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Stereoselective synthesis of pyrazoline derivatives by 1,3-dipolar cycloaddition of diazoalkanes to α,β-unsaturated carbonyl derivatives of sugars

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ABSTRACT

New pyrazoline acyclonucleosides have been prepared by 1,3-dipolar cycloaddition reactions of diazoalkanes to derivatives of D-*galacto*-oct-2-enonate and D-*galacto*-non-3-enulose. The reactions were highly regio- and stereo-selective, and single isomers were obtained in good yields. A tautomeric equilibrium between the 1- and 2-pyrazoline structures was observed for some of the isomers in solution.

INTRODUCTION

We have described the preparation of 3-nitro-4-(penta-*O*-acetyl-D-*galacto*-pentitol-1-yl)pyrazolines[1] and 3-nitro-4-(penta-*O*-acetyl-D-*manno*-pentitol-1-yl)pyrazolines[2] by the reaction of derivatives of sugar nitro-olefins with diazoalkanes. The presence of the sugar chain attached to one of the olefinic carbons resulted in one stereoisomer being obtained in each reaction.

We now report an extension of this reaction to α,β-unsaturated carbonyl sugar derivatives to give 4-(penta-*O*-acetyl-D-*galacto*-pentitol-1-yl)pyrazolines having a carbonyl substituent attached to C-3 of the heterocycle. These new acyclonucleosides are analogues of compounds which have received attention as antiviral drugs[3,4].

RESULTS AND DISCUSSION

Wittig condensation of 2,3,4,5,6-penta-*O*-acetyl-*aldehydo*-D-galactose with an excess of the appropriate phosphorane (see Experimental) in boiling benzene[5] gave the olefins **1**–**3** in good yields. The formation of one geometric isomer in each reaction was apparent from the n.m.r. spectra. The large vinyl couplings for **2** ($J_{2,3}$ 15.6 Hz) and **3** ($J_{3,4}$ 16.1 Hz) and the allylic coupling ($J_{Me,3}$ 1.5 Hz) for **1** were indicative of *E* configurations[6]. Compound **1** also had a $J_{3,4}$ value of 8.6 Hz, in agreement with an *anti* disposition of H-3,4. Hence, the favored conformation (**18**) in solution had H-4 eclipsed with the ethylenic bond and no 1,3-parallel interactions of the acetoxyl groups. This conforma-

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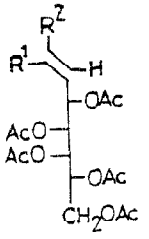
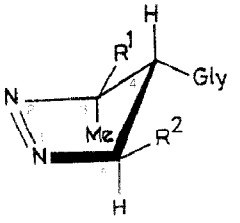
tion is similar to that (**19**) observed for the (*E*)-4,5,6,7,8-penta-*O*-acetyl-1,2,3-trideoxy-2-*C*-nitro-D-*galacto*-oct-2-enitol[1]. The olefins **2** and **3** had values ($J_{3,4}$ 4.5, $J_{4,5}$ 4.1 Hz, respectively) for the corresponding couplings that indicated the presence of *gauche* forms in the conformational equilibrium.





