

Supporting Information for:

Diastereoselective Synthesis of the Aminocyclitol Core of Jogyamycin *via* an Allene Aziridination Strategy

Nels C. Gerstner, Christopher S. Adams, R. David Grigg, Maik Tretbar, Jared W. Rigoli and

Jennifer M. Schomaker

*Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue,
Madison, WI, 53706-1396*

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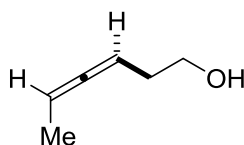
I. General Information

All glassware was either oven dried at 130 °C, or flame dried under vacuum and purged with nitrogen before use. All glassware was either cooled in a desiccator filled with Drierite as a desiccant or under nitrogen after placing under vacuum. Unless otherwise specified, reagents were used as obtained from the vendor without further purification. Tetrahydrofuran was passed through an alumina column before use or freshly distilled from Na/benzophenone ketyl. Dichloromethane was freshly distilled from calcium hydride or passed through an alumina column before use. Acetonitrile, toluene and benzene were all freshly distilled from calcium hydride before use. Xylenes were used without further purification. Other solvents were purified using accepted procedures from the sixth edition of "Purification of Laboratory Chemicals".¹ Air- and moisture- sensitive reactions were performed using standard Schlenk techniques under a nitrogen atmosphere. Analytical thin layer chromatography (TLC) was performed using pre-coated silica gel 60 F₂₄ plates containing a fluorescent indicator. Either KMnO₄ or ceric ammonium molybdate (CAM stain) were used to visualize the reaction products. Preparative chromatography for most compounds, unless otherwise specified, was performed using SilicaFlash P60 silica gel (230-400 mesh) via Still's method.² Unless stated otherwise, columns were typically run using a gradient method with mixtures of EtOAc/hexanes.

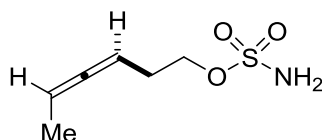
¹H NMR and ¹³C NMR spectra were obtained using Bruker Avance-500 spectrometers. For ¹H NMR, chemical shifts are reported relative to the tetramethylsilane peak (δ 0.00 ppm), except in acetone-d₆ and toluene-d₈, where the chemical shifts are reported relative to the residual protiated solvent peak (2.05 ppm and 2.09 ppm, respectively). ¹³C NMR spectra were measured at 125 MHz on the same instruments noted above for recording ¹H NMR spectra. Chemical shifts are reported relative to the solvent peaks (δ 77.16 ppm for CDCl₃, 128.06 ppm for C₆D₆, 206.68

ppm for acetone-d₆, and 20.40 ppm for toluene-d₈). Accurate mass measurements were acquired at the University of Wisconsin, Madison, using a Micromass LCT (electrospray ionization or electron impact methods). The NMR and Mass Spectrometry facilities are funded by the NSF (CHE-1048642, CHE-0342998, CHE-9304546 and CHE-9208463), the University of Wisconsin as well as a generous gift by Paul J. Bender.

II. Experimental procedures for the synthesis of all new compounds.

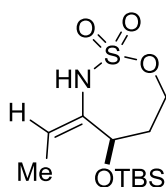


Compound 18. The homoallylic alcohol is commercially available from Aldrich (#767336), but can be conveniently prepared on multi-gram scale according to the procedure of Blakey and coworkers.³ Spectra were consistent with reported values.³



Compound 19. The sulfamate was prepared according to the procedure of Du Bois and coworkers.⁴ To a flame-dried, three-neck roundbottom flask under N₂ was added chlorosulfonyl isocyanate (19.4 mL, 224.5 mmol, 2.2 equiv). The flask was cooled to 0 °C in an ice bath, and formic acid (8.46 mL, 224.5 mmol, 2.2 equiv) was added slowly over ~15 min via syringe (caution: vigorous evolution of CO₂/CO; reaction must be carried out in a well-ventilated hood). After completion of the addition, the mixture was stirred at 0 °C until a white solid had formed,

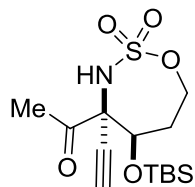
and then 200 mL dry MeCN were added. This solution was stirred overnight at rt (12 h), after which the solution was cooled to 0 °C and alcohol **18** (10 g, 102.0 mmol, 1 equiv), dissolved in 200 mL N,N-dimethylacetamide, was added over 2-3 min. The solution was stirred at 0 °C for 1.5 h, then at rt for 2 h. The reaction mixture was quenched by the addition of 500 mL of H₂O and poured into a separatory funnel containing 500 mL of Et₂O. The organic phase was collected and the aqueous layer was extracted with 2 x 300 mL of Et₂O. The combined organic extracts were washed with 5 x 200 mL of H₂O, dried over MgSO₄ and concentrated under reduced pressure. Purification of the oily residue by chromatography on silica gel (0% to 30% EtOAc/hexanes) afforded 16.2 g (91.4 mmol, 90% yield) of the product as a light yellow oil. ¹H NMR (500 MHz, CDCl₃) δ 5.15 (tp, *J* = 6.8, 2.9 Hz, 1H), 5.06 (qq, *J* = 6.5, 3.2 Hz, 1H), 4.76 (bs, 2H), 4.26 (t, *J* = 6.8 Hz, 2H), 2.43 (qd, *J* = 6.7, 2.8 Hz, 2H), 1.66 (dd, *J* = 7.0, 3.2 Hz, 3H). ¹³C NMR (126 MHz, CDCl₃) δ 205.69, 87.22, 85.10, 70.62, 28.47, 14.44. HRMS (ESI) *m/z* calculated for C₆H₁₅N₂O₃S [M + NH₄⁺] 195.0799, found 195.0798.



Compound 21. A flame-dried roundbottom flask equipped with a stir bar was charged with homoallenenic sulfamate **18** (5.0 g, 28.4 mmol, 1 equiv) and Rh₂(OAc)₄ (94.0 mg, 0.21 mmol, 0.0075 equiv). Dry dichloromethane was added to prepare a 0.1 M solution, and the mixture stirred vigorously to yield a faint green-blue solution. Iodosylbenzene (6.52 g, 29.6 mmol, 1.04 equiv) was added in one portion, and the resulting suspension stirred at rt for 1 h. The reaction mixture was monitored by TLC for consumption of starting material (100% CH₂Cl₂ solvent

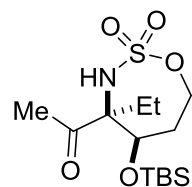
system, CAM stain; the reaction progress can also easily be monitored by NMR). Upon complete consumption of the starting material, the solution was concentrated by rotary evaporation (without heating the sample above 30 °C in order to avoid decomposition of the bicyclic methyleneaziridine), and CH₃CN was added to the residue to prepare a 0.4 M solution. Water (2.10 ml, 117 mmol, 4.1 equiv) was added, and the solution stirred at rt for 2.5 h until TLC indicated complete consumption of the intermediate bicyclic methyleneaziridine (~30% EtOAc/hex or 100% CH₂Cl₂ solvent system, CAM stain; reaction progress can also be easily monitored by NMR). Upon completion, the reaction mixture was poured into a beaker of appropriate size and diluted by a factor of 2-3 with CH₂Cl₂. The solution was dried by the addition of Na₂SO₄ until the initially cloudy solution turned clear, and the resulting suspension decanted. The residual material was washed twice with CH₂Cl₂, the organic portions combined and concentrated by rotary evaporation. The residue was then dissolved in dry CH₂Cl₂ (0.4 M) and cooled to 0 °C. A portion of 2,6-lutidine (3.30 mL, 28.3 mmol, 1.0 equiv) was added, followed by the slow addition of TBSOTf (6.50 mL, 28.2 mmol, 0.99 equiv) over approximately 1 min. The reaction was stirred at 0 °C for 45 min, at which point complete consumption of the starting material was observed by TLC (~30% EtOAc/hex or 100% CH₂Cl₂ solvent system, CAM stain). The reaction mixture was diluted with CH₂Cl₂ and washed twice with saturated NH₄Cl and NaCl solutions. The organic layer was dried over Na₂SO₄, concentrated by rotary evaporation and the crude material was purified by column chromatography (0% to 12% EtOAc/hexanes) to yield **21** (4.33 g, 14.1 mmol, 50%) as a white solid. ¹H NMR (500 MHz, CDCl₃) δ 6.33 (s, 1H), 5.80 (q, *J* = 7.3 Hz, 1H), 4.83 (t, *J* = 3.1 Hz, 1H), 4.68 (t, *J* = 12.6 Hz, 1H), 4.15 (dt, *J* = 13.0, 3.2 Hz, 1H), 2.11 (ddt, *J* = 15.2, 12.2, 3.0 Hz, 1H), 1.84 (dt, *J* = 15.1, 3.4 Hz, 1H), 1.72 (d, *J* = 7.3 Hz, 3H), 0.89 (s, 9H), 0.10 (s, 4H), 0.07 (s, 3H). ¹³C NMR (126 MHz,

CDCl₃) δ 132.25, 124.73, 77.16, 64.77, 64.45, 37.47, 25.77, 18.22, 12.21, -4.84, -5.04. HRMS (ESI) m/z calculated for C₁₂H₂₉N₂O₅SSi [M+NH₄]⁺ 325.1612, found 325.1621.



