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Note

Synthesis of 4-(4,6-di-*O*-benzyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)pyrazoles from 3,4,6-tri-*O*-acetyl-D-glucal

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Abstract

3-(4,6-Di-*O*-benzyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-2,4-pentanedione and its analogue 2-(4,6-di-*O*-benzyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-1-phenyl-1,3-butanedione, prepared from 3,4,6-tri-*O*-acetyl-1,5-anhydro-2-deoxy-D-*arabino*-hex-1-enitol (3,4,6-tri-*O*-acetyl-D-glucal), reacted with hydrazine and its methyl-, phenyl-, *p*-tolyl, and *p*-methoxyphenyl- derivatives in ethanol, at room temperature, to afford, in 71–96% yields, a series of 4-(4,6-di-*O*-benzyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-3-methylpyrazoles having the N-1 free or substituted by the foregoing groups, and the C-5 substituted by a methyl or phenyl group. The reactions of the 1-phenyl-1,3-butanedione derivative were highly regioselective. Catalytic hydrogenation of some of these novel compounds gave the respective 4′,6′-di-*O*-deprotected-2′,3′-saturated compounds in 51–67% yields. The acetolysis/methanolysis of one of the title compounds led to the formation of the 4′,6′-di-*O*-debenzylated 2′,3′-unsaturated pyrazole *C*-nucleoside in poor yield.

Keywords: 4-(4,6-Di-*O*-benzyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-3-methylpyrazoles; 3,4,6-Tri-*O*-acetyl-D-glucal; Hydrazines; Debenzylation with and without reduction of the 2′,3′ double bond

The design of nucleoside analogues has in recent years undergone renewed impetus due, among other causes, to the activity shown by azidothymidine (AZT) and other 2′,3′-dideoxynucleosides against the human immunodeficiency virus (HIV) as a consequence of their reverse transcriptase inhibition effect. The lack of a 3′-OH group is critical for the anti-retroviral activity and, thus, other 2′,3′-dideoxynucleosides such as 2′,3′-dideoxycytidine (ddC) and 2′,3′-dideoxyinosine (ddI) have been also used as therapeutical agents [1]. Further modifications may increase the efficiency of drugs of this type; thus, the presence of a 2′,3′ double bond is a structural feature that leads to a strong and selective inhibition of the HIV replication, as is the case [2] of 2′,3′-didehydro-2′,3′-dideoxythymidine (d4T), a stereoselective synthesis of which has been recently reported [3]. On the other hand, the well known resistance of *C*-nucleosides to hydrolysis has led us to design novel nucleoside

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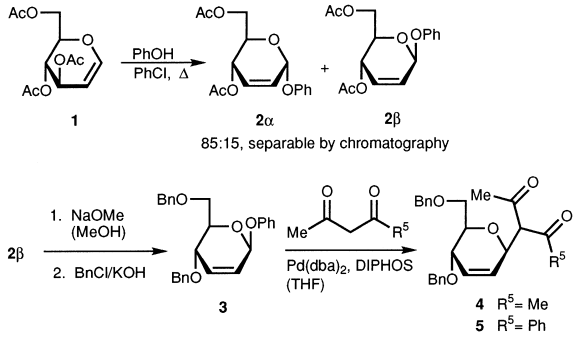
analogues having this additional feature, in order to avoid a decrease of activity as a consequence of the probable hydrolysis in the cell. As a first approach, we now describe the preparation of a series of 4-(2-enoglycosyl)pyrazoles by reaction of 2-(2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-1,3-diketones with hydrazines. To our knowledge, the only 2′,3′-unsaturated-*C*-nucleoside of pyrazole described [4] is a 3-(2-enoglycosyl)pyrazolo[4,3-*d*]-pyrimidine, prepared from a formycin derivative.

1. Results and discussion

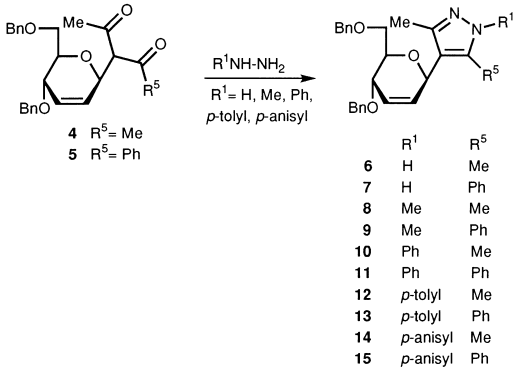
We have used as starting materials the unsaturated sugar 1,3-diketones **4** and **5**, derived from 2,4-pentanedione and 1-phenyl-1,3-butanedione, respectively. Compound **4** was prepared following the method described previously [5]. 3,4,6-Tri-*O*-acetyl-1,5-anhydro-2-deoxy-D-*arabino*-hex-1-enitol (3,4,6-tri-*O*-acetyl-D-glucal, **1**) was first transformed into a mixture of phenyl 4,6-di-*O*-acetyl-2,3-dideoxy-α- and β-D-*erythro*-hex-2-enopyranoside (**2**α and **2**β, respectively); after chromatographic separation, the β-isomer (**2**β) was deacetylated and benzylated to afford the 4,6-di-*O*-benzyl derivative **3**, which was finally treated with 2,4-pentanedione in THF in the presence of bis(dibenzylideneacetone) Pd(0) [$Pd(dba)_2$] associated with bis(diphenylphosphino)ethane (DIPHOS) as the catalyst (Scheme 1). The new compound **5**, an analogue of **4**, was prepared as a mixture of epimers at the new stereogenic centre, by applying the same procedure to 1-phenyl-1,3-butanedione.

Since the transformation of **3** into **4** occurs with total retention of the β configuration and, on the other hand, the α anomer of **3** reacts with 2,4-pentanedione under the same conditions to afford an α/β mixture of *C*-glycosides [5], we chose the β anomer **3** for the preparation of the pure β *C*-glycosides **4** and **5**. Chaguir et al. have described [6] that the α anomer of **3** reacts with 2,4-pentanedione in the presence of a large excess of triphenylphosphine to afford exclusively the β anomer **4**; this fact allows one to increase the overall yield of **4** and **5** from **1**.

Reaction of the 1,3-diketones **4** and **5** with hydrazines resulted in a series of 4′,6′-di-*O*-benzyl-2′,3′-unsaturated pyrazole *C*-nucleosides (**6**–**15**) (Scheme 2). Besides hydrazine itself, its methyl-, phenyl-, *p*-tolyl-, and *p*-methoxyphenyl- derivatives have been used as the reagent. The new compounds **6**–**15** were isolated, after column chromatography, as colourless syrups in good to high yields (71–96%), and characterized on the basis of their elemental analyses and/or spectral properties, in particular the ^1H and ^{13}C NMR spectra (Tables 1 and 2, respectively). The mild conditions under which the reaction was carried out (ethanol, room temperature, 5 min) and the low basicity of the hydrazines used as the reagent allowed us to expect no anomerisation of the substrate (**4** or **5**) through a reverse Michael reaction; in fact, the products **6**–**15** were obtained as pure β-anomers. In this respect, it is known that related 2′,3′-unsaturated-*C*-hexopyranosides had proved to be anomerically stable to weak bases [7]. As their precursors (**4** and **5**) and other 2′,3′-unsaturated β-D-*erythro*-*C*-hexopyranosides, compounds **6**–**15** should assume the half-chair $^0H_5$ conformation (Scheme 3), for which the $J_{4',5'}$ is expected [8,9] to show values in the range 8–10 Hz; that is so (Table 1) with the sole exception of **9** (7.5 Hz). The olefinic proton signals had δ values ranging from 5.70 to 5.84 ppm for H-2′, and from 5.89 to 6.08 ppm for H-3′, the assignments being confirmed by COSY experiments. Chemical shifts for the other protons at the sugar moiety, and coupling constants between



Scheme 1.



Scheme 2.

