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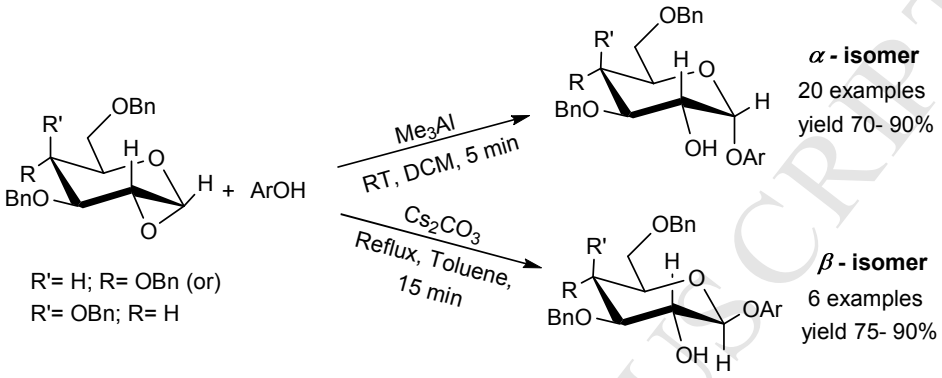

Tunable stereoselectivity in the synthesis of *α*- and *β*- aryl glycosides using 1,2-*α*-anhydrosugars as glycosyl donors

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Abstract

The stereochemical course of *O*-glycosidation of 1,2-*α*-D-anhydrosugars (glycal epoxides) with phenols can be tuned by varying the metal ion of the base. While the reaction of 1,2-*α*-D-anhydrosugars with phenols mediated by trimethylaluminium leads exclusively to 1,2-*cis*-*α*-*O*-aryl glycosides, similar reaction mediated by caesium carbonate gives exclusively 1,*2-trans*-*β*-*O*-aryl glycosides. In contrast, reaction with phenoxides generated from Grignard reagent and calcium salts affords mixture of the anomers.

Keywords 1,2-anhydrosugars, Glycal epoxides, aryl glycosides, stereoselective, glycosidation

1.0 Introduction

Naturally occurring carbohydrates carrying aromatic aglycons have received considerable attention as some of them are antibiotics, exhibiting chemotherapeutic and antitumor action, like vancomycin and chromomycin.[1] Glycosylated phenols of plant origin are also known; like that of Arbutin, Skimmin, SennosideA and Glucofrangulin.[2] Some of the aryl glycosides form ordered macrostructures such as micelles and liquid crystalline phases.[3] In recent years, the synthesis of aryl glycosides has received considerable attention from both synthetic[4] and medicinal chemists because of their diverse biological activities and pharmaceutical potentials.[5] The review of Marten *et al* gives an excellent account on various methods towards synthesis of aryl glycosides.[6] Glycosyl acetates, phosphates, halides, trichloroacetimidates, and sulphoxides, *etc.*, have been used as glycosyl donors with phenols in the presence of Lewis or Bronsted acids to yield aromatic glycosides.[7] Glycal derivatives with good leaving groups at the allylic position can be readily converted into 2,3-unsaturated aryl glycosides by treatment of phenols; either thermally or using Lewis acids and Pd complexes.[8] Contrary to glycosylation of alcohols and other sugar alcohols, it is not easy to obtain good yields of the glycosides of aromatic aglycons due to dimerisation[9] and formation of *C*-glycosides,[10] especially in the case of activated aromatic compounds.[11] In many cases, mixtures of both the anomers[12] have been reported. Though there are many methods for the synthesis of aryl glycosides, there is still a need for mild, efficient and highly

stereoselective method which will also provide a free hydroxyl at C-2 for further elaboration and access to C-2 branched sugars.

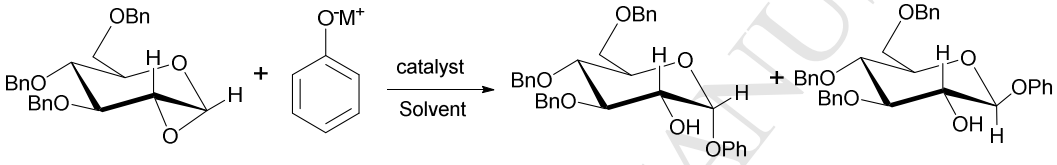
The 1,2-D-anhydrosugars have also been widely used as glycosyl donors[13] for glycosylation reactions. Most importantly, this approach directly provides access to glycosides with a free hydroxyl group at C-2 position of the sugar moiety that can be exploited for the synthesis of carbohydrates containing 1,2-linkage, as found in many natural glycoconjugates, such as saponins[14]. The *α*- and *β*-isomers of 1,2-D-anhydrosugars can be accessed by oxidation of the glycals.[15] The use of 1,2-D-anhydrosugars as glycosyl donors for the synthesis of aryl glycosides has far less been investigated compared to that of alkyl glycosides.[16] One drawback could be that its stereochemical outcome is not predictable when Lewis acids are employed to catalyze the ring opening reaction. The stereochemical course of such reactions are influenced by external additives and electronic nature of the substitutents.[17] Higher selectivity in favour of *β*-anomer has been reported when the glycosidation was conducted using gold[18] complex, PTC condition[17a] and KO^{t}Bu.[17d] Recently, Tanaka *et al* have reported 1,2-cis-*α*-stereoselective glucosylation[19a] and 1,2-cis-*β*-stereoselective mannosylation of alcohols utilizing catalytic amount of boronic esters of these alcohols .[19b] Regioselective and 1,2- cis- stereoselective glycosylation of sugar 1,2-diols and 1,3-diols using catalytic amount of cyclic boronate esters derived from these diols is also known.[20] The utility of this novel methodology for the stereoselective synthesis of 1,2-cis- α-aryl glycosides has not been explored. This triggered our interest to investigate the stereochemistry and ease of glycosidation of 1,2-D-anhydrosugars with phenols mediated by triphenyl borate, aluminium phenoxide, titanium phenoxide as well as by phenoxides derived from other common metal ions like Mg, Ca, Cu *etc.*, Herein we describe a very facile 1,2-cis-*α*-stereoselective *O*-glycosidation of phenols with 1,2-*α*-D-anhydroglucose and 1,2-*α*-D-anhydrogalactose mediated by Me_3Al which is superior to the glycosidation mediated by $B(OPh)_3$ in terms of yield , stereoselectivity and reaction time.

2.0 Result and Discussion

The substrates, 1,2-*α*-D-anhydroglucose **1** and galactose **4** were obtained by stereoselective oxidation of 3,4,6-tri-*O*-benzyl-D-gucal and d-galactal respectively *via in situ* generation of dimethyldioxirane (DMDO) using oxone/acetone in a biphasic system.[21] The reaction of **1** with phenoxides of monovalent metals like Li, Na, K and Cs afforded exclusively the *β*-*O*-aryl glycoside **3a** (Table 1, entries 1-5). Cs_2CO_3 was found to be the best base in terms of yield and reaction time (Table 1, entry 4). The phenoxides of Mg, Ca and Cu yielded mixture of *α*- and *β*-anomers, but Mg salt showed a greater preference for *β*-anomer, while Ca and Cu salts exhibited preference to *α*-anomer **2a**. In contrast to these metal phenoxides, $B(OPh)_3$ favoured *α*-anomer **2a** (Table1, entry 10) at ambient temperature. $Ti(OPh)_4$ prepared from titaniumisoproxide yielded exclusively *α*-*O*-phenyl glycoside **2a** (Table1, entry

12), albeit in relatively lower yield. Interestingly, the reaction of **1** with phenol in the presence of Me_3Al afforded exclusively the *α-O*-phenyl glycopyranoside **2a** in high yield. This reaction was extremely fast and proceeded to completion in a matter of 3-5 minutes that too at ambient temperature. The crude product from all these reactions was analyzed by NMR and HPLC for determining the anomeric ratios.[22] The structure of **2a** was further confirmed by converting it to the known phenyl-2,3,4,6–tetra-*O*-benzyl-*α*-D-glucopyranoside[23a] and phenyl 2-*O*-acetyl-3,4.6-tri-*O*-benzyl-*α*-D-glucopyranoside.[23b] Thus, Me_3Al turned out to be the best mediator for obtaining exclusively the *α*-anomer in high yield and short reaction time and Cs_2CO_3 for the synthesis of *β*- anomer. These data reveal that the anomeric selectivity on glycosidation of 1,2-*α*-D-anhydrosugar can be fine tuned by varying the metal counter ion of the phenoxide.

Table 1. Glycosidation of 1,2-D-anhydrosugar 1 with different metal phenoxides



1 **2a** **3a**

Entry	Metal ion precursor	Solvent	Reaction condition	Yield (%)	2a :3a[22] *α* : *β*
1	NaH	Toluene	RT, 30 min	73	*β* only
2	Na_2CO_3	Toluene	Reflux, 45 min	83	*β* only
3	K_2CO_3	Toluene	Reflux, 45 min	85	*β* only
4	Cs_2CO_3	Toluene	Reflux, 15 min	90	*β* only
5	CH_3Li	DCM: DEA	RT, 20 min	74	*β* only
6	CH_3MgCl	DCM: THF	RT, 150 min	65	10 : 90
7	CaH_2	Toluene	Reflux, 15 min	76	91 : 9
8	$CaCO_3$	Toluene	Reflux, 30 min	75	92 : 8
9	$CuCO_3$	Toluene	Reflux, 30 min	73	91 : 9
10	$B(OPh)_3$	Toluene	RT, 30 min	88	92 : 8
11	$Al(CH_3)_3$	DCM: Toluene	RT, 5 min	90	*α* only
12	$Ti(OPh)_4$[(a]	Toluene	RT, 15 min	82	*α* only

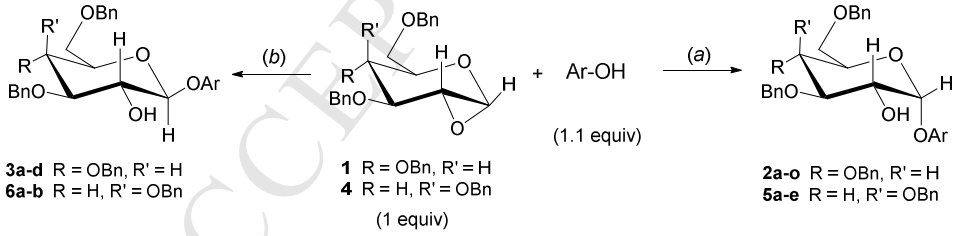
([a] prepared from the reaction of $Ti(O^iPr)_4$ with phenol[24] and isolated.

