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Stereoselective Control of Planar α-Dimethylsulfonium Benzyl Carbanions. Synthesis of Optically Pure *trans*-Aziridines

Yolanda Arroyo,[†] Ángela Meana,[†] J. Félix Rodríguez,[†] M. Ascensión Sanz-Tejedor,*[,†] Inés Alonso,[‡] and José L. García Ruano*[,‡]

Departamento de Química Orgánica (ETSII), Universidad de Valladolid, P[o] del Cauce s/n, 47011 Valladolid, Spain, and Departamento de Química Orgánica (C-I), Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain

atejedor@eis.uva.es; joseluis.garcia.ruano@uam.es

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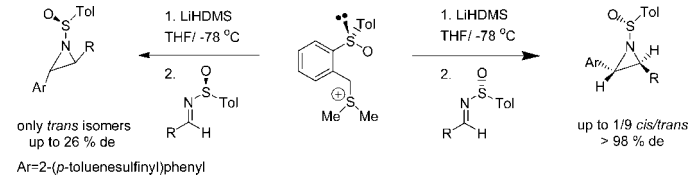

(*R*)-*N*-Sulfinylimine and (*S*)-*N*-sulfinylimine react with the ylide derived from (*S*)-dimethyl-[2-(*p*-toluenesulfinyl)phenyl]sulfonium salt, affording *trans*-2,3-disubstituted aziridines. A complete *trans* selectivity in low facial diastereoselectivity is observed when the configuration at the sulfur atoms of the reagents is the same. Otherwise, when their configurations are different, the reaction evolved with total facial diastereoselectivity and the *cis*/*trans* ratio ranged between 1/4.2 and 1/9. Theoretical calculations indicate the reaction proceeds mainly by evolution of a planar free carbanion. The relative stability of the transition states predicts a *trans*/*cis* ratio that is in excellent agreement with the experimental results.

Introduction

Aziridines are versatile building blocks that have found numerous applications in organic synthesis.[1] They have been used as ligand and chiral auxiliaries in asymmetric synthesis,[2] and they are relevant structural moieties in many natural products and biologically active molecules.[3] Hence, there has been a continued interest toward developing efficient methods to access these valuable compounds. Insertion of nitrenes to alkenes and the addition of carbenes to imines are the two most direct routes to aziridines.[4] However, most of these procedures offer a highly diastereo- and enantioselective protocol only for the preparation of *cis*-aziridines. Alternatively, aza-Darzens reaction dominantly provides *cis*-aziridines.[5] Another attractive approach, developed independently by the groups of Aggarwal[6] and Dai,[7] is the reaction of sulfur ylides with imines. In this context, high enantiomeric excesses have been achieved by using a chiral sulfide but the *cis*/*trans* diastereoselectivity in this process is, in most cases, low or moderate.[8] The addition of

[†] Universidad de Valladolid.
[‡] Universidad Autónoma de Madrid.

(1) For reviews, see: (a) Tanner, D. *Angew. Chem., Int. Ed. Engl.* **1994**, *33*, 599. (b) Ibuka, T. *Chem. Soc. Rev.* **1998**, *27*, 145. (c) McCoull, W.; Davis, F. A. *Synthesis* **2000**, 1347. (d) Sweeney, J. B. *Chem. Soc. Rev.* **2002**, *31*, 247. (e) Hu, X. E. *Tetrahedron* **2004**, *60*, 2701. (f) Hou, X. L.; Wu, J.; Fan, R. H.; Ding, Ch. H.; Luo, Z. B.; Dai, X. L. *Synlett* **2006**, 181. (g) Watson, I. D. G.; Yu, L.; Yudin, A. K. *Acc. Chem. Res.* **2006**, *39*, 194. For recent references, see: (h) Ferbeck, E. M.; Evans, C. D.; Guilleran, J. A.; Li, P.; Joullie, M. M. *J. Am. Chem. Soc.* **2007**, *129*, 14463. (i) Schneider, C. *Angew. Chem., Int. Ed.* **2009**, *48*, 2. (j) Schmidt, F.; Keller, F.; Vedrene, E.; Aggarwal, V. K. *Angew. Chem., Int. Ed.* **2009**, *48*, 1149.

(2) (a) Shi, M.; Jiang, J. K.; Feng, Y. S. *Tetrahedron: Asymmetry* **2000**, *11*, 4923. (b) Ekegren, J. K.; Roth, P.; Källström, K.; Tarnai, T.; Andersson, P. G. *Org. Biomol. Chem.* **2003**, *1*, 358. (c) Ferioli, F.; Fiorelli, C.; Martelli, G.; Monari, M.; Savoria, D.; Tobaldin, P. *Eur. J. Org. Chem.* **2005**, 1416. (d) Isleyen, A.; Dogan, Ö. *Tetrahedron: Asymmetry* **2007**, *18*, 679.

(3) (a) Rajski, S.; Williams, R. M. *Chem. Rev.* **1998**, *98*, 2723. Hodgkinson, T. J.; Shipman, M. *Tetrahedron* **2001**, *57*, 4467. (c) Fuemeier, S.; Metzger, J. O. *Eur. J. Org. Chem.* **2003**, 649.

(4) For reviews, see: (a) Osborn, H. M. I.; Sweeney, J. *Tetrahedron: Asymmetry* **1997**, *8*, 1693. (b) Li, A.-H.; Dai, L.-X.; Aggarwal, V. K. *Chem. Rev.* **1997**, *97*, 2341. (c) Müller, P.; Fruit, C. *Chem. Rev.* **2003**, *103*, 2905. See also 1a,1d, and 1f. For recent references, see: (d) Wipf, P.; Lyon, M. A. *ARKIVOC* **2007**, 91. (e) Hashimoto, T.; Uchiyama, N.; Maruoka, K. *J. Am. Chem. Soc.* **2008**, *130*, 14380.

(5) (a) Cantrill, A. A.; Hall, L. D.; Jarvis, A. N.; Osborn, H. M.; Raphy, J.; Sweeney, J. B. *Chem. Commun.* **1996**, 2631. (b) Davis, F. A.; Liu, H.; Zhou, P.; Fang, T.; Reddy, G. V.; Zhang, Y. *J. Org. Chem.* **1999**, *64*, 7559. (c) Davis, F. A.; Ramachandar, T.; Wu, Y. *J. Org. Chem.* **2003**, *68*, 6894. (d) Davis, F. A.; Wu, Y.; Yan, H.; McCoul, W.; Prasad, A. R. *J. Org. Chem.* **2003**, *68*, 2410, and references therein. (e) Sweeney, J. B.; Cantrill, A. A.; McLaren, A. B.; Thobhani, S. *Tetrahedron* **2006**, *62*, 3681.

(6) For reviews, see: (a) Li, A.-H.; Dai, L.-X.; Aggarwal, V. K. *Chem. Rev.* **1997**, *97*, 2341. (b) Aggarwal, V. K. *Synlett* **1998**, 329. (c) Fulton, J. R.; Aggarwal, V. K.; Vicente, J. *Eur. J. Org. Chem.* **2005**, 1479, and references therein.

(7) For a review, see: (a) Dai, L.-X.; Hou, X.-L.; Zhou, Y.-G. *Pure Appl. Chem.* **1999**, *71*, 369, and references thereinFor a recent reference, see: (b) Yang, X.-F.; Zhang, M.-J.; Hou, X.-L.; Dai, L.-X. *J. Org. Chem.* **2002**, *67*, 8097.

