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Copper(I)-Catalyzed N-Arylation of N^1,N^3-Dibenzylmalonamide and N^1,N^3-Dibutylmalonamide Followed by Cleavage of the Malonyl Group with Aryl Halides Under Ligand-Free Conditions

W.J. ZHENG[1], W.F. XU[1], C.X. SHI[2], F.B. REN[1,3], X.L. LU[1,*] and Y.F. ZHOU[1,3,*]

[1]Zhejiang Provincial Key Laboratory of Biometrology and Inspection & Quarantine, College of Life Sciences, China Jiliang University, Zhejiang 310018, P.R. China
[2]School of Environmental and Chemical Engineering, Shanghai University, 99 Shangda Road, BaoShan District 200444, Shanghai, P.R. China
[3]Zhejiang Apeloa Medical Technology Co. Ltd, Dongyang 322118, P.R. China

*Corresponding authors: Fax: +86 571 86914449; Tel: +86 571 86835702; E-mail: cjluyh@163.com

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We primarily developed a practical and convenient protocol to synthesize of aromatic amines based on CuI-catalyzed N-arylation of N^1,N^3-dibenzylmalonamide and N^1,N^3-dibutylmalonamide followed by cleavage of the malonyl group with aryl halides under ligand-free conditions giving good yields.

Key Words: Copper, Cleavage, Cross-coupling, N^1,N^3-Dibenzylmalonamide, N^1,N^3-Ditutylmalonamide.

INTRODUCTION

Transition-metal-catalyzed amination of aryl halides is considered to be an important strategy that finds wide applications in the synthesis of many substances, such as natural products, agrochemicals, materials, dyes and pharmaceuticals[1]. A number of transition metals, such as Pd[2], Cu[3], Fe[4], $Cd(OAc)_2$[5], $MnCl_2$[6] are among the most widely used metals to perform such carbon-nitrogen bond-forming progress. Migita and co-workers[7] first reported the cross coupling of tributyltin amide with aryl bromide catalyzed by $PdCl_2[P(o\text{-}C_6H_4Me)_3]_2$. Although highly efficient methods are currently available, ligands would be applied in most of these successful examples. Iron complexes need amino acid[8] and DMEDA[9] ligands, palladium bearing sterically hindered phosphine ligands and copper complexes having electron-rich ligands such as ethyl 2-oxocyclohexanecarboxylate[10], natural alkaloids[11], diazaphospholane[12], amino acids[13], BINOL[14,15], pyrrol-2-carbohydrazides[16], sulfonato-Cu(salen) complex[17], oxalyldihydrazide[18,19], dimines[20,21], 2-hydroxybenzaldehyde N-phenylhydrazone[22], 2,2-biimidazole[23]. Wang and Ding[24] reported CuI-catalyzed N-arylation of aryl halides with CuI and 2-pyridinyl β-ketones as the ligand, but no product obtained without ligand. Wu and co-workers[17] found sulfonato-Cu(salen) complex catalyzed N-arylation of aliphatic amines with aryl halides in high yields, but the experiments carried out in the absence of catalyst led to trace yields. Some ligand-free reactions have been employed, but with the drawbacks including low yields or long reaction time[25]. Although there are significant improvements in the arylation of amines, little information on the N-arylation of acidamines followed by-cleavage of the acyl group with arylhalides. Bolm and co-workers[26] reported that iron-catalyzed arylation of N-acetylation-protecting anilines, followed by NH-liberation of the resulting arylated products was proposed to provide aromatic amines. To the best of our knowledge, there was little known about monoarylation of N-acylation-protecting alicyclic amines to acquire N-arylated aliphatic amines. In this study, our focus is to explore a new method of C-N bond formation: CuI-catalyzed N-arylation of aliphatic amines followed by cleavage of the malonyl group with aryl halides under ligand-free conditions.

