JOC The Journal of Organic Chemistry

Article

pubs.acs.org/joc

Functionalization of Amides via Copper-Catalyzed Oxyalkylation of Vinylarenes and Decarboxylative Alkenylation of sp^3 C–H

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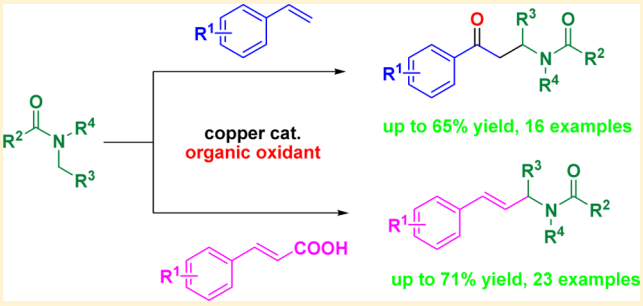
Supporting Information

ABSTRACT: An efficient protocol was developed to prepare a series of derivatives from amides by copper-catalyzed oxyalkylation of vinylarenes and decarboxylative alkenylation of sp^3 C–H. This method is simple, practical, and inexpensive.



INTRODUCTION

It is well-known that the allylic amide and *N*-(3-oxoalkyl) amide motifs appear in many natural products (Figure 1). For example, compound **A** is a potent antimicrotubule agent that is highly effective at inhibiting the growth of tumors, which proved more potent in *in vitro* cytotoxicity and antimitotic activity than its analogues, such as the natural product hemiasterlin **B**.[1] Compound **C** (DNK 333) has been discovered as a potent and balanced neurokinin (tachykinin) NK1/NK2 receptor antagonist.[2] Compound **D** represents a new class of proteasome inhibitors bearing *N*-allyl vinyl ester based peptides.[3] In addition, a series of novel Asp32-replacement tetrapeptide analogues (**E**) have been proved as potent and selective CCK-A agonists.[4] In consideration of their wide application in medicinal chemistry, we have great interest in preparation of these functionalized amides. Up to the present day, most methods to synthesize this class of amides are through traditional metal-catalyzed allylic substitution reactions[5] or through preparation of the prerequisite activated materials in multistep reactions.[6] Therefore, an inexpensive and direct way to synthesize these amides is highly desirable until now.

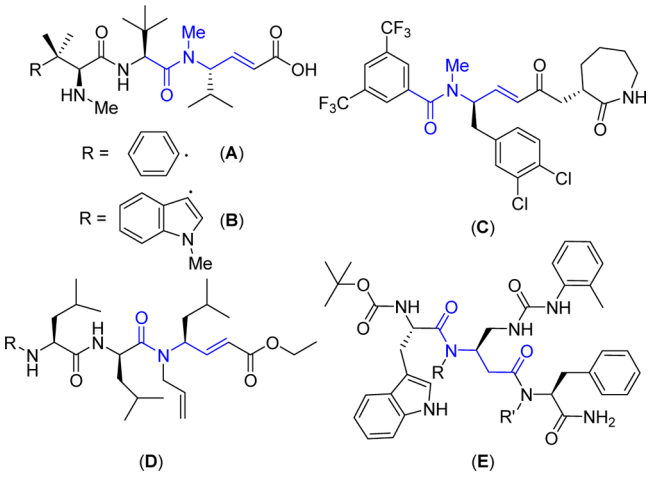


Figure 1. Useful amide moieties in biologically active compounds.

In the past few years, sp^3 C–H bond functionalization[7] has been extensively studied, resulting in new, powerful methods for streamlining organic synthesis by using simple starting material. Despite significant developments, syntheses of allylic amides and *N*-(3-oxoalkyl) amides by sp^3 C–H functionalization of *N*-alkyl amide remain challenging. Previous methods for allowing access to allylic amides were through the addition reactions of the sp^3 C–H bond into alkynes and either involved a costly iridium complex or afforded an undesirable mixture of E/Z isomers.[8] In the long run, our group and others have been devoted to the cheap, metal-catalyzed sp^3 C–H functionalization related to cinnamic acids[9] and olefins[10] in recent years. Synthesizing these kinds of functionalized amides from commercially available olefins or cinnamic acids seems feasible and interesting.[9,10b–d,11] Kantam et al. and we independently developed a similar method to prepare *N*-substituted formamides.[12] To be noted, 5-allylic γ-lactams was successfully synthesized in Kantams et al.'s work. Just recently, Wang and co-workers reported the nickel-catalyzed decarboxylative cross-coupling of α,β-unsaturated carboxylic acids to prepare *N*-(3-oxoalkyl) amides.[13] In order to expand our understanding of sp^3 C–H functionalization of amides, herein, we report a novel and direct method to selectively synthesize *N*-(3-oxo-3-

Received: June 7, 2014
Published: July 16, 2014

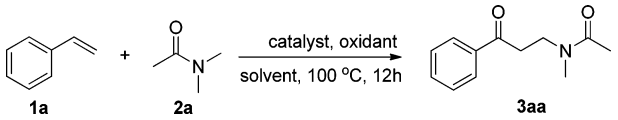
   dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103–7111

phenylpropyl)acetamide and *N*-cinnamylacetamide derivatives efficiently from *N*-alkylamides via oxyalkylation of olefins or decarboxylation of cinnamic acids.

RESULTS AND DISCUSSION

Initially, we performed the oxyalkylation of styrene **1a** in DMA (*N*,*N*-dimethylacetamide) **2a** in the presence of copper catalysts and TBHP as oxidant. The related results are listed in Table 1. In the control experiment, the oxyalkylation could not occur without the copper catalyst (entry 1). When copper catalyst was added, the oxyalkylation procceded smoothly, which indicated that the copper catalyst played a critical role in the reaction (entry 2). Next, various copper sources were screened. Different copper salts had distinct effects on the yield of *N*-methyl-*N*-(3-oxo-3-phenylpropyl)acetamide **3aa** (entries 3−7). The product was not acquired at all when the reaction was conducted using $Cu(OTf)_2$ or CuI (entries 3 and 5). Copper fluoride exhibited the best catalytic efficiency among these copper salts (50% yield, entry 7). In addition, iron sources were also able to catalyze the reaction. However, they were less efficient than copper fluoride (entry 7 vs entries 8−9). Other than TBHP, oxidants such as DTBP, DCP (dicumyl peroxide), DDQ, and $Na_2S_2O_8$ did not give the oxyalkylative product at all (entries 10−14). If the reaction was performed in toluene or DMSO (2 mL) as the solvent and 4 equiv of DMA was employed as the substrate, only a trace amount of **3aa** was observed (entries 15−16). Subsequently, the catalyst loading was studied (entries 17−18) and the oxyalkylative product was obtained in 60% yield when 10 mol % loading catalyst was used (entry 17). Finally, extending the reaction time to 48 h gave the best result (65% yield, entry 19).

Table 1. Screening Catalytic Conditions in the Copper-Catalyzed Oxyalkylation of Styrene in DMAc[a]



1a 2a 3aa

entry	catalyst	oxidant	solvent	yield [%]
1		TBHP	DMAc	trace
2	$CuSO_4$	TBHP	DMAc	25
3	$Cu(OTf)_2$	TBHP	DMAc	NR
4	CuO	TBHP	DMAc	30
5	CuI	TBHP	DMAc	NR
6	Cu	TBHP	DMAc	45
7	$CuF_2{\cdot}2H_2O$	TBHP	DMAc	50
8	FeF_3	TBHP	DMAc	10
9	FeF_2	TBHP	DMAc	40
10[b]	$CuF_2{\cdot}2H_2O$	TBHP	DMAc	15
11	$CuF_2{\cdot}2H_2O$	DTBP	DMAc	NR
12	$CuF_2{\cdot}2H_2O$	DCP	DMAc	NR
13	$CuF_2{\cdot}2H_2O$	DDQ	DMAc	trace
14	$CuF_2{\cdot}2H_2O$	$Na_2S_2O_8$	DMAc	NR
15	$CuF_2{\cdot}2H_2O$	TBHP	toluene	trace
16	$CuF_2{\cdot}2H_2O$	TBHP	DMSO	trace
17[c]	$CuF_2{\cdot}2H_2O$	TBHP	DMAc	60
18[d]	$CuF_2{\cdot}2H_2O$	TBHP	DMAc	35
19[c,e]	$CuF_2{\cdot}2H_2O$	TBHP	DMAc	65

[a]Catalytic conditions: styrene (0.5 mmol), DMAc (2 mmol), catalyst (20 mol %), oxidant (2 mmol), solvent (1.5 mL), 100 °C, 12 h, air. [b]TBHP (5−6M) in decane. [c]Catalyst (10 mol %). [d]Catalyst (5 mol %). [e]48 h.

