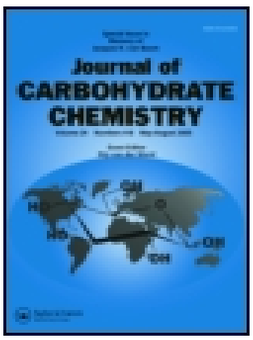


Journal of Carbohydrate Chemistry

ISSN: 0732-8303 (Print) 1532-2327 (Online) Journal homepage: https://www.tandfonline.com/loi/lcar20

Collective syntheses of phenylethanoid glycosides by interrupted Pummerer reaction mediated glycosylations

Yueqi Zhao, Jing Zeng, Yan Liu, Xiong Xiao, Guangfei Sun, Jiuchang Sun, Penghua Shu, Dengxian Fu, Lingkui Meng & Qian Wan

To cite this article: Yueqi Zhao, Jing Zeng, Yan Liu, Xiong Xiao, Guangfei Sun, Jiuchang Sun, Penghua Shu, Dengxian Fu, Lingkui Meng & Qian Wan (2019): Collective syntheses of phenylethanoid glycosides by interrupted Pummerer reaction mediated glycosylations, Journal of Carbohydrate Chemistry, DOI: 10.1080/07328303.2018.1541997

To link to this article: https://doi.org/10.1080/07328303.2018.1541997

JOURNAL OF CARBOHYDRATE CHEMISTRY
https://doi.org/10.1080/07328303.2018.1541997

Collective syntheses of phenylethanoid glycosides by interrupted Pummerer reaction mediated glycosylations

Yueqi Zhao[a], Jing Zeng[a], Yan Liu[a], Xiong Xiao[a], Guangfei Sun[a], Jiuchang Sun[a], Penghua Shu[a], Dengxian Fu[a], Lingkui Meng[a], and Qian Wan[a,b]

[a]Hubei Key Laboratory of Natural Medicinal Chemistry and Resource Evaluation, School of Pharmacy, Huazhong University of Science and Technology, Wuhan, China; [b]Institute of Brain Research, Huazhong University of Science and Technology, Wuhan, China

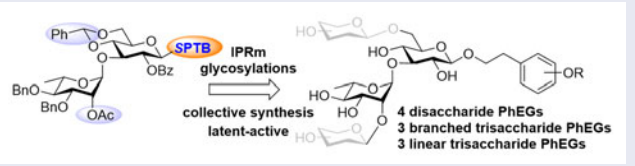
ABSTRACT

The collective total syntheses of nine natural phenylethanoid glycosides (PhEGs) together with proposed Incanoside B in a divergent mode were described. By using a core disaccharide as common intermediate, our developed interrupted Pummerer reaction mediated (IPRm) glycosylations adopting latent-active strategy enables the efficient, concise and divergent syntheses of these bioactive PhEGs. Among them, five natural PhEGs, Darendoside B (**1**), Cistanoside G (**3**), Decaffeoyl acteoside (**4**), Kankanoside F (**5**) and 4‴-*epi*-Leonoside F (**7**) were the first time being synthesized. According to the synthesis of 4‴-*epi*-Leonoside F (**7**), we also elucidated the real structure of carbohydrate component of the PhEG isolated from *Rehmannia glutinosa* which was misled as "Leonoside F".

KEYWORDS

Phenylethanoid glycosides; collective synthesis; structure revision; interrupted Pummerer reaction

GRAPHICAL ABSTRACT



Introduction

Phenylethanoid glycosides (PhEGs) are common components of many medicinal plants, which usually present noteworthy bioactivities.[1] Structurally, PhEGs are glycosides bearing a substituted phenylethanoid aglycon attached to various carbohydrates (Figure 1a). Hundreds of PhEGs have been isolated and identified to date, among which the different

CONTACT Qian Wan wanqian@hust.edu.cn Hubei Key Laboratory of Natural Medicinal Chemistry and Resource Evaluation, School of Pharmacy, Huazhong University of Science and Technology, 7 Hangkong Road, Wuhan, Hubei, 430030, China; Institute of Brain Research, Huazhong University of Science and Technology, 7 Hangkong Road, Wuhan, Hubei, 430030, China

Supplemental data for this article can be accessed on the publisher's website.

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/lcar

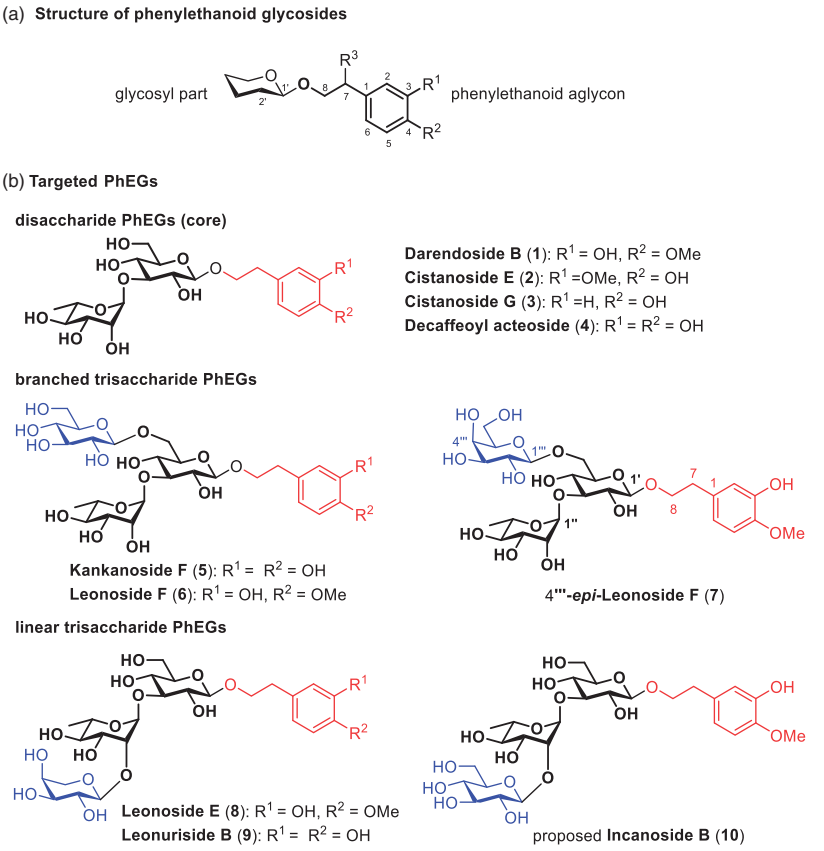
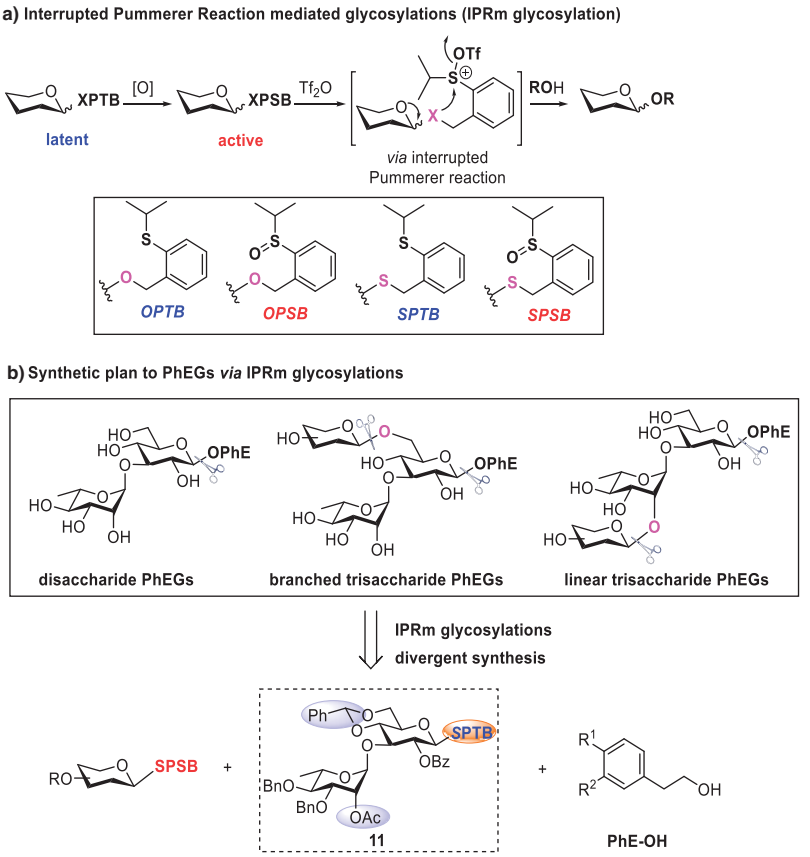


Figure 1. Common structure of PhEGs and targeted PhEGs.

linkage of glycosides and the variation of the aromatic aglycons or residues account for their structural diversity.[2] Updating reviews introduced the isolation and bioactivities of new PhEGs[3] and the chemical synthesis of some PhEGs have also been reported.[4] However, despite inherent structure similarity of these PhEGs, the collective synthesis of PhEGs in a divergent way was rare.

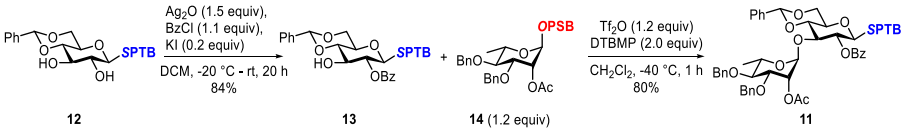
Recently, we have developed two interrupted Pummerer reaction mediated (IPRm) glycosylations.[5] These methods are convenient and efficient in synthesizing complex glycosides due to the allowance of employing latent-active glycosylation strategy. In the IPRm glycosylations, *O*/*S*-2-(2-propylthio)benzyl (*O*/*S*-PTB) glycosides were introduced as "latent" glycosyl donors, which are quite stable under most of glycosylation and many protection/deprotection conditions. The latent *O*/*S*-PTB glycosides can be conveniently oxidized to their "active" counterparts, *O*/*S*-2-(2-propylsulfinyl)benzyl (*O*/*S*-PSB) glycosides, to perform satisfying reactivity in the glycosylation process *via* an interrupted Pummerer reaction mechanism[6] (Scheme 1a). With the newly developed IPRm glycosylations, we



Scheme 1. Interrupted Pummerer reaction mediated (IPRm) glycosylations and synthetic plan to PhEGs.

have accomplished the total syntheses as well as the structural revisions of several PhEGs including Leonoside E, F and Leonuriside B.[5a,5c]

Taking account of the important bioactivities and the structure similarity of PhEGs as well as the efficiency of our newly developed IPRm glycosylation method, here we report the collective total syntheses of a series of PhEGs, including Darendoside B (**1**),[7] Cistanoside E (**2**),[8] Cistanoside G (**3**),[9] Decaffeoyl acteoside (**4**),[10] Kankanoside F (**5**),[11] Leonoside F (**6**),[12] 4‴-*epi*-Leonoside F (**7**), Leonoside E (**8**),[12] Leonuriside B (**9**)[13] and Incanoside B (**10**)[14] (Figure 1b). Most of them have been reported to present interesting bioactivities. For example, Darendoside B (**1**), Cistanoside G (**3**), and Leonuriside B (**9**) present antioxidative activity,[2b,4,15g] Decaffeoyl acteoside (**4**) has antitumor effect,[2b] Kankanoside F (**5**) showed vasorelaxant activity,[11] Leonoside E (**8**) exhibit potent hepatoprotective activity against D-galactosamine-induced toxicity in HL-7702 cells at concentration of 1×10^{-5} M.[12] From structure point of view, **1–4** are



Scheme 2. Synthesis of core disaccharide **11**.

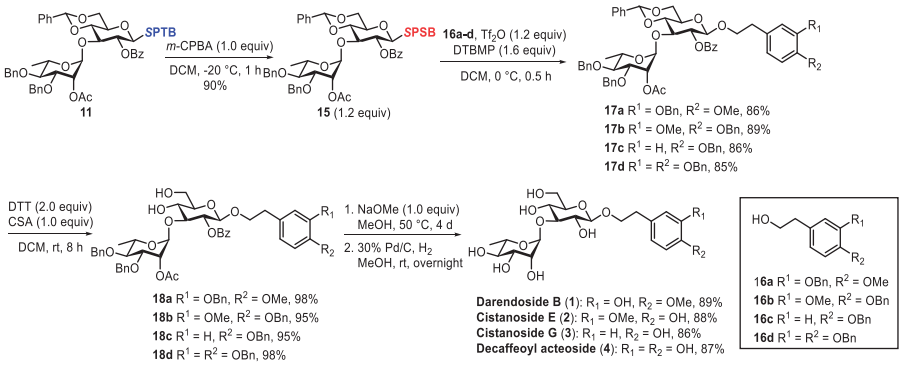
disaccharide PhEGs, **5–7** belong to branched trisaccharide PhEGs, **8–10** are linear trisaccharide PhEGs. Most importantly, all these PhEGs possess the same α-L-rhamnopyranosyl-(1→3)-β-D-glucopyranosyl core disaccharide moiety. This intrinsic structural character promoted us to synthesize these PhEGs from a common disaccharide intermediate **11** incorporating the interrupted Pummerer reaction mediated glycosylations. We envisaged that compound **11** bearing the cleavable acetyl and benzylidene groups could be easily converted to corresponding glycosyl acceptors to link with the third glycosides. More importantly, the latent 1-SPTB group of **11** could be oxidized to its active 1-SPSB pattern whenever needed, and act as glycosyl donors to link with various aglycons (Scheme 1b).

