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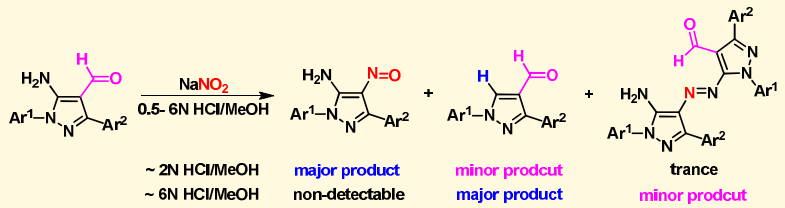

Selective Synthesis of Functionalized Pyrazoles from 5-Amino-1*H*-pyrazole-4-carbaldehydes with Sodium Nitrite: 5-Amino-4-nitrosopyrazoles and Pyrazole-4-carbaldehydes

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Key words: 5-Amino-1*H*-pyrazole-4-carbaldehydes, 5-amino-4-nitrosopyrazole, pyrazole, pyrazole-4-carbaldehyde, nitrosation, sodium nitrite

ABSTRACT: A novel and efficient redox reaction was developed to react 5-amino-1*H*-pyrazole-4-carbaldehyde with sodium nitrite ($NaNO_2$) in an acidic solution (HCl/MeOH) to generate 5-amino-4-nitrosopyrazole, pyrazole-4-carbaldehyde, or diazenylpyrazole selectively. The results showed that 5-amino-4-nitrosopyrazoles were formed as the major product in the diluted acidic solution (≤ 2 N HCl in MeOH solution) through redox, formylation, and nitrosation reactions of $NaNO_2$. Intriguingly, pyrazole-4-carbaldehyde was the main product under 6 N HCl in MeOH solution.

INTRODUCTION

The pyrazole system is a class of heterocyclic molecules, containing in some anti-inflammatory drugs and anabolic steroids, which attract the attention in medicinal and pharmaceutical fields.[1-9] Therefore, development of efficient synthetic methods for pharmaceutically active pyrazole derivatives is important for drug discovery. For example, substituted 5-amino-4-nitrosopyrazoles, bearing nitroso group at the pyrazolic ring, were designed for the synthesis of 5-substituted imidazo[4,5-*c*]pyrazoles as central nervous system (CNS) depressants[10] or pyrazolo[3,4,-*b*]pyrazine as various medical agents.[11-13] Moreover, compounds carrying azomethine functional group (–C=N–), which is known as Schiff base, have gained importance in the medicinal and pharmaceutical fields.[14] Many pharmacologically active drugs are in fact derived from the pyrazole through formation of Schiff base.[15-16] Moreover, pyrazole-4-carbaldehydes were considered to be one of the versatile intermediates or precursors for the construction of the central structure of pyrazoles via Schiff base.[17]

Nitrosation chemistry[18] is an important method in organic synthesis, including nitroso aldol reactions,[19] [4 + 2],[20] [3 + 3],[21] and [2 + 2] cycloadditions,[22] and ene reactions.[23] Many organic and biological chemists have made significant efforts to combine both the synthetic and mechanistic aspects of nitrosation or transnitrosation in constructing novel pharmacological molecules.[24-25] Recently, sodium nitrite ($NaNO_2$) in an acidic solution was found to act as an effective oxidant[26] to oxidize hydrocarbons to the corresponding alcohol,[27] or acyclic and cyclic secondary alcohols to ketones and dicarboxylic acids.[28] Herein, we report a novel and efficient method to synthesize 5-amino-4-nitrosopyrazole, pyrazole-4-carbaldehyde, and diazenylpyrazole from 5-amino-1*H*-pyrazole-4-carbaldehyde in diffenent concentrations of acidic

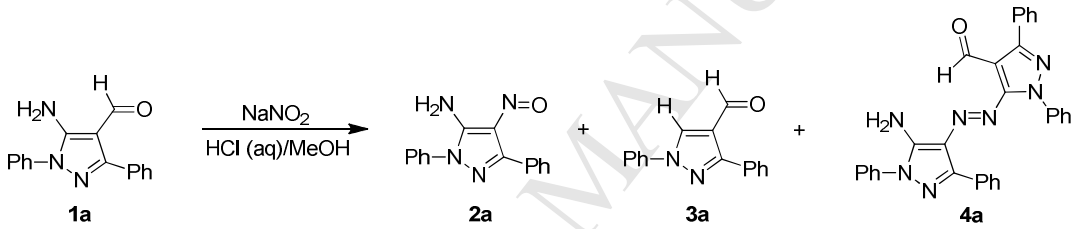
solution. In this reaction, we also discovered a new deformylation reaction for 5-amino-1*H*-pyrazole-4-carbaldehyde, which led to the formation of 5-amino-4-nitrosopyrazole and diazenylpyrazole.

RESULTS AND DISCUSSION

$NaNO_2$ in acidic medium, such as acetic acid, methanesulfonic acid, acetic anhydride, or trifluoroacetic acid etc., has been reported as an effective oxidizing agent to generate the active species, including nitrosonium ion (NO^+) and nitronium ion (NO_2^+).[26,29] The oxidation rates were dependent on the reaction temperature, concentration of the acidic substrate, and the presence of metal ion catalysts.[30] To investigate the reactivity of such reactions, we prepared a series of 5-amino-1*H*-pyrazole-4-carbaldehydes **1a–l** as the starting materials based on the reported method.[31] 5-Amino-1*H*-pyrazole-4-carbaldehyde **1a** was served as the model reactant, which was reacted with $NaNO_2$ in the presence of various equivalent concentrations (0.5 N, 1.0 N, 2.0 N, 3.0 N, and 6.0 N) of HCl in a THF/MeOH solution. The new procedure was involved in the treatment of 5-amino-1*H*-pyrazole-4-carbaldehyde **1a** with ~3.0 equivalent of $NaNO_2$ at room temperature in THF/MeOH solution containing different equivalent concentrations of HCl aqueous solution. According to the results shown in Table 1, the 5-amino-4-nitrosopyrazole **2a** could be formed as the major product with a trace amount of pyrazole-4-carbaldehyde **3a** or diazenylpyrazole **4a** under the ≤ 2N acidic condition once the redox reaction time was prolonged to more than 11 h (Entries 1–3, Table 1). When the HCl concentration was increased to 3 N and 6 N, the dediazonation product pyrazole-4-carbaldehyde **3a** was obtained as the major product (Entries 4–5, Table 1). In a further control experiment under 6 N HCl/THF/MeOH, the reduction reaction was performed with bubbling H_2 or N_2 under atmospheric

pressure. We found that both H_2 and N_2 were unbeneficial for the redox reaction (Entries 6 and 7, Table1). Particularly, when the reaction time was prolonged to more than 16 h, the reactant **1a** was recovered in 41% under H_2 atmospheric pressure (Entry 7, Table1). On the other hand, when the same reaction was carried out in the 9 N HCl/MeOH, the reaction produced carbaldehyde **3a** and diazenylpyrazole **4a** with 27% and 36% yield, respectively, without detectable nitrosation product **2a** (Entry 8, Table 1)**.**

Table 1. Nitrosation of 5-amino-1,3-diphenyl-1*H*-pyrazole-4-carbaldehyde **1a** with sodium nitrite ($NaNO_2$) in different concentrations of $HCl_{(aq)}$ and various organic acids.



