# Simple Asymmetric Synthesis of 2*H*-Azirines Derived from Phosphine Oxides†

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The highly strained 2*H*-azirine ring systems, the smallest of the nitrogen-unsaturated heterocycles, represent a very important class of compounds because of not only their theoretical interest but also the high reactivity of this ring system toward nucleophilic and electrophilic reagents,[1] as well as their versatile thermal and photochemical behavior.[2,3] Each of the three bonds of the azirine ring can be cleaved, depending on the experimental conditions, and they can be used as key intermediates in the preparation of functionalized amino derivatives such as nonproteinogenic amino acids[1a,4a,b] and peptolides,[4c] as well as for the synthesis of substituted aziridines,[4d] indoles,[4e] bis-steroidal pyrazines,[4f] or bicyclic compounds.[4g] Optically active 2*H*-azirines with an asymmetric center in the azirine cycle, namely, azirinomycin[5a] (**Ia**, R = Me, R′ = H, Figure 1), isolated from *Streptomyces aureus*, and both (−)-(*R*)-[5b] and (+)-(*S*)-disydazirine,[5c] (**Ib**, R = (*E*)-$C_{13}H_{27}CH{=}CH$, R ′= Me, Figure 1) and (+)-(*S*)-antazirine[5c] (**Ic**, R = (*E*)-$Br_2C{=}CH(CH_2)_9CH{=}CH$, R′ = Me, Figure 1), isolated from the marine sponge *Dysidea fragilis*, are naturally occurring antibiotics. The configuration of the asymmetric center seems to play an important role in the biological activity of these compounds; whereas (−)-(*R*)-disydazirine is cytotoxic and inhibits the growth of Gram-negative bacteria,[5b] (+)-(*S*)-disydazirine enantiomer or (+)-(*S*)-antazirine are inactive against a standard panel of microorganisms.[5c] For this reason the development of new asymmetric syntheses of substituted 2-azirines is an important synthetic goal.

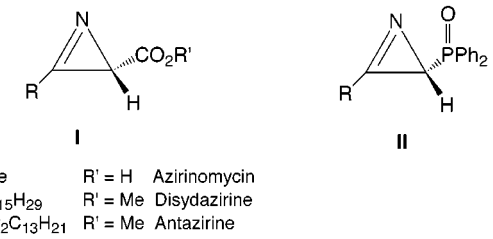


**Figure 1.** Biologically active 2*H*-azirines.

Substituted and functionalized azirines are excellent precursors to potential medicinal targets. In particular, 2*H*-azirines containing a carboxylic ester group[1] are excellent reagents for preparing functionalized aziridines[1,6] and α-[6b,7a−d] and *β*-amino acid derivatives.[6b,7e−g] Furthermore, phosphorus substituents regulate many important biological functions with molecular modifications influencing the biological activity.[8] For these reasons, functionalized azirines containing a phosphorus substituent in the 2-position (**II**, Figure 1) are potential isosteric analogues of **I** in the enantioselective synthesis of α- and *β*-aminophosphorus derivatives.

Many procedures for the synthesis of 2*H*-azirines involve the thermolysis or photolysis of vinyl azides,[1a,b,9a−c] the thermolysis of isoxazoles[9d] or oxazaphospholines,[9e] or the ring closure of nitrile ylides[9f] or employ the Neber reaction.[9g−i] However, 2*H*-azirines directly substituted with a phosphorus-containing functional group have received scarce attention. To the best of our knowledge, only the 2-phosphino-, 2-phosphonio-, and 2-thioxo-phos-

† Dedicated to Professor Dr. José Elguero on the occasion of his 65th birthday.

