Diels–Alder Additions, Ene Reactions, and Condensations of 4-(Acylamino)-5-nitrosopyrimidines – Synthesis of 8-Substituted Guanines and of 6-Substituted Pteridinones

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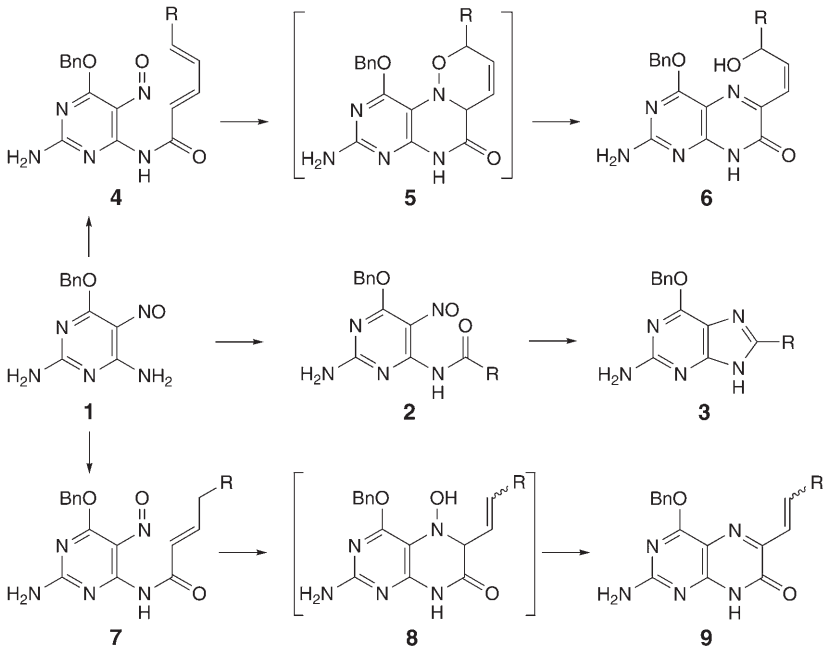
4-(Acylamino)-5-nitrosopyrimidines react either by a reductive condensation to provide 8-substituted guanines, or by a *Diels–Alder* cycloaddition, or an ene reaction, to provide 6-substituted pteridinones, depending on the nature of the acyl group and the reaction conditions. Experimental details are provided for the transformation of (acylamino)-nitrosopyrimidines to 8-substituted guanines, and the scope of the reaction is further demonstrated by transforming the trifluoro acetamide **25** to the 8-(trifluoromethyl)guanine (**27**), and the *N,N′*-bis(nitrosopyrimidinyl)-dicarboxamide **29** to the (*R,R*)-1,2-di(guan-8-yl)ethane-1,2-diol (**32**). An intramolecular *Diels–Alder* reaction of the *N*-sorbyl (= *N*-hexa-2,4-dienoyl) nitrosopyrimidine **10**, followed by a spontaneous elimination to cleave the N,O bond of the initial cycloaddition product provided the pteridinones **14** or **15**, characterized by a (*Z*)- or (*E*)-3-hydroxyprop-1-enyl group at C(6). Treatment of **10** with Ph_3P led to the *C(8)*-penta-1,3-dienyl-guanine **18**. The ene reaction of the *N*-crotonyl (= *N*-but-2-enoyl) nitrosopyrimidine **19** provided the 6-vinyl-pteridinone **20a** that dimerized readily to **21a**, while treatment of **19** with Ph_3P led in high yield to 8-(prop-1-enyl)guanine (**23**). The structure of the dimer **21** was established by X-ray analysis of its bis(*N,N*-dimethylformamidine) derivative **21b**. The crystal structure of the nitroso amide **10** is characterized by two molecules in the centrosymmetric unit cell. Intermolecular H-bonds connect the amino group to the amide carbonyl and to N(1). The crystalline bis(purine) **30** forms a left-handed helix with four molecules per turn and a pitch of 30.2 Å.

Introduction. – According to the modified *Traube* synthesis explored by *Pfleiderer* and co-workers, 4-(acylamino)-5-nitrosopyrimidines are transformed into purines by reduction of the N=O to an amino group followed by condensation [1]. We have communicated a simplified procedure for this transformation whereby 4-(acylamino)-2-amino-5-nitrosopyrimidines of type **2** (*Scheme 1*) are treated with 2 equiv. of a phosphine or a phosphite at elevated temperature to provide 8-substituted guanines **3** in one step [2]. The required amides are, as a rule, readily obtained by acylating the pyrimidine **1**. The convenient procedure and the high yields of the resulting guanines prompted us to further explore the reactivity of nitroso-pyrimidines. We found that *N*-(alka-2,4-dienoyl)-4-amino-5-nitrosopyrimidines **4** undergo a facile, high-yielding intramolecular *Diels–Alder* cycloaddition to **5**, followed by a spontaneous elimination, leading to pteridinones **6** possessing a (*Z*)-3-hydroxyalk-1-enyl group at C(6) [3]. Pteridinones **9** possessing an (*E*)-configured alkenyl substituent at C(6) result from a stereoselective nitroso-ene reaction of *N*-alk-2-enoyl derivatives **7** [4]. Similarly as for the cycloaddition of **4**, the initial product of the ene reaction is a hydroxylamine derivative **8** that could not be observed. The ene reaction of *N*-alk-2-enoyl derivatives

Scheme 1



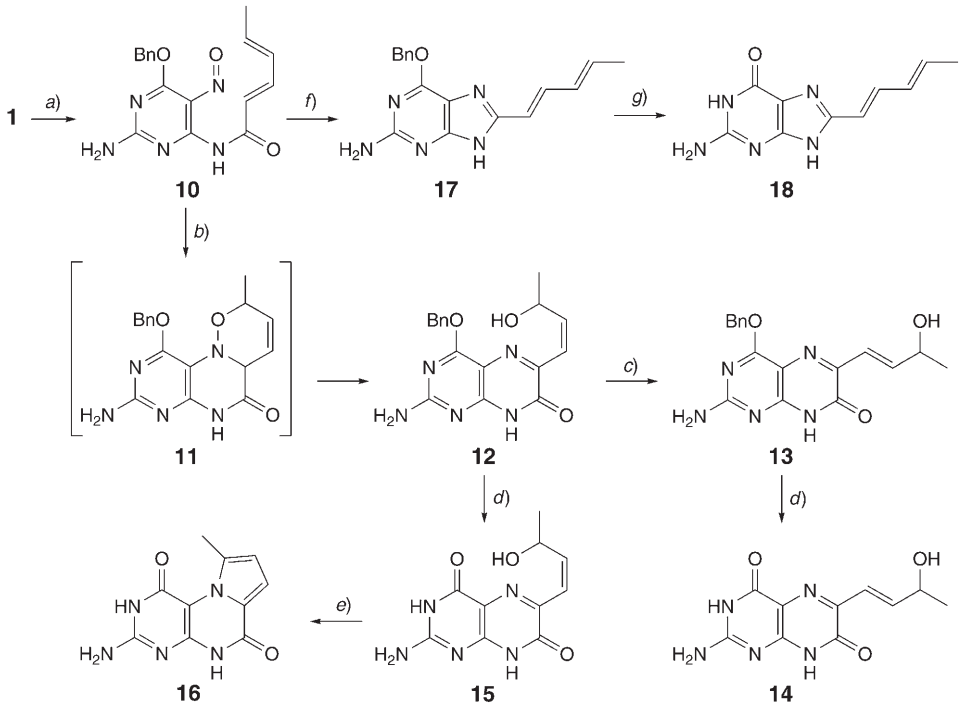
substituted at C(2′) led to the formation of pyrimido-diazepinones that were intercepted by a *Diels–Alder* cycloaddition [5].

We now provide experimental details for the synthesis of 8-substituted guanines, and further document the scope of the method by describing the synthesis of a few otherwise less readily accessible guanines. We also report reaction conditions that transform alka-1,4-dienoyl and alk-1-enoyl derivatives of the amino-nitroso-pyrimidine **1** into either pteridinones or guanines.

Results and Discussion. – The alternative transformation of an *N*-dienoyl nitroso-pyrimidine into either a guanine or a pteridinone was studied with the *N*-(sorbylamino)-nitroso-pyrimidine **10** that was obtained in 86% yield by acylating a suspension of **1** [6] in CH_2Cl_2 with sorbyl chloride in the presence of DMAP (*Scheme 2*). Careful control of the temperature was essential to avoid the formation of mixtures of the amide **10** and the pteridinone **12**, besides minor products that were not isolated.

A suspension of **10** in toluene turned into a solution at 100°, and **10** was progressively transformed into a yellow precipitate of pteridinone **12**. Pure (*Z*)-configured **12** was isolated in almost quantitative yield by filtration and washing with H_2O, AcOEt, and Et_2O. In an attempt to observe the primary addition product, we followed the conversion of a solution of **10** in (D_6)DMSO to **12** by ^{1}H-NMR spectroscopy at ambient temperature. The conversion was completed after 2 d. No trace of the expected dihydrooxazino **11** was detected, evidencing that its trans-

Scheme 2



a) Sorbyl chloride (= hexa-2,4-dienoyl chloride), 4-(dimethylamino)pyridine (DMAP), CH_2Cl_2; 86%. *b*) Toluene; *ca.* 98%. *c*) Toluene/AcOH 99 : 1; *ca.* 98%. *d*) 1N NaOH/dioxane 5 : 1; 87% of **14**; 92% of **15**. *e*) $< 10^{-4}$ mbar, 300°; 29%. *f*) Ph_3P, *o*-xylene; 86%. *g*) LiBr, Me_3SiCl, MeCN; 95%.

formation to **12** is more rapid than its formation from **10**. Prolonged heating of **12** in toluene containing 1% AcOH at 80° led to complete isomerisation to the (*E*)-allylic alcohol **13**, as evidenced by the change of $J(1',2')$ from 12.3 to 15.9 Hz, and a strong downfield shift of H–C(2′) from 5.95 to 6.95 ppm. This strong downfield shift is rationalized by the localization of H–C(2′) of one of the rotamers of the (*E*)-configured alkenyl substituent at C(6) in the deshielding cone of the C=O group. The influence of the configuration of **12** and **13** on the UV spectra is only minimal. The diastereoisomers **12** and **13** were hydrolysed in boiling aqueous 1N NaOH/dioxane [7] to the isoxanthopterine derivatives **14** and **15**, respectively. Their structure follows unambiguously from the ^{1}H- and ^{13}C-NMR, and from the IR data. Attempted purification of **15** by sublimation resulted in the elimination of 1 equiv. of H_2O and formation of the pyrrole **16** (29%), by a process related to known acid-promoted cyclisations of this type [8][9].

To transform the diene **10** into a purine, we treated its suspension in *o*-xylene with Ph_3P at 23°. This led to disappearance of the green colour of **10** within 1 h, and formation of a new product, as evidenced by TLC. Raising the temperature to 145° transformed the intermediate into the blue-fluorescent ($\lambda = 366$ nm) 8-pentadienyl-

purine **17** that was isolated in a yield of 86%. It was debenzylated in 95% yield by treatment with *in situ* generated Me_3SiBr, leading to the poorly soluble 8-(penta-1,3-dienyl)guanine (**18**) that was filtered off, and purified by washing with H_2O, Et_2O, and pentane.

