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A new and efficient approach to pyrazolines. First synthesis of 3-aryl-5-dichloromethyl-2-pyrazolines

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ABSTRACT

An efficient synthetic method for dichloromethylated pyrazolines has been established. 1-Aryl-4,4-dichlorobut-3-en-1-ones **4** were efficiently prepared by treatment of acetophenones with anhydrous chloral, followed by dehydration and reductive dechlorination. Compounds **4** reacted with hydrazine hydrate and methylhydrazine to give the respective 5-dichloromethyl-2-pyrazolines in high to quantitative yields. The molecular structure of 5-dichoromethyl-1-methyl-3-(2-naphthyl)-2-pyrazoline has been determined by X-ray crystallography.

1. Introduction

Chloral is an inexpensive, multipurpose starting material for organic synthesis.[1] It is able to react with a range of functional groups to provide trichloromethylated derivatives of a high electrosynthetic potential, which has attracted our research work for some years. Chloral reacts with amides to yield chloralamides. From these primary derivatives we developed a number of significant synthetic processes on the basis of a conjunction of chemical and key electrochemical reactions.[2–10] The main advantages of this synthetic methodology are the high selectivity of the electrochemical reductions and the utilization of pre-chlorinated derivatives from chloral to avoid the frequently observed lack of selectivity of the usual chlorinating reagents. Chloral **1** also reacts with acetophenones to give 1-aryl-4,4,4-trichloro-3-hydroxybutan-1-ones **2** (chloralacetophenones). In this reaction we recognized an initial point to develop an exclusive approach[11] to a new type of pyrazoline compounds: 3-aryl-5-dichloromethyl-2-pyrazolines **6** and **7**.

Over the years, the chemistry of 2-pyrazolines[12,13] has received considerable attention. It is worthy of note that substances containing a 2-pyrazoline moiety have been described as having potential therapeutic utility, such as anti-inflammatory,[14–16] antidepressant,[17,18] antipyretic,[19] antibacterial,[20–25] antifungal[20,23,26] and antitumoral.[27] Of particular interest is the use of pyrazolines as synthetic intermediates for preparing cyclopropane[28–30] and pyrazole[12,31–34] derivatives. 2-Pyrazolines have usually been prepared by starting from aldehydes or ketones, which have either actual or potential α,β-unsaturation.[12,35–49] 1,3-Dipolar cycloadditions between diazoalkanes and different types of molecules containing activated double bonds are also exploitable reactions.[12,28,29,50,51] In our case, the synthesis of compounds **6** and **7** was achieved by following an unprecedented reaction sequence such as that shown in Scheme 1, which involves: (a) dehydration of chloralacetophenones **2** to obtain the corresponding 2,2,2-trichloroethylideneacetophenones **3**,(b) selective electrochemical reduction to give dichlorovinylacetophenones **4** (1-aryl-4,4-dichlorobut-3-en-1-ones) and (c) treatment with commercial hydrazines to provide the final dichloromethylated pyrazoline derivatives **6** and **7**. Our first results were communicated preliminarily.[11] We later studied the formation and properties of synthetic intermediates **3** and **4** and drew conclusions concerning the total selectivity of the reductive electrochemical reactions of compounds **3** yielding unconjugated β,γ-unsaturated ketones **4**, instead of the conjugated α,β-unsaturated enone isomers[52,53] **5**. In this paper, we report full details of the synthesis, spectroscopic properties and X-ray crystallographic molecular structure of one of the novel 3-aryl-5-dichloromethyl-2-pyrazolines.

2. Results and discussion

In the search for a good approach to prepare still unavailable compounds **6** and **7** on the basis of our synthetic methodology, one would expect that compounds **4** might be of utility, since they

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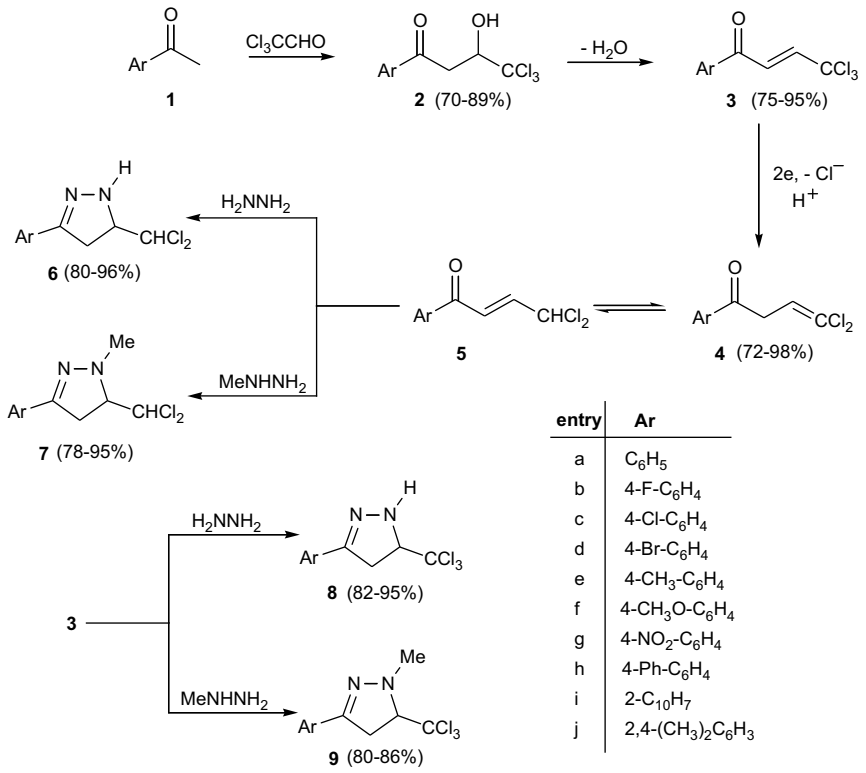

Scheme 1.

contain two electrophilic active centres with potential ability to react with hydrazines, leading to the compounds sought. Intermediates **2**,**3** and **4** were efficiently prepared starting from anhydrous chloral and acetophenones according to the reaction route shown in Scheme 1. Detailed protocols for each implied reaction were previously reported.[11,52] Yields ranged from high to quantitative.

Compounds **4** were treated with commercial hydrazine hydrate in ethanol under reflux temperature. The progress of these reactions could be well checked by TLC showing a complete transformation of starting materials to single products, which were easily isolated by cooling at −18 °C and filtration of the precipitated solid. Highly pure products were isolated in this manner and were crystallized and identified by IR, MS, high field NMR spectroscopy and elemental analyses as 3-aryl-5-dichloromethyl-2-pyrazolines **6**. Yields ranged from high to almost quantitative. No synthesis of this type of pyrazolines had been previously reported. This seems to be attributable to incompatibility of pyrazolines with the reagents mostly used to generate dichloromethyl groups.[54] However, the aim of this approach is to circumvent such synthetic problems by utilization of a pre-chlorinated intermediate derived from chloral with the advantageous result of the development of a general, facile and highly efficient synthetic method.