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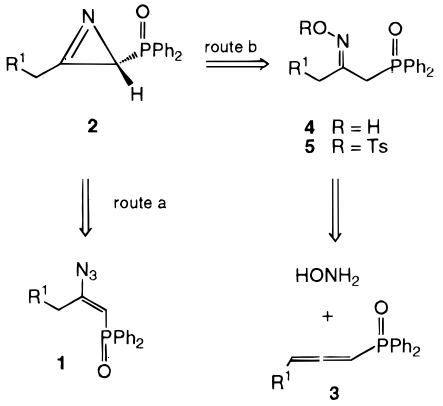
**Scheme 1. General Strategy for the Preparation of 2*H*-Azirines**

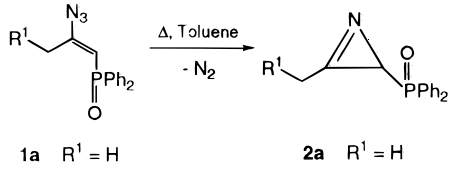



phoranyl-2-silyl-2*H*-azirines[10a,b] and 2-(diethoxyphosphoryl)-2*H*-azirines[10c] with a phenyl group in the 2-position have been described.

We are interested in the design of new 2*H*-azirine derivatives bearing a phosphorus-containing group in the 2-position of the heterocyclic system. In this context, we have used functionalized vinyl azides in the synthesis of azadienes[11a,b] and *β*-functionalized phosphorus derivatives in the preparation of phosphorylated nitrogen heterocycles[11c,d] and unsaturated oximes.[11e] Continuing with our interest in the synthesis of new phosphorus-substituted heterocycles, we here report an easy and high yielding synthesis of 2-phosphinoyl-2*H*-azirines **2** from 1-phosphinoylvinyl azides **1** (Scheme 1, route a) and the synthesis of 2*H*-azirines **2** from easily available tosyloximes containing a phosphine oxide **5** (R = Ts, Scheme 1, route b). The required oximes **4** (R = H, Scheme 1) can be prepared by addition of hydroxylamine[11e] to allenes **3**. Subsequent tosylation gives *β*-phosphorylated tosyloximes **5**. Enantiomerically enriched 2-alkoxycarbonyl-2*H*-azirines were previously prepared from chiral *N*-substituted aziridine 2-carboxylic esters,[12a,b] by using the Neber reaction.[12c,d] Nevertheless, the asymmetric preparation and synthetic use of 2*H*-azirines with a phosphine oxide group have not, to the best of our knowledge, been studied.

2-Phosphinoyl-2*H*-azirine **2a** ($R^1$ = H) was generated in good yield by refluxing a toluene solution of functionalized vinyl azide **1a** ($R^1$ = H).[11b] This process involved nitrogen loss from the vinyl azide **1a** followed by ring closure to give exclusively 3-phosphorylated 2*H*-azirines derived from phosphine oxide **2a** ($R^1$ = H) in good yields in a regioselective fashion (Scheme 2). Spectroscopic data were in agreement with the assigned structure of compound **2**.

**Scheme 2. 2*H*-Azirine Formation through Reaction of Vinyl Azide 1**




**Scheme 3. 2*H*-Azirine Formation through Modified Neber Reaction of Tosyl Ketoximes 5**

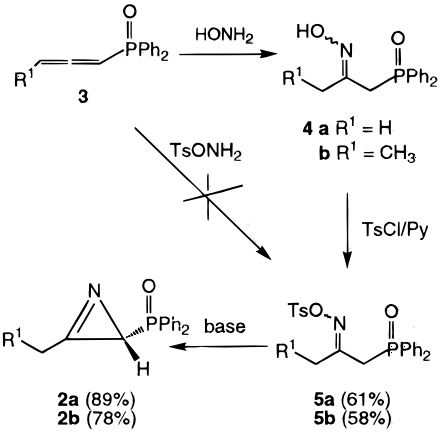



**Table 1. Nonracemic Azirines 2**

| entry | compound | base | yield (%) | ee (%)[a] | $[\alpha]^{22}_D$ (deg)[b] |
|---|---|---|---|---|---|
| 1 | **2a** | quinidine | 96 | 82 (*R*) | −17.41 |
| 2 | **2a** | hydroquinidine | 94 | 24 (*R*) | −4.98 |
| 3 | **2b** | quinidine | 95 | 30 (*R*) | −4.98 |

[a] Determined by $^{31}$P NMR using Yb(tfc)$_3$ as chiral shift reagent. [b] Determined using concentration $c$ = 0.75 in $CH_2Cl_2$.

