JOC The Journal of Organic Chemistry

Article

pubs.acs.org/joc

Direct α-Arylation of α-Amino Carbonyl Compounds with Indoles Using Visible Light Photoredox Catalysis

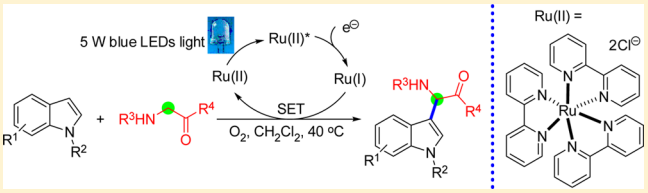
Zhi-Qiang Wang,[†,‡] Ming Hu,[†,‡] Xiao-Cheng Huang,[†,‡] Lu-Bing Gong,[†,‡] Ye-Xiang Xie,[†] and Jin-Heng Li*[,†]

[†]State Key Laboratory of Chemo/Biosensing and Chemometrics, College of Chemistry and Chemical Engineering, Hunan University, Changsha 410082, China

[‡]Key Laboratory of Chemical Biology & Traditional Chinese Medicine Research (Ministry of Education), Hunan Normal University, Changsha 410081, China

Supporting Information

ABSTRACT: A general and mild method for the construction of functionalized 2-(1*H*-indol-3-yl)-2-amino-carbonyl compounds was achieved, which represents the first example of direct α-arylation of α-amino carbonyl compounds with indoles using the visible light photoredox catalysis strategy.



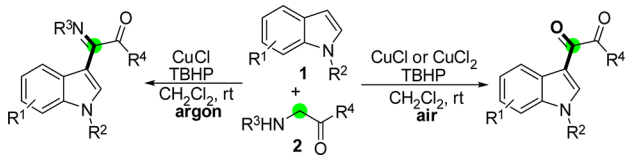
INTRODUCTION

The α-amino carbonyl motif is an important structure component of multitudinous natural products and biomolecules.[1,2] For these reasons, many mild, general and efficient methods have been well-established for accessing this important motif. However, despite progress in the field, transition metal-catalyzed functionalization of α-C−H bond in α-amino carbonyl compounds remains one of the biggest challenges because there are some highly reactive functional groups, such as a free N−H bond and a carbonyl group, often resulting in some competitive reactions.[1−4] In particular, methods for α-arylation of α-amino carbonyls are rare and are more limited: the α-arylation reaction often requires a base to in situ generate the carbonyl enolate by α-deprotonation, thereby reacting with expensive aryl sources (often aryl halides or pseudohalides) with the aid of transition metal catalysts.[3]

A general synthesis of nonnaturally α-arylated amino carbonyl compounds from cleavage of α-C−H bond without the aid of bases would greatly expand the methods that are available for their preparation. Very recently, we report a new, mild base-free copper-catalyzed α-arylation of α-amino carbonyls with indoles in the presence of TBHP through a C−H oxidation strategy.[4] However, 2-(1*H*-indol-3-yl)-2-imino-carbonyls and 2-(1*H*-indol-3-yl)-2-oxo-carbonyls, not α-amino carbonyl products, were selectively obtained as the terminal products under argon or air atmosphere (Scheme 1).

Very recently, Stephenson and co-workers reported that $Ru(bpy)_3Cl_2$-catalyzed Friedel−Crafts amidoalkylation was achieved by oxidation of dialkylamides using an oxidant persulfate[6n] under the visible light at room temperature, via a reactive *N*-acyliminium intermediate (Scheme 2).[6] Although this protocol is not consistent with either indole or 1-methylindole with low yields,[6n] we envision that it may be applied to α-arylation of α-amino carbonyl compounds with indoles leading to 2-(1*H*-indol-3-yl)-2-amino-carbonyl compounds. However, these reaction conditions cannot be employed for α-arylation of α-amino carbonyl compounds with either indole or even 1-benzylindole.

Scheme 1. Direct α-Arylation Using the Cu-Catalyzed C−H Oxidation Strategy



These compelled us to screen other viable reaction conditions. After a series of trials, we found a new visible-light photoredox catalysis strategy for 2-(1*H*-indol-3-yl)-2-amino-carbonyl compounds synthesis by direct α-arylation between α-amino carbonyl compounds and indoles with the aid of $Ru(bpy)_3Cl_2$, 5 W blue LEDs light and O_2, avoiding both the use of bases and the conversion of the amino groups into imino groups in the products (Scheme 2).[5,6] It is noteworthy that the products containing an indole unit would be valuable in chemical synthesis because indole derivatives are important motifs of numerous natural products, pharmaceutical molecules and functional materials.[7]

RESULTS AND DISCUSSION

The reaction between 1*H*-indole (**1a**) and 1-phenyl-2-(phenylamino)ethanone (**2a**) was chosen to screen the optimal conditions, and the results are summarized in Table 1. In the presence of $Ru(bpy)_3Cl_2$, O_2 and 37 W compact fluorescent

Received: August 9, 2012
Published: September 17, 2012

   dx.doi.org/10.1021/jo301691h | J. Org. Chem. 2012, 77, 8705−8711

Scheme 2. Direct Arylation with Indoles Using Visible Light Photoredox Catalysis

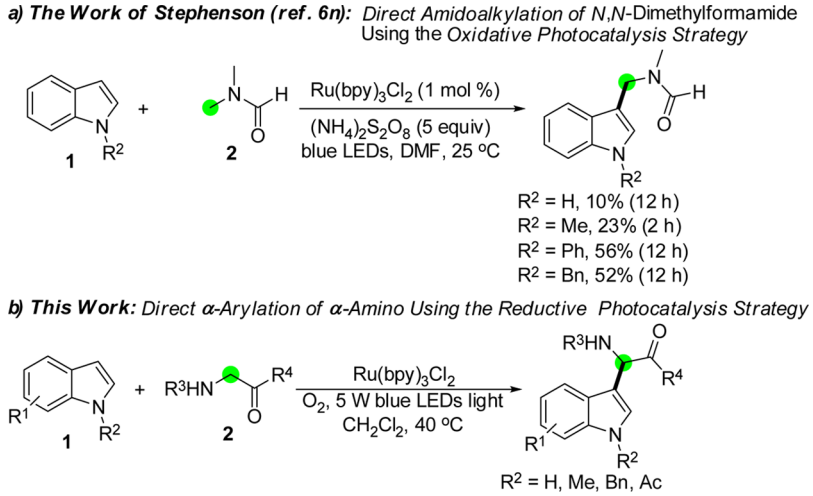
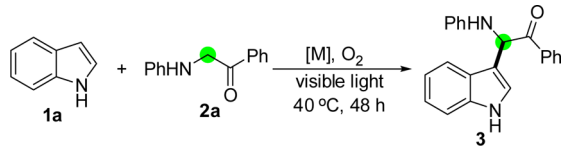


Table 1. Screening Optimal Conditions[a]



entry	[M] (mol %)	solvent	isolated yield (%)
1[b]	$Ru(bpy)_3Cl_2$ (10)	CH_2Cl_2	32
2[b]	$Ru(bpy)_3Cl_2$ (3)	CH_2Cl_2	26
3[b]	$Ru(bpy)_3Cl_2$ (15)	CH_2Cl_2	34
4[b]		CH_2Cl_2	0
5[c]	$Ru(bpy)_3Cl_2$ (10)	CH_2Cl_2	0
6	$Ru(bpy)_3Cl_2$ (10)	CH_2Cl_2	60
7	$Ir(ppy)_3$ (10)	CH_2Cl_2	30
8	Eosin Y (10)	CH_2Cl_2	37
9	$Ru(bpy)_3Cl_2$ (10)	CH_2ClCH_2Cl	trace
10	$Ru(bpy)_3Cl_2$ (10)	MeCN	54
11	$Ru(bpy)_3Cl_2$ (10)	toluene	6
12[d]	$Ru(bpy)_3Cl_2$ (10)	CH_2Cl_2	trace
13[e]	$Ru(bpy)_3Cl_2$ (10)	CH_2Cl_2	20

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (2.5 equiv), [M], O_2 (1 atm) and solvent (2 mL) with 5 W blue LEDs light at 40 °C for 48 h. $Ru(bpy)_3Cl_2$ = tris(2,2′-bipyridine)ruthenium dichloride, $Ir(ppy)_3$ = tris(2-phenylpyridine)iridium(III). [b]With 37 W compact fluorescent light. [c]Without additional visible light. [d]Under argon atmosphere. [e]At room temperature.

