

New Investigation of Vilsmeier-Type Reaction Using

Pyrazolones with Various Amides

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Key words: Vilsmeier-type reaction, pyrazolones, amides, formylation, dipyrazolylmethane

Abstract

New investigation of Vilsmeier-type reaction was evaluated to realize the solvent effect by using pyrazolones to react with various of amides, including formamide, *N*-methylformamide, *N*-propylformamide, *N*-*tert*-butylformamide, *N,N*-dimethylformamide (DMF), *N,N*-diethylformamide (DEF), *N,N*-dipropylformamide (DPF), *N,N*-diisopropylformamide, *N,N*-dibutylformamide, piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde, in the presence of phosphorous oxychloride POCl₃. The unexpected resulting products were observed in this work according to the difference chemoseletivities of substituted amides. A plausible reactive pathways were proposed to explain the experimental result.

Introduction

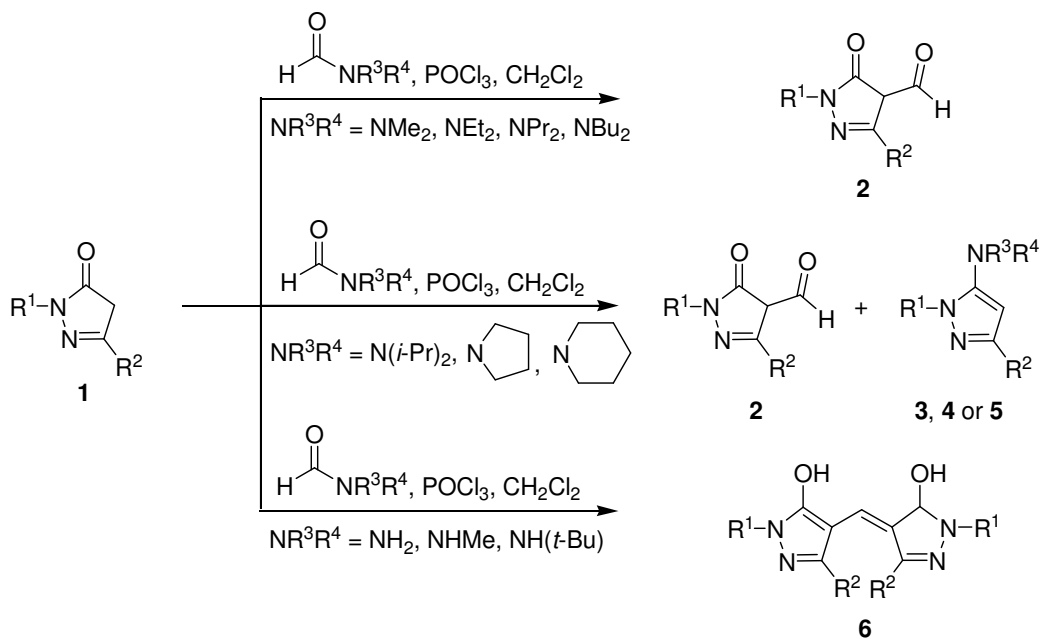
Functionalized *N*-arylpyrazole moiety has been shown to exhibit antihyperglycemic, analgesic, anti-inflammatory, sedative, and hypnotic activities.¹⁻³ More specifically, 5-alkyl/arylamino substituted pyrazoles have been exploited in the design of pharmaceuticals and agrochemical agents exhibiting a range of biological activities.^{2,4-6}

Vilsmeier-type reaction belongs to electrophilic aromatic substitution reaction for the formylation⁹ of activated aromatic substrates and carbonyl compounds by halomethyleniminium salt. It is a powerful synthetic tool for the construction of many heterocyclic compounds.¹⁰⁻¹² Formylpyrazoles are prepared by this reaction and attract attention for its being powerful building blocks for the design of complex pyrazolic assemblies in the agrochemistry and biomedical chemistry fields.^{7,8} Herein, we are greatly interesting in the study of the reactivity of various amides in the presence of phosphorous oxychloride POCl₃ as the reactants¹³ with pyrazolones. These amides include formamide, *N*-methylformamide, *N*-propylformamide, *N*-*tert*-butylformamide, *N,N*-dimethylformamide (DMF), *N,N*-diethylformamide (DEF), *N,N*-dipropylformamide (DPF), *N,N*-diisopropylformamide, *N,N*-dibutylformamide, piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde. In this study, we found the formation of unexpected products resulted from the different reactivity of the substituted amides serving as the Vilsmeier reagent by reacting with POCl₃. We provided the plausible reactive pathways to explain our experimental result.

Result and Discussion

5-Pyrazolone derivatives were prepared as the substrates following the reported procedure via tandem condensation and thermal cyclization.¹⁴ In this newly

investigation, we chose a series of 1,3-disubstituted-1*H*-pyrazol-5-ones **1a–1h** as the substrates to react with various of amides, including formamide, *N*-methylformamide, *N*-propylformamide, *N*-*tert*-butylformamide, *N,N*-dimethylformamide (DMF), *N,N*-diethylformamide (DEF), *N,N*-dipropylformamide (DPF), *N,N*-diisopropylformamide, *N,N*-dibutylformamide, piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde with POCl₃ in CH₂Cl₂ co-solution. For improving the previous procedure of the Vilsmeier reaction, we modified the solvent system by using amide/CH₂Cl₂ co-solvent system (see Scheme 1). Initially, compounds **1a–1f** were allowed to react with *N,N*-dimethylformamide (DMF) or *N,N*-diethylformamide (DEF, 3.0 equiv) with POCl₃ (5.0 equiv) in CH₂Cl₂ solution at reflux (~50–60 °C) within 0.5–1 h. After aqueous worked-up and purified by column chromatography on silica gel, we isolated the corresponding formylated product **2a–2f** in >87% yields (see Scheme 1 and Table 1). In this modified solvent system (amide/CH₂Cl₂ = 1/1), the reaction time was decreased from ~12 h to 0.5–1 h. All of the 4-formylpyrazolone products **2a–2f** were fully characterized by spectroscopic methods (see Table 1) and the data were consistence with the previous literature reported.^{7,8} Furthermore, we extended the reaction condition to 1,3-diphenyl-1*H*-pyrazol-5-one (**1a**) by using *N,N*-dipropylformamide (DPF) and *N,N*-dibutylformamide with CH₂Cl₂ as the reaction solvent. The corresponding 4-formylpyrazolone product **2a** was also obtained in excellent yields (> 83%, see Table 1 and Scheme 1).



