Synthesis and Herbicidal Activity of 1,5-Diarylpyrazole Derivatives

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A series of diarylpyrazolecarboxylates and carboxamides were prepared, and their herbicidal activities were investigated. Some of these compounds showed noticeable pre-emergent herbicidal activities against various kinds of weeds. Among the synthesized compounds, methyl 4-chloro-1-(2,5-difluorophenyl)-5-(4-flurophenyl)-pyrazole-3-carboxylate 19t exhibited good activity. Diarylimidazolecarboxylates and carboxamides were also synthesized, but they did not show any herbicidal activities.

Key words pyrazolecarboxylate; pyrazolecarboxamide; herbicide; imidazolecarboxylate; imidazolecarboxamide

Pyrazole and imidazole compounds have attracted great interest in agrochemicals and drugs.[1] Aryl group substituted pyrazoles and imidazoles, in particular, have been studied because their biological activities are strongly dependent on their substituents on the pyrazole ring system. 1,5-Diaryl substituted pyrazole (SR141716A, **1**), which has a hydrazide group on the 3-position of the pyrazole ring, has recently been synthesized and identified as the first antagonist for the cannabinoid receptor.[2] A 3-trifluoromethyl group substituted 1,5-diarypyrazole derivative (SC-558, **2**) was reported to be a new class of selective inhibitors of cyclooxygenase-2 (cox-**2**).[3] As an agrochemical, 1-arylimidazole, which has a carboxylic ester group on the 4-position of the imidazole ring (**3**), was reported to be a herbicide antidote.[4] 1,5-Diaryl substituted 1,2,4-triazole-3-carboxamide, previously known as flupoxam (**4**),[5] is a selective herbicide against broadleaf weeds, and is completely safe against wheat (Fig. 1). We focused on the synthesis of 4-nonsubstituted or 4-chloro-substituted pyrazolecarboxamides (**5** or **6**), and 5-nonsubstituted or 5-chloro-substituted imidazole carboxamides (**7** or **8**) and sought to learn their herbicidal activities (Chart 1).

It was speculated that 1,5-diarylpyrazoles could be synthesized by condensation of arylhydrazines and aroylpyruvates, which were prepared from acetophenone derivatives and dimethyl oxalate. An arylhydrazine having the same substituents as flupoxam (**4**) was synthesized as shown in Chart 2. 2-Chlorobenzyl chloride (**9**) was treated with potassium nitrate and sulfuric acid to give the nitro-form (**10**). Introduction of a 1,1,1,2,2-pentafluoropropyl group was performed with the reaction of compound **10**, the corresponding alcohol, and potassium hydroxide. Reduction of the nitro group of compound **11**, without cleavage of the benzylic ether moiety, was accomplished with zinc powder in 90% acetic acid to afford the aniline derivative (**12**). Conversion of amino group into hydrazine proceeded by diazotization, followed by reduction with stannous chloride,[6] giving rise to the desired aryl hydrazine (**13a**) in good yield. With hydrazine in hand, compound **13a** was condensed with benzoylpyruvate (**15a**), which was prepared from acetophenone (**14a**) and dimethyl oxalate,[7] to give the desired 1,5-diarylpyrazole **16a** in 93.1% yield, along with 1,3-diarylpyrazole **17a** in 3.2% yield (Chart 3). These two isomers can be easily separated by silica gel column chromatography, and can be readily distinguished by their NMR spectra, because it is reported that the pyrazole C-4 proton in the 1,5-diarylisomer always resonates in a higher field than that in the 1,3-diarylisomer.[8] Conversion of the

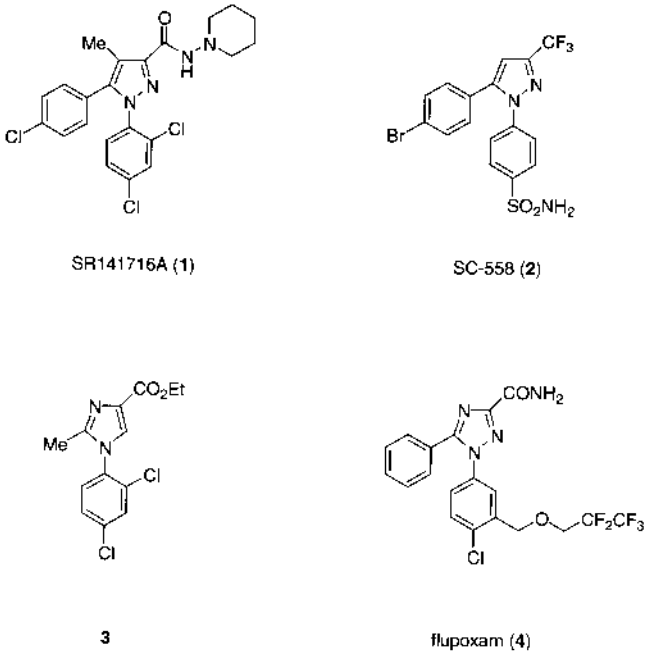

Fig. 1

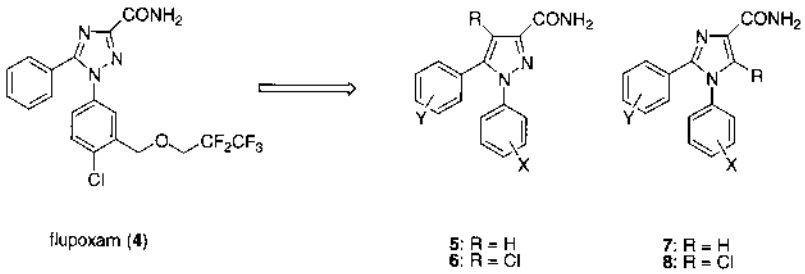

Chart 1

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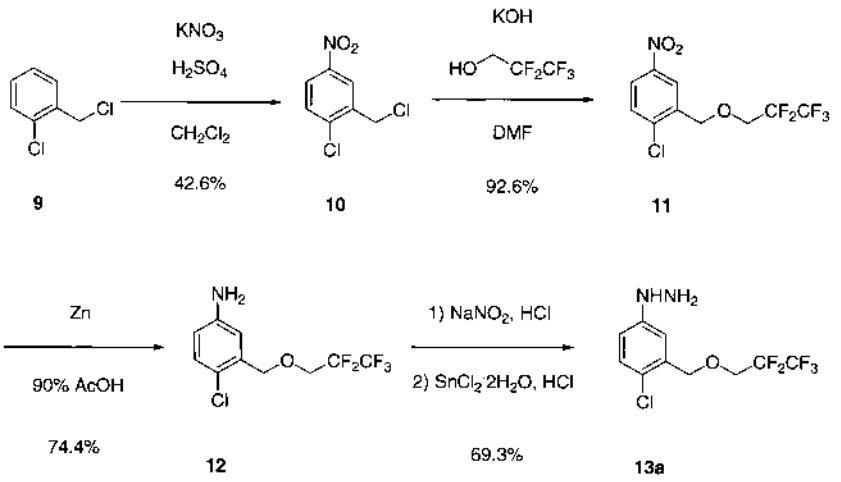


Chart 2

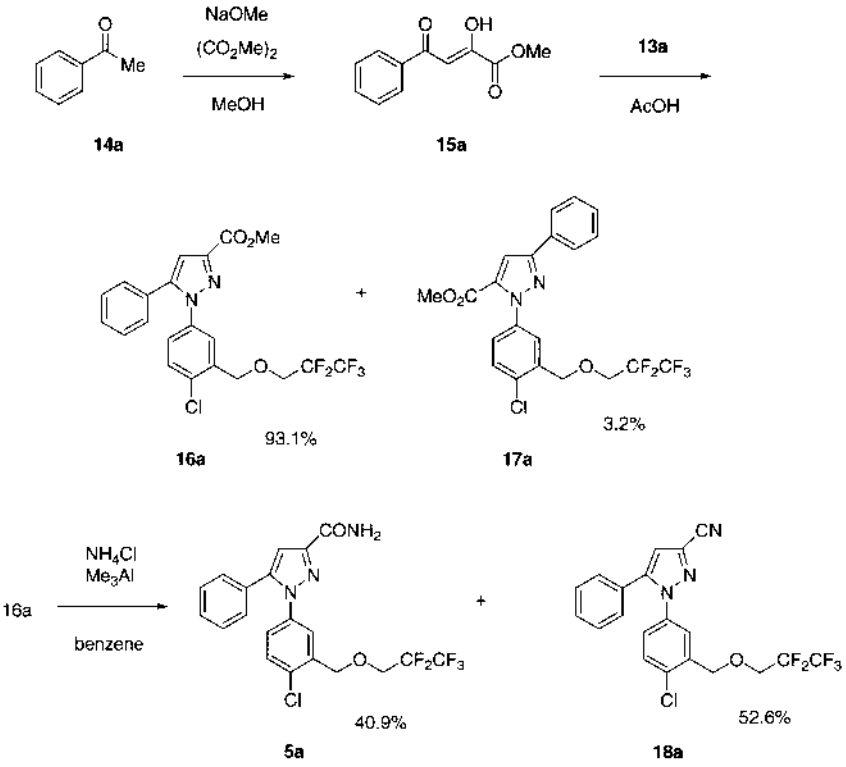


Chart 3

ester group to an amide group was accomplished using ammonium chloride and trimethyl aluminum in benzene at 60 °C[9] to give the desired pyrazole analogue of flupoxam (**5a**). A longer reaction time or a higher temperature afforded the corresponding cyano-form (**18a**) along with **5a**.[10] Compound **16a** was chlorinated with sulfuryl chloride to afford **19a.** Compound **19a** was converted to the desired 4-chloro substituted pyrazole analogue of flupoxam (**6a**) by the reagent generated from ammonium chloride and trimethylaluminum (Chart 4).

Contrary to our expectation, pyrazole analogues of flupoxam (**5a** and **6a**) did not show any herbicidal activities. But among the other concurrently synthesized derivatives, some 4-chloro substituted pyrazole esters showed slight or moderate herbicidal activities. Therefore, the next objective was optimization of the desired activity. A series of aroylpyruvates (**15**), prepared from corresponding acetophenones (**14**), were condensed with arylhydrazines (or their hydrochloride salts) to give 1,5-diarylpyrazole **16** (Chart 5). Treatment of **16** with sulfuryl chloride provided the chloride **19**, which was transformed into amide-form (**6**) using ammonium chloride and trimethyl aluminum together with cyano-form (**20**). A variety of pyrazole derivatives were synthesized in this manner. The results of these syntheses are shown in Table 1. Characterization data for new pyrazoles prepared during the course of this work are given in Tables 2—7.

Various ester and amide derivatives were synthesized as depicted in Chart 6. Hydrolysis of esters **19g** and **19t** afforded carboxylic acids **21g** and **21t**, respectively, which readily reacted with alcohols or amines in the presence of

Mukaiyama's reagent,[11] or substituted alkylhalides and potassium carbonate to yield the corresponding esters or amides (**22**). Reduction of the ester group using diisobutylaluminum hydride gave hydroxymethyl-derivative (**23t**). These results are summarized in Table 8.

Bromo-containing derivative was synthesized from **16t** with bromine instead of sulfuryl chloride (Chart 7).

Next, we planned to synthesize the imidazole analogue of flupoxam. It seemed difficult to synthesize the most direct imidazole analogue that has the same substituents as those of flupoxam, and 1-(3-methylphenyl)-1-phenyltriazole-3-carboxamide (triazofenamide, **25**) was reported to be useful as a herbicide (Fig. 2).[12] Therefore, we decided to synthesize imidazole analogues that have simple substituents as depicted in Charts 8 and 10. Benzamide oxime (**26**) smoothly reacted with methyl propiolate to give an adduct **27**, which was converted to imidazolecarboxylate (**28**), *via* [3,3]-sigmatropic rearrangement and subsequent dehydration, simply by heating in diphenyl ether.[13] Introduction of the other aromatic group was performed by treatment of **28** with 4-fluoronitrobenzene or 5-fluoro-2-nitrotoluene to afford **29** as a single isomer.

