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Highly efficient and selective biocatalytic acylation studies on triazolylsugars

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Abstract—Different acid anhydrides (of C_2 to C_7 aliphatic fatty acids and benzoic acid) have been used to study the selective acylation of primary/secondary hydroxyl groups in 2-phenyl-4-(D-*threo*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole, 2-phenyl-4-(D-*erythro*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole, 2-phenyl-4-(D-*arabino*-1′,2′,3′,4′-tetrahydroxybutyl)-2*H*-1,2,3-triazole and 2-phenyl-4-(D-*lyxo*-1′,2′,3′,4′-tetrahydroxybutyl)-2*H*-1,2,3-triazole in the presence of *Candida antarctica* lipase B in diisopropyl ether. Among the different acid anhydrides, butanoic anhydride was found to be the most efficient acylating agent (for butanoylation); for acetylation, vinyl acetate gave the best results. The reactions with both these acylating agents were highly selective and efficient yielding exclusively the monoacylated products in 95–99% yields in 1–5 h.

1. Introduction

Enzyme-catalyzed organic reactions have provided a great impetus to organic synthesis during the last two decades. Enzymes, especially lipases are known for their low cost and great tolerance towards their substrates. In fact lipase-catalyzed acylation and deacylation reactions today represent an important class of enzymatic transformations in organic synthesis.[1–3]

Carbohydrates are probably the most complex of all polyhydroxy compounds due to the presence of nearly equivalent hydroxy groups and multiple chiral centers.[4] Carbohydrate derivatives have recently ushered in a new era of drug development with the discovery of their role in intercellular interactions and cell–cell communications. Further, the nucleosides derived from modified sugars, e.g. AZT, ddC, d4T, etc. have shown excellent antiviral activity and are being used as drugs.[5–8] In addition, the sugar-modified nucleosides like LNA monomer form the backbone of a new therapeutic strategy called oligonucleotide therapeutics including antigene and antisense approaches. Multistep synthetic protocols are required to synthesize these bioactive compounds involving several protection and deprotection steps, which often result in relatively low yields, thus making the whole protocol cumbersome and expensive.[9,10]

We have shown in our recent publications the capability of *Candida antarctica* lipase, *Pseudomonas* sp. lipase and porcine pancreatic lipase for carrying out highly selective protection of hydroxyl groups in 2-deoxy-D-ribose, 4-*C*-hydroxymethylated furanose derivatives and triazolylsugars.[11–15] In this report, we have carried out highly selective and efficient CAL B-catalyzed acylations of hydroxyl groups in 2-phenyl-4-(D-*threo*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole (**1**), 2-phenyl-4-(D-*erythro*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole (**2**), 2-phenyl-4-(D-*arabino*-1′,2′,3′,4′-tetrahydroxybutyl)-2*H*-1,2,3-triazole (**3**) and 2-phenyl-4-(D-*lyxo*-1′,2′,3′,4′-tetrahydroxybutyl)-2*H*-1,2,3-triazole (**4**), precursors for the synthesis of triazolylacyclonucleosides[16] using anhydrides of acetic, propanoic, butanoic, pentanoic, hexanoic, heptanoic and benzoic acids, and 2,2,2-trifluoroethyl butyrate and vinyl acetate as acylating agents.

2. Results and discussion

The triazolylsugars **1**–**4** were prepared in two steps starting from the corresponding sugars, i.e. D-xylose, D-ribose,

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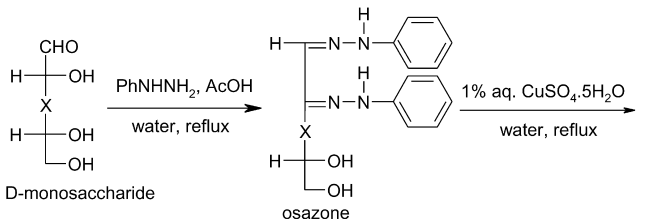
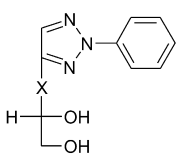
D-glucose and D-galactose, respectively, via their conversion into phenylosazones, followed by oxidative cyclization with 1% $CuSO_4$ in overall yields of 43–54% (Scheme 1).[17–20] The structures of these triazolyl sugar derivatives were unambiguously established on the basis of their spectral analysis. The melting points of all the four compounds **1**–**4** and spectral data of compounds **1** and **3** were found identical with those reported in the literature,[13,16–20] however the spectral data for triazolyl sugar derivatives **2** and **4** is being reported here for the first time.

Different lipases, i.e. *C. antarctica* lipase B (CAL), *C. rugosa* lipase (CRL) and porcine pancreatic lipase (PPL) were screened for selective acylation of primary/secondary hydroxyl groups in triazolyl sugar derivatives **1**–**4** using propanoic anhydride as the acylating agent. Diisopropyl ether was used as solvent in the case of screening reactions catalyzed by CAL and CRL, whereas tetrahydrofuran was employed as the solvent when PPL was used as the biocatalyst, based on our earlier experience.[2,13,14] None of the above triazolylsugars were accepted as substrates by CRL for propanoylation with propanoic anhydride. Both CAL and PPL were found to transform the starting triazolylsugars **1**–**4** into less polar products (as seen on TLC) upon incubation with propanoic anhydride, however the rate of transformation was much slower in the reaction catalyzed by PPL than the reaction catalyzed by CAL, and the reaction was incomplete even after 120 h (5 days) of stirring in the former case. On the basis of the screening test, CAL in diisopropyl ether was selected for further acylation studies on triazolyl sugars **1**–**4**.

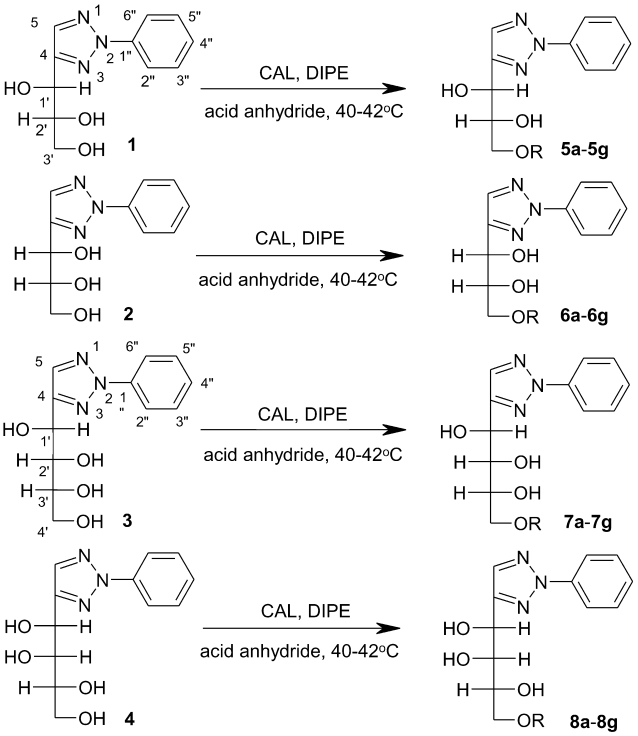
In a typical reaction, a mixture of triazolyl sugar (**1**–**4**, 1 mmol) and propanoic anhydride (1 mmol) in DIPE (20 ml) was shaken with CAL (150 mg) in an incubator shaker at 42–45°C and the progress of the reaction was monitored on TLC (Scheme 2). The substrates were not soluble in DIPE initially, however the solubility increased with the progress of the reaction. On completion of the

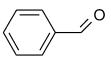




X	Substrate	Product	% Yield
HO—H	D-xylose	**1**	46
H—OH	D-ribose	**2**	43
HO—H / H—OH	D-glucose	**3**	54
HO—H / HO—H	D-galactose	**4**	51

Scheme 1.



Compounds	R
a	CH_3-CO*
b	CH_3-CH_2-CO
c	CH_3-CH_2-CH_2-CO*
d	CH_3-CH_2-CH_2-CH_2-CO
e	CH_3-CH_2-CH_2-CH_2-CH_2-CO
f	CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CO
g	

*Acetyl triazolylsugars **5a-8a** and butanoyl triazolylsugars **5c-8c** were also obtained by carrying out acylations with vinyl acetate and 2,2,2-trifluoroethyl butyrate, respectively as detailed in **Table 1**.

Scheme 2.

reaction the enzyme was filtered off and solvent was removed under reduced pressure. The crude product thus obtained was purified by passing through a short column of silica gel, which afforded the acylated compound in a pure form. It was observed that CAL in diisopropyl ether exclusively acylates the lone primary hydroxyl group over two secondary hydroxyl groups, in compounds **1** and **2** and over three secondary hydroxyl groups in compounds **3** and **4** leading to the formation of propanoyl derivatives **5b**–**8b**, respectively, in 20–70% yields (Scheme 2, Table 1).

