Facile Synthesis of Fluorinated 1-Desazapurines

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Dedicated to Professor Wolfgang Pfleiderer on the occasion of his 80th birthday

Abstract: A preparative approach towards 1-desazapurines, starting from 4(5)-aminoimidazoles and polyfluoroalkyl-containing 1,3-CCC-biselectrophiles was developed. As a result, a set of fluorinated 1-desazapurines was synthesized. Additionally, a synthetic route to 1-desazapurines bearing a sugar-mimicking group is proposed.

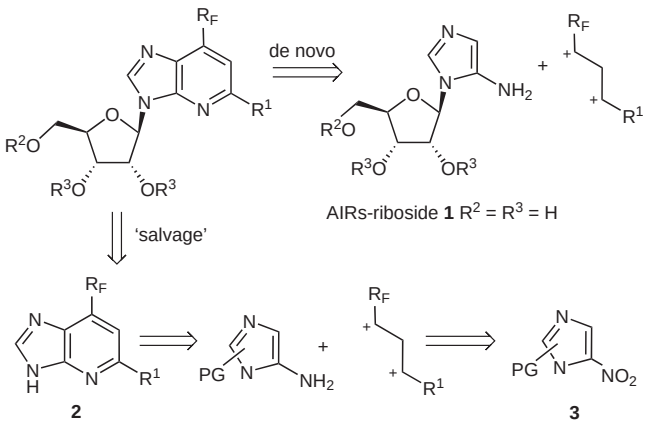
Key words: imidazoles, pyridines, annulations, fluorine, diketones, regioselectivity

Imidazo[4,5-*b*]pyridines (1-desazapurines) make up an important class of heterocyclic compounds that exhibit a wide range of biological activities and pharmacological properties.[1] Purines and desazapurines possessing fluorine-containing substituents are rare in the literature, as there are no general synthetic approaches towards them.

Fluorinated 1-desazapurines are potential phosphodiesterase inhibitors,[2] GPR4 receptor antagonists,[3a] or inhibitors of aurora kinase.[3b,c] This indicates that fluorine-containing 1-desazapurines could be promising anticancer drugs.

Fluorinated purine[4] nucleosides are attracting attention because of the high cytostatic activity of some 6-(trifluoromethyl)purine ribosides;[4a] adenosine A3 receptor antagonists[4b] indicate that the trifluoromethyl group facilitates hydration at the 6-position of the purine ring, and that the adducts forming at the 6-position might mimic the transition state of adenosine hydrolytic deamination.[4c]

Nature synthesizes purine nucleotides by two general strategies: the first is a 'de novo' approach,[5] via multistep nucleobase elaboration of 5-phospho-D-ribosylamine, and the second is a base 'salvage' strategy (Scheme 1).[5a,b,6] The de novo synthetic pathway has unique linear solutions to the biosynthesis of various natural purines. However, the salvage pathway shares a common approach with the de novo one, namely the catalyzed addition of nucleobases to anomerically activated ribose. By modification of the known natural synthetic access, a potent pathway for assembling diverse fluorinated purine or 1-desazapurine nucleosides could be developed.



Scheme 1 Retrosynthetic analysis

Taking into account the low chemical stability of the commercially unavailable AIRs-riboside **1**[7] (see Scheme 1), the de novo pathway to fluorinated purines and 1-desazapurines is precluded as a method for their assembly. However, the salvage nucleoside synthetic pathway has found broad application in the laboratory.

4(5)-Aminoimidazoles are potent starting materials for the synthesis of purines and 1-desazapurines, but data on the properties and synthetic potential of these amino-substituted heterocycles are very rare.[8] During the course of pyridine and pyrimidine annulation studies involving cyclocondensation with aminoheterocycles,[9] we have investigated the formation of fluorine-substituent-containing 1-desazapurines by the coupling of various fluorine-substituent-containing 1,3-CCC-biselectrophiles **4**–**10** (Figure 1) with 4(5)-aminoimidazoles.

The limited chemical utility of 4(5)-aminoimidazoles could be explained by their low stability and high reactivity; therefore, synthetic work with these compounds is a challenge.[10a] However, a few methods have been developed recently, allowing the preparation of 4(5)-aminoimidazoles on large scale, and these we have used in our

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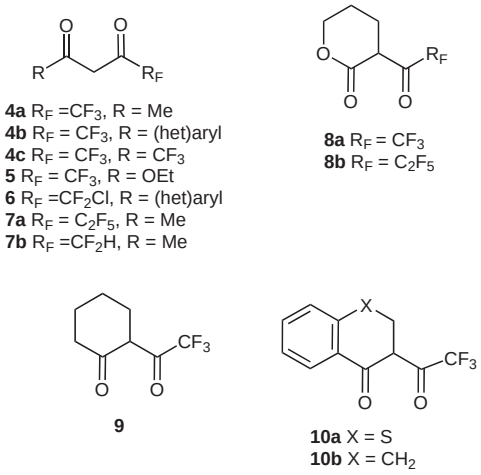
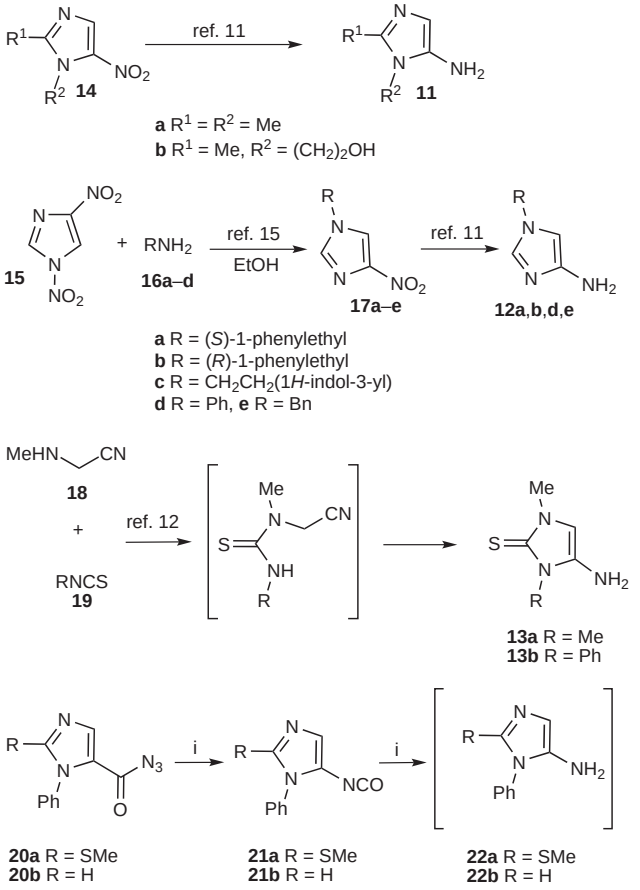


Figure 1 Variety of 1,3-CCC-biselectrophiles used for constructing imidazo[4,5-*b*]pyridines

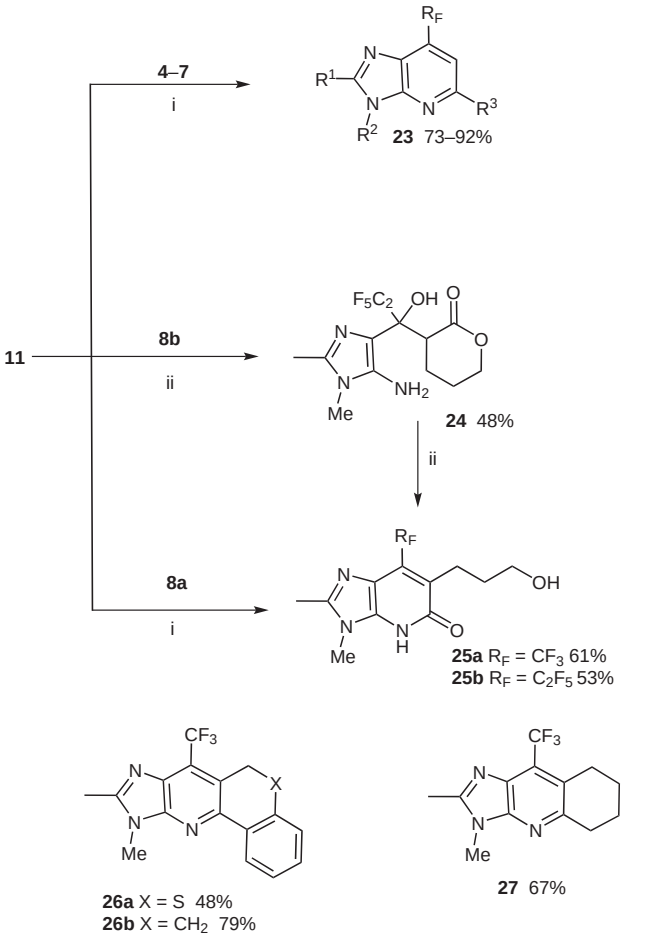
current work (Scheme 2). One of these methods is based on the catalytic reduction of the corresponding nitro derivatives on palladium-on-carbon,[10] and another proceeds via intermolecular interaction of amino and cyano groups.[11] Yet another approach elaborated in our laboratory is based on the Curtius rearrangement, with subsequent hydrolysis of the formed isocyanates under acidic conditions. This novel procedure for the generation of 4(5)-aminoimidazoles in situ was successfully used by us for the generation of 2-aminobenzofuran.[9b]



Scheme 2 *Reagents and conditions*: (i) DMF–AcOH, 140 °C.

4-Nitroimidazoles **17** can be synthesized easily by two convenient methods, either by the basic alkylation of N-unsubstituted 4(5)-nitroimidazole,[12] or by the reaction of 1,4-dinitro-1*H*-imidazole **15** with aliphatic or aromatic amines **16** (Scheme 2).[13] First, we investigated the interaction between aminoimidazole **11a** (obtained by reduction) and diketones **4**–**7** (Scheme 3). Aminoimidazoles **11** appeared to be unstable in acetic acid media, and sensitive to oxygen; the destruction of the initial aminoheterocycles proceeds as fast as the corresponding cycloaddition, thereby reducing the overall yields.

