Aza-Darzens Asymmetric Synthesis of *N*-(*p*-Toluenesulfinyl)aziridine 2-Carboxylate Esters from Sulfinimines (*N*-Sulfinyl Imines)

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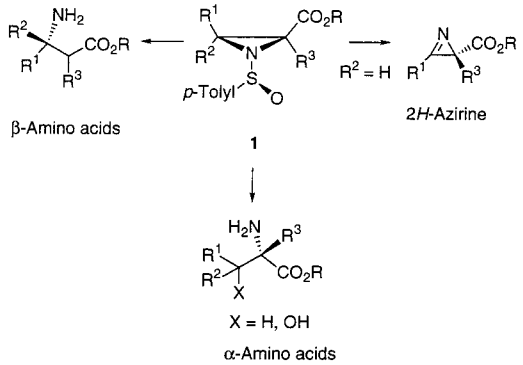
The one-step aza-Darzens reaction of sulfinimines **2** with lithium α-bromoenolates readily affords diversely substituted *cis* and *trans N*-sulfinylaziridine 2-carboxylate esters **3** and **7** in good yield and excellent diastereoselectivity. Higher yields, but lower de's, result when a mixture of the α-bromo ester and **2** are treated with base. The *N*-sulfinyl group is transformed, nearly quantitatively, without ring opening, into the *N*-tosyl activating group by oxidation with *m*-CPBA. Selective removal of the *N*-sulfinyl group in aziridines **3a** and **3h** with TFA/H_2O affords 1*H*-aziridines **21** which are difficult to prepared by other means. However, C(3) activated azirines such as **3b** undergo ring-opening under these conditions. Alternatively, the *N*-sulfinyl group, even in C(3)-activated aziridines, was selectively and efficiently removed by treatment of the aziridine with 2 equiv of MeMgBr.

Highly regio- and stereocontrolled ring-opening reactions of aziridines have considerable value in organic synthesis.[1] This is particularly true for aziridine 2-carboxylic acids and esters which not only lead to α- and *β*-amino acids, but also can be transformed into vinyl aziridines[2] and aziridino alcohols[3−5] which themselves are useful building blocks and auxiliaries.[4,5] Methods for the asymmetric syntheses of aziridine 2-carboxylic acids and esters include cyclization of synthetic and naturally occurring *β*-hydroxy α-amino acids, azide displacement of chiral oxiranes followed by the Staudinger reaction, nitrene addition to α,*β*-unsaturated esters, and kinetic resolution,[5−7] A catalytic method has recently been introduced.[8] Unfortunately, most of these procedures afford *N*-substituted derivatives and are lengthy, limited in scope, and nonstereospecific.[1,6] Another key issue is the difficulty in varying the *N*-substituent, which plays a critical role in controlling the ring-opening regiochemistry and stereoselectivity.

In preliminary communications we described the synthesis of enantiopure *N*-sulfinylaziridine 2-carboxylate esters **1**, which were utilized as building blocks in highly stereoselective asymmetric syntheses of α-amino acids,[7] α-alkyl *β*-amino acids,[9a] α-methyl[9b] and *β*-substituted α-amino acids,[10] the antibiotic thiamphenacol,[11] *β*-hydroxy α-amino acids,[12] *β*-hydroxy α-methyl α-amino acids,[9b] the protein kinase C inhibitors D-*erythro* and L-*threo*-sphingosine,[12] and the smallest of the unsaturated nitrogen heterocycles 2*H*-azirine 2-carboxylate esters[10] including the cytotoxic antibiotic (*R*)-(−)-dysidazirine.[13] Our synthesis, which appears to be unparalleled in its simplicity and the ease of incorporating diverse ring and nitrogen substituents, involves a one-step aza-Darzens reaction of sulfinimines (*N*-sulfinyl imines) with α-bromoenolates.[14] This protocol has recently been extended to the asymmetric synthesis of 2-substituted *N*-sulfinylaziridines[15,16] and *N*-sulfinylaziridine 2-phosphonates which were used in the first asymmetric synthesis of azirinyl phosphonates.[17] In this paper we give a full account of our asymmetric synthesis of *N*-sulfinylaziridine 2-carboxylate esters from sulfinimines.



Results and Discussion

Synthesis of Aziridines. The *N*-sulfinylaziridine 2-carboxylates were prepared by treating sulfinimines (*N*-sulfinyl imines **2**) with α-haloenolates in the aza-Darzens reaction outlined in Scheme 1. The lithium enolate of methyl α-chloroacetate (X = Cl, R^2 = Me), generated by

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Scheme 1

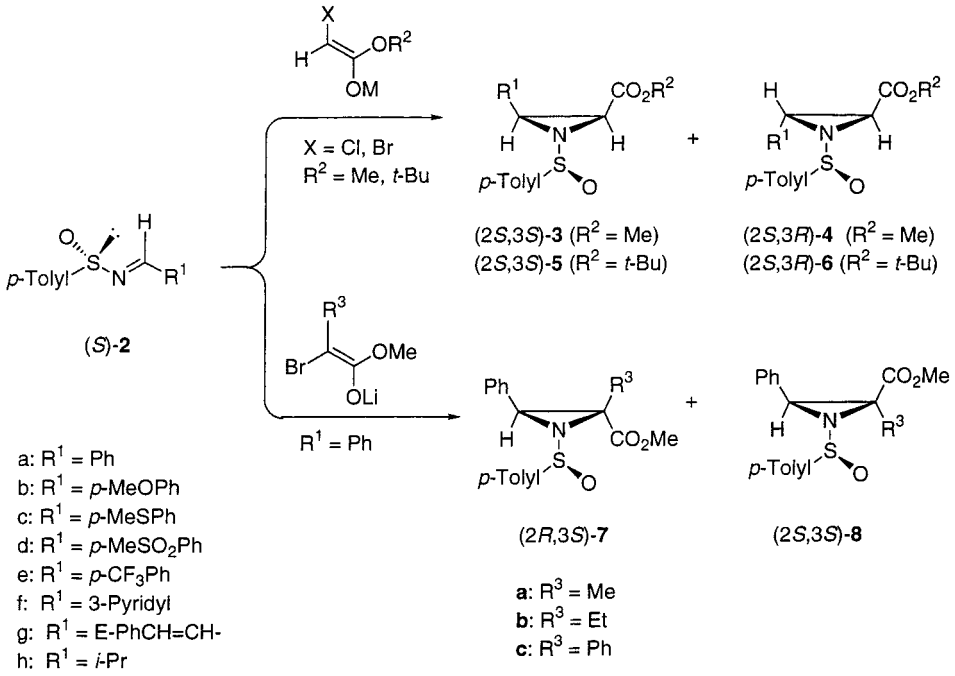

Table 1. Asymmetric Synthesis of *N*-(*p*-Toluenesulfinyl)aziridine 2-Carboxylate Esters 3−8 from (*S*)-2 in THF

entry	sulfinimine (*S*)-**2** R^1 =	X	α-haloester R^3	α-haloester R^2	reaction conditions base/temp (°C)/time (h)	config de[a] of major	% de[a] [*b*]	% isolated yield [*b*] major	% isolated yield [*b*] minor
1	**2a** (Ph)	Cl	H	Me	LDA/−78/5			decomposition	
2		Cl	H	*t*-Bu	LiHMDS/−78/5	(2*S*,3*S*)-**5a**	54	50	
3		Cl	H	*t*-Bu	KHMDS/−78/5	(2*S*,3*S*)-**5a**	13	57	
4		Br	H	*t*-Bu	LiHMDS/−78/5	(2*S*,3*S*)-**5a**	68	63	
5		Br	H	*t*-Bu	LiHMDS/−78/2.5	(2*S*,3*S*)-**5a**	68	80	
6		Br	H	Me	LiHMDS/−78/2.5	(2*S*,3*S*)-**3a**	94[81]	65[89]	[8]
7		Br	H	Me	LiHMDS/−78 to rt/2.5	(2*S*,3*S*)-**3a**	80	77	
8		Br	H	Me	LiHMDS/−78/2.5[c]	(2*S*,3*S*)-**3a**	76	60	
9		Br	H	Me	LiHMDS/−78/2.5[d]	(2*S*,3*S*)-**3a**	[44]	22[55]	[21]
10		Br	H	Me	NaHMDS/−78/2.5	(2*S*,3*S*)-**3a**	[42]	e[55]	[22]
11		Br	Me	Me	LiHMDS/−78/0.5	(2*R*,3*S*)-**7a**	90[46]	85[50]	2[22]
12		Br	Et	Me	LiHMDS/−78/0.5	(2*R*,3*S*)-**7b**	90	84	3
13		Br	Ph	Me	LiHMDS/−78/0.5	(2*R*,3*S*)-**7c**	>95	61	
14	(*R*)-**2a** (Ph)	Br	H	Me	LiHMDS/−78/2.5	(2*R*,3*R*)-**3a**	98	70	
15	**2b** (*p*-MeOPh)	Br	H	Me	LiHMDS/−78/2.5	(2*S*,3*S*)-**3b**	98[90]	74[93]	
16	**2c** (*p*-MeSPh)	Br	H	Me	LiHMDS/−78/2.5	(2*S*,3*S*)-**3c**	98	68	
17	**2c** (*p*-MeSPh)	Br	H	*t*-Bu	LiHMDS/−78/2.5	(2*S*,3*S*)-**5c**	74	71	
18	**2d** (*p*-$MeSO_2$Ph)	Br	H	Me	LiHMDS/−78/2.5	(2*S*,3*S*)-**3d**	52[41]	20[55]	
19	**2e** (*p*-CF_3Ph)	Br	H	Me	LiHMDS/−78/2.5	(2*S*,3*S*)-**3e**	98[42]	22[61]	[15]
20	**2f** (3-Pyridyl)	Br	H	Me	LiHMDS/−78/0.5	(2*S*,3*S*)-**3f**	82[82]	48[63]	
21	**2g** (*E*-PhCH=CH)	Br	H	Me	LiHMDS/−78/0.5	(2*S*,3*S*)-**3g**	98[73]	50[78]	
22	**2h** (*i*-Pr)	Br	H	Me	LiHMDS/−78/3.0	(2*S*,3*S*)-**3h**	98[56]	64[73]	[24]

[a] de's determined on the crude reaction mixture by ^{1}H NMR. [b] Results using the in situ, one-step procedure for 30 min; see text. [c] A rt solution of **2a** was added to the −78 °C enolate. [d] Reaction performed in the presence of HMPA. [e] Decomposition.

treatment with LDA at −78 °C, and (*S*)-(+)-*N*-(benzylidene)-*p*-toluenesulfinamide (**2a**) resulted in a complex mixture of products from which no aziridine compound was identified (Table 1, entry 1). Successful aziridination was first realized using the enolate of *tert*-butyl chloroacetate which afforded aziridines (2*S*,3*S*)-**5a** and (2*S*,3*R*)-**6a** in a ratio of 77:23 in 50% yield (Table 1, entry 2). The yield was improved to 57% by use of the potassium enolate; however, the diastereoselectivity was reduced (Table 1, compare entry 3 with entry 2). Use of the enolate of *tert*-butyl α-bromoacetate increased the de to 68% (entry 4), and when the reaction time was reduced to 2.5 h the yield was 80% (entry 5).

