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Stereoselective Synthesis of Indoline, Tetrahydroquinoline, and Tetrahydrobenzazepine Derivatives from *o*-Bromophenyl *N*-*tert*-Butylsulfinyl Aldimines

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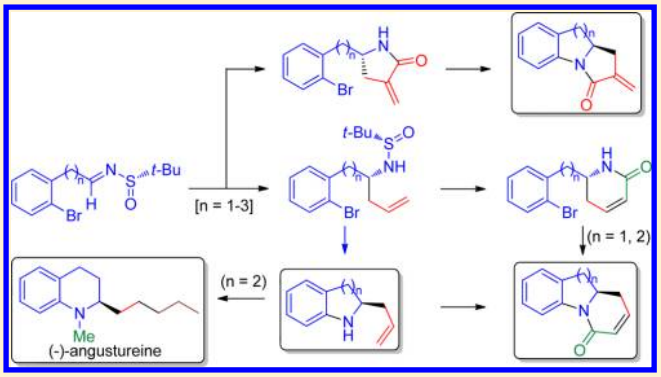
Supporting Information

ABSTRACT: The diastereoselective addition of an allylic indium intermediate to chiral *o*-bromophenyl sulfinyl imine **4** proceeded with good levels of diastereoselectivity. The resulting homoallylic amine derivatives were transformed into lactams **7** and **12**, which upon copper-mediated intramolecular *N*-arylation led to the formation of benzo-fused 1-azabicyclo[*j*.*k*.0]alkanes **8** and **13**. Benzo-fused 2-allyl-substituted heterocycles **14** could also be prepared by means of a palladium-catalyzed *N*-arylation of the corresponding free amines. The synthesis of the alkaloid (−)-angustureine was easily accomplished from (*S*)-2-allyltetrahydroquinoline (**14b**).



INTRODUCTION

Substituted benzo-fused 1-azabicyclo[*j*.*k*.0]alkanes with the general structures **I**−**VI** (Figure 1) are embedded in numerous natural products and other biologically active compounds. Because of that, the rapid assembly of such molecules, in addition to the search for new molecular scaffolds, represents a constant challenge to synthetic organic and medicinal chemists. Thus, the development of new methodologies to access to these systems is of great interest. Related to the benzo-fused pyrrolizidine **I** is, for instance, (−)-isatisine A (**1**), a complex alkaloid isolated from the leaves of *Isatis indigotica* Fort,[1] a herbaceous plant species used in Chinese folk medicine. One acetonide of (−)-isatisine A exhibits cytotoxicity against C8166 cells and anti-HIV activitiy. On the other hand, 14,15-didehydro-10,11-dimethoxy-16-epivincamine (**2**),[2] an alkaloid isolated from *Ervatamia officinalis*, *Ervatamia divaricata*, and *E. divaricata* Gouyahua plants of the Apocynaceae family, which have been applied in China as folklore herbs for the treatment of hypertension and sore throat, is an example of the benzo-fused indolizidine **II** (Figure 1). Structurally related to azabicycloalkane **III** is the pyridoacridine marine alkaloid arnoamine C (**3**),[3] isolated from ascidians of the genus *Cystodytes*, which displays strong cytotoxic activity in different cell lines at low concentration (Figure 1). In addition, compounds bearing the 1-benzazepine moiety, a structural motif common to heterocycles of types **V** and **VI**, have achieved significant relevance as drugs, especially as anti-depressants, for the treatment of neurodegenerative disorders, and also in cardiovascular diseases. This class of compounds exhibit biological activity toward different targets, such as enzymes, ion channels, and G-protein-coupled receptors (GPCRs).[4] Different synthetic methodologies have been used to access the benzo-fused 1-azabicyclo[*j*.*k*.0]alkanes **I**−**VI** in either a racemic or enantioselective manner. For instance, the Schmidt reaction involving benzocycloalkyl carbocations and alkyl azides has been applied to the synthesis of heterocycles of types **I** and **III**−**V**.[5] The benzopyrrolizidine and -indolizidine units (**I** and **II**, respectively) were also synthesized through palladium(II)-catalyzed[6] or copper-promoted[7] oxidative tandem cyclizations using *N*-acryloyl- or -benzoyl *o*-allyl aromatic amines as substrates. The same types of heterocycles were prepared by means of a general catalytic protocol of non-carbonyl-stabilized rhodium carbenoid C−H insertions starting from *N*-aziridinyl imines[8] and also using a selenium-based approach for a solid-phase synthesis.[9] Tricycles with general structures **I** and **III** were obtained under palladium catalysis from chiral unsaturated amines by means of an intramolecular *N*-arylation reaction followed by an intermolecular alkene carboamination reaction.[10] A recently reported methodology involving regio- and stereoselective allylation and crotylation of indoles with potassium organotrifluoroborate salts combined with ring-closing metathesis allowed the synthesis in this case of compounds of type **II**.[11] Iridium-catalyzed enantioselective hydrogenation of 2-substituted quinolines was used as the key step in the stereoselective synthesis of heterocyclic compounds of types **III** and **IV**.[12] Enantioenriched benzo-fused indolizidines and quinolizidines of types **III** and **IV** were also accessed

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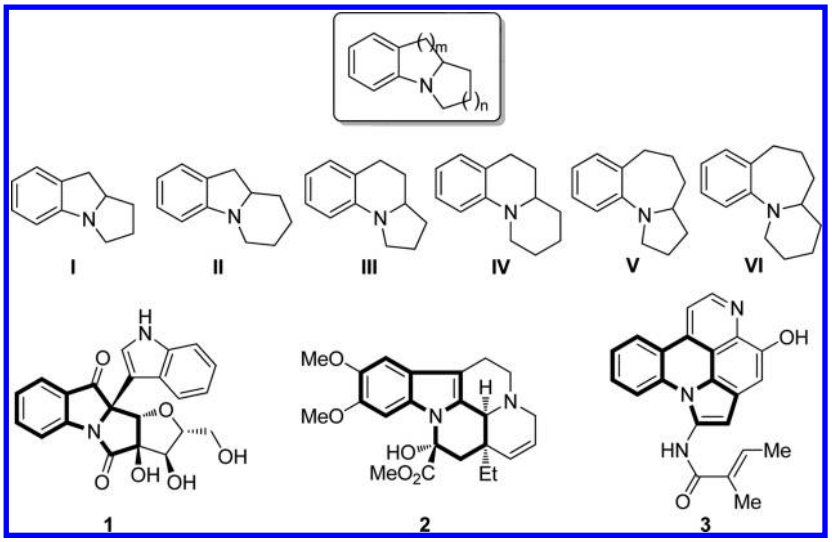
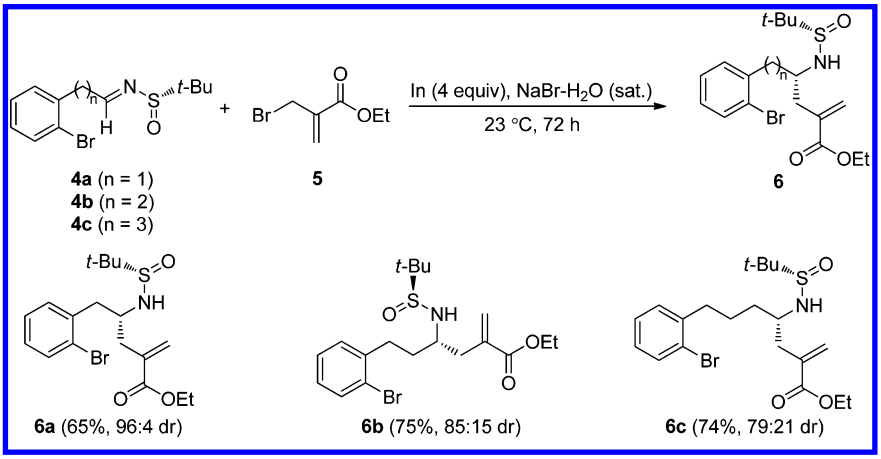


Figure 1. Basic structures of benzo-fused 1-azabicyclo[*j.k*.0]alkanes and representative natural products.

Scheme 1. Diastereoselective Synthesis of Amino Ester Derivatives 6



via a catalytic asymmetric hydrogenation cascade using Hantzsch dihydropyridine as the hydride donor and catalytic amounts of a chiral BINOL-based phosphoric acid[13] as well as through 7-*endo*-*trig*/ring contraction cascades involving phenonium ions, but in this last case in a racemic form.[14] Regarding 1-benzazepine derivatives **V** and **VI**, many methodologies to synthesize these compounds are based on the expansion of smaller rings involving cationic and radical intermediates.[15] More recently, palladium-catalyzed C−C and C−N bond-forming reactions have also been employed for the preparation of these compounds.[16] On the other hand, we have described the stereoselective allylation of *N*-*tert*-butylsulfinyl aldimines[17] and ketimines[18] with allylindium species and the first one-pot α-aminoallylation of aldehydes with chiral *tert*-butanesulfinamide, allyl bromides, and indium, which provides homoallylic amines with high chemo- and stereoselectivity.[19] It is worth mentioning that *N*-*tert*-butylsulfinyl derivatives[20] have found high applicability in synthesis as electrophiles because both enantiomers are accessible in large-scale processes[21] and because the chiral auxiliary is easily removed under acidic conditions. In addition, practical processes for recycling the *tert*-butanesulfinyl group upon deprotection of *N*-*tert*-butylsulfinyl amines have also been reported.[22] Being aware of the importance of heterocycles having the general structures **I**−**VI** with regard to biological activity and organic synthesis, we decided to apply the indium-promoted diastereoselective addition of allylic bromides to *N*-*tert*-butylsulfinyl aldimines bearing an *o*-bromophenyl unit, in combination with an intramolecular *N*-arylation, to develop new and flexible synthetic pathways to target compounds of types **I**−**VI**.

RESULTS AND DISCUSSION

We have previously reported that the reaction of ethyl 2-(bromomethyl)acrylate (**5**) with different chiral *N*-sulfinyl aldimines in a saturated aqueous sodium bromide solution in the presence of 4 equiv of indium at room temperature for 48 h proceeds with high diastereoselectivity to afford the corresponding amino ester derivatives, which could be easily transformed into α-methylene-γ-butyrolactams.[24] When we applied these reaction conditions to chiral imines **4**, amino esters **6** were obtained in reasonable yields and diastereoselectivities (Scheme 1). The diastereomeric ratios for compounds bearing the *tert*-butylsulfinyl unit were easily determined by ^{1}H NMR analysis of the crude reaction mixtures through comparison of the integrals of the *t*-Bu and the N−H groups for each diastereoisomer. On the other hand, the yields given in Scheme 1 are isolated yields of the major diastereomers after column chromatography purification. The stereochemical pathway of the process is well-known:[24] the

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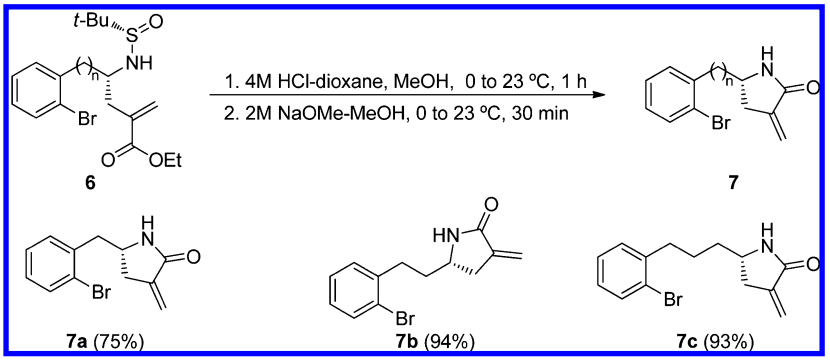
Scheme 2. Synthesis of α-Methylene-γ-butyrolactams 7 from Amino Ester Derivatives 6

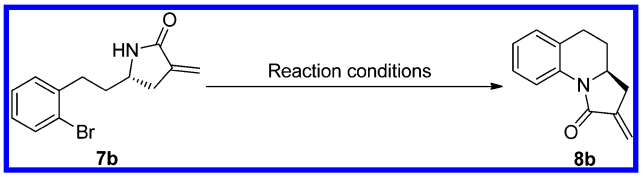


attack of the allylic indium intermediate occurs preferentially on the *Re* face of these imines with the *S* configuration at the sulfur atom.

Amino ester derivatives **6** were converted into butyrolactams **7** upon removal of the *tert*-butylsulfinyl group by treatment first with a 4 M HCl dioxane solution in methanol and then with sodium methoxide in methanol to basic pH. Good to excellent yields were achieved for compounds **7**, and the corresponding α-methylene-γ-butyrolactams were isolated in an almost enantiopure form (Scheme 2).

Next, we carried out an intramolecular *N*-arylation in compounds **7** under Ullmann-type reaction conditions. For a model reaction, we optimized the cyclization of compound **7b** using a simple catalyst system developed by Buchwald and co-workers: CuI, a diamine ligand, and K_2CO_3 as the base.[25] All of the reactions were performed at 100 °C in the presence of 2 equiv of K_2CO_3. Regarding the solvent, a higher conversion was achieved using dioxane instead of toluene (Table 1, compare

Table 1. Optimization of the Intramolecular *N*-Arylation of Compound 7b



entry	reaction conditions	conversion (%)[a]
1	CuI (5 mol %), DMEDA (10 mol %), K_2CO_3 (2 equiv), PhMe, 110 °C, 20 h	28
2	CuI (5 mol %), DMEDA (10 mol %), K_2CO_3 (2 equiv), 1,4-dioxane, 100 °C, 20 h	50
3	CuI (8 mol %), DMEDA (16 mol %), K_2CO_3 (2 equiv), 1,4-dioxane, 100 °C, 20 h	100

[a]Based on the disappearance of the starting compound **7b** as monitored by ^{1}H NMR spectroscopy.

entries 1 and 2). In all cases, the copper(I) salt (CuI) and the diamine [*N*,*N*′-dimethylethylenediamine (DMEDA)] were in a 1:2 molar ratio, and 8 mol % was the optimal loading of copper(I) salt that led to complete conversion (Table 1, entry 3).