To prevent the side reactions leading to aminoimidazole destruction, we used Schlenk techniques, and conducted the reactions under inert atmosphere in anhydrous solvents. It was found that the optimal conditions for the cyclization consisted of refluxing imidazoles **11** with fluorinated 1,3-diones **4**–**7** in dichloromethane under an argon atmosphere; this afforded imidazo[4,5-*b*]pyridines **23** as the sole products in 73–92% yields (Scheme 3, Table 1). The structures of the obtained fused pyridines **23** were confirmed by spectral criteria described by us previously.[9b,f] Significant evidence for the γ-CF_3 isomeric structure is provided by the chemical shifts of the CF_3 group (^{19}F NMR: δ = –62) and that of C7 (^{13}C NMR: δ ~ 130, $^2J_{CF}$ ~ 30 Hz).



Scheme 3 *Reagents and conditions*: (i) CH_2Cl_2, reflux; (ii) MeOH, acid cat., reflux.

Table 1 Yields of Imidazo[4,5-*b*]pyridines **23**

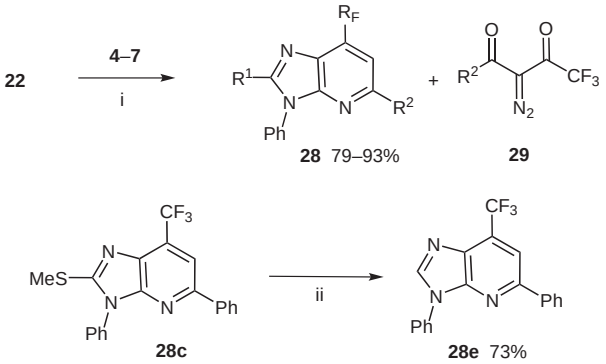
23	R^1	R^2	R^3	R_F	Yield (%)
23a	Me	Me	CF_3	CF_3	89
23b	Me	Me	Ph	CF_3	92
23c	Me	Me	*p*-$(F_2HCO)C_6H_4$	CF_3	73
23d	Me	Me	Ph	CF_2Cl	84
23e	Me	$(CH_2)_2OH$	Ph	CF_3	87

Acylated δ-valerolactones **8** react with **11a** depending on the reaction conditions (Scheme 3). Under neutral conditions in dichloromethane, the main product is compound **24**; under acidic conditions, cycloaddition occurs and the reaction delivers the corresponding imidazo[4,5-*b*]pyridines **25**.

The reactions of 1,3-diketones **9** and **10** with aminoimidazole **11** yield polycyclic imidazopyridines **26** and **27**. The fused imidazopyridine **26** is an unknown heterocyclic system. In this case, methanol was used as solvent instead of dichloromethane, and *p*-toluenesulfonic acid was used as the acid catalyst (Scheme 3).

For the generation of aminoimidazoles **22** in situ from acyl azides **20** by Curtius rearrangement, acetic acid provided the best reaction conditions (Scheme 2). However, aminoimidazoles **22** are very unstable under these conditions, and decompose so fast that attempts to isolate pure compounds as the free base or salt failed. However, when the Curtius rearrangement is carried out in the presence of excess diones **4**–**7** and water, dezazapurines **28** form (Scheme 4). The most convenient procedure for the transformation appears to be slow addition of an *N*,*N*-dimethylformamide solution of azide **20** and building blocks **4**–**7** in a 1:3 ratio to a boiling acetic acid–water (25:1) mixture, followed by workup. In this case, compounds **28** formed in 73–93% yields. Side products **29** were seen in the ^{19}F NMR spectra of the reaction mixture. The spectral data of compounds **28** thus obtained have similarities to those of compounds **23**, thus confirming their structure. It should be noted that the methylsulfanyl group in **28b** can be removed by treatment with freshly prepared Raney nickel in ethanol (Scheme 4, Table 2).

Aminoheterocycles **13** are less reactive, and, as a result, more stable. Thus, cyclization to form imidazo[4,5-*b*]pyridines **30** and **31** can be carried out in acetic acid. However, to optimize the yields, the reaction was performed in absolute ethanol under reflux for four to five hours in an inert atmosphere in the presence of a catalytic amount of *p*-toluenesulfonic acid. According to GC-MS and ^{19}F NMR spectroscopy, the reactions proceeded regioselectively, producing only the γ-CF_3 isomers in 79–89% yields (Scheme 5, Table 3). The most convincing evidence for the formation of structures **30** is the presence of long-range coupling ($^6J_{HF} \sim 2$ Hz, $^5J_{CF} \sim 5$ Hz) between the methyl group in the 1-position and the fluorine of the trifluoromethyl group on the 7-position of the ring.

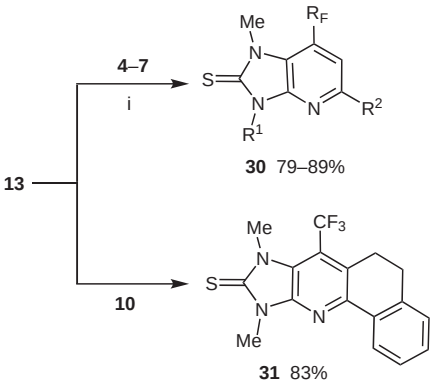


Scheme 4 *Reagents and conditions*: (i) DMF–AcOH, 140 °C; (ii) Raney Ni, EtOH, 2 h.

Table 2 Yields of Imidazo[4,5-*b*]pyridines **28**

28	R^1	R^2	R_F	Yield (%)
28a	SMe	CF_3	CF_3	88
28b	SMe	Me	CF_3	93
28c	SMe	Ph	CF_3	89
28d	SMe	Me	CF_2H	87
28e	H	Ph	CF_3	79 73[a]
28f	H	2-thienyl	CF_3	82
28g	H	OH	CF_3	89
28h	H	Ph	CF_2Cl	85
28i	H	2-thienyl	CF_2Cl	90

[a] Yield of **28e** from **28c**.



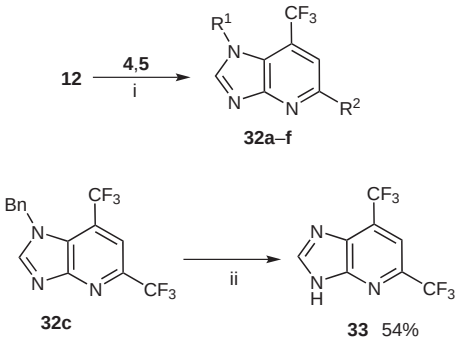
Scheme 5 *Reagents and conditions*: (i) MeOH, PTSA, reflux, 2–3 h.

The use of 4-aminoimidazoles **12** was also attempted (Scheme 6). This isomer is unstable and earlier was used only in situ as a 1,4-dioxane solution after reduction of the corresponding nitro derivatives. We found that the fast evaporation of 1,4-dioxane in vacuo without heating allowed us to obtain compounds **12** in pure form. Imidazoles **12** should be used immediately for further

Table 3 Yields of Imidazo[4,5-*b*]pyridines **30**

30	R^1	R^2	R_F	Yield (%)
30a	Me	Me	CF_3	84
30b	Me	Ph	CF_3	89
30c	Ph	CF_3	CF_3	87
30d	Ph	Me	CF_2H	79
30e	Ph	Me	C_2F_5	81

transformations. Thus the reactions of **12** with diones **4** and **5** in ethanol in the presence of *p*-toluenesulfonic acid afford the corresponding imidazo[4,5-*b*]pyridines **32** in 43–70% yields. Acetic acid can also be used as solvent in the reaction, but then more side product forms. NMR spectra of these compounds have spectral patterns similar to those of compound **23** and **28**. In this case, the presence of long-range coupling (e.g., $^5J_{CF}$ ~ 5 Hz for **32e**,**f**) between the groups in the 1-position and the trifluoromethyl group is evidence for γ-CF_3 isomer formation (Scheme 6, Table 4).



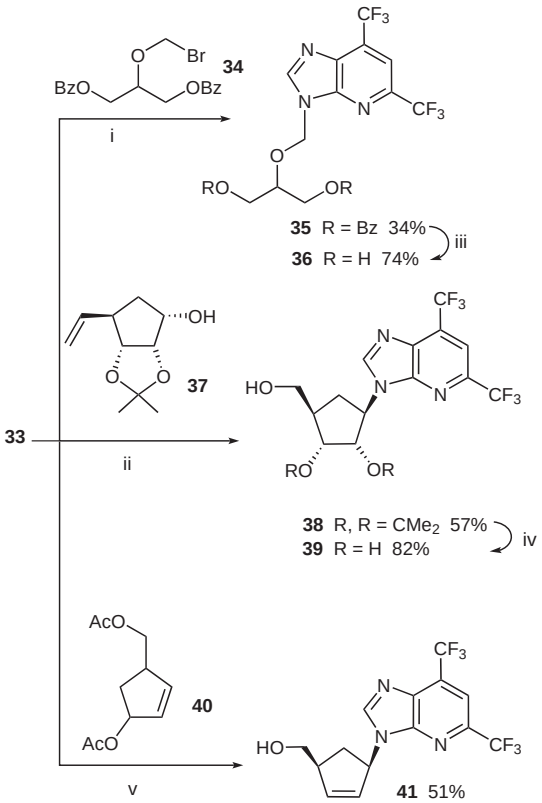
Scheme 6 *Reagents and conditions*: (i) MeOH, acid cat., reflux; (ii) H_2, Pd/C, MeOH, 2 h.

Table 4 Yields of Imidazo[4,5-*b*]pyridines **32**

32	R^1	R^2	Yield (%)
32a	Ph	Me	70
32b	Ph	2-thienyl	67
32c	Bn	CF_3	69
32d	Bn	OH	51
32e	(*S*)-1-phenylethyl	CF_3	49
32f	(*R*)-1-phenylethyl	CF_3	43

The benzyl group was specially introduced into **32c** as a protecting group (Scheme 6) at the 4-nitroimidazole stage, with the purpose of subsequent cleavage at the 1-desazapurines stage. The protecting group was removed by hydrogenation over palladium on carbon in PARR apparatus. The substitution pattern in 5,7-bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (**33**) is convenient for subsequent glycosylation with the purpose to synthesize the corresponding fluorinated 1-desazapurine nucleosides and nucleoside mimetics (Scheme 6).

