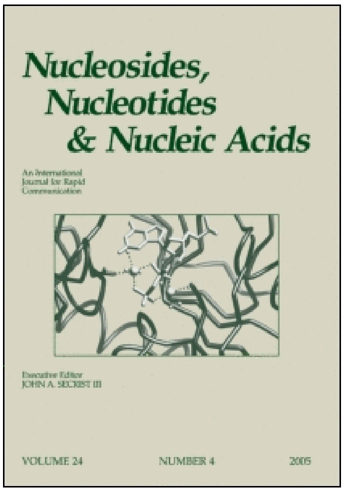

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Studies ON Epimeric-D-*asabino*-and-D-*ribo*-tetritol-1-yl-2-phenyl-2 *H*-1,2,3-triazoles. Synthesis and Anomeric Configuration of 4-(α-and β-D-Erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-Triazole *C*-Nucleoside Analogs

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STUDIES ON EPIMERIC-D-*ARABINO*- AND -D-*RIBO*-TETRITOL-1-YL-2-PHENYL-2 *H*-1,2,3-TRIAZOLES. SYNTHESIS AND ANOMERIC CONFIGURATION OF 4-(α- AND β-D-ERYTHROFURANOSYL)-2-PHENYL-2 *H*-1,2,3-TRIAZOLE *C*-NUCLEOSIDE ANALOGS

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Abstract- Treatment of 4-(**D**-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole (**1**) with one mole equivalent of tosyl chloride in pyridine solution, afforded the *C*-nucleoside analogs, 4-(α-**D**-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (**2**) in 25% yield, as well as the byproduct 4-(4-chloro-4-deoxy-**D**-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole(**3**). Treatment of the epimeric 4-(**D**-*ribo*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole(**8**) with tosyl chloride in pyridine solution afforded the anomeric *C*-nucleoside analogs, 4-(β-**D**-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (**9**) in 23% yield. Similar treatment of **8** with trifluoromethanesulfonyl chloride in pyridine solution afforded **9**. The structure and anomeric configuration of these compounds were determined by acylation, NMR, NOE, circular dichroism spectroscopy and mass spectrometry.

We have been interested[1-7] in the synthesis of *C*-nucleoside analogs by acid-catalyzed dehydrative cyclization of heterocyclic polyhydroxyalkyl analogs. Heterocycle pentahydroxypentyl analogs give a mixture of anomeric pyranosyl and furanosyl *C*-nucleosides[6]. Studies on acid catalyzed dehydration of epimeric saccharide tetrahydroxybutyl heterocycles indicated that the reaction is stereospecific with the formation of a preponderant furanosyl *C*-nucleoside analog having *trans* arrangement of C-2′-OH and the base moiety[3-5,7,8]. The preponderant isomer is obtained from both epimers without inversion at C-1′ of the precursor acyclic epimer having the

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*To whom correspondence should be addressed *cis* arrangement of 1′-OH and 2′-OH, and with inversion at C-1′ of the precursor epimer having the *trans* arrangement of 1′-OH and 2′-OH. The ease of the acid catalyzed dehydrative cyclization process is greatly affected by the type and bulk of the base moiety[4].

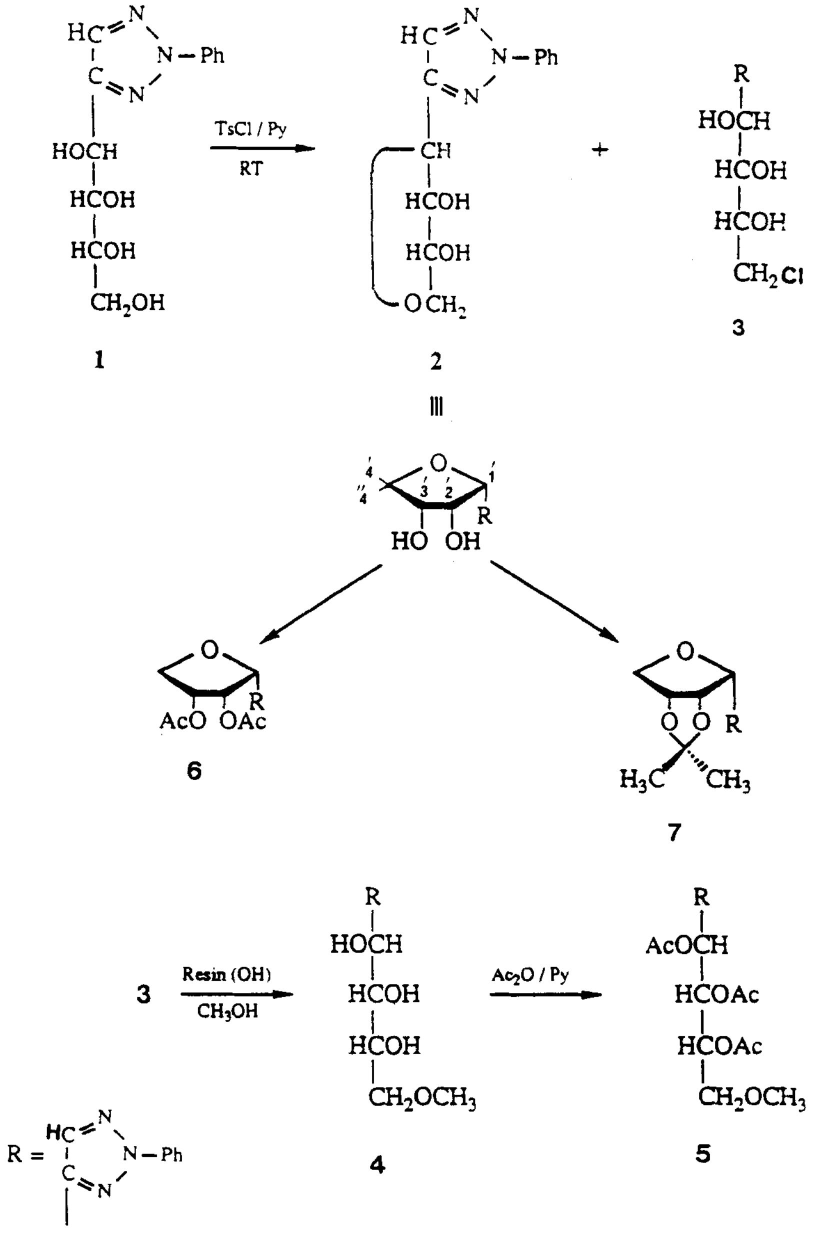
In this work the dehydrative cyclization of two epimeris, 4-(**D**-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole **1** and 4-(**D**-*ribo*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole **8**, was studied in basic medium, using tosyl chloride or trifluoromethanesulfonyl chloride in pyridine solution. The structure and anomeric configuration of the products were determined by ^{1}H NMR spectroscopy and mass spectrometry.