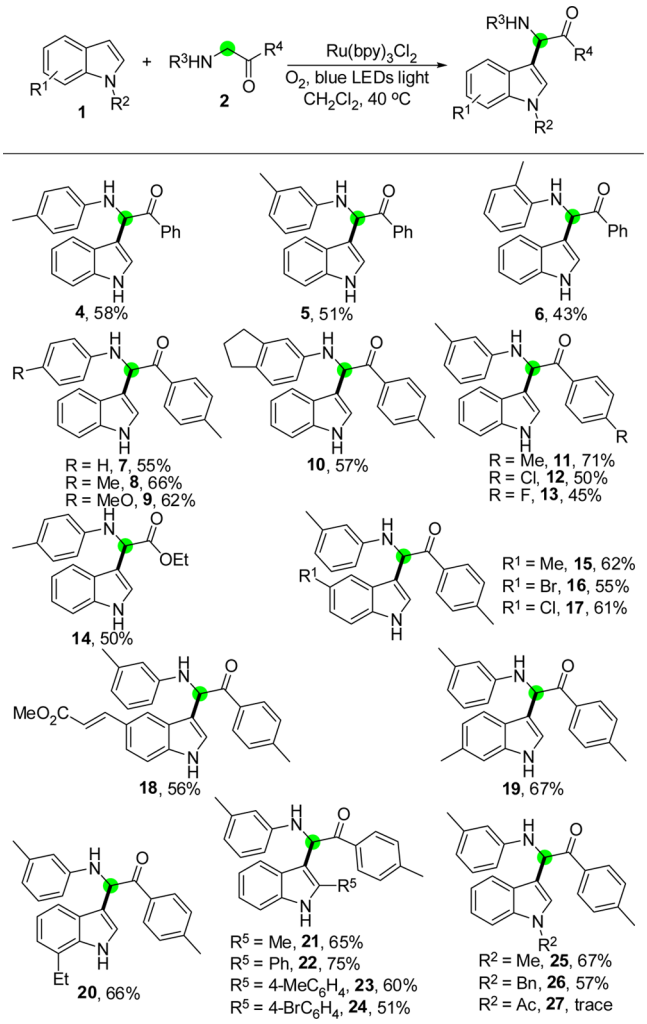
light, 1*H*-indole (**1a**) was treated with 1-phenyl-2-(phenylamino)ethanone (**2a**) at 40 °C smoothly, affording the desired product **3** in 32% yield after 48 h (Table 1, entry 1). Encouraged by these results, the amount of $Ru(bpy)_3Cl_2$ was investigated: the yield was lowered to 26% yield at 3 mol % $Ru(bpy)_3Cl_2$ (entry 2), and identical results to those of 10 mol % $Ru(bpy)_3Cl_2$ were observed when 15 mol % $Ru(bpy)_3Cl_2$ was added (entry 3). It is noteworthy that the reaction cannot take place without either $Ru(bpy)_3Cl_2$ or additional visible light (entries 4 and 5). Gratifyingly, the yield was enhanced sharply to 60% using 5 W blue LEDs light instead of 37 W compact fluorescent light (entry 6). Two other visible-light photoredox catalysts, $Ir(ppy)_3$ and Eosin Y, were subsequently examined, and screening revealed that they were inferior to $Ru(bpy)_3Cl_2$ (entries 7 and 8). Among the effect of solvents examined, it turned out that CH_2Cl_2 was the most effective solvent (entries 9−11). While both CH_2ClCH_2Cl and toluene displayed a lower effect, the reaction in MeCN still gave moderate yield. Notably, only a trace of product **3** was observed in the absence of O_2 (entry 12). Finally, the reaction at room temperature was tested: it could take place, but a low yield was isolated in 48 h (entry 13).

As shown in Scheme 3, we have probed the scope of both indoles **1** and α-amino carbonyls **2** for this oxidative α-arylation under the optimal reaction conditions. In the presence of indole (**1a**), $Ru(bpy)_3Cl_2$, O_2 and 5 W blue LEDs light, a number of other arylamino groups in α-amino carbonyls **2** were initially investigated (Products **4**−**10**). For 1-phenyl-2-aminoethanones having Me-substituted phenylamino groups, the order of the reactivity is *para* > *meta* > *ortho* in terms of yields (Products **4**−**6**). The results demonstrated that substituents, such as phenylamino, *p*-tolylamino, *p*-methoxyphenylamion and 2,3-dihydro-1*H*-inden-5-ylamino groups, in 2-amino-1-*p*-tolylethanones were compatible with the optimal conditions (Products **7**−**10**). Interestingly, halo substituents, Cl and F, on the aryl ring of the arylethanone moiety were consistent with the optimal conditions, thereby facilitating additional modifications at the halogenated positions (Products **12** and **13**). It was noted that ethyl 2-(*p*-tolylamino)acetate, an amino ester, was successfully reacted with indole (**1a**), $Ru(bpy)_3Cl_2$ and O_2 under 5 W blue LEDs light, providing the desired product **14** in 50% yield.

The optimal conditions were found to be viable for a wide range of indoles **1** with high substituents compatibility: several substituents, including Me, Br, Cl, acryl, Et and aryl groups, on the aromatic ring of indoles **1** were well-tolerated in the presence of 1-*p*-tolyl-2-(*m*-tolylamino)ethanone (Products **15**−**24**). For example, treatment of Me-substituted indole with 1-*p*-tolyl-2-(*m*-tolylamino)ethanone, $Ru(bpy)_3Cl_2$, O_2 and 5 W blue LEDs light afforded the corresponding products **15** and **19** in 62 and 67% yields, respectively. The introduction of Br, Cl or olefin into this system makes this methodology more useful for the preparation of pharmaceuticals and natural products (Products **16**−**18**). Gratifyingly, substituents, Me or aryl, at the 2-position of indoles were also compatible with the optimal conditions (Products **21**−**24**). In the presence of $Ru(bpy)_3Cl_2$, O_2 and 5 W blue LEDs light, 2-methyl-1*H*-indole successfully underwent the arylation reaction with 1-*p*-tolyl-2-(*m*-tolylamino)ethanone leading to the desired product **21** in

dx.doi.org/10.1021/jo301691h | J. Org. Chem. 2012, 77, 8705−8711

Scheme 3. Direct α-Arylation of α-Amino Carbonyl Compounds (2) with Indoles (1) Using Visible Light Photoredox Catalysis[a]

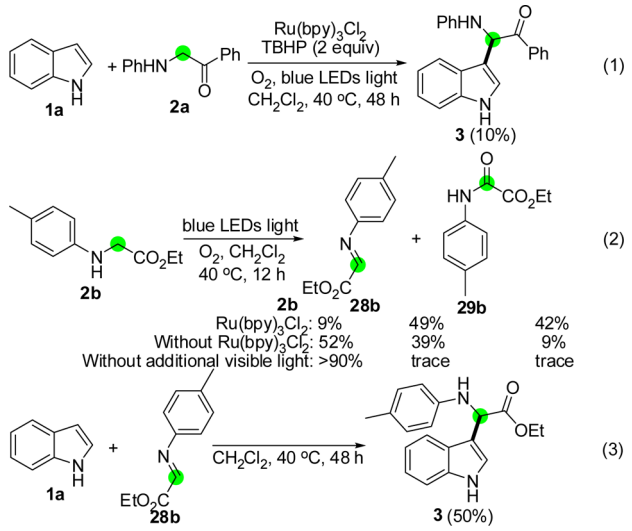


[a]Reaction conditions: **1** (0.3 mmol), **2** (2.5 equiv), $Ru(bpy)_3Cl_2$ (10 mol %), O_2 (1 atm) and CH_2Cl_2 (2 mL) with 5 W blue LEDs light at 40 °C for 48−72 h.