Best results were observed for the lithium enolate of methyl α-bromo acetate where the de's were better than 90% (Table 1). Typically, methyl α-bromo acetate (2 mmol) was treated with an equivalent amount of lithium

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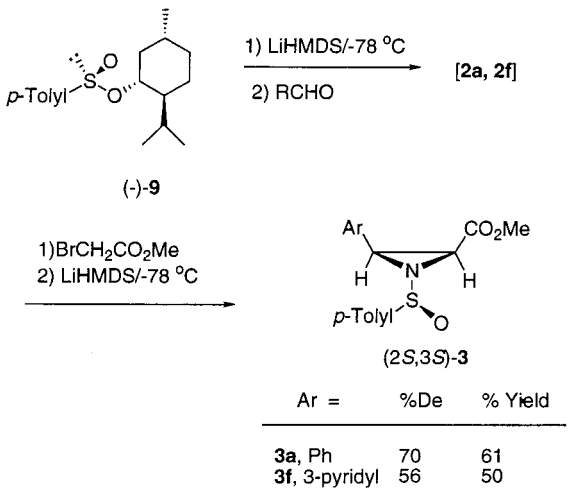
bis(trimethylsilyl)amide (LiHMDS) in THF at −78 °C. After 30 min, a THF solution of 1.0 mmol of the appropriate sulfinimine **2**, precooled at −78 °C, was added to the preformed enolate via cannula. The reaction mixture was quenched after 2.5 h with H_2O, and the *N*-sulfinylaziridines were purified by flash chromatography. The diastereomeric excess was determined by ^{1}H NMR based on the integration of C(2) protons (d, 3.18−3.66 ppm, J_{cis} = 7.3−7.4 Hz, J_{trans} = 3.5−4.0 Hz) of the crude products. For aziridines **7** and **8**, the de's were determined by integration of the C(3) protons. These results are summarized in Table 1.

Aziridination with the lithium enolate of methyl α-bromoacetate is general for aromatic, aliphatic as well as α,β-unsaturated sulfinimines **2**. The aza-Darzens reaction takes place readily at −78 °C, affording the corresponding *cis*-aziridine products in 50−77% yield and in high diastereoselectivity (94−98%, Table 1, entries 6, 15, 16, 21, and 22). However, warming the reaction from −78 °C to room temperature reduced the diastereomeric ratio from 94 to 80%, although the isolated yield was improved by 12% (Table 1, compare entries 6 and 7). The selectivity was reduced to 76% de on adding a room temperature solution of the **2a** to the enolate (entry 8). Notable exceptions were aziridines **3d** and **3e**, prepared from (*S*)-(+)-*N*-(*p*-methylsulfonylbenzylidene)-*p*-toluenesulfinamide (**2d**) and (*S*)-(+)-*N*-(*p*-trifluoromethylbenzylidene)-*p*-toluenesulfinamide (**2e**), where the yields were 20−22% (entries 18 and 19). The lithium enolates of methyl α-bromopropionate, α-bromobutyrate, and α-bromophenylacetate with (*S*)-(+) **2a** gave predominantly the *trans*-aziridines (2*R*,3*S*)-**7a**−**c** (Table 1; entries 11−13). The diastereoselectivity was 90% and yields were 61−85%. It should be noted that the configuration of the aziridine product is controlled by the sulfur stereogenic center in that (*S*)-sulfinimines afforded the (2*S*,3*S*)-aziridine product **3a** and the (*R*)-sulfinimine gave (2*R*,3*R*)-**3a** (Table 1, entries 6 and 14).

The modest yields of aziridines **3** obtained using methyl α-bromoacetate most likely reflect the instability of this enolate and its propensity to undergo self-condensation and dimerization reactions.[18] The somewhat better yields of **7**, prepared from substituted α-bromoenolates, which are more resistant to self-condensation, undoubtedly reflect this. In an attempt to improve the yields of **3** the in situ trapping method, which is a useful technique for dealing with unstable reaction species, was employed.[19] In this one-step procedure 2 equiv of methyl bromoacetate and 1 equiv of (*S*)-**2a** were treated with 1.3 equiv of LiHMDS at −78 °C. The reaction was complete within 20 min, affording an 89% yield of (2*S*,3*S*)-**3a** (entry 6). However, the de decreased from 94 to 81%. In the presence of HMPA the two-pot procedure gave less than 22% yield of **3a**, whereas the one-step procedure resulted in a 55% and 21% isolated yields of *cis*-(2*S*,3*S*)-**3a** and *trans*-(2*S*,3*R*)-**4a** (44% de, entry 9). With NaHMDS, which gave no aziridine products in the two-step method,

Scheme 2



Ar =	%De	% Yield
3a, Ph	70	61
3f, 3-pyridyl	56	50

a similar 55% and 22% of *cis*-(2*S*,3*S*)-**3a** and *trans*-(2*S*,3*R*)-**4a** were obtained for the one-step procedure (entry 10). Dramatic improvement in the yields of aziridines **3d** and **3e**, prepared from sulfinimines **2d** (R = *p*-$MeSO_2Ph$) and **2e** (*p*-CF_3Ph), was also noted (20−22% vs 55−61%) (entries 18 and 19). However, with methyl α-bromopropionate, the one-step method resulted in reduced yields affording 50 and 22% yields of (2*R*,3*S*)-**7a** and (2*S*,3*S*)-**8a**, respectively (entry 11). While the in-situ, one-step, aza-Darzens synthesis of aziridines generally provides higher yields, the selectivity is lower than that found in the two-step process. The importance of the former method is that it makes available useful quantities of the minor aziridine isomer which are required for structure determination and mechanistic studies.

We also explored the possibility of preparing *N*-sulfinylaziridines (+)-**3a** and (+)-**3f** in one pot from the sulfinimine precursor (1*R*,2*S*,5*R*)-(−)-menthyl (*S*)-*p*-toluenesulfinate (**9**). This was accomplised by treating (−)-**9** with 1.2 equiv of lithium bis(trimethylsilyl)amide (LiHMDS) at −78 °C followed by the aldehyde to produce the intermediate sulfinimines **2a** and **2f**, respectively.[20] To this reaction mixture, at −78 °C, was added 2.0 equiv of methyl bromoacetate followed by LiHMDS. Flash chromatography afforded (+)-**3a** and (+)-**3f** in 61 and 50% overall isolated yields (Scheme 2). While the direct synthesis of aziridines from **9**, the sulfinimine precursor, eliminates several steps, the *cis*/*trans* selectivity was the lowest of the procedures (Table 1).

Recently we described a new method for the asymmetric synthesis of 3,3-disubstituted aziridines 2-carboxylate esters such as **11** via the addition of Grignard reagents to 2*H*-azirine 2-carboxylates, which are otherwise difficult to prepare.[10] As an extension of this chemistry, we applied our aza-Darzens aziridine synthesis to the acetophenone-derived sulfinimine (*S*)-(+)-**10**.[21] (2*S*,3*S*)-(−)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-methyl-3-phenylaziridine (**11**) was isolated as a single isomer (Scheme 3) in 41% yield. However, the reaction did not proceed at −78 °C, and warming to 0 °C was necessary. In addition to **11**, a 23% yield of enamine **13** was also obtained. This material was prepared independently by

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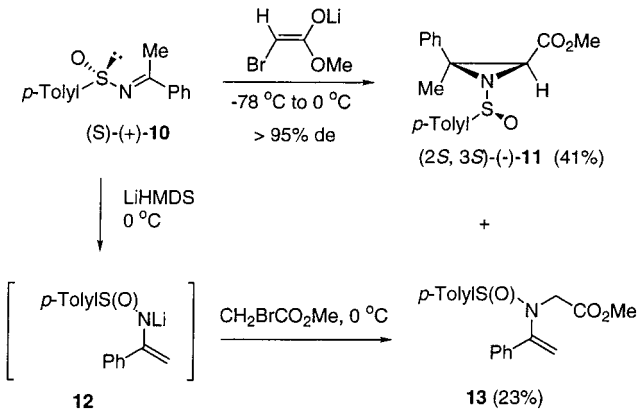
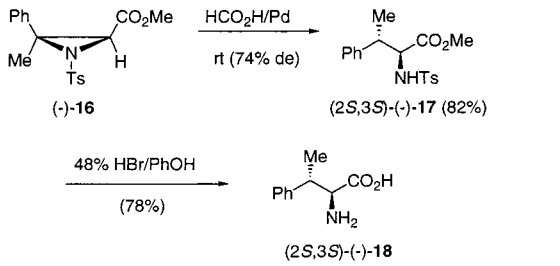
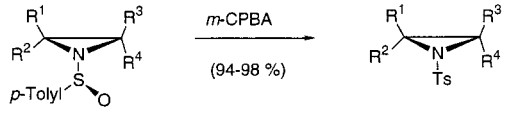
Scheme 3



Scheme 4



Scheme 5



treating **10** with LiHMDS, to generate aza enolate **12**, followed by reaction with methyl bromoacetate. By contrast, addition of the lithium enolate of methyl acetate to **10** gave the corresponding β-amino acid *N*-(*p*-toluenesulfinyl)-3-amino-3-phenylbutanoate, in 84% yield.[22] Competitive enolization was not detected.[22]

