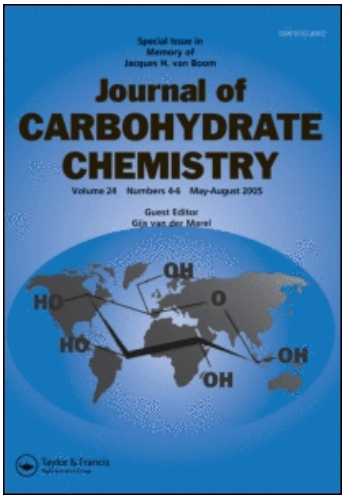

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Synthesis of *C*-Nucleoside Analogues Starting from 1-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-one[#]

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CONTENTS

[#]Dedicated to Professor Dr. Willi Kantlehner on the occasion of his 60th birthday.

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ABSTRACT

1-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-one **(4)** was synthesized by the reaction of (methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)ethanal (**2**) with lithium phenylethynide and following oxidation. Compound **4** and hydrazine hydrate provided the 3(5)-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl-methyl)-5(3)-phenyl-1*H*-pyrazole **(5).** The reactions of **4** with amidinium salts and a *S*-methyl-isothiouronium salt, respectively, furnished the pyrimidine *C*-nucleoside analogues **6a**–**6c**. Treatment of **4** with 2-aminobenzimidazole afforded 2-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-ylmethyl)-4-phenyl-benzo[4,5]imidazo [1,2-*a*]pyrimidine (**7a**). Compound **4** and sodium azide yielded 2-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-1-[5(4)-phenyl-1*H*(2*H*)-1,2,3-triazole-4(5)-yl]ethanone (**8**).

Key Words: *C*-Nucleoside analogues; Glycosylalkynone; Pyrazoles; Pyrimidines; Benzo[4,5]imidazo[1,2-*a*]pyrimidine.

INTRODUCTION

C-Nucleosides characterized by a C–C bond between the monosaccharide component and the aglycone are showing an increased hydrolytic and enzymatic stability. Therefore, the synthesis of representatives of this nucleoside subclass is of growing interest.[1–3] In *iso*-*C*-nucleosides, the nucleobase is linked by a carbon–carbon bond to the sugar unit through a nonanomeric carbon atom. *Iso*-*C*-nucleosides of this type are relatively rare in the literature but, recently, intensified efforts into their syntheses could be observed.[4–7]

Starting from push–pull functionalized monosaccharide derivatives, recently, we have reported the formation of *C*-nucleosides[8] and *iso*-*C*-nucleosides in which the former C-6 of the pyranose now is a part of the heterocycle.[9] Much more seldom are *iso*-*C*-nucleosides with a docking position at a ring carbon atoms of the saccharide part and an integrated spacer between the two nucleoside building blocks. Only a few examples of carbon atom[10–12] and heteroatom[13–15] spacer nucleosides are known. Some of these unusual nucleoside analogues show interesting glycosidase inhibitory properties.[13,14] To enlarge this class of compounds and to continue our program dealing with *C*-nucleosides, we present in this paper, the synthesis of spacer *iso*-*C*-nucleosides.