good yield. Screening revealed that indoles with a phenyl, 4-MeC_6H_4 or 4-BrC_6H_4 group also displayed high reactivity under the same conditions, furnishing the target products **22**−**24** in good yields. Finally, substituents on the nitrogen atom of the indole moiety were tested (Products **25**−**27**). While 1-alkyl indoles (1-Me or 1-Bn) were successfully reacted with 1-*p*-tolyl-2-(*m*-tolylamino)ethanone, $Ru(bpy)_3Cl_2$, O_2 and 5 W blue LEDs light in good yields (Products **25** and **26**), 1-Ac-substituted indole has no reactivity (Product **27**).

Some control experiments were carried out to elucidate the mechanism (Scheme 4). The results in eq 1 disclosed that the addition of TBHP disfavored the reaction. In the presence of $Ru(bpy)_3Cl_2$, TBHP, O_2 and 5 W blue LEDs light, treatment of indole (**1a**) with 1-phenyl-2-(phenylamino)ethanone (**2a**) afforded product **3** in a low yield together with some unidentified byproduct. Interestingly, the GC−MS analysis results disclosed that without indoles ethyl 2-(*p*-tolylamino)-acetate (**2b**) could be converted into ethyl 2-(*p*-tolylimino)-acetate (**28b**) and ethyl 2-oxo-2-(p-tolylamino)acetate (**29b**) in the presence of $Ru(bpy)_3Cl_2$, O_2 and 5 W blue LEDs light: 49%

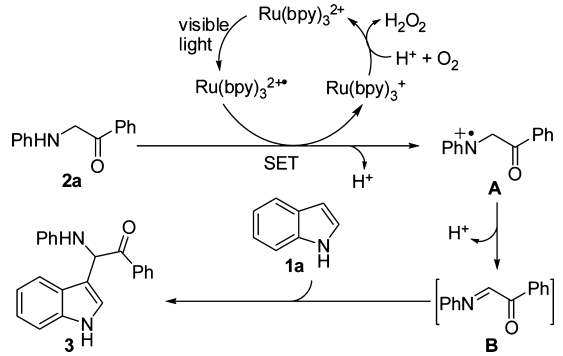
Scheme 4. Control Experiments



GC yield of product **28b** together with 42% GC yield of product **29b** were isolated after 12 h (eq 2). Both products **28b** and **29b** could also be furnished even without $Ru(bpy)_3Cl_2$, albeit with a yield significantly lower than that with $Ru(bpy)_3Cl_2$ (eq 2). Notably, blue LEDs light play an important role in this reaction: only traces of the target products **28b** and **29b** were observed without blue LEDs light (eq 2). Consequently, we deduce that $Ru(bpy)_3Cl_2$ combined with visible light is employed to only catalyze the formation of imines.[6m] As expected, treatment of indole (**1a**) with ethyl 2-(*p*-tolylimino)acetate (**28b**) offered the desired product **3** in the absence of both Ru catalysts and additional light (eq 3).[8]

Consequently, a possible mechanism as outlined in Scheme 5 is proposed.[5,6,8] Initially, the active $Ru(bpy)_3^{2+}$ species is

Scheme 5. Possible Mechanism



converted to the excited state $Ru(bpy)_3^{2+\bullet}$ by irradiating with visible light. Subsequently, a single electron transfer (SET) from the excited state $Ru(bpy)_3^{2+\bullet}$ to 1-phenyl-2-(phenylamino)ethanone **2a** takes place to offer the radical intermediate **A** and $Ru(bpy)_3^{+}$.[5,6] The radical intermediate **A** readily undergoes the deprotonation reaction leading to imine intermediate **B**.[6m] Finally, the reaction of indole (**1a**) with intermediate **B** affords the desired product **3**,[8] and the active $Ru(bpy)_3^{2+}$ species is regenerated from the oxidation of $Ru(bpy)_3^{+}$ with O_2 to start a new catalytic cycle.

dx.doi.org/10.1021/jo301691h | J. Org. Chem. 2012, 77, 8705−8711

CONCLUSIONS

In summary, we have established a general and mild method for constructing numerous functionalized 2-(1*H*-indol-3-yl)-2-amino-carbonyl compounds via direct α-arylation of α-amino carbonyl compounds with indoles using the visible-light photoredox catalysis strategy. This new protocol has several attractive features, including (i) a low operating temperature (40 °C) without the requirement of bases, ligands or dangerous peroxides (TBHP), (ii) high functional group tolerance and broad substrate scope, and (iii) simple operation by visible-light photoredox catalysis. Importantly, it opens a new door to synthesize natural and nonnatural α-amino carbonyl compounds by the introduction of the heterocycle unit into them, which makes the obtanied α-amino carbonyl compounds more valuable with some special complex bioactivities.

EXPERIMENTAL SECTION

General Considerations. The ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ or DMSO-d_6 solvents on 500 MHz spectrometer using TMS as internal standard. HRMS was measured using a Finnigan MAT95XP-HRMS analyzer in an EI mode. Melting points determined are uncorrected.

Typical Experimental Procedure for the Ru-Catalyzed Direct α-Arylation of α-Amino Carbonyl Compounds with Indoles. To a Schlenk tube were added indole **1** (0.3 mmol), *a*-amino carbonyl **2** (2.5 equiv), $Ru(bpy)_2Cl_2$ (10 mol %), and CH_2Cl_2 (2 mL). Then the tube was charged with O_2 (1 atm), and illuminated with 5 W blue LED at 40 °C (oil bath temperature) for the indicated time until complete consumption of starting material as monitored by TLC and GC−MS analysis. After the reaction was finished, the reaction mixture was cooled to room temperature, diluted in diethyl ether, and washed with brine. The aqueous phase was re-extracted with diethyl ether. The combined organic extracts were dried over Na_2SO_4 and concentrated in a vacuum, and the resulting residue was purified by silica gel column chromatography (hexane/ethyl acetate = 5:1) to afford the desired product.

2-(1H-Indol-3-yl)-1-phenyl-2-(phenylamino)ethanone (**3**). 58.7 mg, yield 60%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.09 (brs, 1H), 8.14 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.55 (t, *J* = 7.0 Hz, 1H), 7.47−7.43 (m, 3H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.07−6.88 (m, 4H), 6.78 (d, *J* = 8.0 Hz, 2H), 6.58 (d, *J* = 8.0 Hz, 1H), 6.51 (t, *J* = 7.5 Hz, 1H), 6.13 (d, *J* = 7.5 Hz, 1H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.6, 147.9, 136.7, 133.6, 129.1 (2C), 128.9, 126.2, 126.1, 121.8, 119.6, 119.5, 116.6, 113.5 (2C), 112.1, 110.9, 55.2; LRMS (EI 70 ev) *m*/*z* (%) 326 (M^+, 1), 324 (4), 281 (3), 253 (3), 219 (100), 165 (6), 142 (5), 116 (7), 77 (24), 51 (9); HRMS (EI) for $C_{22}H_{18}N_2O$ (M^+) calcd 326.1419, found 326.1415.