In order to find out the tolerance of CAL for different acid anhydrides as acylating agents and also to find out the best lipase-anhydride combination for selective and efficient acylation, different acid anhydrides, e.g. acetic, butanoic, pentanoic, hexanoic, heptanoic and benzoic anhydrides together with propanoic anhydride have been examined for the acylation of triazolylsugars **1**–**4**. The *C. antarctica* lipase in diisopropyl ether was found to accept all these seven acid anhydrides as acylating agents and transfers the acyl group exclusively at the primary hydroxyl group of triazolylsugars over the secondary hydroxyl groups leading to the formation of the monoacylated products **5a**–**5g**, **6a**–**6g**, **7a**–**7g** and **8a**–**8g** in 15–99% yields (Table 1).

Table 1. Regioselective acylation of triazolylsugars **1**–**4** mediated by CAL in diisopropyl ether at 42–45°C using different acylating agents[a]

Substrate	Acylating agent/reaction time	Product	% Yield
Trihydroxytriazole **1**	Acetic anhydride/48 h	Acetyltriazole **5a**	60
	Propanoic anhydride/48 h	Propanoyltriazole **5b**	70
	Butanoic anhydride/45 min	Butanoyltriazole **5c**	98
	Pentanoic anhydride/1 h	Pentanoyltriazole **5d**	97
	Hexanoic anhydride/45 min	Hexanoyltriazole **5e**	98
	Heptanoic anhydride/1 h	Heptanoyltriazole **5f**	98
	Benzoic anhydride/48 h	Benzoyltriazole **5g**	65
	2,2,2-Trifluoroethyl butyrate/4.5 h	Butanoyltriazole **5c**	82
	Vinyl acetate/4 h	Acetyltriazole **5a**	95
Trihydroxytriazole **2**	Acetic anhydride /48 h	Acetyltriazole **6a**	50
	Propanoic anhydride/48 h	Propanoyltriazole **6b**	40
	Butanoic anhydride /1 h	Butanoyltriazole **6c**	99
	Pentanoic anhydride/7 h	Pentanoyltriazole **6d**	82
	Hexanoic anhydride/10 h	Hexanoyltriazole **6e**	83
	Heptanoic anhydride/9 h	Heptanoyltriazole **6f**	83
	Benzoic anhydride/48 h	Benzoyltriazole **6g**	54
	2,2,2-Trifluoroethyl butyrate/7 h	Butanoyltriazole **6c**	75
	Vinyl acetate/5 h	Acetyltriazole **6a**	95
Tetrahydroxytriazole **3**	Acetic anhydride/48 h	Acetyltriazole **7a**	15
	Propanoic anhydride/48 h	Propanoyltriazole **7b**	20
	Butanoic anhydride/2.5 h	Butanoyltriazole **7c**	99
	Pentanoic anhydride/10 h	Pentanoyltriazole **7d**	85
	Hexanoic anhydride/8 h	Hexanoyltriazole **7e**	84
	Heptanoic anhydride/8 h	Heptanoyltriazole **7f**	85
	Benzoic anhydride/48 h	Benzoyltriazole **7g**	15
	2,2,2-Trifluoroethyl butyrate/12 h	Butanoyltriazole **7c**	53
	Vinyl acetate/2.5 h	Acetyltriazole **7a**	97
Tetrahydroxytriazole **4**	Acetic anhydride/48 h	Acetyltriazole **8a**	30
	Propanoic anhydride/48 h	Propanoyltriazole **8b**	35
	Butanoic anhydride/5 h	Butanoyltriazole **8c**	95
	Pentanoic anhydride/11 h	Pentanoyltriazole **8d**	88
	Hexanoic anhydride/10 h	Hexanoyltriazole **8e**	85
	Heptanoic anhydride/14 h	Heptanoyltriazole **8f**	89
	Benzoic anhydride/48 h	Benzoyltriazole **8g**	32
	2,2,2-Trifluoroethyl butyrate/10 h	Butanoyltriazole **8c**	65
	Vinyl acetate/3 h	Acetyltriazole **8a**	97

[a] All these reactions when performed under identical conditions without adding the lipase yielded mixtures of acylated compounds without any selectivity

Although CAL in diisopropyl ether accepts different aliphatic and aromatic acid anhydrides as acylating agents, butanoic anhydride was found to be the most efficient acylating agent among all seven anhydrides in this study on different triazolylsugars. Thus, incubation of triazolylsugars **1**–**4** with CAL in diisopropyl ether and butanoic anhydride led to the formation of corresponding mono-esters **5c**, **6c**, **7c** and **8c** in nearly quantitative yields, i.e. 98, 99, 99 and 95%, respectively. It is not only the yield, the acylation reaction affected by butanoic anhydride takes minimum time as well, e.g. the rate of monoacylation of 2-phenyl-4-(D-*threo*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole (**1**) mediated by CAL in diisopropyl ether with butanoic anhydride is 64 times faster than the rate of acylation of the same substrate with acetic anhydride (Table 1). This study indicates the utility of butanoic, pentanoic, hexanoic and heptanoic anhydrides as acylating agents over acetic and propanoic anhydrides, thus indicating that the increase in lipophilicity of the acylating agent increases the rate and turnover of the acylation reaction catalyzed by CAL in diisopropyl ether, as the yields of the acylation reactions with butanoic, pentanoic, hexanoic and heptanoic anhydrides are of the same order (Table 1). However the time taken for the reactions with higher fatty acid anhydrides are longer, thereby indicating that the increase of chain length of acylating agent beyond C_4 may disturb the finer fitting of the acylating agent in the active site of the enzyme leading to a slight decrease in turnover and increase in the reaction time of enzyme-catalyzed acylation reaction. The aromatic acid anhydride, benzoic anhydride was found to be a poor acylating agent for all four triazolylsugars.

Among the four triazolylsugars **1**–**4**, compound **1** was found to be the best substrate for CAL mediated acylation reaction with all the seven anhydrides, both in terms of the turnover of the reaction and the average reaction time. For example, the average turnover and the average reaction time in case of CAL-catalyzed acylation of triazolylsugar **1** are 84% and 21.1 h, respectively, whereas the average turnover/reaction time in case of triazolylsugars **2**–**4** are 70%/24.4 h, 56%/24.6 h and 64%/26.3 h, respectively.

The enzymatic reactions with CAL in DIPE on the substrates **1**–**4** were also tried using 2,2,2-trifluoroethyl butyrate and vinyl acetate, both of these acylating agents exhibited exclusive selectivity for the primary hydroxyl group on all the substrates like the acid anhydrides. However, in comparison to 2,2,2-trifluoroethyl butyrate, butanoic anhydride is a better agent for butanoylation as yields with the former were 53–82% as compared to

95–99% with the latter (Table 1). On the other hand, vinyl acetate is a better acetylating agent as compared to acetic anhydride, as the yields with vinyl acetate were 95–97% compared to those (15–60%) obtained with acetic anhydride (Table 1).

The monoacylated triazolylsugars **5a**–**5g**, **6a**–**6g**, **7a**–**7g** and **8a**–**8g** of this study are new compounds and have been synthesized for the first time, except for **5a** and **7a**.[13] The structures of all these twenty eight compounds were unambiguously established on the basis of their spectral analysis (IR, ^{1}H, ^{13}C NMR and high resolution mass spectra). The assignments of ^{1}H NMR spectra of two representative compounds, viz. 2-phenyl-4-(D-*arabino*-4′-butanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (**7c**) and 2-phenyl-4-(D-*lyxo*-4′-propanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (**8b**) have also been confirmed from their ^{1}H–^{1}H COSY NMR spectra.

3. Conclusions

This study has clearly demonstrated the specificity of CAL for the acylation of primary hydroxyl groups over the secondary hydroxyl groups of triazolylsugars using acid anhydrides as acylating agents. This work further reveals that butanoic anhydride and vinyl acetate are the most suitable acylating agents for CAL–diisopropyl ether system. The biocatalytic route developed in this paper can find utility for selective manipulation of multiple hydroxyl groups in triazolyl sugar derivatives while synthesizing bioactive molecules of this class, viz. in the synthesis of triazolylacyclonucleosides.

4. Experimental

Melting points were determined on a Mettler FP62 instrument or in a sulfuric acid bath and are uncorrected. The IR spectra were recorded either on a Perkin–Elmer model 2000 FT-IR or RXI FT-IR spectrometer. The ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AC-300 Avance spectrometer at 300 and at 75.5 MHz, respectively, using TMS as internal standard. The chemical shift values are on δ scale and the coupling constants (J) are in Hz. The FAB-HRMS spectra of all the compounds to measure their accurate masses were recorded on a JOEL JMS-AX505W high resolution mass spectrometer in positive mode using the matrix HEDS (bishydroxyethylsulfide) doped with sodium acetate. The optical rotations were measured on a Perkin–Elmer 241 polarimeter. The *C. antarctica* lipase B immobilized on accurel was gifted by Novo Nordisk Co. and used after storing in vacuo over P_2O_5 for about 25–30 h. The enzymes, *C. rugosa* lipase (CRL, Type VII) and porcine pancreatic lipase (PPL, Type II) were purchased from Sigma Chemical Co. (USA) and used after storing in vacuo over P_2O_5 for 24 h. Diisopropyl ether (DIPE) was distilled over activated molecular sieves (4 Å) prior to use. Analytical TLCs were performed on pre-coated Merck silica gel 60F_{254} plates; the spots were detected either under UV light or by charring with 4% alcoholic H_2SO_4. Silica gel (100–200 mesh) was used for column chromatography.