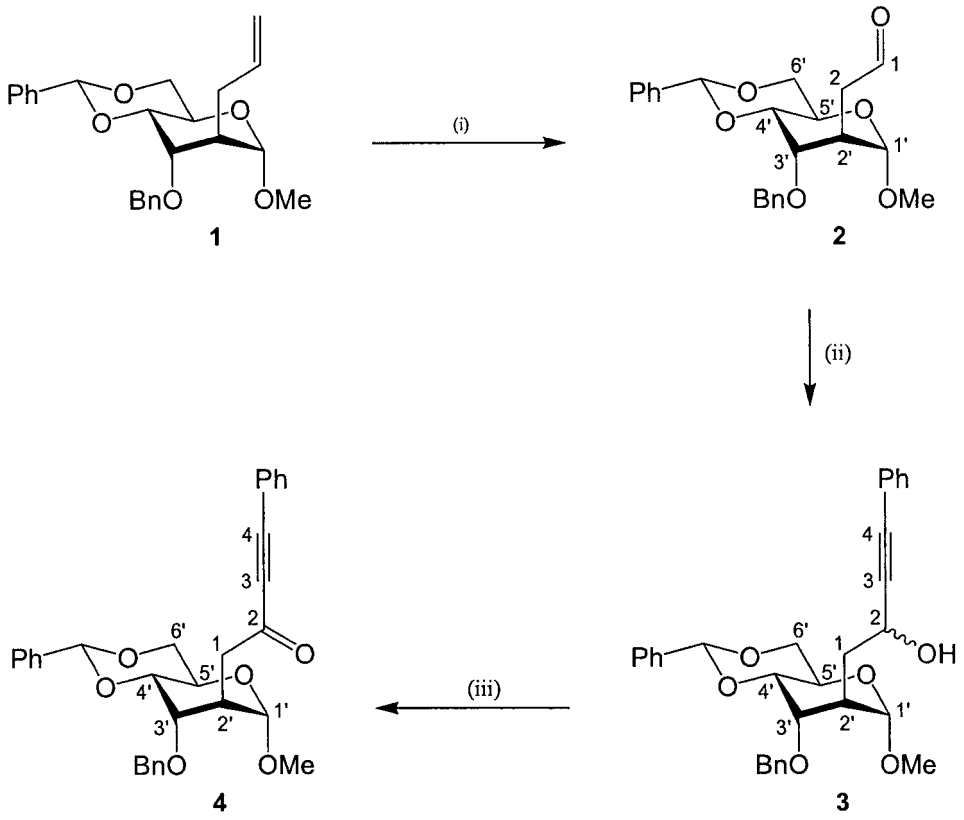
RESULTS AND DISCUSSION

Starting from D-glucose, the branched-chain D-altropyranoside **1** can be synthesized in six steps.[16,17] The branching was achieved by a regioselective ring opening of methyl 2,3-anhydro-4,6-*O*-benzylidene-α-D-allopyranoside with allylmagnesium chloride to afford methyl 4,6-*O*-benzylidene-2-deoxy-2-*C*-(prop-2-enyl)-α-D-altropyranoside. We were able to perform an x-ray structure analysis of this α-D-altropyranoside validating unequivocally the *altro*-configuration. Through 3-*O*-benzylation, the compound **1** was

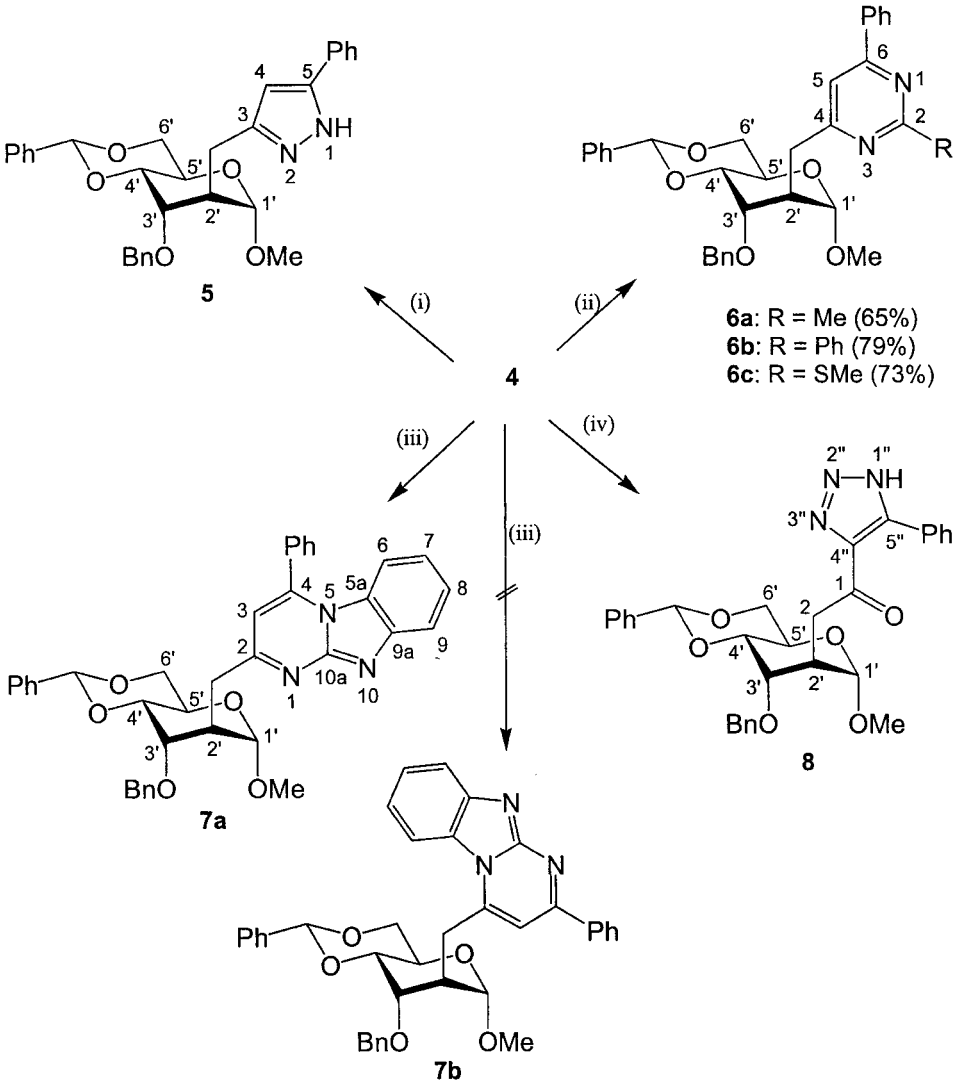
prepared and in an one-pot reaction transformed into the altropyranosid-2-ylethanal **2** first using osmium tetroxide as reagent and then sodium periodate (Sch. 1).[18]