To demonstrate the suitability of 1-desazapurines for nucleoside synthesis, we studied the reaction of **33** with the acyclic sugar mimetic 2-(bromomethoxy)propane-1,3-diyl dibenzoate (**34**),[14] compound **37**,[15] and (4-acetoxycyclopent-2-enyl)methyl acetate (**40**),[16] with the purpose to develop a preparative synthetic pathway towards 1-desazapurine carbanucleosides and nucleoside mimetics (Scheme 7).



Scheme 7 *Reagents and conditions*: (i) NaH, MeCN; (ii) 1. DIAD, Ph_3P, THF; 2. $NaIO_4$, OsO_4, MeOH–H_2O; 3. $NaBH_4$, MeOH; (iii) NH_3, MeOH, r.t., 4 h; (iv) TFA–H_2O (9:1); (v) $Pd(PPh_3)_4$, NaH, DMF, then MeOH.

The alkylation of **33** with **34** was performed by the generally described method[17] for nitropyrrole alkylation; it was conducted with sodium hydride in anhydrous acetonitrile to produce the precursor ester derivatives **35**. Deprotection of the sugar mimetic group was carried out by treatment of **35** with a solution of ammonia in methanol (Scheme 7).[17] Compound **36** can be considered as an analogue of ganciclovir,[18] a potent HBV inhibitor, both in cell culture against duck-HBV (DHBV) and in animal models.

The building blocks **37** and **40** were recently used for the synthesis of the two well-known biologically active molecules aristeromycin[19] and carbovir,[20] respectively. Subjecting **37** to a Mitsunobu reaction, according to a previously described method,[15] with 1-desazapurines **33**, followed by a two-step, one-pot sequence consisting of

oxidative cleavage of the double bond with osmium tetroxide/sodium periodate, followed by sodium borohydride reduction provided **38** in 57% yield (Scheme 7). The deprotection of **38** was carried out in a trifluoroacetic acid–water mixture (9:1).[9g] Stereoselective palladium-catalyzed alkylation[16] of **33** by **40** gave **41**. The reaction proceeds smoothly, leading to the formation of only the *cis*-isomer of **41** in a 51% yield (Scheme 7).

The formation of the 9-isomer was confirmed by ^{1}H, ^{13}C, and ^{19}F NMR spectroscopy. Additionally, the through-space coupling between the carbon nuclei in the 9-position and the CF_3 group in the 6-position typical for the 7-isomers was not observed for **36**, **39**, and **41** (Scheme 7). The main evidence for the presence of a sugar-mimicking group in the 9-position of the 1-desazapurine framework was provided by 2D NMR spectral correlation. The HMBC spectra of compound **35** show a long-range interaction between carbon C-7a at δ = 161 in the 1-desazapurine skeleton with the protons at δ = 6.01 of the OCH_2 fragment of the (methoxy)propane-1,3-diyl moiety (Figure 2). In compound **38**, carbon C-7a correlated in the HMBC spectrum with the anomeric proton at δ = 4.85–4.91 in position 6 of the cyclopentane-1,2,3-triol group (Figure 2).

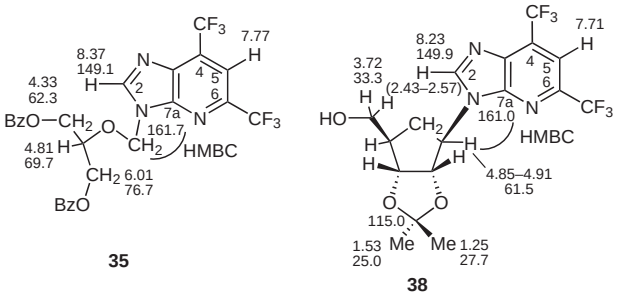


Figure 2 Significant NMR data of compounds **35** and **38**

In summary, reactions of 4(5)-aminoimidazoles **11**, **12**, **13**, and **22** with fluorine-substituent-containing 1,3-CCC-biselectrophiles **4**–**10** were investigated. A convenient synthetic approach towards 1-desazapurines substituted at the 6-position by fluorine-containing groups was elaborated. The simple synthetic procedures and satisfying yields make these methods promising and very attractive for the synthesis of various substituted 1-desazapurines, useful scaffolds for organic and medicinal chemistry. Experiments to study the glycosylation reactions of 3*H*-imidazo[4,5-*b*]pyridines, obtained in much the same way as **33**, with the purpose to obtain corresponding nucleosides, desoxynucleosides, and their mimetics, are currently underway in our laboratory.

All solvents were purified and dried by standard methods. NMR spectra were recorded on Jeol JNM-LA 400, Varian VXR-300, Varian Mercury-400, and Bruker 600 spectrometers. TMS was used as an internal standard for ^{1}H and ^{13}C NMR spectroscopy, and $CFCl_3$ was used for ^{19}F NMR spectroscopy. IR spectra were recorded on a Perkin Elmer FT IR 1600 spectrometer for samples prepared as KBr discs. Mass spectra were obtained on a Hewlett-Packard HPGC/MS 5890/5972 instrument (EI, 70 eV) for which a GC inlet was used, or on a MX-1321 instrument (EI, 70 eV) with a direct inlet. Column chromatography was performed on silica gel (63–200 mesh, Merck). Silica gel plates (Merck $60F_{254}$) were used for TLC. 1-Substituted 4-nitro-1*H*-imidazoles **17** were obtained,[15] and 4(5)-nitroimidazoles were reduced[12] according to published procedures. Fluorinated 1,3-dicarbonyl compounds were obtained by Claisen-type condensation of the appropriate carbonyl compounds with the corresponding fluorinated acid esters in the presence of NaOMe or LiH.[21] The corresponding imidazole-5-carbonyl chloride used for the preparation of acyl azides **20** was obtained from the corresponding acids.[22] Compounds **35**,[14] **38**,[15] and **41**[16] were prepared according to published procedures.

4(5)-Aminoimidazoles 11, 12, and 13; General Procedure

The appropriate nitroimidazole (0.1 mol) and 10% Pd/C (2 g) were placed in a 2-L one-necked round-bottomed Schlenk flask under a flow of anhyd argon. Anhyd, degassed 1,4-dioxane (1300 mL) was added. The hydrogenation was conducted with the aid of a big glass burette under atmospheric pressure. After the H_2 (3 equiv) had been absorbed (ca. 12–16 h), the reaction mixture was filtered through a Kieselgur pad (3–5 cm thick). The kieselguhr was washed a few times with 1,4-dioxane. The solvent was removed under reduced pressure (the temperature of the water bath should not rise above 40 °C) and the residue was dried under reduced pressure over 2 d. The thus formed aminoimidazoles (**11a**, dark yellow residue; **11b**, **13**, orange oils) are not stable and extremely sensitive to heat and O_2. However, they could be stored in a sealed flask under an argon atmosphere at –25 °C for at least 1 month. With time, the material becomes darker. All subsequent manipulations with these compounds were conducted under an inert atmosphere; the starting material was transferred in a glovebox in an anhyd and inert atmosphere. Reactions were carried out in anhyd solvents, since the commercially available aminoimidazoles have been described to be hydrolytically unstable.

1,2-Dimethyl-1*H*-imidazol-5-amine (11a)

Yellow solid.

^{1}H NMR ($CDCl_3$): δ = 2.21 (s, CH_3), 3.3 (s, NCH_3), 4.51 (br s, NH_2), 6.21 (s, CH).

2-(5-Amino-2-methyl-1*H*-imidazol-1-yl)ethanol (11b)

Orange oil.

^{1}H NMR ($CDCl_3$): δ = 2.25 (s, 3 H, CH_3), 3.58 (t, $^{3}J_{HH}$ = 7.4 Hz, 2 H, CH_2), 3.71 (t, $^{3}J_{HH}$ = 7.4 Hz, 2 H, CH_2), 4.51 (br s, 2 H, NH_2), 6.23 (s, 1 H, CH).

1-[(*S*)-1-Phenylethyl]-1*H*-imidazol-4-amine (12a)

Orange oil.

^{1}H NMR ($CDCl_3$): δ = 1.69 (d, $^{3}J_{HH}$ = 6.8 Hz, 3 H, CH_3), 4.73 (br s, 2 H, NH_2), 5.09 (q, $^{3}J_{HH}$ = 6.8 Hz, 1 H, CH), 6.40 (br s, 1 H, CH), 7.25 (br s, 1 H, CH), 7.33 (br m, 2 H, CH), 7.41 (br m, 3 H, CH).

1-[(*R*)-1-Phenylethyl]-1*H*-imidazol-4-amine (12b)

Orange oil.

^{1}H NMR ($CDCl_3$): δ = 1.64 (d, $^{3}J_{HH}$ = 6.8 Hz, 3 H, CH_3), 4.73 (br s, 2 H, NH_2), 5.03 (q, $^{3}J_{HH}$ = 6.8 Hz, 1 H, CH), 6.40 (br s, 1 H, CH), 7.25 (br s, 1 H, CH), 7.35 (br m, 2 H, CH), 7.40 (br m, 3 H, CH).

1-Phenyl-1*H*-imidazol-4-amine (12d)

Orange oil.

^{1}H NMR ($CDCl_3$): δ = 5.01 (br s, 2 H, NH_2), 6.59 (br s, 1 H, CH), 7.30 (br m, 3 H, CH), 7.43 (br m, 2 H, CH), 7.55 (br s, 1 H, CH).

1-Benzyl-1*H*-imidazol-4-amine (12e)
Orange oil.

^{1}H NMR ($CDCl_3$): δ = 4.73 (br s, 2 H, NH_2), 4.81 (s, 2 H, CH_2), 6.33 (br s, 1 H, CH), 7.22 (br s, 1 H, CH), 7.29 (br m, 2 H, CH), 7.38 (br m, 3 H, CH).