EXPERIMENTAL

All the commercial chemicals were obtained from Sinopharm Chemical Reagent Co. Ltd. or J & K and used without further purification. Solvents for synthesis purposes were used at AR grade. Analytical TLC was performed using Qingdao Haiyang Chemical Co., Ltd. GF254 silica gel plates. Visualization was by UV light (254 nm). NMR spectra were recorded in a Bruker DPX-400 Avance spectrometer, operating at 400 MHz for ^{1}H NMR; 100 MHz for ^{13}C NMR. ESI-MS spectra were measured with a Thermo Fisher LCQ Fleet manual sampler with methanol as carrier solvent.

General procedure: A solution of diethyl malonate (16 g, 10 mmol), *n*-butylamine (5.84 g, 80 mmol) or benzylamine

(8.56 g, 80 mmol), xylene 80 mL in dry round flask refluxed for 2 h. The reaction was cooled to room temperature and for formation of crystals, filtered to afford the product N^1,N^3-dibutylmalonamide and N^1,N^3-dibenzylmalonamide[27].

All reactions were carried out under a nitrogen atmosphere with N^1,N^3-dibutylmalonamide or N^1,N^3-dibenzylmalonamide (2 mmol) and aryl halides (1 mmol) were allowed to react with CuI (9.5 mg, 0.05 mmol), KOt-Bu (0.34 g, 3 mmol), H_2O (90 mg, 5 mmol), DMSO 4 mL at 160 ºC for 8 h in PTFE airtight reaction. The reaction mixture was filtered and washed with 30 mL ethyl acetate after the reaction finished, the filtrate was washed with water and dried over Na_2SO_4, concentrated *in vacuo*. The residue was purified by silica gel chromatography to provide the desired product.

Spectral data of product

N^1,N^3-Dibutylmalonamide (I): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.24 (dd, *J* = 14.0, 7.9 Hz, 6H), 1.54-1.40 (m, 4H), 1.38-1.30 (m, 4H), 0.92 (t, *J* = 7.4 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 167.67, 43.09, 39.30, 31.28, 21.01, 13.65; ESI-MS: m/z 451.58 $[2M+Na]^+$.

N^1,N^3-Dibenzylmalonamide(II): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.64 (s, 2H), 7.26 (ddd, *J* = 17.4, 7.0 Hz, 10H), 4.36 (d, *J* = 5.7 Hz, 4H), 3.20 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 167.41, 137.80, 128.67, 127.55, 43.54, 42.98; ESI-MS: m/z 587.26 $[2M+Na]^+$.

N-Butylaniline (Table-4, entry 1 and 2): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.18 (dd, *J* = 22.0, 14.3 Hz), 6.68 (t, *J* = 7.3 Hz, 1H), 6.60 (d, *J* = 7.8 Hz, 2H), 3.59 (s, 1H), 3.10 (t, *J* = 7.1 Hz, 2H), 1.64-1.56 (m, 2H), 1.47-1.38 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.55, 129.24, 117.10, 112.71, 43.70, 31.70, 20.33, 13.94; ESI-MS: m/z 150.12 $[M+H]^+$.

N-Butyl-2-methylaniline (Table-4, entry 3): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.12 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 7.1 Hz, 1H), 6.64 (dd, *J* = 12.1, 7.7 Hz, 2H), 3.15 (t, *J* = 7.1 Hz, 2H), 2.13 (s, 3H), 1.67-1.62 (m, 2H), 1.48-1.41 (m, 2H), 0.97 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.28, 130.04, 127.15, 112.80, 116.76, 109.79, 43.75, 31.69, 20.40, 17.47, 13.96; ESI-MS: m/z 164.02 $[M+H]^+$.

N-Butyl-3-methylaniline (Table-4, entry 4): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.05 (t, *J* = 7.7 Hz, 1H), 6.51 (d, *J* = 7.4 Hz, 1H), 6.41 (d, *J* = 7.4 Hz, 2H), 3.53 (s, 1H), 3.09 (t, *J* = 7.1 Hz, 2H), 2.27 (s, 3H), 1.59-1.55 (m, 2H), 1.47-1.37 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.60, 138.99, 129.11, 118.06, 113.50, 109.90, 43.73, 31.74, 21.65, 20.33, 13.94; ESI-MS: m/z 164.02 $[M+H]^+$.