Treatment of the altropyranosid-2-ylethanal **2** with a solution of lithium phenylethynide in THF resulted in the formation of the 1-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-ol (**3**). Due to the ^{1}H and ^{13}C NMR spectra, only one of the both possible diastereomeric alcohols was originated in 81% yield. The band for the OH group is displayed in the IR spectrum at 3454 cm^{-1}. The absolute configuration at C-2 could not be assigned, but this fact did not represent a decisive disadvantage because in the next reaction step even this OH group of the compound **3** was oxidized with pyridinium chlorochromate yielding the 1-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-one (**4**). The ^{13}C NMR chemical shifts of the carbonyl group and of the acetylene C-atoms were found at $\delta = 184.5$, 91.9, and 87.4, respectively. In the IR spectrum, the carbonyl band was at 1669 cm^{-1} and that of the carbon–carbon triple bond at 2200 cm^{-1}.

Ynone systems are well-known precursors for the construction of different types of heterocycles.[19–21] First the heterocyclization of the compound **4** with hydrazine hydrate was performed (Sch. 2). The reaction carried out in methanol at r.t. was finished



Scheme 1. (i) OsO_4, $NaIO_4$, dioxane–H_2O, r.t. (82%);[18] (ii) LiC≡CPh, THF, r.t. (81%); (iii) PCC, CH_2Cl_2, r.t. (63%).



Scheme 2. (i) $NH_2NH_2 \cdot H_2O$, MeOH, r.t. (64%); (ii) $RC(NH_2)=NH_2^+Cl^-/HSO_4^-$, Na_2CO_3, $AcOEt/H_2O$, reflux; (iii) 2-aminobenzimidazole, NEt_3, MeOH, reflux (61%); (iv) NaN_3, DMF, r.t. (88%).

already after 30 min. The formation of 3(5)-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl-methyl)-5(3)-phenyl-1*H*-pyrazole (**5**) could be confirmed by the absence of the signals for the carbonyl group and of the triple bond in the ^{13}C NMR and the IR spectra. Furthermore, the CH group of the pyrazole ring gave new signals at $\delta = 6.26$ in the ^1H NMR and at $\delta = 101.5$ in the ^{13}C NMR spectrum, respectively. Due to the fast exchange process of the NH proton between both the nitrogen atoms of the pyrazole **5**, this NH signal was not visible in the ^1H NMR spectrum.

Treatment of the ynone **4** with acetamidinium, benzamidinium, and *S*-methyl isothiouronium salts under basic conditions in refluxing ethyl acetate allowed the synthesis of the 2-substituted 4-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-ylmethyl)-6-phenyl-pyrimidines **6a**–**6c**. All the analytical data were in accordance with the proposed structures. In the mass spectra, the molecular peaks can be obviously detected. The typical signals of a pyrimidine ring as well as resonances for the new methyl, phenyl, or methylthio groups appeared in the ^{13}C NMR spectrum.

In order to synthesize an *iso*-*C*-nucleoside with a more complex heterocyclic unit, the ynone **4** was treated with 2-aminobenzimidazole in methanol in the presence of triethylamine under reflux temperature. 2-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-ylmethyl)-4-phenyl-benzo[4,5]imidazo[1,2-*a*]pyrimidine (**7a**) was isolated after 5 hr as a yellow solid in 61% yield. The fact that bands and signals for the carbonyl group and the carbon–carbon triple bond in the ^{13}C NMR and the IR spectra are not observed confirmed the successful ring closure reaction. In the mass spectra, the expected peak for the molecular mass of 613 could be clearly identified. Depending on the primary attack with the amino group or ring nitrogen of the 2-aminobenzimidazole, the ynone **4** should be afforded two different substituted benzo[4,5]imidazo[1,2-*a*]pyrimidines **7a** and **7b**, respectively. Unfortunately, it was not possible to determine the exact structure of the formed product by NMR measurements. But, there are known two examples from the literature for the reaction of an ynone with 2-aminobenzimidazole.[22] In these cases, only the attack of one of the ring nitrogen atoms of the 2-aminobenzimidazole occurred on the end of the vinylogous system without following cyclization. On the other hand, ynones were added through imidazol and amines at the triple bond and not at the carbonyl group.[22–24] Furthermore, the comparable enones indeed reacted with 2-aminobenzimidazole in an analogous way reported herein for the reaction pathway of the formation of compound **7a**.[25,26] Having this in mind, the assumed structure of compound **7a** should to be the right one.

