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# Divergent Synthesis of Natural Benzyl Salicylate and Benzyl Gentisate Glucosides

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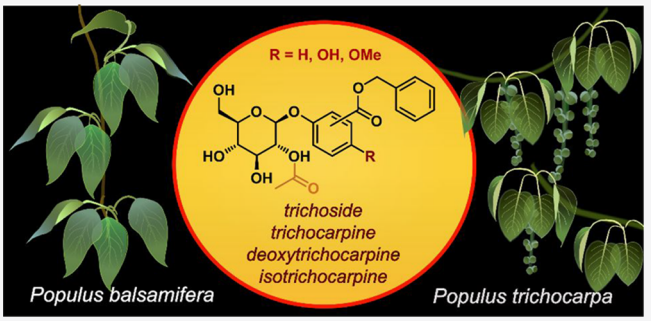
**ABSTRACT:** Herein is reported the first total synthesis of benzyl salicylate and benzyl gentisate glucosides present in various plant species, in particular the *Salix* genus, such as *Populus balsamifera* and *P. trichocarpa*. The method permits the synthesis of several natural phenolic acid derivatives and their glucosides starting from salicylic or gentisic acid. The divergent approach afforded access to three different acetylated glucosides from a common synthetic intermediate. The key step in the total synthesis of naturally occurring glycosides—the selective deacetylation of the sugar moiety—was achieved in the presence of a labile benzyl ester group by employing mild deacetylation conditions. The protocol permitted synthesis of trichocarpine (4 steps, 40% overall yield), isotrichocarpine (3 steps, 51% overall yield), trichoside (6 steps, 40% overall yield), and deoxytrichocarpine (3 steps, 42% overall yield) for the first time (>95% purity). Also, the optimized mild deacetylation conditions allowed synthesis of 2-*O*-acetylated derivatives of all four glycosides (5−17% overall yield, 90−95% purity), which are rare plant metabolites.






Naturally occurring phenolic compounds and their glycosides (also referred to as salicinoids or salicinoid phenolic glycosides) constitute a broad class of secondary metabolites found in higher plants.[1] A subclass of these metabolites is derived from salicylic (**1**) and gentisic acids (**2**), and their derivatives play the key role in plant defense[2,3] and regulate interactions between the plant and mammalian or insect herbivores.[4] Such compounds are particularly common in plants of the willow family (*Salicaceae*) and can account for up to 20 wt % of dry biomass.[5] Besides the importance of these phenolic compounds for regulation of biological functions in plants, a variety have also been identified as active pharmaceutical substances.[6] Nevertheless, the total synthesis of the related phenolic glycosides remains relatively unexplored.[7]

Benzyl salicylate (**3**) has been identified as one of the main constituents of Walter's dogwood (*Cornus walteri*)[8] and other plants, including *Notopterygium incisium*,[9] *Ocotea pulchella*,[10] *Friesodielsia enghiana*,[11] and several species of the *Aniba* genus.[12] Benzyl salicylate (**3**) has been shown to display significant nephroprotective[8] and monoamine oxidase inhibitory effects,[13] while it is also commonly used in the fragrance industry[14] and as an active component in sunscreens.[15] Gentisic acid (**2**) and its esters have been found in numerous plants[16] and showed prominent wound healing and skin lightening properties.[17] Benzyl gentisate (**4**) and its glucoside were isolated from *Populus balsamifera*,[18] suggesting that such phenolic esters are contained in plant tissues primarily in the glycosylated form. The glucoside of benzyl gentisate—trichocarpine (**5**)—was first isolated from *P. trichocarpa*[19] and *P. balsamifera*[20] along with its aglycone. However, in subsequent reports only the presence of trichocarpine **5**,[21] 2-*O*-acetyl trichocartpine (**6**),[22] and its isomer, isotrichocarpine (**7**),[23] with no free aglycone was demonstrated for various plant species. Similarly, the analogous glucoside trichoside (**8**) was isolated with no detectable free aglycone,[24,25] indicating that the free aglycone found in the early studies was likely formed during the isolation process due to glucosidic bond hydrolysis. Despite the abundance of benzyl salicylate (**3**) in plants, the isolation of its glucoside **9** has been reported only once, from *Sarcandra glabra* (Chloranthaceae).[26] Finally, salicylates and their glycosides can also be used for recognition of certain plant species including morphologically similar species or hybrids,[27,28] as well as for understanding of interactions of plants and insects with different levels of specialization.[29,30]

In the present work, we describe the total synthesis of four phenolic glucosides, namely, trichocarpine (**5**), isotrichocar-

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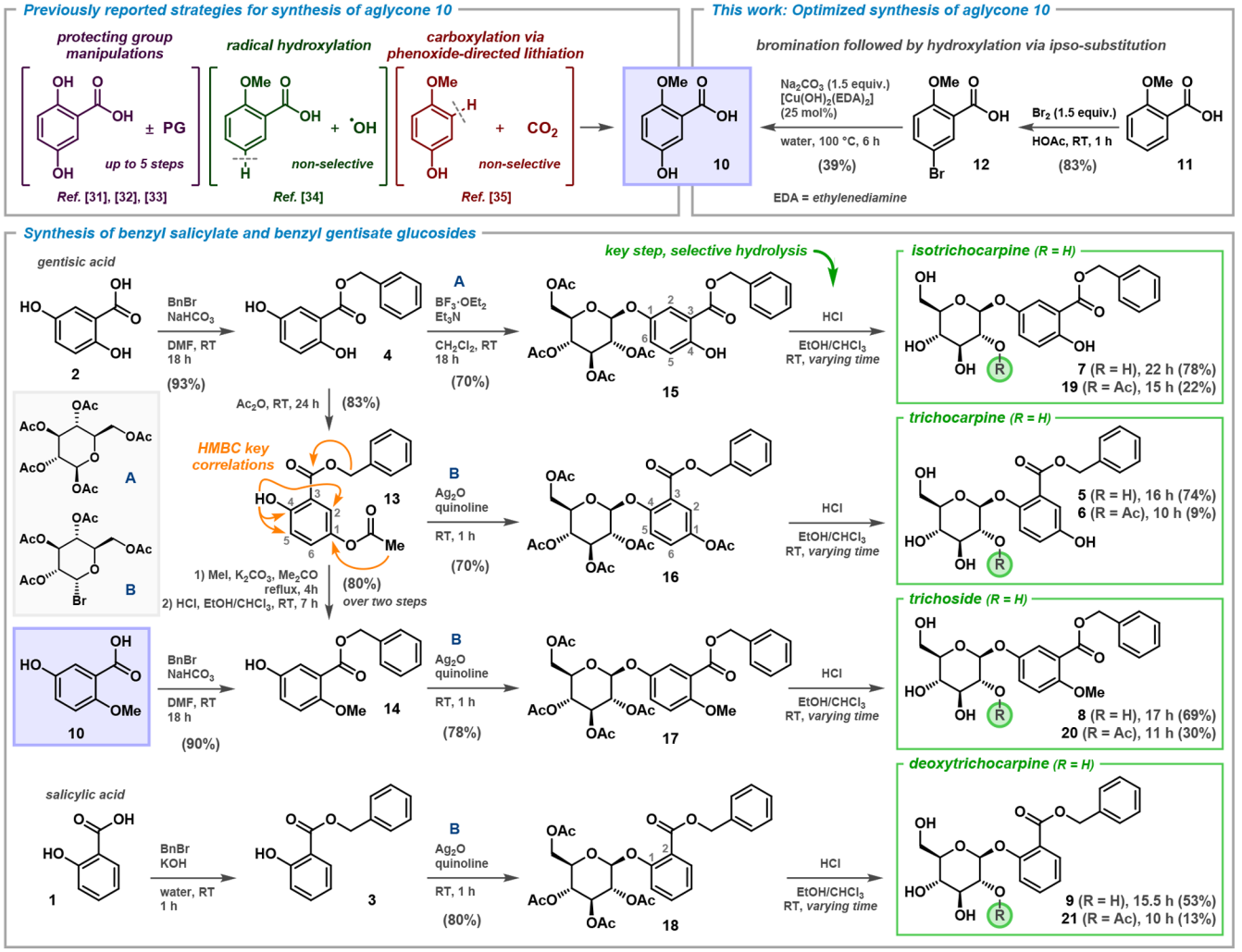


**Figure 1.** Preparation of benzyl gentisates (**4**, **13**, **14**), benzyl salicylate (**3**), and their glucosides (**5**–**9**, **19**–**21**).

pine (**7**), trichoside (**8**), and deoxytrichocarpine (**9**), as well as their 2-*O*-acetyl derivatives **6**, **19**, **20**, and **21**, respectively, with the respective aglycones obtained from the ubiquitous gentisic and salicylic acids. Additionally, a divergent synthetic route to an aglycone of trichoside (**8**) is discussed.