Regarding the formation of products **6**, and considering our observation that unconjugated enones **4** undergo base catalyzed isomerization[52] to conjugated enones **5**, the participation of these isomers seems plausible. A further fact that provides support to this suggestion is the much greater reactivity showed by isomers **5** with respect to that of compounds **4**. This was evidenced by a competitive experiment between compounds **4f** and **5e**, which was obtained by base isomerization[52] of **4e**. When an equimolar mixture of **4f** and **5e** was treated with a half molar amount of hydrazine hydrate, the only pyrazoline product was **6e** (total conversion) whereas **4f** remained fully unaltered.

Reactions of compounds **4** with anhydrous methylhydrazine led to the novel 3-aryl-5-dichloromethyl-1-methyl-2-pyrazolines **7**, whose formation, isolation and characterization were carried out in the same way as hydrazine hydrate reactions. However, analogous syntheses using phenylhydrazine could not be achieved, since the formation of a complex mixture of unidentified products was observed.

Geometrical characteristics of the new class of pyrazoline compounds were determined by single crystal X-ray crystallography of **7i**. The molecular structure found is illustrated in Figure 1. Selected intramolecular distances and bond angles are given in Table 1. Figure 2 corresponds to a perspective of the crystal packing, showing hydrogen interactions of molecules with a helical arrangement.

The possibility of preparing compounds **6** and **7** via an alternative procedure was also investigated without participation of intermediates **4**, involving a prior formation of the pyrazoline ring system from intermediates **3** and subsequent electrochemical dechlorination. Thus, compounds **3** were treated with hydrazine hydrate or methylhydrazine leading to the corresponding

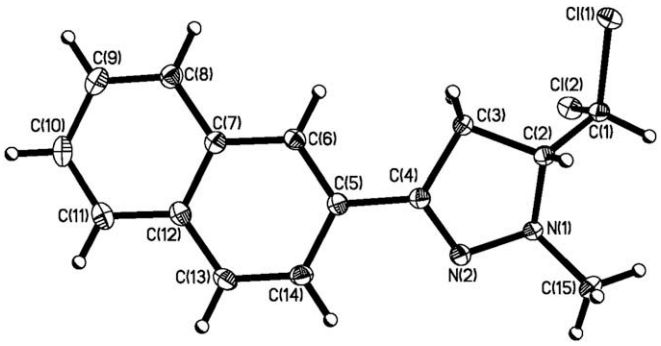

Figure 1. ORTEP of **7i**, with thermal ellipsoids shown at 50% probability.

Table 1
Selected bond lengths and bond angles in crystal structure of **7i**

Bond lengths (Å)			
Cl(1)–C(1)	1.7839(14)	N(2)–C(4)	1.2907(17)
Cl(2)–C(1)	1.7818(14)	C(1)–C(2)	1.5213(18)
N(1)–N(2)	1.4078(16)	C(2)–C(3)	1.5301(18)
N(1)–C(15)	1.4580(17)	C(3)–C(4)	1.5096(18)
N(1)–C(2)	1.4750(17)	C(4)–C(5)	1.4655(18)
Bond angles (°)			
N(2)–N(1)–C(15)	112.06(10)	Cl(2)–C(1)–Cl(1)	109.66(7)
N(2)–N(1)–C(2)	107.71(10)	N(1)–C(2)–C(1)	111.29(10)
C(15)–N(1)–C(2)	116.01(11)	N(1)–C(2)–C(3)	102.77(10)
C(4)–N(2)–N(1)	109.13(11)	C(1)–C(2)–C(3)	116.54(11)
C(2)–C(1)–Cl(2)	113.02(10)	C(4)–C(3)–C(2)	99.87(10)
C(2)–C(1)–Cl(1)	111.29(10)	N(2)–C(4)–C(3)	113.22(11)

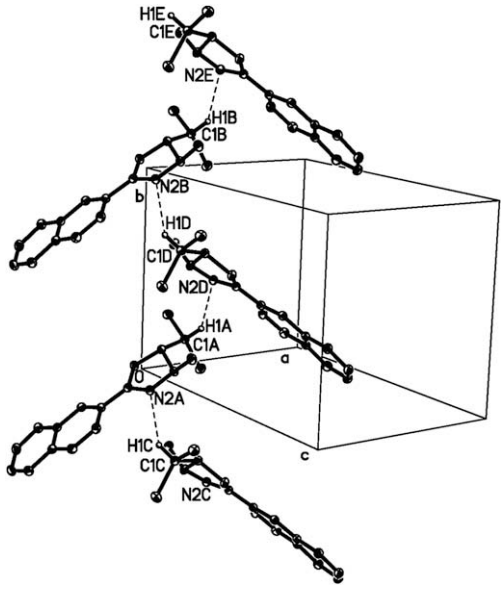

Figure 2. A perspective of the crystal packing of **7i**, showing the hydrogen interactions.

trichloromethylpyrazolines **8** and **9** in high yields. However, attempts to promote a selective cathodic dehalogenation of these compounds to generate the final products **6** and **7** gave mediocre or bad results. For example, reductions of **8e** and **9a** led to the respective dichloromethylpyrazolines in low yields: **6e** (25%) and **7a** (48%).

To conclude, a high yield new method for the synthesis of 3-aryl-5-dichloromethyl-2-pyrazolines, a previously unattainable class of compounds, is reported. Easy availability of starting materials and simple experimental procedure are noteworthy advantages of this approach.

3. Experimental

3.1. General

NMR spectra were determined on Bruker AV-200, Bruker AV-300 or Bruker AV-400 with tetramethylsilane as internal reference. Electron-impact mass spectra were obtained on Thermoquest trace MS spectrometer under an ionizing voltage of 70 eV. IR spectra (Nujol emulsions) were recorded on a Nicolet Impact 400 Spectrometer. Microanalyses were performed on a Carlo Erba EA-1108 analyzer. Melting points were determined on a Büchi Melting point B-540, and are uncorrected. Compounds **2**–**4** were prepared as previously described.[11,52]

3.2. Preparation of 3-aryl-5-dichloromethyl-2-pyrazolines (6) and (7)

To a suspension of **4** (7 mmol) in EtOH (15 ml) a solution of hydrazine hydrate or methylhydrazine (8.4 mmol) in EtOH (7 ml) was added dropwise. The mixture was refluxed for 10 min. Then the solution was concentrated under reduced pressure (half of volume) and was kept at −18 °C until the precipitation of a pale yellow solid, which was collected by filtration and crystallized from the appropriate solvent.

