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Formyl Substituent at C-4 of Pyrazoles: A Temporary Protecting Group for Regioselective Palladium-Catalyzed Direct Arylation at C-5

Imen Smari,[a,b] Chiraz Youssef,[c] Kedong Yuan,[b] Anissa Beladhria,[b,c] Hamed Ben Ammar,*[a,c] Bechir Ben Hassine,[a] and Henri Doucet*[b]

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Pyrazoles with an aldehyde function at C-4 underwent a palladium-catalyzed direct arylation reaction to provide a regioselective approach to 5-aryl-substituted pyrazoles. The reaction proceeds in moderate to high yields with a variety of aryl bromides in the presence of 2 mol-% of $Pd(OAc)_2$ as the catalyst. The use of an aldehyde function at C-4 of the pyrazoles presents several advantages: (1) 4-formylpyrazoles are easily prepared from hydrazine derivatives, ketones, and *N*,*N*-dimethylformamide (DMF), (2) the control of the regioselectivity of the arylation at C-5 of the pyrazole, (3) the aldehyde substituent can easily be transformed into a wide variety of other substituents, and (4) the formyl group can be considered a temporary protecting group, as it can be removed by a straightforward reaction.

Introduction

Among heterocycle derivatives, (hetero)aryl-substituted pyrazoles display important biological properties. For example, rimonabant is an antiobesity agent, celecoxib is an anti-inflammatory agent, and regadenoson a vasodilator (see Figure 1).

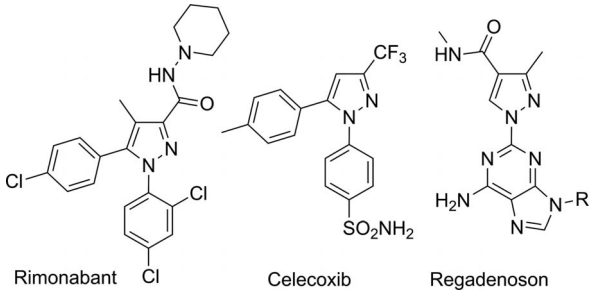

Figure 1. Examples of bioactive pyrazoles.

[a] Laboratoire de Synthèse Asymétrique et Catalyse Homogène (UR 11ES56), Université de Monastir, Faculté des Sciences de Monastir,
Avenue de l'environnement, Monastir 5000, Tunisie
E-mail: hamed_benammar@yahoo.fr
[b] Institut des Sciences Chimiques de Rennes, UMR 6226 CNRS – Université de Rennes "Organométalliques: Matériaux et Catalyse", Campus de Beaulieu,
35042 Rennes, France
E-mail: henri.doucet@univ-rennes1.fr
http://scienceschimiques.univ-rennes1.fr/catalyse/personal%20web%20pages/page%20web%20Doucet.pdf
[c] Laboratoire de Chimie Organique Physique (UR11ES74), Université de Sfax, Faculté des Sciences de Sfax,
Route de la Soukra, 3038 Sfax, Tunisie

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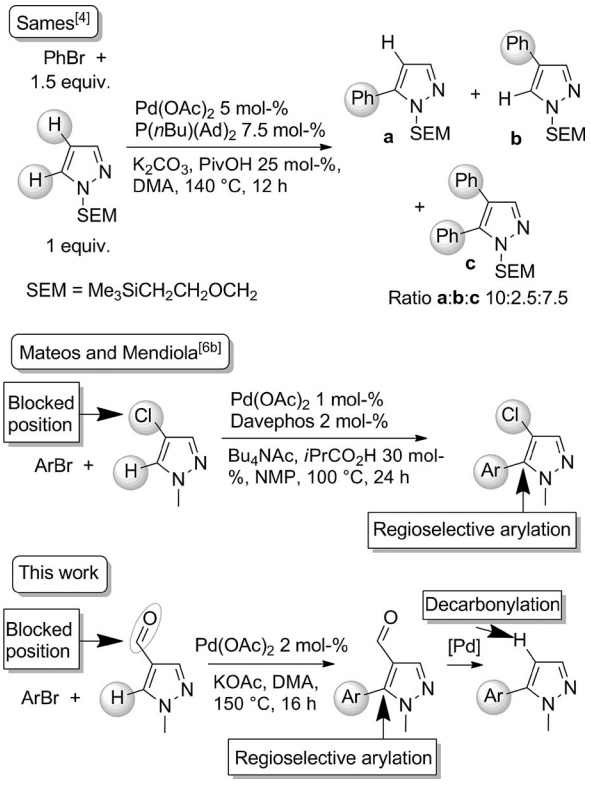
In recent years, the palladium-catalyzed direct arylation of heteroaromatic compounds has emerged as a very powerful tool for simple access to a wide variety of (hetero)-arylated heteroaromatic compounds.[1–3] However, there are still limitations to these reactions in terms of their scope of substrates. Only a few examples of palladium-catalyzed direct arylations of pyrazoles have been reported to date.[4–8] This is because of the lack of regioselectivity that is observed in the course of these coupling reactions.[4,5] Sames and co-workers determined the regioselectivity of the catalytic C–H arylation of pyrazoles (see Scheme 1, top).[4] The SEM-substituted pyrazole [SEM = 2-(trimethylsilyl)ethoxymethyl] was treated with bromobenzene using 5 mol-% of $Pd(OAc)_2$ and 7.5 mol-% of the electron-rich and congested phosphine $Pd(n\text{Bu})(Ad)_2$ as the catalyst (Ad = adamantyl) to give a mixture of products. These results indicated a higher reactivity at the 5-position relative to the 4-position and a very low reactivity at the 3-position.

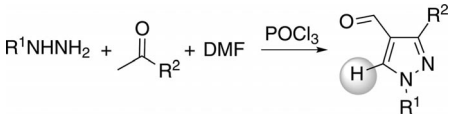
In the course of this reaction, 5-phenylpyrazole **a** was obtained in 40% yield, and 4-phenylpyrazole **b** was produced in only 10% yield. Moreover, the formation of a significant amount of 4,5-diarylated pyrazole **c** (30%) was also observed. Our studies of the arylation of 1-methylpyrazole with various aryl bromides confirmed that the regioselective control of such reactions is very challenging, as in all cases, we obtained mixtures of 4- and 5-arylated pyrazoles.[5] As a consequence, only a few examples of selective 5-arylations of pyrazoles have been described.[6,7] In several cases of intermolecular coupling reactions, the C-4 position was blocked by a chloro substituent to control the regioselectivity (see Scheme 1, middle).[6b,6d]

The reaction between hydrazine derivatives, *N*,*N*-dimethylformamide (DMF), ketones, and $POCl_3$ is a well-known approach to access a wide variety of 4-formylpyrazoles and



Scheme 1. Regioselectivity of palladium-catalyzed direct arylation of pyrazoles (Piv = pivaloyl, DMA = *N*,*N*-dimethylacetamide, NMP = *N*-methylpyrrolidone).

generally gives the desired heteroarenes in high yields (see Scheme 2).[9] Moreover, the 4-formylpyrazole units are important building blocks in organic synthesis. The formyl substituent can be easily transformed into other useful functional groups such as alcohols, imines, and thiocarbonyls (see Figure 2).[10] In the presence of Pd catalysts and by using specific reaction conditions, their decarbonylation is also possible, which can make the formyl substituent a temporary protecting group.[11]



Scheme 2. Synthesis of 4-formylpyrazoles.

