JOC The Journal of Organic Chemistry

Article

Synthesis of Amide Enol Carbamates and Carbonates through Cu(OTf)2-Catalyzed Reaction of Ynamides with t-Butyl Carbamates/Carbonates

Pan Han, Zhuo-Ya Mao, Ming Li, Chang-Mei Si, Bang-Guo Wei, and Guo-Qiang Lin

J. Org. Chem., **Just Accepted Manuscript** • DOI: 10.1021/acs.joc.9b03512 • Publication Date (Web): 12 Mar 2020

Just Accepted

is published by the American Chemical Society. 1155 Sixteenth Street N.W., Washington, DC 20036

Synthesis of Amide Enol Carbamates and Carbonates through Cu(OTf)$_2$-Catalyzed Reaction of Ynamides with *t*-Butyl Carbamates/Carbonates

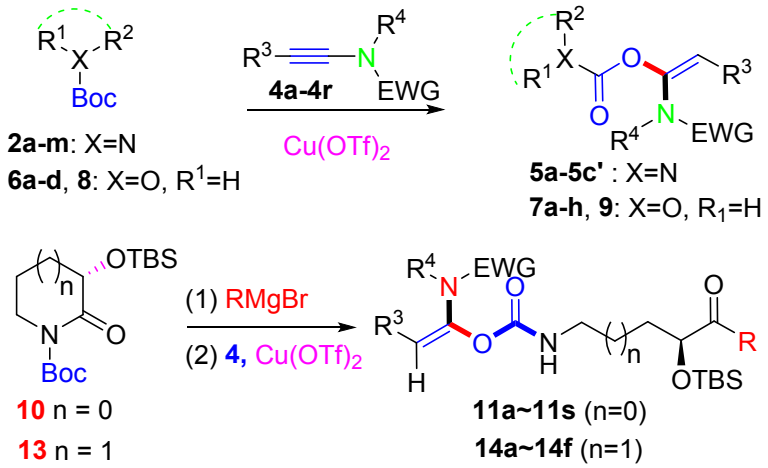
Pan Han,[†,‡] Zhuo-Ya Mao,[†] Ming Li,[†] Chang-Mei Si,*[,†] Bang-Guo Wei*[,†] and Guo-Qiang Lin[§]

[†] *Department of Natural Medicine, School of Pharmacy, Fudan University, 826 Zhangheng Road, Shanghai 201203, China*

[‡] *College of Chemistry and Chemical Engineering, China West Normal University, 1 Shida Road, Nanchong 637002, China*

[§] *Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, 345 Lingling Road, Shanghai 200032, China*

Abstract

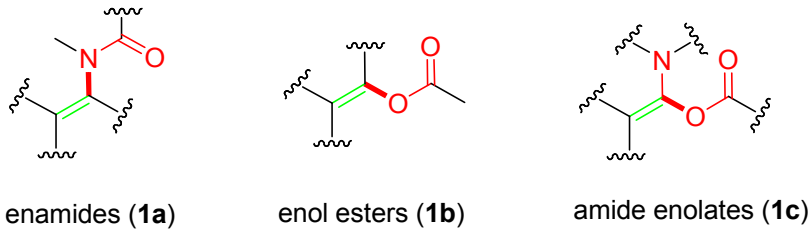


A highly regioselective approach to access amide enol carbamates and carbonates **5a-5c'**, **7a-7h** and **9** was developed through Cu(OTf)$_2$ catalyzed reactions of ynamides **4** with *t*-butyl carbamates **2**, **8** and *t*-butyl carbonates **6**. Moreover, this strategy was successfully applied to generate amide enol carbamates **11a-11s** and **14a-14f** from imide **10** and **13** with ynamides through a N-Boc cleavage-addition-ring opening process. A range of substituents were amenable to this transformation and the desired amide enol carbamates and carbonates were obtained in moderate to good yields.

Introduction

The discovery of an efficient reaction or versatile synthetic method for new chemical bonds or new functional groups is one of the most challenging and fascinating tasks in

organic chemistry,[1] as it provides important new applications in pharmaceuticals and biologically active compounds.[2] Among them, the formation of enamides (**1a**) is one of the most important reactions in organic chemistry owing to the wide occurrence in depsipeptides,[3] pharmaceuticals[4] and important natural products.[5] Enol esters (**1b**) are also versatile intermediates in organic chemistry, which are not only frequently used as mild acylation reagents,[6] but also applied as substrates in polymerization,[7] hydrogenation,[8] cycloaddition,[9] aldol-[10] and Mannich-type reactions[11] and cross-coupling reactions.[12] However, amide enolates (**1c**) are rarely present in literature. To our best knowledge, very few approaches were reported to synthesize amide enolates: through metal salt or acid catalyzed hydroacyloxylation of ynamides with carboxylic acids (**Figure 1**),[13,14] suffering from complicated operation process or harsh reaction conditions.[15]



enamides (**1a**) enol esters (**1b**) amide enolates (**1c**)

Figure 1. The structures of enamides, enol esters and amide enolates.

The transition metal-catalyzed addition of carboxylic acids to alkynes was an efficient method for the preparation of enol esters.[16,17] Ynamide, a kind of functionalized alkyne, is wildly used in modern organic synthesis and many important transformations due to the advantages of high regio- and stereoselectivity.[18,19] Hydroacyloxylation of ynamides is an efficient method for the synthesis of α-acyloxyenamides. For example, Lam and co-workers reported an efficient and regioselective $Pd(OAc)_2$ catalyzed addition between carboxylic acids and ynamides (**Figure 2**, a).[13] A catalyst-free addition was later established by Bi and co-workers (**Figure 2**, b).[14] Gillaizeau achieved 3-amino isocoumarin derivatives through acid-catalyzed intramolecular hydroacyloxylation of ynamide by *tert*-butyl carboxylate (**Figure 2**, c).[20] In addition, Zhao applied α-acyloxy enamide

intermediates, in situ generated from ynamides and carboxylic acids, in the synthesis of amides and peptides without causing any racemization.[21]

Enol carbamates have been recognized as integral structural motifs of pharmaceuticals and agrochemicals[22] and have also served as versatile synthons in organic transformations.[23] Very recently, we found that the carbonyl oxygen atom of Boc group could attack ynamide-derived intermediates upon the cleavage of *t*-butyl-O bond under Lewis acid conditions.[24] The driving force of this novel transformation intrigued us to investigate the potential of such nucleophilic addition directly onto the triple bond of ynamides. Herein we present an efficient approach for the synthesis of amide enol carbamates and carbonates from ynamides through $Cu(OTf)_2$-catalyzed hydroacyloxylation with *t*-butyl carbamates/carbonates (**Figure 2**, d).

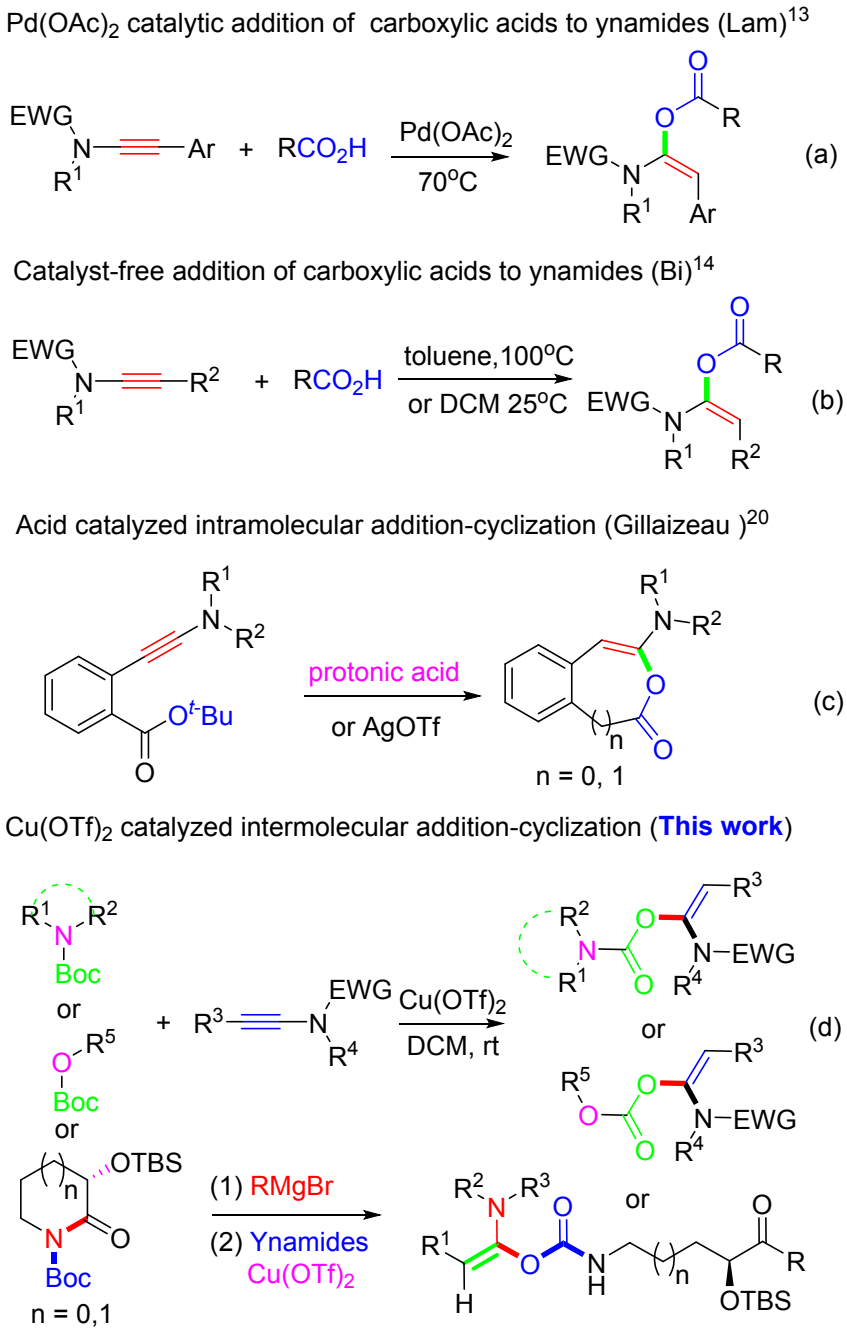


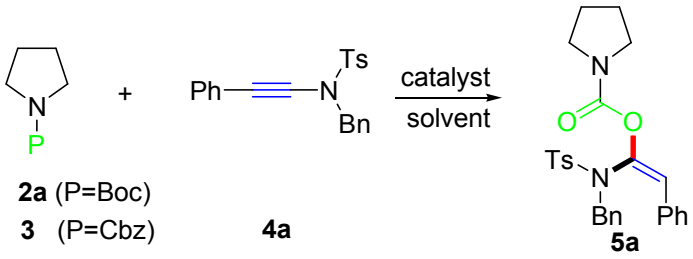
Figure 2. Hydroacyloxylation of ynamides.

Results and discussions

Our investigation commenced with the reaction of ynamide **4a** with carbamate **2a** under Brønsted acid or Lewis acid-promoted conditions. Obviously, the addition reaction did not take place in the absence of catalyst (Table 1, entry 1). The subsequent trials with Brønsted acid TFA and TfOH also turned out to be fruitless (Table 1, entries 2-3). When catalytic amount of $BF_3{\cdot}Et_2O$ was examined, ynamide **4a**

was almost recovered (Table 1, entry 4). However, stoichiometric $BF_3{\cdot}Et_2O$ could lead to the desired product **5a** in 34% yield (Table 1, entry 5). Lewis acid LiCl and $ZnCl_2$ proved to be effectiveless, likely due to their poor solubility in DCM (Table 1, entries 6-7). Then we moved to screen different triflate salts owing to their stronger acidity and better solubility in DCM. As shown in Table 1, all the examined trifluoromethanesulfonates could catalyze this addition reaction (Table 1, entries 8-13), and $Cu(OTf)_2$ afforded **5a** in the highest yield of 84% (Table 1, entry 13). Different solvents were also examined for the $Cu(OTf)_2$ catalyzed process (entries 14-16). Both DCE and toluene led to significant drop in yield for the formation of **5a**, and THF failed to deliver the desired product. It is worth mentioning that benzylcarbamate **3** was not suitable for this transformation (Table 1, entry 17). Ynamide **4a** was almost completely recovered when copper salts $Cu(OAc)_2$, $CuBr_2$, CuCl, CuBr or CuI was used as catalyst (Table 1, entry 18). Moreover, the reaction on a gram scale (5 mmol of **2a**) was also performed to obtain the addition product **5a** with 83% yield (Table 1, entry 19).

Table 1. Optimization of reaction conditions.



2a (P=Boc)
3 (P=Cbz) **4a** **5a**

Entry[a]	Catalyst	Solvent	T(°C)	Y (%)[f]
1	--	DCM	rt	NR
2	TFA	DCM	rt	NR
3	TfOH	DCM	rt	NR
4	$BF_3{\cdot}Et_2O$	DCM	-78~rt	trace
5[b]	$BF_3{\cdot}Et_2O$	DCM	-78~rt	34
6	$ZnCl_2$	DCM	rt	NR
7	LiCl	DCM	rt	NR

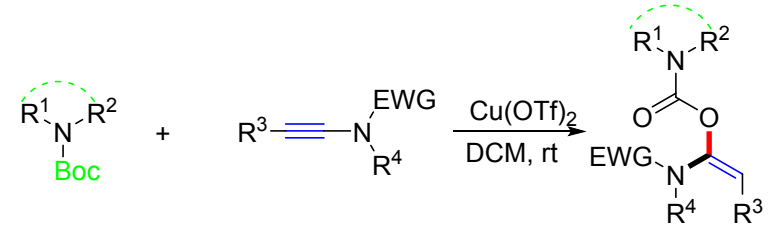
8	$Zn(OTf)_2$	DCM	rt	34
9	AgOTf	DCM	rt	62
10	$AgNTf_2$	DCM	rt	75
11	$Ce(OTf)_3$	DCM	rt	71
12	$Ni(OTf)_2$	DCM	rt	70
13	$Cu(OTf)_2$	DCM	rt	84
14	$Cu(OTf)_2$	DCE	rt	45
15	$Cu(OTf)_2$	PhMe	rt	58
16	$Cu(OTf)_2$	THF	rt	NR
17[c]	$Cu(OTf)_2$	DCM	rt	trace
18[d]	CuX	DCM	rt	NR
19[e]	$Cu(OTf)_2$	DCM	rt	83

[a] The reactions were performed with **2a** (0.5 mmol), **4a** (0.5 mmol) and catalyst (0.05 mmol) in dry solvent (2 mL) at assigned reaction temperature for 15 min-1 h. [b] 1 mmol $BF_3{\cdot}Et_2O$ was used; [c] The protecting group of pyrrolidine was Cbz; [d] CuX = $Cu(OAc)_2$, $CuBr_2$, CuCl, CuBr or CuI. [e] The reactions were performed with **2a** (5 mmol), **4a** (5 mmol) and $Cu(OTf)_2$ (0.5 mmol) in dry DCM (20 mL) at rt for 30 min. [f] Isolated yield. NR = No reaction.

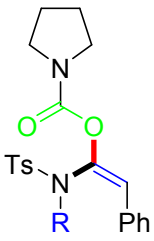
Next, we turned to investigate the scope and limitation of ynamides **4** with carbamates **2** for this novel $Cu(OTf)_2$-catalyzed transformation . As shown in Scheme 1, various *N*-Ts ynamides with benzyl, aryl, alkyl and allyl substituents could afford the desired products in moderate to good yields (**5a-5m**). *N*-Ms ynamides also worked well to give the desired products **5n-5p** in moderate yields. The low yield for **5k** was probably caused by the steric hindrance of *o*-methoxy group (38%). It is worth mentioning that aliphatic alkyl substituted ynamides could also produce the desired **5l-5o** in moderate yields. As for the carbamate substrates **2**, both α-substituent (**2b**) and β-substituent (**2c**) at *N*-Boc pyrrolidine were tolerated, providing the corresponding products **5r** and **5s** in 60% and 61% yields, respectively. Other *N*-Boc substrates were also tested. Piperidine and morpholine derivatives **2d** and **2e**

successfully produced the desired **5t** and **5u** in 85% and 65% yields, respectively. Seven-membered hexamethyleneimine derived substrate **2f**, as well as bicyclic carbamates **2g** and **2h**, also smoothly generated the desired products **5v-5x** in moderate yields. Notably, non-cyclic secondary amine-derived carbamates were also suitable for this transformation (42-82% yield), except for the reaction with very hindered *N*-Boc diisopropylamide (**5a´**).