*3.2.1. 5-Dichloromethyl-3-phenyl-2-pyrazoline (**6a**)*

Yield 92%; crystallization from ethanol gave pale yellow needles; mp 129–131 °C (dec).(Found C, 52.35; H, 4.39; N, 12.18. $C_{10}H_{10}Cl_2N_2$ requires C, 52.42; H, 4.40; N, 12.23.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.11 (dd, 1H, J=17.1, 7.4 Hz), 3.30 (dd, 1H, J=17.1, 10.4 Hz), 4.32 (dt, 1H, J=10.4, 7.4 Hz), 5.06 (br s, 1H), 5.62 (d, 1H, J=7.4 Hz), 7.32–7.40 (m, 3H), 7.61–7.65 (m, 2H); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.44, 68.17, 73.94, 126.05, 128.66, 129.32, 132.01, 151.52; MS m/z (%) 230 (M^++2, 9), 228 (M^+, 14), 145 (100), 118 (34), 104 (9), 91 (23), 77 (36); IR (Nujol) 3280, 1591, 1566, 1420, 1249, 1206, 1158, 1062, 907, 864, 815, 761, 688 cm^{-1}.

*3.2.2. 5-Dichloromethyl-3-(4-fluorophenyl)-2-pyrazoline (**6b**)*

Yield 85%; crystallization from ethanol gave yellow prisms; mp 87–91 °C (dec).(Found C, 48.58; H, 3.65; N, 11.36. $C_{10}H_9Cl_2FN_2$ requires C, 48.61; H, 3.67; N, 11.34.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.10 (dd, 1H, J=17.0, 7.3 Hz), 3.29 (dd, 1H, J=17.0, 10.4 Hz), 4.34 (dt, 1H, J=10.4, 7.3 Hz), 5.64 (d, 1H, J=7.3 Hz), 7.07 (t, 2H, J=8.6 Hz), 7.62 (dd, 2H, J=8.6, 5.4 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.55, 68.21, 73.85, 115.76 (d, J=21.8 Hz), 127.93 (d, J=8.4 Hz), 128.33 (d, J=3.2 Hz), 150.73, 163.40 (d, J=249.8 Hz); MS m/z (%) 248 (M^++2, 4), 246 (M^+, 6), 163 (100), 146 (10), 136 (15), 120 (11), 109 (12), 95 (11), 75 (9); IR (Nujol) 3278, 1599, 1512, 1419, 1240, 1207, 1152, 1065, 910, 837, 771, 745, 676 cm^{-1}.

*3.2.3. 5-Dichloromethyl-3-(4-chlorophenyl)-2-pyrazoline (**6c**)*

Yield 93%; crystallization from ethanol gave yellow needles; mp 126–128 °C.(Found C, 45.65; H, 3.41; N, 10.60. $C_{10}H_9Cl_3N_2$ requires C, 45.57; H, 3.44; N, 10.63.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.09 (dd, 1H, J=17.1, 7.3 Hz), 3.28 (dd, 1H, J=17.1, 10.5 Hz), 4.35 (dt, 1H, J=10.5, 7.3 Hz), 5.13 (br s, 1H), 5.63 (d, 1H, J=7.3 Hz), 7.54 (d, 2H, J=8.7 Hz), 7.56 (d, 2H, J=8.7 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.34, 68.26, 73.79, 127.28, 128.91, 130.53, 135.17, 150.48; MS m/z (%) 266 (M^++4, 24), 264 (M^++2, 64), 262 (M^+, 64), 227 (8), 181 (100), 179 (50), 152 (33), 117 (29), 144 (24); IR (Nujol) 3278, 1636, 1598, 1495, 1430, 1206, 1092, 1068, 1009, 907, 828, 745 cm^{-1}.

*3.2.4. 3-(4-Bromophenyl)-5-dichloromethyl-2-pyrazoline (**6d**)*

Yield 89%; crystallization from EtOH gave yellow needles; mp 124–125 °C (dec).(Found C, 38.98; H, 2.92; N, 8.98. $C_{10}H_9BrCl_2N_2$ requires C, 39.00; H, 2.95; N, 9.10.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.09 (dd, 1H, J=17, 7.3 Hz), 3.82 (dd, 1H, J=17, 10.5 Hz), 4.35 (dt, 1H, J=10.5, 7.3 Hz), 5.63 (d, 1H, J=7.3 Hz), 7.50 (s, 4H); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.26, 68.25, 73.77, 123.42, 127.49, 130.94, 131.84, 150.45; MS m/z (%) 310 (M^++4, 30), 308 (M^++2, 63), 306 (M^+, 39), 223 (100), 225 (100), 144 (98), 128 (22), 117 (26), 102 (25), 75 (31); IR (Nujol) 3279, 1636, 1399, 1252, 1203, 1064, 1005, 904, 822, 746 cm^{-1}.

*3.2.5. 5-Dichloromethyl-3-(4-methylphenyl)-2-pyrazoline (**6e**)*

Yield 85%; crystallization from ethanol gave pale yellow needles; mp 160–161 °C (dec).(Found C, 54.14; H, 5.03; N, 11.58. $C_{11}H_{12}Cl_2N_2$ requires C, 54.34; H, 4.97; N, 11.52.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 2.36 (s, 3H), 3.10 (dd, 1H, J=17.1, 7.3 Hz), 3.29 (dd, 1H, J=17.1, 10.3 Hz), 4.31 (dt, 1H, J=10.3, 7.3 Hz), 5.32 (br s, 1H), 5.62 (d,

1H, *J*=7.3 Hz), 7.17 (d, 2H, *J*=8.1 Hz), 7.53 (d, 2H, *J*=8.1 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 21.45, 36.58, 68.09, 73.97, 126.06, 129.19, 129.38, 139.55, 151.92; MS *m*/*z* (%) 244 (M^++2, 17), 242 (M^+, 27), 160 (30), 159 (100), 132 (13), 117 (16), 91 (25), 79 (14); IR (Nujol) 3279, 1636, 1515, 1227, 1066, 908, 817, 761, 740, 674 cm^{-1}.