4.1. Preparation of tri- and tetrahydroxytriazolyl sugars 1–4

The tri- and tetrahydroxytriazolyl sugars **1**–**4** were prepared by following the literature procedures.[17–20] Thus, condensation of D-xylose, D-ribose, D-glucose and D-galactose with phenylhydrazine led to the formation of respective phenylosazones, which upon the oxidative action of aq. $CuSO_4$ gave the corresponding triazolylsugars **1**–**4** (Scheme 1). The structures of **1**–**4** were established from their spectral data. The melting points and optical rotation values of all the four compounds and spectral data of two known compounds **1** and **3** were found identical with those reported in literature.[13,16–18]

4.1.1. 2-Phenyl-4-(D-*erythro*-1′,2′,3′-trihydroxypropyl)-2*H*-1,2,3-triazole (2). It was obtained from D-ribose in 43% yield, mp 79–80°C (lit.[19] 80–81°C). R_f: 0.24 (chloroform–methanol, 9:1); $[\alpha]_D^{29}$=+20.0 (*c* 0.81, H_2O), lit.[19] $[\alpha]_D^{20}$=+23.1 (*c* 0.80, H_2O); ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.26 (2H, 2 brs, 2×OH), 3.83 (2H, m, C-3′H and OH), 3.72 (1H, d, J=8.4 Hz, C-3′H), 4.06 (1H, brs, C-2′H), 5.08 (1H, d, J=4.2 Hz, C-1′H), 7.35–7.37 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 8.02 (2H, d, J=7.9 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 63.34 (C-3′), 68.39 (C-2′), 74.48 (C-1′), 119.16 (C-3″and C-5″), 127.96 (C-4″), 129.61 (C-2″ and C-6″), 134.59 (C-5), 139.83 (C-1″) and 150.04 (C-4).

4.1.2. 2-Phenyl-4-(D-*lyxo*-1′,2′,3′,4′-tetrahydroxybutyl)-2*H*-1,2,3-triazole (4). It was obtained from D-galactose in 51% yield, mp 109–110°C (lit.[20] 110–111°C). R_f: 0.20 (chloroform–methanol, 9:1); $[\alpha]_D^{29}$=−16.4 (*c* 0.20, $CHCl_3$), lit.[20] $[\alpha]_D^{20}$=−13.3 (*c* 0.20, $CHCl_3$); ^{1}H NMR (300 MHz, DMSO-d_6): δ 3.40–3.48 (3H, m, C-4′H and OH), 3.72 (1H, d, J=8.4 Hz, C-3′H), 3.80 (1H, t, J=6.0 Hz and 5.7 Hz, C-2′H), 4.77 (1H, d, J=8.4 Hz, C-1′H), 7.39 (1H, t, J=7.3 Hz, C-4″H), 7.55 (2H, d, J=7.7 Hz, C-3″H and C-5″H), 7.96 (1H, s, C-5H) and 7.99 (2H, d, J= 8.1 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 63.09 (C-4′), 66.10 (C-3′), 70.22 (C-2′), 72.64 (C-1′), 118.39 (C-3″ and C-5″), 127.57 (C-4″), 129.99 (C-2″ and C-6″), 135.25 (C-5), 139.70 (C-1″) and 153.29 (C-4).

4.2. General procedure of *C. antarctica* lipase-catalyzed acylation of triazolylsugars 1–4 with acid anhydrides

To a mixture of the triazolyl sugar (**1**–**4**, 1 mmol) and dry diisopropyl ether (20 ml), appropriate acid anhydride (1.2 mmol) was added, followed by *C. antarctica* lipase B (150 mg). The reaction mixture was stirred at 42–45°C in an incubator shaker and progress of the reaction was monitored periodically by TLC. On completion the reaction was stopped by filtering off the enzyme and solvent evaporated to dryness under vacuum. The crude product thus obtained was purified either by crystallization from a mixture of petroleum ether–ethyl acetate or by elution with a mixture of chloroform–methanol through a short glass column of silica gel.

4.2.1. 2-Phenyl-4-(D-*threo*-3′-acetoxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5a). It was obtained as a white crystalline solid (166.2 mg) in 60% yield, mp 130–131°C.

R_f: 0.51 (chloroform–methanol, 9:1); $[\alpha]_D^{30}=-8.0$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.09 (3H, s, $OCOCH_3$), 2.99 and 3.05 (2H, 2 brs, 1H each, 2×OH), 4.22–4.26 (2H, m, C-3′H), 4.30–4.32 (1H, m, C-2′H), 4.94 (1H, brs, C-1′H), 7.35–7.37 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 8.02 (2H, d, *J*=7.9 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 21.29 ($OCOCH_3$), 65.56 and 67.63 (C-2′ and C-3′), 72.68 (C-1′), 119.39 (C-3″ and C-5″), 128.21 (C-4″), 129.81 (C-2″ and C-6″), 134.60 (C-5), 140.13 (C-1″), 149.77 (C-4) and 171.77 (C=O); IR (KBr): 3345 (OH), 2928, 1743 (C=O), 1598, 1500, 1373, 1310, 1230, 1124, 1038, 974 and 757 cm^{-1}; FAB-HRMS: *m/z* 300.0988 ([M+Na]$^+$, $C_{13}H_{15}N_3O_4Na$ calcd 300.0960).

4.2.2. 2-Phenyl-4-(D-*threo*-3′-propanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5b). It was obtained as a white crystalline solid (203 mg) in 70% yield, mp 110–112°C. R_f: 0.54 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-25.4$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.15 (3H, t, *J*=7.3 Hz, $OCOCH_2CH_3$), 2.34–2.42 (2H, q, *J*=7.3 Hz, $OCOCH_2CH_3$), 2.98 and 3.03 (2H, 2 brs, 1H each, 2×OH), 4.23–4.28 (2H, m, C-3′H), 4.31–4.36 (1H, m, C-2′H), 4.94 (1H, brs, C-1′H), 7.32–7.37 (1H, m, C-4″H), 7.45–7.50 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 8.02 (2H, d, *J*=7.9 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 9.03 ($OCOCH_2CH_3$), 27.45 ($OCOCH_2CH_3$), 64.97 and 67.17 (C-2′ and C-3′), 72.28 (C-1′), 118.90 (C-3″ and C-5″), 127.72 (C-4″), 129.32 (C-2″ and C-6″), 134.12 (C-5), 139.65 (C-1″), 149.28 (C-4) and 174.80 (C=O); IR (KBr): 3352 (OH), 2926, 1751 (C=O), 1499, 1182, 975 and 753 cm^{-1}; FAB-HRMS: *m/z* 314.1146 ([M+Na]$^+$, $C_{14}H_{17}N_3O_4Na$ calcd 314.1117).

4.2.3. 2-Phenyl-4-(D-*threo*-3′-butanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5c). It was obtained as a white solid (298 mg) in 98% yield, mp 90°C. R_f: 0.56 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-17.2$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.95 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_2CH_3$), 1.63–1.70 (2H, m, $OCOCH_2CH_2CH_3$), 2.34 (2H, t, *J*=7.4 Hz, $OCOCH_2CH_2CH_3$), 4.23–4.28 (2H, m, C-3′H), 4.33–4.36 (1H, m, C-2′H), 4.95 (1H, brs, C-1′H), 7.35–7.38 (1H, m, C-4″H), 7.45–7.50 (2H, m, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.01–8.05 (2H, m, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 12.87 ($OCO(CH_2)_2CH_3$), 17.62 ($OCOCH_2CH_2CH_3$), 35.27 ($OCOCH_2CH_2CH_3$), 64.10 and 66.43 (C-2′ and C-3′), 71.54 (C-1′), 118.14 (C-3″ and C-5″), 126.96 (C-4″), 128.56 (C-2″ and C-6″), 133.38 (C-5), 138.89 (C-1″), 148.56 (C-4) and 173.28 (C=O); IR (KBr): 3433 (OH), 2926, 1727 (C=O), 1500, 1462, 1103, 967 and 752 cm^{-1}; FAB-HRMS: *m/z* 328.1289 ([M+Na]$^+$, $C_{15}H_{19}N_3O_4Na$ calcd 328.1273).

4.2.4. 2-Phenyl-4-(D-*threo*-3′-pentanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5d). It was obtained as colorless oil (309 mg) in 97% yield. R_f: 0.57 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-9.6$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.91 (3H, t, *J*=7.3 Hz, $OCO(CH_2)_3CH_3$), 1.31–1.41 (2H, m, OCO $(CH_2)_2CH_2CH_3$), 1.57–1.67 (2H, m, $OCOCH_2CH_2CH_2CH_3$), 2.35 (2H, t, *J*=7.5 Hz, $OCOCH_2(CH_2)_2CH_3$), 4.22–4.28 (2H, m, C-3′H), 4.31–4.36 (1H, m, C-2′H), 4.94 (1H, brs, C-1′H), 7.33–7.37 (1H, m, C-4″H), 7.45–7.50 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 8.03 (2H, d, *J*=7.9 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.66 ($OCO(CH_2)_3CH_3$), 22.20 ($OCO(CH_2)_2CH_2CH_3$), 26.96 ($OCOCH_2CH_2CH_2CH_3$), 33.89 ($OCOCH_2(CH_2)_2CH_3$), 64.89 and 67.20 (C-2′ and C-3′), 72.35 (C-1′), 118.93 (C-3″ and C-5″), 127.73 (C-4″), 129.33 (C-2″ and C-6″), 134.15 (C-5), 139.66 (C-1″), 149.27 (C-4) and 179.76 (C=O); IR (KBr): 3408 (OH), 2927, 1728 (C=O), 1176, 1104 and 756 cm^{-1}; FAB-HRMS: *m/z* 342.1423 ([M+Na]$^+$, $C_{16}H_{21}N_3O_4Na$ calcd 342.1430).