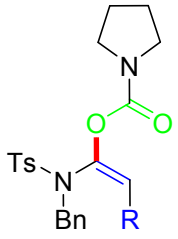
Scheme 1. The reactions of ynamides with *t*-butyl carbamates[a,b]



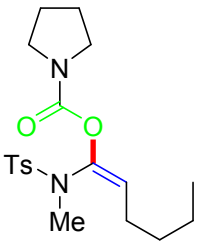
2a-2m **4** **5**



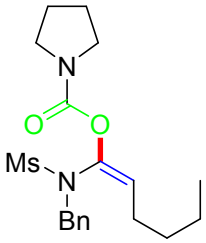
5a R=Bn, 84%
5b R=Ph, 80%
5c R=Me, 90%
5d R=*n*-C_4H_9-, 80%
5e R=Allyl-, 82%



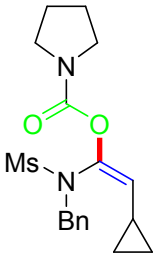
5f R=4-$MeOC_6H_4$-, 69%
5g R=4-MeC_6H_4-, 73%
5h R=4-FC_6H_4-,80%
5i R=4-BrC_6H_4-,85%
5j R=4-ClC_6H_4-,78%
5k R=2-$MeOC_6H_4$-, 38%
5l R=*n*-C_4H_9-,62%



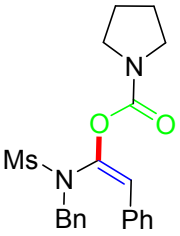
5m 77%



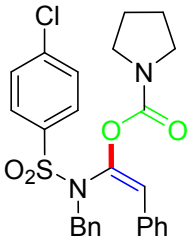
5n 74%



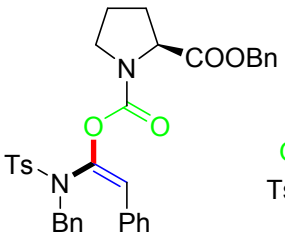
5o 77%



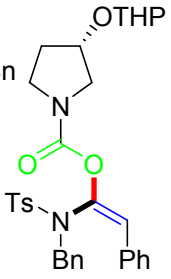
5p 85%



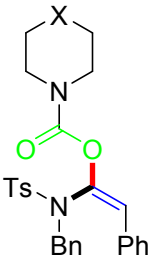
5q 74%



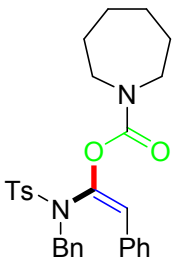
5r 60%



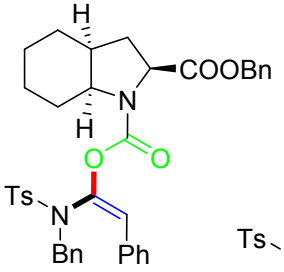
5s 61%



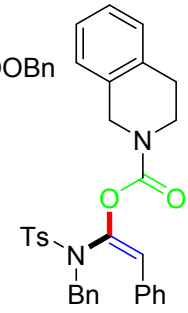
5t X = CH_2, 85%
5u X = O, 65%



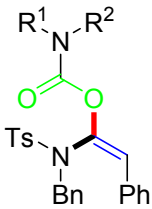
5v 76%



5w 77%



5x 70%

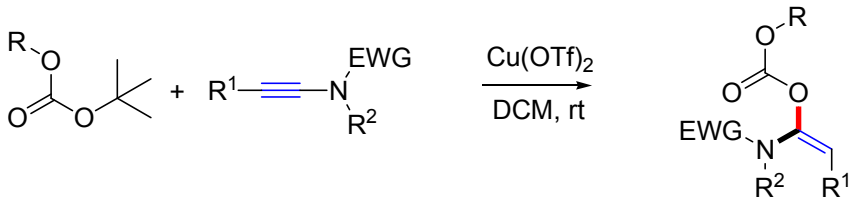


5y $R^1 = R^2$ = Ethyl-, 82%
5z $R^1 = R^2$ = *n*-Propyl-, 81%
5a' $R^1 = R^2$ = *i*-Propyl-, 0%
5b' R^1 = Bn, R^2 = Me, 74%
5c' $R^1 = R^2$ = Bn, 42%

[a]The reactions were performed with *t*-butyl carbamates **2** (0.5 mmol), ynamides **4** (0.5 mmol) and $Cu(OTf)_2$ (0.05 mmol) in dry DCM (2 mL) at rt for 15 min-1 h. [b] Isolated yield.

Amide enol allyl carbonates, an important synthetic intermediates which have been prepared by Stoltz and his collaborators through two complicated process in 2017.[15b] Based on our above results, we continued to investigate the potential use of *t*-butyl carbonates in this $Cu(OTf)_2$-catalyzed process, and the results are summarized in **Scheme 2**. The allylic carbonates **6a-c** could react with different ynamides, producing the desired products **7a-7g** in moderate yields. Furthermore, the propargyl carbonate **6d** could afford the desired amide enol carbonate **7h** in 61% yield.

Scheme 2. The reactions of ynamides with *t*-butyl carbonates[a,b]



7a R = Bn, 82%
7b R = Me, 58%
7c R = Allyl-, 77%
7d R = *n*-C_4H_9-, 35%

7e 79%

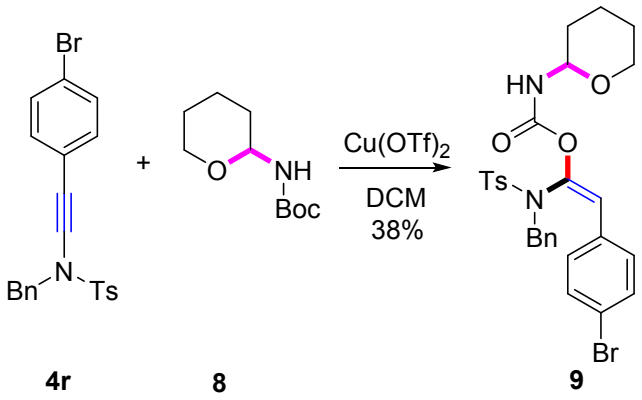
7f R = 1-methylallyl-, 54%
7g R = 3-phenylallyl-, 71%
7h R = propynyl-, 61%

[a] The reactions were performed with *t*-butyl carbonates **6** (0.5 mmol), ynamide **4** (0.5 mmol) and $Cu(OTf)_2$ (0.05 mmol) in dry DCM (2 mL) at rt for 15 min-1 h. [b] Isolated yield.

This transformation could be extended to *N,O*-acetals. Compound **8**, an unstable carbamate intermediate prepared according to our previous process,[25] successfully reacted with ynamide **4r** without destroying the *N,O*-acetal skeleton (**Scheme 3**), and structure of the desired amide enol carbamate **9** was unambiguously confirmed by

X-ray crystallographic analysis (see Supporting Information).

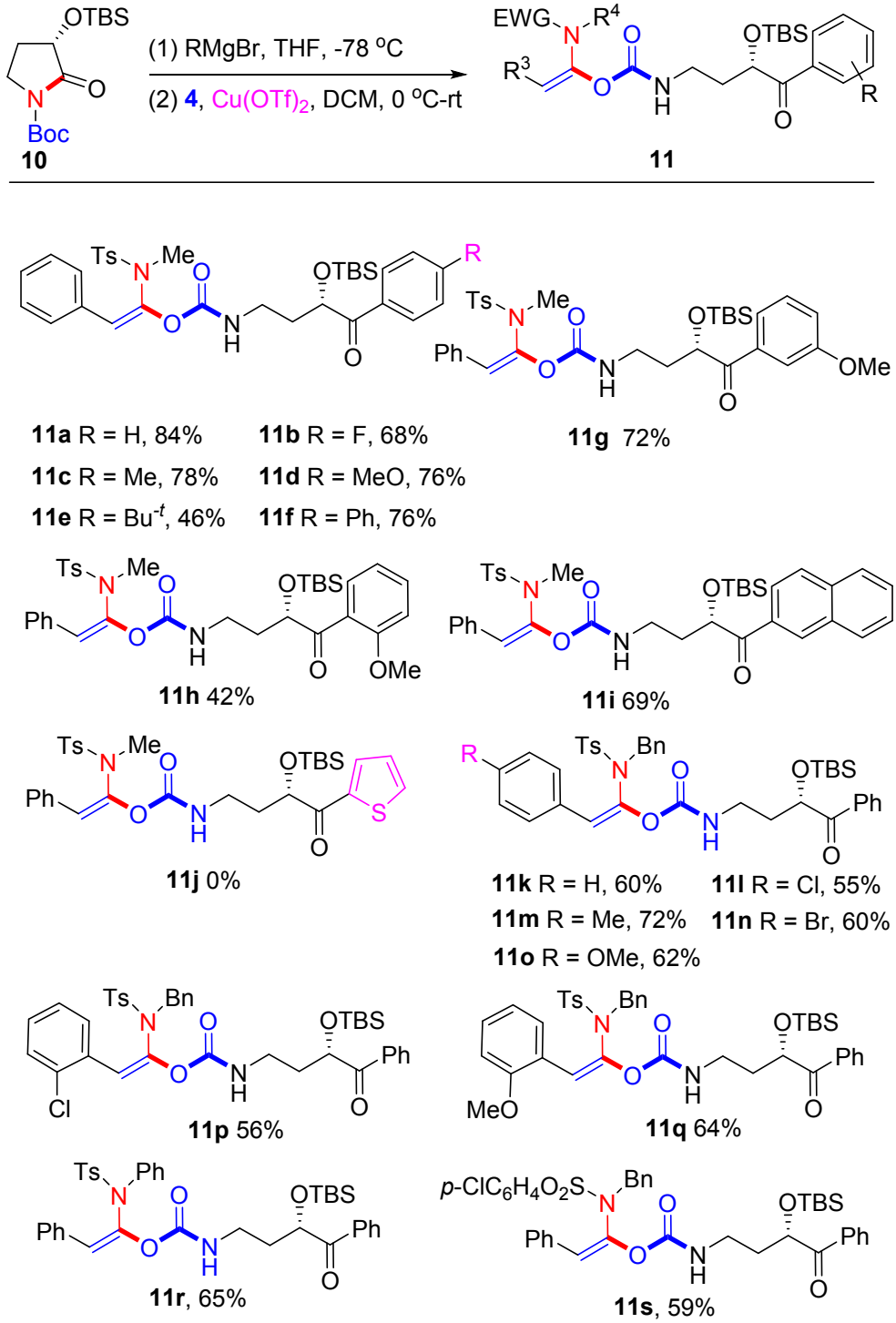
Scheme 3. The reaction of *N,O*-acetal 8 with ynamide 4r.



4r **8** **9**

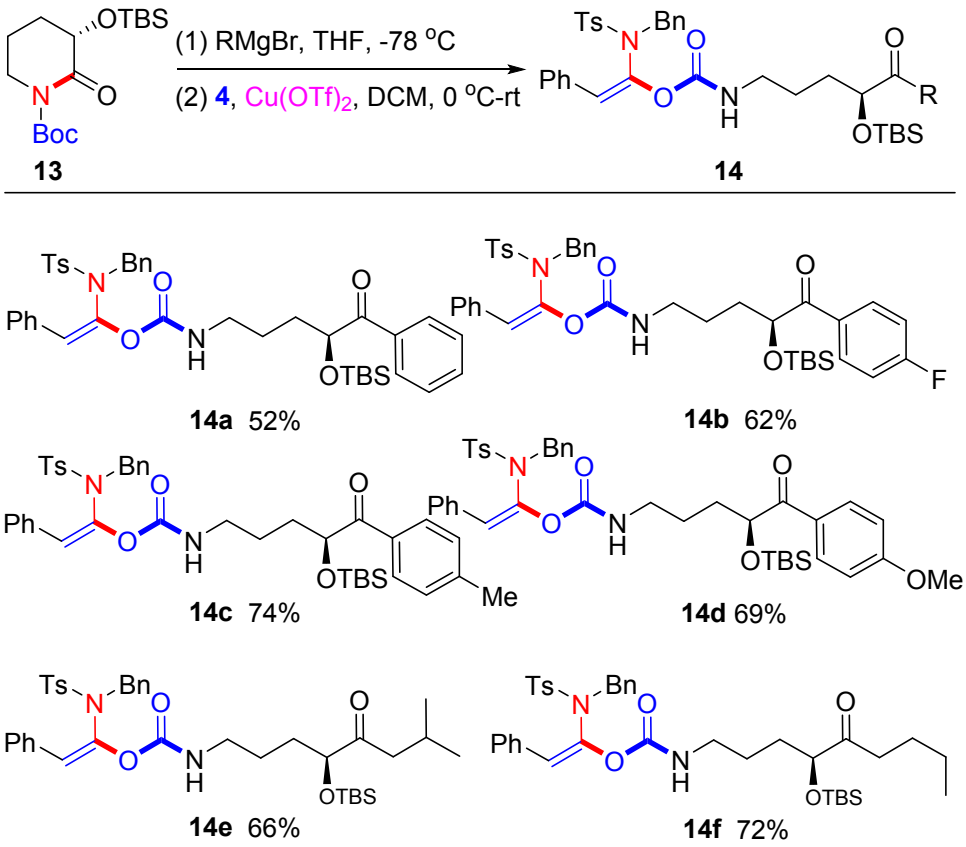
Furthermore, we extended the method to imide substrates (**10** and **13**) to afford the corresponding amide enol carbamates via two steps. The intermediates from addition of Grignard reagent to imide reacted with ynamides were catalyzed by $Cu(OTf)_2$ to obtain amide enol carbamates (**Schemes 4 and 5**). Various addition products of pyrrolidine imide **10** with different Grignard reagent were surveyed under the optimal conditions. All proceeded smoothly to give the desired products in moderate yields (**11a-11s**), with their structures unambiguously determined by X-ray crystallographic analysis of the desilylation product **12** from compound **11a** (see Supporting Information). As for the piperidine imide **13** which reacted with Grignard reagent to give intermediates bearing either an aryl (**13a-d**) or aliphatic (**13e-f**) substituent could also lead to the desired keto products **14a-f** in moderated yields.

Scheme 4. The reactions of pyrrolidine imide with ynamides[a, b].



[a]Reaction conditions: (1) **10** (1.0 mmol) and RMgBr (2.0 mmol) in dry THF (10 mL) at -78 °C for 1.5 h; (2) The crude product, ynamide **4** (0.5 mmol) and $Cu(OTf)_2$ (0.05 mmol) in dry DCM (2 mL) at 0 °C - rt for 15 min-1 h. [b] Isolated yield.

Scheme 5. The reactions of piperidine imide with ynamides[a, b].



[a]Reaction conditions: (1) **13** (1.0 mmol) and RMgBr (2.0 mmol) in dry THF (10 mL) at -78 °C for 1.5 h; (2) The crude product, ynamide **4** (0.5 mmol) and $Cu(OTf)_2$ (0.05 mmol) in dry DCM (2 mL) at 0 °C - rt for 15 min-1 h. [b] Isolated yield.

On the basis of our obtained experimental results and the precedent ynamide chemistrys,[24,26] a possible mechanism for this $Cu(OTf)_2$-catalyzed transformation was illustrated in **Figure 3**. First, the triple bond in ynamide **4** was activated by copper (II) triflate. The resulting vinyl Cu(II) intermediate **int-1** was subsequently attacked by carbamates/carbonates through the cleavage of *t*-butyl group to give **int-2**, which was finally hydrolyzed to generate the desired amide enol carbamates/carbonates.

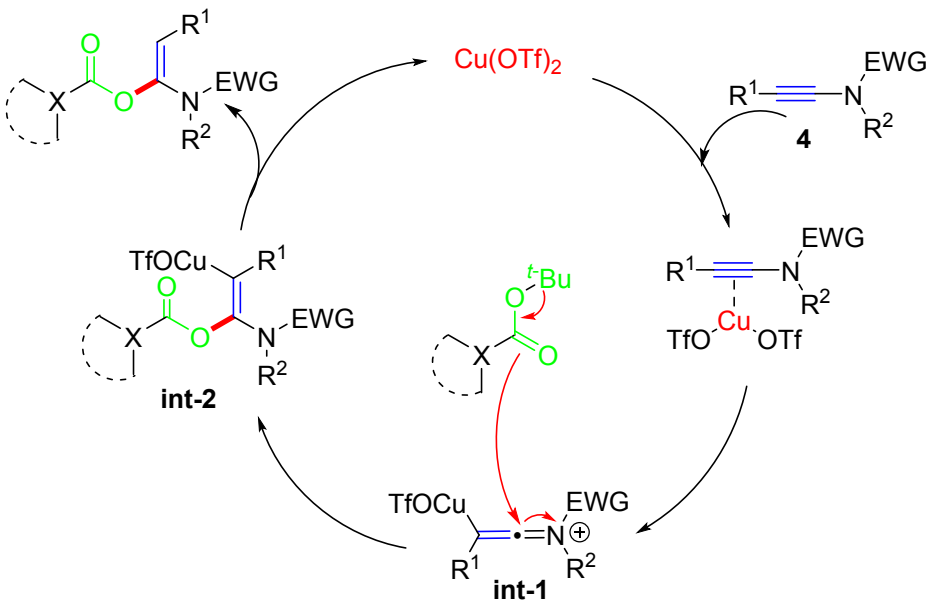


Figure 3. The proposed reaction mechanism

Conclusion

In summary, we established a highly regioselective approach for the synthesis of amide enol carbamates **5**. The reaction went through a $Cu(OTf)_2$-catalyzed process from ynamides **4** and t-butyl carbamates **2**. Moreover, *t*-butyl carbonates **6a-d** could also react with ynamides **4** to give amide enol carbonates **7a-7h** under mild reaction conditions. It is worth mentioning that amide enol carbamates **11a-11s** and **14a-14f** were successfully synthesized through this $Cu(OTf)_2$-catalyzed strategy from *N*,O-acetals **10** and 1**3**.

