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Efficient and Versatile Catalytic Systems for the *N*-Methylation of Primary Amines with Methanol Catalyzed by *N*-Heterocyclic Carbene Complexes of Iridium

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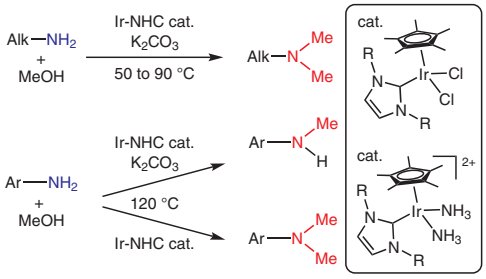

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Abstract Efficient and versatile catalytic systems were developed for the *N*-methylation of both aliphatic and aromatic primary amines using methanol as the methylating agent. Iridium complexes bearing an *N*-heterocyclic carbene (NHC) ligand exhibited high catalytic performance for this type of transformation. For aliphatic amines, selective *N*,*N*-dimethylation was achieved at low temperatures (50–90 °C). For aromatic amines, selective *N*-monomethylation and selective *N*,*N*-dimethylation were accomplished by simply changing the reaction conditions (presence or absence of a base with an appropriate catalyst). These findings can be used to develop methods for synthesizing useful amine compounds having *N*-methyl or *N*,*N*-dimethyl moieties.

Key words iridium, carbene ligands, hydrogen transfer, amines, methylation

N-Methylation of amines is one of the most important transformations for synthesizing useful amine compounds, including physiologically active chemicals and agricultural chemicals, because those contain *N*-methyl or *N*,*N*-dimethyl moieties in many cases.[1] Conventionally, the synthesis of *N*-methyl and *N*,*N*-dimethyl amines is performed via *N*-methylation reactions using highly toxic methylating agents, for example, methyl iodide or dimethyl sulfate.[2] Reductive *N*-methylation of amines using formaldehyde is another commonly employed approach; however, in this approach, either a highly toxic reducing reagent (e.g., $NaBH_3CN$) or explosive hydrogen gas is required to be used.[3] Under these circumstances, the catalytic *N*-methylation of amines using methanol, which is easy to handle and inexpensive, as a methylating agent, has received considerable attention.

To date, considerably few examples of *N*-methylation of aliphatic primary amines with methanol have appeared.[4] Furthermore, in all these examples the *N*-methylation has been performed under high-temperature conditions (over 100 °C). Therefore, a new and efficient catalytic system for the *N*-methylation of aliphatic amines with methanol under mild conditions (below 100 °C) must be developed.

In contrast, there are relatively many publications concerning the *N*-monomethylation of aromatic amines with methanol;[4a–d,5] however, in most cases, either a strong base was used[4a,c,d,5b–f,5h,i] or a high temperature (over 150 °C) was required for the reactions to occur.[5a,d,i,j] Furthermore, only a few catalytic systems have been developed for the *N*,*N*-dimethylation of aromatic amines with methanol. These systems required an extremely high temperature (over 180 °C) for the reactions to occur.[6]

We previously developed several catalytic systems for the *N*-alkylation of amines using alcohols as alkylating agents based on 'borrowing hydrogen' or 'hydrogen autotransfer' using iridium complexes as catalysts.[7] During the course of our research, we recently found that trivalent iridium complexes bearing *N*-heterocyclic carbene (NHC) and pentamethylcyclopentadienyl (Cp*) ligands exhibited high catalytic performance for the *N*-alkylation of aqueous ammonia with a variety of alcohols.[8,9]

Herein, we report the development of new and efficient catalytic systems for the *N*-methylation of various primary amines with methanol catalyzed by NHC complexes of iridium. The iridium catalysts having a NHC ligand used in this study are shown in Figure 1. We newly synthesized the catalysts **1c**[10] and **2c**. The remaining catalysts were prepared according to the procedures published in the literature.

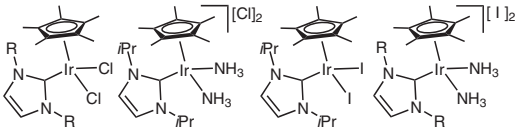


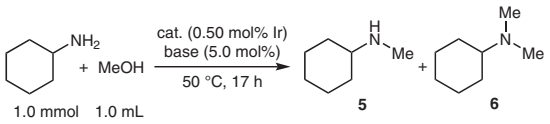
Figure 1 Iridium catalysts **1**–**4** used in this study

First, the activities of iridium catalysts for the *N*-methylation of an aliphatic primary amine with methanol were investigated using cyclohexanamine as the substrate. The reactions were performed in a sealed reactor at 50 °C. The results are summarized in Table 1. When the reaction of cyclohexanamine (1.0 mmol) with methanol (1.0 mL, 24.7 mmol) was conducted at 50 °C for 17 hours in the presence of $[Cp^*IrCl_2]_2$ (0.0025 mmol, 0.50 mol% Ir) without an NHC ligand, and K_2CO_3 (5.0 mol%), only trace amounts of *N*-methylcyclohexanamine (**5**) were detected (Table 1, entry 1). Other iridium catalysts, such as $[Cp^*IrI_2]_2$, $[Cp^*Ir(NH_3)_3][I]_2$, **1a**, and **1b** also exhibited little catalytic activity (entries 2–5). However, interestingly, the use of catalyst **1c**, which has isopropyl substituents on the nitrogen atoms in the NHC ligand, considerably improved the catalytic activity, affording *N*,*N*-dimethylcyclohexanamine (**6**) in 88% yield along with **5** in 4% yield (entry 6). The NHC ligand with isopropyl substituents was necessary for achieving high catalytic activity (entries 6–9). Among these catalysts, **1c** exhibited the highest activity, leading to the selective formation of *N*,*N*-dimethylated product **6** in good yield. The effect of the base as an additive was also examined. When the reaction was conducted in the absence of a base, only compound **5** was formed in a very low yield (5%) (entry 12). The addition of Na_2CO_3, Cs_2CO_3, MeOK, and *t*-BuOK improved the catalytic activity (entries 13–16), however, K_2CO_3 gave the best results. The highest yield and selectivity for compound **6** was accomplished by performing the reaction at 60 °C (entry 17). As mentioned earlier, the currently available *N*,*N*-dimethylating catalytic systems for primary aliphatic amines using methanol require a high reaction temperature (over 100 °C).[4] In the catalytic system shown in Table 1, these reactions were all performed at 50 °C or 60 °C, which is a significant improvement for reaction mildness. Thus, the present catalytic system is currently the most efficient system for the *N*,*N*-dimethylation of aliphatic amines using methanol.

To evaluate the scope of this catalytic system employing **1c**, reactions of a variety of aliphatic primary amines under the optimized conditions were conducted. The results are summarized in Table 2. The reactions of primary amines with saturated cyclic substituents proceeded smoothly at 60 °C, affording *N*,*N*-dimethylated products in high to excellent yields (Table 2, entries 1–4). Non-cyclic primary amines were also *N*,*N*-dimethylated by this catalytic system, although slightly higher temperatures (70 °C) and longer reaction times (40 h) were required for achieving high yields (entries 5–7). Phenylmethanamine derivatives also serve as good substrates for this reaction. *N*,*N*-Dimethylation proceeded at 70 °C, with phenylmethanamines containing electron-donating substituents on the aromatic ring (entries 8–12); however, a reaction temperature of 90 °C was required with phenylmethanamines containing electron-withdrawing substituents on the aromatic ring (entries 13–17). 1-Phenylethanamine derivatives also served as promising candidates for this catalytic system, affording *N*,*N*-dimethylated products in excellent yields (entries 18–20).