4-Nitro-1-[(*S*)-1-phenylethyl]-1*H*-imidazole (17a)
Yellow oil; yield: 4.52 g (52%); R_f = 0.75 (EtOAc).

^{1}H NMR ($CDCl_3$): δ = 1.80 (d, $^3J_{HH}$ = 7.0 Hz, 3 H, CH_2), 5.37 (q, $^3J_{HH}$ = 7.0 Hz, 1 H, CH), 7.16 (m, 2 H, CH), 7.33 (m, 3 H, CH), 7.45 (d, $^4J_{HH}$ = 1.6 Hz, 1 H, CH), 7.71 (d, $^4J_{HH}$ = 1.6 Hz, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 21.6, 58.2, 118.3, 126.2, 129.0, 129.4, 135.0, 139.0, 142.3.

MS (EI, 70 eV): *m*/*z* (%) = 217 [M^+ – 1] (7), 105 (100), 79 (10), 77 (12).

4-Nitro-1-[(*R*)-1-phenylethyl]-1*H*-imidazole (17b)
Yellow oil; yield: 4.78 g (55%); R_f = 0.75 (EtOAc).

^{1}H NMR ($CDCl_3$): δ = 1.82 (d, $^3J_{HH}$ = 7.0 Hz, 3 H, CH_2), 5.35 (q, $^3J_{HH}$ = 7.0 Hz, 1 H, CH), 7.17 (m, 2 H, CH), 7.34 (m, 3 H, CH), 7.46 (d, $^4J_{HH}$ = 1.6 Hz, 1 H, CH), 7.73 (d, $^4J_{HH}$ = 1.6 Hz, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 21.6, 58.4, 118.1, 126.1, 129.2, 129.5, 135.1, 139.0, 142.3.

MS (EI, 70 eV): *m*/*z* (%) = 217 [M^+ – 1] (7), 105 (100), 79 (10), 77 (12).

3-[2-(4-Nitro-1*H*-imidazol-1-yl)ethyl]-1*H*-indole (17c)
Colorless solid; yield: 6.15 g (60%); mp 185–186 °C (MeOH).

^{1}H NMR (DMSO-d_6): δ = 3.21 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, CH_2), 4.36 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, NCH_2), 6.98 (t, $^3J_{HH}$ = 7.2 Hz, 1 H, CH), 7.07 (m, 2 H, CH), 7.35 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.58 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.76 (s, 1 H, CH), 8.42 (s, 1 H, CH), 10.90 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 26.3, 48.0, 109.8, 111.5, 118.3, 118.5, 121.2, 121.7, 123.3, 126.9, 136.2, 137.4, 146.8.

MS (EI, 70 eV): *m*/*z* (%) = 256 [M^+] (56), 255 (13), 130 (100), 126 (33).

Acyl Azides 20a,b; General Procedure
The appropriate imidazole-5-carbonyl chloride (10 mmol) was dissolved in anhyd DMF (20 mL) and added dropwise to a suspension of NaN_3 (1.3 g, 20 mmol) in anhyd DMF (10 mL). After addition was completed, the mixture was left overnight, and poured into H_2O (400 mL). The precipitate that formed was filtered, washed with H_2O (2×), and dried under reduced pressure. These two azides **20a**,**b** are stable and can be stored for a long time in the refrigerator at –20 °C.

2-(Methylsulfanyl)-3-phenyl-3*H*-imidazole-4-carbonyl Azide (20a)
Pale yellow solid; yield: 2.33 g (90%); mp 207 °C (dec.).

^{1}H NMR ($CDCl_3$): δ = 2.56 (s, 3 H, CH), 7.19 (m, 2 H, CH), 7.45 (m, 3 H, CH), 7.81 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 14.3, 126.4, 127.0, 129.2, 129.6, 135.1, 139.6, 154.4, 162.3.

3-Phenyl-3*H*-imidazole-4-carbonyl Azide (20b)
Pale yellow solid; yield: 1.81 g (85%); mp 200 °C (dec.).

^{1}H NMR ($CDCl_3$): δ = 7.25 (m, 2 H, CH), 7.60 (m, 3 H, CH), 7.75 (s, 1 H, CH), 8.51 (s, 1 H, CH).

Imidazo[4,5-*b*]pyridines 23 and 24 from 5-Aminoimidazole 11 and Fluorine-Containing 1,3-Diketones; General Procedure
A mixture of the appropriate aminoimidazole **11** (2 mmol) and diketone (2.2 mmol) was heated under reflux in CH_2Cl_2 (25 mL) in an inert atmosphere for 6–10 h. Afterwards the solvent was evaporated under reduced pressure, and the crude material that had formed was recrystallized from an appropriate solvent, or subjected to column chromatography (silica gel).

2,3-Dimethyl-5,7-bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (23a)
Colorless solid; yield: 0.5 g (89%); mp 57–59 °C; R_f = 0.65 (EtOAc).

^{1}H NMR ($CDCl_3$): δ = 2.67 (s, 3 H, 2-CH_3), 3.84 (s, 3 H, 3-CH_3), 7.71 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 14.5, 29.0, 114.7 (m), 122.5 (q, $^1J_{CF}$ = 275 Hz), 122.7 (q, $^1J_{CF}$ = 275 Hz), 127.3 (q, $^2J_{CF}$ = 35 Hz), 133.0, 141.1 (q, $^2J_{CF}$ = 35 Hz), 149.5, 159.1.

MS (EI, 70 eV): *m*/*z* (%) = 284 [M^+ + 1] (12), 283 [M^+] (100), 282 (19), 268 (24), 264 (15), 262 (11), 215 (20), 195 (18).

2,3-Dimethyl-5-phenyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (23b)
Colorless solid; yield: 0.54 g (92%); mp 179–180 °C (EtOH).

^{1}H NMR (DMSO-d_6): δ = 2.61 (s, 3 H, 2-CH_3), 3.78 (s, 3 H, 3-CH_3), 7.16 (t, $^3J_{HH}$ = 4.2 Hz, 1 H, CH), 7.66 (d, $^3J_{HH}$ = 4.2 Hz, 1 H), 7.95–8.00 (br m, 2 H, CH).

^{13}C NMR (DMSO-d_6): δ = 14.2, 28.3, 109.4 (q, $^3J_{CF}$ = 4.4 Hz), 122.6 (q, $^1J_{CF}$ = 285 Hz), 127.4, 129.7, 126.3 (q, $^2J_{CF}$ = 35 Hz), 138.0, 150.9, 151.7, 158.0.

MS (EI, 70 eV): *m*/*z* (%) = 292 [M^+ + 1] (20), 291 [M^+] (100), 290 (16), 276 (13), 154 (10).

5-[4-(Difluoromethoxy)phenyl]-2,3-dimethyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (23c)
Colorless solid; yield: 0.52 g (73%); mp 168–170 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 2.64 (s, 3 H, 2-CH_3), 3.83 (s, 3 H, 1-CH_3), 7.29 (d, $^3J_{HH}$ = 8.4 Hz, 1 H, CH), 7.35 (t, $^3J_{HF}$ = 73.8 Hz, 1 H, $OCHF_2$), 8.02 (s, 1 H, CH), 8.28 (d, $^3J_{HH}$ = 8.4 Hz, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 14.2, 28.6, 109.9 (q, $^3J_{CF}$ = 4 Hz), 116.3 (t, $^1J_{CF}$ = 256 Hz), 118.8, 122.9 (q, $^1J_{CF}$ = 275 Hz), 125.4 (q, $^2J_{CF}$ = 33 Hz), 128.5, 129.5 (q, $^3J_{CF}$ = 1.6 Hz), 134.8, 148.8, 149.7, 151.7 (t, $^3J_{CF}$ = 3.2 Hz), 157.4.

^{19}F NMR (DMSO-d_6): δ = –60.1 (s), –82.3 (t, $^3J_{HF}$ = 73.8 Hz).

MS (EI, 70 eV): *m*/*z* (%) = 358 [M^+ + 1] (19), 357 [M^+] (100), 307 (27), 306 (17), 278 (10).

7-(Chlorodifluoromethyl)-2,3-dimethyl-5-phenyl-3*H*-imidazo[4,5-*b*]pyridine (23d)
Colorless solid; yield: 0.52 g (0.84%); mp 135–138 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 2.69 (s, 3 H, 2-CH_3), 3.86 (s, 3 H, 1-CH_3), 7.38–7.49 (br m, 3 H, CH), 7.80 (s, 1 H, CH), 8.00 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH_2).

^{13}C NMR ($CDCl_3$): δ = 14.2, 28.6, 110.0 (t, $^3J_{CF}$ = 5.6 Hz), 124.6 (t, $^1J_{CF}$ = 285 Hz), 127.1, 129.1, 132.9 (t, $^2J_{CF}$ = 27 Hz), 138.8, 150.2, 151.4, 155.7.

MS (EI, 70 eV): *m*/*z* (%) = 309 [M^+ + 2] (33), 308 [M^+ + 1] (18), 307 [M^+] (89), 273 (24), 272 (100), 136 (18).

2-[2-Methyl-5-phenyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]ethanol (23e)
Colorless solid; yield: 0.56 g (87%); mp 158–159 °C; R_f = 0.40 (EtOAc–hexane, 1:2).

^{1}H NMR ($CDCl_3$): δ = 2.67 (s, 3 H, 2-CH_3), 3.71 (br s, 1 H, OH), 4.06 (t, $^3J_{HH}$ = 4.8 Hz, 2 H, CH_2), 4.40 (t, $^3J_{HH}$ = 4.8 Hz, 2 H, CH_2), 7.35–7.45 (br m, 3 H, CH), 7.77 (s, 1 H, CH), 7.94 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH_2).

^{13}C NMR ($CDCl_3$): δ = 14.3, 45.9, 60.7, 111.0 (q, $^3J_{CF}$ = 4 Hz), 122.5 (q, $^1J_{CF}$ = 275 Hz), 126.4, 127.1 (q, $^2J_{CF}$ = 33 Hz), 128.3, 128.6, 129.3 (q, $^3J_{CF}$ = 1.6 Hz), 137.7, 149.1, 150.9, 155.8.

