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Synthesis of *N*-Alkenylpurines by Rearrangements of the Corresponding *N*-Allyl Isomers: Scopes and Limitations

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N-9- and *N*-7-alkenylpurines have been synthesized by rearrangement of the corresponding *N*-allyl derivatives, often in good yields and with high stereoselectivity. Base promoted and transition metal mediated rearrangements have been studied. Simple allylpurines were easily rearranged with catalytic amounts of $RuClH(CO)(PPh_3)_3$. The efficiency of base promoted rearrangement was highly dependent on the detailed structure of the starting material, but this reaction often occurred with surprisingly high *Z*-selectivity.

Introduction

9-Vinylpurines have been prepared first as monomers for polymerization reactions,[1] but later also as synthetic intermediates for 1,3-dipolar cycloadditions in synthesis of nucleoside analogs[2] and as the vinylic partner in Heck couplings.[3] 9-Alkenylpurines have to some extent been studied for their biological activities; antiviral-[4] or anticancer activities,[4a,5] interaction with adenosine deaminase[6] or kinase inhibiting activities[3b,3c] are reported. In contrast to *N*-alkylation of purines, there are few convenient routes to *N*-alkenylpurines. Direct *N*-9 vinylation can be achieved with vinyl acetate in the presence of toxic Hg-salts,[1a,1b,2b,7] or with di- or tetrachloroethene in carcinogenic HMPA.[8] More benign methods include Cu-mediated *N*-alkenylation employing boronic acids,[9] or Michael addition to activated alkynes.[5,10] Quite often 9-alkenylpurines are synthesized by alkylation followed by an elimination in cases were there is a leaving group in the alkyl β-position.[4b,11] There are also a couple of examples of a more atom-efficient strategy; migration of an allylic double bond in the presence of *t*BuOK.[6,12] Miscellaneous syntheses of 9-alkenylpurines include Horner–Wadsworth–Emmons reactions on 9-[(diethoxyphosphoryl)methyl]purines,[3b,13] reactions of 9-(2,2-diethoxyethyl)purines with malonic acid,[14] and ring opening of 9-(cyclobutenyl)purines.[15]

7-Alkenylated purines are hardly known in the literature. *N*-Vinylation of purines with vinyl acetate and $Hg(OAc)_2$ may give the 7-vinylisomer as a by-products in low yields.[7] It was recently reported that azathioprine reacts with esters of acetylenecarboxylates in the presence of PPh_3 to give only the *N*-7-alkenylated Michael-type adducts.[16] We have shown that the *N*-7 allyl group in N^6,*N*-7-diallyladenine can be selectively rearranged to propenyl and used the product in an RCM-mediated synthesis of the heterocyclic part of asmarines (marine bioactive natural products).[17] The reaction took place with a much weaker base (K_2CO_3) compared to what has been used for the rearrangement of certain 9-allylpurines.[6,12] In our current strategy for asmarine synthesis, we needed 7-alkenyl-6-halopurines, and we soon learned that synthesis of these compounds required a slightly different strategy. Hence we chose to explore the scope and limitations for rearrangement of 7-allylpurines to the corresponding *N*-alkenylpurines under basic conditions as well as in the presence of transition metal complexes. Since there are few convenient routes to 9-alkenylpurines, we also included rearrangement studies of 9-allylpurines.

Results and Discussion

Substrates for the rearrangements were prepared by *N*-allylation of purines **1** (Scheme 1). Allylation of compounds **1b**, **1c** or **1d** in the presence of base gave generally mixtures of isomers **2** and **3**, with the *N*-9 allylpurines **3** as the major products. Structure elucidations were based on NMR spectroscopy, especially HMBC and HMQC, and on the general trends found for the ^1H and ^{13}C NMR shifts of *N*-alkylpurine isomers.[18] Adenine **1a** was allylated according to a literature procedure, but in contrast to what was reported before,[19] NMR spectroscopy revealed that the minor isomer was not 7-allyladenine **2a**, but the 3-allylated compound **4**. The 6-halo-7-allylpurines **2c** and **2e** were also available from regioselective allylation in the presence of methylaquacobaloxime. Compounds **2a**, **2b** and **2f** were formed by exchange of the chloride in compound **2c**. The 9-allylpurines **3b** and **3f** were synthesized from chloropurine **3c** by the same methodology.

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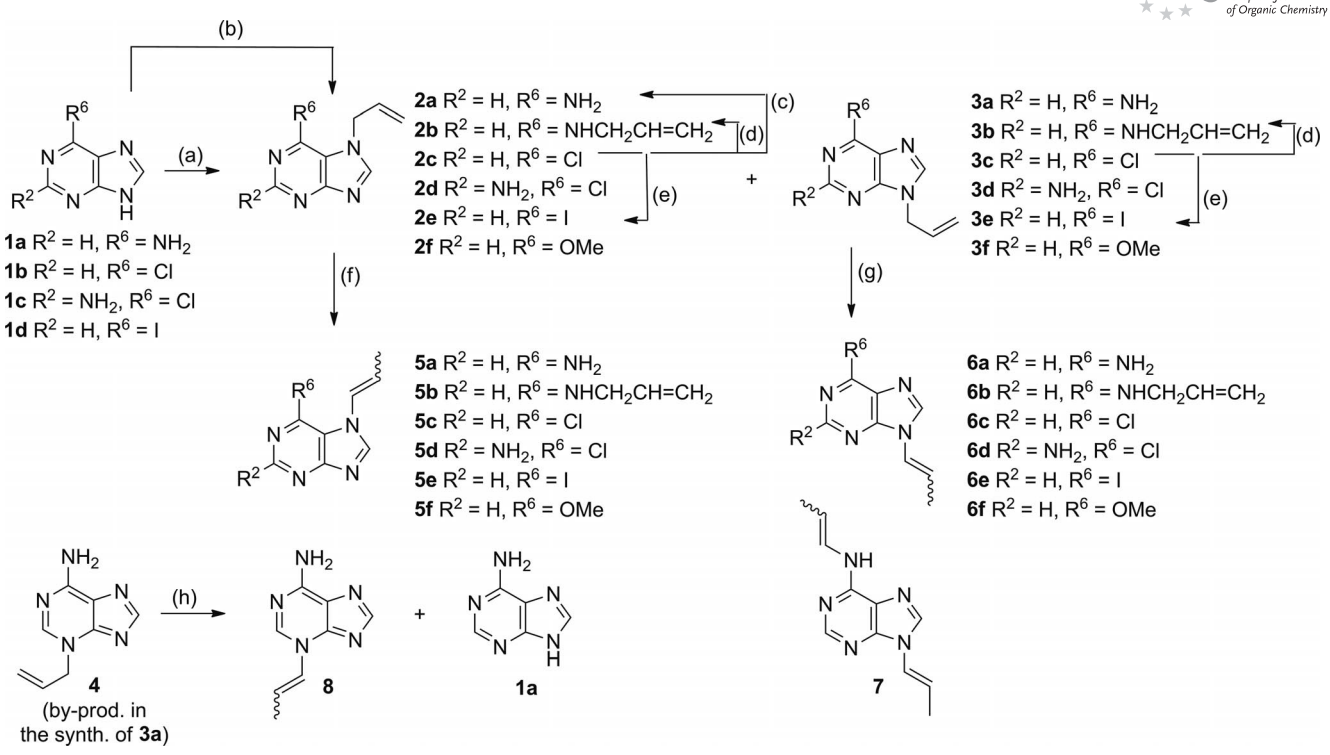


Scheme 1. (a) CH_2=$CHCH_2X$, base, see exp. part; (b) CH_2=$CHCH_2I$, methylaquacobaloxime, K_2CO_3, MeCN; (c) NH_3, *t*BuOH, 120 °C; (d) CH_2=$CHCH_2NH_2$, base, see exp. part; (e) MeONa, MeOH, Δ; (f) see Table 1; (g) see Table 2; (h) K_2CO_3, *n*BuOH, Δ.

The 7-allylpurines **2** were subjected to the rearrangement conditions earlier employed on compound **2b** (K_2CO_3 in refluxing MeCN).[17a] Both allyladenines **2a** and **2b** were rearranged with complete selectivity for the *Z*-isomer, to give compounds **5a** and **5b**, but the reaction of **2a** was slower than on **2b** (Scheme 1, Table 1). None of the other substrates reacted when treated with K_2CO_3 in refluxing MeCN. Higher boiling solvents (i.e. dioxane or chlorobenzene) were also tried without success. When the 6-methoxypurine **2f** was treated with K_2CO_3 in the refluxing *n*BuOH, some rearrangement was observed, but also exchange of the methoxy with a butoxy group. The adenine **2a**, which cannot participate in nucleophilic substitutions, was also treated with *t*BuOK in DMSO. The rearrangement was efficient even at ambient temperature, but, in contrast to rearrangements with a milder base, the *E*-isomer was the predominant product.

We then turned to alternative strategies for the rearrangement and chose to study transition metal-catalyzed reactions. All substrates **2** could easily be rearranged to 7-propenylpurines when $RuClH(CO)(PPh_3)_3$ was employed as catalyst in refluxing xylenes. High conversion and, in most cases, good isolated yields were obtained. In contrast to the surprisingly *Z*-selective rearrangement under mild basic conditions, the *E*-isomer was generally the major product (ca. 75%), except for the reaction on iodopurine **2e** where the *E* and *Z* isomers were formed in equal amounts.

In the Ru-catalyzed rearrangement of the iodopurine **2e**, it was found that a minor amount of rearranged product contained chloride instead of iodide. Since the Ru complex must have been the chloride source, an alternative catalyst, $RhH(CO)(PPh_3)_3$ was also tried on this substrate, but the conversion to the propenylpurine **5e** was very low (data not shown).

Table 1. Rearrangement of the 7-allylpurines **2**.

R^2	R^6	Method	Time [h]	Conversion [%][a]	*E*/*Z*[a]	Yield [%] **5**[b]
H	NH_2	MeCN, Δ	96	n.r.	–	–
H	NH_2	A[c]	96	90	>1:99	53, **5a**
H	NH_2	B[d]	0.30	98	69:31	84, **5a**
H	NH_2	C[e]	24	80	38:62	38, **5a**
H	NHallyl	A	17	100	>1:99	100, **5b**[f]
H	NHallyl	C	24	40	28:72	–[g]
H	Cl	A	24	n.r.	–	–
H	Cl	C	3	99	75:25	76, **5c**
NH_2	Cl	A	96	n.r.	–	–
NH_2	Cl	C	3	89	74:26	78, **5d**
H	I	A	24	n.r.	–	–
H	I	C	3	90	50:50	73, **5e**[h]
H	OMe	A	24	n.r.[i]	–	–
H	OMe	A[j]	96	–[k]	–	–
H	OMe	C	3	97	81:19	87, **5f**

[a] From ^{1}H NMR of the crude product. [b] Isolated yield. [c] Method A: K_2CO_3, MeCN, Δ. [d] Method B: *t*BuOK, DMSO, room temp. [e] Method C: Cat. $RuClH(CO)(PPh_3)_3$, xylenes, Δ. [f] Taken from ref. 17a. [g] Not isolated in pure form. [h] Calculated yield of **5e**, was isolated together with minor amounts of **5c**. [i] Also n.r. in refluxing dioxane or PhCl. [j] *n*BuOH as solvent. [k] Double bond migration took place, but the methoxy group was also partly exchanged with a butoxy group.

