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Graphical Abstract

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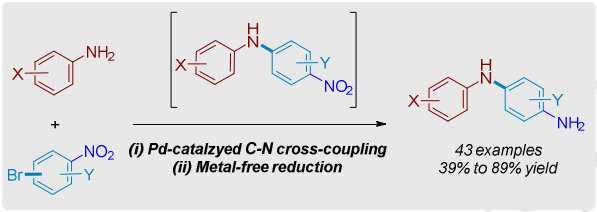

A study of the synthesis of amino-di(hetero)arylamines has been reported. The molecular structures can be constructed via a one-pot Buchwald–Hartwig C–N cross-coupling and nitro reduction sequence, from (hetero)arylamines and halogenated nitrobenzenes.

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One-Pot Propagation of (Hetero)Arylamines: Modular Synthesis of Diverse Amino-di(hetero)arylamines

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ABSTRACT

Formal propagation of (hetero)arylamine is achieved via a one-pot Buchwald–Hartwig C–N cross-coupling and nitro reduction sequence, enabling a rapid modular synthesis of diverse amino-di(hetero)arylamines from (hetero)arylamines and halogenated nitrobenzenes. Various functionalized aromatic amines with different electronic and steric environments can be efficiently prolongated to formally incorporate another arylamino fragments. This approach has been successfully applied in the synthesis of more than forty amino-di(hetero)arylamines. The applicability of this method has also been demonstrated in the synthesis of oligoanilines and the tyrosine-kinase inhibitor Imatinib.

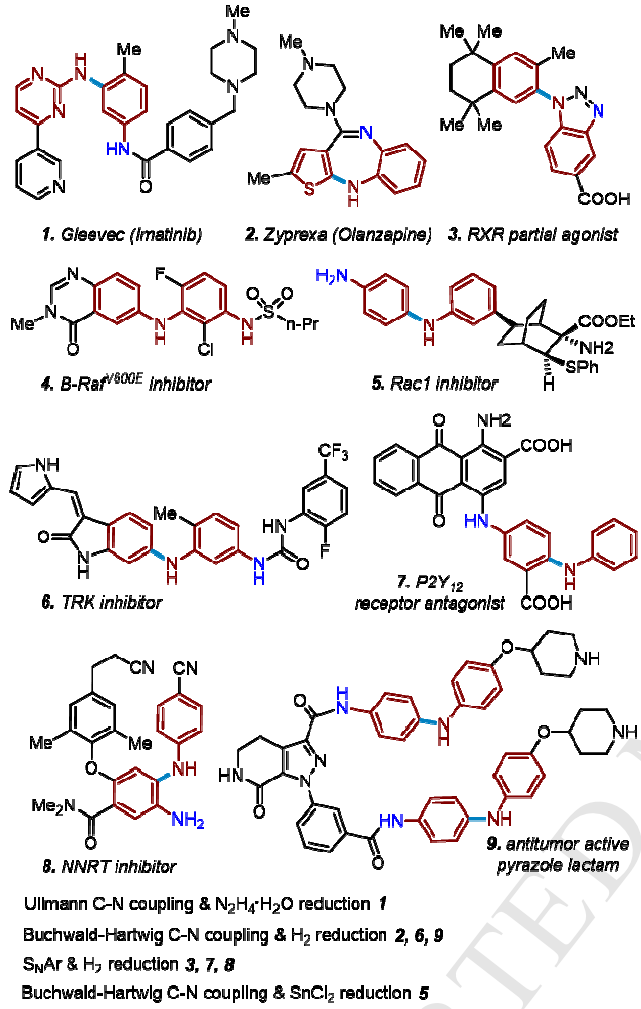
1. Introduction

The arylamine motif is present in a myriad of molecules that find wide-ranging application in chemical, pharmaceutical and material industries. In particular, compounds containing amino-di(hetero)arylamine skeletons are commonly encountered as synthetical intermediates, pharmaceuticals and organic materials.

For example, the top-selling drugs Gleevec (imatinib)[1] and Zyprexa (olanzapine)[2] contain meta- and ortho-amino-heteroarylphenylamine skeleton separately (**Scheme 1**). In addition, such skeleton represents the principle architecture of various biological active molecules and drug candidates with various potential therapeutic applications, such as RXR partial agonist **3** (a new type of target for the treatment of type II diabetes),[3] B-RafV600E inhibitor **4** (tumour growth inhibitor),[4] Rac1 inhibitor **5**,[5] TRK inhibitor **6**,[6] potent $P2Y_{12}$ receptor antagonist **7**,[7] anti-HIV-1 active NNRT inhibitor **8** [8] and anticancer active **9**.[9] Moreover, amino-di(hetero)arylamines, especially the ortho-amino-di(hetero)arylamines, function prevalently as synthetical precursors of nitrogen-containing cycles,[10] as exemplified in the synthesis of olanzapine **2** [2] and RXR partial agonist **3**.[3] In the field of materials science, polyaniline, which has been one of the most extensively studied conducting polymers,[11] formally consists of repetitive amino-diphenylamine structure units. Polyanilines and oligoanilines have been widely applied in many areas, such as organic semiconductors, electronic chemical sensors, electromechanical actuator, supercapacitors, and so on.[12]

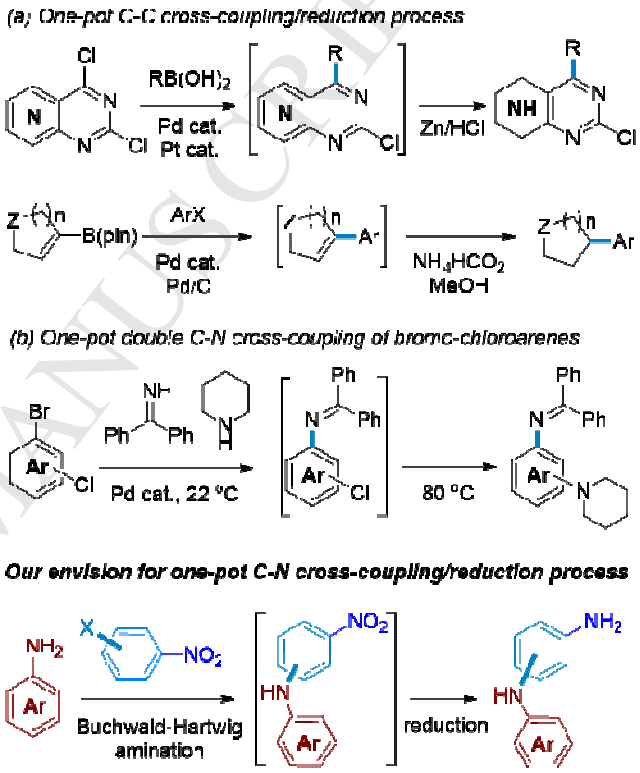
The most common strategy to construct amino-di(hetero)arylamine skeletons involves an amination-reduction synthetical sequence. Firstly, amination of nitro-haloarenes (commonly nitro-fluoroarenes) is realized via a noncatalytic nucleophilic aromatic substitution (S_NAr) process. Then, Pd/C-catalyzed reduction of nitro groups with H_2 affords target structures. The practicality of such process is restricted, since the execution of S_NAr reactions usually depends heavily on the electronic property of the aromatic nucleus and harsh reaction conditions, which result in limited substrate scope and poor functional group tolerance. Therefore, Buchwald–Hartwig and Ullmann C–N cross-coupling reactions are increasingly adopted to realize amination of nitro-haloarenes, especially in the synthesis of bioactive compounds.[13] Furthermore, Pd/C is able to reduce many types of multiple bonds and aromatic (hetero)cycles, which may bring about chemoselectivity problems. In the meantime, the use of inflammable hydrogen gas and sometimes special high-pressure equipment also complicates the synthesis of target skeletons. As indicated in **Scheme 1**, although some alternatives to H_2 reduction step exist, hazardous reagents such as $N_2H_4 \cdot H_2O$ and $SnCl_2$ should

be used.[14] Such drawbacks reinforce the need for a change of synthetical strategy. A new practical and efficient synthetical methodology should be valuable supplements to the existing ones.



Scheme 1. Drugs and biologically active molecules containing amino-di(hetero)arylamines structures and their construction methods. Nitrogen atoms of blue derive from reduction of nitro groups. Bold bonds of green represent the amination position.

Besides the problems that await to be addressed in a single amination or reduction step, merging these two separate reactions into one-pot conversion also deserves endeavours. In fact, the development and application of one-pot multistep reactions have been persistently pursued to bypass the intermediate isolation and purification steps, and therefore to enhance the efficiency and economics of chemical synthesis.[15] Despite such advantages, the challenge to realize such reactions is also apparent. Generally, a set of reaction conditions are elaborately screened to satisfy a specific transformation, which is usually invalid and even detrimental to other types of reactions. When two or more sets of reactants and reaction parameters for single-step reactions are fused within the same vessel, it is hard to avoid reagent incompatibility and maintain the desired chemoselectivity. To solve this problem, sequential multistep reactions, which are regulated by materials adding order or reaction temperature, should be helpful. For examples, recently, Watson group has developed two one-pot Suzuki−Miyaura cross-coupling/reduction strategies, providing rapid access to bicyclic amino-azaheterocycles[16] and formal C(sp^2)−C(sp^3) coupling products[17] separately (**Scheme 2a**). In some cases of such transformations, the reductants of the second step were added or released to the reaction mixtures after the completion of the first step. More recently, a chemoselective one-pot double Buchwald–Hartwig amination of bromo-chloro(hetero)arenes process was developed to construct amino-aniline structures, whose reactive sequence was regulated by the cooperation of reaction temperature and active catalysts (**Scheme 2b**).[18]



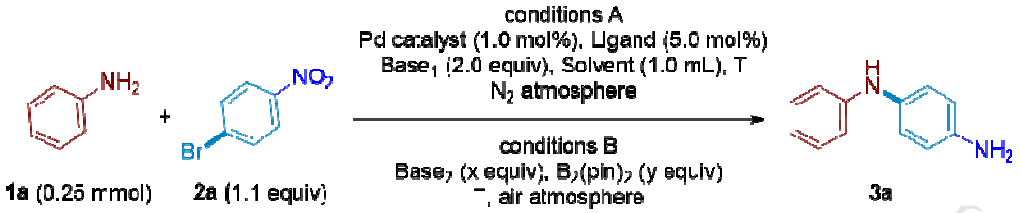
Scheme 2. (a) Sequential one-pot C−C cross-coupling/reduction reactions; (b) Sequential one-pot double C−N cross-coupling reactions.

