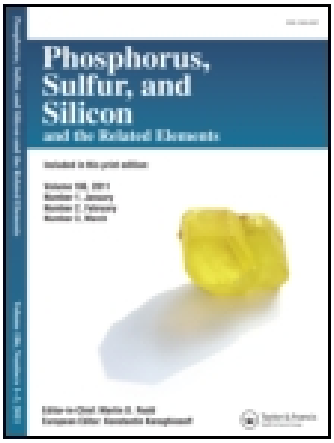

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Preparation of Optically Active 4-Aminopyrrolidines by Radical Addition/Cyclization to Chiral N-(2-(Methoxyimino)Ethyl)-β-Amino-α-Methylene Esters

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PREPARATION OF OPTICALLY ACTIVE 4-AMINOPYRROLIDINES BY RADICAL ADDITION/CYCLIZATION TO CHIRAL *N*-(2-(METHOXYIMINO)ETHYL)-β-AMINO-α-METHYLENE ESTERS

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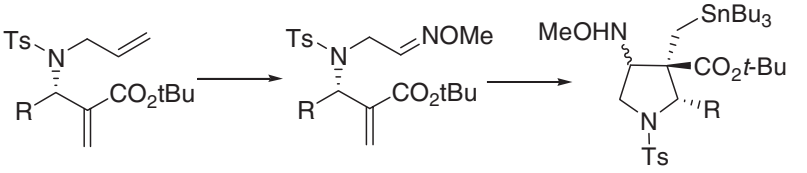
GRAPHICAL ABSTRACT



Abstract *Optically active 4-aminopyrolidines were prepared by radical cyclization induced by addition of tin radical to N-(2-(methoxyimino)ethyl)-β-amino-α-methylene esters, which were readily prepared by Michael/aldol domino reaction to chiral sulfinimines.*

Keywords Radical cyclization; radical addition; 4-aminopyrroidine

INTRODUCTION

Radical cyclization is a good reaction for constructing carbo- or heterocyclic compounds, and frequently used in organic synthesis.[1] Among many known generation of radicals, tin radical chemistry is recognized the most useful methodology and widely applied for synthetic reactions. Tin radical is usually generated by thermal treatment with tin hydride in the presence of radical initiator such as AIBN. Bu_3SnH is usually the first choice of tin hydride reagent because it is readily available and the radical process with it is highly efficient. The three butyl groups on tin atom are normally inert in the reaction. However, we have recently found the reaction in which one of the butyl group was kicked out by S_H2

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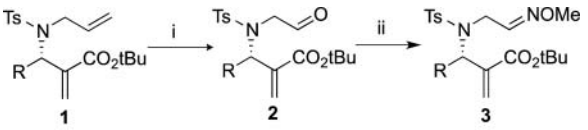
process[2] by vinyl radical and butyl radical and stannacyclopentane were generated in high yields.[3] This is a very new process and we were interested in the extension of the reaction with other radical accepter such as oxime ethers,[4] which were expected to give bicyclic stannapyrrolidines containing tin-nitrogen bond. In this article, we report that optically active *N*-(2-(methoxyimino)ethyl)-β-amino-α-methylene esters[5] underwent simple radical addition/cyclization to give chiral 4-aminopyrrolidines in good yield.

RESULTS AND DISCUSSION

The precursor of the radical cyclization was prepared by treatment of *N*-allyl-β-amino-α-methylene ester **1** under oxidative conditions followed by oxime formation. The results are summarized in Scheme 1.

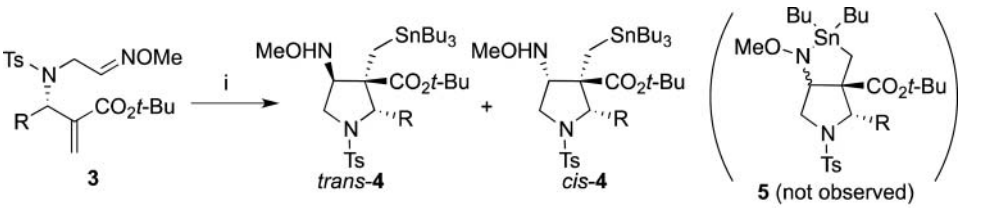


3a, R = p-Tol, 70%; **3b**, R = Ph, 68%; **3c**, R = p-ClC$_6$H$_4$, 62%; **3d**, p-MeOC$_6$H$_4$, 30%; **3e**, o-Tol, 62%; **3f**, 2-naphthyl, 61%; **3g**, 2-thienyl, 29%; **3h**, R = Pr, 47%.

Scheme 1 *Reagents and conditions: i, OsO_4, 2,6-lutidine,$NaIO_4$, dioxane/Water (3:1), r.t.; ii, $NH_2OMe.HCl$, NaOAc, MeOH, r.t.*

For example, compound **1a** underwent oxidation at the *N*-allylic unit that firstly afforded corresponding diol, which then gave aldehyde **2a** through carbon–carbon bond cleavage by the presence of $NaIO_4$. During the oxidation with OsO_4 took place chemselectively and the α, β-unsaturated alkene unit survived under these conditions. Exposure of **2a** to hydroxylamine methyl ether resulted in desired formation of oxime ether smoothly and cyclization precursor **3a** was isolated in 70% yield in two steps.

With desired precursors **3** in hand, we examined radical addition/cyclization for these compounds by treatment with Bu_3SnH. The results are summarized in Scheme 2.