## RESULTS AND DISCUSSION

One of the challenges in the total synthesis of glycosides of salicylic acid derivatives is the synthesis of their relatively simple aglycone moieties. The core part of the trichoside aglycone **14** consists of 2-methoxy-5-hydroxybenzoic acid (**10**). Synthesis of this acid has been described via multistep procedures starting from gentisic acid (**2**) and using tosyl,[31] benzyl,[32] or *tert*-butyldimethylsilyl (TBS)[33] protecting groups (Figure 1). Several one-step procedures for preparation of acid **10** from 2-methoxybenzoic acid (**11**)[34] or 4-methoxyphenol[35] have been described; however, these procedures only gave the target product with poor selectivity and low yield. Synthesis of acid **10** via selective demethylation of fully methylated gentisic acid was mentioned previously;[36] however, our attempts at reproducing this procedure resulted in isolation of only trace amounts of the target product.

In this work, we devised an alternative strategy for the synthesis of acid **10** needed for accessing aglycone **14**. In this strategy, 2-methoxybenzoic acid (**11**) was converted to aryl bromide **12** with molecular bromine in 83% yield, followed by *ipso*-substitution of bromide **12** by a hydroxy group. The latter reaction was carried out with the use of a common copper(II) catalyst [$Cu(OH)_2$-ethylenediamine] in water with the addition of $K_2CO_3$ as a mild base, to afford **10** in satisfactory yield (39%). The reaction provided a slightly lower yield when the copper(II) catalyst was prepared *in situ* from $CuSO_4$ and ethylenediamine. Interestingly, the described optimized procedure allowed avoiding conversion of the bromide **12** to the respective aryl iodide, which was pivotal in the case of the published procedures.[37,38] Finally, benzylation of acid **10** furnished aglycone **14** in an excellent yield of 94%.

An alternative route for preparation of aglycone **14** starting from gentisic acid (**2**) was also explored (Figure 1). In this divergent route, aglycones **4** and **13** were also synthesized as synthetic intermediates of aglycone **14**. Gentisic acid was benzylated to provide aglycone **4** (93% yield), which was selectively acetylated with $Ac_2O$ to afford the monoacetyl derivative **13**. The initial attempts at pyridine-assisted acetylation of **4** with a stoichiometric amount of $Ac_2O$ resulted in isolation of a mixture of mono- and diacetylated products. Fortunately, conducting the reaction in neat $Ac_2O$ in the absence of pyridine allowed selective monoacetylation and provided **13** in 83% yield. Under these conditions, it is likely


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that the regioselectivity of the reaction relies on the steric hindrance exerted by the carboxybenzyl group in phenol **4**. Introduction of the acetyl group at C-1 in **13** was confirmed by HMBC experiments (Figure 1, see the Supporting Information), which demonstrated correlation between the $CH_3$ protons of the acetyl group and C-1 ($\delta_H$ 2.30/$\delta_C$ 142.5) and between the OH proton and C-4 ($\delta_H$ 10.70/$\delta_C$ 159.5). Acetate **13** was converted to aglycone **14** via sequential methylation and deacetylation reactions. Despite the presence of two ester groups in methylated **13**, selective deacetylation was achieved in good yield when conducting the reaction under mild acidic conditions (HCl in EtOH/$CHCl_3$).[7f] No trace of the debenzylated product was detected during deacetylation, providing trichoside aglycone **14** in 80% yield over two steps.

The phenolic glucosides were then synthesized with phenols **4**, **13**, and **14** as glucosyl acceptors, affording tetraacetate glucosides isotrichocarpine (**15**), trichocarpine (**16**), and trichoside (**17**), respectively. Isotrichocarpine tetraacetate (**15**) was prepared in one step from benzyl gentisate (**4**), using penta-*O*-acetyl-*β*-D-glucose as the glucosyl donor. In this reaction, the steric hindrance exerted by the carboxybenzyl group permitted selective formation of only one product with no traces of the isomeric glucoside or diglucoside. Surprisingly, the same glucosylation method (*β*-D-glucose pentaacetate, promoted by $BF_3{\cdot}Et_2O$)[39] did not result in formation of any product in the case of phenols **13**, **14**, and **3**. Presumably, for these aglycones strong coordination of the Lewis acid between the *ortho*-positioned phenolic and ester groups prevents nucleophilic attack on the reactive species generated from the glucosyl donor. Gratifyingly, glucosylation of **13**, **14**, and **3** was achieved successfully under Koenigs−Knorr conditions,[40] providing the target glucosides **16**, **17**, and **18** in high yields (70%, 78%, and 80%, respectively).

The final step in the total synthesis of the glucosylated salicylic acid derivatives comprises selective deacetylation of tetraacetate precursors **15**−**18**. Herein, chemoselective deacetylation plays a crucial role, sine the precursors **15**−**18** contain both acetyl ester groups in the sugar moiety and a benzyl ester group in the aglycone moiety. The typical procedures for deacetylation, such as the Zemplen procedure (sodium methoxide in methanol)[41,42] or other base-catalyzed deacetylation procedures,[43] proved nonselective for removal of the acetyl ester groups. Therefore, an alternative procedure that was recently applied by our group for selective removal of acetyl groups in the presence of other ester groups for a number of phenolic glycosides was employed.[7d−f] Selective deacetylation of tetraacetates **15**, **16**, **17**, and **18** was thereby achieved through mild acidic ethanolysis and afforded the target naturally occurring glucosides isotrichocarpine (**7**), trichocarpine (**5**), trichoside (**8**), and deoxytrichocarpine (**9**), respectively, in good yields (78%, 74%, 69%, and 53%). This is the first demonstration of the total synthesis of these natural compounds. Along with glucosides **5**, **7**, **8**, and **9**, their 2-*O*-acetyl derivatives **6**, **19**, **20**, and **21**, respectively, could also be obtained by carefully controlling the reaction time. Owing to the higher hydrolytic stability of 2-*O*-acetyl groups in phenyl glucosides,[44,45] selective deacetylation of tetra-*O*-acetyl glucosides under reduced reaction times furnished the 2-*O*-acetyl derivatives **6**, **19**, **20**, and **21**, albeit in moderate yields (9%, 22%, 30%, and 13%).

In conclusion, efficient procedures for the preparative synthesis of several natural glucosides of salicylic and gentisic acid benzyl esters were developed. Using a divergent approach three glucosides, namely, trichocarpine, isotrichocarpine, and trichoside, along with their 2-*O*-acetyl derivatives were obtained using benzyl gentisate as a common synthetic intermediate. The preparation of the core trichoside aglycone, 2-methoxy-5-hydroxybenzoic acid, was improved by reducing the number of synthetic steps from four or five in the previously reported procedures to two in the current approach. Selective HCl-catalyzed deacetylation permitted preparation of deprotected glycosides in high yields (74% for trichocarpine, 78% for isotrichocarpine, 69% for trichoside, and 53% for deoxytrichocarpine) and their 2-*O*-acetyl derivatives in modest yields (9% for 2-*O*-acetyltrichocarpine, 22% for 2-*O*-acetylisotrichocarpine, 30% for 2-*O*-acetyltrichoside, and 13% for 2-*O*-acetyldeoxytrichocarpine). The purity of all products was estimated from $^1$H NMR spectra and exceeded 95% for fully deprotected glycosides and 90−95% for 2-*O*-acetylglucosides.

