Thiosugars, 2[+]

Preparation of 2,3,5-Tri-*O*-benzyl-4-thio-L-*arabino*-furanosides and the Corresponding 4′-Thionucleoside Analogues

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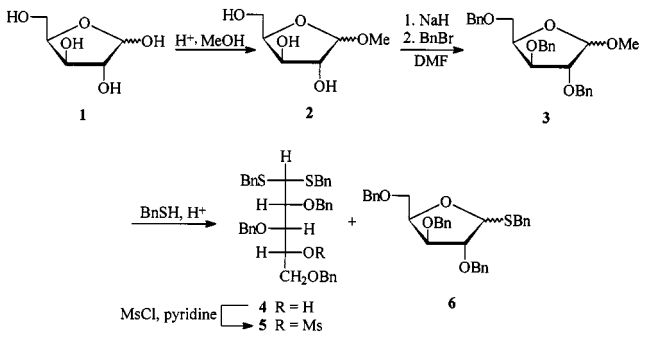
1-*O*-Acetyl-2,3,5-tri-*O*-benzyl-4-thio-*L*-*arabino*-furanose (**9**) has been prepared from D-xylose via the 1,4-dithio-L-*arabino*-furanoside **8**. The crucial step of the reaction, i.e. the intramolecular cyclization of the open-chain dithioacetal **5**, has been achieved in a yield of 90% by applying tetrabutylammonium iodide as promoter. Reaction of **9** with bis(trimethylsilyl)uracil or -thymine led to the benzyl derivatives **12** and **13** from which the deprotected 4′-thionucleoside analogues **14** and **15** have been prepared by debenzylation with boron tribromide.

Carbohydrates with a sulfur atom in the 4-position of the furanose ring have been of interest for a period of 30 years. The main target of all recent syntheses was and still is to prepare such compounds with a minimum number of steps. In 1964 Whistler et al.[1] reported the synthesis of methyl 4-deoxy-4-thio-D-*ribo*-furanoside − one of the earliest publications in this research area. Of course 4-thio-D-ribose[2,3] and 2-deoxy-4-thio-D-ribose[4,5] derivatives are the most popular compounds, because they are precursors for unnatural 4′-thionucleosides[6,7] and 2′-deoxy-4′-thionucleosides.[8,9] In 1995 Barascut and Imbach published the first results on the synthesis of 4′-thio-oligo-*ribo*-nucleotides;[10] the starting material for 4′-thio-RNA.

As a consequence of our studies on 2-(alkylthio)thiolanes − prototypes of 1,4-dithiofuranosides − we became interested in producing such 4-thiofuranosides, especially with L configuration at C-4, and studying their structure and chemistry. We describe here a novel synthesis of the 4-thio-L-*arabino*-furanose derivative **9** and its transformation into the 4′-thionucleoside analogues **14** and **15**, which might exhibit interesting biochemical properties on account of their L configuration. − The acetate **9** has very recently been prepared by a different route by Yoshimura et al.[11] who also obtained **15** and ist cytosine analogue. − The counterpart of **9** with D-*xylo* configuration has also been used as a key intermediate for the synthesis of adenine nucleosides[12,13] as well as the enantiomer D-**9** which served as precursor for several nucleosides.[14,15]

Results and Discussion

Our synthesis started with commercially available and cheap D-xylose (**1**) which was transformed into the protected D-xylose derivative **3** with 85% yield following literature procedures.[5,16] Both the α and the β anomer were obtained in a ratio of 2:1 (α/β). It was possible to separate the anomers by column chromatography. In the next step sulfur was introduced into the sugar moiety by using phenylmethanethiol in the presence of concentrated hydrochloric acid. This two-step process gave an 84% yield of the open-chain dithioacetal **4**. This high yield demonstrates the possibility to use the protected D-xylose derivative **3** directly in contrast to the analogous 2,3,5-tri-*O*-benzyl-L-*lyxo*-furanose which requires deprotection in the 1-position.[7] Besides **4** a 6% yield of the intermediate 1-*S*-benzyl D-*xylo*-furanoside **6** was obtained as by-product in an anomeric ratio of 1:1.3 (Scheme 1).



Scheme 1

The free C-4 hydroxy group of **4** was mesylated at room temperature in pyridine to obtain **5** which exhibits a good leaving group for the following cyclisation step. Earlier[17,18] and numerous recent publications[5,19] propose sodium iodide and barium carbonate in dry acetone at reflux temperature for this cyclisation. We also tried this procedure but were unable to obtain acceptable yields. In the best case we achieved 20% of **8** and a large quantity of decomposition products. The use of tetrabutylammonium iodide and barium carbonate in dry DMF at 120°C gave, however, 60% of **8**. The best cyclisation conditions turned out to be tetra-

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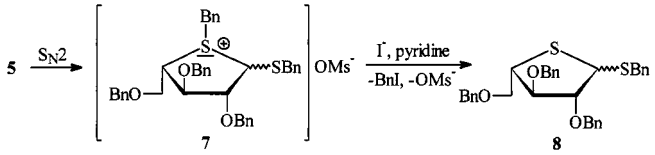
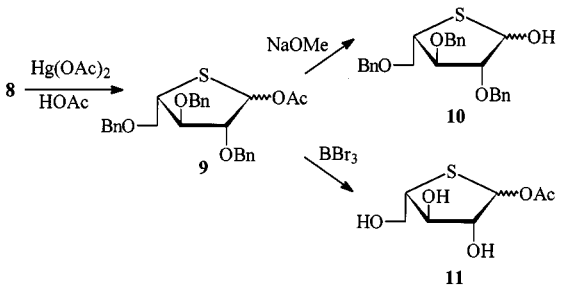
butylammonium iodide and barium carbonate in dry pyridine at reflux temperature.[7] This yielded 94% of **8** with an anomeric ratio of 6.7:1. Compared with the other methods there are obvious advantages: 1) the better solubility of tetrabutylammonium iodide as compared with sodium iodide; 2) a higher reaction temperature and thus a shorter reaction time as compared with acetone and, as a consequence, the high yield of over 90% (Scheme 2).