When we applied the optimized conditions depicted in Table 1, entry 3, to enantioenriched butyrolactams **7**, pyrroloindoline (**8a**), -tetrahydroquinoline (**8b**), and -tetrahydrobenzazepine (**8c**) derivatives were obtained, although in a modest yield in the case of compound **8c** (Scheme 3). These compounds possess pattern hydrocarbon skeletons of types **I**, **III**, and **V** in

Scheme 3. Synthesis of Tricyclic Compounds 8 from α-Methylene-γ-butyrolactams 7

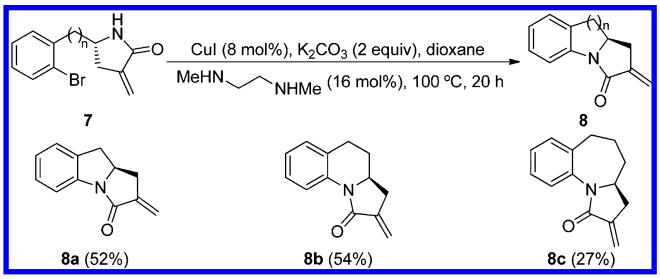


Figure 1, respectively, and exhibit the *S* configuration at the stereogenic center. The corresponding enantiomers could be produced through the same synthetic pathway starting from the chiral aldimines **4** with the *R* configuration at the sulfur atom.

In order to access compounds with pattern hydrocarbon skeletons of types **II**, **IV**, and **VI** in Figure 1, we envisioned a different protocol wherein the allylation of chiral *tert*-butylsulfinyl imines **1** would be the first step of the synthesis. The allylation of imines **4** under standard conditions developed in our group (i.e., treatment with allyl bromide in the presence of indium metal at 60 °C) produced the homoallylamine derivatives **9** in excellent yields and diastereoselectivities (Scheme 4).[23] The same reaction products were prepared in slightly lower yields and with almost identical diastereoselectivities by performing a one-pot α-aminoallylation of the corresponding aldehydes with (*S*)-*tert*-butanesulfinamide and allyl bromide in the presence of indium metal and titanium tetraethoxide (Scheme 4).[19] Column chromatography purification allowed access to compounds **9** with high optical purity. The attack of the allylindium here also took place on the *Re* face of these imines with the *S* configuration at the sulfur atom.

Removal of the *tert*-butylsulfinyl unit in homoallylamine derivatives **9** took place under acidic conditions, giving rise to the free amines **10** in almost quantitative yields (Scheme 5). Treatment of amines **10** under Shotten−Baumann reaction conditions with acryloyl chloride at 0 °C in a two-phase solvent system consisting of 4 M aqueous sodium hydroxide and dichloromethane led to the formation of the target acrylamide derivatives **11** in good yields (Scheme 5). It is found to be important to perform the acylation at 0 °C because at higher temperatures the 3-chloropropanamide derivative resulting from conjugate addition of the chloride anion to the acrylamide is formed in a significant amount. In addition, column chromatography separation of acrylamides and 3-chloropropanamides is not an easy task. Although these undesired reaction products do not interfere in the next step of the synthesis, this

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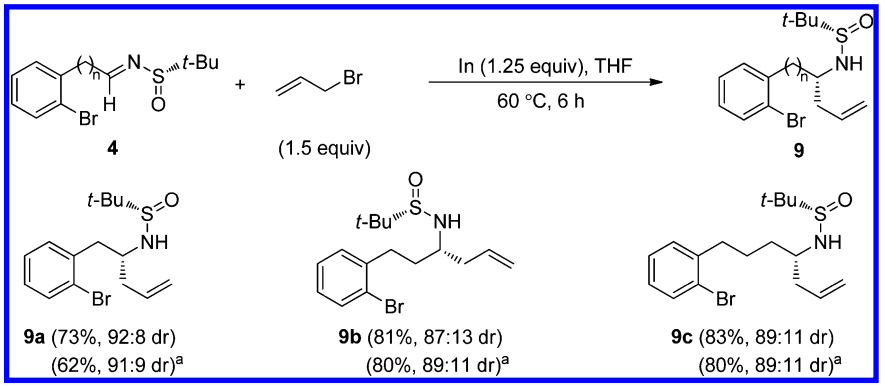
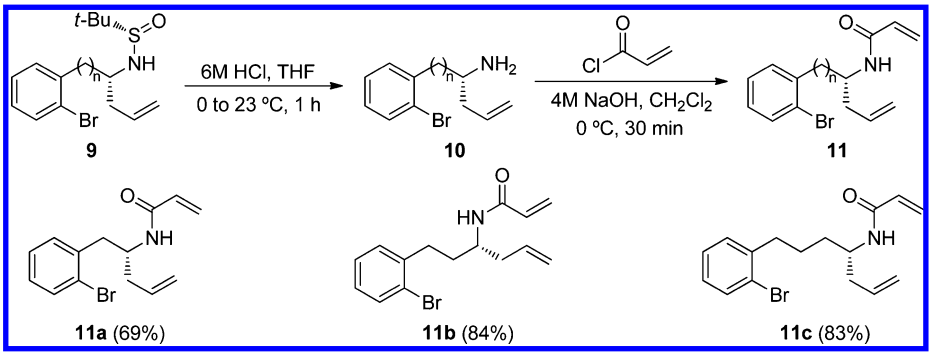
Scheme 4. Diastereoselective Synthesis of Homoallylamine Derivatives 9

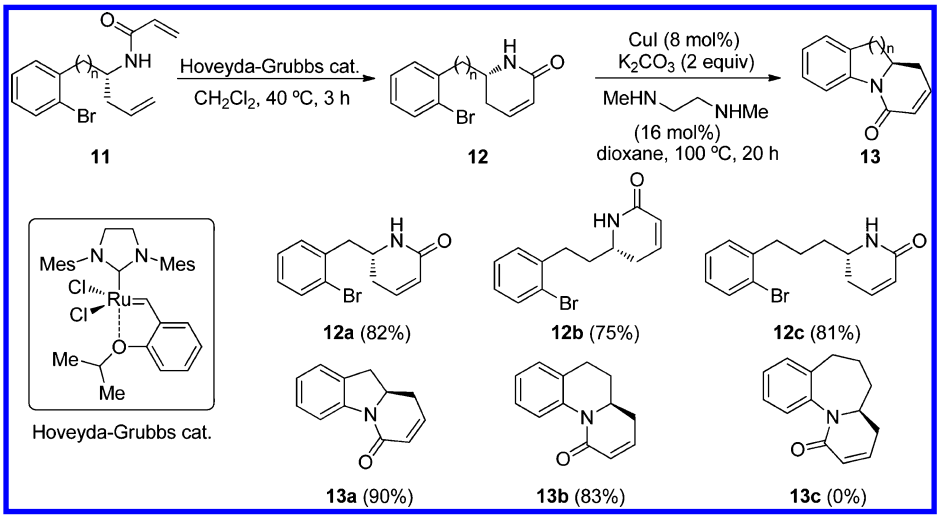


[a]Obtained by one-pot aminoallylation of the corresponding aldehyde with (*S*)-*tert*-butanesulfinamide.

Scheme 5. Synthesis of Acrylamides 11 from Homoallylamine Derivatives 9



Scheme 6. Synthesis of Tricyclic Compounds 13 from Dihydropyridin-2-ones 12



side reaction could be an important drawback by affecting the yield of the whole process.

Ring-closing metathesis (RCM) of acrylamides **11** using a Hoveyda–Grubbs second-generation ruthenium catalyst produced dihydropyridin-2-ones **12** in high yields in all cases (Scheme 6). Compounds **12** were then treated under the optimized conditions depicted in Table 1, entry 3 to perform an intramolecular *N*-arylation, leading to the expected tricyclic compounds **13a** and **13b** in excellent yields. However, the reaction failed in the case of the pyridotetrahydrobenzazepine derivative **13c**, the starting lactam **12c** being recovered at the end of the reaction (Scheme 6). The pyridoindoline (**13a**) and -tetrahydroquinoline (**13b**) derivatives possess the pattern hydrocarbon skeletons of types **II** and **IV** in Figure 1, respectively, but through this synthetic strategy we could not access a member of the type **VI** family, such as compound **13c**.

Since the formation of the seven-membered ring through an Ullmann-type intramolecular *N*-arylation from bromophenyl dihydropyridin-2-one derivative **12c** failed, we planned to perform first an intramolecular *N*-arylation of the free amine **10c** to synthesize the seven-membered ring of the benzazepine unit and after that to form the lactam ring. In order to find out the best reaction conditions for the intramolecular *N*-arylation, we took homoallylamine derivative **10b** as a model compound.

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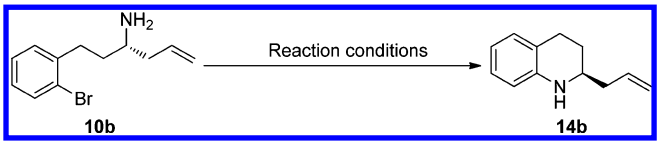
As we expected, cyclization did not take place under the Ullmann-type reaction conditions depicted in Table 1, entry 3, which were found to be optimal for the lactam derivatives **7** and **12** (Table 2, entry 1). We were please to find that 100% conversion was achieved under palladium catalysis using 5 mol % $Pd(OAc)_2$ and 7.5 mol % (±)-BINAP with 2 equiv of Cs_2CO_3 as a base in toluene at 100 °C for 15 h (Table 2, entry 2).[26] Total conversion was also achieved under very similar reaction conditions but using 15 mol % PPh_3 instead of the more expensive ligand (±)-BINAP (Table 2, entry 3). Unfortunately, decreasing the loading of $Pd(OAc)_2$ from 5 to 2 mol % led to a lower conversion (Table 2, entry 4).

Table 2. Optimization of the Intramolecular *N*-Arylation of Homoallylamine 10b



entry	reaction conditions	conversion (%)[a]
1	CuI (8 mol %), DMEDA (16 mol %), K_2CO_3 (2 equiv), 1,4-dioxane, 100 °C, 20 h	0
2	$Pd(OAc)_2$ (5 mol %), (±)-BINAP (7.5 mol %), Cs_2CO_3 (2 equiv), PhMe, 110 °C, 15 h	100
3	$Pd(OAc)_2$ (5 mol %), PPh_3 (15 mol %), Cs_2CO_3 (2 equiv), PhMe, 110 °C, 21 h	100
4	$Pd(OAc)_2$ (2 mol %), PPh_3 (6 mol %), Cs_2CO_3 (2 equiv), PhMe, 110 °C, 24 h	68

[a]Based on the disappearance of the starting **10b** as monitored by ^1H NMR spectroscopy.

Bicyclic compounds **14** were obtained when homoallylamine derivatives **10** were submitted to the reaction conditions shown in Table 2, entry 3. Purification of the reaction products was very easy by performing an acidic−basic workup. Concerning the chemical efficiency of the cyclization in regard to the size of the ring, 2-allylindoline (**14a**) was formed in lower yield than the tetrahydroquinoline (**14b**) and tetrahydrobenzazepine (**14c**) derivatives (Scheme 7).

Fortunately, pyridotetrahydrobenzazepine derivative **13c** could be prepared in two steps from tetrahydrobenzazepine **14c**: initial *N*-acylation with acryloyl chloride in dichloromethane under anhydrous reaction conditions and subsequent RCM of the resulting acrylamide **15c** using the Hoveyda−Grubbs second-generation ruthenium catalyst (Scheme 8). Just for a comparative study regarding the effectiveness of the two synthetic strategies to access compounds **13**, pyridotetrahydroquinoline derivative **13b** was also synthesized from 2-allyltetrahydroquinoline (**14b**) in two steps, and the yields were a little bit higher than for **13c** (Scheme 8). Thus, starting from common intermediate **10b**, the overall yield was 52.3% for the process **10b** → **11b** → **12b** → **13b** (lactam formation followed by *N*-arylation), while the route **10b** → **14b** → **15b** → **13b** (palladium-catalyzed *N*-arylation followed by formation of the lactam) was carried out in 45.5% overall yield. The first strategy seems to be superior, although benzazepine derivative **13c** could be prepared only by following the second route.