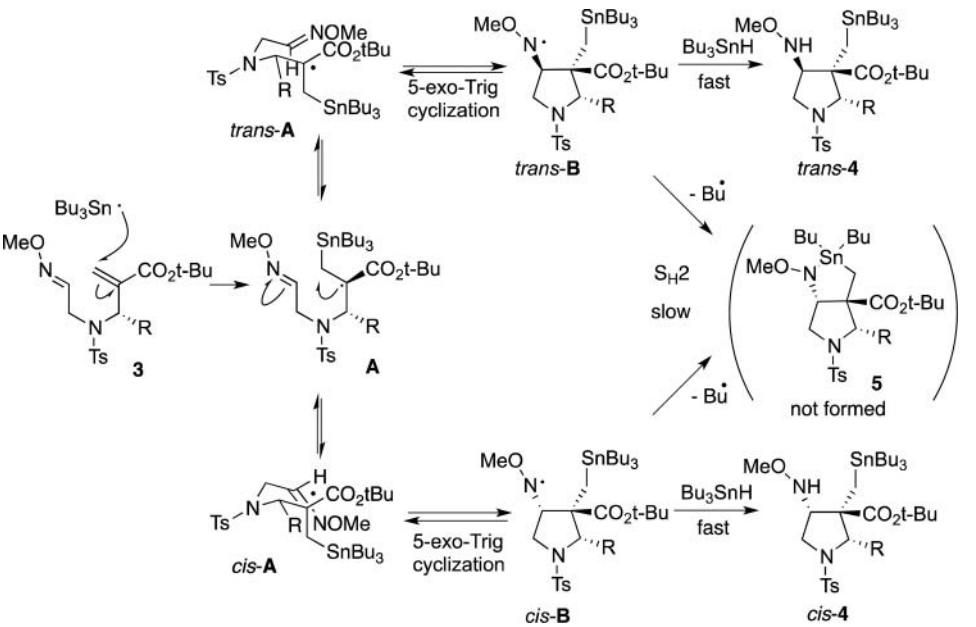
4a, R = p-Tol, 76%, *trans/cis* = 64/36 (95%ee)
4b, R = Ph, 81%, *trans/cis* = 67/33
4c, R = R = p-ClC$_6$H$_4$, 68%, *trans/cis* = 64/36 (89%ee)
4d, R = p-MeOC$_6$H$_4$, 56%, *trans/cis* = 65/35 (99%ee)
4e, R = o-Tol, 66%, *trans/cis* = 65/35 (95%ee)
4f, R = 2-naphthyl, 84%, *trans/cis* = 63/37
4g, R = 2-thienyl, 76%, *trans/cis* = 57/43 (94%ee)
4h, R = Pr, 73%, *diasteromeric ratio* 23/77

Scheme 2 *Reagents and conditions: i, Bu_3SnH, Et_3B, toluene, r.t.*

Tin radical was generated by Et_3B in the presence of air. The reaction took place smoothly and the precursor **3** was consumed smoothly. For example, precursor **3a** disappeared within 2 h and two diastereomers of **4a** was produced. ^1H NMR spectrum for compound **4a** revealed that both isomers of **4a** contained Bu_3Sn unit. The terminal methyl groups derived from Bu_3Sn radical were observed as a single triplet. This observation suggested that the butyl groups attaching to tin atom was chemically equivalent. Thus, the formation of **5** did not happen during the reaction although we expected to obtain bicyclic azastannolane **5** during the reaction. The S_H2 substitution on tin atom by aminyl radical did not takes place from the reaction of **3**.

The structure of compound **4** was unambiguously determined by X-ray crystallographic analyses.[6] For example, the two diastereomers of compound **4e** was separated by careful flash chromatography and these isomers were isolated as solid products. X-ray crystallographic analyses for both compounds revealed *trans* structure for major **4e** and *cis* structure for minor **4e**. It was interesting that the both isomer had the same configuration at the quaternary center and the difference was the configuration at methoxyamino carbon. Other derivatives for compounds **4** showed a similar pattern in NMR so all configurations of the two isomers of **4** were determined.

Although the expected S_H2 process to give compound **5** did not occur from the precursor **3**, we assumed the reaction mechanism as shown in Scheme 3.



Scheme 3

Compound **3** underwent radical addition by Bu_3Sn radical to give intermediate **A**, which contained the two conformational state, *trans*-**A** and *cis*-**A**. The difference of them is conformation of the oxime ether unit, which occupies pseudoequatorial position in *trans*-**A** and pseudoaxial position in *cis*-**A**. It should be noted that the favorable conformation at radical center was always the same and the ester group occupies pseudoequatorial position, because both isomers of **4** have the same configuration at the quaternary carbon as mentioned

before. The radical in intermediate **A** attacks the oxime ether unit in a 5-exo-trig manner to give intermediate *trans*-**B** and *cis*-**B**. If the resulting aminyl radical attack the tin atom, desired S_H2 reaction occurs and bicyclic azastannolane **5** should be formed. However, this process never occurs. Instead, simple hydrogen abstraction from Bu_3SnH dominates and *trans*-**4** and *cis*-**4** were produced exclusively. One reason why no S_H2 process happens is hydrogen abstraction from intermediate **B** should be much faster than the S_H2 process. Also, geometry of aminyl radical in *trans*-**B** and *cis*-**B** should be important; the radical center should be too far from the tin atom to progress efficient S_H2 process. Unfortunately, *cis*/*trans* selectivity for the formation of **4** was in a moderate level. This is probably due to energy differences between intermediates *cis*-**A** and *trans*-**A** are close and probably the stereoselectivity just reflected the conformational ratio for these two intermediates.

CONCLUSION

Radical treatment of *N*-(2-(methoxyimino)ethyl)-β-amino-α-methylene esters **3** lead an efficient formation of 4-aminopyrrolidine derivatives through radical addition/cyclization process. The aminyl radical intermediate did not undergo S_H2 process but simple hydrogen abstraction from Bu_3SnH dominates. Since the precursors of the reaction are readily prepared in optically active form, the present method will provide a useful preparation of multifunctionalized 4-aminopyrrrolidine derivatives.

