SUGAR-MODIFIED DERIVATIVES OF CYTOSTATIC 6-(HET)ARYL-7-DEAZAPURINE NUCLEOSIDES: 2′-*C*-METHYLRIBONUCLEOSIDES, ARABINONUCLEOSIDES AND 2′-DEOXY-2′-FLUOROARABINONUCLEOSIDES

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Dedicated to Professor Antonín Holý on the occasion of his 75th birthday.

A series of novel sugar-modified derivatives of cytostatic 6-hetaryl-7-deazapurine ribonucleosides: 2′-*C*-methylribonucleosides, arabinonucleosides and 2′-deoxy-2′-fluoroarabinonucleosides bearing an alkyl, aryl and hetaryl group in position 6 were prepared by palladium catalyzed cross-coupling reactions of corresponding (protected) 6-chloro-(7-fluoro)-7-deazapurine nucleosides with (het)arylboronic, hetarylstannanes and trimethylaluminium eventually followed by deprotection. Key intermediate 6-chloro-7-deazapurine 2′-*C*-methyl-β-D-ribofuranoside was prepared via a stereoselective nucleobase anion glycosylation with toluoyl-protected 1,2-anhydro-2-*C*-methylribofuranose. The 1,2-anhydro sugar was synthesized in 3 steps starting from readily available 2-*C*-methylribonolactone. The 6-chloro-7-deazapurine arabinofuranoside intermediate was obtained by epimerization from 3′,5′-protected 6-chloro-7-deazapurine ribofuranoside via 2′-hydroxyl oxidation followed by reduction. None of the prepared compounds showed any considerable cytostatic or antiviral activity.

Keywords: Nucleosides; Cross-coupling; Antitumor agents; Purines; 7-Deazapurines; 7*H*-Pyrrolo[2,3-*d*]pyrimidine; Cytostatic agents.

Biological activity of purine ribonucleosides bearing aryl or hetaryl groups at position 6 have been a long term topic of our laboratory (Chart 1). The parent 6-(het)arylpurine ribonucleosides **1** possess[1] significant cytostatic and anti-HCV activities. However, any of the prepared 2- and 8-substituted derivatives[2] or 2′-, 3′- and 5′-deoxyribonucleosides[3] were inactive, whereas the corresponding L-ribonucleosides[4] showed only moderate anti-HCV effect. Recently, we found[5] that 6-hetaryl-7-deazapurine **2** and 6-hetaryl-

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7-fluoro-7-deazapurine ribonucleosides **3** exert even pronounced cytostatic effect in nanomolar concentrations. However, their cycloSal-phosphate and ProTide prodrugs[6] were less active due to efflux from the cells. Since some sugar-modified purine nucleosides (i.e. Fludarabine[7] or Clofarabine[8]) are clinically used cytostatics and 7-deazaadenine 2′-*C*-methylribonucleoside[9] is in clinical trials for treatment of HCV, we decided to prepare and study the biological activity of three types of sugar-modified derivatives of 6-(hetaryl)-7-deazapurine nucleosides: 2′-*C*-methylribonucleosides (analogues of the anti-HCV drug candidate), arabinosides (analogues

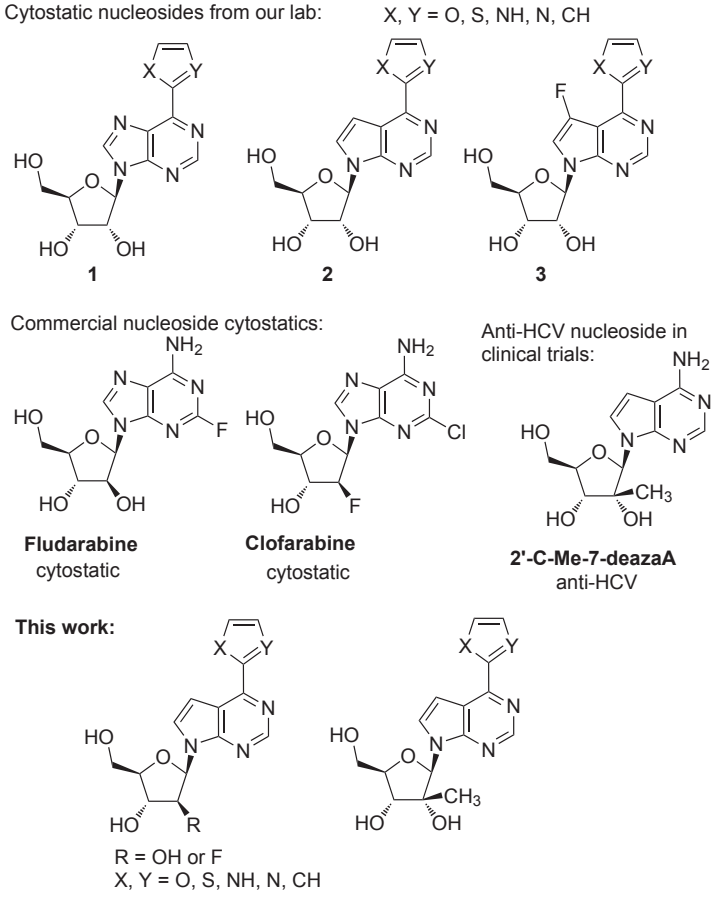


CHART 1
Structures of modified purine and deazapurine cytostatics and antivirals

of Fludarabine) and 2′-deoxy-2′-fluoroarabinonucleosides (analogue of Clofarabine).

The synthesis of 2′-*C*-methylribonucleosides required the preparation of 6-chloro-7-deazapurine 2′-*C*-methylriboside key intermediate. The corresponding free nucleoside was synthesized by Merck researchers[10] by nucleobase anion glycosylation of 6-chloro-7-deazapurine with 3,5-bis-*O*-(2,4-dichlorobenzyl)-2-*C*-methylribofuranosylbromide followed by benzyl deprotection. The authors later found that actual glycosylating agent is anomeric α-epoxide[11] formed from halogenose by internal S_N2 reaction of bromohydrin unit under basic reaction conditions. The observed clean stereoselective outcome of nucleosidation (only β anomer formation) was then explained by S_N2 ring opening of α-epoxide. The starting 2-*C*-methylribofuranosylbromide was prepared by lengthy multi-step sequence from D-ribose. For larger scale preparation of 7-deaza-2′-*C*-methyladenosine (Chart 2), potent inhibitor of HCV RNA replication, the authors later developed a more suitable toluoyl-protected epoxide **4** [11] and successfully utilized it in multi-kilogram glycosylation of *N*-phtalimido-7-deazaadenine. The epoxide **4** is generated from key diol **5** by mesylation rather than via halogenose. Although practical and efficient, Merck synthesis of key diol **5** comprises nine steps starting from diacetone glucose and thus is not just convenient for rapid access to epoxide **4** in laboratory small scale.

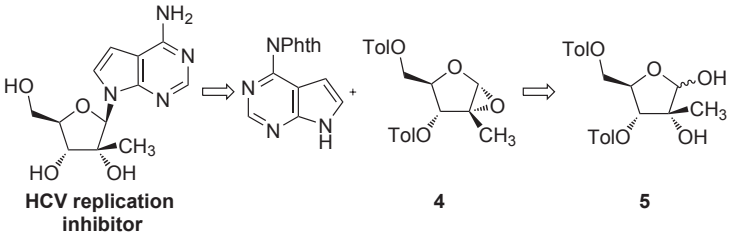
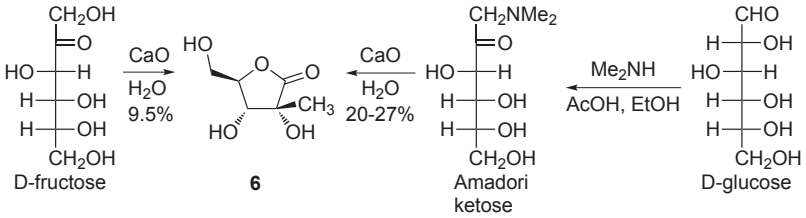


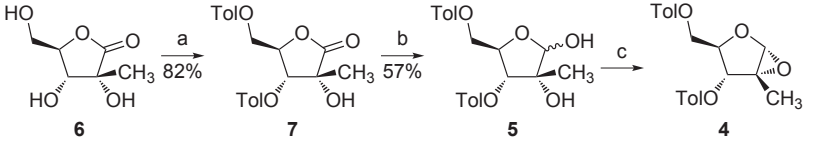
CHART 2
Retrosynthetic analysis of 7-deazapurine 2′-*C*-methylribonucleoside

We envisaged 2-*C*-methyl-D-ribonolactone **6** (Scheme 1) as attractive starting material for epoxide **4**, because it is a product of calcium hydroxide promoted isomerization of cheap D-fructose[12]. Although not high yielding (ca. 10% after crystallization) this one step process enables access to crystalline branched sugar **6** without chromatographic separation. Fleet group has more recently disclosed a new one-pot procedure[13] to lactone **6** from D-glucose by similar isomerization of in situ formed Amadori ketose in yields up to 27%.



Scheme 1

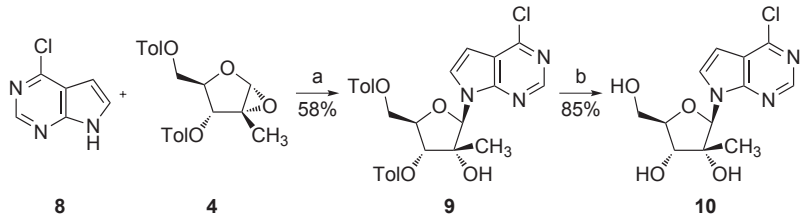
The lactone **6** was prepared by the published procedure[12,13] and then it was selectively 3,5-diacylated[14] (Scheme 2) by the action of 2 equivalents of *p*-toluoyl chloride in the mixture of dichloromethane-pyridine (4:1) at –20 °C affording 3,5-di-*O*-toluoyl lactone **7** [15] in 82% yield after crystallization. Under these conditions the formation of 2,3,5-tri-*O*-toluoyl derivative is minimized compared to older procedure[15] and this contaminant is easily discarded from crude product by crystallization. The next step, partial reduction of lactone **7** to the desired lactol **5** was complicated by the presence of free 2-hydroxy group, which precludes reducing reagents susceptible to alcoholysis (like DIBAH). As the reduction of free lactone **6** to 2-*C*-methyl-D-ribose by sodium borohydride in water was reported[16], we attempted the reduction of more hydrophobic lactone **7** by the treatment with sodium borohydride in THF/MeOH mixture, but desired diol **5** was isolated in less then 35% yields whereas overreduction of hemiacetal **5** was prevalent. As sodium bis(2-methoxyethoxy)aluminumhydride (SMEAH, Red-Al) modified by the introduction of ethoxy group simply by the addition of one equivalent of absolute ethanol to the Red-Al solution is well established reagent for partial reduction of lactones to lactols[17], we presumed that free 2-hydroxy group could at least partly play the role of Red-Al modifier instead of ethanol. Thus the lactone **7** was treated with equimolar amount of Red-Al in toluene at –15 °C and desired diol **5** was isolated in satisfactory 57% yield. Unreacted lactone **7** was recovered in 8% yield and non-isolated remaining material was the product of overreduction. Crystalline diol **5** was



Scheme 2
(a) TolCl, CH_2Cl_2/Pyridine (4:1), –20 °C; (b) Red-Al, toluene, –15 °C; (c) MsCl, NEt_3, CH_2Cl_2, r.t.

then mesylated with methanesulfonyl chloride in the presence of triethylamine in dichloromethane to almost quantitatively afford epoxide **4**. In accord with observations of its inventors[11], 1,2-anhydro sugar **4** displayed enhanced stability towards hydrolysis, uncommon amongst other known glycal epoxides[18] (mainly benzyl or TBS protected).

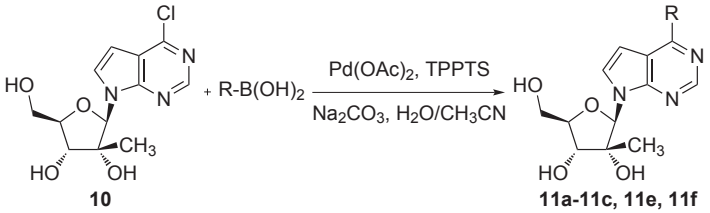
The glycosylation of 6-chloro-7-deazapurine **8** with epoxide **4** in the presence of NaH as base in DMF/toluene afforded the desired protected 2′-*C*-methyl ribonucleoside intermediate **9** in 58% yield (Scheme 3). Compound **9** was deprotected by the treatment with methanolic ammonia at room temperature affording free 2′-*C*-methylriboside **10** in 85% yield.



SCHEME 3
(a) NaH, DMF-toluene, r.t.; (b) 27 wt.% ammonia in MeOH, r.t.

With the key chlorodeazapurine nucleoside intermediate **10** in hand, the aqueous Suzuki cross-coupling reactions[19] were conducted with a set of boronic acids affording 6-(het)aryl-7-deazapurine 2′-*C*-methyl ribosides **11a–11c**, **11e** and **11f** in a single step in good to excellent yields (Scheme 4, Table I).

An alternative nucleosidation route was used for the synthesis of 7-fluorinated 6-hetaryl-7-deazapurine 2′-*C*-methylribonucleosides. We anticipated that the corresponding protected 7-fluorinated 6-chloro-7-deazapurine 2′-*C*-methylribonucleoside might be accessible by Silyl–Hilbert–Johnson reaction, similarly to the synthesis of per-*O*-benzoyl 7-halogenated 6-chloro-7-deazapurine ribonucleosides by TMSOTf-catalyzed glycosylation[20] of 5-halogenated 4-chloro-7*H*-pyrrolo[2,3-*d*]pyrimidines with 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranose. Thus the reaction of 1,2,3,5-tetra-*O*-benzoyl-2-*C*-methyl-β-D-ribofuranose **12** (Scheme 5) with 4-chloro-5-fluoropyrrolo[2,3-*d*]pyrimidine **13** [20a] was performed in the presence of DBU and TMSOTf in acetonitrile at 70 °C to give the desired 2′-*C*-methylribonucleoside **14** in 21% unoptimized yield. This hydrophobic benzoyl-protected 2′-*C*-methylribofuranoside **14** was directly reacted with 2-thiophene and 2-furane boronic acids under the conditions of aqueous Suzuki–

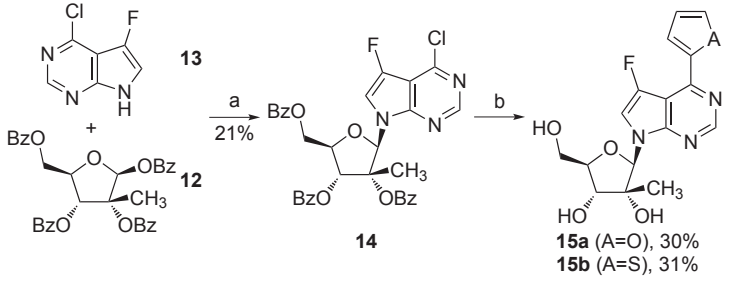


SCHEME 4

TABLE I
Suzuki–Myiaura reaction of chlorodeazapurine nucleoside **10** with boronic acids

11	R	Cross-coupling product (yield)	**11**	R	Cross-coupling product (yield)
a		**11a** (73%)	**e**		**11e** (99%)
b		**11b** (81%)	**f**		**11f** (75%)
c		**11c** (84%)			

Myiaura reaction[19]. Although the reaction mixtures were unhomogeneous, full conversions of starting chloride **14** were reached and only small degree of acyl deprotection was observed under quite harsh and basic reaction

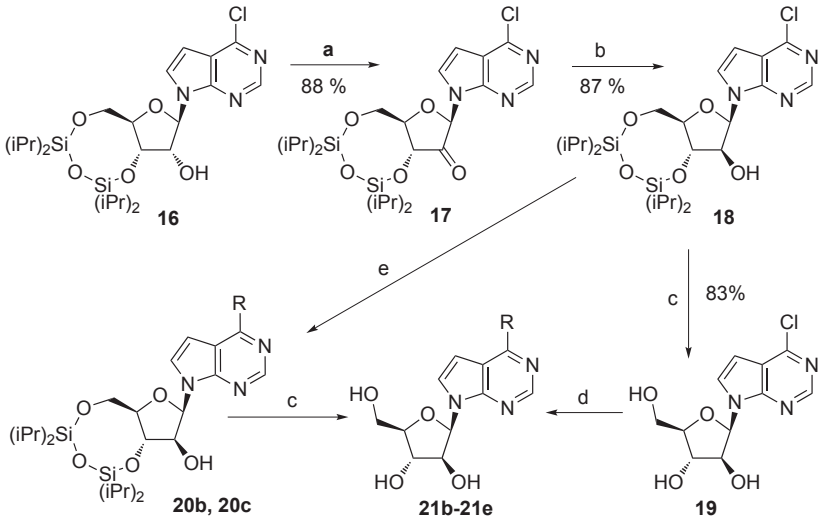


SCHEME 5
(a) DBU, TMSOTf, MeCN, 70 °C; (b) 1. $RB(OH)_2$, $Pd(OAc)_2$, TPPTS, Na_2CO_3, H_2O/CH_3CN (2:1), 100 °C; 2. CH_3ONa/CH_3OH, pyridine

conditions. Crude reaction mixtures were directly deprotected using methanolic sodium methoxide in pyridine and, after purification by reverse phase chromatography, the desired 6-hetaryl-7-fluoro-7-deazapurine 2-*C*-methylribonucleosides **15a** and **15b** were obtained in moderate 30 and 31% overall yields from **14**.