The thermolysis of vinyl azides is not suited for the preparation of single enantiomers of azirines. For this reason, the modified Neber reaction of the tosyl ketoximes **5a** was investigalted. The C-1 methylene protons in these substrates are doubly activated, and therefore the use of a mild base could be sufficient for the formation of the azirine. The preparation of *β*-tosyloximes **5** by the addition of tosyl hydroxylamine to allenes **3** ($R^1$ = H, $CH_3$) was not successful, but the desired *β*-tosyloximes **5** were conveniently obtained by the addition of hydroxylamine to allenyl-phosphine oxides **3**.[11e] Subsequent reaction of functionalized *β*-oximes **4** with tosyl chloride in pyridine led to the formation of *β*-tosyloximes **5** (Scheme 3). Compounds **5** were isolated as a mixture of the (*Z*)- and (*E*)-oximes **5**.

2*H*-Azirines **2** were prepared from *β*-ketoximes **5** by treatment with triethylamine at room temperature for 1 h in benzene (Scheme 3). This process can be used for the asymmetric synthesis of 2*H*-azirine **2** by employing hydroquinidine or quinidine bases,[12d] with the best results being obtained with quinidine in benzene (Scheme 3, Table 1, entries 1−3). The enantiopurity[13] of azirines derived from phosphine oxide **2** (ee 24−82%) was determined by $^{31}$P NMR measurements in $CDCl_3$ using a chiral shift reagent (Yb(tfc)$_3$). The absolute configuration of the azirines **2** was established by reduction to aziridines and

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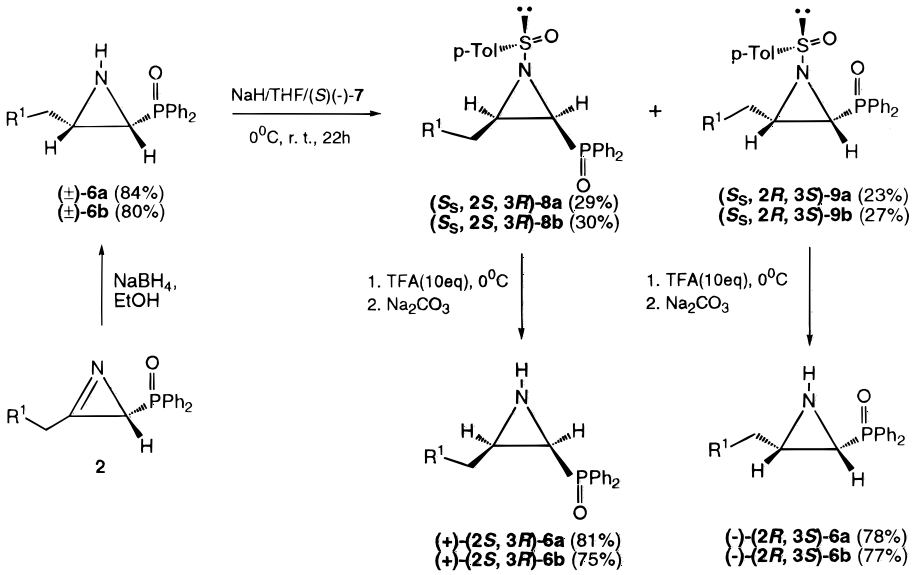
(13) Further studies using other chiral bases and varying the experimental conditions are now in progress in our laboratories to improve the enantiopurity of azirines.

**Scheme 4. Formation of Enantiopure Aziridines 6, 8, and 9**




formation of the enantiopure *cis*-*N*-(*p*-toluenesulfinyl)-aziridine-2-phosphine oxides **8** and **9** and *N*-unsubstituted aziridines **6**.

Reduction of azirines **2** with sodium borohydride in ethanol led exclusively to the formation of the previously unknown *cis*-aziridines **6**. The stereochemical assignment was based on the large ring proton coupling constant observed for **6a** ($^3J_{HH}$ = 6.9 Hz), while in the case of *trans* isomers a lower coupling constant has been reported ($^3J_{HH}$ = 2.3−4.0 Hz).[7d,14] Furthermore, no trace of the *trans*-aziridine could be observed by $^{31}$P NMR,[4a,12d] and no loss of chirality was observed.