2-(1H-Indol-3-yl)-1-phenyl-2-(p-tolylamino)ethanone (**4**). 59.2 mg, yield 58%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.07 (brs, 1H), 8.13 (d, *J* = 8.5 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.54 (t, *J* = 7.5 Hz, 1H), 7.45−7.43 (m, 3H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.05 (t, *J* = 8.0 Hz, 1H), 6.99 (t, *J* = 8.0 Hz, 1H), 6.83 (d, *J* = 8.0 Hz, 2H), 6.70 (d, *J* = 8.0 Hz, 2H), 6.55 (d, *J* = 7.0 Hz, 1H), 5.92 (d, *J* = 8.0 Hz, 1H), 2.10 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.8, 145.7, 136.8, 135.7, 133.6, 129.6, 129.1, 128.9, 126.2, 126.1, 125.1, 121.8, 119.7, 119.5, 113.7, 112.1, 111.1, 55.4, 20.6; LRMS (EI 70 ev) *m*/*z* (%) 340 (M^+, 1), 339 (1), 233 (100), 207 (12), 91 (13), 77 (4), 65 (11); HRMS (EI) for $C_{23}H_{20}N_2O$ (M^+) calcd 340.1576, found 340.1571.

2-(1H-Indol-3-yl)-1-phenyl-2-(m-tolylamino)ethanone (**5**). 52.0 mg, yield 51%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.09 (brs, 1H), 8.15 (d, *J* = 7.5 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.47−7.44 (m, 3H), 7.31 (d, *J* = 8.0 Hz, 1H), 7.06 (t, *J* = 7.5 Hz, 1H), 7.00 (t, *J* = 7.5 Hz, 1H), 6.91 (t, *J* = 8.0 Hz, 1H), 6.63 (s, 1H), 6.60−6.57 (m, 2H), 6.34 (d, *J* = 7.5 Hz, 1H), 6.03 (d, *J* = 7.5 Hz, 1H), 2.14 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.7, 147.9, 138.0, 135.7, 133.7, 129.1, 129.0, 128.9, 126.2, 126.1, 121.8, 119.7, 119.5, 117.6, 114.3, 112.2, 111.1, 110.7, 55.2, 21.8; LRMS (EI 70 ev) *m*/*z* (%) 340 (M^+, 1), 339 (1), 233 (100), 207 (20), 91 (8), 77 (5), 65 (15); HRMS (EI) for $C_{23}H_{20}N_2O$ (M^+) calcd 340.1576, found 340.1572.

2-(1H-Indol-3-yl)-1-phenyl-2-(o-tolylamino)ethanone (**6**). 43.9 mg, yield 43%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.15 (brs, 1H), 8.21 (d, *J* = 7.0 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.64 (s, 1H), 7.55 (t, *J* = 7.5 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 2H), 7.33 (d, *J* = 7.5 Hz, 1H), 7.08−6.95 (m, 4H), 6.88 (d, *J* = 8.0 Hz, 1H), 6.75 (d, *J* = 7.5 Hz, 1H), 6.53 (t, *J* = 7.5 Hz, 1H), 5.31 (d, *J* = 7.5 Hz, 1H), 2.20 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.5, 145.1, 136.9, 135.3, 133.9, 130.4, 129.2 (2C), 127.2, 126.8, 125.9, 122.5, 121.9, 119.8, 119.3, 117.1, 112.5, 111.6, 110.9, 55.3, 17.8; LRMS (EI 70 ev) *m*/*z* (%) 340 (M^+, 1), 322 (1), 233 (15), 204 (19), 130 (11), 106 (27), 77 (18), 40 (100); HRMS (EI) for $C_{23}H_{20}N_2O$ (M^+) calcd 340.1576, found 340.1572.

2-(1H-Indol-3-yl)-2-(phenylamino)-1-p-tolylethanone (**7**). 56.1 mg, yield 55%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.09 (brs, 1H), 8.05 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 7.5 Hz, 1H), 7.47 (s, 1H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.06−6.98 (m, 4H), 6.78 (d, *J* = 8.0 Hz, 2H), 6.55 (d, *J* = 7.5 Hz, 1H), 6.50 (t, *J* = 7.5 Hz, 1H), 6.15 (d, *J* = 7.5 Hz, 1H), 2.30 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.2, 148.0, 144.2, 136.8, 133.1, 129.9, 129.7, 129.1 (2C), 126.2, 126.1, 121.8, 119.7, 119.5, 116.6, 113.5, 112.2, 111.2, 55.0, 21.6; LRMS (EI 70 ev) *m*/*z* (%) 340 (M^+, 1), 339 (1), 221 (100), 207 (6), 91 (10), 77 (4), 51 (15); HRMS (EI) for $C_{23}H_{20}N_2O$ (M^+) calcd 340.1576, found 340.1570.

2-(1H-Indol-3-yl)-1-p-tolyl-2-(p-tolylamino)ethanone (**8**). 70.1 mg, yield 66%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.05 (brs, 1H), 8.04 (d, *J* = 8.0 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 1H), 7.44 (s, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 7.5 Hz, 2H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.98 (t, *J* = 7.5 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 2H), 6.70 (d, *J* = 7.5 Hz, 2H), 6.51 (d, *J* = 7.5 Hz, 1H), 5.89 (d, *J* = 7.5 Hz, 1H), 2.30 (s, 3H), 2.10 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.3, 145.7, 144.1, 136.7, 133.1, 129.7, 129.6, 129.1, 126.1, 125.0, 121.7, 119.7, 119.5, 113.7 (2C), 112.1, 111.3, 55.2, 21.6, 20.5; LRMS (EI 70 ev) *m*/*z* (%)354 (M^+, 1), 353 (1),, 338 (3), 235 (100), 204 (7), 118 (30), 91 (25), 40 (13); HRMS (EI) for $C_{24}H_{22}N_2O$ (M^+) calcd 354.1732, found 354.1728.

2-(1H-Indol-3-yl)-2-(4-methoxyphenylamino)-1-p-tolylethanone (**9**). 68.8 mg, yield 62%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.05 (brs, 1H), 8.04 (d, *J* = 7.5 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.44 (s, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.04 (t, *J* = 8.0 Hz, 1H), 6.98 (t, *J* = 7.5 Hz, 1H), 6.75 (d, *J* = 8.5 Hz, 2H), 6.65 (d, *J* = 8.5 Hz, 2H), 6.49 (d, *J* = 8.0 Hz, 1H), 5.74 (d, *J* = 8.0 Hz, 1H), 3.59 (s, 3H), 2.30 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.5, 151.5, 144.1, 142.1, 136.7, 133.2, 129.7, 129.1, 126.1 (2C), 121.7, 119.7, 119.4, 114.8, 114.7, 112.1, 111.4, 55.7 (2C), 21.6; LRMS (EI 70 ev) *m*/*z* (%) 370 (M^+, 1), 369 (1), 368 (2), 251 (55), 219 (17), 204 (20), 123 (41), 108 (52), 80 (121), 40 (100); HRMS (EI) for $C_{24}H_{22}N_2O_2$ (M^+) calcd 370.1681, found 370.1676.

2-(2,3-Dihydro-1H-inden-5-ylamino)-2-(1H-indol-3-yl)-1-p-tolylethanone (**10**). 65.0 mg, yield 57%. Brown oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.04 (brs, 1H), 8.04 (d, *J* = 8.0 Hz, 2H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.43 (s, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.98 (t, *J* = 7.5 Hz, 1H), 6.86 (d, *J* = 8.0 Hz, 1H), 6.80 (s, 1H), 6.58 (d, *J* = 7.5 Hz, 1H), 6.51 (d, *J* = 7.5 Hz, 1H), 6.85 (d, *J* = 7.5 Hz, 1H), 2.71−2.63(m, 4H), 2.30 (s, 3H), 1.93−1.87 (m, 2H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.4, 146.7, 144.5, 144.1, 136.7, 133.2, 131.7, 129.7 (2C), 129.1, 126.1 (2C), 124.6, 121.7, 119.7, 119.4, 112.1, 111.4, 109.7, 55.4, 33.1, 31.9, 25.7, 21.6; LRMS (EI 70 ev) *m*/*z* (%) 380 (M^+, 1), 379 (2), 378 (7), 259 (100), 234 (15), 144 (29), 115 (25), 40 (98); HRMS (EI) for $C_{26}H_{24}N_2O$ (M^+) calcd 380.1889, found 380.1885.

