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Gold-Catalyzed Stereoselective Synthesis of Bicyclic Lactams and Ketones from *N*-Tosylynamidomethyl-Tethered Cyclohexenes

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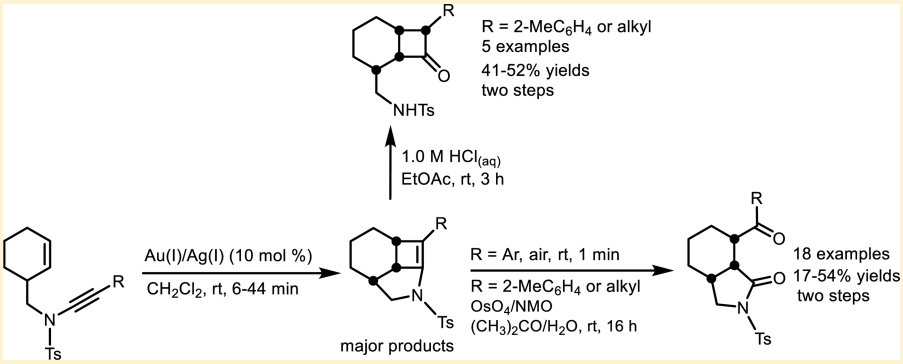
Supporting Information



ABSTRACT: Six-membered ring 3-enynamides underwent cycloisomerization in the presence of a catalytic amount of a gold(I) complex delivering mainly 4-azatricyclo[4.3.1.0^{3,10}]dec-2-ene derivatives and dibenz[*cd*,*f*]indole derivatives as the minor products under mild reaction conditions. Upon exposure to air, most aryl-substituted azatricycles led to bicyclic γ-lactams, while the *ortho*-tolyl- or alkyl-substituted azatricycles provided the corresponding bicyclic γ-lactams after oxidation with osmium tetraoxide and *N*-methylmorpholine-*N*-oxide. Under acidic conditions, the *ortho*-tolyl- or alkyl-substituted azatricycles were further transformed into 5-*N*-tosylaminomethyl-tethered bicyclo[4.2.0]octan-7-ones. The gold(I)-catalyzed tandem cycloisomerization/oxidation reaction also provided a new route for the synthesis of bridged bicyclic δ-lactams from six-membered ring 4-enynamides. The mild reaction conditions allowed the synthesis of a range of bicyclic γ- and δ-lactams and *N*-tosylaminomethyl-tethered bicyclo[4.2.0]octan-7-ones with high diastereoselectivities.

INTRODUCTION

Ynamides are versatile *N*-containing building blocks for the synthesis of nitrogen-containing heterocycles and nitrogen-substituted carbocycles.[1] Recently, transition-metal-catalyzed enynamide cyclization reactions have been studied extensively for the synthesis a variety of azabicycles including the palladium-catalyzed synthesis of indole derivatives from halogenated enynamides,[2] the cobalt-catalyzed synthesis of azabicyclo[3.3.0]octenones via the intramolecular Pauson−Khand reaction of 3-enynamides,[3] the platinum-catalyzed cycloisomerization of enynamides in the synthesis of azabicyclo[4.2.0]octenes,[4] the gold-catalyzed synthesis of the azabicyclo[3.1.0]heptenes from acyclic 3-enynamides,[5] the rhodium-catalyzed [4 + 2] cycloaddition of 1,3-dienes with ynamides in the synthesis of tetrahydroindoles,[6] and the gold-catalyzed oxidation of *N*-arylynamides in the synthesis of oxindoles.[7] In our recent study, we described that six-membered ring 2-enynamides underwent a carbochlorination reaction with $FeCl_2$ in dry air providing chlorinated bicyclic γ-lactams in a high stereoselective fashion and in good yields (Scheme 1, eq 1).[8] However, treatment of six-membered ring 3-enynamides with $FeCl_2$ under the same reaction conditions failed to give any bicyclic lactams. Inspired by the work of Cossy on the gold-catalyzed cycloisomerization of an acyclic 3-enynamide to the 2-azabicyclo[3.2.0]heptene intermediate, which after hydration, affording an aminoethyl-tethered cyclobutanone,[5a] we envisage that a cyclic 3-enynamide may undergo the similar cycloisomerization with a gold(I) cationic complex forming a strained azatricycles. Herein, we report the formation of 4-azatricyclo[4.3.1.0^{3,10}]dec-2-enes via Au(I)/Ag(I)-catalyzed cycloisomerization of six-membered ring 3-enynamides (Scheme 1, eq 2). Most aryl-substituted azatricyclic compounds oxidized spontaneously in air generating fused bicyclic γ-lactams, while the *o*-tolyl- and alkyl-substituted azatricycles transformed into the corresponding bicyclic γ-lactams upon treatment with OsO_4 and *N*-methylmorpholine-*N*-oxide in acetone/water. Moreover, bridged bicyclic δ-lactams were formed via a Au(I)/Ag(I)-catalyzed cycloisomerization/oxidation sequence from six-membered ring 4-enynamides (Scheme 1, eq 3).

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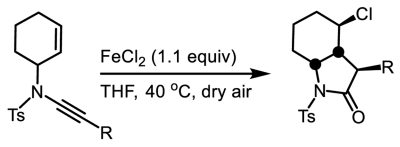
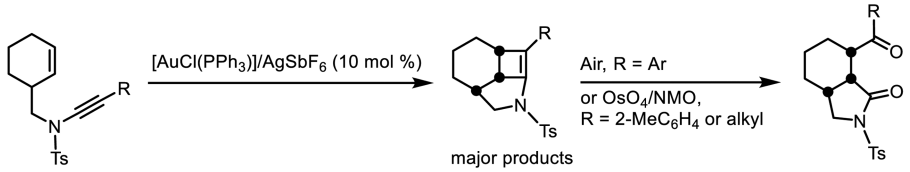
Scheme 1. $FeCl_2$- and Au(I)/Ag(I)-Promoted Cyclization Reactions of Six-Membered Ring Enynamides

Previous work:[8]



(1)

This work:



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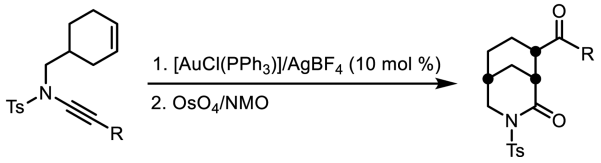

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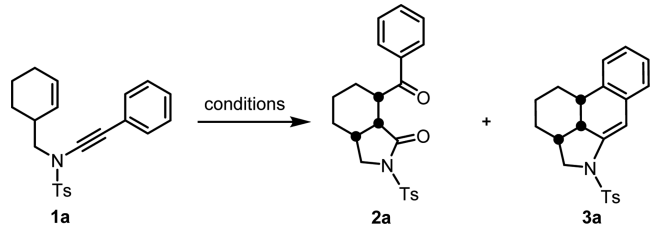
Table 1. Optimization of the Cycloisomerization Reaction Conditions[a]



1a **2a** **3a**

entry	catalyst	solvent	temp (°C)	time	yield (%)[b] 2a	yield (%)[b] 3a
1	$FeCl_2$	THF	28	3 min	–	–
2	$[AuCl(PPh_3)]/AgPF_6$	DCM	28	1.5 h	35	15
3	$[AuCl(PPh_3)]/AgBF_4$	DCM	28	2 h	38	15
4	$[AuCl(PPh_3)]/AgSbF_6$	DCM	28	15 min	52	17
5	$[AuCl(PCy_3)]/AgSbF_6$	DCM	28	8 min	34	12
6	$[AuCl(P(C_6F_5)_3)]/AgSbF_6$	DCM	28	5 min	29	14
7	[AuCl(Ipr)][c]/$AgSbF_6$	DCM	28	18 min	50	20
8	[AuCl(JhonPhos)][d]/$AgSbF_6$	DCM	28	10 min	31	15
9[e]	$[AuCl(PPh_3)]/AgSbF_6$	DCM	28	14 min	50	13
10	$[AuCl(PPh_3)]/AgSbF_6$	DCM	reflux	10 min	44	12
11	$[AuCl(PPh_3)]/AgSbF_6$	Toluene	28	1 h	47	17
12	$[AuCl(PPh_3)]/AgSbF_6$	DCE	28	24 h	N.R.	N.R.
13	$[AuCl(PPh_3)]/AgSbF_6$	THF	28	24 h	–	–
14	$[AuCl(PPh_3)]/AgSbF_6$	ACN	28	24 h	–	–
15	$PtCl_2$	Toluene	90	24 h	N.R.	N.R.
16	$In(NTf_2)_3$[f]	DCM	28	5 min	–	17
17	$HNTf_2$	DCM	28	1.2 h	–	15

[a]Reaction conditions: all reactions were carried out using **1a** (0.3 mmol) and the catalyst (10 mol %) in the indicated solvent (3 mL). [b]Isolated yields obtained from column chromatography over silica gel. [c][AuCl(Ipr)] = chloro[1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene]gold(I). [d][AuCl(JhonPhos)] = chloro[(1,1′-biphenyl-2-yl)di-*tert*-butylphosphine]gold(I). [e]The concentration of **1a** was 0.03 M in DCM. [f]Tf = trifluoromethanesulfonyl.

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RESULTS AND DISCUSSION

The model substrate **1a** was prepared starting from addition of *n*-BuLi to cyclohexene followed by quenching the resulting cyclohexenyl anion with paraformaldehyde to give 3-hydroxymethylcyclohexene. The hydroxyl group was replaced by NHTsBoc under the Mitsunobu reaction conditions,[9] followed by removal of the Boc group to give 3-tosylaminomethylcyclohexene.[10] Finally, a copper-assisted amidation[11] of phenylbromoacetylene with 3-*N*-tosylaminomethylcyclohexene furnished **1a** in a 33% overall yield from cyclohexene (see Experimental Section for details). Results of screening of various acids for the cycloisomerization of **1a** are shown in Table 1. First, performing the reaction of **1a** with $FeCl_2$, following our previous reaction conditions for the cyclization of cyclic 2-enynamide (40 °C, THF, dry air),[8] led to a complex mixture (Table 1, entry 1). Next, we turned our attention to the Au(I)/Ag(I) catalyst. Reaction of **1a** with the 10 mol % of $[AuCl(PPh_3)]/AgPF_6$ catalyst in DCM (0.1 M) at room temperature for 1.5 h led to bicyclic γ-lactam **2a** in 35% yield together with dibenz[*cd*,*f*]indole derivative **3a** in 15% isolated yield (Table 1, entry 2). The assignment of all cis relative stereochemistry of the protons at ring junctures was further confirmed by X-ray diffraction analysis of both **2a** (Figure 1)

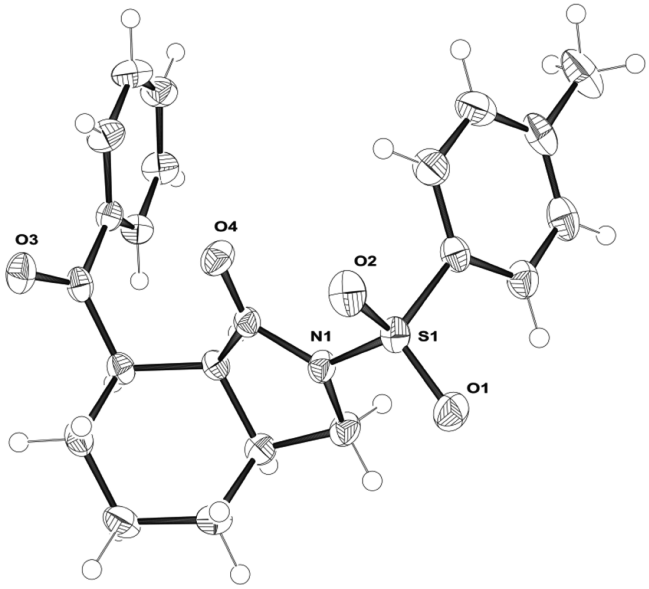

Figure 1. ORTEP plot of the crystal structure of **2a** (50% thermal ellipsoids).

and **3a**.[12] It has been described previously that a Au(I)/Ag(I) complex was used for the synthesis of bicyclic γ-lactams from acyclic *N*-allylynamides.[13a] However, in this transformation, pyridine *N*-oxide (2 molar equiv) was used as an oxygen delivery reagent to oxidize the alkynyl carbon adjacent to the nitrogen atom of the ynamides.[13b] Our current method for the construction of the bicyclic γ-lactam **2a** from the cyclic 3-enynamide **1a** required only a Au(I)/Ag(I) catalyst in DCM at room temperature and the oxygen in air. With the goal to optimize the yield of **2a**, effects of different silver salts with $[AuCl(PPh_3)]$ were examined (Table 1, entrie 3−4). In this series, the better yield was obtained in 15 min with 10 mol % of $[AuCl(PPh_3)]/AgSbF_6$ leading to **2a** and **3a** in 52 and 17% isolated yield, respectively (Table 1, entry 4). Next, several Au(I) complexes with various ligands, in combination with $AgSbF_6$, were screened. (Table 2, entries 5−8). The use of 10 mol % of $[AuCl(IPr)]/AgSbF_6$ ([AuCl(IPr)] = chloro[1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene]gold(I)) gave the similar result as that of $[AuCl(PPh_3)]/AgSbF_6$ as **2a** (50%) and **3a** (20%) were isolated in minutes and in comparable yields (Table 1, entry 7). Increasing the concentration of $[AuCl(PPh_3)]/AgSbF_6$ from 0.1 to 0.3 M in DCM did not significantly affect the reaction time (14 min) and yields (**2a**, 50%, **3a**, 13%) (Table 1, entry 9). Next, the reaction was heated at reflux in DCM, while the reaction time was slightly decreased to 10 min, the yield of **2a** and **2b** was diminished to 44 and 12%, respectively (Table 1, entry 10). The solvent effect on the cycloisomerization was also investigated. The use of toluene as solvent afforded **2a** (47%) and **3a** (17%) in comparable yields, albeit requiring a longer reaction time (1 h, Table 1, entry 11). Other solvents, such as dichloroethane (DCE), THF, and acetonitrile (ACN) were totally ineffective (Table 1, entries 12−14). It has been reported that platinum dichloride was capable of transforming acyclic enynamides in toluene into cyclobutenyl azabicyclic compounds.[14] However, the starting substrate **1a** was recovered quantitatively when **1a** was treated with $PtCl_2$ (10 mol %) in toluene at 90 °C for 24 h (Table 1, entry 15). Moreover, performing the reaction with $In(NTf_2)_3$ or $HNTf_2$ afforded the dibenz[*cd*,*f*]indole derivative **3a** as the only cycloisomerization product in 17 and 15% yield, respectively (Table 1, entries 16 and 17). Therefore, we identified 10 mol % of $[AuCl(PPh_3)]$ and 10 mol % of $AgSbF_6$ in DCM (0.1 M concentration) under nitrogen at ambient temperatures as the optimum reaction conditions for the formation of the bicyclic γ-lactam **2a** and the dibenz[*cd*,*f*]indole derivative **3a** (Table 1, entry 4).

Suggested reaction paths for the formation of **2a** and **3a** from **1a** are shown in Scheme 2. Initially, reaction of $[AuCl(PPh_3)]$ with $AgSbF_6$ generated the gold(I) cation species. Coordination of the gold(I) cation to the alkyne formed a gold-activated alkyne complex, which was then attacked by the pendant olefin to produce the cationic vinylgold species **4**. Intermediate **4** led to the cyclopropylgold carbene **5** (path a). Ring expansion of **5** gave a cationic azatricyclic skeleton. The 4-azatricyclo-[4.3.1.$0^{3,10}$]dec-2-ene intermediate **8** was formed by attack of hexafluoroantimonate anion (SbF_6^-) at the gold center of the cationic azatricycle and regeneration of the gold(I) cation into the catalytic cycle. This observation was consistent with the formation of the carbotricyclic analog **7** via platinum-[15] and gold-[16] catalyzed cycloisomerization of carbocyclic enynes of type **6** (Figure 2). Carbotricycles **7** containing a strained cyclobutene moiety were stable under air at room temperature. Although the gold(I)-catalyzed cycloisomerization of **1a** was conducted under nitrogen, subsequent exposure of the crude mixture to air was sufficient to promote the oxidation of the strained cyclobutene moiety of azatricycle **8** and delivered the bicyclic γ-lactam derivative **2a**. Thus, the current approach allowed a direct access to the bicyclic γ-lactam **2a** from a simple cyclic 3-enynamide **1a** without an additional oxidant. However, the cationic intermediate **4** may undergo Freidel−Crafts alkylation of the pendant phenyl group by the carbonium ion to provide a tetracyclic carbocation **9** (path b). Rearomatization followed by protodeauration led to the dibenz[*cd*,*f*]indole derivative **3a** and regenerated the gold(I) cation.

The cycloisomerization of various cyclic 3-enynamides **1** was then evaluated with the optimized reaction conditions (10 mol % $[AuCl(PPh_3)]/AgSbF_6$, DCM, rt). As illustrated in Table 2, substrates **1b**, **1e**, and **1f**, with a methyl or phenyl group at the

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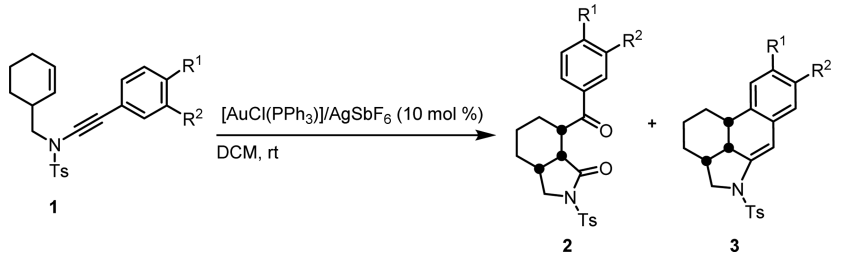
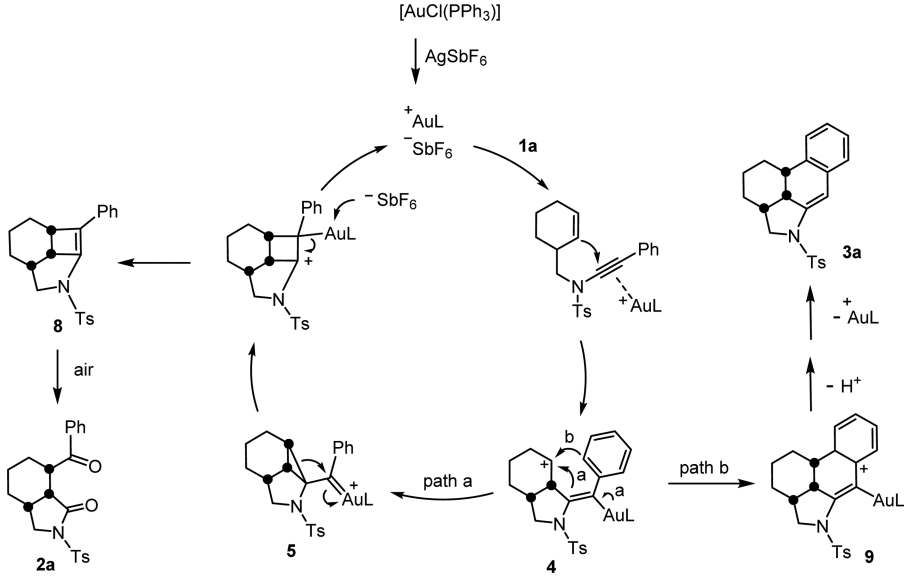
Table 2. Gold-Catalyzed Cycloisomerzation of 1



entry	Ar	substrate	time (min)	product (%)[a]	
1	R^1 = H, R^2 = H	**1a**	15	**2a**[12] (52%)	**3a**[12] (17%)
2	R^1 = Me, R^2 = H	**1b**	7	**2b** (42%)	**3b** (21%)
3	R^1 = H, R^2 = Me	**1c**	44	**2c** (45%)	trace
4	R^1 = Me, R^2 = Me	**1e**	7	**2e** (44%)	**3e** (26%)
5	R^1 = Ph, R^2 = H	**1f**	9	**2f**[12] (54%)	**3f**[12] (18%)
6	R^1 = OMe, R^2 = H	**1g**	300	**2g** (17%)	**3g** (28%)
7	R^1 = H, R^2 = OMe	**1h**	10	**2h**[12] (50%)	**3h**[12] (23%)
8	R^1 = F, R^2 = H	**1i**	6	**2i** (51%)	**3i**[12] (14%)
9	R^1 = Cl, R^2 = H	**1j**	7	**2j** (41%)	**3j** (10%)
10	R^1 = Br, R^2 = H	**1k**	7	**2k** (39%)	**3k** (12%)
11	R^1 = CO_2Me, R^2 = H	**1l**	10	**2l** (41%)	**3l** (7%)
12	R^1 = NO_2, R^2 = H	**1m**	9	**2m** (50%)	–
13	R^1 = H, R^2 = NO_2	**1n**	19	**2n** (43%)	–

[a]Isolated yields obtained from column chromatography over silica gel.

Scheme 2. Proposed Mechanism for the Gold-Catalyzed Cycloisomerization of 1a to 2a and 3a



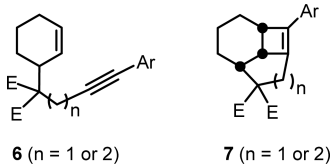


Figure 2. Structures of **6** and **7**.

para-position of the phenyl ring, were found to react well with the Au(I)/Ag(I) catalyst in 7–9 min producing bicyclic γ-lactams **2b**, **2e**, and **2f**[12] in yields ranging from 42 to 54% (Table 2, entries 2 and 4–5) and the minor products dibenz[*cd*,*f*]indoles **3b**, **3e**, and **3f**[12] in yields ranging from 18 to 26%. However, a methyl substituent at the *meta*-position of the phenyl moiety, **1c**, gave the corresponding bicyclic γ-lactams **2c** in 45% yield and a trace amount of the Friedel-Craft cyclization product (Table 2, entry 3). While the electron-donating *meta*-methoxyphenyl-substituted enynamide, **1h**, was well tolerated forming **2h**[12] (50%) and **3h**[12] (23%) in 10 min (Table 2, entry 7), the *para*-methoxyphenyl-substituted ynamide **1g** required a longer reaction time (300 min) and gave low yields of **2g** (17%) and **3g** (28%) (Table 2, entry 6). Substrtaes **1i–k**, bearing a halogen atom at the *para*-position of the phenyl ring, were well tolerated and produced the corresponding bicyclic γ-lactams **2i–k** (39–51%) and the minor products dibenz[*cd*,*f*]indoles **3i**[12]**–k** (10–14%) in comparable yields in 6–7 min (Table 2, entries 8–10). Substrate **1l**, with an electron-deficient ester group at the *para*-

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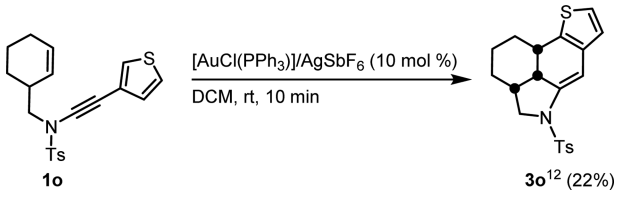
J. Org. Chem. 2017, 82, 481–501

position of the phenyl ring, also generated the desired cyclized products (**2l**, 41%; **3l**, 7%) in 10 min (Table 2, entry 11). Only bicyclic γ-lactams **2m** (50%) and **2n** (43%) were isolated when subjecting electron-deficient nitroarene enynamides **1m** and **1n**, to the optimized reaction conditions. No trace of Freidel–Craft cyclization products were detected in both cases (Table 2, entries 12 and 13).

The effect of a thienyl group at the alkyne terminus, **1o**, was explored in this cycloisomerization process. Compound **1o** produced the Freidel–Craft cyclization product **3o**[12] in 10 min in 22% yield when treated with the Au(I)/Ag(I) catalyst under the optimized reaction conditions and none of the desired bicyclic γ-lactam was obtained (Scheme 3).