We further explored other *in situ* methods for generating $Al(OPh)_3$ (Table 2). In case of alumina, the reaction was rather slow and incomplete at ambient temperature, but the reaction was highly stereoselective furnishing only *α*-anomer. Under reflux conditions in toluene, it could be driven to completion, but with a slight loss of stereoselectivity affording a mixture of the anomeric glycosides **2a** and **3a** with predominant *α*-anomer (Table 2, entry 2). Aluminium isopropoxide was found to be a better base for *in situ* generation of $Al(OPh)_3$ when compared to alumina as it yielded only the *α*-anomer. It is to be noted here that no isopropyl glycoside was formed during this reaction. However, the reaction was rather slow when compared to Me_3Al mediated reaction. The glycosidation of **1** with $Al(OPh)_3$[25] at ambient temperature was very slow in CH_2Cl_2, but addition of toluene as co-solvent accelerated the reaction.

Table 2. Glycosidation of **1a** and phenol with various Aluminum reagents

Entry	Metal ion precursor	Solvent	Reaction condition	Yield[a] (%)	2a : 3a *α* : *β*
1	Al_2O_3	Toluene	RT, 12 Hrs	40[b]	*α* only
2	Al_2O_3	Toluene	Reflux, 15 min	95	95 : 5
3	$Al(CH_3)_3$	CH_2Cl_2: Toluene	RT, 5 min	95	*α* only
4	$Al(O\text{-}iPr)_3$	Toluene	RT, 15min	82	*α* only
5	$Al(OPh)_3$[c]	CH_2Cl_2	RT, 120 min	78	*α* only
6	$Al(OPh)_3$[c]	CH_2Cl_2: Toluene	RT, 15 min	85	*α* only

[a]Isolated yield after purification.[b]Reaction incomplete [c]Reaction performed with isolated $Al(OPh)_3$, no phenol added.[25]



Legends:(a) 0.33 equiv. Me_3Al, Toluene/DCM, RT, 5 min. (b) 1 equiv. Cs_2CO_3, Toluene, Reflux, 15 min.

Scheme 1. Synthesis of stereoselective *α*- and *β*-*O*-aryl glycosides.

Based on these findings, we chose Me_3Al as the mediator to study the generality of this 1,2-cis-*α*-stereoselective *O*-glycosidation reaction of **1** with phenols (Scheme 1). Me_3Al mediated glycosidation reaction of various phenols with **1** went to completion in a few minutes at ambient temperature to afford exclusively the respective *α*-aryl glycosides **2a-o** in high yields (Table 3). This reaction protocol exhibited

a fair degree of functional group tolerance. Functional groups such as CN, F, Cl, Br, OMe and CHO groups were found to be compatible excepting *p*-nitro group (entry 11). However, in this case the reaction could be driven successfully by using alumina instead of Me_3Al to afford **2j** in good yields. Also, the synthesis of *α*-naphthyl glycoside **2m** could be achieved with no trace of formation of any isomeric *C*-naphthyl glycosides. 4- methyl- umbelliferone (Table 3, entry 15) too underwent smooth glycosylation with **1** affords the corresponding *α*-anomer **2o** in moderate yields. The galactal epoxide **4** was also found to be a versatile substrate for the 1,2-*cis*-α stereoselective *O*-aryl glycosidation mediated by Me_3Al enabling the synthesis of several aryl *α*-D-galactosides **5a-e** in good yields (Table 3, entries 16-20).

Table 3. Me_3Al mediated glycosidation of 1,2-*α*-D-anhydro sugars for the synthesis of α-*O*-aryl glycosides.

Entry	Substrate	R	R^1	Ar	Product	Yield[a](%)
1	**1**	OBn	H	Phenyl	**2a**	95
2	**1**	OBn	H	2-Me-phenyl	**2b**	82
3	**1**	OBn	H	3-Me-phenyl	**2c**	88
4	**1**	OBn	H	4-Me-phenyl	**2d**	86
5	**1**	OBn	H	4-OMe-phenyl	**2e**	84[c]
6	**1**	OBn	H	2-naphthyl	**2f**	73
7	**1**	OBn	H	4-F-phenyl	**2g**	87
8	**1**	OBn	H	2-Cl-phenyl	**2h**	78
9	**1**	OBn	H	3-Br-phenyl	**2i**	90
10	**1**	OBn	H	4-NO_2-phenyl[b]	**2j**	72[d]
11	**1**	OBn	H	2-isopropyl-phenyl	**2k**	76
12	**1**	OBn	H	4-CN-phenyl	**2l**	75
13	**1**	OBn	H	1-naphthyl	**2m**	76[c]
14	**1**	OBn	H	4-CHO-phenyl	**2n**	68[c]
15	**1**	OBn	H	4-Me-comarin-7-yl	**2o**	54[c]
16	**4**	H	OBn	Phenyl	**5a**	92
17	**4**	H	OBn	2-Me-phenyl	**5b**	84
18	**4**	H	OBn	4-Me-phenyl	**5c**	86
19	**4**	H	OBn	4-F-phenyl	**5d**	80
20	**4**	H	OBn	4-CN-phenyl	**5e**	76

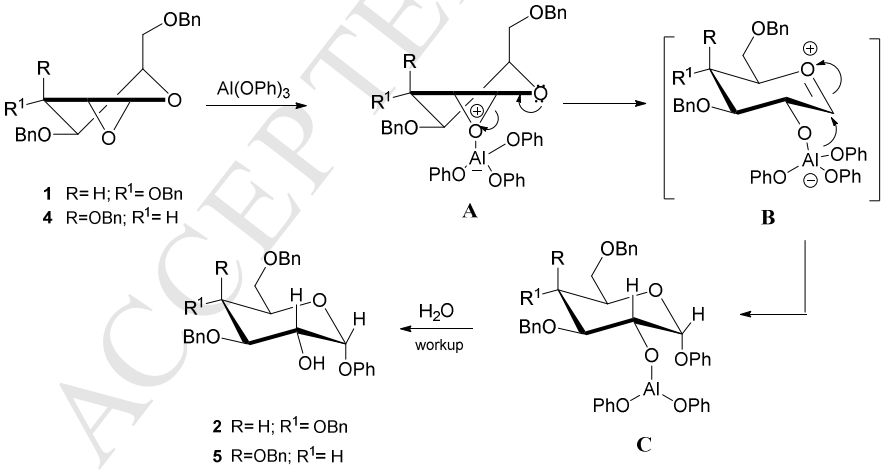
[a]Isolated yield after purification; [b]Al_2O_3 used instead of Me_3Al; [c]trace amount of the free sugar arising out of epoxide with water; [d]>98% α-anomer

Traditionally, synthesis of aryl *β*-glycosides have been reported using bases like K_2CO_3,[17a-c] KO^{t}Bu,[17d] and also at times in biphasic system using PTC like 18-crown-6,[17a-c] with additives like tetramethylguanidine.[17a] The "balanced base" Cs_2CO_3 is known to be superior for *O*-arylation of phenols[26] and *N*-alkylation of amines.[27] However, it has not been explored for the synthesis of aryl glycosides. We have observed that the ring opening of **1** and **4** with phenols in toluene mediated by Cs_2CO_3 proceeded well affording exclusively aryl *β*-glycosides **3a-d** and **6a-b**, respectively in high yields, shorter duration and without the need of any external additives or catalyst (Scheme 1, Table 4)

Table 4. Cs_2CO_3 mediated glycosidation of 1,2-*α*-D-anhydro sugars for the synthesis of *β*-*O*-aryl glycosides.[28]

Entry	Substrate	R	R^1	Ar	Product	Yield[a] (%)
1	**1**	OBn	H	Phenyl	**3a**	90
2	**1**	OBn	H	2-Me-phenyl	**3b**	86
3	**1**	OBn	H	3-Me-phenyl	**3c**	88
4	**1**	OBn	H	4-Me-phenyl	**3d**	85
5	**4**	H	OBn	Phenyl	**6a**	88
6	**4**	H	OBn	4-OMe-phenyl	**6b**	76

[a] *Isolated yield after column chromatographic purification.*



Scheme 2. Proposed mechanism for the stereoselectivity of the glycosidation of **1** and **4**.