2-(1H-Indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**11**). 75.4 mg, yield 71%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.06 (brs, 1H), 8.04 (d, *J* = 8.0 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 1H), 7.45 (s, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.24 (d, *J* = 8.5 Hz, 2H), 7.04 (t, *J* = 7.5 Hz, 1H), 6.98 (t, *J* = 7.5 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 2H), 6.70 (d, *J* = 8.0 Hz, 2H), 6.52 (d, *J* = 8.0 Hz, 1H), 5.91 (d, *J* = 8.0 Hz, 1H), 2.30 (s, 3H), 2.10 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.4, 145.7, 144.1, 136.7, 133.2, 129.7 (2C), 129.6, 129.1, 126.2, 126.1, 125.1,

dx.doi.org/10.1021/jo301691h | J. Org. Chem. 2012, 77, 8705−8711

121.7, 119.7, 119.5, 113.8 (2C), 112.1, 111.3, 55.2, 21.6, 20.6; LRMS (EI 70 ev) *m*/*z* (%) 354 (M^+, 1), 353 (1), 352 (1), 338 (2), 235 (100), 204 (14), 118 (35), 91 (28), 77 (18), 40 (13); HRMS (EI) for $C_{24}H_{22}N_2O$ (M^+) calcd 354.1732, found 354.1729.

1-(4-Chlorophenyl)-2-(1H-indol-3-yl)-2-(m-tolylamino)ethanone (**12**). 56.1 mg, yield 50%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.09 (brs, 1H), 8.14 (d, J = 8.5 Hz, 2H), 7.72 (d, J = 8.0 Hz, 1H), 7.51 (d, J = 8.5 Hz, 2H), 7.45 (s, 1H), 7.30 (d, J = 8.5 Hz, 1H), 7.05 (t, J = 8.5 Hz, 1H), 6.99 (t, J = 7.5 Hz, 1H), 6.89 (t, J = 7.5 Hz, 1H), 6.62 (s, 1H), 6.59−6.54 (m, 2H), 6.34 (d, J = 7.5 Hz, 1H), 6.04 (d, J = 7.5 Hz, 1H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.8, 147.8, 138.6, 138.1, 136.8, 134.3, 131.6, 130.9, 129.2, 129.0, 126.3, 126.0, 121.8, 119.6 (2C), 117.7, 114.3, 112.2, 110.8, 55.3, 21.8; LRMS (EI 70 ev) *m*/*z* (%) 376 (M^++2, 1), 374 (1), 373 (1), 372 (3), 269 (4), 233 (100), 204 (5), 144 (51), 91 (28), 65 (14), 40 (34); HRMS (EI) for $C_{23}H_{19}ClN_2O$ (M^+) calcd 374.1186, found 374.1181.

1-(4-Fluorophenyl)-2-(1H-indol-3-yl)-2-(m-tolylamino)ethanone (**13**). 48.3 mg, yield 45%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.08 (brs, 1H), 8.23−8.21 (m, 2H), 7.73 (d, J = 7.5 Hz, 1H), 7.60 (s, 1H), 7.31−7.25 (m, 3H), 7.05 (t, J = 7.5 Hz, 1H), 6.99 (t, J = 7.5 Hz, 1H), 6.90 (t, J = 8.0 Hz, 1H), 6.62 (s, 1H), 6.59−6.54 (m, 2H), 6.34 (d, J = 7.0 Hz, 1H), 6.01 (t, J = 7.5 Hz, 1H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.9, 147.8, 138.0, 136.7, 132.3, 132.0, 131.9, 129.0, 126.1, 121.8, 119.6, 119.5, 117.7, 116.2, 116.0, 114.3, 112.1, 111.0, 110.7, 55.3, 21.8; LRMS (EI 70 ev) *m*/*z* (%) 358 (M^+, 1), 251 (5), 235 (26), 130 (24), 107 (18), 66 (15), 40 (100); HRMS (EI) for $C_{23}H_{19}FN_2O$ (M^+) calcd 358.1481, found 358.1474.

Ethyl 2-(1H-indol-3-yl)-2-(p-tolylamino)acetate (**14**). 46.2 mg, yield 50%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.11 (brs, 1H), 7.68 (d, J = 7.5 Hz, 1H), 7.42 (s, 1H), 7.37 (d, J = 8.0 Hz, 1H), 7.10 (t, J = 7.5 Hz, 1H), 7.01 (t, J = 7.5 Hz, 1H), 6.89 (d, J = 8.0 Hz, 2H), 6.61 (d, J = 8.5 Hz, 2H), 5.90 (d, J = 7.5 Hz, 1H), 5.32 (d, J = 8.0 Hz, 1H), 4.16−4.09 (m, 1H), 4.06−3.99 (m, 1H), 2.14 (s, 3H), 1.11 (t, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 173.1, 145.7, 136.7, 129.7, 126.2, 125.5, 124.7, 121.9, 119.6, 119.4, 113.4, 112.1, 111.3, 61.0, 54.1, 20.6, 14.6; LRMS (EI 70 ev) *m*/*z* (%) 308 (15), 235 (100), 118 (40), 107 (49), 66 (27), 40 (78); HRMS (EI) for $C_{19}H_{20}N_2O_2$ (M^+) calcd 308.1525, found 308.1522.

2-(5-Methyl-1H-indol-3-yl)-1-p-tolyl-2-(p-tolylamino)ethanone (**15**). 68.4 mg, yield 62%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.91 (brs, 1H), 8.02 (d, J = 7.5 Hz, 2H), 7.51 (s, 1H), 7.36 (s, 1H), 7.24 (d, J = 8.0 Hz, 2H), 7.17 (d, J = 8.0 Hz, 1H), 6.86−6.88 (m, 1H), 6.82 (d, J = 8.0 Hz, 2H), 6.68 (d, J = 8.0 Hz, 2H), 6.45 (d, J = 8.0 Hz, 1H), 5.85 (d, J = 8.0 Hz, 1H), 2.36 (s, 3H), 2.30 (s, 3H), 2.10 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.4, 145.7, 144.0, 135.1, 133.2, 129.8, 129.6, 129.5, 129.0, 127.9, 126.3, 126.1, 125.0, 123.3, 119.1, 113.6, 111.8, 110.7, 55.3, 21.8, 21.5, 20.5; LRMS (EI 70 ev) *m*/*z* (%) 368 (M^+, 1), 249 (100), 218 (41), 158 (17), 144 (43), 106 (87), 65 (29), 40 (26); HRMS (EI) for $C_{25}H_{24}N_2O$ (M^+) calcd 368.1889, found 368.1885.

2-(5-Bromo-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**16**). 71.3 mg, yield 55%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.26 (brs, 1H), 8.05 (d, J = 8.0 Hz, 2H), 7.93 (s, 1H), 7.53 (s, 1H), 7.25−7.28 (m, 3H), 7.14−7.16 (m, 1H), 6.89 (t, J = 7.5 Hz, 1H), 6.64 (s, 1H), 6.59 (d, J = 8.0 Hz, 1H), 6.54 (d, J = 8.0 Hz, 1H), 6.33 (d, J = 7.5 Hz, 1H), 6.09 (d, J = 8.0 Hz, 1H), 2.31 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.2, 147.8, 144.2, 138.0, 135.4, 129.7 (2C), 129.1, 129.0, 127.9, 127.7, 124.2, 122.1, 117.6, 114.3, 114.1, 112.2, 111.2, 110.8, 54.8, 21.8, 21.5; LRMS (EI 70 ev) *m*/*z* (%) 434 (M^++2, 1), 432 (M^+,1), 313 (46), 208 (12), 119 (36), 91 (33), 65 (13), 40 (100); HRMS (EI) for $C_{24}H_{21}BrN_2O$ (M^+) calcd 432.0837, found 432.0834.