We next focused on the *N*-methylation of aromatic primary amines with methanol. To optimize the reaction conditions, aniline was used as a model substrate. The results are summarized in Table 3. When the reaction of aniline (1.0 mmol) with methanol (1.0 mL, 24.7 mmol) was conducted at 110 °C for 17 hours in the presence of $[Cp^*IrCl_2]_2$ (0.0025 mmol, 0.50 mol% Ir) and K_2CO_3 (5.0 mol%), *N*-methylaniline (**7**) was obtained in a very low yield (Table 3, entry 1). Other catalysts, including $[Cp^*IrI_2]_2$ and $[Cp^*Ir(NH_3)_3][I]_2$, also exhibited little catalytic activity (entries 2 and 3). In-

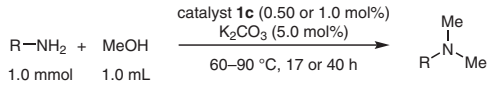
Table 1 Reactions of Cyclohexanamine with Methanol under Various Conditions Giving *N*-Methylcyclohexanamine (**5**) and *N*,*N*-Dimethylcyclohexanamine (**6**)

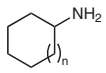
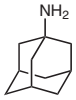
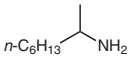
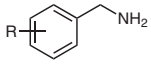
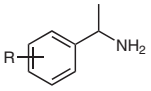


Entry	Catalyst	Base	Yield of **5** (%)[a]	Yield of **6** (%)[a]
1	$[Cp^*IrCl_2]_2$	K_2CO_3	2	0
2	$[Cp^*IrI_2]_2$	K_2CO_3	3	0
3	$[Cp^*Ir(NH_3)_3][I]_2$	K_2CO_3	2	0
4	**1a**	K_2CO_3	1	0
5	**1b**	K_2CO_3	2	0
6	**1c**	K_2CO_3	4	88
7	**2c**	K_2CO_3	14	61
8	**3c**	K_2CO_3	16	56
9	**4c**	K_2CO_3	22	32
10	**4a**	K_2CO_3	2	0
11	**4b**	K_2CO_3	4	0
12	**1c**	none	5	0
13	**1c**	Na_2CO_3	18	21
14	**1c**	Cs_2CO_3	20	34
15	**1c**	MeOK	23	34
16	**1c**	*t*-BuOK	22	34
17[b]	**1c**	K_2CO_3	1	99

[a] Determined by GC.
[b] Reaction performed at 60 °C.

Table 2 *N*,*N*-Dimethylation of Various Aliphatic Amines with Methanol Catalyzed by **1c**

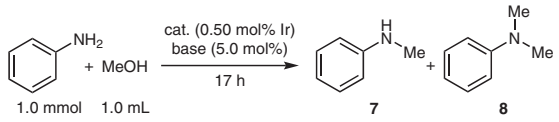


Entry	Substrate	Cat. **1c** (mol%)	Temp (°C)	Time (h)	Yield (%)[a]
					
1	n = 1	0.50	60	17	98[b]
2	n = 2	0.50	60	17	86
3	n = 3	0.50	60	17	90
4		1.0	60	40	90
5	*n*-$C_6H_{13}NH_2$	1.0	70	40	99[b]
6	*n*-$C_8H_{17}NH_2$	1.0	70	40	88
7		1.0	70	40	95
					
8	R = H	1.0	70	40	89[b]
9	R = 2-Me	1.0	70	40	88
10	R = 3-Me	1.0	70	40	92
11	R = 4-Me	1.0	70	40	93
12	R = 4-OMe	1.0	70	40	97
13	R = 2-Cl	1.0	90	40	97
14	R = 3-Cl	1.0	90	40	93
15	R = 4-Cl	1.0	90	40	98
16	R = 4-CN	1.0	90	40	75
17	R = 4-CF_3	1.0	90	40	77
					
18	R = H	1.0	90	40	92
19	R = 4-OMe	1.0	90	40	96
20	R = 4-Cl	1.0	90	40	90

[a] Isolated yield.
[b] Determined by GC.

terestingly, the use of catalyst **1a**, bearing an NHC ligand, resulted in the selective formation of compound **7** in 76% yield (entry 4). From a comparison of the catalytic activities of catalysts **1a–c** (entries 4–6), catalyst **1c**, which has isopropyl substituents on the nitrogen atoms in the NHC ligand, exhibited the highest performance, affording **7** in 86% yield (entry 6). By the survey of a series of NHC iridium catalysts, the best results for the *N*-monomethylation were achieved using catalyst **4c** (entry 11). An almost quantitative formation of **7** was accomplished using catalyst **4c** at 120 °C (entry 12). We also examined the similar reaction in the absence of base. Interestingly, a considerable amount of *N*,*N*-dimethylaniline (**8**) was formed under the similar reaction conditions using catalyst **4a** (entries 14 and 15). Finally, selective and quantitative *N*,*N*-dimethylation was achieved using of 2.0 mol% of catalyst **4a** at 120 °C in the absence of a base (entry 16). To the best of our knowledge, the current catalytic system is the most efficient system for the *N*,*N*-dimethylation of aromatic primary amines using methanol as the methylating agent.[6,11]

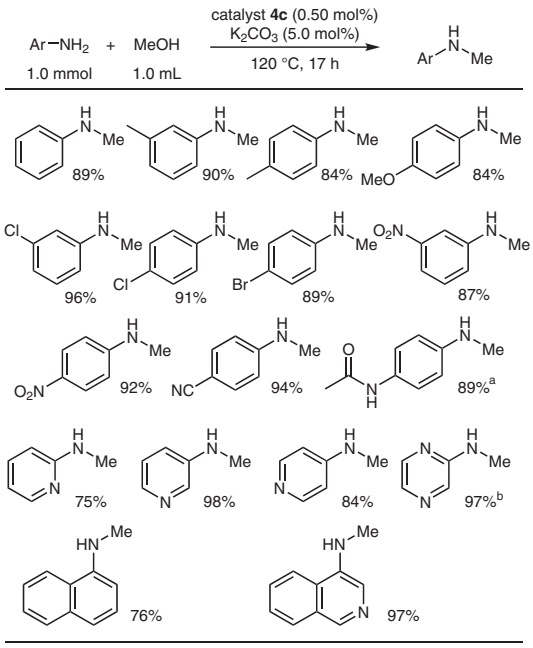
Table 3 Reactions of Aniline with Methanol under Various Conditions Giving *N*-Methylaniline (**7**) and *N*,*N*-Dimethylaniline (**8**)



Entry	Catalyst	Base	Temp (°C)	Yield of **7** (%)[a]	Yield of **8** (%)[a]
1	$[Cp^*IrCl_2]_2$	K_2CO_3	110	8	0
2	$[Cp^*IrI_2]_2$	K_2CO_3	110	7	0
3	$[Cp^*Ir(NH_3)_3][I]_2$	K_2CO_3	110	21	0
4	**1a**	K_2CO_3	110	76	0
5	**1b**	K_2CO_3	110	57	0
6	**1c**	K_2CO_3	110	86	0
7	**2c**	K_2CO_3	110	90	1
8	**3c**	K_2CO_3	110	85	0
9	**4a**	K_2CO_3	110	92	1
10	**4b**	K_2CO_3	110	88	1
11	**4c**	K_2CO_3	110	94	0
12	**4c**	K_2CO_3	120	98	1
13	**4c**	none	110	8	0
14	**4a**	none	110	42	15
15[b]	**4a**	none	110	0	98
16[b]	**4a**	none	120	0	quant.