Subsequently, the reactions of a variety of alkenes **1** and amides **2** were investigated under the optimized conditions. As demonstrated in Table 2, the reactions of olefins **1b**−**1f** bearing both electron-rich and electron-deficient functional groups at the *para*-position of the aryl ring afforded the corresponding oxyalkylative products (**3ba**−**3fa**) in moderate to good yields. Moreover, 3,4,5-trimethoxyl styrene (**1g**) was successfully employed as the substrate, and the desired product **3ga** was obtained with a moderate yield (50%). 1-Vinylnaphthalene was also a suitable substrate, and the expected oxyalkylative product **3ha** was obtained in 59% yield. In addition to terminal alkenes, internal alkenes were examined. Symmetrical stilbene reacted with DMA, giving a single product (**3ia**) in 43% yield, whereas the unsymmetrical 4-methoxystilbene **1k** was not a suitable substrate. Having demonstrated the scope on styrene derivatives, we next investigated the scope of amides. **1a**, **1b**, **1c**, and **1e** were chosen to react with *N*-methylacetamide **2b**, and the results showed that the substituted group of styrene greatly influenced the reactivity. The corresponding alkylative products (**3ab**, **3bb**, and **3eb**) were formed in moderate yields, whereas, for **3cb**, the yield was very low (13%). *N*,*N*-Dimethylpropionamide **2c** was also a suitable substrate for this reaction system, which could react with styrenes **1a** smoothly to produce the desired oxyalkylative product in moderate yield. By contrast, diethylacetamide was a less reactive substrate, only affording **3ad** and **3bd** in low yields.

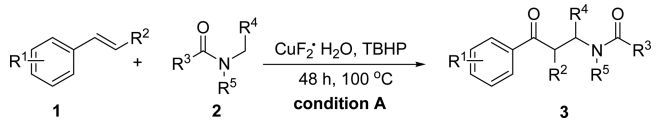
In addition, the reaction between DMF (*N*,*N*-dimethylformamide) and styrene was performed under the standard condition **A**, and the products were complicated. However, when the reaction was carried out in the presence of Cu_2O as the catalyst and sodium persulfate as the oxidant at 100 °C for 48 h (Scheme 1), *N*-cinnamyl-*N*-methylformamide **3ag** and *N*,*N*-dimethylcinnamamide **3ag′** were afforded in 45% combined yield with 3:1 regioselectivity, which suggested that the C−H functionalization of the methyl was more favorable.

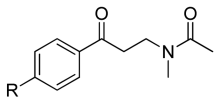
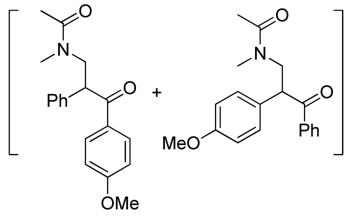
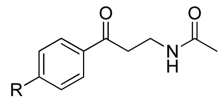
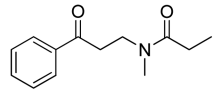
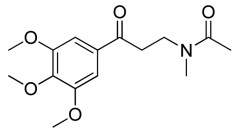
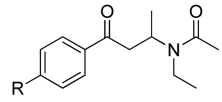
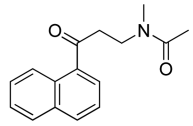
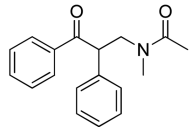
Because cinnamic acid and its derivatives are cheap and commercially available substitutes for styrenes via oxidative decarboxylation, we further expanded our oxidative conditions to cinnamic acid. As shown in Table 3, the copper catalyst did not afford the oxyalkylation product, but the decarboxylative alkenylation product. Under the condition of CuO as catalyst and DTBP as oxidant in the argon atmosphere, we obtained *N*-cinnamyl-*N*-methylacetamide **5aa** in 63% yield.

With this optimized catalytic system in hand, we next explored substrate scope for carboxylic acids and amides (Table 4). The electron-donating methoxy, methyl, and isopropyl group substituted **4b**−**4d**, **4j**−**4k**, and **4o** were well tolerated and resulted in their corresponding decarboxylative coupling products (**5ba**−**5da**, **5ja**−**5ka**, **5oa**) with moderate to good yields. Only 3-methoxycinnamic acid (**4l**) showed low reactivity and produced the expected product (**5la**) in poor yield. In addition, this protocol can also be successfully applied to cinnamic acids bearing electron-withdrawing halogen atoms, such as F and Cl, and ester groups, such as COOMe and CF_3 as well as CN. Notably, the ester group OAc and hydroxyl group were well tolerated and afforded the corresponding coupling products (**5ma**, 47% yield, and **5na**, 57% yield), respectively. The reaction of 1-naphthylacrylic acid proceeded smoothly as well and gave a highly selective product with 54% yield. Electron-rich heteroarylacrylic acids including 2-thienylacrylic acid and 2-furylacrylic acid were suitable substrates, and the

dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103−7111

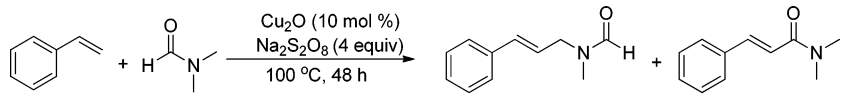
Table 2. Copper-Catalyzed Oxyalkylation of Vinylarenes[a,b]



entry	product	yield	entry	product	yield
1		H, **3aa**, 65%	10		**3ja+3ja'**, trace
2		Me, **3ba**, 65%	11		H, **3ab**, 54%
3		OMe, **3ca**, 50%	12		Me, **3bb**, 53%
4		tBu, **3da**, 46%	13		OMe, **3cb**, 13%
5		F, **3ea**, 55%	14		F, **3eb**, 41%
6		Cl, **3fa**, 47%[b]	15		**3ac**, 50%
7		**3ga**, 50%	16		H, **3ad**, 30%
8		**3ha**, 59%	17		Me, **3bd**, 26%
9		**3ia**, 43%			

[a]Catalytic conditions: vinylarene (0.5 mmol), amide (1.5 mL), catalyst (10 mol %), TBHP (2 mmol), 100 °C, 48 h, air. [b]TBHP (1 mmol).

Scheme 1. Copper-Catalyzed Oxyalkylation of Styrene in DMF



corresponding decarboxylative products were obtained in 52% and 71% yields, respectively. However, the electron-deficient heteroarylacrylic acid (3-pyridylacrylic acid) did not afford the desired product.

Different from arylacrylic acids, 3-methylbut-2-enoic acid reacting with DMA did not produce the expected decarboxylative coupling product under the standard conditions **B**. However, a cross-dehydrogenative coupling reaction occurred and gave **5ta** in 65% yield as shown in Scheme 2.

To gain insight into the possible mechanism, a series of experiments were conducted as shown in Scheme 3. The reaction of styrene was carried out with DMA in an argon atmosphere under the same conditions. It was found that the yield of **3aa** just slightly decreased. It is assumed that the main oxygen source was TBHP. When styrene or cinnamic acid reacted with DMA in the presence of a radical scavenger, such as 2,6-di-*tert*-butyl-4-methylphenol (BHT), both of the reactions were significantly inhibited. It is indicated that the radical processes might be involved.