Sulfinimines (*S*)-**2a**−**h** and (*S*)-**10** were prepared in one-pot from commercially available (1*R*,2*S*,5*R*)-(−)-menthyl (*S*)-*p*-toluenesulfinate (**9**), LiHMDS, and the aldehydes[20] or by the direct condensation of (*S*)-(+)-*p*-toluenesulfinamide (*p*-tolyl-S(O)NH_2) with the aldehyde or ketone in the presence of $Ti(OEt)_4$.[21] This latter procedure avoids separation of the menthol byproduct which is sometimes problematic. Sulfinimines **2**, developed in our laboratory, are widely used chiral building blocks for the asymmetric synthesis of amine derivatives, because the *N*-sulfinyl auxiliary activates the C=N bond for addition, is highly stereodirecting and is easily removed from the product under mild acid or base conditions, problems that plague other imine auxiliaries.[23,24]

Structure and Formation of Aziridines. The barrier to *syn*/*anti* inversion in *N*-sulfinylaziridines is low ($\Delta G^{\ddagger} = 10-14$ kcal/mol)[25] and, as a consequence, several of the aziridines **3a**, **7a**, etc., were initially produced as mixtures of invertomers as indicated by a doubling of the C(2) and C(3) proton resonances. However, within minutes to hours a single invertomer was generally formed which presumably has the sterically favored *trans*-orientation, i.e., **3**.[26]

The stereochemical assignments for aziridines **3** and **4** are based on the large ring proton coupling constants observed for *cis*-**3** vs *trans*-**4**, (e.g., $J = 7.3-7.4$ Hz vs 3.5−3.6 Hz, respectively).[27,28] The absolute stereochemistry of (+)-**3a** was established by selective removal of the *N*-sulfinyl group (vide infra) to give the known methyl (+)-(2*S*,3*S*)-3-phenyl-1*H*-aziridine-2-carboxylate (**21a**)[29] and hydrolysis to *syn*-β-phenylserine.[7] By analogy, and on the basis of the similar coupling constants, the major aziridines **3b**−**h** isomers are assumed to have the *cis* geometry.

The minor *trans* aziridine **4a**, isolated as a pair of invertomers, was oxidized with *m*-CPBA to give the *N*-tosylaziridine as a single isomer **20b** (vide infra). This aziridine had ^{1}H NMR spectra identical to methyl (2*R*,3*S*)-(+)-*trans*-*N*-(*p*-toluenesulfonyl)-3-phenylaziridine-2-carboxylate prepared by Evans and co-workers[28] except for the sign of optical rotation indicating that the configuration of the minor isomer has the *trans* (2*S*,3*R*)-configuration.

The structures of *trans*-(2*R*,3*S*)-(+)-*N*-(*p*-toluenesulfinyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (**7a**), its *cis* isomer (2*S*,3*S*)-(+)-**8a**, and *cis*-(2*S*,3*S*)-(−)-*N*-(*p*-toluenesulfinyl)-2-carbomethoxy-3-methyl-3-phenylaziridine (**11**) are based on ^{1}H NOE experiments and their transformations into known compounds. It was not possible to directly establish the stereochemistry of **7a** and **8a** by NOE experiments because they exist as *cis* and *trans* invertomers. This problem was overcome by *m*-CPBA oxidation (vide infra) of the *N*-*p*-toluenesulfinyl group to the bulky tosyl derivatives **14** and **15** which exist as single invertomers (Scheme 5). The fact that irradiation of the C(2) Me protons in **14** and **15** produces NOE enhancements of 3% and 10% at the C(3) phenyl and C(3) hydrogen, respectively, is consistent with the *trans* nature of the ring substitutes in (2*R*, 3*S*)-(+)-**7a** and the *cis* nature in (2*S*,3*S*)-(+)-**8a**. As reported earlier, the absolute stereochemistry of (2*R*,3*S*)-(+)-**14** was determined by ring-opening hydrogenolysis and removal of the tosyl group to give the known (*R*)-(+)-α-methylphenylalanine.[9b]

The relative stereochemistry of (2*S*,3*S*)-(−)-*N*-(*p*-toluenesulfinyl)-2-carbomethoxy-3-methyl-3-phenylaziridine (**11**) is based on the difference in its spectral properties compared to the *trans*-(2*S*,3*R*) isomer which

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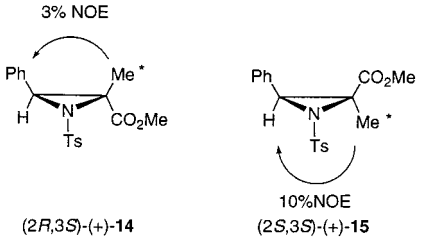
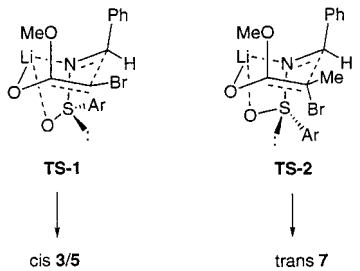


(2*R*,3*S*)-(+)-**14** (2*S*,3*S*)-(+)-**15**

was prepared independently by addition of methylmagnesium bromide to (*S*)-(+)-3-phenyl-2*H*-azirine 2-carboxylate.[10] The absolute stereochemistry of (−)-**11** was determined by *m*-CPBA oxidation of the tosyl derivative **16** and subsequent conversion into *erythro*-(2*S*,3*S*)-(−)-3-methylphenylalanine (**18**), previously prepared by Hruby et al. (Scheme 4).[30] Transfer hydrogenation of (−)-**16** gave mainly the inversion product (2*S*,3*S*)-(−)-2-*N*-(*p*-toluenesulfonyl)amino-3-phenylbutyrate (**17**) in 74% de. The diastereoisomers were separated by flash chromatography affording (−)-**17** in 82% yield. The *N*-tosyl protecting group was removed by refluxing in 48% HBr in the presence of phenol to produce a 78% yield of (2*S*,3*S*)-(−)-**18** (Scheme 4).

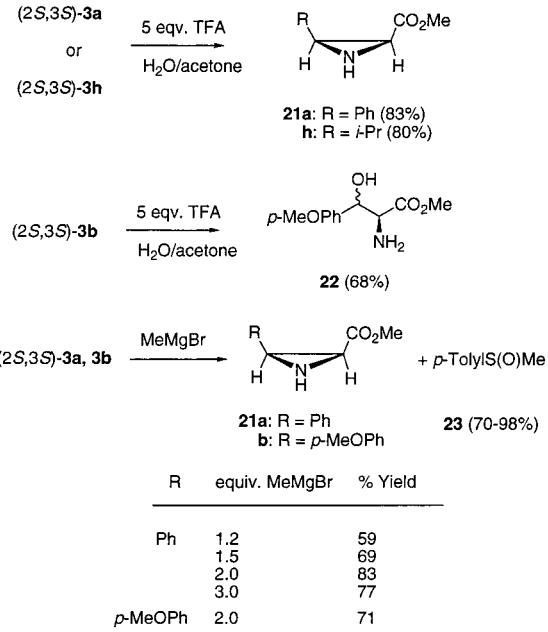
In the aza-Darzens reactions of sulfinimines **2** with α-bromoenolates, two new stereocenters are created at C(2) and C(3) producing, in principle, four stereoisomeric aziridines. However, only the *cis* and *trans* aziridines are formed with *cis*-**3**/**5** predominating for the enolate of α-bromoacetate and *trans*-**7** for the substituted α-bromoacetate enolates. The high *cis*-selectivity for **3**/**5** is consistent with a six-membered chairlike transition containing a four-membered metallocycle, **TS-1**. It is assumed that the enolate of methyl α-bromoacetate has the *E*-geometry as has been proposed by others.[31,32] It is also assumed that in solution the sulfinimines also adopt the same sterically favored *E*-geometry as they have in the solid state.[20] Furthermore, **2** may be locked into this geometry as a consequence of the metal cation of the enolate being coordinated with both nitrogen and oxygen atoms of the sulfinimine. A similar transition state, **TS-2**, provides a rational for the *trans*-selectivity of aziridines **7** observed with substituted α-bromoenolates. Here the *Z*-geometry for the enolate is required and is supported by the Ireland six-membered transition state for kinetic enolate formation.[32] However, attempts to verify this by TMS-Cl trapping of the enolate were unsuccessful.



cis **3**/**5** trans **7**

Variation of the Aziridine Nitrogen Substituent. We have seen that the aziridination of sulfinimines is a highly efficient and versatile method for preparing structurally diverse C(2)- and C(3)-substituted aziridines (Scheme 1). Equally important is being able to vary the nitrogen substituent, because aziridine ring-opening requires activation at nitrogen which determines regio- and stereoselectivity.[1,32] As mentioned earlier, many of the methods used to prepare aziridines produce *N*-substituted derivatives where it is difficult or impossible to remove or alter the nitrogen substituent.

Scheme 6



R	equiv. MeMgBr	% Yield
Ph	1.2	59
	1.5	69
	2.0	83
	3.0	77
p-MeOPh	2.0	71

Many aziridine *N*-activating groups have been studied with *N*-tosyl activation, often affording superior reactivity and regiospecificity.[1,33] However, attempts to tosylate 1*H*-3-arylaziridine-2-carboxylate esters with tosyl chloride lead predominantly to ring-opened products.[33] By contrast, this key activating group is readily installed, prior to ring opening, by oxidation of *N*-sulfinylaziridines (Scheme 5). Thus, treatment of aziridines (2*S*,3*S*)-**3a**, **4a**, (2*R*,3*S*)-**7a**, (2*S*,3*S*)-**8a**, and (2*S*,3*S*)-**11** with 1.5 equiv of 57% *m*-CPBA in $CHCl_3$ gave nearly quantitative yields of the corresponding *N*-tosyl aziridines, respectively (Table 2).