A synthetic path to 6-hetaryl-7-deazapurine arabinonucleosides was developed starting from 3′,5′-*O*-disiloxane ribonucleoside **16** [21] (Scheme 6, Table II). First, the 2′-hydroxyl group of riboside **16** was oxidized using Dess–Martin periodinane to ketone **17** in 88% yield. The application of Dess–Martin oxidation led to higher yield compared to CrO_3 oxidation described in literature[21]. The follow up reduction of the 2′-oxo group by sodium borohydride in ethanol provided arabino-derivative **18** stereoselectively in high 87% yield. Silyl protecting group was cleaved by TBAF affording the unprotected 6-chloro-7-deazapurine arabinoside **19** in 83% yield. 6-Hetaryl-7-deazapurine arabinonucleosides were prepared by two different strategies. The first one was the Suzuki cross-coupling reaction of unprotected 6-chloro-7-deazapurine arabinofuranoside **19** with hetarylboronic acids using aqueous-phase conditions[19] that led to 6-hetaryl-7-deazapurine arabinosides **21d** and **21e** in good yields after crystallization. Alternatively, 6-hetaryl-7-deazapurine arabinosides were synthesized starting from silyl-protected arabino-derivative **18** using Stille cross-coupling reaction with hetaryltributylstannanes. By this reaction, derivatives **20b** and **20c** were prepared in high yields. In the case of reaction of compound **18** and 2-thienyltributylstannane, concomitant isomeration of 3′,5′-disiloxane-protected group to 2′,3′ position was observed. This rearrangement is known to be acid-catalyzed[22]. In this particular case the rearrangement was catalyzed by $PdCl_2(PPh_3)_4$ as a Lewis acid. Final desilylations of **20b** and **20c** using TBAF led to target 6-hetaryl-7-deazapurine arabinonucleosides **21b** and **21c** in 72 and 77% yields, respectively.

To get access to the 2′-deoxy-2′-fluoroarabino series, key starting materials: benzoyl-protected 6-chloro-7-deazapurine 2′-deoxy-2′-fluoroarabinonucleoside **23** [23] and its 7-fluoro derivative **24** [24] were prepared by stereoselective S_N2 nucleobase-anion glycosylation with α-bromo sugar **25** (Scheme 7). Compound **23** was obtained in 72% yield by the glycosylation of 6-chloro-7-deazapurine **8** using Seela's protocol[24] (KOH, TDA-1 {TDA-1 = tris[2-(2-methoxyethoxy)ethyl]amine)}, MeCN) instead of original one[23] (NaH, MeCN). The reaction should be monitored and quenched as soon as the conversion is completed to avoid concomitant saponification of benzoyl groups under strongly basic reaction conditions. This observation was also noted in a recent related communication[25]. The bromide **25** [26] was



SCHEME 6

(a) Dess–Martin periodinane, CH_2Cl_2, 0 °C; (b) $NaBH_4$/EtOH; (c) TBAF, THF; (d) $RB(OH)_2$, $Pd(OAc)_2$, TPPTS, Na_2CO_3, H_2O/CH_3CN (2:1), 100 °C; (e) $RSnBu_3$, $PdCl_2(PPh_3)_2$, DMF, 105 °C

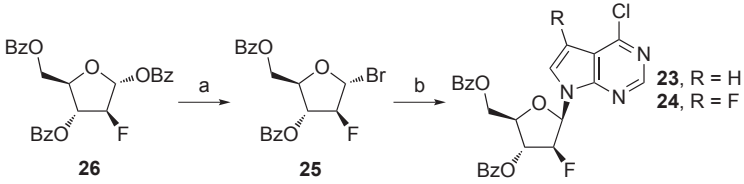
TABLE II

Cross-coupling reactions of chlorodeazapurine nucleosides **18** and **19** with boronic acids or stannanes

20, **21**	Starting compound	R	Cross-coupling product (yield)	Deprotection product (yield)
b	**18**		**20b** (99%)	**21b** (72%)
c	**18**		**20c**[a] (88%)	**21c** (77%)
d	**19**		**21d** (78%)	–
e	**19**		**21e** (68%)	–

[a] Mixture of 3′,5′-*O*-protected **20c** and 2′,3′-*O*-protected derivative **22c** was obtained.

obtained by treatment of 2-deoxy-2-fluoro-1,3,5-tri-*O*-benzoyl-α-D-arabinofuranose **26** with 30% HBr in acetic acid.

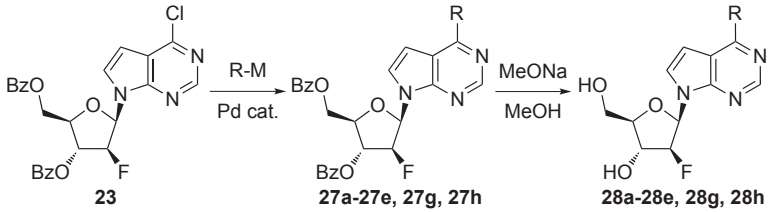


SCHEME 7
(a) HBr, AcOH; (b) **8** or **13**, KOH, TDA-1, MeCN

Palladium catalyzed cross-coupling reactions of chloride **23** (Scheme 8, Table III) with the corresponding (het)arylboronic acids, stannanes and trimethylaluminium provided the desired 6-substituted benzoyl-protected 2-deoxy-2-fluoroarabinonucleosides **27a–27e**, **27g**, **27h**, which after deprotection by NaOMe in MeOH afforded final free 6-substituted 7-deazapurine 2′-deoxy-2′-fluoroarabinonucleosides **28a–28e**, **28g**, **28h**.

Similarly, analogous 7-fluoro-6-hetaryl-7-deazapurine 2′-deoxy-2′-fluoroarabinonucleosides **30b–30e** (Scheme 9, Table IV) were prepared by cross-couplings of protected 6-chloro nucleoside **24** followed by deprotection of benzoylated intermediates **29b–29e**.

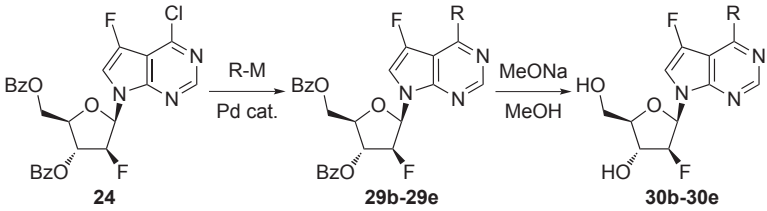
In summary, five types of sugar-modified 6-(het)aryl-7-deazapurine nucleosides were prepared: five examples of 6-(het)aryl-7-deazapurine 2′-*C*-methyl ribosides **11a–11c**, **11e**, **11f**, two examples of 6-hetaryl-7-fluoro-7-deazapurine 2′-*C*-methylribonucleosides **15a**, **15b**, four examples of 6-hetaryl-7-deazapurine arabinonucleosides **21b–21e**, seven examples of 6-substituted 7-deazapurine 2′-deoxy-2′-fluoroarabinonucleosides **28a–28e**, **28g**, **28h** and four examples of 7-fluoro-6-hetaryl-7-deazapurine 2′-deoxy-2′-fluoroarabinonucleosides **30b–30e**. All of them were tested for in vitro cytostatic (HL60, HeLa S3, CCRF-CEM, A549, NCI-H23, Du145, PC3, HCT-116, HCT-15, Hs-578 and BT-549 cell-lines)[5] and for anti-HCV [4] activity. None of them showed any considerable activity in any of these assays indicating that the cytostatic activity of 6-hetaryl-7-deazapurine nucleosides is only limited to ribonucleosides. Also the introduction of the 2′-*C*-methyl did not lead to selectivity toward inhibition of RNA-depending RNA polymerase of HCV.



SCHEME 8

TABLE III
Cross-couplings of **23** and deprotections

27, **28**	R	M	Cross-coupling product (yield)	Deprotection product (yield)
a		$B(OH)_2$	**27a** (95%)	**28a** (92%)
b		$SnBu_3$	**27b** (97%)	**28b** (90%)
c		$SnBu_3$	**27c** (91%)	**28c** (85%)
d		$B(OH)_2$	**27d** (97%)	**28d** (86%)
e		$B(OH)_2$	**27e** (95%)	**28e** (89%)
g		$SnBu_3$	**27g** (81%)	**28g** (69%)
h	Me	$AlMe_2$	**27h** (99%)	**28h** (85%)



SCHEME 9

TABLE IV
Cross-coupling of **24** and deprotections

27, **28**	R	M	Cross-coupling product (yield)	Deprotection product (yield)
b		$SnBu_3$	**29b** (88%)	**30b** (94%)
c		$SnBu_3$	**29c** (89%)	**30c** (91%)
d		$B(OH)_2$	**29d** (91%)	**30d** (93%)
e		$B(OH)_2$	**29e** (88%)	**30e** (90%)

EXPERIMENTAL

Melting points were determined on a Kofler block and are uncorrected. Optical rotations were measured at 25 °C, $[\alpha]_D^{20}$ values are given in 10^{-1} deg cm^2 g^{-1}. NMR spectra were measured at 400.1 MHz for ^{1}H and 100.6 MHz for ^{13}C nuclei, or at 499.8 MHz for ^{1}H and 125.7 MHz for ^{13}C, or at 600.1 MHz for ^{1}H and 150.9 MHz for ^{13}C in $CDCl_3$ (TMS was used as internal standard), MeOH-d_4 (referenced to the residual solvent signal), DMSO-d_6 (referenced to the residual solvent signal), D_2O (methanol as internal standard, referenced to C**H**$_3$OH singlet 3.34 ppm and to **C**H$_3$OH signal 49.5 ppm). ^{19}F NMR spectra were recorded at 470.3 MHz. Chemical shifts are given in ppm (δ-scale), coupling constants (*J*) in Hz. Complete assignment of all NMR signals was performed using a combination of H,H-COSY,

H,H-ROESY, H,C-HSQC and H,C-HMBC experiments. High resolution mass spectra were measured using electrospray ionization. Reverse phase high performance flash chromatography (HPFC) purifications were performed with Biotage SP1 apparatus on KP-C18-HS columns. 6-Chloro-7-deazapurine (4-chloro-7*H*-pyrrolo[2,3-*d*]pyrimidine) **8** and 2-deoxy-2-fluoro-1,3,5-tri-*O*-benzoyl-α-D-arabinofuranose **26** and 1,2,3,5-tetra-*O*-benzoyl-2-*C*-methyl-β-D-ribofuranose **12** were purchased from Nucleo Chemisty Co. (Shenzhen, China).

2-*C*-Methyl-3,5-di-*O*-(4-methylbenzoyl)-D-ribono-1,4-lactone (**7**)

Finely powdered 2-*C*-methylribonolactone **6** [12,13] (20 g, 0.123 mol) was nearly fully dissolved in dichloromethane (400 ml)/pyridine (100 ml) by vigorous stirring at r.t., the mixture was cooled to –20 °C (bath temperature) and *p*-toluoyl chloride (34 ml, 0.257 mol) was dropwise added. The mixture was stirred at –20 °C for 2 h and then was left stand overnight at 5 °C (refrigerator). The volatiles were evaporated in vacuo and the residue was partitioned between AcOEt (500 ml) and aq. hydrochloric acid (3 M, 200 ml). Aqueous phase was re-extracted with AcOEt (2 × 100 ml) and combined organic phases were washed with water (200 ml) and aq. $NaHCO_3$ (sat., 100 ml), dried over $MgSO_4$ and evaporated. The crude product was recrystallized from heptane–AcOEt (ca. 400 ml/80 ml) affording **7** (40.4 g, 82%) as white fine needles. M.p. 123–125 °C (heptane–AcOEt), lit.[15] 123 °C (diisopropylether); $[\alpha]_D$ –81.5 (*c* 0.254, DMSO). ^{1}H NMR (400.1 MHz, $CDCl_3$): 1.65 (s, 3 H, CH_3-2); 2.39, 2.41 (2 × s, 2 × 3 H, CH_3-Tol); 2.95 (s, 1 H, OH); 4.56 (dd, 1 H, J_{gem} = 12.5, $J_{5b,4}$ = 5.7, H-5b); 4.68 (dd, 1 H, J_{gem} = 12.5, $J_{5a,4}$ = 3.8, H-5a); 4.93 (ddd, 1 H, $J_{4,3}$ = 5.7, $J_{4,5}$ = 5.7, 3.8, H-4); 5.38 (d, 1 H, $J_{3,4}$ = 5.7, H-3); 7.20, 7.24 (2 × m, 2 × 2 H, H-*m*-Tol); 7.88, 7.94 (2 × m, 2 × 2 H, H-*o*-Tol). ^{13}C NMR (100.6 MHz, $CDCl_3$): 21.66, 21.72 (CH_3-Tol); 23.17 (CH_3-2); 62.74 (CH_2-5); 72.69 (C-2); 74.07 (CH-3); 78.24 (CH-4); 125.56, 126.295 (C-*i*-Tol); 129.17, 129.32 (CH-*m*-Tol); 129.75, 130.00 (CH-*o*-Tol); 144.24, 144.90 (C-*p*-Tol); 165.49, 165.97 (CO); 174.63 (CO-1). MS (ESI) *m/z*: 421 (M + Na). HRMS (ESI) for $C_{22}H_{22}O_7Na$ [M + Na] calculated: 421.1258; found: 421.1255.

2-*C*-Methyl-3,5-di-*O*-(4-methylbenzoyl)-α,β-D-ribofuranose (**5**)

To a stirred solution of lactone **7** (8.81 g, 22.1 mmol) in toluene (150 ml) was dropwise added sodium bis(2-methoxyethoxy)aluminum hydride (Red-Al®) (65 wt.% in toluene, 7 ml, 22.9 mmol) at –15 °C during 10 min. The mixture was stirred while the temperature (bath) was gradually increased to 0 °C within 3 h. The reaction was quenched by the addition of aq. hydrochloric acid (3 M, 100 ml) at 0 °C [*Caution! Exothermic*]. The mixture was filtered through celite, phases separated and aqueous phase was re-extracted with toluene (2 × 50 ml). Combined organics were washed with brine (100 ml), dried over $MgSO_4$ and evaporated. Column chromatography of the residue on silica (hexanes–AcOEt, 6:1→2:1) afforded unreacted starting material **7** (714 mg, 8%) and diol **5** (5.09 g, 57%) as a colorless oil which solidified on standing. The α/β ratio according to ^{1}H NMR in $CDCl_3$ solution is ca. 4.5:1. Compound can be crystallized from heptane–AcOEt. M.p. 116–118 °C. α anomer: ^{1}H NMR (499.8 MHz, $CDCl_3$): 1.47 (s, 3 H, CH_3-2); 2.38 and 2.40 (2 × s, 2 × 3 H, CH_3-Tol); 3.12 (s, 1 H, OH-2); 4.05 (bd, 1 H, $J_{OH,1}$ = 5.5, OH-1); 4.48 (dd, 1 H, J_{gem} = 11.4, $J_{5b,4}$ = 4.8, H-5b); 4.63 (m, 1 H, H-4); 4.64 (dd, 1 H, J_{gem} = 11.4, $J_{5a,4}$ = 3.6, H-5a); 5.10 (d, 1 H, $J_{3,4}$ = 5.4, H-3); 5.13 (bd, 1 H, $J_{1,OH}$ = 5.5, H-1); 7.18 and 7.22 (2 × m, 2 × 2 H, H-*m*-Tol); 7.90 and 7.94 (2 × m, 2 × 2 H, H-*o*-Tol). ^{13}C NMR (125.7 MHz, $CDCl_3$): 21.61 and 21.66 (CH_3-Tol); 23.43

(CH_3-2); 64.00 (CH_2-5); 76.34 (CH-3); 76.39 (C-2); 79.16 (CH-4); 100.67 (CH-1); 126.40 and 126.81 (C-*i*-Tol); 129.06 and 129.18 (CH-*m*-Tol); 129.70 and 129.83 (CH-*o*-Tol); 143.85 and 144.31 (C-*p*-Tol); 165.91 and 166.35 (CO). β anomer: ^{1}H NMR (499.8 MHz, $CDCl_3$): 1.42 (s, 3 H, CH_3-2); 2.35 and 2.41 (2 × s, 2 × 3 H, CH_3-Tol); 2.43 (s, 1 H, OH-2); 3.72 (bd, 1 H, $J_{OH,1}$ = 3.1, OH-1); 4.50 (m, 1 H, H-4); 4.54 (dd, 1 H, J_{gem} = 15.4, $J_{5b,4}$ = 6.2, H-5b); 4.63 (dd, 1 H, J_{gem} = 15.4, $J_{5a,4}$ = 3.6, H-5a); 5.22 (bd, 1 H, $J_{1,OH}$ = 3.1, H-1); 5.52 (d, 1 H, $J_{3,4}$ = 6.9, H-3); 7.13 and 7.24 (2 × m, 2 × 2 H, H-*m*-Tol); 7.88 and 7.94 (2 × m, 2 × 2 H, H-*o*-Tol). ^{13}C NMR (125.7 MHz, $CDCl_3$): 19.89 (CH_3-2); 21.59 and 21.66 (CH_3-Tol); 65.53 (CH_2-5); 76.87 (CH-3); 78.57 (CH-4); 79.71 (C-2); 102.87 (CH-1); 126.18 and 126.91 (C-*i*-Tol); 129.00 and 129.25 (CH-*m*-Tol); 129.70 and 129.83 (CH-*o*-Tol); 143.74 and 144.53 (C-*p*-Tol); 165.70 and 166.59 (CO). MS (ESI) *m/z*: 423 (M + Na). HRMS (ESI) for $C_{22}H_{24}O_7Na$ [M + Na] calculated: 423.1414; found: 423.1413.