Scheme 2

Obviously, the cyclisation is the key step for any synthesis of a 4-thiofuranoside. Numerous reaction conditions for this step have been reported in the past decade. Unanimously, iodide was used as a co-reagent and is in fact necessary for the success of the reaction, which, according to our own experience[20] does not at all take place in the absence of iodide. This observation does, however, neither imply the formation of an intermediate 4-iodopentose[18] nor a two-step mechanism with two inversions of the configuration at the 4-position. Rather the reaction is an intramolecular S_N2 reaction with only a single inversion at C-4, which thus leads from the D to the L series. We have undoubtedly proved this stereochemical course by NMR spectroscopy.[20] The essential role which the iodide ions play is to remove the *S*-benzyl group from the intermediate cyclic sulfonium ion **7** by nucleophilic displacement. This cannot be brought about by the mesylate anions present on account of their poor nucleophilicity.[21]

The 1-*O*-acetyl-4-thio-L-*arabino*-furanose derivative **9** was obtained from **8** under the Seebach conditions.[17,22] Using mercuric acetate in glacial acetic acid we achieved a yield of 76% of **9α** + **9β** as a 4:1 anomeric mixture (Scheme 3). Separation of the two anomers could not be achieved. The assignment was, however, possible on the basis of the optical rotation. Our 4:1 mixture exhibited $[\alpha]_D^{20} = -103.5$ (c = 1.3, $CHCl_3$), whereas Yoshimura et al.[11] reported $[\alpha]_D^{25} = +29.8$ (c = 2.0, $CHCl_3$) for their 1:2 mixture which contained the β anomer as the main component. The surprising difference of the anomeric ratios can be explained by Yoshimura's different route of preparation (Pummerer reaction of 1,4-anhydro-4-thio-L-arabitol).



Scheme 3

Sodium methoxide removed the acetyl group of **9** to yield 79% of 2,3,5-tri-*O*-benzyl-4-thio-L-*arabino*-furanose (**10**). The anomers **10α** and **10β** were formed in a 1:1 ratio but could not be separated. Also debenzylation of **9** was possible with boron tribromide. The product yield of 1-*O*-acetyl-4-thio-L-*arabino*-furanose (**11**), again a mixture of the two anomers, was, however, only moderate (29%) since quenching of boron tribromide caused losses and made the work-up procedure difficult.

1-*O*-Acetylfuranoses represent suitable starting compounds for nucleoside syntheses.[9,19] Reaction of **9** with bis(trimethylsilyl)uracil or -thymine in the presence of trimethysilyl triflate was indeed successful and the tri-*O*-benzyl-4′-thionucleoside analogues **12** and **13** were obtained with good yields. Their structures were assigned by NMR spectroscopy. In particular, the observed NOE (cf. Figure 1) unequivocally prove the configurations at C-1 and C-4. Interactions between 6-H and 2′-H and 4′-H are only possible in the L-α-*arabino* stereoisomers **12α** and **13α**. Correspondingly, interactions between 6-H and 3′-H and 5′-H and between 2′-H and 4′-H are observed in the β anomers **12β** and **13β**.

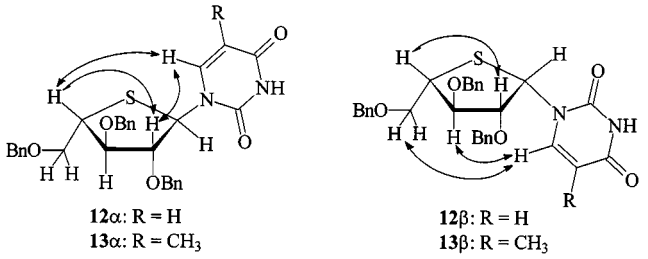
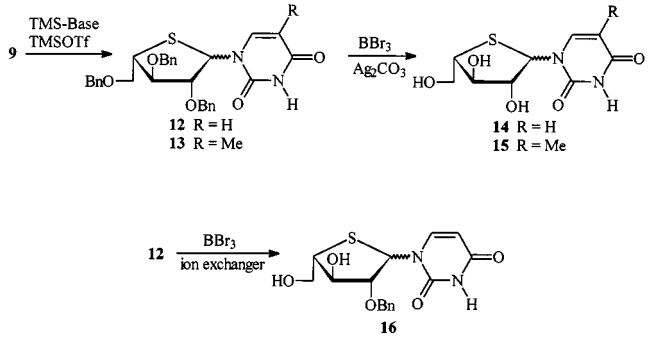


Figure 1. Observed NOE (↔) as indicators for the α- and β-L-*arabino* configuration of **12** and **13**

In a final step deprotection of **12** and **13** was performed with boron tribromide. In order to isolate the desired free 4′-thionucleoside analogues **14** and **15** it was necessary to neutralize the strongly acidic solution with silver carbonate after methanolic quenching of the excess boron tribromide since otherwise no product could be recovered. Unexpectedly, we obtained the partially deprotected 2-*O*-benzyl derivative **16** from one reaction batch when we neutralized the solution with an Amberlite® ion exchanger (Scheme 4).



Scheme 4

Experimental Section

General: IR: ATI Mattson Genesis spectrometer. − NMR: Bruker AMX 400 and DRX 500. Chemical shifts (ppm) are related to Me_4Si (^1H) and $CDCl_3$ (^{13}C, δ = 77.05). Standard correlation techniques were used for assignments. − Mass spectra: Varian CH 7 (EI) and VG Analytical 70-250 S (FAB, HRMS). − TLC was carried out on Merck PF_{254} foils (detection: UV light, iodine vapour, or EtOH/H_2SO_4 spray/200°C), and column chromatography on Merck Kieselgel 60 (70−230 mesh). Solvents were purified and dried according to standard laboratory procedures.[23]

Methyl 2,3,5-Tri-*O*-benzyl-D-*xylo*-furanoside (3): Compound **3** was prepared from methyl D-*xylo*-furanoside (**2**) according to standard procedures.[5,16] Compound **3** has been mentioned by Yoshimura et al.[11] without data which are therefore dealt with here. − IR (film): $\tilde{\nu}$ = 3062, 3030, 2910, 2870, 1496, 1454, 1365, 1311, 1250, 1205, 1122, 1100, 908, 820, 737, 698, 607 cm^{-1}. − **3α**: $[\alpha]_D^{20}$ = +60.1 (*c* = 1.0, $CHCl_3$). − ^1H NMR (400 MHz, $CDCl_3$): δ = 3.40 (s, 3 H, CH_3), 3.59 (dd, 1 H, 5_a-H), 3.71 (dd, 1 H, 5_b-H), 4.02 (dd, 1 H, 2-H), 4.31 (dd, 1 H, 3-H), 4.39 (ddd, 1 H, 4-H), 4.49−4.69 (m, 6 H, CH_2Ph), 4.81 (d, 1 H, 1-H), 7.23−7.37 (m, 15 H, ArH); $J_{1,2}$ = 4.3, $J_{2,3}$ = 6.0, $J_{3,4}$ = 7.1, $J_{4,5a}$ = 6.8, $J_{4,5b}$ = 4.0, $J_{5a,5b}$ = 10.6 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 54.85 (OCH_3), 68.99 (C-5), 72.18, 72.20, 73.04 (*C*H_2Ph), 75.49 (C-4), 81.14 (C-3), 83.51 (C-2), 100.09 (C-1), 127.11, 127.15, 127.20, 127.34, 127.47, 127.70, 127.89, 127.92, 127.98 ($C_{Ar}H$), 137.29, 137.69, 137.80 (C_q). − **3β**: $[\alpha]_D^{20}$ = −17.5 (*c* = 1.0, $CHCl_3$) − ^1H NMR (400 MHz, $CDCl_3$): δ = 3.38 (s, 3 H, CH_3), 3.72 (dd, 1 H, 5_a-H), 3.78 (dd, 1 H, 5_b-H), 3.97 (dd, 1 H, 2-H), 4.04 (dd, 1 H, 3-H), 4.43−4.64 (m, 7 H, CH_2Ph, 4-H), 4.91 (d, 1 H, 1-H), 7.25−7.37 (m, 15 H, ArH); $J_{1,2}$ = 1.6, $J_{2,3}$ = 2.6, $J_{3,4}$ = 5.9, $J_{4,5a}$ = 7.2, $J_{4,5b}$ = 4.9, $J_{5a,5b}$ = 10.2 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 55.61 (OCH_3), 69.73 (C-5), 71.98, 72.17, 73.40 (*C*H_2Ph), 80.07 (C-4), 81.50 (C-3), 86.83 (C-2), 108.13 (C-1), 127.52, 127.59, 127.68, 127.74, 127.78, 127.82, 128.30, 128.37, 128.41 ($C_{Ar}H$), 137.54, 137.76, 138.28 (C_q). − MS (70 eV); *m*/*z* (%): 343 (0.05) [M^+ − C_7H_7], 311 (0.66) [M^+ − C_7H_7 − CH_3OH], 253 (16), 181 (7), 92 (15), 91 (100) [$C_7H_7^+$], 65 (5).