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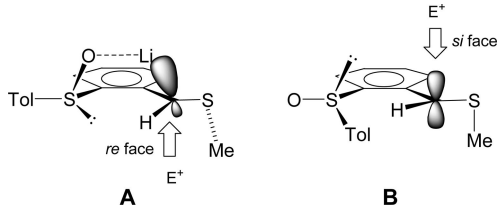


FIGURE 1. Reactive conformations of Li-(*S*)-**1** and favored approaches for E^+.

achiral sulfonium ylides to enantiopure sulfinimines has also been described, but only modest *trans* selectivity was achieved.[9]

We have recently described the highly stereoselective reaction of the α-methylsulfenyl benzyl carbanion Li-(*S*)-**1** with (*S*)-*N*-sufinylimines to afford enantiopure *vic*-sulfanylamines.[10] According to theoretical calculations,[10b] the possible structures (Figure 1) of the carbanion that can account for the experimental results are the chelated species **A**, with the lithium intramolecularly stabilized by the sulfinyl oxygen, and the planar nonchelated species **B** displaying the oxygen far from the carbanionic carbon, thus minimizing their electrostatic repulsion. The first one, with only the *re* face accessible for the approach of the electrophile, is more stable and justifies both the almost complete stereoselectivity observed in these reactions and the *S*-configuration at benzylic carbon of the resulting *vic*-sulfanylamines.

We have taken advantage of this behavior in the synthesis of the optically pure (*R*,*R*)-*trans*-aziridines[11] **2** starting from the corresponding *vic*-sulfanylamines and following the synthetic sequence shown in Scheme 1 (route A). It involves the transformation of these products into the corresponding 2-aminosulfonium salts and stereoselective elimination of the sulfur moiety according to an internal S_N2 process. At this point, we reasoned that the reaction of the α-dimethylsulfonium benzyl carbanion Li-(*S*)-**3** with imines could allow the highly stereoselective synthesis of 2,3-disubstituted aziridines in only one step (Scheme 1, route B). Additionaly, due to the high electron-withdrawing character of the $[SMe_2]^+$ group, the formation of the planar species like **B** could be more favorable. As the favored approach of the electrophile on species **A** and **B** must presumably be the opposite (see Figure 1) due to steric reasons, a change of the stereochemistry of these processes could be possible. The synthetic results obtained in this study and the theoretical calculations supporting the mechanistic proposal are reported in this paper.

Results and Discussion

The synthesis of enantiopure *N*-*p*-tolylsulfinylimines **5a**−**g**[12] as well as the compounds (*S*)-**1**[10a] and (*S*)-**4**[13] has been previously reported. The sulfonium salt (*S*)-**3′** was initially prepared from bromide (*S*)-**4** and dimethyldisulfide using Aggarwal's procedure.[14] Unfortunately, the reaction was not efficient, and only 48% conversion of the starting material was observed (Scheme 2). As an alternative, we prepared the perchlorate of (*S*)-**3** by alkylation of the (*S*)-α-methylthio-2-(*p*-tolylsulfinyl)toluene **1** with MeI in the presence of silver perclorate.[7b] The resulting salt (*S*)-**3** was isolated in quantitative yield simply by filtration of the crude reaction mixture through a pad of Celite followed by washing with CH_2Cl_2 and evaporating to dryness[15] (Scheme 2).

To determine the role played by the sulfur configuration of each reagent in controlling the newly created chiral centers, we first studied the reactions of (*S*)-**3** with (*S*)-*N*-*p*-tolylsulfinylimines **5a**−**e** bearing neutral, electron-donating or electron-withdrawing groups. Several bases were used to generate the ylide, with the best results being obtained with LiHMDS. Aziridination reactions were performed in THF at −78 °C, and after 10 min, a mixture of two *trans*-aziridines, (2*R*,3*R*)-**2** and (2*S*,3*S*)-**6**, was obtained (Table 1). The complete *trans* selectivity observed in these reactions (*cis*-diastereoisomers were not detected in any case) and their modest facial selectivity (de ≤26%) are remarkable.

trans-Aziridines, **2** and **6**, are readily separated by chromatography as diastereomerically pure compounds except for *trans*-**6b** (Table 1, entry 2). The spectroscopic parameters and optical rotations of the minor *trans* isomers **2a**−**e** are identical with those of the aziridines **2** previously obtained by using the sequence of the Scheme 1 (route A).[11] They allowed us to unequivocally assign the *R* configuration at their two ring carbons. The *trans* assignment of the major aziridines **6** was easily made from the values of their vicinal coupling constants ($^3J = 4.2-4.3$ Hz) so they should exhibit a 2*S*,3*S* configuration.

Next, we studied the reactions of (*S*)-**3** with the imines (*R*)-**5a**−**g**, both exhibiting opposite configuration at sulfur. The results are summarized in Table 2. The reaction of (*S*)-**3** with (*R*)-**5a** afforded, after 10 min, a 12:88 mixture of only two aziridines *cis*-**7a** and *trans*-**8a** (entry 1, Table 2). Similar results could be observed for imines derived from aromatic (entries 2−5, Table 2), heteroaromatic (entry 6), and aliphatic aldehydes (entry 7). Although a slight variation of the *trans* selectivity was observed with the substituent at the imine, most of them afforded a *cis*/*trans* ratio ranging between 1/7.3 and 1/9 (entries 1, 2, and 4−6). In reactions carried out with the electron-deficient imine **5c** and alkylimine **5g**, this ratio decreased to 1/5.2 and 1/4.2, respectively (entries 3 and 7). It is remarkable that the electronic effect of the substituents has scarce influence on the diastereomeric *trans*/*cis* ratio. Fortunately, a complete facial diastereoselectivity (de >98%) was observed in all of the experiences for both the *trans* and the *cis* isomers.

Chromatographic separation of the obtained mixtures provided diastereomerically pure compounds whose *cis* or *trans* stereochemistry was easily assigned on the basis on the values of their vicinal coupling constants[16] ($^3J_{trans} = 3.9-4.3$ Hz, $^3J_{cis} = 6.7-8.0$ Hz). The absolute configuration was unequivocally

(8) (a) Saito, T.; Sakairi, M.; Akiba, D. *Tetrahedron Lett.* **2001**, *42*, 5451. (b) Solladié-Cavallo, A.; Roje, M.; Welter, R.; Sunjic, V. *J. Org. Chem.* **2004**, *69*, 1409. (c) Stipetic, I.; Roje, M.; Hamersak, Z. *Synlett* **2008**, 3149.

(9) (a) Morton, D.; Pearson, D.; Field, R. A.; Stockman, R. A. *Org. Lett.* **2004**, *6*, 2377. (b) Morton, D.; Pearson, D.; Field, R. A.; Stockman, R. A. *Chem. Commun.* **2006**, 1833.

(10) (a) Arroyo, Y.; Meana, A.; Rodríguez, J. F.; Santos, M.; Sanz-Tejedor, M. A.; García Ruano, J. L. *J. Org. Chem.* **2005**, *70*, 3914. (b) Arroyo, Y.; Meana, A.; Sanz-Tejedor, M. A.; Alonso, I.; García Ruano, J. L. *J. Org. Chem.* **2009**, *74*, 764.

(11) Arroyo, Y.; Meana, A.; Rodríguez, J. F.; Santos, M.; Sanz-Tejedor, M. A.; García-Ruano, J. L. *Tetrahedron* **2006**, *62*, 8525.