Results and discussion

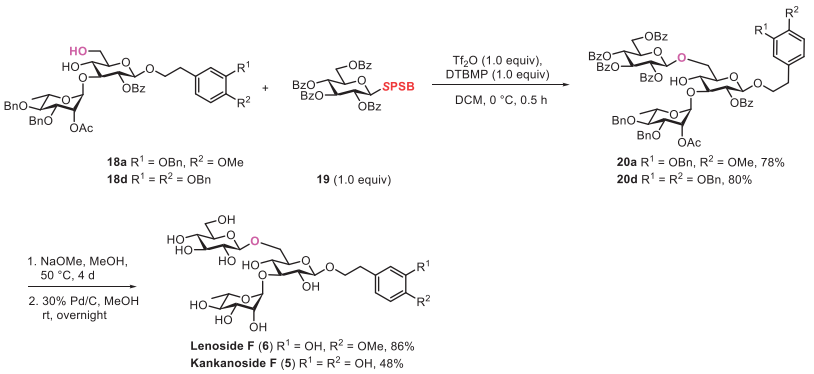
Our collective syntheses of PhEGs commenced from the preparation of the core disaccharide **11** (Scheme 2). Treatment of 2,3-dihydroxyl SPTB glycoside **12**[5c] with Ag_2O (1.5 equiv), BzCl (1.1 equiv) and catalytic amount of KI (0.2 equiv) selectively afforded the mono-benzoylated acceptor **13**.[16] The regioselectivity was confirmed by the downfield shift of H-2 signal from δ 3.41 of **12** to δ 5.19 of **13** in ^{1}H NMR spectrum. Further glycosylation of the latent SPTB glycoside **13** with 1.2 equiv of OPSB donor **14** in the presence of 1.2 equiv of Tf_2O and 2.0 equiv DTBMP furnished the core disaccharide **11** in 80% yield with absolute stereo-control.

With the core disaccharide intermediate **11** in hand, we started to synthesize the disaccharide PhEGs **1–4** following the route showed in Scheme 3. After oxidation of **11** to its active pattern, the obtained donor **15** was coupled with four different phenylethanol aglycons **16a–d** respectively in the presence of 1.2 equiv of Tf_2O and 1.6 equiv of DTBMP, which provided **17a–d** in yields ranging from 85% to 89%. Deprotection of benzylidene groups of **17a–d** with our recently reported 1,4-dithiotretol (DTT) mediated acetal groups deprotection method provided **18a–d** efficiently.[17] Further deacylations and debenzylations successfully afforded the disaccharide PhEGs Darendoside B (**1**), Cistanoside E (**2**), Cistanoside G (**3**) and Decaffeoyl acteoside (**4**) respectively in excellent yields. The spectral data of **1–4** were in good agreement with those reported for isolated natural products.[7–10]

The obtaining of **18a–d** possessing free hydroxy groups during the synthesis of PhEGs **1–4** allowed the quick access to branched PhEGs **5–6** by



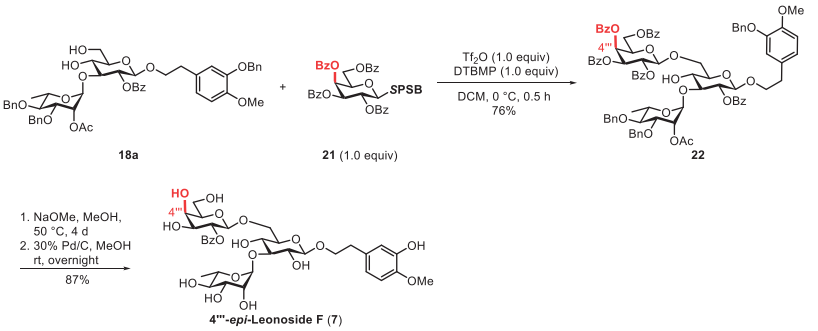
Scheme 3. Syntheses of disaccharide PhEGs **1**–**4**.



Scheme 4. Syntheses of branched PhEGs **5** and **6**.

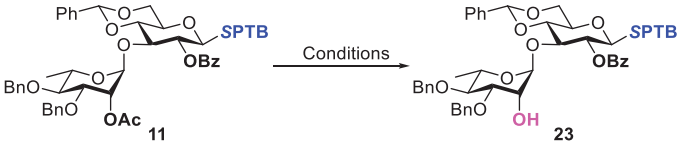
selective attaching the third carbohydrate moieties to the primary hydroxy group. The coupling reaction between SPSB glycoside **19** and disaccharide **18a** or **18d** under the standard activation conditions proceeded smoothly, which offered trisaccharide **20a** or **20d** regioselectively. Further deprotection reactions provided Leonoside F (**6**, revised structure)[5a] and Kankanoside F (**5**) successfully (Scheme 4).

We have recently reported the structure revision of Leonoside F[5a] which was originally isolated from Chinese motherwort (*Leonurus japonicus Houtt*)[12]. Following this isolation, it was reported that Leonoside F was also isolated from Chinese foxglove (*Rehmannia glutinosa*).[18] However, it was found that the ^{13}C-NMR spectra of the latter Leonoside F is different from that of the revised Leonoside F in the region δ 69.0–79.0 ppm which were assigned to the branched glucose component. By carefully analyzing the spectra, we suspected that the branched glucose of "Leonoside F" isolated from Chinese foxglove was incorrectly elucidated; most possibly it would be galactose. To verify this hypothesis, we synthesized 4‴-*epi*-Leonoside F containing galactose moiety followed the procedure depicted



Scheme 5. Synthesis of 4‴-*epi*-Leonoside F (**7**).

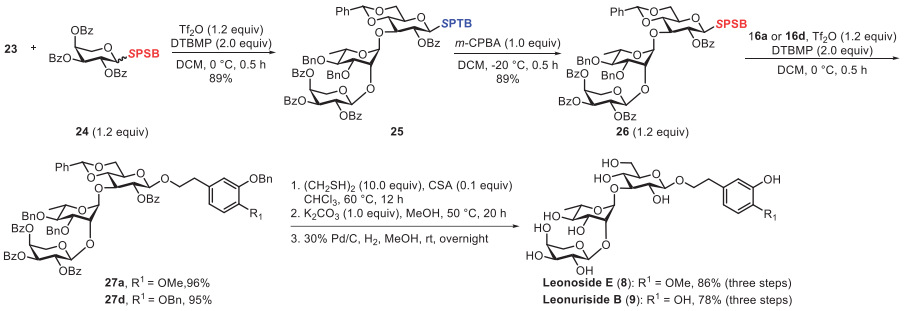
Table 1. Selective removal of acetyl group of 11.



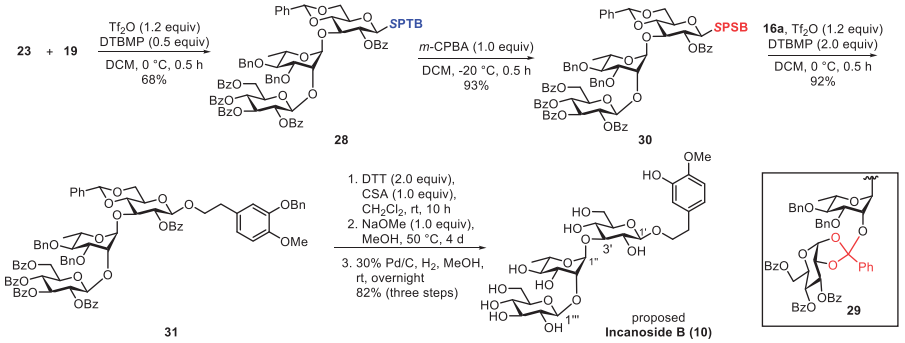
Entry	Conditions	Yield (%)
1	K_2CO_3, DCM/MeOH, rt, 10 h	65
2	NaOMe, DCM/MeOH, rt, 29 h	71
3	N_2H_4-H_2O (10 eq), THF, rt, 12 h	0
4	N_2H_4-H_2O(100 eq), THF, 60 °C, 30 h	78

in Scheme 5. As predicted, the NMR data of the trisaccharide moiety of 4‴-*epi*-Leonoside F is perfectly matched with the isolated one, which suggested the real structure of the carbohydrate component of "Leonoside F" isolated from Chinese foxglove. However, slightly difference still exist in the aromatic part ($\Delta\delta \pm 0.4$ ppm in ^{13}C-NMR) possibly due to the different chemical environment in NMR test.[19]

The successful synthesis of the disaccharide and branched PhEGs encouraged us to further apply this strategy to the synthesis of linear PhEGs **8**–**10**. The structure difference of these PhEGs lies not only on the aglycon moiety but also on the terminal sugar components. We planned to install the terminal sugars to the core disaccharide **11** first which required the selective removal of the acetyl group of **11** in the presence of the benzoyl group. As shown in Table 1, when treatment of **11** with NaOMe in dry DCM/MeOH,[20] the desired product **23** was obtained in 71% yield, together with some debenzoylation by-product. The utilization of K_2CO_3 gave a similar result. Then N_2H_4-H_2O was employed as deacetylation reagent.[21] However, the starting material **11** is quite stable when applying 10 equiv of N_2H_4-H_2O at room temperature, after increasing N_2H_4-H_2O to



Scheme 6. Syntheses of linear PhEGs **8** and **9**.



Scheme 7. Synthesis of proposed Incanoside B (**10**).

100 equiv and elevating reaction temperature to 60 °C, **23** was finally obtained in 78% yield.

We then moved on synthesizing Leonoside E (**8**) and Leonuriside B (**9**) bearing the same trisaccharide glycan (Scheme 6). The latent trisaccharide **25** was obtained as single isomer by coupling of donor **24** with disaccharide acceptor **23**. Further oxidation and glycosylation with **16a** or **16d** provided **27a** or **27d** in high efficiency. Final global deprotection of benzylidene group, acyl group and benzyl group offered Leonoside E (**8**) and Leonuriside B (**9**) in 86% and 78% yield respectively.

However, when application of above mentioned glycosylation conditions to the synthesis of trisaccharide moiety **28**, only 13% of desired product was obtained, accompanied with 69% of ortho-ester by-product **29,** possibly resulting from the over basicity reaction conditions by using 2.0 equiv of DTBMP. Thus, we decreased the dosage of DTBMP to 0.5 equiv, and to our delight, the ortho-ester by-product decreased effectively and **28** was obtained in 68% yield. Following the subsequent glycosylation and deprotection reactions as described in Scheme 7, finally, we successfully obtained the proposed structure of Incanoside B (**10**). However, it was found that the chemical shifts of the proposed structure were inconsistent with those of isolated one at C3' and C4'

position ($\Delta\delta$ 1.6 and 1.2 ppm of ^{13}C NMR respectively, see the Supporting Information), which indicated that the rhamnose moiety of the real structure of Incanoside B most possibly linked to C4' position other than C3' position.

Conclusion

In summary, we have collectively synthesized ten phenylethanoid glycosides (PhEGs), including four disaccharide, three branched trisaccharide and three linear trisaccharide, based on interrupted Pummerer reaction mediated glycosylations in a divergent manner. The synthesis employed a core disaccharide **11** as a key intermediate. Starting from this common intermediate, PhEGs **1**–**4** were obtained in 5 steps in total yields of 62–68%; branched PhEGs **5**–**7** were acquired in 6 steps in total yield of 30–51%; and linear PhEGs **8**–**10**, were produced in 7 steps in total yields of 37–51%. Among these PhEGs, the syntheses of Darendoside B (**1**), Cistanoside G (**3**), Decaffeoyl acteoside (**4**), Kankanoside F (**5**) are first reported. In addition, during the synthesis, we also revised the structure of the glycan moiety of Leonoside F isolated from Chinese foxglove, although the exact structure requires further elucidation. We also found that the structure of Incanoside B (**10**) was incorrectly assigned, elucidation of its real structure is under way.

Experimental section

General experimental methods

NMR spectra were recorded on Bruker AM-400 spectrometer (400 MHz), and the ^{1}H and ^{13}C NMR chemical shifts were referenced to the solvent or solvent impurity peaks for $CDCl_3$ at δ H 7.24 and δ C 77.16. Optical rotations were measured at 20 °C with a Rudolph Autopol IV automatic polarimeter using a quartz cell with 2 mL capacity and a 1 dm path length. Concentrations (*c*) are given in g/100 mL. High resolution mass spectra were recorded on a Bruker micro TOF II spectrometer using electrospray ionization (ESI). Thin layer chromatography (TLC) was performed on silica-gel-coated TLC plates (Yantai Chemical Industry Research Institute) and revealed with either a UV lamp (λ_{max} = 254 nm) or by spraying with 10% H_2SO_4 (10% H_2SO_4 in ethanol) and subsequent charring by heating. Column chromatography was performed using silica gel (Qingdao Marine Chemical Inc., China).

Materials

Prior to running the glycosylation reactions, all reagents except Tf_2O and those with low boiling point (<180 °C) were dried by repeated azeotropic removal of water using toluene and a rotary evaporator at 27 °C. Solvents for reactions were dried on an Innovative Technologies Pure Solv400 solvent purifier. Molecular sieves (4 Å, powder <50 μm) for reactions were flame dried immediately before use. Trifluoromethanesulfonic anhydride (Tf_2O), 3-Chloroperoxybenzoic acid (*m*-CPBA) and all other commercial available chemicals were purchased from Adamas and used without further purification.

S-2-Isopropylmercaptobenzyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-1-thio-β-D-glucopyranoside (11)

A solution of **14** (100 mg, 0.18 mmol)[5a] and DTBMP (61.6 mg, 0.29 mmol) in CH_2Cl_2 (1.76 mL) in the presence of 4 Å MS (100 wt%) was stirred at −40 °C for 15 min. After addition of Tf_2O (30 μL, 0.18 mmol), the solution was stirred at −40 °C for 3 min, and then **13** (81.3 mg, 0.15 mmol) [5c] in CH_2Cl_2 (0.98 mL) was added. The reaction mixture was stirred at −40 °C for 1 h and quenched with saturated aqueous $NaHCO_3$. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **11** (108 mg, 80% yield) as white solid. R_f = 0.49 (petroleum -EtOAc 4:1). $[\alpha]_D^{20}$ −41.2 (*c*, 1.00 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96–7.94 (2 H, dd, J = 8.4, 1.2 Hz, Ar-H), 7.57–7.13 (22 H, m, Ar-H), 5.54 (1 H, s, PhC*H*O_2), 5.36 (1 H, dd, J = 10.0, 8.8 Hz, H-2$_{Glu}$), 5.17 (1 H, dd, J = 3.2, 1.6 Hz, H-2$_{Rham}$), 4.79 (1 H, d, J = 10.8 Hz, ArCH_2), 4.78 (1 H, d, J = 1.6 Hz, H-1$_{Rham}$), 4.57 (1 H, d, J = 10.8 Hz, ArCH_2), 4.55 (1 H, d, J = 10.0 Hz, H-1$_{Glu}$), 4.46 (1 H, d, J = 11.0 Hz, ArCH_2), 4.38 (1 H, dd, J = 10.4, 5.2 Hz), 4.37 (1 H, d, J = 11.0 Hz, ArCH_2), 4.22 (1 H, d, J = 13.2 Hz, ArCH_2), 4.08–4.00 (3 H, m), 3.82 (1 H, dd, J = 8.8, 3.2 Hz), 3.78 (1 H, t, J = 10.0 Hz), 3.68 (1 H, t, J = 9.6 Hz), 3.52 (1 H, td, J = 9.6, 4.8 Hz, H-5$_{Glu}$), 3.27 (1 H, hepta. J = 6.4 Hz, -SC*H*$(CH_3)_2$), 3.22 (1 H, t, J = 9.6 Hz), 1.77 (3 H, s, -OAc), 1.19 (3 H, d, J = 6.4 Hz, -SCH$(CH_3)_2$), 1.16 (3 H, d, J = 6.4 Hz, -SCH$(CH_3)_2$), 0.89 (3 H, d, J = 6.4 Hz, H-6$_{Rham}$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.3 (C = O), 165.1 (C = O), 139.4, 138.8, 138.2, 137.0, 135.6, 133.4, 133.2, 130.5, 130.2, 130.2, 129.3, 129.1, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 128.2, 128.2, 127.9, 127.8, 127.8, 127.7, 127.6, 127.2, 126.4, 126.4 (Ar), 101.8, 98.7, 83.7, 80.0, 79.2, 78.0, 77.9, 75.1, 73.0, 71.7, 71.1, 68.7, 68.4, 68.0, 39.0, 33.0, 23.2, 23.1, 20.7, 17.5. HRMS calc. for $C_{52}H_{56}NaO_{11}S_2$ $[M + Na]^+$:943.3156, found: 943.3158.

S-2-Isopropylsulfinylbenzyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-1-thio-β-D-glucopyranoside (15)

A solution of **11** (500 mg, 0.54 mmol) in CH_2Cl_2 (2.71 mL) was cooled to −20 °C, followed by dropwise addition of the solution of 3-chloroperoxybenzoic acid (75%) (125 mg, 0.54 mmol) in CH_2Cl_2 (2.71 mL). The reaction mixture was stirred at −20 °C for 1 h, diluted with EtOAc, washed with 10% $Na_2S_2O_3$ aqueous solution. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **15** (457 mg, 90% yield) as white foam, R_f = 0.29 (petroleum -EtOAc 2:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (2 H, d, J = 7.6 Hz, Ar-H), 7.96 (2 H, d, J = 7.6 Hz, Ar-H), 7.84–7.79 (2 H, m, Ar-H), 7.60–7.18 (42 H, m, Ar-H), 5.55 (1 H, s, PhC*H*O_2), 5.54 (1 H, s, PhC*H*O_2), 5.43–5.35 (2 H, m), 5.15 (1 H, dd, J = 3.2, 1.6 Hz, H-2$_{Rham}$), 5.12 (1 H, dd, J = 3.2, 1.6 Hz, H-2$_{Rham}$), 4.83 (1 H, brs, H-1$_{Rham}$), 4.79–4.75 (3 H, m), 4.64 (1 H, d, J = 10.0 Hz, H-1$_{Glu}$), 4.54 (1 H, d, J = 11.2 Hz, ArC*H*$_2$), 4.53 (1 H, d, J = 11.2 Hz, ArC*H*$_2$), 4.49–4.46 (2 H, m), 4.44–4.38 (2 H, m), 4.37–4.30 (3 H, m), 4.12–4.10 (3 H, m), 4.09–4.05 (1 H, t, J = 9.2 Hz), 4.03–3.96 (3 H, m), 3.89 (1 H, d, J = 13.2 Hz, ArC*H*$_2$), 3.82–3.78 (3 H, m), 3.76–3.69 (2 H, m), 3.67 (1 H, t, J = 9.6 Hz), 3.58–3.51 (2 H, m), 3.25–3.19 (2 H, m), 3.02 (1 H, hepta. J = 6.4 Hz, -SC*H*(CH$_3$)$_2$), 2.90 (1 H, hepta. J = 6.4 Hz, -SC*H*(CH$_3$)$_2$), 1.77 (3 H, s, -OAc), 1.75 (3 H, s, -OAc), 1.21 (3 H, d, J = 6.8 Hz, -SCH(C*H*$_3$)$_2$), 1.12 (3 H, d, J = 6.8 Hz, -SCH(C*H*$_3$)$_2$), 1.02 (3 H, d, J = 6.8 Hz, -SCH(C*H*$_3$)$_2$), 0.99 (3 H, d, J = 6.8 Hz, -SCH(C*H*$_3$)$_2$), 0.89 (3 H, d, J = 6.4 Hz, H-6$_{Rham}$), 0.87 (3 H, d, J = 6.4 Hz, H-6$_{Rham}$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.2, 169.2, 165.1, 164.9 (C = O), 141.5, 141.4, 138.7, 138.6, 138.0, 138.0, 136.8, 136.8, 135.3, 134.6, 133.6, 133.6, 131.0, 131.0, 130.9, 130.7, 130.0, 130.0, 130.0, 130.0, 129.1, 129.0, 128.9, 128.8, 128.5, 128.5, 128.5, 128.5, 128.3, 128.3, 128.3, 128.3, 128.3, 128.3, 128.3, 128.3, 128.2, 128.2, 128.2, 128.2, 128.1, 128.1, 128.0, 128.0, 128.0, 127.7, 127.7, 127.7, 127.7, 127.6, 127.6, 127.5, 127.5, 126.3, 126.3, 126.3, 126.3, 126.3, 125.7, 125.7 (Ar), 101.8, 101.8, 98.7, 98.7, 83.9, 82.6, 79.8, 79.8, 79.0, 79.0, 77.8, 77.8, 77.7, 77.6, 77.2, 77.2, 75.0, 75.0, 72.7, 72.7, 71.7, 71.7, 71.2, 71.2, 68.4, 68.4, 68.0, 67.9, 53.8, 53.5, 29.8, 29.3, 20.6, 20.6, 17.4, 17.4, 17.4, 17.2, 12.7, 12.7. HRMS calc. for $C_{52}H_{56}NaO_{12}S_2$ $[M + Na]^+$:959.3111, found: 959.3143.

General procedure for the preparation of 17a–d

A solution of **15** (100 mg, 0.11 mmol, 1.2 equiv), **16** (**a-d**) (0.09 mmol, 1.0 equiv) and DTBMP (29.8 mg, 0.14 mmol, 1.6 equiv) in CH_2Cl_2 (1.78 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min. Tf_2O (17.9 μL, 0.11 mmol, 1.2 equiv) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture was quenched with Et_3N, then filtered

and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **17a-d**.

3-Benzoxyl-4-methoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O -benzoyl-4,6-O- benzylidene-β-D-glucopyranoside (17a)

White solid, R_f = 0.50 (petroleum-EtOAc 3:1). $[\alpha]_D^{20}$ −11.4 (*c*, 3.45 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (2 H, d, J = 8.0 Hz, Ar-H), 7.57–7.19 (23 H, m, Ar-H), 6.67 (1 H, s, H-2), 6.62 (1 H, d, J = 8.0 Hz, H-6), 6.50 (1 H, d, J = 8.0 Hz, H-5), 5.51 (1 H, s, PhC*H*O_2), 5.31 (1 H, t, J = 8.0 Hz, H-2$_{Glu}$), 5.20 (1 H, brs, H-2$_{Rham}$), 5.07 (2 H, s, PhCH_2O-), 4.81 (1 H, appar. s, H-1$_{Rham}$), 4.70 (1 H, d, J = 11.8 Hz, PhCH_2), 4.60 (1 H, d, J = 8.4 Hz, H-1$_{Glu}$), 4.58 (1 H, d, J = 11.8 Hz, PhCH_2), 4.47 (1 H, d, J = 10.8 Hz, PhCH_2), 4.38 (1 H, d, J = 10.8 Hz, PhCH_2), 4.36 (1 H, dd, J = 9.6, 5.2 Hz), 4.09–3.99 (3 H, m), 3.85 (1 H, dd, J = 9.2, 3.2 Hz), 3.77 (1 H, dd, J = 10.4, 10.0 Hz), 3.69 (3 H, s, -OMe), 3.66 (1 H, t, J = 9.6 Hz), 3.60 (1 H, m), 3.53 (1 H, m, H-5$_{Glu}$), 3.24 (1 H, t, J = 9.6 Hz), 2.71 (2 H, m, ArCH_2CH_2O-), 1.80 (3 H, s, -OAc), 0.91 (3 H, d, J = 6.0 Hz, H-6$_{Rham}$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.4 (C = O), 165.0 (C = O), 148.2, 147.9, 138.8, 138.2, 137.4, 137.0, 133.3, 130.9, 130.0, 130.0, 129.4, 129.1, 128.6, 128.6, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 128.2, 128.2, 127.9, 127.8, 127.8, 127.7, 127.6, 127.5, 127.5, 126.4, 126.4, 121.7 (Ar), 115.0, 111.7, 101.8, 101.4, 98.6, 80.0, 79.2, 77.9, 76.8, 75.1, 74.4, 71.7, 71.0, 70.9, 68.8, 68.5, 67.9, 66.8, 56.0, 35.6, 20.7, 17.5. HRMS calc. for $C_{58}H_{60}NaO_{14}$ $[M + Na]^+$:1003.3875, found: 1003.3898.

4-Benzoxyl-3-methoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O -benzoyl-4,6-O- benzylidene-β-D-glucopyranoside (17b)

White solid, R_f = 0.45 (petroleum-EtOAc 3:1). $[\alpha]_D^{20}$ −9.2 (*c*, 0.75 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (2 H, d, J = 7.2 Hz, Ar-H), 7.56–7.19 (23 H, m, Ar-H), 6.66 (1 H, d, J = 0.8 Hz, H-2), 6.57–6.52 (2 H, m, H-5, 6), 5.52 (1 H, s, PhC*H*O_2), 5.32 (1 H, t, J = 8.0 Hz, H-2$_{Glu}$), 5.19 (1 H, dd, J = 3.2, 2.0 Hz, H-2$_{Rham}$), 4.96 (2 H, s, PhCH_2O-), 4.81 (1 H, appar. s, H-1$_{Rham}$), 4.79 (1 H, d, J = 11.6 Hz, PhCH_2), 4.65 (1 H, d, J = 7.6 Hz, H-1$_{Glu}$), 4.57 (1 H, d, J = 10.8 Hz, PhCH_2), 4.47 (1 H, d, J = 10.8 Hz, PhCH_2), 4.37 (1 H, d, J = 10.8 Hz, PhCH_2), 4.36 (1 H, dd, J = 10.8, 5.2 Hz), 4.09–4.00 (3 H, m), 3.83 (1 H, dd, J = 9.2, 3.2 Hz), 3.80 (3 H, s, -OMe), 3.78 (1 H, t, J = 10.4 Hz), 3.67 (1 H, t, J = 9.2 Hz), 3.64 (1 H, m), 3.53 (1 H, m, H-5$_{Glu}$), 3.23 (1 H, t, J = 9.6 Hz), 2.74 (2 H, m, ArCH_2CH_2O-), 1.80 (3 H, s, -OAc), 0.90 (3 H, d, J = 6.4 Hz, H-6$_{Rham}$). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.3 (C = O), 164.9 (C = O), 149.4, 146.6, 138.7, 138.1, 137.4, 136.9, 133.2, 131.5,

129.9, 129.9, 129.3, 129.0, 128.5, 128.5, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 128.1, 128.1, 128.1, 128.1, 127.7, 127.7, 127.7, 127.6, 127.5, 127.2, 127.2, 126.3, 126.3, 120.8, 113.8, 112.8 (Ar), 101.7, 101.3, 98.5, 79.9, 79.1, 77.8, 75.0, 74.4, 71.6, 70.9, 70.9, 68.7, 68.4, 67.9, 66.7, 55.9, 35.7, 20.6, 17.4. (one ^{13}C signal may overlapped with $CDCl_3$ solvent peaks) HRMS calc. for $C_{58}H_{60}NaO_{14}$ $[M+Na]^+$:1003.3875, found: 1003.3882.