Scheme 3. Gold-Catalyzed Cycloisomerization of 1o



However, Subjection of the 2-methylphenyl-substituted enynamide **1d**, or aliphatic enynamides **1p–s** to the optimum reaction conditions did not provide the corresponding bicyclic γ-lactams after aqueous workup and column chromatography over silica gel. Instead, the reactions gave air- and moisture-stable 4-azatricyclo[4.3.1.0^{3,10}]dec-2-enes **8a–e** in 44 to 50% isolated yields (Scheme 4). The relative stereochemistry of three protons at the ring junctures of **8a**[12] was assigned as all-cis and was further confirmed by X-ray diffraction analysis (Figure 3). It must be mentioned that the terminal alkyne, **1t**, gave a mixture of unidentified products when subjected to the standard reaction conditions. Moreover, azatricyclic *N*-tosylenamines **8a–e** could further be oxidized quantitatively to bicyclic γ-lactams **2d** and **2p–s** after treatment with OsO_4 and *N*-methylmorpholine-*N*-oxide (NMO) in acetone/H_2O without

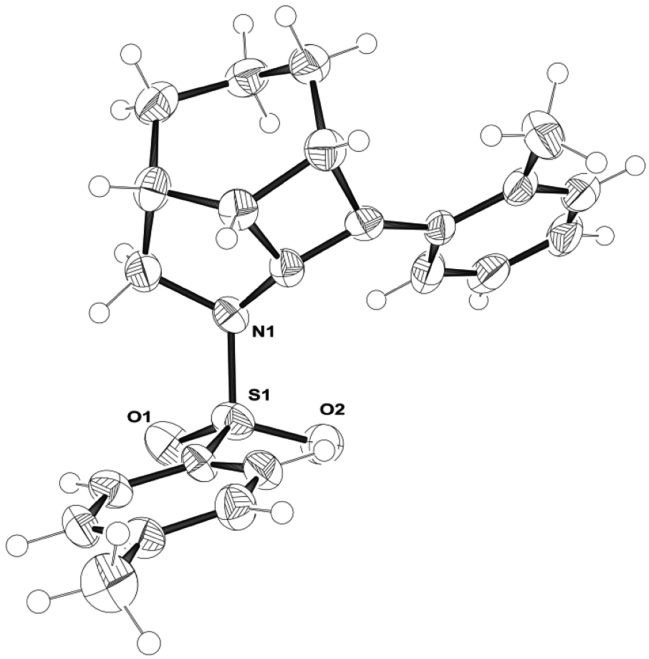
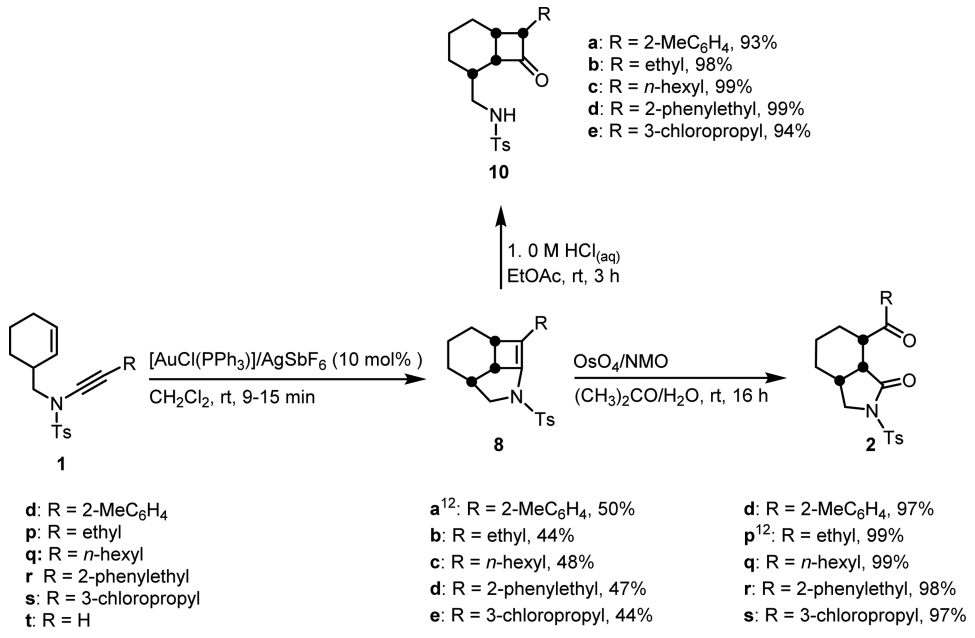


Figure 3. ORTEP plot of the crystal structure of **8a** (50% thermal ellipsoids).

the use of iodobenzene diacetate ($PhI(OAc)_2$) (Scheme 4).[17] Furthermore, azatricyclic *N*-tosylenamines **8a–e** were treated with 1.0 M $HCl_{(aq)}$ in EtOAc for 3 h to afford 5-*N*-tosylaminomethyl-tethered bicyclo[4.2.0]octan-7-ones **10a–e** in high yields (93–99%) and with high stereoselectivity in each case.[4a] The all cis relative chemistry of four adjoining stereogenic centers was determined by their NMR spectropic measurements and was compared to those of the related bicyclic ketone **14** (vide infra), which was confirmed by X-ray analysis. In general, bicyclo[4.2.0]octan-7-ones were available by the [2 + 2] cycloaddition reaction of dichloroketene with cyclohexene derivatives followed by reductive dechlorination

Scheme 4. Gold-Catalyzed Cycloisomerization of 1d, and 1p–t Followed by Oxidation or Hydration



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with Zn and acetic acid.[18] Thus, the present gold(I)-catalyzed cycloisomerization/hydration sequence provided an alternative to 5,8-disubstituted bicyclo[4.2.0]octan-7-ones in a diastereoselective fashion from simple six-membered ring 3-enynamides under mild reaction conditions.

The gold-catalyzed cycloisomerization/oxidation strategy can also be applied in preparation of bridged bicyclic δ-lactams. The starting substrate C-4-*N*-tosylynamidomethyl-tethered cyclohexene **11a** was prepared in three steps from cyclohex-3-ene-1-carbaldehyde (see Experimental Section for details). However, treatment of **11a** with 10 mol % $[AuCl(PPh_3)]/AgSbF_6$ failed to provide any cyclized product. Next, various combinations of Au(I)/Ag(I) catalysts, solvents, and reaction temperatures were screened, the best result was obtained with 10 mol % of $[AuCl(PPh_3)]/AgBF_4$ in DCM at 40 °C. Thus, treatment of **11a** with 10 mol % of $[AuCl(PPh_3)]/AgBF_4$ in DCM at 40 °C for 10 min furnished the 4-azatricyclo[4.2.2.$0^{3,8}$]dec-2-ene derivative **12a**[12] in 78% isolated yield. The azatricyclic compound **12a** was stable at room temperature and could further be oxidized with OsO_4 and NMO in acetone/H_2O to afford the bridged bicyclic δ-lactam **13a**[12] in 60% yield over two steps. Thus, the current approach provided an alternative to the synthesis of the 3-azabicyclo[3.3.1]nonan-2-one skeleton which is known to possess pharmacological properties.[19] The relationship of three methine protons was assigned as all cis for **13a** and was further confirmed by X-ray diffraction analysis (Figure 4). Results of the gold(I)-catalyzed cycloisomerization/

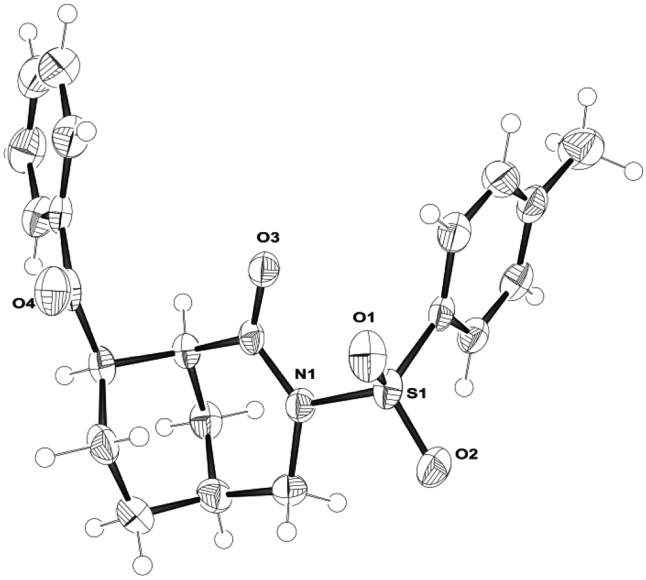

Figure 4. ORTEP plot of the crystal structure of **13a** (50% thermal ellipsoids).

oxidation sequence of C-4-*N*-tosylynamidomethyl-tethered cyclohexenes **11** to provide directly bridged bicyclic δ-lactams **13** are shown in Scheme 5. Substrates with a methyl, methoxy, carbmethoxy, or halogen substituent on the phenyl ring were well tolerated and afforded the corresponding bridged bicyclic δ-lactams **13a**–**j**[12] in 43–70% isolated yields over two steps. Substrates **11k** and **11l**, with a strong electron-withdrawing *para*-CF_3 and -NO_2 groups, respectively, gave low yields of the desired products (**13k**, 30%, **13l**, 20%). The two-step sequence also performed well with the substrate containing a thienyl fragment. The thienyl-substituted cyclic 4-enynamide **11m** furnished **13m** in 51% isolated yield. The cycloisomerization/oxidation sequence leading to the bridged bicyclic δ-lactams was not restricted to aromatic enynamides, the aliphatic enynamides, **11n**–**11p**, were also effective generating the desired bridged bicyclic δ-lactams **13n**–**13p** in 31–55% yield.[12] Unfortunately, enynamide **11q**, bearing a terminal alkyne, decomposed when treated with 10 mol % of $[AuCl(PPh_3)]/AgBF_4$ in DCM. Moreover, gold-catalyzed cycloisomerization of the ethyl-substituted enynamide **11n** followed by hydration of the resultant azatricyclic intermediate **12n** with 1 M $HCl_{(aq)}$ in EtOAc furnished the 4-*N*-tosylaminomethyl-tethered bicyclo[4.2.0]octan-7-one **14**[12] in 60% yield over two steps (Scheme 6). Compound **14** was isolated as a single stereoisomer. The relative stereochemistry of four stereocenters of bicyclic ketone **14** was determined as all cis and was further confirmed by X-ray diffraction analysis (Figure 5).

CONCLUSION

In conclusion, we have shown a simple and mild gold-catalyzed cycloisomerization/oxidation of cyclic enynamides generating fused and bridged bicyclic γ-lactams in a stereoselective manner. In a gold-catalyzed cycloisomerization/hydration sequence, *N*-tosylaminomethyl-tethered bicyclo[4.2.0]octan-7-ones were obtained in good yields over two steps and with high stereoselectivity. The substrate scope was proved to be general for both aryl- and alkyl-substituted cyclic enynamides, providing a series of bicyclic γ- and δ-lactams and *N*-tosylaminomethyl-tethered bicyclo[4.2.0]octanones, which may be of interest in synthetic organic chemistry.

EXPERIMENTAL SECTION

General Considerations. All reactions were conducted under nitrogen atmosphere in dried glassware with dry solvents. The addition of anhydrous solvents or liquid (reagents) was performed with an oven-dried syringe or cannula through a septum. Solids were added under gentle stream of nitrogen. Solvents were predried by molecular sieves and then by passing through activate Al_2O_3 columns. All commercially available reagents were used as received without further purification. Melting points were measured in open glass capillaries with an electronic apparatus and were uncorrected. Flash column chromatography was carried out using silica gel P60, 40–63 m (230–400 mesh). Infrared spectra were recorded as a solid or a thin film on an infrared spectroscopy. ^{1}H nuclear magnetic resonance (NMR) spectra were recorded with a 400 or 500 MHz spectrometer. Chemical shifts (δ) are quoted in parts per million (ppm) relative to Me_4Si (0.00 ppm) using Me_4Si or the residual solvent signal ($CHCl_3$: 7.26 ppm) as internal standard. Abbreviations used in the description of coupling patterns are s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet). Coupling constants (*J*) are given in Herz (Hz). Proton-decoupled ^{13}C NMR spectra were recorded with a 100 or 125 MHz spectrometer. Chemical shifts (δ) are quoted in parts per million (ppm) downfield from tetramethylsilane, using the residual solvent signal ($CDCl_3$: 77.0 ppm) as internal standard. Mass spectra were determined by using a spectrometer at a 70 eV ionization potential. Peaks are listed according to their mass/charge (*m*/*e*) value with percent relative abundance. High-resolution mass spectra were obtained with a double-focusing mass spectrometer.

Representative Experimental Procedure for the Synthesis of Aryl-Substituted 3-*N*-Tosylynamidomethyl-Tethered Cyclohexene 1a. Tetramethylethylenediamine (TMEDA, 15.0 mL) was slowly added to a stirred solution of 1.6 M *n*-butyllithium (67.0 mL) in hexanes at 0 °C under nitrogen. Cyclohexene (82.0 mL, 800 mmol) was then added, and the resulting reaction mixture was stirred for 16 h at room temperature. Paraformaldehyde (3.9901 g, 166.25 mmol) was added over a period of 2 h while the reaction temperature was kept under 30 °C. The reaction mixture was stirred for 3 h at room

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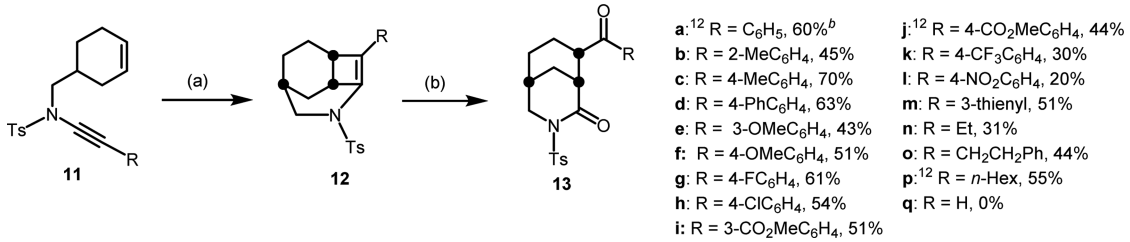
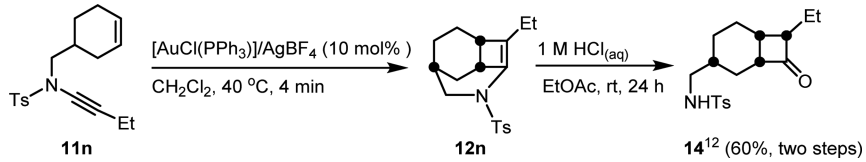
Scheme 5. Gold-Catalyzed Cycloisomerization/Oxidation of Six-Membered Ring 4-Enynamides 11 to Bridged Bicyclic δ-Lactams 13[a]



[a]Reagents and conditions: (a) 10 mol % $[AuCl(PPh_3)]/AgBF_4$, CH_2Cl_2, 40 °C, 4–25 min; (b) OsO_4/NMO, $(CH_3)_2CO/H_2O$, rt, 24 h. [b]All yields were reported over two steps.

Scheme 6. Cycloisomerization/Hydration of 11n to 14



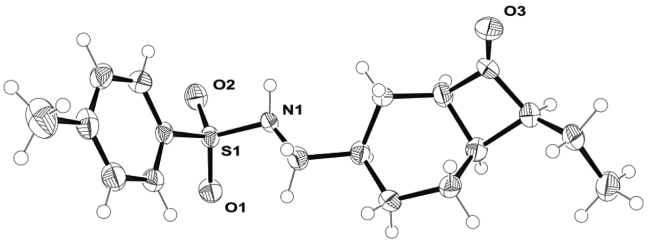


Figure 5. ORTEP plot of the crystal structure of **14** (50% thermal ellipsoids).

temperature followed by addition of water (100.0 mL) and $HCl_{(aq)}$ (10.0 mL). The water layer was extracted with ether (200.0 mL × 3) and $NaCl_{(aq)}$ (200.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixtures (7.1142 g), was further purified by vacuum distillation [51–54 °C (1.3 mmHg)] to give 2-cyclohexenemethanol as an oil (4.6001 g, 41.010 mmol, 41%). To a flame-dried flask were added triphenylphosphine (5.3242 g, 20.299 mmol), diisopropyl azodicarboxylate (DIAD, 4.0 mL, 20.3 mmol), TsNH(Boc) (4.6004 g, 16.955 mmol), and THF (85.0 mL) at 0 °C. After 0.5 h, a solution of 2-cyclohexenemethanol (2.0522 g, 18.295 mmol) in THF (10.0 mL) was added to the reaction mixture at 0 °C. The reaction was allowed to warm to room temperature and stirred for an additional 0.5 h. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give *tert*-butyl(cyclohex-2-en-1-ylmethyl)(tosyl)carbamate as a white solid (5.5771 g, 15.259 mmol, 90%). To a solution of *tert*-butyl (cyclohex-2-en-1-ylmethyl) (tosyl)-carbamate (5.5771 g, 15.259 mmol) in CH_2Cl_2 (153.0 mL) was added trifluoroacetic acid (TFA, 5.8 mL). The reaction mixture was stirred for 4 h at room temperature, then added saturated $NaHCO_{3(aq)}$ (keep the pH value of the aqueous layer above 10). The water layer was extracted with CH_2Cl_2 (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give *N*-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide as a white solid (4.0040 g, 15.087 mmol, 99%). To a dry and nitrogen-flushed 2-neck-flask, equipped with a magnetic stirring bar and a septum, were charged with (bromoethynyl)benzene (0.5975 g, 3.301 mmol), toluene (3.0 mL), *tert*-butyl(cyclohex-2-en-1-ylmethyl)(tosyl)-carbamate (0.7961 g, 3.000 mmol), and K_2CO_3 (0.8292 g, 6.000 mmol). The reaction mixture was stirred at room temperature for 5 min and then were added $CuSO_4 \cdot 5H_2O$ (0.0754 g, 0.302 mmol), and 1,10-phenanthroline (0.1081 g, 0.5999 mmol). The reaction was stirred at 70 °C until no trace of starting material can be detected on TLC. Upon cooling to room temperature, the reaction mixture was filtered and concentrated. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give *N*-(cyclohex-2-en-1-ylmethyl)-4-methyl-*N*-(phenylethynyl)-benzenesulfon- amide (**1a**) as a white solid (0.9871 g, 2.701 mmol, 90%): mp 105–106 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86–7.81 (m, 2H), 7.38–7.32 (m, 4H), 7.31–7.25 (m, 3H), 5.83–5.76 (m, 1H), 5.59–5.53 (m, 1H), 3.35–3.22 (m, 2H), 2.67–2.56 (m, 1H), 2.45 (s, 3H), 2.04–1.97 (m, 2H), 1.87–1.78 (m, 1H), 1.77–1.67 (m, 1H), 1.58–1.49 (m, 1H), 1.46–1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 134.5, 131.3, 129.7, 129.7, 128.2, 127.7, 127.7, 127.0, 122.9, 82.6, 70.6, 56.1, 34.1, 26.0, 25.2, 21.6. 20.3; IR (CH_2Cl_2) 2932, 2236, 1598, 1443, 1367, 1168, 754, 586 cm^{-1}; MS (ESI) *m*/*e* (%) 366.2 ([M + H]$^+$, 100), 282.3 (70), 122.0 (30); HRMS (ESI) *m*/*e* calcd for $C_{22}H_{24}NO_2S$ [M + H]$^+$ 366.1528, found 366.1533.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(p-tolylethynyl)-benzenesulfonamide (**1b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1b** as a white solid (0.8312 g, 2.190 mmol, 73%): mp 103–104 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86–7.81 (m, 2H), 7.37–7.32 (m, 2H), 7.27–7.23 (m, 2H), 7.11–7.04 (m, 2H), 5.82–5.76 (m, 1H), 5.59–5.53 (m, 1H), 3.29 (dd, *J* = 12.5, 8.6 Hz, 1H), 3.24 (dd, *J* = 12.5, 6.6 Hz, 1H), 2.66–2.56 (m, 1H), 2.45 (s, 3H), 2.34 (s, 3H), 2.03–1.97 (m, 2H), 1.86–1.78 (m, 1H), 1.76–1.67 (m, 1H), 1.60–1.49 (m, 1H), 1.46–1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 137.9, 134.6, 131.4, 129.7, 129.0, 128.4, 127.7, 127.1, 119.7, 81.9, 70.6, 56.1, 34.1, 26.1, 25.2, 21.6, 21.2, 20.4; IR (CH_2Cl_2) 2922, 2236, 1362, 1170, 816, 583 cm^{-1}; MS (ESI) *m*/*e* (%) 388.2 (35), 380.2 ([M + H]$^+$, 100); HRMS (ESI) *m*/*e* calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1678.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(m-tolylethynyl)-benzenesulfonamide (**1c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1c** as a white solid (0.8881 g, 2.340 mmol, 78%): mp 64–65 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86–7.81 (m, 2H), 7.38–7.32 (m, 2H), 7.21–7.14 (m, 3H), 7.12–7.06 (m, 1H), 5.83–5.76 (m, 1H), 5.59–5.53 (m, 1H), 3.30 (dd, *J* = 12.6, 8.6 Hz, 1H), 3.24 (dd, *J* = 12.4, 6.6 Hz, 1H), 2.67–2.57 (m, 1H), 2.45 (s, 3H), 2.31 (s, 3H), 2.04–1.97 (m, 2H), 1.87–1.78 (m, 1H), 1.77–1.67 (m, 1H), 1.61–1.49 (m, 1H), 1.46–1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 137.9, 134.6, 131.9, 129.7, 128.6, 128.4, 128.1, 127.7, 122.7, 82.3, 70.8, 56.1, 34.1, 26.1, 25.2, 21.6, 21.2, 20.4; IR (CH_2Cl_2) 2925, 2234, 1598, 1365,

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J. Org. Chem. 2017, 82, 481–501

1167, 1090, 879, 753, 586 cm^{-1}; MS (ESI) *m/e* (%) 402.3 ([M + Na]$^+$, 100), 380.2 ([M + H]$^+$, 79); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1686.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(o-tolylethynyl)-benzenesulfonamide (**1d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1d** as a colorless oil (0.7742 g, 2.040 mmol, 68%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.81 (m, 2H), 7.36−7.29 (m, 3H), 7.19−7.15 (m, 2H), 7.15−7.08 (m, 1H), 5.82−5.77 (m, 1H), 5.59−5.54 (m, 1H), 3.33 (dd, *J* = 12.5, 8.7 Hz, 1H), 3.25 (dd, *J* = 12.5, 6.6 Hz, 1H), 2.69−2.59 (m, 1H), 2.44 (s, 3H), 2.37 (s, 3H), 2.04−1.97 (m, 2H), 1.88−1.79 (m, 1H), 1.77−1.67 (m, 1H), 1.60−1.49 (m, 1H), 1.47−1.37 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 139.6, 134.6, 131.3, 129.7 (2C), 129.3, 127.7 (2C), 125.4, 122.7, 86.3, 69.6, 56.1, 34.1, 26.0, 25.2, 21.6, 20.7, 20.3; IR (CH_2Cl_2) 2935, 2236, 1598, 1452, 1367, 1168, 1091, 944, 815 cm^{-1}; MS (ESI) *m/e* (%) 380.1 ([M + H]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1689.

*N-(Cyclohex-2-en-1-ylmethyl)-N-((3,4-dimethylphenyl)ethynyl)-4-methylbenzenesulfonamide (**1e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1e** as a white solid (0.9563 g, 2.430 mmol, 81%): mp 103−104 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85−7.80 (m, 2H), 7.35−7.29 (m, 2H), 7.17−7.07 (m, 2H), 7.05−6.99 (m, 1H), 5.82−5.73 (m, 1H), 5.61−5.52 (m, 1H), 3.33−3.19 (m, 2H), 2.68−2.55 (m, 1H), 2.41 (s, 3H), 2.21 (s, 3H), 2.19 (s, 3H), 2.02−1.94 (m, 2H), 1.86−1.76 (m, 1H), 1.75−1.65 (m, 1H), 1.59−1.47 (m, 1H), 1.59−1.47 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.3, 136.5, 136.3, 134.3, 132.4, 129.5, 129.4, 129.4, 128.8, 127.5, 126.9, 119.8, 81.5, 70.5, 55.9, 33.9, 25.9, 25.1, 21.4, 20.2, 19.5, 19.3; IR (CH_2Cl_2) 2923, 2235, 1598, 1494, 1450, 1365, 1169, 816, 666, 587 cm^{-1}; MS (ESI) *m/e* (%) 394.3 ([M + H]$^+$, 100), 238.2 (24); HRMS (ESI) *m/e* calcd for $C_{24}H_{28}NO_2S$ [M + H]$^+$ 394.1838, found 394.1841.