Enantiopure (+)-(*S*s,2*S*,3*R*)- and (+)-(*S*s,2*R*,3*S*)-*cis*-*N*-sulfinyl aziridines **8a** and **9a**, respectively, were prepared by treatment of (−)-(*S*)-menthyl *p*-toluenesulfinate **7**[15] with aziridine **6** in THF at 0 °C in the presence of sodium hydride (Scheme 4). The products were isolated by flash chromatography, and new aziridines (+)-(*S*s,2*S*,3*R*)-**8a** and (+)-(*S*s,2*R*,3*S*)-**9a** were obtained. Similarly, aziridines (−)-(*S*s,2*S*,3*R*)-**8b** and (−)-(*S*s,2*R*,3*S*)-**9b** were prepared (Scheme 4). *N*-Sulfinyl aziridines **8** and **9** were treated separately with trifluoroacetic acid at 0 °C for 2 h to afford (+)- and (−)-aziridines **6**, respectively, (Scheme 4) with retention of the configuration.[16] The chirality at the 2-position in (+)-**8a** was established as (*S*) by single-crystal X-ray analysis. The corresponding ORTEP drawing with the appropriate atom numbering is available in Supporting Information. In the conversion of (+)-**2a** to (+)-**6a** and (+)-**8a** the bonds around the chiral carbon are not broken, so it is possible to assign the (*S*) configuration to the minor enantiomer (+)-**2a** and the (*R*) configuration to the major enantiomer (−)-**2a**, as well as the (2*R*,3*S*) configuration for the aziridine (−)-**6a**.

In conclusion, we have devised a simple, mild, and convenient strategy for the asymmetric synthesis of 2*H*-azirines **2**, as well as of enantiopure aziridines **6**, **8**, and **9** substituted with a phosphine oxide group in the 2-position, from available starting materials. These heterocycles may be very useful intermediates in organic synthesis[1,4] and for the preparation of a large variety of molecules that could be useful in the synthesis of biologically active compounds.[1,4−7]

## Experimental Section

See reference 11e for general experimental methods. Vinyl azide **1a**,[11b] allenes **3**,[17] oximes **4**,[11e] and (−)-(*S*)-menthyl-*p*-toluenesulfinate **7**[15] were synthesized according to literature procedures.

**Preparation of 2-Diphenylphosphoryl-3-methyl-1-azirine (2a) from Vinyl Azide (1a). Route a:** A solution of (2-azido-1-propenyl)diphenylphosphine oxide **1a** (5 mmol) in toluene (10 mL) was stirred at reflux for 1 h. When the nitrogen loss stopped the solvent was evaporated under reduced pressure. The residue was precipitated with diethyl ether and crystallized from hexane/AcOEt to yield 1.15 g (90%) of **2a** as a white solid: mp 97−98 °C; $^1$H NMR (300 MHz, $CDCl_3$) $\delta$ 7.88−7.36 (m, 10H), 2.38 (s, 3H), 2.18 (d, $^2J_{PH}$ = 36.5 Hz, 1H); $^{13}$C NMR (75 MHz, $CDCl_3$) $\delta$ 163.1 (d, $^3J_{PC}$ = 3.5 Hz), 133.1−128.3 (m), 27.2 (d, $^1J_{PC}$ = 111.8 Hz), 13.9 (d, $^3J_{PC}$ = 1.5 Hz); $^{31}$P NMR (120 MHz, $CDCl_3$) $\delta$ 29.8; IR (KBr) 3062, 1442, 1192; MS (EI) *m*/*z* 255 ($M^+$, 63), 201 ($POPh_2^+$, 36). Anal. Calcd for $C_{15}H_{14}NOP$: C, 70.58; H, 5.53; N, 5.49. Found: C, 70.35; H, 5.51; N, 5.51.