Scheme 1

Table 1. Reaction of the pyrazolones with *N,N*-dimethylformamide, *N,N*-diethylformamide, *N,N*-dipropylformamide, or *N,N*-dibutylformamide in the presence of POCl₃

S.M.	Pyrazolones (1a–1f)		Amides HCONR ³ R ⁴	Products	
	N1-R ¹	C3-R ²	NR ³ R ⁴	4-Formylpyrazolones (2a–2f)	
				No.	Yields (%)
1a	Ph	Ph	NMe ₂	2a	95
1b	<i>o</i> -MePh	Ph	NMe ₂	2b	96
1c	<i>p</i> -OMePh	Ph	NMe ₂	2c	93
1d	<i>p</i> -BrPh	Ph	NMe ₂	2d	93
1e	Ph	Me	NMe ₂	2e	96
1f	Ph	<i>i</i> -Pr	NMe ₂	2f	94
1a	Ph	Ph	NEt ₂	2a	93
1b	<i>o</i> -MePh	Ph	NEt ₂	2b	91

1c	<i>p</i> -OMePh	Ph	NEt ₂	2c	87
1d	<i>p</i> -BrPh	Ph	NMe ₂	2d	93
1e	Ph	Me	NEt ₂	2e	94
1f	Ph	<i>i</i> -Pr	NEt ₂	2f	91
1a	Ph	Ph	NPr ₂	2a	88
1a	Ph	Ph	NBu ₂	2a	83

To extend the reaction to bulky *N,N*-diisopropylformamide, or flexible cyclic piperidine-1-carbaldehyde and pyrrolidine-1-carbaldehyde, which possess the steric effect and ring stress effect in amide functional groups. We carried out the same reaction condition toward pyrazolones **1a–1d**, which owned *N*1-substituted phenyl and aryl group, with various *mono*-substituents including *o*-MePh, *p*-BrPh, and *p*-OMePh. The 4-formylpyrazolones **2a–2d** were obtained as the major products to in 63%, 51–62% and 54–59% yields, respectively (see Table 2). Particularly, unexpected amination¹⁵ products **3a**, **4a–4d** or **5a–5d** were observed and isolated in 28%, 32–46% or 31–39% yields, respectively (see Scheme 1 and Table 2). However, we also preformed the above strategy to pyrazolones **1e–1g** bearing C-3 Me, *n*-Pr, or *i*-Pr group. The traditional Vilsmeier formylated products **2e–2g** were achieved in 51–54% and 54–58% yields, respectively. Similarly, the unexpected amination¹⁵ products **4e–4g** or **5e–5g** were also provided in 32–38% or 31–36% yields (see Scheme 1 and Table 2).

Table 2. Reactions pyrazolones with *N,N*-diisopropylformamide, piperidine-1-carbaldehyde or pyrrolidine-1-carbaldehyde in the presence of POCl₃

Pyrazolones (1a–1h)		Amides HCONR ³ R ⁴	Products				
			4-Formylpyrazolones		5-Aminopyrazoles		
S.M.	N1-R ¹	C3-R ²	-NR ³ R ⁴	No.	Yields (%)	No.	Yields (%)

1a	Ph	Ph	N(<i>i</i> -Pr) ₂	2a	63	3a	28
1a	Ph	Ph	Pyrrolidinyl	2a	62	4a	33
1b	<i>o</i> -MePh	Ph	Pyrrolidinyl	2b	59	4b	37
1c	<i>p</i> -OMePh	Ph	Pyrrolidinyl	2c	56	4c	42
1d	<i>p</i> -BrPh	Ph	Pyrrolidinyl	2d	51	4d	46
1e	Ph	Me	Pyrrolidinyl	2e	53	4e	38
1f	Ph	<i>i</i> -Pr	Pyrrolidinyl	2f	54	4f	37
1g	Ph	<i>n</i> -Pr	Pyrrolidinyl	2g	51	4g	32
1a	Ph	Ph	Piperidinyl	2a	59	5a	34
1b	<i>o</i> -MePh	Ph	Piperidinyl	2b	53	5b	33
1c	<i>p</i> -OMePh	Ph	Piperidinyl	2c	49	5c	39
1d	<i>p</i> -BrPh	Ph	Piperidinyl	2d	54	5e	35
1e	Ph	Me	Piperidinyl	2e	57	5e	34
1f	Ph	<i>i</i> -Pr	Piperidinyl	2f	58	5f	31
1g	Ph	<i>n</i> -Pr	Piperidinyl	2g	54	5g	36

To examine solvent effect of other amide, we applied the same condition to 1,3-disubstituted-1*H*-pyrazol-5-ones **1a–1f** with original formamide. Particularly, we did not isolate and detect the 4-formylpyrazolones product **2** in this solvent system. When we fully identified and characterized the isolated products by spectroscopic methods, the dipyrazolylmethane products **6a–6f** were obtained in 84–96% isolated yields under the reaction condition (see Scheme 1 and Table 3). For example, compound **6a** presented a peak at δ 8.51 ppm for $-\text{C}^1\text{H}=\text{C}$ in ^1H NMR. In ^{13}C NMR spectrum, compound **6a** possessed characterization absorptions at δ 109.5 ppm for methylene carbon $-\text{CH}=\text{C}$. The IR absorptions of **6a** showed peaks at 2109 cm^{-1} for stretching of the $-\text{CH}=\text{C}$ group and at 3291 cm^{-1} for stretching of the $-\text{OH}$ group.

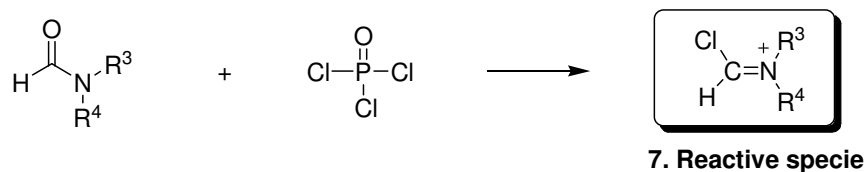
For the further investigation of other amide agents, pyrazolones **1a–1f** were reacted with *N*-methylformamide. Fortunately, the dipyrazolylmethane products **6a–6f** were also obtained as the only corresponding products in 82–95% yields. Whatever, the formylated compounds **2** were also not detectable in the presence of *N*-methylformamide as the reaction solvent (see Scheme 1 and Table 3). When applying *N*-*tert*-butylformamide toward 1,3-diphenyl-1*H*-pyrazol-5-ones **1a** under the same condition, we obtained the corresponding dipyrazolylmethane product **6a** in lower yield (47%). The result indicated that the bulky functional alkyl group on the nitrogen atom is not favor for the formation of dipyrazolylmethane product (see scheme 3 and Table 3).

Table 3. Reaction of pyrazolones with formamide, *N*-methylformamide, or *N*-*tert*-butylformamide in the presence of POCl₃

Pyrazolones (1a–1g)			Amides HCONR ³ R ⁴	Products	
				Dipyrazoylmethanes	
S.M.	N1-R ¹	C3-R ²	NR ³ R ⁴	No.	Yields (%)
1a	Ph	Ph	NH ₂	6a	96
1b	<i>o</i> -MePh	Ph	NH ₂	6b	90
1c	<i>p</i> -OMePh	Ph	NH ₂	6c	84
1d	<i>p</i> -BrPh	Ph	NH ₂	6d	93
1e	Ph	Me	NH ₂	6e	93
1f	Ph	<i>i</i> -Pr	NH ₂	6f	91
1a	Ph	Ph	NHMe	6a	95
1b	<i>o</i> -MePh	Ph	NHMe	6b	90
1c	<i>p</i> -OMePh	Ph	NHMe	6c	82
1d	<i>p</i> -BrPh	Ph	NHMe	6d	91

1e	Ph	Me	NHMe	6e	94
1f	Ph	<i>i</i> -Pr	NHMe	6f	91
1a	Ph	Ph	NH(<i>t</i> -Bu)	6a	47

