JOC The Journal of Organic Chemistry

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Ruthenium Pybox-Catalyzed Enantioselective Intramolecular C−H Amination of Sulfamoyl Azides en Route to Chiral Vicinal Diamines

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Cite This: https://dx.doi.org/10.1021/acs.joc.0c02279 Read Online

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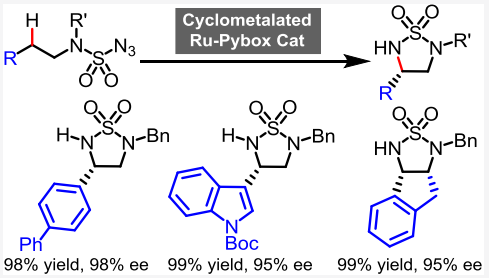
ABSTRACT: Enantioselective C(sp^3)−H aminations allow an efficient access to nonracemic chiral amines. This work reports the catalytic asymmetric synthesis of chiral 1,2,5-thiadiazolidine-1,1-dioxides by an enantioselective ring-closing 1,5-C−H amination of sulfamoyl azides. The reaction is catalyzed by a recently introduced simple chiral ruthenium bis(oxazoline) (pybox) complex (*Angew. Chem. Int. Ed.* **2020**, *59*, 12395) and provides cyclic 5-membered sulfamide products in up to 98% yield and up to 98% ee if the C−H bond is in a benzylic position. Mechanistic experiments support a stepwise mechanism in which an intermediate ruthenium nitrenoid species initiates a 1,5-hydrogen atom transfer followed by an immediate radical rebound. The cyclic sulfamide products are suitable intermediates for the synthesis of chiral vicinal diamines as has been verified for a representative example.



INTRODUCTION

The enantioselective direct C(sp^3)−H amination of prochiral methylene groups is a powerful synthetic strategy for the generation of chiral nitrogen-containing compounds, which are key structural motifs in natural products, pharmaceuticals, chiral catalysts, chiral ligands, and auxiliaries, among others. Within the modality of nitrene insertion, regio- and stereocontrolled ring-closing C(sp^3)−H aminations have been applied successfully to the catalytic asymmetric generation of nitrogen heterocycles, some of which such as cyclic carbamates, cyclic urea, cyclic sulfamidates, and cyclic sulfamides can be further processed by ring-opening to provide chiral aminoalcohols and chiral diamines.[1,2]

Azide-containing compounds are attractive nitrene precursors since molecular nitrogen is the only byproduct in the course of the C−H amination reaction.[3] Sulfonyl azides,[4] sulfamoyl azides,[5] azidoformates,[6] and aliphatic azides[7] have been reported as substrates for enantioselective intramolecular C(sp^3)−H aminations. The ring-closing C(sp^3)−H amination of sulfamoyl azides caught our attention because it generates cyclic sulfamides, which can subsequently be converted to chiral diamines. Zhang and co-workers reported an enantioselective ring-closing 1,5-C−H amination of sulfamoyl azides to cyclic sulfamides using metalloradical catalysis (Figure 1a).[5a,b] Interestingly, depending on the achiral aryl substituents on the porphyrin core, both enantiomers could be obtained in an enantiodivergent fashion.[5b] However, the cobalt catalyst is structurally very complicated, which hampers its practicability. Arnold and co-workers, on the other hand, recently reported a cytochrome P450-catalyzed method for the enantioselective ring-closing 1,5-C−H amination of sulfamoyl azides but which comes along with all of the advantages and disadvantages of enzymatic catalysis (Figure 1b).[5c]

Our group recently reported in preliminary results a single example of an enantioselective ring-closing C−H amination with a sulfamoyl azide using a simple chiral ruthenium bis(oxazoline) (pybox) catalyst.[8] Here, we provide a full report on this chemistry in which cyclic sulfamides can be accessed with yields of up to 99% and up to 98% ee (Figure 1c). We further demonstrate that the obtained chiral sulfamides can be hydrolyzed to provide chiral vicinal diamines without any loss of enantiomeric excess.

RESULTS AND DISCUSSION

Initial Experiments and Optimization. Previously, we reported a simple new chiral transition-metal catalyst in which a cyclometalated *N*-(4-nitrophenyl)-imidazo[1,5-*a*]pyridine ligand is combined with a standard chiral C_2-symmetric ruthenium pyridine-2,6-bis(oxazoline) (pybox) fragment.[8] The strongly electron-donating cyclometalated *N*-heterocyclic carbene (NHC) ligand modulates the catalytic activity of the ruthenium center, and we revealed that such complexes are suitable for enantioselective nitrene C−H insertion chemistry. Furthermore, we demonstrated that the catalytic activity and asymmetric induction can be affected by substituents in the imidazo[1,5-*a*]pyridine moiety. For example, sulfamoyl azide **1a** was converted to the cyclic sulfamide **2a** in 53% yield and with 70% ee using 5 mol % catalyst **Ru1** at 50 °C in 1,2-

Received: October 2, 2020

https://dx.doi.org/10.1021/acs.joc.0c02279
J. Org. Chem. XXXX, XXX, XXX−XXX

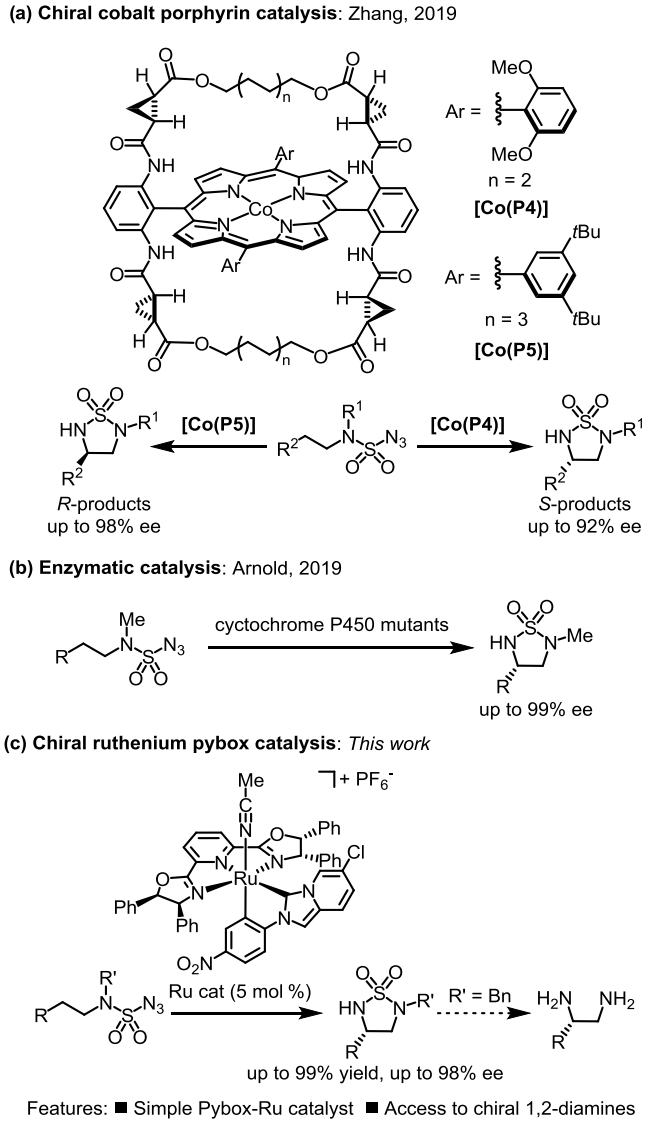


Figure 1. Enantioselective intramolecular C(sp^3)−H aminations of sulfamoyl azides to provide cyclic sulfamides.

dichloroethane (DCE) (Table 1, entry 1). Replacing the trimethylsilyl group with a bromine (**Ru2**) provided an improved 80% yield with 93% ee. A chlorine substituent (**Ru3**) provided the best results with 93% yield and 95% ee (entry 3). Thus, we selected **Ru3** as the most suitable catalyst to further optimize the reaction conditions. Increasing the concentration from 100 to 400 mM improved the yield from 93 to 95% (compare entries 3 and 4). When we further raised the reaction temperature from 50 to 55 °C, an optimal NMR yield of 99% and isolated yield of 97% were achieved with a slightly improved 96% ee (entry 5). Thus, we selected these as our standard conditions. Other conditions turned out to be inferior. For example, increasing the temperature further to 80 °C provided slightly reduced yield and enantioselectivity (entry 6), while reducing the catalyst loading to 2.0 and 1.0 mol % provided a more sluggish conversion with somewhat reduced enantioselectivities (entries 7 and 8). Other tested solvents were also less favorable. For example, replacing DCE with $CHCl_3$ or tetrahydrofuran (THF) both reduced yields and enantiomeric excess (entries 9 and 10). Interestingly, adding 1% water (entry 11) or executing the reaction under air (entry 12) only resulted in a marginal decrease of yield and enantiomeric excess, which indicates that it is possible to run this reaction under open flask conditions.

Substrate Scope. With the optimized conditions in hand (Table 1, entry 5), we next investigated the substrate scope of sulfamoyl azides. We started by introducing substituents into the phenyl moiety of the phenethyl substituent of the initial sulfamoyl azide **1a** (Figure 2). A methyl group in the *para*- or *meta*-position provided the benzylic C−H amination products **2b** or **2c** in high yields and with high ee values. A methyl group in the more sterically hindering *ortho*-position afforded the cyclic sulfamide **2d** with a somewhat reduced yield of 76% and with 90% ee. A *para*-phenyl substituent gave the highest enantioselectivity of all tested substrates, providing cyclic sulfamide **2e** in 98% yield and with 98% ee. An electron-donating *para*-methoxy group afforded the cyclic sulfamide **2f** in 92% yield and with 97% ee. Similarly, the electron-rich benzodioxole group provided the benzylic C−H amination product **2g** in 96% yield and with 96% ee. Electron-withdrawing substituents in the phenyl moiety decrease both the yield and the enantioselectivity. For example, a strongly electron-withdrawing CF_3-group in the *para*-position of the phenyl moiety gave the corresponding cyclic sulfamide **2h** with just 51% yield and 84% ee. Fluorine or chlorine substituents in the *para*-position provided better results with fluorinated cyclic sulfamide **2i** isolated in 89% yield and with 94% ee, while the chlorinated cyclic sulfamide **2j** was isolated in 81% yield and with 94% ee. Replacing the phenyl moiety with a benzannulated 2-naphthyl, heteroaromatic 2-thiophene, or *N*-Boc-protected 3-indole moiety provided the cyclic sulfamides **2k−m** in 83−99% yield and with 95−97% ee. The cyclic sulfamide **2n** bearing two vicinal stereocenters was obtained with 99% yield and 95% ee by desymmetrization of an indane substrate. We also tested the C−H amination at allylic and propargylic positions and found that they occurred with significantly reduced enantiomeric excess as showcased for the cyclic sulfamides **2o** and **2p**.

In all of the examples discussed so far, the cyclic sulfamide products (**2a−p**) contained an *N*-benzyl protection group. Next, we evaluated the tolerance of the ruthenium pybox catalysis regarding different *N*-alkyl groups (Figure 3). Accordingly, methyl, ethyl, *n*-propyl, and phenethyl substituents were well-tolerated and provided the cyclic sulfamides **2q−t** in 87−92% yields and with 94−96% ee. Even an *N*-allyl substituent provided the cyclic sulfamide **2u** with excellent 94% yield and 96% ee without any observation of competing aziridination. On the other hand, an *n*-propargyl substituent provided the cyclic sulfamide **2v** with a decreased yield of 55% but with a still respectable 90% ee.