4.2.5. 2-Phenyl-4-(D-*threo*-3′-hexanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5e). It was obtained as colorless oil (326 mg) in 98% yield. R_f: 0.58 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-20.0$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.88 (3H, t, *J*=6.6 Hz, $OCO(CH_2)_4CH_3$), 1.28–1.31 (4H, m, $OCO(CH_2)_2CH_2CH_2CH_3$), 1.59–1.67 (2H, m, $OCOCH_2CH_2(CH_2)_2CH_3$), 2.33 (2H, t, *J*=7.4 Hz, $OCOCH_2(CH_2)_3CH_3$), 3.19 (2H, 2 brs, 1H each, 2×OH), 4.18–4.34 (3H, m, C-2′H and C-3′H), 4.93 (1H, brs, C-1′H), 7.32–7.36 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.84 (1H, s, C-5H) and 8.02 (2H, d, *J*=7.8 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.88 ($OCO(CH_2)_4CH_3$), 22.28 ($OCO(CH_2)_3CH_2CH_3$), 24.57 ($OCO(CH_2)_2CH_2CH_2CH_3$), 31.28 ($OCOCH_2CH_2(CH_2)_2CH_3$), 34.13 ($OCOCH_2(CH_2)_3CH_3$), 64.88 and 67.19 (C-2′ and C-3′), 72.30 (C-1′), 118.90 (C-3″ and C-5″), 127.71 (C-4″), 129.32 (C-2″ and C-6″), 134.14 (C-5), 139.65 (C-1″), 149.33 (C-4) and 174.23 (C=O); IR (KBr): 3413 (OH), 2957, 2931, 1737 (C=O), 1498, 1173, 968 and 757 cm^{-1}; FAB-HRMS: *m/z* 356.1590 ([M+Na]$^+$, $C_{17}H_{23}N_3O_4Na$ calcd 356.1586).

4.2.6. 2-Phenyl-4-(D-*threo*-3′-heptanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5f). It was obtained as colorless oil (340 mg) in 98% yield. R_f: 0.60 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-22.6$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.87 (3H, brs, $OCO(CH_2)_5CH_3$), 1.25–1.28 (6H, m, $OCO(CH_2)_2(CH_2)_3CH_3$), 1.60–1.64 (2H, m, $OCOCH_2CH_2(CH_2)_3CH_3$), 2.34 (2H, t, *J*=7.4 Hz, $OCOCH_2(CH_2)_4CH_3$), 4.22–4.35 (3H, m, C-2′H and C-3′H), 4.95 (1H, brs, C-1′H), 7.32–7.37 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 8.02 (2H, d, *J*=8.0 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 14.35 ($OCO(CH_2)_5CH_3$), 22.82 ($OCO(CH_2)_4CH_2CH_3$), 25.22 ($OCO(CH_2)_3CH_2CH_2CH_3$), 29.15 ($OCO(CH_2)_2CH_2(CH_2)_2CH_3$), 31.78 ($OCOCH_2CH_2(CH_2)_3CH_3$), 34.54 ($OCOCH_2(CH_2)_4CH_3$), 65.24 and 67.56 (C-2′ and C-3′), 72.68 (C-1′), 119.27 (C-3″ and C-5″), 128.08 (C-4″), 129.68 (C-2″ and C-6″), 134.50 (C-5), 140.02 (C-1″), 149.66 (C-4) and 174.59 (C=O); IR (KBr): 3415 (OH), 2928, 1726 (C=O), 1498, 1169, 968 and 756 cm^{-1}; FAB-HRMS: *m/z* 370.1767 ([M+Na]$^+$, $C_{18}H_{25}N_3O_4Na$ calcd 370.1743).

4.2.7. 2-Phenyl-4-(D-*threo*-3′-benzoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (5g). It was obtained as a white crystalline solid (220 mg) in 65% yield, mp 137–138°C. R_f: 0.57 (chloroform–methanol, 9:1); $[\alpha]_D^{30}=-23.0$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, DMSO-d_6): δ 4.09 (1H, brs, C-2′H), 4.24–4.30 and 4.36–4.42 (2H, 2m, 1H each, C-3′H_a and C-3′H_b), 4.93 (1H, brs, C-1′H), 5.33 and 5.73 (2H, 2 brs, 1H each, 2×OH), 7.36–7.95 (10H, m,

Ar-H) and 8.02 (1H, s, C-5H); ^{13}C NMR (75.5 MHz, DMSO-d_6): δ 66.77 and 68.01 (C-2′ and C-3′), 72.23 (C-1′), 119.19, 128.43, 129.54, 129.64, 130.19, 130.26, 130.64, 130.76, 133.85, 134.25, 136.15, 140.27, 152.50 (aromatic carbons, C-4 and C-5) and 166.67 (C═O); IR (KBr): 3330 (OH), 2925, 1720 (C═O), 1271, 1130 and 712 cm^{-1}; FAB-HRMS: *m/z* 362.1129 ([M+Na]$^+$, $C_{18}H_{17}N_3O_4Na$ calcd 362.1117).

4.2.8. 2-Phenyl-4-(D-*erythro*-3′-acetoxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6a). It was obtained as a white crystalline solid (138 mg) in 50% yield, mp 85–87°C. R_f: 0.52 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+15.8 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.10 (3H, s, $OCOCH_3$), 3.06–3.13 (2H, 2brs, 1H each, 2×OH), 4.20–4.40 (3H, m, C-2′H and C-3′H), 4.96 (1H, brs, C-1′H), 7.35 (1H, t, *J*=7.26 Hz, C-4″H), 7.47 (2H, t, *J*=7.71 Hz, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.03 (2H, t, *J*=7.99 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 21.18 ($OCOCH_3$), 65.50 and 68.08 (C-2′ and C-3′), 73.35 (C-1′), 119.25 (C-3″ and C-5″), 128.10 (C-4″), 129.70 (C-2″ and C-6″), 134.59 (C-5), 139.98 (C-1″), 149.48 (C-4) and 172.13 (C═O); IR (KBr): 3342 (OH), 2903, 1740 (C═O), 1250, 1055 and 766 cm^{-1}; FAB-HRMS: *m/z* 300.0976 ([M+Na]$^+$, $C_{13}H_{15}N_3O_4Na$ calcd 300.0960).

4.2.9. 2-Phenyl-4-(D-*erythro*-3′-propanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6b). It was obtained as a white crystalline solid (116 mg) in 40% yield, mp 86–88°C. R_f: 0.55 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+26.6 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.13 (3H, t, *J*=7.4 Hz, $OCOCH_2CH_3$), 2.33–2.40 (2H, m, $OCOCH_2CH_3$), 3.20 (2H, 2 brs, 1H each, 2×OH), 4.19–4.40 (3H, 2m, 2H and 1H each, C-3′H and C-2′H), 4.95 (1H, d, *J*=5.4 Hz, C-1′H), 7.34 (1H, t, *J*=7.1 Hz, C-4″H), 7.47 (2H, t, *J*=7.4 Hz, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.01 (2H, d, *J*=7.8 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 8.83 ($OCOCH_2CH_3$), 27.43 ($OCOCH_2CH_3$), 64.92 and 67.83 (C-2′ and C-3′), 72.86 (C-1′), 118.90 (C-3″ and C-5″), 127.69 (C-4″), 129.32 (C-2″ and C-6″), 134.36 (C-5), 139.60 (C-1″), 149.14 (C-4) and 175.31 (C═O); IR (KBr): 3329 (OH), 2905, 1741 (C═O), 1498, 1192, 1057 and 759 cm^{-1}; FAB-HRMS: *m/z* 314.1151 ([M+Na]$^+$, $C_{14}H_{17}N_3O_4Na$ calcd 314.1117).