Mechanistically, depending upon the conditions, the stereochemical outcome may be either under kinetic or thermodynamic control. Exclusive stereoselectivity in favour of *α*-anomer in the case of $Al(Me)_3$ mediated glycosidation of **1** and **4** can be rationalised as outlined in Scheme 2. Initial complexation of Al^{3+} metal centre to the oxygen of the epoxide to form (**A**), followed by cleavage of the *C-O* bond, facilitated by sugar ring oxygen, would lead to the formation of the aluminate oxecarbenium ion intermediate (**B**). Subsequent intramolecular transfer of the phenoxide ligand from the aluminate complex (**B**) to the anomeric carbon would result in stereoselective formation of the *α*-anomer **2** and **5**. A similar syn-addition mechanism has been proposed by Rainer et al for *α-C*-arylation of **1** using triaryl aluminium.[29] and by Nakagava *et al* for the glycosidation of sugar cis-1,2-diol and 1,3-diols catalysed by cyclic boronate ester.[20]

This proposed mechanism is in consistent with our finding that no isopropyl glycoside was formed when the reaction of the epoxide **1** with $Al(OPh)_3$ was done in the presence of stoichiometric amounts of isopropanol. In case of Cs_2CO_3 promoted glycosylation, the possibility of internal ligand transfer does not exist and hence the reaction course takes the S_N2 pathway leading to the formation of the *β*-glycosides *via trans*-ring opening of the epoxide ring. However, formation of anomeric mixture of the glycosides in the cases of Mg, Ca and Cu ions indicates that both S_N1 and S_N2 type mechanisms are occurring simultaneously.

3.0 Conclusions

In summary, we have developed a highly stereoselective and practical method for the synthesis of *α-O*-aryl glycosides promoted by Me_3Al and *β-O*-glycosides by Cs_2CO_3. This glycosylation protocol is extremely fast, high yielding, easy to carry out and amenable for scale up.

4.0 General experimental considerations

CH_2Cl_2 was dried by distilling over CaH_2 under argon. Products obtained were purified over silica gel (60 Å, 230-400 mesh) in flash column chromatography using ethyl acetate and hexane as eluant. Analytical thin-layer chromatography (TLC) was performed on pre-coated silica gel plates (Ultra Pure Silica Gel Plates purchased from Merck), visualized with a Spectroline UV254 lamp. Products were purified flash column chromatography are reported as v/v ratios. Melting points were obtained using Sigma Melting Point apparatus, and are uncorrected. UV specral analysis was done by using Shimadzu UV-2600 spectrophotometer. Specific optical rotations were determined on a *JASCO P2000* Polarimeter under the conditions indicated using the sodium D line (589 nm). ^1H and ^{13}C NMR were recorded at 400 MHz and 500 MHz on a Bruker spectrometer. Proton chemical shifts were internally referenced to the residual

proton resonance in $CDCl_3$ (δ 7.26 ppm). Carbon chemical shifts were internally referenced to the dueterated solvent signals in $CDCl_3$ (δ 77.20 ppm). FT-IR spectra were recorded on a *JASCO 6300* spectrometer with samples loaded as neat. Mass spectra were recorded on a JEOL GCMATE II GC-MS instrument.

5.0 General experimental procedure for glycosidation of 1 & 4 using Me_3Al:

To a solution of phenol (1.1 equiv.) in 1mL of CH_2Cl_2, 2.0 M solution of Me_3Al in toluene (0.04 mL, 0.33 equiv.) was added at ambient temperature followed by the addition of 1,2-anhydrosugar **1** or **4** (100 mg , 1.0 equiv.) under nitrogen atmosphere. After 5 min (as monitored by TLC), about 5 ml of water was added and worked up. Reaction mixture was extracted using CH_2Cl_2, concentrated in *vacuo* and purified by flash column chromatography using 5% ethyl acetate and n-hexane as mobile phase, to afford α-*O*-aryl glycosides **2a-o** or **5a-e**, respectively.

5.1 Phenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2a)

White solid (95%); **m.p.:** 103˚C; **$[\alpha]_D^{30}$**= +26. 5˚(*c* 1.0, CH_2Cl_2); **IR** (cm^{-1}): 3518, 3061, 3030, 2914, 2884, 1597, 1453, 1049, 1024, 729, 696, 474; **^{1}H NMR**($CDCl_3$,500MHz, δ): 2.21 (*d*, 1H, *J* = 10Hz, OH), 3.61 (*d*, 1H, *J* =10Hz, H-6a), 3.76 (*d*, 1H, *J* = 15Hz, H-4), 3.80 (*d*, 1H, *J* =10Hz, H-6b), 3.87-3.91 (*m*, 2H, H-2 & H-3), 3.96-4.08 (*t*, 1H, *J* = 10, 10Hz, H-5), 4.44, 4.51, 4.62, 4.84, 4.92, 4.98 (6*d*, 6H, -C<u>H$_2$</u>Ph), 5.60 (*bs*, 1H, H-1), 7.02-7.15 (*m*, 5H, Ar-H), 7.23-7.35 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, δ): 68.2 (*t*, C-6), 71.2 (*d*, C-3), 72.7 (*d*, C-2), 73.5 (*d*, Ar-C), 75.1 (*d*, Ar-C), 75.5 (*d*, Ar-C), 76.8 (*d*, C-4), 83.2 (*d*, C-5), 97.2 (*d*, C-1), 116.7, 122.7, 127.8, 127.8, 127.8, 127.9, 127.9, 127.9, 128.0, 128.4, 128.4, 128.5, 128.5, 128.6, 129.6 (20*d*, Ar-C), 137.8, 138.1, 138.6, 156.4 (4s, Ar-C); **HRMS**(TOF MS ES+)Calculated for $C_{33}H_{34}O_6$: 507.2899; found: 507.2902.

5.2 2-methylphenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2b)

Off-white semi solid (82%); **$[\alpha]_D^{30}$**= + 29.3 ˚(*c* 1.0, CH_2Cl_2); **IR** (cm^{-1}) 3436, 2915, 2867, 1125, 1029, 733, 693, 474; **^{1}H NMR**($CDCl_3$,500MHz): δ_H 2.03 (*d*, 1H, *J* = 9 Hz, -OH), 2.23 (*s*, 3H, -CH_3), 3.62-3.66 (*m*,1H, H-6a), 3.77 (*bd*, 1H, H-6b), 3.80 (*bd*, 1H, H-4), 3.85-3.89 (*m*, 2H, H-2 & H-3), 3.94-3.98 (*m*, 1H , H-5), 4.46, 4.55, 4.62, 4.86, (4H, 4d, *J*= 12, 11, 12, 11 Hz, 2* -O-<u>CH$_2$</u>-Ph), 4.91-4.97 (m, 2H, -O-<u>CH$_2$</u>-Ph) 5.57 (*d*, 1H, *J*= 3.5Hz, H-1), 6.94 (t,1H, *J*= 7.5, 7 Hz, Ar-H), 7.13 (*bd*, 2H, *J*= 7.5 Hz , Ar-H), 7.16

(*m*, 1H, Ar-H) 7.16-7.41 (*m*, 15H, Ar-H); **^{13}C NMR**($CHCl_3$, 125MHz): 16.3 (q, C), 68.3 (t, C-6), 71.4 (d, C-3), 72.8 (d, C-2), 73.5 ,75.1 ,75.4 (*3t*, C-Ar), 75.8 (*d*, C-4), 82.9 (*d*, C-5), 97.4 (*d*, C-1), 114.7, 122.4, 127.1(3*d*, Ar-C), 127.3 (*s*, Ar-C), 127.5, 127.7, 127.8, 127.9, 127.9, 127.9, 128.0, 128.1, 128.3, 128.4, 128.4, 128.5, 128.6, 130.9 (14*d*, Ar-C), 137.9, 138.1,138.5, 154.8 (4*s*, Ar-C); **HRMS** calculated for $C_{34}H_{36}O_6Na$: 563.2404; found: 563.2397.

5.3 3-methylphenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2c)

Off-white solid (88 %); **m.p.:** 83˚C ; **[α]**$_D^{30}$= -33.8 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3353, 2921, 1454, 1126, 1063, 1028, 730, 693, 474; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.16 (*d*, 1H, *J*= 8.5 Hz, -OH), 2.31 (*s*, 3H, -CH_3), 3.63 (*bd*, 1H, *J*= 11 Hz, H-6a), 3.75 (*dd*, 1H, *J*= 3.5 , 5, 2.5 Hz , H4), 3.78 (*d*, 1H, *J*= 10 Hz, H6-b), 3.87-3.89 (*m*,1H, H2), 3.90 (*d*, 1H , *J*= 7 Hz, H3), 3.97 (*t*, 1H , H-5), 4.45, 4.53, 4.61, 4.85, 4.91, 4.98 (6*d* , 6H, *J*= 12, 11.5, 12, 11, 11, 11 Hz, 3* -O-$\underline{CH_2}$-Ph), 5.58 (*d*, 1H, *J*= 3.5Hz, H-1), 6.85 (*d*, 1H, *J*= 7.5Hz, Ar-H), 6.90-6.93 (*m*, 2H, Ar-H), 7.14 -7.17(*m*, 1H, Ar-H) 7.24-7.41 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 21.4 (*q*, C), 68.3 (*t*, C-6), 71.2 (*d*, C-3), 72.8 (*d*, C-2), 73.4, 75.0,75.4 (3*t*, Ar-C), 77.3 (*d*, C-4), 83.2 (*d*, C-5), 97.3 (*d*, C-1), 113.7,117.6, 123.5,127.7, 127.7, 127.7, 127.8, 127.9, 127.9, 128.3, 128.4, 128.5, 129.3 (13*d*, Ar-C), 137.9, 138.2, 138.7, 139.7, 156.5 (5*s*, Ar-C); **HRMS** calculated for $C_{34}H_{36}O_6Na$: 563.2404; found: 563.2397.