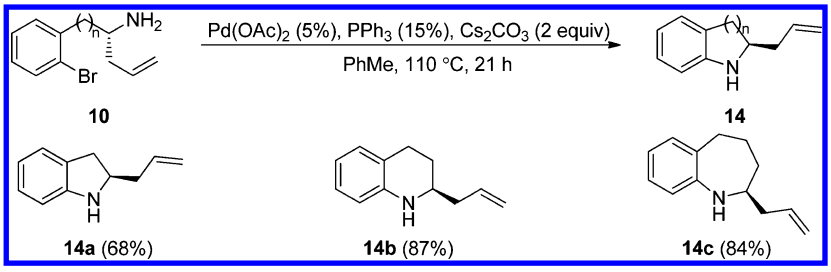
Compounds **8** and **13** are of interest not only because of their basic molecular architectures but also because their α,β-unsaturated lactam moieties allow further structural modifications, leading to more complex systems (Figure 2). In addition, the double bond of the allylic moiety in compounds **14** can participate in a number of further synthetically useful transformations, including cross-metathesis, epoxidation, oxidative cleavage, Heck-type reactions, cycloaddition, hydroboration, hydroformylation, hydrogenation, hydration, ozonolysis, etc.[27]

For instance, the synthetic utility of (*S*)-2-allyltetrahydroquinoline (**14b**) was exemplified in the synthesis of the natural alkaloid (−)-angustureine (**18**) isolated from *Galipea officinalis*,[28] a Venezuelan shrubby tree used in folk medicine as a tonic in dyspepsia, dysentery, and chronic diarrhea and also as an antipyretic (Scheme 9).[29] First, tetrahydroquinoline derivative **14b** was treated with paraformaldehyde and $NaBH_3CN$ to give 2-allyl-*N*-methyltetrahydroquinoline (**16**) in 95% yield, and this was followed by cross-metathesis with (*Z*)-hex-3-ene and final in situ hydrogenation of the resulting olefin **17** (Scheme 9). From compound **16** it was also possible to synthesize dehydrohomocuspareine (**19**), a compound related to the tetrahydroquinoline alkaloid cuspareine, by performing a Heck-type reaction with 4-bromoveratrol (Scheme 9).

CONCLUSION

Benzo-fused 1-azabicyclo[*j*.*k*.0]alkanes **8** and **13** with the general structures **I**−**VI** as well as 2-allylindoline, -tetrahydroquinoline, and -tetrahydrobenzazepine **14** were easily accessible in high optical purity from imines derived from aliphatic aldehydes with a 2-bromophenyl substituent and (*S*)-*tert*-butanesulfinamide. The methodology presented here comprised as key steps a diastereoselective addition of an allylic indium intermediate to the chiral sulfinyl imine **4** and an intramolecular *N*-arylation using either Ullmann-type reaction conditions (for lactams **7** and **12**) or a palladium-mediated process (for free amines **10**). The functionalized tricyclic compounds **8** and **13** as well as 2-allyl-substituted heterocycles **14** could be used as building blocks for the synthesis of more complex molecules. As an example, the natural alkaloid (−)-angustureine (**18**) was synthesized starting from (*S*)-2-allyltetrahydroquinoline (**14b**).

Scheme 7. Synthesis of 2-Allylindoline 14a, -tetrahydroquinoline 14b, and -tetrahydrobenzazepine 14c from Homoallylamines 10



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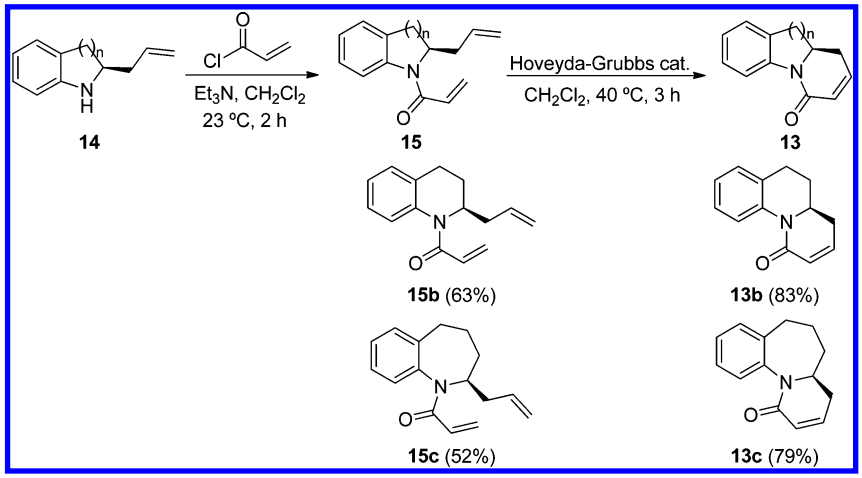
Scheme 8. Synthesis of Tricyclic Compounds 13b and 13c from 14b and 14c



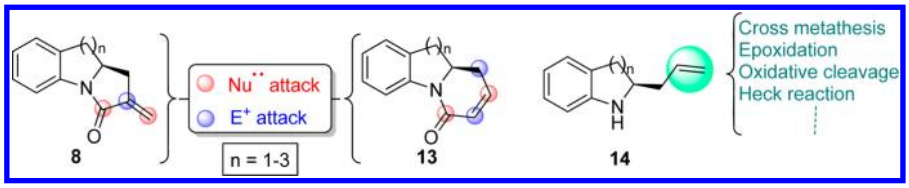
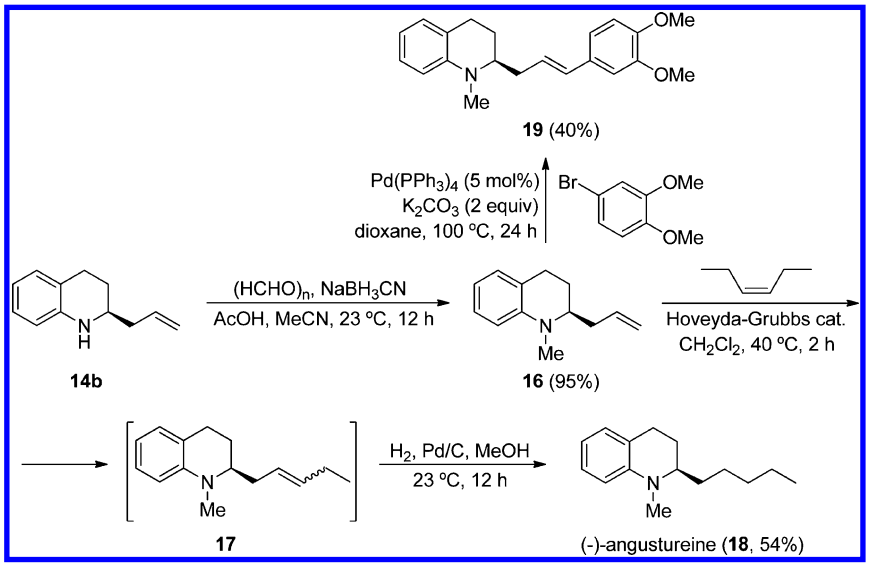


Figure 2. Potential applications of compounds **8**, **13**, and **14** in synthesis.

Scheme 9. Synthesis of (−)-Angustureine (18) from (*S*)-2-Allyltetrahydroquinoline (14b)



EXPERIMENTAL SECTION

General Remarks. (S_S)-*tert*-Butanesulfinamide and its enantiomer were a gift of Medalchemy (>99% ee by chiral HPLC on a Chiracel AS column, 90:10 *n*-hexane/*i*-PrOH, 1.2 mL/min, λ = 222 nm). TLC was performed on silica gel 60 F_{254} using aluminum plates and visualized with phosphomolybdic acid (PMA) stain. Flash chromatography was carried out on hand-packed columns of silica gel 60 (230−400 mesh). Melting points are uncorrected. Optical rotations were measured using a polarimeter with a thermally jacketed 5 cm cell at approximately 20 °C, and concentrations (*c*) are given in g/100 mL. Infrared analyses were performed with a spectrophotometer equipped with an ATR component; wavenumbers are given in cm^{-1}. Low-resolution mass spectra were obtained using electron impact (EI) mode at 70 eV; fragment ions are reported in *m*/*z* with relative intensities (%) in parentheses. High-resolution mass spectrometry (HRMS) was also carried out in EI mode at 70 eV on an apparatus equipped with a time-of-flight (TOF) analyzer, and the samples were ionized by ESI techniques and introduced through an ultrahigh-pressure liquid chromatograph. ^{1}H NMR spectra were recorded at 300 or 400 MHz using $CDCl_3$ as the solvent and TMS (0.00 ppm) as an internal standard. The data are reported in the form chemical shift (multiplicity, coupling constant(s) in Hz, integration). The multiplicities are denoted as follows: s = singlet, d = doublet, t = triplet, q = quadruplet, h = heptet, m = multiplet or unresolved, br = broad signal. ^{13}C NMR spectra were recorded with ^{1}H decoupling at 100 MHz and referenced to $CDCl_3$ at 77.16 ppm. DEPT-135 experiments were performed to assign CH, CH_2, and CH_3. Compounds **4a**,[10] **4b**,[10] and **4c**[23] were prepared from the corresponding *o*-bromophenyl aldehydes and (S_S)-*tert*-butanesulfinamide in THF in the presence of 2 equiv of titanium tetraethoxide.

General Procedure for the Synthesis of Amino Ester Derivatives 6. A mixture of the corresponding aldimine **4** (0.5

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mmol), ethyl 2-(bromomethyl)acrylate (**5**) (0.128 g, 0.65 mmol), and indium powder (0.226 g, 2.0 mmol) in a saturated aqueous NaBr solution (5 mL) was stirred for 48 h at 23 °C. Then the resulting mixture was hydrolyzed with water (10 mL), extracted with EtOAc (3 × 10 mL), dried over anhydrous $MgSO_4$, and evaporated (15 Torr). The resulting residue was purified by column chromatography (silica gel, hexane/EtOAc) to yield the pure product **6**. Yields and physical and spectroscopic data follow.

*(4R,S$_S$)-Ethyl N-(tert-Butylsulfinyl)-4-amino-5-(2-bromophenyl)-2-methylenepentanoate (**6a**).* The general procedure was followed using imine **4a** (302 mg, 1 mmol). Purification by column chromatography (hexane/AcOEt, 2:1) yielded **6a** (272 mg, 65%) as a colorless oil. $[\alpha]_D^{23}$ +2 (*c* 1.01, CH_2Cl_2); R_f 0.45 (AcOEt); IR ν (film) 3220, 1714, 1472, 1045 cm^{-1}; δ_H 7.52 (dd, *J* = 8.0, 0.9 Hz, 1H), 7.25 (d, *J* = 7.6, 2.2 Hz, 1H), 7.22 (d, *J* = 7.6, 1.2 Hz, 1H), 7.07 (ddd, *J* = 8.0, 6.9, 2.3 Hz, 1H), 6.35 (d, *J* = 1.3 Hz, 1H), 5.74 (d, *J* = 1.1 Hz, 1H), 4.22 (q, *J* = 7.1 Hz, 2H), 3.89−3.78 (m, 1H), 3.60 (br d, *J* = 7.0 Hz, 1H), 2.96 (dd, *J* = 13.8, 5.7 Hz, 1H), 2.89 (dd, *J* = 13.8, 8.8 Hz, 1H), 2.83 (dd, *J* = 14.0, 7.1 Hz, 1H), 2.64 (ddd, *J* = 14.1, 5.8, 0.6 Hz, 1H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.04 (s, 9H); δ_C 167.4 (C), 138.2 (C), 137.0 (C), 133.0 (CH), 132.0 (CH), 128.9 (CH_2), 128.3 (CH), 127.4 (CH), 125.2 (C), 61.2 (CH_2), 56.7 (CH), 56.0 (C), 42.2 (CH_2), 38.9 (CH_2), 22.6 (CH_3), 14.3 (CH_3); LRMS (EI) *m*/*z* (%) 361 ([M(^{81}Br) − C_4H_8]$^+$, 2), 281 (16), 270 (21), 268 (18), 262 (15), 247 (73), 245 (70), 208 (14), 207 (62), 191 (15), 190 (100), 184 (40), 182 (38), 174 (89), 172 (18), 171 (43), 169 (45), 166 (27), 144 (22), 143 (15), 142 (96), 129 (11), 128 (35), 118 (31), 117 (24), 116 (21), 115 (25), 112 (11), 100 (37), 96 (19), 91 (37), 90 (33), 89 (31), 87 (20), 69 (33), 63 (10), 59 (10); HRMS (EI) calcd for $C_{14}H_{18}{}^{81}BrNO_3S$ ([M − C_4H_8]$^+$) 361.0170, found 361.0161.

*(4S,S$_S$)-Ethyl N-(tert-Butylsulfinyl)-4-amino-6-(2-bromophenyl)-2-methylenehexanoate (**6b**).* The general procedure was followed using imine **4b** (316 mg, 1 mmol). Purification by column chromatography (hexane/AcOEt, 2:1) yielded **6b** (324 mg, 75%) as a colorless oil. $[\alpha]_D^{23}$ +40 (*c* 1.01, CH_2Cl_2); R_f 0.66 (AcOEt); IR ν (film) 3276, 1714, 1471, 1370, 1046 cm^{-1}; δ_H 7.52 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.19−7.26 (m, 2H), 7.06 (ddd, *J* = 8.1, 6.7, 2.4 Hz, 1H), 6.32 (d, *J* = 1.3 Hz, 1H), 5.72 (d, *J* = 1.0 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.71 (br d, *J* = 6.4 Hz, 1H), 3.45−3.61 (m, 1H), 2.91 (ddd, *J* = 13.5, 11.1, 5.0 Hz, 1H), 2.69−2.78 (m, 2H), 2.65 (dd, *J* = 14.2, 5.6 Hz, 1H), 1.84 (ddd, *J* = 13.9, 10.8, 5.4 Hz, 1H), 1.66−1.77 (m, 1H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.25 (s, 9H); δ_C 167.5 (C), 141.2 (C), 137.1 (C), 132.9 (CH), 130.4 (CH), 128.6 (CH_2), 127.8 (CH), 127.7 (CH), 124.4 (C), 61.2 (CH_2), 56.1 (C), 55.5 (CH), 38.7 (CH_2), 35.9 (CH_2), 32.6 (CH_2), 22.9 (CH_3), 14.27 (CH_3); LRMS (EI) *m*/*z* (%) 375 ([M(^{81}Br) − C_4H_8]$^+$, 2), 294 (13), 261 (81), 260 (10), 259 (78), 197 (57), 195 (57), 191 (13), 171 (100), 170 (10), 169 (100), 142 (11), 132 (43), 130 (11), 117 (53), 116 (12), 115 (28), 104 (10), 103 (11), 91 (14), 90 (20), 89 (13), 87 (25), 77 (16), 69 (13); HRMS (ESI) calcd for $C_{19}H_{29}{}^{79}BrNO_3S$ ([M + H]$^+$) 430.1052, found 430.1054.