1a **2a** **3a** **4a**

Entry	Acid medium	pH	pKa	R.T. (h)	**2a** (%)	**3a** (%)	**4a** (%)
1	0.5 N $HCl_{(aq)}$	<1	–8	48	56	-[a]	20
2	1.0 N $HCl_{(aq)}$	<1	–8	24	81	9	4
3	2.0 N $HCl_{(aq)}$	<1	–8	11	86	12	-[a]
4	3.0 N $HCl_{(aq)}$	<1	–8	5	43	52	-[a]
5	6.0 N $HCl_{(aq)}$	<1	–8	3	-[a]	88	-[a]
6	6.0 N $HCl_{(aq)}$ bubble N_2	<1	–8	3	9	52	5
7	6.0 N $HCl_{(aq)}$ bubble H_2	<1	–8	>16	29	12	-[a]
8	9.0 N $HCl_{(aq)}$	<1	–8	2	-[a]	27	36
9	Methanesulfonic acid/THF	–1.3	–1.9	3	8	52	9
10	Methanesulfonic acid/THF/MeOH	–0.93	–1.9	3	14	69	8

11	Trifluoroacetic acid/THF	0.30	0.30	17	-[a]	-[a]	18
12	Trifluoroacetic acid/THF/MeOH	0.84	0.30	17	-[a]	-[a]	17
13	Formic acid/THF	0.63	3.75	17	-[a]	-[a]	-[a]
14	Formic acid/THF/MeOH	1.2	3.75	17	-[a]	-[a]	-[a]
15	Acetic acid/THF	0.63	4.76	17	-[a]	-[a]	-[a]
16	Acetic acid/THF/MeOH	1.2	4.76	17	-[a]	-[a]	-[a]

[a]Non-detectable

To further investigate the effect of acidity, we studied the reactions under various organic acids, including acetic acid, formic acid, methanesulfonic acid, and trifluoroacetic acid in protic or aprotic solvents at room temperature (Entries 9–16, Table 1). Several experimental observations are worthy discussions . Firstly, we found that the relative nitrosation reaction, formylation, and dimerization did not occur under weak organic acids such as formic acid (pKa = 3.75) and acetic acid (pKa = 4.76) (Entries 13–16, Table 1). Secondly, under the stronger trifluoroacetic acid (pKa = 0.30), a low isolated yield (<18%) of dimer products was observed, which showed that the nitrosation reaction and formylation were slightly initiated and the dimerization was enhanced (Entries 11–12, Table 1). Unexpected, most of the starting material **1a** was recovered. Thirdly, when the strong methanesulfonic acid (pKa = –0.19) was used, the 5-amino-1*H*-pyrazole-4-carbaldehyde **1a** was found to be completely consumed and converted to the corresponding products 5-amino-4-nitrosopyrazole **2a**, pyrazole-4-carbaldehyde **3a**, and diazenylpyrazole **4a** (Entries 9–10, Table 1). Moreover, pyrazole-4-carbaldehyde **3a** was formed as the major product (52% and 69%). We also found that the protic solvent system (THF/MeOH) seemed to facilitate the formation of pyrazole-4-carbaldehyde **3a** in the methanesulfonic acid system (69%).

The structures of all the products were fully characterized by spectroscopic methods as described below. The diazenylpyrazole **4a** shows a singlet peak at δ 10.20 ppm for its 4-formyl functional group (–CH=O) ^{1}H NMR and at a peak at δ 186.14 ppm in ^{13}C NMR spectrum. It also presented two characteristic absorptions peaks at 3279 cm^{-1} for the stretching of the NH_2 group and at 1627 cm^{-1} for the stretching of the –CH=O group in IR spectrum. As a result, we believe that diazenylpyrazole **4a** is generated from the reaction of starting material 5-amino-1*H*-pyrazole-4-carbaldehydes **1a** with 5-amino-4-nitrosopyrazole product **2a.** Moreover, the structure of compound **4a** was further confirmed by X-ray crystallographic analyses and the result of single-crystal X-ray diffraction study (ORTEP) is presented in Figure 1.

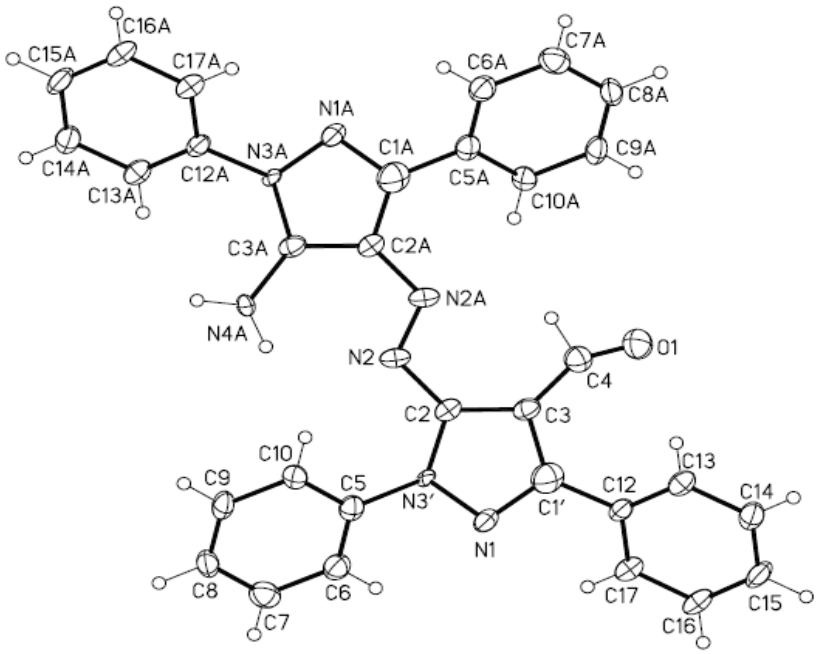


Figure 1. The ORTEP diagram of diazenylpyrazole **4a** (CCDC No. 1903694).

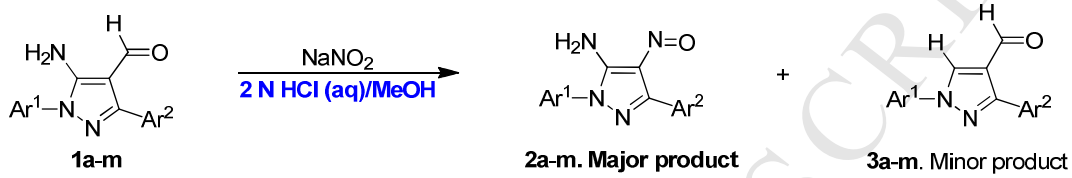
5-Amino-4-nitrosopyrazole derivatives **2** and central building precursors are functionally important in biologically active materials,[32] as well as in chelating and extracting ligands for transition metal ions.[33] Following the above experimental results, we explored of the reliable synthetic procedure for

5-amino-4-nitrosopyrazoles **2** in the 2 N HCl/MeOH solution. To demonstrate the practical usefulness of the new methodology, 5-amino-1*H*-pyrazole-4-carbaldehydes **1a–j** bearing various *N*-1 substituents, including *o*-, *m*-, *p*-Me-Ph, *o*-, *m*-, *p*-Cl-Ph, *p*-Br-Ph, and *p*-OMe-Ph, were treated with $NaNO_2$ at room temperature in 2 N HCl/MeOH solution. The redox reaction also took place smoothly to generate the corresponding 5-amino-4-nitrosopyrazoles **2a**–**i** with 73–91% yields as the major products and pyrazole-4-carbaldehyde **3a** as minor products with <14% yields (Entries 1–11, Table 2). Introduction of a methyl or chloro group at the *ortho*-position of the pyrazolic moiety of compound **1b** and **1e** seemed to afford lower conversions yields (**2b**, 78% yield and **2e**, 74% yield). Other substitutions at the *para*-position ofpyrazolic ring with electron-donating groups, such as methyl, chloro, bromo, and methoxy electron-withdrawing groups appeared to favor this conversion system (**2d**, 87% yield; **2g**, 83% yield; **2h**, 91% yield; **2i**, 88% yield). With the optimized reaction conditions in hand, the 5-amino-1*H*-pyrazole-4-carbaldehydes with electron-withdrawing groups including *p*-CN-Ph and *p*-NO_2-Ph scope of the substrates were then examined under the same conditions. Unfortunately, no targeted products were obtained.