N-Butyl-4-methylaniline (Table-4, entry 5): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.98 (d, *J* = 8.2 Hz, 2H), 6.53 (d, *J* = 8.3 Hz, 2H), 3.39 (s, 1H), 3.09-3.06 (m, 2H), 2.23 (s, 3H), 1.58-1.55 (m, 2H), 1.46-1.37 (m, 2H), 0.94(t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.32, 129.73, 126.32, 112.95, 44.11, 31.76, 20.40, 20.37, 13.96; ESI-MS: m/z 164.05 $[M+H]^+$.

N-Butyl-2-methoxyaniline (Table-4, entry 6): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.88-6.80 (m, 1H), 6.75 (dd, *J* = 7.8, 0.9 Hz, 1H), 6.63 (ddd, *J* = 11.3, 8.3, 1.2 Hz, 2H), 4.16 (s, 1H), 3.83 (s, 3H), 3.11 (m, 2H), 1.67-1.60 (m, 2H), 1.44 (dd, *J* = 15.1, 7.4 Hz, 2H), 0.95 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.75, 138.54, 121.33, 116.09, 109.35, 55.40, 43.42, 31.68, 20.42, 13.98; ESI-MS: m/z 180.04 $[M+H]^+$.

N-Butyl-3-methoxyaniline (Table-4, entry 7): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.06 (t, *J* = 8.1 Hz, 1H), 6.26-6.20 (m, 2H), 6.15 (s, 1H), 3.76 (s, 3H), 3.09 (t, *J* = 7.1 Hz, 2H), 1.63-1.55 (m, 2H), 1.46-1.39 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.88, 149.94, 129.94, 105.96, 102.19, 98.63, 55.07, 43.70, 31.64, 20.31, 13.92; ESI-MS: m/z 180.04 $[M+H]^+$.

N-Butyl-4-methoxyaniline (Table-4, entry 8): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.78 (d, *J* = 8.2 Hz, 2H), 6.58 (d, *J* = 8.3 Hz, 2H), 3.74 (s, 3H), 3.06 (t, *J* = 7.0 Hz, 2H), 1.62-1.55 (m, 2H), 1.47-1.37 (m, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 152.01, 142.83, 114.92, 55.85, 44.76, 31.79, 29.72, 20.34, 13.95; ESI-MS: m/z 180.02 $[M+H]^+$.

N-Butylnaphthalen-1-amine (Table-4, entry 9): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.79 (dd, *J* = 8.7, 6.1 Hz, 2H), 7.39-7.34 (m, 2H), 7.32 (t, *J* = 7.9 Hz, 1H), 7.24-7.21 (m, 1H), 6.62 (d, *J* = 7.5 Hz, 1H), 3.27 (t, *J* = 7.1 Hz, 2H), 1.80-1.72 (m, 2H), 1.53-1.47 (m, 2H), 1.00 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 143.55, 134.33, 128.69, 126.68, 125.67, 124.62, 123.36, 119.80, 117.17, 104.33, 44.02, 31.53, 20.53, 14.00; ESI-MS: m/z 200.14 $[M+H]^+$.

N-Benzylaniline (Table-4, entry 10, 11, 12): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.28-7.24 (m, 4H), 7.19-7.16 (m, 1H), 7.16-7.14 (m, 2H), 6.71 (t, *J* = 7.3 Hz, 1H), 6.62 (d, *J* = 7.7 Hz, 2H), 4.30 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.15, 139.46, 129.33, 128.70, 127.58, 127.30, 117.66, 112.94, 48.38; ESI-MS: m/z 183.84 $[M+H]^+$.

N-Benzyl-2-methylaniline (Table-4, entry 13): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.36 (dt, *J* = 14.8, 7.4 Hz, 4H), 7.27 (dd, *J* = 15.2, 8.3 Hz, 1H), 7.09 (dd, *J* = 12.8, 7.2 Hz, 2H), 6.78-6.61 (m, 2H), 4.37 (s, 2H), 2.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 145.99, 139.44, 130.10, 128.68, 127.60, 127.29, 127.18, 122.02, 117.28, 110.09, 48.38, 17.58; ESI-MS: m/z 197.92 $[M+H]^+$.