We next looked into rearrangement of the *N*-9 allylpurines **3** (Scheme 1, Table 2). All substrates could easily be transformed to the 9-propenylpurines **6** in the presence of catalytic $RuClH(CO)(PPh_3)_3$. The *E*-selectivity (83–86%)

was somewhat higher that what was observed for the regioisomers **5**. Again some halogen exchange took place in the reaction of the iodide **3e**. The diallylpurine **3b** probably gave the double rearrangement product **7**, but this compound was not isolated in pure form due to limited stability.

Table 2. Rearrangement of the 9-allylpurines **3**.

R^2	R^6	Method[a]	Time [h]	Conversion [%][b]	*E*/*Z*[b]	Yield [%] **6**[c]
H	NH_2	A	96	n.r.	–	–
H	NH_2	A[d]	96	92	37:63	69, **6a**
H	NH_2	B[e]	0.30	>99	95:5	92, **6a**[f]
H	NH_2	B	0.30	>99	93:7	93, **6a**
H	NH_2	C	3	98	86:14	84, **6a**
H	NHallyl	A	96	n.r.	–	–
H	NHallyl	A[d]	48	90	35:65	89, **6b**
H	NHallyl	C	3	>99[g]	–[g]	–[g]
H	Cl	A	24	n.r.	–	–
H	Cl	B	0.30	–[h]	–	–
H	Cl	C	3	97	86:14	85, **6c**
NH_2	Cl	A	24	n.r.	–	–
NH_2	Cl	C	3	97	83:17	76, **6d**
H	I	A	24	n.r.	–	–
H	I	C	3	95	84:16	77, **6e**[i]
H	OMe	A	24	n.r.[j]	–	–
H	OMe	A[d]	96	–[k]	–	–
H	OMe	C	3	97	83:17	86, **6f**

[a] Methods A, B and C are defined in Table 1. [b] From ^{1}H NMR of the crude product. [c] Isolated yield. [d] *n*BuOH as solvent. [e] At 100 °C. [f] Performed according to ref. 12. [g] NMR indicated that compound **7** (*E*/*Z* 35:65) was formed, but the compound was not isolated in pure form. [h] A complex mixture formed; the chloride exchanged with the *t*BuO group. [i] Calculated yield of **6e**, was isolated together with minor amounts of **6c**. [j] Also n.r. in dioxane, Δ or PhCl, Δ. [k] Double bond migration took place, but the methoxy group was also partly exchanged with butoxy.

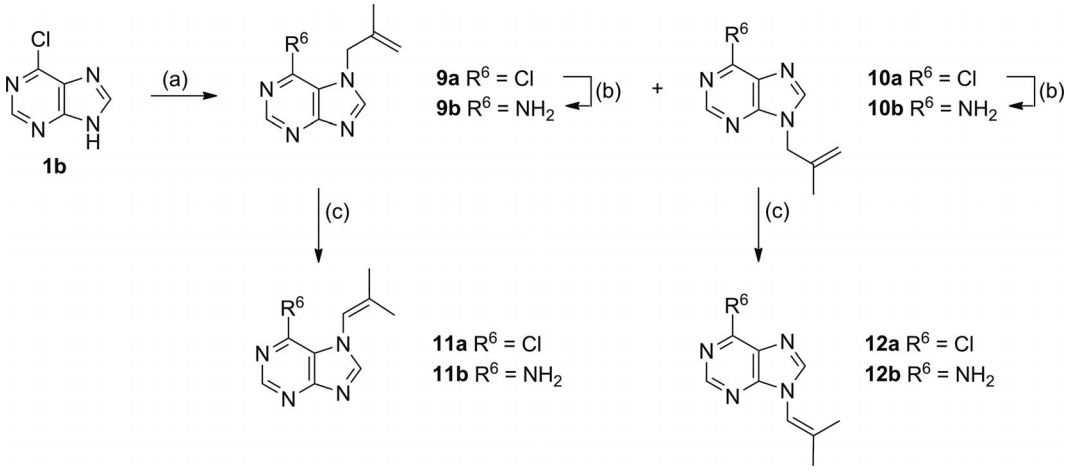
As previously found for 7-allylpurines **2**, successful rearrangement in the presence of K_2CO_3 was only possible for the adenine derivatives **3a** and **3b**, but in both cases the reaction only took place in refluxing *n*BuOH and not in MeCN. Both substrates gave mostly *Z*-products (63–65%), but the reactions were not as selective as those performed on the regioisomers **2a** and **2b**. In case of substrate **3b**, only rearrangement of the *N*-9 allyl group was observed. The 6-methoxypurine **3f** reacted in the presence of K_2CO_3 in the refluxing *n*BuOH, but, as also seen for the isomer **2f**, also methoxy/butoxy group exchange took place.

Prior to our work, there has been one report on allyl to propenyl rearrangement on 9-allyladenine **3a**; reaction with *t*BuOK in DMSO at 100 °C, to give the 9-propenyladenine **6a** in high yield after only 20 min, but the *E*/*Z* ratio was not described in this article.[12] We repeated the experiment and can confirm that the reaction is indeed efficient, but also that the rearrangement under these conditions occurs with very high *E*-selectivity (95%). Hence we also reacted the same substrate with K_2CO_3 in DMSO at 100 °C (data not shown). The reaction was significantly slower than in *n*BuOH, but as with the other K_2CO_3-mediated rearrangements the *Z*-isomer was the major product (84%). Full conversion and high *E*-selectivity was achieved when the substrate was treated with *t*BuOK in DMSO at ambient temperature, so the high reaction temperature reported before[12] was not required for this substrate.

The 3-allyladenine **4** was also treated with K_2CO_3 and with $RuClH(CO)(PPh_3)_3$ (Scheme 1). Surprisingly, the substrate did not react at all in the presence of the Ru-catalyst under standard conditions. When reacted with K_2CO_3 in refluxing *n*BuOH, some rearrangement took place but also deallylation was observed. After one day the ratio between product **8**, starting material **4** and adenine **1a** was found to be 49:25:26. The *E*/*Z* ratio in **8** was 1:1. When *t*BuOK in DMSO at 100 °C was used, the rearrangement was complete after ca. 20 min, and the *E*/*Z* selectivity was 85:15.

We extended the rearrangement study to substituted allylpurines. Substrates for double bond migration **9** and **10**, carrying a substituent at the allylic C-2, were prepared by *N*-allylation of 6-chloropurine (**1b**) followed by amination for the synthesis of **9b** and **10b**. (Scheme 2).

Compounds **9** and **10** were treated with base and with cat. $RuClH(CO)(PPh_3)_3$ in order to explore their tendency to undergo double bond migration (Scheme 2, Table 3). Not unexpectedly, the chlorides **9a** and **10a** were inert to K_2CO_3 in refluxing MeCN. The 7-alkenyladenine **11b** was formed in high yield from allyladenine **9b** under these reaction con-



Scheme 2. (a) 2-Methylallyl bromide, K_2CO_3, DMF; (b) NH_3, *t*BuOH, 120 °C; (c) see Table 3.

ditions, but the *N*-9-allylated isomer **10b** was considerably less reactive. Even at 200 °C under microwave conditions, the conversion to 9-alkenyladenine **12b** was only 50% after 16 h. Both adenines **9b** and **10b**, reacted readily when treated with *t*BuOK in DMSO at ambient temperature.

Table 3. Rearrangement of the allylpurines **9** and **10**.

Starting material	R^6	Method[a]	Time [h]	Conversion [%] to **11** or **12**[b]	Yield [%] **11** or **12**[c]
9a	Cl	A	24	n.r.	–
9a	Cl	C	24	6	–
9b	NH_2	A	48	94	90
9b	NH_2	B	0.30	92	74
9b	NH_2	C	24	n.r.	–
10a	Cl	A	48	n.r.	–
10a	Cl	C	48	21	–
10a	Cl	D[d]	24	71[e]	48
10b	NH_2	A[f]	16	50	–
10b	NH_2	B	0.30	93	87
10b	NH_2	C	48	6	–

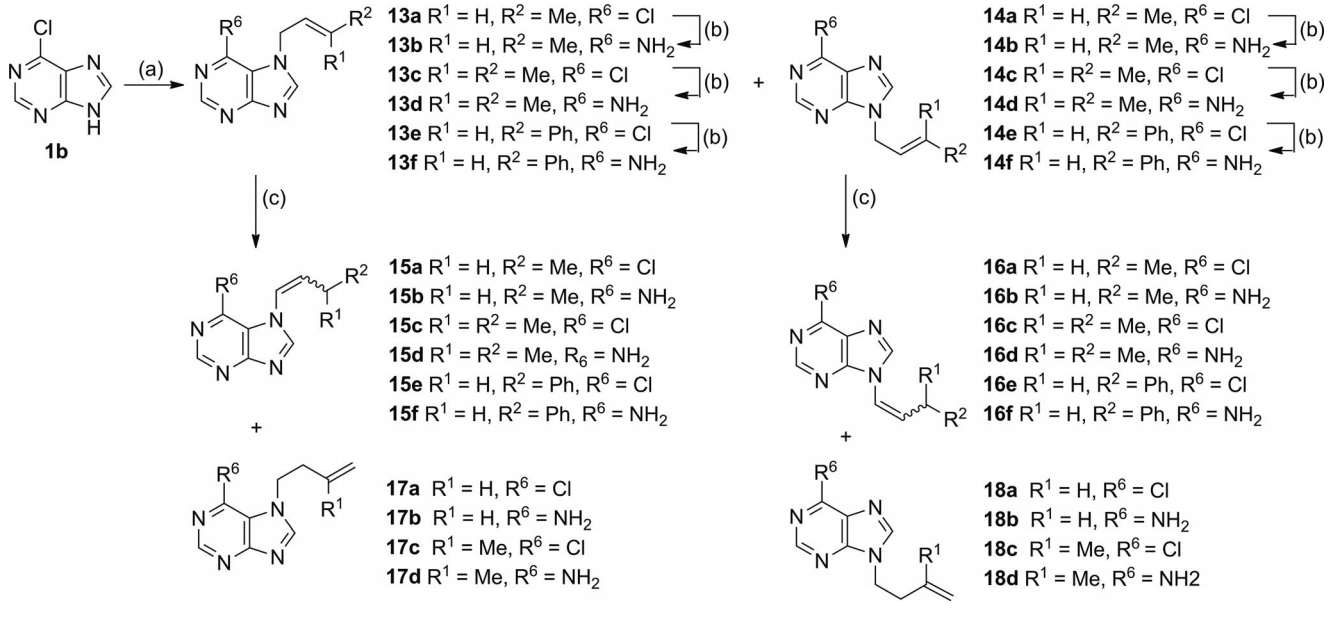
[a] Methods A, B and C are defined in Table 1. [b] From ^1H NMR of the crude product. [c] Isolated yield. [d] Method D: $Fe(CO)_5$ one eq., per 6 h, xylenes, 138 °C, sealed tube. [e] Ca. 6% reductive removal of the chloride in **10a** was also observed by NMR spectroscopy. [f] 200 °C, microwave cond.

In contrast to the simple allylpurines **2** and **3**, hardly any double bond migration was seen when the (2-methylallyl)-purines **9** and **10** were exposed to cat. $RuClH(CO)(PPh_3)_3$. Microwave conditions were also tried but without any significant improvements. The Ru-mediated rearrangement is believed to occur via a hydride addition-elimination mechanism.[20] In order to achieve successful isomerization of the (2-methylallyl)purines, the ruthenium must be attached to the most substituted alkene carbon after the Ru-H addition, which might explain the low reactivity observed.