*(4S,S$_S$)-Ethyl N-(tert-Butylsulfinyl)-4-amino-7-(2-bromophenyl)-2-methyleneheptanoate (**6c**).* The general procedure was followed using imine **4c** (304 mg, 0.92 mmol). Purification by column chromatography (hexane/AcOEt, 2:1) yielded **6c** (306 mg, 74%) as a colorless oil. $[\alpha]_D^{23}$ +39 (*c* 1.01, CH_2Cl_2); R_f 0.67 (AcOEt); IR ν (film) 3228, 2978, 1712, 1174, 1049, 751 cm^{-1}; δ_H 7.52 (dd, *J* = 7.9, 1.1 Hz, 1H), 7.24−7.16 (m, 2H), 7.05 (ddd, *J* = 8.0, 6.9, 2.3 Hz, 1H), 6.30 (d, *J* = 1.3 Hz, 1H), 5.69 (d, *J* = 1.1 Hz, 1H), 4.21 (q, *J* = 7.1 Hz, 2H), 3.60 (d, *J* = 5.9 Hz, 1H), 3.54−3.42 (m, 1H), 2.72 (t, *J* = 7.6 Hz, 2H), 2.61 (br d, *J* = 6.2 Hz, 2H), 1.82−1.48 (m, 4H), 1.31 (t, *J* = 7.1 Hz, 3H), 1.19 (s, 9H); δ_C 167.6 (C), 141.5 (C), 137.2 (C), 132.9 (CH), 130.4 (CH), 128.5 (CH_2), 127.7 (CH), 127.5 (CH), 124.5 (C), 61.2 (CH_2), 55.9 (C), 55.2 (CH), 38.3 (CH_2), 36.1 (CH_2), 35.1 (CH_2), 25.9 (CH_2), 22.9 (CH_3), 14.3 (CH_3); LRMS (EI) *m*/*z* (%) 389 ([M(^{81}Br) − C_4H_8]$^+$, 4), 275 (35), 273 (36), 211 (43), 209 (48), 207 (10), 187 (10), 174 (11), 171 (22), 169 (24), 146 (11), 132 (11), 131 (100), 130 (16), 115 (23), 104 (19), 103 (11), 91 (21), 90 (12), 87 (18), 77 (12), 69 (13); HRMS (EI) calcd for $C_{16}H_{22}{}^{81}BrNO_3S$ ([M − C_4H_8]$^+$) 387.0504, found 387.0490.

General Procedure for the Synthesis of α-Methylene-γ-butyrolactams 7. To a solution of the corresponding amino ester **6** (0.2 mmol) in MeOH (1 mL) was added a 4 M HCl dioxane solution (0.5 mL) at 0 °C. After 2 h of stirring at the same temperature, a 2 M NaOMe MeOH solution (2 mL) was added, and the resulting mixture was stirred for 1 h at 0 °C. After that, it was hydrolyzed with water (10 mL), extracted with EtOAc (3 × 10 mL), dried over anhydrous $MgSO_4$, and evaporated (15 Torr). The resulting residue was purified by column chromatography (silica gel, hexane/EtOAc) to yield the pure product **7**. Yields and physical and spectroscopic data follow.

*(R)-5-(2-Bromobenzyl)-3-methylenepyrrolidin-2-one (**7a**).* The general procedure was followed using amino ester derivative **6a** (129 mg, 0.31 mmol). Purification by column chromatography (hexane/AcOEt, 1:1) yielded **7a** (62 mg, 75%) as a colorless oil. $[\alpha]_D^{23}$ −60 (*c* 0.85, CH_2Cl_2); R_f 0.57 (AcOEt); IR ν (film) 3210, 1694, 1658, 1439 cm^{-1}; δ_H 7.58 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.28 (dd, *J* = 7.3, 1.3 Hz, 1H), 7.21 (dd, *J* = 7.6, 2.0 Hz, 1H), 7.13 (ddd, *J* = 7.9, 7.2, 2.0 Hz, 1H), 6.42 (br s, 1H), 6.01 (t, *J* = 2.7 Hz, 1H), 5.37 (t, *J* = 2.3 Hz, 1H), 4.08−3.99 (m, 1H), 3.04 (dd, *J* = 13.5, 5.8 Hz, 1H), 2.99 (ddt, *J* = 17.1, 7.8, 2.6 Hz, 1H), 2.86 (dd, *J* = 13.5, 8.0 Hz, 1H), 2.61 (ddt, *J* = 17.1, 4.0, 2.6 Hz, 1H); δ_C 170.2 (C), 138.9 (C), 136.7 (C), 133.4 (CH), 131.5 (CH), 128.9 (CH), 127.9 (CH), 124.8 (C), 116.7 (CH_2), 50.8 (CH), 43.5 (CH_2), 32.9 (CH_2); LRMS (EI) *m*/*z* (%) 267 ([M(^{81}Br)]$^+$, 1), 96 (100), 53 (14); HRMS (ESI) calcd for $C_{12}H_{13}{}^{79}BrNO$ ([M + H]$^+$) 266.0181, found 266.0192.

*(S)-5-(2-Bromophenylethyl)-3-methylenepyrrolidin-2-one (**7b**).* The general procedure was followed using amino ester derivative **6b** (202 mg, 0.47 mmol). Purification by column chromatography (hexane/AcOEt, 1:1) yielded **7b** (124 mg, 94%) as a colorless oil. $[\alpha]_D^{23}$ −25 (*c* 0.91, CH_2Cl_2); R_f 0.46 (AcOEt); IR ν (film) 3203, 1693, 1658, 1299, 1022, 924 cm^{-1}; δ_H 7.53 (d, *J* = 7.8 Hz, 1H), 7.42 (br s, 1H), 7.26−7.21 (m, 1H), 7.12−7.03 (m, 1H), 5.99 (q, *J* = 2.4 Hz, 1H), 5.36 (t, *J* = 2.3 Hz, 1H), 3.77−3.66 (m, 1H), 3.02 (ddt, *J* = 17.1, 7.8, 2.5 Hz, 1H), 2.80 (t, *J* = 8.0 Hz, 2H), 2.54 (ddt, *J* = 17.2, 4.3, 2.7 Hz, 1H), 1.92−1.79 (m, 2H); δ_C 170.9 (C), 140.4 (C), 139.5 (C), 133.0 (CH), 130.5 (CH), 128.1 (CH), 127.8 (CH), 124.4 (C), 116.2 (CH_2), 51.0 (CH), 37.5 (CH_2), 33.1 (CH_2), 32.4 (CH_2); LRMS (EI) *m*/*z* (%) 200 ([M − Br]$^+$, 81), 201 (14), 97 (10), 96 (100), 53 (15); HRMS (ESI) calcd for $C_{13}H_{15}{}^{79}BrNO$ ([M + H]$^+$) 280.0337, found 280.0333.

*(S)-5-(3-Bromophenylpropyl)-3-methylenepyrrolidin-2-one (**7c**).* The general procedure was followed using amino ester derivative **6c** (115 mg, 0.26 mmol). Purification by column chromatography (hexane/AcOEt, 1:1) yielded **7c** (71 mg, 93%) as a white solid. Mp 59−61 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −17 (*c* 0.91, CH_2Cl_2); R_f 0.51 (AcOEt); IR ν (KBr) 3199, 1694, 1658, 1439, 1291, 749 cm^{-1}; δ_H 7.53 (dd, *J* = 8.0, 0.9 Hz, 1H), 7.25−7.18 (m, 2H), 7.06 (ddd, *J* = 8.0, 6.9, 2.2 Hz, 1H), 6.94 (br s, 1H), 5.97 (t, *J* = 2.8 Hz, 1H), 5.34 (s, 1H), 3.73−3.64 (m, 1H), 2.98 (dd, *J* = 17.1, 7.8 Hz, 1H), 2.76 (t, *J* = 7.5 Hz, 2H), 2.45 (ddt, *J* = 17.1, 4.3, 2.7 Hz, 1H), 1.73−1.50 (m, 4H); δ_C 170.6 (C), 141.1 (C), 139.4 (C), 133.0 (CH), 130.5 (CH), 127.9 (CH), 127.6 (CH), 124.5 (C), 116.2 (CH_2), 51.2 (CH), 37.0 (CH_2), 36.0 (CH_2), 33.2 (CH_2), 26.0 (CH_2); LRMS (EI) *m*/*z* (%) 295 ([M(^{81}Br)]$^+$, 1), 214 (59), 171 (5), 169 (5), 96 (100), 53 (12); HRMS (EI) calcd for $C_{14}H_{16}{}^{81}BrNO$ 295.0395, found 295.0390.

General Procedure for the Synthesis of Tricyclic Compounds 8 from α-Methylene-γ-butyrolactams 7. A mixture of the corresponding α-methylene-γ-butyrolactam **7** (0.3 mmol), CuI (4.6 mg, 0.024 mmol), K_2CO_3 (83 mg, 0.6 mmol), and *N*,*N*′-dimethylethylenediamine (5.6 mg, 7 μL, 0.048 mmol) in dry dioxane (0.75 mL) was stirred at 100 °C under Ar for 20 h in a high-pressure tube. Then the resulting mixture was cooled to room temperature, hydrolyzed with H_2O (5 mL), extracted with AcOEt (3 × 10 mL), dried over anhydrous $MgSO_4$, and evaporated (15 Torr). The resulting residue was purified by column chromatography (silica gel, hexane/EtOAc) to yield the pure product **8**. Yields and physical and spectroscopic data follow.

*(S)-2-Methylene-9,9a-dihydro-1H-pyrrolo[1,2-a]indol-3(2H)-one (**8a**).*[30] The general procedure was followed using lactam **7a** (42 mg, 0.16 mmol). Purification by column chromatography (hexane/AcOEt,

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3:1) yielded **8a** (15 mg, 52%) as a white solid. Mp 76−78 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +285 (*c* 1.09, CH_2Cl_2); R_f 0.24 (hexane/AcOEt: 3/1); IR ν (KBr) 1686, 1657, 1602, 1480, 1410, 757 cm^{-1}; δ_H 7.68 (d, *J* = 7.8 Hz, 1H), 7.26−7.19 (m, 2H), 7.07 (t, *J* = 7.5 Hz, 1H), 6.07 (dd, *J* = 3.4, 1.6 Hz, 1H), 5.42 (dd, *J* = 2.9, 1.4 Hz, 1H), 4.65−4.55 (m, 1H), 3.21 (dd, 15.7, 8.2 Hz, 1H), 3.24−3.14 (m, 2H), 2.90 (dd, *J* = 15.4, 10.7 Hz, 1H), 2.78−2.68 (m, 1H); δ_C 164.4 (C), 143.7 (C), 139.7 (C), 134.1 (C), 128.0 (CH), 125.4 (CH), 124.8 (CH), 117.1 (CH_2), 115.2 (CH), 60.2 (CH), 36.3 (CH_2), 34.2 (CH_2); LRMS (EI) *m*/*z* (%) 185 (M^+, 100), 186 (14), 184 (18), 157 (16), 156 (32), 117 (42), 90 (14), 89 (16), 68 (14); HRMS (ESI) calcd for $C_{12}H_{12}NO$ ($[M + H]^+$) 186.0919, found 186.0915.

*(S)-2-Methylene-3,3a,4,5-tetrahydropyrrolo[1,2-a]quinolin-1(2H)-one (**8b**).* The general procedure was followed using lactam **7b** (89 mg, 0.318 mmol). Purification by column chromatography (hexane/AcOEt, 4:1) yielded **8b** (34 mg, 54%) as a white solid. Mp 88−92 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +150 (*c* 1.11, CH_2Cl_2); R_f 0.33 (hexane/AcOEt, 3:1); IR ν (KBr) 3062, 2843, 1681, 1655, 1390, 905, 745 cm^{-1}; δ_H 8.71 (d, *J* = 8.3 Hz, 1H), 7.23 (t, *J* = 7.8 Hz, 1H), 7.14 (d, *J* = 7.5 Hz, 1H), 7.05 (td, *J* = 7.5, 1.1 Hz, 1H), 6.10 (t, *J* = 2.8 Hz, 1H), 5.40 (t, *J* = 2.4 Hz, 1H), 3.93−3.84 (m, 1H), 3.06 (ddt, *J* = 16.8, 7.6, 2.1 Hz, 1H), 3.01−2.94 (m, 1H), 2.93−2.85 (m, 1H), 2.49 (ddt, *J* = 16.9, 6.3, 3.1 Hz, 1H), 2.23−2.16 (m, 1H), 1.75 (ddd, *J* = 25.0, 12.7, 5.6 Hz, 1H); δ_C 166.3 (C), 139.6 (C), 136.8 (C), 129.3 (CH), 126.9 (CH), 126.3 (C), 124.1 (CH), 120.0 (CH), 116.5 (CH_2), 54.7 (CH), 31.4 (CH_2), 29.6 (CH_2), 27.7 (CH_2); LRMS (EI) *m*/*z* (%) 199 (M^+, 100), 200 (14), 198 (43), 170 (39), 131 (24), 130 (26); HRMS (EI) calcd for $C_{13}H_{13}NO$ 199.0997, found 199.0983.