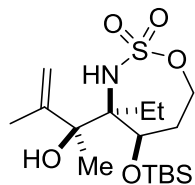
Compound 24. A flame dried round bottom flask equipped with a stir bar was charged with **21** (3.78 g, 12.3 mmol, 1.0 equiv.) and 4Å MS (3.96 g, ~1:1 4Å MS:**21**). Freshly prepared DMDO (0.22 M in CH₂Cl₂, 98 mL, 21.6 mmol, 1.76 equiv) was added and the reaction mixture was stirred for 2 h. The reaction was then filtered through Celite and solvent was removed until the imine solidified. While the DMDO oxidation reaction was running, an oven-dried roundbottom flask equipped with stir bar was charged with a solution of ethynylmagnesium bromide (0.5 M in THF, 76 ml, 38 mmol, 3.0 equiv). The solution was cooled in an ice bath for 1 h prior to addition of the imine. The solution rapidly went from transparent to murky within 10 min due to the precipitation of salts; however, an extended stir time of 1 h was necessary in order to achieve reproducible results. The solid imine was dissolved in THF (24.0 ml, 0.51 M) and added dropwise to the Grignard solution. The mixture was allowed to stir for 1 h, after which the reaction was quenched with saturated NH₄Cl. The aqueous phase was extracted 3x with portions of CH₂Cl₂, the combined organics washed with brine, dried with Na₂SO₄, filtered and the solvent removed. The crude oil was dissolved in CH₂Cl₂ (123 ml, 0.10 M) and Dess-Martin periodane (6.28 g, 14.8 mmol, 1.20 equiv) was added. The reaction mixture was stirred for 16 h, after which a Na₂S₂O₃ solution was added and the biphasic mixture stirred for 30 min. A saturated NaHCO₃ solution was added and the aqueous layer extracted 3x with portions of CH₂Cl₂. The

combined organics were washed with brine, dried with Na₂SO₄, filtered and the solvent was removed. The crude material was purified by flash chromatography (49.25/49.25/0.5 to 99.5/0/0.5% CH₂Cl₂/Hexanes/EtOAc, major diastereomer eluting at ~80% CH₂Cl₂), yielding 2.79 g of a 23:1 mixture of the major diastereomer **24**:minor diastereomer and an additional 117 mg of the minor diastereomer. The overall recovery of products was 2.91 g (8.37 mmol, 68% yield) with a *dr* of 11.5:1. Major diastereomer **24**: ¹H NMR (500 MHz, C₆D₆) δ 5.83 (s, 1H), 4.41 – 4.34 (m, 2H), 3.51 (dt, *J* = 12.8, 3.5 Hz, 1H), 2.19 (s, 1H), 2.20 – 2.11 (m, 1H), 1.97 (s, 3H), 1.15 (dt, *J* = 15.9, 4.4 Hz, 1H), 0.73 (s, 9H), -0.16 (s, 3H), -0.23 (s, 3H). ¹³C NMR (125 MHz, C₆D₆) δ 198.8, 80.9, 75.6, 71.9, 65.7, 64.0, 33.2, 25.7, 25.0, 18.0, -4.7, -5.1. HRMS (ESI) *m/z* calculated for C₁₄H₂₉N₂O₅SSi [M+NH₄]⁺ 365.1561, found 365.1548.



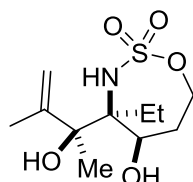
Compound 16. A 100 mL, one-neck roundbottom flask was charged with the aminoketone **24** (995 mg, 2.86 mmol, 1 equiv) and 29 mL THF (0.1 M). Pd/C (5 wt%, 305 mg, 0.144 mmol Pd, 0.05 equiv Pd) was added, and the flask was fitted with a septum. The atmosphere in the flask was evacuated, back-filled with hydrogen three times using a Schlenk line and then placed under a hydrogen balloon at 1 atm. The reaction mixture was stirred at rt for 2 h, at which point the balloon was removed and the atmosphere in the roundbottom flask was purged with N₂. The reaction was passed through a pad of Celite with EtOAc and the filtrate concentrated by rotary evaporation to give the desired product (1.03 g, 2.93 mmol, 98%) as a white solid. ¹H NMR (500 MHz, CDCl₃) δ 5.78 (s, 1H), 4.61 – 4.53 (m, 1H), 4.45 (dd, *J* = 5.4, 1.5 Hz, 1H), 4.14 (ddd,

$J = 12.7, 5.0, 2.6$ Hz, 1H), 2.26 (s, 3H), 2.25 – 2.18 (m, 2H), 1.94 – 1.82 (m, 2H), 0.94 (t, $J = 7.4$ Hz, 3H), 0.87 (s, 9H), 0.08 (s, 3H), 0.04 (s, 3H). ^{13}C NMR (126 MHz, CDCl_3) δ 207.05, 73.62, 73.52, 64.62, 33.22, 27.78, 25.86, 25.05, 18.08, 8.30, -4.14, -4.91. HRMS (ESI) m/z calculated for $\text{C}_{14}\text{H}_{33}\text{N}_2\text{O}_5\text{SSi}$ $[\text{M}+\text{NH}_4]^+$ 369.1874, found 369.1874.

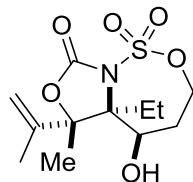


Compound 25. In a glovebox, anhydrous CeCl_3 (3.51 g, 14.2 mmol, 5 equiv) was added to a three-neck, 250 mL roundbottom flask. The flask was capped and removed from the glovebox, and 30 mL dry THF was added. The CeCl_3 -THF slurry was stirred overnight at rt under N_2 . The following day, the reaction mixture was cooled to -78 °C in a dry ice/acetone bath, and isopropenylmagnesium bromide (0.4 M in THF, 35.6 mL, 14.2 mmol, 5 equiv) added via syringe. The mixture was stirred at -78 °C for 1.5 h and then aminoketone **16** (1.00 g, 2.84 mmol, 1 equiv) was added as a solution in 6 mL THF. The mixture was stirred at -78 °C for 2 h, warmed to 0 °C and stirred for an additional 1 h. The reaction mixture was quenched by the addition of 75 mL 0.5 M AcOH, poured into a separatory funnel and extracted 3x with portions of CH_2Cl_2 . The combined organic layers were washed with saturated NaHCO_3 and then brine, dried over Na_2SO_4 and concentrated by rotary evaporation. The resulting crude material was purified by column chromatography (5% to 30% EtOAc/hexanes) to give 1.05 g (2.66 mmol, 94%) of **25** as a white powder. ^1H NMR (500 MHz, CDCl_3) δ 6.02 (s, 1H), 5.07 (bs, 1H), 5.01 (s, 1H), 4.67 (dd, $J = 12.7, 11.5$ Hz, 1H), 4.55 (dd, $J = 4.7, 1.9$ Hz, 1H), 4.10 (ddd, $J = 12.7, 4.3, 2.3$ Hz, 1H), 3.67 (s, 1H), 2.46 – 2.23 (m, 2H), 2.00 (s, 3H), 1.99 – 1.83 (m, 2H), 1.59 (s, 3H),

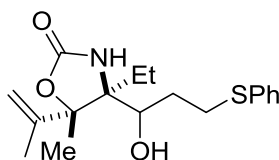
0.97 (s, 9H), 0.94 (t, $J = 7.8$ Hz, 3H), 0.23 (s, 3H), 0.18 (s, 3H). ^{13}C NMR (125 MHz, CDCl_3) δ 147.3, 114.9, 80.0, 73.9, 65.3, 63.7, 33.2, 26.6, 26.2, 24.2, 21.0, 18.3, 9.1, -2.7, -4.5. HRMS (ESI) m/z calculated for $\text{C}_{17}\text{H}_{39}\text{N}_2\text{O}_5\text{SSi}$ $[\text{M}+\text{NH}_4]^+$ 411.2344, found 411.2358.



Compound SI-01. A 50 mL, one-neck roundbottom flask was charged with compound **25** (432 mg, 1.10 mmol, 1 equiv) and 8.5 mL THF (0.13 M). The flask was cooled to 0 °C in an ice bath, then tetrabutylammonium fluoride (1.0 M in THF, 1.32 mL, 1.32 mmol, 1.2 equiv) was added via syringe. The flask was removed from the cold bath and stirred at rt for 40 min, poured into a separatory funnel, diluted with EtOAc and washed successively with two portions of saturated NH_4Cl solution and one portion of brine. The organic layer was dried over Na_2SO_4 , concentrated by rotary evaporation and purified by column chromatography (30% to 80% EtOAc/hexanes) to give 263 mg (0.942 mmol, 86%) of **SI-01** as a faintly yellow solid. ^1H NMR (500 MHz, CDCl_3) δ 5.93 (bs, 1H), 5.12 (bs, 1H), 5.11 (s, 1H), 4.79 (t, $J = 12.5$ Hz, 1H), 4.52 (m, 1H), 4.12 (dt, $J = 12.5, 3.1$ Hz, 1H), 3.28 (t, $J = 1.5$ Hz, 1H), 2.64 (s, 1H), 2.36 (m, 2H), 2.02 (s, 3H), 1.87 (m, 2H), 1.68 (s, 3H), 0.97 (t, $J = 7.7$ Hz, 3H). ^{13}C NMR (125 MHz, CDCl_3) δ 147.4, 115.9, 81.1, 70.8, 65.1, 64.1, 33.3, 27.0, 24.0, 21.2, 9.1. HRMS (ESI) m/z calculated for $\text{C}_{11}\text{H}_{25}\text{N}_2\text{O}_5\text{S}$ $[\text{M}+\text{NH}_4]^+$ 297.1479, found 297.1471. A sample of this compound suitable for X-ray crystallographic analysis was prepared.