5.4 4-methylphenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2d)

Off-white solid (86 %); **m.p.:** 88˚C ; **[α]**$_D^{30}$= +8.5 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3510, 2915,2881, 1455, 1112, 1051, 730, 692, 469; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.19 (*d*, 1H, J= 9.0 Hz, -OH), 2.29 (*s*,3H, -CH_3), 3.61 (*d*,1H, *J*= 10.5 Hz, H-6a), 3.75 (dd, 1H, *J*= 3, 3.5, 4 Hz, H-4), 3.78 (*d*, 1H, *J*= 10 Hz, H-6b), 3.86-3.87 (*m*, 1H, H2), 3.92 (*d*, 1H , *J*= 10 Hz, H-3), 3.95- 3.99 (*m*, 1H, H-5), 4.44, 4.52, 4.60, 4.84, 4.90, 4.98 (6*d*, 6H, *J*= 12, 10.5, 12, 10.5, 11, 11Hz , 3* -O-$\underline{CH_2}$-Ph), 5.54 (d, 1H,*J*= 3.5Hz, H1), 6.98-7.00 (*ab q* , 2H, *J*= 8.5Hz Ar-H), 7.03 (*ab q* , 4H, *J*= 8.5Hz, 8.5 Hz, Ar-H), 7.15 (*d*, 2H, *J*= 12Hz, Ar-H), 7.22-7.41 (*m*,13H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 20.6 (*q*, C), 68.4 (*d*, C-6), 71.2 (*d*, C-3), 72.9 (*d*, C-2), 73.5, 75.1 ,75.5 (3*t*, Ar-C), 77.3 (*d*, C-4), 83.3 (*d*, C-5), 97.5 (*d*, C-1), 116.8, 127.7, 127.8, 127.9, 127.9, 127.9, 128.4, 128.4, 128.5, 130.0 (10*d*, Ar-C), 132.1, 137.9, 138.2, 138.7, 154.3 (5*s*, Ar-C); **HRMS** calculated for $C_{34}H_{36}O_6Na$: 563.2404; found: 563.2398.

5.5 4-methoxyphenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2e)

Off-white solid (84%); **m.p.:** 98˚C ; **[α]**$_D^{30}$= +5.9 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3431, 2917, 2863, 1502, 1206, 1123, 1056, 1029, 737, 696; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.20 (*d*, 1H, *J*=8.5 Hz, -OH), 3.64 (*d*, 1H, *J*=10.5Hz, H-6a), 3.73-3.77 (*m*, 2H, H-6b & H-4),3.76 (*s*, 3H, -OMe), 3.82-3.87 (*m*, 1H, H-3), 3.94-3.97 (*m*, 2H, H-5 & H-4), 4.44-4.99 (6*d*, 6H, 3* -O-$\underline{CH_2}$-Ph), 5.51 (*d*, 1H,*J*= 4Hz, H1), 6.80 -7.04 (*ab q*, 4H, 4*Ar-H), 7.15-7.41 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 56.1 (*q*, C), 68.2 (*d*, C-6), 71.2 (*d*, C-3), 72.8 (*d*, C-2), 73.5, 75.0 ,75.5 (3*t*, Ar-C), 77.3 (*d*, C-4), 83.2 (*d*, C-5), 97.2 (*d*, C-1), 116.8, 127.7, 127.7, 127.8, 127.9, 127.9, 127.9, 128.2, 128.4, 128.4, 128.5, 128.6,129.6 (10*d*, Ar-C), 137.8, 138.1, 138.6, 156.4 (5*s*, Ar-C); **HRMS**calculated for $C_{34}H_{36}O_7$ (TOF MS ES+):537.3005; found: 537.3019.

5.6 *β*-naphthyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2f)

Off-white solid (73 %); **m.p.:** 123˚C ; **[α]**$_D^{30}$= +10.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3516, 2917, 2880, 1594, 1458, 1361, 1123, 1047, 730, 695, 468; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.28 (*d*, 1H, *J*=10Hz, -OH), 3.63 (*dd*, 1H, *J*= 10Hz, H-6a), 3.76 (*dd*, 1H, *J*=10Hz, H-6b), 3.80-3.83 (*m*,1H, H-4), 3.94-3.96 (*m*, 2H, H-2 & H-3), 4.04 (*t*, 1H, *J*= 10, 10Hz, H-5), 4.43, 4.53, 4.61, 4.86, 4.94, 5.00 (6d, 6H, *J*= 12, 10, 10, 10, 10, 10 Hz, 3* -O-$\underline{CH_2}$-Ph), 5.74 (*d*, 1H, *J*= 5Hz, H-1), 7.16 (*d*, 1H, *J*= 5Hz, Ar-H), 7.23-7.37 (*m*, 15H, 3* -O-CH_2-$\underline{Ph}$), 7.53 (*d*, 1H, Ar-H), 7.72 (*d*, 1H, *J*= 10Hz, Ar-H) , 7.77 (*t*, 2H, *J*= 10, 5, 10 Hz, Ar-H).;**^{13}C NMR**($CHCl_3$, 125MHz): 68.2 (*d*, C-6), 71.3 (*d*, C-3), 72.8 (*d*, C-2), 73.5, 75.1 ,75.6 (3*t*, Ar-C), 77.3 (*d*, C-4), 83.2 (*d*, C-5), 97.2 (*d*, C-1), 111.1, 126.5, 127.3, 127.7, 127.8, 127.8, 127.9, 127.9, 128.0, 128.4, 128.5, 128.6, 129.6 (13*d*, Ar-C), 129.8, 134.3, 137.7, 138.1, 138.6, 154.0 (6*s*, Ar-C); **HRMS** calculated for $C_{37}H_{36}O_6$ (TOF MS ES+):557.3056; found: 557.3063.

5.7 4-fluorophenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2g)

Off-white solid (87%); **m.p.:** 115˚C ; **[α]**$_D^{30}$= +20.7 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3506, 2903, 1498, 1360, 1203, 1130, 1091, 1037, 742, 695; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.22 (*d*, 1H, *J*= 8.0 Hz ,-OH,), 3.62 (*d*, 1H, *J*=10.5Hz, H-6a), 3.73-3.78 (*m*, 2H, H-6b& H-4), 3.85-3.98 (*m* , 3H, H-2, H-3 & H-5), 4.45, 4.53, 4.61, 4.84 (4*d*, 4H, *J*= 12, 11, 12, 10.5 Hz, 2* -O-$\underline{CH_2}$-Ph), 5.50 (*d*, 1H, *J*= 3.5Hz, H-1), 6.96 (*t*, 2H, *J*= 8.5, 8.5 Hz, Ar-H), 7.04-7.07 (*m*, 2H, Ar-H) 7.15-7.41 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.3 (*t*, C-6), 71.3 (*d*, C-3), 72.6 (*d*, C-2), 73.5 , 75.1 ,75.5(3*t*, Ar-C), 76.8 (*d*, C-4), 83.0 (*d*, C-5), 98.0 (*d*, C-1), 115.9, 116.1, 118.3, 118.3, 127.6, 127.8, 127.8, 127.8, 127.9, 127.9,127.9, 128.0, 128.4, 128.4,

128.5 (15*d*, Ar-C), 137.8, 138.0, 138.5 ,152.5 (4*s*, Ar-C), 157.5, 159.4 (*d*, Ar-C-F); **HRMS** calculated for $C_{33}H_{33}O_6F$ Na:567.2153; found: 567.2153.

5.8 2-chlorophenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2h)

Off-white solid (78 %); **m.p.:** 85˚C ; **[α]**$_D^{30}$= +23.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3541, 2909, 1478, 1234, 1116, 1051, 739, 695, 447; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.36 (*d*, 1H, *J*= 10 Hz, -OH,), 3.71 (*bd*, 1H, *J*= 10.5 Hz, H-6a), 3.78-3.83 (*m*, 2H, H-6b& H-4), 3.92 (*dt*,1H, *J*= 3.5, 3.5, 3.5 Hz, H-5), 4.02-4.06 (*m*, 2H , H-3& H-2), 4.512, 4.58, 4.65, 4.92, 4.95, 5.06 (6*d*, 6H, *J*= 12, 11, 12, 11, 11, 11 Hz, 3* -O-$\underline{CH_2}$-Ph), 5.57 (*d*,1H, *J*= 3.5Hz, H-1), 7.03 (*t*,1H , *J= 7.5, 7.5Hz*, Ar-H), 7.21-7.26 (*m*, 3H, Ar-H), 7.28-7.47 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz):, 68.4 (*t*, C-6), 71.7 (*d*, C-3), 73.1 (*d*, C-2), 73.5, 75.1, 75.5 (3*t*, Ar-C), 77.3 (*d*, C-4), 83.0 (*d*, C-5), 99.4 (*d*, C-1), 117.6, 124.1, 127.8 (3*d*, Ar-C), 127.9 (*s*, Ar-C), 127.9, 128.1, 128.1, 128.2, 128.3, 128.4, 128.5, 130.2 (8*d*, Ar-C), 137.8, 138.5, 152.3 (3*s*, Ar-C); **HRMS** calculated for $C_{33}H_{33}O_6Cl$ Na : 583.1857; found: 583.1858.