Additional Experiments. Additional experiments are shown in Figure 4. First, substrate **1w** containing an aliphatic *n*-propyl side chain did not undergo any intramolecular C−H amination and instead provided the reduced acyclic sulfonamide as the main product (Figure 4a). From this experiment, we can conclude that an activation of the C(sp^3)−H group by a neighboring aryl, alkenyl, or alkynyl group is a requirement for an effective C(sp^3)−H amination with **Ru3**. We also probed the competition between 5- and 6-membered ring-closing C−H amination. Substrate **1x** containing a 3-phenylpropyl side chain afforded the 6-membered cyclic sulfamide **3x** as the main product without any formation of the 5-membered product **2x** (Figure 4b). However, the reaction provided just 46% yield of the 6-membered cyclic

https://dx.doi.org/10.1021/acs.joc.0c02279
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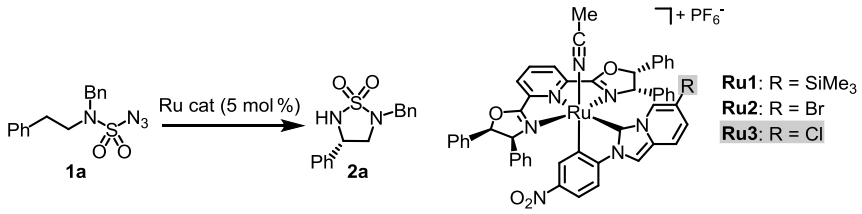
Table 1. Initial Experiments and Optimization of Reaction Conditions[a]



entry	catalyst/mol %	T (°C)	solvent[b]	concn (M)	yield (%)[c]	ee (%)[d]
1	**Ru1** (5.0)	50	DCE	0.1	53	70
2	**Ru2** (5.0)	50	DCE	0.1	80	93
3	**Ru3** (5.0)	50	DCE	0.1	93	95
4	**Ru3** (5.0)	50	DCE	0.4	95	95
5	**Ru3** (5.0)	55	DCE	0.4	99 (97)[e]	96
6	**Ru3** (5.0)	80	DCE	0.4	94	92
7	**Ru3** (2.0)	55	DCE	0.4	76[f]	94
8	**Ru3** (1.0)	55	DCE	0.4	46[g]	93
9	**Ru3** (5.0)	55	$CHCl_3$	0.4	78	90
10	**Ru3** (5.0)	55	THF	0.4	74	89
11[h]	**Ru3** (5.0)	55	DCE	0.4	88	94
12[i]	**Ru3** (5.0)	55	DCE	0.4	80	93

[a]Reaction conditions: Substrate **1a** (0.05 mmol) and catalyst (5 mol %) in the indicated solvent at the indicated temperature for 48 h under a nitrogen atmosphere unless indicated otherwise. [b]DCE, 1,2-dichloroethane. [c]Yields determined by ^{1}H NMR using 1,1,2,2-tetrachloroethane as the internal standard. [d]Determined by high-performance liquid chromatography (HPLC) on the chiral stationary phase. [e]Isolated yield in brackets. [f]87% conversion. [g]72% conversion. [h]In the presence of 1% H_2O. [i]Performed under air.

sulfamide **3x** with a low enantiomeric excess (20% ee). The main side product was the formation of the reduced acyclic sulfamide. Moreover, when we used the substrate **1y** in which both *N*-alkyl side chains bear a benzylic C−H group, one leading to a 5-membered (**2y**) and the other to a 6-membered ring (**3y**), only the 5-membered cyclic sulfamide **2y** was formed in 73% yield with 96% ee, demonstrating that the formation of 5-membered sulfamides is strongly favored. Thus, these experiments, together with the scope shown in Figures 2 and 3, demonstrate that 2-arylethyl side chains provide the best results to generate 5-membered cyclic sulfamides in high yields and with high enantioselectivities. We also confirmed that the ring-closing C−H amination of sulfamoyl azides can be performed on a gram scale (Figure 4c). Under standard conditions, 4 mmol of **1a** was converted to (*S*)-**2a** in 95% yield and with 95% ee. At the same time, 65% of the catalyst was recovered for further use. To demonstrate the utility of this new method, we converted the cyclic sulfamide **2a** to the diamine **4a** in 95% yield with 95% ee using hydrazine at 110 °C (Figure 4d).[9,10] The benzylic group could then be removed by Pd-catalyzed hydrogenation (**4a** → **5a**).

Proposed Mechanism. Finally, we briefly investigated the expected nitrene mechanism. Transition-metal nitrenoids typically react in a facile fashion with alkenes to form aziridines.[11] To probe this, we synthesized substrate (*E*)-**8** bearing an internal alkene. Accordingly, when we reacted (*E*)-**8** with **Ru3** (8 mol %) at elevated temperature (60 °C), we obtained the bicyclic aziridine **9** in 34% yield and with 79% ee (Figure 5a). Thus, this experiment supports the intermediate formation of a ruthenium nitrenoid species followed by an intramolecular alkene addition. Such intramolecular formation of bicyclic aziridine sulfamides has been reported before by Zhang and co-workers.[12] However, to our knowledge, this is the first example of an enantioselective version of this transformation. Of note, using catalyst **Ru1** instead of **Ru3** provided the bicyclic aziridine in a further improved yield of 72% and with an improved 98% ee, thus revealing the synthetic utility of this asymmetric intramolecular aziridination.

For a further understanding of the reaction mechanism, we determined the primary kinetic isotope effect (KIE) by measuring relative rates of two individual reactions (Figure 5b). As a result, the initial rate of the amination of the CH_2 group in **1a** (k_H) was significantly faster compared to the CD_2 group in **1a′** (k_D) with a determined ratio k_H/k_D = 3.5. This KIE value of 3.5 reveals that the cleavage of the C−H bond occurs during the rate-determining step of the overall C−H bond amination process. Interestingly, but not unusual, an intermolecular competition experiment with **1a** and **1a′** provided only a diminished KIE of 1.4 as determined from the product ratio **2a**:**2a′**. This is consistent with a mechanism in which the two substrates compete for the same binding site at the catalyst, followed by a fast and irreversible conversion to a ruthenium nitrenoid intermediate. In contrast, an intramolecular competition experiment with the deuterated substrate **1t′** resulted in a very high KIE value of 12.2 as determined by the ratio of the two products **2t′** and **2t′′**. This high KIE value demonstrates that the C−H cleavage in this intramolecular competition experiment is the selectivity-determining step, and it implicates a stepwise radical mechanism in which a ruthenium nitrene radical intermediate abstracts a benzylic hydrogen rather than a concerted nitrene C−H insertion, generating a diradical intermediate.[13,14] Recombination of this diradical then leads to the cyclic sulfamide. Apparently, this radical rebound must be very rapid as can be seen for the diastereoretentive allylic C−H aminations shown in Figure 5c.[15] While the *E*-configured substrate (*E*)-**1z** converts to the *E*-configured cyclic sulfamide (*E*)-**2z**, the *Z*-configured substrate (*Z*)-**1z** (*Z*/*E* > 99:1) leads to the cyclic sulfamide (*Z*)-**2z** as the main product but with a measurable amount of *Z* → *E* isomerization (*Z*/*E* = 40:1). The degree of *Z* → *E* isomerization further increases to *Z*/*E* = 28:1 at 80 °C.

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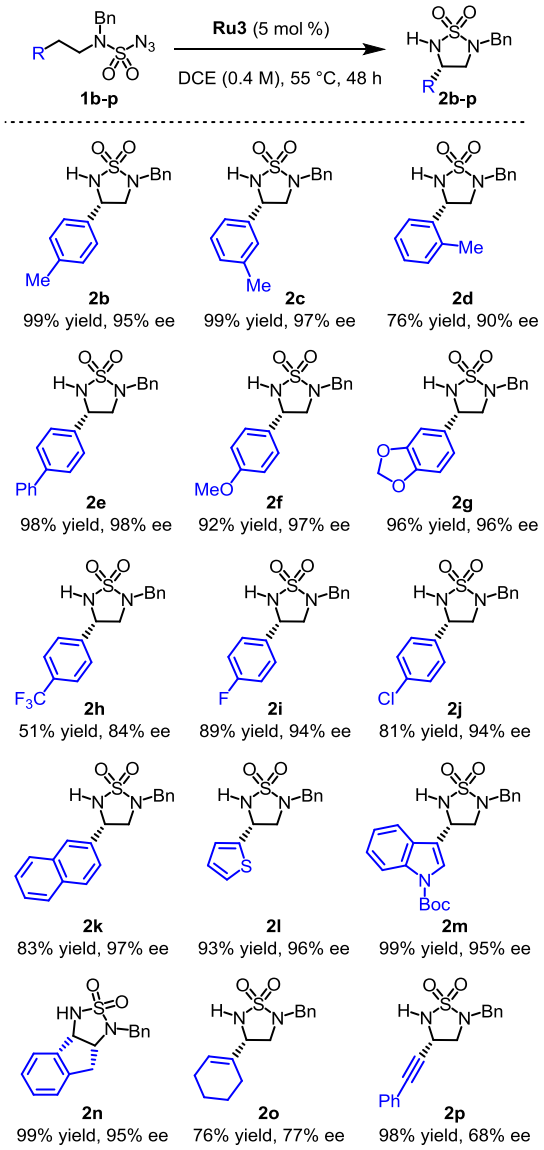

Figure 2. Substrate scope with *N*-benzyl sulfamoyl azides.

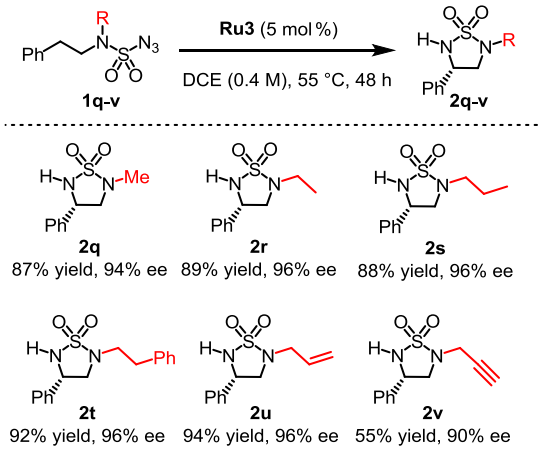

Figure 3. Substrate scope with sulfamoyl azides bearing different substituents at the nitrogen.

Together with the existing literature[1−7] and the performed mechanistic experiments, the following mechanism is proposed (Figure 6). The reaction of ruthenium catalyst and sulfamoyl azide provides a ruthenium nitrenoid intermediate **I** under release of molecular nitrogen. This nitrenoid species is initially formed in its singlet state ($\mathbf{I}^{S}$) and then converts to a triplet state ($\mathbf{I}^{T}$) to form a nitrenoid radical complex.[16,17] This ruthenium nitrenoid radical then initiates a 1,5-hydrogen atom transfer (HAT) at the benzylic position to provide the intermediate diradical **II**, followed by an instantaneous radical−radical rebound to the catalyst bound complex **III** and release of the product, followed by a new catalytic cycle.

CONCLUSIONS

We here demonstrated that a simple chiral ruthenium pybox catalyst can be used to perform an efficient ring-closing C(sp^3)−H amination of sulfamoyl azides to provide 5-membered cyclic sulfamides, which are precursors of chiral vicinal diamines. If the C(sp^3)−H bond is in a benzylic position, the reaction typically proceeds with high yields and high enantioselectivities. C−H aminations at allylic and propargylic positions are also possible albeit with reduced enantioselectivities. Mechanistic experiments support a radical hydrogen atom abstraction/radical rebound C−H amination pathway. Future work will investigate other catalytic asymmetric conversions with this new class of chiral ruthenium pybox catalysts.