1,2-Anhydro-2-*C*-methyl-3,5-di-*O*-(4-methylbenzoyl)-α-D-ribofuranose (**4**)

To a stirred solution of diol **5** (2.00 g, 5 mmol) and triethylamine (1.74 ml, 12.5 mmol) in dichloromethane (20 ml) was dropwise added mesyl chloride (465 µl, 6 mmol) within 20 min at r.t.. The mixture was stirred for 1 h and then diluted with toluene (100 ml) and washed with phosphate buffer (pH 7; 75 ml). Aqueous phase was re-extracted with toluene (25 ml), combined organics (cloudy) were dried over Na_2SO_4 and evaporated in vacuo providing epoxide **1** as a colorless oil which was directly used in next. NMR spectra of epoxide **4** were recorded in "common" undried NMR grade $CDCl_3$ (stabilized with silver wire); ^{1}H spectrum revealed the presence of only single clean compound. ^{1}H NMR (499.8 MHz, $CDCl_3$): 1.56 (s, 3 H, CH_3-2); 2.39, 2.43 (2 × s, 2 × 3 H, CH_3-Tol); 4.25 (ddd, 1 H, $J_{4,3}$ = 6.5, $J_{4,5}$ = 5.1, 3.4, H-4); 4.46 (dd, 1 H, J_{gem} = 12.1, $J_{5b,4}$ = 5.1, H-5b); 4.62 (dd, 1 H, J_{gem} = 12.1, $J_{5a,4}$ = 3.4, H-5a); 5.15 (s, 1 H, H-1); 5.54 (d, 1 H, $J_{3,4}$ = 6.5, H-3); 7.18, 7.26 (2 × m, 2 × 2 H, H-*m*-Tol); 7.88, 7.99 (2 × m, 2 × 2 H, H-*o*-Tol). ^{13}C NMR (125.7 MHz, $CDCl_3$): 14.08 (CH_3-2); 21.64, 21.71 (CH_3-Tol); 63.12 (CH_2-5); 63.68 (C-2); 75.87 (CH-3); 78.16 (CH-4); 85.90 (CH-1); 126.15, 126.87 (C-*i*-Tol); 129.06, 129.19 (CH-*m*-Tol); 129.68, 130.01 (CH-*o*-Tol); 143.83, 144.46 (C-*p*-Tol); 166.07, 166.28 (CO). MS (ESI) *m/z*: 383 (M + H). HRMS (ESI) for $C_{22}H_{23}O_6$ [M + H] calculated: 383.1489; found: 383.1486.

4-Chloro-7-[2-*C*-methyl-3,5-di-*O*-(4-methylbenzoyl)-β-D-ribofuranosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**9**)

6-Chloro-7-deazapurine **8** (691 mg, 4.5 mmol) was added to a stirred mixture of NaH (50% suspension in oil, 98 mg, 2.25 mmol) in dry DMF (10 ml) under argon at 0 °C. The mixture was stirred for 15 min, followed by the addition of a solution of epoxide **4** (prepared from 5 mmol of diol **5**) in toluene (20 ml). The mixture was stirred for 18 h at r.t. and then diluted with AcOEt (100 ml) and washed with aq. KH_2PO_4 (0.3 M, 75 ml). Organic phase was washed with 5% brine (3 × 50 ml), dried over $MgSO_4$, concentrated in vacuo and final chromatography on the column of silica (hexanes–AcOEt, 6:1) afforded protected nucleoside **9** as a colorless foam (1.41 g, 58%). ^{1}H NMR (400.1 MHz, $CDCl_3$): 1.08 (s, 3 H, CH_3-2′); 2.42 and 2.44 (2 × s, 2 × 3 H, CH_3-Tol); 3.21 (s, 1 H, OH-2′); 4.66 (dd, 1 H, J_{gem} = 12.1, $J_{5'b,4'}$ = 4.8, H-5′b); 4.73 (ddd, 1 H, $J_{4',3'}$ = 7.3, $J_{4',5'}$ = 4.8, 3.3, H-4′); 4.85 (dd, 1 H, J_{gem} = 12.1, $J_{5'a,4'}$ = 3.3, H-5′a); 5.65 (d, $J_{3',4'}$ = 7.3, H-3′); 6.44 (s, 1 H, H-1′); 6.61 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.23, 7.27 (2 × m, 2 × 2 H, H-*m*-Tol); 7.53 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 7.92–8.00 (m, 4 H, H-*o*-Tol);

8.65 (s, 1 H, H-2). ^{13}C NMR (100.6 MHz, $CDCl_3$): 21.08 (CH_3-2); 21.67 and 21.71 (CH_3-Tol); 63.06 (CH_2-5′); 75.51 (CH-3′); 78.46 (CH-4′); 79.34 (C-2′); 91.62 (CH-1′); 100.62 (CH_2-5); 118.24 (C-4a); 125.92 (C-*i*-Tol); 126.65 (CH-6); 126.79 (C-*i*-Tol); 129.22, 129.30 (CH-*m*-Tol); 129.69, 129.93 (CH-*o*-Tol); 144.10, 144.75 (C-*p*-Tol); 150.67 (C-4); 150.85 (CH-2); 152.58 (C-7a); 165.58, 166.25 (CO). MS (ESI) *m/z*: 536 (M + H), 558 (M + Na). HRMS (ESI) for $C_{28}H_{27}N_3O_6Cl$ [M + H] calculated: 536.1583; found: 536.1573.

4-Chloro-7-(2-*C*-methyl-β-D-ribofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**10**)

Protected nucleoside **9** (281 mg, 0.52 mmol) was treated with methanolic ammonia (27 wt.%, 6 ml) at r.t. for 24 h. Volatiles were removed under reduced pressure and the residue was co-evaporated with silica and chromatographed on the column of silica (3% MeOH in $CHCl_3$) affording free chloro nucleoside **10** (133 mg, 85%) as a colorless oil which solidified on standing. Compound was recrystallized from water as colorless prisms. M.p. 158–160 °C. $[\alpha]_D$ –8.6 (*c* 0.360, DMSO). ^{1}H NMR (400.1 MHz, D_2O): 0.65 (s, 3 H, CH_3-2′); 3.90 (dd, J_{gem} = 13.1, $J_{5'b,4}$ = 3.8, H-5′b); 4.02–4.13 (m, 3 H, H-5′a, H-4′, H-3′); 6.20 (s, 1 H, H-1′); 6.46 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.61 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.32 (s, 1 H, H-2). ^{13}C NMR (100.6 MHz, D_2O): 19.12 (CH_3-2′); 60.63 (CH_2-5′); 73.06 (CH-3′); 80.00 (C-2′); 82.45 (CH-4′); 91.65 (CH-1′); 101.36 (CH-5); 118.20 (C-4a); 128.20 (CH-6); 150.22 (C-4); 150.37 (CH-2); 152.11 (C-7a). MS (ESI) *m/z*: 300 (M + H), 322 (M + Na). HRMS (ESI) for $C_{12}H_{14}N_3O_4ClNa$ [M + Na] calculated: 322.0565; found: 322.0567. For $C_{12}H_{14}N_3O_4Cl$ calculated: 48.09% C, 4.71% H, 14.02% N; found: 48.05% C, 4.63% H, 13.78% N.

7-(2-*C*-Methyl-β-D-ribofuranosyl)-4-(phenyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**11a**)

An argon purged mixture of compound **10** (157 mg, 0.52 mmol), phenylboronic acid (95 mg, 0.78 mmol), Na_2CO_3 (167 mg, 1.57 mmol), $Pd(OAc)_2$ (5.9 mg, 0.026 mmol) and TPPTS (37 mg, 0.065 mmol) in water–MeCN (2:1, 3 ml) was stirred at 100 °C for 3 h. After cooling the mixture was neutralized by the addition of aq. HCl (3 M), volatiles were removed in vacuo and purification of the residue by reverse phase HPFC on C-18 (0→100% MeOH in water) afforded product **11a** (129 mg, 73%) as an amorphous tan solid. M.p. 177–179 °C. $[\alpha]_D$ –26.3 (*c* 0.353, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 0.71 (s, 3 H, CH_3); 3.70 (ddd, 1 H, J_{gem} = 12.3, $J_{5'b,OH}$ = 5.0, $J_{5'b,4'}$ = 3.2, H-5′b); 3.87 (ddd, 1 H, J_{gem} = 12.3, $J_{5'a,OH}$ = 5.0, $J_{5'a,4'}$ = 2.1, H-5′b); 3.92 (ddd, 1 H, $J_{4',3'}$ = 9.2, $J_{4',5'}$ = 3.2, 2.1, H-4′); 4.02 (dd, 1 H, $J_{3',4'}$ = 9.2, $J_{3',OH}$ = 7.0, H-3′); 5.207 (t, 1 H, $J_{OH,3'}$ = 5.0, OH-5′); 5.210 (d, 1 H, $J_{OH,3'}$ = 7.0, OH-3′); 5.23 (s, 1 H, OH-2′); 6.37 (s, 1 H, H-1′); 6.99 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.56 (m, 1 H, H-*p*-Ph); 7.59 (m, 2 H, H-*m*-Ph); 8.09 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.17 (m, 2 H, H-*o*-Ph); 8.89 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 19.90 (CH_3); 59.75 (CH_2-5′); 72.15 (CH-3′); 79.00 (C-2′); 82.60 (CH-4′); 90.73 (CH-1′); 100.96 (CH-5); 115.24 (C-4a); 127.89 (CH-6); 128.91 (CH-*o*-Ph); 129.19 (CH-*m*-Ph); 130.56 (CH-*p*-Ph); 137.74 (C-*i*-Ph); 151.25 (CH-2); 151.59 (C-7a); 156.34 (C-4). MS (ESI) *m/z*: 364 (M + Na). HRMS (ESI) for $C_{18}H_{20}N_3O_4$ [M + H] calculated: 342.1448; found: 342.1448. HRMS (ESI) for $C_{18}H_{19}N_3O_4Na$ [M + Na] calculated: 364.1268; found: 364.1267. For $C_{18}H_{19}N_3O_4 \cdot 0.7CH_4O$ calculated: 61.74% C, 6.04% H, 11.55% N; found: 62.01% C, 5.79% H, 11.06% N.

4-(Furan-2-yl)-7-(2-*C*-methyl-β-D-ribofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**11b**)

Compound **11b** was prepared as described for **11a** by the reaction of compound **10** (257 mg, 0.86 mg) and furane-2-boronic acid. Yield 230 mg (81%). Compound crystallized from MeOH as yellowish needles. M.p. 183–184 °C. $[\alpha]_D$ –26.9 (*c* 0.309, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 0.68 (s, 3 H, CH_3); 3.70 (ddd, 1 H, J_{gem} = 12.3, $J_{5'b,OH}$ = 5.0, $J_{5'b,4'}$ = 3.2, H-5′b); 3.86 (ddd, 1 H, J_{gem} = 12.3, $J_{5'a,OH}$ = 5.0, $J_{5'a,4'}$ = 2.1, H-5′b); 3.91 (ddd, 1 H, $J_{4',3'}$ = 9.1, $J_{4',5'}$ = 3.2, 2.1, H-4′); 4.01 (dd, 1 H, $J_{3',4'}$ = 9.1, $J_{3',OH}$ = 7.0, H-3′); 5.17 (d, 1 H, $J_{OH,3'}$ = 7.0, OH-3′); 5.18 (t, 1 H, $J_{OH,3'}$ = 5.0, OH-5′); 5.19 (s, 1 H, OH-2′); 6.33 (s, 1 H, H-1′); 6.79 (dd, 1 H, $J_{4,3}$ = 3.5, $J_{4,5}$ = 1.8, H-4-furyl); 7.04 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.47 (dd, 1 H, $J_{3,4}$ = 3.5, $J_{3,5}$ = 0.8, H-3-furyl); 8.057 (dd, 1 H, $J_{5,4}$ = 1.8, $J_{5,3}$ = 0.8, H-5-furyl); 8.062 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.78 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 19.74 (CH_3); 59.66 (CH_2-5′); 72.05 (CH-3′); 78.88 (C-2′); 82.52 (CH-4′); 90.56 (CH-1′); 101.09 (CH-5); 112.37 (C-4a); 112.84 (CH-4-furyl); 113.41 (CH-3-furyl); 127.74 (CH-6); 146.49 (CH-5-furyl); 146.58 (C-4); 151.15 (CH-2); 151.59 (C-7a); 152.65 (C-2-furyl). MS (ESI) *m/z*: 354 (M + Na). HRMS (ESI) for $C_{16}H_{18}N_3O_5$ [M + H] calculated: 332.1241; found: 332.1241. HRMS (ESI) for $C_{16}H_{17}N_3O_5Na$ [M + Na] calculated: 354.1060; found: 354.1060. For $C_{16}H_{17}N_3O_5$ calculated: 58.00% C, 5.17% H, 12.68% N; found: 57.97% C, 4.95% H, 12.46% N.

7-(2-*C*-Methyl-β-D-ribofuranosyl)-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**11c**)

Compound **11c** was prepared as described for **11a** by the reaction of compound **10** (133 mg, 0.44 mmol) and thiophene-2-boronic acid as a white powder. Yield 129 mg (84%). Compound was recrystallized from MeOH. M.p. 180–181 °C. $[\alpha]_D$ –15.2 (*c* 0.309, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 0.69 (s, 3 H, CH_3); 3.70 (ddd, 1 H, J_{gem} = 12.4, $J_{5'b,OH}$ = 5.0, $J_{5'b,4'}$ = 3.1, H-5′b); 3.87 (ddd, 1 H, J_{gem} = 12.4, $J_{5'a,OH}$ = 5.0, $J_{5'a,4'}$ = 2.1, H-5′b); 3.92 (ddd, 1 H, $J_{4',3'}$ = 9.1, $J_{4',5'}$ = 3.1, 2.1, H-4′); 4.02 (dd, 1 H, $J_{3',4'}$ = 9.1, $J_{3',OH}$ = 7.0, H-3′); 5.22 (d, 1 H, $J_{OH,3'}$ = 7.0, OH-3′); 5.226 (s, 1 H, OH-2′); 5.231 (t, 1 H, $J_{OH,3'}$ = 5.0, OH-5′); 6.33 (s, 1 H, H-1′); 7.15 (dd, 1 H, $J_{5,6}$ = 3.8, *J* = 0.3, H-5); 7.30 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,3}$ = 3.8, H-4-thienyl); 7.84 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,3}$ = 1.1, H-5-thienyl); 8.09 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.16 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.1, H-3-thienyl); 8.75 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 19.87 (CH_3); 59.74 (CH_2-5′); 72.13 (CH-3′); 79.04 (C-2′); 82.64 (CH-4′); 90.74 (CH-1′); 100.86 (CH-5); 112.80 (C-4a); 128.05 (CH-6); 129.40 (CH-4-thienyl); 129.87 (CH-3-thienyl); 131.03 (CH-5-thienyl); 142.68 (C-2-thienyl); 150.37 (C-4); 151.03 (CH-2); 151.64 (C-7a). MS (ESI) *m/z*: 348 (M + H), 370 (M + Na). HRMS (ESI) for $C_{16}H_{18}N_3O_4S$ [M + H] calculated: 348.1012; found: 348.1013. HRMS (ESI) for $C_{16}H_{17}N_3O_4SNa$ [M + Na] calculated: 370.0832; found: 370.0831. For $C_{16}H_{17}N_3O_4S$ calculated: 55.32% C, 4.93% H, 12.10% N; found: 55.14% C, 4.72% H, 11.84% N.

7-(2-*C*-Methyl-β-D-ribofuranosyl)-4-(thiophen-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**11e**)

Compound **11e** was prepared as described for **11a** by the reaction of compound **10** (150 mg, 0.5 mmol) and thiophene-3-boronic acid as an off-white foamy solid. Yield 172 mg (99%). M.p. 154–156 °C. $[\alpha]_D$ –24.0 (*c* 0.329, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 0.69 (s, 3 H, CH_3); 3.71 (ddd, 1 H, J_{gem} = 12.4, $J_{5'b,OH}$ = 5.0, $J_{5'b,4'}$ = 3.1, H-5′b); 3.87 (ddd, 1 H, J_{gem} = 12.4, $J_{5'a,OH}$ = 5.0, $J_{5'a,4'}$ = 2.1, H-5′b); 3.92 (ddd, 1 H, $J_{4',3'}$ = 9.1, $J_{4',5'}$ = 3.1, 2.1, H-4′); 4.02 (dd, 1 H, $J_{3',4'}$ = 9.1, $J_{3',OH}$ = 7.0, H-3′); 5.195 (d, 1 H, $J_{OH,3'}$ = 7.0, OH-3′); 5.21 (s, 1 H, OH-2′); 5.22 (t, 1 H, $J_{OH,3'}$ = 5.0, OH-5′); 6.35 (s, 1 H, H-1′); 7.12 (d, 1 H, $J_{5,6}$ = 3.8, H-5);

7.74 (dd, 1 H, $J_{5,4}$ = 5.1, $J_{5,2}$ = 2.9, H-5-thienyl); 7.95 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,2}$ = 1.3, H-4-thienyl); 8.08 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.53 (dd, 1 H, $J_{2,5}$ = 2.9, $J_{2,4}$ = 1.3, H-2-thienyl); 8.82 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 19.84 (CH_3); 59.72 (CH_2-5′); 72.12 (CH-3′); 78.98 (C-2′); 82.58 (CH-4′); 90.66 (CH-1′); 100.96 (CH-5); 114.30 (C-4a); 128.05 (CH-6); 127.38 (CH-5-thienyl); 127.65 (CH-4-thienyl); 127.68 (CH-6); 128.78 (CH-2-thienyl); 140.13 (C-3-thienyl); 151.15 (CH-2); 151.62, 151.66 (C-4,7a). MS (ESI) *m/z*: 348 (M + H), 370 (M + Na). HRMS (ESI) for $C_{16}H_{18}N_3O_4S$ [M + H] calculated: 348.10125; found: 348.10125. HRMS (ESI) for $C_{16}H_{17}N_3O_4SNa$ [M + Na] calculated: 370.0832; found: 370.0832. For $C_{16}H_{17}N_3O_4S$ calculated: 55.32% C, 4.93% H, 12.10% N; found: 55.27% C, 4.78% H, 11.80% N.