5.9 3-bromophenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2i)

Off-white solid (90%); **m.p.:** 91˚C; **[α]**$_D^{30}$= +35.9 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3362, 2866, 1581, 1462, 1126, 1063, 1023, 733, 696; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.20 (*bs*, 1H, -OH), 3.65 (*dd*, 1H, *J*=10.5, 12 Hz, H-6a), 3.78 (*d*, 1H, *J*=10.5Hz, H-6b), 3.83 (*d*, 1H, *J*= 9.5 Hz, H-4), 3.89-3.90 (*m*,1H, H-2), 3.91-3.92 (*m*, 1H, H-3), 3.99 (*d*, 1H, *J*= 9Hz, H-5), 4.48, 4.57, 4.66, 4.88 (4*d*, 4H, *J*= 12, 10.5, 12, 11Hz, 2* -O-$\underline{CH_2}$-Ph), 4.98 (*q*, 2H, *J*= 11, 6, 11 Hz, -O-$\underline{CH_2}$-Ph), 5.61 (*d*, 1H, *J*= 3.5Hz, H-1), 6.78 (*m*, 1H, Ar-H), 6.88-6.93 (*m*, 2H, Ar-H), 7.18-7.19 (*m*, 1H, Ar-H) 7.20-7.44 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.2 (*d*, C-6), 71.5 (*d*, C-3), 72.5 (*d*, C-2), 73.5, 75.0 , 75.5 (3*t*, -O-$\underline{C}$H2-Ph), 76.8 (*d*, C-4), 82.9 (*d*, C-5), 97.4 (*d*, C-1), 104.5, 104.7, 109.4, 109.6, 112.4, 112.4, 127.6, 127.8, 127.8, 127.8, 127.9, 127.9, 128.0, 128.0, 128.1, 128.3, 128.4, 128.4, 128.4, 128.5, 128.6, (21*d*, Ar-C), 130.3, 130.4, 137.7, 138.0, 138.5, 157.5, 157.6, 162.4, 164.4 (*s*, Ar-C); **HRMS** calculated for $C_{33}H_{33}O_6Br$ (TOF MS ES+):585.2004; found: 585.2014.

5.10 4-nitrophenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2j)

Yellowish semi solid (72%); **m.p.:** 128.5˚C ; **[α]**$_D^{30}$= +3.2 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3535, 2894, 1596, 1487, 1455, 1267, 1158,1089, 1044, 974, 736, 689; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.31 (*bs*, 1H, -OH),

3.58 (*bd*, 1H, *J*=13Hz, H-6a), 3.73 (*dd*, 1H, d, *J*=10, 3 Hz , H-6b), 3.81 (*d*, 2H, *J*= 9.5 Hz, H-4 & H-2), 3.93 (*m*, 1H, H3), 3.99 (*d*, 1H, *J*= 11Hz, H-5), 4.45, 4.55, 4.61, 4.840(4*d*, 4H, *J*= 15, 13.5, 15, 13 Hz, 2* -O-$\underline{CH_2}$-Ph), 4.94 (*dd*, 2H, *J*= 14 , 8.5, 14 Hz, -O-$\underline{CH_2}$-Ph) 5.69 (*d*, 1H, *J*= 4.5Hz, H-1), 7.14- 7.16 (*m*, 1H, Ar-H), 7.19 (*d*, 2H, *J= 11.5 Hz* , Ar-H), 7.25 -7.41 (*m*, 14H, Ar-H), 8.19 (*d*, 2H, *J*= 12 Hz, Ar-H); **^{13}C NMR**($CHCl_3$, 125MHz): 68.0 (*d*, C-6), 71.9 (*d*, C-3), 72.1 (*d*, C-2), 73.5, 75.1 , 75.6 (3*t*, Ar-C), 77.1 (*d*, C-4), 82.5 (*d*, C-5), 97.0 (*d*, C-1), 116.6, 125.8, 127.9, 128.0, 128.5, 128.5, 128.6 (7*d*, Ar-C), 137.5, 137.8, 138.3, 142.8, 157.5, 161.5 (6*s*, Ar-C); **HRMS** calculated for $C_{33}H_{33}NO_8Na$: 594.2099; found: 594.2096.

5.11 2-isopropyl phenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2k)

Off-white solid (76%); **m.p.:** 88˚C; **[α]**$_D^{30}$= +6.4 (*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3383, 2923, 1432, 1128, 1073, 1038, 734, 693, 473; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 1.25, 1.27 (2*d*, 6H, *J*= 3Hz, 3 Hz, 2*-CH3), 2.04 (*d*, 1H, *J*= 6.0 Hz, -OH), 3.29 (*sep*, 1H, -CH), 3.69 (*d*,1H, *J*= 11 Hz, H-6a), 3.83 (*dd*, 1H, *J*= 3, 3, 3 Hz, H-4), 3.88 (*d*, 1H, *J*= 9.5 Hz, H-6b), 3.92-4.02 (*m*, 3H, H-2, H-3 & H-5), 4.52, 4.61, 4.61, 4.91 (4*d*, 4H, *J*= 12, 10.5, 12, 10.5 Hz, 2* -O-$\underline{CH_2}$-Ph), 4.99 (*t*, 2H, -O-$\underline{CH_2}$-Ph), 5.62 (*d*, 1H, *J*= 3.5Hz, H-1), 7.05 (*t* , 1H, *J*= 7.5, 7.5Hz , Ar-H), 7.18 (*t*, 1H, *J*= 7.5, 7.5Hz , Ar-H), 7.23-7.41(*m*,17H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 22.8, 22.9 (*2q*, C), 27.0 (*d*, C), 68.3 (*d*, C-6), 71.5 (*d*, C-3), 72.7 (*d*, C-2), 73.6, 75.1 ,75.3 (3*t*, Ar-C), 77.4 (*d*, C-4), 82.5 (*d*, C-5), 97.6 (*d*, C-1), 114.6, 122.6, 126.2, 126.9, 127.8, 127.8, 127.9, 128.0, 128.0, 128.1, 128.3, 128.4, 128.5, 128.6 (14*d*, Ar-C),137.5,137.8,138.1,138.5,153.9 (5*s*, Ar-C); **HRMS** calculated for $C_{36}H_{40}O_6Na$: 591.2717; found: 591.2716.

5.12 4-cyanophenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2l)

Off-white solid (75%); **m.p.:** 103˚C; **[α]**$_D^{30}$= +8.8 (*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3466, 2911, 2227, 1601, 1500, 1128, 1093, 1040, 740, 698, 474; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.31 (*bs*, 1H, -OH), 3.70 (*d*, 1H, *J= 10 Hz*, H-6a), 3.73 (*d*, 1H, *J*=11 Hz, H-6b), 3.79 (*m*, 2H, H-4 & H-2), 3.89-3.91 (*bd*, 1H , H-3), 3.96-3.99 (*m*, 1H , H-5), 4.44, 4.52, 4.59, 4.83 (4*d*, 4H, *J*= 12, 10.5, 12, 11 Hz, 2* -O-$\underline{CH_2}$-Ph),4.91- 4.96 (*m*, 2H, -O-$\underline{CH_2}$-Ph), 5.64 (*d*, 1H, *J*= 3.5Hz, H-1), 7.15-7.17 (*m*, 4H, Ar-H), 7.24-7.57 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.1 (*t*, C-6), 71.8 (*d*, C-3), 72.2 (*d*, C-2), 73.5, 75.1, 75.6 (3*t*, -O-$\underline{C}$H2-Ph), 76.8 (*d*, C-4), 82.6 (*d*, C-5), 97.0 (*d*, C-1), 106.0 (*s*, $\underline{C}$-CN), 117.3 (*d*, Ar-C),118.8 (*s*, $\underline{C}$N) 127.8, 127.9, 127.9, 127.9, 128.0, 128.4, 128.5, 128.6, 134.0, 134.1 (10*d*, Ar-C), 137.6, 137.9, 138.4, 159.6 (4*s*, Ar-C); **HRMS** calculated for $C_{34}H_{33}NO_6Na$: 574.2201; found: 574.2097.

5.13 1-naphthyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2m)

Off-white solid (76%); **m.p.:** 133˚C; **[α]**$_D^{30}$= +13.6 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3466, 2911, 2227, 1601, 1500, 1128, 1093, 1040, 740, 698, 474; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.18 (*d*, 1H, *J*= 5 Hz, -OH), 3.59 (*d*, 1H, *J= 10 Hz*, H-6a), 3.74 (*d*, 1H, *J*=10 Hz, H-6b), 3.82 (*t*, 1H, *J*= 10, 10 Hz H-4), 3.93 (*bd*, 2H , H-2 & H-3), 4.12 (*t*, 1H , *J*= 10, 10 Hz, H-5), 4.44, 4.52, 4.56, 4.59 (4*d*, 4H, *J*= 10, 10, 10, 10 Hz, 2* -O-$\underline{CH_2}$-Ph),4.98 (*m*, 2H, -O-$\underline{CH_2}$-Ph) 5.75 (*d*, 1H, *J*= 5Hz, H-1), 7.14 (*d*, 2H, *J*= 10 Hz, Ar-H), 7.20-7.47 (*m*, 18H, Ar-H), 7.78 (*d*, 1H, *J*= 5 Hz, Ar-H), 8.09 (*d*, 1H, *J*= 5 Hz, Ar-H) ; **^{13}C NMR** ($CHCl_3$, 125MHz): 68.5 (*t*, C-6), 71.8 (*d*, C-8.8 3), 73.0 (*d*, C-2), 73.7, 75.3, 75.7 (3*t*, -O-$\underline{C}$H2-Ph), 77.0 (*d*, C-4), 82.9 (*d*, C-5), 97.6 (*d*, C-1), 109.1, 121.7, 122.4, 125.9, 128.0, 128.0, 128.1, 128.4, 128.6, 128.7, 128.8 (11*d*, Ar-C), 134.8, 138.0, 138.3, 138.7, 152.1 (5*s*, Ar-C); **HRMS** calculated for $C_{37}H_{36}O_6Na$: 599.2408; found: 599.2405.