*N-([1,1′-Biphenyl]-4-ylethynyl)-N-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (**1f**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1f** as a white solid (0.9538 g, 2.160 mmol, 72%): mp 107−108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88−7.83 (m, 2H), 7.60−7.56 (m, 2H), 7.55−7.50 (m, 2H), 7.47−7.40 (m, 4H), 7.39−7.34 (m, 3H), 5.84−5.77 (m, 1H), 5.60−5.54 (m, 1H), 3.36−3.24 (m, 2H), 2.69−2.58 (m, 1H), 2.46 (s, 3H), 2.05−1.98 (m, 2H), 1.88−1.80 (m, 1H), 1.78−1.68 (m, 1H), 1.62−1.50 (m, 1H), 1.47−1.38 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 140.5, 140.4, 134.6, 131.7, 129.7, 128.8, 127.7, 127.1, 127.0, 126.9, 121.9, 83.3, 70.6, 56.2, 34.1, 26.1, 25.2, 21.6, 20.4; IR (CH_2Cl_2) 2929, 2233, 1366, 1168, 764, 586 cm^{-1}; MS (ESI) *m/e* (%) 442.2 ([M + H]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{28}H_{28}NO_2S$ [M + H]$^+$ 442.1841, found 442.1839.

*N-(Cyclohex-2-en-1-ylmethyl)-N-((4-methoxyphenyl)ethynyl)-4-methylbenzenesulfonamide (**1g**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1g** as a white solid (0.9136 g, 2.310 mmol, 77%): mp 102−103 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85−7.81 (m, 2H), 7.38−7.28 (m, 4H), 6.84−6.79 (m, 2H), 5.82−5.75 (m, 1H), 5.59−5.53 (m, 1H), 3.80 (s, 3H), 3.29 (dd, *J* = 12.5, 8.6 Hz, 1H), 3.23 (dd, *J* = 12.5, 6.6 Hz, 1H), 2.66−2.55 (m, 1H), 2.45 (s, 3H), 2.04−1.96 (m, 2H), 1.86−1.78 (m, 1H), 1.76−1.67 (m, 1H), 1.60−1.49 (m, 1H), 1.46−1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.4, 144.4, 134.5, 133.3, 129.6, 129.6, 127.6, 127.1, 114.7, 113.8, 81.1, 70.2, 56.1, 55.2, 34.0, 26.0, 25.2, 21.6, 20.3; IR (CH_2Cl_2) 2931, 2237, 1606, 1513, 1366, 1249, 1170, 1030, 833, 584 cm^{-1}; MS (ESI) *m/e* (%) 459.2 (90), 418.1 ([M + Na]$^+$, 28); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_3NaS$ [M + Na]$^+$ 418.1453, found 418.1445.

*N-(Cyclohex-2-en-1-ylmethyl)-N-((3-methoxyphenyl)ethynyl)-4-methylbenzenesulfonamide (**1h**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1h** as a white solid (0.9729 g, 2.460 mmol, 82%): mp 59−60 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.82 (m, 2H), 7.38−7.33 (m, 2H), 7.19 (t, *J* = 8.0 Hz, 1H), 6.97−6.93 (m, 1H), 6.90−6.87 (m, 1H), 6.85−6.81 (m, 1H), 5.83−5.76 (m, 1H), 5.59−5.52 (m, 1H), 3.90 (s, 3H), 3.34−3.22 (m, 2H), 2.67−2.55 (m, 1H), 2.45 (s, 3H), 2.05−1.97 (m, 2H), 1.87−1.78 (m, 1H), 1.77−1.67 (m, 1H), 1.61−1.49 (m, 1H), 1.47−1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3, 144.6, 134.6, 129.7, 127.7, 127.0, 124.0, 123.8, 116.3, 114.1, 82.6, 70.7, 56.1, 55.3, 34.1, 26.1, 22.7, 21.6, 20.4; IR (CH_2Cl_2) 2930, 2237, 1599, 1366, 1169, 586, 547 cm^{-1}; MS (ESI) *m/e* (%) 459.2 (60), 418.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_3SNa$ [M + Na]$^+$ 418.1453, found 418.1444.

*N-(Cyclohex-2-en-1-ylmethyl)-N-((4-fluorophenyl)ethynyl)-4-methylbenzenesulfonamide (**1i**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1i** as a white solid (0.8283 g, 2.160 mmol, 72%): mp 93−94 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.81 (m, 2H), 7.38−7.30 (m, 4H), 7.02−6.95 (m, 2H), 5.82−5.76 (m, 1H), 5.58−5.52 (m, 1H), 3.30 (dd, *J* = 12.5, 8.6 Hz, 1H), 3.24 (dd, *J* = 12.6, 6.7 Hz, 1H), 2.65−2.55 (m, 1H), 2.45 (s, 3H), 2.04−1.97 (m, 2H), 1.86−1.77 (m, 1H), 1.77−1.65 (m, 1H), 1.61−1.49 (m, 1H), 1.46−1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2 (d, *J* = 247.6 Hz), 144.6, 134.5, 133.4 (d, *J* = 8.3 Hz), 129.7, 129.7, 127.7, 127.0, 118.9, 115.5 (d, *J* = 21.9 Hz), 82.2, 69.5, 56.1, 34.1, 26.0, 25.2, 21.6, 20.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −111.58; IR (CH_2Cl_2) 2929, 2239, 1600, 1510, 1367, 1170, 837, 584 cm^{-1}; MS (ESI) *m/e* (%) 406.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{22}NO_2FSNa$ [M + Na]$^+$ 406.1253, found 406.1247.

*N-((4-Chlorophenyl)ethynyl)-N-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (**1j**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1j** as a white solid (0.9358 g, 2.340 mmol, 78%): mp 108−109 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.80 (m, 2H), 7.38−7.33 (m, 2H), 7.30−7.23 (m, 4H), 5.83−5.76 (m, 1H), 5.58−5.52 (m, 1H), 3.34−3.21 (m, 2H), 2.65−2.54 (m, 1H), 2.45 (s, 3H), 2.05−1.96 (m, 2H), 1.86−1.77 (m, 1H), 1.76−1.67 (m, 1H), 1.61−1.49 (m, 1H), 1.45−1.35 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 134.8, 134.0, 132.8, 130.1, 128.9, 128.0, 127.2, 121.7, 83.9, 56.4, 34.4, 26.3, 25.5, 21.9, 20.6; IR (CH_2Cl_2) 2930, 2361, 2234, 1367, 1169, 1091, 828 cm^{-1}; MS (ESI) *m/e* (%) 400.1 ([M + H]$^+$, 100), 334.8 (2), 244.2 (10), 218.9 (3); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_2SCl$ [M + H]$^+$ 400.1138, found 400.1138.

*N-((4-Bromophenyl)ethynyl)-N-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (**1k**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1k** as a yellow solid (0.9865 g, 2.220 mmol, 74%): mp 114−115 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.79 (m, 2H), 7.44−7.39 (m, 2H), 7.37−7.34 (m, 2H), 7.23−7.18 (m, 2H), 5.83−5.76 (m, 1H), 5.58−5.51 (m, 1H), 3.34−3.21 (m, 2H), 2.65−2.54 (m, 1H), 2.45 (s, 3H), 2.05−1.96 (m, 2H), 1.86−1.77 (m, 1H), 1.77−1.66 (m, 1H), 1.60−1.49 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 134.5, 132.6, 131.5, 129.8, 129.8, 127.6, 126.9, 121.9, 121.7, 83.8, 69.8, 56.0, 34.1, 26.0, 25.2, 21.6, 20.3; IR (CH_2Cl_2) 2360, 1366, 1170, 680 cm^{-1}; MS (ESI) *m/e* (%) 446.1 ([M + 2 + H]$^+$, 100), 444.1 ([M + H]$^+$, 98); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_2SBr$ [M + H]$^+$ 444.0633, found 444.0632.

*Methyl 4-((N-(cyclohex-2-en-1-ylmethyl)-4-methylphenylsulfonamido)ethynyl)benzoate (**1l**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1l** as a white solid (0.9656 g, 2.280 mmol, 76%): mp 136−137 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97−7.94 (m, 2H), 7.85−7.82 (m, 2H), 7.40−7.34 (m, 4H), 5.84−5.78 (m, 1H), 5.58−5.52 (m, 1H), 3.91 (s, 3H), 3.37−3.25 (m, 2H), 2.67−2.57 (m, 1H), 2.45 (s, 3H), 2.05−1.98 (m, 2H), 1.87−1.78 (m, 1H), 1.77−1.67 (m, 1H), 1.61−1.50 (m, 1H), 1.46−1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 144.8, 134.5, 130.5, 129.9, 129.8, 129.5, 128.7, 127.9, 127.7, 126.8, 86.0, 70.8, 56.1, 52.2, 34.2, 26.0, 25.2, 21.6, 20.3; IR (CH_2Cl_2) 2928, 2230, 1723, 1602, 1365, 1275, 1170, 1105, 765 cm^{-1}; MS (FAB$^+$) *m/e* (%) 442.2 (32), 424.1 ([M + H]$^+$, 53), 307.1 (30), 154.1 (100), 136.1 (65); HRMS (FAB$^+$) *m/e* calcd for $C_{24}H_{26}NO_4S$ [M + H]$^+$ 424.1583, found 424.1575.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-((4-nitrophenyl)-ethynyl)benzenesulfonamide (**1m**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:15) to give **1m** as a yellow solid (0.7759 g, 1.890 mmol, 63%): mp

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J. Org. Chem. 2017, 82, 481−501

107−108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18−8.13 (m, 2H), 7.86−7.81 (m, 2H), 7.47−7.42 (m, 2H), 7.40−7.35 (m, 2H), 5.85−5.79 (m, 1H), 5.57−5.51 (m, 1H), 3.35 (dd, J = 11.5, 8.5 Hz, 1H), 3.31 (dd, J = 11.5, 4.4 Hz, 1H), 2.66−2.55 (m, 1H), 2.46 (s, 3H), 2.05−1.98 (m, 2H), 1.87−1.78 (m, 1H), 1.77−1.68 (m, 1H), 1.62−1.50 (m, 1H), 1.45−1.35 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 145.1, 134.4, 130.8, 130.4, 130.1, 129.9, 127.6, 127.6, 123.6, 88.7, 70.6, 56.0, 34.2, 26.0, 25.2, 21.6, 20.3; IR (CH_2Cl_2) 2930, 2228, 1595, 1516, 1368, 1342, 1170, 1104, 1000, 853 cm^{-1}; MS (EI, 40 *eV*) *m*/*e* (%) 410.1 (3), 241.1 (82), 155.1 (22), 149.0 (59), 119.1 (98), 119.1 (59); HRMS (EI, 40 *eV*) *m*/*e* calcd for $C_{22}H_{22}N_2O_4S$ [M]$^+$ 410.1298, found 410.1300.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-((3-nitrophenyl)-ethynyl)benzenesulfonamide (**1n**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:15) to give **1n** as a yellow oil (0.7266 g, 1.770 mmol, 59%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16−8.13 (m, 1H), 8.13−8.09 (m, 2H), 7.86−7.81 (m, 1H), 7.67−7.63 (m, 1H), 7.50−7.44 (m, 1H), 7.41−7.36 (m, 2H), 5.85−5.79 (m, 1H), 5.58−5.52 (m, 1H), 3.34 (dd, J = 12.0, 8.6 Hz, 1H), 3.29 (dd, J = 12.0, 5.6 Hz, 1H), 2.66−2.56 (m, 1H), 2.47 (s, 3H), 2.06−1.98 (m, 2H), 1.87−1.79 (m, 1H), 1.78−1.68 (m, 1H), 1.62−1.50 (m, 1H), 1.46−1.36 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.1, 145.0, 136.6, 134.5, 130.0, 129.9, 129.3, 127.7, 126.7, 125.7, 125.0, 122.2, 85.5, 69.2, 56.1, 34.2, 26.1, 25.2, 21.7, 20.3; IR (CH_2Cl_2) 2928, 2234, 1530, 1350, 1168, 886, 785, 586 cm^{-1}; MS (ESI) *m*/*e* (%) 411.2 ([M + H]$^+$, 100); HRMS (ESI) *m*/*e* calcd for $C_{22}H_{23}N_2O_4S$ [M + H]$^+$ 411.1379, found 411.1381.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(thiophen-3-ylethynyl)benzenesulfonamide (**1o**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1o** as a white solid (0.7468 g, 2.010 mmol, 67%): mp 93−94 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.79 (m, 2H), 7.37−7.31 (m, 3H), 7.26−7.21 (m, 1H), 7.04 (dd, J = 5.0, 1.0 Hz, 1H), 5.82−5.74 (m, 1H), 5.59−5.51 (m, 1H), 3.28 (dd, J = 12.5, 8.6 Hz, 1H), 3.23 (dd, J = 12.6, 6.7 Hz, 1H), 2.65−2.54 (m, 1H), 2.43 (s, 3H), 2.02−1.95 (m, 2H), 1.85−1.76 (m, 1H), 1.75−1.65 (m, 1H), 1.59−1.47 (m, 1H), 1.45−1.34 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 134.3, 130.1, 129.6, 129.5, 128.5, 127.5, 126.9, 125.1, 121.4, 81.8, 65.5, 56.0, 33.9, 25.9, 25.1, 21.5, 20.2; IR (CH_2Cl_2) 2930 2360, 1701, 1357, 1168, 585 cm^{-1}; MS (ESI) *m*/*e* (%) 394.1 ([M + Na]$^+$, 22), 372.2 ([M + H]$^+$, 100); HRMS (ESI) *m*/*e* calcd for $C_{20}H_{22}NO_2S_2$ [M + H]$^+$ 372.1092, found 372.1091.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(oct-1-yn-1-yl)-benzenesulfonamide (**1q**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:30) to give **1q** as a colorless oil (1.008 g, 2.698 mmol, 90%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.35−7.31 (m, 2H), 5.80−5.74 (m, 1H), 5.55−5.49 (m, 1H), 3.17 (dd, J = 12.4, 8.7 Hz, 1H), 3.25 (dd, J = 12.4, 6.5 Hz, 1H), 2.57−2.48 (m, 1H), 2.45 (s, 3H), 2.25 (t, J = 6.9 Hz, 2H), 2.03−1.96 (m, 2H), 1.81−1.65 (m, 2H), 1.58−1.49 (m, 1H), 1.49−1.42 (m, 2H), 1.41−1.23 (m, 7H), 0.89 (t, J = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 134.5, 129.5, 129.3, 127.5, 127.2, 73.2, 70.1, 55.9, 33.8, 31.2, 28.8, 28.3, 25.9, 25.2, 22.5, 21.5. 20.3, 18.4, 13.9; IR (CH_2Cl_2) 2932, 2363, 1598, 1357, 1161, 668 cm^{-1}; MS (FAB+) *m*/*e* 374.2 ([M + H]$^+$, 40); HRMS (FAB+) *m*/*e* calcd for $C_{22}H_{32}NO_2S$ [M + H]$^+$ 374.2154, found 374.2147.

*N-(Cyclohex-2-en-1-ylmethyl)-4-methyl-N-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (**1r**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1r** as a white solid (1.027 g, 2.610 mmol, 87%): mp 86−87 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72−7.67 (m, 2H), 7.31−7.24 (m, 4H), 7.23−7.16 (m, 3H), 5.79−5.72 (m, 1H), 5.50−5.44 (m, 1H), 3.11 (dd, J = 12.4, 8.7 Hz, 1H), 3.03 (dd, J = 12.4, 6.6 Hz, 1H), 2.79 (t, J = 7.3 Hz, 2H), 2.57 (t, J = 7.3 Hz, 2H), 2.47−2.36 (m, 1H), 2.44 (s, 3H), 2.02−1.94 (m, 2H), 1.75−1.62 (m, 2H), 1.56−1.44 (m, 1H), 1.35−1.25 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 140.6, 134.6, 129.6, 129.4, 128.5, 128.3, 127.6, 127.2, 126.2, 74.1, 69.4, 56.0, 35.2, 33.7, 26.0, 25.2, 24.6, 20.6, 20.4; IR (CH_2Cl_2) 2930, 2247, 1596, 1452, 1361, 1168, 815 cm^{-1}; MS (ESI) *m*/*e* (%) 416.2 ([M + Na]$^+$, 100); HRMS (ESI) *m*/*e* calcd for $C_{24}H_{27}NO_2SNa$ [M + Na]$^+$ 416.1660, found 416.1662.

Experimental Procedure for the Synthesis of Alkyl-Substituted 3-*N*-Tosylynamidomethyl-Tethered Cyclohexene 1t. A solution of *N*-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (1.351 g, 5.091 mmol) in THF (33.0 mL) at 0 °C was treated with *n*-BuLi (3.5 mL, 1.6 M in hexanes). After 5 min, a solution of formylbenzotriazole (0.8980 g, 6.103 mmol) in THF (3.0 mL) was added and the mixture stirred for 2 h at room temperature. The crude mixture was diluted with EtOAC (50.0 mL) and washed with saturated aqueous $NaHCO_3$ solution. The water layer was extracted with EtOAC (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:15) to give *N*-(cyclohex-2-en-1-ylmethyl)-*N*-tosylformamide as a white solid (1.164 g, 3.968 mmol, 78%). *N*-(Cyclohex-2-en-1-ylmethyl)-*N*-tosylformamide (1.164 g, 3.968 mmol) and PPh_3 (3.124 g, 11.91 mmol) were dissolved in THF (40.0 mL). Carbon tetrachloride (3.0 mL) was added via syringe over a period of 6 h at 70 °C. After stirring for an additional hour, the mixture was diluted with EtOAc (20.0 mL). The water layer was extracted with EtOAc (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give *N*-(cyclohex-2-en-1-ylmethyl)-*N*-(2,2-dichlorovinyl)-4-methylbenzenesulfonamide as a white solid (1.144 g, 3.175 mmol, 80%). A solution of the dichlorovinylamide (0.3001 g, 0.8329 mmol) in THF (4.2 mL) was cooled to −78 °C and treated with *n*-BuLi (1.20 mL, 1.6 M in hexanes). After 5 min at −78 °C and 1 h at −30 °C the reaction was then quenched with methanol (0.1 mL). The reaction temperature was raised to room temperature over a period of 2 h. The crude mixture the mixture was diluted with EtOAc (20.0 mL) and washed with a saturated aqueous solution of $NaHCO_{3(aq)}$. The water layer was extracted with EtOAc (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give *N*-(cyclohex-2-en-1-ylmethyl)-*N*-ethynyl-4-methylbenzenesulfonamide (**1t**) as yellow solid (0.1802 g, 0.6227 mmol, 76%): mp 79−80 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.78 (m, 2H), 7.38−7.33 (m, 2H), 5.81−5.75 (m, 1H), 5.54−5.48 (m, 1H), 3.20 (dd, J = 12.6, 8.7 Hz, 1H), 3.15 (dd, J = 12.6, 6.7 Hz, 1H), 2.74 (s, 1H), 2.60−2.51 (m, 3H), 2.45 (s, 3H), 2.03−1.96 (m, 2H), 1.82−1.65 (m, 2H), 1.59−1.47 (m, 1H), 1.40−1.30 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 134.5, 129.7, 127.6, 126.8, 76.3, 59.0, 55.7, 33.8, 25.2, 21.6, 21.6, 20.3; IR (CH_2Cl_2) 3284, 2932, 2133, 1596, 1400, 1366, 1169, 722, 586 cm^{-1}; MS (ESI) *m*/*e* (%) 312.1 ([M + Na]$^+$, 100); HRMS (ESI) *m*/*e* calcd for $C_{16}H_{19}NO_2NaS$ [M + Na]$^+$ 312.1034, found 312.1033.

*N-(But-1-yn-1-yl)-N-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (**1p**).* A solution of the dichlorovinylamide (0.3001 g, 0.8329 mmol) in THF (4.2 mL) was cooled to −78 °C and treated with *n*-BuLi (1.20 mL, 1.6 M in hexanes). The mixture was slowly warmed to −30 °C over 1 h and then ethyl iodide (0.18 mL) was added. The mixture was slowly warmed to room temperature over 2 h. The crude mixture was diluted with EtOAc (5.0 mL), washed with a saturated aqueous solution of $NaHCO_3$. The water layer was extracted with EtOAc (50.0 mL × 3) and washed with NaCl (50.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1p** as a yellow oil (0.1949 g, 0.6140 mmol, 74%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.80 (m, 2H), 7.36−7.31 (m, 2H), 5.80−5.74 (m, 1H), 5.55−5.49 (m, 1H), 3.20−3.05 (m, 2H), 2.57−2.47 (m, 1H), 2.45 (s, 3H), 2.26 (q, J = 7.5 Hz, 2H), 2.02−1.96 (m, 2H), 1.81−1.65 (m, 2H), 1.57−1.48 (m, 1H), 1.41−1.32 (m, 1H), 1.12 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 134.6, 129.5, 129.4, 17.6, 127.3, 72.8, 71.5, 56.0, 33.9, 26.0, 25.2, 21.6, 20.4, 14.2, 12.2; IR (CH_2Cl_2) 2930, 2253, 1597, 1450, 1364, 1290, 1169, 815, 584 cm^{-1};

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MS (ESI) *m/e* (%) 340.2 ([M + Na]$^+$, 100), 318.3 ([M + H]$^+$, 86), 162.2 (23); HRMS (ESI) *m/e* calcd for $C_{18}H_{24}NO_2S$ [M + H]$^+$ 318.1528, found 318.1529.

*N-(5-Chloropent-1-yn-1-yl)-N-(cyclohex-2-en-1-ylmethyl)-4-methylbenzenesulfonamide (**1s**).* The synthesis of **1s** was according to the procedure above for the synthesis of **1p** using dichlorovinylamide (0.3019 g, 0.8379 mmol), THF (4.2 mL), *n*-BuLi (1.20 mL, 1.6 M in hexanes) and 1-chloro-3-iodopropane (0.22 mL). The crude mixture after workup was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **1s** as a colorless oil (0.2365 g, 0.6463 mmol, 78%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.37−7.32 (m, 2H), 5.82−5.75 (m, 1H), 5.55−5.48 (m, 1H), 3.59 (t, *J* = 6.4 Hz, 2H), 3.18 (dd, *J* = 12.5, 8.7 Hz, 1H), 3.11 (dd, *J* = 12.4, 6.6 Hz, 1H), 2.56−2.48 (m, 1H), 2.46 (t, *J* = 6.7 Hz, 2H), 2.45 (s, 3H), 2.03−1.96 (m, 2H), 1.97−1.89 (m, 2H), 1.82−1.66 (m, 2H), 1.59−1.48 (m, 1H), 1.41−1.31 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.4, 134.6, 129.6, 129.6, 127.6, 127.1, 74.5, 68.2, 55.9, 43.6, 34.0, 31.6, 26.1, 25.2, 21.6, 20.4, 16.0; IR (CH_2Cl_2) 2929, 2253, 1598, 1446, 1365, 814, 657, 585 cm^{-1}; MS (ESI) *m/e* (%) 388.1 ([M + Na]$^+$, 100), 366.3 ([M + H]$^+$, 63); HRMS (ESI) *m/e* calcd for $C_{19}H_{25}NO_2SCl$ [M + H]$^+$ 366.1295, found 366.1295.

