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Coinage Metals-Catalyzed Cascade Reactions of Aryl Alkynylaziridines: Silver(I)-Single vs Gold(I)-Double Cyclizations

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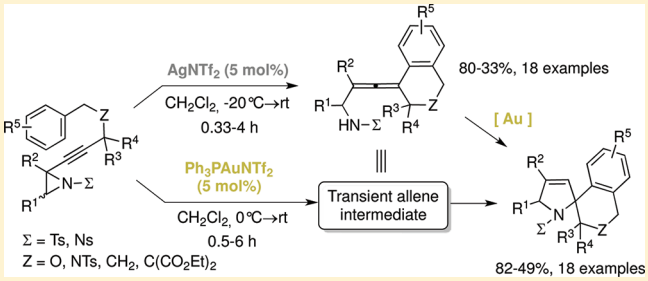
Supporting Information

ABSTRACT: Alkynylaziridines carrying an aryl group could be efficiently converted into aminoallenylidene isochromans, isoquinolines, or tetrahydronaphtalenes with silver(I) salts and into 1-azaspiro[4.5]decane derivatives with gold(I) complexes. Mechanistic investigations revealed that both Ag- and Au-catalyzed reactions involved a Friedel−Crafts type intramolecular reaction leading to an allene and that Au also rapidly promoted a second intramolecular cyclization of the aminoallene intermediate to the corresponding spiro derivative. Stereochemical investigations suggested an *anti*-SN_2'-type pathway for the first cyclization leading to a stereodefined allene, which could then be cyclized to the corresponding stereodefined spiro product. These results highlight the duality between oxo- or azaphilicity and alkynophilicity of Ag and Au as well as their complementarity in terms of reactivity.



INTRODUCTION

As metal, silver and gold have been known since ancient times and used for jewelry and ornaments and as coinage metals, with a special fascination for gold due to its bright-yellow color. From a chemical point of view, their historical use was far more recent, with a special emphasis on silver(I).[1] In the past decade, a fast reversal of tendency was noticed, especially in organic chemistry due to the (re)discovery of the strong relativistic effects[2] associated with gold conferring to its cations, gold(I) and (III), both π and σ Lewis acidities. Indeed, it has been shown at the beginning of the 21st century that gold salts exhibit higher catalytic activity, faster reaction rate and better yields under milder reaction conditions than silver salts.[3] More remarkably, gold salts also offer new reactivities such as rearrangements,[2] C−H activations,[4] cycloisomerizations[5] and, more recently, oxidative cross coupling reactions.[6]

The major drawback of gold salts compared to silver salts is unquestionably their prices, but sometimes, the strong catalytic activities of gold complexes could also be detrimental leading to unwanted byproduct. This high reactivity can be ascribed to the strong π and σ Lewis acidities of gold cations. Silver(I) also possesses these properties although to a lower extent.[7] This silver dual ability, that is, carbophilicity and oxo- or azaphilicity, has been demonstrated in the literature but not always recognized as such.[8] In contrast, the recent developments in gold organic chemistry were essentially based on alkyne, allene or alkene activation.

In our laboratory, we are interested in revealing such duality and exploiting it, especially in cascade reactions. Indeed, the presence of an alkyne and at least one heteroatom within the same structure offers the possibility of silver or gold cations to act as both π and σ Lewis acid, leading to new reactions. Thus, during the past four years, we have demonstrated that alkynyloxiranes or alkynylaziridines could lead to various interesting motifs (Scheme 1). Furans could be generated from alkynyl epoxides by treatment with either Ag(I) or Au(I) in the presence of an alcohol as cocatalyst.[9] Mechanistic studies revealed a cascade pathway, through an alcohol addition-cyclization-elimination process initiated by the σ Lewis acidity of gold or silver catalysts. The introduction at the propargylic position of an acyl group led to acyloxylated divinyl ketones, which are ideal candidates for a subsequent Nazarov reaction.[10] In this rearrangement, the ambivalent nature of coinage cations has been emphasized by recent theoretical mechanistic studies.[11] Performed in the presence of an external nucleophile, such as alcohol or thiol, these starting materials rearranged to substituted furans or pyrroles.[12] Switching to a different internal nucleophile, we very recently found that alkynyl aziridines bearing a benzyl group at the propargylic position were efficiently converted into 1-azaspiro[4.5]decane derivatives through most probably two successive cyclizations via aminoallene intermediates.[13]

In the present contribution, we report the extension of the latter gold(I)-catalyzed double cyclization cascade to new substrates and we also provide further insights into the mechanism allowing confirmation of it. Furthermore, we were able to stop the cascade at the first cyclization step using softer

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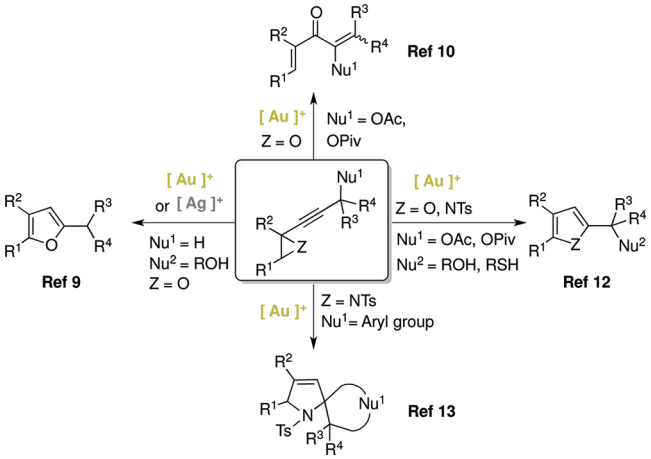
Scheme 1. Gold(I) or Silver(I)-Catalyzed Cascades Initiated by Intra- or Intermolecular Nucleophilic Addition on Alkynyl Epoxides or Aziridines



silver(I) salts. This led to a new synthesis of aminoallenes, which we also exemplify here.

RESULTS AND DISCUSSION

Substrate Preparation. Aryloxylated alkynylaziridines **1a–u** (see Table 2 for the nature of R_1, R_2, R_3, R_4 and R_5) were obtained in 3 or 4 steps using different strategies (Scheme 2). For compounds oxygenated at the propargylic position, the condensation of lithiated commercially available enynes[14] with aldehydes or ketones afforded enynols **A** in excellent yields (see Experimental Section for the nature of R_1, R_2, R_3 and R_4). Ethers and malonates derivatives **Ca,c–e,g,h,l,o–u** were prepared under classical conditions using the appropriate benzyl chloride or bromide derivatives, with yields routinely higher than 80% from **A** or **D**. Alternatively, the benzyl-protected propargylic alcohols **B** (see Experimental Section for the nature of R_3, R_4 and R_5) were engaged in Sonogashira reactions with iodo or bromoalkenes, giving the enyne ethers **Cf,m,n** in good to moderate yields mostly due to the formation of homocoupling byproduct. Enynes **Ci** and **Cj** were prepared by addition of the lithiated 3-benzyloxyprop-1-yne to respectively cycloheptanone and cyclooctanone, followed by elimination in the presence of phosphorus oxychloride. For all the enynes **Ca-t**, the final aziridination was best achieved using the reaction conditions described by Andersson,[15] affording the 2-(aryloxyprop-1-ynyl)aziridines **1a–u** with good to low yields depending on the substrate nature.

Gold-Catalyzed Double Cyclizations. As previously reported,[13] a rapid screening of simple gold complexes and salts revealed that the Gagosz's catalyst[16] in dichloromethane at room temperature was the most effective in rearranging 2-(3-benzyloxyprop-1-ynyl)-2-methyl-*N*-tosylaziridine **1a** (Table 1, entry 1) to the azaspiro[4.5] product **2a** in 70% yield. Other counterions, such as BF_4^-, OTf^- and SbF_6^-, led to lower yields (entries 2–4). Whatever the catalyst, two side products could be detected in ^1H NMR spectra of the crude mixtures, that is, the transient aminoallene intermediate **3a**, only detected as trace[17] (see Stereochemical Aspects and Mechanism section) and the pyrrole compound **4a**, observed in variable amounts (Table 1). The formation of the latter could be ascribed to the presence of water[9] contained in the silver salts used to *in situ* activate the precatalyst (Ph_3PAuCl). The already active and stable triphenylphosphinogold(I) triflimidate complex prevented the formation of **4a** by avoiding the chloride abstraction step with Ag salts (entry 1). To further optimize this rearrangement, gold(I) complexes, either with ligands of various size and electronic density or dinuclear, were prepared and evaluated as catalysts. The less electron donating phosphite complex **5** still efficiently catalyzed the reaction but gave slightly lower yield than the Gagosz catalyst (entry 5 vs 1; Figure 1). The family of bulky dialkylbiarylphosphine gold(I) complexes **6a–e**, known to be very efficient for various gold-catalyzed reactions,[18] was then examined. The rearrangement still occurred but more or less efficiently depending on the catalyst bulkiness (entries 6–10). Using the bulkiest catalysts **6a–c** (R^1 = *t*Bu), reaction completion required 2 h at reflux instead of 1 h at room temperature (entries 6–8 vs 1). Moderate yields of **2a** were thus achieved, with the concomitant formation of pyrrole **4a** and various unidentified byproduct. Decreasing steric hindrance by replacing *tert*-butyl with cyclohexyl substituents restored the catalyst activity. Indeed, a complete conversion was obtained in less than 1 h at room temperature (entries 9 and 10). For these catalysts, the hexafluoroantimonate counterion gave better results than the triflimidate, **6d** and **6e** furnishing the spiro[isochroman-4,2′-pyrrolines] in respectively 57 and

Scheme 2. Preparation of the Arylalkynyl Aziridine 1a–u

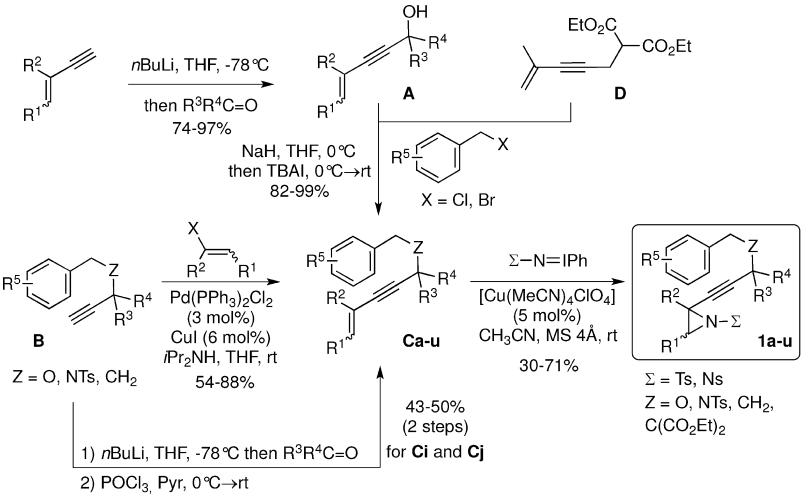


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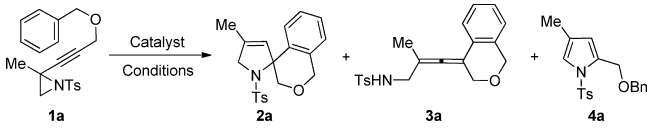
Table 1. Screening of Reaction Conditions for the Gold(I)-Catalyzed Transformation of Alkynylaziridine 1a



1a 2a 3a 4a

entry	catalyst (5 mol %)	conditions[a]	time (h)	yield 2a (%)	yield[b] 3a (%)	yield[b] 4a (%)
1	PPh_3AuNTf_2	CH_2Cl_2, 0 °C→r.t.	1	**70**		
2	PPh_3AuCl/AgOTf	CH_2Cl_2, 0 °C→r.t.	1	46		11
3	PPh_3AuCl/$AgBF_4$	CH_2Cl_2, 0 °C→r.t.	1	60		6
4	PPh_3AuCl/$AgSbF_6$	CH_2Cl_2, 0 °C→r.t.	1	62		3
5	**5**	CH_2Cl_2, 0 °C→r.t.	1	67	trace	
6	**6a**	CH_2Cl_2, r.t.→rfx	2	56		9
7	**6b**	CH_2Cl_2, r.t.→rfx	2	54		trace
8	**6c**	CH_2Cl_2, r.t.→rfx	2	58		10
9	**6d**	CH_2Cl_2, r.t.	0.75	57		6
10	**6e**	CH_2Cl_2, r.t.	0.5	**70**		trace
11	**7**	CH_2Cl_2, r.t.	15	55		34
12	**8**[c]	CH_2Cl_2, 0 °C→r.t.	1	56	trace	6

[a]Reactions run under argon, C = 0.1 mol/L. [b]Estimated yield on the ^1H NMR of the crude mixture; [c]2.5 mol % of catalyst was used (5 mol % in gold).

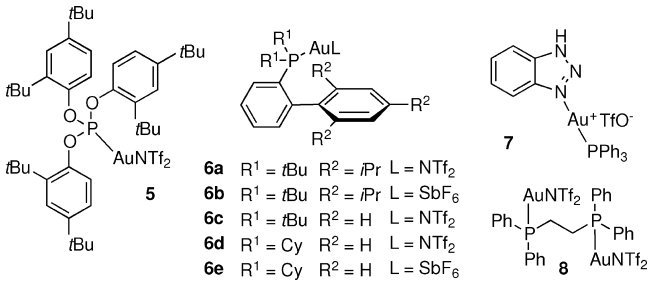


Figure 1. Structure of the gold catalysts screened.

70%. The stable and silver-free gold(I) triazolate complex[19] **7** proved to be far less reactive, requiring long reaction time (entry 11). Under these conditions, the spiro compound **2a** was obtained in moderate yield, together with a significant amount of pyrrole. Although as reactive as the most efficient catalysts, the dinuclear gold-complex **8** did not give any advantage (entry 12).

From the optimization studies, two catalysts, PPh_3AuNTf_2 and **6e**, appeared to be the most effective for the cycloisomerization reaction. Due to its handling convenience, the Gagosz catalyst was chosen for studying the scope of this rearrangement (Table 2), this choice also allowed to compare with our preliminary results.[13]

To explore the scope and limitations of the present cycloisomerization, various substrates exhibiting variations in nitrogen substitution, in substituents and in aryl group nature as well as in the linker between the aryl and alkynyl parts have been screened (Table 2). Switching from tosyl to nosyl aziridine to offer a more labile protecting group led to a slight decrease in yield together with a slightly longer reaction time (entry 1 vs 2). Such effects can easily be rationalized by the decrease in nitrogen nucleophilicity due to this modification. Steric hindrance at the propargylic position across the aziridine part was assessed with compounds **1c−e** (entries 3−6). The introduction of a single substituent (**1c**) led to the formation of 2 diastereoisomers in 1/1 ratio. Both reacted but with a dramatically reduced reaction time (from 1 to 16 h; entry 3 vs 1). However, the yield was improved in this case (77 vs 70%, entry 3 vs 1). This observation and reaction monitoring suggested that hindrance at the propargylic position slowed down the second cyclization. This hypothesis was confirmed by the rearrangement of compounds **1d** and **1e**. With such starting materials, the first cyclization proceeded but far more slowly (entries 4, 6 vs 1) due to the creation of neopentylic positions. The latter inhibited the next step and only the aminoallenes **3d** and **3e** were isolated, with respectively 60 and 74% despite the prolonged contact time (entries 4 and 6). Nevertheless, switching to the Echavarren catalyst **6e** allowed to go further and in the case of **1d**, the azaspiro product **2d** could be formed in high yield although with a long reaction time (entry 5).[20] The latter results highlighted the complementarity between the Gagosz and Echavarren catalyst **6e**, while revealing the higher reactivity of the latter.

Substitutions at the aziridine part did not have such strong influence (entries 9−12), except in the case of the *gem*-disubstituted aziridine **1f**. Introduction of large substituent at the *gem*-position of aziridine indeed led to poor yield under standard conditions (entry 7 vs 1), as expected from a possible transition state for the first cyclization in which such substituent would hamper Au coordination (see the mechanistic section). Once again, the use of **6e** significantly increased the isolated amount of azaspiro **2f** (entry 8 vs 7).

Trisubstituted aziridines efficiently furnished the double-cyclization products in good to high yields under standard conditions, but as mixtures of diastereoisomers with variable ratios (entries 9−12). The relative stereochemistry of the corresponding spiro products was established by NOE NMR experiments (**2g** and **2j**) or from X-ray Diffraction (**2h**). Interestingly, the *cis* aziridine **1g** mostly gave the *trans* product (entry 9),[21] while the bicyclic aziridines **1h−j** mostly gave the *cis* products, although in different ratios, from 1:1 to 5:1 (entries 10−12). These trends strongly suggested a common but stereocontrolled process (see the Stereochemical and Mechanistic section). It is noteworthy that mono- and *cis* or *trans*-disubstituted alkynylaziridines could not be compared as substrates due to problems in their syntheses, notably at the final aziridination step.

The introduction of different linkers between the alkynylaziridine and aryl parts of the substrate (Z = NTs, CH_2, $C(CO_2Et)_2$ instead of O) did not impair the cyclization cascade and afforded the expected 1-azaspiro[4.5]decane derivatives in good yields (entries 13−15). It is worth mentioning the significant improvement brought by a *gem*-dicarboxylate motif, probably due to Thorpe-Ingold effect (entry 14 vs 13 and 15). However, the reduction of the aliphatic chain from 3 to 2 carbons exclusively yielded the pyrrole **4n** instead of the expected azaspiro[4.4]nonane derivative (entry 16 vs 15).