2-(5-Chloro-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**17**). 71.0 mg, yield 61%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.25 (brs, 1H), 8.06 (d, J = 8.0 Hz, 2H), 7.79 (s, 1H), 7.56 (s, 1H), 7.31 (d, J = 8.5 Hz, 1H), 7.25 (d, J = 8.0 Hz, 2H), 7.04 (d, J = 9.0 Hz, 1H), 6.90 (t, J = 7.5 Hz, 1H), 6.64 (s, 1H), 6.59 (d, J = 8.0 Hz, 1H), 6.55 (d, J = 7.5 Hz, 1H), 6.33 (d, J = 7.5 Hz, 1H), 6.09 (d, J = 7.5 Hz, 1H), 2.31 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.2, 147.8, 144.2, 138.0, 135.2, 133.0, 129.7, 129.1, 129.0, 128.0, 127.2, 124.2, 121.7, 119.1, 117.7, 114.3, 113.6, 111.3, 110.8, 54.8, 21.8, 21.6; LRMS (EI 70 ev) *m*/*z* (%) 388 (M^+, 1), 269 (41), 253 (5, -Cl), 207 (4), 164 (17), 119 (27), 91 (26), 65 (9), 40 (100); HRMS (EI) for $C_{24}H_{21}ClN_2O$ (M^+) calcd 388.1342, found 388.1337.

(E)-Methyl 3-(3-(2-oxo-2-p-tolyl-1-(m-tolylamino)ethyl)-1H-indol-5-yl)acrylate (**18**). 73.6 mg, yield 56%. Yellow solid: mp 136.7−138.9 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.07 (brs, 1H), 8.16 (s, 1H), 8.06 (d, J = 8.5 Hz, 2H), 7.75 (d, J = 11.0 Hz, 1H), 7.51 (s, 1H), 7.43 (d, J = 8.5 Hz, 1H), 7.32 (d, J = 9.0 Hz, 1H), 7.26 (d, J = 8.0 Hz, 2H), 6.90 (t, J = 8.0 Hz, 1H), 6.66 (s, 1H), 6.58−6.63 (m, 2H), 6.54 (s, 1H), 6.34 (d, J = 7.0 Hz, 1H), 6.15 (d, J = 8.0 Hz, 1H), 3.74 (s, 3H), 2.31 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.1, 167.5, 147.8, 147.0, 144.1, 138.0 (2C), 133.0, 129.7, 129.0, 128.9, 127.4, 126.4, 125.7, 121.7 (2C), 117.6, 114.6, 114.3, 112.6, 112.5, 110.8, 54.7, 51.6, 21.7, 21.5; LRMS (EI 70 ev) *m*/*z* (%) 438 (M^+, 1), 317 (44), 214 (80), 119 (48), 107 (52), 77 (12), 40 (100); HRMS (EI) for $C_{28}H_{26}N_2O_3$ (M^+) calcd 438.1943, found 438.1940.

2-(6-Methyl-1H-indol-3-yl)-1-p-tolyl-2-(p-tolylamino)ethanone (**19**). 73.9 mg, yield 67%. Yellow oil: ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.88 (brs, 1H), 8.01 (d, J = 8.0 Hz, 2H), 7.61 (d, J = 8.0 Hz, 1H), 7.33 (s, 1H), 7.23 (d, J = 8.0 Hz, 2H), 7.07 (s, 1H), 6.81 (d, J = 7.5 Hz, 3H), 6.68 (d, J = 8.0 Hz, 2H), 6.46 (d, J = 7.5 Hz, 1H), 5.84 (d, J = 8.0 Hz, 1H), 2.33 (s, 3H), 2.30 (s, 3H), 2.09 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.3, 145.6, 144.0, 137.1, 133.2, 130.7, 129.6, 129.5, 129.0, 125.3, 125.0, 124.0, 121.2, 119.3, 113.7, 111.8, 111.2, 55.3, 21.7, 21.5, 20.5; LRMS (EI 70 ev) *m*/*z* (%) 368 (M^+, 1), 261 (39), 249 (100), 218 (38), 144 (52), 106 (86), 65 (27), 40 (88); HRMS (EI) for $C_{25}H_{24}N_2O$ (M^+) calcd 368.1889, found 368.1885.

2-(7-Ethyl-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**20**). 75.6 mg, yield 66%. Brown solid: mp 112.6−115.4 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.03 (brs, 1H), 8.04 (d, J = 8.0 Hz, 2H), 7.57 (d, J = 8.0 Hz, 1H), 7.42 (s, 1H), 7.24 (d, J = 7.5 Hz, 2H), 6.93 (t, J = 7.5 Hz, 1H), 6.87 (d, J = 7.0 Hz, 1H), 6.82 (d, J = 8.0 Hz, 2H), 6.69 (d, J = 8.0 Hz, 2H), 6.50 (d, J = 7.0 Hz, 1H), 5.89 (d, J = 7.5 Hz, 1H), 2.78−2.74 (m, 2H), 2.30 (s, 3H), 2.10 (s, 3H), 1.20 (t, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.3, 145.7, 144.1, 135.4, 133.2, 129.8, 129.7, 129.6, 129.1, 127.5, 126.0, 125.8, 125.0, 120.4, 119.8, 117.3, 114.5, 113.7, 111.7, 55.3, 24.1, 21.6, 20.6, 14.7; LRMS (EI 70 ev) *m*/*z* (%) 382 (M^+, 1), 261 (100), 158 (31), 119 (40), 91 (41), 40 (50); HRMS (EI) for $C_{26}H_{26}N_2O$ (M^+) calcd 382.2045, found 382.2041.

2-(2-Methyl-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**21**). 71.8 mg, yield 65%. Yellow solid: mp 125.4−128.1 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 10.94 (brs, 1H), 7.91 (d, J = 8.0 Hz, 2H), 7.70−7.65 (m, 1H), 7.21 (d, J = 8.5 Hz, 2H), 7.17−7.15 (m, 1H), 6.97−6.93 (m, 2H), 6.88 (t, J = 8.0 Hz, 1H), 6.56 (s, 1H), 6.52 (d, J = 8.0 Hz, 1H), 6.40 (d, J = 7.0 Hz, 1H), 6.32 (d, J = 7.5 Hz, 1H), 5.91 (d, J = 7.0 Hz, 1H), 2.46 (s, 3H), 2.28 (s, 3H),; 2.11 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.5, 147.7, 143.8, 137.9, 135.6, 134.8, 133.7, 129.6, 128.9, 128.6, 127.2, 120.7, 119.3, 118.7, 117.5, 114.3, 111.0, 110.8, 106.4, 54.8, 21.8, 21.5, 12.4; LRMS (EI 70 ev) *m*/*z* (%) 368 (M^+, 1), 261 (24), 249 (100), 218 (14), 119 (22), 107 (37), 65 (14), 40 (73); HRMS (EI) for $C_{25}H_{24}N_2O$ (M^+) calcd 368.1889, found 368.1883.