Table 1
Selected 500 MHz ^{1}H NMR data for compounds **6**–**15** in $CDCl_3$

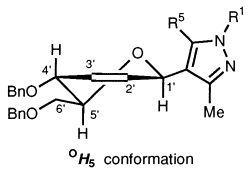
Compound	Chemical shift, δ (ppm)				Coupling constant, $J_{4',5'}$ (Hz)
	H-3′		H-2′	H-1′	H-4′
6	6.00 ddd	5.74 ddd	5.16 m	4.15 dddd	8.6
7	5.94 ddd	5.76 ddd	5.24 m	4.16 dddd	8.6
8	6.08 ddd	5.73 ddd	5.13 m	4.17 dddd	8.6
9	5.89 ddd	5.70 ddd	4.99 m	4.07 dddd	7.5
10	6.05 ddd	5.81 ddd	5.23 m	4.19 dddd	8.6
11	5.97 ddd	5.80 ddd	5.11 m	4.15 dddd	8.4
12	6.07 ddd	5.84 ddd	5.25 m	4.23 dddd	8.3
13	5.96 ddd	5.79 ddd	5.10 m	4.13 dddd	8.6
14	6.06 ddd	5.83 ddd	5.24 m	4.21 dddd	8.4
15	5.96 ddd	5.80 ddd	5.10 m	4.13 dddd	8.4

them, have values within narrow ranges. The ^{13}C NMR resonances were assigned on the basis of the data reported for related compounds, and were confirmed by heteronuclear 2D correlated experiments. In agreement with the β anomeric configuration, C-5′ gives rise to a signal at 77.43–77.84 ppm (Table 2), in the range (77.3–78.4) observed [5,6,9] for **4** and related compounds; for α anomers, the range expected [5,6,9] for C-5′ is 71.9–74.5 ppm. The β configuration was confirmed for compound **11** by 1D NOESY experiments, as unambiguous proof [6,9]; thus, irradiation at the H-1′ proton produced the inversion of the H-5′ signal, as expected [6,9] for β anomers of this kind. Apart from the reaction with unsubstituted hydrazine, which affords a mixture of tautomers, the regioselectivity observed for the reactions of the 1-phenyl-1,3-butanedione derivative **5**, leading to 3-methyl-5-phenylpyrazoles (**9**, **11**, **13**, **15**), is evidenced by the downfield shift observed for the C-4 signal on substituting the Me-5 of **8**, **10**, **12**, **14** by Ph. For simpler, structurally related pyrazole derivatives, such a change of substituents at C-5 causes [10] a downfield shift of 1.0 ppm, whereas the same change, performed at C-3, gives rise to an upfield shift of 2.2 ppm on the signal of C-4. Actually, for each of the pairs **8**–**9**, **10**–**11**, **12**–**13**, and **14**–**15**, the shift observed is a downfield shift (0.89, 1.19, 1.37, and 1.00 ppm, respectively). Another structural feature that can be deduced from the NMR spectra refers to the coplanarity of a phenyl ring and the pyrazole ring when they are directly bonded one to the other. It is well known [11] that, in 1,5-diphenylpyrazoles, both phenyl rings are twisted out of the plane of the pyrazole ring. This seems to be the case also for the 1-methyl-5-phenylpyrazole **9**, which has the Ph-5, as its analogues **11**, **13**, and **15**, flanked by two bulky groups, since on going from the first to the second component of each pair of the *N*-methyl or *N*-aryl compounds **8**–**9**, **10**–**11**, and so on, the C-1′ signal undergoes an upfield shift of 0.14–0.33 ppm. This fact may be attributed to the anisotropy effect of the non-coplanar phenyl R^5 in the corresponding compounds. In agreement with that, a similar upfield shift of 0.12–0.15 ppm is observed for the H-1′ signal in the ^{1}H NMR spectra of the 5-phenylpyrazoles **9**, **11**, **13**, and **15**, in relation to the respective 5-methylpyrazoles. The influence of the anisotropic effect of the twisted phenyl group at C-5 seems to affect also C-2′, C-5′,

Table 2
Selected 125.8 MHz ^{13}C NMR data for compounds **6**–**15** in $CDCl_3$

Compound	Chemical shift, δ (ppm)			
	C-2′	C-4	C-5′	C-1′
6	130.88	114.18	77.59	69.38
7	130.87	114.09	77.66	69.41
8	131.13	114.98	77.84	69.86
9	130.78	115.87	77.43	69.53
10	130.39	116.50	77.68	69.68
11	130.14 [a]	117.69	77.46	69.54
12	130.75	116.08	77.70	69.84
13	130.64	117.45	77.54	69.61
14	130.89	116.12	77.78	69.96
15	130.71	117.12	77.52	69.66

[a] Overlapped with one of the aromatic C signals (double intensity).



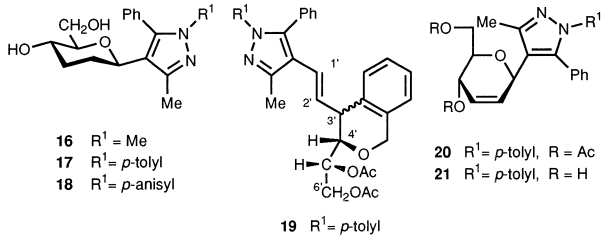
Scheme 3.

and H-2′, since all these nuclei become slightly shielded in the 5-phenyl derivatives in comparison with the corresponding 5-methyl substituted analogues, as shown in Tables 1 and 2.

Hydrogenation of compounds **9**, **13**, and **15** at atmospheric pressure in the presence of $Pd(OH)_2/C$ as the catalyst afforded 51–67% of the 4′,6′-di-*O*-debenzylated-2′,3′-saturated pyranosyl-*C*-nucleosides **16**–**18** (Scheme 4), respectively. From the observed values of $J_{1',2'ax}$ (11.6, 11.7, and 11.7 Hz) was evidenced the β configuration, which was unambiguously [6,9] confirmed for **18** by 1D NOESY experiments: irradiation at the H-1′ proton inverted the signals of the H-2′eq, H-3′ax, H-5′ax, and Me-3 protons; irradiation at the H-4′ proton affected similarly the H-2′ax and H-3′eq signals. This fact indirectly demonstrates that the parent 2′,3′-unsaturated compounds should have also the β configuration. The novel compounds **16**–**18** possess a 2′,3′-dideoxy saturated sugar moiety and, in this respect, are similar to ddC and ddI; this fact allows one to expect for them some biological activity.

A preliminary study on the di-*O*-debenzylation of any of the 2′,3′-unsaturated compounds **6**–**15** without reducing the 2′,3′ double bond was carried out. Besides sodium in liquid ammonia, we used some other reagents for which certain examples of selective debenzylation in the presence of carbon–carbon double bonds have been reported, such as boron trifluoride/ethanethiol [12], and cyclohexene as hydrogen donor in the presence of palladium on charcoal [13]. These methods, as applied to **8** (Na/liq. NH_3) and **13**, proved to be ineffective, since NMR of the complex reaction mixtures obtained in all cases indicated the lack of ethylenic protons or the presence of open-chain unsaturated sugar derivatives as main products ($J \approx 16$ Hz for *trans* arranged ethylenic protons, incompatible with the inclusion of the double bond in a six-membered ring), as well as partially debenzylated products. The formation of the desired di-*O*-debenzylated-2′,3′-unsaturated product in poor, but appreciable yield, was observed only when the acetolysis/methanolysis procedure [14] was applied to **13**. The main product of the acetolysis was, after chromatography, a 2.5:1 mixture of two epimers tentatively formulated, from the NMR data and fast-atom bombardment high-resolution mass spectrum (FABHRMS), as **19** (29%), the formation of which may be explained if the participation of the 4′-*O*-benzyl group of an intermediate 5′,6′-di-*O*-acetyl-4′-*O*-benzyl open-chain allylic cation is assumed; the high value of $J_{1',2'}$ (16.1 Hz) again indicates that the ethylenic protons must have the *trans* relationship. Another fraction (18%) of the acetolysis mixture contained as the main component a product, tentatively formulated as the expected 4′,6′-di-*O*-acetyl-2′,3′-unsaturated *C*-nucleoside **20** (10% yield from **13**, by ^{1}H NMR), the FABHRMS and NMR data of which being consistent with this structure; particularly, the value of $J_{2',3'}$ (10.3 Hz) evidenced the *Z* configuration of the double bond, and the high values of $J_{4',5'}$ (8.9 Hz) and δ for C-5′ (74.71 ppm) agreed with those expected from the β configuration (a related compound, as the 4′,6′-di-*O*-acetyl-2′,3′-dideoxy-β-D-*erythro*-hex-2′-enopyranosyl derivative of acetophenone shows [7] values of 8.7 Hz for $J_{4',5'}$ and 74.531 ppm for δ of C-5′, while for its α isomer the respective values are 3.5 Hz and 68.295 ppm). Treatment of the crude product **20** with sodium methoxide in methanol led, after preparative TLC, to a mixture, of which a main component was tentatively identified by NMR ($J_{2',3'}$ 10.5 Hz, $J_{4',5'}$ 8.7 Hz, δ for C-5′ 76.01 ppm) and DCIHRMS data as the desired 4′,6′-di-*O*-deacetylated-2′-enoglycosyl compound **21**.