General Experimental Procedure for the Cyclization of the Aryl-Substituted 3-*N*-Tosylynamidomethyl-Tethered Cyclohexene 1a. *Formation of **2a** and **3a**.* A solution of $AgSbF_6$ (10.3 mg, 0.0299 mmol) in CH_2Cl_2 (1.0 mL) was in an oven-dried 2-neck-flask equipped with a stirrer bar and capped with a rubber septum at room temperature was evacuated (oil pump) and filled with nitrogen three times. To the solution at room temperature were then added sequentially [AuCl(PPh_3)] (14.9 mg, 0.0301 mmol) and six-membered ring 3-enynamides **1a** (109.5 mg, 0.2996 mmol) in CH_2Cl_2 (2.0 mL) under nitrogen. After **1a** had been consumed (15 min, monitored by TLC), the resulting solution was filtered through a bed of Celite. The filtrate was concentrated in vacuo to give the crude mixture. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2a** as a white solid (63.6 mg, 0.155 mmol, 52%) and **3a** as a white solid (18.6 mg, 0.0509 mmol, 17%).

(3aR,7S*,7aR*)-7-Benzoyl-2-tosyloctahydro-1H-isoindol-1-one (**2a**).* A white solid (63.6 mg, 0.155 mmol, 52%): mp 177−178 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86−7.81 (m, 2H), 7.75−7.70 (m, 2H), 7.51−7.47 (m, 1H), 7.43−7.39 (m, 2H), 7.28 (d, *J* = 6.4 Hz, 2H), 3.80 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.51 (dd, *J* = 10.1, 0.8 Hz, 1H), 3.26−3.19 (m, 2H), 2.50−2.41 (m, 1H), 2.43 (s, 3H), 1.94−1.87 (m, 1H), 1.78−1.70 (m, 2H), 1.40−1.20 (m, 2H), 0.86−0.76 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.9, 170.9, 145.0, 137.3, 135.1, 132.1, 129.6, 128.5, 127.9, 127.9, 51.8, 45.9, 44.0, 33.4, 27.3, 23.4, 22.7, 21.7; IR (CH_2Cl_2) 1733, 1683, 1575, 1447, 1353, 1234, 1186, 1172, 809 cm^{-1}; MS (ESI) *m/e* (%) 420.1 ([M + Na]$^+$, 100), 282.2; HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_4NaS$ [M + Na]$^+$ 420.1245, found 420.1246. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,3a^{1}S*,10bS*)-5-Tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole (**3a**).* The crude mixture was purified by flash column chromatography to give **3a** as a white solid (18.6 mg, 0.0509 mmol, 17%): mp 190−191 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.80−7.77 (m, 2H), 7.28−7.27 (m, 1H), 7.26−7.25 (m, 1H), 7.16−7.12 (m, 1H), 7.09−7.06 (m, 1H), 7.05−7.00 (m, 2H), 6.58−6.56 (m, 1H), 3.63 (d, *J* = 9.6 Hz, 1H), 3.44 (dd, *J* = 9.6, 5.1 Hz, 1H), 2.85−2.76 (m, 2H), 2.39 (s, 3H), 2.26−2.18 (m, 1H), 1.67−1.60 (m, 1H), 1.59−1.52 (m, 1H), 1.48−1.42 (m, 1H), 1.27−1.12 (m, 2H), 1.05−0.95 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.1, 139.6, 136.5, 134.5, 134.0, 129.6, 126.3, 125.5, 103.0, 56.5, 42.6, 39.0, 34.4, 29.5, 27.0, 22.9, 21.5; IR (CH_2Cl_2) 2931, 1651, 1354, 1164, 1066, 966, 664 cm^{-1}; MS (ESI) *m/e* (%) 366.2 ([M + H]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{24}NO_2S$ [M + H]$^+$ 366.1528, found 366.1521. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,7S*,7aR*)-7-(4-Methylbenzoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2b** as a white solid (47.8 mg, 0.126 mmol, 42%): mp 168−169 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.81 (m, 2H), 7.66−7.61 (m, 2H), 7.31−7.25 (m, 1H), 7.22−7.18 (m, 2H), 7.17−7.13 (m, 1H), 3.80 (dd, *J* = 10.1 5.3 Hz, 1H), 3.50 (d, *J* = 10.1 Hz, 1H), 3.27−3.19 (m, 2H), 2.50−2.40 (m, 1H), 2.42 (s, 3H), 2.38 (s, 3H), 1.91−1.84 (m, 1H), 1.76−1.68 (m, 2H), 1.40−1.18 (m, 2H), 0.84−0.73 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.4, 171.0, 144.9, 142.8, 135.1, 134.4, 129.6, 129.6, 129.2, 128.0, 127.9, 51.7, 45.9, 43.8, 33.4, 27.2, 23.5, 22.6, 21.6, 21.5; IR (CH_2Cl_2) 2925, 1732, 1674, 1354, 1235, 1173, 1106, 666, 584 cm^{-1}; MS (ESI) *m/e* (%) 434.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_4NaS$ [M + Na]$^+$ 434.1402, found 434.1395.

(3aR,3a^{1}S*,10bS*)-9-Methyl-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole (**3b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3b** as a white solid (23.9 mg, 0.0630 mmol, 21%): mp 122−123 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79−7.75 (m, 2H), 7.27−7.23 (m, 2H), 7.00−6.93 (m, 2H), 6.84 (s, 1H), 6.57−6.55 (m, 1H), 3.62 (d, *J* = 9.6 Hz, 1H), 3.42 (dd, *J* = 9.5, 5.1 Hz, 1H), 2.81−2.70 (m, 2H), 2.38 (s, 3H), 2.28 (s, 3H), 2.25−2.16 (m, 1H), 1.67−1.59 (m, 1H), 1.59−1.52 (m, 1H), 1.48−1.41 (m, 1H), 1.27−1.10 (m, 2H), 1.06−0.94 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.0, 138.7, 136.5, 135.1, 134.5, 131.2, 129.6, 128.2, 127.5, 127.2, 126.2, 103.0, 56.5, 42.6, 39.1, 34.3, 29.6, 27.0, 23.0, 21.5, 21.1; IR (CH_2Cl_2) 2934, 2860, 1650, 1598, 1353, 1165, 814, 667, 596 cm^{-1}; MS (FAB$^+$) *m/e* (%) 379.1 ([M]$^+$), 154.1(76), 136.1(48); HRMS (FAB$^+$) *m/e* calcd for $C_{23}H_{25}NO_2S$ [M]$^+$ 379.1606, found 379.1616.

(3aR,7S*,7aR*)-7-(3-Methylbenzoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2c** as a white solid (51.2 mg, 0.135 mmol, 45%): mp 122−123 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.82 (m, 2H), 7.57−7.54 (m, 1H), 7.51−7.47 (m, 1H), 7.33−7.27 (m, 4H), 3.81 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.50 (d, *J* = 10.0 Hz, 1H), 3.26−3.19 (m, 2H), 2.51−2.41 (m, 1H), 2.43 (s, 3H), 2.38 (s, 3H), 1.93−1.84 (m, 1H), 1.76−1.68 (m, 2H), 1.34−1.17 (m, 2H), 0.85−0.73 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 201.1, 171.0, 144.9, 138.5, 137.2, 135.2, 133.0, 129.6, 128.6, 128.3, 127.9, 124.9, 51.8, 45.9, 44.0, 33.4, 27.3, 23.5, 22.7, 21.7, 21.4; IR (CH_2Cl_2) 2937, 1726, 1530, 1355, 1232, 1174, 1104, 812, 668, 584 cm^{-1}; MS (ESI) *m/e* (%) 845.0 ([2M + Na]$^+$, 30), 434.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_4S$ [M + H]$^+$ 412.1583, found 412.1584.

(3aR,7S*,7aR*)-7-(3,4-Dimethylbenzoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2e** as a white solid (51.9 mg, 0.132 mmol, 44%): mp 168−169 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.83 (m, 2H), 7.54−7.52 (m, 1H), 7.47−7.42 (m, 1H), 7.32−7.25 (m, 2H), 7.17−7.13 (m, 1H), 3.81 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.50 (d, *J* = 10.1 Hz, 1H), 3.27−3.20 (m, 2H), 2.51−2.41 (m, 1H), 2.43 (s, 3H), 2.29 (s, 6H), 1.91−1.83 (m, 1H), 1.77−1.67 (m, 2H), 1.40−1.18 (m, 2H), 0.84−0.72 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.6, 171.0, 144.9, 141.6, 137.0, 135.1, 134.8, 129.6, 129.6, 129.2, 127.9, 125.4, 51.7, 46.0, 43.7, 33.4, 27.3, 23.5, 22.6, 21.7, 20.0, 19.8; IR (CH_2Cl_2) 2930, 1731, 1681, 1446, 1402, 1367, 1170, 664, 593 cm^{-1}; MS (ESI) *m/e* (%) 873.0 ([2M + Na]$^+$, 100), 484.1 (25), 426.2 ([M + H]$^+$, 22); HRMS (ESI) *m/e* calcd for $C_{24}H_{28}NO_4S$ [M + H]$^+$ 426.1739, found 426.1734.

(3aR,3a^{1}S*,10bS*)-8,9-Dimethyl-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole (**3e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3e** as a white solid (30.7 mg, 0.0780 mmol, 26%): mp 117−118 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79−7.75 (m, 2H), 7.26−7.24 (m, 2H), 6.88 (s, 1H), 6.80 (s, 1H), 6.53 (d, *J* = 2.4 Hz, 1H), 3.62 (d, *J* = 9.5 Hz, 1H), 3.41 (dd, *J* = 9.5, 5.1 Hz, 1H), 2.80−2.67 (m, 2H), 2.38 (s, 3H), 2.26−2.15 (m, 1H), 2.22 (s, 3H), 2.20 (s, 3H), 1.67−1.51 (m, 2H), 1.38−1.49 (m, 1H), 1.25−1.10 (m, 2H), 1.06−0.94 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.9, 138.7, 134.8, 134.5, 134.1, 133.7, 131.5, 129.5, 128.8, 127.7, 127.2, 103.0, 56.5, 42.8, 38.6, 34.4, 29.7, 27.0, 23.0, 21.5, 19.4; IR (CH_2Cl_2) 2933, 1649, 1353, 1165, 892, 663 cm^{-1}; MS (ESI) *m/e* (%) 394.2 ([M +

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J. Org. Chem. 2017, 82, 481−501

H]$^+$); HRMS (ESI) *m/e* calcd for $C_{24}H_{28}NO_2S$ [M + H]$^+$ 394.1841, found 394.1836.

(3aR,7S*,7aR*)-7-([1,1′-Biphenyl]-4-carbonyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2f**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2f** as a white solid (76.7 mg, 0.162 mmol, 54%): mp 145−146 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.78 (m, 4H), 7.65−7.58 (m, 4H), 7.50−7.37 (m, 3H), 7.32−7.25 (m, 2H), 3.82 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.52 (d, *J* = 10.1 Hz, 1H), 3.31−3.24 (m, 2H), 2.53−2.45 (m, 1H), 2.41 (s, 3H), 1.97−1.88 (m, 1H), 1.80−1.70 (m, 2H), 1.44−1.20 (m, 2H), 0.89−0.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.4, 171.0, 144.9, 140.0, 135.8, 135.1, 129.6, 128.9, 128.5, 128.1, 127.9, 127.2, 51.7, 46.0, 44.0, 33.4, 27.3, 23.5, 22.6, 21.6, 20.0, 19.8; IR (CH_2Cl_2) 2941, 1731, 1681, 1603, 1448, 1402, 1367, 1234, 1172, 815, 747, 665, 586 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 473.1 ([M]$^+$, 30), 318.1 (49), 290.1 (50), 181.1 (100), 153.1 (21); HRMS (ESI) *m/e* calcd for $C_{28}H_{28}NO_4S$ [M + H]$^+$ 474.1739, found 474.1739. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,3a^{1}S*,10bS*)-9-Phenyl-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3f**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3f** as a white solid (23.8 mg, 0.0540 mmol, 18%): mp 154−155 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81−7.78 (m, 2H), 7.58−7.54 (m, 2H), 7.44−7.37 (m, 3H), 7.33−7.25 (m, 4H), 7.17−7.14 (m, 1H), 6.64−6.61 (m, 1H), 3.65 (d, *J* = 9.5 Hz, 1H), 3.46 (dd, *J* = 9.4, 4.8 Hz, 1H), 2.91−2.83 (m, 2H), 2.40 (s, 3H), 2.29−2.20 (m, 1H), 1.70−1.62 (m, 1H), 1.61−1.47 (m, 2H), 1.31−1.14 (m, 2H), 1.08−0.96 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 141.1, 139.8, 138.3, 137.0, 134.5, 133.3, 129.6, 128.7, 127.2, 126.9, 126.7, 126.6, 126.2, 125.6, 102.6, 56.5, 42.7, 39.2, 34.3, 29.6, 27.0, 22.9, 21.5; IR (CH_2Cl_2) 3031, 2936, 1650, 1599, 1355, 1164, 766, 737, 700, 666, 587, 550 cm^{-1}; MS (ESI) *m/e* (%) 969.0 (50), 464.2 ([M + Na]$^+$, 56), 442.2 ([M + H]$^+$, 100), 286.3 (35); HRMS (ESI) *m/e* calcd for $C_{28}H_{28}NO_2S$ [M + H]$^+$ 442.1841, found 442.1840. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,7S*,7aR*)-7-(4-Methoxybenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2g**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2g** as a white solid (51.9 mg, 0.051 mmol, 17%): mp 140−141 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88−7.82 (m, 2H), 7.76−7.70 (m, 2H), 7.31−7.26 (m, 2H), 6.92−6.87 (m, 2H), 3.87 (s, 3H), 3.82 (dd, *J* = 10.1, 5.1 Hz, 1H), 3.52 (dd, *J* = 10.1, 1.0 Hz, 1H), 3.29−3.19 (m, 2H), 2.51−2.41 (m, 1H), 2.43 (s, 3H), 1.91−1.81 (m, 1H), 1.77−1.67 (m, 2H), 1.45−1.18 (m, 2H), 0.89−0.75 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.0, 171.0, 162.8, 144.9, 135.2, 130.1, 129.8, 129.6, 127.9, 113.8, 55.4, 51.7, 46.0, 43.6, 33.4, 27.2, 23.7, 22.5, 21.7; IR (CH_2Cl_2) 2939, 1738, 1682, 1598, 1451, 1354, 1168, 1106, 668, 587 cm^{-1}; MS (ESI) *m/e* (%) 450.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_5S$ [M + H]$^+$ 428.1532, found 428.1535.

(3aR,3a^{1}S*,10bS*)-9-Methoxy-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3g**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3g** as a white solid (33.2 mg, 0.0840 mmol, 28%): mp 148−149 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.29−7.23 (m, 2H), 7.00 (d, *J* = 5.9 Hz, 1H), 6.69 (dd, *J* = 8.3, 2.6 Hz, 1H), 6.61 (d, *J* = 2.6 Hz, 1H), 6.54 (d, *J* = 1.9 Hz, 1H), 3.77 (s, 3H), 3.61 (d, *J* = 9.6 Hz, 1H), 3.41 (dd, *J* = 9.5, 5.1 Hz, 1H), 2.80−2.70 (m, 2H), 2.38 (s, 3H), 2.24−2.14 (m, 1H), 1.67−1.52 (m, 2H), 1.50−1.43 (m, 1H), 1.28−1.10 (m, 2H), 1.05−0.93 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.7, 143.9, 138.2, 137.5, 134.4, 129.5, 127.2, 127.0, 113.9, 111.3, 102.7, 56.4, 55.3, 42.2, 39.4, 34.3, 29.5, 26.9, 22.9, 21.5; IR (CH_2Cl_2) υ 2934, 1489, 1349, 1250, 1163, 665 cm^{-1}; MS (ESI) *m/e* (%) 443.2 (24), 418.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1637.

(3aR,7S*,7aR*)-7-(3-Methoxybenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2h**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2h** as a white solid (64.1 mg, 0.150 mmol, 50%): mp 131−132 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.81 (m, 2H), 7.33−7.25 (m, 5H), 7.07−7.01 (m, 1H), 3.85 (s, 3H), 3.80 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.51 (d, *J* = 10.1 Hz, 1H), 3.29−3.16 (m, 2H), 2.51−2.38 (m, 1H), 2.42 (s, 3H), 1.94−1.85 (m, 1H), 1.79−1.70 (m, 2H), 1.34−1.21 (m, 2H), 0.88−0.74 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.6, 170.9, 159.9, 145.0, 138.6, 135.2, 129.6, 129.4, 127.9, 120.0, 118.3, 113.1, 55.5, 51.7, 46.0, 44.1, 33.5, 27.3, 23.4, 22.7, 21.7; IR (CH_2Cl_2) 2938, 1740, 1582, 1358, 1257, 1169, 1107, 666 cm^{-1}; MS (ESI) *m/e* (%) 877.0 ([2M + Na]$^+$, 100), 507.5 (34), 450.3 ([M + Na]$^+$, 77), 428.3 ([M + H]$^+$, 22); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_5S$ [M + H]$^+$ 428.1532, found 428.1534. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,3a^{1}S*,10bS*)-8-Methoxy-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3h**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3h** as a white solid (27.3 mg, 0.0690 mmol, 23%): mp 131−132 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.30−7.26 (m, 2H), 7.11−7.07 (m, 1H), 7.00−6.97 (m, 2H), 6.54−6.51 (m, 1H), 3.79 (s, 3H), 3.63 (d, *J* = 9.6 Hz, 1H), 3.45 (dd, *J* = 9.6, 5.1 Hz, 1H), 2.82−2.72 (m, 2H), 2.40 (s, 3H), 2.27−2.18 (m, 1H), 1.68−1.60 (m, 1H), 1.56−1.52 (m, 1H), 1.49−1.42 (m, 1H), 1.27−1.10 (m, 2H), 1.02−0.90 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 139.9, 138.2, 134.5, 132.6, 130.3, 129.6, 127.4, 127.2, 127.2, 126.8, 101.9, 56.5, 42.3, 38.9, 34.2, 29.3, 26.8, 22.7, 21.6; IR (CH_2Cl_2) 2937, 1652, 1597, 1479, 1446, 1446, 1354, 1163, 663, 594 cm^{-1}; MS (ESI) *m/e* (%) 396.2 ([M + H]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1632. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,7S*,7aR*)-7-(4-Fluorobenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2i**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2i** as a white solid (63.6 mg, 0.153 mmol, 51%): mp 125−126 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.81 (m, 2H), 7.80−7.74 (m, 2H), 7.32−7.27 (m, 2H), 7.12−7.06 (m, 2H), 3.82 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.52 (d, *J* = 10.1 Hz, 1H), 3.26−3.18 (m, 2H), 2.53−2.40 (m, 2H), 2.44 (s, 3H), 1.95−1.86 (m, 1H), 1.80−1.70 (m, 2H), 1.41−1.19 (m, 1H), 0.89−0.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3, 170.9, 165.0 (d, *J* = 252.0 Hz), 145.0, 135.0, 130.4 (d, *J* = 9.0 Hz), 129.6, 127.8, 115.6 (d, *J* = 21.7 Hz), 51.7, 45.9, 43.8, 33.3, 27.2, 23.5, 22.5, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ −107.7; IR (CH_2Cl_2) 2928, 1726, 1678, 1597, 1354, 1229, 1105, 666 cm^{-1}; MS (ESI) *m/e* (%) 438.3 ([M + Na]$^+$, 99); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_4SF$ [M + H]$^+$ 416.1332, found 416.1334.

(3aR,3a^{1}S*,10bS*)-9-Fluoro-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3i**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3i** as a white solid (16.1 mg, 0.0420 mmol, 14%): mp 140−147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.76 (m, 2H), 7.30−7.26 (m, 2H), 7.03−6.99 (m, 1H), 6.82 (td, *J* = 8.6, 2.7 Hz, 1H), 6.70 (dd, *J* = 9.1, 2.7 Hz, 1H), 6.55−6.53 (m, 1H), 3.63 (d, *J* = 9.6 Hz, 1H), 3.44 (dd, *J* = 9.5, 5.0 Hz, 1H), 2.83−2.73 (m, 2H), 2.40 (s, 3H), 2.26−2.16 (m, 1H), 1.69−1.60 (m, 1H), 1.60−1.52 (m, 1H), 1.49−1.41 (m, 1H), 1.27−1.10 (m, 2H), 1.05−0.91 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8 (d, *J* = 242.8 Hz), 144.1, 138.9, 138.6 (d, *J* = 6.8 Hz), 134.5, 130.0, 130.0, 129.6, 127.2 (d, *J* = 7.7 Hz), 127.2, 114.4 (d, *J* = 21.6 Hz), 113.3 (d, *J* = 21.0 Hz), 102.0, 56.5, 42.1, 39.1, 34.2, 29.3, 26.8, 22.8, 21.5; ^{19}F NMR (100 MHz, $CDCl_3$) δ −118.3; IR (CH_2Cl_2) 2931, 1652, 1493, 1354, 1245, 1163, 967, 662, 545 cm^{-1}; MS (FAB$^+$) *m/e* (%) 383.1 ([M]$^+$, 56), 228.1 (70); HRMS (FAB$^+$) *m/e* calcd for $C_{22}H_{22}NO_2SF$ [M]$^+$ 383.1355, found 383.1353. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,7S*,7aR*)-7-(4-Chlorobenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2j**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2j** as a white solid (53.1 mg, 0.123 mmol, 41%): mp 139−140 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.80 (m, 2H), 7.68−7.64 (m, 2H), 7.40−7.35 (m, 2H), 7.31−7.27 (m, 2H), 3.78 (dd, *J* = 10.0, 5.2 Hz, 1H), 3.51 (d, *J* = 10.0 Hz, 1H), 3.21−3.14 (m, 2H), 2.50−2.41 (m, 1H), 2.43 (s, 3H), 1.94−1.86 (m, 1H), 1.79−1.70 (m, 2H), 1.40−1.17 (m, 2H), 0.88−0.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ

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199.8, 170.9, 145.0, 138.3, 135.6, 135.0, 129.6, 129.3, 128.8, 127.8, 51.7, 45.9, 44.0, 33.3, 27.2, 23.4, 22.6, 21.7; IR (CH_2Cl_2) 2930, 1727, 1682, 1590, 1355, 1174, 1105, 666, 583 cm^{-1}; MS (ESI) *m/e* (%) 456.5 ($[M + 2 + Na]^+$, 37), 454.5 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_4SCl$ $[M + H]^+$ 432.1036, found 432.1039.

(3aR,3a^{1}S*,10bS*)-9-Chloro-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3j**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3j** as a white solid (12.0 mg, 0.0300 mmol, 10%): mp 175−176 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.30−7.26 (m, 2H), 7.11−7.07 (m, 1H), 7.00−6.97 (m, 2H), 6.54−6.51 (m, 1H), 3.63 (d, *J* = 9.6 Hz, 1H), 3.45 (dd, *J* = 9.6, 5.1 Hz, 1H), 2.82−2.72 (m, 2H), 2.40 (s, 3H), 2.27−2.18 (m, 1H), 1.68−1.60 (m, 1H), 1.56−1.52 (m, 1H), 1.49−1.42 (m, 1H), 1.27−1.10 (m, 2H), 1.02−0.90 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 139.9, 138.2, 134.5, 132.6, 130.3, 129.6, 127.4, 127.2, 127.2, 126.8, 101.9, 56.5, 42.3, 38.9, 34.2, 29.3, 26.8, 22.7, 21.6; IR (CH_2Cl_2) 2937, 1652, 1597, 1479, 1446, 1446, 1354, 1163, 663, 594 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 399.1($[M]^+$, 100), 244.1(97), 164.0 (63); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_2SCl$ $[M + H]^+$ 400.1138, found 400.1145.