EXPERIMENTAL

General: All ^1H and ^{13}C NMR spectra were recorded on JEOL JNM-ECA500 Delta2 (500 MHz for ^1H and 126 MHz for ^{13}C) spectrometer. High-resolution mass spectra (HRMS) were measured at Tokiwa Instrumentation Center, Yamaguchi University. Compounds 1 were prepared by the reported methods.[5]

Preparation of (S)-*tert*-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)(p-tolyl)methyl)acrylate (3a): A mixture of **1a** (1.4170 g, 3,21 mmol), 2,6-lutidine (0.75 mL, 6.47 mmol), OsO_4 (0.033 g, 0.130 mmol, 4 mol%) and $NaIO_4$ (2.0689 g, 9.67 mmol) in dioxane-water (35 mL, 3:1 v/v) was stirred at room temperature for 90 min. Saturated $Na_2S_2O_3$aq (60 mL) and brine (20 mL) was added to the reaction mixture and the resulting mixture was extracted with CH_2Cl_2 (60 mL $\times$ 5). Organic phase was combined, washed with 1M HCl (5 mL $\times$ 2) and saturated $Na_2S_2O_3$ (20 mL $\times$ 1), and dried over Na_2SO_4. After filtration, the filtrate was concentrated in vacuo and the residue was subjected to flash chromatography (silica gel/hexane-EtOAc 15:1 then 2:1 v/v) to give aldehyde **2a** in 73% yield (1.0437g, 2.36 mmol), which was used for the next step without further purification. Colorless oil; $[\alpha]_D$ +45.6 (c 1.03, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 8.85 (s, 1H), 7.72 (d, J = 8.2 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 7.06 (d, J = 7.9 Hz, 2H), 6.97 (d, J = 8.1 Hz, 2H), 6.25 (s, 1H), 6.19 (d, J = 1.6 Hz, 1H), 5.18 (d, J = 1.9 Hz, 1H), 3.84 (d, J = 19.6 Hz, 1H), 3.54 (dd, J = 18.7, 2.1 Hz, 1H), 2.44 (s, 3H), 2.28 (s, 3H), 1.24 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 199.2, 164.9, 144.2, 139.9, 138.6, 136.6, 129.9, 129.8, 128.4, 127.5, 125.6, 81.8, 61.7, 53.4, 27.8, 21.7, 21.2; and HRMS (ESI M + MeOH + Na) m/z 498.1932. Calcd for $C_{25}H_{33}NNaO_6S$ 498.1926.

To a mixture of NaOAc (0.1879 g, 2.29 mmol) and *p*-methylhydroxylamine hydrochloride (0.1908 g, 2.28 mmol) in MeOH (40 mL) was added **2a** (0.6730 g, 1.52 mmol) in MeOH (10 mL) and the reaction mixture was stirred for 23 h at room temperature. Water (20 mL) was added and the resulting mixture was extracted with CH_2Cl_2 (20 mL $\times$ 3).

Organic phase was combined, washed with water (20 mL × 2) and dried over Na_2SO_4. After filtration, the filtrate was concentrated in vacuo and the residue was subjected to flash chromatography (silica gel/hexane-EtOAc 15:1 v/v) to give oxime ether **3a** in 94% yield (0.6887 g, 1.40 mmol). White solid; mp 62–63 °C; The enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 16.3 min (minor); t_R 17.4 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 88/12, 1.00 mL/min] as 95%ee; $[\alpha]_D$ +89.4 (c 1.03, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.70 (d, J = 8.3 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 7.04 (d, J = 7.9 Hz, 2H), 6.90 (d, J = 8.0 Hz, 2H), 6.54 (t, J = 5.6 Hz, 1H), 6.28 (d, J = 1.7 Hz, 1H), 6.13 (s, 1H), 5.43 (d, J = 1.9 Hz, 1H), 3.99 (dd, J = 16.6, 6.1 Hz, 1H), 3.69 (dd, J = 16.6, 5.2 Hz, 1H), 2.42 (s, 3H), 2.29 (s, 3H), 1.25 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.0, 146.8, 143.7, 140.4, 138.1, 137.3, 134.2, 129.70, 129.5, 128.5, 127.7, 126.0, 81.6, 61.8, 61.5, 44.0, 27.8, 21.7, 21.2; and HRMS (ESI M + H) m/z 473.2064. Calcd for $C_{25}H_{33}N_2O_5S$ 473.2110.

Other compounds **3** were prepared in a similar manner.

(S)-tert-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)(phenyl)- methyl)acrylate (3b): White solid; mp 82–83 °C; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 15.7 min (minor); t_R 16.9 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 88/12, 1.00 mL/min] as 92%ee; $[\alpha]_D$ +77.9 ($CHCl_3$, c 1.02); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74–7.67 (m, 2H), 7.29–7.21 (m, 5H), 7.07–7.01 (m, 2H), 6.54 (t, J = 5.6 Hz, 1H), 6.30 (s, 1H), 6.18 (s, 1H), 4.01 (ddd, J = 16.5, 6.0, 2.5 Hz, 1H), 3.75–3.66 (m, 1H), 3.60 (s, 3H), 2.42 (s, 3H), 1.24 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.92, 146.63, 140.20, 137.33, 137.25, 129.81, 129.72, 128.83, 128.60, 128.23, 127.65, 126.35, 81.65, 61.99, 61.47, 44.08, 27.75, 21.67; and HRMS (ESI M + H) m/z 459.1960. Calcd for $C_{24}H_{31}N_2O_5S$ 459.1954.

(S)-tert-butyl 2-((4-chlorophenyl)(*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)methyl)acrylate (3c): White solid; mp 82–83 °C; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 16.3 min (minor); t_R 17.4 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 88/12, 1.00 mL/min] as 92%ee; $[\alpha]_D$ +58.9 ($CHCl_3$, c 1.02); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 7.23 (d, J = 8.4 Hz, 2H), 7.00 (d, J = 8.4 Hz, 2H), 6.69 (t, J = 5.7 Hz, 1H), 6.29 (d, J = 1.6 Hz, 1H), 6.15 (s, 1H), 5.38 (d, J = 1.9 Hz, 1H), 3.99 (dd, J = 16.5, 5.3 Hz, 1H), 3.69 (dd, J = 16.6, 5.1 Hz, 1H), 3.61 (s, 3H), 2.42 (s, 3H), 1.27 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.7, 146.3, 144.0, 139.6, 137.1, 136.0, 134.2, 130.0, 129.8, 129.0, 127.6, 126.8, 81.9, 61.6, 61.2, 44.2, 27.8, 21.7; and HRMS (ESI M + H) m/z 493.1581. Calcd for $C_{24}H_{30}ClN_2O_5S$ 493.1564.

