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Fluorine-containing furan-3(2*H*)-ones in reactions with binucleophiles: CF_3 *vs* C_2F_5

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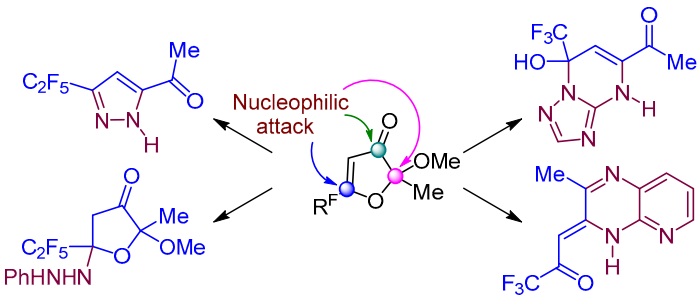


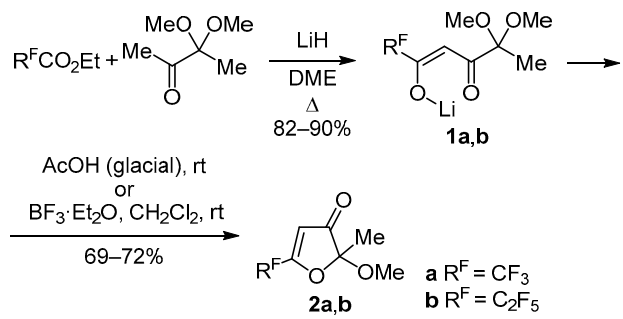
Five- and six-membered fluorine-containing azaheterocycles were synthesized based on available furan-3(2*H*)-ones, and the influence of the nature of the fluoroalkyl substituent on the direction of the chemical transformations by the action of N,N- and N,O-binucleophiles was revealed.

Keywords: 4,7-dihydro[1,2,4]triazolo[1,5-*a*]pyrimidine, furan-3(2*H*)-ones, 2-methoxy-2-methyl-5-(perfluoroethyl)furan-3(2*H*)-one, pyrazole, 1,1,1-trifluoro-3-(2-methylpyrido[2,3-*b*]pyrazin-3(4*H*)-ylidene)propan-2-one, N,N- and N,O-binucleophiles.

The increased interest in fluorine chemistry in the search for new drugs and promising materials is due to the significant influence of fluorine-containing substituents on the physicochemical properties of the molecule.[1] Additionally, the introduction of fluorine atom(s) into the structures of organic compounds leads to an increase in their reactivity which makes new transformations possible that are different from those characteristic of hydrocarbon analogs.[2] The widely used fluorine-containing building blocks include unsaturated compounds, di- or tricarbonyl compounds, as well as their analogs.[3] Trifluoromethyl-functionalized compounds are the most investigated, the reactions of them with mono- and binucleophiles lead to various acyclic and heterocyclic derivatives.[2,3] However, in recent decades, special attention was paid to the strategy of introduction in the various structures of organic compounds of fluorine-containing groups and studying of their influence on the reactivity and properties of the molecule.[4]

We have previously developed a method for the synthesis of functionalized lithium diketonates **1a**,**b** and furan-3(2*H*)-ones **2a**,**b**, which have promising coordinating capabilities and reactivity, since they are hidden analogs of 1,2,4-triketones (Scheme 1).[5] However, further transformations into substituted pyrazoles, isoxazolines, quinoxalines, and furo[2,3-*d*]imidazol-2-ones were studied exclusively for trifluoromethyl-containing derivatives **1a** and **2a**.[5] In this work, we replaced the CF_3 substituent (compound **2a**) with C_2F_5 (compound **2b**) and investigated similarity and differences in the chemical transformations

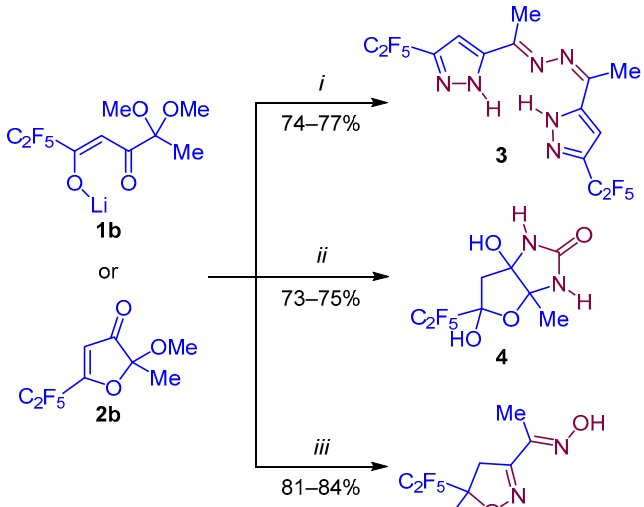
Scheme 1. Synthesis of lithium diketonates **1a**,**b** and furan-3(2*H*)-ones **2a**,**b**[5a,e]