7-(2-*C*-Methyl-β-D-ribofuranosyl)-4-(pyridin-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**11f**)

Compound **11f** was prepared as described for **11a** by the reaction of compound **10** (157 mg, 0.52 mmol) and pyridine-3-boronic acid. Yield 134 mg (75%). Compound crystallized from MeOH tan solid. M.p. 191–193 °C. $[\alpha]_D$ –20.3 (*c* 0.310, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 0.71 (s, 3 H, CH_3); 3.71 (ddd, 1 H, J_{gem} = 12.4, $J_{5'b,OH}$ = 5.0, $J_{5'b,4'}$ = 3.2, H-5′b); 3.87 (ddd, 1 H, J_{gem} = 12.4, $J_{5'a,OH}$ = 5.0, $J_{5'a,4'}$ = 2.1, H-5′b); 3.93 (ddd, 1 H, $J_{4',3'}$ = 9.1, $J_{4',5'}$ = 3.2, 2.1, H-4′); 4.03 (dd, 1 H, $J_{3',4'}$ = 9.1, $J_{3',OH}$ = 7.0, H-3′); 5.23 (t, 1 H, $J_{OH,3'}$ = 5.0, OH-5′); 5.24 (d, 1 H, $J_{OH,3'}$ = 7.0, OH-3′); 5.25 (s, 1 H, OH-2′); 6.37 (s, 1 H, H-1′); 7.05 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.62 (dd, 1 H, $J_{5,4}$ = 8.0, $J_{5,6}$ = 4.8, H-5-py); 8.13 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.52 (ddd, 1 H, $J_{4,5}$ = 8.0, $J_{4,2}$ = 2.3, $J_{4,6}$ = 1.7, H-4-py); 8.74 (bd, 1 H, $J_{6,5}$ = 4.8, H-6-py); 8.93 (s, 1 H, H-2); 9.32 (bs, 1 H, H-2-py). ^{13}C NMR (125.7 MHz, DMSO-d_6): 19.94 (CH_3); 59.78 (CH_2-5′); 72.18 (CH-3′); 79.05 (C-2′); 82.68 (CH-4′); 90.81 (CH-1′); 100.76 (CH-5); 115.58 (C-4a); 124.42 (CH-5-py); 128.49 (CH-6); 133.44 (C-3-py); 136.43 (CH-4-py); 149.52 (CH-2-py); 151.23 (CH-6-py); 151.36 (CH-2); 151.56 (C-7a); 153.91 (C-4). MS (ESI) *m/z*: 365 (M + Na). HRMS (ESI) for $C_{17}H_{19}N_4O_4$ [M + H] calculated: 343.1401; found: 343.1401. HRMS (ESI) for $C_{17}H_{18}N_4O_4Na$ [M + Na] calculated: 365.12203; found: 365.12200. For $C_{17}H_{18}N_4O_4 \cdot 0.2H_2O$ calculated: 59.02% C, 5.36% H, 16.19% N; found: 58.92% C, 5.11% H, 15.96% N.

4-Chloro-5-fluoro-7-(2,3,5-tri-*O*-benzoyl-2-*C*-methyl-β-D-ribofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**14**)

To a mixture of 6-chloro-7-fluoro-7-deazapurine **13** [20a] (577 mg, 3.36 mmol) and per-*O*-benzoyl-2-*C*-methylribofuranose **12** (1.68 g, 2.90 mmol) and DBU (1.3 ml, 8.71 mmol) in dry CH_3CN (20 ml) was dropwise added TMSOTf (2.1 ml, 11.63 mmol). The mixture was stirred at 70 °C for 24 h, cooled to r.t. diluted with $CHCl_3$ (50 ml) and washed with aq. $NaHCO_3$ (sat., 50 ml). Aqueous phase was re-extracted with $CHCl_3$ (2 × 10 ml), combined organics were dried over $MgSO_4$ and evaporated. The residue was purified twice by column chromatography on silica (hexanes–AcOEt, 10:1) affording product **14** as a colorless foam (380 mg, 21%). ^{1}H NMR (499.8 MHz, $CDCl_3$): 1.60 (s, 3 H, CH_3); 4.70 (td, 1 H, $J_{4',3'}$ = 5.7, $J_{4',5'}$ = 5.7, 3.5, H-4′); 4.87 (dd, 1 H, J_{gem} = 12.3, $J_{5'b,4'}$ = 5.7, H-5′b); 4.93 (dd, 1 H, J_{gem} = 12.3, $J_{5'a,4'}$ = 3.5, H-5′a); 5.975 (d, 1 H, $J_{3',4'}$ = 5.7, H-3′); 6.97 (d, 1 H, $J_{H,F}$ = 0.9, H-1′); 7.33 (m, 2 H, H-*m*-Bz); 7.36 (d, 1 H, $J_{H,F}$ = 2.4, H-6); 7.46 (m, 4 H, H-*m*-Bz); 7.54, 7.59, 7.61 (3 × m, 3 × 1 H, H-*p*-Bz); 7.95, 8.10, 8.11 (3 × m, 3 × 2 H, H-*o*-Bz); 8.76 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, $CDCl_3$): 17.80 (CH_3); 63.28 (CH_2-5′); 75.48 (CH-3′); 80.09 (CH-4′); 84.83 (C-2′); 88.39 (CH-1′); 107.96 (d, $J_{C,F}$ = 13.8, C-4a); 110.58 (d, $J_{C,F}$ = 27.1, CH-6); 128.49, 128.54, 128.57 (CH-*m*-Bz); 128.65, 129.49, 129.61 (C-*i*-Bz); 129.74, 129.83, 129.93 (CH-*o*-Bz); 133.41,

133.65, 133.72 (CH-*p*-Bz); 141.39 (d, $J_{C,F}$ = 254.2, C-5); 146.82 (C-7a); 151.02 (d, $J_{C,F}$ = 3.9, C-4); 151.83 (CH-2); 165.05, 165.34, 166.31 (CO). MS (ESI) *m/z*: 630 (M + H), 652 (M + Na). HRMS (ESI) for $C_{33}H_{25}ClFN_3O_7Na$ [M + Na] calculated: 652.1263; found: 652.1260.

5-Fluoro-4-(furan-2-yl)-7-(2-*C*-methyl-β-D-ribofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**15a**)

To an argon purged mixture of compound **14** (185 mg, 0.29 mmol), furane-2-boronic acid (41 mg, 0.37 mmol), Na_2CO_3 (94 mg, 0.89 mmol) was added a pre-prepared solution of $Pd(OAc)_2$ (3 mg, 0.013 mmol) and TPPTS (21 mg, 0.037 mmol) in water/CH_3CN (2:1, 2.5 ml). The reaction mixture was stirred at 100 °C for 3 h. The volatiles were removed under reduced pressure and the residue was twice co-evaporated with absolute ethanol, dissolved in pyridine (2 ml), followed by addition of MeONa (1 M in MeOH, 0.9 ml, 0.9 mmol). After 15 min the the mixture was desalted with Dowex 50 (pyridinium form) and after removal of volatiles final reverse phase chromatography on C-18 (0→100% MeOH in water) afforded product **15a** as a colorless solid (31 mg, 30%). M.p. 222–224 °C. $[\alpha]_D$ –16.7 (*c* 0.132, DMSO). ^{1}H NMR (600.1 MHz, CD_3OD): 0.86 (s, 3 H, CH_3); 3.86 (m, 1 H, H-5′b); 4.01–4.05 (m, 2 H, H-4′,5′a); 4.13 (d, 1 H, $J_{3',4'}$ = 8.9, H-3′); 6.51 (d, 1 H, $J_{H,F}$ = 1.7, H-1′); 6.73 (dd, 1 H, $J_{4,3}$ = 3.6, $J_{4,5}$ = 1.7, H-4-furyl); 7.54 (dd, 1 H, $J_{3,4}$ = 3.6, $J_{3,5}$ = 0.8, H-3-furyl); 7.87 (dd, 1 H, $J_{5,4}$ = 1.7, $J_{5,3}$ = 0.8, H-5-furyl); 7.96 (d, 1 H, $J_{H,F}$ = 2.0, H-6); 8.73 (s, 1 H, H-2). ^{13}C NMR (150.9 MHz, CD_3OD): 19.84 (CH_3); 60.92 (CH_2-5′); 73.41 (CH-3′); 80.51 (C-2′); 83.94 (CH-4′); 91.97 (CH-1′); 103.55 (d, $J_{C,F}$ = 15.7, C-4a); 111.52 (d, $J_{C,F}$ = 31.4, CH-6); 113.82 (CH-4-furyl); 116.50 (d, $J_{C,F}$ = 9.6, CH-3-furyl); 143.31 (d, $J_{C,F}$ = 249.9, C-5); 147.54 (CH-5-furyl); 147.73 (d, $J_{C,F}$ = 3.8, C-4); 148.34 (d, $J_{C,F}$ = 3.2, C-7a); 151.87 (C-2-furyl); 152.37 (CH-2). ^{19}F NMR (470.3 MHz, DMSO-d_6): –162.07. MS (ESI) *m/z*: 350 (M + H), 372 (M + Na). HRMS (ESI) for $C_{16}H_{16}FN_3O_5Na$ [M + Na] calculated: 372.0971; found: 372.0965.

5-Fluoro-7-(2-*C*-methyl-β-D-ribofuranosyl)-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**15b**)

Compound **15b** was prepared as described for **15a** from compound **14** (182 mg, 0.29 mmol) and thiophene-2-boronic acid. Yield 33 mg (31%). Colorless solid. M.p. 146–148 °C. ^{1}H NMR (600.1 MHz, CD_3OD): 0.87 (s, 3 H, CH_3); 3.86 (m, 1 H, H-5′b); 4.01–4.05 (m, 2 H, H-4′,5′a); 4.13 (d, 1 H, $J_{3',4'}$ = 9.0, H-3′); 6.51 (d, 1 H, $J_{H,F}$ = 1.9, H-1′); 7.25 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,3}$ = 3.8, H-4-thienyl); 7.73 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,3}$ = 1.0, H-5-thienyl); 7.96 (d, 1 H, $J_{H,F}$ = 1.9, H-6); 8.13 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.0, H-3-thienyl); 8.69 (s, 1 H, H-2). ^{13}C NMR (150.9 MHz, CD_3OD): 19.86 (CH_3); 60.94 (CH_2-5′); 73.42 (CH-3′); 80.51 (C-2′); 83.92 (CH-4′); 92.02 (CH-1′); 103.95 (d, $J_{C,F}$ = 15.4, C-4a); 111.16 (d, $J_{C,F}$ = 32.1, 3.4, CH-6); 129.74 (d, $J_{C,F}$ = 2.3, CH-4-thienyl); 131.65 (d, $J_{C,F}$ = 16.5, CH-3-thienyl); 132.12 (CH-5-thienyl); 143.00 (d, $J_{C,F}$ = 1.1, C-2-thienyl); 143.36 (d, $J_{C,F}$ = 247.5, C-5); 148.39 (d, $J_{C,F}$ = 3.1, C-7a); 152.45 (d, $J_{C,F}$ = 3.9, C-4); 152.46 (CH-2). ^{19}F NMR (470.3 MHz, DMSO-d_6): –161.16. MS (ESI) *m/z*: 366 (M + H), 388 (M + Na). HRMS (ESI) for $C_{16}H_{16}FN_3O_4SNa$ [M + Na] calculated: 388.0743; found 388.0736.

4-Chloro-7-[3,5-*O*-(tetraisopropyldisiloxan-1,3-diyl)-β-D-*erythro*-pentofuran-2-ulosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**17**)

Dess–Martin periodinane (3.61 g, 8.51 mmol) was dissolved in anhydrous dichloromethane (20 ml) and the solution was cooled to 0 °C. Then the solution of compound **16** (1.50 g, 2.83 mmol) in anhydrous dichloromethane (10 ml) was added. The reaction mixture was stirred at 0 °C for 5 min and then was allowed to warm to r.t. and stirred overnight. Then the reaction mixture was diluted with chloroform (50 ml) and the solution of $Na_2S_2O_3 \cdot 5H_2O$ (19.20 g) in aq. $NaHCO_3$ (sat., 150 ml) was added. The organic phase was extracted with water, dried over $MgSO_4$ and evaporated under reduced pressure. The crude product was purified by column chromatography on silica (hexane–EtOAc, 10:1) to give the ketone **17** (1.31 g, 88%) as a white solid. ^{1}H NMR (500.0 MHz, $CDCl_3$): 1.05–1.22 (m, 28 H, $(CH_3)_2$CHSi); 4.03 (dt, 1 H, $J_{4',3'}$ = 9.8, $J_{4',5'}$ = 2.9, H-4′); 4.14, 4.20 (2 × dd, 2 × 1 H, J_{gem} = 13.1, $J_{5',4'}$ = 2.9, H-5′); 5.52 (d, 1 H, $J_{3',4'}$ = 9.8, H-3′); 5.74 (d, 1 H, $J_{1',3'}$ = 0.6, H-1′); 6.65 (d, 1 H, $J_{5,6}$ = 3.7, H-5); 7.26 (d, 1 H, $J_{6,5}$ = 3.7, H-6); 8.49 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, $CDCl_3$): 12.44, 12.54, 12.94, 13.47 ((CH_3)$_2$**C**HSi); 16.75, 16.78, 16.82, 16.90, 17.20, 17.27, 17.29, 17.32 (($\mathbf{C}H_3$)$_2$CHSi); 60.94 (CH_2-5′); 72.50 (CH-3′); 78.60 (CH-4′); 82.43 (CH-1′); 101.23 (CH-5); 118.54 (C-4a); 129.17 (CH-6); 150.81 (C-7a); 150.90 (CH-2); 152.69 (C-4); 206.07 (C-2′). MS (ESI) *m/z*: 548 [M + Na], 550 [M + 2 + Na], 558 [M + H + MeOH], 560 [M + H + MeOH], 580 [M + Na + MeOH], 582 [M + 2 Na + MeOH]. HRMS (ESI) for $C_{23}H_{36}O_5N_3ClNaSi_2$ [M + Na] calculated: 548.1774; found: 548.1772.

4-Chloro-7-[3,5-*O*-(tetraisopropyldisiloxan-1,3-diyl)-β-D-arabinofuranosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**18**)

A solution of sodium borohydride (173 mg, 4.58 mmol) in ethanol (99%, 30 ml) was slowly added to a solution of ketone **17** (1.20 g, 2.28 mmol) in ethanol (99%, 50 ml) at 0 °C. The reaction mixture was stirred at r.t. for 1 h. The reaction was quenched with aq. NH_4Cl (sat., 15 ml). The reaction mixture was extracted with EtOAc (100 ml). The organic phase was washed with water, dried over $MgSO_4$ and evaporated under reduced pressure. The crude product was purified by column chromatography on silica (hexane–EtOAc, 10:1) to give the arabino-derivative **18** (1.05 g, 87%) as a white solid. ^{1}H NMR (500.0 MHz, $CDCl_3$): 0.97–1.17 (m, 28 H, $(CH_3)_2$CHSi); 2.96 (bs, 1 H, OH-2′); 3.85 (dt, 1 H, $J_{4',3'}$ = 8.4, $J_{4',5'}$ = 3.0, H-4′); 4.05, 4.11 (2 × dd, 2 × 1 H, J_{gem} = 13.0, $J_{5',4'}$ = 3.0, H-5′); 4.54 (dd, 1 H, $J_{3',4'}$ = 8.4, $J_{3',2'}$ = 7.8, H-3′); 4.66 (dd, 1 H, $J_{2',3'}$ = 7.8, $J_{2',1'}$ = 6.3, H-2′); 6.43 (d, 1 H, $J_{1',2'}$ = 6.3, H-1′); 6.63 (d, 1 H, $J_{5,6}$ = 3.7, H-5); 7.70 (d, 1 H, $J_{6,5}$ = 3.7, H-6); 8.57 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, $CDCl_3$): 12.42, 13.00, 13.01, 13.49 ((CH_3)$_2$**C**HSi); 16.86, 16.90, 16.94, 17.04, 17.31, 17.33, 17.37, 17.49 (($\mathbf{C}H_3$)$_2$CHSi); 60.01 (CH_2-5′); 73.68 (CH-3′); 76.98 (CH-2′); 80.85 (CH-4′); 83.80 (CH-1′); 100.03 (CH-5); 118.47 (C-4a); 128.34 (CH-6); 150.40 (CH-2); 150.85 (C-7a); 152.37 (C-4). MS (ESI) *m/z*: 528 [M + H], 530 [M + 2 + H], 550 [M + Na], 552 [M + 2 + Na]. HRMS (ESI) for $C_{23}H_{39}O_5N_3ClSi_2$ [M + H] calculated: 528.2111; found: 528.2112.

4-Chloro-7-(β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**19**)

Compound **18** (363 mg, 0.69 mmol) was dissolved in anhydrous THF (10 ml) and cooled to 0 °C. Then, the solution of tetrabutylammonium fluoride (433 mg, 1.37 mmol) in anhydrous THF (1.4 ml) was slowly added. The reaction mixture was stirred at r.t. for 2 h. The reaction mixture was evaporated under reduced pressure and purified by column chromatog-

raphy on silica (4% MeOH in $CHCl_3$) to give the free nucleoside **19** (163 mg, 83%) as a white solid. M.p. 163–165 °C. ^{1}H NMR (500.0 MHz, DMSO-d_6): 3.64 (dt, 1 H, J_{gem} = 11.8, $J_{5'b,OH}$ = $J_{5'b,4'}$ = 5.3, H-5'b); 3.71 (ddd, 1 H, J_{gem} = 11.8, $J_{5'a,OH}$ = 5.3, $J_{5'a,4'}$ = 3.9, H-5'a); 3.79 (ddd, 1 H, $J_{4',5'}$ = 5.3, 3.9, $J_{4',3'}$ = 4.7, H-4'); 4.11 (dt, 1 H, $J_{3',2'}$ = 5.0, $J_{3',OH}$ = $J_{3',4'}$ = 4.7, H-3'); 4.19 (ddd, 1 H, $J_{2',OH}$ = 5.5, $J_{2',1'}$ = 5.2, $J_{2',3'}$ = 5.0, H-2'); 5.08 (t, 1 H, $J_{OH,5'}$ = 5.3, OH-5'); 5.50 (d, 1 H, $J_{OH,2'}$ = 5.5, OH-2'); 5.52 (d, 1 H, $J_{OH,3'}$ = 4.7, OH-3'); 6.55 (d, 1 H, $J_{1',2'}$ = 5.2, H-1'); 6.67 (dd, 1 H, $J_{5,6}$ = 3.7, ^5J = 0.4, H-5); 7.88 (d, 1 H, $J_{6,5}$ = 3.7, H-6); 8.64 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.85 (CH_2-5'); 74.83 (CH-3'); 76.15 (CH-2'); 83.97, 83.98 (CH-1',4'); 98.61 (CH-5); 117.14 (C-4a); 130.66 (CH-6); 150.40 (CH-2); 150.53 (C-4); 150.97 (C-7a). MS (ESI) *m/z*: 284 [M–H], 286 [M + 2 – H]. HRMS (ESI) for $C_{11}H_{11}O_4N_3Cl$ [M – H] calculated: 284.0444; found: 284.0444.

