Carbohydr. Res 341,1930 (2006)

DBU assisted Aldol type reaction and elimination: an expeditious synthesis of glycosyl 1,3-dienes via glycosylated β-hydroxy esters

Shyam S. Verma, Namrata Dwivedi, Biswajit. K. Singh and Rama P. Tripathi*
Medicinal and Process Chemistry Division, Central Drug Research Institute, Lucknow- India 226001

Abstract: A novel method for the synthesis of glycosyl dienes *via* aldol type condensation has been reported. DBU catalysed condensation of unsaturated glycosyl uronoates with aldehydes produces the corresponding β-hydroxy esters, which on treatment with methanesulfonylchloride gave the corresponding methanesulfonyloxy derivative as an intermediate. Later on E2 reaction catalyzed again with DBU gave the respective glycosyl dienes in moderate to good yield.

Key Words: DBU, Aldol type condensation, Glycosyl uronoates, Glycosyl Dienes

1. Introduction

Conjugated 1,3-butadienes are not only synthetically important intermediates but also biologically important structural units in most naturally occurring molecules and synthetic polymers.[1,2] As synthetic intermediates 1,3-butadienes have been used in organic synthesis in electrophilic addition and particularly in Diels-Alder cycloadditions for the synthesis of large variety of biologically active compounds.[3] *C*-Glycosides as chiral building blocks have been used for the synthesis of many antibiotics and other compounds of great medicinal value.[4] The enantioselective cycloaddition reactions leading to many biologically important molecules have generally been achieved either by use of chiral catalyst [5] or by chiral dienophile[6]. However, the use of chiral dienes in such reactions is of very limited notice primarily due to their difficult synthesis or low yields during reactions. A number of reports exist in the literature for the synthesis of chiral dienes.[7-10]

Among various practical methods for the synthesis of 1,3-chiral dienes reported in the literature very recently, synthesis of glycosyl dienes by dehydrohalogenation of the preformed sugar dihalides with DBU[11]; and addition of allyl magnesium halide to the sugar lactones[12] followed by dehydration are noteworthy. Encouraged by the above reports we were interested to synthesize glycosyl dienes wherein the conjugated 1,3-diene system is attached with C-4 of the glycofuranose ring. Our strategy is based on the β, γ- unsaturated glycosyl uronoates as a starting material, which were already obtained earlier by our group as an unexpected isomerisation product during Michael addition of amines on α, β-unsaturated glycosyl uronoates.[13] We thought if we could introduce a leaving group such as methansulfonyloxy group β- to the existing double bond the purpose would be solved as the elimination of the leaving group

---

CDRI Communication No. 6761

* Correspondence, Email: rpt_56@yahoo.com Fax No.91-522-2624305, Ph. No. 91-522-262412 Ext.4382

(methansulfonyloxy) would introduce another double bond conjugated with the existing one as well as with the carbethoxy group. This, in turn, can be achieved by Aldol type condensation of the starting unsaturated glycosyl uronoates **2a** and **2b** with different aldehydes leading to the formation of β-hydroxy esters followed by mesylation and E2 reaction.

One of the important methods to prepare β-hydroxy esters is Aldol type condensation in presence of bases and Lewis acids.[14] However; these methods suffer the drawback of either low yields or incompatibility of the reagents with the functional group present in the molecule. DBU promoted condensation of acyldiazomethanes to aldehydes and imines,[15] and a direct catalytic Aldol type condensation of aldehydes with ethyl diazoacetate has been reported by Wang group recently. [16] Encouraged with the above we were prompted to prepare the required intermediate β-hydroxy esters by Aldol type reaction of glycosyl uronoates **2a** and **2b** with different aldehydes.

Our method of preparing glycosyl dienes is novel in the sense that the reaction conditions are very simple, involve the use of inexpensive reagents and only one base DBU performs all the three functions of isomerisation, condensation and elimination. No special work up is required and the products are purified by simple filtration on a short column of silica. To the best of our knowledge this is the first approach to synthesize glycosyl dienes by Aldol type condensation followed by elimination. These dienes bearing stereochemically rich sugars may be used in many enantioselective syntheses.[17]

2. Results and discussion

The required β, γ- unsaturated glycosyl uronoates (**2a** and **2b**) were obtain on heating α, β- unsaturated glycosyl uronoates (**1a** and **1b)** with DBU (1,8-diazabicyclo[5.4.0]undec-7-ene) (25 mol %), in dry THF at 80^0C for 5 hrs as earlier reported by us separately [13] (Scheme **1**).

Please insert Scheme 1

The above β,γ- unsaturated uronoates (**2a** and **2b**) have *Z* geometry and were characterized on the basis of their physical data and microanalysis. The disappearance of H-4 signals (at δ 4.20 and 4.15 in **1a** and **1b** respectively) and appearance of triplets at δ 4.82 and 4.81 for H-5 in the ^{1}H NMR spectral data of compounds **2a** and **2b** respectively; and appearance of *d* at δ 3.18 and 3.21 for H-6 along with other usual signals in the above compounds **2a** and **2b** respectively evidenced the migration of double bond from α,β- to β,γ-position. In ^{13}C NMR spectra of the above compounds **2a** and **2b** the signals for C-4 appear at δ153.8, 153.6; C-5 at δ 97.6, 97.4 while those of C-6 appear at δ 31.4 and 31.3 respectively. The *Z* geometry of the double bond in compounds **2a** and **2b** was evidenced by NOE experiments, which show 30% and 20% enhancement in the intensity of H-3 on irradiation of the H-5 (Figure 1).

Please insert Figure 1

The above glycosyl uronoates **2a** and **2b** were reacted with selected aldehydes (Scheme **2**) separately at 0-30 ^{0}C in presence of DBU (50 mol %) for different intervals of time to yield the respective glycosyl β-aryl-β- hydroxy esters **3a-j** in varying yields (Table 1). It is evident from Table 1 the aromatic aldehydes with electron-withdrawing substituents gave better yields of β- hydroxyl esters than those with electron donating substitutents. Heteroaromatic aldehydes *viz* 2-pridyl, 3-pyridyl and thiophene-2- carboxaldehyde also gave good yields of the respective β- hydroxy esters. Compounds **3a-j** were characterized on the basis of their IR, MS, ^{1}H, ^{13}C NMR spectral data and microanalysis. All of the them were isolated as distereoisomeric mixtures; the individual isomers could not be separated in pure forms and used as such for the subsequent reactions. Due to the diastereoisomeric nature of the compounds (**3a-j**) the ^{13}C and ^{1}H NMR spectra of these compounds were somewhat complicated and most of the proton and few carbon signals were duplicated. FAB MS of compound **3a** showed molecular ion peak at 456 while its IR spectrum exhibited absorption band at 3397, 1726, cm^{-1} showing the presence of hydroxyl and ester functionalities. The anomeric proton in compound **3a** appeared as two distinct doublets at δ 6.08 and 5.97 having coupling constant of 3.3 and 2.7 Hz, while the signals for other protons *viz* H-5, H-6 and H-7 were also duplicated and appeared as multiplets. Similarly compounds **3b-j** were also characterized and duplicity of many proton and carbon signals were observed. The signals for H-5, H-6 and H-7 in the above compounds **3b-j** also appeared in the range of δ 4.70-4.60, 3.80-3.60, and 5.30-4.90 respectively.

Please insert Scheme 2

It is interesting to note that even the reaction of α,β-unsaturated glycosyl uronoates **1a** and **1b,** with the aldehydes in presence of DBU under the above experimental condition did not lead to any Baylis Hilmann adduct instead we got the isomerized esters **2a** and **2b** along with the respective aldol products in very low yields but the reaction was never completed even after 36 hrs (Scheme 3).