With these issues in mind, together with our continuing effort to explore valuable and chemoselective reduction methods,[19] we aimed to realize an easily-handled one-pot amination/reduction sequence and enable the step-economic synthesis of amino-di(hetero)arylamines, which we demonstrate herein.

2. Results and Discussion

Initially, Buchwald–Hartwig C–N cross-coupling reactions using dialkylbiaryl phosphine ligands are chosen to realize the amination process due to their relatively mild reaction conditions and better functional group compatibility, compared with traditional S_NAr reactions. And then we started to locate a nitro reduction method, which should be economic, safe and easy-to-use, to fit in with the amination reactions.[20] Recently, Wu and co-workers disclosed a metal-free protocol for reduction of aromatic nitro compounds to the corresponding amines.[21] Bis(pinacolato)diboron (B_2pin_2), a

Table 1. Reaction development and optimization.

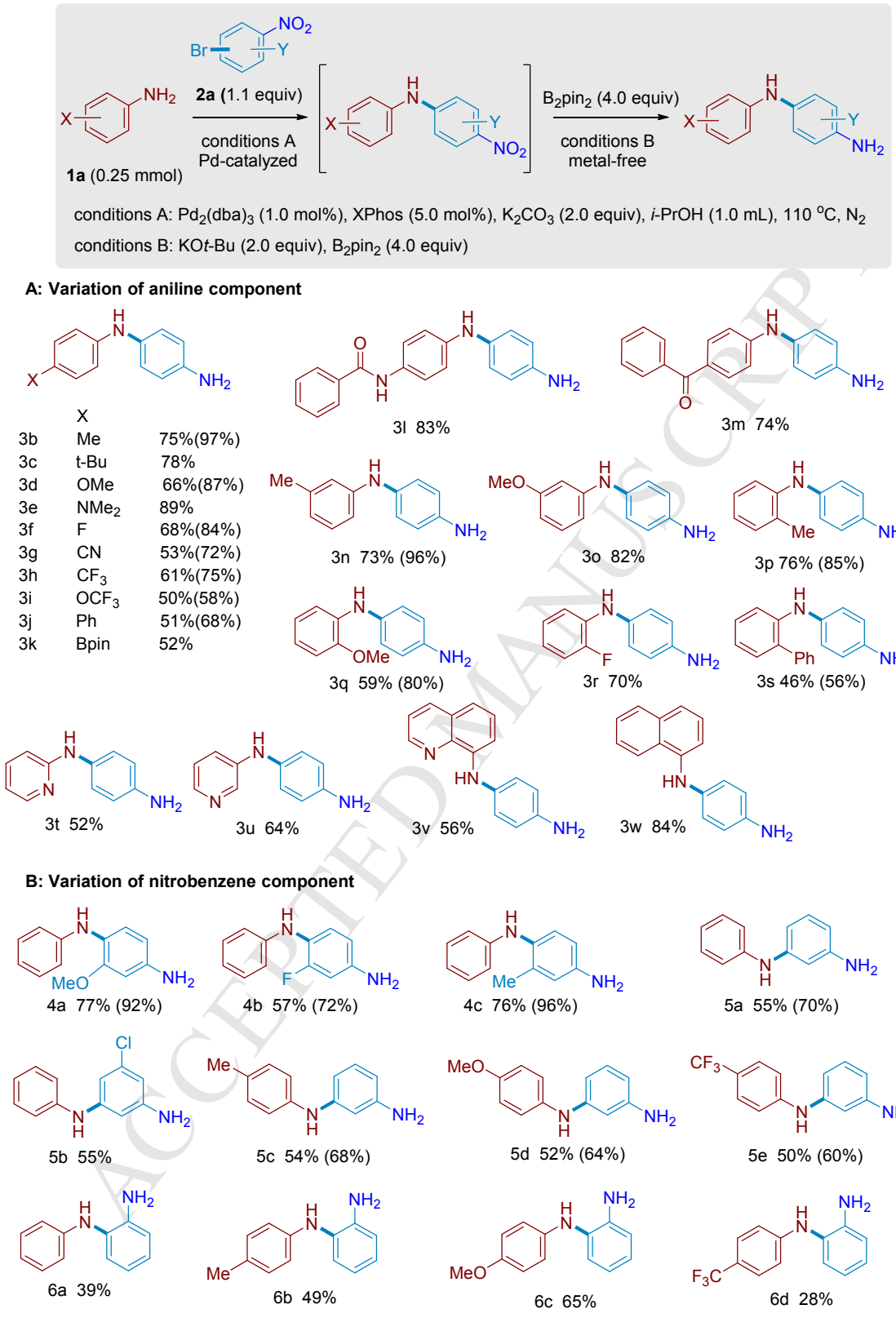


Entry	conditions A					conditions B		Yield [a]
	Pd catalyst	Ligand	Base1	Solvent	T1 °C	$Base_2$ (x eq.)	$B_2(pin)_2$ (y eq.)	
1.	$Pd_2(dba)_3$	XPhos	KO*t*-Bu	*i*-PrOH	110	-	$B_2(pin)_2$ (4.0 eq.)	24
2.	$Pd_2(dba)_3$	XPhos	NaO*t*-Bu	*i*-PrOH	110	-	$B_2(pin)_2$ (4.0 eq.)	44
3.	$Pd_2(dba)_3$	XPhos	Cs_2CO_3	*i*-PrOH	110	-	$B_2(pin)_2$ (4.0 eq.)	66
4.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	110	-	$B_2(pin)_2$ (4.0 eq.)	76
5.	$Pd_2(dba)_3$	XPhos	TEA	*i*-PrOH	110	-	$B_2(pin)_2$ (4.0 eq.)	N.R.
6.	$Pd_2(dba)_3$	XPhos	K_2CO_3	MeOH	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	69
7.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	85
8.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*t*-BuOH	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	72
9.	$Pd_2(dba)_3$	XPhos	K_2CO_3	Dioxane	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	12
10.	$Pd_2(dba)_3$	XPhos	K_2CO_3	MeCN	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	13
11.	$Pd_2(dba)_3$	XPhos	K_2CO_3	THF	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	10
12.	$Pd_2(dba)_3$	XPhos	K_2CO_3	toluene	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	12
13.	$Pd_2(dba)_3$	XPhos	K_2CO_3	H_2O	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	Trace
14.	$Pd_2(dba)_3$	XPhos	K_2CO_3	DMSO	80	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	N.R.
15.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	30	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	N.R.
16.	$Pd_2(dba)_3$	XPhos	K2CO3	*i*-PrOH	50	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	43
17.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	100	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	92
18.	**$Pd_2(dba)_3$**	**XPhos**	**K_2CO_3**	***i*-PrOH**	**110**	**KO*t*-Bu (2.0)**	**$B_2(pin)_2$ (4.0 eq.)**	**98 (75) [b]**
19.	$Pd(OAc)_2$	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	92
20.	$Pd(acac)_2$	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	85
21.	$Pd(PPh_3)_4$	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	64
22.	-	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	N.R.
23.	$Pd_2(dba)_3$	SPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	87
24.	$Pd_2(dba)_3$	PPh_3	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	Trace
25.	$Pd_2(dba)_3$	-	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (4.0 eq.)	N.R.
26.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (2.0)	$B_2(pin)_2$ (3.5 eq.)	69
27.	$Pd_2(dba)_3$	XPhos	K_2CO_3	*i*-PrOH	110	KO*t*-Bu (1.5)	$B_2(pin)_2$ (4.0 eq.)	82

[a] NMR yield. [b] Isolated yield in parentheses.

nontoxic commercially available and shelf-stable borylating reagent,[22] was utilized as chemoselective reductant in the presence of KO*t*-Bu and isopropanol solvent. This metal-free method became our prior option, in view that tert-butoxy alkalis serve as one of the most versatile bases and alcoholic solvent is one of the most common solvents for Pd-catalyzed C–N cross-coupling reactions with dialkylbiaryl phosphine ligands. Such consistence might reduce the compatibility issues.

To examine the above hypothesis, various reaction conditions were screened for the propagation of aniline (**1a**) with 1.1 equivalent amount of 1-bromo-4-nitrobenzene (**2a**). Initially, Pd-catalyzed C–N cross-coupling reactions with XPhos and several bases were in situ followed by simple addition of B_2pin_2 (**Table 1**, Entries 1-5). The results revealed the significant impact of amination conditions on the extent of reduction. The target product could be obtained in 24% yield when KO*t*-Bu used (Entry 1). Then, the yield could be improved to 76% by employing K_2CO_3 (Entry 4), while organic base TEA was ineffective (Entry 5). As mentioned above, KO*t*-Bu worked well in the reduction of nitro groups, so the inefficiency of KO*t*-Bu in the whole transformation indicated its unsuitability towards the amination step, suggesting a separate addition of KO*t*-Bu in the second step. Such plan was then verified in different



Scheme 3. Substrate scope of the one-pot transformation.

solvents at 80 °C (Entries 6-14). In *i*-PrOH, the additional use of KOt-Bu resulted in increased yield to 85% (Entry 7). The screening of solvents also revealed the obvious advantage of alcoholic solvents relative to other polar and nonpolar solvents. The yield of the target product, which had a positive correlation with reaction temperature (Entries 7, 15-18), could be further increased to 98% by enhancing the reaction temperature to 110 °C (Entry 18).