Another advantage of the *N*-sulfinyl group in aziridines is that it can be removed under comparatively mild conditions, affording enantiopure 1*H*-aziridines. 1*H*-Aziridines are precursors of *N*-substituted aziridines and can be elaborated into 2*H*-azirines.[34] Reaction of aziridines **3a** and **3h** with 5 equiv of TFA in 50% aqueous acetone for 15−20 min afforded 1*H*-aziridines **21a** and **21h** in 83 and 80% yield, respectively (Scheme 6). However, under the same conditions the 3-(*p*-methoxyphenyl)aziridine **3b** gave a 1:1 mixture of the *erythro* and *threo* β-hydroxy α-amino acids **22**. The *p*-methoxy phenyl group in **3b**, under these acidic conditions, apparently activates aziridine ring-opening by stabilizing a carbocation at C(3). To circumvent this problem, a procedure was developed for removing the sulfinyl group under basic, nucleophilic conditions. With 2.0 equiv of

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Table 2. Oxidation of *N*-Sulfinyl Aziridine 2-Carboxylate Esters to *N*-Tosyl Aziridine 2-Carboxylate Esters with *m*-CPBA at 25 °C in $CHCl_3$

entry	*N*-sulfinyl aziridine	*N*-tosyl aziridine	R^1	R^2	R^3	R^4	(% yield)[a]
1	(2*S*,3*S*)-**3a**	(2*S*,3*S*)-**19**	Ph	H	CO_2Me	H	(94)
2	(2*S*,3*R*)-**4a**	(2*S*,3*R*)-**20**	H	Ph	CO_2Me	H	(95)
2	(2*R*,3*S*)-**7a**	(2*R*,3*S*)-**14**	Ph	H	Me	CO_2Me	(98)
3	(2*S*,3*S*)-**8a**	(2*S*,3*S*)-**15**	Ph	H	CO_2Me	Me	(95)
4	(2*S*,3*S*)-**11**	(2*S*,3*S*)-**16**	Ph	Me	CO_2Me	H	(95)

[a] Isolated yields.

MeMgBr aziridine **3a** gave **21a** in 83% yield in addition to methyl *p*-toluene sulfoxide (**23**). The latter product indicates that the Grignard reagent efficiently attacks at the aziridine sulfinyl sulfur. With more than 2.0 equiv of MeMgBr, yields were lower. The (*p*-methoxyphenyl)-aziridine **3b** with 2.0 equiv of MeMgBr gave the corresponding 1*H*-aziridine **21b** in 71% isolated yield and sulfoxide **23** in 98% yield (Scheme 5).

Conclusions. The aza-Darzens aziridination of sulfinimines with α-bromo enolates represents a versatile one-step method for the asymmetric synthesis of structurally diverse *N*-sulfinylaziridine 2-carboxylate esters, valuable building blocks for the enantioselective synthesis of α- and *β*-amino acids. Furthermore, the *N*-sulfinyl group is easily transformed, without ring-opening, into the *N*-tosyl activating group, which often provides for superior aziridine ring-opening regio- and stereoselectivities. 1*H*-Aziridines, which are difficult to prepare by other methods, are easily available because the *N*-sulfinyl group can be efficiently removed under mild acid or base conditions.

Experimental Section

General Procedure. Column chromatography was performed on silica gel, Merck grade 60 (230−400 mesh). Analytical and preparative thin-layer chromatography was performed on precoated silica gel plates (250 and 1000 μm) purchased from Analtech Inc. TLC plates were visualized with UV, in an iodine chamber or with phosphomolybdic acid unless noted otherwise. THF was freshly distilled under nitrogen from a purple solution of sodium and benzophenone.

Unless stated otherwise, all reagents were purchased from commercial sources and used without additional purification. Sulfinimines were prepared as previously described.[20,21]

(S_s)-(−)-*N*-(*p*-Methylthiobenzylidene)-*p*-toluenesulfinamide (2c): eluant, EtOAc:hexanes (3:7); yield 2.30 g (80%); mp 132−134 °C; $[\alpha]^{20}_D$ −40.2 (*c* 1.1, $CHCl_3$); IR (KBr) cm^{-1} 1587, 1548, 1495, 1405, 1089; ^1H NMR ($CDCl_3$) δ 8.68 (s, 1H), 7.72 (d, 2H, J = 8.3 Hz), 7.62 (d, 2H, J = 8.3 Hz), 7.30 (d, 2H, J = 8.3 Hz), 7.25 (d, 2H, J = 8.3 Hz), 2.50 (s, 3H), 2.39 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 159.3, 144.9, 141.5, 141.2, 129.8, 129.4, 124.9, 124.4, 21.2, 14.6. Anal. Calcd for $C_{15}H_{15}NOS_2$: C, 62.25; H, 5.22. Found: C, 62.48; H, 5.28.

(S_s)-(+)-*N*-(*p*-Methylsulfonylbenzylidene)-*p*-toluenesulfinamide (2d): crystallization from EtOAc; yield 1.11 g (80%); mp 139−140 °C; $[\alpha]^{20}_D$ 35.2 (*c* 1.1, $CHCl_3$); IR (KBr) cm^{-1} 3006, 1606, 1566, 1310, 1290, 1146; ^1H NMR ($CDCl_3$) δ 8.80 (s, 1H), 8.03 (s, 4H), 7.63 (d, 2H, J = 8.1 Hz), 7.33 (d, 2H, J = 8.1 Hz), 3.06 (s, 3H), 2.40 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 158.7, 143.4, 142.0, 140.8, 138.1, 130.1, 129.9, 127.9, 127.8, 124.6, 44.3, 21.3; HRMS calcd for $C_{15}H_{16}NS_2O_3$ (M + H) 322.0572, found 322.0569. Anal. Calcd for $C_{15}H_{15}NS_2O_3$: C, 56.07; H, 4.67; N, 4.36. Found: C, 56.11; H, 4.75; N, 4.25.

(S_s)-(+)-*N*-(*p*-Trifluoromethylbenzylidene)-*p*-toluenesulfinamide (2e): eluant, EtOAc:*n*-pentane (1:9); yield 3.80 g (67%); mp 92−93 °C; $[\alpha]^{20}_D$ 85.0 (*c* 0.4, $CHCl_3$); IR (KBr) cm^{-1} 2923, 1608, 1324, 1170; ^1H NMR ($CDCl_3$) δ 8.79 (s, 1H), 7.96 (d, 2H, J = 8.1 Hz), 7.71 (d, 2H, J = 8.3 Hz), 7.64 (d, 2H, J = 8.2 Hz), 7.33 (d, 2H, J = 8.3 Hz), 2.41 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 159.1, 141.8, 141.1, 136.6, 133.6 (q, J = 132 Hz, CF_3), 129.8, 129.6, 125.7, 124.6, 121.3, 21.2; HRMS calcd for $C_{15}H_{13}NF_3SO$ (M + H) 312.0670, found 312.0671. Anal. Calcd for $C_{15}H_{12}NF_3SO$: C, 57.88; H, 3.86; N, 4.50. Found: C, 57.77; H, 3.94; N, 4.38.

Preparation of *cis*- and *trans*-*N*-(*p*-Toluenesulfinyl)-2-carbo-*tert*-butoxy-3-phenylaziridines 5a and 6a: Typical Two-Step Procedure. In a 50 mL oven-dried, two-necked, round-bottomed flask fitted with a magnetic stirring bar, rubber septum, and an argon-filled balloon was placed 2.0 mL (2.0 mmol, 1.0 M in THF) of lithium bis(trimethylsilyl)amide (LiHMDS) in THF (5 mL). The solution was cooled to −78 °C, and 0.33 mL (2.0 mmol) of *tert*-butyl α-bromoacetate was added. The reaction was stirred at −78 °C for 30 min, and 0.243 g (1.0 mmol) of (*S*)-(+)-**2a** in THF (5 mL) precooled to −78 °C was added to the enolate via a double-ended needle over a period of 30 min. The reaction mixture was stirred for 2.5 h at −78 °C, quenched with H_2O (2 mL), and diluted with EtOAc (20 mL). The organic layer was separated, washed with brine (10 mL), dried ($MgSO_4$), filtered, and concentrated to give a crude 84:16 ratio mixture of diastereomers by ^1H NMR. The crude mixture was purified by chromatography (EtOAc/hexanes, 2:8) to afford 0.29 g (81%) of *cis*-(2*S*,3*S*)-**5a** and 0.03 g (7%) of *trans*-(2*S*,3*R*)-**6a**.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-*p*-Toluenesulfinyl-2-carbo-*tert*-butoxy-3-phenylaziridine (5a):** mp 79−80 °C; $[\alpha]^{20}_D$ 24.6 (*c* 1.6, $CHCl_3$); IR (KBr) cm^{-1} 2976, 1742, 1596, 1072; ^1H NMR ($CDCl_3$) δ 7.74 (d, 2H, J = 8.2 Hz), 7.49−7.30 (m, 7H), 3.85 (d, 1H, J = 7.4 Hz), 3.39 (d, 1H, J = 7.4 Hz), 2.43 (s, 3H), 1.07 (s, 9H); the ^{13}C NMR could not be obtained because this aziridine exists as a slowly interconverting mixture of invertomers at nitrogen. Anal. Calcd for $C_{20}H_{23}NO_3S$: C, 67.20; H, 6.49. Found: C, 67.05; H, 6.64.

***trans*-(S_s,2*S*,3*R*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbo-*tert*-butoxy-3-phenylaziridine (6a):** mp 84−86 °C; $[\alpha]^{20}_D$ 60.1 (*c* 2.0, $CHCl_3$); IR (KBr) cm^{-1} 2978, 1720, 1230, 1155; ^1H NMR ($CDCl_3$) δ 7.71 (d, 2H, J = 8.1 Hz), 7.27−7.10 (m, 7H), 3.81 (d, 1H, J = 3.5 Hz), 3.24 (d, 1H, J = 3.5 Hz), 2.38 (s, 3H), 1.53 (s, 9H); the ^{13}C NMR could not be obtained because this aziridine exists as a slowerly interconverting mixture of invertomers at nitrogen. Anal. Calcd for $C_{20}H_{23}NO_3S$: C, 67.20; H, 6.49. Found: C, 67.38; H, 6.71.