EXPERIMENTAL SECTION

All reactions were carried out under an atmosphere of nitrogen with magnetic stirring unless otherwise stated. The catalytic reactions were performed using standard Schlenk techniques. Solvents were distilled under nitrogen from calcium hydride (CH_3CN, CH_2Cl_2) and sodium/benzophenone (THF, Et_2O). HPLC grade of acetone, methanol, and ethanol was used without further purification. Flash column chromatography was performed with silica gel 60 M from Macherey-Nagel (irregular shaped; 230−400 mesh; pH 6.8; pore volume: 0.81 mL × g^{-1}; mean pore size: 66 Å; specific surface: 492 $m^2 \times g^{-1}$; particle size distribution: 0.5% <25 μm and 1.7% >71 μm; water content: 1.6%). ^{1}H NMR, proton decoupled ^{13}C NMR, and ^{19}F NMR spectra were recorded on Bruker Avance 250 (250 MHz), Bruker Avance 300 (300 MHz), or Bruker AM (500 MHz) spectrometers at an ambient temperature. NMR yields were determined using 1,1,2,2-tetrachloroethane as the internal standard. NMR standards were used as follows: ^{1}H NMR spectroscopy: δ = 7.26 ppm ($CDCl_3$), 5.32 ppm (CD_2Cl_2); ^{13}C NMR spectroscopy: δ = 77.0 ppm ($CDCl_3$), 53.8 ppm (CD_2Cl_2); ^{19}F NMR spectroscopy: 0 ppm ($CFCl_3$). Melting points (MPs) were determined on a Mettler Toledo MP70 using one end closed capillary tubes. IR spectra were recorded on a Bruker Alpha FT-IR spectrophotometer. High-resolution mass spectra were recorded on a Bruker En Apex Ultra 7.0 TFT-MS instrument using the ESI/EI technique with an FT-ICR mass analyzer. Optical rotations were measured on a Krüss P8000-T polarimeter with $[\alpha]_D^{22}$ values reported in degrees with concentrations reported in g/100 mL. Chiral HPLC chromatography was performed with an Agilent 1200 or Agilent 1260 HPLC system with a Daicel Chiralpak OD-H, IG, or IA column (250 × 4.6 mm) using *n*-hexane/isopropanol as the mobile phase. The catalysts **Ru1**−**Ru3**[8] and the substrates **1a**,[5b] **1f**,[5b] **1h**,[5b] **1j**−**o**,[5b] **1p**−**q**,[15] **1r**,[4a] **1x**,[5a] **1y**,[5b] (*E*)-**1z**,[15] and (*Z*)-**1z**[15] were synthesized as reported.

Procedure for the Synthesis of Substrates.[5b] To a mixture of amine (1 mmol, 1 equiv) and DBU (1.2 mmol, 1.2 equiv) in CH_2Cl_2 was added dropwise a solution of $N_3SO_2N_3$[5b] (2 mmol, 2 equiv, 0.3 M in CH_2Cl_2) via a syringe at 0 °C. After the reaction was completed (monitored by thin-layer chromatography, TLC), the solvent was removed under reduced pressure at room temperature and the residue was purified by flash chromatography on silica gel (*n*-hexane/EtOAc

https://dx.doi.org/10.1021/acs.joc.0c02279
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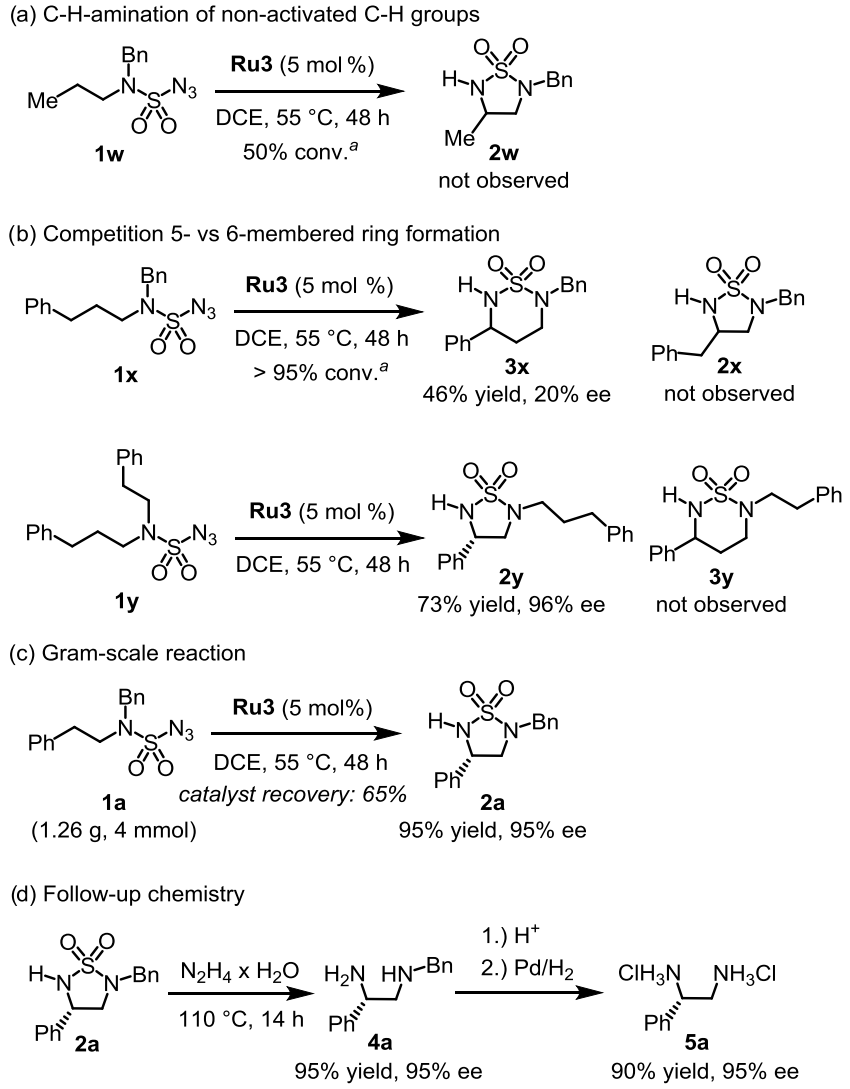

Figure 4. Additional experiments. [a]Reduction of the azide to an amino group observed as a side reaction.

= 50:1 to 10:1) to afford the sulfamoyl azides. Note: Azides can be explosive and should be handled carefully.

*1-(2-((Azidosulfonyl)(benzyl)amino)ethyl)-4-methylbenzene (**1b**).* Colorless oil (290.8 mg, 0.88 mmol, 88% yield; eluent: *n*-hexane/EtOAc = 20:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.29 (m, 5H), 7.09 (d, J = 8.0, 2H), 6.97 (d, J = 8.0 Hz, 2H), 4.42 (s, 2H), 3.45−3.35 (m, 2H), 2.86−2.74 (m, 2H), 2.31 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 136.5, 134.7, 134.6, 129.5, 129.1, 128.8, 128.7, 128.6, 53.1, 50.2, 34.0, 21.1. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_4O_2S_1Na$ [M + Na]$^+$: 353.1043, found: 353.1048. IR (film): ν (cm^{-1}) 3029, 2927, 2121, 1515, 1496, 1455, 1377, 1293, 1263, 1203, 1162, 1122, 1085, 1063, 1025, 995, 933, 910, 882, 850, 808, 788, 730, 697, 589, 562, 529, 503, 480, 457.

*1-(2-((Azidosulfonyl)(benzyl)amino)ethyl)-3-methylbenzene (**1c**).* Colorless oil (251.1 mg, 0.76 mmol, 76% yield; eluent: *n*-hexane/EtOAc = 20:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.29 (m, 5H), 7.21−7.13 (m, 1H), 7.03 (d, J = 7.5, 1H), 6.94−6.84 (m, 2H), 4.42 (s, 2H), 3.48−3.37 (m, 2H), 2.87−2.74 (m, 2H), 2.31 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.5, 137.7, 134.7, 129.6, 129.1, 128.8, 128.7, 128.6, 127.7, 125.8, 53.1, 50.2, 34.4, 21.4. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_4O_2S_1Na$ [M + Na]$^+$: 353.1043, found: 353.1047. IR (film): ν (cm^{-1}) 3031, 2928, 2121, 1609, 1493, 1455, 1376, 1265, 1203, 1162, 1122, 1099, 1064, 1028, 1000, 982, 939, 906, 804, 776, 728, 696, 582, 532, 506, 457, 440.

*1-(2-((Azidosulfonyl)(benzyl)amino)ethyl)-2-methylbenzene (**1d**).* Colorless oil (185.0 mg, 0.56 mmol, 56% yield; eluent: *n*-hexane/EtOAc = 20:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.29 (m, 5H), 7.15−7.06 (m, 3H), 7.04−6.95 (m, 1H), 4.47 (s, 2H), 3.38−3.29 (m, 2H), 2.88−2.79 (m, 2H), 2.19 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 136.3, 135.8, 134.7, 130.7, 129.7, 129.1, 128.8, 128.7, 127.2, 126.4, 53.3, 49.0, 32.1, 19.1. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_4O_2S_1Na$ [M + Na]$^+$: 353.1043, found: 353.1057. IR (film): ν (cm^{-1}) 3029, 2927, 2121, 1494, 1457, 1378, 1264, 1205, 1164, 1131, 1113, 1083, 1064, 1030, 983, 935, 908, 850, 797, 733, 698, 608, 588, 553, 533, 503, 452.

*4-(2-((Azidosulfonyl)(benzyl)amino)ethyl)-1,1′-biphenyl (**1e**).* White solid (365.0 mg, 0.93 mmol, 93% yield; eluent: *n*-hexane/EtOAc = 10:1). MP: 190−191 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.60−7.48 (m, 4H), 7.47−7.30 (m, 8H), 7.20−7.12 (m, 2H), 4.45 (s, 2H), 3.52−3.42 (m, 2H), 2.94−2.83 (m, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 140.8, 139.9, 136.8, 134.6, 129.3, 129.1, 129.0, 128.8, 128.7, 127.5, 127.4, 127.1, 53.2, 50.1, 34.2. HRMS (ESI, m/z) calcd for $C_{21}H_{20}N_4O_2S_1Na$ [M + Na]$^+$: 415.1199, found: 415.1200. IR (film): ν (cm^{-1}) 3029, 2943, 2125, 1486, 1455, 1406, 1380, 1342, 1293, 1259, 1191, 1158, 1110, 1081, 1056, 1007, 978, 934, 905, 820, 788, 744, 713, 692, 605, 593, 540, 518, 486, 469.