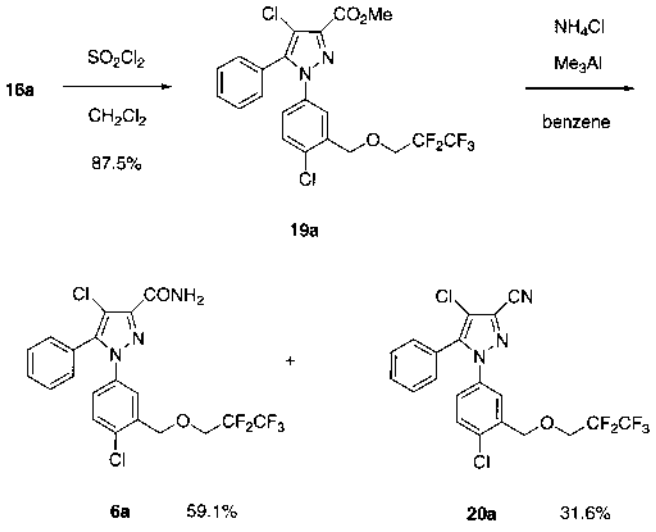


Chart 4

The structures of **29** were determined to be 1,2-diarylimidazole-4-carboxylate, and not 1,2-diarylimidazole-5-carboxylate, because the reaction of 2-methylimidazole-5-carboxylate (**30**) and 2,4-dinitrofluorobenzene reportedly afforded 1-(2,4-dinitrophenyl)-2-methylimidazole-4-carboxylate (the attack took place from the A-side) as shown in Chart 9.[4] It seems that 2,4-dinitrofluorobenzene attacked from the less sterically hindered A-side, rather than the B-side. Reduction of the nitro group with stannous chloride[14] afforded anilines (**32**), which were allowed to react with sodium nitrite and hypophosphorous acid[15] to give **33**. Chlorination with sulfuryl chloride gave chlorides **34**. Compounds **34** were treated with ammonium chloride and trimethylaluminum to yield the desired imidazole analogue of triazofenamide (**8**), together with nitriles **35**.

Biological Results

The comparative herbicidal activity of the synthesized compounds was measured at the whole plant level *via* a greenhouse assay. Some tested compounds showed good activity against barnyardgrass (*Echinochloa oryzicola* Vasing). The effects of substituents of the phenyl group on herbicidal activity are listed in Table 9. Pyrazole analogue of flupoxam (**5a** and **6a**) did not show any herbicidal activity, and the other pyrazole amide derivatives did not give satisfactory results. Compound **19b**, which has no substituent on the phenyl ring, exhibited a relatively high level of activity. The introduction of a chlorine atom (**19l**) or a methyl group (**19c**, **o**) to the aromatic ring slightly decreased the herbicidal activity; the introduction of a methoxy (**19h**) or nitro group (**19i**) gave no herbicidal activities. Replacement of the phenyl ring by a pyridine ring (**19j**, **k**) had a negative effect on the activity. But the introduction of two fluorine atoms into the 1-phenyl group and one fluorine atom into the 5-phenyl group gave the best result for enhancing its activity against all weeds (compound **19t**). The substitution of a chlorine atom on the 4-position of the pyrazole ring to a bromine atom (**24**) reduced the activity. Hydoxymethylsubstituted compound (**23t**), which was prepared by reduction of the corresponding ester (**19t**) showed decreased herbicidal activity. Carboxamide compounds (**6g**, **t**) proved to be less active than the corre-

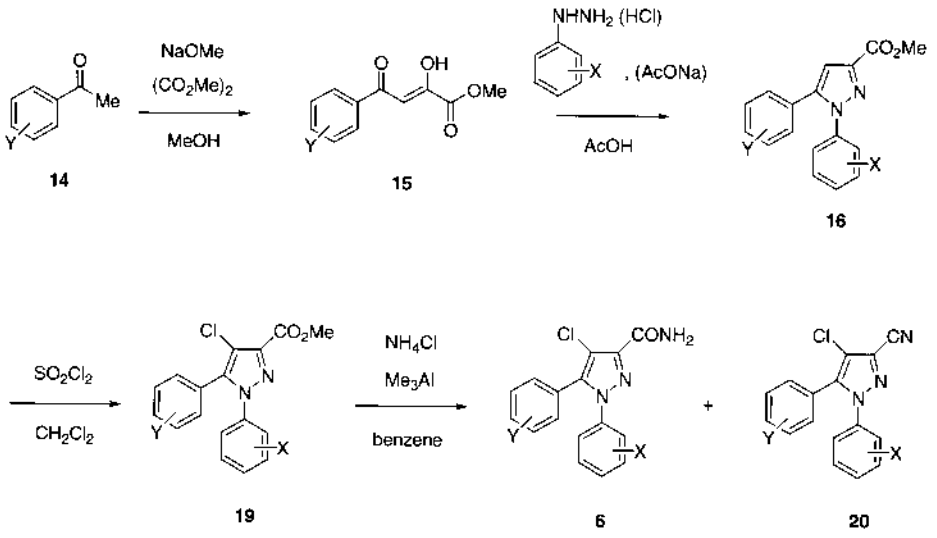
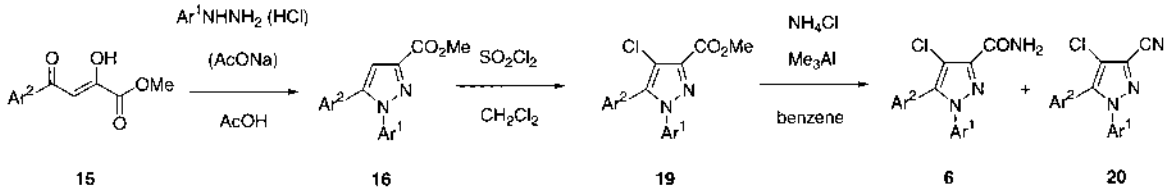


Chart 5

Table 1. Yields of Pyrazole Derivatives **6**, **16**, **19**, and **20**



Entry No.	Ar^1	Ar^2	**16**	**19**	**6**	**20**
b	C_6H_5	Ph	85.1	93.6	63.1	
c	3-MeC_6H_4	Ph	82.1	90.4	66.6	
d	4-MeC_6H_4	Ph	45.0	88.4	56.8	
e	4-ClC_6H_4	Ph	73.9	93.4	76.5	
f	4-FC_6H_4	Ph	Quant.	87.7	66.3	31.2
g	2,5-$F_2C_6H_3$	Ph	98.6	91.4	53.8	11.4
h	4-$MeOC_6H_4$	Ph	86.8	99.6	41.6	
i	4-$NO_2C_6H_4$	Ph	94.1	90.3	61.0	26.1
j	2-Pyridyl	Ph	56.8	95.7	32.4	47.8
k	3-Cl-5-CF_3-2-Pyridyl	Ph	Quant.	41.8	58.3	11.8
l	Ph	3-ClC_6H_4	96.9	83.2	71.0	5.8
m	Ph	4-FC_6H_4	82.4	97.8	59.5	22.6
n	Ph	2-MeC_6H_4	Quant.	92.5	55.4	38.7
o	Ph	3-MeC_6H_4	84.0	87.0	81.8	17.6
p	3-MeC_6H_4	3-MeC_6H_4	91.9	87.8	53.9	35.5
q	3-MeC_6H_4	3-ClC_6H_4	93.0	83.6	78.8	
r	3-MeC_6H_4	4-FC_6H_4	96.9	98.6	65.3	21.7
s	4-ClC_6H_4	3-MeC_6H_4	89.2	76.8	23.6	
t	2,5-$F_2C_6H_3$	4-FC_6H_4	Quant.	79.1	72.2	8.0

Table 2. Spectral Data for Compounds **16**

16	^{1}H-NMR	IR	MS
c	2.33 (3H, s), 3.97 (3H, s), 7.02—6.97 (1H, m), 7.05 (1H, s), 7.16—7.34 (8H, m)	1723, 1237, 1194, 1117, 1014	292 (M^+), 261, 234, 91, 83 (base)
d	2.37 (3H, s), 3.97 (3H, s), 7.05 (1H, s), 7.12—7.34 (9H, m)	1718, 1709, 1230	292 (M^+, base), 261, 234, 131, 91
e	3.98 (3H, s), 7.05 (1H, s), 7.19—7.37 (9H, m)	1731, 1721, 1237	312 (M^+, base), 281, 254, 218, 104
f	3.98 (3H, s), 7.00—7.09 (3H, m), 7.18—7.36 (7H, m)	1723, 1514, 1236, 1221	296 (M^+, base), 265, 238, 104
g	3.97 (3H, s), 7.02—7.14 (3H, m), 7.21—7.35 (6H, m)	1718, 1254, 1228, 1177, 1125, 1006	314 (M^+, base), 283, 256, 116, 104
j	3.98 (3H, s), 7.06 (1H, s), 7.22—7.35 (6H, m), 7.59 (1H, d, J=8.1 Hz), 7.77—7.86 (1H, m), 8.38 (1H, dd, J=4.8, 1.5 Hz)	1714, 1470, 1240	278 (M^+-1, base), 246, 220, 78
k	3.98 (3H, s), 7.12 (1H, s), 7.20—7.36 (5H, m), 8.07 (1H, d, J=1.8 Hz), 8.75 (1H, br s)	1722, 1323, 1244, 1145	381 (M^+, base), 350, 314, 296
l	7.19—7.41 (8H, m), 7.02—7.08 (2H, m), 3.98 (3H, s)	1723, 1232, 1120	312 (M^+, base), 281, 254, 218, 117, 77
m	3.96 (3H, s), 6.95—7.04 (3H, m), 7.15—7.38 (7H, m)	1713, 1236	296 (M^+), 224, 165 (base), 123, 95
n	2.00 (3H, s), 3.99 (3H, s), 6.95 (1H, s), 7.16—7.26 (9H, m)	1723, 1233, 1119	292 (M^+, base), 261, 233, 77
o	2.25 (3H, s), 3.94 (3H, s), 6.91—6.95 (1H, m), 7.01 (1H, s), 7.05—7.14 (3H, m), 7.31 (5H, s)	1732, 1231, 1118	292 (M^+, base), 261, 234, 118, 77
p	2.26 (3H, s), 2.30 (3H, s), 3.93 (3H, s), 6.91—7.18 (8H, m), 7.27 (1H, s)	1723, 1240, 1195, 1116	306 (M^+, base), 275, 248, 232, 208, 91
q	2.35 (3H, s), 3.97 (3H, s), 7.07—6.97 (3H, m), 7.33—7.19 (6H, m)	1712, 1239	326 (M^+, base), 295, 268, 197, 91
r	2.20 (3H, s), 3.83 (3H, s), 6.91—6.82 (4H, m), 7.15—7.04 (5H, m)	1732, 1236, 1160, 1117	310 (M^+, base), 279, 252, 236, 131, 91
s	2.32 (3H, s), 3.98 (3H, s), 6.93—6.97 (1H, m), 7.03 (1H, s), 7.09 (1H, s), 7.15—7.36 (6H, m)	1720, 1237	326 (M^+, base), 295, 268, 232, 118
t	3.98 (3H, s), 6.98—7.35 (8H, m)	1721, 1255, 1224	332 (M^+, base), 301, 134, 122

sponding ester compounds (**19g**, **t**), but the introduction of a methyl or methoxy group into the carboxamide group increased the herbicidal activity (**22a**, **b**) (Table 9). Introduction of an aniline group decreased total herbicidal activity (**22d**, **e**). Modification of the ester moiety tended to maintain the herbicidal activity, but the activity moderately dropped off with increasing size of the ester substituents (**22i**, **j**, **k**). The isopropylester compound (**22k**) was not sufficiently active. The alkoxycarbonylalkylester compounds (**22m**, **n**, **o**, **p**) tended to maintain the activity, while the alkoxyalkylester compounds (**22q**, **r**) showed high herbicidal activity against *Lindernia pyxidaria* L. (LP), *Cyperus serotinus* Rottb. (CS), and *Eleocharis kuroguwai* Ohwi (EK), but modest activity against *Echinochloa oryzicola* Vasing (EO). Contrary to our expectation, imidazole ester (**34**) and amide (**8**) derivatives did not show satisfactory herbicidal activity.