The ^{1}H-NMR spectrum of the (*E*)-isomer **14** in (D_6)DMSO shows the Me *d* at 1.18 ppm ($J = 6.6$ Hz), the alkenyl H-atom signals at 6.90 (*dd*, $J = 15.9$ and 5.4 Hz) and 6.71 ppm (*d*, $J = 15.6$ Hz), and the signal of the allylic H-atom at 4.31 ppm, in keeping with a ^{13}C *q* at 23.57 ppm, and *d*s at 143.72, 121.70, and 66.45 ppm. The Me group of the (*Z*)-isomer **15** resonates at 1.22 ppm (*d*, $J = 6.6$ Hz), the alkenyl H-atoms at 6.58 (*dd*, $J = 12.3$ and 1.2 Hz) and 5.89 ppm (*dd*, $J = 12.3$ and 7.2 Hz), and the allylic H-atom at 5.06 ppm (*m*), in keeping with a ^{13}C *q* at 22.64 ppm, and *d*s at 144.12, 119.38, and 63.04 ppm. The six *s*s of **14** and **15** were assigned by comparison with **12** [3]. Due to the low solubility of **14** and **15**, their high-resolution (HR)-MALDI mass spectra show $[M + H]^+$ and $[M + Na]^+$ peaks of low intensity relative to the matrix signals. In the ^{1}H-NMR spectum of **16**, the two pyrrole H-atoms resonate as *d*s at 6.92 and 6.27 ppm ($J = 4.0$ Hz). They show cross-peaks with two *d*s at 112.73 and 111.66 ppm in the HSQC spectrum. The HSQC spectrum also reveals a *q* at 16.57 ppm. The corresponding ^{1}H signal is hidden by the signal of residual DMSO. The structure of **16** is further evidenced by a comparison of the UV, and ^{1}H- and ^{13}C-NMR spectra with those of closely related pyrrolocarbamides [10–12], by a high-resolution MALDI-MS, and by elemental analysis. The ^{1}H-NMR spectum of **18** shows signals at 7.45 (*dd*), 6.41 (*dd*), 6.34 (*d*), and 6.17 ppm (*dq*) with $J(1',2') = 15.6$, $J(2',3') = 10.5$, and $J(3',4') = 15.3$ Hz, coupling constants that are typical of pentadienes. H–N(1) gives rise to a very broad signal between 12 and 14 ppm.

Deep green crystals of **10** were obtained in hexane/$CHCl_3$ at 4°. Even at this low temperature, **10** was partially transformed into a yellow precipitate of **12**, indicating the ease of the hetero-*Diels–Alder* cycloaddition.

The unit cell of crystalline[1]) **10** (*Fig. 1*) represents a centrosymmetric duplex connected by four N(2)–H···O=C(2′) and N(2)–H···N(3) H-bonds, with H···O and H···N distances of 2.20 and 2.12 Å, respectively. The intramolecular H-bond between the N=O group and the amide H-atom (1.87 Å) prevents the [4 + 2] cycloaddition of **10** in the solid state. The strength of this H-bond is also reflected in the ^{1}H-NMR spectrum ((D_6)DMSO) where N–*H* resonates at 12.36 ppm.

That the transformation of the dienoyl nitrosoamide **10** into guanine **17** competes successfully with the readily occurring *Diels–Alder* cycloaddition suggested that it should not be difficult to find conditions to favour either the ene reaction of *N*-alkenoyl analogues, such as **19**, or their reductive condensation (*Scheme 3*). The amide **19** was prepared by acylating **1** with crotonyl chloride in THF. This led initially to a yellow

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[1]) The crystallographic data have been deposited with the *Cambridge Crystallographic Data Center* as deposition No. CCDC-670298 for **10**, CCDC-670299 for **21b**, and CCDC-670300 for **30**. Copies of the data can be obtained free of charge *via* http://www.ccdc.cam.ac.uk/data_request/cif (or from the *Cambridge Crystallographic Data Center*, 12 Union Road, Cambridge CB2 1EZ (fax: +44(1223)336033; e-mail: deposit@ccdc.cam.ac.uk).

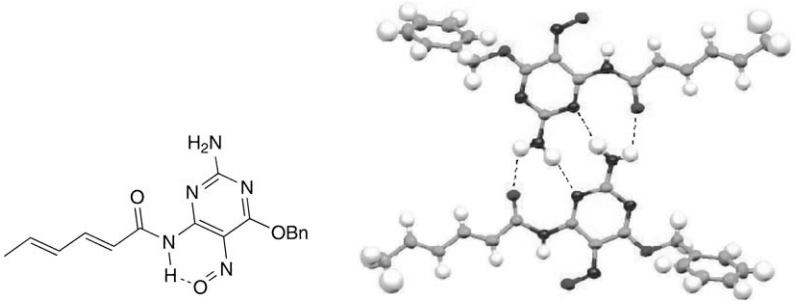

Fig. 1. *Crystal structure of* **10** (ORTEP drawing of the centrosymmetric dimer)

precipitate[2]) and, after basic aqueous workup, to the *N*-crotonyl-nitrosopyrimidine **19** that was isolated as a blue-green powder. It was best recrystallized in boiling EtOH, as heating in boiling toluene effected the ene reaction that proceeded quantitatively within 10 min. The product, however, was a dimer rather than the expected vinylpteridine **20a**. The HSQC spectrum of **21a** showed a conspicuous ^{1}H signal at 6.18 ppm and a cross-peak with a C-atom resonating at 54.8 ppm, suggesting that the ene reaction was followed by an aza-*Diels–Alder* reaction[3]) to **21a**. The strong deshielding of the signal at 6.18 ppm indicated a conformation of **21a** with the tertiary H–C(10) in the deshielding cone of the pteridinone C=O group. Screening of solvents showed that performing the ene reaction in MeCN allowed isolation of the 6-vinylpteridine **20a** that was transformed into **21a** upon heating in toluene.

Treatment of **20a** with *Bredereck*'s reagent led to the amidine **20b** that is well soluble in a range of apolar solvents (compare [15][16]). Its solution in DMSO formed a dimer already at room temperature, *i.e.,* even more readily than **20a**, in agreement with a narrow HOMO/LUMO energy gap, as suggested by semiempirical calculations[4]) (*Table*).

The structure of **20a** is evidenced by the HR-MALDI mass spectrum, elemental analysis, ATR-IR NH bands at 3407 and 3214 cm^{-1}, and the NMR spectra ((D$_6$)DMSO), with the alkenyl H-atom resonating at 6.89 (*dd*, $J = 17.7$ and 11.1 Hz), 6.39 (*dd*, $J = 17.7$ and 2.4 Hz), and 5.52 ppm (*dd*, $J = 11.1$ and 2.4 Hz), in keeping with a

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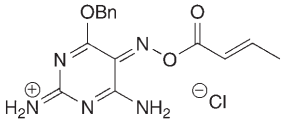
[2]) Filtration led to a very hygroscopic solid. Its ^{1}H-NMR spectrum evidenced a mixture of at least two products, presumably of **19** and the *O*-acylated **24**.



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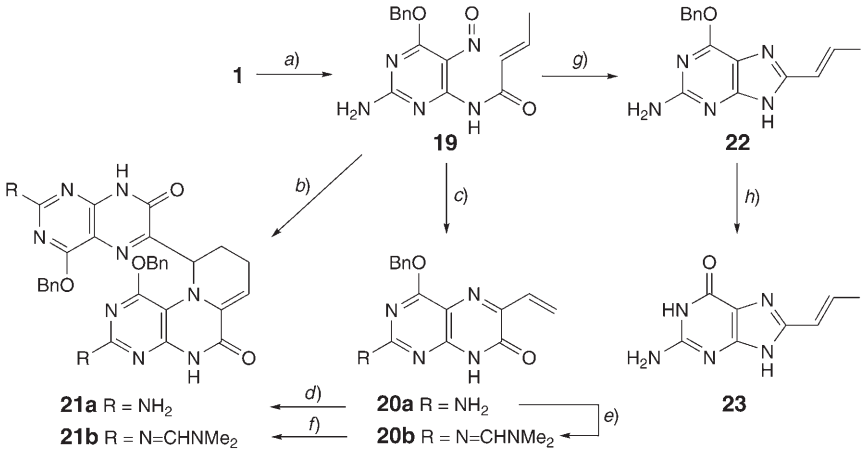
[3]) For the inverse electron demand *Diels–Alder* reaction of similarly substituted 1-azabuta-1,3-dienes, *cf.* the work of *Boger et al.* [13][14].

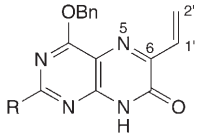
[4]) For comparison, we calculated the HOMO and LUMO energies of cyclopentadiene ($\Delta\varepsilon =$ 9.561 eV) and fulvene ($\Delta\varepsilon = 8.622$ eV). Comparison of these values with experimental data [17] and with values obtained by more sophisticated calculations [18] show agreement only for the HOMO/LUMO energy differences.

Scheme 3



a) Crotonyl chloride (= but-2-enoyl chloride), THF; 85%. *b*) Toluene; *ca.* 96%. *c*) MeCN; 91%. *d*) Toluene; *ca.* 98%. *e*) *t*-BuOCH(NMe)$_2$, MeCN; 89%. *f*) Toluene; quant. *g*) Ph_3P, *o*-xylene; 80%. *h*) LiBr, Me_3SiCl, MeCN; 92%.

Table. *LUMO and HOMO Energies and Orbital Coefficients of* **20a** *and* **20b** *Obtained from AM1 Calculations* [19]



20a R = NH_2
20b R = N=$CHNMe_2$

		e [eV]	Δe [eV]	π-Orbital coefficients[a])			
				C(5)	C(6)	C(1′)	C(2′)
20a	LUMO	– 1.291	7.831	*– 0.320*	0.412	0.085	*– 0.259*
	HOMO	– 9.122		0.258	0.390	*– 0.268*	*– 0.368*
20b	LUMO	– 1.158	7.564	*– 0.294*	0.379	0.080	*– 0.237*
	HOMO	– 8.722		0.211	0.380	*– 0.216*	*– 0.321*

[a]) Figures in *italics* refer to favourable HOMO – LUMO interactions.

^{13}C *d* at 131.56 and a *t* at 120.86 ppm. A single crystal[1]) of **21b** was obtained by slowly evaporating a solution of **21b** in CH_2Cl_2/MeOH/toluene. The X-ray analysis confirms the proposed structure (*Fig. 2*) and shows a co-crystallizing mixture of enantiomers.

The NMR spectra of **21a** and **21b** are very similar, and the proximity of H–C(10) to O=C(7′) (2.63 Å) and to C(1)–*O*–CH_2Ph (2.15 Å), as in the crystal structure of **21b**, is indeed responsible for the strong downfield shift for H–C(10) of **21a** (6.18 ppm) and **21b** (6.33 ppm). In the HMBC spectrum of **21b**, the formamidinyl H-atoms show cross-peaks with C(2′) and C(3) at 163.58 and 156.52 ppm, indicating that the assignment of C(2) and C(8a) in [3] and [4] has to be reversed.