(3aR,7S*,7aR*)-7-(4-Bromobenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2k**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2k** as a yellow solid (55.7 mg, 0.117 mmol, 39%): mp 141−142 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.2 Hz, 2H), 7.62−7.51 (m, 4H), 7.33−7.25 (m, 2H), 3.78 (dd, *J* = 10.1, 5.1 Hz, 1H), 3.51 (d, *J* = 10.1 Hz, 1H), 3.22−3.12 (m, 2H), 2.52−2.39 (m, 1H), 2.43 (s, 3H), 1.95−1.85 (m, 1H), 1.80−1.68 (m, 2H), 1.40−1.16 (m, 2H), 0.89−0.75 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.0, 170.9, 145.0, 136.0, 135.0, 131.8, 129.6, 129.5, 127.8, 126.9, 51.7, 45.9, 44.0, 33.3, 27.2, 23.4, 22.6, 21.7; IR (CH_2Cl_2) 2928, 1729, 1683, 1356, 1173, 1105, 665, 584 cm^{-1}; MS (ESI) *m/e* (%) 500.1 (100), 498.2 ($[M + Na]^+$, 97); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_4SBr$ $[M + H]^+$ 476.0531, found 476.0529.

(3aR,3a^{1}S*,10bS*)-9-Bromo-5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole* (**3k**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3k** as a white solid (16.1 mg, 0.0360 mmol, 12%): mp 140−147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.73 (m, 2H), 7.30−7.26 (m, 2H), 7.26−7.21 (m, 1H), 7.15−7.13 (m, 1H), 6.93 (d, *J* = 8.1 Hz, 1H), 6.52−6.50 (m, 1H), 3.63 (d, *J* = 9.6 Hz, 1H), 3.45 (dd, *J* = 9.6, 5.1 Hz, 1H), 2.82−2.72 (m, 2H), 2.40 (s, 3H), 2.27−2.18 (m, 1H), 1.67−1.59 (m, 1H), 1.59−1.52 (m, 1H), 1.49−1.42 (m, 1H), 1.26−1.10 (m, 2H), 1.02−0.90 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 140.1, 138.5, 134.4, 133.0, 130.2, 129.7, 129.6, 127.6, 127.1, 118.3, 101.9, 56.5, 42.4, 38.8, 34.2, 29.3, 26.8, 22.7, 21.5; IR (CH_2Cl_2) 2931, 2362, 1648, 1477, 1355, 1164, 666, 592 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 443.0 ($[M]^+$, 97), 288.0 (70), 58.0 (35), 43.0 (100); HRMS (ESI) *m/e* calcd for $C_{22}H_{22}NO_2SBr$ $[M + H]^+$ 443.0560, found 443.0556.

Methyl 4-((3aR,4S*,7aR*)-3-oxo-2-tosyloctahydro-1H-isoindole-4-carbonyl)benzoate* (**2l**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2l** as a white solid (56.0 mg, 0.123 mmol, 41%): mp 230−231 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08−8.05 (m, 2H), 7.84−7.80 (m, 2H), 7.77−7.73 (m, 2H), 7.31−7.26 (m, 2H), 3.94 (s, 3H), 3.78 (dd, *J* = 10.1, 5.2 Hz, 1H), 3.52 (d, *J* = 10.1 Hz, 1H), 3.24−3.14 (m, 2H), 2.50−2.41 (m, 1H), 2.42 (s, 3H), 1.98−1.90 (m, 1H), 1.80−1.71 (m, 2H), 1.39−1.21 (m, 2H), 0.89−0.77 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.9, 170.9, 166.3, 145.1, 141.1, 135.0, 133.0, 129.8, 129.7, 127.8, 127.8, 52.4, 51.8, 45.8, 44.4, 33.3, 27.2, 23.3, 22.6, 21.6; IR (CH_2Cl_2) 2940, 1730, 1677, 1373, 1278, 1176, 1105, 734, 681, 659, 545 cm^{-1}; MS (ESI) *m/e* (%) 478.3 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_6S$ $[M + H]^+$ 456.1481, found 456.1480.

(3aR,3a^{1}S*,10bS*)-Methyl 5-tosyl-1,2,3,3a,3a^1,4,5,10b-octahydrodibenz[cd,f]indole-9-carboxylate* (**3l**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3l** as a white solid (8.9 mg, 0.021 mmol, 7%): mp 219−220 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.77 (m, 3H), 7.70−7.69 (m, 1H), 7.29 (d, *J* = 8.1 Hz, 2H), 7.10 (d, *J* = 8.0 Hz, 1H), 6.61−6.58 (m, 1H), 3.88 (s, 3H), 3.65 (d, *J* = 9.6 Hz, 1H), 3.50 (dd, *J* = 9.6, 5.1 Hz, 1H), 2.92−2.84 (m, 2H), 2.40 (s, 3H), 2.30−2.21 (m, 1H), 1.69−1.60 (m, 1H), 1.60−1.52 (m, 1H), 1.52−1.45 (m, 1H), 1.27−1.15 (m, 2H), 1.01−0.89 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.1, 144.4, 123.3, 139.0, 136.2, 134.5, 129.7, 128.6, 128.5, 127.1, 126.7, 125.9, 102.0, 56.6, 51.9, 42.8, 38.6, 34.2, 29.3, 26.8, 22.7, 21.6; IR (CH_2Cl_2) 2927. 2856, 1717, 1649, 1355, 1280, 1165, 664 cm^{-1}; MS (ESI) *m/e* (%) 869.0 ($[2M + Na]^+$, 35), 478.2 (40), 446.2 ($[M + Na]^+$, 100), 268.2 (30); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_4S$ $[M + H]^+$ 424.1583, found 424.1584.

(3aR,7S*,7aR*)-7-(4-Nitrobenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2m**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2m** as a yellow solid (66.4 mg, 0.150 mmol, 50%): mp 219−220 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.27−8.22 (m, 2H), 7.88−7.77 (m, 4H), 7.31−7.25 (m, 2H), 3.78 (dd, *J* = 10.2, 5.1 Hz, 1H), 3.52 (d, *J* = 10.2 Hz, 1H), 3.25−3.10 (m, 2H), 2.53−2.38 (m, 1H), 2.42 (s, 3H), 2.03−1.91 (m, 1H), 1.83−1.72 (m, 2H), 1.41−1.15 (m, 2H), 0.90−0.74 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.2, 170.9, 149.5, 145.2, 142.8, 134.9, 129.7, 128.8, 127.7, 123.7, 51.8, 45.8, 44.6, 33.3, 27.2, 23.2, 22.6, 21.6; IR (CH_2Cl_2) 2933, 1735, 1693, 1602, 1525, 1352, 1229, 1171, 910, 860, 729 cm^{-1}; MS (ESI) *m/e* (%) 465.3 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}N_2O_6S$ $[M + H]^+$ 443.1277, found 443.1276.

(3aR,7S*,7aR*)-7-(3-Nitrobenzoyl)-2-tosyloctahydro-1H-isoindol-1-one* (**2n**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2n** as a yellow solid (57.1 mg, 0.129 mmol, 43%): mp 201−202 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49−8.45 (m, 1H), 8.38−8.33 (m, 1H), 8.14−8.10 (m, 1H), 7.85−7.79 (m, 2H), 7.64 (t, *J* = 8.0 Hz, 1H), 7.32−7.27 (m, 2H), 3.81 (dd, *J* = 10.2, 5.2 Hz, 1H), 3.53 (d, *J* = 10.2 Hz, 1H), 3.28−3.22 (m, 1H), 3.21−3.16 (m, 1H), 2.57−2.48 (m, 1H), 2.43 (s, 3H), 1.98−1.92 (m, 1H), 1.82−1.74 (m, 2H), 1.38−1.23 (m, 2H), 0.89−0.77 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.0, 170.9, 147.9, 145.2, 138.7, 134.9, 134.4, 130.1, 129.7, 127.8, 126.5, 122.1, 51.8, 45.8, 44.1, 33.3, 27.2, 23.3, 22.5, 21.7; IR (CH_2Cl_2) 2945, 1736, 1686, 1357, 1167, 815, 668, 585 cm^{-1}; MS (ESI) *m/e* (%) 465.2 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}N_2O_6S$ $[M + H]^+$ 443.1277, found 443.1277.

(3aR,3a^{1}R*,9bS*)-5-Tosyl-1,2,3,3a,3a^1,4,5,9b-octahydrobenzo[cd]thien[2,3-f]indole* (**3o**). The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **3o** as a yellow solid (22.3 mg, 0.0600 mmol, 22%): mp 115−116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.76 (m, 2H), 7.30−7.26 (m, 2H), 7.04 (d, *J* = 7.3 Hz, 1H), 6.86 (d, *J* = 5.0 Hz, 1H), 6.57−6.55 (m, 1H), 3.65 (d, *J* = 9.6 Hz, 1H), 3.46 (dd, *J* = 9.6, 5.2 Hz, 1H), 2.99−2.89 (m, 2H), 2.40 (s, 3H), 2.25−2.15 (m, 1H), 1.67−1.60 (m, 1H), 1.60−1.52 (m, 1H), 1.20−1.06 (m, 3H), 1.03−0.92 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.0, 137.7, 134.6, 134.4, 133.9, 129.6, 127.2, 125.6, 122.3, 98.7, 56.8, 44.2, 34.8, 34.4, 29.9, 27.1, 22.4, 21.5; IR (CH_2Cl_2) 2931, 1447, 1353, 1244, 1165, 1085, 1072, 962 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 371.1 ($[M]^+$, 58), 216.1 (100); HRMS (ESI) *m/e* calcd for $C_{20}H_{22}NO_2S_2$ $[M + H]^+$ 372.1092, found 372.1093. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

General Experimental Procedure for Cyclization of Six-Membered Ring 3-Enynamides 1d and 1p−s. *Example for the Synthesis of* ***8a***. A solution of $AgSbF_6$ (13.7 mg, 0.0402 mmol) in CH_2Cl_2 (1.0 mL) was in an oven-dried 2-neck-flask equipped with a stirrer bar and capped with a rubber septum at room temperature was evacuated (oil pump) and filled with nitrogen three times. To the solution at room temperature were then added sequentially [AuCl(PPh_3)] (19.8 mg, 0.0400 mmol) and six-membered ring 3-enynamides **1d** (151.8 mg, 0.4000 mmol) in CH_2Cl_2 (3.0 mL) under nitrogen. After **1d** had been consumed (monitored by TLC, 9 min), the resulting solution was filtered through a bed of Celite. The filtrate was concentrated in vacuo to give the crude mixture. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give (2a^{1}S*,3aS*,6aR*)-3-(*o*-

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tolyl)-2-tosyl-1,2,2a[1],3a,4,5,6,6a-octahydrocyclobuta[*cd*]isoindole (**8a**) as a white solid (56.9 mg, 0.150 mmol, 50%): mp 107−108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.77 (m, 1H), 7.73−7.69 (m, 2H), 7.29−7.24 (m, 2H), 7.23−7.12 (m, 3H), 3.82 (dd, J = 11.0, 7.3 Hz, 1H), 3.49 (dd, J = 11.1, 2.0 Hz, 1H), 3.20−3.16 (m, 1H), 2.44 (s, 3H), 2.42 (s, 3H), 2.32 (dd, J = 8.8, 4.0 Hz, 1H), 2.19−2.10 (m, 1H), 1.75−1.64 (m, 1H), 1.61−1.47 (m, 2H), 1.46−1.30 (m, 2H), 1.16−1.07 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.7, 136.8, 136.7, 135.1, 134.6, 131.5, 130.4, 129.5, 128.6, 128.0, 127.8, 125.5, 63.1, 39.0, 34.2, 30.9, 27.9, 25.7, 21.5, 20.8, 17.9; IR (CH_2Cl_2) 2929, 1652, 1598, 1457, 1353, 1165, 754, 669 cm^{-1}; MS (ESI) m/e (%) 380.2 ([M + H]$^+$); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1671, found 380.1684. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(2a[1]S,3aS*,6aR*)-3-Ethyl-2-tosyl-1,2,2a1,3a,4,5,6,6a-octahydrocyclobuta[cd]isoindole (**8b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **8b** as a colorless oil (41.9 mg, 0.132 mmol, 44%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 8.1 Hz, 2H), 7.30 (J = 8.1 Hz, 2H), 3.73 (dd, J = 10.7, 6.8 Hz, 1H), 3.35 (d, J = 10.8 Hz, 1H), 2.76−2.70 (m, 1H), 2.43 (s, 3H), 2.41−2.28 (m, 2H), 2.17−2.08 (m, 1H), 2.05−1.93 (m, 1H), 1.69−1.51 (m, 2H), 1.48−1.29 (m, 2H), 1.20−1.03 (m, 2H), 1.07 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.6, 135.1, 135.0, 133.2, 129.5, 127.7, 62.7, 38.6, 32.3, 31.7, 27.6, 25.5, 21.5, 19.7, 18.2, 11.3; IR (CH_2Cl_2) 2928, 1679, 1598, 1455, 1351, 1162, 1091, 1014, 814, 667 cm^{-1}; MS (EI, 40 *eV*) m/e (%) 317.1 ([M]$^+$, 39), 248.1 (70), 162.1 (97), 134.1 (95); HRMS (EI, 40 *eV*) m/e calcd for $C_{18}H_{23}NO_2S$ [M]$^+$ 317.1454, found 317.1451.

(2a[1]S,3aS*,6aR*)-3-Hexyl-2-tosyl-1,2,2a[1],3a,4,5,6,6a-octahydrocyclobuta[cd]isoindole (**8c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **8c** as a colorless oil (53.8 mg, 0.144 mmol, 48%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78−7.73 (m, 1H), 7.32−7.27 (m, 2H), 3.73 (dd, J = 10.7, 6.9 Hz, 1H), 3.35 (dd, J = 10.7, 1.8 Hz, 1H), 2.72−2.68 (m, 1H), 2.43 (s, 3H), 2.35−2.28 (m, 2H), 2.16−2.07 (m, 1H), 1.98−1.88 (m, 1H), 1.69−1.59 (m, 1H), 1.56−1.25 (m, 11H), 1.20−1.13 (m, 1H), 1.13−1.04 (m, 1H), 0.93−0.87 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.5, 135.4, 135.1, 132.4, 129.5, 127.7, 62.6, 38.7, 32.5, 31.8, 31.7, 29.3, 27.5, 26.9, 26.3, 25.4, 22.6, 21.5, 18.2, 14.1; IR (CH_2Cl_2) 2927, 2857, 1679, 1598, 1456, 1352, 1164, 1091, 814, 666 cm^{-1}; MS (ESI) m/e (%) 374.2 ([M + H]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{31}NO_2S$ [M + H]$^+$ 374.2154, found 374.2173.

(2a[1]S,3aS*,6aR*)-3-Phenethyl-2-tosyl-1,2,2a[1],3a,4,5,6,6a-octahydrocyclobuta[cd]isoindole (**8d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **8d** as a white solid (55.5 mg, 0.141 mmol, 47%): mp 128−129 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, J = 8.2 Hz, 2H), 7.32−7.23 (m, 6H), 7.22−7.17 (m, 1H), 3.67 (dd, J = 10.6, 6.7 Hz, 1H), 3.35 (dd, J = 10.6, 1.6 Hz, 1H), 2.91−2.63 (m, 4H), 2.41(s, 3H), 2.32−2.21 (m, 2H), 2.15−2.06 (m, 1H), 1.67−1.57 (m, 1H), 1.56−1.47 (m, 1H), 1.46−1.28 (m, 2H), 1.19−1.08 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.5, 142.0, 136.2, 134.9, 130.8, 129.5, 128.4, 128.2, 127.5, 125.7, 62.5, 38.8, 33.2, 32.6, 31.8, 28.0, 27.4, 25.3, 21.5, 18.3; IR (CH_2Cl_2) 2926, 1351, 1164, 1091, 814, 666, 549 cm^{-1}; MS (ESI) m/e (%) 416.3 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{24}H_{28}NO_2S$ [M + H]$^+$ 394.1841, found 394.1842.

(2a[1]S,3aS*,6aR*)-3-(3-Chloropropyl)-2-tosyl-1,2,2a[1],3a,4,5,6,6a-octahydrocyclobuta[cd]isoindole (**8e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **8e** as a colorless oil (48.3 mg, 0.132 mmol, 44%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77−7.73 (m, 2H), 7.33−7.28 (m, 2H), 3.72 (dd, J = 10.7, 6.8 Hz, 1H), 3.68−3.55 (m, 2H), 3.37 (dd, J = 10.7, 1.8 Hz, 1H), 2.74−2.68 (m, 1H), 2.51−2.41 (m, 1H), 2.44 (s, 3H), 2.36−2.30 (m, 1H), 2.18−2.08 (m, 2H), 2.06−1.97 (m, 2H), 1.72−1.62 (m, 1H), 1.61−1.52 (m, 1H), 1.50−1.31 (m, 2H), 1.23−1.06 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.8, 136.8, 135.0, 130.2, 129.6, 127.7, 62.6, 45.0, 38.9, 32.8, 31.7, 30.0, 27.5, 25.4, 23.8, 21.6, 18.2; IR (CH_2Cl_2) 2929, 1682, 1447, 1352, 1164, 1091, 814, 666 cm^{-1}; MS (ESI) m/e (%) 390.4 (39), 388.5 ([M + Na]$^+$, 100), 368.4 (24), 366.6 ([M + H]$^+$, 74); HRMS (ESI) m/e calcd for $C_{19}H_{25}NO_2SCl$ [M + H]$^+$ 366.1295, found 366.1297.

General Experimental Procedure for the Oxidation of 4-Azatricyclo[4.3.1.0^{3,10}]dec-2-ene Derivatives 8a−e to Bicyclic γ-Lactams 2d and 2p−s. *Example for the Synthesis of **2d**.* To a solution of **8a** (56.9 mg, 0.150 mmol) in acetone/H_2O (1.5 mL) were added NMO (35.1 mg, 0.300 mmol) and OsO_4 (0.05 equiv, 2.5 wt %, in *t*-BuOH). The reaction mixture was stirred for 16 h at room temperature. The solvent was removed under reduced pressure. The crude mixture was added EtOAc (10.0 mL). The resulting solution was filtered through a bed of Celite/silica gel, and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the desired product **2d** as a white solid (59.9 mg, 0.146 mmol, 97%).

(3aR,7S*,7aR*)-7-(2-Methylbenzoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2d** as a white solid (59.9 mg, 0.146 mmol, 97%): mp 138−139 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85−7.82 (m, 2H), 7.39−7.36 (m, 1H), 7.32−7.27 (m, 3H), 7.24−7.21 (m, 1H), 7.18−7.14 (m, 1H), 3.75 (dd, J = 10.1, 5.0 Hz, 1H), 3.48 (d, J = 10.2 Hz, 1H), 3.17−3.13 (m, 1H), 3.06−3.01 (m, 1H), 2.49 (s, 3H), 2.43 (s, 3H), 2.41−2.34 (m, 1H), 1.98−1.89 (m, 1H), 1.78−1.68 (m, 2H), 1.27−1.18 (m, 2H), 0.84−0.73 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 204.0, 171.2, 144.9, 138.6, 137.4, 135.1, 132.1, 130.4, 129.6, 127.8, 126.8, 125.1, 51.8, 46.0, 45.7, 33.6, 27.2, 23.3, 23.2, 21.6, 20.2; IR (CH_2Cl_2) 2935, 1738, 1688, 1364, 1172, 667, 585 cm^{-1}; MS (ESI) m/e (%) 434.3 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_4S$ [M + H]$^+$ 412.1583, found 412.1586.

(3aR,7S*,7aR*)-7-Butyryl-2-tosyloctahydro-1H-isoindol-1-one (**2p**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2p** as a white solid (45.8 mg, 0.131 mmol, 99%): mp 137−138 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89−7.84 (m, 2H), 7.35−7.30 (m, 2H), 3.82 (dd, J = 10.0, 4.9 Hz, 1H), 3.57 (d, J = 10.0 Hz, 1H), 3.39−3.33 (m, 1H), 2.61−2.47 (m, 2H), 2.44 (s, 3H), 2.41−2.32 (m, 1H), 2.28−2.21 (m, 1H), 1.99−1.91 (m, 1H), 1.77−1.68 (m, 2H), 1.32−1.07 (m, 2H), 1.04 (t, J = 7.0 Hz, 3H), 0.93−0.80 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 210.8, 171.8, 145.1, 135.1, 129.7, 127.8, 52.0, 47.5, 46.5, 33.4, 33.2, 27.0, 23.5, 23.2, 21.7, 7.5; IR (CH_2Cl_2) 2936, 1732, 1709, 1360, 1171, 668, 594 cm^{-1}; MS (ESI) m/e (%) 372.2 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{18}H_{24}NO_4S$ [M + H]$^+$ 350.1426, found 350.1429. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(3aR,7S*,7aR*)-7-Heptanoyl-2-tosyloctahydro-1H-isoindol-1-one (**2q**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2q** as a white solid (57.2 mg, 0.141 mmol, 98%): mp 186−187 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90−7.86 (m, 2H), 7.36−7.31 (m, 2H), 3.85 (dd, J = 10.0, 5.0 Hz, 1H), 3.58 (d, J = 10.0 Hz, 1H), 3.39−3.34 (m, 1H), 2.57−2.43 (m, 2H), 2.45 (s, 3H), 2.42−2.34 (m, 1H), 2.28−2.21 (m, 1H), 1.99−1.92 (m, 1H), 1.78−1.69 (m, 2H), 1.61−1.53 (m, 2H), 1.35−1.21 (m, 6H), 1.20−1.07 (m, 2H), 0.94−0.81 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 210.2, 171.7, 145.0, 135.1, 129.7, 127.8, 51.9, 47.7, 46.3, 39.9, 33.4, 31.7, 28.8, 27.0, 23.4, 23.3, 23.2, 22.5, 21.6, 14.0; IR (CH_2Cl_2) 2919, 1727, 1714, 1440, 1356, 1175, 1111, 666, 559 cm^{-1}; MS (ESI) m/e (%) 428.3 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{32}NO_4S$ [M + H]$^+$ 406.2052, found 406.2056.

(3aR,7S*,7aR*)-7-(3-Phenylpropanoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2r**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2r** as a white solid (59.4 mg, 0.140 mmol, 99%): mp 169−170 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89−7.86 (m, 2H), 7.35−7.30 (m, 2H), 7.29−7.24 (m, 2H), 7.20−7.15 (m, 3H), 3.81 (dd, J = 10.1, 5.0 Hz, 1H), 3.57 (d, J = 10.1 Hz, 1H), 3.36−3.31 (m, 1H), 2.93−2.73 (m, 4H), 2.44 (s, 3H), 2.40−2.30 (m, 1H), 2.25−2.18 (m, 1H), 1.97−1.89 (m, 1H), 1.76−1.67 (m, 2H), 1.28−1.05 (m, 2H), 0.93−0.80 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.1, 171.8, 145.1, 141.5,

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135.1, 129.7, 128.4, 128.4, 127.9, 125.9, 52.0, 47.9, 46.4, 41.8, 33.4, 29.5, 27.0, 23.4, 21.7; IR (CH_2Cl_2) 2938, 1726, 1710, 1357, 1107, 665, 596 cm^{-1}; MS (ESI) *m/e* (%) 448.4 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{28}NO_4S$ $[M + H]^+$ 426.1739, found 426.1740.

(3aR,7S*,7aR*)-7-(4-Chlorobutanoyl)-2-tosyloctahydro-1H-isoindol-1-one (**2s**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20, 3% Et_3N) to give **2s** as a white solid (50.9 mg, 0.128 mmol, 97%): mp 156−160 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.90−7.83 (m, 2H), 7.37−7.29 (m, 2H), 3.83 (dd, *J* = 10.0, 4.9 Hz, 1H), 3.61−3.54 (m, 3H), 3.36 (t, *J* = 5.8 Hz, 1H), 2.70−2.63 (m, 2H), 2.44 (s, 3H), 2.43−2.34 (m, 1H), 2.32−2.23 (m, 1H), 2.12−2.02 (m, 2H), 2.00−1.91 (m, 1H), 1.79−1.68 (m, 2H), 1.29−1.07 (m, 2H), 0.93−0.80 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.9, 171.8, 145.1, 135.0, 129.7, 127.8, 52.0, 47.8, 46.4, 44.7, 36.6, 33.3, 27.0, 26.1, 23.3, 23.1, 21.6; IR (CH_2Cl_2) 2924, 1734, 1711, 1360, 1169, 668, 590 cm^{-1}; MS (ESI) *m/e* (%) 422.1 (36), 420.1 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{19}H_{25}NO_4SCl$ $[M + H]^+$ 398.1193, found 398.1196.

