Synthesis of 5-aroylmethylpyrazoles and their hydrazones from difluoroboron chelates of aroylacetones

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A convenient method for the synthesis of 5-aroylmethylpyrazoles and their hydrazones from difluoroboron complexes of aroylacetones, acetals of amides, and hydrazines was developed.

Key words: aroylacetones, difluoroboron chelates, hydrazines, acetals of amides, 5-aroylmethylpyrazoles, hydrazones.

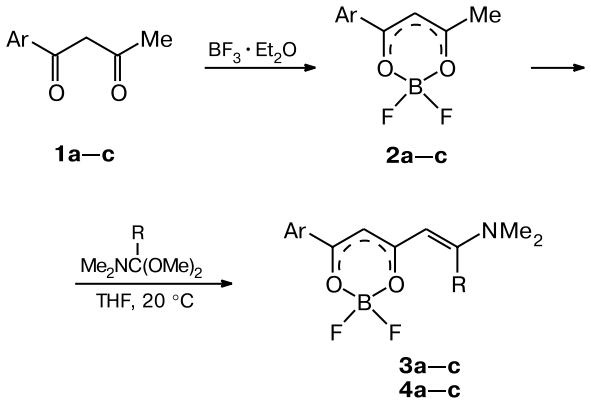
β-Diketones differ substantially from their boron chelates in chemical properties, which opens up the possibility of making non-standard use of these popular reagents in the synthesis of nitrogen-containing heterocycles. Earlier,[1] we have proposed a route to pyridazine derivatives through a difluoroboron chelate of acetylacetone. It has been found that arenediazonium salts react with the difluoroboron complex not only at the central C atom of the chelate ring but also at the exocyclic methyl group and alcoholysis of the resulting azo compounds brings about their deboronation and cyclization into 1-aryl-5-arylazo-6-methyl-1*H*-pyridazin-4-ones.

In the present work, we employed boron β-diketonates for the synthesis of functionalized pyrazoles. It has been reported[2] that a difluoroboron complex of benzoylacetone can undergo condensation with dimethylformamide dimethyl acetal on heating in DMF. Starting from aroylacetones **1a**—**c**, we synthesized difluoroboron chelates **2a**—**c**, which proved to react with dimethylformamide dimethyl acetal and dimethylacetamide dimethyl acetal in THF even at ~20 °C to give condensation products: chelate complexes **3a**—**c** and **4a**—**c**, respectively (Scheme 1).

1-Aryl-5-dimethylaminopent-4-ene-1,3-diones and 1-aryl-5-dimethylaminohex-4-ene-1,3-diones, which act as chelating ligands in compounds **3a**—**c** and **4a**—**c**, respectively, cannot be obtained directly from aroylacetones since acetals of amides are known[3] to react with β-diketones at the active methylene group.

Crystalline chelates **3a**—**c** and **4a**—**c** were isolated in good yields. They are stable in air, soluble in DMF, DMSO, pyridine, chloroform, and acetone, poorly soluble in THF, acetonitrile, and ethanol, and insoluble in ether and hexane. The ^{11}B NMR spectra of these chelates show signals at δ ~−1.12 to 0.24 corresponding to the tetra-

Scheme 1



R = H (**3**); Me (**4**); Ar = Ph (**a**), 4-ClC_6H_4 (**b**), 4-$MeOC_6H_4$ (**c**).

coordinated B atom. Their mass spectra contain molecular ion peaks [M^+]. The ^1H NMR spectra of compounds **3a**—**c** and **4a**—**c** in $CDCl_3$ show a set of signals with two characteristic singlets for the NMe_2 protons at δ ~3.00—3.32 and singlets for the CH protons of the chelate ring at δ ~6.05—6.12. For doublets due to the protons at the double bond in compounds **3a**—**c** (δ ~5.0 and 8.1), the coupling constant is ~12 Hz, which corresponds to the *E*-configuration.

We found that chelate complexes **3a**—**c** react with two equivalents of phenylhydrazine in boiling pyridine to give hydrazones of aroylmethylpyrazoles (**5a**—**c**). An analogous reaction of compound **4a** yielded pyrazole derivative **6** (Scheme 2). Earlier,[4] we have used this approach to obtain ethoxycarbonyl(pyrazolyl)ketene aminals from products prepared by condensation of a difluoroboron chelate of acetyl(ethoxycarbonyl)ketene *N*-benzoylaminal with acetals of amides.