N-Benzyl-3-methylaniline (Table-4, entry 14): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.29 (ddd, *J* = 26.5, 13.2, 3.7 Hz, 5H), 7.05 (dd, *J* = 12.4, 7.6 Hz, 1H), 6.56-6.53 (m, 1H), 6.45 (d, *J* = 7.3 Hz, 2H), 4.30 (d, *J* = 4.5 Hz, 2H), 3.97 (s, 1H), 2.26 (d, *J* = 4.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 148.23, 139.57, 139.09, 129.20, 128.67, 127.60, 127.26, 118.62, 113.72, 110.05, 48.42, 21.69; ESI-MS: m/z 197.97 $[M+H]^+$.

N-Benzyl-4-methylaniline (Table-4, entry 15): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.37-7.30 (m, 4H), 7.26 (dd, *J* = 14.8, 7.9 Hz, 1H), 6.97 (d, *J* = 8.2 Hz, 2H), 6.55 (d, *J* = 8.3 Hz, 2H), 4.29 (s, 2H), 2.23 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 145.88, 139.65, 129.79, 128.64, 127.56, 127.20, 126.85, 113.09, 48.71, 20.44; ESI-MS: m/z 197.93 $[M+H]^+$.

N-Benzyl-2-methoxyaniline (Table-2, entry 16): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.36-7.31 (m, 5H), 6.84-6.76 (m, 2H), 6.67 (t, *J* = 7.7 Hz, 1H), 6.59 (d, *J* = 7.8 Hz, 1H), 4.33 (s, 2H), 3.82 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.86, 139.61, 138.13, 129.95, 128.63, 127.57, 127.17, 121.33, 116.73, 110.18, 109.46, 55.45, 48.11; ESI-MS: m/z 213.92 $[M+H]^+$.

N-Benzyl-3-methoxyaniline (Table-4, entry 17): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.34 (q, *J* = 7.8 Hz, 4H), 7.26

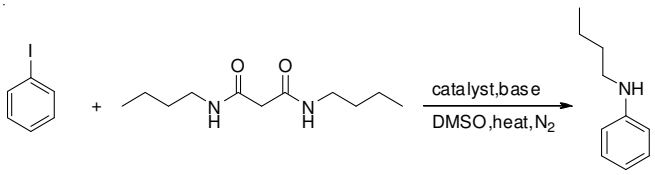
(dd, *J* = 12.1, 5.2 Hz, 1H), 7.08 (t, *J* = 8.1 Hz, 1H), 6.26 (t, *J* = 8.8 Hz, 2H), 7.08 (t, *J* = 8.1 Hz, 1H), 6.19 (s, 1H), 7.08 (t, *J* = 8.1 Hz, 1H), 4.31 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.81, 149.45, 139.30, 129.96, 128.63, 127.54, 127.26, 106.08, 102.82, 98.98, 55.06, 48.34; ESI-MS: m/z 213.91 $[M+H]^+$.

N-Benzyl-4-methoxyaniline (Table-4, entry 18): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.38-7.32 (m,4H), 7.28-7.26 (m, 1H), 6.77 (d, *J* = 8.9 Hz, 2H), 6.61 (d, *J* = 8.9 Hz, 2H), 4.28 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 152.23, 142.29, 139.57, 128.59, 127.57, 127.18, 114.88, 114.18, 55.78, 49.29; ESI-MS: m/z 213.87 $[M+H]^+$.

N-Benzylnaphthalen-1-amine (Table-4, entry 19): ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.81 (t, *J* = 8.9 Hz, 2H), 7.35-7.24 (m, 9H), 6.63 (d, *J* = 7.4 Hz, 1H), 4.49 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.11, 139.03, 134.31, 128.75, 128.74, 127.80, 127.45, 126.61, 125.79, 124.81, 123.42, 119.93, 117.77, 104.91, 48.70; ESI-MS: m/z 234.12 $[M+H]^+$.