In conclusion, the 4′,6′-di-*O*-benzyl-2′,3′-unsaturated *C*-nucleosides of pyrazole **6**–**15**, easily obtained in a short sequence starting from triacetylglucal, are immediate precursors of interesting saturated, deprotected sugar derivatives such as **16**–**18**. However, an improved method for the transformation of **6**–**15** into deprotected 2′-enoglycosyl derivatives such as **21** should be developed.



Scheme 4.

2. Experimental

General methods.—TLC was performed on Silica Gel 60 plates (DC-Alufolien F_{254}, E. Merck, or ALUGRAM SIL G/UV_{254}, Macherey-Nagel), and detection with UV light (254 nm) or by charring

with H_2SO_4. Silica Gel 60 (E. Merck) was used for column chromatography and hexane–EtOAc mixtures as eluants. Solutions were concentrated under diminished pressure at $<40°$. Optical rotations were measured with a Perkin-Elmer 241 MC polarimeter. IR spectra (films on KBr discs) were recorded with a FTIR Bomem Michelson MB-120 spectrometer. UV spectra were obtained on a Philips PU 8710 spectrophotometer. ^{1}H NMR spectra (500 MHz) and ^{13}C NMR spectra (125.8 MHz) were recorded for solutions in $CDCl_3$ with a Bruker AMX-500 spectrometer. Assignments were confirmed by decoupling and/or homonuclear 2D COSY, 1D NOESY, and heteronuclear 2D correlated (HETCOR) experiments. HR-EI mass spectra (70 eV) were measured with a Kratos MS-80RFA instrument, with an ionising current of 100 mA, an accelerating voltage of 4 kV, and a resolution of 10,000 (10% valley definition). Fast-atom bombardment mass spectrometry (FABMS) was performed on the same instrument; ions were produced by a beam of xenon atoms (6–7 keV) using a matrix consisting of nitrobenzene or thioglycerol and NaI as salt. FABHRMS was obtained on a VG Autospec spectrometer (Fisons Instruments) (30 keV). DCIHRMS (methane) were recorded with an AutospecQ instrument (Micromass).

*General procedure for the preparation of 2-(4,6-di-*O*-benzyl-2,3-dideoxy-*β*-*D*-erythro-hex-2-enopyranosyl) derivatives of 1,3-dicarbonyl compounds (***4***, ***5***).*—A solution of phenyl 4,6-di-*O*-benzyl-2,3-dideoxy-*β*-*D*-*erythro*-hex-2-enopyranoside (**3**) [5] (0.40 g, 1 mmol) in THF (3 mL), was transferred at room temperature, under nitrogen, into a stirred solution of bis(dibenzylideneacetone)Pd(0) [$Pd(dba)_2$, 29 mg, 0.05 mmol] [15], and 1,2-bis(diphenylphosphino)ethane (DIPHOS, 24 mg, 0.056 mmol) in THF (2 mL). To this mixture was then added the 1,3-dicarbonyl compound (2 mmol) and the reaction mixture was heated at 70 °C and stirred until complete transformation of **3** had taken place (TLC, 4:1 hexane–EtOAc, several hours). After evaporation of the solvent at reduced pressure, the residue was purified by column chromatography on silica gel (10:1 to 6:1 gradient of hexane–EtOAc) to afford pure *C*-glycosides (**4**, **5**).

*3-(4,6-Di-*O*-benzyl-2,3-dideoxy-*β*-*D*-erythro-hex-2-enopyranosyl)-2,4-pentanedione* (**4**): mp 76–77 °C, lit. oil [5]; $[\alpha]_D^{29}$ +38° (*c* 1, CH_2Cl_2), lit. $[\alpha]_D^{20}$ +33.1° [5]; ^{1}H NMR (500 MHz): δ 7.40–7.20 (m, 10 H, 2 Ph), 5.97 (ddd, 1 H, $J_{2',3'}$ 10.4, $J_{1',3'} \approx J_{3',4'}$ 1.9 Hz, H-3′), 5.73 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.6 Hz, H-2′), 4.85 (dddd, 1 H, $J_{1',3}$ 8.4 Hz, $J_{1',4'}$ 1.3 Hz, H-1′), 4.61 and 4.47 (each d, each 1 H, *J* 11.5 Hz, CH_2Ph), 4.55 and 4.51 (each d, each 1 H, *J* 12.3 Hz, CH_2Ph), 4.02 (dddd, 1 H, $J_{4',5'}$ 8.4 Hz, H-4′), 3.81 (d, 1 H, H-3), 3.70 (dd, 1 H, $J_{5',6'a}$3.9, $J_{6'a,6'b}$ 9.2 Hz, H-6′a), 3.65–3.60 (m, 2 H, H-5′ and H-6′b), 2.24 (s, 3 H, Me), and 2.21 (s, 3 H, Me); ^{13}C NMR (125.8 MHz): d 202.37 and 202.22 (2 C=O), 138.26 and 137.86 (C-2′ and C-3′), 128.37, 128.30, 128.18, 127.85, 127.79, 127.64, and 127.49 (2 Ph), 77.30 (C-5′), 73.55 (C-1′), 72.29 (C-4′), 73.21 and 71.20 (2 O*C*H_2Ph), 69.92 (C-3), 69.43 (C-6′), 30.74 (Me), and 29.67 (Me).

2(R,S)*-2-(4,6-Di-*O*-benzyl-2,3-dideoxy-*β*-*D*-erythro-hex-2-enopyranosyl)-1-phenyl-1,3-butanedione* (**5**): 0.409 g, 87%; 67:33 epimeric mixture, by ^{1}H NMR [from 1-phenyl-1,3-butanedione (0.324 g)]; λ_{max} (CH_2Cl_2) 251 nm (ε_{mM} 10.29); ν_{max} 1719, 1672 cm^{-1}; FABMS: *m*/*z* 493 (100, $[M+Na]^+$). Anal. Calcd for $C_{30}H_{30}O_5$: C, 76.57; H, 6.43. Found: C, 76.72; H, 6.32. Major isomer ^{1}H NMR: δ 8.02–7.14 (m, 15 H, 3 Ph), 5.91 (ddd, 1H, $J_{2',3'}$ 10.5, $J_{1',3'} \approx J_{3',4'}$ 1.9 Hz, H-3′), 5.72 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.13 (m, 1 H, $J_{1',4'}$ 3.1 Hz, H-1′), 4.64 (d, 1 H, $J_{1',2}$ 9.6 Hz, H-2), 4.60, 4.47 (each d, each 1 H, $J_{H,H}$ 11.8 Hz, CH_2Ph), 4.55, 4.52 (each d, each 1 H, $J_{H,H}$ 12.2 Hz, CH_2Ph), 3.99 (dddd, 1 H, $J_{1',4'}$ 3.1, $J_{2',4'} \approx J_{3',4'}$ 1.9, $J_{4',5'}$ 8.7 Hz, H-4′), 3.71 (dd, 1 H, $J_{5',6'a}$1.8, $J_{6'a,6'b}$ 10.6 Hz, H-6′a), 3.67 (ddd, 1 H, $J_{5',6'a}$1.7, $J_{5',6'b}$ 5.3, $J_{4',5'}$ 8.7 Hz, H-5′), 3.61 (dd, 1 H, $J_{5',6'b}$ 5.2, $J_{6'a,6'b}$ 10.5 Hz, H-6′b), and 2.27 (s, 3 H, Me); ^{13}C NMR: δ 201.73 (Me–*C*=O), 193.60 (Ph*C*=O), 138.25–127.31 (C-2′, C-3′, and 3 Ph), 77.30 (C-5′), 74.63 (C-1′), 73.16 and 71.11 (2 *C*H_2Ph), 69.91 (C-4′), 69.33 (C-6′), 67.86 (C-2), and 28.33 (Me). Minor isomer ^{1}H NMR: δ 8.02–7.14 (m, 15 H, 3 Ph), 6.01 (ddd, 1H, $J_{2',3'}$ 10.5, $J_{1',3'} \approx J_{3',4'}$ 1.9 Hz, H-3′), 5.95 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.6 Hz, H-2′), 5.03 (m, 1 H, H-1′), 4.75 (d, 1 H, $J_{1',2}$ 7.8 Hz, H-2), 4.60, 4.47 (each d, each 1 H, $J_{H,H}$ 11.8 Hz, CH_2Ph), 4.55, 4.52 (each d, each 1 H, $J_{H,H}$ 12.2 Hz, CH_2Ph), 4.09 (m, 1 H, H-4′), 3.73–3.60 (m, 3 H, H-5′, H-6′a, and H-6′b), and 2.21 (s, 3 H, Me); ^{13}C NMR: δ 201.73 (Me–*C*=O), 194.68 (Ph*C*=O), 138.25–127.31 (C-2′, C-3′, and 3 Ph), 77.49 (C-5′), 74.33 (C-1′), 73.03 and 71.11 (2 *C*H_2Ph), 69.78 (C-4′), 69.15 (C-6′), 66.03 (C-2), and 30.55 (Me).