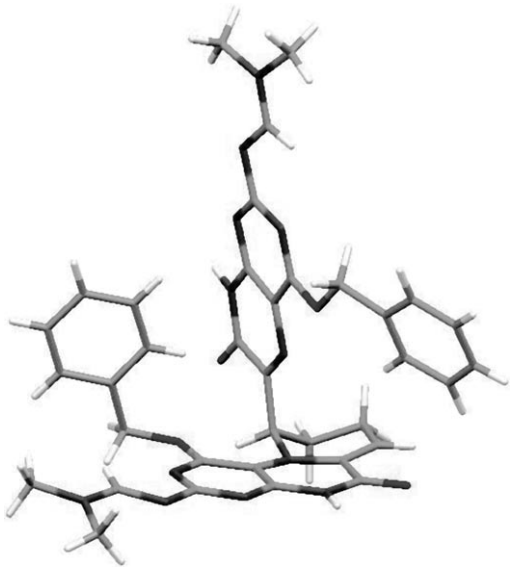
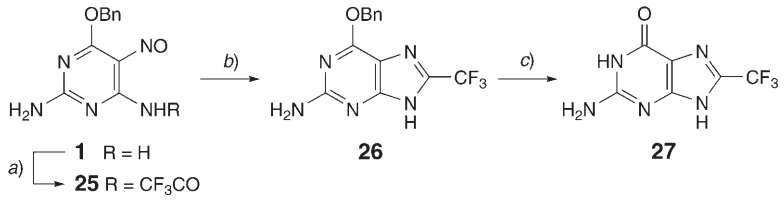


Fig. 2. *Crystal structure of* **21b**

Treating the *N*-crotonoyl-nitrosopyrimidine **19** with Ph_3P in boiling *o*-xylene yielded 80% of the purine **22** that was debenzylated with *in situ* generated Me_3SiBr to yield 92% of the poorly soluble 8-(prop-1-enyl)guanine (**23**).

The scope of the P^{III}-mediated condensation of vicinal (acylamino)-nitrosopyrimidines was further tested by synthesizing two guanine derivatives that may not be readily prepared by alternative methods. First, we synthesized the known 8-(trifluoromethyl)-purines **26** and **27**. 8-(Trifluoromethyl)guanine (**27**) had been obtained in a yield of 77% by heating pyrimidine-5,6-diamine with a mixture of $(CF_3CO)_2O$ and CF_3COOH to 260° [20], or in a yield of 46% by treating guanine with CF_3I, $FeSO_4$, and H_2O_2 in a H_2O/DMSO mixture [21]. The *O*-benzyl derivative **26** had been obtained in 29% overall yield by chlorinating **27** with phosphorous oxychloride followed by treatment with benzyl alcohol and NaH [22]. We prepared **26** from **1** *via* the nitroso amide **25** (*Scheme 4*), maintaining the temperature below −20° to avoid overacylation. As **25** proved labile towards MeOH and silica, we treated the crude acylation product with Ph_3P in boiling *o*-xylene and obtained **26** in a yield of 81% from **1**.

Scheme 4

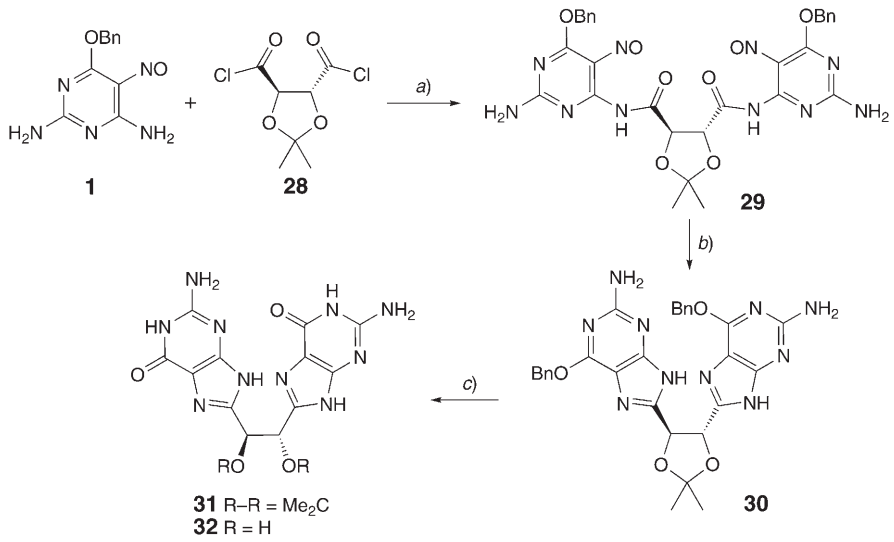


a) $(CF_3CO)_2O$, THF. *b*) Ph_3P, *o*-xylene; 81% from **1**. *c*) LiBr, Me_3SiCl, MeCN; 86%.

8-(Trifluoromethyl)guanine (**27**) was obtained in a yield of 86% by treating **26** with Me_3SiBr. The spectroscopic data of **26** match the data provided by *Chae et al.* [22], and the data of **27** those provided by *Pfleiderer* and *Shanshal* [20]. The ^{13}C-NMR spectrum of **26** shows a *q* of the CF_3 group at 118.88 ppm ($J = 267.8$ Hz) and a *q* at 136.92 ppm ($J = 38.8$ Hz) for the vicinal ^{13}C(8). Similarly, the ^{13}C-NMR spectrum of **27** showed the corresponding *q* at 118.67 ppm ($J = 267.7$ Hz) and at 133.92 ppm ($J = 40.5$ Hz).

As a second example, we selected the C_2-symmetric bisguanidines **30**–**32** in view of the tendence of guanines to form linear or cyclic associates [23–26]. Acylation of **1** with L-tartaryl chloride **28** [27][28] in THF provided the dicarboxamide **29** as a blue solid that was isolated by precipitation from THF and treated with Ph_3P in boiling *o*-xylene to yield 81% of **30** (*Scheme 5*).

Scheme 5



a) **28**, THF; 93%. *b*) Ph_3P, *o*-xylene; 87%. *c*) 1. LiBr, Me_3SiCl, MeCN; 82%. 2. 1N HCl/THF 1:1; *ca.* 98%.

Debenzylation of **30** with Me_3SiCl provided **31** (82%) that was deisopropylidenated by aqueous HCl in THF (*Scheme 5*) to provide **32** in 80% yield from **29**. The structure of the C_2-symmetric **32** is evidenced by a HR-MALDI mass spectrum and by the NMR spectra ((D_6)DMSO), where C(1) resonates as a *d* at 68.85 ppm and H–C(1) as a *s* at 5.22 ppm. A broad HN(1′) and OH band from 3350 to 2250 in the ATR-IR spectrum evidences the formation of H-bonded aggregates in the solid state.

Single crystals[1]) of **30** were obtained by isothermal distillation of hexane into a solution of **30** in $CHCl_3$/MeOH. The crystal structure shows a left handed helix (*Fig. 3*) held together by four H-bonds per purine residue, with H···X distances (X = O or N) of 2.08 and 2.03 ($NH_2\cdots O^iPr$), 1.93 and 1.94 (N(3′)···H–N(9′)), 1.99 and 1.98 (N(9′)–H···N(3′)), and 2.04 and 1.98 Å ($^iPrO\cdots H_2N$) for the short and long edge, respectively. Four molecules form one turn of the helix with a pitch of 30.2 Å. The projection of the purinyl residues parallel to the axes of the helix defines a rectangular core with the dimensions of 5.7×8.5 Å.

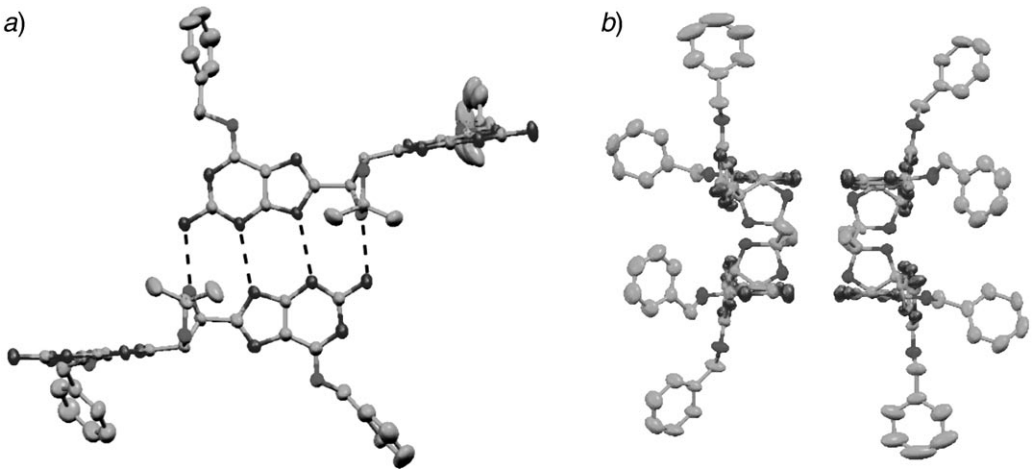


Fig. 3. *Crystal structure of* **30**. *a*) Side view on the helix displaying the four intermolecular H-bonds per purine residue. *b*) Top view on a helix formed by 20 molecules.

We thank the *ETH-Zürich* for generous support, Dr. *Bruno Bernet* for checking the analytical data, and Dr. *W. Bernd Schweizer* for determining the crystal structures.

Experimental Part

General. Solvents were distilled before use. Reactions were carried out under N_2, unless stated otherwise. Qual. TLC: precoated silica-gel plates (*Merck* silica gel *60* F_{254}); detection under UV light (254 nm). Flash chromatography (FC): silica gel *Fluka 60* (0.04–0.063 mm). M.p.: uncorrected. UV Spectra: λ_{max} (log ε). FT-IR spectra: neat (ATR), absorption in cm^{-1}. ^{1}H- and ^{13}C-NMR spectra: chemical shift δ in ppm rel. to TMS as external standard; coupling constants *J* in Hz. HR-MALDI-MS: in gentisic acid (=2,5-dihydroxybenzoic acid, DHB) or 3-hydroxypropionaldehyde (3-HPA) matrix.

N-*[2-Amino-6-(benzyloxy)-5-nitrosopyrimidin-4-yl]hexa-2,4-dienamide* (**10**). A vigorously stirred suspension of **1** (490 mg, 2.0 mmol) and DMAP (122 mg, 1.0 mmol) in dry CH_2Cl_2 (30 ml) was cooled to $-20°$ and treated with a precooled soln. of sorbyl chloride (0.301 ml, 2.4 mmol) in CH_2Cl_2 (4 ml) in one single portion. The mixture was kept at $-15°$ for 12 h, diluted with sat. aq. $NaHCO_3$ soln. (20 ml), and extracted with CH_2Cl_2 (3×100 ml). The combined org. phases were washed with brine, dried (Na_2SO_4), concentrated to 50 ml, and filtered through a pad of silica (MeOH/CH_2Cl_2 3:97). After concentration to 70 ml, addition of hexane led to a precipitate of **10** (583 mg, 86%). Green powder. R_f (CH_2Cl_2/MeOH 9:1) 0.65. M.p. 130° (dec.). UV (MeOH, $c = 0.06$ mM): 205 (4.49), 263 (4.50), 347 (4.52). VIS (DMSO, $c = 0.005$M): 630 (1.99). IR (ATR): 3480*w*, 3304*w*, 3204*m*, 2918*w*, 1717*w*, 1626*s*, 1603*s*, 1533*s*, 1497*m*, 1485*s*, 1455*s*, 1441*s*, 1397*m*, 1337*s*, 1331*s*, 1306*m*, 1272*m*, 1240*s*, 1202*s*, 1171*s*, 1143*s*, 1113*s*, 1055*m*, 1035*m*, 1008*s*, 983*m*, 918*w*, 881*m*, 842*w*, 788*m*, 772*w*, 735*s*, 711*m*, 687*m*, 625*m*, 616*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.36 (*s*, HN–C(4′)); 8.75 (*s*, NH_2); 7.56–7.40 (*m*, 5 arom. H); 7.28 (*dd*, $J = 15.0$, 6.9, H–C(3)); 7.02 (*d*, $J = 15.0$, H–C(2)); 6.46–6.28 (*m*, H–C(4), H–C(5)); 5.62 (*s*, PhCH_2); 1.86 (*d*, $J = 5.7$, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 166.15 (*s*, C=O); 163.34 (*s*, C(6′)); 144.60 (*d*, C(3)); 140.65 (*d*, C(5)); 138.53 (*s*, C(4′)); 135.47 (*s*); 130.04 (*d*, C(2)); 128.34 (2*d*); 128.29 (2*d*); 128.11 (*d*); 122.62 (*d*, C(4)); 68.47 (*t*, Ph*C*H_2); 18.64 (*q*, Me); signals of C(5′) and C(2′) not visible due to coalescence. HR-MALDI-MS: 340.1401 (100, $C_{17}H_{18}N_5O_3^+$, $[M+H]^+$; calc. 340.1404).