of furan-3(2*H*)-ones **2a**,**b** by the action of N,N- and N,O-bi-nucleophiles.

It has been established that C_2F_5-containing analogs **1b** and **2b** exhibit similar properties with trifluoromethyl analogs[5b] when conducting reactions with hydrazine, hydroxylamine, and urea in the presence of an acid. The reaction of diketonate **1b** and furan-3(2*H*)-one **2b** with these N,N- and N,O-binucleophiles results in functionalized bispyrazole **3**, hexahydro-2*H*-furo[2,3-*d*]imidazol-2-one **4**, and isoxazoline **5** with good yields (Scheme 2).

Scheme 2. Reaction of diketonate **1b** and furan-3(2*H*)-one **2b** with N,N- and N,O-binucleophiles

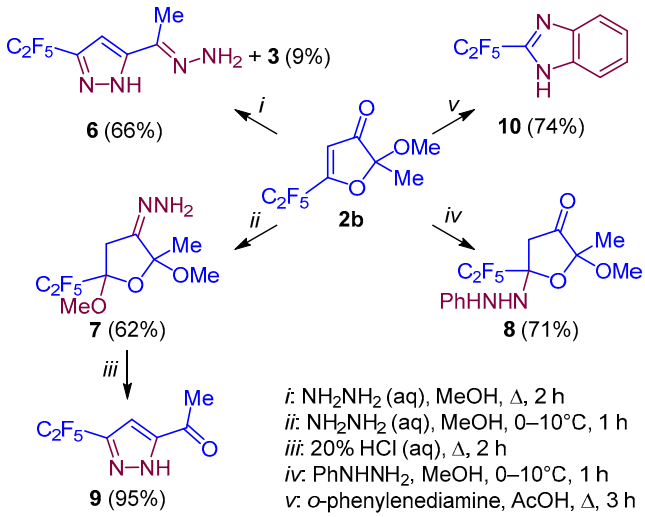


i: NH_2NH_2 (aq), AcOH, 100°C, 5 h
ii: $(NH_2)_2CO$, AcOH, 40°C, 7 h
iii: $NH_2OH \cdot HCl$, EtOH, Δ, 4 h

Scheme 3 shows the transformations of C_2F_5-furanone **2b** which are different from its trifluoromethyl analog **2a**. In the absence of acid catalysis, pyrazole **6** is formed in good yield in the reaction of furan-3(2*H*)-one **2b** with an excess of hydrazine hydrate by heating under reflux in MeOH. Additionally, unlike similar transformations of CF_3-furan-3(2*H*)-one **2a**, bispyrazole **3** is formed as a by-product. The reaction of furanone **2b** with hydrazine hydrate at 0–10°C takes place without opening the furan ring to form functionalized furan **7**. The formation of this product can be explained by base-catalyzed addition of the solvent molecule (MeOH) as O-nucleophile to activated C=C bond of furan-3(2*H*)-one **2b** followed by an attack of hydrazine at the carbonyl group with the formation of a hydrazone fragment. Compound **7** is unstable during storage, and subsequent treatment of it by acid allowed us to obtain 5-acetylpyrazole **9**. Previously, we were unable to isolate and characterize the products of the reaction of CF_3-furan-3(2*H*)-one **2a** with phenylhydrazine due to their resinification. Furanone **8** was formed by the action of phenylhydrazine on C_2F_5-analog **2b** as a result of the addition of an N-nucleophile at the C=C bond of the heterocycle. It should be noted that attempts to realize further transformations of compound **8** by the action of acids or heating led to the formation of a complex product mixture.

Benzimidazole **10** was formed as a result of the reaction of *o*-phenylenediamine with furanone **2b**. The same reaction with CF_3-analogs led to the formation of substituted quinoxalines.[5b,6] Thus, the regioselectivity of reactions in the case of substrate **2b** is determined by the initial nucleophilic 1,4-addition at the activated bond C=C (the Michael reaction).