*General procedure for the preparation of 4-(4,6-di-*O*-benzyl-2,3-dideoxy-*β*-*D*-erythro-hex-2-enopyranosyl)pyrazoles (***6***–***15***).*—To a soln of the 2-(4,6-

di-*O*-benzyl-2,3-dideoxy-*β*-D-*erythro*-hex-2-enopyranosyl)-1,3-dicarbonyl compound (**4**, **5**) (1 mmol) in EtOH (10 mL), the corresponding hydrazine (8.2 mmol) (the *p*-tolyl and *p*-anisyl derivatives were released by treatment of the respective hydrochloride with aq $NaHCO_3$) was gradually added. The resulting solution was stirred at room temperature until complete transformation of the starting sugar derivative (5 min, monitored by TLC, 4:1 hexane–EtOAc). The solvent was then evaporated under reduced pressure and the residue was purified by column chromatography on silica gel (1:3 hexane–EtOAc) to give the pure pyrazole derivative (**6**–**15**).

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3,5-dimethyl-1*H-*pyrazole* (**6**): 0.388 g (96%) [from **4** (0.408 g) and hydrazine hydrate (0.410 g, 0.50 mL)]; $[\alpha]_D^{22}$ +92° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 230, 252 nm (e_{mM} 7.90, 9.25); ν_{max} 3202 (NH), 1721, 1657 (C=C), 1497 (phenyl), 1587 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.34–7.26 (m, 10 H, 2 Ph), 6.00 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'} \approx J_{3',4'}$ 2.1 Hz, H-3′), 5.74 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.55 (bs, 1 H, H-1), 5.16 (m, 1 H, H-1′), 4.66 and 4.51 (each d, each 1 H, *J* 11.4 Hz, CH_2Ph), 4.60 and 4.53 (each d, each 1 H, *J* 12.3 Hz, CH_2Ph), 4.15 (dddd, 1 H, $J_{1',4'}$ 3.1, $J_{4',5'}$ 8.6 Hz, H-4′), 3.73 (dd, 1 H, $J_{5',6'a}$5.4, $J_{6'a,6'b}$ 10.7 Hz, H-6′a), 3.81–3.70 (m, 2 H, H-5′ and H-6′b), and 2.21 (s, 6 H, 2 Me); ^{13}C NMR: δ 142.80 (C-3 and C-5), 130.88 (C-2′), 138.21, 137.97, 128.21, 128.08, 127.66, 127.56, and 127.28 (2 Ph), 125.60 (C-3′), 114.18 (C-4), 77.59 (C-5′), 73.15 and 71.07 (2 O*C*H_2Ph), 70.50 (C-4′), 69.73 (C-6′), 69.38 (C-1′), and 10.99 (2 Me); FABMS: *m*/*z* 427 (100, $[M+Na]^+$), 405 (50, $[M+H]^+$); HRMS: *m*/*z* 404.2089 (Calcd for $C_{25}H_{28}N_2O_3$: 404.2099). Anal. Calcd for $C_{25}H_{28}N_2O_3$: C, 74.23; H, 6.98; N, 6.92. Found: C, 74.28; H, 6.61; N, 6.77.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3(5)-methyl-5(3)-phenyl-1*H-*pyrazole* (**7**): 0.441 g (95%) [from **5** (0.470 g) and hydrazine hydrate (0.410 g, 0.50 mL)]; $[\alpha]_D^{22}$ +67° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 243 nm (e_{mM} 9.32); ν_{max} 3194 (NH), 1721, 1655 (C=C), 1605 and 1495 (Ph), 1585 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.55–7.24 (m, 15 H, 3 Ph), 5.94 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'} \approx J_{3',4'}$ 1.7 Hz, H-3′), 5.76 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.6 Hz, H-2′), 5.24 (m, 1 H, H-1′), 4.63 and 4.49 (each d, each 1 H, *J* 11.6 Hz, CH_2Ph), 4.61 and 4.53 (each d, each 1 H, *J* 12.3 Hz, CH_2Ph), 4.16 (dddd, 1 H, $J_{1',4'}$ 3.0, $J_{4',5'}$ 8.6 Hz, H-4′), 3.87 (bs, 1 H, H-1), 3.74 (dd, 1 H, $J_{5',6'a}$5.4, $J_{6'a,6'b}$ 10.2 Hz, H-6′a), 3.84–3.78 (m, 2 H, H-5′ and H-6′b), and 2.14 (s, 3 H, Me); ^{13}C NMR: δ 148.09 (C-3), 143.29 (C-5), 130.87 (C-2′), 138.36, 138.04, 131.79, 128.60, 128.29, 128.23, 128.16, 127.98, 127.73, 127.64, 127.59, and 127.35 (3 Ph), 126.00 (C-3′), 114.09 (C-4), 77.66 (C-5′), 73.37 and 71.04 (2 O*C*H_2Ph), 70.53 (C-4′), 69.90 (C-6′), 69.41 (C-1′), and 11.30 (Me); FABMS: *m*/*z* 489 (60, $[M+Na]^+$), 467 (100, $[M+H]^+$); HRMS: *m*/*z* 466.2265 (Calcd for $C_{30}H_{30}N_2O_3$: 466.2256). Anal. Calcd for $C_{30}H_{30}N_2O_3$: C, 77.23; H, 6.48; N, 6.00. Found: C, 77.36; H, 6.60; N, 5.94.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-1,3,5-trimethylpyrazole* (**8**): 0.376 g (90%) [from **4** (0.41 g) and methylhydrazine (0.377 g, 0.43 mL)]; $[\alpha]_D^{24}$ +150° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 259 nm (e_{mM} 3.79); ν_{max} 1724, 1661 (C=C), 1597, 1495 (Ph), 1572 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.34–7.24 (m, 10 H, 2 Ph), 6.08 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'} \approx J_{3',4'}$ 1.8 Hz, H-3′), 5.73 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.13 (m, 1 H, H-1′), 4.65 and 4.50 (each d, each 1 H, *J* 11.5 Hz, CH_2Ph), 4.59 and 4.52 (each d, each 1 H, *J* 12.2 Hz, CH_2Ph), 4.17 (dddd, 1 H, $J_{1',4'}$ 3.1, $J_{4',5'}$ 8.6 Hz, H-4′), 3.73 (dd, 1 H, $J_{5',6'a}$5.4, $J_{6'a,6'b}$ 10.8 Hz, H-6′a), 3.80–3.76 (m, 2 H, H-5′ and H-6′b), 3.65 (s, 3 H, Me-1), and 2.19 (s, 6 H, Me-3 and Me-5); ^{13}C NMR: δ 145.81 (C-3), 138.43 (C-5), 131.13 (C-2′), 138.11, 137.46, 128.32, 128.19, 127.77, 127.66, 127.59, and 127.36 (2 Ph), 125.71 (C-3′), 114.98 (C-4), 77.84 (C-5′), 73.26 and 71.20 (2 OCH_2Ph), 70.60 (C-4′), 69.92 (C-6′), 69.86 (C-1′), 35.55 (Me-1), 12.18 (Me-3), and 9.84 (Me-5); HRMS: *m*/*z* 418.2241 (Calcd for $C_{26}H_{30}N_2O_3$: 418.2256). Anal. Calcd for $C_{26}H_{30}N_2O_3 \cdot 0.75\ H_2O$: C, 72.28; H, 7.35; N, 6.48. Found: C, 72.49; H, 7.08; N, 6.50.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-1,3-dimethyl-5-phenylpyrazole* (**9**): 0.370 g (77%) [from **5** (0.470 g) and methylhydrazine (0.377 g, 0.43 mL)]; $[\alpha]_D^{22}$ +87° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 243 nm (e_{mM} 9.33); ν_{max} 1605 (C=C), 1578 (Ph), 1554 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.40–7.23 (m, 15 H, 3 Ph), 5.89 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 2.5, $J_{3',4'}$ 1.7 Hz, H-3′), 5.70 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 4.99 (m, 1 H, H-1′), 4.61 and 4.47 (each d, each 1 H, *J* 11.5 Hz, CH_2Ph), 4.60 and 4.52 (each d, each 1 H, *J* 12.1 Hz, CH_2Ph), 4.07 (dddd, 1 H, $J_{1',4'}$ 2.8, $J_{4',5'}$ 7.5 Hz, H-4′), 3.82–3.69 (m, 3 H, H-5′, H-6′a, and H-6′b), 3.67 (s, 3 H, Me-1), and 2.29 (s, 3 H, Me-3);