^{19}F NMR ($CDCl_3$): δ = –62.1.

MS (EI, 70 eV): *m*/*z* (%) = 322 [M^+ + 1] (10), 321 [M^+] (100), 291 (16), 290 (12), 278 (18), 277 (100), 276 (33), 270 (13).

3-[1-(5-Amino-1,2-dimethyl-1*H*-imidazol-4-yl)-2,2,3,3,3-pentafluoro-1-hydroxypropyl]tetrahydro-2*H*-pyran-2-one (24)
Colorless solid; yield: 0.34 g (48%); mp 95–97 °C; R_f = 0.45 (EtOAc).

^{1}H NMR (DMSO-d_6): δ = 1.61–1.70 (m, 4 H, CH), 2.65 (s, 3 H, 2-CH_3), 3.35 (m, 1 H, CH), 3.82 (s, 3 H, 1-CH_3), 4.18 (m, 2 H, CH), 6.25 (br m, 3 H, NH_2+OH).

^{13}C NMR ($CDCl_3$): δ = 13.5, 22.3, 24.4, 28.1, 43.2, 68.3, 72.1 (t, $^2J_{CF}$ = 29 Hz), 135.3, 139.7, 149.9, 175.4.

MS (EI, 70 eV): *m*/*z* (%) = 357 [M^+] (31), 351 (19), 341 (29), 327 (53), 258 (15), 257 (100), 239 (25), 96 (70).

1-Desazopurines 25, 26, 28, 30, and 31; General Procedure
A mixture of the appropriate aminoimidazole (2 mmol) and diketone (2.2 mmol) in absolute MeOH (20 mL) with a catalytic amount of PTSA was heated under reflux under an inert atmosphere for 2–3 h. The solvent was evaporated under reduced pressure. The material that had formed was recrystallized from an appropriate solvent, or was subjected to column chromatography (silica gel).

6-(3-Hydroxypropyl)-2,3-dimethyl-7-(trifluoromethyl)-3,4-dihydro-5*H*-imidazo[4,5-*b*]pyridin-5-one (25a)
Colorless solid; yield: 0.35 g (61%); mp 157–158 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 1.69 (br m, 2 H, CH), 2.69 (s, 3 H, 2-CH_3), 2.85 (t, 2 H, $^2J_{HH}$ = 5.6 Hz), 3.78 (s, 3 H, 1-CH_3), 4.07 (t, 2 H, $^2J_{HH}$ = 6.4 Hz), 4.38 (br s, 1 H, OH), 12.04 (br s, 1 H, NH).

^{13}C NMR (DMSO-d_6): δ = 14.7, 28.2, 29.4, 31.0, 59.9, 123.1 (q, $^2J_{CF}$ = 275 Hz), 132.0, (q, $^2J_{CF}$ = 33 Hz), 130.1, 139.3, 141.0, 154.0, 165.8.

MS (EI, 70 eV): *m*/*z* (%) = 290 [M^+ + 1] (11), 289 [M^+] (11), 271 (17), 266 (18), 178 (100), 43 (35).

6-(3-Hydroxypropyl)-2,3-dimethyl-7-(pentafluoroethyl)-3,4-dihydro-5*H*-imidazo[4,5-*b*]pyridin-5-one (25b)
Colorless solid; yield: 0.36 g (53%); mp 139–142 °C; R_f = 0.20 (EtOAc).

^{1}H NMR (DMSO-d_6): δ = 1.68 (br m, 2 H, CH), 2.61 (s, 3 H, 2-CH_3), 2.89 (t, 2 H, $^2J_{HH}$ = 5.6 Hz), 3.80 (s, 3 H, 1-CH_3), 4.09 (t, 2 H, $^2J_{HH}$ = 6.4 Hz), 4.55 (br s, 1 H, OH), 11.43 (br s, 1 H, NH).

^{13}C NMR (DMSO-d_6): δ = 14.4, 28.1, 29.9, 31.3, 59.7, 129.3, (t, $^2J_{CF}$ = 28 Hz), 130.1, 139.3, 141.0, 154.0, 165.8.

MS (EI, 70 eV): *m*/*z* (%) = 339 [M^+] (30), 321 (48), 247 (39), 211 (100), 123 (17).

9,10-Dimethyl-7-(trifluoromethyl)-6*H*,10*H*-5-thia-8,10,11-triaza-cyclopenta[*b*]phenanthrene (26a)
Colorless solid; yield: 0.32 g (48%); mp 180–183 °C (MeOH).

^{1}H NMR (DMSO-d_6): δ.61 (s, 3 H, 2-CH_3), 3.80 (s, 3 H, 1-CH_3), 4.00 (br s, 2 H, CH_2), 7.20–7.31 (br m, 3 H, CH), 7.61 (s, 1 H, CH), 8.14 (d, $^3J_{CH}$ = 7.8 Hz, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 15.5, 27.7, 33.1, 117.3, 123.2 (q, $^1J_{CF}$ = 275 Hz), 124.1(q, $^2J_{CF}$ = 35 Hz), 127.4 128.7, 129.2, 129.4, 131.0, 132.8, 134.0, 143.2, 154.6, 162.0.

MS (EI, 70 eV): *m*/*z* (%) = 336 [M^+ + 1] (19), 335 [M^+] (100), 303 (43).

9,10-Dimethyl-7-(trifluoromethyl)-5,10-dihydro-6*H*-8,10,11-triaza-cyclopenta[*b*]phenanthrene (26b)
Colorless solid; yield: 0.50 g (79%); mp 177–179 °C (MeOH).

^{1}H NMR (DMSO-d_6): δ = 2.61 (s, 3 H, 2-CH_3), 2.94 (br s, 2 H, CH_2), 3.29 (br s, 2 H, CH_2), 3.80 (s, 3 H, 1-CH_3), 7.27–7.35 (br m, 3 H, CH), 7.58 (s, 1 H, CH), 8.11 (d, $^3J_{CH}$ = 7.8 Hz, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 15.5, 25.4, 27.3, 31.5, 115.8, 123.5 (q, $^1J_{CF}$ = 275 Hz), 124.4, 124.9 (q, $^2J_{CF}$ = 35 Hz), 126.5, 129.2, 131.0, 133.4, 134.9, 149.2, 153.2, 162.0, 166.3.

MS (EI, 70 eV): *m*/*z* (%) = 318 [M^+ + 1] (17), 317 [M^+] (100), 248 (77).

2,3-Dimethyl-9-(trifluoromethyl)-5,6,7,8-tetrahydro-3*H*-imidazo[4,5-*b*]quinoline (27)
Colorless solid; yield: 0.36 g (67%); mp 74–75 °C; R_f = 0.85 (EtOAc–hexane, 1:3).

^{1}H NMR ($CDCl_3$): δ = 1.75–1.84 (br m, 4 H, CH), 2.56 (s, 3 H, CH_3), 2.94–2.99 (br m, 4 H, CH), 3.68 (s, 3 H, CH_3).

^{13}C NMR ($CDCl_3$): δ = 14.1, 22.3, 22.5, 25.7 (q, J_{CF} = 3.2 Hz), 28.3, 33.4, 123.4(q, $^1J_{CF}$ = 275 Hz), 124.6 (q, J_{CF} = 2.4 Hz), 124.9 (q, $^2J_{CF}$ = 32 Hz), 129 (q, J_{CF} = 1.6 Hz), 147.2, 152.4, 154.6, 174.3.

MS (EI, 70 eV): *m*/*z* (%) = 269 [M^+] (100), 240 (17), 202 (33), 161 (14), 124 (21), 67 (15).

1-Desazapurines 28 from Azides 20; General Procedure
A mixture of the appropriate dielectrophile (1 mmol) and azide **20** (3 mmol) in anhyd DMF (40 mL) was added dropwise, very slowly, through the long condenser above a boiling soln of AcOH (30 mL) and H_2O (2 mL) (oil bath temperature ca. 145 °C). After complete addition, the mixture was refluxed for another 3 h. After evaporation of the solvent, the residue was subjected to column chromatography (silica gel), or recrystallized from an appropriate solvent. A 1:3 azide/electrophile ratio is recommended for providing an almost quantitative yield of the 1-desazapurines.

2-(Methylsulfanyl)-3-phenyl-5,7-bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (28a)
Colorless solid; yield: 0.33 g (88%); mp 157–159 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ.75 (s, 3 H, 2-SCH_3), 7.43–7.55 (br m, 5 H, CH), 7.71 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 14.4, 24.3, 111.4 (m), 122.3 (q, $^1J_{CF}$ = 275 Hz), 123.2 (q, $^1J_{CF}$ = 275 Hz), 125.8 (q, $^2J_{CF}$ = 33 Hz), 127.1, 129.9, 132.7, 134.3, 140.5 (q, $^2J_{CF}$ = 33 Hz), 151.1, 162.6.

MS (EI, 70 eV): *m*/*z* (%) = 378 [M^+ + 1] (15), 377 [M^+] (81), 362 (11), 344 (13), 342 (19), 268 (13), 92 (13), 91 (100), 77 (25), 51 (12).

5-Methyl-2-(methylsulfanyl)-3-phenyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (28b)
Colorless solid; yield: 0.30 g (93%); mp 145–147 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 2.51 (s, 3 H, 5-CH_3), 2.68 (s, 3 H, 2-CH_3), 7.15 (s, 1 H, CH), 7.37–7.49 (br m, 5 H, CH).

^{13}C NMR ($CDCl_3$): δ = 14.2, 24.3, 113.7 (q, $^3J_{CF}$ = 4.6 Hz), 122.3 (q, $^1J_{CF}$ = 275 Hz), 126.0 (q, $^2J_{CF}$ = 33 Hz), 127.3, 129.3, 129.6, 129.9 (q, $^3J_{CF}$ = 1.6 Hz), 133.5, 150.9, 152.2, 157.2.

^{19}F NMR ($CDCl_3$): δ = –61.7.