Experimental Section

I General Methods

THF was distilled from sodium/benzophenone, and DCM was distilled from phosphorus pentoxide. Reactions were monitored by TLC-FID. Flash chromatography was performed on silica gel (300−400 mesh) with petroleum/EtOAc as the eluent. HRMS was conducted on a Thermo Scientific LTQ Orbitrap XL apparatus. IR spectra were measured using a film on a Fourier transform infrared spectrometer. NMR spectra were recorded at 400 MHz, and chemical shifts are reported in δ (ppm)

referenced to an internal TMS standard for ^{1}H NMR and $CDCl_3$ (77.16 ppm) for $^{13}C\{^{1}H\}$ NMR. The heat source was an oil bath.

II Experimental

General Procedure for Synthesis of *N*-Boc amides 2.[27]

To a solution of DMAP (0.25 mmol), amine (5 mmol) in DCM (10 mL) was slowly added Boc_2O (5.5 mmol) at rt. After stirring for 1 h, the mixture was concentrated in vacuo and the resides was purified by flash chromatography to give pure *N*-Boc amides.

General Procedure for Synthesis of *O*-Boc esters 6.[28]

To a solution of DMAP (0.25 mmol), alcohol (10 mmol) in DCM (10 mL) was slowly added Boc_2O (5 mmol) at rt. After stirring for 1 h, the mixture was concentrated in vacuo and the residue was purified by flash chromatography to give pure *O*-Boc esters.

General Procedure for Synthesis of ynamide 4. [29]

To a mixture of an amide (2 mmol), K_3PO_4 (4 mmol), $CuSO_4 \bullet 5H_2O$ (0.2mmol,) and 1,10-phenanthroline (0.4 mmol,) in toluene at N_2 atmosphere was added a solution 1-bromoalkyne (2.2 mmol) in toluene. The reaction was stirred at 75 ^{o}C for 24 h at N_2 atmosphere. The reaction mixture was cooled to room temperature and diluted with EtOAc and filtered through Celite and the filtrate was concentrated in vacuo. The crude products were purified by silica gel flash chromatography to afford the desired ynamide.

General Procedure for Synthesis of 5, 7 and 9.

To a solution of *N*-Boc amides **2** or *O*-Boc esters **6** (0.5 mmol) and ynamides **4** (0.5 mmol) in dry DCM (2 mL) was added $Cu(OTf)_2$ (18 mg, 0.05 mmol) at rt. After stirring for 15 min to 1 h, the reaction mixture was quenched with aqueous $NaHCO_3$. Extracted with DCM (10 ml × 3), and the combined organic layers were washed with brine. Dried, filtered, and concentrated, the residue was purified by flash

chromatography on silica gel.

Procedure for synthesis of 5a (5 mmol scale)

To a solution of *N*-Boc amide **2a** (856 mg, 5 mmol) and ynamide **4a** (1.81 g, 5 mmol) in dry DCM (20 mL) was added $Cu(OTf)_2$ (180 mg, 0.5 mmol) at rt. After stirring for 30 min, the reaction mixture was quenched with aqueous $NaHCO_3$. Extracted with DCM (30 mL × 3), and the combined organic layers were washed with brine. Dried, filtered, and concentrated, the residue was purified by flash chromatography on silica gel (PE/EtOAc = 4/1) to give colorless oil **5a** (1.98 g, 83%).

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5a).** Colorless oil (200 mg, 84%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); IR (film): ν_{max} 3062, 3029, 2974, 2877, 1727, 1404, 1355, 1164, 1065, 816, 710, 658 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.31-7.21 (m, 6H), 7.15-7.09 (m, 6H), 6.34 (s, 1H), 4.47 (s, 2H), 3.36 (t, J = 6.0 Hz, 2H), 2.98 (t, J = 6.8 Hz, 2H), 2.41 (s, 3H), 1.86-1.77 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.1, 143.7, 137.3, 137.1, 134.9, 132.5, 129.9, 129.4, 128.7, 128.2, 128.1, 128.0, 127.9, 127.7, 122.5, 52.7, 46.5, 46.0, 25.7, 24.9, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{29}N_2O_4S$, 477.1843; found, 477.1847.

(*E*)-1-((4-methyl-N-phenylphenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5b).** Pale yellow solid (185 mg, 80%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 118-120 °C; IR (film): ν_{max} 3061, 2976, 2878, 1731, 1403, 1360, 1167, 1111, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.60-7.54 (m, 4H), 7.32-7.26 (m, 4H), 7.25-7.18 (m, 5H), 7.17 (s, 1H), 6.48 (s, 1H), 3.42 (t, J = 6.8 Hz, 2H), 3.13 (t, J = 6.8 Hz, 2H), 2.39 (s, 3H), 1.89-1.82 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 151.5, 143.9, 139.5, 139.2, 137.1, 132.7, 129.2, 129.0, 128.9, 128.3, 128.2, 127.9, 127.6, 126.8, 120.6, 46.6, 46.2, 25.8, 25.0, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{26}H_{27}N_2O_4S$, 463.1686; found, 463.1690.

(*E*)-1-((N,4-dimethylphenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5c).** White solid (180 mg, 90%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 97-99 °C; IR (film): ν_{max} 3057, 2975, 2878, 1724, 1408, 1354, 1158, 1067, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.4 Hz, 2H), 7.51 (d, J = 7.2 Hz, 2H), 7.36-7.31 (m, 2H), 7.29-7.25 (m,

3H), 6.20 (s, 1H), 3.20-3.15 (m, 4H), 3.10 (s, 3H), 2.42 (s, 3H), 1.84-1.78 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.3, 143.6, 140.4, 136.9, 132.4, 129.4, 128.6, 128.5, 128.0, 127.6, 118.1, 46.3, 46.2, 36.9, 25.7, 24.9, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{21}H_{25}N_2O_4S$, 401.1530; found, 401.1533.

(*E*)-1-((N-butyl-4-methylphenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5d).** Foam solid (177 mg, 80%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); IR (film): ν_{max} 3056, 2958, 2874, 1728, 1405, 1355, 1166, 1065, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, J = 8.4 Hz, 2H), 7.63 (d, J = 7.6 Hz, 2H), 7.34-7.24 (m, 5H), 6.44 (s, 1H), 3.34 (t, J = 6.8 Hz, 2H), 3.27 (t, J = 7.6 Hz, 2H), 2.94 (t, J = 6.4 Hz, 2H), 2.41 (s, 3H), 1.86-1.76 (m, 4H), 1.60-1.52 (m, 2H), 1.25-1.15 (m, 2H), 0.77 (t, J = 7.2 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.1, 143.6, 137.4, 136.9, 132.8, 129.4, 129.1, 128.3, 128.2, 128.0, 122.5, 48.8, 46.5, 45.9, 30.0, 25.7, 24.9, 21.6, 20.2, 13.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{24}H_{31}N_2O_4S$, 443.1999; found, 443.2001.

(*E*)-1-((N-allyl-4-methylphenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5e).** White solid (175 mg, 82%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 102-103 ^oC; IR (film): ν_{max} 3057, 3025, 2976, 2877, 1728, 1404, 1356, 1165, 1065, 663 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, J = 8.4 Hz, 2H), 7.54 (d, J = 7.2 Hz, 2H), 7.32-7.22 (m, 5H), 6.40 (s, 1H), 5.86-5.75 (m, 1H), 5.16-5.10 (m, 1H), 5.05-5.01 (m, 1H), 3.99 (d, J = 6.8 Hz, 2H), 3.32 (t, J = 6.8 Hz, 2H), 3.02 (t, J = 6.8 Hz, 2H), 2.41 (s, 3H), 1.84-1.78 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 151.9, 143.7, 138.0, 137.1, 132.8, 132.4, 129.4, 128.9, 128.4, 128.2, 128.0, 121.2, 119.4, 52.6, 46.4, 46.0, 25.7, 24.9, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{23}H_{27}N_2O_4S$, 427.1686; found, 427.1692.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(4-methoxyphenyl)vinyl pyrrolidine-1-carboxylate **(5f).** Foam solid (175 mg, 69%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); IR (film): ν_{max} 33032, 2955, 2878, 2837, 1725, 1607, 1161, 737 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, J = 7.2 Hz, 2H), 7.48 (d, J = 8.0 Hz, 2H), 7.35-7.26 (m, 5H), 7.08 (d, J = 8.0 Hz, 2H), 6.76 (d, J = 8.0 Hz, 2H), 5.52 (s, 1H), 4.82 (s, 2H), 3.75 (s, 3H), 3.26-3.20 (m, 4H), 2.43 (s, 3H), 1.87-1.79 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 159.3, 151.3, 143.4, 137.8, 137.1, 136.7, 129.9, 129.6, 129.4, 128.4, 127.8, 127.7, 125.8, 120.6, 113.8, 55.3, 53.9, 46.4, 46.3, 25.8, 24.9, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$

calcd for $C_{28}H_{31}N_2O_5S$, 507.1948; found, 507.1952.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(p-tolyl)vinyl pyrrolidine-1-carboxylate **(5g).** White solid (179 mg, 73%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 127-129 °C; IR (film): ν_{max} 3060, 2978, 2920, 2880, 1724, 1407, 1354, 1164, 1069, 736 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 7.2 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 7.17-7.10 (m, 5H), 6.93 (d, J = 8.0 H, 2H), 6.30 (s, 1H), 4.47 (s, 2H), 3.34 (t, J = 6.4 Hz, 2H), 2.98 (t, J = 6.4 Hz, 2H), 2.41 (s, 3H), 2.27 (s, 3H), 1.86-1.75 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.2, 143.7, 137.6, 137.3, 136.8, 135.1, 129.9, 129.6, 129.4, 128.8, 128.6, 128.2, 128.1, 127.9, 122.5, 52.7, 46.5, 46.0, 25.7, 24.9, 21.6, 21.3 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{28}H_{31}N_2O_4S$, 491.1999; found, 491.2006.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(4-fluorophenyl)vinyl pyrrolidine-1-carboxylate **(5h).** White solid (198 mg, 80%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 160-162 °C; IR (film): ν_{max} 3033, 2975, 2878, 1726, 1405, 1352, 1163, 1068, 658 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, J = 7.6 Hz, 2H), 7.31-7.25 (m, 4H), 7.22-7.17 (m, 2H), 7.16-7.10 (m, 3H), 6.78 (t, J = 8.4 Hz, 2H), 6.30 (s, 1H), 4.45 (s, 2H), 3.35 (t, J = 6.0 Hz, 2H), 2.96 (t, J = 6.4 Hz, 2H), 2.42 (s, 3H), 1.86-1.77 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 162.3 (d, J = 245.8 Hz, 1C), 152.0, 143.9, 137.0, 136.9, 134.8, 130.4, 130.3, 129.9, 129.5, 128.6, 128.5, 128.2, 128.1, 121.9, 115.0, 114.8, 52.5, 46.5, 46.0, 25.7, 24.9, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{28}FN_2O_4S$, 495.1748; found, 495.1757.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(4-bromophenyl)vinyl pyrrolidine-1-carboxylate **(5i).** White solid (236 mg, 85%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 148-149 °C; IR (film): ν_{max} 3032, 2974, 2878, 1728, 1404, 1355, 1164, 1071, 660 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, J = 7.6 Hz, 2H), 7.30-7.24 (m, 4H), 7.23-7.18 (m, 2H), 7.18-7.11 (m, 3H), 7.05 (d, J = 8.0 Hz, 2H), 6.28 (s, 1H), 4.46 (s, 2H), 3.36 (t, J = 6.4 Hz, 2H), 2.98 (t, J = 6.8 Hz, 2H), 2.43 (s, 3H), 1.87-1.78 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 151.9, 143.9, 137.7, 137.0, 134.7, 131.6, 131.1, 130.2, 130.0, 129.5, 128.3, 128.2, 128.1, 121.7, 52.5, 46.5, 46.0, 25.7, 24.9, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{28}BrN_2O_4S$, 555.0948; found, 555.0955.

(*E*)-1-(N-benzylmethylsulfonamido)-2-(4-chlorophenyl)vinyl

pyrrolidine-1-carboxylate **(5j).** White solid (170 mg, 78%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 126-127 °C; IR (film): ν_{max} 3064, 3032, 2976, 2879, 1726, 1405, 1348, 1157, 1067, 732, 708 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41-7.37 (m, 2H), 7.23-7.19 (m, 5H), 7.16-7.11 (m, 2H), 6.33 (s, 1H), 4.52 (s, 2H), 3.49 (t, J = 6.8 Hz, 2H), 3.39 (t, J = 6.8 Hz, 2H), 2.90 (s, 3H), 1.96-1.91 (m, 4H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.1, 138.7, 134.8, 133.7, 131.0, 130.1, 129.8, 128.5, 128.4, 128.3, 120.3, 53.0, 46.8, 46.5, 41.1, 25.8, 25.0 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + H]$^+$ calcd for $C_{21}H_{24}ClN_2O_4S$, 435.1140; found, 435.1147.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(2-methoxyphenyl)vinyl pyrrolidine-1-carboxylate **(5k).** Foam solid (96 mg, 38%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); IR (film): ν_{max} 3064, 2953, 2878, 1726, 1405, 1352, 1163, 1068, 658 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 8.4 Hz, 2H), 7.44 (dd, J = 7.6, 1.2 Hz, 1H), 7.27-7.24 (m, 2H), 7.22 (d, J = 8.0 Hz, 2H), 7.15-7.06 (m, 4H), 6.72 (t, J = 7.6 Hz, 1H), 6.64 (d, J = 7.6 Hz, 1H), 6.57 (s, 1H), 4.47 (s, 2H), 3.66 (s, 3H), 3.34 (t, J = 6.8 Hz, 2H), 3.03 (t, J = 6.8 Hz, 2H), 2.40 (s, 3H), 1.85-1.78 (m, 4H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 156.8, 152.2, 143.5, 137.5, 137.4, 135.1, 129.9, 129.3, 129.1, 129.0, 128.1, 128.0, 127.7, 121.6, 120.3, 116.9, 110.2, 55.5, 53.0, 46.4, 46.0, 25.7, 25.0, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + H]$^+$ calcd for $C_{28}H_{31}N_2O_5S$, 507.1948; found, 507.1952.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)hex-1-en-1-yl pyrrolidine-1-carboxylate **(5l).** This compound was obtained in 92% purity as judged by NMR analysis. White solid (142 mg, 62%), purified by column chromatography on silica gel (PE/EtOAc = 5/1); mp 83-84 °C; IR (film): ν_{max} 3031, 2955, 2928, 2873, 1727, 1404, 1353, 1164, 1085, 659 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.4 Hz, 2H), 7.46-7.41 (m, 2H), 7.32-7.26 (m, 5H), 5.38 (t, J = 7.6 Hz, 1H), 4.42 (s, 2H), 3.31 (t, J = 6.4 Hz, 2H), 2.92 (t, J = 6.4 Hz, 2H), 2.42 (s, 3H), 1.82-1.73 (m, 6H), 1.06-0.98 (m, 2H), 0.94-0.84 (m, 2H), 0.72 (t, J = 6.8 Hz, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.4, 143.5, 137.6, 136.0, 135.8, 129.9, 129.5, 128.4, 128.0, 127.9, 125.3, 51.7, 46.4, 45.9, 30.9, 27.0, 25.7, 24.9, 22.4, 21.6, 13.9 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + H]$^+$ calcd for $C_{25}H_{33}N_2O_4S$, 457.2156; found, 457.2164.