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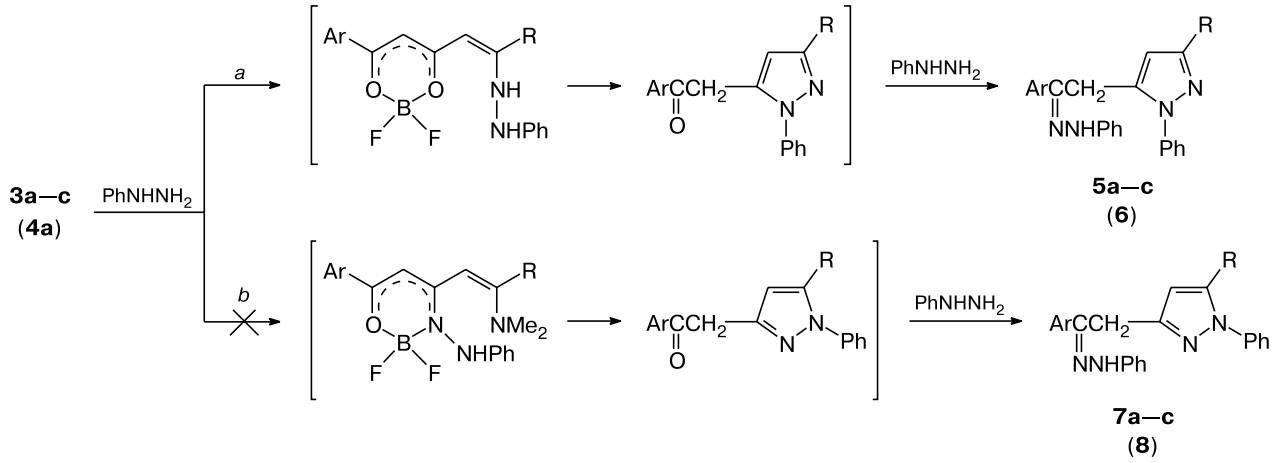
Scheme 2



5, 7: R = H, Ar = Ph (**a**), 4-ClC_6H_4 (**b**), 4-$MeOC_6H_4$ (**c**). **6, 8:** R = Me, Ar = Ph.

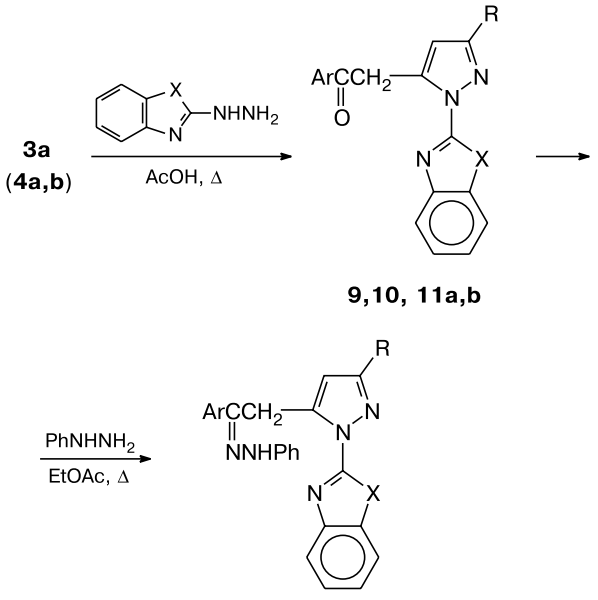
Apparently, the initial step of the process is replacement of the Me_2N group by a phenylhydrazino group (Scheme 2, pathway *a*). Subsequent steps involve cyclization with opening of the chelate ring and hydrazone formation *via* an interaction of a second phenylhydrazine molecule with the C=O group of the aroylmethyl substituent. Alternatively, cyclization could involve an initial attack of phenylhydrazine on the chelate ring of compounds **3** or **4** (pathway *b*), yielding compounds **7a—c** and **8**, which are isomeric with pyrazoles **5a—c** and **6**.

The exclusive formation of hydrazones **5a—c** and **6** was proved by 2D NMR spectroscopy (*i.e.*, boron chelates undergo regioselective transformations along pathway *a*). In the NOE-difference spectrum of pyrazole **5a**, irradiation of the CH_2 protons changes the intensities of the signals for the *ortho*-protons of two out of three benzene rings present in the molecule and of the signal for the CH proton in the pyrazole ring (although such an effect is possible in both structures **5a** and **7a**). The NOESY spectrum of compound **5a** shows cross peaks due to interactions of the NH proton with the aromatic protons of only one benzene ring. None of the *ortho*-protons in the two other benzene rings interacts with the NH proton. Therefore, two benzene rings, neither of which is bound to the NH group, are spatially close to the CH_2 group. Structure **5a** meets this condition, while structure **7a** does not.

Reactions of chelates **3** or **4** with one equivalent of phenylhydrazine also gave hydrazones **5** or **6**; however, intermediate aroylmethylpyrazoles were not detected.

