Convergent and Biomimetic Enantioselective Total Synthesis of (–)-Communesin F

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Supporting Information Placeholder

ABSTRACT: The first biomimetic enantioselective total synthesis of (–)-communesin F based on a late-stage heterodimerization and aminal exchange is described. Our synthesis features the expedient diazene–directed assembly of two advanced fragments to secure the congested C3a–C3a' linkage in three steps, followed by a highly efficient biogenetically inspired aminal reorganization to access the heptacyclic communesin core in only two additional steps. Enantioselective syntheses of the two fragments were developed, with highlights including the catalytic asymmetric halocyclization and diastereoselective oxyamination reactions of tryptamine derivatives, a stereoselective sulfinimine allylation, and an efficient cyclotryptamine–C3a-sulfamate synthesis by either a new silver–promoted nucleophilic amination or a rhodium–catalyzed C–H amination protocol. The versatile synthesis of the fragments, their stereocontrolled assembly, and the efficient aminal–exchange as supported by in situ monitoring experiments, in addition to the final stage N1'-acylation of the communesin core provide a highly convergent synthesis of (–)-communesin F.

Introduction. The communesin alkaloids are a family of structurally complex natural products isolated from various marine and terrestrial *Penicillium* fungi, which have been shown to possess insecticidal and antiproliferative activities as well as significant cytotoxicity against lymphocytic leukemia.[1,2] The core structures of these alkaloids share a unique heptacyclic skeleton containing two aminals and at least five stereogenic centers, of which two are vicinal and quaternary (Figure 1). This exquisite structural complexity coupled with an array of interesting biological properties has prompted investigations directed towards the chemical synthesis of these alkaloids,[2] culminating in innovative solutions for the total synthesis of (±)-communesin F (**1**) by Qin,[3] Weinreb,[4] and Funk,[5] in addition to a formal synthesis by Stoltz.[6] To date, Ma's total synthesis of (–)-communesin F (**1**)[7] remains the only enantioselective solution for this archetypical alkaloid. As an outgrowth of our investigations in the area of *calycanthaceous* alkaloids,[8,9] we sought to develop a unified and convergent approach to the communesin alkaloids. We drew inspiration from a speculated biogenesis involving the stereocontrolled oxidative union of two dissimilar tryptamine derivatives followed by reorganization of a C3a–C3a' linked heterodimer,[10,11,12,13] reminiscent of the pathways leading to the related calycanthoids.[12,14,] While our biosynthetic considerations were purely hypothetical at the outset of this synthesis campaign, Houk, Garg, and Tang have recently disclosed[15] incisive biosynthetic and computational studies that echo the key transformations developed in our synthesis. Herein, we present the shortest enantioselective total chemical synthesis of (–)-communesin F (**1**) with late-stage chemistry that fortuitously parallels the latest insights[15b] and hypotheses concerning the biogenesis of these alkaloids.

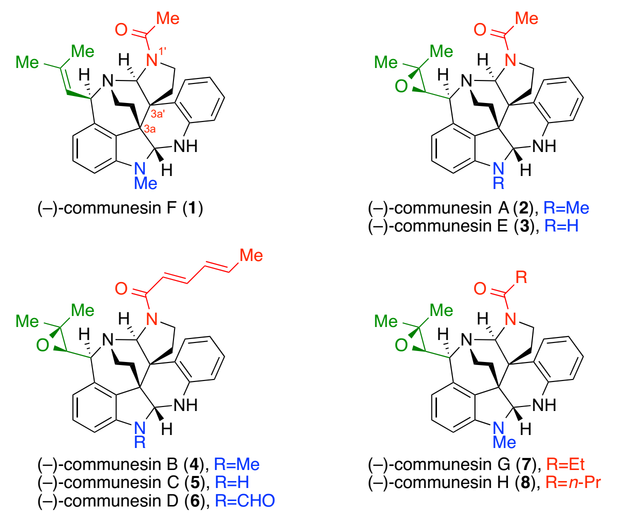
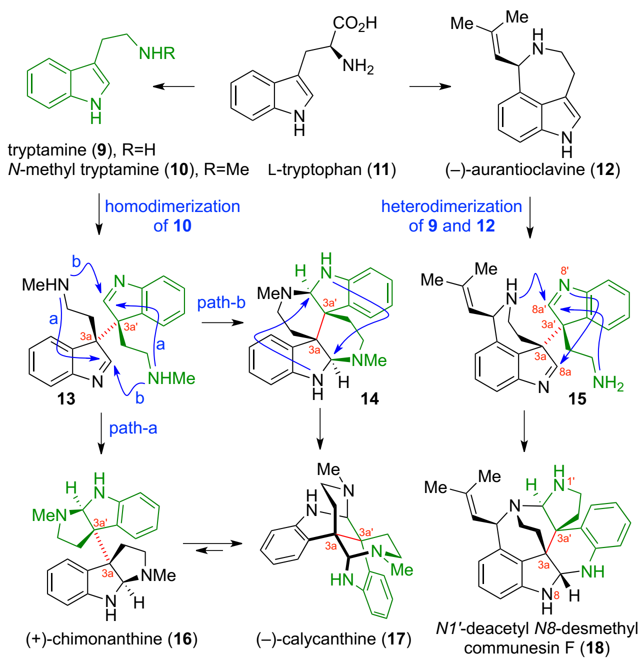


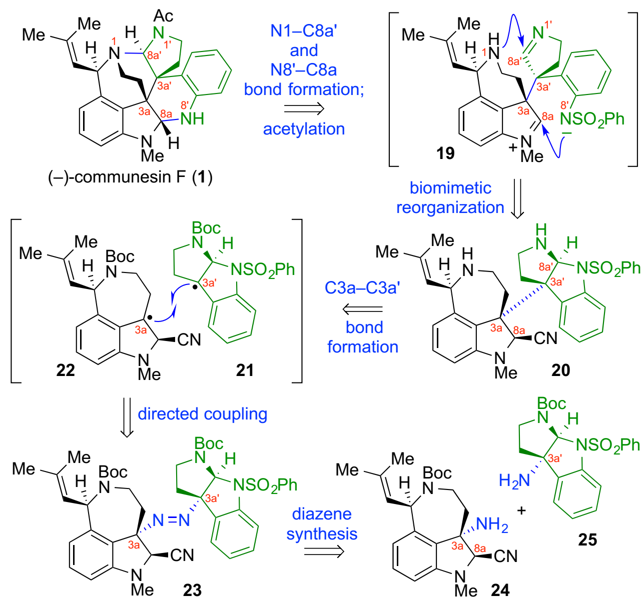
Figure 1. The Structure of Communesin Alkaloids

The expectation that the biosynthesis of *calycanthaceous* family of alkaloids[14] has relevance to the biogenesis of the communesins stems from the structural similarity of these alkaloids and their precursors (Scheme 1).

Scheme 1. Comparison of the Bond Formations in the Biogenesis of Structurally Related Dimeric Alkaloids



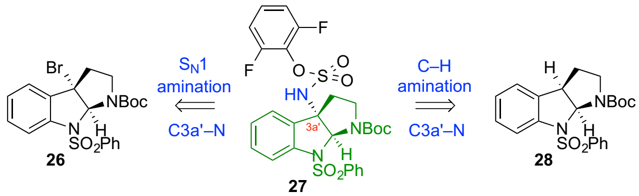
Scheme 2. Biogenetically Inspired Retrosynthetic Analysis of (–)-Communesin F (**1**)



Woodward and Robinson independently proposed that the biogenesis of the calycanthoids is predicated on the oxidative homodimerization of *N*-methyl tryptamine (**10**) to form indolenine dimers, such as **13**, which can give rise to five constitutional isomers upon reorganization of the two aminal functional groupings.[10–11] In the illustrative case of indolenine dimer **13** (Scheme 1), amine cyclization via path-a results in (+)-chimonanthine (**16**), whereas an alternative cyclization via path-b, perhaps through the intermediacy of hexacycle **14**, affords the isomeric alkaloid (–)-calycanthine (**17**). Indeed, the equilibration of (+)-chimonanthine (**16**) to (–)-calycanthine (**17**) under acidic aqueous conditions (**16**:**17**=15:85)[8a,16] demonstrates the potential dynamic nature of these polycyclic structures. Anticipating a related biogenesis for the communesins, we expected the heterodimeric intermediate **15** to undergo a similar dynamic reorganization to afford heptacycle **18**. Consistent with this hypothesis, an enzyme capable of the oxidative coupling of tryptamines and *Penicillium* fungal alkaloid (–)-aurantioclavine (**12**)[17,18] has been identified that leads to the formation of the communesin core or an isomeric heptacycle depending on the tryptamine.[15b] We began our studies with the recognition that successful implementation of a biomimetic strategy for the efficient synthesis of these alkaloids requires the directed and stereocontrolled union of two dissimilar fragments followed by selective reorganization of a C3a–C3a' linked heterodimer to a single constitutional isomer consistent with the communesin skeleton **18**.

Results and Discussion. As illustrated in our retrosynthetic analysis of (–)-communesin F (**1**, Scheme 2), strict adherence to the central paradigm in the biogenesis of *calycanthaceous* alkaloids focused our design on the efficient assembly and reorganization of a key heterodimeric intermediate **20**. Prompted by our strategy for directed heterodimerization of cyclotryptamines,[19] we envisioned hexacycle **20** (Scheme 2) to serve as a surrogate for the hypothetical biosynthetic intermediate **15** (Scheme 1). We anticipated the N8'-sulfonamide would guide the opening of the C8a'-aminal to present the C8a'-imine for N1-addition. Furthermore, we projected the ionization of the C8a-nitrile would offer the C8a-iminium ion needed for aminal formation via N8'-addition. The challenging C3a–C3a' linkage of heterodimer **20** required a directed and stereocontrolled union of a cyclotryptamine fragment **21** and aurantioclavine derivative **22** to simultaneously secure the two critical quaternary stereocenters. Our diazene-based strategy for directed complex fragment assembly[19] provided the essential framework to explore this exciting and convergent approach to (–)-communesin F (**1**). While we were confident the C8a'-stereochemisry of the cyclotryptamine moiety would guide the desired C3a'-stereochemical outcome in this union, we were intrigued by the potential level of stereochemical control expected at C3a during carbon–carbon bond formation. We envisioned the synthesis of complex heterodimeric diazene **23** from tricyclic amines **24** and **25** as tryptamine–surrogates necessary for securing the C3a–C3a' linkage (Scheme 2).

Scheme 3. Strategies for Synthesis of Tricycle **27**

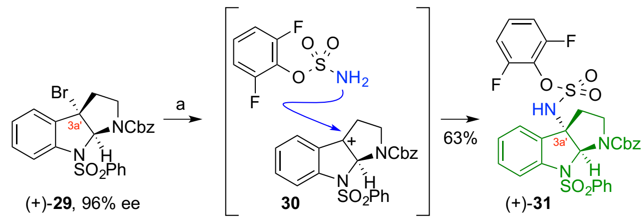


Our synthesis of (–)-communesin F (**1**) commenced with the preparation of the two key tricyclic amines **24** and **25** required for the assembly of critical diazene **23** (Scheme 2). We pursued two approaches to the synthesis of the C3a'-amino cyclotryptamine **25** and the corresponding sulfamate **27** (Scheme 3). In the first approach, motivated by efficient access to enantiomerically enriched C3a'-halocyclotryptamine derivatives,[20a] we envisioned a nucleophilic C3a'-amination (Scheme 4) reminiscent of our Friedel-Crafts strategy for C3a-derivatization developed in the context of our naseseazine alkaloid total synthesis.[21] Our second approach to amine **25** relied on Du Bois amination[22] of cyclotryptamine **28** to secure the sulfamate **27** (Scheme 5).[19c]

Given the versatility of cyclotryptamine–sulfamates as precursors to the corresponding mixed sulfamides,[19c] we developed an efficient synthesis to access sulfamate (+)-**31** and related derivatives starting with C3a'-bromocyclotryptamine (+)-**29** (Scheme 4). Enantioselective bromocyclization[20a] of *Nβ*-Cbz-*N1*-benzenesulfonyltryptamine catalyzed by (*S*)-3,3′-bis(2,4,6-triisopropylphenyl)-1,1′-binaphthyl-2,2′-diyl hydrogenphosphate (TRIP)[20b] afforded C3a'-bromocyclotryptamine (+)-**29** in 93% yield and 96% enantiomeric excess.[23] Significantly, electrophilic activation[21] of the tricyclic bromide (+)-**29** in the presence of 2,6-difluorophenylsulfamate[22] provided the desired sulfamate (+)-**31** in 63% yield (Scheme 4). The use of 2,6-difluorophenylsulfamate as a nucleophile to trap an intermediate C3a'-electrophile **30** provides a new and expedient route for the directed synthesis of complex diazenes.[19c] While this new single-step synthesis of C3a'-sulfamates from the corresponding C3a'-bromides offers a concise solution to the desired precursors, its utility in conversion of the more acid sensitive *tert*-butyl carbamate substrate **26** to sulfamate **27** gave capricious and inferior outcomes (~50% yield).

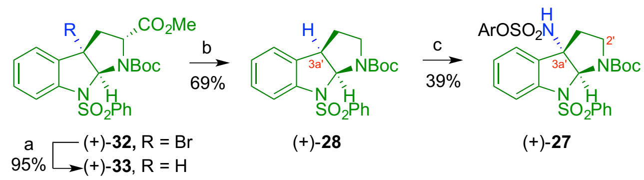
Our alternate approach for the synthesis of *tert*-butyl-carbamate derivative **27** relied on the C–H amination chemistry illustrated in Scheme 5. Mild reduction of bromocyclotryptophan (+)-**32** provided the desired C3a'–H cyclotryptophan (+)-**33** in 95% yield.[23] Subsequent decarboxylation furnished cyclotryptamine (+)-**28**

Scheme 4. Concise Synthesis of Sulfamate (+)-**31**[a]



[a]Reagents and conditions: (a) $AgSbF_6$, 2,6-di-*tert*-butyl-4-methylpyridine, 2,6-difluorophenylsulfamate, CH_2Cl_2, 23 °C, 63%.

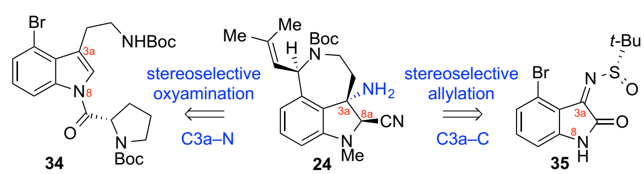
Scheme 5. Gram-scale Synthesis of Sulfamate (+)-**27**[a]



[a]Reagents and conditions: (a) $(Me_3Si)_3SiH$, Et_3B, air, 23 °C, >99:1 dr; (b) (i) KOH (aq.), MeOH, CH_2Cl_2, 23 °C, (ii) *N,N,N′,N′*-tetramethylchloroformamidinium hexafluorophosphate, thiopyridine *N*-oxide, 4-(*N,N*-dimethylamino)pyridine, Et_3N, THF; *t*-BuSH, hν, 23 °C; (c) $Rh_2(esp)_2$, H_2NSO_3Ar, $PhI(OAc)_2$, $Ph(CH_3)_2CCO_2H$, MgO, 5Å-MS, *i*-PrOAc, 23 °C; Ar=2,6-difluorobenzene.

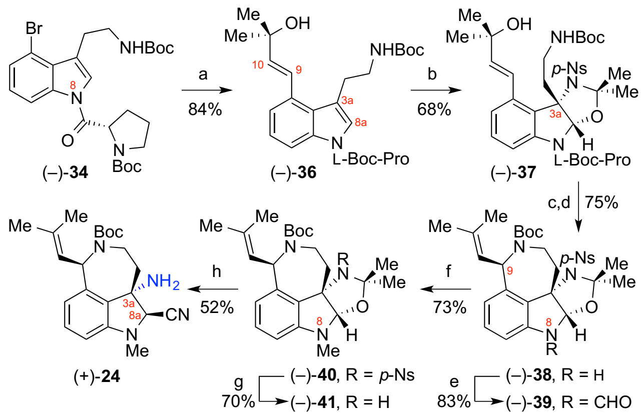
in 69% yield. Under optimal conditions, a Rh-catalyzed C–H amination[22] of cyclotryptamine (+)-**28** afforded the desired sulfamate (+)-**27** in 39% yield after recrystallization.[24] This three-step sequence efficiently generated gram quantities of (+)-**27** from the readily available bromocyclotryptophan (+)-**32** as an activated form of C3a'-aminocyclotryptamine **25** (Scheme 2) that is ready for coupling with tricyclic amine **24** for diazene synthesis.

Scheme 6. Strategies for Synthesis of Tricycle **24**



With an expedient synthesis of sulfamate (+)-**27** available, we turned our attention to the synthesis of the tricyclic amine **24** (Scheme 6). While syntheses of aurantioclavine (**12**) have been reported,[18] the synthesis of a derivative needed to mimic fragment **22**, necessary for our biomimetic approach to (–)-communesin F (**1**), has not been described. As a result, we sought to develop an

Scheme 7. Oxyamination Approach to Tricycle (+)-**24**[a]

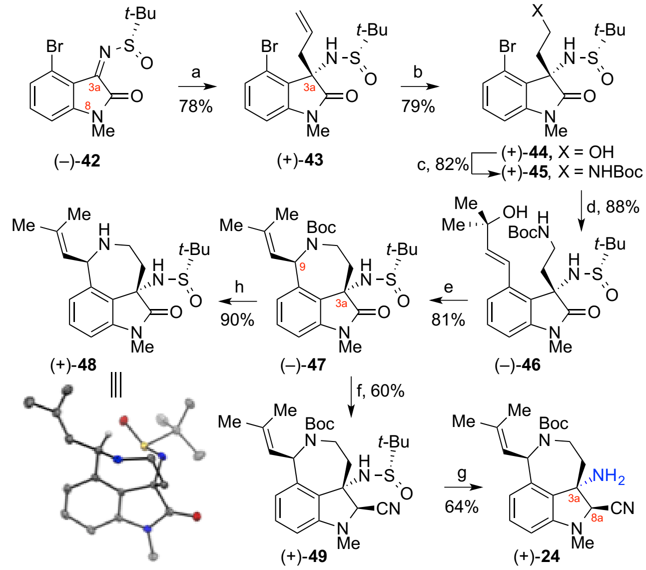


[a]Reagents and conditions: (a) 1,1-dimethylallyl alcohol, $Pd(OAc)_2$, $P(o\text{-tol})_3$, Et_3N, MeCN, 95 °C; (b) 3,3-dimethyl-2-(*p*-nitrobenzenesulfonyl)-1,2-oxaziridine, $CuCl_2$, $n\text{-}Bu_4NCl$, $CHCl_3$, 21 °C, 89:11 dr; (c) $PdCl_2(MeCN)_2$, MeCN, 82 °C; (d) (i) $i\text{-}Bu_2AlH$, THF, 0 °C, (ii) 1,8-diazabicyclo[5.4.0]undec-7-ene, MeOH, 21 °C; (e) Ac_2O, HCO_2H, pyridine, CH_2Cl_2, 21 °C; (f) $NaBH_4$, TFA, THF, 0 °C; (g) PhSH, K_2CO_3, DMF, 50 °C; (h) Me_3SiCN, $(F_3C)_2CHOH$, H_2O, 21 °C; *p*-Ns = *para*-nitrobenzenesulfonyl.

enantioselective synthesis of a tricycle reminiscent of alkaloid **12** that would allow for implementation of our synthetic strategy (Scheme 2). The tricyclic aminonitrile **24** offered the necessary C3a-amine for diazene synthesis and the C8a-aminonitrile to allow for mild generation of the corresponding C8a-iminium ion needed for aminal synthesis. We developed two strategies to access the key intermediate **24** as illustrated in Scheme 6. The first strategy involved tryptamine **34** as the substrate for the application of Yoon's oxyamination chemistry,[25] while the second strategy utilized *tert*-butyl sulfinimine **35** and Ellman's asymmetric allylation[26] of such substrates.[27]

The oxyamination[25] route to aminonitrile **24** commenced with a Mizoroki-Heck reaction of bromoindole (–)-**34**[23] with 1,1-dimethylallyl alcohol to provide allylic alcohol (–)-**36**. Despite early reservations regarding possible competing C9-C10-oxyamination[25b-f] of vinyl indole (–)-**36** in place of the desired C3a-C8a-oxyamination, we observed higher levels of diastereoselection[28] for the oxyamination of the more advanced substrate (–)-**36** (Scheme 7). The use of stoichiometric copper(II) chloride facilitated the reaction and gave oxazoline (–)-**37** in 68% yield (89:11 dr). Treatment of alcohol (–)-**37** with bis(acetonitrile)dichloropalladium(II) in acetonitrile to form the desired azepane (85% yield)[23] followed

Scheme 8. Sulfinimine Allylation Approach to Tricycle (+)-**24**[a]



[a]Reagents and conditions: (a) allylMgBr, $MgBr_2$, CH_2Cl_2, –78 °C, >98:2 dr; (b) O_3, MeOH, –78 °C; $NaBH_4$, –78 → 23 °C; (c) *o*-NsNHBoc, diisopropyl azodicarboxylate, polystyrene–PPh_3, THF, 50 °C; PhSH, Cs_2CO_3, 50 °C; (d) $Me_2C(OH)CH{=}CHSn(n\text{-}Bu)_3$, $PdCl_2(PPh_3)_2$, PhMe, THF, 110 °C; (e) $PdCl_2(MeCN)_2$, MeCN, 80 °C; (f) (i) $LiBH_4$, MeOH, THF, 0 → 23 °C; (ii) Me_3SiCN, $(F_3C)_2CHOH$, 0 °C; (g) HCl, dioxane, MeOH, 23 °C; (h) $Sc(OTf)_3$, F_3CCH_2OH, 23 °C; *o*-Ns = *ortho*-nitrobenzenesulfonyl. ORTEP representation of amine (+)-**48**: thermal ellipsoids drawn at 50% probability.[23]

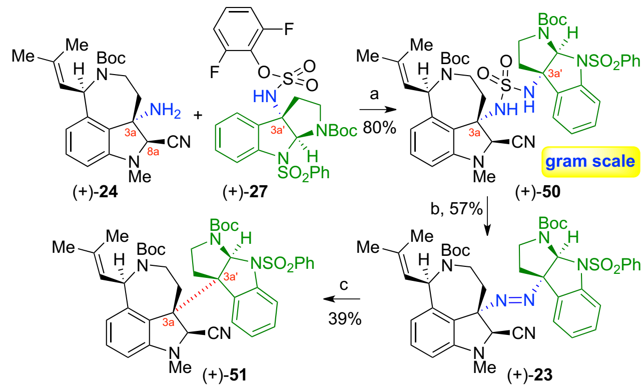
by removal of the chiral auxiliary (88% yield) provided the desired indoline (–)-**38**. The formylation of indoline (–)-**38** to give formamide (–)-**39** (83% yield) followed by mild reduction with sodium borohydride in the presence of trifluoroacetic acid gave the desired *N*-methylindoline (–)-**40** (73% yield).[29] Exposure of sulfonamide (–)-**40** to thiophenol and potassium carbonate led to removal of the *para*-nitrobenzenesulfonyl group and the isolation of the stable oxazolidine (–)-**41** in 70% yield. Given the propensity of oxazolidine (–)-**41** and aminonitrile (+)-**24** toward elimination of the C3a-amino group under strongly acidic or basic conditions, we developed mild hydrolysis conditions to allow for cyanation of a transient C8a-hemiaminal leading to aminonitrile (+)-**24** in 52% yield in addition to the C8a-epimer (26%). While this approach provides flexibility for the late-stage introduction of various N8-substituents and establishes the C3a-configuration, the challenge in unraveling the oxazolidine substructure prompted our investigation of an alternate route to aminonitrile (+)-**24** (Scheme 6) involving C3a–C bond formation.

Our alternative synthesis of aminonitrile (+)-**24** began with the diastereoselective allylation[26] of N8-methyl sulfinimine (–)-**42** (Scheme 8) to provide allyl oxindole (+)-**43** in 78% yield and with excellent diastereopurity after trituration of the crude addition product with hexane (>98:2 dr).[23] In contrast to our first approach to aminonitrile (+)-**24**, the placement of the chiral auxiliary on the C3a-substituent enabled our use of the N8-methyl variant of sulfinimine **35** (Scheme 6).[23] Ozonolysis of alkene (+)-**43** followed by a reductive work-up afforded the primary alcohol (+)-**44** in 79% yield. The alcohol (+)-**44** was then converted to *tert*-butyl carbamate (+)-**45** in 82% yield via a Mitsunobu displacement and subsequent in situ desulfonylation. The allylic alcohol needed for synthesis of the azepane substructure was introduced via a Stille vinylation to furnish allylic alcohol (–)-**46** in 88% yield.[30] A palladium-catalyzed allylic amination provided azepane (–)-**47** in 81% yield as a single diastereomer. The stereochemistry at C3a and C9 of azepane (–)-**47** was confirmed unambiguously through analysis of the crystal structure of the corresponding amine (+)-**48** (Scheme 8). We then focused on development of conditions for mild and efficient conversion of oxindole (–)-**47** to the desired aminonitrile (+)-**24**. Partial reduction of oxindole (–)-**47** with lithium borohydride afforded a mixture of C8a-hemiaminal diastereomers that were too labile for isolation. Direct treatment of the crude hemiaminal with trimethylsilyl cyanide in hexafluoroisopropanol[31] furnished the desired aminonitrile (+)-**49** in 60% yield[32] and the easily separable minor C8a-epimer (30%).[23] Methanolysis of the *tert*-butyl sulfinamide (+)-**49** provided the desired amino-azepane (+)-**24** in 64% yield.[33] The C8a-aminonitrile proved to be an ideal trigger for late stage hemiaminal formation[34] while providing adequate stability for the implementation of an efficient fragment assembly. We anticipate future adaptation of this robust synthetic route to other N8-variants of azepane (+)-**24** via judicious N8-substitution of sulfinimine **35**.