Subsequently, we further screened 5-amino-1*H*-pyrazole-4-carbaldehydes **1j–l** with *p*-Me-Ph, *p*-Cl-Ph, or *p*-OMe-Ph groups on the C-3 position of pyrazolic ring. The results revealed that the corresponding 5-amino-4-nitrosopyrazoles **2j–l** were the major products with 71%, 73%, and 74% yields, respectively (Entries 12–14, Table 2). The minor pyrazole-4-carbaldehydes **3a**–**l** were obtained with < 14% yields (calculated from ^{1}H-NMR spectra). According to the spectra, compound **2d** presented two characteristic absorptions peaks at 3278 cm^{-1} for the stretching of the NH_2 group and at 1630 cm^{-1} for the stretching of the –N=O group in IR spectrum. On the other

hands, the structure of compound **2d** was further confirmed by X-ray crystallographic analyses and the result of single-crystal X-ray diffraction study (ORTEP) is presented in Figure 2.

Table 2. The study results of Nitrosation of 5-amino-1,3-diphenyl-1*H*-pyrazole-4-carbaldehydes **1a–m** with sodium nitrite in 2N $HCl_{(aq)}$/THF/MeOH.



Entry	Sarting materials **1a–l**			**2a–l** (%)[a]		**3a–l** (%)[b]	
	No	Ar^1	Ar^2				
1	**1a**	Ph	Ph	**2a**	86	**3a**	12
2	**1b**	*o*-Me-Ph	Ph	**2b**	78	**3b**	6
3	**1c**	*m*-Me-Ph	Ph	**2c**	83	**3c**	10
4	**1d**	*p*-Me-Ph	Ph	**2d**	87	**3d**	7
5	**1e**	*o*-Cl-Ph	Ph	**2e**	74	**3e**	14
6	**1f**	*m*-Cl-Ph	Ph	**2f**	73	**3f**	11
7	**1g**	*p*-Cl-Ph	Ph	**2g**	83	**3g**	13
8	**1h**	*p*-Br-Ph	Ph	**2h**	91	**3h**	3
9	**1i**	*p*-OMe-Ph	Ph	**2i**	88	**3i**	9
10	**1j**	Ph	*p*-Me-Ph	**2j**	71	**3j**	10
11	**1k**	Ph	*p*-Cl-Ph	**2k**	73	**3k**	9
12	**1l**	Ph	*p*-OMe-Ph	**2l**	74	**3l**	8

[a] Isolated yield.

[b] Determined by ^{1}H-NMR.

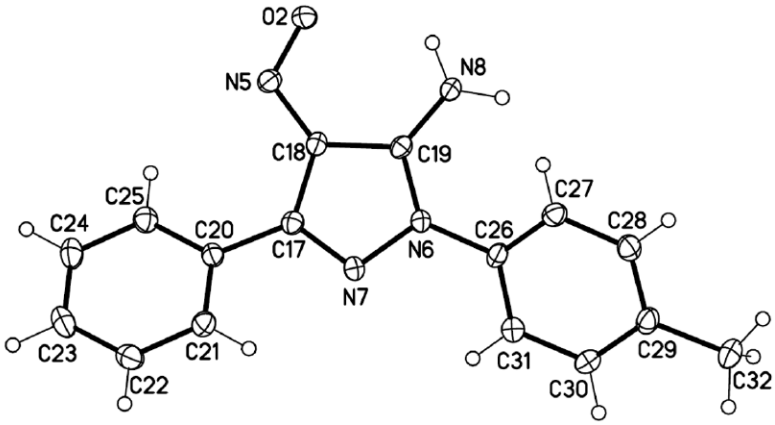


Figure 2. The ORTEP diagram of 5-Amino-4-nitroso-1-(4-methylphenyl)-3-phenylpyrazole **2d** (CCDC No. 1903691).

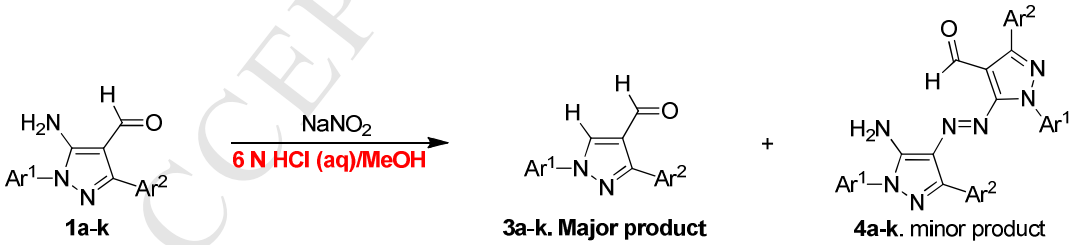
Interestingly, we explored a series of 5-amino-1*H*-pyrazole-4-carbaldehydes **1a–k** with $NaNO_2$ (~6.0 equiv) at room temperature in 6N $HCl_{(aq)}$/MeOH solution. Reactants **1a**–**k** were tolerated under above reaction conditions, giving the deamination pyrazole-4-carbaldehyde products **3a**–**k** as the major products with 74–91% yields (Table 3). However, the expected products, 5-amino-4-nitrosopyrazoles **2**, were not obtained. On the other hand, trace amount of diazenylpyrazoles **4** (< 9% yields) were observed and characterized as the minor products.

Based on the results, both electron-donating (**1a**−**d**, and **1i**) and halogen substituents (**1e**−**h**) were well tolerated to give pyrazole-4-carbaldehyde products **3a**–**h** with better yields (Table 3). A broad range of substituent groups with diverse steric and electronic properties (*o*-, *m*-, and, *p*-Me, *o*-, *m*-, and, *p*-Cl, Br, and OMe) was compatible with this versatile functionalized transformations. All of pyrazole-4-carbaldehyde **3a**–**h** were also fully characterized by spectroscopic methods. For example, compound **3a** possessed one two peaks at δ 8.52 ppm for pyrazole ring and at δ 10.03 ppm for formyl group in ^{1}H NMR and at δ 185.12 ppm for formyl carbon H–C=O in ^{13}C NMR spectrum. The IR absorptions of **3a** showed singlet peaks

at 1673 cm^{-1} for the stretching of the O=C–H group. The formylation of selectively sole main products seemed to be related to the amount of $NaNO_2$ used and the concentration of aqueous HCl/MeOH solution employed.

In addition, 5-amino-1*H*-pyrazole-4-carbaldehydes **1j–l** substrates containing *p*-Me-Ph, *p*-Cl-Ph, or *p*-OMe-Ph groups on the C-3 position of pyrazolic moiety were subjected to the above reaction conditions to produce the corresponding pyrazole-4-carbaldehyde products **3j–l** with 74%, 79%, and 81% yields, respectively (Entries 10–11, Table 3). For all the cases above, the nitrosation reactions did not occur and no 5-amino-1,3-diaryl-4-nitroso-1*H*-pyrazoles **2** were detected by ^{1}H-NMR spectra. A trace amount of diazenylpyrazoles **4** (< 6% yield) was also detected, which could be produced from 5-amino-1*H*-pyrazole-4-carbaldehydes **1** after reaction with pyrazole-4-carbaldehyde **2** equivalents. However, we did not carry out futher investigations because of insufficient amount of compounds **4b–k**, except for compound **4a**.