Further variation of the reaction conditions in Entry 18 led to low reactivity and even no reaction (Entries 19-30). The omission of palladium catalyst (Entry 22) or dialkylbiaryl phosphine ligand (Entries 24, 25) was fatal to this transformation, while other palladium source and bulky, monoligated ligand were detrimental (Entries 19-21, 23). Obviously decreased yields were observed in attempts to reduce the dosage of KO*t*-Bu or B_2pin_2 (Entries 26, 27).

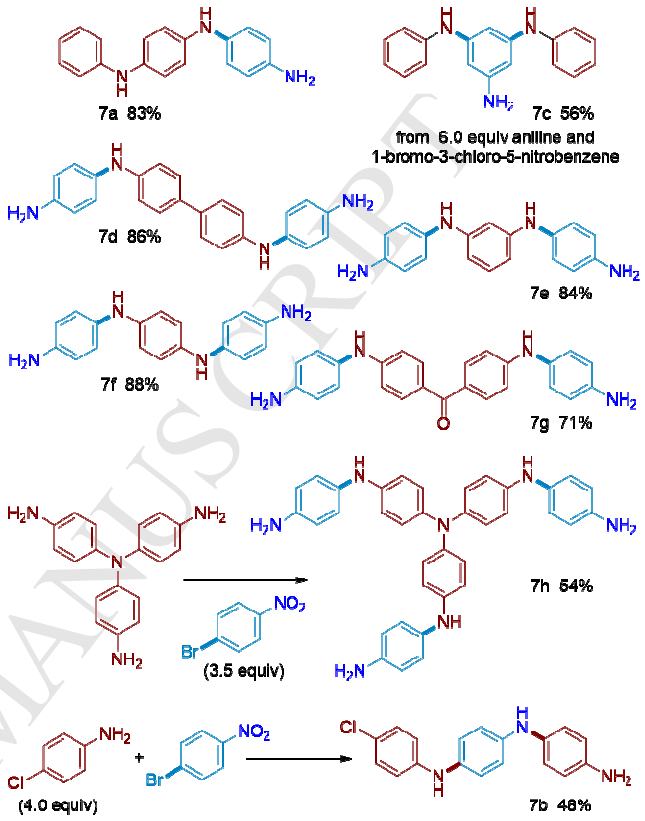
The identified optimal conditions for the one-pot sequential coupling/reduction process (**Table 1**, Entry 18) were then applied to various starting materials to explore its substrate scope. Isolated overall yields of pure target products were reported here. In some cases, NMR yields were included in parentheses. The disparity between these two yields was derived from the loss during purification, when B_2pin_2 was hard to separate from the reaction mixtures.

Under standard conditions, a variety of para-substituted anilines were converted to their formally propagated amino-diarylamines derivatives (**Scheme 3A**). Moderate to excellent isolated overall yields from 50% (**3i**) to 89% (**3e**) could be obtained for these transformations. The reaction tolerated a broad range of electronically distinct functional groups on aniline component, such as 4-NMe_2, 4-OMe, 4-Me, 4-Ph, 4-F, 4-CF_3, and 4-CN substitution. In addition, chemoselective reduction towards nitro groups could be observed amide (**3l**) and ketone (**3m**) moieties remained unscathed, which might suffer from reduction of double bonds under metal-catalyzed reduction conditions using H_2. An example of 4-Bpin substituted aniline propagation to **3k** in 52% yield is also provided. After the one-pot sequential transformation, the valuable boronic ester moiety remained intact in the product, thus allowing for subsequent functionalization to access even more complex products.

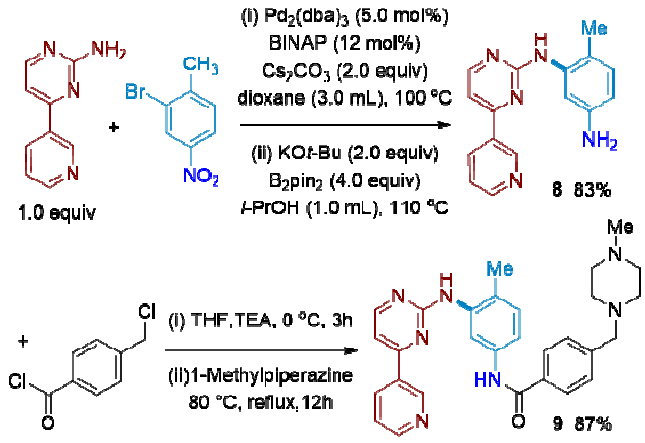
With respect to the steric effects, further variation of the aniline component revealed 2- and 3-substituted anilines also participated well in the reaction (**3n-3s**). The obtained yields were generally equal to those of 4-substituted anilines containing the same functional groups. Heterocyclic aromatic amines (**3t**, **3u**, **3v**), which are attractive scaffolds from a medicinal chemistry perspective, and naphthylamine (**3w**) were also tolerated and afforded the target products in 52-84% yields. The retention of heterocyclic core in quinoline derivative **3v**, which might be reduced under metal-catalyzed reduction conditions using H_2, also verified the chemoselectivity of the method.

Then, variation of the nitrobenzene component was tested (**Scheme 3B**). 4-Br-nitrobenzenes, with the ortho position of bromide substituted by electron-withdrawing or donating substituents, afforded moderate to good yields of desired products (**4a-4c**), showing insensitivity towards the steric and electronic effects. 3- and 2-Br-nitrobenzenes were also competent starting substrates for this transformation. For bromo-chloro-nitroarene electrophiles, preferential reactivity of Aryl–Br was observed (**5b**), as anticipated.

Following the substrate scope exploration, we sought to further underline the utility of this method. Firstly, a variety of oligoanilines and their analogs, which have been applied as diverse organic materials, was efficiently accessed via this one-pot process (**Scheme 4**). **3a**, the propagated product of simple aniline, could be further propagated under the same reaction conditions, affording **7a** in 83% yield. When 1-Br-3-Cl-5-nitrobenzene was mixed with much excess aniline, both bromide and chloride underwent amination reactions and further reduction furnished **7c** in 56% yield based on nitrobenzene. Compounds containing two amino groups could couple 1-bromo-4-nitrobenzene twice, and the following in situ reduction of the formed intermediates led to **7d-7g** in good to excellent yields (71%-88%). Tris(4-aminophenyl)amine was also suitable substrate, triple C–N cross-coupling and triple reduction in one-pot process resulted in 54% yield of **7h**. Interestingly, when 1-bromo-4-nitrobenzene reacted with 4.0 equivalent 4-chloroaniline, **7b** was formed in 48% yield, which might derive from further amination between **3f** and 4-chloroaniline.



Scheme 4. The synthesis of oligoanilines and their analogs.



Scheme 5. The synthesis of Gleevec (imatinib).

The practical applicability of such one-pot protocol was further validated by synthesizing compound 8, a synthetical precursor of the tyrosine-kinase inhibitor Imatinib (Gleevec®). Pleasingly, a modified set of reaction conditions tolerated the heterocyclic aromatic amine well, which contained both pyrimidine and pyridine cores. The target product **8** could be

obtained in 83% overall yield. Then a transformation containing double nucleophilic substitution reactions led to imatinib **9** in 87% yield.[23]

3. Conclusions

In conclusion, we have developed a one-pot protocol for propagation of (hetero)arylamines. Diverse amino-di(hetero)arylamines can be obtained via sequential Buchwald–Hartwig amination and B_2pin_2 mediated reduction of nitro groups, without isolation and purification steps. This pot-economic and operation-simple strategy has also been successfully applied in the synthesis of oligoanilines and imatinib. Further studies in synthesis of other drug like intermediates via this protocol are underway in our laboratory.

4. Experimental Section

General. Unless otherwise noted, Buchwald–Hartwig amination reactions were carried out under an atmosphere of nitrogen, the following reduction reactions were performed under air. Flash column chromatography was performed using silica gel (200–300 mesh). All the products in this article are compatible with standard silica gel chromatography. Analytical thin-layer chromatography was performed using glass plates pre-coated with 0.25 mm 230-400 mesh silica gel impregnated with a fluorescent indicator (254 nm). ^{1}H NMR (400 MHz) and ^{13}C NMR (101 MHz) spectra were recorded with Bruker Ascend 400 spectrometer and chemical shifts (δ) are reported in ppm. NMR spectra were referenced internally to corresponding solvent resonance. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad. Infrared spectra were collected on a Thermo Fisher Nicolet 6700 FT-IR spectrometer using ATR (Attenuated Total Reflectance) method. Absorption maxima (ν max) are reported in wavenumbers (cm^{-1}). High resolution mass spectra (HRMS) were acquired on Thermo Scientific LTQ Orbitrap XL with an ESI source. Commercial reagents and solvent were purchased and used as received unless otherwise stated.

General procedure A

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 1-bromo-4-nitrobenzene (0.275 mmol, 1.1 eq.), $Pd_2(dba)_3$ (2.3 mg, 0.0025 mmol, 1 mol%), XPhos (5.9 mg, 0.0125 mmol, 5 mol%), K_2CO_3 (69.1 mg, 0.5 mmol, 2.0 eq.) and arylamines (0.25 mmol, 1.0 eq., if solid). After evacuation and refill with dry nitrogen for three times, arylamines (0.25 mmol, 1.0 eq., if liquid) and *i*PrOH (1.0 mL) were added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 ºC for 24 h. Then, B_2pin_2 (1.0 mmol, 4.0 eq.) and KO*t*-Bu (0.5 mmol, 2.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 4 h. After cooling to room temperature, the crude production was diluted with ethyl acetate and then washed with saturated NaCl solution. The organic layers dried over anhydrous Na_2SO_4, concentrated in vacuo, and purified by flash column chromatograph to give the pure products.