MS (EI, 70 eV): *m*/*z* (%) = 324 [M^+ + 1] (20), 323 [M^+] (100), 308 (22), 290 (25), 214 (35), 91 (42), 77 (11).

2-(Methylsulfanyl)-3,5-diphenyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (28c)

Colorless solid; yield: 0.34 g (89%); mp 153–155 °C (EtOH).

^{1}H NMR ($CDCl_3$): δ = 2.82 (s, 3 H, 2-SCH_3), 7.37–7.45 (br m, 3 H, CH), 7.52 – 7.64 (br m, 5 H, CH), 7.87 (s, 1 H, CH), 7.98 (d, $^3J_{HH}$ = 7.8 Hz, 2 H, CH).

^{13}C NMR ($CDCl_3$): δ = 14.3, 111.3 (q, $^3J_{CF}$ = 4.6 Hz), 122.3 (q, $^1J_{CF}$ = 275 Hz), 126.1(q, $^3J_{CF}$ = 33 Hz), 126.9, 127.1, 128.8, 129.0, 129.2, 129.6. 131.1 (q, $^3J_{CF}$ = 1.6 Hz), 133.5, 138.4, 150.9, 151.3, 158.5.

MS (EI, 70 eV): *m*/*z* (%) = 386 [M^+ + 1] (26), 385 [M^+] (100), 370 (18), 352 (26), 276 (36), 91 (36).

7-(Difluoromethyl)-5-methyl-2-(methylsulfanyl)-3-phenyl-3*H*-imidazo[4,5-*b*]pyridine (28d)

Colorless solid; yield: 0.27 g (87%); mp 150–152 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 2.71 (s, 3 H, 2-SCH_3), 7.27 (s, 1 H, CH), 7.33 (d, $^2J_{HF}$ = 55 Hz, 1 H, CF_2H), 7.56–7.65 (br m, 5 H, CH).

^{13}C NMR (DMSO-d_6): δ = 14.2, 24.3, 110.5, 112.2 (t, $^1J_{CF}$ = 235 Hz), 113.7 (t, $^3J_{CF}$ = 5.0 Hz), 127.9, 129.6 (t, $^2J_{CF}$ = 24 Hz), 129.7, 130.0, 130.8 (t, $^3J_{CF}$ = 5.0 Hz), 133.8, 150.5, 152.4, 156.3.

MS (EI, 70 eV): *m*/*z* (%) = 306 [M^+ + 1] (20), 305 [M^+] (100), 304 (10), 290 (22), 272 (26), 196 (32), 91 (24), 77 (11).

3,5-Diphenyl-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (28e)

Colorless solid; yield: 0.27 g (79%); mp 162–164 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 7.46–7.55 (br m, 4 H, CH), 7.65–7.72 (br m, 2 H, CH), 8.00 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH), 8.12 (s, 1 H, CH), 8.16 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH), 9.05 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 111.7 (q, $^3J_{CF}$ = 4.6 Hz), 122.8 (q, $^1J_{CF}$ = 275 Hz), 123.8, 127.0, 127.8 (q, $^2J_{CF}$ = 33 Hz), 127.9, 128.9, 129.5, 129.6, 130.4 (q, $^3J_{CF}$ = 1.6 Hz), 134.6, 137.6, 146.8, 147.7, 152.1.

^{19}F NMR (DMSO-d_6): δ = – 60.5.

MS (EI, 70 eV): *m*/*z* (%) = 340 [M^+ + 1] (21), 339 [M^+] (100), 77 (18).

3-Phenyl-5-(2-thienyl)-7-(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (28f)

Colorless solid; yield: 0.28 g (82%); mp 173–176 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 6.99 (t, $^3J_{HH}$ = 4.7 Hz, 1 H, CH), 7.28 (d, $^3J_{HH}$ = 5.0 Hz, 1 H, CH), 7.36 (t, $^3J_{HH}$ = 7.4 Hz, 1 H, CH), 7.48 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.55 (d, $^3J_{HH}$ = 4.0 Hz, 1 H, CH), 7.71 (d, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.75 (s, 1 H, CH), 8.33 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 111.0 (q, $^3J_{CF}$ = 4.6 Hz), 123.0 (q, $^1J_{CF}$ = 275 Hz), 123.1 125.7, 128.1, 128.2, 128.4, 129.4 (q, $^2J_{CF}$ = 33 Hz), 129.7, 130.5 (q, $^3J_{CF}$ = 1.6 Hz), 134.6, 143.7, 144.3, 147.2, 148.8.

MS (EI, 70 eV): *m*/*z* (%) = 346 [M^+ + 1] (19), 345 [M^+] (100), 77 (22).

3-Phenyl-7-(trifluoromethyl)-3,4-dihydro-5*H*-imidazo[4,5-*b*]pyridin-5-one (28g)

Colorless solid; yield: 0.25 g (89%); mp 157–160 °C (EtOH).

^{1}H NMR (DMSO-d_6): δ = 6.91 (s, 1 H, CH), 7.46 (t, $^3J_{HH}$ = 7.2 Hz, 1 H, CH), 7.59 (t, $^3J_{HH}$ = 7.2 Hz, 2 H, CH), 7.82 (d, $^3J_{HH}$ = 7.2 Hz, 2 H, CH), 8.68 (s, 1 H, CH), 11.6 (s, 1 H, NH).

^{13}C NMR (DMSO-d_6): δ = 102.2 (q, $^3J_{CF}$ = 4.8 Hz), 122.7 (q, $^1J_{CF}$ = 275 Hz), 124.1, 125.1 (q, $^3J_{CF}$ = 1.6 Hz), 128.0, 129.5, 130.4 (q, $^2J_{CF}$ = 33 Hz), 134.7, 143.0, 145.8, 161.0.

MS (EI, 70 eV): *m*/*z* (%) = 280 [M^+ + 1] (11), 279 [M^+] (71), 104 (92), 93 (15), 78 (13), 77 (100), 69 (27), 51 (46), 43 (32).

7-(Chlorodifluoromethyl)-3,5-diphenyl-3*H*-imidazo[4,5-*b*]pyridine (28h)

Colorless solid; yield: 0.30 g (85%); mp 184–186 °C (EtOH).

^{1}H NMR (DMSO-d_6): δ = 7.42–7.54 (br m, 4 H, CH), 7.69–7.75 (br m, 2 H, CH), 8.01 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH), 8.09 (s, 1 H, CH), 8.19 (d, $^3J_{HH}$ = 8.2 Hz, 2 H, CH), 9.17 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 110.5 (t, $^3J_{CF}$ = 5.6 Hz), 124.1, 125.7 (t, $^1J_{CF}$ = 285 Hz), 127.7, 131.0 (t, $^2J_{CF}$ = 27 Hz), 127.7, 129.1, 129.3, 129.7, 130.9, 134.7, 137.0, 146.9, 148.0, 152.7.

^{19}F NMR (DMSO-d_6): δ = –51.0.

MS (EI, 70 eV): *m*/*z* (%) = 357 [M^+ + 2] (35), 356 [M^+ + 1] (23), 355 [M^+] (100), 321 (20), 320 (88), 77 (23).

7-(Chlorodifluoromethyl)-3-phenyl-5-(2-thienyl)-3*H*-imidazo[4,5-*b*]pyridine (28i)

Colorless solid; yield: 0.33 g (90%); mp 192–198 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 7.01 (t, $^3J_{HH}$ = 4.7 Hz, 1 H, CH), 7.27 (d, $^3J_{HH}$ = 5.0 Hz, 1 H, CH), 7.38 (t, $^3J_{HH}$ = 7.4 Hz, 1 H, CH), 7.45 (t, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.54 (d, $^3J_{HH}$ = 4.0 Hz, 1 H, CH), 7.69 (d, $^3J_{HH}$ = 7.4 Hz, 2 H, CH), 7.78 (s, 1 H, CH), 8.39 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 110.7 (t, $^3J_{CF}$ = 5.6 Hz), 123.2 (q, $^1J_{CF}$ = 275 Hz), 125.2 (t, $^2J_{CF}$ = 33 Hz), 126.6, 127.9, 129.0, 129.1, 130.1, 130.2, 130.2 (t, $^3J_{CF}$ = 1.6 Hz), 133.5, 143.8, 146.5, 151.0, 158.7.

^{19}F NMR (DMSO-d_6): δ = –51.2.

MS (EI, 70 eV): *m*/*z* (%) = 363 [M^+ + 2] (39), 362 [M^+ + 1] (21), 361 [M^+] (100), 326 (64), 77 (17).

1,3,5-Trimethyl-7-(trifluoromethyl)-1,3-dihydro-2*H*-imidazo[4,5-*b*]pyridine-2-thione (30a)

Colorless solid; yield: 0.44 g (84%); mp 59–61 °C; R_f = 0.30 (EtOAc–hexane, 1:4).

^{1}H NMR ($CDCl_3$): δ = 2.57 (s, 3 H, 5-CH_3), 3.78 (s, 3 H, 3-CH_3), 3.91 (q, $^3J_{HF}$ = 2.0 Hz, 3 H, 1-CH_3), 7.15 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 23.9, 30.7, 33.4 (q, J_{CF} = 5.6 Hz), 113.6 (q, $^3J_{CF}$ = 5.6 Hz), 118.4 (q, $^2J_{CF}$ = 35 Hz), 120.1, 122.4 (q, $^1J_{CF}$ = 275 Hz), 146.7, 152.5, 173.0.

MS (EI, 70 eV): *m*/*z* (%) = 262 [M^+ + 1] (16), 261 [M^+] (100).

1,3-Dimethyl-5-phenyl-7-(trifluoromethyl)-1,3-dihydro-2*H*-imidazo[4,5-*b*]pyridine-2-thione (30b)

Colorless solid; yield: 0.58 g (89%); mp 223–226 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 2.57 (s, 3 H, 5-CH_3), 3.78 (s, 3 H, 3-CH_3), 3.91 (q, $^3J_{HF}$ = 2.0 Hz, 3 H, 1-CH_3), 7.15 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 31.2. 34.0 (q, J_{CF} = 5.6 Hz), 113.6 (q, $^3J_{CF}$ = 5.6 Hz), 118.5 (q, $^2J_{CF}$ = 35 Hz), 120.2, 122.3 (q, $^1J_{CF}$ = 275 Hz), 127.2 128.0, 130.0, 137.1, 146.1, 152.4, 173.9.