*3.2.6. 5-Dichloromethyl-3-(4-methoxyphenyl)-2-pyrazoline (**6f**)*

Yield 95%; crystallization from ethanol gave yellow prisms; mp 107–109 °C (dec).(Found C, 51.01; H, 4.76; N, 10.81. $C_{11}H_{12}Cl_2N_2O$ requires C, 50.98; H, 4.67; N, 10.81.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.08 (dd, 1H, *J*=17.1, 7.2 Hz), 3.27 (dd, 1H, *J*=17.1, 10.2 Hz), 3.82 (s, 3H), 4.30 (dt, 1H, *J*=10.2, 7.2 Hz), 5.23 (br s, 1H), 5.62 (d, 1H, *J*=7.2 Hz), 6.90 (d, 2H, *J*=9.0 Hz), 7.57 (d, 2H, *J*=9.0 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.67, 55.39, 68.10, 74.05, 114.08, 124.77, 127.57, 151.55, 160.59; MS *m*/*z* (%) 260 (M^++2, 13), 258 (M^+, 19), 223 (3), 187 (8), 175 (100), 160 (49), 132 (24), 115 (15), 77 (19); IR (Nujol) 3281, 1600, 1512, 1415, 1308, 1245, 1168, 1061, 1033, 906, 837, 757, 672 cm^{-1}.

*3.2.7. 5-Dichloromethyl-3-(4-nitrophenyl)-2-pyrazoline (**6g**)*

Yield 87%; crystallization from ethanol gave orange powder; mp 110–112 °C.(Found C, 43.91; H, 3.40; N, 15.16. $C_{10}H_9Cl_2N_3O_2$ requires C, 43.82; H, 3.31; N, 15.33.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.16 (dd, 1H, *J*=17.1, 7.3 Hz), 3.35 (dd, 1H, *J*=17.1, 10.5 Hz), 4.45 (dtd, 1H, *J*=10.5, 7.3, 2.4 Hz), 5.66 (d, 1H, *J*=7.3 Hz), 6.40 (br s, 1H), 7.77 (d, 2H, *J*=8.7 Hz), 8.23 (d, 2H, *J*=8.7 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 35.83, 68.48, 73.49, 124.01, 126.42, 138.16, 147.67, 148.58; MS *m*/*z* (%) 277 (M^++4, 7), 275 (M^++2, 25), 273 (M^+, 35), 238 (6), 190 (100), 191 (37), 144 (85), 117 (20), 76 (17); IR (Nujol) 3364, 1595, 1561, 1505, 1334, 1109, 1075, 851, 754, 692 cm^{-1}.

*3.2.8. 3-(4-Biphenylyl)-5-dichloromethyl-2-pyrazoline (**6h**)*

Yield 80%; crystallization from ethanol gave yellow needles; mp 157 °C.(Found C, 62.60; H, 4.69; N, 8.98. $C_{16}H_{14}Cl_2N_2$ requires C, 62.97; H, 4.62; N, 9.21.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.14 (dd, 1H, *J*=17, 7.5 Hz), 3.33 (d, 1H, *J*=17, 10.4 Hz), 4.34 (dt, 1H, *J*=10.4, 7.5 Hz), 5.63 (d, 1H, *J*=7.5 Hz), 6.13 (br s, 1H), 7.36 (t, 1H, *J*=5.4 Hz), 7.44 (t, 2H, *J*=7.2 Hz), 7.62–7.60 (m, 4H), 7.40 (d, 2H, *J*=8.4 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.47, 68.24, 73.95, 126.51, 127.06, 127.32, 127.72, 128.93, 130.95, 140.36, 141.97, 151.18; MS *m*/*z* (%) 306 (M^++2, 15), 304 (M^+, 23), 221 (100), 222 (32), 194 (8), 178 (9), 152 (20), 111 (11); IR (Nujol) 3297, 3258, 1641, 1412, 1342, 1219, 1065, 907, 843, 768, 754, 724, 696 cm^{-1}.

*3.2.9. 5-Dichloromethyl-3-(2-naphthyl)-2-pyrazoline (**6i**)*

Yield 86%; crystallization from ethanol gave yellow needles; mp 131–132 °C.(Found C, 59.62; H, 4.32; N, 9.97. $C_{14}H_{12}Cl_2N_2$ requires C, 60.23; H, 4.33; N, 10.03.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.22 (dd, 1H, *J*=16.9, 7.3 Hz), 3.40 (dd, 1H, *J*=16.9, 10.4 Hz), 4.36 (dt, 1H, *J*=10.4, 7.3 Hz), 5.65 (d, 1H, *J*=7.3 Hz), 7.50–7.46 (m, 2H), 7.84–7.79 (m, 4H), 7.95 (dd, 1H, *J*=8.7, 1.7 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.42, 68.30, 73.98, 123.27, 125.91, 126.64, 126.78, 127.87, 128.30, 128.43, 129.64, 133.15, 133.69, 151.56; MS *m*/*z* (%) 280 (M^++2, 7), 278 (M^+, 53), 196 (50), 195 (100), 178 (20), 168 (25), 153 (22), 127 (40); IR (Nujol) 3320, 3260, 1638, 1339, 1319, 1205, 1162, 1062, 860, 821, 754 cm^{-1}.

*3.2.10. 5-Dichloromethyl-1-methyl-3-phenyl-2-pyrazoline (**7a**)*

Yield 85%; column chromatography (silica gel–AcOEt–Hexane, 1:2) gave red oil; (Found C, 54.30; H, 5.01; N, 11.50. $C_{11}H_{12}Cl_2N_2$ requires C, 54.34; H, 4.97; N, 11.52.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.05 (s, 3H), 3.28 (dd, 1H, *J*=17.1, 10.5 Hz), 3.46 (dd, 1H, *J*=17.1, 10.5 Hz), 3.82 (td, 1H, *J*=10.5, 4.5 Hz), 5.86 (d, 1H, *J*=4.5 Hz), 7.32–7.40 (m, 3H), 7.63–7.66 (m, 2H); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.85, 43.12, 73.07, 74.69, 126.03, 128.60, 129.14, 132.02, 149.60; MS *m*/*z* (%) 244 (M^++2, 11), 242 (M^+, 18), 207 (4), 160 (30), 159 (100), 117 (13), 91 (13), 77 (19); IR 3061, 2966, 2870, 2795, 1636, 1594, 1448, 1362, 1136, 1043, 930, 760, 695, 669 cm^{-1}.

*3.2.11. 3-(4-Chlorophenyl)-5-dichloromethyl-1-methyl-2-pyrazoline (**7c**)*

Yield 90%; column chromatography (silica gel–AcOEt–Hexane, 1:2) gave yellow powder; mp 72–73 °C.(Found C, 47.66; H, 4.01; N, 10.05. $C_{11}H_{11}Cl_3N_2$ requires C, 47.60; H, 3.99; N, 10.09.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.04 (s, 3H), 3.25 (dd, 1H, *J*=17.1, 10.8 Hz), 3.41 (dd, 1H, *J*=17.1, 10.8 Hz), 3.83 (td, 1H, *J*=10.8, 4.5 Hz), 5.86 (d, 1H, *J*=4.5 Hz), 7.32 (d, 2H, *J*=11.4 Hz), 7.56 (d, 2H, *J*=11.4 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.59, 42.91, 72.88, 74.74, 127.21, 128.81, 130.58, 134.88, 148.33; MS *m*/*z* (%) 280 (M^++4, 2), 278 (M^++2, 7), 276 (M^+, 7), 195 (33), 193 (100), 158 (4), 128 (4), 75 (4); IR 3056, 2958, 2916, 2868, 2846, 2796, 1639, 1589, 1495, 1447, 1405, 1363, 1138, 1093, 1037, 926, 829, 762 cm^{-1}.