Preparation and Characterization Data for Isolated Products

4.1. N^1-phenylbenzene-1,4-diamine (3a)

Follow general procedure A, using aniline **1a** (23.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3a** was obtained as gray solid (34.5 mg, isolated yield 75%); Melting point (°C): 69.0-75.0; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 (dd, *J* = 8.8, 7.6 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 6.88 – 6.82 (m, 2H), 6.78 (t, *J* = 7.2 Hz, 1H), 6.67 (d, *J* = 8.8 Hz, 2H), 5.41 (s, 1H), 3.54 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.92, 142.15, 133.85, 129.28, 123.36, 119.02, 116.16, 115.10; HRMS (ESI) m/z calcd for $C_{12}H_{13}N_2^+$ $(M+H)^+$ 185.10732, found 185.10771; IR (cm^{-1}): 3458, 3370, 2361, 2343, 1594, 1507, 1281, 812, 744.

4.2. N^1-(p-tolyl)benzene-1,4-diamine (3b)

Follow general procedure A, using p-toluidine **1b** (26.8 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3b** was obtained as purple solid (37.1 mg, isolated yield 75%); Melting point (°C): 106.6-108.5; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.00 (d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 2H), 6.78 (d, *J* = 8.4 Hz, 2H), 6.63 (d, *J* = 8.8 Hz, 2H), 5.29 (s, 1H), 3.49 (s, 2H), 2.25 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.22, 141.60, 134.78, 129.79, 128.68, 122.37, 116.25, 115.91, 20.56; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.12297, found 199.12276; IR (cm^{-1}): 3353, 3027, 2915, 1504, 1306, 810.

4.3. N^1-(4-(tert-butyl)phenyl)benzene-1,4-diamine (3c)

Follow general procedure A, using 4-tert-butylaniline **1c** (39.8 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **3c** was obtained as brown liquid (46.8 mg, isolated yield 78%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, *J* = 8.4 Hz, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 6.81 (d, *J* = 8.8 Hz, 2H), 6.64 (d, *J* = 8.4 Hz, 2H), 5.12 (s, 1H), 3.46 (s, 2H), 1.28 (s, 9H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 144.48, 143.81, 139.88, 132.84, 125.97, 122.26, 115.27, 114.24, 34.01, 31.90; HRMS (ESI) m/z calcd for $C_{16}H_{21}N_2^+$ $(M+H)^+$ 241.16993, found 241.16945; IR (cm^{-1}): 3417, 2361, 2342, 1621, 1312, 822.

4.4. N^1-(4-methoxyphenyl)benzene-1,4-diamine (3d)

Follow general procedure A, using 4-methoxyaniline **1d** (31.1 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3d** was obtained as brown solid (35.3mg, isolated yield 66%); Melting point (°C): 99.0-102.8; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.78 (d, *J* = 8.8 Hz, 2H), 6.65 (d, *J* = 8.4 Hz, 2H), 5.35 (s, 1H), 3.54 (s, 2H), 2.41 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.78, 140.91, 138.83, 136.04, 120.89, 118.57, 116.33, 114.72, 55.70; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.11789, found 215.11728; IR(cm^{-1}): 3381, 2918, 1590, 1485, 1302, 1218, 811.

4.5. N^1-(4-aminophenyl)-N^4,N^4-dimethylbenzene-1,4-diamine (3e)

Follow general procedure A, using n,n-dimethyl-p-phenylenediamine **1e** (34.0 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using ethyl acetate: petroleum ether = 2 : 1. **3e** was obtained as black solid (50.6 mg, isolated yield 89%); Melting point (°C): 74.3-76.8; ^{1}H NMR (400 MHz, DMSO-d_6) δ 6.95 (s, 1H), 6.77 (d, *J* = 9.2 Hz, 2H), 6.71 (d, *J* = 8.4Hz, 2H), 6.64 (d, *J* = 9.2 Hz, 2H), 6.48 (d, *J* = 8.4Hz, 2H), 4.54 (s, 2H), 2.75 (s, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 144.77, 142.50, 137.45, 135.01, 119.87, 117.64, 115.42, 115.07, 41.83; HRMS (ESI) m/z calcd for $C_{14}H_{18}N_3^+$ $(M+H)^+$ 228.14952, found 228.14980; IR (cm^{-1}): 3377, 2926, 2360, 2342, 1559, 1237, 851, 688.

4.6. N^1-(4-fluorophenyl)benzene-1,4-diamine (3f)

Follow general procedure A, using 4-fluoroaniline **1f** (28.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash

chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **3f** was obtained as brown solid (34.4 mg, isolated yield 68%); Melting point (^{o}C): 66.3-68.0; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.93 – 6.86 (m, 4H), 6.82 – 6.77 (m, 2H), 6.67 – 6.62 (m, 2H), 5.28 (s, 1H), 3.53 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.83 (d, *J* = 236 Hz), 141.96 (d, *J* = 2 Hz), 141.90, 134.62, 122.50, 116.96 (d, *J* = 7 Hz), 116.27, 115.73 (d, *J* = 22 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -125.30; HRMS (ESI) m/z calcd for $C_{12}H_{12}FN_2^+$ $(M+H)^+$ 203.09790, found 203.09776; IR (cm^{-1}): 3377, 3022, 2360, 2342, 1582, 1054, 821.

4.7. 4-((4-aminophenyl)amino)benzonitrile (3g)

Follow general procedure A, using 4-ethenylbenzenamine **1g** (29.3 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3g** was obtained as white solid (27.7 mg, isolated yield 53%); Melting point (^{o}C): 164.2-166.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (d, *J* = 8.8 Hz, 2H), 6.99 (d, *J* = 8.8 Hz, 2H), 6.77 – 6.66 (m, 4H), 5.86 (s, 1H), 3.72 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 150.25, 144.20, 133.72, 130.46, 125.75, 120.36, 116.02, 113.49, 99.76; HRMS (ESI) m/z calcd for $C_{13}H_{12}N_3^+$ $(M+H)^+$ 210.10257, found 210.10287; IR (cm^{-1}): 3358, 2361, 2342, 2211, 1596, 1507, 1289, 1173, 815.

4.8. N^1-(4-(trifluoromethyl)phenyl)benzene-1,4-diamine (3h)

Follow general procedure A, using 4-(trifluoromethyl)aniline **1h** (31.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3h** was obtained as yellow solid (38.5 mg, isolated yield 61%); Melting point (^{o}C): 74.2-75.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 8.4 Hz, 2H), 6.78 (d, *J* = 8.4 Hz, 2H), 6.68 (d, *J* = 8.8 Hz, 2H), 5.65 (s, 1H), 3.53 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 149.23, 143.48, 131.75, 126.62 (q, *J* = 4 Hz), 124.87 (q, *J* = 269 Hz), 125.11, 119.95 (q, *J* = 33 Hz), 116.09, 113.40; ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.10; HRMS (ESI) m/z calcd for $C_{13}H_{12}F_3N_2^+$ $(M+H)^+$ 253.09471, found 253.09496; IR (cm^{-1}): 3397, 3036, 2362, 2341, 1606, 1507, 1314, 1154, 1059, 823.

4.9. N^1-(4-(trifluoromethoxy)phenyl)benzene-1,4-diamine (3i)

Follow general procedure A, using 4-(trifluoromethoxy)aniline **1i** (41.1 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **3i** was obtained as brown liquid (33.5 mg, isolated yield 50%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.01 (d, *J* = 8.8 Hz, 2H), 6.94 (d, *J* = 8.4 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.66 (d, *J* = 8.4 Hz, 2H), 5.43 (s, 1H), 3.48 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.01, 142.68, 141.39, 133.20, 123.93, 122.35, 120.70 (q, *J* = 254 Hz), 116.18, 115.23; ^{19}F NMR (376 MHz, $CDCl_3$) δ -58.37; HRMS (ESI) m/z calcd for $C_{13}H_{12}F_3N_2O^+$ $(M+H)^+$ 269.08962, found 269.08926; IR (cm^{-1}): 3385, 2360, 2342, 1876, 1625, 1270, 1049, 823.

4.10. N^1-([1,1'-biphenyl]-4-yl)benzene-1,4-diamine (3j)

Follow general procedure A, using 4-aminobiphenyl **1j** (42.3 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3j** was obtained as white solid (33.2 mg, isolated yield 51%); Melting point (^{o}C): 134.7-136.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, *J* = 7.6 Hz, 2H), 7.46 – 7.34 (m, 4H), 7.26 (d, *J* = 7.2 Hz, 1H), 6.98 (d, *J* = 8.4 Hz, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.65 (d, *J* = 8.4 Hz, 2H), 5.47 (s, 1H), 3.44 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.38, 142.30, 141.12, 133.58, 131.82, 128.72, 127.95, 126.41, 126.29, 123.54, 116.21, 115.23; HRMS (ESI) m/z calcd for $C_{18}H_{17}N_2^+$ $(M+H)^+$ 261.13862, found 261.13879; IR (cm^{-1}): 3255, 2361, 2342, 1457, 767, 691, 668.

4.11. N^1-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)benzene-1,4-diamine (3k)

Follow general procedure A, using 4-aminophenylboronic acid pinacol ester **1k** (54.8 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3k** was obtained as light yellow solid (40.3 mg, isolated yield 52%); Melting point (^{o}C): 130.8-131.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.4 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2 H), 6.78 (d, *J* = 8.0 Hz, 2H), 6.66 (d, *J* = 8.4 Hz, 2H), 5.60 (s, 1H), 3.57 (s, 2H), 1.31 (s, 12H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.01, 142.68, 141.39, 133.20, 123.93, 122.35, 116.18, 115.23; HRMS (ESI) m/z calcd for $C_{18}H_{24}BN_2O_2^+$ $(M+H)^+$ 311.19253, found 311.19296; IR (cm^{-1}): 3394, 3331, 2978, 1599, 1508, 1354, 1139, 1087, 825.