General Experimental Procedure for the Hydration of 4-Azatricyclo[4.3.1.0^{3,10}]dec-2-ene Derivatives 8a−e to Bicyclic Ketones 10a−e. *Example for the Synthesis of **10a**.* To a solution of **8a** (56.9 mg, 0.150 mmol) in EtOAc (6.0 mL) was added hydrochloric acid (1 M HCl, 0.80 mL). The reaction mixture was stirred for 3 h at room temperature, then added saturated $NaHCO_{3(aq)}$ (it is important to keep the pH value of the aqueous layer above pH 10). The water layer was extracted with EtOAc (30.0 mL × 3) and $NaCl_{(aq)}$ (30.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give 4-methyl-*N*-(((1*S**,2*R**,6*S**,7*R**)-8-oxo-7-(*o*-tolyl)bicyclo-[4.2.0]octan-2-yl)- methyl)benzenesulfonamide (**10a**) as a white solid (55.5 mg, 0.140 mmol, 93%): mp 119−121 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 7.79−7.76 (m, 2H), 7.69−7.65 (m, 1H), 7.33−7.29 (m, 2H), 7.17−7.12 (m, 3H), 5.65−5.60 (m, 1H), 4.50 (dd, *J* = 8.9, 2.0 Hz, 1H), 3.43 (t, *J* = 7.9 Hz, 1H), 3.28−3.21 (m, 1H), 3.06−3.00 (m, 1H), 2.92−2.84 (m, 1H), 2.43 (s, 3H), 2.24 (s, 3H), 1.97−1.89 (m, 1H), 1.65−1.58 (m, 2H), 1.57−1.50 (m, 1H, H-2), 1.20−1.09 (m, 1H), 1.07−0.97 (m, 1H), 0.78−0.68 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 209.2, 143.1, 137.3, 135.5, 133.3, 129.8, 129.7, 128.1, 127.2, 127.0, 125.7, 61.3, 57.0, 46.4, 36.2, 28.5, 27.1, 25.7, 22.7, 21.5, 19.3; IR (CH_2Cl_2) 3282, 2928, 1759, 1450, 1327, 1159, 1094, 665 cm^{-1}; MS (ESI) *m/e* (%) 420.1 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{28}NO_3S$ $[M + H]^+$ 398.1790, found 398.1790.

N-(((1S,2R*,6R*,7S*)-7-Ethyl-8-oxobicyclo[4.2.0]octan-2-yl)-methyl)-4-methylbenzenesulfonamide (**10b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give **10b** as a white solid (43.0 mg, 0.128 mmol, 98%): mp 103−104 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.77−7.71 (m, 2H), 7.32−7.25 (m, 2H), 5.91−5.82 (m, 1H), 3.27−3.02 (m, 3H), 3.00−2.86 (m, 1H), 2.56−2.38 (m, 1H), 2.41 (s, 3H), 1.99−1.76 (m, 2H), 1.74−1.48 (m, 3H), 1.46−1.32 (m, 1H), 1.20−1.07 (m, 1H), 1.07−0.84 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 210.8, 142.9, 137.2, 129.5, 126.9, 61.9, 56.6, 46.2, 35.7, 26.8, 26.3, 24.3, 22.8, 21.4, 17.0, 12.4; IR (CH_2Cl_2) 3284, 2932, 1753, 1452, 1328, 1158, 1095, 815, 666 cm^{-1}; MS (ESI) *m/e* (%) 358.2 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{18}H_{26}NO_3S$ $[M + H]^+$ 336.1633, found 336.1631.

N-(((1S,2R*,6R*,7S*)-7-Hexyl-8-oxobicyclo[4.2.0]octan-2-yl)-methyl)-4-methylbenzenesulfonamide (**10c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give **10c** as a white solid (56.0 mg, 0.143 mmol, 99%): mp 101−102 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 7.76−7.72 (m, 2H), 7.30−7.27 (m, 2H), 5.78−5.72 (m, 1H), 3.25−3.10 (m, 3H), 2.92 (dt, *J* = 4.3, 4.4, 12.9 Hz, 1H), 2.52−2.43 (m, 1H), 2.41 (s, 3H), 1.96−1.88 (m, 1H), 1.87−1.79 (m, 1H), 1.74−1.66 (m, 1H), 1.59−1.51 (m, 2H), 1.41−1.21 (m, 9H), 1.19−1.09 (m, 1H), 1.07−0.97 (m, 1H), 0.97−0.85 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.0, 143.0, 137.3, 129.6, 127.0, 60.4, 56.8, 46.3, 35.7, 31.6, 29.2, 28.0, 26.8, 26.6, 24.6, 23.6, 22.9, 22.5, 21.5, 14.0; IR (CH_2Cl_2) 3275, 2931, 2860, 1755, 1453, 1331, 1160, 1095, 666, 551 cm^{-1}; MS (ESI) *m/e* (%) 414.2 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{34}NO_3S$ $[M + H]^+$ 392.2259, found 392.2257.

4-Methyl-N-(((1S,2R*,6R*,7S*)-8-oxo-7-phenethylbicyclo[4.2.0]-octan-2-yl)methyl)benzenesulfonamide (**10d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give **10d** as a white solid (57.4 mg, 0.140 mmol, 99%): mp 146−147 °C; ^1H NMR (500 MHz, $CDCl_3$) δ 7.75−7.72 (m, 2H), 7.30−7.26 (m, 4H), 7.21−7.13 (m, 3H), 5.76−5.71 (m, 1H), 3.23−3.10 (m, 3H), 2.92 (dt, *J* = 10.3, 3.5 Hz, 1H), 2.71−2.57 (m, 2H), 2.47−2.38 (m, 1H), 2.41 (s, 3H), 1.96−1.78 (m, 3H), 1.73−1.65 (m, 2H), 1.58−1.52 (m, 1H), 1.13 (qt, *J* = 2.5, 12.9 Hz, 1H), 1.05−0.96 (m, 1H), 0.96−0.88 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 210.5, 143.0, 141.4, 137.2, 129.5, 128.4, 128.3, 127.0, 126.0, 59.3, 46.2, 35.7, 34.0, 26.8, 26.6, 25.4, 24.6, 22.9, 21.4; IR (CH_2Cl_2) 2931, 2859, 1756, 1451, 1328, 1160, 1095, 816, 667 cm^{-1}; MS (ESI) *m/e* (%) 434.3 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{30}NO_3S$ $[M + H]^+$ 412.1946, found 412.1948.

N-(((1S,2R*,6R*,7S*)-7-(3-Chloropropyl)-8-oxobicyclo[4.2.0]-octan-2-yl)methyl)-4-methylbenzenesulfonamide (**10e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give **10e** as a white solid (45.9 mg, 0.124 mmol, 94%): mp 77−78 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.76−7.72 (m, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 5.68−5.59 (m, 1H), 3.58−3.46 (m, 2H), 3.29−3.23 (m, 2H), 3.22−3.12 (m, 2H), 2.93 (dt, *J* = 13.0, 4.5 Hz, 1H), 2.56−2.44 (m, 1H), 2.42 (s, 3H), 1.99−1.66 (m, 6H), 1.64−1.53 (m, 1H), 1.22−1.09 (m, 1H), 1.07−0.86 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 209.9, 143.0, 137.3, 129.6, 127.0, 59.4, 56.9, 46.2, 44.6, 35.8, 31.0, 26.8, 26.6, 24.7, 22.8, 21.5, 21.3; IR (CH_2Cl_2) 3279, 2931, 2860, 2363, 1753, 1444, 1328, 1159, 1094, 937, 815, 667, 550 cm^{-1}; MS (ESI) *m/e* (%) 408.1 ($[M + 2 + Na]^+$, 38), 406.2 ($[M + Na]^+$, 100); HRMS (ESI) *m/e* calcd for $C_{19}H_{27}NO_3SCl$ $[M + H]^+$ 384.1400, found 384.1402.

Representative Experimental Procedure for the Synthesis of Six-Membered Ring 4-Enynamides 11a−m and 11o−p. To an ice cold suspension of cyclohex-3-ene-1-carbaldehyde (3.3045 g, 30.000 mmol) in 11 mL of THF was added dropwise via cannula a solution of $LiAlH_4$ in THF (30 mL). After the addition, the reaction flask was removed from the ice bath, warmed to room temperature and stirred for 3 h. The mixture was then cooled to 0 °C and 1.70 mL of H_2O was added dropwise over a period of 2 min followed by slow addition of 1.70 mL of 15% v/v aqueous NaOH, and 5.1 mL of H_2O. The resulting white suspension was stirred vigorously for 12 h. The mixture was filtered through a pad of Celite to give cyclohex-3-en-1-ylmethanol (3.6285 g, 30.000 mmol, 99%). To a flame-dried flask were added triphenylphosphine (3.1596 g, 12.000 mmol), diisopropyl azodicarboxylate (DIAD, 2.4 mL, 12.00 mmol), TsNH(Boc) (2.7133 g, 10.000 mmol), and THF (40.0 mL), at 0 °C. After 0.5 h, a solution of cyclohex-3-en-1-ylmethanol (1.1778 g, 10.500 mmol) in THF (10.0 mL) was added to the reaction mixture at 0 °C. The reaction was allowed to warm to room temperature and stirred for an additional 3 h. The crude mixture was purified via flash column chromatography over silica gel to give *tert*-butyl (cyclohex-3-en-1-ylmethyl) (tosyl)-carbamate as a white solid (2.7070 g, 7.4060 mmol, 74%). To a solution of *tert*-butyl(cyclohex-3-en-1-ylmethyl)(tosyl)carbamate (1.9458 g, 5.3240 mmol) in CH_2Cl_2 (53.0 mL) was added trifluoroacetic acid (TFA, 2.0 mL). The reaction mixture was stirred for 12 h at room temperature, then added saturated $NaHCO_{3(aq)}$ (it is important to keep the pH value of the aqueous layer above pH 10). The water layer was extracted with CH_2Cl_2 (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:10) to give *N*-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide as a white solid (1.9458 g, 7.3324 mmol, 99%).

*Example for the Synthesis of **11a**.* To a dry and nitrogen-flushed 2-neck-flask, equipped with a magnetic stirring bar and a septum, were charged with (bromoethynyl)benzene (0.5975 g, 3.301 mmol), toluene (3.0 mL), *N*-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide (0.7961 g, 3.000 mmol), and K_2CO_3 (0.8292 g, 6.000

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J. Org. Chem. 2017, 82, 481−501

mmol). The reaction mixture was stirred at room temperature for 5 min and then were added $CuSO_4 \cdot 5H_2O$ (0.0754 g, 0.302 mmol), and 1,10-phenanthroline (0.1081 g, 0.5999 mmol). The reaction was stirred at 70 °C until no trace of starting material can be detected on TLC. Upon cooling to room temperature, the reaction mixture was filtered and concentrated. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give *N*-(cyclohex-3-en-1-ylmethyl)-4-methyl-*N*-(phenylethynyl)-benzenesulfon- amide (**11a**). as a white solid (1.0091 g, 2.7610 mmol, 92%): mp 111−112 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84 (d, J = 8.3 Hz, 2H), 7.38−7.32 (m, 4H), 7.32−7.25 (m, 3H), 5.72−5.60 (m, 2H), 3.35−3.23 (m, 2H), 2.45 (s, 3H), 2.24−1.97 (m, 4H), 1.88−1.71 (m, 2H), 1.40−1.28 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.5, 134.5, 131.3, 129.7, 128.2, 127.7, 127.7, 127.0, 125.3, 122.9, 82.8, 70.4, 56.7, 32.5, 28.9, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 2919, 2234, 1598, 1441, 1364, 1168, 1090, 984, 755, 691, 654, 587 cm^{-1}; MS (ESI) m/e (%) 388.3 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{24}NO_2S$ [M + H]$^+$ 366.1528, found 366.1526.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-(o-tolylethynyl)-benzenesulfonamide (**11b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11b** as a white solid (1.0707 g, 2.8210 mmol, 94%): mp 69−70 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 8.3 Hz, 2H), 7.35 (d, J = 8.1 Hz, 2H), 7.32−7.29 (m, 1H), 7.19−7.15 (m, 2H), 7.15−7.07 (m, 1H), 5.73−5.60 (m, 2H), 3.37−3.26 (m, 2H), 2.45 (s, 3H), 2.36 (s, 3H), 2.25−1.98 (m, 4H), 1.89−1.72 (m, 2H), 1.43−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 139.6, 134.6, 131.3, 129.7, 129.4, 127.6, 127.0, 125.5, 125.3, 122.7, 86.5, 69.4, 56.7, 32.5, 28.9, 25.7, 24.2, 21.6, 20.7; IR (CH_2Cl_2) 3024, 2919, 2232, 1599, 1438, 1366, 1186, 1169, 1092, 991, 813, 756, 655, 588 cm^{-1}; MS (ESI) m/e (%) 402.3 ([M + Na]$^+$, 70); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1686.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-(p-tolylethynyl)-benzenesulfonamide (**11c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11c** as a colorless oil (0.7975 g, 2.101 mmol, 70%): mp 112−113 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.3 Hz, 2H), 7.35 (d, J = 8.2 Hz, 2H), 7.27−7.23 (m, 2H), 7.09 (d, J = 7.96 Hz, 2H), 5.72−5.60 (m, 2H), 3.33−3.23 (m, 2H), 2.45 (s, 3H), 2.34 (s, 3H), 2.23−1.97 (m, 4H), 1.87−1.71 (m, 2H), 1.40−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 137.9, 134.6, 131.4, 129.7, 129.0, 127.7, 127.0, 125.3, 119.7, 82.1, 70.3, 56.7, 32.5, 28.9, 25.7, 24.2, 21.6, 21.4; IR (CH_2Cl_2) 3026, 2920, 2235, 1451, 1364, 1168, 815, 661, 583 cm^{-1}; MS (ESI) m/e (%) 402.1 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1680.

*N-([1,1′-Biphenyl]-4-ylethynyl)-N-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide (**11d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11d** as a white solid (0.7962 g, 1.803 mmol, 60%): mp 119−120 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89−7.83 (m, 2H), 7.61−7.50 (m, 4H), 7.48−7.40 (m, 4H), 7.39−7.32 (m, 3H), 5.73−5.61 (m, 2H), 3.37−3.26 (m, 2H), 2.45 (s, 3H), 2.25−1.99 (m, 4H), 1.90−1.73 (m, 2H), 1.42−1.29 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 140.5, 140.3, 134.5, 131.7, 129.7, 128.8, 127.7, 127.5, 127.0, 126.9, 125.3, 121.8, 83.5, 70.3, 56.7, 32.5, 28.9, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 3032, 2919, 2234, 1364, 1168, 1115, 1090, 988, 763, 659, 586 cm^{-1}; MS (ESI) m/e (%) 464.1 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{28}H_{28}NO_2S$ [M + H]$^+$ 442.1841, found 442.1841.

*N-(Cyclohex-3-en-1-ylmethyl)-N-((3-methoxyphenyl)ethynyl)-4-methylbenzenesulfonamide (**11e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11e** as a white solid (0.8275 g, 2.092 mmol, 70%): mp 53−54 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.80 (m, 2H), 7.39−7.32 (m, 2H), 7.23−7.16 (m, 1H), 6.98−6.92 (m, 1H), 6.90−6.86 (m, 1H), 6.85−6.80 (m, 1H), 5.73−5.59 (m, 2H), 3.79 (s, 3H), 3.36−3.23 (m, 2H), 2.44 (s, 3H), 2.24−1.97 (m, 4H), 1.88−1.70 (m, 2H), 1.41−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3, 144.6, 134.5, 129.7, 129.3, 127.7, 127.0, 125.3, 123.9, 123.8, 116.3, 114.1, 82.7, 70.4, 56.7, 55.3, 32.5, 28.9, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 3024, 2921, 2838, 2237, 1599, 1583, 1452, 1431, 1365, 1168, 1108, 1090, 1045, 850, 655, 587, 547 cm^{-1}; MS (ESI) m/e (%) 396.1 ([M + H]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1631.

*N-(Cyclohex-3-en-1-ylmethyl)-N-((4-methoxyphenyl)ethynyl)-4-methylbenzenesulfonamide (**11f**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11f** as a white solid (0.7484 g, 1.892 mmol, 63%): mp 91−92 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.3 Hz, 2H), 7.35 (d, J = 8.1 Hz, 2H), 7.32−7.28 (m, 2H), 6.85−6.79 (m, 2H), 5.71−5.60 (m, 2H), 3.80 (s, 3H), 3.32−3.22 (m, 2H), 2.45 (s, 3H), 2.24−1.97 (m, 4H), 1.87−1.70 (m, 2H), 1.40−1.27 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.4, 144.4, 134.5, 133.3, 129.7, 127.7, 127.0, 125.3, 114.8, 113.9, 81.3, 70.0, 56.8, 55.3, 32.4, 28.9, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 3023, 2920, 2838, 2237, 1606, 1364, 1249, 1169, 813, 663, 585 cm^{-1}; MS (ESI) m/e (%) 396.4 ([M + H]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1629.

*N-(Cyclohex-3-en-1-ylmethyl)-N-((4-fluorophenyl)ethynyl)-4-methylbenzenesulfonamide (**11g**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11g** as a white solid (0.7472 g, 1.948 mmol, 65%): mp 114−115 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.80 (m, 2H), 7.39−7.30 (m, 4H), 7.02−6.95 (m, 2H), 5.73−5.61 (m, 2H), 3.34−3.23 (m, 2H), 2.46 (s, 3H), 2.23−1.98 (m, 4H), 1.87−1.71 (m, 2H), 1.40−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2 ($^1J_{C-F}$ = 247.4 Hz, d), 144.6, 134.5, 133.4 ($^3J_{C-F}$ = 8.3 Hz, d), 129.7, 127.7, 127.0, 125.3, 118.9, 115.5 ($^2J_{C-F}$ = 21.9 Hz, d), 82.4, 69.3, 56.7, 32.5, 28.9, 25.7, 24.2, 21.6; ^{19}F NMR (375 MHz, $CDCl_3$) δ −111.6; IR (CH_2Cl_2) 3025, 2919, 2839, 2238, 1599, 1509, 1365, 1230, 1169, 1091, 835, 662, 583 cm^{-1}; MS (EI, 40 *eV*) m/e (%) 383.1 ([M]$^+$, 10), 228.1 (50), 123.0 (100); HRMS (ESI) m/e calcd for $C_{22}H_{23}NO_2FS$ [M + H]$^+$ 384.1434, found 384.1429.

*N-((4-Chlorophenyl)ethynyl)-N-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide (**11h**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11h** as a white solid (0.8406 g, 2.102 mmol, 70%): mp 114−115 °C: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84−7.80 (m, 2H), 7.38−7.34 (m, 2H), 7.29−7.24 (m, 4H), 5.73−5.60 (m, 2H), 3.34−3.23 (m, 2H), 2.46 (s, 3H), 2.23−1.98 (m, 4H), 1.87−1.70 (m, 2H), 1.40−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 134.5, 133.7, 132.5, 129.8, 128.6, 127.7, 127.1, 125.3, 121.4, 83.7, 69.5, 56.7, 32.5, 28.8, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 3023, 2918, 2238, 1640, 1366, 1169, 1090, 814, 719, 658, 573 cm^{-1}; MS (ESI) m/e (%) 400.4 ([M + H]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{23}NO_2SCl$ [M + H]$^+$ 400.1138, found 400.1143.

*Methyl 3-((N-(cyclohex-3-en-1-ylmethyl)-4-methylphenylsulfonamido)ethynyl)benzoate (**11i**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11i** as a white solid (0.7616 g, 1.798 mmol, 60%): mp 54−55 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02−7.99 (m, 1H), 7.96−7.91 (m, 1H), 7.87−7.82 (m, 2H), 7.55−7.50 (m, 1H), 7.40−7.34 (m, 3H), 5.73−5.60 (m, 2H), 3.92 (s, 3H), 3.36−3.26 (m, 2H), 2.46 (s, 3H), 2.24−1.99 (m, 4H), 1.88−1.72 (m, 2H), 1.43−1.29 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.4, 144.7, 135.3, 134.5, 132.2, 130.3, 129.8, 128.6, 128.4, 127.7, 127.0, 125.2, 123.4, 83.7, 69.7, 56.7, 52.2, 32.5, 28.8, 25.6, 24.2, 21.6; IR (CH_2Cl_2) 3025, 2920, 2840, 2236, 1725, 1598, 1439, 1365, 1283, 1259, 1169, 1092, 991, 754, 657, 587 cm^{-1}; MS (EI, 40 *eV*) m/e (%) 423.2 ([M]$^+$, 20), 268.1 (70), 163.0 (100); HRMS (ESI) m/e calcd for $C_{24}H_{26}NO_4S$ [M + H]$^+$ 424.1583, found 424.1580.

*Methyl 4-((N-(cyclohex-3-en-1-ylmethyl)-4-methylphenylsulfonamido)ethynyl)benzoate (**11j**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11j** as a white solid (0.6357 g, 1.501 mmol, 50%): mp 129−130 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98−7.93 (m, 2H), 7.86−7.82 (m, 2H), 7.41−7.34 (m, 4H), 5.73−5.61 (m, 2H), 3.91 (s, 3H), 3.38−3.27 (m, 2H), 2.45 (s, 3H), 2.24−1.99 (m, 4H), 1.88−1.72 (m, 2H), 1.41−1.29 (m, 1H): ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.5, 144.8, 134.4, 130.5, 129.8, 129.4, 128.7, 127.9, 127.6, 127.0, 125.2, 86.1, 70.5, 56.6, 52.1, 32.5, 28.8, 25.6, 24.2, 21.6; IR (CH_2Cl_2) 3024, 2920, 2840, 2231, 1721, 1605, 1436, 1368, 1275, 1259, 1170, 1118, 990, 768, 657, 590 cm^{-1}; MS (EI, 40 *eV*) m/e (%)

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423.2 ([M]$^+$, 20), 268.1 (50), 163.0 (100); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_4S$ [M + H]$^+$ 424.1583, found 424.1577.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-((4-(trifluoromethyl)-phenyl)ethynyl)benzenesulfonamide (**11k**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11k** as a white solid (1.1440 g, 2.639 mmol, 88%): mp 87−88 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.3 Hz, 2H), 7.54 (d, J = 8.2 Hz, 2H), 7.43 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 5.73−5.60 (m, 2H), 3.38−3.26 (m, 2H), 2.45 (s, 3H), 2.24−1.98 (m, 4H), 1.88−1.71 (m, 2H), 1.41−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 134.5, 130.9, 129.2 ($^2J_{C-F}$ = 32.4 Hz, q), 127.6, 127.1, 126.9, 125.2, 124.0 ($^1J_{C-F}$ = 270.3 Hz, q), 85.5, 69.8, 56.6, 32.6, 28.8, 25.7, 24.2, 21.6, 24.2, 21.6; ^{19}F NMR (375 MHz, $CDCl_3$) δ −63.7; IR (CH_2Cl_2) 3027, 2921, 2841, 2235, 1615, 1368, 1323, 1169, 1125, 1107, 991, 841, 657, 590 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 433.1 ([M]$^+$, 30), 278.1 (100), 173.0 (70); HRMS (ESI) *m/e* calcd for $C_{23}H_{23}NO_2F_3S$ [M + H]$^+$ 434.1402, found 434.1398.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-((4-nitrophenyl)-ethynyl)benzenesulfonamide (**11l**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11l** as a yellow solid (0.9232 g, 2.249 mmol, 75%): mp 92−93 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, J = 8.7 Hz, 2H), 7.84 (d, J = 8.2 Hz, 2H), 7.44 (d, J = 8.7 Hz, 2H), 7.38 (d, J = 8.1 Hz, 2H), 5.74−5.61 (m, 2H), 3.40−3.29 (m, 2H), 2.46 (s, 3H), 2.24−1.99 (m, 4H), 1.88−1.72 (m, 2H), 1.41−1.29 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 145.1, 134.4, 130.8, 130.3, 129.9, 127.6, 127.0, 125.1, 123.6, 88.8, 70.3, 56.6, 32.6, 28.8, 25.6, 24.1, 21.7; IR (CH_2Cl_2) 3026, 2919, 2839, 2228, 1595, 1517, 1368, 1341, 1171, 1105, 852, 657 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 410.1 ([M]$^+$, 20), 255.1 (100), 150.0 (60); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}N_2O_4S$ [M + H]$^+$ 411.1379, found 411.1376.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-(thiophen-3-ylethynyl)benzenesulfonamide (**11m**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11m** as a white solid (0.6015 g, 1.619 mmol, 54%): mp 101−102 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.80 (m, 2H), 7.38−7.33 (m, 3H), 7.28−7.23 (m, 1H), 7.07−7.03 (m, 1H), 5.72−5.60 (m, 2H), 3.33−3.22 (m, 2H), 2.46 (s, 3H), 2.23−1.97 (m, 4H), 1.87−1.69 (m, 2H), 1.40−1.26 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 134.5, 130.2, 129.7, 128.6, 127.7, 127.0, 125.3, 125.1, 121.6, 82.1, 65.4, 56.7, 32.4, 28.8, 25.7, 24.2, 21.6; IR (CH_2Cl_2) 3110, 3025, 2919, 2839, 2238, 1598, 1436, 1421, 1362, 1306, 1186, 1167, 1106, 1091, 999, 907, 856, 814, 782, 737, 658, 585, 548 cm^{-1}; MS (EI, 40 *eV*) *m/e* (%) 371.1 ([M]$^+$, 10), 232.1 (60), 216.1 (70); HRMS (ESI) *m/e* calcd for $C_{20}H_{22}NO_2S_2$ [M + H]$^+$ 372.1092, found 372.1088.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-(4-phenylbut-1-yn-1-yl)benzenesulfonamide (**11o**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11o** as a white solid (0.8735 g, 2.219 mmol, 74%): mp =79−80 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72−7.68 (m, 2H), 7.32−7.24 (m, 4H), 7.22−7.15 (m, 3H), 5.71−5.58 (m, 2H), 3.14−3.03 (m, 2H), 2.79 (t, J = 7.3 Hz, 2H), 2.57 (t, J = 7.3 Hz, 2H), 2.44 (s, 3H), 2.13−1.84 (m, 4H), 1.77−1.61 (m, 2H), 1.30−1.19 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 140.5, 134.6, 129.6, 128.5, 128.3, 127.6, 127.0, 126.2, 125.4, 74.2, 69.1, 56.5, 35.2, 32.1, 28.8, 25.6, 24.2, 21.6, 20.5; IR (CH_2Cl_2) 3026, 2920, 2253, 1688, 1454, 1363, 1167, 812, 699, 655, 585 cm−^{1}; MS (ESI) *m/e* (%) 416.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{28}NO_2S$ [M + H]$^+$ 394.1841, found 394.1839.