Successful $Fe(CO)_5$-mediated double bond migrations on *N*-(2-methylallyl)amides are reported,[21] and the chloride **10a**, which cannot be rearranged with *t*BuOK, was treated with this reagent. A good conversion of the starting material was achieved, although some reductive removal of the chloride took place and ca. 6% 9-(2-methylallyl)-9*H*-purine was formed according to the NMR spectroscopy. Unfortunately rearrangement of the isomer **9a** was not successful, here only reductive removal of the chloride was observed (data not shown). We have also previously observed (in Negishi couplings) that 7-substituted-6-chloropurines are more prone to reduction compared to their 9-substituted isomers.[22]

Finally, compounds **13** and **14**, substituted at the end of the allylic moiety, were synthesized by standard methodology and treated with base and with $RuClH(CO)(PPh_3)_3$ (Scheme 3, Table 4). All compounds were totally inert to K_2CO_3 in refluxing MeCN (2 d, data not shown). The adenine derivatives, which were not prone to nucleophilic substitution, were reacted in refluxing *n*BuOH, but only in case of 9-cinnamyladenine **14f**, some isomerization was observed. Also ca. 4% *E* to *Z* isomerization of the unreacted starting material was seen. The dimethylallyladenines **13d** and **14d** were reacted under microwave conditions. Partial deallylation to adenine (**1a**) was observed for the 7-allylated adenine **13d**, whereas the isomer **14d** was completely unreactive.

When treated with *t*BuOK in DMSO at ambient temperature, less than 20% double bond migration was observed for the adenine derivatives **13b**, **13d**, **13f**, **14b**, **14d** and **14f**. Somewhat surprisingly, taking into account the results using this base on the unsubstituted *N*-allylpurines **2** and **3** (see Tables 1 and 2), compounds **13b** and **14b** gave the *Z*-product as the major isomer. In all cases some deallylation and the formation of adenine (**1a**) took place. If the



Scheme 3. (a) Allyl halide, K_2CO_3, DMF; (b) NH_3, *t*BuOH, 120 °C; (c) see Table 4.

Table 4. Rearrangement of the allylpurines **13** and **14**.

Starting material	R^1	R^2	R^6	Method[a]	Time [h]	Conversion [%][b] **13** or **14**	**15** or **16**	**17** or **18**	Adenine	Yield [%] **15** or **16** (*E*/*Z*)[c]	*E*/*Z* recovered **13** or **14**
13a	H	Me	Cl	C	24	58	32	11	n.d.[d]	28 (85:15)	79:21
13b	H	Me	NH_2	A[e]	24	>99	n.d.	n.d.	n.d.	–	>99:1
13b	H	Me	NH_2	B	0.30	83	13	1	3	12 (34:66)	>99:1
13b	H	Me	NH_2	C	24	75	22	3	n.d.	20 (67:33)	88:12
13c	Me	Me	Cl	C	24	>99	n.d.	n.d.	n.d.	–	–
13d	Me	Me	NH_2	A[e]	72	>99	n.d.	n.d.	n.d.	–	–
13d	Me	Me	NH_2	A[f]	7	54	n.d.	n.d.	46	–	–
13d	Me	Me	NH_2	B	0.30	94	n.d.	5	1	–	–
13d	Me	Me	NH_2	C	24	>99	n.d.	n.d.	n.d.	–	–
13e	H	Ph	Cl	C	24	91	9	–	n.d.	– (>99:1)	95:5
13f	H	Ph	NH_2	A[e]	24	>99	n.d.	–	n.d.	–	>99:1
13f	H	Ph	NH_2	B	0.30	78	2	–	20	– (>99:1)	>99:1
13f	H	Ph	NH_2	C	24	>99	n.d.	–	n.d.	–	>99:1
14a	H	Me	Cl	C	24	47	46	7	n.d.	42 (90:10)	79:21
14b	H	Me	NH_2	A[e]	72	>99	n.d.	n.d.	n.d.	–	>99:1
14b	H	Me	NH_2	B	0.30	79	16	1	4	9 (54:46)[g]	>99:1
14b	H	Me	NH_2	C	24	47	48	5	n.d.	35 (>99:1)[h]	84:16
14c	Me	Me	Cl	C	24	82	8	10	n.d.	– (>99:1)	–
14d	Me	Me	NH_2	A[e]	72	>99	n.d.	n.d.	n.d.	–	–
14d	Me	Me	NH_2	A[f]	3	>99	n.d.	n.d.	n.d.	–	–
14d	Me	Me	NH_2	B	0.30	71	n.d.	18	11	–	–
14d	Me	Me	NH_2	C	24	93	3	4	n.d.	– (>99:1)	–
14e	H	Ph	Cl	C	24	87	13	–	n.d.	– (>99:1)	97:3
14f	H	Ph	NH_2	A[e]	72	89	11	–	n.d.	10 (80:20)	96:4
14f	H	Ph	NH_2	B	0.30	54	n.d.	–	46	–	>99:1
14f	H	Ph	NH_2	C	48	88	12	–	n.d.	9 (>99:1)	97:3

[a] Methods A, B and C are defined in Table 1. [b] From ^{1}H NMR of the crude product. [c] Isolated yield. [d] Not detected. [e] *n*BuOH as solvent. [f] 200 °C, microwave cond. [g] Ratio from ^{1}H NMR of the crude product 40:60. [h] Ratio from ^{1}H NMR of the crude product 87:13.

reactions were carried out at 100 °C (data not shown) the deallylation was almost complete in 20 min. The 7-dimethylallyladenines **13d** and **14d** gave only the terminal alkenes **17d** and **18d** and not the conjugated alkenes **15d** and **16d**. However, it cannot be excluded that deprotonation of the CH_2 leads to fast deallylation and the formation of adenine (**1a**) so the only isomerized products observed, are those formed from deprotonation on the other side of the double bond. Debenzylation of *N*-benzylpurines in the presence of a strong base has been noted before,[23] and the cinnamyladenines **13f** and **14f**, which can only be deprotonated at the CH_2, were those substrates found to be most prone to deallylation when treated with *t*BuOK. Also the *N*-but-2-enylpurines **13b** and **14b** gave very minor amounts of the terminal alkenes **17b** and **18b**, when treated with *t*BuOK. The terminal alkenes were not isolated pure and the structure elucidation was based on comparison with spectra of reference compounds **17** and **18** synthesized by alkylation of purines with the appropriate homoallylic halides (see Exp. Sect.).

Ru-mediated double bond migration was attempted on the *N*-allylpurines **13** and **14**. The conversion was generally higher than what was observed with the *N*-(2-methylallyl)-purines **9** and **10**, but not as good as with the unsubstituted allylpurines **2** and **3**. Generally the *E*-selectivity was quite high. When both conjugated- and terminal alkenes could be formed, both were observed, but the conjugated compounds **15** and **16** were generally the major products. Interestingly, also some *E* to *Z* migration of the starting materials took place. Deallylation was not seen when the *N*-allylpurines **13** and **14** were exposed to the ruthenium catalyst.

Conclusions

N-Alkenylpurines can be formed by base or transition metal mediated double-bond migration on *N*-allylpurines, the latter compounds are readily available from direct *N*-allylation. Simple allylpurines were easily rearranged with good *E*-selectivity when treated with catalytic amounts of $RuClH(CO)(PPh_3)_3$, but the catalyst appeared to be highly sensitive to steric hindrance, and substitution on the allyl group often resulted in substantially reduced reactivity. In these cases, *E*-*Z* isomerization of the starting material could be observed and sometimes also rearrangement to homoallylpurines. *N*-(2-methylallyl)purines were more efficiently rearranged with $Fe(CO)_5$.

Most substrates studied were inert to K_2CO_3, but could be rearranged when exposed to a stronger base (*t*BuOK). Some of these reactions occurred with a surprisingly high *Z*-selectivity. Certain substituted allylpurines were prone to deallylation, when treated with the strong base.

Experimental Section

General Information: ^{1}H NMR spectra were recorded at 500 MHz on a Bruker DRX 500 instrument, at 400 MHz on a Bruker AVII 400 instrument or at 300 MHz on a Bruker Avance DPX 300 in-

strument. The decoupled ^{13}C NMR spectra were recorded at 125, 100 or 75 MHz using the instruments mentioned above. Assignments of ^{1}H and ^{13}C resonances are inferred from 1D ^{1}H NMR, 1D ^{13}C NMR, DEPT or APT, and 2D NMR (COSY, HMQC, HMBC and/or NOESY) spectroscopic data. Mass spectra under electron impact conditions were recorded on a VG Prospec instrument at 70 eV ionizing voltage, and are presented as *m*/*z* (% rel. int.). Melting points were determined on a Büchi Melting Point B-545 apparatus. Experiments under microwave conditions were carried out in a microwave synthesis reactor Monowave 300, Anton Paar GmbH, Graz, Austria, equipped with a Ruby thermometer for temperature control. Dry MeCN and DMF were obtained from a solvent purification system, MB SPS-800 from MBraun, Garching, Germany. Xylenes (isomeric mixture) were distilled from Na/benzophenone. DMSO was filtered through a pad of BaO and distilled under reduced pressure from CaH_2. Alcohols *n*BuOH and *t*BuOH were stirred with K_2CO_3 and $MgSO_4$ and distilled. MeOH was dried by magnesium and distilled. All other reagents were commercially available and used as received. Silica gel for flash chromatography was purchased from Merck, Darmstadt, Germany (Merck No. 09385). Compounds available by literature methods: **2b**,[17a] **2c**,[24] **2d**,[24] **3a**,[19] **3b**,[17a] **3c**,[25] **3d**,[24] **3e**,[26] **4**,[27] **5b**.[17a]

7-Allyl-7*H*-adenine (2a): 7-Allyl-6-chloro-7*H*-purine (**2c**, 195 mg, 1.00 mmol) was stirred in *t*BuOH (10 mL) saturated with NH_3 (g) in a sealed container at 120 °C for 21 h. The mixture was evaporated in vacuo and the crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:6); yield 153 mg (87%), colorless powder. ^{1}H NMR (400 MHz, [D_6]-DMSO): δ = 4.85 (d, J = 17.2 Hz, 1 H, H_A in =CH_2), 5.06 (m, 2 H, NCH_2), 5.17 (d, J = 10.4 Hz, 1 H, H_B in =CH_2), 6.04 (m, 1 H, =CH), 7.13 (br. s, 2 H, NH_2), 8.25 (s, 1 H, 2-H), 8.31 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D_6]DMSO): δ = 48.1 (NCH_2), 110.8 (C-5), 116.6 (=CH_2), 134.8 (CH=), 146.2 (C-8), 151.4 (C-6), 151.3 (C-2), 158.5 (C-4) ppm. MS (EI): *m*/*z* (%) = 175 (100) [M^+], 174 (38), 160 (15), 147 (20), 135 (10), 120 (10), 108 (8), 80 (8). HRMS (EI): $C_8H_9N_5$ calcd. 175.0858, found 175.0855.