## EXPERIMENTAL SECTION

**General Experimental Procedures.** The reactions were performed with commercial reagents purchased from Merck, Darmstadt, Germany, or Acros Organics (Thermo Fisher Scientific), Geel, Belgium. Anhydrous solvents were purified and dried according to standard procedures. Uncorrected melting points were determined using an MP50 melting point system (Mettler Toledo). UV spectra were recorded using EtOH solutions (ca. 0.005 wt %) with an Evolution 600 UV−visible spectrophotometer. Optical rotations were measured on a POP-1/2 automatic compact polarimeter. IR spectra were recorded on neat samples using an Agilent Cary 630 FTIR spectrometer with attenuated total reflectance (ATR). $^1$H and $^{13}$C NMR spectra were acquired for solutions in $CDCl_3$, DMSO-$d_6$, or methanol-$d_4$ on a Bruker AVANCE III HD instrument (400 and 101 MHz for $^1$H and $^{13}$C, respectively). The $^1$H NMR chemical shifts are referenced to the residual signal of $CHCl_3$ ($\delta_H$ 7.26), DMSO-$d_5$ ($\delta_H$ 2.50), methanol-$d_3$ ($\delta_H$ 3.31), acetone-$d_5$ ($\delta_H$ 2.05), or HDO ($\delta_H$ 4.79), and the $^{13}$C NMR shifts are referenced to the central line of the $CDCl_3$ signal ($\delta_C$ 77.00), DMSO-$d_6$ ($\delta_C$ 39.52), acetone-$d_6$ ($\delta_C$ 29.84), and methanol-$d_4$ ($\delta_C$ 49.00). Assignment of the signals in the NMR spectra was performed using 2D-NMR experiments (COSY, HSQC, and HMBC). The purity of the synthesized compounds was estimated from $^1$H NMR spectra. HR-ESIMS spectra were recorded in positive ion mode on a Bruker micrOTOF II mass spectrometer for $2 \times 10^{-5}$ M solutions in MeCN. Column chromatography was performed on silica gel 60 (40−63 μm, Merck, Darmstadt, Germany). Flash chromatography was carried out on a Reveleris X2 Büchi chromatograph using FlashPure Select $C_{18}$ 30 μm columns. TLC was carried out on silica gel 60 $F_{254}$ plates on aluminum foil (Merck, Darmstadt, Germany). The eluent systems used for chromatographic purification and TLC are specified for each compound in their respective synthetic procedures. TLC spots were visualized under UV light (254 nm) or by heating the TLC plates to ca. 300 °C after immersion in a 1:10 (v/v) mixture of 85% aqueous $H_3PO_4$ and MeOH (for glucosides) or in a 2% solution of $FeCl_3$ in water (for aglycones).

*5-Bromo-2-methoxybenzoic acid (**12**).* 2-Methoxybenzoic acid **11** (7.6 g, 50 mmol) was dissolved in glacial HOAc (25 mL), and a solution of $Br_2$ (3.88 mL, 75 mmol) in HOAc (25 mL) was added dropwise over 1 h. The reaction mixture was stirred at room temperature (~20 °C) for 2 h, ice-cold water (150 mL) was added, stirring was continued for 30 min, and the precipitate was filtered and extensively washed with water. The precipitate was recrystallized from EtOH and air-dried to give the title compound as white needles (9.7 g, 84%, purity >95%): $R_f$ = 0.37 (hexanes/EtOAc, 7:2); mp 116−117 °C (lit. 120−122 °C);[46] UV (EtOH) $\lambda_{max}$ 231, 306 nm; ATR-FTIR $\nu_{max}$ 3070−2200 (br) 1699, 1666, 1485, 1232, 1012, 812, 674 cm$^{-1}$; $^1$H NMR (400 MHz, $CDCl_3$, $\delta$, ppm, *J*, Hz) 4.07 (s, 3H, OMe), 6.96 (d, 1H, *J* 8.7, H-5), 7.67 (dd, 1H, *J* 2.6, *J* 8.7, H-6), 8.29 (s, 1H, H-2); $^{13}$C NMR (101 MHz, $CDCl_3$, $\delta$, ppm) 57.0, 113.5, 114.7, 119.3,


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136.2, 137.6, 157.1, 164.1. The spectroscopic data are in agreement with literature data.[46]

*5-Hydroxy-2-methoxybenzoic acid (**10**).* Bromide **12** (0.3 g, 1.3 mmol) and $K_2CO_3$ (0.27 g, 1.9 mmol) were dissolved in water (12 mL) under sonication, followed by addition of a 1 M aqueous solution of $[Cu(OH)_2(EDA)_2]$ (0.32 mL, 0.32 mmol, 25 mol %) and purging of the reaction mixture with nitrogen for 10 min. The reaction mixture was heated at 100 °C for 6 h under nitrogen, after which it was cooled and the pH of the mixture was adjusted to 4 with 0.1 M aqueous HCl. The mixture was extracted with EtOAc (4 × 20 mL), and the combined organic extract was dried over $Na_2SO_4$, filtered, and concentrated, resulting in a crude product as a yellow solid. The crude product was purified by silica gel column chromatography (toluene/acetone, 6:1, → toluene/acetone, 1:1, 0.05% (v/v) HOAc) to give the product as an off-white solid: 86 mg (39%), purity >95%; $R_f$ = 0.30 (hexanes/EtOAc, 7:2); mp 155−156 °C (lit. 171−173 °C from EtOAc);[31] UV (EtOH) $\lambda_{max}$ 232, 320 nm; ATR-FTIR $\nu_{max}$ 3426 (br), 2920, 2851, 1667, 1584, 1490, 1261, 1206, 1180, 890, 814, 749, 676 $cm^{-1}$; $^1H$ NMR (400 MHz, acetone-$d_6$, $\delta$, ppm, $J$, Hz) 3.99 (s, 3H, OMe), 7.06 (dd, 1H, $J$ 3.0, $J$ 8.9, H-6), 7.11 (d, 1H, $J$ 8.9, H-5), 7.43 (d, 1H, $J$ 3.0, H-2), 8.35 (s, 1H, OH), 10.98 (s, 1H, OH); $^{13}C$ NMR (101 MHz, acetone-$d_6$, $\delta$, ppm) 57.5, 115.0, 118.8, 120.4, 121.9, 152.3, 152.9, 165.9. The spectroscopic data are in agreement with the literature.[31]

*Benzyl 2,5-dihydroxybenzoate (benzyl gentisate) (**4**):* Gentisic acid **2** (7.86 g, 51 mmol) and $NaHCO_3$ (22 g, 260 mmol) were dissolved in dry DMF (50 mL), the mixture was stirred for 5 min, and BnBr (6 mL, 51 mmol) was added. The reaction mixture was stirred at room temperature (∼20 °C) for 18 h, ice-cold water (200 mL) was added, and stirring was continued for 30 min, after which the precipitate was filtered and extensively washed with water. The precipitate was transferred to a beaker, and boiling toluene (100 mL) was added. After the complete dissolution of all solids the upper toluene layer was accurately transferred to dry a beaker and slowly cooled to −20 °C. The precipitate was filtered, washed with cold toluene (2 × 30 mL), and air-dried to give the title compound as white needles (11.57 g, 93%, purity >95%): $R_f$ = 0.48 (toluene/EtOH, 9:1); mp 102−103 °C (lit. 104.5 °C,[18] 102−103 °C[47]); UV (EtOH) $\lambda_{max}$ 230, 290 nm; ATR-FTIR $\nu_{max}$ 3227 (br), 2940, 2873, 1654, 1616, 1483, 1194, 1071, 779, 695 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, $\delta$, ppm, $J$, Hz) 5.35 (s, 2H, $CH_2$), 6.88 (d, 1H, $J$ 8.9, H-5), 7.00 (dd, 1H, $J$ 3.0, $J$ 8.9, H-6), 7.32 (d, 1H, $J$ 3.0, H-2), 7.36−7.41 (m, 5H, $C_6H_5$), 10.39 (s, 1H, OH); $^{13}C$ NMR (101 MHz, $CDCl_3$, $\delta$, ppm) 67.1 ($CH_2$), 112.1, 114.8, 118.5, 124.2, 128.2 (2 × CH), 128.6, 128.7 (2 × CH), 135.1, 147.7, 155.7, 169.5. The spectroscopic data are in agreement with the literature data.[18,48]