For the preparation of five-membered heterocycles, the reaction of acetylenes with azides in terms of a 1,3-dipolar cycloadditions is a suitable strategy. In this way, the treatment of the ynone **4** with sodium azide resulted in the formation of 2-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-1-[5(4)-phenyl-1*H*(2*H*)-1,2,3-triazole-4(5)-yl]ethanone (**8**) having a two-carbon spacer between the monosaccharide unit and the heterocycle. Also, in this case, the fast exchange process of the NH proton between the three nitrogen atoms is the reason for the NH signal in the ^{1}H NMR spectrum as well as resonances of the triazole ring carbon atoms in the ^{13}C NMR spectrum were not observable.

EXPERIMENTAL

General Procedures

Solvents were distilled and if necessary dried using standard procedures. TLC was carried out on silica gel 60 GF_{254} (Merck) with detection by UV light ($\lambda = 254$ nm) and/or by charring with 10% sulfuric acid in methanol. Silica gel 60 (63–200 mesh) (Merck) was used for column chromatography. Melting points were determined by using a Boetius melting point apparatus and are corrected. Specific rotations were

determined with a Polar LμP (IBZ Messtechnik). IR spectra were recorded with a Nicolet 205 FT-IR spectrometer. ^{1}H NMR (250.13 and 300.13 MHz, respectively) and ^{13}C NMR (62.9 and 75.5 MHz, respectively) spectra were recorded on Bruker instruments AC 250 and ARX 300, respectively, with $CDCl_3$ as solvent. The calibration of spectra was carried out on $CDCl_3$ (^{1}H and ^{13}C) and TMS (internal, ^{1}H) signals (^{1}H $CDCl_3 = 7.25$; δ ^{1}H TMS $= 0$; δ ^{13}C $CDCl_3 = 77.0$). The ^{1}H and ^{13}C NMR signals were assigned by DEPT and/or two dimensional ^{1}H,^{13}C correlation experiments. The mass spectra were recorded on an AMD 402/3 spectrometer (AMD Intectra GmbH). Elemental analyses were performed on a Leco CHNS-932 instrument.

1-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-ol (3). To a stirred solution of compound **2** (0.797 g, 2 mmol) in anhyd. THF (10 mL) was given dropwise at r.t. lithium phenylethynide (8 mL, 1 M solution in THF) and stirring was continued for 24 hr. Then, water (20 mL) was added and the resulting mixture was extracted with diethyl ether (3 × 20 mL). The combined organic phases were washed with water (2 × 20 mL), dried (Na_2SO_4), and evaporated. The residue was purified by column chromatography (toluene/ethyl acetate, 3 : 1). Compound **3** was isolated as a colorless syrup. Yield: 0.811 g (81%); $[\alpha]_D^{21} + 24.3^\circ$ (*c* 1, $CHCl_3$); R_f 0.33 (toluene/ethyl acetate, 3 : 1). IR (capillary), ν (cm^{-1}): 3454 (OH). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 7.50–7.20 (m, 15H, Ph); 5.54 (s, 1H, C*H*–Ph); 4.80 (s, 2H, CH_2–Ph); 4.63 (s, 1H, H-1′); 4.57 (m, 1H, H-2); 4.45 (m, 1H, H-5′); 4.32 (dd, 1H, $^2J_{6'a,6'b} = 10.1$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.87 (t, 1H, H-3′); 3.79–3.69 (m, 2H, H-4′, H-6b′); 3.40 (s, 3H, OMe); 2.62 (ddd, 1H, $^3J_{2',1a}$, $^3J_{2',1b} = 6.7$ Hz, $^3J_{2',3'} = 2.1$ Hz, H-2′); 2.03–1.92 (m, 2H, H-1a, OH); 1.80 (m, 1H, H-1b). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 138.9, 137.7, 122.1 (3 × phenyl C-1); 128.4, 128.3, 128.2, 128.1, 127.5, 127.4, 127.2, 127.1, 126.3 (phenyl C-2–C-6); 102.5 (*C*H–Ph); 102.3 (C-1′); 88.9 (C-3); 85.7 (C-4); 77.4 (C-4′); 75.0 (C-3′); 72.1 (*C*H_2–Ph); 69.6 (C-6′); 61.4 (C-2); 58.3 (C-5′); 55.7 (OMe); 40.5 (C-2′); 38.3 (C-1). MS: m/z (EI): 499 $[M - 1]^+$.