In summary, some synthesized pyrazole-3-carboxylates showed acceptable levels of herbicidal activity and selectivity to transplanted rice. Although several compounds were investigated more fully in the greenhouse, none were consid-

Table 3. Spectral Data for Compounds **19**

19	^{1}H-NMR	IR	MS
a	3.80 (2H, dt, J=13.0 Hz for triplet, 1.1 Hz for doublet), 4.01 (3H, s), 4.65 (2H, s), 7.21—7.42 (8H, m)	1717, 1242, 1211, 1198	508 (M^+, base), 477, 265
b	4.00 (3H, s), 7.23—7.43 (10H, m)	1725, 1238, 1231, 1065	312 (M^+, base), 281, 219, 77
c	2.30 (3H, s), 3.99 (3H, s), 6.90—6.94 (1H, m), 7.12—7.15 (2H, m), 7.21—7.31 (3H, m), 7.34—7.39 (3H, m)	1732, 1236, 1197, 1066	326 (M^+, base), 295, 233, 91, 65
d	2.34 (3H, s), 4.00 (3H, s), 7.07—7.17 (4H, m), 7.24—7.31 (2H, m), 7.35—7.40 (3H, m)	1739, 1249, 1196, 1178	326 (M^+, base), 311, 295, 233, 194, 91
e	4.00 (3H, s), 7.13—7.42 (9H, m)	1727, 1257, 1182	346 (M^+, base), 315, 253, 214, 111, 75
f	3.99 (3H, s), 6.97—7.05 (2H, m), 6.97—7.05 (2H, m), 7.36—7.41 (3H, m)	1741, 1723, 1513, 1252, 1222, 1069	330 (M^+, base), 299, 237, 95
g	4.01 (3H, s), 6.95—7.16 (2H, m), 7.22—7.40 (6H, m)	1743, 1728, 1514, 1266, 1241, 1204, 1184	348 (M^+, base), 317, 255, 216, 150, 77
h	3.79 (3H, s), 4.00 (3H, s), 6.81 (2H, d, J=9.1 Hz), 7.17 (2H, d, J=9.1 Hz), 7.24—7.29 (2H, m), 7.35—7.40 (3H, m)	1727, 1514, 1349	342 (M^+, base), 327, 311, 194, 123
i	4.03 (3H, s), 7.31—7.26 (2H, m), 7.50—7.42 (5H, m), 8.19 (2H, d, J=9.1 Hz)	1730, 1526, 1346, 1254, 1179	357 (M^+, base), 326, 280, 264, 76
j	4.01 (3H, s), 7.24—7.41 (6H, m), 7.52 (1H, d, J=8.1 Hz), 7.74—7.83 (1H, m), 8.34 (1H, dd, J=4.4, 1.5 Hz)	1729, 1240, 1065	312 (M^+-1, base), 280, 190, 140, 78
k	3.99 (3H, s), 7.27—7.39 (5H, m), 8.04 (1H, d, J=1.6 Hz), 8.71 (1H, d, J=1.6 Hz)	1737, 1324, 1169, 1129, 1092	415 (M^+, base), 384, 322, 180
l	3.91 (3H, s), 7.04 (1H, d, J=7.4 Hz), 7.17—7.26 (8H, m)	1736, 1238, 1065	346 (M^+, base), 315, 253, 77
m	3.93 (3H, s), 6.96—7.05 (2H, m), 7.18—7.30 (7H, m)	1724, 1241, 1228, 1203, 1068	330 (M^+, base), 299, 237, 198, 77
n	2.04 (3H, s), 4.01 (3H, s), 7.14—7.39 (9H, m)	1721, 1234	326 (M^+, base), 295, 259, 233, 77
o	2.25 (3H, s), 3.94 (3H, s), 6.96—6.99 (1H, m), 7.07—7.29 (8H, m)	1725, 1237, 1222, 1064	326 (M^+, base), 295, 233, 77
p	2.32 (3H, s), 2.33 (3H, s), 4.00 (3H, s), 6.87—6.95 (1H, m), 7.00—7.04 (1H, m), 7.12—7.28 (6H, m)	1728, 1232, 1071	340 (M^+, base), 309, 247, 208, 91
q	2.33 (3H, s), 4.00 (3H, s), 6.87—6.93 (1H, m), 7.08—7.37 (7H, m)	1731, 1232, 1197, 1178	360 (M^+, base), 329, 302, 267, 91
r	2.32 (3H, s), 4.00 (3H, s), 6.87—6.93 (1H, m), 7.03—7.30 (7H, m)	1730, 1236	344 (M^+, base), 313, 286, 251, 91
s	2.35 (3H, s), 4.01 (3H, s), 6.98—7.03 (1H, m), 7.11 (1H, s), 7.19—7.32 (6H, m)	1721, 1235, 1070	360 (M^+, base), 329, 267, 228, 164, 149, 111, 75
t	4.00 (3H, s), 6.99—7.15 (4H, m), 7.24—7.32 (3H, m)	1733, 1232	366 (M^+, base), 335, 273, 234, 168

Table 4. Physical Data for Compounds **19**

19	mp (°C)	Formula	Analysis (%)					
			Calcd			Found		
			C	H	N	C	H	N
a	120—122	$C_{21}H_{15}Cl_2F_5N_2O_3$	49.53	2.97	5.50	49.64	3.20	5.54
b	153—155	$C_{17}H_{13}ClN_2O_2$	65.29	4.19	8.96	65.07	3.96	8.75
c	71—73	$C_{18}H_{15}ClN_2O_2$	66.16	4.63	8.57	65.99	4.37	8.52
d	131—133	$C_{18}H_{15}ClN_2O_2$	66.16	4.63	8.57	65.98	4.70	8.56
e	133—135	$C_{17}H_{12}Cl_2N_2O_2$	58.81	3.48	8.07	58.83	3.61	8.17
f	102—104	$C_{17}H_{12}ClFN_2O_2$	61.74	3.66	8.47	61.70	3.79	8.46
g	140—142	$C_{17}H_{11}ClF_2N_2O_2$	58.55	3.18	8.03	58.49	3.17	7.98
h	81—83	$C_{18}H_{15}ClN_2O_3$	63.07	4.41	8.17	62.78	4.58	8.03
i	172—173	$C_{17}H_{12}ClN_3O_4$	57.08	3.38	11.75	56.94	3.60	11.63
j	91—93	$C_{16}H_{12}ClN_3O_2$	61.25	3.86	13.39	61.04	3.62	13.32
k	119—122	$C_{17}H_{10}Cl_2F_3N_3O_2$	49.06	2.42	10.10	49.23	2.66	9.84
l	128—130	$C_{17}H_{12}Cl_2N_2O_2$	58.81	3.48	8.07	58.91	3.78	8.17
m	143—144	$C_{17}H_{12}ClFN_2O_2$	61.74	3.66	8.47	61.64	3.91	8.37
n	96—98	$C_{18}H_{15}ClN_2O_2$	66.16	4.63	8.57	66.17	4.84	8.61
o	121.5—122	$C_{18}H_{15}ClN_2O_2$	66.16	4.63	8.57	65.98	4.82	8.48
p	85	$C_{19}H_{17}ClN_2O_2$	66.96	5.03	8.22	67.15	5.05	8.16
q	85	$C_{18}H_{14}Cl_2N_2O_2$	59.85	3.91	7.76	59.75	3.98	7.71
r	100—102	$C_{18}H_{14}ClFN_2O_2$	62.71	4.09	8.13	62.81	4.12	8.23
s	142	$C_{18}H_{14}Cl_2N_2O_2$	59.85	3.91	7.76	59.92	4.03	7.66
t	98	$C_{17}H_{10}ClF_3N_2O_2$	55.68	2.75	7.64	55.85	2.64	7.68

ered to be worthy of detailed field evaluation.

Experimental

Synthesis All melting points (mp) are uncorrected. Infrared (IR) spectra were measured on a Perkin-Elmer 1600 spectrometer. ^{1}H-NMR spectra were recorded at 200 MHz on a Varian Gemini 200 spectrometer with tetramethylsilane as an internal standard. Mass spectra (MS) and high-resolution mass spectra (HRMS) were obtained with a JEOL JMS-D300 mass spectrometer and a VG Auto Spec M mass spectrometer.

4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)nitrobenzene (11) **11** was prepared according to the method described in reference 5.

4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)aniline (12) Zinc powder (8.00 g, 122 mmol) was added to a solution of **11** (4.07 g, 12.75 mmol) in 90% acetic acid (AcOH) (30 ml) at 0 °C and the resulting mixture