*Benzyl 5-acetoxy-2-hydroxybenzoate (**13**).* Phenol **4** (4.88 g, 20 mmol) was dissolved in $Ac_2O$ (6.8 mL, 72 mmol). The reaction mixture was stirred at room temperature (∼20 °C) for 24 h, the solvent was evaporated *in vacuo*, and the residue was purified by silica gel column chromatography (toluene → toluene/EtOAc, 7:1) to give the title compound as a white solid (4.75 g, 83%, purity >95%): $R_f$ = 0.88 (toluene/EtOAc, 20:1); mp 55−56 °C; UV (EtOH) $\lambda_{max}$ 237, 314 nm; ATR-FTIR $\nu_{max}$ 3201 (br), 3073, 1758, 1671, 1485, 1204, 743, 681 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, $\delta$, ppm, $J$, Hz) 2.27 (s, 3H, $CH_3$, Ac), 5.37 (s, 2H, $CH_2$), 6.99 (d, 1H, $J$ 9.0, H-5), 7.19 (dd, 1H, $J$ 2.9, $J$ 9.0, H-6), 7.37−7.45 (m, 5H, $C_6H_5$), 7.57 (d, 1H, $J$ 2.9, H-2), 10.68 (s, 1H, OH); $^{13}C$ NMR (101 MHz, $CDCl_3$, $\delta$, ppm) 20.9 ($CH_3$, Ac), 67.3 ($CH_2$), 112.3 (C-3), 118.4 (C-5), 122.1 (C-2), 128.4 (2 × CH, $C_6H_5$), 128.6 (2 × CH, $C_6H_5$), 128.7 (CH, $C_6H_5$), 129.5 (C-6), 134.9 (C, $C_6H_5$), 142.3 (C-1), 159.4 (C-4), 169.2 (CO), 169.7 (CO, Ac). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 5-hydroxy-2-methoxybenzoate (**14**).* From acid **10**: Benzylation of **10** (100 mg, 0.6 mmol) was carried out under the same conditions as for **4**; yield of **14**, 145 mg (94%). From phenol **13**: Monoacetate **13** (5.7 g, 20 mmol) was dissolved in dry acetone (100 mL), $K_2CO_3$ (15 g, 108 mmol) and MeI (1.37 mL, 22 mmol) were added, and the mixture was refluxed for 4 h until complete consumption of the starting material. The acetone was evaporated *in vacuo*, the residue was dissolved in $CH_2Cl_2$ (50 mL) and washed with 1 M NaOH (2 × 50 mL) and water (2 × 50 mL), and the aqueous layer was extracted with $CH_2Cl_2$ (2 × 30 mL). The combined organic extract was dried over $Na_2SO_4$ and filtered, and the solids were washed with $CH_2Cl_2$ (4 × 10 mL). The combined filtrate was concentrated under reduced pressure and dried *in vacuo*. The residue was purified by silica gel column chromatography (toluene → toluene/EtOAc, 9:1) to give the methylated compound as a colorless oil: $R_f$ = 0.49 (toluene/EtOAc, 45:1); HR-ESIMS $m/z$ 323.0891 (calcd for $C_{17}H_{16}O_5Na$, 323.0890). The residue was dissolved in a mixture of EtOH and $CHCl_3$ (35 mL, 1.8:1 v/v), and concentrated HCl (4.5 mL) was added. The reaction mixture was stirred at room temperature (∼20 °C) for 7 h, solvents were evaporated *in vacuo*, the residue was dissolved in toluene (50 mL) and washed with saturated aqueous $NaHCO_3$ (2 × 50 mL), and the aqueous layer was extracted with toluene (2 × 30 mL). The combined organic extract was dried over $Na_2SO_4$ and filtered, and the solids were washed with toluene (4 × 10 mL). The combined filtrate was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography (toluene → toluene/EtOAc, 75:25) to give 4.12 g (80% over 2 steps, purity 94%) of the title compound as a white solid: $R_f$ = 0.28 (toluene/EtOAc, 45:1); mp 60−62 °C; UV (EtOH) $\lambda_{max}$ 238, 325 nm; ATR-FTIR $\nu_{max}$ 3372, 2843, 1735, 1575, 1487, 1200, 1027, 784 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, $\delta$, ppm, $J$, Hz) 3.81 (s, 3H, OMe), 5.31 (s, 2H, $CH_2$), 6.84 (d, 1H, $J$ 8.9, H-5), 6.98 (dd, 1H, $J$ 3.0, $J$ 8.9, H-6), 7.26−7.42 (m, 6H, H-2, $C_6H_5$); $^{13}C$ NMR (101 MHz, $CDCl_3$, $\delta$, ppm) 56.6 (OMe), 66.7 ($CH_2$), 113.8 (C-5), 118.1 (C-2), 119.9 (C-3), 120.8 (C-6), 128.1 (CH, $C_6H_5$), 128.1 (2 × CH, $C_6H_5$), 128.5 (2 × CH, $C_6H_5$), 135.9 (C, $C_6H_5$), 149.1 (C-1), 153.6 (C-4), 165.9 (CO); HR-ESIMS $m/z$ 281.0785 (calcd for $C_{15}H_{14}O_4Na$, 281.0784). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 5-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyloxy)-2-hydroxybenzoate (isotrichocarpine tetraacetate) (**15**).* Benzyl gentisate (**4**) (1.013 g, 4.15 mmol) and the pentaaceate of β-D-glucose **A** (2.56 g, 6.57 mmol) were dissolved in dry $CH_2Cl_2$ (30 mL) under nitrogen, and $Et_3N$ (0.460 mL, 3.3 mmol) was added, followed by $BF_3{\cdot}Et_2O$ (1.96 mL, 16.4 mmol). The reaction mixture was stirred at room temperature (∼20 °C) for 18 h, saturated $NaHCO_3$ (50 mL) was added, the organic layer was separated, the aqueous layer was extracted with $CH_2Cl_2$ (3 × 50 mL), the combined organic extract was dried over $Na_2SO_4$, filtered, concentrated under reduced pressure, and the residue was recrystallized from hot EtOH to give the title compound as white crystals (1.66 g, 70%, purity >95%): $R_f$ = 0.44 (PhMe/EtOH, 18:1); mp 105−106 °C; $[\alpha]^{26}_D$ −5.9 ($c$ 0.49, $CHCl_3$); UV (EtOH) $\lambda_{max}$ 238, 324 nm; ATR-FTIR $\nu_{max}$ 3142, 2972, 1750, 1677, 1485, 1202, 1038, 836, 788, 701 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, $\delta$, ppm, $J$, Hz) 2.02, 2.03, 2.03, 2.03 (s, 4 × 3H, Ac), 3.76 (ddd, 1H, $J$ 2.0, $J$ 4.6, $J$ 9.8, H-$5_{Glc}$), 4.06 (dd, 1H, $J$ 2.0, $J$ 12.3, H-$6a_{Glc}$), 4.27 (dd, 1H, $J$ 4.6, $J$ 12.3, H-$6b_{Glc}$), 4.94 (d, 1H, $J$ 7.4, H-$1_{Glc}$), 5.16 (dd∼t, 1H, $J$ 9.5, H-$4_{Glc}$), 5.19−5.29 (m, 2H, H-$2_{Glc}$, H-$3_{Glc}$), 5.37 (s, 2H, $CH_2$), 6.91 (d, 1H, $J$ 9.0, H-5), 7.16 (dd, 1H, $J$ 2.9, $J$ 9.0, H-6), 4.37−7.44 (m, 5H, $C_6H_5$), 7.47 (d, 1H, $J$ 2.9, H-2), 10.48 (s, 1H, OH); $^{13}C$ NMR (101 MHz, $CDCl_3$, $\delta$, ppm) 20.56, 20.59, 20.61 (4 × $CH_3$, Ac), 61.6 (C-6), 67.2 ($CH_2$), 68.0 (C-$4_{Glc}$), 71.1 (C-$2_{Glc}$ or C-$3_{Glc}$), 72.0 (C-$5_{Glc}$), 72.6 (C-$2_{Glc}$ or C-$3_{Glc}$), 100.3 (C-$1_{Glc}$), 112.2 (C-3), 118.2 (C-2), 118.5 (C-5), 126.5 (C-6), 128.3 (2 × CH, $C_6H_5$), 128.7 (CH, $C_6H_5$), 128.7 (2 × CH, $C_6H_5$), 135.0 (C, $C_6H_5$), 148.9 (C-4), 158.0 (C-1), 169.2, 169.3, 169.3, 170.2, 170.5 (CO); HR-ESIMS $m/z$ 597.1577 (calcd for $C_{28}H_{30}O_{13}Na$, 597.1579). The spectroscopic data are in agreement with the anticipated structure.