4-(Furan-2-yl)-7-[3,5-*O*-(tetraisopropyldisiloxan-1,3-diyl)-β-D-arabinofuranosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**20b**)

An argon purged mixture of compound **18** (220 mg, 0.42 mmol), 2-(tributylstannyl)furane (230 mg, 0.64 mmol) and $PdCl_2(PPh_3)_2$ (15 mg, 0.021 mmol) in DMF (2 ml) was stirred at 100 °C for 2 h. After cooling volatiles were removed in vacuo and the residue was several times co-evaporated with toluene. Column chromatography on silica (hexanes–AcOEt, 10:1→3:1) afforded product **20b** (230 mg, 99%) as a colorless oil. ^{1}H NMR (400.0 MHz, $CDCl_3$): 0.97–1.15 (m, 28 H, $(CH_3)_2CHSi$); 3.62 (bs, 1 H, OH-2'); 3.84 (dt, 1 H, $J_{4',3'}$ = 8.0, $J_{4',5'}$ = 3.2, H-4'); 4.04–4.05 (m, 2 H, H-5'); 4.60–4.70 (m, 2 H, H-2', H-3'); 6.40 (d, 1 H, $J_{1',2'}$ = 6.4, H-1'); 6.63 (dd, 1 H, *J* = 3.6, *J* = 2.0, H-4-furyl); 7.03 (d, 1 H, $J_{5,6}$ = 3.6, H-5); 7.44 (m, 1 H, H-3-furyl); 7.64 (d, 1 H, $J_{6,5}$ = 3.6, H-6); 7.71 (m, 1 H, H-5-furyl); 8.74 (s, 1 H, H-2). MS (ESI) *m/z*: 560 [M + H], 582 [M + Na]. HRMS (ESI) for $C_{27}H_{42}O_6N_3Si_2$ [M + H] calculated: 560.2607; found: 560.2608.

4-(Thiophene-2-yl)-7-[3,5-*O*-(tetraisopropyldisiloxan-1,3-diyl)-β-D-arabinofuranosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**20c**) and 4-(Thiophene-2-yl)-7-[2,3-*O*-(tetraisopropyldisiloxan-1,3-diyl)-β-D-arabinofuranosyl]-7*H*-pyrrolo[2,3-*d*]pyrimidine (**22c**)

An argon purged mixture of compound **18** (220 mg, 0.42 mmol), 2-(tributylstannyl)-thiophene (240 mg, 0.64 mmol) and $PdCl_2(PPh_3)_2$ (15 mg, 0.021 mmol) in DMF (2 ml) was stirred at 100 °C for 2 h. After cooling volatiles were removed in vacuo and the residue was several times co-evaporated with toluene. HPFC of the residue on silica (0→100% EtOAc in hexane) afforded product **20c** (32 mg, 13%) as a colourless oil, product **22c** (32 mg, 13%) as a colourless oil and the mixture of compounds **20c** and **22c** (146 mg, 61%). The overall yield of the cross-coupling products **20c** and **22c** is 210 mg (88%).

20c: ^{1}H NMR (400.0 MHz, $CDCl_3$): 1.00–1.15 (m, 28 H, $(CH_3)_2CHSi$); 3.55 (bs, 1 H, OH-2'); 3.83 (dt, 1 H, $J_{4',3'}$ = 7.6, $J_{4',5'}$ = 3.2, H-4'); 4.01–4.10 (m, 2 H, H-5'); 4.28–4.70 (m, 2 H, H-2', H-3'); 6.41 (d, 1 H, $J_{1',2'}$ = 6.0, H-1'); 7.89 (d, 1 H, $J_{5,6}$ = 3.6, H-5); 7.22 (dd, 1 H, *J* = 5.2, *J* = 3.6, H-4-thienyl); 7.57 (dd, 1 H, *J* = 5.2, *J* = 1.2, H-3-thienyl); 7.67 (d, 1 H, $J_{5,6}$ = 4.0, H-6); 7.98 (d, 1 H, *J* = 3.2, H-3-thienyl); 8.74 (s, 1 H, H-2). MS (ESI) *m/z*: 576 [M + H], 598 [M + Na]. HRMS (ESI) for $C_{27}H_{42}O_5N_3SSi_2$ [M + H] calculated: 576.2378; found: 576.2379.

22c: ^{1}H NMR (400.0 MHz, $CDCl_3$): 0.92–1.10 (m, 28 H, $(CH_3)_2CHSi$); 3.74 (bs, 1 H, OH-5'); 3.87 (bd, 1 H, $J_{5'a,5'b}$ = 12.4, H-5'a); 3.96 (dt, 1 H, $J_{4',3'}$ = 8.8, $J_{4',5'}$ = 2.0, H-4');

4.08 (dd, 1 H, $J_{5'a,5'b}$ = 12.0, $J_{4',5'}$ = 2.0, H-5′b); 4.70 (dd, 1 H, $J_{4',3'}$ = 8.0, $J_{2',3'}$ = 7.6, H-2′); 4.85 (t, 1 H, $J_{1',2'} = J_{2',3'}$ = 7.6, H-3′); 6.54 (d, 1 H, $J_{1',2'}$ = 7.2, H-1′); 6.85 (d, 1 H, $J_{5,6}$ = 3.6, H-5); 7.22 (dd, 1 H, *J* = 5.2, *J* = 3.6, H-4-thienyl); 7.42 (d, 1 H, $J_{5,6}$ = 3.6, H-6); 7.56 (dd, 1 H, *J* = 4.8, *J* = 0.8, H-5-thienyl); 7.96 (bs, 1 H, H-3-thienyl); 8.78 (s, 1 H, H-2). MS (ESI) *m/z*: 576 [M + H], 598 [M + Na]. HRMS (ESI) for $C_{27}H_{42}O_5N_3SSi_2$ [M + H] calculated: 576.2378; found: 576.2378.

4-(Furan-2-yl)-7-(β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**21b**)

Deprotection of nucleoside **20b** (200 mg, 0.36 mmol) was performed as described for compound **19**. White crystalline solid (82 mg, 72%). Compound was recrystallized (H_2O–methanol, 2:1). M.p. 228–230 °C. $[\alpha]_D^{20}$ –19.6 (*c* 0.204, DMSO). IR (ATR): 3509, 1601, 1572, 1466, 1249, 1069, 1018 cm^{-1}. ^1H NMR (500.0 MHz, DMSO-d_6): 3.64 (dt, 1 H, J_{gem} = 11.6, $J_{5'b,OH} = J_{5'b,4'}$ = 5.3, H-5′b); 3.71 (ddd, 1 H, J_{gem} = 11.6, $J_{5'a,OH}$ = 5.3, $J_{5'a,4'}$ = 4.1, H-5′a); 3.79 (ddd, 1 H, $J_{4',5'}$ = 5.3, 4.1, $J_{4',3'}$ = 4.7, H-4′); 4.12 (q, 1 H, $J_{3',2'} = J_{3',OH} = J_{3',4'}$ = 4.7, H-3′); 4.17 (ddd, 1 H, $J_{2',OH}$ = 5.6, $J_{2',1'}$ = 5.3, $J_{2',3'}$ = 4.7, H-2′); 5.07 (t, 1 H, $J_{OH,5'}$ = 5.3, OH-5′); 5.51 (d, 1 H, $J_{OH,2'}$ = 5.6, OH-2′); 5.52 (d, 1 H, $J_{OH,3'}$ = 4.7, OH-3′); 6.60 (d, 1 H, $J_{1',2'}$ = 5.1, H-1′); 6.78 (dd, 1 H, $J_{4,3}$ = 3.5, $J_{4,5}$ = 1.7, H-4-furyl); 7.00 (d, 1 H, $J_{5,6}$ = 3.7, H-5); 7.45 (dd, 1 H, $J_{3,4}$ = 3.5, $J_{3,5}$ = 0.8, H-3-furyl); 7.81 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 8.06 (dd, 1 H, $J_{5,4}$ = 1.7, $J_{5,3}$ = 0.8, H-5-furyl); 8.75 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 61.15 (CH_2-5′); 75.35 (CH-3′); 76.17 (CH-2′); 83.34 (CH-1′); 83.94 (CH-4′); 100.11 (CH-5); 112.44 (C-4a); 112.78 (CH-4-furyl); 113.17 (CH-3-furyl); 130.17 (CH-6); 146.18 (C-4); 146.35 (CH-5-furyl); 150.88 (CH-2); 151.91 (C-7a); 152.79 (C-2-furyl). MS (ESI) *m/z*: 318 [M + H], 340 [M + Na]. HRMS (ESI) for $C_{15}H_{15}O_5N_3Na$ [M + Na] calculated: 340.0904; found: 340.0904. For $C_{15}H_{15}O_5N_3$ calculated: 56.78% C, 4.76% H, 13.24% N; found: 56.45% C, 4.75% H, 12.82% N.

4-(Thiophene-2-yl)-7-(β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**21c**)

Deprotection of the **20c** and **22c** mixture (180 mg, 0.31 mmol) was performed as described for compound **19**. Pale yellow needles (80 mg, 77%). Compound was recrystallized (H_2O–methanol, 2:1). M.p. 225–227 °C. $[\alpha]_D^{20}$ –15.7 (*c* 0.172, DMSO). IR (ATR): 3126, 1567, 1439, 1072, 1023 cm^{-1}. ^1H NMR (499.8 MHz, DMSO-d_6): 3.65 (dt, 1 H, J_{gem} = 11.7, $J_{5'b,OH} = J_{5'b,4'}$ = 5.3, H-5′b); 3.72 (ddd, 1 H, J_{gem} = 11.7, $J_{5'a,OH}$ = 5.3, $J_{5'a,4'}$ = 4.3, H-5′a); 3.79 (ddd, 1 H, $J_{4',5'}$ = 5.3, 4.3, $J_{4',3'}$ = 4.6, H-4′); 4.13 (dt, 1 H, $J_{3',2'}$ = 5.1, $J_{3',OH} = J_{3',4'}$ = 4.6, H-3′); 4.19 (dt, 1 H, $J_{2',OH}$ = 6.0, $J_{2',1'} = J_{2',3'}$ = 5.1, H-2′); 5.09 (t, 1 H, $J_{OH,5'}$ = 5.3, OH-5′); 5.522 (d, 1 H, $J_{OH,2'}$ = 6.0, OH-2′); 5.523 (d, 1 H, $J_{OH,3'}$ = 4.6, OH-3′); 6.61 (d, 1 H, $J_{1',2'}$ = 5.1, H-1′); 7.10 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.31 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,3}$ = 3.8, H-4-thienyl); 7.84 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 7.85 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,3}$ = 1.0, H-5-thienyl); 8.15 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.0, H-3-thienyl); 8.73 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 61.07 (CH_2-5′); 75.21 (CH-3′); 76.19 (CH-2′); 83.43 (CH-1′); 83.91 (CH-4′); 99.72 (CH-5); 112.74 (C-4a); 129.21 (CH-4-thienyl); 129.49 (CH-3-thienyl); 130.33 (CH-6); 130.69 (CH-5-thienyl); 142.76 (C-2-thienyl); 149.82 (C-4); 150.66 (CH-2); 151.85 (C-7a). MS (ESI) *m/z*: 334 [M + H]. HRMS (ESI) for $C_{15}H_{16}O_4N_3S$ [M + H] calculated: 334.0856; found: 334.0856. For $C_{15}H_{15}O_4N_3S \cdot 1.5H_2O$ calculated: 49.99% C, 5.03% H, 11.66% N; found: 50.30% C, 4.98% H, 11.45% N.

4-(Furan-3-yl)-7-(β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**21d**)

An argon purged mixture of compound **19** (130 mg, 0.45 mmol), furane-2-boronic acid (63 mg, 0.56 mmol), Na_2CO_3 (144 mg, 1.36 mmol), $Pd(OAc)_2$ (5.1 mg, 0.023 mmol) and TPPTS (39 mg, 0.069 mmol) in water–MeCN (2:1, 2 ml) was stirred at 100 °C for 3 h. After cooling the mixture was neutralized by the addition of aq. HCl (3 M), volatiles were removed in vacuo and purification of the residue by reverse phase HPFC on C-18 (0→100% MeOH in water) and crystallization (H_2O–methanol, 2:1) afforded product **21d** (112 mg, 78%) as a white crystalline solid. M.p. 212–214 °C. $[\alpha]_D^{20}$ –13.9 (*c* 0.245, DMSO). IR (ATR): 3494, 1579, 1461, 1165, 1074, 1022 cm^{-1}. ^1H NMR (499.8 MHz, DMSO-d_6): 3.64, 3.71 (2 × dt, 2 × 1 H, J_{gem} = 11.8, $J_{5',OH}$ = $J_{5',4'}$ = 5.3, H-5′); 3.78 (td, 1 H, $J_{4',5'}$ = 5.3, $J_{4',3'}$ = 4.3, H-4′); 4.13 (ddd, 1 H, $J_{3',2'}$ = 5.0, $J_{3',OH}$ = 4.7, $J_{3',4'}$ = 4.3, H-3′); 4.18 (ddd, 1 H, $J_{2',OH}$ = 6.1, $J_{2',1'}$ = 5.3, $J_{2',3'}$ = 5.0, H-2′); 5.08 (t, 1 H, $J_{OH,5'}$ = 5.3, OH-5′); 5.50 (d, 1 H, $J_{OH,2'}$ = 6.1, OH-2′); 5.51 (d, 1 H, $J_{OH,3'}$ = 4.7, OH-3′); 6.60 (d, 1 H, $J_{1',2'}$ = 5.3, H-1′); 7.02 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.25 (bs, 1 H, H-4-furyl); 7.79 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 7.90 (bs, 1 H, H-5-furyl); 8.71 (bs, 1 H, H-2-furyl); 8.76 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 61.08 (CH_2-5′); 75.23 (CH-3′); 76.19 (CH-2′); 83.33 (CH-1′); 83.86 (CH-4′); 99.65 (CH-5); 109.58 (CH-4-furyl); 114.25 (C-4a); 125.32 (C-3-furyl); 129.65 (CH-6); 144.73 (CH-5-furyl); 144.87 (CH-2-furyl); 149.70 (C-4); 150.88 (CH-2); 151.42 (C-7a). MS (ESI) *m/z*: 318 [M + H]. HRMS (ESI) for $C_{15}H_{16}O_5N_3$[M + H] calculated: 318.10845; found: 318.10838. For $C_{15}H_{15}O_5N_3$ calculated: 56.7% C, 4.76% H, 13.24% N; found: 56.28% C, 4.7% H, 12.82% N.

4-(Thiophene-3-yl)-7-(β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**21e**)

Compound **21e** was prepared as described for compound **21d** from compound **19** (155 mg, 0.54 mmol) and 3-thienylboronic acid. Compound **21e** (123 mg, 68%) was obtained as an off-white crystalline solid after recrystallization (H_2O–MeOH, 2:1). M.p. 215–217 °C. $[\alpha]_D^{20}$ –9.5 (*c* 0.211, DMSO). IR (ATR): 3520, 1578, 1461, 1248, 1076, 1026 cm^{-1}. ^1H NMR (499.8 MHz, DMSO-d_6): 3.65 (ddd, 1 H, J_{gem} = 11.7, $J_{5'b,OH}$ = 5.4, $J_{5'b,4'}$ = 4.8, H-5′b); 3.72 (ddd, 1 H, J_{gem} = 11.7, $J_{5'a,OH}$ = 5.4, $J_{5'a,4'}$ = 4.2, H-5′a); 3.79 (ddd, 1 H, $J_{4',3'}$ = 5.0, $J_{4',5'}$ = 4.8, 4.2, H-4′); 4.13 (dt, 1 H, $J_{3',4'}$ = 5.0, $J_{3',OH}$ = 4.4, $J_{3',2'}$ = 4.2, H-3′); 4.18 (ddd, 1 H, $J_{2',OH}$ = 5.9, $J_{2',1'}$ = 5.1, $J_{2',3'}$ = 4.2, H-2′); 5.08 (t, 1 H, $J_{OH,5'}$ = 5.4, OH-5′); 5.516 (d, 1 H, $J_{OH,2'}$ = 5.9, OH-2′); 5.518 (d, 1 H, $J_{OH,3'}$ = 4.4, OH-3′); 6.62 (d, 1 H, $J_{1',2'}$ = 5.1, H-1′); 7.07 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.74 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,2}$ = 2.9, H-5-thienyl); 7.83 (d, 1 H, $J_{6,5}$ = 3.8, H-6); 7.95 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,2}$ = 1.2, H-4-thienyl); 8.53 (dd, 1 H, $J_{2,5}$ = 2.9, $J_{2,4}$ = 1.2, H-2-thienyl); 8.79 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 61.10 (CH_2-5′); 75.28 (CH-3′); 76.18 (CH-2′); 83.37 (CH-1′); 83.89 (CH-4′); 99.87 (CH-5); 114.27 (C-4a); 127.27 (CH-5-thienyl); 127.59 (CH-4-thienyl); 128.47 (CH-2-thienyl); 129.99 (CH-6); 140.23 (C-3-thienyl); 150.83 (CH-2); 151.17 (C-4); 151.85 (C-7a). MS (ESI) *m/z*: 334 [M + H]. HRMS (ESI) for $C_{15}H_{16}O_4N_3S$ [M + H] calculated: 334.0856; found: 334.0856. For $C_{15}H_{15}O_4N_3S$ calculated: 54.04% C, 4.54% H, 12.60% N; found: 54.05% C, 4.51% H, 12.42% N.

