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Iron/Copper Co-Catalyzed Cross-Coupling Reaction for the Synthesis of 6-Substituted 7-Deazapurines and the Corresponding Nucleosides

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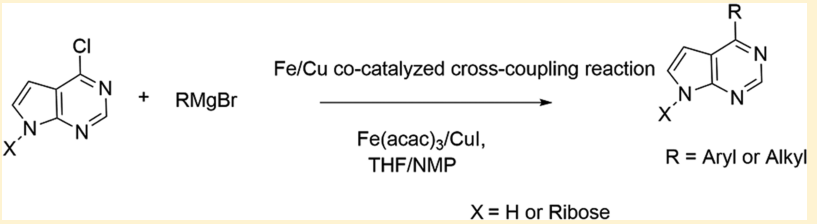
Supporting Information



ABSTRACT: An efficient access to 6-substituted 7-deazapurine and the corresponding nucleosides by coupling aryl or alkyl Grignard reagents and halogenated purine nucleosides in the presence of $Fe(acac)_3$/CuI is described. A series of 6-substituted 7-deazapurines and the corresponding nucleosides were obtained in medium to good yields. For the synthesis of modified nucleosides that will be the subject of biological testing, we propose to use iron-catalyzed instead of palladium-catalyzed reaction. The synthesized compounds were tested for their antiproliferative activity. The cytotoxicity study of compounds **11a−q** shows that by modifying the 6-position of 7-deazapurine ribonucleosides, the compounds may become selective for certain cancer cell lines.

INTRODUCTION

Purine nucleosides and their analogues display a wide range of biological activities. Several of these purine nucleosides are clinically used for treatment of cancers (e.g., fludarabine, cladribine, nelarabine, and clofarabine) and viral infections (e.g., carbovir and adefovir). A particular series of purine nucleoside analogues that have not been systematically studied are 6-substituted 7-deazapurine nucleosides (tubercidin analogues), due to their difficult accessibility by chemical synthesis. As seen in Figure 1, tubercidin (**1**) itself is a naturally occurring cytostatic antibiotic.[1−3] The study of the synthesis of derivatives of tubercidin[4−7] has already led to the identification of 7-deazapurine nucleosides with antiviral,[7] antibiotic,[8] or cytostatic[9−13] activity. For example, 7-thienyl-7-deazapurine ribonucleoside (**2**) shows cytostatic activity toward a wide panel of cancer cell lines.[13] Compound **3** was proven to be a potent inhibitor of poliovirus (PV) replication (IC_{50} = 0.011 μM), and it is also a potent inhibitor of dengue virus (DENV2) replication (IC_{50} = 0.039 μM).[14] The 6-methyl-7-deazapurine ribonucleoside was later found to display potent activity against hepatitis C virus.[15]

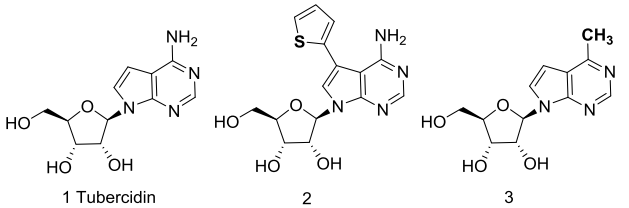


Figure 1. Structure of tubercidin and two examples of biologically active 7-deazapurine ribonucleosides.

Classical protocols for the synthesis of 6-substituted-7-deazapurine ribonucleosides rely on the Suzuki−Miyaura cross-coupling reaction with palladium catalysts, aryl halides, and organic boron compounds.[13] The synthesis of 6-methyl-7-deazapurine ribonucleoside was also carried out with trimethylaluminum as reagent and palladium as catalyst[14,15] (Scheme 1). These transformations require the presence of palladium or nickel as catalysts. These metals are costly or toxic and often necessitate sophisticated and expensive ligands of high molecular weight. We aim for cheap and environmentally friendly catalysts that do not require complicated ligands to carry out such reactions. Another reason to avoid the use of palladium chemistry in nucleoside research is that these modified nucleosides are often tested as potential antiviral and antitumoral compounds. The presence of a trace amount of palladium in these compounds could lead to erroneous biological data.

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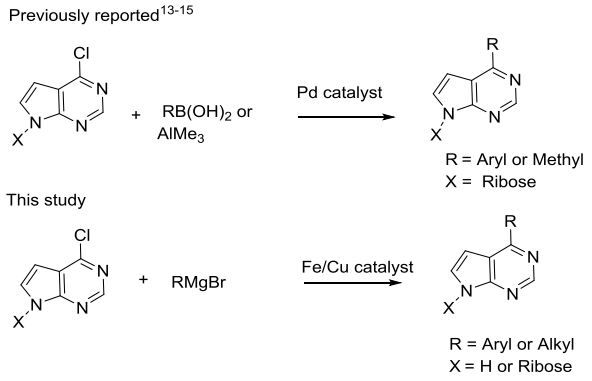
Scheme 1. Synthetic Strategy with Pd and Fe Catalysts



In recent years, iron catalysis has emerged as an increasing and promising alternative in many organic transformations, in particular for C−C bond-forming reactions, because of their low cost and toxicity.[16]

Since the pioneering works of Kochi in the 1970s,[17] iron-catalyzed cross-coupling reaction has been extensively studied.[18] Fürstner et al. developed general conditions for cross-coupling reactions of alkyl and aryl Grignard reagents with aryl chlorides.[19,20] Unlike aryl chlorides, the corresponding bromides and iodides are prone to reduction of the C−X bonds due to a radical decomposition pathway.

As a first example in the nucleoside field, Hoeck et al. described the introduction of a methyl group by using CH_3MgBr as reagent and $Fe(acac)_3$ as catalyst on 2,6-dichloropurine[21] and 2,6,8-trichloropurine.[22] Hence, we describe a general and efficient coupling of 6-chloro-7-deazapurine and its ribonucleoside with a variety of functionalized aryl and alkyl Grignard reagents by using iron/copper bimetallic catalysts, leading to a series of 6-substituted-7-deazapurine nucleoside analogues.

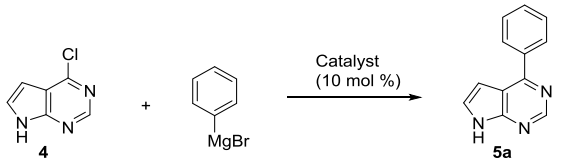
RESULTS AND DISCUSSION

Chemistry. We observed that coupling reaction occurred in the presence of a catalytic system combining Fe catalyst [$FeCl_3$ or $Fe(acac)_3$] and copper(I) iodide under mild conditions to give the corresponding cross-coupling products in medium to good yields. This catalytic mixture offers an efficient alternative to the Pd- and Ni-catalyzed procedures often used until now.

We first examined the coupling of 6-chloro-7-deazapurine (**4**) with phenylmagnesium bromide using $FeCl_3$ (10 mol %) as the catalyst in tetrahydrofuran (THF) as the solvent at 0 °C to room temperature (rt). The desired product **5a** was isolated in 57% yield. However, no desired product was obtained when the reaction was carried out without catalysts or in the presence of $ZnCl_2$ and $CuCl_2$. The yield (55%) to afford **5a** by using $FeCl_3{\cdot}6H_2O$ was comparable to the yield obtained with $FeCl_3$. In the light of Fürstner's previous work[20] and recent mechanistic studies on addition of *N*-methylpyrrolidone (NMP) in Fe-catalyzed cross-coupling reaction,[23] we could observe an increase in the yield by using *N*-methylpyrrolidone (NMP) as the cosolvent in combination with $FeCl_3$ (Table 1, entry 6).

With the optimized reaction conditions in hand, 6-chloro-7-deazapurine (**4**) was reacted with a series of aryl and alkyl Grignard reagents (Scheme 2). The results summarized in Scheme 2 show that the conditions described above proved to be useful for the coupling of **4** with a series of functionalized

Table 1. Fe-Catalyzed Cross-Coupling of 6-Chloro-7-deazapurine (4) with Phenylmagnesium Bromide[a]



entry	solvent	catalyst	yield (%)
1	THF	$FeCl_3$	57
2	THF	none	0
3	THF	$ZnCl_2$	0
4	THF	$CuCl_2$	0
5	THF	$FeCl_3{\cdot}6H_2O$	55
6	THF/NMP (10:1)	$FeCl_3$	65

[a]Reaction conditions: **4** (1 equiv), PhMgBr (5.00 equiv), catalyst (0.1 equiv), THF (5 mL), or THF/NMP (5/0.5 mL), 0 °C to rt, 3 h, and isolated yields after silica gel chromatography.

Grignard reagents. 4-Methoxy-, 4-methyl-, and 4-ethylphenylmagnesium bromide underwent reaction with **4** to give products **5b−d** in 50−70% yields (Scheme 2). Apart of C sp^2−C sp^2 bond formation, we could demonstrate that the reaction has a generic character by successfully carrying out C sp^2−C sp^2 bond formation (Scheme 2). Primary as well as secondary alkyl Grignard reagents reacted well with **4** to give the coupling products **5e−k** in good yields. Reaction of ethylmagnesium bromide with **4** without *N*-methylpyrrolidone (NMP) gave **5i** in low yield together with the 6-dechlorinated compound.

The same reaction was tested out for the synthesis of the corresponding nucleoside analogues. The starting material (compound **9**) was obtained as shown in Scheme 3.

Compound **8** was obtained according to the literature reported by Seela et al.[24] Deiodination of **8** was achieved by iodine−magnesium exchange reaction using Knochel's Turbo-Grignard reagent[25,26] (*i*PrMgCl·LiCl) and subsequent hydrolysis of the magnesium intermediate to give 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**)[27] in 71% yield.

As seen in Table 2, we used the coupling of 4-methylphenylmagnesium bromide with substrate **9** as a model reaction. $FeCl_3$ is less effective than $Fe(acac)_3$ as a catalyst in this case. Subsequently, we examined $Fe(acac)_3$ as a catalyst in the coupling reaction of substrate **9** with methylmagnesium bromide. The results revealed no significant improvement in yield (Table 3, entry 1). However, the reaction could be improved if an additive is included in the reaction system. Among the tested additives, CuI appears to be the better one, resulting in **10b** and **10c** in good yields (Table 3, entries 2 and 4). The use of organic zinc reagent or CuI as sole catalyst was not successful in the cross-coupling reaction between substrate **9** and isopropylmagnesium bromide (Table 3, entries 5 and 6).

Under the optimized reaction conditions, we subsequently investigated the substrate scope for the Fe/Cu-catalyzed coupling of structurally diverse Grignard reagents with substrate **9** (Scheme 4). The results, summarized in Scheme 4, show that arylmagnesium bromide underwent reaction with **9** to give products **10m−q** in medium to good yields (Scheme 4, **10m−q**). We also examined the potential of this reaction for a C sp^2−C sp^2 bond formation (Scheme 4, **10b−l**). The

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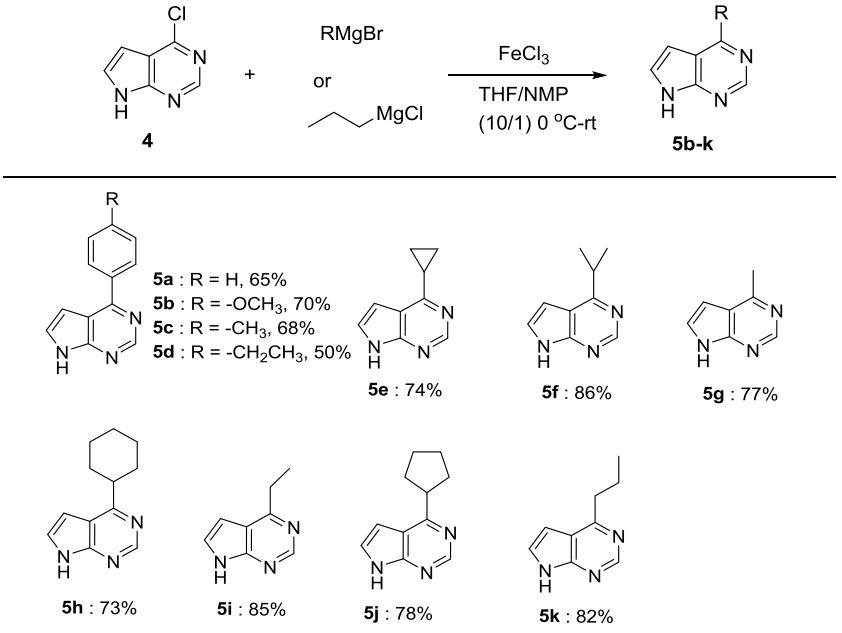
J. Org. Chem. XXXX, XXX, XXX−XXX

Scheme 2. Examples of 6-Aryl-7-deazapurines and 6-Alkyl-7-deazapurines[a]



[a]Reaction conditions: **4** (1 equiv), RMgBr (2−8.00 equiv), $FeCl_3$ (0.1 equiv), THF/NMP (5/0.5 mL), 0 °C to rt, thin-layer chromatography (TLC) monitoring till starting material disappear, and isolated yields after silica gel chromatography.

Scheme 3. Synthesis of 6-Chloro-7-deazapurine Ribonucleoside

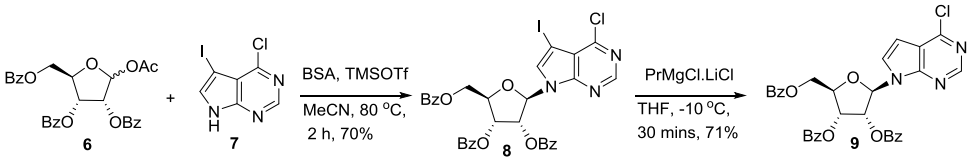
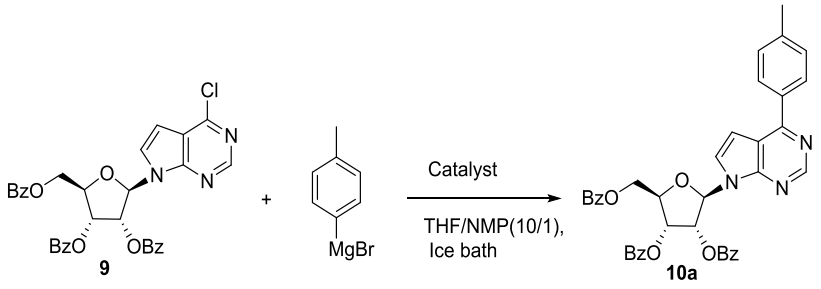


Table 2. Fe-Catalyzed Cross-Coupling of Substrate 9 with 4-Methylphenylmagnesium Bromide[a]



entry	catalyst	yield (%)
1	$FeCl_3$ (10 mol %)	42
2	$Fe(acac)_3$ (10 mol %)	55

[a]Reaction conditions: **9** (1 equiv), PhMgBr (5.00 equiv), Fe catalyst (0.1 equiv), THF/NMP (5/0.5 mL), 0 °C to rt, TLC monitor till starting material disappear, and isolated yields after silica gel chromatography. acac = acetylacetonate.

coupling reaction of substrate **9** with alkyl Grignard reagents (Scheme 4, **10b−l**) resulted in higher yields than with aryl Grignard reagents (Scheme 4, **10m−q**).