*(S)-2-Methylene-2,3,3a,4,5,6-hexahydro-1H-benzo[f]pyrrolo[1,2-a]azepin-1-one (**8c**).* The general procedure was followed using lactam **7c** (67 mg, 0.228 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **8c** (13 mg, 27%) as a white solid. Mp 101−103 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −31 (*c* 1.03, CH_2Cl_2); R_f 0.17 (hexane/AcOEt, 3:1); IR ν (KBr) 2931, 1689, 1659, 1494, 1402 cm^{-1}; δ_H 7.35 (dd, *J* = 7.5, 1.1 Hz, 1H), 7.29−7.14 (m, 3H), 6.13 (t, *J* = 2.8 Hz, 1H), 5.45 (ddd, *J* = 2.6, 1.7, 0.7 Hz, 1H), 3.63−3.53 (m, 1H), 3.16 (ddt, *J* = 16.7, 8.7, 3.3 Hz, 1H), 2.83−2.66 (m, 2H), 2.51 (ddd, *J* = 16.8, 3.6, 1.8 Hz, 1H), 2.08−1.94 (m, 2H), 1.74−1.55 (m, 1H), 1.54−1.36 (m, 1H); δ_C 167.5 (C), 139.4 (C), 139.3 (C), 138.7 (C), 130.3 (CH), 127.4 (CH), 127.2 (CH), 127.1 (CH), 117.0 (CH_2), 58.3 (CH), 39.5 (CH_2), 35.2 (CH_2), 33.8 (CH_2), 25.8 (CH_2); LRMS (EI) *m*/*z* (%) 213 (M^+, 100), 214 (15), 212 (45), 198 (14), 185 (11), 184 (33), 156 (15), 145 (10), 144 (18), 117 (23), 68 (10); HRMS (EI) calcd for $C_{14}H_{16}NO$ 214.1232, found 214.1223.

General Procedure for the Synthesis of Homoallylamine Derivatives 9 from Imines 4. A mixture of the corresponding *N*-*tert*-butylsulfinyl imine **4** (1.0 mmol), allyl bromide (166 mg, 0.132 mL, 1.5 mmol), and indium (144 mg, 1.25 mmol) in dry THF (3 mL) was stirred for 6 h at 60 °C. Then the resulting mixture was hydrolyzed with H_2O (5 mL), and the solution was extracted with AcOEt (3 × 5 mL). The combined organic phases were washed with brine (3 × 10 mL), dried with anhydrous $MgSO_4$, and evaporated (15 Torr). The residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield the product **9**. Yields and physical and spectroscopic data follow.

*(2R,S$_S$)-1-(2-Bromophenyl)-N-(tert-butylsulfinyl)pent-4-en-2-amine (**9a**).*[23] The general procedure was followed using imine **4a** (453 mg, 1.5 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9a** (378 mg, 73%) as a yellow solid. Mp 42−45 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +9 (*c* 1.08, CH_2Cl_2); R_f 0.32 (hexane/AcOEt, 1:1); IR ν (KBr) 3216, 1736, 1472, 1045, 1024, 912, 749 cm^{-1}; δ_H 7.53 (d, *J* = 8.5 Hz, 1H), 7.21−7.25 (m, 2H), 7.03−7.11 (m, 1H), 5.79−5.93 (m, 1H), 5.18−5.25 (m, 2H), 3.63−3.72 (m, 1H), 3.34 (br d, *J* = 6.9 Hz, 1H), 2.95 (dd, *J* = 7.2, 5.5 Hz, 2H), 2.48 (t, *J* = 6.7 Hz, 2H), 1.06 (s, 9H); δ_C 138.3 (C), 133.9 (CH), 133.0 (CH), 132.0 (CH), 128.3 (CH), 127.4 (CH), 125.2 (C), 119.5 (CH_2), 56.2 (CH), 56.0 (C), 41.8 (CH_2), 40.7 (CH_2), 22.6 (CH_3); LRMS (EI) *m*/*z* (%) 247 (3), 245 (3), 208 (9), 184 (8), 182 (8), 171 (11), 169 (11), 118 (100), 91 (11), 90 (11), 89 (10).

*(3S,S$_S$)-1-(2-Bromophenyl)-N-(tert-butylsulfinyl)hex-5-en-3-amine (**9b**).*[23] The general procedure was followed using imine **4b** (221 mg, 0.70 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9b** (202 mg, 81%) as a colorless oil. $[\alpha]_D^{23}$ +43 (*c* 0.95, CH_2Cl_2); R_f 0.34 (hexane/AcOEt, 1:1); IR ν (film) 3215, 1471, 1439, 1052, 1022, 749 cm^{-1}; δ_H 7.52 (d, *J* = 7.9 Hz, 1H), 7.19−7.26 (m, 2H), 7.03−7.09 (m, 1H), 5.75−5.87 (m, 1H), 5.15−5.22 (m, 2H), 3.37−3.46 (m, 1H), 3.33 (br d, *J* = 6.6 Hz, 1H), 2.89 (ddd, *J* = 13.5, 11.1, 5.1 Hz, 1H), 2.73 (ddd, *J* = 13.5, 11.1, 5.7 Hz, 1H), 2.39−2.55 (m, 2H), 1.70−1.91 (m, 2H), 1.25 (s, 9H); δ_C 141.3 (ArC), 134.0 (CH), 133.0 (CH), 130.4 (CH), 127.9 (CH), 127.7 (CH), 124.5 (ArC), 119.4 (CH_2), 56.1 (C), 55.1 (CH), 40.7 (CH_2), 35.5 (CH_2), 32.7 (CH_2), 22.9 (CH_3); LRMS (EI) *m*/*z* (%) 261 (29), 259 (29), 222 (46), 197 (37), 195 (37), 172 (16), 171 (97), 169 (100), 132 (39), 118 (23), 117 (49), 115 (10), 104 (12), 103 (14), 102 (15), 91 (24), 90 (28), 89 (17), 77 (26), 70 (21).

*(4S,S$_S$)-7-(2-Bromophenyl)-N-(tert-butylsulfinyl)hept-1-en-4-amine (**9c**).*[23] The general procedure was followed using imine **4c** (300 mg, 0.91 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9c** (318 mg, 94%) as a colorless oil. $[\alpha]_D^{23}$ +40 (*c* 1.06, CH_2Cl_2); R_f 0.44 (hexane/AcOEt, 1:1); IR ν (film) 3217, 1471, 913, 750 cm^{-1}; δ_H 7.50−7.56 (m, 1H), 7.16−7.26 (m, 2H), 7.01−7.10 (m, 1H), 5.70−5.86 (m, 1H), 5.11−5.20 (m, 2H), 3.31−3.41 (m, 1H), 3.22 (br d, *J* = 6.0 Hz, 1H), 2.72 (t, *J* = 7.6 Hz, 2H), 2.38−2.46 (m, 1H), 2.27−2.37 (m, 1H), 1.51−1.78 (m, 4H), 1.20 (s, 9H); δ_C 141.5 (C), 134.2 (CH), 132.9 (CH), 130.4 (CH), 127.7 (CH), 127.5 (CH), 124.5 (C), 119.1 (CH_2), 55.9 (C), 54.7 (CH), 40.5 (CH_2), 36.2 (CH_2), 34.7 (CH_2), 25.9 (CH_2), 22.8 (CH_3); LRMS (EI) *m*/*z* (%) 317 (20), 315 (19), 275 (11), 273 (11), 224 (10), 211 (29), 209 (30), 171 (25), 169 (25), 146 (12), 132 (11), 131 (100), 130 (18), 118 (24), 115 (16), 104 (29), 103 (18), 102 (15), 91 (40), 90 (21), 89 (16), 77 (25), 70 (14), 56 (15), 55 (10).

General Procedure for the Synthesis of Homoallylamine Derivatives 9 from 2-Bromophenyl Aldehydes. A mixture of indium powder (173 mg, 1.50 mmol), (*S*)-*tert*-butanesulfinamide (121 mg, 1.00 mmol), the corresponding 2-bromophenyl aldehyde (1.15 mmol), and $Ti(OEt)_4$ (456 mg, 0.450 mL, 2.00 mmol) in THF (2 mL) was stirred under Ar for 1 h at 23 °C. At this time, allyl bromide (166 mg, 0.132 mL, 1.5 mmol) was added, and the reaction mixture was heated for 5 h at 60 °C. The mixture was allowed to cool to room temperature, quenched with brine (2 mL), and diluted with EtOAc. The resulting suspension was filtered through a short pad of Celite and concentrated in vacuo (15 Torr). The residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield the product **9**. Yields follow.

*(2R,S$_S$)-1-(2-Bromophenyl)-N-(tert-butylsulfinyl)pent-4-en-2-amine (**9a**).*[23] The general procedure was followed using (2-bromophenyl)acetaldehyde (995 mg, 5.0 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9a** (1.07 g, 62%) as a yellow solid.

*(3S,S$_S$)-1-(2-Bromophenyl)-N-(tert-butylsulfinyl)hex-5-en-3-amine (**9b**).*[23] The general procedure was followed using 3-(2-bromophenyl)-propanal (782 mg, 3.67 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9b** (1.04 g, 80%) as a colorless oil.

*(4S,S$_S$)-7-(2-Bromophenyl)-N-(tert-butylsulfinyl)hept-1-en-4-amine (**9c**).*[23] The general procedure was followed using 4-(2-bromophenyl)butanal (1.16 g, 5.11 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **9c** (1.51 g, 80%) as a colorless oil.

General Procedure for the Synthesis of Homoallylamines 10 from Homoallylamine Derivatives 9. To a solution of the corresponding homoallylamine derivative **9** (0.5 mmol) in dry THF (1 mL) at 0 °C was added HCl (6 M solution, 0.25 mL, 1.5 mmol). The reaction mixture was stirred at room temperature for 1 h, and then cooled to 0 °C. NaOH (4 M solution, 1 mL, 4 mmol) was added, and the mixture was diluted with AcOEt (10 mL). The aqueous phase was extracted with AcOEt (2 × 10 mL), and then the organic phases were washed with H_2O (10 mL), dried with anhydrous $MgSO_4$, and evaporated (15 Torr) to yield the free amine **10**. Yields and physical and spectroscopic data follow.

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*(R)-1-(2-Bromophenyl)pent-4-en-2-amine (**10a**).* The general procedure was followed using sulfinamide **9a** (688 mg, 2.0 mmol). Removal of the solvents at low pressure yielded **10a** (475 mg, 97%) as a yellow oil. $[\alpha]_D^{23}$ −10 (*c* 1.11, CH_2Cl_2); R_f 0.41 (CH_2Cl_2/MeOH, 9:1); IR ν (film) 2923, 2856, 1470, 1438 cm^{-1}; δ_H 7.55 (d, *J* = 7.8 Hz, 1H), 7.26−7.22 (m, 2H), 7.12−7.05 (m, 1H), 5.84 (dddd, *J* = 16.8, 10.2, 7.9, 6.4 Hz, 1H), 5.20−5.08 (m, 2H), 3.19 (tt, *J* = 8.2, 4.9 Hz, 1H), 2.95 (dd, *J* = 13.4, 5.0 Hz, 1H), 2.64 (dd, *J* = 13.4, 8.4 Hz, 1H), 2.31 (dddt, *J* = 13.8, 6.3, 4.7, 1.4 Hz, 1H), 2.18−2.05 (m, 1H), 1.47 (br s, 2H); δ_C 139.1 (C), 135.6 (CH), 133.1 (CH), 131.7 (CH), 128.1 (CH), 127.4 (CH), 125.0 (C), 117.9 (CH_2), 50.6 (CH), 44.3 (CH_2), 42.1 (CH_2); LRMS (EI) *m*/*z* (%) 200 ([M(^{81}Br) − C_3H_5]$^+$, 22), 198 (22), 119 (16), 118 (11), 91 (11), 70 (100); HRMS (ESI) calcd for $C_{11}H_{15}{}^{79}BrN$ ([M + H]$^+$) 240.0388, found 240.0379.

*(S)-1-(2-Bromophenyl)hex-5-en-3-amine (**10b**).* The general procedure was followed using sulfinamide **9b** (573 mg, 1.50 mmol). Removal of the solvents at low pressure yielded **10b** (380 mg, 100%) as a colorless oil. $[\alpha]_D^{23}$ −7 (*c* 1.16, CH_2Cl_2); R_f 0.37 (CH_2Cl_2/MeOH, 9:1); IR ν (film) 2917, 1470, 1438, 1022, 913, 747 cm^{-1}; δ_H 7.52 (d, *J* = 7.8 Hz, 1H), 7.24−7.21 (m, 2H), 7.11−7.00 (m, 1H), 5.89−5.73 (m, 1H), 5.16−5.11 (m, 1H), 5.10−5.08 (m, 1H), 2.93−2.71 (m, 3H), 2.36−2.25 (m, 1H), 2.12−1.97 (m, 1H), 1.75 (dddd, *J* = 13.5, 10.8, 5.9, 5.0 Hz, 1H), 1.66−1.53 (m, 1H), 1.46 (br d, *J* = 0.8 Hz, 2H); δ_C 141.7 (C), 135.7 (CH), 132.9 (CH), 130.4 (CH), 127.7 (CH), 127.6 (CH), 124.5 (C), 117.7 (CH_2), 50.5 (CH), 42.7 (CH_2), 38.0 (CH_2), 33.1 (CH_2); LRMS (EI) *m*/*z* (%) 214 ([M(^{81}Br) − C_3H_5]$^+$, 98), 213 (12), 212 (100), 197 (8), 195 (8), 171 (77), 169 (78), 90 (13), 70 (19); HRMS (ESI) calcd for $C_{12}H_{17}{}^{79}BrN$ ([M + H]$^+$) 254.0544, found 254.0537.