**General Procedure for the Preparation of (*Z*)- and (*E*)-2-(*N*-*p*-Toluenesulfonyloximino)alkyldiphenylphosphine Oxide (5).** To a 0 °C solution of (*Z*)- and (*E*)-2-(*N*-hydroximino)alkyldiphenylphosphine oxide **4** (5 mmol) in pyridine (2.4 mL) was added tosyl chloride (1.05 g, 5.5 mmol, freshly recrystallized from hexane) in portions. Then, the mixture was allowed to warm to room temperature, and the reaction mixture was stirred for 3 h. A portion of ice water was added with continued stirring, and a white precipitate was formed rapidly. This was collected by suction filtration, washed with cold water and ethyl ether, and dried under reduced pressure. The products were crystallized from hexane/AcOEt to yield **5**.

***(Z)*- and *(E)*-2-(*N*-*p*-Toluenesulfonyloximino)propyldiphenylphosphine Oxide (5a).** As described in the general procedure, 1.30 g (61%) of **5a** was obtained as a white solid from (*Z*)- and (*E*)-2-(*N*-hydroximino)propyldiphenylphosphine oxide **4a** (1.37 g, 5 mmol): $^1$H NMR (300 MHz, $CDCl_3$) $\delta$ 7.78−7.21 (m, 28H) for *Z* and *E* isomers, 3.53 (d, $^2J_{PH}$ = 15.0 Hz, 2H) for *Z* isomer, 3.29 (d, $^2J_{PH}$ = 14.1 Hz, 2H) for *E* isomer, 2.44 (s, 3H)

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for *E* isomer, 2.40 (s, 3H) for *Z* isomer, 2.11 (d, $^4J_{PH}$ = 1.8 Hz, 3H) for *Z* isomer, 2.08 (d, $^4J_{PH}$ = 1.8 Hz, 3H) for *E* isomer; $^{13}$C NMR (75 MHz, $CDCl_3$) $\delta$ 161.8 (d, $^2J_{PC}$ = 6.3 Hz) for *E* isomer, 159.3 (d, $^2J_{PC}$ = 6.3 Hz) for *Z* isomer, 144.8 for *Z* isomer, 144.7 for *E* isomer, 132.3−128.5 (m) for *Z* and *E* isomers, 37.8 (d, $^1J_{PC}$ = 63.3 Hz) for *E* isomer, 33.7 (d, $^1J_{PC}$ = 64.7 Hz) for Z isomer, 21.6 for *Z* and *E* isomer, 17.2 for *Z* and *E* isomers; $^{31}$P NMR (120 MHz, $CDCl_3$) $\delta$ 27.6 and 26.7 for *E* and *Z* isomers; IR (KBr) 3040, 1593, 1434, 1363, 1190; MS (APCI) *m*/*z* 428 ($M^+$ + 1, 46), 256 ($M^+$ − TsO, 100), 201 ($POPh_2^+$, 19). Anal. Calcd for $C_{22}H_{22}NO_4PS$: C, 61.82; H, 5.19; N, 3.28; S, 7.50. Found: C, 61.95; H, 5.17; N, 3.29; S, 7.45.

**General Procedure for the Preparation of 2-Diphenylphosphoryl-3-alkyl-1-azirine (2). Route b:** To a 0−5 °C solution of (*E*)- and (*Z*)-2-(*N*-*p*-toluenesulfonyloximino)alkyldiphenylphosphine oxide **5** (5 mmol) in benzene was added the corresponding base (5.5 mmol) slowly. Then, the mixture was allowed to warm to room temperature, and the reaction mixture was stirred for 1−2 h. The solution was diluted with $CH_2Cl_2$ and washed with 2 N hydrochloric acid and water. The organic layer was dried with anhydrous magnesium sulfate and filtered, and the solvent was evaporated under reduced pressure. The oil was precipitated with diethyl ether and crystallized from hexane/AcOEt to yield **2**. The base was recovered with 2 N sodium hydroxide solution.

**2-Diphenylphosphoryl-3-methyl-1-azirine (2a).** As described in the general procedure 1.13 g (89%) of **2a** was obtained as a white solid from (*E*)- and (*Z*)-2-(*N*−*p*-toluenesulfonyloximino)propyldiphenylphosphine oxide **5a** (2.14 g, 5 mmol), using triethylamine as a base. For spectroscopic data see above.