Prompted by the successful cross-coupling condition by using the $Fe(acac)_3$/CuI combination, we examined back the synthesis of 6-aryl-7-deazapurine and 6-alkyl-7-deazapurine, as described in Table 4, using the $Fe(acac)_3$/CuI bimetallic system. Likewise, somewhat improved yields were obtained for the synthesis of compounds **5a**, **5c**, **5d**, **5h**, and **5j** by using this catalyst.

Finally, we evaluated the influence of CuI on this Fe-catalyzed cross-coupling reaction, using the synthesis of compound **10f** as a model reaction. Three reaction conditions were carried out. Compound **10f** was first synthesized by using $Fe(acac)_3$ and pentylmagnesium bromide in the absence of CuI in 58% yield, and a light brown precipitate was formed (Figure 2a). The yield to obtain compound **10f** increased to 70% by addition of 20 mol % CuI in the reaction mixture, and a dark brown precipitate was formed (Figure 2b). When substrate **9** reacted with the Gilman reagent, which was

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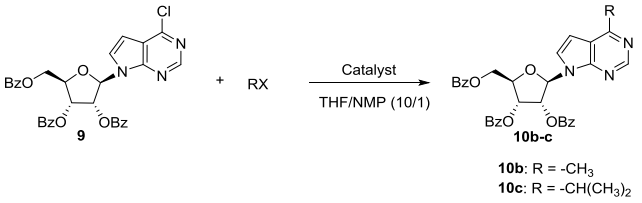
J. Org. Chem. XXXX, XXX, XXX−XXX

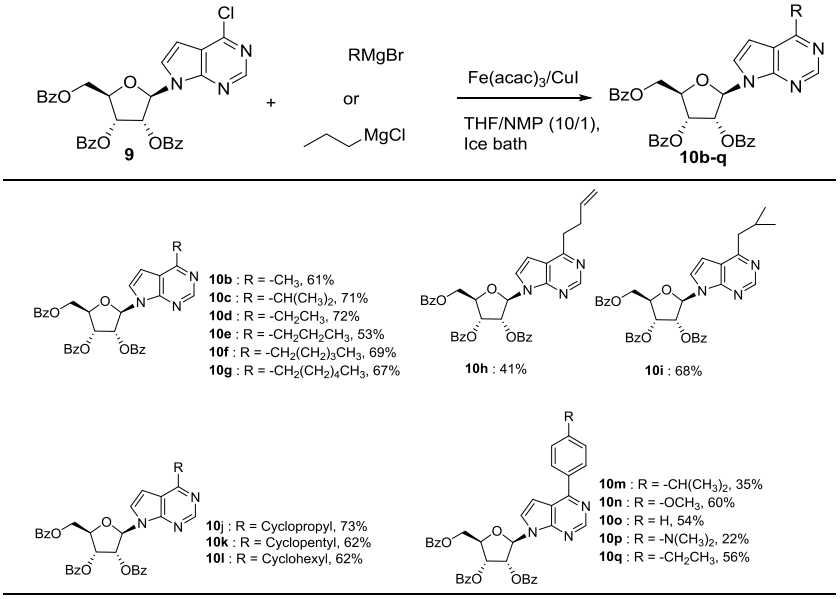
Table 3. Evaluation of the Reaction Conditions[a] for the Synthesis of 6-Alkyl 7-Deazapurine Ribonucleosides



entry	RX	catalyst	yield (%)
1	CH_3MgBr	$Fe(acac)_3$ (10 mol %)	41
2	CH_3MgBr	$Fe(acac)_3$ (10 mol %)/CuI (20 mol %)	61
3	$(CH_3)_2CHMgBr$	$Fe(acac)_3$ (10 mol %)	57
4	$(CH_3)_2CHMgBr$	$Fe(acac)_3$ (10 mol %)/CuI (20 mol %)	71
5	$(CH_3)_2CHZnCl$	$Fe(acac)_3$ (10 mol %)	0
6	$(CH_3)_2CHMgBr$	CuI (10 mol %)	0[b]

[a]Reaction conditions: **9** (1 equiv), metal complex (2.00 equiv), Fe catalyst (0.1 equiv), CuI (0.2 equiv), THF/NMP (5 mL /0.5 mL), ice bath, TLC monitoring, and isolated yields after silica gel chromatography. acac = acetylacetonate. [b]Reaction with CuI alone gave no product.

Scheme 4. Examples of 6-Alkyl- and 6-Aryl-Substituted 7-Deazapurine Ribonucleosides[a]



[a]Reaction conditions: **9** (1 equiv), RMgX (1.5–9.00 equiv), $Fe(acac)_3$ (0.1 equiv), CuI (0.2 equiv), THF/NMP (5/0.5 mL), ice bath, TLC monitoring, and isolated yields after silica gel chromatography. acac = acetylacetonate.

prepared according to the literature[28] from pentylmagnesium bromide (2 equiv) and CuI (1.2 equiv) in THF at −78 °C, only 32% of compound **10f** was obtained and a black precipitate was formed in the reaction mixture (Figure 2c).

In the Fe-catalyzed Grignard cross-coupling, Kochi proposed an Fe(I)/Fe(III) mechanistic cycle,[29] and the active Fe(I) is formed by reduction of Fe(III) precatalyst by Grignard reagent. Later, Fürstner proposed a Fe(II)/Fe(0) mechanistic cycle.[20]

Based on a similar reaction to synthesize 1,1-diarylethylenes,[30] we assume that the reaction proceeds through a similar mechanism, which formed an alkenyliron species, as seen in Scheme 5. The oxidative addition of 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-*β*-D-ribofuranosyl-7-desazapurine (**9**) to a low-valent iron species A, which is generated by the reaction of $Fe(acac)_3$ with the Grignard reagent, would give alkenyliron species B. Transmetalation with organocopper reagent forming di-organoiron species C followed by reductive elimination of the cross-coupling product regenerates low-valent iron species A.

Finally, subsequent debenzoylation of compound **10a−q** by treatment with 7 N ammonia in methanol gave compound **11a−q**, as seen in Scheme 6.

Antitumoral Activity. Evaluation of these compounds against a series of tumor cell lines (glioblastoma LN-229, pancreatic adenocarcinoma Capan-1, colorectal carcinoma HCT-116, lung carcinoma NCI-H460, acute lymphoblastic leukemia DND-41, acute myeloid leukemia, HL-60, chronic myeloid leukemia K-562, non-Hodgkin lymphoma Z-138) confirms the high cytotoxicity of the 6-methylated compound (**11b**) against all of these cell lines[15] (Table 5). However, some of the analogues keep antitumoral activity, while becoming cell-type-specific. The isopropoyl analogue (**11c**) and the cyclohexyl analogue (**11l**) show antiproliferative activity in the glioblastoma (LN-229) cell line and the lung carcinoma (NCI-H460) cell line (3.1 and 5.9 *μ*M, respectively). The isopropyl analogue (**11c**) is also active in the chronic myeloid leukemia

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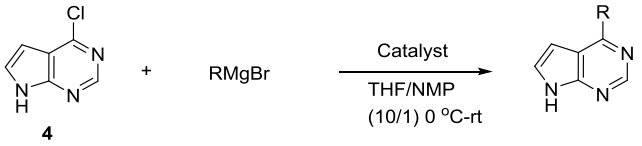
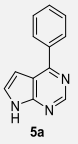
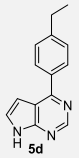
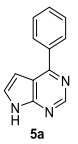
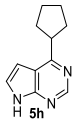
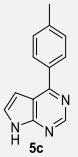
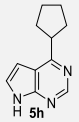
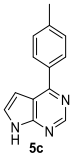
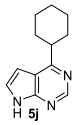
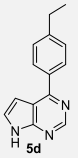
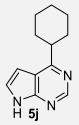
Table 4. Comparison of $FeCl_3$ versus $Fe(acac)_3$/CuI Catalyst for the Synthesis of 6-Substituted 7-Deazapurine[a]



Entry	Catalyst	Product	Yield	Entry	Catalyst	Product	Yield
1	$FeCl_3$	 5a	65%	6	$Fe(acac)_3$/CuI	 5d	62%
2	$Fe(acac)_3$/CuI	 5a	75%	7	$FeCl_3$	 5h	78%
3	$FeCl_3$	 5c	68%	8	$Fe(acac)_3$/CuI	 5h	82%
4	$Fe(acac)_3$/CuI	 5c	76%	9	$FeCl_3$	 5j	73%
5	$FeCl_3$	 5d	50%	10	$Fe(acac)_3$/CuI	 5j	76%

[a]Reaction conditions: **4** (1 equiv), RMgX (3−6 equiv), $FeCl_3$ or $Fe(acac)_3$ (0.1 equiv)/CuI (0.2 equiv), THF/NMP (5/0.5 mL), ice bath to rt, TLC monitoring, and isolated yields after silica gel chromatography. acac = acetylacetonate.

(K-562) cell line (3.9 μM). In contrast, the fenylethyl-substituted compound (**11q**) only shows activity in the acute lymphoblastic leukemia (DND-41) cell line (3.9 μM). Finally, non-Hodkin lymphoma (Z-138) cells can be inhibited by the isopropyl (**11c**, 5.3 μM), the cyclohexyl (**11l**, 7.1 μM), and the ethyl analogue (**11d**, 5.5 μM). Only activity below 10 μM is considered here. This means that by modification of the 6-position of 7-deazapurine ribonucleosides, the compounds may become selective for certain cancer cell lines.

CONCLUSIONS

In conclusion, we demonstrated a cooperative metallic effect of $FeCl_3$ or $Fe(acac)_3$ that allows the formation of C sp^2−C sp^2 and C sp^2−C sp^2 bonds by coupling 6-chloro-7-deazapurine and 6-chloro-7-deazapurine ribonucleoside with a series of functionalized Grignard reagents. To the best of our knowledge, the $Fe(acac)_3$/CuI combination has not been employed as a catalytic system for cross-couplings of Grignard reagents with halogenated purine nucleosides. Our optimized reaction conditions proved to be generic and chemoselective. This approach has advantages because of the commercial availability and low cost of the catalysts, mild conditions, experimental simplicity, and environment friendliness. We also propose the use of iron-catalyzed instead of palladium-catalyzed reaction for the synthesis of modified nucleosides that will be tested biologically because of the potential cellular toxicity of traces of palladium catalyst that could remain present in the final compounds. The cytotoxicity study of compounds **11a−q** shows that by modifying the 6-position of 7-deazapurine nucleosides, the compounds may become selective for certain cancer cell lines.

EXPERIMENTAL SECTION

General Information. All reagents and solvents were purchased from commercial sources and used as obtained. Moisture-sensitive reactions were carried out using oven-dried glassware under a nitrogen or argon atmosphere. ^{1}H NMR and ^{13}C NMR spectra were

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J. Org. Chem. XXXX, XXX, XXX−XXX

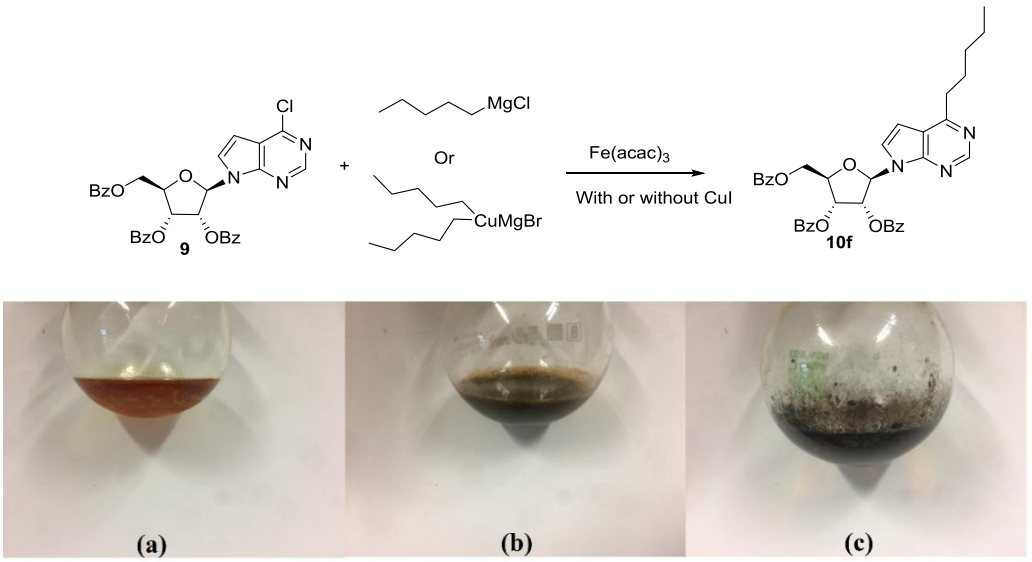
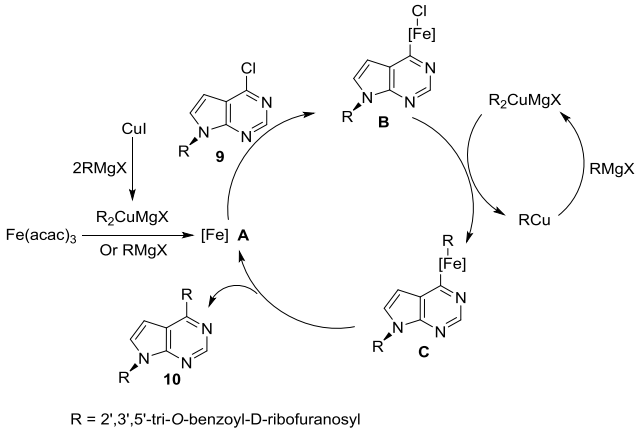


Figure 2. Visualization of CuI participation in the Fe-catalyzed cross-coupling reaction. Reaction with (a) $Fe(acac)_3$, 58% yield. (b) $Fe(acac)_3$ + CuI, 70% yield. (c) Gilman reagent, 32% yield.