Preparation of *cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-phenylaziridine (3a): Typical One-Step Procedure. In a 100 mL, two-necked, round-bottomed flask fitted with a magnetic stirring bar, a rubber septum, and an argon-filled balloon was placed 2.00 g (8.24 mmol) of (*S*)-(+)-**2a** in THF (50 mL). The solution was cooled to −78 °C, and 1.56 mL (16.5 mmol) of methyl α-bromoacetate was added. After 3 min, 10.7 mL (10.7 mmol, 1.0 M in THF) of LiHMDS was added slowly. The reaction was stirred at −78 °C for 20 min, quenched with H_2O (5 mL), and diluted with EtOAc (15 mL). The organic layer was separated, and the aqueous phase was washed with EtOAc (2 × 15 mL). The combined organic phases were washed with brine (15 mL), dried ($MgSO_4$), and concentrated to give a crude 91:9 mixture of diastereomers. Purification by flash chromatography (EtOAc/hexanes, 2:8) afforded 2.32 g (89%) of (2*S*,3*S*)-(+)-**3a** and 0.20 g (8%) of (2*S*,3*R*)-(+)-**4a**.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-phenylaziridine (3a):** mp 72−73 °C; $[\alpha]^{20}_D$ 51.4 (*c* 1.5, $CHCl_3$); IR (KBr) cm^{-1} 3031, 1754, 1596, 1204, 1074; ^1H NMR ($CDCl_3$) δ 7.72 (d, 2H, J = 8.2 Hz), 7.50−7.20 (m, 7H), 3.88 (d, 1H, J = 7.4 Hz), 3.50 (d, 1H, J = 7.4 Hz), 3.39 (s, 3H), 2.43 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 165.8, 141.9, 140.6, 132.3, 129.5,

128.1, 127.9, 127.6, 125.0, 51.9, 42.1, 34.8, 21.5. Anal. Calcd for $C_{17}H_{17}NO_3S$: C, 64.74; H, 5.43. Found: C, 64.72; H, 5.50.

***trans*-(S_s,2*S*,3*R*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-phenylaziridine (4a):** oil; $[\alpha]^{20}_D$ 38.3 (*c* 0.2, $CHCl_3$); IR (neat) cm^{-1} 2952, 1735, 1438, 1206, 1109; ^1H NMR ($CDCl_3$) δ 7.70 (d, 2H, J = 8.0 Hz), 7.30−7.24 (m, 5H), 7.17−7.13 (m, 2H), 3.90 (d, 1H, J = 4.0 Hz), 3.84 (s, 3H), 3.31 (d, 1H, J = 3.5 Hz), 2.39 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.7, 142.7, 141.9, 134.0, 129.7, 128.4, 126.9, 125.3, 52.9, 45.1, 44.0, 21.5. Anal. Calcd for $C_{17}H_{17}NO_3S$: C, 64.74; H, 5.43; N, 4.44. Found: C, 64.61; H, 5.50; N, 4.67.

***cis*-(S_R,2*R*,3*R*)-(−)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-phenylaziridine (3a).** The typical two-step procedure was followed using (*R*)-(−)-**2a**; 98% de; eluant, EtOAc/hexanes (2:8); yield 70%; oil; $[\alpha]^{20}_D$ −50.8 (*c* 1.5, $CHCl_3$); its spectral properties were identical to (S_s,2*S*, 3*S*)-(+)-**3a**.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-(*p*-methoxyphenyl)aziridine (3b).** The typical two-step procedure was followed; 98% de; eluant, EtOAc/*n*-pentane (3:7); yield 0.23 g (74%); oil; $[\alpha]^{20}_D$ 26.4 (*c* 1.7, $CHCl_3$); IR (neat) cm^{-1} 3001, 1752, 1596, 1204, 1074; ^1H NMR ($CDCl_3$) δ 7.54 (d, 2H, J = 8.2 Hz), 7.22 (d, 2H, J = 8.8 Hz), 7.16 (d, 2H, J = 8.2 Hz), 6.69 (d, 2H, J = 8.8 Hz), 3.66 (d, 1H, J = 7.3 Hz), 3.62 (s, 3H), 3.28 (d, 1H, J = 7.3 Hz), 3.23 (s, 3H), 2.25 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.0, 159.4, 142.0, 140.6, 129.6, 128.9, 125.1, 124.4, 113.5, 55.2, 52.1, 42.0, 34.9, 21.6. Anal. Calcd for $C_{18}H_{19}NO_4S$: C, 62.59; H, 5.54. Found: C, 62.48; H, 5.28.

***cis*-(S_s,2*S*,3*S*)-(−)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-(*p*-methylthiophenyl)aziridine (3c).** The typical two-step procedure was followed; 98% de; eluant, EtOAc/*n*-pentane (3:7); yield 64%; mp 86−88 °C; $[\alpha]^{20}_D$ −2.3 (*c* 0.5, $CHCl_3$); IR (KBr) cm^{-1} 1751, 1592, 1495, 1437, 1095; ^1H NMR ($CDCl_3$) δ 7.70 (d, 2H, J = 8.1 Hz), 7.39 (d, 2H, J = 8.2 Hz), 7.33 (d, 2H, J = 8.1 Hz), 7.20 (d, 2H, J = 8.2 Hz), 3.82 (d, 1H, J = 7.3 Hz), 3.47 (d, 1H, J = 7.3 Hz), 3.41 (s, 3H), 2.47 (s, 3H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.1, 142.3, 140.8, 138.9, 129.8, 129.3, 128.3, 126.1, 125.2, 52.1, 41.9, 34.9, 21.5, 15.6. Anal. Calcd for $C_{18}H_{19}NO_3S_2$: C, 59.82; H, 5.30. Found: C, 60.12; H, 5.52.

***cis*-(S_s,2*S*,3*S*)-(−)-*N*-(*p*-Toluenesulfinyl)-2-carbo-*tert*-butoxy-3-(*p*-methylthiophenyl)aziridine (5c).** The typical two-step procedure was followed; 74% de; eluant, EtOAc/*n*-pentane (2:8); yield 0.58 g (71%); oil; $[\alpha]^{20}_D$ −16.6 (*c* 1.2, $CHCl_3$); IR (KBr) cm^{-1} 2978, 1744, 1368, 1153; ^1H NMR ($CDCl_3$) δ 7.43 (d, 2H, J = 8.2 Hz), 7.41−7.20 (m, 6H), 3.79 (d, 1H, J = 7.4 Hz), 3.36 (d, 1H, J = 7.4 Hz), 2.47 (s, 3H), 2.43 (s, 3H), 1.10 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 164.2, 141.4, 140.8, 138.1, 129.3, 129.1, 127.9, 125.5, 124.9, 81.4, 41.3, 35.4, 27.3, 21.2, 15.5. Anal. Calcd for $C_{21}H_{25}NO_3S_2$: C, 65.50; H, 6.24. Found: C, 65.10; H, 6.46.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-(4-methylsulfonylphenyl)aziridine (3d).** The typical one-step procedure was followed; 41% de; eluant, EtOAc/hexanes (presaturated with ammonia, 4:6); yield 0.34 (55%); mp 139−140 °C; $[\alpha]^{20}_D$ 14.0 (*c* 0.4, $CHCl_3$); IR (KBr) cm^{-1} 3006, 1746, 1315, 1206, 1146, 1092; ^1H NMR ($CDCl_3$) δ 7.86 (d, 2H, J = 8.4 Hz), 7.64 (d, 4H, J = 8.4 Hz), 7.29 (d, 2H, J = 8.1 Hz), 3.85 (d, 1H, J = 7.5 Hz), 3.48 (d, 1H, J = 7.5 Hz), 3.34 (s, 3H), 3.30 (s, 3H), 2.37 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 165.6, 142.5, 140.3, 138.9, 129.9, 129.8, 129.0, 128.9, 127.3, 127.1, 125.1, 124.9, 52.2, 44.4, 41.4, 34.7, 21.5; HRMS calcd for $C_{18}H_{20}NS_2O_5$ (M + H) 394.0783, found 394.0774. Anal. Calcd for $C_{18}H_{19}NS_2O_5$: C, 54.96; H, 4.83; N, 3.56. Found: C, 55.21; H, 4.87; N, 3.39.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-(4-trifluoromethylphenyl)aziridine (3e).** The typical one-step procedure was followed; 42% de; eluant, EtOAc/hexanes (2:8); yield 0.35 g (61%); mp 89−90 °C; $[\alpha]^{20}_D$ 42.1 (*c* 0.4, $CHCl_3$); IR (KBr) cm^{-1} 2954, 1752, 1325, 1167, 1125; ^1H NMR ($CDCl_3$) δ 7.72 (d, 2H, J = 8.0 Hz), 7.61 (s, 4H), 7.34 (d, 2H, J = 8.0 Hz), 3.90 (d, 1H, J = 7.0 Hz), 3.53 (d, 1H, J = 7.0 Hz), 3.40 (s, 3H), 2.43 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 165.8, 142.5, 140.5, 136.7, 130.4 (q, J = 129 Hz, CF_3), 129.8, 128.4, 125.8, 125.1, 122.2, 52.1, 41.6, 34.7, 21.4; HRMS calcd for $C_{18}H_{16}F_3NNaO_3S$ (m+Na) 406.0701, found 406.0699. Anal. Calcd for $C_{18}H_{16}NF_3SO_3$: C, 56.40; H, 4.18; N, 3.66. Found: C, 56.00; H, 4.27; N, 3.21.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-(3-pyridyl)aziridine (3f).** The typical one-step procedure was followed; 82% de; eluant, Et_2O:EtOAc (1:1); yield 63%; mp 74−76 °C; $[\alpha]^{20}_D$ 51.9 (*c* 1.1, $CHCl_3$); IR (KBr) cm^{-1} 1718, 1576, 1424, 1096; ^1H NMR ($CDCl_3$) δ 8.71 (d, 1H, J = 1.5 Hz), 8.57 (dd, 1H, J = 1.5 Hz, 5.0 Hz), 7.84 (dt, 1H, J = 1.5 Hz, 8.0 Hz), 7.71 (d, 2H, J = 8.5 Hz), 7.36 (d, 2H, J = 8.5 Hz), 7.30−7.27 (m, 1H), 3.88 (d, 1H, J = 7.0 Hz), 3.52 (d, 1H, J = 7.0 Hz), 3.42 (s, 3H), 2.44 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.5, 150.3, 150.2, 143.2, 141.1, 136.3, 130.5, 129.3, 125.8, 123.7, 52.9, 40.7, 35.1, 22.2. Anal. Calcd for $C_{16}H_{16}N_2O_3S$: C, 60.74; H, 5.10; N, 8.85. Found: C, 60.53; H, 5.13; N, 8.71.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-[(2-phenyl)-*E*-1-ethenyl]aziridine (3g).** The typical two-step procedure was followed; 98% de; eluant, EtOAc:*n*-pentane (3:7); yield 0.43 g (50%); mp 107−109 °C; $[\alpha]^{20}_D$ 109.0 (*c* 1.0, $CHCl_3$); IR (KBr) cm^{-1} 1735, 1593, 1210, 1095, 1074; ^1H NMR ($CDCl_3$) δ 7.64 (d, 2H, J = 8.1 Hz), 7.42−7.25 (m, 7H), 6.85 (d, 1H, J = 16.0 Hz), 6.23 (dd, 1H, J = 8.3 Hz, 16.0 Hz), 3.61 (s, 3H), 3.50−3.39 (m, 2H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.9, 142.0, 140.5, 136.4, 135.6, 129.5, 128.4, 128.1, 126.4, 124.6, 121.2, 52.3, 42.6, 32.7, 21.5. Anal. Calcd for $C_{19}H_{19}NO_3S$: C, 66.83; H, 5.61. Found: C, 66.38; H, 5.65.