**Asymmetric Synthesis of (−)-(*R*)-2-Diphenylphosphoryl-3-methyl-1-azirine (2a).** (A) As described in the general procedure, 1.22 g (96%) was obtained as a white solid from (*E*)- and (*Z*)-2-(*N*-*p*-toluenesulfonyloximino) propyldiphenylphosphine oxide **5a** (2.14 g, 5 mmol) and using quinidine as a base: ee 82%; $[\alpha]^{22}_D$ −17.41 (*c* 0.75, $CH_2Cl_2$). For spectroscopical data see compound **(±)-2a**. (B) As described in the general procedure, 1.20 g (94%) was obtained as a white solid from (*E*)- and (*Z*)-2-(*N*-*p*-toluenesulfonyloximino)propyldiphenylphosphine oxide **5a** (2.14 g, 5 mmol), using hydroquinidine as a base: ee 24%; $[\alpha]^{22}_D$ −4.98 (*c* 0.75, $CH_2Cl_2$). For spectroscopical data see compound **(±)-2a**.

**General Procedure for the Preparation of (±)-*cis*-3-Alkyl-2-diphenylphosphorylaziridine (6).** To a 0 °C solution of the corresponding 3-alkyl-2-diphenylphosphoryl-1-azirine **2** (5 mmol) in ethanol (15 mL) was added sodium borohydride (0.57 g, 15 mmol) in portions. Then, the mixture was allowed to warm to room temperature, and the reaction mixture was stirred for 2 h. The solution was diluted with $CH_2Cl_2$ and washed with water. The organic layer was dried with anhydrous magnesium sulfate and filtered, and the solvents were evaporated under reduced pressure. The solid residue was washed with ethyl ether and crystallized from hexane/$CH_2Cl_2$ to yield **6** as a white solid.

**(±)-*cis*-2-Diphenylphosphoryl-3-methylaziridine (6a).** As described in the general procedure, 1.09 g (85%) was obtained as a white solid from 2-diphenylphosphoryl-3-methyl-1-azirine **2a** (1.28 g, 5 mmol): mp 161−162 °C; $^1$H NMR (300 MHz, $CDCl_3$) $\delta$ 7.77−7.37 (m, 10H), 2.32 (m, 1H), 2.19 (ddd, $^2J_{PH}$ = 23.1 Hz, $^3J_{HH}$ = 6.6 Hz, $^3J_{HH}$ = 6.9 Hz, 1H), 1.95 (s, 1H), 1.41 (d, $^3J_{HH}$ = 5.7 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) $\delta$ 132.1−128.5 (m), 32.8 (d, $^1J_{PC}$ = 102.7 Hz), 30.8, 14.5; $^{31}$P NMR (120 MHz, $CDCl_3$) $\delta$ 28.4; IR (KBr) 3204, 3065, 1443, 1188; MS (EI) *m*/*z* 257 ($M^+$, 9), 242 ($M^+$ − $CH_3$, 18), 201 ($POPh_2^+$, 100). Anal. Calcd for $C_{15}H_{16}NOP$: C, 70.03; H, 6.27; N, 5.44. Found: C, 69.92; H, 6.25; N, 5.43.

**(−)-(2*R*,3*S*)-*cis*-2-Diphenylphosphoryl-3-methylaziridine (6a).** As described in the general procedure, 1.08 g (84%) was obtained as a white solid from (−)-(*R*)-2-diphenylphosphoryl-3-methyl-1-azirine **2a** (1.28 g, 5 mmol, ee 82%): ee 82%; $[\alpha]^{22}_D$ −1.14 (*c* 0.61, $CH_2Cl_2$). For spectroscopical data see compound **(±)-6a**.