(*E*)-1-((N,4-dimethylphenyl)sulfonamido)hex-1-en-1-yl pyrrolidine-1-carboxylate **(5m).** This compound was obtained in 89% purity as judged by NMR analysis. Colorless oil (146 mg, 77%); purified by column chromatography

on silica gel (PE/EtOAc = 5/1); IR (film): ν_{max} 2955, 2930, 2874, 1725, 1407, 1354, 1167, 1085, 711, 695 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.4 Hz, 2H), 7.29 (d, J = 8.0 Hz, 2H), 5.31 (t, J = 7.6 Hz, 1H), 3.29-3.24 (m, 2H), 3.06 (s, 3H), 3.06-3.03 (m, 2H), 2.42 (s, 3H), 2.11-2.04 (m, 2H), 1.82-1.77 (m, 4H), 1.38-1.26 (m, 4H), 0.88 (t, J = 6.8 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.8, 143.5, 139.6, 136.5, 129.4, 127.8, 121.4, 46.3, 46.0, 36.9, 31.1, 26.4, 25.7, 24.9, 22.4, 21.6, 14.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{19}H_{29}N_2O_4S$, 381.1843; found, 381.1849.

(*E*)-1-(N-benzylmethylsulfonamido)hex-1-en-1-yl pyrrolidine-1-carboxylate **(5n).** White solid (141mg, 74%), purified by column chromatography on silica gel (PE/EtOAc = 5/1); mp 62-64 °C; IR (film): ν_{max} 3035, 2955, 2930, 2873, 1714, 1642, 1342, 1083, 755 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.50-7.46 (m, 2H), 7.35-7.28 (m, 3H), 5.38 (t, J = 7.6 Hz, 1H), 4.50 (s, 2H), 3.45 (t, J = 6.4 Hz, 2H), 3.39 (t, J = 6.8 Hz, 2H), 3.00 (s, 3H), 1.97-1.89 (m, 4H), 1.84-1.77 (m, 2H), 1.10-1.02 (m, 2H), 1.00-0.91 (m, 2H), 0.74 (t, J = 7.2 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.9, 136.5, 135.9, 129.9, 128.5, 128.1, 124.9, 51.8, 46.7, 46.4, 40.2, 30.9, 27.1, 25.9, 25.0, 22.4, 13.9 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{19}H_{29}N_2O_4S$, 381.1843; found, 381.1849.

(*E*)-1-(N-benzylmethylsulfonamido)-2-cyclopropylvinyl pyrrolidine-1-carboxylate **(5o).** White solid (140 mg, 77%), purified by column chromatography on silica gel (PE/EtOAc = 5/1); mp 71-73 °C; IR (film): ν_{max} 3064, 3006, 2976, 2878, 1722, 1408, 1343, 1155, 1075, 757, 703 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.53 (d, J = 6.8 Hz, 1.48H), 7.43 (d, J = 6.8 Hz, 0.52H), 7.35-7.27 (m, 3H), 4.84 (d, J = 10.0 Hz, 0.74H), 4.66 (s, 0.52H), 4.60 (s, 1.48H), 4.47 (d, J = 9.6 Hz, 0.26H), 3.48-3.40 (m, 2.96H), 3.38-3.33 (m, 1.04H), 3.03 (s, 2.24H), 3.02 (s, 0.76H), 1.94-1.87 (m, 4H), 1.36-1.28 (m, 0.26H), 1.26-1.17 (m, 0.74H), 0.76-0.70 (m, 0.52H), 0.55-0.48 (m, 1.48H), 0.33-0.27 (m, 0.52H), 0.27-0.21 (m, 1.48H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 152.9 (152.3), 136.3 (136.7), 136.1 (136.8), 130.0, 129.4, 128.9, 128.45, 128.40 (127.9), 128.1 (126.4), 52.2 (52.1), 46.6 (46.5), 46.4, 40.6 (40.3), 25.8 (25.9), 25.00 (25.04), 9.6 (8.7), 7.0, 6.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{18}H_{25}N_2O_4S$, 365.1530; found, 365.1533.

(*E*)-1-(N-benzylmethylsulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5p).** White solid (170 mg, 85%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 91-93 °C; IR (film): ν_{max} 2976, 2879, 1724, 1405, 1348, 1155,

1065, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.44-7.40 (m, 2H), 7.36-7.32 (m, 2H), 7.25-7.18 (m, 6H), 6.38 (s, 1H), 4.55 (s, 2H), 3.47 (t, J = 6.8 Hz, 2H), 3.36 (t, J = 6.8 Hz, 2H), 2.83 (s, 3H), 1.94-1.89 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.2, 138.7, 135.2, 132.5, 130.1, 128.6, 128.5, 128.4, 128.3, 128.0, 120.9, 53.2, 46.8, 46.4, 41.4, 25.8, 25.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{21}H_{25}N_2O_4S$, 401.1530; found, 401.1532.

(*E*)-1-((N-benzyl-4-chlorophenyl)sulfonamido)-2-phenylvinyl pyrrolidine-1-carboxylate **(5q).** White solid (184 mg, 74%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); mp 128-129 ^oC; IR (film): ν_{max} 3063, 2975, 2878, 1728, 1404, 1359, 1167, 1084, 754, 634 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.79-7.74 (m, 2H), 7.40-7.35 (m, 2H), 7.33-7.29 (m, 2H), 7.21-7.11 (m, 8H), 6.35 (s, 1H), 4.52 (s, 2H), 3.36 (t, J = 6.8 Hz, 2H), 3.00 (t, J = 6.8 Hz, 2H), 1.88-1.82 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 151.9, 139.4, 138.5, 137.1, 134.7, 132.3, 130.0, 129.6, 129.0, 128.6, 128.3, 128.2, 128.1, 127.9, 122.8, 53.1, 46.6, 46.1, 25.7, 24.9 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{26}H_{26}ClN_2O_4S$, 497.1296; found, 497.1302.

(*E*)-2-benzyl 1-(1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl) (S)-pyrrolidine-1,2-dicarboxylate **(5r).** Foam solid (183 mg, 60%); purified by column chromatography on silica gel (PE/EtOAc = 3/1); IR (film): ν_{max} 3063, 3031, 2955, 2882, 1729, 1401, 1355, 1164, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.76 (d, J = 8.4 Hz, 1H), 7.69 (d, J = 8.4 Hz, 1H), 7.35-7.31 (m, 4H), 7.29-7.24 (m, 3H), 7.24-7.18 (m, 3H), 7.15-7.10 (m, 5H), 7.10-7.07 (m, 2H), 6.35 (s, 0.56H), 6.21 (s, 0.44H), 5.23-5.12 (m, 2H), 4.50-4.39 (m, 2H), 4.38-4.34 (m, 0.56H), 3.99-3.94 (m, 0.44H), 3.66-3.60 (m, 0.44H), 3.50-3.42 (m, 0.44H), 3.19-3.13 (m, 0.56H), 3.08-3.00 (m, 0.56H), 2.40 (s, 1.69H), 2.38 (s, 1.31H), 2.22-2.12 (m, 1H), 2.08-1.96 (m, 1H), 1.92-1.80 (m, 2H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 171.9 (172.1), 152.2 (152.0), 143.76 (143.81), 137.2 (137.0), 137.1, 135.7 (135.5), 134.9 (135.0), 132.32 (132.28), 129.93 (129.89), 129.5, 128.8, 128.7, 127.68 (128.63), 128.38 (128.45), 128.25, 128.22, 128.20, 128.04 (128.02), 127.93 (127.97), 127.84 (127.78), 122.9, 67.1 (67.3), 59.5 (59.1), 52.5(52.2), 46.6 (47.2), 29.9 (30.9), 24.3 (23.3), 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{35}H_{35}N_2O_6S$, 611.2210; found, 611.2211.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl (3S)-3-((tetrahydro-2H-pyran-2-yl)oxy)pyrrolidine-1-carboxylate **(5s).** Colorless oil

(176 mg, 61%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80-7.75 (m, 2H), 7.29-7.19 (m, 6H), 7.15-7.10 (m, 6H), 6.35 (s, 1H), 4.71-4.59 (m, 1H), 4.52-4.44 (m, 2H), 4.42-4.30 (m, 1H), 3.91-3.81 (m, 1H), 3.58-3.42 (m, 3H), 3.24-3.12 (m, 1H), 3.12-3.04 (m, 1H), 2.41 (s, 3H), 2.08-1.78 (m, 3H), 1.78-1.68 (m, 1H), 1.62-1.50 (m, 4H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.2 (152.0), 143.8, 137.3, 137.1, 134.9, 132.5, 129.9, 129.8, 129.5, 128.7, 128.2, 128.19, 128.06, 128.02, 127.8, 122.7 (122.5), 98.1 (97.9), 97.6 (97.5), 75.0 (74.8), 74.1 (74.0), 63.2 (62.9), 62.8 (62.7), 52.7 (52.9), 52.5 (52.6), 51.7 (51.3), 44.8 (44.0), 44.4, 32.6 (31.9), 31.0 (30.2), 25.5 (21.7), 19.9 (19.7), 19.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{32}H_{36}N_2NaO_6S$, 599.2186; found, 599.2191.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl piperidine-1-carboxylate **(5t).** Colorless oil (208 mg, 85%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); IR (film): ν_{max} 3062, 3029, 2937, 2857, 1721, 1426, 1356, 1229, 1164, 1058, 814, 693, 659 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.4 Hz, 2H), 7.31-7.27 (m, 2H), 7.26-7.21 (m, 4H), 7.15-7.09 (m, 6H), 6.29 (s, 1H), 4.45 (s, 2H), 3.42-3.36 (m, 2H), 3.09-3.03 (m, 2H), 2.40 (s, 3H), 1.60-1.50 (m, 4H), 1.39-1.31 (m, 2H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.7, 143.7, 137.6, 137.2, 135.0, 132.4, 129.9, 129.5, 128.6, 128.2, 128.1, 128.0, 127.9, 127.8, 122.7, 52.6, 45.3, 25.9, 25.6, 24.3, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{28}H_{31}N_2O_4S$, 491.1999; found, 491.1997.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl morpholine-4-carboxylate **(5u).** Foam solid (160 mg, 65%); purified by column chromatography on silica gel (PE/EtOAc = 3/1); IR (film): ν_{max} 3062, 3030, 2964, 2922, 2859, 1725, 1423, 1356, 1234, 1164, 1115, 1065, 849, 816, 693, 659 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 8.0 Hz, 2H), 7.29-7.24 (m, 2H), 7.24-7.21 (m, 2H), 7.20-7.11 (m, 8H), 6.32 (s, 1H), 4.48 (s, 2H), 3.69-3.61 (m, 2H), 3.51-3.46 (m, 2H), 3.46-3.41 (m, 2H), 3.11-3.05 (m, 2H), 2.41 (s, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.7, 143.9, 137.4, 137.2, 135.1, 132.1, 129.8, 129.5, 128.6, 128.2, 128.1, 127.9, 122.8, 66.6, 66.4, 52.9, 44.6, 44.2, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{29}N_2O_5S$, 493.1792; found, 493.1793.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl azepane-1-carboxylate **(5v).** Colorless oil (191, 76%), purified by column chromatography on silica gel (PE/EtOAc = 4/1); IR (film): ν_{max} 3062, 3029, 2927, 2855, 1720, 1356, 1164, 1059, 731 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J =

8.4 Hz, 2H), 7.33-7.29 (m, 2H), 7.25-7.19 (m, 4H), 7.16-7.08 (m, 6H), 6.29 (s, 1H), 4.46 (s, 2H), 3.40 (t, J = 6.0 Hz, 2H), 3.09-3.04 (m, 2H), 2.40 (s, 3H), 1.73-1.67 (m, 2H), 1.57-1.51 (m, 2H), 1.51-1.45 (m, 4H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 153.7, 143.8, 137.5, 137.2, 135.1, 132.5, 129.9, 129.5, 128.6, 128.2, 128.1, 128.0, 127.7, 122.6, 52.5, 47.4, 46.9, 28.6, 28.1, 27.3, 27.1, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{29}H_{33}N_2O_4S$, 505.2156; found, 505.2165.

2-benzyl 1-((*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl) (2S,3aS,7aS)-octahydro-1H-indole-1,2-dicarboxylate **(5w).** Foam solid (255 mg, 77%); purified by column chromatography on silica gel (PE/EtOAc = 3/1); IR (film): ν_{max} 3063, 3031, 2928, 2857, 1724, 1452, 1357, 1165, 1078, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.76 (d, J = 8.0 Hz, 1.24H), 7.68 (d, J = 8.0 Hz, 0.76H), 7.36-7.28 (m, 6H), 7.28-7.24 (m, 2H), 7.21-7.14 (m, 4H), 7.14-7.10 (m, 3H), 7.08-7.02 (m, 2H), 6.31 (s, 0.62H), 6.17 (s, 0.38H), 5.26-5.14 (m, 2H), 4.50-4.39 (m, 2H), 4.36 (t, J = 9.2 Hz, 0.62H), 4.00 (t, J = 9.2 Hz, 0.38H), 3.92-3.84 (m, 0.38H), 3.45-3.37 (m, 0.62H), 2.41 (s, 1.86H), 2.38 (s, 1.14H), 2.32-2.21 (m, 1H), 2.20-2.11 (m, 1H), 2.08-1.91 (m, 1H), 1.76-1.64 (m, 2H), 1.62-1.52 (m, 2H), 1.52-1.45 (m, 1H), 1.45-1.10 (m, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 172.4 (172.6), 152.2 (151.8), 143.7, 137.2, 137.0, 135.8 (135.5), 135.1, 132.4 (132.3), 129.9, 129.6 (129.5), 128.8 (128.5), 128.7, 128.3, 128.27, 128.24, 128.19, 128.1, 128.0 (127.9), 127.8 (127.7), 122.7 (122.9), 67.0 (67.3), 59.5 (59.0), 57.8 (58.4), 52.4 (52.2), 37.2 (36.5), 31.4 (32.6), 27.8 (27.0), 25.8 (25.7), 24.0 (23.6), 21.7 (21.6), 20.3 (20.5) ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{39}H_{41}N_2O_6S$, 665.2680; found, 665.2676.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl 3,4-dihydroisoquinoline-2(1H)-carboxylate **(5x).** Foam solid (189 mg, 70%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); IR (film): ν_{max} 3062, 3028, 2926, 1724, 1356, 1164, 1108, 692 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.78-7.70 (m, 2H), 7.31-7.25 (m, 3H), 7.24-7.18 (m, 4H), 7.18-7.08 (m, 9H), 6.36 (s, 0.51H), 6.33 (s, 0.49H), 4.58 (s, 0.98H), 4.50 (s, 1.02H), 4.49 (s, 0.98H), 4.20 (s, 1.02H), 3.65 (t, J = 5.6 Hz, 1.02H), 3.31 (t, J = 6.0 Hz, 0.98H), 2.82 (t, J = 5.6 Hz, 1.02H), 2.65 (t, J = 6.0 Hz, 0.98H), 2.33 (s, 1.47H), 2.27 (s, 1.53H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 152.9, 143.8, 137.7 (137.4), 137.3 (137.2), 135.0, 134.5 (134.2), 132.6 (133.1), 132.3, 129.9, 129.5, 129.0 (128.6), 128.7, 128.2, 128.17, 128.10, 128.04, 128.00, 127.9, 126.9, 126.6 (126.7), 126.2 (126.5), 122.6

(123.0), 53.1 (52.8), 45.8 (46.0), 41.8 (42.0), 28.8 (29.0), 21.5 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{32}H_{31}N_2O_4S$, 539.1999; found, 539.2005.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl diethylcarbamate **(5y).** White solid (196 mg, 82%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); mp 79-81 °C; IR (film): ν_{max} 3062, 3029, 2975, 2933, 1722, 1420, 1164, 1116, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.75 (d, J = 7.2 Hz, 2H), 7.32-7.28 (m, 2H), 7.25-7.20 (m, 4H), 7.17-7.10 (m, 6H), 6.28 (s, 1H), 4.46 (s, 2H), 3.28 (q, J = 7.2 Hz, 2H), 2.98 (q, J = 7.2 Hz, 2H), 2.40 (s, 3H), 1.13 (t, J = 7.2 Hz, 3H), 0.94 (t, J = 7.2 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 153.3, 143.8, 137.5, 137.2, 135.1, 132.5, 129.9, 129.5, 128.6, 128.2, 128.1, 128.0, 127.8, 122.5, 52.6, 42.3, 41.6, 21.6, 14.2, 13.4 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{31}N_2O_4S$, 479.1999; found, 479.2004.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl dipropylcarbamate **(5z).** Colorless oil (205 mg, 81%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); IR (film): ν_{max} 3062, 3029, 2964, 2932, 2874, 1722, 1418, 1357, 1164, 1118, 693, 658 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 8.4 Hz, 2H), 7.32-7.28 (m, 2H), 7.23 (d, J = 8.4 Hz, 2H), 7.20-7.10 (m, 8H), 6.25 (s, 1H), 4.46 (s, 2H), 3.19 (t, J = 7.6 Hz, 2H), 2.94 (t, J = 7.6 Hz, 2H), 2.40 (s, 3H), 1.60-1.51 (m, 2H), 1.46-1.38 (m, 2H), 0.89 (t, J = 7.6 Hz, 3H), 0.82 (t, J = 7.6 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 153.8, 143.8, 137.7, 137.2, 135.2, 132.5, 129.9, 129.5, 128.6, 128.2, 128.1, 128.0, 127.7, 122.1, 52.5. 49.6, 48.9, 21.8, 21.6, 21.2, 11.3 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{29}H_{35}N_2O_4S$, 507.2312; found, 507.2319.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl benzyl(methyl)carbamate **(5b').** Foam solid (195 mg, 74%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); IR (film): ν_{max} 3062, 3029, 2924, 1724, 1356, 1164, 1107, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$, rotamers) δ 7.74 (d, J = 8.0 Hz, 1H), 7.68 (d, J = 7.2 Hz, 1H), 7.36-7.31 (m, 3H), 7.30-7.21 (m, 5H), 7.18-7.08 (m, 8H), 7.08-7.03 (m, 1H), 6.37 (s, 0.53H), 6.34 (s, 0.47H), 4.48 (s, 1H), 4.44 (s, 2H), 4.11 (s, 1H), 2.84 (s, 1.41H), 2.58 (s, 1.59H), 2.34 (s, 1.59H), 2.26 (s, 1.41H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$, rotamers) δ 154.3 (153.9), 143.8 (143.9), 138.0, 137.2 (137.4), 136.9 (137.0), 135.7, 135.0, 132.4 (132.3), 129.9 (129.8), 129.5 (129.6), 128.8, 128.7, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.3, 122.3 (123.0), 53.01 (53.04), 52.6 (52.4), 33.8 (34.6), 21.6 ppm; HRMS

(ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{31}H_{31}N_2O_4S$, 527.1999; found, 527.1995.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl dibenzylcarbamate **(5c').** White solid (127 mg, 42%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); mp 115-117 °C; IR (film): ν_{max} 3062, 3029, 2925, 1722, 1452, 1417, 1357, 1213, 1164, 1085, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, J = 8.4 Hz, 2H), 7.38-7.32 (m, 6H), 7.32-7.27 (m, 2H), 7.27-7.25 (m, 2H), 7.25-7.22 (m, 2H), 7.19-7.16 (m, 3H), 7.15-7.08 (m, 3H), 7.08-7.04 (m, 2H), 6.97 (d, J = 8.0 Hz, 2H), 6.42 (s, 1H), 4.45 (s, 2H), 4.40 (s, 2H), 4.01 (s, 2H), 2.22 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 154.3, 143.8, 137.7, 137.0, 136.8, 136.6, 134.9, 132.3, 129.9, 129.6, 128.8, 128.7, 128.5, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.6, 122.7, 52.7, 49.7, 49.1, 21.5 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{37}H_{34}N_2NaO_4S$, 625.2132; found, 625.2137.

(*E*)-allyl (1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl) carbonate **(7a).** Foam solid (190 mg, 82%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); ^1H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.4 Hz, 2H), 7.28-7.24 (m, 4H), 7.22-7.18 (m, 3H), 7.14-7.04 (m, 5H), 6.40 (s, 1H), 6.97-5.86 (m, 1H), 5.40-5.28 (m, 2H), 4.63-4.60 (m, 2H), 4.37 (s, 2H), 2.42 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.8, 144.1, 138.1, 136.5, 134.3, 131.9, 131.2, 129.6, 129.5, 128.7, 128.4, 128.3, 128.2, 128.1, 121.6, 119.4, 69.2, 52.5, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{26}H_{25}NNaO_5S$, 486.1346; found, 486.1350.

(*E*)-allyl (1-((N,4-dimethylphenyl)sulfonamido)-2-phenylvinyl) carbonate **(7b).** White solid (112 mg, 58%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); mp 76-78 °C; IR (film): ν_{max} 3061, 3027, 2947, 1762, 1357, 1243, 1206, 943, 711 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, J = 8.4 Hz, 2H), 7.50 (d, J = 8.4 Hz, 2H), 7.38-7.33 (m, 2H), 7.32-7.27 (m, 3H), 6.30 (s, 1H), 5.89-5.78 (m, 1H), 5.35-5.26 (m, 2H), 4.47-4.44 (m, 2H), 3.03 (s, 3H), 2.42 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 153.2, 144.0, 140.6, 136.1, 131.7, 131.0, 129.7, 128.8, 128.7, 128.6, 128.0, 119.4, 118.6, 69.2, 36.8, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{20}H_{21}NNaO_5S$, 410.1033; found, 410.1040.

(*E*)-allyl (1-((N-allyl-4-methylphenyl)sulfonamido)-2-phenylvinyl) carbonate **(7c).** Colorless oil (158 mg; 77%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); IR (film): ν_{max} 3065, 3026, 2984, 2924, 1763, 1356, 1232, 1163, 663 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, J = 8.4 Hz, 2H), 7.53-7.49 (m, 2H), 7.35-7.26 (m, 5H), 6.47 (s, 1H), 5.95-5.85 (m, 1H), 5.68-5.59 (m, 1H), 5.38-5.28 (m,

2H), 5.08-4.98 (m, 2H), 4.61-4.58 (m, 2H), 3.93-3.90 (m, 2H), 2.42 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.7, 144.1, 138.6, 136.6, 132.0, 131.8, 131.2, 129.6, 128.9, 128.6, 128.5, 128.4, 120.9, 119.8, 119.4, 69.2, 52.4, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{22}H_{23}NNaO_5S$, 436.1189; found, 436.1191.

(*E*)-allyl (1-((N-butyl-4-methylphenyl)sulfonamido)-2-phenylvinyl) carbonate **(7d).** Colorless oil (75 mg; 35%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); IR (film): ν_{max} 3062, 2959, 2873, 1764, 1357, 1230, 1166, 968, 758 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, J = 8.4 Hz, 2H), 7.59-7.55 (m, 2H), 7.34-7.27 (m, 5H), 6.51 (s, 1H), 5.96-5.85 (m, 1H), 5.38-5.28 (m, 2H), 4.63-4.60 (m, 2H), 3.21 (t, J = 7.6 Hz, 2H), 2.42 (s, 3H), 1.48-1.42 (m, 2H), 1.17-1.10 (m, 2H), 0.73 (t, J = 7.6 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.9, 144.0, 138.2, 136.4, 132.0, 131.2, 129.6, 129.0, 128.6, 128.4, 122.0, 119.4, 69.2, 48.9, 29.9, 21.7, 20.0, 13.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{23}H_{27}NNaO_5S$, 452.1502; found, 452.1509.

(*E*)-allyl (1-(N-benzylmethylsulfonamido)-2-phenylvinyl) carbonate **(7e).** Collorless oil (153 mg, 79%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); IR (film): ν_{max} 3063, 3029, 2935, 1763, 1352, 1232, 1157, 955, 758 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.38-7.34 (m, 2H), 7.34-7.30 (m, 2H), 7.30-7.26 (m, 2H), 7.25-7.22 (m, 4H), 6.46 (s, 1H), 6.03-5.92 (m, 1H), 5.45-5.32 (m, 2H), 4.74-4.70 (m, 2H), 4.49 (s, 2H), 2.86 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.8, 139.2, 134.6, 131.8, 131.0, 129.7, 128.7, 128.6, 128.55, 128.50, 128.4, 120.1, 120.1, 69.5, 53.4, 41.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{20}H_{21}NNaO_5S$, 410.1033; found, 410.1038.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl but-3-en-2-yl carbonate **(7f).** White solid (129 mg; 54%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); mp 97-98 ^oC; IR (film): ν_{max} 3063, 3030, 2984, 2932, 1762, 1357, 1240, 1165, 1034, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 7.2 Hz, 2H), 7.29-7.22 (m, 4H), 7.22-7.18 (m, 3H), 7.13-7.08 (m, 1H), 7.08-7.04 (m, 4H), 6.38 (s, 1H), 5.89-5.79 (m, 1H), 5.32-5.19 (m, 2H), 5.19-5.12 (m, 1H), 4.37 (s, 2H), 2.42 (s, 3H), 1.37 (d, J = 6.4 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 152.3, 144.0, 138.2, 136.7, 136.6, 134.4, 132.0, 129.6, 128.7, 128.4, 128.3, 128.2, 128.1, 128.0, 121.5, 117.0, 76.3, 52.6, 21.7, 20.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{27}H_{27}NNaO_5S$, 500.1502; found, 500.1507.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl cinnamyl

carbonate **(7g).** White solid (191 mg, 71%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); mp 107-108 °C; IR (film): ν_{max} 3062, 3029, 2950, 1763, 1356, 1231, 1164, 693 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.42-7.38 (m, 2H), 7.38-7.33 (m, 2H), 7.32-7.26 (m, 3H), 7.24-7.19 (m, 5H), 7.14-7.09 (m, 1H), 7.09-7.05 (m, 4H), 6.70 (d, J = 16.0 Hz, 1H), 6.41 (s, 1H), 6.31-6.22 (m, 1H), 4.78 (dd, J = 6.4, 1.2 Hz, 2H), 4.38 (s, 2H), 2.35 (s, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.9, 144.1, 138.2, 136.5, 136.0, 135.5, 134.3, 131.9, 129.7, 129.6, 128.8, 128.7, 128.6, 128.3, 128.2, 128.1, 126.9, 122.0, 121.7, 69.2, 52.6, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + Na]$^+$ calcd for $C_{32}H_{29}NNaO_5S$, 562.1659; found, 562.1658.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl prop-2-yn-1-yl carbonate **(7h).** Colorless oil (141 mg, 61%); purified by column chromatography on silica gel (PE/EtOAc = 8/1); IR (film): ν_{max} 3063, 3031, 2919, 1769, 1356, 1229, 1164, 984, 694 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 2H), 7.29-7.25 (m, 4H), 7.23-7.19 (m, 3H), 7.14-7.03 (m, 5H), 6.42 (s, 1H), 4.71 (d, J = 2.8 Hz, 2H), 4.37 (m, 2H), 2.57 (t, J = 2.4 Hz, 1H), 2.43 (s, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.4, 144.2, 138.1, 136.3, 134.2, 131.7, 129.7, 129.6, 128.8, 128.3, 128.2, 128.1, 121.8, 76.6, 76.3, 56.0, 52.5, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + Na]$^+$ calcd for $C_{26}H_{23}NNaO_5S$, 484.1189; found, 484.1194.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-(4-bromophenyl)vinyl (tetrahydro-2H-pyran-2-yl)carbamate **(9).** White solid (111 mg, 38%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); mp 127-129 °C; IR (film): ν_{max} 3064, 3033, 2943, 2853, 1750, 1526, 1353, 1163, 1033, 717 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 8.0 Hz, 2H), 7.25-7.16 (m, 6H), 7.16-7.09 (m, 3H), 6.97 (d, J = 8.4 Hz, 2H), 6.29 (s, 1H), 5.24-5.16 (m, 1H), 4.87-4.79 (m, 1H), 4.40 (s, 2H), 4.01-3.94 (m, 1H), 3.63-3.53 (m, 1H), 2.42 (s, 3H), 1.92-1.85 (m, 1H), 1.82-1.74 (m, 1H), 1.60-1.54 (m, 1H), 1.54-1.48 (m, 2H), 1.39-1.30 (m, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, $CDCl_3$) δ 152.7, 144.2, 137.7, 136.7, 134.4, 131.2, 130.1, 130.0, 129.6, 128.3, 128.2, 121.9, 121.6, 80.0, 67.2, 52.5, 31.5, 25.0, 22.8, 21.7 ppm; HRMS (ESI-Orbitrap) *m/z*: [M + H]$^+$ calcd for $C_{28}H_{30}BrN_2O_5S$, 585.1053; found, 585.1058.

General Procedure for Synthesis of **11** and **14**.

*General Procedure for Synthesis of **11a-11s, 14a-14f.***

To a solution of **10** or **13** (1.0 mmol) in dry THF (10 mL) was dropwise added newly prepared Grignard reagent (2.0 mmol) at -78°C. The reaction mixture was stirred for

1.5 h and quenched with aqueous NH_4Cl (10 mL). Extracted with ethyl acetate (20 mL × 3), and the combined organic layers were washed with brine. Dried, filtered, and concentrated, crude product was got. $Cu(OTf)_2$ (18 mg, 0.05 mmol) was added to a solution of the above crude product and ynamide (0.5 mmol) in DCM (2 mL) and the mixture was stirred for 1 h at 0 °C to room temperature. The reaction mixture was quenched with aqueous $NaHCO_3$. Extracted with DCM (10 ml × 3), and the combined organic layers were washed with brine. Dried, filtered, and concentrated, the residue was purified by flash chromatography on silica gel.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11a)**. This compound was obtained in 85% purity as judged by NMR analysis. Colorless Oil (262 mg, 84%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{12}$ = -3.29 (*c* 0.850, $CHCl_3$); IR (film): ν_{max} 3440, 3061, 3027, 2951, 2927, 2855, 1746, 1672, 837, 777 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 7.6 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.63-7.57 (m, 1H), 7.51-7.45 (m, 4H), 7.36-7.30 (m, 2H), 7.29-7.25 (m, 3H), 6.13 (s, 1H), 5.11 (s, 1H), 5.02-4.95 (m, 1H), 3.24-3.14 (m, 2H), 3.02 (s, 3H), 2.36 (s, 3H), 1.99-1.90 (m, 2H), 0.92 (s, 9H), 0.05 (s, 3H), 0.02 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.7, 153.9, 143.9, 140.2, 136.4, 134.7, 133.6, 132.2, 129.6, 129.0, 128.8, 128.7, 128.6, 128.2, 127.9, 118.5, 75.4, 38.1, 36.6, 35.0, 25.9, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{33}H_{43}N_2O_6SSi$, 623.2606; found, 623.2601.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-(4-fluorophenyl)-4-oxobutyl)carbamate **(11b)**. Colorless Oil (218 mg, 68%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = -7.55 (*c* 0.94, $CHCl_3$); IR (film): ν_{max} 3440, 3065, 3027, 2952, 2928, 2856, 1747, 1673, 1597, 1355, 778 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.12-8.06 (m, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 7.6 Hz, 2H), 7.35-7.27 (m, 5H), 7.18-7.12 (m, 2H), 6.14 (s, 1H), 5.07 (s, 1H), 4.88-4.82 (m, 1H), 3.25-3.16 (m, 2H), 3.02 (s, 3H), 2.37 (s, 3H), 1.98-1.91 (m, 2H), 0.90 (s, 9H), 0..05 (s, 3H), -0.01 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 199.2, 167.3, 164.7, 153.9, 144.0, 140.2, 136.4, 132.2, 132.1, 132.0, 129.6, 128.7, 128.6, 128.2, 127.9, 118.4, 116.1, 115.8, 75.9, 38.1, 36.6, 35.2, 25.9, 21.6, 18.3, -4.6, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{33}H_{42}FN_2O_6SSi$, 641.2511; found, 641.2515.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-(p-tolyl)butyl)carbamate **(11c)**. Colorless Oil (248 mg, 78%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{12}$ = -1.28 (*c* 1.48, $CHCl_3$); IR (film): ν_{max} 3424, 3066, 3028, 2952, 2928, 2856, 1747, 1671, 1355, 836, 779 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 2H), 7.75 (d, *J* = 7.2 Hz, 2H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.36-7.31 (m, 2H), 7.29-7.24 (m, 5H), 6.12 (s, 1H), 5.14 (s, 1H), 4.98-4.93 (m, 1H), 3.22-3.13 (m, 2H), 3.02 (s, 3H), 2.42 (s, 3H), 2.36 (s, 3H), 1.97-1.88 (m, 2H), 0.92 (s, 9H), 0.04 (s, 3H), 0.02 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.2, 153.9, 144.6, 143.9, 140.2, 136.5, 132.2, 132.1, 129.6, 129.5, 129.2, 128.7, 128.6, 128.2, 127.9, 118.4, 75.4, 38.2, 36.6, 35.1, 25.9, 21.8, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{34}H_{45}N_2O_6SSi$, 637.2762; found, 637.2766.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-(4-methoxyphenyl)-4-oxobutyl)carbamate **(11d)**. Colorless Oil (248 mg, 76%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); $[\alpha]_D^{13}$ = -1.48 (*c* 1.88, $CHCl_3$); IR (film): ν_{max} 3421, 3033, 3028, 2953, 2929, 1746, 1659, 1599, 1354, 1257, 837, 779 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.8 Hz, 2H), 7.75 (d, *J* = 8.4 Hz, 2H), 7.46 (d, *J* = 7.2 Hz, 2H), 7.35-7.30 (m, 2H), 7.28-7.24 (m, 3H), 6.94 (d, *J* = 9.2 Hz, 2H), 6.11 (s, 1H), 5.15 (s, 1H), 4.91-4.86 (m, 1H), 3.87 (s, 3H), 3.25-3.13 (m, 2H), 3.01 (s, 3H), 2.36 (s, 3H), 1.97-1.90 (m, 2H), 0.91 (s, 9H), 0.04 (s, 3H), 0.01 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 199.1, 166.9, 153.9, 143.9, 140.2, 136.4, 132.2, 131.5, 129.6, 128.7, 128.6, 128.2, 127.9, 127.4, 118.4, 114.0, 75.6, 55.6, 38.2, 36.6, 35.3, 25.9, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{34}H_{45}N_2O_7SSi$, 653.2711; found, 653.2716.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-(4-(*tert*-butyl)phenyl)-3-((tert-butyldimethylsilyl)oxy)-4-oxobutyl)carbamate **(11e)**. Colorless Oil (156 mg, 46%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = +1.29 (*c* 0.805, $CHCl_3$); IR (film): ν_{max} 3442, 3061, 2955, 2928, 1748, 1692, 1603, 1358, 1049, 838, 779 cm^{-1}; 1H NMR (400 MHz, CDCl3) δ 7.93 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 8.4 Hz, 2H), 7.51-7.45 (m, 4H), 7.36-7.30 (m, 2H), 7.29-7.24 (m, 3H), 6.16 (s, 1H), 5.13 (s, 1H), 5.04-4.98 (m, 1H), 3.26-3.14 (m, 2H), 3.02 (s, 3H), 2.36 (s, 3H), 1.98-1.84 (m, 2H), 1.34 (s, 9H), 0.93 (s, 9H), 0.05 (s, 6H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.1, 157.5, 153.9, 143.9, 140.3, 136.5, 132.3, 132.1, 129.6, 128.9, 128.7, 128.6, 128.2, 127.9, 125.8, 118.5, 75.2, 38.2, 36.6, 35.3, 35.0,

