was concentrated in vacuo to afford the crude intermediate **22**. To a solution of the obtained compound **22** in MeOH (5 mL) was added Cs_2CO_3 (47 mg, 0.14 mmol) at room temperature. After being warmed to 75 °C and stirred overnight, the reaction mixture was cooled to rt and evaporated under reduced pressure. The residue was dissolved in DCM and filtrated to remove the undissolved substance, and the filtrate was concentrated and purified directly by flash column chromatography (PE-EtOAc, 3:1) to afford **23** (162 mg, 95%) as a yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +20.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 – 6.74 (m, 37H), 6.58 (s, 1H), 6.22 – 5.92 (m, 1H), 5.55 – 4.14 (m, 20H), 3.85 – 3.29 (m, 5H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9/173.8, 162.5/161.8, 160.7/159.5, 159.1/159.1, 154.2/154.1, 150.8/150.6, 146.1/146.0, 141.1, 139.0/138.9, 138.8/138.6, 138.4/138.3, 138.1/137.6, 136.0, 135.9/135.8, 132.9, 129.3, 129.0, 128.9, 128.7, 128.7, 128.5, 128.5, 128.4, 128.4, 128.4, 128.3, 128.2, 128.0, 128.0, 127.9, 127.8, 127.7, 127.7, 127.5, 127.4, 127.3, 127.2, 127.2, 127.1, 127.0, 126.9, 118.7/118.0, 117.9/117.9, 116.2/116.1, 111.1/110.3, 108.2/108.1, 101.1/101.0, 97.3/96.9, 87.9/87.6, 80.5/79.4, 78.5/78.4, 78.3/77.4, 75.4/75.1, 75.0/74.9, 74.4/74.2, 74.0/73.4, 73.3/73.1, 71.1/70.9, 70.5/70.0, 69.9/69.7, 69.17, 65.08 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{71}H_{65}O_{11}$ [M + H]$^+$ 1093.4521, found 1093.4531.

1,3,6-Tri-*O*-benzyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-7-hydroxyxanthone (24). Glycosyl xanthone **23** (707 mg, 0.65 mmol) was dissolved in anhydrous THF (10 mL) at room temperature, and $Pd(PPh_3)_4$ (15 mg, 0.013 mmol) and $NaBH_4$ (49 mg, 1.29 mmol) were added successively. The reaction mixture was stirred at rt for 1 h, and then diluted with DCM. The organic layer was washed with 1N HCl (aq) and brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 4:1) to afford **24** (580 mg, 85%) as a light yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.63 (m, 3H), 7.56 – 6.99 (m, 31H), 6.95 – 6.75 (m, 3H), 6.58 (s, 1H), 5.96 – 5.59 (m, 1H), 5.48 – 4.68 (m, 10H), 4.63 – 4.31 (m, 5H), 4.29 – 4.09 (m, 1H), 3.80 – 3.60 (m, 3H), 3.60 – 3.24 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 162.5/161.4, 160.5/159.4, 159.0/158.9, 152.0/151.6, 149.9/149.6, 143.3, 139.0/138.8, 138.7/138.5, 138.4/138.2, 138.2/138.1, 138.0/137.6, 135.9, 135.4/135.3, 129.3, 128.7, 128.5, 128.5, 128.4, 128.4, 128.3, 128.3, 128.2, 128.1, 128.1, 128.0, 128.0, 127.9, 127.8, 127.7, 127.5, 127.4, 127.4, 127.3, 127.2, 127.0, 118.1/117.4, 116.7/116.3, 110.9/110.3, 110.1/109.9, 99.63, 97.4/96.7, 87.7/87.6, 80.4, 79.2/79.1, 78.5/78.3, 77.4/77.3, 75.2/75.0, 74.9, 74.3/74.1, 73.9/73.4, 73.2/73.1, 71.3/71.2, 70.8/70.7, 69.2, 69.1 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{68}H_{61}O_{11}$ [M + H]$^+$ 1053.4208, found 1053.4181.