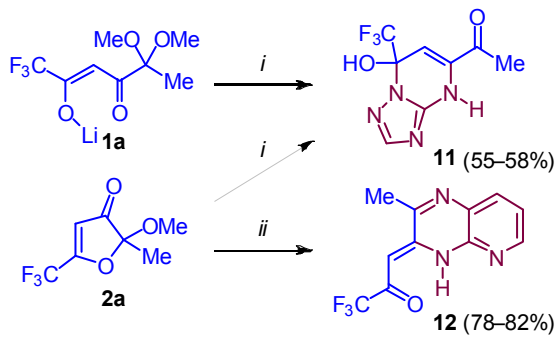
Scheme 3. Reaction of furan-3(2*H*)-one **2b** with N,N-binucleophiles



i: NH_2NH_2 (aq), MeOH, Δ, 2 h
ii: NH_2NH_2 (aq), MeOH, 0–10°C, 1 h
iii: 20% HCl (aq), Δ, 2 h
iv: $PhNHNH_2$, MeOH, 0–10°C, 1 h
v: *o*-phenylenediamine, AcOH, Δ, 3 h

Trifluoromethyl-containing compounds **1a**, **2a** exhibited greater reactivity when reacting with amino-1,2,4-triazole and 2,3-diaminopyridine, since bicyclic azaheterocycles **11** and **12** were obtained in these reactions under mild conditions. C_2F_5-analogs **1b**, **2b**, however, could not be involved in such transformations (Scheme 4).

Scheme 4. Synthesis of CF_3-azaheterocycles on the basis of lithium diketonate **1a** and furan-3(2*H*)-one **2a**



i: amino-1,2,4-triazole, AcOH, 30–35°C, 12 h
ii: 2,3-diaminopyridine, AcOH, rt, 6 h

Judging by the ^1H and ^{19}F NMR spectroscopy data, the product of the reaction of amino-1,2,4-triazole with both CF_3-analogs **1a** and **2a** is triazolopyrimidine **11**. In the ^1H NMR spectrum, downfield singlets recorded at 8.55 and 10.96 ppm belong to NH and OH groups, respectively. The presence of the carbonyl carbon atom signal of the acetyl group at 192.5 ppm in the ^{13}C NMR spectrum makes it possible to make an unequivocal choice in favor of

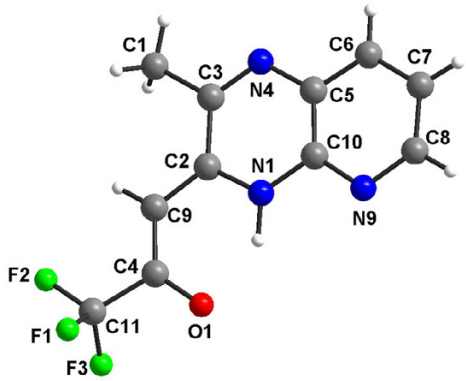


Figure 1. Molecular structure of compound **12**.

structure **11**. The carbon signal at the CF_3 substituent in the form of a quartet at 82.5 ppm ($^2J_{CF}$ = 33.7 Hz) indicates its location at the quaternary carbon atom. We were unable to grow a crystal of this compound to establish its regio-isomeric structure. However, literature data indicate the predominant involvement of the nitrogen atom N(2) of the starting amino-1,2,4-triazole in the cyclization.[7]

It was found using X-ray structural analysis that 3,4-dihydropyrido[2,3-*b*]pyrazine **12** is formed as a result of the reaction of CF_3-furan-3(2*H*)-one **2a** with 2,3-diaminopyridine (Fig. 1).

Based on the obtained results, it can be assumed that the initial attack of binucleophiles in the reactions of trifluoromethyl-containing compounds occurs *via* the keto group of the hidden α-dicarbonyl fragment, and the direction of further intramolecular cyclization is determined by the nature of the binucleophile, leading to the formation of five- or six-membered azaheterocycles. In the case of 2-methoxy-2-methyl-5-(1,1,2,2,2-pentafluoroethyl)furan-3(2*H*)-one, it becomes possible to realize a second reaction, 1,4-addition of N- and O-nucleophiles at the activated C=C bond (the Michael reaction). The predominant 1,2-addition of the 2-methoxy-2-methyl-5-(trifluoromethyl)furan-3(2*H*)-one to the enone system is due to the higher electron-withdrawing effect of the CF_3 substituent as compared to the C_2F_5 group. In turn, the smaller influence exerted by the fluoroalkyl group upon transition to the C_2F_5 group in 2-methoxy-2-methyl-5-(1,1,2,2,2-pentafluoroethyl)furan-3(2*H*)-one reduced the regioselectivity of the processes, which we observed in the reaction with hydrazine. It may be noted that, unlike C_2F_5-analogs, CF_3 derivatives showed higher reactivity, which allowed us to obtain new azaheterocycles under mild conditions.