(12) (a) Davis, F. K.; Reddy, R. E.; Szewczyk, J. M.; Reddy, G. V.; Portonovo, P. S.; Zhang, H.; Fanelli, D.; Reddy, R. T.; Zhou, P.; Carrol, P. J. *J. Org. Chem.* **1997**, *62*, 2555. (b) Davis, F. K.; Zhang, Y.; Andemichael, Y.; Fang, T.; Fanelli, D. L.; Zhang, H. *J. Org. Chem.* **1999**, *64*, 1403.

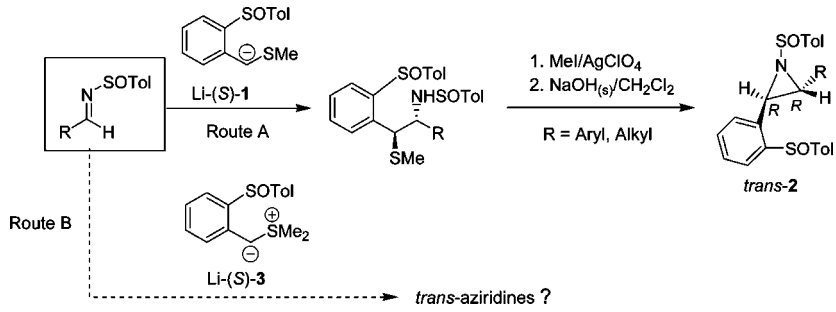
(13) Arroyo, Y.; Meana, A.; Sanz-Tejedor, M. A.; García; Ruano, J. L. *Org. Lett.* **2008**, *10*, 2151.

(14) Aggarwal, V. K.; Thomson, A.; Jones, R. V. H. *Tetrahedron Lett.* **1994**, *35*, 8659.

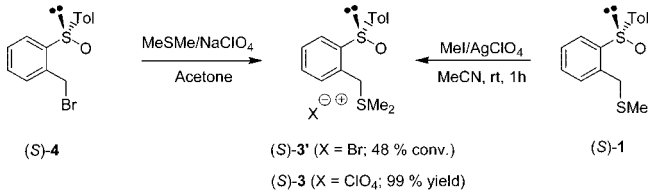
(15) The complete removal of the residual silver salts is critical for obtaining good results in the aziridination step since their presence results in the formation of black reaction crudes and strongly decreases the diastereoselectivity.

(16) Khusainova, N. G.; Bredikhina, Z. A.; Ishmaeva, E. A.; Musina, A. A.; Pudovick, A. N. J. *Gen. Chem., USSR* **1981**, *51*, 526.

SCHEME 1



SCHEME 2



established for the *trans*-**8a** isomer by chemical correlation. Thus, reaction of *trans*-**8a** with *tert*-BuLi (2.2 equiv) under very mild conditions (−78 °C, 15 min) simultaneously removed the two sulfinyl groups affording (−)-(*S*,*S*)-2,3-diphenylaziridine **9a**,[17] which unequivocally demonstrated that *trans*-**8a** has the *S* configuration at the two ring carbons. The similar behavior observed in all aziridination reactions shown in Table 2 suggests that the absolute configuration for aziridines **8b**−**g** must be identical to that determined for **8a**. The absolute configuration of the minor *cis*-(2*R*,3*S*)-**7a** was unequivocally established by comparison of the spectroscopic data with those of its diastereoisomer *cis*-(2*S*,3*R*)-2-phenyl-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)aziridine.[18]

We have also checked the efficiency of the C- and N-desulfinylation process starting from compounds **8b**, **8e**, and **8g**. The corresponding NH-aziridines **9b**, **9e**, and **9g** were obtained in good yields as pure compounds (see Supporting Information). At this point, it is important to note that there is no one-step protocol to synthesize NH-aziridines, and most of the asymmetric syntheses of aziridines provided N-protected aziridines where the substituents at the nitrogen are usually difficult to remove.

The stereochemical model proposed for justifying the results indicated in Tables 1 and 2 should explain not only the different behavior of the ylide (*S*)-**3** in its reaction with the (*R*)- and (*S*)-*N*-sulfinylimines (the *R* isomer evolves with good *trans* selectivity and a complete facial selectivity, whereas the *S* isomer reacts with a complete *trans* selectivity but low facial selectivity) but also the 2*S*,3*S* configuration exhibited for the major diastereoisomers, *trans*-**8** and *trans*-**6**, obtained, respectively, in both processes. This is in contrast with the results indicated in Scheme 1 (route A), where (2*R*,3*R*)-aziridines **2** were exclusively formed. According to computational studies[19] and crossover experiments,[20] the addition of the semistabilized ylide onto imines is a nonreversible process, and therefore, the configuration of the aziridinic carbons will be determined in such a step. It suggests a different structure for the benzylcarbanion Li-(*S*)-**1** and the ylide derived from (*S*)-**3** that should explain they evolve with the opposite facial selectivity in their reaction with sulfinylimines. Two possible structures can be proposed for the ylide: a pyramidal chelated species and a planar nonchelated species, like those derived from α-methylsulfenyl carbanion Li-(*S*)-**1** (see Figure 1). The formation of the planar **B** species must be more favorable when the benzylic carbanion is more stabilized by electron-withdrawing groups such as $[SMe_2]^+$. As the favored approach of the electrophile on species **A** and **B** must presumably be the opposite (*re* face in **A** and *si* face in **B**) due to steric reasons, the different stereochemical evolution of the carbanions derived from (*S*)-**1** and (*S*)-**3** could be understandable on the basis of their different structure.

In order to investigate the participation of these species during the reaction, their structures have been studied theoretically at the DFT (B3LYP)[21] level by using the Gaussian03 program.[22,23] Most stable structures found for model carbanion−Li^+ complexes and free carbanions are shown in Figure 2. Dimethyl ether and dimethylamine were used as a simplified model for solvent and base, respectively, and have been included as ligands for the lithium atom. The tolyl group has also been simplified as a phenyl one. The most stable carbanion−Li^+ complex found is the chelated species **I**, with the sulfinyl oxygen coordinated to the lithium atom and the carbanion stabilized by a hydrogen bond with the dimethylamine ligand. This type of complex would be probably the first formed after the deprotonation step.[24] In this conformation, the presence of the metal with its ligands

(17) Lohray, B. B.; Ahujas, J. R. *J. Chem. Soc., Chem. Commun.* **1991**, 95.

(18) CCDC 719589 contains the supplementary crystallographic data for this compound. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif. Unpublished results.

(19) (a) Aggarwal, V. K.; Charmant, J. P. H.; Fuentes, D.; Harvey, J. N.; Hynd, G.; Ohara, D.; Picoul, W.; Robiette, R.; Smith, C.; Vasse, J.-L.; Winn, C. L. *J. Am. Chem. Soc.* **2006**, *128*, 2105. (b) Robiette, R. *J. Org. Chem.* **2006**, *71*, 2726. (c) Janardanan, D.; Sunoj, R. B. *Chem.—Eur. J.* **2007**, *13*, 4805. (d) Janardanan, D.; Sunoj, R. B. *J. Org. Chem.* **2008**, *73*, 8163.

(20) Aggarwal, V. K.; Charment, J. P. H.; Ciampi, C.; Hornby, J. M.; O'Brien, C. J.; Hynd, G.; Parson, R. *J. Chem. Soc., Perkin Trans. 1* **2001**, 3159.