MS (EI, 70 eV): *m*/*z* (%) = 324 [M^+ + 1] (100), 323 [M^+] (100).

1-Methyl-3-phenyl-5,7-bis(trifluoromethyl)-1,3-dihydro-2*H*-imidazo[4,5-*b*]pyridine-2-thione (30c)

Colorless solid; yield: 0.66 g (87%); mp 193–194 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 4.01 (q, $^3J_{CF}$ = 2.0 Hz, 3 H, 3-CH_3), 7.42–7.53 (br m, 5 H, CH), 7.71 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 34.7 (q, J_{CF} = 4.7 Hz,), 113.3, 118.5 (q, $^2J_{CF}$ = 35 Hz), 120.9, 122.3 (q, $^1J_{CF}$ = 275 Hz), 122.9 (qv, $^2J_{CF}$ = 35 Hz), 128.6, 129.4, 129.5, 134.9, 146.7, 153.3, 173.0.

MS (EI, 70 eV): *m*/*z* (%) = 378 [M^+ + 1] (100), 377 [M^+] (100)

7-(Difluoromethyl)-1,5-dimethyl-3-phenyl-1,3-dihydro-2*H*-imidazo[4,5-*b*]pyridine-2-thione (30d)
Colorless solid; yield: 0.48 g (79%); mp 211–212 °C (*i*-PrOH).

^{1}H NMR ($CDCl_3$): δ = 2.51 (s, 3 H, 5-CH_3), 4.05 (s, 3 H, 1-CH_3), 6.92 (t, $^2J_{HF}$ = 55 Hz, 1 H, CF_2H), 7.11 (s, 1 H, CH), 7.49–7.59 (br m, 5 H, CH).

^{13}C NMR ($CDCl_3$): δ = 24.1, 34.2 (t, J_{CF} = 4.7 Hz,), 113.1 (t, $^1J_{CF}$ = 240 Hz), 115.9 (t, $^3J_{CF}$ = 8.0 Hz), 120.9 (t, J_{CF} = 2.4 Hz), 122.9 (t, $^2J_{CF}$ = 24.0 Hz), 128.6, 129.4, 129.5, 134.9, 146.7, 153.3, 173.0.

MS (EI, 70 eV): *m*/*z* (%) = 306 [M^+ + 1] (18), 305 [M^+] (100), 304 (70).

1,5-Dimethyl-7-(pentafluoroethyl)-3-phenyl-1,3-dihydro-2*H*-imidazo[4,5-*b*]pyridine-2-thione (30e)
Colorless solid; yield: 0.60 g (81%); mp 134–135 °C; R_f = 0.80 (EtOAc–hexane, 1:3).

^{1}H NMR ($CDCl_3$): δ = 2.46 (s, 3 H, 5-CH_3), 3.96 (t, J_{HF} = 4.0 Hz, 3 H, 1-CH_3), 7.08 (s, 1 H, CH), 7.41–7.53 (m, 5 H, CH).

^{13}C NMR ($CDCl_3$): δ = 23.9, 34.8 (t, J_{CF} = 8.4 Hz), 115.9 (t, $^3J_{CF}$ = 8.0 Hz), 117.7 (t, $^2J_{CF}$ = 25 Hz), 121.3 (t, $^3J_{CF}$ = 3.2 Hz), 128.5, 129.3, 129.4, 134.8, 147.1, 152.7, 173.9.

MS (EI, 70 eV): *m*/*z* (%) = 374 [M^+ + 2] (23), 373 [M^+ + 1] (93), 372 [M^+] (100).

8,10-Dimethyl-7-(trifluoromethyl)-5,6,8,10-tetrahydro-8,10,11-triaza-cyclopenta[*b*]phenanthrene-9-thione (31)
Colorless solid; yield: 0.58 g (83%); mp 199–202 °C (EtOH).

^{1}H NMR (DMSO-d_6): δ = 2.55 (s, 3 H, 5-CH_3), 2.90 (br s, 2 H, CH_2), 3.22 (br s, 2 H, CH_2), 3.91 (q, $^3J_{HF}$ = 2.0 Hz, 3 H, 1-CH_3), 7.30–7.39 (br m, 3 H, CH), 7.63 (s, 1 H, CH), 8.23 (d, $^3J_{CH}$ = 7.8 Hz, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 25.3, 26.1, 30.7, 33.4 (q, J_{CF} = 5.6 Hz), 119.9 (q), 121.9, 122.3 (q, $^1J_{CF}$ = 275 Hz), 123.0 (q, $^2J_{CF}$ = 35 Hz), 125.8, 126.3 128.1, 128.4. 135.2. 136.9, 149.2, 153.1, 171.0.

MS (EI, 70 eV): *m*/*z* (%) = 350 [M^+ + 1] (20), 349 [M^+] (100), 313 (19).

5-Methyl-1-phenyl-7-(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridine (32a)
Colorless solid; yield: 0.39 g (70%); mp 149–151 °C; R_f = 0.75 (EtOAc–hexane, 2:1).

^{1}H NMR ($CDCl_3$): δ = 2.72 (s, 3 H, CH_3), 7.30 (m, 3 H, CH), 7.49 (m, 3 H, CH), 8.13 (m, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 24.5, 115.5 (t, $^3J_{CF}$ = 5.6 Hz), 122.2 (q, $^1J_{CF}$ = 275 Hz), 122.5 (q, $^2J_{CF}$ = 35 Hz), 127.6 (q, $^3J_{CF}$ = 1.6 Hz), 129.5, 130.1, 136.2, 148.0, 154.7, 157.8.

MS (EI, 70 eV): *m*/*z* (%) = 278 [M^+ + 1] (13), 277 [M^+] (100), 77 (35).

1-Phenyl-5-(2-thienyl)-7-(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridine (32b)
Colorless solid; yield: 0.46 g (67%); mp 131–133 °C; R_f = 0.65 (EtOAc–hexane, 2:1).

^{1}H NMR ($CDCl_3$): δ = 2.37 (s, 3 H, CH_3), 7.05 (t, $^3J_{HH}$ = 4.2 Hz, 1 H, CH), 7.31–7.36 (br m, 3 H, CH), 7.45–7.51 (br m, 3 H, CH), 7.64 (d, $^3J_{HH}$ = 4.2 Hz, 2 H, CH), 7.76 (s, 1 H, CH), 8.19 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 111.5 (t, $^3J_{CF}$ = 5.6 Hz), 118.4, 122.3 (q, $^1J_{CF}$ = 275 Hz), 122.4 (q, $^2J_{CF}$ = 35 Hz), 126.8, 127.6 (q, $^3J_{CF}$ = 1.6 Hz), 128.5, 128.9, 129.3, 129.6, 130.3, 136.4, 144.1, 148.2, 150.5, 158.0.

MS (EI, 70 eV): *m*/*z* (%) = 346 [M^+ + 1] (20), 345 [M^+] (100), 77 (19).

1-Benzyl-5,7-bis(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridine (32c)
Colorless solid; yield: 0.48 g (69%); mp 113–115 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 5.76 (s, 2 H, CH_2), 7.10 (d, $^3J_{HH}$ = 7.8 Hz, 2 H, CH), 7.36 (br m, 2 H, CH), 8.15 (s, 1 H, CH), 9.16 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 50.1 (q, J_{CF} = 4 Hz), 111.9, 121.4 (q, $^1J_{CF}$ = 275 Hz), 121.5 (q, $^2J_{CF}$ = 35 Hz), 121.7 (q, $^1J_{CF}$ = 275 Hz), 123.7, 125.9, 127.7, 128.7, 135.9, 140.8, 153.6, 157.9.

MS (EI, 70 eV): *m*/*z* (%) = 346 [M^+ + 1] (15), 345 [M^+] (67), 92(17), 91 (100), 65 (23).

1-Benzyl-7-(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridin-5(4*H*)-one (32d)
Colorless solid; yield: 0.30 g (51%); mp 185–187 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 5.50 (s, 2 H, CH_2), 6.72 (s, 1 H, CH), 6.93 (m, 2 H, CH), 7.29 (s, 3 H, CH), 8.42 (s, 1 H, CH), 12.02 (s, 1 H, NH).

^{13}C NMR (DMSO-d_6): δ = 102.2 (q, $^3J_{CF}$ = 4.8 Hz), 122.7 (q, $^1J_{CF}$ = 275 Hz), 124.1, 125.1 (q, $^3J_{CF}$ = 1.6 Hz), 128.0, 129.5, 130.4 (q, $^2J_{CF}$ = 33 Hz), 134.7, 143.0, 145.8, 161.0.

MS (EI, 70 eV): *m*/*z* (%) = 280 [M^+ + 1] (11), 279 [M^+] (71), 104 (92), 93 (15), 78 (13), 77 (100), 69 (27), 51 (46), 43 (32).

1-[(*S*)-1-Phenylethyl]-5,7-bis(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridine (32e)
Colorless solid; yield: 0.35 g (49%); mp 99–101 °C; R_f = 0.75 (EtOAc–hexane, 1:1).

^{1}H NMR ($CDCl_3$): δ = 1.88 (d, $^3J_{HH}$ = 7.0 Hz, 3 H, CH_2), 5.44 (m, 1 H, CH), 8.18 (s, 1 H, CH), 9.17 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 21.7, 59.9 (q, J_{CF} = 4.7 Hz), 111.5, 121.2 (q, $^1J_{CF}$ = 275 Hz), 121.4 (q, $^2J_{CF}$ = 35 Hz), 121.9 (q, $^1J_{CF}$ = 275 Hz), 124.8, 126.3, 129.5, 129.8, 135.1, 140.1, 153.0, 158.1.