Effects of aromatic substitution were then investigated with compounds **1o−r** carrying either one electron donating or one

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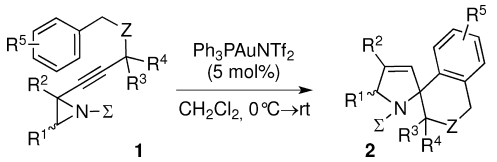
Table 2. Scope of the Gold(I)-Catalyzed Transformation of Various Aryl Alkynylaziridines



1 2

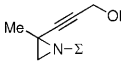
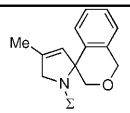
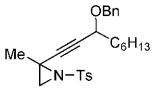
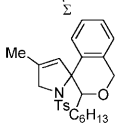
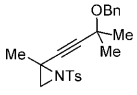
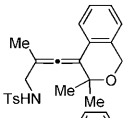
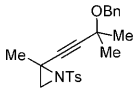
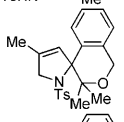
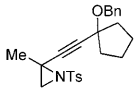
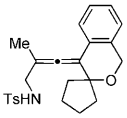
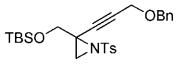
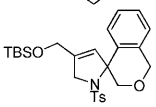
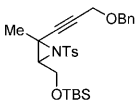
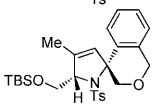
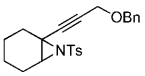
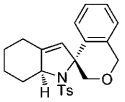
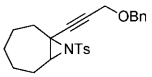
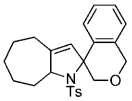
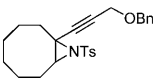
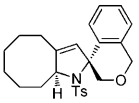
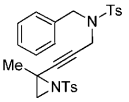
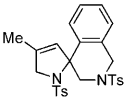
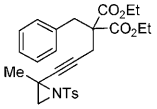
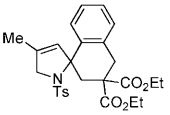
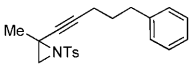
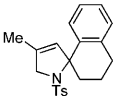
Entry	Aryl Alkynylaziridines		Products		Time (h)	Yields (%)
1		Σ = Ts **1a**		**2a**	1	70
2		Σ = Ns **1b**		**2b**	1.5	60
3		**1c**	 *dr* 1:1	**2c**	16	77
4		**1d**		**3d**	24	60
5		**1d**		**2d**	24	68[a]
6		**1e**		**3e**	24	74[b]
7		**1f**		**2f**	1.5	36
8					1	60[a]
9		**1g**	 *dr* 2:1	**2g**[c]	2	74
10		**1h**	 *dr* 3:1	**2h**[c]	1.5	67
11		**1i**	 *dr* 1:1	**2i**	3	66
12		**1j**	 *dr* 5:1	**2j**[c]	5	77
13		**1k**		**2k**	1.5	68
14		**1l**		**2l**	0.5	74
15		**1m**		**2m**	1	72

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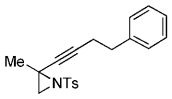
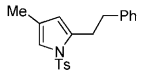
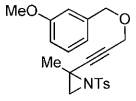
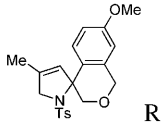
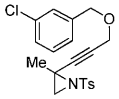
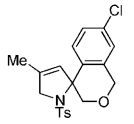
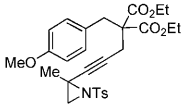
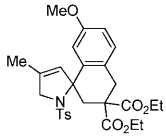
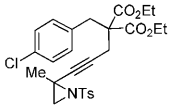
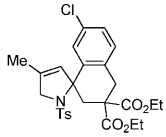
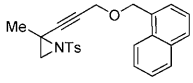
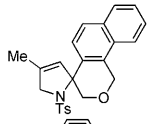
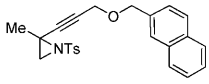
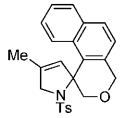
Table 2. continued

Entry	Aryl Alkynylaziridines		Products		Time (h)	Yields (%)
16		**1n**		**4n**	2	58
17		**1o**	 Regioisomers 5.6:1	**2o**[c]	0.5	80
18		**1p**	 Regioisomers 1.8:1	**2p**[c]	3	26[d]
19		**1q**		**2q**	5[e]	61
20		**1r**		**2r**	5[e]	49
21		**1s**		**2s**	0.5	82
22		**1t**		**2t**	1.5	78

[a]Reaction run with 5 mol % of **6e**. [b]Catalyst **6e** failed to give the azaspiro compound. [c]Only the major isomer was represented. [d]35% of pyrrole was observed on the ^{1}H NMR of the crude mixture; [e]Performed at reflux.

electron-withdrawing group (**1o,q** R^5 = OMe and **1p,r** R^5 = Cl, respectively) (entries 17−20). As expected, a strong effect was observed with such substituents at the *meta* position (entries 17−18). For the methoxy compound **1o**, a fast reaction was observed giving the corresponding spiro compound **2o** with an excellent yield of 80% and a good regioselectivity in favor of the less strain product **2o** (entries 17). With the deactivated chloro substrate **1p**, the azaspiro derivative **2p** was obtained in poor yield and low regioselectivity, together with a significant amount of unstable pyrrole (entries 18). To avoid the formation of regioisomers, *para* substituted arylalkynylaziridines were prepared and examined. Not so surprisingly, with reaction kinetic drastically decreased for both substrates and even under reflux, 5 h were required to reach full conversion (entries 19 and 20). Interestingly, when the 1- or 2-naphtyl group was introduced into the substrate, a single spiro product was produced with high yields (entries 21 and 22). The 1-naphtyl derivative **1s** was rapidly and very efficiently rearranged, while the 2-naphtyl **1t** required longer time and gave the spiro **2t** with a slightly lower yield.

Silver-Catalyzed Single Cyclization. Monitoring the evolution of these gold−catalyzed reactions revealed the appearance and disappearance of an intermediate product, which could be isolated in a few cases (entries 4 and 6, Table 2). The latters revealed an allenic structure, suggesting the transient allene formation in each Au-catalyzed cycloisomerization of alkynylaziridines. To validate this hypothesis, and to isolate some of these intermediates, we explored the reactivity of silver salts toward alkynylaziridines. Since silver salts and complexes are usually less active as catalysts than their gold analogs, we expected to slow the cascade process and produce more efficiently this intermediate.

Our model compound **1a** was thus submitted to various silver salts (Table 3). The most electrophilic of them, silver hexafluoroantimonate, led to degradation at room temperature (entry 1). However, other salts gave at room temperature the same transformation as gold catalysts, but in very slow reactions (24 h vs 1 h; Table 3, entries 2−4 vs Table 1, entries 1−4). During this reaction, both the spiro compound and the intermediate were observed but the latter was produced earlier and slowly disappeared. Rewardingly, stopping the reaction catalyzed by silver triflimide after just one hour at −20 °C allowed to exclusively form the allene **3a** in 55% yield (entry 5). Spectroscopic analysis confirmed the expected allenylidenyl isochroman **3a** structure of this compound. Other silver salts also gave the allene **3a** but with the concomitant formation of pyrrole **4a**, probably due to the presence of water as contaminant in these Ag salts, more hygroscopic than the triflimide (entries 5−7). Using $AgSbF_6$ as catalyst only gave the pyrrole **4a**, although in modest yield (entry 8).

The allenylidenyl isochroman **3a** motif is so far unreported in the literature and thus, the present new Ag-catalyzed cyclization

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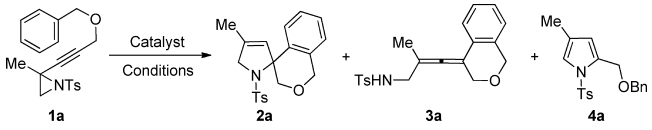
Table 3. Screening of Reaction Conditions for the Silver(I)-Catalyzed Transformation of Alkynylaziridine 1a



1a 2a 3a 4a

entry	catalyst (5 mol %)	conditions[a]	time (h)	yield 2a (%)	yield 3a (%)	yield 4a (%)
1	$AgSbF_6$	CH_2Cl_2, 0 °C→r.t.	24	-[b]	-[b]	-[b]
2	$AgNTf_2$	CH_2Cl_2, 0 °C→r.t.	24	54	trace	-
3	AgOTf	CH_2Cl_2, 0 °C→r.t.	24	48	12	trace
4	$AgBF_4$	CH_2Cl_2, 0 °C→r.t.	24	41	9	trace
5	$AgNTf_2$	CH_2Cl_2, −20 °C	1	trace	**55**	-
6	AgOTf	CH_2Cl_2, −20 °C	1	trace	54	10
7	$AgBF_4$	CH_2Cl_2, −20 °C	1	trace	52	4[c]
8	$AgSbF_6$	CH_2Cl_2, −20 °C	3	trace	trace	34

[a]Reactions run under argon, C = 0.1 mol/L. [b]Degradation occurs leading to unidentified byproduct. [c]Calculated yield from the ^{1}H NMR spectrum of the crude mixture.

could open the way to the synthesis of this new family of compounds. To substantiate such idea, this Ag-promoted rearrangement was further investigated. Its scope was thus explored with the substrates **1a−t** (Table 4).

As observed for the gold-catalyzed double cyclization, the presence of a more electron-withdrawing group at the aziridine nitrogen favored the first opening-cyclization step and disfavored the following cyclization, due to the formation of a less nucleophilic amine. A nosyl group indeed significantly increased the allene yield compared to a tosyl group (entry 2 vs 1).

As already observed with Au catalysts, hindering the cyclization site could slow down the hydroamination step. Aziridines of increasing substitution at the propargylic position indeed gave the corresponding allene with increasing yields (entries 3−5). No significant difference was observed with a single substituent (entry 3 vs 1), but with two simple methyl groups, the apparition of the spiro compound resulting from the second cyclization was markedly delayed and the allene **3d** was thus isolated with higher yield (entry 4 vs 1). A cyclic substituent was even more efficient (entry 5 vs 4 vs 1). The presence of a bulky group (TBS) spatially closed to coordination sites slowed down the rate and gave lower yield (entry 6) but did not alter the reaction when remote from the coordination sites (entry 7). Bicyclic aziridines furnished the corresponding allene in good to high yields depending on the ring size (entries 8−10). Surprisingly, it was necessary to perform the reaction at higher temperature for the azabicycloheptane and -octane systems (entries 9−10 vs 1).

Interestingly, the Ag-cyclization of aziridines **1c**,**1g−j** gave diastereomeric mixtures of allenes **3c**, **3g−j** in unequal amounts, suggesting a stepwise formation although a non-equivalent consumption of allenes in the subsequent cyclization step cannot be ruled out (entries 7−8 and 10 vs 9). These diastereoisomeric ratios were identical to those obtained in the Au-catalyzed cascade reaction.

As for the gold-catalyzed reaction, variation of the connecting (Z in Table 4) part between the alkyne function and aryl parts in the starting materials afforded other allenylidene derivatives (entries 11−15).

Substituting the oxygen atom by nitrogen improved rate and yield (entry 11 vs 1), affording the allenylidenyl tetrahydroisoquinoline **3k**. The introduction of a carbodiester moiety in **1l** had a beneficial impact on the reaction, which became faster and gave higher yield. The analog but simpler **1m** did not beneficiate from this improvement, suggesting the key role of the Thorpe-Ingold effect brought by the gem-diester motif (entry 13 vs 12).

As expected, the *meta*-methoxy substituted **1o** proved very reactive, even at low temperature and provided the allenes **3o** in the same 5.6/1 ratio as the one obtained in gold-catalyzed reaction but with several unidentified byproduct (entry 14). In contrast, and as expected, the *meta*-chloro analog **1p** did not readily react and even at reflux, only small amount of the allene **3p** could be observed among unidentified byproduct (entry 15). A mixture of regioisomeric cyclization products was formed with a ratio close to 1. As for the Au-catalyzed cascade, the corresponding *para*-substituted analogs produced lower amounts of aminoallenes, but significant amounts of pyrroles (entries 16 and 17).

As for the Au-catalyzed cascade, aromatic groups other than phenyl could also be involved in this silver-catalyzed rearrangement. Naphtyl derivatives **1s−t** indeed gave the corresponding allenes in good yields (entries 18 and 19). Whatever the naphtyl connectivity, the reactions were faster and the allenes **3s−t** were obtained as single regioisomers.

As showed, the present Ag-catalyzed cyclization thus provided a convenient access to various new types of compounds, that is, allenylidenyl isochroman, isoquinoline[22] or tetrahydronaphtalene.

Mechanism and Stereochemical Aspects. Both set of results showed that the above-described Au- and Ag-catalyzed cycloisomerizations most probably proceeded through the same mechanism.

To confirm this hypothesis and to clearly identify the intermediate compound in the Au-catalyzed cascade, the reaction of the aziridine **1a** was run in a NMR tube at −70 °C in the presence of PPh_3AuNTf_2 and the evolution of **1a** was monitored by NMR upon warming (see Figure 2 in Supporting Information). After only 10 min at −70 °C, the characteristic protons of **1a** (red arrows on spectrum **a**) had already disappeared (spectrum **b**). After an additional 10 min and warming to −40 °C, total conversion was reached and the intermediate was clearly the major product (spectrum **c**). The latter could be unambiguously attributed to the allene **3a** by comparison with a sample of **3a** obtained by the silver-catalyzed rearrangement (see Table 4, entry 1). Between −40 and −20 °C, no evolution was noticed, but warming the mixture above −20 °C slowly promoted further transformation and new peaks emerged from the baseline (spectrum **e**). Warming up to 0 °C clearly showed that this evolution occurred in favor of the spiro compound **2a** (spectrum **f**). The presence of a vinylic proton (green arrow in spectrum **j**) and of three AB systems (blue, red and orange arrows in spectrum **j**) was indeed typical of this azaspiro structure. Finally, after 2 h at 0 °C, the consumption of **3a** was completed and the product **2a** was cleanly produced (spectrum **j**).

To get more insight into the mechanism, we focused on reactions providing mixture of diastereoisomers. In some cases, the same starting aziridine was converted by the Au- or Ag-cycloisomerization into the corresponding 1-azaspiro[4.5]-decane or aminoallene derivatives as mixture of diastereoisomers (Table 2, entries 9−12 and Table 4, entries 7−

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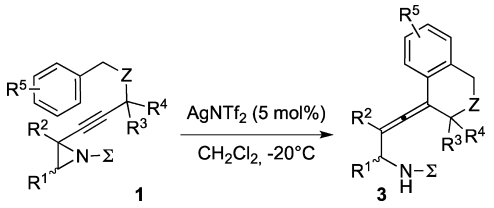
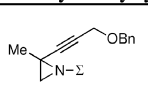
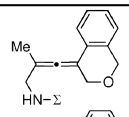
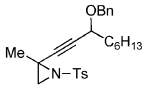
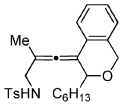
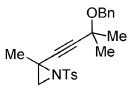
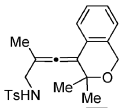
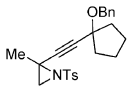
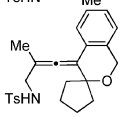
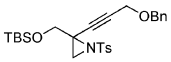
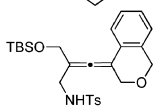
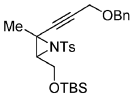
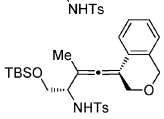
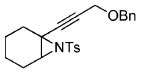
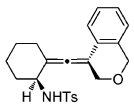
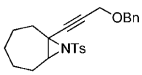
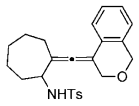
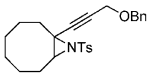
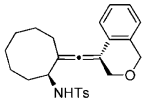
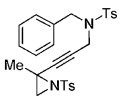
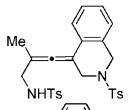
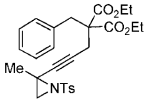
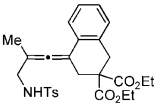
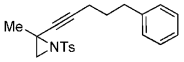
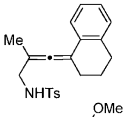
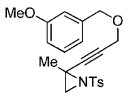
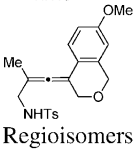
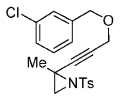
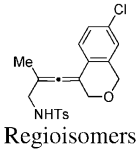
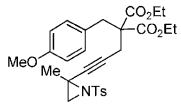
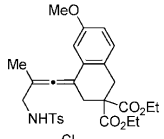
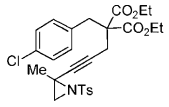
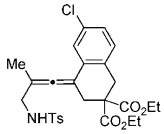
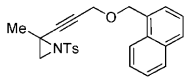
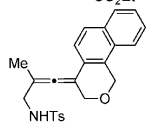
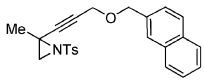
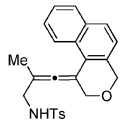
Table 4. Scope of Silver(I)-Catalyzed Aminoallene Formation



Entry	Aryl Alkynylaziridines		Allenes		Time (h)	Yields (%)[a]
1	 Σ = Ts	**1a**		**3a**	0.75	55
2	Σ = Ns	**1b**		**3b**	0.75	68
3		**1c**	 *dr* 1:1	**3c**	0.75	50
4		**1d**		**3d**	0.75	61
5		**1e**		**3e**	0.75	74
6		**1f**		**3f**	1.5	44
7		**1g**	 *dr* 2:1	**3g**	1	60
8		**1h**	 *dr* 3:1	**3h**	4	71
9		**1i**	 *dr* 1:1	**3i**	4[c]	59
10		**1j**	 *dr* 4:1	**3j**	2[c]	52
11		**1k**		**3k**	0.75	80
12		**1l**		**3l**	0.75[b]	71
13		**1m**		**3m**	0.75	52
14		**1o**	 Regioisomers 5.6:1	**3o**	0.33	54[d]

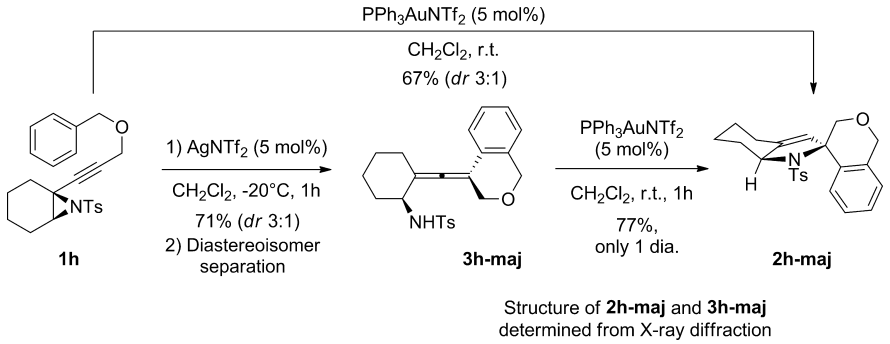
dx.doi.org/10.1021/jo300294r | J. Org. Chem. 2012, 77, 4323−4341

Table 4. continued

Entry	Aryl Alkynylaziridines		Allenes		Time (h)	Yields (%)[a]
15		**1p**	 Regioisomers 1.8:1	**3p**	1[c]	33[d]
16		**1q**		**3q**	0.33	50[e]
17		**1r**		**3r**	0.33	33[d,e]
18		**1s**		**3s**	0.33	66
19		**1t**		**3t**	0.75	56

[a]Spiro derivatives **2** were also detected in some cases. [b]Performed at −60 °C. [c]Performed at reflux. [d]NMR yields; degradation occurs leading to unidentified byproduct. [e]Pyrroles were also isolated with 10% and 34% yields for respectively entriy 14 and 15.

Scheme 3. Evidences for the Stereochemical Course of the Gold(I) and Silver(I) Rearrangements of 1h



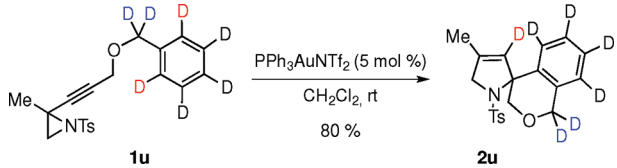
10). Depending on the starting materials, variable ratios were observed but with a perfect correlation between the allene and the spiro products. For example, from the racemic aziridine **1h**, the silver-mediated process gave the allene **3h** with a 3 to 1 *dr* and the gold-catalyzed reaction gave the azaspiro compound **2h** with an identical ratio (Scheme 3). This correlation was clearly substantiated by the NMR monitoring results and suggested that the stereochemical outcome at the allene stage was further transferred into the spiro structure.

To check this assumption, the major diastereoisomer of **3h** (**3h-maj**) was isolated from the mixture of diastereoisomers and resubmitted to the gold-catalyzed cyclization conditions. As suspected, this single allene diastereoisomer gave a single spiro diastereoisomer, which corresponded to the major isomer (**2h-maj**) observed in the direct reaction from **1h** (Scheme 3). Furthermore, we were able to crystallize both compounds (**2h-maj** and **3h-maj**) and thus, the relative configurations of each could be assigned from their respective X-ray diffraction patterns (see Supporting Information).[23]

These data confirmed the two-steps sequence of the Au-catalyzed reaction initiated by an intramolecular Friedel−Crafts type reaction[24] and followed by hydroamination[25] of the aminoallene transient intermediate. They also confirmed that the stereochemical course of the whole cascade was determined at the first step.

To get further insights into this key step, common to the Au- and Ag-catalyzed cycloisomerizations, we prepared the perdeuterated compound **1u** and monitored the deuterium labeling into the products (Scheme 4). In Friedel−Crafts type

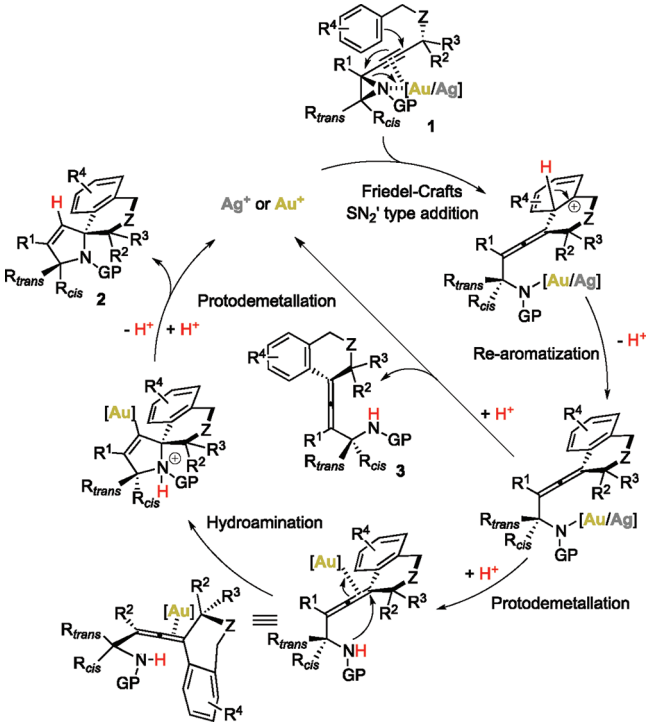
Scheme 4. Deuterium Distribution in Product 2u from Labeled Compound 1u



dx.doi.org/10.1021/jo300294r | J. Org. Chem. 2012, 77, 4323−4341

reaction, a proton/deuterium should be lost, but the latter should be then involved into protodemetalation[26] during Ag- or Au-mediated reactions (Scheme 5). In the Ag-catalyzed

Scheme 5. Mechanism and Stereochemistry for the Ag(I) or Au(I)-Catalyzed Cascade Reaction of Arylalkynyl Aziridine



reaction, this proton/deuterium would end up at the sulfonyl amine group and being thus quite labile, it should be mostly lost due to workup, while in the Au-catalyzed reaction, it could be transferred, at least in part, into the pyrroline moiety. This was actually the case. Deuterium labeling was indeed found at the expected vinylic position of the pyrroline ring in the Au-catalyzed reaction (Scheme 4).