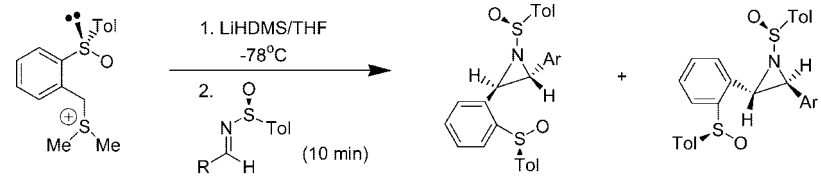
(21) (a) Lee, C.; Yang, W.; Parr, R. G. *Phys. Rev. B* **1988**, *37*, 785. (b) Becke, A. D. *J. Chem. Phys.* **1993**, *98*, 1372.

(22) Frisch, M. J.; *Gaussian 03*, revision E.01; Gaussian, Inc.: Wallingford, CT, 2004.

(23) Geometries have been fully optimized using the standard 6-31G(d) basis set for all the atoms: (a) Ditchfield, R.; Hehre, W. J.; Pople, J. A. *J. Chem. Phys.* **1971**, *54*, 724. Frequencies and zero-point energy (ZPE) were also computed at the same level of theory. Final energies have been obtained using the more extended 6-311+G** basis set for all atoms: (b) McLean, A. D.; Chandler, G. S. *J. Chem. Phys.* **1980**, *72*, 5639. (c) Krishnan, R.; Binkley, J. S.; Seeger, R.; Pople, J. A. *J. Chem. Phys.* **1980**, *72*, 650. Relative free energies (in kcal/mol) were evaluated at the B3LYP/6-311+G** level with ZPE and entropy corrections evaluated at 298 K using the frequencies previously calculated at B3LYP/6-31G(d) level. Because of the importance of solvent effects, especially when charged species are involved, model structures **I**−**IV** have also been optimized in a dielectric medium mimicking THF, using the IEF-PCM model: (d) Cancès, M. T.; Mennucci, B.; Tomasi, J. *J. Chem. Phys.* **1997**, *107*, 3032. (e) Cossi, M.; Barone, V.; Mennucci, B.; Tomasi, J. *Chem. Phys. Lett.* **1998**, *286*, 253. In the case of model transition states, this optimization including solvent effects was not possible. .

(24) Complexes varying C−S−O−Li and C−C−S−O dihedral bonds as well as a boat-like structure with Li atom bonded to benzylic carbon resulted in less stability (see Supporting Information complexes **Ib**−**Id**).

TABLE 1. Stereoselective Aziridination of (*S*)-*N*-*p*-Tolylsulfinylimines 5 with (*S*)-3

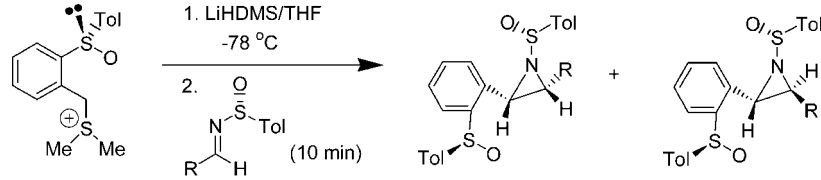


(*S*)-**3** (*S*)-**5a-e** (2*R*,3*R*)-**2a-e** (2*S*,3*S*)-**6a-e**

entry	imine	R	*cis*/*trans*[a]	*trans*-**2**/*trans*-**6**[a]	yield (%)[b] *trans*-**2**/*trans*-**6**
1	(*S*)-**5a**	Ph	−:>98	38:62	30:50
2	(*S*)-**5b**	*p*-$MeOC_6H_4$	−:>98	45:55	75[c]
3	(*S*)-**5c**	*p*-CNC_6H_4	−:>98	40:60	37:56
4	(*S*)-**5d**	*o*-BrC_6H_4	−:>98	41:59	24:36
5	(*S*)-**5e**	2-naphthyl	−:>98	37:63	28:48

[a] Determined by ^{1}H NMR on the crude reaction mixture. [b] Isolated yield. [c] Combined yield.

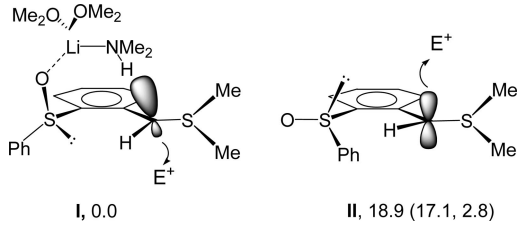
TABLE 2. Stereoselective Aziridination of (*R*)-*N*-*p*-Tolylsulfinylimines 5 with (*S*)-3



(*S*)-**3** (*R*)-**5a-g** (2*R*,3*S*)-**7** (2*S*,3*S*)-**8**

entry	imine	R	*cis*-**7**/*trans*-**8**[a]	% de[a] *cis*-**7**	% de[a] *trans*-**8**	yield (%)[b] *trans*-**8**
1	(*R*)-**5a**	Ph	12:88	>98	>98	69
2	(*R*)-**5b**	*p*-$MeOC_6H_4$	10:90	>98	>98	67
3	(*R*)-**5c**	*p*-CNC_6H_4	16:84	>98	>98	76
4	(*R*)-**5d**	*o*-Br C_6H_4	10:90	>98	>98	75
5	(*R*)-**5e**	2-naphthyl	10:90	>98	>98	77
6	(*R*)-**5f**	2-thienyl	12:88	>98	>98	72
7	(*R*)-**5g**	*n*-Bu	19:81	>98	>98	59

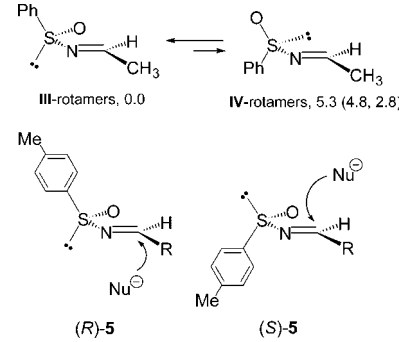
[a] Determined by ^{1}H NMR on the crude reaction mixture. [b] Isolated yield.



I, 0.0 **II**, 18.9 (17.1, 2.8)

FIGURE 2. Molecular structures and energies (kcal·mol^{-1}) of possible carbanionic species and favored approaches for E^+. The first value indicates the relative energy, with ZPE correction included, between structures **I** and **II** (**II**+Li(NHMe$_2$)(OMe$_2$)$_3$-**I**-OMe$_2$). Free energy correction is indicated in brackets, first in vacuo, second "in THF" (mimicked by IEFPCM).

precludes the approach of the electrophile to the *si* face of the anion as in model **A**, although the *re* face is not completely free of steric interactions. The situation shown in structure **II**, in which the *si* face is clearly favored for the approach of the electrophile, is only reached when Li^+ is not stabilizing the carbanion, like in model **B**. This intermediate is much more unstable in vacuo than the chelated species **I** (18.9 kcal·mol^{-1}). However, when solvent effects are taken into account, the difference in energy dramatically decreases (2.8 kcal·mol^{-1})[25] and the reaction could proceed by approach of the electrophile to the *si* face of the structure **II** if the activation barrier for the C−C bond formation is not very high.