RESULTS AND DISCUSSION

Treatment of 4-(**D**-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole **1** with one mole equivalent of tosyl chloride in pyridine solution afforded the *C*-nucleoside analog namely; 4-(α-**D**-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole **2** in 25% yield. In addition, 4-(4-chloro-4-deoxy-**D**-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole **3** was isolated as a byproduct by silica gel chromatography (Scheme 1). When the chromatographic separation was affected on basic ion exchange resin (Dowex OH$^-$ form) with gradient elution with aqueous methanol, compound **3** was converted into the 4′-methoxy analog (**4**). Compound **4** upon acetylation afforded the tri-*O*-acetyl derivative (**5**).

The ^{1}H NMR spectrum of **2** showed the anomeric proton as a doublet at δ 5.12 having a coupling constant ($J_{1',2'}$) of 4.4 Hz. This coupling constant value is not low enough to define the anomeric configuration[9-11] of **2**. Likewise, its acetyl derivative (**6**) showed the anomeric proton as a doublet at δ 5.42 having a coupling constant ($J_{1',2'}$) of 5.2 Hz. The isopropylidene derivative (**7**), showed the anomeric proton as a doublet at δ 4.82 with a coupling constant ($J_{1',2'}$) of 3.7 Hz which cannot uniquivocally ascertain the anomeric configuration. The difference Δδ value 0.21 (1.55-1.34) between the chemical shift of the methyl signals of the 2,2-dimethyldioxolane ring for **7** is confusing as it lies in the range corresponding to the β anomers[12-14].

The ^{1}H NMR spectrum of compound **3** showed three doublets at δ 4.90, 5.30, and 5.42 corresponding to three secondary hydroxyl groups, which disappeared by deuteration. Its mass spectrum showed molecular ion peaks at m/z 283 and 285 in the ratio of 3:1 for the chlorine isotops. The position of the chlorine atom was ascertained from its ^{13}C NMR spectrum which showed upfield shift (δ 49.1) of C-4′. These results are in accord with the acyclic structure **3**. Upon chromatographic separation of the tosylating mixture on basic ion exchange resin and elution with aqueous methanol, compound **3** was converted into the 4′-methoxy analog **4**. Its ^{1}H NMR spectrum showed a singlet at δ 3.27 corresponding to the methoxyl group and three doublets at δ 4.70, 4.86, and 5.31 corresponding to three secondary hydroxyl groups which