RESULTS AND DISCUSSION

In our initial study, the reaction between N^1,N^3-dibutylmalonamide and iodobenzene was chosen as a model system for optimizing the reaction conditions. We find the reaction occurred to afford N-butylaniline in 98.6 % yield when it stirred for 12 h at 180 ºC in the presence of 15 mol % of CuI, 3 equiv of KOt-Bu and 5 equiv. H_2O in 4 mL DMSO under N_2 in PTFE airtight reaction (**Scheme-I**, Table-1, entry 3). We carried out the reaction with different Lewis acids and metallic oxides, such as CuCl, CuBr, CuI, $CuCl_2{\cdot}2H_2O$, $CuSO_4{\cdot}5H_2O$, $Cu(acac)_2$, $Cu(AcO)_2$, $FeCl_3$, $ZnCl_2$, $AlCl_3$, nano-CuO, alkaline Al_2O_3. As expected, only 9.5 % yield was detected in the absence of catalyst (Table-1, entry 13). Amongst them, the reaction catalyzed with $FeCl_3$, alkaline Al_2O_3, $AlCl_3$ and $ZnCl_2$ gave low yields of the products (Table-1, entry 8, 9, 10, 12). All the copper compounds catalysts provided good yields of products. However, CuI was found to be efficient for the N-arylation of aliphatic amines via the O = C-N bond-breaking of N^1,N^3-dibutylmalonamide with iodobenzene.



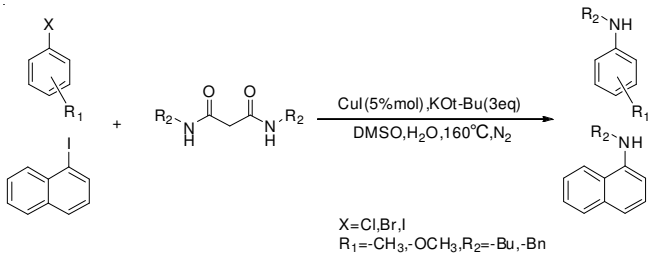
Scheme-I: Reaction between N^1,N^3-dibutylmalonamide and iodobenzene

TABLE-1
OPTIMIZATION OF THE CATALYSIS CONDITIONS[a]

Entry	Catalyst	Base	Yield(%)[b]
1	CuCl	KOt-Bu	81.5
2	CuBr	KOt-Bu	89.6
3	CuI	KOt-Bu	98.6
4	$CuCl_2{\cdot}2H_2O$	KOt-Bu	85.0
5	$CuSO_4{\cdot}5H_2O$	KOt-Bu	80.9
6	$Cu(acac)_2$	KOt-Bu	73.7
7	$Cu(AcO)_2$	KOt-Bu	89.2
8	$FeCl_3$	KOt-Bu	6.3
9	Alkaline-Al_2O_3	KOt-Bu	12.8
10	$AlCl_3$	KOt-Bu	9.3
11	nano-CuO	KOt-Bu	80.2
12	$ZnCl_2$	KOt-Bu	10.8
13	None	KOt-Bu	9.5

[a]The reaction was carried out with iodobenzene 1mmol, N^1,N^3-dibutylmalonamide 2 mmol, catalyst (15 % mol), KOt-Bu (3 equiv.), H_2O (5 equiv.) in 4 mL DMSO at 180 ºC for 12 h; [b]Isolated yield.

Next, we probed the base and temperature of the reaction. With screened the bases, preliminary results showed that KOt-Bu was the best base choice which gave an excellent yield 98.3 % both than K_3PO_4 and K_2CO_3 (Table-1, entry 4, 6, 7). Then we explored the temperature and discovered that the product was obtained in moderate to good yield ranging from 100 to 160 ºC for 12 h (Table-2, entry 1 to 4), so the temperature of 160 ºC is suitable for the reaction.



Scheme-II: N-arylation of aliphatic amines *via* the O=C-N bond-breaking of N^1,N^3-dibenzylmalonamide and N^1,N^3-dibutylmalonamide with aryl halides

TABLE-2
OPTIMIZATION OF THE BASE AND TEMPERATURE[a]

Entry	Temperature (ºC)	Base	Yield (%)[b]
1	100	KOt-Bu	38.4
2	120	KOt-Bu	46.4
3	140	KOt-Bu	51.2
4	160	KOt-Bu	98.3
5	180	KOt-Bu	96.8
6	160	K_2CO_3	81.3
7	160	K_3PO_4	65.3

[a]The reaction was carried out with iodobenzene 1 mmol, N^1,N^3-dibutylmalonamide 2 mmol, CuI (15 % mol), base (3 equiv.), H_2O (5 equiv) in 4 mL DMSO for 12 h; [b]Isolated yield.