It turned out that reactions of complexes **3a** and **4a,b** with benzoimidazolyl- and benzothiazolylhydrazines afford only 5-aroylmethyl-1-benzoazolylpyrazoles **9**, **10**, and **11a,b** (Scheme 3). Apparently, this is due to the lower nucleophilicity of the NH_2 group in these heterocyclic hydrazines compared to phenylhydrazine. Indeed, we failed to obtain the corresponding hydrazone by refluxing phenacylpyrazole **9** with an excess of benzothiazolylhydrazine in ethyl acetate in the presence of catalytic amounts of acetic acid. In contrast, a reaction of compound **9** with phenylhydrazine yielded the corresponding hydrazone **12**.

Scheme 3



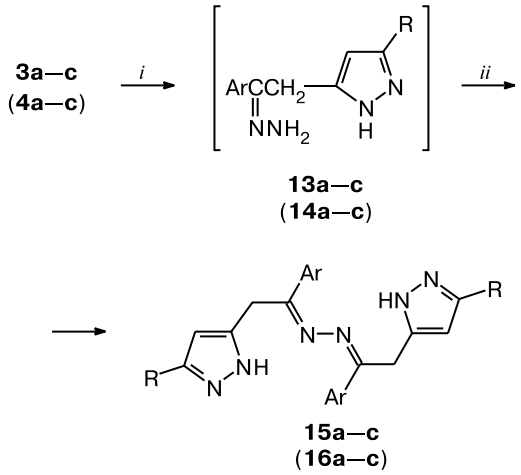
Compound	R	X	Ar
9	H	NH	Ph
10	H	S	Ph
11	Me	S	Ph (**a**), 4-ClC_6H_4 (**b**)
12	H	S	Ph

Compounds **9**, **10**, **11a,b**, and **12** form colorless crystals; they are moderately soluble in chloroform but are insoluble in ethanol, hexane, or diethyl ether.

The mass spectra of biheterocycles **9**, **10**, and **11a,b** contain molecular ion peaks [M^+]. Their ^{1}H NMR spectra show signals for the methylene protons as singlets at δ ~4.80—5.05 and for the H(4) proton of the pyrazole ring at δ ~6.00—6.50.

Treatment of complexes **3a**—**c** and **4a**—**c** with an excess of hydrazine hydrate under mild conditions gave 1-aryl-2-(pyrazol-3-yl)ethanone azines **15a**—**c** and **16a**—**c**, respectively (Scheme 4).

Scheme 4



Reagents and conditions: *i*. $N_2H_4 \cdot H_2O$, EtOH, 20 °C, 3—5 days. *ii*. H_2O, Δ.

R = H (**15**), Me (**16**)
Ar = Ph (**a**), 4-ClC_6H_4 (**b**), 4-$MeOC_6H_4$ (**c**)

Apparently, the reaction passes through the formation of intermediate hydrazones **13a**—**c** and **14a**—**c**, which undergo rapid self-condensation into the corresponding bisproducts **15a**—**c** and **16a**—**c**. It should be noted that intermediates **13a**—**c** and **14a**—**c** were detected by ^{1}H NMR spectroscopy. However, we failed to isolate oily compounds **13a**—**c** and **14a,c** from the reaction mixture, probably because of their easy transformations into azines **15a**—**c** and **16a,c**, respectively. In contrast, hydrazone **14b** was isolated in the crystalline form. According to ^{1}H NMR data, this compound is only slightly contaminated; however, attempts to purify it failed. When heated, hydrazone **14b** completely transformed into azine **16b**.

Azines **15a**—**c** and **16a**—**c** are yellow or pale yellow crystalline solids that are poorly soluble in organic solvents. The ^{1}H NMR spectra of compounds **15a**—**c** and **16a**—**c** contain signals for the methylene protons at δ ~4.20—4.32 and for the H(4) proton of the pyrazole ring at δ ~5.50—5.87 and a broadened singlet for the NH protons of the pyrazole rings at δ ~12.10—12.48. Compounds **15** and **16** can be regarded as potential polydentate ligands for the preparation of metal complexes.

Experimental

All manipulations with organoboron compounds were carried out under dry nitrogen; solvents were dehydrated. ^{1}H NMR spectra were recorded on a Bruker WM-250 instrument (250 MHz) at 25 °C. ^{11}B NMR spectra were recorded on a Bruker AC-200P instrument (64.21 MHz) with $BF_3 \cdot OEt_2$ as the external standard. Low-field signals with respect to the etherate are indicated with the "+" sign. IR spectra were recorded on a Specord M-82 instrument (in KBr pellets). Mass spectra were recorded on a KRATOS MS-30 instrument (EI, 70 eV).