4-Benzoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-β-D-glucopyranoside (17c)

White solid, R_f = 0.27 (petroleum-EtOAc 4:1). $[\alpha]_D^{20}$ −9.1 (*c*, 0.9 in $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (2 H, d, J = 7.6 Hz, Ar-H), 7.56–7.19 (23 H, m, Ar-H), 6.99 (2 H, d, J = 8.4 Hz, H-2, 6), 6.65 (2 H, d, J = 8.4 Hz, H-3, 5), 5.50 (1 H, s, PhC*H*O_2), 5.32 (1 H, dd, J = 8.4, 8.0 Hz, H-2_{Glu}), 5.20 (1 H, dd, J = 2.8, 1.6 Hz, H-2_{Rham}), 4.87–4.78 (4 H, m), 4.63 (1 H, d, J = 7.6 Hz, H-1_{Glu}), 4.58 (1 H, d, J = 10.8 Hz, PhCH_2), 4.47 (1 H, d, J = 10.8 Hz, PhCH_2), 4.38 (1 H, d, J = 10.8 Hz, PhCH_2), 4.36 (1 H, dd, J = 9.6, 4.8 Hz), 4.09–3.98 (3 H, m), 3.84 (1 H, dd, J = 9.6, 3.2 Hz), 3.77 (1 H, t, J = 10.4 Hz), 3.66 (1 H, t, J = 9.2 Hz), 3.62 (1 H, m), 3.52 (1 H, td, J = 9.6, 4.8 Hz, H-5_{Glu}), 3.24 (1 H, t, J = 9.6 Hz), 2.80–2.71 (2 H, m, ArCH_2CH_2O-), 1.80 (3 H, s, -OAc), 0.90 (3 H, d, J = 6.0 Hz, H-6_{Rham}). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.4 (C = O), 165.0 (C = O), 157.3, 138.8, 138.2, 137.2, 137.0, 133.4, 130.9, 130.1, 130.1, 130.0, 130.0, 129.5, 129.1, 128.7, 128.7, 128.5, 128.5, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 128.0, 127.8, 127.8, 127.7, 127.6, 127.5, 127.5, 126.4, 126.4, 114.7, 114.7 (Ar), 101.8, 101.3, 98.6, 80.0, 79.2, 77.9, 75.1, 74.5, 71.8, 71.0, 69.9, 68.8, 68.5, 67.9, 66.8, 35.2, 20.8, 17.5. (one ^{13}C signal may overlapped with $CDCl_3$ solvent peaks) HRMS calc. for $C_{57}H_{58}NaO_{13}$ $[M+Na]^+$:973.3770, found: 973.3776.

3,4-Dibenzoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-β-D-glucopyranoside (17d)

White solid, R_f = 0.50 (petroleum-EtOAc 3:1). $[\alpha]_D^{20}$ −10.9 (*c*, 1.24 in $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ 7.98 (2 H, d, J = 7.6 Hz, Ar-H), 7.54–7.18 (28 H, m, Ar-H), 6.72 (1 H, s, H-2), 6.58 (2 H, m, H-5, 6), 5.51 (1 H, s, PhC*H*O_2), 5.30 (1 H, t, J = 8.4 Hz, H-2_{Glu}), 5.18 (1 H, dd, J = 2.4, 1.6 Hz, H-2_{Rham}), 5.07 (2 H, s, PhCH_2O-), 4.95 (2 H, s, PhCH_2O-), 4.80 (1 H, appar. s, H-1_{Rham}), 4.78 (1 H, d, J = 10.8 Hz, PhCH_2), 4.60 (1 H, d, J = 7.6 Hz, H-1_{Glu}), 4.56 (1 H, d, J = 10.8 Hz, PhCH_2), 4.46 (1 H, d, J = 10.8 Hz, PhCH_2), 4.37 (1 H, d, J = 10.8 Hz, PhCH_2), 4.36 (1 H, dd, J = 10.4, 4.8 Hz), 4.06 (1 H, t, J = 9.2 Hz), 4.04–3.98 (2 H, m), 3.83 (1 H, dd, J = 9.6, 3.6 Hz), 3.78 (1 H, t, J = 10.0 Hz), 3.66 (1 H, t, J = 9.6 Hz),

3.60 (1 H, m), 3.51 (1 H, td, $J = 9.6$, 4.8 Hz, H-5_{Glu}), 3.23 (1 H, t, $J = 9.6$ Hz), 2.71 (2 H, m, ArCH_2CH_2O-), 1.79 (3 H, s, -OAc), 0.90 (3 H, d, $J = 6.4$ Hz, H-6_{Rham}). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.4 (C = O), 165.0 (C = O), 148.9, 147.6, 138.8, 138.2, 137.6, 137.6, 137.1, 133.3, 131.8, 130.0, 130.0, 129.5, 129.1, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 127.8, 127.8, 127.8, 127.8, 127.7, 127.6, 127.5, 127.5, 127.4, 127.4, 126.4, 126.4, 122.0, 116.1, 115.1 (Ar), 101.8, 101.5, 98.7, 80.0, 79.3, 78.0, 75.1, 74.5, 71.8, 71.4, 71.4, 71.0, 68.8, 68.5, 68.0, 66.8, 35.7, 20.8, 17.5. (one ^{13}C signal may overlapped with $CDCl_3$ solvent peaks) HRMS calc. for $C_{64}H_{64}NaO_{14}$ $[M + Na]^+$:1079.4188, found: 1079.4218.

General procedure for the preparation of 18a-d

17a-d (0.05 mmol, 1.0 equiv) and DTT (0.1 mmol, 2.0 equiv) was dissolved in CH_2Cl_2 (0.5 mL), followed by quick addition of CSA (0.05 mmol, 1.0 equiv), the reaction mixture was stirred at room temperature for 8 h, diluted with EtOAc, washed with water and brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give the deprotection of benzylidene product **18a-d**.

3-Benzoxyl-4-methoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-β-D- glucopyranoside (18a)

White solid, R_f = 0.24 (petroleum-EtOAc 1:1). $[\alpha]_D^{20}$ +19.8 (*c*, 0.41 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03–8.01 (2 H, d, $J = 8.0$ Hz, Ar-H), 7.58–7.11 (18 H, m, Ar-H), 6.66 (1 H, brs, H-2), 6.63 (1 H, d, $J = 8.0$ Hz, H-6), 6.50 (1 H, d, $J = 8.0$ Hz, H-5), 5.14 (1 H, t, $J = 8.8$ Hz, H-2_{Glu}), 5.06 (2 H, s, PhCH_2O-), 4.95 (1 H, appar. s, H-2_{Rham}), 4.84–4.82 (2 H, m), 4.54 (1 H, d, $J = 8.0$ Hz, H-1_{Glu}), 4.52 (1 H, d, $J = 11.2$ Hz, PhCH_2), 4.21 (2 H, s, PhCH_2), 4.04–4.00 (2 H, m), 3.98–3.90 (2 H, m), 3.84–3.77 (2 H, m), 3.71 (3 H, s, -OMe), 3.68–3.56 (3 H, m), 3.41–3.34 (2 H, m), 2.70 (2 H, m, ArCH_2CH_2O-), 2.12 (1 H, brs. -OH), 1.97 (3 H, s, -OAc), 1.30 (3 H, d, $J = 6.0$ Hz, H-6_{Rham}). ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.0 (C = O), 165.3 (C = O), 148.2, 148.0, 138.3, 137.7, 137.4, 133.4, 130.9, 129.9, 129.9, 129.8, 128.7, 128.7, 128.6, 128.6, 128.5, 128.5, 128.5, 128.5, 128.3, 128.3, 128.0, 128.0, 127.9, 127.9, 127.8, 127.5, 127.5, 121.6, 115.1, 111.8 (Ar), 101.0, 99.8, 86.6, 79.4, 77.0, 75.4, 75.3, 72.1, 71.5, 71.0, 70.9, 70.4, 69.6, 68.8, 62.6, 56.0, 35.6, 21.0, 18.2. HRMS calc. for $C_{51}H_{56}NaO_{14}$ $[M + Na]^+$: 915.3562, found: 915.3549.

3,4-Dibenzoxylphenylethyl 2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-β-D- glucopyranoside (18d)

White solid, R_f = 0.28 (petroleum-EtOAc 1:1). $[\alpha]_D^{20}$ +19.7 (*c*, 0.3 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 (2 H, dd, J = 8.4, 1.2 Hz, Ar-H), 7.54 (1 H, t, J = 7.6 Hz, Ar-H), 7.44–7.20 (20 H, m, Ar-H), 7.11 (2 H, m, Ar-H), 6.72 (1 H, br s, H-2), 6.61–6.56 (2 H, m, H-5,6), 5.14 (1 H, t, J = 8.8 Hz, H-2'), 5.06 (2 H, s, -ArOCH_2Ph), 4.96 (2 H, s, -ArOCH_2Ph), 4.94 (1 H, dd, J = 2.8, 2.4 Hz, H-2″), 4.83–4.01 (2 H, m), 4.55 (1 H, d, J = 8.0 Hz, H-1'), 4.51 (1 H, d, J = 10.8 Hz), 4.19 (2 H, s, ArCH_2), 4.00 (2 H, m), 3.92 (2 H, m), 3.82 (1 H, dd, J = 9.2, 3.2 Hz), 3.78 (1 H, brs), 3.67–3.57 (3 H, m), 3.39 (1 H, m), 3.36 (1 H, t, J = 9.6 Hz), 2.71 (2 H, m, ArCH_2CH_2O-), 2.05 (1 H, br s), 1.97 (3 H, s, -OAc), 1.30 (3 H, d, J = 6.0 Hz, H-6″). ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.0 (C = O), 165.3 (C = O), 148.8, 147.5, 138.3, 137.7, 137.6, 137.6, 133.4, 131.8, 129.9, 129.9, 129.7, 128.7, 128.7, 128.6, 128.6, 128.6, 128.6, 128.5, 128.5, 128.5, 128.5, 128.3, 128.3, 128.0, 128.0, 127.9, 127.8, 127.8, 127.8, 127.5, 127.5, 127.4, 127.4, 121.9, 116.0, 115.0 (Ar), 101.0, 99.8, 86.8, 79.3, 77.0, 75.4, 75.3, 72.0, 71.5, 71.3, 71.3, 70.9, 70.5, 69.6, 68.8, 62.6, 35.7, 21.0, 18.2. HRMS calc. for $C_{57}H_{60}NaO_{14}$ $[M + Na]^+$: 991.3881, found: 991.3903.

General procedure for the preparation of 1–4

18a–d (0.05 mmol, 1.0 equiv) was dissolved in methanol (1.0 mL), followed by the addition of NaOMe (0.05 mmol, 1.0 equiv), the reaction mixture was stirred at 50 °C until the completion of deprotection of acyl group, the reaction mixture was evaporated and purified by silica gel column chromatography. After that, the obtained product was dissolved in methanol (1 mL), the solution was added to 30 wt% Pd/C (10% Palladium on activated carbon) in a Schlenk tube, the reaction system was degassed with H_2, and stirred under H_2 atmosphere at room temperature overnight. The solid materials were filtrated off, and the solution was concentrated. The residue was chromatographed on a Sephadex LH-20 column (CH_2Cl_2/MeOH 1:1) to give **1–4** as final products.

Darendoside B (1)

Colorless glass, R_f = 0.42 (EtOAc:MeOH:H_2O 39:11:4). $[\alpha]_D^{20}$ −43.8 (*c*, 0.13 in CH_3OH). ^{1}H NMR (400 MHz, methanol-d_4) δ 6.81 (1 H, d, J = 8.4 Hz, H-5), 6.72 (1 H, d, J = 2.0 Hz, H-2), 6.67 (1 H, dd, J = 8.4, 2.0 Hz, H-6), 5.15 (1 H, d, J = 2.0 Hz, H-1″), 4.29 (1 H, d, J = 8.0 Hz, H-1'), 4.07–3.97 (2 H, m), 3.95 (1 H, m), 3.87 (1 H, dd, J = 11.6, 2.0 Hz), 3.81 (3 H, s, -OMe), 3.74–3.66 (3 H, m), 3.49 (1 H, t, J = 8.8 Hz), 3.40 (1 H, t, J = 9.6 Hz), 3.31 (1 H, m), 3.31–3.26 (2 H, m), 2.80 (2 H, m, H-7), 1.25 (3 H, d, J = 6.4 Hz,

H-6″). ^{13}C NMR (100 MHz, methanol-d_4) δ 147.5, 147.3, 132.9, 121.1, 117.1, 112.9, 104.2, 102.7, 84.5, 77.8, 75.6, 74.0, 72.3, 72.2, 72.0, 70.2, 70.0, 62.7, 56.5, 36.5, 17.9. HRMS calc. for $C_{21}H_{32}NaO_{12}$ $[M+Na]^+$: 499.1786, found: 499.1762.

Cistanoside E (2)

Colorless glass, R_f = 0.40 (EtOAc:MeOH:H_2O 39:11:4). $[\alpha]_D^{20}$ −48.0 (*c*, 0.20 in CH_3OH). ^{1}H-NMR (400 MHz, methanol-d_4) δ 6.84 (1 H, d, J = 2.0 Hz, H-2), 6.70 (1 H, d, J = 8.0 Hz, H-5), 6.67 (1 H, dd, J = 8.0, 2.0 Hz, H-6), 5.16 (1 H, d, J = 1.2 Hz, H-1″), 4.31 (1 H, d, J = 7.6 Hz, H-1'), 4.04 (1 H, m), 3.99 (1 H, m), 3.95 (1 H, m), 3.87 (1 H, dd, J = 12.0, 2.0 Hz), 3.83 (3 H, s, -OMe), 3.76–3.66 (3 H, m), 3.50 (1 H, t, J = 8.8 Hz), 3.40 (1 H, t, J = 9.6 Hz), 3.37–3.32 (2 H, m), 3.28 (1 H, m), 2.84 (2 H, m, H-7), 1.25 (3 H, d, J = 6.4 Hz, H-6″). ^{13}C NMR (100 MHz, methanol-d_4) δ 148.8, 145.8, 131.5, 122.4, 116.0, 113.7, 104.1, 102.7, 84.4, 77.8, 75.6, 73.9, 72.3, 72.0, 70.2, 70.0, 62.6, 56.4, 36.7, 17.9. HRMS calc. for $C_{21}H_{32}NaO_{12}$ $[M+Na]^+$: 499.1786, found: 499.1803.