[a] Determined by GC.
[b] Catalyst loading was 2.0 mol%.

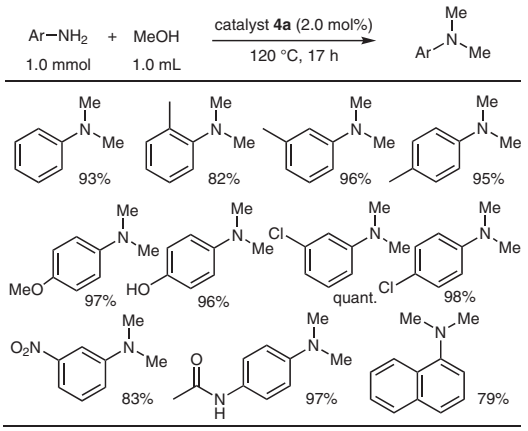
Subsequently, the reactions of various aromatic primary amines under the optimized conditions for *N*-monomethylation using catalyst **4c** (see entry 12 in Table 3) were conducted to investigate the substrate scope. The results are summarized in Scheme 1. Methyl, methoxy, chloro, bromo, nitro, cyano, and amide substituents were tolerated in the present *N*-monomethylation system. In addition to simple primary amines with phenyl rings, the primary amines with the pyridyl, pyrazyl, naphthyl, and isoquinolinyl rings could also be methylated using the present catalytic system.



Scheme 1 *N*-Monomethylation of various aromatic amines with methanol catalyzed by **4c**. Isolated yields are shown. [a] Reaction temperature: 100 °C. [b] Reaction time: 24 h.

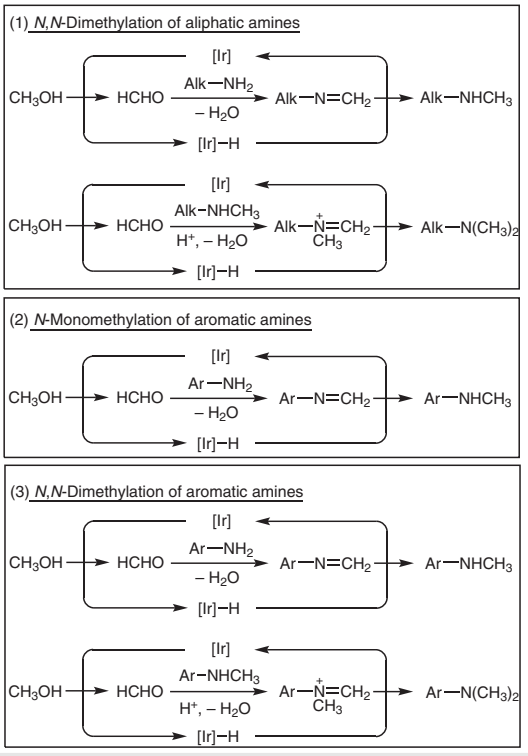
Furthermore, the reactions of various aromatic primary amines under the optimized conditions for *N*,*N*-dimethylation using catalyst **4a** (see entry 16 in Table 3) were conducted. The results are summarized in Scheme 2. Methyl, methoxy, hydroxy, chloro, nitro, and amide substituents were tolerant, giving tertiary amines with *N*,*N*-dimethyl moiety in good to excellent yields. As mentioned earlier, the currently available *N*,*N*-dimethylating systems for primary aromatic amines using methanol require an extremely high reaction temperature (over 180 °C).[6] Using the optimized conditions with catalyst **4a** and no base, the *N*,*N*-dimethylation of aromatic amines could be performed under milder reaction conditions (at 120 °C), indicating a significant improvement for reaction mildness. Thus, the present catalytic system is currently the most efficient system for the *N*,*N*-dimethylation of aromatic amines using methanol.

In the present study, the following three types of *N*-methylation reactions by using methanol as a methylating agent were achieved: (1) *N*,*N*-dimethylation of aliphatic primary amines catalyzed by **1c**, (2) *N*-monomethylation of aromatic primary amines catalyzed by **4c**, and (3) *N*,*N*-dimethylation of aromatic primary amines catalyzed by **4a**. Plausible reaction pathways for these reactions are summarized in Scheme 3. It should be noted that in the case of the reaction pattern (1), only the iridium catalyst bearing an NHC ligand with isopropyl groups on the nitrogen atoms, such as **1c**, **2c**, **3c**, and **4c**, showed catalytic activity to give *N*,*N*-dimethylated product (see Table 1). On the other hand,



Scheme 2 *N*,*N*-Dimethylation of various aromatic amines with methanol catalyzed by **4a**. Isolated yields are shown.

in the case of the reaction pattern (2), most of the iridium NHC catalyst exhibited catalytic activity, while the slightly better results were obtained by using catalyst **4c** (see Table 3), which is dicationic diammine complex having isopropyl groups on nitrogen atoms. Additionally, in the case of the reaction pattern (3), only the catalyst **4a** showed high catalytic activity. While it is very difficult to understand these characteristics of the reactivity, selectivity, and optimal



Scheme 3 Reaction pathways for three types of *N*-methylation reactions by using methanol as a methylating agent achieved in the present study

choice of the catalyst according to the substrates, we have attempted to propose plausible explanations (for details, see the Supporting Information).

In summary, we have developed multiple efficient and versatile catalytic systems for the *N*-methylation of both aliphatic and aromatic amines using methanol as the methylating agent. Selective *N*,*N*-dimethylation of aliphatic primary amines, *N*-monomethylation of aromatic primary amines, and *N*,*N*-dimethylation of aromatic primary amines could be achieved using an appropriate catalyst and base combination. These findings can be used to develop methods for the synthesizing useful amine compounds having *N*-methyl or *N*,*N*-dimethyl moieties.

All reactions and manipulations were performed under argon atmosphere using standard Schlenk techniques. ^{1}H and ^{13}C{^{1}H} NMR spectra were recorded on JEOL ECX-500 and ECS-400 spectrometers. Gas chromatography analyses were performed on a GL-Sciences GC-4000 Plus or GC353B gas chromatograph with a capillary column (InertCap for Amines or InertCap Pure WAX). Elemental analyses were carried out at the Microanalysis Center of Kyoto University. Melting points were determined under air on a J-Science RFS-10 apparatus. The complexes, $[Cp^*IrCl_2]_2$,[12] $[Cp^*IrI_2]_2$,[13] $[Cp^*Ir(NH_3)_3][I]_2$,[7f] **1a**,[8] **1b**,[14] **3c**,[8] and **4a**–**c**,[8] were prepared according to the literature methods. Column chromatography was carried out by using Wako-gel C-200. Organic solvents were dried by passage through columns (either alumina or activated molecular sieves) on a Glass Contour solvent system. All other reagents are commercially available and were used as received.