To the best of our knowledge, no examples have been reported to date of a palladium-catalyzed direct arylation of pyrazoles that contain a formyl substituent at C-4. Such direct arylations would allow: (1) control of the regioselectivity of the arylation, and (2) access to a wide scope of pyrazole derivatives. Therefore, the discovery of an effective method for the direct selective coupling at C-5 of 4-formylpyrazole derivatives with aryl halides, especially using an affordable catalyst and base as well as simple reaction conditions, would be attractive for synthetic chemists. We now report: (1) the conditions for the palladium-catalyzed direct arylation of 4-formylpyrazoles with a series of (hetero)aryl bromides using an inexpensive base and an easily accessible

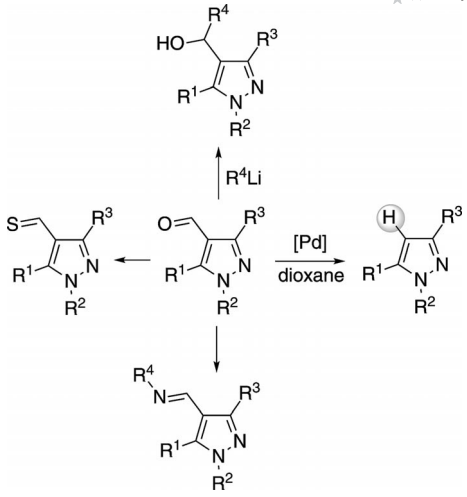


Figure 2. Reactivity of 4-formylpyrazoles.

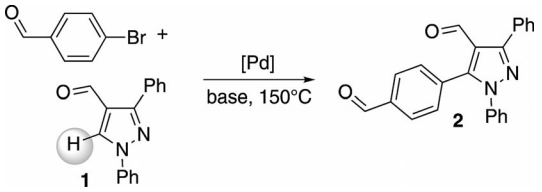
and air-stable catalyst, (2) the influence of substituents on the arene ring at C-3 of the pyrazole, and (3) the subsequent decarbonylation of the prepared 4-formyl-5-arylpyrazoles (see Scheme 1, bottom).

Results and Discussion

We started our investigation with the C–H functionalization of 1,3-diphenylpyrazole-4-carbaldehyde (**1**) using 4-bromobenzaldehyde as the coupling partner. The reaction that employed 2 mol-% of $PdCl(C_3H_5)$(dppb) as the catalyst [dppb = 1,4-bis(diphenylphosphino)butane] and KOAc as the base at 150 °C in DMAproceeded towards completion in 24 h to afford **2** in 54% yield (see Table 1, Entry 1). In the course of this reaction, the formation of a small amount of a decarbonylated compound was also observed by GC–MS analysis of the crude mixture. This side reaction was expected, as the palladium-catalyzed decarbonylation of 4-formylpyrrole has already been described.[11] A slightly higher yield of **2** was obtained in the presence of 2 mol-% of $Pd(OAc)_2$ as the catalyst (see Table 1, Entry 3). Next, the influence of a few different bases was examined. CsOAc gave a mixture of **2** and the decarbonylated product in a low yield (see Table 1, Entry 5). In the presence of NaOAc, a large amount of the decarbonylated product was produced, and only a trace amount of **2** was observed (see Table 1, Entry 6). 1,3-Diphenylpyrazole-4-carbaldehyde (**1**) was recovered unreacted when we employed Cs_2CO_3 as the base (see Table 1, Entry 7). The influence of a few different solvents was then examined. NMP and DMF led to a trace amount of **2**, but a large amount of decarbonylated product was formed (see Table 1, Entries 8 and 9).

Next, we studied the scope of this reaction with various (hetero)aryl bromides, 2 mol-% of $Pd(OAc)_2$ as the catalyst, KOAc as the base, and DMA as the solvent (see Scheme 3 and Tables 2, 3, and 4). Very high yields of **3** and **4** were obtained for the coupling reactions of **1** with 4-bromobenzonitrile and 4-bromonitrobenzene, respectively (see Table 2, Entries 1 and 2). Good results were also obtained

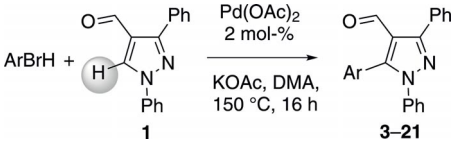
Table 1. Influence of the reaction conditions on the palladium-catalyzed direct arylation of 1,3-diphenylpyrazole-4-carbaldehyde (**1**) with 4-bromobenzaldehyde.[a]



Entry	Catalyst (mol-%)	Base	Solvent	% Yield **2**
1	$PdCl(C_3H_5)(dppb)$ (2)	KOAc	DMA	54[b]
2	$PdCl(C_3H_5)(dppb)$ (0.5)	KOAc	DMA	41[b]
3	$Pd(OAc)_2$ (2)	KOAc	DMA	60[b]
4	$Pd(OAc)_2$ (0.5)	KOAc	DMA	21[b]
5	$Pd(OAc)_2$ (0.5)	CsOAc	DMA	19[b]
6	$Pd(OAc)_2$ (0.5)	NaOAc	DMA	11[c]
7	$Pd(OAc)_2$ (2)	Cs_2CO_3	DMA	0
8	$Pd(OAc)_2$ (2)	KOAc	NMP	3[c]
9	$Pd(OAc)_2$ (2)	KOAc	DMF	4[c]

[a] Reagents and conditions: 4-bromobenzaldehyde (1.0 equiv.), pyrazole derivative (1.5 equiv.), base (2.0 equiv.), solvent, 16 h, 150 °C. [b] <10% decarbonylated product was also observed. [c] >20% decarbonylated product was also observed.

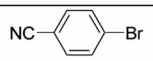
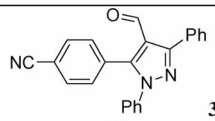
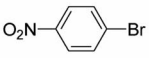
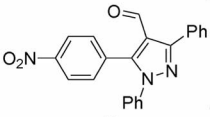
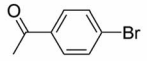
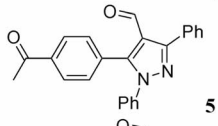
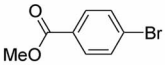
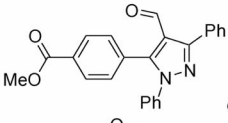
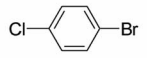
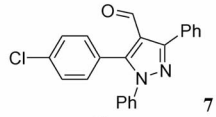
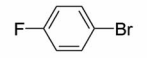
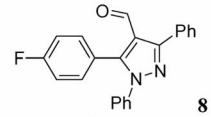
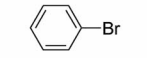
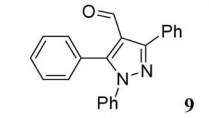
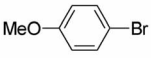
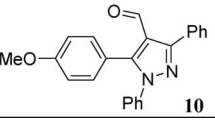
by using 4-bromoacetophenone and methyl 4-bromobenzoate as the coupling partners, as the desired coupling products **5** and **6** were obtained in 78 and 77% yield, respectively (see Table 2, Entries 3 and 4). In the presence of 4-chlorobromobenzene, **7** was isolated in 68% yield without the cleavage of the C–Cl bond, which will allow for further transformations (see Table 2, Entry 5). Even bromobenzene was reactive under these conditions to produce **9** in 68% yield, whereas electron-rich 4-bromoanisole gave **10** in only 41% yield (Table 2, Entries 7–9). The oxidative addition of this aryl bromide appears to be quite slow under these conditions. The use of $PdCl(C_3H_5)(dppb)$ as a catalyst for this reaction did not improve the yield.