Please insert Scheme 3

In the next step of the sequential synthesis of glycosyl dienes the glycosyl β-aryl-β-hydroxy esters **3a**-**j** were converted into respective *O*-(methanesulfonyl) derivatives by treatment of with methanesulfonyl chloride in anhydrous dichloromethane using triethyl amine as a base. The crude intermediate methanesulfonyl derivatives were isolated in quantitative yields and used as such (these compounds were not stable even at room temperature for a longer time) in the final step for the synthesis of conjugated dienes. It is appropriate to mention here that the methanesulfonyl derivatives were also obtained as distereoisomeric mixture. Finally, the methanesulfonyloxy derivatives obtained from the respective hydroxyl derivatives were refluxed in toluene in presence of DBU (100 mol%) to give the corresponding glycosylated dienes **4a-j** (Scheme 3) in moderate to good yields (Table-**2**) and were characterized on the basis of their spectroscopic data and microanalysis. That the glycosyl dienes were a mixture of two geometrical isomers (*ZZ* and *ZE*) which was evidenced on the basis of their ^{1}H NMR spectral data and NOE experiments.

Please Insert Table 1 and 2

The FAB MS of compound **4a** showed $(M+H)^+$ peak at 438 while its IR spectrum exhibited absorption band at 1729 cm^{-1} indicating the presence of a conjugated carbethoxy group. In ^{1}H NMR spectrum of the above compound the olefinic proton H-7 appeared as a singlet at δ 6.80 while H-5 was observed as two distinct singlets at δ 5.46 and 5.33 respectively indicating the presence of the two geometrical isomers (*ZZ* and *ZE*). The anomeric proton (H-1) was also observed as two doublets at δ 6.21 and 6.00 having coupling constant of 3.0 Hz due to the presence of two geometrical isomers *ZZ* and *ZE*. The ratioof two geometrical isomers was determined on the basis of the integration of the H-1 in the two isomers and it was found to be 11:9. The *ZZ* and *ZE* configuration of the double bond was evidenced on the basis of NOE experiments with the compound **4a** where irradiation of H-5(major isomer) signal resulted in an enhancement of the intensity of H-3 and H-7, indicating a *ZZ* geometry of the double bonds in major isomer while the irradiation of H-5 (minor isomer) signal did not show any NOE with H-7 indicating *ZE* geometry of the diene. In the ^{13} C NMR spectrum of the compound **4a** also, duplicity of anomeric (C-1) and many other carbons in almost all the compounds was observed due to the presence of two geometrical isomers. The newly generated sp^2 carbon (C-6) in the above compound **4a** was observed as a duplictated signal at δ 148.7 and 148.4 while the same for C-7 was observed at δ 136.7.

Please insert **Scheme 4**

Similarly all other glycosyl dienes **4b-j** were found to be a mixture of two geometrical isomers as evidenced by their ^{1}H NMR spectra and the ratio of the two isomers was determined on the basis of the integration of H-1. The signals of C-7 in the above compounds appeared in the range of δ 136.0-137.0 while those of C- 6 were observed in the range of δ 151.0-153.0. The chemical shifts for C-5 in the above compounds were observed in the range of δ 97.0-99.0.

3. Conclusion

In conclusion we have developed a new and simple method for the syntheses of glycosyl dienes in a straight forward manner. It involves DBU catalysed Aldol type reaction of β, γ-unsaturated glycosyl uronoates and aldehydes and subsequent elimination reaction of the intermediate methanesulfonyloxy derivatives. These glycosyl dienes rich in stereocentres may be useful in asymmetric synthesis of other compounds.

4. Experimental

4.1. General

Commercially available chemicals were of reagent grade and used as received. Dry toluene was obtained from distillation over Na, triethylamine was dried over KOH and distilled. Anhydrous THF was purchased from Spectrochem. Pvt Ltd. Bombay and dried before use over Na. The reactions were monitored by thin-layer chromatography (TLC) using silica gel plates (Kieselgel 60 F_{254}, E. Merck). Compounds were visualized by UV irradiation and/or spraying with 20% H_2SO_4 in EtOH, followed by charring at 150 °C. Column chromatography was performed on Silica Gel (230–400 mesh, Merck). IR spectra were recorded as thin films or neat chloroform solution with a Perkin-Elmer Spectrum RX-1 (4000-450 cm^{-1}) spectrophotometer. The ^{1}H and ^{13}C NMR spectra were recorded on a Brucker DRX -300 in (*D*) chloroform, shift values in ppm relative to $SiMe_4$ as internal reference, unless otherwise stated; signals are reported as s (singlet), d (doublet), t (triplet), m (multiplet); *J* in Hz. Fast atom bombardement mass spectra (FABMS) were performed by the Mass Spectrometer Jeol SX-102(FAB). Elemental analyses were performed on a Perkin-Elmer 2400 II elemental analyzer. The optical rotations were measured in a 1.0 dm tube with a Rudolf Autopol III polarimeter in chloroform. The excess of the reagents or solvents were evaporated under reduced pressure at a bath temperature between 55 and 60 °C.

(4*Z)*-Ethyl(1*R*,2*R*,3*S*)(3-*O*-benzyl-1,2-*O*-isopropylidene-1,4-tetrahydrofuranos-4-yl)-hept-4-enoate (2a): To a magnetically stirred solution of the above compound **1a (**1.2g, 3.44 mmol) in THF (6.0 mL), DBU (0.13mL, 25 mol%) was added and the reaction mixture was stirred at 80 ^{o}C for 5 hrs. Reaction mixture was cooled and solvent evaporated under reduced pressure to give a crude product. The latter was dissolved in ethyl acetate (2x25mL) and washed with water (2 x 5mL), the organic layer was dried (Na_2SO_4) and evaporated under reduced pressure to give a crude syrup (1.30 g). The crude product, thus obtained, was chromatographed over silica gel (230-400 mesh) using hexane: ethyl acetate (9:1) as eluant to give compound **2a** as colourless oil. $[\alpha]_D = +35^0$ (*c* = 0.10), $CDCl_3$) Yield 1.0 g (84%). υ_{max} (Neat) 1730, 1600 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 7.34-7.34-7.28 (*m,* 5H, Ar-*H*), 6.10 (*d*, *J* = 3.2 Hz, H-1), 4.82 (*t*, J = 7.0 Hz, 1H, H-5), 4.71 (*d*, *J* = 11.8Hz, 1H, CH_APh), 4.51 (*d*, *J* = 11.8Hz, 1H, CH_BPh), 4.45 (*d*, *J* = 3.2 Hz, 1H, H-2), 4.25 (*s*, 1H, H-3) 4.16 (*q*, 2H, *J* = 7.2 Hz, OCH_2CH_3), 3.21 (*dd*, *J* = 7.2, 1.0 Hz, 2H, H-6), 1.45 and 1.30 [each s, each 3H, $C(CH_3)_2$], 1.23 (*t*, *J* = 7.2 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 172.1 (*C*=O), 153.8 (C–4), 137.6, 128.9, 128.3, 128.2, 127.9, 127.4 (Ar-*C*), 114.2 {$(CH_3)_2C$}, 107.1 (C-1), 97.6 (C-5), 83.6, 80.7 (C-2, C-3), 70.5 (O*C*H_2Ph), 61.0 (OCH_2CH_3), 31.1 (C-6), 28.3, 27.6 (2 x CH_3), 14.6(CH_3). Anal. Calcd for $C_{19}H_{24}O_6$: C, 65.51; H, 6.89. Found: C, 65.22; H, 6.62; MS FAB *m/z* = 349 $(M+H)^+$.