(S)-tert-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)(4-methoxyphenyl)methyl)acrylate (3d): Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 40 °C) t_R 44.4 min (minor); t_R 47.1 min (major) [CHIRALPAK ID (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 90/10, 0.50 mL/min] as 98%ee; $[\alpha]_D$ +69.3 ($CHCl_3$, c 1.01); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.70 (d, J = 8.4 Hz, 2H), 7.28 (d, J = 7.7 Hz, 2H), 6.95 (d, J = 8.7 Hz, 2H), 6.77 (d, J = 8.8 Hz, 2H), 6.59 (t, J = 5.7 Hz, 1H), 6.27 (d, J = 1.8 Hz, 1H), 6.12 (s, 1H), 5.41 (d, J = 1.9 Hz, 1H), 4.00 (dd, J = 16.7, 5.8 Hz, 1H), 3.76 (s, 3H), 3.68 (dd, J = 16.6, 5.4 Hz, 1H), 3.62 (s, 3H), 2.43 (s, 3H), 1.26 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.0, 159.5, 146.8, 143.7, 140.5, 137.3, 129.8, 129.7, 129.2, 127.6, 125.7, 114.1, 81.6, 61.5, 61.5, 55.3, 44.0, 27.8, 21.7; and HRMS (ESI M + H) m/z 489.2068. Calcd for $C_{25}H_{33}N_2O_6S$ 489.2059.

(S)-tert-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)(o-tolyl)- methyl)acrylate (3e): Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 24.4 min (major); t_R 34.8 min (minor) [CHIRALPAK AD (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 98/2, 0.80 mL/min] as 97%ee; $[\alpha]_D$ +135.0 ($CHCl_3$, c 1.02); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67 (d, $J = 8.3$ Hz, 2H), 7.25 (d, $J = 7.8$ Hz, 2H), 7.21–7.13 (m, 2H), 7.07 (td, $J = 7.3$, 2.0 Hz, 1H), 6.96 (dd, $J = 7.7$, 1.2 Hz, 1H), 6.55 (t, $J = 5.5$ Hz, 1H), 6.39 (s, 1H), 6.24 (d, $J = 1.6$ Hz, 1H), 5.08 (d, $J = 1.8$ Hz, 1H), 3.98 (ddd, $J = 16.7$, 5.4, 0.8 Hz, 1H), 3.71 (dd, $J = 16.8$, 5.6 Hz, 1H), 3.56 (s, 3H), 2.41 (s, 3H), 2.39 (s, 3H), 1.21 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 146.6, 143.8, 140.3, 137.6, 136.8, 135.3, 131.04, 129.6, 128.4, 128.1, 127.9, 126.2, 125.7, 81.6, 61.4, 59.2, 44.1, 27.7, 21.7, 19.5; and HRMS (ESI M + H) m/z 473.2146. Calcd for $C_{25}H_{33}N_2O_5S$ 473.2110.

(S)-tert-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)-(naphthalen-2-yl)methyl)acrylate (3f): White solid; mp 137–138 °C; the enantiomeric purity was determined by HPLC analysis (230 nm, 35 °C) t_R 28.3 min (major); t_R 35.5 min (minor) [CHIRALPAK AD (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 95/5, 1.00 mL/min] as 95%ee; $[\alpha]_D$ +113.0 (c 1.03, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81–7.76 (m, 1H), 7.74 (d, $J = 8.7$ Hz, 2H), 7.72 (d, $J = 8.3$ Hz, 2H), 7.67–7.62 (m, 1H), 7.51–7.42 (m, 2H), 7.26 (d, $J = 7.9$ Hz, 2H), 7.18 (dd, $J = 8.5$, 1.9 Hz, 1H), 6.64 (t, $J = 5.6$ Hz, 1H), 6.36 (s, 2H), 5.43 (d, $J = 1.5$ Hz, 1H), 4.03 (dd, $J = 16.5$, 5.6 Hz, 1H), 3.79 (dd, $J = 16.5$, 5.8 Hz, 1H), 3.29 (s, 3H), 2.42 (s, 3H), 1.23 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.0, 146.5, 143.8, 140.1, 137.2, 134.6, 133.2, 133.0, 129.8, 128.8, 128.1, 127.7, 127.6, 127.4, 126.7, 126.6, 126.5, 126.5, 81.8, 62.0, 61.2, 44.3, 27.8, 21.7; and HRMS (ESI M + H) m/z 509.2105. Calcd for $C_{28}H_{33}N_2O_5S$ 509.2110.

(R)-tert-butyl 2-((*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)- (thiophen-2-yl)methyl)acrylate (3g): Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 40 °C) t_R 38.9 min (minor); t_R 41.7 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 95/5, 0.80 mL/min] as 94%ee; $[\alpha]_D$ +80.8 ($CHCl_3$, c 1.03); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 (d, $J = 8.4$ Hz, 2H), 7.26 (d, $J = 8.5$ Hz, 2H), 7.18 (dd, $J = 5.1$, 1.2 Hz, 1H), 6.87 (dd, $J = 5.1$, 3.5 Hz, 1H), 6.76 (dd, $J = 2.8$, 1.8 Hz, 1H), 6.73 (dd, $J = 6.1$, 5.3 Hz, 1H), 6.37 (d, $J = 1.8$ Hz, 1H), 6.32 (d, $J = 1.7$ Hz, 1H), 5.60 (d, $J = 1.9$ Hz, 1H), 4.01 (dd, $J = 16.5$, 6.1 Hz, 1H), 3.78 (dd, $J = 16.6$, 5.2 Hz, 1H), 3.68 (s, 3H), 2.42 (s, 3H), 1.34 (s, 9H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.7, 146.5, 143.8, 140.6, 140.1, 136.8, 129.7, 127.7, 127.7, 126.9, 126.4, 126.3, 81.9, 61.6, 57.2, 44.0, 27.9, 21.7; and HRMS (ESI M + H) m/z 465.1528. Calcd for $C_{22}H_{29}N_2O_5S_2$ 465.1518.