Cistanoside G (3)

White solid, R_f = 0.44 (EtOAc:MeOH:H_2O 39:11:4). $[\alpha]_D^{20}$ −52.5 (*c*, 0.08 in CH_3OH). ^{1}H-NMR (400 MHz, methanol-d_4) δ 7.06 (2 H, d, J = 8.4 Hz, H-2, 6), 6.69 (2 H, d, J = 8.0 Hz, H-3, 5), 5.15 (1 H, appar. s, H-1″), 4.29 (1 H, d, J = 8.0 Hz, H-1'), 4.06–3.96 (2 H, m), 3.94 (1 H, m), 3.86 (1 H, dd, J = 12.0, 2.0 Hz), 3.73–3.66 (3 H, m), 3.49 (1 H, t, J = 8.8 Hz), 3.40 (1 H, t, J = 9.6 Hz), 3.31 (1 H, m), 3.30–3.26 (2 H, m), 2.82 (2 H, m, H-7), 1.24 (3 H, d, J = 6.0 Hz, H-6″). ^{13}C NMR (100 MHz, methanol-d_4) δ 156.8, 130.9, 130.9, 130.8, 116.1, 116.1, 104.2, 102.8, 84.5, 77.9, 75.6, 74.0, 72.4, 72.2, 72.1, 70.2, 70.1, 62.7, 36.4, 17.9. $C_{20}H_{30}NaO_{11}$ $[M+Na]^+$: 469.1680, found: 469.1662.

Decaffeoyl acteoside (4)

Colorless glass, R_f = 0.33 (EtOAc:MeOH:H_2O 39:11:4). ^{1}H-NMR (400 MHz, methanol-d_4) δ 6.68 (1 H, d, J = 2.0 Hz, H-2), 6.67 (1 H, d, J = 8.0 Hz, H-5), 6.55 (1 H, dd, J = 8.0, 2.0 Hz, H-6), 5.16 (1 H, appar. s, H-1″), 4.29 (1 H, d, J = 8.0 Hz, H-1'), 4.03 (1 H, m), 3.99 (1 H, m), 3.94 (1 H, m), 3.87 (1 H, dd, J = 12.0, 1.6 Hz), 3.72–3.66 (3 H, m), 3.49 (1 H, t, J = 8.8 Hz), 3.42–3.37 (2 H, m), 3.32–3.26 (2 H, m), 2.77 (2 H, m, H-7), 1.24 (3 H, d, J = 6.4 Hz, H-6″). ^{13}C NMR (100 MHz, methanol-d_4) δ 146.1, 144.6, 131.5, 121.2, 117.1, 116.3, 104.2, 102.7, 84.4, 77.8, 75.6, 74.0, 72.3, 72.2, 72.1, 70.2, 70.0, 62.6, 36.5, 17.9. HRMS calc. for $C_{20}H_{30}NaO_{12}$ $[M+Na]^+$: 485.1629, found: 485.1647.

General procedure for the preparation of 20a and 20d

A solution of **19** (1.0 equiv), **18a** or **18d** (1.0 equiv) and DTBMP (1.0 equiv) in CH_2Cl_2 (C = 0.05 M) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (1.0 equiv) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **20a** or **20d.**

2-(3-Benzyloxy-4-methoxyphenyl)ethyl 2-O-benzoyl-3-O-(2-O-acetyl-3,4-di-O-benzyl-α-L -rhamnopynosyl)-6-(2,3,4,6- tetra-O-benzoyl-β-D-glucopyranosyl)-β-D-glucopyranoside (20a)

White solid, R_f = 0.51 (petroleum -EtOAc 3:2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (2 H, d, J = 7.6 Hz, Ar-H), 7.95 (2 H, d, J = 7.2 Hz, Ar-H), 7.90–7.87 (4 H, m, Ar-H), 7.80 (2 H, d, J = 7.6 Hz, Ar-H), 7.56–7.26 (23 H, m, Ar-H), 7.22–7.20 (5 H, m, Ar-H), 7.13–7.11 (2 H, m, Ar-H), 6.61 (1 H, br s, H-2), 6.57 (1 H, d, J = 8.0 Hz, H-6), 6.42 (1 H, d, J = 8.4 Hz, H-5), 5.88 (1 H, t, J = 9.6 Hz, H-3‴), 5.67 (1 H, t, J = 9.6 Hz, H-4‴), 5.53 (1 H, dd, J = 9.6, 8.0 Hz, H-2‴), 5.07–5.00 (3 H, m, $ArOCH_2Ph$, H-2'), 4.96 (1 H, d, J = 8.0 Hz, H-1‴), 4.92 (1 H, br s, $ArOCH_2Ph$), 4.82 (1 H, d, J = 10.8 Hz), 4.73 (1 H, d, J = 1.2 Hz, H-1"), 4.64 (1 H, dd, J = 12.0, 2.8 Hz, H-6‴a), 4.50 (2 H, m), 4.30 (1 H, d, J = 8.0 Hz, H-1'), 4.27 (1 H, appar. d, J = 11.2 Hz), 4.24 (1 H, d, J = 12.8 Hz, $PhCH_2$), 4.19 (1 H, d, J = 11.2 Hz, $PhCH_2$), 4.16–4.11 (1 H, m), 3.88–3.73 (5 H, m), 3.66 (3 H, s, OMe), 3.51–3.46 (2 H, m), 3.36–3.28 (3 H, m), 2.58–2.45 (2 H, m), 1.94 (3 H, s, OAc), 1.26 (3 H, d, J = 6.0 Hz, CH_3). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1, 161.5, 161.2, 160.6, 160.4, 160.4, 143.3, 143.1, 133.6, 133.0, 132.8, 128.8, 128.6, 128.5, 128.5, 126.6, 125.2, 125.2, 125.2, 125.2, 125.1, 125.1, 125.1, 125.1, 125.0, 124.6, 124.2, 123.8, 123.8, 123.8, 123.8, 123.8, 123.8, 123.8, 123.8, 123.7, 123.7, 123.7, 123.7, 123.7, 123.5, 123.5, 123.5, 123.5, 123.2, 123.2, 123.2 123.2, 123.1, 123.1, 122.8, 122.8, 122.8, 122.8, 116.9, 110.2, 107.0, 97.0, 95.9, 95.1, 81.7, 74.6, 70.5, 70.4, 68.2, 67.6, 67.4, 67.3, 66.7, 66.2, 65.7, 65.6, 65.0, 64.7, 64.0, 51.2, 30.6, 16.2, 13.3.

2-(3,4-Di-benzyloxy)ethyl 2-O-benzoyl-3-O-(2-O-acetyl-3,4-di-O-benzyl-α-L-rhamnopynosyl)-6-(2,3,4,6- tetra-O-benzoyl-β-D-glucopyranosyl)-β-D-glucopyranoside (20d)

White solid, R_f = 0.42 (petroleum -EtOAc 3:2). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (2 H, d, J = 8.0 Hz, Ar-H), 7.96 (2 H, d, J = 8.0 Hz, Ar-H), 7.91–7.88 (4 H, m, Ar-H), 7.81 (2 H, d, J = 8.0 Hz), 7.54–7.46 (4 H, m, Ar-H), 7.44–7.21 (29 H, m, Ar-H), 7.14–7.12 (2 H, m, Ar-H), 6.69 (1 H, br s,

H-2), 6.55 (1 H, d, $J = 8.0$ Hz, H-6), 6.52 (1 H, d, $J = 8.0$ Hz, H-5), 5.89 (1 H, t, $J = 9.6$ Hz, H-3‴), 5.68 (1 H, t, $J = 9.6$ Hz, H-4‴), 5.55 (1 H, dd, $J = 9.6$, 8.0 Hz, H-2‴), 5.06 (2 H, s, -ArOCH_2Ph), 5.04 (1 H, m, H-2'), 4.97 (1 H, d, $J = 8.0$ Hz, H-1‴), 4.92 (2 H, s, -ArOCH_2Ph), 4.92 (1 H, m, H-2″), 4.83 (1 H, d, $J = 10.8$ Hz), 4.74 (1 H, br s, H-1″), 4.65 (1 H, dd, $J = 12.0$, 2.0 Hz, H-6‴a), 4.52 (1 H, m, H-6‴b), 4.52 (1 H, m), 4.33 (1 H, d, $J = 8.0$ Hz, H-1'), 4.29 (1 H, appar. d, $J = 10.8$ Hz), 4.24 (1 H, d, $J = 11.6$ Hz, PhCH_2-), 4.19 (1 H, d, $J = 11.6$ Hz, PhCH_2-), 4.15 (1 H, m, H-5‴), 3.86 (1 H, m, H-5″), 3.81–3.74 (4 H, m), 3.53–3.47 (2 H, m), 3.37–3.29 (3 H, m), 2.60–2.46 (2 H, m, -OCH$_2$CH_2Ar), 1.95 (3 H, s, -OAc), 1.27 (3 H, d, $J = 6.0$ Hz). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 166.3, 165.9, 165.3, 165.2, 165.2 (C = O), 148.7, 147.3, 138.4, 137.7, 137.7, 137.7, 133.6, 133.4, 133.4, 133.3, 133.3, 132.3, 130.0, 130.0, 129.9, 129.9, 129.9, 129.9, 129.9, 129.8, 129.8, 129.8, 129.8, 129.8, 129.7, 129.3, 128.9, 128.6, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.5, 128.4, 128.3, 128.3, 128.0, 128.0, 127.8, 127.8, 127.8, 127.7, 127.5, 127.5, 127.3, 127.3, 121.9, 115.9, 115.0, 101.7, 100.6, 99.8, 86.5, 79.4, 77.0, 75.3, 75.1, 73.0, 72.4, 72.1, 72.0, 71.4, 71.3, 71.2, 70.5, 70.3, 69.8, 69.7, 69.4, 68.7, 63.1, 35.4, 20.9, 18.1. HRMS calc. for $C_{91}H_{86}NaO_{23}$ $[M + Na]^+$: 1569.5452, found: 1569.5491.

General procedure for the preparation of PhGs 5 and 6

A solution of **20a** or **20d** (1.0 equiv) in methanol and CH_2Cl_2 was added NaOMe (1.0 equiv)), the reaction mixture was stirred at 50 °C until the completion of the reaction, the reaction mixture was evaporated and purified by silica gel column chromatography. After that, the obtained product was dissolved in methanol, the solution was added to 30 wt% Pd/C (10% Palladium on activated carbon) in a Schlenk tube, the reaction system was degassed with H_2, and stirred under H_2 atmosphere at room temperature overnight. The solid materials were filtrated off, and the solution was concentrated. The residue was chromatographed on a Sephadex LH-20 column (CH_2Cl_2/MeOH 1:1) to give PhGs **5** or **6**.

Kankanoside F (5)

White solid. ^{1}H NMR (400 MHz, CD_3OD) δ 6.69 (1 H, d, $J = 2.0$ Hz, H-2), 6.67 (1 H, d, $J = 8.0$ Hz, H-5), 6.56 (1 H, dd, $J = 8.0$, 2.0 Hz, H-6), 5.16 (1 H, d, $J = 1.2$ Hz, H-1''), 4.37 (1 H, d, $J = 7.6$ Hz, H-1‴), 4.30 (1 H, d, $J = 8.0$ Hz, H-1'), 4.15 (1 H, dd, $J = 11.2$, 1.2 Hz, H-6'), 4.00 (2 H, m), 3.93 (1 H, m), 3.87 (1 H, m), 3.80 (1 H, m), 3.70 (3 H, m), 3.46 (3 H, m), 3.38 (2 H, m), 3.24 (4 H, m), 2.78 (2 H, m), 1.24 (3 H, d, $J = 6.4$ Hz). ^{13}C NMR (100 MHz, CD_3OD) δ 146.1, 144.7, 131.5, 121.3, 117.1, 116.3, 104.9, 104.3, 102.7, 84.0, 78.0, 78.0, 77.0, 75.7, 75.1, 74.0, 72.4, 72.3, 72.3, 71.6, 70.0, 69.9, 69.7, 62.7,

36.6, 17.9. HRMS calc. for $C_{26}H_{40}NaO_{17}$ $[M+Na]^+$: 647.2158, found: 647.2163.