All these results clearly established the two-step mechanism, with an intramolecular Friedel–Crafts type reaction and a hydroamination of the intermediate allene (Scheme 5).

For both coinage-metal-catalyzed rearrangements, the stereochemical outcomes showed that an *anti*-addition pathway (SN_2')[27] mostly occurred at the first intramolecular Friedel–Crafts step (Scheme 5). This pathway allowed to rationalize the stereochemical relationship between the allenes **3** and the spiro derivatives **2**, since a Friedel–Crafts cyclization more or less concerted with an *anti*-opening of the aziridine part would led to an allene of defined stereochemistry, which could only cyclize further to a single spiro product. The *cis/trans* relationships observed from the aziridine to the spiro compounds (see Table 2, entries 9 vs 10–12 and comments) could also be understood through this SN_2' pathway. It also explained the production of diastereoisomers starting from the *cis* aziridine **1g** and from the bicyclic aziridines **1h–j**. Depending on steric hindrance (for **1g** R^1_{cis} in Scheme 5), on the ring size and strain due to conformations[28] (for **1h–j** R^1_{trans}, R^1–R^2 = $-(CH_2)_{3-5}-$ in Scheme 5), the *anti*-conformation leading to the Wheland intermediate of the Friedel–Crafts cyclization might be difficult to achieve and nonconcerted pathways could become competitive.

CONCLUSION

In the present work, we demonstrated the stereoselective formation of aminoallenylidene isochromans, isoquinolines or tetrahydronaphtalenes with silver(I) salts as catalyst and of 1-azaspiro[4.5]decane derivatives with gold(I) complexes as catalysts from alkynylaziridines carrying an aryl group. Mechanistic investigations showed that both Ag- and Au-catalyzed reactions involved a Friedel–Crafts type intramolecular reaction leading to an allene and that Au also rapidly promoted the further cyclization of the aminoallene intermediate to the corresponding spiro derivative. Stereochemical investigations suggested an *anti*-SN_2'-type pathway for the first cyclization leading to a stereodefined allene, which could then be cyclized to the corresponding stereodefined spiro product.

These results highlight the duality between oxo- or azaphilicity and alkynophilicity of silver and gold catalysts and their complementarity in term of reactivity.

EXPERIMENTAL SECTION

General Information. Proton (^{1}H NMR) and carbon (^{13}C NMR) nuclear magnetic resonance spectra were recorded on 300, 400, or 500 MHz instruments. Chemical shifts are given in part per million (ppm) on the delta scale. Solvent peaks were used as reference values, with $CDCl_3$ at 7.26 ppm for ^{1}H NMR and 77.23 ppm for ^{13}C NMR. Data are presented as followed: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, m = multiplet), integration and coupling constants (J in Hz). Assignments were determined on the basis of either unambiguous chemical shifts or coupling patterns, and of COSY, HMQC, HMBC, ROESY experiments when required. Infrared spectra were recorded neat. Wavelengths of maximum absorbance (ν_{max}) are quoted in wave numbers (cm^{-1}). Mass spectra were recorded by ElectroSpray Ionization (ESI). The parent ions $[M + H]^+$, $[M + Na]^+$ or $[M + Li]^+$ are quoted. Analytical Thin Layer Chromatographies (TLC) were carried out on silica gel 60 F_{254} plates with visualization by ultraviolet, potassium permanganate or Ceric Ammonium Molybdate (CAM) dip. Flash column chromatography was carried out using silica gel 60 (40–63 μm) and the procedure included the subsequent evaporation of solvents *in vacuo*. Reagents and solvents were purified using standard means. Dichloromethane (CH_2Cl_2) and acetonitrile (CH_3CN) were distilled from CaH_2 under an argon atmosphere; THF was distilled from sodium metal/benzophenone. AuCl (*Premion* grade, 99.99%), $AuCl_3$ (99.9%) and $NaAuCl_4.2H_2O$ (*Premion* grade, 99.99%) were purchased from Alfa Aesar whereas $AgSbF_6$ (98%), AgOTf (99%), $AgBF_4$ (99%), Ag_2CO_3 (99%+) and AgCl (99.9%) were purchased from STREM Chemicals. $AgNTf_2$ was prepared from commercially available $HNTf_2$ and Ag_2CO_3.[29] All phosphinegold(I) chloride precatalysts were prepared by reduction of $NaAuCl_4$ with thiodiethanol and subsequent addition of the appropriate phosphine.[30] Silver-free preactivated catalysts were prepared either from the corresponding phosphinegold chloride and $AgSbF_6$ in acetonitrile[31] or $AgNTf_2$ in CH_2Cl_2 and filtration over a short pad of silica gel.[16] All other chemicals were used as received. All other extractive procedures were performed using technical solvents and all aqueous solutions used were saturated.

General Procedure 1 for the Gold-catalyzed Conversion of Alkynylaziridines to 1-Azaspiro[4,5]decane Derivatives. To a solution cooled at 0 °C of alkynylaziridine (0.1 mmol) in CH_2Cl_2 (1 mL) was added $Ph_3PAuNTf_2$ (0.005 mmol). The resulting mixture was allowed to warm at room temperature. Monitored by thin-layer chromatography, the reaction was stirred until complete conversion of both the starting material and allene intermediate. After concentration of the reaction mixture, the crude residue was purified by flash chromatography (Cyclohexane/EtOAc).

4′-Methyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2a**). Prepared following the general procedure 1 in 70% yield (35 mg)

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from 50 mg of **1a**. Colorless oil; R_f = 0.18 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2924, 2849, 1448, 1337, 1157, 1092, 814, 760, 710, 698, 577, 543; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.75 (dd, 3 H, J = 1.4 Hz), 2.40 (s, 3 H), 3.91 (d, 1 H, J_{ab} = 10.8 Hz), 4.14 (d, 1 H, J_{ab} = 13.1 Hz), 4.25 (d, 1 H, J_{ab} = 13.0 Hz), 4.61 (d, 1 H, J_{ab} = 10.8 Hz), 4.72 (d, 1 H, J_{ab} = 14.4 Hz), 4.91 (d, 1 H, J_{ab} = 14.4 Hz), 5.54−5.59 (m, 1 H), 6.90−7.09 (m, 3 H), 7.15 (dd, 1 H, J = 7.2, 1.5 Hz), 7.19 (d, 2 H, J = 8.3 Hz), 7.49 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.5, 58.8, 68.7, 72.9, 73.4, 123.9, 126.8, 127.1, 127.4, 127.6, 129.2, 129.7, 131.4, 134.6, 136.6, 137.3, 143.0; HR-MS 362.144 ($C_{20}H_{21}NO_3S$+Li, calcd 362.140).

*4′-Methyl-1′-(4-nitrophenylsulfonyl)-1′,5′-dihydrospiro-[isochroman-4,2′-pyrrole] (**2b**).* Prepared following the general procedure 1 in 60% yield (30 mg) from 50 mg of **1b**. Pale-yellow solid: mp =164−165 °C; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3103, 2918, 2851, 1529, 1347, 1158, 1090, 948, 852, 738, 688, 608, 554, 459; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.76−1.84 (m, 3 H), 3.91 (d, 1 H, J_{ab} = 11.3 Hz), 4.29 (s, 2 H), 4.51 (d, 1 H, J_{ab} = 11.3 Hz), 4.71 (d, 1 H, J_{ab} = 14.7 Hz), 4.92 (d, 1 H, J_{ab} = 14.7 Hz), 5.45−5.53 (m, 1 H), 6.74 (d, 1 H, J = 7.4 Hz), 6.92 (t, 1 H, J = 7.4 Hz), 7.02 (d, 1 H, J = 7.4 Hz), 7.18 (dt, 1 H, J = 1.0 Hz, 7.4 Hz), 7.69 (d, 2 H, J = 8.8 Hz), 8.18 (d, 2 H, J = 8.8 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.9, 59.2, 68.6, 72.8, 73.4, 123.8, 124.2, 126.6, 126.8, 127.7, 129.0, 132.1, 135.1, 135.3, 145.6, 149.7; HR-MS 409.080 ($C_{19}H_{18}N_2O_5S$+Na, calcd 409.083).

*3-Hexyl-4′-methyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2c**).* Prepared following the general procedure 1 in 77% yield (77 mg, *dr* 1:1) from 100 mg of **1c**. Mixture of diastereoisomers: IR (neat) ν_{max} 2959, 2848, 1447, 1335, 1156, 1094, 763, 720, 669, 579, 545; HR-MS 462.204 ($C_{26}H_{33}NO_3S$+Na calcd 462.208). Diastereoisomer 1: Colorless oil; R_f = 0.48 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.88 (t, 3 H, J = 6.9 Hz), 1.10−1.38 (m, 8 H), 1.56 (s, 2 H), 1.76 (d, 3 H, J = 1.3 Hz), 2.41 (s, 3 H), 4.11 (d, 1 H, J_{ab} = 13.0 Hz), 4.30 (d, 1 H, J_{ab} = 13.0 Hz), 4.39 (dd, 1 H, J = 8.9 Hz, 2.5 Hz), 4.77 (d, 1 H, J_{ab} = 14.4 Hz), 4.94 (d, 1 H, J_{ab} = 14.4 Hz), 5.39 (q, 1 H, J = 1.5 Hz), 6.99−7.03 (m, 3 H), 7.12−7.20 (m, 1 H), 7.22 (d, 2 H, J = 8.3 Hz), 7.52 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 14.1, 21.5, 22.7, 26.4, 29.6, 30.5, 31.2, 59.2, 69.2, 80.5, 123.6, 126.7, 126.9, 127.2, 127.6, 127.7, 129.3, 131.2, 134.5, 137.6, 138.4, 143.0. Diastereoisomer 2: Colorless oil; R_f = 0.45 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.88 (t, 3 H, J = 6.8 Hz), 1.10−1.37 (m, 8 H), 1.56 (s, 2 H), 1.84 (d, 3 H, J = 1.3 Hz), 2.35 (s, 3 H), 3.43 (dd, 1 H, J = 9.5 Hz, 2.2 Hz), 4.13 (d, 1 H, J_{ab} = 13.4 Hz), 4.28 (d, 1 H, J_{ab} = 13.4 Hz), 4.73 (d, 1 H, J_{ab} = 15.4 Hz), 5.00−5.07 (m, 1 H), 5.05 (d, 1 H, J_{ab} = 15.4 Hz), 6.84 (d, 1 H, J = 7.3 Hz), 6.95 (t, 1 H, J = 7.1 Hz), 7.14−7.23 (m, 1 H), 7.21 (t, 2 H, J = 6.2 Hz), 7.26 (d, 2 H, J = 8.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 14.1, 21.4, 22.7, 26.4, 29.2, 29.4, 31.9, 60.2, 68.1, 74.5, 81.5, 123.7, 126.2, 127.1, 127.6, 128.7, 128.9, 134.2, 135.6, 135.9, 137.8, 142.2.

*3,3,4′-Trimethyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2d**).* Prepared following the general procedure 1 in 70% yield (35 mg) from 50 mg of **1d** using catalyst **6e** instead of $Ph_3PAuNTf_2$. Colorless oil; R_f = 0.21 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2983, 2921, 2844, 1447, 1343, 1156, 1093, 1039, 907, 814, 726, 686, 532, 543; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.17 (s, 3 H), 1.21 (s, 3 H), 1.65 (s, 3 H), 2.35 (s, 3 H), 4.07 (d, 1 H, J_{ab} = 13.8 Hz), 4.21 (d, 1 H, J_{ab} = 13.8 Hz), 4.86 (d, 1 H, J_{ab} = 15.6 Hz), 5.04 (d, 1 H, J_{ab} = 15.6 Hz), 5.14 (q, 1 H, J = 1.6 Hz), 6.92−6.97 (m, 1H), 6.98−7.06 (m, 2H), 7.06 (d, 2H, J = 8.6 Hz), 7.16 (d, 2H, J = 8.6 Hz), 7.21−7.29 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.2, 21.4, 21.7, 24.0, 30.2, 30.9, 59.8, 62.9, 123.2, 126.0, 126.2, 127.6, 127.7, 128.7, 129.1, 132.5, 136.3, 136.4, 137.7, 142.2; HR-MS 406.143 ($C_{22}H_{25}NO_3S$ + Na, calcd 406.145).

*4′-(((tert-Butyldimethylsilyl)oxy)methyl)-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2f**).* Prepared following the general procedure 5 in 60% yield (30 mg) from 50 mg of **1f**. Colorless oil; R_f = 0.27 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2954, 2927, 2855, 1462, 1338, 1253, 1158, 1094, 835, 777, 731, 667, 598, 545; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.03 (s, 3H), 0.04 (s, 3H), 0.87 (s, 9H), 2.40 (s, 3H), 3.94 (d, 1H, J_{ab} = 11.0 Hz), 4.23 (s, 2H), 4.24 (d, 1H, J_{ab} = 13.4 Hz), 4.35 (d, 1H, J_{ab} = 13.4 Hz), 4.62 (d, 1H, J_{ab} = 11.0 Hz), 4.74 (d, 1H, J_{ab} =14.7 Hz), 4.93 (d, 1H, J_{ab} = 14.7 Hz), 5.70−5.77 (m, 1H), 6.89−6.96 (m, 1H), 6.97−7.04 (m, 2H), 7.16−7.27 (m, 1H), 7.19 (d, 2H, J = 8.3 Hz), 7.48 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.3, 18.3, 21.5, 25.8, 55.7, 60.1, 68.8, 72.7, 73.2, 124.0, 126.9, 127.3, 127.5, 127.7, 129.0, 129.2, 134.7, 135.8, 136.1, 137.3, 143.1; HR-MS 508.194 ($C_{26}H_{35}NO_4SSi$ + Na calcd 508.195).

*5′-((tert-Butyldimethylsilyloxy)methyl)-4′-methyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2g**).* Prepared following the general procedure 1 in 74% yield (74 mg, *dr* 2:1) from 100 mg of alkynylaziridine **1g**. Mixture of diastereoisomers: colorless oil; IR (neat) ν_{max} 2959, 2929, 2851, 1686, 1592, 1328, 1303, 1253, 1224, 1159, 1087, 1026, 1006, 966; HR-MS 522.210 ($C_{27}H_{37}NO_4SSi$ + Na calcd 522.210). Major diastereoisomer (2′*S**,5′*S**): Colorless oil; R_f = 0.40 (Cyclohexane/EtOAc 20%); 1H NMR (300 MHz, $CDCl_3$) δ 0.02 (s, 3 H), 0.06 (s, 3 H), 0.89 (s, 9 H), 1.75 (s, 3 H), 2.38 (s, 3 H), 3.83 (dd, 1 H, J_{ab} = 10.7, 1.9 Hz), 4.00 (dd, 1 H, J_{ab} = 11.0, 2.0 Hz), 4.01 (d, 1 H, J = 11.2 Hz), 4.49−4.57 (m, 1 H), 4.52 (d, 1 H, J = 11.2 Hz), 4.69 (d, 1 H, J_{ab} = 14.5 Hz), 4.91 (d, 1 H, J_{ab} = 10.5 Hz), 5.43−5.52 (m, 1 H), 6.75 (d, 1 H, J = 7.9 Hz), 6.90 (t, 1 H, J = 7.4 Hz), 7.00 (d, 1 H, J = 7.6 Hz), 7.11 (d, 2 H, J = 7.9 Hz), 7.14 (t, 1 H, J = 7.4 Hz), 7.33 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.71, −5.38, 13.7, 18.3, 21.4, 25.9, 62.2, 68.6, 71.5, 71.9, 74.6, 124.0, 126.3, 127.0, 127.6, 128.5, 128.9, 129.5, 133.8, 135.1, 135.9, 138.7, 142.6. Minor diastereoisomer (2′*S**,5′*R**): Colorless oil; R_f = 0.32 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.10 (s, 3 H), 0.11 (s, 3 H), 0.92 (s, 9 H), 1.73 (s, 3 H), 2.36 (s, 3 H), 3.73 (d, 1 H, J = 10.5 Hz), 4.00 (dd, 1 H, J = 11.1, 2.0 Hz), 4.35 (dd, 1 H, J = 11.0, 3.3 Hz), 4.44 (m, 1 H), 4.70 (d, 1 H, J_{ab} = 14.7 Hz), 4.76 (d, 1 H, J = 10.7 Hz), 4.83 (d, 1 H, J_{ab} = 14.5 Hz), 5.60 (s, 1 H), 6.87 (dd, 1 H, J = 7.2, 0.7 Hz), 7.06−7.14 (m, 4 H), 7.56 (d, 2 H, J = 8.4 Hz), 7.86 (dd, 1 H, J = 8.8, 1.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.52, −5.35, 13.8, 18.4, 21.5, 25.9, 62.6, 68.7, 70.9, 72.0, 73.2, 123.3, 126.7, 127.0, 127.8, 128.6, 129.1, 130.0, 133.2, 133.8, 137.5, 138.1, 142.9.

*1-Tosyl-1,4,5,6,7,7a-hexahydrospiro[indole-2,4′-isochroman] (**2h**).* Prepared following the general procedure 1 in 68% yield (34 mg, *dr* 3/1) from 50 mg of **1h**. Mixture of diastereoisomers: colorless solid; IR (neat) ν_{max} 2855, 2840, 1337, 1096, 1029, 949, 757, 666, 578, 544; HR-MS 418.145 ($C_{23}H_{25}NO_3S$ + Na calcd 418.145); Major diastereoisomer (2*S**,7a*R**): mp = 90 °C; R_f = 0.38 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.19−1.38 (m, 3 H), 1.79−1.82 (m, 2H), 1.96−2.07 (m, 1 H), 2.39 (s, 3 H), 2.39−2.46 (m, 1 H), 2.53−2.57 (m, 1 H), 3.99 (dd, 1 H, J = 10.8, 1.0 Hz), 4.31−4.37 (m, 1 H), 4.64 (d, 1 H, J = 10.8 Hz), 4.70 (d, 1 H, J_{ab} = 14.4 Hz), 4.92 (d, 1 H, J_{ab} = 14.4 Hz), 5.36−5.42 (m, 1 H), 6.71 (dd, 1 H, J = 7.4, 1.0 Hz), 6.91 (dt, 1 H, J = 1.0 Hz, 7.4 Hz), 6.99 (d, 1 H, J = 7.4 Hz), 7.11−7.14 (m, 3 H), 7.34 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 23.9, 26.6, 28.3, 37.6, 67.3, 68.8, 72.7, 75.4, 124.0, 124.9, 126.5, 127.0, 127.6, 128.2, 129.0, 135.3, 135.7, 138.4, 138.5, 142.8. Minor diastereoisomer (2*S**,7a*S**): R_f = 0.38 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, C_6D_6) δ 0.71−1.96 (m, 7 H), 1.83 (s, 3 H), 2.78−2.87 (m, 1 H), 3.90 (d, 1 H, J = 10.4 Hz), 4.16 (dd, 1 H, J = 11.0, 4.7 Hz), 4.56 (d, 1 H, J_{ab} = 14.8 Hz), 4.76 (d, 1 H, J_{ab} = 14.8 Hz), 5.03 (d, 1 H, J = 10.4 Hz), 5.31−5.37 (m, 1 H), 6.59−6.68 (m, 3 H), 6.77 (d, 1 H, J = 7.9 Hz), 6.92 (dt, 1 H, J = 3.8, 1.5 Hz), 7.02 (t, 1 H, J = 7.1 Hz), 7.66 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, C C_6D_6) δ 21.3, 24.1, 26.6, 27.4, 38.6, 67.0, 69.2, 73.7, 76.0, 124.2, 126.3, 127.2, 127.3, 128.3, 128.5129.5, 135.1, 138.0, 138.5, 140.0, 142.6.