2,3,5-Tri-*O*-benzyl-D-xylose Dibenzyl Dithioacetal (4): Compound **3** (21.93 g, 50.5 mmol) was dissolved in phenylmethanethiol (33 mL, 34 g, 270 mmol) and concd. aq. HCl (30 mL) and stirred at room temp. for 72 h. The mixture was diluted with water (200 mL) and dichloromethane (200 mL), the organic phase separated, washed twice with saturated $NaHCO_3$ and water, dried with $MgSO_4$ and concentrated under reduced pressure. Column chromatography of the residue (petroleum ether/ethyl acetate, 4:1, R_f = 0.21) yielded **4** (27.47 g, 84%) as yellow syrup, $[\alpha]_D^{20}$ = −77.4 (*c* = 1.0, $CHCl_3$). The first fraction [R_f(**6α,β**) = 0.39] was identified as a 1:1.3 mixture of the α and β anomer of 1-*S*-benzyl 2,3,5-tri-*O*-benzyl-D-*xylo*-furanoside (**6**) (1.53 g, 6%); yellow oil. − **4**: IR (film): $\tilde{\nu}$ = 3456, 3087, 3061, 3030, 2915, 2862, 1496, 1455, 1397, 1352, 1239, 1209, 1104, 1072, 1028, 914, 878, 737, 700 cm^{-1}. − ^1H NMR (500 MHz, $CDCl_3$): δ = 2.25 (d, 1 H, 4-OH), 3.17 (dd, 1 H, 5_a-H), 3.33 (dddd, 1 H, 4-H), 3.35 (dd, 1 H, 5_b-H), 3.71 (d, 1 H, 1-H), 3.76 (dd, 1 H, 3-H), 3.77, 3.81 (AB system, 4 H, J_{AB} = 13.6 Hz, SCH_2Ph), 4.12 (dd, 1 H, 2-H), 4.39, 4.44 (AB system, 2 H, J_{AB} = 11.7 Hz, OCH_2Ph), 4.47, 4.74 (AB system, 2 H, J_{AB} = 11.2 Hz, OCH_2Ph), 4.75, 4.91 (AB system, 2 H, J_{AB} = 11.0 Hz, OCH_2Ph), 7.17−7.41 (m, 25 H, ArH); $J_{1,2}$ = 3.0, $J_{2,3}$ = 7.5, $J_{3,4}$ = 2.0, $J_{4,OH}$ = 6.5, $J_{4,5a}$ = 4.9, $J_{4,5b}$ = 6.9, $J_{5a,5b}$ = 9.1 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 35.39, 36.16 (S*C*H_2Ph), 51.34 (C-1), 69.52 (C-4), 71.38 (C-5), 73.16, 75.05, 75.39 (O*C*H_2Ph), 79.51 (C-3), 82.09 (C-2), 126.98, 127.08, 127.49, 127.68, 127.72, 127.83, 128.23, 128.27, 128.31, 128.37, 128.45, 128.60, 129.07, 129.18 ($C_{Ar}H$), 138.03, 138.17, 138.37, 138.44 (C_q). − $C_{40}H_{42}O_4S_2$ (650.9): calcd. C 73.81, H 6.50, S 9.85; found C 73.92, H 6.64, S 9.57. − **6**: IR (film): $\tilde{\nu}$ = 3086, 3062, 3030, 2920, 2865, 1496, 1454, 1396, 1363, 1310, 1245, 1207, 1099, 1066, 1028, 913, 737, 698 cm^{-1}. − Major anomer: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.81−3.92 (m, 4 H, 5_a-H, 5_b-H, SCH_2Ph), 3.95−3.97 (m, 1 H, 4-H), 3.99 (dd, 1 H, 2-H), 4.31−4.63 (m, 7 H, 3-H, OCH_2Ph), 4.98 (d, 1 H, 1-H), 7.18−7.37 (m, 20 H, ArH); $J_{1,2}$ = 2.2, $J_{2,3}$ = 4.7 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 35.55 (S*C*H_2Ph), 68.75 (C-5), 71.79, 71.89, 73.46 (O*C*H_2Ph), 81.02 (C-3), 82.01 (C-2), 86.38 (C-1), 87.04 (C-4), for signals of aromatic C atoms see note below. − Minor anomer: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.70 (dd, 1 H, 5_a-H), 3.79 (dd, 1 H, 5_b-H), 3.81−3.92 (m, 2 H, SCH_2Ph), 4.08−4.11 (m, 2 H, 2-H, 4-H), 4.31−4.63 (m, 7 H, 3-H, OCH_2Ph), 5.44 (d, 1 H, 1-H), 7.18−7.37 (m, 20 H, ArH); $J_{1,2}$ = 5.0, $J_{4,5a}$ = 6.2, $J_{4,5b}$ = 5.5, $J_{5a,5b}$ = 10.3 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 34.29 (S*C*H_2Ph), 68.13 (C-5), 72.11, 72.75, 73.38 (O*C*H_2Ph), 77.37 (C-3), 82.37 (C-2), 83.96 (C-4), 85.94 (C-1). − It was not possible to assign the chemical shifts of the signals of aromatic C atoms for both anomers; the observed chemical shifts are: δ = 126.85, 126.98, 127.57, 127.61, 127.27, 127.737, 127.744, 127.78, 127.87, 127.88, 128.34, 128.38, 128.39, 128.42, 128.77, 129.10, 129.12 ($C_{Ar}H$), 137.35, 137.40, 137.67, 137.85, 138.04, 138.27, 138.44 (C_q). − $C_{33}H_{34}O_4S$ (526.7): calcd. C 75.25, H 6.51, S 6.09; found C 74.77, H 6.58, S 6.72.