Experimental

^{1}H, ^{13}C, and ^{19}F NMR spectra were acquired on Bruker DRX-500 (500, 125, and 470 MHz, respectively) and Bruker DRX-400 (400, 125, and 376 MHz, respectively) spectrometers, with TMS and C_6F_6 as internal standards. The assignment of signals in the ^{13}C NMR spectra are made on the basis of the spectra of analogs.[5,7] Elemental analysis was performed on a PerkinElmer Series II 2400 Elemental Analyzer. Melting points were determined in open capillaries on a Stuart SMP3 apparatus. Monitoring of the reaction progress was done by TLC on Alugram Sil G/UV_{254} TLC plates.

The original fluorine-containing lithium diketonates **1a**,**b**[5a,e] and furanone **2a**[5a] were synthesized by known methods.

2-Methoxy-2-methyl-5-(1,1,2,2,2-pentafluoroethyl)-furan-3(2*H*)-one (2b). Lithium diketonate **1b** (10.00 g, 35 mmol) was dissolved in Et_2O (100 ml), and a solution of oxalic acid dihydrate (12.00 g) in water (200 ml) was slowly added. The organic phase was separated, the aqueous layer was extracted with Et_2O (2×50 ml). The combined organics were dried over $MgSO_4$, the solvent was removed under reduced pressure, and the residue was distilled. Yield 5.88 g (68%), yellow liquid, bp 141–143°C (bp 143–145°C[5e]). ^{1}H NMR spectrum (500 MHz, $CDCl_3$), δ, ppm: 1.57 (3H, s, CH_3); 3.31 (3H, s, CH_3O); 6.11 (1H, s, CH). ^{13}C NMR spectrum (125 MHz, $CDCl_3$), δ, ppm (*J*, Hz): 20.8 (CH_3); 52.8 (CH_3O); 106.8 ($CH_3\underline{C}$); 108.2 (tq, $^1J_{CF}$ = 256.5, $^2J_{CF}$ = 40.4, CF_2); 110.7 (CH); 117.9 (qt, $^1J_{CF}$ = 287.0, $^2J_{CF}$ = 35.3, $\underline{C}F_3$); 173.5 (t, $^2J_{CF}$ = 30.4, $CF_2\underline{C}$); 199.5 (C=O). ^{19}F NMR spectrum (470 MHz, $CDCl_3$), δ, ppm (*J*, Hz): 40.2 (2F, dq, $^3J_{FF}$ = 2.3, $^2J_{FF}$ = 10.0, CF_2); 78.6 (3F, t, $^3J_{FF}$ = 2.0, CF_3). Found, %: C 38.92; H 2.71. $C_8H_7F_5O_3$. Calculated, %: C 39.04; H 2.87.

3-(1,1,2,2,2-Pentafluoroethyl)-5-[({1-[3-(1,1,2,2,2-pentafluoroethyl)-1*H*-pyrazol-5-yl]ethylidene}hydrazinylidene)ethyl]-1*H*-pyrazole (3). Lithium diketonate **1b** (0.57 g, 2 mmol) (or furanone **2b** (0.49 g, 2 mmol)) and hydrazine hydrate (0.50 g, 10 mmol) were dissolved in glacial AcOH (20 ml). The mixture was heated to 100°C in a water bath for 5 h, then water (70 ml) was added. The formed precipitate was filtered off, and the product was purified by recrystallization from Et_2O–hexane, 1:2 mixture. Yield 0.35 g (77%, from compound **2b**), white powder, mp 234–235°C. ^{1}H NMR spectrum (400 MHz, DMSO-d_6), δ, ppm: 2.34 (6H, s, $2CH_3$); 7.27 (2H, s, 2CH); 14.34 (2H, s, 2NH). ^{13}C NMR spectrum (125 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 15.2 (CH_3); 101.6 (tq, $^1J_{CF}$ = 249.2, $^2J_{CF}$ = 38.8, CF_2); 105.8 (C-4); 118.6 (qt, $^1J_{CF}$ = 285.8, $^2J_{CF}$ = 38.2, CF_3); 140.0 (t, $^2J_{CF}$ = 28.5, $CF_2\underline{C}$); 142.7 (C-5); 151.1 (C=N). ^{19}F NMR spectrum (376 MHz, DMSO-d_6 + C_6F_6), δ, ppm: 51.7 (2F, s, CF_2); 79.0 (3F, t, *J* = 3.8, CF_3). Found, %: C 36.98; H 2.11; N 18.35. $C_{14}H_{10}F_{10}N_6$. Calculated, %: C 37.18; H 2.23; N 18.58.