**General Procedure for $Ag_2O$-Promoted Glycosylation.** α-Bromotetra-*O*-acetylglucose (**B**) (1 equiv) and phenol **3**, **13**, or **14** (1.05 equiv) were dissolved in quinoline (1 mL per 1 g of α-bromotetra-*O*-acetylglucose), and ground $Ag_2O$ (1.05 equiv) was added. The reaction mixture was stirred using a glass spatula upon thickening at room temperature (∼20 °C) for 1 h, followed by addition of $CHCl_3$ (30 mL). The reaction mixture was centrifuged, the supernatant was combined, and the solids were carefully washed with $CHCl_3$ (3 × 10 mL). The combined organic phases were washed


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with 1 M KOH (4 × 50 mL) and 5% aqueous $H_2SO_4$ (4 × 50 mL), dried over $Na_2SO_4$, filtered through a glass filter filled with $SiO_2$ to remove residual silver salts, washed with $CHCl_3$ (150 mL), and concentrated under reduced pressure, and the residue was recrystallized from hot EtOH.

*Benzyl 2-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyloxy)-5-acetoxybenzoate (trichocarpine pentaacetate) (**16**).* **16** was prepared following the general procedure from phenol **13** (0.45 g, 1.6 mmol) and isolated as white crystals (0.69 mg, 70%, purity >95%): $R_f$ = 0.83 (toluene/EtOH, 9:1); mp 113−114 °C (lit 117−118 °C);[48] $[\alpha]^{26}_D$ −17.9 (*c* 0.39, $CHCl_3$); UV (EtOH) $\lambda_{max}$ 230, 290 nm; ATR-FTIR $\nu_{max}$ 2943, 1731, 1493, 1207, 1032, 751, 696 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, *δ*, ppm, *J*, Hz) 2.03, 2.04, 2.04, 2.06, 2.28 (s, 5 × $CH_3$, Ac), 3.81 (ddd, 1H, *J* 2.0, *J* 5.2, *J* 9.2, H-$5_{Glc}$), 4.15 (dd, 1H, *J* 2.0, *J* 12.2, H-$6a_{Glc}$), 4.26 (dd, 1H, *J* 5.2, *J* 12.2, H-$6b_{Glc}$), 5.06 (d, 1H, *J* 7.2, H-$1_{Glc}$), 5.15 (dd∼t, 1H, *J* 9.2, H-$4_{Glc}$), 5.24−5.33 (m, 4H, $CH_2$, H-$2_{Glc}$, H-$3_{Glc}$), 7.15−7.20 (m, 2H, H-6, H-5), 7.31−7.42 (m, 5H, $C_6H_5$), 7.48−7.49 (m, 1H, H-2); $^{13}C$ NMR (101 MHz, $CDCl_3$, *δ*, ppm) 20.57, 20.58, 20.7, 20.9 (5 × $CH_3$, Ac), 61.8 (C-$6_{Glc}$), 66.8 ($CH_2$), 68.2 (C-$4_{Glc}$), 70.7 (C-$2_{Glc}$), 72.0 (C-$5_{Glc}$), 72.6 (C-$3_{Glc}$), 100.0 (C-$1_{Glc}$), 119.2 (C-5), 123.4 (C-3), 124.1 (C-2), 126.3 (C-6), 128.2 (CH, $C_6H_5$), 128.3 (2 × CH, $C_6H_5$), 128.5 (2 × CH, $C_6H_5$), 135.8 (C, $C_6H_5$), 145.7 (C-1), 153.4 (C-4), 164.0 (CO), 169.3, 169.4, 169.4, 170.2, 170.5 (5 × CO, Ac); HR-ESIMS *m*/*z* 639.1680 (calcd for $C_{30}H_{32}O_{14}Na$, 639.1684). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 2-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyloxy)-5-acetoxybenzoate (trichoside tetraacetate) (**17**).* **17** was prepared following the general procedure from phenol **14** (1.0 g, 3.9 mmol) and isolated as white crystals (1.69 g, 78%, purity >95%): $R_f$ = 0.52 (toluene/EtOH, 9:1); mp 103−105 °C (lit. 116−118 °C);[24] $[\alpha]^{26}_D$ −10.3 (*c* 0.60, $CHCl_3$); UV (EtOH) $\lambda_{max}$ 209, 237, 308 nm; ATR-FTIR $\nu_{max}$ 2968, 1751, 1733, 1498, 1375, 1206, 1069, 1039, 825, 746, 699 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, *δ*, ppm, *J*, Hz) 2.02, 2.03, 2.04, 2.04 (s, 4 × $CH_3$, Ac), 3.78 (ddd, 1H, *J* 2.3, *J* 5.0, *J* 9.9, H-$5_{Glc}$), 3.86 (s, 3H, OMe), 4.08 (dd, 1H, *J* 2.3, *J* 12.3, H-$6a_{Glc}$), 4.26 (dd, 1H, *J* 5.0, *J* 12.3, H-$6b_{Glc}$), 4.97 (d, 1H, *J* 7.5, H-$1_{Glc}$), 5.15 (dd∼t, 1H, *J* 9.5, H-$4_{Glc}$), 5.24 (m, 2H, H-$2_{Glc}$, H-$3_{Glc}$), 5.33 (s, 2H, $CH_2$), 6.90 (d, 1H, *J* 9.1, H-5), 7.13 (dd, 1H, *J* 3.1, *J* 9.0, H-6), 7.32−7.45 (m, 5H, $C_6H_5$), 7.47 (d, 1H, *J* 3.1, H-2); $^{13}C$ NMR (101 MHz, $CDCl_3$, *δ*, ppm) 20.55, 20.57, 20.59, 20.61 (4 × $CH_3$, Ac), 56.5 (OMe), 61.7 (C-$6_{Glc}$), 66.7 ($CH_2$), 68.0 (C-$4_{Glc}$), 71.1 (C-$2_{Glc}$ or C-$3_{Glc}$), 72.0 (C-$5_{Glc}$), 72.6 (C-$2_{Glc}$ or C-$3_{Glc}$), 100.0 (C-$1_{Glc}$), 113.3 (C-5), 120.4 (C-3), 120.5 (C-6), 123.2 (C-5), 128.0 (2 × CH, $C_6H_6$), 128.2 (CH, $C_6H_6$), 128.5 (2 × CH, $C_6H_6$), 135.9 (C, $C_6H_6$), 149.9 (C-4), 155.6 (C-1), 165.2 (CO), 169.3, 169.3, 170.2, 170.6 (4 × CO, Ac); HR-ESIMS *m*/*z* 611.1737 (calcd for $C_{29}H_{32}O_{13}Na$, 611.1735). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 2-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyloxy)-benzoate (deoxytrichocarpine tetraacetate) (**18**).* **18** was prepared following the general procedure from phenol **3** (1.0 g, 4.4 mmol) as white crystals (1.87 g, 80%, purity >95%): $R_f$ = 0.54 (hexanes/EtOAc, 1:1); mp 107−108 °C; $[\alpha]^{26}_D$ − 74.2 (*c* 0.59, $CHCl_3$); UV (EtOH) $\lambda_{max}$ 227, 284 nm. ATR-FTIR $\nu_{max}$ 2967, 1753, 1730, 1374, 1223, 1038, 761 $cm^{-1}$; $^1H$ NMR (400 MHz, $CDCl_3$, *δ*, ppm, *J*, Hz) 2.04, 2.05 (s, 4 × $CH_3$, Ac), 3.85 (ddd, 1H, *J* 2.2, *J* 4.8, *J* 7.0, H-$5_{Glc}$), 4.17 (d, 1H, *J* 12.2, H-$6a_{Glc}$), 4.27 (d, 1H, *J* 12.2, H-$6b_{Glc}$), 5.10 (d, 1H, *J* 6.8, H-1), 5.16 (dd∼t, 1H, *J* 9.2, H-$4_{Glc}$), 5.26−5.35 (m, 4H, H-$2_{Glc}$, H-$3_{Glc}$, $CH_2$), 7.11−7.17 (m, 2H, CH, Ar), 7.26−7.44 (m, 6H, $C_6H_5$, CH, Ar), 7.75 (d, 1H, *J* 7.5, CH, Ar); $^{13}C$ NMR (101 MHz, $CDCl_3$, *δ*, ppm) 20.6, 20.6, 20.6 (4 × $CH_3$, Ac), 61.9 (C-$6_{Glc}$), 66.6 ($CH_2$), 68.2 (C-$4_{Glc}$), 70.7 (C-$2_{Glc}$ or C-$3_{Glc}$), 72.0 (C-$5_{Glc}$), 72.6 (C-$2_{Glc}$ or C-$3_{Glc}$l), 99.7 (C-$1_{Glc}$), 117.5 (CH, Ar), 122.6 (C-2), 123.2 (CH, Ar), 128.1 (CH, $C_6H_5$), 128.2 (2 × CH, $C_6H_5$), 128.5 (2 × CH, $C_6H_5$), 131.1 (CH, Ar), 133.0 (CH, Ar), 136.0 (C, $C_6H_5$), 155.7 (C-1), 165.3 (CO), 169.4, 169.4, 170.2, 170.5 (4 × CO, Ac); HR-ESIMS *m*/*z* 581.1624 (calcd for $C_{28}H_{30}O_{12}Na$, 581.1629). The spectroscopic data are in agreement with the anticipated structure.