After developing versatile syntheses of both essential fragments, we next examined the union of azepane (+)-**24** and cyclotryptamine (+)-**27** to introduce the critical C3a–C3a' bond. Dissolution of the two fragments in tetrahydrofuran in the presence of 4-(*N*,*N*-dimethylamino)pyridine afforded sulfamide (+)-**50** in 80% yield on gram-scale (Scheme 9).[23] Consistent with our prior observation, the oxidation of sterically shielded sulfamides containing electron-rich arenes, such as the *N*-methyl aniline substructure of sulfamide (+)-**50**, suffers from competitive arene-halogenation. After extensive experimentation, we discovered the unique ability of tertiary *N*-chloroamides to effect chemoselective oxidation of sulfamide (+)-**50** to the corresponding diazene (Scheme 9) without competitive arene-halogenation. Exposure of sulfamide (+)-**50** to *N*-chloro-*N*-methylbenzamide (6 equiv) in conjunction with polystyrene-bound 2-*tert*-butylimino-2-diethylamino-1,3-dimethyl-perhydro-1,3,2-diazaphosphorine (BEMP) in methanol provided the desired diazene (+)-**23** in 57% yield.[35] Photoexcitation and expulsion of dinitrogen from a thin film of diazene (+)-**23**, followed by radical combination of the resulting cyclotryptamine **21** and azepane **22** (Scheme 2), afforded the desired heterodimer (+)-**51** in 39% yield as a single diastereomer.[36] While the stereochemical outcome at C3a' of heterodimer (+)-**51** is anticipated,[19] the remarkable diastereoselection at C3a is notable and likely due to the confluence of a rapid radical combination step and the additional stereoinduction imposed by the C8a-nitrile.[23,37] Importantly, our diazene-based strategy for directed complex fragment assembly allowed for the stereoselective construction of the critical C3a–C3a' linkage, securing the corresponding vicinal quaternary stereocenters.

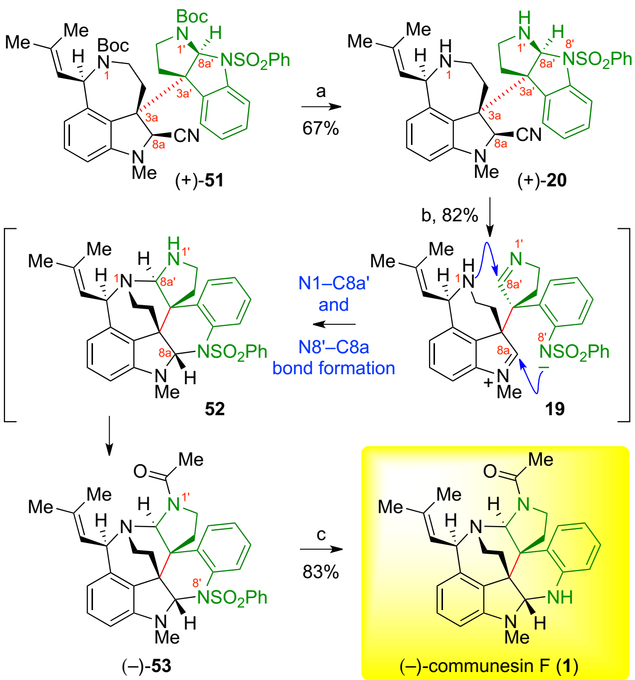
With the successful union of the tricyclic–azepane and the cyclotryptamine fragments at hand, we turned our attention to the development of a biogenetically inspired aminal reorganization of heterodimer (+)-**51** to access the heptacyclic communesin core. Informed by experience in rearrangement of the *calycanthaceous*

Scheme 9. Directed Synthesis of Heterodimer (+)-**51**[a]



[a]Reagents and conditions: (a) 4-(*N*,*N*-dimethylamino)pyridine, THF, 23 °C; (b) polystyrene–2-*t*-butylimino-2-diethylamino-1,3-dimethyl-perhydro-1,3,2-diazaphos-phorine, *N*-chloro-*N*-methylbenzamide, MeOH, 23 °C; (c) hν (350 nm), 25 °C.

Scheme 10. Synthesis of (–)-Communesin F (**1**) via a Biogenetically Inspired Final Stage Reorganization[a]



[a]Reagents and conditions: (a) $Sc(OTf)_3$, F_3CCH_2OH, 23 °C; (b) *t*-BuOLi, MeOH, 50 °C; dry PPTS, Ac_2O, 23 °C; (c) Na(Hg), NaH_2PO_4, THF, MeOH, 23 °C.

alkaloids,[8,14] we recognized the significance in the judicious choice of reaction conditions for the planned transformation due to the sensitive nature of the C3a–C3a' linkage. Furthermore, we anticipated that an appropriate sequence of amine unveiling would maximize efficiency for the desired aminal exchange. We projected that unveiling the N1- and N1'-amines of heterodimer (+)-**51** would allow opening of the C8a' aminal with the benzenesulfonamide as the leaving group, thus allowing rapid trapping of the C8a'-imine of intermediate **19** en route to heptacycle **52**. Treatment of heterodimer (+)-**51** with scandium trifluoromethanesulfonate in trifluoroethanol provided the desired heterodimer (+)-**20** by selective removal of the *tert*-butyl carbamates while preserving the sensitive C8a-aminonitrile (Scheme 10). The electron-withdrawing N8'-sulfonamide enabled our examination of basic conditions to selectively open the cyclotryptamine substructure. In the event, treatment of heterodimer (+)-**20** with lithium *tert*-butoxide in methanol provided clean and complete conversion to the desired heptacyclic structure **52** within 1 h at 50° C as observed by in situ ^{1}H-NMR spectroscopy.[23] Significantly, only the desired heptacycle **52** was formed in preference to other constitutional isomers.[15b] Methanol was found to be an excellent solvent[38] for this transformation, likely due to its ability to stabilize reactive intermediates as the corresponding *O*-alkyl-hemiaminals. Although intermediate **52** could be observed by in situ ^{1}H NMR spectroscopy,[23] this compound did not show sufficient stability for isolation. We suspect this may be due to the sensitive nature of the C8a'-aminal of heptacycle **52**, which upon reversible opening to the C8a'-imine increases the lability of the C3a–C3a' bond. As a testimony to the sensitivity of the C3a–C3a' linkage of heterodimer (+)-**20**, simple heating of a derivative (C8a-OMe instead of C8a-CN) in acetonitrile-d_3 at 80 °C predominantly led to fragmentation.[39] Indeed, treatment of the basic solution of heptacycle **52** with pyridinium *p*-toluenesulfonate to quench the alkoxides, followed by addition of acetic anhydride afforded the *N*1'-acetyl derivative (–)-**53** in 82% overall yield.[23] A final-step unveiling of the N8'-amine was accomplished by treatment of (–)-**53** with sodium amalgam to provide (–)-communesin F (**1**) in 83% yield. All ^{1}H and ^{13}C NMR data as well as optical rotation (observed $[\alpha]_D^{24} = -249$, $c = 0.13$, $CHCl_3$; literature $[\alpha]_D^{20} = -264$, $c = 0.34$, $CHCl_3$),[1c,23] for our synthetic (–)-communesin F (**1**) were in agreement with literature data.

Conclusion. A highly convergent enantioselective total synthesis of (–)-communesin F (**1**) with late-stage chemistry that parallels the latest insights[15] and hypotheses concerning the biogenesis of these alkaloids is described. Our expedient synthesis involves the union of fragments (+)-**24** and (+)-**27** to provide complex sulfamide (+)-**50** on gram-scale. This advanced intermediate is converted to alkaloid (–)-**1** in only five additional steps (Schemes 9 and 10) which include the application of our diazene-directed fragment assembly strategy to secure the congested C3a–C3a' linkage, and a guided biomimetic rearrangement to selectively provide the heptacyclic core of these alkaloids. Highlights of our synthesis include an efficient cyclotryptamine–C3a-sulfamate synthesis by either a new silver–promoted nucleophilic amination or rhodium–catalyzed C–H amination protocol, application of catalytic asymmetric halocyclization and diastereoselective oxyamination reactions in complex settings, a stereoselective sulfinimine allylation, and efficient assembly and utility of a richly functional diazene for complex fragment coupling. The successful implementation of this synthetic strategy and the versatile synthesis of the fragments, along with a final stage acylation of the communesin core provide a foundation for a unified synthetic route to access structurally related complex alkaloids and derivatives.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website. Experimental procedures, spectroscopic data, crystal structure of (+)-**48** (CIF), and copies of NMR spectra (PDF).

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Notes

The authors declare no competing financial interests.

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(28) For comparison, the oxyamination of the corresponding L-(3,5-di-*tert*-butylphenylcarbamoyl)-Pro derivatives of substrates (–)-**34** and (–)-**36** gave the desired product in 27% (53:47 dr) and 79% (73:27 dr) yield, respectively.

(29) Methylation of indoline (–)-**38** with Meerwein's reagent or its reductive amination with formalin and $NaBH_3CN$ resulted in the desired *N*-methylindoline (–)-**40** in 15% and 21% yield, respectively.

(30) Likely due to the greater steric constraints imposed by the fully substituted tetrahedral C3a in bromide (+)-**45**, related Heck protocols described in prior syntheses of alkaloid **1** were unsuccessful.

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(32) The C8a-configuration of the major diastereomer was determined by nOe analysis of a derivative.

(33) Exposure of the C8a-epimer to the same conditions resulted in only 22% yield of the desired epimeric aminonitrile.

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(35) Use of *N*-chlorosuccinimide (6 equiv) as the oxidant in conjunction with *N,N*-dimethylaniline (1 equiv) as electrophilic chlorine scavenger gave only 37% yield of diazene (+)-**23**, in addition to recovered (+)-**50** (17%), and a tricyclic cyanoindole side product (25%) arising from E2-elimination of C3a-sulfamide.

(36) The formation of the tricyclic cyanoindole (~47%) and a C3a'-H cyclotryptamine **28** (~51%) as disproportionation products is reflective of the significant steric barrier for C3a–C3a' bond formation and competitive C8a-H abstraction.

(37) Calculations suggest the C8a-CN provides 3.8 kcal/mol preference for the desired C3a stereochemical outcome.

(38) Use of tetrahydrofuran-d_8 as solvent led to a less efficient aminal reorganization and afforded product (–)-**53** in 52% yield.

(39) Experiment conducted over 13 h in the absence of acid or base promoter. We reason that reversible C8a-iminium ion formation in the absence of the desired N8'-nucleophile increases the lability of C3a–C3a' bond.

Convergent and Biomimetic Enantioselective Total Synthesis of (–)-Communesin F

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Supporting Information

General Procedures. All reactions were performed in oven-dried or flame-dried round-bottom flasks, unless noted otherwise. The flasks were fitted with rubber septa, and reactions were conducted under a positive pressure of argon. Cannulae or gas-tight syringes with stainless steel needles were used to transfer air- or moisture-sensitive liquids. Where necessary (so noted), solutions were deoxygenated by sparging with argon for a minimum of 10 min. Flash column chromatography was performed as described by Still et al.[1] using granular silica gel (60-Å pore size, 40–63 µm, 4–6% H_2O content, Zeochem). Analytical thin layer chromatography (TLC) was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm, EMD Millipore 105715). TLC plates were visualized by exposure to short wave ultraviolet light (254 nm) and irreversibly stained by treatment with an aqueous solution of ceric ammonium molybdate (CAM) followed by heating (~ 1 min) on a hot plate (~ 250 ºC). Organic solutions were concentrated at 30 °C on rotary evaporators capable of achieving a minimum pressure of ~2 torr. The diazene photolysis was accomplished by irradiation in a Rayonet RMR-200 photochemical reactor (Southern New England Ultraviolet Company, Branford, CT, USA) equipped with 16 lamps.

Materials. Commercial reagents and solvents were used as received with the following exceptions: dichloromethane, acetonitrile, tetrahydrofuran, methanol, pyridine, toluene, and triethylamine were purchased from J. T. Baker (Cycletainer™) and were purified by the method of Grubbs *et al.* under positive argon pressure.[2] Benzene was dried by distillation over calcium hydride under an inert nitrogen atmosphere. Chloroform was dried by distillation over potassium carbonate under an inert argon atmosphere. Silver hexafluoroantimonate and scandium(III) trifluoromethansulfonate were purchased from Strem Chemicals; 2,6-di-*tert*-butyl-4-methylpyridine was purchased from Matrix Scientific and was further purified by flash column chromatography on silica gel (eluent: hexanes); L-tryptophan methyl ester hydrochloride was purchased from Chem-Impex International, Inc.; di-*tert*-butyl dicarbonate (Boc_2O) and hexafluoroisopropanol (HFIP) were purchased from Oakwood Chemicals, Inc.; tetra-*n*-butylammonium hydrogen sulfate, 2-mercaptopyridine *N*-oxide, and 2-methyl-2-phenylpropionic acid were purchased from TCI America; tryptamine and *N*,*N*,*N*′,*N*′-tetramethylchloroformamidinium hexafluorophosphate (TCFH) were purchased from AK Scientific, Inc.; (*S*)-(–)-2-methyl-2-propanesulfinamide was purchased from AllyChem. All other solvents and chemicals were purchased from Sigma–Aldrich.

Instrumentation. Proton nuclear magnetic resonance (^1H NMR) spectra were recorded with a Bruker AVANCE 600 spectrometer, a Varian inverse probe 500 INOVA spectrometer, or a Bruker AVANCE III 400 spectrometer. Chemical shifts are recorded in parts per million on the δ scale and are referenced from the residual protium in the NMR solvent ($CHCl_3$: δ 7.24, $CDHCl_2$: 5.32, CD_2HCN: 1.94, CD_3SOCD_2H: 2.50, C_6D_5H: 7.16). Data are reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constant(s) in Hertz, integration, assignment]. Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra were recorded with a Bruker AVANCE 600 spectrometer, a Varian 500 INOVA spectrometer, or a Bruker AVANCE III 400 spectrometer and are recorded in parts per million on the δ scale and are referenced from the carbon resonances of the solvent ($CDCl_3$: δ 77.23: CD_2Cl_2:

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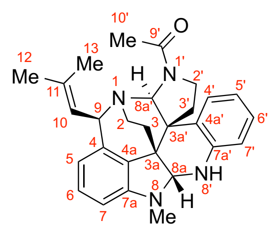
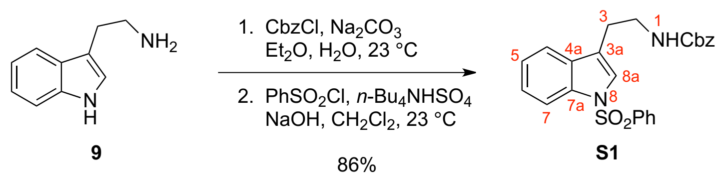
54.00 CD_3CN: 118.69, DMSO-d_6: 39.51, C_6D_6: 128.39). Data are reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constant(s) in Hertz, assignment]. Fluorine-19 nuclear magnetic resonance spectra were recorded with a Varian 300 INOVA spectrometer and are recorded in parts per million on the δ scale and are referenced from the fluorine resonances of trifluoroacetic acid (CF_3CO_2H δ –76.55). Data are reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constant(s) in Hertz, integration, assignment]. Infrared data were obtained with a Perkin-Elmer 2000 FTIR and are reported as follows: [frequency of absorption (cm^{-1}), intensity of absorption (s = strong, m = medium, w = weak, br = broad), assignment]. Optical rotations were measured on a Jasco-1010 polarimeter with a sodium lamp and are reported as follows: $[\alpha]_{\lambda}^{T\,°C}$ (c = g/100 mL, solvent). We thank Dr. Li Li at the Massachusetts Institute of Technology Department of Chemistry Instrumentation Facility for obtaining mass spectroscopic data. High resolution mass spectra (HRMS) were recorded on a Bruker Daltonics APEXIV 4.7 Tesla FT-ICR-MS using electrospray (ESI) (*m/z*) ionization source or direct analysis in real time (DART) ionization source.

Positional Numbering System. In assigning the ^1H and ^{13}C NMR data of all intermediates en route to (−)-communesin F, we have employed a uniform numbering system.



(–)-Communesin F (**1**)



Tryptamine S1:

Benzyl chloroformate (926 µL, 6.49 mmol, 1.04 equiv) was added via syringe to a mixture of tryptamine (1.00 g, 6.24 mmol, 1 equiv) and sodium carbonate (661 mg, 6.24 mmol, 1 equiv) partitioned between diethyl ether (31 mL) and deionized water (31 mL) at 23 ºC under an air atmosphere. After vigorous stirring for 40 min, the layers were separated and the aqueous layer was extracted with diethyl ether (3 × 20 mL). The combined organic extracts were washed successively with an aqueous hydrochloric acid solution (1 N, 30 mL) and a saturated aqueous sodium chloride solution (30 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to yield crude benzyl (2-(1*H*-indol-3-yl)ethyl)carbamate which was used directly in the next step without further purification.

Benzenesulfonyl chloride (1.00 mL, 7.80 mmol, 1.25 equiv) was added via syringe to a suspension of crude (2-(1*H*-indol-3-yl)ethyl)carbamate, freshly crushed sodium hydroxide (748 mg, 18.7 mmol, 3.00 equiv), and tetra-*n*-butylammonium hydrogen sulfate (212 mg, 0.624 mmol, 0.100 equiv) in dichloromethane (25 mL) at 23 ºC under an air atmosphere. After 2.5 h, the yellow suspension was cooled in a 0 ºC ice bath and was acidified by portionwise addition of an aqueous hydrogen chloride solution (1 N, 25 mL) over 2 min. After warming to 23 ºC, the layers were separated and the aqueous phase was extracted with dichloromethane (2 × 20 mL). The combined organic extracts were washed successively with water (2 × 40 mL) and a saturated aqueous sodium chloride solution (40 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 25%→30% ethyl acetate in hexanes) to afford tryptamine **S1** (2.33 g, 85.8%) as a colorless, highly viscous syrup. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

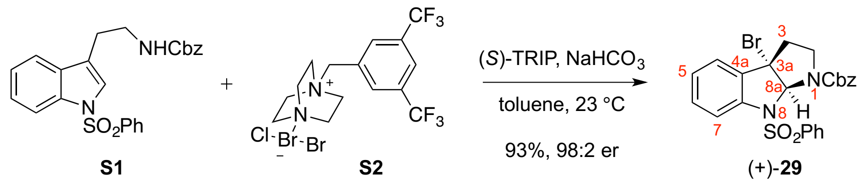
^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ 8.00 (d, *J* = 8.3 Hz, 1H, C_7**H**), 7.89–7.78 (m, 2H, N_8SO_2Ph-*o*-**H**), 7.50 (d, *J* = 7.4 Hz, 1H, C_4**H**), 7.44 (d. *J* = 7.4 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.41–7.27 (m, 9H, C_6**H**, C_{8a}**H**, $N_1CO_2CH_2$Ph-*o*-**H**, $N_1CO_2CH_2$Ph-*m*-**H**, $N_1CO_2CH_2$ Ph-*p*-**H**, N_8SO_2Ph-*m*-**H**), 7.21 (t, *J* = 7.8 Hz, 1H, C_5**H**), 5.10 (s, 2H, $N_1CO_2C\mathbf{H}_2Ph$), 5.02–4.86 (m, 1H, **H**$N_1CO_2CH_2Ph$), 3.46 (app-q, *J* = 6.3 Hz, 2H, C_2**H**), 2.87 (t, *J* = 6.8 Hz, 2H, C_3**H**).

^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ 156.5 ($N_1\mathbf{C}O_2CH_2Ph$), 138.1 (N_8SO_2Ph-*ipso*-**C**), 136.6 ($N_1CO_2CH_2$Ph-*ipso*-**C**), 135.5 ($\mathbf{C}_{7a}$), 133.9 (N_8SO_2Ph-*p*-**C**), 130.8 ($\mathbf{C}_{4a}$), 129.3 (N_8SO_2Ph-*m*-**C**), 128.7 ($N_1CO_2CH_2$Ph-*m*-**C**), 128.3 ($N_1CO_2CH_2$Ph-*p*-**C**), 128.2 ($N_1CO_2CH_2$Ph-*o*-**C**), 126.8 (N_8SO_2Ph-*o*-**C**), 125.1 ($\mathbf{C}_6$), 123.6 ($\mathbf{C}_{8a}$), 123.4 ($\mathbf{C}_5$), 120.1 ($\mathbf{C}_{3a}$), 119.6 ($\mathbf{C}_4$), 113.9 ($\mathbf{C}_7$), 66.8 ($N_1CO_2\mathbf{C}H_2Ph$), 40.5 ($\mathbf{C}_2$), 25.6 ($\mathbf{C}_3$).

FTIR (thin film) cm^{-1}: 3415 (s), 3333 (s), 1720 (m), 1525 (m), 1175 (s).

HRMS (DART) (*m/z*): calc'd for $C_{24}H_{22}BrN_2O_4S$ $[M+H]^+$: 513.0478, found: 513.0486.

TLC (25% ethyl acetate in hexanes), R*f*: 0.21 (UV, CAM).



Bromocyclotryptamine (+)-29:

A sample of bromine salt **S2**[3] (522 mg, 0.977 mmol, 1.30 equiv) was added to a suspension of tryptamine **S1** (326 mg, 0.750 mmol, 1 equiv), *(S)*-3,3′-bis(2,4,6-triisopropylphenyl)-1,1′-binaphthyl-2,2′-diyl hydrogenphosphate ((*S*)-TRIP, 56.5 mg, 0.0750 mmol, 0.100 equiv), and sodium hydrogen carbonate (252 mg, 3.00 mmol, 4.00 equiv) in toluene (15 mL) at 23 ºC. After stirring for 24 h, the yellow suspension was diluted with a saturated aqueous sodium thiosulfate solution (30 mL) and was stirred vigorously for 10 min. The colourless biphasic mixture was further diluted with deionized water (30 mL) and was then extracted with dichloromethane (3 × 30 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (50 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 20% ethyl acetate in hexanes) to afford bromocyclotryptamine (+)-**29** (358 mg, 93.0%, 98:2 er) as a white foam.[4] The enantiomeric ratio was determined by chiral HPLC analysis (Chiralpak IA, 40% *i*PrOH / 60% hexanes, 0.75 mL/min, 254 nm, t_R (major) = 10.0 min, t_R (minor) = 13.9 min).

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (400 MHz, CD_3CN, 60 °C): δ 7.90–7.79 (m, 2H, N_8SO_2Ph-*o*-**H**), 7.58 (tt, *J* = 7.5, 1.4 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.53 (app-dt, *J* = 8.1, 0.8 Hz, 1H, C_7**H**), 7.48–7.32 (m, 9H, C_4**H**, C_6**H**, $N_1CO_2CH_2Ph$-*o*-**H**, $N_1CO_2CH_2Ph$-*m*-**H**, $N_1CO_2CH_2Ph$-*p*-**H**, N_8SO_2Ph-*m*-**H**), 7.22 (td, *J* = 7.6, 1.0 Hz, 1H, C_5**H**), 6.37 (s, 1H, C_{8a}**H**), 5.24 (d, *J* = 12.4 Hz, 1H, $N_1CO_2C\mathbf{H}_aPh$), 5.11 (d, *J* = 12.4 Hz, 1H, $N_1CO_2C\mathbf{H}_bPh$), 3.85–3.75 (m, 1H, $C_2\mathbf{H}_a$), 2.84–2.67 (m, 3H, $C_2\mathbf{H}_b$, $C_3\mathbf{H}_2$).

^{13}C NMR (100 MHz, CD_3CN, 60 °C): δ 155.6 ($N_1\mathbf{C}O_2CH_2Ph$), 142.8 ($\mathbf{C}_{7a}$), 140.7 (N_8SO_2Ph-*ipso*-**C**), 138.6 ($N_1CO_2CH_2Ph$-*ipso*-**C**), 135.5 ($\mathbf{C}_{4a}$), 135.4 (N_8SO_2Ph-*p*-**C**), 132.6 ($\mathbf{C}_6$), 130.8 (N_8SO_2Ph-*m*-**C**), 130.2 ($N_1CO_2CH_2Ph$-*m*-**C**), 129.9 ($N_1CO_2CH_2Ph$-*o*-**C**), 129.8 ($N_1CO_2CH_2Ph$-*p*-**C**), 129.4 (N_8SO_2Ph-*o*-**C**), 127.8 ($\mathbf{C}_5$), 126.5 ($\mathbf{C}_4$), 119.0 ($\mathbf{C}_7$), 89.1 ($\mathbf{C}_{8a}$), 69.0 ($N_1CO_2\mathbf{C}H_2Ph$), 64.1 ($\mathbf{C}_{3a}$), 47.9 ($\mathbf{C}_2$), 43.5 ($\mathbf{C}_3$).

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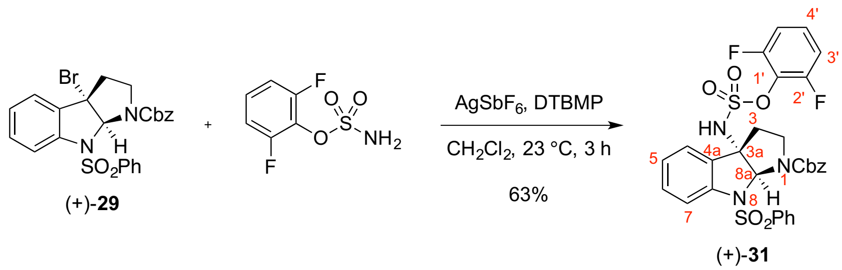
[3] Xie, W.; Jiang, G.; Liu, H.; Hu, J.; Pan, X.; Zhang, H.; Wan, X.; Lai, Y.; Ma, D. *Angew. Chem. Int. Ed.* **2013**, *52*, 12924.
[4] Further elution with 60% ethyl acetate in hexanes allows for the recovery of the (*S*)-TRIP catalyst.