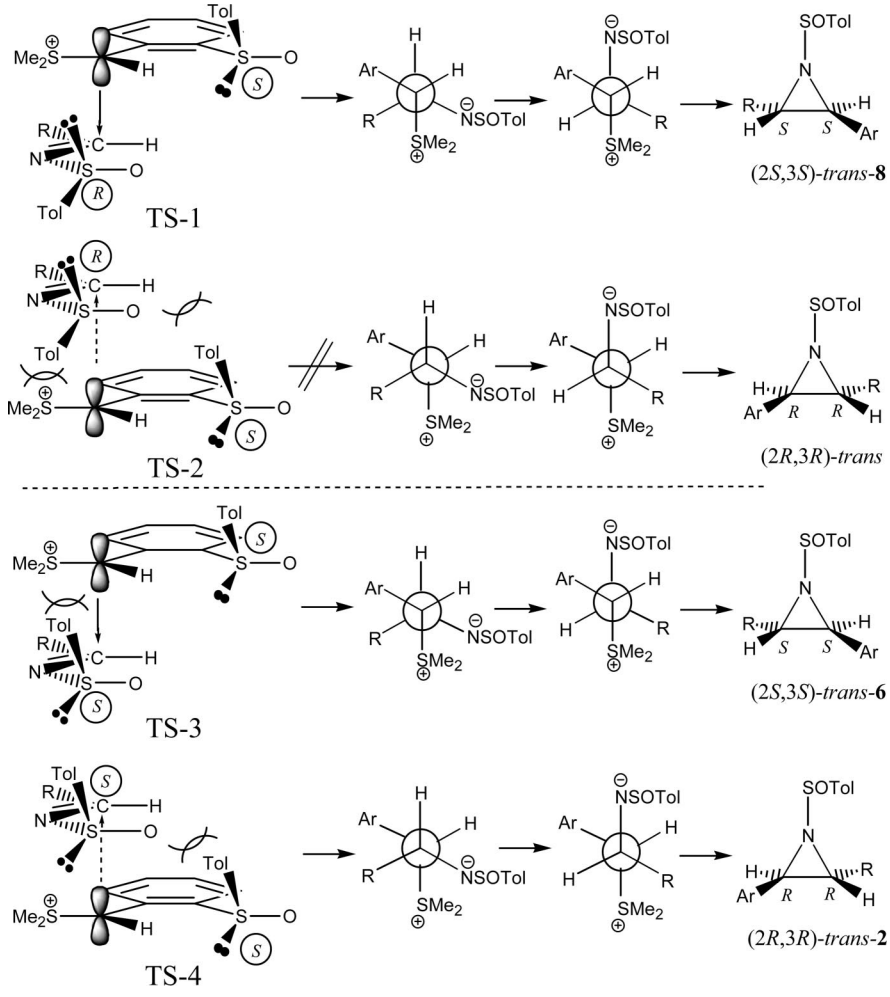
III-rotamers, 0.0 **IV**-rotamers, 5.3 (4.8, 2.8)

(*R*)-**5** (*S*)-**5**

FIGURE 3. Relative energies of the most stable conformations of imines (kcal·mol^{-1}, ZPE correction included) and nucleophilic attack preferred for (*R*)-**5** and (*S*)-**5** in their most stable *s*-*cis* rotamers. Free energy correction is indicated in brackets, first in vacuo, second "in THF" (mimicked by IEFPCM).

We have also studied the conformational stability of the imines because it must be related to the facial selectivity around the C=N. The (*E*)-*N*-phenylsulfinylimine derived from acetaldehyde was used as a model (Figure 3). Rotamer **III**, with the sulfinyl oxygen in *s*-*cis* arrangement with respect to the C=N bond, was 5.3 kcal/mol more stable than the rotamer **IV**, with the lone electron pair in *s*-*cis* arrangement, probably due to the minimization of the dipolar moment (2.84 and 4.81 D for **III**

SCHEME 3. Addition Intermediates for Aziridination of Sulfur Ylides and Imines



and **IV**, respectively). This energetic difference should be enough to shift almost completely the conformational equilibrium toward the rotamer **III**, which arranges the phenyl group blocking the *upper* face of the C=N plane (Figure 3) and therefore would determine that the nucleophilic attack of the benzylcarbanion to imines (*R*)-**5** and (*S*)-**5** would take place mainly to the *re* and *si* faces, respectively. Again, the difference in energy between both conformers decreases when solvent effects are considered (2.8 kcal/mol), making possible the participation of **IV** in the TS (vide infra) if stronger stabilizing interactions can be established.

The stereochemistry of the major products of the reactions collected in Tables 1 and 2 could be explained by assuming that sulfonium ylide reacts through the planar structure **II** (Figure 2), with the *si* face being the favored for attacking electrophiles. If *N*-sulfinylimines mainly adopt their presumably most stable conformation around the N−S bond, with the sulfinyl oxygen in the *s-cis* arrangement (Figure 3), there are two possible approaches for each enantiomeric *N*-sulfinylimine. They have been depicted in Scheme 3 and provide the routes leading to the *trans*-aziridines. On the basis of the theoretical calculations performed by Robiette[19b] and Sunoj,[19c,d] *cisoid* transition states are generally favored with respect to the *transoid* ones in the addition of semistabilized ylides to aldimines conducting to aziridines, and they have been exclusively considered in Scheme 3. The approach of the carbanion, adopting structure **II**, with its favored *si* face on the *si* face of the (*R*)-sulfinylimine (in the most stable *s-cis* conformation) would yield the TS-1, without any significant steric interaction. TS-2, resulting from the most hindered *re* face of the carbanion approaching the *re* face of the imine, should be much less stable than TS-1 as a consequence of the steric interactions produced by the *p*-tolyl groups at both molecules (Scheme 3). The complete facial selectivity observed in reactions of the ylide (*S*)-**3** with (*R*)-sulfinylimines only yielding the *trans*-(2*S*,3*S*)-**8** (Table 2) is compatible with this description. In other way, (*S*)-sulfinylimines would react through TS-3 and TS-4 (Scheme 3), both exhibiting the interaction of the tolyl group at one of the reagents with the other reagent and, therefore, exhibiting a not too much different stability, thus explaining the low facial selectivity observed in these reactions (Table 1).

However, this simple model is not able to explain the differences in *trans*/*cis* selectivity observed for both imines. It suggests the real situation must be more complex, and the participation of other conformations of the imine and the carbanion cannot be underestimated. In order to clarify these points, we have studied the relative stability of the different

(25) These values are considerably lower than those found for the sulfenyl analogous A and B (≈75 kcal·mol^{-1} in vacuo, 7 kcal·mol^{-1} in solution; see ref 9b and Figure 1). This demonstrates that the more stabilized the carbanion by the electron-withdrawing benzylic substituent $[SMe_2]^+$, the more favored the planar free carbanion conformation.

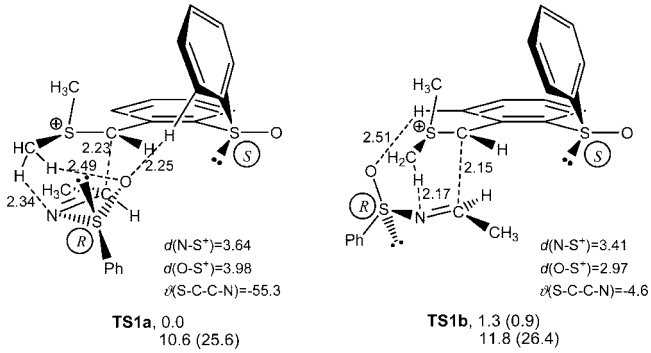


FIGURE 4. Molecular structures, representative distances (Å), dihedral angles (deg), and energies (kcal·mol^{-1}) of possible transition states **TS1a** and **TS1b** between model anion **II** and model imine (*R*)-**III** that would yield *trans*-**8** and *cis*-**7**, respectively. The first value indicates the relative energy, with ZPE correction included, between structures **TS1a** and **TS1b** separately. Free energy correction is indicated in brackets. In the second row, activation barriers with respect to **II** and (*R*)-**III** in *s-cis* conformation (ZPE correction included, free energy correction is indicated in brackets) are indicated.

transition states leading to compounds **2** and **6**−**8** by theoretical calculations. Thus, starting from different conformations and relative orientations of model carbanion **II** and model imine (*R*)-**III**, two TSs,[26] **TS1a** and **TS1b**, have been found that can account for the *trans*/*cis* selectivity observed in these processes (Figure 4).