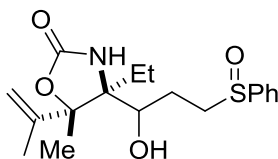


Compound 26. Compound **SI-01** (127 mg, 0.455 mmol, 1 equiv) and DMAP (139 mg, 1.14 mmol, 2.5 equiv) were added to a 50 mL screwcap pressure vial and dissolved in 9.1 mL MeCN (0.05 M). Triphosgene (149 mg, 0.501 mmol, 1.1 equiv) was added in one portion, and the vial was immediately sealed and immersed in a 70 °C oil bath. After 1 h, the vial was cooled to rt and the solvent removed by rotary evaporation. The resulting crude material was purified by column chromatography (30% to 90% EtOAc/hexanes) to give 77.1 mg (0.253 mmol, 56%) of **26** as a white powder. ¹H NMR (500 MHz, d₆-acetone) δ 5.23 (s, 1H), 5.20 (q, *J* = 1.4 Hz, 1H), 5.00 (t, *J* = 12.4 Hz, 1H), 4.81 (d, *J* = 3.6 Hz, 1H), 4.51 (m, 1H), 4.48 (dt, *J* = 12.4, 3.2 Hz, 1H), 2.52 (m, 1H), 2.48 (m, 1H), 1.99 (m, 1H), 1.94 (d, *J* = 1.4 Hz, 3H), 1.89 (s, 3H), 1.85 (m, 1H), 0.95 (t, *J* = 7.6 Hz, 3H). ¹³C NMR (125 MHz, d₆-acetone) δ 151.6, 147.1, 117.3, 88.0, 73.3, 68.6, 67.4, 33.3, 24.2, 21.6, 20.0, 8.1. HRMS (ESI) *m/z* calculated for C₁₂H₂₃N₂O₆S [M+NH₄]⁺ 323.1272, found 323.1277.



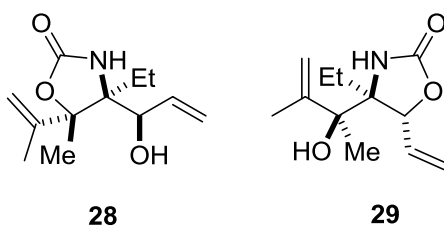
Compound 27. A 10 mL roundbottom flask was charged with compound **26** (82.0 mg, 0.269 mmol, 1 equiv) and 3 mL MeCN (0.09 M). Thiophenol (66.0 μL, 0.648 mmol, 2.4 equiv) and potassium carbonate (74.0 mg, 0.538 mmol, 2 equiv) were added in sequence, the flask was capped with a septum and sonicated at rt for 1 h. The resulting white, sludgy mixture was

diluted with 5 mL EtOAc and 5 mL 0.5 M HCl, then stirred vigorously at rt for 8 h. The biphasic solution was quenched with saturated NaHCO₃ and extracted twice with EtOAc. The combined organic layers were washed with saturated NaHCO₃ and brine, concentrated by rotary evaporation and purified by silica gel chromatography (10% to 70% EtOAc/hexanes) to afford **27** (78.5 mg, 0.234 mmol, 87%) as a colorless oil. ¹H NMR (500 MHz, CDCl₃) δ 7.35 (d, *J* = 7.7 Hz, 2H), 7.29 (t, *J* = 7.7 Hz, 2H), 7.18 (t, *J* = 7.2 Hz, 1H), 6.39 (bs, 1H), 5.03 (s, 1H), 5.01 (s, 1H), 4.14 (t, *J* = 6.3 Hz, 1H), 3.25 (dt, *J* = 13.4, 5.8 Hz, 1H), 3.07 (dt, *J* = 13.4, 7.5 Hz, 1H), 2.17 (s, 1H), 1.80 (s, 3H), 1.78 (m, 2H), 1.66 (m, 1H), 1.54 (s, 3H), 1.51 (m, 1H), 0.83 (t, *J* = 7.4 Hz, 3H). ¹³C NMR (125 MHz, CDCl₃) δ 159.3, 144.6, 135.8, 129.3, 129.2, 126.4, 115.2, 90.5, 71.5, 68.1, 30.9, 30.3, 24.9, 22.4, 20.9, 8.6. HRMS (ESI) *m/z* calculated for C₁₈H₂₉N₂O₃S [M+NH₄]⁺ 353.1894, found 353.1898.



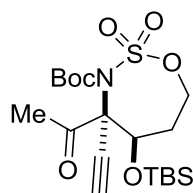
Compound SI-02. A 1.5 dram screwcap vial was charged with compound **27** (78.5 mg, 0.234 mmol, 1 equiv) and phenol (303 mg, 3.23 mmol, 13.8 equiv). The mixture was homogenized by adding 20 μL H₂O and sonicating the vial for 30 sec, then 30% aqueous H₂O₂ was added (53.5 μL, 0.538 mmol, 2.3 equiv). The vial was capped and stirred at rt for 1 h. The crude reaction was loaded onto a silica gel column with ~1 mL CH₂Cl₂ and purified (50% to 100% EtOAc, then 5% MeOH/EtOAc) to afford **SI-02** (64.5 mg, 0.183 mmol, 78%) as a white foam. The product was characterized as a 1:1 mixture of diastereomers (epimeric at S). ¹H NMR (500 MHz, CDCl₃) δ 7.62 (m, 4H), 7.55 – 7.47 (m, 6H), 6.95 (s, 1H), 6.77 (s, 1H), 5.07 (s, 1H), 5.05 (s, 1H), 5.04 (s,

2H), 4.53 (d, $J = 7.4$ Hz, 1H), 4.48 (d, $J = 7.0$ Hz, 1H), 4.06 (ddd, $J = 10.4, 7.1, 2.7$ Hz, 1H), 3.90 (ddd, $J = 11.1, 7.0, 2.5$ Hz, 1H), 3.26 (ddd, $J = 13.6, 7.6, 5.8$ Hz, 1H), 3.16 – 2.99 (m, 2H), 2.89 (dt, $J = 14.1, 7.2$ Hz, 1H), 2.06 (m, 1H), 1.95 (m, 1H), 1.92 (s, 3H), 1.89 (s, 3H), 1.87 (m, 1H), 1.82 (s, 1H), 1.69 (s, 3H), 1.67 (m, 2H), 1.62 (s, 3H), 1.53 (m, 2H), 0.82 (t, $J = 7.6$ Hz, 3H), 0.80 (t, $J = 7.6$ Hz, 3H). ^{13}C NMR (125 MHz, CDCl_3) δ 159.8, 159.6, 146.0, 145.8, 143.0, 142.8, 131.3, 131.3, 129.6, 129.5, 124.3, 124.2, 115.1, 115.0, 89.9, 89.8, 71.3, 70.6, 67.9, 67.9, 53.5, 53.4, 25.1, 25.0, 24.9, 24.8, 22.1, 22.1, 20.7, 20.7, 8.6, 8.5. HRMS (ESI) m/z calculated for $\text{C}_{18}\text{H}_{26}\text{NO}_4\text{S}$ $[\text{M}+\text{H}]^+$ 352.1578, found 352.1585.



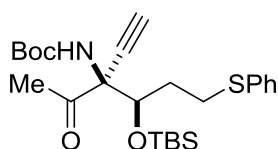
Compounds 28 and 29. A 50 mL screwcap pressure vial was charged with compound **SI-02** (64.5 mg, 0.183 mmol, 1 equiv) and 12 mL toluene (0.015 M). Sodium bicarbonate (61.7 mg, 0.734 mmol, 4 equiv) was added, and the vial was capped and heated to 125 °C for 16 h. The solution was cooled to rt and diluted with EtOAc, then washed with successive portions of H_2O and brine. The organic layer was dried over Na_2SO_4 , concentrated by rotary evaporation and purified by silica gel chromatography (10% to 50% EtOAc/hexanes) to afford 13.6 mg of the major diene isomer **29**, and 10.9 mg of the minor isomer **28** (combined: 24.5 mg, 0.109 mmol, 60% combined yield, 1.25:1 ratio), both as colorless oils. Compound **29**: ^1H NMR (500 MHz, CDCl_3) δ 5.96 (ddd, $J = 16.9, 10.8, 5.7$ Hz, 1H), 5.93 (bs, 1H), 5.54 (dt, $J = 16.9, 1.4$ Hz, 1H), 5.39 (dt, $J = 10.8, 1.4$ Hz, 1H), 5.30 (app d, $J = 5.7$ Hz, 1H), 5.09 (m, 2H), 2.28 (s, 1H), 1.88 (d, $J = 0.8$ Hz, 3H), 1.77 (m, 1H), 1.73 – 1.64 (m, 1H), 1.39 (s, 3H), 0.96 (t, $J = 7.4$ Hz, 3H). ^{13}C

NMR (125 MHz, CDCl₃) δ 159.1, 148.3, 131.9, 119.9, 114.9, 81.6, 77.8, 69.1, 24.3, 23.1, 21.8, 8.6. HRMS (ESI) m/z calculated for C₁₂H₂₀NO₃ [M+H]⁺ 226.1438, found 226.1435. Compound **28**: ¹H NMR (500 MHz, CDCl₃) δ 5.99 (ddd, J = 17.2, 10.4, 7.3 Hz, 1H), 5.93 (s, 1H), 5.46 (dt, J = 17.2, 1.2 Hz, 1H), 5.36 (dt, J = 10.4, 1.2 Hz, 1H), 5.14 (s, 1H), 5.04 (p, J = 1.2 Hz, 1H), 4.47 (d, J = 7.3 Hz, 1H), 2.52 (s, 1H), 1.88 (bs, 3H), 1.75 (m, 1H), 1.68 (s, 3H), 1.54 (dq, J = 14.8, 7.5 Hz, 1H), 0.91 (t, J = 7.5 Hz, 3H). ¹³C NMR (125 MHz, CDCl₃) δ 158.8, 144.7, 136.0, 119.6, 114.8, 89.8, 74.7, 67.4, 25.2, 22.5, 20.8, 8.4. HRMS (ESI) m/z calculated for C₁₂H₂₀NO₃ [M+H]⁺ 226.1438, found 226.1431.