FTIR (thin film) cm^{-1}:	3065 (s), 2956 (s), 1701 (m), 1601 (s), 1457 (br-m).
HRMS (DART) (*m/z*):	calc'd for $C_{24}H_{22}BrN_2O_4S$ $[M+H]^+$: 513.0478, found: 513.0486.
$[\alpha]_D^{24}$:	+157 (*c* = 0.60, CH_2Cl_2).
TLC (20% ethyl acetate in hexanes), R*f*:	0.22 (UV, CAM).



Sulfamate ester (+)-31:

A sample of silver hexafluoroantimonate (772 mg, 2.25 mmol, 2.00 equiv) was added to a solution of bromocyclotryptamine (+)-**29** (577 mg, 1.12 mmol, 1 equiv), 2,6-difluorophenyl sulfamate[5] (470 mg, 2.25 mmol, 2.00 equiv), and 2,6-di-*tert*-butyl-4-methylpyridine (DTBMP, 592 mg, 2.88 mmol, 2.57 equiv) in dichloromethane (28 mL) at 23 ºC in the dark. After 3 h, the off-white suspension was diluted with ethyl acetate (45 mL) and was filtered through a 2.2 cm pad of silica gel covered with a 1.2 cm pad of Celite in a 60 mL medium-porosity fritted glass funnel. The beige filter cake was washed with ethyl acetate (285 mL) and the filtrate was concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 35%→38% ethyl acetate in hexanes) to afford sulfamate ester (+)-**31** (453 mg, 62.8%) as a white foam.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (400 MHz, CD_3CN, 60 °C): δ 7.80 (d, 2H, *J* = 7.6 Hz, N_8SO_2Ph-*o*-**H**), 7.62 (app-d, *J* = 8.1, 1H, C_7**H**), 7.55 (tt, *J* = 7.1, 1.3 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.47–7.28 (m, 10H, C_4**H**, C_6**H**, $C_{4'}$**H**, $N_1CO_2CH_2$Ph-*o*-**H**, $N_1CO_2CH_2$Ph-*m*-**H**, $N_1CO_2CH_2$ Ph-*p*-**H**, N_8SO_2Ph-*m*-**H**), 7.20 (td, *J* = 7.6, 0.9 Hz, 1H, C_5**H**), 7.14–7.05 (m, 2H, $C_{3'}$**H**), 6.58 (s, 2H, C_{8a}**H**, N**H**SO_3Ar), 5.21 (d, *J* = 12.4 Hz, 1H, N_1CO_2C**H**$_a$Ph), 5.10 (d, *J* = 12.4 Hz, 1H, N_1CO_2C**H**$_b$Ph), 4.03–3.94 (m, 1H, C_2**H**$_a$), 2.90–2.71 (m, 2H, C_2**H**$_b$, C_3**H**$_a$), 2.46–2.33 (m, 1H, C_3**H**$_b$).

^{13}C NMR (100 MHz, CD_3CN, 60 °C): δ 155.8 (N_1**C**O_2CH_2Ph), 157.7 (dd, *J* = 252.0, 3.5 Hz, **C**$_{2'}$), 143.9 (**C**$_{7a}$), 140.5 (N_8SO_2Ph-*ipso*-**C**), 138.6 ($N_1CO_2CH_2$Ph-*ipso*-**C**), 135.2 (N_8SO_2Ph-*p*-**C**), 132.6 (**C**$_6$), 131.9 (**C**$_{4a}$), 130.9 (N_8SO_2Ph-*m*-**C**), 130.1 ($N_1CO_2CH_2$Ph-*m*-**C**), 130.0 (t, *J* = 9.5 Hz, **C**$_{4'}$), 129.8 ($N_1CO_2CH_2$Ph-*p*-**C**), 129.7 ($N_1CO_2CH_2$Ph-*o*-**C**), 128.9 (N_8SO_2Ph-*o*-**C**), 128.2 (t, *J* = 15.8 Hz, **C**$_{1'}$), 126.9 (**C**$_4$), 126.7 (**C**$_5$), 117.7 (**C**$_7$),

[5] Roizen, J. L.; Zalatan, D. L.; Du Bois, J. *Angew. Chem. Int. Ed.* **2013**, *52*, 11343.

114.6–114.3 (m, **C**$_{3'}$), 84.9 (**C**$_{8a}$), 74.7 (**C**$_{3a}$), 69.0 (N_1CO_2**C**H_2Ph), 46.6 (**C**$_2$), 38.1 (**C**$_3$).

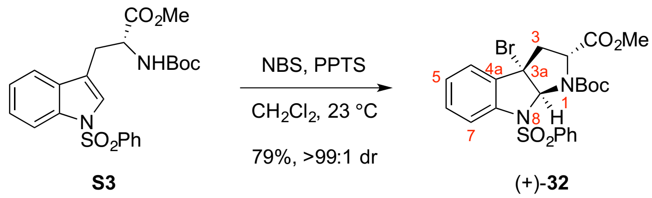
^{19}F NMR (282 MHz, CD_3CN, 20 °C): δ –125.3 (s, C_6H_3**F**$_2$).

FTIR (thin film) cm^{-1}: 3179 (br-s), 2895 (s), 1685 (m), 1605 (s), 1175 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{30}H_{25}F_2KN_3O_7S_2$ $[M+K]^+$: 680.0734, found: 680.0735.

$[\alpha]_D^{24}$: +39 (c = 1.42, CH_2Cl_2).

TLC (35% ethyl acetate in hexanes), R*f*: 0.21 (UV, CAM).



Bromocyclotryptophan (+)-32:

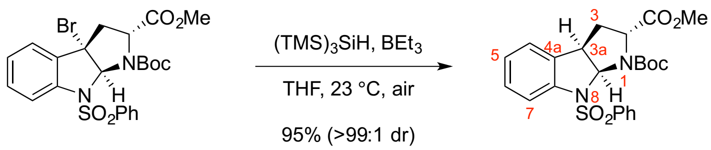
A sample of *N*-bromosuccinimide (4.04 g, 22.7 mmol, 1.05 equiv) was added to a solution of tryptophan derivative **S3**[6] (9.90 g, 21.6 mmol, 1 equiv) and pyridinium *p*-toluenesulfonate (5.70 g, 22.7 mmol, 1.05 equiv) in dichloromethane (216 mL) at 23 ºC. After 1.5 h, the homogeneous yellow reaction mixture was washed sequentially with a saturated aqueous sodium bicarbonate solution (100 mL) followed by a saturated aqueous sodium thiosulfate solution (100 mL), and finally saturated aqueous sodium chloride solution (100 mL). The organic layer was dried over anhydrous sodium sulfate, was filtered, and was concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 50% diethyl ether in hexanes) to afford bromocyclotryptophan (+)-**32** (11.6 g, 99.6%, 17.5:1 dr) as a white foam. The diastereomeric ratio was further enriched by recrystallization from 27% ethyl acetate in hexanes to yield bromocyclotryptophan (+)-**32** (9.13 g over two batches, 78.7%, >99:1 dr) as colorless plates.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C):	δ 7.92 (d, *J* = 7.6 Hz, 2H, N_8SO_2Ph-*o*-**H**), 7.57 (t, *J* = 7.5 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.45 (m, 4H, C_7**H**, C_4**H**, N_8SO_2Ph-*m*-**H**), 7.39 (app-td, *J* = 7.9, 1.2 Hz, 1H, C_6**H**), 7.23 (app-td, *J* = 7.5, 0.8 Hz, 1H, C_5**H**), 6.30 (s, 1H, C_{8a}**H**), 3.83 (dd, *J* = 9.8, 6.5 Hz, 1H, C_2**H**), 3.72 (s, 3H, $CO_2C\mathbf{H}_3$), 3.26 (dd, *J* = 13.1, 6.5 Hz, 1H, $C_3\mathbf{H}_a$), 2.75 (dd, *J* = 13.1, 9.8 Hz, 1H, $C_3\mathbf{H}_b$), 1.44 (s, 9H, $N_1CO_2C(C\mathbf{H}_3)_3$).
^{13}C NMR (125.8 MHz, CD_3CN, 60 °C):	δ 172.7 ($\mathbf{C}O_2CH_3$), 153.8 ($N_1\mathbf{C}O_2C(CH_3)_3$), 141.9 ($\mathbf{C}_{7a}$), 140.7 ($N_8SO_2$Ph-*ipso*-**C**), 136.1 ($\mathbf{C}_{4a}$), 135.4 (N_8SO_2Ph-*p*-**C**), 132.7 ($\mathbf{C}_6$), 130.6 (N_8SO_2Ph-*m*-**C**), 130.0 (N_8SO_2Ph-*o*-**C**), 128.1 ($\mathbf{C}_5$), 126.2 ($\mathbf{C}_4$), 119.8 ($\mathbf{C}_7$), 88.9 ($\mathbf{C}_{8a}$), 83.7 ($N_1CO_2\mathbf{C}(CH_3)_3$), 61.5 ($\mathbf{C}_{3a}$), 61.3 ($\mathbf{C}_2$), 53.7 ($CO_2\mathbf{C}H_3$), 44.6 ($\mathbf{C}_3$), 29.2 ($N_1CO_2C(\mathbf{C}H_3)_3$).
FTIR (thin film) cm^{-1}:	2980 (m), 1752 (s), 1700 (s), 1600 (w), 1367 (m)

[6] López, C. S.; Pérez-Baldo, C.; Rodríguez-Graña, P.; de Lera, Á. R. *Org. Lett.* **2008**, *10*, 77.

HRMS (ESI) (*m/z*):	calc'd for $C_{23}H_{26}BrN_2O_6S$ $[M+H]^+$: 537.0689, found: 537.0701.
$[\alpha]_D^{24}$:	+191 (c = 0.75, CH_2Cl_2).
TLC (33% acetone in hexanes), R*f*:	0.34 (UV, CAM).



(+)-**32** (+)-**33**

__**Cyclotryptophan (+)-33:**__

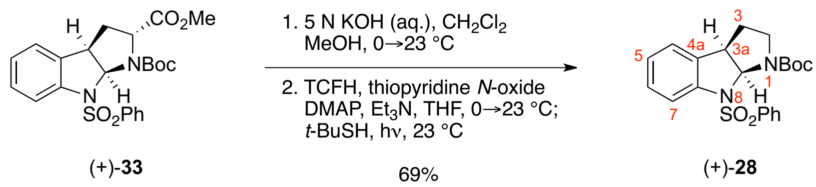
Triethylborane (1.0 M in THF, 1.7 mL, 1.7 mmol, 0.10 equiv) was added via syringe to a solution of bromocyclotryptophan (+)-**32** (9.01 g, 16.7 mmol, 1 equiv) and tris(trimethylsilyl)silane (15.5 mL, 50.1 mmol, 3.00 equiv) in tetrahydrofuran (129 mL) at 23 ºC under an air atmosphere. After 10 min, the homogeneous colorless solution was diluted with a saturated aqueous sodium bicarbonate solution (130 mL). After vigorous stirring for 10 min, the heterogeneous biphasic mixture was diluted with deionized water (100 mL) then extracted with dichloromethane (3 × 200 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to yield a colorless semi-solid suspended in a colorless oil. The colorless oil was decanted and the remaining residue was purified via flash chromatography on silica gel (eluent: 25%→32% ethyl acetate in hexanes) to afford cyclotryptophan (+)-**33** (7.27 g, 94.9%, >99:1 dr) as a white foam.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C):	δ 7.70 (d, *J* = 7.5 Hz, 2H, N_8SO_2Ph-*o*-**H**), 7.55 (app-t, *J* = 7.5 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.50 (d, *J* = 8.1 Hz, 1H, C_7**H**), 7.41 (app-t, *J* = 7.6 Hz, 2H, N_8SO_2Ph-*m*-**H**), 7.30–7.25 (m, 1H, C_6**H**), 7.14–7.10 (m, 2H, C_4**H**, C_5**H**), 6.22 (d, *J* = 5.9 Hz, 1H, C_{8a}**H**), 3.89–3.83 (m, 1H, C_{3a}**H**), 3.69 (s, 3H, CO_2C**H_3**), 3.57–3.52 (m, 1H, C_2**H**), 2.37 (ddd, *J* = 13.1, 7.2, 2.9 Hz, 1H, C_3**H_a**), 2.21 (dt, *J* = 13.1, 8.0 Hz, 1H, C_3**H_b**), 1.47 (s, 9H, $N_1CO_2C(C$**H**$_3)_3$).
^{13}C NMR (125.8 MHz, CD_3CN, 60 °C):	δ 174.3 (**C**O_2CH_3), 154.8 (N_1**C**$O_2C(CH_3)_3$), 142.8 (**C**$_{7a}$), 140.0 (N_8SO_2Ph-*ipso*-**C**), 136.3 (**C**$_{4a}$), 135.0 (N_8SO_2Ph-*p*-**C**), 130.6 (N_8SO_2Ph-*m*-**C**), 130.3 (**C**$_6$), 129.1 (N_8SO_2Ph-*o*-**C**), 127.6 (**C**$_5$), 126.1 (**C**$_4$), 120.2 (**C**$_7$), 83.1 (**C**$_{8a}$), 82.8 (N_1CO_2**C**$(CH_3)_3$), 61.0 (**C**$_{3a}$), 53.4 (CO_2**C**H_3), 46.8 (**C**$_2$), 35.1 (**C**$_3$), 29.3 ($N_1CO_2C($**C**$H_3)_3$).
FTIR (thin film) cm^{-1}:	2979 (w), 1750 (s), 1719 (s), 1697 (s), 1366 (m).
HRMS (ESI) (*m/z*):	calc'd for $C_{23}H_{27}N_2O_6S$ $[M+H]^+$: 459.1584, found: 459.1603.

$[\alpha]_D^{24}$: +168 (c = 0.77, CH_2Cl_2).

TLC (33% acetone in hexanes), R*f*: 0.26 (UV, CAM).



Cyclotryptamine (+)-28:

An aqueous sodium hydroxide solution (5 N, 79.0 mL, 395 mmol, 25.0 equiv) was added in portions over 5 min to a solution of cyclotryptophan (+)-**33** (7.25 g, 15.7 mmol, 1 equiv) in methanol (240 mL) and dichloromethane (31 mL) cooled to 0 ºC in an ice bath under an air atmosphere. After 5 min, the ice bath was removed and the milky white solution was allowed to stir at 23 °C. After 7 h, the reaction mixture was cooled to 0 ºC in an ice bath and acidified to pH ~ 3 by the portionwise addition of an aqueous hydrochloric acid solution (12 N, 34 mL) over 10 min. The resulting white suspension was allowed to warm to 23 °C and was then concentrated under reduced pressure to remove methanol. The white suspension was then diluted with deionized water (100 mL) and extracted with dichloromethane (3 × 200 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (100 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to afford the crude carboxylic acid (8.0 g, >99%) as a white foam, which was used directly in the next step after azeotropic drying by concentration from toluene (HPLC grade, 3 × 100 mL).

Samples of 2-mercaptopyridine *N*-oxide (3.20 g, 25.2 mmol, 1.60 equiv), 4-(dimethylamino)pyridine (192 mg, 1.57 mmol, 0.100 equiv), and *N*,*N*,*N′*,*N′*-tetramethylchloroformamidinium hexafluorophosphate (TCFH, 6.62 g, 23.6 mmol, 1.50 equiv) were added sequentially to a solution of the crude carboxylic acid in tetrahydrofuran (157 mL) cooled to 0 ºC in an ice bath. The reaction flask was subsequently removed from the ice bath, covered in aluminum foil, and charged with triethylamine (8.80 mL, 63.0 mmol, 4.00 equiv) in a slow stream over 30 s while the reaction mixture was still cold. After 2.75 h, *tert*-butyl mercaptan (8.90 mL, 78.7 mmol, 5.00 equiv) was added via syringe. The aluminum foil was then removed from the flask and the resulting green suspension was irradiated with a flood lamp (500 W). To maintain an internal temperature of 23 °C, the flask was immersed in a 20 °C water bath. After 2 h, the lamp was shut off and a saturated aqueous sodium bicarbonate–water solution (1:1, 400 mL) was added. The aqueous layer was extracted with dichloromethane (3 × 200 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (150 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 20→25% acetone in hexanes) to afford cyclotryptamine (+)-**28** (4.35 g, 69.0% overall from (+)-**33**) as a white foam.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C): δ 7.66 (d, *J* = 5.3 Hz, 2H, N_8SO_2Ph-*o*-**H**), 7.56 (t, *J* = 7.5 Hz, 1H, N_8SO_2Ph-*p*-**H**), 7.47 (d, *J* = 8.2 Hz, 1H, C_7**H**), 7.41 (t, *J* = 7.9 Hz, 2H, N_8SO_2Ph-*m*-**H**), 7.26–7.22 (m, 1H, C_6**H**), 7.14–7.09 (m, 2H, C_4**H**, C_5**H**), 6.22 (d, J = 6.5 Hz, 1H, C_{8a}**H**), 3.67 (dd, J = 11.0, 7.9 Hz, 1H, C_2**H**$_a$), 3.59 (t, J = 6.9 Hz, 1H, C_{3a}**H**), 2.62 (dt, J = 16.1, 8.2 Hz, 1H, C_2**H**$_b$), 2.06 (tt, J = 12.0, 7.7 Hz, 1H, C_3**H**$_a$), 1.94 (dd, J = 12.7, 5.3 Hz, 1H, C_3**H**$_b$), 1.49 (s, 9H, $N_1CO_2C(C\mathbf{H}_3)_3$).

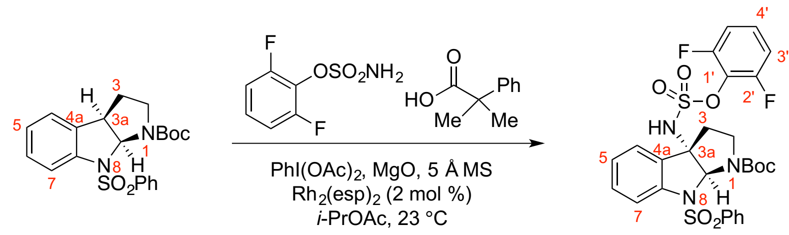
^{13}C NMR (125.8 MHz, CD_3CN, 60 °C): δ 154.8 ($N_1\mathbf{C}O_2C(CH_3)_3$), 143.1 (**C**$_{7a}$), 139.6 ($N_8SO_2$Ph-*ipso*-**C**), 136.0 (**C**$_{4a}$), 134.6 (N_8SO_2Ph-*p*-**C**), 130.4 (N_8SO_2Ph-*m*-**C**), 129.6 (**C**$_6$), 128.5 (N_8SO_2Ph-*o*-**C**), 127.0 (**C**$_5$), 125.9 (**C**$_4$), 118.9 (**C**$_7$), 81.5 (2C, **C**$_{8a}$, $N_1CO_2\mathbf{C}(CH_3)_3$), 47.3 (**C**$_{3a}$), 46.0 (**C**$_2$), 31.4 (**C**$_3$), 29.0 ($N_1CO_2C(\mathbf{C}H_3)_3$).

FTIR (thin film) cm^{-1}: 2976 (m), 1697 (s), 1477 (w), 1393 (s), 1172 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{21}H_{25}N_2O_4S$ $[M+H]^+$: 401.1530, found: 401.1558.

$[\alpha]_D^{24}$: +188 (c = 1.3, CH_2Cl_2).

TLC (25% acetone in hexanes), R*f*: 0.26 (UV, CAM).



(+)-**28** (+)-**27**

Sulfamate ester (+)-27:

A round bottom flask equipped with a stir bar was charged with crushed 5Å molecular sieves (1.06 g, 200 mg/mmol of **28**), and magnesium oxide (853 mg, 21.2 mmol, 4.00 equiv). The flask and its contents were flame-dried under vacuum for 7 min. The reaction vessel was allowed to cool to 23 °C and was then backfilled with argon. Bis[rhodium(α,α,α',α'-tetramethyl-1,3-benzenedipropionic acid)] (80.2 mg, 106 µmol, 0.0200 equiv), cyclotryptamine (+)-**28** (2.13 g, 5.29 mmol, 1 equiv), 2,6-difluorophenyl sulfamate[5] (1.44 g, 6.88 mmol, 1.30 equiv), and 2-methyl-2-phenylpropionic acid (434 mg, 2.65 mmol, 0.500 equiv) were then added sequentially. The flask was evacuated and backfilled with argon (three cycles) and was then charged with isopropyl acetate (7.0 mL). The resulting green suspension was stirred vigorously for 5 min then (diacetoxyiodo)benzene (3.41 g, 10.6 mmol, 2.00 equiv) was added in a single portion. The flask was sealed and the suspension was allowed to stir vigorously at 23 °C under a static atmosphere of argon. After 26 h, the reaction mixture was filtered through a pad of Celite and the filter cake was rinsed with ethyl acetate (50 mL). The filtrate was concentrated under reduced pressure and the resulting residue was purified by flash column chromatography on silica gel (eluent: 20→30% acetone in hexanes) to afford a mixture of the desired sulfamate ester (+)-**27** along with a minor amount of the regioisomeric C2 amination product (5.4:1). The mixture was further purified by recrystallization from dichloromethane, hexanes, and diethyl ether (1:1:1, 4.5 mL) at 5 ºC to afford exclusively the sulfamate ester (+)-**27** (1.26 g, 39.2%) as an off-white solid.

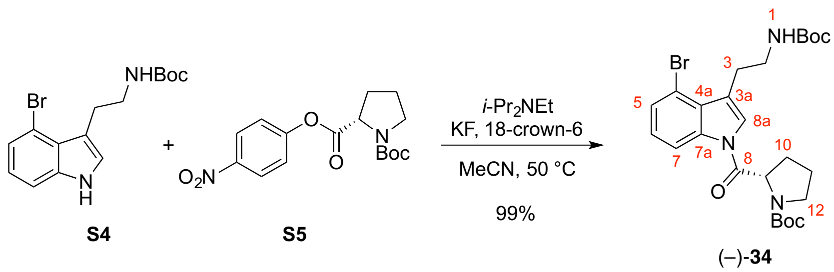
As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C): δ 7.81 (br-s, 2H, N_8SO_2Ph-*o*-**H**), 7.58–7.54 (m, 2H, N_8SO_2Ph-*p*-**H**, C_7**H**), 7.47–7.38 (m, 4H, N_8SO_2Ph-*m*-**H**, C_6**H**, C_4**H**), 7.37–7.32 (m, 1H, $C_{4'}$**H**), 7.20 (app-td, J = 7.7, 1.0 Hz, 1H, C_5**H**), 7.13 (app-t, J = 8.3 Hz, 1H $C_{3'}$**H**), 6.61 (br-s, 1H, N**H**SO_3Ar), 6.51 (s, 1H, C_{8a}**H**), 3.91 (br-s, 1H, C_2**H**$_a$), 2.80–2.60 (m, 2H, C_2**H**$_b$, C_3**H**$_a$), 2.36 (dd, J = 12.0, 4.6 Hz, 1H, C_3**H**$_b$), 1.47 (s, 9H, $N_1CO_2C(CH_3)_3$).

^{13}C NMR (125.8 MHz, CD_3CN, 60 °C): δ 157.3 (dd, J = 251.7, 3.5 Hz, **C**$_{2'}$), 154.6 (N_1**C**$O_2C(CH_3)_3$), 143.5 (**C**$_{7a}$), 139.9 (N_8SO_2Ph-*ipso*-**C**), 134.8 (N_8SO_2Ph-*p*-**C**), 132.3 (**C**$_6$), 131.6 (**C**$_{4a}$), 130.6 (N_8SO_2Ph-*m*-**C**), 129.8 (app-t, J = 9.5 Hz, **C**$_{4'}$), 128.4 (N_8SO_2Ph-*o*-**C**), 127.7 (app-t, J =

15.7 Hz, $\mathbf{C}_{1'}$), 126.6 ($\mathbf{C}_4$), 126.4 ($\mathbf{C}_5$), 117.7 ($\mathbf{C}_7$), 114.1 (dd, J = 18.4, 4.0 Hz), 84.3 ($\mathbf{C}_{8a}$), 81.9 ($N_1CO_2\mathbf{C}(CH_3)_3$), 74.3 ($\mathbf{C}_{3a}$), 46.0 ($\mathbf{C}_2$), 36.9 ($\mathbf{C}_3$), 28.9 ($N_1CO_2C(\mathbf{C}H_3)_3$).

^{19}F NMR (282 MHz, $CDCl_3$, 20 °C):	δ –124.8 (s, $C_6H_3\mathbf{F}_2$).
FTIR (thin film) cm^{-1}:	3231 (br-w), 2979 (w), 1701 (s), 1676 (s), 1481 (s).
HRMS (ESI) (*m/z*):	calc'd for $C_{27}H_{28}F_2N_3O_7S_2$ $[M+H]^+$: 608.1331, found: 608.1347.
$[\alpha]_D^{24}$:	+42 (c = 0.97, CH_2Cl_2).
TLC (33% acetone in hexanes), R*f*:	0.34 (UV, CAM).