1 R^1 = Me, R^2 = COOEt

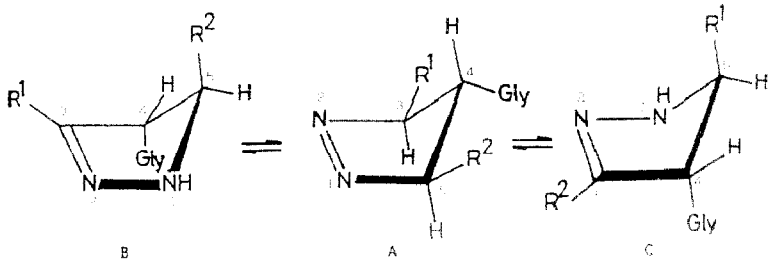
2 R^1 = H, R^2 = COOMe

3 R^1 = H, R^2 = COMe

4 R^1 = COOEt, R^2 = Me

5 R^1 = COOEt, R^2 = H

20 R^1 = NO_2, R^2 = Me



6 (B) R^1 = COOMe, R^2 = Me

7 (A–C) R^1 = COOMe, R^2 = H

8 (B or C) R^1 = COOMe, R^2 = COOEt

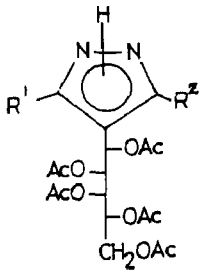
9 (B) R^1 = COMe, R^2 = Me

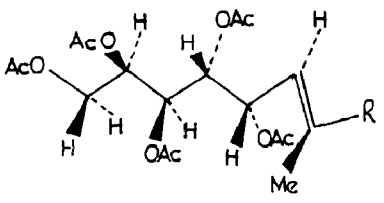
10 (A, B) R^1 = COMe, R^2 = H

11 (B or C) R^1 = COMe, R^2 = COOEt

Gly = penta-*O*-acetyl-D-glycero-pentitol-1-yl

The reaction of **1** with diazoethane or diazomethane in 1,4-dioxane gave the pyrazoline derivatives **4** and **5**, respectively, in high yields. These structures are to be expected from the regioselectivity in this kind of reaction[7], and they were confirmed by the ^{1}H-n.m.r. data for H-4 in **4** (δ 2.21, dd, $J_{4,5}$ 8.6, $J_{4,4'}$ 10.2 Hz) and **5** (δ 2.70, m, $J_{4,3a}$ 9.5, $J_{4,3b} = J_{4,4'} = 8.3$ Hz). As in the addition to the nitro-olefin **19**, the stereochemistry of C-3,4 must be governed by the addition of the dipole to the less hindered face of the olefin to give the 3*R*,4*R* diastereomer. The 5*R* configuration was assigned on the basis of the $J_{4,5}$ value (8.6 Hz), which was similar to that observed for **20**, obtained from **19**.





12 R^1 = COOMe, R^2 = Me

13 R^1 = COOMe, R^2 = H

14 R^1 = COOMe, R^2 = COOEt

15 R^1 = COMe, R^2 = Me

16 R^1 = COMe, R^2 = H

17 R^1 = COMe, R^2 = COOEt

18 R = COOEt (1*E*)

19 R = NO_2

indicative of an *anti* disposition of H-4,5 and the ^4E conformation. This structure has been confirmed for **20** by X-ray diffraction[8]. As for **4**, **5** must have the 3*R*,4*R* configuration. The $J_{4,5a}$ and $J_{4,5b}$ values (9.5 and 8.3 Hz, respectively) are correlated with dihedral angles of $-7.5°$ and $-147°$, deduced by using the Altona equation[9] and in agreement with a slightly flattened ^4E conformation.

The addition of diazoethane to the olefins **2** and **3** in 1,4-dioxane also gave crystalline products, in high yields, that had the 2-pyrazoline structures **6B** and **9B**, respectively, as demonstrated by the n.m.r. data. Thus, the respective ^{1}H-n.m.r. spectra contained signals (bs) for NH at δ 5.40 and 6.30, and for Me-5 (d, $J_{Me,5}$ 6.4 Hz) at δ 1.03, which eliminated the tautomeric structures **6C** and **9C**. The 1-pyrazoline structures **6A** and **9A** were also discarded because of the nature of the H-4 signals at δ 3.07 (**6B**, dd, $J_{4,5}$ 2.7, $J_{4,1'}$ 9.3 Hz) and 3.14 (**9B**, dd, $J_{4,5}$ 3.2, $J_{4,1'}$ 9.4 Hz). The structures **6A** and **9A** were also discarded because the ^{13}C-n.m.r. spectra contained signals for disubstituted olefinic carbons at δ 138.6 and 146.6, as shown by DEPT experiments. The resonances for C-4,5 appeared at δ 50.8 and 60.2 for **6B** and at δ 49.3 and 59.9 for **9B**. On the assumption that, as for the products obtained from the olefin **1**, the 1-pyrazolines **6A** and **9A** were the initial products of the reaction, which then tautomerised into the 2-pyrazolines **6B** and **9B**, they must have the 4*R*,5*R* configuration. The $J_{4,5}$ values (2.7 and 3.2 Hz, respectively, for **6B** and **9B**) are indicative of a *gauche* disposition of H-4,5 in agreement with the assigned configuration in the ^5E conformation.