Scheme 3.

To enlarge the scope of substrates for this reaction, we also performed the arylations with *meta*- and *ortho*-substituted aryl bromides (see Table 3). Aryl bromides that contained nitrile, nitro, acetyl, formyl, or chloro groups in the *meta* position were successfully coupled with 1,3-diphenylpyrazole-4-carbaldehyde (**1**) to provide **11–15** in 55–91% yield (see Table 3, Entries 1–5). By using 3,5-bis(trifluoromethyl)bromobenzene and 4-bromo-1-nitro-2-(trifluoromethyl)benzene as the coupling partners, the expected products **16** and **17** were also obtained in the high yields of 94 and 80%, respectively (see Table 3, Entries 6 and 7). A lower yield of 58% was obtained for **18** by employing the more congested 2-bromobenzonitrile (see Table 3, Entry 8).

Table 2. Palladium-catalyzed direct arylations of 1,3-diphenylpyrazole-4-carbaldehyde (**1**) with *para*-substituted aryl bromides (see Scheme 3).[a]

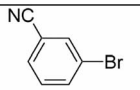
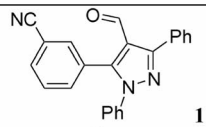
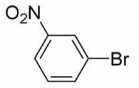
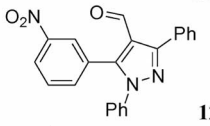
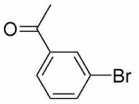
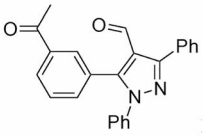
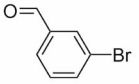
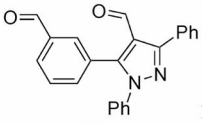
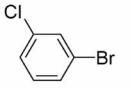
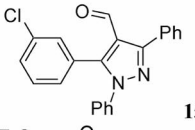
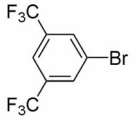
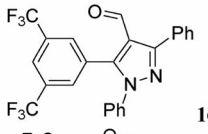
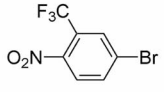
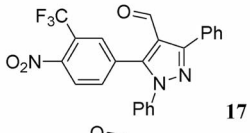
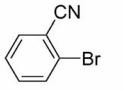
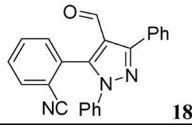
Entry	Aryl bromide	Product	Yield (%)
1		 **3**	90
2		 **4**	92
3		 **5**	78
4		 **6**	77
5		 **7**	68
6		 **8**	71
7		 **9**	68
8			41
9		 **10**	35[b]

[a] Reagents and conditions: $Pd(OAc)_2$ (0.02 equiv.), aryl bromide (1.0 equiv.), pyrazole derivative (1.5 equiv.), KOAc (2.0 equiv.), DMA, 16 h, 150 °C. [b] $PdCl(C_3H_5)(dppb)$ (0.02 equiv.) was used as a catalyst.

The pyridine motif is found in many bioactive compounds. Therefore, the introduction of the pyridine, quinolone, or pyrimidine motifs into the pyrazole structure would also be very useful. We observed that the coupling reactions between 3-bromopyridine, 3-bromoquinoline, and 5-bromopyrimidine with 1,3-diphenylpyrazole-4-carbaldehyde (**1**) by again using 2 mol-% of $Pd(OAc)_2$ also proceeded nicely to give **19–21** in 60–83% yield (see Table 4).

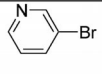
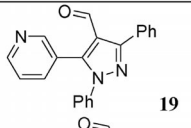
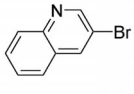
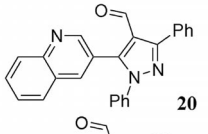
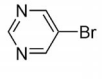
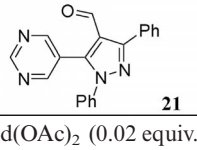
We then studied the influence of a substituted benzene ring at the C-3 position of the pyrazole (see Scheme 4). Six aryl bromides were treated with 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (**22**, see Scheme 4, top). A nitro group on the benzene ring appears to have a minor influence on the reaction, as in all cases the target products **23–28** were obtained in good to excellent yields. The best results were obtained by using 4-chlorobromobenzene and 3,5-bis(trifluoromethyl)bromobenzene as the coupling partners, as **23** and **26** were isolated in 91 and 93% yields,

Table 3. Palladium-catalyzed direct arylations of 1,3-diphenylpyrazole-4-carbaldehyde (**1**) with *meta*- or *ortho*-substituted aryl bromides (see Scheme 3).[a]

Entry	Aryl bromide	Product	Yield (%)
1		 **11**	88
2		 **12**	55
3		 **13**	77
4		 **14**	74
5		 **15**	91
6		 **16**	94
7		 **17**	80
8		 **18**	58

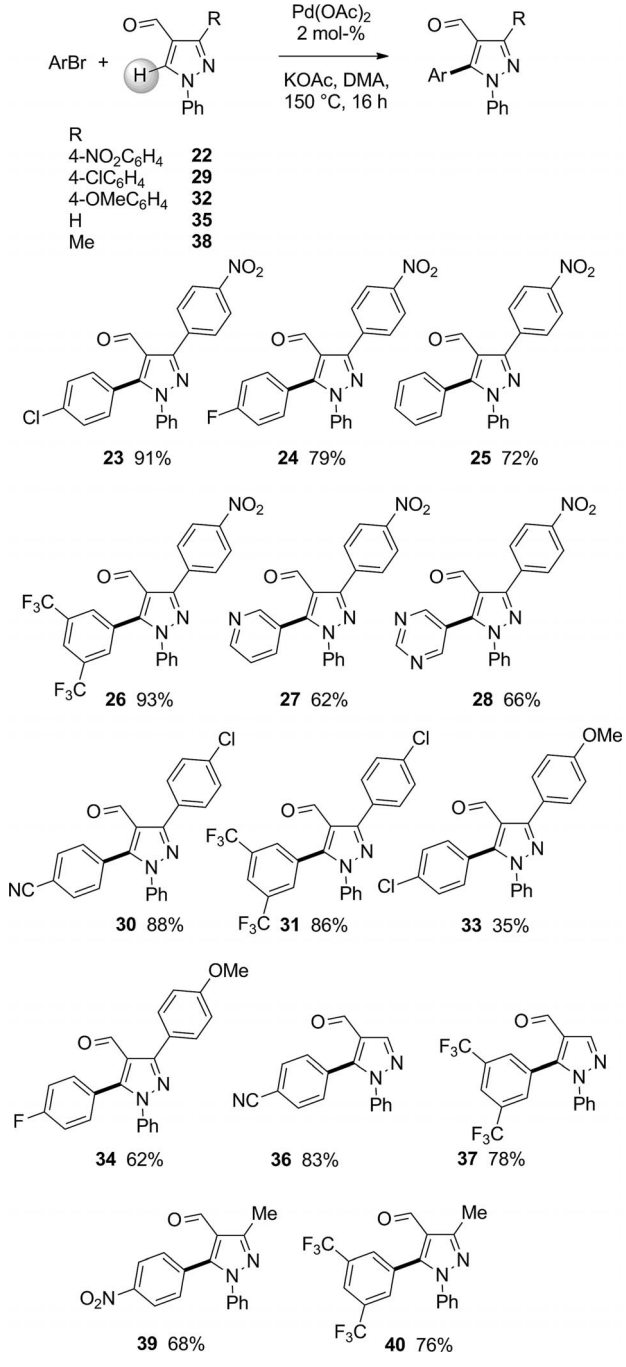
[a] Reagents and conditions: $Pd(OAc)_2$ (0.02 equiv.), aryl bromide (1.0 equiv.), pyrazole derivative (1.5 equiv.), KOAc (2.0 equiv.), DMA, 16 h, 150 °C.