The NMR data of Leonoside F (**6**) is consistent with the literature previously reported by us.[5a]

2-(3-Benzyloxy-4-methoxyphenyl)ethyl 2-O-benzoyl-3-O-(2-O-acetyl-3,4-di-O-benzyl-α-L -rhamnopynosyl)-6-(2,3,4,6- tetra-O-benzoyl-β-D-galatopyranosyl)-β-D- glucopyranoside (22)

A solution of **21** (50.0 mg, 0.06 mmol), **18a** (56.3 mg, 0.06 mmol) and DTBMP (12.9 mg, 0.06 mmol) in CH_2Cl_2 (1.26 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (10.6 µL, 0.06 mmol) was added, the solution was stirred at for 30 min. The reaction mixture was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **22** (70.5 mg, 76% yield) as white solid, $R_f = 0.47$ (petroleum -EtOAc 3:2). $[\alpha]_D^{20}$ +27.8 (*c*, 0.09 in $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.07 (2 H, d, $J = 7.6$ Hz, Ar-H), 8.02 (2 H, d, $J = 7.2$ Hz, Ar-H), 7.95 (2 H, d, $J = 7.2$ Hz, Ar-H), 7.88 (2 H, d, $J = 7.2$ Hz, Ar-H), 7.76 (2 H, d, $J = 7.2$ Hz, Ar-H), 7.61–7.12 (30 H, m, Ar-H), 6.61 (1 H, appar. s, H-2), 6.56 (1 H, appar. d, $J = 8.0$ Hz, H-6), 6.41 (1 H, d, $J = 8.0$ Hz, H-5), 5.99 (1 H, d, $J = 3.2$ Hz, H-1″), 5.81 (1 H, dd, $J = 9.6$, 8.4 Hz), 5.60 (1 H, dd, $J = 10.4$, 3.2 Hz), 5.08–5.01 (3 H, m), 4.96–4.93 (2 H, m), 4.83 (1 H, d, $J = 10.8$ Hz, ArCH_2), 4.74 (1 H, appar. s), 4.70 (1 H, dd, $J = 11.2$, 6.4 Hz), 4.52 (1 H, d, $J = 10.8$ Hz, ArCH_2), 4.43–4.39 (4 H, m), 4.24 (1 H, d, $J = 11.2$ Hz, ArCH_2), 4.19 (1 H, d, $J = 11.2$ Hz, ArCH_2), 3.86 (1 H, dd, $J = 9.2$, 6.4 Hz), 3.81–3.73 (4 H, m), 3.66 (3 H, s, -OMe), 3.55–3.47 (2 H, m), 3.37–3.29 (3 H, m), 2.58–2.42 (2 H, m, H-7), 1.95 (3 H, s, -OAc), 1.27 (3 H, d, $J = 6.4$ Hz, H-6″). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 166.2, 165.7, 165.7, 165.4, 165.2 (C = O), 148.0, 147.9, 138.4, 137.7, 137.5, 133.7, 133.4, 133.4, 133.4, 133.3, 131.3, 130.2, 130.2, 130.0, 130.0, 129.9, 129.9, 129.8, 129.8, 129.8, 129.7, 129.7, 129.6, 129.4, 129.2, 128.9, 128.8, 128.8, 128.6, 128.6, 128.6, 128.6, 128.6, 128.6, 128.5, 128.5, 128.5, 128.5, 128.4, 128.4, 128.3, 128.3, 128.0, 128.0, 128.0, 127.9, 127.8, 127.8, 127.5, 127.5, 127.5, 121.7, 115.0, 111.7 (Ar), 102.0, 100.6, 99.9, 86.5, 79.4, 77.0, 75.3, 75.1, 72.0, 71.8, 71.5, 71.5, 70.9, 70.4, 70.4, 70.0, 69.6, 69.5, 68.7, 68.3, 62.2, 56.0, 35.4, 20.9, 18.1. HRMS calc. for $C_{85}H_{82}NaO_{23}$ $[M+Na]^+$: 1493.5145, found: 1493.5132.

4‴-epi-Leonoside F (7)

A solution of **22** (41 mg, 0.03 mmol) in methanol (1.0 mL) was added NaOMe (1.5 mg, 0.03 mmol), the reaction mixture was stirred at 50 °C until

the completion of the reaction, the reaction mixture was evaporated and purified by silica gel column chromatography. After that, the obtained product was dissolved in methanol (0.56 mL), the solution was added to 30 wt% Pd/C (10% Palladium on activated carbon) in a Schlenk tube, the reaction system was degassed with H_2, and stirred under H_2 atmosphere at room temperature overnight. The solid materials were filtrated off, and the solution was concentrated. The residue was chromatographed on a Sephadex LH-20 column (CH_2Cl_2/MeOH 1:1) to give **7** (15.5 mg, 87% yield for two steps) as white solid, R_f = 0.19 (EtOAc:MeOH:H_2O 39:11:4). $[\alpha]_D^{20}$ −42.0 (*c*, 0.05 in CH_3OH). ^{1}H-NMR (400 MHz, methanol-d_4) δ 6.82 (1 H, d, J = 8.0 Hz, H-5), 6.73 (1 H, d, J = 2.0 Hz, H-2), 6.68 (1 H, dd, J = 8.0, 2.0 Hz, H-6), 5.16 (1 H, d, J = 1.2 Hz, H-1″), 4.33 (1 H, d, J = 7.6 Hz, H-1‴), 4.30 (1 H, d, J = 8.0 Hz, H-1'), 4.15 (1 H, dd, J = 11.2, 0.8 Hz), 4.05-3.99 (2 H, m), 3.93 (1 H, dd, J = 2.8, 1.6 Hz), 3.81 (3 H, s), 3.79 (1 H, m), 3.75 (1 H, m), 3.73-3.68 (3 H, m), 3.56–3.44 (6 H, m), 3.44–3.37 (2 H, m), 3.29 (1 H, m), 2.80 (2 H, m, H-7), 1.24 (3 H, d, J = 6.0 Hz, H-6″). ^{13}C NMR (100 MHz, methanol-d_4) δ 147.5, 147.3, 133.0, 121.2, 117.1, 112.9, 106.8, 104.1, 101.6, 84.5, 82.7, 78.1, 77.9, 77.8, 75.7, 75.4, 74.3, 72.0, 71.9, 71.3, 70.1, 69.9, 62.7, 62.7, 56.5, 36.5, 17.9. $C_{27}H_{42}NaO_{17}$ $[M+Na]^+$: 661.2314, found: 661.2310.

S-2-Isopropylmercaptobenzyl-3,4-di-O-benzyl-α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-1-thio-β-D-glucopyranoside (23)

To a solution of **11** (20 mg, 0.02 mmol) in THF (0.43 mL) was added N_2H_4-H_2O (0.11 mL, 2.17 mmol), the reaction mixture was stirred at 60 °C for 30 h, after the reaction mixture was cooled to r.t., it was concentrated and diluted with EtOAc, washed with water and brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **23** (14.8 mg, 78% yield). R_f = 0.24 (petroleum -EtOAc 4:1). $[\alpha]_D^{20}$ −50.8 (*c*, 1.0 in $CHCl_3$). ^{1}H NMR (400 MHz, acetone-d_6) δ 8.02–8.00 (2 H, m, Ar-H), 7.69–7.64 (1 H, m, Ar-H), 7.56–7.20 (21 H, m, Ar-H), 5.70 (1 H, s, PhC*H*O_2), 5.29 (1 H, dd, J = 10.2, 9.0 Hz, H-2), 4.88 (1 H, d, J = 10.2 Hz, H-1), 4.87 (1 H, d, J = 2.4 Hz, H-1′), 4.81 (1 H, d, J = 11.2 Hz, ArC*H*$_2$), 4.62 (1 H, d, J = 11.6 Hz, ArC*H*$_2$), 4.52 (1 H, d, J = 11.2 Hz, ArC*H*$_2$), 4.48 (1 H, d, J = 11.6 Hz, ArC*H*$_2$), 4.36 (1 H, dd, J = 10.4, 4.8 Hz, H-6a), 4.22 (1 H, t, J = 9.0 Hz, H-3), 4.19 (1 H, d, J = 12.6 Hz, ArC*H*$_2$), 4.09 (1 H, d, J = 12.6 Hz, ArC*H*$_2$), 4.04 (1 H, m, H-5′), 3.90 (1 H, m, H-2′), 3.86-3.80 (3 H, m, H-4, 6 b, 2′-OH), 3.72–3.66 (2 H, m, H-3′, 5), 3.88–3.32 (2 H, m, H-4′, SC*H*$(CH_3)_2$), 1.16 (3 H, d, J = 6.6 Hz, SCH(CH_3)$_2$), 1.13 (3 H, d, J = 6.6 Hz, SCH(CH_3)$_2$), 0.86 (3 H, d, J = 6.0 Hz, H-6′). ^{13}C NMR (100 MHz, acetone-d_6) δ 165.9 (C = O), 140.6, 140.2, 139.8, 138.7, 136.2, 134.3, 134.0, 131.3, 130.6, 130.5, 130.5,

129.5, 129.5, 129.5, 129.0, 129.0, 128.9, 128.9, 128.8, 128.8, 128.6, 128.4, 128.4, 128.4, 128.4, 128.1, 128.1, 128.0, 127.2, 127.2 (Ar), 102.2, 101.6, 84.3, 80.0, 80.7, 80.2, 78.0, 75.2, 74.3, 71.6, 71.5, 69.0, 68.6, 68.3, 39.3, 33.3, 23.4, 23.3, 18.0. HRMS calc. for $C_{50}H_{54}NaO_{10}S_2$ $[M+Na]^+$: 901.3051, found: 901.3074.

2-Isopropylmercaptobenzyl 2,3,4-tri-O-benzoyl-α-L-arabinopyranosyl-(1→2)-3,4-di-O-benzyl-α-L- rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O-benzylidene-1-thio-β-D- glucopyranoside (25)

A solution of **24** (90 mg, 0.14 mmol), **23** (100 mg, 0.11 mmol) and DTBMP (47.7 mg, 0.23 mmol) in CH_2Cl_2 (2.28 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (22.9 µL, 0.14 mmol) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **25** (134 mg, 89% yield). The NMR data was consistent with the literature[5c] previously reported by us.

The preparation and NMR data of **26**, **27a**, **27d**, **8** and **9** are consistent with the literature previously reported by us.[5c]

2-Isopropylmercaptobenzyl 2,3,4,6-tetra-O-benzoyl-β-D-glucopyranosyl-(1→2)-3,4-di-O-benzyl-α-L- rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O-benzylidene-1-thio-β-D- glucopyranoside (28)

A solution of **19** (108 mg, 0.14 mmol), **23** (100 mg, 0.11 mmol) and DTBMP (11.7 mg, 0.06 mmol) in CH_2Cl_2 (2.28 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (22.9 µL, 0.14 mmol) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **28** (113 mg, 68% yield) as white solid, R_f = 0.45 (petroleum-EtOAc 3:1). $[\alpha]_D^{20}$ −3.9 (*c*, 0.66 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97–7.95 (4 H, m, Ar-H), 7.87 (2 H, d, J = 7.6 Hz, Ar-H), 7.82 (2 H, d, J = 8.0 Hz, Ar-H), 7.76 (2 H, d, J = 7.6 Hz, Ar-H), 7.55–7.01 (32 H, m, Ar-H), 6.94 (2 H, m, Ar-H), 5.58 (1 H, t, J = 9.6 Hz), 5.47 (1 H, s, PhC*H*O_2), 5.37–5.29 (2 H, m), 5.25 (1 H, dd, J = 9.6, 9.2 Hz), 4.89 (1 H, s, H-1'), 4.69 (1 H, d, J = 8.0 Hz), 4.43 (1 H, d, J = 10.4 Hz), 4.37 (2 H, s, PhCH_2), 4.33 (1 H, dd, J = 10.4, 4.4 Hz), 4.17 (1 H, d, J = 13.2 Hz), 4.13 (1 H, d, J = 11.2 Hz), 4.01 (1 H, dd, J = 11.6, 3.6 Hz), 3.97–3.989 (3 H, m), 3.85–3.80 (3 H, m), 3.72 (1 H, t, J = 10.0 Hz), 3.69 (1 H, dd, J = 9.2, 2.0 Hz), 3.58 (1 H, t, J = 9.6 Hz), 3.43 (1 H, m), 3.38 (1 H, m), 3.33 (1 H, hepta. J = 6.8 Hz, -SC*H*$(CH_3)_2$), 3.04 (1 H, t, J = 9.6 Hz), 1.16 (3 H, d, J = 6.8 Hz, -SCH$(CH_3)_2$), 1.13 (3 H, d, J = 6.8 Hz,

-SCH(CH_3)$_2$), 0.72 (3 H, d, J = 6.0 Hz, H-6'). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 165.9, 165.4, 165.3, 164.9 (C = O), 139.3, 138.9, 138.6, 137.0, 135.6, 133.8, 133.5, 133.3, 133.2, 133.2, 133.2, 130.4, 130.1, 130.1, 130.1, 130.1, 130.0, 130.0, 129.9, 129.9, 129.9, 129.9, 129.8, 129.6, 129.5, 129.1, 129.0, 128.9, 128.9, 128.6, 128.6, 128.5, 128.5, 128.5, 128.5, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 127.9, 127.6, 127.6, 127.6, 127.5, 127.5, 127.4, 127.2, 126.5, 126.5, 126.5 (Ar), 101.9 (PhCHO$_2$), 101.6, 99.8 (C-1'), 83.7, 80.5, 79.5, 79.4, 78.3, 76.1, 74.7, 73.2, 72.7, 72.1, 71.9, 71.7, 70.9, 70.0, 68.7, 68.3, 63.1, 39.0 (-SCH(CH_3)$_2$), 33.0, 23.2 (-SCH(CH_3)$_2$), 23.1 (-SCH(CH_3)$_2$), 17.3 (C-6'). HRMS calc. for $C_{84}H_{80}NaO_{19}S_2$ $[M + Na]^+$: 1479.4627, found: 1479.4614.