(S)-tert-butyl 3-(*N*-(2-(methoxyimino)ethyl)-4-methylphenylsulfonamido)-2- methylenehexanoate (3h): Pale yellow oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 35 °C) t_R 16.4 min (major); t_R 19.4 min (minor) [CHIRALPAK AD (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 95/5, 0.80 mL/min] as 97%ee; $[\alpha]_D$ –38.1 (c 1.00, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ (a mixture of E/Z isomers) 7.71 (dd, $J = 8.4$, 2.4 Hz, 2H for one isomer), 7.70 (dd, $J = 8.4$, 2.4 Hz, 2H for other isomer), 7.33–7.16 (m, 3H), 6.55 (t, $J = 4.1$ Hz, 1H for one isomer), 6.19 (s, 1H for one isomer), 6.16 (s, 1H for other isomer), 5.58 (s, 1H for one isoemr), 5.52 (s, 1H for other isomer), 5.03 (t, $J = 7.6$ Hz, 1H for one isomer), 4.96 (t, $J = 7.6$ Hz, 1H for other isomer), 4.10 (dd, $J = 19.3$, 4.4 Hz, 1H), 3.86 (dd, $J = 13.7$, 7.9 Hz, 1H), 3.84 (d, $J = 0.9$ Hz, 3H for one isomer), 3.78 (s, 3H for other isomer), 2.39 (s, 3H), 1.75–1.50 (m, 4H), 1.43 (s, 9H for one isomer), 1.42 (s, 9H for other isomer), 0.89 (td, $J = 7.4$ Hz, 3H for one isomer), 0.88

(td, $J = 7.4$ Hz, 3H for other isomer); ^{13}C NMR (126 MHz, $CDCl_3$) δ (a mixture of E/Z isomers) 165.54, 165.42, 150.16, 147.90, 143.31, 143.31, 140.06, 140.05, 137.60, 137.53, 137.53, 129.48, 129.48, 127.84, 127.76, 126.41, 126.37, 81.54, 81.43, 62.11, 61.66, 57.20, 56.99, 43.20, 39.41, 33.76, 33.39, 28.03, 21.58, 21.57, 19.80, 19.78, 13.80, 13.74; and HRMS (ESI M + H) m/z 425.2098. Calcd for $C_{21}H_{33}N_2O_5S$ 425.2110.

Preparation of (2S,3S)-tert-butyl 4-(methoxyamino)-2-(p-tolyl)-1-tosyl-3-((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4a): Compound **3a** (0.2363 g, 0.500 mmol) was dissolved in toluene (50 mL) and Bu_3SnH (0.26 mL, 0.981 mmol) and Et_3B (1 M in hexane, 1.0 mL, 1 mmol) were added. The resulting solution was purged by air for 5 min and stirred for 2 h at room temperature. Solvent was evaporated and the residue was subjected to flash chromatography (silica gel/hexane-EtOAc 25:1 then 5:1 v/v) to give **4a** in 76% yield (0.3049 g, 0.379 mmol). HPLC analysis revealed *trans*/*cis* ratio was 64/36. HRMS (ESI M + H) m/z 765.3333. Calcd for $C_{37}H_{61}N_2O_5SSn$ 765.3323.

Careful chromatographic treatment separated *trans*-**4a** and *cis*-**4a** in pure form.

***trans*-4a**: Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 10.6 min (minor); t_R 17.5 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 90/10, 0.80 mL/min] as 95%ee; $[\alpha]_D$ -27.2 (c 1.03, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, $J = 8.1$ Hz, 2H), 7.08 (d, $J = 8.0$ Hz, 2H), 6.98 (d, $J = 7.7$ Hz, 2H), 6.86 (d, $J = 7.5$ Hz, 2H), 5.90 (d, $J = 9.5$ Hz, 1H), 5.05 (s, 1H), 3.85 (dd, $J = 9.3$, 7.2 Hz, 1H), 3.77–3.63 (m, 1H), 3.54 (dt, $J = 9.6$, 7.6 Hz, 1H), 3.43 (s, 3H), 2.35 (s, 3H), 2.30 (s, 3H), 1.48 (s, 9H), 1.35–1.14 (m, 12H), 0.82 (t, $J = 7.2$ Hz, 9H), 0.66 (dd, $J = 9.2$, 7.2 Hz, 6H), 0.52 (d, $J = 12.9$ Hz, 1H), 0.47 (d, $J = 13.0$ Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.4, 142.8, 137.3, 136.6, 135.3, 129.1, 128.8, 128.4, 127.3, 82.5, 70.5, 67.3, 61.7, 59.4, 51.7, 29.1, 28.1, 27.5, 21.5, 21.2, 11.1.

cis-**4a**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (d, $J = 8.2$ Hz, 2H), 7.24 (d, $J = 8.6$ Hz, 2H), 7.11 (d, $J = 7.6$ Hz, 2H), 7.07 (d, $J = 8.2$ Hz, 2H), 5.33 (d, $J = 9.0$ Hz, 1H), 4.78 (s, 1H), 3.77–3.67 (m, 2H), 3.64–3.54 (m, 1H), 3.45 (s, 3H), 2.39 (s, 3H), 2.32 (s, 3H), 1.32 (s, 9H), 1.31–1.12 (m, 12H), 0.81 (t, $J = 7.2$ Hz, 9H), 0.71–0.62 (m, 6H), 0.51 (d, $J = 13.0$ Hz, 1H), 0.26 (d, $J = 12.9$ Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.6, 143.4, 137.3, 135.3, 134.1, 129.5, 128.7, 128.3, 128.0, 81.9, 71.2, 64.0, 62.0, 60.2, 51.5, 29.1, 27.8, 27.5, 21.6, 21.3, 13.8, 10.9.

Other compound **4** were prepared in a similar manner.