Benzyl 2,3,5-Tri-*O*-benzyl-1,4-dithio-L-*arabino*-furanoside (8): A solution of mesyl chloride (4.3 mL, 6.3 g, 55 mmol) in dry pyridine (60 mL) was added dropwise to an ice-cold solution of **4** (17.27 g, 26.53 mmol) in dry pyridine (130 mL). The mixture was allowed to warm to room temp. and stirred for 24 h. When the reaction was complete the pyridine was evaporated, the residue dissolved in dichloromethane and extracted with 0.1 N HCl, water and saturated $NaHCO_3$ solution to give the crude mesylate **5** (18.80 g). This was dissolved in dry pyridine (200 mL), tetrabutylammonium iodide (9.60 g, 25.79 mmol) and barium carbonate (5.30 g, 26.86 mmol) were added and the mixture was refluxed for 2.5 h. Solid compounds were filtered off and the pyridine was removed under reduced pressure. The residue was dissolved in dichloromethane and extracted as described above. The crude product was chromatographed [petroleum ether/ethyl acetate, 4:1, R_f(**8α,β**) = 0.43] to give **8** (13.55 g, 94%) as a 6.7:1 anomeric mixture (anomers were not separable); pale yellow syrup. − IR (film): $\tilde{\nu}$ = 3090, 3067, 3032, 2923, 2865, 1498, 1454, 1400, 1365, 1313, 1244, 1210, 1180, 1103, 1076, 1027, 912, 737, 699 cm^{-1}. − Major anomer: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.47 (ddd, 1 H, 4-H), 3.55 (dd, 1 H, 5_a-H), 3.80 (dd, 1 H, 5_b-H), 3.87 (s, 2 H, SCH_2Ph), 4.19−4.21 (m, 2 H, 2-H, 3-H), 4.36 (d, 1 H, 1-H), 4.39, 4.56 (AB system, 2 H, J_{AB} = 11.7 Hz, OCH_2Ph), 4.50, 4.54 (AB system, 2 H, J_{AB} = 11.9 Hz, OCH_2Ph), 4.60, 4.67 (AB system, 2 H, J_{AB} = 11.7 Hz, OCH_2Ph), 7.21−7.36 (m, 20 H, ArH); $J_{1,2}$ = 4.6, $J_{3,4}$ = 5.0, $J_{4,5a}$ = 7.2, $J_{4,5b}$ = 7.3, $J_{5a,5b}$ = 9.3 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 35.68 (S*C*H_2Ph), 47.38 (C-4), 52.01 (C-1), 72.12, 72.66, 73.07 (O*C*H_2Ph), 73.59 (C-5), 84.96 (C-3), 86.62 (C-2), 127.79, 127.83, 127.91, 128.31, 128.35, 128.53, 129.07 ($C_{Ar}H$), 137.50, 137.70, 138.07, 138.15 (C_q). − Minor anomer: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.53−3.59 (m, 1 H, 5_a-H), 3.65−3.71 (m, 2 H, H-4, 5_b-H), 3.85 (s, 2 H, SCH_2Ph), 3.97 (dd, 1 H, 2-H), 4.05 (dd, 1 H, 3-H), 4.19−4.21 (m, 1 H, 1-H), 4.44−4.63 (m, 6 H, OCH_2Ph), 7.21−7.36 (m, 20 H, ArH); $J_{1,2}$ = 6.5, $J_{2,3}$ = 5.5, $J_{3,4}$ = 5.3 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 36.35 (S*C*H_2Ph), 48.64 (C-4), 52.38 (C-1), 71.14 (C-5), 72.71, 72.92, 73.12 (O*C*H_2Ph), 85.81 (C-2), 89.74 (C-3), 127.66, 127.69, 127.74, 127.84, 127.93, 128.38, 128.45, 128.58, 128.98, 129.08, 129.09 ($C_{Ar}H$), 137.47, 137.63,

137.89, 137.92 (C_q). − MS (70 eV); *m/z* (%): 542 (0.05) [M^+], 181 (3), 107 (8), 106 (7), 92 (8), 91 (100) [$C_7H_7^+$], 79 (9), 77 (8), 65 (7). − $C_{33}H_{34}O_3S_2$ (542.8): calcd. C 73.03, H 6.31, S 11.81; found C 72.68, H 6.34, S 11.72.

1-*O*-Acetyl-2,3,5-tri-*O*-benzyl-4-thio-L-*arabino*-furanose (9): 8 (993 mg, 1.83 mmol) and mercuric acetate (1.28 g, 3.71 mmol) were dissolved in glacial acetic acid (25 mL) and stirred at room temperature for 2.5 h. After the reaction was completed (TLC, petroleum ether/ethyl acetate, 4:1), the solvent was removed, the residue diluted with dichloromethane, filtered through a Celite pad and the crude product purified by column chromatography [petroleum ether/ethyl acetate, 4:1, R_f(**9α,β**) = 0.22] to yield the acetate **9** (668 mg, 76%) as an unseparable 4:1 anomeric mixture; colourless oil. − IR (film): ṽ = 3087, 3063, 3030, 2924, 2865, 1745, 1498, 1452, 1396, 1311, 1246, 1228, 1101, 1016, 960, 912, 794, 739, 700, 606 cm^{-1}. − **9α**: ^1H NMR (500 MHz, $CDCl_3$): δ = 2.10 (s, 3 H, CH_3), 3.50 (dd, 1 H, 5_a-H), 3.79 (dd, 1 H, 5_b-H), 3.81 (ddd, 1 H, 4-H), 4.08 (dd, 1 H, 3-H), 4.31 (dd, 1 H, 2-H), 4.52 (s, 2 H, CH_2Ph), 4.60, 4.69 (AB system, 2 H, J_{AB} = 11.7 Hz, CH_2Ph), 4.58−4.72 (m, 2 H, CH_2Ph), 6.03 (d, 1 H, 1-H), 7.28−7.39 (m, 15 H, ArH); $J_{1,2}$ = 3.0, $J_{2,3}$ = 5.3, $J_{3,4}$ = 6.4, $J_{4,5a}$ = 6.8, $J_{4,5b}$ = 6.1, $J_{5a,5b}$ = 9.6 Hz. − ^{13}C NMR (125 MHz, $CDCl_3$): δ = 21.10 (CH_3), 49.35 (C-4), 70.88 (C-5), 72.59, 72.68, 73.13 (*C*H_2Ph), 81.93 (C-1), 84.60 (C-3), 88.83 (C-2), 127.67, 127.79, 127.84, 127.91, 128.35, 128.37, 128.45 (C_{Ar}H), 137.44, 137.85, 137.87 ($C_{q,Ar}$), 170.20 ($C_{q,OAc}$). − **9β**: ^1H NMR (500 MHz, $CDCl_3$): δ = 2.10 (s, 3 H, CH_3), 3.41−3.47 (m, 1 H, 4-H), 3.55 (dd, 1 H, 5_a-H), 3.72 (dd, 1 H, 5_b-H), 4.17 (dd, 1 H, 3-H), 4.22 (dd, 1 H, 2-H), 4.56 (s, 2 H, CH_2Ph), 4.58−4.72 (m, 2 H, CH_2Ph), 4.70, 4.86 (AB system, 2 H, J_{AB} = 11.5 Hz, CH_2Ph), 6.12 (d, 1 H, H-1), 7.28−7.39 (m, 15 H, ArH); $J_{1,2}$ = 4.1, $J_{2,3}$ = 8.5, $J_{3,4}$ = 7.0, $J_{4,5a}$ = 7.0, $J_{4,5b}$ = 5.8, $J_{5a,5b}$ = 9.7 Hz. − ^{13}C NMR (125 MHz, $CDCl_3$): δ = 21.29 (CH_3), 45.27 (C-4), 72.77, 73.12, 73.14 (*C*H_2Ph), 73.39 (C-5), 74.65 (C-1), 83.78 (C-3), 85.99 (C-2), 127.65, 127.66, 127.68, 127.80, 127.90, 127.97, 128.34, 128.37, 128.45 (C_{Ar}H), 137.44, 137.92, 138.26 ($C_{q,Ar}$), 170.15 ($C_{q,OAc}$). − MS (70 eV); *m/z* (%): 122 (5), 108 (8), 107 (7), 105 (12), 92 (7), 91 (100) [$C_7H_7^+$], 79 (8), 77 (14), 66 (7), 60 (6), 52 (7). − $C_{28}H_{30}O_5S$ (478.6): calcd. C 70.27, H 6.32, S 6.70; found C 69.72, H 6.32, S 7.07.