The reaction of the olefins **2** and **3** with diazomethane took place readily in 1,4-dioxane at 0°, to give crystalline **7** and **10** in high yields. The n.m.r. spectra of **7** revealed the three tautomeric forms **7A**–**C**. Thus, in the ^{1}H-n.m.r. spectrum, a low field signal at δ 6.76 (dd, $J_{3,4}$ 1.9 Hz), attributable only to the olefinic proton of **7C**, was observed. This structure was confirmed by the ^{13}C-n.m.r. spectrum which contained a signal for a monosubstituted olefinic carbon at δ 140.8 (DEPT experiments). The presence of the tautomer **7B** was demonstrated by the signal of C-3, as a disubstituted

olefinic carbon at δ 141.3. The signals of H-3,4,5a,5b of the tautomer **7A** were also detected in the ^{1}H-n.m.r. spectrum, as multiplets, at δ 5.14 ($J_{3,5a}$ 2.4, $J_{3,5b}$ 1.8 Hz), 2.45 ($J_{4,5a}$ 9.0, $J_{4,5b}$ 6.2 Hz), 4.80 ($J_{5a,5b}$ −18.1 Hz), and 4.41, respectively. However, for **10**, only the tautomeric forms **10A** and **10B** were detected. The ^{1}H-n.m.r. spectrum of **10A** was similar to that of **7A**, with the signals of H-3,4,5a,5b appearing, respectively, at δ 5.27 ($J_{3,5a}$ 2.8, $J_{3,5b}$ 2.2 Hz), 3.51 ($J_{4,5a}$ 9.5, $J_{4,5b}$ 6.6 Hz), 4.66 ($J_{5a,5b}$ −18.6 Hz), and 4.38, as multiplets. As for **7B**, the presence of **10B** was also demonstrated by the signals of C-3, as a disubstituted olefinic carbon at δ 149.6. The ^{13}C-n.m.r. spectrum of **10A**, similar to that obtained for **5**, also confirmed the proposed structures. As in the preceding compounds, the *R* configuration was assigned tentatively to the new chiral centers.

The reaction of **2** or **3** with ethyl diazoacetate was slow and gave a complex mixture of products (t.l.c.), column chromatography of which gave crystalline **8** (40%) and **11** (50%), respectively. The n.m.r. spectra of **8** and **11** corresponded to only one tautomeric form which consisted of one of the two possible 2-pyrazoline structures **B** or **C**. Thus, the ^{1}H-n.m.r. spectra contained signals for H-4 (dd) at δ 3.93 and 3.98, respectively, and for NH (s) at δ 7.10 and 7.90, respectively. The ^{13}C-n.m.r. spectra each contained a signal for a disubstituted olefinic carbon at δ 140.4 (**8**) and 148.4 (**11**), respectively.

The reaction of **1** with ethyl diazoacetate under conditions similar to those used above did not yield a pyrazoline derivative and general decomposition occurred.

Compounds **6**–**11** were aromatised to the corresponding pyrazoles (**12**–**17**), by treatment with bromine or 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ).

EXPERIMENTAL

General methods. — Solutions were concentrated *in vacuo* at < 40°. Melting points were determined with an Electrothermal apparatus and are uncorrected. Optical rotations were measured at 20–25° with a Perkin–Elmer 241 polarimeter (10-cm cell). I.r. spectra (KBr discs) were recorded with a Perkin–Elmer 1310 spectrophotometer and the u.v. spectra (ethanol solutions) with a Perkin–Elmer Lambda 5 instrument. Fourier-transform n.m.r. spectra were obtained with Bruker WP-80-SY and Varian XL-200 spectrometers on solutions in $CDCl_3$ (internal Me_4Si). Only key n.m.r. data are given. T.l.c. was performed on Silica Gel $60F_{254}$ (Merck) with detection by u.v. light or charring with sulfuric acid.