Following the experimental result, we tried to realize the reactivity and reaction mechanism on various amide solvent systems. Since, we propose the plausible reaction mechanism as shown in Scheme 2 and Scheme 3 to account the formation of the different resulting products. At first, amide agents was treated with phosphorous oxychloride POCl₃ to *in situ* form the very reactive specie Vilsmeier reagent halomethyleniminium salts **7** (see Scheme 2).¹⁶

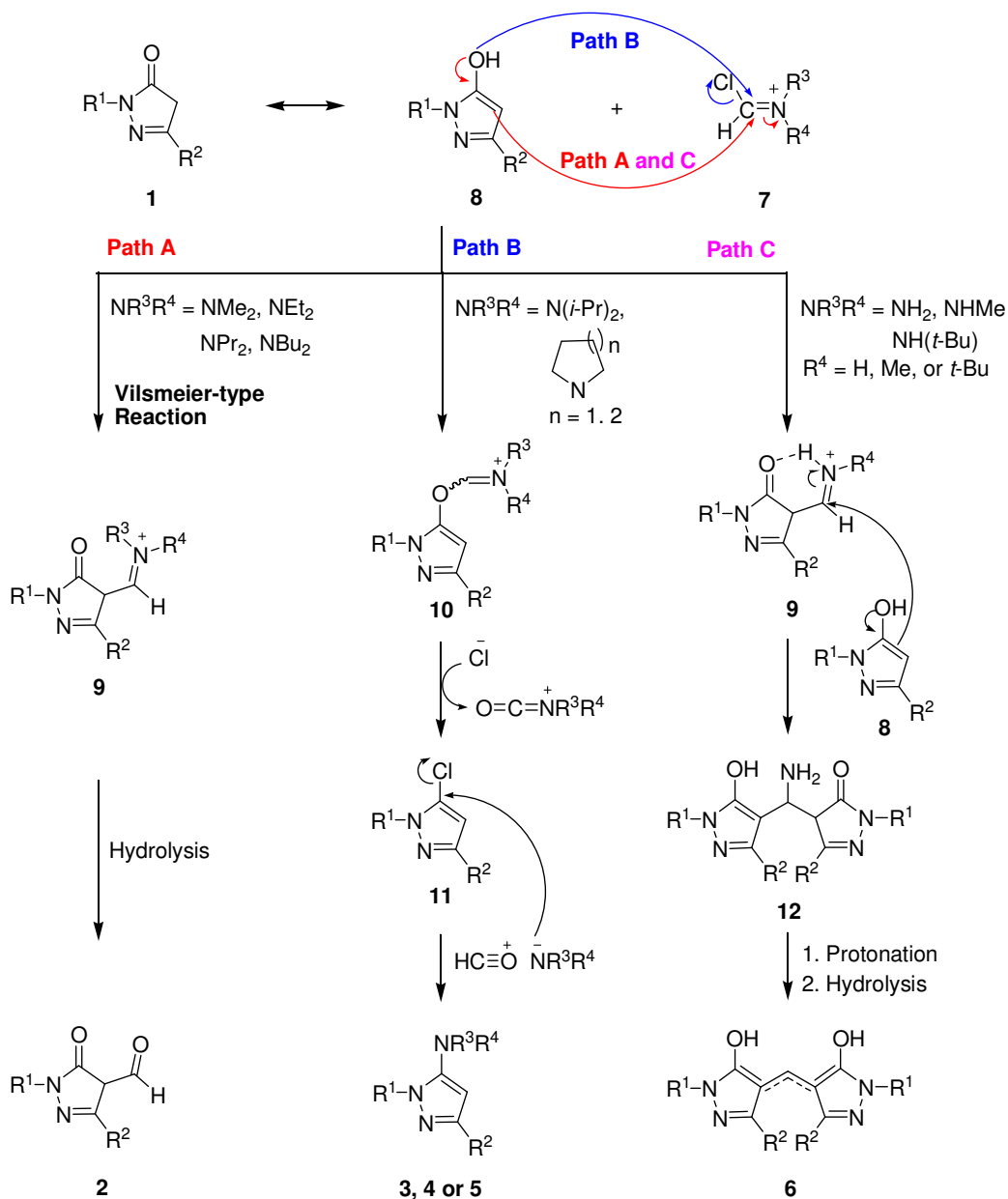


Scheme 2

In acid catalytic condition, pyrazolones **1** was efficiently converted to 5-hydroxypyrazole **8**. Simultaneously, 5-hydroxy pyrazoles **8** was preliminarily reacted with the active iminium species **7** by means of C-enolization (**A** and **C**) and *O*-substitution **B** in three probably reaction pathways. In the **A** reaction pathway, the active iminium species **7** was generated from various amides including *N,N*-dimethylformamide, *N,N*-diethylformamide, *N,N*-dipropylformamide, and *N,N*-dibutylformamide. 5-Hydroxy pyrazoles **8** was allowed to react with an active iminium species **7** by following the normal Vilsmeier reaction to form β -ketoamide intermediate **9**. After the hydrolysis was completed, the traditional Vilsmeier products **2** were obtained.^{7,8}

When *N,N*-diisopropylformamide, piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde were used as the reactants to generate active iminium

species **7**, the competitive pathway **A** and **B** were provided to describe the resulting data. In the pathway **B**, the activated β -ketoamide intermediate **10** was formed by *O*-substitution from 5-hydroxypyrazole **8** with active iminium species **7**. The activated intermediate **10** replaced by the chloride anion as a nucleophile¹⁷ to lead to 5-chloropyrazole **11**.¹⁸ Due to the steric effect of di-*iso*-propyl group or large ring-stress effect of piperidinyl and pyrrolidinyl groups between the nitrogen and the carbon substituent on halomethyleniminium salts, the dissociation of iminium **7** was happened and released the amino anion and CO⁺ species.^{19,20} After the further amination was performed between 5-chloropyrazole **11** and amino anion (di-*iso*-propyl, piperidinyl and pyrrolidinyl groups), the final 5-aminopyrazole products **3a**, **4a–4g** and **5a–5g** were usefully obtained in 31–46% yields (see Scheme 3 and Table 2). Consequently, the classical Vilsmeier-type reaction (Pathway **A**) was also observed to afford the corresponding products **2a–2g** in 49–62% yields as the major products.



Scheme 3

For formamide, *N*-methylformamide, and *N-tert*-butylformamide solvent systems, the pathway **C** was used to describe the formation of dipyrzoylmethanes **6**. Since the intramolecular hydrogen-bonding was sequentially formed on β -ketoamide intermediate **9** by using formamide *N*-methylformamide, and *N-tert*-butylformamide as reactants, the more stable β -ketoamide intermediate **9** possessed enough the life-time to react with secondary equivalent of 5-hydroxypyrazole **8** to proceed the

Michel addition and generate dipyrazolyl-aminomethane **12**. After the protonation and hydrolysis reactions were simultaneously performed, the final dipyrazolylmethane products **6** were usefully obtained in good to excellent yields under formamide and *N*-methylformamide two systems (see Scheme 3 and Table 3). When *N*-*tert*-butylformamide was applied in the same condition, the steric effect of *tert*-butyl group on the nitrogen atom is not favor to the hydrogen bonding formation of β -ketoamide intermediate **9**. Since, the corresponding dipyrazolylmethane product **6** was obtained in the lower yield (47%, see Table 3).