5,6a-Dihydroxy-3a-methyl-5-(1,1,2,2,2-pentafluoroethyl)hexahydro-2*H*-furo[2,3-*d*]imidazol-2-one (4). Lithium diketonate **1b** (0.57 g, 2 mmol) (or furanone **2b** (0.49 g, 2 mmol)) and urea (0.18 g, 3 mmol) were dissolved in glacial AcOH (15 ml); the mixture was kept at 40°C for 7 h. The formed precipitate was filtered off, washed with Et_2O (2×5 ml), and dried at 70°C. Yield 0.44 g (75%, from compound **2b**), white powder, mp 149–150°C. ^{1}H NMR spectrum (400 MHz, DMSO-d_6), δ, ppm: 1.30 (3H, s, CH_3); 2.38 (2H, s, CH_2); 6.15 (1H, s, OH); 7.28 (1H, s, OH); 7.42 (1H, s, NH); 7.57 (1H, s, NH). ^{13}C NMR spectrum (125 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 20.7 (CH_3); 44.2 (CH_2); 91.0 ($CH_3\underline{C}$); 99.1 (C–OH); 99.9 (m, $CF_2\underline{C}$); 111.6 (tq, $^1J_{CF}$ = 261.3, $^2J_{CF}$ = 34.2, CF_2); 118.7 (qt, $^1J_{CF}$ = 287.2, $^2J_{CF}$ = 35.8, CF_3); 157.7 (C=O). ^{19}F NMR

spectrum (376 MHz, DMSO-d_6 + C_6F_6), δ, ppm (*J*, Hz): 34.1 (1F, d, $^2J_{FF}$ = 270.6, CF<u>F</u>); 38.6 (1F, d, $^2J_{FF}$ = 270.8, C<u>F</u>F); 83.8 (3F, s, CF_3). Found, %: C 32.77; H 3.03; N 9.50. $C_8H_9F_5N_2O_4$. Calculated, %: C 32.89; H 3.11; N 9.59.

3-(1-Hydroxyethanimidoyl)-5-(1,1,2,2,2-pentafluoroethyl)-4,5-dihydro-1,2-oxazol-5-ol (5). Lithium diketonate **1b** (0.57 g, 2 mmol) (or furanone **2b** (0.49 g, 2 mmol)) and hydroxylamine hydrochloride (0.28 g, 4 mmol) were dissolved in EtOH (10 ml); the mixture was heated under reflux for 4 h. Upon completion of the reaction, the solvent was evaporated under reduced pressure, the solid residue was washed with a mixture Et_2O–hexane, 1:1, and dried at 70°C. Yield 0.45 g (84%, from compound **2b**), white powder, mp 247–248°C (decomp.). ^{1}H NMR spectrum (400 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 2.03 (3H, s, CH_3); 3.28 (1H, d, $^2J_{HH}$ = 18.7, C<u>H</u>H); 3.58 (1H, d, $^2J_{HH}$ = 18.5, CH<u>H</u>); 8.83 (1H, s, OH); 12.11 (1H, s, OH). ^{13}C NMR spectrum (125 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 10.1 (CH_3); 41.2 (CH_2); 105.6 (m, CF_2<u>C</u>); 111.3 (tq, $^1J_{CF}$ = 260.4, $^2J_{CF}$ = 36.3, CF_2); 118.5 (qt, $^1J_{CF}$ = 287.2, $^2J_{CF}$ = 35.3, CF_3); 147.6 (C=NOH); 156.9 (C=N). ^{19}F NMR spectrum (376 MHz, DMSO-d_6 + C_6F_6), δ, ppm (*J*, Hz): 35.7 (1F, d, $^2J_{FF}$ = 274.0, CF<u>F</u>); 40.2 (1F, d, $^2J_{FF}$ = 274.0, C<u>F</u>F); 88.4 (3F, s, CF_3). Found, %: C 31.99; H 2.57; N 10.56. $C_7H_7F_5N_2O_3$. Calculated, %: C 32.07; H 2.69; N 10.69.