4-Chloro-7-(2-deoxy-2-fluoro-3,5-di-*O*-benzoyl-β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**23**)

A mixture of powdered KOH (840 mg, 85%, 12.75 mmol), TDA-1 (0.26 ml, 0.81 mmol) in dry MeCN (40 ml) was stirred at r.t. for 10 min before 6-chloro-7-deazapurine **8** (768 mg, 5 mmol) was added. Stirring was continued for another 15 min and then 2-deoxy-2-fluoro-

3,5-di-*O*-benzoyl-β-D-arabinofuranosyl bromide **25** [26] (2.12 g, 5 mmol, prepared from **26**) in MeCN (40 ml) was added and the mixture was stirred at r.t. for 10 min. The mixture was neutralized by the addition of AcOH, evaporated to dryness and the residue was co-evaporated with silica. Column chromatography (hexanes–AcOEt, 6:1) afforded chloro nucleoside **23** (1.79 g, 72%) as a colorless solid. Analytical data of compound **23** are as described[23].

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-phenyl-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27a**)

An argon purged mixture of 4-chloro-7-(2-deoxy-2-fluoro-3,5-di-*O*-benzoyl-β-D-arabinofuranosyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine **23** (414 mg, 0.83 mmol), phenylboronic acid (153 mg, 1.25 mmol), K_2CO_3 (230 mg, 1.67 mmol) and $Pd(PPh_3)_4$ (48 mg, 0.04 mmol) in toluene (5 ml) was stirred at 100 °C for 3 h. After cooling the solids were filtered off and the filtrate was co-evaporated with silica and chromatography on silica (hexanes–AcOEt, 6:1) afforded product **27a** (426 mg, 95%) as a colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.59 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.9, H-4′); 4.82 (m, 2 H, H-5′a and 5′b); 5.38 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.9, H-2′); 5.78 (ddd, 1 H, $J_{H,F}$ = 17.3, $J_{3',4'}$ = 3.0, $J_{3',2'}$ = 0.8, H-3′); 6.89 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 6.99 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.8, H-1′); 7.43–7.69 (m, 10 H, H-*m*-Bz, H-6, H-*p*-Bz); 8.09–8.16 (m, 6 H, H-*o*-Bz); 8.98 (s, 1 H, H-2). MS (ESI) *m/z*: 538 (M + H), 560 (M + Na). HRMS (ESI) for $C_{31}H_{25}N_3O_5F$ [M + H] calculated: 538.1773; found 538.1771.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(furan-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27b**)

An argon purged mixture of compound **23** (496 mg, 1 mmol), 2-(tributylstannyl)furane (411 µl, 1.30 mmol) and $PdCl_2(PPh_3)_2$ (35 mg, 0.05 mmol) in DMF (5 ml) was stirred at 100 °C for 1 h. After cooling volatiles were removed in vacuo and the residue was several times co-evaporated with toluene. Column chromatography on silica (hexanes–AcOEt, 20:1→6:1) afforded product **27b** (511 mg, 97%) as a colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.57 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.9, H-4′); 4.81 (m, 2 H, H-5′a and 5′b); 5.36 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.8, $J_{2',3'}$ = 0.9, H-2′); 5.76 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 0.8, H-3′); 6.63 (dd, 1 H, $J_{4,3}$ = 3.5, $J_{4,5}$ = 1.8, H-4-furyl); 6.94 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.8, H-1′); 7.08 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 7.42–7.67 (m, 8 H, H-*m*-Bz, H-6, H-3-furyl, H-*p*-Bz); 7.71 (dd, 1 H, $J_{5,4}$ = 1.8, $J_{5,3}$ = 0.8, H-5-furyl); 8.11 (m, 4 H, H-*o*-Bz); 8.86 (s, 1 H, H-2). MS (ESI) *m/z*: 528 (M + H), 550 (M + Na). HRMS (ESI) for $C_{29}H_{23}N_3O_6F$ [M + H] calculated: 528.1565; found 528.1562.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27c**)

Compound **27c** was prepared as described for **27b** by the reaction of compound **23** (496 mg, 1 mmol) and 2-(tributylstannyl)thiophene. Yield 495 mg (91%). Colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.58 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.9, H-4′); 4.81 (m, 2 H, H-5′a and 5′b); 5.37 (ddd, 1 H, $J_{H,F}$ = 50.0, $J_{2',1'}$ = 2.8, $J_{2',3'}$ = 0.9, H-2′); 5.77 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 0.9, H-3′); 6.94 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 6.96 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.8, H-1′); 7.23 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,3}$ = 3.8, H-4-thienyl); 7.46, 7.51 (2 × m, 2 × 2 H,

H-*m*-Bz); 7.55–7.61 (m, 1 H, H-6); 7.57 (dd, 1 H, $J_{5,4}$ = 5.2, $J_{5,3}$ = 1.2, H-5-thienyl); 7.62, 7.65 (2 × m, 2 × 1 H, H-*p*-Bz); 7.98 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.2, H-3-thienyl); 8.11 (m, 4 H, H-*o*-Bz); 8.86 (s, 1 H, H-2). MS (ESI) *m/z*: 544 (M + H), 566 (M + Na). HRMS (ESI) for $C_{29}H_{23}N_3O_5FS$ [M + H] calculated: 544.1337; found 544.1334.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(furan-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27d**)

Compound **27d** was prepared as described for **27a** by the reaction of compound **23** (372 mg, 0.75 mmol) and furane-3-boronic acid. Yield 384 mg (97%). Colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.58 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.9, H-4′); 4.81 (m, 2 H, H-5′a and 5′b); 5.37 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.8, $J_{2',3'}$ = 0.8, H-2′); 5.76 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 3.0, $J_{3',2'}$ = 0.8, H-3′); 6.75 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 6.95 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.8, H-1′); 7.14 (dd, 1 H, $J_{4,5}$ = 1.9, $J_{4,2}$ = 0.9, H-4-furyl); 7.41–7.68 (m, 8 H, H-*m*-Bz, H-6, H-5-furyl, H-*p*-Bz); 8.27 (dd, 1 H, $J_{2,5}$ = 1.5, $J_{2,4}$ = 0.9, H-2-furyl); 8.08–8.14 (m, 4 H, H-*o*-Bz); 8.87 (s, 1 H, H-2). MS (ESI) *m/z*: 528 (M + H), 550 (M + Na). HRMS (ESI) for $C_{29}H_{23}N_3O_6F$ [M + H] calculated: 528.1565; found 528.1564.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiophen-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27e**)

Compound **27e** was prepared as described for **27a** by the reaction of compound **23** (621 mg, 1.25 mmol) and thiophene-3-boronic acid. Yield 645 mg (95%). Colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.58 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 3.0, H-4′); 4.81 (m, 2 H, H-5′a and 5′b); 5.37 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.8, $J_{2',3'}$ = 0.9, H-2′); 5.77 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 0.9, H-3′); 6.88 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 6.97 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.8, H-1′); 7.43–7.69 (m, 8 H, H-*m*-Bz, H-6, H-5-thienyl, H-*p*-Bz); 7.89 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,2}$ = 1.3, H-4-thienyl); 8.09-8.16 (m, 4 H, H-*o*-Bz); 8.20 (dd, 1 H, $J_{2,5}$ = 3.0, $J_{2,4}$ = 1.3, H-2-thienyl); 8.91 (s, 1 H, H-2). MS (ESI) *m/z*: 544 (M + H), 566 (M + Na). HRMS (ESI) for $C_{29}H_{23}N_3O_5FS$ [M + H] calculated: 544.1337; found 544.1334.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiazol-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27g**)

Compound **27g** was prepared as described for **27b** by the reaction of compound **23** (337 mg, 0.68 mmol) and 2-(tributylstannyl)thiazole. Reaction time 18 h. Yield 300 mg (81%). Yellowish oil. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.59 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 3.0, H-4′); 4.82 (m, 2 H, H-5′a and 5′b); 5.37 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.9, H-2′); 5.77 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 3.0, $J_{3',2'}$ = 0.9, H-3′); 6.97 (dd, 1 H, $J_{H,F}$ = 23.0, $J_{1',2'}$ = 2.9, H-1′); 7.43–7.70 (m, 9 H, H-5-thiazolyl, H-5, H-*m*-Bz, H-6, H-*p*-Bz); 8.09–8.15 (m, 5 H, H-4-thiazolyl, H-*o*-Bz); 8.91 (s, 1 H, H-2). MS (ESI) *m/z*: 545 (M + H), 567 (M + Na).

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-4-methyl-7*H*-pyrrolo[2,3-*d*]pyrimidine (**27h**)

An argon purged mixture of compound **23** (337 mg, 0.68 mmol), trimethylaluminium (2 M in toluene, 680 µl, 1.36 mmol) and $Pd(PPh_3)_4$ (39 mg, 0.034 mmol) in THF (3 ml) was stirred at 100 °C for 6 h. The mixture was diluted with $CHCl_3$ (20 ml) and treated with aq.

NH_4Cl (sat., 20 ml). The slurry was filtered through cellite and after phase separation, aqueous phase was re-extracted with $CHCl_3$ (2 × 10 ml). Combined organics were dried over $MgSO_4$, evaporated and the residue was chromatographed on silica (hexanes–AcOEt, 2:1) affording compound **27h** (320 mg, 99%) as a colorless oil. ^{1}H NMR (400.1 MHz, $CDCl_3$): 2.76 (s, 3 H, CH_3); 4.56 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 3.0, H-4′); 4.79 (m, 2 H, H-5′a and 5′b); 5.34 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.8, $J_{2',3'}$ = 1.0, H-2′); 5.76 (ddd, 1 H, $J_{H,F}$ = 17.3, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 1.0, H-3′); 6.62 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 6.91 (dd, 1 H, $J_{H,F}$ = 23.2, $J_{1',2'}$ = 2.9, H-1′); 7.45 (m, 2 H, H-*m*-Bz); 7.48–7.55 (m, 3 H, H-*m*-Bz and H-6); 7.58, 7.66 (2 × m, 2 × 1 H, H-*p*-Bz); 8.11 (m, 4 H, H-*o*-Bz); 8.78 (s, 1 H, H-2). MS (ESI) *m/z*: 476 (M + H). HRMS (ESI) for $C_{26}H_{23}N_3O_5F$ [M + H] calculated: 476.1616; found 476.1607.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-phenyl-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28a**)

Compound **27a** (400 mg, 0.74 mmol) was treated with NaOMe (1 M in MeOH, 200 µl, 0.2 mmol) in MeOH (5 ml) for 12 h at r.t.. The mixture was co-evaporated with silica and chromatographed on a column of silica (2.5% MeOH in $CHCl_3$) affording product **28a** (225 mg, 92%) as a colorless foamy solid. M.p. 72–76 °C. $[\alpha]_D$ +44.2 (*c* 0.339, DMSO). ^{1}H NMR (400.1 MHz, DMSO-d_6): 3.66 (dtd, 1 H, J_{gem} = 11.9, $J_{5'b,OH}$ = $J_{5'b,4'}$ = 5.7, $J_{H,F}$ = 0.9, H-5′b); 3.725 (dddd, 1 H, J_{gem} = 11.9, $J_{5'a,OH}$ = 5.7, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.4, H-5′a); 3.88 (dddd, 1 H, $J_{4',5'}$ = 5.7, 4.3, $J_{4',3'}$ = 5.1, $J_{H,F}$ = 0.5, H-4′); 4.45 (dtd, 1 H, $J_{H,F}$ = 19.0, $J_{3',4'}$ = $J_{3',OH}$ = 5.1, $J_{3',2'}$ = 3.8, H-3′); 5.13 (t, 1 H, $J_{OH,5'}$ = 5.7, OH-5′); 5.24 (ddd, 1 H, $J_{H,F}$ = 52.7, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.8, H-2′); 5.99 (d, 1 H, $J_{OH,3'}$ = 5.0, OH-3′); 6.80 (dd, 1 H, $J_{H,F}$ = 15.1, $J_{1',2'}$ = 4.6, H-1′); 7.02 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.54–7.63 (m, 3 H, H-*m*,*p*-Ph); 7.85 (dd, 1 H, $J_{6,5}$ = 3.8, $J_{H,F}$ = 2.2, H-6); 8.17 (m, 2 H, H-*o*-Ph); 8.92 (s, 1 H, H-2). ^{13}C NMR (100.6 MHz, DMSO-d_6): 60.62 (CH_2-5′); 73.07 (d, $J_{C,F}$ = 23.3, CH-3′); 81.40 (d, $J_{C,F}$ = 16.8, CH-1′); 83.41 (d, $J_{C,F}$ = 5.0, CH-4′); 96.02 (d, $J_{C,F}$ = 191.7, CH-2′); 101.05 (CH-5); 115.13 (C-4a); 128.78 (CH-*o*-Ph); 129.05 (CH-*m*-Ph); 129.09 (d, $J_{C,F}$ = 3.9, CH-6); 130.45 (CH-*p*-Ph); 137.56 (C-*i*-Ph); 151.30 (CH-2); 151.72 (C-7a); 156.31 (C-4). ^{19}F NMR (470.3 MHz, DMSO-d_6): -197.90. MS (ESI) *m/z*: 330 (M + H), 352 (M + Na). HRMS (ESI) for $C_{17}H_{17}N_3O_3F$ [M + H] calculated: 330.1249; found: 330.1248. HRMS (ESI) for $C_{17}H_{16}N_3O_3FNa$ [M + Na] calculated: 352.1068; found: 352.1067. For $C_{17}H_{16}N_3O_3F{\cdot}0.3H_2O$ calculated: 61.00% C, 5.00% H, 12.55% N; found: 61.28% C, 4.97% H, 12.28% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(furan-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28b**).

Deprotection of **27b** (495 mg, 0.94 mmol) as described for **28a** gave compound **28b** as a beige foam. Yield 270 mg (90%). Compound **28b** crystallized from MeOH(trace)–AcOEt–hexanes as a beige microcrystalline solid. M.p. 185–187 °C. $[\alpha]_D$ +39.9 (*c* 0.321, DMSO). ^{1}H NMR (600.1 MHz, DMSO-d_6): 3.65 (dddd, 1 H, J_{gem} = 11.8, $J_{5'b,OH}$ = 5.7, $J_{5'b,4'}$ = 5.3, $J_{H,F}$ = 0.9, H-5′b); 3.71 (dddd, 1 H, J_{gem} = 11.8, $J_{5'a,OH}$ = 5.7, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.6, H-5′a); 3.86 (tdd, 1 H, $J_{4',5'}$ = 5.3, 4.3, $J_{4',3'}$ = 5.3, $J_{H,F}$ = 0.8, H-4′); 4.42 (dddd, 1 H, $J_{H,F}$ = 19.0, $J_{3',4'}$ = 5.3, $J_{3',OH}$ = 5.0, $J_{3',2'}$ = 3.7, H-3′); 5.13 (t, 1 H, $J_{OH,5'}$ = 5.7, OH-5′); 5.22 (ddd, 1 H, $J_{H,F}$ = 52.6, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.7, H-2′); 5.98 (d, 1 H, $J_{OH,3'}$ = 5.0, OH-3′); 6.74 (dd, 1 H, $J_{H,F}$ = 15.2, $J_{1',2'}$ = 4.6, H-1′); 6.79 (dd, 1 H, $J_{4,3}$ = 3.5, $J_{4,5}$ = 1.8, H-4-furyl); 7.07 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.49 (dd, 1 H, $J_{3,4}$ = 3.5, $J_{3,5}$ = 0.8, H-3-furyl); 7.81 (dd, 1 H, $J_{6,5}$ = 3.8, $J_{H,F}$ = 2.3, H-6); 8.07 (dd,

1 H, $J_{5,4}$ = 1.8, $J_{5,3}$ = 0.8, H-5-furyl); 8.79 (s, 1 H, H-2). ^{13}C NMR (150.9 MHz, DMSO-d_6): 60.63 (CH_2-5′); 73.01 (d, $J_{C,F}$ = 23.2, CH-3′); 81.22 (d, $J_{C,F}$ = 16.8, CH-1′); 83.35 (d, $J_{C,F}$ = 5.2, CH-4′); 96.05 (d, $J_{C,F}$ = 191.6, CH-2′); 101.41 (CH-5); 112.34 (C-4a); 112.92 (CH-4-furyl); 113.60 (CH-3-furyl); 129.16 (d, $J_{C,F}$ = 3.6, CH-6); 146.62 (C-4); 146.64 (CH-5-furyl); 151.37 (CH-2); 151.86 (C-7a); 152.59 (C-2-furyl). ^{19}F NMR (470.3 MHz, DMSO-d_6): –194.35. MS (ESI) *m/z*: 320 (M + H), 342 (M + Na). HRMS (ESI) for $C_{15}H_{15}N_3O_4F$ [M + H] calculated: 320.1041; found: 320.1041. HRMS (ESI) for $C_{15}H_{14}N_3O_4FNa$ [M + Na] calculated: 342.0861; found: 342.0860. For $C_{15}H_{14}N_3O_4F$ calculated: 56.43% C, 4.42%% H, 13.16% N; found: 56.12% C, 4.53% H, 12.87% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28c**)