7-Allyl-6-iodo-7*H*-purine (2e): 6-Iodo-9*H*-purine (**1d**, 1.8 g, 7.3 mmol) and methylaquacobaloxime (2.6 g, 8.1 mmol) in dry MeCN (73 mL) were stirred at ambient temperature under N_2. After 5 min, K_2CO_3 (1.12 g, 8.08 mmol) was added and the mixture was stirred for additional 30 min. Allyl iodide (1.33 mL, 14.6 mmol) was added and the mixture was stirred in the dark for a total of 120 h, additional allyl iodide (1.37 mL, 5.00 mmol) was added after 24 h and 48 h. The mixture was evaporated in vacuo, the residue dissolved in CH_2Cl_2 (100 mL) and washed with aq. NaOH (2 M, 100 mL). The aqueous phase was extracted with CH_2Cl_2 (3 × 50 mL). The combined organic extracts were washed with brine (50 mL), dried ($MgSO_4$) and evaporated in vacuo. The product was purified by flash chromatography on silica gel eluting with acetone/CH_2Cl_2 (1:4); yield 1.28 g (61%), pale yellow solid, m.p. 116–117 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 5.01 (d, J = 17.4 Hz, 1 H, H_A in =CH_2), 5.13 (d, J = 5.4 Hz, 1 H, NCH_2), 5.37 (d, J = 10.4 Hz, 1 H, H_B in =CH_2), 6.09 (m, 1 H, =CH), 8.32 (s, 1 H, 8-H), 8.72 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 48.0 (NCH_2), 108.6 (C-6), 119.4 (=CH_2), 128.7 (C-5), 131.9 (=CH), 150.0 (C-8), 152.5 (C-2), 159.5 (C-4) ppm. MS (EI): *m*/*z* (%) = 286 (100) [M^+], 159 (98), 132 (95), 119 (6), 105 (24). HRMS (EI): $C_8H_7IN_4$ calcd. 285.9715, found 285.9718.

7-Allyl-6-methoxy-7*H*-purine (2f): A mixture of MeONa (167 mg, 3.09 mmol) 7-allyl-6-chloro-7*H*-purine (**2c**, 200 mg, 1.03 mmol) in dry MeOH (10 mL) was stirred at reflux under Ar for 2 h. Water (10 mL) was added and the pH was adjusted to neutral by the addition of 1 M HCl. The mixture was extracted with EtOAc (50 mL, followed by 5 × 10 mL). The combined organic extracts were washed with brine (10 mL), dried ($MgSO_4$) and evaporated in vacuo. The product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:32); yield 188 mg (94%), pale yellow solid, m.p. 75–77 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 4.11 (s, 3 H, CH_3O), 4.90 (d, J = 5.7 Hz, 2 H, NCH_2), 5.14 (d, J = 17.0 Hz, 1 H, H_A in =CH_2), 5.27 (d, J = 10.2 Hz, 1 H, H_B in =CH_2), 6.01 (m, 1 H, =CH), 7.98 (s, 1 H, 8-H), 8.60 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 49.6 (NCH_2), 54.0 (CH_3O), 112.9 (C-5), 118.9 (=CH_2), 132.3 (CH=), 145.2 (C-8), 152.1 (C-2), 157.1 (C-6), 161.6 (C-4) ppm. MS (EI): *m*/*z* (%) = 190 (100) [M^+], 175 (26), 162 (7), 148 (6), 136 (43). HRMS (ESI): $C_9H_{10}N_4O$ calcd. 190.0855, found 190.0852.

9-Allyl-6-methoxy-9*H*-purine (3f): A mixture of MeONa (83.5 mg, 1.53 mmol) and 9-allyl-6-chloro-9*H*-purine (**3c**, 100 mg, 0.510 mmol) in dry MeOH (5 mL) was stirred at ambient temperature under Ar for 48 h. Water (10 mL) was added and the pH was adjusted to neutral by the addition of 1 M HCl. The mixture was extracted with EtOAc (50 mL, followed by 5 × 10 mL). The combined organic extracts were washed with brine (10 mL), dried ($MgSO_4$) and evaporated in vacuo. The product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:49); yield 95 mg (97%), pale yellow solid, m.p. 77–79 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 4.16 (s, 3 H, CH_3O), 4.82–4.85 (m, 2 H, NCH_2), 5.16 (d, J = 17.1 Hz, 1 H, H_A in =CH_2), 5.28 (d, J = 9.7 Hz, 1 H, H_B in =CH_2), 5.95–6.08 (m, 1 H, CH=), 7.90 (s, 1 H, 8-H), 8.52 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 46.0 (NCH_2), 54.2 (OCH_3), 119.3 (=CH_2), 121.1 (C-5), 131.6 (CH=), 141.9 (C-8), 151.9 (C-4), 152.1 (C-2), 161.1 (C-6) ppm. MS (EI): *m*/*z* (%) = 190 (100) [M^+], 160 (7), 148 (20), 132 (9), 120 (10). HRMS (EI): $C_9H_{10}N_4O$ calcd. 190.0855, found 190.0861.

General Procedure for K_2CO_3-Mediated Rearrangement (Method A): The reactions were carried out as described for the rearrangement of N^6,7-diallyl-7*H*-purine (**2b**) before.[17a] For choice of solvent, temperatures, and reaction times, see Table 1, Table 2, Table 3, and Table 4.

General Procedure for *t*BuOK-Mediated Rearrangement (Method B): To a solution of potassium *tert*-butoxide (88 mg, 0.50 mmol) in DMSO (2 mL) the *N*-allyladenine (0.50 mmol) was added. The resulting solution was stirred at ambient temperature for 20 min. The mixture was diluted with water (2 mL) and taken to pH 8 with the excess of solid carbon dioxide. The resulting thick sludge was evaporated to dryness in vacuo and the residue was purified by flash chromatography on silica gel.

General Procedure for Ru-catalyzed Rearrangement (Method C): The *N*-allylpurine (0.51 mmol) and $RuClH(CO)(PPh_3)_3$ (49 mg, 0.051 mmol) in xylenes (10 mL) were heated at reflux under Ar for the times given in Table 1, Table 2, Table 3, and Table 4. The solvent was removed in vacuo and the residue was purified by flash chromatography on silica gel.

6-Amino-7-(prop-1-en-1-yl)-7*H*-purine (5a): MeOH/CH_2Cl_2 (gradient, 1:16 to 1:13) was used for flash chromatography; yield 61 mg (53%), off-white solid, pure *Z*-isomer from K_2CO_3-mediated rearrangement (Method A), m.p. 189–192 °C, ^{1}H NMR (400 MHz, [D_6]DMSO): δ = 1.64 (dd, J_1 = 6.8, J_2 = 1.6 Hz, 3 H, CH_3), 5.90–6.00 (m, 1 H, =CH), 6.78 (br. s, 2 H, NH_2), 7.11 (dd, J_1 = 8.4, J_2 = 2.0 Hz, 1 H, NCH=), 8.21 (s, 1 H, 2-H), 8.26 (s, 1 H, 8-H) ppm. ^{13}C NMR (75 MHz, [D_6]DMSO): δ = 12.0 (CH_3), 110.7 (C-5), 123.15 (NCH=), 126.5 (=CH), 144.8 (C-8), 151.6 (C-6), 152.7 (C-2), 159.1 (C-4) ppm. MS (EI): *m*/*z* (%) = 175 (100) [M^+], 174 (25),

160 (14), 147 (30), 120 (20). HRMS (EI): $C_8H_8N_5$ calcd. 175.0858, found 175.0854.

Ru-mediated rearrangement (Method C) gave 34 mg (38%), off-white solid, *E*/*Z*-mixture. NMR spectroscopic data for the ***E*-isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.84 (dd, J_1 = 6.8, J_2 = 1.5 Hz, 3 H, CH_3), 6.06–6.15 (m, 1 H, =CH), 6.94 (br. s, 2 H, NH_2), 7.32 (dd, J_1 = 13.6, J_2 = 1.6 Hz, 1 H, NCH=), 8.19 (s, 1 H, 2-H), 8.45 (s, 1 H, 8-H) ppm. ^{13}C NMR (75 MHz, [D$_6$]DMSO): δ = 14.7 (CH_3), 109.9 (C-5), 121.7 (=CH), 123.57 (NCH=), 143.1 (C-8), 151.4 (C-6), 152.6 (C-2), 159.6 (C-4) ppm.

6-Chloro-7-(prop-1-en-1-yl)-7*H*-purine (5c): MeOH/CH_2Cl_2 (gradient, 1:199 to 1:99) was used for flash chromatography; yield 75 mg (76%), pale yellow solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.76 (dd, J_1 = 7.2, J_2 = 1.8 Hz, 3 H, CH_3), 5.98–6.12 (m, 1 H, =CH), 6.96 (dd, J_1 = 6.3, J_2 = 1.8 Hz, 1 H, NCH=), 8.19 (s, 1 H, 8-H), 8.89 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.4 (CH_3), 122.0 (C-5), 122.1 (NCH=), 127.3 (=CH), 143.7 (C-6), 148.4 (C-8), 152.7 (C-2), 161.4 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.95 (dd, J_1 = 8.1, J_2 = 1.8 Hz, 3 H, CH_3), 6.03–6.14 (m, 1 H, =CH), 7.20 (dd, J_1 = 15.6, J_2 = 3.3 Hz, 1 H, NCH=), 8.33 (s, 1 H, 8-H), 8.87 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.2 (CH_3), 122.0 (C-5), 122.6 (NCH=), 124.3 (=CH), 143.5 (C-6), 146.7 (C-8), 152.5 (C-2), 161.7 (C-4) ppm. MS (EI): *m*/*z* (%) = 196/194 (33/100) [M$^+$], 167 (8), 159 (15), 132 (13), 105 (15). HRMS (EI): $C_8H_7ClN_4$ calcd. 194.0359, found 194.0354.

2-Amino-6-chloro-7-(prop-1-en-1-yl)-7*H*-purine (5d): MeOH/CH_2Cl_2 (gradient, 1:199 to 1:32) was used for flash chromatography; yield 65 mg (78%), pale yellow solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.68 (dd, J_1 = 6.8, J_2 = 1.6 Hz, 3 H, CH_3), 5.89–6.11 (m, 1 H, =CH), 6.68 (br. s, 2 H, NH_2), 6.90 (dd, J_1 = 8.0, J_2 = 1.6 Hz, 1 H, NCH=), 8.38 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 12.0 (CH_3), 115.1 (C-5), 122.6 (NCH=), 124.8 (=CH), 142.7 (C-2), 148.7 (C-8), 160.1 (C-6), 163.6 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (400 MHz, [D$_6$]-DMSO): δ = 1.83 (dd, J_1 = 6.8, J_2 = 1.6 Hz, 3 H, CH_3), 6.13–6.19 (m, 1 H, =CH), 6.68 (br. s, 2 H, NH_2), 7.12 (dd, J_1 = 13.6, J_2 = 1.6 Hz, 1 H, NCH=), 8.56 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 14.8 (CH_3), 114.3 (C-5), 120.9 (=CH), 122.6 (NCH=), 142.5 (C-2), 146.9 (C-8), 160.0 (C-6), 164.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 211/209 (33/100) [M$^+$], 205 (11), 174 (29), 147 (9). HRMS (EI): $C_8H_8ClN_5$ calcd. 209.0468, found 209.0461.

6-Iodo-7-(prop-1-en-1-yl)-7*H*-purine (5e): The Ru-mediated rearrangement (Method C) was performed in 0.70 mmol scale. MeOH/CH_2Cl_2 (gradient, 1:199 to 1:99) was used for flash chromatography; yield 153 mg of compounds **5e** and **5c** (9:1) (ca. 73% yield of **5e**), pale yellow solid, *E*/*Z* mixture.