Preparation of the Complex 1c

In a flask, 1,3-diisopropylimidazolium iodide (0.2835 g, 1.01 mmol), Ag_2O (0.1171g, 0.505 mmol), and CH_2Cl_2 (12.0 mL) were placed. The mixture was stirred at r.t. for 4 h. Then, $[Cp^*IrCl_2]_2$ (0.4033 g, 0.506 mmol) was added and the mixture stirred at r.t. for 20 h. The mixture was filtered through a glass filter. Evaporation of the filtrate gave a crude product of **1c**. Recrystallization by slow diffusion of Et_2O into a CH_2Cl_2 solution of the crude product gave the pure product of **1c** as red crystals; yield: 0.4237 g (0.769 mmol, 76%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.99 (s, 2 H, CH=CH), 5.26 [sept, *J* = 7 Hz, 2 H, NC*H*$(CH_3)_2$], 1.63 [s, 15 H, $C_5(CH_3)_5$], 1.56 [d, *J* = 7 Hz, 6 H, NCH(C*H*$_3)_2$], 1.38 [d, *J* = 7 Hz, 6 H, NCH(C*H*$_3)_2$].

^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ = 153.6 (s, CIr), 118.7 (s, CH=CH), 88.8 [s, $C_5(CH_3)_5$], 51.5 [s, N*C*H(CH_3)], 25.5 [s, NCH(*C*H$_3)$], 25.3 [s, NCH(*C*H$_3)$], 9.3 [s, $C_5(CH_3)_5$].

Anal. Calcd for $C_{19}H_{31}Cl_2IrN_2$: C, 41.44; H, 5.69; N, 5.09. Found: C, 41.18; H, 5.55; N, 5.10.

Preparation of the Complex 2c

In a flask, the complex **1c** (0.4139 g, 0.752 mmol), aq ammonia (28%, 4.0 mL, 59 mmol), and MeOH (32 mL) were placed. The mixture was stirred at r.t. for 5 h. Evaporation of the solvent gave a crude product of **2c**. Recrystallization by slow diffusion of Et_2O ether into a solution of the crude product in ammonia solution of MeOH (7 mol/L) gave the pure product of **2c** as yellow crystals; yield: 0.4358 g (0.702 mmol, 93%).

^{1}H NMR (500 MHz, CD_3OD): δ = 7.61 (s, 2 H, CH=CH), 4.37–4.31 [m, 2 H, (NC*H*$(CH_3)_2$], 1.78 [s, 15 H, $C_5(CH_3)_5$], 1.55–1.51 [m, 12 H, NCH(C*H*$_3)_2$].

^{13}C{^{1}H} NMR (125.65 MHz, CD_3OD): δ = 151.2 (s, CIr), 121.7 (s, CH=CH), 91.0 [s, $C_5(CH_3)_5$], 53.0 [s, N*C*H(CH_3)], 24.9 [s, NCH(*C*H$_3)$], 24.8 [s, NCH(*C*H$_3)$], 9.2 [s, $C_5(CH_3)_5$].

Anal. Calcd for $C_{19}H_{37}Cl_2N_4Ir\cdot(H_2O)_2$: C, 36.77; H, 6.66; N, 9.03. Found: C, 36.81; H, 6.59; N, 8.84.

Reactions of Cyclohexanamine with Methanol under Various Conditions Shown in Table 1; General Procedure

In a stainless reactor bomb, cyclohexanamine (99 mg, 1.0 mmol), catalyst (0.50 mol% Ir), base (5.0 mol%), and MeOH (1.0 mL) were placed. Then, the reactor was sealed with a stainless stopper, and the mixture was stirred for 17 h at 50 °C. The yield of *N*-methylcyclohexanamine (**5**) and *N*,*N*-dimethylcyclohexanamine (**6**) were determined by GC analysis using naphthalene as an internal standard.

N,*N*-Dimethylation of a Variety of Aliphatic Amines with Methanol Catalyzed by 2c Shown in Table 2; General Procedure

In a stainless reactor bomb, the corresponding aliphatic amine (1.0 mmol), **1c** (0.50 mol%), K_2CO_3 (5.0 mol%), and MeOH (1.0 mL) were placed. Then, the reactor was sealed with a stainless stopper, and the mixture was stirred under indicated conditions. After removing MeOH under reduced pressure, the products were isolated by silica gel column chromatography.

N,*N*-Dimethylcycloheptanamine (Table 2, entry 2)[15]

Yellow oil; yield: 121.6 mg (0.861 mmol, 86%); eluent: hexane/EtOAc/Et_2NH (45:5:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.50–2.45 [m, 1 H, C*H*N$(CH_3)_2$], 2.23 [s, 6 H, N$(CH_3)_2$], 1.81–1.35 (m, 12 H, CH_2).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 65.0 [s, *C*N$(CH_3)_2$], 40.8 [s, N$(CH_3)_2$], 29.5 (s, CH_2), 28.2 (s, CH_2), 25.6 (s, CH_2).

N,*N*-Dimethylcyclooctanamine (Table 2, entry 3)[16]

Yellow oil; yield: 140.5 mg (0.905 mmol, 90%); eluent: hexane/EtOAc/Et_2NH (40:10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.51 [br, 1 H, C*H*N$(CH_3)_2$], 2.21 [s, 6 H, N$(CH_3)_2$], 1.91–1.43 (m, 14 H, CH_2).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 63.7 [s, *C*N$(CH_3)_2$], 40.8 [s, N$(CH_3)_2$], 28.9 (s, CH_2), 26.7 (s, CH_2), 26.5 (s, CH_2), 25.5 (s, CH_2).

N,*N*-Dimethyladamantan-1-amine (Table 2, entry 4)[17]

Yellow oil; yield: 160.7 mg (0.896 mmol, 90%); eluent: hexane/MeOH (25:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.27 [s, 6 H, N$(CH_3)_2$], 2.08 (br, 3 H, CH), 1.73–1.57 (m, 12 H, CH_2).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 53.4 [s, N$(CH_3)_2$], 37.9 [s, *C*N$(CH_3)_2$], 37.0 (s, CH_2), 36.8 (s, CH_2), 29.5 (s, CH).

N,*N*-Dimethyloctan-1-amine (Table 2, entry 6)[18]

Yellow oil; yield: 138.8 mg (0.882 mmol, 88%); eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.24–2.21 [m, 8 H, CH_2N(C$H_3)_2$], 1.46–1.28 (m, 12 H, CH_2), 0.87 (t, *J* = 7 Hz, 3 H, CH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 60.0 [s, *C*N(CH_3)$_2$], 45.5 [s, N(CH_3)$_2$], 31.9 (s, CH_2), 29.6 (s, CH_2), 29.3 (s, CH_2), 27.9 (s, CH_2), 27.5 (s, CH_2), 22.7 (s, CH_2), 14.1 (s, CH_3).

***N,N*-Dimethyloctan-2-amine (Table 2, entry 7)**[19]

Yellow oil; yield: 150.5 mg (0.957 mmol, 95%); eluent: EtOAc/Et_2NH (50:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.50–2.42 (m, 1 H, CH), 2.22 [s, 6 H, N(CH_3)$_2$], 1.51–1.18 (m, 10 H, CH_2), 0.93 (d, *J* = 7 Hz, 3 H, CH_3), 0.88 (t, *J* = 7 Hz, 3 H, CH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 59.2 [s, *C*N(CH_3)$_2$], 40.6 [s, N(CH_3)$_2$], 33.6 (s, CH_2), 31.9 (s, CH_2), 29.7 (s, CH_2), 26.8 (s, CH_2), 22.7 (s, CH_2), 14.1 (s, CH_3), 13.6 (s, CH_3).

