JOC The Journal of Organic Chemistry

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Di-*tert*-butyl Peroxide-Promoted α-Alkylation of α-Amino Carbonyl Compounds by Simple Alkanes

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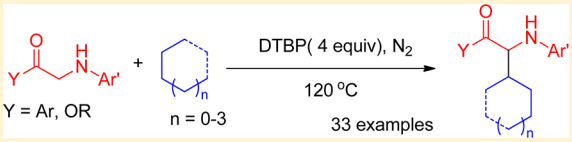
Supporting Information

ABSTRACT: A di-*tert* butyl peroxide (DTBP)-promoted α-alkylation of α-amino carbonyl compounds by simple alkanes is developed, proceeding through dual sp^3 C−H bonds cleavage. The reaction was applicable for α-amino ketones and α-amino esters, providing a facile pathway for the α-functionalization of these substrates. The radical pathway is involved in this transformation.



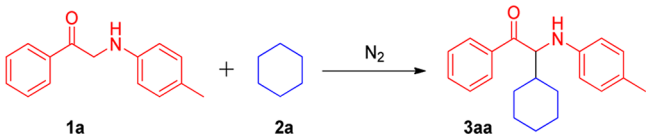
The α-functionalization of the α-amino carbonyl compounds represents a key transformation in organic chemistry since these frameworks are ubiquitous in biologically active natural and unnatural products, biomolecules, therapeutic agents, and intermediates.[1−6] Compared with the traditional strategy starting from halo-functionalized substrates,[7−12] the direct transformation of α-C−H bond in α-amino carbonyl compounds by another C−H bond features less reaction steps and waste.[13−16] For example, Zhao and Li described direct functionalization of glycine derivatives for C−C bond formation.[17] Subsequently, Xie and Huang demonstrated the cross-dehydrogenative coupling between glycine esters and ketones leading to amino acid derivatives.[18] Recently, Li and co-workers reported the copper-catalyzed α-alkylation of α-amino carbonyl compounds with ethers via dual $C(sp^3)$−H bond oxidative cross coupling.[19]

However, the functionalization of simple alkanes remains more practical because they are major constituents of petroleum and natural gas.[20−27] Recently, much attention has been paid in this field.[28−33] The radical reaction provides a solid pathway for the functionalization of the alkane C−H bond.[34,35] For example, the cyclohexylation of disulfides,[36,37] isonitriles,[38,39] and alkenes,[40,41] was well developed. In light of these, we envisioned to apply this strategy to the direct α-functionalization of α-amino carbonyl compounds by simple alkanes. Herein, we wish to report our study on it (Scheme 1). This procedure featured (1) metal-free reaction conditions and (2) cleavage of dual $C(sp^3)$−H bonds involving simple alkanes.

Scheme 1. α-Functionalization of α-Amino Carbonyl Compounds by Simple Alkanes

We selected the combination of 1-phenyl-2-(*p*-tolylamino)-ethanone and benzoyl peroxide (BPO, 4.0 equiv) in cyclohexane (2 mL) under N_2 at 120 °C as the model reaction. Disappointingly, no desired product was detected (Table 1, entry 1). The reaction took place in 24% yield by replacing

Table 1. Selected Results for Screening the Optimized Reaction Conditions[a]



entry	catalyst (mol %)	peroxide (equiv)	temp (°C)	yield (%)[b]
1		BPO (4)	120	<5
2		TBHP (4)	120	24[c]
3		DCP (4)	120	50
4		AIBN (4)	120	<5
5		DTBP (4)	120	79 (70)[d] (50)[e] (71)[f]
6	$FeCl_2$ (5)	DTBP (4)	120	58
7	$FeCl_3$ (5)	DTBP (4)	120	52
8	CuBr (5)	DTBP (4)	120	<5
9	$Cu(OAc)_2$ (5)	DTBP (4)	120	39
10	Bu_4NI (5)	DTBP (4)	120	69
11		DTBP (4)	110	45
12		DTBP (4)	130	46
13		DTBP (2)	120	42
14		DTBP (6)	120	65

[a]Reaction conditions: **1a** (0.2 mmol), peroxide (4.0 equiv) (DTBP = di-*tert*-butyl peroxide, BPO = benzoyl peroxide, DCP = dicumyl peroxide, AIBN = azobis(isobutyronitrile)), in cyclohexane (2 mL), under N_2 for 14 h, sealed tube. [b]Isolated yields. [c]TBHP (5−6 M in decane). [d]Under air. [e]Cyclohexane, 1.5 mL. [f]Cyclohexane, 2.5 mL.

Received: July 30, 2014
Published: September 22, 2014

dx.doi.org/10.1021/jo5017426 | J. Org. Chem. 2014, 79, 9847−9853

BPO with TBHP (Table 1, entry 2). Pleasingly, the yield further increased to 50% by using dicumyl peroxide (DCP) (Table 1, entry 3). Azobis(isobutyronitrile) (AIBN) inhibited the reaction (Table 1, entry 4). To our delight, **3aa** was obtained in 79% yield by using di-*tert*-butyl peroxide (DTBP) (Table 1, entry 5). Under air, the yield slightly decreased. Some catalysts that may take part in the single electron transfer (SET) were tested, and no improvement in the reaction efficiency was found (Table 1, entries 6−10). The reaction efficiency decreased under elevated or reduced temperature (Table 1, entries 11 and 12). The yield decreased using 2 or 6 equiv of DTBP (Table 1, entries 13 and 14).

Under the optimized reaction conditions, the substrate scope of α-amino ketones was studied, as shown in Figure 1. As