Table 4. Palladium-catalyzed direct arylations of 1,3-diphenylpyrazole-4-carbaldehyde (**1**) with heteroaryl bromides (see Scheme 3).[a]

Entry	Aryl bromide	Product	Yield (%)
1		 **19**	79
2		 **20**	83
3		 **21**	60

[a] Reagents and conditions: $Pd(OAc)_2$ (0.02 equiv.), aryl bromide (1.0 equiv.), pyrazole derivative (1.5 equiv.), KOAc (2.0 equiv.), DMA, 16 h, 150 °C.

respectively. Lower yields of 62 and 66% of **27** and **28** were obtained by employing 3-bromopyridine and 5-bromopyrimidine, respectively.

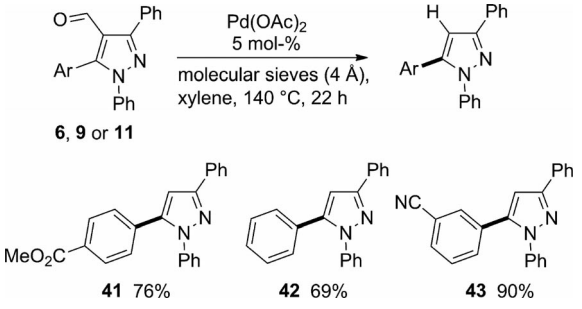


Scheme 4.

A chloro-substituted benzene ring at C-3 of the pyrazole was also tolerated. By starting from **29** and 4-bromobenzonitrile and 3,5-bis(trifluoromethyl)bromobenzene, the desired products **30** and **31** were obtained in 88 and 86% yield, respectively (see Scheme 4, middle). In these cases, no cleavage of the C–Cl bond was observed. On the other hand, the presence of a methoxy substituent on the benzene

ring at C-3 of the pyrazole led to low to moderate yields of **33** and **34**. Finally, the C-5 arylated products **36**, **37**, **39**, and **40** were also obtained in good yields from 1-phenylpyrazole-4-carbaldehyde (**35**) and 3-methyl-1-phenylpyrazole-4-carbaldehyde (**38**). No arylation at C-3 of **35** was detected by GC–MS analysis of the crude mixture (see Scheme 4, bottom).

The decarbonylation of (hetero)arenes in the presence of a catalytic amount of $Pd(OAc)_2$ and molecular sieves in cyclohexane was recently reported by Maiti and coworkers.[11] To further demonstrate that 4-formyl substituents of pyrazoles can be considered as temporary protecting groups, we studied the decarboxylation of three different 5-aryl-substituted pyrazoles. Using quite similar reaction conditions to those reported by Maiti, the decarbonylations of **6**, **9**, and **11** proceeded nicely to afford **41**–**43** in 69–90% yield (see Scheme 5).



Scheme 5.

Conclusions

In summary, we have demonstrated that the presence of a formyl substituent at C-4 of a pyrazole allows the regioselective control of the palladium-catalyzed direct arylation with aryl bromides. The desired 5-aryl-4-formylpyrazoles were obtained in good to excellent yields by using 2 mol-% of $Pd(OAc)_2$ as the catalyst and KOAc as the base. This method tolerates several functional groups, both on the aryl bromide and on the benzene ring at C-3 of the pyrazole. This protocol employs a moderate loading of a phosphine-free air-stable catalyst and an inexpensive base. In addition, the major byproducts of these coupling reactions are KBr and AcOH instead of the metallic salts that are produced by more classical coupling procedures. This makes this process economically viable and environmentally attractive. Moreover, the formyl substituent can easily be removed by using a Pd catalyst, and, therefore, can be considered a temporary protecting group.

Experimental Section

General Methods: All the reactions were performed under argon with a Schlenk tube apparatus and predried glassware. All chemical reactants, except the 4-formylpyrazoles, were obtained from commercial sources and used without further purification. DMAc analytical grade (99%) was not distilled before use. NaOAc (99+%), KOAc (99+%), CsOAc (99+%), and Cs_2CO_3 (99%) were used. 4-Formylpyrazoles were prepared according to a reported procedure.[9] Flash chromatography was performed with silica gel (230–400 mesh). Thin layer chromatography was carried out with Merck silica gel GF_{254} plates. Chromatograms were recorded with a SHIMADZU GC–MS-GP2010S gas chromatograph mass spectrometer. The ^1H and ^{13}C NMR spectroscopic data were recorded with a Bruker Avance-300 or -400 spectrometer. The chemical shifts are reported in ppm (δ) relative to $CDCl_3$ (^1H NMR, 7.26 ppm; ^{13}C NMR, 77.0 ppm).

Representative Procedure for the Arylation of 4-Formylpyrazoles without Decarbonylation: The aryl bromide (1 mmol), 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol), and KOAc (0.196 g, 2 mmol) in the presence of $Pd(OAc)_2$ (4.4 mg, 0.02 mmol) or $PdCl(C_3H_5)(dppb)$ (12.2 mg, 0.02 mmol) (see Tables 1, 2, 3, and 4) were dissolved in DMA (4 mL) under argon. The reaction mixture was stirred in a preheated oil bath at 150 °C for 16 h. After the reaction mixture was cooled to room temperature, the evaporation of the solvent and chromatography on a silica gel column afforded the coupling product.

5-(4-Formylphenyl)-1,3-diphenyl-pyrazole-4-carbaldehyde (2): 4-Bromobenzaldehyde (0.185 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **2** (0.211 g, 60% yield). ^1H NMR (400 MHz, $CDCl_3$): δ = 10.06 (s, 1 H), 9.95 (s, 1 H), 7.90 (d, J = 8.0 Hz, 2 H), 7.87 (d, J = 8.0 Hz, 2 H), 7.54 (d, J = 8.0 Hz, 2 H), 7.52–7.47 (m, 3 H), 7.36–7.25 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 191.4, 185.4, 154.9, 146.2, 138.4, 136.7, 133.8, 131.4, 131.1, 129.6, 129.4, 129.3, 129.2, 128.7, 128.6, 125.5, 118.9 ppm. $C_{23}H_{16}N_2O_2$ (352.39): calcd. C 78.39, H 4.58; found C 78.48, H 4.69.

4-(4-Formyl-2,5-diphenylpyrazol-3-yl)-benzonitrile (3): 4-Bromobenzonitrile (0.182 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **3** (0.314 g, 90% yield). ^1H NMR (400 MHz, $CDCl_3$): δ = 9.88 (s, 1 H), 7.76 (d, J = 8.0 Hz, 2 H), 7.59 (d, J = 8.0 Hz, 2 H), 7.45–7.38 (m, 5 H), 7.32–7.28 (m, 2 H), 7.20–7.15 (m, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.3, 155.2, 144.9, 138.2, 132.6, 132.1, 131.4, 130.9, 129.4, 129.3, 129.2, 128.9, 128.7, 125.5, 118.8, 118.1, 113.5 ppm. $C_{23}H_{15}N_3O$ (349.38): calcd. C 79.07, H 4.33; found C 78.88, H 4.19.