*5-(2-((Azidosulfonyl)(benzyl)amino)ethyl)benzo[d][1,3]dioxole (**1g**).* Colorless oil (320.7 mg, 0.89 mmol, 89% yield; eluent: *n*-hexane/EtOAc = 30:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.29 (m, 5H), 6.74−6.67 (m, 1H), 6.56−6.50 (m, 2H), 5.92 (s, 2H), 4.41 (s, 2H), 3.41−3.32 (m, 2H), 2.78−2.68 (m, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 147.9, 146.5, 134.6, 131.4, 129.1, 128.8, 128.7, 121.9,

https://dx.doi.org/10.1021/acs.joc.0c02279
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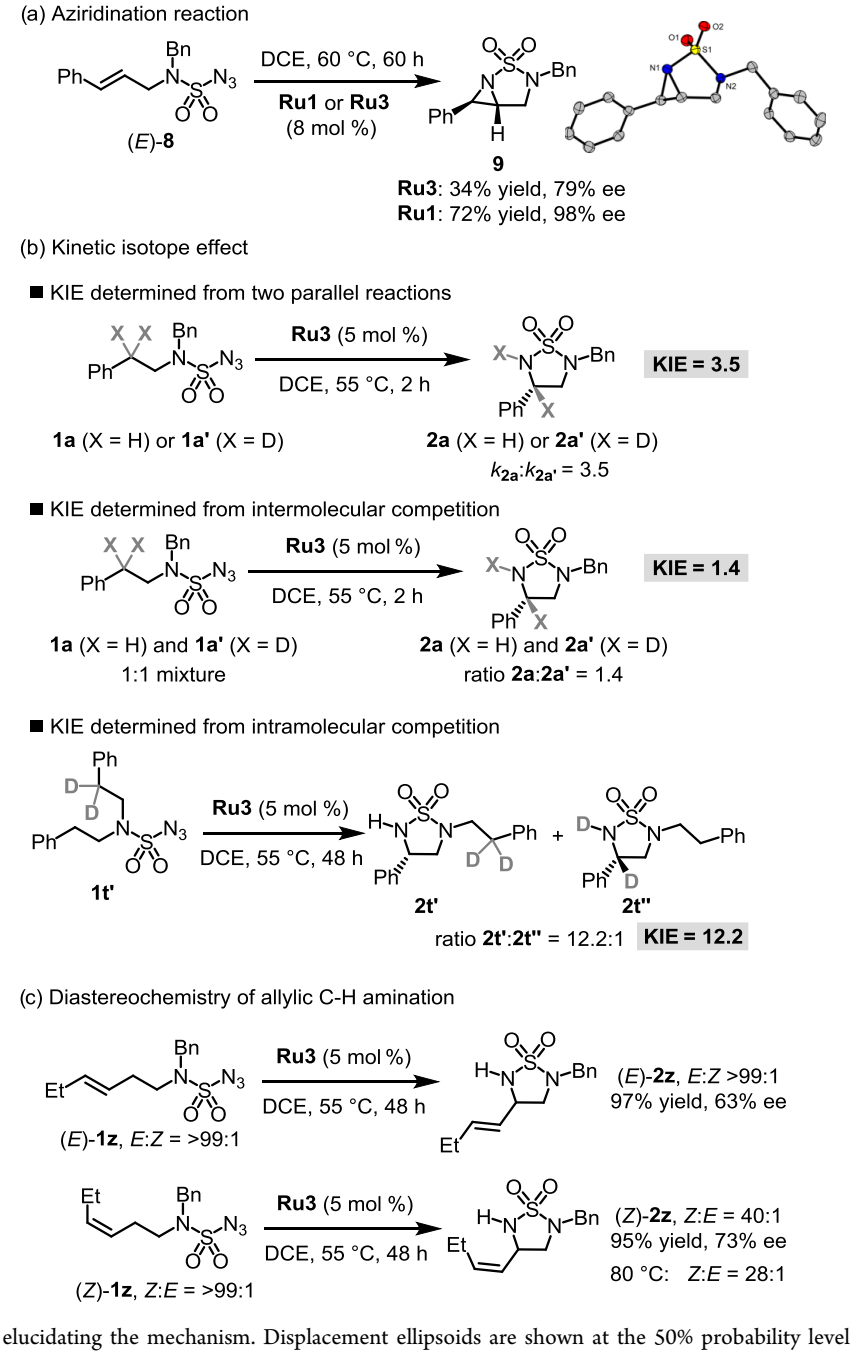

Figure 5. Experiments for elucidating the mechanism. Displacement ellipsoids are shown at the 50% probability level at 100 K.

109.2, 108.6, 101.1, 53.3, 50.4, 34.3. HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{16}N_4O_4S_1Na$ [M + Na]$^+$: 383.0784, found: 383.0794. IR (film): ν (cm^{-1}) 2893, 2122, 1501, 1489, 1443, 1375, 1246, 1190, 1161, 1120, 1102, 1063, 1037, 987, 927, 881, 860, 808, 795, 735, 697, 636, 586, 551, 528, 489, 458, 425.

*1-(2-((Azidosulfonyl)(benzyl)amino)ethyl)-4-fluorobenzene (**1i**).* Colorless oil (260.8 mg, 0.78 mmol, 78% yield; eluent: *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.46−7.28 (m, 5H), 7.10−6.90 (m, 4H), 4.41 (s, 2H), 3.44−3.34 (m, 2H), 2.84−2.74 (m, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 163.6 (C−F, $^1J_{C-F}$ = 245.7 Hz), 160.3 (C−F, $^1J_{C-F}$ = 245.7 Hz), 134.6, 133.4, 133.3, 130.4 (C−F, $^3J_{C-F}$ = 7.7 Hz), 130.3 (C−F, $^3J_{C-F}$ = 7.7 Hz), 129.1, 128.8, 128.7, 115.8 (C−F, $^2J_{C-F}$ = 21.0 Hz), 115.8 (C−F, $^2J_{C-F}$ = 21.0 Hz), 53.4, 50.3, 33.8. ^{19}F NMR (235 MHz, $CDCl_3$) δ −116.0. HRMS (ESI, *m*/*z*) calcd for $C_{15}H_{15}F_1N_4O_2S_1Na$ [M + Na]$^+$: 357.0797, found: 357.0798. IR (film): ν (cm^{-1}) 2122, 1603, 1510, 1456, 1377, 1219, 1160, 1123, 1102, 1083, 1061, 1015, 985, 940, 910, 882, 857, 825, 796, 730, 697, 589, 562, 530, 511, 478, 458, 424.

*(2-((Azidosulfonyl)(propyl)amino)ethyl)benzene (**1s**).* Colorless oil (198.6 mg, 0.74 mmol, 74% yield; eluent: *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.36−7.19 (m, 5H), 3.52−3.44 (m, 2H), 3.25−3.17 (m, 2H), 2.99−2.90 (m, 2H), 1.63 (sext, J = 7.6 Hz, 2H), 0.92 (t, J = 7.4 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.8, 128.9, 128.8, 127.0, 51.6, 51.0, 35.0, 21.4, 11.1. HRMS (ESI, *m*/*z*) calcd for $C_{11}H_{16}N_4O_2S_1Na$ [M + Na]$^+$: 291.0886, found: 291.0889. IR (film): ν (cm^{-1}) 2969, 2937, 2878, 2119, 1496, 1456, 1377, 1203, 1178, 1157, 1120, 1080, 1034, 973, 893, 836, 796, 731, 698, 588, 546, 512, 496.

*(2-((Azidosulfonyl)(phenethyl)amino)ethyl)benzene (**1t**).* Colorless oil (280.8 mg, 0.85 mmol, 85% yield; eluent: *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38−7.14 (m, 10H), 3.53−3.40 (m, 4H), 2.95−2.84 (m, 4H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.7, 128.9 (2C), 127.0, 51.6, 34.9. HRMS (ESI, *m*/*z*) calcd for $C_{16}H_{18}N_4O_2S_1Na$ [M + Na]$^+$: 353.1043, found: 353.1048. IR (film): ν (cm^{-1}) 3028, 2940, 2120, 1603, 1496, 1454, 1377, 1202, 1161, 1126, 1094, 1057, 1030, 963, 909, 845, 736, 696, 600, 515, 495.

https://dx.doi.org/10.1021/acs.joc.0c02279
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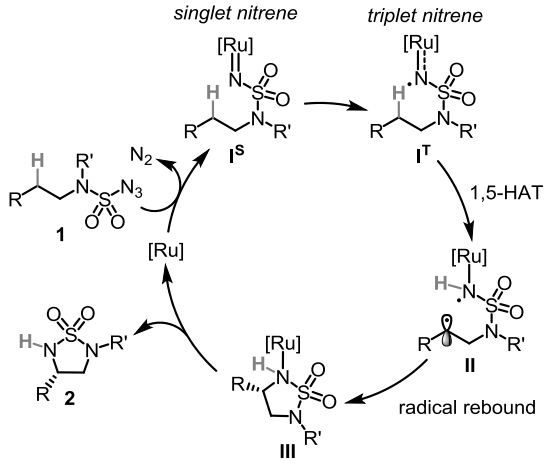

Figure 6. Proposed mechanism. HAT, hydrogen atom transfer.

*(2-(Allyl(azidosulfonyl)amino)ethyl)benzene (**1u**).* Colorless oil (210.4 mg, 0.79 mmol, 79% yield; eluent: *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.16 (m, 5H), 5.90−5.75 (m, 1H), 5.35−5.25 (m, 2H), 3.84 (d, J = 6.5 Hz, 2H), 3.54−3.45 (m, 2H), 2.98−2.89 (m, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.8, 131.6, 128.9, 128.8, 127.0, 120.5, 52.2, 50.0, 34.8. HRMS (ESI, m/z) calcd for $C_{11}H_{15}N_4O_2S_1$ $[M + H]^+$: 267.0910, found: 267.0913. IR (film): ν (cm^{-1}) 3029, 2938, 2121, 1603, 1497, 1454, 1420, 1378, 1284, 1202, 1164, 1116, 1086, 1055, 984, 929, 902, 878, 837, 780, 733, 699, 644, 600, 576, 512, 496.

*(2-((Azidosulfonyl)(prop-2-yn-1-yl)amino)ethyl)benzene (**1v**).* White solid (235.2 mg, 0.89 mmol, 89% yield; eluent: *n*-hexane/EtOAc = 10:1). MP: 46−47 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38−7.20 (m, 5H), 4.02 (d, J = 2.5 Hz, 2H), 3.66−3.58 (m, 2H), 3.01−2.93 (m, 2H) 2.45 (t, J = 2.5 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.5, 128.9 (2C), 127.1, 76.5, 75.0, 49.8, 38.6, 34.5. HRMS (ESI, m/z) calcd for $C_{11}H_{13}N_4O_2S_1$ $[M + H]^+$: 265.0754, found: 265.0757. IR (film): ν (cm^{-1}) 3294, 2938, 2131, 1492, 1454, 1423, 1380, 1340, 1283, 1206, 1162, 1126, 1093, 1057, 1030, 985, 924, 908, 835, 774, 756, 724, 702, 681, 662, 639, 596, 558, 540, 506, 468.

*(((Azidosulfonyl)(propyl)amino)methyl)benzene (**1w**).* Colorless oil (216.2 mg, 0.85 mmol, 85% yield; eluent: *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.30 (m, 5H), 4.46 (s, 2H), 3.19 (t, J = 7.7 Hz, 2H), 1.58 (sext, J = 7.7 Hz, 2H), 0.85 (t, J = 7.3 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 134.9, 129.0, 128.6, 128.5, 52.6, 50.5, 20.8, 11.1. HRMS (ESI, m/z) calcd for $C_{10}H_{14}N_4O_2S_1Na$ $[M + Na]^+$: 277.0730, found: 277.0734. IR (film): ν (cm^{-1}) 2970, 2937, 2878, 2120, 1496, 1455, 1375, 1256, 1204, 1178, 1158, 1120, 1079, 1020, 939, 911, 887, 783, 733, 697, 587, 526, 457.

*(2-((Azidosulfonyl)(2-phenylethyl-2,2-d2)amino)ethyl)benzene (**1t′**).* Colorless oil (302.5 mg, 0.91 mmol, 91% yield; *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.15 (m, 10H), 3.52−3.42 (m, 4H), 2.94−2.84 (m, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.7, 128.9 (2C), 127.0, 51.6, 51.5, 34.9. HRMS (ESI, m/z) calcd for $C_{16}H_{16}D_2N_4O_2S_1Na$ $[M + Na]^+$: 355.1168, found: 355.1173. IR (film): ν (cm^{-1}) 3027, 2120, 1496, 1452, 1377, 1202, 1164, 1107, 1072, 1028, 962, 911, 840, 796, 731, 696, 596, 514, 494.