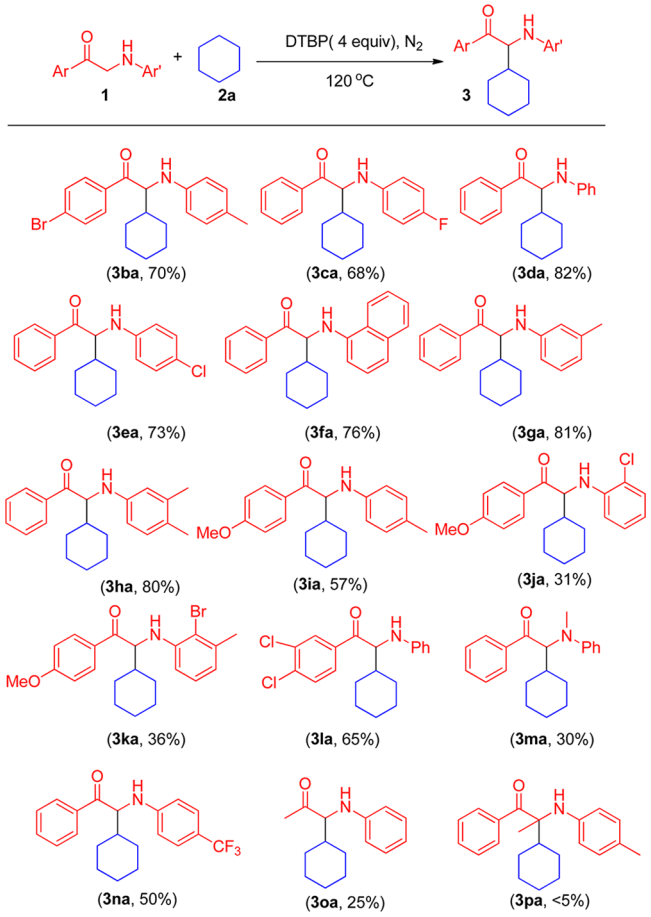


Figure 1. Scope of α-amino ketones. Reaction conditions: **1** (0.2 mmol), DTBP (0.8 mmol), cyclohexane (2.0 mL), 120 °C, N_2, 14 h. Isolated yields.

expected, all substrates reacted smoothly under the procedure to provide the corresponding products in moderate to good yields. The bromo and chloro groups attached on the phenyl ring survived well, serving as handles for further potential functionalizations. However, the introduction of a methyl in the amino group or an *ortho* substituent on the phenyl ring attached to the amino group dramatically decreased the reaction efficiency (eg., **3ja**, **3ka**, and **3ma**).

Next, the scope of alkanes was investigated, as shown in Figure 2. Once again, cyclohexane, cyclopentane, cycloheptane, and cyclooctane all worked well, providing the α-alkylation products (**3aa**−**3ad**) in good yields. Reducing the amount of

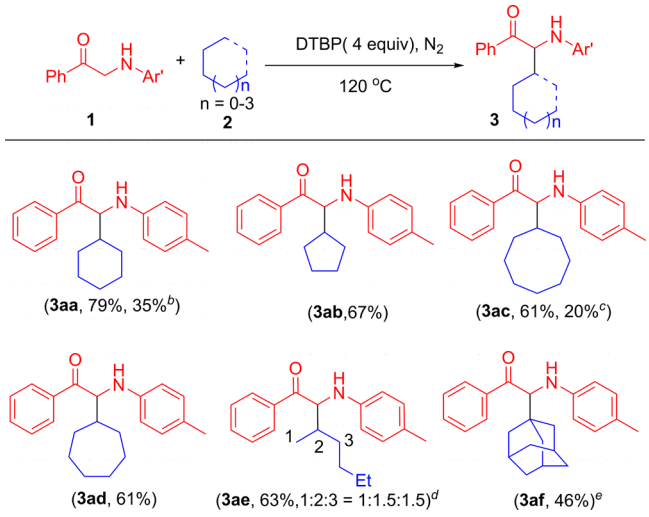


Figure 2. Scope of alkanes.[a] [a]Reaction conditions: **1** (0.2 mmol), DTBP (0.8 mmol), alkane **2** (2.0 mL), 120 °C, N_2, 14 h, isolated yields. [b,c]Alkane 2 mmol, MeCN 2 mL. [d]Determined by ^{1}H NMR. [e]Adamantane 2 mmol, chlorobenzene 2 mL.

alkane resulted in low efficiency. Particularly, for hexane, the reaction took place at the 1-, 2-, and 3- position of hexane with a ratio of 1:1.5:1.5 as determined by ^{1}H NMR in 63% total yield. Adamantane also took part in the reaction in 46% yield. Intriguingly, no other isomer was detected by ^{1}H NMR.

Notably, the procedure was applicable to glycine esters, as shown in Figure 3. Importantly, the scope was not limited to ethyl esters, because the *tert*-butyl, methyl, benzyl, and

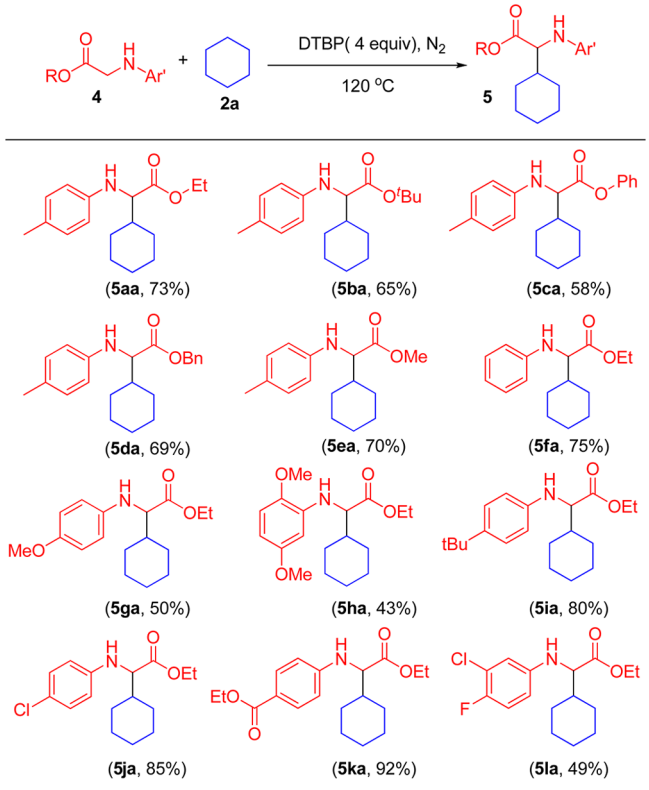


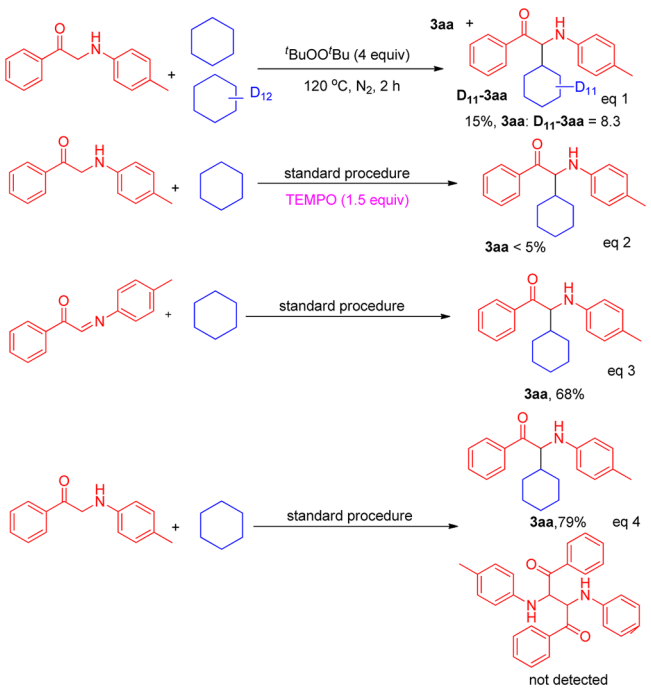
Figure 3. Scope of of glycine esters. Reaction conditions: **4** (0.2 mmol), DTBP (0.8 mmol), cyclohexane (2.0 mL), 120 °C, N_2, 14 h. Isolated yields.