In conclusion, the different chemoselectivity of Vilsmeier reaction was completely explored by using pyrazolones with variety of amides, including formamide, *N*-methylformamide, *N*-propylformamide, *N*-*tert*-butylformamide, *N,N*-dimethylformamide (DMF), *N,N*-diethylformamide (DEF), *N,N*-dipropylformamide (DPF), *N,N*-diisopropylformamide, *N,N*-dibutylformamide, piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde in the presence of POCl₃. We believed the steric effect of substituted amide play a key role to control the chemoselective results. Furthermore, three plausible pathways were also provided to describe the chemoselective reactions.

Experimental Section

General Procedure: All chemicals were reagent grade and used as purchased. All reactions were carried out under nitrogen atmosphere and monitored by TLC analysis. Flash column chromatography was carried out on silica gel (230–400 mesh). Commercially available reagents were used without further purification unless otherwise noted. Dichloromethane, ethyl acetate, hexanes, and methanol were purchased from Mallinckrodt Chemical Co. The following compounds were purchased from Acros Chemical Co: ethyl Butyrylacetate, 2,4-dinitrophenyl

hydrazine, formamide, *N,N*-diethylformamide, ethyl acetoacetate, *N*-formylpiperidine, *N*-methylformamide, phenylhydrazine, *o*-tolylhydrazine hydrochloride, *m*-tolylhydrazine hydrochloride, *p*-tolylhydrazine hydrochloride. *N*-Formylpyrrolidine was purchased from Aldrich Chemical Co. *N,N*-Diethylformamide was purchased from Scharlau Chemical Co. 2,4,6-Trichlorophenyl hydrazine was purchased from TCI Chemical Co. 4-Bromophenylhydrazine hydrochloride, 2-chlorophenylhydrazine hydrochloride, 3-chlorophenylhydrazine hydrochloride, 4-chlorophenylhydrazine hydrochloride, ethyl benzoylacetate, ethyl isobutyrylacetate, ethyl trifluoroacetoacetate, 4-methoxyphenylhydrazine hydrochloride were purchased from Alfa Chemical Co. Phosphorylchloride were purchased from FERAK Chemical Co. Purification by gravity column chromatography was carried out by use of Merck Reagents Silica Gel 60 (particle size 0.063–0.200 mm, 70–230 mesh ASTM). Infrared (IR) spectra were measured on a Bomem Michelson Series FT-IR spectrometer. The wavenumbers reported are referenced to the polystyrene 1601 cm^{-1} absorption. Absorption intensities are recorded by the following abbreviations: s, strong; m, medium; w, weak. Proton NMR spectra were obtained on a Bruker (200 or 400 MHz) spectrometer by use of CDCl_3 as solvent. Carbon-13 NMR spectra were obtained on a Bruker (50 or 100 MHz) spectrometer by used of CDCl_3 as solvent. Carbon-13 chemical shifts are referenced to the center of the CDCl_3 triplet (δ 77.0 ppm). Multiplicities are recorded by the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; *J*, coupling constant (Hz). Elemental analyses were carried out on a Heraeus CHN–O RAPID element analyzer.

Standard Procedure for the preparation of 4-formylpyrazolone products (2a–2g), amination products (3a, 4a–4g and 5a–5g) and dipyrazolylmethane products (6a–6f).

The reliable procedure involved the treatment of pyrazolones (**1a-1g**, 1.0 equivalent) with catalytic amount of POCl₃ (~3 equivalent) with various of amide (2 mL) including formamide, *N*-methylformamide, *N,N*-dimethylformamide (DMF), *N,N*-diethylformamide (DEF), piperidine-1-carbaldehyde, and pyrrolidine-1-carbaldehyde in CH₂Cl₂ solution (2 mL) at 50–60 °C within 0.5–1 h. When the reaction was completed, the reaction mixture was concentrated, added to saturate sodium bicarbonate (15 mL) and extracted with dichloromethane (15 mL). The organic extracts were dried over MgSO₄, filtered, and concentrated under reduced pressure. The residues were purified by column chromatography on silica gel to give the corresponding 4-formylpyrazolone products **2a–2g**, amination products **3a**, **4a–4g** and **5a–5g**, dipyrazolylmethane products **6a–6f** were obtained.

1,3-Diphenyl-4-formyl-2-pyrazolin-5-one (2a): mp (recrystallized from ethanol) 241–242 °C; ¹H NMR (CDCl₃, 200 MHz) δ 7.13 (t, 1H, J=7.6, ArH), 7.37–7.46 (m, 5H, ArH), 7.71–7.75 (m, 2H, ArH), 7.82 (d, 2H, J=7.6 Hz, ArH) 10.1 (s, 1H, CHO); ¹³C NMR (50 MHz, CDCl₃) δ 116.3, 125.3 (2 × CH), 128.4 (2 × CH), 128.8 (2 × CH), 129.1 (2 × CH), 129.3 (2 × CH), 130.7, 133.1, 136.8, 154.1, 183.6; IR (KBr) 3067 (m), 1698 (s, C=O), 1591 (s, C–N), 1482 (m), 1386 (m), 1331 (m), 1179 (m), 1121 (m), 901 (m) cm⁻¹; Anal. Calcd for C₁₆H₁₂N₂O₂; C: 72.72; H: 4.58; N: 10.60, Found: C: 72.76; H:4.56; N: 10.62.

1-(2'-Methylphenyl)-3-phenyl-4-formyl-2-pyrazolin-5-one (2b): mp (recrystallized from ethanol) 231–233 °C; ¹H NMR (CD₃OD, 200 MHz) δ 2.31 (s, 3H, CH₃), 7.46 (d, 2H, J=7.2, ArH), 7.49–7.55 (m, 5H, ArH), 7.73 (d, 2H, J=7.2, ArH), 9.92 (s, 1H, CHO); ¹³C NMR (50 MHz, CD₃OD) δ 16.3, 125.9 (2 × CH), 126.2, 127.2, 128.1, 128.3, 129.1 (2 × CH), 131.1, 131.2, 131.5, 131.7, 135.9, 136.7, 149.6, 157.4; IR (KBr) 3293 (m), 3124 (s), 1880 (m), 1537 (s, C–N), 1472 (m), 1305 (m), 1147 (m), 982 (m), 807 (m) cm⁻¹ Anal. Calcd for C₃₃H₂₆N₄O₂; Anal. Calcd for C₁₇H₁₄N₂O₂; C:

73.37; H: 5.07; N: 10.07, Found: C: 73.35; H:5.11; N: 10.09.