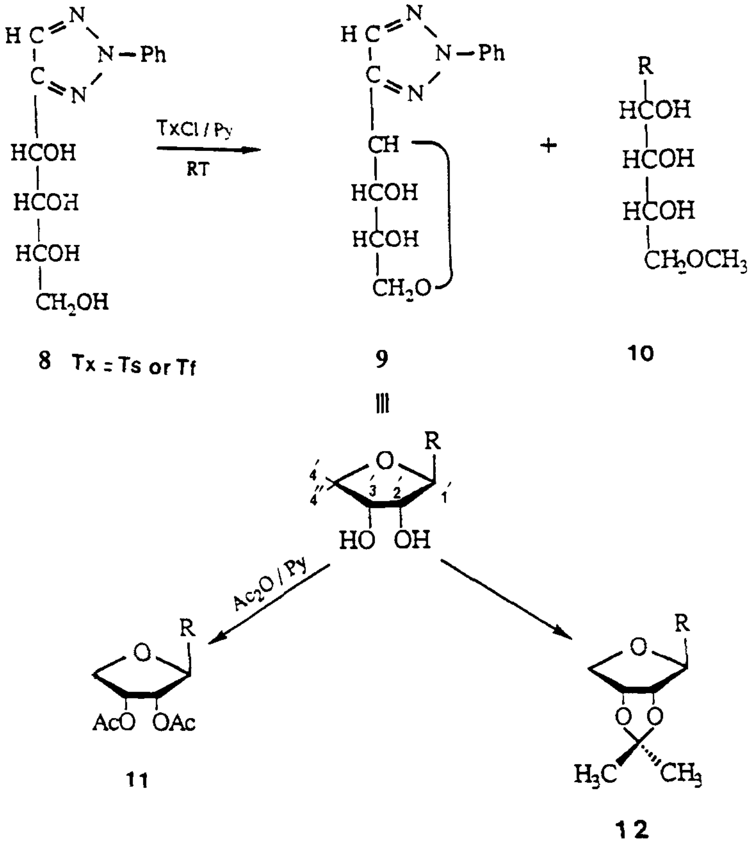


Scheme 1

disappeared by deuteration. The ^{13}C NMR spectrum of **4** showed a downfield shift of C-4′ (δ 74.7) which appeared as the most downfield signal, whereas the corresponding C-4′ signal for **3** was the most upfield shifted signal. This is explained by the reverse anisotropic effect of the methoxyl group at **4** and the chlorine atom at **3**. Acetylation of **4** afforded the tri-*O*-acetyl derivative **5**. Its ^{1}H NMR spectrum showed three *O*-acetyl signals at δ 2.07, 2.08, and 2.13, in addition to the methoxyl signal at δ 3.32. The position of the methoxyl group at **5** was confirmed by the downfield shift of H-1′, H-2′, and H-3′ compared to that of **4** due to α-acetylation at these positions.

In order to confirm the anomeric configuration of **2** and to shed some light on the mechanism and the steric course of the dehydration process in basic medium, 4-(**D**-*ribo*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole (**8**), was similarly treated with equimolar amount of tosyl chloride in pyridine solution and the products were separated by chromatography on Dowex OH^- form. It gave the *C*-nucleoside analog, namely; 4-(β-**D**-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole **9** in 22% yield as well as the acyclic 4′-methoxyl analog (**10**) (Scheme 2).

Treatment of **8**, with one molar equivalent of trifluoromethanesulfonyl chloride instead of tosyl chloride, in pyridine solution afforded **9** in 36% yield. The ^{1}H NMR spectrum of **9** showed the anomeric proton as a doublet at δ 4.80 having a coupling constant $J_{1',2'}$ 6.6 Hz, and its diacetyl derivative (**11**) showed the anomeric proton H-1′ as a doublet at δ 5.20 having a coupling constant $J_{1',2'}$ 5.7 Hz. However, its isopropylidene derivative (**12**) showed the anomeric proton H-1′ as a singlet at δ 5.29. This zero coupling constant value is a uniquivocal proof[10] of a *trans* arrangement of H-1′ and H-2′, i.e. β-**D**-erythrofuranosyl configuration. The anomeric isopropylidene derivative **7** having $J_{1',2'}$ 3.7 Hz, can therefore by comparison with **12**, be given the α-**D**-erythrofuranosyl configuration. The two methyl signals of the 2,2-dimethyldioxolane ring for **12**, were shown at δ 1.59 and 1.39 having Δδ 0.20, which is very close to the value for the anomer **7** (Δδ 0.21). Thus, the anomeric configuration of these type of compounds cannot be determined from the Δδ criterion[12] even if we have the two anomers on hand, and this concept should be used with care for anomeric assignment of 1,2,3-triazole *C*-nucleoside analogs. Having the two anomers **2** and **9** on hand, their anomeric configuration can be ascertained from their chemical shift values[15,16]. Compound **2** having the anomeric proton (H-1′) at lower field (δ 5.12) indicates *cis* arrangement of H-1′ and H-2′, whereas compound **9** having the anomeric proton (H-1′) at higher field (δ 4.80) was given the *trans* arrangement. This chemical shift concept is also applicable for the anomeric di-*O*-acetyl pair **6** and **11**. Compound **6** showed the anomeric resonance at lower field (δ 5.42) than compound **11** (δ 5.20) which is in accord with *cis* arrangement of H-1′ and H-2′ for **6** and *trans* arrangement for **11**. However, the



Scheme 2

isopropylidene derivatives **7** and **12**, showed an opposite correlation. The *trans* anomeric proton of **12** was shown at lower field (δ 5.29) than that of the *cis* anomer **7** (δ 4.82).

Nuclear Overhauser Effect (NOE) is considered as a more reliable tool for anomeric assignment[17,18] (without the need for comparison with the corresponding anomer). For β-glycofuranosides, the configuration of carbons bonded to the ring oxygen (C-1′ and C-4′) place the respective hydrogens on the same face of the furanosyl ring and an NOE at H-4″[19] upon saturation of H-1′ indicates β-configuration. Irradiation of H-1′ of compound **9** resulted in an enhancement (1.8%) of H-4″. Similarly, irradiation of H-4″ resulted in an enhancement (3.0%) of H-1′, in accord with the β-configuration for **9**. For α-furanosides, saturation of H-1′ results in an NOE at H-3′. Irradiation of H-1′ of compound **2** showed enhancement (5.1%) of H-3′ without enhancement of H-4″. Similarly, saturation of H-3′ showed enhancement (5.6%) of H-1′, in accord with the α-configuration for compound **2**.