**General Procedure for Selective Deacetylation.** Acetylated glucosides **15**−**18** (0.45 mmol) were separately dissolved in a mixture of $CHCl_3$ (1.2 mL) and EtOH (3 mL), and concentrated HCl (1 mL) was added. The reaction mixture was stirred at room temperature (∼20 °C) for 10−22 h and concentrated under reduced pressure (the bath temperature should not exceed 40 °C and distillation time should not exceed 20 min). The residue was purified by silica gel column chromatography ($CHCl_3$/EtOH, 90:10 → 50:50) to give both deacetylated compound and the 2-*O*-acetyl derivative. The reaction time determines the yield of each.

*Benzyl 2-(β-D-glucopyranosyloxy)-5-hydroxybenzoate (trichocarpine) (**5**).* **5** was obtained following the general procedure from pentaacetate **16** (207 mg, 0.34 mmol) with 16 h of reaction time and additionally recrystallized from EtOH to give 100 mg (74%, purity >95%) of colorless crystals: $R_f$ = 0.45 ($CHCl_3$/EtOH, 5:1); mp 134−136 °C (lit. 134−136 °C);[22] $[\alpha]^{26}_D$ −19.8 (*c* 0.50, EtOH); UV (EtOH) $\lambda_{max}$ 238, 312 nm; ATR-FTIR $\nu_{max}$ 3408 (br), 2921, 2851, 1701, 1496, 1201, 1065, 695 $cm^{-1}$; $^1H$ NMR (400 MHz, methanol-$d_4$, *δ*, ppm, *J*, Hz) 3.35−3.41 (m, 2H, H-$4_{Glc}$, H-$5_{Glc}$), 3.42−3.49 (m, 2H, H-$2_{Glc}$, H-$3_{Glc}$), 3.69 (dd, 1H, *J* 5.4, *J* 12.1, H-$6a_{Glc}$), 3.90 (dd, 1H, *J* 1.8, *J* 12.1, H-$6b_{Glc}$), 4.72 (m, 1H, H-$1_{Glc}$), 5.33 (ABq∼q, 2H, *J* 12.4, $CH_2$), 6.96 (dd, 1H, *J* 3.1, *J* 8.9, H-6), 7.19 (d, 1H, *J* 3.1, H-2), 7.28 (d, 1H, *J* 8.9, H-5), 7.39 (m, 5H, $C_6H_5$); $^{13}C$ NMR (101 MHz, methanol-$d_4$, *δ*, ppm) 62.6 (C-$6_{Glc}$), 68.1 ($CH_2$), 71.3 (C-$4_{Glc}$), 75.0 (C-$2_{Glc}$ or C-$3_{Glc}$), 77.5 (C-$2_{Glc}$ or C-$3_{Glc}$), 78.4 (C-$5_{Glc}$), 105.3 (C-$1_{Glc}$), 117.6 (C-2), 121.5 (C-5), 121.9 (C-6), 123.2 (C-3), 129.3 (2 × CH, $C_6H_5$), 129.4 (CH, $C_6H_5$), 129.6 (2 × CH, $C_6H_5$), 137.4 (C, $C_6H_5$), 151.9 (C-1), 154.1 (C-4), 167.8 (CO); HR-ESIMS *m*/*z* 429.1145 (calcd for $C_{20}H_{22}O_9Na$, 429.1156). The spectroscopic data are in agreement with the literature.[22,49]

*Benzyl 2-(2-O-acetyl-β-D-glucopyranosyloxy)-5-hydroxybenzoate (2-O-acetyltrichocarpine) (**6**).* **6** was obtained following the general procedure from pentaacetate **16** (207 mg, 0.34 mmol) with 10 h of reaction time to give 14 mg (9%, purity 90%) of a white, amorphous powder: $R_f$ = 0.50 ($CHCl_3$/EtOH, 5:1); $[\alpha]^{26}_D$ −17.6 (*c* 0.50, EtOH); UV (EtOH) $\lambda_{max}$ 232, 308 nm; ATR-FTIR $\nu_{max}$ 3442 (br), 2924, 2863, 1720, 1496, 1200, 1066, 1027, 697 $cm^{-1}$; $^1H$ NMR (400 MHz, methanol-$d_4$, *δ*, ppm, *J*, Hz) 2.08 (s, 3H, $CH_3$, Ac), 3.43−3.47 (m, 2H, H-$3_{Glc}$, H-$5_{Glc}$), 3.58 (dd∼t, 1H, *J* 9.1, H-$4_{Glc}$), 3.70 (dd, 1H, *J* 5.1, *J* 12.1, H-$6a_{Glc}$), 3.90 (d, 1H, *J* 12.1, H-$6b_{Glc}$), 4.93 (d, 1H, *J* 8.1, H-$1_{Glc}$), 5.00 (dd, 1H, *J* 8.1, *J* 9.2, H-$2_{Glc}$), 5.25, 5.32 (ABq, 2H, *J* 12.4, $CH_2$), 6.90 (dd, 1H, *J* 3.1, *J* 9.0, H-6), 7.04 (d, 1H, *J* 3.1, H-2), 7.18 (d, 1H, *J* 9.0, H-5), 7.36 (m, 5H, $C_6H_5$); $^{13}C$ NMR (101 MHz, methanol-$d_4$, *δ*, ppm) 19.8 ($CH_3$, Ac), 61.1 (C-$6_{Glc}$), 66.4 ($CH_2$), 69.9 (C-$4_{Glc}$), 73.4 (C-$2_{Glc}$), 74.7 (C-$3_{Glc}$), 76.9 (C-$5_{Glc}$), 100.5 (C-$1_{Glc}$), 115.7 (C-5), 118.8 (C-3), 119.4 (C-2), 123.0 (C-6), 127.8 (CH, $C_6H_5$), 127.9 (2 × CH, $C_6H_5$), 128.2 (2 × CH, $C_6H_5$), 136.3 (C, $C_6H_5$), 149.0 (C-1), 152.4 (C-4), 166.1 (CO), 170.6 (CO, Ac). The spectroscopic data are in agreement with the literature.[22]

*Benzyl 5-(β-D-glucopyranosyloxy)-2-hydroxybenzoate (isotrichocarpine) (**7**).* **7** was obtained following the general procedure from tetraacetate **15** (246 mg, 0.43 mmol) with 22 h of reaction time and additionally recrystallized from EtOH to give 136 mg (78%, purity >95%) of colorless crystals: $R_f$ = 0.21 ($CHCl_3$/EtOH, 10:1); mp 124−125 °C; $[\alpha]^{28}_D$ −36.8 (*c* 0.50, EtOH); UV (EtOH) $\lambda_{max}$ 240, 331 nm; ATR-FTIR $\nu_{max}$ 3514 (br), 3379 (br), 3045, 2927, 2868, 1686, 1616, 1488, 1201, 1072, 1015, 730, 691 $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$, *δ*, ppm, *J*, Hz) 3.13−3.26 (m, 4H, H-$2_{Glc}$, H-$3_{Glc}$, H-$4_{Glc}$, H-$5_{Glc}$), 3.47 (ddd∼dt, 1H, *J* 5.7, *J* 11.6, H-$6a_{Glc}$), 3.63 (dd, 1H, *J* 4.8, *J* 10.8, H-$6b_{Glc}$), 4.58 (dd∼t, 1H, *J* 5.7, OH-$6_{Glc}$), 4.69 (d, 1H, *J* 7.4, H-$1_{Glc}$), 5.03 (d, 1H, *J* 5.0, $OH_{Glc}$), 5.10 (d, 1H, *J* 4.4,OH $_{Glc}$), 5.33 (d, 1H, *J* 4.7, $OH_{Glc}$), 5.36, 5.40 (ABq, 2H, *J* 12.6, $CH_2$), 6.94 (d, 1H, *J* 9.0, H-5), 7.28 (dd, 1H, *J* 3.0, *J* 9.0, H-6), 7.35−7.50 (m, 6H, H-2, $C_6H_5$), 10.15 (s, 1H, OH); $^{13}C$ NMR (101 MHz, DMSO-$d_6$, *δ*, ppm) 60.5 (C-$6_{Glc}$), 66.6 ($CH_2$), 69.5 (C-$4_{Glc}$), 73.2 (C-$2_{Glc}$), 76.5 (C-$3_{Glc}$), 77.1 (C-$5_{Glc}$), 101.9 (C-$1_{Glc}$), 113.0 (C-3), 117.0 (C-2), 118.3 (C-5), 125.2 (C-6), 128.1 (2 × CH, $C_6H_5$), 128.3 (CH, $C_6H_5$), 128.6 (2 × CH, $C_6H_5$), 135.7 (C, $C_6H_5$), 149.9 (C-4), 155.3 (C-1), 168.1 (CO); HR-ESIMS *m*/*z* 429.1145 (calcd for $C_{20}H_{22}O_9Na$, 429.1156). The spectroscopic data are in agreement with the literature.[23]