Scheme 5. Proposed Catalytic Cycle for the Iron-Catalyzed Arylation and Alkylation Reaction



recorded on a Bruker Avance 300 MHz spectrometer using tetramethylsilane as internal standard or referenced to the residual solvent signal. The following abbreviations were used to indicate multiplicities: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad), and dd (doublet of doublets). Coupling constants are expressed in hertz (Hz). High-resolution mass spectra (HRMS) were obtained on a quadrupole orthogonal acceleration time-of-flight mass spectrometer (Synapt G2 HDMS, Waters, Milford, MA). The samples were infused at 3 μL/min, and spectra were obtained in positive ionization mode with a resolution of 15 000 [full width at half-maximum (fwhm)] using leucine enkephalin as lock mass. Precoated aluminum sheets (254 nm) were used for thin-layer chromatography (TLC), and spots were visualized with UV light. All products were purified by flash column chromatography on silica gel (40−60 μm, 60 Å).

General Procedure for the $FeCl_3$-Catalyzed Cross-Coupling of 6-Chloro-7-deazapurine with Grignard Reagents. An oven-dried flask was charged with 6-chloro-7-deazapurine (1.3 mmol, 1 equiv) in THF (5 mL), NMP (0.5 mL), and $FeCl_3$ (0.13 mmol, 0.1 equiv). The mixture was cooled to 0 °C, and a solution of RMgX (2.0−8.0 mmol, 1.5−6.2 equiv) in THF was added. The reaction mixture was stirred for 2 h with gradual warming to room temperature. After monitoring with TLC till starting material disappeared, the reaction was quenched by the addition of aqueous (aq) saturated solution of NH_4Cl and extracted with EtOAc (3 × 10 mL). The organic solution was dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by silica gel chromatography to afford the desired product.

6-Phenyl-7-deazapurine (5a). Following the general procedure, compound **5a** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), phenylmagnesium bromide 1 M in THF (539.82 mg, 3.0 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel [heptane/EtOAc = 5:1, to dichloromethane (DCM)/MeOH = 30:1, v/v] as a white solid (166 mg, 65% yield). ^{1}H NMR [300 MHz, dimethyl sulfoxide (DMSO)-d_6] δ 12.27 (br, 1H, N*H*), 8.85 (s, 1H, H-2), 8.17 (m, 2H, Ph-*H*), 7.65 (d, $J_{8,7}$ = 3.6 Hz, 1H, H-8), 7.62−7.52 (m, 3H, Ph-*H*), 6.88 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 155.7 (C-6), 152.7 (C-4), 151.0 (C-2), 138.0 (C-Ph), 130.0 (C-Ph), 128.9 (C-Ph), 128.6 (C-Ph), 127.7 (C-8), 114.6 (C-5), 100.0 (C-7); HRMS [electrospray ionization time-of-flight (ESI-TOF)] *m*/*z*: calcd for $C_{12}H_9N_3$ ([M + H]$^+$), 196.0869, found 196.0871.

6-(4-Methoxylphenyl)-7-deazapurine (5b). Following the general procedure, compound **5b** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), 4-methoxylphenylmagnesium bromide 1 M in THF (545.87 mg, 2.6 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (206 mg, 70% yield). ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.20 (br, 1H, N*H*), 8.79 (s, 1H, H-2), 8.18 (d, *J* = 9.1 Hz, 2H, Ph-*H*), 7.61 (d, $J_{8,7}$ = 3.6 Hz, 1H, H-8), 7.12 (d, *J* = 9.1 Hz, 2H, Ph-*H*), 6.87 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 3.41 (s, 3H, OCH_3); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 160.9 (C-6), 155.3 (C-4), 152.6 (C-Ph), 150.9 (C-2), 130.5 (C-Ph), 130.2 (C-Ph), 127.3 (C-8), 114.3 (C-5), 113.9 (C-Ph), 100.1 (C-7), 55.4 (OCH_3); HRMS (ESI-TOF) *m*/*z*: calcd for $C_{13}H_{11}N_3O$ ([M + H]$^+$), 226.0974, found 226.0979.

6-(4-Methylphenyl)-7-deazapurine (5c). Following the general procedure, compound **5c** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), 4-methylphenylmagnesium bromide 1 M in THF (775.84 mg, 4.0 mmol, added as portions added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (185 mg, 68% yield). ^{1}H NMR (300 MHz, DMSO-d_6) δ 12.23 (br, 1H, N*H*), 8.81 (s, 1H, H-2), 8.08 (d, *J* = 8.0 Hz, 2H, Ph-*H*), 7.63 (dd, $J_{8,7}$ = 3.6 Hz, $J_{8,NH}$ = 2.4 Hz, 1H, H-8), 7.38 (d, *J* = 7.9 Hz, 2H, Ph-*H*), 6.87 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 2.39 (s, 3H, CH_3);

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J. Org. Chem. XXXX, XXX, XXX−XXX

Scheme 6. Debenzoylation Reaction To Obtain the Compounds that Were Subject of Biological Testing

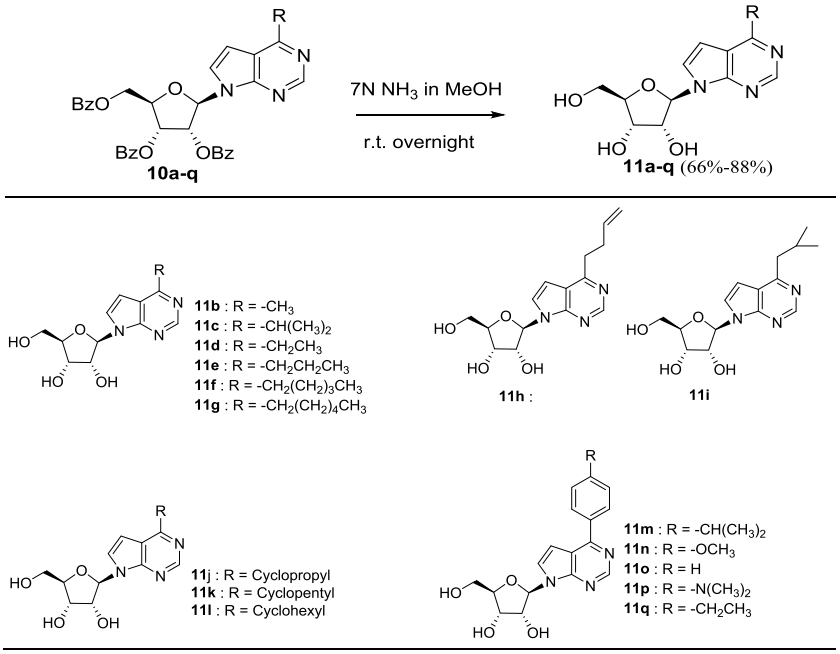

Table 5. Cytotoxic Activity of Compounds 11a−q in Different Cancer Cell Lines

	IC_{50} (μM)[a]							
P[b]	LN-229	Capan-1	HCT-116	NCI-H460	DND-41	HL-60	K-562	Z-138
11a	>100	>100	>100	>100	>100	>100	>100	>100
11b	**0.03**	**0.05**	**0.05**	**1.7**	**0.4**	**0.4**	**2.4**	**0.2**
11c	**2.5**	>100	>100	**3.1**	44.4	48.1	**3.9**	**5.3**
11d	16.0	25.0	50.5	>100	31.5	>100	**5.5**	34.8
11e	>100	54.8	>100	>100	>100	>100	>100	>100
11f	>100	>100	>100	>100	>100	>100	>100	>100
11g	12.6	>100	>100	39.2	38.9	79.9	50.7	26.6
11h	>100	>100	>100	>100	>100	>100	>100	>100
11i	>100	>100	>100	>100	>100	>100	>100	>100
11j	>100	>100	>100	>100	>100	>100	>100	95.3
11k	>100	>100	>100	47.6	95.2	>100	>100	>100
11l	**2.7**	>100	>100	**5.9**	**8.5**	16.8	>100	**7.1**
11m	>100	>100	>100	>100	>100	>100	>100	>100
11n	>100	>100	>100	>100	>100	>100	>100	>100
11o	>100	>100	>100	>100	>100	>100	>100	>100
11p	>100	>100	>100	>100	>100	>100	>100	>100
11q	20.4	51.0	69.8	36.6	**3.9**	58.4	>100	87.1
ref 1[c]	0.003	0.0024	0.008	0.002	0.004	0.004	0.01	0.006
ref 2[d]	0.06	0.04	0.06	0.05	0.03	0.02	0.02	0.01

The bold values mean only activity below 10 μM is considered. [a]IC_{50} is the compound concentration required to inhibit tumor cell viability by 50%. [b]P = product. [c]Ref 1 = docetaxel. [d]Ref 2 = staurosporine.

$^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 155.7 (C-6), 152.7 (C-4), 151.0 (C-2), 139.8 (C-Ph), 135.3 (C-Ph), 129.5 (C-Ph), 128.6 (C-Ph), 127.5 (C-8), 125.8 (C-Ph), 114.2 (C-5), 100.1 (C-7), 21.0 (CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{13}H_{11}N_3$ ([M + H]$^+$), 210.1025, found 210.1029.

6-(4-Ethylphenyl)-7-deazapurine (5d). Following the general procedure, compound **5d** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), 4-ethylphenylmagnesium bromide 1 M in THF (2.72 g, 13.0 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (145 mg, 50% yield). ^1H NMR (300 MHz, DMSO-d_6) δ 12.24 (br, 1H, N*H*), 8.82 (s, 1H, H-2), 8.12 (d, J = 8.1 Hz, 2H, Ph-*H*), 7.63 (dd, $J_{8,7}$ = 3.6 Hz, $J_{8,NH}$ = 2.4 Hz, 1H, H-8), 7.41 (d, J = 8.0 Hz, 2H, Ph-*H*), 6.87 (dd, $J_{7,8}$ = 3.6 Hz, $J_{7,NH}$ = 1.8 Hz, 1H, H-7), 2.69 (q, J = 7.4 Hz, 2H, CH_2CH_3), 1.23 (t, J = 7.5 Hz, 2H, CH_2CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 155.7 (C-6), 152.7 (C-4), 151.0 (C-2), 146.0 (C-Ph), 128.6 (C-Ph), 128.3 (C-Ph), 127.5 (C-8), 114.4 (C-5), 100.1 (C-7), 28.1 (CH_2CH_3), 15.4 (CH_2CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{14}H_{13}N_3$ ([M + H]$^+$), 224.1182, found 224.1180.

6-Cyclopropyl-7-deazapurine (5e). Following the general procedure, compound **5e** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), 4-cyclopropylmagnesium bromide 0.7 M in THF (244.07 mg, 1.7 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL),

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J. Org. Chem. XXXX, XXX, XXX−XXX

and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (154 mg, 74% yield). ^{1}H NMR (300 MHz, CD_3OD) δ 8.50 (s, 1H, H-2), 7.38 (d, $J_{8,7}$ = 3.6 Hz, H-8), 6.74 (d, $J_{7,8}$ = 3.6 Hz, H-7), 2.51−2.42 (m, 1H, C*H*$(CH_2)_2$), 1.32−1.41 (m, 4H, CH(C*H*$_2)_2$); ^{13}C{^{1}H} NMR (75 MHz, CD_3OD) δ 163.9 (C-6), 149.9 (C-2), 149.6 (C-4), 124.9 (C-8), 116.6 (C-5), 98.6 (C-7), 13.6 (*C*H$(CH_2)_2$), 9.3 (2 × CH$(C\mathit{H}_2)_2$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_9H_9N_3$ ([M + H]$^+$), 160.0869, found 160.0871.

6-Isopropyl-7-deazapurine (5f). Following the general procedure, compound **5f** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), 4-isopropylmagnesium bromide 3 M in THF (662.84 mg, 4.5 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (180 mg, 86% yield). ^{1}H NMR (300 MHz, CD_3OD) δ 8.64 (s, 1H, H-2), 7.41 (d, $J_{8,7}$ = 3.6 Hz, H-8), 6.66 (d, $J_{7,8}$ = 3.6 Hz, H-7), 3.52−3.43 (m, 1H, C*H*$(CH_3)_2$), 1.41 (d, *J* = 6.9 Hz, 6H, CH(C*H*$_3)_2$); ^{13}C{^{1}H} NMR (75 MHz, CD_3OD) δ 167.1 (C-6), 150.8 (C-2), 149.8 (C-4), 125.3 (C-8), 115.6 (C-5), 98.8 (C-7), 33.3 (*C*H$(CH_3)_2$), 20.0 (CH-$(C\mathit{H}_3)_2$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_9H_{11}N_3$ ([M + H]$^+$), 162.1025, found 162.1027.

6-Methyl-7-deazapurine (5g). Following the general procedure, compound **5g** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), methylmagnesium bromide 3 M in THF (536.60 mg, 4.5 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (133 mg, 77% yield). ^{1}H NMR (300 MHz, CD_3OD) δ 8.58 (s, 1H, H-2), 7.41 (d, $J_{8,7}$ = 3.6 Hz, 1H, H-8), 6.64 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 2.70 (s, 3H, C*H*$_3$); ^{13}C{^{1}H} NMR (75 MHz, CD_3OD) δ 158.4 (C-6), 150.2 (C-2), 149.4 (C-4), 125.4 (C-8), 117.3 (C-5), 99.0 (C-7), 19.2 (*C*H$_3$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_7H_7N_3$ ([M + H]$^+$), 134.0712, found 134.0710.