dx.doi.org/10.1021/jo5017426 | J. Org. Chem. 2014, 79, 9847−9853

phenyloxy analogues all worked well, providing the α-alkylation products **5ba**, **5ea**, **5da**, and **5ca** in 65%, 70%, 69%, and 58% yields, respectively. The procedure tolerated functional groups such as chloro and ethyloxycarbonyl on the phenyl rings. Thus, it represents a practical method allowing the efficient installation of alkyl in the α-position of glycine esters.

The intermolecular isotopic kinetic study revealed the K_H/K_D for cyclohexane was 8.3, indicating that the cleavage of the sp^3 C−H bond is the rate-determining step in this reaction (Scheme 2). Moreover, adding 1.5 equiv of TEMPO inhibited

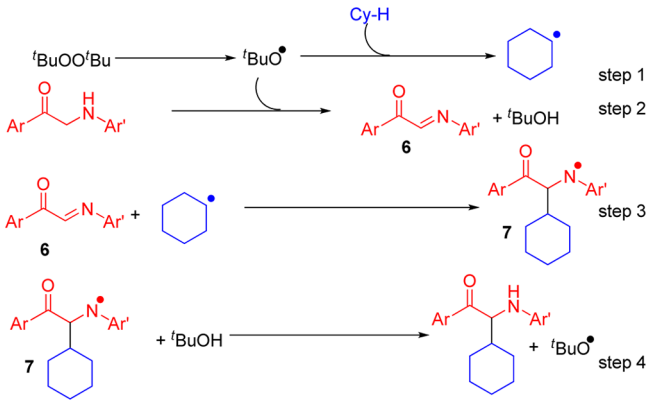
Scheme 2. Mechanism Studies



the reaction, and the adduct of TEMPO with the intermediate was detected by GC-MS, indicating that a radical pathway may be involved (Scheme 2, see Supporting Information for details). 1-Phenyl-2-(*p*-tolylimino)ethanone was subjected to the standard procedure, and **3aa** was isolated in 68% yield. Furthermore, no homocoupling product of α-carbonyl radical was detected.

Based on these experimental results, the proposed mechanism is outlined in Scheme 3. In step one, *tert*-butoxy radical is formed by homolytic cleavage of DTBP. Then *tert*-butoxy radical abstracts one H of cyclohexane to form cyclohexyl radical. This step is the rate-determining step. In step two, α-amino carbonyl forms imine intermediate **6**.[42] Then, the addition of cyclohexyl radical to **6** produces radical intermediate **7**. Finally, intermediate **7** abstracts one H from ^{t}BuOH to provide the final product.

Scheme 3. Proposed Mechanism



In conclusion, we have developed a DTBP-promoted alkylation of α-amino carbonyl compounds by simple alkanes. The procedure featured the metal-free cleavage of unactive sp^3 C−H bonds. Thus, it represents a facile pathway for the functionalization of α-amino ketones and esters.

EXPERIMENTAL SECTION

General Information. Chemicals were used as received without special purification unless stated otherwise. ^{1}H and ^{13}C NMR were recorded at ambient temperature on 300 or 400 MHz NMR spectrometer (75 or 100 MHz for ^{13}C NMR). NMR experiments are reported in δ units, parts per million (ppm), and were referenced to $CDCl_3$ (7.26 or 77.0 ppm) as the internal standard. The coupling constants J are given in Hz. Column chromatography was performed using EM Silica gel 60 (300−400 mesh).

Experimental Procedure. A sealed tube was charged with α-amino carbonyl compound (0.2 mmol) and DTBP (0.8 mmol, di-*tert*-butyl peroxide, 97%). Then, 2.0 mL of alkane was added as solvent. The mixture was purged with nitrogen and kept stirring under nitrogen at 120 °C for 14 h. After completion of the reaction (monitored by TLC), the mixture was concentrated in vacuo, and the residue was purified by flash column chromatography on silica gel with petroleum ether−ethyl acetate as eluent to give the desired product.

1-(4-Bromophenyl)-2-cyclohexyl-2-(p-tolylamino)ethanone (***3ba***). Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (54.1 mg, 70% yield) as red liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.83 (d, J = 8.6 Hz, 2H), 7.63 (d, J = 8.3 Hz, 2H), 6.96 (d, J = 8.2 Hz, 2H), 6.61 (d, J = 8.4 Hz, 2H), 4.77 (s, 1H), 4.46 (s, 1H), 2.21 (s, 3H), 1.81−1.73 (m, 4H), 1.63−1.60 (m, 2H), 1.38−1.06 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.6, 145.7, 134.9, 132.1, 129.8, 129.8, 128.6, 127.4, 114.1, 63.7, 41.9, 30.8, 27.9, 26.3, 26.1, 26.0, 20.3. MS (EI): 385 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{25}BrNO$ $(M + H)^+$ 386.1114, found 386.1115. IR (KBr) ν 3377, 2926, 2853, 1682, 1616, 1583 cm^{-1}.

2-Cyclohexyl-2-((4-fluorophenyl)amino)-1-phenylethanone (***3ca***). Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (42.4 mg, 68% yield) as a yellow solid. Mp 95−98 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.96 (d, J = 7.7 Hz, 2H), 7.60 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.7 Hz 2H), 6.85 (d, J = 8.7 Hz, 2H), 6.65−6.62 (m, 2H), 4.79 (s, 1H), 4.53 (s, 1H), 1.87−1.73 (m, 6H), 1.39−1.35 (m, 1H), 1.28−1.22 (m, 1H) 1.12−1.11 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.3, 156.1 (d, J_{C-F} = 234.2 Hz), 144.6, 136.0, 133.5, 128.8, 128.3, 115.6 (d, J_{C-F} = 22.3 Hz), 115.1 (d, J_{C-F} = 7.3 Hz), 64.2, 41.8, 30.9, 27.6, 26.4, 26.1, 26.0. MS (EI): 311 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{20}H_{23}FNO$ $(M + H)^+$ 312.1758, found 312.1762. IR (KBr) ν 3369, 2924, 2853, 1682, 1597, 1510 cm^{-1}.