***N,N*-Dimethyl(2-methylphenyl)methanamine (Table 2, entry 9)**[20]

Yellow oil; yield: 131.8 mg (0.883 mmol, 88%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.26–7.12 (m, 4 H_{arom}), 3.37 (s, 2 H, CH_2), 2.36 (s, 3 H, Ar*CH*$_3$), 2.24 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 137.3 (s, C_{arom}), 137.2 (s, C_{arom}), 130.3 (s, C_{arom}), 129.9 (s, C_{arom}), 127.1 (s, C_{arom}), 125.6 (s, C_{arom}), 62.1 (s, CH_2), 45.6 [s, N(CH_3)$_2$], 19.2 (s, Ar*C*H$_3$).

***N,N*-Dimethyl(3-methylphenyl)methanamine (Table 2, entry 10)**[20]

Yellow oil; yield: 137.3 mg (0.920 mmol, 92%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21 (t, *J* = 8 Hz, 1 H_{arom}), 7.14 (s, 1 H_{arom}), 7.08 (t, *J* = 6 Hz, 2 H_{arom}), 3.38 (s, 2 H, CH_2), 2.35 (s, 3 H, Ar*CH*$_3$), 2.24 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 138.8 (s, C_{arom}), 137.8 (s, C_{arom}), 129.8 (s, C_{arom}), 128.1 (s, C_{arom}), 127.8 (s, C_{arom}), 126.2 (s, C_{arom}), 64.4 (s, CH_2), 45.4 [s, N(CH_3)$_2$], 21.4 (s, Ar*C*H$_3$).

***N,N*-Dimethyl(4-methylphenyl)methanamine (Table 2, entry 11)**[20]

Yellow oil; yield: 139.3 mg (0.933 mmol, 93%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.19 (d, *J* = 8 Hz, 2 H_{arom}), 7.13 (d, *J* = 8 Hz, 2 H_{arom}), 3.38 (s, 2 H, CH_2), 2.34 (s, 3 H, Ar*CH*$_3$), 2.23 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 136.5 (s, C_{arom}), 135.8 (s, C_{arom}), 129.0 (s, C_{arom}), 128.9 (s, C_{arom}), 64.1 (s, CH_2), 45.3 [s, N(CH_3)$_2$], 21.1 (s, Ar*C*H$_3$).

***N,N*-Dimethyl(4-methoxyphenyl)methanamine (Table 2, entry 12)**[20]

Yellow oil; yield: 160.5 mg (0.971 mmol, 97%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22–7.20 (m, 2 H_{arom}), 6.87–6.84 (m, 2 H_{arom}), 3.80 (s, 3 H, OCH_3), 3.35 (s, 2 H, CH_2), 2.22 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 158.6 (s, C_{arom}), 130.8 (s, C_{arom}), 130.1 (s, C_{arom}), 113.4 (s, C_{arom}), 63.6 (s, CH_2), 55.0 (s, OCH_3), 45.1 [s, N(CH_3)$_2$].

***N,N*-Dimethyl(2-chlorophenyl)methanamine (Table 2, entry 13)**[20]

Yellow oil; yield: 164.3 mg (0.968 mmol, 97%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.42–7.35 (m, 2 H_{arom}), 7.26–7.17 (m, 2 H_{arom}), 3.53 (s, 2 H, CH_2), 2.30 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 136.4 (s, C_{arom}), 134.3 (s, C_{arom}), 130.9 (s, C_{arom}), 129.4 (s, C_{arom}), 128.2 (s, C_{arom}), 126.6 (s, C_{arom}), 60.8 (s, CH_2), 45.1 [s, N(CH_3)$_2$].

***N,N*-Dimethyl(3-chlorophenyl)methanamine (Table 2, entry 14)**[20]

Yellow oil; yield: 158.6 mg (0.935 mmol, 93%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21–7.11 (m, 4 H_{arom}), 3.33 (s, 2 H, CH_2), 2.18 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 141.2 (s, C_{arom}), 134.2 (s, C_{arom}), 129.5 (s, C_{arom}), 129.0 (s, C_{arom}), 127.2 (s, C_{arom}), 127.1 (s, C_{arom}), 63.8 (s, CH_2), 45.4 [s, N(CH_3)$_2$].

***N,N*-Dimethyl(4-chlorophenyl)methanamine (Table 2, entry 15)**[20]

Yellow oil; yield: 166.9 mg (0.984 mmol, 98%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.30–7.22 (m, 4 H_{arom}), 3.38 (s, 2 H, CH_2), 2.22 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 137.5 (s, C_{arom}), 132.7 (s, C_{arom}), 130.3 (s, C_{arom}), 128.4 (s, C_{arom}), 63.6 (s, CH_2), 45.3 [s, N(CH_3)$_2$].

***N,N*-Dimethyl(4-cyanophenyl)methaneamine (Table 2, entry 16)**[20]

Yellow oil; yield: 120.1 mg (0.750 mmol, 75%); eluent: hexane/EtOAc/Et_2NH (30:20:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.62–7.60 (m, 2 H_{arom}), 7.44–7.42 (m, 2 H_{arom}), 3.46 (s, 2 H, CH_2), 2.24 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 144.7 (s, C_{arom}), 132.0 (s, C_{arom}), 129.4 (s, C_{arom}), 118.9 (s, C_{arom}), 110.7 (s, C_{arom}), 63.7 (s, CH_2), 45.3 [s, N(CH_3)$_2$].

***N,N*-Dimethyl(4-trifluoromethylphenyl)methanamine (Table 2, entry 17)**[21]

Yellow oil; yield: 156.1 mg (0.768 mmol, 77%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.57 (d, *J* = 8 Hz, 2 H_{arom}), 7.43 (d, *J* = 8 Hz, 2 H_{arom}), 3.47 (s, 2 H, CH_2), 2.25 [s, 6 H, N(CH_3)$_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 143.3 (s, C_{arom}), 129.4 (q, *J* = 32 Hz, C_{arom}), 129.2 (s, C_{arom}), 125.3 (q, *J* = 4 Hz, C_{arom}), 124.4 (q, *J* = 271 Hz, CF_3), 63.9 (s, CH_2), 45.5 [s, N(CH_3)$_2$].

***N,N*-Dimethyl-1-phenylethan-1-amine (Table 2, entry 18)**[22]

Yellow oil; yield: 137.1 mg (0.919 mmol, 92%); eluent: hexane/EtOAc/Et_2NH (40:10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.33–7.21 (m, 5 H_{arom}), 3.24 (q, *J* = 7 Hz, 1 H, CH), 2.20 [s, 6 H, N(CH_3)$_2$], 1.37 (d, *J* = 7 Hz, 3 H, CH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 144.2 (s, C_{arom}), 128.2 (s, C_{arom}), 127.5 (s, C_{arom}), 126.9 (s, C_{arom}), 66.0 (s, *C*HCH$_3$), 43.3 [s, N(CH_3)$_2$], 20.3 (s, CH*C*H$_3$).