*Ethyl (E)-4,5,6,7,8-penta-*O*-acetyl-2,3-dideoxy-2-methyl-*D*-galacto-oct-2-enonate* (**1**). — A solution of penta-*O*-acetyl-*aldehydo*-D-galactose[10] (1.0 g, 2.56 mmol) in dry benzene (10 mL) and ethoxycarbonylethylidenetriphenylphosphorane (1.45 g, 3.00 mmol) was heated under reflux for 6 h, then filtered, and concentrated to dryness. The solid residue was crystallised from 2-propanol to give **1** (850 mg, 70%), m.p. 72–74°, $[\alpha]_D$ +7° (*c* 0.5, dichloromethane); ν_{max} 1740 (C=O), 1660 cm^{-1} (C=C). ^{1}H-N.m.r. data: δ 6.38 (m, 1 H, $J_{3,4}$ 8.6 Hz, H-3), 5.67 (m, 1H, H-4), 1.97 (d, 3 H, $J_{Me,3}$ 1.5 Hz, Me-2).

Anal. Calc. for $C_{21}H_{30}O_{12}$: C, 53.16; H, 6.37. Found: C, 52.96; H, 6.46.

*Methyl (E)-4,5,6,7,8-penta-*O*-acetyl-2,3-dideoxy-*D*-galacto-oct-2-enonate* (**2**). —

A solution of penta-*O*-acetyl-*aldehydo*-D-galactose (1.50 g, 3.84 mmol) in benzene (12 mL) and methoxycarbonylmethylenetriphenylphosphorane (1.50 g, 4.52 mmol) was heated under reflux for 4 h, then worked-up as for **1**, to give **2** (1.47 g, 86%), m.p. 129–131°, $[\alpha]_D$ +9° (*c* 0.5, dichloromethane); ν_{max} 1750 (C=O), 1668 cm^{-1} (C=C). ^{1}H-N.m.r. data: δ 6.73 (dd, 1 H, $J_{2,3}$ 15.6, $J_{3,4}$ 4.5 Hz, H-3), 5.89 (dd, 1 H, H-2), 5.58 (dd, 1 H, H-4).

Anal. Calc. for $C_{19}H_{26}O_{12}$: C, 51.12; H, 5.87. Found: C, 51.32; H, 5.91.

*(E)-5,6,7,8,9-penta-*O*-acetyl-1,3,4-trideoxy-*D*-galacto-non-3-enulose* (**3**). — The procedure described for **1** was used with acetylmethylenetriphenylphosphorane (2 h under reflux). Work-up and crystallisation of the product from 2-propanol gave **3** (70%), m.p. 140–142°; lit.[11] m.p. 142–143°. ^{1}H-N.m.r. data: δ 6.57 (dd, 1 H, $J_{3,4}$ 16.1, $J_{4,5}$ 4.1 Hz, H-4), 6.05 (dd, 1 H, H-3).

*(3R,4R,5R)-3-Ethoxycarbonyl-3,5-dimethyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-1-pyrazoline* (**4**). — To a solution of **1** (500 mg, 1.05 mmol) in 1,4-dioxane (5 mL) at 0° was added dropwise a solution of diazoethane (134 mg, 2.41 mmol) in ether (5 mL). The mixture was stored for 48 h at 0°, then concentrated, and the residue was recrystallised from ethanol to give **4** (540 mg, ~100%), m.p. 88–90°, $[\alpha]_D$ +8° (*c* 0.5, dichloromethane), R_F 0.40 (ether–hexane, 3:1); ν_{max} 1700 cm^{-1} (C=O). ^{1}H-N.m.r. data: δ 5.28 (dd, 1 H, $J_{1',4}$ 10.2 Hz, H-1'), 4.25 (m, 1 H, H-5), 2.21 (dd, 1 H, $J_{4,5}$ 8.6 Hz, H-4).