Anal. calcd for $C_{31}H_{32}O_6$ (500.59): C, 74.38; H, 6.44. Found: C, 74.09; H, 6.47.

1-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-4-phenyl-but-3-yn-2-one (4). A mixture of **3** (0.75 g, 1.5 mmol) and PCC (0.808 g, 3.75 mmol) in anhyd. dichloromethane (15 mL) was stirred for 12 hr at r.t. After filtration the residue was washed several times with ethyl acetate. The combined filtrates were evaporated and the remaining residue was purified by column chromatography (toluene/ethyl acetate, 2 : 1). Compound **4** was obtained as colorless syrup. Yield: 0.471 g (63%); $[\alpha]_D^{21} + 9.1^\circ$ (*c* 1, $CHCl_3$); R_f 0.56 (toluene/ethyl acetate, 5 : 1). IR (capillary), ν (cm^{-1}): 2200 (C≡C); 1669 (CO). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 7.59–7.15 (m, 15H, Ph); 5.56 (s, 1H, C*H*–Ph); 4.82 (s, 2H, CH_2-NPh); 4.50 (s, 1H, H-1′); 4.47 (m, 1H, H-5′); 4.33 (dd, 1H, $^2J_{6'a,6'b} = 10.4$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.78 (m, 3H, H-3′, H-4′, H-6′b); 3.41 (s, 3H, OMe); 3.04 (m, 1H, H-2′); 2.92 (dd, 1H, $^2J_{1a,1b} = 17.1$ Hz, $^3J_{1a,2'} = 8.3$ Hz, H-1a); 2.71 (dd, 1H, $^2J_{1a,1b} = 17.1$ Hz, $^3J_{1b,2'} = 6.1$ Hz, H-1b). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 184.5 (C-2); 138.7, 136.6, 119.5 (3 × phenyl C-1); 133.1, 131.0, 129.0, 128.7, 128.2, 128.1, 127.5, 127.2, 126.3 (phenyl C-2–C-6); 102.3 (*C*H–Ph); 101.4 (C-1′); 91.9 (C-4); 87.4 (C-3); 77.3 (C-4′); 74.5 (C-3′); 72.0 (*C*H_2–Ph); 69.5 (C-6′); 58.3 (C-5′); 55.7 (OMe); 46.2 (C-1); 39.1 (C-2′). MS: m/z (EI): 498 $[M]^+$.

Anal. calcd for $C_{31}H_{30}O_6$ (498.57): C, 74.68; H, 6.06. Found: C, 74.81; H, 5.90.

3(5)-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl-methyl)-5(3)-phenyl-1*H*-pyrazole (5). Compound **4** (0.249 g, 0.5 mmol) and hydrazine hydrate (36 μL, 0.75 mmol) were dissolved in anhyd. methanol (5 mL). The mixture was stirred at r.t. for 30 min. Then the solvent was removed by evaporation and the residue was purified by column chromatography (toluene/ethyl acetate, 2 : 1). Compound **5** was isolated as a white solid. Yield: 0.164 g (64%); mp 69–71°C; $[\alpha]_D^{21} + 35.5$ (*c* 1.0, $CHCl_3$); R_f 0.33 (toluene/ethyl acetate, 1 : 2). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 7.61–7.58 (m, 2H, Ph), 7.18–7.09 (m, 13H, Ph); 6.26 (s, 1H, H-4); 5.51 (s, 1H, C*H*–Ph); 4.74, 4.64 (2 × d, 2H, $^2J_{a,b} = 12.8$ Hz, CH_2–Ph); 4.52 (s, 1H, H-1′); 4.46 (m, 1H, H-5′); 4.31 (dd, 1H, $^2J_{6'a,6'b} = 10.1$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.84–3.68 (m, 3H, H-3′, H-4′, H-6′b); 3.34 (s, 3H, OMe); 2.87–2.61 (m, 3H, H-2′, CH_2). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 147.7, 147.3 (C-3, C-5); 138.7, 137.7, 131.0 (3 × phenyl C-1); 129.0, 128.8, 128.2, 128.0, 127.6, 127.2, 126.2, 125.5, 125.2 (phenyl C-2–C-6); 102.3 (*C*H–Ph); 101.5, 101.4 (C-4, C-1′); 77.2 (C-4′); 73.8 (C-3′); 72.5 (*C*H_2–Ph); 69.5 (C-6′); 58.5 (C-5′); 55.5 (OMe); 44.3 (C-2′); 28.5 (CH_2). MS: *m*/*z* (CI, *iso*-butane): 513 $[M + 1]^+$.

Anal. calcd for $C_{31}H_{32}N_2O_5$ (512.6): C, 72.64; H, 6.29; N, 5.46. Found: C, 72.57; H, 6.45; N, 5.69.