(4*Z*)Ethyl(1*R*,2*R*,3*S*)(1,2-*O*-isopropylidene-3-*O*-methyl-1,4-tetrahydrofuranos-4-yl)-hept-4-enoate (2b) To a magnetically stirred solution of ester **1b** (1.2g, 4.83 mmol) in THF (6.0 mL), DBU (0.18mL, 25mol%) was added and the reaction mixture was stirred at $80^{\circ}C$ for 5 h. Worked up the reaction mixture as above and column chromatography of the crude product using hexane: ethyl acetate (9:1) as eluant to give **2b** as colorless oil. $[\alpha]_D +32^0$ (*c* = 0.10), $CDCl_3$) Yield 1.10 g (91%). υ_{max} (Neat) 1728, 1616 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$):δ 6.04 (*d*, *J* = 3.2 Hz, H-1), 4.81 (*t*, *J* = 7.0 Hz, 1H, H-5), 4.50 (*d*, *J* = 3.2 Hz, 1H, H-2), 4.05 (*s*, 1H, H-3), 4.14 (*q*, J = 7.2, 2H, OCH_2CH_3), 3.34 (*s*, 3H, OCH_3), 3.18 (*dd*, *J* = 7.0, 2.0 Hz, 2H, H-6), 1.47 and 1.30 [each *s*, each 3H, $C(CH_3)_2$], 1.23(*t*, *J* = 7.2 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 172.1 (C=O), 153.6 (C–4), 114.2 {$(CH_3)_2C$}, 107.0 (C-1), 97.4 (C-5), 83.3, 80.1 (C-2, C-3), 61.9 (OCH_2CH3), 31.3 (C-6), 28.3, 27.6 (2 x CH_3), 14.5(CH_3). Anal. Calcd for $C_{13}H_{20}O_6$: C, 54.58; H, 7.47. Found: C, 54.23; H, 7.28;. MS FAB *m/z* = 273 $(M+H)^+$.

(4*Z*)3-*O*-benzyl-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy 1,2-*O*-isopropylidene-7-(3-pyridyl)-α-D-xyloheptafuranose (3a): To a magnetically stirred solution of β, γ-isomerised olefinic ester **2a** (1.0g, 2.87mmol) in dry THF (5.0mL) at 0^0C 3-pyridylcarboxaldehyde (0.3mL 3.16 mmol) and DBU (0.21mL, 50 mol%) were added sequentially. The reaction mixture was stirred for 30 min. at 0^0C followed by additional 9h at ambient temperature. The solvent evaporated and the residue, thus obtained was partitioned between ethyl acetate and water. Ethyl acteate layer separated, dried (Na_2SO_4) and evaporated under reduced pressure to give a crude mass. The latter was chromatographed over SiO_2 (240-400 mesh) using a gradient of heaxane: ethyl acetate (4:1) to give compound **3a** as colourless viscous syrup 85% (1.10g) yield; $[\alpha]_D - 29^o$ (*c* = 0.10, $CDCl_3$); υ_{max} (Neat) 3397, 1726, cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ 8.57 (*d*, *J* = 14.7Hz, 1H, Py-*H*), 8.44 (*s*, 1H, Py-H), 7.79-7.72 (*m*, 1H, Py-H), 7.41-7.15 (*m,* 6H, 1 x Py-*H*, 5 x Ar-*H*), 6.08, 5.97 (each *d*, *J* = 3.3 and 2.7 Hz, 1H, H-1), 5.01 (*m*, 1H, H-7), 4.64-4.57 (*m*, 1H, H-5), 4.47-4.37 (*m*, 2H, OCH_2Ph), 4.23-4.01 (*m*, 4H, H-2, OCH_2CH_3, H-3), 3.89-3.68 (*m*, 1H, H-6), 2.05 (*bs*, 1H, -O*H*), 1.39 and 1.37 [each *s*, each 3H, $C(CH_3)_2$], 1.20 (*t*, *J* = 8.7 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 173.5, 173.1 (*C*=O), 156.0, 155.0 (C–4), 149.5, 148.9, 137.5, 137.4, 135.0, (Py-*C*), 128.9, 128.2, 128.1, 123.7, 123.4 (Ar-*C*), 114.4, 114.3 $(CH_3)_2C$, 107.3 (C-1), 98.9, 98.4 (C-5), 83.4, 80.7 (C-2, C-3), 73.7 (C-7), 70.5, 70.1 (OCH_2Ph), 61.5 (OCH_2CH_3), 50.3, 50.1 (C-6), 28.2, 27.9, 27.7, 27.3 (2 x CH_3), 14.4 (OCH_2CH_3). Anal. Calcd for $C_{25}H_{29}O_7N$: C, 65.93; H, 6.15; N, 3.07. Found: C, 65.80; H, 6.10; N, 3.10. MS FAB *m/z* = 456 $(M+H)^+$.

(4*Z*)-3-*O*-benzyl-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy 1,2-*O*-isopropylidene-7-(2-pyridyl)-α-D-xyloheptafuranose (3b)

The compound **3b** was prepared from compound **2a** and pyridyl 2-carboxaldehyde described as above as colourless viscous syrup (82%, 1.05g); $[\alpha]_D$ - 40^0 (*c* = 0.10), $CDCl_3$); υ_{max} (Neat): 3449, 1722 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 8.53-8.42 (*m*, 1H, Py-*H*), 7.67-7.17 (*m,* 8H, Py*H*, Ar*H*), 5.94, 5.84 (each *d*, *J* = 3.0 and 2.8 Hz, 1H, H-1), 5.28-5.00 (*m*, 1H, H-7), 4.84-4.60 (*m*, 1H, H-5), 4.50-4.24(*m*, 2H, benzylic CH_2), 4.21-4.04 (m, 4H, H-2, OCH_2, H-3), 3.70-3.65 (*m*, 1H, H-6), 2.26 (*bs*, 1H, -O*H*), 1.37 and 1.32 (each *s*, each 3H, $C(CH_3)_2$), 1.13 (*t*, *J* = 6.8 Hz, 3H, (CH_3); ^{13}C NMR (50 MHz, $CDCl_3$): δ 172.8 (*C*=O), 154.6, 154.1 (C-4), 148.7, 148.1, 137.6, 136.9 (Py-*C*), 128.8, 128.2 (2xAr-C), 123.0, 121.8, (Ar-*C*, Py *C*), 114.3 $(CH_3)_2C$, 107.3, 107.0 (C-1), 99.7, 98.1 (C-5), 83.5, 80.6 (C-2, C-3), 73.4 (C-7), 70.4 (OCH_2Ph), 61.4, 61.1 (OCH_2CH_3), 50.2, 49.3 (C-6), 28.2, 27.6 (2 x CH_3), 14.5 (CH_3). Anal. Calcd for $C_{25}H_{29}O_7N$: C, 65.93; H, 6.15; N, 3.07. Found: C, 65.90; H, 6.12; N, 3.11. MS FAB *m/z* = 456 $(M+H)^+$.

(4*Z*)-3-*O*-benzyl-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy -1,2-O-isopropylidene-7-(3,4-dimethoxyphenyl)-α-D-xyloheptafuranose (3c)

Compound **3c** was obtained by reaction of olefinic ester **2a** and 3,4-dimethoxybenzaldehyde as described above as colourless viscous syrup (83%, 1.21g); $[\alpha]_D$ -37^0 (*c* = 0.10, $CDCl_3$); υ_{max} (Neat): 3469, 1725 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ_H 7.36-7.26 (*m,* 5H, Ar*H*), 7.11-7.01 (m, 3H, Ar-*H*), 6.07, 5.99 (each *d*, *J* = 3.4, 1H, H-1), 4.96-4.89 (*m*, 1H, H-7), 4.69-4.50 (m, 1H, H-5), 4.50-4.40 (*m*, 3H, benzylic CH_2, H-2), 4.20(*q*, J = 7.2 Hz, 2H, OCH_2), 4.09 (s, 1H, H-3), 3.86, 3.71 (s, 3H, OCH_3), 3.90 (*m*, 1H, H-6), 2.06 (*bs*, 1H, -O*H*), 1.41, 1.39 (each *s*, each 3H, $C(CH_3)_2$), 1.19 (*t*, *J* = 7.2 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 173.7, 173.5 (*C*=O), 154.5, 154.1 (C–4), 137.4, 134.3, 128.8, 128.7, 128.2, 128.1, 120.0, 119.4 (Ar-*C*), 114.3 $\{(CH_3)_2\boldsymbol{C}\}$, 107.3 (C-1), 98.3 (C-5), 83.5, 80.7 (C-2, C-3), 75.3 (C-7), 70.2 (OCH_2Ph), 61.2 (OCH_2CH_3), 56.1, 55.9 (OCH_3), 50.5, 50.1 (C-6), 28.2, 27.3 (2 x CH_3), 14.5(CH_3). Anal. Calcd for $C_{28}H_{34}O_9$: C, 65.36; H, 6.61. Found: C, 65.30; H, 6.60. MS FAB *m/z* = 515 $(M+H)^+$.