(2S,3S)-tert-butyl 4-(methoxyamino)-2-phenyl-1-tosyl-3-((tributylstannyl)methyl)-pyrrolidine-3-carboxylate (4b): HRMS (ESI M + H) m/z 751.3202. Calcd for $C_{36}H_{59}N_2O_5SSn$ 751.3167.

trans-**4b** White solid; mp 55–56 °C; $[\alpha]_D$ -24.2 (c 1.01, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, $J = 8.2$ Hz, 2H), 7.26–7.13 (m, 3H), 7.09 (d, $J = 8.1$ Hz, 2H), 6.97 (d, $J = 6.0$ Hz, 2H), 5.92 (d, $J = 9.7$ Hz, 1H), 5.10 (s, 1H), 3.86 (dd, $J = 9.3$, 7.2 Hz, 1H), 3.70 (dd, $J = 9.4$, 7.9 Hz, 1H), 3.54 (dt, $J = 9.7$, 7.5 Hz, 1H), 3.43 (s, 3H), 2.35 (s, 3H), 1.49 (s, 9H), 1.40–1.13 (m, 12H), 0.81 (t, $J = 7.2$ Hz, 9H), 0.67 (dd, $J = 9.2$, 6.8 Hz, 6H), 0.52 (d, $J = 12.9$ Hz, 1H), 0.42 (d, $J = 13.0$ Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.3, 142.9, 138.3, 136.5, 129.2, 128.3, 128.1, 127.7, 127.3, 82.6, 70.7, 67.2, 61.7, 59.4, 51.7, 29.1, 28.1, 27.4, 21.5, 13.8, 11.1.

cis-**4b**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (d, $J = 8.2$ Hz, 2H), 7.30–7.21 (m, 7H), 5.32 (d, $J = 9.0$ Hz, 1H), 4.83 (s, 1H), 3.80–3.70 (m, 2H), 3.65–3.58 (m, 1H), 3.46 (s, 3H), 2.39 (s, 3H), 1.34 (s, 9H), 1.33–1.13 (m, 12H), 0.81 (t, $J = 7.3$ Hz, 9H), 0.71–0.63 (m, 6H), 0.50 (d, $J = 12.9$ Hz, 1H), 0.23 (d, $J = 13.0$ Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$)

δ 173.6, 143.5, 138.4, 134.2, 129.6, 128.4, 127.9 (2C), 127.7, 82.0, 71.3, 64.0, 62.0, 60.3, 51.5, 29.1, 27.8, 27.5, 21.6, 13.8, 10.9.

(2S,3S)-tert-butyl 2-(4-chlorophenyl)-4-(methoxyamino)-1-tosyl-3-((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4c): HRMS (ESI M + H) m/z 785.2777. Calcd for $C_{36}H_{58}ClN_2O_5SSn$ 785.2759.

***trans*-4c**: Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 9.8 min (minor); t_R 13.3 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 90/10, 0.70 mL/min] as 89%ee; $[\alpha]_D$ –15.5 (c 1.02, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 (d, J = 8.2 Hz, 2H), 7.17 (d, J = 8.1 Hz, 2H), 7.14 (d, J = 8.1 Hz, 2H), 6.95 (d, J = 8.0 Hz, 2H), 5.83 (d, J = 9.7 Hz, 1H), 5.05 (s, 1H), 3.85 (dd, J = 9.6, 6.9 Hz, 1H), 3.69 (dd, J = 9.6, 7.4 Hz, 1H), 3.50–3.44 (m, 1H), 3.42 (s, 3H), 2.38 (s, 3H), 1.47 (s, 9H), 1.37–1.15 (m, 12H), 0.82 (t, J = 7.2 Hz, 9H), 0.71–0.65 (m, 6H), 0.50 (d, J = 13.0 Hz, 1H), 0.41 (d, J = 13.0 Hz, 1H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.9, 143.3, 137.0, 136.1, 133.6, 129.7, 129.4, 128.2, 127.3, 82.8, 69.9, 67.2, 61.7, 59.4, 51.6, 29.1, 28.1, 27.5, 21.6, 13.8, 11.2.

cis-**4c**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (d, J = 8.2 Hz, 2H), 7.29–7.17 (m, 6H), 5.26 (d, J = 7.8 Hz, 1H), 4.78 (s, 1H), 3.79–3.66 (m, 2H), 3.58 (dd, J = 9.8, 5.2 Hz, 1H), 3.47 (s, 3H), 2.40 (s, 3H), 1.33 (s, 9H), 1.32–1.15 (m, 12H), 0.82 (t, J = 7.3 Hz, 9H), 0.72–0.65 (m, 6H), 0.45 (d, J = 12.9 Hz, 1H), 0.22 (d, J = 12.9 Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.4, 143.7, 137.1, 134.0, 133.5, 129.9, 129.6, 128.1, 127.9, 82.2, 70.6, 64.0, 62.2, 60.2, 51.5, 29.1, 27.8, 27.5, 21.6, 13.8, 10.9.

(2S,3S,4S)-tert-butyl 4-(methoxyamino)-2-(4-methoxyphenyl)-1-tosyl-3-((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4d): HRMS (ESI M + H) m/z 781.3274. Calcd for $C_{37}H_{61}N_2O_6SSn$ 781.3272.

***trans*-4d**: Colorless oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 40 °C) t_R 13.6 min (minor); t_R 22.0 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 95/5, 1.00 mL/min] as 99%ee; $[\alpha]_D$ –43.5 (c 0.54, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.37 (d, J = 8.3 Hz, 2H), 7.10 (d, J = 7.9 Hz, 2H), 6.90 (d, J = 8.0 Hz, 2H), 6.72 (d, J = 8.3 Hz, 2H), 5.92 (d, J = 9.7 Hz, 1H), 5.05 (s, 1H), 3.85 (dd, J = 9.4, 7.1 Hz, 1H), 3.79 (s, 3H), 3.68 (d, J = 8.2 Hz, 1H), 3.53 (dt, J = 10.0, 7.6 Hz, 1H), 3.44 (s, 3H), 2.36 (s, 3H), 1.49 (s, 9H), 1.37–1.16 (m, 12H), 0.83 (t, J = 7.2 Hz, 9H), 0.71–0.65 (m, 6H), 0.54 (d, J = 13.1 Hz, 1H), 0.47 (d, J = 13.2 Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.4, 159.1, 142.8, 136.6, 130.4, 129.6, 129.2, 127.3, 113.4, 82.6, 70.3, 67.2, 61.7, 59.5, 55.3, 51.6, 31.7, 29.2, 28.2, 27.5, 21.5, 13.8, 11.1.