Anal. Calc. for $C_{23}H_{34}N_2O_{12}$: C, 52.07; H, 6.46; N, 5.28. Found: C, 51.89; H, 6.50; N, 5.13.

*(3R,4R)-3-Ethoxycarbonyl-3-methyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-1-pyrazoline* (**5**). — The procedure used in the preparation of **4** was followed, using **1** (500 mg, 1.05 mmol) and diazomethane (493 mg, 3.15 mmol), to give **5** (543 mg, ~100%), m.p. 78–80° (from ethanol), $[\alpha]_D$ +13° (*c* 0.5, dichloromethane), R_F 0.42 (ether–hexane, 3:1); ν_{max} 3365 (NH), 1750 cm^{-1} (C=O). ^{1}H-N.m.r. data: δ 5.26 (d, 1 H, $J_{1',4}$ 8.3 Hz, H-1'), 4.70 (dd, 1 H, $J_{4,5a}$ 9.5 Hz, H-5a), 4.25 (dd, 1H, $J_{4,5b}$ 8.3 Hz, H-5b), 2.70 (q, 1 H, H-4).

Anal. Calc. for $C_{22}H_{32}N_2O_{12}$: C, 51.16; H, 6.24; N, 5.42. Found: C, 50.74; H, 6.27; N, 5.47.

*(4R,5R)-3-Methoxycarbonyl-5-methyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-2-pyrazoline* (**6B**). — A solution of **2** (2.0 g, 4.48 mmol) in 1,4-dioxane (15 mL) was treated with diazoethane (600 mg, 10.80 mmol), under the conditions used in the preparation of **4**, to yield a syrup that was crystallised from 90% methanol to give **6B** (1.86 g, 82%), m.p. 146–148°, $[\alpha]_D$ +24° (*c* 0.5, dichloromethane), R_F 0.20 (ether–hexane, 3:1); ν_{max} 3360 (NH), 1740 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{21}H_{30}N_2O_{12}\cdot 0.25H_2O$: C, 49.75; H, 6.06; N, 5.53. Found: C, 49.85; H, 6.04; N, 5.69.

*(3R,4R)-3-Methoxycarbonyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-1-pyrazoline* (**7A**) *or (4R)-3-methoxycarbonyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-2-pyrazoline* (**7B**) *or (4R,5R)-5-methoxycarbonyl-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-2-pyrazoline* (**7C**). — Treatment of **2** (700 mg, 1.57 mmol) with diazomethane (540 mg, 3.45 mmol), as described in the preparation of **4**, gave a solid which

was recrystallised from methanol to give **7** (684 mg, 89%), m.p. 120–122°, $[\alpha]_D$ +22° (*c* 0.5, dichloromethane), R_F 0.20 (ether–hexane, 3:1); ν_{max} 3400 (NH), 1750 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{20}H_{28}N_2O_{12}$: C, 49.18; H, 5.78; N, 5.74. Found: C, 48.96; H, 5.54; N, 5.79.

(4R,5R)-5-Ethoxycarbonyl-3-methoxycarbonyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**8B**) *or (4R,5R)-3-ethoxycarbonyl-5-methoxycarbonyl-4-(penta*-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**8C**). — A solution of **2** (1.0 g, 2.24 mmol) and ethyl diazoacetate (0.50 g, 4.41 mmol) in dichloromethane (10 mL) was heated under reflux for 8 days, then concentrated, and cyclohexane was evaporated several times from the residue. Column chromatography (hexane–ethyl acetate, 4:1) then gave a solid (466 mg, 37%) that was recrystallised from methanol to yield **8**, m.p. 151–153°, $[\alpha]_D$ −16° (*c* 0.5, dichloromethane), R_F 0.10 (ether–hexane, 3:1); ν_{max} 3360 (NH), 1740 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{23}H_{32}N_2O_{14}$: C, 49.29; H, 5.75; N, 5.00. Found: C, 49.35; H, 5.65; N, 5.40.