*N-(Cyclohex-3-en-1-ylmethyl)-4-methyl-N-(oct-1-yn-1-yl)-benzenesulfonamide (**11p**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11p** as a white solid (1.0654 g, 2.852 mmol, 95%): mp 53−54 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.75 (m, 2H), 7.35−7.30 (m, 2H), 5.71−5.60 (m, 2H), 3.19−3.09 (m, 2H), 2.45 (s, 3H), 2.24 (t, J = 7.0 Hz, 2H), 2.19−1.96 (m, 4H), 1.83−1.66 (m, 2H), 1.50−1.41 (m, 2H), 1.38−1.21 (m, 7H), 0.88 (t, J = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 134.6, 129.5, 127.6, 127.0, 125.4, 73.5, 70.0, 56.6, 32.3, 31.3, 28.9, 28.4, 25.7, 24.3, 22.6, 21.6, 18.5, 14.0; IR (CH_2Cl_2) 3025, 2922, 2860, 2255, 1598, 1509, 1450, 1366, 1168, 1092, 813, 656, 585 cm^{-1}; MS (ESI) *m/e* (%) 374.1 ([M + H]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{32}NO_2S$ [M + H]$^+$ 374.2154, found 374.2150.

*Synthesis of N-(Cyclohex-3-en-1-ylmethyl)-N-ethynyl-4-methyl-benzenesulfonamide (**11q**).* A solution of *N*-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide (2.6537 g, 10.000 mmol) in THF (60.0 mL) at 0 °C was treated with *n*-BuLi (6.9 mL, 1.6 M in hexanes). After 5 min, a solution of formylbenzotriazole (1.7656 g, 12.000 mmol) in THF (10.0 mL) was added and the mixture stirred for 2 h at room temperature. The crude mixture was diluted with EtOAC (50.0 mL), washed with a saturated aqueous solution of $NaHCO_3$. The water layer was extracted with EtOAC (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:15) to give *N*-(cyclohex-3-en-1-ylmethyl)-*N*-tosylformamide as a white solid (1.672 g, 5.699 mmol, 57%). *N*-(cyclohex-3-en-1-ylmethyl)-*N*-tosylformamide (1.4500 g, 4.942 mmol) and PPh_3 (3.8887 g, 14.826 mmol) were dissolved in THF (49.0 mL). CCl_4 (4.8 mL) was added via syringe over a period of 6 h at 70 °C. After stirring for an additional hour, the mixture was diluted with EtOAc (30.0 mL). The water layer was extracted with EtOAc (100.0 mL × 3) and $NaCl_{(aq)}$ (100.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:15) to give *N*-(cyclohex-3-en-1-ylmethyl)-*N*-(2,2-dichlorovinyl)-4-methylbenzenesulfonamide as a white solid (1.6550 g, 4.5934 mmol, 93%). A solution of the white solid (0.7206 g, 2.000 mmol) in THF (10 mL) was cooled to −78 °C and treated with *n*-BuLi (2.8 mL, 1.6 M in hexanes). The mixture was slowly warmed to −30 °C over 1 h and then methanol (0.40 mL) was added. The mixture was slowly warmed to room temperature over 2 h. The crude mixture was diluted with EtOAc (10.0 mL), washed with a saturated aqueous solution of $NaHCO_3$. The water layer was extracted with EtOAc (50.0 mL × 3) and washed with $NaCl_{(aq)}$ (50.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11q** as a white solid (0.5987 g, 2.069 mmol, 69%): mp 107−108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, J = 8.2 Hz, 2H), 7.35 (d, J = 8.1 Hz, 2H), 5.72−5.58 (m, 2H), 3.25−3.14 (m, 2H), 2.72 (s, 1H), 2.45 (s, 3H), 2.20−1.96 (m, 4H), 1.83−1.66 (m, 2H), 1.36−1.23 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 134.4, 129.7, 127.5, 126.9, 125.2, 58.8, 56.2, 32.2, 28.7, 25.5, 24.1, 21.6; IR (CH_2Cl_2) 3283, 3023, 2922, 2132, 1362, 1169, 1091, 986, 736, 719, 658, 589, 547 cm^{-1}; MS (ESI) *m/e* (%) 290.5 ([M + H]$^+$, 50); HRMS (ESI) *m/e* calcd for $C_{16}H_{20}NO_2S$ [M + H]$^+$ 290.1215, found 290.1213.

*Synthesis of N-(But-1-yn-1-yl)-N-(cyclohex-3-en-1-ylmethyl)-4-methylbenzenesulfonamide (**11n**).* A solution of *N*-(cyclohex-3-en-1-ylmethyl)-*N*-(2,2-dichlorovinyl)-4-methyl- benzenesulfonamide (0.7206 g, 2.000 mmol) in THF (10 mL) was cooled to −78 °C and treated with *n*-BuLi (2.8 mL, 1.6 M in hexanes). The mixture was slowly warmed to −30 °C over 1 h and then ethyl iodide (0.40 mL) was added. The mixture was slowly warmed to room temperature over 2 h. The crude mixture was diluted with EtOAc (10.0 mL), washed with a saturated aqueous solution of $NaHCO_3$. The water layer was extracted with EtOAc (50.0 mL × 3) and washed with $NaCl_{(aq)}$ (50.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **11n** as a yellow solid (0.4571 g, 1.440 mmol, 72%): mp 49−50 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, J = 8.3 Hz, 2H), 7.33 (d, J = 8.2 Hz, 2H), 5.71−5.59 (m, 2H), 3.19−3.08 (m, 2H), 2.44 (s, 3H), 2.26 (q, J = 7.5 Hz, 2H), 2.18−1.97 (m, 4H), 1.83−1.66 (m, 2H), 1.35−1.23 (m, 1H), 1.11 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 134.6, 129.5, 127.6, 127.0, 125.4, 73.0, 71.2, 56.5, 32.3, 28.9, 25.7, 24.2, 21.6, 14.2, 12.2; IR (CH_2Cl_2) 2918, 2253, 1598, 1361, 1168, 1030, 814, 657, 586, 546 cm−^{1}; MS (ESI) *m/e* (%) 340.5

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([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{18}H_{24}NO_2S$ [M + H]$^+$ 318.1528, found 318.1528.

General Experimental Procedure for the Cyclization of Six-Membered Ring 4-Enynamides 11 to Azatricyclic Compounds 12. *Example for the Synthesis of* ***12a.*** A solution of $AgBF_4$ (8.7 mg, 0.0446 mmol) in CH_2Cl_2 (3.0 mL) in an oven-dried 2-neck-flask equipped with a stirrer bar and capped with a rubber septum at room temperature was evacuated (oil pump) and filled with nitrogen three times. To the solution at 40 °C were then added sequentially [AuCl(PPh_3)] (14.9 mg, 0.0301 mmol) and *N*-(cyclohex-3-en-1-ylmethyl)-4-methyl-*N*-(phenylethynyl)benzenesulfonamide **11a** (109.6 mg, 0.2999 mmol) under nitrogen. After **11a** had been consumed (monitored by TLC, 10 min), the resulting solution was filtered through a bed of Celite. The filtrate was concentrated in vacuo to give the crude mixture. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give (1*S**,6*R**,8*R**)-2-phenyl-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]dec-2-ene (**12a**) as a white solid (85.9 mg, 0.235 mmol, 78%): mp 202−203 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89−7.84 (m, 2H), 7.72−7.68 (m, 2H), 7.40−7.28 (m, 5H), 3.75−3.67 (m, 2H), 3.05−3.02 (m, 1H), 2.93−2.90 (m, 1H), 2.45 (s, 3H), 2.10−1.97 (m, 2H), 1.84−1.77 (m, 1H), 1.70−1.64 (m, 1H), 1.62−1.54 (m, 1H), 1.36−1.27 (m, 1H) 0.67−0.61 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.2, 143.6, 136.0, 134.8, 132.6, 129.6, 128.6, 128.6, 127.8, 126.5, 62.5, 42.3, 36.1, 27.1, 26.2, 24.1, 23.6, 21.6; IR (CH_2Cl_2) 2931, 1599, 1447, 1343, 1161, 1092, 676, 599 cm^{-1}; MS (ESI) m/e (%) 388.1 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{24}NO_2S$ [M + H]$^+$ 366.1528, found 366.1531. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(1S,6R*,8R*)-2-(o-Tolyl)-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]dec-2-ene (**12b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12b** as a white solid (55.8 mg, 0.147 mmol, 49%): mp 175−176 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19−8.12 (m, 1H), 7.88−7.82 (m, 2H), 7.35−7.29 (m, 2H), 7.24−7.16 (m, 2H), 7.15−7.10 (m, 1H), 3.87−3.75 (m, 2H), 3.14−3.10 (m, 1H), 2.98−2.94 (m, 1H), 2.46 (s, 6H), 2.06−1.96 (m, 1H), 1.88−1.74 (m, 2H), 1.67−1.55 (m, 2H), 1.41−1.30 (m, 1H), 0.72−0.64 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.8, 143.6, 136.6, 136.2, 135.7, 132.0, 130.9, 129.5, 128.5, 128.1, 127.8, 126.1, 62.4, 42.1, 38.7, 26.7, 26.0, 24.3, 24.1, 21.6, 21.1. IR (CH_2Cl_2) 2930, 2868, 1650, 1458, 1344, 1160, 679, 603 cm^{-1}; MS (ESI) m/e (%) 402.1 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1681.

(1S,6R*,8R*)-2-(p-Tolyl)-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]dec-2-ene (**12c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12c** as a white solid (83.5 mg, 0.220 mmol, 73%): mp 184−185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, J = 8.2 Hz, 2H), 7.60 (d, J = 8.1 Hz, 2H), 7.33 (d, J = 8.1 Hz, 2H), 7.18 (d, J = 8.0 Hz, 2H), 3.74−3.65 (m, 2H), 3.02−2.98 (m, 1H), 2.92−2.88 (m, 1H), 2.45 (s, 3H), 2.36 (s, 3H), 2.09−1.94 (m, 2H), 1.83−1.75 (m, 1H), 1.69−1.62 (m, 1H), 1.61−1.52 (m, 1H), 1.35−1.24 (m, 1H), 0.65−0.57 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.2, 143.5, 138.6, 136.0, 133.4, 130.0, 129.5, 129.2, 127.8, 126.4, 62.5, 42.2, 36.0, 27.1, 26.1, 24.0, 23.6, 21.6, 21.5; IR (CH_2Cl_2) 2930, 1598, 1449, 1344, 1160, 819, 678, 598 cm^{-1}; MS (ESI) m/e (%) 402.5 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_2S$ [M + H]$^+$ 380.1684, found 380.1686. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(1S,6R*,8R*)-2-([1,1′-Biphenyl]-4-yl)-4-tosyl-4-azatricyclo-[4.2.2.0^{3,8}]dec-2-ene (**12d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12d** as a white solid (90.1 mg, 0.204 mmol, 68%): mp 184−185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90−7.85 (m, 2H), 7.81−7.76 (m, 2H), 7.64−7.59 (m, 4H), 7.48−7.41 (m, 2H), 7.38−7.31 (m, 3H), 3.79−3.67 (m, 2H), 3.09−3.03 (m, 1H), 2.98−2.91 (m, 1H), 2.45 (s, 3H), 2.13−1.99 (m, 2H), 1.86−1.77 (m, 1H), 1.72−1.55 (m, 2H), 1.41−1.29 (m, 1H), 0.69−0.59 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.8, 143.6, 141.1, 140.7, 136.0, 134.9, 131.5, 129.5, 128.8, 127.8, 127.4, 127.2, 127.0, 126.9, 62.5, 42.5, 36.1, 27.1, 26.2, 24.2, 23.6, 21.6; IR (CH_2Cl_2) 3033, 2927, 1486, 1342, 1161, 1005, 767, 678, 600 cm^{-1}; MS (ESI) m/e (%) 464.2 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{28}H_{28}NO_2S$ [M + H]$^+$ 442.1841, found 442.1839.

(1S,6R*,8R*)-2-(3-Methoxyphenyl)-4-tosyl-4-azatricyclo-[4.2.2.03,8]dec-2-ene (**12e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12e** as a white solid (53.8 mg, 0.136 mmol, 45%): mp 182−183 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88−7.82 (m, 2H), 7.45−7.41 (m, 1H), 7.36−7.30 (m, 2H), 7.30−7.24 (m, 1H), 7.22−7.18 (m, 1H), 6.90−6.84 (m, 1H), 3.86 (s, 3H), 3.75−3.64 (m, 2H), 3.03−2.99 (m, 1H), 2.92−2.87 (m, 1H), 2.45 (s, 3H), 2.11−1.97 (m, 2H), 1.85−1.77 (m, 1H), 1.71−1.54 (m, 2H), 1.38−1.25 (m, 1H), 0.68−0.59 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 151.2, 143.6, 136.0, 135.1, 133.8, 129.5, 129.4, 127.6, 118.7, 115.1, 111.0, 62.5, 55.3, 42.4, 36.2, 27.2, 26.2, 24.1, 23.5, 21.5; IR (CH_2Cl_2) 2930, 2358, 1597, 1458, 1341, 1160, 1044, 877, 782, 681, 542 cm^{-1}; MS (ESI) m/e (%) 418.1 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1633.

(1S,6R*,8R*)-2-(4-Methoxyphenyl)-4-tosyl-4-azatricyclo-[4.2.2.03,8]dec-2-ene (**12f**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12f** as a white solid (64.1 mg, 0.162 mmol, 54%): mp 177−178 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89−7.84 (m, 2H), 7.69−7.64 (m, 2H), 7.35−7.30 (m, 2H), 6.93−6.89 (m, 2H), 3.83 (s, 3H), 3.76−3.63 (m, 2H), 3.02−2.97 (m, 1H), 2.92−2.86 (m, 1H), 2.45 (s, 3H), 2.09−1.92 (m, 2H), 1.83−1.74 (m, 1H), 1.69−1.51 (m, 2H), 1.36−1.24 (m, 1H), 0.64−0.56 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8, 150.7, 143.5, 135.9, 131.6, 129.5, 127.9, 127.7, 125.8, 113.9, 62.3, 55.2, 42.0, 35.9, 27.0, 26.0, 23.9, 23.5, 21.5; IR (CH_2Cl_2) 2927, 1599, 1342, 1247, 1161, 1090, 1032, 813, 679, 556 cm^{-1}; MS (ESI) m/e (%) 418.5 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{23}H_{26}NO_3S$ [M + H]$^+$ 396.1633, found 396.1636.

(1S,6R*,8R*)-2-(4-Fluorophenyl)-4-tosyl-4-azatricyclo-[4.2.2.0^{3,8}]dec-2-ene (**12g**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12g** as a white solid (74.0 mg, 0.193 mmol, 64%): mp 114−115 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88−7.83 (m, 2H), 7.74−7.68 (m, 2H), 7.36−7.31 (m, 2H), 7.10−7.02 (m, 2H), 3.75−3.63 (m, 2H), 3.03−2.97 (m, 1H), 2.93−2.87 (m, 1H), 2.45 (s, 3H), 2.11−1.92 (m, 2H), 1.85−1.77 (m, 1H), 1.70−1.54 (m, 2H), 1.32−1.21 (m, 1H), 0.64−0.55 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7 ($^1J_{C-F}$ = 247.3 Hz, d), 150.0, 143.7, 135.8, 134.1, 129.5, 129.0 ($^4J_{C-F}$ = 3.1 Hz, d), 128.3 ($^3J_{C-F}$ = 8.1 Hz, d), 115.6 ($^2J_{C-F}$ = 21.5 Hz, d), 62.4, 42.3, 36.1, 27.0, 26.1, 24.0, 23.4, 21.5; ^{19}F NMR (375 MHz, $CDCl_3$) δ −111.5; IR (CH_2Cl_2) 2930, 1650, 1507, 1343, 1225, 1161, 1092, 842, 678, 596 cm^{-1}; MS (ESI) m/e (%) 406.0 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{23}NO_2FS$ [M + H]$^+$ 384.1434, found 384.1433.

(1S,6R*,8R*)-2-(4-Chlorophenyl)-4-tosyl-4-azatricyclo-[4.2.2.0^{3,8}]dec-2-ene (**12h**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12h** as a white solid (71.6 mg, 0.179 mmol, 60%): mp 172−173 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88−7.82 (m, 2H), 7.68−7.62 (m, 2H), 7.37−7.31 (m, 4H), 3.75−3.64 (m, 2H), 3.04−2.98 (m, 1H), 2.94−2.88 (m, 1H), 2.45 (s, 3H), 2.11−1.92 (m, 2H), 1.86−1.76 (m, 1H), 1.70−1.54 (m, 2H), 1.31−1.19 (m, 1H), 0.66−0.57 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.9, 143.8, 135.8, 135.6, 134.2, 131.0, 129.6, 128.8, 127.7, 127.7, 62.5, 42.5, 36.1, 27.0, 26.1, 24.1, 23.5, 21.6; IR (CH_2Cl_2) 2925, 1662, 1458, 1342, 1161, 1091, 837, 677, 600 cm^{-1}; MS (ESI) m/e (%) 422.4 ([M + Na]$^+$, 100); HRMS (ESI) m/e calcd for $C_{22}H_{23}NO_2SCl$ [M + H]$^+$ 400.1138, found 400.1138.

Methyl 3-((1S,6R*,8R*)-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]dec-2-en-2-yl)benzoate (**12i**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12i** as a white solid (68.6 mg, 0.162 mmol, 54%): mp 174−175 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (d, J = 7.8 Hz, 1H), 8.06 (s, 1H), 7.98 (d, J = 7.8 Hz, 1H), 7.87 (d, J = 8.2 Hz, 2H), 7.51−7.46 (m, 1H), 7.34 (d, J = 8.1 Hz, 2H), 3.93 (s, 3H), 3.74−3.67 (m, 2H), 3.11−3.06 (m, 1H), 2.98−2.93 (m, 1H), 2.46 (s, 3H), 2.14−2.00 (m, 2H), 1.87−1.79 (m, 1H), 1.74−1.55 (m, 2H), 1.32−1.20 (m, 1H) 0.72−0.63 (m, 1H); ^{13}C

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J. Org. Chem. 2017, 82, 481−501

NMR (100 MHz, $CDCl_3$) δ 166.9, 150.1, 143.7, 136.4, 135.9, 132.8, 131.3, 130.4, 129.6, 129.5, 128.9, 127.8, 126.8, 62.6, 52.2, 42.5, 36.2, 27.1, 26.2, 24.2, 23.5, 21.6; IR (CH_2Cl_2) 2933, 2865, 1723, 1439, 1345, 1276, 1262, 1161, 1090, 677, 602 cm^{-1}; MS (ESI) *m/e* (%) 446.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{25}NO_4NaS$ [M + Na]$^+$ 446.1402, found 446.1399.

Methyl 4-((1S,6R*,8R*)-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]dec-2-en-2-yl)benzoate (**12j**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12j** as a white solid (58.6 mg, 0.138 mmol, 46%): mp 199−200 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07−8.02 (m, 2H), 7.89−7.84 (m, 2H), 7.78−7.73 (m, 2H), 7.38−7.33 (m, 2H), 3.92 (s, 3H), 3.74−3.68 (m, 2H), 3.11−3.04 (m, 1H), 2.99−2.93 (m, 1H), 2.46 (s, 3H), 2.13−1.98 (m, 2H), 1.88−1.79 (m, 1H), 1.73−1.66 (m, 1H), 1.66−1.56 (m, 1H), 1.31−1.20 (m, 1H), 0.71−0.63 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.8, 150.2, 143.8, 138.4, 136.4, 135.7, 129.9, 129.6, 127.7, 126.2, 62.7, 52.1, 42.8, 36.2, 27.1, 26.2, 24.2, 23.5, 21.6; IR (CH_2Cl_2) 2923, 1719, 1606, 1436, 1344, 1279, 1161, 1106, 1092, 676, 600 cm^{-1}; MS (ESI) *m/e* (%) 446.5 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_4S$ [M + H]$^+$ 424.1583, found 424.1579. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(1S,6R*,8R*)-2-(Thiophen-3-yl)-4-tosyl-4-azatricyclo[4.2.2.0^{3,8}]-dec-2-ene (**12m**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:20) to give **12m** as a yellow solid (59.1 mg, 0.159 mmol, 53%): mp 206−207 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87−7.82 (m, 2H), 7.58−7.55 (m, 1H), 7.52−7.49 (m, 1H), 7.35−7.29 (m, 3H), 3.75−3.69 (m, 1H), 3.67−3.60 (m, 1H), 2.98−2.89 (m, 2H), 2.45 (s, 3H), 2.10−1.91 (m, 2H), 1.85−1.77 (m, 1H), 1.71−1.53 (m, 2H), 1.37−1.26 (m, 1H), 0.70−0.62 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.0, 143.5, 136.0, 134.6, 132.2, 129.5, 127.6, 126.3, 125.8, 123.4, 62.3, 42.6, 36.6, 27.1, 26.2, 24.2, 23.4, 21.6; IR (CH_2Cl_2) 3099, 2928, 1598, 1445, 1342, 1160, 1091, 1000, 789, 667, 585, 548 cm^{-1}; MS (ESI) *m/e* (%) 394.5 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{20}H_{22}NO_2S_2$ [M + H]$^+$ 372.1092, found 372.1092.