*(S)-7-(2-Bromophenyl)hept-1-en-4-amine (**10c**).* The general procedure was followed using sulfinamide **9c** (502 mg, 1.35 mmol). Removal of the solvents at low pressure yielded **10c** (357 mg, 99%) as a colorless oil. $[\alpha]_D^{23}$ −4 (*c* 1.01, CH_2Cl_2); R_f 0.34 (CH_2Cl_2/MeOH, 9:1); IR ν (film) 2925, 1470, 1437, 1022, 913 cm^{-1}; δ_H 7.53−7.50 (m, 1H), 7.23−7.20 (m, 2H), 7.08−7.01 (m, 1H), 5.85−5.73 (m, 1H), 5.12−5.06 (m, 2H), 2.88−2.79 (m, 1H), 2.79−2.67 (m, 2H), 2.30−2.20 (m, 1H), 2.06−1.94 (m, 1H), 1.79−1.58 (m, 2H), 1.57−1.34 (m, 4H); δ_C 141.8 (C), 135.8 (CH), 132.9 (CH), 130.4 (CH), 127.6 (CH), 127.5 (CH), 124.5 (C), 117.5 (CH_2), 50.5 (CH), 42.6 (CH_2), 37.3 (CH_2), 36.3 (CH_2), 26.7 (CH_2); LRMS (EI) *m*/*z* (%) 214 ([M(^{81}Br) − C_3H_5]$^+$, 99), 227 (12), 226 (100), 169 (11), 130 (39), 129 (12), 104 (14), 70 (23), 56 (12); HRMS (ESI) calcd for $C_{13}H_{19}{}^{79}BrN$ ([M + H]$^+$) 268.0701, found 268.0691.

General Procedure for the Synthesis of Acrylamides 11 from Homoallylamine Derivatives 9. To a solution of the corresponding homoallylamine derivative **9** (0.5 mmol) in dry THF (1 mL) at 0 °C was added HCl (6 M solution, 0.25 mL, 1.5 mmol). The reaction mixture was stirred at room temperature for 1 h and then cooled to 0 °C. NaOH (4 M solution, 1 mL, 4 mmol) was added, and after 5 min, CH_2Cl_2 (1.5 mL) and acryloyl chloride (54 mg, 51 μL, 0.6 mmol) were also added. The resulting reaction mixture was stirred for 30 min at room temperature and then diluted with AcOEt (15 mL). The aqueous phase was extracted with AcOEt (2 × 15 mL), and then the organic phases were washed with H_2O (10 mL), dried with anhydrous $MgSO_4$, and evaporated (15 Torr). The residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield the product **11**. Yields and physical and spectroscopic data follow.

*(R)-N-Acryloyl-1-(2-bromophenyl)pent-4-en-2-amine (**11a**).* The general procedure was followed using sulfinamide **9a** (473 mg, 1.38 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **11a** (281 mg, 69%) as a white solid. Mp 81−83 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −18 (*c* 1.04, CH_2Cl_2); R_f 0.56 (hexane/AcOEt, 1:1); IR ν (KBr) 3215, 1471, 1439, 1052, 1022, 749 cm^{-1}; δ_H 7.52 (dd, *J* = 7.9, 1.0 Hz, 1H), 7.29−7.19 (m, 2H), 7.06 (ddd, *J* = 8.0, 6.9, 2.2 Hz, 1H), 6.19 (dd, *J* = 17.0, 1.6 Hz, 1H), 6.02 (dd, *J* = 17.0, 10.1 Hz, 1H), 5.92−5.73 (m, 1H), 5.76 (br d, *J* = 6.7 Hz, 1H), 5.57 (dd, *J* = 10.1, 1.6 Hz, 1H), 5.17−5.07 (m, 2H), 4.47−4.33 (m, 1H), 2.99 (d, *J* = 7.2 Hz, 1H), 2.45−2.26 (m, 2H); δ_C 165.2 (C), 137.9 (C), 134.2 (CH), 132.9 (CH), 131.3 (CH), 131.1 (CH), 128.3 (CH), 127.7 (CH), 126.3 (CH_2), 125.0 (C), 118.4 (CH_2), 49.9 (CH), 39.9 (CH_2), 38.8 (CH_2); LRMS (EI) *m*/*z* (%) 295 ([M(^{81}Br)]$^+$, 2), 254 (29), 252 (29), 214 (10), 200 (33), 198 (34), 124 (100), 91 (10), 90 (11), 89 (10), 70 (53), 55 (46); HRMS (ESI) calcd for $C_{14}H_{17}{}^{79}BrNO$ ([M + H]$^+$) 294.0494, found 294.0485.

*(S)-N-Acryloyl-1-(2-bromophenyl)hex-5-en-3-amine (**11b**).* The general procedure was followed using sulfinamide **9b** (179 mg, 0.50 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **11b** (230 mg, 84%) as a white solid. Mp 50−53 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +17 (*c* 1.05, CH_2Cl_2); R_f 0.56 (hexane/AcOEt, 1:1); IR ν (KBr) 3271, 1654, 1626, 1543, 1438 cm^{-1}; δ_H 7.51 (d, *J* = 7.8 Hz, 1H), 7.25−7.20 (m, 2H), 7.10−7.00 (m, 1H), 6.29 (dd, *J* = 17.0, 1.6 Hz, 1H), 6.11 (dd, *J* = 17.0, 10.1 Hz, 1H), 5.88−5.71 (m, 1H), 5.64 (dd, *J* = 10.1, 1.6 Hz, 1H), 5.59 (br d, *J* = 8.8 Hz, 1H), 5.15−5.04 (m, 2H), 4.19 (m, 1H), 2.88−2.67 (m, 2H), 2.42−2.22 (m, 2H), 1.87 (dddd, *J* = 10.4, 6.2, 5.5, 3.7 Hz, 1H), 1.79−1.62 (m, 1H); δ_C 165.3 (C), 141.0 (C), 134.1 (CH), 132.9 (CH), 131.2 (CH), 130.6 (CH), 127.9 (CH), 127.7 (CH), 126.5 (CH_2), 124.3 (C), 118.3 (CH_2), 48.7 (CH), 39.3 (CH_2), 34.8 (CH_2), 33.0 (CH_2); LRMS (EI) *m*/*z* (%) 309 ([M(^{81}Br)]$^+$, 2), 307 (2), 269 (11), 268 (85), 267 (12), 266 (86), 215 (10), 214 (97), 213 (11), 212 (100), 197 (24), 195 (25), 171 (43), 169 (45), 132 (16), 125 (13), 116 (12), 115 (11), 90 (14), 89 (10), 84 (10), 77 (13), 72 (28), 7 (16), 55 (69); HRMS (ESI) calcd for $C_{15}H_{19}{}^{79}BrNO$ ([M + H]$^+$) 308.0650, found 308.0638.

*(S)-N-Acryloyl-7-(2-bromophenyl)hept-1-en-4-amine (**11c**).* The general procedure was followed using sulfinamide **9c** (155 mg, 0.42 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **11c** (111 mg, 83%) as a white solid. Mp 73−75 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −2.5 (*c* 1.02, CH_2Cl_2); R_f 0.57 (hexane/AcOEt, 1:1); IR ν (KBr) 3273, 2941, 1653, 1625, 1545, 748 cm^{-1}; δ_H 7.51 (d, *J* = 8.0 Hz, 1H), 7.23−7.16 (m, 2H), 7.04 (ddd, *J* = 8.0, 6.4, 2.7 Hz, 1H), 6.26 (dd, *J* = 16.9, 1.6 Hz, 1H), 6.07 (dd, *J* = 16.9, 10.2 Hz, 1H), 5.85−5.68 (m, 1H), 5.62 (dd, *J* = 10.2, 1.6 Hz, 1H), 5.45 (br d, *J* = 9.0 Hz, 1H), 5.13−5.02 (m, 2H), 4.22−4.07 (m, 1H), 2.82−2.65 (m, 2H), 2.37−2.16 (m, 2H), 1.75−1.39 (m, 4H); δ_C 165.2 (C), 141.5 (C), 134.2 (CH), 132.9 (CH), 131.2 (CH), 130.5 (CH), 127.7 (CH), 127.5 (CH), 126.4 (CH_2), 124.5 (C), 118.2 (CH_2), 48.5 (CH), 39.2 (CH_2), 36.0 (CH_2), 34.1 (CH_2), 26.4 (CH_2); LRMS (EI) *m*/*z* (%) 323 ([M(^{81}Br)]$^+$, 1), 282 (32), 280 (32), 228 (77), 226 (79), 211 (40), 209 (41), 171 (20), 169 (15), 152 (13), 130 (19), 129 (11), 124 (10), 91 (11), 90 (12), 72 (52), 70 (26), 56 (13), 55 (100); HRMS (ESI) calcd for $C_{16}H_{21}{}^{79}BrNO$ ([M + H]$^+$) 322.0807, found 322.0811.

General Procedure for the Synthesis of Pyridine-2-ones 12 from Acrylamides 11. A mixture of the corresponding acrylamide **11** (0.75 mmol) and Hoveyda−Grubbs ruthenium catalyst (19 mg, 0.0225 mmol) in dry CH_2Cl_2 (7.5 mL) was stirred at 40 °C under Ar for 3 h. Then the solvent was evaporated (15 Torr), and the resulting residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield the product **12**. Yields and physical and spectroscopic data follow.

*(R)-6-(2-Bromobenzyl)-5,6-dihydropyridin-2(1H)-one (**12a**).* The general procedure was followed using acrylamide **11a** (221 mg, 0.75 mmol). Purification by column chromatography (hexane/AcOEt, 3:2) yielded **12a** (164 mg, 82%) as a white solid. Mp 69−72 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −13 (*c* 1.02, CH_2Cl_2); R_f 0.47 (AcOEt); IR ν (KBr) 3220, 1672, 1609, 1470, 1426 cm^{-1}; δ_H 7.57 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.28 (td, *J* = 7.4, 1.2 Hz, 1H), 7.21 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.14 (td, *J* = 7.9, 1.8 Hz, 1H), 6.61 (ddd, *J* = 9.9, 4.9, 3.5 Hz, 1H), 5.94 (ddd, *J* = 9.9, 3.6, 2.0 Hz, 1H), 5.68 (br s, 1H), 4.00−3.91 (m, 1H), 3.06 (dd, *J* = 13.5, 6.0 Hz, 1H), 2.95 (dd, *J* = 13.5, 8.2 Hz, 1H), 2.45 (dt, *J* = 17.7, 5.3 Hz, 1H), 2.28 (dddd, *J* = 17.7, 9.5, 3.4, 2.3 Hz, 1H); δ_C 166.3 (C), 140.4 (CH), 136.3 (C), 133.5 (CH), 131.6 (CH), 129.0 (CH), 127.9 (CH), 124.9 (C), 124.7 (CH), 50.5 (CH), 41.7 (CH_2), 29.6 (CH_2); LRMS (EI) *m*/*z* (%) 171 ([M(^{81}Br) − C_5H_6NO]$^+$, 3), 169 (3), 97 (6), 96 (100), 95 (12), 78 (12), 68 (10); HRMS (ESI) calcd for $C_{12}H_{13}{}^{79}BrNO$ ([M + H]$^+$) 266.0181, found 266.0177.

*(S)-6-(2-Bromophenethyl)-5,6-dihydropyridin-2(1H)-one (**12b**).* The general procedure was followed using acrylamide **11b** (90 mg, 0.29 mmol). Purification by column chromatography (hexane/AcOEt, 3:2) yielded **12b** (61 mg, 75%) as a white solid. Mp 80−83 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +26 (*c* 0.70, CH_2Cl_2); R_f 0.38 (AcOEt); IR ν

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(KBr) 3220, 1672, 1610, 1470, 1422 cm^{-1}; δ_H 7.53 (d, J = 7.8 Hz, 1H), 7.24 (d, J = 4.1 Hz, 2H), 7.08 (dt, J = 8.0, 4.4 Hz, 1H), 6.61 (ddd, J = 9.9, 5.2, 3.3 Hz, 1H), 6.44 (br s, 1H), 5.93 (ddd, J = 9.9, 3.5, 2.1 Hz, 1H), 3.72−3.60 (m, 1H), 2.81 (ddd, J = 9.1, 6.9, 2.4 Hz, 2H), 2.46 (tt, J = 9.7, 4.9 Hz, 1H), 2.31−2.18 (m, 1H), 1.97−1.80 (m, 2H); δ_C 166.6 (C), 140.6 (CH), 140.3 (C), 133.0 (CH), 130.4 (CH), 128.1 (CH), 127.8 (CH), 124.6 (CH), 124.4 (C), 50.6 (CH), 35.6 (CH_2), 32.1 (CH_2), 29.8 (CH_2); LRMS (EI) m/z (%) 200 ([M − Br]$^+$, 54), 132 (10), 96 (100), 78 (10), 68 (11); HRMS (ESI) calcd for $C_{13}H_{15}{}^{79}BrNO$ ([M + H]$^+$) 280.0337, found 280.0330.