Finally, we optimized the time and the additive amount of CuI of the reaction. When the reaction was stopped at 8 h, the desired product was obtained in 97.6 % yield (Table-3, entry 2) and the yield kept its balance as the reaction continued to react for more 2 h. On the other hand, additive amount of CuI was also investigated and the reaction produced 97.8 % yield when only 5 % CuI was added (Table-3, entry 6) and the reaction got an identical yield with higher amounts of CuI. It is noteworthy that only 78.0 % yield of product was found without adding any water (Table-3, entry 9). In summary, the optimal results were obtained when N^1,N^3-dibutylmalonamide (2 equiv.) and iodobenzene (1 equiv.) were allowed to react with CuI (5 % mol), KOt-Bu (3 equiv.), H_2O (5 equiv.) at 160 ºC for 8 h.

Next the scope of the process was investigated by exploring the cross-coupling of N^1,N^3-dibenzylmalonamide and N^1,N^3-dibutylmalonamide *via* the O = C-N bond-breaking with differently substituted aryl halides under the optimized conditions. In general, aryl iodides were more reactive than aryl bromides (Table-4, entry 1 and 11), giving the corresponding N-arylated

TABLE-3
OPTIMIZATION OF TIME AND THE ADDITIVE AMOUNT OF CuI[a]

Entry	Time (h)	CuI (mol %)	Yield (%)[b]
1	6	15	85.4
2	8	15	97.6
3	10	15	98.2
4	12	15	97.8
5	8	1	77.1
6	8	5	97.8
7	8	10	98.1
8	8	20	98.0
9[c]	8	5	78.1

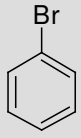
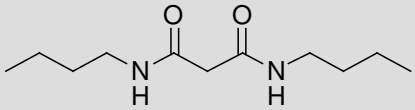
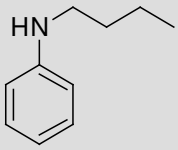
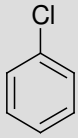
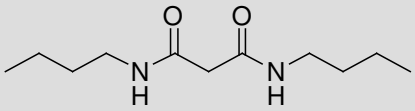
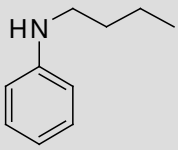
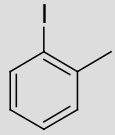
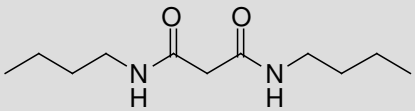
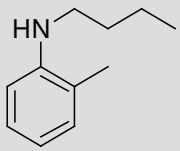
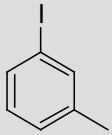
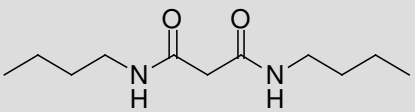
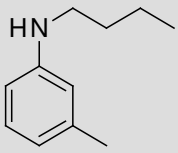
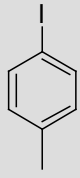
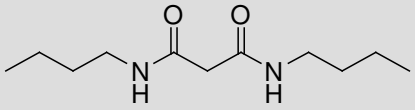
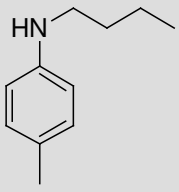
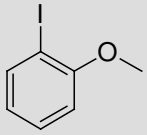
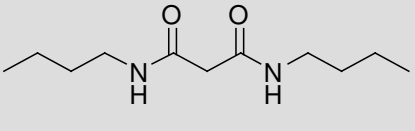
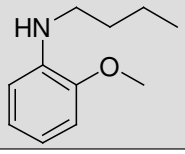
[a]The reaction was carried out with iodobenzene 1 mmol, N^1,N^3-dibutylmalonamide 2 mmol, CuI, KOt-Bu (3 equiv.), H_2O (5 equiv.) in 4 mL DMSO at 160 ºC; [b]Isolated yield; [c]No water added.