2-Methyl-4-(methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-ylmethyl)-6-phenyl-pyrimidine (6a). Compound **4** (0.249 g, 0.5 mmol) was dissolved in ethyl acetate (2 mL). Water (10 μL), acetamidinium chloride (0.61 g, 0.65 mmol) and Na_2CO_3 (0.138 g, 1.3 mmol) were added and heating the mixture under reflux was carried out until compound **4** disappeared (detected by TLC; approximately 3 hr). After addition of more ethyl acetate (15 mL) the reaction mixture was washed with water (3 × 20 mL) and dried (Na_2SO_4). The residue obtained after removing the solvent was purified by column chromatography (toluene/ethyl acetate, 2 : 1). Compound **6a** was obtained as a white solid. Yield: 0.175 g (65%); mp 106–108°C; $[\alpha]_D^{21} + 22.6°$ (*c* 1, $CHCl_3$); R_f 0.35 (toluene/ethyl acetate, 2 : 1). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 8.04–8.0 (m, 2H, Ph), 7.53–7.12 (m, 14H, Ph, H-5); 5.61 (s, 1H, C*H*–Ph); 4.78, 4.72 (2 × d, 2H, $^2J_{a,b} = 12.8$ Hz, CH_2–Ph); 4.56 (s, 1H, H-1′); 4.48 (m, 1H, H-5′); 4.35 (dd, 1H, $^2J_{6'a,6'b} = 10.4$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.92 (dd, 1H, $^3J_{4',5'} = 10.0$ Hz, $^3J_{4',3'} = 3.1$ Hz, H-4′); 3.83–3.68 (m, 2H, H-3′, H-6′b); 3.39 (s, 3H, OMe); 2.98–2.86 (m, 2H, H-2′, CH_2a); 2.79 (dd, 1H, $^2J_{a,b} = 9.5$ Hz, $^3J_{CH_2b,2'} = 5.5$ Hz, CH_2b); 2.74 (s, 3H, CH_3). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 168.3, 167.9 (C-2, C-4); 164.4 (C-6); 138.6, 137.7, 136.9 (3 × phenyl C-1); 130.7, 129.0, 128.9, 128.2, 127.9, 127.4, 127.2, 127.1, 126.2 (phenyl C-2–C-6); 113.1 (C-5); 102.3 (*C*H–Ph); 101.7 (C-1′); 77.3 (C-4′); 73.5 (C-3′); 72.3 (*C*H_2–Ph); 69.5 (C-6′); 58.5 (C-5′); 55.6 (OMe); 43.7 (C-2′); 38.8 (CH_2); 26.2 (Me). MS: *m*/*z* (CI, *iso*-butane): 539 $[M + 1]^+$.

Anal. Calcd for $C_{33}H_{34}N_2O_5$ (538.64): C, 73.59; H, 6.36; N 5.20. Found: C, 73.32; H, 6.45; N, 4.92.

4-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl-methyl)-2,6-diphenyl-pyrimidine (6b). The reaction of **4** (0.249 g, 0.5 mmol) with benzamidinium chloride (0.102 g, 0.65 mmol) in ethyl acetate (2 mL) in the presence of water (10 μL) and Na_2CO_3 (0.138 g, 1.3 mmol) was carried out as described for **6a**. After evaporation, the residue was purified by column chromatography (toluene/ethyl acetate, 5 : 1). Compound **6b** was isolated as a white solid. Yield 0.237 g (79%); mp 180–182°C; $[\alpha]_D^{21} + 30.8°$ (*c* 1, $CHCl_3$); R_f 0.52 (toluene/ethyl acetate, 5 : 1). ^{1}H NMR (250.1 MHz,

$CDCl_3$), δ (ppm): 8.53–6.99 (6 × m, 21H, Ph, H-5); 5.55 (s, 1H, C*H*–Ph); 4.72, 4.67 (2 × d, 2H, $^2J_{a,b} = 13.1$ Hz, CH_2–Ph); 4.58 (s, 1H, H-1′); 4.45 (m, 1H, H-5′); 4.30 (dd, 1H, $^2J_{6'a,6'b} = 10.4$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.88 (dd, 1H, $^3J_{4',5'} = 10.0$ Hz, $^3J_{4',3'} = 3.1$ Hz, H-4′); 3.78–3.70 (m, 2H, H-3′, H-6′b); 3.34 (s, 3H, OMe); 3.05–2.92 (m, 2H, H-2′, CH_2a); 2.82 (dd, 1H, $^2J_{a,b} = 12.8$ Hz, $^3J_{CH_2}$b,2′ = 6.1 Hz, CH_2b). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 168.0 (C-4); 164.3, 164.2 (C-2, C-6); 138.6, 137.8, 137.7, 137.0 (4 × phenyl C-1); 130.9, 130.7, 129.0, 128.9, 128.5, 128.4, 128.2, 128.0, 127.5, 127.2, 127.1, 126.0 (phenyl C-2–C-6); 113.9 (C-5); 102.3 (*C*H–Ph); 101.9 (C-1′); 77.5 (C-4′); 73.6 (C-3′); 72.3 (*C*H_2–Ph); 69.6 (C-6′); 58.5 (C-5′); 55.7 (OMe); 43.2 (C-2′); 38.8 (CH_2). MS: m/z (CI, *iso*-butane): 601 $[M + 1]^+$.