Table 3. Nitrosation of 5-amino-1,3-diphenyl-1*H*-pyrazole-4-carbaldehydes **1a–l** with sodium nitrite in 6 N $HCl_{(aq)}$/THF/MeOH.



Entry	Sarting materials **1a–k** No	Ar^1	Ar^2	**3a–l** (%)[a]		**4a–l** (%)[b]	
1	**1a**	Ph	Ph	**3a**	88	**4a**	-
2	**1b**	*o*-Me-Ph	Ph	**3b**	82	**4b**	3
3	**1c**	*m*-Me-Ph	Ph	**3c**	77	**4c**	6
4	**1d**	*p*-Me-Ph	Ph	**3d**	91	**4d**	-

5	**1e**	*o*-Cl-Ph	Ph	**3e**	84	**4e**	3
6	**1f**	*m*-Cl-Ph	Ph	**3f**	82	**4f**	2
7	**1g**	*p*-Cl-Ph	Ph	**3g**	81	**4g**	4
8	**1h**	*p*-Br-Ph	Ph	**3h**	83	**4h**	3
9	**1i**	*p*-OMe-Ph	Ph	**3i**	86	**4i**	-
10	**1j**	Ph	*p*-Me-Ph	**3j**	74	**4j**	5
11	**1k**	Ph	*p*-Cl-Ph	**3k**	79	**4k**	-
11	**1l**	Ph	*p*-OMe-Ph	**3l**	81	**4l**	-

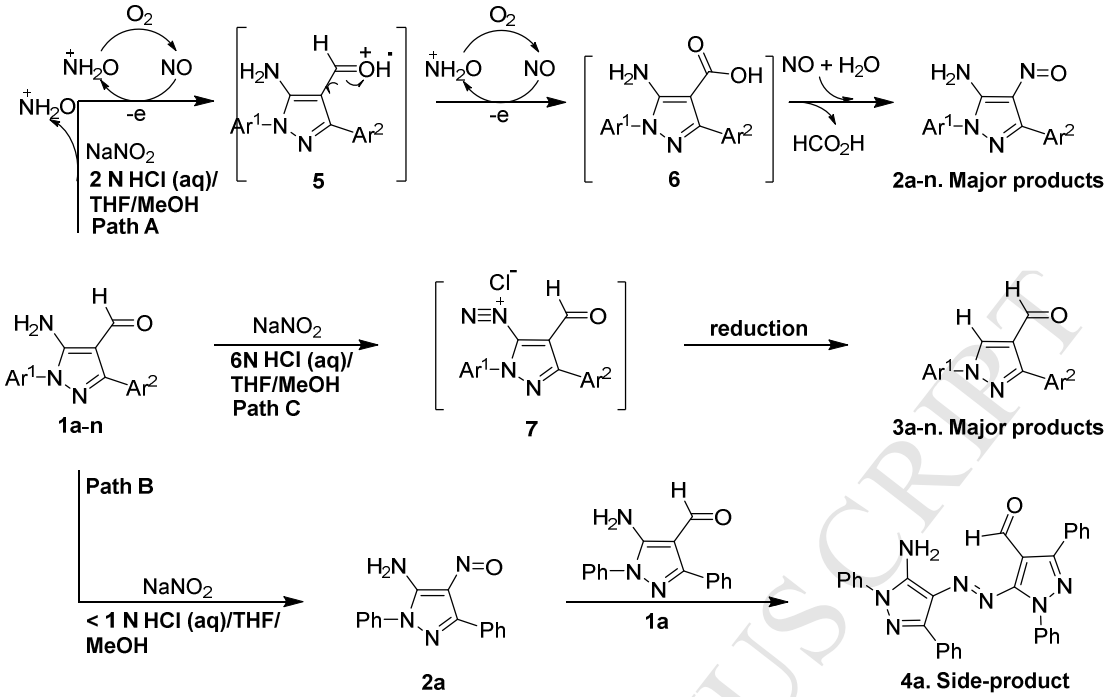
[a] Isolated yield.

[b] Determined by ^{1}H-NMR.

Based on the current results and our previous reports,[34] we provided a plausible mechanism of the reaction shown in Scheme 1. In the diluted ≤ 2 N HCl/THF/MeOH acid solution (**Path A** in Scheme 1), $NaNO_2$ was rapidly oxidized and transferred to NO^+ as the oxidant.[35] 5-Amino-1*H*-pyrazole-4-carbaldehyde **1** initially reacted with NO^+ for electron transformation to produce intermediate **5** at room temperature under atmospheric pressure.[36] Simultaneously, NO^+ was also converted to NO· by O_2. Under the following oxidation and electron transformation reactions, the oxidized carboxylation took place and subsequtntly formed intermediate **6**.[37] Its exposure to $NaNO_2$ in the presence of acidic medium could initiate the decaroxylation and nitrosation reaction to generate the corresponding major product 5-amino-4-nitrosopyrazole **2** (Path A in Scheme 1). In the present stiudy, the carboxylated intermediate **6a** was synthesized via the reported method[38] and treated with $NaNO_2$ under the same conditions. The corresponding 5-amino-4-nitrosopyrazole **2a** was successfully obtained with 76% yield. This result was consistence with the reported data[38] and provided the supporting evidence for the **Path A** of proposed mechanism. On the other hand, the redox reaction would become

more tardiness under ≤ 1 N HCl/THF/MeOH condition (**Path B** in Scheme 1). Part of 5-amino-4-nitrosopyrazole **2** was believe to have sufficient reaction time to react with the starting material 5-amino-1H-pyrazole-4-carbaldehyde **1** for coupling dimeric reaction and to yield trace amount of diazenylpyrazole product **4**.

When 5-amino-1*H*-pyrazole-4-carbaldehyde **1** was treated with $NaNO_2$ under high concentration of acidic medium (≥ 6N HCl/THF/MeOH),[39,40] pyrazole-5-diazonium chloride **7** was generated as the intermediate, as reported inin a previous study (**Path C** in Scheme 1).[41] Notably, the hydro-dediazoniation occurred with a higher protonic medium to provide the unexpected pyrazole-4-carbaldehyde product **3**. This observed phenomenon was consistent with the finding from Prof. Moyano's group.[42] Intriguingly, pyrazole-4-carbaldehydes **3** were firstly reported as the main product through the novel and efficient redox reaction in the present study. In the further control experiment of **path C**, pyrazole-4-carbaldehyde **3a** was exposed to $NaNO_2$ under acidic medium 1 N, 2 N, and 6 N $HCl_{(aq)}$ in THF/MeOH solution. No nitrosation product **2a** and diazenylpyrazole **4a** were detected after 24 h. This observation was taken as supportive data for **path C** as individual and independent reaction pathway.



Scheme 1. The plausible mechanism for new redox reaction of 5-amino-1*H*-pyrazole-4-carbaldehyde with sodium nitrite ($NaNO_2$) under acidic medium solution.

CONCLUSIONS

We have successfully developed the one-pot selective redox reaction by using 5-amino-1*H*-pyrazole-4-carbaldehyde with $NaNO_2$ under acidic solution to furnish the product of 5-amino-4-nitrosopyrazole, pyrazole-4-carbaldehyde, or trace diazenylpyrazole selectively. Based on our experimental results, under mild acidic solution (≤ 2 N HCl in MeOH solution), 5-amino-4-nitrosopyrazole is formed as the major product through redox reaction, deformylation and, nitrosation. Furthermore, 5-amino-1*H*-pyrazole-4-carbaldehyde **1** is efficiently converted to diazonium salt by $NaNO_2$ with highacidic medium (≥ 6 N HCl/MeOH). Subsequently, the dediazonation on reducing surfaces happened to afford pyrazole-4-carbaldehyde as the sole product.