*1-Tosyl-4,5,6,7,8,8a-hexahydro-1H-spiro[cyclohepta[b]pyrrole-2,4′-isochroman] (**2i**).* Prepared following the general procedure 1 in 66% yield (33 mg) from 50 mg of **1i**. Reaction was complete after 3 h stirring at room temperature. Two diastereoisomers: *dr* 1:1; pale-yellow oil; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2920, 2846, 1451, 1333, 1154, 1091, 759, 663, 575, 546; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.47−1.59 (m, 7H), 1.67−2.09 (m, 7H), 2.34−2.14 (m, 6H), 2.30−2.38 (m, 1H), 2.38 (s, 3H), 2.39 (s, 3H), 2.60−2.71 (m, 1H), 3.71 (d, 1H, J_{ab} = 10.6 Hz), 4.00 (d, 1H, J_{ab} = 11.1 Hz), 4.54−4.48 (m, 1H), 4.55 (d, 1H, J_{ab} = 11.1 Hz), 4.65−4.59 (m, 1H), 4.70 (d, 1H, J_{ab} = 14.6 Hz), 4.72 (d, 1H, J_{ab} = 10.3 Hz), 4.73 (d, 1H, J_{ab} = 14.6 Hz), 4.84 (d, 1H, J_{ab} = 14.6 Hz), 4.92 (d, 1H, J_{ab} = 14.6 Hz),

5.49 (dd, 1H, J = 7.0 Hz, 3.5 Hz), 5.53 (dd, 1H, J = 7.0 Hz, 3.5 Hz), 6.68−6.73 (m, 1H), 6.89−6.93 (m, 2H), 6.97−7.01 (m, 1H), 7.10−7.21 (m, 7H), 7.29 (d, 2H, J = 8.3 Hz), 7.43−7.49 (m, 1H), 7.61 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.4, 24.7, 25.3, 26.7, 27.8, 27.9, 28.0, 29.7, 29.8, 30.2, 35.3, 35.7, 68.6, 68.7, 70.3, 70.4, 72.3, 72.6, 72.8, 75.3, 123.6, 124.0, 126.4, 127.0, 127.2, 127.5, 127.6, 127.8, 128.0, 128.3, 128.9, 129.2, 133.6, 135.3, 135.6, 137.7, 138.2, 138.5, 141.0, 141.6, 142.7, 142.9; HR-MS 432.156 ($C_{24}H_{27}NO_3S$ + Na calcd 432.160).

(2R,9aS*)-1-Tosyl-1,4,5,6,7,8,9,9a-octahydrospiro[cycloocta[b]-pyrrole-2,4′-isochroman] (**2j**).* Prepared following the general procedure 1 in 77% yield (38.5 mg) from 50 mg of **1j**. Reaction was complete after 5 h stirring at room temperature: 2 diastereoisomers; *dr* 5:1; yellow oil; R_f = 0.37 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2925, 2855, 1737, 1446, 1333, 1156, 1090, 662, 582, 546; Major diastereomer: ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.46−1.54 (m, 2H), 1.62−1.76 (m, 4H), 1.86−2.03 (m, 2H), 2.16−2.38 (m, 2H), 2.39 (s, 3H), 2.40−2.49 (m, 1H), 3.72 (d, 1H, J_{ab} = 10.1 Hz), 4.41−4.47 (m, 1H), 4.73 (d, 1H, J_{ab} = 10.1 Hz), 4.76 (d, 1H, J_{ab} = 14.9 Hz), 4.90 (d, 1H, J_{ab} = 14.9 Hz), 5.59 (s, 1H), 6.93−6.98 (m, 1H), 7.12−7.21 (m, 2H), 7.22 (d, 2H, J = 8.4 Hz), 7.57−7.60 (m, 1H), 7.64 (d, 2H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 23.6, 25.3, 25.6, 29.2, 29.5, 29.8, 30.2, 68.8, 68.8, 72.6, 72.8, 123.8, 127.0, 127.0, 127.1, 127.8, 129.1, 129.3, 133.7, 138.0, 140.5, 143.1 ; HR-MS 446.176 ($C_{25}H_{29}NO_3S$ + Na calcd 446.176).

*4′-Methyl-1′,2-ditosyl-1′,2,3,5′-tetrahydro-1H-spiro[isoquinoline-4,2′-pyrrole] (**2k**).* Prepared following the *general procedure 1* in 68% yield (34 mg) from 50 mg of **1k**. White solid: mp =115 °C (d); R*f* = 0.43 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3040−2880, 1597, 1460, 1332, 1155, 1094, 1056, 899, 811, 765, 730, 701, 543; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.76 (s, 3H), 2.43 (s, 3H), 2.46 (s, 3H), 3.61 (d, 1H, J_{ab} = 10.6 Hz), 3.82 (d, 1H, J_{ab} = 14.6 Hz), 3.89 (dd, 1H, J_{ab} = 10.6 Hz, 1.8 Hz), 4.17 (d, 1H, J_{ab} = 13.1 Hz), 4.25 (d, 1H, J_{ab} = 13.1 Hz), 4.64 (dd, 1H, J_{ab} =14.3 Hz, 1.9 Hz), 5.70 (q, 1H, J = 1.8 Hz), 6.87−6.94 (m, 1H), 6.99−7.08 (m, 2H), 7.15 (ddd, 1H, J =7.2 Hz, 8.3 Hz, 1.0 Hz), 7.21 (d, 2H, J =8.3 Hz), 7.37 (d, 2H, J = 8.3 Hz), 7.39 (d, 2H, J = 8.3 Hz), 7.70 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.6, 21.6, 48.6, 53.2, 58.8, 74.7, 126.0, 127.2, 127.4, 127.4, 127.6, 127.7, 129.3, 129.8, 129.9, 131.1, 131.3, 132.8, 137.1, 137.3, 143.3, 144.1; HR-MS 531.137 ($C_{27}H_{28}N_2O_2S$ + Na calcd 531.139).

*Diethyl 4′-Methyl-1′-tosyl-1′,5′-dihydro-2H-spiro[naphthalene-1,2′-pyrrole]-3,3(4H)-dicarboxylate (**2l**).* Prepared following the general procedure 1 in 74% yield (37 mg) from 50 mg of **1l**. Reaction was complete within 30 min. Colorless oil; R_f = 0.22 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 1730, 1451, 1259, 1153, 1091, 666, 580, 544; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.05 (t, 3H, J = 7.1 Hz), 1.29 (t, 3H, J = 7.1 Hz), 1.77 (d, 3H, J = 1.5 Hz), 2.34 (s, 3H), 2.87 (dd, 1H, J_{ab} =14.1 Hz, 2.5 Hz), 3.36 (dd, 1H, J_{ab} = 15.3 Hz, 2.5 Hz), 3.44 (d, 1H, J_{ab} = 14.1 Hz), 3.51 (d, 1H, J_{ab} = 15.3 Hz), 4.02 (t, 2H, J = 7.1 Hz), 4.02 (d, 1H, J_{ab} = 13.3 Hz), 4.18 (d, 1H, J_{ab} = 13.3 Hz), 4.24 (q, 2H, J = 7.1 Hz), 5.48 (q, 1H, J = 1.5 Hz), 6.60 (d, 1H), 6.72−6.84 (m, 1H), 7.03 (d, 2H, J = 8.1 Hz), 7.12 (d, 2H, J = 8.1 Hz), 7.12 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.9, 14.1, 21.4, 30.9, 34.9, 41.6, 55.7, 58.0, 61.2, 61.8, 74.5, 126.6, 127.1, 127.6, 128.5, 128.7, 129.0, 130.3, 131.8, 135.3, 136.0, 136.9, 142.4, 170.7, 170.8; HR-MS 520.177 ($C_{27}H_{31}NO_6S$ + Na calcd 520.176).

*4′-Methyl-1′-tosyl-1′,3,4,5′-tetrahydro-2H-spiro[naphthalene-1,2′-pyrrole] (**2m**).* Prepared following the general procedure 1 in 72% yield (36 mg) from 50 mg of **1m**. Colorless oil; R_f = 0.40 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3158, 2923, 1330, 1151, 1093, 1046, 765, 688, 659, 582, 540; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.71 (s, 3H), 1.60−1.78 (m, 1H), 2.38 (s, 3H), 2.64−2.80 (m, 1H), 2.88−3.06 (m, 2H), 4.12−4.21 (m, 2H), 5.47 (q, 1H, J = 1.7 Hz), 6.82−6.97 (m, 2H), 7.01−7.13 (m, 2H), 7.15 (d, 2H, J = 8.3 Hz), 7.46 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.5, 22.1, 29.7, 30.2, 36.6, 58.5, 76.3, 125.9, 126.8, 127.4, 128.3, 128.5, 128.7, 129.1, 129.6, 131.5, 137.3, 137.8, 139.3, 142.6; HR-MS 376.132 ($C_{21}H_{23}NO_2S$ + Na calcd 376.134).

*7-Methoxy-4′-methyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] (**2o**).* Prepared following the general procedure 1 in 65% yield (32.5 mg) from 50 mg of **1o**. 5-Methoxy-4′-methyl-1′-tosyl-1′,5′-dihydrospiro[isochroman-4,2′-pyrrole] was also formed in 15% yield, and could not be separated from **2o**. Major regioisomer: Pale-yellow oil; R_f = 0.20 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2930, 2855, 1710, 1500, 1335, 1248, 1154, 1094, 964, 813, 708, 660, 545; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.75 (s, 3H), 2.40 (s, 3H), 3.77 (s, 3H), 3.88 (d, 1H, J_{ab} = 11.0 Hz), 4.12 (d, 1H, J_{ab} = 12.9 Hz), 4.23 (d, 1H, J_{ab} = 12.9 Hz), 4.56 (d, 1H, J_{ab} = 11.0 Hz), 4.68 (d, 1H, J_{ab} = 14.8 Hz), 4.88 (d, 1H, J_{ab} = 14.8 Hz), 5.50 (ddd, 1H, J = 1.7 Hz, 1.7 Hz, 1.7 Hz), 6.50 (d, 1H; J = 2.6 Hz), 6.57 (dd, 1H, J = 8.6 Hz, 2.6 Hz), 6.83 (d, 1H, J = 8.6 Hz), 7.19 (d, 2H, J = 8.2 Hz), 7.49 (d, 2H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.5, 30.2, 55.3, 58.7, 68.9, 72.5, 73.5, 108.2, 113.3, 127.5, 129.0, 129.2, 129.6, 131.3, 136.1, 137.5, 143.0, 158.6; HR-MS 408.124 ($C_{21}H_{23}NO_4S$ + Na calcd 408.124).

*Diethyl 7-Methoxy-4′-methyl-1′-tosyl-1′,5′-dihydro-2H-spiro-[naphthalene-1,2′-pyrrole]-3,3(4H)-dicarboxylate (**2q**).* Prepared following the general procedure 1 in 61% yield (30.5 mg) from 50 mg of **1q**. TLC monitoring showed completion of the reaction after 5 h heating at 40 °C. Colorless solid: mp = 120 °C (d); R_f = 0.32 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2984, 2920, 1728, 1502, 1463, 1234, 1150, 1091, 666; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.06 (t, 3H, J = 7.0 Hz), 1.29 (t, 3H, J = 7.0 Hz), 1.73−1.81 (m, 3H), 2.34 (s, 3H), 2.87 (dd, 1H, J_{ab} = 14.4 Hz, 2.5 Hz), 3.30 (dd, 1H, J_{ab} = 15.0 Hz, 2.5 Hz), 3.38 (s, 3H), 3.39 (d, 1H, J_{ab} = 14.4 Hz), 3.45 (d, 1H, J_{ab} = 15.0 Hz), 3.95−4.09 (m, 2H + 1H), 4.13−4.34 (m, 2H + 1H), 5.50−5.54 (m, 1H), 5.93 (d, 1H, J = 2.5 Hz), 6.66 (dd, 1H, J = 8.5 Hz, 2.5 Hz), 7.01 (d, 2H, J = 8.3 Hz), 7.01−7.09 (m, 1H), 7.06 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.8, 13.9, 14.1, 21.4, 30.2, 34.1, 41.8, 54.4, 56.0, 57.8, 61.2, 61.7, 74.5, 113.5, 113.8, 127.0, 127.8, 128.8, 129.7, 130.3, 132.0, 136.4, 136.8, 157.9, 170.7, 170.9; HR-MS 550.185 ($C_{28}H_{33}NO_7S$ + Na calcd 550.187).

*Diethyl 7-Chloro-4′-methyl-1′-tosyl-1′,5′-dihydro-2H-spiro-[naphthalene-1,2′-pyrrole]-3,3(4H)-dicarboxylate (**2r**).* Prepared following the general procedure 1 in 48% yield (34 mg) from 70 mg of **1r**. Reaction was complete after 5 h heating at 40 °C. Colorless solid: mp = 186 °C (d); R_f = 0.42 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2939, 1726, 1485, 1340, 1262, 1156, 1094, 670, 668, 584, 543; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.07 (t, 3H, J = 7.0 Hz), 1.29 (t, 3H, J = 7.0 Hz), 1.79 (s, 3H), 2.37 (s, 3H), 3.32 (dd, 1H, J_{ab} = 15.4 Hz, 2.5 Hz), 3.41 (d, 1H, J_{ab} = 14.4 Hz), 3.45 (d, 1H, J_{ab} = 15.4 Hz), 3.96−4.08 (m, 2H + 1H), 4.19−4.29 (m, 2H + 1H), 5.41−5.49 (m, 1H), 6.31−6.38 (m, 1H), 7.03−7.10 (m, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.9, 14.1, 21.5, 30.2, 34.4, 41.7, 55.7, 57.8, 61.4, 61.9, 73.9, 126.6, 127.9, 128.8, 129,1, 130.1, 131.2, 131.5, 132.3, 134.3, 136.5, 137.4, 143.0, 170.4, 170.6; HR-MS 554.137 ($C_{27}H_{30}ClNO_6S$ + Na calcd 554.137).

*4′-Methyl-1′-tosyl-1,1′,3,5′-tetrahydrospiro[benzo[h]-isochromene-4,2′-pyrrole] (**2s**).* Prepared following the general procedure 1 in 82% yield (41 mg) from 50 mg of **1s**. Pale-yellow crystals: mp = 165 °C; R_f = 0.23 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2930, 2846, 1588, 1336, 1154, 1096, 1068, 811, 667, 565, 542; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.80 (s, 3H), 2.38 (s, 3H), 3.97 (d, 1H, J_{ab} = 10.7 Hz), 4.21 (ddt, 1H, J_{ab} = 13.1 Hz, 0.8 Hz, 1.0 Hz), 4.35 (ddt, 1H, J_{ab} = 13.1 Hz, 0.8 Hz, 1.0 Hz), 4.69 (d, 1H, J_{ab} = 10.7 Hz), 5.28 (s, 2H), 5.59 (d, 1H), 7.10 (d, 1H, J = 8.6 Hz), 7.14 (d, 2H, J = 8.2 Hz), 7.45−7.56 (m, 3H), 7.51 (d, 2H, J = 8.2 Hz), 7.66−7.71 (m, 1H), 7.77−7.81 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.5, 59.0, 66.7, 72.5, 73.2, 122.2, 124.7, 125.9, 126.5, 127.1, 127.4, 128.6, 128.8, 129.1, 129.2, 129.4, 132.2, 132.3, 133.9, 137.3, 143.1; HR-MS 428.128 ($C_{24}H_{23}NO_3S$ + Na calcd 428.129).

*4′-Methyl-1′-tosyl-1′,2,4,5′-tetrahydrospiro[benzo[f]-isochromene-1,2′-pyrrole] (**2t**).* Prepared following the general procedure 1 in 78% yield (39 mg) from 50 mg of **1t**. Colorless oil; R_f = 0.32 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2926, 2844, 1529, 1344, 1156, 1093, 808, 730, 706, 688, 666, 582, 544; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.84 (s, 3 H), 2.27 (s, 3 H), 3.93 (d, 1 H, J_{ab} = 11.3 Hz), 4.27 (d, 1 H, J_{ab} = 13.8 Hz), 4.47 (d, 1 H, J_{ab} = 13.8 Hz), 4.60 (d, 1 H, J_{ab} = 11.3 Hz), 4.85 (d, 1 H, J_{ab} = 15.2 Hz), 5.11 (d, 1 H, J_{ab} = 15.2 Hz), 5.63 (q, 1 H, J = 1.7 Hz), 6.82 (d, 2 H, J = 8.2 Hz), 6.97 (ddd, 1 H, J = 7.1 Hz, 8.3 Hz, 1.5 Hz), 7.07−7.13 (m, 3H), 7.27 (ddd,

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1 H, 7.1 Hz, 8.3 Hz, 1.5 Hz), 7.39 (d, 1 H, J = 8.7 Hz), 7.68−7.81 (m, 2 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 21.5, 60.0, 69.8, 72.4, 75.7, 122.5, 124.2, 124.5, 125.6, 127.0, 128.5, 128.6, 128.7, 128.8, 129.6, 131.7, 132.8, 133.1, 134.7, 136.3, 142.5; HR-MS 428.126 ($C_{24}H_{23}NO_3S$ + Na, calcd 428.129).

General Procedure 2 for the Silver-Catalyzed Preparation of Aminoallenes. To a solution cooled at −20 °C of alkynylaziridine (0.1 mmol) in CH_2Cl_2 (1 mL) was added $AgNTf_2$ (0.005 mmol). Monitored by thin-layer chromatography, the reaction was stirred until conversion of the starting material to the corresponding allene (of lower R_f) then, the reaction mixture was filtered throughout a pad of silica gel and rinsed with CH_2Cl_2. After concentration of the reaction mixture, the crude residue was purified by flash chromatography (Cyclohexane/EtOAc).

*N-(3-(Isochroman-4-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3a**).* Prepared following the general procedure 2 in 55% yield (22 mg) from 40 mg of **1a**. Colorless oil; R_f = 0.22 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3254, 2911, 2837, 1329, 1158, 1088, 811, 762; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.79 (s, 3 H), 2.41 (s, 3 H), 3.60 (d, 2 H, J = 6.0 Hz), 4.40 (d, 2 H, J = 1.9 Hz), 4.55−4.61 (m, 1 H), 4.76 (s, 2 H), 6.99−7.04 (m, 1 H), 7.14−7.19 (m, 2 H), 7.22−7.34 (m, 3 H), 7.72 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 18.8, 21.6, 45.8, 67.7, 88.7, 101.1, 102.8, 124.7, 126.3, 127.0, 127.1, 127.3, 128.5, 129.8, 133.9, 136.7, 143.5, 195; HR-MS 378.111 ($C_{20}H_{21}NO_3S$ + Na, calcd 378.113).

*N-(3-(Isochroman-4-ylidene)-2-methylallyl)-4-nitrobenzenesulfonamide (**3b**).* Prepared following the general procedure 2 in 68% yield (17 mg) from 25 mg of **1b**. Yellow powder: mp = 51−52 °C; R_f = 0.13 (Cyclohexane/EtOAc 20%). IR (neat) ν_{max} 3273, 2922, 2851, 1526, 1346, 1157, 1091, 734, 608; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.79 (s, 3 H), 3.60−3.80 (m, 2 H), 4.39 (s, 2 H), 4.74 (s, 2 H), 5.03 (t, 1 H, J = 5.7 Hz), 7.00 (d, 1 H, J = 6.9 Hz), 7.11−7.19 (m, 2 H), 7.29 (t, 1 H, J = 8.2 Hz), 7.97 (d, 2 H, J = 8.9 Hz), 8.19 (d, 2 H, J = 8.9 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.9, 45.7, 67.7, 68.7, 101.6, 102.8, 124.3, 124.8, 126.2, 126.4, 127.0, 127.6, 128.1, 129.7, 133.9, 145.9, 194.8; HR-MS 409.080 ($C_{19}H_{18}N_2O_5S$ + Na, calcd 409.083).