**General Procedure for the Preparation of (*S*s,2*S*,3*R*)- and (*S*s,2*R*,3*S*)-*cis*-3-Alkyl-2-diphenylphosphoryl-*N*-*p*-toluenesulfinylaziridine (8) and (9).** To a 0 °C suspension of sodium hydride (0.14 g, 6 mmol) in THF (25 mL) was added the corresponding (±)-*cis*-3-alkyl-2-diphenylphosphorylaziridine **6** (5 mmol) in portions. Then, the mixture was allowed to warm to room temperature, and the reaction mixture was stirred for 1 h. The solution was cooled to 0 °C and, then (−)-(*S*)-menthyl-*p*-toluenesulfinate **7** (0.21 g, 7.5 mmol) was added in portions. The mixture was allowed to warm to room temperature, the reaction mixture was stirred for 22 h, methanol was added, and the solvents were evaporated. The residue was diluted with $CH_2Cl_2$ and washed with water. The organic layer was dried with anhydrous magnesium sulfate and filtered, and the solvent was evaporated under reduced pressure, affording a mixture of diastereoisomers **8** and **9** (3:2 ratio). The mixture was separated and purified by flash chromatography eluting with 1:2 AcOEt/hexane and crystallized from hexane/$CH_2Cl_2$.

**(+)-(*S*s,2*S*,3*R*)-*cis*-2-Diphenylphosphoryl-3-methyl-*N*-*p*-toluenesulfinylaziridine (8a) and (+)-(*S*s,2*R*,3*S*)-*cis*-2-Diphenylphosphoryl-3-methyl-*N*-*p*-toluensulfinylaziridine (9a).** As described in the general procedure, **8a** and **9a** were obtained from (±)-*cis*-2-diphenylphosphoryl-3-methylaziridine **6a** (1.29 g, 5 mmol). Data for **8a**: 0.57 g (29%) as a white solid; mp 129−130 °C; $[\alpha]^{22}_D$ +1.45 (*c* 0.55, $CH_2Cl_2$); $^1$H NMR (300 MHz, $CDCl_3$) $\delta$ 7.65−6.87 (m, 14H), 3.05 (dd, $^2J_{PH}$ = 23.2 Hz, $^3J_{HH}$ = 7.2 Hz, 1H), 2.84 (ddd, $^3J_{PH}$ = 6.0 Hz, $^3J_{HH}$ = 5.8 Hz, $^3J_{HH}$ = 7.2 Hz, 1H), 2.23 (s, 3H), 1.57 (d, $^3J_{HH}$ = 5.8 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) $\delta$ 141.5, 140.7, 132.0−124.8 (m), 35.9 (d, $^2J_{PC}$ = 4.0 Hz), 29.1 (d, $^1J_{PC}$ = 102.7 Hz), 21.4, 13.4; $^{31}$P NMR (120 MHz, $CDCl_3$) $\delta$ 24.0; IR (KBr) 3051, 1440, 1208; MS (APCI) *m*/*z* 396 ($M^+$ + 1, 18), 256 ($M^+$ − $CH_3PhSO$, 60), 201 ($POPh_2^+$, 36). Anal. Calcd for $C_{22}H_{22}NO_2PS$: C, 66.82; H, 5.61; N, 3.54; S, 8.11. Found: C, 66.97; H, 5.62; N, 3.55; S, 8.01. Data for **9a**: 0.45 g (23%) as a white solid; mp 112−113 °C; $[\alpha]^{22}_D$ +1.59 (*c* 0.50, $CH_2Cl_2$); $^1$H NMR (300 MHz, $CDCl_3$) $\delta$ 7.75−7.23 (m, 14H), 2.75 (m, 2 H), 2.34 (s, 3H), 1.20 (d, $^3J_{HH}$ = 5.8 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) $\delta$ 142.1, 141.1, 133.5−124.9 (m), 35.2 (d, $^1J_{PC}$ = 103.8 Hz), 30.8 (d, $^2J_{PC}$ = 4.5 Hz), 21.4, 12.9; $^{31}$P NMR (120 MHz, $CDCl_3$) $\delta$ 24.7; IR (KBr) 3051, 1433, 1202; MS (APCI) *m*/*z* 396 ($M^+$ + 1, 81), 256 ($M^+$ − $CH_3PhSO$, 68), 201 ($POPh_2^+$, 29). Anal. Calcd for $C_{22}H_{22}NO_2PS$: C, 66.82; H, 5.61; N, 3.54; S, 8.11. Found: C, 66.91; H, 5.60; N, 3.54; S, 7.99.