(4Z)-3-O-benzyl-6-carbethoxy-5,6-dideoxy-4-eno-7-hydroxy 1,2-O-isopropylidene-7-(thiophen-2-carboxaldehyde)-α-D-xyloheptafuranose (3d)

It was obtained by reaction of compound **2a** and thiophen-2-carboxaldehyde as colourless viscous syrup. (78%, 1.03g); $[\alpha]_D$ -25^0 (*c* = 0.10, $CDCl_3$); υ_{max} (Neat): 3470, 1722 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 7.36-7.17 (*m,* 5H, ArH), 7.03 (*d*, *J* = 3.2 Hz, 1H, Thio-H), 6.96-6.88 (m, 2H,Thio-H), 6.08, 6.06 (each *d*, *J* = 3.0, 1H, H-1), 5.23-5.16 (*m*, 1H, H-7), 4.72- 4.59 (m, 1H, H-5), 4.40 (*d*, 1H, benzylic CH_A), 4.25 (*d*, 1H, benzylic CH_B), 4.16 (*d*, *J* = 3.0 Hz, 1H, H-2), 4.13(*q*, *J* = 7.2, 2H, OCH_2), 4.00 (*s*, 1H, H-3), 3.69 (*m*, 1H, H-6), 2.06 (*bs*, 1H, O*H*), 1.39, 1.35 (each *s*, each 3H, $C(CH_3)_2$), 1.22 (*t*, *J* = 7.2 Hz, 3H, OCH_2CH_3); ^{13}C

NMR (50 MHz, $CDCl_3$): δ 173.2(*C*=O), 154.7 (C–4), 137.5, 128.8, 128.7, 128.2, 128.1, 126.9, 125.4, 125.1, 124.9, 124.6 (Ar-*C*, Thio-*C*), 114.3 {$(CH_3)_2C$}, 107.4 (C-1), 99.4(C-5), 83.5, 80.6(C-2, C-3), 71.8 (C-7), 70.3 (O*C*H_2Ph), 61.3 (O*C*H2), 50.3, (C-6), 28.3, 27.6(2 x *C*H_3), 14.5(*C*H_3). Anal. Calcd for $C_{24}H_{28}O_7S$: C, 62.60; H, 6.08;. Found: C, 62.61; H, 6.03. MS FAB *m/z* = 461 $(M+H)^+$.

(4Z)-3-*O*-Benzyl-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy-1,2-*O*-isopropylidene-7-(cinnamyl)-α-D-xyloheptafuranose (3e)

Compound **3e** was obtained by reaction of olefinic ester **2a** and cinnamaldehyde as colourless viscous syrup 45% (0.80) yield; $[\alpha]^{27}_{D}$ -68^0 (*c* = 0.10, $CDCl_3$); υ_{max} (Neat): 3430 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$) δ_H 7.36-7.25 (*m,* 9H, ArH), 7.11 (*d*, *J* = 3.0 Hz, 1H, Ar-*H*), 6.67 (*d*, *J* = 10.6 Hz, Cinnam-*H*), 6.26 (*m*, 1H, Cinnam-*H*), 6.12 (*d*, *J* = 2.0 Hz, 1H, H-1), 4.80-4.71 (*m*, 1H, H-7), 4.67-4.58 (*m*, 1H, H-5), 4.54 (*d*, *J* = 8.0 Hz, 1H, benzylic CH_A), 4.37 (*d*, *J* = 8.0 Hz, 1H, benzylic CH_B), 4.24 (*d*, *J* = 3.0 Hz, 1H, H-2), 4.12(*q*, J = 6.9 Hz, 2H, OC*H_2*), 4.00 (*s*, 1H, H-3), 3.85-3.79 (*m*, 1H, H-6), 2.06 (*bs*, -O*H*), 1.41, 1.39 and 1.40,1.33 (each *s*, each 3H, C(C*H_3*)$_2$), 1.21 (*t*, *J* = 7.2 Hz, 3H, C*H_3*); *m/z* = 481 $(M+H)^+$.Anal. Calcd for $C_{28}H_{32}O_7$: C, 70.02; H, 6.67;. Found: C, 69.90; H, 6.58. MS FAB *m/z* = 481$(M+H)^+$.

(4*Z*)-3-*O*-benzyl-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy -1,2-*O*-isopropylidene-7-phenyl-α-D-xyloheptafuranose (3f)

Reaction of olefinic ester **2a** and benzaldehyde as above led to the preparation of compound **3f** as colourless viscous syrup (85%, 1.10g); $[\alpha]^{27}_{D}$ -16^0 (*c* = 0.10, $CDCl_3$); υ_{max} (Neat) 3470, 1722, cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 7.41-7.11 (*m,* 10H, Ar*H*), 6.09, 6.00 (each *d*, *J* = 3.2 , 2.8 Hz, 1H, H-1), 5.22-5.16 (*m*, 1H, H-7), 4.99- 4.67 (m, 1H, H-5), 4.69 (*m*, 2H, benzylic C*H_2*), 4.40 (*d*, *J* = 3.0 Hz, 1H, H-2), 4.19(m, 2H, OC*H_2*), 4.00 (s, 1H, H-3), 3.71, 3.69 (*m*, 1H, H-6), 2.06 (*bs*, exchangeable H, -O*H*), 1.41, 1.39 and 1.35,1.30 [each *s*, each 3H, C(C*H_3*)$_2$], 1.19 (*t*, *J* = 7.0 Hz, 3H, C*H_3*); Anal. Calcd for $C_{26}H_3O_7$: C, 68.72; H, 6.60;. Found: C, 68.69; H, 6.78. MS FAB *m/z* = 455 $(M+H)^+$.

(4*Z*)-6-carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy-1,2-*O*-isopropylidene-3-*O*-methyl-7-(3-pyridyl)-α-D-xyloheptafuranose (3g)

Reaction of compound **2b** and 3-pyridyl carboxaldehyde followed by purification of the crude product as above led to the compound **3g** as colourless viscous syrup. (87%, 1.20g); $[\alpha]_D$ - 60^o (*c* = 0.10, $CDCl_3$); IR neat υ_{max} 3469, 1729 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.59-8.46 (*m*, 2H, Py-*H*), 7.72 (*t*, *J* = 8.0 Hz, Py-*H*), 7.30-7.20 (*m*, 1H, Py-*H*), 6.01, 5.89 (each *d*, *J* = 3.0 and 2.8 Hz, 1H, H-1), 5.30-5.19 (*m*, 1H, H-7), 4.82-4.60 (*m*, 1H, H-5), 4.46-4.39 (m, 1H, H-2), 4.16-4.09 (*m,* 2H, OC*H_2*CH_3), 3.94,3.92 (each *s*, each 1H, H-3), 3.70- 3.65 (m, 1H, H-6), 3.32, 3.13 (each *s*, each 3H, OC*H_3*), 2.90 (*bs*, 1H, -O*H*), 1.40, 1.35 (each *s*, each 3H, (C*H_3*)$_2$C), 1.16 (*m,* 3H, C*H_3*). ^{13}C NMR (50 MHz, $CDCl_3$); δ 173.8, 173.5 (C=O), 155.5, 154.8 (C-4), 149.3, 148.7,137.5, 134.7, 123.7 (Py-C), 114.4 $(CH_3)_2C$, 107.1 (C-1), 98.5 (C-5), 83.1, 82.8 (C-2, C-3), 73.6, 73.2 (C-7), 61.5 (OC*H_2*), 56.5 (OCH_2), 52.4 (OC*H_3*), 52.4, 50.2 (C-6), 28.2, 27.9, 27.5, 27.3 (*C*H_3)$_2$C, 14.4 (*C*H_3); Anal. Calcd for $C_{19}H_{25}O_7N$: C, 60.15; H, 6.59; N, 3.69. Found: C, 60.11; H, 6.60; N, 3.65. MS FAB *m/z* 380 $(M+H)^+$

(4Z)-6-Carbethoxy-5,6-dideoxy-4-eno-7-hydroxy-1,2-O-isopropylidene-3-O-methyl-7-(3-nitrophenyl)-α-D-xyloheptafuranose (3h)