1-(4'-Methoxyphenyl)-3-phenyl-4-formyl-2-pyrazolin-5-one (2c): mp (recrystallized from ethanol) 152–153 °C; ¹H NMR (CDCl₃, 200 MHz) δ 3.81 (s, 3H, CH₃), 6.87 (d, 2H, J=6.8 Hz, ArH), 7.36–7.40 (m, 3H, ArH), 7.68 (d, 2H, J=7.2 Hz, ArH), 7.72 (d, 2H, J=6.8 Hz, ArH), 10.2 (s, 1H, CHO); ¹³C NMR (50 MHz, CDCl₃) δ 38.1, 114.0 (2 × CH), 121.0 (2 × CH), 125.9 (2 × CH), 128.9 (2 × CH), 129.8, 130.4, 130.7, 131.3, 131.6, 153.5, 156.2, 179.1; IR (KBr) 2972 (m), 1691 (s, C=O), 1492 (s, C–N), 1497 (m), 1238 (m), 1032 (m), 851 (m) cm⁻¹; Anal. Calcd for C₁₇H₁₄N₂O₃; C: 69.38; H: 4.79; N: 9.52, Found: C: 69.34; H: 4.83; N: 9.51.

1-(4'-Bromophenyl)-4-formyl-2-pyrazolin-5-one (2d): mp (recrystallized from ethanol) 201–203 °C; ¹H NMR (CD₃OD, 200 MHz) δ 7.27 (m, 2H, ArH); 7.46 (m, 2H, ArH); 7.78 (m, 2H, ArH); 7.93 (m, 2H, ArH); 9.8 (s, 1H, CHO); ¹³C NMR (50 MHz, CD₃OD) δ 119.3, 125.1 (2 × CH), 128.6 (2 × CH), 128.9 (2 × CH); 130.1 (2 × CH), 130.5, 130.7, 130.9, 154.9, 178.4; IR (KBr) 3133 (m), 3025 (s), 1790 (m), 1483 (s, C–N), 1456 (m), 1307 (m), 1139 (m), 977 (m), 794 (m) cm⁻¹; Anal. Calcd for C₁₆H₁₁BrN₂O₂; C: 56.00; H: 3.23; N: 8.16, Found: C: 55.98; H: 3.27; N: 8.15.

1-Phenyl-3-methyl-4-formyl-2-pyrazolin-5-one (2e): mp (recrystallized from ethanol) 175–176 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.2 (s, 3H, CH₃), 7.3–7.9 (m, 6H, Ph), 9.85 (s, 1H, CHO); ¹³C NMR (50 MHz, CDCl₃) δ 17.0, 116.9, 125.5 (2 × CH), 129.8 (2 × CH), 133.9, 134.6, 137.1, 155.7, 181.5; IR (KBr) 3152 (s), 2812 (m), 1659 (s, C=O), 1598 (s, C–N), 1463 (m), 1408 (m), 1296 (s), 1230 (m), 1029 (m), 958 (m) cm⁻¹; Anal. Calcd for C₁₁H₁₀N₂O₂; C: 65.34; H: 4.98; N: 13.85, Found: C: 65.32; H: 4.94; N: 13.86.

1-Phenyl-3-isopropyl-4-formyl-2-pyrazolin-5-one (2f): mp (recrystallized from ethanol) 149–150 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.28 (d, 6H, J=7.4, CH(CH₃)₂), 2.59–2.73 (m, 1H, CHMe₂), 7.09 (t, 1H, J=7.4, ArH), 7.27 (dd, 2H, J = 8.1, 7.4 Hz,

ArH), 7.65 (d, 2H, J = 8.1 Hz, ArH), 9.92 (s, 1H, CHO); ^{13}C NMR (50 MHz, CDCl_3) δ 17.8 (2 \times CH_3), 29.5, 35.7, 117.6 (2 \times CH), 121.2, 127.7 (2 \times CH), 138.1, 158.3, 179.7; IR (KBr) 3202 (s), 2799 (m), 1601 (s, C=O), 1581 (s, C–N), 1481 (m), 1423 (m), 1312 (s), 1209 (m), 1036 (m), 956 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{13}\text{H}_{14}\text{N}_2\text{O}_2$: C: 67.81; H: 6.13; N: 12.17, Found: C: 67.78; H: 6.11; N: 12.20.

1,3-Diphenyl-5-di-isopropylaminopyrazole (3a): mp (recrystallized from ethanol) 92–93 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 1.22–1.24 (m, 12H), 3.54–3.60 (m, 1H), 4.12–4.18 (m, 1H), 6.16 (s, 1H), 7.09–7.12 (m, 1H), 7.33–7.36 (m, 2H), 7.39–7.52 (m, 4H), 8.01–8.03 (m, 2H), 8.17 (s, H); ^{13}C NMR (50 MHz, CDCl_3) δ 20.16 (CH_3), 20.96 (CH_3), 23.96 (CH_3), 29.64 (CH_3), 46.51 (CH), 48.28 (CH), 97.92, 120.13, 124.24, 128.28 (3 \times CH), 128.47 (3 \times CH), 128.82, 129.04 (2 \times CH), 139.63, 149.43, 161.54; IR (KBr) 3048 (s), 2811 (m), 1560 (s, C–N), 1428 (m), 1413 (m), 1309 (s), 1247 (m), 1179 (m), 973 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{21}\text{H}_{25}\text{N}_3$: C: 78.96; H: 7.89; N: 13.15. Found: C: 78.93; H: 7.91; N: 13.17.

1,3-Diphenyl-5-pyrrolidinopyrazole (4a): mp (recrystallized from ethanol) 87–88 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 2.35 (m, 4H), 3.50 (m, 4H), 5.89 (s, 1H), 7.18–7.25 (m, 2H), 7.35 (t, 2H, J = 7.6 Hz), 7.37(t, 2H, J = 7.6 Hz), 7.71 (d, 2H, J = 7.4 Hz), 7.82 (d, 2H, J = 7.6 Hz); ^{13}C NMR (50 MHz, CDCl_3) δ 23.1 (2 \times CH), 53.8 (2 \times CH), 89.3, 122.8 (2 \times CH), 125.2 (2 \times CH), 126.9 (2 \times CH), 128.1 (2 \times CH), 128.7, 129.6, 133.1, 140.4, 150.7, 162.8; IR (KBr) 3050 (s), 2814 (m), 1558 (s, C–N), 1432 (m), 1409 (m), 1298 (s), 1256 (m), 1183 (m), 975 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{19}\text{H}_{19}\text{N}_3$: C: 78.86; H: 6.62; N: 14.52. Found: C: 78.82; H: 6.65; N: 14.49.

1-(2'-Methylphenyl)-3-phenyl-5-pyrrolidinopyrazole (4b): mp (recrystallized from ethanol) 93–94 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 2.37 (m, 4H), 3.53 (m, 4H), 2.36 (s, 3H, CH_3), 5.97 (s, 1H), 7.46 (d, 2H, J=7.2, ArH), 7.51–7.58 (m, 5H, ArH), 7.72 (d,

2H, $J=7.2$, ArH); ^{13}C NMR (50 MHz, CDCl_3) δ 15.3, 23.8 (2 \times CH), 54.6 (2 \times CH), 89.5, 125.8 (2 \times CH), 126.1, 126.8, 128.5, 129.3 (2 \times CH), 131.2, 131.8, 132.7, 135.6, 136.9, 149.1, 158.3; IR (KBr) 3079 (m), 2984 (s), 1617, 1587 (s, C–N), 1479 (m), 1334 (m), 1130 (m), 988 (m), 815 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{20}\text{H}_{21}\text{N}_3$: C: 79.17; H: 6.98; N: 13.85. Found: C: 79.14; H: 6.95; N: 13.87.