(4R,5R)-3-Acetyl-5-methyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**9B**). — A solution of **3** (860 mg, 2.00 mmol) in 1,4-dioxane was reacted with diazoethane (257 mg, 4.60 mmol), as in the preparation of **4**. Recrystallisation of the product from ethanol gave **9B** (970 mg, ~100%), m.p. 150–152°, $[\alpha]_D$ +18° (*c* 0.5, dichloromethane), R_F 0.30 (ether–hexane, 3:1); ν_{max} 3300 (NH), 1750 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{21}H_{30}N_2O_{11}$: C, 51.85; H, 6.22; N, 5.76. Found: C, 51.58; H, 6.15; N, 5.78.

(3R,4R)-3-Acetyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)-1-pyrazoline* (**10A**) *or (4R)-3-acetyl-4-(penta*-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**10B**). — Treatment of **3** (673 mg, 1.56 mmol) with diazomethane (540 mg, 3.45 mmol), as in the preparation of **4**, and recrystallisation of the product from methanol gave **10** (739 mg, ~100%), m.p. 126–128°, $[\alpha]_D$ +9° (*c* 0.5, dichloromethane), R_F 0.48 (ether–hexane, 3:1); ν_{max} 3380 (NH), 1750 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{20}H_{28}N_2O_{11}$: C, 50.85; H, 5.97; N, 5.93. Found: C, 50.54; H, 6.07; N, 6.01.

(4R,5R)-3-Acetyl-5-ethoxycarbonyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**11B**) *or (4R,5R)-5-acetyl-3-ethoxycarbonyl-4-(penta*-O-*acetyl*-D-galacto-*pentitol-1-yl)-2-pyrazoline* (**11C**). — A solution of **3** (1.0 g, 2.32 mmol) was treated with ethyl diazoacetate (0.50 g, 4.41 mmol) in dichloromethane (10 mL) as in the preparation of **8**. Recrystallisation of the product from ethanol gave **11** (645 mg, 51%), m.p. 160–162°, $[\alpha]_D$ −20° (*c* 0.5, dichloromethane), R_F 0.50 (ethyl acetate–hexane, 5:1); ν_{max} 3300 (NH), 1750 cm^{-1} (C=O). See text for the key n.m.r. data.

Anal. Calc. for $C_{23}H_{32}N_2O_{13}$: C, 50.73; H, 5.92; N, 5.14. Found: C, 50.40; H, 5.93; N, 5.15.

3(5)-Methoxycarbonyl-5(3)-methyl-4-(penta-O-acetyl-D-galacto-*pentitol-1-yl)-pyrazole* (**12**). — To a stirred solution of **6B** (1.0 g, 2.0 mmol) in chloroform (10 mL) was

added slowly a solution of bromine (0.30 g, 2.10 mmol) in chloroform (10 mL). The solution was then treated with sodium hydrogen carbonate, dried (Na_2SO_4), and concentrated to dryness. The residue was recrystallised from methanol to give **12** (600 mg, 60%), m.p. 167–169°, $[\alpha]_D$ +19° (*c* 0.5, dichloromethane), R_F 0.45 (ethyl acetate–hexane, 5:1); λ_{max} 233 nm (ε_{mM} 2.90); ν_{max} 3300 (NH), 1750 cm^{-1} (C=O).

Anal. Calc. for $C_{21}H_{28}N_2O_{12}$: C, 50.40; H, 5.64; N, 5.60. Found: C, 50.67; H, 5.89; N, 5.72.

3(5)-Methoxycarbonyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)pyrazole* (**13**). — A solution of **7** (1.0 g, 2.10 mmol) in chloroform (10 mL) was treated with bromine (0.30 g, 2.05 mmol), as described for **12**, to give **13** (900 mg, 90%), m.p. 150–152° (from methanol), $[\alpha]_D$ +39° (*c* 0.5, dichloromethane), R_F 0.48 (ethyl acetate–hexane, 3:1); λ_{max} 235 nm (ε_{mM} 4.07); ν_{max} 3350 (NH), 1760 cm^{-1} (C=O).