4.12. N-(4-((4-aminophenyl)amino)phenyl)benzamide (3l)

Follow general procedure A, using 4'-aminobenzanilide **1l** (53.1 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 2 : 1. **3l** was obtained as gray solid (62.9 mg, isolated yield 83%); Melting point (^{o}C): 214.6-217.3; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.96 (s, 1H), 7.95 – 7.90 (m, 2H), 7.56 – 7.46 (m, 5H), 7.41 (s, 1H), 6.80 (dd, *J* = 16.4, 8.4Hz, 4H), 6.54 (d, *J* = 8.4Hz, 2H), 4.73 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 165.19, 143.97, 143.41, 135.71, 132.63, 131.64, 129.89, 128.76, 127.93, 122.51, 122.26, 115.26, 114.30; HRMS (ESI) m/z calcd for $C_{19}H_{18}N_3O^+$ $(M+H)^+$ 304.14444, found 304.14462; IR (cm^{-1}): 3206, 3288, 1646, 1545, 1499, 1318, 823, 694.

4.13. ((4-aminophenyl)amino)phenyl)(phenyl)meth anone (3m)

Follow general procedure A, using 4-aminobenzophenone **1m** (49.3 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 1 : 1. **3m** was obtained as yellow solid (53.3 mg, isolated yield 74%); Melting point (^{o}C): 154.9-155.6; ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.33 (s, 1H), 6.57 – 6.48 (m, 5H), 6.43 (t, *J* = 7.6 Hz, 2H), 5.83 (d, *J* = 8.4 Hz, 2H), 5.72 (d, *J* = 8.8 Hz, 2H), 5.52 (d, *J* = 8.8 Hz, 2H), 3.90 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 193.81, 151.90, 146.01, 139.37, 132.96, 131.66, 129.33, 128.70, 125.20, 124.76, 115.05, 112.36; HRMS (ESI) m/z calcd for $C_{19}H_{17}N_2O^+$ $(M+H)^+$ 289.13354, found 289.13373; IR (cm^{-1}): 3390, 2361, 2341, 1715, 1521, 1240, 1128, 689.

4.14. N^1-(m-tolyl)benzene-1,4-diamine (3n)

Follow general procedure A, using 3-methylaniline **1n** (27.0 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3n** was obtained as brown liquid (36.1 mg, isolated yield 73%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.01 (d, *J* = 8.4 Hz, 2H), 6.96 (dd, *J* = 7.6, 1.6 Hz, 1H), 6.88 – 6.77 (m, 2H), 6.73 (td, *J* = 7.6, 1.6 Hz, 1H), 6.67 (d, *J* = 8.4 Hz, 2H), 5.89 (s, 1H), 3.88 (s, 3H), 3.54 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.91, 142.05, 139.12, 133.97, 129.13, 123.39, 119.94, 116.16, 115.78, 112.28, 21.59; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.12297, found 199.12262; IR (cm^{-1}): 2363, 2342, 1586, 1506, 1274, 1162, 820, 766.

4.15. N^1-(3-methoxyphenyl)benzene-1,4-diamine (3o)

Follow general procedure A, using m-anisidine **1o** (29.7 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **3o** was obtained as brown liquid (43.9 mg,

isolated yield 82%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (t, *J* = 8.0 Hz, 1H), 6.96 (d, *J* = 8.4 Hz, 2H), 6.64 (d, *J* = 8.4 Hz, 2H), 6.41 (dt, *J* = 13.2, 1.6 Hz, 2H), 6.34 (dd, *J* = 8.4, 2.0 Hz, 1H), 5.41 (s, 1H), 3.73 (s, 3H), 3.55 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.79, 147.47, 142.36, 133.51, 130.04, 123.79, 116.13, 107.89, 104.22, 100.76, 55.16; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.11789, found 215.11755; IR (cm^{-1}): 3418, 2974, 2361, 2340, 1615, 1515, 1048, 744.

4.16. N^1-(o-tolyl)benzene-1,4-diamine (3p)

Follow general procedure A, using o-toluidine **1p** (27.0 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3p** was obtained as brown solid (37.7 mg, isolated yield 76%); Melting point (°C): 58.5-59.2; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12 (d, *J* = 7.6 Hz, 1H), 7.04 (t, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 6.8 Hz, 3H), 6.76 (t, *J* = 7.2 Hz, 1H), 6.66 (d, *J* = 8.4 Hz, 2H), 5.13 (s, 1H), 3.50 (s, 2H), 2.23 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.10, 141.94, 134.30, 130.62, 126.79, 124.33, 123.42, 119.24, 116.22, 114.21, 17.77; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.12297, found 199.12274; IR (cm^{-1}): 3412, 3200, 2952, 2360, 2341, 1516, 1179, 742.

4.17. N^1-(2-methoxyphenyl)benzene-1,4-diamine (3q)

Follow general procedure A, using ortho-anisidine **1q** (28.9 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3q** was obtained as brown solid (31.6 mg, isolated yield 59%); Melting point (°C): 80.7-81.8; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.07 (t, *J* = 7.6 Hz, 1H), 6.96 (d, *J* = 8.4 Hz, 2H), 6.63 (dd, *J* =18.0, 8.4 Hz, 5H), 5.36 (s, 1H), 3.51 (s, 2H), 2.26 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.17, 141.86, 135.74, 133.69, 123.71, 120.97, 118.05, 116.23, 112.26, 110.13, 55.57; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.11789, found 215.11760; IR (cm^{-1}): 3334, 2918, 2361, 2342, 1497, 1251, 1111, 796.

4.18. N^1-(2-fluorophenyl)benzene-1,4-diamine (3r)

Follow general procedure A, using 2-fluoroaniline **1r** (24.2 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3r** was obtained as brown solid (35.4 mg, isolated yield 70%); Melting point (°C): 38.0-40.0; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.06 – 6.96 (m, 4H), 6.96 – 6.89 (m, 1H), 6.72 – 6.64 (m, 3H), 5.56 (s, 1H), 3.55 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ151.91 (d, *J* = 238 Hz), 142.75, 134.57 (d, *J* = 11 Hz), 132.53, 124.33 (d, *J* = 3 Hz), 124.09, 118.28 (d, *J* = 7 Hz), 116.15, 115.00 (d, *J* = 19 Hz), 114.54 (d, *J* = 3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -135.49; HRMS (ESI) m/z calcd for $C_{12}H_{12}FN_2^+$ $(M+H)^+$ 203.09790, found 203.09763; IR (cm^{-1}): 3442, 2361, 2342, 1633, 1402, 1095, 741.

4.19. N^1-([1,1'-biphenyl]-2-yl)benzene-1,4-diamine (3s)

Follow general procedure A, using 2-aminobiphenyl **1s** (42.3 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3s** was obtained as gray liquid (29.9 mg, isolated yield 46%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.41 (m, 4H), 7.34 (t, *J* = 7.2 Hz, 1H), 7.16 (t, *J* = 7.2 Hz, 2H), 7.03 (d, *J* = 8.0 Hz, 1H), 6.93 (d, *J* = 8.4 Hz, 2H), 6.85 (t, *J* = 7.6 Hz, 1H), 6.66 (d, *J* = 8.4 Hz, 2H), 5.46 (s, 1H), 3.77 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 142.84, 141.44, 139.33, 134.40, 130.65, 129.42, 129.18, 128.97, 128.35, 127.37, 123.71, 119.00, 116.50, 114.37; HRMS (ESI) m/z calcd for $C_{18}H_{17}N_2^+$ $(M+H)^+$ 261.13862, found 261.13852; IR (cm^{-1}): 3433, 2361, 2342, 1629, 1400, 1049, 742.

4.20. N^1-(pyridin-2-yl)benzene-1,4-diamine (3t)

Follow general procedure A, using 2-aminopyridine **1t** (23.5 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **3t** was obtained as white solid (24.1 mg, isolated yield 52%); Melting point (°C): 127.4-129.0; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.36 (s, 1H), 8.01 (dd, *J* = 4.8, 1.2 Hz, 1H), 7.42 (ddd, *J* = 4.8, 2.0,8.8 Hz, 1H), 7.19 (d, *J* = 8.4 Hz, 2H), 6.64 – 6.48 (m, 4H), 4.79 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 157.57, 147.91, 143.98, 137.31, 131.09, 122.09, 114.75, 113.17, 109.14; HRMS (ESI) m/z calcd for $C_{11}H_{12}N_3^+$ $(M+H)^+$ 186.10257, found 186.10294; IR (cm^{-1}): 3348, 3221, 3026, 1595, 1440, 1271, 770.

4.21. N^1-(pyridin-3-yl)benzene-1,4-diamine (3u)

Follow general procedure A, using 3-aminopyridine **1u** (23.5 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **3u** was obtained as yellow solid (29.6 mg, isolated yield 64%); Melting point (°C): 155.7-156.7; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.12 – 8.07 (m, 1H), 7.84 – 7.79 (m, 1H), 7.68 (s, 1H), 7.11 – 7.05 (m, 2H), 6.84 (d, *J* = 8.8 Hz, 2H), 6.56 (d, *J* = 8.4 Hz, 2H), 4.85 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 144.99, 143.56, 138.44, 137.11, 130.74, 124.12, 123.30, 119.21, 115.22; HRMS (ESI) m/z calcd for $C_{11}H_{12}N_3^+$ $(M+H)^+$ 186.10257, found 186.10243; IR (cm^{-1}): 3250, 3040, 1576, 1509, 1478, 1326, 1257, 698.

4.22. N^1-(quinolin-8-yl)benzene-1,4-diamine (3v)

Follow general procedure A, using 8-aminoquinoline **1v** (36.0 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3v** was obtained as gray solid (32.9 mg, isolated yield 56%). Melting point (°C): 118.5-119.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.06 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.87 (s, 1H), 7.39 – 7.28 (m, 2H), 7.20 – 7.15 (m, 2H), 7.11 (t, *J* = 8.0 Hz, 2H), 6.71 (d, *J* = 8.8 Hz, 2H), 3.58 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.10, 142.60, 138.21, 136.13, 132.95, 128.89, 127.55, 124.43, 121.54, 116.13, 115.14, 106.45; HRMS (ESI) m/z calcd for $C_{15}H_{14}N_3^+$ $(M+H)^+$ 236.11822, found 236.11835; IR (cm^{-1}): 3437, 3398, 3219, 2361, 2342, 1507, 1373, 1280, 783.