^{13}C NMR: δ 146.63 (C-3), 142.73 (C-5), 130.78 (C-2′), 138.35, 137.96, 129.93, 128.55, 128.48, 128.18, 128.07, 127.63, 127.52, 127.48, and 127.25 (3 Ph), 125.72 (C-3′), 115.87 (C-4), 77.43 (C-5′), 73.14 and 70.91 (2 O*C*H$_2$Ph), 70.41 (C-4′), 69.89 (C-6′), 69.53 (C-1′), 36.49 (Me-1), and 12.53 (Me-3); FABMS: *m/z* 503 (60, $[M+Na]^+$), 481 (100, $[M+H]^+$); HRMS: *m/z* 480.2409 (Calcd for $C_{31}H_{32}N_2O_3$: 480.2413). Anal. Calcd for $C_{31}H_{32}N_2O_3$: C, 77.47; H, 6.71; N, 5.83. Found: C, 77.40; H, 6.93; N, 5.82.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3,5-dimethyl-1-phenylpyrazole* (**10**): 0.451 g (94%) [from **4** (0.408 g) and phenylhydrazine (0.886 g, 0.81 mL)]; $[\alpha]_D^{23}$ +88° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 252 nm (e_{mM} 16.11); ν_{max} 1719, 1653 (C=C), 1597, 1505 (Ph), 1570 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.60–6.57 (m, 15 H, 3 Ph), 6.05 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 2.4, $J_{3',4'}$ 1.9 Hz, H-3′), 5.81 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.23 (m, 1 H, H-1′), 4.67 and 4.51 (each d, each 1 H, *J* 11.4 Hz, C*H*$_2$Ph), 4.61 and 4.54 (each d, each 1 H, *J* 12.3 Hz, C*H*$_2$Ph), 4.19 (dddd, 1 H, $J_{1',4'}$ 3.3, $J_{4',5'}$ 8.6 Hz, H-4′), 3.83–3.81 (m, 1 H, H-5′), 3.82 (dd, 1 H, $J_{5',6'b}$ 2.0, $J_{6'a,6'b}$ 11.0 Hz, H-6′b), 3.75 (dd, 1 H, $J_{5',6'a}$ 5.6 Hz, H-6′a), 2.32 (s, 3 H, Me-3), and 2.26 (s, 3 H, Me-5); ^{13}C NMR: δ 147.63 (C-3), 138.78 (C-5), 130.39 (C-2′), 138.23, 138.16, 137.89, 129.19, 128.90, 128.23, 128.10, 127.68, 127.61, 127.52, 127.32, and 125.17 (3 Ph), 126.09 (C-3′), 116.50 (C-4), 77.68 (C-5′), 73.18 and 71.15 (2 O*C*H$_2$Ph), 70.37 (C-4′), 69.68 (C-1′), 69.65 (C-6′), 12.02 (Me-3), and 10.83 (Me-5); FABMS: *m/z* 503 (90, $[M+Na]^+$), 481 (100, $[M+H]^+$); HRMS: *m/z* 480.2384 (Calcd for $C_{31}H_{32}N_2O_3$: 480.2413).

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3-methyl-1,5-diphenylpyrazole* (**11**): 0.412 g (76%) [from **5** (0.470 g) and phenylhydrazine (0.886 g, 0.81 mL)]; $[\alpha]_D^{21}$ +84° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 256 nm (e_{mM} 14.42); ν_{max} 1724 (C=C), 1599, 1505 (Ph), 1562 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.39–7.14 (m, 20 H, 4 Ph), 5.97 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 2.5, $J_{3',4'}$ 1.7 Hz, H-3′), 5.80 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.6 Hz, H-2′), 5.11 (m, 1 H, H-1′), 4.64 and 4.49 (each d, each 1 H, *J* 11.5 Hz, C*H*$_2$Ph), 4.63 and 4.55 (each d, each 1 H, *J* 12.1 Hz, C*H*$_2$Ph), 4.15 (dddd, 1 H, $J_{1',4'}$ 3.0, $J_{4',5'}$ 8.4 Hz, H-4′), 3.86–3.72 (m, 3 H, H-5′, H-6′a, and H-6′b), and 2.38 (s, 3 H, Me); NOE contacts (1D NOESY): H-1′, H-2′, H-5′ and Me-3; ^{13}C NMR: δ 148.60 (C-3), 141.88 (C-5), 130.14 (C-2′), 139.68, 138.32, 137.94, 130.56, 130.14, 129.64, 128.48, 128.25, 128.20, 127.64, 127.55, 127.49, 127.27, 126.02, and 124.68 (4 Ph), 126.60 (C-3′), 117.69 (C-4), 77.46 (C-5′), 73.15 and 70.97 (2 O*C*H$_2$Ph), 70.38 (C-4′), 69.83 (C-6′), 69.54 (C-1′), and 12.82 (Me); FABMS: *m/z* 565 (45, $[M+Na]^+$), 543 (100, $[M+H]^+$); HRMS: *m/z* 542.2547 (Calcd for $C_{36}H_{34}N_2O_3$: 542.2569). Anal. Calcd for $C_{36}H_{34}N_2O_3 \cdot 0.6\ H_2O$: C, 78.12; H, 6.41; N, 5.06. Found: C, 78.39; H, 6.58; N, 4.74.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3,5-dimethyl-1-(*p-*tolyl)pyrazole* (**12**): 0.385 g (78%) [from **4** (0.408 g) and *p*-tolylhydrazine (released from its hydrochloride: 1.30 g)]; $[\alpha]_D^{21}$ +153° (*c* 0.8, $CHCl_3$); λ_{max} (CH_2Cl_2) 252 nm (e_{mM} 11.0); ν_{max} 1723, 1661 (C=C), 1586, 1497 (Ph), 1568 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.41–7.30 (m, 14 H, 2 Ph and *p*-C$_6$*H*$_4$–Me), 6.07 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 1.6, $J_{3',4'}$ 1.5 Hz, H-3′), 5.84 (ddd, 1 H, $J_{1',2'}$ 1.6, $J_{2',4'}$ 1.5 Hz, H-2′), 5.25 (m, 1 H, H-1′), 4.70 and 4.54 (each d, each 1 H, *J* 11.5 Hz, C*H*$_2$Ph), 4.64 and 4.57 (each d, each 1 H, *J* 12.3 Hz, C*H*$_2$Ph), 4.23 (dddd, 1 H, $J_{1',4'}$ 2.8, $J_{4',5'}$ 8.3 Hz, H-4′), 3.86–3.84 (m, 2 H, H-5′ and H-6′b), 3.79 (dd, 1 H, $J_{5',6'a}$ 5.6, $J_{6'a,6'b}$ 11.1 Hz, H-6′a), 2.41 (s, 3 H, *p-Me*–C$_6$H$_4$), 2.31 (s, 3 H, Me-3), and 2.26 (s, 3 H, Me-5); ^{13}C NMR: δ 147.49 (C-3), 138.27 (C-5), 130.75 (C-2′), 137.96, 137.65, 137.18, 137.04, 129.36, 128.23, 128.09, 127.67, 127.58, 127.51, 127.28, and 124.92 (2 Ph and *p*-C$_6$H$_4$–Me), 125.81 (C-3′), 116.08 (C-4), 77.70 (C-5′), 73.16 and 71.12 (2 O*C*H$_2$Ph), 70.45 (C-4′), 69.84 (C-1′), 69.74 (C-6′), 20.89 (*p*-C$_6$H$_4$–*Me*), 12.27 (Me-3), and 10.78 (Me-5); FABMS: *m/z* 517 (60, $[M+Na]^+$), 495 (20, $[M+H]^+$), 413 (100, [M−81]); HRMS: *m/z* 494.2566 (Calcd for $C_{32}H_{34}N_2O_3$: 494.2569). Anal. Calcd for $C_{32}H_{34}N_2O_3$: C, 77.70; H, 6.93; N, 5.66. Found: C, 77.62; H, 6.96; N, 5.43.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-3-methyl-5-phenyl-1-(*p-*tolyl)pyrazole* (**13**): 0.417 g (75%) [from **5** (0.470 g) and *p*-tolylhydrazine (released from its hydrochloride: 1.30 g)]; $[\alpha]_D^{21}$ +89° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 239, 254 nm (e_{mM} 18.67, 18.05); ν_{max} 1723 (C=C), 1609, 1497 (Ph), 1587 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.35–7.03 (m, 19 H, 3 Ph and *p*-C$_6$*H*$_4$–Me), 5.96 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 2.6, $J_{3',4'}$ 1.7 Hz, H-3′), 5.79 (ddd, 1 H, $J_{1',2'}$ 1.6, $J_{2',4'}$ 1.7 Hz, H-2′), 5.10 (m, 1 H, H-1′), 4.63 and 4.49 (each d, each 1 H, *J* 11.5 Hz, C*H*$_2$Ph), 4.62 and 4.55 (each d, each 1 H, *J* 12.1 Hz, C*H*$_2$Ph), 4.13 (dddd, 1 H, $J_{1',4'}$ 3.0, $J_{4',5'}$ 8.6 Hz, H-4′), 3.83–3.71 (m, 3 H, H-5′, H-6′a, and H-6′b), 2.37 (s, 3 H, *p-Me*–C$_6$H$_4$),