6-Cyclohexyl-7-deazapurine (5h). Following the general procedure, compound **5h** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), cyclohexylmagnesium bromide 0.5 M in THF (309.15 mg, 1.7 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (190 mg, 73% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 11.49 (br, 1H, N*H*), 8.86 (s, 1H, H-2), 7.35 (dd, $J_{8,7}$ = 3.6 Hz, $J_{8,NH}$ = 2.4 Hz, 1H, H-8), 6.66 (dd, $J_{7,8}$ = 3.6 Hz, $J_{7,NH}$ = 1.8 Hz, 1H, H-7), 3.18−3.06 (m, 1H, C*H*$(CH_2)_5$), 2.00−1.39 (m, 10H, CH(C*H*$_2)_5$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 167.6 (C-6), 152.0 (C-2), 151.4 (C-4), 124.7 (C-8), 116.6 (C-5), 100.1 (C-7), 44.6 (*C*H$(CH_2)_5$), 31.9, 26.7, 26.7, 26.3, 26.3 (5×*C*H$_2$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_{12}H_{15}N_3$ ([M + H]$^+$), 202.1338, found 202.1338.

6-Ethyl-7-deazapurine (5i). Following the general procedure, compound **5i** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), ethylmagnesium bromide 2 M in THF (266.54 mg, 2.0 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (164 mg, 85% yield). ^{1}H NMR (300 MHz, CD_3OD) δ 8.62 (s, 1H, H-2), 7.41 (d, $J_{8,7}$ = 3.6 Hz, 1H, H-8), 6.66 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 3.04 (q, *J* = 7.6 Hz, 2H, C*H*$_2$), 1.37 (t, *J* = 7.6 Hz, 3H, C*H*$_3$); ^{13}C{^{1}H} NMR (75 MHz, CD_3OD) δ 163.4 (C-6), 150.6 (C-2), 149.7 (C-4), 125.4 (C-8), 116.4 (C-5), 98.8 (C-7), 27.4 (*C*H$_2$), 11.7 (*C*H$_3$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_8H_9N_3$ ([M + H]$^+$), 148.0869, found 148.0874.

6-Cyclopentyl-7-deazapurine (5j). Following the general procedure, compound **5j** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), cyclopentylmagnesium bromide 0.5 M in THF (286.0 mg, 1.7 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (190 mg, 75% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 11.07 (br, 1H, N*H*), 8.85 (s, 1H, H-2), 7.33 (dd, $J_{8,7}$ = 3.6 Hz, $J_{8,NH}$ = 2.4 Hz, 1H, H-8), 6.64 (dd, $J_{7,8}$ = 3.6 Hz, $J_{7,NH}$ = 1.8 Hz, 1H, H-7), 3.36−3.53 (m, 1H, C*H*$(CH_2)_4$), 2.17−1.75 (m, 8H, CH(C*H*$_2)_4$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 167.2 (C-6), 151.7 (C-2), 151.6 (C-4), 124.5 (C-8), 117.1 (C-5), 100.4 (C-7), 45.4 (*C*H$(CH_2)_4$), 32.8, 32.8, 26.5, 26.5 (4×*C*H$_2$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_{11}H_{13}N_3$ ([M + H]$^+$), 188.1182, found 188.1182.

6-Propyl-7-deazapurine (5k). Following the general procedure, compound **5k** was obtained starting from 6-chloro-7-deazapurine (**4**) (200 mg, 1.3 mmol), $FeCl_3$ (21 mg, 1.3 mmol), propylmagnesium chloride 2 M in THF (370.24 mg, 3.6 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1, v/v) as a white solid (170 mg, 82% yield). ^{1}H NMR (300 MHz, CD_3OD) δ 8.62 (s, 1H, H-2), 7.42 (d, $J_{8,7}$ = 3.6 Hz, 1H, H-8), 6.69 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 3.03 (t, *J* = 7.2 Hz, 2H, C*H*$_2$CH$_2$), 1.91−1.83 (m, 2H, C*H*$_2$CH$_3$), 1.00 (t, *J* = 7.7 Hz, 3H, CH$_2$C*H*$_3$); ^{13}C{^{1}H} NMR (75 MHz, CD_3OD) δ 162.2 (C-6), 150.6 (C-2), 149.6 (C-4), 125.5 (C-8), 117.0 (C-5), 98.9 (C-7), 36.2 (*C*H$_2$CH$_2$), 21.7 (*C*H$_2$CH$_3$), 12.5 (*C*H$_3$); HRMS (ESI-TOF) *m*/*z*: calcd for $C_9H_{11}N_3$ ([M + H]$^+$), 162.1025, found 162.1029.

2′,3′,5′-Tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-deazapurine (9). To a solution of compound **8**[24] (9 g, 12.5 mmol) in dry THF (50 mL) was dropwise added *i*PrMgCl·LiCl (1.3 M in THF, 1.89 g, 13 mmol) at −10 °C and the solution was stirred at this temperature yet for 30 min. Then, the reaction mixture was poured on the mixture of ice and saturated aq NH_4Cl (100 mL) and was extracted with EtOAc (200 mL, then 3 × 20 mL). Combined organic phases were dried over Na_2SO_4 and evaporated to dryness in vacuo. Purification by silica gel chromatography resulted in 9 g of compound **9** (5 g, 71%) as a foam. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.60 (s, 1H, H-2), 8.12−7.19 (m, 6H, Ph-*H*), 7.60−7.32 (m, 10H, H-8, Ph-*H*), 6.68 (d, *J* = 5.6 Hz, 1H, H-1′), 6.62 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.25 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.15 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.2 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.2 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 4.68 (dd, $J_{5'',4'}$ = 3.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5″); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 152.8 (C-6), 151.8 (C-4), 151.4 (C-2), 134.0 (C-Ph), 133.7 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 127.0 (C-8), 118.9 (C-5), 101.7 (C-7), 87.2 (C-1′), 80.7 (C-4′), 74.3 (C-2′), 71.8 (C-3′), 64.0 (C-5′).

General Procedure for the Fe(acac)$_3$/CuI-Catalyzed Cross-Coupling of 2′,3′,5′-Tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (9) with Grignard Reagents. An oven-dried flask was charged with 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (0.2 mmol, 1 equiv) in THF (5 mL), NMP (0.5 mL), Fe(acac)$_3$ (0.02 mmol, 0.1 equiv), and CuI (0.04 mol, 0.2 equiv). A solution of RMgX (0.5−1.8 mmol, 2.5−9.0 equiv) in THF was added in an ice bath. The reacton mixture was stirred for 30 min in the ice bath. After monitoring with TLC till starting material disappeared, the reaction was quenched by the addition of sat. aq solution of NH_4Cl and extracted with EtOAc (3 × 10 mL). The organic solution was dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by silica gel chromatography to afford the desired product.

2′,3′,5′-Tri-*O*-benzoyl-6-(4-methylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (10a). Following the general procedure, compound **10a** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), Fe(acac)$_3$ (7 mg, 0.02 mmol), 4-methylphenylmagnesium bromide 1 M in THF (128.25 mg, 0.85 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (75 mg, 55% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.95 (s, 1H, H-2), 8.13 (d, *J* = 7.4 Hz, 2H, Ph-*H*), 8.02−7.93 (m, 6H, Ph-*H*), 7.58−7.32 (m, 12H, H-8, Ph-*H*), 6.82 (d, $J_{7,8}$ = 3.5 Hz, 1H, H-7), 6.81 (d, *J* = 5.6 Hz, 1H, H-1′), 6.30 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.0 Hz,

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J. Org. Chem. XXXX, XXX, XXX−XXX

1H, H-2′), 6.19 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.2 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.43 (s, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 158.4 (C-6), 152.6 (C-4), 152.2 (C-2), 151.2 (C-Ph), 140.7 (C-Ph), 135.3 (C-Ph), 133.9 (C-Ph), 133.7 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 126.1 (C-8), 116.8 (C-5), 103.0 (C-7), 86.6 (C-1′), 80.5 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 21.7 (CH_3); HRMS (ESI-TOF) *m/z*: calcd for $C_{39}H_{31}N_3O_7$ ($[M + H]^+$), 654.2234, found 654.2250.

2′,3′,5′-Tri-*O*-benzoyl-6-methyl-9-β-D-ribofuranosyl-7-deazapurine (10b). Following the general procedure, compound **10b** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), $Fe(acac)_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.04 mol), methylmagnesium bromide 3 M in THF (75.12 mg, 0.63 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (70 mg, 61% yield). ^1H NMR (300 MHz, $CDCl_3$) δ 8.75 (s, 1H, H-2), 8.14 (d, *J* = 7.9 Hz, 2H, Ph-*H*), 8.01 (d, *J* = 7.9 Hz, 2H, Ph-*H*), 7.93 (d, *J* = 7.9 Hz, 2H, Ph-*H*), 7.58−7.31 (m, 10H, H-8, Ph-*H*), 6.75 (d, *J* = 5.5 Hz, 1H, H-1′), 6.59 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.27 (dd, $J_{2',1'}$ = 5.5 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.18 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.88 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.80 (ddd, $J_{4',3'}$ = 4.2 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.69 (s, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 160.1 (C-6), 151.9 (C-2), 151.1 (C-4), 133.9 (C-Ph), 133.7 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.3 (C-8), 119.0 (C-5), 101.7 (C-7), 86.5 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 21.8 (CH_3); HRMS (ESI-TOF) *m/z*: calcd for $C_{33}H_{27}N_3O_7$ ($[M + H]^+$), 578.1921, found 578.1931.

2′,3′,5′-Tri-*O*-benzoyl-6-isopropyl-9-β-D-ribofuranosyl-7-deazapurine (10c). Following the general procedure, compound **10c** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (140 mg, 0.234 mmol), $Fe(acac)_3$ (8 mg, 0.0234 mmol), CuI (9 mg, 0.046 mol), isopropylmagnesium bromide 3 M in THF (88.38 mg, 0.6 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (100 mg, 71% yield). ^1H NMR (300 MHz, $CDCl_3$) δ 8.83 (s, 1H, H-2), 8.14 (d, *J* = 7.5 Hz, 2H, Ph-*H*), 7.99 (d, *J* = 7.5 Hz, 2H, Ph-*H*), 7.94 (d, *J* = 7.5 Hz, 2H, Ph-*H*), 7.65−7.30 (m, 10H, H-8, Ph-*H*), 6.77 (d, *J* = 5.7 Hz, 1H, H-1′), 6.61 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.26 (dd, $J_{2',1'}$ = 5.7 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.16 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.6 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.44−3.36 (m, 1H, $CH(CH_3)_2$), 1.40 (s, 3H, CH_3), 1.37 (s, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 168.6 (C-6), 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 152.6 (C-2), 151.6 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph),128.8 (C-Ph), 128.7 (C-Ph), 125.0 (C-8), 117.4 (C-5), 101.5 (C-7), 86.5 (C-1′), 80.4 (C-4′), 74.1 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 34.1 ($CH(CH_3)_2$), 21.7 ($CH(CH_3)_2$), 21.6 ($CH(CH_3)_2$); HRMS (ESI-TOF) *m/z*: calcd for $C_{35}H_{31}N_3O_7$ ($[M + H]^+$), 606.2234, found 606.2233.

2′,3′,5′-Tri-*O*-benzoyl-6-ethyl-9-β-D-ribofuranosyl-7-deazapurine (10d). Following the general procedure, compound **10d** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (140 mg, 0.234 mmol), $Fe(acac)_3$ (8 mg, 0.0234 mmol), CuI (9 mg, 0.046 mol), ethylmagnesium bromide 3 M in THF (67.97 mg, 0.51 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (100 mg, 72% yield). ^1H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.14 (d, *J* = 8.1 Hz, 2H, Ph-*H*), 8.00 (d, *J* = 8.1 Hz, 2H, Ph-*H*), 7.94 (d, *J* = 8.1 Hz, 2H, Ph-*H*), 7.60−7.32 (m, 10H, H-8, Ph-*H*), 6.75 (d, *J* = 5.8 Hz, 1H, H-1′), 6.59 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 6.26 (dd, $J_{2',1'}$ = 5.8 Hz, $J_{2',3'}$ = 5.3 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.87 (dd, $J_{5',4'}$ = 3.2 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.2 Hz, $J_{4',5'}$ = 3.2 Hz, $J_{4',5''}$ = 3.9 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.96 (q, *J* = 7.6 Hz, 2H, CH_2), 1.38 (t, *J* = 7.6 Hz, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 164.9 (C-6), 152.1 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.2 (C-8), 118.2 (C-5), 101.6 (C-7), 86.6 (C-1′), 80.4 (C-4′), 74.1 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 28.8 (CH_2), 13.0 (CH_3); HRMS (ESI-TOF) *m/z*: calcd for $C_{34}H_{29}N_3O_7$ ($[M + H]^+$), 592.2078, found 592.2092.

2′,3′,5′-Tri-*O*-benzoyl-6-propyl-9-β-D-ribofuranosyl-7-deazapurine (10e). Following the general procedure, compound **10e** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), $Fe(acac)_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.043 mol), propylmagnesium chloride 2 M in THF (53.48 mg, 0.54 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (64 mg, 53% yield). ^1H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.13 (d, *J* = 7.4 Hz, 2H, Ph-*H*), 8.00 (d, *J* = 8.3 Hz, 2H, Ph-*H*), 7.94 (d, *J* = 8.3 Hz, 2H, Ph-*H*), 7.59−7.31 (m, 10H, H-8, Ph-H), 6.76 (d, *J* = 5.7 Hz, 1H, H-1′), 6.58 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.28 (dd, $J_{2',1'}$ = 5.7 Hz, $J_{2',3'}$ = 5.1 Hz, 1H, H-2′), 6.19 (dd, $J_{3',2'}$ = 5.1 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.88 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.80 (ddd, $J_{4',3'}$ = 4.2 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.9 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.96 (t, *J* = 7.0 Hz, 2H, CH_2CH_2), 1.89−1.81 (m, 2H, CH_2CH_3), 0.98 (t, *J* = 7.6 Hz, 3H, CH_2CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 163.9 (C-6), 152.1 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.3 (C-8), 118.8 (C-5), 101.6 (C-7), 86.6 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 37.6 (CH_2CH_2), 22.3 (CH_2CH_2), 14.3 (CH_2CH_3); HRMS (ESI-TOF) *m/z*: calcd for $C_{35}H_{31}N_3O_7$ ($[M + H]^+$), 606.2234, found 606.2230.