cis-**4d**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 10.7 Hz, 2H), 7.20–7.09 (m, 2H), 6.80 (d, J = 8.9 Hz, 2H), 5.32 (d, J = 8.3 Hz, 1H), 4.76 (s, 1H), 3.79 (s, 3H), 3.75–3.65 (m, 2H), 3.67–3.55 (m, 1H), 3.46 (s, 3H), 2.39 (s, 3H), 1.33 (s, 9H), 1.32–1.14 (m, 12H), 0.82 (t, J = 7.3 Hz, 9H), 0.70–0.64 (m, 6H), 0.50 (d, J = 13.0 Hz, 1H), 0.27 (d, J = 13.0 Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.7, 159.1, 143.4, 134.3, 130.4, 129.5, 129.2, 127.9, 113.3, 81.9, 70.9, 63.9, 62.0, 60.3, 55.3, 29.14, 27.8, 27.5, 13.8, 10.9.

(2S,3S)-tert-butyl 4-(methoxyamino)-2-(o-tolyl)-1-tosyl-3-((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4e): HRMS (ESI M + H) m/z 765.3308. Calcd for $C_{37}H_{61}N_2O_5SSn$ 765.3323.

***trans*-4e:** White solid; mp 124–125 °C; The enantiomeric purity was determined by HPLC analysis (230 nm, 40 °C) t_R 8.8 min (minor); t_R 11.3 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 90/10, 1.00 mL/min]

as 95%ee; $[\alpha]_D$ +10.1 (c 1.00, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 7.39 (d, $J = 8.2$ Hz, 2H), 7.17–7.06 (m, 4H), 6.94 (td, $J = 7.5$, 1.7 Hz, 1H), 6.71 (dd, $J = 7.9$, 1.2 Hz, 1H), 6.35 (d, $J = 12.2$ Hz, 1H), 5.43 (s, 1H), 3.94 (dd, $J = 8.7$, 7.6 Hz, 1H), 3.67 (t, $J = 8.9$ Hz, 1H), 3.56 (ddd, $J = 12.2$, 9.1, 7.6 Hz, 1H), 3.47 (s, 3H), 2.41 (s, 3H), 2.34 (s, 3H), 1.47 (s, 9H), 1.38–1.13 (m, 12H), 0.87 (d, $J = 13.1$ Hz, 0H), 0.83 (d, $J = 13.1$ Hz, 1H), 0.81 (t, $J = 7.3$ Hz, 9H), 0.70 (t, $J = 8.2$ Hz, 6H), 0.05 (d, $J = 12.9$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.2, 142.9, 136.9, 136.5, 130.4, 129.2, 127.3, 127.1, 126.0, 82.6, 67.1, 65.5, 61.3, 59.5, 29.2, 28.08, 27.4, 21.5, 20.2, 13.8, 13.0, 11.1.

***cis*-4e**: White solid; mp 95–96 °C; $[\alpha]_D$ +40.6 (c 0.51, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 7.55 (d, $J = 8.2$ Hz, 2H), 7.35 (d, $J = 7.3$ Hz, 1H), 7.21 (d, $J = 9.4$ Hz, 2H), 7.16–7.06 (m, 3H), 5.32 (d, $J = 10.3$ Hz, 1H), 5.17 (s, 1H), 3.93 (dd, $J = 10.2$, 1.6 Hz, 1H), 3.87–3.80 (m, 1H), 3.62 (dd, $J = 10.1$, 5.4 Hz, 1H), 3.50 (s, 3H), 2.38 (s, 3H), 2.34 (s, 3H), 1.55 (s, 9H), 1.36–1.15 (m, 12H), 0.81 (t, $J = 7.3$ Hz, 9H), 0.75–0.70 (m, 6H), 0.54 (d, $J = 13.0$ Hz, 1H), 0.05 (d, $J = 13.0$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.3, 143.4, 137.4, 136.1, 134.5, 130.4, 129.5, 128.2, 127.9, 127.3, 125.8, 82.2, 67.2, 64.2, 61.8, 60.8, 52.0, 29.1, 27.8, 27.4, 21.5, 20.3, 13.7, 10.7.

(2S,3S)-tert-butyl 4-(methoxyamino)-2-(naphthalen-2-yl)-1-tosyl-3- ((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4f): HRMS (ESI M + H) m/z 801.3330. Calcd for $C_{40}H_{61}N_2O_5SSn$ 801.3323.

***trans*-4f**: Colorless oil; $[\alpha]_D$ –22.5 (c 1.03, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 7.77 (dd, $J = 6.2$, 3.3 Hz, 1H), 7.68–7.58 (m, 2H), 7.50–7.42 (m, 2H), 7.29 (d, $J = 8.0$ Hz, 2H), 7.20–7.03 (m, 2H), 6.91 (d, $J = 7.9$ Hz, 2H), 5.98–5.89 (m, 1H), 5.28 (s, 1H), 3.95 (dd, $J = 9.3$, 7.2 Hz, 1H), 3.80 (dd, $J = 9.3$, 7.8 Hz, 1H), 3.66 (q, $J = 8.1$ Hz, 1H), 3.47 (s, 3H), 2.23 (s, 3H), 1.54 (d, $J = 1.3$ Hz, 9H), 1.31–1.05 (m, 12H), 0.75 (d, $J = 7.6$ Hz, 9H), 0.66–0.58 (m, 6H), 0.55 (s, 2H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.2, 142.9, 136.7, 135.6, 133.0, 132.9, 129.5, 129.5, 129.1, 128.1, 127.8, 127.6, 127.1, 126.2, 126.1, 82.7, 70.7, 61.9, 59.6, 51.9, 29.1, 28.2, 27.4, 21.4, 13.7, 11.1.