5-(4-Nitrophenyl)-1,3-diphenylpyrazole-4-carbaldehyde (4): 4-Bromonitrobenzene (0.202 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **4** (0.339 g, 92% yield). ^1H NMR (400 MHz, $CDCl_3$): δ = 9.98 (s, 1 H), 8.23 (d, J = 8.2 Hz, 2 H), 7.82 (d, J = 8.0 Hz, 2 H), 7.56 (d, J = 8.0 Hz, 2 H), 7.53–7.48 (m, 3 H), 7.40–7.25 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 155.4, 148.3, 144.4, 138.1, 134.5, 131.7, 130.8, 129.5, 129.4, 129.3, 129.0, 128.7, 125.5, 123.5, 119.0 ppm. $C_{22}H_{15}N_3O_3$ (369.37): calcd. C 71.54, H 4.09; found C 71.41, H 4.35.

5-(4-Acetylphenyl)-1,3-diphenylpyrazole-4-carbaldehyde (5): 4-Bromoacetophenone (0.199 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **5** (0.285 g, 78% yield). ^1H NMR (400 MHz, $CDCl_3$): δ = 9.93 (s, 1 H), 7.97 (d, J = 8.0 Hz, 2 H), 7.88 (d, J = 8.0 Hz, 2 H), 7.52–7.47 (m, 5 H), 7.36–7.25 (m, 5 H), 2.63 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 197.9, 186.0, 155.3, 147.3, 139.1, 138.4, 133.1, 131.8, 131.6, 130.0, 129.9, 129.3, 129.2, 129.0, 126.1, 119.6, 27.3 ppm. $C_{24}H_{18}N_2O_2$ (366.41): calcd. C 78.67, H 4.95; found C 78.80, H 5.11.

Methyl 4-(4-Formyl-2,5-diphenylpyrazol-3-yl)benzoate (6): Methyl 4-bromobenzoate (0.215 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **6** (0.294 g, 77% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.92 (s, 1 H), 8.06 (d, J = 8.2 Hz, 2 H), 7.89 (d, J = 8.0 Hz, 2 H), 7.51–7.40 (m, 5 H), 7.33–7.20 (m, 5 H), 3.94 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.3, 165.3, 153.5, 146.0, 137.4, 131.3, 130.3, 130.2, 129.7, 128.7, 128.3, 128.2, 127.5, 127.4, 124.4, 117.8, 51.4 ppm. $C_{24}H_{18}N_2O_3$ (382.41): calcd. C 75.38, H 4.74; found C 75.24, H 4.61.

5-(4-Chlorophenyl)-1,3-diphenylpyrazole-4-carbaldehyde (7): 4-Bromochlorobenzene (0.191 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **7** (0.243 g, 68% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.91 (s, 1 H), 7.89 (d, J = 8.0 Hz, 2 H), 7.50–7.25 (m, 12 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 154.5, 146.9, 138.5, 136.1, 131.9, 131.2, 129.3, 129.2, 129.1, 128.9, 128.5, 128.4, 126.2, 125.5, 118.7 ppm. $C_{22}H_{15}ClN_2O$ (358.82): calcd. C 73.64, H 4.21; found C 73.48, H 4.37.

5-(4-Fluorophenyl)-1,3-diphenylpyrazole-4-carbaldehyde (8): 4-Bromofluorobenzene (0.175 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **8** (0.243 g, 71% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.80 (s, 1 H), 7.88 (d, J = 8.0 Hz, 2 H), 7.45–7.17 (m, 12 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.5, 162.9 (d, J = 253.0 Hz), 153.3, 146.3, 137.5, 131.6, 131.5, 130.3, 128.2, 128.1 (d, J = 8.7 Hz), 127.4, 124.4, 122.7 (J = 3.4 Hz), 117.6, 114.8 (J = 21.6 Hz) ppm. $C_{22}H_{15}FN_2O$ (342.37): calcd. C 77.18, H 4.42; found C 77.01, H 4.27.

1,3,5-Triphenylpyrazole-4-carbaldehyde (9):[12] Bromobenzene (0.157 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **9** (0.220 g, 68% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.82 (s, 1 H), 7.82 (d, J = 8.0 Hz, 2 H), 7.45–7.10 (m, 11 H), 7.01 (t, J = 7.8 Hz, 2 H) ppm.

5-(4-Methoxyphenyl)-1,3-diphenylpyrazole-4-carbaldehyde (10): 4-Bromoanisole (0.187 g) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **10** (0.145 g, 41% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.80 (s, 1 H), 7.87 (d, J = 7.8 Hz, 2 H), 7.45–7.20 (m, 10 H), 6.85 (d, J = 7.8 Hz, 2 H), 3.77 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.8, 160.7, 153.9, 149.0, 138.9, 132.0, 131.6, 129.2, 129.1, 129.0, 128.3, 128.1, 125.4, 119.6, 118.5, 114.1, 55.3 ppm. $C_{23}H_{18}N_2O_2$ (354.40): calcd. C 77.95, H 5.12; found C 77.78, H 5.21.

3-(4-Formyl-2,5-diphenylpyrazol-3-yl)-benzonitrile (11): 3-Bromobenzonitrile (0.182 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **11** (0.307 g, 88% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.86 (s, 1 H), 7.75 (d, J = 8.0 Hz, 2 H), 7.61 (d, J = 8.0 Hz, 1 H), 7.56 (s, 1 H), 7.53 (d, J = 8.0 Hz, 1 H), 7.45–7.38 (m, 4 H), 7.32–7.16 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.3, 154.1, 143.5, 137.0, 133.8, 132.9, 132.1, 129.9, 128.5, 128.3 (m, 4 C), 127.9, 127.6, 124.5, 117.8, 116.8, 111.9 ppm. $C_{23}H_{15}N_3O$ (349.38): calcd. C 79.07, H 4.33; found C 78.97, H 4.50.

5-(3-Nitrophenyl)-1,3-diphenylpyrazole-4-carbaldehyde (12): 3-Bromonitrobenzene (0.202 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **12** (0.203 g, 55% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.99 (s, 1 H), 8.28 (d, J = 8.0 Hz, 1 H), 8.24 (s, 1 H), 7.83 (d, J = 8.0 Hz, 2 H), 7.70 (d, J = 8.0 Hz, 1 H), 7.58 (t, J = 8.0 Hz, 1 H), 7.55–7.25 (m, 8 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 155.3, 148.0, 144.1, 138.0, 136.5, 130.8, 129.8, 129.5, 129.4, 129.3, 129.2, 129.0, 128.7, 125.7, 125.6, 124.5, 118.9 ppm. $C_{22}H_{15}N_3O_3$ (369.37): calcd. C 71.54, H 4.09; found C 71.27, H 4.01.