*N-(3-(3-Hexylisochroman-4-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3c**).* Prepared following the general procedure 2 in 50% yield (15 mg, *dr* 1:1) from 30 mg of **1c**. Mixture of inseparable diastereoisomers: White crystalline powder: R_f = 0.26 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3262, 2926, 2851, 1327, 1160, 1089, 813, 660, 548; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.83−0.91 (m, 3 H), 1.14−1.36 (m, 8 H), 1.55−1.70 (m, 2 H), 1.72−1.85 (m, 3 H), 2.35−2.48 (m, 3 H), 3.55−3.63 (m, 2 H), 4.18−4.27 (m, 1 H), 4.47−4.54 (m, 1 H), 4.71−4.84 (m, 2 H), 7.00−7.04 (m, 1 H), 7.14−7.36 (m, 5 H), 7.68−7.76 (m, 2 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 16.6, 16.9, 21.6, 22.6, 25.4, 25.8, 29.3, 29.4, 30.2, 31.9, 33.5, 33.8, 45.6, 46.0, 67.6, 67.8, 75.5, 75.6, 102.2, 103.2, 106.0, 124.5, 124.6, 127.0, 127.1, 128.9, 129.8, 134.0, 136.7, 143.5, 195.4, 195.8; HR-MS 462.204 ($C_{26}H_{33}NO_3S$ + Na, calcd 462.207).

*N-(3-(3,3-Dimethylisochroman-4-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3d**).* Prepared following the general procedure 2 in 64% yield (32 mg) or following the general procedure 1 in 61% yield (30.5 mg) from 50 mg of **1d**. Colorless oil; R_f = 0.20 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3280, 2977, 2930, 2851, 1706, 1324, 1153, 1085, 815, 662, 542; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.39 (s, 6 H), 1.83 (s, 3 H), 2.40 (s, 3 H), 3.59 (dd, 2 H, J = 6.0 Hz, 2.1 Hz), 4.40 (t, 1 H, J = 6.0 Hz), 4.80 (s, 2 H), 7.00−7.10 (m, 1H), 7.12−7.28 (m, 3 H), 7.28 (d, 2 H, J = 8.1 Hz), 7.72 (d, 2 H, J = 8.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.8, 21.5, 26.8, 27.0, 45.8, 62.6, 73.0, 103.1, 110.1, 124.4, 126.9, 127.1, 128.1, 129.8, 133.2, 136.7, 143.6, 195.4; HR-MS 390.173 ($C_{22}H_{25}NO_3S$ + Li, calcd 390.171).

*4-Methyl-N-(2-methyl-3-(spiro[cyclopentane-1,3′-isochroman]-4′-ylidene)allyl)benzenesulfonamide (**3e**).* Prepared following either the general procedure 1 or the general procedure 2 in 74% yield (37 mg) from 50 mg of **1e**. Orange crystalline powder: mp = 136−137 °C; R_f = 0.27 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3288, 2955, 2859, 1326, 1156, 1079, 812, 762, 726, 661, 546; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60−1.78 (m, 6 H), 1.82 (s, 3 H), 1.90−2.11 (m, 2 H), 2.41 (s, 3 H), 3.60 (dd, 2 H, J = 5.9 Hz, 2.0 Hz), 4.57 (t, 1 H, J = 5.9 Hz), 4.77 (s, 2 H), 7.00−7.05 (m, 1 H), 7.09−7.23 (m, 2 H), 7.20−7.30 (m, 1 H), 7.26 (d, 2 H, J = 8.3 Hz), 7.72 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.8, 21.5, 23.6, 37.2, 37.6, 45.9, 63.1, 83.8, 102.9, 108.7, 124.4, 126.8, 127.0, 127.1, 129.8, 133.4, 136.6, 143.5, 195.5; HR-MS 432.157 ($C_{24}H_{27}NO_3S$ + Na, calcd 432.160).

*N-(2-(((Tert-butyldimethylsilyl)oxy)methyl)-3-(isochroman-4-ylidene)allyl)-4-methylbenzenesulfonamide (**3f**).* Prepared following the general procedure 2 in 44% yield (22 mg) from 50 mg of **1f**. Colorless oil; R_f = 0.21 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3286, 2927, 2855, 1329, 1252, 1157, 1090, 834, 777, 732, 663, 548; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.03 (s, 3H), 0.04 (s, 3H), 0.86 (s, 9H), 2.41 (s, 3H), 3.76 (d, 2H, J = 5.8 Hz), 4.24 (d, 2H, J = 5.1 Hz), 4.41 (s, 2H), 4.77 (s, 2H), 4.85 (t, 1H, J = 11.6 Hz), 7.00−7.05 (m, 1H), 7.14−7.20 (m, 2H), 7.28 (d, 2H, J = 8.2 Hz), 7.31−7.38 (m, 1H), 7.74 (d, 2H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.4, −5.3, 18.2, 21.6, 25.4, 25.8, 43.1, 63.1, 67.4, 68.7, 102.1, 106.7, 124.7, 126.5, 127.2, 127.2, 127.6, 127.9, 129.7, 133.9, 136.8, 143.5, 194.8; HR-MS 508.195 ($C_{26}H_{35}NO_4SSi$ + Na calcd 508.195).

*N-(1-(tert-Butyldimethylsilyloxy)-4-(isochroman-4-ylidene)-3-methylbut-3-en-2-yl)-4-methylbenzenesulfonamide (**3g**).* Prepared following the general procedure 2 in 60% yield (60 mg, *dr* 2:1) from 100 mg of **1g**. Colorless oil; Mixture of diastereoisomers: R_f = 0.38 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3284, 2953, 2928, 2857, 1460, 1402, 1331, 1254, 1159, 1089, 1031, 1005, 906, 835, 727; MS (ESI) m/z (%) 1021 (100, $2M^{+\cdot}$ + Na), 522 (95, $M^{+\cdot}$ + Na); HR-MS 522.210 ($C_{27}H_{37}NO_4SSi$ + Na calcd 522.211). Major diastereoisomer (2*S**,4*S**): ^{1}H NMR (300 MHz, $CDCl_3$) δ −0.01 (s, 6 H), 0.85 (s, 9 H), 1.80 (s, 3 H), 2.43 (s, 3 H), 3.57−3.87 (m, 3 H), 4.47 (s, 2 H), 4.76 (s, 2 H), 5.00 (d, 1 H, J = 7.3 Hz), 7.00−7.06 (m, 1 H), 7.14−7.35 (m, 5 H), 7.72 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.64, −5.61, 16.3, 18.2, 21.5, 25.8, 57.4, 64.4, 67.7, 68.7, 100.2, 104.7, 124.5, 126.4, 126.9, 127.0, 127.1, 128.6, 129.6, 133.7, 137.4, 143.3, 196.5. Minor diastereoisomer (2*R**,4*S**): ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.01 (s, 3 H), 0.05 (s, 3 H), 0.88 (s, 9 H), 1.82 (s, 3 H), 2.43 (s, 3 H), 3.57−3.87 (m, 3 H), 4.30 (d, 1 H, J_{ab} = 13.0 Hz), 4.35 (d, 1 H, J_{ab} = 13.0 Hz), 4.76 (s, 2 H), 4.92 (d, 1 H, J = 7.1 Hz), 7.00−7.06 (m, 1 H), 7.14−7.35 (m, 5 H), 7.73 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.56, −5.52, 16.3, 18.3, 21.4, 25.9, 57.4, 64.4, 67.5, 68.7, 100.7, 105.0, 124.5, 126.6, 126.9, 127.0, 127.1, 128.5, 129.6, 133.7, 137.4, 143.3, 196.2.

*N-(2-(Isochroman-4-ylidenemethylene)cyclohexyl)-4-methylbenzenesulfonamide (**3h**).* Prepared following the general procedure 2 in 71% yield (35.5 mg, *dr* 3:1) from 50 mg of **1h**. IR (neat) ν_{max} 3158, 2925, 2851, 1444, 1314, 1152, 1097, 926, 810, 758, 734, 656, 545; HR-MS 418.141 ($C_{23}H_{25}NO_3S$ + Na, calcd 418.145); Major diastereoisomer (2*S**,*R**): colorless crystalline powder: mp = 153 °C; R_f = 0.19 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.30−1.53 (m, 2 H), 1.69−1.88 (m, 2 H), 1.96−2.12 (m, 1 H), 2.19−2.33 (m, 1 H), 2.35−2.45 (m, 1 H), 2.40 (s, 3 H), 3.64−3.72 (m, 1 H), 4.46 (d, 2 H, J = 2.1 Hz), 4.75−4.88 (m, 1 H), 4.79 (s, 2 H), 6.95 (d, 1 H, J = 7.4 Hz), 7.02 (d, 1 H, J = 7.6 Hz), 7.08 (d, 1 H, J = 7.6 Hz), 7.14 (d, 2 H, J = 8.3 Hz), 7.19 (d, 1 H, J = 7.4 Hz), 7.63 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 24.4, 26.8, 31.1, 36.8, 53.0, 68.2, 68.7, 102.4, 110.7, 124.6, 126.4, 126.8, 126.9, 127.3, 128.6, 129.6, 133.9, 137.6, 143.0, 190.5. Minor diastereoisomer (2*R**,*R**): white crystalline powder: mp = 114 °C; R_f = 0.24 (Cyclohexane/EtOAc 20%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.14−1.97 (m, 6 H), 2.25−2.37 (m, 2 H), 2.43 (s, 3 H), 3.60−3.77 (m, 1 H), 4.13 (d, 1 H, J_{ab} = 12.7 Hz), 4.25 (d, 1 H, J_{ab} = 12.7 Hz), 4.63 (d, 1 H, J = 7.6 Hz), 4.78 (d, 2 H, J = 3.0 Hz), 7.00−7.07 (m, 1 H), 7.11−7.25 (m, 2 H), 7.28−7.45 (m, 1 H), 7.30 (d, 2 H, J = 8.1 Hz), 7.73 (d, 2 H, J = 8.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 25.0, 27.2, 31.6, 37.6, 53.3, 67.5, 68.7, 102.7, 111.3, 124.9, 125.7, 127.0, 127.3, 127.5, 128.6, 129.7, 134.0, 137.9, 143.3, 190.1.

*N-(2-((3,4-Dihydronaphthalen-1(2H)-ylidene)methylene)-cycloheptyl)-4-methylbenzenesulfonamide (**3i**).* Prepared following the general procedure 2 in 59% total yield (29.5 mg) from 50 mg of **1i**, after 4 h stirring at room temperature. Two diastereoisomers: *dr* 1:1. Pale-yellow oil; IR (neat) ν_{max} 3271, 2915, 2846, 1710, 1446, 1327, 1156, 1090, 729, 663, 547. Diastereoisomer 1: R_f = 0.33 (Cyclo-

hexane/EtOAc 30%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60−1.69 (m, 6H), 1.77−1.84 (m, 1H), 2.02−2.15 (m, 2H), 2.31−2.38 (m, 1H), 2.41 (s, 3H), 3.89−3.97 (m, 1H), 4.15 (d, 1H, J = 12.9 Hz), 4.25 (d, 1H, J = 12.9 Hz), 4.64 (broad d, 1H, J = 7.3 Hz), 4.76 (s, 2H), 7.02−7.05 (m, 1H), 7.18−7.21 (m, 2H), 7.26 (d, 2H, J = 8.3 Hz), 7.35−7.38 (m, 1H), 7.71 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 24.7, 28.5, 29.3, 30.6, 37.2, 55.4, 67.5, 68.7, 102.1, 113.3, 124.8, 125.8, 127.1, 127.3, 127.5, 128.6, 129.6, 133.9, 137.6, 143.3, 195.1; HR-MS 432.159 ($C_{24}H_{27}NO_3S$ + Na calcd 432.160). Diastereoisomer 2: R_f = 0.30 (Cyclohexane/EtOAc 30%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.56−1.70 (m, 6H), 1.75−1.84 (m, 1H), 1.96−2.23 (m, 2H), 2.25−2.33 (m, 1H), 2.34 (s, 3H), 3.95−4.01 (m, 1H), 4.41 (s, 2H), 4.68 (d, 1H, J = 7.0 Hz), 4.77 (s, 2H), 7.00−7.19 (m, 6H), 7.13 (d, 2H, J = 8.2 Hz), 7.65 (d, 2H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 24.5, 28.9, 29.6, 30.1, 30.2, 36.7, 55.3, 67.9, 68.7, 101.4, 113.0, 124.7, 126.2, 127.0, 127.2, 128.5, 129.6, 133.9, 137.4, 143.1, 195.9; HR-MS 432.159 ($C_{24}H_{27}NO_3S$ + Na calcd 432.160).

*N-(2-((3,4-Dihydronaphthalen-1(2H)-ylidene)methylene)-cyclooctyl)-4-methylbenzenesulfonamide (**3j**).* Prepared following the *general procedure 2* in 52% yield (26 mg) from 50 mg of **1j**, after 2h20 refluxing in dichloromethane. Two diastereoisomers: ***dr 5:1***; pale yellow oil; Rf = 0.32 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3271, 2920, 2851, 1694, 1446, 1328, 1155, 1091, 729, 665, 548. *Major diastereoisomer:* ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.59−1.75 (m, 9H), 1.99−2.04 (m, 2H), 2.29−2.38 (m, 1H), 2.41 (s, 3H), 3.89−3.93 (m, 1H), 4.23 (d, 1H, J = 12.9 Hz), 4.25 (d, 1H, J = 12.9 Hz), 4.63 (broad d, 1H, J = 7.5 Hz), 4.77 (d, 2H, J = 2.3 Hz), 7.01−7.04 (m, 1H), 7.16−7.20 (d, 2H, J = 8.3 Hz), 7.24−7.28 (m, 2H), 7.36−7.39 (m, 1H), 7.73 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.2, 26.2, 28.3, 30.2, 30.6, 34.1, 43.5, 55.2, 67.6, 68.7, 102.1, 113.0, 124.8, 126.5, 127.1, 127.2, 127.4, 129.7, 134.0, 137.8, 143.3, 195.9; HR-MS 446.176 ($C_{25}H_{29}NO_3S$ + Na calcd 446.176).

*4-Methyl-N-(2-methyl-3-(2-tosyl-2,3-dihydroisoquinolin-4(1H)-ylidene)allyl)benzenesulfonamide (**3k**).* Prepared following the general procedure *2* in 70% yield (35 mg) from 50 mg of **1k**. Colorless solid: mp = 80 °C; R*f* = 0.22 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3291 (broad), 2910, 1597, 1327, 1155, 1088, 909, 758, 728, 659, 546; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.76 (s, 3H), 2.38 (s, 3H), 2.39 (s, 3H), 3.56 (dd, 2H, J = 1.3 Hz, 5.7 Hz), 3.93 (d, 1H, J_{ab} = 14.0 Hz), 4.02 (d, 1H, J_{ab} = 14.0 Hz), 4.31 (d, 1H, J_{ab} = 15.3 Hz), 4.38 (d, 1H, J_{ab} = 15.3 Hz), 4.52 (t, 1H, J = 6.3 Hz), 6.98−7.06 (m, 1H), 7.08−7.13 (m, 2H), 7.20 (d, 2H, J = 8.3 Hz), 7.26 (d, 2H, J =8.3 Hz), 7.23−7.33 (m, 1H), 7.61 (d, 2H, J = 8.3 Hz), 7.70 (d, 2H, J =8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.6, 21.5, 21.6, 45.8, 47.1, 48.4, 99.9, 103.2, 126.5, 127.1, 127.2, 127.6, 127.8, 128.8, 128.9, 129.6, 129.7, 129.8, 130.9, 133.8, 143.6, 143.8, 196.9; HR-MS 531.136 ($C_{27}H_{28}N_2O_4S_2$ + Na calcd 531.138).

*Diethyl 4-(2-Methyl-3-(4-methylphenylsulfonamido)prop-1-en-1-ylidene)-3,4-dihydronaphthalene-2,2(1H)-dicarboxylate (**3l**).* Prepared following the general procedure 2 in 69% yield (34.5 mg) from 50 mg of **1l**, after 50 min stirring at −20 °C. Colorless solid: mp = 83 °C; R_f = 0.16 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3261, 2979, 1720, 1575, 1472, 1159, 1091, 662, 551; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.13 (t, 3H, J = 7.1 Hz), 1.26 (t, 3H, J = 7.1 Hz), 1.76 (s, 3H), 2.40 (s, 3H), 2.84 (d, 1H, J = 14.3 Hz), 3.05 (dd, 1H, J = 14.3 Hz, 1.5 Hz), 3.33−3.40 (m, 2H), 3.48 (dd, 1H, J = 15.0 Hz, 3.5 Hz), 3.64 (dd, 1H, J = 14.9 Hz, 7.1 Hz), 4..10−4.30 (m, 4H), 5.25 (dd, 1H, J = 3.5 Hz, 7.0 Hz), 7.05−7.22 (m, 4H), 7.18 (d, 2H, J = 8.3 Hz), 7.68 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 14.1, 16.8, 21.5, 34.5, 35.2, 45.6, 53.8, 61.9, 62.1, 100.6, 103.1, 126.7, 126.8, 127.1, 127.5, 129.1, 129.6, 130.1, 132.7, 137.2, 143.1, 170.87 170.8, 198.0; HR-MS 520.171 ($C_{27}H_{31}NO_6S$ + Na calcd 520.176).

*N-(3-(3,4-Dihydronaphthalen-1(2H)-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3m**).* Prepared following the general procedure 2 in 69% yield (34.5 mg) from 50 mg of **1m**, after 45 min stirring at −20 °C. Colorless oil; R_f = 0.25 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3273, 2924, 1597, 1450, 1323, 1155, 1091, 812, 759, 661, 549; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.76 (s, 3H), 1.80−1.92 (m, 2H), 2.40 (m, 2H), 2.37−2.46 (s, 3H), 2.80 (t, 2H, J = 6.1 Hz), 3.57 (d, 2H, J = 5.6 Hz), 4.47 (t, 1H, J = 5.6 Hz), 7.00−7.14 (m, 3H), 7.16−7.25 (m, 1H), 7.26 (d, 2H, J = 8.3 Hz), 7.72 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.9, 21.6, 23.1, 29.0, 30.0, 45.7, 99.5, 105.5, 126.0, 126.8, 127.0, 127.1, 129.3, 129.7, 131.4, 136.8, 136.9, 143.4, 197.2; HR-MS 376.133 ($C_{21}H_{23}NO_2S$ + Na calcd 376.134).

*Diethyl 6-methoxy-4-(2-methyl-3-(4-methylphenylsulfonamido)-prop-1-en-1-ylidene)-3,4-dihydronaphthalene-2,2(1H)-dicarboxylate (**3q**).* Prepared following the general procedure 2 in 50% yield (25 mg) from 50 mg of **1q**, after 15 min stirring at −20 °C. Colorless oil; R_f = 0.21 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3276, 2979, 1728, 1613, 1485, 1226, 1157, 1092, 1043, 663, 548; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.15 (t, 3H, J = 7.1 Hz), 1.25 (t, 3H, J = 7.1 Hz), 1.75 (s, 3H), 2.38 (s, 3H), 2.81 (d, 1H, J_{ab} = 14.4 Hz), 3.03 (dd, 1H, J_{ab} = 14.4 Hz, 1.4 Hz), 3.25−3.34 (m, 2H), 3.49 (dd, 1H, J_{ab} = 15.1 Hz, 3.5 Hz), 3.63 (dd, 1H, J_{ab} = 15.1 Hz, 6.9 Hz), 3.71 (s, 3H), 4.12−4.26 (m, 4H), 5.32 (dd, 1H, J = 7.0 Hz, 3.5 Hz), 6.67−6.76 (m, 2H), 7.04 (d, 1H, J = 8.4 Hz), 7.16 (d, 2H, J = 8.2 Hz), 7.66 (d, 2H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 14.1, 16.7, 21.5, 34.5, 45.5, 54.0, 55.2, 61.8, 62.1, 100.8, 103.3, 110.9, 114.3, 125.2, 127.1, 128.8, 129.5, 130.0, 131.0, 137.0, 142.9, 158.2, 170.8, 170.8, 198.0; HR-MS 550.188 ($C_{28}H_{33}NO_7S$ + Na calcd 550.187).