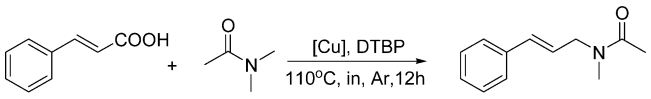
On the basis of the experiments and previous mechanistic studies, we propose the following mechanism (Scheme 4). The oxidative aminoalkylation of olefin with DMA is initiated by a copper catalyst, and the oxidant first generates *tert*-butoxy radical and hydroxyl radical. Then, *tert*-butoxy radical abstracts a H atom from the strong C−H bond of DMA, to give the acetamidomethyl radical **F**,[14] whose addition to olefin results in formation of the alkyl radical species **G**.[15] Subsequently, the oxidization of **G** provides **3** and intermediate **H**.[10b] Intermediate **H**, which could also be formed from the combination of alkyl radical **G** and hydroxyl radical, is further converted to **3**. In the oxidative decarboxylation of cinnamic acids, DTBP is the catalytic cycle initiator, which gives *tert*-butoxy radical by homolysis. Similarly, acetamidomethyl radical **F** is formed by the abstraction of a H atom from DMA and then affords the intermediate **I** by addition to cupric cinnamate.[9b] In contrast to the former reaction mechanism, *N*-cinnamyl-*N*-methylacetamide **5** is ultimately formed by the decarboxylative elimination from intermediate **I** in the last step.

■ CONCLUSIONS

In summary, we have developed a new strategy for selective synthesis of the important class of *N*-(3-oxo-3-phenylpropyl)-acetamide and *N*-cinnamylacetamide derivatives via the copper-catalyzed oxidative coupling between *N*,*N*-substituted amides

dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103−7111

Table 3. Screening Catalytic Conditions of Copper-Catalyzed Decarboxylative Alkenylation of Cinnamic Acids[a,b]



4a 2a 5aa

entry	cat.	solvent	T (°C)	yield [%]
1	Fe_3O_4	DMAc	110	NR
2	ferrocene	DMAc	110	NR
3	$FeCl_3$	DMAc	110	NR
4	Cu	DMAc	110	18
5	CuBr	DMAc	110	29
6	CuO	DMAc	110	63
7	$CuF_2{\cdot}2H_2O$	DMAc	110	trace
8	$Cu(OTf)_2$	DMAc	110	trace
9[b]	CuO	DCE	80	NR
10[b]	CuO	PEG-400	110	trace
11[b]	CuO	AcOH	110	trace
12[b]	CuO	pyridine	110	trace

[a]Catalytic conditions: cinnamic acid (0.3 mmol), catalyst (20 mol %), DTBP (4 equiv), solvent (2 mL), 12 h, in Ar. [b]DMAc (25 equiv).

and olefins or cinnamic acids. A wide scope of substrates is successfully acquired using our protocol. It is noteworthy that this method is simple, practical, and inexpensive, which may be potentially useful in the industrial synthesis. Moreover, amides **3** and **5** could be potential precursors for the preparation of β-amino carbonyls and cinnamyl amines by further hydrolysis. Application of this method in the synthesis of bioactive and more complicated amides is currently in progress.

EXPERIMENTAL SECTION

General Information. Reactions were carried out under an argon atmosphere condition or in air. Solvents were dried and degassed by standard methods, and all vinylarenes, cinnamic acids, and *N*,*N*-substituted amides were commercially available. Flash column chromatography was performed using silica gel (300−400 mesh). Analytical thin-layer chromatography was performed using glass plates precoated with 200−400 mesh silica gel impregnated with a fluorescent indicator (254 nm). NMR spectra were measured in $CDCl_3$ on a 400 or 300 MHz NMR spectrometer with TMS as an internal reference. Products were characterized by comparison of ^1H NMR, ^{13}C NMR, and HRMS.

General Procedure for Copper-Catalyzed Oxyalkylation of Vinylarenes. To a test tube equipped with a magnetic stir bar was added *N*-substituted acetamide (1.5 mL), $CuF_2{\cdot}2H_2O$ (0.05 mmol, 6.9 mg), styrene (0.5 mmol, 0.058 mL), and TBHP (*tert*-butyl hydroperoxide, 70% in water, 2 mmol, 0.267 mL) in air. The resulting reaction mixture was kept stirring at 100 °C for 48 h. At the end of the reaction, the reaction mixture was cooled to room temperature. After removal of the solvent, the residue was subjected to column chromatography on silica gel using ethyl acetate and petroleum ether mixtures to afford the desired product in high purity.

General Procedure for Copper-Catalyzed Decarboxylative Alkenylation. To a Schlenk tube equipped with a magnetic stir bar was added under argon CuO (0.06 mmol, 4.8 mg) and cinnamic acid (0.3 mmol, 44.4 mg). Under argon, *N*-substituted acetamide (2.0 mL) and DTBP (di-*tert*-butyl peroxide, 1.2 mmol, 0.226 mL) were added. The resulting reaction mixture was kept stirring at 110 °C for 24 h. At the end of the reaction, the reaction mixture was cooled to room temperature. After removal of the solvent, the residue was subjected to column chromatography on silica gel using ethyl acetate and petroleum ether mixtures to afford the desired product in high purity.

***N*-Methyl-*N*-(3-oxo-3-phenylpropyl)acetamide (3aa).**[13] White solid. 66.7 mg, 65%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.95 (t, J = 9.3 Hz, 2H), 7.59−7.54 (m, 1H), 7.50−7.43 (m, 2H), 3.78−3.72 (m, 2H), 3.31−3.20 (m, 2H), 3.07 (s, 2H), 2.94 (s, 1H), 2.15 (s, 1H), 2.05 (s, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 198.8, 197.5, 170.7, 170.4, 136.5, 136.2, 133.5, 133.1, 128.7, 128.5, 127.9, 127.8, 45.7, 44.1, 37.3, 36.8, 36.6, 33.0, 21.8, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{16}NO_2$ 206.1181, found 206.1173.

***N*-Methyl-*N*-(3-oxo-3-(*p*-tolyl)propyl)acetamide (3ba).**[13] Yellow oil. 71.3 mg, 65%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.87 (t, J = 9.4 Hz, 2H), 7.31−7.26 (m, 2H), 3.79−3.73 (m, 2H), 3.29−3.22 (m, 2H), 3.09 (s, 2H), 2.96 (s, 1H), 2.44 (s, 1H), 2.42 (s, 2H), 2.17 (s, 1H), 2.08 (s, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 198.6, 198.3, 170.8, 170.5, 144.5, 144.0, 134.1, 133.8, 129.4, 129.2, 128.2, 128.0, 45.9, 44.3, 37.5, 36.7, 36.6, 33.1, 21.9, 21.6, 21.5, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_2$ 220.1338, found 220.1335.

***N*-(3-(4-Methoxyphenyl)-3-oxopropyl)-*N*-methylacetamide (3ca).**[13] Yellow oil. 58.8 mg, 50%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.94−7.88 (m, 2H), 6.93−6.88 (m, 2H), 3.85−3.83 (m, 3H), 3.76−3.68 (m, 2H), 3.21−3.15 (m, 2H), 3.04 (s, 2H), 2.91 (s, 1H), 2.12 (s, 1H), 2.03 (s, 2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 197.5, 196.0, 170.8, 170.5, 163.8, 163.5, 130.3, 130.2, 129.7, 129.4, 113.8, 113.7, 55.4, 55.4, 45.9, 44.4, 37.4, 36.4, 33.1, 30.8, 21.9, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_3$ 236.1287, found 236.1286.