4.23. N^1-(naphthalen-1-yl)benzene-1,4-diamine (3w)

Follow general procedure A, using 1-naphthylamine **1w** (58.0 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **3w** was obtained as gray solid (49.2 mg, isolated yield 84%); Melting point (°C): 69.5-70.2; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.28 (d, *J* = 7.6 Hz, 1H), 7.79 (d, *J* = 7.6 Hz, 1H), 7.71 (s, 1H), 7.49 – 7.41 (m, 2H), 7.26 – 7.19 (m, 2H), 6.94 (d, *J* = 8.4 Hz, 2H), 6.79 (dd, *J* = 6.0, 3.2 Hz, 1H), 6.62 (d, *J* = 8.4 Hz, 2H), 4.86 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 144.93, 143.72, 134.82, 132.23, 128.41, 126.89, 126.24, 124.71, 124.64, 124.59, 122.63, 117.73, 115.23, 107.47; HRMS (ESI) m/z calcd for $C_{16}H_{15}N_2^+$ $(M+H)^+$ 235.12297, found 235.12286; IR (cm^{-1}): 3411, 3050, 2361, 2342, 1515, 1404, 1255, 789, 769.

4.24. 2-methoxy-N^1-phenylbenzene-1,4-diamine (4a)

Follow general procedure A, using 2-bromo-5-nitroanisole **2b** (39.4 mg, 0.275 mmol, 1.1 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **4a** was obtained as gray liquid (41.3 mg, isolated yield 77%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 (dd, *J* =

8.4, 7.6 Hz, 2H), 7.09 (d, *J* = 8.4 Hz, 1H), 6.92 (d, *J* = 7.6 Hz, 2H), 6.79 (t, *J* = 7.6 Hz, 1H), 6.28 (dd, *J* = 16.0, 2.4 Hz, 2H), 5.61 (s, 1H), 3.77 (s, 3H), 3.41 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.80, 145.46, 142.05, 129.19, 123.53, 121.36, 119.26, 115.75, 107.04, 99.77, 55.57; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.11789, found 215.11726; IR (cm^{-1}): 3405, 2361, 2343, 1621, 1455, 1048, 880.

4.25. 2-fluoro-N^1-phenylbenzene-1,4-diamine (4b)

Follow general procedure A, using 4-bromo-3-fluoronitrobenzene **2c** (60.5 mg, 0.275 mmol, 1.1 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **4b** was obtained as gray solid (28.8 mg, isolated yield 57%); Melting point (°C): 86.2-87.4; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (t, *J* = 7.6 Hz, 2H), 7.11 (t, *J* = 8.4 Hz, 1H), 6.83 (dd, *J* = 11.6, 7.2 Hz, 3H), 6.48 (d, *J* = 12.0 Hz, 1H), 6.42 (d, *J* = 8.4 Hz, 1H), 5.32 (s, 1H), 3.61 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.46 (d, *J* = 241 Hz), 145.27, 143.26 (d, *J* = 10 Hz), 129.27, 124.70 (d, *J* = 3 Hz), 121.19 (d, *J* = 13 Hz), 119.57, 115.28, 110.94 (d, *J* = 3 Hz), 103.28 (d, *J* = 23 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ -126.28; HRMS (ESI) m/z calcd for $C_{12}H_{12}FN_2^+$ $(M+H)^+$ 203.09790, found 203.09776; IR (cm^{-1}): 3362, 3046, 2360, 2342, 1594, 1490, 1268, 817, 743.

4.26. 2-methyl-N^1-phenylbenzene-1,4-diamine (4c)

Follow general procedure A, using 2-bromo-5-nitrotoluene **2d** (59.4 mg, 0.275 mmol, 1.1 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **4c** was obtained as liquid (37.6 mg, isolated yield 76%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (dd, *J* = 8.4, 7.2 Hz, 2H), 7.00 (d, *J* = 8.0 Hz, 1H), 6.73 (t, *J* = 7.2 Hz, 1H), 6.65 (dd, *J* = 8.8, 1.2 Hz, 2H), 6.58 (d, *J* = 2.4 Hz, 1H), 6.51 (dd, *J* = 8.0, 2.4 Hz, 1H), 5.12 (s, 1H), 3.53 (s, 2H), 2.14 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 146.95, 143.45, 134.78, 131.59, 129.24, 126.31, 118.25, 117.60, 114.29, 113.62, 18.05; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.12297, found 199.12285; IR (cm^{-1}): 3424, 2360, 2342, 1626, 1505, 1299, 741.

4.27. N^1-phenylbenzene-1,3-diamine (5a)

Follow general procedure A, using 3-bromonitrobenzene **2f** (55.5 mg, 0.275 mmol, 1.1 eq.) and aniline **1a** (23.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **5a** was obtained as gray solid (25.4 mg, isolated yield 55%); Melting point (°C): 60.5-61.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 – 7.22 (m, 2H), 7.04 (dd, *J* = 16.0, 7.6 Hz, 3H), 6.92 (t, *J* = 7.2 Hz, 1H), 6.46 (ddd, *J* = 0.8, 2.4, 2.8 Hz, 1H), 6.41 (t, *J* = 2.4 Hz, 1H), 6.26 (dd, *J* = 8.0, 1.6 Hz, 1H), 5.60 (s, 1H), 3.55 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.52, 144.36, 143.08, 130.22, 129.30, 121.01, 118.33, 108.37, 108.11, 104.03; HRMS (ESI) m/z calcd for $C_{12}H_{13}N_2^+$ $(M+H)^+$ 185.10732, found 185.10721; IR (cm^{-1}): 3415, 3379, 2360, 2342, 1588, 1494, 1152, 762, 691.

4.28. 5-chloro-N^1-phenylbenzene-1,3-diamine (5b)

Follow general procedure A, using 1-bromo-3-chloro-5-nitrobenzene **2g** (147.8 mg, 0.25 mmol, 2.5 eq.) and aniline **1a** (23.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **5b** was obtained as gray solid (30.0 mg, isolated yield 55%); Melting point (°C): 57.6-60.4; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 (t, *J* = 8.0 Hz, 1H), 7.04 (dd, *J* = 14.4, 7.2 Hz, 3H), 6.91 (t, *J* = 7.2 Hz, 1H), 6.45 (dd, *J* = 8.0, 2.0 Hz, 1H), 6.39 (t, *J* = 2.0 Hz, 1H), 6.25 (dd, *J* = 7.6, 1.6 Hz, 1H), 5.61 (s, 1H), 3.46 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.56, 144.38, 143.12, 130.23, 129.32, 121.01, 118.34, 108.37, 108.14, 104.10; HRMS (ESI) m/z calcd for $C_{12}H_{12}C_lN_2^+$ $(M+H)^+$ 219.06835, found 219.06804; IR (cm^{-1}): 3413, 2277, 2360, 2342, 1582, 1489, 1154, 785, 694.

4.29. N^1-(p-tolyl)benzene-1,3-diamine (5c)

Follow general procedure A, using 3-bromonitrobenzene 2f (55.5 mg, 0.275 mmol, 1.1 eq.) and p-toluidine **1b** (26.8 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **5c** was obtained as yellow solid (26.8 mg, isolated yield 54%); Melting point (°C): 86.5-88.1; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (d, *J* = 8.0 Hz, 2H), 7.04 – 6.98 (m, 3H), 6.40 (ddd, *J* = 1.2, 2.4, 3.2 Hz, 1H), 6.36 (t, *J* = 2.0 Hz, 1H), 6.22 (ddd, *J* = 0.8, 2.0, 2.8 Hz, 1H), 5.51 (s, 1H), 3.32 (s, 2H), 2.30 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.49, 145.22, 140.24, 130.97, 130.19, 129.82, 119.44, 107.57, 107.48, 103.13, 20.72; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.1152, found 199.1155.

4.30. N^1-(4-methoxyphenyl)benzene-1,3-diamine(5d)

Follow general procedure A, using 3-bromonitrobenzene **2f** (55.5 mg, 0.275 mmol, 1.1 eq.) and 4-methoxyaniline **1d** (31.1 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **5d** was obtained as yellow solid (27.8 mg, isolated yield 52%); Melting point (°C): 67.3-69.0; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 – 7.03 (m, 2H), 6.99 (t, *J* = 8.0 Hz, 1H), 6.88 – 6.82 (m, 2H), 6.31 (ddd, *J* = 0.8, 2.0, 2.8 Hz, 1H), 6.24 (t, *J* = 2.4 Hz, 1H), 6.18 (dd, *J* = 8.0, 1.6 Hz, 1H), 5.35 (s, 1H), 3.79 (s, 3H), 3.25 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.31, 147.52, 146.46, 135.69, 130.20, 122.70, 114.61, 106.82, 106.51, 101.99, 55.59; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.1101, found 215.1106.

4.31. N^1-(4-(trifluoromethyl)phenyl)benzene-1,3-diamine (5e)

Follow general procedure A, using 3-bromonitrobenzene **2f** (55.5 mg, 0.275 mmol, 1.1 eq.) and 4-(trifluoromethyl)aniline **1i** (31.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 3 : 1. **5e** was obtained as white solid (31.5 mg, isolated yield 50%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (d, *J* = 8.4 Hz, 2H), 7.10 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 8.4 Hz, 2H), 6.56 – 6.50 (m, 1H), 6.48 (t, *J* = 2.4 Hz, 1H), 6.38 (ddd, *J* = 8.0, 2.0, 0.8 Hz, 1H), 5.83 (s, 1H), 3.64 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.64, 146.76, 142.32, 130.40, 126.63 (q, *J* = 4 Hz), 124.67 (q, *J* = 269 Hz), 121.52 (q, *J* = 32 Hz), 115.71, 110.25, 109.87, 106.21; ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.44; HRMS (ESI) m/z calcd for $C_{13}H_{12}F_3N_2^+$ $(M+H)^+$ 253.0869, found 253.0806.