*3.2.12. 5-Dichloromethyl-1-methyl-3-(4-methylphenyl)-2-pyrazoline (**7e**)*

Yield 86%; crystallization from MeOH–H_2O gave yellow needles, mp 72–73 °C.(Found C, 55.89; H, 5.44; N, 10.78. $C_{12}H_{14}Cl_2N_2$ requires C, 56.05; H, 5.49; N, 10.89.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 2.36 (s, 3H), 3.02 (s, 3H), 3.25 (dd, 1H, *J*=17.1, 10.6 Hz), 3.58 (dd, 1H, *J*=17.1, 10.6 Hz), 3.77 (td, 1H, *J*=10.6, 4.6 Hz), 5.84 (d, 1H, *J*=4.6 Hz), 7.20 (d, 2H, *J*=8.2 Hz), 7.53 (d, 2H, *J*=8.2 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 21.44, 37.02, 43.25, 73.17, 74.73, 126.02, 129.25, 129.31, 139.27, 149.80; MS *m*/*z* (%) 260 (M^++4, 15), 258 (M^++2, 71), 256 (M^+, 81), 221 (9), 173 (100), 174 (43), 128 (10), 115 (8), 91 (13); IR (Nujol) 2784, 1585, 1517, 1138, 1039, 935, 925, 870, 817, 753, 713 cm^{-1}.

*3.2.13. 5-Dichloromethyl-3-(4-methoxyphenyl)-1-methyl-2-pyrazoline (**7f**)*

Yield 83%; column chromatography (AcOEt–Hexane, 1:2) gave yellow powder; mp 62–64 °C.(Found C, 52.73; H, 5.22; N, 10.30. $C_{12}H_{14}Cl_2N_2O$ requires C, 52.76; H, 5.17; N, 10.26.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.01 (s, 3H), 3.24 (dd, 1H, *J*=17.1, 10.8 Hz), 3.43 (dd, 1H, *J*=17.1, 10.8 Hz), 3.76 (td, 1H, *J*=10.8, 4.5 Hz), 3.83 (s, 3H), 5.85 (d, 1H, *J*=4.5 Hz), 6.89 (d, 2H, *J*=8.8 Hz), 7.58 (d, 2H, *J*=8.8 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 37.10, 43.41, 55.39, 73.19, 74.77, 114.01, 124.79, 127.57, 149.72, 160.47; MS *m*/*z* (%) 274 (M^++2, 14), 272 (M^+, 22), 237 (4), 190 (31), 189 (100), 174 (42), 146 (14), 115 (9), 77 (6); IR 3045, 3003, 2957, 2916, 2837, 2794, 2039, 1608, 1515, 1455, 1363, 1308, 1250, 1043, 922, 831, 762, 608 cm^{-1}.

*3.2.14. 5-Dichloromethyl-1-methyl-3-(4-nitrophenyl)-2-pyrazoline (**7g**)*

Yield 78%; crystallization from ethanol gave orange micro needles; mp 117–118 °C. (Found C, 45.79; H, 3.83; N, 14.59. $C_{11}H_{11}Cl_2N_3O_2$ requires C, 45.85; H, 3.85; N, 14.58.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.13 (s, 3H), 3.34 (dd, 1H, *J*=17.4, 10.9 Hz), 3.46 (dd, 1H, *J*=17.4, 10.9 Hz), 4.00 (td, 1H, *J*=10.9, 4.2 Hz), 5.90 (d, 1H, *J*=4.2 Hz), 7.75 (d, 2H, *J*=9 Hz), 8.22 (d, 2H, *J*=9 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.03, 42.05, 72.44, 74.47, 124.01, 126.22, 138.29, 146.11, 147.46; MS *m*/*z* (%) 289 (M^++2, 12), 287 (M^+, 18), 252 (6), 205 (36), 204 (100), 158 (84), 128 (11), 102 (8), 89 (7), 76 (10); IR (Nujol) 1640, 1601, 1545, 1507, 1343, 1137, 1109, 1039, 941, 853, 763, 753, 700 cm^{-1}.

*3.2.15. 3-(4-Biphenylyl)-5-dichloromethyl-1-methyl-2-pyrazoline (**7h**)*

Yield 80%; crystallization from ethanol–H_2O gave pale yellow prisms; mp 119–124 °C (dec). (Found C, 60.76; H, 4.88; N, 8.64. $C_{17}H_{16}Cl_2N_2$ requires C, 63.96; H, 5.05; N, 8.78.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.06 (s, 3H), 3.30 (dd, 1H, *J*=17.2, 10.8 Hz), 3.48 (dd, 1H, *J*=17.2, 10.8 Hz), 3.83 (td, 1H, *J*=10.8, 4.5 Hz), 5.86 (d, 1H, *J*=4.5 Hz),

7.35 (t, 1H, J=7.2 Hz), 7.44 (t, 2H, J=8.1 Hz), 7.59–7.62 (m, 4H), 7.70 (d, 2H, J=8.4 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 36.88, 43.11, 73.08, 74.72, 126.49, 127.06, 127.25, 127.67, 128.91, 130.99, 140.43, 141.77, 149.26; MS m/z (%) 320 (M^++2, 29), 318 (M^+, 42), 283 (6), 236 (71), 235 (100), 179 (15), 152 (30), 118 (4); IR (Nujol) 1636, 1577, 1413, 1336, 1319, 1135, 1043, 933, 842, 762, 722, 689 cm^{-1}.

3.2.16. 5-Dichloromethyl-1-methyl-3-(2-naphthyl)-2-pyrazoline (**7i**)

Yield 80%; crystallization from ethanol gave pale yellow prisms, mp 156–157 °C.(Found C, 61.36; H, 4.83; N, 9.49. $C_{15}H_{14}Cl_2N_2$ requires C, 61.45; H, 4.81; N, 9.55.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.08 (s, 3H), 3.39 (dd, 1H, J=17, 10.7 Hz), 3.56 (dd, 1H, J=17, 10.7 Hz), 3.86 (td, 1H, J=10.7, 4.5 Hz), 5.89 (d, 1H, J=4.5 Hz), 7.46–7.50 (m, 2H), 7.79–7.84 (m, 4H), 7.96 (dd, 1H, J=8.6, 1.7 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 36.84, 43.05, 73.07, 74.75, 123.41, 125.77, 126.57, 126.66, 127.85, 128.30, 128.31, 129.67, 133.23, 133.65, 149.63; MS m/z (%) 294 (M^++2, 17), 292 (M^+, 26), 210 (42), 209 (100), 178 (14), 153 (18), 127 (33), 105 (13); IR (Nujol) 2798, 1598, 1250, 1202, 1136, 932, 861, 825, 478, 703 cm^{-1}.