Deprotection of **27c** (470 mg, 0.86 mmol) as described for **28a** gave compound **28c** as an amorphous yellow solid. Yield 247 mg (85%). Compound **28c** was recrystallized from EtOH as an yellow crystalline solid. M.p. 144–146 °C. $[\alpha]_D$ +39.8 (*c* 0.587, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.66 (dddd, 1 H, J_{gem} = 11.8, $J_{5'b,OH}$ = 5.7, $J_{5'b,4'}$ = 5.3, $J_{H,F}$ = 0.8, H-5′b); 3.72 (dddd, 1 H, J_{gem} = 11.8, $J_{5'a,OH}$ = 5.7, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.6, H-5′a); 3.86 (tdd, 1 H, $J_{4',5'}$ = 5.3, 4.3, $J_{4',3'}$ = 5.3, $J_{H,F}$ = 0.7, H-4′); 4.44 (dddd, 1 H, $J_{H,F}$ = 19.0, $J_{3',4'}$ = 5.3, $J_{3',OH}$ = 5.0, $J_{3',2'}$ = 3.9, H-3′); 5.15 (t, 1 H, $J_{OH,5'}$ = 5.7, OH-5′); 5.23 (ddd, 1 H, $J_{H,F}$ = 52.8, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.9, H-2′); 5.99 (d, 1 H, $J_{OH,3'}$ = 5.0, OH-3′); 6.75 (dd, 1 H, $J_{H,F}$ = 14.5, $J_{1',2'}$ = 4.6, H-1′); 7.19 (d, 1 H, $J_{5,6}$ = 3.9, H-5); 7.31 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,3}$ = 3.8, H-4-thienyl); 7.85 (dd, 1 H, $J_{6,5}$ = 3.9, $J_{H,F}$ = 2.3, H-6); 7.87 (dd, 1 H, $J_{5,4}$ = 5.1, $J_{5,3}$ = 1.1, H-5-thienyl); 8.18 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.1, H-3-thienyl); 8.78 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.58 (CH_2-5′); 72.91 (d, $J_{C,F}$ = 23.2, CH-3′); 81.30 (d, $J_{C,F}$ = 16.8, CH-1′); 83.31 (d, $J_{C,F}$ = 5.4, CH-4′); 96.06 (d, $J_{C,F}$ = 191.7, CH-2′); 101.04 (CH-5); 112.68 (C-4a); 129.32 (d, $J_{C,F}$ = 3.6, CH-6); 129.35 (CH-4-thienyl); 129.91 (CH-3-thienyl); 131.08 (CH-5-thienyl); 142.50 (C-2-thienyl); 150.34 (C-4); 151.15 (CH-2); 151.79 (C-7a). ^{19}F NMR (470.3 MHz, DMSO-d_6): -194.43. MS (ESI) *m/z*: 336 (M + H), 358 (M + Na). HRMS (ESI) for $C_{15}H_{15}N_3O_3FS$ [M + H] calculated: 336.0813; found: 336.0813. HRMS (ESI) for $C_{15}H_{14}N_3O_3FSNa$ [M + Na] calculated: 358.0632; found: 358.0632. For $C_{15}H_{14}N_3O_3FS$ calculated: 53.72% C, 4.21% H, 12.53% N; found: 53.47% C, 4.38% H, 12.24% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(furan-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28d**)

Deprotection of **27d** (370 mg, 0.70 mmol) as described for **28a** gave compound **28d** as a white foam. Yield 193 mg (86%). Compound **28d** crystallized from MeOH–water as white leaves. M.p. 112–114 °C. $[\alpha]_D$ +38.7 (*c* 0.336, DMSO). ^{1}H NMR (400.1 MHz, DMSO-d_6): 3.66 (dt, 1 H, J_{gem} = 12.0, $J_{5'b,OH}$ = $J_{5'b,4'}$ = 5.6, H-5′b); 3.72 (dddd, 1 H, J_{gem} = 12.0, $J_{5'a,OH}$ = 5.6, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.5, H-5′a); 3.87 (ddd, 1 H, $J_{4',5'}$ = 5.6, 4.3, $J_{4',3'}$ = 5.3, H-4′); 4.44 (dddd, 1 H, $J_{H,F}$ = 19.2, $J_{3',4'}$ = 5.3, $J_{3',OH}$ = 5.0, $J_{3',2'}$ = 3.9, H-3′); 5.12 (t, 1 H, $J_{OH,5'}$ = 5.6, OH-5′); 5.22 (ddd, 1 H, $J_{H,F}$ = 52.7, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.9, H-2′); 5.97 (d, 1 H, $J_{OH,3'}$ = 5.0, OH-3′); 6.75 (dd, 1 H, $J_{H,F}$ = 14.7, $J_{1',2'}$ = 4.6, H-1′); 7.11 (d, 1 H, $J_{5,6}$ = 3.8, H-5); 7.26 (dd, 1 H, $J_{4,5}$ = 1.9, $J_{4,2}$ = 0.8, H-4-furyl); 7.80 (dd, 1 H, $J_{6,5}$ = 3.8, $J_{H,F}$ = 2.2, H-6); 7.90 (dd, 1 H, $J_{5,4}$ = 1.9, $J_{5,2}$ = 1.4, H-5-furyl); 8.74 (dd, 1 H, $J_{2,5}$ = 1.4, $J_{2,4}$ = 0.8, H-2-furyl); 8.81 (s, 1 H, H-2). ^{13}C NMR (100.6 MHz, DMSO-d_6): 60.59 (CH_2-5′); 73.00 (d, $J_{C,F}$ = 23.3, CH-3′); 81.26 (d, $J_{C,F}$ = 16.9,

CH-1′); 83.31 (d, $J_{C,F}$ = 5.1, CH-4′); 96.02 (d, $J_{C,F}$ = 191.7, CH-2′); 100.84 (CH-5); 109.51 (CH-4-furyl); 114.16 (C-4a); 125.11 (C-3-furyl); 128.58 (d, $J_{C,F}$ = 3.6, CH-6); 144.73 (CH-5-furyl); 145.02 (CH-2-furyl); 150.21 (C-4); 151.26 (CH-2); 151.32 (C-7a). ^{19}F NMR (470.3 MHz, DMSO-d_6): –198.01. MS (ESI) *m/z*: 320 (M + H), 342 (M + Na). HRMS (ESI) for $C_{15}H_{15}N_3O_4F$ [M + H] calculated: 320.1041; found: 320.1041. HRMS (ESI) for $C_{15}H_{14}N_3O_4FNa$ [M + Na] calculated: 342.0861; found: 342.0860. For $C_{15}H_{14}N_3O_4F{\cdot}0.5H_2O$ calculated: 54.88% C, 4.61% H, 12.80% N; found: 55.10% C, 4.61% H, 12.48% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiophen-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28e**)

Deprotection of **27e** (620 mg, 1.14 mmol) as described for **28a** gave compound **28e** as a brownish foamy solid after evaporation from MeOH. Yield 340 mg (89%). M.p. 71–73 °C. $[\alpha]_D$ +41.6 (*c* 0.375, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.66 (ddd, 1 H, J_{gem} = 12.0, $J_{5'b,4'}$ = 5.1, $J_{H,F}$ = 0.8, H-5′b); 3.72 (ddd, 1 H, J_{gem} = 12.0, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.5, H-5′a); 3.87 (dddd, 1 H, $J_{4',3'}$ = 5.4, $J_{4',5'}$ = 5.1, 4.3, $J_{H,F}$ = 0.8, H-4′); 4.44 (ddd, 1 H, $J_{H,F}$ = 19.1, $J_{3',4'}$ = 5.4, $J_{3',2'}$ = 3.8, H-3′); 5.10 (bs, 1 H, OH-5′); 5.22 (ddd, 1 H, $J_{H,F}$ = 52.7, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.8, H-2′); 5.98 (bs, 1 H, OH-3′); 6.77 (dd, 1 H, $J_{H,F}$ = 14.9, $J_{1',2'}$ = 4.6, H-1′); 7.15 (dd, 1 H, $J_{5,6}$ = 3.9, $J_{H,F}$ = 0.3, H-5); 7.75 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,2}$ = 2.9, H-5-thienyl); 7.83 (dd, 1 H, $J_{6,5}$ = 3.9, $J_{H,F}$ = 2.2, H-6); 7.96 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,2}$ = 1.3, H-4-thienyl); 8.55 (dd, 1 H, $J_{2,5}$ = 2.9, $J_{2,4}$ = 1.3, H-2-thienyl); 8.84 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.63 (CH_2-5′); 73.01 (d, $J_{C,F}$ = 23.1, CH-3′); 81.32 (d, $J_{C,F}$ = 16.9, CH-1′); 83.34 (d, $J_{C,F}$ = 5.2, CH-4′); 96.07 (d, $J_{C,F}$ = 191.7, CH-2′); 101.20 (CH-5); 114.24 (C-4a); 127.42 (CH-5-thienyl); 127.62 (CH-4-thienyl); 128.91 (CH-2-thienyl); 129.02 (d, $J_{C,F}$ = 3.5, CH-6); 139.93 (C-3-thienyl); 151.25 (CH-2); 151.65 (C-4); 151.80 (C-7a). ^{19}F NMR (470.3 MHz, DMSO-d_6): –197.97. MS (ESI) *m/z*: 336 (M + H), 358 (M + Na). HRMS (ESI) for $C_{15}H_{15}N_3O_3FS$ [M + H] calculated: 336.0813; found: 336.0813. HRMS (ESI) for $C_{15}H_{14}N_3O_3FSNa$ [M + Na] calculated: 358.0632; found: 358.0632. For $C_{15}H_{14}N_3O_3FS$ calculated: 53.72% C, 4.21% H, 12.53% N; found: 53.61% C, 4.47% H, 12.15% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(thiazol-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28g**)

Deprotection of **27g** (290 mg, 0.53 mmol) as described for **28a** gave compound **28g** as a yellowish foamy solid after evaporation from diethylether. Yield 123 mg (69%). M.p. 150–152 °C. $[\alpha]_D$ +39.5 (*c* 0.324, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.66 (dd, 1 H, J_{gem} = 11.9, $J_{5'b,4'}$ = 5.1, H-5′b); 3.72 (ddd, 1 H, J_{gem} = 11.9, $J_{5'a,4'}$ = 4.1, $J_{H,F}$ = 1.3, H-5′a); 3.87 (dddd, 1 H, $J_{4',3'}$ = 5.6, $J_{4',5'}$ = 5.1, 4.1, $J_{H,F}$ = 0.8, H-4′); 4.43 (dddd, 1 H, $J_{H,F}$ = 18.7, $J_{3',4'}$ = 5.6, $J_{3',OH}$ = 4.4, $J_{3',2'}$ = 3.8, H-3′); 5.13 (bs, 1 H, OH-5′); 5.24 (ddd, 1 H, $J_{H,F}$ = 52.7, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.8, H-2′); 5.99 (bd, 1 H, $J_{OH,3'}$ = 4.4, OH-3′); 6.77 (dd, 1 H, $J_{H,F}$ = 14.9, $J_{1',2'}$ = 4.6, H-1′); 7.31 (dd, 1 H, $J_{5,6}$ = 3.7, $J_{H,F}$ = 0.4, H-5); 7.91 (dd, 1 H, $J_{6,5}$ = 3.7, $J_{H,F}$ = 2.2, H-6); 8.05 (d, 1 H, $J_{5,4}$ = 3.1, H-5-thiazolyl); 8.21 (d, 1 H, $J_{4,5}$ = 3.1, H-4-thiazolyl); 8.90 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.61 (CH_2-5′); 72.98 (d, $J_{C,F}$ = 23.2, CH-3′); 81.38 (d, $J_{C,F}$ = 16.8, CH-1′); 83.41 (d, $J_{C,F}$ = 5.3, CH-4′); 96.07 (d, $J_{C,F}$ = 191.7, CH-2′); 102.16 (CH-5); 113.41 (C-4a); 124.31 (CH-5-thiazolyl); 130.73 (d, $J_{C,F}$ = 3.6, CH-6); 145.78 (CH-4-thiazolyl); 148.27 (C-4); 151.19 (CH-2); 152.41 (C-7a); 167.33 (C-2-thiazolyl). ^{19}F NMR (470.3 MHz, DMSO-d_6): –197.98. MS (ESI) *m/z*: 337 (M + H), 359 (M + Na). HRMS (ESI) for $C_{14}H_{14}N_4O_3FS$

[M + H] calculated: 337.0765; found: 337.0765. HRMS (ESI) for $C_{14}H_{13}N_4O_3FSNa$ [M + Na] calculated: 359.0585; found: 359.0584. For $C_{14}H_{13}N_4O_3FS{\cdot}0.45C_4H_{10}O$ calculated: 51.33% C, 4.77% H, 15.15% N; found: 51.59% C, 4.53% H, 15.06% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-4-(methyl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**28h**)

Deprotection of **27h** (300 mg, 0.63 mmol) as described for **28a** gave compound **28h** as a white solid. Yield 143 mg (85%). Column chromatography (4% MeOH in $CHCl_3$). Compound **28h** was recrystallized from water as white prisms. M.p. 175–177 °C. $[\alpha]_D$ +32.2 (*c* 0.317, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 2.66 (s, 3 H, CH_3); 3.63 (ddd, 1 H, J_{gem} = 12.0, $J_{5'b,OH}$ = 5.7, $J_{5'b,4'}$ = 5.2, $J_{H,F}$ = 0.8, H-5'b); 3.69 (dddd, 1 H, J_{gem} = 12.0, $J_{5'a,OH}$ = 5.7, $J_{5'a,4'}$ = 4.3, $J_{H,F}$ = 1.5, H-5'a); 3.84 (dddd, 1 H, $J_{4',5'}$ = 5.2, 4.3, $J_{4',3'}$ = 5.0, $J_{H,F}$ = 0.9, H-4'); 4.40 (dtd, 1 H, $J_{H,F}$ = 19.1, $J_{3',4'}$ = $J_{3',OH}$ = 5.0, $J_{3',2'}$ = 3.8, H-3'); 5.08 (t, 1 H, $J_{OH,5'}$ = 5.7, OH-5'); 5.18 (ddd, 1 H, $J_{H,F}$ = 52.7, $J_{2',1'}$ = 4.6, $J_{2',3'}$ = 3.8, H-2'); 5.93 (d, 1 H, $J_{OH,3'}$ = 5.0, OH-3'); 6.69 (dd, 1 H, $J_{H,F}$ = 15.0, $J_{1',2'}$ = 4.6, H-1'); 6.76 (dd, 1 H, $J_{5,6}$ = 3.8, $J_{H,F}$ = 0.4, H-5); 7.67 (dd, 1 H, $J_{6,5}$ = 3.8, $J_{H,F}$ = 2.2, H-6); 8.67 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 21.33 (CH_3); 60.62 (CH_2-5'); 72.98 (d, $J_{C,F}$ = 23.2, CH-3'); 81.20 (d, $J_{C,F}$ = 16.9, CH-1'); 83.21 (d, $J_{C,F}$ = 5.3, CH-4'); 96.02 (d, $J_{C,F}$ = 191.7, CH-2'); 100.29 (CH-5); 117.58 (C-4a); 127.46 (d, $J_{C,F}$ = 3.6, CH-6); 150.09 (C-7a); 151.11 (CH-2); 159.21 (C-4). ^{19}F NMR (470.3 MHz, DMSO-d_6): –198.03. MS (ESI) *m/z*: 268 (M + H), 290 (M + Na). HRMS (ESI) for $C_{12}H_{15}N_3O_3F$ [M + H] calculated: 268.1092; found: 268.1092. HRMS (ESI) for $C_{12}H_{14}N_3O_3FNa$ [M + Na] calculated: 290.0911; found: 290.0912. For $C_{12}H_{14}N_3O_3F$ calculated: 53.93% C, 5.28% H, 15.72% N; found: 53.87% C, 5.25% H, 15.63% N.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(furan-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**29b**)

Compound **29b** was prepared as described for **27b** by the reaction of compound **24** (514 mg, 1 mmol) and 2-(tributylstannyl)furane. Yield 480 mg (88%). Yellowish oil. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.56 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.9, H-4'); 4.79 (m, 2 H, H-5'a and 5'b); 5.35 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.9, H-2'); 5.74 (ddd, 1 H, $J_{H,F}$ = 17.3, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 0.9, H-3'); 6.65 (dd, 1 H, $J_{4,3}$ = 3.6, $J_{4,5}$ = 1.7, H-4-furyl); 6.99 (ddd, 1 H, $J_{H,F}$ = 22.8, 1.7, $J_{1',2'}$ = 2.9, H-1'); 7.39 (dd, 1 H, $J_{H,F}$ = 2.8, 2.3, H-6); 7.43–7.70 (m, 7 H, H-*m*-Bz, H-3-furyl, H-*p*-Bz); 7.74 (dd, 1 H, $J_{5,4}$ = 1.8, $J_{5,3}$ = 0.8, H-5-furyl); 8.11 (m, 4 H, H-*o*-Bz); 8.88 (s, 1 H, H-2). MS (ESI) *m/z*: 546 (M + H), 568 (M + Na). HRMS (ESI) for $C_{29}H_{22}N_3O_6F_2$ [M + H] calculated: 546.1471; found: 546.1468.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**29c**)

Compound **29c** was prepared as described for **27b** by the reaction of compound **24** (514 mg, 1 mmol) and 2-(tributylstannyl)thiophene. Yield 500 mg (89%). Yellowish oil. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.56 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 3.0, H-4'); 4.80 (m, 2 H, H-5'a and 5'b); 5.35 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.8, H-2'); 5.74 (ddd, 1 H, $J_{H,F}$ = 17.2, $J_{3',4'}$ = 2.9, $J_{3',2'}$ = 0.7, H-3'); 6.99 (ddd, 1 H, $J_{H,F}$ = 23.2, 1.8, $J_{1',2'}$ = 2.8, H-1'); 7.23 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,3}$ = 3.9, H-4-thienyl); 7.39 (dd, 1 H, $J_{H,F}$ = 3.0, 2.2, H-6); 7.43–7.69 (m, 7 H, H-*m*-Bz, H-5-thienyl, H-*p*-Bz); 8.12 (m, 4 H, H-*o*-Bz); 8.17 (dd, 1 H, $J_{3,4}$ = 3.9, $J_{3,5}$ = 1.1,

H-3-thienyl); 8.81 (s, 1 H, H-2). MS (ESI) *m/z*: 562 (M + H), 584 (M + Na). HRMS (ESI) for $C_{29}H_{22}N_3O_5F_2S$ [M + H] calculated: 562.1243; found: 562.1240. HRMS (ESI) for $C_{29}H_{21}N_3O_5F_2SNa$ [M + Na] calculated: 584.1062; found: 584.1060.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(furan-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**29d**)

Compound **29d** was prepared as described for **27a** by the reaction of compound **24** (514 mg, 1 mmol) and furane-3-boronic acid. Yield 496 mg (91%). Colorless foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.56 (dt, 1 H, $J_{4',5'}$ = 4.8, 4.8, $J_{4',3'}$ = 3.0, H-4′); 4.79 (m, 2 H, H-5′a and 5′b); 5.35 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.8, H-2′); 5.74 (ddd, 1 H, $J_{H,F}$ = 17.4, $J_{3',4'}$ = 2.7, $J_{3',2'}$ = 0.7, H-3′); 6.99 (ddd, 1 H, $J_{H,F}$ = 23.2, 1.8, $J_{1',2'}$ = 2.8, H-1′); 7.25 (m, 1 H, H-4-furyl); 7.37 (t, 1 H, $J_{H,F}$ = 2.6, H-6); 7.42–7.70 (m, 7 H, H-*m*-Bz, H-5-furyl, H-*p*-Bz); 8.11 (m, 4 H, H-*o*-Bz); 8.41 (dd, 1 H, $J_{2,5}$ = 1.5, $J_{2,4}$ = 0.8, H-2-furyl); 8.86 (s, 1 H, H-2). MS (ESI) *m/z*: 546 (M + H), 568 (M + Na). HRMS (ESI) for $C_{29}H_{22}N_3O_6F_2$ [M + H] calculated: 546.1471; found: 546.1467.