Compound **3h** was prepared on reaction of olefinic ester **2b** with 3-nitrobenzaldehyde give **3h** as colourless viscous syrup in (97%1.50g) yield ; $[\alpha]_D$ – 50° (*c* = 0.10, $CDCl_3$); IR Neat υ_{max}; 3433, 1720 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.23 (*s*, 1H, Ar-*H*), 8.14 (*d*, *J* = 5.4 Hz, 1H, Ar-*H*), 7.84 (*t*, *J* = 8.0 Hz, 1H, Ar-*H*), 7.62 (*d*, *J* = 8.0 Hz, Ar-*H*), 6.01, 5.87(each *d*, *J* = 2.8 Hz, 1H, H-1), 5.26-4.94 (*m*, 1H, H-7), 4.81-4.58 (*m*, 1H, H-5), 4.39 (*d* = 2.8 Hz, 1H, H-2), 4.04 (*q*, *J* = 7.2 Hz, 2H, OCH_2), 3.63 (*s*, 1H, H-3), 3.37 (*s*, 3H, OCH_3), 3.03-2.84 (*m*, 1H, H-6), 2.90 (*bs*, 1H, -O*H*), 1.28, 1.20 (each *s*, each 3H, $(CH_3)_2C$), 1.16 (*t*, *J* = 7.2 Hz, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 177.5, 177.1 (C=O), 153.1 (C-4), 138.6, 138.3, 137.7, 134.0, 133.9, 123.7 (Ar-*C*), 118.8 $(CH_3)_2C$, 111.7, 111.6 (C-1), 103.7 (C-5), 87.9, 87.5 (C-2, C-3), 79.4, 79.1 (C-7), 65.8 (OCH_2), 61.0 (OCH_2), 57.0, 56.1 (C-6), 32.9, 32.7 $(CH_3)_2C$, 19.2 (CH_3); Anal. Calcd for $C_{20}H_{25}O_9N$: C, 56.73; H, 5.91; N, 3.30. Found: C, 56.68; H, 5.90; N, 3.38. MS FAB *m/z* 424 $(M+H)^{+\cdot}$

(4Z)-6-Carbethoxy-5,6-dideoxy-4-*eno*-7-hydroxy 1,2-*O*-isopropylidene-3-*O*-methyl-7-(4-bromophenyl)-α-D-xyloheptafuranose (3i)

Compound **3i** was obtained by reaction of olefinic ester **2b** and 3-bromobenzaldehyde as colourless syrup in (86%, 1.14g) yield; $[\alpha]_D$ -37° (*c* = 0.10, $CDCl_3$); υ_{max} 3481, 1731, cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$); δ 7.44-7.25 (*m*, 2H, Ar-*H*), 7.24-7.20 (m, 2H,Ar-*H*), 5.99, 5.92(each *d*, *J* = 3.6 Hz, 1H, H-1), 5.13-5.09 (*m*, 1H, H-7), 4.75, 4.54 (each *d*, *J* = 10.6 Hz, 1H, H-5), 4.40 (*d*, *J* = 3.6Hz, 1H, H-2), 3.99 (*s*, 1H, H-3), 3.687 (*q*, *J* = 7.2 Hz, 2H, OCH_2), 3.48- 3.43 (m, 1H, H-6), 3.31, 3.25 (each *s*, each 3H, OCH_3), 2.90 (*bs*, 1H, -O*H*), 1.39, 1.35, (each *s*, each 3H, $(CH_3)_2C$), 1.19 (*t*, *J* = 7.2 Hz, CH_3). ^{13}C NMR (50 MHz, $CDCl_3$) δ 173.7 (C=O), 155.3, 154.4 (C-4), 140.5, 131.5, 131.3, 128.6, 128.4, 121.5 (Ar-*C*), 114.1 $(CH_3)_2C$, 107.0 (C-1), 98.7, 97.1 (C-5), 83.0, 82.2 (C-2, C-3), 75.0, 73.0 (C-7), 66.0 (OCH_2), 56.4 (OCH_2), 50.1, 49.6 (C-6), 27.7, 27.1 $(CH_3)_2C$, 15.4 (CH_3); Anal. Calcd for $C_{20}H_{25}O_7Br$: C, 52.51; H,5.47. Found: C, 52.50; H, 5.42. MS FAB *m/z* 458 $(M+H)^+$

(4Z)-6-Carbethoxy-5,6-dideoxy-4-eno-7-hydroxy-1,2-*O*-isopropylidene-3-O-methyl-7-(3-chlorophenyl)-α-D-xyloheptafuranose (3j)

It was be obtained by reaction of **2b** and 3-chlorobenzaldehyde as colourless oil in (90%, 1.36g) yield; $[\alpha]_D$ -15° (*c* = 0.10, $CDCl_3$); υ_{max} 3448, 1723 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 7.36 (*s*, 1H, Ar-*H*), 7.26-7.22 (*m*, 3H, Ar-*H*), 6.01, 5.94(each *d*, *J* = 3.2 Hz, 1H, H-1), 5.12-4.91 (*m*, 1H, H-7), 4.74-4.59 (*m*, 1H, H-5), 4.45-4.40 (*m*, 1H, H-2), 4.18-4.07 (*m*, 2H, OCH_2), 3.98 (*s*, 1H, H-3), 3.95-3.89 (*m*, 1H, H-6), 3.35 (*s*, 3H, OCH_3), 2.90 (*bs*, 1H, -OH), 1.40, 1.33 (each *s*, each3H, $(CH_3)_2C$), 1.16 (*t*, *J* = 7.0 Hz, 3H, CH_3). ^{13}C NMR (50 MHz, $CDCl_3$) δ 173.2(C=O), 155.1, 154.2(C-4), 140.5, 131.5, 131.3, 128.6, 128.4, 121.5 (Ar-*C*), 114.0 $(CH_3)_2C$, 106.9 (C-1), 98.6,97.3 (C-5), 83.0, 82.1 (C-2, C-3), 74.6, 73.0 (C-7), 66.1(OCH_2), 56.6 (OCH_2), 50.3, 49.4 (C-6), 27.7, 27.2 $(CH_3)_2C$, 15.2 (CH_3); Anal. Calcd for $C_{20}H_{25}O_7Cl$: C, 58.11; H, 6.05. Found: C, 58.10; H, 6.02. MS FAB *m/z* 414 $(M+H)^+$

(4-*Z*,6-*E*/*Z*)-3-*O*-Benzyl-6-carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-7-(3-pyridyl)-α-D-*xylo*-heptafuranose (4a): **Typical Procedure**:

To a magnetically stirring solution of compound **3a** (0.5g, 1.10 mmol) and triethyl amine (1 mL) in dichloromethane (5 mL) at 0 ^{0}C, methanesulfonyl chloride (0.14 mL, 1.21 mmol)) was slowly added and stirring continued for additional 1h at the same temperature till the disappearance of starting material (tlc). The solvent evaporated and the residue, thus obtained was filtered on flash silica gel to give the intermediate methansuphonyloxy derivative (0.40g) which was used in the next step. The above intermediate and DBU (0.17 mL, 100 mol%) in anhydrous toluene (5 mL) was refluxed at 130 ^{0}C for 3 h. The reaction mixture cooled, the solvent evaporated and the residue was dissolved in ethyl acetate (2x25mL) and washed with water (2x12.5mL). Organic layer was dried (Na_2SO_4) and evaporated under reduced pressure to give a residual mass (0.35g) which was chromatographed over SiO2 column using a gradient of hexane: EtOAc (9:1) to give **4a** as colourless foam in (36%, 0.18g). $[\alpha]_D$ – 50^o (*c* = 0.10, $CDCl_3$); υ_{max} (Neat) 1721 cm^{-1};^{1}H NMR (200 MHz, $CDCl_3$) δ_H 8.63- 8.52 (*m*, 3H, Py-*H*), 7.82-7.45 (*m*, 6H, Py-*H*, Ar-*H*), 6.85 (*s*, 1H, H-7), 6.41 (*d*, *J* = 3.0 Hz, 1H, H-1), 5.67(*s*, 1H, H-5), 4.98 (*d*, *J* = 11.2 Hz, 1H, benzylic H_A), 4.87 (*d*, *J* = 3.0 Hz, 1H, H-2), 4.77 (*d*, *J* = 11.2 Hz, 1H, benzylic H_B), 4.60 (s, 1H, H-3), 4.35 (*q*, *J* = 7.2 Hz, 2H, OCH_2), 1.62 and 1.51 [each s, each 3H, $C(CH_3)_2$], 1.32 (*t*, *J* = 7.2 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 169.1 (*C*=O), 154.4 (C–4), 149.8 (C-6), 137.4, 136.8, 132.4, 132.3 (Py-C), 130.7, 128.9, 128.9, 128.4, 128.3, 123.4 (Py-C), 127.6 (Ar-C), 115.3 {$(CH_3)2$}, 108.6 (C-1), 102.8 (C-7), 96.1 (C-5), 82.8, 82.1 (C-2, C-3), 71.0 (OCH_2Ph), 61.8 (OCH_2), 28.2, 27.6 (2 x CH_3), 14.6 (CH_3). Anal. Calcd for $C_{25}H_{27}O_6N$: C, 68.64; H, 5.94; N, 3.20. Found: C, 68.62;H, 5.90; N, 3.10. MS FAB *m/z* = 438 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)- 3-*O*-Benzyl- 6-carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-7-(2-pyridyl)-α-D-*xylo*-heptafuranose (4b)

The reaction of the above compound **3b** (0.5g, 1.10 mmol) with methasulfonyl chloride followed by treatment of the intermediate mesyloxy derivative with DBU as above led to the isolation of compound **4b** as colourless foam, (50%, 0.20g). $[\alpha]_D$ – 14^o (*c* = 0.10, $CDCl_3$); υ_{max} (Neat) 1728 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 8.50 (*d*, *J* = 4.0 Hz, 1H, Py-*H*), 7.58 (m, 1H, Py*H*), 7.38, 7.08 (m, 7H, Ar-H, Py-H), 6.70 (*s*, 1H, H-7), 6.22 (*d*, *J* = 3.2 Hz, 1H, H-1), 5.28 (*s*, 1H, H-5), 4.73-4.48 (*m*, 4H, OCH_2Ph, H-2, H-3), 4.39-4.33 (*q*, *J* = 7.2 Hz, OCH_2CH_3), 1.44 and 1.38 (each *s*, each 3H, $C(CH_3)_2$), 1.32 (*t*, *J* = 7.2 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$); δ 170.0 (*C*OOEt), 154.4 (C–4), 149.5 (C-6), 142.4 (Py-C), 137.4, 136.5, 135.0, 133.6, 128.9, 128.4, 128.2 127.6 (Ar-C, Py-C), 123.9, 122.8 (Py-C), 114.9 {$(CH_3)_2C$}, 108.7 (C-1), 103.2 (C-7), 98.3 (C-5), 82.8, 82.2 (C-2, C-3), 70.9 (OCH_2Ph), 61.4 (OCH_2), 28.2, 27.6 (2 x CH_3), 14.6 (CH_3). Anal. Calcd for $C_{25}H_{27}O_6N$: C, 68.64; H, 5.94; N, 3.20. Found: C, 68.62; H, 6.01; N, 3.16. MS FAB: *m/z* = 438 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)- 3-*O*-Benzyl- 6-carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-7-(3,4-dimethoxyphenyl)-α-D-*xylo*-heptafuranose (4c)

It was prepared in two steps from compound **3c** as described above as colourless foam in (40%, 0.20g) yield. $[\alpha]_D$ -58° (c = 0.10, $CDCl_3$); υ_{max} (Neat) 1724 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$) δ_H 7.44-6.92 (m, 8H, ArH), 6.68 (*s*, 1H, H-7), 6.21, 6.04 (each *d*, *J* = 3.0 Hz, 1H, H-1), 5.48, 5.28 (each *s*, 1H, H-5), 4.98 (*d*, *J* = 11.2 Hz, 1H, benzylic H_A), 4.87 (*d*, *J* = 3.0 Hz, 1H, H-2), 4.77 (*d*, *J* = 11.2 Hz, 1H, benzylic H_B), 4.60 (s, 1H, H-3), 4.35 (*q*, *J* = 7.2 Hz, 2H, OCH_2CH_3), 1.50 and 1.37 (each *s*, each 3H, $C(CH_3)_2$), 1.28 (*t*, *J* = 7.2 Hz, 3H, OCH_2CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 170.1 (*C*OOEt), 154.8 (C–4), 152.6 (C-6), 137.6, 135.0, 132.4, 128.9, 128.3, 127.2, 124.6, 121.9 (Ar-C), 114.7 $(CH_3)_2$, 108.4, 107.7 (C-1), 104.0 (C-7), 99.5 (C-5), 83.2, 82.1 (C-2, C-3), 71.0 (OCH_2Ph), 61.6 (OCH_2), 56.5, 56.2 (OCH_3), 28.3, 28.2, (2 x CH_3), 14.7, 14.3 (CH_3). Anal. Calcd for $C_{28}H_{32}O_8$: C, 67.74; H, 6.45. Found: C, 67.68; H, 6.42. MS FAB *m/z* = 497 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)- 3-*O*-Benzyl- 6-carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-7-(thiophen-2-carboxaldehyde)-α-D-*xylo*-heptafuranose (4d):

It was prepared from compound **3d** as colourless foam in (41%, 0.20g) yield. $[\alpha]_D$ -54° (c = 0.10, $CDCl_3$); υ_{max} (Neat) 1706 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 7.41 (*s*, 1H, Thio-H), 7.42-7.26 (*m*, 7H, ArH, Thio-H), 7.05 (*s*, 1H, H-7), 6.20, 6.12(each *d*, *J* = 3.2 Hz, 1H, H-1), 5.48, 5.32 (each *s*, 1H, H-5), 4.89 (*d*, *J* = 11.6 Hz, 1H, benzylic H_A), 4.68 (*d*, *J* = 11.6 Hz, 1H, benzylic H_B), 4.56 (*m*, 1H, H-2), 4.60 (s, 1H, H-3), 4.33 (*q*, *J* = 6.8 Hz, 2H, OCH_2), 1.60 and 1.38 (each *s*, each 3H, $C(CH_3)_2$), 1.32 (*t*, *J* = 6.8 Hz, 3H, CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 168.9, 167.8 (*C*=O), 155.9 (C–4), 152.9 (C-6), 139.5, 137.7, 137.5, 137.5 132.5, 128.9, 128.6, 127.4, 125.4, 123.6 (Ar-*C*, Thio-*C*), 114.8, 114.6 $(CH_3)_2$, 107.9 (C-1), 103.4 (C-7), 98.8 (C-5), 83.4, 82.1 (C-2, C-3), 70.9 (OCH_2Ph), 61.8, 51.3 (OCH_2), 30.7, 30.0, 28.3, 28.1(2 x CH_3), 14.7, 14.4 (CH_3). Anal. Calcd for $C_{24}H_{26}O_6S$: C, 65.16; H, 5.88. Found: C, 65.08; H, 5.75. MS FAB *m/z* = 443 $(M+H)^+$.