4.2.10. 2-Phenyl-4-(D-*erythro*-3′-butanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6c). It was obtained as a white solid (301 mg) in 99% yield, mp 135–137°C. R_f: 0.56 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+13.8 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.88 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_2CH_3$), 1.53–1.65 (2H, m, $OCOCH_2CH_2CH_3$), 2.27 (2H, t, *J*=7.4 Hz, $OCOCH_2CH_2CH_3$), 3.00 (2H, 2 brs, 1H each, 2×OH), 4.08–4.13 (1H, m, C-3′$H_{a/b}$), 4.17–4.22 (1H, dd, *J*=11.9 and 3.3 Hz, C-3′$H_{b/a}$), 4.30–4.36 (1H, dd, *J*=11.9 and 5.7 Hz, C-2′H), 4.87 (1H, d, *J*=5.9 Hz, C-1′H), 7.28 (1H, t, *J*=7.3 Hz, C-4″H), 7.41 (2H, t, *J*=8.1 Hz, C-3″H and C-5″H), 7.79 (1H, s, C-5H) and 7.95 (2H, d, *J*=7.8 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 12.60 ($OCO(CH_2)_2CH_3$), 17.37 ($OCOCH_2CH_2CH_3$), 35.00 ($OCOCH_2CH_2CH_3$), 63.89 and 66.68 (C-2′ and C-3′), 72.05 (C-1′), 117.86 (C-3″ and C-5″), 126.96 (C-4″), 128.31 (C-2″ and C-6″), 133.21 (C-5), 138.60 (C-1″), 148.13 (C-4) and 173.47 (C═O); IR (KBr): 3406 (OH), 2927, 1740 (C═O), 1462, 1185, 1058 and 756 cm^{-1}; FAB-HRMS: *m/z* 328.1290 ([M+Na]$^+$, $C_{15}H_{19}N_3O_4Na$ calcd 328.1273).

4.2.11. 2-Phenyl-4-(D-*erythro*-3′-pentanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6d). It was obtained as a white solid (261 mg) in 82% yield, mp 53–54°C. R_f: 0.56 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+25.8 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.90 (3H, t, *J*=7.5 Hz, $OCO(CH_2)_3CH_3$), 1.32–1.34 (2H, m, $OCO(CH_2)_2CH_2CH_3$), 1.60 (2H, brs, $OCOCH_2CH_2CH_2CH_3$), 2.34 (2H, brs, $OCOCH_2(CH_2)_2CH_3$), 3.12–3.24 (2H, brs, 2×OH), 4.19–4.35 (3H, m, 2H and 1H each, respectively, C-3′H and C-2′H), 4.94 (1H, s, C-1′H), 7.35 (1H, m, C-4″H), 7.47 (2H, brs, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.02 (2H, brs, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 12.90 ($OCO(CH_2)_3CH_3$), 21.47 ($OCO(CH_2)_2CH_2$ CH_3), 26.19 ($OCOCH_2CH_2CH_2CH_3$), 33.12 ($OCOCH_2(CH_2)_2CH_3$), 64.16 and 66.93 (C-2′ and C-3′), 72.28 (C-1′), 118.11 (C-3″ and C-5″), 126.95 (C-4″), 128.57 (C-2″ and C-6″), 133.48 (C-5), 139.30 (C-1″), 148.39 (C-4) and 173.95 (C═O); IR (KBr): 3342 (OH), 2931, 1739 (C═O), 1498, 1182, 971 and 757 cm^{-1}; FAB-HRMS: *m/z* 342.1454 ([M+Na]$^+$, $C_{16}H_{21}N_3O_4Na$ calcd 342.1430).

4.2.12. 2-Phenyl-4-(D-*erythro*-3′-hexanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6e). It was obtained as a white crystalline solid (276 mg) in 83% yield, mp 58–59°C. R_f: 0.59 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+21.4 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.88 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_4CH_3$), 1.28 (4H, brs, $OCO(CH_2)_2(CH_2)_2CH_3$), 1.61 (2H, brs, $OCOCH_2CH_2(CH_2)_2CH_3$), 2.32 (2H, t, *J*=7.3 Hz, $OCOCH_2(CH_2)_3CH_3$), 2.93 (2H, brs, 2×OH), 4.19–4.39 (3H, m, 2H and 1H each, respectively, C-3′H and C-2′H), 4.95 (1H, d, *J*=5.3 Hz, C-1′H), 7.34–7.36 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.01 (2H, d, *J*=7.7 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 12.36 ($OCO(CH_2)_4CH_3$), 20.76 ($OCO(CH_2)_3CH_2CH_3$), 23.06 ($OCO(CH_2)_2CH_2CH_2CH_3$), 29.75 ($OCOCH_2CH_2$ $(CH_2)_2CH_3$), 32.62 ($OCOCH_2(CH_2)_3CH_3$), 63.41 and 66.21 (C-2′ and C-3′), 71.52 (C-1′), 117.36 (C-3″ and C-5″), 126.19 (C-4″), 127.81 (C-2″ and C-6″), 132.73 (C-5), 138.11 (C-1″), 147.65 (C-4) and 173.18 (C═O); IR (KBr): 3341 (OH), 2931, 1741 (C═O), 1498, 1180, 1056 and 757 cm^{-1}; FAB-HRMS: *m/z* 356.1595 ([M+Na]$^+$, $C_{17}H_{23}N_3O_4Na$ calcd 356.1586).

4.2.13. 2-Phenyl-4-(D-*erythro*-3′-heptanoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6f). It was obtained as a white solid (288 mg) in 83% yield, mp 68–70°C. R_f: 0.60 (chloroform–methanol, 9:1); $[\alpha]_D^{22}$=+17.9 (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.87 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_5CH_3$), 1.27 (6H, brs, $OCOCH_2CH_2(CH_2)_3CH_3$), 1.60 (2H, brs, $OCOCH_2CH_2$ $(CH_2)_3CH_3$), 2.33 (2H, t, *J*=7.3 Hz, $CH_2OCOCH_2(CH_2)_4CH_3$), 3.30 (2H, brs, 2×OH), 4.19–4.40 (3H, m, 2H and 1H each, respectively, C-3′H and C-2′H), 4.95 (1H, d, *J*=5.0 Hz, C-1′H), 7.32–7.37 (1H, m, C-4″H), 7.44–7.49 (2H, m, C-3″H and C-5″H), 7.86 (1H, s, C-5H) and 8.02 (2H, d, *J*=7.7 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 14.02 ($OCO(CH_2)_5CH_3$), 22.48 ($OCO(CH_2)_4CH_2CH_3$), 24.88 ($OCO(CH_2)_3CH_2CH_2CH_3$), 28.80 ($OCO(CH_2)_2CH_2$ $(CH_2)_2CH_3$), 31.43 ($OCOCH_2CH_2(CH_2)_3CH_3$), 34.20

($OCOCH_2(CH_2)_4CH_3$), 64.94 and 67.77 (C-2′ and C-3′), 73.05 (C-1′), 118.89 (C-3″ and C-5″), 127.71 (C-4″), 129.35 (C-2″ and C-6″), 134.29 (C-5), 139.65 (C-1″), 149.22 (C-4) and 174.70 (C=O); IR (KBr): 3340 (OH), 2928, 1740 (C=O), 1177, 1055 and 757 cm^{-1}; FAB-HRMS: *m/z* 370.1744 ($[M+Na]^+$, $C_{18}H_{25}N_3O_4Na$ calcd 370.1743).

4.2.14. 2-Phenyl-4-(D-*erythro*-3′-benzoyloxy-1′,2′-dihydroxypropyl)-2*H*-1,2,3-triazole (6g). It was obtained as a white crystalline solid (183 mg) in 54% yield, mp 65–67°C. R_f: 0.59 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=+10.9$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 4.35 (1H, brs, C-2′H), 4.46–4.61 (2H, m, C-3′H), 5.07 ((1H, brs, C-1′H), 7.27–7.49 (6H, m, Ar-H), 7.86 (1H, s, C-5H) and 7.94–7.96 (4H, m, Ar-H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 67.37 and 69.82 (C-2′ and C-3′), 74.93 (C-1′), 120.76, 129.54, 130.31, 131.17, 131.40, 131.64, 135.21, 136.21, 141.48, 151.09 (aromatic carbons, C-4 and C-5) and 169.15 (C=O); IR (KBr): 3339 (OH), 2923, 1721 (C=O), 1271, 1112, 1049 and 713 cm^{-1}; FAB-HRMS: *m/z* 362.1154 ($[M+Na]^+$, $C_{18}H_{17}N_3O_4Na$ calcd 362.1117).

4.2.15. 2-Phenyl-4-(D-*arabino*-4′-acetoxy-1′,2′, 3′-trihydroxybutyl)-2*H*-1,2,3-triazole (7a). It was obtained as a white crystalline solid (46 mg) in 15% yield, mp 111–113°C. R_f: 0.49 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-10.7$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 2.12 (3H, s, $OCOCH_3$), 2.91–3.19 (3H, brs, 3 x OH), 3.97 (1H, brs, C-2′H), 4.03 (1H, brs, C-3′H), 4.36–4.38 (1H, m, C-4′H_a), 4.44–4.47 (1H, m, C-4′H_b), 5.26 (1H, s, C-1′H), 7.33–7.37 (1H, m, C-4″H), 7.45–7.50 (2H, m, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.02 (2H, d, *J*=7.86 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 22.60 ($OCOCH_3$), 68.10 and 68.20 (C-2′ and C-4′), 72.48 (C-3′), 74.73 (C-1′), 120.65 (C-3″ and C-5″), 129.48 (C-4″), 131.09 (C-2″ and C-6″), 136.08 (C-5), 141.07 (C-1″), 151.85 (C-4) and 173.67 (C=O); IR(KBr): 3428 (OH), 2924, 1707 (C=O), 1284, 1092, 1039 and 753 cm^{-1}; FAB-HRMS: *m/z* 330.1086 ($[M+Na]^+$, $C_{14}H_{17}N_3O_5Na$ calcd 330.1066).