7-(3,5-Di-*O*-benzoyl-2-deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(thiophen-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**29e**)

Compound **29e** was prepared as described for **27a** by the reaction of compound **24** (514 mg, 1 mmol) and thiophene-3-boronic acid. Yield 494 mg (88%). Yellowish foam. ^{1}H NMR (400.1 MHz, $CDCl_3$): 4.56 (dt, 1 H, $J_{4',5'}$ = 4.7, 4.7, $J_{4',3'}$ = 2.8, H-4′); 4.80 (m, 2 H, H-5′a and 5′b); 5.36 (ddd, 1 H, $J_{H,F}$ = 50.1, $J_{2',1'}$ = 2.9, $J_{2',3'}$ = 0.9, H-2′); 5.74 (ddd, 1 H, $J_{H,F}$ = 17.3, $J_{3',4'}$ = 3.0, $J_{3',2'}$ = 0.9, H-3′); 7.01 (ddd, 1 H, $J_{H,F}$ = 23.2, 2.0, $J_{1',2'}$ = 2.9, H-1′); 7.38 (dd, 1 H, $J_{H,F}$ = 3.0, 2.2, H-6); 7.42–7.69 (m, 7 H, H-*m*-Bz, H-5-thienyl, H-*p*-Bz); 7.93 (dd, 1 H, $J_{4,5}$ = 5.1, $J_{4,2}$ = 1.0, H-4-thienyl); 8.12 (m, 4 H, H-*o*-Bz); 8.30 (dd, 1 H, $J_{2,5}$ = 3.0, $J_{2,4}$ = 0.9, H-2-thienyl); 8.88 (s, 1 H, H-2). MS (ESI) *m/z*: 562 (M + H), 584 (M + Na). HRMS (ESI) for $C_{29}H_{22}N_3O_5F_2S$ [M + H] calculated: 562.1243; found: 562.1240.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(furan-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**30b**)

Deprotection of **29b** (465 mg, 0.85 mmol) as described for **28a** gave compound **30b** as a yellowish oil which solidified on standing. Yield 270 mg (94%). Compound **30b** was recrystallized from MeOH. M.p. 187–188 °C. $[\alpha]_D$ +46.9 (*c* 0.460, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.64 (dddd, 1 H, J_{gem} = 12.0, $J_{5'b,OH}$ = 5.6, $J_{5'b,4'}$ = 4.7, $J_{H,F}$ = 0.6, H-5′b); 3.71 (dddd, 1 H, J_{gem} = 12.0, $J_{5'a,OH}$ = 5.6, $J_{5'a,4'}$ = 4.0, $J_{H,F}$ = 1.6, H-5′a); 3.85 (dddd, 1 H, $J_{4',3'}$ = 5.5, $J_{4',5'}$ = 4.7, 4.0, $J_{H,F}$ = 0.8, H-4′); 4.41 (ddd, 1 H, $J_{H,F}$ = 19.2, $J_{3',4'}$ = 5.5, $J_{3',OH}$ = 5.1, $J_{3',2'}$ = 4.3, H-3′); 5.13 (t, 1 H, $J_{OH,5'}$ = 5.6, OH-5′); 5.23 (ddd, 1 H, $J_{H,F}$ = 52.8, $J_{2',1'}$ = 4.7, $J_{2',3'}$ = 4.3, H-2′); 5.95 (t, 1 H, $J_{OH,3'}$ = 5.1, OH-3′); 6.80 (ddd, 1 H, $J_{H,F}$ = 13.3, 1.7, $J_{1',2'}$ = 4.7, H-1′); 6.81 (dd, 1 H, $J_{4,3}$ = 3.5, $J_{4,5}$ = 1.7, H-4-furyl); 7.49 (dd, 1 H, $J_{3,4}$ = 3.5, $J_{3,5}$ = 0.8, H-3-furyl); 7.85 (t, 1 H, $J_{H,F}$ = 1.9, H-6); 8.08 (dd, 1 H, $J_{5,4}$ = 1.7, $J_{5,3}$ = 0.8, H-5-furyl); 8.82 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.42 (CH_2-5′); 72.51 (d, $J_{C,F}$ = 23.0, CH-3′); 80.75 (d, $J_{C,F}$ = 16.9, CH-1′); 83.17 (d, $J_{C,F}$ = 5.9, CH-4′); 95.98 (d, $J_{C,F}$ = 192.0, CH-2′); 101.90 (d, $J_{C,F}$ = 15.9, C-4a); 111.85 (dd, $J_{C,F}$ = 30.7, 3.4, CH-6); 113.13 (CH-4-furyl); 115.02 (d, $J_{C,F}$ = 5.8, CH-3-furyl); 141.33 (d, $J_{C,F}$ = 249.0, C-5); 146.06 (d, $J_{C,F}$ = 3.7, C-4); 147.08 (CH-5-furyl); 147.26 (d, $J_{C,F}$ = 3.1, C-7a); 150.99 (d, $J_{C,F}$ = 1.6, C-2-furyl); 151.88 (CH-2). ^{19}F NMR

(470.3 MHz, DMSO-d_6): –198.80 (ddd, $J_{F,H}$ = 52.8, 19.2, 13.3); –161.19 (s). MS (ESI) *m/z*: 338 (M + H), 360 (M + Na). HRMS (ESI) for $C_{15}H_{14}N_3O_4F_2$ [M + H] calculated: 338.0947; found: 338.0947. HRMS (ESI) for $C_{15}H_{13}N_3O_4F_2Na$ [M + Na] calculated: 360.0766; found: 360.0766. For $C_{15}H_{13}N_3O_4F_2$ calculated: 53.42% C, 3.88% H, 12.46% N; found: 53.40% C, 4.12% H, 12.07% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(thiophen-2-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**30c**)

Deprotection of **29c** (485 mg, 0.86 mmol) as described for **28a** gave compound **30c** as a yellow foamy solid. Yield 278 mg (91%). Compound **30c** was crystallized from MeOH–water as off white needles. M.p. 104–106 °C. $[\alpha]_D$ +43.8 (*c* 0.653, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.65 (ddd, 1 H, J_{gem} = 12.1, $J_{5'b,4'}$ = 5.0, $J_{H,F}$ = 0.7, H-5'b); 3.72 (ddd, 1 H, J_{gem} = 12.0, $J_{5'a,4'}$ = 4.1, $J_{H,F}$ = 1.6, H-5'a); 3.85 (dddd, 1 H, $J_{4',3'}$ = 5.7, $J_{4',5'}$ = 5.0, 4.1, $J_{H,F}$ = 0.9, H-4'); 4.42 (ddd, 1 H, $J_{H,F}$ = 19.1, $J_{3',4'}$ = 5.7, $J_{3',2'}$ = 4.2, H-3'); 5.24 (ddd, 1 H, $J_{H,F}$ = 52.8, $J_{2',1'}$ = 4.8, $J_{2',3'}$ = 4.2, H-2'); 6.80 (ddd, 1 H, $J_{H,F}$ = 13.2, 1.9, $J_{1',2'}$ = 4.8, H-1'); 7.305 (dd, 1 H, $J_{4,5}$ = 5.0, $J_{4,3}$ = 3.8, H-4-thienyl); 7.88 (t, 1 H, $J_{H,F}$ = 1.9, H-6); 7.89 (dd, 1 H, $J_{5,4}$ = 5.0, $J_{5,3}$ = 1.1, H-5-thienyl); 8.07 (dd, 1 H, $J_{3,4}$ = 3.8, $J_{3,5}$ = 1.1, H-3-thienyl); 8.78 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.48 (CH_2-5'); 72.56 (d, $J_{C,F}$ = 23.0, CH-3'); 80.93 (d, $J_{C,F}$ = 16.9, CH-1'); 83.26 (d, $J_{C,F}$ = 5.9, CH-4'); 96.02 (d, $J_{C,F}$ = 192.1, CH-2'); 102.30 (d, $J_{C,F}$ = 15.4, C-4a); 111.84 (dd, $J_{C,F}$ = 31.7, 3.2, CH-6); 129.42 (d, $J_{C,F}$ = 2.4, CH-4-thienyl); 130.45 (d, $J_{C,F}$ = 16.2, CH-3-thienyl); 132.10 (CH-5-thienyl); 141.48 (d, $J_{C,F}$ = 246.1, C-5); 141.85 (d, $J_{C,F}$ = 1.4, C-2-thienyl); 147.25 (d, $J_{C,F}$ = 3.5, C-7a); 150.35 (d, $J_{C,F}$ = 3.9, C-4); 151.82 (CH-2). ^{19}F NMR (470.3 MHz, DMSO-d_6): –198.76 (ddd, $J_{F,H}$ = 52.8, 19.1, 13.2); –160.20 (s). MS (ESI) *m/z*: 354 (M + H), 376 (M + Na). HRMS (ESI) for $C_{15}H_{14}N_3O_3F_2S$ [M + H] calculated: 354.0718; found: 354.0718. HRMS (ESI) for $C_{15}H_{13}N_3O_3F_2SNa$ [M + Na] calculated: 376.0538; found: 376.0537. For $C_{15}H_{13}N_3O_3F_2S{\cdot}0.2H_2O{\cdot}0.6CH_4O$ calculated: 49.81% C, 4.23% H, 11.17% N; found: 49.90% C, 4.12% H, 11.05% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(furan-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**30d**)

Deprotection of **29d** (480 mg, 0.88 mmol) as described for **28a** gave compound **30d** as a yellow foamy solid. Yield 276 mg (93%). Compound **30d** was crystallized from MeOH–diethylether as a ochry solid. M.p. 77–79 °C. $[\alpha]_D$ +32.8 (*c* 0.445, DMSO). ^{1}H NMR (600.1 MHz, DMSO-d_6): 3.65 (ddd, 1 H, J_{gem} = 12.0, $J_{5'b,4'}$ = 4.9, $J_{H,F}$ = 0.7, H-5'b); 3.71 (ddd, 1 H, J_{gem} = 12.0, $J_{5'a,4'}$ = 4.0, $J_{H,F}$ = 1.5, H-5'a); 3.84 (dddd, 1 H, $J_{4',3'}$ = 5.7, $J_{4',5'}$ = 4.9, 4.0, $J_{H,F}$ = 0.9, H-4'); 4.41 (ddd, 1 H, $J_{H,F}$ = 19.3, $J_{3',4'}$ = 5.7, $J_{3',2'}$ = 4.2, H-3'); 5.12 (bs, 1 H, OH-5'); 5.23 (ddd, 1 H, $J_{H,F}$ = 52.8, $J_{2',1'}$ = 4.8, $J_{2',3'}$ = 4.2, H-2'); 5.96 (bs, 1 H, OH-3'); 6.80 (ddd, 1 H, $J_{H,F}$ = 13.2, 1.9, $J_{1',2'}$ = 4.8, H-1'); 7.17 (dt, 1 H, $J_{4,5}$ = 1.8, $J_{4,2}$ = $J_{H,F}$ = 0.7, H-4-furyl); 7.83 (t, 1 H, $J_{H,F}$ = 1.9, H-6); 7.90 (dd, 1 H, $J_{5,4}$ = 1.8, $J_{5,2}$ = 1.5, H-5-furyl); 8.48 (dt, 1 H, $J_{2,5}$ = 1.5, $J_{2,4}$ = $J_{H,F}$ = 0.7, H-5-furyl); 8.84 (s, 1 H, H-2). ^{13}C NMR (150.9 MHz, DMSO-d_6): 60.45 (CH_2-5'); 72.53 (d, $J_{C,F}$ = 23.0, CH-3'); 80.78 (d, $J_{C,F}$ = 16.9, CH-1'); 83.18 (d, $J_{C,F}$ = 5.9, CH-4'); 95.99 (d, $J_{C,F}$ = 192.1, CH-2'); 103.82 (d, $J_{C,F}$ = 15.6, C-4a); 109.91 (d, $J_{C,F}$ = 6.3, CH-4-furyl); 111.39 (dd, $J_{C,F}$ = 30.8, 3.2, CH-6); 124.42 (d, $J_{C,F}$ = 1.0, C-3-furyl); 141.42 (d, $J_{C,F}$ = 246.0, C-5); 144.90 (d, $J_{C,F}$ = 0.9, CH-5-furyl); 145.55 (d, $J_{C,F}$ = 13.3, CH-2-furyl); 146.92 (d, $J_{C,F}$ = 3.4, C-7a); 149.74 (d, $J_{C,F}$ = 3.7, C-4); 152.09 (CH-2). ^{19}F NMR

(470.3 MHz, DMSO-d_6): –198.79 (ddd, $J_{F,H}$ = 52.8, 19.3, 13.2); –162.57 (s). MS (ESI) *m/z*: 338 (M + H), 360 (M + Na). HRMS (ESI) for $C_{15}H_{14}N_3O_4F_2$ [M + H] calculated: 338.0947; found: 338.0947. HRMS (ESI) for $C_{15}H_{13}N_3O_4F_2Na$ [M + Na] calculated: 360.0766; found: 360.0766. For $C_{15}H_{13}N_3O_4F_2 \cdot 0.7H_2O \cdot 0.2C_4H_{10}O$ calculated: 52.03% C, 4.53% H, 11.52% N; found: 52.04% C, 4.48% H, 11.46% N.

7-(2-Deoxy-2-fluoro-β-D-arabinofuranosyl)-5-fluoro-4-(thiophen-3-yl)-7*H*-pyrrolo[2,3-*d*]pyrimidine (**30e**)

Deprotection of **29e** (478 mg, 0.85 mmol) as described for **28a** gave compound **30e** as a yellowish foamy solid. Yield 271 mg (90%). Compound **30e** was crystallized from MeOH–water as ochry plates. M.p. 90–92 °C. $[\alpha]_D$ +42.5 (*c* 0.442, DMSO). ^{1}H NMR (499.8 MHz, DMSO-d_6): 3.65 (ddd, 1 H, J_{gem} = 12.0, $J_{5'b,4'}$ = 5.0, $J_{H,F}$ = 0.7, H-5'b); 3.72 (ddd, 1 H, J_{gem} = 12.0, $J_{5'a,4'}$ = 4.0, $J_{H,F}$ = 1.6, H-5'a); 3.85 (dddd, 1 H, $J_{4',3'}$ = 5.7, $J_{4',5'}$ = 5.0, 4.0, $J_{H,F}$ = 0.9, H-4'); 4.42 (ddd, 1 H, $J_{H,F}$ = 19.1, $J_{3',4'}$ = 5.7, $J_{3',2'}$ = 4.2, H-3'); 5.24 (ddd, 1 H, $J_{H,F}$ = 52.8, $J_{2',1'}$ = 4.8, $J_{2',3'}$ = 4.2, H-2'); 6.82 (ddd, 1 H, $J_{H,F}$ = 13.3, 1.8, $J_{1',2'}$ = 4.8, H-1'); 7.74 (dd, 1 H, $J_{5,4}$ = 5.1, $J_{5,2}$ = 2.9, H-5-thienyl); 7.83 (ddd, 1 H, $J_{4,5}$ = 5.1, $J_{4,2}$ = 1.3, $J_{H,F}$ = 0.9, H-4-thienyl); 7.865 (t, 1 H, $J_{H,F}$ = 1.9, H-6); 8.37 (ddd, 1 H, $J_{2,5}$ = 2.9, $J_{2,4}$ = 1.3, $J_{H,F}$ = 0.7, H-2-thienyl); 8.87 (s, 1 H, H-2). ^{13}C NMR (125.7 MHz, DMSO-d_6): 60.48 (CH_2-5'); 72.57 (d, $J_{C,F}$ = 23.0, CH-3'); 80.86 (d, $J_{C,F}$ = 17.0, CH-1'); 83.22 (d, $J_{C,F}$ = 5.9, CH-4'); 96.03 (d, $J_{C,F}$ = 192.0, CH-2'); 103.99 (d, $J_{C,F}$ = 15.0, C-4a); 111.64 (dd, $J_{C,F}$ = 31.1, 3.3, CH-6); 127.36 (CH-5-thienyl); 128.02 (d, $J_{C,F}$ = 10.8, CH-4-thienyl); 129.77 (d, $J_{C,F}$ = 10.8, CH-2-thienyl); 138.88 (C-3-thienyl); 141.52 (d, $J_{C,F}$ = 246.7, C-5); 147.23 (d, $J_{C,F}$ = 3.3, C-7a); 151.75 (d, $J_{C,F}$ = 4.0, C-4); 151.98 (CH-2). ^{19}F NMR (470.3 MHz, DMSO-d_6): –198.73 (ddd, $J_{F,H}$ = 52.8, 19.1, 13.3); –160.48 (s). MS (ESI) *m/z*: 354 (M + H), 376 (M + Na). HRMS (ESI) for $C_{15}H_{14}N_3O_3F_2S$ [M + H] calculated: 354.0718; found: 354.0718. HRMS (ESI) for $C_{15}H_{13}N_3O_3F_2SNa$ [M + Na] calculated: 376.0538; found: 376.0537. For $C_{15}H_{13}N_3O_3F_2S \cdot 0.2H_2O \cdot 0.55CH_4O$ calculated: 49.86% C, 4.20% H, 11.22% N; found: 49.92% C, 4.15% H, 11.16% N.

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