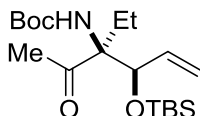


Compound 30. A flame dried roundbottom flask equipped with a stir bar was charged with **24** (503 mg, 1.45 mmol, 1.0 equiv), Boc₂O (478 mg, 2.19 mmol, 1.5 equiv), triethylamine (0.22 ml, 1.58 mmol, 1.10 equiv) and THF (14.5 mL, 0.099 M). DMAP (163 mg, 0.146 mmol, 0.09 equiv) was then added to the solution. The reaction progress was monitored closely by TLC, which showed complete consumption of starting material after 20 min. The reaction mixture was quenched with saturated NH₄Cl and extracted 3x with portions of CH₂Cl₂. The combined organics were washed with brine, dried with sodium sulfate and then filtered. The solvent was removed and the crude material was purified by flash chromatography (0 to 10% EtOAc/Hexanes in 2% increments). The product **30** was isolated as a white solid (592 mg, 1.32 mmol, 91% yield) that was stable at rt and could be stored for long periods of time in a -78 °C freezer. Rotamer issues led to an uninterpretable NMR spectrum at rt in CDCl₃. These issues

were solved by taking NMR spectra in toluene-d₈ at 90 °C. ¹H NMR (500 MHz, toluene-d₈, 90 °C) δ 4.93 (dd, *J* = 7.7, 1.7 Hz, 1H), 4.20 (br t, *J* = 8.6 Hz, 1H), 3.90 (ddd, *J* = 11.5, 8.4, 2.6 Hz, 1H), 2.53 – 2.38 (m, 1H), 2.34 (s, 3H), 2.23 (s, 1H), 1.76 (dd, *J* = 16.4, 7.4 Hz, 1H), 1.37 (s, 9H), 0.83 (s, 9H), 0.12 (s, 3H), -0.00 (s, 3H). ¹³C NMR (126 MHz, Toluene-d₈, 90 °C) δ 195.90, 151.51, 85.30, 81.75, 76.87, 75.99, 68.97, 68.43, 34.66, 28.11, 27.95, 26.15, 26.11, 18.27, -4.07, -5.06. HRMS (ESI) *m/z* calculated for C₁₉H₃₃NO₇SiS [M+Na]⁺ 470.1639, found 470.1636.

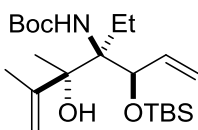


Compound 31. A 1.5 dram vial equipped with a stir bar was charged with **30** (97.2 mg, 0.217 mmol, 1.0 equiv), MeCN (1.10 mL, 0.20 M of **30**) and thiophenol (55 μL, 0.54 mmol, 2.5 equiv). K₂CO₃ (63.0 mg, 0.456 mmol, 2.1 equiv) was then added and the reaction was stirred for 15 h, after which the reaction was quenched with 0.5 M HCl. The aqueous layer was extracted with EtOAc and the combined organics washed with saturated NaHCO₃. Following a brine wash, the organics were dried over sodium sulfate, filtered and the solvent removed. The crude material was purified by flash chromatography (0 to 10% EtOAc/Hexanes), yielding **31** (101 mg, 0.212 mmol, 98% yield) as a clear oil. ¹H NMR (500 MHz, CDCl₃) δ 7.34 – 7.30 (m, 2H), 7.28 (d, *J* = 7.4 Hz, 2H), 7.21 – 7.16 (m, 1H), 5.54 (s, 1H), 4.39 (dd, *J* = 6.5, 3.8 Hz, 1H), 3.08 (ddd, *J* = 13.1, 9.3, 5.1, 1H), 2.92 (ddd, *J* = 13.1, 9.1, 6.9 Hz, 1H), 2.50 (s, 1H), 2.42 (s, 3H), 1.99 (dddd, *J* = 13.6, 9.4, 6.9, 4.0 Hz, 1H), 1.87 – 1.78 (m, 1H), 1.45 (s, 9H), 0.90 (s, 9H), 0.15 (s, 3H), 0.09 (s, 3H). ¹³C NMR (126 MHz, CDCl₃) δ 200.67, 153.35, 134.65, 128.58, 127.92, 125.20, 79.38, 74.52, 72.61, 65.13, 32.33, 29.35, 27.32, 25.74, 24.88, 17.15, -4.92, -5.21. HRMS (ESI) *m/z* calculated for C₂₅H₄₀NO₄SiS [M+H]⁺ 478.2442, found 478.2242.



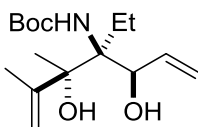
Compound 32. A 1.5 dram vial with stir bar was charged with **31** (264 mg, 0.553 mmol, 1.0 equiv) and phenol (1.28 g, 13.6 mmol, 24.6 equiv). H₂O₂ (30% in H₂O, 0.25 mL, 2.21 mmol, 4.0 equiv) was added and the solids became a slurry within 10 min. The reaction was quenched with a Na₂S₂O₃ solution after 30 min, diluted with water and K₂CO₃ (1.8 g, 13.0 mmol, 23.5 equiv) and extracted 2x with portions of EtOAc. The combined organics were washed with brine, dried with Na₂SO₄ and filtered. The solvent was removed and the crude material was passed through a silica gel column to remove the residual phenol (5 to 50% EtOAc/Hexanes). The product was a ~1:1 mixture of diastereomers, which was carried on to the next step without further purification. The sulfoxide was dissolved in EtOAc (55 mL, 0.01 M) in a Parr reactor. CHCl₃ (0.70 mL, 0.8 M) was then added and the solution was sparged with nitrogen. A portion of 5% Pd/C (555 mg, 200%) was added to the mixture and the reactor pressurized with hydrogen gas to 750 psi. After 13 h, the pressure was relieved and the solution was filtered through Celite. The solvent was removed and the crude material was dissolved in xylenes (22.0 mL, 0.025 M) in an oven-dried 100 mL pressure tube equipped with a stir bar. NaHCO₃ (187 mg, 2.22 mmol, 4.0 equiv) was added and the reaction mixture was heated to 130 °C for 15 h. The reaction was cooled to rt, diluted with H₂O and extracted with EtOAc. The combined organics were washed with brine, dried with Na₂SO₄ and filtered. The EtOAc was removed under reduced pressure. The crude material was passed through a silica plug to remove the xylenes (100% Hexanes until all the xylenes had eluted, then 100% EtOAc to elute the remaining material). The crude material was purified by flash chromatography (0 to 20% EtOAc/Hex, product eluting at 6% EtOAc/Hex), yielding slightly impure **32** (140 mg, 0.38 mmol, 68% yield) as an oil. ¹H NMR (500 MHz,

CDCl₃) δ 5.88 (s, 1H), 5.63 (ddd, *J* = 16.9, 10.4, 6.4 Hz, 1H), 5.19 (dt, *J* = 17.1, 1.5 Hz, 1H), 5.13 (dt, *J* = 10.5, 1.5 Hz, 1H), 4.84 (d, *J* = 6.3 Hz, 1H), 2.54 (dq, *J* = 15.0, 7.6 Hz, 1H), 2.27 (s, 3H), 2.19 – 2.08 (m, 1H), 1.43 (d, *J* = 3.5 Hz, 9H), 0.94 (s, 9H), 0.70 (t, *J* = 7.5 Hz, 3H), 0.18 (s, 3H), 0.05 (s, 3H). ¹³C NMR (126 MHz, CDCl₃) δ 207.57, 153.87, 136.52, 117.02, 78.87, 74.36, 71.74, 28.40, 27.08, 25.90, 23.42, 18.09, 7.96, -4.27, -4.77. HRMS (ESI) *m/z* calculated for C₁₉H₃₈NO₄Si [M+H]⁺ 372.2565, found 372.2568.



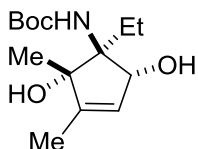
Compound 33. A 50 mL roundbottom flask taken into a nitrogen-filled glovebox and charged with a solution of CeCl₃-2LiCl (0.35 M in THF, 3.1 mL, 1.1 mmol, 10 equiv). The flask was sealed with a septum, removed from the glovebox and placed under nitrogen. The flask was cooled to -78 °C before isopropylmagnesium bromide (0.5 M in THF, 2.15 mL, 1.1 mmol, 10 equiv) was added dropwise over approximately 1 min. While the organometallic solution stirred at -78 °C, a conical vial was charged with **32** (40.4 mg, 0.109 mmol, 1 equiv) in the glovebox, fitted with a septum, removed from the glovebox and placed under nitrogen. After the cerium solution had stirred for 1 h at -78 °C, the brown slurry was quickly placed in a pre-cooled bath at -40 °C. A solution of **32** dissolved in THF (1.0 mL) was then cannulaed over to the organocerium solution dropwise. The flask was rinsed with more THF (1.0 mL) and again cannulaed to the organocerium solution in a dropwise fashion. This mixture was allowed to stand for 15 h before the reaction was quenched by dropwise addition of acetic acid (1.0 mL), during which the mixture became a colorless, clear solution. This solution was diluted with water and the aqueous mixture extracted three times with EtOAc. The combined organics were washed

with saturated NaHCO_3 and then brine, dried with sodium sulfate and concentrated by rotary evaporation. The crude material was purified by silica gel (0 to 5% EtOAc/Hex), yielding 27.4 mg of **33** (0.0662 mmol, 61%) as a clear oil in >20:1 *dr*. ^1H NMR (500 MHz, CDCl_3) δ 6.06 (ddd, $J = 17.5, 10.4, 7.5$ Hz, 1H), 5.41 (s, 1H), 5.32 – 5.25 (m, 2H), 5.24 (s, 1H), 5.10 (d, $J = 1.6$ Hz, 1H), 4.94 (t, $J = 1.5$ Hz, 1H), 4.37 (d, $J = 7.5$ Hz, 1H), 2.49 (dq, $J = 14.9, 7.5$ Hz, 1H), 1.88 (d, $J = 1.3$ Hz, 3H), 1.85 – 1.76 (m, 1H), 1.42 (s, 10H), 1.40 (s, 3H), 0.93 (s, 8H), 0.88 (t, $J = 7.3$ Hz, 3H), 0.11 (s, 3H), 0.05 (s, 3H). ^{13}C NMR (126 MHz, CDCl_3) δ 156.24, 150.40, 138.04, 118.43, 114.27, 80.72, 79.27, 78.07, 65.11, 28.52, 26.19, 25.97, 21.98, 18.24, 8.89, 1.17, -3.50, -4.95. HRMS (ESI) m/z calculated for $\text{C}_{22}\text{H}_{44}\text{NO}_4\text{Si}$ $[\text{M}+\text{H}]^+$ 414.3034, found 414.3030.