Table 5. Spectral Data for Compounds **6**

6	^{1}H-NMR	IR	MS
a	3.84 (2H, dt, *J*=13.0 Hz), 4.68 (2H, s), 5.90 (1H, br s), 6.86 (1H, br s), 7.17 (1H, dd, *J*=8.6, 2.5 Hz), 7.25—7.32 (3H, m), 7.34—7.45 (4H, m)	3483, 3314, 1667, 1480, 1210	493 (M^+, base), 477, 265
b	5.66 (1H, br s), 6.87 (1H, br s), 7.22—7.42 (10H, m)	3394, 3286, 3204, 1654	297 (M^+, base), 281, 219, 180, 149, 77
c	2.32 (3H, s), 6.05 (1H, br s), 6.91—6.96 (2H, m), 7.12—7.18 (3H, m), 7.22—7.32 (2H, m), 7.35—7.42 (3H, m)	3468, 3444, 3202, 3156, 1690, 1666	311 (M^+, base), 295, 91
d	2.35 (3H, s), 6.08 (1H, br s), 6.89 (1H, br s), 7.12 (4H, s), 7.24—7.32 (2H, m), 7.35—7.40 (3H, m)	3426, 3374, 3288, 3186, 1657	311 (M^+, base), 295, 149, 91
e	6.23 (1H, br s), 6.87 (1H, br s), 7.17—7.43 (9H, m)	3423, 3376, 1659, 1498	331 (M^+, base), 315, 214, 111, 75
f	5.58 (1H, br s), 6.84 (1H, br s), 6.99—7.09 (2H, m), 7.18—7.31 (4H, m), 7.37—7.42 (3H, m)	3391, 3292, 3207, 1659, 1514, 1336, 1220, 838	315 (M^+, base), 299, 198, 95, 75, 44
g	6.05 (1H, br s), 6.82 (1H, br s), 6.97—7.44 (8H, m)	3465, 3161, 1698	333 (M^+, base), 317, 216, 150, 77
h	3.80 (3H, s), 5.87 (1H, br s), 6.84 (2H, d, *J*=9.0 Hz), 7.16 (2H, d, *J*=9.0Hz), 7.24—7.30 (2H, m), 7.34—7.40 (3H, m)	3427, 3409, 1687, 1518, 1251	327 (M^+, base), 309, 149
i	5.83 (1H, br s), 6.86 (1H, br s), 7.28—7.32 (2H, m), 7.41—7.48 (5H, m), 8.02 (2H, d, *J*=9.1Hz)	3400, 3296, 3210, 1684, 1656, 1596, 1525, 1348	342 (M^+, base), 326, 280, 179, 76
j	7.19—7.36 (7H, m), 7.65—7.74 (1H, m), 8.34 (1H, dd, *J*=3.9, 1.0 Hz)	3393, 3214, 1655, 1468, 1456, 1337	298 (M^+), 297 (base), 280, 78
k	6.72 (1H, br s), 6.86 (1H, br s), 7.25—7.37 (5H, m), 8.05 (1H, d, *J*=2.2 Hz), 8.70 (1H, d, *J*=2.2Hz)	3413, 3302, 3267, 3189, 1693, 1664, 1331	400 (M^+), 365, 348, 180, 77, 44 (base)
l	6.30 (1H, br s), 6.89 (1H, br s), 7.08—7.13 (1H, m), 7.21—7.38 (8H, m)	3458, 3282, 3215, 1675	331 (M^+, base), 315, 253, 214, 77
m	5.68 (1H, br s), 6.86 (1H, br s), 7.04—7.14 (2H, m), 7.21—7.30 (4H, m), 7.34—7.39 (3H, m)	3456, 3287, 3215, 3151, 1688	315 (M^+, base), 299, 237, 198, 77
n	2.03 (3H, s), 6.47 (1H, br s), 6.94 (1H, br s), 7.14—7.38 (9H, m)	3473, 3281, 3202, 3147, 1681	311 (M^+, base), 295, 259, 231, 77
o	2.31 (3H, s), 5.90 (1H, br s), 6.88 (1H, br s), 7.00—7.35 (9H, m)	3407, 3287, 3192, 1657	311 (M^+, base), 295, 233, 194, 77
p	2.31 (6H, s), 6.62 (1H, br s), 6.89—7.02 (3H, m), 7.13—7.27 (6H, m)	3443, 3286, 3190, 1666	325 (M^+, base), 309, 91
q	2.32 (3H, d, *J*=1.6 Hz), 6.61 (1H, br s), 6.90—7.37 (9H, m)	3442, 3286, 3176, 1686, 1666	345 (M^+, base), 329, 267, 149, 108, 91
r	2.31 (3H, s), 6.63 (1H, br s), 6.90—7.29 (10H, m)	3443, 3286, 3162, 1669	329 (M^+, base), 313, 251, 212, 108, 91
s	2.34 (3H, s), 6.29 (1H, br s), 6.87 (1H, br s), 6.98—7.32 (8H, m)	3392, 3294, 3218, 1661	345 (M^+, base), 329, 228, 111, 75
t	6.26 (1H, br s), 6.83 (1H, br s), 7.01—7.31 (7H, m)	3461, 3289, 3168, 3086, 1694, 1611, 1511	351 (M^+, base), 335, 273, 234, 168, 95

Table 6. Physical Data for Compounds **6**

6	mp (°C)	Formula	Analysis (%)					
			Calcd			Found		
			C	H	N	C	H	N
a	130—132	$C_{20}H_{14}Cl_2F_5N_3O_2$	48.60	2.86	8.50	48.77	3.13	8.59
b	235—237	$C_{16}H_{12}ClN_3O$	64.54	4.06	14.11	64.33	4.11	13.87
c	164—166	$C_{17}H_{14}ClN_3O$	65.49	4.53	13.48	65.32	4.51	13.34
d	171—173	$C_{17}H_{14}ClN_3O$	65.49	4.53	13.48	65.26	4.56	13.26
e	187—189	$C_{16}H_{11}Cl_2N_3O$	57.85	3.34	12.65	57.58	3.56	12.47
f	262—264	$C_{16}H_{11}ClFN_3O$	60.87	3.51	13.31	60.70	3.73	13.06
g	189	$C_{16}H_{10}ClF_2N_3O$	57.59	3.02	12.59	57.48	2.96	12.47
h	184—186	$C_{17}H_{14}ClN_3O_2$	62.30	4.31	12.82	62.23	4.27	12.71
i	189	$C_{16}H_{11}ClN_4O_3$	56.07	3.24	16.35	56.09	3.36	16.34
j	124—126	$C_{15}H_{11}ClN_4O$	60.31	3.71	18.76	60.17	3.50	18.48
k	183	$C_{16}H_9Cl_2F_3N_4O$	47.90	2.26	13.97	48.10	2.44	13.91
l	177—179.5	$C_{16}H_{11}Cl_2N_3O$	57.85	3.34	12.65	57.88	3.61	12.48
m	217—220	$C_{16}H_{11}ClFN_3O$	60.87	3.51	13.31	60.83	3.75	13.34
n	116.5	$C_{17}H_{14}ClN_3O$	65.49	4.53	13.48	65.29	4.80	13.41
o	143	$C_{17}H_{14}ClN_3O$	65.49	4.53	13.48	65.71	4.70	13.44
p	151	$C_{18}H_{16}ClN_3O$	66.36	4.95	12.90	66.42	4.98	12.86
q	144—147	$C_{17}H_{13}Cl_2N_3O$	58.98	3.79	12.14	59.02	3.86	12.09
r	153—154	$C_{17}H_{13}ClFN_3O$	61.92	3.97	12.74	61.95	4.01	12.76
s	139	$C_{17}H_{13}Cl_2N_3O$	58.98	3.79	12.14	59.16	3.87	12.12
t	171.5	$C_{16}H_9ClF_3N_3O$	54.64	2.58	11.95	54.71	2.52	12.04

was stirred at room temperature for 35 min. The reaction mixture was diluted with water and ethyl acetate (AcOEt) and filtered through celite. The filtrate was extracted with AcOEt (×1), washed with saturated aqueous $NaHCO_3$ (×2) and brine (×1), dried over $MgSO_4$, and evaporated. The residue was subjected to silica gel column chromatography to give 2.75 g (74.4%) of **12** as a yellow oil. ^{1}H-NMR ($CDCl_3$) δ: 3.71 (2H, br s), 3.98 (2H, dt, *J*=13.1 Hz for triplet, *J*=1.2 Hz for doublet), 4.68 (2H, s), 6.56 (1H, dd, *J*=8.4, 2.9 Hz), 6.77 (1H, d, *J*=2.9 Hz), 7.12 (1H, d, *J*=8.4 Hz).

4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)phenylhydrazine (13a) Aniline **12** (1.18 g, 4.08 mmol) was diazotized with $NaNO_2$ (302 mg, 4.38 mmol) in concentrated HCl (8 ml), the resulting mixture was added to a solution of $SnCl_2 \cdot 2H_2O$ (2.85 g, 12.63 mmol) in concentrated HCl (10 ml) at 0 °C and the reaction mixture was stirred for 1.5 h. The reaction mixture was poured into saturated aqueous K_2CO_3 and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated. The residue was subjected to silica gel column chromatography

Table 7. Spectral Data for Compounds **20**

20	^{1}H-NMR	IR	MS
a	3.85 (2H, dt, J=13.0 Hz for triplet, 1.1 Hz for doublet), 4.67 (2H, s), 7.16—7.45 (8H, m)	2247, 1485, 1199	475 (M^+, base), 326, 145, 89
g	6.99—7.29 (5H, m), 7.34—7.45 (3H, m)	2247	315 (M^+), 295, 280, 216, 113, 77, 63 (base)
i	7.25—7.31 (2H, m), 7.41—7.53 (5H, m), 8.22 (2H, d, J=9.0 Hz)	2246, 1524, 1348	324 (M^+, base), 277, 243, 190, 139, 77
j	7.25—7.50 (7H, m), 7.78—7.87 (1H, m), 8.34 (1H, dd, J=4.8, 1.7 Hz)	2245, 1591, 1467, 1448, 1364, 1089, 790, 700	279 (M^+, base), 245, 216, 202, 78
k	7.44—7.25 (5H, m), 8.10 (1H, d, J=1.8 Hz), 8.71 (1H, d, J=1.8 Hz)	2250	382(M^+), 347 (base), 77
l	7.06—7.13 (1H, m), 7.21—7.44 (8H, m)	2246	313 (M^+, base), 278, 243, 77
m	7.05—7.14 (2H, m), 7.20—7.28 (4H, m), 7.35—7.42 (3H, m)	2245	297 (M^+, base), 261, 77
n	2.03 (3H, s), 7.43—7.15 (9H, m)	2245	293 (M^+, base), 258, 180, 149, 77
o	2.32 (3H, s), 6.98—7.02 (1H, s), 7.09 (1H, s), 7.21—7.28 (4H, m), 7.31—7.38 (3H, m)	2245	293 (M^+, base), 278, 77
p	6.89—7.02 (2H, m), 7.10—7.30 (6H, m)	2245	307 (M^+, base), 292, 91, 65
r	2.33 (3H, s), 6.90—6.94 (1H, m), 7.05—7.29 (7H, m)	2250	311 (M^+, base), 296, 275, 190, 91
t	7.01—7.30 (7H, m)	2249	333 (M^+, base), 313, 298, 234, 113

to give 862 mg (69.3%) of **13a** as a yellow oil. ^{1}H-NMR ($CDCl_3$) δ: 4.00 (2H, dt, J=13.2 Hz for triplet, J=1.2 Hz for doublet), 4.72 (2H, s), 6.73 (1H, dd, J=8.7, 2.9 Hz), 6.92 (1H, d, J=2.9 Hz), 7.20 (1H, d, J=8.7 Hz). IR ν_{max} cm^{-1} (KBr): 3344, 2391, 2889, 1476, 1201, 1150. MS (*m/z*): 304 (M^+, base), 288, 239, 155, 140, 112, 77. HRMS Calcd for $C_{10}H_{10}ClF_5N_2O$: 304.0402. Found: 304.0399.

Methyl Benzoylpyruvate (15a) Methyl benzoylpyruvate (**15a**) was prepared from acetophenone (**14a**) and dimethyl oxalate according to reference 7.

Methyl 1-[4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)phenyl]-5-phenylpyrazole-3-carboxylate (16a) and Methyl 1-[4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)phenyl]-3-phenylpyrazole-5-carboxylate (17a) A solution of **13a** (855 mg, 2.81 mmol) and **15a** (527 mg, 2.56 mmol) in AcOH (25 ml) was heated under reflux for 2 h. The reaction mixture was poured into a saturated aqueous $NaHCO_3$ solution and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 1.13 g (93.1%) of **16a** as a light yellow oil and 39 mg (3.2%) of **17a** as a yellow oil. **16a**: ^{1}H-NMR ($CDCl_3$) δ: 3.82 (2H, dt, J=13.1 Hz for triplet, 1.1 Hz for doublet), 3.98 (3H, s), 4.68 (2H, s), 7.05 (1H, s), 7.19—7.27 (3H, m), 7.31—7.39 (5H, m). IR ν_{max} cm^{-1} (KBr): 1726, 1235, 1198, 1121. MS (*m/z*): 474 (M^+), 443, 231, 167, 149 (base), 57. HRMS Calcd for $C_{21}H_{16}ClF_5N_2O_3$: 474.0770. Found: 474.0771. **17a**: ^{1}H-NMR ($CDCl_3$) δ: 3.83 (3H, s), 4.05 (2H, t, J=12.6 Hz), 4.82 (2H, s), 7.33 (1H, d, J=0.7 Hz), 7.36—7.51 (5H, m), 7.61 (1H, d, J=2.2 Hz), 7.84—7.89 (2H, m). IR ν_{max} cm^{-1} (KBr): 1733, 1214, 1194, 1118. MS (*m/z*): 474 (M^+, base), 354, 231, 149. HRMS Calcd for: $C_{21}H_{16}ClF_5N_2O_3$: 474.0770. Found: 474.0770.