***N*-(3-(4-(*tert*-Butyl)phenyl)-3-oxopropyl)-*N*-methylacetamide (3da).** Yellow oil. 60.1 mg, 46%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.91−7.86 (m, 2H), 7.50−7.45 (m, 2H), 3.77−3.71 (m, 2H), 3.27−3.20 (m, 2H), 3.06 (s, 2H), 2.93 (s, 1H), 2.14 (s, 1H), 2.05 (s, 2H), 1.32 (d, J = 4.2 Hz, 9H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 198.6, 197.2, 170.8, 170.5, 157.4, 157.0, 134.0, 133.7, 128.0, 127.9, 125.7, 125.5, 45.9, 44.3, 37.5, 36.7, 35.1, 35.0, 33.2, 31.0, 31.0, 21.9, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{16}H_{24}NO_2$ 262.1807, found 262.1802.

***N*-(3-(4-Fluorophenyl)-3-oxopropyl)-*N*-methylacetamide-(3ea).** Yellow oil. 61.4 mg, 55%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 8.01−7.94 (m, 2H), 7.16−7.09 (m, 2H), 3.77−3.69 (m, 2H), 3.25−3.19 (m, 2H), 3.06 (s, 2H), 2.92 (s, 1H), 2.14 (s, 1H), 2.04 (s, 2H). $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 197.4, 196.0, 170.9, 170.5, 167.3 (d, J = 253.5 Hz), 133.1 (d, J = 3.0 Hz), 133.0 (d, J = 3.0 Hz), 132.8 (d, J = 9.8 Hz), 130.5, 115.9 (d, J = 21.8 Hz), 115.7 (d, J = 21.8 Hz), 45.7, 44.4, 37.5, 36.7, 33.2, 21.9, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{15}FNO_2$ 224.1087, found 224.1089.

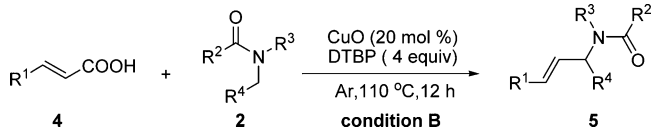
***N*-(3-(4-Chlorophenyl)-3-oxopropyl)-*N*-methylacetamide (3fa).**[13] Yellow oil. 56.3 mg, 47%. The ratio of two conformational isomers is about 2.9:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.92−7.87 (m, 2H), 7.47−7.42 (m, 2H), 3.78−3.70 (m, 2H), 3.27−3.20 (m, 2H), 3.08 (s, 2.3H), 2.94 (s, 0.8H), 2.15 (s, 0.8H), 2.06 (s, 2.3H). $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 197.8, 196.4, 171.0, 170.5, 140.1, 139.7, 134.9, 134.6, 129.5, 129.3, 129.1, 128.9, 45.7, 44.4, 37.6, 36.9, 36.8, 33.2, 21.9, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{15}ClNO_2$ 240.0791, found 240.0787.

***N*-Methyl-*N*-(3-oxo-3-(3,4,5-trimethoxyphenyl)propyl)-acetamide (3ga).** Yellow oil. 73.8 mg, 50%. The ratio of two conformational isomers is about 3.1:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, J = 32.0 Hz, 2H), 3.90 (s, 6H), 3.89 (s, 3H), 3.78−3.69 (m, 2H), 3.25−3.18 (m, 2H), 3.07 (s, 2.2H), 2.94 (s, 0.7H), 2.14 (s, 0.7H), 2.05 (s, 2.2H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 197.6, 196.2, 170.8, 170.4, 153.0, 152.9, 142.4, 142.2, 131.7, 131.4, 105.4, 105.3, 60.8, 60.7, 56.2, 56.1, 45.8, 44.6, 37.4, 36.6, 36.5, 33.1, 21.8, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{15}H_{22}NO_5$ 296.1498, found 296.1494.

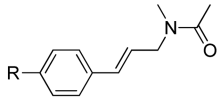
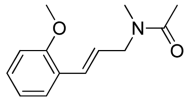
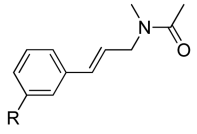
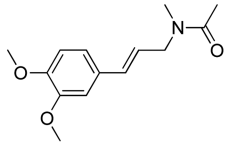
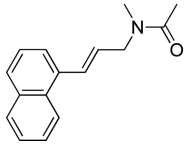
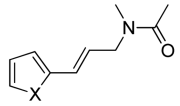
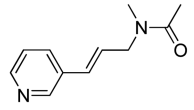
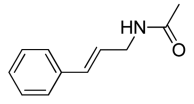
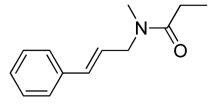
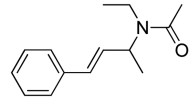
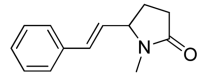
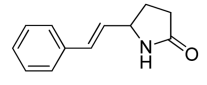
***N*-Methyl-*N*-(3-(naphthalen-1-yl)-3-oxopropyl)acetamide (3ha).** Yellow oil. 75.3 mg, 59%. The ratio of two conformational isomers is about 2:1. ^1H NMR (400 MHz, $CDCl_3$) δ 8.70−8.64 (m, 1H), 8.05−7.87 (m, 3H), 7.63−7.49 (m, 3H), 3.86−3.81 (m, 2H),

dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103−7111

Table 4. Copper-Catalyzed Decarboxylative Couplings between Cinnamic Acids with *N*,*N*-Substituted Amides[a,b,c,d]

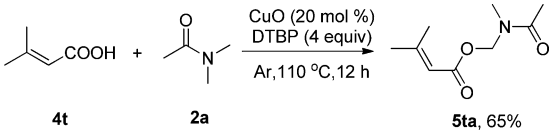


4 2 condition B 5

entry	product	yield	entry	product	yield
1		H, **5aa**, 63%			
2		OMe, **5ba**, 58%			
3		Me, **5ca**, 42%[b]			
4		isopropyl, **5da**, 51%[b]			
5		COOMe, **5ea**, 25%			
6		CF_3, **5fa**, 21%[bc]			
7		CN, **5ga**, 26%			
8		F, **5ha**, 59%[b]			
9		Cl, **5ia**, 27%			
10		**5ja**, 67%[b]			
11		Me, **5ka**, 53%[b]			
12		OMe, **5la**, 26%[bd]			
13		OAc, **5ma**, 47%[bd]			
14		OH, **5na**, 57%			
15		**5oa**, 60%[b]			
16		**5pa,** 53%			
			17		S, **5qa**, 52%
			18		O, **5ra**, 71%
			19		**5sa**, 0%
			20		**5ab**, 44%
			21		**5ac**, 40%
			22		**5ad**, 60%
			23		**5ae**, 47%
			24		**5af**, 39%

[a]Catalytic conditions: cinnamic acid (0.3 mmol), CuO (20 mol %), DTBP (4 equiv), *N*,*N*-substituted amide (2 mL), 12 h, Ar. [b]DTBP (2 equiv). [c]8 h. [d]24 h.

Scheme 2. Copper-Catalyzed Coupling between 3-Methylbut-2-enoic Acid and DMA



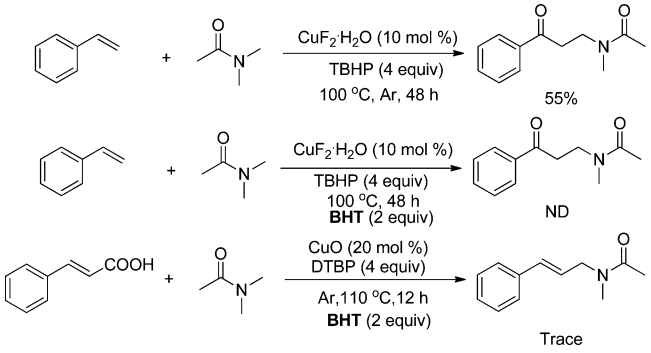
4t 2a **5ta**, 65%

3.41−3.34 (m, 2H), 3.11 (s, 2H), 2.98 (s, 1H), 2.19 (s, 1H), 2.08 (s, 2H). $^{13}C\{^1H\}$ NMR (75 MHz, $CDCl_3$) δ 202.8, 201.4, 170.9, 170.6, 135.1, 134.8, 134.0, 133.9, 133.5, 133.1, 130.1, 130.0, 128.5, 128.5, 128.3, 128.1, 126.7, 126.4, 125.7, 125.5, 124.4, 124.3, 46.2, 44.7, 40.2, 39.9, 37.6, 33.2, 22.0, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{16}H_{18}NO_2$ 256.1338, found 256.1340.