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.70 (dd, J_1 = 7.2, J_2 = 2.1 Hz, 3 H, CH_3), 6.01–6.19 (m, 1 H, =CH), 7.06 (dd, J_1 = 8.1, J_2 = 1.8 Hz, 1 H, NCH=), 8.16 (s, 1 H, 8-H), 8.74 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.6 (CH_3), 108.8 (C-6), 121.5 (NCH=), 128.5 (=CH), 128.7 (C-5), 147.5 (C-8), 152.8 (C-2), 158.3 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.96 (dd, J_1 = 6.9, J_2 = 1.8 Hz, 3 H, CH_3), 6.01–6.19 (m, 1 H, =CH), 7.32 (dd, J_1 = 13.8, J_2 = 1.8 Hz, 1 H, NCH=), 8.28 (s, 1 H, 8-H), 8.72 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.3 (CH_3), 108.6 (C-6), 122.0 (NCH=), 126.0 (=CH), 128.2 (C-5), 146.7 (C-8), 152.6 (C-2), 158.8 (C-4) ppm. HRMS (EI) $C_8H_7IN_4$ calcd. 285.9715, found 285.9713.

6-Methoxy-7-(prop-1-en-1-yl)-7*H*-purine (5f): MeOH/CH_2Cl_2 (gradient, 1:99 to 1:32) was used for flash chromatography; yield 84 mg (87%), yellow solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.77 (dd, J_1 = 6.9, J_2 = 1.8 Hz, 3 H, CH_3), 4.07 (s, 3 H, OCH_3), 5.70–5.78 (m, 1 H, =CH), 6.90 (dd, J_1 = 8.4, J_2 = 1.8 Hz, 1 H, NCH=), 8.05 (s, 1 H, 8-H), 8.58 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.5 (CH_3), 54.0 (OCH_3), 112.6 (C-5), 122.3 (=CH), 123.0 (NCH=), 144.7 (C-8), 152.4 (C-2), 157.4 (C-6), 161.1 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.85 (dd, J_1 = 6.9, J_2 = 1.8 Hz, 3 H, CH_3), 4.10 (s, 3 H, OCH_3), 5.94–6.03 (m, 1 H, =CH), 7.06 (dd, J_1 = 14.1, J_2 = 1.8 Hz, 1 H, NCH=), 8.19 (s, 1 H, 8-H), 8.58 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.0 (CH_3), 54.1 (OCH_3), 111.9 (C-5), 118.9 (=CH), 123.6 (NCH=), 142.2 (C-8), 152.1 (C-2), 157.2 (C-6), 161.4 (C-4) ppm. MS (EI): *m*/*z* (%) = 190 (100) [M$^+$], 175 (26), 162 (7), 148 (6), 136 (43). HRMS (EI): $C_9H_{10}N_4O$ calcd. 190.0855, found 190.0852.

6-Amino-9-(prop-1-en-1-yl)-9*H*-purine (6a): MeOH/CH_2Cl_2 (gradient, 1:49 to 1:24) was used for flash chromatography; yield 75 mg (84%), off-white solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.76 (dd, J_1 = 7.2, J_2 = 1.2 Hz, 3 H, CH_3), 5.74–5.81 (m, 1 H, =CH), 6.83 (dd, J_1 = 8.8, J_2 = 1.6 Hz, 1 H, NCH=), 7.29 (br. s, 2 H, NH_2), 8.15 (s, 1 H, 2-H), 8.24 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]-DMSO): δ = 12.7 (CH_3), 118.0 (C-5) 120.6 (NCH=), 121.3 (=CH), 139.7 (C-8) 149.3 (C-4), 153.0 (C-2), 156.0 (C-6) ppm. ***E*-isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.82 (dd, J_1 = 6.8, J_2 = 0.8 Hz, 3 H, CH_3), 6.49–6.57 (m, 1 H, =CH), 7.05 (dd, J_1 = 14.4, J_2 = 1.6 Hz, 1 H, NCH=), 7.29 (br. s, 2 H, NH_2), 8.17 (s, 1 H, 2-H), 8.36 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 15.0 (CH_3), 115.9 (=CH), 119.0 (C-5) 121.6 (NCH=), 138.4 (C-8) 148.4 (C-4), 153.0 (C-2), 156.0 (C-6) ppm. MS (EI): *m*/*z* (%) = 175 (100) [M$^+$], 160 (7), 148 (39), 135 (13), 120 (9). HRMS (EI): $C_8H_9N_5$ calcd. 175.0858, found 175.0853.

***N*^{6}-Allyl-9-(prop-1-en-1-yl)-9*H*-purine (6b):** MeOH/CH_2Cl_2 (gradient, 1:99 to 1:32) was used for flash chromatography; yield 44 mg (89%), pale yellow solid, *E*/*Z*-mixture from K_2CO_3-mediated rearrangement (Method A).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.80 (dd, J_1 = 7.2, J_2 = 1.8 Hz, 3 H, CH_3), 4.32 (br. s, 2 H, NCH_2), 5.15 (d, J = 10.2 Hz, 1 H, H_A in =CH_2), 5.25 (d, J = 17.1 Hz, 1 H, H_B in =CH_2), 5.79–5.84 (m, 1 H, =CH), 5.93–6.08 (m, 2 H, NH and CH=), 6.80 (dd, J_1 = 8.7, J_2 = 1.8 Hz, 1 H, NCH=), 7.83 (s, 1 H, 8-H), 8.39 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.9 (CH_3), 43.2 (NCH_2), 116.4 (=CH_2), 119.1 (C-5), 120.3 (NCH=), 123.2 (=CH), 134.4 (CH=), 139.1 (C-8), 149.2 (C-4), 153.6 (C-2), 154.8 (C-6) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.87 (dd, J_1 = 6.9, J_2 = 1.8 Hz, 3 H, CH_3), 4.31 (br. s, 2 H, NCH_2), 5.17 (d, J = 10.2 Hz, 1 H, H_A in =CH_2), 5.27 (d, J = 17.2 Hz, 1 H, H_B in =CH_2), 5.92–6.05 (m, 2 H, NH and CH=), 6.25–6.37 (m, 1 H, =CH), 6.95 (dd, J_1 = 14.1, J_2 = 1.5 Hz, 1 H, NCH=), 7.86 (s, 1 H, 8-H), 8.39 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.4 (CH_3), 43.1 (NCH_2), 116.4 (=CH_2), 118.2 (=CH), 120.0 (C-5), 121.2 (NCH=), 134.3 (CH=), 137.4 (C-8), 148.5 (C-4), 153.5 (C-2), 154.8 (C-6) ppm. MS (EI): *m*/*z* (%) = 215 (62) [M$^+$], 200 (100), 188 (15), 174 (15), 160 (8). HRMS (EI): $C_{11}H_{13}N_5$ calcd. 215.1171, found 215.1164.

6-Chloro-9-(prop-1-en-1-yl)-9*H*-purine (6c): MeOH/CH_2Cl_2 (gradient, 1:399 to 1:199) was used for flash chromatography; yield 85 mg

(85%), off-white solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.81 (dd, J_1 = 7.2, J_2 = 1.8 Hz, 3 H, CH_3), 5.93–6.03 (m, 1 H, =CH), 6.84 (dd, J_1 = 8.4, J_2 = 1.8 Hz, 1 H, NCH=), 8.18 (s, 1 H, 8-H), 8.74 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.0 (CH_3), 119.7 (NCH=), 125.5 (=CH), 131.1 (C-5), 144.4 (C-8), 151.3 (C-6), 151.5 (C-4), 152.4 (C-2) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.93 (dd, J_1 = 6.9, J_2 = 1.8 Hz, 3 H, CH_3), 6.41–6.53 (m, 1 H, =CH), 6.99 (dd, J_1 = 14.4, J_2 = 1.8 Hz, 1 H, NCH=), 8.22 (s, 1 H, 8-H), 8.74 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 15.4 (CH_3), 120.5 (=CH), 120.5 (NCH=), 131.9 (C-5), 142.8 (C-8), 150.6 (C-4), 151.3 (C-6), 152.3 (C-2) ppm. MS (EI): *m*/*z* (%) = 196/194 (33/100) [M^+], 167 (46), 166 (44), 154 (15), 132 (20). HRMS (EI): $C_8H_7ClN_4$ calcd. 194.0359, found 194.0366.

2-Amino-6-chloro-9-(prop-1-en-1-yl)-9*H*-purine (6d): MeOH/CH_2Cl_2 (gradient, 1:199 to 1:99) was used for flash chromatography; yield 81 mg (76%), yellow solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.72 (dd, J_1 = 7.2, J_2 = 1.2 Hz, 3 H, CH_3), 5.77–5.85 (m, 1 H, =CH), 6.67 (dd, J_1 = 8.4, J_2 = 1.6 Hz, 1 H, NCH=), 6.99 (br. s, 2 H, NH_2), 8.20 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 12.6 (CH_3), 120.4 (NCH=), 122.7 (C-5), 122.8 (=CH), 142.1 (C-8), 149.6 (C-2), 153.7 (C-4), 160.0 (C-6) ppm. ***E*-isomer:** ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.79 (dd, J_1 = 6.8, J_2 = 1.2 Hz, 3 H, CH_3), 6.44–6.53 (m, 1 H, =CH), 6.90 (dd, J_1 = 14.4, J_2 = 1.2 Hz, 1 H, NCH=), 6.99 (br. s, 2 H, NH_2), 8.33 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 15.0 (CH_3), 116.7 (=CH), 121.2 (NCH=), 123.5 (C-5), 140.8 (C-8), 149.6 (C-2), 152.7 (C-4), 159.9 (C-6) ppm. MS (EI): *m*/*z* (%) = 211/209 (30/100) [M^+], 182 (33), 172 (12), 159 (9), 146 (11). HRMS (EI): $C_8H_8ClN_5$ calcd. 209.0468, found 209.0465.

6-Iodo-9-(prop-1-en-1-yl)-9*H*-purine (6e): MeOH/CH_2Cl_2 (gradient, 1:399 to 1:99) was used for flash chromatography; yield 118 mg of compounds **6e** and **6c** (93:7) (ca. 77% yield of **6e**), pale yellow solid *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.80 (dd, J_1 = 7.2, J_2 = 1.8 Hz, 3 H, CH_3), 5.92–6.02 (m, 1 H, =CH), 6.82 (dd, J_1 = 8.4, J_2 = 1.8 Hz, 1 H, NCH=), 8.17 (s, 1 H, 8-H), 8.63 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.0 (CH_3), 119.7 (NCH=), 122.3 (C-6), 125.5 (=CH), 138.0 (C-5) 143.8 (C-8), 147.8 (C-4), 152.4 (C-2) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.93 (dd, J_1 = 6.9, J_2 = 1.5 Hz, 3 H, CH_3), 6.40–6.52 (m, 1 H, =CH), 6.96 (dd, J_1 = 12.6, J_2 = 1.6 Hz, 1 H, NCH=), 8.22 (s, 1 H, 8-H), 8.62 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 15.4 (CH_3), 120.4 (=CH), 120.6 (NCH=), 122.3 (C-6), 138.8 (C-5) 142.1 (C-8), 146.9 (C-4), 152.3 (C-2) ppm. MS (EI): *m*/*z* (%) = 286 (100) [M^+], 159 (30), 144 (12), 132 (25), 105 (7). HRMS (EI): $C_8H_7ClN_4$ calcd. 285.9715, found 285.9713.