*(((Azidosulfonyl)(2-phenylethyl-2,2-d2)amino)methyl)benzene (**1a′**).* Colorless oil (264.3 mg, 0.83 mmol, 83% yield; *n*-hexane/EtOAc = 10:1). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45−7.20 (m, 8H), 7.14−7.04 (m, 2H), 4.42 (s, 2H), 3.42 (s, 2H). ^{13}C{1H} NMR (125 MHz, $CDCl_3$) δ 137.6, 134.6, 129.1, 128.9, 128.8 (2C), 128.7, 126.9, 53.1, 50.0, 33.8 (quint, J = 19.9 Hz). HRMS (ESI, m/z) calcd for $C_{15}H_{14}D_2N_4O_2S_1Na$ $[M + Na]^+$: 341.1012, found: 341.1020. IR (film): ν (cm^{-1}) 2122, 1496, 1451, 1376, 1201, 1164, 1108, 1077, 982, 937, 906, 803, 770, 731, 695, 590, 531, 497, 458.

*(E)-(3-((Azidosulfonyl)(benzyl)amino)prop-1-en-1-yl)benzene ((E)-**8**).* White solid (308.7 mg, 0.94 mmol, 94% yield; *n*-hexane/EtOAc = 10:1). MP: 73−74 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.28 (m, 10H), 6.52 (d, J = 15.8 Hz, 1H), 6.16 (dt, J = 15.8, 7.0 Hz, 1H), 4.49 (s, 2H), 4.99 (d, J = 6.9 Hz, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 136.1, 136.0, 134.6, 129.1, 128.9, 128.8, 128.6, 128.5, 126.8, 121.7, 51.5, 50.2. HRMS (ESI, m/z) calcd for $C_{16}H_{16}N_4O_2S_1Na$ $[M + Na]^+$: 351.0886, found: 351.0892. IR (film): ν (cm^{-1}) 3023, 2145, 1494, 1452, 1433, 1378, 1344, 1245, 1192, 1160, 1111, 1073, 1026, 1002, 972, 927, 899, 841, 772, 741, 718, 693, 598, 560, 541, 524, 489, 474, 456.

Procedure for the Amination Reactions. A 10 mL Schlenk tube was charged with catalyst **Ru3** (5.4 mg, 0.005 mmol, 5 mol %) under an atmosphere of nitrogen. Subsequently, 1,2-dichloroethane (0.25 mL) containing sulfamoyl azide (0.1 mmol, 1 equiv) was added via a syringe under a nitrogen atmosphere. The resulting solution was stirred under a nitrogen atmosphere at a 55 °C oil bath temperature for 48 h. Afterward, the reaction solution was directly purified by flash chromatography on silica gel (*n*-hexane/EtOAc = 10:1 to 3:1) to afford the product. The enantiomeric excess was determined by chiral HPLC analysis. The absolute configuration of **2j** was determined by single-crystal X-ray structure analysis as *S*-configuration (see the Supporting Information), and all other products were assigned accordingly.

*(S)-2-Benzyl-4-phenyl-1,2,5-thiadiazolidine-1,1-dioxide (**2a**).*[5b] Starting from **1a** (31.6 mg, 0.1 mmol) according to the general procedure, **2a** was afforded as a white solid (28.0 mg, 0.097 mmol, 97% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 75:25, flow rate 1.0 mL/min, 25 °C, t_r (major) = 14.5 min, t_r (minor) = 13.1 min). $[\alpha]_D^{22}$ = −69.4° (c 1.0, CH_2Cl_2). MP: 123−124 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.44−7.29 (m, 10H), 4.85−4.75 (m, 1H), 4.69 (d, J = 6.1 Hz, 1H), 4.37 (d, J = 13.6 Hz, 1H), 4.01 (d, J = 13.6 Hz, 1H), 3.56 (dd, J = 9.6, 7.1 Hz, 1H), 3.13 (dd, J = 9.5, 8.2 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.5, 135.0, 129.2, 128.9, 128.8, 128.4, 56.1, 55.2, 50.7.

*(S)-2-Benzyl-4-(p-tolyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2b**).* Starting from **1b** (33.0 mg, 0.1 mmol) according to the general procedure, **2b** was afforded as a white solid (29.9 mg, 0.099 mmol, 99% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 95% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 75:25, flow rate 1.0 mL/min, 25 °C, t_r (major) = 13.6 min, t_r (minor) = 15.0 min). $[\alpha]_D^{22}$ = −89.3° (c 1.0, CH_2Cl_2). MP: 134−135 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.24 (m, 7H), 7.20−7.12 (m, 2H), 4.75 (dd, J = 14.6, 7.1 Hz, 1H), 4.61 (d, J = 6.2 Hz, 1H), 4.36 (d, J = 13.7 Hz, 1H), 4.02 (d, J = 13.6 Hz, 1H), 3.52 (dd, J = 9.6, 7.1 Hz, 1H), 3.13 (dd, J = 9.4, 8.4 Hz, 1H), 2.33 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.9, 135.4, 135.1, 129.8, 128.9, 128.8, 128.4, 126.5, 55.9, 55.3, 50.7, 21.2. HRMS (ESI, m/z) calcd For $C_{16}H_{18}N_2O_2S_1Na$ $[M + Na]^+$: 325.0981, found: 325.0999. IR (film): ν (cm^{-1}) 3249, 3066, 3034, 2919, 2881, 2859, 1515, 1497, 1474, 1455, 1403, 1370, 1355, 1343, 1311, 1297, 1275, 1249, 1213, 1200, 1185, 1150, 1111, 1083, 1057, 1023, 1009, 944, 924, 900, 818, 782, 738, 719, 695, 644, 625, 586, 542, 511, 474, 430, 416.

*(S)-2-Benzyl-4-(m-tolyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2c**).* Starting from **1c** (33.0 mg, 0.1 mmol) according to the general procedure, **2c** was afforded as a white solid (30.0 mg, 0.099 mmol, 99% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 97% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 85:15, flow rate 1.0 mL/min, 25 °C, t_r (major) = 18.6 min, t_r (minor) = 20.9 min). $[\alpha]_D^{22}$ = −85.6° (c 1.0, CH_2Cl_2). MP: 110−111 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.30 (m, 5H), 7.28−7.10 (m, 4H), 4.76 (dd, J = 14.5, 7.2 Hz, 1H), 4.65 (d, J = 5.5 Hz, 1H), 4.37 (d, J = 13.6 Hz, 1H), 4.01 (d, J = 13.6 Hz, 1H), 3.53 (dd, J = 9.6, 7.1 Hz, 1H), 3.13 (dd, J = 9.3, 8.6 Hz, 1H), 2.34 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 139.1, 138.4, 135.1, 129.7, 129.1, 128.9, 128.8, 128.4, 127.1, 123.6, 56.1, 55.2, 50.7, 21.5. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_2O_2S_1Na$ $[M + Na]^+$: 325.0981, found: 325.0992. IR (film): ν (cm^{-1}) 3241, 3032, 2919, 2883, 2858, 1607, 1491, 1474,

https://dx.doi.org/10.1021/acs.joc.0c02279
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1453, 1405, 1372, 1342, 1297, 1277, 1251, 1203, 1151, 1108, 1082, 1054, 1009, 961, 929, 900, 829, 779, 738, 718, 693, 634, 614, 585, 511, 479, 448, 428.

*(S)-2-Benzyl-4-(o-tolyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2d**).* Starting from **1d** (33.0 mg, 0.1 mmol) according to the general procedure, **2d** was afforded as a white solid (23.0 mg, 0.076 mmol, 76% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 90% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 80:20, flow rate 1.0 mL/min, 25 °C, t_r (major) = 15.9 min, t_r (minor) = 13.3 min). $[\alpha]_D^{22} = -52.9°$ (c 1.0, CH_2Cl_2). MP: 73−74 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.65−7.56 (m, 1H), 7.40−7.28 (m, 5H), 7.28−7.18 (m, 2H), 7.15−7.09 (m, 1H), 5.05 (dd, J = 14.7, 7.2 Hz, 1H), 4.59 (d, J = 6.5 Hz, 1H), 4.37 (d, J = 13.6 Hz, 1H), 4.03 (d, J = 13.6 Hz, 1H), 3.56 (dd, J = 9.6, 7.2 Hz, 1H), 3.10 (dd, J = 9.5, 8.1 Hz, 1H), 2.28 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 136.5, 135.2, 135.0, 130.8, 128.9, 128.8, 128.6, 128.4, 127.1, 126.1, 54.3, 52.6, 50.1, 19.1. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_2O_2S_1Na$ $[M + Na]^+$: 325.0981, found: 325.0989. IR (film): ν (cm^{-1}) 3249, 3028, 2960, 2922, 2866, 1491, 1457, 1407, 1381, 1351, 1323, 1301, 1218, 1146, 1117, 1094, 1076, 1054, 1011, 917, 899, 782, 745, 695, 637, 602, 572, 551, 535, 509, 484, 454, 438.

*(S)-4-([1,1′-Biphenyl]-4-yl)-2-benzyl-1,2,5-thiadiazolidine-1,1-dioxide (**2e**).* Starting from **1e** (39.2 mg, 0.1 mmol) according to the general procedure, **2e** was afforded as a white solid (35.7 mg, 0.098 mmol, 98% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 98% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 20.5 min, t_r (minor) = 31.4 min). $[\alpha]_D^{22} = -158.0°$ (c 1.0, CH_2Cl_2). MP: 190−191 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62−7.52 (m, 4H), 7.49−7.41 (m, 4H), 7.40−7.29 (m, 6H), 4.84 (dd, J = 14.5, 7.3 Hz, 1H), 4.71 (d, J = 6.4 Hz, 1H), 4.40 (d, J = 13.6 Hz, 1H), 4.03 (d, J = 13.6 Hz, 1H), 3.59 (dd, J = 9.6, 7.2 Hz, 1H), 3.17 (dd, J = 9.5, 8.3 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 142.0, 140.4, 137.4, 135.0, 129.0, 128.9, 128.8, 128.4, 127.9, 127.8, 127.2, 127.0, 55.8, 55.2, 50.7. HRMS (ESI, m/z) calcd for $C_{21}H_{21}N_2O_2S_1$ $[M + H]^+$: 365.1324, found: 365.1322. IR (film): ν (cm^{-1}) 3278, 3029, 2923, 2854, 1485, 1454, 1395, 1363, 1344, 1307, 1278, 1208, 1152, 1118, 1063, 1007, 938, 903, 836, 809, 765, 726, 694, 648, 611, 587, 563, 546, 518, 499, 480, 426.

*(S)-2-Benzyl-4-(4-methoxyphenyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2f**).*[5b] Starting from **1f** (34.6 mg, 0.1 mmol) according to the general procedure, **2f** was afforded as a white solid (29.3 mg, 0.092 mmol, 92% yield; *n*-hexane/EtOAc = 5:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 97% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 15.2 min, t_r (minor) = 17.8 min). $[\alpha]_D^{22} = -101.1°$ (c 1.0, CH_2Cl_2). MP: 113−114 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.27 (m, 7H), 6.92−6.84 (m, 2H), 4.74 (dd, J = 14.3, 7.2 Hz, 1H), 4.60 (d, J = 5.5 Hz, 1H), 4.36 (d, J = 13.6 Hz, 1H), 4.03 (d, J = 13.6 Hz, 1H), 3.79 (s, 3H), 3.51 (dd, J = 9.6, 7.1 Hz, 1H), 3.13 (dd, J = 9.5, 8.3 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 160.1, 135.1, 130.4, 128.9, 128.8, 128.4, 127.9, 114.5, 55.7, 55.5, 55.4, 50.6.