5-(1-Hydrazinylideneethyl)-3-(1,1,2,2,2-pentafluoroethyl)-1*H*-pyrazole (6). Hydrazine hydrate (0.20 g, 4 mmol) was added to a solution of furanone **2b** (0.50 g, 2 mmol) in MeOH (15 ml), and the mixture was heated under reflux for 2 h. The solvent was then evaporated under reduced pressure, the residue was washed with hexane and dried. Yield 0.32 g (66%), white powder, mp 127–128°C. ^{1}H NMR spectrum (500 MHz, DMSO-d_6), δ, ppm: 2.01 (3H, s, CH_3); 6.66 (2H, s, NH_2); 6.76 (1H, s, CH); 13.63 (1H, s, NH). ^{13}C NMR spectrum (100 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 11.9 (CH_3); 101.4 (C-4); 111.0 (tq, $^1J_{CF}$ = 248.7, $^2J_{CF}$ = 39.0, CF_2); 118.7 (qt, $^1J_{CF}$ = 286.0, $^2J_{CF}$ = 38.0, CF_3); 132.7 (C-5); 139.5 (t, $^2J_{CF}$ = 28.2, CF_2<u>C</u>); 144.8 (C=N). ^{19}F NMR spectrum (470 MHz, DMSO-d_6 + C_6F_6), δ, ppm: 51.9 (2F, s, CF_2); 79.0 (3F, s, CF_3). Found, %: C 34.64; H 2.78; N 23.03. $C_7H_7F_5N_4$. Calculated, %: C 34.72; H 2.91; N 23.14.

Synthesis of substituted furans 7 and 8 (General method). Hydrazine monohydrate (0.10 g, 2 mmol) (or phenylhydrazine (2 mmol)) was added to a solution of furanone **2b** (0.50 g, 2 mmol) in MeOH (15 ml) at 0–10°C. The reaction mixture was then stirred for 1 h. The formed precipitate was filtered off and washed with Et_2O (2×5 ml).

[2,5-Dimethoxy-2-methyl-5-(1,1,2,2,2-pentafluoroethyl)-dihydrofuran-3(2*H*)-ylidene]hydrazine (7). Yield 0.37 g (66%), white powder, mp 115–116°C. ^{1}H NMR spectrum (400 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 1.42 (3H, s, CH_3); 2.85 (1H, d, $^2J_{HH}$ = 18.2, C<u>H</u>H); 3.00 (1H, d, $^2J_{HH}$ = 18.5, CH<u>H</u>); 3.11 (3H, s, CH_3O); 3.14 (3H, s, CH_3O); 7.22 (1H, s, NH); 7.56 (1H, s, NH). ^{19}F NMR spectrum (376 MHz, DMSO-d_6 + C_6F_6), δ, ppm (*J*, Hz): 38.03 (1F, d, $^2J_{FF}$ = 268.8, C<u>F</u>F); 43.74 (1F, d, $^2J_{FF}$ = 269.0, CF<u>F</u>); 83.81 (3F, s, CF_3). Found, %: C 36.64; H 4.25; N 9.31. $C_9H_{13}F_5N_2O_3$. Calculated, %: C 36.99; H 4.48; N 9.59.

2-Methoxy-2-methyl-5-(1,1,2,2,2-pentafluoroethyl)-5-(2-phenylhydrazinyl)dihydrofuran-3(2*H*)-one (8). Yield 0.51 g (84%), white powder, mp 112–113°C. ^{1}H NMR spectrum (400 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 1.36 (3H, s, CH_3); 2.82 (1H, d, $^2J_{HH}$ = 18.6, C<u>H</u>H); 3.09 (1H, d, $^2J_{HH}$ = 18.6, CH<u>H</u>); 3.38 (3H, s, CH_3); 6.28 (1H, s, NH); 6.42 (1H, s, NH); 6.71 (1H, t, *J* = 8.0, H Ph); 6.80–6.82 (2H, m, H Ph); 7.12–7.16 (2H, m, H Ph). ^{19}F NMR spectrum (376 MHz, DMSO-d_6 + C_6F_6), δ, ppm (*J*, Hz): 36.9 (1F, d, $^2J_{FF}$ = 277.2, CF<u>F</u>); 42.2 (1F, d, $^2J_{FF}$ = 277.4, CF<u>F</u>); 84.17 (3F, s, CF_3). Found, %: C 47.21; H 4.07; N 26.62. $C_{14}H_{15}F_5N_2O_3$. Calculated, %: C 47.46; H 4.27; N 26.81.