6-Methoxy-9-(prop-1-en-1-yl)-9*H*-purine (6f): MeOH/CH_2Cl_2 (gradient, 1:399 to 1:199) was used for flash chromatography; yield 84 mg (86%), off-white solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.79 (dd, J_1 = 7.2, J_2 = 2.1 Hz, 3 H, CH_3), 4.18 (s, 3 H, OCH_3), 5.83–5.93 (m, 1 H, =CH), 6.83 (dd, J_1 = 8.7, J_2 = 1.8 Hz, 1 H, NCH=), 7.99 (s, 1 H, 8-H), 8.53 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.9 (CH_3), 54.3 (OCH_3), 120.1 (NCH=) 120.9 (C-5), 124.0 (=CH), 141.4 (C-8), 151.8 (C-4), 152.6 (C-2), 161.2 (C-6) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.88 (dd, J_1 = 6.9, J_2 = 1.5 Hz, 3 H, CH_3), 4.15 (s, 3 H, OCH_3), 6.31–6.42 (m, 1 H, =CH), 6.97 (dd, J_1 = 14.4, J_2 = 1.5 Hz, 1 H, NCH=), 8.02 (s, 1 H, 8-H), 8.51 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.3 (CH_3), 54.1 (OCH_3), 118.7 (=CH), 120.9 (NCH=) 121.6 (C-5), 139.6 (C-8), 150.8 (C-4), 152.3 (C-2), 161.0 (C-6) ppm. MS (EI): *m*/*z* (%) = 190 (100) [M^+], 175 (7), 163 (28), 145 (10), 133 (10), 120 (15). HRMS (EI): $C_9H_{10}N_4O$ calcd. 190.0855, found 190.0849.

3-(Prop-1-en-1-yl)-3*H*-purin-6-amine (8): MeOH/CH_2Cl_2 (gradient, 1:24 to 1:13) was used for flash chromatography; yield 20 mg (23%), beige solid, pure *E*-isomer from *t*BuOK-mediated rearrangement (Method B).

M.p. 263–266 °C. ^{1}H NMR (400 MHz, CD_3OD): δ = 1.97 (dd, J_1 = 6.8, J_2 = 1.5 Hz, 3 H, CH_3), 6.50–6.59 (m, 1 H, =CH), 7.10 (dd, J_1 = 14.0, J_2 = 1.6 Hz, 1 H, NCH=), 7.89 (s, 1 H, 8-H), 8.39 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, CD_3OD): δ = 15.4 (CH_3), 120.6 (C-5), 125.6 (=CH), 126.1 (NCH=) 143.3 (C-2), 149.8 (C-4), 153.2 (C-8), 156.6 (C-6) ppm. MS (EI): *m*/*z* (%) = 175 [M^+], 163 (49), 162 (67), 135 (80), 108 (100), 81 (10). HRMS (EI): $C_8H_9N_5$ calcd. 175.0858, found 175.0854.

6-Chloro-7-(2-methylallyl)-7*H*-purine (9a): The title compound was formed as a by-product in the synthesis of compound **10a**. Yield 190 mg (23%), yellow solid, m.p. 108–110 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.80 (s, 3 H, CH_3), 4.48 (s, 1 H, H_A in =CH_2), 4.98 (s, 2 H, NCH_2), 5.00 (s, 1 H, H_B in =CH_2), 8.21 (s, 1 H, 8-H), 8.86 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.0 (CH_3), 52.2 (NCH_2), 113.6 (=CH_2), 122.5 (C-5), 139.7 [*C*(CH_2)CH_3], 143.2 (C-6), 149.3 (C-8), 152.5 (C-2), 161.8 (C-4) ppm. MS (EI): *m*/*z* (%) = 210/208 (36/100) [M^+], 193 (30), 146 (13), 119 (8). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0517.

7-(2-Methylallyl)-7*H*-purin-6-amine (9b): The title compound was prepared from chloropurine **9a** (226 mg, 1.08 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:16); yield 178 mg (87%), off-white solid, m.p. 207–209 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.67 (s, 3 H, CH_3), 4.36 (s, 1 H, H_A in =CH_2), 4.84 (s, 1 H, H_B in =CH_2), 4.97 (s, 2 H, NCH_2), 6.74 (br. s, 2 H, NH_2), 8.17 (s, 1 H, 2-H), 8.23 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 19.5 (CH_3), 51.1 (NCH_2), 111.0 (C-5), 111.1 (=CH_2), 142.5 [*C*(CH_2)CH_3], 146.0 (C-8), 151.4 (C-6), 152.3 (C-2), 159.8 (C-4) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M^+], 174 (15), 161 (12), 148 (20). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1020.

6-Chloro-9-(2-methylallyl)-9*H*-purine (10a): Potassium carbonate (1.61 g, 11.7 mmol) was added to a stirred solution of 6-chloropurine (**1b**, 600 mg, 3.89 mmol) in dry DMF (23 mL) at ambient temperature under N_2. After 20 min, 2-methylallyl bromide (0.78 mL, 7.8 mmol) was added and the resulting mixture was stirred at room temperature for 17 h, filtered and evaporated in vacuo. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:99); yield 553 mg (68%), yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.74 (s, 3 H, CH_3), 4.79 (s, 1 H, H_A in =CH_2), 4.81 (s, 2 H, NCH_2), 5.03 (s, 1 H, H_B in =CH_2), 8.07 (s, 1 H, 8-H), 8.75 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 19.9 (CH_3), 49.6 (NCH_2), 114.8 (=CH_2), 131.4 (C-5), 139.0 [*C*(CH_2)CH_3], 145.2 (C-8), 151.2 (C-6), 152.0 (C-4), 152.1 (C-2) ppm. MS (EI): *m*/*z* (%) = 210/208 (33/100) [M^+], 193 (18), 146 (30), 119 (8). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0510.

9-(2-Methylallyl)-9*H*-purin-6-amine (10b): The title compound was prepared from chloropurine **10a** (260 mg, 1.25 mmol) as described for the synthesis of compound **2a** above the crude product was purified by flash chromatography on silica gel eluting with MeOH/

CH_2Cl_2 (1:19); yield 215 mg (91%), off-white solid, m.p. 185–188 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.67 (s, 3 H, CH_3), 4.53 (s, 1 H, H_A in =CH_2), 4.70 (s, 2 H, NCH_2), 4.86 (s, 1 H, H_B in =CH_2), 7.19 (br. s, 2 H, NH_2), 8.07 (s, 1 H, 8-H), 8.12 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 19.8 (CH_3), 47.9 (NCH_2), 111.9 (=CH_2), 118.5 (C-5), 140.9 [*C*(CH_2)CH_3], 141.0 (C-8), 149.6 (C-4), 152.5 (C-2), 156.0 (C-6) ppm. MS (EI): *m*/*z* (%) = 189 (98) [M$^+$], 188 (100), 174 (9), 161 (9), 148 (32), 135 (6). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1017.

7-(2-Methylprop-1-en-1-yl)-7*H*-purin-6-amine (11b): MeOH/CH_2Cl_2 (gradient, 1:99 to 1:16) was used for flash chromatography; yield 45 mg (90%), off-white crystals, from K_2CO_3-mediated rearrangement (Method A), m.p. 222–224 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.57 (s, 3 H, CH_3), 1.89 (s, 3 H, CH_3), 6.71 (br. s, 2 H, NH_2), 6.86 (s, 1 H, NCH=), 8.15 (8-H), 8.19 (2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 21.4 (CH_3), 21.9 (CH_3), 110.9 (C-5), 117.6 (NCH=), 138.1 [*C*(CH_3)$_2$], 145.2 (C-8), 151.7 (C-6), 152.5 (C-2), 159.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M$^+$], 174 (20), 161 (25), 148 (14), 134 (10). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1009.

6-Chloro-9-(2-methylprop-1-en-1-yl)-9*H*-purine (12a): A mixture of 6-chloro-9-(2-methylallyl)-9*H*-purine (**10a**, 50 mg, 0.24 mmol) and $Fe(CO)_5$ (32 μL, 0.24 mmol) in xylenes (1.9 mL) was heated at 138 °C under Ar. Additional $Fe(CO)_5$ (32 μL, 0.24 mmol) in xylenes (0.25 mL) was added every 6 h. After 24 h, the mixture was cooled, filtered through short silica gel pad and purified by flash chromatography on silica gel eluting with acetone-hexane (gradient, 1:49 to 1:14); yield 24 mg (48%), pale yellow powdery crystals, m.p. 100–102 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.70 (s, 3 H, CH_3), 1.98 (s, 3 H, CH_3), 6.56 (s, 1 H, NCH=), 8.05 (s, 1 H, 8-H), 8.73 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 18.2 (CH_3), 22.7 (CH_3), 114.4 (NCH=), 131.1 (C-5), 138.9 [*C*(CH_3)$_2$], 145.3 (C-8), 151.2 (C-6), 151.9 (C-4), 152.3 (C-2) ppm. MS (EI): *m*/*z* (%) = 210/208 (36/100) [M$^+$], 193 (16), 180 (30), 167 (67), 145 (52). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0508.

9-(2-Methylprop-1-en-1-yl)-9*H*-purin-6-amine (12b): MeOH/CH_2Cl_2 (gradient, 1:49 to 1:24) was used for flash chromatography; yield 82 mg (87%), off-white crystals, from *t*BuOK-mediated rearrangement (Method B), m.p. 215–217 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.66 (s, 3 H, CH_3), 1.90 (s, 3 H, CH_3), 6.60 (s, 1 H, NCH=), 7.26 (br. s, 2 H, NH_2), 8.11 (8-H), 8.12 (2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 17.4 (CH_3), 21.7 (CH_3), 115.2 (NCH=), 117.6 (C-5), 133.7 [*C*(CH_3)$_2$], 139.9 (C-8), 149.1 (C-4), 152.3 (C-2), 155.5 (C-6) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M$^+$], 174 (11), 161 (22), 148 (55). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1020.

(*E*)-7-(But-2-en-1-yl)-6-chloro-7*H*-purine (13a): The title compound was formed as a by-product in the synthesis of compound **14a**. Yield 216 mg (16%), yellow crystals, m.p. 72–74 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.73 (d, *J* = 4.8 Hz, 3 H, CH_3), 5.01–5.02 (m, 2 H, NCH_2), 5.65–5.77 (m, 2 H, =CH and CH=), 8.22 (s, 1 H, 8-H), 8.85 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 17.7 (CH_3), 49.0 (NCH_2), 122.4 (C-5), 124.4 (=CH), 132.3 (CH=), 143.1 (C-6), 148.6 (C-8), 152.4 (C-2), 162.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 210/208 (26/70) [M$^+$], 193 (19), 154 (11), 119 (11), 55 (100). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0518.

(*E*)-7-(But-2-enyl)-7*H*-purinamine (13b): The title compound was prepared from chloropurine **13a** (178 mg, 0.850 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:12); yield 162 mg (97%), off-white solid, m.p. 199–201 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.62 (d, *J* = 6.2 Hz, 3 H, CH_3), 4.96 (m, 2 H, NCH_2), 5.54–5.67 (m, 2 H, =CH and CH=), 6.80 (s, 2 H, NH_2), 8.17 (s, 1 H, 2-H), 8.22 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 16.8 (CH_3), 47.0 (NCH_2), 110.3 (C-5), 126.8 (=CH), 127.9 (CH=), 144.9 (C-8), 150.9 (C-6), 151.7 (C-2), 159.4 (C-4) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M$^+$], 174 (30), 135 (42), 108 (31). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1009.