Compound 29

A solution of **19** (43.3 mg, 0.06 mmol), **23** (40 mg, 0.05 mmol) and DTBMP (19.0 mg, 0.09 mmol) in CH_2Cl_2 (0.91 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (9.4 µL, 0.06 mmol) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **29** (45.8 mg, 69% yield) as white solid, R_f = 0.51 (petroleum-EtOAc 3:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05–8.01 (4 H, m, Ar-H), 7.92 (2 H, d, J = 7.2 Hz, Ar-H), 7.82 (2 H, dd, J = 8.0, 0.8 Hz, Ar-H), 7.62–7.56 (2 H, m, Ar-H), 7.50–7.11 (32 H, m, Ar-H), 6.70 (2 H, m, Ar-H), 5.63 (1 H, d, J = 5.2 Hz, H-1''), 5.50 (1 H, dd, J = 3.2, 0.8 Hz), 5.47 (1 H, s, PhCHO$_2$), 5.41 (1 H, d, J = 8.0 Hz), 5.25 (1 H, dd, J = 10.0, 9.2 Hz, H-2), 5.01 (1 H, d, J = 1.6 Hz, H-1'), 4.82 (1 H, d, J = 11.2 Hz, ArCH_2), 4.69 (1 H, m), 4.46 (1 H, d, J = 10.0 Hz, H-1), 4.47–4.43 (2 H, m), 4.34 (1 H, dd, J = 10.4, 4.8 Hz), 4.17 (1 H, d, J = 13.2 Hz, ArCH_2), 4.12 (1 H, dd, J = 8.8, 3.6 Hz), 4.08 (1 H, d, J = 12.4 Hz, ArCH_2), 3.96–3.92 (2 H, m), 3.90 (1 H, dd, J = 9.6, 6.4 Hz), 3.83 (1 H, d, J = 12.0 Hz, ArCH_2), 3.73 (1 H, dd, J = 10.4, 10.0 Hz), 3.66–3.61 (2 H, m), 3.58 (1 H, t, J = 9.2 Hz), 3.46 (1 H, td, J = 9.6, 4.8 Hz), 3.38 (1 H, t, J = 9.6 Hz), 3.21 (1 H, hepta., J = 6.4 Hz, -SCH(CH_3)$_2$), 1.16 (3 H, d, J = 6.4 Hz, -SCH(CH_3)$_2$), 1.12 (3 H, d, J = 6.4 Hz, -SCH(CH_3)$_2$), 0.77 (3 H, d, J = 6.0 Hz, H-6'). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.2, 165.3, 165.0, 164.5 (C = O), 139.2, 138.9, 138.8, 137.0, 135.5, 134.5, 133.7, 133.6, 133.4, 133.2, 133.1, 130.4, 130.4, 130.3, 130.3, 130.1, 130.1, 129.9, 129.9, 129.8, 129.8, 129.7, 129.6, 129.5, 129.2, 129.1, 129.1, 128.8, 128.8, 128.6, 128.6, 128.4, 128.4, 128.4, 128.4, 128.3, 128.3, 128.3, 128.2, 128.2, 128.1, 128.1, 128.1, 127.9, 127.9, 127.9, 127.5, 127.2, 127.1, 127.1, 127.1, 126.7, 126.5, 126.5 (Ar), 121.7 (PhCO_3), 102.0 (PhCHO$_2$), 99.5 (C-1'), 97.4 (C-1''), 83.9 (C-1), 80.1, 79.6, 78.2, 77.9, 75.2, 72.9, 72.2, 71.2, 71.0, 70.0, 68.8, 68.6, 68.2, 67.8, 67.6, 63.8, 38.9 (-SCH(CH_3)$_2$), 33.0, 23.2 (-SCH(CH_3)$_2$), 23.1 (-SCH(CH_3)$_2$), 17.5 (C-6'). HRMS calc. for $C_{84}H_{80}NaO_{19}S_2$ $[M + Na]^+$: 1479.4627, found: 1479.4612.

2-Isopropylsulfinylbenzyl 2,3,4,6-tetra-O-benzoyl-β-D-glucopyranosyl-(1→2)-3,4-di-O-benzyl-α-L -rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O-benzylidene-1-thio-β-D-glucopyranoside (30)

A solution of **28** (80 mg, 0.05 mmol) in CH_2Cl_2 (0.27 mL) was cooled to −20 °C, followed by the dropwise addition of the solution of 3-chloroperoxybenzoic acid (12.6 mg, 0.05 mmol) in CH_2Cl_2 (0.27 mL). The reaction mixture was stirred at −20 °C for 1 h, diluted with EtOAc, washed with 10% $Na_2S_2O_3$ aqueous solution. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **30** (75.2 mg, 93% yield) as white solid, R_f = 0.10 (petroleum-EtOAc 2:1). A sulfoxide mixture (*R* and *S* 1:0.8), ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07–7.75 (21.48 H, m, Ar-H), 7.60–7.14 (60.05 H, m, Ar-H), 4.94-6.92 (3.80 H, m, Ar-H), 5.62 (0.8 H, t, J = 9.6 Hz), 5.59 (1 H, t, J = 9.6 Hz), 5.50 (1.8 H, s, PhC*H*O_2), 5.38–5.26 (5.6 H, m), 4.97 (0.8 H, d, J = 1.6 Hz, H-1'), 4.91 (1 H, d, J = 1.6 Hz, H-1'), 4.74 (1.8 H, t, J = 8.0 Hz), 4.53 (0.8 H, d, J = 10.0 Hz), 4.39–4.35 (5.9 H, m), 4.30 (0.8 H, dd, J = 10.4, 4.8 Hz), 4.13–4.02 (5.9 H, m), 3.99 (0.8 H, m), 3.95 (0.8 H, d, J = 2.8 Hz), 3.93–3.77 (9.9 H, m), 3.75–3.68 (3.5 H, m), 3.63 (1 H, t, J = 9.2 Hz), 3.60 (1 H, dd, J = 10.8, 9.2 Hz), 3.53–3.43 (4.1 H, m), 3.06–2.95 (2.9 H, m), 2.85 (1 H, hepta. J = 6.8 Hz, -SC*H*$(CH_3)_2$), 1.18 (2.4 H, d, J = 6.8 Hz, -SCH$(CH_3)_2$), 1.08 (3 H, d, J = 6.8 Hz, -SCH$(CH_3)_2$), 0.99 (2.4 H, d, J = 6.8 Hz, -SCH$(CH_3)_2$), 0.96 (3 H, d, J = 6.8 Hz, -SCH$(CH_3)_2$), 0.75 (2.4 H, d, J = 6.0 Hz, H-6'), 0.71 (3 H, d, J = 6.0 Hz, H-6'). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 166.0, 165.8, 165.8, 165.4, 165.4, 165.3, 165.3, 165.0, 164.9 (C = O), 141.7, 141.5, 138.9, 138.9, 138.6, 138.6, 136.9, 136.9, 135.3, 134.6, 134.1, 133.5, 133.3, 133.3, 133.2, 133.2, 131.1, 131.0, 130.7, 130.1, 130.0, 129.9, 129.9, 129.8, 129.8, 129.7, 129.6, 129.6, 129.3, 129.2, 129.1, 129.1, 129.1, 129.1, 129.0, 128.6, 128.5, 128.5, 128.4, 128.4, 128.4, 128.3, 128.2, 128.2, 127.6, 127.6, 127.5, 127.5, 127.5, 127.5, 127.4, 126.4, 126.4, 125.9, 125.8 (Ar), 101.9, 101.9, 101.6, 101.5, 99.9, 99.8, 84.0, 82.7, 80.5, 80.5, 79.5, 79.5, 79.5, 79.4, 77.9, 77.8, 75.8, 75.8, 74.7, 74.6, 72.9, 72.8, 72.6, 72.6, 72.2, 72.2, 71.9, 71.9, 71.8, 71.7, 71.2, 71.1, 70.1, 70.1, 68.5, 68.5, 68.4, 68.4, 63.2, 63.2, 53.8, 53.5, 29.8, 29.4, 17.5, 17.3, 17.3, 17.2, 12.8, 12.8. $C_{84}H_{80}NaO_{20}S_2$ $[M + Na]^+$: 1495.4576, found: 1495.4604.

3-Benzoxyl-4-methoxylphenylethyl 2,3,4,6-tetra-O-benzoyl-β-D-glucopyranosyl-(1→2)-3,4-di-O-benzyl -α-L-rhamnopyranosyl-(1→3)-2-O-benzoyl-4,6-O- benzylidene-1-thio-β-D-glucopyranoside (31)

A solution of **30** (70.0 mg, 0.05 mmol), **16a** (10.2 mg, 0.04 mmol) and DTBMP (16.2 mg, 0.08 mmol) in CH_2Cl_2 (0.79 mL) in the presence of 4 Å MS (100 wt%) was stirred at 0 °C for 10 min, Tf_2O (8.0 μL, 0.05 mmol) was added, the solution was stirred at 0 °C for 30 min. The reaction mixture

was quenched with Et_3N, then filtered and extracted with EtOAc. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give compound **31** (66.3 mg, 92% yield) as white solid. R_f = 0.35 (petroleum -EtOAc 3:1). $[\alpha]_D^{20}$ +12.12 (*c*, 1.37 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00–7.96 (4 H, m, Ar-H), 7.88 (2 H, d, *J* = 7.6 Hz, Ar-H), 7.82 (2 H, d, *J* = 7.6 Hz, Ar-H), 7.77 (2 H, d, *J* = 7.6 Hz, Ar-H), 7.55–7.15 (33 H, m, Ar-H), 6.95 (2 H, m, Ar-H), 6.61 (1 H, d, *J* = 1.6 Hz, H-2), 6.56 (1 H, dd, *J* = 8.0, 1.6 Hz, H-6), 6.47 (1 H, d, *J* = 8.0 Hz, H-5), 5.61 (1 H, t, *J* = 9.6 Hz), 5.46 (1 H, s, PhC*H*O_2), 5.38 (1 H, dd, *J* = 9.6, 4.0 Hz), 5.36 (1 H, dd, *J* = 9.6, 5.6 Hz), 5.22 (1 H, t, *J* = 8.4 Hz), 5.04 (2 H, s, ArOCH_2Ph), 4.94 (1 H, appar. s, H-1″), 4.71 (1 H, d, *J* = 8.0 Hz), 4.49 (1 H, d, *J* = 8.0 Hz), 4.38 (2 H, s, ArCH_2), 4.33 (1 H, dd, *J* = 10.4, 4.8 Hz), 4.13 (1 H, d, *J* = 11.2 Hz, ArCH_2), 4.06 (1 H, dd, *J* = 12.0, 3.6 Hz), 4.00–3.92 (3 H, m), 3.87–3.80 (3 H, m), 3.76–3.71 (2 H, m), 3.69 (3 H, s, OMe), 3.60–3.51 (2 H, m), 3.48–3.40 (2 H, m), 3.05 (1 H, t, *J* = 9.6 Hz, H-4″), 2.65 (2 H, m, ArCH_2CH_2O-), 0.74 (3 H, d, *J* = 6.0 Hz, H-6″). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 165.9, 165.2, 165.2, 165.0 (C = O), 148.2, 147.9, 138.9, 138.6, 137.4, 137.0, 133.7, 133.5, 133.3, 133.2, 133.1, 130.8, 130.1, 130.1, 130.0, 130.0, 129.9, 129.9, 129.9, 129.9, 129.9, 129.8, 129.7, 129.6, 129.1, 129.0, 129.0, 128.9, 128.9, 128.6, 128.6, 128.6, 128.6, 128.6, 128.5, 128.5, 128.5, 128.5, 128.4, 128.4, 128.3, 128.3, 128.2, 128.2, 128.2, 128.2, 127.9, 127.6, 127.6, 127.6, 127.5, 127.5, 127.5, 127.5, 127.4, 126.5, 126.5, 121.6, 115.0, 111.7 (Ar), 101.9, 101.7, 101.5, 99.9, 80.5, 79.6, 79.4, 76.2, 74.7, 74.6, 72.6, 72.1, 71.9, 71.7, 71.0, 71.0, 70.0, 68.8, 68.3, 66.7, 63.1, 56.0, 35.6, 17.3. (one ^{13}C signal may overlapped with $CDCl_3$ solvent peaks) HRMS calc. for $C_{90}H_{84}NaO_{22}$ $[M + Na]^+$:1539.5346, found: 1539.5318.

Proposed incanoside B (10)

A solution of **31** (40 mg, 0.03 mmol) and DTT (8.1 mg, 0.05 mmol) in CH_2Cl_2 (0.53 mL) was added CSA (6.1 mg, 0.03 mmol), the reaction mixture was stirred at room temperature for 9 h, diluted with EtOAc, washed with water and brine, dried (Na_2SO_4), concentrated, and purified by silica gel column chromatography to give the deprotection of benzylidene product, which was dissolved in methanol (1.0 mL), followed by the addition of NaOMe (1.4 mg, 0.03 mmol), the reaction mixture was stirred at 50 °C until the completion of deprotection of acyl group, the reaction mixture was evaporated and purified by silica gel column chromatography. After that, the obtained product was dissolved in methanol (0.53 mL), the solution was added to 30 wt% Pd/C (10% Palladium on activated carbon) in a Schlenk tube, the reaction system was degassed with H_2, and stirred under H_2

atmosphere at room temperature overnight. The solid materials were filtrated off, and the solution was concentrated. The residue was chromatographed on a Sephadex LH-20 column (CH_2Cl_2/MeOH 1:1) to give **10** as white solid, R_f = 0.19 (EtOAc:MeOH:H_2O 39:11:4). $[\alpha]_D^{20}$ −42.0 (*c*, 0.05 in CH_3OH). ^{1}H-NMR (400 MHz, methanol-d_4) δ 6.82 (1 H, d, J = 8.0 Hz, H-5), 6.73 (1 H, d, J = 2.0 Hz, H-2), 6.68 (1 H, dd, J = 8.0, 2.0 Hz, H-6), 5.57 (1 H, d, J = 0.8 Hz, H-1″), 4.43 (1 H, d, J = 7.6 Hz, H-1‴), 4.29 (1 H, d, J = 8.0 Hz, H-1'), 4.05-3.96 (3 H, m), 3.90–3.85 (2 H, m), 3.81 (3 H, s, -OMe), 3.78 (1 H, dd, J = 10.0, 3.6 Hz), 3.74–3.67 (2 H, m), 3.65 (1 H, dd, J = 12.0, 4.4 Hz), 3.48 (1 H, t, J = 8.8 Hz), 3.41–3.32 (4 H, m), 3.29–3.26 (4 H, m), 2.84–2.77 (2 H, m, H-7), 1.25 (3 H, d, J = 6.0 Hz, H-6″).^{13}C NMR (100 MHz, methanol-d_4) δ 147.5, 147.3, 133.0, 121.2, 117.1, 112.9, 106.8, 104.1, 101.6, 84.5, 82.7, 78.1, 77.9, 77.8, 75.7, 75.4, 74.3, 72.0, 71.9, 71.3, 70.1, 69.9, 62.7, 62.7, 56.5, 36.5, 17.9. $C_{27}H_{42}NaO_{17}$ $[M+Na]^+$: 661.2314, found: 661.2310.

Funding

Financial support from National Natural Science Foundation of China [21672077, 21761132014, 21772050, 21702068], the State Key Laboratory of Bioorganic and Natural Products Chemistry [SKLBNPC13425], Wuhan Creative Talent Development Fund, "Thousand Talents Program" Young Investigator Award, and Huazhong University of Science and Technology are greatly appreciated.