31.2, 25.9, 21.6, 18.4, -4.4, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{37}H_{51}N_2O_6SSi$, 679.3232; found, 679.3237.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-([1,1'-biphenyl]-4-yl)-3-((*tert*-butyldimethylsilyl)oxy)-4-oxobutyl)carbamate **(11f)**. Colorless Oil (266 mg, 76%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = -1.47 (*c* 1.29, $CHCl_3$); IR (film): ν_{max} 3440, 2953, 2928, 1745, 1669, 1354, 836, 695 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.13-8.07 (m, 2H), 7.80-7.74 (m, 2H), 7.73-7.68 (m, 2H), 7.67-7.61 (m, 2H), 7.54-7.40 (m, 6H), 7.33-7.27 (m, 4H), 6.12 (s, 1H), 5.12 (s, 1H), 5.03-4.97 (m, 1H), 3.30-3.16 (m, 2H), 3.02 (s, 3H), 2.37 (s, 3H), 2.04-1.94 (m, 2H), 0.93 (s, 9H), 0.11-0.04 (m, 6H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.2, 153.9, 146.3, 143.9, 140.2, 139.8, 136.4, 133.2, 132.2, 129.7, 129.6, 129.2, 128.7, 128.6, 128.2, 127.9, 127.4, 118.5, 75.5, 38.1, 36.6, 35.1, 25.9, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{39}H_{47}N_2O_6SSi$, 699.2919; found, 699.2918.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-(3-methoxyphenyl)-4-oxobutyl)carbamate **(11g)**. Colorless Oil (235 mg, 72%); purified by column chromatography on silica gel (PE/EtOAc = 3/1); This compound was obtained in 92% purity as judged by NMR analysis. $[\alpha]_D^{24}$ = -1.41 (*c* 0.620, $CHCl_3$); IR (film): ν_{max} 3440, 3065, 3027, 2951, 2928, 1746, 1695, 1355, 1258, 1047, 838, 779 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 8.4 Hz, 2H), 7.57 (d, *J* = 7.6 Hz, 1H), 7.53-7.50 (m, 1H), 7.48-7.44 (m, 2H), 7.40-7.39 (m, 4H), 7.28-7.26 (m, 1H), 7.26-7.23 (m, 1H), 7.16-7.11 (m, 1H), 6.13 (s, 1H), 5.13 (s, 1H), 5.00-4.95 (m, 1H), 3.86 (s, 3H), 3.24-3.14 (m, 2H), 3.01 (s, 3H), 2.36 (s, 3H), 2.00-1.87 (m, 2H), 0.92 (s, 9H), 0.05 (s, 3H), 0.04 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.4, 160.0, 153.9, 143.9, 140.2, 136.5, 136.0, 132.2, 129.8, 129.6, 128.7, 128.6, 128.2, 127.9, 121.4, 120.0, 118.4, 113.4, 75.3, 55.6, 38.1, 36.6, 35.0, 25.9, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{34}H_{45}N_2O_7SSi$, 653.2711; found, 653.2714.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-(2-methoxyphenyl)-4-oxobutyl)carbamate **(11h)**. Foam solid (137 mg, 42%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); $[\alpha]_D^{24}$ = -8.50 (*c* 1.00, $CHCl_3$); IR (film): ν_{max} 3439, 3065, 3026, 2950, 2928, 1746, 1676, 1355, 1246, 837, 712 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 8.4 Hz, 2H), 7.66-7.62 (m, 1H), 7.50-7.46 (m, 3H), 7.35-7.30 (m, 2H), 7.28-7.23 (m, 3H),

7.06-7.01 (m, 1H), 6.97 (d, J = 8.4 Hz, 1H), 6.15 (s, 1H), 5.25-5.19 (m, 2H), 3.91 (s, 3H), 3.21-3.11 (m, 2H), 3.01 (s, 3H), 2.39 (s, 3H), 1.94-1.85 (m, 1H), 1.77-1.68 (m, 1H), 0.94 (s, 9H), 0.11(s, 3H), 0.06 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.6, 157.9, 153.8, 143.9, 140.3, 136.5, 133.9, 132.3, 130.8, 129.6, 128.7, 128.6, 128.1, 127.9, 126.6, 121.3, 118.4, 111.7, 77.0, 55.8, 38.4, 36.5, 33.4, 26.0, 21.7, 18.5, -4.4, -5.2 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{34}H_{45}N_2O_7SSi$, 653.2711; found, 653.2714.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-(naphthalen-2-yl)-4-oxobutyl)carbamate **(11i)**. This compound was obtained in 84% purity as judged by NMR analysis. Colorless Oil (232 mg, 69%); purified by column chromatography on silica gel (PE/EtOAc = 6/1); $[\alpha]_D^{13}$ = -7.56 (*c* 1.27, $CHCl_3$); IR (film): ν_{max} 3440, 3059, 2951, 2927, 1740, 1671, 1353, 1119, 1048, 837, 779 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.61 (s, 1H), 8.06-8.02 (m, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.93-7.87 (m, 2H), 7.74 (d, J = 8.0 Hz, 2H), 7.65-7.60 (m, 1H), 7.58-7.53 (m, 1H), 7.42 (d, J = 7.6 Hz, 2H), 7.34-7.28 (m, 2H), 7.26-7.21 (m, 3H), 6.08 (s, 1H), 5.12 (s, 1H), 5.10-5.05 (m, 1H), 3.28-3.18 (m, 2H), 3.00 (s, 3H), 2.33 (s, 3H), 2.06-1.99 (m, 2H), 0.93 (s, 9H), 0.08 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.5, 153.8, 143.8, 140.1, 136.4, 135.7, 132.4, 132.1, 131.7, 130.9, 129.7, 129.5, 128.8, 128.6, 128.5, 128.4, 128.0, 127.8, 127.7, 127.0, 124.5, 118.3, 75.7, 38.0, 36.5, 35.2, 25.8, 21.5, 18.3, -4.6, -5.2 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{37}H_{45}N_2O_6SSi$, 673.2762; found, 673.2761.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11k)**. Colorless Oil (210 mg, 60%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = -0.217 (*c* 1.38, $CHCl_3$); IR (film): ν_{max} 3385, 3062, 3029, 2951, 2928, 1745, 1696, 1597, 1353, 1291, 1212, 1166, 837, 778, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, J = 7.2 Hz, 2H), 7.72 (d, J = 8.4 Hz, 2H), 7.59-7.54 (m, 1H), 7.46-7.42 (m, 2H), 7.24 (d, J = 8.0 Hz, 2H), 7.18-7.13 (m, 7H), 7.11-7.07 (m, 3H), 6.20 (s, 1H), 5.08 (s, 1H), 5.04-4.99 (m, 1H), 4.36 (s, 2H), 3.36-3.30 (m, 2H), 2.39 (s, 3H), 2.08-1.95 (m, 2H), 0.91 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.7, 153.5, 143.9, 137.6, 136.8, 134.7, 133.5, 132.2, 129.6, 129.4, 128.9, 128.7, 128.5, 128.2, 128.1, 128.0, 127.9, 127.7, 121.4, 75.2, 52.4, 38.0, 35.0, 25.8, 21.6, 18.3, -4.6, -5.2 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{39}H_{47}N_2O_6SSi$, 699.2919; found, 699.2917.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-(4-chlorophenyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11l)**. Colorless Oil (202 mg, 55%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{14}$ = -0.309 (*c* 1.94, $CHCl_3$); IR (film): ν_{max} 3385, 3064, 3032, 2952, 2928, 1747, 1696, 1596, 1352, 1252, 1166, 1090, 837, 778, 699 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 6.8 Hz, 2H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.60-7.54 (m, 1H), 7.48-7.42 (m, 2H), 7.28-7.26 (m, 1H), 7.26-7.24 (m, 1H), 7.18 (d, *J* = 7.6 Hz, 2H), 7.15-7.09 (m, 3H), 7.06-7.03 (m, 4H), 6.15 (s, 1H), 5.09 (s, 1H), 5.04-4.99 (m, 1H), 4.36 (s, 2H), 3.36-3.28 (m, 2H), 2.41 (s, 3H), 2.08-1.96 (m, 2H), 0.91 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.8, 153.5, 144.2, 137.8, 136.7, 134.7, 134.6, 133.6, 133.5, 130.9, 129.9, 19.8, 129.6, 129.1, 128.8, 128.2, 128.1, 120.9, 75.3, 52.4, 38.1, 35.0, 25.9, 21.7, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{39}H_{46}ClN_2O_6SSi$, 733.2529; found, 733.2530.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-(p-tolyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11m)**. Colorless Oil (257 mg, 72%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = +0.909 (*c* 1.76, $CHCl_3$); IR (film): ν_{max} 3439, 3063, 3031, 2951, 2927, 1745, 1697, 1353, 1252,1166, 1120, 837, 778 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.6 Hz, 2H), 7.71 (d, *J* = 8.0 Hz, 2H), 7.59-7.54 (m, 1H), 7.47-7.42 (m, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.20-7.16 (m, 2H), 7.14-7.08 (m, 3H), 7.05 (d, *J* = 8.0 Hz, 2H), 6.96-6.91 (m, 2H), 6.16 (s, 1H), 5.06 (s, 1H), 5.03-4.99 (m, 1H), 4.37 (s, 2H), 3.36-3.29 (m, 2H), 2.39 (s, 3H), 2.28 (s, 3H), 2.08-1.94 (m, 2H), 0.91 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.9, 153.7, 143.9, 137.7, 137.2, 137.0, 135.0, 134.8, 133.6, 129.8, 129.5, 129.4, 129.0, 128.9, 128.8, 128.5, 128.2, 128.1, 127.9, 121.4, 75.3, 52.5, 38.1, 35.1, 25.9, 21.7, 21.4, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{40}H_{49}N_2O_6SSi$, 713.3075; found, 713.3076.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-(4-bromophenyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11n)**. Colorless Oil (233 mg, 60%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = -0.550 (*c* 2.18, $CHCl_3$); IR (film): ν_{max} 3381, 3064, 3032, 2952, 2928, 1746, 1696, 1352, 1166, 1120, 837, 779, 714 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.2 Hz, 2H), 7.72 (d, *J* = 8.4 Hz, 2H), 7.60-7.54 (m, 1H), 7.48-7.42 (m, 2H), 7.27 (s,

1H), 7.25 (s, 1H), 7.21-7.16 (m, 4H), 7.14-7.08 (m, 3H), 6.97 (d, J = 8.4 Hz, 2H), 6.13 (s, 1H), 5.08 (s, 1H), 5.04-4.99 (m, 1H), 4.36 (s, 2H), 3.36-3.28 (m, 2H), 2.41 (s, 3H), 2.08-1.96 (m, 2H), 0.91 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.8, 153.4, 144.2, 137.9, 136.6, 134.7, 134.5, 133.6, 131.4, 131.2, 130.1, 129.8, 129.6, 129.0, 128.8, 128.3, 128.2, 128.1, 121.7, 120.9, 75.3, 52.4, 38.1, 35.0, 25.9, 21.7, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{39}H_{46}BrN_2O_6SSi$, 777.2024; found, 777.2028.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-(4-methoxyphenyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11o)**. Foam solid (226 mg, 62%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); $[\alpha]_D^{13}$ = 0.654 (*c* 1.07, $CHCl_3$); IR (film): ν_{max} 3439, 3063, 3032, 2952, 2928, 1744, 1696, 1511, 1352, 1251, 1166, 1118, 836, 779, 702 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, J = 7.2 Hz, 2H), 7.74 (d, J = 8.4 Hz, 2H), 7.59-7.54 (m, 1H), 7.47-7.42 (m, 2H), 7.25 (d, J = 8.0Hz, 2H), 7.22-7.18 (m, 2H), 7.15-7.11 (m, 3H), 7.11-7.08 (m, 2H), 6.66 (d, J = 8.8 Hz, 2H), 6.14 (s, 1H), 5.06-4.98 (m, 2H), 4.38 (s, 2H), 3.77 (s, 3H), 3.36-3.29 (m, 2H), 2.40 (s, 3H), 2.06-1.95 (m, 2H), 0.91 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.9, 159.3, 153.8, 143.9, 137.0, 136.3, 135.0, 134.8, 133.6, 130.0, 129.8, 129.5, 129.0, 128.8, 128.2, 128.1, 128.0, 124.8, 121.5, 113.6, 75.3, 55.3, 52.5, 38.1, 35.1, 25.9, 21.7, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{40}H_{49}N_2O_7SSi$, 729.3024; found, 729.3026.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-(2-chlorophenyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11p)**. Colorless Oil (205 mg, 56%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = 1.88 (*c* 1.97, $CHCl_3$); IR (film): ν_{max} 3438, 3065, 3032, 2953, 2928, 1749, 1696, 1351, 1166, 1127, 837, 778, 717 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, J = 7.2 Hz, 2H), 7.72 (d, J = 8.4 Hz, 2H), 7.60-7.54 (m, 1H), 7.48-7.42 (m, 3H), 7.26 (s, 1H), 7.24 (s, 1H), 7.15-7.09 (m, 4H), 7.09-7.04 (m, 4H), 6.41 (s, 1H), 5.12 (s, 1H), 5.05-5.00 (m, 1H), 4.32 (s, 2H), 3.37-3.31 (m, 2H), 2.40 (s, 3H), 2.08-1.95 (m, 2H), 0.92 (s, 9H), 0.06 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.8, 153.3, 144.0, 139.1, 136.8, 134.7, 134.3, 133.8, 133.6, 131.2, 130.1, 129.7, 129.6, 129.0, 128.9, 128.8, 128.2, 127.9, 126.5, 118.3, 75.3, 52.8, 38.2, 35.1, 25.9, 21.7, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for

$C_{39}H_{46}ClN_2O_6SSi$, 733.2529; found, 733.2532.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-(2-methoxyphenyl)vinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11q)**. Foam solid (209 mg, 64%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); $[\alpha]_D^{14}$ = -5.34 (*c* 0.880, $CHCl_3$); IR (film): ν_{max} 3385, 3065, 2951, 2928, 2855, 1746, 1696, 1597, 1352, 1249, 1155, 1051, 837, 778, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 7.2 Hz, 2H), 7.73 (d, *J* = 8.0 Hz, 2H), 7.68 (d, *J* = 6.8 Hz, 1H), 7.62-7.58 (m, 1H), 7.52-7.44 (m, 2H), 7.26-7.21 (m, 3H), 6.97-6.91 (m, 1H), 6.87-6.82 (m, 1H), 6.45 (s, 1H), 5.11 (s, 1H), 5.00-4.94 (m, 1H), 3.81 (s, 3H), 3.24-3.14 (m, 2H), 2.99 (s, 3H), 2.35 (s, 3H), 2.00-1.87 (m, 2H), 0.92 (s, 9H), 0.05 (s, 3H), 0.02 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.7, 157.0, 154.0, 143.7, 140.3, 136.7, 134.7, 133.6, 129.6, 129.4, 129.0, 128.8, 128.6, 127.8, 121.1, 120.9, 112.6, 110.5, 75.4, 55.6, 38.1, 36.7, 35.1, 25.9, 21.6, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{34}H_{45}N_2O_7SSi$, 653.2711; found, 653.2714.