5.14 4-carboxaldehyde phenyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2n)

Off-white solid (68%); **m.p.:** 132˚C; **[α]**$_D^{30}$= +34.8 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3466, 2911, 2227, 1601, 1500, 1128, 1093, 1040, 740, 698, 474; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.25 (*bs*, 1H, -OH), 3.57 (*d*, 1H, *J= 10 Hz*, H-6a), 3.72 (*d*, 1H, *J*=10 Hz, H-6b), 3.74-3.80 (*m*, 2H, H-4 & H-2), 3.91 (*bs*, 1H , H-3), 3.97-4.00 (*m*, 1H , H-5), 4.43, 4.52, 4.59, 4.83 (4*d*, 4H, *J*= 10, 15, 15, 10 Hz, 2* -O-$\underline{CH_2}$-Ph),4.93 (*s*, 2H, -O-$\underline{CH_2}$-Ph) 5.69 (*d*, 1H, *J*= 3.5Hz, H-1), 6.90 (*d*, 2H, *J*= 4 Hz, Ar-H), 7.13-7.37 (*m*, 15H, Ar-H), 7.75 (*d*, 2H, *J*= 4Hz, Ar-H), 9.82 (s, 1H, -CHO); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.3 (*t*, C-6), 71.9 (*d*, C-3), 72.5 (*d*, C-2), 73.7, 75.3, 75.8 (3*t*, -O-$\underline{C}$H2-Ph), 76.8 (*d*, C-4), 82.9 (*d*, C-5), 97.0 (*d*, C-1), 116.2,117.0 (2*d*, Ar-C), 128.1, 128.2, 128.7, 128.7, 128.8, 132.2, 132.6 (7*d*, Ar-C), 138.0, 138.1, 138.3, 162.5 (4*s*, Ar-C), 191.2 (*s*, Ar-CHO); **HRMS** calculated for $C_{34}H_{34}O_7Na$: 577.2200; found: 577.2198.

5.15 4-methyl umbelliferyl 3,4,5-tri-*O*-benzyl-*α*-D-glucopyranoside (2o)

Off-white solid (54%); **m.p.:** 165˚C; **[α]**$_D^{30}$= +53.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3540, 2911, 1698, 1681,1652, 1576, 1454, 1336, 1158, 1126, 1068, 1019, 890, 878, 808, 755, 693; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.36 (*bs*, 1H, -OH), 2.39 (*s*, 3H, CH_3), 3.58 (*bd*, 1H, *J*=11Hz, H-6a), 3.74 (*dd*, 1H, *J*=10.5 Hz, H-6b), 3.82 (*d*, 2H, *J= 9.5 Hz*, H-4 & H-2), 3.93 (*bd*, 1H, H-3), 3.99-4.01 (*m*, 1H, *J*= 11Hz, H-5), 4.46 (*d*, 1H, *J*= 12 Hz, -O-$\underline{CH_2}$-Ph), 4.53 (*q*, 2H, *J*= 10.5, 10.5, 8.5 Hz, -O-$\underline{CH_2}$-Ph), 4.63 (*d*, 1H, *J*= 12 Hz, -O-$\underline{CH_2}$-Ph), 4.83 (*d*, 1H, *J*= 11 Hz, -O-$\underline{CH_2}$-Ph), 4.95 (*s*, 2H, -O-$\underline{CH_2}$-Ph), 5.67 (*d*, 1H, *J*= 3.5Hz, H-1), 6.17 (*s*, 1H, H-3'), 7.04 (*d*, 1H, *J*= 9Hz, Ar-H), 7.10 (*s*, 1H, Ar-H), 7.15 (*d*, 2H, *J*= 6.5 Hz,

Ar-H), 7.19 -7.50 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.0 (*d*, C-6), 71.8 (*d*, C-3), 72.3 (*d*, C-2), 73.6, 75.1 , 75.6 (3*t*, Ar-C), 77.1 (*d*, C-4), 84.2 (*d*, C-5), 97.2 (*d*, C-1), 104.4, 112.9, 113.5 (3*d*, Ar-C), 115.0 (*s*, Ar-C), 125.7, 127.7, 127.8, 127.9, 127.9, 127.9, 128.0, 128.3, 128.4, 128.4, 128.5, 128.6 (13*d*, Ar-C), 137.7, 137.9, 138.4, 152.3, 154.9, 159.1, 161.1 (7*s*, Ar-C); **HRMS** calculated for $C_{37}H_{36}O_8Na$: 631.2306; found: 631.2303.

5.16 Phenyl 3,4,5-tri-*O*-benzyl-*α*-D-galactopyranoside (5a)

White solid (92%); **m.p.:**109˚C; **[α]**$_D^{30}$= -7.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3476, 3374, 2904, 1591, 1214, 1073, 1033, 735, 694; **^{1}H NMR** ($CDCl_3$,500MHz, *δ*): 2.25 (*bs*, 1H, OH), 3.54 (*dd*, 1H, *J* = 9, 5.5 Hz, H-6a), 3.65 (*t*, 1H, *J* = 8 Hz , 8.5 Hz, H-4), 3.80 (*dd*, 1H, *J* = 10, 2Hz, H-6b), 4.10-4.12 (*m*, 2H, H-3 & H-5), 4.34 (*dd*, 1H, *J* = 9.5, 2.5 Hz, H-2), 4.37, 4.42, 4.59, 4.75, 4.80, 4.93 (6*d*, 6H, J= 11.5, 11.5, 11.5, 11.5, 11.5, 11 Hz, 3* -O-C$\underline{H_2}$Ph), 5.62 (d, 1H, *J*= 3.5 Hz, H-1), 7.03 (*t*, 1H, *J*= 7.5, 7.5 Hz, Ar-H), 7.09 (*d*, 1H, *J*= 8Hz, Ar-H) 7.21-7.42 (*m*, 18H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, *δ*): 68.6 (*t*, C-6), 68.9 (*d*, C-3), 70.4 (*d*, C-2), 73.5 (*t*, Ar-C), 75.1 (*t*, Ar-C), 75.6 (*t*, Ar-C), 76.8 (*d*, C-4), 83.2 (*d*, C-5), 97.2 (*d*, C-1), 116.8, 122.7,127.8,127.8, 127.9, 127.9, 127.9, 127.9, 128.0, 128.4, 128.5, 128.5, 128.6, 128.6, 129.6 (20*d*, Ar-C), 137.8, 138.1, 138.6, 156.4 (4*s*, Ar-C); **HRMS** calculated for $C_{33}H_{34}O_6Na$: 549.2243; found: 549.2248.

5.17 4-methyl phenyl 3,4,5-tri-*O*-benzyl-*α*-D-galactopyranoside (5b)

White solid (84%); **m.p.:** 98˚C ; **[α]**$_D^{30}$= -2.7 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3397, 2914, 1506, 1218, 1077, 1032, 734, 697; **^{1}H NMR** ($CDCl_3$,500MHz, *δ*): 2.17 (*bs*, 1H, OH), 2.28 (s, 3H, Ar-CH3), 3.53 (*dd*, 1H, *J* = 5.5, 6 Hz, H-6a), 3.64 (*t*, 1H, *J* = 8 Hz , 9 Hz, H-4), 3.91 (*dd*, 1H, *J* = 10, 2.5 Hz, H-6b), 4.08-4.13 (*m*, 2H, H-3 & H-5), 4.32 (*m*, 1H, H-2), 4.37, 4.43, 4.59, 4.75, 4.78, 4.93 (6*d*, 6H, J= 11.5, 11.5, 11.5, 12, 12, 11 Hz, 3* -O-C$\underline{H_2}$Ph), 5.57 (*d*, 1H, *J*= 4 Hz, H-1), 6.98 (*d*, 2H, J= 9 Hz, Ar-H), 7.06 (d, 2H, *J*= 8Hz, Ar-H) 7.22-7.42 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, *δ*): 20.6 (*q*, Ar-C), 68.6 (*t*, C-6), 68.9 (*d*, C-3), 70.3 (*d*, C-2), 72.5 (*t*, Ar-C), 73.8 (*d*, C-4), 74.8 (*t*, Ar-C), 79.6 (*d*, C-5), 98.0 (*d*, C-1), 117.1, 127.8,127.9, 128.2, 128.3, 128.4, 128.6, (7*d*, Ar-C), 137.9, 138.2, 138.5, 154.6 (4*s*, Ar-C); **HRMS** calculated for $C_{33}H_{36}O_6Na$: 563.2404; found: 563.2388.

5.18 4-methoxy phenyl 3,4,5-tri-*O*-benzyl-*α*-D-galactopyranoside (5c)

White solid (86%); **m.p.:**103 ˚C ; **[α]**$_D^{30}$= -32.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3394, 2913, 1502, 1208, 1108, 1075, 1029, 735, 696; **^{1}H NMR**($CDCl_3$,500MHz, *δ*): 2.25 (*bs*, 1H, OH), 3.56 (*dd*, 1H, *J* = 6, 9 Hz, H-6a), 3.62-3.65 (*m*, 1H, H-4), 3.75 (*s*, 3H, -O-CH3), 3.90 (*dd*, 1H, *J* = 10, 2.5 Hz, H-6b), 4.07 (*bs*, 1H, H-3), 4.14 (*t*, 1H, J= 6.5 Hz, 6.5 Hz, H-5), 4.31 (*bs*, 1H, H-2), 4.39, 4.45, 4.59, 4.75, 4.08, 4.93 (6*d*, 6H, *J*= 11.5, 12, 11.5, 11.5, 11.5, 11 Hz, 3* -O-C$\underline{H_2}$Ph), 5.48 (*d*, 1H, *J*= 4 Hz, H-1), 6.79 (*d*, 2H, *J*= 9 Hz, Ar-H), 7.02 (*d*, 2H, *J*= 8Hz, Ar-H) 7.23-7.42 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, *δ*): 55.6 (*q*, O-C), 68.8 (*t*, C-6), 68.9 (*d*, C-3), 70.4 (*d*, C-2), 72.5 (*t*, Ar-C), 73.5 (*t*, Ar-C), 73.9 (*d*, C-4),74.8 (t, Ar-C), 79.6 (*d*, C-5), 98.9 (*d*, C-1), 114.6, 118.7,127.7,127.8, 127.8, 127.8, 128.2, 128.3, 128.4, 128.4, 128.6 (11*d*, Ar-C), 137.9, 138.2, 138.4, 155.3 (4*s*, Ar-C); **HRMS** calculated for $C_{33}H_{36}O_7Na$: 579.2353; found: 579.2345.