1-(4'-Methoxyphenyl)-3-phenyl-5-pyrrolidinopyrazole (4c): mp (recrystallized from ethanol) 129–130 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 2.42 (m, 4H), 3.61 (m, 4H), 3.79 (s, 3H, CH_3), 5.93 (s, 1H), 6.69 (d, 2H, $J=6.8$ Hz, ArH), 7.20–7.25 (m, 3H, ArH), 7.43 (d, 2H, $J=7.2$ Hz, ArH), 7.48 (d, 2H, $J=6.8$ Hz, ArH); ^{13}C NMR (50 MHz, CDCl_3) δ 23.2 (2 \times CH), 38.9, 53.9 (2 \times CH), 89.2, 113.9 (2 \times CH), 122.3 (2 \times CH), 126.7 (2 \times CH), 128.2 (2 \times CH), 129.5, 130.1, 131.3, 131.6, 152.5, 161.3; IR (KBr) 3109 (m), 1566 (s, C–N), 1479 (m), 1251 (m), 1023 (m), 874 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{20}\text{H}_{21}\text{N}_3\text{O}$: C: 75.21; H: 6.63; N: 13.16. Found: C: 75.18; H: 6.65; N: 13.20.

1-(4'-Bromophenyl)-3-phenyl-5-pyrrolidinopyrazole (4d): mp (recrystallized from ethanol) 125–126 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 2.39 (m, 4H), 3.51 (m, 4H), 5.88 (s, 1H), 7.12 (m, 2H, ArH); 7.29 (m, 2H, ArH); 7.57 (m, 2H, ArH); 7.76 (m, 2H, ArH); ^{13}C NMR (50 MHz, CD_3OD) δ 23.7 (2 \times CH), 53.7 (2 \times CH), 89.6, 118.1, 126.2 (2 \times CH), 128.7 (2 \times CH), 129.2 (2 \times CH); 130.5 (2 \times CH), 131.4, 132.3, 154.2, 162.7; IR (KBr) 3172 (m), 3061 (s), 1582 (s, C–N), 1431 (m), 1323 (m), 1221 (m), 961 (m), 798 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{19}\text{H}_{18}\text{BrN}_3$: C: 61.97; H: 4.93; N: 11.41. Found: C: 61.94; H: 4.89; N: 11.38.

3-Methyl-1-phenyl-5-pyrrolidinopyrazole (4e): mp (recrystallized from ethanol) 114–115 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 1.19 (s, 3H, CH_3), 2.39 (m, 4H), 3.57 (m, 4H), 6.01 (s, 1H), 7.4–7.9 (m, 6H, Ph); ^{13}C NMR (50 MHz, CD_3OD) δ 19.7, 23.4 (2 \times CH), 53.1 (2 \times CH), 89.6, 114.8, 119.6 (2 \times CH), 123.5 (2 \times CH), 149.5, 162.4; IR

(KBr) 3132 (s), 2864 (m), 1501 (s, C–N), 1423 (m), 1410 (m), 1287 (s), 1229 (m), 1017 (m), 951 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{14}\text{H}_{17}\text{N}_3$: C: 73.98; H: 7.54; N: 18.49. Found: C: 73.95; H: 7.57; N: 18.53.

3-*iso*-Propyl-1-phenyl-5-pyrrolidinopyrazole (4f): mp (recrystallized from ethanol) 123–124 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.27 (d, 6H, $J=7.4$, $\text{CH}(\text{CH}_3)_2$), 2.38 (m, 4H), 2.61–2.75 (m, 1H, CHMe_2), 3.52 (m, 4H), 6.31 (s, 1H), 6.98 (t, 1H, $J=7.4$, ArH), 7.14 (dd, 2H, $J = 8.1, 7.4$ Hz, ArH), 7.57 (d, 2H, $J = 8.1$ Hz, ArH); NMR (50 MHz, CDCl_3) δ 17.8 (2 \times CH3), 23.4 (2 \times CH), 29.6, 40.6, 53.9 (2 \times CH), 90.1, 118.6 (2 \times CH), 121.7, 126.6 (2 \times CH), 147.2, 162.7; IR (KBr) 3102 (s), 2813 (m), 1581 (s, C–N), 1471 (m), 1429 (m), 1315 (s), 1199 (m), 1036 (m), 957 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{16}\text{H}_{21}\text{N}_3$: C: 75.26; H: 8.29; N: 16.46. Found: C: 75.23; H: 8.31; N: 16.50.

3-*n*-Propyl-1-phenyl-5-pyrrolidinopyrazole (4g): mp (recrystallized from ethanol) 129–130 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.06 (t, $J = 7.4$ Hz, 3H), 1.68–1.76 (m, 2H), 2.36 (m, 4H), 2.50 (t, $J = 7.5$ Hz, 2H), 3.59 (m, 4H), 5.97 (s, 1H), 7.12 (t, $J = 7.4$ Hz, 1H), 7.28 (dd, $J = 7.4, 7.7$ Hz, 2H), 7.81 (d, $J = 7.7$ Hz, 2H); ^{13}C NMR (50 MHz, CD_3OD) δ 14.2, 20.4, 23.9 (2 \times CH), 30.5, 53.1 (2 \times CH), 90.3, 120.3, 125.8, 130.4, 138.5, 156.1, 163.0; IR (KBr) 3112 (s), 2836 (m), 1541 (s, C–N), 1452 (m), 1412 (m), 1301 (s), 1197 (m), 1041 (m), 955 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{16}\text{H}_{21}\text{N}_3$: C: 75.26; H: 8.29; N: 16.46. Found: C: 75.29; H: 8.28; N: 16.44.

1,3-Diphenyl-5-*N*-piperidinopyrazole (5a): mp (recrystallized from ethanol) 98–99 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.44–1.47 (m, 2H), 1.50–1.56 (m, 4H), 2.79 (t, 4H, $J = 5.4$ Hz), 6.09 (s, 1H), 7.16–7.23 (m, 2H), 7.35 (t, 2H, $J = 7.6$ Hz), 7.37 (t, 2H, $J = 7.6$ Hz), 7.77 (d, 2H, $J = 7.4$ Hz), 7.84 (d, 2H, $J = 7.6$ Hz); ^{13}C NMR (50 MHz, CDCl_3) δ 23.1, 26.5 (2 \times CH), 53.8 (2 \times CH), 91.3, 122.6 (2 \times CH), 125.1 (2 \times CH), 126.4 (2 \times CH), 127.9 (2 \times CH), 128.7, 129.1, 133.6, 140.5, 150.8, 163.9; IR (KBr)

3060 (s), 2944 (m), 1549 (s, C–N), 1450 (m), 1421 (m), 1301 (s), 1251 (m), 1199 (m), 965 (m) cm^{-1} . Anal. Calcd for $\text{C}_{20}\text{H}_{21}\text{N}_3$: C: 79.17; H: 6.98; N: 13.85. Found: C: 79.14; H: 6.95; N: 13.87.