1-[3-(1,1,2,2,2-Pentafluoroethyl)-1*H*-pyrazol-5-yl]-ethanone (9). 20% Aqueous HCl (25 ml) was added to compound **7** (0.3 g, 1 mmol), the reaction mixture was heated under reflux for 2 h, the formed precipitate was then filtered off and dried. Yield 0.22 g (95%), white powder, mp 86–87°C. ^{1}H NMR spectrum (500 MHz, DMSO-d_6), δ, ppm: 2.55 (3H, s, CH_3); 7.54 (1H, s, CH); 14.73 (1H, s, NH). ^{13}C NMR spectrum (125 MHz, DMSO-d_6), δ, ppm (*J,* Hz): 27.3 (CH_3); 108.8 (CH); 110.5 (tq, $^1J_{CF}$ = 249.4, $^2J_{CF}$ = 38.9, CF_2); 118.7 (qt, $^1J_{CF}$ = 285.7, $^2J_{CF}$ = 38.3, CF_3); 140.1 (t, $^2J_{CF}$ = 28.8, CF_2<u>C</u>); 142.6 (C-5); 188.3 (C=O). ^{19}F NMR spectrum (470 MHz, DMSO-d_6 + C_6F_6), δ, ppm: 51.6 (2F, s, CF_2); 78.9 (3F, s, CF_3). Found, %: C 36.78; H 2.14; N 12.11. $C_7H_5F_5N_2O$. Calculated, %: C 36.86; H 2.21; N 12.28.

Reaction of 2-methoxy-2-methyl-5-(perfluoroethyl)furan-3(2*H*)-one (2b) with *o*-phenylenediamine. *o*-Phenylenediamine (0.216 g, 2 mmol) was added to a solution of furanone **2b** (0.500 g, 2 mmol) in glacial AcOH (10 ml), and the mixture was heated under reflux for 3 h. After cooling to room temperature, water (50 ml) was added. The formed precipitate was filtered off, and the product was recrystallized from aqueous EtOH to afford 2-(1,1,2,2,2-pentafluoroethyl)-1*H*-benzimidazole (**10**). Yield 0.35 g (74%), white powder, mp 212–213°C (mp 210–212°C[8]). ^{1}H NMR spectrum (500 MHz, DMSO-d_6), δ, ppm: 7.36–7.43 (2H, m, H Ph); 7.70–7.78 (2H, m, H Ph); 13.96 (1H, br. s, NH). ^{19}F NMR spectrum (470 MHz, DMSO-d_6 + C_6F_6), δ, ppm (*J*, Hz): 49.8 (2F, q, $^2J_{FF}$ = 2.9, CF_2); 79.9 (3F, t, $^2J_{FF}$ = 3.0, CF_3). Found, %: C 45.64; H 1.98; N 11.73. $C_9H_5F_5N_2$. Calculated, %: C 45.78; H 2.13; N 11.86.

1-[7-Hydroxy-7-(trifluoromethyl)-4,7-dihydro[1,2,4]-triazolo[1,5-*a*]pyrimidin-5-yl]ethanone (11). Lithium diketonate **1a** (0.47 g, 2 mmol) (or furanone **2a** (0.39 g, 2 mmol)) and amino-1,2,4-triazole (0.168 g, 2 mmol) were dissolved in glacial AcOH (10 ml), the mixture was stirred at 30–35°C for 12 h. The formed precipitate was filtered off and washed with hexane. Yield 0.36 g (58%, from compound **2a**), white powder, mp 222–223°C. ^{1}H NMR spectrum (500 MHz, DMSO-d_6), δ, ppm: 2.51 (3H, s, CH_3); 5.95 (1H, s, CH); 7.87 (1H, s, CH); 8.55 (1H, s, NH); 10.96 (1H, s, OH). ^{13}C NMR spectrum (125 MHz, DMSO-d_6), δ, ppm (*J*, Hz): 25.5 (CH_3); 82.5 (q, $^2J_{CF}$ = 33.7, CF_3<u>C</u>); 100.2; 122.2 (q, $^1J_{CF}$ = 288.0, CF_3); 136.4; 148.7 (<u>C</u>COCH_3); 151.0; 192.5 (C=O). ^{19}F NMR spectrum (470 MHz, DMSO-d_6 + + C_6F_6), δ, ppm: 83.2 (3F, s, CF_3).