2-Cyclohexyl-1-phenyl-2-(phenylamino)ethanone (***3da***). Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (48.1 mg, 82% yield) as a yellow solid. Mp 45−46 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.00 (d, J = 7.4 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.50 (t, J = 7.8 Hz, 2H), 7.16 (t, J = 8.1 Hz, 2H), 6.73−6.69 (m, 3H), 4.93−6.90 (m, 1H), 4.68−4.66 (m, 1H), 1.90−1.73 (m, 4H), 1.68−1.55 (m, 2H), 1.42−1.09 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.2, 148.2, 136.0, 133.4, 129.3, 128.8, 128.3, 117.9, 113.8, 63.0, 41.9, 30.8, 27.7, 26.3, 26.1, 26.0. MS (EI): 293 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{20}H_{24}NO$ $(M + H)^+$ 294.1852, found 294.1852. IR (KBr) ν 3340, 2924, 2851, 1682, 1605, 1447 cm^{-1}.

2-((4-Chlorophenyl)amino)-2-cyclohexyl-1-phenylethanone (***3ea***). Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (47.9 mg, 73% yield) as a

dx.doi.org/10.1021/jo5017426 | J. Org. Chem. 2014, 79, 9847−9853

yellowish solid. Mp 98−100 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.97 (d, J = 7.3 Hz, 2H), 7.61 (t, J = 7.4 Hz, 1H), 7.50 (t, J = 7.8 Hz, 2H), 7.08 (d, J = 8.8 Hz, 2H), 6.63 (d, J = 8.8 Hz, 2H), 4.84 (s, 1H), 4.67 (s, 1H), 1.87−1.84 (m, 1H), 1.79−1.71 (m, 3H), 1.66−1.61 (m, 2H), 1.38−1.21 (m, 2H), 1.14−1.05 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.8, 146.7, 135.8, 133.6, 129.0, 128.8, 128.3, 122.4, 114.9, 63.1, 41.9, 30.8, 27.6, 26.3, 26.1, 26.0. MS (EI): 327 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{20}H_{23}ClNO$ $(M + H)^+$ 328.1463, found 328.1453. IR (KBr) ν 3368, 2924, 2851, 1684, 1595, 1508 cm^{-1}.

*2-Cyclohexyl-2-(naphthalen-1-ylamino)-1-phenylethanone (**3fa**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (52.2 mg, 76% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.06−8.02 (m, 3H), 7.77 (d, J = 8.3 Hz, 1H), 7.62−7.58 (m, 1H), 7.52−7.43 (m, 4H), 7.28−7.20 (m, 2H), 6.64 (d, J = 7.4 Hz, 1H), 5.47 (d, J = 8.5 Hz, 1H), 5.15−5.12 (m, 1H), 2.00−1.61 (m, 7H), 1.42−1.35 (m, 1H), 1.22−1.08 (m, 3H). ^{13}C NMR (CDCl3, 100 MHz): δ 201.3, 143.3, 136.0, 134.5, 133.5, 128.9, 128.6, 128.4, 126.3, 125.8, 124.8, 124.0, 120.4, 117.8, 105.3, 62.8, 42.2, 30.9, 28.1, 26.4, 26.2, 26.0. MS (EI): 343 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{24}H_{26}NO$ $(M + H)^+$ 344.2009, found 344.2006. IR (KBr) ν 3391, 2926, 2851, 1682, 1582, 1529 cm^{-1}.

*2-Cyclohexyl-1-phenyl-2-(m-tolylamino)ethanone (**3ga**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (49.8 mg, 81% yield) as a yellow solid. Mp 66−68 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.98 (d, J = 7.3 Hz, 2H), 7.60 (t, J = 7.4 Hz, 1H), 7.50 (t, J = 7.8 Hz, 2H), 7.04 (t, J = 7.6 Hz, 1H), 6.54−6.51 (m, 3H), 4.89 (s, 1H), 4.61(s, 1H), 2.26 (s, 3H), 1.86−1.72 (m, 4H), 1.62−1.60 (m, 2H), 1.41−1.08 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.3, 148.2, 139.0, 136.1, 133.4, 129.1, 128.8, 128.3, 118.9, 114.9, 110.8, 63.0, 42.0, 30.8, 27.7, 26.3, 26.1, 26.0, 21.6. MS (EI): 307 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{26}NO$ $(M + H)^+$ 308.2009, found 308.2005. IR (KBr) ν 3358, 2922, 2850, 1682, 1601, 1508, 1495 cm^{-1}.

*2-Cyclohexyl-2-((3,4-dimethylphenyl)amino)-1-phenylethanone (**3ha**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (51.4 mg, 80% yield) as a red liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.98 (d, J = 7.4 Hz, 2H), 7.59 (t, J = 7.4 Hz, 1H), 7.49 (t, J = 7.8 Hz, 2H), 6.89 (d, J = 8.1 Hz, 1H), 6.56 (s, 1H), 6.48 (d, J = 8.1 Hz, 1H), 4.85 (s, 1H), 4.49 (s, 1H), 2.17 (s, 3H), 2.12 (s, 3H), 1.84−1.72 (m, 5H), 1.42−1.30 (m, 1H), 1.27−1.08 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.6, 146.4, 137.3, 136.2, 133.4, 130.2, 128.8, 128.3, 126.0, 116.0, 111.1, 63.5, 41.9, 30.8, 27.7, 26.4, 26.1, 26.0, 20.0, 18.6. MS (EI): 321 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{22}H_{28}NO$ $(M + H)^+$ 322.2165, found 322.2165. IR (KBr) ν 3340, 2918, 2851, 1682, 1616, 1506 cm^{-1}.

*2-Cyclohexyl-1-(4-methoxyphenyl)-2-(phenylamino)ethanone (**3ia**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:80) gave the product (38.5 mg, 57% yield) as a yellowish liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.98 (d, J = 8.9 Hz, 2H), 6.98−6.95 (m, 4H), 6.63 (d, J = 8.4 Hz, 2H), 4.81 (s, 1H), 4.55 (s, 1H), 3.88 (s, 3H), 2.21 (s, 3H), 1.85−1.61 (m, 6H), 1.14−1.09 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 199.8, 163.7, 146.0, 130.6, 129.7, 129.1, 127.0, 114.0, 113.9, 63.0, 55.4, 42.1, 30.8, 27.9, 26.4, 26.1, 26.0, 20.3. MS (EI): 337 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{22}H_{28}NO_2$ $(M + H)^+$ 338.2115, found 338.2121. IR (KBr) ν 3371, 2926, 2853, 1672, 1599, 1520 cm^{-1}.