6-Chloro-7-(3-methylbut-2-en-1-yl)-7*H*-purine (13c): The title compound was formed as a by-product in the synthesis of compound **14c**. Yield 242 mg (28%), yellow oil. The spectroscopic data were in good agreement with those reported before.[28]

7-(3-Methylbut-2-en-1-yl)-7*H*-purin-6-amine (13d): The title compound was prepared from chloropurine **13c** (172 mg, 0.77 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:19); yield 120 mg (77%), off-white solid, m.p. 191–196 °C (lit. 194 °C).[29] ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.83 (s, 6 H, 2 × CH_3), 4.89 (d, *J* = 6.3 Hz, 2 H, NCH_2), 5.40–5.44 (m, 3 H, NH_2, CH=), 7.93 (s, 1 H, 8-H), 8.44 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 18.4 (CH_3), 25.7 (CH_3), 45.8 (NCH_2), 112.1 (C-5), 119.4 (CH=), 139.6 [*C*(CH_3)$_2$], 145.1 (C-8), 150.8 (C-6), 153.2 (C-2), 161.2 (C-4) ppm. MS (EI): *m*/*z* (%) = 203 (94) [M$^+$], 188 (20), 135 (100), 108 (27), 69 (69). HRMS (EI): $C_{10}H_{13}N_5$ calcd. 203.1171, found 203.1169.

(*E*)-6-Chloro-7-cinnamyl-7*H*-purine (13e): The title compound was formed as a by-product in the synthesis of compound **14e**. Yield 282 mg (27%), yellow amorphous solid, m.p. 99–102 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.25 (d, *J* = 6.0 Hz, 2 H, NCH_2), 6.32–6.39 (m, 1 H, CH=), 6.55 (d, *J* = 16.0 Hz, =CH), 7.26–7.34 (m, 5 H, Ph) 8.30 (8-H), 8.88 (2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 49.1 (NCH_2), 122.2 (CH=) 122.4 (C-5), 126.7, 128.7, 128.8 (CH in Ph), 135.1 (=CH, C in Ph), 143.1 (C-6), 148.7 (C-8), 152.6 (C-2), 162.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 272/272 (12/35) [M$^+$], 117 (100), 115 (26), 91 (13). HRMS (EI): $C_{14}H_{11}ClN_4$ calcd. 270.0672, found 270.0667.

(*E*)-7-Cinnamyl-7*H*-purin-6-amine (13f): The title compound was prepared from chloropurine **13e** (240 mg, 0.89 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:12); yield 178 mg (80%), off-white crystals, m.p. 216–220 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 5.21 (d, *J* = 4.8 Hz, 2 H, NCH_2), 6.38–6.51 (m, 2 H, CH and CH), 6.84 (br. s, 2 H, NH_2), 7.21–7.38 (m, 5 H, Ph) 8.18 (8-H), 8.31 (2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 47.7 (NCH_2), 110.9 (C-5), 126.0 (CH=), 126.4, 127.9, 128.6 (CH in Ph), 131.4 (=CH), 135.8 (C in Ph), 145.7 (C-8), 151.4 (C-6), 152.3 (C-2), 160.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 251 (75) [M$^+$], 250 (25), 136 (9), 117 (100), 115 (38), 91 (21). HRMS (EI): $C_{14}H_{13}N_5$ calcd. 251.1171, found 251.1174.

(*E*)-9-(But-2-enyl)-6-chloro-9*H*-purine (14a): The title compound was prepared from 6-chloropurine (**1b**, 1.00 g, 6.50 mmol) and crotyl bromide (965 mg, 7.15 mmol, *E*/*Z* = 95:5) as described for the synthesis of compound **10a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:99). In order to obtain the pure *E*-isomer, the product was crystallized twice from CH_2Cl_2/hexane; yield 304 mg (22%), colorless crystals, m.p. 65–67 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.75 (dd, J_1 = 6.5, J_2 = 1.3 Hz, 3 H, CH_3), 4.82–4.84 (m, 2 H, NCH_2), 5.65–5.73 (m, 1 H, =CH), 5.80–5.89 (m, 1 H, CH=), 8.12 (s, 1 H, 8-H), 8.75 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 17.7 (CH_3), 45.9 (NCH_2), 123.7 (=CH), 131.7 (C-5), 132.5 (CH=), 144.8 (C-8), 151.0 (C-6), 151.7 (C-4), 151.9 (C-2) ppm. MS (EI): *m*/*z* (%)

= 210/208 (18/55) [M+], 193 (100), 173 (13), 167 (10), 154 (32). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0508.

(*E*)-9-(But-2-enyl)-9*H*-purinamine (14b): The title compound was prepared from chloropurine **14a** (400 mg, 1.91 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:24); yield 345 mg (95%), white powdery crystals, m.p. 163–166 °C (lit. 255–260 °C).[27] NMR spectroscopic data were in good agreement with those reported before.[27]

6-Chloro-9-(3-methylbut-2-en-1-yl)-9*H*-purine (14c): The title compound was prepared from 6-chloropurine (**1b**, 500 mg, 3.24 mmol) and 3,3-dimethylallyl bromide (0.75 mL, 6.5 mmol) as described for the synthesis of compound **10a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:99); yield 540 mg (63%), yellow solid, m.p. 51–54 °C (lit. 56–58 °C).[30] The ^{1}H NMR spectroscopic data were in good agreement with those reported before.[30]

9-(3-Methylbut-2-en-1-yl)-9*H*-purin-6-amine (14d): The title compound was prepared from chloropurine **14c** (343 mg, 1.54 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:24); yield 283 mg (91%), off-white solid, m.p. 166–168 °C (lit. 164–166 °C).[31] The ^{1}H NMR spectroscopic data were in good agreement with those reported before.[31,32]

(*E*)-6-Chloro-9-cinnamyl-9*H*-purine (14e): The title compound was prepared from 6-chloropurine (**1b**, 600 mg, 3.89 mmol) and (*E*)-(3-bromoprop-1-en-1-yl)benzene (1.53 g, 7.78 mmol) as described for the synthesis of compound **10a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:99); yield 712 mg (68%), yellow crystals, m.p. 98–103 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.09 (d, J = 6.4 Hz, 2 H, NCH_2), 6.35–6.42 (m, 1 H, CH=), 6.71 (d, J = 15.6 Hz, =CH), 7.29–7.29 (m, 5 H, Ph) 8.22 (8-H), 8.80 (2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 46.0 (NCH_2), 121.4 (CH=), 126.7, 128.6, 128.7 (CH in Ph), 131.6 (C-5), 135.2 (C in Ph), 135.6 (=CH), 144.8 (C-8), 151.1 (C-6), 151.7 (C-4), 152.1 (C-2) ppm. MS (EI): *m*/*z* (%) = 272/270 (31/86) [M+], 117 (100), 115 (62), 91 (22). HRMS (EI): $C_{14}H_{11}ClN_4$ calcd. 270.0672, found 270.0673.

(*E*)-9-Cinnamyl-9*H*-purin-6-amine (14f): The title compound was prepared from chloropurine **14e** (406 mg, 1.50 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:24); yield 326 mg (86%), off-white powdery crystals, m.p. 239–242 °C (lit. 237.3 °C).[33] The spectroscopic data were in good agreement with those reported before.[34]

7-(But-1-en-1-yl)-6-chloro-7*H*-purine (15a): MeOH/CH_2Cl_2 (gradient, 1:199 to 1:99) was used for flash chromatography; yield 28 mg (28%), yellow solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.06 (t, J = 7.5 Hz, 3 H, CH_3), 2.09–2.15 (m, 2 H, CH_2), 5.90–5.96 (m, 1 H, =CH), 6.92 (d, J = 8.6 Hz, 1 H, NCH=), 8.15 (s, 1 H, 8-H), 8.87 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 13.6 (CH_3), 20.1 (CH_2), 120.4 (NCH=), 122.6 (C-5), 134.2 (=CH), 143.7 (C-6), 148.4 (C-8), 152.7 (C-2), 161.4 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.4 Hz, 3 H, CH_3), 2.28–2.35 (m, 2 H, CH_2), 6.08–6.15 (m, 1 H, =CH), 7.19 (d, J = 13.9 Hz, 1 H, NCH=), 8.34 (s, 1 H, 8-H), 8.85 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 13.1 (CH_3), 23.1 (CH_2), 121.2 (NCH=), 122.0 (C-5), 130.6 (=CH), 143.5 (C-6), 146.6 (C-8), 152.5 (C-2), 162.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 210/208 (32/96) [M+], 193 (100), 166 (5), 157 (8), 131 (13). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0518.

7-(But-1-en-1-yl)-7*H*-purin-6-amine (15b): MeOH/CH_2Cl_2 (gradient, 1:19 to 1:13) was used for flash chromatography; yield 14 mg (20%), yellow amorphous solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.03 (t, J = 7.5 Hz, 3 H, CH_3), 2.05–2.15 (m, 2 H, CH_2), 5.45 (s, 2 H, NH_2), 6.02–6.10 (m, 1 H, =CH), 6.84 (d, J = 7.9 Hz, 1 H, NCH=), 7.85 (s, 1 H, 8-H), 8.48 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.4 (CH_3), 20.1 (CH_2), 111.6 (C-5), 121.0 (NCH=), 138.2 (=CH), 144.5 (C-8), 151.1 (C-6), 153.5 (C-2), 160.0 (C-4) ppm. ***E*-isomer:** ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.4 Hz, 3 H), 2.27–2.37 (m, 2 H, CH_2), 5.40 (s, 2 H, NH_2), 6.09–6.18 (m, 1 H, =CH), 6.93 (d, J = 13.7 Hz, 1 H, NCH=), 7.97 (s, 1 H, 8-H), 8.48 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.3 (CH_3), 23.1 (CH_2), 111.1 (C-5), 121.6 (NCH=), 134.5 (=CH), 144.1 (C-8), 150.9 (C-6), 153.4 (C-2), 160.5 (C-4) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M+], 174 (30), 160 (14), 147 (15), 135 (21). HRMS (EI): HRMS (EI) $C_9H_{11}N_5$ calcd. 189.1014, found 189.1010.

9-(But-1-en-1-yl)-6-chloro-9*H*-purine (16a): MeOH/CH_2Cl_2 (gradient, 1:399 to 1:199) was used for flash chromatography; yield 42 mg (42%), yellow amorphous solid, *E*/*Z*-mixture from Ru-mediated rearrangement (Method C).

***Z*-Isomer:** ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.08 (t, J = 7.5 Hz, 3 H, CH_3), 2.16–2.24 (m, 2 H, CH_2), 5.83–5.89 (m, 1 H, =CH), 6.78 (d, J = 8.6 Hz, 1 H, NCH=), 8.14 (s, 1 H, 8-H), 8.75 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.6 (CH_3), 20.8 (CH_2), 117.9 (NCH=), 132.0 (C-5), 132.5 (=CH), 142.7 (C-8), 151.4 (C-4), 151.9 (C-6), 152.4 (C-2) ppm. ***E*-isomer:** ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.16 (t, J = 7.5 Hz, 3 H), 2.26–2.34 (m, 2 H, CH_2), 6.47–6.54 (m, 1 H, =CH), 6.99 (d, J = 14.4 Hz, 1 H, NCH=), 8.24 (s, 1 H, 8-H), 8.75 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.3 (CH_3), 23.4 (CH_2), 119.1 (NCH=), 126.7 (=CH), 132.5 (C-5), 142.7 (C-8), 150.7 (C-4), 151.3 (C-6), 152.3 (C-2) ppm. MS (EI): *m*/*z* (%) = 210/208 (32/100) [M+], 193 (58), 181 (6), 173 (16), 167 (25), 154 (22). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0510.