General Experimental Procedure for Oxidation of 4-Azatricyclo[4.2.2.0^{3,8}]dec-2-ene Derivatives 12 to Bicyclic δ-Lactams 13. *Example for the Synthesis of **13a**.* To a solution of crude mixture **12a** (vide supra) in acetone (3 mL) and H_2O (0.3 mL) were added NMO (140.6 mg, 0.300 mmol, 50% w/w in H_2O) and OsO_4 (0.05 equiv, 2.5 wt %, in *t*-BuOH). The reaction mixture was stirred for 24 h at room temperature. The solvent was removed under reduced pressure. The crude mixture was added EtOAc (10.0 mL). The resulting solution was filtered through a bed of Celite/silica gel (1:1 wt.). The filtrate was concentrated in vacuo to give the crude mixture. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give (1*R**,5*R**,8*S**)-8-benzoyl-3-tosyl-3-azabicyclo[3.3.1]nonan-2-one (**13a**) as a white solid (71.6 mg, 0.180 mmol, 60%): mp 203−204 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91−7.88 (m, 2H), 7.80−7.77 (m, 2H), 7.51−7.47 (m, 1H), 7.43−7.38 (m, 2H), 7.33−7.30 (m, 2H), 3.98−3.90 (m, 2H), 3.44−3.38 (m, 1H), 3.02−2.97 (m, 1H), 2.44−2.41 (m, 1H), 2.44 (s, 3H), 2.09−1.94 (m, 3H), 1.89−1.75 (m, 2H), 1.73−1.67 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.0, 169.3, 144.8, 136.3, 136.0, 132.6, 129.3, 128.6, 128.6, 128.0, 52.4, 47.8, 43.1, 31.2, 29.3, 26.7, 21.7, 20.6; IR (CH_2Cl_2) 3058, 2927, 2869, 1693, 1598, 1448, 1360, 1272, 1169, 1140, 1090, 731, 706, 696, 565, 548 cm^{-1}; MS (ESI) *m/e* (%) 420.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{24}NO_4S$ [M + H]$^+$ 398.1426, found 398.1422. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(1R,5R*,8S*)-8-(2-Methylbenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13b**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13b** as a white solid (56.0 mg, 0.136 mmol, 45%): mp 165−166 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93−7.88 (m, 2H), 7.46−7.41 (m, 1H), 7.36−7.27 (m, 3H), 7.24−7.19 (m, 1H), 7.19−7.13 (m, 1H), 3.98−3.87 (m, 2H), 3.21 (dt, *J* = 12.2, 3.6 Hz, 1H), 2.97−2.91 (m, 1H), 2.45 (s, 3H), 2.43−2.37 (m, 1H), 2.34 (s, 3H), 2.09−1.95 (m, 2H), 1.89−1.82 (m, 1H), 1.81−1.69 (m, 2H), 1.64−1.51 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 202.8, 169.6, 144.8, 139.2, 137.1, 135.9, 132.2, 130.7, 129.2, 128.8, 126.9, 125.1, 52.2, 49.8, 42.2, 31.3, 29.3, 26.6, 21.7, 20.5, 20.3; IR (CH_2Cl_2) 2933, 1686, 1458, 1360, 1272, 1169, 1141, 1089, 686, 555 cm^{-1}; MS (ESI) *m/e* (%) 434.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_4NaS$ [M + Na]$^+$ 434.1402, found 434.1405.

(1R,5R*,8S*)-8-(4-Methylbenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13c**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13c** as a yellow solid (86.8 mg, 0.211 mmol, 70%): mp 245−246 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.3 Hz, 2H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 8.3 Hz, 2H), 7.20 (d, *J* = 8.0 Hz, 2H), 3.99−3.88 (m, 2H), 3.42−3.36 (m, 1H), 3.01−2.96 (m, 1H), 2.46−2.39 (m, 1H), 2.44 (s, 3H), 2.37 (s, 3H), 2.09−1.93 (m, 3H), 1.91−1.73 (m, 2H), 1.72−1.65 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.5, 169.3, 144.7, 143.3, 136.0, 133.7, 129.3, 129.2, 128.6, 128.1, 52.4, 47.7, 43.2, 31.2, 29.3, 26.7, 21.7, 21.5, 20.7; IR (CH_2Cl_2) 2922, 1678, 1346, 1270, 1168, 1140, 689, 546 cm^{-1}; MS (ESI) *m/e* (%) 434.4 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_4NaS$ [M + Na]$^+$ 434.1402, found 434.1400.

(1R,5R*,8S*)-8-([1,1′-Biphenyl]-4-carbonyl)-3-tosyl-3-azabicyclo[3.3.1]nonan-2-one (**13d**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13d** as a white solid (90.0 mg, 0.190 mmol, 63%): mp 235−236 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93−7.84 (m, 4H), 7.65−7.60 (m, 2H), 7.60−7.56 (m, 2H), 7.48−7.42 (m, 2H), 7.41−7.35 (m, 1H), 7.34−7.29 (m, 2H), 4.00−3.89 (m, 2H), 3.49−3.41 (m, 1H), 3.07−3.02 (m, 1H), 2.47−2..40 (m, 1H), 2.43 (s, 3H), 2.11−1.95 (m, 3H), 1.95−1.68 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.6, 169.3, 145.3, 144.7, 140.0, 135.9, 134.9, 129.3, 128.9, 128.6, 128.6, 128.1, 127.3, 127.2, 52.4, 47.8, 43.2, 31.2, 29.3, 26.7, 21.7, 20.6; IR (CH_2Cl_2) 2934, 1686, 1604, 1361, 1271, 1169, 1140, 1089, 743, 688, 548 cm^{-1}; MS (ESI) *m/e* (%) 496.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{28}H_{27}NO_4NaS$ [M + Na]$^+$ 496.1565, found 496.1556.

(1R,5R*,8S*)-8-(3-Methoxybenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13e**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13e** as a white solid (55.6 mg, 0.130 mmol, 43%): mp 211−212 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92−7.87 (m, 2H), 7.38−7.28 (m, 5H), 7.07−7.01 (m, 1H), 4.00−3.88 (m, 2H), 3.83 (s, 3H), 3.43−3.36 (m, 1H), 3.04−2.98 (m, 1H), 2.46−2.39 (m, 1H), 2.43 (s, 3H), 2.09−1.93 (m, 3H), 1.92−1.74 (m, 2H), 1.73−1.65 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.7, 169.3, 159.9, 144.7, 137.6, 135.9, 129.4, 129.2, 128.6, 120.2, 119.0, 112.9, 55.4, 52.4, 47.9, 43.2, 31.2, 29.3, 26.7, 21.7, 20.7; IR (CH_2Cl_2) 2940, 1685, 1596, 1458, 1360, 1348, 1265, 1169, 1139, 1046, 706, 688, 548 cm^{-1}; MS (ESI) *m/e* (%) 450.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{25}NO_5NaS$ [M + Na]$^+$ 450.1351, found 450.1356.

(1R,5R*,8S*)-8-(4-Methoxybenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13f**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13f** as a white solid (65.5 mg, 0.153 mmol, 51%): mp 115−116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91−7.86 (m, 2H), 7.82−7.77 (m, 2H), 7.32−7.27 (m, 2H), 6.90−6.85 (m, 2H), 3.98−3.86 (m, 2H), 3.82 (s, 3H), 3.39 (dt, *J* = 11.9, 3.4 Hz, 1H), 2.99−2.94 (m, 1H), 2.45−2.38 (m, 1H), 2.42 (s, 3H), 2.07−1.93 (m, 3H), 1.92−1.73 (m, 2H), 1.70−1.62 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.3, 169.3, 163.1, 144.6, 135.9, 130.2, 129.2, 129.0, 128.5, 113.7, 55.4, 52.4, 47.3, 43.3, 31.1, 29.2, 26.6, 21.6, 20.7; IR (CH_2Cl_2) 2934, 1686, 1675, 1600, 1360, 1349, 1253, 1170, 1140, 834, 688, 564, 548 cm^{-1}; MS (ESI) *m/e* (%) 450.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{26}NO_5S$ [M + H]$^+$ 428.1532, found 428.1529.

(1R,5R*,8S*)-8-(4-Fluorobenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13g**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13g** as a white solid (76.1 mg, 0.183 mmol, 61%): mp 211−212 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91−7.86 (m, 2H), 7.84−7.79 (m, 2H), 7.34−7.29 (m, 2H), 7.11−7.05 (m, 2H), 3.99−3.88 (m, 2H), 3.41−3.41 (m, 1H), 2.99−2.94 (m, 1H), 2.48−2.40 (m, 1H), 2.44 (s, 3H), 2.10−1.93 (m, 3H), 1.91−1.73 (m, 2H), 1.73−1.62 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.4, 169.2, 165.4 ($^1J_{C-F}$ = 252.5 Hz, d), 144.8,

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135.9, 132.6 ($^4J_{C-F}$ = 2.8 Hz, d), 130.6 ($^3J_{C-F}$ = 9.1 Hz, d), 129.3, 128.6, 115.7 ($^2J_{C-F}$ = 21.8 Hz, d), 52.4, 47.7, 43.1, 31.1, 29.2, 26.6, 21.7, 20.6; ^{19}F NMR (375 MHz, $CDCl_3$) δ −106.0; IR (CH_2Cl_2) 3073, 2940, 1683, 1597, 1360, 1348, 1169, 1140, 839, 687, 562, 548 cm^{-1}; MS (ESI) *m/e* (%) 438.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{22}NO_4FNaS$ [M + Na]$^+$ 438.1151, found 438.1148.

(1R,5R*,8S*)-8-(4-Chlorobenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13h**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13h** as a white solid (70.0 mg, 0.162 mmol, 54%): mp 250−251 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91−7.85 (m, 2H), 7.76−7.69 (m, 2H), 7.41−7.35 (m, 2H), 7.34−7.28 (m, 2H), 3.98−3.87 (m, 2H), 3.40−3.32 (m, 1H), 2.98−2.92 (m, 1H), 2.47−2.39 (m, 1H), 2.43 (s, 3H), 2.10−1.92 (m, 3H), 1.89−1.64 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.9, 169.2, 144.8, 138.9, 135.8, 134.6, 129.4, 129.2, 128.9, 128.6, 52.4, 47.8, 43.1, 31.0, 29.2, 26.6, 21.7, 20.5; IR (CH_2Cl_2) 2924, 1659, 1358, 1168, 1140, 1088, 688, 548 cm^{-1}; MS (ESI) *m/e* (%) 454.5 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}NO_4SCl$ [M + H]$^+$ 432.1036, found 432.1037.

Methyl 3-((1R,5R*,6S*)-4-oxo-3-tosyl-3-azabicyclo[3.3.1]-nonane-6-carbonyl)- benzoate (**13i**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13i** as a white solid (70.2 mg, 0.154 mmol, 51%): mp 213-214 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (s, 1H), 8.16 (d, *J* = 7.7 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 1H), 7.89 (d, *J* = 8.2 Hz, 2H), 7.51 (t, *J* = 7.8 Hz, 1H), 7.32 (d, *J* = 8.1 Hz, 2H), 3.99−3.88 (m, 2H), 3.94 (s, 3H), 3.50−3.43 (m, 1H), 3.00−2.94 (m, 1H), 2.47−2.40 (m, 1H), 2.44 (s, 3H), 2.10−1.96 (m, 3H), 1.89−1.78 (m, 2H), 1.78−1.67 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.4, 169.2, 166.3, 144.8, 136.6, 135.8, 133.3, 132.7, 130.4, 129.2, 129.0, 128.6, 128.5, 52.4, 52.3, 47.8, 42.9, 31.0, 29.1, 26.5, 21.7, 20.5; IR (CH_2Cl_2) 2950, 2873, 1721, 1686, 1601, 1361, 1286, 1170, 1141, 712, 688, 567, 548 cm^{-1}; MS (ESI) *m/e* (%) 478.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_6S$ [M + H]$^+$ 456.1481, found 456.1485.

Methyl 4-((1R,5R*,6S*)-4-oxo-3-tosyl-3-azabicyclo[3.3.1]-nonane-6-carbonyl)- benzoate (**13j**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13j** as a white solid (60.1 mg, 0.132 mmol, 44%): mp 245−246 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10−8.05 (m, 2H), 7.91−7.86 (m, 2H), 7.84−7.79 (m, 2H), 7.35−7.30 (m, 2H), 3.99−3.89 (m, 2H), 3.93 (s, 3H), 3.44−3.36 (m, 1H), 2.99−2.94 (m, 1H), 2.47−2.41 (m, 1H), 2.44 (s, 3H), 2.10−1.93 (m, 3H), 1.86−1.68 (m, 2H), 1.67−1.61 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 169.1, 166.2, 144.9, 139.9, 135.8, 133.3, 129.8, 129.3, 128.6, 127.9, 52.4, 48.2, 42.9, 31.0, 29.2, 26.6, 21.7, 20.5; IR (CH_2Cl_2) 2936, 2340, 1722, 1693, 1360, 1276, 1169, 1140, 1117, 712, 687, 548 cm^{-1}; MS (ESI) *m/e* (%) 478.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{26}NO_6S$ [M + H]$^+$ 456.1481, found 456.1485. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

(1R,5R*,8S*)-3-Tosyl-8-(4-(trifluoromethyl)benzoyl)-3-azabicyclo[3.3.1]nonan-2-one (**13k**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13k** as a white solid (41.9 mg, 0.090 mmol, 30%): mp 224−225 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92−7.82 (m, 4H), 7.71−7.64 (m, 2H), 7.35−7.28 (m, 2H), 3.99−3.87 (m, 2H), 3.45−3.34 (m, 1H), 3.00−2.91 (m, 1H), 2.49−2.38 (m, 1H), 2.44 (s, 3H), 2.10−1.93 (m, 3H), 1.86−1.66 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.5, 169.2, 144.9, 139.4, 135.8, 133.8 ($^2J_{C-F}$ = 32.5 Hz, q), 129.3, 128.5, 128.3, 125.6, 123.6 ($^1J_{C-F}$ = 271.0 Hz, q), 52.3, 48.2, 42.9, 30.9, 29.1, 26.5, 21.7, 20.4; ^{19}F NMR (375 MHz, $CDCl_3$) δ −63.1; IR (CH_2Cl_2) 2940, 2870, 1687, 1361, 1327, 1274, 1169, 1132, 1090, 1067, 834, 705, 691, 565, 548 cm^{-1}; MS (ESI) *m/e* (%) 488.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{23}H_{23}NO_4F_3S$ [M + H]$^+$ 466.1300, found 466.1302.

(1R,5R*,8S*)-8-(4-Nitrobenzoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13l**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13l** as a yellow solid (27.0 mg, 0.061 mmol, 20%): mp 229−230 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29−8.23 (m, 2H), 7.93−7.85 (m, 4H), 7.36−7.30 (m, 2H), 3.99−3.89 (m, 2H), 3.42−3.35 (m, 1H), 2.97−2.91 (m, 1H), 2.51−2.41 (m, 1H), 2.45 (s, 3H), 2.13−1.93 (m, 3H), 1.87−1.70 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.2, 169.1, 149.9, 145.0, 141.5, 135.7, 129.3, 129.0, 128.6, 123.8, 52.3, 48.5, 42.8, 30.8, 29.0, 26.5, 21.7, 20.3; IR (CH_2Cl_2) 3112, 2940, 1698, 1686, 1525, 1348, 1317, 1273, 1169, 1140, 830, 732, 710, 687, 568, 548 cm^{-1}; MS (ESI) *m/e* (%) 465.1 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{23}N_2O_6S$ [M + H]$^+$ 443.1277, found 443.1280.

(1R,5R*,8S*)-8-(Thiophene-3-carbonyl)-3-tosyl-3-azabicyclo-[3.3.1]nonan-2-one (**13m**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13m** as a white solid (61.7 mg, 0.153 mmol, 51%): mp 253−254 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95−7.87 (m, 3H), 7.47−7.43 (m, 1H), 7.34−7.25 (m, 3H), 4.00−3.88 (m, 2H), 3.24 (dt, *J* = 9.1, 3.5 Hz, 1H), 3.07−3.02 (m, 1H), 3.46−3.40 (m, 1H), 2.43 (s, 3H), 2.11−1.64 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 192.9, 169.2, 144.7, 140.9, 135.9, 131.1, 129.3, 128.6, 127.2, 126.4, 52.4, 49.7, 43.4, 31.1, 29.4, 26.6, 21.7, 20.5; IR (CH_2Cl_2) 3099, 2934, 1674, 1358, 1187, 1168, 1140, 1088, 814, 688, 563, 547 cm^{-1}; MS (ESI) *m/e* (%) 426.5 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{20}H_{21}NO_4S_2Na$ [M + Na]$^+$ 426.0810, found 426.0814.

(1R,5R*,8S*)-8-Propionyl-3-tosyl-3-azabicyclo[3.3.1]nonan-2-one (**13n**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13n** as a white solid (32.5 mg, 0.093 mmol, 31%): mp 209−210 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.3 Hz, 2H), 7.82 (d, *J* = 8.2 Hz, 2H), 3.97−3.89 (m, 2H), 3.10−3.05 (m, 1H), 2.58−2.40 (m, 2H), 2.42 (s, 3H), 2.40−2.33 (m, 1H), 2.22−2.04 (m, 2H), 1.98−1.89 (m, 1H), 1.87−1.80 (m, 1H), 1.74−1.59 (m, 2H), 1.58−1.44 (m, 1H), 0.94 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 209.6, 170.1, 144.9, 135.9, 129.3, 128.7, 52.6, 52.4, 42.4, 33.2, 31.1, 29.3, 26.5, 21.7, 20.6, 7.6; IR (CH_2Cl_2) 2934, 1694, 1350, 1170, 842, 686, 548 cm^{-1}; MS (ESI) *m/e* (%) 372.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{18}H_{23}NO_4SNa$ [M + Na]$^+$ 372.1245, found 372.1247.

(1R,5R*,8S*)-8-(3-Phenylpropanoyl)-3-tosyl-3-azabicyclo[3.3.1]-nonan-2-one (**13o**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13o** as a white solid (56.2 mg, 0.132 mmol, 44%): mp 163−164 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91−7.86 (m, 2H), 7.32−7.22 (m, 4H), 7.20−7.11 (m, 3H), 3.96−3.86 (m, 2H), 3.13−3.07 (m, 1H), 2.93−2.74 (m, 3H), 2.60−2.50 (m, 1H), 2.43−2.32 (m, 2H), 2.41 (s, 3H), 2.10−2.02 (m, 1H), 1.94−1.86 (m, 1H), 1.83−1.76 (m, 1H), 1.71−1.57 (m, 2H), 1.53−1.39 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 208.1, 170.1, 144.9, 141.3, 135.8, 129.3, 128.5, 128.3, 128.3, 125.9, 52.9, 52.4, 42.3, 41.7, 30.9, 29.6, 29.2, 26.5, 21.7, 20.4; IR (CH_2Cl_2) 3032, 2934, 2870, 1686, 1362, 1272, 1169, 1140, 1089, 703, 687, 548 cm^{-1}; MS (ESI) *m/e* (%) 448.2 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{24}H_{27}NO_4NaS$ [M + Na]$^+$ 448.1558, found 448.1556.

(1R,5R*,8S*)-8-Heptanoyl-3-tosyl-3-azabicyclo[3.3.1]nonan-2-one (**13p**).* The crude mixture was purified by flash column chromatography over silica gel (EtOAc/hexanes = 1:3) to give **13p** as a white solid (66.9 mg, 0.165 mmol, 55%): mp 178−179 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91−7.86 (m, 2H), 7.33−7.29 (m, 2H), 3.97−3.87 (m, 2H), 3.11−3.06 (m, 1H), 2.54−2.34 (m, 3H), 2.44 (s, 3H), 2.28−2.17 (m, 1H), 2.12−2.05 (m, 1H), 1.96−1.88 (m, 1H), 1.86−1.80 (m, 1H), 1.72−1.60 (m, 2H), 1.54−1.40 (m, 3H), 1.33−1.13 (m, 6H), 0.87 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 209.2, 170.1, 144.8, 135.9, 129.3, 128.6, 52.7, 52.4, 42.3, 40.1, 31.6, 31.1, 29.3, 28.8, 26.6, 23.5, 22.5, 21.7, 20.5, 14.0; IR (CH_2Cl_2) 2922, 2358, 1702, 1460, 1348, 1270, 1169, 1142, 1086, 1070, 846, 704, 687, 552 cm^{-1}; MS (ESI) *m/e* (%) 428.3 ([M + Na]$^+$, 100); HRMS (ESI) *m/e* calcd for $C_{22}H_{31}NO_4NaS$ [M + Na]$^+$ 428.1871, found 428.1869. Crystals suitable for X-ray diffraction analysis were grown from CH_2Cl_2 and hexanes.[12]

Experimental Procedure for the Hydration of 2-Ethyl-substituted 4-Azatricyclo[4.2.2.0^{3,8}]dec-2-ene (12n) to Bicyclic Ketone 14. To a solution of the crude mixture **12n** in EtOAc (12.0 mL) was added hydrochloric acid (1 M $HCl_{(aq)}$, 1.50 mL). The reaction mixture was stirred for 12 h at room temperature, then added saturated $NaHCO_{3(aq)}$ (it is important to keep the pH value of the aqueous layer above pH 10). The water layer was extracted with

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J. Org. Chem. 2017, 82, 481−501

EtOAc (30.0 mL × 3) and brine (30.0 mL × 3) and dried over anhydrous $MgSO_4$, evaporated under reduced pressure to give the crude product. The crude mixture was purified via flash column chromatography over silica gel (EtOAc/hexanes = 1:7) to give *N*-((7-ethyl-8-oxobicyclo[4.2.0]octan-3-yl)methyl)-4-methylbenzenesulfonamide (**14**) as a white solid (60.0 mg, 0.179 mmol, 60%): mp 137−138 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76−7.72 (m, 2H), 7.33−7.28 (m, 2H), 4.86 (t, J = 5.1 Hz, 1H), 3.26−3.14 (m, 2H), 2.83−2.71 (m, 2H), 2.50−2.41 (m, 1H), 2.42 (s, 3H), 1.77−1.67 (m, 1H), 1.66−1.57 (m, 3H), 1.55−1.19 (m, 5H), 0.96−0.91 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 213.3, 143.2, 137.0, 129.6, 127.0, 62.7, 53.3, 47.8, 31.5, 25.4, 24.0, 22.0, 21.4, 19.3, 17.6, 12.6; IR (CH_2Cl_2) 3285, 2928, 1763, 1327, 1159, 1094, 816, 665, 552 cm^{-1}; MS (ESI) m/e (%) 358.5 ($[M + Na]^+$, 100); HRMS (ESI) m/e calcd for $C_{18}H_{26}NO_3S$ $[M + H]^+$ 336.1633, found 336.1631. Crystals suitable for X-ray diffraction analysis were grown from acetone and hexanes.[12]

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b02479.

NMR spectra for compounds **1a−t**, **2a−n**, **2p−2s**, **3a−b**, **3e−3l**, **3o**, **8a−e**, **10a−e**, **11a−q**, **12a−j**, **12m**, **13a−13p**, and **14** (PDF)

X-ray crystallographic information files for compounds
2a (CIF)
2f (CIF)
2h (CIF)
2p (CIF)
3a (CIF)
3f (CIF)
3h (CIF)
3i (CIF)
3o (CIF)
8a (CIF)
12a (CIF)
12c (CIF)
12j (CIF)
13a (CIF)
13j (CIF)
13p (CIF)
14 (CIF)

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Notes

The authors declare no competing financial interest.

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(12) Supporting Information contains the crystallographic data for this compound. CCDC 14931133 (**2a**), 1491130 (**2f**), 1491085 (**2h**), 1491131 (**2p**), 1491125 (**3a**), 1491134 (**3f**), 1491128 (**3h**), 1491135 (**3i**), 1491129 (**3o**), 1424383 (**8a**), 1497578 (**12a**), 1497577 (**12c**), 1497580 (**12j**), 1497575 (**13a**), 1497581 (**13j**), 1497579 (**13p**) and 1497576 (**14**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Center via www.ccdc.cam.ac.uk/data_request/cif.

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