1-(2'-Methylphenyl)-3-phenyl-5-N-piperidinopyrazole (5b): mp (recrystallized from ethanol) 103–104 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.45–1.48 (m, 2H), 1.52–1.58 (m, 4H), 2.36 (s, 3H, CH_3), 2.82 (t, 4H, $J = 5.4$ Hz), 6.13 (s, 1H), 7.45 (d, 2H, $J = 7.2$, ArH), 7.49–7.56 (m, 5H, ArH), 7.68 (d, 2H, $J = 7.2$, ArH); ^{13}C NMR (50 MHz, CDCl_3) δ 15.3, 22.9, 27.4 (2 \times CH), 54.3 (2 \times CH), 92.1, 125.9 (2 \times CH), 126.2, 127.2, 128.3, 129.1 (2 \times CH), 131.1, 131.5, 131.7, 135.9, 136.7, 149.6, 159.4; IR (KBr) 3159 (m), 3108 (s), 1607, 1537 (s, C–N), 1472 (m), 1321 (m), 1143 (m), 979 (m), 810 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{21}\text{H}_{23}\text{N}_3$: C: 79.46; H: 7.30; N: 13.24. Found: C: 79.49; H: 7.28; N: 13.21.

1-(4'-Methoxyphenyl)-3-phenyl-5-N-piperidinopyrazole (5c): mp (recrystallized from ethanol) 124–125 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.44–1.47 (m, 2H), 1.51–1.57 (m, 4H), 2.23 (s, 3H, CH_3), 2.79 (t, 4H, $J = 5.4$ Hz), 3.79 (s, 3H, CH_3), 6.10 (s, 1H), 6.77 (d, 2H, $J = 6.8$ Hz, ArH), 7.20–7.26 (m, 3H, ArH), 7.47 (d, 2H, $J = 7.2$ Hz, ArH), 7.59 (d, 2H, $J = 6.8$ Hz, ArH); ^{13}C NMR (50 MHz, CDCl_3) δ 23.5, 28.2 (2 \times CH), 39.2, 53.9 (2 \times CH), 90.1, 114.0 (2 \times CH), 121.0 (2 \times CH), 125.9 (2 \times CH), 128.9 (2 \times CH), 129.8, 130.4, 131.3, 131.6, 153.5, 161.1; IR (KBr) 3207 (m), 1562 (s, C–N), 1487 (m), 1243 (m), 1031 (m), 863 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{21}\text{H}_{23}\text{N}_3\text{O}$: C: 75.65; H: 6.95; N: 12.60. Found: C: 75.61; H: 6.93; N: 12.57.

1-(4'-Bromophenyl)-3-phenyl-5-N-piperidinopyrazole (5d): mp (recrystallized from ethanol) 118–119 °C; ^1H NMR (CDCl_3 , 200 MHz) δ 1.45–1.48 (m, 2H), 1.53–1.61 (m, 4H), 2.35 (s, 3H, CH_3), 2.84 (t, 4H, $J = 5.4$ Hz), 6.02 (s, 1H), 7.13 (m, 2H, ArH); 7.37 (m, 2H, ArH); 7.68 (m, 2H, ArH); 7.81 (m, 2H, ArH); ^{13}C NMR (50

MHz, CDCl₃) δ 1.46–1.49 (m, 2H), 1.53–1.59 (m, 4H), 2.82 (t, 4H, J = 5.4 Hz), 6.13 (s, 1H), ¹³C NMR (50 MHz, CD₃OD) δ 24.2, 29.5 (2 \times CH), 40.6, 54.2 (2 \times CH), 93.6, 119.3, 125.1 (2 \times CH), 128.6 (2 \times CH), 128.9 (2 \times CH); 130.1 (2 \times CH), 130.5, 130.9, 154.9, 163.4; IR (KBr) 3213 (m), 3095 (s), 1472 (s, C–N), 1432 (m), 1314 (m), 1119 (m), 981 (m), 793 (m) cm⁻¹; Anal. Calcd for C₂₀H₂₀BrN₃: C: 62.83; H: 5.27; N: 10.99. Found: C: 62.80; H: 5.29; N: 11.02.

3-Methyl-1-phenyl-5-N-piperidinopyrazole (5e): mp (recrystallized from ethanol) 101–102 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.19 (s, 3H, CH₃), 1.41–1.44 (m, 2H), 1.48–1.54 (m, 4H), 2.69 (t, 4H, J = 5.4 Hz), 6.11 (s, 1H), 7.3–7.9 (m, 6H, Ph); ¹³C NMR (50 MHz, CD₃OD) δ 19.3, 24.2, 29.5 (2 \times CH), 40.6, 54.2 (2 \times CH), 92.6, 115.8, 124.9 (2 \times CH), 127.6 (2 \times CH), 153.4, 161.3; IR (KBr) 3132 (s), 2864 (m), 1501 (s, C–N), 1423 (m), 1410 (m), 1287 (s), 1229 (m), 1017 (m), 951 (m) cm⁻¹; Anal. Calcd for C₁₅H₁₉N₃: C: 74.65; H: 7.94; N: 17.41. Found: C: 74.63; H: 7.92; N: 17.39.

3-iso-Propyl-1-phenyl-5-N-piperidinopyrazole (5f): mp (recrystallized from ethanol) 120–121 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.27 (d, 6H, J = 7.4, CH(CH₃)₂), 1.45–1.49 (m, 2H), 1.51–1.58 (m, 4H), 2.61–2.75 (m, 1H, CHMe₂), 2.82 (t, 4H, J = 5.4 Hz), 6.31 (s, 1H), 6.98 (t, 1H, J = 7.4, ArH), 7.14 (dd, 2H, J = 8.1, 7.4 Hz, ArH), 7.57 (d, 2H, J = 8.1 Hz, ArH); NMR (50 MHz, CDCl₃) δ 17.8 (2 \times CH₃), 24.2, 28.5 (2 \times CH), 29.6, 40.6, 53.2 (2 \times CH), 90.1, 116.6 (2 \times CH), 121.3, 126.8 (2 \times CH), 139.1, 162.7; IR (KBr) 3102 (s), 2813 (m), 1581 (s, C–N), 1471 (m), 1429 (m), 1315 (s), 1199 (m), 1036 (m), 957 (m) cm⁻¹; Anal. Calcd for C₁₇H₂₃N₃: C: 75.80; H: 8.61; N: 15.60. Found: C: 75.77; H: 8.64; N: 15.58.

3-n-Propyl-5-N-piperidinopyrazole (5g): mp (recrystallized from ethanol) 126–127 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.06 (t, J = 7.4 Hz, 3H), 1.44–1.47 (m, 2H), 1.50–1.56 (m, 4H), 1.68–1.76 (m, 2H), 2.50 (t, J = 7.5 Hz, 2H), 2.79 (t, 4H, J = 5.4

Hz), 6.14 (s, 1H), 7.15 (t, J = 7.4 Hz, 1H), 7.29 (dd, J = 7.4, 7.7 Hz, 2H), 7.87 (d, J = 7.7 Hz, 2H); ^{13}C NMR (50 MHz, CD_3OD) δ 14.2, 20.4, 24.2, 29.5 (2 \times CH), 33.5, 40.6, 54.2 (2 \times CH), 92.3, 119.3, 125.4, 129.2, 138.6, 158.3, 163.8; IR (KBr) 3112 (s), 2836 (m), 1541 (s, C–N), 1452 (m), 1412 (m), 1301 (s), 1197 (m), 1041 (m), 955 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{17}\text{H}_{23}\text{N}_3$: C: 75.80; H: 8.61; N: 15.60. Found: C: 75.81; H: 8.58; N: 15.64.