***N,N*-Dimethyl-1-(4-methoxyphenyl)ethan-1-amine (Table 2, entry 19)**[23]

Yellow oil; yield: 172.4 mg (0.962 mmol, 96%); eluent: hexane/EtOAc/Et_2NH (95:5:2).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22–7.18 (m, 2 H_{arom}), 6.87–6.84 (m, 2 H_{arom}), 3.80 (s, 3 H, OCH_3), 3.21 (q, *J* = 7 Hz, 1 H, CH), 2.18 [s, 6 H, N(CH_3)$_2$], 1.35 (d, *J* = 7 Hz, 3 H, CH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 158.4 (s, C_{arom}), 135.9 (s, C_{arom}), 128.4 (s, C_{arom}), 113.4 (s, C_{arom}), 65.1 (s, *C*HCH$_3$), 55.0 (s, OCH$_3$), 43.0 [s, N(CH$_3$)$_2$], 20.1 (s, CH*C*H$_3$).

N,*N*-Dimethyl-1-(4-chlorophenyl)ethan-1-amine (Table 2, entry 20)[24]

Yellow oil; yield: 164.3 mg (0.895 mmol, 90%); eluent: hexane/EtOAc/Et$_2$NH (49:1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.16–7.12 (m, 2 H_{arom}), 7.03–6.99 (m, 2 H_{arom}), 2.90 (q, *J* = 7 Hz, 1 H, CH), 1.99 [s, 6 H, N(CH$_3$)$_2$], 1.08 (d, *J* = 7 Hz, 3 H, CH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 144.0 (s, C_{arom}), 132.6 (s, C_{arom}), 129.0 (s, C_{arom}), 128.7 (s, C_{arom}), 65.3 (s, *C*HCH$_3$), 43.2 [s, N(CH$_3$)$_2$], 20.5 (s, CH*C*H$_3$).

Reactions of Aniline with Methanol under Various Conditions Shown in Table 3; General Procedure

In a stainless reactor bomb, aniline (93 mg, 1.0 mmol), catalyst (0.50 mol% Ir), K_2CO_3 (5.0 mol%), and MeOH (1.0 mL) were placed. Then, the reactor was sealed with a stainless stopper, and the mixture was stirred for 17 h at 110 °C. The yield of *N*-methylaniline (**7**) and *N*,*N*-dimethylaniline (**8**) were determined by GC analysis using naphthalene as an internal standard.

N-Monomethylation of a Variety of Aromatic Amines with Methanol Catalyzed by 4c Shown in Scheme 1; General Procedure

In a stainless reactor bomb, the respective aromatic amine (1.0 mmol), **4c** (0.50 mol%), K_2CO_3 (5.0 mol%), and MeOH (1.0 mL) were placed. Then, the reactor was sealed with a stainless stopper, and the mixture was stirred for 17 h at 120 °C. After removing MeOH under reduced pressure, the products were isolated by silica gel column chromatography.

N-Methylaniline[25]

Colorless oil; yield: 96.2 mg (0.898 mmol, 89%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22–7.17 (m, 2 H_{arom}), 6.73–6.70 (m, 1 H_{arom}), 6.63–6.61 (m, 2 H_{arom}), 3.70 (br, 1 H, NH), 2.84 (s, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 149.1 (s, C_{arom}), 128.8 (s, C_{arom}), 116.6 (s, C_{arom}), 112.0 (s, C_{arom}), 30.1 (s, NCH$_3$).

N-Methyl-*m*-toluidine[25]

Yellow oil; yield: 108.7 mg (0.897 mmol, 90%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.10–7.06 (m, 1 H_{arom}), 6.54 (d, *J* = 8 Hz, 1 H_{arom}), 6.44–6.43 (m, 2 H_{arom}), 3.65 (br, 1 H, NH), 2.83 (s, 3 H, NCH$_3$), 2.29 (s, 3 H, ArC*H*$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 149.5 (s, C_{arom}), 139.0 (s, C_{arom}), 129.1 (s, C_{arom}), 118.2 (s, C_{arom}), 113.2 (s, C_{arom}), 109.7 (s, C_{arom}), 30.8 (s, NCH$_3$), 21.7 (s, Ar*C*H$_3$).

N-Methyl-*p*-toluidine[25]

Colorless oil; yield: 101.5 mg (0.838 mmol, 84%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.01 (d, *J* = 8 Hz, 2 H_{arom}), 6.57–6.54 (m, 2 H_{arom}), 3.57 (br, 1 H, NH), 2.82 (s, 3 H, NCH$_3$), 2.24 (s, 3 H, ArC*H*$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 147.2 (s, C_{arom}), 129.7 (s, C_{arom}), 126.4 (s, C_{arom}), 112.6 (s, C_{arom}), 31.1 (s, NCH$_3$), 20.4 (s, Ar*C*H$_3$).

N-Methyl-4-methoxyaniline[25]

White solid; yield: 115.7 mg (0.843 mmol, 84%); mp 35.1–36.6 °C; eluent: hexane/EtOAc (25:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.82–6.78 (m, 2 H_{arom}), 6.62–6.57 (m, 2 H_{arom}), 3.75 (s, 3 H, OCH$_3$), 3.45 (br, 1 H, NH), 2.81 (s, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 152.0 (s, C_{arom}), 143.7 (s, C_{arom}), 114.9 (s, C_{arom}), 113.6 (s, C_{arom}), 55.8 (s, OCH$_3$), 31.6 (s, NCH$_3$).

N-Methyl-3-chloroaniline[25]

Yellow oil; yield: 135.2 mg (0.955 mmol, 96%); eluent: hexane/EtOAc (200:3).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.08 (t, *J* = 8 Hz, 1 H_{arom}), 6.67–6.65 (m, 1 H_{arom}), 6.58–6.57 (m, 1 H_{arom}), 6.48–6.46 (m, 1 H_{arom}), 3.80 (br, 1 H, NH), 2.82 (s, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 150.4 (s, C_{arom}), 134.9 (s, C_{arom}), 130.1 (s, C_{arom}), 116.8 (s, C_{arom}), 111.8 (s, C_{arom}), 110.8 (s, C_{arom}), 30.4 (s, NCH$_3$).

N-Methyl-4-chloroaniline[25]

Yellow oil; yield: 128.1 mg (0.905 mmol, 91%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15–7.11 (m, 2 H_{arom}), 6.55–6.51 (m, 2 H_{arom}), 3.72 (br, 1 H, NH), 2.81 (s, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 147.9 (s, C_{arom}), 128.9 (s, C_{arom}), 121.5 (s, C_{arom}), 113.4 (s, C_{arom}), 30.7 (s, NCH$_3$).

N-Methyl-4-bromoaniline[5e]

Colorless oil; yield: 165.6 mg (0.890 mmol, 89%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.28–7.24 (m, 2 H_{arom}), 6.50–6.46 (m, 2 H_{arom}), 3.73 (br, 1 H, NH), 2.81 (s, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 148.3 (s, C_{arom}), 131.8 (s, C_{arom}), 113.9 (s, C_{arom}), 108.6 (s, C_{arom}), 30.7 (s, NCH$_3$).

N-Methyl-3-nitroaniline[4d]

Orange solid; yield: 133.2 mg (0.875 mmol, 87%); mp 64.8–66.1 °C; eluent: CH_2Cl_2.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.54–7.51 (m, 1 H_{arom}), 7.39 (t, *J* = 2 Hz, 1 H_{arom}), 7.28 (t, *J* = 8 Hz, 1 H_{arom}), 6.88–6.85 (m, 1 H_{arom}), 4.06 (br, 1 H, NH), 2.91 (d, *J* = 5 Hz, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 150.1 (s, C_{arom}), 149.5 (s, C_{arom}), 129.7 (s, C_{arom}), 118.6 (s, C_{arom}), 111.8 (s, C_{arom}), 105.8 (s, C_{arom}), 30.6 (s, NCH$_3$).