Crystal data. $C_{15}H_{14}Cl_2N_2$, M_r=293.18, monoclinic, space group $P2(1)/c$, a=9.5009(10), b=9.3486(10), c=15.3811(17) Å, β=99.616(2)°, V=1347.0(3) Å^3 at −100 K; Z=4, D_x=1.446 g/cm^3, $F(000)$=608, μ=0.479/mm. *Data collection*. A colourless block 0.25×0.24×0.18 mm was mounted in inert oil on a glass fibre and transferred to the cold gas stream of the diffractometer (Bruker SMART APEX CCD). Of 15,090 measured reflections, 3120 were independent (R_{int}=0.0516) and were used for all calculations. *Structure refinement*. The structures were refined anisotropically against F^2 (program SHELXL-97, G.M. Sheldrick, University of Göttingen). The methyl group was refined as a rigid group, other H with a riding model. The final wR_2 value was 0.0876 for all reflections, 173 parameters and 6 restraints, with $R1$ 0.0339 for reflections with $I>2\sigma(I)$; max $\Delta\rho$ 0.370 e/Å^3, S 1.08.

Tables of fractional atomic coordinates, thermal parameters, bond lengths and angles have been deposited at the Cambridge Crystallographic Center (CCDC 724981).

3.2.17. 5-Dichloromethyl-1-methyl-3-(2,4-dimethylphenyl)-2-pyrazoline (**7j**)

Yield 92%; column chromatography (AcOEt–Hexane, 1:2) gave orange powder; mp 42–44 °C.(Found C, 57.55; H, 6.00; N, 10.31. $C_{13}H_{16}Cl_2N_2$ requires C, 57.58; H, 5.95; N, 10.33.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 2.32 (s, 3H), 2.51 (s, 3H), 3.02 (s, 3H), 3.26 (dd, 1H, J=17, 10.6 Hz), 3.43 (dd, 1H, J=17, 10.6 Hz), 3.72 (td, 1H, J=10.6, 4.6 Hz), 5.85 (d, 1H, J=4.6 Hz), 7.02–7.04 (m, 2H), 7.21 (d, 1H, J=7.8 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 21.20, 22.89, 39.46, 43.54, 73.30, 74.23, 126.38, 128.17, 128.44, 132.45, 137.49, 138.41, 150.85; MS m/z (%) 272 (M^++2, 17), 270 (M^+, 26), 235 (5), 188 (53), 187 (100), 172 (10), 145 (12), 131 (20), 115 (12), 86 (14); IR 2963, 2922, 2867, 2843, 2794, 1614, 1588, 1505, 1447, 1351, 1209, 1136, 935, 918, 814, 759 cm^{-1}.

3.3. Preparation of 3-aryl-5-trichloromethyl-2-pyrazolines (8) and (9)

To a suspension of **3** (11 mmol) in EtOH (45 ml) a solution of hydrazine hydrate or methylhydrazine (13 mmol) in EtOH (40 ml) was added dropwise. The mixture was refluxed for 10 min. Then the solution was concentrated under reduced pressure (half of volume) and was kept at −18 °C until the precipitation of a white solid, which was collected by filtration and crystallized from EtOH.

3.3.1. 3-(4-Chlorophenyl)-5-trichloromethyl-2-pyrazoline (**8c**)

Yield 82%; crystallization from ethanol gave white needles; mp 176–180 °C (dec).(Found C, 40.09; H, 2.75; N, 9.37. $C_{10}H_8Cl_4N_2$ requires C, 40.30; H, 2.71; N, 9.40.) ^{1}H NMR δ (DMSO-d_6, 200 MHz) 3.12 (ddd, 1H, J=18.2, 7.6, 1.2 Hz), 3.52 (dd, 1H, J=18.2, 11.8 Hz), 4.82 (ddd, 1H, J=11.8, 7.6, 4.1 Hz), 7.42 (d, 2H, J=8.6 Hz), 7.63 (d, 2H, J=8.6 Hz), 8.22 (d, 1H, J=4.1 Hz); ^{13}C NMR δ (DMSO-d_6, 50.4 MHz) 36.79, 74.56, 102.64, 127.17, 128.57, 131.05, 132.97, 147.52; MS m/z (%) 298 (M^++2, 5), 296 (M^+, 4), 261 (3), 226 (5), 179 (100), 117 (7), 75 (8); IR (Nujol) 3295, 1604, 1498, 1416, 1403, 1377, 1362, 1292, 1091, 1076, 1009, 900, 828, 786, 727 cm^{-1}.

3.3.2. 3-(4-Methylphenyl)-5-trichloromethyl-2pyrazoline (**8e**)

Yield 94%; crystallization from ethanol gave white needles; mp 166–168 °C (dec).(Found C, 47.49; H, 4.02; N, 10.11. $C_{11}H_{11}Cl_3N_2$ requires C, 47.60; H, 3.99; N, 10.09.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 2.37 (s, 3H), 3.34 (dd, 1H, J=17.7, 7.0 Hz), 3.40 (dd, 1H, J=17.7, 10.5 Hz), 4.70 (dd, 1H, J=10.5, 7.0 Hz), 5.12 (br s, 1H), 7.19 (d, 2H, J=8.2 Hz), 7.55 (d, 2H, J=8.2 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 21.46, 37.26, 75.20, 101.58, 126.10, 129.01, 129.40, 139.59, 151.23; MS m/z (%) 280 (M^++4), 278 (M^++2, 11), 276 (M^+, 12), 241 (3), 205 (8), 159 (100), 132 (17), 117 (20), 91 (29), 65 (16); IR (Nujol) 3278, 1603, 1516, 1424, 1354, 1075, 902, 818, 799, 776, 676 cm^{-1}.