and 2.29 (s, 3 H, Me-3); ^{13}C NMR: δ 148.36 (C-3), 141.98 (C-5), 130.64 (C-2′), 138.41, 138.03, 137.16, 136.61, 130.23, 129.70, 129.16, 128.28, 128.16, 128.13, 127.72, 127.63, 127.57, 127.35, and 124.64 (3 Ph and *p*-C_6H_4–Me), 126.10 (C-3′), 117.45 (C-4), 77.54 (C-5′), 73.23 and 71.05 (2 O*C*H_2Ph), 70.47 (C-4′), 69.92 (C-6′), 69.61 (C-1′), 20.87 (*p*-C_6H_4–*Me*), and 12.83 (Me-3); FABMS: *m*/*z* 579 (70, $[M+Na]^+$), 557 (100, $[M+H]^+$); HRMS: *m*/*z* 556.2724 (Calcd for $C_{37}H_{36}N_2O_3$: 556.2726). Anal. Calcd for $C_{37}H_{36}N_2O_3$: C, 79.83; H, 6.52; N, 5.03. Found: C, 79.62; H, 6.57; N, 4.83.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-1-(*p-*methoxyphenyl)-3,5-dimethylpyrazole* (**14**): 0.367 g (72%) [from **4** (0.408 g) and *p*-methoxyphenylhydrazine (released from its hydrochloride: 1.43 g)]; $[\alpha]_D^{22}$ +111° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 251 nm (e_{mM} 18.19); ν_{max} 1721 (C=C), 1607, 1589, and 1518 (Ph), 1570 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.37–6.95 (m, 14 H, 2 Ph and *p*-C_6H_4–OMe), 6.06 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'}$ 1.9, $J_{3',4'}$ 1.5 Hz, H-3′), 5.83 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.24 (m, 1 H, H-1′), 4.69 and 4.53 (each d, each 1 H, *J* 11.5 Hz, CH_2Ph), 4.64 and 4.56 (each d, each 1 H, *J* 12.3 Hz, CH_2Ph), 4.21 (dddd, 1 H, $J_{1',4'}$ 3.0, $J_{4',5'}$ 8.4 Hz, H-4′), 3.86–3.81 (m, 2 H, H-5′ and H-6′b), 3.78 (dd, 1 H, $J_{5',6'a}$ 5.7, $J_{6'a,6'b}$ 11.1 Hz, H-6′a), 3.85 (s, 3 H, *p*-*Me*O–C_6H_4), 2.30 (s, 3 H, Me-3), and 2.23 (s, 3 H, Me-5); ^{13}C NMR: δ 147.42 (C-3), 138.37 (C-5), 130.89 (C-2′), 158.83, 138.05, 137.89, 132.77, 128.35, 128.21, 127.79, 127.70, 127.62, 127.41, 126.64, and 113.38 (2 Ph and *p*-C_6H_4–OMe), 125.87 (C-3′), 116.12 (C-4), 77.78 (C-5′), 73.26 and 71.24 (2 O*C*H_2Ph), 70.55 (C-4′), 69.96 (C-1′), 69.83 (C-6′), 55.44 (O*Me*), 12.38 (Me-3), and 10.89 (Me-5); FABMS: *m*/*z* 533 (80, $[M+Na]^+$), 511 (85, $[M+H]^+$); HRMS: *m*/*z* 510.2524 (Calcd for $C_{32}H_{34}N_2O_4$: 510.2518). Anal. Calcd for $C_{32}H_{34}N_2O_4$: C, 75.27; H, 6.71; N, 5.45. Found: C, 75.43; H, 6.79; N, 5.45.

4-(4,6-Di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)-1-(*p-*methoxyphenyl)-3-methyl-5-phenylpyrazole* (**15**): 0.406 g (71%) [from **5** (0.470 g) and *p*-methoxyphenylhydrazine (released from its hydrochloride: 1.43 g); $[\alpha]_D^{23}$ +80° (*c* 1, $CHCl_3$); λ_{max} (CH_2Cl_2) 240 nm (e_{mM} 26.28); ν_{max} 1719 (C=C), 1516 (Ph), 1578 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.36–6.75 (m, 19 H, 3 Ph and *p*-C_6H_4–OMe), 5.96 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'} \approx J_{3',4'}$ 1.7 Hz, H-3′), 5.80 (ddd, 1 H, $J_{1',2'} \approx J_{2',4'}$ 1.7 Hz, H-2′), 5.10 (m, 1 H, H-1′), 4.63 and 4.49 (each d, each 1 H, *J* 11.5 Hz, CH_2Ph), 4.62 and 4.55 (each d, each 1 H, *J* 12.0 Hz, CH_2Ph), 4.13 (dddd, 1 H, $J_{1',4'}$ 2.9, $J_{4',5'}$ 8.4 Hz, H-4′), 3.84–3.73 (m, 3 H, H-5′, H-6′a, and H-6′b), 3.76 (s, 3 H, O*Me*), and 2.36 (s, 3 H, Me-3); ^{13}C NMR: δ 148.23 (C-3), 141.97 (C-5), 130.71 (C-2′), 138.40, 158.20, 138.01, 133.04, 130.23, 129.72, 128.28, 128.20, 128.16, 128.10, 127.72, 127.62, 127.57, 127.34, 126.19, and 113.74 (3 Ph and *p*-C_6H_4–OMe), 126.02 (C-3′), 117.12 (C-4), 77.52 (C-5′), 73.21 and 71.03 (2 O*C*H_2Ph), 70.47 (C-4′), 69.91 (C-6′), 69.66 (C-1′), 55.27 (O*Me*), and 12.87 (Me-3); FABMS: *m*/*z* 595 (100, $[M+Na]^+$), 573 (80, $[M+H]^+$); HRMS: *m*/*z* 572.2676 (Calcd for $C_{37}H_{36}N_2O_4$: 572.2675). Anal. Calcd for $C_{37}H_{36}N_2O_4$: C, 77.60; H, 6.34; N, 4.89. Found: C, 77.59; H, 6.56; N, 4.76.

Catalytic hydrogenation of 4-(4,6-di-O-*benzyl-2,3-dideoxy*-β-D-erythro-*hex-2-enopyranosyl)pyrazoles*.—Dry 20% $Pd(OH)_2$/C catalyst (91 mg) was added to a solution of the corresponding, thoroughly dried, substrate (0.12 mmol) in dry MeOH (6 mL). Hydrogen (atmospheric pressure) was bubbled through this suspension for 5 min, and the mixture was then kept under stirring in a hydrogen atmosphere at room temperature for 24 h (monitoring by TLC, 2:1 hexane–EtOAc). If necessary, a similar additional amount of the catalyst was used and the hydrogen atmosphere reset for 1 h. The catalyst was filtered off and washed with MeOH. Evaporation of the solvent afforded the product as an oil.