X-Ray Analysis of **10**. Crystals of **10** were obtained by isothermal distillation of hexane into a soln. of **10** in $CHCl_3$ at 4° (dimensions of the analyzed crystal: $0.28 \times 0.14 \times 0.02$ mm; colour: green). $C_{17}H_{17}N_5O_3$, M_r 339.355, triclinic, *P*1, $a = 7.5948(2)$, $b = 10.0150(3)$, $c = 11.9388(4)$ Å, $\alpha = 108.6795(14)$,

$\beta = 94.398(2)$, $\gamma = 102.6297(13)^\circ$, $V = 828.80(4)$ Å^3, $Z = 2$, $D_x = 1.360$ Mg/m^3. Intensities were measured on a *Nonius Kappa CCD* diffractometer, with MoK_α radiation $\lambda = 0.71073$ Å. Cell parameters from 10948 refl., $\theta = 0.998 - 27.485^\circ$, $\mu = 0.097$ mm^{-1}, $T = 223$ K. 7167 measured reflections, 3789 independent reflections, 2428 observed reflections ($> 2\sigma(I)$). Refinement on F^2: full-matrix least-squares refinement, R(all) = 0.0924, R(gt) = 0.0542. All diagrams and calculations were performed using *maXus* (*Bruker Nonius*, *Delft MacScience*, Japan). The program SIR97 was used to solve the structure and the program SHELXL-97 to refine it.

*2-Amino-4-(benzyloxy)-6-[(*Z*)-3-hydroxybut-1-enyl]pteridin-7(8*H*)-one* (**12**). A suspension of **10** (339 mg, 1 mmol) in toluene (10 ml) was heated to 100°, affording a green soln. After 3 h at 100°, the yellow suspension was filtered. The solid washed with H_2O, AcOEt, and Et_2O. Drying *in vacuo* gave **12** (332 mg, 98%). Yellow powder. M.p. 242° (dec.). UV: 211 (4.59), 235 (4.14), 290 (3.82), 378 (4.27). IR (ATR): 3420*m*, 3323*w*, 3208*m*, 2834*w*, 2737*w* (br.), 1802*w*, 1670*w*, 1614*s*, 1560*s*, 1538*m*, 1496*m*, 1490*m*, 1464*m*, 1428*s*, 1387*m*, 1356*s*, 1327*m*, 1307*m*, 1182*s*, 1052*s*, 975*m*, 927*m*, 905*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.40 (*s*, H–N(8)); 7.53–7.32 (*m*, 5 arom. H); 7.24 (*s*, NH_2); 6.61 (*dd*, $J = 12.3$, 1.2, H–C(1′)); 5.95 (*dd*, $J = 12.0$, 7.5, H–C(2′)); 5.49, 5.44 (2*d*, $J = 12.6$, PhCH_2); 5.18–5.11 (*m*, H–C(3′)); 4.89 (*d*, $J = 4.2$, OH); 1.20 (*d*, $J = 6.3$, Me). ^{13}C-NMR (100 MHz, (D_6)DMSO): 164.51 (*s*, C(4)); 161.39 (*s*, C(2)); 157.13 (*s*, C(7)); 150.63 (*s*, C(8a)); 146.08 (*s*, C(6)); 145.75 (*d*, C(2′)); 136.31 (*s*); 128.23 (2*d*); 127.77 (2*d*); 127.36 (*d*); 118.56 (*d*, C(1′)); 107.54 (*s*, C(4a)); 67.32 (*t*, Ph*C*H$_2$); 63.45 (*d*, C(3′)); 22.26 (*q*, Me). HR-MALDI-MS: 362.1223 (82, $C_{17}H_{17}N_5NaO_3^+$, $[M + Na]^+$; calc. 362.1229), 340.1402 (35, $C_{17}H_{18}N_5O_3^+$, $[M + H]^+$; calc. 340.1410), 322.1299 (100, $C_{17}H_{16}N_5O_2^+$, $[M - OH]^+$; calc. 322.1304). Anal. calc. for $C_{17}H_{17}N_5O_3$ (339.35): C 60.17, H 5.05, N 20.64; found: C 60.38, H 5.15, N 20.50.

*2-Amino-4-(benzyloxy)-6-[(*E*)-3-hydroxybut-1-enyl]pteridin-7(8*H*)-one* (**13**). A suspension of **12** (100 mg, 0.295 mmol) in toluene (5 ml) was treated with AcOH (50 µl) and stirred for 12 h at 80°. Filtration gave **13** (98 mg, 98%). M.p. > 245° (dec.). UV (MeOH): 213 (4.54), 236 (4.14), 292 (3.86), 373 (4.30). IR (ATR): 3344*m*, 3190*m*, 2973*m*, 2888*w*, 2835*w*, 2767*w*, 1653*s*, 1614*s*, 1557*s*, 1530*s*, 1497*s*, 1480*m*, 1443*s*, 1390*m*, 1340*s*, 1304*m*, 1275*m*, 1215*w*, 1178*m*, 1084*m*, 1063*m*, 981*w*, 942*m*, 911*w*, 847*w*, 798*w*, 756*m*, 702*m*, 690*w*, 652*w*, 619*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.39 (*s*, H–N(8)); 7.55–7.35 (*m*, 5 arom. H); 7.19 (*s*, NH_2); 6.95 (*dd*, $J = 15.9$, 5.4, H–C(2′)); 6.74 (*dd*, $J = 15.9$, 1.2, H–C(1′)); 5.49 (*s*, PhCH_2); 4.93 (br. *s*, OH); 4.31 (*quint.*, $J = 6.3$, H–C(3′)); 1.18 (*d*, $J = 6.6$, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 164.44 (*s*, C(4)); 161.17 (*s*, C(2)); 156.94 (*s*, C(7)); 150.85 (*s*, C(8a)); 145.27 (*s*, C(6)); 142.47 (*d*, C(2′)); 136.38 (*s*); 128.46 (2*d*); 128.41 (2*d*); 128.07 (*d*); 121.82 (*d*, C(1′)); 107.73 (*s*, C(4a)); 67.37 (*t*, Ph*C*H$_2$); 66.42 (*d*, C(3′)); 23.50 (*q*, Me).

*2-Amino-6-[(*E*)-3-hydroxybut-1-enyl]pteridin-4,7(3*H*,8*H*)-dione* (**14**). A soln. of **13** (150 mg, 0.442 mmol) in 1N aq. NaOH/dioxane 5:1 (18 ml) was heated under reflux for 2 h, and treated with charcoal (20 mg) for 10 min. The hot suspension was filtered, and the filtrate was added dropwise to a boiling soln. of H_2O/AcOH 6:1 (17.5 ml). Filtration of the precipitate and washing of the solid with H_2O and EtOH gave **14** (96 mg, 87%). Yellow powder. M.p. > 330° (dec.). IR (ATR): 3476*w*, 3128*m*, 2864*m*, 2772*m*, 1633*s*, 1597*s*, 1555*s*, 1476*m*, 1442*m*, 1389*s*, 1338*m*, 1258*w*, 1183*w*, 1161*w*, 1107*w*, 1056*m*, 916*m*, 842*w*, 819*w*, 782*w*, 748*w*, 702*w*, 657*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.33 (*s*, H–N(8)); 11.00 (*s*, H–N(3)); 7.03 (br, *s*, NH_2); 6.90 (*dd*, $J = 15.9$, 5.4, H–C(2′)); 6.71 (*d*, $J = 15.6$, H–C(1′)); 4.93 (br. *s*, OH); 4.31 (*quint.*, $J \approx 5.9$ H–C(3′)); 1.18 (*d*, $J = 6.6$, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 158.63 (*s*, C(2)); 156.80 (*s*, C(7)); 154.60 (*s*, C(4)); 150.46 (*s*, C(8a)); 143.72 (*d*, C(2′)); 141.24 (*s*, C(6)); 121.70 (*d*, C(1′)); 111.01 (*s*, C(4a)); 66.45 (*d*, C(3′)); 23.57 (*q*, Me).

*2-Amino-6-[(*Z*)-3-hydroxybut-1-enyl]pteridin-4,7(3*H*,8*H*)-dione* (**15**). A soln. of **13** (678 mg, 2.0 mmol) in 1N aq. NaOH/dioxane 5:1 (72 ml) was heated under reflux for 2 h and treated with charcoal (50 mg) for 10 min. The hot suspension was filtered, and the filtrate was added dropwise to a boiling soln. of H_2O/AcOH 6:1 (70 ml). Filtration of the precipitate and washing of the solid with H_2O and EtOH gave **15** (458 mg, 92%). Yellow powder. M.p. > 330° (dec.). IR (ATR): 3475*w*, 3128*m*, 2864*m*, 2772*m*, 1633*s*, 1597*s*, 1556*s*, 1476*m*, 1442*m*, 1407*m*, 1389*s*, 1338*m*, 1258*w*, 1183*w*, 1161*w*, 1107*w*, 1056*m*, 916*m*, 843*w*, 819*w*, 785*w*, 748*w*, 702*w*, 657*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.35 (*s*, H–N(8)); 11.11 (*s*, H–N(3)); 7.02 (br. *s*, NH_2); 6.58 (*dd*, $J = 12.3$, 1.2, H–C(1′)); 5.89 (*dd*, $J = 12.3$, 7.2, H–C(2′)); 5.09–5.04 (*m*, H–C(3′), OH); 1.22 (*d*, $J = 6.6$, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 158.50 (*s*, C(2)); 157.08 (*s*, C(7)); 154.75 (*s*, C(4)); 150.48 (*s*, C(8a)); 144.50 (*s*, C(6)); 144.12 (*d*, C(2′)); 119.38 (*d*, C(1′)); 110.83 (*s*,

C(4a)); 63.04 (*d*, C(3′)); 22.64 (*q*, Me). HR-MALDI-MS: 272.0749 (100, $C_{10}H_{11}N_5NaO^+$, $[M+Na]^+$; calc. 250.0754), 250.0938 (50, $C_{10}H_{12}N_5O^+$, $[M+H]^+$; calc. 250.0935).