(*E*)-1-((4-Methyl-N-phenylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11r)**. Foam solid (222 mg, 65%); purified by column chromatography on silica gel (PE/EtOAc = 4/1); $[\alpha]_D^{13}$ = -7.83 (*c* 0.920, $CHCl_3$); IR (film): ν_{max} 3440, 3062, 3027, 2952, 2927, 1750, 1596, 1360, 1167, 837, 779, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.01 (d, *J* = 7.2Hz, 2H), 7.60-7.51 (m, 5H), 7.49-7.43 (m, 2H), 7.34-7.26 (m, 3H), 7.24-7.15 (m, 7H), 6.34 (s, 1H), 5.33 (s, 1H), 5.10-5.04 (m, 1H), 3.45-3.37 (m, 2H), 2.38 (s, 3H), 2.14-2.03 (m, 2H), 0.91 (s, 9H), 0.07 (s, 3H), 0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.9, 153.0, 144.2, 139.7, 139.1, 136.4, 134.7, 133.6, 134.7, 133.6, 132.4, 129.4, 129.3, 129.0, 128.9, 128.8, 128.6, 128.4, 128.3, 128.0, 127.6, 126.7, 119.9, 75.2, 38.2, 35.1, 25.9, 21.7, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{38}H_{45}N_2O_6SSi$, 685.2762; found, 685.2762.

(*E*)-1-((N-Benzyl-4-chlorophenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-((*tert*-butyldimethylsilyl)oxy)-4-oxo-4-phenylbutyl)carbamate **(11s)**. Colorless Oil (212 mg, 59%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{13}$ = -0.206 (*c* 2.43, $CHCl_3$); IR (film): ν_{max} 3439, 3063, 3028, 2951, 2927,1747, 1696, 1358, 1252, 1165, 836, 778, 756, 698 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 7.2 Hz, 2H), 7.70 (d, *J* = 8.8 Hz, 2H), 7.60-7.55 (m, 1H), 7.49-7.43 (m, 2H), 7.37 (d, *J* = 8.8 Hz, 2H), 7.22-7.18 (m, 2H), 7.17-7.14 (m, 2H), 7.14-7.10 (m, 6H), 6.21 (s, 1H), 5.18 (s, 1H), 5.06-5.02 (m, 1H), 4.42 (s, 2H), 3.40-3.28 (m, 2H), 2.10-1.99 (m, 2H),

0.92 (s, 9H), 0.07 (s, 3H), 0.04 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 200.8, 153.5, 139.6, 138.3, 137.5, 134.8, 134.5, 133.6, 132.2, 129.9, 129.6, 129.1, 129.0, 128.8, 128.5, 128.3, 128.2, 128.0, 121.8, 75.4, 52.9, 38.2, 35.0, 25.9, 18.4, -4.5, -5.1 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{38}H_{44}ClN_2O_6SSi$, 719.2372; found, 719.2378.

(*E*)-1-((N,4-Dimethylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(3-hydroxy-4-oxo-4-phenylbutyl)carbamate **(12)** To a solution of **11a** (210 mg, 0.34 mmol) in THF (1 mL) was dropwise added HF·Py (2 mL) at 0 °C. The reaction was stirred for 2 h at room temperature. Saturated aqueous solution of $NaHCO_3$ was carefully added to quench the reaction and extracted with EtOAc (10 mL × 3), and the combined organic layers were washed with brine. Dried, filtered, and concentrated, the residue was purified by flash chromatography on silica gel (PE/EA = 1:1) to give white solid **12** (121 mg, 70%)。 $[\alpha]_D^{13}$ = -3.57 (*c* 1.26, $CHCl_3$); IR (film): ν_{max} 3439, 3059, 3027, 2939, 1741, 1676, 1352, 1155, 1046, 711, 695 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.94-7.86 (m, 2H), 7.83-7.74 (m, 2H), 7.69-7.64 (m, 1H), 7.55-7.43 (m, 4H), 7.38-7.31 (m, 2H), 7.31-7.24 (m, 3H), 6.15 (s, 1H), 5.43 (s, 1H), 5.12-5.02 (m, 1H), 3.90 (s, 1H), 3.34-3.24 (m, 2H), 3.05 (s, 3H), 2.37 (s, 3H), 2.18-2.04 (m, 1H), 1.65-1.51 (m, 1H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 201.3, 154.1, 144.0, 140.2, 136.4, 134.4, 133.2, 132.2, 129.6, 129.2, 128.8, 128.7, 128.5, 128.2, 127.9, 118.5, 71.8, 38.3, 36.6, 35.0, 21.6 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{27}H_{29}N_2O_6S$, 509.1741; found, 509.1743.

(*E*)-1-((N-Benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((*tert*-butyldimethylsilyl)oxy)-5-oxo-5-phenylpentyl)carbamate **(14a)**. Colorless Oil (185 mg, 52%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{14}$ = -11.4 (*c* 1.40, $CHCl_3$); IR (film): ν_{max} 3439, 3062, 3030, 2951, 2928, 2359, 1745, 1353, 1251, 1166, 837, 777, 694 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.4 Hz, 2H), 7.70 (d, *J* = 8.4 Hz, 2H), 7.58-7.53 (m, 1H), 7.48-7.42 (m, 2H), 7.20 (d, *J* = 8.0 Hz, 2H), 7.18-7.11 (m, 8H), 7.09 (d, *J* = 7.2 Hz, 2H), 6.27 (s, 1H), 4.87-4.81 (m, 2H), 4.38 (s, 2H), 3.23-3.13 (m, 2H), 2.38 (s, 3H), 1.87-1.79 (m, 2H), 1.78-1.68 (m, 1H), 1.64-1.55 (m, 1H), 0.89 (s, 9H), 0.06 (s, 3H), 0.00 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, $CDCl_3$) δ 201.1, 153.7, 144.0, 137.8, 136.9, 134.8, 134.7, 133.4, 132.3, 129.8, 129.5, 129.2, 128.7, 128.6, 128.3, 128.2, 128.1, 128.0, 127.8, 121.4, 76.8, 52.6, 41.0, 33.0, 26.0, 25.9, 21.7, 18.4, -4.5, -5.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + H]^+$ calcd for $C_{40}H_{49}N_2O_6SSi$, 713.3075; found, 713.3077.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((tert-butyl dimethylsilyl)oxy)-5-(4-fluorophenyl)-5-oxopentyl)carbamate **(14b)**. Colorless Oil (227 mg, 62%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{25}$ = -4.32 (*c* 1.39, $CHCl_3$); IR (film): ν_{max} 3380, 3066, 3032, 2952, 2928, 1745, 1679, 1597, 1353, 1162, 839, 777, 711 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.15-8.10 (m, 2H), 7.71-7.67 (m, 2H), 7.22-7.19 (m, 2H), 7.17-7.11 (m, 8H), 7.11-7.07 (m, 4H), 6.26 (s, 1H), 4.87 (s, 1H), 4.75-4.69 (m, 1H), 4.42-4.36 (m, 2H), 3.27-3.12 (m, 2H), 2.39 (s, 3H), 1.86-1.79 (m, 2H), 1.77-1.67 (m, 1H), 1.61-1.53 (m, 1H), 0.88 (s, 9H), 0.05 (s, 3H), -0.03 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$) δ 199.7, 167.2, 164.6, 153.8, 144.0, 137.9, 136.9, 134.8, 132.3, 132.2, 131.0, 129.7, 129.5, 128.6, 128.3, 128.2, 128.1, 128.0, 127.8, 121.3, 115.9, 115.7, 77.8, 52.6, 41.0, 33.1, 26.1, 25.9, 21.7, 18.3, -4.6, -5.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{40}H_{47}FN_2NaO_6SSi$, 753.2800; found, 753.2795.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((tert-butyl dimethylsilyl)oxy)-5-oxo-5-(p-tolyl)pentyl)carbamate **(14c)**. Colorless Oil (269 mg, 74%); purified by column chromatography on silica gel (PE/EtOAc = 5/1); $[\alpha]_D^{26}$ = -3.25 (*c* 2.03, $CHCl_3$); IR (film): ν_{max} 3377, 3063, 3030, 2952, 2928, 2856, 1745, 1691, 1606, 1353, 1212, 1163, 836, 778, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.97-7.94 (m, 2H), 2.72-2.68 (m, 2H), 7.26-7.23 (m, 2H), 7.22-7.19 (m, 2H), 7.17 (s, 1H), 7.16-7.13 (m, 5H), 7.13-7.05 (m, 4H), 6.27 (s, 1H), 4.86-4.82 (m, 2H), 4.39-4.37 (m, 2H), 3.23-3.13 (m, 2H), 2.40-2.38 (m, 6H), 1.85-1.77 (m, 2H), 1.72-1.67 (m, 1H), 1.64-1.56 (m, 1H), 0.90 (s, 9H), 0.06 (s, 3H), 0.01 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$) δ 200.6, 153.7, 144.3, 144.0, 137.9, 136.9, 134.8, 132.4, 132.3, 129.8, 129.5, 129.4, 129.3, 128.6, 128.3, 128.2, 128.1, 128.0, 127.8, 121.4, 77.0, 52.6, 41.1, 33.0, 26.0, 25.9, 21.8, 21.6, 18.4, -4.5, -5.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{41}H_{50}N_2NaO_6SSi$, 749.3051; found, 749.3054.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((tert-butyl dimethylsilyl)oxy)-5-(4-methoxyphenyl)-5-oxopentyl)carbamate **(14d)**. Colorless Oil (256 mg, 69%); purified by column chromatography on silica gel (PE/EtOAc = 2/1); $[\alpha]_D^{25}$ = -1.66 (*c* 1.86, $CHCl_3$); IR (film): ν_{max} 3378, 3063, 3029, 2952, 2929, 2855, 1744, 1599, 1510, 1353, 1257, 1163, 1118, 837, 777, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.09-8.05 (m, 2H), 7.71-7.68 (m, 2H), 7.22-7.18 (m, 2H), 7.16 (s, 1H), 7.16-7.12 (m, 5H), 7.12-7.05 (m, 4H), 6.93-6.89 (m, 2H), 6.27 (s, 1H), 4.87-4.82 (m, 1H), 4.80-4.75 (m, 1H), 4.39-4.36 (m, 2H), 3.83 (s, 3H), 3.24-3.13 (m, 2H), 2.38 (s,

3H), 1.85-1.78 (m, 2H), 1.73-1.68 (m, 1H), 1.64-1.56 (m, 1H), 0.89 (s, 9H), 0.05 (s, 3H), -0.01 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$) δ 199.5, 163.7, 153.7, 144.0, 137.8, 136.9, 134.8, 132.3, 131.7, 129.8, 129.5, 128.6, 128.2, 128.15, 128.11, 128.0, 127.8, 127.6, 121.4, 113.8, 77.3, 55.5, 52.6, 41.0, 33.2, 26.1, 25.9, 21.6, 18.4, -4.5, -5.0 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{41}H_{50}N_2NaO_7SSi$, 765.3000; found, 765.3001.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((tert-butyl dimethylsilyl)oxy)-7-methyl-5-oxooctyl)carbamate **(14e)**. Colorless Oil (229 mg, 66%); purified by column chromatography on silica gel (PE/EtOAc = 6/1); $[\alpha]_D^{26}$ = -1.40 (*c* 1.79, $CHCl_3$); IR (film): ν_{max} 3382, 3063, 3031, 2955, 2929, 2857, 1746, 1668, 1354, 1251, 1213, 1163, 1118, 1042, 837, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.74-7.70 (m, 2H), 7.25-7.21 (m, 2H), 7.18-7.15 (m, 3H), 7.15-7.12 (m, 4H), 7.12-7.06 (m, 3H), 6.29 (s, 1H), 4.88-4.83 (m, 1H), 4.41-4.38 (m, 2H), 4.04-4.00 (m, 1H), 3.22-3.10 (m, 2H), 2.43-2.42 (m, 1H), 2.42-2.40 (m, 4H), 2.21-2.10 (m, 1H), 1.71-1.58 (m, 2H), 1.58-1.50 (m, 2H), 0.93 (s, 9H), 0.93-0.89 (m, 6H), 0.07 (s, 3H), 0.06 (s, 3H) ppm; $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$) δ 213.0, 153.7, 143.9, 137.9, 136.9, 134.8, 132.3, 129.8, 129.5, 128.6, 128.3, 128.2, 128.1, 128.0, 121.4, 78.4, 52.6, 46.7, 41.2, 31.8, 25.9, 25.3, 23.6, 22.8, 22.7, 21.7, 18.2, -4.7 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{38}H_{52}N_2NaO_6SSi$, 715.3208; found, 715.3205.

(*E*)-1-((N-benzyl-4-methylphenyl)sulfonamido)-2-phenylvinyl-(*S*)-(4-((tert-butyl dimethylsilyl)oxy)-5-oxononyl)carbamate **(14f)**. Colorless Oil (249 mg, 72%); purified by column chromatography on silica gel (PE/EtOAc = 6/1); $[\alpha]_D^{26}$ = -1.99 (*c* 0.805, $CHCl_3$); IR (film): ν_{max} 3406, 3066, 3033, 2955, 2929, 2857, 1746, 1633, 1598, 1353, 1251, 1163, 1119, 837, 693 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73-7.69 (m, 2H), 7.25-7.21 (m, 2H), 7.19-7.15 (m, 3H), 7.15-7.12 (m, 4H), 7.12-7.08 (m, 3H), 6.29 (s, 1H), 4.85-4.81 (m, 1H), 4.41-4.38 (m, 2H), 4.07-4.03 (m, 1H), 3.21-3.11 (m, 2H), 2.56-2.51 (m, 2H), 2.41 (s, 3H), 1.72-1.59 (m, 2H), 1.58-1.50 (m, 4H), 1.34-1.27 (m, 2H), 0.93 (s, 9H), 0.93-0.88 (m, 3H), 0.07 (s, 6H) ppm; $^{13}C\{^1H\}$ NMR (150 MHz, $CDCl_3$) δ 213.8, 153.7, 143.9, 137.9, 136.9, 134.8, 132.4, 129.8, 129.5, 128.6, 128.3, 128.2, 128.1, 128.0, 127.8, 121.4, 78.3, 52.6, 41.2, 37.5, 31.9, 25.9, 25.4, 25.3, 22.6, 21.7, 18.2, 14.0, -4.7, -4.8 ppm; HRMS (ESI-Orbitrap) *m/z*: $[M + Na]^+$ calcd for $C_{38}H_{52}N_2NaO_6SSi$, 715.3208; found, 715.3208.

Supporting Information: Copies of ^1H, $^{13}C\{^1H\}$ NMR spectra and X-ray structural

data (CIF) (**9**) and (**12**). The Supporting Information is available free of charge on the ACS Publications website at http://pubs.acs.org.

Accession Codes

CCDC 1951185 (**9**), 1938988 (**12**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by emailing da-ta_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crys-tallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033

AUTHOR INFORMATION

Corresponding Author

*E-mail: sicm@fudan.edu.cn. (C.-M. Si)

*E-mail: bgwei1974@fudan.edu.cn (B.-G. Wei)

ORCID

Bang-Guo Wei: 0000-0003-3470-6741

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENT. We thank the National Natural Science Foundation of China (21772027 to B.-G. Wei and 81701755 to M. Li) for financial support. The authors also thank Dr Han-Qing Dong (Arvinas, Inc.) for helpful suggestions.

References

(1) (a) Corey, E. J.; Cheng, X. The Logic of Chemical Synthesis; John Wiley & Sons, Inc.: New York, 1995. (b) Bauer, I.; Knölker, H.-J., Iron Catalysis in Organic Synthesis. *Chem. Rev*. **2015**, *115*, 3170-3387. (c) Zhao, K.; Shen, L.; Shen, Z.-L.; Loh, T.-P., Transition metal-catalyzed cross-coupling reactions using organoindium reagents. *Chem. Soc. Rev*. **2017**, *46*, 586-602.

(2) Li, L.; Chen, Z.; Zhang, X.; Jia, Y., Divergent Strategy in Natural Product Total

Synthesis. *Chem. Rev.* **2018**, *118*, 3752-3832.

(3) Cui, C.; Dai, W.-M., Total Synthesis of Laingolide B Stereoisomers and Assignment of Absolute Configuration. *Org. Lett.* **2018**, *20*, 3358-3361.

(4) Fosgerau, K.; Hoffmann, T., Peptide therapeutics: current status and future directions. *Drug Discovery Today* **2015**, *20*, 122-128.