Difluoroboron complexes of aroylacetones **2a**—**c** were prepared according to a modified procedure[5] by adding $BF_3 \cdot OEt_2$ to a solution of an appropriate diketone in benzene.

Difluoroboron chelates of 1-aryl-5-dimethylaminopent-4-ene-1,3-diones 3a—c and 1-aryl-5-dimethylaminohex-4-ene-1,3-diones 4a—c (general procedure). Dimethylformamide dimethyl acetal or dimethylacetamide dimethyl acetal (15 mmol) were added to a suspension of difluoroboron chelate **2a**—**c** (10 mmol) in THF (5 mL). The reaction mixture was allowed to stand at 20 °C for 16 h. The precipitate that formed was filtered off, washed with ether (20 mL), and dried *in vacuo* to give compounds **3a**—**c** and **4a**—**c**.

Difluoroboron chelate of 5-dimethylamino-1-phenylpent-4-ene-1,3-dione (3a). The yield was 93%, m.p. 215—216 °C (*cf.* Ref. 2: m.p. 215—216 °C). MS, *m/z* (I_{rel} (%)): 265 $[M]^+$ (82), 221 $[M - NMe_2]^+$ (100). ^{1}H NMR ($CDCl_3$), δ: 3.02, 3.29 (both s, 3 H each, N—Me); 5.05, 8.08 (both d, 1 H each, CH=, J = 12.2 Hz); 6.14 (s, 1 H, CH=); 7.48 (m, 3 H, Ar); 7.94 (d, 2 H, Ar, J = 8.5 Hz). IR, ν/cm^{-1}: 1644, 1592, 1560.

Difluoroboron chelate of 5-dimethylamino-1-phenylhex-4-ene-1,3-dione (4a). The yield was 81%, m.p. 253—255 °C. Found (%): C, 60.22; H, 6.13; N, 5.04. $C_{14}H_{16}BF_2NO_2$. Calculated (%): C, 60.25; H, 5.78; N, 5.02. MS, *m/z* (I_{rel} (%)): 279 $[M]^+$ (78), 235 $[M - NMe_2]^+$ (100). ^{1}H NMR (DMSO-d_6), δ: 2.60 (s, 3 H, Me); 3.21, 3.23 (both s, 3 H each, N—Me); 5.30, 6.50 (both s, 1 H each, CH=); 7.50 (m, 3 H, Ph); 7.82 (m, 2 H, Ph). IR, ν/cm^{-1}: 1608, 1552.

Difluoroboron chelate of 1-(4-chlorophenyl)-5-dimethylaminopent-4-ene-1,3-dione (3b). The yield was 93%, m.p. 233—234 °C. Found (%): C, 52.19; H, 4.28; N, 4.62. $C_{13}H_{13}BClF_2NO_2$. Calculated (%): C, 52.13; H, 4.37; N, 4.68. MS, *m/z* (I_{rel} (%)): 299 $[M]^+$ (69), 255 $[M - NMe_2]^+$ (100). ^{1}H NMR ($CDCl_3$), δ: 3.04, 3.29 (both s, 3 H each, N—Me); 5.05, 8.12 (both d, 1 H each, CH=, J = 11.8 Hz); 6.09 (s, 1 H, CH=); 7.41 (m, 2 H, Ar); 7.87 (d, 2 H, Ar, J = 9.2 Hz). IR, ν/cm^{-1}: 1640, 1580, 1560.

Difluoroboron chelate of 1-(4-chlorophenyl)-5-dimethylaminohex-4-ene-1,3-dione (4b). The yield was 86%, m.p. 271—272 °C. Found (%): C, 53.58; H, 4.86; N, 4.51. $C_{14}H_{15}BClF_2NO_2$. Calculated (%): C, 53.63; H, 4.82; N 4.47. MS, *m/z* (I_{rel} (%)): 313 $[M]^+$ (29), 269 $[M - NMe_2]^+$ (100). ^{1}H NMR (DMSO-d_6), δ: 2.57 (s, 3 H, Me); 3.11, 3.29 (both s, 3 H each, N—Me); 5.32, 6.48 (both s, 1 H each, CH=); 7.54, 7.83 (both d, 2 H each, Ar, J = 8.8 Hz). IR, ν/cm^{-1}: 1612, 1544.

Difluoroboron chelate of 5-dimethylamino-1-(4-methoxyphenyl)pent-4-ene-1,3-dione (3c). The yield was 91%, m.p. 222—223 °C. Found (%): C, 56.95; H, 5.49; N, 4.80. $C_{14}H_{16}BF_2NO_3$. Calculated (%): C, 56.98; H, 5.47; N, 4.75. MS, *m/z* (I_{rel} (%)): 295 $[M]^+$ (91), 251 $[M - NMe_2]^+$ (81). ^{1}H NMR ($CDCl_3$), δ: 3.00, 3.24 (both s, 3 H each, N—Me); 3.87 (s, 3 H, OMe); 5.03, 8.05 (both d, 1 H each, CH=, J = 12.2 Hz); 6.06 (s, 1 H, CH=); 6.93, 7.91 (both d, 2 H each, Ar, J = 8.8 Hz). IR, ν/cm^{-1}: 1652, 1588, 1504.