2,3,5-Tri-*O*-benzyl-4-thio-L-*arabino*-furanose (10): A solution of **9** (200 mg, 0.42 mmol) in dry methanol (2 mL) was added dropwise to a sodium methoxide solution from 1 mg (0.04 mmol) of sodium and dry methanol (4 mL) and stirred at room temp. for 2 h. After the reaction was complete, water (10 mL) was added, the solution was neutralized and concentrated. The residue was dissolved in dichloromethane, extracted with water, dried with $MgSO_4$ and concentrated. The crude product was purified by column chromatography [petroleum ether/ethyl acetate, 4:1, R_f(**10α,β**) = 0.14] to yield a 1:1 anomeric mixture of **10** (145 mg, 79%), pale yellow syrup. − IR (film): ṽ = 3406, 3088, 3063, 3030, 2923, 2863, 1498, 1454, 1402, 1362, 1253, 1207, 1106, 1029, 883, 740, 699, 600, 437 cm^{-1}. − Anomer 1: ^1H NMR (500 MHz, $CDCl_3$): δ = 3.29 (br. s, 1 H, OH), 4.22 (ddd, 1 H, 4-H), 3.52 (dd, 1 H, 5_a-H), 3.57 (dd, 1 H, 5_b-H), 4.08 (dd, 1 H, 2-H), 4.20−4.23 (m, 1 H, 3-H), 4.42−4.72 (m, 6 H, CH_2Ph), 5.18 (br. d, 1 H, 1-H), 7.21−7.35 (m, 15 H, ArH); $J_{1,2}$ = 3.8, $J_{2,3}$ = 7.2, $J_{3,4}$ = 4.9, $J_{4,5a}$ = 4.8, $J_{4,5b}$ = 5.1, $J_{5a,5b}$ = 9.5 Hz. − ^{13}C NMR (125 MHz, $CDCl_3$): δ = 47.30 (C-4), 71.86, 71.94 (*C*H_2Ph), 72.14 (C-5), 73.04 (*C*H_2Ph), 76.46 (C-1), 83.87 (C-3), 88.15 (C-2), for signals of aromatic C atoms see note below. − Anomer 2: ^1H NMR (500 MHz, $CDCl_3$): δ = 3.27 (br. s, 1 H, OH), 3.45 (dd, 1 H, 5_a-H), 3.65 (dd, 1 H, 5_b-H), 3.93−3.96 (m, 1 H, 4-H), 4.20−4.23 (m, 1 H, 2-H), 4.28 (dd, 1 H, 3-H), 4.42−4.72 (m, 6 H, CH_2Ph), 5.39 (br. d, 1 H, 1-H), 7.21−7.35 (m, 15 H, ArH); $J_{1,2}$ = 9.6, $J_{2,3}$ = 1.3, $J_{3,4}$ = 2.7, $J_{4,5a}$ = 5.9, $J_{4,5b}$ = 9.6, $J_{5a,5b}$ = 9.6 Hz. − ^{13}C NMR (125 MHz, $CDCl_3$): δ = 51.95 (C-4), 72.26 (*C*H_2Ph), 72.49 (C-5), 72.81, 73.44 (*C*H_2Ph), 84.33 (C-3), 85.77 (C-1), 89.00 (C-2). − It was not possible to assign the chemical shifts of the signals of aromatic C atoms for both anomers; the observed chemical shifts are as follows: δ = 127.61, 127.68, 127.76, 127.88, 127.90, 127.94, 127.96, 127,98, 128.08, 128.38, 128.48, 128.51, 128.56 (C_{Ar}H), 137.01, 137.36, 137.41, 137.53 ($C_{q,Ar}$). − $C_{26}H_{28}O_4S$ (436.6): calcd. C 71.50, H 6.46, S 7.34; found C 70.95, H 6.53, S 7.45.