Found, %: C 38.63; H 2.69; N 22.42. $C_8H_7F_3N_4O_2$. Calculated, %: C 38.72; H 2.84; N 22.58.

1,1,1-Trifluoro-3-(2-methylpyrido[2,3-*b*]pyrazin-3(4*H*)-ylidene)propan-2-one (12). Furanone **2a** (0.392 g, 2 mmol) and 2,3-diaminopyridine (0.218 g, 2 mmol) were dissolved in glacial AcOH (10 ml), and the mixture was stirred at room temperature for 6 h. Water (50 ml) was then added, the formed precipitate was filtered off and washed with hexane. Yield 0.53 g (82%), yellow powder, mp 189–190°C. ^{1}H NMR spectrum (400 MHz, $CDCl_3$), δ, ppm (*J*, Hz): 2.64 (3H, s, CH_3); 5.96 (1H, s, CH); 7.46 (1H, br. s, H Ar); 8.12 (1H, d, *J* = 7.0, H Ar); 8.65 (1H, br. s, H Ar); 14.28 (1H, br. s, NH). ^{13}C NMR spectrum (125 MHz, $CDCl_3$), δ, ppm (*J*, Hz): 22.3 (CH_3); 85.7 ($\underline{C}COCF_3$); 117.1 (q, $^1J_{CF}$ = 288.0, CF_3); 122.2 (C-2(3)); 131.0 (C-3(2)); 136.3 (C-7); 140.1 (C-5); 147.2 (C-6); 151.2 (C-10); 157.0 (C-8); 178.4 (q, $^2J_{CF}$ = 34.4, $CF_3\underline{C}$). ^{19}F NMR spectrum (376 MHz, $CDCl_3$ + C_6F_6), δ, ppm: 85.2 (3F, s, CF_3). Found, %: C 51.55; H 3.05; N 16.34. $C_{11}H_8F_3N_3O$. Calculated, %: C 51.77; H 3.16; N 16.47.

X-ray structural analysis of compound 12 was performed on an automatic 4-circle diffractometer Xcalibur 3 with CCD-detector according to the standard routine (MoKα radiation, graphite monochromator, ω-scanning with 1° step at 295(2) K). Empirical absorption correction was introduced. The structure was solved with the direct method and refined against F^2 by the least-squares technique in the full-matrix anisotropic approximation for all non-hydrogen atoms. The positions of the hydrogen atoms of the CH bonds were calculated geometrically, the positions of the hydrogen atoms of the NH groups were refined independently in the isotropic approximation. All calculations were performed using the SHELXTL software set. The main crystallographic parameters of compound **12**: triclinic crystals, spatial symmetry group *P*1; *a* 7.1677(10), *b* 11.3987(18), *c* 14.1021(18) Å; α 82.982(12); β 81.581(11), γ 86.054(12)°; *V* 1129.7(3) Å^3. For substance with empirical formula $C_{11}H_8F_3N_3O$: *Z* 4; μ 0.134 mm^{-1}. At angles 3.61 < θ < 26.37°, 6257 reflections were collected, 4460 (R_{int} 0.0565) were independent, including 1405 with $I > 2\sigma(I)$. The final refinement parameters: R_1 0.2056, wR_2 0.2000 (over all reflections), R_1 0.0702, wR_2 0.1416 (over reflections with $I > 2\sigma(I)$) with the quality factor *GOOF* 0.997. Peaks of residual electron density 0.228/–0.249 e·Å^{-3}. The full set of X-ray structural data for compound **12** was deposited at the Cambridge Crystallographic Data Center (deposit CCDC 1905414).

Supplementary information file containing ^{1}H, ^{13}C, and ^{19}F NMR spectra of all synthesized compounds is available at the journal website at http://link.springer.com/journal/10593.

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