Additional evidence for the anomeric configuration of compounds **2** and **9** was obtained from their chiroptical properties. Both compounds **2** and **9** showed negative specific rotations ($[\alpha]_D^{22}$ in pyridine: **2**, -67.5°; **9**, -71.8°). However, in their circular dichroism (CD) spectra (FIG. 1), they showed an opposite Cotton effect at 230-300 nm. The absorption at this region is manifested by the configuration of the carbon atom α to the triazole base moiety. Compound **2** showed negative Cotton effect at 230-300 nm having the same sign of the precursor triazole **1** (FIG. 2), in accord with L-*glycero*-configuration of C-1′ in the Fischer projection formula. Therefore compound **2** was obtained from **1** without inversion in the configuration of C-1′, that is, having the α-**D**-*erythro*-configuration of the furanosyl group formed. On the other hand, compound **9**, having a positive Cotton effect at the same region, with a similar sign for its precursor triazole **8**, is in accord with the **D**-*glycero*-configuration of C-1′. That is, **9** is obtained from **8** without inversion in the configuration of C-1′, i.e. having the β-**D**-*erythro*-configuration of the furanosyl group formed.

The formation of the *C*-nucleoside triazole **2** from its precursor **1** in basic medium, can be explained by the formation of the primary tosyl intermediate **13**, as a kinetic product which cyclizes by S_N2 attack of C-1′ to the 4′-leaving group, giving the thermodyamically stable *C*-nucleoside **2** (Scheme 3). Similar explanation can be given for the formation of **9** from **8**.

In conclusion, the dehydrative cyclization of tetrahydroxybutyl 2-phenyl-2 *H*-1,2,3-triazoles in basic medium is an S_N^2 process, without inversion at C-1′, making accessible the two anomeric *C*-nucleoside analogs from their precursor acyclic epimers; the *cis* (base moiety and 2′-OH) α-*C*-nucleoside **2** from **1**, and the *trans* β-*C*-nucleoside **9** from **8**. The latter can be obtained in better yield from either **1** or **8** by cyclization in acid medium. However, the less amenable *cis* α-*C*-nucleoside **2** can only be obtained from **1** in basic medium. The yield in basic medium is in general lower than in acidic medium, due to the formation of more mobile partially tosylated *C*-nucleoside derivatives and the byproduct 4′-chloro-4′-deoxy analog. The formation of the latter is common in this type of reactions and the change of tosyl chloride to trifluoromethanesulfonyl chloride did not eliminate the formation of this byproduct.

The mass spectrum of compound **2** showed molecular ion peak at *m/z* 247. The base peak was shown at *m/z* 174 corresponding to the fragment BCHOH which is characteristic for *C*-nucleosides. The mass spectra of compounds **4** and **10** showed molecular ion peak at *m/z* 279. The base peak was shown at *m/z* 174 corresponding to the fragment BCHOH. Compound **5** showed molecular ion peak *m/z* 405 and the base peak was shown at m/z 258 corresponding to the fragment M - AcOH - Ac - CH_2OMe. The mass spectra of the acetyl derivatives **6** and **11** showed the molecular ion peaks at *m/z* 331 and the base peak was shown at *m/z* 212

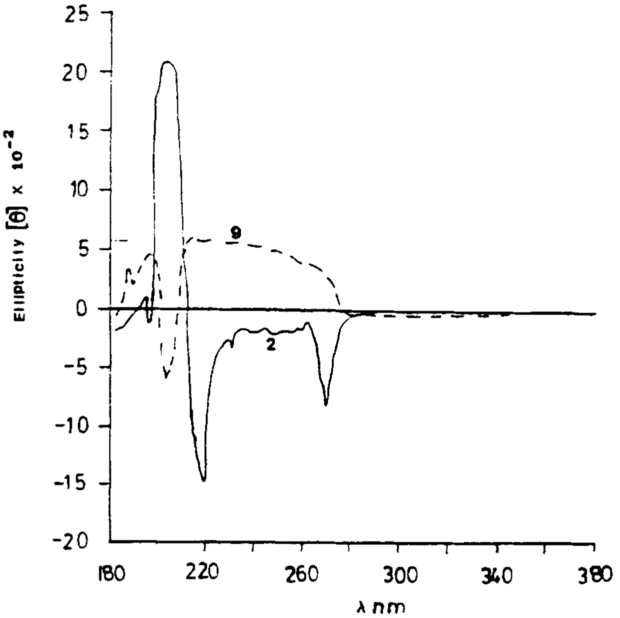


FIG. 1. C.d. spectra of (**2**) 4-(α-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (——), and (**9**) 4-(β-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (- - - -).