References

[1] (a) Birkofer, L.; Kaiser, C.; Thomas, U. Acteoside and neoacteoside: sugar esters from *Syringa Vulgaris* (L.). *Z Naturforsch B*. **1968**, 23, 1051–1058. DOI: 10.1515/znb-1968-0806. (b) Zhang, F.; Yang, Y.-N.; Song, X.-Y.; Shao, S.-Y.; Feng, Z.-M.; Jiang, J.-S.; Li, L.; Chen, N.-H.; Zhang, P.-C. Forsythoneosides A-D, neuroprotective phenethanoid and flavone glycoside heterodimers from the fruits of *Forsythia suspense*. *J. Nat. Prod*. **2015**, 78, 2390–2397. DOI: 10.1021/acs.jnatprod.5b00372. (c) Morikawa, T.; Ninomiya, K.; Kuramoto, H.; Kamei, I.; Yoshikawa, M.; Muraoka, O. Phenylethanoid and phenylpropanoid glycosides with melanogenesis inhibitory activity from the flowers of *Narcissus Tazetta* Var. *chinensis*. *J. Nat. Med*. **2016**, 70, 89–101. DOI:10.1007/s11418-015-0941-5.

[2] (a) Ahmad, I.; Ahmad, N.; Wang, F. Antioxidant phenylpropanoid glycosides from *Buddleja Davidii*. *J. Enzym. Inhib. Med. Chem*. **2009**, 24, 993–997. DOI: 10.1080/14756360802565072. (b) Argyropoulou, A.; Samara, P.; Tsitsilonis, O.; Skaltsa, H. Polar constituents of *Marrubium Thessalum Boiss*. & Heldr. (Lamiaceae) and their cytotoxic/cytostatic activity. *Phytother. Res. Res*. **2012**, 26, 1800. DOI: 10.1002/ptr.4654. (c) Liao, F.; Zheng, R. L.; Gao, J. J.; Jia, Z. J. Retardation of skeletal muscle fatigue by the two phenylpropanoid glycosides: verbascoside and martynoside from *Pedicularis plicata* maxim. *Phytother. Res*. **1999**, 13, 621–623. DOI: 10.1002/(SICI)1099-1573(199911)13. (d) Saracoglu, I.; Inoue, M.; Calis, I.; Ogihara, Y. Studies on constituents with cytotoxic and cytostatic activity of two Turkish

medicinal plant *Phlomis armeniaca* and *Scutellaria salviifolia*. *Biol. Pharm. Bull.* **1995**, 18, 1396–1400. DOI: 10.1248/bpb.18.1396. (e) Sahpaz, S.; Garbacki, N.; Tits, M.; Bailleul, F. Isolation and pharmacological activity of phenylpropanoid esters from *Marrubium vulgare*. *J. Ethnopharmacol*. **2002**, 79, 389–392. DOI: 10.1016/S0378-8741(01)00415-9.

[3] (a) Jiménez, C.; Riguera, R. Phenylethanoid glycosides in plants: structure and biological activity. *Nat. Prod. Rep*. **1994**, 11, 591–606. DOI: 10.1039/NP9941100591. (b) Fu, G.; Pang, H.; Wong, Y.; H. Naturally occurring phenylethanoid glycosides: potential leads for new therapeutics. *CMC* **2008**, 15, 2592–2613. DOI: 10.2174/092986708785908996. (c) He, J.; Hu, X.-P.; Zeng, Y.; Li, Y.; Wu, H.-Q.; Qiu, R.-Z.; Ma, W.-J.; Li, T.; Li, C.-Y.; He, Z.-D. Advanced research on acteoside for chemistry and bioactivities. *J. Asian Nat. Prod. Res*. **2011**, 13, 449–464. DOI: 10.1080/10286020.2011.568940. (d) Alipieva, K.; Korkina, L.; Orhan, I. E.; Georgiev, M. I. Verbascoside – a review of its occurrence, (bio)synthesis and pharmacological significance. *Biotechnol. Adv*. **2014**, 32, 1065–1076. DOI: 10.1016/j.biotechadv.2014.07.001.

[4] (a) Li, Z.-J.; Huang, H.-Q.; Cai, M.-S. Facile synthesis of the sugar cores from phenylpropanoid glycosides. *Carbohydr. Res*. **1994**, 265, 227–236. DOI: 10.1016/0008-6215(94)00226-6. (b) Zhang, S.-Q.; Li, Z.-J.; Wang, A.-B.; Cai, M.-S.; Feng, R. Total synthesis of the phenylpropanoid glycoside grayanoside A. *Carbohydr. Res*. **1997**, 299, 281–285. DOI: 10.1016/S0008-6215(97)00032-3. (c) Zhang, S.-Q.; Li, Z.-J.; Wang, A.-B.; Cai, M.-S.; Feng, R. Synthesis of a phenylpropanoid glycoside, osmanthuside B6. *Carbohydr. Res*. **1998**, *308*, 281–285. DOI: 10.1016/S0008-6215(98)00092-5. (d) Duynstee, H. I.; de Koning, M. C.; Ovaa, H.; van der Marel, G. A.; van Boom, J. H. I.; de Koning, M. C.; Ovaa, H.; Van Der Marel, G. A.; Van Boom, J. H . Synthesis of verbascoside: A dihydroxyphenylethyl glycoside with diverse bioactivity. *Eur. J. Org. Chem*. **1999**, *1999*, 2623–2632. DOI: 10.1002/(SICI)1099-0690(199910)1999:10 < 2623. (e) Kawada, T.; Asano, R.; Hayashida, S.; Sakuno, T. Total synthesis of the phenylpropanoid glycoside, acteoside. *J. Org. Chem*. **1999**, *64*, 9268–9271. DOI: 10.1021/jo9906983.(f) Gu, G.; Zhao, Y.; Guo, Z. Synthesis of leonosides E and F derived from Leonurus Japonicas Houtt. *Carbohydr. Res*. **2013**, *380*, 174–180. DOI: 10.1016/j.carres.2013.07.012. (g) Clayton, E.; Hattie, M.; Debowski, A. W.; Stubbs, K. A. Synthesis of carbohydrate-based natural products from Leonurus Japonicus and their biological evaluation as anti-oxidants. *Aust. J. Chem*. **2014**, *67*, 1461. 1470. DOI: 10.1071/CH13621. (h) Guchhait, G.; Misra, A. K. Short synthesis of the common trisaccharide core of kankanose and Kankanoside Isolated from Cistanche tubulosa. *Beilstein J. Org. Chem*. **2013**, *9*, 705–709. DOI: 10.3762/bjoc.9.80.

[5] (a) Shu, P.; Xiao, X.; Zhao, Y.; Xu, Y.; Yao, W.; Tao, J.; Wang, H.; Yao, G.; Lu, Z.; Zeng, J.; Wan, Q. Interrupted Pummerer reaction in latent-active glycosylation: glycosyl donors with recyclable and regenerative leaving group. *Angew. Chem. Int. Ed*. **2015**, 54, 14432–14436. DOI: 10.1002/anie.201507861. (b) Shu, P.; Yao, W.; Xiao, X.; Sun, J.; Zhao, X.; Zhao, Y.; Xu, Y.; Tao, J.; Yao, G.; Zeng, J.; Wan, Q. Glycosylation via remote activation of anomeric leaving groups: development of 2-(2-propylsulfinyl)benzyl glycosides as novel glycosyl donors. *Org. Chem. Front*. **2016**, 3, 177–183. DOI: 10.1039/C5QO00359H. (c) Xiao, X.; Zhao, Y.; Shu, P.; Zhao, X.; Liu, Y.; Sun, J.; Zhang, Q.; Zeng, J.; Wan, Q. Remote activation of disarmed thioglycosides in latent-active glycosylation via interrupted pummerer reaction. *J. Am. Chem. Soc*. **2016**, 138, 13402–13407. DOI: 10.1021/jacs.6b08305. (d) Chen, W.; Zeng, J.; Wang,

H.; Xiao, X.; Meng, L.; Wan, Q. Tracking the leaving group in the remote activation of O-2-[(Propan-2-yl)sulfinyl]benzyl (OPSB) glycoside. *Carbohydr. Res*. **2017**, 452, 1–5. DOI: 10.1016/j.carres.2017.09.013. (e) Meng, L.; Zeng, J.; Wan, Q. Interrupted Pummerer reaction in latent/active glycosylation. *Synlett* **2018**, 29, 148–156. DOI: 10.1055/s-0036-1588582.

[6] (a) Bur, S. K.; Padwa, A. The Pummerer reaction: methodology and strategy for the synthesis of heterocyclic compounds. *Chem. Rev*. **2004**, 104, 2401–2432. DOI: 10.1021/cr020090l. (b) Feldman, K. S. Modern Pummerer-type reactions. *Tetrahedron* **2006**, 62, 5003–5034. DOI: 10.1016/j.tet.2006.03.004. (c) Akai, S.; Kita, Y. Recent advances in Pummerer reactions. *Top. Curr. Chem*. **2007**, 274, 35–76. DOI: 10.1007/128_073. (d) Smith, L. H. S.; Coote, S. C.; Sneddon, H. F.; Procter, D. J. Beyond the Pummerer reaction: recent developments in thionium ion chemistry. *Angew. Chem. Int. Ed*. **2010**, 49, 5832–5844. DOI: 10.1002/anie.201000517.

[7] Çaliş, I.; Saracoğlu, I.; Başaran, A. A.; Sticher, O. Two phenethyl alcohol glycosides from *Scutellaria Orientalis subsp. pinnatifida*. *Phytochemistry* **1993**, 32, 1621–1623. DOI: 10.1016/0031 -9422(93)85194-V.

[8] Kobayashi, H.; Karasawa, H.; Miyase, T.; Fukushima, S. Studies on the constituents of Cistanchis Herba. V. Isolation and structures of two new phenylpropanoid glycosides, cistanosides E and F. *Chem. Pharm. Bull*. **1985**, 33, 1452–1457. DOI: 10.1248/cpb.33.1452.

[9] Karasawa, H.; Kobayashi, H.; Takizawa, N.; Miyase, T.; Fukushima, S. Studies on the constituents of Cistanchis Herba. VIII. Isolation and structure of a new phenylethanoid, cistanoside. *G. Yakugaku Zasshi*. **1986**, 106, 721–724. DOI: 10.1248/yakushi1947.106.8_721.

[10] Burger, J. F. W.; Brandt, E. V.; Ferreira, D. Iridoid and phenolic glycosides from *Harpagophytum Procumbens*. *Phytochemistry* **1987**, 26, 1453–1457. DOI: 10.1016/S0031-9422(00) 81833-6.

[11] Yoshikawa, M.; Matsuda, H.; Morikawa, T.; Xie, H.; Nakamura, S.; Muraoka, O. Phenylethanoid oligoglycosides and acylated oligosugars with vasorelaxant activity from *Cistanche Tubulosa*. *Bioorg. Med. Chem* **2006**, 14, 7468–7475. DOI: 10.1016/j.bmc.2006.07.018.

[12] Li, Y.; Chen, Z.; Feng, Z.; Yang, Y.; Jiang, J.; Zhang, P. Hepatoprotective glycosides from *Leonurus Japonicus* Houtt. *Carbohydr. Res*. **2012**, 348, 42–46. DOI: 10.1016/j.carres.2011.10.034.

[13] Sugaya, K.; Hashimoto, F.; Ono, M.; Ito, Y.; Masuoka, C.; Nohara, T. Anti-oxidative constituents from Leonurii Herba (*Leonurus Japonicus*). *Fsti*. **1998**, 4, 278–281. DOI: 10.3136/fsti9596t9798.4.278.

[14] Gao, J. J.; Han, G. Q.; Yang, L. Two new phenylpropanoid glycosides from *Caryopteris Incana* (Thunb) Miq. *Chin. Chem. Lett*. **1996**, 7, 445–448.

[15] Heilmann, J.; Calis, I.; Kirmizibekmez, H.; Schühly, W.; Harput, S.; Sticher, O. Radical scavenger activity of phenylethanoid glycosides in FMLP stimulated human polymorphonuclear leukocytes: structure-activity relationships. *Planta Med*. **2000**, 66, 746–748. DOI: 10.1055/s-2000-9566.

[16] Wang, H.; She, J.; Zhang, L.-H.; Ye, X.-S. Silver(I) oxide mediated selective monoprotection of diols in pyranosides. *J. Org. Chem*. **2004**, 69, 5774–5777. DOI: 10.1021/jo0497252.

[17] Liu, Y.; Zeng, J.; Sun, J.; Cai, L.; Zhao, Y.; Fang, J.; Hu, B.; Shu, P.; Meng, L.; Wan, Q. 1,4-Dithiothreitol mediated cleavage of the acetal and ketal type of diol protecting groups. *Org. Chem. Front*. **2018**, 5, 2427–2431. DOI: 10.1039/C8QO00247A.

[18] Feng, W.; Li, M.; Zheng, X.; Song, K.; Wang, J.; Li, C.; Zhang, M. Study on chemical constituents of immunosuppressive parts from the roots of *Rehmannia glutinosa*. *Chin. Pharm. J.* **2014**, 49, 1496–1502.

[19] Variation of aromatic substituents led to great changes in chemical shifts, see the supporting information.

[20] Chiesa, M. V.; Schmidt, R. R. Synthesis of an asparagine-linked heptasaccharide - basic structure of *N*-glycans. *Eur. J. Org. Chem*. **2000**, 2000, 3541–3554. DOI: 10.1002/1099-0690(200011) 2000:21%3C3541.

[21] Li, J.; Wang, Y. An efficient and regioselective deprotection method for acetylated glycosides. *Synth. Commun*. **2004**, 34, 211–217. DOI: 10.1081/SCC-120027255.