EXPERIMENTAL SECTION

General Procedure: All reagents were used as obtained commercially. All reactions were carried out under argon or nitrogen atmosphere and monitored by TLC. Flash column chromatography was carried out on silica gel (230–400 mesh). Analytical thin-layer chromatography (TLC) was performed using precoated plates (silica gel 60 F-254) purchased from Merck Inc. Flash column chromatography purification was carried out by gradient elution using *n*-hexane in ethyl acetate (EtOAc) unless otherwise stated. Infrared (IR) spectra were measured with a Bomem Michelson Series FT-IR spectrometer. The wavenumbers reported are referenced to the polystyrene absorption at 1601 cm^{-1}. Absorption intensities are recorded by the following abbreviations: s, strong; m, medium; w, weak. All proton and carbon-13 NMR spectra were obtained by a Bruker (400 MHz or 500 MHz) and a Bruker (100 MHz or 125 MHz) instrument. Proton and carbon-13 NMR spectra were acquired using deuterochloroform ($CDCl_3$) solvent. Multiplicities are recorded by the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; *J*, coupling constant (Hz). ESI-MS analyses were performed on an Applied Biosystems API 300 mass spectrometer. High-resolution mass spectra were obtained from a JEOL JMS-HX110 mass spectrometer.

Standard procedure for synthesis of 5-amino-4-nitrosopyrazole 2a, pyrazole-4-carbaldehyde 3a, and diazenylpyrazole 4a. The reliable procedure were involved the treatment of 5-amino-1*H*-pyrazole-4-carbaldehyde **1a** (1.0 equiv.) with sodium nitrite ($NaNO_2$, ~3.0 equiv.) in THF/MeOH (0.5 mL/8.0 mL) or THF (8.5 mL) at room temperature. The reaction mixture was cooled in an ice-bath and added with the different concentration of aqueous hydrochloride acid (0.5 N, 1.0 N, 2.0 N, 3.0 N, and 6.0 N, 5.0 mL) or organic acids (1.5 mL) including acetic acid, formic acid, methanesulfonic acid, and trifluoroacetic acidfor stirring 3h to 48h. The clearly solution was transferred to the red suspension. On completion of the reaction (TLC),

the mixture was concentrated under reduced pressure and extracted with CH_2Cl_2 (20 mL × 2), washed with 5% $NaHCO_3$ (20 mL × 2), brine (20 mL × 2), and dry over $MgSO_4$. The organic layer was concentrated under reduced pressure. Consequently, the residue was charged onto the column in a little CH_2Cl_2 and the solvent was allowed to percolate down to the surface of silica gel. The column was then eluted with EtOAc/*n*-Hexane (2:8) to isolated 5-amino-4-nitrosopyrazole **2a**, pyrazole-4-carbaldehyde **3a**, and diazenylpyrazol**e 4a** in 28–65%, 9–72%, and 4–25% yields, respectively.

5-Amino-4-nitroso-1,3-diphenyl-pyrazole (2a): crimson solid; mp 208–211 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.01 (br, 2H, NH_2), 7.45–7.50 (m, 4H, ArH), 7.53–7.57 (m, 4H, ArH), 8.40–8.42 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 123.99 (2 × CH), 128.61 (2 × CH), 128.77 (2 × CH), 129.22, 129.91, 130.25 (2 × CH), 130.57, 135.08, 135.70, 150.88, 151.29; IR (KBr): 3351, 3267, 3057, 1641, 1499, 1449, 1250, 1158, cm^{-1}; EIMS m/z: 264 (M^+, 100), 265 (18), 246 (24), 144 (39), 128 (21), 117(24), 91(21), 77(73). HRMS calcd. for $C_{15}H_{12}ON_5$: 264.1011; found: 264.1003.

Pyrazole-4-carbaldehyde (3a): Dark brown solid; mp 83–86 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.35–7.39 (m, 1H, ArH), 7.45–7.51 (m, 5H, ArH), 7.76–7.82 (m, 4H, ArH), 8.52 (s, 1H, ArH), 10.03 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 119.68 (2 × CH), 122.45, 127.89, 128.70 (2 × CH), 128.90 (2 × CH), 129.23, 129.61 (2 × CH), 130.94, 131.28, 138.94, 154.70, 185.12; IR (KBr): 3124, 3064, 1678, 1527, 1203, 757 cm^{-1}; MS (EI): 249.1(15), 248.1(100), 247.1(83), 219.1(19), 77.1(31), 51.0(12) ; HRMS: Calcd. for $C_{16}H_{12}N_2O$: 248.0950. Found: 248.0958.

Diazenylpyrazole (4a): Orange solid; mp 192–197 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.73 (br, 2H, NH_2), 7.35 (m, 2H, ArH), 7.44–7.48 (d, 8H, ArH), 7.56–7.57 (m, 4H, ArH), 7.63–7.65 (m, 2H, ArH), 7.85–7.90 (m, 4H, ArH), 10.20 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 110.97, 124.01 (2 × CH), 125.64 (2 × CH), 126.01,

128.02 (2 × CH), 128.26 (2 × CH), 128.45 (2 × CH), 128.54, 128.80, 129.15 (4 × CH), 129.28 (2 × CH), 130.10 (2 × CH), 130.86, 131.83, 136.63, 138.93, 139.33, 150.37, 153.70, 153.97, 186.14; IR (KBr): 3279, 3065, 1628, 1528, 1493, 1451, 1264, 1166, 967 cm^{-1}; MS (EI): 510(30), 509(93), 508(46) , 480(13), 464(20), 406(24), 405(34), 403(19), 263(35), 262(100), 261(54), 260(24), 250(25), 249(20), 235(13), 144(21), 129(14), 128(23),119(45), 77(82); HRMS: Calcd. for $C_{31}H_{23}N_7O$: 509.1964 Found: 509.1960.

Standard procedure for synthesis of 5-amino-4-nitrosopyrazole 2b–l. The reliable procedure were involved the treatment of 5-amino-1*H*-pyrazole-4-carbaldehydes **1b–l** (1.0 equiv.) with sodium nitrite ($NaNO_2$, ~3.0 equiv.) in MeOH (5.0 mL) at room temperature. The reaction mixture was cooled in an ice-bath and added with 2.0 N aqueous hydrochloride acid (5.0 mL) for stirring 3h. The clearly solution was transferred to the red suspension. On completion of the reaction (TLC), the mixture was concentrated under reduced pressure and extracted with CH_2Cl_2 (20 mL × 2), washed with 5% $NaHCO_3$ (20 mL × 2), brine (20 mL × 2), and dry over $MgSO_4$. The organic layer was concentrated under reduced pressure. Consequently, the residue was charged onto the column in a little CH_2Cl_2 and the solvent was allowed to percolate down to the surface of silica gel. The column was then eluted with EtOAc/*n*-Hexane (3:7) to isolate 5-amino-4-nitrosopyrazoles **2b–l** in 71–91% yields.

5-Amino-4-nitroso-1-(2-methylphenyl)-3-phenylpyrazole (2b): Orange solid; mp 237–240 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.22 (s, 3H, CH_3), 6.67 (br, 2H, NH_2), 7.34–7.36 (m, 2 H, ArH), 7.41–7.44 (m, 2H, ArH), 7.46–7.48 (m, 3H, ArH), 8.38–8.41 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 17.60, 127.33, 127.61, 128.58 (2 × CH), 128.72 (2 × CH), 129.82, 130.69, 130.76, 132.09, 133.41, 136.04, 136.49, 150.42, 150.93; IR (KBr): 3336, 2925, 2862, 1650, 1502, 1242, 1164, 963

cm^{-1}; EIMS: 278, 260 (14), 158 (25), 132 (25), 131 (58), 128 (21), 104 (19), 103 (13); HRMS: Calcd. for $C_{16}H_{14}N_4O$: 278.1168. Found: 278.1176.