Difluoroboron chelate of 5-dimethylamino-1-(4-methoxyphenyl)hex-4-ene-1,3-dione (4c). The yield was 87%, m.p. 253—254 °C. Found (%): C, 58.25; H, 5.93; N, 4.55. $C_{15}H_{18}BF_2NO_3$. Calculated (%): C, 58.28; H, 5.87; N, 4.53. MS, *m/z* (I_{rel} (%)): 309 $[M]^+$ (22), 265 $[M - NMe_2]^+$ (26). ^{1}H NMR (DMSO-d_6), δ: 2.58 (s, 3 H, Me); 3.19, 3.21 (both s, 3 H each, N—Me); 3.82 (s, 3 H, OMe); 5.27, 6.38 (both s, 1 H each, CH=); 7.05, 7.80 (both d, 2 H each, Ar, J = 8.8 Hz). IR, ν/cm^{-1}: 1616, 1570, 1508.

Reactions of difluoroboron chelates 3a—c and 4c with phenylhydrazine (general procedure). A mixture of chelate **3a—c** or **4c** (1 mmol) and phenylhydrazine (2 mmol) was refluxed in pyridine (15 mL) for 4—5 h. The solvent was removed, chloroform was added, and the mixture was filtered through a thin layer of silica gel and concentrated. Recrystallization from benzene gave pyrazoles **5a—c** and **6** as white or cream-colored powders.

1-Phenyl-5-[2-phenyl-2-(phenylhydrazono)ethyl]pyrazole (5a). The yield was 67%, m.p. 177—178 °C. Found (%): C, 78.24; H, 5.65; N, 16.18. $C_{23}H_{20}N_4$. Calculated (%): C, 78.38; H, 5.72; N, 15.90. MS, *m/z* (I_{rel} (%)): 352 $[M]^+$ (100), 260 $[M - HNPh]^+$ (85). ^{1}H NMR (DMSO-d_6), δ: 4.22 (s, 2 H, CH_2); 5.96 (d, 1 H, H(4) pyraz., J = 1.2 Hz); 6.80 (br.s, 1 H, H(3) pyraz.); 7.68—7.15 (m, 15 H, Ar); 9.62 (s, 1 H, NH). IR, ν/cm^{-1}: 3260, 3052, 1600, 1584, 1560.

3-Methyl-1-phenyl-5-[2-phenyl-2-(phenylhydrazono)ethyl]pyrazole (6). The yield was 32%, m.p. 160—161 °C. Found (%): C, 78.56; H, 6.22; N, 15.46. $C_{24}H_{22}N_4$. Calculated (%): C, 78.66; H, 6.05; N, 15.29. MS, *m/z* (I_{rel} (%)): 366 $[M]^+$ (28), 274 $[M - HNPh]^+$ (35). ^{1}H NMR (DMSO-d_6), δ: 2.08 (s, 3 H, Me); 4.18 (s, 2 H, CH_2); 5.73 (s, 1 H, H(4) pyraz.), 7.67—7.15 (m, 15 H, Ar); 9.69 (s, 1 H, NH). IR, ν/cm^{-1}: 3276, 3052, 1604, 1588, 1548.

5-[2-(4-Chlorophenyl)-2-phenylhydrazono]ethyl-1-phenylpyrazole (5b). The yield was 60%, m.p. 188—189 °C. Found (%): C, 71.55; H, 5.05; N, 14.61. $C_{23}H_{19}ClN_4$. Calculated (%): C, 71.40; H, 4.95; N, 14.48. MS, *m/z* (I_{rel} (%)): 386 $[M]^+$ (65), 294 $[M - HNPh]^+$ (31). ^{1}H NMR (DMSO-d_6), δ: 4.24 (s, 2 H, CH_2); 5.92 (d, 1 H, H(4) pyraz., J = 1.2 Hz); 6.78 (br.s, 1 H, H(3) pyraz.); 7.67—7.21 (m, 14 H, Ar); 9.78 (s, 1 H, NH). IR, ν/cm^{-1}: 3260, 3052, 1600, 1580, 1556.