Anal. Calcd for $C_{38}H_{36}N_2O_5$ (600.71): C, 75.98; H 6.04; N 4.66. Found: C, 75.84; H, 6.11; N, 4.94.

4-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl-methyl)-2-methylthio-6-phenyl-pyrimidine (6c). The reaction of **4** (0.249 g, 0.5 mmol) with *S*-methyl-isothiouronium sulfate (0.181 g, 0.65 mmol) in ethyl acetate (2 mL) in the presence of water (10 μL) and Na_2CO_3 (0.138 g, 1.3 mmol) was carried out as described for **6a**. After evaporation the residue was purified by column chromatography (toluene/ethyl acetate, 5 : 1). Compound **6c** was obtained as a white solid. Yield: 0.208 g (73%); mp 135–137°C; $[\alpha]_D^{21} + 31.3°$ (*c* 1, $CHCl_3$); R_f 0.49 (toluene/ethyl acetate, 5 : 1). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 8.07–7.10 (5m, 16H, Ph,H-5); 5.60 (s, 1H, C*H*–Ph); 4.79, 4.73 (2 × d, 2H, $^2J_{a,b} = 12.8$ Hz, CH_2–Ph); 4.57 (s, 1H, H-1′); 4.49 (m, 1H, H-5′); 4.35 (dd, 1H, $^2J_{6'a,6'b} = 10.4$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.89 (dd, 1H, $^3J_{4',5'} = 10.0$ Hz, $^3J_{4',3'} = 3.1$ Hz, H-4′); 3.82–3.74 (m, 2H, H-3′, H-6′b); 3.40 (s, 3H, OMe); 2.96–2.88 (m, 2H, H-2′, CH_2a); 2.76 (dd, 1H, $^2J_{a,b} = 16.2$ Hz, $^3J_{CH_2}$b,2′ = 10.8 Hz, CH_2b); 2.63 (s, 3H, SMe). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 172.7 (C-2); 168.1 (C-4); 164.1 (C-6); 138.6, 137.7, 136.4 (3 × phenyl C-1); 131.1, 129.0, 128.8, 128.3, 128.0, 127.6, 127.2 (2 x), 126.3 (phenyl C-2–C-6); 111.2 (C-5); 102.3 (*C*H–Ph); 101.7 (C-1′); 77.4 (C-4′); 73.5 (C-3′); 72.3 (*C*H_2–Ph); 69.6 (C-6′); 58.5 (C-5′); 55.7 (OMe); 43.3 (C-2′); 38.7 (CH_2); 14.2 (SMe). MS: m/z (EI): 570 $[M]^+$.

Anal. calcd for $C_{33}H_{34}N_2O_5S$ (570.70): C, 69.45; H, 6.00; N, 4.91; S, 5.62. Found: C, 69.31; H, 6.05; N, 4.65; S, 5.35.

2-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-ylmethyl)-4-phenyl-benzo[4,5]imidazo[1,2-*a*]pyrimidine (7a). Compound **4** (0.249 g, 0.5 mmol), 2-aminobenzimidazole (0.073 g, 0.55 mmol) and triethylamine (140 μL, 1 mmol) were dissolved in anhyd. methanol (5 mL). After heating under reflux for 5 hr water (15 mL) was added and the reaction mixture was extracted with dichloromethane (3 × 20 mL). The combined organic phases were washed with water (2 × 20 mL), dried (Na_2SO_4), and evaporated. Purification of the remaining residue was carried out by column chromatography (toluene/ethyl acetate, 1 : 1). Compound **7** was obtained as yellow solid. Yield: 0.187 g (61%); mp 166–168°C; $[\alpha]_D^{21} + 5.8$ (*c* 0.5, $CHCl_3$); R_f 0.23 (toluene/ethyl acetate, 1 : 1). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 7.92 (m, 1H, Ar), 7.63–6.61 (8m, 18H, Ph, Ar); 6.43 (s, 1H, H-3); 5.55 (s, 1H, C*H*–Ph); 4.74, 4.66 (2 × d, 2H, $^2J_{a,b} = 13.1$ Hz, CH_2-Ph); 4.57 (s, 1H, H-1′); 4.42 (m, 1H, H-5′); 4.29 (dd, 1H, $^2J_{6'a,6'b} = 10.1$ Hz, $^3J_{6'a,5'} = 5.2$ Hz, H-6′a); 3.88 (dd, 1H, $^3J_{4',5'} = 9.8$ Hz, $^3J_{4',3'} = 2.8$ Hz, H-4′); 3.78–3.68 (m, 2H, H-3′, H-6b′); 3.36 (s, 3H, OMe); 3.01 (dd, 1H, $^2J_{a,b} = 17.8$ Hz, $^3J_{CH_2a,2'} = 10.7$ Hz, CH_2a); 2.92–2.82 (m, 2H, H-2′, CH_2b). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 165.6 (C-2); 151.3 (C-4); 149.1 (C-10a); 144.6