*Diethyl 6-Chloro-4-(2-methyl-3-(4-methylphenylsulfonamido)-prop-1-en-1-ylidene)-3,4-dihydronaphthalene-2,2(1H)-dicarboxylate (**3r**).* Prepared following the *general procedure 2* in 32% yield (16 mg) from 50 mg of **1r**, after 15 min stirring at −20 °C. Colorless oil; Rf = 0.31 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3291, 2994, 2920, 1728, 1584, 1463, 1158, 1091, 730, 663, 549; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.16 (t, 3H, J = 7.0 Hz), 1.26 (t, 3H, J = 7.0 Hz), 1.76 (m, 3H), 2.40 (s, 3H), 2.81 (d, 1H, J = 14.3 Hz), 3.04 (dd, 1H, J = 14.4 Hz, 1.4 Hz), 3.27−3.36 (m, 2H), 3.51 (dd, 1H, J = 15.0 Hz, 3.5 Hz), 3.64 (dd, 1H, J = 15.0 Hz, 7.0 Hz), 4.13−4.28 (m, 4H), 5.26 (dd, 1H, J = 7.0 Hz, 3.5 Hz), 7.03−7.13 (m, 3H), 7.19 (s, 2H, J = 8.3 Hz), 7.64 (s, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 14.1, 16.7, 21.6, 34.3, 34.6, 45.4, 53.6, 62.0, 62.3, 101.5, 102.3, 126.4, 127.2, 127.8, 129.7, 130.5, 131.3, 132.0, 132.5, 136.9, 143.2, 170.5, 170.6, 198.2; HR-MS 554.136 ($C_{27}H_{30}ClNO_6S$ + Na calcd 554.137).

*N-(3-(1H-Benzo[h]isochromen-4(3H)-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3s**).* Prepared following the general procedure 2 in 66% yield (33 mg) from 50 mg of **1s**. Colorless crystals: mp = 147 °C; R_f = 0.12 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3251, 1417, 1329, 1158, 1085, 814, 744, 669, 555; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.84 (s, 3H), 2.33 (s, 3H), 3.63 (t, 2H, J = 5.4 Hz), 4.45 (d, 1H, J = 1.6 Hz), 4.84 (t, 1H, J = 6.0 Hz), 5.21 (d, 2H, J = 2.2 Hz), 7.20 (d, 2H, J = 8.3 Hz), 7.34 (d, 1H, J = 8.6 Hz), 7.44−7.54 (m, 2H), 7.63 (d, 1H, J = 8.6 Hz), 7.64−7.69 (m, 1H), 7.84−7.78 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 16.9, 21.5, 45.9, 66.4, 67.1, 101.8, 102.8, 121.9, 124.1, 125.9, 126.0, 126.6, 127.1, 127.2, 128.8, 129.4, 129.7, 129.0, 132.5, 136.8, 143.4, 196.0; HR-MS 428.128 ($C_{24}H_{23}NO_3S$ + Na calcd 428.129).

*N-(3-(2,4-Dihydro-1H-benzo[f]isochromen-1-ylidene)-2-methylallyl)-4-methylbenzenesulfonamide (**3t**).* Prepared following the general procedure 2 in 56% yield (28 mg) from 50 mg of **1t**. Bright-orange crystals: mp = 99 °C; R_f = 0.18 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3251, 2911, 2834, 1314, 1158, 1081, 810, 662, 550; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.92 (s, 3 H), 2.34 (s, 3 H), 3.64 (dd, 2 H, J = 6.0 Hz, 2.2 Hz), 4.44 (d, 2 H, J = 2.2 Hz), 4.63 (t, 1 H, J = 6.0 Hz), 4.96 (s, 2 H), 7.05−7.18 (m, 3 H), 7.35−7.50 (m, 2 H), 7.60−7.72 (m, 2 H), 7.72 (d, 1 H, J = 8.4 Hz), 7.78−7.86 (m, 1 H), 8.30−8.40 (m, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 17.2, 21.5, 46.1, 69.1, 70.1, 98.8, 122.7, 123.9, 125.5, 126.7, 127.0, 128.4, 128.9, 129.6, 130.8, 132.0, 133.1, 136.6, 143.4, 199.7; HR-MS 428.126 ($C_{24}H_{23}NO_3S$ + Na, calcd 428.129).

General Procedure 3 for Preparation of Enynyl Alcohol. To a cooled solution of *n*-BuLi (1.6 M in hexanes, 10.5 mmol) in THF (20 mL) at −78 °C and under argon was added dropwise the corresponding enyne (10 mmol). The resulting reaction mixture was stirred at the same temperature for 30 min, then a ketone or an aldehyde (11 mmol) was added at −78 °C. The reaction mixture was then allowed to reach room temperature and was further stirred until reaction completion as monitored by TLC. The mixture was quenched with aqueous NH_4Cl (5 mL) and extracted twice with Et_2O (20 mL).

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The combined organic extracts were dried over $MgSO_4$. After filtration and evaporation, the crude product was purified by flash chromatography (Cyclohexane/EtOAc) to afford the title compound.

4-Methylpent-4-en-2-yn-1-ol (***A1***). Prepared following the general procedure 3 in 99% yield (1.89 g) from 1.32 g of 2-methylbut-1-en-3-yne and 696 mg of *p*-formaldehyde. Pale-yellow oil; R_f = 0.23 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3300, 2925, 2210, 1613, 1435, 1289, 1070, 999, 896; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.75 (t, 1 H, J = 5.7 Hz, −OH), 1.88 (dd, 3 H, J = 1.3 Hz, 1.3 Hz), 4.38 (d, 2 H, J = 5.2 Hz), 5.23 (quint, 1 H, J = 1.7 Hz,), 5.30 (s, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.3, 51.4, 86.3, 86.8, 122.3, 126.2.

2-Methylundec-1-en-3-yn-5-ol (***A2***). Prepared following the general procedure 3 in 73% yield (1.29 g) from 0.661 g of 2-methylbut-1-en-3-yne and 1.232 g of heptanal. Pale-yellow oil; R_f = 0.21 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3334, 3097, 2954, 2924, 2857, 2223, 1614, 1455, 1434, 1373, 1337, 1335, 1286, 1182, 1041, 1009, 893, 725; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.90 (t, 3 H, J = 6.9 Hz), 1.28−1.58 (m, 10 H), 1.68−1.80 (m, 2 H), 1.90 (s, 3 H), 4.50 (t, 1 H, J = 6.4 Hz), 5.24 (s, 1 H), 5.30 (s, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 22.5, 23.4, 25.1, 28.9, 31.7, 37.8, 62.8, 85.9, 89.3, 122.0, 126.3.

2,5-Dimethylhex-5-en-3-yn-2-ol (***A3***). Prepared following the general procedure 3 in 85% yield (1.63 g) from 1.32 g of 2-methylbut-1-en-3-yne and 696 mg of *p*-formaldehyde. Pale-yellow oil; R_f = 0.25 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3305, 2925, 2210, 1611, 1440, 1289, 1073, 1001; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.51 (s, 6 H), 1.85 (s, 3 H), 2.32 (s, 1 H, −OH), 5.15−5.21 (m, 1 H), 5.24 (s, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 31.4, 65.3, 83.1, 92.8, 121.7, 126.3.

1-(3-Methylbut-3-en-1-ynyl)cyclopentanol (***A4***). Prepared following the general procedure 3 in 56% yield (586 mg) from 462 mg of 2-methylbut-1-en-3-yne and 647 mg of cyclopentanone. Pale-yellow oil; R_f = 0.34 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3340, 2961, 2214, 1614, 1205, 994, 892; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.72−1.80 (m, 4 H), 1.84−1.91 (m, 4 H), 1.91−1.99 (m, 4 H), 5.20 (quint, 1 H, J = 1.7 Hz), 5.24−5.27 (m, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.5, 23.6, 42.5, 74.8, 84.3, 91.9, 121.7, 126.5.

(Z)-1-tert-Butyldimethylsilyloxy-3-methylpent-2-en-4-yne. *tert*-Butyldimethylsilyl chloride (1.56 g, 11 mmol) was added to a solution of distilled (*Z*)-3-methylpent-2-en-4-yn-1-ol (1 g, 10 mmol) and imidazole (817 mg, 12 mmol) in dry CH_2Cl_2 (20 mL). The mixture was stirred at room temperature for 16 h. The reaction was quenched by addition of water (10 mL). The aqueous layer was extracted twice with CH_2Cl_2 (10 mL). The combined organic layers were washed with brine and dried over Na_2SO_4. After filtration and evaporation, the crude mixture was filtered through a pad of silica gel with cyclohexane to afford 1.80 g of the title compound (85%, 8.5 mmol) as a colorless oil. R_f = 0.75 (Cyclohexane/EtOAc 15%); IR (neat) ν_{max} 2954, 2929, 2857, 1471, 1463, 1361, 1253, 1104, 1058, 1004, 938, 832, 776 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.07 (s, 6 H), 0.90 (s, 9 H), 1.87 (s, 3 H), 3.13 (s, 1 H), 4.36 (d, 2 H, J = 6.3 Hz), 5.85 (t, 1 H, J = 6.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.1, 18.3, 22.8, 26.0, 62.1, 81.8, 82.0, 117.7, 138.6.

(Z)-6-(tert-Butyldimethylsilyloxy)-4-methylhex-4-en-2-yn-1-ol (***A5***). Prepared following the general procedure 3 in 63% yield (1.25 g) from 1.75 g of (*Z*)-1-*tert*-Butyldimethylsilyloxy-3-methylpent-2-en-4-yne and 262 mg of *p*-formaldehyde. Pale-yellow oil; R_f = 0.44 (Cyclohexane/EtOAc 25%); IR (neat) ν_{max} 3343, 2953, 2856, 1471, 1462, 1379, 1360, 1253, 1198, 1110, 1065, 1034, 1002, 938, 832, 812, 774; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.08 (s, 6 H), 0.90 (s, 9 H), 1.78 (broad, 1 H, −OH), 1.85 (s, 3 H), 4.34 (dd, 2 H, J = 6.4, 1.2 Hz), 4.41 (d, 2 H, J = 4.7 Hz), 5.79 (dt, 1 H, J = 6.4, 1.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.1, 18.3, 23.0, 26.0, 51.5, 62.1, 84.0, 91.9, 118.2, 137.2.

3-(Cyclohex-1-enyl)prop-2-yn-1-ol (***A6***). Prepared following the general procedure 3 in 72% yield (2.03 g) from 2.1 g of 1-ethynylcyclohexene and 732 mg of *p*-formaldehyde. Pale-yellow oil; R_f = 0.20 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3317, 3026, 2926, 2857, 2834, 2218, 1631, 1434, 1346, 1270, 1206, 1135, 1017, 975, 918, 844, 799; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.54−1.61 (m, 4 H), 1.74 (s, 1 H), 2.06−2.10 (m, 4 H), 4.37 (s, 2 H), 6.10 (quint, 1 H, J = 1.8 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.4, 22.2, 25.5, 29.0, 51.5, 84.5, 87.4, 120.0, 135.4.

General Procedure 4 for Preparation of Enynyl Benzyl Ether/Enynyl Benzyl Malonate. To a solution at 0 °C of enynyl alcohol or enynyl malonate (8 mmol) in THF (20 mL) were added *N*-tetrabutylammonium iodide (0.8 mmol) and sodium hydride by portions (8.8 mmol) at 0 °C. The solution was stirred under argon for 20 min. The appropriate benzyl or methyl naphtyl halide (8.8 mmol) was then added at 0 °C. The mixture was then warmed to room temperature and stirred overnight. The mixture was quenched with saturated NH_4Cl (5 mL). THF was removed under vacuo and the aqueous layer was extracted twice with Et_2O (20 mL). The combined organic extracts were dried over Na_2SO_4. After filtration and evaporation, the crude product was purified by flash chromatography to afford the title compound.

5-Benzyloxy-2-methylpent-1-en-3-yne (***Ca***). Prepared following the general procedure 4 in 94% yield (1.65 g) from 900 mg of **A1**. Colorless liquid; R_f = 0.57 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2962, 1724, 1454, 1259, 1070, 1010, 795, 698; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.91 (dd, 3 H, J = 1.3 Hz, 1.3 Hz), 4.29 (s, 2 H), 4.61 (s, 2 H), 5.26 (s, 1 H), 5.33 (s, 1 H), 7.26−7.62 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 57.8, 71.6, 76.6, 122.0, 127.9, 128.1, 128.4, 128.8, 129.0, 137.5.

5-Benzyloxy-2-methylundec-1-en-3-yne (***Cc***). Prepared following the general procedure 4 in 99% yield (1.93 g) from 1.29 g of **A2**. Colorless liquid; R_f = 0.63 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2923, 2856, 1454, 1065, 895, 733, 696; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.89 (t, 3 H, J = 6.6 Hz), 1.24−1.43 (m, 6 H), 1.46−1.53 (m, 2 H), 1.71−1.82 (m, 2 H), 1.93 (dd, 3 H, J = 1.3 Hz, 1.3 Hz), 4.21 (t, 1 H, J = 6.5 Hz), 4.33 (d, 1 H, J_{AB} = 11.6 Hz), 4.66 (d, 1 H, J_{AB} = 11.6 Hz), 5.23 (quint, 1 H, J = 1.4 Hz), 5.32 (s, 1 H), 7.26−7.41 (m, 5 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 22.6, 23.6, 25.4, 29.0, 31.8, 35.8, 69.1, 70.5, 87.1, 87.5, 121.9, 126.5, 127.6, 128.0, 128.3, 138.2.

5-Benzyloxy-2,2-dimethylpent-1-en-3-yne (***Cd***). Prepared following the general procedure 4 in 88% yield (1.52 g) from 1 g of **A3**. Colorless liquid; R_f = 0.55 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2984, 2924, 2851, 1590, 1453, 1377, 1292, 1150, 832, 732, 695; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.56 (s, 6 H), 1.89 (dd, 3 H, J = 1.3 Hz, 1.3 Hz), 4.63 (s, 2 H), 5.20−5.24 (m, 1 H), 5.25−5.29 (m, 1 H), 7.14−7.64 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.6, 29.0, 66.6, 71.0, 72.2, 85.7, 90.6, 121.8, 127.4, 127.8, 128.4, 139.3.

1-Benzyloxy-1-(3-methylbut-3-en-1-ynyl)-cyclopentane (***Ce***). Prepared following the general procedure 4 in 91% yield (830 mg) from 571 mg of **A4**. Colorless liquid; R_f = 0.64 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2955, 2870, 1613, 1495, 1453, 1372, 1291, 1201, 1084, 1051, 1027, 894, 731, 694; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.71−1.85 (m, 4 H), 1.90 (s, 3 H), 1.89−2.00 (m, 2 H), 2.07−2.18 (m, 2 H), 4.60 (s, 2 H), 5.22 (quint, 1 H, J = 1.7 Hz), 5.26−5.30 (m, 1 H), 7.22−7.42 (m, 5 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 23.6, 39.7, 67.0, 80.9, 86.3, 90.0, 121.5, 126.8, 127.3, 127.7, 129.3, 139.2.

(Z)-6-(Benzyloxy)-1-(tert-butyl)dimethylsilyloxy-3-methylhex-2-en-4-yne (***Cg***). Prepared following the general procedure 4 in 99% yield (1.50 g) from 1.10 g of **A5**. Colorless oil; R_f = 0.70 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2952, 2928, 2884, 2855, 1471, 1452, 1352, 1253, 1084, 1066, 1028, 1004, 938, 833, 775; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.09 (s, 6 H), 0.91 (s, 9 H), 1.89 (s, 3 H), 4.34 (s, 2 H), 4.39 (d, 2 H, J = 6.5 Hz), 4.63 (s, 2 H), 5.82 (t, 1 H, J = 6.4 Hz), 7.30−7.37 (m, 5 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.0, 18.4, 23.0, 26.0, 57.8, 62.3, 71.5, 84.9, 89.8, 118.2, 127.9, 128.1, 128.4, 137.3, 137.5.

[1-(3-Benzyloxy)prop-1-ynyl]cyclohex-1-ene (***Ch***). Prepared following the general procedure 4 in 77% yield (1.69 g) from 1.32 g of **A6**. Colorless liquid; R_f = 0.53 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2927, 2853, 1453, 1348, 1205, 1070, 918, 734, 696; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.55−1.68 (m, 4 H), 2.05−2.18 (m, 4 H), 4.30 (s, 2 H), 4.62 (s, 2 H), 6.15 (quint, 1 H, J = 2.0 Hz), 7.26−7.39 (m, 5 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 22.3, 25.6, 29.2, 58.0, 71.4, 82.5, 88.6, 120.5, 127.8, 128.1, 128.4, 135.4, 138.0.

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*1-Methoxy-3-(((4-methylpent-4-en-2-yn-1-yl)oxy)methyl)-benzene (**Co**).* Prepared following the general procedure 4 in 86% yield (465 mg) from 240 mg of **A1** and 484 mg of 3-methoxybenzyl chloride. Pale-yellow oil ; R_f = 0.34 (Pentane/Et_2O 5%); IR (neat) ν_{max} 2944, 2837, 1586, 1489, 1455, 1351, 1263, 1154, 1084, 1050, 898, 780, 692; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.91 (m, 3H), 3.81 (s, 3H), 4.29 (s, 2H), 4.59 (s, 2H), 5.25 (dq, 1H, J = 1.6 Hz, 1.6 Hz), 5.33 (s, 1H), 6.82−6.87 (m, 1H), 6,92−6.96 (m, 2H), 7.23−7.29 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4., 55.3, 57.8, 71.5, 84.0, 87.7, 113.3, 113.6, 120.3, 122.3, 126.3, 129.5, 139.1, 159.8.

*1-Chloro-3-(((4-methylpent-4-en-2-yn-1-yl)oxy)methyl)benzene (**Cp**).* Prepared following the general procedure 4 in 91% yield (840 mg) from 400 mg of **A1** and 1.057 g of 3-chlorobenzyl bromide. Colorless oil; R_f = 0.60 (Pentane/Et_2O 5%); IR (neat) ν_{max} 2850, 1575, 1431, 1350, 1289; 1204, 1079, 896, 778, 681; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.91 (s, 3H), 4.31 (s, 2H), 4.58 (s, 2H), 5.24−5.29 (m, 1H), 5.30−5.35 (s, 1H), 7.20−7.25 (m, 1H), 7.27−7.32 (m, 2H), 7.35−7.39 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 58.1, 70.8, 83.7, 88.0, 126.0, 126.2, 127.9, 128.0, 129.7, 134.4, 139.7.

*(5-Methylhex-5-en-3-yn-1-yl)benzene (**Cs**).* Prepared following the general procedure 4 in 89% yield (1.260 g) from 577 mg of **A1** and 1165 mg of 1-chloromethylnaphtalene. Colorless oil; R_f = 0.56 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2851, 1610, 1520, 1354, 1288, 1088, 895, 791, 774; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.95 (t, 3H, J = 1.4 Hz), 4.35 (s, 2H), 5.07 (s, 2H), 5.28 (quint, 1H, J = 1.4 Hz), 5.36 (s, 1H), 7.44 (dd, 1H, J = 7.3 Hz, 8.0 Hz), 7.49−7.58 (m, 3H), 7.82−7.89 (m, 2H), 8.20 (d, 1H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 57.9, 69.9, 84.2, 87.9, 122.3, 124.1, 125.2, 126.3, 126.4, 127.1, 128.5, 128.9, 131.9, 133.0, 133.8.