5-[2-(4-Methoxyphenyl)-2-phenylhydrazono]ethyl-1-phenylpyrazole (5c). The yield was 36%, m.p. 171—172 °C. Found (%): C, 75.28; H, 5.91; N, 14.73. $C_{24}H_{22}N_4O$. Calculated (%): C, 75.37; H, 5.80; N, 14.65. MS, *m/z* (I_{rel} (%)): 382 $[M]^+$ (75), 290 $[M - HNPh]^+$ (20), 263 (25). ^{1}H NMR (DMSO-d_6), δ: 4.20 (s, 2 H, CH_2); 5.90 (d, 1 H, H(4) pyraz., J = 1.2 Hz); 6.74 (br.s, 1 H, H(3) pyraz.); 7.67—6.82 (m, 14 H, Ar); 9.58 (s, 1 H, NH). IR, ν/cm^{-1}: 3256, 3004, 1600, 1540.

Reactions of difluoroboron chelates 3a and 4a,b with benzoazolylhydrazines (general procedure). A mixture of chelate **3a** or **4a,b** (1 mmol) and a benzoazolylhydrazine (2.5 mmol) was refluxed in acetic acid for 3 h. The flaky precipitate that formed was filtered off and recrystallized from little amount of ethyl acetate to give aroylmethylpyrazoles **9**, **10**, and **11a,b**.

1-(Benzoimidazol-2-yl)-5-phenacylpyrazole (9). The yield was 47%, m.p. 180—181 °C. Found (%): C, 71.18; H, 4.98; N, 18.72. $C_{18}H_{14}N_4O$. Calculated (%): C, 71.51; H, 4.67; N, 18.53. MS, *m/z* (I_{rel} (%)): 302 $[M]^+$ (46), 274 (12). ^{1}H NMR (DMSO-d_6), δ: 5.06 (s, 2 H, CH_2); 6.54 (s, 1 H, H(4) pyraz.); 7.85—7.09 (m, 8 H, Ph, H(3) pyraz.); 8.02 (d, 2 H, *o*-Ph, J = 7.3 Hz); 12.92 (s, 1 H, NH). IR, ν/cm^{-1}: 3360, 3140, 2912, 1700, 1632, 1592, 1568, 1556.

1-(Benzothiazol-2-yl)-5-phenacylpyrazole (10). The yield was 45%, m.p. 188—189 °C. Found (%): C, 67.18; H, 4.15; N, 13.13. $C_{18}H_{13}N_3OS$. Calculated (%): C, 67.69; H, 4.10; N, 13.16. MS, *m/z* (I_{rel} (%)): 319 $[M]^+$ (18). ^{1}H NMR (DMSO-d_6), δ: 5.04 (s, 2 H, CH_2); 6.43 (s, 1 H, H(4) pyraz.); 7.05 (m, 1 H, H(3) pyraz.); 8.09—7.32 (m, 9 H, Ar). ^{13}C NMR (DMSO-d_6), δ: 37.3 (CH_2); 112.3, 121.5, 122.7, 124.9, 126.5, 128.1, 128.7, 132.2, 133.1, 137.0, 139.2, 143.0, 150.5, 160.6, 195.3 (C=O). IR, ν/cm^{-1}: 3096, 2920, 1676, 1600, 1568, 1540.

1-(Benzothiazol-2-yl)-3-methyl-5-phenacylpyrazole (11a). The yield was 32%, m.p. 182—183 °C. Found (%): C, 67.97; H, 4.74; N, 12.56. $C_{19}H_{15}N_3OS$. Calculated (%): C, 68.45; H, 4.53; N, 12.60. MS, *m/z* (I_{rel} (%)): 333 $[M]^+$ (48), 187 (22). ^{1}H NMR (DMSO-d_6), δ: 2.29 (s, 3 H, Me); 5.00 (s, 2 H, CH_2); 6.45 (s, 1 H, H(4) pyraz.); 8.09—7.04 (m, 9 H, Ar). IR, ν/cm^{-1}: 3024, 2916, 1696, 1604, 1580, 1540.

1-(Benzothiazol-2-yl)-5-(4-chlorobenzoyl)methyl-3-methylpyrazole (11b). The yield was 41%, m.p. 175—176 °C. Found (%): C, 61.88; H, 3.95; N, 11.53. $C_{19}H_{14}ClN_3OS$. Calculated (%): C, 62.04; H, 3.84; N, 11.42. MS, *m/z* (I_{rel} (%)): 367 $[M]^+$ (52), 187 (17). ^{1}H NMR (DMSO-d_6), δ: 2.29 (s, 3 H, Me); 4.96 (s, 2 H, CH_2); 6.44 (s, 1 H, H(4) pyraz.); 7.04 (m, 1 H, Ar); 7.30 (m, 2 H, Ar); 7.67 (d, 2 H, Ar, J = 8.5 Hz); 7.97 (m, 1 H, Ar); 8.08 (d, 2 H, Ar, J = 8.5 Hz). IR, ν/cm^{-1}: 3026, 2924, 1684, 1604, 1580, 1540.