1-*O*-Acetyl-4-thio-L-*arabino*-furanose (11): Preparation as described for **14**, using **9** (205 mg, 0.43 mmol) in dry dichloromethane (3.0 mL) and boron tribromide (0.19 mL, 500 mg, 2.00 mmol) in dry dichloromethane (1.9 mL). Neutralization was performed with silver carbonate (1.68 g, 6.09 mmol). After chromatography [chloroform/methanol, 9:1, R_f(**11α,β**) = 0.14], **11** (26 mg, 29%) was isolated with an anomeric ratio of 5:4; colourless oil. − Major anomer: ^1H NMR (400 MHz, CD_3OD): δ = 3.13 (ddd, 1 H, 4-H), 3.32 (s, 3 H, CH_3), 3.50 (m, 1 H, 5_a-H), 3.85−3.89 (m, 2 H, 3-H, 5_b-H), 3 97 (dd, 1 H, 2-H), 4.68 (d, 1 H, 1-H); $J_{1,2}$ = 4.3, $J_{2,3}$ = 7.6, $J_{3,4}$ = 4.6, $J_{4,5a}$ = 7.8, $J_{4,5b}$ = 7.7, $J_{5a,5b}$ = 11.0 Hz. − ^{13}C NMR (125 MHz, CD_3OD): δ = 50.67 (C-4), 56.81 (CH_3), 67.24 (C-5), 78.25 (C-3), 81.12 (C-2), 88.06 (C-1), 169.56 ($C_{q,OAc}$). − Minor anomer: ^1H NMR (400 MHz, CD_3OD): δ = 3.35 (s, 3 H, CH_3), 3.40 (ddd, 1 H, 4-H), 3.58 (dd, 1 H, 5_a-H), 3.75 (dd, 1 H, 3-H), 3.90 (dd, 1 H, 5_b-H), 3.99 (dd, 1 H, 2-H), 4.84 (d, 1 H, 1-H); $J_{1,2}$ = 4.5, $J_{2,3}$ = 6.6, $J_{3,4}$ = 5.9, $J_{4,5a}$ = 7.2, $J_{4,5b}$ = 7.7, $J_{5a,5b}$ = 10.6 Hz. − ^{13}C NMR (125 MHz, CD_3OD): δ = 53.17 (C-4), 57.82 (CH_3), 65.01 (C-5), 79.05 (C-3), 84.55 (C-2), 92.77 (C-1), 170.12 ($C_{q,OAc}$). − MS (70 eV); *m/z* (%): 208 (0.1) [M^+], 180 (5), 163 (8), 162 (42), 145 (7), 103 (20), 89 (30), 87 (26), 77 (100), 74 (90), 73 (51), 62 (35), 60 (44), 58 (49), 48 (24), 46 (63).

1-(2,3,5-Tri-*O*-benzyl-4-thio-L-*arabino*-furanosyl)uracil (12): A solution of **9** (488 mg, 1.02 mmol), 2,4-bis-*O*-(trimethylsilyl)uracil (988 mg, 3.85 mmol) and molecular sieves (20 mg) in dry acetonitrile (10 mL) was cooled to −18°C. Under stirring TMSOTf (0.45 mL, 554 mg, 2.49 mmol) was added and stirring was continued for 2 h. Then a saturated aq. $NaHCO_3$ solution (20 mL) was added, followed by filtration and extraction with dichloromethane. The organic phase was dried with $MgSO_4$ and the resulting crude product was purified by column chromatography [petroleum ether/ethyl acetate, 1:1, R_f(**12β**) = 0.37, R_f(**12α**) = 0.30] to yield **12α** + **12β** (2:1) (488 mg, 88%), colourless amorphous solid. − IR (KBr): ṽ = 3191, 3088, 3058, 3032, 2922, 2861, 1689, 1496, 1454, 1380, 1251, 1209, 1178, 1092, 1028, 909, 810, 738, 699, 605, 515 cm^{-1}. − **12α**: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.53 (dd, 1 H, $5'_a$-H), 3.76 (dd, 1 H, $5'_b$-H), 3.91 (ddd, 1 H, 4′-H), 4.11 (dd, 1 H, 2′-H), 4.13−4.22 (m, 1 H, 3′-H), 4.33−4.67 (m, 4 H, CH_2Ph), 4.63, 4.88 (AB system, 2 H, J_{AB} = 12.2 Hz, CH_2Ph), 5.50 (d, 1 H, 5-H), 6.29 (d, 1 H, 1′-H), 7.24−7.39 (m, 15 H, ArH), 7.88 (d, 1 H, 6-H), 9.29 (br. s, 1 H, NH); $J_{1',2'}$ = 2.0, $J_{2',3'}$ = 1.9, $J_{3',4'}$ = 2.0, $J_{4',5'a}$ = 6.7, $J_{4',5'b}$ = 8.6, $J_{5'a,5'b}$ = 9.5, $J_{5,6}$ = 8.3 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 53.45 (C-4′), 66.53 (C-1′), 71.41 (C-5′), 71.72, 71.83, 72.82 (*C*H_2Ph), 84.49 (C-3′), 88.87 (C-2′), 100.78 (C-5), 127.27, 127.31, 127.37, 127.58, 127.62, 128.01, 128.06, 128.08, 128.12 (C_{Ar}H), 136.29, 136.88, 137.40 (C_q), 142.26 (C-6), 150.37 (2-CO), 162.92 (4-CO). − **12β**: ^1H NMR (400 MHz, $CDCl_3$): δ = 3.42 (ddd, 1 H, 4′-H), 3.63 (dd, 1 H, $5'_a$-H), 3.70 (dd, 1 H, $5'_b$-H), 4.13−4.22 (m, 2 H, 2′-H, 3′-H), 4.33−4.74 (m, 6 H, CH_2Ph), 5.22 (d, 1 H, 5-H), 6.35 (d, 1 H, 1′-H), 7.24−7.39 (m, 15 H, ArH), 8.19 (d, 1 H, 6-H), 9.16 (br. s, 1 H, NH); $J_{1',2'}$ = 5.7, $J_{3',4'}$ = 2.0, $J_{4',5'a}$ = 3.8, $J_{4',5'b}$ = 3.8, $J_{5'a,5'b}$ = 10.3, $J_{5,6}$ = 8.2 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 45.96 (C-4′), 57.90 (C-1′), 68.10 (C-5′), 72.64, 73.06, 73.26

(CH_2Ph), 79.69 (C-3′), 84.82 (C-2′), 101.11 (C-5), 127.37, 127.51, 127.61, 127.62, 127.65, 127.74, 127.77, 127.78, 128.15 (C_{Ar}H), 136.51, 136.95, 137.29 (C_q), 142.68 (C-6), 150.79 (2-CO), 162.83 (4-CO). − FAB MS (mNBA); *m/z*: 531 [M + H]. − $C_{30}H_{30}N_2O_5S$ (530.7): calcd. C 67.90, H 5.70, N 5.28, S 6.04; found[25] C 66.80, H 5.73, N 5.08, S 6.39.