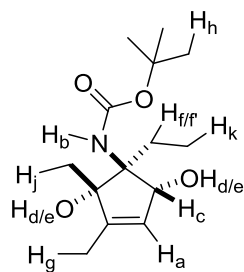
Compound SI-03. To a 20 mL scintillation vial containing **33** (25.6 mg, 0.0619 mmol, 1 equiv) was added THF (1.25 mL, 0.05 M of **33**). The mixture was briefly stirred and a solution of TBAF (1.0 M in THF, 0.62 mL, 0.62 mmol, 10 equiv) was added. The reaction was stirred for 30 min until TLC (10% EtOAc/Hex) indicated complete consumption of the starting material. The solution was diluted with EtOAc and water and the resulting aqueous layer extracted three times with EtOAc. The combined organics were washed with brine, dried with sodium sulfate and the solvent removed. The crude oil was purified by column chromatography (0 to 10% EtOAc/Hex), and **SI-03** (11.1 mg, 0.0371 mmol, 60% yield) was isolated as a clear oil with a minor impurity by NMR. ^1H NMR (500 MHz, CDCl_3) δ 6.07 (ddd, $J = 17.6, 10.3, 7.5$ Hz, 1H), 5.45 (s, 1H), 5.36 (dt, $J = 17.2, 1.3$ Hz, 1H), 5.25 (ddd, $J = 10.3, 1.6, 0.8$ Hz, 1H), 5.16 (d, $J = 0.9$ Hz, 1H), 5.08 (p, $J = 1.5$ Hz, 1H), 4.88 (s, 1H), 4.39 (t, $J = 8.0$ Hz, 1H), 4.33 (s, 1H), 1.90 – 1.87 (s, 3H),

1.77 (dq, $J = 15.2, 7.7$ Hz, 1H), 1.58 (s, 3H), 1.51 (dq, $J = 15.2, 7.6$ Hz, 1H), 1.45 (s, 9H), 0.92 (t, $J = 7.6$ Hz, 3H). ^{13}C NMR (126 MHz, CDCl_3) δ 157.76, 148.18, 137.18, 118.24, 115.35, 81.69, 80.15, 76.20, 65.21, 28.49, 27.14, 25.48, 21.79, 9.69. HRMS (ESI) m/z calculated for $\text{C}_{16}\text{H}_{30}\text{NO}_4$ $[\text{M}+\text{H}]^+$ 300.2169, found 300.2165.



Compound 14. A 1.5 dram vial containing **SI-03** (10.5 mg, 0.0351 mmol, 1 equiv) was taken into a nitrogen filled glovebox and charged with Grubbs-II catalyst (1.6 mg, 0.0019 mmol, 0.05 equiv). Toluene (0.62 mL, 0.06 M of **SI-03**) was added and the vial sealed before removing from the glovebox. The reaction progress was monitored by TLC, which showed the complete consumption of starting material after 1.25 h. The solvent was removed under reduced pressure. The crude red oil was purified by column chromatography (0 to 25% EtOAc/Hex), yielding **14** (8.7 mg, 0.032 mmol, 91%) as a clear oil with a minor impurity by NMR. ^1H NMR (500 MHz, CDCl_3) δ 5.32 (s, 1H), 5.09 (s, 1H), 4.51 (s, 1H), 3.32 – 2.85 (m, 2H), 1.92 (q, $J = 7.5$ Hz, 2H), 1.73 (t, $J = 2.0$ Hz, 3H), 1.45 (s, 9H), 1.17 (s, 3H), 0.91 (t, $J = 7.5$ Hz, 3H). ^{13}C NMR (126 MHz, CDCl_3) δ 157.16, 146.06, 124.78, 84.00, 80.55, 80.09, 72.75, 28.47, 23.27, 22.30, 11.64, 11.33. HRMS (ESI) m/z calculated for $\text{C}_{14}\text{H}_{26}\text{NO}_4$ $[\text{M}+\text{H}]^+$ 272.1856, found 372.1852. The stereochemistry at the C-5 position was confirmed by NOESY analysis as shown below in Figure 1.

Figure 1. NOE correlations in Compound **14**.

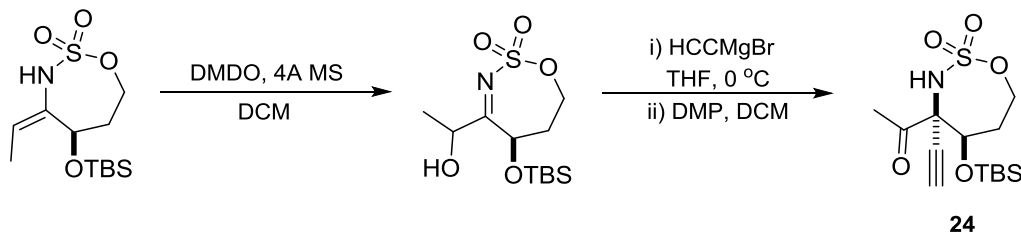


Observed NOE correlations

	H _a	H _b	H _c	H _d	H _e	H _{ff'}	H _g	H _h	H _j	H _k
H _b	0%	N/A	4.7%	0%	0%	1.4%	0%	0.9%	3.5%	1.0%
H _c	3.5%	3.5%	N/A	0.8%	1.0%	0.4%	0.2%	0.2%	2.8%	0.3%
H _f	0.4%	1.3%	0.4%	1.3%	1.7%	N/A	0.3%	0.4%	0.2%	7.0%
H _j	0.4%	3.8%	3.5%	0.6%	0.7%	0.3%	3.3%	0.7%	N/A	0.3%

III. X-ray crystallographic information.

Crystal Structure of **24** (CCDC-no. 1439718).



Preparation of Crystals: 60 mg of the colorless solid **24** were dissolved in 2 mL diethyl ether. Pentane was used for vapor diffusion over night at room temperature. The obtained crystals were air-stable and selected under microscope.

Data Collection: A colorless crystal with approximate dimensions 0.26 x 0.24 x 0.20 mm³ (block) with a mosaicity of 0.75 was selected under oil under ambient conditions and attached to the tip of a X-ray capillary (MiTeGenMicroMount[®]). The crystal was mounted in a stream of cold nitrogen at 100.0(15) K and centered in the X-ray beam by using a video camera. The crystal evaluation and data collection were performed on a three-circle Bruker SMART APEXII diffractometer with Copper K_α (α = 1.54178 Å) radiation and the diffractometer to crystal/detector distance of 4.96 cm. The initial cell constants were obtained from three series of ω scans at different starting angles. The reflections were successfully indexed by an automated indexing routine built in the APEXII program suite. The final cell constants were calculated from a set of 9514 strong from the actual data collection. The data were collected by using the full sphere data collection routine to survey the reciprocal space to the extent of a full sphere to a resolution of 0.83 Å. A total of 31048 reflection data were harvested by collecting 19 sets of frames with 0.7° scans in ω (15 runs) and φ (4 runs) with different exposure times per frame (4, 8 sec). These highly redundant datasets were corrected for Lorentz and polarization effects. The absorption correction was based on fitting a function to the empirical transmission surface as sampled by multiple equivalent measurements.^[5,6]

Structure Solution and Refinement: The systematic absences in the diffraction data were consistent for two orthorhombic, the centrosymmetric space group *Pbcm* and the non-centrosymmetric space group *Pca2₁*. The *E*-statistics strongly suggested the non-centrosymmetric space group *Pca2₁* that yielded chemically reasonable and computationally stable results of refinement.^[7,8] A successful solution by ShelXS-2013 provided most non-hydrogen atoms from the *E*-map and were refined using ShelXL-2013. All non-hydrogen atoms were refined with anisotropic displacement coefficients. All hydrogen atoms were included in the structure factor calculation at idealized positions and were allowed to ride on the neighboring atoms with relative isotropic displacement coefficients.

Table 1. Crystal data collection and structure solution refinement for **24**.