***N*-Methyl-*N*-(3-oxo-2,3-diphenylpropyl)acetamide (3ia).** Yellow oil. 60.5 mg, 43%. The ratio of two conformational isomers is about 2.5:1. ^1H NMR (400 MHz, $CDCl_3$) δ 7.92 (t, J = 9.3 Hz, 2H), 7.46−7.19 (m, 8H), 5.25−4.79 (m, 1H), 4.00−3.65 (m, 2H), 2.87 (s, 0.8H), 2.73 (s, 2H), 2.00 (s, 2H), 1.83 (s, 0.8H). $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 199.1, 197.9, 171.4, 171.3, 137.4, 136.5, 136.4, 135.9, 133.4, 133.1, 129.5, 129.1, 128.8, 128.7, 128.7, 128.5, 128.4, 128.1, 128.0, 127.5, 54.1, 53.0, 52.4, 51.5, 38.8, 33.8, 22.0, 20.9. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{18}H_{20}NO_2$ 282.1494, found 282.1496.

dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103−7111

Scheme 3. Copper-Catalyzed Functionalization of Amides in the Presence of BHT



***N*-(3-Oxo-3-phenylpropyl)acetamide (3ab).**[16] Yellow oil. 31.0 mg, 54%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, J = 7.6 Hz, 2H), 7.57 (t, J = 7.4 Hz, 1H), 7.45 (t, J = 7.7 Hz, 2H), 6.31 (s, 1H), 3.67–3.62 (m, 2H), 3.22 (t, J = 5.5 Hz, 2H), 1.93 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 199.6, 170.2, 136.4, 133.5, 128.7, 128.0, 38.2, 34.3, 23.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{11}H_{14}NO_2$ 192.1025, found 192.1027.

***N*-(3-Oxo-3-(*p*-tolyl)propyl)acetamide (3bb).** Yellow oil. 54.4 mg, 53%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 7.6 Hz, 2H), 6.25 (s, 1H), 3.64–3.60 (m, 2H), 3.17 (t, J = 5.5 Hz, 2H), 2.38 (s, 3H), 1.91 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 198.3, 169.2, 143.5, 132.9, 128.4, 127.1, 37.0, 33.3, 22.3, 20.7. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{16}NO_2$ 206.1181, found 206.1185.

***N*-(3-(4-Methoxyphenyl)-3-oxopropyl)acetamide (3cb).** Yellow oil. 14.4 mg, 13%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 8.9 Hz, 2H), 6.93 (d, J = 8.9 Hz, 2H), 6.28 (s, 1H), 3.86 (s, 3H), 3.66–3.61 (m, 2H), 3.16 (t, J = 5.5 Hz, 2H), 1.93 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 197.1, 169.2, 162.8, 129.3, 128.5, 112.8, 54.5, 36.8, 33.4, 22.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{16}NO_3$ 222.1130, found 222.1131.

***N*-(3-(4-Fluorophenyl)-3-oxopropyl)acetamide (3eb).** Yellow oil. 42.9 mg, 41%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99–7.92 (m, 2H), 7.13 (t, J = 8.0 Hz, 2H), 6.28 (s, 1H), 3.66–3.62 (m, 2H), 3.19 (t, J = 5.1 Hz, 2H), 1.93 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 196.9, 169.3, 164.9 (d, J = 254.3 Hz), 131.8 (d, J = 3.0 Hz), 129.7 (d, J = 9.8 Hz), 114.8 (d, J = 21.8 Hz), 37.1, 33.3, 22.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{11}H_{13}FNO_2$ 210.0930, found 210.0933.

***N*-Methyl-*N*-(3-oxo-3-phenylpropyl)propionamide (3ac).** Yellow oil. 54.8 mg, 50%. The ratio of two conformational isomers is about 2:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97–7.91 (m, 2H), 7.60–7.52 (m, 1H), 7.50–7.40 (m, 2H), 3.77–3.71 (m, 2H), 3.28–3.17 (m, 2H), 3.04 (s, 2H), 2.94 (s, 1H), 2.42–2.26 (m, 2H), 1.19–1.09 (m, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 199.2, 199.1, 174.1, 174.0, 136.8, 136.7, 133.3, 133.1, 128.7, 128.5, 128.2, 128.1, 44.8, 43.0, 37.0, 36.7, 31.3, 26.8, 17.5, 9.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_2$ 220.1338, found 220.1337.

***N*-Ethyl-*N*-(4-oxo-4-phenylbutan-2-yl)acetamide (3ad).** Yellow oil. 35.0 mg, 30%. The ratio of two conformational isomers is about 2:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00–7.91 (m, 2H), 7.60–7.42 (m, 3H), 4.64–4.36 (m, 1H), 3.67–3.03 (m, 4H), 2.20 (s, 1H), 2.03 (s, 2H), 1.38–1.28 (m, 3H), 1.22–1.08 (m, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 199.0, 197.1, 170.6, 170.4, 136.9, 136.6, 133.6, 133.2, 128.8, 128.6, 128.3, 128.0, 50.7, 49.7, 43.6, 43.6, 43.4, 36.1, 22.7, 22.2, 19.9, 18.7, 15.3, 14.7. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{14}H_{20}NO_2$ 234.1494, found 234.1495.

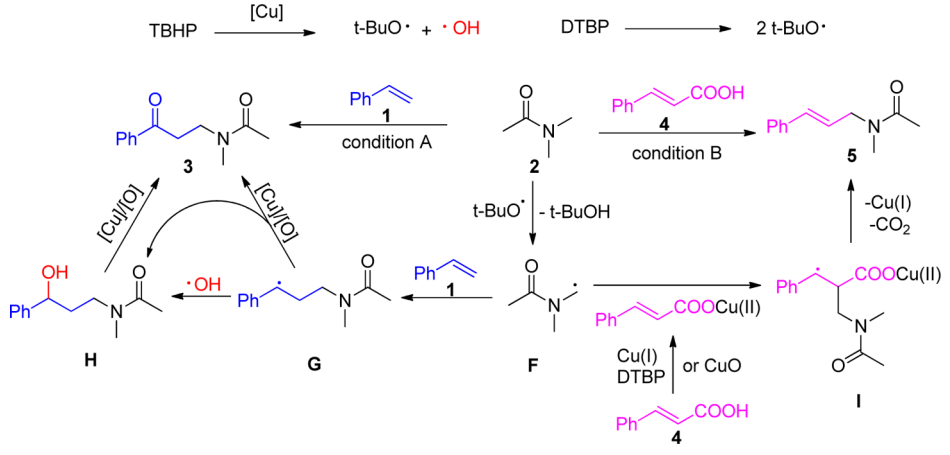
***N*-Ethyl-*N*-(4-oxo-4-(p-tolyl)butan-2-yl)acetamide (3bd).** Yellow oil. 32.2 mg, 26%. The ratio of two conformational isomers is about 2:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89–7.80 (m, 2H), 7.27–7.22 (m, 2H), 4.62–4.35 (m, 1H), 3.69–2.99 (m, 4H), 2.40 (s, 1H), 2.38 (s, 2H), 2.20 (s, 1H), 2.03 (s, 2H), 1.36–1.26 (m, 3H), 1.21–1.06 (m, 3H). ^{13}C{1H} NMR (100 MHz, $CDCl_3$) δ 198.6, 196.7, 170.6, 170.5, 144.5, 144.0, 134.4, 134.1, 129.5, 129.3, 128.4, 128.1, 50.8, 49.8, 43.5, 43.4, 36.2, 22.7, 22.2, 21.7, 21.1, 19.9, 18.7, 15.2, 14.7. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{15}H_{22}NO_2$ 248.1651, found 248.1649.