(4-Z, 6-E/Z)- 3-O-Benzyl- 6-carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-O-isopropylidene-7-(phenyl)-α-D-*xylo*-heptafuranose (4f)

Diene **4f** was prepared from compound **3f** as colourless foam, (42%, 0.21g). $[\alpha]_D$ -49° (c = 0.10, $CDCl_3$); υ_{max} (Neat) 1706, 1110., 984 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 7.34-7.21 (m, 10H, ArH,), 6.70 (*s*, 1H, H-7), 6.20, 6.12 (each *d*, *J* = 3.4 Hz, 1H, H-1), 5.48 (*s*, 1H, H-5), 4.89 (*d*, *J* = 11.2 Hz, 1H, benzylic H_A), 4.66 (*d*, *J* = 11.2 Hz, 1H, benzylic H_B), 4.56 (m, 1H, H-2), , 4.09 (s,1H, H-3), 4.33 (*q*, *J* = 7.0 Hz, 2H, (OCH_2), 1.60 and 1.38 [each *s*, each 3H, $C(CH_3)_2$], 1.32 (*t*, *J* = 7.0 Hz, 3H, CH_3); Anal. Calcd for $C_{26}H_{28}O_6$: C, 71.55; H, 6.42. Found: C, 71.52; H, 6.41. MS FAB *m/z* = 437 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)-6-Carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-3-*O*-methyl- 7-(3-pyridyl)-α-D-*xylo*-heptafuranose (4g)

The reaction of compound **3g** with methane sulfonyl chloride followed by its treatment with DBU as described above gave diene **4g** as colourless foam, (40%, 0.18g). $[\alpha]_D$ -30° (c = 0.10, $CDCl_3$); υ_{max} 1722 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 8.71 (*s*, 1H, Py-*H*), 8.50-8.44 (*m*, 1H, Py-*H*), 7.36-7.25 (*m*, 2H, Py-*H*), 6.83 (*s*, 1H, H-7), 6.17, 5.94 (each *d*, *J* = 3.2 Hz, 1H, H-1), 5.36, 5.30 (*s*, 1H, H-5), 4.52(d, *J* = 3.2 Hz, 1H, H-2), 4.29- 4.16 (*m,* 2H, OCH_2), 3.82 (each *s*, 1H, H-3), 3.44, 3.40 (each s, each 3H, OCH_3), 1.48, 1.45, 1.37, 1.36 (each s, each 3H, $(CH_3)_2C$), 1.22 (*t*, J = 7.2 Hz, CH_3). Anal. Calcd for $C_{19}H_{23}O_6N$: C, 63.16; H, 6.37; N, 3.88. Found: C, 63.10; H, 6.42. N, 3.80. MS FAB *m/z* = 362 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)-6-Carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-3-*O*-methyl- 7-(3-nitrophenyl)-α-D-*xylo*-heptofuranose (4h)

It was prepared from compound **3h** as described above as colourless foam in (48%, 0.34g) yield. $[\alpha]_D$ -52^o (*c* = 0.10, $CDCl_3$); υ_{max} 1723 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 8.17 (*t*, *J* = 3.4 Hz, 1H, Ar-H), 8.08 (*d*, *J* = 8.4 Hz, 1H, Ar-H), 7.62-7.42 (*m*, 2H, Ar-*H*), 6.86 (*s*, 1H, H-7), 6.17 (*d*, *J* = 3.0 Hz, 1H, H-1), 5.35, 5.30 (each *s*, 1H, H-5), 4.51(*d*, *J* = 3.0 Hz, 1H, H-2), 4.28 (*q*, *J* = 7.8 Hz, 2H, OCH_2), 3.81 (*s*, 1H, H-3), 3.40, (*s*, 3H, OCH_3), 1.46, 1.34 (each s, each 3H, $(CH_3)_2C$) , 1.22 (*t*, *J* = 7.8 Hz, 3H CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 169.0, 168.5 (C=O), 156.1 (c-4), 148.3 (C-6), 137.3 (C-7), 135.4, 133.7, 130.5, 130.2 (Ar-C), 113.9 $(CH_3)_2C$, 108.2, 107.6 (C-1), 102.3 (C-7), 98.6 (C-5), 83.4, 81.9 (C-3, C-2), 61.4 (OCH_2), 56.4 (OCH_3), 27.9, 27.7 $(CH_3)_2C$, 13.9 (CH_3); Anal. Calcd for $C_{20}H_{23}O_8N$: C, 59.25; H, 5.68; N, 3.45. Found: C, 59.15; H, 5.61; N, 3.38. MS FAB *m/z* = 406 $(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)-6-Carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-3-*O*-methyl- 7-(4-bromophenyl)-α- D-*xylo*-heptafuranose (4i)

Reaction of compound **3i** with methanesulfonyl chloride followed by treatment of the intermediate with DBU led to the preparation of compound **4i** as colourless foam (35%, 0.28g). $[\alpha]_D$ -62^o (*c* = 0.25, $CDCl_3$); υ_{max} 1726 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$); δ 7.46-7.38 (*m*, 2H, Ar-*H*), 7.33-7.13 (*m*, 2H, Ar-*H*), 6.69 (*s*, 1H, H-7), 6.14, 5.97 (*d*, *J* = 3.0 Hz, 1H, H-1), 5.41, 5.31(*s*, 1H, H-5), 4.52(*d*, *J* = 3.0 Hz, 1H, H-2), 4.14 (q, *J* = 7.2 Hz, 2H, OCH_2), 3.80 (s, 1H, H-3), 3.38 (s, 3H, OCH_3), 1.48, 1.36(each s, each 3H, $(CH_3)_2C$) , 1.25 (t, J = 7.2 Hz, 3H CH_3); ^{13}C NMR (50 MHz, $CDCl_3$) δ 169.9 (C=O), 155.3 (C-4), 153.6 (C-6), 136.5 (C-7), 135.1, 131.9, 129.9,123.0, 122.2 (Ar-C), 114.8 $(CH_3)_2C$, 108.4, 107.6 (C-1), 103.2 (C-7), 98.3 (C-5), 84.5, 82.8 (C-3, C-2), 57.1 (OCH_2), 52.6 (OCH_3), 28.1, 27.6 $(CH_3)_2C$, 13.9 (CH_3); Anal. Calcd for $C_{20}H_{23}O_6Br$: C, 54.66; H, 5.24;. Found: C, 54.62; H, 5.22;. MS FAB *m/z* = 439$(M+H)^+$.

(4-*Z*, 6-*E*/*Z*)-6-Carbethoxy-5,6,7-trideoxy-4,6-dieno-1,2-*O*-isopropylidene-3-*O*-methyl- 7-(3-chlorophenyl)-α- D-*xylo*-heptafuranose (4j)

It was prepared from compound **3j** as colourless foam (45%, 0.21g). $[\alpha]_D$ -48^o (*c* = 0.10, $CDCl_3$); υ_{max} 1725 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$); δ 7.32-7.19 (*m*, 4H, Ar-*H*), 6.75 (*s*, 1H, H-7), 6.15 (*d*, *J* = 3.2 Hz, 1H, H-1), 5.43, 5.31 (each *s*, 1H, H-5), 4.51(*d*, *J* = 3.2 Hz, 1H, H-2), 4.25 (*q*, *J* = 6.6 Hz, 2H, OCH_2), 4.18 (*s*, 1H, H-3), 3.39 (*s*, 3H, OCH_3), 1.45, 1.39 (each *s*, each 3H, $(CH_3)_2C$) , 1.23 (*t*, *J* = 6.6 Hz, 3H CH_3); ^{13}C NMR (50 MHz, $CDCl_3$): δ 174.0 (C=O), 153.8 (C-4), 149.2 (C-6), 138.2, 134.5, 128.8, 128.3, 126.6 (Ar-*C*), 114.8 $(CH_3)_2C$, 108.5, 107.8 (C-1), 102.9 (C-7), 98.3 (C-5), 84.5, 83.9 (C-3, C-2), 61.7 (OCH_2), 56.9 (OCH_3), 27.3, 27.6 $(CH_3)_2C$, 14.6 (CH_3); Anal. Calcd for $C_{20}H_{23}O_6Cl$: C, 60.76; H, 5.82;. Found: C, 60.66; H, 5.80;. MS FAB *m/z* = 395$(M+H)^+$.

Acknowledgements: SSV, ND and BS are thankful to UGC and CSIR for financial assistance in the form of JRF. We are thankful to RSIC for giving the spectral data and analysis.