Follow general procedure A, using Li*Ot*-Bu (70.0 mg, 0.875 mmol, 3.5 eq.) as base for 6a, 6b, 6c, 6d.

4.32. N^1-phenylbenzene-1,2-diamine(6a)

Follow general procedure A, using 2-bromo nitrobenzene **2h** (55.5 mg, 0.275 mmol, 1.1 eq.) and aniline **1a** (23.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **6a** was obtained as white solid (17.9 mg, isolated yield 39%); Melting point (°C): 77.2-80.5; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23 – 7.17 (m, 2H), 7.12 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.04 – 6.98 (m, 1H), 6.84 – 6.78 (m, 2H), 6.78 – 6.72 (m, 3H), 5.16 (s, 1H), 3.48 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.31, 140.92, 128.28, 127.49, 124.69, 123.86, 118.27, 118.11,

115.12, 114.17; HRMS (ESI) m/z calcd for $C_{12}H_{13}N_2^+$ $(M+H)^+$ 185.10732, found 185.10771; IR (cm^{-1}): 3441, 2359, 2341, 1634, 1399, 1128, 737.

4.33. N^1-(p-tolyl)benzene-1,2-diamine (6b)

Follow general procedure A, using 2-bromo nitrobenzene **2h** (55.5 mg, 0.275 mmol, 1.1 eq.) and p-toluidine **1b** (26.8 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **6b** was obtained as brown liquid (24.3 mg, isolated yield 49%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.99 (dd, *J* = 8.0, 1.6 Hz, 1H), 6.92 (dd, *J* = 12.0,8.0 Hz 2H), 6.88 (dd, *J* = 7.6, 1.2 Hz, 1H), 6.71 – 6.66 (m, 1H), 6.64 (dd, *J* = 7.6, 1.6 Hz, 1H), 6.61 – 6.56 (m, 2H), 4.99 (s, 1H), 3.63 (s, 2H), 2.18 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 142.79, 141.45, 129.89, 129.55, 128.91, 125.17, 123.97, 119.26, 116.23, 115.90, 20.60; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2^+$ $(M+H)^+$ 199.12297, found 199.12285; IR (cm^{-1}): 3440, 2921, 2357, 2341, 1879, 1633, 741.

4.34. N^1-(4-methoxyphenyl)benzene-1,2-diamine (6c)

Follow general procedure A, using 2-bromo nitrobenzene **2h** (55.5 mg, 0.275 mmol, 1.1 eq.) and 4-methoxyaniline **1d** (31.1 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **6c** was obtained as brown liquid (34.8 mg, isolated yield 65%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.01 (dd, *J* = 7.6, 1.2 Hz, 1H), 6.93 (td, *J* = 8.0, 1.6 Hz, 1H), 6.82 – 6.70 (m, 6H), 5.01 (s, 1H), 3.75 (s, 3H), 3.69 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.83, 140.32, 138.41, 130.90, 124.27, 122.24, 119.40, 118.17, 116.29, 114.82, 55.72; HRMS (ESI) m/z calcd for $C_{13}H_{15}N_2O^+$ $(M+H)^+$ 215.11789, found 215.11775; IR (cm^{-1}): 3442, 2359, 2342, 2059, 1633, 1505, 1399, 742.

4.35. N^1-(4-(trifluoromethyl)phenyl)benzene-1,2-diamine (6d)

Follow general procedure A, using 2-bromo nitrobenzene **2h** (55.5 mg, 0.275 mmol, 1.1 eq.) and 4-(trifluoromethyl)aniline **1i** (31.3 μL, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 4 : 1. **6d** was obtained as brown liquid (17.6 mg, isolated yield 28%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (d, *J* = 8.8 Hz, 2H), 7.10 (ddd, *J* = 14.4, 8.0, 1.2 Hz, 2H), 6.85 – 6.75 (m, 2H), 6.72 (d, *J* = 8.4 Hz, 2H), 5.43 (s, 1H), 3.79 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.54, 142.80, 127.17, 126.69 (q, *J* = 4 Hz), 126.51, 126.38, 124.77 (q, *J* = 269 Hz), 120.63 (q, *J* = 32 Hz), 119.20, 116.31, 113.81; ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.24; HRMS (ESI) m/z calcd for $C_{13}H_{12}F_3N_2^+$ $(M+H)^+$ 253.09471, found 253.09480; IR (cm^{-1}): 3425, 2360, 2342, 1614, 1331, 1112, 1064, 830.

4.36. N^1-(4-aminophenyl)-N^4-phenylbenzene-1,4-diamine (7a)

Follow general procedure A, using 4-aminodiphenylamine (46.1 mg, 0.25 mmol, 1.0 eq.) as starting material, purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **7a** was obtained as brown solid (57.1 mg, isolated yield 83%); Melting point (^{o}C): 152.7-153.9; ^{1}HNMR (400 MHz, DMSO-d_6) δ 7.62 (s, 1H), 7.25 (s, 1H), 7.15 – 7.07 (m, 2H), 6.91 (d, *J* = 8.8 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 2H), 6.78 (dd, *J* = 8.8, 5.2 Hz, 4H), 6.64 (t, *J* = 7.2 Hz, 1H), 6.52 (d, *J* = 8.8 Hz, 2H), 4.66 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 146.42, 143.45, 141.48, 133.87, 133.48, 129.47, 121.88, 121.50, 117.95, 115.94, 115.32, 114.61; HRMS (ESI) m/z calcd for $C_{18}H_{18}N_3^+$ $(M+H)^+$ 276.14952, found 276.14957; IR (cm^{-1}): 3362, 3046, 2360, 2342, 1594, 1506, 1268, 817, 743.

4.37. N^1-(4-aminophenyl)-N^4-(4-chlorophenyl)benzene-1,4-diamine (7b)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 1-bromo-4-nitrobenzene **2a** (0.25 mmol, 1.0 eq.), $Pd_2(dba)_3$ (11.5 mg, 0.0125 mmol, 5 mol%), XPhos (14.3 mg, 0.03 mmol, 12 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.) and 4-chloroaniline **1f** (127.6 mg, 0.25 mmol, 4.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (1.5 mmol, 6.0 eq.) and KO*t*-Bu (0.75 mmol, 3.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 4h. Purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **7b** was obtained as brown solid (37.2 mg, isolated yield 48%); Melting point (^{o}C): 95.5-97.1; ^{1}HNMR (400 MHz, DMSO-d_6) δ 7.28 (d, *J* = 21.2 Hz, 1H), 7.12 (d, *J* = 7.8 Hz, 2H), 6.85 (d, *J* = 47.3 Hz, 8H), 6.64 (s, 1H), 6.52 (s, 2H), 4.73 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 146.41, 143.24, 129.47, 121.85, 121.44, 117.97, 116.00, 115.42, 114.63; HRMS (ESI) m/z calcd for $C_{18}H_{17}ClN_3^+$ $(M+H)^+$ 310.11055, found 310.11008; IR (cm^{-1}): 3359, 2361, 2342, 1507, 1261, 816, 743.

4.38. N^1,N^3-diphenylbenzene-1,3,5-triamine (7c)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 1-bromo-3-chloro-5-nitrobenzene 2g (59.1 mg, 0.25 mmol, 1.0 eq.), $Pd_2(dba)_3$ (11.5 mg, 0.0125 mmol, 5 mol%), XPhos (14.3 mg, 0.03 mmol, 12 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.) and aniline **1a** (139.8 μL, 1.5 mmol, 6.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (1.5 mmol, 6.0 eq.) and KO*t*-Bu (0.75 mmol, 3.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 4 h. Purification by flash chromatography on silica gel using petroleum ether : ethyl acetate = 2 : 1. **7c** was obtained as white solid (38.5 mg, isolated yield 56%); Melting point (^{o}C): 107.5-108.7; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 (t, *J* = 8.4 Hz, 4H), 7.07 (d, *J* = 7.6 Hz, 4H), 6.92 (t, *J* = 7.6 Hz, 2H), 6.16 (s, 1H), 6.00 (d, *J* = 1.6 Hz, 2H), 5.56 (s, 2H), 3.57 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.39, 145.40, 142.89, 129.26, 121.13, 118.77, 97.48, 97.04; HRMS (ESI) m/z calcd for $C_{18}H_{18}N_3^+$ $(M+H)^+$ 276.14952, found 276.14981; IR (cm^{-1}): 3368, 2361, 2342, 1577, 1491, 1244, 748, 688.

4.39. N^1,$N^{1'}$-([1,1'-biphenyl]-4,4'-diyl)bis(benzene-1,4-diamine) (7d)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with benzidine (46.1 mg, 0.25 mmol, 1.0 eq.) and 1-bromo-4-nitrobenzene (111.1 mg, 0.55 mmol, 2.2 eq.), $Pd_2(dba)_3$ (4.6 mg, 0.005 mmol, 2 mol%), XPhos (11.8 mg, 0.025 mmol, 10.0 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 ºC for 24 h. Then, B_2pin_2 (2.0 mmol, 8.0 eq.) and KO*t*-Bu (1.0 mmol, 4.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 4 h. Purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 2 : 1. **7d** was obtained as yellow solid (78.8 mg, isolated yield 86%); Melting point (^{o}C): 229.5-231.5; ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.50 (s, 2H), 7.32 (d, *J* = 8.8 Hz, 4H), 6.83 (dd, *J* = 11.6, 8.8 Hz, 8H), 6.54 (d, *J* = 8.4 Hz, 4H), 4.75 (s, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 145.41, 144.18, 132.22, 129.97, 126.57, 122.68, 115.21, 114.62; HRMS (ESI) m/z calcd

for $C_{24}H_{23}N_4^+$ $(M+H)^+$ 367.19172, found 367.19153; IR (cm^{-1}): 3408, 3032, 2361, 2342, 1604, 1490, 1264, 1178, 816.