*2-((2-Chlorophenyl)amino)-2-cyclohexyl-1-(4-methoxyphenyl)-ethanone (**3ja**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:80) gave the product (22.2 mg, 31% yield) as a reddish brown liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.00 (d, J = 8.9 Hz, 2H), 7.25 (d, J = 7.9 Hz, 1H), 7.05 (t, J = 7.6 Hz, 1H), 6.97 (d, J = 8.9 Hz 2H), 6.66 (d, J = 8.2 Hz, 1H), 6.60 (t, J = 7.6 Hz, 1H), 5.31 (d, J = 8.2 Hz, 1H), 4.87 (t, J = 6.3 Hz, 1H), 3.88 (s, 3H), 1.92−1.90 (m, 1H), 1.79−1.62 (m, 5H), 1.35−1.09 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 198.5, 163.8, 143.9, 130.7, 129.4, 128.8, 127.6, 120.0, 117.4, 114.0, 111.7, 62.2, 55.5, 42.2, 30.7, 28.0, 26.3, 26.1, 26.0. MS (EI): 357 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{25}ClNO_2$ $(M + H)^+$ 358.1568, found 358.1568. IR (KBr) ν 3400, 2928, 2853, 1674, 1597, 1506 cm^{-1}.

*2-((2-Bromo-3-methylphenyl)amino)-2-cyclohexyl-1-(4-methoxyphenyl)ethanone (**3ka**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:80) gave the product (30.0 mg, 36% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.00 (d, J = 8.8 Hz, 2H), 7.28 (d, J = 8.0 Hz, 1H), 6.98 (d, J = 8.9 Hz, 2H), 6.45 (s, 1H), 6.36 (d, J = 8.0 Hz, 1H), 5.26 (d, J = 8.3 Hz, 1H), 4.87−4.83 (m, 1H), 3.89 (s, 3H), 2.21 (s, 3H), 1.92−1.89 (m, 1H), 1.80−1.69 (m, 5H), 1.32−1.24 (m, 2H), 1.18−1.12 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 199.5, 163.8, 144.6, 138.2, 132.3, 130.7, 128.8, 119.0, 114.0, 112.6, 107.4, 62.5, 55.5, 42.2, 30.7, 28.0, 26.3, 26.1, 26.0, 21.5. MS (EI): 415 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{22}H_{27}BrNO_2$ $(M + H)^+$ 416.1220, found 416.1206. IR (KBr) ν 3387, 2926, 2853, 1672, 1599, 1510 cm^{-1}.

*2-Cyclohexyl-1-(3,4-dichlorophenyl)-2-(phenylamino)ethanone (**3la**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (47.1 mg, 65% yield) as a reddish brown liquid. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 8.05(s, 1H), 7.79 (d, J = 8.4 Hz, 1H), 7.58 (d, J = 8.3 Hz, 1H), 7.16 (t, J = 8.2 Hz, 2H), 6.74−6.68 (m, 3H), 4.78 (s, 1H), 4.54 (s, 1H), 1.77−1.62 (m, 6H), 1.35−1.23 (m, 2H), 1.17−1.10 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 199.3, 147.7, 138.1, 135.6, 133.6, 130.9, 130.2, 129.3, 127.2, 118.2, 113.8, 63.4, 41.8, 30.7, 27.9, 26.2, 26.1, 26.0. MS (EI): 361 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{20}H_{22}Cl_2NO$ $(M + H)^+$ 362.1073, found 362.1073. IR (KBr) ν 3391, 2926, 2853, 1688, 1601, 1504 cm^{-1}.

*2-Cyclohexyl-2-(methyl(phenyl)amino)-1-phenylethanone (**3ma**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (21.7 mg, 30% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.80 (d, J = 7.2 Hz, 2H), 7.45 (t, J = 7.4 Hz, 1H), 7.31 (t, J = 8.0 Hz, 2H), 7.26−7.22 (m, 2H), 6.84 (d, J = 8.1 Hz, 2H), 6.73 (t, J = 7.2 Hz, 1H), 4.92 (d, J = 10.2 Hz, 1H), 2.71 (s, 3H), 2.37−2.28 (m, 1H), 1.72−1.70 (m, 6H), 1.38−1.28 (m, 2H), 1.16−0.92 (m, 3H) ; ^{13}C NMR ($CDCl_3$, 100 MHz): δ 197.4, 149.4, 137.2, 132.9, 129.3, 128.5, 128.0, 117.1, 112.8, 65.4, 36.3, 31.9, 31.0, 29.5, 26.6, 26.2, 26.0. MS (EI): 307 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{26}NO$ $(M + H)^+$ 308.2009, found 308.2007. IR (KBr) ν 2924, 2851, 1680, 1597, 1504 cm^{-1}.

*2-Cyclohexyl-1-phenyl-2-(4-(trifluoromethyl)phenylamino)-ethanone (**3na**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (35.9 mg, 50% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.98 (t, J = 7.1 Hz, 2H), 7.95−7.60 (m, 1H), 7.54−7.49 (m, 2H), 7.37 (d, J = 8.4 Hz, 2H), 5.03−4.94 (m, 2H), 1.90−1.61 (m, 6H), 1.35−1.22 (m, 2H), 1.15−1.06 (m, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 200.2, 150.3, 135.6, 133.8, 128.9, 128.3, 126.6 (q, J_{C-F} = 3.75 Hz), 125.2, 119.2 (q, J_{C-F} = 32.4 Hz), 112.7, 62.0, 42.0, 30.8, 27.6, 26.3, 26.0, 25.9. MS (EI): 361 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{22}F_3NO$ $(M + H)^+$ 362.1726, found 362.1731. IR (KBr) ν3381, 2928, 2854, 1682, 1616, 1531 cm^{-1}.

*1-Cyclohexyl-1-(phenylamino)propan-2-one (**3oa**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (11.2 mg, 25% yield) as a brownish solid. Mp 62−63 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.17 (t, J = 7.4 Hz, 3H), 6.72 (t, J = 7.3 Hz, 3H), 6.58 (d, J = 7.8 Hz, 2H), 4.24 (s, 1H), 3.79 (d, J = 5.5 Hz, 1H), 2.16 (s, 3H), 1.81−1.78 (m, 2H), 1.73−1.61 (m, 4H), 1.32−1.23 (m, 3H), 1.22−1.13 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 210.8, 147.7, 129.4, 118.0, 113.2, 68.8, 30.3, 28.6, 27.4, 26.2, 26.1, 26.0. MS (EI): 231 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{15}H_{21}NO$ $(M + H)^+$ 232.1696, found 232.1699. IR (KBr) ν 3362, 2920, 2851, 1693, 1605, 1518 cm^{-1}.