The most stable **TS1a**, which would yield aziridine *trans*-**8**, results from addition in *si*,*re* fashion between anion and imine, and groups around the incipient C−C bond are oriented in a staggered conformation. The imine partner shows a distorted *s-cis* conformation that allows the formation of two hydrogen-bonding interactions between the oxygen atom of the sulfinyl function on the imine with two hydrogen atoms [a hydrogen of the $^{+}SMe_2$ (O···H−C = 2.49 Å) and another one of the PhSO (O···H−C = 2.24 Å) groups] of the approaching ylide. In **TS1b**, the anion with its *si* face approaches the *si* imine face, yielding aziridine *cis*-**7**. Despite the imine partner adopting an *s-trans* conformation and groups around the newly forming C−C bond show an almost eclipsed arrangement, this TS is quite stable probably due to a strong stabilizing electrostatic interaction between the two polar groups, sulfonium and NSOTol (O···S distance = 2.97 Å). Thus, the difference in energy between these transition states (0.9 kcal·mol^{-1}) predicts a *trans*/*cis* ratio of 4.6, in excellent agreement with the experimental results.

For model imine (*S*)-**III**, a similar study of the possible approaches afforded transition states indicated in Figure 5. In the most stable **TS3a** (the *si* face of the anion adds to the *si* face of the imine), groups around the newly forming C−C bond are oriented in a staggered fashion and would yield aziridine *trans*-**6**. The imine partner adopts an *s-trans* conformation, which makes possible two favorable hydrogen-bonding interactions (with $^{+}SMe_2$: O···H−C = 2.28 Å, with PhSO O···H−C = 2.27 Å) along with stabilizing electrostatic interaction between the polar NSOTol and sulfonium groups. Transition state **TS3b** is found when imine partner adopts a distorted *s-cis* conformation (anion approach to the *si* imine face) and would yield the corresponding *cis*-aziridine. However, this transition state shows a completely eclipsed conformation and is considerably less stable than **TS3a**. Indeed, no *cis*-aziridine is observed in reactions with (*S*)-imine. The approach of the carbanion with its unfavorable *re* face on the *re* face of the imine, in the most stable *s-cis* conformation, afforded **TS4** that would yield *trans*-**2**. The high instability of this intermediate with respect to **TS3a** (5.6 kcal·mol^{-1}) does not correlate with the experimental results. This fact suggests that *trans*-**2** could be formed from TS with the carbanion partner in a chelated form such as in model **I** that would show a less steric hindrance in the lower face than in the case of model **II**.[27]

According to data shown in Figure 4, since the approach of the carbanion with its *si* face (the *re* face must be sterically hindered) on both faces of the (*R*)-imine takes place with a not very high activation barrier, the reaction proceeds by the evolution of the planar free anion **II** affording *trans*-**8** and *cis*-**7**. In reactions between (*S*)-**3** and (*S*)-imines (Figure 5), aziridine *trans*-**2** must be formed by the reaction of both anion and imine in their most stable conformation (chelated complex **I** and *s-cis* conformation, respectively). However, since this mode of reaction is not free of steric interactions, evolution of free anion **II** affording *trans*-**6** takes place to a great extent.

Conclusion

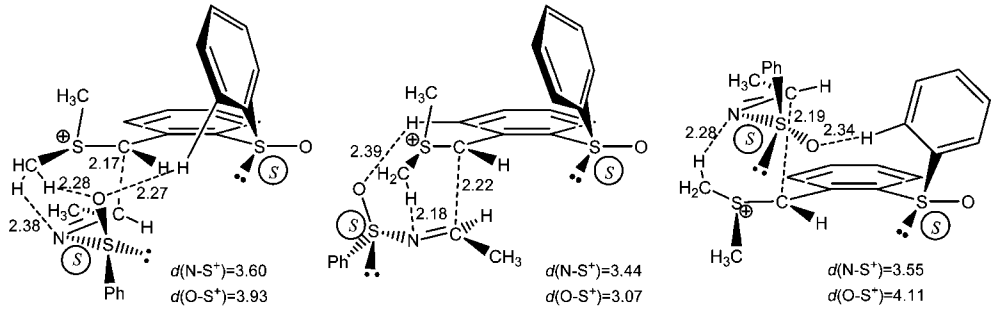
In conclusion, we have described a highly diastereoselective ylide aziridination, based on the reaction of *N*-*p*-tolylsulfinylimines with the ylide derived from (*S*)-dimethyl-[2-(*p*-toluenesulfinyl)phenyl]sulfonium salt. Total *trans* selectivity in low diastereomeric excess was observed starting from (*S*)-sulfinylimines, while excellent facial selectivity (>98% de) in good *trans* selectivity was attained by using (*R*)-sulfinylimines. Theoretical calculations indicate that the stability of different structures of the carbanion depends on the electron-withdrawing character of the benzylic substituent. In the case of sulfonium salt, reactions proceed mainly by evolution of the planar free carbanion, despite that it is less stable than chelated species, because of the lower steric interactions with the approaching imines. Strong electrostatic interactions between the polar groups, sulfonium and NSOTol, justify the participation of less stable *s-trans* conformations of the imines in transition states leading to minor aziridines.

Experimental Section

Synthesis of (*S*)-Dimethyl-[2-(*p*-toluenesulfinyl)phenyl]sulfonium perchlorate, (*S*)-3. To a solution of (*S*)-α-methylthio-2-(*p*-tolylsulfinyl)toluene[10a] (276 mg, 1.0 mmol) in MeI (5 mL) was added silver perchlorate (208 mg, 1.0 mmol). The mixture was stirred for 1 h at rt and then filtered through a pad of Celite. The filter cake was washed with CH_2Cl_2, and the solvent was removed under reduced pressure to give the sulfonium salt as a white syrup (99% yield), which was used without further purification: $[\alpha]^{20}_{D}$ = +39.6 (*c* 0.5, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.73 (d, 1H, *J* = 6.8 Hz), 7.58−7.49 (m, 3H), 7.42 and 7.24 (AA′BB′ system, 4H), 4.78 (AB system, 2H, J_{gem} = 13.0 Hz), 2.98 and 2.94 (2s, 6H), 2.30 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.2, 142.4,

(26) Although with a small difference in energy, *cisoid* approach of the reactants is usually more favorable than what can be attributed to the favorable Coulombic interactions between opposite charges located at nitrogen and sulfur atoms. In our case only one *transoid* TS resulting from *si*,*si* approach between ylide and imine could be found (J(S−C−C−N) =−133.1) being 2 kcal·mol^{-1} less stable than the corresponding *cisoid* one (**TS1b**). Probably the *transoid* approach in our case is destabilized due to steric interactions with the *ortho* TolSO group in the ylide.

(27) The optimization of this type of transition states has not been still possible due to the high degree of conformational freedom shown by all the ligands around the metal. It is being tried with a simple substrate.