4.40. N^1,$N^{1'}$-(1,3-phenylene)bis(benzene-1,4-diamine) (7e)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with benzene-1,3-diamine (27.0 mg, 0.25 mmol, 1.0 eq.) and 1-bromo-4-nitrobenzene (111.1 mg, 0.55 mmol, 2.2 eq.), $Pd_2(dba)_3$ (4.6 mg, 0.005 mmol, 2 mol%), XPhos (11.8 mg, 0.025 mmol, 10 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (2.0 mmol, 8.0 eq.) and KO*t*-Bu (1.0 mmol, 4.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 ° C for 4 h. purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 2 : 1. **7e** was obtained as black solid (61.0 mg, isolated yield 84%); Melting point (°C): 160.2-161.5; ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.23 (s, 2H), 6.80 (dd, *J* = 13.6, 8.0 Hz, 5H), 6.50 (d, *J* = 8.4 Hz, 4H), 6.32 (s, 1H), 6.10 (dd, *J* = 8.0, 2.0 Hz, 2H), 4.68 (s, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 152.49, 148.59, 137.34, 134.48, 127.47, 119.86, 109.21, 104.65; HRMS (ESI) m/z calcd for $C_{18}H_{19}N_4^+$ $(M+H)^+$ 291.16042, found 291.16098; IR (cm^{-1}): 3342, 2361, 2341, 1507, 1256, 1160, 828, 668.

4.41. N^1,$N^{1'}$-(1,4-phenylene)bis(benzene-1,4-diamine) (7f)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with p-phenylenediamine (27.0 mg, 0.25 mmol, 1.0 eq.) and 1-bromo-4-nitrobenzene (111.1 mg, 0.55 mmol, 2.2 eq.), $Pd_2(dba)_3$ (4.6 mg, 0.005 mmol, 2 mol%), XPhos (11.8 mg, 0.025 mmol, 10 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (2.0 mmol, 8.0 eq.) and KO*t*-Bu (1.0 mmol, 4.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 ° C for 4 h. Purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 2 : 1. **7f** was obtained as black solid (63.9 mg, isolated yield 88%); Melting point (°C): 202.9-203.7; ^{1}H NMR (400 MHz, DMSO-d_6) δ 6.99 (s, 2H), 6.72 (t, *J* = 5.2 Hz, 8H), 6.48 (d, *J* = 8.8 Hz, 4H), 4.56 (s, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 142.60, 138.45, 134.81, 120.10, 117.44, 115.40; HRMS (ESI) m/z calcd for $C_{18}H_{19}N_4^+$ $(M+H)^+$ 291.16042, found 291.16068; IR (cm^{-1}): 3327 ,3031, 2361, 2342, 1507, 1280, 817.

4.42. bis(4-((4-aminophenyl)amino)phenyl)methanone (7g)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 4,4'-diaminobenzophenone (53.1 mg, 0.25 mmol, 1.0 eq.) and 1-bromo-4-nitrobenzene (111.1 mg, 0.55 mmol, 2.2 eq.), $Pd_2(dba)_3$ (4.6 mg, 0.005 mmol, 2 mol%), XPhos (11.8 mg, 0.025 mmol, 10 mol%), K_2CO_3 (138.2 mg, 1.0 mmol, 4.0 eq.). After evacuation and refill with dry nitrogen for three times, and *i*PrOH (2.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (2.0 mmol, 8.0 eq.) and KO*t*-Bu (1.0 mmol, 4.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 4 h. Purification by flash chromatography on silica gel using ethyl acetate : petroleum ether = 2 : 1. **7g** was obtained as yellow solid (70.0 mg, isolated yield 71%); Melting point (°C): 224.7-225.7; ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.18 (s, 2H), 7.51 (d, *J* = 8.8 Hz, 4H), 6.89 (d, *J* = 8.4 Hz, 4H), 6.77 (d, *J* = 8.8 Hz, 4H), 6.58 (d, *J* = 8.8 Hz, 4H), 4.93 (s, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 192.18, 150.83, 145.67, 132.26, 129.90, 126.86, 124.49, 115.07, 112.25; HRMS (ESI) m/z calcd for $C_{25}H_{23}N_4O^+$ $(M+H)^+$ 395.18664, found 395.18683; IR (cm^{-1}): 3309, 2362, 2343, 1715, 1594, 1507, 1318, 1166, 830, 759.

4.43. N^1-(4-aminophenyl)-N^4,N^4-bis(4-((4-aminophenyl)amino)phenyl)benzene-1,4-diamine (7h)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 1-bromo-4-nitrobenzene (176.8 mg, 0.875 mmol, 3.5 eq.), $Pd_2(dba)_3$ (11.5 mg, 0.0125 mmol, 5 mol%), XPhos (14.3 mg, 0.03 mmol, 12 mol%), K_2CO_3 (207.3 mg, 1.5 mmol, 6.0 eq.) and tris(4-aminophenyl)amine, (0.25 mmol, 72.6 mg, 1.0 eq.) After evacuation and refill with dry nitrogen for three times. *i*PrOH (3.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 110 °C for 24 h. Then, B_2pin_2 (2.0 mmol, 8.0 eq.) and KO*t*-Bu (1.0 mmol, 4.0 eq.) were added and the mixture was then stirred in the preheated oil bath at 110 °C for 5 h. Purification by flash chromatography on silica gel using ethyl acetate. **7h** was obtained as black solid (76.1 mg, isolated yield 54%); Melting point (°C): 122.8-123.8; ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.26 (s, 3H), 6.74 (d, *J* = 24.8 Hz, 18H), 6.51 (d, *J* = 8.4 Hz, 6H), 4.67 (s, 6H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 148.35, 146.38, 144.55, 137.92, 129.31, 126.58, 120.49, 120.04; HRMS (ESI) m/z calcd for $C_{36}H_{34}N_7^+$ $(M+H)^+$ 564.28702, found 564.28754; IR (cm^{-1}): 3367, 2360, 2342, 1496, 1260, 816.

4.44. 6-methyl-N^1-(4-(pyridin-3-yl)pyrimidin-2-yl)benzene-1,3-diamine (8)

In a dried schlenk flask (25 mL in volume) equipped with a stirring bar were placed with 2-bromo-4-nitrotoluene (54.0 mg, 0.25 mmol, 1.0 eq.), and 4-(3-pyridinyl)-2-pyrimidine amine (43.0 mg, 0.25 mmol, 1.0 eq.), $Pd_2(dba)_3$ (11.5 mg, 0.0125 mmol, 5 mol%), BINAP (18.7 mg, 0.03 mmol, 12 mol%), Cs_2CO_3 (163.0 mg, 0.5 mmol, 2.0 eq.). After evacuation and refill with dry nitrogen for three times, dioxane (3.0 mL) was added with syringes under a stream of nitrogen. The resulting mixture was allowed to stir at 100 °C for 24 h, and dioxane was removed. Then, B_2pin_2 (1.0 mmol, 4.0 eq.) and KO*t*-Bu (0.5 mmol, 2.0 eq.) in 1.0 ml *i*PrOH was added and the mixture was then stirred in the preheated oil bath at 110 °C for 4h. Purification by flash chromatography on silica gel using dichloromethane : methanol = 50 : 1. **8** was obtained as yellow solid (57.5 mg, isolated yield 83%). When expanded to 1.0 mmol, 0.208 g product can be obtained, yield 75%. Melting point (°C): 133.0-135.0; ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.27 (dd, *J* = 2.0, 0.4 Hz, 1H), 8.73 – 8.68 (m, 2H), 8.48 (d, *J* = 4.8 Hz, 1H), 8.44 – 8.39 (m, 1H), 7.54 (ddd, *J* = 0.8, 4.8, 5.6 Hz, 1H), 7.37 (d, *J* = 4.8 Hz, 1H), 6.89 (d, *J* = 8.0 Hz, 1H), 6.82 (d, *J* = 2.4 Hz, 1H), 6.36 (dd, *J* = 8.0, 2.4 Hz, 1H), 4.87 (s, 2H), 2.08 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 161.96, 161.78, 159.82, 151.79, 148.60, 147.24, 138.42, 134.73, 132.77, 130.80, 124.28, 119.78, 111.58, 111.39, 107.54, 17.70; HRMS (ESI) m/z calcd for $C_{16}H_{16}N_5^+$ $(M+H)^+$ 278.14002, found 278.14035; IR (cm^{-1}): 3434, 3346, 3214, 2360, 2343, 1592, 1323, 1151, 767, 676.

4.45. N-(4-methyl-3-((4-(pyridin-2-yl)pyrimidin-2-yl)amino)phenyl)-4-((4-methylpiperazin-1-yl)methyl)benzamide (9)

^{1}H NMR (400 MHz, DMSO-d_6) δ 10.16 (s, 1H), 9.28 (d, *J* = 1.6 Hz, 1H), 8.97 (s, 1H), 8.68 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.51 (d, *J* = 5.2 Hz, 2H), 8.50 – 8.45 (m, 1H), 8.08 (d, *J* = 2.0 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 2H), 7.55 – 7.46 (m, 2H), 7.46 – 7.40 (m, 3H), 7.20 (d, *J* = 8.4 Hz, 1H), 3.52 (s, 2H), 2.35 (d, *J* = 19.6 Hz, 8H), 2.22 (s, 3H), 2.15 (s, 3H); ^{13}C NMR (101 MHz, MeOD-

d_4) δ 167.07, 162.30, 161.21, 158.91, 150.38, 147.64, 141.47, 137.64, 136.81, 135.41, 134.01, 133.15, 130.17, 129.17, 127.73, 127.29, 123.98, 117.25, 116.93, 107.33, 61.88, 54.33, 52.18, 44.58, 16.46.

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