Parameter	NCG2072	Parameter	NCG2072
empiric formula	C ₁₄ H ₂₅ NO ₅ SiS	$\rho_{\text{calc.}}$ [g · cm ⁻³]	1.272
MW [g · mol ⁻¹]	347.50	crystal size [mm]	0.26 × 0.24 × 0.20
X-ray lab code	Schomaker42	T [K]	100.0(15)
a [Å]	16.204(3)	radiation type / λ [nm]	Cu K α / 1.54178
b [Å]	10.0147(17)	μ [mm ⁻¹]	5.427
c [Å]	11.186(2)	F(000)	744.0
α [°]	90.000°	Reflections collected	29296
β [°]	90.000°	Independent reflections	3495 [R _{int} = 0.0254]
γ [°]	90.000°	Data/restraints/parameters	3495/1/209
V [Å ³]	1815.1(6)	Goof on F ²	1.124
Z	4	Largest diff. peak/hole [eÅ ⁻³]	0.99/-0.28
crystal system	orthorhombic	2 θ range for data collection	5.72 to 136.76°
crystal color	colorless	Final R ₁ ^[a] / wR ₂ ^[b] all data	0.0333 / 0.0920
space group	Pca2 ₁	Final R ₁ ^[a] / wR ₂ ^[b] I>2s(I)	0.0330 / 0.0919
Flack parameter	0.046(5)		

^[a] $R_1 = \sum |F_o| - |F_c| / \sum |F_o|$; ^[b] $wR_2 = [\sum \{w(F_o^2 - F_c^2)^2\} / \sum \{w(F_o^2)^2\}]^{1/2}$

The final least-squares refinement of 209 parameters against 29296 data resulted in $R = 0.0330$ (based on F^2 for I>2s) and $wR_2 = 0.0920$ (based on F^2 for all data), respectively. The final structure was visualized using Interactive Molecular Graphics. ^[9]

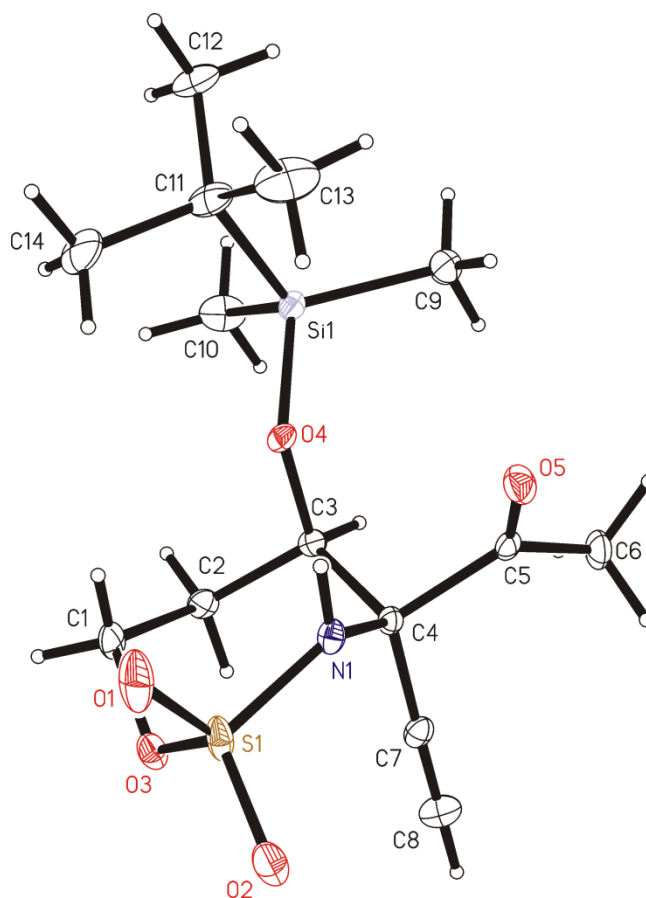


Figure 2. Thermal-ellipsoid of **24** are set with 50 % probability.

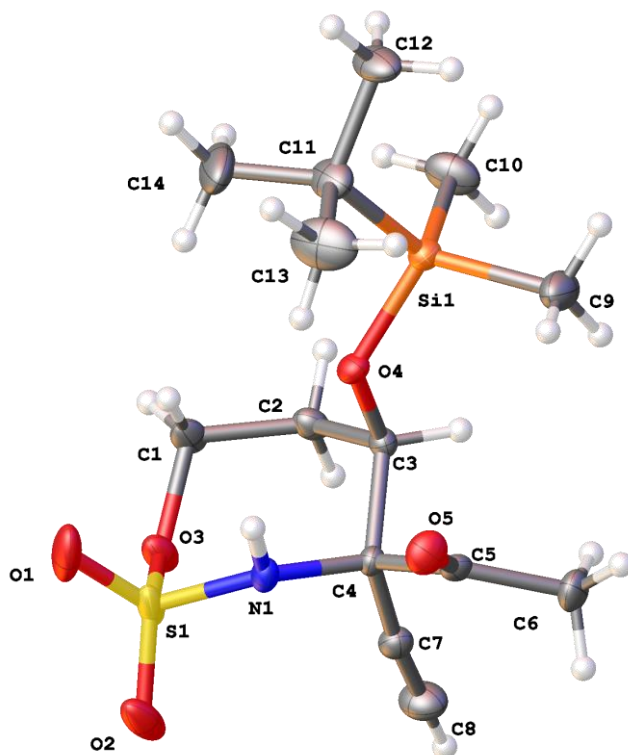


Table 2. Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for **24**. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij} tensor.

Atom	x	y	z	U_{eq}
S1	1375.1(4)	5503.4(8)	992.7(7)	25.2(2)
Si1	874.8(4)	1043.9(7)	-1770.8(8)	18.40(19)
O1	2107.1(15)	4924(3)	1470(3)	40.7(7)
O2	1006.3(16)	6596(3)	1599(2)	37.6(6)
O3	1526.2(14)	6050(2)	-297(2)	25.6(5)
O4	924.2(12)	2479(2)	-995.8(19)	17.8(4)
O5	-263.3(13)	2290(2)	1129(2)	27.2(5)
N1	731.3(14)	4277(3)	837(2)	17.8(5)
C1	1775.2(18)	5089(3)	-1227(3)	24.4(6)
C2	1026.7(18)	4645(3)	-1923(3)	20.5(6)
C3	468.9(16)	3636(3)	-1290(3)	15.7(5)
C4	95.7(16)	4170(3)	-82(3)	15.3(5)
C5	-498.2(17)	3061(3)	387(3)	18.1(6)
C6	-1342.9(18)	3003(3)	-152(3)	27.6(7)
C7	-351.7(18)	5414(3)	-310(3)	21.0(6)
C8	-733(2)	6360(4)	-607(4)	32.2(7)
C9	-149(2)	250(3)	-1581(4)	35.0(9)

C10	1016(3)	1377(4)	-3399(3)	34.4(8)
C11	1745(2)	39(3)	-1143(3)	30.3(7)
C12	1872(2)	-1217(3)	-1904(4)	34.7(8)
C13	1535(3)	-354(5)	162(4)	48.8(11)
C14	2543(2)	876(4)	-1182(5)	50.8(12)

Table 3. Anisotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for **24**. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^*^2U_{11}+\dots+2hka \times b \times U_{12}]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S1	18.8(3)	40.5(4)	16.3(4)	-8.7(3)	2.8(3)	-13.4(3)
Si1	15.9(3)	19.0(4)	20.2(4)	-0.8(3)	0.2(3)	1.7(3)
O1	20.9(12)	72.7(18)	28.4(13)	-4.9(13)	-6.2(10)	-14.4(12)
O2	41.0(14)	43.6(14)	28.2(13)	-18.3(11)	16.1(11)	-21.8(11)
O3	26.3(11)	30.1(12)	20.5(12)	-8.0(9)	8.2(9)	-12.2(8)
O4	14.6(9)	19.4(9)	19.4(11)	-1.2(8)	-0.9(7)	3.6(7)
O5	24.9(10)	28.3(11)	28.5(12)	6.6(10)	3.9(10)	-2.8(8)
N1	13.5(10)	25.2(12)	14.6(13)	-1(1)	-1.1(9)	-1.9(9)
C1	22.2(14)	31.4(15)	19.6(15)	-7.0(12)	10.2(13)	-9.0(12)
C2	23.8(14)	21.0(13)	16.6(16)	-3.2(11)	2.8(12)	-1.9(10)
C3	14.6(11)	16.3(12)	16.1(13)	-2.2(10)	-1.7(10)	-0.2(10)
C4	11.4(12)	18.0(12)	16.5(14)	-2.2(11)	-0.4(10)	-0.9(10)
C5	15.2(13)	20.1(13)	18.9(14)	-5.3(12)	5(1)	-0.6(11)
C6	15.2(14)	34.2(17)	33.4(18)	-4.5(14)	1.4(13)	-6.4(12)
C7	18.5(14)	24.4(14)	20.0(15)	-3.3(11)	1.3(12)	0.8(11)
C8	36.8(18)	26.1(16)	33.7(19)	-2.1(14)	-2.9(15)	9.8(14)
C9	24.1(16)	29.0(16)	52(2)	-12.3(16)	5.3(15)	-4.0(13)
C10	53(2)	31.8(16)	18.7(16)	0.6(14)	-1.9(15)	6.8(16)
C11	31.0(17)	29.2(16)	30.8(18)	-2.0(14)	-10.8(15)	11.9(13)
C12	38.2(17)	29.1(16)	37(2)	-9.0(15)	-11.1(16)	18.5(13)
C13	73(3)	47(2)	26(2)	8.8(17)	-11(2)	22(2)
C14	21.4(16)	47(2)	83(4)	-21(2)	-17(2)	7.2(16)

Table 4. Bond Lengths for **24**.

Atom	Atom	Length/ \AA	Atom	Atom	Length/ \AA
S1	O2	1.419(3)	N1	C4	1.459(4)
S1	O1	1.424(3)	C1	C2	1.508(4)
S1	O3	1.563(2)	C2	C3	1.529(4)
S1	N1	1.621(2)	C3	C4	1.574(4)
Si1	O4	1.680(2)	C4	C7	1.464(4)
Si1	C9	1.851(3)	C4	C5	1.560(4)

Si1	C10	1.866(4)	C5	C6	1.497(4)
Si1	C11	1.869(3)	C7	C8	1.179(5)
O3	C1	1.473(4)	C11	C12	1.533(5)
O4	C3	1.413(3)	C11	C14	1.542(5)
O5	C5	1.196(4)	C11	C13	1.550(6)

Table 5. Bond Angles for **24**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O2	S1	O1	119.07(18)	O4	C3	C4	106.2(2)
O2	S1	O3	103.70(15)	C2	C3	C4	113.6(2)
O1	S1	O3	110.99(15)	N1	C4	C7	114.2(2)
O2	S1	N1	111.40(13)	N1	C4	C5	104.5(2)
O1	S1	N1	105.51(16)	C7	C4	C5	111.0(2)
O3	S1	N1	105.49(12)	N1	C4	C3	111.0(2)
O4	Si1	C9	110.52(13)	C7	C4	C3	109.2(2)
O4	Si1	C10	110.19(14)	C5	C4	C3	106.5(2)
C9	Si1	C10	107.4(2)	O5	C5	C6	123.1(3)
O4	Si1	C11	103.33(13)	O5	C5	C4	119.8(3)
C9	Si1	C11	113.67(17)	C6	C5	C4	117.2(3)
C10	Si1	C11	111.74(17)	C8	C7	C4	173.1(4)
C1	O3	S1	117.7(2)	C12	C11	C14	108.5(3)
C3	O4	Si1	123.84(18)	C12	C11	C13	110.2(3)
C4	N1	S1	125.8(2)	C14	C11	C13	110.4(4)
O3	C1	C2	109.7(2)	C12	C11	Si1	109.5(2)
C1	C2	C3	115.5(3)	C14	C11	Si1	109.2(2)
O4	C3	C2	109.9(2)	C13	C11	Si1	109.0(3)

Table 6. Torsion Angles for **24**.