4-(2,3-Dideoxy-β-D-erythro-*hexopyranosyl)-1,3-dimethyl-5-phenylpyrazole* (**16**): 21 mg (58%) [from **9** (58 mg)]; λ_{max} (CH_2Cl_2) 246 nm (e_{mM} 4.55); ν_{max} 3336 br (OH), 1503 (Ph), 1553 cm^{-1} (pyrazole C=N); ^{1}H NMR: δ 7.48–7.25 (m, 5 H, Ph), 4.23 (dd, 1 H, $J_{1',2'ax}$ 11.6, $J_{1',2'eq}$ 2.3 Hz, H-1′), 3.77 (dd, 1 H, $J_{6'a,6'b}$ 11.5, $J_{5',6'a}$ 4.5 Hz, H-6′a), 3.73 (dd, 1 H, $J_{5',6'b}$ 4.7 Hz, H-6′b), 3.61 (s, 3 H, Me-1), 3.52 (ddd, 1 H, $J_{4',5'} \approx J_{3'ax,4'}$ 9.2, $J_{3'eq,4'}$ 4.7 Hz, H-4′), 3.19 (ddd, 1 H, H-5′), 2.34 (s, 3 H, Me-3), 2.06 (dddd, 1 H, J_{gem} 12.7, $J_{2'ax,3'eq}$ 3.8, $J_{2'eq,3'eq}$ 6.5 Hz, H-3′eq), 1.83 (dddd, 1 H, J_{gem} 13.7, $J_{2'ax,3'ax}$ 11.7 Hz, H-2′ax), 1.68 (dddd, 1 H, $J_{2'eq,3'ax}$ 4.0 Hz, H-2′eq), and 1.47 (dddd, 1 H, H-3′ax); ^{13}C NMR: δ 145.60 (C-3), 141.90 (C-5), 130.32, 129.91, 128.78, 128.72, 128.47, and 128.21 (Ph), 117.45 (C-4), 81.43 (C-5′), 72.69 (C-1′), 67.25 (C-4′), 63.41 (C-6′), 36.45 (Me-1), 32.84 (C-3′), 30.97 (C-2′), and 13.02 (Me-3); FABMS: *m*/*z* 325 (100, $[M+Na]^+$), 303 (19, $[M+H]^+$); HRMS: *m*/*z* 302.1633 (Calcd for $C_{17}H_{22}N_2O_3$: 302.1630).

4-(2,3-Dideoxy-β-D-erythro-hexopyranosyl)-3-methyl-5-phenyl-1-(p-tolyl)pyrazole (**17**): 23 mg (51%) [from **13** (67 mg)]; λ_{max} (CH_2Cl_2) 242sh and 254 nm (e_{mM} 10.79 and 11.10); ν_{max} 3420 and 3178 br (OH), 1611, 1518, 1493 (Ph), 1588 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.37–6.97 (m, 9 H, Ph and *p*-C_6H_4–Me), 4.33 (dd, 1 H, $J_{1',2'ax}$ 11.7, $J_{1',2'eq}$ 2.3 Hz, H-1′), 3.81 (dd, 1 H, $J_{6'a,6'b}$ 11.5, $J_{5',6'a}$ 4.3 Hz, H-6′a), 3.77 (dd, 1 H, $J_{5',6'b}$ 4.8 Hz, H-6′b), 3.60 (ddd, 1 H, $J_{4',5'}$ 9.2 $J_{3'ax,4'}$ 11.1, $J_{3'eq,4'}$ 4.4 Hz, H-4′), 3.23 (ddd, 1 H, H-5′), 2.44 (s, 3 H, Me-3), 2.28 (s, 3 H, *p-Me*–C_6H_4), 2.11 (dddd, 1 H, J_{gem} 12.5, $J_{2'ax,3'eq}$ 4.1, $J_{2'eq,3'eq}$ 3.7 Hz, H-3′eq), 1.96 (dddd, 1 H, J_{gem} 13.7, $J_{2'ax,3'ax}$ 11.5 Hz, H-2′ax), 1.77 (dddd, 1 H, $J_{2'eq,3'ax}$ 4.1 Hz, H-2′eq), and 1.51 (dddd, 1 H, H-3′ax); ^{13}C NMR: δ 147.28 (C-3), 141.09 (C-5), 137.27, 136.66, 130.46, 130.21, 129.21, 128.42, 128.29, and 124.67 (Ph and *p*-C_6H_4–Me), 118.88 (C-4), 81.52 (C-5′), 72.70 (C-1′), 67.42 (C-4′), 63.55 (C-6′), 32.93 (C-3′), 30.96 (C-2′), 20.93 (*p*-C_6H_4–*Me*), and 13.39 (Me-3); FABMS: *m/z* 401 (100, $[M+Na]^+$), 379 (25, $[M+H]^+$); HRMS: *m/z* 378.1948 (Calcd for $C_{23}H_{26}N_2O_3$: 378.1943).

4-(2,3-Dideoxy-β-D-erythro-hexopyranosyl)-1-(p-methoxyphenyl)-3-methyl-5-phenylpyrazole (**18**): 32 mg (67%) after column chromatography [from **15** (69 mg)]; λ_{max} (CH_2Cl_2) 242 and 254sh nm (e_{mM} 13.52 and 12.87); ν_{max} 3404 br (OH), 1609, 1516 (Ph), 1588 cm^{-1} (pyrazole C=N); ^1H NMR: δ 7.36–6.70 (m, 9 H, Ph and *p*-C_6H_4–OMe), 4.33 (dd, 1 H, $J_{1',2'ax}$ 11.7, $J_{1',2'eq}$ 2.3 Hz, H-1′), 3.80 (dd, 1 H, $J_{6'a,6'b}$ 11.4, $J_{5',6'a}$ 4.4 Hz, H-6′a), ≈3.75 (dd, 1 H, $J_{5',6'b}$ 4.8 Hz, H-6′b), 3.74 (s, 3 H, OMe), 3.56 (ddd, 1 H, $J_{4',5'}$ 9.2, $J_{3'ax,4'}$ 11.0, $J_{3'eq,4'}$ 4.6 Hz, H-4′), 3.22 (ddd, 1 H, H-5′), 2.43 (s, 3 H, Me-3), 2.10 (dddd, 1 H, J_{gem} 12.5, $J_{2'ax,3'eq}$ 3.7, $J_{2'eq,3'eq}$ 4.0 Hz, H-3′eq), 1.95 (dddd, 1 H, J_{gem} 13.5, $J_{2'ax,3'ax}$ 11.5 Hz, H-2′ax), 1.76 (dddd, 1 H, $J_{2'eq,3'ax}$ 2.7 Hz, H-2′eq), and 1.50 (dddd, 1 H, H-3′ax); NOE contacts (1D NOESY): H-1′, H-2′eq, H-3′ax, H-5′ax, and Me-3; H-4′, H-2′ax, and H-3′eq; ^{13}C NMR: δ 147.12 (C-3), 141.24 (C-5), 158.38, 132.96, 130.39, 130.22, 128.40, 128.27, 126.30, and 113.83 (Ph and *p*-C_6H_4–OMe), 118.65 (C-4), 81.56 (C-5′), 72.73 (C-1′), 67.38 (C-4′), 63.53 (C-6′), 55.34 (OMe), 32.91 (C-3′), 30.95 (C-2′), and 13.27 (Me-3); FABMS: *m/z* 417 (100, $[M+Na]^+$), 395 (57, $[M+H]^+$); HRMS: *m/z* 394.1897 (Calcd for $C_{23}H_{26}N_2O_4$: 394.1893).