1-[4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)phenyl]-5-phenylpyrazole-3-carboxamide (5a) and 1-[4-Chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)phenyl]-5-phenylpyrazole-3-carbonitrile (18a) A 1.01 M solution of trimethyl aluminum in hexane (8.0 ml, 8.08 mmol) was added to a suspension of NH_4Cl (454 mg, 8.49 mmol) in benzene (12 ml) and the mixture was stirred at room temperature for 1 h. To the resulting mixture was added a solution of **16a** (398 mg, 0.838 mmol) in benzene (4 ml) at room temperature and the mixture was stirred at 60 °C for 1 h. The reaction mixture was poured into diluted HCl and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 158 mg (40.9%) of **5a** as a white powder and 195 mg (52.6%) of **18a** as a white amorphous. **5a**: ^{1}H-NMR ($CDCl_3$) δ: 3.86 (2H, dt, J=13.0 Hz for triplet, 1.1 Hz for doublet), 4.71 (2H, s), 5.59 (1H, br s), 6.87 (1H, br s), 7.06 (1H, s), 7.18—7.27 (3H, m), 7.32—7.44 (5H, m). IR ν_{max} cm^{-1} (KBr): 3474, 3300, 1679, 1482, 1200. MS (*m/z*): 459 (M^+, base), 443, 231. *Anal*. Calcd for $C_{20}H_{15}ClF_5N_3O_2$: C, 52.24; H, 3.29; N, 9.14. Found: C, 52.41; H, 3.50; N, 9.14. **18a**: ^{1}H-NMR ($CDCl_3$) δ: 3.86 (2H, dt, J=13.0 Hz for triplet, 1.1 Hz for doublet), 4.69 (2H, s), 6.87 (1H, s), 7.18—7.26 (3H, m), 7.31—7.41 (5H, m). IR ν_{max} cm^{-1} (KBr): 2244, 1488, 1199. MS (*m/z*): 441 (M^+, base), 292, 129. HRMS Calcd for $C_{20}H_{13}ClF_5N_3O$: 441.0667. Found: 441.0667.

Methyl 4-Chloro-1-[4-chloro-3-(2,2,3,3,3-pentafluoropropoxymethyl)-phenyl]-5-phenylpyrazole-3-carboxylate (19a) SO_2Cl_2 (0.16 ml, 1.99 mmol) was added to a solution of **16a** (418 mg, 0.88 mmol) in dichloromethane (12 ml) and the resulting mixture was stirred for 6 h. The reaction mixture was poured into saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 417 mg (92.9%) of **19a** as a white powder, mp 120—122 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.80 (2H, dt, J=13.0 Hz for triplet, 1.1 Hz for doublet), 4.01 (3H, s), 4.65 (2H, s), 7.21—7.42 (8H, m). IR ν_{max} cm^{-1} (KBr): 1717, 1242, 1211, 1198. MS (*m/z*): 508 (M^+, base), 477, 265. *Anal*. Calcd for $C_{21}H_{15}Cl_2F_5N_2O_3$: C, 49.53; H, 2.97; N, 5.50. Found: C, 49.64; H, 3.20; N, 5.54.

Compounds **6a**—**6t**, **15**, **16b**—**16t**, **19b**—**19t**, and **20f**—**20t** were synthesized in the manner described above.

Methyl 1-(3-Methylphenyl)-5-phenylpyrazole-3-carboxylate (16c) Oil. HRMS Calcd for $C_{18}H_{16}N_2O_2$: 292.1212. Found: 292.1213.

Methyl 1-(4-Methylphenyl)-5-phenylpyrazole-3-carboxylate (16d) mp 93—95 °C, *Anal*. Calcd for $C_{18}H_{16}N_2O_2$: C, 73.96; H, 5.52; N, 9.58. Found: C, 73.99; H, 5.51; N, 9.55.

Methyl 1-(4-Chlorophenyl)-5-phenylpyrazole-3-carboxylate (16e) Oil, *Anal*. Calcd for $C_{17}H_{13}ClN_2O_2$: C, 65.29; H, 4.19; N, 8.96. Found: C, 65.11; H, 4.35; N, 8.93.

Methyl 1-(4-Fluorophenyl)-5-phenylpyrazole-3-carboxylate (16f) Oil, HRMS Calcd for $C_{17}H_{13}FN_2O_2$: 296.0961. Found: 296.0961.

Methyl 1-(2,5-Difluorophenyl)-5-phenylpyrazole-3-carboxylate (16g) mp 130—131 °C, *Anal*. Calcd for $C_{17}H_{12}F_2N_2O_2$: C, 64.97; H, 3.85; N, 8.91. Found: C, 64.51; H, 3.78; N, 8.84.

Methyl 5-Phenyl-1-(2-pyridyl)pyrazole-3-carboxylate (16j) Oil, *Anal*. Calcd for $C_{16}H_{13}N_3O_2$: C, 68.81; H, 4.69; N, 15.05. Found: C, 69.05; H, 4.85; N, 14.94.

Methyl 1-(3-Chloro-5-trifluoromethylpyridin-2-yl)-5-phenylpyrazole-3-carboxylate (16k) mp 119—121 °C, HRMS Calcd for $C_{17}H_{11}ClF_3N_3O_2$: 381.0492. Found: 381.0491.

Methyl 5-(3-Chlorophenyl)-1-phenylpyrazole-3-carboxylate (16l) Oil, HRMS Calcd for $C_{17}H_{13}ClN_2O_2$: 312.0666. Found: 312.0665.

Methyl 5-(4-Fluorophenyl)-1-phenylpyrazole-3-carboxylate (16m) mp 96 °C, *Anal*. Calcd for $C_{17}H_{13}FN_2O_2$: C, 68.91; H, 4.42; N, 9.46. Found: C, 68.96; H, 4.46; N, 9.48.

Methyl 5-(2-Methylphenyl)-1-phenylpyrazole-3-carboxylate (16n) Oil, HRMS Calcd for $C_{18}H_{16}N_2O_2$: 292.1212. Found: 292.1210.

Methyl 5-(3-Methylphenyl)-1-phenylpyrazole-3-carboxylate (16o) Oil, HRMS Calcd for $C_{18}H_{16}N_2O_2$: 292.1212. Found: 292.1213.

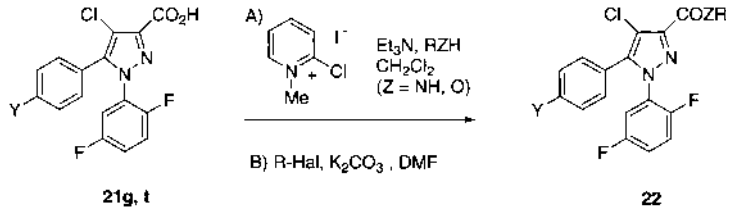
Methyl 1,5-Bis(3-methylphenyl)pyrazole-3-carboxylate (16p) Oil, HRMS Calcd for $C_{19}H_{18}N_2O_2$: 306.1368. Found: 306.1370.

Methyl 5-(3-Chlorophenyl)-1-(3-methylphenyl)pyrazole-3-carboxylate (16q) mp 82 °C, *Anal*. Calcd for $C_{18}H_{15}ClN_2O_2$: C, 66.16; H, 4.63; N, 8.57. Found: C, 66.14; H, 4.66; N, 8.53.

Methyl 5-(4-Fluorophenyl)-1-(3-methylphenyl)pyrazole-3-carboxylate (16r) Oil, HRMS Calcd for $C_{18}H_{15}FN_2O_2$: 310.1118. Found: 310.1116.

Methyl 1-(4-Chlorophenyl)-5-(3-methylphenyl)pyrazole-3-carboxylate (16s) mp 99—100 °C, HRMS Calcd for $C_{18}H_{15}ClN_2O_2$: 326.0822. Found:

Table 8. Yields and Spectral Data for Compounds **21** and **22**



21g, t **22**

Compound No.	Y	COZR	Condition	Yield (%)	^{1}H-NMR	IR	MS
21g	H	CO_2H		99.6	6.97—7.18 (2H, m), 7.24—7.42 (6H, m)	3069, 2978, 2882, 2757, 2610, 1702, 1515, 1499, 1260	334 (M^+, base), 317, 255, 216, 77
21t	F	CO_2H		97.1	6.99—7.07 (4H, m), 7.20—7.26 (3H, m)	3088, 2970, 2866, 2751, 2608, 1702, 1515, 1491, 1211	352 (M^+, base), 335, 273, 234, 168, 95
22a	H	CONHMe	A	78.2	3.01 (3H, d, J=5.0 Hz), 6.85 (1H, br s), 7.04—7.41 (8H, m)	3417, 1678, 1511	347 (M^+, base), 317, 290, 255, 216, 150, 77
22b	H	CONHOMe	A	51.6	3.92 (3H, s), 7.02—7.40 (8H, m), 9.33 (1H, s)	3226, 1681, 1513	363 (M^+), 333, 317 (base), 254, 216, 149, 77
22c	H	$CONHCMe_2Ph$	A	89.3	1.85 (6H, s), 6.97—7.39 (12H, m), 7.51 (2H, d, J=7.4 Hz),	3397, 1683, 1533, 1512	451 (M^+), 436, 317 (base), 59
22d	H	$CONH(2,6\text{-}Et_2C_6H_3)$	A	52.1	1.24 (6H, t, J=7.6 Hz), 2.72 (4H, q, J=7.6 Hz), 6.99—7.42 (11H, m), 8.18 (1H, br s)	3268, 2974, 1656, 1522, 1508	465 (M^+), 447, 402, 317, 216, 148 (base), 77
22e	H	$CONMe(4\text{-}ClC_6H_4)$	A	75.5	3.52 (3H, s), 6.83—7.10 (3H, m), 7.15—7.19 (4H, m), 7.26—7.35 (5H, m)	1654, 1515	457 (M^+), 317 (base), 150, 77
22f	H	$CON(iso\text{-}Pr)(4\text{-}FC_6H_4)$	A	84.2	1.23 (6H, d, J=6.8 Hz), 5.18 (1H, heptet, J=6.8 Hz), 7.33—6.81 (12H, m)	1663, 1509	469 (M^+), 317, 152 (base)
22g	H	$CON(iso\text{-}Pr)(2,4\text{-}F_2C_6H_3)$	A	35.9	1.19 (3H, dd, J=6.8, 2.2 Hz), 1.28 (3H, d, J=6.8 Hz), 5.14 (1H, heptet, J=6.8Hz), 6.68—7.34 (11H, m)	1652, 1511	487 (M^+), 317, 170 (base)
22h	F	CONHOMe	A	57.9	3.91 (3H, s), 7.02—7.29 (7H, m), 9.34 (1H, s)	3212, 1682, 1514, 1494, 1239	381 (M^+), 351, 335 (base), 234, 168
22i	F	CO_2Et	A	73.1	1.44 (3H, t, J=7.1 Hz), 4.48 (2H, q, J=7.1 Hz), 7.02—7.11 (4H, m), 7.23—7.31 (3H, m)	1721, 1517, 1227, 1202, 1064	380 (M^+, base), 335, 308, 273, 234, 168
22j	F	CO_2Pr	A	92.3	1.03 (3H, t, J=7.4 Hz), 1.83 (2H, sixtet, J=7.1 Hz), 4.38 (2H, t, J=6.8 Hz), 7.01—7.10 (4H, m), 7.23—7.30 (3H, m)	1720, 1517, 1225, 1200, 1063	394 (M^+, base), 352, 335, 306, 273, 234, 168
22k	F	CO_2iso-Pr	A	40.5	1.43 (6H, d, J=6.3 Hz), 5.37 (1H, heptet, J=6.3 Hz), 6.98—7.12 (4H, m), 7.23—7.32 (3H, m)	1723, 1515, 1467, 1237, 1204, 1106, 1062	394 (M^+), 352, 335, 308, 273 (base), 234, 168, 95
22l	F	CO_2CH_2(2-tetrahydrofuranyl)	A	68.7	1.67—2.05 (4H, m), 3.81—3.95 (2H, m), 4.32—4.43 (3H, m), 6.99—7.11 (4H, m), 7.23—7.30 (3H, m)	1733, 1515, 1226, 1198, 1058	436 (M^+), 353, 335, 168, 84, 71 (base), 43
22m	F	$CO_2CHMeCO_2Me$	B	84.4	1.67 (3H, d, J=7.1 Hz), 3.78 (3H, s), 5.41 (1H, q, J=7.1 Hz), 6.94—7.17 (4H, m), 7.22—7.34 (3H, m)	1749, 1736, 1516, 1224, 1198, 1065	438 (M^+), 335 (base), 308, 272, 234, 168
22n	F	$CO_2CHEtCO_2Et$	B	63.8	1.11 (3H, t, J=7.5 Hz), 1.30 (3H, t, J=7.1 Hz), 2.06 (2H, quintet, J=6.8 Hz), 4.26 (2H, q, J=7.1 Hz), 5.27 (1H, t, J=6.2 Hz), 6.95—7.17 (4H, m), 7.23—7.36 (3H, m)	1731, 1515, 1224, 1197, 1064	466 (M^+), 366, 335 (base), 308, 273, 234, 168, 95
22o	F	$CO_2CMe_2CO_2Et$	B	15.2	1.29 (3H, t, J=7.1 Hz), 1.74 (6H, s), 4.26 (2H, q, J=7.1 Hz), 6.94—7.18 (4H, m), 7.21—7.37 (3H, m)	1730, 1516, 1231, 1137, 1060	466 (M^+), 366, 335 (base), 234, 168, 149, 95
22p	F	$CO_2CH_2CO_2t$Bu	B	80.2	1.49 (9H, s), 4.81 (2H, s), 6.95—7.18 (4H, m), 7.22—7.34 (3H, m)	1737, 1514, 1220, 1198, 1157	466 (M^+), 335, 308, 273, 234, 168, 57 (base)
22q	F	CO_2CH_2OMe	B	90.7	3.59 (3H, s), 5.55 (2H, s), 6.96—7.18 (4H, m), 7.24—7.32 (3H, m)	1737, 1515, 1229, 1085, 1159	396 (M^+), 335, 308, 273, 234, 45 (base)
22r	F	CO_2CH_2OEt	B	88.5	1.25 (3H, t, J=7.1 Hz), 3.82 (2H, q, J=7.1 Hz), 5.59 (2H, s), 6.95—7.17 (4H, m), 7.23—7.32 (3H, m)	1732, 1514, 1229, 1035	410 (M^+), 335, 308 (base), 273, 234, 168, 59
22s	F	$CO_2CH_2CH_2OMe$	B	39.6	3.42 (3H, s), 3.74—3.79 (2H, m), 4.54—4.59 (2H, m), 6.94—7.17 (4H, m), 7.23—7.31 (3H, m)	1730, 1517, 1224, 1198, 1062	410 (M^+), 352, 335 (base), 272, 234, 168
22t	F	$CO_2CH_2CH_2OEt$	B	59.2	1.21 (3H, t, J=7.0 Hz), 3.58 (2H, q, J=7.0 Hz), 3.77—3.82 (2H, m), 4.53—4.58 (2H, m), 6.95—7.17 (4H, m), 7.23—7.31 (3H, m)	1724, 1518, 1226, 1068	424 (M^+), 352 (base), 335, 234, 168
22u	F	CO_2CH_2SMe	B	34.8	2.36 (3H, s), 5.48 (2H, s), 6.96—7.19 (4H, m), 7.24—7.32 (3H, m)	1738, 1732, 1515, 1495, 1192, 1176, 1050	412 (M^+), 366, 335 (base), 308, 273, 234, 168, 95, 61
22v	F	$CO_2CH_2CH_2SMe$	B	93.3	2.18 (3H, s), 2.88 (2H, t, J=7.2 Hz), 4.56 (2H, t, J=7.2 Hz), 6.94—7.16 (4H, m), 7.22—7.30 (3H, m)	1730, 1514, 1227, 1197, 1062	426 (M^+), 352, 335, 234, 168 (base), 75
22w	F	$CO_2CH_2CH_2SEt$	B	97.7	1.27 (3H, t, J=7.4 Hz), 2.63 (2H, q, J=7.4 Hz), 2.91 (2H, t, J=7.4 Hz), 4.53 (2H, t, J=7.4Hz), 6.94—7.16 (4H, m), 7.22—7.29 (3H, m)	1728, 1514, 1227, 1199, 1058	440 (M^+), 352, 335, 168, 88 (base), 60
22x	F	$CO_2CH_2CH(OMe)_2$	B	22.8	3.45 (6H, s), 4.43 (2H, d, J=5.5 Hz), 4.79 (1H, t, J=5.5 Hz), 6.95—7.18 (4H, m), 7.23—7.33 (3H, m)	1727, 1514, 1228, 1202, 1076, 1065	440 (M^+), 409, 335, 272, 234, 168, 149, 75 (base)

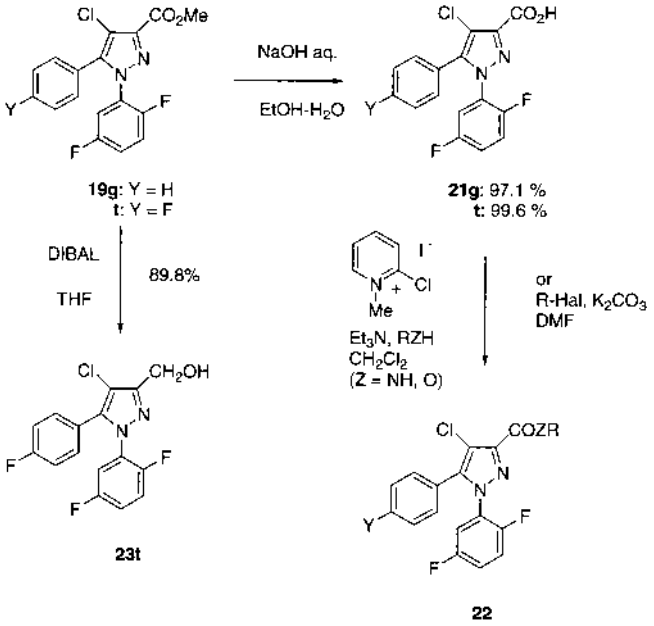


Chart 6

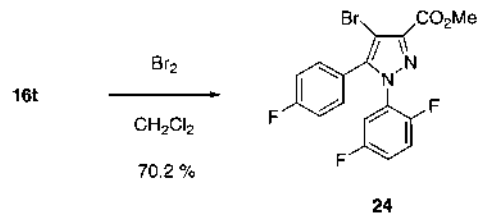
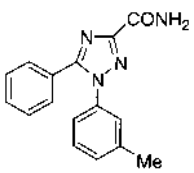


Chart 7



triazofenamide (**25**)

Fig. 2

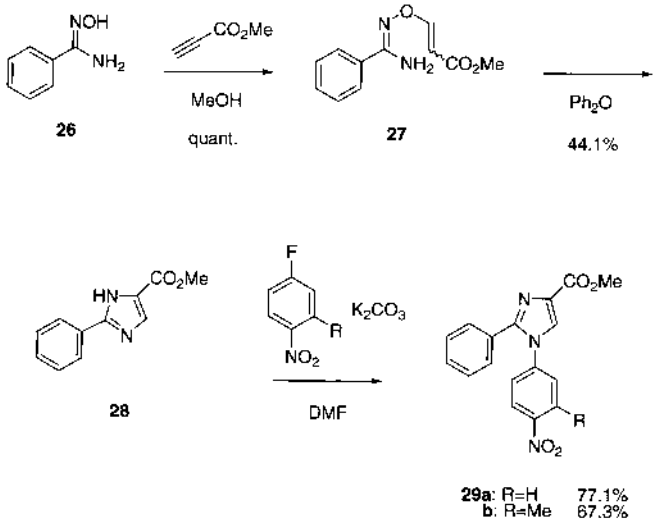


Chart 8

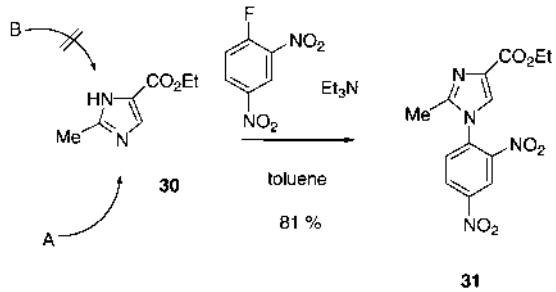


Chart 9

326.0823.

Methyl 1-(2,5-Difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (16t) mp 127—129 °C, *Anal*. Calcd for $C_{17}H_{11}F_3N_2O_2$: C, 61.45; H, 3.34; N, 8.43. Found: C, 61.72; H, 3.45; N, 8.54.

The physical data of the compounds **16b**,[16] **16h**,[17] **16i**[16] has been reported.

4-Chloro-1-(4-fluorophenyl)-5-phenylpyrazole-3-carbonitrile (20f) mp 99.5—101 °C, HRMS Calcd for $C_{16}H_9ClFN_3$: 297.0469. Found: 297.0470.

4-Chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carbonitrile (20g) mp 73 °C, *Anal*. Calcd for $C_{16}H_8ClF_2N_3$: C, 60.87; H, 2.55; N, 13.31. Found: C, 61.13; H, 2.78; N, 13.23.

4-Chloro-1-(4-nitrophenyl)-5-phenylpyrazole-3-carbonitrile (20i) mp 136—139.5 °C, HRMS Calcd for $C_{16}H_9ClN_4O_2$: 324.0414. Found: 324.0415.

4-Chloro-5-phenyl-1-(2-pyridyl)pyrazole-3-carbonitrile (20j) mp 74.5 °C, *Anal*. Calcd for $C_{15}H_9ClN_4$: C, 64.18; H, 3.23; N, 19.96. Found: C, 64.34; H, 3.55; N, 19.78.

4-Chloro-1-(3-chloro-5-trifluoromethylpyridin-2-yl)-5-phenylpyrazole-3-carbonitrile (20k) mp 127—128 °C, HRMS Calcd for $C_{16}H_7Cl_2F_3N_4$: 382.0000. Found: 382.0002.

4-Chloro-5-(3-chlorophenyl)-1-phenylpyrazole-3-carbonitrile (20l) Amorphous, HRMS Calcd for $C_{16}H_9Cl_2N_3$: 313.0174. Found: 313.0172.

4-Chloro-5-(4-fluorophenyl)-1-phenylpyrazole-3-carbonitrile (20m) mp 75 °C, HRMS Calcd for $C_{16}H_9ClFN_3$: 297.0469. Found: 297.0468.

4-Chloro-5-(2-methylphenyl)-1-phenylpyrazole-3-carbonitrile (20n) mp 112—113 °C, HRMS Calcd for $C_{17}H_{12}ClN_3$: 293.0720. Found: 293.0721.

4-Chloro-5-(3-methylphenyl)-1-phenylpyrazole-3-carbonitrile (20o) Oil, HRMS Calcd for $C_{17}H_{12}ClN_3$: 293.0720. Found: 293.0718.

4-Chloro-1,5-bis(3-methylphenyl)pyrazole-3-carbonitrile (20p) Amorphous, HRMS Calcd for $C_{18}H_{14}ClN_3$: 307.0876. Found: 307.0877.