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*Benzyl 5-(2-O-acetyl-β-D-glucopyranosyloxy)-2-hydroxybenzoate (2-O-acetylisotrichocarpine) (**19**).* **19** was obtained following the general procedure from tetraacetate **15** (269 mg, 0.47 mmol) with 15 h of reaction time and additionally recrystallized from EtOH to give 46 mg (22%, purity >95%) of colorless crystals: $R_f$ = 0.40 ($CHCl_3$/EtOH, 10:1); mp 178−180 °C; $[\alpha]^{29}_D$ −19.0 (*c* 0.17, EtOH); UV (EtOH) $\lambda_{max}$ 240, 331 nm; ATR-FTIR $\nu_{max}$ 3503 (br), 3255 (br), 2970, 2895, 1725, 1682, 1489, 1213, 1088, 1033, 787, 730 $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$, δ, ppm, *J*, Hz) 2.01 (s, 3H, $CH_3$, Ac), 3.27 (ddd, 1H, *J* 3.4, *J* 5.3, *J* 8.9, H-$4_{Glc}$), 3.35 (m, 1H, H-$5_{Glc}$, overlapped with $H_2O$ peak), 3.44−3.51 (m, 2H, H-$3_{Glc}$, H-$6a_{Glc}$), 3.64 (dd, 1H, *J* 5.3, *J* 11.2, H-$6b_{Glc}$), 4.66 (dd∼t, 1H, *J* 5.8, OH-$6_{Glc}$), 4.72 (dd, 1H, *J* 8.1, *J* 9.3, H-$2_{Glc}$), 5.00 (d, 1H, *J* 8.1, H-$1_{Glc}$), 5.26 (d, 1H, *J* 5.3, OH-$4_{Glc}$), 5.34−5.40 (m, 2H, $CH_2$, OH-$3_{Glc}$), 6.94 (d, 1H, *J* 9.0, H-5), 7.21 (dd, 1H, *J* 3.0, *J* 9.0, H-6), 7.36 (d, 1H, *J* 3.0, H-2), 7.36−7.49 (m, 5H, $C_6H_5$), 10.17 (s, 1H, OH); $^{13}C$ NMR (101 MHz, DMSO-$d_6$, δ, ppm) 20.8 ($CH_3$, Ac), 60.3 (C-$6_{Glc}$), 66.6 ($CH_2$), 69.6 (C-$4_{Glc}$), 73.6 (C-$2_{Glc}$), 73.8 (C-$3_{Glc}$), 77.1 (C-$5_{Glc}$), 99.4 (C-$1_{Glc}$), 113.2 (C-3), 117.3 (C-2), 118.4 (C-5), 125.4 (C-6), 128.0 (2 × CH, $C_6H_5$), 128.3 (CH, $C_6H_5$), 128.6 (2 × CH, $C_6H_5$), 135.6 (C, $C_6H_5$), 149.3 (C-4), 155.6 (C-1), 167.9 (CO), 169.3 (CO, Ac); HR-ESIMS *m*/*z* 471.1251 (calcd for $C_{22}H_{24}O_{10}Na$, 471.1262). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 2-(β-D-glucopyranosyloxy)-5-hydroxybenzoate (trichoside) (**8**).* **8** was obtained following the general procedure from tetraacetate **17** (251 mg, 0.43 mmol) with 17 h of reaction time and additionally recrystallized from EtOH to give 123 mg (69%, purity 95%) of colorless crystals: $R_f$ = 0.24 ($CHCl_3$/EtOH, 10:1); mp 159−160 °C (lit. 163−165 °C);[24] $[\alpha]^{28}_D$ −25.0 (*c* 0.18, EtOH); UV (EtOH) $\lambda_{max}$ 233, 326 nm; ATR-FTIR $\nu_{max}$ 3536, 3309 (br), 2938, 2875, 1725, 1500, 1206, 1070, 1020, 819, 692 $cm^{-1}$. The spectroscopic data are in agreement with the literature.[24] $^1H$ NMR (400 MHz, methanol-$d_4$, δ, ppm, *J*, Hz) 3.38−3.41 (m, 2H, H-$4_{Glc}$, H-$5_{Glc}$), 3.42−3.44 (m, 2H, H-$2_{Glc}$, H-$3_{Glc}$), 3.69 (dd, 1H, *J* 4.6, *J* 12.1, H-$6a_{Glc}$), 3.83 (dd, 4H, *J* 1.8, *J* 12.1, H-$6b_{Glc}$), 3.83 (s, 3H, OMe), 4.78−4.80 (m, 1H, H-$1_{Glc}$), 5.31 (s, 2H, $CH_2$), 7.05 (d, 1H, *J* 9.1, H-5), 7.32 (dd, 2H, *J* 3.0, *J* 9.1, H-6), 7.34−7.46 (m, 5H, $C_6H_5$), 7.54 (d, 1H, *J* 3.0, H-2); $^{13}C$ NMR (101 MHz, methanol-$d_4$, δ, ppm) 54.9 (OMe), 60.3 (C-$6_{Glc}$), 65.7 ($CH_2$), 69.2 (C-$4_{Glc}$), 72.9 (C-$2_{Glc}$), 75.9 (C-$3_{Glc}$), 76.1 (C-$5_{Glc}$), 101.4 (C-$1_{Glc}$), 112.7 (C-5), 119.0 (C-2), 119.3 (C-3), 121.7 (C-6), 127.1 (2 × CH, $C_6H_5$), 127.2 (CH, $C_6H_5$), 127.6 (2 × CH, $C_6H_5$), 135.6 (C, $C_6H_5$), 150.4 (C-4), 154.2 (C-1), 165.3 (CO); HR-ESIMS *m*/*z* 443.1302 (calcd for $C_{21}H_{24}O_9Na$, 443.1313). The NMR data are consistent with the structure.