2′,3′,5′-Tri-*O*-benzoyl-6-pentyl-9-β-D-ribofuranosyl-7-deazapurine (10f). Following the general procedure, compound **10f** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (110 mg, 0.183 mmol), $Fe(acac)_3$ (6 mg, 0.0183 mmol), CuI (7 mg, 0.036 mol), pentylmagnesium bromide 2 M in THF (157.82 mg, 0.9 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (80 mg, 67% yield). ^1H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.13 (d, *J* = 7.6 Hz, 2H, Ph-H), 8.00 (d, *J* = 7.6 Hz, 2H, Ph-H), 7.94 (d, *J* = 7.2 Hz, 2H, Ph-H), 7.59−7.32 (m, 10H, H-8, Ph-H), 6.75 (d, *J* = 5.8 Hz, 1H, H-1′), 6.82 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.27 (dd, $J_{2',1'}$ = 5.8 Hz, $J_{2',3'}$ = 5.3 Hz, 1H, H-2′), 6.19 (dd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.97 (t, *J* = 7.2 Hz, 2H, $CH_2(CH_2)_3$), 1.84−1.79 (m, 2H, CH_2CH_3), 1.38−1.33 (m, 4H, $CH_2(CH_2)_2$), 0.90−0.85 (t, *J* = 7.0 Hz, 3H, $(CH_2)_4CH_3$); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 164.1 (C-6), 152.1 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.7 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.7 (C-Ph), 129.1 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.3 (C-8), 118.7 (C-5), 101.6 (C-7), 86.5 (C-1′), 80.4 (C-4′), 74.1 (C-2′), 71.8 (C-3′), 64.2 (C-5′), 35.7, 32.0, 28.8, 22.7, 14.2 (aliphatic chain); HRMS (ESI-TOF) *m/z*: calcd for $C_{37}H_{35}N_3O_7$ ($[M + H]^+$), 634.2547, found 634.2552.

2′,3′,5′-Tri-*O*-benzoyl-6-hexyl-9-β-D-ribofuranosyl-7-deazapurine (10g). Following the general procedure, compound **10g** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), $Fe(acac)_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.043 mol), hexylmagnesium bromide 2 M in

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J. Org. Chem. XXXX, XXX, XXX−XXX

THF (170.44 mg, 0.9 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (86 mg, 67% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.13 (d, J = 7.6 Hz, 2H, Ph-*H*), 8.00 (d, J = 7.6 Hz, 2H, Ph-*H*), 7.94 (d, J = 7.6 Hz, 2H, Ph-*H*), 7.59−7.32 (m, 10H, H-8, Ph-*H*), 6.75 (d, J = 5.7 Hz, 1H, H-1′), 6.58 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.27 (dd, $J_{2',1'}$ = 5.7 Hz, $J_{2',3'}$ = 5.2 Hz, 1H, H-2′), 6.19 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.2 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.97 (t, J = 7.2 Hz, 2H, $CH_2(CH_2)_3$), 1.85−1.75 (m, 2H, CH_2CH_3), 1.40−1.27 (m, 6H, $(CH_2)_3CH_3$), 0.88−0.83 (t, J = 7.0 Hz, 3H, $(CH_2)_4CH_3$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 164.1 (C-6), 152.0 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.3 (C-8), 118.6 (C-5), 101.6 (C-7), 86.6 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 35.7, 31.8, 29.5, 29.0, 22.7, 14.3 (aliphatic chain); HRMS (ESI-TOF) m/z: calcd for $C_{38}H_{37}N_3O_7$ ([M + H]$^+$), 648.2704, found 648.2720.

2′,3′,5′-Tri-*O*-benzoyl-6-(but-3-en-1-yl)-9-β-D-ribofuranosyl-7-desazapurine (10h). Following the general procedure, compound **10h** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), Fe(acac)$_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.043 mol), 3-butenylmagnesium bromide 0.5 M in THF (286.76 mg, 1.8 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (50 mg, 41% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.13 (d, J = 7.7 Hz, 2H, Ph-*H*), 8.00 (d, J = 7.7 Hz, 2H, Ph-*H*), 7.94 (d, J = 7.7 Hz, 2H, Ph-*H*), 7.60−7.32 (m, 10H, H-8, Ph-*H*), 6.75 (d, J = 5.7 Hz, 1H, H-1′), 6.58 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.25 (dd, $J_{2',1'}$ = 5.7 Hz, $J_{2',3'}$ = 5.2 Hz, 1H, H-2′), 6.19 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 4.5 Hz, 1H, H-3′), 5.94−5.81 (m, 1H, *CH*=CH$_2$), 5.07 (d, J = 17.1 Hz, 1H, CH=C*H*′), 4.97 (d, J = 17.1 Hz, 1H, CH=C*H*″), 4.88 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.5 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.9 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.07 (t, J = 7.1 Hz, 2H, CH$_2$), 2.65−2.55 (m, 2H, CH$_2$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 163.0 (C-6), 152.1 (C-2), 151.4 (C-4), 137.6 (CH=*C*H$_2$), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.4 (C-8), 118.7 (C-5), 115.6 (*C*H=CH$_2$), 101.6 (C-7), 86.6 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.8 (C-3′), 64.2 (C-5′), 35.0 (*C*H$_2$), 32.7 (*C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{36}H_{31}N_3O_7$ ([M + H]$^+$), 618.2234, found 618.2228.

2′,3′,5′-Tri-*O*-benzoyl-6-isobutyl-9-β-D-ribofuranosyl-7-deazapurine (10i). Following the general procedure, compound **10i** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), Fe(acac)$_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.043 mol), isobutylmagnesium bromide 2 M in THF (241.99 mg, 1.5 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (84 mg, 68% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.79 (s, 1H, H-2), 8.13 (d, J = 7.6 Hz, 2H, Ph-*H*), 8.00 (d, J = 7.6 Hz, 2H, Ph-*H*), 7.94 (d, J = 7.6 Hz, 2H, Ph-*H*), 7.59−7.32 (m, 10H, H-8, Ph-*H*), 6.75 (d, J = 5.6 Hz, 1H, H-1′), 6.57 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.27 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.2 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.85 (d, J = 7.2 Hz, 2H, CH_2CH), 2.31−2.22 (m, 1H, $CH(CH_3)_2$), 0.97−0.94 (m, 6H, $CH(CH_3)_2$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 163.3 (C-6), 152.0 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.3 (C-8), 119.3 (C-5), 101.7 (C-7), 86.6 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 44.7 (*C*H$_2$CH), 29.1 *C*H(CH$_3$)$_2$, 23.0(*C*H$_3$); HRMS (ESI-TOF) m/z: calcd for $C_{36}H_{33}N_3O_7$ ([M + H]$^+$), 620.2391, found 620.2413.

2′,3′,5′-Tri-*O*-benzoyl-6-cyclopropyl-9-β-D-ribofuranosyl-7-deazapurine (10j). Following the general procedure, compound **10j** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (130 mg, 0.217 mmol), Fe(acac)$_3$ (8 mg, 0.0217 mmol), CuI (9 mg, 0.043 mol), cyclopropylmagnesium bromide 0.7 M in THF (209.85 mg, 1.1 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (95 mg, 73% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.68 (s, 1H, H-2), 8.13 (d, J = 7.4 Hz, 2H, Ph-*H*), 7.99 (d, J = 7.4 Hz, 2H, Ph-*H*), 7.93 (d, J = 7.4 Hz, 2H, Ph-*H*), 7.65−7.30 (m, 10H, H-8, Ph-*H*), 6.75 (d, J = 5.9 Hz, 1H, H-1′), 6.65 (d, $J_{7,8}$ = 3.8 Hz, 1H, H-7), 6.25 (dd, $J_{2',1'}$ = 5.9 Hz, $J_{2',3'}$ = 5.3 Hz, 1H, H-2′), 6.15 (dd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.86 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.2 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.34−2.26 (m, 1H, C*H*), 1.34−1.11 1.32−1.41 (m, 4H, CH(C*H*$_2$)$_2$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 165.1 (C-6), 152.2 (C-2), 150.8 (C-4), 133.8 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 124.8 (C-8), 118.3 (C-5), 101.4 (C-7), 86.4 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 14.8 (*C*H(CH$_2$)$_2$), 11.1 (2× *C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{35}H_{29}N_3O_7$ ([M + H]$^+$), 604.2078, found 604.2097.

2′,3′,5′-Tri-*O*-benzoyl-6-cyclopentyl-9-β-D-ribofuranosyl-7-deazapurine (10k). Following the general procedure, compound **10k** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), Fe(acac)$_3$ (8 mg, 0.02 mmol), CuI (9 mg, 0.04 mol), cyclopentylmagnesium bromide 1 M in THF (112.67 mg, 0.65 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (80 mg, 62% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.82 (s, 1H, H-2), 8.14 (d, J = 7.8 Hz, 2H, Ph-*H*), 8.00 (d, J = 7.8 Hz, 2H, Ph-*H*), 7.94 (d, J = 7.8 Hz, 2H, Ph-*H*), 7.59−7.32 (m, 10H, H-8, Ph-*H*), 6.78 (d, J = 5.8 Hz, 1H, H-1′), 6.60 (d, $J_{7,8}$ = 3.5 Hz, 1H, H-7), 6.28 (dd, $J_{2',1'}$ = 5.8 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.88 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.2 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.5 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.5 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.53−3.47 (m, 1H, C*H*), 2.08−1.73 (m, 8H, (C*H*$_2$)$_4$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 167.4 (C-6), 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 152.1 (C-2), 151.4 (C-4), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.0 (C-8), 118.2 (C-5), 101.7 (C-7), 86.5 (C-1′), 80.4 (C-4′), 74.1 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 45.1 (*C*H(CH$_2$)$_4$), 32.9, 32.8, 26.5, 26.5 (4× *C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{37}H_{33}N_3O_7$ ([M + H]$^+$), 632.2391, found 632.2407.

2′,3′,5′-Tri-*O*-benzoyl-6-cyclohexyl-9-β-D-ribofuranosyl-7-deazapurine (10l). Following the general procedure, compound **10l** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), Fe(acac)$_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.043 mol), cyclohexylmagnesium bromide 1 M in THF (121.79 mg, 0.65 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (80 mg, 62% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.81 (s, 1H, H-2), 8.14 (d, J = 7.3 Hz, 2H, Ph-H), 8.00 (d, J = 7.3 Hz, 2H, Ph-H), 7.94 (d, J = 7.3 Hz, 2H, Ph-H), 7.60−7.30 (m, 10H, H-8, Ph-H), 6.76 (d, J = 5.9 Hz, 1H, H-1′), 6.62 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.25 (dd, $J_{2',1'}$ = 5.9 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.16 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.86 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.78 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.5 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.07−2.99 (m, 1H, C*H*(CH$_2$)$_5$), 1.90−1.35 (m, 10H, CH(C*H*$_2$)$_5$); ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 167.7 (C-6), 166.4 (*C*OOPh), 165.7 (*C*OOPh), 165.4 (*C*OOPh), 152.1 (C-2), 151.6 (C-4), 133.9

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J. Org. Chem. XXXX, XXX, XXX−XXX

(C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 124.9 (C-8), 117.7 (C-5), 101.6 (C-7), 86.4 (C-1′), 80.4 (C-4′), 74.1 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 44.4 ($CH(CH_2)_5$), 31.8, 31.8, 26.7, 26.7, 26.2 ($5\times CH_2$); HRMS (ESI-TOF) m/z: calcd for $C_{38}H_{35}N_3O_7$ ($[M + H]^+$), 646.2547, found 646.2576.

2′,3′,5′-Tri-*O*-benzoyl-6-(4-isoproylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (10m). Following the general procedure, compound **10m** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (110 mg, 0.183 mmol), $Fe(acac)_3$ (6.5 mg, 0.0183 mmol), CuI (7 mg, 0.026 mol), 4-isopropylphenylmagnesium bromide 0.5 M in THF (268.08 mg, 1.2 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (100 mg, 35% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.95 (s, 1H, H-2), 8.14 (d, J = 7.9 Hz, 2H, Ph-*H*), 8.02−7.93 (m, 5H, Ph-*H*), 7.59−7.35 (m, 13H, H-8, Ph-*H*), 6.84 (d, $J_{7,8}$ = 3.5 Hz, 1H, H-7), 6.84 (d, J = 5.6 Hz, 1H, H-1′), 6.30 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.18 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.2 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.2 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.05−2.94 (m, 1H, $CH(CH_3)_2$), 1.30 (d, J = 7.1 Hz, 6H, $CH(CH_3)_2$); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 158.4 (C-6), 152.6 (C-4), 152.2 (C-2), 151.6 (C-Ph), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.2 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 127.2 (C-Ph), 126.1 (C-8), 116. (C-5), 103.0 (C-7), 86.4 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 34.8 ($CH(CH_3)_2$), 24.1, 24.1 ($CH(CH_3)_2$); HRMS (ESI-TOF) m/z: calcd for $C_{41}H_{35}N_3O_7$ ($[M + H]^+$), 682.2547, found 682.2553.

2′,3′,5′-Tri-*O*-benzoyl-6-(4-methoxylphenyl)-9-β-D-ribofuranosyl-7-desazapurine (10n). Following the general procedure, compound **10n** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), $Fe(acac)_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.04 mol), 4-methoxylphenylmagnesium bromide 1 M in THF (158.51 mg, 0.75 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (80 mg, 60% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.91 (s, 1H, H-2), 8.17−8.92 (m, 8H, Ph-*H*), 7.60−7.35 (m, 9H, H-8, Ph-*H*), 7.05 (d, J = 8.7 Hz, 2H, Ph-*H*), 6.83 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 6.80 (d, $J_{1',2'}$ = 5.6 Hz, 1H, H-1′), 6.28 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.88 (dd, $J_{5',4'}$ = 3.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.80 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.0 Hz, $J_{4',5''}$ = 3.9 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.88 (s, 3H, OCH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 161.7 (C-6), 157.9 (C-Ph), 152.6 (C-4), 152.2 (C-2), 133.8 (C-Ph), 133.6 (C-Ph), 130.8, (C-Ph), 130.6 (C-Ph), 130.1 (C-Ph), 129.8 (C-Ph),129.2 (C-Ph), 128.9 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.9 (C-8), 116.3 (C-5), 102.9 (C-7), 86.5 (C-1′), 80.5 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 55.6 (OCH_3); HRMS (ESI-TOF) m/z: calcd for $C_{39}H_{31}N_3O_8$ ($[M + H]^+$), 670.2183, found 670.2195.