Amide (–)-34:

A 100 mL Schlenk flask containing a magnetic stir-bar was charged with 18-crown-6 (5.50 g, 20.8 mmol, 2.00 equiv), potassium fluoride (2.44 g, 41.6 mmol, 4.00 equiv), bromotryptamine **S4** (3.53 g, 10.4 mmol, 1 equiv), and L-proline derivative **S5** (6.12 g, 18.2 mmol, 1.75 equiv) sequentially.[7] The reaction flask and its contents were placed under vacuum and backfilled with argon (three cycles). Acetonitrile (42 mL) and *N*,*N*-diisopropylethylamine (6.40 mL, 46.8 mmol, 4.50 equiv) were then added. The resulting bright yellow heterogeneous mixture was sonicated for 1 h and then the flask was immersed in a pre-heated oil bath at 50 °C and stirred vigorously for 16 h. The reaction mixture was concentrated under reduced pressure. The residue was dissolved in ethyl acetate (100 mL) and was washed sequentially with deionized water (50 mL), a saturated aqueous potassium carbonate–water solution (1:1, 2 × 50 mL), deionized water (50 mL), and a saturated aqueous sodium chloride solution (2 × 50 mL). The organic phase was dried over anhydrous sodium sulfate, was filtered, and was concentrated under reduced pressure. The resulting light brown oil was purified by flash column chromatography on silica gel (eluent: 10%→40% ethyl acetate in hexanes) to afford amide (–)-**34** (5.50 g, 98.6%) as a white foam. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C, 1.6:1 mixture of atropisomers, *denotes minor atropisomer): δ 8.51 (d, J = 8.3 Hz, 1H, C_7**H**), 8.41 (d, J = 8.2 Hz, 1H, C_7**H***), 7.62 (br-s, 2H, C_{8a}**H,** C_{8a}**H***), 7.47 (d, J = 7.8 Hz, 1H, C_5**H**), 7.46 (d, J = 7.9 Hz, 1H, C_5**H***), 7.22 (app-t, J = 8.1 Hz, 1H, C_6**H**), 7.20 (app-t, J = 8.1 Hz, 1H, C_6**H***), 5.42 (br-s, 2H, N_1**H**, N_1**H***), 5.04 (dd, J = 8.9, 3.8 Hz, 1H, C_9**H***), 5.01 (dd, J = 8.6, 4.5 Hz, 1H, C_9**H**), 3.55–3.46 (m, 4H, $C_{12}\mathbf{H}_2$, $C_{12}\mathbf{H}_2$*), 3.46–3.41 (m, 4H, $C_2\mathbf{H}_2$, $C_2\mathbf{H}_2$*), 3.04–3.19 (m, 4H, $C_3\mathbf{H}_2$, $C_3\mathbf{H}_2$*), 2.47–2.36 (m, 2H, $C_{10}\mathbf{H}_a$, $C_{10}\mathbf{H}_a$*), 2.08–1.97 (m, 2H, $C_{10}\mathbf{H}_b$, $C_{10}\mathbf{H}_b$*), 1.97–1.87 (m, 4H, $C_{11}\mathbf{H}_2$, $C_{11}\mathbf{H}_2$*), 1.43 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$*), 1.38 (s, 9H, $NHCO_2C(C\mathbf{H}_3)_3$), 1.37 (s, 9H, $NHCO_2C(C\mathbf{H}_3)_3$*), 1.18 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$).

^{13}C NMR (125.8 MHz, CD_3CN, 20 °C, 1.6:1 mixture of atropisomers, *denotes minor atropisomer): δ 173.2 (**C**$_8$), 172.4 (**C**$_8$*), 157.3

[7] (a) Benkovics, T.; Guzei, I. A.; Yoon, T. P. *Angew. Chem. Int. Ed.* **2010**, *49*, 9153. (b) Delgado, R.; Blakey, S. B. *Eur. J. Org. Chem.* **2009**, 1506.

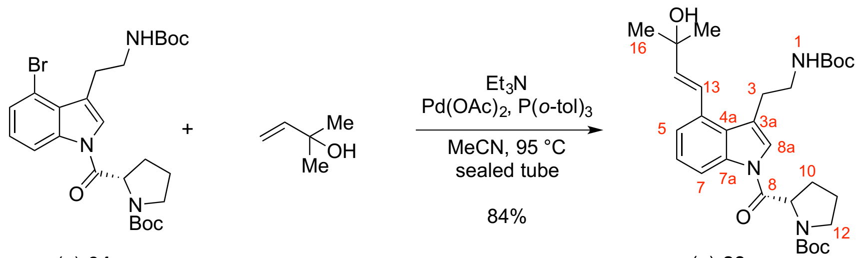
(NH**C**O_2C$(CH_3)_3$), 155.5 (N**C**O_2C$(CH_3)_3$*), 154.7 (N**C**O_2C$(CH_3)_3$), 139.1 (**C**$_{7a}$, **C**$_{7a}$*), 129.8 (**C**$_{4a}$, **C**$_{4a}$*), 129.6 (**C**$_5$), 129.5 (**C**$_5$*), 127.5 (**C**$_6$), 127.4 (**C**$_6$*), 125.9 (2C, **C**$_{8a}$*, **C**$_{8a}$), 121.4 (**C**$_{3a}$), 121.3 (**C**$_{3a}$*), 117.1 (**C**$_7$), 117.1 (**C**$_7$*), 115.0 (**C**$_4$, **C**$_4$*), 80.7 (NCO_2**C**$(CH_3)_3$*), 80.6 (NCO_2**C**$(CH_3)_3$), 79.5 (NHCO_2**C**$(CH_3)_3$), 60.7 (**C**$_9$), 60.6 (**C**$_9$*), 48.1 (**C**$_{12}$*), 47.8 (**C**$_{12}$), 41.64 (**C**$_2$), 41.61 (**C**$_2$*), 32.3 (**C**$_{10}$), 31.4 (**C**$_{10}$*), 29.1 (NCO_2C(**C**$H_3)_3$*), 29.0 (NCO_2C(**C**$H_3)_3$), 28.7 (NHCO_2C(**C**$H_3)_3$), 28.1 (**C**$_3$*), 28.1 (**C**$_3$), 25.5 (**C**$_{11}$), 24.9 (**C**$_{11}$).

FTIR (thin film) cm^{-1}: 3360 (br-w), 2977 (m), 1700 (s), 1423 (s), 1167 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{25}H_{35}BrN_3O_5$ $[M+H]^+$: 536.1755, found: 536.1759.

$[\alpha]_D^{24}$: –52 (c = 0.54, CH_2Cl_2).

TLC (30% ethyl acetate in hexanes), R*f*: 0.13 (UV, CAM).



(–)-**34** (–)-**36**

Allylic alcohol (–)-36:

Acetonitrile (10.8 mL), triethylamine (2.00 mL, 14.5 mmol, 1.50 equiv), and 1,1-dimethylallyl alcohol (4.65 mL, 43.6 mmol, 4.50 equiv) were sequentially added to a 100 mL pressure tube containing palladium(II) acetate (174 mg, 0.78 mmol, 0.0800 equiv), tri(*o*-tolyl)phosphine (590 mg, 1.94 mmol, 0.200 equiv), and amide (–)-**34** (5.20 g, 9.69 mmol, 1 equiv). The reaction tube was sealed under an argon atmosphere and immersed in a pre-heated oil bath at 95 °C. After 3.5 h, the reaction mixture was cooled to 23 °C and was filtered through a pad of silica gel. The filter cake was washed with ethyl acetate (100 mL) and the filtrate was concentrated under reduced pressure. The thick orange oil was purified by flash column chromatography on silica gel (eluent: 10%→75% acetone in hexanes). The resulting yellow sticky foam was purified by flash column chromatography on silica gel (eluent: 10%→40% ethyl acetate in hexanes) to afford allylic alcohol (–)-**36** (4.40 g, 83.8%) as a white foam. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C, 1.6:1 mixture of atropisomers, *denotes minor atropisomer): δ 8.39 (d, J = 8.0 Hz, 1H, C_7**H**), 8.34 (d, J = 8.3 Hz, 1H, C_7**H***), 7.55 (s, 1H, C_{8a}**H***), 7.54 (s, 1H, C_{8a}**H**), 7.35 (d, J = 7.4 Hz, 2H, C_5**H**, C_5**H***), 7.30 (app-t, J = 7.4 Hz, 2H, C_6**H**, C_6**H***), 7.28 (d, J = 15.5 Hz, 2H, C_{13}**H**, C_{13}**H***), 6.34 (d, J = 15.8 Hz, 2H, C_{14}**H**, C_{14}**H***), 5.61 (br-dd, J = 12.7, 7.0 Hz 2H, N_1**H**, N_1**H***), 5.03 (dd, J = 8.4, 3.1 Hz, 1H, C_9**H***), 5.01 (dd, J = 8.4, 4.2 Hz, 1H, C_9**H**), 3.64 (s, 2H, O**H**, O**H***), 3.56–3.44 (m, 4H, C_{12}**H**$_2$, C_{12}**H**$_2$*), 3.34–3.29 (m, 4H, C_2**H**$_2$, C_2**H**$_2$*), 3.01 (app-t, J = 7.5 Hz, 4H, C_3**H**$_2$, C_3**H**$_2$*), 2.46–2.35 (m, 2H, C_{10}**H**$_a$, C_{10}**H**$_a$*), 2.08–1.88 (m, 6H, C_{10}**H**$_b$, C_{10}**H**$_b$*, C_{11}**H**$_2$, C_{11}**H**$_2$*), 1.44 (s, 9H, $NCO_2C(C$**H**$_3)_3$*), 1.41 (s, 9H, $NHCO_2C(C$**H**$_3)_3$), 1.36 (s, 12H, C_{16a}**H**$_3$, C_{16a}**H**$_3$*, C_{16b}**H**$_3$, C_{16b}**H**$_3$*), 1.17 (s, 9H, $NCO_2C(C$**H**$_3)_3$).

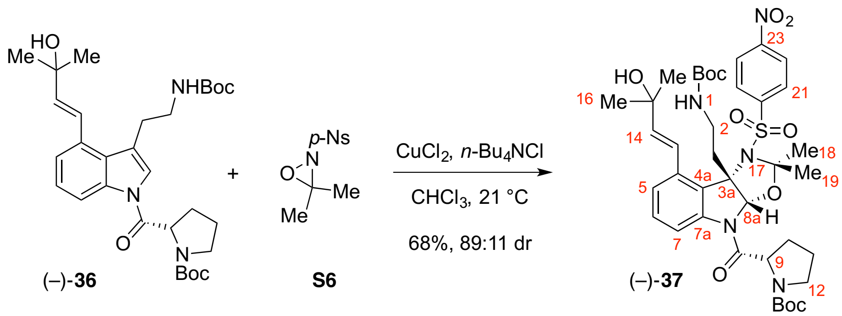
^{13}C NMR (125.8 MHz, CD_3CN, 20 °C, 1.6:1 mixture of atropisomers, *denotes minor atropisomer): δ 173.2 (**C**$_8$), 172.4 (**C**$_8$*), 157.5 (NH**C**$O_2C(CH_3)_3$*), 155.6 (N**C**$O_2C(CH_3)_3$), 154.8 (N**C**$O_2C(CH_3)_3$), 143.4 (**C**$_{14}$), 143.3 (**C**$_{14}$*), 138.3 (2C, **C**$_{7a}$, **C**$_{7a}$*), 133.5 (**C**$_4$), 133.4 (**C**$_4$*), 128.7 (2C, **C**$_{4a}$, **C**$_{4a}$*), 126.6 (2C, **C**$_6$, **C**$_6$*) 124.8 (**C**$_{8a}$, **C**$_{8a}$*), 124.4 (**C**$_{13}$), 124.3 (**C**$_{13}$*), 123.0 (2C, **C**$_{5,}$ **C**$_5$*), 121.8 (**C**$_{3a}$*), 121.6 (**C**$_{3a}$), 116.5 (2C, **C**$_7$, **C**$_7$*), 80.7 (NCO_2**C**$(CH_3)_3$*), 80.5 (NCO_2**C**$(CH_3)_3$), 80.0 ($NHCO_2$**C**$(CH_3)_3$), 71.6 (2C, **C**$_{15,}$ **C**$_{15}$*), 60.6 (**C**$_9$), 60.5 (**C**$_9$*), 48.1 (**C**$_{12}$*), 47.9 (**C**$_{12}$), 42.2 (2C, **C**$_{2,}$ **C**$_2$*), 32.3 (**C**$_{10}$), 31.4 (**C**$_{10}$*), 30.6 (2C, **C**$_{16}$*, **C**$_{16}$), 29.6 (2C, **C**$_3$*, **C**$_3$), 29.1 ($NCO_2C($**C**$H_3)_3$*), 29.0 ($NCO_2C($**C**$H_3)_3$), 28.7 ($NHCO_2C($**C**$H_3)_3$), 25.5 (**C**$_{11}$*), 24.9 (**C**$_{11}$).

FTIR (thin film) cm^{-1}: 3397 (br-m), 2975 (s), 1696 (s), 1521 (m), 1163 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{30}H_{47}N_4O_6$ $[M+NH_4]^+$: 559.3490, found: 559.3493.

$[\alpha]_D^{24}$: –50 (c = 0.80, CH_2Cl_2).

TLC (30% acetone in hexanes), R*f*: 0.33 (UV, CAM).



<u>Oxazoline (–)-37:</u>

Copper(II) chloride (1.03 g, 7.62 mmol, 1.00 equiv) and tetra-*n*-butylammonium chloride[8] (4.13 g, 7.62 mmol, 1.00 equiv) were added to a 100 mL Schlenk flask. Chloroform (38 mL) was added and the resulting dark red mixture was stirred vigorously for 20 min, at which point allylic alcohol (–)-**36** (4.13 g, 7.62 mmol, 1 equiv) and oxaziridine **S6**[9] (2.56 g, 9.91 mmol, 1.30 equiv) were added. After stirring at 21 °C for 1.5 h, the reaction mixture was filtered through a pad of silica gel, and the filter cake was washed with an ethyl acetate–hexanes solution (1:1, 800 mL). The yellow filtrate was concentrated under reduced pressure and the residue was purified by flash column chromatography on silica gel (eluent: 10%→40% ethyl acetate in hexanes). Further purification by chromatography on silica gel (eluent: 10%→30% acetone in hexanes) afforded oxazoline (–)-**37** (4.16 g, 68.1%) as a pale yellow foam as an inseparable mixture of diastereomers (89:11 dr). The diastereomeric ratio was determined after derivatization of oxazoline (–)-**37**. Structural assignments for the major diastereomer were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C, ~1.9:1 mixture of atropisomers, *denotes minor atropisomer): δ 8.05 (d, *J* = 8.1 Hz, 1H, C_7**H**), 7.98 (d, *J* = 7.8 Hz, 1H, C_7**H***), 7.90 (d, *J* = 9.1 Hz, 4H, C_{22}**H**$_2$, C_{22}**H**$_2$*), 7.48 (d, *J* = 9.0 Hz, 4H, C_{21}**H**$_2$, C_{21}**H**$_2$*), 7.32 (d, *J* = 15.7 Hz, 1H, C_{13}**H***), 7.31 (d, *J* = 15.8 Hz, 1H, C_{13}**H**), 6.99 (app-t, *J* = 8.1 Hz, 1H, C_6**H**), 6.95 (app-t, *J* = 8.1 Hz, 1H, C_6**H***), 6.66 (d, *J* = 7.8 Hz, 1H, C_5**H**), 6.61 (d, *J* = 7.3 Hz, 1H, C_5**H***), 6.61 (s, 1H, C_{8a}**H***), 6.33 (s, 1H, C_{8a}**H**), 6.14 (d, *J* = 15.8 Hz, 1H, C_{14}**H**), 6.13 (d, *J* = 15.8 Hz, 1H, C_{14}**H***), 5.56 (br-s, 1H, N_1**H***), 5.50 (br-s, 1H, N_1**H**), 4.68 (dd, *J* = 7.7, 5.8 Hz, 1H, C_9**H***), 4.50 (dd, *J* = 7.6, 6.0 Hz, 1H, C_9**H**), 3.86 (s, 1H, O**H***), 3.80 (s, 1H, O**H**), 3.52–3.40 (m, 4H, C_{12}**H**$_2$, C_{12}**H**$_2$*), 3.39–3.28 (m, 2H, C_3**H**, C_3**H***), 3.21–3.07 (m, 2H, C_2**H**, C_2**H***), 2.68–2.55 (m, 2H, C_2**H***, C_2**H**), 2.53–2.46 (m, 1H, C_{10}**H**), 2.35–2.28 (m, 1H, C_{10}**H***), 2.25–2.11 (m, 3H, C_3**H**, C_3**H***, C_{11}**H***), 2.10–2.00 (m, 3H, C_{10}**H**, C_{10}**H***, C_{11}**H**), 1.92–1.86 (m, 14H, C_{18}**H**$_3$,

[8] This reagent was azeotropically dried by concentration from benzene (three times) immediately before use.
[9] Benkovics, T.; Du, J. Guzei, I. A.; Yoon, T. P. *J. Org. Chem.* **2009**, *74*, 5545.

C_{18}**H**$_3$* C_{19}**H**$_3$, C_{19}**H**$_3$*, C_{11}**H**, C_{11}**H***), 1.45–1.34 and 1.06 (app-m, 36H, $NCO_2C(C$**H**$_3)_3$, $NCO_2C(C$**H**$_3)_3$*, $N_1HCO_2C(C$**H**$_3)_3$, $N_1HCO_2C(C$**H**$_3)_3$*).

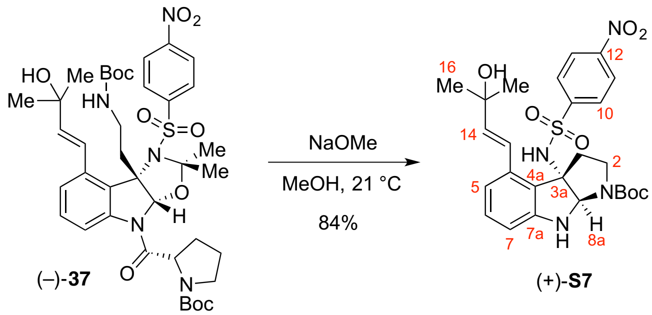
^{13}C NMR (125.8 MHz, CD_3CN, 20 °C, ~1.9:1 mixture of atropisomers, *denotes minor atropisomer): δ 176.0 (**C**$_8$*), 175.6 (**C**$_8$), 157.4 (2C, N_1H**C**$O_2C(CH_3)_3$, N_1H**C**$O_2C(CH_3)_3$*), 155.9 (N**C**$O_2C(CH_3)_3$*), 154.5 (N**C**$O_2C(CH_3)_3$), 150.8 (2C, **C**$_{20/23}$, **C**$_{20/23}$*), 147.7 (**C**$_{20/23}$*), 147.6 (**C**$_{20/23}$), 144.3 (**C**$_{14/7a}$), 144.2 (**C**$_{14/7a}$*), 144.1 (**C**$_{14/7a}$*), 144.0 (**C**$_{14/7a}$), 138.1 (2C, **C**$_4$, **C**$_4$*), 132.4 (**C**$_6$), 132.3 (**C**$_6$*), 129.3 (2C, **C**$_{21}$, **C**$_{21}$*), 129.2 (2C, **C**$_{22,}$ **C**$_{22}$*), 124.0 (C_{13}), 122.5 (**C**$_5$), 122.3 (**C**$_5$*), 116.5 (**C**$_7$*), 115.7 (**C**$_7$), 103.2 (**C**$_{17}$), 102.7 (**C**$_{17}$*), 97.8 (**C**$_{8a}$*), 97.5 (**C**$_{8a}$), 80.8 (NCO_2**C**$(CH_3)_3$), 80.5 (3C, NCO_2**C**$(CH_3)_3$, (NCO_2**C**$(CH_3)_3$), (NCO_2**C**$(CH_3)_3$), 75.9 (**C**$_{3a}$), 75.7 (**C**$_{3a}$*), 71.5 (2C, **C**$_{15,}$ **C**$_{15}$*), 60.1 (**C**$_9$), 59.3 (**C**$_9$*), 48.6 (**C**$_{12}$), 48.5 (**C**$_{12}$*), 38.4 (**C**$_2$*), 38.3 (**C**$_2$), 30.7, 30.6, 30.4, 30.2, 29.7, 29.1, 29.0, 28.8 36.6 (2C, **C**$_3$, **C**$_3$*), 33.1 (**C**$_{10}$), 32.9 (2C), 31.5 (**C**$_{10}$*), 26.2 (**C**$_{11}$*), 25.2 (**C**$_{11}$).

FTIR (thin film) cm^{-1}: 3447 (br-w), 2976 (m), 1685 (s), 1533 (s), 1164 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{39}H_{57}N_6O_{11}S$ $[M+NH_4]^+$: 817.3801, found: 817.3808.

$[\alpha]_D^{24}$: –84 (*c* = 0.51, CH_2Cl_2).

TLC (30% acetone in hexanes), R*f*: 0.33 (UV, CAM).



Aminocyclotryptamine (+)-S7:

A solution of sodium methoxide (142 mg, 2.50 mmol, 50.0 equiv) in methanol (1.0 mL) was added to a solution of oxazoline (–)-**37** (40.0 mg, 50.0 µmol, 1 equiv) in methanol (0.5 mL). After stirring at 21 °C for 24 h, the light yellow solution was diluted with a mixture of saturated aqueous ammonium chloride–water (1:1, 10 mL) and was extracted with dichloromethane (5 × 5 mL). The combined extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting yellow film was purified by flash column chromatography on silica gel (eluent: 10%→40% ethyl acetate in hexanes) to afford aminocyclotryptamine (+)-**S7** (4.40 g, 83.8%, 89:11 er) as a yellow solid. The enantiomeric ratio was determined by chiral HPLC analysis (Chiralpak IA, 80% *i*PrOH / 20% hexanes, 1.0 mL/min, 254 nm, t_R (major) = 7.8 min, t_R (minor) = 6.5 min). Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C, ~1.5:1 mixture of atropisomers): δ 8.05 (d, J = 8.6 Hz, 2H, $C_{11}\mathbf{H}_2$), 7.49 (d, J = 8.2 Hz, 1H, $C_{10}\mathbf{H}_2$), 7.01 (app-t, 1H, J = 7.5 Hz, $C_6\mathbf{H}$), 6.88 (br-s, 1H, O**H**/N**H**), 6.50 (br-d, J = 7.9 Hz, 1H, $C_7\mathbf{H}$), 6.46 (d, J = 7.8 Hz, 1H, $C_5\mathbf{H}$), 6.26 (d, J = 16.0 Hz, 1H, $C_{13}\mathbf{H}$), 5.96 (d, J = 15.9 Hz, 1H, $C_{14}\mathbf{H}$), 5.63 (s, 0.4H, $N_{8a}\mathbf{H}$), 5.57 (s, 0.6H, $N_{8a}\mathbf{H}$), 5.47 (s, 0.4H, $N_8\mathbf{H}$), 5.44 (s, 0.6H, $N_8\mathbf{H}$), 3.60 (dd, J = 10.4, 6.7 Hz, 1H, $C_2\mathbf{H}_a$), 2.85–2.71 (m, 2H, $C_2\mathbf{H}_b$, O**H**/N**H**), 2.41–2.32 (m, 2H, $C_3\mathbf{H}_a$, $C_3\mathbf{H}_b$), 1.48 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$), 1.43 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$), 1.22 (s, 3H, $C_{16}\mathbf{H}_3$), 1.19 (s, 3H, $C_{16}\mathbf{H}_3$).

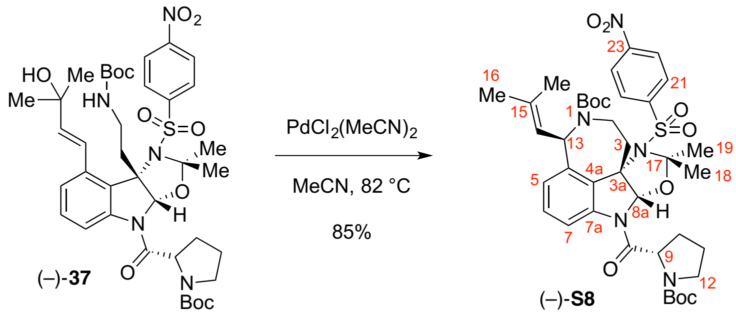
^{13}C NMR (125.8 MHz, CD_3CN, 20 °C, ~1.5:1 mixture of atropisomers, *denotes minor atropisomer): δ 155.3 (N**C**$O_2C(CH_3)_3$*), 154.7 (N**C**$O_2C(CH_3)_3$), 152.9 (**C**$_{7a}$), 150.9 (**C**$_{9/12}$), 147.9 (**C**$_{9/12}$), 141.5 (**C**$_{14}$), 136.1 (**C**$_{14}$), 131.8 (**C**$_6$), 129.5 (**C**$_{10/11}$), 125.2 (**C**$_{10/11}$), 122.5 (**C**$_{4a}$), 122.0 (**C**$_{13}$), 116.3 (**C**$_5$*), 116.2 (**C**$_5$), 109.7 (**C**$_7$*), 109.5 (**C**$_7$), 82.2 (**C**$_{8a}$), 81.1 (NCO_2**C**$(CH_3)_3$), 80.9 (NCO_2**C**$(CH_3)_3$*), 74.8 (**C**$_{3a}$), 73.9 (**C**$_{3a}$*), 71.4 (**C**$_{15}$), 44.9 (**C**$_2$*), 44.2 (**C**$_2$), 38.5 (**C**$_3$*), 38.0 (**C**$_3$), 30.5 (**C**$_{16}$), 30.2 (**C**$_{16}$), 24.9 ($NCO_2C($**C**$H_3)_3$).

FTIR (thin film) cm^{-1}: 3393 (br-m), 2976 (m), 1684 (s), 1532 (s), 1162 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{26}H_{33}N_4O_7S$ $[M+H]^+$: 545.2064, found: 545.2037.

$[\alpha]_D^{24}$: +134 (c = 0.83, CH_2Cl_2).

TLC (50% ethyl acetate in hexanes), R*f*: 0.17 (UV, CAM).