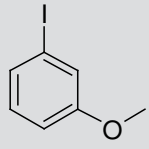
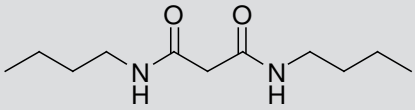
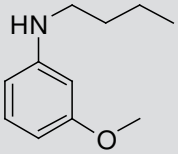
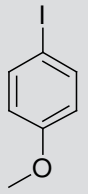
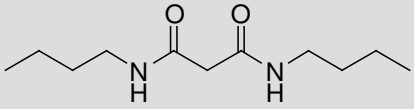
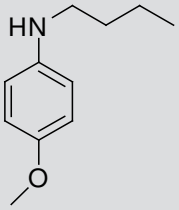
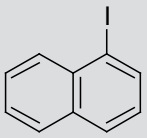
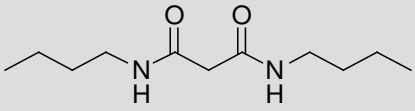
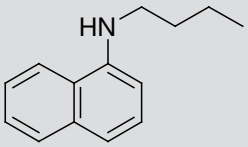
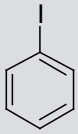
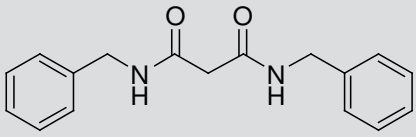
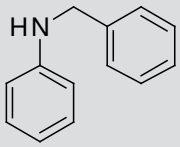
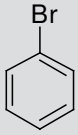
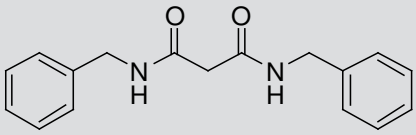
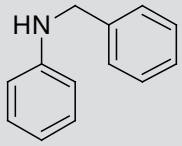
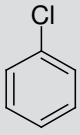
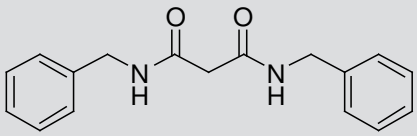
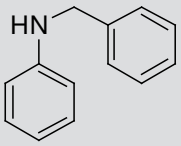
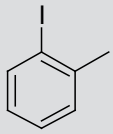
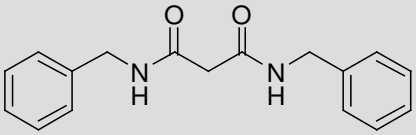
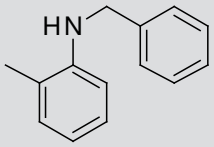
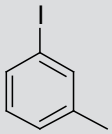
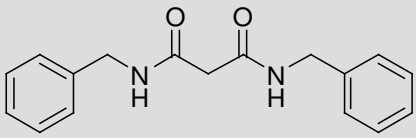
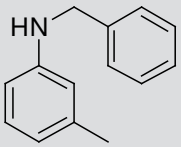
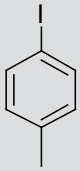
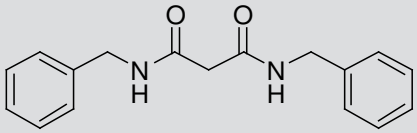
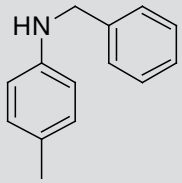
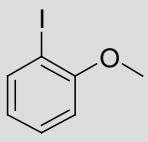
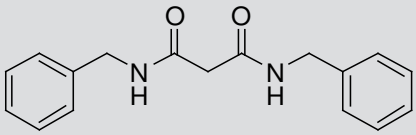
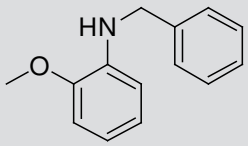
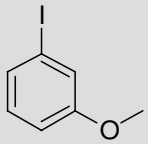
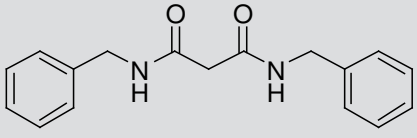
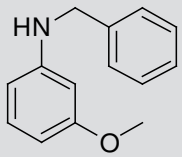
products in high yields. Aryl chlorides were the worst reactive beside fluoroaromatics giving the products in lowest yields (Table-4, entry 2 and 12). Likewise, variously substituted aryl iodides could be employed but several electronic restrictions were observed. Whereas the 1-iodo-4-methoxybenzene and N^1,N^3-dibenzylmalonamide took place to lead to N-butyl-2-methoxyaniline in good yield 81.8 % (Table-4,entry 18),while 1-iodo-2-methoxybenzene and 1-iodo-3-methoxybenzene react with N^1,N^3-dibenzylmalonamide giving lower yields of products (Table-4, entry 16 and 17). Moreover, the steric effect was also significant, 2-iodotoluene reacting with N^1,N^3-dibutylmalonamide hampered the reaction and led to the formation of the product N-butyl-2-methylaniline for only 23.2 % yield (Table-4 entry 3) while 3-iodotoluene and 4-iodotoluene underwent reaction to give good yields (Table-4, entry 4 and 5). Interestingly, N-arylation of aliphatic amines *via* the O = C-N bond-breaking of N^1,N^3-dibenzylmalonamide and N^1,N^3-dibutylmalonamide with iodonaphthalene also gave moderate yields 34.8 and 23.7 % (Table-4, entry 9 and 19).