2′,3′,5′-Tri-*O*-benzoyl-6-phenyl-9-β-D-ribofuranosyl-7-deazapurine (10o). Following the general procedure, compound **10o** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (70 mg, 0.117 mmol), $Fe(acac)_3$ (4 mg, 0.0117 mmol), CuI (5 mg, 0.02 mol), phenylmagnesium bromide 1 M in THF (54.39 mg, 0.3 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (40 mg, 54% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.96 (s, 1H, H-2), 8.15−8.79 (m, 8H, Ph-*H*), 7.59−7.32 (m, 13H, H-8, Ph-*H*), 6.83 (d, $J_{7,8}$ = 3.6 Hz, 1H, H-7), 6.82 (d, J = 5.6 Hz, 1H, H-1′), 6.29 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.3 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.4 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.1 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.4 Hz, $J_{4',5'}$ = 3.1 Hz, $J_{4',5''}$ = 3.5 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.5 Hz, J_{gem} = 11.9 Hz, 1H, H-5″); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 158.4 (C-6), 152.7 (C-4), 152.2 (C-2), 138.2 (C-Ph), 133.9 (C-Ph), 133.6 (C-Ph), 130.4 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 129.0 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 126.4 (C-8), 116.9 (C-5), 102.8 (C-7), 86.7 (C-1′), 80.5 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′); HRMS (ESI-TOF) m/z: calcd for $C_{38}H_{29}N_3O_7$ ($[M + H]^+$), 640.2078, found 640.2086.

2′,3′,5′-Tri-*O*-benzoyl-6-(4-(dimethylamino)phenyl)-9-β-D-ribofuranosyl-7-deazapurine (10p). Following the general procedure, compound **10p** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (100 mg, 0.167 mmol), $Fe(acac)_3$ (6 mg, 0.0167 mmol), CuI (6 mg, 0.032 mol), 4-(dimethylamino)phenylmagnesium bromide 0.5 M in THF (235.60 mg, 1.05 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as light yellow foam (25 mg, 22% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.87 (s, 1H, H-2), 8.15−8.79 (m, 8H, Ph-*H*), 7.59−7.32 (m, 11H, Ph-*H*), 6.86 (d, $J_{8,7}$ = 3.7 Hz, 1H, H-8), 6.83 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.80 (d, J = 5.6 Hz, 1H, H-1′), 6.27 (dd, $J_{2',1'}$ = 5.6 Hz, $J_{2',3'}$ = 5.3 Hz, 1H, H-2′), 6.17 (dd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.4 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 2.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.79 (ddd, $J_{4',3'}$ = 4.4 Hz, $J_{4',5'}$ = 2.9 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.70 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.01 (s, 6H, 2 × CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 158.4 (C-6), 152.6 (C-4), 152.2 (C-2), 152.1 (C-Ph), 133.8 (C-Ph), 133.6 (C-Ph), 130.4 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 125.7 130.1 (C-Ph), 125.1 (C-8), 115.7 (C-Ph), 112.1 (C-5), 103.3 (C-7), 86.7 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.3 (C-5′), 40.4 ($2\times CH_3$); HRMS (ESI-TOF) m/z: calcd for $C_{40}H_{34}N_4O_7$ ($[M + H]^+$), 683.2500, found 683.2499.

2′,3′,5′-Tri-*O*-benzoyl-6-(4-ethylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (10q). Following the general procedure, compound **10q** was obtained starting from 2′,3′,5′-tri-*O*-benzoyl-6-chloro-9-β-D-ribofuranosyl-7-desazapurine (**9**) (120 mg, 0.2 mmol), $Fe(acac)_3$ (7 mg, 0.02 mmol), CuI (8 mg, 0.04 mol), 4-ethylphenylmagnesium bromide 0.5 M in THF (345.46 mg, 1.65 mmol, added as portions, and TLC monitoring), dry THF (5.0 mL), and NMP (0.5 mL) after column chromatography on silica gel (heptane/EtOAc = 5:1, to 2:1, v/v) as white foam (75 mg, 56% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.94 (s, 1H, H-2), 8.14 (d, J = 7.8 Hz, 2H, Ph-*H*), 8.02−7.93 (m, 5H, Ph-*H*), 7.59−7.35 (m, 13H, H-8, Ph-*H*), 6.84 (d, J = 5.8 Hz, 1H, H-1′), 6.82 (d, $J_{7,8}$ = 3.7 Hz, 1H, H-7), 6.29 (dd, $J_{2',1'}$ = 5.8 Hz, $J_{2',3'}$ = 5.0 Hz, 1H, H-2′), 6.18 (dd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 4.3 Hz, 1H, H-3′), 4.89 (dd, $J_{5',4'}$ = 3.2 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 4.81 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.2 Hz, $J_{4',5''}$ = 3.8 Hz, 1H, H-4′), 4.69 (dd, $J_{5'',4'}$ = 3.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.74 (q, J = 7.4 Hz, 2H, CH_2), 1.29 (t, J = 7.4 Hz, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 166.4 (COOPh), 165.7 (COOPh), 165.4 (COOPh), 158.4 (C-6), 152.6 (C-4), 152.2 (C-2), 147.0 (C-Ph), 133.9 (C-Ph), 133.6 (C-Ph), 130.1 (C-Ph), 130.0 (C-Ph), 129.8 (C-Ph), 129.1 (C-Ph), 128.8 (C-Ph), 128.7 (C-Ph), 128.6 (C-Ph), 126.1 (C-8), 116.7 (C-5), 103.2 (C-7), 86.4 (C-1′), 80.4 (C-4′), 74.2 (C-2′), 71.9 (C-3′), 64.2 (C-5′), 29.0 (CH_2), 26.2 (CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{40}H_{33}N_3O_7$ ($[M + H]^+$), 668.2391, found 668.2390.

6-(4-Methylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (11a). Compound **10a** (70 mg, 0.107 mmol) was dissolved in 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol), and the reaction mixture was stirred at room temperature overnight in a sealed vessel. It was then concentrated under reduced pressure, and the resulting crude residue was purified by column chromatography on silica gel (gradient CH_2Cl_2/MeOH = 10:1, v/v) to give **11a** (30 mg, 83%) as a white solid. ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.87 (s, 1H, H-2), 8.07 (d, J = 8.0 Hz, 2H, Ph-*H*), 7.95 (d, J = 3.8 Hz, 1H, H-8), 7.40 (d, J = 8.0 Hz, 2H, Ph-*H*), 7.00 (d, J = 3.8 Hz, 1H, H-7), 6.29 (d, J = 6.1 Hz, 1H, H-1′), 5.41 (d, $J_{OH,2'}$ = 6.3 Hz, 1H, OH-2′), 5.22 (d, $J_{OH,3'}$ = 4.5 Hz, 1H, OH-3′), 5.13 (dd, $J_{OH,5'}$ = 5.6 Hz, $J_{OH,5''}$ = 4.4 Hz, 1H, OH-5′),

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J. Org. Chem. XXXX, XXX, XXX−XXX

4.47 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 4.7 Hz, $J_{2',OH}$ = 6.3 Hz, 1H, H-2′), 4.15 (ddd, $J_{3',2'}$ = 4.7 Hz, $J_{3',4'}$ = 3.7 Hz, $J_{3',OH}$ = 4.5 Hz, 1H, H-3′), 3.96 (ddd, $J_{4',3'}$ = 3.7 Hz, $J_{4',5'}$ = 4.5 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 3.70−3.63 (ddd, $J_{5',4'}$ = 4.5 Hz, $J_{5',OH}$ = 5.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.61−3.54 (ddd, $J_{5'',4'}$ = 3.7 Hz, $J_{5'',OH}$ = 4.4 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.40 (s, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 156.2 (C-6), 152.0 (C-4), 151.0 (C-2), 140.2 (C-Ph), 134.9 (C-Ph), 129.6 (C-Ph), 128.6 (C-Ph), 127.9 (C-8), 115.3 (C-5), 101.1 (C-7), 87.0 (C-1′), 85.3 (C-4′), 74.2 (C-2′), 70.7 (C-3′), 61.7 (C-5′), 21.1 (CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{17}H_{19}N_3O_4$ ([M + H]$^+$), 342.1448, found 342.1447.

6-Methyl-9-β-D-ribofuranosyl-7-deazapurine (11b). Following a similar procedure to that used for the synthesis of **11a**, compound **11b** was obtained starting from **10b** (70 mg, 0.255 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (25 mg, 78%). ^1H NMR (300 MHz, DMSO-d_6) δ 8.65 (s, 1H, H-2), 7.78 (d, J = 3.8 Hz, 1H, H-8), 6.75 (d, J = 3.8 Hz, 1H, H-7), 6.18 (d, J = 6.1 Hz, 1H, H-1′), 5.35 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.18 (d, $J_{OH,3'}$ = 4.7 Hz, 1H, OH-3′), 5.10 (dd, $J_{OH,5'}$ = 5.9 Hz, $J_{OH,5''}$ = 4.9 Hz, 1H, OH-5′), 4.42 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.11 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 3.8 Hz, $J_{3',OH}$ = 4.7 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 3.8 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.68−3.61 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.60−3.54 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 4.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.65 (s, 3H, CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 159.0 (C-6), 150.8 (C-4), 150.4 (C-2), 126.5 (C-8), 118.0 (C-5), 100.1 (C-7), 87.1 (C-1′), 85.2 (C-4′), 74.1 (C-2′), 70.7 (C-3′), 61.7 (C-5′), 21.2 (CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{12}H_{15}N_3O_4$ ([M + H]$^+$), 266.1135, found 266.1133.

6-Isopropyl-9-β-D-ribofuranosyl-7-deazapurine (11c). Following a similar procedure to that used for the synthesis of **11a**, compound **11c** was obtained starting from **10c** (100 mg, 0.255 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (40 mg, 83%). ^1H NMR (300 MHz, DMSO-d_6) δ 8.72 (s, 1H, H-2), 7.78 (d, J = 3.7 Hz, 1H, H-8), 6.80 (d, J = 3.7 Hz, 1H, H-7), 6.20 (d, J = 6.3 Hz, 1H, H-1′), 5.37 (br, 1H, OH-2′), 5.19 (br, 1H, OH-3′), 5.11 (dd, $J_{OH,5'}$ = 5.7 Hz, $J_{OH,5''}$ = 4.6 Hz, 1H, OH-5′), 4.47 (dd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, 1H, H-2′), 4.14 (dd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, 1H, H-3′), 3.94 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.69−3.62 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.60−3.54 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 4.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.45−3.40 (m, 1H, $CH(CH_3)_2$), 1.31 (d, J = 6.9 Hz, 6H, 2 × CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 167.1 (C-6), 151.0 (C-4), 150.8 (C-2), 126.6 (C-8), 116.4 (C-5), 99.8 (C-7), 86.9 (C-1′), 85.2 (C-4′), 74.0 (C-2′), 70.7 (C-3′), 61.7 (C-5′), 33.0 ($CH(CH_3)_2$), 21.5, 21.5 ($CH(CH_3)_2$); HRMS (ESI-TOF) m/z: calcd for $C_{14}H_{19}N_3O_4$ ([M + H]$^+$), 294.1448, found 294.1447.

6-Ethyl-9-β-D-ribofuranosyl-7-deazapurine (11d). Following a similar procedure to that used for the synthesis of **11a**, compound **11d** was obtained starting from **10d** (100 mg, 0.169 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (40 mg, 85%). ^1H NMR (300 MHz, DMSO-d_6) δ 8.69 (s, 1H, H-2), 7.79 (d, J = 3.8 Hz, 1H, H-8), 6.77 (d, J = 3.8 Hz, 1H, H-7), 6.19 (d, J = 6.1 Hz, 1H, H-1′), 5.36 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.18 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.10 (dd, $J_{OH,5'}$ = 5.9 Hz, $J_{OH,5''}$ = 5.1 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.12 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.68−3.61 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.58−3.51 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.99 (q, J = 7.7 Hz, 2H, CH_2CH_3), 1.30 (t, J = 7.7 Hz, 3H, CH_2CH_3); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 163.6 (C-6), 151.0 (C-2), 150.6 (C-4), 126.6 (C-8), 117.2 (C-5), 99.9 (C-7), 87.0 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 27.8 (CH_2CH_3), 12.7 (CH_2CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{19}N_3O_4$ ([M + H]$^+$), 280.1291, found 280.1291.

6-Propyl-9-β-D-ribofuranosyl-7-deazapurine (11e). Following a similar procedure to that used for the synthesis of **11a**, compound **11e** was obtained starting from **10e** (64 mg, 0.146 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (25 mg, 81%). ^1H NMR (300 MHz, DMSO-d_6) δ 8.69 (s, 1H, H-2), 7.79 (d, J = 3.7 Hz, 1H, H-8), 6.77 (d, J = 3.7 Hz, 1H, H-7), 6.19 (d, J = 6.2 Hz, 1H, H-1′), 5.37 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.18 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.10 (dd, $J_{OH,5'}$ = 5.8 Hz, $J_{OH,5''}$ = 5.0 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.2 Hz, $J_{2',3'}$ = 5.4 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.12 (ddd, $J_{3',2'}$ = 5.4 Hz, $J_{3',4'}$ = 4.3 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.93 (ddd, $J_{4',3'}$ = 4.3 Hz, $J_{4',5'}$ = 3.5 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.68−3.61 (ddd, $J_{5',4'}$ = 3.5 Hz, $J_{5',OH}$ = 5.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.59−3.52 (ddd, $J_{5'',4'}$ = 3.3 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.94 (t, J = 7.3 Hz, 2H, CH_2CH_2), 1.85−1.73 (m, 2H, CH_2CH_3), 0.92 (t, J = 7.3 Hz, 3H, CH_2CH_3), $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 162.4 (C-6), 150.9 (C-2), 150.6 (C-4), 126.6 (C-8), 117.8 (C-5), 100.0 (C-7), 87.0 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 36.5 (CH_2CH_2), 21.5 (CH_2CH_2), 13.9 (CH_2CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{19}N_3O_4$ ([M + H]$^+$), 294.1448, found 294.1446.