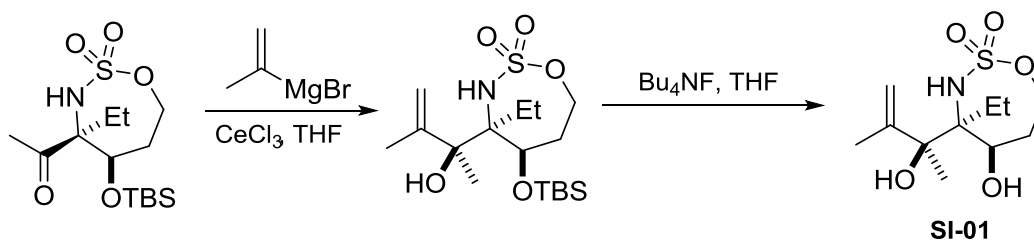
A	B	C	D	Angle/°	A	B	C	D	Angle/°
O2	S1	O3	C1	-169.7(2)	O4	C3	C4	C7	177.1(2)
O1	S1	O3	C1	61.3(2)	C2	C3	C4	C7	56.1(3)
N1	S1	O3	C1	-52.5(2)	O4	C3	C4	C5	-62.9(3)
C9	Si1	O4	C3	-68.6(3)	C2	C3	C4	C5	176.1(2)
C10	Si1	O4	C3	49.9(3)	N1	C4	C5	O5	-19.7(3)
C11	Si1	O4	C3	169.5(2)	C7	C4	C5	O5	-143.3(3)
O2	S1	N1	C4	81.0(3)	C3	C4	C5	O5	97.9(3)
O1	S1	N1	C4	-148.4(2)	N1	C4	C5	C6	161.7(2)
O3	S1	N1	C4	-30.9(3)	C7	C4	C5	C6	38.0(3)
S1	O3	C1	C2	96.3(3)	C3	C4	C5	C6	-80.8(3)
O3	C1	C2	C3	-76.2(3)	O4	Si1	C11	C12	-170.7(2)

Si1	O4	C3	C2	-102.1(2)	C9	Si1	C11	C12	69.5(3)
Si1	O4	C3	C4	134.55(19)	C10	Si1	C11	C12	-52.2(3)
C1	C2	C3	O4	-58.4(3)	O4	Si1	C11	C14	-51.9(3)
C1	C2	C3	C4	60.5(3)	C9	Si1	C11	C14	-171.8(3)
S1	N1	C4	C7	-42.2(3)	C10	Si1	C11	C14	66.5(3)
S1	N1	C4	C5	-163.73(19)	O4	Si1	C11	C13	68.8(3)
S1	N1	C4	C3	81.9(3)	C9	Si1	C11	C13	-51.1(3)
O4	C3	C4	N1	50.3(3)	C10	Si1	C11	C13	-172.8(3)
C2	C3	C4	N1	-70.7(3)					

Table 7. Hydrogen Atom Coordinates ($\text{\AA}\times 10^4$) and Isotropic Displacement Parameters ($\text{\AA}^2\times 10^3$) for **24**.

Atom	x	y	z	U(eq)
H1	970(20)	3513(19)	1000(40)	34(11)
H1A	2037	4321	-858	29
H1B	2170	5502	-1763	29
H2A	1211	4255	-2671	25
H2B	701	5428	-2118	25
H3	17	3388	-1827	19
H6A	-1566	2122	-54	41
H6B	-1310	3213	-988	41
H6C	-1695	3638	241	41
H8	-1033	7107	-841	39
H9A	-236	49	-751	53
H9B	-170	-560	-2039	53
H9C	-571	850	-1854	53
H10A	576	1935	-3681	52
H10B	1011	547	-3829	52
H10C	1535	1819	-3525	52
H12A	1366	-1713	-1941	52
H12B	2295	-1761	-1551	52
H12C	2035	-963	-2697	52
H13A	1413	436	615	73
H13B	1997	-806	513	73
H13C	1063	-934	166	73
H14A	2632	1197	-1980	76
H14B	3002	332	-942	76
H14C	2492	1622	-647	76

Crystal Structure of SI-01 (CCDC-no. 1439719).



Preparation of Crystals: A sample consisting of 25 mg racemic **SI-01** (column purified) was dissolved in 2 mL dichloromethane and crystallized by slow evaporation at room temperature slowly over three days. The air-stable crystals were selected using a microscope to choose the best sample for X-ray crystallography.

Data Collection: A colorless crystal with approximate dimensions 0.140 x 0.07 x 0.05 mm³ (needles) was selected under oil under ambient conditions and attached to the tip of a X-ray capillary (MiTeGenMicroMount[®]). The crystal was mounted in a stream of cold nitrogen at 100.0(15) K and centered in the X-ray beam by using a video camera. The crystal evaluation and data collection were performed on a three-circle Bruker Quazar SMART APEXII diffractometer with copper radiation K_α (λ = 1.54184 Å) and the diffractometer to crystal distance of 4.96 cm. The initial cell constants were obtained from three series of ω scans at different starting angles. Each series consisted of 35 frames collected at intervals of 0.7° in 25° range about ω with the exposure time of 10 seconds per frame. The reflections were successfully indexed by an automated indexing routine built in the APEXII program suite. The final cell constants were calculated from a set of 9893 strong from the actual data collection. The data were collected by using the full sphere data collection routine to survey the reciprocal space to the extent of a full sphere to a high-resolution of 0.83 Å. A total of 42352 reflection data were harvested by collecting 19 sets of frames with 0.7° scans in ω and φ with exposure times of 10/20 sec per frame. These highly redundant datasets were corrected for Lorentz and polarization effects. The absorption correction was based on fitting a function to the empirical transmission surface as sampled by multiple equivalent measurements.^[5,6]

Structure Solution and Refinement: The systematic absences in the diffraction data were consistent for the orthorhombic space groups $P2_12_12_1$. The E-statistics strongly suggested the chiral space group that yielded chemically reasonable and computationally stable results of refinement.^[7,8] The systematic absences in the diffraction data were uniquely consistent for the space group $P2_12_12_1$. A successful solution by the direct methods by using SHELX-2013 provided most non-hydrogen atoms from the E-map. Using Olex2, all non-hydrogen atoms were refined with anisotropic displacement coefficients. All hydrogen atoms were included in the structure factor calculation at idealized positions and were allowed to ride on the neighboring atoms with relative isotropic displacement coefficients. The only crystal large enough for the single-crystal X-ray diffraction experiment proved to be a non-merohedral twin with a 38.6(2)% second component contribution.

Table 8. Crystal data collection and structure solution refinement for **SI-01**.

Parameter	SI-01	Parameter	SI-01
empiric formula	C ₁₁ H ₂₁ NO ₅ S	$\rho_{\text{calc.}}$ [g · cm ⁻³]	1.427
MW [g · mol ⁻¹]	279.35	crystal size [mm]	0.14 x 0.07 x 0.05
X-ray lab code	Schomaker48	T [K]	100.0(2)
a [Å]	7.4335(15)	radiation type / λ [nm]	Cu K α / 1.54184
b [Å]	12.118(2)	μ [mm ⁻¹]	2.358
c [Å]	14.438(3)	F(000)	604.0
β [°]	90.000(0)°	Reflections collected	42352
α [°]	90.000(0)	Independent reflections	2451
γ [°]	90.000(0)°	Data/restraints/parameters	2461/0/179
V [Å ³]	1300.6(5)	Goof on F ²	1.045
Z	4	Largest diff. peak/hole [eÅ ⁻³]	0.22 / -0.31
crystal system	orthorhombic	Flack x parameter	0.160(21)
crystal color	colorless	Final $R_1^{[a]}$ / $wR_2^{[b]}$ all data	0.0280 / 0.0723
space group	$P2_12_12_1$	Final $R_1^{[a]}$ / $wR_2^{[b]}$ I>2s(I)	0.0274 / 0.0726

$$^{[a]} R_1 = \sum |F_o| - |F_c| / \sum |F_o| ; ^{[b]} wR_2 = [\sum \{w(F_o^2 - F_c^2)^2\} / \sum \{w(F_o^2)^2\}]^{1/2}$$

The final least-squares refinement of 221 parameters against 1442 data resulted in $R = 0.0274$ (based on F^2 for I>2s) and $wR_2 = 0.0723$ (based on F^2 for all data), respectively. The final structure was visualized using Interactive Molecular Graphics.^[9]

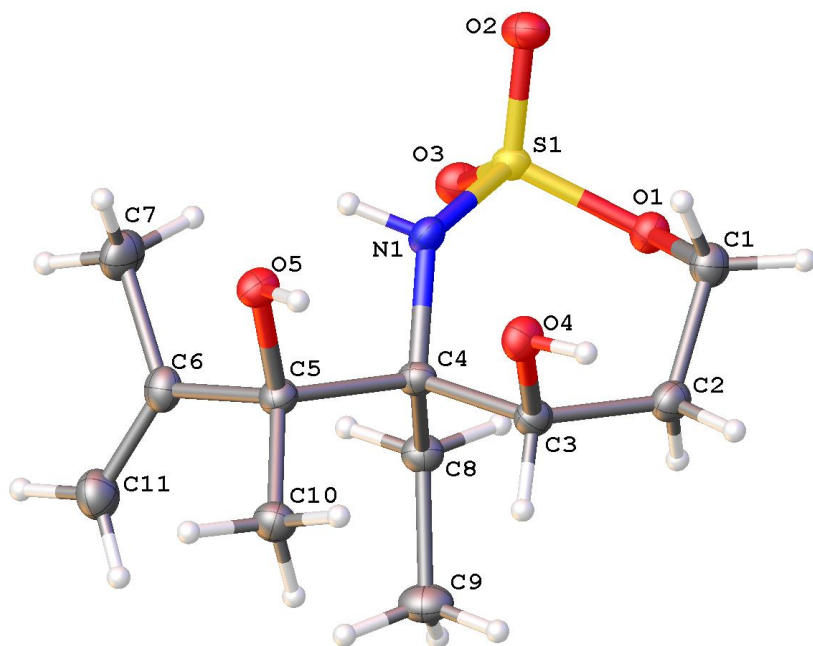


Figure 3. Thermal-ellipsoid of **SI-01** are set with 50 % probability.