Azepine (–)-S8:

Acetonitrile (70 mL) was added to a pressure tube containing bis(acetonitrile)dichloropalladium(II) (190 mg, 720 µmol, 0.15 equiv) and oxazoline (–)-**37** (89:11 dr, 3.85 g, 4.81 mmol, 1 equiv). The tube was sealed under an argon atmosphere and was immersed in a pre-heated oil bath at 82 °C. After 4 h, the orange solution was cooled to 21 °C and the solvent was then removed under reduced pressure. The orange residue was purified by flash column chromatography on silica gel (eluent: 10%→20% acetone in hexanes) to afford azepine (–)-**S8** (3.19 g, 84.8%) as a white powder. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C, ~1.1:1 mixture of atropisomers, *denotes minor atropisomer): δ 8.07 (d, J = 8.1 Hz, 1H, C_7**H**), 8.04 (d, J = 8.0 Hz, 1H, C_7**H***), 7.91 (d, J = 8.8 Hz, 2H, C_{22}**H**$_2$/C_{22}**H**$_2$*), 7.89 (d, J = 8.8 Hz, 2H, C_{22}**H**$_2$/C_{22}**H**$_2$*), 7.16 (app-t, J = 8.1 Hz, 1H, C_6**H**), 7.12–7.08 (m, 5H, C_6**H***, C_{21}**H**$_2$, C_{21}**H**$_2$*), 6.65 (d, J = 8.0 Hz, 1H, C_5**H**), 6.59 (d, J = 8.0 Hz, 1H, C_5**H***), 6.27 (s, 1H, C_{8a}**H***), 6.02 (s, 1H, C_{8a}**H**), 6.00–5.95 (app-m, 2H, C_{13}**H**, C_{13}**H***), 5.21 (d, J = 9.6 Hz, 1H, C_{14}**H**), 5.14 (d, J = 9.4 Hz, 1H, C_{14}**H***), 4.64 (dd, J = 7.5, 4.6 Hz, 1H, C_9**H***), 4.43 (dd, J = 7.7, 5.9 Hz, 1H, C_9**H**), 3.94–3.80 (m, 2H, C_{2a}**H**, C_{2a}**H***), 3.59–3.41 (m, 4H, C_{12}**H**$_2$, C_{12}**H**$_2$*), 3.20–3.15 (m, 4H, C_{2b}**H**, C_{2b}**H***, C_{3a}**H**, C_{3a}**H***), 2.26 (app-dt, J = 13.1, 7.3 Hz, 1H, C_{10a}**H**/C_{10a}**H***), 2.20–2.12 (m, 2H, C_{10a}**H**/C_{10a}**H***, C_{11a}**H**/C_{11a}**H***), 2.11–2.04 (m, 1H, C_{11a}**H**/C_{11a}**H***), 2.02–1.93 (m, 2H, C_{10b}**H**, C_{10b}**H***), 1.86 (s, 3H, C_{16}**H**$_3$), 1.84 (s, 3H, $C_{18/19}$**H**$_3$), 1.84–1.80 (m, 1H, C_{11b}**H**/C_{11b}**H***), 1.75–1.74 (app-m, 3H, C_{16}**H**$_3$*), 1.60–1.59 (app-m, 3H, $C_{18/19}$**H**$_3$*), 1.49, 1.34 and 1.05 (36H, $NCO_2C(C$**H**$_3)_3$, $NCO_2C(C$**H**$_3)_3$* $N_1HCO_2C(C$**H**$_3)_3$, $N_1HCO_2C(C$**H**$_3)_3$*).

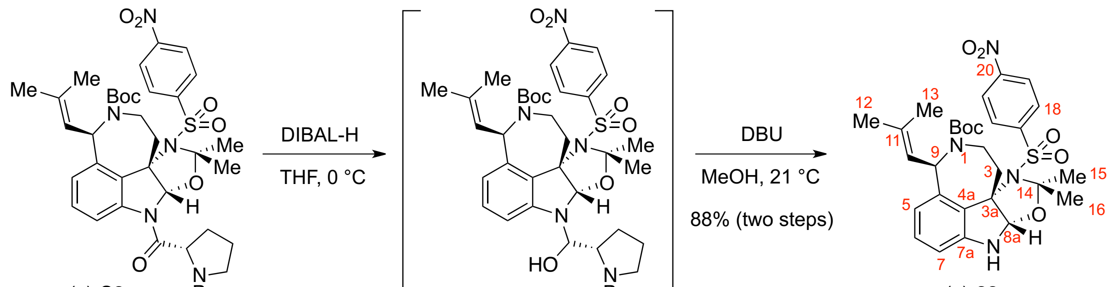
^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C, ~1.1:1 mixture of atropisomers, *denotes minor atropisomer): δ 175.2 (**C**$_8$*), 174.9 (**C**$_8$), 154.7 (**C**$O_2C(CH_3)_3$), 153.2 (**C**$O_2C(CH_3)_3$), 149.4 (2C, **C**$_{23}$, **C**$_{23}$*), 147.7 (**C**$_{20}$*), 147.5 (**C**$_{20}$), 143.9 (2C, **C**$_{7a}$, **C**$_4$), 142.4 (**C**$_{7a*/4*}$), 142.2 (**C**$_{7a*/4*}$), 134.1 (**C**$_{15}$, br), 131.1 (**C**$_6$), 130.8 (**C**$_6$*), 128.2 (2C, **C**$_{21}$, **C**$_{21}$*), 124.6 (**C**$_{14/14*}$), 124.5 (**C**$_5$), 124.4 (C$_5$*), 124.2 (**C**$_{14/14*}$), 123.7 (**C**$_{22}$), 123.6 (**C**$_{22}$*), 123.4 (**C**$_{4a}$), 115.0 (**C**$_7$*), 114.3 (**C**$_7$), 100.8 (**C**$_{8a}$), 100.7 (**C**$_{17}$), 100.4 (**C**$_{17}$*), 80.4 (CO_2**C**$(CH_3)_3$), 80.2 (CO_2**C**$(CH_3)_3$), 75.8 (**C**$_{3a}$*), 75.5 (**C**$_{3a}$), 58.2 (**C**$_9$*), 58.1 (**C**$_9$), 58.0 (**C**$_{13}$), 47.51 (**C**$_{12}$), 47.49 (**C**$_{12}$*), 41.6 (**C**$_2$), 41.4 (**C**$_2$*), 39.3 (**C**$_3$), 39.1 (**C**$_3$*), 31.7 (**C**$_{10/11}$), 31.6 (**C**$_{10/11}$), 30.4 (**C**$_{10}$*), 29.3 (**C**$_{18/19}$), 29.2 (**C**$_{18/19}$), 28.8 ($CO_2C($**C**$H_3)_3$), 28.6 ($CO_2C($**C**$H_3)_3$), 28.3 ($CO_2C($**C**$H_3)_3$), 25.9 (**C**$_{16}$), 25.0 (**C**$_{10/11}$), 24.3 (**C**$_{10/11}$), 18.9 (**C**$_{16}$).

FTIR (thin film) cm^{-1}: 2977 (m), 1685 (s), 1533 (m), 1395 (s), 1166 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{39}H_{52}N_5O_{10}S$ $[M+H]^+$: 782.3429, found: 782.3449.

$[\alpha]_D^{24}$: –53 (c = 0.51, CH_2Cl_2).

TLC (20% acetone in hexanes), R*f*: 0.21 (UV, CAM).



Indoline (–)-38:

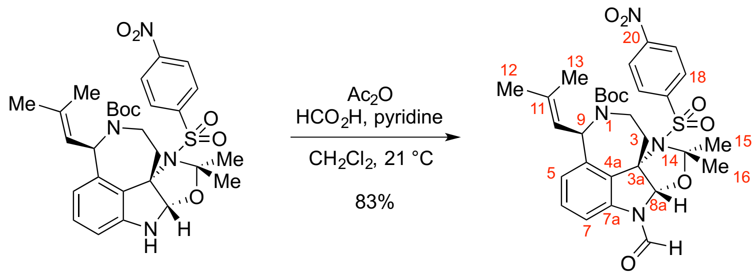
A solution of azepine (–)-**S8** (3.10 g, 3.96 mmol, 1 equiv) in tetrahydrofuran (59 mL) was cooled to −20 °C and diisobutylaluminum hydride (1.0 M in hexanes, 11.9 mL, 11.0 mmol, 3.00 equiv) was added dropwise over 10 min. After 2 min, the reaction mixture was warmed to 0 °C and the orange solution was allowed to stir at this temperature. After 3 h, excess reducing agent was quenched cautiously by the dropwise addition of deionized water (11.9 mL). After gas evolution had subsided, an aqueous sodium hydroxide solution (1 N, 60 mL) was added. The resulting mixture was stirred vigorously for 15 min and was then extracted with ethyl acetate (3 × 120 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered through a pad of Celite, and were concentrated under reduced pressure. The residual ethyl acetate in the residue was removed by concentration from hexanes (3 × 20 mL) under reduced pressure to furnish crude hemiaminal intermediate as a yellow solid, containing a minor amount of the desired indoline (–)-**38** based on TLC analysis.

The crude mixture was dissolved in methanol (32 mL) at 21 °C and 1,8-diazabicycloundec-7-ene (890 µL, 5.95 mmol, 1.50 equiv) was added via syringe. After stirring for 2.5 h, the solvent was removed under reduced pressure and the resulting orange oil was filtered through a pad of silica gel, washing the filter cake with ethyl acetate–hexanes solution (1:1, 250 mL). The filtrate was concentrated and the resulting orange oil was purified by flash column chromatography on silica gel (eluent: 10%→20% ethyl acetate in hexanes) to afford indoline (–)-**38** (2.04 g, 87.9%) as a bright yellow solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CDCl$_3$, 20 °C): δ 7.87 (d, J = 9.0 Hz, 2H, $C_{19}\mathbf{H}_2$), 7.17 (d, J = 9.0 Hz, 2H, $C_{18}\mathbf{H}_2$), 7.01 (app-t, J = 7.9 Hz, 1H, $C_6\mathbf{H}$), 6.46 (d, J = 7.9 Hz, 1H, $C_5\mathbf{H}$), 6.31 (d, J = 7.7 Hz, 1H, $C_7\mathbf{H}$), 5.96 (d, J = 8.5 Hz, 1H, $C_9\mathbf{H}$), 5.54 (d, J = 2.4 Hz, 1H, $C_{8a}\mathbf{H}$), 5.33 (d, J = 9.1 Hz, 1H, $C_{10}\mathbf{H}$), 4.34 (s, 1H, N**H**), 3.86 (d, J = 13.1 Hz, 1H, $C_2\mathbf{H}_a$), 3.23 (app-t, J = 11.6 Hz, 1H, $C_2\mathbf{H}_b$), 2.85 (ddd, J = 14.5, 10.6, 3.0 Hz, 1H, $C_3\mathbf{H}_a$), 2.25 (d, J = 15.0 Hz, 1H, $C_3\mathbf{H}_b$), 1.81 (s, 3H, $C_{12/13}\mathbf{H}_3$), 1.80 (s, 3H, $C_{15/16}\mathbf{H}_3$), 1.77 (s, 3H, $C_{12/13}\mathbf{H}_3$), 1.71 (s, 3H, $C_{15/16}\mathbf{H}_3$), 1.45 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$).

^{13}C NMR (125.8 MHz, CDCl$_3$, 20 °C): δ 155.0 ($N\mathbf{C}O_2C(CH_3)_3$), 150.0 ($\mathbf{C}_{7a}$), 149.1 ($\mathbf{C}_{17/20}$), 148.4 ($\mathbf{C}_{17/20}$), 143.1 ($\mathbf{C}_4$), 134.0 ($\mathbf{C}_{11}$), 130.7 ($\mathbf{C}_6$), 128.6 ($\mathbf{C}_{18}$), 124.2 ($\mathbf{C}_{10}$), 123.3 ($\mathbf{C}_{19}$), 122.0 ($\mathbf{C}_{4a}$), 119.7 (**C**$_5$), 108.6 (**C**$_7$), 103.6 (**C**$_{8a}$), 100.5 (**C**$_{14}$), 80.0 (NCO$_2$**C**(CH$_3$)$_3$), 76.9 (**C**$_{3a}$), 58.4 (**C**$_9$), 42.7 (**C**$_2$), 39.5 (**C**$_3$), 32.1 (**C**$_{15/16}$), 28.8 (NCO$_2$C(**C**H$_3$)$_3$), 28.3 (**C**$_{15/16}$), 26.0 (**C**$_{12/13}$), 18.8 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}:	3311 (br-w), 2977 (m), 1685 (s), 1530 (s), 1350 (s).
HRMS (ESI) (*m/z*):	calc'd for $C_{29}H_{37}N_4O_7S$ $[M+H]^+$: 585.2377, found: 585.2394.
$[\alpha]_D^{24}$:	–109 (c = 0.58, CH_2Cl_2).
TLC (20% ethyl acetate in hexanes), R*f*:	0.17 (UV, CAM).



(–)-**38** (–)-**39**

Formamide (–)-39:

A mixture of acetic anhydride (3.20 mL, 34.0 mmol, 10.0 equiv) and formic acid (1.30 mL, 34.0 mmol, 10.0 equiv) was added to a solution of indoline (–)-**38** (1.98 g, 3.38 mmol, 1 equiv) and pyridine (274 μL, 3.39 mmol, 1.00 equiv) in dichloromethane (13.5 mL) at 0 °C.[10] The reaction mixture was warmed to 21 °C and stirred vigorously. After 2 h, a saturated aqueous sodium bicarbonate solution (80 mL) was slowly introduced and the resulting mixture was stirred vigorously for 1 h, at which time gas evolution had ceased. The layers were separated and the aqueous layer was extracted with dichloromethane (3 × 40 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to give a light yellow solid. Purification by flash column chromatography on silica gel (eluent: 10%→40% ethyl acetate in hexanes) afforded formamide (–)-**39** as a light yellow solid. This solid was suspended in hexanes (60 mL) and was filtered to provide formamide (–)-**39** (1.72 g, 83.1%) as a white solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C): δ 8.51, (s, 1H, C**H**O), 7.90 (d, *J* = 8.8 Hz, 2H, $C_{19}\mathbf{H}_2$), 7.87 (d, *J* = 7.9 Hz, 1H, $C_7\mathbf{H}$), 7.20 (app-t, *J* = 8.0 Hz, 1H, $C_6\mathbf{H}$), 7.08 (d, *J* = 8.4 Hz, 2H, $C_{18}\mathbf{H}_2$), 6.74 (d, *J* = 8.1 Hz, 1H, $C_5\mathbf{H}$), 6.01 (d, *J* = 8.5 Hz, 1H, $C_9\mathbf{H}$), 5.81 (s, 1H, $C_{8a}\mathbf{H}$), 5.25 (d, *J* = 9.5 Hz, 1H, $C_{10}\mathbf{H}$), 3.89 (d, *J* = 13.4 Hz, 1H, $C_2\mathbf{H}_a$), 3.16 (ddd, *J* = 13.6, 11.3, 1.9 Hz, 1H, $C_2\mathbf{H}_b$), 3.00 (ddd, *J* = 14.6, 11.5, 2.8 Hz, 1H, $C_3\mathbf{H}_a$), 2.39 (d, *J* = 16.5 Hz, 1H, $C_3\mathbf{H}_b$), 1.86 (s, 3H, $C_{15/16}\mathbf{H}_3$), 1.85 (s, 3H, $C_{12/13}\mathbf{H}_3$), 1.76 (s, 3H, $C_{12/13}\mathbf{H}_3$), 1.62 (s, 3H, $C_{15/16}\mathbf{H}_3$), 1.47 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C): δ 160.0 (**C**HO), 154.7 ($N\mathbf{C}O_2C(CH_3)_3$), 149.4 ($\mathbf{C}_{17/20}$), 147.5 ($\mathbf{C}_{17/20}$), 143.2 ($\mathbf{C}_4$), 141.6 ($\mathbf{C}_{7a}$), 134.5 ($\mathbf{C}_{11}$), 131.1 ($\mathbf{C}_6$), 128.3 ($\mathbf{C}_{18}$), 125.0 ($\mathbf{C}_5$), 124.0 ($\mathbf{C}_{10}$), 123.6 ($\mathbf{C}_{19}$), 123.4 ($\mathbf{C}_{4a}$), 114.3 ($\mathbf{C}_7$), 102.0 ($\mathbf{C}_{14}$), 100.1 ($\mathbf{C}_{8a}$), 80.4 ($NCO_2\mathbf{C}(CH_3)_3$), 75.9 ($\mathbf{C}_{3a}$), 58.2 ($\mathbf{C}_9$), 42.0 ($\mathbf{C}_2$), 38.6 ($\mathbf{C}_3$), 31.7 ($\mathbf{C}_{15/16}$), 28.8 ($NCO_2C(\mathbf{C}H_3)_3$), 28.7 ($\mathbf{C}_{15/16}$), 26.0 ($\mathbf{C}_{12/13}$), 18.9 ($\mathbf{C}_{12/13}$).

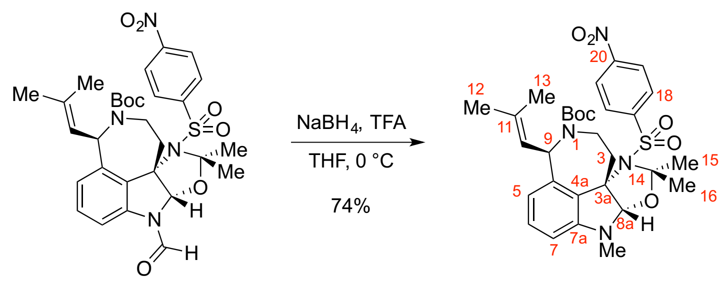
[10] The mixture of acetic anhydride and formic acid was aged at 21 °C for 20 min before it was added to the reaction mixture.

FTIR (thin film) cm^{-1}: 2978 (m), 1690 (s), 1531 (s), 1350 (s), 1166 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{30}H_{37}N_4O_8S$ $[M+H]^+$: 613.2327, found: 613.2318.

$[\alpha]_D^{24}$: –87 (c = 0.51, CH_2Cl_2).

TLC (40% ethyl acetate in hexanes), R*f*: 0.33 (UV, CAM).



(–)-**39** (–)-**40**

***N*-Methyl indoline (–)-40:**

A sample of sodium borohydride (643 mg, 16.6 mmol, 6.00 equiv) was added to a solution of formamide (–)-**39** (1.70 g, 2.77 mmol, 1 equiv) in tetrahydrofuran (55 mL). The resulting suspension was cooled to 0 °C and trifluoroacetic acid (1.27 g, 16.6 mmol, 6.00 equiv) was then added. After stirring at this temperature for 1.5 h, excess sodium borohydride was quenched by slow addition of a saturated aqueous sodium bicarbonate solution (55 mL). The resulting white suspension was diluted with deionized water (55 mL) and was extracted with ethyl acetate (3 × 120 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: 20% ethyl acetate in hexanes) to afford *N*-methyl indoline (–)-**40** (1.22 g, 73.5%) as a yellow solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C): δ 7.86 (d, *J* = 9.0 Hz, 2H, $C_{19}\mathbf{H}_2$), 7.16 (d, *J* = 9.1 Hz, 2H, $C_{18}\mathbf{H}_2$), 7.08 (app-t, *J* = 7.9 Hz, 1H, $C_6\mathbf{H}$), 6.43 (d, *J* = 7.9 Hz, 1H, $C_5\mathbf{H}$), 6.16 (d, *J* = 7.8 Hz, 1H, $C_7\mathbf{H}$), 5.96 (d, *J* = 6.7 Hz, 1H, $C_9\mathbf{H}$), 5.30 (d, *J* = 9.4 Hz, 1H, $C_{10}\mathbf{H}$), 4.91 (s, 1H, $C_{8a}\mathbf{H}$), 3.85 (d, *J* = 11.4 Hz, 1H, $C_2\mathbf{H}_a$), 3.19 (app-t, *J* = 12.5 Hz, 1H, $C_2\mathbf{H}_b$), 2.88 (ddd, *J* = 14.6, 10.9, 3.1 Hz, 1H, $C_3\mathbf{H}_a$), 2.61 (s, 3H, $NC\mathbf{H}_3$), 2.23 (d, *J* = 16.3 Hz, 1H, $C_3\mathbf{H}_b$), 1.82 (s, 6H, $C_{12/13}\mathbf{H}_3$, $C_{15/16}\mathbf{H}_3$), 1.76 (s, 3H, $C_{12/13}\mathbf{H}_3$), 1.62 (s, 3H, $C_{15/16}\mathbf{H}_3$), 1.46 (s, 9H, $NCO_2C(C\mathbf{H}_3)_3$).

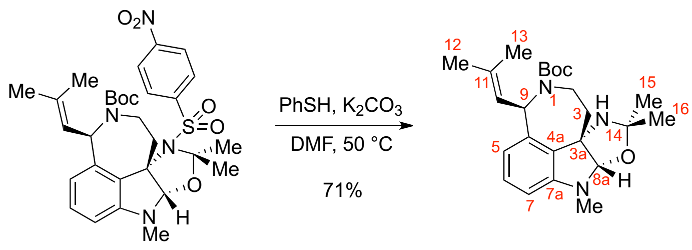
^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C): δ 155.0 ($N\mathbf{C}O_2C(CH_3)_3$), 151.7 ($\mathbf{C}_{7a}$), 149.1 ($\mathbf{C}_{17/20}$), 148.4 ($\mathbf{C}_{17/20}$), 142.7 ($\mathbf{C}_4$), 133.8 ($\mathbf{C}_{11}$), 130.8 ($\mathbf{C}_6$), 128.6 ($\mathbf{C}_{18}$), 124.3 ($\mathbf{C}_{10}$), 123.2 ($\mathbf{C}_{19}$), 121.5 ($\mathbf{C}_{4a}$), 119.1 ($\mathbf{C}_5$), 108.6 ($\mathbf{C}_{8a}$), 106.1 ($\mathbf{C}_7$), 100.4 ($\mathbf{C}_{14}$), 80.0 ($NCO_2\mathbf{C}(CH_3)_3$), 75.8 ($\mathbf{C}_{3a}$), 58.3 ($\mathbf{C}_9$), 42.4 ($\mathbf{C}_2$), 39.4 ($\mathbf{C}_3$), 32.0 ($N\mathbf{C}H_3$), 31.8 ($\mathbf{C}_{15/16}$), 28.8 ($NCO_2C(\mathbf{C}H_3)_3$), 28.0 ($\mathbf{C}_{15/16}$), 26.0 ($\mathbf{C}_{12/13}$), 18.8 ($\mathbf{C}_{12/13}$).

FTIR (thin film) cm^{-1}: 2978 (m), 1685 (s), 1530 (s), 1349 (s), 1163 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{30}H_{39}N_4O_7S$ $[M+H]^+$: 599.2534, found: 599.2558.

$[\alpha]_D^{24}$: –55 (c = 0.54, CH_2Cl_2).

TLC (20% acetone in hexanes), R*f*: 0.32 (UV, CAM).



(–)-**40** (–)-**41**

<u>Hemiaminal (–)-41:</u>

Thiophenol (1.0 mL, 10 mmol, 10 equiv) was added to a mixture of *N*-methyl indoline (–)-**40** (0.620 g, 1.00 mmol, 1 equiv) and potassium carbonate (1.43 g, 10.4 mmol, 10.0 equiv) in dimethylformamide (10.4 mL) and the resulting brown suspension was heated to 50 °C. After 2 h, the reaction mixture was cooled to 21 °C, was diluted with deionized water (100 mL), and was extracted with diethyl ether (4 × 100 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: 10%→20% ethyl acetate in hexanes). A second chromatographic purification on silica gel (eluent: 0%→10% ethyl acetate in dichloromethane) followed by azeotropic drying of the sticky foam with toluene furnished hemiaminal (–)-**41** (304 mg, 70.9%) as a white solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 70 °C): δ 7.07 (app-t, *J* = 7.8 Hz, 1H, C_6**H**), 6.45 (app-s, 1H, C_5**H**), 6.45 (d, *J* = 7.8 Hz, 1H, C_7**H**), 5.99 (app-s, 1H, C_9**H**), 5.44 (app-br-s, 1H, C_{10}**H**), 5.01 (s, 1H, C_{8a}**H**), 3.70 (app-s, 1H, C_2**H**$_a$), 3.13 (app-br-s, 1H, C_2**H**$_b$), 2.88 (s, 3H, NC**H**$_3$), 2.47–2.09 (br-m, 1H, C_3**H**$_a$), 1.99 (app-dt, *J* = 10.9, 6.1 Hz, 1H, C_3**H**$_b$), 1.83 (s, 3H, $C_{12/13}$**H**$_3$), 1.77 (s, 3H, $C_{12/13}$**H**$_3$), 1.44 (s, 9H, NCO_2C(C**H**$_3$)$_3$), 1.40 (s, 3H, $C_{15/16}$**H**$_3$), 0.97 (s, 3H, $C_{15/16}$**H**$_3$).