*(S)-4-(Benzo[d][1,3]dioxol-5-yl)-2-benzyl-1,2,5-thiadiazolidine-1,1-dioxide (**2g**).* Starting from **1g** (36.0 mg, 0.1 mmol) according to the general procedure, **2g** was afforded as a white solid (31.9 mg, 0.096 mmol, 96% yield; *n*-hexane/EtOAc = 5:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 13.1 min, t_r (minor) = 16.0 min). $[\alpha]_D^{22} = -123.3°$ (c 1.0, CH_2Cl_2). MP: 130−131 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.30 (m, 5H), 6.92 (d, J = 1.6 Hz, 1H), 6.83−6.72 (m, 2H), 5.96 (s, 2H), 4.71 (dd, J = 13.1, 7.3 Hz, 1H), 4.61 (d, J = 5.7 Hz, 1H), 4.36 (d, J = 13.6 Hz, 1H), 4.01 (d, J = 13.6 Hz, 1H), 3.51 (dd, J = 9.6, 7.1 Hz, 1H), 3.09 (dd, J = 9.6, 8.1 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 148.5, 148.2, 135.0, 132.3, 128.9, 128.8, 128.4, 120.2, 108.6, 106.9, 101.5, 55.9, 55.3, 50.7. HRMS (ESI, m/z) calcd for $C_{16}H_{17}N_2O_4S_1$ $[M + H]^+$: 333.0904, found: 333.0918. IR (film): ν (cm^{-1}) 3227, 3088, 3064, 3033, 2909, 2787, 1503, 1491, 1442, 1401, 1352, 1311, 1278, 1260, 1213, 1185, 1150, 1104, 1084, 1042, 964, 923, 897, 878, 818, 771, 716, 696, 645, 623, 610, 589, 564, 511, 474, 420.

*(S)-2-Benzyl-4-(4-(trifluoromethyl)phenyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2h**).*[5b] Starting from **1h** (38.4 mg, 0.1 mmol) according to the general procedure, **2h** was afforded as a white solid (18.2 mg, 0.051 mmol, 51% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 84% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 85:15, flow rate 1.0 mL/min, 25 °C, t_r (major) = 10.6 min, t_r (minor) = 15.1 min). $[\alpha]_D^{22} = -50.1°$ (c 1.0, CH_2Cl_2). MP: 133−134 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.63 (d, J = 8.3 Hz, 2H), 7.52 (d, J = 8.3 Hz, 2H), 7.40−7.30 (m, 5H), 4.92−4.76 (m, 2H), 4.40 (d, J = 13.6 Hz, 1H), 3.96 (d, J = 13.6 Hz, 1H), 3.63 (dd, J = 9.9, 7.3 Hz, 1H), 3.06 (dd, J = 9.6, 7.9 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 142.8, 134.7, 131.4 (C−F, $^2J_{C-F}$ = 32.9 Hz), 130.9 (C−F, $^2J_{C-F}$ = 32.9 Hz), 129.0, 128.8, 128.5, 126.9, 126.2 (C−F, $^3J_{C-F}$ = 3.9 Hz), 126.1 (C−F, $^3J_{C-F}$ = 3.9 Hz), 125.7 (C−F, $^1J_{C-F}$ = 271.8 Hz), 122.1 (C−F, $^1J_{C-F}$ = 271.8 Hz), 55.3, 54.8, 50.7. ^{19}F NMR (235 MHz, $CDCl_3$) δ −62.7 (s, 3F).

*(S)-2-Benzyl-4-(4-fluorophenyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2i**).* Starting from **1i** (33.4 mg, 0.1 mmol) according to the general procedure, **2i** was afforded as a white solid (27.3 mg, 0.089 mmol, 89% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 94% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 85:15, flow rate 1.0 mL/min, 25 °C, t_r (major) = 15.5 min, t_r (minor) = 17.3 min). $[\alpha]_D^{22} = -79.8°$ (c 1.0, CH_2Cl_2). MP: 136−137 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41−7.29 (m, 7H), 7.09−7.00 (m, 2H), 4.86−4.62 (m, 2H), 4.38 (d, J = 13.6 Hz, 1H), 3.99 (d, J = 13.6 Hz, 1H), 3.56 (dd, J = 9.6, 7.1 Hz, 1H), 3.08 (dd, J = 9.5, 8.1 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 164.6 (C−F, $^1J_{C-F}$ = 248.2 Hz), 161.4 (C−F, $^1J_{C-F}$ = 248.2 Hz), 134.9, 134.4 (2C), 129.0, 128.9, 128.4 (C−F, $^3J_{C-F}$ = 8.8 Hz), 128.3 (C−F, $^3J_{C-F}$ = 8.8 Hz), 116.3 (C−F, $^2J_{C-F}$ = 21.9 Hz), 116.0 (C−F, $^2J_{C-F}$ = 21.9 Hz), 55.4, 55.2, 50.6. ^{19}F NMR (235 MHz, $CDCl_3$) δ −112.8. HRMS (ESI, m/z) calcd for $C_{15}H_{15}F_1N_2O_2S_1Na$ $[M + Na]^+$: 329.0730, found: 329.0738. IR (film): ν (cm^{-1}) 3264, 2923, 2855, 1606, 1510, 1478, 1455, 1404, 1360, 1337, 1288, 1224, 1205, 1150, 1120, 1086, 1056, 1015, 945, 899, 832, 789, 754, 739, 719, 695, 645, 620, 582, 541, 513, 498, 474, 427.

*(S)-2-Benzyl-4-(4-chlorophenyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2j**).*[5b] Starting from **1j** (35.1 mg, 0.1 mmol) according to the general procedure, **2j** was afforded as a white solid (26.1 mg, 0.081 mmol, 81% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 94% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 8.9 min, t_r (minor) = 10.6 min). $[\alpha]_D^{22} = -114.0°$ (c 1.0, CH_2Cl_2). MP: 160−161 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.29 (m, 9H), 4.77 (dd, J = 14.4, 7.2 Hz, 1H), 4.69 (d, J = 6.5 Hz, 1H), 4.38 (d, J = 13.6 Hz, 1H), 3.98 (d, J = 13.6 Hz, 1H), 3.56 (dd, J = 9.7, 7.3 Hz, 1H), 3.06 (dd, J = 9.6, 8.1 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 137.2, 134.9, 134.8, 129.4, 129.0, 128.9, 128.5, 127.9, 55.4, 55.0, 50.7.

*(S)-2-Benzyl-4-(naphthalen-2-yl)-1,2,5-thiadiazolidine-1,1-dioxide (**2k**).*[5b] Starting from **1k** (36.6 mg, 0.1 mmol) according to the general procedure, **2k** was afforded as a white solid (28.1 mg, 0.083 mmol, 83% yield; *n*-hexane/EtOAc = 5:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 97% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 14.2 min, t_r (minor) = 17.9 min). $[\alpha]_D^{22} = -119.9°$ (c 1.0, CH_2Cl_2). MP: 163−164 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.90−7.76 (m, 4H), 7.55−7.46 (m, 3H), 7.42−7.28 (m, 5H), 4.96 (dd, J = 14.4, 7.4 Hz, 1H), 4.78 (d, J = 6.4 Hz, 1H), 4.41 (d, J = 13.6 Hz, 1H), 4.03 (d, J = 13.6 Hz, 1H), 3.63 (dd, J = 9.7, 7.2 Hz, 1H), 3.21 (dd, J = 9.6, 8.3 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 135.7, 135.0, 133.5, 133.3, 129.4, 129.0, 128.9, 128.4, 128.1, 127.9, 126.9, 126.8, 125.9, 123.7, 56.2, 55.1, 50.7.

*(R)-2-Benzyl-4-(thiophen-2-yl)-1,2,5-thiadiazolidine-1,1-dioxide (**2l**).*[5b] Starting from **1l** (32.2 mg, 0.1 mmol) according to the general

https://dx.doi.org/10.1021/acs.joc.0c02279
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procedure, **2l** was afforded as a white solid (27.4 mg, 0.093 mmol, 93% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 80:20, flow rate 1.0 mL/min, 25 °C, t_r (major) = 20.9 min, t_r (minor) = 16.0 min). $[\alpha]_D^{22} = -94.8°$ (c 1.0, CH_2Cl_2). MP: 112−113 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42−7.31 (m, 5H), 7.29 (dd, J = 5.1, 1.2 Hz, 1H), 7.05 (d, J = 3.5 Hz, 1H), 6.96 (dd, J = 5.1, 3.5 Hz, 1H), 5.06 (t, J = 7.1 Hz, 1H), 4.32 (d, J = 13.6 Hz, 1H), 4.13 (d, J = 13.6 Hz, 1H), 3.58 (dd, J = 9.6, 6.8 Hz, 1H), 3.54 (br s, 1H), 3.30 (dd, J = 9.6, 7.4 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 141.4, 135.0, 129.0, 128.8, 128.4, 127.3, 126.4, 126.1, 55.3, 52.1, 50.7.

*tert-Butyl (S)-3-(5-Benzyl-1,1-dioxido-1,2,5-thiadiazolidin-3-yl)-1H-indole-1-carboxylate (**2m**).*[5b] Starting from **1m** (45.6 mg, 0.1 mmol) according to the general procedure, **2m** was afforded as a white solid (42.3 mg, 0.099 mmol, 99% yield; *n*-hexane/EtOAc = 3:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 95% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 12.1 min, t_r (minor) = 16.8 min). $[\alpha]_D^{22} = -90.8°$ (c 1.0, CH_2Cl_2). MP: 59−60 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.15 (d, J = 8.2 Hz, 1H), 7.70 (d, J = 7.8 Hz, 1H), 7.60 (s, 1H), 7.44−7.22 (m, 7H), 5.06 (dd, J = 14.8, 7.1 Hz, 1H), 4.60 (d, J = 6.7 Hz, 1H), 4.38 (d, J = 13.6 Hz, 1H), 4.14 (d, J = 13.6 Hz, 1H), 3.57 (dd, J = 9.6, 7.1 Hz, 1H), 3.44 (dd, J = 9.5, 8.3 Hz, 1H), 1.66 (s, 9H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 149.4, 136.1, 135.1, 129.0, 128.9, 128.4, 127.6, 125.4, 124.2, 123.2, 119.3, 117.3, 115.8, 84.5, 53.3, 50.7, 49.7, 28.3.

*(3aS,8aR)-1-Benzyl-3,3a,8,8a-tetrahydro-1H-indeno[1,2-c][1,2,5]thiadiazole 2,2-dioxide (**2n**).*[5b] Starting from **1n** (32.8 mg, 0.1 mmol) according to the general procedure, **2n** was afforded as a white solid (29.7 mg, 0.099 mmol, 99% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 95% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 75:25, flow rate 1.0 mL/min, 25 °C, t_r (major) = 13.3 min, t_r (minor) = 10.6 min). $[\alpha]_D^{22} = -154.7°$ (c 1.0, CH_2Cl_2). MP: 135−136 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45−7.34 (m, 6H), 7.33−7.23 (m, 2H), 7.16−7.08 (m, 1H), 5.11 (t, J = 7.8 Hz, 1H), 4.50 (d, J = 13.8 Hz, 1H), 4.31 (d, J = 8.0 Hz, 1H), 4.19−4.09 (m, 2H), 3.02−2.90 (m, 1H), 2.88−2.76 (m, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 141.6, 138.3, 135.3, 130.0, 129.3, 128.9, 128.4, 128.0, 125.6, 125.3, 63.4, 61.1, 50.2, 38.1.