Table 9. Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for **SI-01**. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{H} tensor.

Atom	x	y	z	U(eq)
S1	8641.2(8)	3744.4(5)	1987.1(4)	15.42(16)
O1	10731(2)	3794.4(15)	-706.5(12)	17.4(4)
O2	12505(3)	2389.3(14)	510.5(12)	19.5(4)
O3	8109(3)	4806.1(15)	2309.6(13)	21.8(4)
O4	7277(3)	2932.7(15)	1814.9(13)	21.8(4)
O5	9967(2)	3316.8(15)	2758.3(11)	18.1(4)
N6	9784(3)	3800.0(18)	1037.6(14)	16.4(4)
C7	11725(4)	4586(2)	-159.9(17)	17.0(5)
C8	11944(4)	5220(2)	1572.4(18)	17.7(5)
C9	13657(4)	4596(2)	-525.7(18)	20.4(5)
C10	12949(4)	2857(2)	2126.4(18)	19.8(6)
C11	10765(4)	5689(2)	-329.3(18)	19.0(6)
C12	12957(4)	3279(2)	1128.8(18)	17.6(5)
C13	13829(4)	5721(2)	1610(2)	24.9(6)
C14	11655(4)	6614(2)	-473(2)	26.0(6)
C15	11193(4)	2411(2)	2498.6(19)	19.9(5)
C16	11634(3)	4234(2)	913.7(17)	15.6(5)

C17 8727(4) 5684(2) -358(2) 27.0(6)

Table 10. Anisotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for **SI-01**. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+\dots+2hka \times b \times U_{12}]$.

Atom	U ₁₁	U ₂₂	U ₃₃	U ₂₃	U ₁₃	U ₁₂
S1	12.9(3)	17.1(3)	16.2(3)	-0.7(2)	1.4(2)	-0.5(2)
O1	17.7(9)	15.4(8)	19.3(8)	-3.9(7)	-1.4(7)	1.2(8)
O2	21.5(10)	15.4(8)	21.6(9)	-2.4(8)	-1.4(8)	4.4(8)
O3	19.6(9)	21.4(9)	24.3(9)	-3.2(8)	3.2(8)	2.3(8)
O4	18.0(9)	25.4(9)	22.1(9)	-1.9(8)	1.5(8)	-4.4(8)
O5	17.6(9)	20.0(8)	16.8(9)	-0.3(7)	0.1(8)	1.7(8)
N6	13.7(10)	19.5(10)	15.9(9)	0.8(9)	-1.5(8)	2.1(9)
C7	17.0(13)	17.0(12)	17.1(12)	-0.6(10)	-1.8(10)	-1.1(11)
C8	17.6(12)	16.9(11)	18.5(12)	-2.7(10)	0.7(10)	0.1(10)
C9	18.5(13)	21.8(13)	21.0(12)	0.7(11)	1.7(11)	-0.9(12)
C10	18.1(12)	19.3(12)	22.1(13)	0.8(11)	-2.2(11)	1.7(11)
C11	22.7(14)	19.0(13)	15.2(12)	-0.3(10)	-0.6(11)	3.2(11)
C12	15.2(12)	16.8(11)	20.8(12)	1(1)	-0.5(10)	0.5(11)
C13	21.6(13)	25.9(13)	27.1(14)	-6.7(12)	-0.2(12)	-6.3(12)
C14	29.5(17)	20.5(13)	27.9(14)	2.9(11)	-1.6(13)	2.1(12)
C15	20.8(13)	17.9(11)	20.8(12)	0.4(10)	-0.2(12)	3.1(11)
C16	13.8(12)	17.5(12)	15.4(11)	-1.1(10)	1(1)	-0.9(10)
C17	24.4(14)	22.9(14)	33.7(15)	2.6(12)	-4.6(13)	6.5(13)

Table 11. Bond Lengths for **SI-01**.

Atom	Atom	Length/ \AA	Atom	Atom	Length/ \AA
S1	O3	1.424(2)	C7	C11	1.535(4)
S1	O4	1.4344(19)	C7	C16	1.609(3)
S1	O5	1.5748(18)	C8	C13	1.528(4)
S1	N6	1.614(2)	C8	C16	1.545(3)
O1	C7	1.446(3)	C10	C12	1.528(4)
O2	C12	1.440(3)	C10	C15	1.512(4)
O5	C15	1.475(3)	C11	C14	1.318(4)
N6	C16	1.483(3)	C11	C17	1.516(4)
C7	C9	1.530(4)	C12	C16	1.550(3)

Table 12. Bond Angles for **SI-01**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O3	S1	O4	118.67(12)	C15	C10	C12	117.2(2)
O3	S1	O5	103.89(10)	C14	C11	C7	122.2(2)
O3	S1	N6	112.72(11)	C14	C11	C17	120.0(3)
O4	S1	O5	109.83(11)	C17	C11	C7	117.7(2)
O4	S1	N6	104.69(11)	O2	C12	C10	109.5(2)
O5	S1	N6	106.54(10)	O2	C12	C16	106.7(2)
C15	O5	S1	116.86(15)	C10	C12	C16	115.9(2)
C16	N6	S1	127.26(17)	O5	C15	C10	111.0(2)
O1	C7	C9	107.3(2)	N6	C16	C7	104.43(19)
O1	C7	C11	104.7(2)	N6	C16	C8	109.8(2)
O1	C7	C16	109.18(19)	N6	C16	C12	107.4(2)
C9	C7	C11	112.0(2)	C8	C16	C7	112.4(2)
C9	C7	C16	112.0(2)	C8	C16	C12	111.1(2)
C11	C7	C16	111.4(2)	C12	C16	C7	111.4(2)
C13	C8	C16	117.8(2)				

Table 13. Torsion Angles for **SI-01**.

A	B	C	D	Angle/°	A	B	C	D	Angle/°
S1	O5	C15	C10	90.7(2)	C9	C7	C11	C17	156.8(2)
S1	N6	C16	C7	-155.30(19)	C9	C7	C16	N6	-156.2(2)
S1	N6	C16	C8	-34.6(3)	C9	C7	C16	C8	84.9(3)
S1	N6	C16	C12	86.3(2)	C9	C7	C16	C12	-40.5(3)
O1	C7	C11	C14	-137.1(3)	C10	C12	C16	N6	-64.7(3)
O1	C7	C11	C17	40.9(3)	C10	C12	C16	C7	-178.5(2)
O1	C7	C16	N6	-37.5(2)	C10	C12	C16	C8	55.3(3)
O1	C7	C16	C8	-156.5(2)	C11	C7	C16	N6	77.6(2)
O1	C7	C16	C12	78.1(3)	C11	C7	C16	C8	-41.4(3)
O2	C12	C16	N6	57.4(2)	C11	C7	C16	C12	-166.8(2)
O2	C12	C16	C7	-56.4(3)	C12	C10	C15	O5	-78.1(3)
O2	C12	C16	C8	177.4(2)	C13	C8	C16	N6	174.8(2)
O3	S1	O5	C15	-160.91(17)	C13	C8	C16	C7	-69.4(3)
O3	S1	N6	C16	69.5(2)	C13	C8	C16	C12	56.1(3)
O4	S1	O5	C15	71.17(19)	C15	C10	C12	O2	-61.4(3)
O4	S1	N6	C16	-160.1(2)	C15	C10	C12	C16	59.2(3)
O5	S1	N6	C16	-43.8(2)	C16	C7	C11	C14	105.0(3)
N6	S1	O5	C15	-41.7(2)	C16	C7	C11	C17	-76.9(3)
C9	C7	C11	C14	-21.2(4)					

Table 14. Hydrogen Atom Coordinates ($\text{\AA}\times 10^4$) and Isotropic Displacement Parameters ($\text{\AA}^2\times 10^3$) for **SI-01**.

Atom	x	y	z	U(eq)
H1	11365	3254	-808	26
H2	13132	1851	629	29
H6	9111	4090	619	20
H8A	11110	5801	1399	21
H8B	11626	4986	2194	21
H9A	14141	3862	-504	31
H9B	14378	5076	-149	31
H9C	13663	4856	-1154	31
H10A	13847	2279	2176	24
H10B	13330	3457	2526	24
H12	14177	3529	981	21
H13A	14111	6049	1022	37
H13B	14689	5153	1747	37
H13C	13871	6276	2084	37
H15A	10625	1954	2031	24
H15B	11429	1954	3037	24
H17A	8324	5167	-818	41
H17B	8300	6409	-513	41
H17C	8265	5473	237	41
H14A	12900(50)	6640(30)	-480(20)	23(8)
H14B	11010(50)	7350(30)	-590(20)	35(9)

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