5-Amino-4-nitroso-1-(3-methylphenyl)-3-phenylpyrazole (2c): Orange solid; mp 144–147 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.42 (s, 3 H, CH_3), 7.03 (br, 2H, NH_2), 7.26 (d, 1H, J =7.52 Hz, ArH), 7.30 (d, 1H, J =8.36 Hz, ArH), 7.36 (s, 1H, ArH), 7.42 (t, 1H, J =7.76 Hz, ArH), 7.46 (d, 2H, J =2.08 Hz, ArH), 7.48 (d, 1H, J =1.76 Hz, ArH), 8.37–8.41 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.40, 120.76, 124.74 128.58 (3 × CH), 128.76 (2 × CH), 129.86, 129.91, 130.01, 130.59, 135.12, 135.55, 140.70, 150.86, 151.17; IR (KBr): 3275, 3198, 3061, 1633, 1495, 1451, 1269, 1161, 1105 cm–1; EIMS: 278 (100), 262 (19), 260 (30), 158 (31), 131 (39), 129 (14), 128 (20) HRMS: Calcd. for $C_{16}H_{14}N_4O$: 278.1168. Found: 278.1175.

5-Amino-4-nitroso-1-(4-methylphenyl)-3-phenylpyrazole (2d): Dark green solid; mp 142–145 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.42 (s, 3 H, CH_3), 6.95 (br, 2H, NH_2), 7.34 (d, 2H, J = 8.28 Hz, ArH), 7.40 (d, 2H, J = 8.44 Hz, ArH), 7.46–7.48 (m, 3H, ArH) 8.38–8.41 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.23, 123.95, 128.58 (3 × CH), 128.74 (2 × CH), 129.83, 130.64, 130.77 (2 × CH), 133.00, 135.12, 139.57, 150.89, 151.08; IR (KBr): 3279, 3055, 1627, 1527, 1264, 1165, 967 cm^{-1}; EIMS: 278 (100), 279 (16), 158 (30), 145(12), 131(12), 128(13), 91(22), 77(11) HRMS: Calcd. for $C_{16}H_{14}N_4O$: 278.1168. Found: 278.1166.

5-Amino-1-(2-chlorophenyl)-4-nitroso-3-phenylpyrazole (2e): Orange solid; mp 235–238 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.84 (br, 2H, NH_2), 7.45–7.49 (m, 6H, ArH), 7.52 (d, 1H, J = 2.39 Hz, ArH), 7.53 (d,1H, J = 2.34 Hz, ArH), 7.57–7.60 (m, 1 H, ArH), 7.59–7.61 (m, 1 H, ArH), 8.38–8.40 (m, 2 H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 128.61 (3 × CH), 128.81 (2 × CH), 129.80, 129.96, 130.49, 131.10, 131.86, 131.94, 132.74, 136.24, 150.25, 151.53; IR (KBr) 3333, 2861, 1656, 1532, 1499,

1450, 1237, 1166 cm^{-1}; EIMS: 298 (100), 282 (16), 178 (21), 153 (16), 143 (31), 128 (30), 111 (27), 103 (40), 77 (35); HRMS: Calcd. for $C_{15}H_{11}ClN_4O$: 298.0621. Found: 298.0628.

5-Amino-1-(3-chlorophenyl)-4-nitroso-3-phenylpyrazole (2f): Dark brown solid; mp 140–143 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.09 (br, 2H, NH_2), 7.42.–7.44 (m, 1 H, ArH), 7.45 (t, 1 H, J = 1.66 Hz, ArH), 7.47–7.49 (m, 4H, ArH), 7.59 (t, 1 H, J = 1.80 Hz, ArH), 8.38–8.41 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 121.61, 124.25, 128.65 (3 × CH), 128.79 (2 × CH), 129.25, 130.08, 130.34, 131.15, 134.97, 136.08, 150.71, 151.63; IR (KBr): 3279, 3069, 2927, 1633, 1593, 1485, 1450, 1286, 1092 cm^{-1}; EIMS : 298 (100), 282 (29), 280 (26), 178 (28), 153 (14), 129 (26), 128 (31), 125 (23), 111 (40),77 (62); HRMS: Calcd. for $C_{15}H_{11}ClN_4O$: 298.0621. Found: 298.0625.

5-Amino-1-(4-chlorophenyl)-4-nitroso-3-phenylpyrazole (2g): Light yellow solid; mp 151–154 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.04 (br, 2H, NH_2), 7.46–7.54 (m, 7H, ArH), 8.37–8.39 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 125.20, 128.65 (3 × CH), 128.75 (2 × CH), 130.05 (2 × CH), 130.41 (2 × CH), 134.24, 135.02, 135.05,150.74, 151.52; IR (KBr): 3347, 3263, 3195, 1632, 1499, 1450, 1260 cm^{-1}; EIMS: 298 (100), 282 (29), 280 (31), 178 (28), 153 (27), 151 (52), 28 (28), 125 (31), 111 (37), 103 (21), 77 (40); HRMS: Calcd. for $C_{15}H_{11}ClN_4O$: 298.0621. Found: 298.0628.

5-Amino-1-(4-bromophenyl)-4-nitroso-3-phenylpyrazole (2h): Light orange solid; mp 162–165 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.44–7.46 (m, 5H, ArH), 7.67 (d, 2H, J = 8.64 Hz, ArH), 8.29–8.32 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 123.04, 125.41, 128.67 (3 × CH), 128.77 (2 × CH), 130.12 (2 × CH), 130.31 (2 × CH), 133.45, 134.75, 150.65, 151.58; IR (KBr): 3271, 3061, 2920, 2851, 1633, 1492, 1450, 1232, 1164 cm^{-1}; EIMS: 342 (100), 328 (39), 326 (62), 324 (28), 197 (50), 195 (40), 171

(37), 169 (39), 143 (83), 103 (65), 77 (60); HRMS: Calcd. for $C_{15}H_{11}BrN_4O$: 342.0116. Found: 342.0121.

5-Amino-1-(4-methoxyphenyl)-4-nitroso-3-phenylpyrazole (2i): Dark brown solid; mp 162–165 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 3.85 (s, 3H, CH_3), 6.88 (br, 2H, NH_2), 7.03–7.05 (d, 2H, J = 8.92 Hz, ArH), 7.41–7.48 (m, 5H, ArH), 8.37–8.40 (m, 2H, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 55.69, 115.37, 125.96 (2 × CH), 128.07 (2 × CH), 128.58 (2 × CH), 128.74, 129.82, 130.65, 135.32, 150.83, 150.97, 160.21; IR (KBr): 3282, 2933, 2835, 1628, 1513, 1451, 1250, 1171, 967, 834 cm^{-1}; EIMS: 294.2 (100), 294.2(100), 276.1(32), 159.1(25), 144.1(31), 77.1(66); HRMS: Calcd. for $C_{16}H_{14}N_4O_2$: 294.1117. Found: 294.1123.

5-Amino-3-(4-methylphenyl)-4-nitroso-1-phenylpyrazole (2j): Orange solid; mp 212–215 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.41 (s, 3H, CH_3), 7.04 (br, 2H, NH_2), 7.28 (d, 2H, J = 8.00 Hz, ArH), 7.43–7.47 (m, 1H, ArH), 7.52–7.57 (m, 4H, ArH), 8.29 (d, 2H, J =8.12 Hz, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.46, 123.96 (2 × CH), 127.71, 128.63 (2 × CH), 129.12, 129.33 (2 × CH), 130.20 (2 × CH), 135.09, 135.74, 140.06, 150.94, 151.31; IR (KBr): 3339, 2954, 2864, 1648, 1503, 1250, 1160, 1095, 960 cm^{-1}; EIMS: 278 (100), 145 (14), 144 (58), 143 (22), 117 (10), 77 (40); HRMS : Calcd. for $C_{16}H_{14}N_4O$: 278.1168. Found: 278.1170.