(*E*)-9-(But-1-en-1-yl)-9*H*-purin-6-amine (16b): MeOH/CH_2Cl_2 (gradient, 1:49 to 1:24) was used for flash chromatography; yield 35 mg (35%), off-white powdery crystals from Ru-mediated rearrangement (Method C), m.p. 154–157 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.13 (t, J = 7.5 Hz, 3 H), 2.22–2.30 (m, 2 H, CH_2), 5.82 (s, 2 H, NH_2), 6.32–6.39 (m, 1 H, =CH), 6.94 (d, J = 14.4 Hz, 1 H, NCH=), 7.94 (s, 1 H, 8-H), 8.37 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.5 (CH_3), 23.4 (CH_2), 119.1 (NCH=), 119.9 (C-5), 124.7 (=CH), 138.1 (C-8), 149.2 (C-4), 153.3 (C-2), 155.5 (C-6) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M+], 174 (24), 148 (26), 135 (30), 108 (15). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1008.

(*E*)-9-(3-Phenylprop-1-en-1-yl)-9*H*-purin-6-amine (16f): MeOH/CH_2Cl_2 (gradient, 1:99 to 1:32) was used for flash chromatography; yield 6 mg (9%), off-white crystals from Ru-mediated rearrangement (Method C), m.p. 180–182 °C. ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.57 (dd, J_1 = 7.2, J_2 = 1.5 Hz, 2 H, CH_2-Ph), 5.64 (s, 2 H, NH_2), 6.54 (m, 1 H, =CH), 6.54 (d, J = 14.4 Hz, 1 H, NCH=), 7.22–7.34 (m, 5 H, Ph), 7.93 (8-H), 8.37 (2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 36.4 (CH_2), 119.9 (C-5), 121.2 (NCH=), 121.3 (=CH), 126.7, 128.6 and 128.7 (Ph), 138.1 (C-8), 138.8 (Ph), 149.3 (C-4), 153.4 (C-2), 155.4 (C-6) ppm. MS (EI): *m*/*z* (%) = 251 (100) [M+], 160 (9), 148 (11), 136 (43), 91 (10). HRMS (EI): $C_{14}H_{13}N_5$ calcd. 251.1171, found 251.1170.

7-(But-3-en-1-yl)-6-chloro-7*H*-purine (17a): The title compound was formed as a by-product in the synthesis of compound **18a**; yield 135 mg (16%), pale yellow solid, m.p. 86–89 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.66 (m, 2 H, CH_2), 4.53 (t, J = 6.9 Hz, 2 H, NCH_2), 5.00 (d, J = 17.7 Hz, 1 H, H_A in $=CH_2$), 5.09 (d, J = 10.7 Hz, 1 H, H_B in $=CH_2$), 5.73 (CH=), 8.17 (s, 1 H, 8-H), 8.86 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 35.7 (CH_2), 46.8 (NCH_2), 119.6 ($=CH_2$), 122.2 (C-5), 132.2 (CH=), 142.9 (C-6), 149.1 (C-8), 152.4 (C-2), 162.1 (C-4) ppm. MS (EI): *m*/*z* (%) = 210/208 (13/41) [M$^+$], 167 (100), 140 (23), 113 (7). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0510.

7-(But-3-en-1-yl)-7*H*-purin-6-amine (17b): The title compound was prepared from chloropurine **17a** (100 mg, 0.48 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:12); yield 86 mg (95%), off-white powdery crystals, m.p. 196–199 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 2.45 (m, 2 H, CH_2), 4.47 (t, J = 6.7 Hz, 2 H, NCH_2), 4.90 (d, J = 17.1 Hz, 1 H, H_A in $=CH_2$), 4.95 (d, J = 10.4 Hz, 1 H, H_B in $=CH_2$), 5.73 (CH=), 6.90 (s, 2 H, NH_2), 8.17 (s, 1 H, 2-H), 8.20 (s, 1 H, 8-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 35.7 (CH_2), 45.3 (NCH_2), 110.7 (C-5), 117.8 ($=CH_2$), 134.2 (CH=), 145.9 (C-8), 151.5 (C-6), 152.1 (C-2), 160.0 (C-4) ppm. MS (EI): *m*/*z* (%) = 189 (100) [M$^+$], 148 (99), 135 (39), 121 (61), 94 (53). HRMS (EI): $C_9H_{11}N_5$ calcd. 189.1014, found 189.1012.

6-Chloro-7-(3-methylbut-3-en-1-yl)-7*H*-purine (17c): The title compound was formed as a by-product in the synthesis of compound **18c**; yield 82 mg (9%), colorless needles, m.p. 86–88 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.79 (s, 3 H, CH_3), 2.60 (t, J = 7.1 Hz, 2 H, CH_2), 4.58 (m, 3 H, NCH_2 and H_A in $=CH_2$), 4.84 (s, 1 H, H_B in $=CH_2$), 8.16 (s, 1 H, 8-H), 8.86 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 22.3 (CH_3), 39.6 (CH_2), 45.8 (NCH_2), 114.4 ($=CH_2$), 122.2 (C-5), 139.9 (*C*=CH_2), 142.9 (C-6), 149.0 (C-8), 152.5 (C-2), 162.1 (C-4) ppm. MS (EI): *m*/*z* (%) = 224/222 (16/47) [M$^+$], 187 (8), 167 (100), 140 (24). HRMS (EI): $C_{10}H_{11}ClN_4$ calcd. 222.0672, found 222.0674.

7-(3-Methylbut-3-en-1-yl)-7*H*-purin-6-amine (17d): The title compound was prepared from chloropurine **17c** (80 mg, 0.36 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:24); yield 32 mg (44%), off-white solid, m.p. 169–170 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.71 (s, 3 H, CH_3), 2.40 (t, J = 6.7 Hz, 2 H, CH_2), 4.40 (s, 1 H, H_A in $=CH_2$), 4.52 (t, J = 6.8 Hz, 2 H, NCH_2), 4.65 (s, 1 H, H_B in $=CH_2$), 6.68 (s, 2 H, NH_2), 8.18 (s, 2 H, 8-H and 2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 21.3 (CH_3), 38.8 (CH_2), 43.8 (NCH_2), 110.1 (C-5), 112.4 ($=CH_2$), 140.7 (*C*=CH_2), 145.4 (C-8), 151.0 (C-6), 151.6 (C-2), 159.5 (C-4) ppm. MS (EI): *m*/*z* (%) = 203 (100) [M$^+$], 188 (10), 148 (85), 135 (44), 121 (54). HRMS (EI): $C_{10}H_{13}N_5$ calcd. 203.1171, found 203.1168.

9-(But-3-en-1-yl)-6-chloro-9*H*-purine (18a): The title compound was prepared from 6-chloropurine (**1b**, 600 mg, 3.89 mmol) and 4-bromobut-1-ene (0.79 mL, 7.8 mmol) as described for the synthesis of compound **10a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:99); yield 603 mg (74%), colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.66 (m, 2 H, CH_2), 4.35 (t, J = 6.8 Hz, 2 H, NCH_2), 5.03 (d, J = 17.5 Hz, 1 H, H_A in $=CH_2$), 5.07 (d, J = 10.2 Hz, 1 H, H_B in $=CH_2$), 5.75 (CH=), 8.08 (s, 1 H, 8-H), 8.74 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 33.9 (CH_2), 43.8 (NCH_2), 119.2 ($=CH_2$), 131.6 (C-5), 132.9 (CH=), 145.1 (C-8), 151.1 (C-6), 151.8 (C-4), 151.9 (C-2) ppm. MS (EI): *m*/*z* (%) = 210/208 (32/100) [M$^+$], 193 (16), 173 (41), 167 (68), 154 (88). HRMS (EI): $C_9H_9ClN_4$ calcd. 208.0516, found 208.0511.

9-(But-3-en-1-yl)-9*H*-purin-6-amine (18b): The title compound was prepared from chloropurine **18a** (150 mg, 0.72 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:25); yield 129 mg (95%), off-white solid, m.p.162–164 °C (lit. 167–169 °C).[34] NMR spectroscopic data were in good agreement with those reported before.[27,34]

6-Chloro-9-(3-methylbut-3-en-1-yl)-9*H*-purine (18c): The title compound was prepared from 6-chloropurine (**1b**, 1.00 g, 6.50 mmol) and 4-bromo-2-methylbut-1-ene[35] (7.78 mmol, 37% solution in hexane) as described for the synthesis of compound **10a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:100); yield 633 mg (73%), colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.78 (s, 3 H, CH_3), 2.61 (t, J = 7.1 Hz, 2 H, CH_2), 4.41 (t, J = 7.0 Hz, 2 H, NCH_2), 4.58 (s, 1 H, H_A in $=CH_2$), 4.78 (s, 1 H, H_B in $=CH_2$), 8.06 (s, 1 H, 8-H), 8.73 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 22.0 (CH_3), 37.7 (CH_2), 42.6 (NCH_2), 114.1 ($=CH_2$), 131.5 (C-5), 140.3 (*C*=CH_2), 145.1 (C-8), 151.0 (C-6), 151.8 (C-4), 151.9 (C-2) ppm. MS (EI): *m*/*z* (%) = 224/222 (32/100) [M$^+$], 207 (20), 187 (30), 167 (44). HRMS (EI): $C_{10}H_{11}ClN_4$ calcd. 222.0672, found 222.0668.

9-(3-Methylbut-3-en-1-yl)-9*H*-purin-6-amine (18d): The title compound was prepared from chloropurine **18c** (200 mg, 0.900 mmol) as described for the synthesis of compound **2a** above. The crude product was purified by flash chromatography on silica gel eluting with MeOH/CH_2Cl_2 (1:24); yield 180 mg (96%), off-white crystals, m.p. 169–170 °C. ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.73 (s, 3 H, CH_3), 2.54 (t, J = 7.1 Hz, 2 H, CH_2), 4.26 (t, J = 7.1 Hz, 2 H, NCH_2), 4.56 (s, 1 H, H_A in $=CH_2$), 4.68 (s, 1 H, H_B in $=CH_2$), 7.14 (s, 2 H, NH_2), 8.11 (s, 1 H, 8-H), 8.13 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, [D$_6$]DMSO): δ = 21.8 (CH_3), 37.2 (CH_2), 41.1 (NCH_2), 112.5 ($=CH_2$), 118.6 (C-5), 140.8 (C-8), 141.7 (*C*=CH_2), 149.5 (C-4), 152.3 (C-2), 155.9 (C-6) ppm. MS (EI): *m*/*z* (%) = 203 (73) [M$^+$], 188 (19), 162 (5), 148 (15), 135 (100), 108 (34). HRMS (EI): $C_{10}H_{13}N_5$ calcd. 203.1171, found 203.1166.

Supporting Information (see footnote on the first page of this article): Copies of the ^{1}H NMR and ^{13}C NMR spectra for all novel products isolated.

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