6-Pentyl-9-β-D-ribofuranosyl-7-deazapurine (11f). Following a similar procedure to that used for the synthesis of **11a**, compound **11f** was obtained starting from **10f** (80 mg, 0.126 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white semisolid (35 mg, 87%). ^1H NMR (300 MHz, DMSO-d_6) δ 8.68 (s, 1H, H-2), 7.78 (d, J = 3.8 Hz, 1H, H-8), 6.76 (d, J = 3.8 Hz, 1H, H-7), 6.18 (d, J = 6.3 Hz, 1H, H-1′), 5.35 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.18 (d, $J_{OH,3'}$ = 4.6 Hz, 1H, OH-3′), 5.09 (dd, $J_{OH,5'}$ = 5.8 Hz, $J_{OH,5''}$ = 5.0 Hz, 1H, OH-5′), 4.43 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.12 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.6 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.7 Hz, $J_{4',5''}$ = 3.1 Hz, 1H, H-4′), 3.67−3.60 (ddd, $J_{5',4'}$ = 3.7 Hz, $J_{5',OH}$ = 5.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.58−3.51 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.96 (t, J = 7.4 Hz, 2H, $CH_2(CH_2)_3$), 1.82−1.74 (m, 2H, CH_2CH_3), 1.32−1.29 (m, 4H, $CH_2(CH_2)_2$), 0.85 (t, J = 6.6 Hz, 3H, $(CH_2)_4CH_3$); $^{13}C\{^1H\}$ NMR (75 MHz, DMSO-d_6) δ 162.7 (C-6), 150.9 (C-4), 150.6 (C-2), 126.6 (C-8), 117.7 (C-5), 99.9 (C-7), 87.0 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 34.4, 31.1, 27.8, 22.0, 13.9 (aliphatic chain); HRMS (ESI-TOF) m/z: calcd for $C_{18}H_{19}N_3O_5$ ([M + H]$^+$), 322.1761, found 322.1762.

6-Hexyl-9-β-D-ribofuranosyl-7-deazapurine (11g). Following a similar procedure to that used for the synthesis of **11a**, compound **11g** was obtained starting from **10g** (86 mg, 0.146 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white semisolid (38 mg, 86%). ^1H NMR (300 MHz, CD_3OD) δ 8.65 (s, 1H, H-2), 7.71 (d, J = 3.8 Hz, 1H, H-8), 6.75 (d, J = 3.8 Hz, 1H, H-7), 6.23 (d, J = 6.3 Hz, 1H, H-1′), 4.65 (dd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.2 Hz, 1H, H-2′), 4.32 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 3.2 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 3.2 Hz, $J_{4',5'}$ = 3.3 Hz, $J_{4',5''}$ = 2.9 Hz, 1H, H-4′), 3.68−3.61 (dd, $J_{5',4'}$ = 3.3 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.60−3.54 (dd, $J_{5'',4'}$ = 2.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.03 (t, J = 7.5 Hz, 2H, $CH_2(CH_2)_3$), 1.86−1.76 (m, 2H, CH_2CH_3), 1.41−1.28 (m, 6H, $(CH_2)_3CH_3$), 0.89 (t, J = 6.8 Hz, 3H, $(CH_2)_4CH_3$); $^{13}C\{^1H\}$ NMR (75 MHz, CD_3OD) δ 163.0 (C-6), 149.9 (C-2), 149.6 (C-4), 127.0 (C-8), 118.4 (C-5), 99.4 (C-7), 88.8 (C-1′), 85.3 (C-2′), 73.9 (C-4′), 70.7 (C-3′), 61.6 (C-5′), 34.1, 30.9, 28.4, 28.3, 21.8, 12.5 (aliphatic chain); HRMS (ESI-TOF) m/z: calcd for $C_{17}H_{25}N_3O_4$ ([M + H]$^+$), 336.1917, found 336.1917.

6-(But-3-en-1-yl)-9-β-D-ribofuranosyl-7-desazapurine (11h). Following a similar procedure to that used for the synthesis of **11a**, compound **11h** was obtained starting from **10h** (80 mg, 0.08 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white semisolid (16 mg, 66%). ^1H NMR (300 MHz, CD_3OD) δ 8.67 (s, 1H, H-2), 7.73 (d, J = 3.8 Hz, 1H, H-8), 6.78 (d, J = 3.8 Hz, 1H, H-7), 6.23 (d, J = 6.3 Hz, 1H, H-1′), 4.65 (dd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.2

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J. Org. Chem. XXXX, XXX, XXX−XXX

Hz, 1H, H-2′), 5.93−5.82 (m, 1H, C*H*═CH$_2$), 5.06 (dd, J = 1.5 and 3.3 Hz, 1H, CH═C*H*), 5.01 (dd, J = 1.5 and 3.3 Hz, 1H, CH═C*H*), 4.64 (dd, $J_{3',2'}$ = 5.2 Hz, $J_{3',4'}$ = 3.1 Hz, 1H, H-3′), 4.32 (ddd, $J_{4',3'}$ = 3.1 Hz, $J_{4',5'}$ = 3.3 Hz, $J_{4',5''}$ = 2.9 Hz, 1H, H-4′), 3.89−3.84 (dd, $J_{5',4'}$ = 3.3 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.79−3.74 (dd, $J_{5'',4'}$ = 2.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.14 (t, J = 7.1 Hz, 2H, C*H*$_2$), 2.62−2.55 (m, 2H, C*H*$_2$); ^{13}C{^{1}H} NMR (75 MHz, CD$_3$OD) δ 162.0 (C-6), 150.0 (C-4), 149.6 (C-2), 136.6 (CH═CH$_2$), 127.0 (C-8), 118.4 (C-5), 114.2 (*C*H═CH$_2$), 99.4 (C-7), 88.8 (C-1′), 85.3 (C-2′), 73.9 (C-4′), 70.7 (C-3′), 61.6 (C-5′), 33.6 (*C*H$_2$), 32.1 (*C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{19}N_3O_4$ ([M + H]$^+$), 306.1448, found 306.1446.

6-Isobutyl-9-β-D-ribofuranosyl-7-deazapurine (11i). Following a similar procedure to that used for the synthesis of **11a**, compound **11i** was obtained starting from **10i** (80 mg, 0.146 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white semisolid (35 mg, 85%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.69 (s, 1H, H-2), 7.78 (d, J = 3.8 Hz, 1H, H-8), 6.76 (d, J = 3.8 Hz, 1H, H-7), 6.19 (d, J = 6.3 Hz, 1H, H-1′), 5.36 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.18 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.09 (dd, $J_{OH,5'}$ = 5.8 Hz, $J_{OH,5''}$ = 5.0 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.3 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.12 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.67−3.60 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.58−3.51 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.84 (d, J = 7.1 Hz, 2H, C*H*$_2$CH), 2.27−2.18 (m, 1H, C*H*(CH$_3$)$_2$), 0.91 (d, J = 6.9 Hz, 6H, CH(C*H*$_3$)$_2$); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 161.9 (C-6), 150.9 (C-2), 150.6 (C-4), 126.6 (C-8), 118.3 (C-5), 100.1 (C-7), 96.9 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 43.6 (*C*H$_2$CH), 28.1 (*C*H(CH$_3$)$_2$), 22.6 (*C*H$_3$), 22.5 (*C*H$_3$); HRMS (ESI-TOF) m/z: calcd for $C_{15}H_{21}N_3O_4$ ([M + H]$^+$), 308.1604, found 308.1607.

6-Cycloproyl-9-β-D-ribofuranosyl-7-deazapurine (11j). Following a similar procedure to that used for the synthesis of **11a**, compound **11j** was obtained starting from **10j** (95 mg, 0.157 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white solid (40 mg, 88%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.58 (s, 1H, H-2), 7.77 (d, J = 3.8 Hz, 1H, H-8), 6.88 (d, J = 3.8 Hz, 1H, H-7), 6.17 (d, J = 6.1 Hz, 1H, H-1′), 5.34 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.17 (d, $J_{OH,3'}$ = 4.6 Hz, 1H, OH-3′), 5.11 (dd, $J_{OH,5'}$ = 5.7 Hz, $J_{OH,5''}$ = 4.6 Hz, 1H, OH-5′), 4.43 (dd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, 1H, H-2′), 4.12 (dd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.69−3.61 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.59−3.53 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 4.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.54−2.46 (m, 1H, C*H*), 1.18−1.10 (m, 4H, CH(C*H*$_2$)$_2$); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 163.6 (C-6), 151.1 (C-2), 149.9 (C-4), 126.4 (C-8), 117.4 (C-5), 99.8 (C-7), 87.0 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 14.0 (*C*H(CH$_2$)$_2$), 10.7 (CH(*C*H$_2$)$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{14}H_{17}N_3O_4$ ([M + H]$^+$), 292.1291, found 292.1291.

6-Cyclopentyl-9-β-D-ribofuranosyl-7-deazapurine (11k). Following a similar procedure to that used for the synthesis of **11a**, compound **11k** was obtained starting from **10k** (80 mg, 0.126 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white semisolid (35 mg, 87%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.70 (s, 1H, H-2), 8.07 (d, J = 8.0 Hz, 2H, Ph-*H*), 7.77 (d, J = 3.8 Hz, 1H, H-8), 6.77 (d, J = 3.8 Hz, 1H, H-7), 6.19 (d, J = 6.1 Hz, 1H, H-1′), 5.36 (d, $J_{OH,2'}$ = 6.3 Hz, 1H, OH-2′), 5.19 (d, $J_{OH,3'}$ = 4.7 Hz, 1H, OH-3′), 5.13 (dd, $J_{OH,5'}$ = 5.7 Hz, $J_{OH,5''}$ = 4.3 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 4.9 Hz, $J_{2',OH}$ = 6.3 Hz, 1H, H-2′), 4.13 (ddd, $J_{3',2'}$ = 4.9 Hz, $J_{3',4'}$ = 3.7 Hz, $J_{3',OH}$ = 4.7 Hz, 1H, H-3′), 3.93 (ddd, $J_{4',3'}$ = 3.7 Hz, $J_{4',5'}$ = 4.5 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 3.67−3.52 (ddd, $J_{5',4'}$ = 4.5 Hz, $J_{5',OH}$ = 5.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.59−3.52 (ddd, $J_{5'',4'}$ = 3.7 Hz, $J_{5'',OH}$ = 4.3 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.09−1.62 (m, 8H); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 165.9 (C-6), 151.0 (C-2), 150.5 (C-4), 126.5 (C-8), 117.2 (C-5), 100.0 (C-7), 86.9 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 43.9 (CH(CH$_2$)$_4$), 32.2, 32.1, 25.9, 25.9 (4× *C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{16}H_{21}N_3O_4$ ([M + H]$^+$), 320.1604, found 320.1607.

6-Cyclohexyl-9-β-D-ribofuranosyl-7-deazapurine (11l). Following a similar procedure to that used for the synthesis of **11a**, compound **11l** was obtained starting from **10l** (80 mg, 0.146 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white semisolid (35 mg, 85%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.69 (s, 1H, H-2), 7.78 (d, J = 3.8 Hz, 1H, H-8), 6.80 (d, J = 3.8 Hz, 1H, H-7), 6.18 (d, J = 6.3 Hz, 1H, H-1′), 5.34 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.16 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.09 (dd, $J_{OH,5'}$ = 5.9 Hz, $J_{OH,5''}$ = 4.8 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.3 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.12 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.92 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.67−3.60 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.58−3.52 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.11 (t, J = 11.4 Hz, 1H, C*H*(CH$_2$)$_5$), 1.84−1.64 (m, 7H), 1.50−1.23 (m, 3H); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 166.2 (C-6), 151.0 (C-2), 150.8 (C-4), 126.5 (C-8), 116.6 (C-5), 99.8 (C-7), 86.9 (C-1′), 85.2 (C-2′), 74.0 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 43.0 (*C*H(CH$_2$)$_5$), 31.3, 31.3, 25.9, 25.7, 25.7 (5×*C*H$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{17}H_{23}N_3O_4$ ([M + H]$^+$), 334.1761, found 334.1762.

6-(4-Isoproylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (11m). Following a similar procedure to that used for the synthesis of **11a**, compound **11m** was obtained starting from **10m** (100 mg, 0.146 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white solid (40 mg, 74%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.87 (s, 1H, H-2), 8.11 (d, J = 8.2 Hz, 2H, Ph-*H*), 7.95 (d, J = 3.8 Hz, 1H, H-8), 7.47 (d, J = 8.2 Hz, 2H, Ph-*H*), 7.01 (d, J = 3.8 Hz, 1H, H-7), 6.28 (d, J = 6.1 Hz, 1H, H-1′), 5.40 (d, $J_{OH,2'}$ = 6.3 Hz, 1H, OH-2′), 5.20 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.11 (dd, $J_{OH,5'}$ = 5.7 Hz, $J_{OH,5''}$ = 4.8 Hz, 1H, OH-5′), 4.47 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.3 Hz, 1H, H-2′), 4.14 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.94 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.69−3.62 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.60−3.54 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 4.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.04−2.95 (m, 1H, C*H*(CH$_3$)$_2$), 1.27 (d, J = 6.9 Hz, 6H, 2× *C*H$_3$); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 156.2 (C-6), 152.1 (C-4), 151.1 (C-2), 150.9 (C-Ph), 135.3 (C-Ph), 128.8 (C-Ph), 127.9 (C-Ph), 126.9 (C-8), 115.4 (C-5), 101.0 (C-7), 87.0 (C-1′), 85.3 (C-4′), 74.2 (C-2′), 70.7 (C-3′), 61.7 (C-5′), 33.4 (*C*H(CH$_3$)$_2$), 23.8, 23.8 (CH(*C*H$_3$)$_2$); HRMS (ESI-TOF) m/z: calcd for $C_{20}H_{23}N_3O_4$ ([M + H]$^+$), 370.1761, found 370.1755.