5-Amino-3-(4-chlorophenyl)-4-nitroso-1-phenylpyrazole (2k): brown solid; mp 222–225 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.98 (br, 2H, NH_2), 7.45 (d, 2H, J = 8.64 Hz, ArH), 7.48–7.52 (m, 2H, ArH), 7.54–7.57 (m, 3H, ArH), 8.39 (d, 2H, J = 8.60 Hz, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 123.98 (2 × CH), 128.87 (2 × CH), 129.12, 129.35, 129.95 (2 × CH), 130.30 (2 × CH), 135.05, 135.58, 136.09, 150.07, 150.72; IR (KBr): 3354, 3274, 3204, 3124, 3069, 1641, 1503, 1250, 1158, 965 cm^{-1}; EIMS: 298 (100), 284 (12), 282 (36), 280 (29), 255 (11), 163 (21), 144 (45), 137 (24), 117 (34), 91 (46), 77(76); HRMS: Calcd. for $C_{15}H_{11}ClN_4O$: 289.0621 Found: 298.0616.

5-Amino-3-(4-methoxyphenyl)-4-nitroso-1-phenylpyrazole (2l): Orange solid; mp 184–187°C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 3.86 (s, 3H, CH_3), 7.00 (d, 2H, J = 8.90 Hz, ArH), 7.43–7.47 (m, 1 H, ArH), 7.52–7.57 (m, 4 H, ArH), 8.36 (d, 2 H, J = 8.90 Hz, ArH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 55.35, 114.07 (2 × CH), 123.17, 123.94 (2× CH), 129.11, 130.22 (4 × CH), 135.11, 135.77, 150.97, 151.03, 161.16; IR (KBr): 3278, 3064, 2965, 2935, 2835, 1611, 1503, 1250, 1030, 688 cm^{-1}; MS (EI): 295.1(18), 294.1(100), 278.1(25), 176.0(35), 148.1(43), 147.0(54), 133.0(40), 128.0(15), 122.0(20), 103.0(60), 77.0(34); HRMS (EI): Calcd. for $C_{16}H_{14}N_4O_2$: 294.1117. Found: 294.1114.

Standard procedure for synthesis of pyrazole-4-carbaldehyde 3a–l. The reliable procedure were involved the treatment of 5-amino-1*H*-pyrazole-4-carbaldehydes **1a–l** (1.0 equiv.) with sodium nitrite ($NaNO_2$, ~6.0 equiv.) in MeOH (5.0 mL) at room temperature. The reaction mixture was cooled in an ice-bath and added with 6.0 N aqueous hydrochloride acid (5.0 mL) for stirring 3h. The clearly solution was transferred to the red suspension. On completion of the reaction (TLC), the mixture was concentrated under reduced pressure and extracted with CH_2Cl_2 (20 mL × 2), washed with 5% $NaHCO_3$ (20 mL × 2), brine (20 mL × 2), and and dry over $MgSO_4$. The organic layer was concentrated under reduced pressure. Consequently, the residue was charged onto the column in a little CH_2Cl_2 and the solvent was allowed to percolate down to the surface of silica gel. The column was then eluted with EtOAc/*n*-Hexane (2:8) to isolate 5-amino-4-nitrosopyrazoles **3a–l** in 74–91% yields.

3-Phenyl-1-(*o*-tolyl)-1*H*-pyrazole-4-carbaldehyde (3b): light brown solid; mp 123–125 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.31 (s, 3 H, CH_3), 7.32–7.40 (m, 4 H, ArH), 7.44–7.48 (m, 3 H, ArH), 7.79–781 (m, 2 H, ArH), 8.20 (s, 1 H, ArH), 10.05 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 18.07, 121.55, 125.89, 126.84, 128.67 (2 ×

CH), 128.94 (2 × CH), 129.13, 129.38, 131.34, 131.54, 133.55, 135.11, 138.76, 154.23, 185.20; IR (KBr): 3124, 3059, 2929, 2859, 1678, 1526, 1188, 762 cm^{-1}; MS (EI): 262.1(100), 261.1(48), 233.1(26), 130.0(12); HRMS: Calcd. for $C_{17}H_{14}N_2O$: 262.1106. Found: 262.1101.

3-Phenyl-1-(*m*-tolyl)-1*H*-pyrazole-4-carbaldehyde (3c): Dark green solid; mp 94–98 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 2.41 (s, 3 H, CH_3), 7.16 (d, 1H, J = 7.68 Hz, ArH), 7.34 (t, 1 H, J = 7.84 Hz, ArH), 7.42–7.54 (m, 4 H, ArH), 7.61 (s, 1 H, ArH), 7.80–7.82 (m, 2 H, ArH), 8.49 (s, 1 H, ArH), 10.02 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.35, 116.64, 120.37, 122.30, 128.64 (3 × CH), 128.87 (2 × CH), 129.15, 129.33, 131.00, 131.29, 138.85, 139.77, 154.54, 185.03; IR (KBr): 3059, 2919, 2832, 1681, 1529, 1214, 1060, 783 cm^{-1}; MS (EI): 261.2(100), 233.2(22), 91.1(21), 77.1(15); HRMS: Calcd. for $C_{17}H_{14}N_2O$: 262.1106. Found: 262.1115.

3-Phenyl-1-(*p*-tolyl)-1*H*-pyrazole-4-carbaldehyde (3d): Brown solid; mp 141–145 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 2.37 (s, 3H, CH_3), 7.25 (d, 2H, J = 8.36 Hz, ArH), 7.40–7.50 (m, 3H, ArH), 7.63 (d, 2H, J = 8.44 Hz, ArH), 7.80–7.82 (m, 2H, ArH) 8.45 (s, 1H, ArH), 10.01 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 20.90, 119.50 (2 × CH), 122.22, 128.62 (2 × CH), 128.85 (2 × CH), 129.10, 130.04 (2 × CH), 130.78, 131.33, 136.63, 137.85, 154.43, 185.01; IR (KBr): 3124, 2914, 2833, 1672, 1529, 1223, 818 cm^{-1}; MS (EI): 262.2(100), 261.2(76), 233.2(13); HRMS: Calcd. for $C_{17}H_{14}N_2O$: 262.1106. Found: 262.1096.

1-(2-Chlorophenyl)-3-phenyl-1*H*-pyrazole-4-carbaldehyde (3e): Yellow orange solid; mp 83–85 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.34–7.37 (m, 2H, ArH), 7.42–7.48 (m, 3H, ArH), 7.50–7.52 (m, 1H, ArH), 7.63–7.66 (m, 1H, ArH), 7.81–7.83 (m, 2H, ArH), 8.45 (s, 1H, ArH), 10.04 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 121.74, 127.52, 127.73, 128.06, 128.52 (2 × CH), 128.82 (2 × CH), 129.12, 129.91,

130.64, 130.95, 136.21, 136.84, 154.12, 184.73; IR (KBr): 3064, 2828, 1682, 1528, 1198, 1075, 757 cm^{-1}; MS (EI): 284.2(31), 283.2(41), 282.2(100), 270.2(13), 111.0(16), 77.1(16); HRMS: Calcd. for $C_{16}H_{11}ClN_2O$: 282.0560. Found: 282.0553.