***cis*-(S_s,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-isopropylaziridine (3h).** The typical one-step procedure was followed; 56% de; eluant, EtOAc/*n*-pentane (1:9); yield 0.55 g (73%); mp 52−55 °C; $[\alpha]^{20}_D$ 110.7 (*c* 1.3, $CHCl_3$); IR (neat) cm^{-1} 2964, 1752, 1597, 1203, 1074; ^1H NMR ($CDCl_3$) δ 7.62 (d, 2H, J = 8.1 Hz), 7.29 (d, 2H, J = 8.1 Hz), 3.61 (s, 3H), 3.21 (d, 1H, J = 7.3 Hz), 2.49 (dd, 1H, J = 7.4 Hz, 9.8 Hz), 2.40 (s, 3H), 1.89−1.71 (m 1H), 1.17 (d, 3H, J = 6.6 Hz), 0.93 (d, 3H, J = 6.6 Hz),. ^{13}C NMR ($CDCl_3$) δ 167.2, 141.5, 140.9, 129.2, 124.5 51.8, 47.4, 31.6, 26.7, 21.2, 20.4, 19.1. Anal. Calcd for $C_{14}H_{19}NO_3S$: C, 59.76; H, 6.80. Found: C, 59.77; H, 6.95.

***trans*-(S_s,2*S*,3*R*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-carbomethoxy-3-isopropylaziridine (4h).** The typical one-step procedure was followed; yield 0.18 g (24%); oil; $[\alpha]^{20}_D$ 30.7 (*c* 1.2, $CHCl_3$); IR (neat) cm^{-1} 2962, 1745, 1440, 1228, 1093; ^1H NMR ($CDCl_3$) δ 7.59 (d, 2H, J = 8.0 Hz), 7.27 (d, 2H, J = 8.5 Hz), 3.63 (s, 3H), 3.15 (d, 1H, J = 4.0 Hz), 2.77 (dd, 1H, J = 4.0 Hz, 9.5 Hz), 2.38 (s, 3H), 1.95−1.85 (m, 1H), 1.06 (d, 3H, J = 7.0 Hz), 0.98 (d, 3H, J = 7.0 Hz); ^{13}C NMR ($CDCl_3$) δ 168.9, 142.7, 141.7, 129.5, 124.9, 52.4, 51.1, 34.1, 27.9, 22.1, 21.4, 21.3; HRMS calcd for $C_{14}H_{20}NSO_3$ (M + H) 282.1164, found 282.1166. Anal. Calcd for $C_{14}H_{19}NSO_3$: C, 59.79; H, 6.76; N, 4.98. Found: C, 59.36; H, 6.51; N, 4.90.

Preparation of *trans*- and *cis*-*N*-(*p*-Toluenesulfinyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (7a and 8a). Typical Procedure. In a 250 mL, two-necked, round-bottomed flask fitted with a magnetic stirring bar, a rubber septum, and an argon-filled balloon was placed 11.1 mL (11.1 mmol, 1.0 M in THF) of LiHMDS in THF (60 mL). The solution was cooled to −78 °C, and 1.24 mL (11.1 mmol) of methyl α-bromopropionate was slowly added. After 35 min 1.00 g (4.11 mmol) of (*S*)-(+)-**2a** in THF (40 mL) precooled to −78 °C was added to the enolate via a cotton-wrapped, double-ended needle over a period of 30 min. The reaction mixture was stirred for 0.5 h, quenched with H_2O (4 mL), and diluted with EtOAc (40 mL). The organic phase was separated, and the aqueous phase was washed with EtOAc (2 × 20 mL). The combined organic extracts were washed with brine (20 mL), dried ($MgSO_4$), and concentrated to give a crude 95:5 mixture of diastereomers. Purification by flash chromatography (EtOAc:*n*-pentane, 1:4) afforded 1.14 g (85%) of *trans*-(2*R*,3*S*)-**7a** and 0.04 g (2%) of *cis*-(2*S*,3*S*)-**8a**.

***trans*-(S_s,2*R*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (7a):** yield 85%; oil; $[\alpha]^{20}_D$ 99.6 (*c* 0.22, $CHCl_3$); IR (neat) cm^{-1} 2950, 1732, 1284, 1154, 1102; ^1H NMR ($CDCl_3$) δ 7.75 (d, 2H, J = 8.1 Hz), 7.31−7.16 (m, 7H), 4.23 (s, 1H), 3.83 (s, 3H), 2.38 (s, 3H), 1.19 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 169.3, 142.1, 142.0, 133.1, 129.4, 128.0, 127.8, 127.3, 125.1, 52.8, 49.6 47.5, 21.3, 15.6; HRMS calcd

for $C_{18}H_{20}NO_3S$ (M + H) 330.1164, found 330.1164. Anal. Calcd for $C_{18}H_{19}NO_3S$: C, 65.65; H, 5.78; N, 4.26. Found: C, 65.00; H, 5.70; N, 4.35.

***cis*-(S$_s$,2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (8a):** yield 2%; oil; $[\alpha]^{20}_D$ 23.37° (*c* 0.95, $CHCl_3$); IR (neat) cm^{-1} 1730, 1452, 1239, 1147, 1099; ^1H NMR ($CDCl_3$) δ 7.84 (d, 2H, J = 6.5 Hz), 7.39−7.26 (m, 7H), 3.92 (s, 1H), 3.35 (s, 3H), 2.43 (s, 3H), 1.70 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.3, 141.7, 141.4, 133.5, 129.6, 128.1, 128.0, 127.3, 127.2, 125.8, 125.0, 54.9, 51.9, 46.5, 21.4, 15.6; HRMS calcd for $C_{18}H_{20}NO_3S$ (M + H) 330.1164, found 330.1164. Anal. Calcd for $C_{18}H_{19}NO_3S$: C, 65.65; H, 5.78; N,4.26. Found: C, 65.95; H, 5.43; N, 4.00.

***trans*-(S$_s$,2*R*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-ethyl-2-carbomethoxy-3-phenylaziridine (7b):** 90% de; eluant, EtOAc/hexanes (1:4); yield 1.16 g (84%); mp 95−96 °C; $[\alpha]^{20}_D$ 150.0 (*c* 0.80, $CHCl_3$); IR (KBr) cm^{-1} 2971, 1729, 1449, 1241, 1160; ^1H NMR ($CDCl_3$) δ 7.72 (d, 2H, J = 10.1 Hz), 7.33−7.25 (m, 7H), 4.29 (s, 1H), 3.82 (s, 3H), 2.41 (s, 3H), 1.65−1.54 (m, 1H), 1.43−1.26 (m, 1H), 0.67 (t, 3H, J = 7.4 Hz); ^{13}C NMR ($CDCl_3$) δ 168.8, 141.9, 141.8, 133.1, 129.3, 128.0, 127.8, 127.4, 125.2, 54.1, 52.6, 46.6, 22.6, 21.3, 9.0; HRMS calcd for $C_{19}H_{22}NO_3S$ (M + H) 344.1253, found 344.1250. Anal. Calcd for $C_{19}H_{21}NO_3S$: C, 66.47; H, 6.12; N, 4.08. Found: C, 66.08; H, 6.54; N, 3.87.

***trans*-(S$_s$,2*R*,3*S*)-(+)-*N*-(*p*-Toluenesulfinyl)-2-phenyl-2-carbomethoxy-3-phenylaziridine (7c):** 95% de; eluant, EtOAc/hexanes (1:9); yield 0.99 g (61%); mp 68−72 °C; $[\alpha]^{20}_D$ 40.4 (*c* 1.1, $CHCl_3$); IR (KBr) cm^{-1} 2952, 1738, 1433, 1264, 1099; ^1H NMR ($CDCl_3$) δ 7.81 (d, 2H, J = 8.2 Hz), 7.36 (d, 2H, J = 8.1 Hz), 7.12−6.95 (m, 10 H), 4.55 (s, 1H), 3.74 (s, 3H), 2.44 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.3, 142.3, 141.3, 132.8, 132.4, 129.5, 128.6, 127.8, 127.7, 127.5, 125.4, 56.5, 52.9, 47.1, 21.5; HRMS calcd for $C_{23}H_{22}NO_3S$ (M + H) 392.1320, found 392.1323. Anal. Calcd for $C_{23}H_{21}NO_3S$: C, 70.59; H, 5.37; N, 3.58. Found: C, 70.40; H, 5.22; N, 3.59.

Synthesis of Aziridine 3a from (1*R*,2*S*,5*R*)-(−)-Menthyl (*S*)-*p*-Toluenesulfinate (9). Typical Procedure. In a 100 mL, two-necked, round-bottomed flask equipped with a magnetic stirring bar, a rubber septum, and an argon-filled balloon was placed 0.92 g (3.1 mmol) of (*S*)-(−)-**9** in THF (30 mL). The solution was cooled to −78 °C, and 3.8 mL (3.8 mmol, 1.0 M in THF) of LiHMDS was added dropwise. The reaction was warmed to room temperature, stirred for 1.5 h, and monitored by TLC for the disappearance of **9**. The mixture was then cooled to −78 °C, and 0.35 mL (3.4 mmol) of benzaldehyde was added. The reaction mixture was stirred for 1 h at −78 °C and 1 h at room temperature and cooled to −78 °C, and 0.59 mL (6.2 mmol) of methyl bromoacetate was added. After 10 min, 4.7 mL (4.7 mmol, 1.0 M in THF) of LiHMDS was added. After another 30 min, the solution was warmed to −45 °C for 10 min, quenched by addition of H_2O (5 mL), and diluted with EtOAc (150 mL). The organic phase was separated, washed with brine (30 mL), dried ($MgSO_4$), and concentrated to give a 85:15 mixture of diastereomers. Flash chromatography (EtOAc/*n*-pentane, 1:9) afforded 0.60 g (61%) of **3a**.