6-(4-Methoxylphenyl)-9-β-D-ribofuranosyl-7-desazapurine (11n). Following a similar procedure to that used for the synthesis of **11a**, compound **11n** was obtained starting from **10n** (80 mg, 0.146 mmol) and 20 mL of 7 N NH$_3$ in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH$_2$Cl$_2$/MeOH = 10:1, v/v) as a white solid (35 mg, 84%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.83 (s, 1H, H-2), 8.18 (d, J = 8.8 Hz, 2H, Ph-*H*), 7.93 (d, J = 3.8 Hz, 1H, H-8), 7.14 (d, J = 8.8 Hz, 2H, Ph-*H*), 7.01 (d, J = 3.8 Hz, 1H, H-7), 6.28 (d, J = 6.1 Hz, 1H, H-1′), 5.40 (d, $J_{OH,2'}$ = 6.3 Hz, 1H, OH-2′), 5.21 (d, $J_{OH,3'}$ = 4.7 Hz, 1H, OH-3′), 5.11 (dd, $J_{OH,5'}$ = 5.9 Hz, $J_{OH,5''}$ = 4.8 Hz, 1H, OH-5′), 4.47 (ddd, $J_{2',1'}$ = 6.3 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.3 Hz, 1H, H-2′), 4.14 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.7 Hz, 1H, H-3′), 3.95 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.86 (s, 3H, C*H*$_3$), 3.70−3.60 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.59−3.54 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.48 (s, 3H, -OC*H*$_3$); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 161.1 (C-6), 155.8 (C-Ph), 152.0 (C-4), 151.0 (C-2), 130.3 (C-Ph), 130.0 (C-Ph), 127.7 (C-8), 114.9 (C-Ph), 114.4 (C-5), 101.1 (C-7), 86.8 (C-1′), 85.3 (C-4′), 74.1 (C-2′), 70.7 (C-3′), 61.7 (C-5′), 55.4 (OCH$_3$); HRMS (ESI-TOF) m/z: calcd for $C_{18}H_{19}N_3O_5$ ([M + H]$^+$), 358.1397, found 358.1391.

6-Phenyl-9-β-D-ribofuranosyl-7-deazapurine (11o). Following a similar procedure to that used for the synthesis of **11a**, compound **11o** was obtained starting from **10o** (80 mg, 0.146 mmol)

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J. Org. Chem. XXXX, XXX, XXX−XXX

and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (15 mg, 75%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.90 (s, 1H, H-2), 8.17 (d, J = 7.9 Hz, 2H, Ph-*H*), 7.97 (d, J = 3.8 Hz, 1H, H-8), 7.61−7.57 (m, 3H), 7.01 (d, J = 3.8 Hz, 1H, H-7), 6.29 (d, J = 6.0 Hz, 1H, H-1′), 5.42 (d, $J_{OH,2'}$ = 5.6 Hz, 1H, OH-2′), 5.22 (d, $J_{OH,3'}$ = 4.4 Hz, 1H, OH-3′), 5.13 (dd, $J_{OH,5'}$ = 5.6 Hz, $J_{OH,5''}$ = 4.2 Hz, 1H, OH-5′), 4.47 (ddd, $J_{2',1'}$ = 6.1 Hz, $J_{2',3'}$ = 5.0 Hz, $J_{2',OH}$ = 5.6 Hz, 1H, H-2′), 4.14 (ddd, $J_{3',2'}$ = 5.0 Hz, $J_{3',4'}$ = 3.7 Hz, $J_{3',OH}$ = 4.4 Hz, 1H, H-3′), 3.93 (ddd, $J_{4',3'}$ = 3.7 Hz, $J_{4',5'}$ = 4.5 Hz, $J_{4',5''}$ = 3.7 Hz, 1H, H-4′), 3.69−3.62 (ddd, $J_{5',4'}$ = 4.5 Hz, $J_{5',OH}$ = 5.6 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.61−3.51 (ddd, $J_{5'',4'}$ = 3.7 Hz, $J_{5'',OH}$ = 4.2 Hz, J_{gem} = 11.9 Hz, 1H, H-5″); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 156.2 (C-6), 152.1 (C-4), 151.1 (C-2), 137.6 (C-Ph), 130.3 (C-Ph), 129.0 (C-Ph), 128.7 (C-Ph), 128.1 (C-8), 115.6 (C-5), 101.0 (C-7), 87.0 (C-1′), 85.3 (C-2′), 74.2 (C-4′), 70.7 (C-3′), 61.7 (C-5′); HRMS (ESI-TOF) m/z: calcd for $C_{17}H_{17}N_3O_4$ ([M + H]$^+$), 328.1291, found 328.1296.

6-(4-(Dimethylamino)phenyl)-9-β-D-ribofuranosyl-7-deazapurine (11p). Following a similar procedure to that used for the synthesis of **11a**, compound **11p** was obtained starting from **10p** (25 mg, 0.036 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (11 mg, 85%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.75 (s, 1H, H-2), 8.12 (d, J = 9.0 Hz, 2H, Ph-*H*), 7.86 (d, J = 3.8 Hz, 1H, H-8), 6.99 (d, J = 3.8 Hz, 1H, H-8), 6.87 (d, J = 9.0 Hz, 2H, Ph-*H*), 6.24 (d, J = 6.1 Hz, 1H, H-1′), 5.38 (d, $J_{OH,2'}$ = 6.3 Hz, 1H, OH-2′), 5.19 (d, $J_{OH,3'}$ = 4.7 Hz, 1H, OH-3′), 5.13 (dd, $J_{OH,5'}$ = 5.9 Hz, $J_{OH,5''}$ = 4.8 Hz, 1H, OH-5′), 4.45 (ddd, $J_{2',1'}$ = 6.3 Hz, $J_{2',3'}$ = 5.6 Hz, $J_{2',OH}$ = 6.3 Hz, 1H, H-2′), 4.13 (ddd, $J_{3',2'}$ = 5.6 Hz, $J_{3',4'}$ = 4.1 Hz, $J_{3',OH}$ = 4.7 Hz, 1H, H-3′), 3.93 (ddd, $J_{4',3'}$ = 4.1 Hz, $J_{4',5'}$ = 3.9 Hz, $J_{4',5''}$ = 3.3 Hz, 1H, H-4′), 3.69−3.62 (ddd, $J_{5',4'}$ = 3.9 Hz, $J_{5',OH}$ = 5.9 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.60−3.54 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 5.0 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 3.03 (s, 6H, 2 × CH_3); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 156.4 (C-6), 151.9 (C-4), 151.8 (C-Ph), 150.9 (C-2), 129.9 (C-Ph), 127.0 (C-Ph), 124.8 (C-8), 114.2 (C-Ph), 111.9 (C-5), 101.3 (C-7), 87.0 (C-1′), 85.2 (C-2′), 74.1 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 39.8 (CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{19}H_{22}N_4O_4$ ([M + H]$^+$), 371.1713, found 371.1708.

6-(4-Ethylphenyl)-9-β-D-ribofuranosyl-7-deazapurine (11q). Following a similar procedure to that used for the synthesis of **11a**, compound **11q** was obtained starting from **10q** (75 mg, 0.112 mmol) and 20 mL of 7 N NH_3 in MeOH (2.38 g, 14.0 mmol) after column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1, v/v) as a white solid (30 mg, 77%). ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.87 (s, 1H, H-2), 8.10 (d, J = 8.2 Hz, 2H, Ph-*H*), 7.95 (d, J = 3.7 Hz, 1H, H-8), 7.44 (d, J = 8.2 Hz, 2H, Ph-*H*), 7.01 (d, J = 3.8 Hz, 1H, H-7), 6.28 (d, J = 6.0 Hz, 1H, H-1′), 5.40 (d, $J_{OH,2'}$ = 6.4 Hz, 1H, OH-2′), 5.20 (d, $J_{OH,3'}$ = 4.8 Hz, 1H, OH-3′), 5.11 (dd, $J_{OH,5'}$ = 5.7 Hz, $J_{OH,5''}$ = 4.8 Hz, 1H, OH-5′), 4.47 (ddd, $J_{2',1'}$ = 6.0 Hz, $J_{2',3'}$ = 5.3 Hz, $J_{2',OH}$ = 6.4 Hz, 1H, H-2′), 4.14 (ddd, $J_{3',2'}$ = 5.3 Hz, $J_{3',4'}$ = 4.0 Hz, $J_{3',OH}$ = 4.8 Hz, 1H, H-3′), 3.94 (ddd, $J_{4',3'}$ = 4.0 Hz, $J_{4',5'}$ = 3.7 Hz, $J_{4',5''}$ = 3.1 Hz, 1H, H-4′), 3.70−3.63 (ddd, $J_{5',4'}$ = 3.7 Hz, $J_{5',OH}$ = 5.7 Hz, J_{gem} = 11.9 Hz, 1H, H-5′), 3.61−3.53 (ddd, $J_{5'',4'}$ = 3.1 Hz, $J_{5'',OH}$ = 4.8 Hz, J_{gem} = 11.9 Hz, 1H, H-5″), 2.71 (q, J = 7.5 Hz, 1H, CH_2CH_3), 1.25 (t, J = 7.5 Hz, 3H, CH_2CH_3); ^{13}C{^{1}H} NMR (75 MHz, DMSO-d_6) δ 156.2 (C-6), 152.0 (C-4), 151.0 (C-2), 146.3 (C-Ph), 135.2 (C-Ph), 128.7 (C-Ph), 128.4 (C-Ph), 127.9 (C-8), 115.3 (C-5), 101.7 (C-7), 87.0 (C-1′), 85.3 (C-2′), 74.2 (C-4′), 70.7 (C-3′), 61.7 (C-5′), 28.1 (CH_2CH_3), 15.4 (CH_2CH_3); HRMS (ESI-TOF) m/z: calcd for $C_{19}H_{21}N_3O_4$ ([M + H]$^+$), 356.1604, found 356.1590.

Scale Up Experiment of Compound 5h. An oven-dried flask was charged with 6-chloro-7-deazapurine (2.0 g, 13 mmol, 1 equiv) in THF (50 mL), NMP (5 mL), Fe(acac)$_3$ (460 mg, 1.3 mmol, 0.1 equiv), and CuI (490 mg, 2.6 mmol, 0.2 equiv). The mixture was placed in an ice bath, and cyclohexylmagnesium bromide 1 M in THF (6.93 g, 37 mmol, added as portions slowly, and TLC monitoring) was added. The reaction mixture was stirred for 30 min in an ice bath. After monitoring with TLC till starting material disappeared, the reaction was quenched by the addition of aq saturated solution of NH_4Cl and extracted with EtOAc (3 × 100 mL). The organic solution was dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by silica gel chromatography (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1) to afford the desired product as a pale white solid (2.2 g, 85%).

Scale Up Experiment of Compound 5k. An oven-dried flask was charged with 6-chloro-7-deazapurine (2.0 g, 13 mmol, 1 equiv) in THF (50 mL), NMP (5 mL), Fe(acac)$_3$ (460 mg, 1.3 mmol, 0.1 equiv), and CuI (490 mg, 2.6 mmol, 0.2 equiv). The mixture was placed in an ice bath, and propylmagnesium chloride 2 M in THF (3.70 g, 36 mmol, added as portions slowly, and TLC monitoring) was added. The reaction mixture was stirred for 20 min in an ice bath. After monitoring with TLC till starting material disappeared, the reaction was quenched by the addition of aq saturated solution of NH_4Cl and extracted with EtOAc (3 × 100 mL). The organic solution was dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by silica gel chromatography (heptane/EtOAc = 5:1, to DCM/MeOH = 30:1), to afford the desired product as a pale white solid (1.7 g, 81%).

Cell Proliferation Assays. Cell lines (HL-60, K-562, Z-138, LN-229, Capan-1, HCT-116, NCI-H460) were acquired from the American Type Culture Collection (ATCC, Manassas, VA), except for the DND-41 cell line, which was purchased from the Deutsche Sammlung von Mikroorganismen und Zellkulturen (DSMZ Leibniz-Institut, Germany). All cell lines were cultured as recommended by the suppliers. Culture media were purchased from Gibco Life Technologies and supplemented with 10% fetal bovine serum (HyClone, GE Healthcare Life Sciences).

Reference inhibitor compounds staurosporine and docetaxel were obtained from Selleckchem (Munich, Germany). All stock solutions were prepared in DMSO.

Adherent cancer cell lines LN-229, Capan-1, HCT-116, and NCI-H460 cells were seeded at a density between 500 and 1500 cells per well, in 384-well, black-walled, clear-bottom tissue culture plates (Greiner). After overnight incubation, the cells were treated with the test compounds at seven different concentrations ranging from 100 to 6.4 × 10^{-3} μM. Suspension cell lines DND-41, HL-60, K-562, and Z-138 were seeded at densities ranging from 2500 to 5500 cells per well in 384-well, black-walled, clear-bottom tissue culture plates containing the test compounds at the same seven concentration points. The plates were incubated at 37 °C and monitored for 72 h in an IncuCyte device (Essen BioScience Inc., Ann Arbor, MI) for real-time imaging. Images were taken every 3 h, with one field imaged per well under 10× magnification. Cell growth was then quantified based on the percent cellular confluence as analyzed by the IncuCyte image analysis software. Area under the curve (AUC) values were calculated and used to determine the IC_{50} values.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.joc.9b02414.

^{1}H and ^{13}C NMR spectra of compounds **5a−k** (Figures S5−S26); ^{1}H and ^{13}C NMR spectra of compounds **9** and **10a−q** (Figures S27−S62); ^{1}H and ^{13}C NMR spectra of compounds **11a−q** (Figures S63−S96); HRMS spectra of compounds **5a−k** (Figures S97−S107); HRMS spectra of compounds **10a−q** (Figures S108−S124); and HRMS spectra of compounds **11a−q** (Figures S125−S141) (PDF)

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J. Org. Chem. XXXX, XXX, XXX−XXX

Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

Notes

The authors declare no competing financial interest.

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