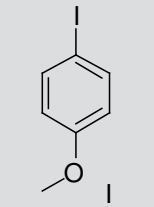
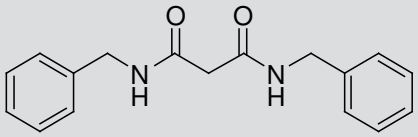
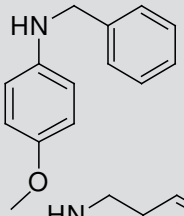
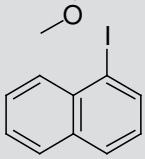
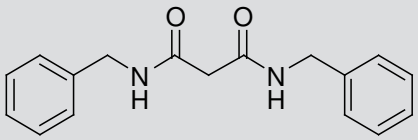
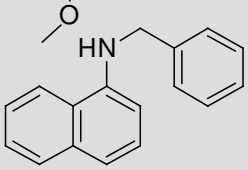
Conclusion

In summary, we developed a practical and convenient protocol to synthesis of aromatic amines based on CuI-catalyzed N-arylation of N^1,N^3-dibenzylmalonamide and N^1,N^3-dibutylmalonamide followed by cleavage of the malonyl group with aryl halides under ligand-free conditions. The procedure is easy and convenient to handle and achieves good yields by

TABLE-4
N-ARYLATION OF ALIPHATIC AMINES *VIA* THE O=C-N BOND-BREAKING OF N^1,N^3-DIBENZYLMALONAMIDE AND N^1,N^3-DIBUTYLMALONAMIDE WITH ARYL HALIDES[a]

Entry	Aryl halides	Amides	Product	Yield (%)[b]
1				80.6
2				5.6
3				23.2
4				70.1
5				95.5
6				60.2

Entry	Aryl halides	Amides	Product	Yield (%)[b]
7				32.5
8				81.7
9				34.8
10				92.5
11				60.1
12				5.1
13				86.6
14				16.3
15				53.2
16				15.9
17				62.6

Entry	Aryl halides	Amides	Product	Yield (%)[b]
18				81.8
19				23.7

[a]The reaction was carried out with aryl halides 1 mmol, N^1,N^3-dibenzylmalonamide or N^1,N^3-dibutylmalonamide 2 mmol, CuI (5 % mol), KOt-Bu (3 equiv.), H_2O (5 equiv.) in 4 mL DMSO at 160 ºC for 8 h; [b]Isolated yield.

using a low cost catalyst. These remarkable advantages will make this approach not only suitable for laboratory scale research but also for pharmaceuticals industrial applications. The further research on the mechanism of the reaction and expanding the application of this method to other catalytic reactions are currently under the way.

ACKNOWLEDGEMENTS

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