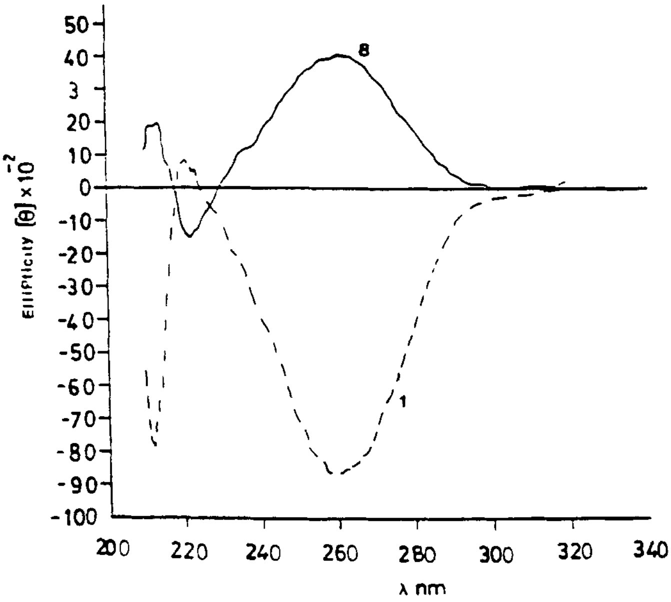
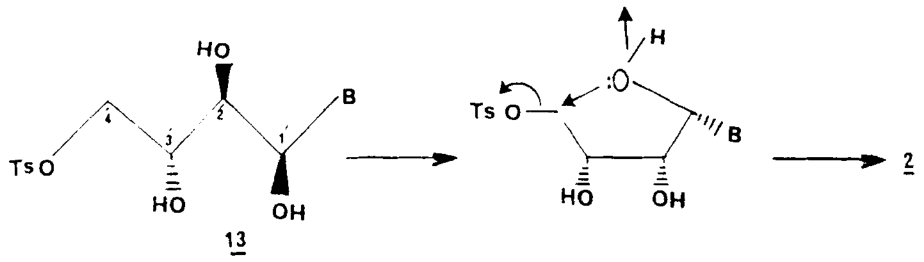


FIG. 2. C.d. spectra of (**1**) 4-(D-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole (- - - -), and (**8**) 4-(D-*ribo*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole (——).



Scheme 3

corresponding to the fragment M - AcOH - OAc. The mass spectra of the isopropylidene derivatives 7 and 12 showed molecular ion peaks at *m/z* 287. The base peaks were shown at *m/z* 173 corresponding to the fragment BCHO.

EXPERIMENTAL

General.- Melting points were uncorrected. Evaporations were performed under diminished pressure at < 60°C. Thin-layer chromatography (TLC) was conducted on silica gel (Kiesel gel G, Merck) with solvent **A**, 3:1 ethylacetate-hexane; solvent **B**, 3:1 benzene-ethanol, and solvent **C**, 2:3 ethylacetate-hexane. The products were detected by UV light at 254 nm. Optical rotations were obtained at 20±2°C with a Perkin-Elmer 241 Polarimeter (10 cm, 1 ml microcell). Circular dichroism (c.d.) measurements were recorded for solutions in methanol on Jasco-J500A spectropolarimeter, at a dynode voltage not exceeding 0.75 kV, at concentrations 1 mg/ml MeOH (0.2 ml microcell). ^{1}H NMR spectra were recorded with Joel EX (400 MHz) or with Bruker (500 MHz) spectrometers using tetramethylsilane as an internal standard. ^{13}C NMR spectra were recorded with Joel Ex 400 instrument at 100.4 MHz, or Bruker 500 instrument at 125.7 MHz. Assignment of carbons was verified by ^{1}H-^{13}C Cosy experiments. Mass spectra were recorded with AEI MS 902 spectrometer. FAB$^+$ mass spectra were obtained on a Finnigan MAT-900 mass spectrometer through ionization with Xe using 3-nitrobenzyl alcohol (3-NBA) as the matrix compound. High resolution mass spectra were recorded with a VG 70-250S spectrometer.

4-(α-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (2).- A solution of 4-(D-*arabino*-tetritol-1-yl)-2 *H*-1,2,3-triazole **1** (1 g, 3.8 mmol) in dry pyridine (30 mL) was treated at room temperature with a solution of *p*-toluenesulfonyl chloride (0.72 g, 1 mol equiv.) in dry pyridine (10 mL) and the mixture was kept at room temperature for 48 h. TLC (solvent A) showed the disappearance of the starting material. A few drops of water were added to stop the reaction and the mixture was evaporated into a syrup. Traces of pyridine were removed by spin coevaporation with toluene, and the dry syrup was applied on a column (45 x 2.5 cm) of silica gel G60, eluted with solvent A and fractions (5 mL) were collected. Identical fractions were collected and evaporated till dryness giving a colorless precipitate, yield 230 mg (25%). It was recrystallized from chloroform-hexane, giving colorless needles of **2**, m.p. 97-98°; R_f 0.37 (solvent A), $[\alpha]_D^{20}$ -67.5 (c 1.09, methanol); $[\alpha]_{589}$ -67.5°, $[\alpha]_{578}$ -82.3°, $[\alpha]_{436}$ -163.9°, $[\alpha]_{365}$ -324.2°; for ^{1}H NMR and ^{13}C NMR data see Tables I and II; mass spectral data (selected ions): *m/z* 247 (17, M), 188 (18, BCH_2CHOH, where B = 2-phenyl-2 *H*-1,2,3-triazole-4-yl moiety), 187 (6, BCH_2CHO), 175 (16, BCH_2OH), 174 (100, BCHOH), 173 (5, BCHO), 158 (6), 92 (9, PhNH), 91 (23, PhN), 77 (22, Ph), and 56 (6, cyclopentadiene ion); accurate measurement of the molecular-ion peak: Found 247.0954 (Calcd for $C_{12}H_{13}N_3O_3$, 247.0957).