5-(3-Acetylphenyl)-1,3-diphenylpyrazole-4-carbaldehyde (13): 3-Bromoacetophenone (0.199 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **13** (0.282 g, 77% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.94 (s, 1 H), 8.01 (d, J = 8.0 Hz, 1 H), 7.89 (s, 1 H), 7.87 (d, J = 8.0 Hz, 1 H), 7.56 (d, J = 8.0 Hz, 1 H), 7.54–7.30 (m, 10 H), 2.52 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 197.0, 185.4, 154.7, 146.8, 138.4, 137.2, 134.9, 131.2, 130.7, 129.4, 129.3 (2 C), 129.2, 128.9, 128.6, 128.5, 128.4, 125.6, 118.7, 26.6 ppm. $C_{24}H_{18}N_2O_2$ (366.41): calcd. C 78.67, H 4.95; found C 78.54, H 5.17.

5-(3-Formylphenyl)-1,3-diphenylpyrazole-4-carbaldehyde (14): 3-Bromobenzaldehyde (0.185 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **14** (0.260 g, 74% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.98 (s, 1 H), 9.94 (s, 1 H), 7.95 (d, J = 8.0 Hz, 1 H), 7.89–7.87 (m, 2 H), 7.62 (d, J = 8.0 Hz, 1 H), 7.57 (t, J = 8.0 Hz, 1 H), 7.52–7.25 (m, 9 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 191.2, 185.4, 154.8, 146.1, 138.3, 136.5, 136.2, 131.9, 131.1, 130.5, 129.4, 129.3 (m), 129.2, 129.1, 128.7, 128.6, 125.5, 118.8 ppm. $C_{23}H_{16}N_2O_2$ (352.39): calcd. C 78.39, H 4.58; found C 78.27, H 4.39.

5-(3-Chlorophenyl)-1,3-diphenylpyrazole-4-carbaldehyde (15): 3-Bromochlorobenzene (0.191 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **15** (0.325 g, 91% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.90 (s, 1 H), 7.90 (d, J = 8.0 Hz, 2 H), 7.52–7.20 (m, 12 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.3, 154.3, 146.8, 138.4, 134.6, 131.2, 130.6, 130.0, 129.8, 129.6, 129.3, 129.2, 128.8, 128.6, 128.5, 128.4, 125.4, 118.8 ppm. $C_{22}H_{15}ClN_2O$ (358.82): calcd. C 73.64, H 4.21; found C 73.80, H 4.07.

5-[3,5-Bis(trifluoromethylphenyl)]-1,3-diphenylpyrazole-4-carbaldehyde (16): 3,5-Bis(trifluoromethyl)bromobenzene (0.293 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **16** (0.432 g, 94% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.99 (s, 1 H), 7.89 (s, 1 H), 7.81 (s, 2 H), 7.79 (d, J = 8.0 Hz, 2 H), 7.52–7.20 (m, 8 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 155.7, 143.1, 137.8, 131.7 (q, J = 34.0 Hz), 130.9 (m), 130.7, 130.1, 129.5, 129.4, 129.3, 129.2, 128.8, 123.2 (m), 122.5 (q, J = 273.0 Hz), 118.7 ppm. $C_{24}H_{14}F_6N_2O$ (460.37): calcd. C 62.61, H 3.07; found C 62.41, H 3.00.

5-(4-Nitro-3-trifluoromethylphenyl)-1,3-diphenylpyrazole-4-carbaldehyde (17): 4-Bromo-1-nitro-2-trifluoromethylbenzene (0.270 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **17** (0.350 g, 80% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 10.03 (s, 1 H), 7.88 (d, J = 8.0 Hz, 1 H), 7.82–7.75 (m, 4 H), 7.60–7.20 (m, 8 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.8, 156.4, 148.3, 142.3, 138.0, 135.6, 133.2, 130.8 (m), 129.8 (m), 129.2, 128.4, 127.1, 126.6, 126.0, 125.5, 125.3, 125.1, 121.5 (q, J = 274.2 Hz), 119.2 ppm. $C_{23}H_{14}F_3N_3O_3$ (437.37): calcd. C 63.16, H 3.23; found C 63.02, H 3.42.

2-(4-Formyl-2,5-diphenylpyrazol-3-yl)-benzonitrile (18): 2-Bromobenzonitrile (0.182 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **18** (0.202 g, 58% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.99 (s, 1 H), 7.85 (d, J = 8.0 Hz, 2 H), 7.73 (d, J = 8.0 Hz, 1 H), 7.63 (t, J = 8.0 Hz, 1 H), 7.55–7.25 (m, 10 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.3, 155.1, 142.6, 138.2, 133.3, 132.6, 132.4, 131.8, 130.9, 130.1, 129.4, 129.3, 129.2, 128.8, 128.7, 125.4, 119.8, 116.8 ppm. $C_{23}H_{15}N_3O$ (349.38): calcd. C 79.07, H 4.33; found C 78.99, H 4.41.

1,3-Diphenyl-5-pyridin-3-ylpyrazole-4-carbaldehyde (19): 3-Bromopyridine (0.158 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbal-

dehyde (0.372 g, 1.5 mmol) were employed to afford **19** (0.256 g, 79% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.96 (s, 1 H), 8.65 (d, J = 3.2 Hz, 1 H), 8.57 (s, 1 H), 7.86 (d, J = 8.0 Hz, 2 H), 7.75 (d, J = 8.2 Hz, 1 H), 7.55–7.20 (m, 9 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 155.3, 149.5, 149.1, 143.1, 139.3, 138.0, 130.9, 129.5 (m), 129.3, 129.0, 128.7, 125.7, 125.1, 123.6, 119.1 ppm. $C_{21}H_{15}N_3O$ (325.36): calcd. C 77.52, H 4.65; found C 77.38, H 4.48.

1,3-Diphenyl-5-quinolin-3-ylpyrazole-4-carbaldehyde (20): 3-Bromoquinoline (0.208 g), and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **20** (0.311 g, 83% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.93 (s, 1 H), 8.68 (s, 1 H), 8.27 (s, 1 H), 8.07 (d, J = 8.0 Hz, 1 H), 7.84–7.70 (m, 5 H), 7.57 (t, J = 8.0 Hz, 1 H), 7.46–7.40 (m, 4 H), 7.20–7.15 (m, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.4, 155.3, 150.0, 147.3, 143.9, 138.9, 138.2, 131.2, 131.0, 129.5, 129.4, 129.3, 129.1, 128.9, 128.6, 128.3, 127.7, 126.9, 125.6, 121.4, 119.2 ppm. $C_{25}H_{17}N_3O$ (375.42): calcd. C 79.98, H 4.56; found C 80.17, H 4.69.

1,3-Diphenyl-5-pyrimidin-5-ylpyrazole-4-carbaldehyde (21): 5-Bromopyrimidine (0.159 g, 1 mmol) and 1,3-diphenylpyrazole-4-carbaldehyde (0.372 g, 1.5 mmol) were employed to afford **21** (0.196 g, 60% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 10.04 (s, 1 H), 9.22 (s, 1 H), 8.75 (s, 2 H), 7.79 (d, J = 8.0 Hz, 2 H), 7.55–7.20 (m, 8 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.5, 157.7, 156.7, 155.0, 138.5, 136.7, 129.6, 128.7, 128.5, 128.4, 128.3, 127.8, 124.8, 118.2 ppm. $C_{20}H_{14}N_4O$ (326.35): calcd. C 73.61, H 4.32; found C 73.40, H 4.19.