cis-**4f**: ^1H NMR (500 MHz, $CDCl_3$) δ 7.82–7.77 (m, 1H), 7.72 (d, $J = 8.6$ Hz, 2H), 7.57 (s, 1H), 7.54 (d, $J = 8.1$ Hz, 2H), 7.49–7.41 (m, 3H), 7.16 (d, $J = 8.0$ Hz, 2H), 5.38 (d, $J = 8.1$ Hz, 1H), 5.04 (s, 1H), 3.85–3.75 (m, 2H), 3.72 (dd, $J = 9.6$, 5.2 Hz, 1H), 3.48 (s, 3H), 2.33 (s, 3H), 1.39 (s, 9H), 1.32–1.06 (m, 12H), 0.75 (t, $J = 7.2$ Hz, 9H), 0.67–0.58 (m, 6H), 0.56 (d, $J = 13.0$ Hz, 1H), 0.30 (d, $J = 12.9$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.7, 143.5, 135.9, 133.1, 133.0, 129.5, 129.1, 128.1, 127.8, 127.7, 127.5, 127.5, 126.7, 126.1, 126.0, 82.2, 71.4, 64.3, 62.1, 60.6, 51.7, 29.1, 27.9, 27.4, 21.5, 13.7, 10.9.

(2R,3S)-tert-butyl 4-(methoxyamino)-2-(thiophen-2-yl)-1-tosyl-3- ((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4g): HRMS (ESI M + H) m/z 757.2717. Calcd for $C_{34}H_{57}N_2O_5S_2Sn$ 757.2731.

***trans*-4g:** Pale yellow oil; the enantiomeric purity was determined by HPLC analysis (230 nm, 30 °C) t_R 11.5 min (minor); t_R 13.7 min (major) [CHIRALPAK IC (0.46 cm × 25 cm) (from Daicel Chemical Ind., Ltd.) hexane/*i*-PrOH, 90/10, 0.70 mL/min] as 94%ee; $[\alpha]_D$ –32.8 (c 1.00, $CHCl_3$); ^1H NMR (500 MHz, $CDCl_3$) δ 7.32 (d, $J = 8.3$ Hz, 2H), 7.12 (dd, $J = 5.0$, 1.2 Hz, 1H), 7.07 (d, $J = 7.9$ Hz, 2H), 6.86 (dd, $J = 5.1$, 3.4 Hz, 1H), 6.82 (dd, $J = 3.5$, 1.2 Hz, 1H), 6.05 (d, $J = 8.2$ Hz, 1H), 5.44 (s, 1H), 3.80–3.57 (m, 3H), 3.46 (s, 3H), 2.34 (s, 3H), 1.56 (s, 9H), 1.42–1.16 (m, 12H), 0.83 (t, $J = 7.3$ Hz, 9H), 0.77 (d, $J = 13.1$ Hz, 1H), 0.71 (ddd, $J = 9.5$, 7.0, 2.3 Hz, 6H), 0.64 (d, $J = 12.9$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.9, 142.7, 141.8, 136.8, 129.4, 129.1, 128.0, 127.0, 126.2, 125.8, 82.9, 67.3, 66.4, 61.8, 59.4, 50.8, 29.1, 7.2, 27.5, 21.6, 13.8, 11.1.

cis-**4g**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53 (d, $J = 8.1$ Hz, 2H), 7.20 (d, $J = 8.1$ Hz, 2H), 7.18 (dd, $J = 3.8$, 2.8 Hz, 1H), 6.92–6.87 (m, 2H), 5.52 (d, $J = 8.6$ Hz, 1H), 5.29 (s, 1H), 3.82–3.75 (m, 1H), 3.67 (dd, $J = 10.4$, 2.9 Hz, 1H), 3.56 (dd, $J = 10.4$, 5.7 Hz, 1H), 3.47 (s, 3H), 2.38 (s, 3H), 1.38 (s, 9H), 1.37–1.17 (m, 12H), 0.83 (t, $J = 7.3$ Hz, 9H), 0.75–0.70 (m, 6H), 0.68 (d, $J = 12.8$ Hz, 1H), 0.52 (d, $J = 12.7$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.5, 143.3, 142.6, 135.0, 129.4, 127.8, 127.7, 126.3, 125.8, 82.4, 66.7, 64.2, 62.1, 60.7, 51.1, 29.1, 27.9, 27.5, 21.6, 13.8, 10.9.

(2S,3S)-tert-butyl 4-(methoxyamino)-2-propyl-1-tosyl-3-((tributylstannyl)methyl)pyrrolidine-3-carboxylate (4h): Colorless oil; $[\alpha]_D$ +15.8 (c 0.53, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.71 (d, $J = 8.2$ Hz, 2H), 7.30 (d, $J = 8.0$ Hz, 3H), 5.29 (d, $J = 7.4$ Hz, 1H), 3.80 (dd, $J = 8.3$, 4.6 Hz, 1H), 3.53 (d, $J = 7.1$ Hz, 2H), 3.44 (s, 3H), 3.38–3.30 (m, 1H), 2.41 (s, 3H), 1.92 (dtd, $J = 11.4$, 6.9, 6.5, 3.3 Hz, 1H), 1.76–1.62 (m, 1H), 1.50–1.24 (m, 16H), 1.24 (s, 9 H), 0.96–0.81 (m, 19H), 0.78 (d, $J = 12.9$ Hz, 1H); and ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.0, 143.4, 135.0, 129.6, 127.8, 81.7, 67.3, 64.1, 62.0, 58.7, 51.2, 34.3, 27.8, 27.5, 21.6, 20.3, 14.3, 13.8, 11.4, 8.5; HRMS (ESI M + H) m/z 717.3328. Calcd for $C_{33}H_{61}N_2O_5SSn$ 717.3323.

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6. CCDC 903025 for *trans*-**4e** (major **4e**) and CCDC 903026 for *cis*-**4e** (minor **4e**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/retrieving.html