*3-Amino-9-methylpyrrolo[1,2-*f*]pteridine-1,6(2*H,5H*)-dione* (**16**). Solid **15** (15 mg, 0.060 mmol) was heated in a sublimation tube to 300° under vacuum ($<10^{-3}$ mbar). After 16 h, sublimed **16** (4 mg, 29%) was obtained. M.p. > 300° (dec.). UV (MeOH): 219 (4.19), 275 (4.23), 304 (3.81). IR (ATR): 3469*w*, 3310*w*, 3097*m*, 2898*m*, 2750*m*, 1642*s*, 1601*s*, 1556*m*, 1493*m*, 1400*m*, 1377*m*, 1351*s*, 1318*m*, 1259*w*, 1211*w*, 1186*m*, 1091*w*, 1037*w*, 1001*w*, 980*w*, 808*w*, 783*m*, 760*m*, 733*m*, 703*w*, 666*w*, 644*w*, 607*w*. ^{1}H-NMR (400 MHz, (D_6)DMSO): 11.04 (br. *s*, H−N(2), H−N(5)); 6.92 (*d*, *J* = 4.0, H−C(7)); 6.71 (br. *s*, NH_2); 6.27 (*dq*, *J* = 4.0, 0.7, H−C(8)); *ca.* 2.5 (hidden by solvent signal, Me). ^{13}C-NMR (100 MHz, (D_6)DMSO): 155.48, 155.33 (2*s*, C(3), C(6)); 152.74 (*s*, C(1)); 149.59 (*s*, C(4a)); 133.59 (*s*, C(9)); 122.92 (*s*, C(6a)); 112.73, 111.66 (2*d*, C(7), C(8)); 98.37 (*s*, C(10a)); 16.57 (*q*, Me). HR-MALDI-MS: 254.0649 (25, $C_{10}H_9N_5NaO_2^+$, $[M+Na]^+$; calc. 254.0649), 232.0824 (100, $C_{10}H_{10}N_5O_2^+$, $[M+H]^+$; calc. 232.0829). Anal. calc. for $C_{10}H_9N_5O_2$ (231.21): C 51.95, H 3.92, N 30.29; found: C 51.46, H 3.85, N 30.19.

*2-Amino-6-(benzyloxy)-8-[(*E,E*)-penta-1,3-dienyl]purine* (**17**). A suspension of **10** (350 mg, 1.032 mmol) in *o*-xylene (10 ml) was treated with Ph_3P (649 mg, 2.478 mmol), warmed to 145°, and stirred at that temp. for 20 h (colourless soln.). Evaporation and FC ($MeOH/CH_2Cl_2$ 3:97) gave **17** (273 mg, 86%). Colourless solid. R_f (CH_2Cl_2/MeOH 9:1) 0.42. M.p. 210° (dec.). UV (MeOH): 207 (4.34), 259 (4.22), 335 (4.51). IR (ATR): 3221*w*, 3200*w*, 2954*w*, 2925*w*, 1606*s*, 1514*m*, 1434*s*, 1338*m*, 1242*m*, 1211*s*, 1149*m*, 1063*m*, 1025*m*, 997*s*, 942*m*, 910*w*, 863*w*, 822*w*, 746*s*, 695*m*, 663*m*. ^{1}H-NMR (400 MHz, (D_6)DMSO): 12.45 (*s*, H−N(9)); 7.51–7.33 (*m*, 5 arom. H); 7.10 (*dd*, *J* = 15.3, 10.2, H−C(2′)); 6.33 (*s*, NH_2); 6.32 (*d*, *J* = 15.3, H−C(1′)); 6.26 (*dd*, *J* = 14.7, 10.2, H−C(3′)); 5.95 (*dq*, *J* = 14.7, 6.9, H−C(4′)); 5.45 (*s*, PhCH_2); 1.80 (*d*, *J* = 6.9, Me). ^{13}C-NMR (100 MHz, (D_6)DMSO): 159.49 (*s*, C(6)); 159.23 (*s*, C(2)); 156.05 (*s*, C(4)); 146.93 (*s*, C(8)); 136.67 (*s*); 133.77 (*d*, C(2′)); 133.04 (*d*, C(4′)); 131.13 (*d*, C(3′)); 128.35 (2*d*); 128.29 (2*d*); 127.90 (*d*); 118.57 (*d*, C(1′)); 114.60 (*s*, C(5)); 66.65 (*t*, Ph*C*H_2); 18.15 (*q*, Me). HR-MALDI-MS: 330.1338 (11, $C_{17}H_{17}N_5NaO^+$, $[M+Na]^+$; calc. 330.1331), 308.1509 (100, $C_{17}H_{18}N_5O^+$, $[M+H]^+$; calc. 308.1506). Anal. calc. for $C_{17}H_{17}N_5O$ (307.35): C 66.43, H 5.57, N 22.79; found: C 66.17, H 5.58, N 22.56.

*8-[(*E,E*)-Penta-1,3-dienyl]guanine* (**18**). At 0°, a suspension of **17** (200 mg, 0.651 mmol) in dry MeCN (6 ml) was treated with anh. LiBr (72 mg, 0.847 mmol) and Me_3SiCl (0.123 ml, 0.977 mmol), warmed to 23°, and stirred for 4 h. The suspension was cooled to 0°, diluted with MeOH (2 ml), stirred for 15 min, and filtered. The colourless solid was washed with H_2O, Et_2O, and pentane. Drying *in vacuo* gave **18** (135 mg, 95%). M.p. > 290° (dec.). UV (MeOH): 205 (4.01), 271 (4.19), 332 (4.22). IR (ATR): 3361*w*, 3306*w*, 3119*m*, 3038*m*, 2927*m*, 2808*m*, 2658*m*, 2559*m*, 1697*m*, 1646*s*, 1606*s*, 1542*s*, 1435*m*, 1355*m*, 1300*m*, 1265*m*, 1225*w*, 1152*m*, 1070*w*, 990*m*, 929*w*, 873*m*, 826*w*, 784*m*, 762*m*, 720*w*, 698*w*, 674*w*, 660*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 14–12 (br. *s*, H−N(1)); 11.65 (br. *s*, H−N(9)); 7.45 (*dd*, *J* = 15.3, 10.5, H−C(2′)); 7.26 (*s*, NH_2); 6.41 (*dd*, *J* = 15.3, 10.2, H−C(3′)); 6.34 (*d*, *J* = 15.9, H−C(1′)); 6.17 (*dq*, *J* = 15.3, 6.9, H−C(4′)); 1.86 (br. *d*, *J* = 6.9, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 154.88 (*s*, C(6)); 153.04 (*s*, C(2)); 150.96 (*s*, C(4)); 145.28 (*s*, C(8)); 140.08 (*d*, C(2′)); 138.68 (*d*, C(4′)); 130.58 (*d*, C(3′)); 112.03 (*d*, C(1′)); 108.53 (*s*, C(5)); 18.57 (*q*, Me). HR-MALDI-MS: 218.1030 (100, $C_{10}H_{12}N_5O^+$, $[M+H]^+$; calc. 218.1036).

N-*[2-Amino-6-(benzyloxy)-5-nitrosopyrimidin-4-yl]but-2-enamide* (**19**). A soln. of **1** (1.150 g, 4.694 mmol) in dry THF (40 ml) was cooled to 0°, treated with freshly distilled crotonyl chloride (0.537 ml, 5.633 mmol), and stirred for 1 h at 0° and 1 h at r.t.. The green suspension was diluted with H_2O (30 ml) and extracted with CH_2Cl_2 (3 × 80 ml). The combined org. phases were dried (Na_2SO_4) and concentrated to 50 ml. Addition of hexane led to precipitation of **19** (1.252 g, 85%). Two crystallisations of a small sample from hot EtOH gave long green needles. R_f (CH_2Cl_2/MeOH 9:1) 0.65. M.p. 168° (dec.). UV (MeOH, *c* = 0.09 mM): 208 (4.34), 263 (4.17), 353 (4.31). VIS (DMSO, *c* = 0.005M): 624 (1.99). IR (ATR): 3486*w*, 3307*m*, 3209*m*, 3030*w*, 1721*m*, 1630*s*, 1595*s*, 1543*s*, 1500*m*, 1486*s*, 1443*s*, 1395*m*, 1352*s*, 1331*s*, 1286*s*, 1271*m*, 1202*s*, 1153*s*, 1129*s*, 1103*s*, 1058*m*, 1031*m*, 995*m*, 968*m*, 941*m*, 920*m*, 845*m*, 830*m*, 792*m*, 769*w*, 731*m*, 715*m*, 687*m*, 669*m*, 662*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.40 (*s*, HN−C(4′)); 8.77, 8.72 (2*s*, NH_2); 7.56–7.36 (*m*, 5 arom. H); 6.95 (*dq*, *J* = 15.3, 6.6, H−C(3)); 6.82 (*dd*, *J* = 15.0, 1.2, H−C(2)); 5.62 (*s*, PhCH_2); 1.92 (*dd*, *J* = 6.6, 1.2, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 165.47 (*s*, C=O); 163.66 (*s*, C(6′)); 144.79 (*d*, C(3)); 138.85 (*s*, C(4′)); 135.64 (*s*); 128.51 (2*d*), 128.45 (2*d*); 128.28

(*d*); 126.24 (*d*, C(2)); 68.47 (*t*, Ph*C*H$_2$); 17.96 (*q*, Me); signals of C(5′) and C(2′) not visible due to coalescence. HR-MALDI-MS: 336.1057 (36, $C_{15}H_{15}N_5NaO_3^+$, $[M+Na]^+$; calc. 336.1067), 314.1242 (64, $C_{15}H_{16}N_5O_3^+$, $[M+H]^+$; calc. 314.1248), 283.1183 (100, $C_{15}H_{15}N_4O_2^+$, $[M-NO]^+$; calc. 283.1190). Anal. calc. for $C_{15}H_{15}N_5O_3$ (313.32): C 57.50, H 4.83, N 22.35; found: C 57.20, H 4.92, N 22.15.

*2-Amino-4-(benzyloxy)-6-ethenylpteridin-7(8*H*)-one* (**20a**). A suspension of **19** (150 mg, 0.479 mmol) in MeCN (10 ml) was heated to reflux, to form a blue soln. After 90 min, the yellow precipitate was filtered off, and washed with CH_2Cl_2/MeOH 9:1. The filtrate was heated to reflux for 3 h, and filtration was repeated. Drying of the combined solids *in vacuo* gave **20a** (121 mg, 91%). Pale yellow solid. M.p. > 300° (dec.). UV (MeOH, sat. soln.): 211 (3.75), 237 (3.36), 290 (3.18), 370 (3.50). IR (ATR): 3407*m*, 3334*w*, 3214*m*, 2837*w*, 2743*w*, 1811*w*, 1654*m*, 1605*s*, 1556*s*, 1536*s*, 1484*s*, 1465*s*, 1439*s*, 1410*m*, 1388*s*, 1356*s*, 1312*m*, 1293*m*, 1261*m*, 1174*m*, 1096*m*, 1072*m*, 1039*m*, 988*m*, 927*m*, 846*w*, 810*w*, 791*w*, 735*m*, 721*m*, 691*m*, 638*w*, 618*m*. ^{1}H-NMR (300 MHz, (D$_6$)DMSO): 12.44 (*s*, H−N(8)); 7.53–7.33 (*m*, 5 arom. H); 7.26 (*s*, NH$_2$); 6.89 (*dd*, *J* = 17.7, 11.1, H−C(1′)); 6.39 (*dd*, *J* = 17.7, 2.4, H$_a$−C(2′)); 5.52 (*dd*, *J* = 11.1, 2.4, H$_b$−C(2′)); 5.49 (*s*, PhC*H*$_2$). ^{13}C-NMR (75 MHz, (D$_6$)DMSO): 164.63 (*s*, C(4)); 161.43 (*s*, C(2)); 156.93 (*s*, C(7)); 151.10 (*s*, C(8a)); 144.85 (*s*, C(6)); 136.31 (*s*); 131.56 (*d*, C(1′)); 128.43 (2*d*); 128.41 (2*d*); 128.07 (*d*); 120.86 (*t*, C(2′)); 107.79 (*s*, C(4a)); 67.42 (*t*, Ph*C*H$_2$). HR-MALDI-MS: 318.0958 (100, $C_{15}H_{13}N_5NaO_2^+$, $[M+Na]^+$; calc. 318.0962), 296.1137 (68, $C_{15}H_{14}N_5O_2^+$, $[M+H]^+$; calc. 296.1142). Anal. calc. for $C_{15}H_{13}N_5O_2$ (295.30): C 61.01, H 4.44, N 23.72; found: C 60.53, H 5.71, N 23.28.