***N*-Cinnamyl-*N*-methylacetamide (5aa).**[8b] Colorless oil. 35.8 mg, 63%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38–7.23 (m, 5H), 6.51–6.44 (m, 1H), 6.18–6.10 (m, 1H), 4.15 (d, J = 6.8 Hz, 1H), 4.06–4.05 (m, 1H), 2.98 (s, 1.5H), 2.98 (s, 1.5H), 2.14 (s, 1.5H), 2.13 (s, 1.5H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.8, 170.5, 136.5, 136.1, 132.8, 131.7, 128.7, 128.5, 127.9, 127.6, 126.4, 124.5, 123.6, 52.6, 49.3, 35.4, 33.5, 21.8, 21.3. HRMS (ESI-TOF) $[M + Na]^+$ calculated for $C_{12}H_{15}NONa$ 212.1051, found 212.1052.

***(E)*-*N*-(3-(4-Methoxyphenyl)allyl)-*N*-methylacetamide (5ba).** Colorless oil. 38.2 mg, 58%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28–7.25 (m, 2H), 6.82 (t, J = 8.4 Hz, 2H), 6.42–6.35 (m, 1H), 5.99–5.91 (m, 1H), 4.08 (d, J = 6.8 Hz, 1H), 3.99 (d, J = 4.8 Hz, 1H), 3.77 (s, 1.5H), 3.76 (s, 1.5H), 2.93 (s, 1.5H), 2.93 (s, 1.5H), 2.10 (s, 1.5H), 2.08 (s, 1.5H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.8, 170.5, 159.5, 159.3, 132.3, 131.3, 129.4, 128.9, 127.6, 127.5, 122.3, 121.3, 114.1, 114.0, 55.3, 55.3, 52.7, 49.4, 35.4, 33.4, 21.8, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_2$ 220.1338, found 220.1340.

***(E)*-*N*-Methyl-*N*-(3-(*p*-tolyl)allyl)acetamide (5ca).** Colorless oil. 25.6 mg, 42%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27–7.25 (m, 2H), 7.13 (t, J = 8.0 Hz, 2H), 6.48–6.42 (m, 1H), 6.12–6.04 (m, 1H), 4.13 (d, J = 6.4 Hz, 1H), 4.04 (d, J = 5.2 Hz, 1H), 2.97 (s, 3H), 2.34 (s, 1.5H), 2.33 (s, 1.5H), 2.14 (s, 1.5H), 2.12(s, 1.5H). ^{13}C{^{1}H} NMR (75 MHz,

Scheme 4. Possible Mechanism



dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103–7111

$CDCl_3$) δ 170.8, 170.5, 137.8, 137.5, 133.7, 133.3, 132.7, 131.7, 129.3, 129.2, 126.2, 123.4, 122.5, 52.6, 49.3, 35.4, 33.4, 21.8, 21.3, 21.1. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO$ 204.1388, found 204.1387.

(*E*)-*N*-(3-(4-Isopropylphenyl)allyl)-*N*-methylacetamide (5da). Colorless oil. 35.4 mg, 51%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31−7.29 (m, 2H), 7.18 (t, J = 8.4 Hz, 2H), 6.49−6.42 (m, 1H), 6.12−6.04 (m, 1H), 4.13 (d, J = 6.8 Hz, 1H), 4.04 (d, J = 5.2 Hz, 1H), 2.96 (s, 3H), 2.91−2.84 (m, 1H), 2.13 (s, 1.5H), 2.11 (s, 1.5H), 1.24 (d, J = 2.8 Hz, 3H), 1.23 (d, J = 2.4 Hz, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.8, 170.4, 148.9, 148.5, 134.1, 133.7, 132.7, 131.6, 126.7, 126.6, 126.3, 126.3, 123.5, 122.6, 52.6, 49.3, 35.3, 33.8, 33.4, 23.9, 21.8, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{15}H_{22}NO$ 232.1701, found 232.1709.

(*E*)-Methyl 4-(3-(*N*-methylacetamido)prop-1-en-1-yl)-benzoate (5ea). White solid. 18.5 mg, 25%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (t, J = 8.8 Hz, 2H), 7.42−7.39 (m, 2H), 6.52−6.47 (m, 1H), 6.29−6.22 (m, 1H), 4.16 (d, J = 6.0 Hz, 1H), 4.08 (d, J = 4.8 Hz, 1H), 3.90 (s, 1.5H), 3.89 (s, 1.5H), 3.00 (s, 1.5H), 2.98 (s, 1.5H), 2.13 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.8, 170.6, 166.8, 166.7, 141.0, 140.5, 131.6, 130.7, 130.0, 129.9, 129.4, 129.0, 127.4, 126.5, 126.3, 126.2, 52.5, 52.1, 52.0, 49.3, 35.7, 33.6, 21.7, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{14}H_{18}NO_3$ 248.1287, found 248.1288.

(*E*)-*N*-Methyl-*N*-(3-(4-(trifluoromethyl)phenyl)allyl)-acetamide (5fa). Colorless oil. 16.2 mg, 21%. The ratio of two conformational isomers is about 0.57:0.43. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58−7.54 (m, 2H), 7.47−7.43 (m, 2H), 6.52−6.47 (m, 1H), 6.28−6.20 (m, 1H), 4.16 (d, J = 6.0 Hz, 1H), 4.10−4.08 (m, 1H), 3.00 (s, 1.7H), 2.98 (s, 1.3H), 2.13 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.8, 170.6, 140.1, 139.5, 131.2, 130.3, 129.9, 129.4 (d, J = 32.4 Hz), 127.5, 126.6, 126.6, 126.5, 125.6 (q, J = 2.9 Hz), 125.5 (q, J = 2.9 Hz), 122.8, 122.7, 52.4, 49.2, 35.7, 33.6, 21.8, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{15}NOF_3$ 258.1106, found 258.1109.

(*E*)-*N*-(3-(4-Cyanophenyl)allyl)-*N*-methylacetamide (5ga). Colorless oil. 16.7 mg, 26%. The ratio of two conformational isomers is about 0.55:0.45. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61−7.57 (m, 2H), 7.43 (t, J = 7.4 Hz, 2H), 6.49−6.44 (m, 1H), 6.31−6.24 (m, 1H), 4.16 (d, J = 6.0 Hz, 1H), 4.1 (d, J = 4.8 Hz, 1H), 3.00 (s, 1.7H), 2.97 (s, 1.3H), 2.13 (s, 1.7H), 2.12 (s, 1.3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.8, 170.7, 141.0, 140.4, 132.5, 132.4, 130.7, 129.8, 128.8, 127.9, 126.9, 126.8, 118.8, 118.7, 111.2, 110.8, 52.4, 49.2, 35.8, 33.7, 21.7, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{15}N_2O$ 215.1184, found 215.1184.

(*E*)-*N*-(3-(4-Fluorophenyl)allyl)-*N*-methylacetamide (5ha). Colorless oil. 36.7 mg, 59%. The ratio of two conformational isomers is about 0.55:0.45. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33−7.29 (m, 2H), 7.02−6.95 (m, 2H), 6.45−6.39 (m, 1H), 6.08−5.99 (m, 1H), 4.11 (d, J = 6.4 Hz, 1H), 4.03 (d, J = 5.2 Hz, 1H), 2.97 (s, 1.6H), 2.95 (s, 1.4H), 2.12 (s, 1.4H), 2.11 (s, 1.6H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.7, 170.5, 162.4 (d, J = 245.9 Hz), 162.3 (d, J = 245.6 Hz,), 132.7 (d, J = 3.2 Hz,), 132.2 (d, J = 3.2 Hz), 131.5, 130.5, 127.9 (d, J = 7.8 Hz), 127.8 (d, J = 7.8 Hz), 124.3, 123.4, 115.5 (d, J = 21.5 Hz), 115.4 (d, J = 21.4 Hz), 52.5, 49.2, 35.5, 33.4, 21.8, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{15}NOF$ 208.1138, found 208.1141.