Preparation of *cis*-(S$_s$,2*S*,3*S*)-(−)-*N*-*p*-(Toluenesulfinyl)-2-carbomethoxy-3-methyl-3-phenylaziridine (11). In a 50 mL, oven-dried, two-necked, round-bottomed flask fitted with a magnetic stirring bar, a rubber septum, and an argon-filled balloon was placed 3.4 mL (3.4 mmol, 1.0 M in THF) of LiHMDS in THF (10 mL). The solution was cooled to −78 °C, and 0.32 mL (3.42 mmol) of methyl α-bromoacetate was slowly added. The reaction misture was stirred for 30 min, and a solution of 0.44 g (1.72 mmol) of (*S*)-(+)-*N*-(α-methylbenzylidene)-*p*-toluenesulfinamide (**10**)[21] in THF (20 mL) was added to the enolate via cannula. The mixture was stirred for 1 h at −78 °C, warmed to 0 °C for 15 min, cooled to −78 °C, quenched by addition of H_2O (3 mL), and diluted with EtOAc (10 mL). The organic phase was separated, and the aqueous phase was washed with EtOAc (2 × 10 mL). The combined organic extracts were washed with brine (10 mL), dried ($MgSO_4$), and concentrated to give an oil which was purified by flash chromatography (EtOAc:*n*-pentane, 5: 95) to give 0.23 g (41%) of *cis*-(S$_s$,2*S*,3*S*)-(−)-**11** and 0.13 g (23%) of enamine **13**.

***cis*-(S$_s$,2*S*,3*S*)-(−)-*N*-*p*-Toluenesulfinyl-2-carbomethoxy-3-methyl-3-phenylaziridine (11):** mp 91−92 °C; $[\alpha]^{20}_D$ −12.40 (*c* 1.0, $CHCl_3$); IR (KBr) cm^{-1} 2955, 1756, 1448, 1232, 1179, 1060; ^1H NMR ($CDCl_3$) δ 7.76 (d, 2H, J = 8.0 Hz), 7.44 (d, 2H, J = 8.5 Hz), 7.35−7.26 (m, 5H), 3.65 (s, 1H), 3.33 (s, 3H), 2.42 (s, 3H), 2.01 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 166.9, 142.2, 141.8, 139.1, 129.6, 128.3, 127.7, 126.7, 125.5, 53.1, 51.9, 39.1, 21.4, 21.2; HRMS calcd for $C_{18}H_{20}NO_3S$ (M + H) 330.1164, found 330.1167. Anal. Calcd for $C_{18}H_{19}NO_3S$: C, 65.65; H, 5.78; N, 4.26. Found: C, 65.14; H, 5.84; N, 4.13.

Compound 13: oil; IR (neat) cm^{-1} 3066, 2951, 1754, 1436, 1205, 1097; ^1H NMR ($CDCl_3$) δ 7.71−7.63 (m, 4H), 7.48−7.36 (m, 5H), 4.97 (s, 1H), 4.90 (s, 1H), 4.08 (d, 1H, J = 17.4 Hz), 3.70 (d, 1H, J = 17.4 Hz), 3.64 (s, 3H), 2.46 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 169.3, 149.3, 142.0, 139.7, 137.3, 129.7, 129.0, 128.6, 128.1, 125.7, 102.3, 52.1, 44.2, 21.4; HRMS calcd for $C_{18}H_{20}NO_3S$ (M + H) 330.1164, found 330.1163. Anal. Calcd for $C_{18}H_{19}NO_3S$: C, 65.65; H, 5.78; N, 4.26. Found: C, 65.18; H, 5.94; N, 4.40.

Preparation of 13. In a 25 mL, oven-dried, two-necked, round-bottomed flask fitted with a magnetic stirring bar, a rubber septum, and an argon-filled balloon was placed 0.10 g (0.41 mmol) of (*S*)-**10** in THF (10 mL). The solution was cooled to 0 °C, and 0.49 mL (0.49 mmol, 1.0 M in THF) of LiHMDS was slowly added. The reaction mixture was stirred for 15 min, and 0.05 mL (0.49 mmol) of methyl α-bromoacetate was added. The mixture was stirred for 30 min at 0 °C, warmed to room temperature for 20 min, and cooled to 0 °C. The solution was quenched by addition of H_2O (1 mL) and diluted with EtOAc (5 mL). The organic phase was separated and the aqueous phase was washed with EtOAc (2 × 5 mL). The combined organic phases were washed with brine (10 mL), dried ($MgSO_4$), and concentrated to give a brown oil. Purification by flash chromatography (EtOAc:*n*-pentane, 5:95) afforded 0.08 g (56%) of **13** and 0.03 g (24%) of sulfinimine **10**.

Oxidation of (2*R*,3*S*)-7a to *trans*-(2*R*,3*S*)-(+)-*N*-(*p*-Toluenesulfonyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (14). Typical Procedure. In a 25 mL, single-necked, round-bottomed flask equipped with a magnetic stirring bar was placed 0.59 g (1.79 mmol) of (2*R*,3*S*)-(+)-**7a** in $CHCl_3$ (10 mL). *m*-Chloroperbenzoic acid (1.03 g, 3.59 mmol, 60%, Aldrich) was added to the reaction in small portions. The reaction mixture was stirred for 25 min and diluted with CH_2Cl_2 (10 mL). The organic phase was washed with saturated $Na_2S_2O_3$ (2 × 10 mL) and saturated $NaHCO_3$ (10 mL), dried ($MgSO_4$), and concentrated to give a crude product which was purified by flash chromatography (EtOAc/*n*-pentane, 20:80) to give 0.61 g (98%) of (2*R*,3*S*)-(+)-**14** as a colorless oil; $[\alpha]^{20}_D$ 44.14 (*c* 0.28, $CHCl_3$); IR (neat) cm^{-1} 2952, 1741, 1336, 1163; ^1H NMR ($CDCl_3$) δ 7.88 (d, 2H, J = 8.4 Hz), 7.35−7.26 (m, 5H), 7.18−7.17 (m, 2H), 4.94 (s, 1 H), 3.90 (s, 3H), 2.45 (s, 3H), 1.23 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 168.1, 144.2, 137.1, 132.2, 129.5, 128.3, 128.1, 127.3, 127.1, 53.9, 53.1, 50.1, 21.5, 15.4; HRMS calcd for $C_{18}H_{20}NO_4S$ (M + H) 346.1113, found 346.1113. Anal. Calcd for $C_{18}H_{19}NO_4S$: C, 62.61; H, 5.51; N, 4.06. Found: C, 62.59; H, 5.80; N, 3.70.

***cis*-(2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfonyl)-2-methyl-2-carbomethoxy-3-phenylaziridine (15):** eluant, EtOAc/hexanes (2:8); yield 0.05 g (95%); mp 105−106 °C; $[\alpha]^{20}_D$ 17.10 (*c* 1.05, $CHCl_3$); IR (neat) cm^{-1} 2952, 1752, 1735, 1331, 1091; ^1H NMR ($CDCl_3$) δ 7.93 (d, 2H, J = 6.7 Hz), 7.32 (d, 2H, J = 8.1 Hz), 7.22−7.18 (m, 3H), 7.11−7.07 (m, 2H), 4.11 (s, 1H), 3.41 (s, 3H), 2.43 (s, 3H), 2.11 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 167.4, 144.4, 137.2, 132.3, 129.6, 128.2, 128.1, 127.5, 126.8, 54.8, 52.4, 52.2, 21.6, 16.3; HRMS calcd for $C_{18}H_{20}NO_4S$ (M + H) 346.1113, found 346.1108. Anal. Calcd for $C_{18}H_{19}NO_4S$: C, 62.61; H, 5.51; N, 4.06. Found: C, 62.57; H, 5.54; N, 4.04.

***cis*-(2*S*,3*S*)-(−)-*N*-(*p*-Toluenesulfonyl)-2-carbomethoxy-3-methyl-3-phenylaziridine (16):** eluant, EtOAc/hexanes (2:8); yield 0.13 g (95%); mp 114−115 °C; $[\alpha]^{20}_D$ −9.54 (*c* 0.43, $CHCl_3$); IR (KBr) cm^{-1} 2961, 1758, 1328, 1158, 1091; ^1H NMR ($CDCl_3$) δ 8.01 (d, 2H, J = 8.4 Hz), 7.41−7.25 (m, 7H), 3.86 (s,

1H), 3.43 (s, 3H), 2.49 (s, 3H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 165.7, 144.5, 138.1, 137.1, 129.7, 128.4, 128.0, 127.5, 126.6, 56.8, 52.2, 49.8, 22.1, 21.7; HRMS calcd for $C_{18}H_{20}NO_4S$ (M + H) 346.1113, found 346.1113. Anal. Calcd for $C_{18}H_{19}NO_4S$: C, 62.61; H, 5.51. Found: C, 62.21; H, 5.53.

***cis*-(2*S*,3*S*)-(+)-*N*-(*p*-Toluenesulfonyl)-2-carbomethoxy-3-phenylaziridine (19):** eluant, EtOAc/*n*-pentane (2:8); yield 94%; mp 85−87 °C; $[\alpha]^{20}_D$ 18.2 (*c* 1.0, $CHCl_3$); IR (KBr) cm^{-1} 3033, 1757, 1598, 1334, 1210, 1164, 1092; ^{1}H NMR ($CDCl_3$) δ 7.92 (d, 2H, J = 8.3 Hz), 7.35 (d, 2H, J = 8.4 Hz), 7.32−7.20 (m, 5H), 4.12 (d, 1H, J = 7.6 Hz), 3.71 (d, 1H, J = 7.7 Hz), 3.49 (s, 3H), 2.44 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 164.5, 145.0, 133.8, 130.9, 129.7, 128.3, 128.0, 127.9, 127.2, 52.3, 45.3, 43.3, 21.6. Anal. Calcd for $C_{17}H_{17}NO_4S$: C, 61.61; H, 5.17. Found: C, 61,43; H, 5.17.

***trans*-(2S,3R)-(−)-*N*-(*p*-Toluenesulfonyl)-2-carbomethoxy-3-phenylaziridine (20):** eluant, EtOAc/*n*-pentane (2:8); yield 95%; mp 42−44 °C; [lit.[28] mp 44.2−44.6 °C]; $[\alpha]^{20}_D$ −29.4 (*c* 0.92, CH_2Cl_2); [lit.[28] $[\alpha]^{20}_D$ 33.1 (*c* 1.0, CH_2Cl_2) for the (2*R*,3*S*)-**20**.