*4-(Benzyloxy)-2-{[(dimethylamino)methylidene]amino}-6-ethenylpteridin-7(8*H*)-one* (**20b**). A suspension of **20a** (140 mg, 0.475 mmol) in MeCN (8 ml) was treated at 23° with *Bredereck*'s reagent. Stirring the mixture for 3 h led to a yellow strongly fluorescent soln. FC (reaction mixture directly adsorbed on silica, CH_2Cl_2/MeOH 19:1) and carefull evaporation (40°, 350 mbar) gave **20b** (148 mg, 89%). R_f (CH_2Cl_2/MeOH 9:1) 0.51. M.p. > 160° (dec.). UV (MeOH): 209 (4.48), 266 (4.12), 378 (4.47). IR (ATR): 3091*w*, 3022*w*, 2924*w*, 1860*w*, 1675*m*, 1634*w*, 1614*w*, 1577*s*, 1544*s*, 1526*s*, 1487*m*, 1461*s*, 1436*s*, 1420*m*, 1377*s*, 1354*s*, 1328*s*, 1279*s*, 1237*m*, 1203*w*, 1151*w*, 1113*s*, 1067*w*, 1017*w*, 998*m*, 985*m*, 953*w*, 928*m*, 896*w*, 884*w*, 859*w*, 814*w*, 796*w*, 748*w*, 727*m*, 693*m*, 669*w*, 623*w*, 616*w*. ^{1}H-NMR (300 MHz, (D$_6$)DMSO): 12.62 (br. *s*, H−N(8)); 8.72 (*s*, HC=N); 7.53–7.35 (*m*, 5 arom. H); 6.96 (*dd*, *J* = 17.7, 11.1, H−C(1′)); 6.47 (*dd*, *J* = 17.7, 2.4, H$_a$−C(2′)); 5.60 (*dd*, *J* = 11.1, 2.4, H$_b$−C(2′)); 5.83 (*s*, PhC*H*$_2$); 3.19, 3.07 (2*s*, Me$_2$N). HR-MALDI-MS: 351.1558 (100, $C_{18}H_{19}N_3O_2^+$, $[M+H]^+$; calc. 351.1564).

*3-Amino-10-[2-amino-4-(benzyloxy)-7-oxo-7,8-dihydropteridin-6-yl]-1-(benzyloxy)-9,10-dihydro-5*H*-pyrido[1,2-f]pteridin-6(8*H*)-one* (**21a**). *From* **19**. A suspension of **19** (50 mg, 0.160 mmol) in toluene (5 ml) was heated to reflux for 10 min. After cooling to r.t., the yellow precipitate was filtered off and washed with CH_2Cl_2/MeOH 9:1. Drying of the residue *in vacuo* gave **21a** (48 mg, 96%).

From **21a**. A suspension of **21a** (200 mg, 0.640 mmol) in toluene (10 ml) was heated to reflux for 6 h. After cooling to r.t., the yellow precipitate was filtered off and washed with CH_2Cl_2/MeOH 9:1. Drying of the residue *in vacuo* gave **21a** (195 mg, 98%).

Data of **21a**. M.p. > 300° (dec.). UV (MeOH, sat. soln.): 209 (4.33), 287 (3.67), 361 (3.88). IR (ATR): 3464*w*, 3318*w*, 3200*w*, 2924*w*, 2867*w*, 2770*w*, 1666*m*, 1614*s*, 1562*s*, 1495*s*, 1453*s*, 1434*s*, 1380*m*, 1351*s*, 1331*s*, 1268*m*, 1246*m*, 1208*w*, 1156*s*, 1096*w*, 1060*m*, 1040*w*, 970*w*, 941*w*, 908*w*, 841*w*, 804*w*, 771*w*, 730*m*, 694*m*, 623*w*. ^{1}H-NMR (400 MHz, (D$_6$)DMSO): 12.34 (br. *s*, H−N(8′)); 10.88 (*s*, H−N(5)); 7.42–7.12 (*m*, 10 arom. H); 7.09 (br. *s*, C(2′)−NH$_2$); 6.18 (*t*, *J* ≈ 3.6, H−C(10)); 5.98 (br. *s*, C(3)−NH$_2$); 5.58 (*t*, *J* ≈ 2.2, H−C(7)); 5.43 (*d*, *J* = 13.4, PhC*H*); 5.39 (*d*, *J* = 12.4, PhC*H*); 5.33 (*d*, *J* = 13.6, PhC*H*); 5.13 (*d*, *J* = 12.5, PhC*H*); 3.37 (br. *d*, *J* = 11.5, H$_a$−C(9)); 2.10–1.89 (*m*, H$_b$−C(9), 2 H−C(8)). ^{13}C-NMR (100 MHz, (D$_6$)DMSO): 164.13 (*s*, C(4′)); 161.29 (*s*, C(2′)); 159.72 (*s*, C(6)); 156.27 (*s*, C(7′)); 155.06, 155.04 (2*s*, C(1), C(3)); 151.10 (*s*, C(8a′)); 149.21 (*s*, C(6′)); 146.77 (*s*, C(4a)); 136.63 (*s*); 136.45 (*s*); 132.40 (*s*, C(6a)); 128.36 (2*d*); 127.91 (2*d*); 127.69 (2*d*); 127.43 (*d*); 127.16 (*d*); 126.25 (2*d*); 106.74 (*s*, C(4a′)); 102.14 (*s*, C(11a)); 101.81 (*d*, C(7)); 66.44, 66.39 (2*t*, 2 Ph*C*H$_2$); 54.83 (*d*, C(10)); 22.87 (*t*, C(9)); 18.48 (*t*, C(8)). HR-MALDI-MS (retro-*Diels–Alder* reaction occurred under the conditions of the measurement): 591.2199 (37, $C_{30}H_{27}N_{10}O_4^+$, $[M+H]^+$; calc. 591.2211), 590.2127 (36, $C_{30}H_{26}N_{10}O_4^{+\bullet}$, $M^{+\bullet}$; calc. 590.2133), 296.1137 (100, $C_{15}H_{14}N_5O_2^+$, $[M/2+H]^+$; calc. 296.1142). Anal. calc. for $C_{30}H_{26}N_{10}O_4$ (590.60): C 61.01, H 4.44, N 23.72; found: C 60.73, H 5.50, N 23.63.

*1-(Benzyloxy)-10-(4-(benzyloxy)-2-{[(dimethylamino)methylidene]amino}-7-oxo-7,8-dihydropteridin-6-yl)-3-{[(dimethylamino)methylidene]amino}-9,10-dihydro-5*H*-pyrido[1,2-f]pteridin-6(8*H*)-one*

(**21b**). A suspension of **20b** (100 mg, 0.286 mmol) in toluene (7 ml) was heated to 60° and stirred for 6 h. Evaporation gave **21b** (100 mg, quant.). R_f (CH_2Cl_2/MeOH 9:1) 0.36. M.p. 199–200° (dec.). UV (MeOH): 207 (4.57), 344 (4.34). IR (ATR): 3180*w*, 2925*w*, 1681*m*, 1618*m*, 1582*s*, 1547*s*, 1432*s*, 1374*s*, 1349*s*, 1318*s*, 1238*m*, 1166*m*, 1155*m*, 1111*m*, 1093*m*, 1062*m*, 1017*w*, 984*w*, 951*w*, 907*w*, 880*w*, 851*w*, 809*w*, 779*w*, 740*w*, 725*m*, 692*m*, 661*w*, 622*w*. ^{1}H-NMR (400 MHz, (D_6)DMSO): 12.33 (br. *s*, H–N(8′)); 11.05 (*s*, H–N(5)); 8.68, 8.30 (2*s*, 2 HC=N); 7.43–7.09 (*m*, 10 arom. H); 6.33 (*t*, $J \approx 3.8$, H–C(10)); 5.68 (*d*, $J \approx 4.8$, H–C(7)); 5.51 (*d*, $J = 13.9$, PhC*H*); 5.46 (*d*, $J \approx 13.0$, PhC*H*); 5.42 (*d*, $J \approx 15.2$, PhC*H*); 5.18 (*d*, $J = 12.7$, PhC*H*); 3.18, 3.06, 3.01, 2.91 (4*s*, 2 Me_2N); 2.47–2.42 (*m*, H_a–C(9)); 2.15–1.91 (*m*, H_b–C(9), 2 H–C(8)). ^{13}C-NMR (100 MHz, (D_6)DMSO): 164.42 (*s*, C(4′)); 163.58 (*s*, C(2′)); 159.19 (*s*, C(6)); 159.11, 157.03 (2*d*, 2 HC=N); 156.52 (*s*, C(3)); 156.04 (*s*, C(7′)); 154.03 (*s*, C(1)); 152.16 (*s*, C(6′)); 150.76 (*s*, C(8a′)); 146.38 (*s*, C(4a)); 136.97 (*s*); 136.69 (*s*); 132.08 (*s*, C(6a)); 128.39 (2*d*); 127.93 (2*d*); 127.36 (*d*); 127.14 (2*d*); 127.07 (*d*); 125.93 (2*d*); 108.95 (*s*, C(4a′)); 105.76 (*s*, C(11a)); 102.92 (*d*, C(7)); 66.70, 66.60 (2*t*, 2 PhCH_2); 55.26 (*d*, C(10)); 40.67, 40.07, 34.64, 34.14 (4*q*, 2 Me_2N); 22.61 (*t*, C(9)); 18.36 (*t*, C(8)). HR-MALDI-MS: 701.3043 (60, $C_{36}H_{37}N_{12}O_4^+$, $[M+H]^+$; calc. 701.3055); 351.1547 (100, $C_{18}H_{19}N_6O_2^+$, $[M/2+H]^+$; calc. 351.1564). Retro-*Diels–Alder* reaction occurred under the conditions of the measurement. Anal. calc. for $C_{36}H_{36}N_{12}O_4$ (700.76): C 61.70, H 5.18, N 23.99; found: C 61.57, H 5.24, N 23.71.