(5) For selected natural product containing enamides, see: (a) Davyt, D.; Entz, W.; Fernandez, R.; Mariezcurrena, R.; Mombrú, A. W.; Saldaña, J.; Domínguez, L.; Coll, J.; Manta, E., A New Indole Derivative from the Red Alga Chondria atropurpurea. Isolation, Structure Determination, and Anthelmintic Activity. *J. Nat. Prod.* **1998**, *61*, 1560-1563. (b) Kuranaga, T.; Sesoko, Y.; Inoue, M., Cu-mediated enamide formation in the total synthesis of complex peptide natural products. *Nat. Prod. Rep.* **2014**, *31*, 514-532. For selected reviews about preparation of enamide, see: (c) Müller, T. E.; Hultzsch, K. C.; Yus, M.; Foubelo, F.; Tada, M., Hydroamination: Direct Addition of Amines to Alkenes and Alkynes. *Chem. Rev*. **2008**, *108*, 3795-3892. (d) Huang, L.; Arndt, M.; Gooßen, K.; Heydt, H.; Gooßen, L. J., Late Transition Metal-Catalyzed Hydroamination and Hydroamidation. *Chem. Rev*. **2015**, *115*, 2596-2697.

(6) (a) Ilankumaran, P.; Verkade, J. G., Highly Selective Acylation of Alcohols Using Enol Esters Catalyzed by Iminophosphoranes. *J. Org. Chem.* **1999**, *64*, 9063-9066. (b) Schröder, H.; Strohmeier, G. A.; Leypold, M.; Nuijens, T.; Quaedflieg, P. J. L. M.; Breinbauer, R., Racemization‐Free Chemoenzymatic Peptide Synthesis Enabled by the Ruthenium‐Catalyzed Synthesis of Peptide Enol Esters via Alkyne‐Addition and Subsequent Conversion Using Alcalase‐Cross‐Linked Enzyme Aggregates. *Adv. Synth. Catal*. **2013**, *355*, 1799-1807.

(7) Monthéard, J. P.; Camps, M.; Seytre, G.; Guillet, J.; Dubois, J. C., Propriétés des esters d'énols I. Polymérisation d'acétoxyalcènes et études diélectriques des polymères obtenus. *Angew. Makromol. Chem.* **1978**, *72*, 45-55.

(8) (a) Burk, M. J.; Kalberg, C. S.; Pizzano, A., Rh−DuPHOS-Catalyzed Enantioselective Hydrogenation of Enol Esters. Application to the Synthesis of Highly Enantioenriched α-Hydroxy Esters and 1,2-Diols. *J. Am. Chem. Soc.* **1998**, *120*, 4345-4353. (b) Kleman, P.; González-Liste, P. J.; García-Garrido, S. E.;

Cadierno, V.; Pizzano, A., Asymmetric Hydrogenation of 1-Alkyl and 1-Aryl Vinyl Benzoates: A Broad Scope Procedure for the Highly Enantioselective Synthesis of 1-Substituted Ethyl Benzoates. *ACS Catal.* **2014**, *4*, 4398-4408.

(9) (a) Trost, B. M.; Toste, F. D.; Pinkerton, A. B., Non-Metathesis Ruthenium-Catalyzed C−C Bond Formation. *Chem. Rev.* **2001**, *101*, 2067-2096. (b) Urabe, H.; Suzuki, D.; Sasaki, M.; Sato, F., Enol Ester as an Olefinic Partner in Enyne Cyclization. A Novel Tandem Cyclization to Stereodefined Bicyclo[3.3.0]octenes. *J. Am. Chem. Soc.* **2003**, *125*, 4036-4037. (c) Hara, H.; Hirano, M.; Tanaka, K., Liquid Enol Ethers and Acetates as Gaseous Alkyne Equivalents in Rh-Catalyzed Chemo- and Regioselective Formal Cross-Alkyne Cyclotrimerization. *Org. Lett.* **2008**, *10*, 2537-2540.

(10) Yanagisawa, M.; Shimamura, T.; Iida, D.; Matsuo, J.; Mukaiyama, T., Aldol reaction of enol esters catalyzed by cationic species paired with tetrakis (pentafluorophenyl) borate. *Chem. Pharm. Bull.* **2000**, *48*, 1838−1840.

(11) Isambert, N.; Cruz, M.; Arévalo, M. J.; Gómez, E.; Lavilla, R., Enol Esters: Versatile Substrates for Mannich-Type Multicomponent Reactions. *Org. Lett*. **2007**, *9*, 4199−4202.

(12) (a) Yu, D.-G.; Li, B.-J.; Shi, Z.-J., Exploration of New C−O Electrophiles in Cross-Coupling Reactions. *Acc. Chem. Res.* **2010**, *43*, 1486-1495. (b) Rosen, B. M.; Quasdorf, K. W.; Wilson, D. A.; Zhang, N.; Resmerita, A.-M.; Garg, N. K.; Percec, V., Nickel-Catalyzed Cross-Couplings Involving Carbon−Oxygen Bonds. *Chem. Rev*. **2011**, *111*, 1346-1416.

(13) Smith, D. L.; Goundry, W. R. F.; Lam, H. W., Palladium-catalyzed hydroacyloxylation of ynamides. *Chem. Commun.* **2012**, *48*, 1505-1507.

(14) Xu, S.; Liu, J.; Hu, D.; Bi, X., Metal-free hydroacyloxylation and hydration reactions of ynamides: synthesis of α-acyloxyenamides and N-acylsulfonamides. *Green Chem.* **2015,** *17*, 184-187.

(15) (a) Kawade, R. K.; Tseng, C.-C.; Liu, R.-S., Copper‐Catalyzed Aerobic Oxidations of 3‐N‐Hydoxyaminoprop‐1‐ynes to Form 3‐Substituted 3‐

Amino - 2 - en - 1 - ones: Oxidative Mannich Reactions with a Skeletal Rearrangement. *Chem. Eur. J.* **2014**, *20*, 13927-13931. (b) Starkov, P.; Moore, J. T.; Duquette, D. C.; Stoltz, B. M.; Marek, I., Enantioselective Construction of Acyclic Quaternary Carbon Stereocenters: Palladium-Catalyzed Decarboxylative Allylic Alkylation of Fully Substituted Amide Enolates. *J. Am. Chem. Soc.* **2017**, *139*, 9615-9620.

(16) Alonso, F.; Beletskaya, I. P.; Yus, M., Transition-Metal-Catalyzed Addition of Heteroatom−Hydrogen Bonds to Alkynes. *Chem. Rev.* **2004**, *104*, 3079−3159.

(17) For selected examples, see: (a) Rotem, M.; Shvo, Y., Addition of carboxylic acids to alkynes catalyzed by ruthenium complexes. Vinyl ester formation. *Organometallics* **1983**, *2*, 1689−1691. (b) Wang, Y.; Wang, Z.; Li, Y.; Wu, G.; Cao, Z.; Zhang, L., A general ligand design for gold catalysis allowing ligand-directed anti-nucleophilic attack of alkynes. *Nat. Commun.* **2014**, *5*, 3470-3477. (c) Jeschke, J.; Gabler, C.; Lang, H., Regioselective Formation of Enol Esters from the Ruthenium-Catalyzed Markovnikov Addition of Carboxylic Acids to Alkynes. *J. Org. Chem.* **2016**, *81*, 476−484.

(18) For selected reviews of ynamides, see: (a) DeKorver, K. A.; Li, H.; Lohse, A. G.; Hayashi, R.; Lu, Z.; Zhang, Y.; Hsung, R. P., Ynamides: A Modern Functional Group for the New Millennium. *Chem. Rev.* **2010**, *110*, 5064–5106; (b) Evano, G.; Coste, A.; Jouvin, K., Ynamides: Versatile Tools in Organic Synthesis. *Angew. Chem., Int. Ed.* **2010**, *49*, 2840-2859. (c) Wang, X.-N.; Yeom, H.-S.; Fang, L.-C.; He, S.; Ma, Z.-X.; Kedrowski, B. L.; Hsung, R. P., Ynamides in Ring Forming Transformations. *Acc. Chem. Res.* **2014**, *47*, 560-578. (d) Pan, F.; Shu, C.; Ye, L.-W., Recent progress towards gold-catalyzed synthesis of N-containing tricyclic compounds based on ynamides. *Org. Biomol. Chem.* **2016**, *14*, 9456-9465. (e) Dodd, R. H.; Cariou, K., Ketenimines Generated from Ynamides: Versatile Building Blocks for Nitrogen - Containing Scaffolds. *Chem. Eur. J.* **2018**, *24*, 2297-2304. (f) Zhou, B.; Tan, T.-D.; Zhu, X.-Q.; Shang, M.; Ye, L.-W., Reversal of Regioselectivity in Ynamide Chemistry. *ACS Catal.* **2019**, *9*, 6393-6406.

(19) (a) Yang, J.; Wang, C.; Xu, S.; Zhao, J., Ynamide‐Mediated Thiopeptide Synthesis. *Angew. Chem. Int. Ed.* **2019**, *58*, 1382-1386. (b) Matsuoka, J.; Kumagai, H.; Inuki, S.; Oishi, S.; Ohno, H., Construction of the Pyrrolo[2,3-d]carbazole Core of Spiroindoline Alkaloids by Gold-Catalyzed Cascade Cyclization of Ynamide. *J. Org. Chem.* **2019,** *84*, 9358-9363. (c) Wen, H.; Cao, W.; Liu, Y.; Wang, L.; Chen, P.; Tang, Y., Metal-Free [2 + 2 + 2] Cycloaddition of Ynamide–Nitriles with Ynamides: A Highly Regio- and Chemoselective Synthesis of δ-Carboline Derivatives. *J. Org. Chem.* **2018,** *83*, 13308-13324. (d) Lin, L.; Zeng, X.; Xu, B., Synthesis of Z-Enamides through Heterogeneous Gold-Catalyzed Stereoselective Hydrogenation of Ynamides. *J. Org. Chem.* **2019,** *84*, 11240-11246. (e) Chen, C.; Cui, S., Iterative Assembly of Nitrile Oxides and Ynamides: Synthesis of Isoxazoles and Pyrroles. *J. Org. Chem.* **2019,** *84*, 12157-12164. (e) Jiang, C.; Yu, P.-P.; Zhang, Q.; Xu, H.-D.; Shen, M.-H., One-pot synthesis of tetrahydroindoles via a copper catalyzed N-alkynation/[4+2] cycloaddition cascade. *Chin. Chem. Lett.* **2019**, *30*, 266-268.

(20) (a) Habert, L.; Retailleau, P.; Gillaizeau, I., Rapid synthesis of 3-amino isocoumarin derivatives from ynamides. *Org. Biomol. Chem.* **2018**, *16*, 7351-7355. (b) Habert, L.; Sallio, R.; Durandetti, M.; Gosmini, C.; Gillaizeau, I., Zinc Chloride Mediated Synthesis of 3H‐Oxazol‐2‐one and Pyrrolo‐oxazin‐1‐one from Ynamide. *Eur. J. Org. Chem.* **2019**, *2019*, 5175-5179.

(21) Hu, L.; Xu, S.; Zhao, Z.; Yang, Y.; Peng, Z.; Yang, M.; Wang, C.; Zhao, J., Ynamides as Racemization-Free Coupling Reagents for Amide and Peptide Synthesis. *J. Am. Chem. Soc.* **2016**, *138*, 13135-13138.

(22) (a) Bisogno, T.; Maccarrone, M., Latest advances in the discovery of fatty acid amide hydrolase inhibitors. *Expert Opin. Drug Discov.* **2013,** *8*, 509-522. (b) Gattinoni, S.; De Simone, C.; Dallavalle, S.; Fezza, F.; Nannei, R.; Amadio, D.; Minetti, P.; Quattrociocchi, G.; Caprioli, A.; Borsini, F.; Cabri, W.; Penco, S.; Merlini, L.; Maccarrone, M., Enol Carbamates as Inhibitors of Fatty Acid Amide Hydrolase (FAAH) Endowed with High Selectivity for FAAH over the Other Targets of the Endocannabinoid System. *ChemMedChem* **2010,** *5*, 357-360.

(23) (a) Superchi, S.; Sotomayor, N.; Miao, G.; Joseph, B.; Campbell, M. G.;

Snieckus, V., α-Aryl O-vinyl carbamates. Tandem carbolithiation-α-alkylation and -[1, 2]-Wittig rearrangement reactions. *Tetrahedron Lett.* **1996,** *37*, 6061-6064. (b) Panella, L.; Feringa, B. L.; de Vries, J. G.; Minnaard, A. J., Enantioselective Rh-Catalyzed Hydrogenation of Enol Acetates and Enol Carbamates with Monodentate Phosphoramidites. *Org. Lett.* **2005,** *7*, 4177-4180. (c) Xu, L.; Li, B.-J.; Wu, Z.-H.; Lu, X.-Y.; Guan, B.-T.; Wang, B.-Q.; Zhao, K.-Q.; Shi, Z.-J., Nickel-Catalyzed Efficient and Practical Suzuki−Miyaura Coupling of Alkenyl and Aryl Carbamates with Aryl Boroxines. *Org. Lett.* **2010,** *12*, 884-887.

(24) (a) Han, P.; Mao, Z.-Y.; Si, C.-M.; Zhou, Z.; Wei, B.-G.; Lin, G.-Q., Stereoselective Synthesis of Pyrido- and Pyrrolo[1,2-c][1,3]oxazin-1-ones via a Nucleophilic Addition–Cyclization Process of N,O-Acetal with Ynamides. *J. Org. Chem.* **2019**, *84*, 914-923. (b) Wang, C.; Mao, Z.-Y.; Liu, Y.-W.; Wang, Q.-E.; Si, C.-M.; Wei, B.-G.; Lin, G.-Q., Stereoselective Intermolecular [4+2] Process of *N,O*-acetals with Terminal Alkynes for Construction of Functional *cis*-Pyrido and Pyrrolo[1,2-c][1,3]oxazin-1-ones. *Adv. Synth. Catal.* **2020**, DOI: 10.1002/adsc.201901141.

(25) Wang, X.-M.; Liu, Y.-W.; Ma, R.-J.; Si, C.-M.; Wei, B.-G., Synthesis of 1,4- and 1,5-Amino Alcohols via Nucleophilic Addition of Semicyclic N,O-Acetal with Organozinc Reagents. *J. Org. Chem.* **2019**, *84*, 11261-11267.

(26) (a) Fisher, M. J.; Overman, L. E., Intramolecular N-(acyloxy)iminium ion-alkyne cycloadditions. A new route to bicyclic .alpha.-amino ketones. *J. Org. Chem*. **1990**, *55*, 1447-1459. (b) Hanessian, S.; Tremblay, M.; Marzi, M.; Del Valle, J. R., Synthetic Studies in the Intramolecular Carbocyclization of N-Acyloxyiminium Ions. Stereoelectronic and Steric Implications of Nucleophilic Alkene, Alkyne, and Allene Tethers. *J. Org. Chem*. **2005**, *70*, 5070-5085. (c) Madelaine, C.; Valerio, V.; Maulide, N., Revisiting Keteniminium Salts: More than the Nitrogen Analogs of Ketenes. *Chem. Asian J.* **2011,** *6*, 2224-2239. (d) Lecomte, M.; Evano, G., Harnessing the Electrophilicity of Keteniminium Ions: A Simple and Straightforward Entry to Tetrahydropyridines and Piperidines from Ynamides. *Angew. Chem. Int. Ed.* **2016,** *55*, 4547-4551. (e) Evano, G.; Lecomte, M.; Thilmany, P.; Theunissen, C.,

Keteniminium Ions: Unique and Versatile Reactive Intermediates for Chemical Synthesis. *Synthesis* **2017,** *49*, 3183-3214.

(27) Taylor, N. J.; Emer, E.; Preshlock, S.; Schedler, M.; Tredwell, M.; Verhoog, S.; Mercier, J.; Genicot, C.; Gouverneur, V., Derisking the Cu-Mediated ^{18}F-Fluorination of Heterocyclic Positron Emission Tomography Radioligands. *J. Am. Chem. Soc.* **2017,** *139*, 8267-8276.

(28) Kraus, J. M.; Gits, H. C.; Silverman, R. B., High yielding allylation of a chiral secondary alcohol containing base sensitive functional groups. *Tetrahedron Lett.* **2012,** *53*, 1319-1322.

(29) Zhang, X.; Zhang, Y.; Huang, J.; Hsung, R. P.; Kurtz, K. C. M.; Oppenheimer, J.; Petersen, M. E.; Sagamanova, I. K.; Shen, L.; Tracey, M. R. Copper(II)-Catalyzed Amidations of Alkynyl Bromides as a General Synthesis of Ynamides and Z-Enamides. An Intramolecular Amidation for the Synthesis of Macrocyclic Ynamides. *J. Org. Chem.* **2006**, *71*, 4170−4177.