Methyl (2*S*,3*S*)-(−)-2-*N*-(*p*-Toluenesulfonyl)amino-3-phenylbutyrate (17). In a 25 mL, single-necked, round-bottomed flask equipped with a magnetic stirring bar was placed 0.05 g (0.14 mmol) of (−)-**16** in ethanol (12 mL). Formic acid (2 mL) was added followed by Pd black (0.10 g, Aldrich). The solution was stirred at room temperature for 2 h, filtered through a short silica column, and concentrated to give a crude 87:13 ratio mixture of diastereomers. Flash chromatography (EtOAc/hexanes, 1:9) afforded 0.04 g (82%) of **17** as a white solid: mp 101−102 °C; $[\alpha]^{20}_D$ −35.2 (*c* 0.89, $CHCl_3$); IR (KBr) cm^{-1} 3458, 2980, 1740, 1344, 1166; ^{1}H NMR ($CDCl_3$) δ 7.66 (d, 2H, J = 8.4 Hz), 7.32−7.27 (m, 5H), 7.12−7.10 (m, 2H), 4.86 (d, 1H, J = 9.6 Hz), 4.08 (dd, 1H, J = 5.1 Hz, 9.9 Hz), 3.47 (s, 3H), 3.32−3.27 (m, 1H), 2.45 (s, 3H), 1.43 (d, 3H, J = 7.2 Hz); ^{13}C NMR ($CDCl_3$) δ 170.9, 143.6, 139.8, 136.4, 129.5, 128.6, 127.7, 127.5, 127.2, 61.0, 52.2, 42.2, 21.5, 17.6; HRMS calcd for $C_{18}H_{22}NO_4S$ (M + H) 348.1270, found 348.1272. Anal. Calcd for $C_{18}H_{21}NO_4S$: C, 62.25; H, 6.05; N, 4.03. Found: C, 61.95; H, 5.96; N, 3.98.

***erythro*-(2S,3S)-(−)-3-Methylphenylalanine (18).** In a 15 mL, single-necked, round-bottomed flask equipped with a magnetic stirring bar and a reflux condenser were placed 0.04 g (0.12 mmol) of (2*S*,3*S*)-(−)-**17**, 0.15 g (1.59 mmol) of phenol, and 5 mL of 48% HBr. The reaction mixture was refluxed at 100 °C for 1 h and then stirred at room temperature for 1 h. The solution was diluted with EtOAc (10 mL) and H_2O (15 mL). The aqueous phase was extracted with EtOAc (2 × 5 mL) and loaded into a distilled H_2O packed ion-exchange column (Dowex 50 × 8−100, H^+). The column was first washed with distilled H_2O (350 mL) until pH 6 and then with 1.5 M NH_4OH (200 mL). The NH_4OH fractions were collected. Removal of water gave a light brown solid which was dissolved in distilled H_2O (2 mL) and filtered through a cotton filter twice to remove insoluble impurities. The filtrate was concentrated to afford 0.016 g (78%) of **18**: mp 184−186 °C [lit.[30] mp 182−184 °C]; $[\alpha]^{20}_D$ −26.6 (*c* 0.35, H_2O), [lit.[30] $[\alpha]^{20}_D$ −26.7 (*c* 1.0, H_2O)]. Compound (2*S*,3*S*)-(−)-**18** has other physical and spectroscopic properties identical with reported values.[30]

Preparation of Methyl (2*S*,3*S*)-(+)-3-Phenyl-1*H*-aziridine-2-carboxylate (21a). Typical Procedure. In 25 mL, round-bottomed flask equipped with a magnetic stirring bar was placed 0.32 g (1.0 mmol) of aziridine (2*S*,3*S*)-**3a** in acetone/H_2O (1:1, 15 mL). Trifluoroacetic acid (0.4 mL, 5.2 mmol) was added dropwise. After 15 min, concentrated NH_4OH was added until the aqueous layer was brought to pH 10. The solution was concentrated, H_2O (7 mL) was added, and the pH was again adjusted to 10 with concentrated NH_4OH. The solution was extracted with CH_2Cl_2 (3 × 15 mL), and the organic extracts were washed with brine (20 mL), dried (Na_2SO_4), and concentrated. Flash chromatography (EtOAc/*n*-pentane, 3:7) gave 0.16 g (89%) of **21a** as a solid: mp 58 °C [lit.[29] mp 51−57 °C]; $[\alpha]^{20}_D$ 20.9 (*c* 1.98, EtOH) [lit.[29] $[\alpha]^{20}_D$ 22.2 (*c* 1.0, EtOH)]; ^{1}H NMR ($CDCl_3$) δ 7.32−7.26 (m, 5H), 3.52 (s, 3H), 3.50 (d, 1H, J = 6.4 Hz), 3.04 (d, 1H J = 6.3 Hz), 1.73 (bs, 1H); ^{13}C NMR ($CDCl_3$) δ 160.3, 134.7, 128.0, 127.6, 127.3, 52.0, 40.2, 37.2.

Methyl (2*S*,3*S*)-(+)-3-isopropyl-1*H*-aziridine-2-carboxylate (21h): eluant, EtOAc/hexanes (3:7); yield 85%; oil; $[\alpha]^{20}_D$ 50.2 (*c* 2.9, $CHCl_3$); IR (neat) cm^{-1} 3266, 2960, 1734, 1208; ^{1}H NMR ($CDCl_3$) δ 3.77 (s, 3H), 2.72 (d, 1H, J = 6.3 Hz), 2.02−1.96 (m, 1H), 1.52−1.42 (m, 2H), 1.11 (d, 3H, J = 6.6 Hz), 0.91 (d, 3H, J = 6.7 Hz); ^{13}C NMR ($CDCl_3$) δ 171.2, 52.2, 45.5, 34.7, 28.0, 21.1, 20.4. Anal. Calcd for $C_7H_{13}NO_2$: C, 58.72; H, 9.15. Found: C, 58.40; H, 8.86.

Methyl (2*S*,3*R*)- and (2*S*,3*S*)-2-Amino-3-hydroxy-3-(*p*-methoxyphenyl)propanoate (22). Using the standard conditions, aziridine (2*S*,3*S*)-**3b** gave a 68% yield of a 1:1 mixture of (2*S*,3*R*)- and (2*S*,3*S*)-**22**. The diastereomers were separated by preparative TLC (MeOH/CH_2Cl_2, 5:95).

Methyl (2*S*,3*R*)-(+)-2-amino-3-hydroxy-3-(*p*-methoxyphenyl)propanoate (22): yield 34%; oil; $[\alpha]^{20}_D$ 26.74 (*c* 2.3, $CHCl_3$); IR (neat) cm^{-1} 3367, 3303, 3032, 1737; ^{1}H NMR ($CDCl_3$) δ 7.24 (d, 2H, J = 8.6 Hz), 6.86 (d, 2H, J = 8.6 Hz), 4.72 (d, 1H, J = 5.3 Hz), 3.78 (s, 3H), 3.62 (s, 3H), 3.53 (d, 1H, J = 5.4 Hz); ^{13}C NMR ($CDCl_3$) δ 174.0, 159.1, 132.7, 127.2, 113.7, 73.8, 60.7, 55.2, 52.1. Anal. Calcd for $C_{11}H_{15}NO_4$: C, 58.66, H, 6.71, N, 6.22. Found C, 58.32, H, 6.57, N, 6.06.

Methyl (2*S*,3*S*)-(+)-2-amino-3-hydroxy-3-(*p*-methoxyphenyl)propanoate (22): yield 34%; mp 107 °C; $[\alpha]^{20}_D$ 18.54 (*c* 1.3, $CHCl_3$); IR (neat) cm^{-1} 3447, 3401, 3322, 3062, 1734; ^{1}H NMR ($CDCl_3$) δ 7.18 (d, 2H, J = 8.8 Hz), 6.85 (d, 2H, J = 8.8 Hz), 4.84 (d, 1H, J = 5.8 Hz), 3.78 (s, 3H), 3.75 (d, 1H, J = 5.8 Hz), 3.66 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 173.5, 159.2, 131.8, 127.4, 113.6, 73.9, 59.9, 55.1, 51.9.

Removal of the *N*-Sulfinyl Group Using MeMgBr. Typical Procedure. In a 25 mL, one-necked, round-bottomed flask fitted with an argon balloon and magnetic stirring bar was placed 0.07 g (0.21 mmol) of aziridine (2*S*,3*S*)-**3a** in THF (4.2 mL). The reaction mixture was cooled to −78 °C, and 0.14 mL (0.42 mmol, 3.0 M in Et_2O) of MeMgBr was added. The mixture was stirred for 30 min at −78 °C and quenched with H_2O (1 mL). The mixture was warmed to room temperature and diluted with EtOAc (50 mL), and the aqueous phase was extracted with EtOAc (2 × 5 mL). The combined organic phases were washed with brine (20 mL), dried ($MgSO_4$), and concentrated. The crude aziridine was purified by preparative TLC (EtOAc/*n*-pentane, 1:1) to afford 0.03 g (83%) of **21a** and 0.03 g (97%) of (*S*)-(−)-methyl *p*-tolyl sulfoxide (**23**) in >96% ee.

Methyl (2*S*,3*S*)-(+)-3-(*p*-Methoxyphenyl)-1*H*-aziridine-2-carboxylate (21b). Preparative TLC (EtOAc/*n*-pentane, 1:1): yield 71%; mp 56−57 °C; $[\alpha]^{20}_D$ 14.4 (*c* 0.93, $CHCl_3$); IR (KBr) cm^{-1} 3458, 3311, 1740; ^{1}H NMR ($CDCl_3$) δ 7.24 (bs, 2H), 6.83 (d, 2H, J = 8.8 Hz), 3.78 (s, 3H), 3.54 (s, 3H), 3.43 (bs, 1H), 2.98 (bs, 1H), 1.68 (bs, 1H); ^{13}C NMR ($CDCl_3$) δ 170.4, 159.8, 129.2, 127.5, 114.2, 55.9, 52.8, 40.8, 37.8; HRMS calcd for $C_{11}H_{13}NO_3$ (M + H) 207.0895, found 207.0889. Anal. Calcd for $C_{11}H_{13}NO_3$: C, 63.76; H, 6.32; N, 6.76. Found: C, 63.36; H, 6.09; N, 6.56.

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