X-Ray Analysis of **21b**. Crystals of **21b** were obtained by slow evaporation of a soln. of **21b** in a mixture of CH_2Cl_2/MeOH/toluene (dimensions of the analyzed crystal: cube $0.36 \times 0.18 \times 0.10$ mm; colour: amber). $2(C_{36}H_{36}N_{12}O_4) \cdot 1.66$ MeOH $\cdot 1.34$ CH_2Cl_2, M_r 1568.49, triclinic, *P*1, $a = 14.4432(3)$, $b = 14.9092(4)$, $c = 20.0995(5)$ Å, $\alpha = 72.2602(12)$, $\beta = 88.0190(14)$, $\gamma = 78.4158(8)°$, $V = 4036.7(2)$ Å^3, $Z = 2$, $D_x = 1.29$ Mg/m^3. Intensities were measured on a *Nonius Kappa CCD* diffractometer, with MoK_α radiation $\lambda = 0.71073$ Å, Cell parameters from 163419 refl., $\theta = 2.425–25.682°$, $\mu = 0.185$ mm^{-1}, $T = 223$ K. 28458 measured reflections, 14997 independent reflections, 10742 observed reflections ($> 2\sigma(I)$). Refinement on F^2: full-matrix least squares refinement, R(all) = 0.1737, R(gt) = 0.1412. Crystal cut from a block with multiple non-merohedral twins. The measured crystal gave rise to overlapping peaks (poor agreement of equivalent reflections). A mixture of disordered CH_2Cl_2 and MeOH is present. All diagrams and calculations were performed using maXus (*Bruker Nonius*, *Delft & MacScience*, Japan). The program SIR97 was used to solve the structure and the program SHELXL-97 to refine it.

*2-Amino-6-(benzyloxy)-8-[(*E*)-prop-1-enyl]purine* (**22**). A suspension of **19** (400 mg, 1.278 mmol) in *o*-xylene (15 ml) was treated with Ph_3P (803 mg, 3.066 mmol), heated to 145° for 24 h, and allowed to cool to r.t. FC (directly adsorbed on silica gel; CH_2Cl_2/MeOH 19:1) gave **22** (287 mg, 80%). R_f (CH_2Cl_2/MeOH 9:1) 0.48. M.p. 220°. UV (MeOH): 215 (4.42), 309 (4.33). IR (ATR): 3480*w*, 3294*w*, 3186*m*, 3033*w*, 2962*w*, 1664*w*, 1618*s*, 1576*s*, 1482*s*, 1454*m*, 1439*m*, 1415*s*, 1395*s*, 1348*s*, 1322*m*, 1303*m*, 1263*s*, 1211*m*, 1153*s*, 1077*m*, 1005*m*, 994*m*, 950*s*, 907*m*, 843*w*, 789*m*, 752*m*, 714*w*, 695*m*, 674*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.42 (*s*, H–N(9)); 7.51–7.34 (*m*, 5 arom. H); 6.60 (*dq*, $J = 16.2, 6.6$, H–C(2′)); 6.32 (*s*, NH_2); 6.27 (*dq*, $J = 16.2, 1.5$, H–C(1′)); 5.46 (*s*, PhCH_2); 1.87 (*dd*, $J = 6.6, 1.5$, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 159.48 (*s*, C(6)); 159.29 (*s*, C(2)) 156.06 (*s*, C(4)); 146.79 (*s*, C(8)); 136.75 (*s*); 131.58 (*d*, C(2′)); 128.39 (2*d*), 128.33 (2*d*); 127.93 (*d*); 121.27 (*d*, C(1′)); 114.06 (*s*, C(5)); 66.63 (*t*, PhCH_2); 18.19 (*q*, Me). HR-MALDI-MS: 304.1170 (9, $C_{15}H_{15}N_5NaO^+$, $[M+Na]^+$; calc. 304.1174), 282.1344 (100, $C_{15}H_{16}N_5O^+$, $[M+H]^+$; calc. 282.1349). Anal. calc. for $C_{15}H_{15}N_5O$ (281.32): C 64.04, H 5.37, N 24.89; found: C 63.78, H 5.60, N 24.81.

*8-[(*E*)-Prop-1-enyl]guanine* (**23**). A suspension of **22** (100 mg, 0.356 mmol) and anh. LiBr (36 mg, 0.427 mmol) in dry MeCN (5 ml) was treated with Me_3SiCl (67 µl, 0.534 mmol), stirred for 12 h, cooled to 0°, treated with MeOH (1 ml), and stirred for 15 min. The colourless precipitate was filtered off, and drying *in vacuo* afforded **23** (62 mg, 92%). M.p. > 350° (dec.). UV (MeOH): 209 (4.13), 259 (4.03), 336 (4.27). IR (ATR): 3312*m*, 3165*m*, 2714*m*, 2628*m*, 2566*m*, 1677*s*, 1647*s*, 1612*s*, 1559*s*, 1453*m*, 1436*m*, 1366*m*, 1244*w*, 1137*w*, 1075*w*, 1016*w*, 959*m*, 859*w*, 765*m*, 671*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 11.85 (*s*, H–N(9)); 7.43 (*s*, NH_2); 4.11 (*dq*, $J = 16.2, 7.2$, H–C(2′)); 6.39 (*dq*, $J = 16.2, 1.8$, H–C(1′)); 1.98 (*dd*, $J = 6.9, 1.8$, Me); H–N(1) not visible. ^{13}C-NMR (75 MHz, (D_6)DMSO): 155.08 (*s*, C(6)); 152.66 (*s*, C(2)); 150.16 (*s*, C(4)); 144.59 (*s*, C(8)); 141.25 (*d*, C(2′)); 114.50 (*d*, C(1′)); 107.10 (*s*, C(5)); 18.73 (*q*, Me). HR-MALDI-MS: 192.0883 (100, $C_8H_{10}N_5O^+$, $[M+H]^+$; calc.192.0880).

2-Amino-6-(benzyloxy)-8-(trifluoromethyl)purine (**26**). A soln. of **1** (490 mg, 2.0 mmol) in dry THF (20 ml) at $-40°$ was treated with $(CF_3CO)_2O$ (0.340 ml, 2.4 mmol). Over 2 h, the temp. was raised to $-20°$. The mixture was diluted with H_2O (30 ml), and extracted with CH_2Cl_2 (3×80 ml). The combined org. phases were dried (Na_2SO_4) and evaporated to yield crude **25** (652 mg) as a blue solid. A suspension of crude **25** in *o*-xylene (20 ml) was treated with Ph_3P (1.257 g, 4.8 mmol), heated to 145°, and stirred for 8 h. Evaporation and FC (CH_2Cl_2/MeOH 96:4) gave **26** (501 mg, 81%). Colourless solid. R_f (CH_2Cl_2/MeOH 9:1) 0.39. M.p. 214.3–215.8°. UV (MeOH): 214 (4.39), 246 (3.84), 290 (4.07). IR (ATR): 3467*w*, 3444*w*, 3303*w*, 3173*w*, 2650*w*, 1637*m*, 1592*s*, 1533*m*, 1484*m*, 1470*m*, 1438*m*, 1399*m*, 1349*m*, 1298*m*, 1274*m*, 1195*m*, 1154*s*, 1143*s*, 1050*w*, 981*m*, 959*m*, 909*w*, 842*m*, 790*w*, 781*w*, 745*m*, 726*m*, 697*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 13.78 (*s*, H–N(9)); 7.53–7.32 (*m*, 5 arom. H); 6.82 (*s*, NH_2); 5.51 (*s*, PhCH_2). ^{13}C-NMR (75 MHz, (D_6)DMSO): 160.84 (*s*, C(6)); 160.01 (*s*, C(2)); 155.16 (*s*, C(4)); 136.92 (*q*, $J = 38.8$, C(8)); 136.00 (*s*); 128.46 (2*d*), 128.26 (2*d*); 128.01 (*d*); 118.88 (*q*, $J = 267.8$, CF_3); 113.62 (*s*, C(5)); 67.14 (*t*, PhCH_2). ^{19}F-NMR (300 MHz, (D_6)DMSO): -62.09 (*s*, CF_3). HR-MALDI-MS: 310.0910 (100, $C_{13}H_{11}F_3N_5O^+$, $[M+H]^+$; calc.: 310.0910).

8-(Trifluoromethyl)guanine (**27**). A suspension of **26** (200 mg, 0.647 mmol) in dry MeCN (8 ml) was treated at 24° with anh. LiBr (72 mg, 0.841 mmol) and Me_3SiCl (0.125 ml, 0.971 mmol), stirred for 4 h, and treated with MeOH (2 ml). After evaporation, the colourless residue was crystallized from hot H_2O to afford **27** (122 mg, 86%). M.p. > 350° (dec.). UV (MeOH): 205 (4.10), 257 (4.10). IR (ATR): 3319*w*, 3152*m*, 3047*m*, 2938*w*, 2719*w*, 1687*s*, 1634*s*, 1561*m*, 1519*m*, 1449*m*, 1357*m*, 1286*m*, 1176*s*, 1140*s*, 1039*w*, 978*m*, 865*m*, 773*m*, 760*w*, 736*w*, 695*w*, 665*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 13.69 (*s*, H–N(9)); 10.78 (*s*, H–N(1)); 6.57 (*s*, NH_2). ^{13}C-NMR (75 MHz, (D_6)DMSO): 156.31 (*s*, C(6)); 154.39 (*s*, C(2)); 152.73 (*s*, C(4)); 133.92 (*q*, $J = 40.5$, C(8)); 118.67 (*q*, $J = 267.7$, CF_3); 116.11 (*s*, C(5)). ^{19}F-NMR (300 MHz, (D_6)DMSO): -61.87 (*s*, CF_3). HR-MALDI-MS: 242.0259 (100, $C_6H_4F_3N_5NaO^+$, $[M+Na]^+$; calc. 242.0266), 220.0443 (78, $C_6H_5F_3N_5O^+$, $[M+H]^+$; calc. 220.0440).

*(4*R*,5*R*)*-N,N′-*Bis[2-amino-6-(benzyloxy)-5-nitrosopyrimidin-4-yl]-2,2-dimethyl-1,3-dioxolane-4,5-dicarboxamide* (**29**). A soln. of **1** (1.150 g, 4.694 mmol) in dry THF (30 ml) at 0° was treated with L-*2,2-dimethyl-1,3-dioxolane-4,5-dicarbonyl dichloride* (**28**; 0.380 ml, 2.347 mmol), stirred for 1 h at 0°, and for 1 h at r.t. The soln. was treated with Et_3N (1.308 ml, 9.388 mmol), filtered, and the solid residue washed with MeOH (5 ml). The filtrate was diluted with hexane (70 ml) and cooled to 4°. After 12 h, the gel-like precipitate was filtered off to afford **29** (1.412 g, 93%) after drying *in vacuo*. Blue powder. R_f (CH_2Cl_2/MeOH 9:1) 0.46. M.p. 172° (dec.). VIS (DMSO, $c = 0.005$M): 639 (2.27). IR (ATR): 3305*w*, 3204*m*, 3131*w*, 1740*m*, 1634*m*, 1596*s*, 1516*s*, 1456*s*, 1396*m*, 1340*s*, 1279*m*, 1257*s*, 1241*s*, 1229*s*, 1210*m*, 1143*s*, 1077*s*, 969*w*, 929*w*, 908*w*, 860*m*, 795*m*, 746*m*, 718*w*, 699*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.99 (*s*, HNC=O); 8.80, 8.76 (2*s*, NH_2); 7.57–7.37 (*m*, 5 arom. H); 5.64 (*s*, PhCH_2); 4.94 (*s*, H–C(4)); 1.66 (*s*, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 169.15 (*s*, 2 C=O); 164.10 (*s*, 2 C(6′)); 139.27 (*s*, 2 C(4′)); 135.66 (2*s*); 128.54 (4*d*); 128.46 (4*d*); 128.30 (2*d*); 113.54 (*s*, C(2)); 78.04 (*d*, 2 C(4), C(5)); 68.49 (*t*, 2 $PhCH_2$); 26.40 (*q*, 2 Me); signals of 2 C(5′) and 2 C(2′) not visible due to coalescence. HR-MALDI-MS: 343.2029 (100, $C_{29}H_{27}N_{10}O_8^-$, $[M-H]^-$; calc. 643.2019).