Anal. Calc. for $C_{20}H_{26}N_2O_{12}$: C, 49.38; H, 5.39; N, 5.76. Found: C, 49.46; H, 5.67; N, 5.65.

3(5)-Ethoxycarbonyl-5(3)-methoxycarbonyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)pyrazole* (**14**). — A solution of **8B** (1.10 g, 1.96 mmol) and 2,3-dichloro-5,6-dicyanobenzoquinone (DDQ; 600 mg, 2.64 mmol) in benzene (15 mL) was heated under reflux (72 h). Evaporation of the solvent and column chromatography (hexane–ethyl acetate, 2:1) of the syrupy residue afforded **14** as a syrup (570 mg, 52%), $[\alpha]_D$ +8° (*c* 0.5, dichloromethane), R_F 0.45 (ethyl acetate–hexane, 5:1); λ_{max} 232 nm (ε_{mM} 2.21); ν_{max} 3300 (NH), 1750 cm^{-1} (C=O).

Anal. Calc. for $C_{23}H_{30}N_2O_{14}$: C, 49.46; H, 5.41; N, 5.02. Found: C, 49.32; H, 5.50; N, 5.22.

3(5)-Acetyl-5(3)-methyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)pyrazole* (**15**). A solution of **8B** (1.0 g, 2.06 mmol) in benzene (15 mL) was dehydrogenated with DDQ (520 mg, 2.32 mmol) for 12 h as described for **14**. Column chromatography (ethyl acetate–hexane, 3:1) and recrystallisation from ethanol gave **15** (318 mg, 32%), m.p. 166–168°, $[\alpha]_D$ +38° (*c* 0.5, dichloromethane), R_F 0.43 (ethyl acetate–hexane, 5:1); λ_{max} 232 nm (ε_{mM} 3.07); ν_{max} 3250 (NH), 1760 cm^{-1} (C=O).

Anal. Calc. for $C_{21}H_{28}N_2O_{11}$: C, 52.06; H, 5.83; N, 5.78. Found: C, 51.93; H, 6.01; N, 5.64.

3(5)-Acetyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)pyrazole* (**16**). — A solution of **10** (1.10 g, 2.33 mmol) in benzene (15 mL) was dehydrogenated with DDQ (600 mg, 2.64 mmol) for 12 h as described for **14**. Column chromatography (ethyl acetate–hexane, 3:1) and recrystallisation from ethanol gave **16** (385 mg, 35%), m.p. 150–151°, $[\alpha]_D$ +42° (*c* 0.5, dichloromethane), R_F 0.45 (ethyl acetate–hexane, 4:1); λ_{max} 232 nm (ε_{mM} 3.72); ν_{max} 3250 (NH), 1730 cm^{-1} (C=O).

Anal. Calc. for $C_{20}H_{26}N_2O_{11}$: C, 51.06; H, 5.57; N, 5.95. Found: C, 51.34; H, 5.80; N, 6.02.

3(5)-Acetyl-5(3)-ethoxycarbonyl-4-(penta-O-*acetyl*-D-galacto-*pentitol-1-yl)pyrazole* (**17**). — A solution of **11** (1.0 g, 1.84 mmol) in chloroform (10 mL) was treated with bromine (0.30 g, 2.10 mmol), as described for **12**, to give **17** as a syrup (740 mg, 74%), $[\alpha]_D$ +12° (*c* 0.5, dichloromethane), R_F 0.43 (ethyl acetate–hexane, 5:1); λ_{max} 237 nm (ε_{mM} 2.54); ν_{max} 3250 (NH), 1760 cm^{-1} (C=O).

Anal. Calc. for $C_{23}H_{30}N_2O_{13}$: C, 50.92; H, 5.36; N, 5.17. Found: C, 50.57; H, 5.48; N, 5.15.

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