2-(2-Phenyl-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**22**). 96.8 mg, yield 75%. Yellow solid: mp 140.6−144.5 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.63 (brs, 1H), 7.64 (d, J = 7.5 Hz, 2H), 7.50−7.60 (m, 3H), 7.51 (t, J = 7.5 Hz, 1H), 7.46 (d, J = 8.5 Hz, 2H), 7.35 (d, J = 8.0 Hz, 1H), 7.08 (t, J = 7.5 Hz, 1H), 7.03 (d, J = 8.0 Hz, 2H), 6.98 (t, J = 7.5 Hz, 1H), 6.85 (d, J = 8.0 Hz, 2H), 6.50 (d, J = 8.5 Hz, 2H), 6.23 (d, J = 7.0 Hz, 1H), 6.16 (d, J = 7.0 Hz, 1H), 2.21 (s, 3H), 2.13 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.5, 147.2, 145.8, 143.9, 137.6, 136.6, 133.3, 132.5, 129.7, 129.5, 129.5, 128.9, 128.8, 128.1, 127.0, 125.1, 122.1, 120.4, 119.9, 113.1, 111.9, 107.2, 56.3, 21.4, 20.5; LRMS (EI 70 ev) *m*/*z* (%) 430 (M^+, 1), 323 (23), 311 (100), 204 (18), 119 (28), 91 (25), 65 (8), 40 (19); HRMS (EI) for $C_{30}H_{26}N_2O$ (M^+) calcd 430.2045, found 430.2040.

1-p-Tolyl-2-(2-p-tolyl-1H-indol-3-yl)-2-(m-tolylamino)ethanone (**23**). 79.9 mg, yield 60%. Yellow solid: mp 155.8−158.2 °C

dx.doi.org/10.1021/jo301691h | J. Org. Chem. 2012, 77, 8705−8711

(uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.55 (brs, 1H), 7.55−7.53 (m, 2H), 7.48 (d, J = 8.0 Hz, 2H), 7.39 (d, J = 7.5 Hz, 2H), 7.33 (d, J = 8.0 Hz, 1H), 7.08−7.04 (m, 3H), 6.97 (t, J = 7.5 Hz, 1H), 6.91 (t, J = 8.0 Hz, 1H), 6.42 (s, 1H), 6.38 (d, J = 7.5 Hz, 2H), 6.35 (d, J = 8.0 Hz, 1H), 6.29 (d, J = 7.0 Hz, 1H), 6.16 (d, J = 7.0 Hz, 1H), 2.41 (s, 3H), 2.22 (s, 3H), 2.12 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.4, 148.0, 143.9, 138.4, 138.1, 137.7, 136.5, 133.3, 130.1, 129.6, 129.5, 129.1, 128.7, 128.1, 127.0, 122.0, 120.2, 119.8, 117.6, 113.8, 111.8, 110.1, 106.7, 56.1, 21.8, 21.4, 21.3; LRMS (EI 70 ev) m/z (%) 444 (M^+, 1), 337 (24), 325 (100), 220 (27), 208 (14), 119 (27), 107 (22), 65 (7), 40 (47); HRMS (EI) for $C_{31}H_{28}N_2O$ (M^+) calcd 444.2202, found 444.2198.

*2-(2-(4-Bromophenyl)-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)-ethanone (**24**).* 77.7 mg, yield 51%. Yellow solid: mp 171.7−174.5 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.65 (brs, 1H), 7.78 (d, J = 8.0 Hz, 2H), 7.56−7.59 (m, 3H), 7.49 (d, J = 8.0 Hz, 2H), 7.35 (d, J = 8.0 Hz, 1H), 7.06−7.11 (m, 3H), 7.00 (t, J = 7.0 Hz, 1H), 6.91 (t, J = 8.0 Hz, 1H), 6.44 (s, 1H), 6.38 (d, J = 7.5 Hz, 2H), 6.30 (d, J = 7.0 Hz, 1H), 6.17 (d, J = 7.5 Hz, 1H), 2.22 (s, 3H), 2.12 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 196.4, 147.9, 143.9, 138.2, 136.6, 136.3, 133.4, 132.5, 131.7, 130.8, 129.5, 129.1, 128.2, 127.0, 122.4, 122.3, 120.4, 120.0, 117.7, 114.0, 111.9, 110.2, 107.6, 55.9, 21.8, 21.4; LRMS (EI 70 ev) m/z (%) 508 (M^+, 1), 389 (100), 284 (21), 205 (30), 119 (27), 91 (35), 40 (44); HRMS (EI) for $C_{30}H_{25}BrN_2O$ (M^+) calcd 508.1150, found 508.1147.

*2-(1-Methyl-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**25**).* 73.9 mg, yield 67%. Yellow solid: mp 90.1−91.1 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.03 (d, J = 8.0 Hz, 2H), 7.79 (t, J = 8.0 Hz, 1H), 7.40 (s, 1H), 7.33 (d, J = 8.5 Hz, 1H), 7.24 (d, J = 7.5 Hz, 2H), 7.12 (t, J = 7.5 Hz, 1H), 7.04 (t, J = 7.5 Hz, 1H), 6.83 (d, J = 8.0 Hz, 2H), 6.69 (d, J = 7.5 Hz, 2H), 6.52 (d, J = 6.5 Hz, 1H), 5.89 (d, J = 7.5 Hz, 1H), 3.68 (s, 3H), 2.30 (s, 3H),; 2.10 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.3, 145.7, 144.2, 137.2, 133.1, 130.0, 129.8, 129.7, 129.6, 129.1, 126.6, 125.1, 121.8, 119.9, 119.8, 119.7, 113.7, 110.6, 110.4, 54.8, 32.9, 21.6, 20.6; LRMS (EI 70 ev) m/z (%) 368 (M^+, 1), 350 (1), 249 (84), 144 (18), 91 (21), 58 (11), 40 (100); HRMS (EI) for $C_{25}H_{24}N_2O$ (M^+) calcd 368.1889, found 368.1887.

*2-(1-Benzyl-1H-indol-3-yl)-1-p-tolyl-2-(m-tolylamino)ethanone (**26**).* 75.9 mg, yield 57%. Yellow solid: mp 133.7−135.5 °C (uncorrected); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.03 (d, J = 8.0 Hz, 2H), 7.73 (d, J = 8.0 Hz, 1H), 7.62 (s, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.25 (d, J = 8.0 Hz, 2H), 7.20−7.19 (m, 3H), 7.06−6.98 (m, 4H), 6.83 (d, J = 8.0 Hz, 2H), 6.71 (d, J = 8.0 Hz, 2H), 6.54 (d, J = 8.0 Hz, 1H), 5.95 (d, J = 8.0 Hz, 1H), 5.33 (s, 2H), 2.32 (s, 3H),; 2.11 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 197.4, 145.6, 144.1, 138.5, 136.6, 133.2, 130.1, 129.6, 129.5, 129.1, 128.9, 127.7, 127.3, 125.1, 122.0, 120.1, 119.8, 113.8, 111.3, 110.8, 55.3, 49.4, 21.6, 20.6; LRMS (EI 70 ev) m/z (%) 444 (M^+, 1), 426 (2), 325 (100), 220 (15), 118 (12), 91 (84), 65 (10), 40 (7); HRMS (EI) for $C_{31}H_{28}N_2O$ (M^+) calcd 444.2202, found 444.2195.

*Ethyl 2-oxo-2-(p-tolylamino)acetate (**29b**).*[9] 26.1 mg, yield 42%. Yellow oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.84 (s, 1H), 7.53−7.51 (m, 2H), 7.17 (d, J = 8.0 Hz, 2H), 4.43−4.39 (m, 2H), 2.33 (s, 3H), 1.42 (t, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.1, 153.7, 135.3, 133.8, 129.7, 119.8, 63.6, 20.9, 14.0; LRMS (EI 70 ev) m/z (%) 207 (M^+, 63), 134 (67), 106 (100), 91 (28), 51 (7).

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Computational details and copies of spectra. This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: jhli@hnu.edu.cn.

Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

We thank the National Natural Science Foundation of China (No. 21172060) and Fundamental Research Funds for the Central Universities (Hunan University) for financial support.