*(4*R*,5*R*)-4,5-Bis[2-amino-6-(benzyloxy)-9*H*-purin-8-yl]-2,2-dimethyl-1,3-dioxolane* (**30**). A suspension of **29** (644 mg, 1 mmol) in *o*-xylene (20 ml) was treated with Ph_3P (1.257 g, 4.8 mmol), and heated to 100° for 6 h. After evaporation, FC (CH_2Cl_2/MeOH 20:1) gave **30** (506 mg, 87%). Colourless solid. R_f (CH_2Cl_2/MeOH 9:1) 0.34. M.p. 204°. UV (MeOH): 212 (4.55), 247 (4.27), 288 (4.35). IR (ATR): 3472*w*, 3362*w*, 3204*w*, 3064*w*, 2987*w*, 1623*s*, 1580*s*, 1467*m*, 1454*m*, 1409*s*, 1352*m*, 1323*m*, 1257*m*, 1239*m*, 1219*m*, 1153*m*, 1081*s*, 1045*m*, 1018*m*, 980*m*, 952*w*, 900*w*, 844*m*, 810*w*, 789*m*, 733*m*, 694*m*, 666*w*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 12.89 (*s*, H–N(9′)); 7.48–7.30 (*m*, 5 arom. H); 6.39 (*s*, NH_2); 5.51 (*s*, H–C(4)); 5.43 (*s*, PhCH_2); 1.47 (*s*, Me). ^{13}C-NMR (75 MHz, (D_6)DMSO): 159.80 (*s*, 2 C(6′)); 159.74 (*s*, 2 C(2′)); 155.99 (*s*, 2 C(4′)); 145.34 (*s*, 2 C(8′)); 136.54 (2*s*); 128.60 (4*d*); 128.34 (4*d*); 128.01 (2*d*); 113.36 (*s*, C(5′)); 111.09 (*s*, C(2)); 74.59 (*d*, 2 C(4), C(5)); 66.77 (*t*, 2 $PhCH_2$); 26.57 (*q*, Me_2C). HR-MALDI-MS: 603.2172 (60, $C_{29}H_{28}N_{10}NaO_4^+$, $[M+Na]^+$; calc. 603.2193), 581.2361 (100, $C_{29}H_{29}N_{10}O_4^+$, $[M+H]^+$; calc. 581.2368). Anal. calc. for $C_{29}H_{28}N_{10}O_4 \cdot 0.75$ MeOH: C 59.10, H 5.17, N 23.17; found: C 58.89, H 5.17, N 23.17.

X-Ray Analysis of **30**. Isothermal distillation of hexane into a soln. of **30** in $CHCl_3$/MeOH gave single crystals (dimensions of the analyzed colourless crystal: $0.33 \times 0.22 \times 0.12$ mm). $2(C_{29}H_{28}N_{10}O_4) \cdot CHCl_3 \cdot$ MeOH, M_r 1312.638, orthorhombic, $P2_12_12_1$, $a = 13.4060(2)$, $b = 15.9895(2)$, $c = 30.2057(4)$ Å,

$V = 6474.8(2)$ Å^3, $Z = 4$, $D_x = 1.347$ Mg/m^3. Intensities were measured on a *Nonius Kappa CCD* diffractometer, with MoK_α radiation $\lambda = 0.71073$ Å, Cell parameters from 42184 refl., $\theta = 0.998 - 25.028°$, $\mu = 0.213$ mm^{-1}, $T = 223$ K. 11017 measured reflections, 10984 independent reflections, 9552 observed reflections ($> 2\sigma(I)$). Refinement on F^2: full-matrix least-squares refinement, $R(\text{all}) = 0.0944$, $R(\text{gt}) = 0.0819$. The structure contains two molecules of $CHCl_3$ and disordered MeOH in the asymmetric unit. All diagrams and calculations were performed using maXus (*Bruker Nonius*, *Delft MacScience*, Japan). The program SIR97 was used to solve the structure and the program SHELXL-97 to refine it.

*(4*R*,5*R*)-4,5-Di(guanin-8-yl)-2,2-dimethyl-1,3-dioxolane* (**31**). A suspension of **30** (200 mg, 0.345 mmol) and LiBr (78 mg, 0.896 mmol) in dry MeCN (5 ml) was treated with TMSCl (130 µl, 1.035 mmol) and stirred for 20 h. The suspension was cooled to 0°, diluted with MeOH (1 ml), and stirred for 15 min. The colourless precipitate was filtered off, and washed with H_2O, Et_2O, and CH_2Cl_2/MeOH 9 : 1. Drying *in vacuo* gave **31** (113 mg, 82%). M.p. > 260° (dec.). UV (MeOH): 202 (4.29), 255 (4.15). IR (ATR): 3322*s* (br.), 3176*m* (br.), 2933*w*, 2762*w*, 1676*s*, 1629*s*, 1593*s*, 1507*m*, 1436*m*, 1348*m*, 1218*m*, 1159*m*, 1092*m*, 998*w*, 888*w*, 777*m*, 725*w*, 689*m*. ^{1}H-NMR (300 MHz, (D_6)DMSO): 10.74 (*s*, H−N(9′)); 6.54 (*s*, NH_2); 5.44 (*s*, H−C(4)); 1.49 (*s*, Me); H−N(1′) not visible. ^{13}C-NMR (75 MHz, (D_6)DMSO): 155.70 (*s*, 2 C(6′)); 153.42 (*s*, 2 C(2′)); 153.02 (*s*, 2 C(4′)); 144.4 (br. *s*, 2 C(8′)); 114.4 (br. *s*, 2 C(5′)); 110.98 (*s*, C(2)); 74.51 (2*d*, C(4), C(5)); 26.59 (*q*, *Me*$_2$C). HR-MALDI-MS: 439.0993 (51, $C_{15}H_{16}KN_{10}O_4^+$, $[M + K]^+$; calc. 439.0993), 423.1250 (100, $C_{15}H_{16}N_{10}NaO_4^+$, $[M + Na]^+$; calc. 423.1254), 401.1429 (87, $C_{15}H_{17}N_{10}O_4^+$, $[M + H]^+$; calc. 401.1429).

*(1R,2*R*)-1,2-Di(guanin-8-yl)ethane-1,2-diol* (**32**). A suspension of **31** (50 mg, 0.114 mmol) in THF (5 ml) was treated with 1N aq. HCl (5 ml) and stirred for 20 h. THF was removed under reduced pressure, and the aq. suspension was lyophilized. M.p. > 250° (dec.). UV (MeOH): 204 (4.15), 259 (4.05). IR (ATR): 3353*m*, 3160*m*, 2854*m*, 2731*m*, 2550*m*, 1692*s*, 1649*s*, 1614*s*, 1543*s*, 1434*w*, 1369*s*, 1263*w*, 1228*m*, 1153*m*, 1111*m*, 1054*m*, 1003*w*, 914*w*, 858*w*, 766*m*, 732*w*, 688*w*, 665*w*. ^{1}H-NMR (500 MHz, (D_6)DMSO): 11.56 (*s*, H−N(9′)); 7.16 (*s*, NH_2); 5.22 (*s*, H−C(1)); H−N(1′) and HO−C(1) not visible. ^{13}C-NMR (125 MHz, (D_6)DMSO): 154.16 (*s*, C(6′)); 153.27 (*s*, C(2′)); 150.40 (*s*, C(4′)); 149.21 (*s*, C(8′)); 108.83 (*s*, C(5′)); 68.85 (*d*, C(1)). HR-MALDI-MS: 383.0938 (25, $C_{12}H_{12}N_{10}NaO_4^+$, $[M + Na]^+$; calc. 383.0941), 361.1117 (100, $C_{12}H_{13}N_{10}O_4^+$, $[M + H]^+$; calc. 361.1116).

REFERENCES

[1] F. E. Kempter, H. Rokos, W. Pfleiderer, *Chem. Ber.* **1970**, *103*, 885.
[2] M. Xu, F. De Giacomo, D. E. Paterson, T. G. George, A. Vasella, *Chem. Commun.* **2003**, *12*, 1452.
[3] M. Xu, A. Vasella, *Helv. Chim. Acta* **2006**, *89*, 1140.
[4] F.-L. Zhang, W. B. Schweizer, M. Xu, A. Vasella, *Helv. Chim. Acta* **2007**, *90*, 521.
[5] F.-L. Zhang, A. Vasella, *Helv. Chim. Acta* **2007**, *90*, 2315.
[6] W. Pfleiderer, R. Lohrmann, *Chem. Ber.* **1961**, *94*, 12.
[7] R. Baur, T. Sugimoto, W. Pfleiderer, *Helv. Chim. Acta* **1988**, *71*, 531.
[8] M. Viscontini, Y. Furuta, *Helv. Chim. Acta* **1973**, *56*, 1819.
[9] A. Kaiser, H. P. Wessel, *Helv. Chim. Acta* **1987**, *70*, 766.
[10] A. Walser, G. Silverman, R. I. Fryer, *J. Org. Chem.* **1973**, *38*, 3502.
[11] G. Abbiati, E. M. Beccalli, G. Broggini, G. Paladino, E. Rossi, *Synthesis* **2005**, *17*, 2881.
[12] V. I. Terenin, A. S. Ivanov, *Chem. Heterocycl. Comp.* **2005**, *41*, 1435.
[13] D. L. Boger, W. L. Corbett, T. T. Curran, A. M. Kasper, *J. Am. Chem. Soc.* **1991**, *113*, 1713.
[14] D. L. Boger, W. L. Corbett, J. M. Wiggins, *J. Org. Chem.* **1990**, *55*, 2999.
[15] J. Lehbauer, W. Pfleiderer, *Nucleosides Nucleotides* **1997**, *16*, 869.
[16] J. Lehbauer, W. Pfleiderer, *Helv. Chim. Acta* **2001**, *84*, 2330.
[17] D. R. Lide, 'Handbook of Chemistry and Physics', CRC Press, 1993, p. 10–208 to 10–226.
[18] M. G. Veliev, A. Z. Chalabieva, M. I. Shatirova, E. G. Akperova, *Russ. J. Org. Chem. (Engl. Transl.)* **2003**, *39*, 825.
[19] Program AMPAC 8.16, *Semichem Inc.*, Shawnee Mission, KS.
[20] W. Pfleiderer, M. Shanshal, *Justus Liebigs Ann. Chem.* **1969**, *726*, 201.

[21] T. Yamakawa, K. Yamamoto, D. Uraguchi, K. Tokuhisa, PCT Int. Appl. 2007.
[22] M.-Y. Chae, K. Swenn, S. Kanugula, M. E. Dolan, A. E. Pegg, R. C. Moschel, *J. Med. Chem.* **1995**, *38*, 359.
[23] K. Araki, I. Yoshikawa, *Top. Curr. Chem.* **2005**, *256*, 133.
[24] 'Quadruplex Nucleic Acids', Eds. S. Neidle, S. Balasubramanian, RSC Publishing, Cambridge, UK, 2006.
[25] S. Neidle, M. A. Read, *Biopolymers* **2001**, *56*, 195.
[26] A. T. Phan, J.-L. Mergny, *Nucleic Acids Res.* **2002**, *30*, 4618.
[27] A. K. Beck, P. Gysi, L. La Vecchia, D. Seebach, *Org. Synth.* **1999**, *76*, 12.
[28] H.-J. Choi, M.-O. Kwak, H. Song, *Synth. Commun.* **1997**, *27*, 1273.

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