*5-(Naphth-2-yl)methyloxy-2-methylpent-1-en-3-yne (**Ct**).* Prepared following the general procedure 4 in 99% yield (1.060 g) from 439 mg of **A1**. Colorless liquid; R_f = 0.56 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3040, 2929, 2856, 1083, 894, 814, 749, 474; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.94 (dd, 3 H, J = 1.3 Hz, 1.3 Hz), 4.35 (s, 2 H), 4.80 (s, 2 H), 5.28 (quint, 1 H, J = 1.3 Hz), 5.36 (s, 1 H), 7.49 (d, 1 H, J = 9.5 Hz), 7.42−7.55 (m, 2 H), 7.84 (s, 1 H), 7.82−7.87 (m, 2 H), 7.85 (d, 1 H, J = 9.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.5, 57.9, 71.7, 84.1, 87.8, 122.4, 126.0, 126.1, 126.5, 127.0, 127.7, 127.9, 128.2, 128.8, 133.1, 133.3, 135.0.

*d_7-5-Benzyloxy-2-methylpent-1-en-3-yne (**Cu**).* Prepared following the general procedure 4 in 84% yield (1.12 g) from 660 mg of **A1** and 1.465 g of d_7-benzyl bromide.[32] Colorless oil; R_f = 0.39 (Pentane/Et_2O 5%); IR (neat) ν_{max} 2845, 1613, 1356, 1289, 1206, 1181, 1095, 898, 539; ^{1}H NMR (300 MHz, $CDCl_3$) δ 11.93 (s, 3H), 4.30 (s, 2H), 5.24−5.31 (m, 1H), 5.32−5.39 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.4, 57.7, 70.6 (m), 84.1, 87.7, 122.3, 126.3, 127.4 (m), 127.6 (m), 127.8 (m), 137.5.

*Ethers **Ci** and **Cj** Were Prepared in Two Steps.* **Step 1**: To a solution at −78 °C under argon of *n*-BuLi (1.6 M in hexanes, 5.25 mmol) in THF (10 mL) was added ((prop-2-yn-1-yloxy)methyl)-benzene[33] (5 mmol). The resulting reaction mixture was stirred at the same temperature for 30 min, and the ketone (5.5 mmol) was then added at −78 °C. The reaction mixture was then allowed to reach room temperature and was stirred further until completion of reaction as monitored by TLC. The mixture was quenched with aqueous NH_4Cl (5 mL) and extracted twice with Et_2O (20 mL). The combined organic layers were dried over $MgSO_4$. After filtration and evaporation, the crude product was purified by flash chromatography (Cyclohexane/EtOAc) to afford the title compound.

1-(3-(Benzyloxy)prop-1-yn-1-yl)cycloheptanol. Prepared in 84% yield (1.180 g) from 800 mg of ((prop-2-yn-1-yloxy)methyl)benzene. Colorless oil; R_f = 0.42 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3394, 2925, 2854, 1640, 1454, 1349, 1068, 1026, 736, 696; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.50−1.75 (m, 8H), 1.81−1.92 (m, 2H), 1.87 (s, 1H), 2.01−2.06 (m, 2H), 4.23 (s, 2H), 4.60 (s, 2H), 7.26−7.37 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 22.7, 28.5, 43.6, 58.1, 72.0, 72.3, 79.6, 91.9, 128.3, 128.6, 128.9, 138.0.

1-(3-(Benzyloxy)prop-1-yn-1-yl)cyclooctanol. Prepared in 80% yield (1.184 g) from 800 mg of ((prop-2-yn-1-yloxy)methyl)benzene. Colorless oil; R_f = 0.39 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3394, 2920, 2851, 1512, 1445, 1351, 1068, 981, 905, 732, 696; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.45−1.52 (m, 3H), 1.58−1.70 (m, 8H), 1.88−1.98 (m, 4H), 4.22 (s, 2H), 4.60 (s, 2H), 7.27−7.40 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 22.1, 24.4, 27.9, 38.1, 57.4, 71.3, 71.4, 78.9, 91.3, 127.8, 128.1, 128.4, 137.5.

Step 2: To a solution of propargylic alcohol (2 mmol) in pyridine (10 mL) was added dropwise phosphorus oxychloride at 0 °C, while stirring under argon. After 20 min, the ice bath was removed and the mixture was allowed to stir at room temperature for 6 h. The reaction was quenched by slow addition of water (10 mL) at 0 °C, then the whole mixture was extracted with EtOAc (2× 10 mL). The organic layer was washed with 1N HCl (20 mL), water (20 mL) and brine (20 mL), dried over $MgSO_4$, then filtered and concentrated under reduced pressure. The residue was then purified by flash chromatography (Cyclohexane/EtOAc) to afford the title compound.

*1-(3-(Benzyloxy)prop-1-yn-1-yl)cyclohept-1-ene (**Ci**).* Prepared in 62% yield (284 mg) from 500 mg of 1-(3-(benzyloxy)prop-1-yn-1-yl)cycloheptanol. Yellow oil; R_f = 0.54 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2926, 1715, 1620, 1452, 1069, 736, 697; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.45−1.69 (m, 4H), 1.70−1.80 (m, 2H), 2.14−2.28 (m, 2H), 2.32−2.36 (m, 2H), 4.29 (s, 2H), 4.61 (s, 2H), 6.32 (t, 1H, J = 6.5 Hz), 7.21−7.40 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 26.5, 26.6, 29.2, 32.1, 34.2, 58.1, 71.5, 82.2, 90.0, 126.3, 127.8, 128.1, 128.4, 137.7, 140.5.

*(E)-1-(3-(Benzyloxy)prop-1-yn-1-yl)cyclooct-1-ene (**Cj**).* Prepared in 79% yield (662 mg) from 500 mg of 1-(3-(benzyloxy)prop-1-yn-1-yl)cyclooctanol. This compound was found to be very unstable, and was readily used for the next aziridination step leading to **1j** without further purification. Yellow oil; R_f = 0.54 (Cyclohexane/EtOAc 20%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.46−1.56 (m, 5H), 1.62−1.71 (m, 3H), 2.14−2.22 (m, 2H), 2.29−2.35 (m, 2H), 4.29 (s, 2H), 4.61 (s, 2H), 6.12 (t, 1H, J = 8.4 Hz), 7.23−7.40 (m, 5H).

*Enynyl Benzyl Malonates were all prepared by alkylation of the following precursor **D**. Diethyl 2-(4-methylpent-4-en-2-yn-1-yl)-malonate (**D**).* Prepared following the general procedure 5 for Sonogashira-type coupling (see below) in 74% yield (1255 mg) from 1.400 g of diethyl 2-(prop-2-yn-1-yl)malonate.[34] Yellow oil; R_f = 0.44 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2974, 1731, 1596, 1412, 1375, 1231, 1151, 1032; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.28 (t, 6H, J = 7.1 Hz), 1.83 (s, 3H), 2.89 (d, 2H, J = 7.7 Hz), 3.56 (t, 1H, J = 7.7 Hz), 4.22 (q, 4H, J = 7.1 Hz), 5.15 (quint, 1H, J = 1.6 Hz), 5.18−5.21 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) 14.1, 19.3, 23.5, 51.5, 61.7, 83.7, 84.4, 121.3, 126.7, 168.0; HR-MS 261.112 ($C_{13}H_{18}O_4$ + Na calcd 261.110).

*Diethyl 2-benzyl-2-(4-methylpent-4-en-2-yn-1-yl)malonate (**Cl**).* Prepared following the general procedure 4 in 85% yield (286 mg) from 245 mg of **D**. Colorless oil; R_f = 0.50 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2984, 1733, 1571, 1470, 1275, 1179, 1085, 1058, 701; ^{1}H NMR (300 MHz, $CDCl_3$) δ 11.26 (t, 6H, J = 7.1 Hz), 1.86−1.92 (m, 3H), 2.78 (s, 2H), 3.40 (s, 2H), 4.21 (q, 4H, J = 7.0 Hz), 5.20 (qt, 1H, J = 1.6 Hz), 5.24−5.30 (m, 1H), 7.35−7.15 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 23.0, 23.7, 37.5, 58.5, 61.7, 83.8, 85.5, 121.8, 126.8, 127.1, 128.4, 129.9, 135.8, 169.8; HR-MS 351.157 ($C_{20}H_{24}O_4$ + Na calcd 351.157).

*Diethyl 2-(4-Methoxybenzyl)-2-(4-methylpent-4-en-2-yn-1-yl)-malonate (**Cq**).* Prepared following the general procedure 4 in 91% yield (600 mg) from 438 mg of **D**. Colorless oil; R_f = 0.43 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2979, 1733, 1587, 1512, 1277, 1248, 1176, 1036, 842; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.27 (t, 6H, J = 7.1 Hz), 1.87−1.92 (m, 3H), 2.77 (s, 2H), 3.33 (s, 2H), 3.77 (s, 3H), 4.21 (q, 4H, J = 7.0 Hz), 5.17−5.21 (m, 1H), 5.23−5.29 (m, 1H), 6.80 (d, 2H, J_{AB} = 8.5 Hz), 7.08 (d, 2H, J_{AB} = 8.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 22.9, 23.7, 36.6, 55.2, 58.5, 61.7, 83.9, 85.5, 113.8, 121.4, 126.8, 127.7, 130.9, 158.7, 169.9; HR-MS 381.165 ($C_{21}H_{26}NO_5$ + Na calcd 381.167).

*Diethyl 2-(4-Chlorobenzyl)-2-(4-methylpent-4-en-2-yn-1-yl)-malonate (**Cr**).* Prepared following the general procedure 4 in 82% yield (547 mg) from 438 mg of **D**. Colorless oil; R_f = 0.56 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2979, 1733, 1586, 1496,

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1268, 1177, 1041, 848; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.26 (t, 6H, J = 7.0 Hz), 1.87−1.91 (m, 3H), 2.76 (s, 2H), 3.35 (s, 2H), 4.21 (q, 4H, J = 7.0 Hz), 5.20−5.23 (m, 1H), 5.24−5.29 (m, 1H), 7.10 (d, 2H, J_{AB} = 8.4 Hz), 7.24 (d, 2H, J_{AB} = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 23.0, 23.6, 36.8, 58.3, 61.8, 83.5, 85.7, 121.5, 126.6, 128.5, 131.3, 133.1, 134.3, 169.6; HR-MS 385.119 ($C_{20}H_{23}ClO_4$ + Na calcd 385.118).

General Procedure 5 for the Coupling of Alkynes with Vinyl Halides. To a solution of the alkyne (4 mmol) in dry and degassed THF (10 mL) were added copper(I) iodide (6 mol %) and $Pd(PPh_3)_2Cl_2$ (3 mol %) while stirring under argon. Diisopropylamine (16 mmol) and the vinyl halide (5 mmol) were then added, and the solution was heated at 50 °C until completion as monitored by TLC. Volatile compounds were then removed in vacuo. The residue was dissolved in Et_2O (15 mL) and washed with 1N HCl (20 mL), water (2× 20 mL) and brine (20 mL). The organic layer was then dried over $MgSO_4$. After filtration and evaporation, the crude product was purified by flash chromatography (cyclohexane/EtOAc) to afford the title compound.

*((5-(Benzyloxy)-2-methylenepent-3-yn-1-yl)oxy)(tert-butyl)-dimethylsilane (**Cf**).* Prepared following the general procedure 5 in 76% yield (1.320 g) from 800 mg of ((prop-2-yn-1-yloxy)methyl)-benzene and 2120 mg of *tert*-butyl((2-iodoallyl)oxy)dimethylsilane.[35] Colorless oil; R_f = 0.44 (Pentane/Et_2O 5%); IR (neat) ν_{max} 2954, 2935, 2855, 1455, 1252, 1093, 834, 777, 736, 696; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.09 (s, 6H), 0.92 (s, 9H), 4.16 (t, 2H, J = 1.7 Hz), 4.30 (s, 2H), 4.61 (s, 2H), 5.49 (dt, 1H, J = 1.7, 1.7 Hz), 5.62 (dt, 1H, J = 1.7, 1.7 Hz), 7.28−7.36 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.3, 18.4, 25.9, 57.8, 65.0, 71.7, 84.6, 86.1, 119.9, 127.9, 128.1, 128.5, 130.4, 139.5.

*N-Benzyl-N-tosyl-4-methylpent-4-en-2-yn-1-amine (**Ck**).* Prepared following the general procedure 5 in 76% yield (783 mg) from 913 mg of *N*-benzyl-*N*-tosylprop-2-yn-1-amine.[22b] Orange solid: mp = 48 °C; R_f = 0.52 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3010−2870, 1590, 1385, 1325, 1164, 1120, 1091, 895, 815, 769, 730, 699, 654, 571; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.63 (dd, 3H, J = 1.3 Hz, 1.3 Hz), 2.41 (s, 3H), 4.03 (s, 2H), 4.32 (s, 2H), 4.94−5.00 (m, 1H), 5.09−5.14 (m, 1H, J = 1.6 Hz), 7.30 (d, 2H, J = 8.3 Hz), 7.27−7.40 (m, 5H), 7.78 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.9, 23.5, 36.8, 50.4, 81.0, 87.6, 122.5, 126.3, 128.3, 128.5, 129.1, 129.2, 129.9, 135.5, 136.4, 143.9.

*7-Phenyl-2-methylhept-1-en-3-yne (**Cm**).* Prepared following the general procedure 5 in 88% yield (900 mg) from 800 mg of commercially available 5-phenyl-1-pentyne and 925 mg of 2-bromopropene. Orange oil; R_f = 0.60 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2940, 1604, 1495, 1453, 890, 742, 697; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.70 (s, 3H), 1.81−1.91 (m, 2H), 2.32 (t, 2H, J = 7.1 Hz), 2.74 (t, 2H, J = 7.5 Hz), 5.16 (s, 1H), 5.23 (s, 1H), 7.17−7.25 (m, 3H), 7.25−7.33 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 18.7, 23.9, 30.3, 34.8, 82.4, 88.9, 120.5, 125.9, 127.3, 128.4, 128.5, 141.7.

*(5-Methylhex-5-en-3-yn-1-yl)benzene (**Cn**).* Prepared following the general procedure 5 in 78% yield (517 mg) from 500 mg of commercially available 4-phenyl-1-butyne and 581 mg of 2-bromopropene. Yellow oil; R_f = 0.61 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2940, 1572, 1453, 1277, 892, 748, 695, 499; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.86 (t, 3H, J = 1.1 Hz), 2.58 (t, 2H, J = 7.4 Hz), 2.86 (t, 2H, J = 7.4 Hz), 5.14 (dq, 1H, J = 1.7 Hz), 5.20 (s, 1H), 7.18−7.33 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.2, 23.4, 34.8, 82.2, 88.1, 120.1, 125.9, 126.8, 127.9, 128.1, 140.3.

General Procedure 6 for Aziridination of Enyne.[15a] To a solution of enyne ether (2 mmol) in acetonitrile (10 mL) were added $[Cu(MeCN)_4]ClO_4$ (0.1 mmol) and 4 Å molecular sieves (500 mg). TsN = IPh (or NsN = IPh in the case of **1b**, 2.2 mmol) was added by portions under argon over 3 h, the reaction was then monitored by thin-layer chromatography and stopped before complete conversion of the starting material (ca. 2 h for TsN = IPh, 5 h for NsN = IPh) to avoid degradation. The solution was filtrated, concentrated in vacuo and the crude residue was purified by flash chromatography (Cyclohexane/EtOAc) to afford the title compound. Starting material could also be recovered.

*2-(3-(Benzyloxy)prop-1-ynyl)-2-methyl-1-tosylaziridine (**1a**).* Prepared following the general procedure 6 in 48% yield (455 mg) from 500 mg of **Ca**. Pale-yellow oil; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3040−2860, 2240, 1598, 1450, 1325, 1159, 1087, 1068, 868, 694, 571; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.63 (s, 3 H), 2.43 (s, 3 H), 2.45 (s, 1 H), 2.92 (s, 1 H), 4.20 (s, 2 H), 4.63 (s, 2 H), 7.23−7.38 (m, 7 H), 7.86 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.7, 38.0, 41.8, 57.2, 71.6, 80.8, 83.2, 127.8, 128.3, 128.4, 129.6, 131.3, 136.7, 137.4, 144.3; HR-MS 378.109 ($C_{20}H_{21}NO_3S$ + Na calcd 378.113).

*2-(3-(Benzyloxy)prop-1-ynyl)-2-methyl-1-(4-nitrophenylsulfonyl)-aziridine (**1b**).* Prepared following the general procedure 6 in 36% yield (260 mg) from 366 mg of **Ca**. Pale-yellow oil; R_f = 0.22 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2925, 2851, 1530, 1346, 1165, 1087, 1010, 854, 791, 740, 686; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.67 (s, 3 H), 2.53 (s, 1 H), 3.00 (s, 1 H), 4.20 (s, 2 H), 4.62 (s, 2 H), 7.25−7.38 (m, 5 H), 8.17 (d, 2 H, J = 8.6 Hz), 8.35 (d, 2 H, J = 8.6 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 23.8, 30.9, 42.6, 57.1, 71.7, 81.6, 82.4, 124.2, 128.0, 128.3, 128.5, 129.2, 137.2, 145.1, 150.5; HR-MS 409.080 ($C_{19}H_{18}N_2O_5S$ + Na calcd 409.083).

*2-(3-(Benzyloxy)non-1-ynyl)-2-methyl-1-tosylaziridine (**1c**).* Prepared following the general procedure 6 in 48% yield (311 mg, *dr* 1:1) from 400 mg of **Cc**. Mixture of diastereoisomers: pale-yellow oil; R_f = 0.34 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2959, 2927, 2855, 1465, 1328, 1160, 1088, 814, 732, 693, 549; ^{1}H NMR (300 MHz, $CDCl_3$) δ 0.87 (t, 3 H, J = 6.4 Hz), 1.20−1.32 (m, 6 H), 1.39−1.48 (m, 2 H), 1.63 (s, 3 H), 1.66−1.80 (m, 2 H), 2.43 (s, 3 H), 2.44 (s, 1 H), 2.93 (s, 1 H), 4.10 (t, 1 H, J = 6.6 Hz), 4.53 (d, 1 H, J_{ab} = 11.6 Hz), 4.79 (dd, 1 H, J_{ab} = 11.6 Hz, 6.4 Hz), 7.31 (d, 2 H, J = 11.6 Hz), 7.22−7.44 (m, 5 H), 7.87 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 21.6, 22.6, 24.0, 25.2, 29.0, 31.7, 35.5, 38.1, 41.8, 68.6, 70.6, 82.4, 84.3, 127.6, 127.8, 128.1, 128.4, 129.6, 136.8, 138.1, 144.3; HR-MS 462.204 ($C_{26}H_{33}NO_3S$ + Na calcd 462.207).

*2-(3-(Benzyloxy)-3-methylbut-1-ynyl)-2-methyl-1-tosylaziridine (**1d**).* Prepared following the general procedure 6 in 44% yield (552 mg) from 647 mg of **Cd**. Pale-yellow oil; R_f = 0.27 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2983, 2930, 2861, 1724, 1453, 1328, 1158, 1087, 1059, 814, 664, 550; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.55 (s, 6 H), 1.61 (s, 3 H), 2.42 (s, 3 H), 2.43 (s, 1 H), 2.91 (s, 1 H), 4.64 (s, 2 H), 7.21−7.42 (m, 7 H), 7.86 (d, 2 H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.7, 24.0, 28.7, 38.1, 41.9, 66.7, 70.6, 81.2, 87.0, 127.3, 127.8, 127.9, 128.3, 129.6, 137.0, 139.2, 144.3; HR-MS 390.173 ($C_{22}H_{25}NO_3S$ + Li calcd 390.171).

*2-((1-(Benzyloxy)cyclopentyl)ethynyl)-2-methyl-1-tosylaziridine (**1e**).* Prepared following the general procedure 6 in 45% yield (311 mg) from 400 mg of **Ce**. Pale-yellow oil; R_f = 0.37 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2976, 2947, 2848, 1595, 1446, 1381, 1324, 1085, 1061, 1022, 923, 902, 817, 732, 693; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60 (s, 3 H), 1.66−1.83 (m, 4 H), 1.88−2.16 (m, 4 H), 2.42 (s, 1 H), 2.43 (s, 3 H), 2.93 (s, 1 H), 4.61 (s, 2 H), 7.21−7.39 (m, 5 H), 7.31 (d, 2 H, J = 8.3 Hz), 7.86 (d, 2 H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.4, 24.1, 38.2, 39.4, 41.9, 67.2, 80.6, 81.6, 86.6, 126.2, 127.3, 127.7, 127.8, 129.6, 136.9, 139.1, 144.2; HR-MS 432.163 ($C_{24}H_{27}NO_3S$ + Na, calcd 432.160).