**General Procedure for the Synthesis of (+)-(2*S*,3*R*)- and (−)-(2*R*,3*S*)-*cis*-3-Alkyl-2-diphenylphosphorylaziridines (6).** To *N*-sulfinylaziridines **8** or **9** (5 mmol) at 0 °C was added trifluoroacetic acid (3.9 mL, 50 mmol), and the mixture was stirred for 2 h at this temperature. The residue was dissolved in $CH_2Cl_2$ and washed with six portions of a saturated solution of sodium carbonate. The organic layer was dried with anhydrous magnesium sulfate and filtered, and the solvent was evaporated under reduced pressure. The solid residue was washed with diethyl ether and crystallized in hexane/$CH_2Cl_2$, affording **6** as a white solid.

**(+)-(2*S*, 3*R*)-*cis*-2-Diphenylphosphoryl-3-methylaziridine (6a).** As described in the general procedure, 1.04 g (81%) was obtained as a white solid from (+)-(*S*s,2*S*,3*R*)-*cis*-2-diphenylphosphoryl-3-methyl-*N*-*p*-toluenesulfinylaziridine **8a** (1.98 g, 5 mmol): $[\alpha]^{22}_D$ +1.40 (*c* 0.50, $CH_2Cl_2$). For spectroscopical data see compound **(±)-6a**.

**X-ray Crystallography.** Single-crystal X-ray diffraction experiments were carried out on a STOE IPDS diffractometer using graphite-monochromated Mo Ka radiation ($\lambda$ = 0.7173 Å). A prismatic crystal of dimensions 0.31 mm × 0.20 mm × 0.15 mm was used for data collection. Crystal data: monoclinic, space group $P2_1/n$, $a$ = 14.263(5), $b$ = 8.366(2), $c$ = 17.032(3) Å, $\beta$ = 95.19(3)°, $V$ = 2024.0(9) Å$^3$, $D_{calcd}$ = 1.298 g cm$^{-3}$. Data collection was performed at 293 K, with $2\theta_{max}$ = 52°. Intensities were measured on a image plate with oscillating crystal geometry. The total number of measured reflections was 13 913, of which 3921 were independent. The criterion for observed reflections was $I > 2\sigma(I)$. Lorentzian polarization correction was applied using STOE software[18] but no absorption correction ($\mu$ = 0.256 mm$^{-1}$). The structure was solved by direct methods, using SIR97 program.[19] It was refined by full-matrix least-squares against $|F|^2$, and all reflections were considered (SHELXL-97 software).[20] The total number of parameters was 245, and all H atoms were

(18) STOE IPDS Software; STOE: Darmstadt, Germany, 1998.

(19) Altomare, A.; Cascarano, G.; Giacovazzo, C.; Guagliardi, A.; Molitemi, A. G. G.; Burla, M. C.; Polidori, G.; Camalli, M.; Spagna, R. SIR97; Universities of Bari, Perugia and Roma: Italy, 1997.

(20) Sheldrick, G. M. *SHELXL-97*; University of Göttingen, Germany, 1997.

generated using geometrical criteria and refined isotropically. Final values for R-indices: $R_w$(all) = 0.1252, $R_w$(obs) = 0.0921, $R$(all) = 0.1093 and $R$(obs) = 0.0395. Residual electron density: min = −0.192 and max = 0.182. Crystallographic data (excluding structure factors) for the structure reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-132458. Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, U.K. (fax: (+44) 1223-336-033; e-mail: deposit@ccdc.cam.ac.uk).

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**Supporting Information Available:** Preparation, analysis, and spectral data ($^1$H, $^{13}$C, and $^{31}$P NMR, IR, and MS) for compounds **5b**, **2b**, **(−)-2b**, **(−)-6a**, **(±)-6b**, **(−)-6b**, **(+)-6b**, **(−)-8b**, and **(−)-9b**, suplementary tables, and ORTEP drawing and X-ray crystallography data for **8a**. This material is available free of charge via the Internet at http://pubs.acs.org.

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