1-(2,3,5-Tri-*O*-benzyl-4-thio-L-*arabino*-furanosyl)thymine (13): Preparation was performed following the same procedure as described for **12**, using **9** (602 mg, 1.26 mmol), 2,4-bis-*O*-(trimethylsilyl)thymine (1.10 g, 4.07 mmol), TMSOTf (0.55 mL, 677 mg, 3.05 mmol) and molecular sieves (20 mg) in dry acetonitrile (20 mL). After chromatography [petroleum ether/ethyl acetate, 1:1, R_f(**13α,β**) = 0.39], **13** (537 mg, 78%) was isolated with an anomeric ratio of 2:1 (α/β), white solid. − IR (KBr): $\tilde{\nu}$ = 3185, 3062, 3030, 2924, 2856, 1688, 1497, 1454, 1387, 1364, 1253, 1206, 1095, 1075, 1027, 820, 737, 699, 605, 573, 481 cm^{-1}. − **13α**: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.66 (d, 3 H, CH_3), 3.55 (dd, 1 H, 5′$_a$-H), 3.77 (dd, 1 H, 5′$_b$-H), 3.92 (ddd, 1 H, 4′-H), 4.12 (dd, 1 H, 2′-H), 4.16−4.20 (m, 1 H, 3′-H), 4.44−4.56 (m, 4 H, CH_2Ph), 4.64, 4.79 (AB system, 2 H, J_{AB} = 12.2 Hz, CH_2Ph), 6.24 (d, 1 H, 1′-H), 7.25−7.37 (m, 15 H, ArH), 7.59 (q, 1 H, 6-H), 9.05 (br. s, 1 H, NH); $J_{1',2'}$ = 2.5, $J_{2',3'}$ = 2.5, $J_{3',4'}$ = 2.6, $J_{4',5'a}$ = 7.2, $J_{4',5'b}$ = 7.9, $J_{5'a,5'b}$ = 9.5, $J_{6,Me}$ = 1.2 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 11.89 (CH_3), 52.68 (C-4′), 65.27 (C-1′), 71.41 (C-5′), 71.91, 71.98, 72.85 (CH_2Ph), 84.82 (C-3′), 88.80 (C-2′), 109.56 (C-5), 127.28, 127.42, 127.50, 127.52, 127.66, 128.02, 128.05, 128.12 (C_{Ar}H), 136.44, 136.89, 137.41 (C_q), 137.68 (C-6), 150.39 (2-CO), 163.32 (4-CO). − **13β**: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.65 (d, 3 H, CH_3), 3.42−3.45 (m, 1 H, 4′-H), 3.63 (dd, 1 H, 5′$_a$-H), 3.70 (dd, 1 H, 5′$_b$-H), 4.16−4.20 (m, 2 H, 2′-H, 3′-H), 4.44−4.73 (m, 6 H, CH_2Ph), 6.39 (d, 1 H, 1′-H), 7.25−7.37 (m, 15 H, ArH), 7.99 (q, 1 H, 6-H), 8.97 (br. s, 1 H, NH); $J_{1',2'}$ = 5.2, $J_{4',5'a}$ = 4.4, $J_{4',5'b}$ = 4.0, $J_{5'a,5'b}$ = 10.2, $J_{6,Me}$ = 1.2 Hz. − ^{13}C NMR (101 MHz, $CDCl_3$): δ = 11.78 (CH_3), 46.12 (C-4′), 57.70 (C-1′), 68.11 (C-5′), 72.60, 72.92, 73.22 (CH_2Ph), 79.94 (C-3′), 84.75 (C-2′), 109.68 (C-5), 127.37, 127.50, 127.56, 127.57, 127.67, 127.71, 128.03, 128.06, 128.16 (C_{Ar}H), 136.51, 137.03, 137.26 (C_q), 138.31 (C-6), 150.86 (2-CO), 163.31 (4-CO). − FAB MS (mNBA); *m/z*: 545 [M + H]. − $C_{31}H_{32}N_2O_5S$ (544.68): calcd. C 68.36, H 5.92, N 5.14, S 5.89; found C 68.12, H 6.18, N 4.66, S 5.90.

1-(4-Thio-L-*arabino*-furanosyl)uracil (14): A solution of boron tribromide (0.28 mL, 739 mg, 2.95 mmol) in dry dichloromethane (2.8 mL) was cooled to −90°C. Into this solution was added dropwise a solution of **12** (331 mg, 0.62 mmol) in dichloromethane (4.4 mL) under vigorous stirring. It is necessary that the reaction temp. does not rise above −80°C. Stirring was continued for 2 h at this temp. followed by quenching of the reaction solution with a 1:1 mixture of methanol/dichloromethane (8 mL). After the solution had warmed to room temp., the hydrobromic acid was neutralized with silver carbonate (2.58 g, 9.34 mmol), followed by filtration and concentration. The crude nucleoside was purified by column chromatography [chloroform/methanol, 4:1, R_f(**14α,β**) = 0.11] to yield **14** (50 mg, 31%) as an anomeric mixture with an α/β ratio of 4:1, white solid. − IR (KBr): $\tilde{\nu}$ = 3430, 1687, 1486, 1401, 1304, 1258, 1178, 1103, 1046, 980, 931, 820, 558 cm^{-1}. − **14α**: ^{1}H NMR (400 MHz, CD_3OD): δ = 3.63−3.66 (m, 2 H, 4′-H, 5′$_a$-H), 3.85−3.97 (m, 2 H, 3′-H, 5′$_b$-H), 4.10 (dd, 1 H, 2′-H), 5.79 (d, 1 H, 5-H), 5.96 (d, 1 H, 1′-H), 8.07 (d, 1 H, 6-H); $J_{1',2'}$ = 6.8, $J_{2',3'}$ = 7.2, $J_{5,6}$ = 8.1 Hz. − ^{13}C NMR (101 MHz, CD_3OD): δ = 53.61 (C-4′), 64.00 (C-1′), 64.64 (C-5′), 77.62 (C-3′), 82.58 (C-2′), 103.29 (C-5), 143.71 (C-6), 153.41 (2-CO), 166.69 (4-CO). − **14β**: ^{1}H NMR (400 MHz, CD_3OD): δ = 3.30−3.32 (m, 1 H, 4′-H), 3.85−3.97 (m, 2 H, 5′$_a$-H, 5′$_b$-H), 4.07−4.09 (m, 1 H, 3′-H), 4.19 (dd, 2 H, 2′-H), 5.69 (d, 1 H, 5-H), 6.28 (d, 1 H, 1′-H), 8.31 (d, 1 H,6-H); $J_{1',2'}$ = 5.8, $J_{3',4'}$ = 6.4, $J_{5,6}$ = 8.1 Hz. − ^{13}C NMR (101 MHz, CD_3OD): δ = 54.18 (C-4′), 62.20 (C-1′), 63.11 (C-5′), 77.56 (C-3′), 79.21 (C-2′), 101.48 (C-5), 145.51 (C-6), 154.23 (2-CO), 169.67 (4-CO). − MS (70 eV); *m/z* (%): 260 (0.35) [M^+], 131 (29), 113 (45), 112 (100), 101 (20), 85 (18), 70 (32), 69 (82), 58 (42), 45 (50). − HR MS [M^+]: calcd. 260.0467; found 260.0464.