^{1}H NMR (500 MHz, CD_3CN, 20 °C, a mixture of conformers):
δ 7.07 (app-t, *J* = 7.7 Hz, 1H, C_6**H**), 6.38 (d, *J* = 7.8 Hz, 1H, C_5**H**), 6.35–6.25 (app-m, 1H, C_7**H**), 6.01 (d, *J* = 9.2 Hz, 1H, C_9**H**), 5.21 (d, *J* = 9.2 Hz, 1H, C_{10}**H**), 5.01, (s, 0.46H, C_{8a}**H**), 4.95 (s, 0.54H, C_{8a}**H**), 4.11 (s, 1H, N**H**), 3.68 (dd, 0.46H, C_2**H**$_a$), 3.64–3.42 (m, 0.54H, C_2**H**$_a$), 2.98–2.88 (m, 1H, C_2**H**$_b$), 2.85 (s, 3H, NC**H**$_3$), 2.45–2.22 (br-m, 1H, C_3**H**$_a$), 1.98–1.95 (m, 1H, C_3**H**$_b$), 1.82 (s, 3H, $C_{12/13}$**H**$_3$), 1.80 (s, 3H, $C_{12/13}$**H**$_3$), 1.60–1.25 (s, 9H, NCO_2C(C**H**$_3$)$_3$, $C_{15/16}$**H**$_3$), 0.95 (s, 1.38H, $C_{15/16}$**H**$_3$), 0.87 (s, 1.62H, $C_{15/16}$**H**$_3$).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C, a mixture of conformers):

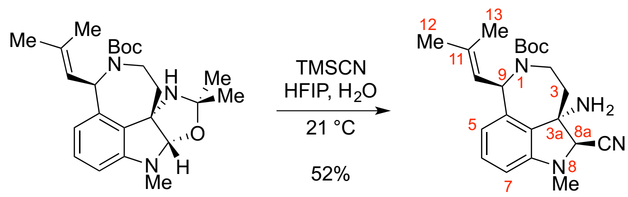
δ 156.8, 156.2 (N**C**O_2C(CH_3)$_3$), 151.6 (**C**$_{7a}$), 139.4 (**C**$_4$), 139.0, 135.9 (**C**$_{11}$), 135.2, 130.7 (**C**$_6$), 129.8, 129.6 (**C**$_{4a}$), 129.2, 124.9 (**C**$_{10}$), 124.8, 124.1, 117.5 (**C**$_7$), 105.8 (**C**$_5$), 103.5 (**C**$_{8a}$), 103.0, 97.6 (**C**$_{14}$), 80.2, 80.0 (NCO_2**C**(CH_3)$_3$), 76.0, 74.2, 74.1 (**C**$_{3a}$), 58.7, 57.8 (**C**$_9$), 50.2, 41.0 (**C**$_2$), 40.5, 37.4 (**C**$_3$), 37.0, 31.8 (N**C**H_3), 31.7, 30.0, 29.9, 29.4, 29.2, 29.1 (NCO_2C(**C**H_3)$_3$, **C**$_{15}$, **C**$_{16}$), 26.2 (**C**$_{12/13}$), 18.9, 18.8 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}: 2975 (m), 1687 (s), 1597 (m), 1477 (s), 1175 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{24}H_{36}N_3O_3$ $[M+H]^+$: 414.2751, found: 414.2760

$[\alpha]_D^{24}$: –130 (c = 0.54, CH_2Cl_2).

TLC (15% ethyl acetate in hexanes), R*f*: 0.13 (UV, CAM).



(–)-**41** (+)-**24**

<u>Tricyclic amine (+)-24:</u>

CAUTION! Trimethylsilyl cyanide is very toxic and should only be used with great caution.[11] A pressure tube containing hemiaminal (–)-**41** (62 mg, 0.15 mmol, 1 equiv) was cooled to 0 °C and was charged sequentially with trimethylsilyl cyanide (58 μL, 0.45 mmol, 3.0 equiv), anhydrous hexafluoroisopropanol (58 μL, 0.54 mmol, 3.6 equiv), and water (8.1 μL, 0.45 mmol, 3.0 equiv). The mixture was warmed to 21 °C and the tube was quickly sealed under an argon atmosphere. After 10 days, an aqueous sodium hydroxide solution (1 N, 1.5 mL) was introduced and the resulting mixture was extracted with dichloromethane (3 × 2 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: 10%→30% ethyl acetate in hexanes) to afford tricyclic amine (+)-**24** (30.0 mg, 52.3%, R*f*: 0.23; 50% ethyl acetate in hexanes) as a white foam and the C8a-epimer (15.0 mg, 26.1%, R*f*: 0.85; 50% ethyl acetate in hexanes) as a white foam.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C): δ 7.14 (app-t, J = 7.8 Hz, 1H, C_6**H**), 6.62 (d, J = 7.7 Hz, 1H, C_5**H**), 6.54 (d, J = 7.8 Hz, 1H, C_7**H**), 5.91 (br-s, 1H, C_9**H**), 5.43 (s, 1H, C_{10}**H**), 4.23 (s, 1H, C_{8a}**H**), 4.08 (br-s, 1H, C_2**H**$_a$), 3.39 (br-s, 1H, C_2**H**$_b$), 2.87 (s, 3H, N_8C**H**$_3$), 2.35 (ddd, J = 14.4, 9.8, 6.5 Hz, 1H, C_3**H**$_a$), 2.16 (ddd, J = 13.8, 5.9, 3.4 Hz, 1H, C_3**H**$_b$), 1.80 (s, 3H, $C_{12/13}$**H**$_3$), 1.73 (s, 3H, $C_{12/13}$**H**$_3$), 1.36 (s, 9H, $N_1CO_2C(C$**H**$_3)_3$).

^{13}C NMR (125.8 MHz, CD_3CN, 60 °C): δ 156.8 (N_1**C**$O_2C(CH_3)_3$), 152.0 (**C**$_{7a}$), 142.4 (**C**$_4$), 138.6 (**C**$_{11}$), 132.9 (**C**$_{4a}$), 130.9 (**C**$_6$), 124.3 (**C**$_{10}$), 120.0 (**C**$_5$), 117.9 (**C**N), 108.9 (**C**$_7$), 81.3 (N_1CO_2**C**$(CH_3)_3$), 73.2 (**C**$_{8a}$), 64.8 (**C**$_{3a}$), 58.8 (**C**$_9$), 42.4 (**C**$_2$), 36.3 (**C**$_3$), 34.7 (N_8**C**H_3), 29.4 ($N_1CO_2C($**C**$H_3)_3$), 26.3 (**C**$_{12/13}$), 19.2 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}: 3380 (w), 2974 (m), 1686 (s), 1598 (m), 1451 (m).

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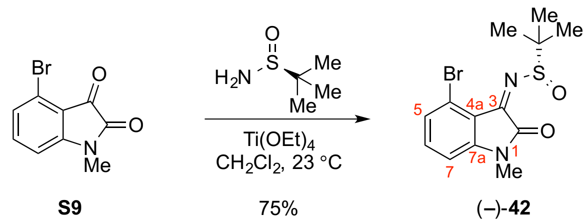
[11] All operations involving trimethylsilyl cyanide were carried out in a well-ventilated fume hood. This includes but is not limited to: measuring the reagent, execution of the transformation, work-up of the reaction mixture, and concentration of the crude reaction mixture.

HRMS (ESI) (*m/z*): calc'd for $C_{22}H_{31}N_4O_2$ $[M+H]^+$: 383.2442, found: 383.2462.

$[\alpha]_D^{24}$: +27 (c = 0.54, CH_2Cl_2).

TLC (33% acetone in hexanes), R*f*: 0.40 (UV, CAM).



tert-Butylsulfinimine (–)-42:

Titanium ethoxide (37.1 mL, 180 mmol, 2.20 equiv) was added dropwise via syringe to a stirred solution of (*S*)-(–)-2-methyl-2-propanesulfinamide (11.9 g, 98.2 mmol, 1.20 equiv) and 4-bromo-1-methylisatin[12] (**S9**, 19.6 g, 81.8 mmol, 1 equiv) in dichloromethane (169 mL) at 23 ºC. After 26 h, the reaction mixture was diluted with dichloromethane (150 mL) and deionized water (6.5 mL) was added dropwise over 3 min with vigorous stirring. The resulting red gel was diluted with an additional portion of dichloromethane (150 mL) and then manually agitated to break up the gel. After stirring for an additional 10 min, dry Celite (45 g, oven-dried at 160 °C for 2 weeks) was added and the resulting suspension was then concentrated under reduced pressure until a free flowing orange powder was obtained. The Celite-adsorbed crude mixture was purified via flash chromatography on silica gel (eluent: 5%→75% ethyl acetate in dichloromethane) to yield *tert*-butylsulfinimine (–)-**42** (21.0 g, 74.8%) as a dark-red solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C): δ 7.31 (dd, *J* = 7.5, 8.2 Hz, 1H, C_6**H**), 7.26 (dd, *J* = 1.0, 8.2 Hz, 1H, C_5**H**), 6.80 (dd, *J* = 1.0, 7.7 Hz, 1H, C_7**H**), 3.23 (s, 3H, N_1C**H**$_3$), 1.37 (s, 9H, C(C**H**$_3$)$_3$).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C): δ 160.3 (**C**$_3$), 156.9 (**C**$_2$), 149.5 (**C**$_{7a}$), 135.7 (**C**$_6$), 128.8 (**C**$_5$), 120.9 (**C**$_4$), 118.2 (**C**$_{4a}$), 108.2 (**C**$_7$), 58.3 (**C**(CH_3)$_3$, 26.6 (N_1**C**H_3), 22.4 (C(**C**H_3)$_3$).

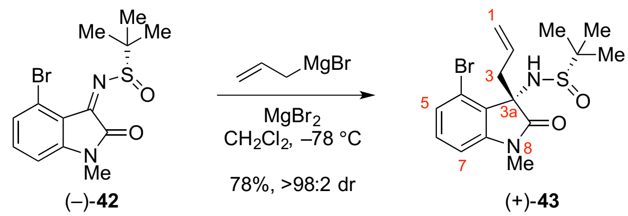
FTIR (thin film) cm^{-1}: 3083 (w), 2959 (w), 1732 (s), 1594 (s), 1454 (m).

HRMS (ESI) (*m/z*): calc'd for $C_{13}H_{16}BrN_2O_2S$ $[M+H]^+$: 343.0110, found: 343.0112.

$[\alpha]_D^{24}$: –616 (*c* = 0.25, CH_2Cl_2).

TLC (15% ethyl acetate in dichloromethane), R*f*: 0.21 (UV, CAM).

[12] Sin, N.; Venables, B. L.; Liu, X.; Huang, S.; Gao, Q.; Ng, A.; Dalterio, R.; Rajamani, R.; Meanwell, N. A. *J. Heterocyclic Chem.* **2009**, *46*, 432.



Allyl Oxindole (+)-43:

A 1 L, 3-neck round-bottom flask equipped with a stir bar, a low-temperature thermometer fitted into a thermometer adapter, a graduated, pressure-equalizing addition funnel, and a rubber septum was charged with magnesium bromide (25.1 g, 136 mmol, 2.00 equiv) and *tert*-butylsulfinimine (–)-**42** (24.3 g, 68.2 mmol, 1 equiv). The flask was then evacuated and backfilled with argon (three cycles). Dichloromethane (400 mL) was added and the resulting red suspension was cooled to –78 ºC. The addition funnel was then charged with a solution of allylmagnesium bromide (0.955 M in diethyl ether, 78.5 mL, 75.0 mmol, 1.10 equiv) and dropwise addition began at a rate such that the internal temperature of the reaction mixture did not exceed –75 ºC (*ca.* 2 mL/min). After stirring for 1.5 h, a saturated aqueous ammonium chloride solution (300 mL) was added to the bright yellow suspension and the mixture was allowed to warm to 23 ºC with vigorous stirring. The resulting biphasic mixture was diluted with deionized water (150 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 200 mL) and the combined organic extracts were washed with a saturated aqueous sodium chloride solution (400 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to afford crude allyl oxindole (+)-**43** (26.7 g, 86:14 dr) as an orange solid. Purification and enrichment of the diastereomeric ratio were achieved by triturating the crude product with *n*-hexane (200 mL) and washing with additional portions of *n*-hexane (500 mL total) to afford pure allyl oxindole (+)-**43** (20.6 g, 78.3%, >98:2 dr) as a light orange solid, which was used in the next step without further purification. Structural assignment of the major diastereomer was made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CDCl$_3$, 20 °C): δ 7.18–7.15 (m, 2H, C$_6$**H**, C$_5$**H**), 6.75 (dd, J = 3.0, 5.6 Hz, 1H, C$_7$**H**), 5.23 (app-dt, J = 7.0, 10.1, 17.0 Hz, 1H, C$_2$**H**), 5.05 (app-dq, J = 1.2, 16.4 Hz, 1H, C$_1$**H**$_a$), 4.89 (dd, J = 1.9, 10.1 Hz, 1H, C$_1$**H**$_b$), 4.13 (s, 1H, N**H**), 3.17 (s, 3H, N$_8$C**H**$_3$), 3.10 (dd, J = 6.9, 13.0 Hz, 1H, C$_3$**H**$_a$), 2.84 (dd, J = 7.7, 13.0 Hz, 1H, C$_3$**H**$_b$), 1.20 (s, 9H, C(C**H**$_3$)$_3$).

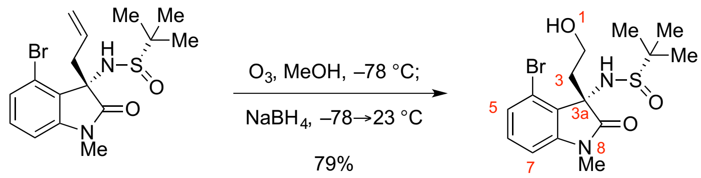
^{13}C NMR (125.8 MHz, CDCl$_3$, 20 °C): δ 174.1 (**C**$_{8a}$), 145.2 (**C**$_{7a}$), 131.1 (**C**$_6$), 129.7 (**C**$_2$), 127.6 (**C**$_4$), 127.2 (**C**$_5$), 120.5 (**C**$_1$), 119.9 (**C**$_{4a}$), 107.7 (**C**$_7$), 66.5 (**C**$_{3a}$), 57.0 (**C**(CH$_3$)$_3$, 39.9 (**C**$_3$), 26.6 (N$_8$**C**H$_3$), 22.5 (C(**C**H$_3$)$_3$).

FTIR (thin film) cm^{-1}: 3249 (s), 2958 (w), 1720 (s), 1602 (s), 1456 (m).

HRMS (ESI) (m/z): calc'd for $C_{16}H_{22}BrN_2O_2S$ [M+H]$^+$: 385.0580, found: 385.0592.

$[\alpha]_D^{24}$: +31 (c = 1.8, CH_2Cl_2).

TLC (33% acetone in hexanes), R*f*: 0.24 (UV, CAM).



(+)-**43** (+)-**44**

Alcohol (+)-44:

Ozone was bubbled through a solution of allyl oxindole (+)-**43** (20.4 g, 52.9 mmol, 1 equiv) in methanol (300 mL) cooled to –78 ºC. After 3 h, ozone bubbling was ceased and the solution was sparged with nitrogen. After 40 min, nitrogen bubbling was ceased, solid sodium borohydride (6.40 g, 169 mmol, 3.20 equiv) was added to the solution in portions over 15 min, and the resulting mixture was allowed to warm to 23 ºC. After 1 h, a saturated aqueous ammonium chloride solution (400 mL) was added and the mixture was extracted with dichloromethane (7 × 300 mL). The combined organic extracts were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 10%→40% acetone in dichloromethane) to afford a single diastereomer of alcohol (+)-**44** (16.3 g, 79.3%) as a pale-green solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C): δ 7.17–7.13 (m, 2H, C_6**H**, C_5**H**), 6.78 (dd, J = 5.4, 3.3 Hz, 1H, C_7**H**), 4.29 (s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.67 (app-dt, J = 11.1, 5.4 Hz, 1H, C_2**H**$_a$), 3.44 (m, 1H, C_2**H**$_b$), 3.17 (s, 3H, N_8C**H**$_3$), 2.57 (ddd, J = 14.1, 8.2, 5.2 Hz, 1H, C_3**H**$_a$), 2.50 (br-s, 1H, O_1**H**), 2.28 (ddd, J = 14.3, 5.5, 4.9 Hz, 1H, C_3**H**$_b$), 1.17 (s, 9H, C(C**H**$_3$)$_3$).

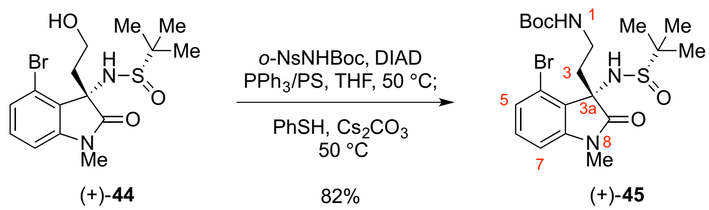
^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C): δ 175.3 (**C**$_{8a}$), 144.9 (**C**$_{7a}$), 131.2 (**C**$_6$), 128.0 (**C**$_4$), 127.3 (**C**$_5$), 119.8 (**C**$_{4a}$), 108.0 (**C**$_7$), 65.3 (**C**$_{3a}$), 58.1 (**C**$_2$), 57.1 (**C**(CH_3)$_3$), 38.2 (**C**$_3$), 26.9 (N_8**C**H_3), 22.4 (C(**C**H_3)$_3$).

FTIR (thin film) cm^{-1}: 3392 (br-m), 2959 (w), 1725 (s), 1605 (s), 1457 (m).

HRMS (ESI) (m/z): calc'd for $C_{15}H_{22}BrN_2O_3S$ [M+H]$^+$: 389.0529, found: 389.0536.

$[\alpha]_D^{24}$: +22 (c = 0.9, CH_2Cl_2).

TLC (33% acetone in hexanes), Rf: 0.18 (UV, CAM).



Carbamate (+)-45:

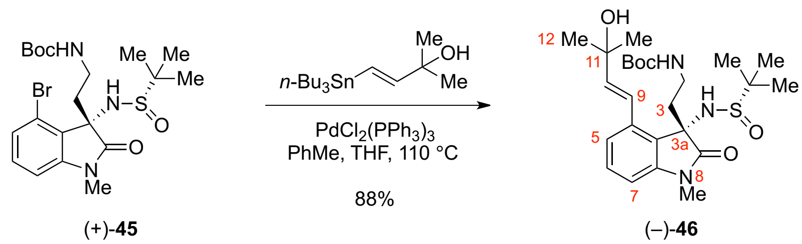
Diisopropyl azodicarboxylate (DIAD, 5.94 mL, 30.2 mmol, 1.16 equiv) was added dropwise via syringe to a suspension of alcohol (+)-**44** (10.1 g, 26.0 mmol, 1 equiv), *tert*-butyl ((2-nitrophenyl)sulfonyl)carbamate[13] (9.13 g, 30.2 mmol, 1.16 equiv), and resin-bound triphenylphosphine (1.49 mmol/g on 100-200 mesh polystyrene cross-linked with 1% divinylbenzene, 20.3 g, 30.2 mmol, 1.16 equiv) in tetrahydrofuran (202 mL) at 23 ºC. The flask was fitted with a reflux condenser, was placed in a preheated 50 ºC oil bath, and was allowed to stir gently. After 2.3 h, the mixture was allowed to cool (10 min) at which point cesium carbonate (33.9 g, 104 mmol, 4.00 equiv) and thiophenol (5.34 mL, 52.0 mmol, 2.00 equiv) were added. The flask was immersed in a pre-heated 50 ºC oil bath and allowed to stir vigorously. After 4 h, the solution was allowed to cool to 23 ºC, was diluted with dichloromethane (250 mL), and was charged with Celite (25 g). The mixture was concentrated under reduced pressure until a free flowing yellow powder was obtained. The Celite-adsorbed crude mixture was purified via flash chromatography on silica gel (eluent: 25%→40% acetone in hexanes) to afford carbamate (+)-**45** (10.5 g, 82.4% yield) as an off-white solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C):	δ 7.17 (d, *J* = 3.7 Hz, 2H, C_6**H**, C_5**H**), 6.78 (app-t, *J* = 4.5 Hz, 1H, C_7**H**), 4.47 (br-s, 1H, N_1**H**), 4.18 (s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.19 (s, 3H, N_8C**H**$_3$), 3.02–2.92 (m, 2H, C_2**H**$_2$), 2.45 (app-dt, *J* = 14.4, 7.2 Hz, 1H, C_3**H**$_a$), 2.38 (app-dt, *J* = 13.1, 6.4 Hz, 1H, C_3**H**$_b$), 1.34 (s, 9H, N_1CO_2C(C**H**$_3$)$_3$), 1.18 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).
^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C):	δ 174.3 (**C**$_{8a}$), 155.5 (N_1**C**O_2C(CH_3)$_3$), 144.9 (**C**$_{7a}$), 131.4 (**C**$_6$), 127.7 (**C**$_4$), 127.4 (**C**$_5$), 120.0 (**C**$_{4a}$), 108.0 (**C**$_7$), 79.4 (N_1CO_2**C**(CH_3)$_3$), 65.3 (**C**$_{3a}$), 57.0 (S(O)**C**(CH_3)$_3$), 35.7 (**C**$_{2/3}$), 35.6 (**C**$_{2/3}$), 28.5 (N_1CO_2C(**C**H_3)$_3$), 26.8 (N_8**C**H_3), 22.4 (S(O)C(**C**H_3)$_3$).
FTIR (thin film) cm^{-1}:	3255 (br-w), 2977 (w), 1718 (s), 1605 (m), 1457 (m), 1364 (w).
HRMS (ESI) (*m/z*):	calc'd for $C_{20}H_{30}BrN_3NaO_4S$ $[M+Na]^+$: 510.1033, found: 510.1042.

[13] Fukuyama, T.; Cheung, M.; Kan, T. *Synlett*, **1999**, 1301.

$[\alpha]_D^{24}$: +31 (c = 0.64, CH_2Cl_2).

TLC (50% acetone in hexanes), R*f*: 0.41 (UV, CAM).



Allylic Alcohol (–)-46:

A solution of freshly prepared (*E*)-2-methyl-4-(tri-*n*-butylstannyl)but-3-en-2-ol[14] (12.8 g, 34.2 mmol, 1.25 equiv) in tetrahydrofuran (68 mL) was added to a suspension of carbamate (+)-**45** (13.4 g, 27.4 mmol, 1 equiv) and bis(triphenylphosphine)palladium(II) dichloride (960 mg, 1.37 mmol, 0.0500 equiv) in toluene (137 mL) via cannula at 23 ºC. The reaction vessel was sealed and placed in a preheated 110 ºC oil bath. After 5 h, the mixture was allowed to cool to 23 ºC and was filtered through a pad of silica gel covered with a pad of Celite. The filter cake was rinsed with a 50% solution of acetone in hexanes (600 mL) and the turbid brown filtrate was concentrated under reduced pressure. The resulting residue was purified by flash chromatography on silica gel (eluent: 37% dichloromethane, 37% hexanes, 25% acetone, 1% methanol→33% dichloromethane, 33% hexanes, 33% acetone, 1% methanol) to afford allylic alcohol (–)-**46** (11.8 g, 87.5%) as a faint yellow solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C): δ 7.27 (t, *J* = 7.9 Hz, 1H, C_6**H**), 7.18 (d, *J* = 7.9 Hz, 1H, C_5**H**), 7.02 (d, *J* = 16.0 Hz, 1H, C_9**H**), 6.68 (d, *J* = 7.6 Hz, 1H, C_7**H**), 6.32 (d, *J* = 15.9 Hz, 1H, C_{10}**H**), 4.58 (br-s, 1H, N_1**H**), 4.08 (s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.66 (br-s, 1H, O**H**), 3.17 (s, 3H, N_8C**H**$_3$), 2.90–2.77 (m, 1H, C_2**H**$_a$), 2.66–2.52 (m, 1H, C_2**H**$_b$), 2.46–2.35 (m, 2H, C_3**H**$_2$), 1.39 (s, 3H, C_{12}**H**$_3$), 1.37 (s, 3H, C_{12}**H**$_3$), 1.33 (s, 9H, N_1CO_2C(C**H**$_3$)$_3$), 1.14 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C): δ 176.0 (**C**$_{8a}$), 155.8 (N_1**C**O_2C(CH_3)$_3$), 143.6 (**C**$_{7a}$), 142.6 (**C**$_{10}$), 136.6 (**C**$_4$), 130.4 (**C**$_6$), 123.9 (**C**$_{4a}$), 122.4 (**C**$_9$), 121.0 (**C**$_5$), 107.4 (**C**$_7$), 79.7 (N_1CO_2**C**(CH_3)$_3$), 70.8 (**C**$_{11}$), 63.6 (**C**$_{3a}$), 56.8 (S(O)**C**(CH_3)$_3$), 37.0 (**C**$_3$), 36.1 (**C**$_2$), 29.6 (**C**$_{12}$), 29.4 (**C**$_{12}$), 28.5 (N_1CO_2C(**C**H$_3$)$_3$), 26.7 (N_8CH_3), 22.6 (S(O)C(**C**H$_3$)$_3$).

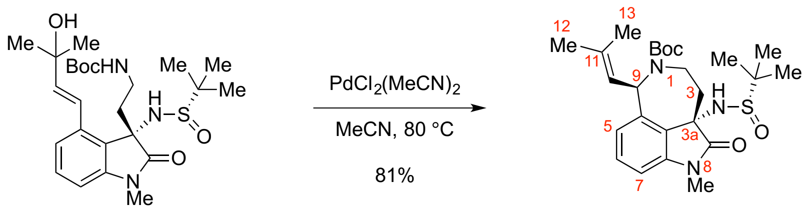
FTIR (thin film) cm^{-1}: 3344 (br-m), 2974 (m), 1716 (s), 1590 (m), 1521 (w). 1464 (m).

HRMS (ESI) (*m/z*): calc'd for $C_{25}H_{40}N_3O_5S$ [M+H]$^+$: 494.2683, found: 494.2671.

[14] Zhang, H. X.; Guibé, F. *J. Org. Chem.* **1990**, *55*, 1857.

$[\alpha]_D^{24}$: –50 (c = 1.6, CH_2Cl_2).

TLC (25% acetone, 1% methanol in hexanes), R*f*: 0.35 (UV, CAM).