*Ethyl 2-Cyclohexyl-2-(p-tolylamino)acetate (**5aa**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (40.2 mg, 73% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.97 (d, J = 8.1 Hz, 2H), 6.55 (d, J = 8.4 Hz, 2H), 4.16 (q, J = 7.1 Hz, 2H), 4.00 (s, 1H), 3.82 (d, J = 6.0 Hz, 1H), 2.23 (s, 3H), 1.87−1.68 (m, 6H), 1.27−1.14 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.8, 145.2, 129.7, 127.3, 113.7, 62.4, 60.7, 41.3, 29.6, 29.2, 26.2, 26.1, 26.0, 20.3, 14.3. MS (EI): 275 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{17}H_{26}NO_2$ $(M + H)^+$ 276.1958, found 276.1953. IR (KBr) ν 3379, 2926, 2853, 1732, 1618, 1520 cm^{-1}.

dx.doi.org/10.1021/jo5017426 | J. Org. Chem. 2014, 79, 9847−9853

*tert-Butyl 2-Cyclohexyl-2-(p-tolylamino)acetate (**5ba**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (39.5 mg, 65% yield) as a yellow solid. Mp 58−60 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.97 (d, J = 8.3 Hz, 2H), 6.55 (d, J = 8.3 Hz, 2H), 4.00 (s 1H), 3.71 (s, 1H), 2.23 (s, 3H), 1.85−1.65 (m, 6H), 1.43 (s, 9H), 1.29−1.14 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.0, 145.4, 129.6, 127.0, 113.7, 81.3, 62.8, 41.3, 29.5, 29.1, 28.1, 26.3, 26.2, 26.1, 20.3. MS (EI): 303 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{19}H_{30}NO_2$ $(M + H)^+$ 304.2271, found 304.2271. IR (KBr) ν 3373, 2928, 2853, 1701, 1620, 1526 cm^{-1}.

*Phenyl 2-Cyclohexyl-2-(p-tolylamino)acetate (**5ca**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (37.6 mg, 58% yield) as a white solid. Mp 123−124 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.36 (t, J = 7.8 Hz, 2H), 7.22 (t, J = 7.4 Hz, 1H), 7.04−6.99 (m, 4H), 6.66 (d, J = 8.3 Hz, 2H), 4.08 (m, 2H), 2.27(s, 3H), 2.04−1.72 (m, 6H), 1.39−1.23 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 172.6, 150.5, 144.9, 129.8, 129.4, 127.7, 125.9, 121.4, 113.8, 62.6, 41.4, 29.7, 29.4, 26.2, 26.1, 26.0, 20.4. MS (EI): 323 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{26}NO_2$ $(M + H)^+$ 324.1958, found 324.1955. IR (KBr) ν 3383, 2916, 2847, 1759, 1612, 1591, 1514 cm^{-1}.

*Benzyl 2-Cyclohexyl-2-(p-tolylamino)acetate (**5da**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (46.6 mg, 69% yield) as a yellowish liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.37−7.26 (m, 5H), 6.98 (d, J = 8.3 Hz, 2H), 6.57 (d, J = 8.4 Hz, 2H), 5.14 (s, 2H), 4.01 (s, 1H), 3.91 (s, 1H), 2.25 (s, 3H), 1.86−1.75 (m, 4H), 1.68−1.62 (m, 2H), 1.31−1.10 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.8, 145.1, 135.6, 129.7, 128.5, 128.2, 128.2, 127.4, 113.8, 66.5, 62.5, 41.3, 29.6, 29.1, 26.1, 26.0, 25.9, 20.3. MS (EI): 337 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{22}H_{28}NO_2$ $(M + H)^+$ 338.2115, found 338.2111. IR (KBr) ν 3383, 2926, 2852, 1732, 1616, 1520 cm^{-1}.

*Methyl 2-Cyclohexyl-2-(p-tolylamino)acetate (**5ea**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (36.0 mg, 70% yield) as a white solid. Mp 42−45 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.98 (d, J = 8.3 Hz, 2H), 6.56 (t, J = 8.4 Hz, 2H), 4.00 (d, J = 9.1 Hz, 1H), 3.87−3.83 (m, 1H), 3.70 (s, 3H), 2.24 (s, 3H), 1.88−1.69 (m, 6H), 1.29−1.13 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 174.4, 145.1, 129.7, 127.3, 113.6, 62.4, 51.7, 41.3, 29.6, 29.2, 26.1, 26.0, 26.0, 20.4. MS (EI): 261 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{16}H_{24}NO_2$ $(M + H)^+$ 262.1802, found 262.1799. IR (KBr) ν 3362, 2926, 2847, 1726, 1614, 1522 cm^{-1}.

*Ethyl 2-Cyclohexyl-2-(phenylamino)acetate (**5fa**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (39.2 mg, 75% yield) as a yellowish solid. Mp 49−50 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.16 (t, J = 8.2 Hz, 2H), 6.72 (t, J = 7.3 Hz, 1H), 6.63 (d, J = 7.8 Hz, 2H), 4.20−4.13 (m, 3H), 3.89−3.85 (m, 1H), 1.80−1.65 (m, 6H), 1.28−1.15 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.7, 147.4, 129.2, 118.0, 113.4, 61.9, 60.7, 41.3, 29.6, 29.1, 26.1, 26.1, 26.0, 14.3. MS (EI): 261 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{16}H_{24}NO_2$ $(M + H)^+$ 262.1802, found 262.1798. IR (KBr) ν 3356, 2926, 2851, 1717, 1601, 1520 cm^{-1}.

*Ethyl 2-Cyclohexyl-2-((4-methoxyphenyl)amino)acetate (**5ga**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:20) gave the product (29.2 mg, 50% yield) as a yellow brown liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.75 (d, J = 8.9 Hz, 2H), 6.60 (d, J = 8.9 Hz, 2H), 4.16 (q, J = 6.9 Hz, 2H), 3.76 (d, J = 6.1 Hz, 1H), 3.73 (m, 3H), 1.88−1.66 (m, 6H), 1.27−1.12 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 174.0, 152.6, 141.6, 115.1, 114.8, 63.3, 60.7, 55.7, 41.3, 29.6, 29.1, 26.2, 26.1, 26.0, 14.3. MS (EI): 291 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{17}H_{26}NO_3$ $(M + H)^+$ 292.1907, found 292.1900. IR (KBr) ν 3377, 2927, 2852, 1732, 1618, 1514 cm^{-1}.