References:

1. (a) Johannsen, M.; Yao, S.; Graven, A.; Jmgensen, K. A. *Pure & Appl. Chern.,* **1998**, *70*, 1117-1122 (b) Haraguchi, N.; Sakaguchi, Y.; Sugiyama, K.; Hirao, A. *Macromol. Chem. Phys.* **2001**, *202*, 2221-2230. (c) Palacios, F.; Alonso, C.; Rubiales, G.; Villegas, M. *Tetrahedron Lett.* **2004**, *45*, 4031-4034 (d) Barluenga, J.; Aznar, F.; Martín, A.; Barluenga, S. *Tetrahedron* **1997**, *53*, 9323-9340 (e) Kolodiazhnyi, Oleg I. *Tetrahedron* **2003**, *59*, 5953-6018 (e) Teitz, L.F. *Chem. Rev.* **1996**, *96*, 115-136 (f) García, A.-B.; Valdés, C., Cabal, M.-P. *Tetrahedron Lett.* **2004**, *45*, 4357-4360 (g) Kozmin, S.; Iwama, T.; Huang, Y. Rawal, V.H. *J. Am. Chem. Soc.* **2002**, *124*, 4628-4641.

2. (a) Douglas, J. D.; Senior, S. J.; Morehouse, C.; Phetsukiri, B.; Campbell, I. B.; Besra, G. S.; Minnikin, D.E. *Microbiology* **2002**, *148*, 3101-3109 (b) Nishida, T.; Vang V.L.; Yamazawa, H.; Yoshida. R.; Naka, H.; T.K. Ando. *Org Lett.* **2005**, *12*, 2469-71. (c) Wong, K.-T.; Hung, Y.-Y.; *Tetrahedron Letters*, **2002,***43*, 285-289 (d) Hirokazu. U.; Keiko. K.; Daisuke. S.; Sato. F. *Coordin. Chem. Rev.* **2005**, *248*, 1085-1158.

3. (a) Ganeshan. A. *Drug Discov. Today* **2002**, *7*, 47-55. (b) Avalos, M.; Babiano, R.; Cintas, P.; Jiménez, J. L.; Molina, M. M.; Palacios, J.C.; Sánchez, J. B. *Tetrahedron Letters* **1991**, *32*, 2513-2516 (c) Dewi, P.; Randl, R.; Blechert, Blechert, S. *Tetrahedron Letters* **2005**, *46*, 577-580 (d) Deagostinoa, A.; Migliardia, M.; Occhiatoa, E. G.; Prandia, C.; Zavattaroa, C.; Venturelloa, P. *Tetrahedron* **2005**, *61*, 3429-3436 (e) Vallin, Karl S. A.; Larhed, M.; Johansson, K.; Hallberg, A. *J. Org. Chem,* **2000**, *65*, 4537-4542 (f) Ma, B.; Snyder, J. K. *Tetrahedron Letters* **2005**, *46*, 703-706

4. (a) Wiley, P.F.; KellarMac, E.L.; Carton, E.L.; Kelly, R.B. *Tetrahedron Lett.* **1968**, *8*, 663-666. (b) Wiley, P.F In Anthracyclin Antibiotics; E.L. Khadim, H. S. Eds. Academic Press: New York, 1982; pp 97-117. (c) Hortan, D.; Phillips, K.D. *Carbohydr. Res.* **1973**, *30*, 367-374. (d) Kaye, A.; Reese, C.B.; Neidle, S.; Rees, C.B. *Tetrahedron Lett.* **1988**, *29*, 1841-44 (f) Postema, M.H.D. C-Glycoside Synthesis; CRC: Boca Raton, 1995 (g) Levy, D.E.; Tang, C. *The Chemistry of C-Glycosides*; Elsevier Science: Oxford, U.K. 1995.

5.(a) Kagan, B. H. Riant, O. *Chem. Rev.* **1992**, *92*, 1007-1019. (b) Evans, D.A.; Murry, J.A.; Von Matt, P.; Norcross, R.D.; Miller, S. J. *Angew. Chem.,Int. Ed. Engl.***1995**, *34*, 798-800. (c) Ishihara, K.; Kurihara, H.;Yamamoto, H. *J. Am. Chem. Soc.* **1996**, *118*, 3049-3050. (d) Hayashi,Y.; Rohde, J.J.; Corey, E.J. *J. Am. Chem. Soc.* **1996**, *118*, 5502-5503.(e) Schaus, S.E.; Branalt, J.; Jacobsen, E.N *.J. Org. Chem.* **1998**, *63*, 403-405. (f) Oppolzer, W. *Angew .Chem., Int. Ed. Engl.* **1984**, *23*, 876-889. (g) Evans, D.A.; Chapman, K.T.; Bisaha, J. *J. Am.Chem.Soc.***1988**, *110*, 1238-1256. (h) Oppolzer, W.; Wills, M.;Kelly, M.J.; Signer, M.; Blagg, J. *Tetrahedron Lett.* **1990**, *31*, 5015-5018. (i) Carretero, J.C.; Garcia Ruano, J.L.; Martín Cabrejas, L.M. *Tetrahedron Asymm.* **1997**, *8*, 2215-2225 and references therein. (j) Winterfeldt, E. *Chem. Rev.* **1993**, *93*, 827-843. (k) Tripathy, R.; Franck, R.W.; Onan, K.D. *J. Am. Chem. Soc.* **1988**, *110*, 3257-3262. (*l*) Hatakeyama, S.; Sugawara, K.; Takano, S. *J. Chem. Soc., Chem. Commun.* **1992**, 953-955. (m) Bloch, R.; Chaptal-Gradoz, N. *J. Org.Chem.* **1994**, *59*, 4162-4169. (n) Crisp, G.T.; Gebauer, M.G. *J. Org. Chem.* **1996**, *61*, 8425-8431.

6. Sarakinos, G.; Corey, E. J. *Org. Lett.*, **1999**, *1*, 1741-1744, and references cited therein.

7. Griffin, F.K.; Murphy, P.V.; Paterson, D.E.; Taylor, R. J. K *Tetrahedron Lett* **1998**, *39*. 8179–8182.

8 Alcaraz,M.-L.; Griffin, F.K.; Paterson D.E.; Taylor, R.J.K. *Tetrahedron Lett.* **1998**, *39*, 8183–8186.

9. Taylor, R.J.K. *Chem. Commun.* **1999**, 217–227.

10. Barluenga, J.; Sobrino, A.S.; Lopez, L.A. *Aldrichim Acta* **1999**, *32*, 3-15.

11. (a) Praly, J.-P.; Z, El Kharraf Descotes, G. *Carbohydr. Res*. **1992**, *232*, 117-123. (b) Praly, J.-P.; Chen, G.-R.; Gola, J.; Hetzer, g.; Rophoz, C. *Tetrahedron Lett*. **1997**, *38*, 8185-88.

12. Yang, W.-B.; Chang, C.-F.; Wang, S.-H.; Teo, C.-F.; Lin, C.-H.; *Tetrahedron Lett*. **2001**, *42*, 4657-60.

13. Tiwari, V.K.; Tripathi, R.P. *Indian J. Chem*, **2002**, *41B*, 1681-1685. (b) Khan, A. R.; Tripathi, R. P.; Tiwari, V. K.; Mishra, R. C.; Reddy, V. J. M.; and Saxena, J.K.; *J. Carbohydr.Chem.* **2002**, *21*, 587-600.

14.(a) Shirashi, H.; Kawasaki, Y.; Sakaguchi, S.; Nishiyama, Y.; Ishii, Y. *Tetrahedron Lett.* **1996**, *37*, 7291-7294 and references cited therein. (b) Mukiyama, T. *Org. React.* **1982**, *28*, 203 (c) Pellicciari, R.; Natalini, B.; Sadeghpour, B. M.; Marinozzi, M.; Snyder J. P.; Bobby Williamson, J. L.; Kuethe, T.; Padwa, A. *J. Am. Chem. Soc.* **1996**, *118*, 1-12. (d) Moody, C.J.; Taylor, R.J. K. *Tetrahedron Lett*. **1987**, *28*, 5351-5352.

15. Jiang, N.; Qu., Z.; Wang, J. *Tetrahedron Lett*. **2002,** *43,* 1285-1287.

16. Yao, W.; wang, J. *Org. Lett*. **2003**, *5*, 1527-1530.

17. Thompson, C. F.; Jamison, T F.; Jacobsen, E. N**.** *J. Am. Chem. Soc*. **2001,** *123,* 9974-81