4-(4-Chloro-4-deoxy-D-*arabino*-tetritol)-2-phenyl-2 *H*-1,2,3-triazole (3).- It was separated at the early fractions (13-20) of the silica gel column chromatography of the original tosylation syrup, having R_f 0.44 (solvent A) at the front R_f of **2**. The fractions were collected and evaporated till dryness giving a colorless precipitate, yield 50 mg. It was recrystallized from chloroform to give colorless needles, m.p. 130-132°C; for ^{1}H NMR and ^{13}C NMR data see Tables I and II; mass spectral data (selected ions): *m/z* 285 (0.2, ^{37}M), 283 (0.6, ^{35}M), 265 (1, M - H_2O), 247 (1, M - 2 H_2O), 204 (1, BCHOHCHOH), 200 (4), 188 (6, BCH_2CHOH), 187 (6, BCH_2CHO), 186 (4), 175 (25, BCH_2OH), 174 (100, BCHOH), 173 (24, BCHO), 172 (BCO), 158 (8), 146 (3, BH_2), 145 (1, BH), 144 (1, B), 119 (2, BHN_3), 92 (24, PhNH), 91 (43, PhN), 77 (39, Ph), 65 (17), 64 (16), and 51 (17); accurate measurement of the molecular ion peak: Found 283.0726 (Calcd for $C_{12}H_{14}N_3O_3Cl$ 283.0724.

Chromatographic separation of 2 on anion exchange resin.- Compound **1** (2 g) in pyridine (20 mL), was treated with tosyl chloride (1.44 g) and the mixture was kept at room temperature for 24 h. The mixture was processed as described before, and the dry syrup was dissolved in the minimum amount of methanol and applied on a column (45 x 2.5 cm) of Dowex 1 x 2 (OH^-) ion exchange resin (200-400 mesh) and eluted with water (1 L), 30% (1.5 L), and 60% (1 L) aqueous methanol and fractions (5 mL) were collected. Fractions 62-90 were identical, collected, and evaporated till dryness giving colorless precipitate of **2**, yield 350 mg (19%). It was recrystallized from chloroform giving colorless needles m.p. and mixed m.p. (with **2**) 97-98°.

4-(4-*O*-Methyl-D-*arabino*-tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole (4).- It was eluted from the resin column chromatography with 60% aqueous methanol at the early fractions before compound **2** as a colorless precipitate, yield 140 mg, recrystallized from chloroform as colorless needles m.p. 134-136°C, R_f 0.24 (solvent B); for ^{1}H NMR and ^{13}C NMR data see Tables I and

TABLE I. ^{1}H NMR DATA, CHEMICAL SHIFTS (δ)[a] AND FIRST-ORDER COUPLING CONSTANTS (J Hz)[a]

Compound	Glycosyl part								2-Phenyl-2 *H*-1,2,3-triazole			
									H-5	phenyl group		
	H-1′	H-2′	H-3′	H-4′	H-4″	OH	OAc (OCH$_3$)	Isop.		*o*	*m*	*p*
(2)[b]	5.12d $J_{1',2'}$ 4.4	4.15t $J_{2',3'}$ 8.8	4.36m	3.91dd $J_{3',4'}$ 6.8	3.73dd $J_{3',4''}$ 6.8 $J_{4',4''}$ 8.3	4.99d 5.03d			7.98s	7.99d	7.56t	7.40t
(3)[b]	5.13s	3.54d $J_{2',3'}$ 8.4	→ 3.87m ←		3.71dd $J_{3',4''}$ 6.4 $J_{4',4''}$ 11.2	4.90d 5.30d 5.42d			7.96s	7.99m	7.56t	7.40t
(4)[b]	5.12d $J_{1',2'}$ 2.0	3.53d $J_{2',3'}$ 8.8	3.73m	3.57dd $J_{3',4'}$ 2.4	3.39dd $J_{3',4''}$ 6.4 $J_{4',4''}$ 9.8	4.70d 4.86d 5.31d	(3.27s)		7.96s	7.98t	7.56m	7.40t
(5)[c]	6.35d $J_{1',2'}$ 4.4	5.74dd $J_{2',3'}$ 7.3	5.26m	3.57dd $J_{3',4'}$ 4.0	3.45dd $J_{3',4''}$ 5.6 $J_{4',4''}$ 10.8		2.07s 2.08s 2.13s (3.32s)		7.74s	8.03d	7.46t	7.35t
(6)[c]	5.42d $J_{1',2'}$ 5.2	5.66dd	5.57m	4.24dd $J_{3',4'}$ 6.2	4.10dd $J_{3',4''}$ 4.9 $J_{4',4''}$ 9.8		1.96s 2.08s		7.86s	8.04d	7.47t	7.35t