4.2.16. 2-Phenyl-4-(D-*arabino*-4′-propanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (7b). It was obtained as a white solid (64 mg) in 20% yield, mp 109–110°C. R_f: 0.51 (chloroform–methanol, 9:1); $[\alpha]_D^{30}=-33.1$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 1.17 (3H, t, *J*=7.5 Hz, $OCOCH_2CH_3$), 2.37–2.45 (2H, q, *J*=7.5 Hz, $OCOCH_2CH_3$), 2.85 (1H, brs, OH), 3.02 and 3.10 (2H, 2 brs, 2×OH), 3.95–4.03 (2H, m, C-2′H and C-3′H), 4.34–4.40 (1H, dd, *J*=12.0 Hz and 5.5 Hz, C-4′H_a), 4.45–4.49 (1H, m, C-4′H_b), 5.27 (1H, brs, C-1′H), 7.33–7.38 (1H, m, C-4″H), 7.48 (2H, t, *J*=7.6 Hz, C-3″H and C-5″H), 7.88 (1H, s, C-5H) and 8.03 (2H, d, *J*=7.6 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 9.07 ($OCOCH_2CH_3$), 27.51 ($OCOCH_2CH_3$), 66.28 and 66.52 (C-2′ and C-4′), 70.91 (C-3′), 72.96 (C-1′), 118.90 (C-3″ and C-5″), 127.73 (C-4″), 129.35 (C-2″ and C-6″), 134.33 (C-5), 139.60 (C-1″), 150.14 (C-4) and 177.05 (C=O); IR (KBr): 3446 (OH), 2924, 1718 (C=O), 1459, 1198, 1094, 964 and 748 cm^{-1}; FAB-HRMS: *m/z* 344.1256 ($[M+Na]^+$, $C_{15}H_{19}N_3O_5Na$ calcd 344.1222).

4.2.17. 2-Phenyl-4-(D-*arabino*-4′-butanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (7c). It was obtained as a white crystalline solid (331 mg) in 99% yield, mp 110–112°C. R_f: 0.53 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-43.9$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 0.87 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_2CH_3$), 1.54–1.61 (2H, m, $OCOCH_2CH_2CH_3$), 2.26 (2H, t, *J*=7.4 Hz, $OCOCH_2CH_2CH_3$), 3.88–3.91 (1H, m, C-2′H), 3.99–4.01 (1H, brs, C-3′H), 4.24–4.30 (1H, m, C-4′H_a), 4.36–4.41 (1H, m, C-4′H_b), 5.23 (1H, brs, C-1′H), 7.25–7.30 (1H, m, C-4″H), 7.37–7.42 (2H, m, C-3″H and C-5″H), 7.85 (1H, s, C-5H) and 7.92 (2H, d, *J*=7.6 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.49 ($OCO(CH_2)_2CH_3$), 18.25 ($OCOCH_2CH_2CH_3$), 35.92 ($OCOCH_2CH_2CH_3$), 65.93 and 66.17 (C-2′ and C-4′), 70.42 (C-3′), 73.11 (C-1′), 118.74 (C-3″ and C-5″), 127.54 (C-4″), 129.18 (C-2″ and C-6″), 134.26 (C-5), 139.49 (C-1″), 150.06 (C-4) and 174.58 (C=O); IR (KBr): 3442 (OH), 2966, 1711 (C=O), 1453, 1192, 964 and 750 cm^{-1}; FAB-HRMS: *m/z* 358.1382 ($[M+Na]^+$, $C_{16}H_{21}N_3O_5Na$ calcd 358.1379).

4.2.18. 2-Phenyl-4-(D-*arabino*-4′-pentanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*,1,2,3-triazole (7d). It was obtained as a white solid (296 mg) in 85% yield, mp 101.5–102.5°C. R_f: 0.54 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-20.0$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 0.90 (3H, t, *J*=7.4 Hz, $OCO(CH_2)_3CH_3$), 1.34 (2H, brs, $OCO(CH_2)_2CH_2CH_3$), 1.61 (2H, brs, $OCOCH_2CH_2CH_2CH_3$), 2.37 (2H, brs, $OCOCH_2(CH_2)_2CH_3$), 3.16–3.40 (3H, 2 brs, 2H and 1H, respectively, 3×OH), 3.95–4.02 (2H, m, C-2′H and C-3′H), 4.37–4.43 (2H, m, C-4′H), 5.26 (1H, s, C-1′H), 7.35 (1H, brs, C-4″H), 7.46 (2H, brs, C-3″H and C-5″H), 7.87 (1H, brs, C-5H) and 8.00 (2H, brs, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 12.91 ($OCO(CH_2)_3CH_3$), 21.47 ($OCO(CH_2)_2CH_2CH_3$), 26.21 ($OCOCH_2CH_2CH_2CH_3$), 33.15 ($OCOCH_2(CH_2)_2CH_3$), 65.38 and 65.63 (C-2′ and C-4′), 69.98 (C-3′), 72.23 (C-1′), 118.10 (C-3″ and C-5″), 126.94 (C-4″), 128.57 (C-2″ and C-6″), 133.59 (C-5), 138.86 (C-1″), 149.38 (C-4) and 174.15 (C=O); IR (KBr): 3448 (OH), 2958, 1720 (C=O), 1187, 1095 and 752 cm^{-1}; FAB-HRMS: *m/z* 372.1565 ($[M+Na]^+$, $C_{17}H_{23}N_3O_5Na$ calcd 372.1535).

4.2.20. 2-Phenyl-4-(D-*arabino*-4′-hexanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*,1,2,3-triazole (7e). It was obtained as a white solid (305 mg) in 84% yield, mp 104–105.2°C. R_f: 0.55 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-21.9$ (*c* 0.01, MeOH); ^1H NMR (300 MHz, $CDCl_3$): δ 0.88 (3H, t, *J*=6.6 Hz, $OCO(CH_2)_4CH_3$), 1.30 (4H, brs, $OCO(CH_2)_2(CH_2)_2CH_3$), 1.61–1.66 (2H, m, $OCOCH_2CH_2(CH_2)_2CH_3$), 2.37 (2H, t, *J*=7.5 Hz, $OCOCH_2(CH_2)_3CH_3$), 3.93–3.96 (1H, m, C-2′H), 4.02–4.04 (1H, m, C-3′H), 4.33–4.39 (1H, m, C-4′H_a), 4.43–4.48 (1H, m, C-4′H_b), 5.27 (1H, brs, C-1′H), 7.32–7.37 (1H, m, C-4″H), 7.45–7.50 (2H, m, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.01 (2H, d, *J*=8.0 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.13 ($OCO(CH_2)_4CH_3$), 21.54 ($OCO(CH_2)_3CH_2CH_3$), 23.85 ($OCO(CH_2)_2CH_2CH_2CH_3$), 30.52 ($OCOCH_2CH_2$ $(CH_2)_2CH_3$), 33.41 ($OCOCH_2(CH_2)_3CH_3$), 65.39 and 65.65 (C-2′ and C-4′), 70.03 (C-3′), 72.17 (C-1′), 118.12 (C-3″ and C-5″), 126.96 (C-4″), 128.58 (C-2″ and C-6″), 133.59 (C-5), 138.85 (C-1″), 149.36 (C-4) and 174.19 (C=O); IR (KBr): 3437 (OH), 2953, 1721 (C=O), 1183, 1043 and 751 cm^{-1}; FAB-HRMS: *m/z* 386.1720 ($[M+Na]^+$, $C_{18}H_{25}N_3O_5Na$ calcd 386.1692).

4.2.21. 2-Phenyl-4-(D-*arabino*-4′-heptanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (7f). It was obtained as a white solid (320.5 mg) in 85% yield, mp 106.6–107.6°C. R_f: 0.58 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-15.3$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.86 (3H, brs, $OCO(CH_2)_5CH_3$), 1.27 (6H, brs, $OCO(CH_2)_2(CH_2)_3CH_3$), 1.62 (2H, brs, $OCOCH_2CH_2(CH_2)_3CH_3$), 2.35 (2H, t, J=7.3 Hz, $OCOCH_2(CH_2)_4CH_3$), 3.20 (2H, brs, 2×OH), 3.45 (1H, brs, OH), 3.93 (1H, d, J=6.6 Hz, C-2′H), 4.03 (1H, brs, C-3′H), 4.35 (1H, d, J=11.5 Hz, C-4′H_a), 4.44 (1H, d, J=11.8 Hz, C-4′H_b), 5.26 (1H, brs, C-1′H), 7.31–7.36 (1H, m, C-4″H), 7.43–7.48 (2H, m, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.0 (2H, d, J=7.8 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.22 ($OCO(CH_2)_5CH_3$), 21.69 ($OCO(CH_2)_4CH_2CH_3$), 24.12 ($OCO(CH_2)_3CH_2CH_2CH_3$), 28.02 ($OCO(CH_2)_2CH_2(CH_2)_2CH_3$), 30.65 ($OCOCH_2CH_2(CH_2)_3CH_3$), 33.45 ($OCOCH_2(CH_2)_4CH_3$), 65.36 and 65.62 (C-2′ and C-4′), 69.97 (C-3′), 72.26 (C-1′), 118.10 (C-3″ and C-5″), 126.93 (C-4″), 128.56 (C-2″ and C-6″), 133.59 (C-5), 138.86 (C-1″), 149.38 (C-4) and 174.16 (C=O); IR (KBr): 3444 (OH), 2954, 2925, 1722 (C=O), 1396, 1241, 1183, 1042 and 751 cm^{-1}; FAB-HRMS: *m/z* 400.1871 ([M+Na]$^+$, $C_{19}H_{27}N_3O_5Na$ calcd 400.1848).