MS (EI, 70 eV): *m*/*z* (%) = 359 [M^+] (12), 105 (100), 77(10)

1-[(*R*)-1-Phenylethyl]-5,7-bis(trifluoromethyl)-1*H*-imidazo[4,5-*b*]pyridine (32f)
Colorless solid; yield: 0.31 g (43%); mp 100–101 °C; R_f = 0.75 (EtOAc–hexane, 1:1).

^{1}H NMR ($CDCl_3$): δ = 1.89 (d, $^3J_{HH}$ = 7.0 Hz, 3 H, CH_2), 5.44 (m, 1 H, CH), 8.17 (s, 1 H, CH), 9.18 (s, 1 H, CH).

^{13}C NMR ($CDCl_3$): δ = 21.7, 60.1 (q, J_{CF} = 4.6 Hz), 111.7, 121.2 (q, $^1J_{CF}$ = 275 Hz), 121.4 (q, $^2J_{CF}$ = 35 Hz), 122.0 (q, $^1J_{CF}$ = 275 Hz), 124.8, 126.3, 129.5, 129.8, 135.1, 140.0, 153.1, 158.0.

MS (EI, 70 eV): *m*/*z* (%) = 359 [M^+] (13), 105 (100), 77 (12).

5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridine (33)
A mixture of **32c** (0.56 g, 2 mmol) in absolute MeOH (20 mL) and 0.1 g of 10% Pd/C was intensively shaken in a PARR apparatus vessel under H_2 (5 atm) for 2 h. Then the precipitate was collected by filtration and washed several times with hot MeOH. The solvent was evaporated and the white residue was recrystallized from a small amount of MeOH.

Colorless solid; yield: 0.28 g (54%); mp 279–280 °C (*i*-PrOH).

^{1}H NMR (DMSO-d_6): δ = 7.71 (s, 1 H, CH), 8.11 (s, 1 H, CH), 12.07 (s, 1 H, NH).

^{13}C NMR (DMSO-d_6): δ = 115.3, 122.7 (q, $^1J_{CF}$ = 275 Hz), 122.9 (q, $^1J_{CF}$ = 275 Hz), 127.7 (q, $^2J_{CF}$ = 35 Hz), 133.9, 141.4 (q, $^2J_{CF}$ = 35 Hz), 149.5, 161.4.

MS (EI, 70 eV): *m*/*z* (%) = 255 [M$^+$] (100), 254 (21).

2-{[5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]methoxy}propane-1,3-diyl Dibenzoate (35)

Compound **35** was prepared according to a published procedure.[14]

Yellow oil; yield: 0.65 g (57%); R_f = 0.90 (EtOAc–hexane, 1:3).

^{1}H NMR (DMSO-d_6): δ = 4.33 (m, 4 H, CH_2), 4.81 (br m, 1 H, CH), 6.01 (br s, 2 H, CH_2), 7.35 (br m, 6 H, CH), 7.77 (s, 1 H, CH), 7.87 (d, $^3J_{HH}$ = 7.2 Hz, 4 H), 8.37 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 62.3, 69.7, 76.7, 115.4, 122.1 (q, $^1J_{CF}$ = 275 Hz), 122.7 (q, $^1J_{CF}$ = 275 Hz), 127.5 (q, $^2J_{CF}$ = 35 Hz), 128.8, 129.7, 130.5, 133.3, 133.9, 141.4 (q, $^2J_{CF}$ = 35 Hz), 149.1, 161.7, 188.9.

MS (EI, 70 eV): *m*/*z* (%) = 567 [M$^+$] (47), 445 (19), 313 (37), 283 (33), 282 (17), 161 (27), 105 (100), 77 (19), 67 (11).

2-{[5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]methoxy}propane-1,3-diol (36)

To a solution of the acylated nucleoside **35** (1 mmol) in abs. MeOH (5 mL) a sat. solution of NH_3 in MeOH (20 mL) was added dropwise at 0 °C. The mixture was stirred for another 30 min and left overnight at r.t. The solvent was removed under reduced pressure, and the formed material was kept for the next 24 h on a vacuum line. The resultant yellow material was purified by column chromatography on silica gel.

Yellow oil; yield: 0.27 g (74%); R_f = 0.75; (EtOAc–hexane, 1:1).

^{1}H NMR (DMSO-d_6): δ = 4.27 (m, 4 H, CH_2), 4.47 (br s, 2 H, OH), 4.54 (br m, 1 H, CH), 5.88 (br s, 2 H, CH_2), 7.79 (s, 1 H, CH), 8.44 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 62.9, 71.0, 78.7, 115.3, 122.3 (q, $^1J_{CF}$ = 275 Hz), 122.8 (q, $^1J_{CF}$ = 275 Hz), 128.1 (q, $^2J_{CF}$ = 35 Hz), 133.9, 141.3 (q, $^2J_{CF}$ = 35 Hz), 149.1, 161.5.

MS (EI, 70 eV): *m*/*z* (%) = 359 [M$^+$] (13), 341 (17), 340 (100), 268 (31), 57 (59).

{(3a*R*,4*R*,6*R*,6a*S*)-6-[5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]-2,2-dimethyltetrahydro-3a*H*-cyclopenta[*d*][1,3]dioxol-4-yl}methanol (38)

Compound **38** was prepared according to a published procedure.[15]

Yellow oil; yield: 0.48 g (57%); R_f = 0.60 (hexane–EtOAc, 3:1).

^{1}H NMR (DMSO-d_6): δ = 1.25 (s, 3 H, CH), 1.53 (s, 3 H, CH), 2.43–2.57 (br m, 3 H, CH), 3.72 (br m, 2 H, CH), 4.61 (dd, $^3J_{HH}$ = 6.0, 4.3 Hz, 1 H, CH), 4.85–4.91 (br m, 2 H, CH), 5.17 (dd, $^3J_{HH}$ = 6.8, 6.0 Hz, 1 H, CH), 7.71 (s, 1 H, CH), 8.13 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 25.0, 27.7, 33.3, 45.0, 60.9, 61.5, 80.0, 83.4, 115.0, 116.3, 122.7 (q, $^1J_{CF}$ = 275 Hz), 122.8 (q, $^1J_{CF}$ = 275 Hz), 127.8 (q, $^2J_{CF}$ = 35 Hz), 133.9, 141.1 (q, $^2J_{CF}$ = 35 Hz), 149.9, 161.0.

MS (EI, 70 eV): *m*/*z* (%) = 425 [M$^+$] (17), 410 (12), 392 (33), 307 (25), 255 (21), 247 (37), 209 (67), 169 (100), 155 (67).

(1*R*,2*S*,3*R*,5*R*)-3-[5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]-5-(hydroxymethyl)cyclopentane-1,2-diol (39)

Compound **39** was obtained from **38** according to a published procedure.[9g]

Colorless oil; yield: 0.32 g (84%); mp 127–128 °C; R_f = 0.80 (EtOAc).

^{1}H NMR (DMSO-d_6): δ = 2.63–2.71 (br s, 2 H, CH), 1.94–2.00 (m, 1 H, CH), 2.25 (m, 1 H, CH), 3.40–3.51 (m, 2 H, CH), 3.91 (m, 1 H, CH), 4.44 (m, 1 H, CH), 4.59–4.67 (m, 2 H, CH), 4.81 (br t, $^3J_{HH}$ = 6.2 Hz, 1 H, CH), 4.95 (d, $^3J_{HH}$ = 6.4 Hz, 1 H), 7.71 (s, 1 H, CH), 8.11 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 28.4, 45.7, 59.0, 63.9, 71.9, 74.0, 115.7, 122.6 (q, $^1J_{CF}$ = 275 Hz), 122.8 (q, $^1J_{CF}$ = 275 Hz), 127.9 (q, $^2J_{CF}$ = 35 Hz), 133.7, 141.0 (q, $^2J_{CF}$ = 35 Hz), 149.0, 161.9.

MS (EI, 70 eV): *m*/*z* (%) = 385 [M$^+$] (14), 368 (32), 367 (100), 332 (21), 311 (72), 299 (60), 271 (22), 254 (43), 202 (23), 169 (13), 131 (32),

{4-[5,7-Bis(trifluoromethyl)-3*H*-imidazo[4,5-*b*]pyridin-3-yl]cyclopent-2-enyl}methanol (41)

Compound **41** was prepared according to a published procedure.[16]

Yellow oil; yield: 0.18 g (51%); R_f = 0.55 (EtOAc).

^{1}H NMR (DMSO-d_6): δ = 1.68 (ddd, $^2J_{HH}$ = 12.5, $^3J_{HH}$ = 5.3, $^3J_{HH}$ = 5.3 Hz, 2 H, CH), 2.60 (ddd, $^2J_{HH}$ = 13.2, $^3J_{HH}$ = 8.2, $^3J_{HH}$ = 8.2 Hz, 2 H, CH), 2.99 (br m, 1 H, CH), 3.41 (br s, 1 H, OH), 3.57 (d, $^2J_{HH}$ = 11.4 Hz, 2 H, OCH2), 5.37–5.44 (m, 1 H, CH), 5.90 (ddd, $^2J_{HH}$ = 5.5, $^3J_{HH}$ = 2.1, $^3J_{HH}$ = 2.1 Hz, 1 H, CH), 6.17 (ddd, $^2J_{HH}$ = 13.2, $^3J_{HH}$ = 2.4, $^3J_{HH}$ = 2.4 Hz, 1 H, CH), 7.77 (s, 1 H, CH), 8.24 (s, 1 H, CH).

^{13}C NMR (DMSO-d_6): δ = 35.4, 47.0, 57.1, 64.3, 115.3, 122.7 (q, $^1J_{CF}$ = 275 Hz), 122.9 (q, $^1J_{CF}$ = 275 Hz), 127.7 (q, $^2J_{CF}$ = 35 Hz), 128.2, 133.9, 137.9, 141.4 (q, $^2J_{CF}$ = 35 Hz), 149.5, 161.4.

MS (EI, 70 eV): *m*/*z* (%) = 351 [M$^+$] (27), 333 (100), 293 (14), 291 (11), 79 (36), 57 (38).

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