(*E*)-*N*-(3-(4-Chlorophenyl)allyl)-*N*-methylacetamide (5ia). Colorless oil. 18.0 mg, 27%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (s, 2H), 7.28 (s, 2H), 6.46−6.40 (m, 1H), 6.16−6.08 (m, 1H), 4.13 (d, J = 6.4 Hz, 1H), 4.06−4.05 (m, 1H), 2.99 (s, 1.5H), 2.97 (s, 1.5H), 2.13 (s, 1.5H), 2.13 (s, 1.5H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.7, 170.5, 135.0, 134.5, 133.5, 133.1, 131.3, 130.3, 128.7, 128.6, 127.5, 127.5, 125.2, 124.3, 52.4, 49.2, 35.5, 33.4, 21.7, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{15}NOCl$ 224.0842, found 224.0845.

(*E*)-*N*-(3-(2-Methoxyphenyl)allyl)-*N*-methylacetamide (5ja). Colorless oil. 44.1 mg, 67%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41−7.37 (m, 1H), 7.24−7.18 (m, 1H), 6.93−6.76 (m, 3H), 6.16−6.09 (m, 1H), 4.14 (d, J = 6.8 Hz, 1H), 4.04−4.02 (m, 1H), 3.82 (s, 1.5H), 3.82 (s, 1.5H), 2.96 (s, 3H), 2.13 (s, 1.5H), 2.10 (s, 1.5H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.7, 170.3, 156.6, 156.4, 128.9, 128.6, 127.6, 127.0, 126.9, 126.7, 125.4, 125.0, 124.9, 124.1, 120.5, 110.8, 110.7, 55.3, 55.3, 53.0, 49.6, 35.2, 33.3, 21.8, 21.3. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_2$ 220.1338, found 220.1341.

(*E*)-*N*-Methyl-*N*-(3-(*m*-tolyl)allyl)acetamide (5ka). Colorless oil. 32.3 mg, 53%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23−7.16 (m, 3H), 7.06 (t, J = 9.0 Hz, 1H), 6.47−6.41 (m, 1H), 6.16−6.07 (m, 1H), 4.13 (d, J = 6.4 Hz, 1H), 4.05−4.03 (m, 1H), 2.97 (s, 1.5H), 2.96 (s, 1.5H), 2.34 (s, 1.5H), 2.33 (s, 1.5H), 2.13 (s, 1.5H), 2.12 (s, 1.5H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.7, 170.4, 138.2, 138.0, 136.4, 135.9, 132.8, 131.8, 128.6, 128.5, 128.4, 127.0, 127.0, 124.2, 123.5, 123.4, 123.3, 52.6, 49.2, 35.3, 33.4, 21.8, 21.3, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO$ 204.1388, found 204.1393.

(*E*)-*N*-(3-(3-Methoxyphenyl)allyl)-*N*-methylacetamide (5la). Colorless oil. 17.1 mg, 26%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26−7.19 (m, 1H), 6.95 (t, J = 4.0 Hz, 1H), 6.89 (d, J = 1.2 Hz, 1H), 6.82−6.77 (m, 1H), 6.47−6.40 (m, 1H), 6.16−6.08 (m, 1H), 4.13 (d, J = 6.8 Hz, 1H), 4.05−4.03 (m, 1H), 3.81 (s, 1.5H), 3.79 (s, 1.5H), 2.97 (s, 1.5H), 2.96 (s, 1.5H), 2.13 (s, 1.5H), 2.12 (s, 1.5H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.8, 170.4, 159.8, 159.7, 137.9, 137.5, 132.6, 131.5, 129.6, 129.5, 124.8, 123.9, 119.0, 118.9, 113.5, 113.4, 111.7, 111.4, 55.2, 55.1, 52.5, 49.2, 35.4, 33.4, 21.8, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{13}H_{18}NO_2$ 220.1338, found 220.1343.

(*E*)-3-(3-(*N*-Methylacetamido)prop-1-en-1-yl)phenyl Acetate (5ma). Colorless oil. 34.9 mg, 47%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35−7.28 (m, 1H), 7.21 (d, J = 7.6 Hz, 1H), 7.09 (t, J = 0.8 Hz, 1H), 6.96 (d, J = 9.6 Hz, 1H), 6.47−6.41 (m, 1H), 6.17−6.10 (m, 1H), 4.13 (d, J = 6.0 Hz, 1H), 4.05 (d, J = 4.8 Hz, 1H), 2.97 (s, 1.5H), 2.96 (s, 1.5H), 2.30 (s, 1.5H), 2.29 (s, 1.5H), 2.12 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.8, 170.5, 169.4, 151.0, 150.9, 138.2, 137.7, 131.7, 130.7, 129.6, 129.5, 125.8, 124.9, 124.0, 124.0, 121.0, 120.7, 119.3, 52.5, 49.2, 35.5, 33.5, 21.8, 21.3, 21.1. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{14}H_{18}NO_3$ 248.1287, found 248.1286.

(*E*)-*N*-(3-(3-Hydroxyphenyl)allyl)-*N*-methylacetamide (5na). Colorless oil. 35.1 mg, 57%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, DMSO) δ 9.42 (s, 0.5H), 9.40 (s, 0.5H), 7.14−7.09 (m, 1H), 6.88−6.80 (m, 2H), 6.66 (d, J = 6.6 Hz, 1H), 6.38 (d, J = 16.8 Hz, 1H), 6.24−6.18 (m, 0.5H), 6.10−6.03 (m, 0.5H), 4.02 (t, J = 6.6 Hz, 2H), 2.93 (s, 1.5H), 2.81 (s, 1.5H), 2.02 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, DMSO) δ 169.7, 169.6, 157.6, 157.6, 137.8, 137.6, 131.6, 131.1, 129.6, 129.6, 124.9, 117.4, 117.3, 114.8, 114.7, 113.0, 112.8, 51.8, 48.3, 35.2, 32.8, 21.6, 21.2. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{12}H_{16}NO_2$ 206.1181, found 206.1183.

(*E*)-*N*-(3-(3,4-Dimethoxyphenyl)allyl)-*N*-methylacetamide (5oa). Colorless oil. 44.9 mg, 60%. The ratio of two conformational isomers is about 0.55:0.45. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.88−6.82 (m, 2H), 6.76 (t, J = 8.6 Hz, 1H), 6.36 (t, J = 15.0 Hz, 1H), 5.99−5.90 (m, 1H), 4.06 (d, J = 6.4 Hz, 1H), 3.98 (d, J = 5.2 Hz, 1H), 3.85−3.81 (m, 6H), 2.93 (s, 1.3H), 2.92 (s, 1.7H), 2.09 (s, 1.3H), 2.07 (s, 1.7H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.7, 170.3, 148.9, 148.8, 148.8, 148.6, 132.3, 131.2, 129.4, 129.0, 122.3, 121.4, 119.4, 119.3, 111.0, 110.8, 108.6, 108.4, 55.7, 55.6, 55.6, 52.4, 49.2, 35.3, 33.3, 21.6, 21.1. HRMS (TOF MS CI$^+$) $[M + H]^+$ calculated for $C_{14}H_{20}NO_3$ 250.1443, found 250.1443.