5-(4-Chlorophenyl)-3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (23): 4-Bromochlorobenzene (0.191 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **23** (0.367 g, 91% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.82 (s, 1 H), 8.32 (d, J = 8.5 Hz, 2 H), 8.21 (d, J = 8.5 Hz, 2 H), 7.45–7.25 (m, 9 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.8, 151.0, 149.3, 148.1, 138.1, 137.8, 136.7, 131.9, 130.1, 129.4, 129.3, 128.9, 125.5, 125.3, 123.5, 119.2 ppm. $C_{22}H_{14}ClN_3O_3$ (403.82): calcd. C 65.43, H 3.49; found C 65.59, H 3.28.

5-(4-Fluorophenyl)-3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (24): 4-Bromofluorobenzene (0.175 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **24** (0.306 g, 79% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.82 (s, 1 H), 8.32 (d, J = 8.5 Hz, 2 H), 8.23 (d, J = 8.5 Hz, 2 H), 7.42–7.22 (m, 7 H), 7.14 (t, J = 8.0 Hz, 2 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.6, 163.8 (d, J = 252.7 Hz), 150.3, 149.3, 147.8, 137.8, 137.5, 132.3 (d, J = 8.7 Hz), 129.7, 129.0, 128.5, 125.0, 123.2, 122.7, 118.8, 116.0 (d, J = 21.6 Hz) ppm. $C_{22}H_{14}FN_3O_3$ (387.36): calcd. C 68.21, H 3.64; found C 68.34, H 3.50.

5-(4-Phenyl)-3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (25): Bromobenzene (0.157 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **25** (0.266 g, 72% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.81 (s, 1 H), 8.32 (d, J = 8.5 Hz, 2 H), 8.27 (d, J = 8.5 Hz, 2 H), 7.50–7.25 (m, 10 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.3, 151.1, 150.6, 148.1, 138.4, 138.1, 130.6, 130.3, 130.1, 129.2, 128.9, 128.7, 127.0, 125.3, 123.4, 119.2 ppm. $C_{22}H_{15}N_3O_3$ (369.37): calcd. C 71.54, H 4.09; found C 71.41, H 4.29.

5-[3,5-Bis(trifluoromethylphenyl)]-3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (26): 3,5-Bis(trifluoromethyl)bromobenzene (0.293 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **26** (0.470 g, 93% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.90 (s, 1 H), 8.32 (d, J = 8.5 Hz, 2 H), 8.09 (d, J = 8.5 Hz, 2 H), 7.94 (s, 1 H), 7.79 (s, 2 H), 7.44–7.22 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.1, 152.1, 148.3, 145.4, 137.4, 137.2, 132.2 (q, J = 34.1 Hz), 130.8 (m), 130.1, 129.6, 129.5, 129.4, 125.6, 123.7, 122.5 (q, J = 273.5 Hz), 119.3 ppm. $C_{24}H_{13}F_6N_3O_3$ (505.37): calcd. C 57.04, H 2.59; found C 56.88, H 2.60.

3-(4-Nitrophenyl)-1-phenyl-5-pyridin-3-ylpyrazole-4-carbaldehyde (27): 3-Bromopyridine (0.158 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **27** (0.229 g, 62% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.87 (s, 1 H), 8.74 (br. s, 1 H), 8.63 (br. s, 1 H), 8.34 (d, J = 8.5 Hz, 2 H), 8.19 (d, J = 8.5 Hz, 2 H), 7.72 (d, J = 8.0 Hz, 1 H), 7.48–7.25 (m, 6 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 183.4, 150.5, 149.7, 149.4, 147.2, 145.3, 137.1, 136.8, 136.5, 129.1, 128.5, 128.2, 124.5, 122.6, 118.6 ppm. $C_{21}H_{14}N_4O_3$ (370.36): calcd. C 68.10, H 3.81; found C 68.24, H 3.60.

3-(4-Nitrophenyl)-1-phenyl-5-pyrimidin-5-ylpyrazole-4-carbaldehyde (28): 5-Bromopyrimidine (0.159 g, 1 mmol) and 3-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (0.439 g, 1.5 mmol) were employed to afford **28** (0.245 g, 66% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.98 (s, 1 H), 9.27 (s, 1 H), 8.75 (s, 2 H), 8.37 (d, J = 8.5 Hz, 2 H), 8.09 (d, J = 8.5 Hz, 2 H), 7.48–7.25 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.0, 159.1, 157.7, 152.6, 148.4, 141.6, 137.4, 137.1, 130.1, 129.8, 129.7, 125.7, 123.9, 122.7, 119.7 ppm. $C_{20}H_{13}N_5O_3$ (371.35): calcd. C 64.69, H 3.53; found C 64.79, H 3.41.

4-[5-(4-Chlorophenyl)-4-formyl-2-phenylpyrazol-3-yl]-benzonitrile (30): 4-Bromobenzonitrile (0.182 g, 1 mmol) and 3-(4-chlorophenyl)-1-phenylpyrazole-4-carbaldehyde (0.423 g, 1.5 mmol) were employed to afford **30** (0.337 g, 88% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.88 (s, 1 H), 7.84 (d, J = 8.0 Hz, 2 H), 7.69 (d, J = 8.0 Hz, 2 H), 7.47 (d, J = 8.0 Hz, 4 H), 7.40–7.25 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.8, 153.5, 145.9, 138.0, 135.6, 132.3, 132.2, 131.3, 130.5, 129.5, 129.4, 129.0, 128.8, 125.4, 118.9, 117.9, 113.8 ppm. $C_{23}H_{14}ClN$ 3.77.

5-[3,5-Bis(trifluoromethylphenyl)]-3-(4-chlorophenyl)-1-phenylpyrazole-4-carbaldehyde (31): 3,5-Bis(trifluoromethyl)bromobenzene (0.293 g, 1 mmol) and 3-(4-chlorophenyl)-1-phenylpyrazole-4-carbaldehyde (0.423 g, 1.5 mmol) were employed to afford **31** (0.425 g, 86% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.88 (s, 1 H), 7.85 (s, 1 H), 7.74 (s, 2 H), 7.72 (d, J = 8.0 Hz, 2 H), 7.42 (d, J = 8.0 Hz, 2 H), 7.35–7.15 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.7, 154.0, 144.0, 137.7, 135.7, 131.9 (q, J = 34.0 Hz), 130.9 (m), 130.6, 129.9, 129.5, 129.3, 129.2, 129.0, 125.6, 123.4 (m), 123.0 (q, J = 273.0 Hz), 118.8 ppm. $C_{24}H_{13}ClF_6N_2O$ (494.82): calcd. C 58.26, H 2.65; found C 58.04, H 2.84.

5-(4-Chlorophenyl)-3-(4-methoxyphenyl)-1-phenylpyrazole-4-carbaldehyde (33): 4-Bromochlorobenzene (0.191 g, 1 mmol) and 3-(4-methoxyphenyl)-1-phenylpyrazole-4-carbaldehyde (0.417 g, 1.5 mmol) were employed to afford **33** (0.136 g, 35% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.87 (s, 1 H), 7.86 (d, J = 8.5 Hz, 2 H), 7.40–7.22 (m, 9 H), 7.01 (d, J = 8.5 Hz, 2 H), 3.87 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.5, 160.5, 154.1, 147.2, 138.5, 136.1, 131.9, 130.6, 129.2, 128.9, 128.4, 126.3, 125.4, 123.7, 118.6, 113.9, 55.3 ppm. $C_{23}H_{17}ClN_2O_2$ (388.85): calcd. C 71.04, H 4.41; found C 70.88, H 4.19.