*Ethyl 2-Cyclohexyl-2-((2,5-dimethoxyphenyl)amino)acetate (**5ha**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:20) gave the product (27.5 mg, 43% yield) as a yellowish liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.66 (d, J = 8.2 Hz, 1H), 6.16−6.14 (m, 2H), 4.76 (d, J = 8.4 Hz, 1H), 4.17 (q, J = 7.1 Hz, 2H), 3.84−3.81 (m, 4H), 3.73 (s, 3H), 1.88−1.65 (m, 6H), 1.28−1.14 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.4, 154.6, 141.7, 138.4, 110.3, 99.4, 98.3, 61.5, 60.7, 56.1, 55.4, 41.2, 29.6, 29.2, 26.1, 26.0, 26.0, 14.3. MS (EI): 321 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{18}H_{28}NO_4$ $(M + H)^+$ 322.2013, found 322.2011. IR (KBr) ν 3420, 2929, 2853, 1732, 1612, 1520 cm^{-1}.

*Ethyl 2-((4-(tert-Butyl)phenyl)amino)-2-cyclohexylacetate (**5ia**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (50.8 mg, 80% yield) as a yellow brown liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.03 (d, J = 8.5 Hz, 2H), 6.59 (d, J = 6.6 Hz, 2H), 4.17 (q, J = 7.2 Hz, 2H), 4.05 (s, 1H), 3.84 (s, 1H), 2.88−2.77 (m, 1H), 1.88−1.67 (m, 7H), 1.30−1.12 (m, 15H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.9, 145.4, 138.5, 127.1, 113.5, 62.3, 60.7, 41.3, 33.1, 29.6, 29.1, 26.2, 26.1, 26.0, 24.2, 14.3. MS (EI): 317 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{20}H_{32}NO_2$ $(M + H)^+$ 318.2428, found 318.2428. IR (KBr) ν 3367, 2928, 2854, 1730, 1610 cm^{-1}.

*Ethyl 2-((4-Chlorophenyl)amino)-2-cyclohexylacetate (**5ja**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (50.1 mg, 85% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.10 (d, J = 8.8 Hz, 2H), 6.54 (d, J = 8.9 Hz, 2H), 4.19−4.13 (m, 3H), 3.82−3.78 (m, 1H), 1.84−1.66 (m, 6H), 1.32−1.05 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.4, 146.0, 129.0, 122.6, 114.6, 62.1, 60.9, 41.2, 29.5, 29.1, 26.1, 26.0, 26.0, 14.3. MS (EI): 295 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{16}H_{23}ClNO_2$ $(M + H)^+$ 296.1412, found 296.1410. IR (KBr) ν 3340, 2928, 2851, 1715, 1599, 1495 cm^{-1}.

*Ethyl 4-((1-Cyclohexyl-2-ethoxy-2-oxoethyl)amino)benzoate (**5ka**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:20) gave the product (61.2 mg, 92% yield) as a yellowish liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.85 (d, J = 8.8 Hz, 2H), 6.57 (d, J = 8.8 Hz, 2H), 4.59 (d, J = 9.0 Hz, 1H), 4.30 (q, J = 7.1 Hz, 2H), 4.18 (q, J = 7.1 Hz, 2H), 3.95−3.92 (m, 1H), 1.82−1.75 (m, 4H), 1.71−1.68 (m, 2H), 1.34 (t, J = 7.1 Hz 3H) 1.27−1.09 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 172.8, 166.7, 151.0, 131.4, 119.4, 112.0, 61.1, 61.1, 60.2, 41.2, 29.4, 29.1, 26.0, 26.0, 25.9, 14.4, 14.2. MS (EI): 333 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{19}H_{28}NO_4$ $(M + H)^+$ 334.2013, found 334.2009. IR (KBr) ν 3369, 2930, 2854, 1732, 1705, 1607 cm^{-1}.

*Ethyl 2-((3-Chloro-4-fluorophenyl)amino)-2-cyclohexylacetate (**5la**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:50) gave the product (30.8 mg, 49% yield) as a yellow liquid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.92 (t, J = 8.8 Hz, 1H), 6.63−6.57 (m, 1H), 6.47−6.43 (m, 1H), 4.18 (q, J = 7.1 Hz, 2H), 4.06 (d, J = 9.6 Hz, 1H), 3.75−3.72 (m, 1H), 1.83−1.62 (m, 6H), 1.29−1.10 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.3, 151.3 (d, J_{C-F} = 237 Hz), 144.4, 121.1 (d, J_{C-F} = 22.3 Hz), 116.8 (d, J_{C-F} = 21.9 Hz), 114.7, 112.9 (d, J_{C-F} = 6.4 Hz), 62.5, 61.0, 41.2, 29.6, 29.1, 26.1, 26.0, 26.0, 14.3. MS (EI): 313 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{16}H_{22}ClFNO_2$ $(M + H)^+$ 314.1318, found 314.1317. IR (KBr) ν 3385, 2928, 2854, 1732, 1616, 1518 cm^{-1}.

*2-Cyclohexyl-1-phenyl-2-(p-tolylamino)ethanone (**3aa**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (48.6 mg, 79% yield) as a yellow solid. Mp 74−75 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.98 (d, J = 7.4 Hz, 2H), 7.60 (t, J = 7.3 Hz, 1H), 7.49 (t, J = 7.7 Hz, 2H), 6.96 (d, J = 8.1 Hz, 2H), 6.64 (d, J = 8.2 Hz, 2H), 4.86 (s, 1H), 4.53 (s, 1H), 2.22 (s, 3H), 1.85−1.77 (m, 4H), 1.68−1.63 (m, 2H), 1.42−1.32 (m, 1H), 1.27−1.09 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.5, 145.9, 136.1, 133.4, 129.7, 128.7, 128.3, 127.2, 114.1, 63.5, 41.9, 30.8, 27.7, 26.4, 26.1, 26.0, 20.3. MS (EI): 307 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{26}NO$ $(M + H)^+$ 308.2009, found 308.2005. IR (KBr) ν 3402, 2920, 2851, 1666, 1614, 1516 cm^{-1}.

*2-Cyclopentyl-1-phenyl-2-(p-tolylamino)ethanone (**3ab**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (39.3 mg, 67% yield) as a yellow solid. Mp 86−88 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.96 (d, J = 7.4 Hz, 2H), 7.58 (t, J = 7.3 Hz, 1H), 7.48 (t, J = 7.8 Hz, 2H), 6.96 (d, J = 8.1 Hz, 2H), 6.64 (d, J = 8.2 Hz, 2H), 4.96 (s, 1H), 4.58 (s, 1H), 2.21 (s, 3H), 1.81−1.70 (m, 1H), 1.74−1.41 (m, 8H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.7, 145.9, 136.1, 133.3, 129.7, 128.7, 128.3, 127.2, 114.1, 61.4, 43.7, 29.8, 27.5, 25.3, 24.8, 20.3. MS (EI): 293 (M^+). HRMS

dx.doi.org/10.1021/jo5017426 | J. Org. Chem. 2014, 79, 9847−9853

(ESI-TOF) m/z calcd for $C_{20}H_{24}NO$ $(M + H)^+$ 294.1852, found 294.1852. IR (KBr) ν 3404, 2941, 2866, 1670, 1614, 1595 cm^{-1}.