3.3.3. 3-(4-Methoxyphenyl)-5-trichloromethyl-2-pyrazoline (**8f**)

Yield 95%; crystallization from ethanol gave white needles; mp 146–147 °C (dec).(Found C, 44.92; H, 3.78; N, 9.51. $C_{11}H_{11}Cl_3N_2O$ requires C, 45.00; H, 3.78; N, 9.54.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.33 (dd, 1H, J=17.6, 6.9 Hz), 3.40 (dd, 1H, J=17.6, 10.6 Hz), 3.83 (s, 3H), 4.70 (dd, 1H, J=10.6, 6.9 Hz), 4.92 (br s, 1H), 6.91 (d, 2H, J=8.8 Hz), 7.60 (d, 2H, J=8.8 Hz); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 37.38, 55.43, 75.18, 101.60, 114.12, 124.51, 127.66, 151.09, 160.68; MS m/z (%) 296 (M^++4), 294 (M^++2, 17), 292 (M^+, 18), 221 (7), 175 (100), 160 (33), 132 (15), 117 (7), 77 (18); IR (Nujol) 3270, 1607, 1515, 1363, 1258, 1178, 1068, 1032, 1017, 914, 835, 775, 695 cm^{-1}.

3.3.4. 3-(2,4-Dimethylphenyl)-5-trichloromethyl-2-pyrazoline (**8j**)

Yield 88%; crystallization from ethanol gave yellow needles; mp 89–91 °C.(Found C, 49.40; H, 4.54; N, 9.60. $C_{12}H_{13}Cl_3N_2$ requires C, 49.43; H, 4.49; N, 9.61.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 2.33 (s, 3H), 2.52 (s, 3H), 3.36 (dd, 1H, J=17.7, 6.9 Hz), 3.45 (dd, 1H, J=17.7, 10.5 Hz), 4.63 (dd, 1H, J=10.5, 6.9 Hz), 5.11 (br s, 1H), 7.03 (d, 1H, J=7.8 Hz), 7.06 (s, 1H), 7.23 (d, 1H, J=7.8 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 21.20, 22.81, 39.55, 74.53, 101.75, 126.44, 128.00, 128.46, 132.54, 137.53, 138.71, 151.96; MS m/z (%) 292 (M^++2, 11), 290 (M^+, 12), 219 (11), 173 (100), 146 (19), 131 (30), 117 (12), 77 (27); IR (Nujol) 3286, 1612, 1588, 1341, 1061, 1007, 908, 791, 769, 721, 666 cm^{-1}.

3.3.5. 1-Methyl-3-phenyl-5-trichloromethyl-2-pyrazoline (**9a**)

Yield 80%; crystallization from ethanol gave white needles; mp 104–105 °C.(Found C, 47.75; H, 3.97; N, 10.13. $C_{11}H_{11}Cl_3N_2$ requires C, 47.60; H, 3.99; N, 10.09.) ^{1}H NMR δ ($CDCl_3$, 400 MHz) 3.23 (s, 3H), 3.36 (dd, 1H, J=18.0, 7.4 Hz), 3.64 (dd, 1H, J=18.0, 11.7 Hz), 4.17 (dd, 1H, J=11.7, 7.4 Hz), 7.33–7.40 (m, 3H), 7.64–7.67 (m, 2H); ^{13}C NMR δ ($CDCl_3$, 100.8 MHz) 39.58, 44.97, 81.36, 102.28, 126.20, 128.65, 129.36, 131.70, 149.37; MS m/z (%) 278 (M^++2, 9), 276 (M^+, 10), 205 (3), 241 (5), 159 (100), 117 (18), 91 (21), 77 (33); IR (Nujol) 1595, 1321, 1143, 1064, 1038, 1013, 927, 786, 758, 693 cm^{-1}.

3.3.6. 1-Methyl-3-(4-nitrophenyl)-5-trichloromethyl-2-pyrazoline (**9g**)

Yield 86%; crystallization from ethanol gave yellow needles; mp 169–171 °C.(Found C, 41.02; H, 3.17; N, 12.98. $C_{11}H_{10}Cl_3N_3O_2$ requires C, 40.96; H, 3.12; N, 13.03.) ^{1}H NMR δ ($CDCl_3$, 300 MHz) 3.33 (s, 3H), 3.40 (dd, 1H, J=18.0, 7.6 Hz), 3.66 (dd, 1H, J=18.0, 11.8 Hz), 4.33 (dd, 1H, J=11.8, 7.6 Hz), 7.77 (d, 2H, J=8.8 Hz), 8.22 (d, 2H, J=8.8 Hz); ^{13}C NMR δ ($CDCl_3$, 75.4 MHz) 39.10, 44.30, 81.41, 101.70, 123.98, 126.43, 137.80, 145.94, 147.63; MS m/z (%) 323 (M^++2, 5), 321 (M^+, 5), 286 (7), 250 (3), 204 (100), 158 (72), 117 (9), 76 (13); IR

(Nujol) 1594, 1569, 1510, 1350, 1336, 1319, 1142, 1106, 1067, 1037, 1020, 927, 847, 786, 690 cm^{-1}.

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Supplementary data

X-ray structural data of compound **7i**; NMR spectra of compounds **6**–**9**. Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.tet.2009.05.084.