TS3a, 0.0
8.4 (23.4)

TS3b, 5.2 (4.8)
13.6 (28.2)

TS4, 5.4 (5.6)
13.9 (29.0)

FIGURE 5. Molecular structures, representative distances (Å), dihedral angles (deg), and energies (kcal·mol^{-1}) of possible transition states **TS3a** and **TS3b** between model anion **II** and model imine (*S*)-**III** that would afford *trans*- and *cis*-aziridines, respectively, and **TS4** that would afford diastereomeric *trans*-aziridine. The first value indicates the relative energy, with ZPE correction included, between structures **TS3a**, **TS3b**, and **TS4** separately. Free energy correction is indicated in brackets. In the second row, the activation barriers with respect to **II** and (*R*)-**III** in *s-cis* conformation (ZPE correction included, free energy correction is indicated in brackets) are indicated.

139.3, 127.0, 133.8, 132.7, 131.2, 130.5, 127.9, 125.0, 43.6, 25.0, 24.7, and 21.2.

General Procedure for Aziridination Reactions Summarized in Tables 1 and 2. To a solution of sulfonium salt (*S*)-**3** (0.13 mmol) in THF (2 mL) under argon at −78 °C was added LiHMDS (1 M in THF, 0.13 mL, 0.13 mmol). After 10 min of stirring, the solution of *N*-sulfinylimine[12] [(*S*)-**5a**−**e** and (*R*)-**5a**−**g** (0.15 mmol)] in THF (1 mL) was added and the stirring continued for another 10 min. Then the reaction was hydrolyzed at −78 °C with 2 mL of water, and the mixture was extracted with CH_2Cl_2 (3 × 4 mL). The organic layers were dried over anhydrous $MgSO_4$, and the solvent was removed under reduced pressure. The residue was purified by flash column chromatography.

***trans*-(2*S*,3*S*)-2-(Phenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*S*)-(*p*-toluenesulfinyl)]aziridine, 6a:** eluent for chromatography hexane/Et_2O 1:4; yield 50%; white syrup; $[\alpha]^{20}_D = -160.8$ (*c* 0.6, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.88 (d, 1H, J = 8.4 Hz), 7.54, 7.30, 7.20, and 7.07 (two AA′BB′ systems, 8H), 7.46−7.34 (m, 8H), 4.28 and 3.60 (2d, 2H, J = 4.2 Hz), 2.37 and 2.28 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.4, 142.6, 141.9, 141.4, 140.8, 134.2, 131.8, 131.5, 130.0, 129.7, 129.5, 129.0, 128.9, 128.5, 127.0, 125.9, 125.1, 53.3, 39.4, 21.5, and 21.3; HRMS calcd for $C_{21}H_{18}NOS$ (M^+ − SOTol) 332.1109, found 332.1106.

***trans*-(2*S*,3*S*)-2-(*p*-Cyanophenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*S*)-(*p*-toluenesulfinyl)aziridine, 6c:** eluent for chromatography hexane/Et_2O 1:2; yield 56%; white syrup; $[\alpha]^{20}_D = -55.4$ (*c* 1.0, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.87 (dd, 1H, J = 6.8, 1.8 Hz), 7.58, 7.49, 7.38, 7.32, 7.18, and 7.13 (three AA′BB′ systems, 12H), 7.55−7.42 (m, 3H), 4.44 and 3.57 (2d, 2H, J = 4.2 Hz), 2.38 and 2.31 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.2, 142.6, 141.9, 140.7, 140.6, 137.1, 134.0, 132.3, 131.8, 131.7, 130.3, 130.1, 129.6, 129.1, 127.3, 125.9, 125.0, 124.6, 51.8, 39.5, 21.5, and 21.4; HRMS calcd for $C_{22}H_{17}N_2OS$ (M^+ − SOTol) 357.1062, found 357.1054.

***trans*-(2*S*,3*S*)-2-(*o*-Bromophenyl)-3-[(*S*)-2-*p*-toluenesulfinyl)phenyl]-1-[(*S*)-(*p*-toluenesulfinyl)]aziridine, 6d:** eluent for chromatography hexane/Et_2O 2:1; yield 36%; white syrup; $[\alpha]^{20}_D = -26.3$ (*c* 1.0, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.92 (dd, 1H, J = 7.0, 1.5 Hz), 7.59−7.48 (m, 4H), 7.43, 7.27, 7.20, and 7.08 (two AA′BB′ systems, 8H), 7.35−7.18 (m, 3H), 4.22 and 3.80 (2d, 2H, J = 4.3 Hz), 2.38 and 2.28 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.0, 142.2, 142.0, 140.8, 132.1, 132.6, 131.3, 130.0, 129.6, 129.3, 127.9, 127.1, 126.6, 126.1, 125.0, 124.7, 50.6, 41.2, 21.5, and 21.3; HRMS calcd for $C_{21}H_{17}BrNOS$ (M^+ − SOTol) 410.0214, found 410.0219.

***trans*-(2*S*,3*S*)-2-(2-Naphthyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*S*)-(*p*-toluenesulfinyl)]aziridine, 6e:** eluent for chromatography hexane/Et_2O 1:3; yield 48%; white syrup; $[\alpha]^{20}_D = -110.0$ (*c* 1.0, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.93−7.35 (m, 11H), 7.54, 7.31, 7.18, and 6.99 (two AA′BB′ systems, 8H), 4.41 and 3.73 (2d, 2H, J = 4.2 Hz), 2.36 and 2.19 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.2, 142.6, 141.9, 141.3, 140.7, 134.2, 133.3, 132.8, 131.5, 130.0, 129.6, 129.3, 129.0, 128.9, 128.2, 128.0, 127.7, 127.0, 126.7, 126.3, 125.9, 125.0, 53,4, 39.6, 21.5, and 21.2; HRMS calcd for $C_{25}H_{20}NOS$ (M^+ − SOTol) 382.1266, found 382.1252.

***trans*-(2*S*,3*S*)-2-(Phenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8a:** eluent for chromatography hexane/Et_2O 1:4; yield 69%; white solid; mp 118−119 °C (hexane/Et_2O); $[\alpha]^{20}_D = -145.5$ (*c* 0.6, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.04 (dd, 1H, J = 7.8, 1.1 Hz), 7.56, 7.41, 7.24, and 7.10 (two AA′BB′ systems, 8H), 7.51 (dd, 1H, J = 7.8, 1.1 Hz), 7.38−7.28 (m, 7H), 4.35 and 3.75 (2d, 2H, J = 4.3 Hz), 2.37 and 2.29 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.4, 142.7, 141.8, 141.6, 141.0, 133.3, 131.2, 130.0, 129.5, 129.2, 128.5, 128.4, 127.8, 126.2, 124.9, 124.8, 45.6, 39.0, 21.4, and 21.3; HRMS calcd for $C_{21}H_{18}NOS$ (M^+ − SOTol) 332.1109, found 332.1106.

***trans*-(2*S*,3*S*)-2-(*p*-Methoxyphenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8b:** eluent for chromatography hexane/Et_2O 1:2; yield 67%; white solid; mp 120−121 °C (hexane/Et_2O); $[\alpha]^{20}_D = -351.9$ (*c* 0.2, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.01 (dd, 1H, J = 7.8, 1.1 Hz), 7.56, 7.38, 7.28, 7.24, 7.09, and 6.88 (three AA′BB′ systems, 12H), 7.54−7.44 (m, 1H), 7.42−7.33 (m, 1H), 7.19−7.15 (m, 1H), 4.46 and 3.59 (2d, 2H, J = 4.3 Hz), 3.83 (s, 3H), 2.38 and 2.29 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.7, 144.2, 142.8, 141.8, 141.6, 141.1, 133.9, 131.2, 130.1, 129.9, 129.7, 129.5, 129.0, 127.5, 126.1, 124.8, 113.8, 55.2, and 21.4 (C-2 and C-3 are missing); HRMS calcd for $C_{22}H_{20}NO_2S$ (M^+ − SOTol) 362.1215, found 362.1225.