*2-Cyclooctyl-1-phenyl-2-(p-tolylamino)ethanone (**3ac**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (40.9 mg, 61% yield) as a yellow solid. Mp 63−65 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ 7.98 (d, J = 7.4 Hz, 2H), 7.60 (t, J = 7.3 Hz, 1H), 7.49 (t, J = 7.7 Hz 2H), 6.95 (d, J = 8.1 Hz 2H), 6.62 (d, J = 8.3 Hz, 2H), 4.83 (m, 1H), 4.41 (s, 1H), 2.20 (s, 3H), 2.15−2.13 (m, 1H), 1.74−1.64 (m, 5H), 1.50−1.37 (m, 8H), 1.34−1.26 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.7, 145.7, 136.3, 133.3, 129.7, 128.7, 128.2, 127.2, 114.1, 64.4, 41.0, 32.0, 27.0, 26.9, 26.6, 26.4, 26.1, 25.1, 20.3. MS (EI): 335 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{23}H_{30}NO$ $(M + H)^+$ 336.2322, found 336.2323. IR (KBr) ν 3348, 2920, 2849, 1680, 1614, 1595, 1518 cm^{-1}.

*2-Cycloheptyl-1-phenyl-2-(p-tolylamino)ethanone (**3ad**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (39.2 mg, 61% yield) as a yellow solid. Mp 96−97 °C. ^1H NMR ($CDCl_3$, 300 MHz): δ 7.96 (t, J = 7.1 Hz, 2H), 7.72 (t, J = 7.3 Hz, 1H), 7.49 (t, J = 7.1 Hz, 2H), 6.96 (d, J = 8.1 Hz, 2H), 6.63 (d, J = 8.4 Hz, 2H), 4.88 (d, J = 4.3, 1H), 4.46 (s, 1H), 2.21 (s, 3H), 1.69−1.63 (m, 1H), 1.53−1.50 (m, 1H), 1.49−1.47 (m, 4H), 1.45−1.44 (m, 5H), 1.35−1.27 (m, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 201.6, 145.8, 136.3, 133.3, 129.8, 128.8, 128.2, 127.3, 114.2, 64.1, 43.2, 32.9, 28.5, 28.4, 27.6, 26.8, 26.7, 20.3. MS (EI): 321 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{23}H_{30}NO$ $(M + H)^+$ 322.2165, found 322.2164. IR (KBr) ν 3400, 2920, 2853, 1670, 1614, 1516 cm^{-1}.

*3-Methyl-1-phenyl-2-(p-tolylamino)heptan-1-one (**3ae**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (39.0 mg, 63% yield, 1:2:3 = 1:1.5:1.5) as a yellow liquid. ^1H NMR ($CDCl_3$, 300 MHz): δ 7.97−7.95 (m, $2H_1$, $2H_2$, $2H_3$), 7.58−7.56 (m, $1H_1$, $1H_2$, $1H_3$), 7.51−7.47 (m, $2H_1$, $2H_2$, $2H_3$), 6.97−6.95 (m, $2H_1$, $2H_2$, $2H_3$), 6.66−6.61 (m, $2H_1$, $2H_2$, $2H_3$), 5.09 (dd, J_1 = 3.3 Hz, J_2 = 12.7 Hz $2H_1$), 5.00 (d, J = 3.2 Hz $1H_2$), 4.88 (d, J = 4.4 Hz $1H_3$), 2.21 (s, $3H_1$, $3H_2$, $3H_3$), 1.12−0.76 (m, $10H_1$, $11H_2$, $11H_3$). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.92, 200.85, 200.37, 145.04, 144.97, 144.78, 135.48, 135.15, 134.86, 132.43, 132.30, 132.22, 128.76, 127.78, 127.77, 127.75, 127.29, 127.23, 127.18, 126.44, 126.42, 126.29, 113.42, 113.34, 113.28, 113.21, 62.68, 61.47, 59.91, 57.44, 41.93, 41.88, 35.78, 35.23, 33.22, 31.90, 30.06, 28.79, 28.38, 21.80, 21.69, 20.63, 19.88, 19.33, 17.40, 16.22, 13.30, 13.12, 13.07, 12.94, 10.56. MS (EI): 309 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{21}H_{28}NO$ $(M + H)^+$ 310.2165, found 310.2159. IR (KBr) ν 3367, 2928, 2872, 1682, 1618, 1520 cm^{-1}.

*2-Adamantan-1-phenyl-2-(p-tolylamino)ethanone (**3af**).* Flash column chromatography on a silica gel (ethyl acetate/petroleum ether, 1:100) gave the product (33.1 mg, 46% yield) as a yellow solid. Mp 117−119 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ 7.95 (d, J = 7.4 Hz, 2H), 7.56 (t, J = 7.3 Hz, 1H), 7.46 (t, J = 7.8 Hz, 2H), 6.94 (d, J = 8.2 Hz 2H), 6.64 (d, J = 8.3 Hz, 2H), 4.69 (d, J = 7.4 Hz, 1H), 4.50 (d, J = 8.2 Hz, 1H), 2.19 (s, 3H), 1.99−1.92 (m, 3H), 1.79−1.76 (m, 2H), 1.68−1.51 (m, 10H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 203.1, 146.1, 138.4, 133.2, 129.7, 128.7, 128.2, 127.2, 114.2, 66.0, 39.5, 37.9, 36.8, 28.4, 20.3. MS (EI): 359 (M^+). HRMS (ESI-TOF) m/z calcd for $C_{25}H_{30}NO$ $(M + H)^+$ 360.2322, found 360.2322. IR (KBr) ν 3404, 2907, 2849, 1674, 1616, 1595 cm^{-1}.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

KIE experiments, radical capture experiments, and ^1H and ^{13}C NMR spectra of compounds **3ba−3oa**, **5aa−5la**, and **3aa−3af**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

We thank the National Natural Science Foundation of China (Grant Nos. 21272028 and 21202013), "Innovation & Entrepreneurship Talents" Introduction Plan of Jiangsu Province, Jiangsu Key Laboratory of Advanced Catalytic Materials & Technology (Grant BM2012110), Jiangsu Province Key Laboratory of Fine Petrochemical Engineering, State Key Laboratory of Coordination Chemistry of Nanjing University, and the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD) for financial support.

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dx.doi.org/10.1021/jo5017426 | *J. Org. Chem.* 2014, 79, 9847−9853