N-Methyl-4-nitroaniline[5c]

Yellow solid; yield: 139.6 mg (0.918 mmol, 92%); mp 149.5–150.9 °C; eluent: CH_2Cl_2.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.13–8.01 (m, 2 H_{arom}), 6.55–6.51 (m, 2 H_{arom}), 4.54 (br, 1 H, NH), 2.94 (d, *J* = 6 Hz, 3 H, NCH$_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 154.3 (s, C_{arom}), 138.0 (s, C_{arom}), 126.5 (s, C_{arom}), 110.8 (s, C_{arom}), 30.3 (s, NCH$_3$).

N-Methyl-4-cyanoaniline[25]

White solid; yield: 124.0 mg (0.938 mmol, 94%); mp 86.1–87.7 °C; eluent: hexane/EtOAc (100:1 to 7:3).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.45–7.42 (m, 2 H_{arom}), 6.57–6.54 (m, 2 H_{arom}), 4.26 (br, 1 H, NH), 2.88 (d, *J* = 6 Hz, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 152.4 (s, C_{arom}), 133.5 (s, C_{arom}), 120.8 (s, CN), 111.7 (s, C_{arom}), 97.6 (s, C_{arom}), 29.7 (s, NCH_3).

***N*-[4-(Methylamino)phenyl]acetamide**[26]

Brown solid; yield: 146.2 mg (0.890 mmol, 89%); mp 92.4–93.8 °C; eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.27–7.24 (m, 2 H_{arom}), 6.61–6.57 (m, 2 H_{arom}), 2.75 (s, 3 H, NCH_3), 2.07 (s, 3 H, $COCH_3$).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 171.1 (s, CO), 148.4 (s, C_{arom}), 129.5 (s, C_{arom}), 123.3 (s, C_{arom}), 113.6 (s, C_{arom}), 31.1 (s, NCH_3), 23.5 (s, $COCH_3$).

***N*-Methylpyridin-2-amine**[27]

Yellow oil; yield: 81.1 mg (0.750 mmol, 75%); eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–8.08 (m, 1 H_{arom}), 7.45–7.41 (m, 1 H_{arom}), 6.59–6.56 (m, 1 H_{arom}), 6.39 (d, *J* = 9 Hz, 1 H_{arom}), 4.50 (br, 1 H, NH), 2.92 (d, *J* = 5 Hz, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 159.7 (s, C_{arom}), 148.2 (s, C_{arom}), 137.5 (s, C_{arom}), 112.8 (s, C_{arom}), 106.2 (s, C_{arom}), 29.2 (s, NCH_3).

***N*-Methylpyridin-3-amine**[28]

Yellow oil; yield: 105.2 mg (0.973 mmol, 98%); eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.04–7.96 (m, 2 H_{arom}), 7.10 (dd, *J* = 8, 5 Hz, 1 H_{arom}), 6.88–6.85 (m, 1 H_{arom}), 3.76 (br, 1 H, NH), 2.86 (s, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 145.3 (s, C_{arom}), 138.0 (s, C_{arom}), 135.4 (s, C_{arom}), 123.6 (s, C_{arom}), 117.8 (s, C_{arom}), 30.0 (s, NCH_3).

***N*-Methylpyridin-4-amine**[4d]

White solid; yield: 90.1 mg (0.833 mmol, 84%); mp 123.5–124.8 °C; eluent: hexane/EtOAc (3:1 to 1:0).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.21–8.19 (m, 2 H_{arom}), 6.44–6.42 (m, 2 H_{arom}), 4.22 (br, 1 H, NH), 2.86–2.85 (m, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 154.4 (s, C_{arom}), 149.7 (s, C_{arom}), 107.2 (s, C_{arom}), 29.2 (s, NCH_3).

***N*-Methylpyrazin-2-amine**[27]

Yellow oil; yield: 105.5 mg (0.967 mmol, 97%); eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.00–7.99 (m, 1 H_{arom}), 7.89 (d, *J* = 2 Hz, 1 H_{arom}), 7.81 (d, *J* = 3 Hz, 1 H_{arom}), 3.60 (br, 1 H, NH), 2.98 (d, *J* = 5 Hz, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 155.3 (s, C_{arom}), 141.7 (s, C_{arom}), 131.9 (s, C_{arom}), 131.8 (s, C_{arom}), 28.0 (s, NCH_3).

***N*-Methylnaphthalen-1-amine**[5c]

Yellow oil; yield: 119.0 mg (0.757 mmol, 76%); eluent: hexane/EtOAc (100:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.83–7.77 (m, 2 H_{arom}), 7.48–7.37 (m, 3 H_{arom}), 7.26–7.24 (m, 1 H_{arom}), 6.62 (d, *J* = 8 Hz, 1 H_{arom}), 4.50 (br, 1 H, NH), 3.03 (s, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 144.6 (s, C_{arom}), 134.2 (s, C_{arom}), 128.7 (s, C_{arom}), 126.7 (s, C_{arom}), 125.7 (s, C_{arom}), 124.7 (s, C_{arom}), 123.4 (s, C_{arom}), 119.9 (s, C_{arom}), 117.3 (s, C_{arom}), 31.0 (s, NCH_3).

***N*-Methylisoquinolin-4-amine**

Brown solid; yield: 154.7 mg (0.978 mmol, 97%); mp 113.2–114.8 °C; eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.71 (s, 1 H_{arom}), 7.92 (d, *J* = 8 Hz, 1 H_{arom}), 7.87 (s, 1 H_{arom}), 7.77 (d, *J* = 8 Hz, 1 H_{arom}), 7.67–7.56 (m, 2 H_{arom}), 4.29 (br, 1 H, NH), 3.08 (d, *J* = 5 Hz, 3 H, NCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 141.2 (s, C_{arom}), 139.0 (s, C_{arom}), 128.6 (s, C_{arom}), 128.2 (s, C_{arom}), 127.5 (s, C_{arom}), 126.7 (s, C_{arom}), 125.6 (s, C_{arom}), 122.2 (s, C_{arom}), 119.4 (s, C_{arom}), 30.4 (s, NCH_3).

Anal. Calcd for $C_{10}H_{10}N_2$: C, 75.91; H, 6.38; N, 17.71. Found: C, 75.85; H, 6.58; N, 17.58.

***N*,*N*-Dimethylation of a Variety of Aromatic Amines with Methanol Catalyzed by 4a Shown in Scheme 2; General Procedure**

In a stainless reactor bomb, the respective aromatic amine (1.0 mmol), **4a** (2.0 mol%), and MeOH (1.0 mL) were placed. Then, the reactor was sealed with a stainless stopper, and the mixture was stirred for 17 h at 120 °C. After removing MeOH under reduced pressure, the products were isolated by silica gel column chromatography.

***N*,*N*-Dimethylaniline**[29]

Colorless oil; yield: 112.1 mg (0.925 mmol, 93%); eluent: hexane/EtOAc (2:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.28–7.22 (m, 2 H_{arom}), 6.77–6.71 (m, 3 H_{arom}), 2.95 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 150.8 (s, C_{arom}), 129.2 (s, C_{arom}), 116.8 (s, C_{arom}), 112.8 (s, C_{arom}), 40.8 (s, CH_3).