*(S)-2-Benzyl-4-(cyclohex-1-en-1-yl)-1,2,5-thiadiazolidine-1,1-dioxide (**2o**).*[5b] Starting from **1o** (32.0 mg, 0.1 mmol) according to the general procedure, **2o** was afforded as a white solid (22.2 mg, 0.076 mmol, 76% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IA column, ee = 77% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 90:10, flow rate 1.0 mL/min, 25 °C, t_r (major) = 14.5 min, t_r (minor) = 17.1 min). $[\alpha]_D^{22} = -40.7°$ (c 1.0, CH_2Cl_2). MP: 108−109 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42−7.28 (m, 5H), 5.80−5.71 (m, 1H), 4.32 (br s, 1H), 4.31 (d, J = 13.7 Hz, 1H), 3.98 (d, J = 13.7 Hz, 1H), 4.16 (dd, J = 14.7, 7.2 Hz, 1H), 3.29 (dd, J = 9.4, 7.1 Hz, 1H), 3.01 (dd, J = 9.2, 8.5 Hz, 1H), 2.12−1.82 (m, 4H), 1.72−1.44 (m, 4H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 135.3, 134.1, 128.9, 128.8, 128.3, 126.4, 57.9, 52.0, 50.6, 25.1, 23.9, 22.4, 22.2.

*(S)-2-Benzyl-4-(phenylethynyl)-1,2,5-thiadiazolidine-1,1-dioxide (**2p**).*[15] Starting from **1p** (34.0 mg, 0.1 mmol) according to the general procedure, **2p** was afforded as a colorless oil (30.6 mg, 0.098 mmol, 98% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 68% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 11.5 min, t_r (minor) = 14.4 min). $[\alpha]_D^{22} = -107.1°$ (c 1.0, CH_2Cl_2). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.47−7.27 (m, 10H), 4.74−4.54 (m, 2H), 4.31 (d, J = 13.8 Hz, 1H), 4.20 (d, J = 13.8 Hz, 1H), 3.55 (dd, J = 9.6, 6.7 Hz, 1H), 3.42 (dd, J = 9.6, 7.2 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 135.0, 132.0, 129.3, 129.0, 128.8, 128.5, 128.4, 121.5, 86.5, 84.2, 54.0, 50.7, 44.6.

*(S)-2-Methyl-4-phenyl-1,2,5-thiadiazolidine-1,1-dioxide (**2q**).*[15] Starting from **1q** (24.0 mg, 0.1 mmol) according to the general procedure, **2q** was afforded as a white solid (18.5 mg, 0.087 mmol, 87% yield; *n*-hexane/EtOAc = 3:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 94% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 16.7 min, t_r (minor) = 14.5 min). $[\alpha]_D^{22} = -14.2°$ (c 1.0, CH_2Cl_2). MP: 119−120 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.50−7.30 (m, 5H), 4.84 (dd, J = 13.9, 7.2 Hz, 1H), 4.66 (d, J = 5.0 Hz, 1H), 3.69 (dd, J = 9.3, 7.3 Hz, 1H), 3.24 (t, J = 8.7 Hz, 1H), 2.76 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.7, 129.2, 129.0, 126.6, 58.0, 55.9, 32.9.

*(S)-2-Ethyl-4-phenyl-1,2,5-thiadiazolidine-1,1-dioxide (**2r**).*[4a] Starting from **1r** (25.4 mg, 0.1 mmol) according to the general procedure, **2r** was afforded as a white solid (20.1 mg, 0.089 mmol, 89% yield; *n*-hexane/EtOAc = 3:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 9.2 min, t_r (minor) = 14.3 min). $[\alpha]_D^{22} = -18.8°$ (c 1.0, CH_2Cl_2). MP: 97−98 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.50−7.30 (m, 5H), 4.83 (dd, J = 14.3, 7.2 Hz, 1H), 4.64 (d, J = 4.5 Hz, 1H), 3.73 (dd, J = 9.4, 7.2 Hz, 1H), 3.28−3.14 (m, 2H), 3.10−2.94 (m, 1H), 1.28 (t, J = 7.2 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.7, 129.2, 129.0, 126.6, 56.0, 55.6, 41.8, 13.2.

*(S)-4-Phenyl-2-propyl-1,2,5-thiadiazolidine-1,1-dioxide (**2s**).* Starting from **1s** (26.8 mg, 0.1 mmol) according to the general procedure, **2s** was afforded as a white solid (21.1 mg, 0.088 mmol, 88% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 80:20, flow rate 1.0 mL/min, 25 °C, t_r (major) = 15.8 min, t_r (minor) = 13.7 min). $[\alpha]_D^{22} = -28.7°$ (c 1.0, CH_2Cl_2). MP: 88−89 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.50−7.30 (m, 5H), 4.83 (dd, J = 14.0, 7.0 Hz, 1H), 4.60 (d, J = 5.1 Hz, 1H), 3.77−3.66 (m, 1H), 3.22 (t, J = 8.7 Hz, 1H), 3.16−3.02 (m, 1H), 2.98−2.84 (m, 1H), 1.66 (sext, J = 7.3 Hz, 2H), 0.99 (t, J = 7.3 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.8, 129.2, 129.0, 126.6, 56.0 (2C), 48.8, 21.3, 11.5. HRMS (ESI, m/z) calcd for $C_{11}H_{17}N_2O_2S_1$ $[M + H]^+$: 241.1005, found: 241.1015. IR (film): ν (cm^{-1}) 3282, 2966, 2930, 2875, 1495, 1460, 1390, 1363, 1347, 1329, 1309, 1272, 1202, 1174, 1138, 1083, 1050, 1029, 988, 939, 906, 890, 805, 772, 746, 718, 695, 626, 608, 572, 518, 455.

*(S)-2-Phenethyl-4-phenyl-1,2,5-thiadiazolidine-1,1-dioxide (**2t**).* Starting from **1t** (33.0 mg, 0.1 mmol) according to the general procedure, **2t** was afforded as a white solid (27.8 mg, 0.092 mmol, 92% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 19.0 min, t_r (minor) = 15.2 min). $[\alpha]_D^{22} = -36.2°$ (c 1.0, CH_2Cl_2). MP: 120−121 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.43−7.33 (m, 5H), 7.32−7.18 (m, 5H), 4.79 (dd, J = 13.9, 7.2 Hz, 1H), 4.59 (d, J = 6.1 Hz, 1H), 3.66 (dd, J = 9.4, 7.1 Hz, 1H), 3.47−3.34 (m, 1H), 3.30−3.16 (m, 2H), 2.97 (t, J = 7.6 Hz, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.6, 138.4, 129.2, 129.0, 128.8, 128.7, 126.8, 126.6, 56.3, 56.0, 48.4, 34.6. HRMS (ESI, m/z) calcd for $C_{16}H_{18}N_2O_2S_1Na$ $[M + Na]^+$: 325.0981, found: 325.0980. IR (film): ν (cm^{-1}) 3279, 3031, 2953, 2925, 2859, 1603, 1494, 1477, 1454, 1399, 1350, 1328, 1309, 1295, 1276, 1210, 1150, 1132, 1090, 1060, 1027, 967, 940, 913, 894, 842, 751, 696, 632, 619, 586, 563, 516, 491, 443.

*(S)-2-Allyl-4-phenyl-1,2,5-thiadiazolidine-1,1-dioxide (**2u**).* Starting from **1u** (26.6 mg, 0.1 mmol) according to the general procedure, **2u** was afforded as a white solid (22.4 mg, 0.094 mmol, 94% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 12.5 min, t_r (minor) = 10.1 min). $[\alpha]_D^{22} = -29.7°$ (c 1.0, CH_2Cl_2). MP: 61−62 °C.^{1}H NMR (300 MHz, $CDCl_3$) δ 7.48−7.30 (m, 5H), 5.98−5.80 (m, 1H), 5.38−5.22 (m, 2H), 4.90−4.74 (m, 2H), 3.84−3.66 (m, 2H), 3.53 (dd, J = 14.0, 6.8 Hz, 1H), 3.19 (dd, J = 9.6, 8.0 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ

https://dx.doi.org/10.1021/acs.joc.0c02279
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138.6, 132.0, 129.2, 128.9, 126.6, 120.1, 56.1, 55.4, 49.7. HRMS (ESI, m/z) calcd for $C_{11}H_{14}N_2O_2S_1Na$ $[M + Na]^+$: 261.0668, found: 261.0670. IR (film): ν (cm^{-1}) 3266, 2924, 2881, 1495, 1470, 1456, 1421, 1397, 1360, 1347, 1310, 1277, 1211, 1200, 1147, 1113, 1083, 1058, 1013, 980, 925, 895, 802, 776, 754, 721, 696, 642, 584, 563, 517, 451.

*(S)-4-Phenyl-2-(prop-2-yn-1-yl)-1,2,5-thiadiazolidine-1,1-dioxide (**2v**).* Starting from **1v** (26.4 mg, 0.1 mmol) according to the general procedure, **2v** was afforded as a yellow oil (13.0 mg, 0.055 mmol, 55% yield; *n*-hexane/EtOAc = 3:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 90% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 9.3 min, t_r (minor) = 10.8 min). $[\alpha]_D^{22}$ = −33.3° (c 1.0, CH_2Cl_2). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.48−7.32 (m, 5H), 4.97−4.85 (m, 1H), 4.66 (d, J = 6.2 Hz, 1H), 3.98 (dd, J = 17.1, 2.5 Hz, 1H), 3.90 (dd, J = 9.9, 7.2 Hz, 1H), 3.83 (dd, J = 17.1, 2.5 Hz, 1H), 3.50 (dd, J = 9.9, 8.5 Hz, 1H), 2.38 (t, J = 2.5 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.2, 129.3, 129.1, 126.6, 74.5, 56.2, 55.4, 36.7. HRMS (ESI, m/z) calcd for $C_{11}H_{12}N_2O_2S_1Na$ $[M + Na]^+$: 259.0512, found: 259.0512. IR (film): ν (cm^{-1}) 3280, 2923, 2854, 1455, 1395, 1293, 1204, 1158, 1067, 1027, 925, 903, 754, 698, 637, 610, 555, 496, 455.

Competition of 5- vs 6-Membered Ring Formation. Starting from **1x** (33.0 mg, 0.1 mmol) according to the general procedure, 2-benzyl-5-phenyl-1,2,6-thiadiazinane-1,1-dioxide **3x** was afforded as a white solid (13.9 mg, 0.046 mmol, 46% yield; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak IG column, ee = 20% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 18.2 min, t_r (minor) = 15.6 min). MP: 126−127 °C. The analytical data of **3x** are in accordance with the literature.[5a] ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.46−7.30 (m, 10H), 4.84−4.72 (m, 1H), 4.52 (d, J = 13.8 Hz, 1H), 4.22 (d, J = 7.9 Hz, 1H), 4.13 (d, J = 13.8 Hz, 1H), 3.52 (td, J = 13.2, 3.1 Hz, 1H), 3.28−3.17 (m, 1H), 2.08−1.90 (m, 1H), 1.90−1.80 (m, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 139.4, 135.6, 129.1, 129.0, 128.9, 128.7, 128.2, 126.4, 59.9, 52.1, 47.6, 29.5.