1-(3-Chlorophenyl)-3-phenyl-1*H*-pyrazole-4-carbaldehyde (3f): Light brown solid; mp 101–105 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ7.34–7.36 (m, 1 H, ArH), 7.42 (t, 1 H, *J* = 8.08 Hz ArH), 7.46–7.52 (m, 3 H, ArH), 7.65 (dq, 1 H, *J* = 8.0, 1.0 Hz, ArH), 7.79–7.81 (m, 2 H, ArH), 7.87 (t, 1 H, *J* = 2.02 Hz ArH), 8.52 (s, 1 H, ArH), 10.04 (s, 1 H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 117.45, 120.18, 122.83, 127.97, 128.82 (2 × CH), 128.94 (2 × CH), 129.47, 130.71, 130.98, 131.05, 135.63, 139.92, 155.02, 185.05; IR (KBr): 3119, 3064, 2919, 2853, 1678, 1526, 1208, 775 cm^{-1}; MS (EI): 284.2(31), 283.2(43), 282.2(100), 281.1(85), 253.2(15), 218.1(11), 111.0(17), 77.1(13); HRMS: Calcd. for $C_{16}H_{11}ClN_2O$: 282.0560. Found: 282.0556.

1-(4-Chlorophenyl)-3-phenyl-1*H*-pyrazole-4-carbaldehyde (3g): Light brown solid; mp 138–142 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.44–7.49 (m, 5 H, ArH), 7.72 (d, 2 H, *J* = 8.88 Hz ArH), 7.79 (dd, 2 H, *J* = 3.09 Hz, ArH), 8.49 (s, 1H, ArH), 10.02 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ120.78 (2 × CH), 122.69, 128.76 (2 × CH), 128.88 (2 × CH), 129.38, 129.74 (2 × CH), 130.81, 131.07, 133.55, 137.47, 154.87, 185.00; IR (KBr): 3129, 3054, 2833, 1675, 1529, 1213, 822 cm^{-1}; MS (EI): 284.2(31), 283.2(42), 282.2(100), 281.1(79), 253.1(14), 111.0(17), 77.1(13); HRMS: Calcd. for $C_{16}H_{11}ClN_2O$: 282.0560. Found: 282.0555.

1-(4-Bromophenyl)-3-phenyl-1*H*-pyrazole-4-carbaldehyde (3h): Brown solid; mp 146–149 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 7.46–7.51 (m, 3H, ArH), 7.60 (d, 2H, *J* = 8.97 Hz, ArH), 7.66 (d, 2H , *J* = 8.94 Hz, ArH), 7.78 (dd, 2H, *J* = 7.84 Hz, ArH), 8.50 (s, 1H, ArH), 10.02 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ121.05 (2 × CH), 121.41, 122.74, 128.77 (2 × CH), 128.89 (2 × CH), 129.40, 130.76, 131.06, 132.72 (2 × CH), 137.95, 154.93, 185.03; IR (KBr): 3124, 3064, 2833, 1677, 1527, 1213, 823

cm^{-1}; MS (EI): 328.0(98), 327.0(81), 326.0(100), 299.0(10), 218.1(16), 156.9(14), 154.9(14), 115(10), 77.0(17); HRMS: Calcd. for $C_{16}H_{11}BrN_2O$: 326.0055. Found: 326.0050.

1-(4-Methoxyphenyl)-3-phenyl-1*H*-pyrazole-4-carbaldehyde (3i): Orange solid; mp 110–114 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 3.75 (s, 3H, CH_3), 6.90 (d, 2H, J = 9.00 Hz, ArH), 7.38–7.47 (m, 3H, ArH), 7.61 (d, 2H, J = 9.00 Hz, ArH), 7.79 (d, 2H, J = 7.96, 1.44 Hz, ArH), 8.35 (s, 1H, ArH), 9.96 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 55.30, 114.41 (2 × CH), 120.93 (2 × CH), 121.95, 128.46 (2 × CH), 128.70 (2 × CH), 128.93, 130.76, 131.23, 132.25, 154.07, 158.95, 184.76; IR (KBr): 3124, 2838, 1672, 1528, 1251, 1043, 830 cm^{-1}; MS (EI): 279.1(17), 278.1(100), 277.1(44), 77.0(15); HRMS: Calcd. for $C_{17}H_{14}N_2O_2$: 278.1055. Found: 278.1053.

1-Phenyl-3-(*p*-tolyl)-1*H*-pyrazole-4-carbaldehyde (3j): Brown solid; mp 119–123 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 2.41 (s, 3H, CH_3), 7.29 (d, 2H, J = 7.84 Hz, ArH), 7.35–7.39 (m, 1H, ArH), 7.47–7.51 (m, 2H, ArH), 7.69 (d, 2H, J = 8.12 Hz, ArH), 7.77 (dd, 2H, J = 8.56, 1.02 Hz, ArH), 8.50 (s, 1H, ArH), 10.03 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 21.33, 119.72 (2 × CH), 122.45, 127.87, 128.44, 128.82 (2 × CH), 129.44 (2 × CH), 129.63 (2 × CH), 130.82, 139.04, 139.32, 154.87, 185.30; IR (KBr): 3124, 3029, 2924, 2838, 1671, 1520, 1219, 755 cm^{-1}; MS (EI): 263.2(17), 262.2(100), 261.1(42), 247.1(36), 233.1(12), 77.0(24); HRMS: Calcd. for $C_{17}H_{14}N_2O$: 262.1106. Found: 262.1099.

3-(4-Chlorophenyl)-1-phenyl-1*H*-pyrazole-4-carbaldehyde (3k): Orange brown solid; mp 91–95 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.39 (t, 1H, J = 7.40 Hz, ArH), 7.44–7.52 (m, 4H, ArH), 7.76 (d, 2H, J = 7.75 Hz, ArH), 7.81 (d, 2H, J = 8.62 Hz, ArH), 8.51 (s, 1H, ArH), 10.01 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 119.72 (2 × CH), 122.50, 128.09, 128.91 (2 × CH), 129.71 (2 × CH), 129.83, 130.17 (2 × CH), 131.98, 135.42, 138.88, 153.18, 184.42; IR (KBr): 3124, 3069, 2828, 1671,

1523, 1228, 1090, 835 cm^{-1}; MS (EI): 284.1(33), 283.1(39), 282.1(100), 281.1(63), 247.1(17), 104.1(15), 77.0(34); HRMS: Calcd. for $C_{16}H_{11}ClN_2O$: 282.0560. Found: 282.0552.

3-(4-Methoxyphenyl)-1-phenyl-1*H*-pyrazole-4-carbaldehyde (3l): Light brown solid; mp 111–115 °C; ^1H NMR ($CDCl_3$, 400 MHz) δ 3.85 (s, 3H, CH_3), 7.00 (d, 2H, J = 8.88 Hz, ArH), 7.36 (t, 1H, J = 7.46 Hz, ArH), 7.48 (t, 2H, J = 8.00 Hz, ArH), 7.75–7.79 (m, 4H, ArH), 8.49 (s, 1H, ArH), 10.02 (s, 1H, CHO); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 55.34, 114.16 (2 × CH), 119.66 (2 × CH), 122.32, 123.82, 127.82, 129.62 (2 × CH), 130.22 (2 × CH), 131.17, 139.02, 154.43, 160.52, 185.10; IR (KBr): 3124, 3079, 2833, 1672, 1520, 1250, 1175, 840 cm^{-1}; MS (EI): 279.1(18), 278.1(100), 277.1(24), 235.1(19), 77.0(23); HRMS: Calcd. for $C_{17}H_{14}N_2O_2$: 278.1055. Found: 278.1056.

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Seletive Synthesis of Functionalized Pyrazoles from 5-Amino-1*H*-pyrazole-4-carbaldehydes with Sodium Nitrite: 5-Amino-4-nitrosopyrazoles and Pyrazole-4-carbaldehydes

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