5.19 4-fluoro phenyl 3,4,5-tri-*O*-benzyl-*α*-D-galactopyranoside (5d)

White solid (80%); **m.p.:**121 ˚C; **[α]**$_D^{30}$= -15.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3506, 2903, 1498, 1360, 1203, 1130, 1091, 1037, 742, 695; **^{1}H NMR** ($CDCl_3$,500MHz, *δ*): 2.22 (*bs*, 1H, OH), 3.48 (*d*, 1H,*J* = 6.0 Hz, H-6a), 3.55 (*d*, 1H, *J* = 7.5 Hz, H-6b) , 3.72 (*d*, 1H, *J* = 12.5 Hz, H-4), 4.01-4.30 (*m*, 2H, H-3 & H-5), 4.36 (*bs*, 1H, H-2), 4.37, 4.50, 4.51, 4.54, 4.66, 4.86 (6*d*, 6H, J= 10, 11.5, 11.5, 11.5, 11.5, 11.5 Hz, 3* -O-C$\underline{H_2}$Ph), 5.44 (d, 1H, *J*= 4 Hz, H-1), 6.88 (*d*, 2H, *J*= 7.5Hz, Ar-H), 6.96 (*d*, 1H, *J*= 8Hz, Ar-H) 7.15-7.34 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, *δ*): 68.7 (*t*, C-6), 68.8 (*d*, C-3), 70.6 (*d*, C-2), 72.5 (*t*, Ar-C), 73.5 (*t*, Ar-C), 74.9 (*t*, Ar-C), 76.8 (*d*, C-4), 79.4 (*d*, C-5), 98.6 (*d*, C-1), 115.8, 115.9, 116.0, 116.1, 116.2, 116.2, 118.6, 118.7, 127.8,127.8, 128.3 (11*d*, Ar-C), 137.8, 138.0, 138.3, 152.9, 157.7 (5*s*, Ar-C); **HRMS** calculated for $C_{33}H_{33}FO_6Na$: 567.2153; found: 567.2147.

5.20 4-cyano phenyl 3,4,5-tri-*O*-benzyl-*α*-D-galactopyranoside (5e)

White solid (76%); **m.p.:**141 ˚C; **[α]**$_D^{30}$= -30.5 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3466, 2911, 2227, 1601, 1500, 1128, 1093, 1040, 740, 698, 474; **^{1}H NMR** ($CDCl_3$,500MHz, *δ*): 2.37 (*bs*, 1H, OH), 3.47 (*dd*, 1H, *J* = 6, 5.5, 9.5 Hz, H-6a), 3.58 (*t*, 1H, *J* = 7.5 Hz , 9 Hz, H-4), 3.88 (*dd*, 1H, *J* = 10, 2.5, 2 Hz, H-6b), 3.95 (*t*, 1H, *J*= 6.5, 6.5 Hz, H-3), 4.04 (*bs*, 1H, H-5), 4.32 (*d*, 1H, *J* = 6 Hz, H-2), 4.34, 4.37, 4.54, 4.67, 4.76, 4.87 (6*d*, 6H, J= 11.5, 11.5, 11, 11.5, 11.5, 11 Hz, 3* -O-C$\underline{H_2}$Ph), 5.62 (*d*, 1H, *J*= 3.5 Hz, H-1), 7.10 (*d*, 2H, *J*= 8.5 Hz, Ar-H), 7.14-7.36 (*m*, 15H, Ar-H), 7.40 (*d*, 1H, *J*= 8.5 Hz, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz, *δ*): 68.5 (*t*, C-6), 68.6 (*d*, C-3), 71.1 (*d*, C-2), 73.6 (*t*, Ar-C), 75.0 (*t*, Ar-C), 75.6 (*t*, Ar-C), 76.9 (*d*, C-4), 79.2 (*d*, C-5), 97.5 (*d*, C-1), 105.9 (*s*, CN), 117.5 (*d*, Ar-C), 119.0 (*s*, Ar-CN), 127.9, 128.2, 128.5, 128.5,

128.7, 134.1 (6*d*, Ar-C), 137.7, 137.9, 138.3, 160.1 (4*s*, Ar-C); **HRMS** calculated for $C_{34}H_{33}NO_6Na$: 574.2200; found: 574.2195.

6.0 General procedure for glycosidation of 1,2-anhydrosugars 1 or 4 using Cs_2CO_3:

A mixture of phenol (1.1 equiv.) and Cs_2CO_3 (1 equiv.) in toluene was refluxed under nitrogen atmosphere for 15 min. 1,2-anhydrosugar (100mg, 1.0 equiv.) **1** or **4** was added and refluxed for 15 min (as monitored by TLC). The reaction mixture was filtered, washed with ethyl acetate, concentrated in *vacuo* and the crude viscous product purified by flash column chromatography using 5% ethyl acetate and n-hexane as mobile phase, to afford *β-O*-arylglycosides**3a-d** or **6a-c**.

6.1 Phenyl 3,4,5-tri-*O*-benzyl-*β*-D-glucopyranoside[1] (3a)

White solid (90%);**m.p.:** 99° C $[\alpha]_D^{30}$= -27.6 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3457, 2859, 1498, 1219, 1050, 737, 692; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H 2.52 (*s*,1H, -OH), 3.69 (*d*, 1H, *J*= 8.5 Hz, H-6a), 3.71-3.76 (*m*, 3H, H-6b, H-4 & H-2), 3.83 (*bd*, 1H, H-3), 3.88 (*t*,1H, *J*= 7.5, 8Hz, H5), 4.56 (*q* , 2H, *J*= 12, 11.5 Hz, -O-$\underline{CH_2}$-Ph), 4.61-4.93 (5H, m,2*-O-$\underline{CH_2}$-Ph& H1), 7.07-7.25 (*m*, 5H, 5*Ar-H,), 7.28-7.43 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.8 (*t*, C-6), 73.5 (*t*, Ar-C), 74.4 (*d*, C-3), 75.1 (*t*, Ar-C),75.3 (*t*, Ar-C), 75.4 (*d*, C-2), 77.5 (*d*, C-4), 84.4 (*d*, C-5), 100.9 (*d*, C-1), 116.9, 122.8 (2*d*, Ar-C), 127.6, 127.8, 127.8, 127.9, 127.9, 128.0, 128.4, 128.4, 128.5, 128.5, 128.5, 129.5 (12d, Ar-C), 138.0, 138.1, 138.5, 157.2 (4*s*, Ar-C).

6.2 2-methylphenyl 3,4,5-tri-*O*-benzyl-*β*-D-glucopyranoside[1] (3b)

White solid (86%); $[\alpha]_D^{30}$= -4.5 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3405, 2916, 1567, 1255, 1056, 736, 692; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H2.27 (s, 3H, Ar-$\underline{Me}$), 2.41 (*d*, 1H, *J*= 1.5 Hz, -OH), 3.60-3.62 (*m*, 1H, H-6a,), 3.66-3.73 (*m*, 3H, H-6b, H-4 & H-2),3.77-3.80 (*bd*, 1H, H-3), 3.88 (*t*, 1H, *J*= 8.0, 8.0 Hz, H-5), 4.52, 4.59, (2*d*, 3H, *J*= 12, 10 Hz, -O-$\underline{CH_2}$-Ph), 4.83 (*d*, 1H, *J*= 7.5 Hz, H-1), 4.86, 4.88, 4.95 (3*d*, 3H, J= 10, 9, 11.5 Hz, 2*-O-$\underline{CH_2}$-Ph), 6.95 (*t*, 1H, *J*= 7.0, 7.5 Hz , Ar-H),7.068 (*t*, 2H, *J*= 8.0, 9.0 Hz , Ar-H),7.13 (*t*, 1H, *J*= 9.0, 7.5 Hz, Ar-H), 7.20-7.39 (*m*, 15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz):16.40 (*q*, Ar- $\underline{C}H_3$) 68.8 (*t*, C-6), 73.5 (*t*, Ar-C), 74.56 (*d*, C-3), 75.0 (*t*, Ar-C),75.3 (*t*, Ar-C), 75.4 (*d*, C-2), 77.5 (*d*, C-4), 84.6 (*d*, C-5), 101.5 (*d*, C-1), 115.5, 127.0 , 127.6, 127.7, 127.7, 127.8, 127.8, 127.9, 128.0, 128.0, 128.3, 128.4, 128.4, 128.4, 128.5, 128.5, 130.8 (17*d*, Ar-C), 138.0, 138.1, 138.5,155.5 (4*s*, Ar-C).