(*E*)-*N*-Methyl-*N*-(3-(naphthalen-1-yl)allyl)acetamide (5pa). Colorless oil. 38.1 mg, 53%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10−8.02 (m, 1H), 7.84 (t, J = 5.8 Hz, 1H), 7.78 (t, J = 9.0 Hz, 1H), 7.58−7.41 (m, 4H), 7.26−7.20 (m, 1H), 6.19−6.10 (m, 1H), 4.26 (d, J = 6.4 Hz, 1H), 4.14 (d, J = 4.8 Hz, 1H), 3.05 (s, 1.5H), 3.04 (s, 1.5H), 2.19 (s, 1.5H), 2.14 (s, 1.5H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.7, 170.4, 134.2, 133.8, 133.5, 130.9, 130.9, 129.9, 129.1, 128.5, 128.5, 128.2, 128.0, 127.7, 126.9, 126.2, 126.0, 125.8, 125.7, 125.5, 125.5, 123.9, 123.6,

dx.doi.org/10.1021/jo501274f | J. Org. Chem. 2014, 79, 7103−7111

123.4, 52.8, 49.4, 35.4, 33.5, 21.8, 21.3. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{16}H_{18}NO$ 240.1388, found 240.1396.

(*E*)-*N*-Methyl-*N*-(3-(thiophen-2-yl)allyl)acetamide (5qa). Colorless oil. 30.5 mg, 52%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16−7.12 (m, 1H), 6.96−6.92 (m, 2H), 6.58 (t, J = 14.0 Hz, 1H), 5.99−5.91 (m, 1H), 4.09 (d, J = 6.4 Hz, 1H), 4.00 (d, J = 5.2 Hz, 1H), 2.97 (s, 1.5H), 2.95 (s, 1.5H), 2.11 (s, 1.5H), 2.10 (s, 1.5H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.7, 170.4, 141.6, 141.0, 127.4, 127.2, 126.1, 125.8, 125.6, 124.8, 124.5, 124.2, 124.1, 123.2, 52.2, 48.9, 35.4, 33.4, 21.7, 21.3. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{10}H_{14}NOS$ 196.0796, found 196.0798.

(*E*)-*N*-(3-(Furan-2-yl)allyl)-*N*-methylacetamide (5ra). Colorless oil. 38.2 mg, 71%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (d, J = 10.4 Hz, 1H), 6.36−6.20 (m, 3H), 6.08−6.01 (m, 1H), 4.09 (d, J = 6.4 Hz, 1H), 4.01 (d, J = 4.8 Hz, 1H), 2.96 (s, 1.5H), 2.94 (s, 1.5H), 2.10 (s, 3H). ^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$) δ 170.9, 170.5, 152.1, 151.6, 142.1, 141.9, 123.0, 122.1, 120.9, 119.8, 111.3, 111.1, 108.3, 107.7, 52.2, 48.8, 35.5, 33.5, 21.7, 21.1. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{10}H_{14}NO_2$ 180.1025, found 180.1022.

(*N*-Methylacetamido)methyl 3-methylbut-2-enoate (5ta). Colorless oil. 36.1 mg, 65%. The ratio of two conformational isomers is about 0.33:0.67. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.65 (s, 1H), 5.40 (s, 0.7H), 5.35 (s, 1.3H), 3.09 (s, 1H), 2.98 (s, 2H), 2.17 (d, J = 18.4 Hz, 5H), 2.10 (s, 1H), 1.89 (s, 2H), 1.86 (s, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 171.9, 166.3, 165.7, 159.1, 158.2, 115.3, 114.9, 73.8, 70.5, 36.1, 33.6, 27.4, 27.4, 21.9, 21.1, 20.3, 20.2. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_9H_{16}NO_3$ 186.1130, found 186.1131.

***N*-Cinnamylacetamide (5ab).**[17] White solid. 23.1 mg, 44%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36−7.29 (m, 4H), 7.25−7.22 (m, 1H), 6.52 (d, J = 16.0 Hz, 1H), 6.22−6.15 (m, 1H), 5.69 (s, 1H), 4.03 (t, J = 12.0 Hz, 2H), 2.02 (s, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.0, 136.4, 132.3, 128.6, 127.7, 126.3, 125.4, 41.7, 23.2. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{11}H_{14}NO$ 176.1075, found 176.1076.

***N*-Cinnamyl-*N*-methylpropionamide (5ac).** Colorless oil. 24.4 mg, 40%. The ratio of two conformational isomers is about 0.50:0.50. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36−7.19 (m, 5H), 6.45 (t, J = 15.4 Hz, 1H), 6.17−6.07 (m, 1H), 4.14 (d, J = 6.4 Hz, 1H), 4.04 (d, J = 5.2 Hz, 1H), 2.97 (s, 1.5H), 2.95 (s, 1.5H), 2.38−2.35 (m, 2H), 1.18−1.14 (m, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 173.9, 173.5, 136.5, 136.0, 132.6, 131.5, 128.5, 128.4, 127.8, 127.5, 126.2, 124.7, 123.9, 51.5, 49.4, 34.4, 33.5, 26.7, 26.1, 9.5, 9.2. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{13}H_{18}NO$ 204.1388, found 204.1386.

(*E*)-*N*-Ethyl-*N*-(4-phenylbut-3-en-2-yl)acetamide (5ad). Colorless oil. 39.1 mg, 60%. The ratio of two conformational isomers is about 0.60:0.40. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37−7.23 (m, 5H), 6.49−6.40 (m, 1H), 6.25−6.15 (m, 1H), 5.42−5.36 (m, 0.6H), 4.60−4.54 (m, 0.4H), 3.49−3.12 (m, 2H), 2.17 (s, 1.2H), 2.14 (s, 1.8H), 1.44 (d, J = 6.8 Hz, 1.2H), 1.35 (d, J = 6.8 Hz, 1.8H), 1.21−1.14 (m, 3H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 170.2, 170.0, 136.7, 136.2, 130.7, 130.5, 130.2, 129.5, 128.6, 128.5, 127.9, 127.5, 126.3, 126.3, 54.8, 50.2, 39.0, 37.0, 22.1, 21.8, 18.7, 17.4, 16.4, 14.9. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{14}H_{20}NO$ 218.1545, found 218.1544.

(*E*)-1-Methyl-5-styrylpyrrolidin-2-one (5ae).[12a] Colorless oil. 28.4 mg, 47%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40−7.28 (m, 5H), 6.57 (d, J = 15.6 Hz, 1H), 6.05−5.99 (m, 1H), 4.13−4.08 (m, 1H), 2.79 (s, 3H), 2.54−2.27 (m, 3H), 1.88−1.80 (m, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 175.0, 135.9, 133.0, 128.9, 128.7, 128.1, 126.5, 63.0, 30.0, 27.9, 25.7. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{13}H_{16}NO$ 202.1232, found 202.1231.

(*E*)-5-Styrylpyrrolidin-2-one (5af).[12a] White solid. 21.9 mg, 39%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38−7.31 (m, 4H), 7.28−7.24 (m, 1H), 6.54 (d, J = 16.0 Hz, 1H), 6.16−6.10 (m, 1H), 6.02 (s, 1H), 4.36−4.30 (m, 1H), 2.46−2.32 (m, 3H), 1.99−1.88 (m, 1H). ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 178.1, 136.0, 131.2, 129.8, 128.7, 128.0, 126.5, 56.5, 29.9, 28.5. HRMS (TOF MS CI$^+$) [M + H]$^+$ calculated for $C_{12}H_{14}NO$ 188.1075, found 188.1073.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

^{1}H and ^{13}C NMR spectra for all products. 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 are grateful for the grants from the Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry, the Priority Academic Program Development of Jiangsu Higher Education Institutions, The Project of Scientific and Technologic Infrastructure of Suzhou (SZS201207), and the Key Laboratory of Organic Synthesis of Jiangsu Province.

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dx.doi.org/10.1021/jo501274f | *J. Org. Chem.* 2014, 79, 7103−7111