■ REFERENCES

(1) For selected reviews, see: (a) Hunt, S. *Chemistry and Biochemistry of the Amino Acids*; Barrett, G. C., Ed.; Chapman and Hall: London, 1985, p 55. (b) Ohfune, Y. *Acc. Chem. Res.* **1992**, *25*, 360. (c) Gellman, S. H. *Acc. Chem. Res.* **1998**, *31*, 173.

(2) (a) Obrecht, D.; Altorfer, M.; Lehmann, C.; Schönholzer, P.; Müller, K. *J. Org. Chem.* **1996**, *61*, 4080. (b) Obrecht, D.; Bohdal, U.; Broger, C.; Bur, D.; Lehmann, C.; Ruffieux, R.; Schönholzer, P.; Spiegler, C.; Müller, K. *Helv. Chim. Acta* **1995**, *78*, 563. (c) Schoepp, D. D.; Jane, D. E.; Monn, J. A. *Neuropharmacology* **1999**, *38*, 1431. (d) Takahashi, A.; Naganawa, H.; Ikeda, D.; Okami, Y. *Tetrahedron* **1991**, *47*, 3621. (e) Schirlin, D.; Gerhart, F.; Hornsperger, J. M.; Hamon, M.; Wagner, J.; Jung, M. J. *J. Med. Chem.* **1988**, *31*, 30. (f) Walsh, J. J.; Metzler, D. E.; Powell, D.; Jacobson, R. A. *J. Am. Chem. Soc.* **1980**, *102*, 7136. (g) Beenen, M. A.; Weix, D. J.; Ellman, J. A. *J. Am. Chem. Soc.* **2006**, *128*, 6304. (h) Zhao, L.; Li, C.-J. *Angew. Chem. Int, Ed.* **2008**, *47*, 7075.

(3) For reviews and papers on α-arylation of α-amino carbonyl compounds under basic conditions, see: (a) Williams, R. M.; Hendrix, J. A. *Chem. Rev.* **1992**, *92*, 889. (b) Culkin, D.; Hartwig, J. F. *Acc. Chem. Res.* **2003**, *36*, 234. (c) Miura, M.; Nomura, M. *Top. Curr. Chem.* **2002**, *219*, 211. (d) Bellina, F.; Rossi, R. *Chem. Rev.* **2010**, *110*, 1082. (e) Gaertzen, O.; Buchwald, S. L. *J. Org. Chem.* **2002**, *67*, 465. (f) Liu, X.; Hartwig, J. F. *Org. Lett.* **2003**, *5*, 1915. (g) Lee, S.; Beare, N. A.; Hartwig, J. F. *J. Am. Chem. Soc.* **2001**, *123*, 8410. (h) Sigman, M. S.; Jacobsen, E. N. *J. Am. Chem. Soc.* **1998**, *120*, 5315. (i) Sigman, M. S.; Jacobsen, E. N. *J. Am. Chem. Soc.* **1998**, *120*, 4901. (j) Reddy, K. L.; Sharpless, K. B. *J. Am. Chem. Soc.* **1998**, *120*, 1207. (k) Chaari, M.; Jenhi, A.; Lavergne, J.-P.; Viallefont, P. *Tetrahedron* **1991**, *47*, 4619. (l) O'Donnell, M. J.; Bennett, W. D.; Jacobsen, W. N.; Ma, Y.; Huffman, J. C. *Tetrahedron Lett.* **1989**, *30*, 3909. (m) Trost, B. M.; Aeiza, X. *J. Am. Chem. Soc.* **1999**, *121*, 10727. (n) Hocek, M. *Heterocycles* **2004**, *63*, 1673. (o) Marsden, S. P.; Watson, E. L.; Raw, S. A. *Org. Lett.* **2008**, *10*, 2905.

(4) Wu, J.-C.; Song, R.-J.; Wang, Z.-Q.; Huang, X.-C.; Xie, Y.-X.; Li, J.-H. *Angew. Chem., Int. Ed.* **2012**, *51*, 3453.

(5) For special reviews on visible-light photoredox catalysis, see: (a) Zeitler, K. *Angew. Chem., Int. Ed.* **2009**, *48*, 9785. (b) Yoon, T. P.; Ischay, M. A.; Du, J. *Nat. Chem.* **2010**, *2*, 527. (c) Narayanam, J. M. R.; Stephenson, C. R. J. *Chem. Soc. Rev.* **2011**, *40*, 102. (d) Teplý, F. *Collect. Czech. Chem. Commun.* **2011**, *76*, 859. (e) Tucker, J. W.; Stephenson, C. R. J. *J. Org. Chem.* **2012**, *77*, 1617.

(6) For papers on the C(sp^3)−H functionalization using visible-light photoredox catalysis, see: (a) Condie, A. G.; González-Gómez, J.; Stephenson, C. R. J. *J. Am. Chem. Soc.* **2010**, *132*, 1464. (b) Freeman, D. B.; Furst, L.; Condie, A. G.; Stephenson, C. R. J. *Org. Lett.* **2012**, *14*, 94. (c) Zou, Y.-Q.; Lu, L.-Q.; Fu, L.; Chang, N.-J.; Rong, J.; Chen, J.-R.; Xiao, W.-J. *Angew. Chem., Int. Ed.* **2011**, *50*, 7171. (d) Xuan, J.; Cheng, Y.; An, J.; Lu, L.-Q.; Zhang, X.-X.; Xiao, W.-J. *Chem. Commun.* **2011**, *47*, 8337. (e) Xie, Z.; Wang, C.; de Krafft, K. E.; Lin, W. *J. Am. Chem. Soc.* **2011**, *133*, 2056. (f) Zhu, M.; Zheng, N. *Synthesis* **2011**, 2223. (g) Rueping, M.; Leonori, D.; Poisson, T. *Chem. Commun.* **2011**, *47*, 9615. (h) Hari, D. P.; König, B. *Org. Lett.* **2011**, *13*, 3852. (i) Rueping, M.; Zhu, S.; Koenigs, R. M. *Chem. Commun.* **2011**, *47*, 8679. (j) Su, F.; Mathew, S. C.; Moehlmann, L.; Antonietti, M.; Wang, X.; Blechert, S. *Angew. Chem., Int. Ed.* **2011**, *50*, 657. (k) Rueping, M.; Zoller, J.; Fabry, D. C.; Poscharny, K.; Koenigs, R. M.; Weirich, T. E. *Chem.—Eur. J.* **2012**, *18*, 3478. (l) Miyake, Y.; Nakajima, K.; Nishibayashi, Y. *J. Am. Chem. Soc.* **2012**, *134*, 3338. (m) Tucker, J. W.; Narayanam, J. M. R.; Shah, P. S.; Stephenson, C. R. J. *Chem. Commun.* **2011**, *47*, 5040. (n) Dai, C.; Meschini, F.; Narayanam, J. M. R.; Stephenson, C. R. J. *J. Org. Chem.* **2012**, *77*, 4425.

(7) (a) Van Order, R. B.; Lindwall, H. G. *Chem. Rev.* **1942**, *30*, 69. (b) Sundberg, R. J. *The Chemistry of Indoles*; Academic Press: New York, 1970. (c) Sundberg, R. J. *Indoles*; Academic Press: London, 1996. (d) Gilchrist, T. L. *Heterocyclic Chemistry*, 3rd ed.; Addison Wesley: Essex, England, 1998. (e) Cacchi, S.; Fabrizi, G. *Chem. Rev.* **2005**, *105*, 2873.
(8) (a) Zhao, J.-L.; Liu, L.; Zhang, H.-B.; Wu, Y.-C.; Wang, D.; Chen, Y.-J. *Synlett* **2006**, 96. (b) Desimoni, G.; Faita, G.; Mella, M.; Toscanini, M.; Boiocchi, M. *Eur. J. Org. Chem.* **2008**, 6232.
(9) Langer, P.; Schroeder, R. *Eur. J. Org. Chem.* **2004**, 1025.