6.3 3-methylphenyl 3,4,5-tri-*O*-benzyl-*β*-D-glucopyranoside[1] (3c)

White solid (88%);**[α]**$_D^{30}$= -87.3 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3407, 2915, 1505, 1224, 1103, 1061, 1028, 733, 694; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H2.30 (s, 3H, Ar-Me), 2.45 (*bs*, 1H, -OH), 3.67-3.72 (*m*, 4H, H-6a,H-6b, H-4 & H-2),3.80 (*dd*, 1H, *J*= 1.5, 1.5 Hz, H-3), 3.83 (*bs*, 1H, H-5), 4.53, 4.59, 4.85, 4.86, 4.87, 4.88, 4.96 (7*d*, 7H, *J*= 12, 10, 12, 7.5, 11, 11.5, 11 Hz, 3* -O-CH_2-Ph & H-1), 7.16 (i, 1H, *J*= 7.5, 7.5 Hz , Ar-H),7.21 (*bd*, 2H, *J*= 6Hz, Ar-H,), 7.27-7.4 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 21.6 (*t*, Ar- CH_3) 69.0 (*d*, C-6), 73.7 (*t*, Ar-C), 74.6(*d*, C-3), 75.2 (*t*, Ar-C),75.4 (*d*, Ar-C), 75.6 (*d*, C-2), 77.4 (*d*, C-4), 84. 5 (*d*, C-5), 101.1 (*d*, C-1), 114.0, 117.9, 123.8, 127.7, 127.9, 127.9, 128.0, 128.1,128.5, 128.6, 128.6, 129.4 (12*d*, Ar-C), 138.2, 138.2, 138.7, 139.7, 157.4 (5*s*, Ar-C).

6.4 4-methylphenyl 3,4,5-tri-*O*-benzyl-*β*-D-glucopyranoside[1] (3d)

White solid (85%);**[α]**$_D^{30}$= -25.4 ℃(*c* 1.0, CH_2Cl_2); **IR**(cm^{-1}) 3505, 3227, 3032, 1505, 1220, 1126, 1036, 738, 695; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H2.17 (*s*, 3H, Ar-Me), 2.30 (*bs*, 1H, -OH), 3.58-3.72 (*m*, 4H, H-6a,H-6b, H-4 & H-2), 3.79 (*dd*, 1H, *J*= 11.5, 2 Hz, H-3), 3.81 (*bd*, 1H, H-5), 4.51, 4.57, 4.59(3*d*, 3H, *J*= 10, 13.5, 15 Hz, -O-CH_2-Ph), 4.82 (*d*, 1H, *J*= 9.5 Hz, H-1), 4.86, 4.87, 4.95 (3*d*, 3H, *J*= 13.5, 14.5, 14 Hz, -O-CH_2-Ph), 6.97 (*d*, 1H, *J*= 10.5 Hz, Ar-H), 7.07 (*d*, 2H, *J*= 10.5 Hz, Ar-H,), 7.21-7.40 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 20.6 (*t*, Ar- CH_3) 68.8 (*d*, C-6), 73.5 (*t*, Ar-C), 74.4 (*d*, C-3), 75.1 (*t*, Ar-C), 75.3 (*d*, Ar-C), 75.4 (*d*, C-2), 77.4 (*d*, C-4), 84. 4 (*d*, C-5), 101.3 (*d*, C-1), 117.0, 127.6, 127.8, 127.9, 128.0, 128.3, 128.4, 128.5, 129.9 (9*d*, Ar-C), 138.1, 138.2, 138.7, 145.7, 157.5 (5*s*, Ar-C).

6.5 Phenyl 3,4,5-tri-*O*-benzyl-*β*-D-galactopyranoside[1] (6a)

White solid (88%); **[α]**$_D^{30}$= -48.5 ℃(*c* 1.0, CH_2Cl_2); **IR** (cm^{-1}) 3371, 2892, 1593, 1490, 1223, 1113, 1058, 732, 695; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H2.55 (*bs*, 1H, -OH), 3.56 (*dd*, 1H, *J*= 7.5, 2.5 Hz, H-6a), 3.68 (*bd*, 2H, H-6b& H-4), 3.76 (*t*, 1H, *J*= 6.5, 6.5 Hz, H-3), 4.01 (*d*, 1H, *J*= 2Hz, H-5), 4.27 (*t*, 1H, *J*= 6.5, 9 Hz, H-2), 4.45, 4.51, 4.67, 4.73, 4.80 (5*d*, 5H, *J*= 12, 11.5, 11.5, 12, 12 Hz, -O-CH_2-Ph), 4.91 (*d*, 1H, *J*= 7.5 Hz, H-1), 4.95 (*d*, H, *J*= 11.5 Hz, -O-CH_2-Ph), 7.04 (*t*, 1H, *J*= 7.5, 7 Hz, Ar-H), 7.09 (*d*, 2H, *J*= 8 Hz, Ar-H,), 7.26-7.42 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 68.8 (*d*, C-6), 71.1(*d*, C-3), 72.5 (*t*, Ar-C), 72.8 (*d*, C-2), 73.6 (*t*, Ar-C), 74.1 (*d*, C-4), 74.6 (*d*, Ar-C), 81.8 (*d*, C-5), 101.3 (*d*, C-1), 117.0, 117.1, 122.6, 127.7, 127.7, 127.8, 127.9, 128.2, 128.3, 128.4, 128.6, 129.4, 129.6 (13*d*, Ar-C), 137.8, 138.0, 138.4, 157.2 (4*s*, Ar-C).

6.6 4-methoxy phenyl 3,4,5-tri-*O*-benzyl-*β*-D-galactopyranoside[1] (6b)

White solid (76%); $[\alpha]_D^{30}$= -40.8 ℃(*c* 1.0, CH_2Cl_2); **IR** (cm^{-1}) 3371, 2892, 1593, 1490, 1223, 1113, 1058, 732, 695; **^{1}H NMR** ($CDCl_3$,500MHz): δ_H2.40 (*bs*, 1H, -OH), 3.56- 3.60 (*m*, 1H, H-6a), 3.67- 3.73 (*m*, 4H, H-6b&OMe), 3.78- 3.84 (*m*, 4H, H-3, H-4, H-2 & H-5), 4.53, 4.58, 4.60, 4.75, 4.86, 4.88, 4.95 (7*d*, 7H, *J*= 12, 11.5, 11.5, 12, 12, 11, 11 Hz, -O-$\underline{CH_2}$-Ph& H-1), 6.80 (*d*, 2H, *J*=9 Hz, Ar-H), 7.04 (*d*, 2H, *J*= 9 Hz, Ar-H,), 7.20-7.40 (*m*,15H, Ar-H); **^{13}C NMR** ($CHCl_3$, 125MHz): 55.6 (*q*, O-CH_3), 68.4 (*d*, C-6), 71.1 (*d*, C-3), 72.8 (*t*, Ar-C), 73.5 (*d*, C-2), 75.1 (*t*, Ar-C), 75.5 (*d*, C-4), 77.3 (*d*, Ar-C), 81.6 (*d*, C-5), 102.6 (*d*, C-1), 114.7, 114.8, 116.1, 118.2, 127.6, 127.7, 127.8, 127.9,127.9, 128.0, 128.0, 128.1, 128.1, 128.1, 128.3, 128.4, 128.4, 128.4, 128.5, 128.6, 128.6, 129.7 (22*d*, Ar-C), 137.9, 138.1, 138.6,150.4, 155.3 (5*s*, Ar-C).

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22 In ^{1}H NMR, H-1 of **2a** (α-anomer) resonates as a doublet (J = 3.5 Hz) at δ 5.64, while H-1 of **3a** (β-anomer) appears at around δ 4.9 that merges with benzylic protons. In ^{13}C NMR, C-1 of **2a** appears at δ 97 and that of **2b** at δ 110. The anomeric purity & ratios were confirmed by reverse phase HPLC in 100% CH_3CN (R_t for **2a** = 4.18 and **3a** = 3.94).

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Tunable stereoselectivity in the synthesis of *α*- and *β*- aryl glycosides using 1,2-*α*-anhydrosugars as glycosyl donors

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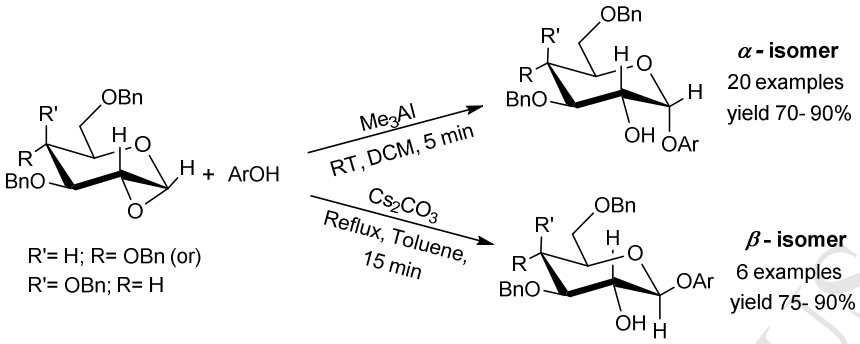

Highlights

- Although varieties of methods are known for β-selectivity, none is reported for α-selectivity. Our strategy provides a route for facile and exclusive synthesis of α- and β-aryl glycosides.
- It is shown that the stereoselectivity of the glycosidation can be tuned by varying the metal counter ion of the phenoxides.
- High yielding and unusually fast (less than 5 minutes at ambient temperatutre) when mediated by trimethylaluminium as metal precursor.
- Ring opening of 1,2-D-anhydrosugars provides access to glycosides with a free hydroxyl group at C-2 position of the sugar moiety that can be exploited for the synthesis of carbohydrates containing 1,2-linkage