(7)[c]	4.82d $J_{1',2'}$ 3.7	4.85dd $J_{2',3'}$ 5.8	4.94dd $J_{3',4'}$ 3.9	4.19d	3.67dd $J_{3',4'}$ 3.8 $J_{4',4'}$ 10.8			1.55s 1.34s Δδ 0.21	7.93s	8.05d	7.46t	7.33t
(9)[d]	4.80d $J_{1',2'}$ 6.6	→ 4.14m ←			3.70dd $J_{3',4'}$ 2.6 $J_{4',4'}$ 9.0	4.99d 5.14d			8.08s	7.99d	7.55m	7.41m
(11)[c]	5.20d $J_{1',2'}$ 5.7	→ 5.57m ←		4.42d $J_{3',4'}$ 5.2	4.00dd $J_{3',4'}$ 3.3 $J_{4',4'}$ 10.2		2.10s 2.13s		7.80s	8.05d	7.35t	7.47t
(12)[c]	5.29s	5.23d	4.93dd $J_{2',3'}$ 6.0	4.10d $J_{3',4'}$ 4.1	3.85dd $J_{3',4'}$ 4.0 $J_{4',4'}$ 10.6			1.59s 1.39s Δδ 0.20	7.75s	8.04dd	7.48m	7.35t

[a] J and δ values for the sugar protons were measured after exchanging with CD_3CO_2D; [b] In Me_2SO-d_6 at 400 MHz; [c] In $CDCl_3$ at 500 MHz; [d] In Me_2SO-d_6 at 500 MHz.

TABLE II. ^{13}C NMR DATA AND CHEMICAL SHIFTS (δ).

Compound	Glycosyl part							2-phenyl-2 *H*-1,2,3-triazole					
	C-1′	C-2′	C-3′	C-4′	CO	CH_3 (OCH_3)	Isop (acetonide C)	C-4	C-5	C-a	C-*o*	C-*m*	C-*p*
(2)[a]	76.0	71.1	71.6	72.0				139.3	136.5	148.5	118.2	129.8	127.5
(3)[b]	65.1	74.0	69.7	49.1				139.3	135.2	152.9	118.0	129.6	127.2
(4)[b]	65.2	73.8	69.2	74.7		(58.3)		139.3	135.2	153.1	118.1	129.6	127.3
(6)[c]	73.6	71.1	71.2	68.9	168.4 168.9	19.5 19.6		138.7	134.1	144.8	117.8	128.3	126.6
(7)[c]	73.1	77.9	→ 81.3 ←				26.0 24.7 Δδ 1.3 (112.6)	139.9	136.0	145.1	118.9	129.2	127.4
(9)[d]	75.6	76.4	70.4	73.0				139.1	134.7	149.9	118.3	129.7	127.6
(11)[c]	75.3	74.8	71.3	71.0	169.7 169.9	20.5 20.6		139.7	134.0	147.0	119.0	129.2	127.7
(12)[c]	79.1	81.3	84.8	72.8			26.5 25.0 Δδ 1.5 (112.8)	139.7	134.2	147.2	118.9	129.3	127.6

[a] In Me_2SO-d_6 + CD_3CO_2D at 100.4 MHz; [b] In Me_2SO-d_6 + CD_3CO_2D at 125.8 MHz; [c] In $CDCl_3$ at 125.8 MHz; [d] In Me_2SO-d_6 at 125.8 MHz.

II; mass spectral data (FAB, selected ions), *m/z* 280 (100, MH), 279 (9, M), 188 (67, BCH_2CHOH), 154 (50), 147 (35, BH_3), 136 (74); (EI, selected ions): *m/z* 280 (0.2, M + 1), 279 (1, M), 234 (1, M - CH_2OCH_3), 216 (10, M - CH_2OCH_3 - H_2O), 188 (8, M - CH_2OCH_3 - CO), 186 (3), 176 (9), 175 (87, BCH_2OH), 174 (100, BCHOH), 173 (11, BCHO), 172 (3, BCO), 146 (5), 93 (20, $PhNH_2$), 92 (18, PhNH), 91 (25, PhN), 88 (28), 87 (7), 77 (32, Ph), 65 (12), 51 (12), and 45 (CH_2OCH_3); accurate measurement of the molecular ion peak: Found 279.1218 (Calcd for $C_{13}H_{17}N_3O_4$, 279.1219).

4-(4-*O*-Methyl-1,2,3-tri-O-acetyl-D-*arabino*-tetritol-1-yl)-2-phenyl-2*H*-1,2,3-triazole (5).– Compound **4** (20 mg) was acetylated with a mixture (1:1) of pyridine-Ac_2O (4 mL) and kept at room temperature for 24 h. The mixture was evaporated till dryness and traces of pyridine were removed by spin coevaporation with toluene. The residual syrup was chromatographed on a short column of silica gel-G 60 (1 x 10 cm) and eluted with solvent C, giving a colorless syrup; R_f 0.54 (solvent A); for ^1H NMR data see Table I; mass spectral data (FAB, selected ions): *m/z* 406 (6, M + 1), 405 (4, M), 391 (29, MH - CH_3), 346 (100, MH - AcOH), 258 (23, M - AcOH - Ac - CH_2OCH_3), 230 (26), 149 (89, BCH_2OH - CN); (EI, selected ions): *m/z* 406 (1, M + 1), 405 (3, M), 345 (11, M - AcOH), 313 (7), 303 (9, M - AcOH - CH_2CO), 300 (14, M - AcOH - Ac), 259 (16, M - 2 OAc - CH_2OMe), 258 (100, M - AcOH - Ac - CH_2OMe), 243 (12), 230 (5), 217 (23, BCH_2OAc), 216 (80, BCHOAc), 212 (10), 200 (8), 188 (13, $BHCH_2CHO$), 187 (17, BCH_2CHO), 175 (15, BCH_2OH), 174 (86, BCHOH), 173 (15, BCHO), 172 (8, BCO), 171 (6), 158 (8), 147 (14), 129 (11), 103 (8), 92 (10, PhNH), 91 (25, PhN), 87 (35), 77 (23, Ph), 64 (7), and 43 (42, CH_3CO); accurate measurement of the molecular ion peak: Found 405.1541 (Calcd for $C_{19}H_{23}N_3O_7$, 405.1536).