(–)-**46** (–)-**47**

Tricyclic Oxindole (–)-47:

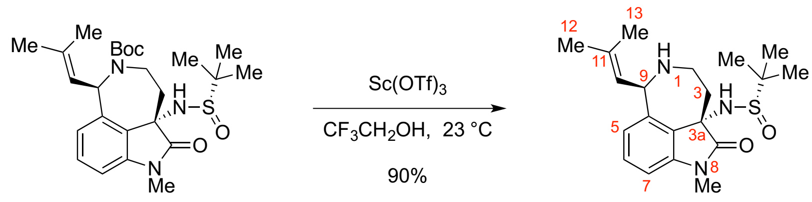
A sample of bis(acetonitrile)dichloropalladium(II) (727 mg, 2.80 mmol, 0.120 equiv) was added to a solution of allylic alcohol (–)-**46** (11.5 g, 23.4 mmol, 1 equiv) in acetonitrile (467 mL) at 23 ºC. The reaction flask was fitted with a reflux condenser and placed in a preheated 80 ºC oil bath. After 3 h, the homogeneous orange solution was allowed to cool to 23 ºC and the flask was then charged with Celite (27 g). The suspension was concentrated under reduced pressure until a free-flowing orange powder was obtained. The Celite-adsorbed crude mixture was purified via flash chromatography on silica gel (eluent: 25%→30% acetone in hexanes) to afford tricyclic oxindole (–)-**47** (8.96 g, 80.6%) as an off-white foam. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C, 2:1 mixture of atropisomers, *denotes minor atropisomer): δ 7.25 (dd, J = 11.0, 4.8 Hz, 1H, C_6**H**), 6.88–6.66 (m, 2H, C_5**H**, C_7**H**), 6.12 (d, J = 8.7 Hz, 1H, C_9**H***), 6.02 (d, J = 7.6 Hz, 1H, C_9**H**), 5.12 (br-s, 1H, C_{10}**H**), 4.05–3.88 (m, 2H, N**H**(S(O)C$(CH_3)_3$, C_2**H**$_a$), 3.85–3.77 (m, 2H, N**H**(S(O)C$(CH_3)_3$*, C_2**H**$_a$*), 3.19 (s, 3H, N_8C**H**$_3$), 3.17 (s, 3H, N_8C**H**$_3$*), 2.91 (br-s, 1H, C_2**H**$_b$), 2.53 (br-s, 1H, C_3**H**$_a$), 1.95–164 (m, 7H, C_3**H**$_b$, C_{12}**H**$_3$, C_{13}**H**$_3$), 1.48 (s, 9H, N_1CO_2C(C**H**$_3$)$_3$*), 1.46 (s, 9H, N_1CO_2C(C**H**$_3$)$_3$), 1.12 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C, 2:1 mixture of atropisomers, *denotes minor atropisomer): δ 175.9 (**C**$_{8a}$), 155.8 (N_1**C**O_2C$(CH_3)_3$), 154.2 (N_1**C**O_2C$(CH_3)_3$*), 143.4 (**C**$_{7a}$), 142.9 (**C**$_{7a}$*), 138.8 (**C**$_4$*), 138.5 (**C**$_4$), 136.6 (**C**$_{11}$*), 135.3 (**C**$_{11}$), 130.0 (**C**$_6$), 126.1 (**C**$_{4a}$*), 125.8 (**C**$_{4a}$), 122.9 (**C**$_5$*), 122.4 (**C**$_5$), 121.93 (**C**$_{10}$), 107.4 (**C**$_7$), 80.7 (N_1CO_2**C**$(CH_3)_3$), 80.2 (N_1CO_2**C**$(CH_3)_3$*), 63.3 (**C**$_{3a}$), 63.1 (**C**$_{3a}$*), 58.5 (**C**$_9$), 57.6 (S(O)**C**$(CH_3)_3$*), 56.4 (S(O)**C**$(CH_3)_3$), 41.4 (**C**$_2$*), 40.8 (**C**$_2$), 33.7 (**C**$_3$*), 32.8 (**C**$_3$), 28.8 (N_1CO_2C(**C**H_3)$_3$), 28.4 (N_1CO_2C(**C**H_3)$_3$*), 26.6 (N_8**C**H_3), 26.0 (**C**$_{12}$*), 25.8 (**C**$_{12}$), 22.5 (S(O)C(**C**H_3)$_3$), 19.0 (**C**$_{13}$), 18.8 (**C**$_{13}$*).

FTIR (thin film) cm^{-1}: 3315 (br-w), 2974 (m), 1724 (s), 1610 (m), 1598 (m).

HRMS (ESI) (*m/z*):	calc'd for $C_{25}H_{38}N_3O_4S$ [M+H]$^+$: 476.2578, found: 476.2567.
$[\alpha]_D^{24}$:	–27 (c = 0.57, CH_2Cl_2).
TLC (33% acetone in hexanes), R*f*:	0.37 (UV, CAM).



(–)-**47** (+)-**48**

Tricyclic Amine (+)-48:

A sample of scandium(III) trifluoromethanesulfonate (103 mg, 0.210 mmol, 2.00 equiv) was added to a solution of tricyclic oxindole (–)-**47** (50.0 mg, 0.105 mmol, 1 equiv) in 2,2,2-trifluoroethanol (2 mL) at 23 ºC. After 30 min, a saturated aqueous sodium bicarbonate solution (5 mL) was added and the mixture was extracted with dichloromethane (3 × 15 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 5%→10% methanol in chloroform) to afford tricyclic amine (+)-**48** (35.0 mg, 89.7%) as a white solid.

As a result of slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 60 °C): δ 7.25 (app-t, J = 7.9 Hz, 1H, C_6**H**), 6.86 (d, J = 8.0 Hz, 1H, C_5**H**), 6.81 (d, J = 7.8 Hz, 1H, C_7**H**), 5.30 (d, J = 8.7 Hz, 1H, C_{10}**H**), 5.09 (d, J = 8.7 Hz, 1H, C_9**H**), 4.94 (br-s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.58 (t, J = 11.3 Hz, 1H, C_2**H**$_a$), 3.20 (app-dt, J = 14.3, 4.3 Hz, 1H, C_2**H**$_b$), 3.14 (s, 3H, N_8C**H**$_3$), 2.09 (ddd, J = 14.2, 4.1, 3.3 Hz, 1H, C_3**H**$_a$), 1.95 (br-s, 1H, N_1**H**), 1.84 (d, J = 1.3 Hz, 3H, $C_{12/13}$**H**$_3$), 1.70 (d, J = 1.3 Hz, 3H, $C_{12/13}$**H**$_3$), 1.55 (ddd, J = 14.5, 10.5, 4.3 Hz, 1H, C_3**H**$_b$), 1.12 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).

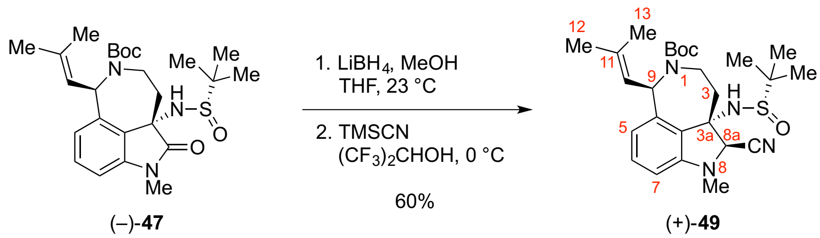
^{13}C NMR (125.8 MHz, CD_3CN, 60 °C): δ 177.9 (**C**$_{8a}$), 146.2 (**C**$_4$), 145.5 (**C**$_{7a}$), 135.2 (**C**$_{11}$), 131.0 (**C**$_6$), 128.9 (**C**$_{4a}$), 127.1 (**C**$_{10}$), 121.5 (**C**$_5$), 108.5 (**C**$_7$), 65.6 (**C**$_{3a}$), 59.3 (**C**$_9$), 57.5 (S(O)**C**(CH_3)$_3$), 46.3 (**C**$_2$), 36.1 (**C**$_3$), 27.4 (N_8**C**H_3), 26.4 (**C**$_{12/13}$), 23.5 (S(O)C(**C**H_3)$_3$), 19.5 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}: 3300 (br-m), 2928 (m), 1717 (s), 1601 (m), 1467 (m).

HRMS (ESI) (m/z): calc'd for $C_{20}H_{30}N_3O_2S$ $[M+H]^+$: 376.2053, found: 376.2033.

$[\alpha]_D^{24}$: +41 (c = 1.3, CH_2Cl_2).

TLC (9% methanol, 1% ammonium hydroxide in chloroform), Rf: 0.26 (UV, CAM).



Aminonitrile (+)-49:

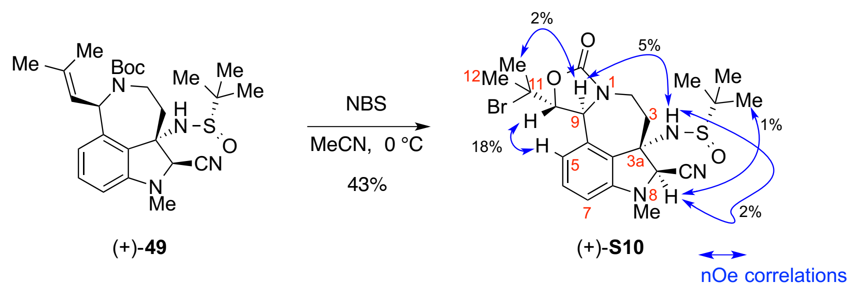
A solution of lithium borohydride (2.0 M in tetrahydrofuran, 7.2 mL, 14 mmol, 2.0 equiv) was added dropwise via syringe over 5 min to a solution of tricyclic oxindole (–)-**47** (3.43 g, 7.21 mmol, 1 equiv) and methanol (2.30 mL, 57.7 mmol, 8.00 equiv) in tetrahydrofuran (72 mL) at 0 ºC. After 10 min, the mixture was allowed to warm to 23 ºC. After 15 h, the reaction mixture was cooled to 0 ºC and a saturated aqueous ammonium chloride solution (70 mL) was added. The resulting mixture was allowed to stir vigorously while warming to room temperature. The mixture was then diluted with deionized water (50 mL) and extracted with ethyl acetate (3 × 100 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (100 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure providing the crude hemiaminal (3.70 g, 2:1 dr).

CAUTION! Trimethylsilyl cyanide is very toxic and should only be used with great caution.[11] The crude hemiaminal was dissolved in hexafluoroisopropanol (72 mL) and cooled to 0 ºC in an ice bath. Trimethylsilyl cyanide (1.44 mL, 10.8 mmol, 1.50 equiv) was then added via syringe. After 2 h, an aqueous sodium hydroxide solution (1 N, 125 mL) was added followed by deionized water (100 mL) and dichloromethane (175 mL). After warming to 23 ºC, the layers were separated and the aqueous layer was extracted with dichloromethane (2 × 100 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (50 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure providing the crude aminonitrile as a mixture of diastereomers (2:1 dr). The diastereomeric mixture could be easily separated by flash column chromatography on silica gel (eluent: 25%→50% ethyl acetate in hexanes) to afford the major diastereomer of aminonitrile (+)-**49** (2.11 g, 60.1%, more polar) as an off-white foam and the minor, less polar diastereomer (1.04 g, 29.6%) as a light yellow foam.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, CD_3CN, 70 °C): δ 7.22 (app-t, *J* = 7.8 Hz, 1H, C_6**H**), 6.75 (d, *J* = 7.7 Hz, 1H, C_5**H**), 6.60 (d, *J* = 7.9 Hz, 1H, C_7**H**), 5.77 (br-s, 1H, C_{10}**H**), 5.59 (d, *J* = 7.0 Hz, 1H, C_9**H**), 4.79 (s, 1H, C_{8a}**H**), 4.06 (s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.79–3.71 (m, 2H, C_2**H**$_a$, C_2**H**$_b$), 2.89 (s, 3H, N_8C**H**$_3$), 2.56 (m, 1H, C_3**H**$_a$), 2.48 (app-dt, *J* = 14.7, 4.0 Hz, 1H, C_3**H**$_a$), 1.84 (s, 3H, $C_{12/13}$**H**$_3$), 1.68 (s, 3H, $C_{12/13}$**H**$_3$), 1.35 (s, 9H, N_1CO_2C(C**H**$_3$)$_3$), 1.17 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).

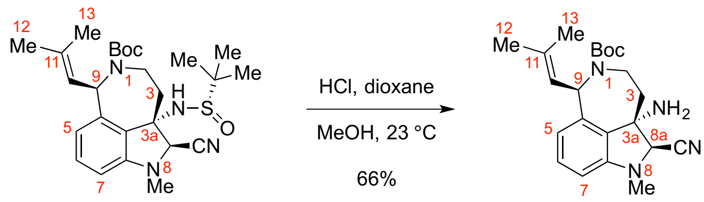
^{13}C NMR (125.8 MHz, CD_3CN, 70 °C):	δ 156.8 (N_1**C**$O_2C(CH_3)_3$), 153.2 (**C**$_{7a}$), 143.6 (**C**$_4$), 137.4 (**C**$_{11}$), 131.9 (**C**$_6$), 128.5 (**C**$_{4a}$), 124.3 (**C**$_{10}$), 120.1 (**C**$_5$), 117.7 (**C**N), 109.4 (**C**$_7$), 81.5 (N_1CO_2**C**$(CH_3)_3$), 70.3 (**C**$_{8a}$), 69.7 (**C**$_{3a}$), 60.3 (**C**$_9$), 57.8 (S(O)**C**$(CH_3)_3$), 46.4 (**C**$_2$), 35.0 (**C**$_3$), 34.4 (N_8**C**H_3), 29.5 ($N_1CO_2C($**C**$H_3)_3$), 26.5 (**C**$_{12/13}$), 23.8 (S(O)C(**C**$H_3)_3$), 19.4 (**C**$_{12/13}$).
FTIR (thin film) cm^{-1}:	3293 (br-w), 2973 (m), 1690 (s), 1592 (m), 1456 (m).
HRMS (ESI) (*m/z*):	calc'd for $C_{26}H_{39}N_4O_3S$ $[M+H]^+$: 487.2737, found: 487.2734.
$[\alpha]_D^{24}$:	+43 (*c* = 1.2, CH_2Cl_2).
TLC (50% ethyl acetate in hexanes), R*f*:	0.24 (UV, CAM).



Oxazolidinone (+)-S10:

A solution of *N*-bromosuccinimide (22.0 mg, 123 µmol, 1.20 equiv) in acetonitrile (500 µL) was added via syringe to a solution of aminonitrile (+)-**49** (50.0 mg, 103 µmol, 1 equiv) in acetonitrile (1.50 mL) at 0 ºC in an ice bath. After 45 min, a saturated aqueous sodium thiosulfate solution (5 mL) was added and the mixture was extracted with dichloromethane (2 × 25 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 15%→40% acetone in hexanes) to afford oxazolidinone (+)-**S10** (22.4 mg, 42.7%) as a white foam. Structural assignments were made using additional information from nOe, gCOSY, HSQC, and HMBC experiments.

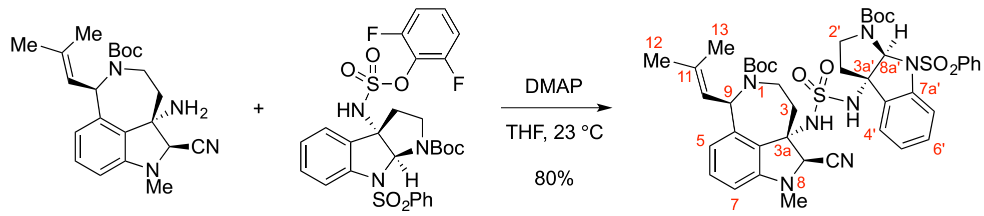
^{1}H NMR (500 MHz, C_6D_6, 20 °C):	δ 6.96 (app-t, *J* = 7.9 Hz, 1H, C_6**H**), 6.53 (d, *J* = 8.1 Hz, 1H, C_5**H**), 6.20 (d, *J* = 8.0 Hz, 1H, C_7**H**), 5.14 (d, *J* = 3.4 Hz, 1H, C_9**H**), 4.93 (s, 1H, C_{8a}**H**), 4.60 (d, *J* = 3.3 Hz, 1H, C_{10}**H**), 4.20 (app-dt, *J* = 14.2, 3.6 Hz, 1H, C_2**H**$_a$), 3.54 (s, 1H, N**H**(S(O)C(CH_3)$_3$), 3.47 (ddd, *J* = 14.0, 12.2, 1.7 Hz, 1H, C_2**H**$_b$), 2.64–2.57 (m, 1H, C_3**H**$_a$), 2.40 (s, 3H, N_8C**H**$_3$), 2.38–2.33 (m, 1H, C_3**H**$_b$), 1.57 (s, 3H, C_{12}**H**$_3$), 1.50 (s, 3H, C_{12}**H**$_3$), 0.79 (s, 9H, NH(S(O)C(C**H**$_3$)$_3$).
^{13}C NMR (125.8 MHz, C_6D_6, 20 °C):	δ 156.6 (**C**O_2), 152.3 (**C**$_{7a}$), 138.7 (**C**$_4$), 131.8 (**C**$_6$), 128.5 (**C**$_{4a}$), 116.1 (**C**$_5$), 115.7 (**C**N), 109.5 (**C**$_7$), 81.1 (**C**$_{10}$), 68.9 (**C**$_{3a}$), 67.6 (**C**$_{8a}$), 66.8 (**C**$_{11}$), 61.3 (**C**$_9$), 56.5 (S(O)**C**(CH_3)$_3$), 41.3 (**C**$_2$), 34.4 (**C**$_3$), 32.9 (N_8**C**H_3), 30.3 (**C**$_{12}$), 28.5 (**C**$_{12}$), 22.7 (S(O)C(**C**H_3)$_3$).
FTIR (thin film) cm^{-1}:	3244 (br-w), 2962 (m), 1750 (s), 1592 (m), 1451(m).
HRMS (ESI) (*m/z*):	calc'd for $C_{22}H_{30}BrN_4O_3S$ $[M+H]^+$: 509.1217, found: 509.1228.
$[\alpha]_D^{24}$:	+34 (*c* = 0.79, CH_2Cl_2).
TLC (33% acetone in hexanes), R*f*:	0.18 (UV, CAM).



(+)-**49** (+)-**24**

Tricyclic amine (+)-24:

A solution of hydrochloric acid in 1,4-dioxane (4.0 M, 2.20 mL, 8.80 mmol, 2.00 equiv) was added via syringe to a solution of aminonitrile (+)-**49** (2.11 g, 4.34 mmol, 1 equiv) in methanol (87 mL) at 23 ºC. After 7 h, an aqueous sodium hydroxide solution (0.5 N, 90 mL) was added and the mixture was extracted with dichloromethane (3 × 300 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (110 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 10%→20% acetone in hexanes) to afford tricyclic amine (+)-**24** (1.09 g, 65.7%) as a white foam. The NMR spectra of the desired tricyclic amine (+)-**24** matched the data described for this compound prepared from the alternative route (page S37).



(+)-**24** (+)-**27** (+)-**50**

Sulfamide (+)-50:

A sample of 4-(dimethylamino)pyridine (518 mg, 4.24 mmol, 2.50 equiv) was added to a solution of tricyclic amine (+)-**24** (662 mg, 1.70 mmol, 1 equiv) and sulfamate ester (+)-**27** (1.21 g, 1.98 mmol, 1.17 eqiuv) in tetrahydrofuran (8.5 mL) at 23 ºC. After 20 h, deionized water (50 mL) was added and the mixture was extracted with dichloromethane (3 × 50 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (35 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 20%→30% ethyl acetate in hexanes) to afford sulfamide (+)-**50** (1.17 g, 80.0%) as an off-white foam.[15]

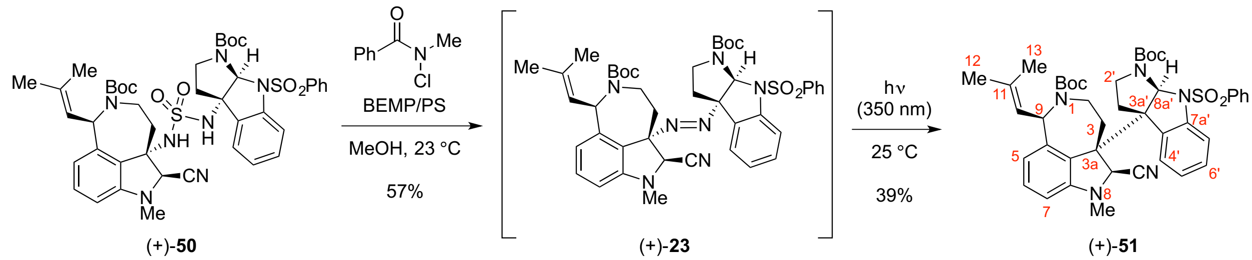
As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature.

^{1}H NMR (500 MHz, C_6D_6, 70 °C): δ 8.06 (br-s, 2H, $N_{8'}SO_2$Ph-*o*-**H**), 7.66 (d, J = 8.1 Hz, 1H, $C_{7'}$**H**), 7.31 (s, 1H, $C_{4'}$**H**), 7.04–6.82 (m, 6H, $N_{8'}SO_2$Ph-*p*-**H**, $N_{8'}SO_2$Ph-*m*-**H**, C_6**H**, $C_{6'}$**H**, $C_{8a'}$**H**), 6.85 (t, J = 7.5 Hz, 1H, $C_{5'}$**H**), 6.48 (d, J = 6.5 Hz, 1H, C_5**H**), 6.13 (d, J = 7.8 Hz, 1H, C_7**H**), 6.03 (br-s, 1H, C_9**H**), 5.28 (s, 1H, C_{8a}**H**), 5.10 (d, J = 6.3 Hz, 1H, C_{10}**H**), 4.48–4.38 (m, 1H, C_2**H**$_a$), 4.17 (s, 1H, SO_2N**H**), 3.92 (br-s, 1H, $C_{2'}$**H**$_a$), 3.12 (dd, J = 14.6, 8.0 Hz, 1H, C_2**H**$_b$), 3.02 (br-s, 1H, C_3**H**$_a$), 2.74 (br-s, 1H, $C_{3'}$**H**$_a$), 2.66–2.50 (m, 2H, $C_{2'}$**H**$_b$, C_3**H**$_b$), 2.44 (s, 3H, N_8C**H**$_3$), 1.98 (br-s, 1H, $C_{3'}$**H**$_b$), 1.54 (s, 12H, NCO_2C(C**H**$_3$)$_3$, $C_{12/13}$**H**$_3$), 1.42 (s, 3H, $C_{12/13}$**H**$_3$), 1.32 (s, 9H, NCO_2C(C**H**$_3$)$_3$).

^{13}C NMR (100 MHz, C_6D_6, 70 °C): δ 156.7 (2C, N**C**$O_2C(CH_3)_3$, N**C**$O_2C(CH_3)_3$), 154.2 (**C**$_{7a'}$), 152.2 (**C**$_{7a}$), 143.6 (**C**$_4$), 143.3 ($N_{8'}SO_2$Ph-*ipso*-**C**), 139.1 (**C**$_{11}$), 133.0 (**C**$_6$), 132.3 (**C**$_{4a'}$), 131.6 ($N_{8'}SO_2$Ph-*p*-**C**), 130.8 (**C**$_{6'}$), 129.3 ($N_{8'}SO_2$Ph-*m*-**C**), 128.2 ($N_{8'}SO_2$Ph-*o*-**C**), 127.7 (**C**$_{4a}$), 125.3 (**C**$_{4'}$), 124.8 (**C**$_{5'}$), 123.0 (**C**$_{10}$), 119.6 (**C**$_5$), 116.8 (**C**$_{7'}$), 115.8 (**C**N), 108.4 (**C**$_7$), 84.3 (**C**$_{8a'}$), 81.2 (NCO_2**C**$(CH_3)_3$), 81.1 (NCO_2**C**$(CH_3)_3$), 73.5

[15] To remove residual ethyl acetate, the sample was dried under high vacuum for 5 days at 50 °C.

	(**C**$_{3a'/3a}$), 67.7 (**C**$_{3a'/3a}$), 66.8 (**C**$_{8a}$), 57.6 (**C**$_{9}$), 45.5 (**C**$_{2'}$), 39.0 (**C**$_{2}$), 38.0 (**C**$_{3'}$), 33.2 (N$_8$**C**H$_3$), 32.7 (**C**$_{3}$), 28.9 (2C, NCO$_2$C(**C**H$_3$)$_3$, NCO$_2$C(**C**H$_3$)$_3$), 25.5 (**C**$_{12/13}$), 18.4 (**C**$_{12/13}$).
FTIR (thin film) cm^{-1}:	3220 (br-w), 2976 (m), 1701 (s), 1663 (s), 1448 (w).
HRMS (ESI) (*m/z*):	calc'd for $C_{43}H_{53}N_7NaO_8S_2$ [M+Na]$^+$: 882.3289, found: 882.3285.
$[\alpha]_D^{24}$:	+84 (*c* = 0.77 CH_2Cl_2).
TLC (33% ethyl acetate in hexanes), R*f*:	0.25 (UV, CAM).



Heterodimer (+)-51:

To a solution of sulfamide (+)-**50** (300 mg, 349 μmol, 1 equiv) in methanol (34.9 mL) in the dark was added *N*-chloro-*N*-methylbenzamide[16] (**S11**, 355 mg, 2.09 mmol, 6.00 equiv) followed immediately by resin-bound BEMP (1.90 g, ~2.2 mmol/g on 200-400 mesh polystyrene resin, 4.19 mmol, 12.0 equiv) in a single portion. After 18 min, the suspension was filtered through a pad of Celite, and the filter cake was washed sequentially with dichloromethane (60 mL) and ethyl acetate (60 mL). The light yellow filtrate was concentrated under reduced pressure and the resulting residue was purified by flash column chromatography on silica gel in low light (eluent: 15%→20% ethyl acetate in hexanes) to afford unsymmetrical diazene (+)-**23** (157 mg, 56.6%) as a light yellow oil, which slowly solidified under reduced pressure.[17] Unsymmetrical diazene (+)-**23** was used directly in the next step without further purification.

A solution of unsymmetrical diazene (+)-**23** (155 mg, 195 μmol, 1 equiv) in dichloromethane (15 mL) was concentrated under reduced pressure in a 200 mL round bottom flask to provide a thin film of diazene (+)-**23** coating the flask. The flask was evacuated and backfilled with argon (three cycles) and was then irradiated in a Rayonet photoreactor equipped with 16 radially distributed (r = 12.7 cm) 25 W lamps (λ = 350 nm) at 25 ºC. After irradiating for 3 h, the lamps were shut off and the resulting residue was purified by flash column chromatography on silica gel (eluent: 20% ethyl acetate in hexanes) to afford an inseparable mixture (~1:1) of heterodimer (+)-**51** and cyclotryptamine **28** according to ^{1}H-NMR analysis (91.4 mg, 38.7% corrected yield of **51**) as an off-white foam. This mixture was used directly in the next step without further purification.