*(S)-6-[3-(2-Bromophenyl)propyl]-5,6-dihydropyridin-2(1H)-one (**12c**).* The general procedure was followed using acrylamide **11c** (129 mg, 0.40 mmol). Purification by column chromatography (hexane/AcOEt, 3:2) yielded **12c** (96 mg, 81%) as a colorless oil. $[\alpha]_D^{23}$ +33 (c 0.77, CH_2Cl_2); R_f 0.47 (AcOEt); IR ν (film) 3221, 2933, 1672, 1610, 749 cm^{-1}; δ_H 7.52 (dd, J = 8.0, 1.0 Hz, 1H), 7.26−7.18 (m, 2H), 7.06 (ddd, J = 7.9, 7.1, 2.1 Hz, 1H), 6.59 (ddd, J = 9.9, 5.3, 3.1 Hz, 1H), 6.04 (br s, 1H), 5.93−5.87 (m, 1H), 3.67−3.58 (m, 1H), 2.80−2.72 (m, 2H), 2.40 (dt, J = 17.7, 5.4 Hz, 1H), 2.20−2.10 (m, 1H), 1.74−1.55 (m, 4H); δ_C 166.6 (C), 141.0 (C), 140.7 (CH), 133.0 (CH), 130.4 (CH), 127.9 (CH), 127.6 (CH), 124.6 (CH), 124.4 (C), 50.9 (CH), 35.9 (CH_2), 35.0 (CH_2), 29.9 (CH_2), 25.8 (CH_2); LRMS (EI) m/z (%) 294 ([M(^{81}Br)]$^+$ − 1, 2), 292 (2), 267 (5), 265 (5), 214 (26), 96 (100); HRMS (ESI) calcd for $C_{14}H_{17}{}^{79}BrNO$ ([M + H]$^+$) 294.0473, found 294.0482.

General Procedure for the Synthesis of Tricyclic Compounds 13 from Pyridine-2-ones 12. A mixture of the corresponding pyridine-2-one **12** (0.3 mmol), CuI (4.6 mg, 0.024 mmol), K_2CO_3 (83 mg, 0.6 mmol), and *N*,*N*′-dimethylethylenediamine (5.6 mg, 7 μL, 0.048 mmol) in dry dioxane (0.75 mL) was stirred at 100 °C under Ar for 20 h in a high-pressure tube. Then the resulting mixture was cooled to room temperature, hydrolyzed with H_2O (5 mL), extracted with AcOEt (3 × 10 mL), dried over anhydrous $MgSO_4$, and evaporated (15 Torr). The resulting residue was purified by column chromatography (silica gel, hexane/EtOAc) to yield the pure product **13**. Yields and physical and spectroscopic data follow.

*(R)-9a,10-Dihydropyrido[1,2-a]indol-6(9H)-one (**13a**).* The general procedure was followed using pyridine-2-one **12a** (112 mg, 0.42 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **13a** (70 mg, 90%) as a white solid. Mp 93−96 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +89 (c 1.00, CH_2Cl_2); R_f 0.41 (hexane/AcOEt, 1:1); IR ν (KBr) 1650, 1587, 1478, 1416 cm^{-1}; δ_H 8.22 (d, J = 7.9 Hz, 1H), 7.26−7.19 (m, 2H), 7.03 (t, J = 7.5 Hz, 1H), 6.68 (ddd, J = 9.8, 6.4, 2.0 Hz, 1H), 6.10 (dd, J = 9.9, 3.0 Hz, 1H), 4.26−4.16 (m, 1H), 3.29 (dd, J = 15.5, 8.3 Hz, 1H), 2.88 (dd, J = 15.5, 10.9 Hz, 1H), 2.70 (dt, J = 17.63, 5.18 Hz, 1H), 2.45−2.34 (m, 1H); δ_C 162.3 (C), 142.4 (C), 139.1 (CH), 129.7 (C), 127.8 (CH), 126.8 (CH), 124.6 (CH), 123.7 (CH), 116.1 (CH), 57.8 (CH), 36.0 (CH_2), 31.1 (CH_2); LRMS (EI) m/z (%) 185 (M$^+$, 100), 186 (13), 156 (16), 118 (97), 117 (56), 90 (26), 89 (28), 68 (61), 63 (10); HRMS (ESI) calcd for $C_{12}H_{12}NO$ ([M + H]$^+$) 186.0919, found 186.0912.

*(S)-4,4a,5,6-Tetrahydro-1H-pyrido[1,2-a]quinolin-1-one (**13b**).* The general procedure was followed using pyridine-2-one **12b** (49 mg, 0.175 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **13b** (29 mg, 83%) as a white solid. Mp 58−60 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ +83 (c 0.81, CH_2Cl_2); R_f 0.44 (hexane/AcOEt, 1:1); IR ν (KBr) 3045, 2942, 1665, 1488, 1397, 1316 cm^{-1}; δ_H 8.06 (dd, J = 8.3, 0.8 Hz, 1H), 7.22−7.16 (m, 1H), 7.10−7.06 (m, 1H), 6.99 (td, J = 7.4, 1.2 Hz, 1H), 6.70−6.65 (m, 1H), 6.08 (ddd, J = 9.7, 2.2, 1.4 Hz, 1H), 4.00−3.92 (m, 1H), 2.82−2.68 (m, 2H), 2.49−2.36 (m, 2H), 2.05 (dq, J = 13.7, 4.6 Hz, 1H), 1.84 (dtd, J = 13.1, 10.1, 4.9 Hz, 1H); δ_C 164.63 (C), 140.27 (CH), 136.91 (C), 130.20 (C), 128.27 (CH), 126.98 (CH), 126.34 (CH), 124.06 (CH), 123.61 (CH), 56.48 (CH), 31.66 (CH_2), 29.77 (CH_2), 27.63 (CH_2); LRMS (EI) m/z (%) 199 (M$^+$, 100), 200 (15), 170 (12), 132 (87), 131 (74), 130 (97), 103 (10), 77 (14), 68 (12); HRMS (ESI) calcd for $C_{13}H_{14}NO$ ([M + H]$^+$) 200.1075, found 200.1066.

General Procedure for the Synthesis of 2-Allyl Benzo-Fused Heterocycles 14 from Homoallylamines 10. A mixture of the corresponding homoallylamine **10** (0.5 mmol), Cs_2CO_3 (326 mg, 1.0 mmol), PPh_3 (20 mg, 0.075 mmol), and $Pd(OAc)_2$ (5.6 mg, 0.025 mmol) in dry toluene (5 mL) was stirred at 110 °C under Ar for 21 h in a high-pressure tube. Then the resulting mixture was cooled to room temperature, hydrolyzed with 3 M HCl (5 mL, 15 mmol), and diluted with AcOEt (10 mL). The organic phase was extracted with 3 M HCl (4 × 10 mL), and then all of the aqueous phases were basicified with NaOH to pH 13 and extracted with AcOEt (4 × 15 mL). The resulting organic phase was dried over anhydrous $MgSO_4$ and evaporated (15 Torr). The residue was purified by column chromatography (silica gel, hexane/EtOAc) to yield the pure product **14**. Yields and physical and spectroscopic data follow.

*(R)-2-Allylindoline (**14a**).* The general procedure was followed using homoallylamine **10a** (96 mg, 0.40 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **14a** (43 mg, 68%) as a yellow oil. $[\alpha]_D^{23}$ +14 (c 0.75, CH_2Cl_2); R_f 0.43 (hexane/AcOEt, 10:1); IR ν (film) 3375, 2926, 1608, 1484, 1466, 1246, 914, 744 cm^{-1}; δ_H 7.07 (d, J = 7.3 Hz, 1H), 7.00 (t, J = 7.6 Hz, 1H), 6.68 (td, J = 7.4, 1.0 Hz, 1H), 6.60 (d, J = 7.7 Hz, 1H), 5.90−5.75 (m, 1H), 5.17−5.06 (m, 2H), 3.89 (dtd, J = 8.7, 7.2, 6.0 Hz, 1H), 3.14 (dd, J = 15.6, 8.7 Hz, 1H), 2.73 (dd, J = 15.6, 7.1 Hz, 1H), 2.36−2.28 (m, 2H); δ_C 150.7 (C), 135.3 (CH), 128.6 (C), 127.4 (CH), 124.9 (CH), 118.7 (CH), 117.6 (CH_2), 109.3 (CH), 58.8 (CH), 41.1 (CH_2), 35.8 (CH_2); LRMS (EI) m/z (%) 159 (M$^+$, 12), 118 (100), 117 (17), 91 (14); HRMS (ESI) calcd for $C_{11}H_{14}N$ ([M + H]$^+$) 160.1126, found 160.1126.

*(S)-2-Allyl-1,2,3,4-tetrahydroquinoline (**14b**).* The general procedure was followed using homoallylamine **10b** (127 mg, 0.50 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **14b** (77 mg, 89%) as a yellow oil. $[\alpha]_D^{23}$ +48 (c 1.07, CH_2Cl_2); R_f 0.55 (hexane/AcOEt, 9:1); IR ν (film) 3398, 2921, 1483, 1309, 913 cm^{-1}; δ_H 6.97−6.91 (m, 2H), 6.59 (td, J = 7.4, 1.1 Hz, 1H), 6.47−6.43 (m, 1H), 5.88−5.76 (m, 1H), 5.19−5.12 (m, 2H), 3.84 (br s, 1H), 3.28 (dddd, J = 9.8, 8.0, 5.0, 2.9 Hz, 1H), 2.87−2.68 (m, 2H), 2.36−2.28 (m, 1H), 2.21−2.12 (m, 1H), 1.95 (dddd, J = 12.5, 5.7, 3.7, 3.0 Hz, 1H), 1.63 (dddd, J = 12.8, 11.2, 9.8, 5.5 Hz, 1H); δ_C 144.61 (C), 135.1 (CH), 129.3 (CH), 126.8 (CH), 121.3 (C), 118.0 (CH_2), 117.1 (CH), 114.2 (CH), 50.6 (CH), 41.3 (CH_2), 28.3 (CH_2), 26.5 (CH_2); LRMS (EI) m/z (%) 173 (M$^+$, 16), 133 (12), 132 (100), 130 (17), 117 (17); HRMS (ESI) calcd for $C_{12}H_{16}N$ ([M + H]$^+$) 174.1283, found 174.1280.

*(S)-2-Allyl-2,3,4,5-tetrahydro-1H-benzo[b]azepine (**14c**).* The general procedure was followed using homoallylamine **10c** (134 mg, 0.50 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **14c** (79 mg, 84%) as a yellow oil. $[\alpha]_D^{23}$ −19 (c 1.07, CH_2Cl_2); R_f 0.61 (hexane/AcOEt, 9:1); IR ν (film) 3341, 2924, 1476, 1258, 737 cm^{-1}; δ_H 7.11−6.99 (m, 2H), 6.83 (td, J = 7.4, 1.2 Hz, 1H), 6.70 (dd, J = 7.7, 1.1 Hz, 1H), 5.83 (dddd, J = 16.2, 11.0, 8.8, 5.3 Hz, 1H), 5.27−5.12 (m, 2H), 3.70 (br s, 1H), 2.86−2.64 (m, 3H), 2.40−2.13 (m, 2H), 2.02−1.81 (m, 2H), 1.66−1.42 (m, 2H); δ_C 148.9 (C), 135.9 (CH), 134.2 (C), 130.6 (CH), 126.7 (CH), 121.2 (CH), 119.9 (CH), 118.4 (CH_2), 57.0 (CH), 42.1 (CH_2), 38.1 (CH_2), 35.6 (CH_2), 26.4 (CH_2); LRMS (EI) m/z (%) 187 (M$^+$, 9), 147 (11), 146 (100), 131 (12), 130 (13), 118 (18); HRMS (ESI) calcd for $C_{13}H_{18}N$ ([M + H]$^+$) 188.1439, found 188.1433.

General Procedure for the Synthesis of Acrylamides 15 from Heterocycles 14. To a solution of the corresponding heterocycle **14** (1.25 mmol) and Et_3N (171 mg, 0.24 mL, 1.7 mmol) in dry CH_2Cl_2 (3 mL) was added dropwise acryloyl chloride (159 g, 0.15 mL, 1.76 mmol) at 0 °C. The reaction mixture was stirred at room temperature for 2 h, hydrolyzed with H_2O (5 mL), and diluted with AcOEt (15 mL). The aqueous phase was extracted with AcOEt (3 × 10 mL), and then the organic phases were dried with anhydrous $MgSO_4$ and evaporated (15 Torr). The residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield the product **15**. Yields and physical and spectroscopic data follow.

*(S)-N-Acryloyl-2-allyl-1,2,3,4-tetrahydroquinoline (**15b**).* The general procedure was followed using heterocycle **14b** (77 mg, 0.44 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **15b** (63 mg, 63%) as a colorless oil. $[\alpha]_D^{23}$ −389 (c 1.03,

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CH_2Cl_2); R_f 0.30 (hexane/AcOEt, 6:1); IR ν (film) 2947, 1651, 1651, 1614, 1489, 1404, 1323, 1241, 914, 750 cm^{-1}; δ_H 7.22−7.13 (m, 3H), 7.02 (d, J = 7.1 Hz, 1H), 6.42 (s, 1H), 6.41 (d, J = 0.8 Hz, 1H), 5.81−5.69 (m, 1H), 5.65−5.59 (m, 1H), 5.00 (s, J = 1.1 Hz, 1H), 4.98−4.94 (m, 1H), 4.93−4.84 (m, 1H), 2.66 (dt, J = 15.1, 5.4 Hz, 1H), 2.56 (ddd, J = 15.2, 10.1, 5.5 Hz, 1H), 2.42−2.25 (m, 2H), 2.20−2.11 (m, 1H), 1.54 (dddd, J = 12.8, 10.1, 6.9, 5.6 Hz, 1H); δ_C 165.4 (C), 137.2 (C), 134.4 (CH), 129.8 (CH), 127.8 (CH), 127.7 (CH2), 126.4 (CH), 126.3 (CH), 125.9 (CH), 117.4 (CH_2), 51.7 (CH), 38.9 (CH_2), 29.7 (CH_2), 25.7 (CH_2); LRMS (EI) m/z (%) 186 ([M − C_3H_5] $^+$, 46), 133 (11), 132 (100), 130 (10), 55 (16); HRMS (ESI) calcd for $C_{15}H_{18}NO$ ([M + H]$^+$) 228.1388, found 228.1383.