1,3,6-Tri-*O*-benzyl-2-*C*-(2,3,4,6-tetra-*O*-benzyl-β-D-glucopyranosyl)-7-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)xanthone (26). To a solution of accepter **24** (210 mg, 0.20 mmol), donor **25** (247 mg, 0.60 mmol) and TBAB (150 mg, 0.47 mmol) in $CHCl_3$ (3 ml) was added 5% NaOH (aq, 2ml). After being stirred for 5 h at 60 °C, the reaction mixture was cooled to rt and then diluted with DCM (25 ml). The organic layers were washed with 1N HCl (aq) and brine, dried over Na_2SO_4, concentrated, and purified by flash column chromatography (PE-EtOAc, 2:1 and DCM-acetone, 20:1) to afford **26** (196 mg, 71%) as a light yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = -32.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (s, 0.7H), 8.00 (s, 0.3H), 7.63 – 7.00 (m, 33H), 6.97 – 6.77 (m, 3H), 6.67 (s, 0.3H), 6.62 (s, 0.7H), 5.43 – 4.67 (m, 14H), 4.64 – 4.07 (m, 8H), 4.02 – 3.21 (m, 6H), 2.09 (s, 2H), 2.06 (s, 2H), 2.04 (s, 1H), 2.02 (s, 2H), 2.01 (s, 1H), 1.93 (s, 1H), 1.82 (s, 2H), 1.80 (s, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.7/173.5, 171.3/171.2, 170.3, 169.6/169.6, 169.3/169.3, 162.7/162.1, 160.8/159.5, 159.2, 154.6/154.5, 152.4/152.3, 144.3/144.2, 139.0/138.9, 138.8/138.6, 138.4/138.3, 138.3/138.1, 137.6, 135.9/135.8, 135.7/135.6, 128.8, 128.8, 128.6, 128.6, 128.5, 128.5, 128.4, 128.4, 128.3, 128.2, 128.1, 128.1, 128.0, 127.9, 127.8, 127.7, 127.6, 127.6, 127.5, 127.4, 127.3, 127.1, 126.9, 119.0/118.1, 116.4/116.3, 113.6, 111.2/110.4, 101.3/101.2, 100.3/100.1, 97.4/97.0, 87.9/87.6, 80.7, 79.4/79.3, 78.5/ 78.3, 77.4/77.3, 75.5/75.2, 75.1/75.0, 74.5/74.3, 73.9, 73.5/73.4, 73.0/72.8, 72.5/72.4, 71.1/71.0, 70.5, 69.9/69.7, 69.2, 68.5, 62.2, 20.7, 20.7, 20.5,

20.4 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{82}H_{79}O_{20}$ $[M + H]^+$ 1383.5159, found 1383.5127.

1,3,6-Tri-*O*-acetyl-2-*C*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-7-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)xanthone (27). To a solution of **26** (50 mg, 0.036 mmol) in MeOH (2 mL) and EtOAc (2 mL) was added 10% $Pd(OH)_2/C$ (20 mg). After being stirred under 1 atm of H_2 for 2 d at room temperature, the suspension was filtrated through Celite to remove the solid catalyst. The filtrate was concentrated in vacuo, and then dissolved in Pyridine (2 mL) at room temperature. Anhydrous acetic anhydride (0.5 mL) was added in, and the mixture was allowed to stir overnight before being diluted with DCM. The organic layers were washed with 1N HCl (aq) and brine, concentrated, and purified by flash column chromatography (PE- EtOAc, 1:1) to afford **27** (32 mg, 85%) as a light yellow solid, with rotamers observed by ^{1}H NMR and ^{13}C NMR: $[\alpha]_D^{25}$ = +24.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (s, 0.3H), 7.70 (s, 0.7H), 7.22 (s, 0.3H), 7.17 (s, 0.7H), 7.12 (s, 0.7H), 7.09 (s, 0.3H), 5.65 (t, *J* = 9.6 Hz, 0.7H), 5.57 (t, *J* = 9.6 Hz, 0.3H), 5.31 – 4.98 (m, 6H), 4.78 (t, *J* = 9.6 Hz, 1H), 4.44 – 4.28 (m, 1H), 4.24 – 4.09 (m, 2H), 4.05 – 3.96 (m, 1H), 3.92 (d, *J* = 12.0 Hz, 1H), 3.75 (d, *J* = 7.6 Hz, 1H), 2.43 (s, 1H), 2.41 (s, 4H), 2.34 (s, 1H), 2.23 (s, 2H), 2.14 (s, 1H), 2.09 – 1.79 (m, 21H), 1.71 (s, 2H), 1.68 (s, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.6/173.3, 171.0/ 170.9, 170.6/170.5, 170.3, 170.0/169.9, 169.7, 169.6, 169.5/169.2, 168.4/168.2, 168.1, 167.7, 157.4/157.1, 154.2/152.4, 151.3/150.9, 150.8/149.5, 146.1/146.0, 120.5/ 120.4, 118.2/117.9, 113.4/112.7, 112.8/112.1, 111.8/110.6, 110.4/110.0, 98.37, 76.9/76.6, 74.6/74.4, 72.8/72.5, 72.5/72.4, 70.5/70.3, 69.5/68.4, 68.2/68.0, 62.0/62.0, 21.4, 21.3, 20.8, 20.7, 20.7, 20.6, 20.6, 20.4, 20.4 ppm; HRMS (ESI-FT-ICR) *m/z* calcd for $C_{47}H_{50}NaO_{27}$ $[M + Na]^+$ 1069.2431, found 1069.2419.

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