4-Chloro-5-(4-fluorophenyl)-1-(3-methylphenyl) pyrazole-3-carbonitrile (20r) Amorphous, HRMS Calcd for $C_{17}H_{11}ClFN_3$: 311.0626. Found: 311.0624.

4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carbonitrile (20t) Oil, HRMS Calcd for $C_{16}H_7ClF_3N_3$: 333.0281. Found: 333.0280.

4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylic acid (21t) NaOH (152 mg, 3.81 mmol) was added to a solution of **19t** (140 mg, 0.382 mmol) in ethanol (20 ml) and water (20 ml) and the resulting mixture was stirred for 4 h. The reaction mixture was acidified with diluted HCl and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo* to give 128 mg (97.1%) of **21t** as a white powder, mp 202—209 °C. *Anal*. Calcd for $C_{16}H_8ClF_3N_2O_2$: C, 54.49; H, 2.29; N, 7.94. Found: C, 54.21; H, 2.47; N, 7.89.

Compound **21g** was prepared in analogy with **21t**. **21g**: mp 193—199 °C, *Anal*. Calcd for $C_{16}H_9ClF_2N_2O_2$: C, 57.42; H, 2.71; N, 8.37. Found: C, 57.40; H, 2.96; N, 8.15.

Ethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22i) Triethylamine (0.15 ml, 1.08 mmol) was added to a solution of **21t** (158 mg, 0.448 mmol), ethanol (27 μl, 0.464 mmol), and 2-chloro-1-methylpyridinium iodide (137 mg, 0.537 mmol) in CH_2Cl_2 (5 ml)

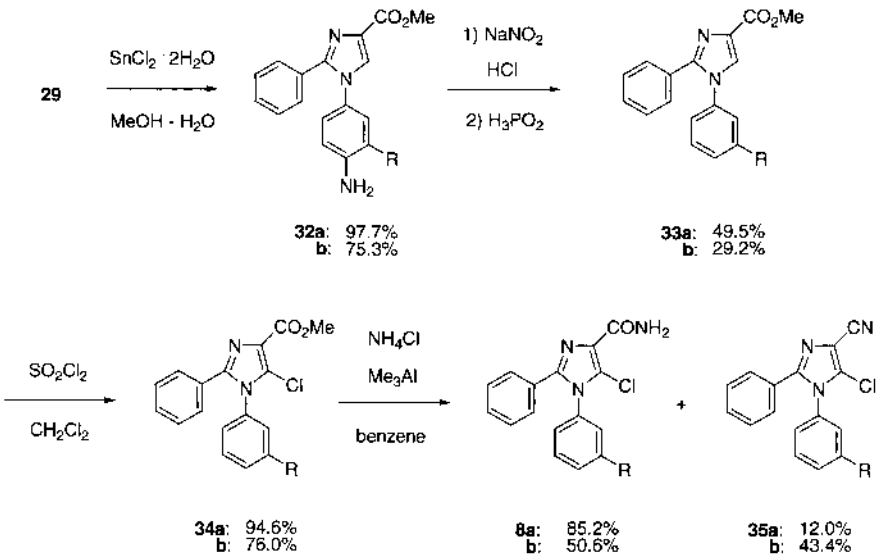


Chart 10

Table 9. Herbicidal Activity of Compounds **6**, **19**, **21**, **22**, and **24**

Compond No.	Herbicidal activity[a,b]							
	EO	LP	SJ	EA	SP	CS	EK	OS
6g	5	3	3	0	0	0	0	0
6t	4	3	3	3	3	1	4	0
19b	5	5	5	3	3	3	3	0
19c	4	3	3	2	3	2	4	0
19g	5	3	4	4	3	3	4	0
19j	4	4	4	3	3	3	3	0
19k	4	4	4	3	1	4	4	0
19l	4	3	3	4	3	3	4	0
19m	5	3	3	3	3	3	4	0
19o	5	3	3	1	3	1	3	0
19r	5	3	3	3	3	3	3	0
19t	5	5	5	5	5	5	5	1
21g	4	4	4	3	3	4	4	1
22a	5	5	5	1	1	4	4	0
22b	5	4	4	3	3	3	5	1
22d	3	3	2	1	1	1	1	0
22e	4	2	1	1	1	0	0	0
21t	5	5	5	1	1	4	5	0
22h	5	3	3	2	1	1	5	0
22i	5	5	5	4	3	3	5	0
22j	5	5	5	5	3	1	3	0
22k	3	1	1	1	1	0	1	0
22l	5	5	4	4	3	3	5	0
22m	5	5	4	3	4	1	4	1
22n	5	5	3	3	3	3	3	1
22o	5	5	4	4	1	3	4	0
22p	5	3	3	3	3	3	3	0
22q	4	5	4	4	3	5	5	1
22r	4	5	4	4	3	5	5	0
22s	5	4	5	5	3	5	5	0
22t	5	5	5	4	4	3	5	0
22u	5	5	5	4	1	4	4	0
22v	5	5	4	4	4	3	5	0
22w	5	4	4	4	4	3	4	0
22x	5	5	5	4	1	4	5	0
24	5	3	3	3	3	3	3	1

a) Herbicidal activity was evaluated at a dose of 5 g/are. *b*) EO: *Echinochloa oryzicola*, LP: *Lindernia procumbens*, SJ: *Scirpus juncoides*, EA: *Eleocharis acicularis*, SP: *Sagittaria pygmaea*, CS: *Cyperus serotinus*, EK: *Eleocharis kuroguwai*, OS: transplanted rice.

and the resulting mixture was stirred for 3 h. The reaction mixture was poured into diluted HCl and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 125 mg (73.1%) of **22i** as an oil. HRMS for $C_{18}H_{12}ClF_3N_2O_2$: 380.0539. Found: 380.0538.

Compounds **22a**—**22x** were synthesized as described above.

***N*-Methyl-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22a)** mp 134 °C, HRMS Calcd for $C_{17}H_{12}ClF_2N_3O$: 347.0637. Found: 347.0638.

***N*-Methoxy-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22b)** Amorphous, HRMS Calcd for $C_{17}H_{12}ClF_2N_3O_2$: 363.0586. Found: 363.0587.

***N*-(1-Methyl-1-phenylethyl)-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22c)** mp 131—134.5 °C, HRMS Calcd for $C_{25}H_{20}ClF_2N_3O$: 451.1263. Found: 451.1264.

***N*-(2,6-Diethylphenyl)-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22d)** mp 179—184 °C, HRMS Calcd for $C_{26}H_{22}ClF_2N_3O$: 465.1419. Found: 465.1418.

***N*-(4-Chlorophenyl)-*N*-methyl-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22e)** mp 145.5—146 °C, HRMS Calcd for $C_{23}H_{15}Cl_2F_2N_3O$: 457.0560. Found: 457.0561.

***N*-(4-Fluorophenyl)-*N*-isopropyl-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22f)** mp 93 °C, HRMS Calcd for $C_{25}H_{19}ClF_3N_3O$: 469.1169. Found: 469.1168.

***N*-(2,4-Difluorophenyl)-*N*-isopropyl-4-chloro-1-(2,5-difluorophenyl)-5-phenylpyrazole-3-carboxamide (22g)** mp 111 °C, HRMS Calcd for $C_{25}H_{18}ClF_4N_3O$: 487.1075. Found: 487.1073.

***N*-Methoxy-4-chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxamide (22h)** Oil, HRMS Calcd for $C_{17}H_{11}ClF_3N_3O_2$: 381.0492. Found: 381.0491.

Propyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22j) Oil, HRMS Calcd for $C_{19}H_{14}ClF_3N_2O_2$: 394.0696. Found: 394.0695.

Isopropyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22k) Oil, HRMS Calcd for $C_{19}H_{14}ClF_3N_2O_2$: 394.0696. Found: 394.0697.

2-Tetrahydrofuranylmethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22l) mp 51 °C, *Anal*. Calcd for $C_{21}H_{16}ClF_3N_2O_3$: C, 57.74; H, 3.69; N, 6.41. Found: C, 57.57; H, 3.88; N, 6.42.

1-Methoxycarbonylethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22m) mp 144 °C, HRMS Calcd for $C_{20}H_{14}ClF_3N_2O_4$: 438.0594. Found: 438.0593.

1-Ethoxycarbonylpropyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22n) Oil, HRMS Calcd for $C_{22}H_{18}ClF_3N_2O_4$: 466.0907. Found: 466.0906.

1-Ethoxycarbonyl-1-methylethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22o) Oil, HRMS Calcd for

$C_{22}H_{18}ClF_3N_2O_4$: 466.0907. Found: 466.0906.

***tert*-Butoxycarbonylmethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22p)** mp 118.5 °C, HRMS Calcd for $C_{22}H_{18}ClF_3N_2O_4$: 466.0907. Found: 466.0908.

Methoxymethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22q) mp 68 °C, HRMS Calcd for $C_{18}H_{12}ClF_3N_2O_3$: 396.0489. Found: 396.0489.

Ethoxymethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22r) mp 71.5 °C, HRMS Calcd for $C_{19}H_{14}ClF_3N_2O_3$: 410.0645. Found: 410.0646.

2-Methoxyethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22s) mp 109 °C, HRMS Calcd for $C_{19}H_{14}ClF_3N_2O_3$: 410.0645. Found: 410.0646.

2-Ethoxyethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22t) mp 86 °C, HRMS Calcd for $C_{20}H_{16}ClF_3N_2O_3$: 424.0802. Found: 424.0802.

Methylthiomethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22u) Oil, HRMS Calcd for $C_{18}H_{12}ClF_3N_2O_2S$: 412.0260. Found: 412.0259.

2-Methylthioethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22v) Oil, HRMS Calcd for $C_{19}H_{14}ClF_3N_2O_2S$: 426.0417. Found: 426.0417.

2-Ethylthioethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-pyrazole-3-carboxylate (22w) mp 87—89 °C, *Anal*. Calcd for $C_{20}H_{16}ClF_3N_2O_2S$: C, 54.49; H, 3.66; N, 6.35. Found: C, 54.64; H, 3.62; N, 6.32.

2,2-Dimethoxyethyl 4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (22x) mp 95—96 °C, *Anal*. Calcd for $C_{20}H_{16}ClF_3N_2O_4$: C, 54.50; H, 3.66; N, 6.36. Found: C, 54.27; H, 3.87; N, 6.31.

4-Chloro-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)-4-hydroxymethylpyrazole (23t) A 1.0 M solution of diisobutylalminum hydride in tetrahydrofuran (THF) (12.9 ml, 12.9 mmol) was added to a solution of **19t** (2.30 g, 6.28 mmol) in THF (30 ml) at 0 °C and the resulting mixture was stirred for 2 h. The reaction mixture was poured into water and extracted with AcOEt (×3). The combined extracts were washed with brine (×1), dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 1.91 g (89.8%) of **23t** as a white powder, mp 139 °C. ^{1}H-NMR ($CDCl_3$) δ: 2.16 (1H, br s), 4.83 (2H, br s), 7.02—7.10 (4H, m), 7.22—7.30 (3H, m). IR ν_{max} cm^{-1} (KBr): 3385, 1514, 1500, 1091, 1023. MS (*m/z*): 338 (M^+, base), 309, 303, 234, 113, 95. *Anal*. Calcd for $C_{16}H_{10}ClF_3N_2O$: C, 56.74; H, 2.98; N, 8.27. Found: C, 57.05; H, 3.07; N, 8.26.