4.2.22. 2-Phenyl-4-(D-*arabino*-4′-benzoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (7g). It was obtained as a white crystalline solid (55 mg) in 15% yield, mp 151–152°C. R_f: 0.56 (chloroform–methanol, 9:1); $[\alpha]_D^{30}=-14.8$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, DMSO-d_6): δ 3.68, 4.00 and 4.29 (3H, 3 brs, 3×OH), 4.54 (1H, m, C-2′H), 4.92 (1H, d, J=7.0 Hz, C-3′H), 5.18–5.24 (2H, m, C-4′H), 5.36–5.38 (1H, brs, C-1′H), and 7.37–7.62 and 7.97–8.06 (11H, m, Ar-H and C-5H); ^{13}C NMR (75.5 MHz, DMSO-d_6): δ 66.29 and 68.19 (C-2′ and C-4′), 69.31 (C-3′), 74.83 (C-1′), 119.07, 128.12, 129.41, 130.28, 130.44, 133.91, 136.20, 140.39, 153.80 (aromatic carbons, C-4 and C-5) and 166.90 (C=O); IR (KBr): 3448 (OH), 2925, 1714 (C=O), 1279, 1042 and 707 cm^{-1}; FAB-HRMS: *m/z* 392.1255 ([M+Na]$^+$, $C_{19}H_{19}N_3O_5Na$ calcd 392.1222).

4.2.23. 2-Phenyl-4-(D-*lyxo*-4′-acetoxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8a). It was obtained as a white crystalline solid (92 mg) in 30% yield, mp 130–134°C. R_f: 0.49 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-15.1$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, DMSO-d_6): δ 2.07 (3H, s, $OCOCH_3$), 3.70 (1H, t, J=7.8 Hz, C-3′H), 4.05–4.11 (3H, brs, 3×OH), 4.67 (1H, d, J=7.5 Hz, C-2′H), 4.81–4.86 (2H, m, C-4′H), 5.61 (1H, d, J=5.54 Hz, C-1′H), 7.44 (1H, t, J=7.2 Hz, C-4″H), 7.57–7.63 (2H, m, C-3″H and C-5″H) and 8.02–8.05 (3H, m, C-2″H, C-6″H and C-5H); ^{13}C NMR (75.5 MHz, DMSO-d_6): δ 21.81 ($OCOCH_3$), 66.43 and 66.67 (C-4′ and C-3′), 68.07 (C-2′), 73.67 (C-1′), 119.11 (C-3″ and C-5″), 128.29 (C-4″), 130.66 (C-2″ and C-6″), 135.98 (C-5), 140.38 (C-1″), 153.72 (C-4) and 171.37 (C=O); IR (KBr): 3446 (OH), 3367 (OH), 3271 (OH), 2938, 1707 (C=O), 1269, 1053, 1014 and 758 cm^{-1}; FAB-HRMS: *m/z* 330.1076 ([M+Na]$^+$, $C_{14}H_{17}N_3O_5Na$ calcd 330.1066).

4.2.24. 2-Phenyl-4-(D-*lyxo*-4′-propanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8b). It was obtained as a white crystalline solid (112 mg) in 35% yield, mp 110–112°C. R_f: 0.50 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-10.4$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.13 (3H, t, J=7.4 Hz, $OCOCH_2CH_3$), 2.32–2.40 (2H, m, $OCOCH_2CH_3$), 3.07 and 3.12 (2H, brs, 2×OH), 3.33 (1H, brs, OH), 3.93 (1H, brs, C-2′H), 4.16 (1H, brs, C-3′H), 4.22–4.34 (2H, m, C-4′H), 5.10 (1H, brs, C-1′H), 7.35 (1H, t, J=7.0 Hz, C-4″H), 7.47 (2H, t, J=7.4 Hz, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.02 (2H, d, J=7.6 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 11.37 ($OCOCH_2CH_3$), 29.83 ($OCOCH_2CH_3$), 68.41 (C-4′), 71.36 and 71.62 (C-3′ and C-1′), 75.37 (C-2′), 121.22 (C-3″ and C-5″), 130.10 (C-4″), 131.70 (C-2″ and C-6″), 136.47 (C-5), 142.00 (C-1″), 152.30 (C-4) and 177.34 (C=O); IR (KBr): 3465 (OH), 3376 (OH), 3295 (OH), 2938, 1710 (C=O), 1211, 1053, 1014 and 755 cm^{-1}; FAB-HRMS: *m/z* 344.1242 ([M+Na]$^+$, $C_{15}H_{19}N_3O_5Na$ calcd 344.1222).

4.2.25. 2-Phenyl-4-(D-*lyxo*-4′-butanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8c). It was obtained as a white solid (318 mg) in 95% yield, mp 97–100°C. R_f: 0.52 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-13.0$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.93 (3H, brs, $OCO(CH_2)_2CH_3$), 1.65 (2H, brs, $OCOCH_2CH_2CH_2CH_3$), 2.31 (2H, brs, $OCOCH_2CH_2CH_3$), 3.17 (3H, 3 brs, 1H each, 3×OH), 3.93 (1H, brs, C-2′H), 4.16 (1H, brs, C-3′H), 4.27 (2H, brs, C-4′H), 5.11 (1H, brs, C-1′H), 7.35 (1H, brs, C-4″H), 7.45 (2H, brs, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.01 (2H, brs, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.47 ($OCO(CH_2)_2CH_3$), 18.23 ($OCOCH_2CH_2CH_3$), 35.91 ($OCOCH_2CH_2CH_3$), 65.78 (C-4′), 68.87 and 69.12 (C-3′ and C-1′), 72.87 (C-2′), 118.73 (C-3″ and C-5″), 127.59 (C-4″), 129.20 (C-2″ and C-6″), 133.97 (C-5), 139.51 (C-1″), 149.81 (C-4) and 174.05 (C=O); IR (KBr): 3430 (OH), 3376 (OH), 3291 (OH), 2932, 2363, 1692 (C=O), 1274, 1053, 1016 and 755 cm^{-1}; FAB-HRMS: *m/z* 358.1362 ([M+Na]$^+$, $C_{16}H_{21}N_3O_5Na$ calcd 358.1379).

4.2.26. 2-Phenyl-4-(D-*lyxo*-4′-pentanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8d). It was obtained as a white solid (307 mg) in 88% yield, mp 65–67°C. R_f: 0.53 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-9.9$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.89 (3H, t, J=7.2 Hz, $OCO(CH_2)_3CH_3$), 1.25–1.39 (2H, m, $OCO(CH_2)_2CH_2CH_3$), 1.54–1.64 (2H, m, $OCOCH_2CH_2CH_2CH_3$), 2.33 (2H, t, J=7.6 Hz, $OCOCH_2(CH_2)_2CH_3$), 3.05, 3.11 and 3.31 (3H, 3 brs, 1H each, 3×OH), 3.93 (1H, brs, C-2′H), 4.15 (1H, brs, C-3′H), 4.21–4.33 (2H, m, C-4′H), 5.10 (1H, brs, C-1′H), 7.35 (1H, t, J=7.3 Hz, C-4″H), 7.47 (2H, t, J=7.5 Hz, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.02 (2H, d, J=8.0 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 14.40 ($OCO(CH_2)_3CH_3$), 22.97 ($OCO(CH_2)_2CH_2CH_3$), 27.68 ($OCOCH_2CH_2CH_2CH_3$), 34.64 ($OCOCH_2(CH_2)_2CH_3$), 66.72 (C-4′), 69.78 and 70.04 (C-3′ and C-1′), 73.73 (C-2′), 119.60 (C-3″ and C-5″), 128.48 (C-4″), 130.09 (C-2″ and C-6″), 134.85 (C-5), 140.38 (C-1″), 150.67 (C-4) and 175.13 (C=O); IR (KBr): 3374 (OH), 3377 (OH), 3282 (OH), 2932, 1691 (C=O), 1278, 1052, 1015, 757 and 667 cm^{-1}; FAB-HRMS: *m/z* 372.1559 ([M+Na]$^+$, $C_{17}H_{23}N_3O_5Na$ calcd 372.1535).