1-(Benzothiazol-2-yl)-5-[2-phenyl-2-(phenylhydrazono)ethyl]pyrazole (12). Two drops of glacial acetic acid were added to a solution of aroylmethylpyrazole **10** (0.32 g, 1 mmol) and phenylhydrazine (0.2 mL, 2 mmol) in ethyl acetate (10 mL). The reaction mixture was refluxed for 10 min and cooled to ~20 °C. The crystals that formed were filtered off and washed with ether. The yield of compound **12** was 0.29 g (72%), m.p. 184—185 °C (from ethyl acetate). Found (%): C, 70.48; H, 4.61; N, 16.93. $C_{24}H_{19}N_5S$. Calculated (%): C, 70.39; H, 4.68; N, 17.10. MS, *m/z* (I_{rel} (%)): 409 $[M]^+$ (49), 317 $[M - HNPh]^+$ (15), 302 (45). ^{1}H NMR (DMSO-d_6), δ: 4.80 (s, 2 H, CH_2); 6.04 (s, 1 H, H(4) pyraz.); 6.77 (br.s, 1 H, H(3) pyraz.); 8.12—7.15 (m, 14 H, Ar); 9.77 (s, 1 H, NH). IR, ν/cm^{-1}: 3268, 3064, 3032, 1604.

Reactions of difluoroboron chelates 3a—c and 4a,c with hydrazine hydrate (general procedure). A suspension of chelates **3a—c** or **4a,c** (2 mmol) and hydrazine hydrate (1 mL) in 96% ethanol (50 mL) was stirred for 3—5 days until the solution became completely colorless. Then the solvent and the excess of hydrazine hydrate were thoroughly removed *in vacuo*. The resulting oil was diluted with water (50 mL) and the mixture was refluxed for 4—5 h. The yellow precipitate that formed was filtered off and recrystallized from considerable amount of ethanol or ethyl acetate to give azines **15a—c** and **16a,c**.

1-Phenyl-2-(pyrazol-3-yl)ethanone azine (15a). The yield was 70%, m.p. 223—224 °C. Found (%): C, 71.37; H, 5.60;

N, 23.17. $C_{22}H_{20}N_6$. Calculated (%): C, 71.71; H, 5.47; N, 22.82. MS, *m/z* (I_{rel} (%)): 368 $[M]^+$ (4), 287 $[M - PyrCH_2]^+$ (91), 184 $[M/2]^+$ (66). ^{1}H NMR (DMSO-d_6), δ: 4.25 (s, 4 H, CH_2); 5.83 (s, 2 H, H(4) pyraz.); 7.42 (br.s, 6 H, Ph); 7.51 (s, 2 H, H(3) pyraz.); 7.96 (s, 4 H, *o*-Ph); 12.45, 12.68 (both s, 2 H each, NH). IR, ν/cm^{-1}: 3156, 3040, 2964, 2908, 1600, 1568.

2-(5-Methylpyrazol-3-yl)-1-phenylethanone azine (16a). The yield was 51%, m.p. 176—177 °C. Found (%): C, 72.61; H, 6.23; N, 21.37. $C_{24}H_{24}N_6$. Calculated (%): C, 72.70; H, 6.10; N, 21.20. MS, *m/z* (I_{rel} (%)): 396 $[M]^+$ (6), 301 $[M - PyrCH_2]^+$ (100), 199 $[M/2]^+$ (27). ^{1}H NMR (DMSO-d_6), δ: 2.02 (s, 6 H, Me); 4.22 (s, 4 H, CH_2); 5.52 (s, 2 H, H(4) pyraz.); 7.42 (br.s, 6 H, Ph); 7.99 (s, 4 H, *o*-Ph); 12.15, 12.28 (both s, 2 H each, NH). IR, ν/cm^{-1}: 3184, 3128, 3104, 3028, 2928, 2872, 1604, 1584, 1572.

1-(4-Chlorophenyl)-2-(pyrazol-3-yl)ethanone azine (15b). The yield was 46%, m.p. 216—217 °C. Found (%): C, 60.23; H, 4.24; N, 19.33. $C_{22}H_{18}Cl_2N_6$. Calculated (%): C, 60.42; H, 4.15; N, 19.22. MS, *m/z* (I_{rel} (%)): 436 $[M - H]^+$ (20), 355 $[M - PyrCH_2]^+$ (72), 219 $[M/2]^+$ (36). ^{1}H NMR (DMSO-d_6), δ: 4.21 (s, 4 H, CH_2); 5.85 (s, 2 H, H(4) pyraz.); 7.46 (s, 2 H, H(3) pyraz.); 7.48, 7.98 (both d, 4 H each, Ar, J = 8.2 Hz); 12.48, 12.67 (both s, 2 H each, NH). IR, ν/cm^{-1}: 3280, 3072, 1600.