(S)-N-Acryloyl-2-allyl-2,3,4,5-tetrahydro-1H-benzo[b]azepine (15c). The general procedure was followed using homoallylamine **14c** (180 mg, 0.96 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **15c** (122 mg, 52%) as a yellow oil. $[\alpha]_D^{23}$ −179 (c 1.09, CH_2Cl_2); R_f 0.28 (hexane/AcOEt, 6:1); IR ν (film) 2928, 1653, 1490, 1405, 1254 cm^{-1}; δ_H 7.31−7.18 (m, 3H), 7.02 (d, J = 6.8 Hz, 1H), 6.36 (dd, J = 16.8, 2.1 Hz, 1H), 5.94 (dd, J = 16.8, 10.3 Hz, 1H), 5.74 (ddt, J = 17.1, 10.3, 6.8 Hz, 1H), 5.48 (dd, J = 10.3, 2.1 Hz, 1H), 5.06−4.93 (m, 3H), 2.81−2.72 (m, 1H), 2.65 (dt, J = 14.2, 4.5 Hz, 1H), 2.15−2.03 (m, 1H), 1.99−1.86 (m, 2H), 1.84−1.72 (m, 1H), 1.65−1.51 (m, 2H); δ_C 165.3 (C), 140.4 (C), 138.3 (C), 135.2 (CH), 130.4 (CH), 129.8 (CH), 129.1 (CH), 128.4 (CH), 127.5 (CH_2), 126.8 (CH), 117.0 (CH_2), 51.3 (CH), 36.1 (CH_2), 33.3 (CH_2), 31.1 (CH_2), 21.2 (CH_2); LRMS (EI) m/z (%) 241 (M$^+$, 3), 201 (10), 200 (66), 147 (13), 146 (100), 55 (14); HRMS (ESI) calcd for $C_{16}H_{20}NO$ ([M + H]$^+$) 242.1545, found 242.1544.

General Procedure for the Synthesis of Tricyclic Compounds 13 from Acrylamides 15. A mixture of the corresponding acrylamide **15** (0.50 mmol) and Hoveyda−Grubbs ruthenium catalyst (12.6 mg, 0.015 mmol) in dry CH_2Cl_2 (5 mL) was stirred under Ar at 40 °C for 3 h. Then the solvent was evaporated (15 Torr), and the resulting residue was purified by column chromatography (silica gel, hexane/AcOEt) to yield products **13**. Yields and physical and spectroscopic data follow.

(S)-4,4a,5,6-Tetrahydro-1H-pyrido[1,2-a]quinolin-1-one (13b). The general procedure was followed using acrylamide **15b** (58 mg, 0.25 mmol). Purification by column chromatography (hexane/AcOEt, 3:1) yielded **13b** (42 mg, 83%) as a white solid.

(S)-4a,5,6,7-Tetrahydrobenzo[f]pyrido[1,2-a]azepin-1(4H)-one (13c). The general procedure was followed using homoallylamine **15c** (87 mg, 0.36 mmol). Purification by column chromatography (hexane/AcOEt, 10:1) yielded **13c** (60 mg, 79%) as a white solid. Mp 130−132 °C (hexane/CH_2Cl_2); $[\alpha]_D^{23}$ −118 (c 1.03, CH_2Cl_2); R_f 0.30 (hexane/AcOEt, 1:2); IR ν (KBr) 1657, 1614, 1595, 1434, 1426 cm^{-1}; δ_H 7.28−7.17 (m, 4H), 6.59 (dddd, J = 9.8, 6.2, 2.4, 1.3 Hz, 1H), 6.06 (ddd, J = 9.9, 3.0, 0.6 Hz, 1H), 3.63−3.54 (m, 1H), 2.92 (ddt, J = 18.0, 7.2, 2.7 Hz, 1H), 2.80 (ddd, J = 14.2, 11.9, 2.3 Hz, 1H), 2.69 (ddd, J = 14.2, 6.2, 2.2 Hz, 1H), 2.34−2.16 (m, 2H), 2.08−1.95 (m, 1H), 1.68−1.58 (m, 1H), 1.58−1.41 (m, 1H); δ_C 163.0 (C), 142.0 (C), 139.7 (C), 138.6 (CH), 130.1 (CH), 128.5 (CH), 127.7 (CH), 127.1 (CH), 125.0 (CH), 57.9 (CH), 34.9 (CH_2), 33.8 (CH_2), 31.0 (CH_2), 26.1 (CH_2); LRMS (EI) m/z (%) 213 (M$^+$, 85), 214 (13), 212 (25), 196 (10), 184 (11), 146 (21), 145 (100), 144 (28), 130 (17), 118 (30), 117 (46), 115 (10), 91 (11), 90 (18), 89 (15), 68 (15); HRMS (ESI) calcd for $C_{14}H_{16}NO$ ([M + H]$^+$) 214.1232, found 214.1225.

Synthesis of (S)-2-Allyl-N-methyl-1,2,3,4-tetrahydroquinoline (16). A mixture of 2-allyltetrahydroquinoline **14b** (123 mg, 0.71 mmol), paraformaldehyde (95 mg, 3.2 mmol), $NaBH_3CN$ (133 mg, 2.1 mmol), and acetic acid (126 mg, 0.120 mL, 2.1 mmol) in acetonitrile (6 mL) was stirred at 23 °C for 16 h. Then the resulting mixture was hydrolyzed with 3 M HCl (5 mL, 15 mmol) and diluted with AcOEt (10 mL). The organic phase was extracted with 3 M HCl (4 × 10 mL), and then all of the aqueous phases were basicified with NaOH to pH 13 and extracted with AcOEt (4 × 15 mL). The resulting organic phase was dried over anhydrous $MgSO_4$ and evaporated (15 Torr) to give 126 mg (0.67 mmol, 95%) of pure compound **16**. Physical and spectroscopic data follow: Yellow wax; $[\alpha]_D^{23}$ −9 (c 1.27, CH_2Cl_2); R_f 0.72 (hexane/AcOEt, 9:1); IR ν (film) 2929, 1602, 1497, 1332, 1213, 911 cm^{-1}; δ_H 7.08 (t, J = 7.8 Hz, 1H), 6.97 (d, J = 7.3 Hz, 1H), 6.59 (td, J = 7.3, 1.1 Hz, 1H), 6.53 (d, J = 8.2 Hz, 1H), 5.79 (dddd, J = 16.8, 10.3, 8.1, 6.4 Hz, 1H), 5.12−5.03 (m, 2H), 3.37−3.27 (m, 1H), 2.93 (s, 3H), 2.89−2.74 (m, 1H), 2.70−2.60 (m, 1H), 2.47−2.36 (m, 1H), 2.21−2.08 (m, 1H), 1.97−1.79 (m, 2H); δ_C 145.3 (C), 135.6 (CH), 128.8 (CH), 127.2 (CH), 121.9 (C), 117.2 (CH_2), 115.6 (CH), 110.6 (CH), 58.8 (CH), 38.0 (CH_3), 36.0 (CH_2), 24.4 (CH_2), 23.5 (CH_2); LRMS (EI) m/z (%) 187 (M$^+$, 12), 147 (11), 146 (100), 144 (11), 131 (17), 130 (15); HRMS (ESI) calcd for $C_{13}H_{18}N$ ([M + H]$^+$) 188.1439, found 188.1445.

Synthesis of (−)-Angustureine (18) from (S)-2-Allyl-N-methyl-1,2,3,4-tetrahydroquinoline (16). A mixture of 2-allyl-*N*-methyltetrahydroquinoline **16** (93 mg, 0.50 mmol), *cis*-3-hexene (86 mg, 0.127 mL, 1.0 mmol), and Hoveyda−Grubbs ruthenium catalyst (12.7 mg, 0.015 mmol) in dry CH_2Cl_2 (6 mL) was stirred under Ar at 40 °C for 3 h, and then the solvent was evaporated (15 Torr). The resulting residue was dissolved in MeOH (9 mL), and 10% Pd/C (27 mg, 0.015 mmol) was added. The resulting reaction mixture was stirred for 12 h at 23 °C under H_2 (1 atm) and then filtered through Celite and evaporated (15 Torr). The resulting residue was purified by column chromatography (silica gel, hexane/AcOEt, 20:1) to yield 59 mg (0.27 mmol, 54%) of pure (−)-angustureine (**18**).[31] Physical and spectroscopic data follow: colorless oil; $[\alpha]_D^{23}$ −6.8 (c 1.00, CH_2Cl_2); R_f 0.18 (hexane/AcOEt, 20:1); IR ν (film) 2926, 1602, 1498, 741 cm^{-1}; δ_H 7.06 (t, J = 7.7 Hz, 1H), 6.95 (d, J = 7.3 Hz, 1H), 6.57 (td, J = 7.3, 1.0 Hz, 1H), 6.51 (d, J = 8.2 Hz, 1H), 3.21 (dq, J = 8.5, 4.2 Hz, 1H), 2.91 (s, 3H), 2.84−2.73 (m, 1H), 2.64 (dt, J = 16.2, 4.2 Hz, 1H), 1.92−1.83 (m, 2H), 1.64−1.53 (m, 1H), 1.45−1.20 (m, 8H), 0.89 (t, J = 6.9 Hz, 3H); δ_C 145.5 (C), 128.7 (CH), 127.2 (CH), 122.0 (C), 115.3 (CH), 110.5 (CH), 59.1 (CH), 38.1 (CH_3), 32.2 (CH_2), 31.4 (CH_2), 25.9 (CH_2), 24.6 (CH_2), 23.7 (CH_2), 22.8 (CH_2), 14.2 (CH_3); LRMS (EI) m/z (%) 217 (M$^+$, 14), 147 (11), 147 (11), 146 (100), 144 (8).

Synthesis of (S,E)-2-[3-(3,4-Dimethoxyphenyl)allyl]-1-methyl-1,2,3,4-tetrahydroquinoline (19). A mixture of 2-allyl-*N*-methyltetrahydroquinoline **16** (51 mg, 0.27 mmol), 4-bromoveratrol (148 mg, 0.100 mL, 0.68 mmol), K_2CO_3 (75 mg, 0.54 mmol), and $Pd(PPh_3)_4$ (15.6 mg, 0.0135 mmol) in dry dioxane (1 mL) was stirred at 100 °C under Ar for 24 h in a high-pressure tube. Then the resulting mixture was cooled to room temperature, diluted with AcOEt (10 mL), filtered through a short pad of Celite, and concentrated in vacuo (15 Torr). The residue was purified by column chromatography (silica gel, hexane/AcOEt, 17:1) to yield 35 mg (0.11 mmol, 40%) of pure compound **19**. Physical and spectroscopic data follow: yellow oil; $[\alpha]_D^{23}$ −29 (c 1.10, CH_2Cl_2); R_f 0.53 (hexane/AcOEt, 3:1); IR ν (film) 2931, 1601, 1511, 1498, 1260 cm^{-1}; δ_H 7.09 (t, J = 7.7 Hz, 1H), 6.99 (d, J = 7.1 Hz, 1H), 6.90−6.85 (m, 2H), 6.81 (d, J = 8.8 Hz, 1H), 6.61 (t, J = 7.3 Hz, 1H), 6.55 (d, J = 8.1 Hz, 1H), 6.36 (d, J = 15.7 Hz, 1H), 6.05 (ddd, J = 15.0, 8.0, 6.8 Hz, 1H), 3.90 (s, 3H), 3.87 (s, 3H), 3.41 (td, J = 8.4, 4.3 Hz, 1H), 2.97 (s, 3H), 2.93−2.81 (m, 1H), 2.73−2.63 (m, 1H), 2.59−2.49 (m, 1H), 2.29 (dt, J = 14.0, 8.6 Hz, 1H), 2.02−1.86 (m, 2H); δ_C 149.2 (C), 148.6 (C), 145.3 (C), 132.0 (CH), 130.8 (C), 128.9 (CH), 127.3 (CH), 125.3 (CH), 121.9 (C), 119.0 (CH), 115.7 (CH), 111.3 (CH), 110.6 (CH), 108.7 (CH), 59.2 (CH_3), 56.1 (CH_3), 56.0 (CH_3), 38.1 (CH), 35.2 (CH_2), 24.7 (CH_2), 23.6 (CH_2); LRMS (EI) m/z (%) 323 (M$^+$, 39), 203 (10), 172 (25), 147 (12), 146 (100), 144 (19), 131 (16), 130 (15), 120 (29), 91 (10); HRMS (ESI) calcd for $C_{21}H_{26}NO_2$ ([M + H]$^+$) 324.1964, found 324.1974.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Copies of ^1H, ^{13}C NMR, and DEPT spectra for all of the reported compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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