4.2.27. 2-Phenyl-4-(D-*lyxo*-4′-hexanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8e). It was obtained as

a white solid (308.5 mg) in 85% yield, mp 102–104°C. R_f: 0.55 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-12.0$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.87 (3H, t, *J*=6.6 Hz, $OCO(CH_2)_4CH_3$), 1.28–1.30 (4H, m, $OCO(CH_2)_2(CH_2)_2CH_3$), 1.58–1.66 (2H, m, $OCOCH_2CH_2(CH_2)_2CH_3$), 2.32 (2H, t, *J*=7.4 Hz, $OCOCH_2(CH_2)_3CH_3$), 3.12, 3.17 and 3.41 (3H, 3 brs, 1H each, 3×OH), 3.93 (1H, brs, C-2′H), 4.15 (1H, brs, C-3′H), 4.21–4.33 (2H, m, C-4′H), 5.10 (1H, brs, C-1′H), 7.35 (1H, t, *J*=7.2 Hz, C-4″H), 7.47 (2H, t, *J*=7.5 Hz, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.01 (2H, d, *J*=7.7 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 14.61 ($OCO(CH_2)_4CH_3$), 23.01 ($OCO(CH_2)_3CH_2CH_3$), 25.30 ($OCO(CH_2)_2CH_2CH_2CH_3$), 32.01 ($OCOCH_2CH_2(CH_2)_2CH_3$), 34.89 ($OCOCH_2(CH_2)_3CH_3$), 66.69 (C-4′), 69.73 and 70.00 (C-3′ and C-1′), 73.75 (C-2′), 119.60 (C-3″ and C-5″), 128.48 (C-4″), 130.09 (C-2″ and C-6″), 134.86 (C-5), 140.37 (C-1″), 150.69 (C-4) and 175.15 (C=O); IR (KBr): 3463 (OH), 3378 (OH), 3298 (OH), 2936, 1709 (C=O), 1498, 1193, 1053, 1015 and 757 cm^{-1}; FAB-HRMS: *m/z* 386.1693 ($[M+Na]^+$, $C_{18}H_{25}N_3O_5Na$ calcd 386.1692).

4.2.28. 2-Phenyl-4-(D-*lyxo*-4′-heptanoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8f). It was obtained as a white solid (335.5 mg) in 89% yield, mp 97–98°C. R_f: 0.57 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-17.8$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.86 (3H, t, *J*=6.8 Hz, $OCO(CH_2)_5CH_3$), 1.26–1.29 (6H, brs, $OCO(CH_2)_2(CH_2)_3CH_3$), 1.55–1.62 (2H, m, $OCOCH_2CH_2(CH_2)_3CH_3$), 2.32 (2H, t, *J*=7.5 Hz, $OCOCH_2(CH_2)_4CH_3$), 2.36 (3H, brs, 3×OH), 3.92 (1H, d, *J*=4.6 Hz, C-2′H), 4.16 (1H, d, *J*=4.8 Hz, C-3′H), 4.21–4.33 (2H, m, C-4′H), 5.11 (1H, d, *J*=5.9 Hz, C-1′H), 7.35 (1H, t, *J*=7.3 Hz, C-4″H), 7.47 (2H, t, *J*=7.98 Hz, C-3″H and C-5″H), 7.87 (1H, s, C-5H) and 8.01 (2H, d, *J*=7.8 Hz, C-2″H and C-6″H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 13.84 ($OCO(CH_2)_5CH_3$), 22.31 ($OCO(CH_2)_4CH_2CH_3$), 24.70 ($OCO(CH_2)_3CH_2CH_2CH_3$), 28.63 ($OCO(CH_2)_2CH_2CH_2CH_2CH_3$), 31.26 ($OCOCH_2CH_2(CH_2)_3CH_3$), 34.05 ($OCOCH_2(CH_2)_4CH_3$), 65.79 (C-4′), 68.83 and 69.11 (C-3′ and C-1′), 72.87 (C-2′), 118.72 (C-3″ and C-5″), 127.59 (C-4″), 129.20 (C-2″ and C-6″), 133.98 (C-5), 139.50 (C-1″), 149.81 (C-4) and 174.27 (C=O); IR (KBr): 3421 (OH), 3367 (OH), 3278 (OH), 2949, 1691 (C=O), 1280, 1052, 1015 and 758 cm^{-1}; FAB-HRMS: *m/z* 400.1848 ($[M+Na]^+$, $C_{19}H_{27}N_3O_5Na$ calcd 400.1848).

4.2.29. 2-Phenyl-4-(D-*lyxo*-4′-benzoyloxy-1′,2′,3′-trihydroxybutyl)-2*H*-1,2,3-triazole (8g). It was obtained as a white crystalline solid (118 mg) in 32% yield, mp 137–140°C. R_f: 0.57 (chloroform–methanol, 9:1); $[\alpha]_D^{22}=-29.9$ (*c* 0.01, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.23 (3H, brs, 3×OH), 4.06 (1H, brs, C-2′H), 4.33 (1H, brs, C-3′H), 4.49–4.60 (2H, m, C-4′H), 5.17 (1H, d, *J*=5.75 Hz, C-1′H), 7.36–7.50 (6H, m, Ar-H), 7.90 (1H, s, C-5H) and 8.01–8.05 (4H, m, Ar-H); ^{13}C NMR (75.5 MHz, $CDCl_3$): δ 67.02 (C-4′), 69.65 and 69.90 (C-3′ and C-1′), 73.53 (C-2′), 119.39, 128.23, 129.00, 129.85, 130.30, 133.86, 134.64, 140.18, 150.45 (aromatic carbons, C-4 and C-5) and 167.59 (C=O); IR (KBr): 3463 (OH), 3375 (OH), 3307 (OH), 2939, 1690 (C=O), 1283, 1053, 1012 and 706 cm^{-1}; FAB-HRMS: *m/z* 392.1245 ($[M+Na]^+$, $C_{19}H_{19}N_3O_5Na$ calcd 392.1222).

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References

1. Zaks, A.; Dodds, D. R. *Drug Discov. Today* **1997**, *2*, 513–531.
2. Parmar, V. S.; Prasad, A. K.; Pati, H. N.; Kumar, R.; Azim, A.; Roy, S.; Errington, W. *Bioorg. Chem.* **1999**, *27*, 119–134.
3. Bashir, N. B.; Phythian, S. J.; Reason, A. J.; Roberts, S. M. *J. Chem. Soc., Perkin Trans. 1* **1995**, 2203–2222.
4. Collins, P.; Ferrier, R. Monosaccharides: Their Chemistry and Their Roles in Natural Products; Wiley: UK, 1995; 431.
5. Sekiyama, T.; Hatsuya, S.; Tanaka, Y.; Uchiyama, M.; Ono, N.; Iwayama, S.; Oikawa, M.; Suzuki, K.; Okunishi, M.; Tsuji, T. *J. Med. Chem.* **1998**, *41*, 1284–1298.
6. Wengel, J. *Acc. Chem. Res.* **1999**, *32*, 301–310.
7. Zhang, X.; Qing, F.-L. *J. Org. Chem.* **2002**, *67*, 1016–1019.
8. Yamada, K.; Sakata, S.; Yoshimura, Y. *J. Org. Chem.* **1998**, *63*, 6891–6899.
9. Reist, E. J.; Fisher, L. V.; Goodman, L. *J. Org. Chem.* **1968**, *33*, 189–192.
10. Prasad, A. K.; Wengel, J. *Nucleosides Nucleotides* **1996**, *15*, 1347–1359.
11. Prasad, A. K.; Sorensen, M. D.; Parmar, V. S.; Wengel, J. *Tetrahedron Lett.* **1995**, *36*, 6163–6166.
12. Sharma, S. K.; Roy, S.; Kumar, R.; Parmar, V. S. *Tetrahedron Lett.* **1999**, *40*, 9145–9146.
13. Prasad, A. K.; Himanshu; Bhattacharya, A.; Olsen, C. E.; Parmar, V. S. *Bioorg. Med. Chem.* **2002**, *10*, 947–951.
14. Prasad, A. K.; Roy, S.; Kumar, R.; Kalra, N.; Wengel, J.; Olsen, C. E.; Cholli, A. L.; Samuelson, L. A.; Kumar, J.; Watterson, A. C.; Gross, R. A.; Parmar, V. S. *Tetrahedron* **2003**, *59*, 1333–1338.
15. Raunak; Prasad, A. K.; Shakil, N. A.; Himanshu; Parmar, V. S. *Pure Appl. Chem.* **2001**, *73*, 167–174.
16. Himanshu; Tyagi, R.; Olsen, C. E.; Errington, W.; Parmar, V. S.; Prasad, A. K. *Bioorg. Med. Chem.* **2002**, *10*, 963–968.
17. Tipson, R. S. *Methods in Carbohydrates Chemistry*; Academic: New York, 1963; Vol. 2. p 16.
18. Hann, R. M.; Hudson, C. S. *J. Am. Chem. Soc.* **1944**, *66*, 735–738.
19. Haskins, W. T.; Hann, R. M.; Hudson, C. S. *J. Am. Chem. Soc.* **1946**, *68*, 1766–1769.
20. Haskins, W. T.; Hann, R. M.; Hudson, C. S. *J. Am. Chem. Soc.* **1945**, *67*, 939–941.