1-(4-Methoxyphenyl)-2-(pyrazol-3-yl)ethanone azine (15c). The yield was 55%, m.p. 130—131 °C. Found (%): C, 67.02; H, 5.71; N, 19.78. $C_{24}H_{24}N_6O_2$. Calculated (%): C, 67.27; H, 5.65; N, 19.61. MS, *m/z* (I_{rel} (%)): 428 $[M]^+$ (17), 347 $[M - PyrCH_2]^+$ (100), 215 $[M/2]^+$ (46). ^{1}H NMR (DMSO-d_6), δ: 3.67 (s, 6 H, OMe); 4.30 (s, 4 H, CH_2); 5.83 (s, 2 H, H(4) pyraz.); 6.96 (d, 4 H, Ar, J = 8.8 Hz); 7.47 (s, 2 H, H(3) pyraz.); 7.96 (d, 4 H, Ar, J = 8.8 Hz); 12.45 (s, 2 H, NH); 12.66 (s, 2 H, NH). IR, ν/cm^{-1}: 3188, 3064, 2936, 1608.

1-(4-Methoxyphenyl)-2-(5-methylpyrazol-3-yl)ethanone azine (16c). The yield was 43%, m.p. 111—112 °C. Found (%): C, 68.23; H, 6.31; N, 18.62. $C_{26}H_{28}N_6O_2$. Calculated (%): C, 68.40; H, 6.18; N, 18.41. MS, *m/z* (I_{rel} (%)): 457 $[M + H]^+$ (6), 361 $[M - PyrCH_2]^+$ (100), 229 $[M/2]^+$ (38). ^{1}H NMR (DMSO-d_6), δ: 2.04 (s, 6 H, Me); 3.77 (s, 6 H, OMe); 4.24 (s, 4 H, CH_2); 5.51 (s, 2 H, H(4) pyraz.); 6.96 (d, 4 H, Ar, J = 8.8 Hz); 7.95 (d, 4 H, Ar, J = 8.8 Hz); 12.09 (s, 2 H, NH). IR, ν/cm^{-1}: 3200, 3132, 3030, 2940, 1600, 1512.

1-(4-Chlorophenyl)-2-(5-methylpyrazol-3-yl)ethanone azine (16b). A mixture of chelate **4b** (314 mg, 1 mmol) and hydrazine hydrate (0.5 mL) in 96% ethanol (25 mL) was stirred at room temperature for 3 days. Then the solution was carefully concentrated in a rotary evaporator. The white crystalline residue was thoroughly washed with water (50 mL) and hexane (20 mL) and dried *in vacuo*. The compound obtained (202 mg) was identified from spectroscopic and analytical data as 5-[2-(4-chlorophenyl)-2-hydrazonoethyl]-3-methylpyrazole (**14b**) containing few impurities. MS, *m/z* (I_{rel} (%)): 248 $[M]^+$ (100), 233 $[M - NH]^+$ (15), 153 (81), 111 (85). ^{1}H NMR (DMSO-d_6), δ: 2.13 (s, 3 H, Me); 3.82 (s, 2 H, CH_2); 5.79 (s, 1 H, H(4) pyraz.); 6.75 (s, 2 H, NH_2); 7.35 (d, 2 H, Ar, J = 8.2 Hz); 7.98 (d, 2 H, Ar, J = 8.2 Hz); 12.18 (br.s, 1 H, NH). Pyrazole **14b** was refluxed in water (30 mL) for 3 h. The precipitate that formed was filtered off, washed with water, and recrystallized from ethanol to give azine **16b** (77%), m.p. 242—243 °C. Found (%): C, 61.78; H, 4.88; N, 18.33. $C_{24}H_{22}Cl_2N_6$. Calculated (%): C, 61.94; H, 4.76; N, 18.06. MS, *m/z* (I_{rel} (%)): 464 $[M - H]^+$ (5), 369 $[M - PyrCH_2]^+$ (23), 233 $[M/2]^+$ (31). ^{1}H NMR (DMSO-d_6), δ: 2.04 (s, 6 H, Me); 4.17 (s, 4 H, CH_2); 5.50 (s, 2 H, H(4) pyraz.); 7.47, 7.98 (both d, 4 H each, Ar, J = 8.2 Hz); 12.14 (br.s, 2 H, NH). IR, ν/cm^{-1}: 3176, 3132, 3100, 3016, 2872, 1604, 1580.

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