Starting from **1y** (34.4 mg, 0.1 mmol) according to the general procedure, (*S*)-4-phenyl-2-(3-phenylpropyl)-1,2,5-thiadiazolidine-1,1-dioxide **2y** was afforded as a white solid (23.1 mg, 0.073 mmol, 73% yield; *n*-hexane/EtOAc = 5:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 96% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 60:40, flow rate 1.0 mL/min, 25 °C, t_r (major) = 19.5 min, t_r (minor) = 14.4 min). $[\alpha]_D^{22}$ = −238.5° (c 1.0, CH_2Cl_2). MP: 91−92 °C. The analytical data of **2y** are in accordance with the literature.[5b] ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.48−7.12 (m, 10H), 4.87−4.76 (m, 1H), 4.69 (d, J = 6.0 Hz, 1H), 3.69 (dd, J = 9.4, 7.1 Hz, 1H), 3.28−3.08 (m, 2H), 3.02−2.90 (m, 1H), 2.73 (t, J = 7.4 Hz, 1H), 1.97 (quint, J = 7.4 Hz, 2H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 141.1, 138.7, 129.2, 129.0, 128.6 (2C), 126.6, 126.2, 56.1, 56.0, 46.5, 30.1, 29.4.

Gram-Scale Reaction. A 50 mL flask was charged with catalyst **Ru3** (216.4 mg, 0.2 mmol, 5 mol %) under an atmosphere of nitrogen. Subsequently, 1,2-dichloroethane (10 mL) containing sulfamoyl azides **1a** (1.26 g, 4.0 mmol) was added via a syringe under a nitrogen atmosphere. The resulting solution was stirred under a nitrogen atmosphere at a 55 °C oil bath temperature for 48 h. Afterward, the reaction solution was directly purified by flash chromatography on silica gel (*n*-hexane/EtOAc = 10:1 to 3:1) to afford **2a** as a white solid (1.10 g, 95% yield). Then, the catalyst (140.7 mg, 0.13 mmol, 65%) was reisolated by changing the eluent to CH_2Cl_2/CH_3CN (100:1 to 20:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 95% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 75:25, flow rate 1.0 mL/min, 25 °C, t_r (major) = 14.5 min, t_r (minor) = 13.1 min).

Follow-up Chemistry. The cyclic 5-membered sulfamide **2a** (57.6 mg, 0.2 mmol) was dissolved in hydrazine monohydrate (3 mL) and stirred for 14 h at a 110 °C oil bath temperature. After removing the solvent under reduced pressure, EtOAc (4 mL) was added and the resulting suspension was filtered through a pad of Celite. The filtrate was extracted with HCl (1 M, 2 × 2 mL), and the combined aqueous layers were adjusted to pH 14 by adding aqueous NaOH (6 M). The aqueous phase was extracted with EtOAc (2 × 3 mL), and the combined organic layers were washed with brine (4 mL) and dried over Na_2SO_4 and concentrated under reduced pressure to afford the benzyl-protected diamine **4a** as a yellow oil (43.0 mg, 0.19 mmol, 95% yield). $[\alpha]_D^{22}$ = +12.1° (c 1.0, CH_2Cl_2). The analytical data of **4a** are in accordance with the literature.[18] ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35−7.20 (m, 10H), 4.05 (dd, J = 8.3, 4.8 Hz, 1H), 3.81 (s, 2H), 2.85 (dd, J = 11.8, 4.8 Hz, 1H), 2.75 (dd, J = 11.8, 8.3 Hz, 1H), 1.82 (s, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 144.6, 140.4, 128.7, 128.5, 128.2, 127.3, 127.1, 126.5, 57.1, 55.7, 53.9.

The free diamine was converted to the corresponding hydrochloride salt by addition of 4 M HCl in 1,4-dioxane (2 equiv). The suspension of hydrochloride salt (29.9 mg, 0.1 mmol) and 15 mg of palladium hydroxide on carbon (20 wt % loading) in methanol (3 mL) was stirred under a hydrogen atmosphere (H_2 balloon) for 14 h. The resulting solution was filtered through a pad of Celite, and the filtrate was concentrated under reduced pressure. The residue was washed with EtOAc (2 × 3 mL) and dried under a vacuum to afford the desired chiral vicinal diamine hydrochloride salt **5a** as a white solid (18.8 mg, 0.09 mmol, 90% yield). $[\alpha]_D^{22}$ = −19.1° (c 1.0, EtOH). The analytical data of **5a** are in accordance with the literature.[19] ^{1}H NMR (300 MHz, DMSO-d_6) δ 8.86 (br s, 6H), 7.66−7.55 (m, 2H), 7.51−7.41 (m, 3H), 4.67 (t, J = 6.4 Hz, 1H), 3.53 (dd, J = 13.4, 6.8 Hz, 1H), 3.25 (dd, J = 13.4, 6.1 Hz, 1H). ^{13}C{1H} NMR (125 MHz, DMSO-d_6) δ 134.8, 129.9, 129.5, 128.4, 52.6, 42.3. An enantiomeric excess of 95% ee was determined after conversion of the diamine hydrochloride salt to its cyclic urea[13d] according to a literature procedure.[20]

Procedure for the Asymmetric Aziridination Reaction. A 10 mL Schlenk tube was charged with sulfamoyl azide (*E*)-**8** (32.8 mg, 0.1 mmol) and **Ru1** (8.9 mg, 0.008 mmol, 8 mol %) under an atmosphere of nitrogen. 1,2-Dichloroethane (0.25 mL) was added via a syringe under a nitrogen atmosphere, and the resulting solution was stirred under a nitrogen atmosphere at a 60 °C oil bath temperature for 60 h. The reaction solution was directly purified by flash chromatography on silica gel (*n*-hexane/EtOAc = 10:1 to 3:1) to afford the bicyclic aziridine **9** (21.6 mg, 0.072 mmol, 72% yield) as a white solid. The absolute configuration of the product **9** was confirmed by single-crystal X-ray diffraction as *R,R*-configuration (see the Supporting Information). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 98% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 70:30, flow rate 1.0 mL/min, 25 °C, t_r (major) = 10.8 min, t_r (minor) = 13.9 min). $[\alpha]_D^{22}$ = −123.0° (c 1.0, CH_2Cl_2). MP: 156−157 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.45−7.27 (m, 10H), 4.52 (d, J = 13.7 Hz, 1H), 3.92 (d, J = 13.7 Hz, 1H), 3.81 (d, J = 3.4 Hz, 1H), 3.57 (d, J = 10.3 Hz, 1H), 3.36 (dd, J = 10.3, 4.0 Hz, 1H), 3.17 (t, J = 3.8 Hz, 1H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 134.9, 133.9, 129.1, 128.9, 128.8 (2C), 128.6, 126.7, 49.2, 46.5, 45.5, 45.1. HRMS (ESI, m/z) calcd for $C_{16}H_{16}N_2O_2S_1Na$ $[M + Na]^+$: 323.0825, found: 323.0826. IR (film): ν (cm^{-1}) 1497, 1455, 1334, 1165, 1134, 1093, 1047, 1018, 993, 937, 872, 842, 816, 796, 767, 744, 720, 694, 657, 610, 570, 530, 487, 470, 421.

Kinetic Isotope Experiments. Two parallel reactions: Ring-closing C−H aminations **1a** → **2a** and **1a′** → **2a′** were performed independently following the general procedure, and partial conversions were determined after 2 h reaction time from ^{1}H NMR using 1,1,2,2-tetrachloroethane as the internal standard. The KIE was determined from the ratio of these relative initial rates. Intermolecular competition reaction: A 1:1 mixture of **1a** (15.8 mg, 0.05 mmol) and **1a′** (15.9 mg, 0.05 mmol) was converted to a mixture of **2a** and **2a′** following the general procedure. After a reaction time of 2 h, the ratio of **2a** and **2a′** was determined by ^{1}H NMR (Figure S1 of the Supporting Information). Intramolecular competition reaction: The ring-closing amination of **1t′** (33.2 mg, 0.1 mmol) following the general procedure provided a mixture of **2t′** and **2t″**, and the ratio was determined by ^{1}H NMR (Figure S2 of the Supporting Information).

https://dx.doi.org/10.1021/acs.joc.0c02279
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Diastereochemistry of Allylic C−H Amination. *(E)-2-Benzyl-4-(but-1-en-1-yl)-1,2,5-thiadiazolidine-1,1-dioxide ((E)-**2z**).* Starting from (*E*)-**1z** (29.4 mg, 0.1 mmol) according to the general procedure, (*E*)-**2z** was afforded as a colorless oil (25.8 mg, 0.097 mmol, 97% yield, *E*:*Z* > 99:1; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 63% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 90:10, flow rate 1.0 mL/min, 25 °C, t_r (major) = 11.0 min, t_r (minor) = 13.5 min). $[\alpha]_D^{22}$ = −33.0° (c 1.0, CH_2Cl_2). The analytical data of (*E*)-**2z** are in accordance with a literature report.[15] ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.28 (m, 5H), 5.78 (dt, *J* = 15.3, 6.2 Hz, 1H), 5.41 (dd, *J* = 15.3, 7.8 Hz, 1H), 4.45 (br s, 1H), 4.28 (d, *J* = 13.7 Hz, 1H), 4.04 (d, *J* = 13.7 Hz, 1H), 4.19 (quint, *J* = 7.1 Hz, 1H), 3.33 (dd, *J* = 9.4, 6.8 Hz, 1H), 2.99 (dd, *J* = 9.3, 7.9 Hz, 1H), 2.03 (quint, *J* = 7.1 Hz, 2H), 0.96 (t, *J* = 7.4 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.2, 135.3, 128.9, 128.7, 128.3, 125.6, 54.9, 53.7, 50.6, 25.2, 13.1.

*(Z)-2-Benzyl-4-(but-1-en-1-yl)-1,2,5-thiadiazolidine-1,1-dioxide ((Z)-**2z**).* Starting from (*Z*)-**1z** (29.4 mg, 0.1 mmol) according to the general procedure, (*Z*)-**2z** was afforded as a colorless oil (25.3 mg, 0.095 mmol, 95% yield, *Z*/*E* = 40:1; *n*-hexane/EtOAc = 4:1). Enantiomeric excess was determined by HPLC analysis on a Chiralpak OD-H column, ee = 73% (absorbance at 210 nm, mobile phase: *n*-hexane/isopropanol = 90:10, flow rate 1.0 mL/min, 25 °C, t_r (major) = 10.7 min, t_r (minor) = 10.0 min). $[\alpha]_D^{22}$ = +9.8° (c 1.0, CH_2Cl_2). The analytical data of (*E*)-**2z** are in accordance with a literature report.[15] ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40−7.29 (m, 5H), 5.70−5.58 (m, 1H), 5.40−5.28 (m, 1H), 4.62−4.48 (m, 1H), 4.41 (d, *J* = 6.0 Hz, 1H), 4.27 (d, *J* = 13.7 Hz, 1H), 4.09 (d, *J* = 13.7 Hz, 1H), 3.31 (dd, *J* = 9.4, 6.8 Hz, 1H), 2.98 (dd, *J* = 9.4, 7.7 Hz, 1H), 2.18−1.94 (m, 2H), 0.95 (t, *J* = 7.5 Hz, 3H). ^{13}C{1H} NMR (75 MHz, $CDCl_3$) δ 138.2, 135.3, 128.9, 128.7, 128.3, 125.6, 53.9, 50.6, 49.6, 21.1, 14.2.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.joc.0c02279.

NMR spectra, HPLC traces, and crystallographic data (**2j** and **9**); NMR spectra of the intermolecular competition KIE experiment (Figure S1); NMR spectra of the intramolecular competition KIE experiment (Figure S2); diastereochemistry and *Z*/*E* ratio at 55 and 80 °C (Figure S3); selected crystallographic data and details of the structure determination for **2j** (Table S1); selected crystallographic data and details of the structure determination for **9** (Table S2) (PDF)

Accession Codes

CCDC 2026683−2026684 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by emailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033.

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Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

We gratefully acknowledge funding from the Deutsche Forschungsgemeinschaft (ME 1805/15-1).

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https://dx.doi.org/10.1021/acs.joc.0c02279
J. Org. Chem. XXXX, XXX, XXX−XXX