*Benzyl 2-(2-O-acetyl-β-D-glucopyranosyloxy)-5-hydroxybenzoate (2-O-acetyltrichoside) (**20**).* **20** was obtained following the general procedure from tetraacetate **17** (251 mg, 0.43 mmol) with 11 h of reaction time and additionally recrystallized from EtOH to give 60 mg (30%, purity 94%) of colorless crystals: $R_f$ = 0.47 ($CHCl_3$/EtOH, 10:1); mp 178−179 °C; $[\alpha]^{26}_D$ −6.9 (*c* 0.49, EtOH); UV (EtOH) $\lambda_{max}$ 232, 313 nm; ATR-FTIR $\nu_{max}$ 3494 (br), 3262 (br), 2900, 1719, 1501, 1272, 1210, 1083, 811, 725 $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$, δ, ppm, *J*, Hz) 2.02 (s, 3H, $CH_3$, Ac), 3.26 (ddd∼td, 1H, *J* 5.5, *J* 9.4, H-$4_{Glc}$), 3.38 (ddd, 1H, *J* 1.6, *J* 5.4, *J* 9.5, H-$5_{Glc}$), 3.44−3.52 (m, 2H, H-$3_{Glc}$, H-$6a_{Glc}$), 3.66 (ddd, 1H, *J* 1.6, *J* 5.5, *J* 11.6, H-$6_{Glc}$), 3.78 (s, 3H, OMe), 4.67 (dd∼t, 1H, *J* 5.5, OH-$6_{Glc}$), 4.73 (dd, 1H, *J* 8.1, *J* 9.5, H-$2_{Glc}$), 5.04 (d, 1H, *J* 8.1, H-$1_{Glc}$), 5.27 (d, 3H, *J* 5.3, OH-$4_{Glc}$), 5.28 (s, 2H, $CH_2$), 5.37 (d, 1H, *J* 5.5, OH-$3_{Glc}$), 7.09 (d, 1H, *J* 9.1, H-5), 7.21 (dd, 1H, *J* 3.1, *J* 9.1, H-6), 7.26 (d, 1H, *J* 3.1, H-2), 7.39 (m, 5H, $C_6H_5$); $^{13}C$ NMR (101 MHz, DMSO-$d_6$, δ, ppm) 20.9 ($CH_3$, Ac), 56.4 (OMe), 60.4 (C-$6_{Glc}$), 66.1 ($CH_2$), 69.6 (C-$4_{Glc}$), 73.6 (C-$2_{Glc}$), 73.8 (C-$3_{Glc}$), 77.1 (C-$5_{Glc}$), 99.1 (C-$1_{Glc}$), 114.0 (C-5), 118.9 (C-2), 120.4 (C-3), 122.0 (C-6), 127.8 (2 × CH, $C_6H_5$), 128.0 (CH, $C_6H_5$), 128.5 (2 × CH, $C_6H_5$), 136.2 (C, $C_6H_5$), 150.1 (C-4), 153.8 (C-1), 164.9 (CO), 169.4 (CO, Ac); HR-ESIMS *m*/*z* 485.1410 (calcd for $C_{23}H_{26}O_{10}Na$, 485.1418). The spectroscopic data are in agreement with the anticipated structure.

*Benzyl 2-(β-D-glucopyranosyloxy)benzoate (deoxytrichocarpine) (**9**).* **9** was obtained following the general procedure from tetraacetate **18** (254 mg, 0.45 mmol) with 15.5 h of reaction time and additionally recrystallized from EtOAc/hexanes to give 92 mg (53%, purity 95%) of colorless crystals: $R_f$ = 0.53 ($CHCl_3$/EtOH, 10:1); mp 93−94 °C; $[\alpha]^{27}_D$ −12.5 (*c* 0.21, EtOH); UV (EtOH) $\lambda_{max}$ 233, 289 nm; ATR-FTIR $\nu_{max}$ 3376 (br), 2871, 1718, 1695, 1241, 1063, 1041, 763, 697 $cm^{-1}$; $^1H$ NMR (400 MHz, methanol-$d_4$, δ, ppm, *J*, Hz) 3.40 (dd, 1H, *J* 8.6, *J* 9.3, H-$4_{Glc}$), 3.46 (ddd, 1H, *J* 2.1, *J* 5.5, *J* 9.7, H-$5_{Glc}$), 3.46−3.55 (m, 2H, H-$2_{Glc}$, H-$3_{Glc}$), 3.71 (dd, 1H, *J* 5.5, *J* 12.1, H-6a), 3.91 (dd, 1H, *J* 2.1, *J* 12.1, H-$6b_{Glc}$), 4.92 (d, 1H, *J* 7.3, H-$1_{Glc}$), 5.33, 5.37 (ABq, 2H, *J* 12.4, $CH_2$), 7.11 (dd∼t, 1H, *J* 7.5, $C_6H_4$), 7.31−7.47 (m, 6H, $C_6H_5$), 7.53 (ddd, 1H, *J* 1.7, *J* 7.3, *J* 8.8, $C_6H_4$), 7.77 (dd, 1H, *J* 1.7, *J* 7.8, $C_6H_4$); $^{13}C$ NMR (101 MHz, methanol-$d_4$, δ, ppm) 62.5 (C-$6_{Glc}$), 68.0 ($CH_2$), 71.2 (C-$4_{Glc}$), 74.9 (C-$2_{Glc}$), 77.5 (C-$3_{Glc}$), 78.4 (C-$5_{Glc}$), 103.9 (C-$1_{Glc}$), 118.8 (C-2), 122.3 (CH), 123.7 (CH), 129.3 (2 × CH, $C_6H_5$), 129.3 (CH, $C_6H_5$), 129.6 (2 × CH, $C_6H_5$), 132.1 (CH), 135.2 (CH), 137.4 (C, $C_6H_5$), 158.8 (C-1), 167.9 (CO); HR-ESIMS *m*/*z* 413.1227 (calcd for $C_{20}H_{22}O_8Na$, 413.1207). The spectroscopic data are in agreement with the literature.[26]

*Benzyl 2-(2-O-acetyl-β-D-glucopyranosyloxy)benzoate (2-O-acetyldeoxytrichocarpine) (**21**).* **21** was obtained following the general procedure from tetraacetate **18** (254 mg, 0.45 mmol) with 10 h of reaction time as colorless, amorphous solids: 24 mg (12.5%, purity >95%); $R_f$ = 0.66 ($CHCl_3$/EtOH, 10:1); mp 125−126 °C; $[\alpha]^{27}_D$ −30.4 (*c* 0.23, EtOH); UV (EtOH) $\lambda_{max}$ 229, 285 nm; ATR-FTIR $\nu_{max}$ 3483 (br), 3234 (br), 2919, 1719, 1492, 1237, 1074, 1042, 749, 693 $cm^{-1}$; $^1H$ NMR (400 MHz, DMSO-$d_6$, δ, ppm, *J*, Hz) 1.95 (s, 3H, $CH_3$, Ac), 3.28 (ddd∼td, 1H, *J* 5.6, *J* 9.0, H-4), 3.45−3.54 (m, 3H, H-$3_{Glc}$, H-$5_{Glc}$, H-$6a_{Glc}$), 3.74 (dd, 1H, *J* 5.3, *J* 10.3, H-$6b_{Glc}$), 4.69 (dd∼t, 1H, *J* 5.6, OH-$6_{Glc}$), 4.82 (dd, 1H, *J* 8.3, *J* 9.4, H-$2_{Glc}$), 5.17 (d, 1H, *J* 8.3, H-$1_{Glc}$), 5.17 (d, 1H, *J* 12.1, $CH_2$), 5.26 (d, 1H, *J* 12.1, $CH_2$), 5.30 (d, 1H, *J* 5.4, $OH_{Glc}$), 5.38 (d, 1H, *J* 5.5, $OH_{Glc}$), 7.07 (dd∼t, 1H, *J* 7.2, CH, Ar), 7.21 (d, 1H, *J* 8.1, CH, Ar), 7.32−7.36 (m, 1H, CH, Ar), 7.41 (d, 1H, *J* 7.5, CH, Ar), 7.53 (dd∼t, 2H, *J* 7.7, $C_6H_5$), 7.67 (dd∼t, 1H, *J* 7.4, CH, Ar), 7.99 (d, 2H, *J* 8.4, $C_6H_5$); $^{13}C$ NMR (101 MHz, DMSO-$d_6$, δ, ppm) 21.2 ($CH_3$, Ac), 61.0 (C-$6_{Glc}$), 61.7 ($CH_2$), 70.3 (C-$4_{Glc}$), 73.9 (C-$2_{Glc}$), 74.2 (C-$3_{Glc}$), 77.7 (C-$5_{Glc}$), 98.7 (C-$1_{Glc}$), 115.6 (C-2), 122.8 (CH), 125.2 (CH), 129.3 (2 × CH, $C_6H_5$), 129.4 (CH), 129.7 (2 × CH, $C_6H_5$), 130.0 (CH, $C_6H_5$), 130.1 (CH), 133.9 (C, $C_6H_5$), 155.1 (C-1), 166.0 (CO), 169.8 (CO, Ac); HR-ESIMS *m*/*z* 455.1311 (calcd for $C_{22}H_{24}O_9Na$, 455.1313). The spectroscopic data are in agreement with the anticipated structure.

## ■ ASSOCIATED CONTENT

### Supporting Information

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$^1H$ NMR, $^{13}C$ NMR, COSY, HSQC, HMBC, ATR-FTIR, and UV spectra (PDF)

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### Notes

The authors declare no competing financial interest.

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