Methyl 4-Bromo-1-(2,5-difluorophenyl)-5-(4-fluorophenyl)pyrazole-3-carboxylate (24) Compound **24** was synthesized as compound **19a** using bromine instead of SO_2Cl_2, mp 122.5 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.96 (3H, s), 6.98—7.08 (4H, m), 7.22—7.30 (3H, m). IR ν_{max} cm^{-1} (KBr): 1728, 1518, 1469, 1232, 1206, 1051. MS (*m/z*): 410 (M^+, Br=79), 379, 273 (base), 234, 133, 113, 95, 63. *Anal*. Calcd for $C_{17}H_{10}BrF_3N_2O_2$: C, 49.66; H, 2.45; N, 6.81. Found: C, 49.67; H, 2.57; N, 6.77.

Methyl 1-(4-Nitrophenyl)-2-phenylimidazole-4-carboxylate (29a) A mixture of **28** (1.00 g, 4.95 mmol), 4-fluoronitrobenzene (0.66 ml, 6.22 mmol), and K_2CO_3 (1.38 g, 9.98 mmol) in *N*,*N*-dimethylformamide (40 ml) was heated at 130 °C for 1 h. The reaction mixture was poured into water and extracted with AcOEt (×4). The combined extracts were dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 1.23 g (77.1%) of **29a** as a white powder, mp 187—189 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.96 (3H, s), 7.29—7.44 (7H, m), 7.92 (1H, s), 8.30 (2H, d, J=9.0 Hz). IR ν_{max} cm^{-1} (KBr): 1719, 1522, 1344, 1213, 1142. MS (*m/z*): 323 (M^+, base), 292, 265, 246, 225, 105, 77. *Anal*. Calcd for $C_{17}H_{13}N_3O_4$: C, 63.16; H, 4.05; N, 13.00. Found: C, 62.92; H, 4.06; N, 12.89.

Methyl 1-(4-Aminophenyl)-2-phenylimidazole-4-carboxylate (32a) $SnCl_2 \cdot H_2O$ (3.92 g, 17.4 mmol) was added to a solution of **29a** (1.11 g, 3.44 mmol) in methanol (20 ml) and concentrated HCl (20 ml) at 0 °C and the resulting mixture was stirred for 14 h. The reaction mixture was treated with 3 N aqueous solution of NaOH (to pH 14) and extracted with AcOEt (×4). The combined extracts were dried over $MgSO_4$, and evaporated *in vacuo* to give 0.99 g (97.7%) of **32a** as a white powder, mp 236—238 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.88 (2H, br s), 3.94 (3H, s), 6.66 (2H, d, J=8.7 Hz), 6.99 (2H, d, J=8.7 Hz), 7.22—7.31 (3H, m), 7.45—7.49 (2H, m), 7.78 (1H, s). IR ν_{max} cm^{-1} (KBr): 3444, 3347, 1729, 1519, 1219. MS (*m/z*): 293 (M^+, base), 262, 235, 208, 195, 131, 105. HRMS Calcd for $C_{17}H_{15}N_3O_2$: 293.1164. Found: 293.1166.

Methyl 1,2-Diphenylimidazole-4-carboxylate (33a) $NaNO_2$ (278 mg, 4.03 mmol) was added to an ice-cooled solution of **32a** (874 mg, 2.98 mmol) in concentrated HCl (20 ml) and the resulting mixture was stirred for 1 h. The reaction mixture was added dropwise to 50% H_3PO_2 (20 ml) at room temperature and stirring was continued for 5 h. The reaction mixture was extracted with AcOEt (×5). The combined extracts were dried over $MgSO_4$, and evaporated *in vacuo*. The residue was subjected to silica gel column chromatography to give 411 mg (49.5%) of **33a** as a white powder, mp 112—114 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.96 (3H, s), 7.23—7.35 (5H, m), 7.41—7.46 (5H, m), 7.87 (1H, s). IR ν_{max} cm^{-1} (KBr): 1708, 1552, 1250, 1213. MS (*m/z*): 278 (M^+, base), 247, 220, 180, 116, 77. HRMS Calcd for $C_{18}H_{12}ClF_3N_2O_2$: 278.1055. Found: 278.1057.

Methyl 5-Chloro-1,2-diphenylimidazole-4-carboxylate (34a) Compound **33a** was chlorinated as described above, mp 145—147 °C. ^{1}H-NMR ($CDCl_3$) δ: 3.99 (3H, s), 7.18—7.30 (5H, m), 7.35—7.40 (2H, m), 7.47—7.53 (3H, m). IR ν_{max} cm^{-1} (KBr): 1727, 1208, 1059. MS (*m/z*): 312 (M^+, base), 277, 146, 77. *Anal*. Calcd for $C_{17}H_{13}ClN_2O_2$: C, 65.29; H, 4.19; N, 8.96. Found: C, 65.07; H, 4.14; N, 8.94.

5-Chloro-1,2-diphenylimidazole-4-carboxamide (8a) and 5-Chloro-1,2-diphenylimidazole-4-carbonitrile (35a) Compound **34a** was treated with NH_4Cl and trimethyl aluminum to afford **8a** and **35a**. **8a**: mp 250—252 °C, ^{1}H-NMR ($CDCl_3$) δ: 5.50 (1H, br s), 7.14 (1H, br s), 7.21—7.37 (6H, m), 7.47—7.55 (4H, m). IR ν_{max} cm^{-1} (KBr): 3398, 3185, 1649, 1379, 699. MS (*m/z*): 297 (M^+), 261 (base), 131, 105, 77. *Anal*. Calcd for $C_{16}H_{12}ClN_3O$: C, 64.54; H, 4.06; N, 14.11. Found: C, 64.51; H, 4.34; N, 13.96. **35a**: mp 124—126 °C, ^{1}H-NMR ($CDCl_3$) δ: 7.20—7.37 (6H, m), 7.47—7.58 (4H, m). IR ν_{max} cm^{-1} (KBr): 2235, 1530, 1498, 1474, 698. MS (*m/z*): 279 (M^+, base), 244, 141, 77. HRMS Calcd for $C_{16}H_{10}ClF_3N_3$: 279.0563. Found: 279.0563.

Compounds **29b**—**35b** were prepared in the same manner as **29a**—**35a**.

Methyl 1-(3-Methyl-4-nitrophenyl)-2-phenylimidazole-4-carboxylate (29b) mp 181—182 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.61 (3H, s), 3.96 (3H, s), 7.16 (1H, dd, J=8.7, 2.3 Hz), 7.26—7.43 (6H, m), 7.88 (1H, s), 8.02 (1H, d, J=8.7 Hz). IR ν_{max} cm^{-1} (KBr): 1708, 1523, 1362, 1335, 1259, 1218, 1144. MS (*m/z*): 337 (M^+, base), 306, 279, 239, 105, 77. *Anal*. Calcd for $C_{18}H_{15}N_3O_4$: C, 64.09; H, 4.48; N, 12.46. Found: C, 64.29; H, 4.57; N, 12.28.

Methyl 1-(4-Amino-3-methylphenyl)-2-phenylimidazole-4-carboxylate (32b) mp 182—183 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.15 (3H, s), 3.94 (3H, s), 6.63 (1H, d, J=8.4 Hz), 6.84 (1H, dd, J=8.4, 2.4 Hz), 6.94 (1H, d, J=2.4 Hz), 7.24—7.27 (3H, m), 7.45—7.50 (2H, m), 7.77 (1H, s). IR ν_{max} cm^{-1} (KBr): 3476, 3349, 1717, 1512, 1221, 1134. MS (*m/z*): 307 (M^+, base), 276, 249, 222, 119, 105, 77. *Anal*. Calcd for $C_{18}H_{17}N_3O_2$: C, 70.34; H, 5.58; N, 13.67. Found: C, 70.06; H, 5.48; N, 13.38.

Methyl 1-(3-Methylphenyl)-2-phenylimidazole-4-carboxylate (33b) mp 117—119 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.36 (3H, s), 3.95 (3H, s), 6.99 (1H, d, J=7.0 Hz), 7.07 (1H, br s), 7.20—7.33 (5H, m), 7.41—7.46 (2H, m), 7.84 (1H, s). IR ν_{max} cm^{-1} (KBr): 1727, 1216, 1192, 1141. MS (*m/z*): 292 (M^+, base), 261, 234, 194, 149, 91. *Anal*. Calcd for $C_{18}H_{16}N_2O_2$: C, 73.96; H, 5.52; N, 9.58. Found: C, 73.69; H, 5.39; N, 9.59.

Methyl 5-Chloro-1-(3-methylphenyl)-2-phenylimidazole-4-carboxylate (34b) mp 165—166 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.39 (3H, s), 3.98 (3H, s), 7.00—7.05 (2H, m), 7.22—7.42 (7H, m). IR ν_{max} cm^{-1} (KBr): 1722, 1216, 1064. MS (*m/z*): 326 (M^+, base), 291, 146, 91, 65. *Anal*. Calcd for $C_{18}H_{15}ClN_2O_2$: C, 66.16; H, 4.63; N, 8.57. Found: C, 66.16; H, 4.84; N, 8.62.

5-Chloro-1-(3-methylphenyl)-2-phenylimidazole-4-carboxamide (8b) mp 169—171 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.39 (3H, s), 5.91 (1H, br s), 7.01—7.05 (2H, m), 7.17—7.41 (8H, m). IR ν_{max} cm^{-1} (KBr): 3410, 3178, 1676, 1651, 1376, 700. MS (*m/z*): 311 (M^+), 275 (base), 131, 105, 91, 65. *Anal*. Calcd for $C_{17}H_{14}ClN_3O$: C, 65.49; H, 4.53; N, 13.48. Found: C, 65.25; H, 4.83; N, 13.34.

5-Chloro-1-(3-methylphenyl)-2-phenylimidazole-4-carbonitrile (35b) mp 137—139 °C, ^{1}H-NMR ($CDCl_3$) δ: 2.40 (3H, s), 7.00—7.05 (2H, m), 7.21—7.44 (7H, m). IR ν_{max} cm^{-1} (KBr): 2235, 1529, 1490, 1470, 701. MS (*m/z*): 293 (M^+, base), 258, 155, 91. HRMS Calcd for $C_{17}H_{12}ClN_3$: 293.0720. Found: 293.0719.

Pre-emergent Herbicide Tests Plastic pots (surface area=100 cm^2) were filled with a clay loam soil and kept in a greenhouse. The test plants were five narrowleaf weeds [*Echinochloa oryzicola* Vasing., *Scirpus juncoides* Roxb var. *ohwianus* T. Koyama, *Eleocharis acicularis* (L.) Roem. *et* Schult. var. *longiseta* Sven., *Cyperus serotinus* Rottb., and *Eleocharis kuroguwai* Ohwi] and one broadleaf weed [*Lindernia pyxidaria* L.], and *Sagittaria pygmaea* Miq., and *Oryza sativa* L. On top of the soil were placed a predetermined number of seeds of the weed. The surface of each pot was

covered with 1 cm of soil, and then *Oryza sativa* L. that had reached the two-leaf stage was transplanted. For the herbicidal test, wettable powders were prepared by mixing the compounds (10%), Emulgen 810 (surfactant; 0.5%), Demol N (surfactant; 0.5%), Kunilite 210 (diatomaceous earth; 20%), and Dieclite CA (clay; 69%). Each compound, formulated as a wettable powder, was applied 3 d after the seeds had been sown. Approximately 3 weeks after treatment, the herbicidal activity of each compound was judged by visual observation of the symptoms of treated plants in comparison with untreated controls. According to the extent of the injury of plants, the herbicidal potency was scaled from 0 to 5 using the following criteria: 5, >91% growth inhibition; 4, 71—90% growth inhibition; 3, 51—70% growth inhibition; 2, 31—50% growth inhibition; 1, 11—30% growth inhibition; 0, growth inhibition <10%.

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