References and notes

1. Luknitskii, F. I. *Chem. Rev.* **1975**, *75*, 259.
2. Guirado, A.; Andreu, R.; Gálvez, J. *Tetrahedron Lett.* **1998**, *39*, 1071.
3. Guirado, A.; Andreu, R.; Cerezo, A.; Gálvez, J. *Tetrahedron* **2001**, *57*, 4925.
4. Guirado, A.; Andreu, R.; Zapata, A.; Cerezo, A.; Bautista, D. *Tetrahedron* **2002**, *58*, 5087.
5. Guirado, A.; Andreu, R.; Gálvez, J.; Jones, P. G. *Tetrahedron* **2002**, *58*, 9853.
6. Guirado, A.; Andreu, R.; Martiz, B.; Gálvez, J. *Tetrahedron* **2004**, *60*, 987.
7. Guirado, A.; Andreu, R.; Martiz, B.; Pérez-Ballester, S. *Tetrahedron* **2006**, *62*, 9688.
8. Guirado, A.; Andreu, R.; Gálvez, J. *Tetrahedron Lett.* **1999**, *40*, 8163.
9. Guirado, A.; Andreu, R.; Gálvez, J. *Tetrahedron Lett.* **2003**, *44*, 3809.
10. Guirado, A.; Andreu, R.; Martiz, B.; Bautista, D.; Ramírez de Arellano, C.; Jones, P. G. *Tetrahedron* **2006**, *62*, 6172.
11. Guirado, A.; Martiz, B.; Andreu, R. *Tetrahedron Lett.* **2004**, *45*, 8523.
12. Berhr, L. C.; Fusco, F.; Jarboe, C. H. In *Pyrazoles, Pyrazolines, Pyrazolidines, Indazoles and Condensed Rings*; Wiley, R. H., Ed.; The Chemistry of Heterocyclic Compounds; Wiley-Interscience: New York, NY, 1967.
13. Elguero, J. In *Comprehensive Heterocyclic Chemistry*; Katritzky, A., Rees, C., Potts, D., Eds.; Pergamon: Oxford, 1984; Vol. 5, p 167.
14. Bansal, E.; Srivastava, V. K.; Kumar, A. *Eur. J. Med. Chem.* **2001**, *36*, 81.
15. Kumar, A.; Archana; Sharma, S.; Malik, N.; Sharma, P.; Kaushik, K.; Saxena, K. K.; Srivastava, V. K.; Verma, R. S.; Sharma, H.; Gupta, S. C.; Gupta, V.; Agarwal, R. C. *Indian J. Chem., Sect. B: Org. Chem. Incl. Med. Chem.* **2004**, *43*, 1532.
16. Barsoum, F. F.; Hosni, H. M.; Girgis, A. S. *Bioorg. Med. Chem.* **2006**, *14*, 3929.
17. Palaska, E.; Aytemir, M.; Uzbay, I. T.; Erol, D. *Eur. J. Med. Chem.* **2001**, *36*, 539.
18. Prasad, Y. R.; Rao, A. L.; Prasoona, L.; Murali, K.; Kumar, P. R. *Bioorg. Med. Chem. Lett.* **2005**, *15*, 5030.
19. Souza, F. R.; Souza, V. T.; Ratzlaff, V.; Borges, L. P.; Oliveira, M. R.; Bonacorso, H. G.; Zanatta, N.; Martins, M. A. P.; Mello, C. F. *Eur. J. Pharmacol.* **2002**, *451*, 141.
20. Safak, C.; Sarac, S.; Balkan, A.; Ertan, M.; Yulug, N. *Hacettepe Univ. Eczacilik Fak. Derg.* **1990**, *10*, 39 CA; 114: 185361.
21. Patel, P.; Koregaokar, S.; Shah, M.; Parekh, H. *Farmaco* **1996**, *51*, 59.
22. Grant, N.; Mishriky, N.; Asaad, F. M.; Fawzy, N. G. *Pharmazie* **1998**, *53*, 543.
23. Nauduri, D.; Reddy, G. B. S. *Chem. Pharm. Bull.* **1998**, *46*, 1254.
24. Holla, B. S.; Akberali, P. M.; Shivananda, M. K. *Farmaco* **2000**, *55*, 256.
25. Solankee, A.; Thakor, I. *Indian J. Chem., Sect. B: Org. Chem. Incl. Med. Chem.* **2006**, *45*, 517.
26. Tiwari, N.; Dwivedi, B.; Nizamuddin, N. *Boll. Chim. Farm.* **1989**, *128*, 332 CA; 115: 179160.
27. Nimavat, K. S.; Popat, K. H.; Joshi, H. S. *Indian J. Heterocycl. Chem.* **2003**, *12*, 225.
28. Van Auken, T. V.; Rinehart, K. L., Jr. *J. Am. Chem. Soc.* **1962**, *84*, 3736.
29. McGreer, D. E.; Morris, P.; Carmichael, G. *Can. J. Chem.* **1963**, *41*, 726.
30. *Reagents for Organic Synthesis*; Fieser, M., Fieser, L. F., Eds.; Wiley-Interscience: New York, NY, 1969; Vol. 2, p 211.
31. Freeman, J. P. *J. Org. Chem.* **1964**, *29*, 1379.
32. Nakamichi, N.; Kawashita, Y.; Hayashi, M. *Org. Lett.* **2002**, *4*, 3955.
33. Nakamichi, N.; Kawashita, Y.; Hayashi, M. *Synthesis* **2004**, 1015.
34. Zolfigol, M. A.; Azarifar, D.; Mallakpour, S.; Mohammadpoor-Baltork, I.; Forghaniha, A.; Maleki, B.; Abdollahi-Alibeik, M. *Tetrahedron Lett.* **2006**, *47*, 833.
35. Ushakov, H. I.; Shusherina, N. P.; Chinaeva, A. D. *Zh. Obshch. Khim.* **1947**, *17*, 1678 CA; 42: 13722.
36. Blicke, F. F.; Burkhalter, J. H. *J. Am. Chem. Soc.* **1942**, *64*, 451.
37. Beech, S. G.; Turnbull, J. H.; Wilson, W. *J. Chem. Soc., Chem. Commun.* **1952**, 4686.
38. Petersen, R. J.; Skell, P. S. *Organic Synthesis Collective*; John Wiley: New York, NY, 1973; Vol. 5, p 929.
39. Smith, L. I.; Rogier, E. R. *J. Am. Chem. Soc.* **1951**, *73*, 3840.
40. Mehr, L.; Becker, E. I.; Spoerri, P. E. *J. Am. Chem. Soc.* **1955**, *77*, 984.
41. *Reagents for Organic Synthesis*; Fieser, M., Fieser, L. F., Eds.; Wiley-Interscience: New York, NY, 1969; Vol. 2, p 332.
42. Hanson, G. A. *Bull. Soc. Chim. Belg.* **1958**, *67*, 707.
43. Huang, Y. R.; Katzenellenbogen, J. A. *Org. Lett.* **2000**, *2*, 2833.
44. Katritzky, A. R.; Wang, M.; Zhang, S.; Voronkov, M. V. *J. Org. Chem.* **2001**, *66*, 6787.
45. Kolhe, S. V.; Doshi, A. G.; Raut, A. W. *Indian J. Heterocycl. Chem.* **2003**, *12*, 281.
46. Kidwai, M.; Kukreja, S.; Thakur, R. *Lett. Org. Chem.* **2006**, *3*, 135.
47. Levai, A.; Jeko, J. *J. Heterocycl. Chem.* **2006**, *43*, 111.
48. Siddiqui, A. H.; Satyanarayana, Y.; Srinivas, M.; Rajeshwar, K. *J. Indian Chem. Soc.* **1992**, *69*, 846.
49. Agrawal, N. N.; Soni, P. A. *Indian J. Chem., Sect. B* **2004**, *43*, 2700.
50. Reimlinger, H.; Moussebois, C. *Chem. Ber.* **1965**, *98*, 1805.
51. García Ruano, J. L.; Alonso de Diego, S. A.; Blanco, D.; Martin Castro, A. M.; Martin, M. R.; Rodríguez Ramos, J. H. *Org. Lett.* **2001**, *3*, 3173.
52. Guirado, A.; Martiz, B.; Andreu, R.; Bautista, D.; Gálvez, J. *Tetrahedron* **2007**, *63*, 1175.
53. Guirado, A.; Martiz, B.; Andreu, R.; Galvez, J. *Electrochim. Acta* **2008**, *53*, 7138.
54. Hill, R. A. In *Comprehensive Organic Functional Groups Transformations*; Kirby, G. W., Katrizky, A. R., Meth-Cohn, O., Rees, C. W., Eds.; Elsevier: Oxford, 1995; Vol. 4, p 11.