4-(2,3-Di-*O*-acetyl-α-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (6).– Compound **2** (10 mg) was treated with a mixture (1:1) of pyridine-Ac_2O (4 mL) and kept at room temperature for 24 h. The mixture was processed as described for **5**. The dry residual syrup was purified by chromatography on a short column of silica gel G 60 (1 x 10 cm) eluted with solvent C. It gave a colorless syrup R_f 0.59 (solvent A); for ^1H NMR and ^{13}C NMR data see Tables I and II; mass spectral data (EI, selected ions): *m/z* 332 (2, M + 1), 331 (12, M), 271 (1, M - AcOH), 213 (14, M - 2 AcO), 212 (100, M - AcOH - OAc), 200 (6), 187 (7, BCH_2CHO), 175 (6, BCH_2OH), 174 (43, BCHOH), 173 (10, BCHO), 172 (8, BCO), 158 (5, BCH_2), 149 (10), 145 (1, BH), 115 (28), 91 (15, PhN), 77 (14, Ph); accurate measurement of the molecular ion peak: Found 331.1173 (Calcd for $C_{16}H_{17}N_3O_5$, 331.1168).

4-(2,3-*O*-Isopropylidene-α-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (7).– A solution of **2** (60 mg) in dry acetone (50 mL), and *p*-toluenesulfonic acid (50 mg) was added and the mixture stirred overnight at room temperature. TLC (solvent A) indicated the absence of the starting material and formation of a more mobile spot R_f 0.69. The mixture was poured onto an ice-cold solution of sodium hydrogen-carbonate, and extracted with chloroform. The extract was washed with water, dried over anhydrous sodium sulfate and evaporated till dryness. It gave colorless syrup which was crystallized from dilute methanol giving **7** as colorless needles, yield 50 mg; m.p. 106-108°; for ^{1}H NMR and ^{13}C NMR data see Tables I and II; mass spectral data (EI, selected ions): *m/z* 288 (4, M + 1), 287 (23, M), 200 (3), 174 (23, BCHOH), 173 (100, BCHO), 172 (9), 136 (3), 118 (5), 91 (PhN), 77 (Ph), 64 (9), and 59 (15); accurate measurement of the molecular ion peak: Found 287.1272 (Calcd for $C_{15}H_{17}N_3O_3$: 287.1270).

4-(β-D-Erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (9).– 4-(D-*ribo*-Tetritol-1-yl)-2-phenyl-2 *H*-1,2,3-triazole **8** (1.5 g) was dissolved in dry pyridine (30 mL) and treated portionwise with *p*-toluenesulfonyl chloride (1.5 g) and the mixture kept for 24 h at room temperature, TLC (solvent B) indicated the disappearance of the starting material. The mixture was evaporated till dryness and traces of pyridine were removed by spin coevaporation with

4-(2,3-*O*-Isopropylidene-β-D-erythrofuranosyl)-2-phenyl-2 *H*-1,2,3-triazole (12).– Compound **9** (60 mg) was dissolved in dry acetone (60 mL), treated with *p*-toluenesulfonic acid (45 mg) and the mixture worked up as described for **7**. It gave colorless syrup which was recrystallized from petroleum ether as colorless needles, yield 45 mg; m.p. 60-62° (Lit.[4] m.p. 62°); for ^{1}H NMR and ^{13}C NMR data see Tables I and II; mass spectral data (EI, selected ions): *m/z* 288 (4, M + 1), 287 (20, M), 273 (11, MH - CH_3), 272 (65, M - CH_3), 212 (21, M - AcOH - CH_3), 200 (4), 174 (25, BCHOH), 173 (100, BCHO), 172 (6, BCO), 158 (5), 149 (5), 136 (4), 118 (5), 106 (4), 92 (8, PhNH), 91 (43, PhN), 85 (4), 77 (21, Ph), 64 (8), and 59 (19); accurate measurement of the molecular ion peak; Found 287.1271 (calcd for $C_{15}H_{17}N_3O_3$, 287.1270).

Treatment of 8 with trifluoromethanesulfonyl chloride in pyridine solution.– Compound **8** (500 mg) in dry pyridine (10 mL) was treated with trifluoromethanesulfonyl chloride (0.30 mL) under nitrogen atmosphere at room temperature, with stirring for 24 h. The mixture was diluted with methanol and evaporated till dryness. Traces of pyridine were removed by spin coevaporation with toluene. The dry residue was chromatographed on a column (30 x 2.5 cm) of silica gel G60 eluted with solvent A. Identical fractions were collected, evaporated till dryness giving compound **9** as a colorless syrup, R_f 0.30 (solvent A), yield 170 mg (36%). It was recrystallized from chloroform-hexane as colorless needles, m.p. and mixed m.p. (with **9**) 84-85 °C.

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