1-(4-Thio-L-*arabino*-furanosyl)thymine (15): Preparation analogous to the procedure described for **14** from **13** (238 mg, 0.44 mmol) in dry dichloromethane (3.1 mL) and boron tribromide (0.20 mL, 528 mg, 2.11 mmol) in dry dichloromethane (2 mL). Neutralization was performed with silver carbonate (2.06 g, 7.47 mmol). After chromatography [chloroform/methanol, 4:1, R_f(**15α,β**) = 0.10], the unprotected nucleoside (56 mg, 47%) was isolated with an anomeric ratio of 5:1 (α/β), white solid. − IR (KBr): $\tilde{\nu}$ = 3389, 2925, 2854, 1687, 1469, 1387, 1257, 1227, 1096, 1045, 900, 826, 780, 723, 659, 567, 478 cm^{-1}. − **15α**: ^{1}H NMR (400 MHz, CD_3OD): δ = 1.92 (d, 3 H, CH_3), 3.60−3.67 (m, 2 H, 4′-H, 5′$_a$-H), 3.84−3.97 (m, 2 H, 3′-H, 5′$_b$-H), 4.11 (dd, 1 H, 2′-H), 5.98 (d, 1 H, 1′-H), 7.82 (q, 1 H, 6-H); $J_{1',2'}$ = 7.5, $J_{2',3'}$ = 7.6, $J_{6,Me}$ = 1.1 Hz (in agreement with ref.[11]). − ^{13}C NMR (101 MHz, CD_3OD): δ = 11.70 (CH_3), 51.77 (C-4′), 61.94 (C-1′), 63.69 (C-5′), 76.28 (C-3′), 81.13 (C-2′), 111.31 (C-5), 137.89 (C-6), 153.19 (2-CO), 166.62 (4-CO). − **15β**: ^{1}H NMR (400 MHz, CD_3OD): δ = 1.89 (d, 1 H, CH_3), 3.27−3.31 (m, 1 H, 4′-H), 3.84−3.97 (m, 2 H, 5′$_a$-H, 5′$_b$-H), 4.09−4.13 (m, 1 H, 3′-H), 4.18 (dd, 1 H, 2′-H), 6.24 (d, 1 H, 1′-H), 8.21 (d, 1 H, 6-H); $J_{1',2'}$ = 5.9, $J_{2',3'}$ = 7.0, $J_{6,Me}$ = 1.1 Hz (in agreement with ref.[11]). − ^{13}C NMR (101 MHz, CD_3OD): δ = 11.68 (CH_3), 52.46 (C-4′), 60.69 (C-1′), 61.52 (C-5′), 76.01 (C-3′), 78.36 (C-2′), 109.74 (C-5), 140.13 (C-6), 153.06 (2-CO), 166.41 (4-CO). − MS (70 eV); *m/z* (%): 274 (0.16) [M^+], 256 (37) [$M^+ - H_2O$], 238 (5), 209 (10), 149 (18), 132 (5), 131 (78), 126 (82), 113 (16), 101 (34), 96 (18), 91 (40), 85 (24), 74 (17), 73 (24), 59 (21), 57 (67), 56 (100), 54 (32), 47 (20), 45 (59). − HR MS [M^+]: calcd. 274.0623; found 274.0669.

1-(2-*O*-Benzyl-4-thio-L-*arabino*-furanosyl)uracil (16): Preparation as described for **14**, using **12** (458 mg, 0.86 mmol) in dry dichloromethane (6.1 mL) and boron tribromide (0.38 mL, 1.00 g, 3.99 mmol) in dry dichloromethane (3.8 mL). Neutralization was performed with ion exchanger Amberlite® IRA-420. After chromatography [chloroform/methanol, 4:1, R_f(**16α,β**) = 0.53], nucleoside **16** (48 mg, 47%) was isolated with an anomeric ratio of 5:2 (α/β), white solid. − IR (KBr): $\tilde{\nu}$ = 3430, 3088, 3030, 2925, 2853, 1702, 1656, 1458, 1391, 1254, 1197, 1089, 1055, 813, 757, 728, 699, 601, 562 cm^{-1}. − **16α**: ^{1}H NMR (500 MHz, [D$_6$]DMSO): δ = 3.37−3.43 (m, 1 H, 5′$_a$-H), 3.55 (ddd, 1 H, 4′-H), 4.13−4.22 (m, 1 H, 3′-H), 3.77−3.86 (m, 1 H, 5′$_b$-H), 4.00−4.05 (m, 1 H, 2′-H), 4.95 (br. s, 1 H, OH-5′), 4.98 (s, 2 H, CH_2Ph), 5.56 (br. s, 1 H, OH-3′), 5.78 (br. s, 1 H, NH), 5.81 (d, 1 H, 1′-H), 5.88 (d, 1 H, 5′-H), 7.23−7.32 (m, 5 H, ArH), 8.11 (d, 1 H, 6-H); $J_{1',2'}$ = 6.7, $J_{3',4'}$ = 4.1, $J_{4',5'a}$ = 7.8, $J_{4',5'b}$ = 7.8, $J_{5,6}$ = 8.2 Hz. − ^{13}C NMR (125 MHz, [D$_6$]DMSO): δ = 44.07 (CH_2Ph), 53.07 (C-4′), 63.69 (C-5′), 63.75 (C-1′), 76.07 (C-3′), 80.76 (C-2′), 101.62 (C-5), 127.54, 128.04, 128.67 (C_{Ar}H), 137.38 (C_q), 141.55 (C-6), 151.66 (2-CO), 162.13 (4-CO). − **16β**: ^{1}H NMR (500 MHz, [D$_6$]DMSO): δ = 3.18 (ddd, 1 H, 4′-H), 3.63−3.72 (m, 1 H, 5′$_a$-H), 3.77−3.86 (m, 1 H, 5′$_b$-H), 3.92−3.96 (m, 1 H, 3′-H), 4.00−4.05 (m, 1 H, 2′-H), 4.97−5.00 (m, 2 H, CH_2Ph), 5.17 (br. s, 1 H, OH-5′), 5.46 (br. s, 1 H, OH-3′), 5.78 (br. s, 1 H, NH), 5.80 (d, 1 H, 5-H), 6.20 (d, 1 H, 1′-H), 7.23−7.32 (m, 5 H, ArH), 8.14 (d, 1 H, 6-H); $J_{1',2'}$ = 5.8, $J_{3',4'}$ = 5.4, $J_{4',5'a}$ = 5.8, $J_{4',5'b}$ = 5.8, $J_{5,6}$ = 8.2 Hz. − ^{13}C NMR (125 MHz, [D$_6$]DMSO): δ = 44.00 (CH_2Ph), 53.86 (C-4′), 61.74 (C-1′), 62.31 (C-5′), 76.15 (C-3′), 77.73 (C-2′), 99.97 (C-5), 127.45, 127.92, 128.64 (C_{Ar}H), 137.43 (C_q), 142.60 (C-6), 151.89 (2-CO), 162.23 (4-

CO). − FAB MS (mNBA); *m/z*: 351 [M + H]. − $C_{16}H_{18}N_2O_5S$ (350.4): calcd. C 54.85, H 5.18, N 7.99, S 9.15; found[25] C 54.27, H 5.51, N 7.30, S 8.42.

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