***N*,*N*-Dimethyl-*o*-toluidine**[29]

Colorless oil; yield: 110.8 mg (0.820 mmol, 82%); eluent: hexane/EtOAc (10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.18–7.14 (m, 2 H_{arom}), 7.05–7.03 (m, 1 H_{arom}), 6.97–6.93 (m, 2 H_{arom}), 2.70 [s, 6 H, $N(CH_3)_2$], 2.33 (s, 3 H, ArCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 152.9 (s, C_{arom}), 132.2 (s, C_{arom}), 131.3 (s, C_{arom}), 126.6 (s, C_{arom}), 122.7 (s, C_{arom}), 118.5 (s, C_{arom}), 44.4 [s, $N(CH_3)_2$], 18.5 (s, ArCH_3).

***N*,*N*-Dimethyl-*m*-toluidine**[29]

Colorless oil; yield: 129.9 mg (0.961 mmol, 96%); eluent: hexane/EtOAc (10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.16–7.12 (m, 1 H_{arom}), 6.58–6.55 (m, 3 H_{arom}), 2.93 [s, 6 H, $N(CH_3)_2$], 2.33 (s, 3 H, ArCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 150.8 (s, C_{arom}), 138.7 (s, C_{arom}), 129.0 (s, C_{arom}), 117.7 (s, C_{arom}), 113.5 (s, C_{arom}), 110.0 (s, C_{arom}), 40.7 [s, $N(CH_3)_2$], 22.0 (s, ArCH_3).

***N*,*N*-Dimethyl-*p*-toluidine**[29]

Colorless oil; yield: 128.0 mg (0.947 mmol, 95%); eluent: hexane/EtOAc (10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.06 (d, *J* = 8 Hz, 2 H_{arom}), 6.71–6.68 (m, 2 H_{arom}), 2.90 [s, 6 H, $N(CH_3)_2$], 2.26 (s, 3 H, ArCH_3).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 147.9 (s, C_{arom}), 129.6 (s, C_{arom}), 126.1 (s, C_{arom}), 113.3 (s, C_{arom}), 41.1 [s, $N(CH_3)_2$], 20.3 (s, $ArCH_3$).

***N*,*N*-Dimethyl-4-methoxyaniline**[29]

Yellow oil; yield: 146.0 mg (0.966 mmol, 97%); eluent: hexane/EtOAc (4:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.93–6.89 (m, 2 H_{arom}), 6.83–6.80 (m, 2 H_{arom}), 3.81 (s, 3 H, OCH_3), 2.92 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 152.0 (s, C_{arom}), 145.7 (s, C_{arom}), 114.8 (s, C_{arom}), 114.5 (s, C_{arom}), 55.6 (s, OCH_3), 41.7 [s, $N(CH_3)_2$].

***N*,*N*-Dimethyl-4-hydroxyaniline**[30]

Orange solid; yield: 131.9 mg (0.962 mmol, 96%); mp 75.8–77.2 °C; eluent: hexane/EtOAc (1:1).

^{1}H NMR (500 MHz, CD_3OD): δ = 6.79–6.77 (m, 2 H_{arom}), 6.72–6.69 (m, 2 H_{arom}), 4.90 (br, 1 H, OH), 2.76 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (126 MHz, $CDCl_3$): δ = 151.6 (s, C_{arom}), 146.2 (s, C_{arom}), 118.0 (s, C_{arom}), 116.6 (s, C_{arom}), 43.2 [s, $N(CH_3)_2$].

***N*,*N*-Dimethyl-3-chloroaniline**[29]

Colorless oil; yield: 154.9 mg (0.999 mmol, quant.); eluent: hexane/EtOAc (10:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15–7.11 (m, 1 H_{arom}), 6.68–6.66 (m, 2 H_{arom}), 6.60–6.57 (m, 1 H_{arom}), 2.94 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 151.5 (s, C_{arom}), 135.0 (s, C_{arom}), 123.0 (s, C_{arom}), 116.1 (s, C_{arom}), 112.2 (s, C_{arom}), 110.5 (s, C_{arom}), 40.4 [s, $N(CH_3)_2$].

***N*,*N*-Dimethyl-4-chloroaniline**[29]

Orange solid; yield: 152.9 mg (0.983 mmol, 98%); mp 33.6–34.8 °C; eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21–7.17 (m, 2 H_{arom}), 6.67–6.63 (m, 2 H_{arom}), 2.94 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 149.1 (s, C_{arom}), 128.8 (s, C_{arom}), 121.4 (s, C_{arom}), 113.7 (s, C_{arom}), 40.7 [s, $N(CH_3)_2$].

***N*,*N*-Dimethyl-3-nitroaniline**[31]

Red solid; yield: 138.0 mg (0.830 mmol, 83%); mp 57.0–58.9 °C; eluent: hexane/EtOAc (1:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.53–7.48 (m, 2 H_{arom}), 7.33 (t, J = 8 Hz, 1 H_{arom}), 6.97–6.94 (m, 1 H_{arom}), 3.04 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (101 MHz, $CDCl_3$): δ = 150.8 (s, C_{arom}), 149.3 (s, C_{arom}), 129.6 (s, C_{arom}), 117.7 (s, C_{arom}), 110.7 (s, C_{arom}), 106.1 (s, C_{arom}), 40.4 [s, $N(CH_3)_2$].

***N*-[4-(Dimethylamino)phenyl]acetamide**[32]

Yellow oil; yield: 172.9 mg (0.970 mmol, 97%); eluent: hexane/EtOAc (1:1).

^{1}H NMR (500 MHz, DMSO-d_6): δ = 9.62 (br, 1 H, NHCO), 7.37–7.35 (m, 2 H_{arom}), 6.68–6.65 (m, 2 H_{arom}), 2.82 [s, 6 H, $N(CH_3)_2$], 1.97 (s, 3 H, $COCH_3$).

^{13}C NMR (126 MHz, DMSO-d_6): δ = 167.9 (s, NHCO), 147.2 (s, C_{arom}), 129.3 (s, C_{arom}), 120.8 (s, C_{arom}), 112.9 (s, C_{arom}), 40.7 [s, $N(CH_3)_2$], 23.9 (s, $COCH_3$).

***N*,*N*-Dimethylnaphthalen-1-amine**[33]

Brown oil; yield: 135.2 mg (0.790 mmol, 79%); eluent: hexane/EtOAc (99:1).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25–8.23 (m, 1 H_{arom}), 7.83–7.81 (m, 1 H_{arom}), 7.53–7.44 (m, 3 H_{arom}), 7.42–7.38 (m, 1 H_{arom}), 7.09–7.07 (m, 1 H_{arom}), 2.91 [s, 6 H, $N(CH_3)_2$].

^{13}C NMR (126 MHz, $CDCl_3$): δ = 150.9 (s, C_{arom}), 134.9 (s, C_{arom}), 128.9 (s, C_{arom}), 128.4 (s, C_{arom}), 125.9 (s, C_{arom}), 125.8 (s, C_{arom}), 125.2 (s, C_{arom}), 124.3 (s, C_{arom}), 123.0 (s, C_{arom}), 114.0 (s, C_{arom}), 45.3 [s, $N(CH_3)_2$].

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Supporting Information

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