(C-9a); 138.5, 137.7, 131.9 (3 × phenyl C-1); 131.2, 129.0, 128.9, 128.2, 127.8, 127.7, 126.7, 126.3, 126.0 (phenyl C-2–C-6); 127.2 (C-5a); 125.3 (C-7); 121.3 (C-8); 120.3 (C-9); 114.5 (C-3); 108.2 (C-6); 102.3 (*C*H–Ph); 102.0 (C-1′); 77.3 (C-4′); 72.5 (C-3′); 72.2 (CH$_2$–Ph); 69.6 (C-6′); 58.5 (C-5′); 55.7 (OMe); 43.4 (C-2′); 39.6 (CH$_2$). MS: m/z (EI): 613 $[M]^+$.

Anal. calcd for $C_{38}H_{35}N_3O_5$ (613.7): C, 74.37; H, 5.75; N, 6.85. Found: C, 74.59; H, 6.04; N, 6.62.

2-(Methyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-deoxy-α-D-altropyranosid-2-yl)-1-[5(4)-phenyl-1*H*(2*H*)-1,2,3-triazole-4(5)-yl]ethanone (8). A solution of **4** (0.249 g, 0.5 mmol) and sodium azide (0.039 g, 0.6 mmol) was stirred at r.t. for 30 min. After addition of water (20 mL), the reaction mixture was extracted with dichloromethane (3 × 25 mL). The combined organic phases were washed with water (2 × 20 mL), dried (Na_2SO_4) and evaporated. Purification of the remaining residue was carried out by column chromatography (toluene/ethyl acetate, 2 : 1). Compound **8** was obtained as a white solid. Yield 0.238 g (88%); mp 94–96°C; $[\alpha]_D^{21} + 28.7$ (*c* 1, $CHCl_3$); R_f 0.34 (toluene/ethyl acetate, 2 : 1). IR (KBr), ν (cm^{-1}): 1692 (CO). ^{1}H NMR (250.1 MHz, $CDCl_3$), δ (ppm): 7.78–7.14 (2 × m, 15H, Ph); 5.57 (s, 1H, C*H*-Ph); 4.82, 4.76 (2 × d, 2H, $^2J_{a,b} = 12.8$ Hz, CH_2-Ph); 4.54 (s, 1H, H-1′); 4.49 (m, 1H, H-5′); 4.33 (dd, 1H, $^2J_{6',6'b} = 10.4$ Hz, $^3J_{6'a,5'} = 5.5$ Hz, H-6′a); 3.86 (dd, 1H, $^3J_{4',5'} = 9.8$ Hz, $^3J_{4',3'} = 3.1$ Hz, H-4′); 3.81–3.72 (m, 2H, H-3′, H-6′b); 3.44–3.33 (m, 4H, OMe, H-2a); 3.20 (dd, 1H, $^2J_{2a,2b} = 17.7$ Hz, $^3J_{2b,2'} = 5.5$ Hz, H-2b); 3.10 (m, 1H, H-2′). ^{13}C NMR (62.9 MHz, $CDCl_3$), δ (ppm): 192.2 (C-1); 138.5, 137.6, 129.8 (3 × phenyl C-1); 130.1, 129.1, 128.5, 128.2, 128.1, 128.0, 127.7, 127.2, 126.2 (phenyl C-2–C-6); 102.3 (*C*H–Ph); 101.7 (C-1′); 77.5 (C-4′); 74.8 (C-3′); 72.1 (CH$_2$–Ph); 69.5 (C-6′); 58.5 (C-5′); 55.7 (OMe); 41.2 (C-2); 38.8 (C-2′). MS: m/z (EI): 541 $[M]^+$.

Anal. Calcd for $C_{31}H_{31}N_3O_6$ (541.59): C, 68.75; H, 5.77; N, 7.76. Found: C, 68.86; H, 5.93; N, 7.71.

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