***trans*-(2*S*,3*S*)-2-(*p*-Cyanophenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8c:** eluent for chromatography hexane/Et_2O/CH_2Cl_2 1.2:1:1; yield 76%; white syrup; $[\alpha]^{20}_D = -262.2$ (*c* 0.9, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.99 (d, 1H, J = 7.7 Hz), 7.60, 7.49, 7.42, 7.41, 7.22, and 7.18 (three AA′BB′ systems, 12H), 7.57−7.52 (m, 1H), 7.29−7.22 (m, 2H), 4.26 and 3.90 (2d, 2H, J = 4.0 Hz), 2.37 and 2.33 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.3, 142.1, 142.0, 140.7, 139.5, 132.6, 118.5, 112.1, 132.2, 131.5, 130.1, 129.6, 129.5, 129.0, 128.3, 126.1, 125.9, 124.6 and 21.4 (C-2 and C-3 are missing); HRMS calcd for $C_{22}H_{17}N_2OS$ (M^+ − SOTol) 357.1062, found 357.1054.

***trans*-(2*S*,3*S*)-2-(*o*-Bromophenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8d:** eluent for chromatography hexane/Et_2O 1:1; yield 75%; white syrup; $[\alpha]^{20}_D = -232.3$ (*c* 0.9, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.00 (d, 1H, J = 7.8 Hz), 7.57−7.40 (m, 4H), 7.58, 7.45, 7.23, and 7.15 (two AA′BB′ systems, 8H), 7.25−7.15 (m, 3H), 4.21 and 4.09 (2d, 2H, J = 4.0 Hz), 2.39 and 2.33 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.6,

142.5, 141.9, 141.7, 141.0, 133.3, 132.4, 131.4, 130.1, 129.9, 129.5, 129.4, 128.8, 127.5, 126.0, 125.3, 124.7, and 21.4 (C-2 and C-3 are missing); HRMS calcd for $C_{21}H_{17}BrNOS$ (M^+ − SOTol) 410.0214, found 410.0219.

***trans*-(2*S*,3*S*)-2-(2-Naphthyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8e:** eluent for chromatography hexane/Et_2O 1:3; yield 77%; white solid; mp 140−141 °C (hexane/Et_2O); $[\alpha]^{20}_D$ = −234.6 (*c* 1.0, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.08 (dd, 1H, *J* = 7.7, 1.1 Hz), 7.91−7.75 (m, 2H), 7.82, 7.58, 7.42, and 7.40 (two AA′BB′ systems, 8H), 7.58−7.47 (m, 5H), 7.38−7.25 (m, 3H), 7.30 and 7.03 (2d, 4H, *J* = 8.1 Hz), 4.47 and 3.90 (2d, 2H, *J* = 4.3 Hz), 2.37 and 2.21 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.3, 142.7, 141.9, 141.7, 141.0, 133.2, 133.1, 132.9, 130.8, 131.3, 130.0, 129.5, 129.3, 128.3, 128.2, 127.9, 127.7, 126.4, 126.3, 125.5, 125.0, 124.8, 21.4, and 21.3 (C-2 and C-3 are missing); HRMS calcd for $C_{25}H_{20}NOS$ (M^+ − SOTol) 382.1266, found 382.1252.

***trans*-(2*S*,3*S*)-2-(2-Thiophenyl)-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8f:** eluent for chromatography hexane/Et_2O 1:3; yield 72%; pale yellow syrup; $[\alpha]^{20}_D$ = −302.0 (*c*. 0.7, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.02 (dd, 1H, *J* = 8.0, 1.0 Hz), 7.57, 7.38, 7.27, and 7.10 (two AA′BB′ systems, 8H), 7.51−7.44 (m, 2H), 7.34−7.24 (m, 2H), 7.14−7.08 (m, 1H), 7.02 (dd, 1H, *J* = 5.2, 3.6 Hz), 4.53 and 3.67 (2d, 2H, *J* = 4.2 Hz), 2.39 and 2.30 (2s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.3, 142.6, 141.8, 141.1, 133.5, 130.8, 131.2, 130.0, 129.7, 129.6, 129.1, 128.4, 127.2, 126.5, 126.1, 124.8, and 21.3 (C-2 and C-3 are missing).

***trans*-(2*S*,3*S*)-2-Butyl-3-[(*S*)-2-(*p*-toluenesulfinyl)phenyl]-1-[(*R*)-(*p*-toluenesulfinyl)]aziridine, 8g:** eluent for chromatography hexane/Et_2O 1:2.5; yield 59%; colorless oil; $[\alpha]^{20}_D$ = −260.0 (*c* 0.8, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.95 (dd, 1H, *J* = 7.8, 1.2 Hz), 7.56, 7.45, 7.23, and 7.20 (two AA′BB′ systems, 8H), 7.39 (dd, 1H, *J* = 7.7, 1.2 Hz), 7.35−7.28 (m, 1H), 6.95 (d, 1H, *J* = 7.7 Hz), 3.82 (d, 1H, *J* = 3.9 Hz), 2.46−2.40 (m, 1H), 2.37 and 2.34 (2s, 6H), 1.87−1.17 (3m, 6H), 0.85 (t, 3H, *J* = 7.0 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.1, 142.6, 141.9, 141.7, 141.5, 135.3, 131.0, 130.1, 129.4, 128.4, 126.5, 126.1, 124.6, 124.5, 30.1, 27.9, 22.3, 21.4, and 13.8 (C-2 and C-3 are missing); HRMS calcd for $C_{19}H_{22}NOS$ (M^+ − SOTol) 312.1422, found 312.1420.

Representative Procedure for Total Desulfinylation of *N*-Sulfinylaziridines. To a stirred solution of **8a** (0.12 mmol) in THF (2 mL) at −78 °C was added *t*-BuLi (0.18 mL, 0.27 mmol, 1.5 M in hexane, 2.2 equiv). When the reaction was completed (15 min), the mixture was hydrolyzed with saturated aqueous NH_4Cl (1 mL) and extracted with CH_2Cl_2 (3 × 3 mL). The combined organic layers were dried over $MgSO_4$, and the solvent was removed under reduced pressure. The residue was purified by SCX column chromatography.

(−)-(2*S*,3*S*)-2,3-Diphenylaziridine 9a: eluent for SCX column chromatography NH_3/methanol (7M); yield 75%; colorless syrup; $[\alpha]^{20}_D$ = −320 (*c* 0.5, $CHCl_3$) [lit.[16] = −328.8 (*c* 1.25, $CHCl_3$)]; spectroscopic data of compound **9a** are coincident with those previously reported: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.29−7.40 (m, 10H), 3.12 (s, 2H), 1.70 (br s, 1H).

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Supporting Information Available: General experimental methods. Characterization data for compounds **2a**−**e**, **6b**, **7a**−**c**, **7e**−**f**, **9b**, **9e**, and **9g**. ^{1}H NMR and ^{13}C NMR spectra of compounds (*S*)-**3**, **6a**, **6c**−**e**, **7c**, **8a**−**g**, **9b**, **9e**, and **9g**. X-ray structure and refinement details for compound *cis*-(2*S*,3*R*)-**7a**. Full citation for ref 23 and Cartesian coordinates for all optimized structures, electronic energies, and ZPVEs. This material is available free of charge via the Internet at http://pubs.acs.org.

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