5-(4-Fluorophenyl)-3-(4-methoxyphenyl)-1-phenylpyrazole-4-carbaldehyde (34): 4-Bromofluorobenzene (0.175 g, 1 mmol) and 3-(4-methoxyphenyl)-1-phenylpyrazole-4-carbaldehyde (0.417 g,

1.5 mmol) were employed to afford **34** (0.231 g, 62% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.87 (s, 1 H), 7.78 (d, J = 8.5 Hz, 2 H), 7.35–7.22 (m, 7 H), 7.10 (t, J = 8.0 Hz, 2 H), 7.01 (d, J = 8.5 Hz, 2 H), 3.87 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.5, 164.0 (d, J = 252.7 Hz), 159.5, 152.9, 146.6, 137.6, 131.6 (d, J = 8.7 Hz), 129.6, 128.1, 127.3, 124.4, 122.8 (d, J = 3.4 Hz), 122.7, 117.5, 114.8 (d, J = 21.9 Hz), 112.8, 54.3 ppm. $C_{23}H_{17}FN_2O_2$ (372.39): calcd. C 74.18, H 4.60; found C 74.04, H 4.69.

4-(4-Formyl-2-phenylpyrazol-3-yl)-benzonitrile (36): 4-Bromobenzonitrile (0.182 g, 1 mmol) and 1-phenylpyrazole-4-carbaldehyde (0.258 g, 1.5 mmol) were employed to afford **36** (0.227 g, 83% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.81 (s, 1 H), 8.26 (s, 1 H), 7.69 (d, J = 8.2 Hz, 2 H), 7.43 (d, J = 8.2 Hz, 2 H), 7.40–7.33 (m, 3 H), 7.24–7.20 (m, 2 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.3, 144.1, 141.6, 138.1, 132.4, 132.2, 131.0, 129.4, 128.9, 125.3, 122.8, 117.8, 113.8 ppm. $C_{17}H_{11}N_3O$ (273.29): calcd. C 74.71, H 4.06; found C 74.84, H 4.00.

5-[3,5-Bis(trifluoromethylphenyl)]-1-phenylpyrazole-4-carbaldehyde (37): From 3,5-bis(trifluoromethyl)bromobenzene (0.293 g, 1 mmol) and 1-phenylpyrazole-4-carbaldehyde (0.258 g, 1.5 mmol) were employed to afford **37** (0.299 g, 78% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.88 (s, 1 H), 8.28 (s, 1 H), 7.92 (s, 1 H), 7.75 (s, 2 H), 7.44–7.20 (m, 5 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 183.9, 142.5, 142.2, 137.7, 132.2 (q, J = 32.2 Hz), 130.4 (m), 129.8, 129.5, 129.3, 125.5, 123.4 (m), 122.7, 122.6 (q, J = 273.0 Hz) ppm. $C_{18}H_{10}F_6N_2O$ (384.28): calcd. C 56.26, H 2.62; found C 56.07, H 2.85.

3-Methyl-5-(4-nitrophenyl)-1-phenylpyrazole-4-carbaldehyde (39): 4-Bromonitrobenzene (0.202 g, 1 mmol) and 3-methyl-1-phenylpyrazole-4-carbaldehyde (0.279 g, 1.5 mmol) were employed to afford **39** (0.209 g, 68% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.84 (s, 1 H), 8.24 (d, J = 8.2 Hz, 2 H), 7.48 (d, J = 8.2 Hz, 2 H), 7.40–7.33 (m, 3 H), 7.24–7.17 (m, 2 H), 2.64 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 185.0, 152.0, 148.4, 145.3, 138.1, 134.1, 131.4, 129.4, 128.7, 125.3, 123.8, 120.0, 13.3 ppm. $C_{17}H_{13}N_3O_3$ (307.30): calcd. C 66.44, H 4.26; found C 66.21, H 4.52.

5-[3,5-Bis(trifluoromethylphenyl)}-3-methyl-1-phenylpyrazole-4-carbaldehyde (40): 3,5-Bis(trifluoromethyl)bromobenzene (0.293 g, 1 mmol) and 3-methyl-1-phenylpyrazole-4-carbaldehyde (0.279 g, 1.5 mmol) were employed to afford **40** (0.302 g, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.87 (s, 1 H), 7.92 (s, 1 H), 7.72 (s, 1 H), 7.40–7.34 (m, 3 H), 7.26–7.16 (m, 3 H), 2.64 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 184.7, 152.2, 144.1, 137.7, 132.2 (q, J = 32.2 Hz), 130.4 (m), 130.0, 129.4, 129.0, 125.5, 123.6 (m), 122.2 (q, J = 273.0 Hz), 119.8 ppm. $C_{19}H_{12}F_6N_2O$ (398.30): calcd. C 57.29, H 3.04; found C 57.35, H 2.89.

Representative Procedure for Deformylation: The pyrazole derivative (1 mmol) and $Pd(OAc)_2$ (11 mg, 0.05 mmol) were dissolved in xylene (3 mL) in the presence of molecular sieves (4 Å, 300 mg) under argon. The reaction mixture was stirred in a preheated oil bath at 140 °C for 22 h. After cooling the reaction mixture to room temperature, the evaporation of the solvent and chromatography on a silica gel afforded the coupling product.

Methyl 4-(2,5-Diphenylpyrazol-3-yl)benzoate (41): Methyl 4-(4-formyl-2,5-diphenylpyrazol-3-yl)benzoate (**6**, 0.382 g, 1 mmol) was employed to afford **41** (0.269 g, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.98 (d, J = 8.2 Hz, 2 H), 7.92 (d, J = 8.0 Hz, 2 H), 7.45–7.35 (m, 10 H), 6.90 (s, 1 H), 3.92 (s, 3 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 165.5, 151.2, 142.3, 138.9, 133.9, 131.8, 128.7, 128.1, 127.7, 127.6, 127.1, 126.8, 124.8, 124.3, 104.7, 51.2 ppm. $C_{23}H_{18}N_2O_2$ (354.40): calcd. C 77.95, H 5.12; found C 78.09, H 4.98.

1,3,5-Triphenylpyrazole (42):[13] 1,3,5-Triphenylpyrazole-4-carbaldehyde (**9**, 0.324 g, 1 mmol) was employed to afford **42** (0.204 g, 63% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.92 (d, J = 8.5 Hz, 2 H), 7.70 (m, 1 H), 7.52 (m, 1 H), 7.47–7.25 (m, 11 H), 6.83 (s, 1 H) ppm.

3-(2,5-Diphenylpyrazol-3-yl)benzonitrile (43): 3-(4-Formyl-2,5-diphenylpyrazol-3-yl)benzonitrile (**11**, 0.349 g, 1 mmol) was employed to afford **43** (0.289 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.83 (d, J = 8.0 Hz, 2 H), 7.60 (d, J = 8.0 Hz, 1 H), 7.59 (s, 1 H), 7.50–7.30 (m, 10 H), 6.88 (s, 1 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.3, 140.9, 138.5, 131.8, 131.5, 130.9, 130.7, 128.4, 128.2, 127.7, 127.3, 127.1, 124.8, 124.3, 117.1, 111.9, 104.8 ppm. $C_{22}H_{15}N_3$ (321.37): calcd. C 82.22, H 4.70; found C 82.34, H 4.81.

Supporting Information (see footnote on the first page of this article): Copies of the ^{1}H and ^{13}C NMR spectra of new compounds.

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