*2-(3-(Benzyloxy)prop-1-yn-1-yl)-2-(((tert-butyldimethylsilyl)oxy)-methyl)-1-tosylaziridine (**1f**).* Prepared following the general procedure 6 in 34% yield (315 mg) from 600 mg of **Cf**. Pale-yellow oil; R_f = 0.27 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2927, 2855, 1329, 1252, 1161, 1087, 835, 779, 732, 696, 548; ^{1}H NMR (300 MHz, $CDCl_3$) δ −0.05 (s, 3H), −0.01 (s, 3H), 0.78 (s, 9H), 2.38 (s, 3H), 2.54 (s, 1H), 2.91 (s, 1H), 3.77 (s, 2H), 4.19 (s, 2H), 4.61 (s, 2H), 7.25 (d, 2H, J = 8.1 Hz), 7.21−7.39 (m, 5H), 7.81 (d, 2H, J = 8.1 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.4, −5.3, 18.3, 21.6, 25.7, 37.2, 41.5, 57.2, 65.1, 71.4, 80.0, 83.5, 127.8, 128.0, 128.3, 128.4, 129.5, 136.4, 137.4, 144.3; HR-MS 508.195 ($C_{26}H_{35}NO_4SSi$ + Na calcd 508.195).

*2-(3-(Benzyloxy)prop-1-ynyl)-3-((tert-butyldimethylsilyloxy)-methyl)-2-methyl-1-tosylaziridine (**1g**).* Prepared following the general procedure 6, in 17% yield (250 mg) from 700 mg of **Cg**. Colorless oil; R_f = 0.5 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2952, 2928, 2883, 2856, 1680, 1455, 1357, 1328, 1303, 1253, 1224,

1159, 1087, 1026, 1006, 966, 897, 833, 777; ^{1}H NMR (300 MHz, $CDCl_3$) δ −0.04 (s, 3 H), −0.01 (s, 3 H), 0.83 (s, 9 H), 1.99 (s, 3 H), 2.42 (s, 3 H), 3.17 (dd, 1 H, J = 6.3, 5.3 Hz), 3.59 (dd, 1 H, J = 11.2, 6.5 Hz), 3.81 (dd, 1 H, J = 11.2, 5.3 Hz), 4.17 (s, 2 H), 4.55 (s, 2 H), 7.30−7.37 (m, 7 H), 7.86 (d, 2 H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ −5.61, 18.1, 20.3, 21.5, 43.8, 52.4, 57.2, 62.3, 71.6, 79.4, 83.5, 127.5, 127.9, 128.0, 128.4, 129.4, 137.1, 137.5, 144.0; HR-MS 522.210 ($C_{27}H_{37}NO_4SSi$ + Na calcd 522.209).

*1-(3-(Benzyloxy)prop-1-ynyl)-7-tosyl-7-azabicyclo[4.1.0]heptane (**1h**).* Prepared following the general procedure 6 in 57% yield (498 mg) from 500 mg of **Ch**. Pale-yellow oil; R_f = 0.34 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2937, 2855, 1325, 1154, 1089, 958, 916, 810, 696, 672, 527; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.10−1.41 (m, 4 H), 1.59−1.70 (m, 1 H), 1.84−1.97 (m, 2 H), 2.10−2.22 (m, 1 H), 2.42 (s, 3 H), 3.36 (dd, 1 H, J = 5.2 Hz, 1.1 Hz), 4.22 (s, 2 H); 4.64 (s, 2 H), 7.23−7.41 (m, 7 H), 7.65 (d, 2 H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.1, 19.2, 21.6, 22.6, 31.3, 40.4, 46.8, 57.3, 71.5, 81.7, 83.4, 127.7, 127.8, 128.0, 128.4, 129.5, 137.2, 137.5, 143.9; HR-MS 418.141 ($C_{23}H_{25}NO_3S$ + Na calcd 418.145).

*1-(3-(Benzyloxy)prop-1-yn-1-yl)-8-tosyl-8-azabicyclo[5.1.0]-octane (**1i**).* Prepared following the general procedure 6 in 30% yield (140 mg) from 280 mg of **Ci**. Yellow oil; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2925, 2851, 1585, 1471, 1326, 1158, 1088, 725, 699 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.33−1.49 (m, 4H), 1.50−1.69 (m, 3H), 1.89−2.00 (m, 2H), 2.09−2.17 (m, 1H), 2.42 (s, 3H), 3.33 (dd, 1H, J = 7.4 Hz, 3.7 Hz), 4.23 (s, 2H), 4.65 (s, 2H), 7.29 (d, 2H, J = 7.9 Hz), 7.31−7.42 (m, 5H), 7.85 (d, 2H, J = 7.9 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.7, 25.0, 25.1, 28.4, 31.2, 36.2, 45.7, 51.4, 57.3, 71.4, 81.3, 87.0, 127.7, 127.8, 128.3, 128.4, 129.5, 137.2, 137.6, 143.9; HR-MS 432.161 ($C_{24}H_{27}NO_3S$ + Na calcd 432.160).

*1-(3-(Benzyloxy)prop-1-yn-1-yl)-9-tosyl-9-azabicyclo[6.1.0]-nonane (**1j**).* Prepared following the general procedure 6 in 37% yield (248 mg) from 400 mg of **Cj**. Yellow oil; R_f = 0.37 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2925, 2841, 1471, 1324, 1155, 1089, 934, 714, 699, 565 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.20−1.78 (m, 10H), 2.03 (ddt, 1H, J = 13.9 Hz, 3.5 Hz, 3.4 Hz), 2.17 (dt, 1H, J = 13.8 Hz, 3.3 Hz), 2.42 (s, 3H), 3.13 (dd, 1H, J = 11.3 Hz, 3.7 Hz), 4.25 (s, 2H), 4.66 (s, 2H), 7.28 (d, 2H, J = 8.3 Hz), 7.26−7.44 (m, 5H), 7.85 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.8, 25.7, 26.0, 26.1, 26.1, 26.2, 32.3, 44.8, 51.6, 57.5, 71.6, 82.5, 82.7, 127.9, 128.0, 128.6, 128.6, 129.7, 137.1, 137.2, 144.2; HR-MS 446.172 ($C_{25}H_{29}NO_3S$ + Na calcd 446.176).

*2-(N-Benzyl-N-tosyl-3-aminoprop-1-ynyl)-2-methyl-1-tosylaziridine (**1k**).* Prepared following the general procedure 6 in 52% yield (390 mg) from 500 mg of (**Ck**). White solid: mp = 103−104 °C; R_f = 0.42 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 3080−2925, 1605, 1457, 1325, 1156, 1094, 899, 815, 766, 693, 665, 535; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.37 (s, 3H), 2.24 (s, 1H), 2.42 (s + s, 3H + 3H), 2.50 (s, 1H), 3.91 (d, 1H, J_{ab} = 18.7 Hz), 4.03 (d, 1H, J_{ab} = 18.7 Hz), 4.37 (d, 1H, J_{ab} = 13.7 Hz), 4.46 (d, 1H, J_{ab} = 13.7 Hz), 7.25−7.37 (m, 7H), 7.39−7.45 (m, 1H), 7.44 (m, 1H), 7.79 (d, 2H, J = 8.3 Hz), 7.81 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 21.6, 23.4, 35.8, 37.4, 41.6, 49.9, 77.7, 82.5, 127.6, 127.8, 127.9, 128.6, 129.0, 129.5, 129.5, 135.1, 136.3, 136.7, 143.3, 144.4; HR-MS 531.137 ($C_{27}H_{28}N_2O_2S$ + Na calcd 531.139).

*Diethyl 2-benzyl-2-(3-(2-methyl-1-tosylaziridin-2-yl)prop-2-yn-1-yl)malonate (**1l**).* Prepared following the general procedure 6 in 52% yield (212 mg) from 270 mg of **Cl**. Colorless oil; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2976, 1731, 1473, 1176, 1338, 1277, 1176, 1040, 665, 585; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.26 (t, 3H, J = 7.1 Hz), 1.61−1.68 (m, 3H), 2.43 (s, 1H), 2.43 (s, 3H), 2.72 (s, 2H), 2.88 (s, 1H), 3.40 (s, 2H), 4.21 (q, 4H, J = 7.0 Hz), 7.16−7.25 (m, 5H), 7.32 (d, 2H, J = 8.3 Hz), 7.86 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 21.6, 22.5, 24.1, 37.4, 38.3, 41.9, 58.3, 61.7, 80.6, 80.8, 127.1, 127.8, 128.4, 129.6, 130.0, 135.7, 137.0, 144.2, 169.7; HR-MS 520.175 ($C_{27}H_{31}NO_6S$ + Na calcd 520.176).

*2-Methyl-2-(5-phenylpent-1-ynyl)-1-tosylaziridine (**1m**).* Prepared following the general procedure 6 in 44% yield (337 mg) from 400 mg of **Cm**. Pale-yellow oil; R_f = 0.30 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2928, 1598, 1325, 1559, 1089, 909, 814, 730, 730; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.63 (s, 3H), 1.78−1.89 (m, 2H), 2.22 (t, 2H, J = 7.0 Hz), 2.43 (s, 3H), 2.44 (s, 1H), 2.74 (t, 2H, J = 7.0 Hz), 2.87 (s, 1H), 7.22 (m, 5H), 7.31 (d, 2H, J = 8.3 Hz), 7.86 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 18.3, 21.6, 24.2, 30.0, 34.7, 35.0, 42.0, 77.3, 85.3, 125.9, 127.8, 128.4, 128.6, 129.5, 137.0, 141.6, 144.1; HR-MS 376.132 ($C_{21}H_{23}NO_2S$ + Na calcd 376.134).

*2-Methyl-2-(4-phenylbut-1-yn-1-yl)-1-tosylaziridine (**1n**).* Prepared following the general procedure 6 in 59% yield (537 mg) from 455 mg of **Cn**. Pale-yellow oil; R_f = 0.33 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2930, 1587, 1324, 1157, 1088, 813, 749, 699, 662, 548 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.60 (s, 3H), 2.43 (s, 1H), 2.44 (s, 3H), 2.50 (t, 2H, J = 7.6 Hz), 2.81 (s, 1H), 2.84 (t, 2H, J = 7.6 Hz), 7.20−7.24 (m, 2H), 7.26−7.33 (m, 3H), 7.32 (d, 2H, J = 8.3 Hz), 7.85 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.1, 21.6, 23.9, 34.7, 38.9, 41.9, 77.7, 84.8, 126.3, 127.8, 128.4, 128.5, 129.5, 136.9, 140.5, 144.1; HR-MS 362.119 ($C_{20}H_{21}NO_2S$ + Na calcd 362.119).

*2-(3-((3-Methoxybenzyl)oxy)prop-1-yn-1-yl)-2-methyl-1-tosylaziridine (**1o**).* Prepared following the general procedure 6 in 34% yield (150 mg) from 250 mg of **Co**. Pale-yellow oil; R_f = 0.19 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2935, 2836, 1596, 1489, 1454, 1324, 1264, 1158, 1086, 868, 785, 692, 549 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.65 (s, 3H), 2.43 (s, 3H), 2.46 (s, 1H), 2.81 (s, 1H), 3.80 (s, 3H), 4.20 (s, 2H), 4.60 (s, 2H), 6.82−6.86 (m, 1H), 6.92−6.99 (m, 2H), 7.26 (t, 1H, J = 8.0 Hz), 7.31 (d, 2H, J = 8.2 Hz), 7.86 (d, 2H, J = 8.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.7, 23.7, 38.1, 41.8, 55.3, 57.2, 71.5, 80.8, 83.2, 113.4, 113.8, 120.5, 127.8, 129.5, 129.6, 136.7, 137.0, 144.3, 159.8; HR-MS 408.124 ($C_{21}H_{23}NO_4S$ + Na calcd 408.124).

*2-(3-((3-Chlorobenzyl)oxy)prop-1-yn-1-yl)-2-methyl-1-tosylaziridine (**1p**).* Prepared following the general procedure 6 in 50% yield (350 mg) from 400 mg of **Cp**. Pale-yellow oil; R_f = 0.27 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 2851, 1597, 1325, 1159, 1085, 869, 783, 892, 549 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.63 (s, 3H), 2.42 (s, 3H), 2.44 (s, 1H), 2.91 (s, 1H), 4.22 (s, 2H), 4.60 (s, 2H), 7.24−7.28 (m, 3H), 7.31 (d, 2H, J = 8.3 Hz), 7.38 (s, 1H), 7.83 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.7, 37.9, 41.8, 57.5, 70.7, 80.5, 83.5, 126.2, 127.8, 127.9, 128.2, 129.6, 129.7, 134.3, 136.7, 139.6, 144.3; HR-MS 412.073 ($C_{20}H_{20}ClNO_3S$ + Na calcd 412.074).

*Diethyl 2-(4-methoxybenzyl)-2-(3-(2-methyl-1-tosylaziridin-2-yl)-prop-2-yn-1-yl)malonate (**1q**).* Prepared following the general procedure 6 in 53% yield (308 mg) from 397 mg of **Cq**. Colorless oil; R_f = 0.35 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2979, 1731, 1584, 1506, 1335, 1249, 1160, 1032, 814, 633; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.26 (t, 6H, J = 7.1 Hz), 1.59−1.66 (m, 3H), 2.42 (s, 1H), 2.43 (s, 3H), 2.71 (s, 2H), 2.88 (s, 1H), 3.34 (s, 2H), 3.76 (s, 3H), 4.11−4.29 (m, 4H), 6.79 (d, 2H, J = 8.6 Hz), 7.11 (d, 2H, J = 8.6 Hz), 7.32 (d, 2H, J = 8.4 Hz), 7.86 (d, 2H, J = 8.4 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.1, 21.6, 22.4, 24.1, 36.5, 38.3, 41.9, 55.2, 58.3, 61.7, 80.5, 80.9, 113.8, 127.6, 127.7, 129.6, 131.0, 136.9, 144.2, 158.6, 169.7; HR-MS 550.186 ($C_{28}H_{33}NO_7S$ + Na calcd 550.187).

*Diethyl 2-(4-chlorobenzyl)-2-(3-(2-methyl-1-tosylaziridin-2-yl)-prop-2-yn-1-yl)malonate (**1r**).* Prepared following the general procedure 6 in 70% yield (554 mg) from 542 mg of **Cr**. Colorless oil; R_f = 0.39 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2979, 1732, 1579, 1480, 1327, 1160, 1091, 1015, 815, 670 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.26 (t, 6H, J = 7.1 Hz), 1.62 (s, 3H), 2.40 (s, 1H), 2.43 (s, 3H), 2.71 (s, 2H), 2.90 (s, 1H), 3.39 (s, 2H), 4.11−4.29 (m, 4H), 7.16 (d, 2H, J = 8.5 Hz), 7.23 (d, 2H, J = 8.5 Hz), 7.32 (d, 2H, J = 8.3 Hz), 7.85 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 14.0, 21.6, 22.5, 24.3, 36.7, 38.1, 42.0, 58.2, 61.8, 77.5, 80.7, 127.7, 128.5, 129.6, 131.5, 133.0, 134.2, 136.9, 144.2, 169.4; HR-MS 554.139 ($C_{27}H_{30}ClNO_6S$ + Na calcd 554.137).

*2-Methyl-2-(3-(naphthalen-1-ylmethoxy)prop-1-yn-1-yl)-1-tosylaziridine (**1s**).* Prepared following the general procedure 6 in 32% yield (284 mg) from 520 mg of **Cs**. Colorless oil; R_f = 0.24 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 1564, 1472, 1323, 1156, 1054, 1017, 866, 821, 782, 690, 640, 546 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.67 (s, 3H), 2.41 (s, 3H), 2.47 (s, 1H), 2.94 (s, 1H), 4.25

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(s, 2H), 5.08 (s, 2H), 7.30 (d, 2H, J = 8.3 Hz), 7.40−7.60 (m, 4H), 7.81−7.89 (m, 2H), 7.87 (d, 2H, J = 8.3 Hz), 8.15−8.21 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.7, 38.1, 41.8, 57.3, 70.0, 81.0, 83.4, 124.3, 125.2, 125.8, 126.3, 127.4, 127.9, 128.5, 128.9, 129.6, 132.0, 132.9, 133.8, 136.7, 144.3; HR-MS 428.130 ($C_{24}H_{23}NO_3S$ + Na calcd 428.129).

*2-Methyl-2-(3-naphthalen-2-ylmethoxy)prop-1-ynyl)-1-tosylaziridine (**1t**).* Prepared following the general procedure 6 in 51% yield (444 mg) from 500 mg of **Ct**. Pale-yellow oil; R_f = 0.32 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3075, 2993, 2941, 2853, 2232, 1585, 1325, 1160, 1086, 909, 868, 813, 728, 691; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.66 (s, 3 H), 2.42 (s, 3 H), 2.46 (s, 1 H), 2.93 (s, 1 H), 4.25 (s, 2 H), 4.80 (s, 2 H), 7.31 (d, 2 H, J = 8.3 Hz), 7.41−7.53 (m, 3 H), 7.80−7.94 (m, 6 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.7, 38.1, 41.8, 57.2, 71.6, 80.7, 83.3, 126.0, 126.1, 126.2, 127.3, 127.6, 127.8, 128.0, 128.2, 129.6, 133.1, 133.3, 134.9, 136.7, 144.4; HR-MS 428.124 ($C_{24}H_{27}NO_3S$ + Na, calcd 428.129).

*d_7-2-(3-(Benzyloxy)prop-1-ynyl)-2-methyl-1-tosylaziridine (**1u**).* Prepared following the general procedure 6 in 56% yield (1.12 g) from 660 mg of **Cu**. Pale-yellow oil; R_f = 0.23 (Cyclohexane/EtOAc 20%); IR (neat) ν_{max} 3273, 2925, 1597, 1324, 1157, 1089, 814, 662, 545; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.65 (s, 3H), 2.43 (s, 3H), 2.46 (s, 1H), 2.92 (s, 1H), 4.20 (s, 2H), 7.30 (d, 2H, J = 8.3 Hz), 7.87 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 22.1, 24.1, 38.5, 42.2, 57.6, 71.2 (m), 81.3, 83.6, 128.0 (m), 128.3, 128.3 (m), 128.7 (m), 130.0, 137.1, 137.5, 144.8; HR-MS 385.156 ($C_{20}H_{14}D_7NO_3S$ + Na, calcd 385.157).

*4-Methyl-2-phenethyl-1-tosyl-1H-pyrrole (**4n**).* Prepared using the same conditions as in the general procedure 1 in 68% yield (34 mg) from 50 mg of **1n** (using catalyst **6** instead of $Ph_3PAuNTf_2$). Colorless oil; R_f = 0.48 (Cyclohexane/EtOAc 30%); IR (neat) ν_{max} 2925, 1733, 1564, 1462, 1169, 1094, 812, 699, 665, 585; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.01 (d, 3H, J = 1.2 Hz), 2.39 (s, 3H), 2.85−2.97 (m, 4H), 5.87 (d, 1H, J = 1.2 Hz), 6.99−7.09 (m, 1H), 7.15−7.31 (m, 3H), 7.26 (d, 2H, J = 8.3 Hz), 7.63 (d, 2H, J = 8.3 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 11.4, 21.2, 28.9, 35.1, 114.6, 119.0, 121.7, 125.6, 126.2, 127.9, 127.9, 129.5, 134.7, 136.3, 140.9, 144.1; HR-MS 362.118 ($C_{20}H_{21}NO_2S$ + Na calcd 362.119).

■ ASSOCIATED CONTENT

Supporting Information

^{1}H and ^{13}C NMR spectra of all compounds and crystallographic data of **2h-maj**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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