Acetolysis of **13**.—A cold soln of concd H_2SO_4 (0.27 mL), glacial HOAc (2.0 mL) and Ac_2O (4.75 mL) was added under stirring to a cold (ice bath) soln of **13** (0.200 g, 0.36 mmol) in a mixture of glacial HOAc (2.0 mL) and Ac_2O (4.75 mL). The mixture was kept in the ice bath under stirring for 2 h, then in the refrigerator until **13** was completely consumed (16 h; TLC, 4:1 and 3:1 hexane–EtOAc). The reaction mixture was poured into ice, stirred for 3.5 h, and extracted with EtOAc (4×50 mL). The combined organic extracts were washed with satd aq $NaHCO_3$ until pH ≈ 7 and then with water (2×50 mL). After drying ($MgSO_4$), evaporation of the organic solvent gave a syrup, which was subjected to preparative TLC (3:1 hexane–EtOAc). Two main fractions were studied (in order of decreasing mobility): **A** (58.3 mg) and **B** (30.0 mg). Fraction **A** consists of a 2.5:1 mixture of two epimers tentatively formulated as 4*R*- and 4*S*-{*E*-2-[5-phenyl-1-(*p*-tolyl)pyrazol-4-yl]vinyl}-3*S*-(D-*glycero*-1,2-diacetoxyethyl)-3,4-dihydro-1*H*-benzo[*c*]pyran (**19**); FABMS: *m/z* 573 (100, $[M+Na]^+$), 551 (84, $[M+H]^+$); FABHRMS: *m/z* 573.2326 (54, $[M+Na]^+$; calcd for $C_{34}H_{34}N_2O_5+Na$: 573.2365), 551.2587 (100, $[M+H]^+$; calcd for $C_{34}H_{34}N_2O_5+H$: 551.2546); major isomer: ^1H NMR (for convenience, the numbering of the sugar moiety is maintained): δ 7.40–6.98 (m, Ph, *p*-C_6H_4–Me, and –C_6H_4– of benzo[*c*]pyran), 6.17 (d, 1 H, $J_{1',2'}$ 16.1 Hz, H-1′), 5.91 (dd, 1 H, $J_{2',3'}$ 9.5 Hz, H-2′), 5.04 (ddd, 1 H, $J_{4',5'}$ 9.7, $J_{5',6'a}$ 2.3, $J_{5',6'b}$ 4.3 Hz, H-5′), 4.90 and 4.81 (each d, each 1 H, *J* 15.0 Hz, CH_2Ph), 4.59 (dd, 1 H, $J_{6'a,6'b}$ 12.3 Hz, H-6′a), 4.30 (dd, 1 H, H-6′b), 3.94 (dd, 1 H, $J_{3',4'}$ 2.7, $J_{4',5'}$ 9.7 Hz, H-4′), 3.42 (dd, 1 H, H-3′), 2.38 (s, 3 H, Me-3), 2.28 (s, 3 H, *p-Me*–C_6H_4), 2.05 (s, 3 H, AcO-5′), and 1.92 (s, 3 H, AcO-6′); ^{13}C NMR: δ 170.7 and 169.4 (2 C=O), 147.2 (C-3), 140.6 (C-5), 128.3 (C-2′), 138–124 (Ph and 2 C_6H_4), 122.3 (C-1′), 116.8 (C-4), 74.7 (C-4′), 71.1 (C-5′), 68.7 (OCH_2Ph), 62.5 (C-6′), 44.2 (C-3′), 20.9 (*p-Me*–C_6H_4), 20.7 (2 *Me*COO), and 14.1 (Me-3); minor isomer: ^1H NMR: δ 7.40–6.98 (m, Ph, *p*-C_6H_4–Me, and –C_6H_4– of benzo[*c*]pyran), 6.47 (d, 1 H, $J_{1',2'}$ 16.1 Hz, H-1′), 5.68 (dd, 1 H, $J_{2',3'}$ 8.6 Hz, H-2′), 5.45 (ddd, 1 H, $J_{4',5'} \approx J_{5',6'a}$ 3.0, $J_{5',6'b}$ 12.6 Hz, H-5′), 4.55 (dd, 1 H, $J_{6'a,6'b}$ 12.3 Hz, H-6′a), 4.31–4.26 (m, 1 H, H-6′b), 3.94 (dd, 1 H, $J_{3',4'} \approx 10$ Hz, H-4′), 3.65 (dd, 1 H, H-3′), 2.41 (s, 3 H, Me-3), 2.30 (s, 3 H, *p-Me*–C_6H_4), 2.09 (s, 3 H, AcO-5′), and 1.98 (s, 3 H, AcO-6′); ^{13}C NMR: δ 170.6 and 170.2 (2 C=O), 147.3 (C-3), 140.8 (C-5), 127.9 (tentative for C-2′), 138–124 (Ph and 2 C_6H_4), 122.5 (tentative for C-1′), 116.7 (C-4), 78.8 (C-4′), 72.2 (C-5′),

68.4 (OCH_2Ph), 62.2 (C-6′), 44.9 (C-3′), and 21.0 (*p*-*Me*–C_6H_4). Fraction **B**: FABMS: *m*/*z* 461 (100, $[M+H]^+$), 483 (62, $[M+Na]^+$); FABHRMS: *m*/*z* 483.1889 (13, $[M+Na]^+$; calcd for $C_{27}H_{28}N_2O_5$ + Na: 483.1895), 461.2071 (100, $[M+H]^+$; calcd for $C_{27}H_{28}N_2O_5$ + H: 461.2076; the major component is tentatively formulated as 4-(4,6-di-*O*-acetyl-2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-3-methyl-5-phenyl-1-(*p*-tolyl)pyrazole (**20**, 10% yield from **13**, by ^{1}H NMR): ^{1}H NMR: δ 7.38–6.99 (m, 9 H, Ph and *p*-C_6H_4–Me), 5.88 (ddd, 1 H, $J_{2',3'}$ 10.3, $J_{1',3'} \approx J_{3',4'}$ 1.7 Hz, H-3′), 5.80 (ddd, 1 H, $J_{1',2'}$ 2.7, $J_{2',4'}$ 1.9 Hz, H-2′), 5.40 (dddd, 1 H, $J_{1',4'}$ 3.3, $J_{4',5'}$ 8.9 Hz, H-4′), 5.13 (ddd, 1 H, H-1′), 4.27 (dd, 1 H, $J_{6'a,6'b}$ 12.1 Hz, H-6′a), 4.20 (dd, 1 H, H-6′b), 3.86 (ddd, 1 H, $J_{5',6'a}$ 2.4, $J_{5',6'b}$ 5.6 Hz, H-5′), 2.38 (s, 3 H, Me-3), 2.29 (s, 3 H, *p*-*Me*–C_6H_4), 2.12 (s, 3 H, AcO-4′), and 2.09 (s, 3 H, AcO-6′); ^{13}C NMR: δ 170.86 and 170.29 (2 C=O), 148.41 (C-3), 142.09 (C-5), 131.94 (C-3′), 137.33, 136.77, 130.26, 129.27, 128.54, 128.45, 128.32, 128.25, and 124.70 (Ph and *p*-C_6H_4–Me), 125.11 (C-2′), 116.72 (C-4), 74.71 (C-5′), 69.92 (C-1′), 65.32 (C-4′), 63.63 (C-6′), 21.00 (*Me*COO), 20.95 (*p*-C_6H_4–*Me*), 20.81 (*Me*COO), and 12.93 (Me-3).

Methanolysis of crude **20**.—To a soln of Fraction **B** without more purification (26 mg) in dry MeOH (2.1 mL) was added M NaOMe (0.1 mL), and the mixture was kept under stirring at room temperature for 1.5 h. TLC (3:1 hexane–EtOAc) showed the consumption of the starting material. After neutralisation with Amberlite IRA-120 (H^+) resin, the solvent was evaporated to give an oily product (17 mg): DCIHRMS: *m*/*z* 377.1845 (100, $[M+1]^+$; calcd for $C_{23}H_{24}N_2O_3$ + H: 377.1865) 376.1805 (53.9, $[M]^+$); calcd for $C_{23}H_{24}N_2O_3$: 376.1787; one main component of the mixture obtained is tentatively formulated as 4-(2,3-dideoxy-β-D-*erythro*-hex-2-enopyranosyl)-3-methyl-5-phenyl-1-(*p*-tolyl)-pyrazole (**21**, ≈25% in the mixture, ^{1}H NMR): ^{1}H NMR ($CDCl_3 + D_2O$): δ 7.41–7.01 (m, 9 H, Ph and *p*-C_6H_4–Me), 5.96 (ddd, 1 H, $J_{2',3'}$ 10.5, $J_{1',3'}$ 2.2, $J_{3',4'}$ 2.0 Hz, H-3′), 5.71 (ddd, 1 H, $J_{1',2'}$ 1.8, $J_{2',4'}$ 1.9 Hz, H-2′), 5.11 (ddd, 1 H, $J_{1',4'}$ 3.0 Hz, H-1′), 4.46 (dddd, 1 H, $J_{4',5'}$ 8.7 Hz, H-4′), 4.30–4.26 (m, 1 H, H-5′), 4.17 (dd, 1 H, $J_{6'a,6'b}$ 10.1, $J_{5',6'a}$ 5.3 Hz, H-6′a), 3.78 (dd, 1 H, $J_{5',6'b}$ 3.2 Hz, H-6′b), 2.46 (s, 3 H, *p*-*Me*–C_6H_4), and 2.27 (s, 3 H, Me-3); ^{13}C NMR: δ 149.84 (C-3), 142.51 (C-5), 131.27 (C-3′), 130.5–124.5 (Ph and *p*-C_6H_4–Me), 127.91 (C-2′), 117.23 (C-4), 76.01 (C-5′), 72.93 (C-6′), 69.61 (C-1′), 66.63 (C-4′), 20.97 (*p*-C_6H_4–*Me*), and 12.82 (Me-3).

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