4,4'-Methylidenebis(1,3-diphenyl-2-pyrazolone) (6a): mp (recrystallized from ethanol) 261.2–262.2 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 7.24 (t, 1H, J=7.6, ArH), 7.44–7.53 (m, 5H, ArH), 7.82–7.86 (m, 2H, ArH), 8.01 (d, 2H, J=7.6 Hz, ArH); ^{13}C NMR (50 MHz, CDCl_3) δ 39.7, 108, 119.1 (2 \times CH), 109.5, 125.3, 126.0 (2 \times CH), 128.9 (2 \times CH), 130.7, 130.9 (2 \times CH), 134.8, 138.1, 154.6, 170.2; IR (KBr) 3067 (m), 1715 (s, C=O), 1601 (s, C–N), 1496 (m), 1383 (m), 1326 (m), 1172 (m), 1116 (m), 899 (m) cm^{-1} ; Anal. Calcd for $\text{C}_{31}\text{H}_{22}\text{N}_4\text{O}_2$: C: 77.16; H: 4.60; N: 11.61, Found: C: 77.13; H:4.62; N: 11.59.

4,4'-Methylidenebis[1-(2'-methylphenyl)-3-phenyl-2-pyrazolone] (6b): mp (recrystallized from ethanol) 205.3–206.3 $^\circ\text{C}$; ^1H NMR (CD_3OD , 200 MHz) δ 2.27 (s, 3H, CH_3), 7.51 (d, 2H, J=7.2, ArH), 7.54–7.59 (m, 5H, ArH), 7.82 (d, 2H, J=7.2, ArH); ^{13}C NMR (50 MHz, CD_3OD) δ 15.9, 126.3 (2 \times CH), 126.6, 127.2, 128.0, 128.5, 129.2 (2 \times CH), 131.1, 131.2, 131.5, 131.7, 136.7, 149.6, 157.4; IR (KBr) 3293 (m), 3124 (s), 1880 (m), 1537 (s, C–N), 1472 (m), 1305 (m), 1147 (m), 982 (m), 807 (m) cm^{-1} Anal. Calcd for $\text{C}_{33}\text{H}_{26}\text{N}_4\text{O}_2$: C: 77.63; H: 5.13; N: 10.97, Found: C: 77.67; H:5.15; N: 10.96.

4,4'-Methylidenebis[1-(4'-methoxyphenyl)-3-phenyl-2-pyrazolone] (6c): mp (recrystallized from ethanol) 128–130 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 200 MHz) δ 3.79 (s, 3H, CH_3), 6.90 (d, 2H, J=6.8 Hz, ArH), 7.40–7.44 (m, 3H, ArH), 7.73 (d, 2H, J=7.2 Hz,

ArH), 7.81 (d, 2H, J=6.8 Hz, ArH); ¹³C NMR (50 MHz, CDCl₃) δ 39.5, 55.5, 114.0 (2 × CH), 121.0 (2 × CH), 125.9 (2 × CH), 128.9 (2 × CH), 130.6, 130.9, 131.5, 154.5, 157.2, 170.0; IR (KBr) 2927 (m), 1709 (s, C=O), 1512 (s, C–N), 1500 (m), 1248 (m), 1030 (m), 832 (m) cm⁻¹; Anal. Calcd for C₃₃H₂₆N₄O₄: C: 73.05; H: 4.83; N: 10.33. Found: C: 73.07; H: 4.85; N: 10.31.

4,4'-Methylidenebis[1-(4'-bromophenyl)-3-phenyl-2-pyrazolone] (6d): mp (recrystallized from ethanol) 183–184 °C; ¹H NMR (CD₃OD, 200 MHz) δ 7.38 (m, 2H, ArH); 7.50 (m, 2H, ArH); 7.81 (m, 2H, ArH); 7.99 (m, 2H, ArH); ¹³C NMR (50 MHz, CD₃OD) δ 120.0; 126.0; 128.9; 129.0; 130.4; 130.7; 130.9; 154.9; 170.1.; IR (KBr) 3293 (m), 3124 (s), 1880 (m), 1537 (s, C–N), 1472 (m), 1305 (m), 1147 (m), 982 (m), 807 (m) cm⁻¹; Anal. Calcd for C₃₁H₂₀Br₂N₄O₂: C: 55.15; H: 3.15; N: 8.75. Found: C: 55.17; H:3.19; N: 8.72.

4,4'-Methylidenebis(3-methyl-1-phenyl-2-pyrazolone) (6e): mp (recrystallized from ethanol) 127–129 °C; ¹H NMR (CDCl₃, 200 MHz) δ 2.15 (s, 3H, CH₃), 7.14 (d, 1H, J=2.2 Hz, ArH), 7.36 (dd, 2H, J=7.8, 2.2 Hz, ArH), 7.81 (d, 2H, J=7.8 Hz, ArH); ¹³C NMR (50 MHz, CDCl₃) δ 17.0, 43.1, 118.9 (2 × CH), 125.1, 128.8 (2 × CH), 137.9, 156.4, 170.6; IR (KBr) 3101 (s), 2802 (m), 1622 (s, C=O), 1584 (s, C–N), 1494 (m), 1412 (m), 1301 (s), 1220 (m), 1035 (m), 967 (m) cm⁻¹; Anal. Calcd for C₂₁H₁₈N₄O₂: C: 70.38; H: 5.06; N: 8.93. Found: C: 70.41; H: 5.09; N: 8.96.

4,4'-Methylidenebis(3-isopropyl-1-phenyl-2-pyrazolone) (6f): mp (recrystallized from ethanol) 101–103 °C; ¹H NMR (CDCl₃, 200 MHz) δ 1.21 (d, 6H, J=7.4, CH(CH₃)₂), 2.68–2.82 (m, 1H, CHMe₂), 7.14 (t, 1H, J=7.4, ArH), 7.35 (dd, 2H, J = 8.1, 7.4 Hz, ArH), 7.84 (d, 2H, J = 8.1 Hz, ArH); ¹³C NMR (50 MHz, CDCl₃) δ 20.1 (2 × CH₃), 30.7, 39.8, 118.8 (2 × CH), 124.9, 128.8 (2 × CH), 138.2, 164.3, 170.6; IR (KBr) 3101 (s), 2802 (m), 1622 (s, C=O), 1584 (s, C–N), 1494 (m), 1412 (m), 1301

(s), 1220 (m), 1035 (m), 967 (m) cm^{-1} . Anal. Calcd for $\text{C}_{25}\text{H}_{26}\text{N}_4\text{O}_2$: C: 72.44; H: 6.32; N: 13.52. Found: C: 72.41; H: 6.35; N: 13.53.

Acknowledgment

We are grateful to the China Medical University (CMU100-S-) and the National Science Council of Republic of China for financial support (NSC-99-2320-B-039-014-MY3). This study is supported in part by Taiwan Department of Health Clinical Trial and Research Center of Excellence (DOH100-TD-B-111-004)

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New Investigation of Vilsmeier-Type Reaction Using Pyrazolones with Various Amides