As a result of the slow conformational equilibration at ambient temperature, NMR spectra were collected at elevated temperature. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments also collected at elevated temperature. Note that NMR analysis was performed on an analytically pure sample of (+)-**51** obtained via flash chromatography (eluent: 33→50% *tert*-butyl methyl ether in hexanes).

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[16] The reagent was prepared using a procedure adapted from Hiegel, G. A.; Hogenauer. T. J.; Lewis, J. C. *Synth. Commun.* **2005**, *35*, 2099. A sample of **S11** was prepared as follows: trichloroisocyanuric acid (860 mg, 3.70 mmol, 0.370 equiv) was added to a solution of *N*-methylbenzamide (1.35 g, 10.0 mmol, 1 equiv) in methanol (20 mL) at 23 ºC. After 4.5 h, Celite (3 g) was added and the suspension was concentrated. The Celite-adsorbed crude mixture was purified via flash column chromatography on silica gel (eluent: 10% ethyl acetate in hexanes, R*f*: 0.27) to yield *N*-chloro-*N*-methylbenzamide **S11** (1.48 g, 87.1%) as a colourless oil. Structural assignments were made using additional information from gCOSY and HSQC experiments. ^{1}H NMR (600 MHz, $CDCl_3$, 25°C): δ 7.55–7.50 (m, 2H, Ph-*o*-**H**), 7.47–7.42 (m, 1H, Ph-*p*-**H**), 7.42–7.36 (m, 2H, Ph-*m*-**H**), 3.41 (s, 3H, NC**H**$_3$). ^{13}C NMR (150 MHz, $CDCl_3$, 25°C): δ 171.9 (N**C**O), 133.6 (Ph-*ipso*-**C**), 131.2 (Ph-*p*-**C**), 128.5 (Ph-*m*-**C**), 128.1 (Ph-*o*-**C**), 43.1 (N**C**H$_3$). HRMS (DART) (*m/z*): calc'd for C_8H_9ClNO [M+H]$^+$: 170.0367, found: 170.0366.

[17] As a result of the sensitivity of this intermediate, its slow conformational equilibrium at ambient temperature, and its instability at elevated temperatures, we were unable to structurally assign the NMR data for this compound. The measured HRMS was consistent with the desired product; HRMS (ESI) (*m/z*): calc'd for $C_{43}H_{51}N_7NaO_6S$ [M+Na]$^+$: 816.3514, found: 816.3526.

^{1}H NMR (500 MHz, CD_3CN, 70 °C): δ 7.90 (d, *J* = 7.1 Hz, 2H, $N_{8'}SO_2$Ph-*o*-**H**), 7.60 (app-t, *J* = 7.4 Hz, 1H, $N_{8'}SO_2$Ph-*p*-**H**), 7.51 (app-t, *J* = 7.9 Hz, 2H, $N_{8'}SO_2$Ph-*m*-**H**), 7.48 (d, *J* = 7.8 Hz, 1H, $C_{4'}$**H**), 7.34–7.29 (m, 2H, C_6**H**, $C_{6'}$**H**), 7.23 (d, *J* = 8.0 Hz, 1H, $C_{7'}$**H**), 7.17 (app-td, *J* = 7.6, 1.1 Hz, 1H, $C_{5'}$**H**), 6.70 (d, *J* = 7.9 Hz, 2H, C_5**H**, C_7**H**), 6.01 (d, *J* = 9.4 Hz, 1H, C_9**H**), 5.98 (s, 1H, $C_{8a'}$**H**), 5.27 (d, *J* = 9.4 Hz, 1H, C_{10}**H**), 3.93 (app-dt, *J* = 14.1, 2.8 Hz, 1H, C_2**H**$_a$), 3.88 (s, 1H, C_{8a}**H**), 3.71 (dd, *J* = 11.4, 7.2 Hz, 1H, $C_{2'}$**H**$_a$), 3.26–3.20 (m, 1H, C_2**H**$_b$), 3.08 (ddd, *J* = 15.8, 12.5, 3.5 Hz, 1H, C_3**H**$_a$), 2.78 (s, 3H, N_8C**H**$_3$), 2.34 (app-td, *J* = 11.9, 4.3 Hz, 1H, $C_{2'}$**H**$_b$), 2.21 (dd, *J* = 11.8, 4.3 Hz, 1H, $C_{3'}$**H**$_a$), 2.17 (app-dt, *J* = 15.2, 2.3 Hz, 1H, C_3**H**$_b$), 1.97–1.91 (m, 1H, $C_{3'}$**H**$_b$), 1.90 (d, *J* = 1.2 Hz, 3H, $C_{12/13}$**H**$_3$), 1.81 (d, *J* = 1.3 Hz, 3H, $C_{12/13}$**H**$_3$), 1.52 (s, 9H, $NCO_2C(C$**H**$_3)_3$), 1.21 (s, 9H, $NCO_2C(C$**H**$_3)_3$).

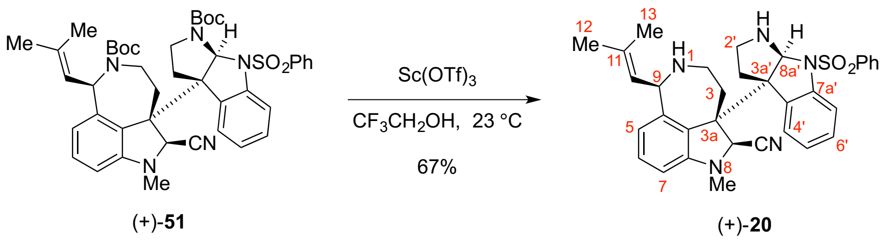
^{13}C NMR (125.8 MHz, CD_3CN, 70 °C): δ 155.6 (N_1**C**$O_2C(CH_3)_3$), 154.5 ($N_{1'}$**C**$O_2C(CH_3)_3$), 153.7 (**C**$_{7a}$), 144.3(**C**$_{7a'}$), 143.7 ($N_{8'}SO_2$Ph-*ipso*-**C**), 140.9 (**C**$_4$), 134.9 (**C**$_{11}$), 134.2 ($N_{8'}SO_2$Ph-*p*-**C**), 132.6 (**C**$_{4a'}$), 131.3 (**C**$_{4a}$), 130.9 (2C, **C**$_{6'}$, **C**$_6$), 130.6 ($N_{8'}SO_2$Ph-*m*-**C**), 127.4 ($N_{8'}SO_2$Ph-*o*-**C**), 126.1 (**C**$_{4'}$), 125.7 (**C**$_{10}$), 125.5 (**C**$_{5'}$), 122.2 (**C**$_5$), 118.1 (**C**N), 115.5 (**C**$_{7'}$), 109.4 (**C**$_7$), 82.7 (**C**$_{8a'}$), 81.4 (2C, NCO_2**C**$(CH_3)_3$), 71.3 (**C**$_{8a}$), 59.3 (**C**$_9$), 58.6 (2C, **C**$_{3a}$, **C**$_{3a'}$), 45.5 (**C**$_{2'}$), 42.9 (**C**$_2$), 37.3 (**C**$_{3'}$), 35.1 (**C**$_3$), 34.5 (N_8**C**H_3), 29.2 ($NCO_2C($**C**$H_3)_3$), 28.6 ($NCO_2C($**C**$H_3)_3$), 26.0 (**C**$_{12/13}$), 19.3 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}: 2976 (m), 1698 (s), 1583 (w), 1477 (m), 1391 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{43}H_{51}N_5NaO_6S$ $[M+Na]^+$: 788.3452, found: 788.3459.

$[\alpha]_D^{24}$: +141 (*c* = 1.04 CH_2Cl_2).

TLC (50% *tert*-butyl methyl ether in hexanes), R*f*: 0.4 (UV, CAM).



Heterodimeric diamine (+)-20:

A sample of scandium(III) trifluoromethanesulfonate (223 mg, 452 μmol, 6.00 equiv) was added to an inseparable mixture of heterodimer (+)-**51** (57.8 mg, 75.4 μmol, 1 equiv) and cyclotryptamine **28** (31.2 mg, 77.8 μmol, 1.03 equiv) dissolved in 2,2,2-trifluoroethanol (7.50 mL) at 23 ºC. After 25 min, a saturated aqueous sodium bicarbonate solution (15 mL) was added and the mixture was extracted with dichloromethane (3 × 15 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (15 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 33% acetone, 1% methanol in dichloromethane) to afford heterodimeric diamine (+)-**20** (28.4 mg, 66.6%) as a light tan foam. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C): δ 8.15 (dd, *J* = 8.5, 1.3 Hz, 2H, $N_{8'}$ SO_2Ph-*o*-**H**), 7.63 (app-t, *J* = 7.4 Hz, 1H, $N_{8'}$ SO_2Ph-*p*-**H**), 7.54 (app-t, *J* = 7.7 Hz, 2H, $N_{8'}$ SO_2Ph-*m*-**H**), 7.25 (app-t, *J* = 7.8 Hz, 1H, C_6**H**), 7.23–7.19 (m, 1H, $C_{6'}$**H**), 7.16 (d, *J* = 7.6 Hz, 1H, $C_{4'}$**H**), 7.13 (d, *J* = 8.0 Hz, 1H, $C_{7'}$**H**), 6.96 (app-td, *J* = 7.5, 1.1 Hz, 1H, $C_{5'}$**H**), 6.76 (d, *J* = 7.8 Hz, 1H, C_5**H**), 6.62 (d, *J* = 7.8 Hz, 1H, C_7**H**), 5.77 (s, 1H, $C_{8a'}$**H**), 5.40 (d, *J* = 8.3 Hz, 1H, C_{10}**H**), 4.77 (d, *J* = 7.5 Hz, 1H, C_9**H**), 4.20 (s, 1H, C_{8a}**H**), 2.83 (dd, *J* = 10.7, 6.7 Hz, 1H, $C_{2'}H_a$), 2.79 (s, 3H, N_8CH_3), 2.78–2.71 (m, 2H C_2H_a, C_2H_b), 2.45 (app-td, *J* = 11.6, 6.8 Hz, 1H, $C_{3'}H_a$), 2.28 (dd, *J* = 11.3, 3.7 Hz, 1H, $C_{3'}H_b$), 2.12 (m, 2H, $C_{2'}H_b$, C_3H_a), 1.89 (dd, *J* = 15.2, 5.2 Hz, 1H, C_3H_b), 1.81 (d, *J* = 1.2 Hz, 3H, $C_{12/13}H_3$), 1.53 (s, 1H, $C_{12/13}H_3$).

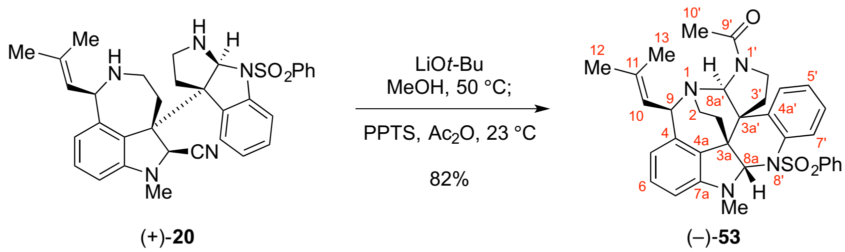
^{13}C NMR (125.8 MHz, CD_3CN, 20 °C): δ 153.1 (**C**$_{7a}$), 143.8 (**C**$_{7a'}$), 141.5 ($N_{8'}SO_2$Ph-*ipso*-**C**), 139.5 (**C**$_4$), 135.8 (**C**$_{11}$), 134.6 ($N_{8'}SO_2$Ph-*p*-**C**), 133.1 (**C**$_{4a'}$), 131.6 (**C**$_6$), 130.6 (**C**$_{6'}$), 130.5 ($N_{8'}SO_2$Ph-*m*-**C**), 129.0 ($N_{8'}SO_2$Ph-*o*-**C**), 128.7 (**C**$_{4a}$), 127.9 (**C**$_{4'}$), 125.8 (**C**$_{10}$), 124.4 (**C**$_{5'}$), 118.5 (**C**$_5$), 117.7 (**C**N), 113.6 (**C**$_{7'}$), 108.7 (**C**$_7$), 86.1 (**C**$_{8a'}$), 68.5 (**C**$_{8a}$), 66.4 (**C**$_{3a'}$), 58.3 (**C**$_{3a}$), 54.2 (**C**$_9$), 46.4 (**C**$_{2'}$), 43.8 (**C**$_2$), 38.9 (**C**$_{3'}$), 34.5 (**C**$_3$), 33.5 (N_8**C**H_3), 26.4 (**C**$_{12/13}$), 19.4 (**C**$_{12/13}$).

FTIR (thin film) cm^{-1}: 3358 (br-w), 2936 (m), 1587 (m), 1476 (s), 1352 (s).

HRMS (ESI) (*m/z*): calc'd for $C_{33}H_{36}N_5O_2S$ $[M+H]^+$: 566.2584, found: 566.2607.

$[\alpha]_D^{24}$: +235 (c = 0.44 CH_2Cl_2).

TLC (9% methanol, 1% ammonium hydroxide in chloroform), R*f*: 0.37 (UV, CAM).



N8'-Benzenesulfonyl Communesin F (–)-53:

A solution of lithium *tert*-butoxide (0.100 M in MeOH, 1.13 mL, 113 μmol, 10.0 equiv) was added to a solution of heterodimer (+)-**20** (6.30 mg, 11.1 μmol, 1 equiv) in methanol (1.13 mL). The vessel was sealed then immersed in a preheated 50 ºC oil bath and was allowed to stir under a static atmosphere of argon. After 4 h, the reaction mixture was cooled to 23 ºC, after which pyridinium *p*-toluenesulfonate (22.4 mg, 89.1 μmol, 8.00 equiv) and acetic anhydride (9.5 μL, 100 μmol, 9.00 equiv) were added sequentially. After 24 min, a saturated aqueous sodium bicarbonate solution (3 mL) was added and the resulting heterogeneous mixture was diluted with deionized water (5 mL) then extracted with dichloromethane (3 × 10 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (10 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified via flash column chromatography (eluent: 25%→30% acetone in hexanes) to afford *N*8´-benzenesulfonyl communesin F (–)-**53** (5.3 mg, 82%) as a white solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, CD_3CN, 20 °C, 2.7:1 mixture of atropisomers, *denotes minor atropisomer): δ 8.00 (d, J = 7.3 Hz, 2H, SO_2Ph-*o*-**H**), 7.71–7.64 (m, 2H, $N_{8'}SO_2$Ph-*p*-**H**, $C_{7'}$**H**), 7.61 (app-t, J = 7.6 Hz, 2H, SO_2Ph-*m*-**H**), 7.25 (app-t, J = 7.8 Hz, 1H, $C_{6'}$**H**), 7.10 (app-t, J = 7.0 Hz, 1H, $C_{5'}$**H**), 6.90 (d, J = 7.7 Hz, 1H, $C_{4'}$**H**), 6.77 (app-td, J = 7.7, 0.7 Hz, 1H, C_6**H**), 6.72 (d, J = 7.8 Hz, 1H, $C_{4'}$**H***), 6.06 (d, J = 9.6 Hz, 1H, C_5**H***), 6.04 (d, J = 7.8 Hz, 1H, C_5**H**), 5.82 (d, J = 7.7 Hz, 1H, C_7**H**), 5.79 (s, 1H, C_{8a}**H**), 5.77 (s, 1H, C_{8a}**H***), 5.25 (s, 1H, $C_{8a'}$**H***), 5.20 (d, J = 9.1 Hz, 1H, C_{10}**H**), 5.13–5.09 (m, 3H, C_9**H**, $C_{8a'}$**H**, C_{10}**H***), 3.62–3.56 (m, 1H, $C_{2'}$**H**$_a$), 3.27 (dd, J = 15.5, 9.8 Hz, 1H, C_2**H**$_a$), 3.23–3.18 (m, 1H, C_2**H**$_a$*), 3.09–2.99 (m, 1H, C_2**H**$_b$), 2.93–2.86 (m, 1H, C_2**H**$_b$*), 2.68 (ddd, J = 19.0, 12.4, 6.7 Hz, 1H, $C_{2'}$**H**$_b$), 2.57–2.49 (m, 4H, N_8C**H**$_3$, $C_{3'}$**H**$_a$), 2.36 (app-dt, J = 17.7, 8.9 Hz, 1H, C_3**H**$_a$), 2.26 (s, 3H, $C_{10'}$**H**$_3$), 2.20–2.11 (m, 1H, C_3**H**$_b$), 1.97 (s, 3H, $C_{10'}$**H**$_3$*), 1.82 (s, 3H, $C_{12/13}$**H**$_3$), 1.76 (s, 3H, $C_{12/13}$**H**$_3$), 1.73 (s, 3H, $C_{12/13}$**H**$_3$*), 1.26 (ddd, J = 25.4, 13.4, 7.4 Hz, 1H, $C_{3'}$**H**$_b$).

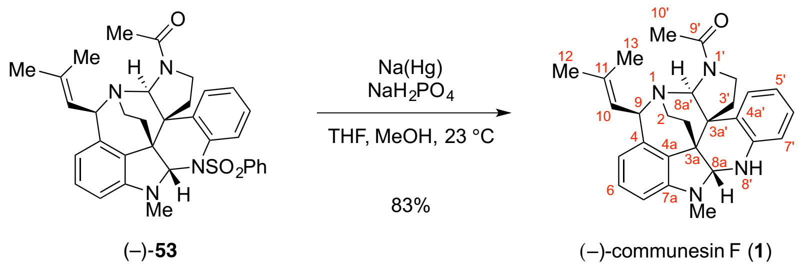
^{13}C NMR (125.8 MHz, CD_3CN, 20 °C, 2.7:1 mixture of atropisomers, *denotes minor atropisomer): δ 171.84 (**C**$_{9'}$), 171.15 (**C**$_{9'}$*), 150.60 (**C**$_{7a}$), 143.71 (**C**$_4$*), 142.85 (**C**$_4$), 142.25 ($N_{8'}SO_2$Ph-*ipso*-**C***), 142.17 ($N_{8'}SO_2$Ph-*ipso*-**C**), 141.07 (**C**$_{4a'}$*), 140.81 (**C**$_{4a'}$), 138.77 (**C**$_{11}$*), 137.35 (**C**$_{11}$), 137.27 (**C**$_{7a'}$), 134.97 ($N_{8'}SO_2$Ph-*p*-**C**), 134.91 ($N_{8'}SO_2$Ph-*p*-**C***), 131.98 (**C**$_{4a}$*), 131.69 (**C**$_{4a}$), 130.94 ($N_{8'}SO_2$Ph-*m*-**C***), 130.92 ($N_{8'}SO_2$Ph-*m*-**C**), 130.02 (**C**$_6$*), 130.00 (**C**$_6$), 128.77 ($N_{8'}SO_2$Ph-*o*-**C***), 128.73 (2C, $N_{8'}SO_2$Ph-*o*-**C**, **C**$_{6'}$), 127.94 (**C**$_{5'}$*), 127.77 (**C**$_{5'}$), 127.06 (**C**$_{7'}$), 125.89 (**C**$_{10}$*), 125.69 (**C**$_{10}$), 125.38 (**C**$_{4'}$), 125.28 (**C**$_{4'}$*) 116.61 (**C**$_5$), 116.51 (**C**$_5$*), 102.39 (**C**$_7$*), 102.32 (**C**$_7$), 86.30 (**C**$_{8a}$*), 86.22 (**C**$_{8a}$), 80.69 (**C**$_{8a'}$), 79.59 (**C**$_{8a'}$*), 65.63 (**C**$_9$*), 65.33 (**C**$_9$), 55.18 (**C**$_{3a}$), 55.09 (**C**$_{3a}$*), 53.57 (**C**$_{3a'}$), 51.44 (**C**$_{3a'}$*), 46.55 (**C**$_{2'}$*), 45.00 (**C**$_{2'}$), 38.96 (**C**$_3$*), 38.60 (**C**$_3$), 37.45 (**C**$_2$*), 37.24 (**C**$_2$), 33.76 (**C**$_{3'}$*), 32.15 (**C**$_{3'}$), 30.78 (N_8**C**H_3*), 30.74 (N_8**C**H_3), 26.32 (**C**$_{12/13}$), 26.09 (**C**$_{12/13}$*), 23.43 (**C**$_{10'}$*), 23.26 (**C**$_{10'}$), 18.97 (**C**$_{12/13}$), 18.93 (**C**$_{12/13}$*).

FTIR (thin film) cm^{-1}: 2927 (m), 1653 (s), 1600 (m), 1486 (m), 1448 (w).

HRMS (ESI) (*m/z*): calc'd for $C_{34}H_{37}N_4O_3S$ $[M+H]^+$: 581.2581, found: 581.2573.

$[\alpha]_D^{24}$: –190 (c = 0.21 CH_2Cl_2).

TLC (50% acetone in hexanes), R*f*: 0.37 (UV, CAM).



(–)-Communesin F (1):

A sample of sodium amalgam[18] (5%-Na, 160 mg, 348 μmol, 20.0 equiv) was added to a suspension of sodium phosphate monobasic monohydrate (52.6 mg, 383 μmol, 22.0 equiv) and *N*8′-benzenesulfonyl communesin F (–)-**53** (10.1 mg, 17.4 μmol, 1 equiv) in tetrahydrofuran (250 μL) and methanol (750 μL) at 23 °C. After 20 min, another portion of sodium phosphate monobasic monohydrate (52.6 mg, 383 μmol, 22.0 equiv) and sodium amalgam (5%-Na, 160 mg, 348 μmol, 20.0 equiv) were added sequentially. After an additional 20 min, another portion of sodium phosphate monobasic monohydrate (52.6 mg, 383 μmol, 22.0 equiv) and sodium amalgam (5%-Na, 160 mg, 348 μmol, 20.0 equiv) were added sequentially. After an additional 20 min, a final portion of sodium phosphate monobasic monohydrate (52.6 mg, 383 μmol, 22.0 equiv) and sodium amalgam (5%-Na, 160 mg, 348 μmol, 20.0 equiv) were added sequentially. After 30 min, an aqueous solution of 5% sodium bicarbonate (5 mL) was added and the resulting mixture was extracted with dichloromethane (3 × 10 mL). The combined organic extracts were washed with a saturated aqueous sodium chloride solution (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting residue was purified by flash column chromatography on silica gel (eluent: 25%→33% acetone in hexanes) to afford (–)-communesin F (**1**) (6.40 mg, 83.1%) as a white solid. Structural assignments were made using additional information from gCOSY, HSQC, and HMBC experiments.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C, 3.1:1 mixture of atropisomers, *denotes minor atropisomer): δ 7.00 (td, *J* = 7.5, 1.5 Hz, 1H, $C_{6'}$**H**), 6.82 (app-t, *J* = 7.7 Hz, 1H, C_6**H**), 6.74–6.66 (m, 3H, $C_{4'}$**H**, C $C_{5'}$**H**, $C_{7'}$**H**), 6.14 (d, *J* = 7.8 Hz, 1H, C_5**H***), 6.08 (d, *J* = 7.8 Hz, 1H, C_5**H**), 5.86 (d, *J* = 7.4 Hz, 1H, C_7**H**), 5.85 (d, *J* = 6.7 Hz, 1H, C_7**H***), 5.48 (s, 1H, $C_{8a'}$**H***), 5.36 (d, *J* = 8.6 Hz, 1H, C_9**H***), 5.23 (br-d, *J* = 8.8 Hz, 1H, C_{10}**H**), 5.11 (s, 1H, $C_{8a'}$**H**), 5.05 (d, *J* = 8.9 Hz, 1H, C_9**H**), 4.67 (s, 1H, C_{8a}**H**), 4.63 (s, 1H, C_{8a}**H***), 4.57 (br-s, 1H, $N_{8'}$**H**), 3.85 (dd, *J* = 11.8, 8.8 Hz, 1H, $C_{2'}$**H**), 3.68 (app-t, *J* = 9.1 Hz, 1H, $C_{2'}$**H***), 3.42 (dd, *J* = 15.3, 9.2 Hz, 1H, C_2**H***), 3.34 (dd, *J* = 15.4, 9.4 Hz, 1H, C_2**H**), 3.22–3.10 (m, 3H, C_2**H,** C_2**H***, $C_{2'}$**H***), 3.03 (td, *J* = 11.4, 7.5 Hz, 1H, $C_{2'}$**H**), 2.95–2.87 (m, 1H, $C_{3'}$**H***), 2.82 (s, 3H, N_8-C**H**$_3$), 2.80 (s, 3H, N_8-C**H**$_3$*), 2.78–2.71 (m, 1H,

[18] The reagent was prepared according to McDonald, R. N.; Reineke, C. E. *Org. Synth.* **1970**, *50*, 50.

$C_{3'}$**H**), 2.40 (s, 3H, $C_{10'}$**H**$_3$), 2.33–2.19 (m, 4H, C_3**H**$_2$, C_3**H**$_2$, C_3**H**$_2$*), 2.11 (s, 3H, $C_{10'}$**H**$_3$*), 2.04–2.00 (m, 1H, $C_{3'}$**H***), 1.99–1.95 (m, 4H, $C_{12/13}$**H**$_3$, $C_{3'}$**H**), 1.85 (d, J = 1.1 Hz, 3H, $C_{12/13}$**H**$_3$), 1.79 (d, J = 0.9 Hz, 3H, $C_{12/13}$**H**$_3$), 1.75 (s, 1H, $C_{12/13}$**H**$_3$*).

^{13}C NMR (125.8 MHz, $CDCl_3$, 20 °C, 3.1:1 mixture of atropisomers, *denotes minor atropisomer): 171.6 (**C**$_{9'}$), 170.7 (**C**$_{9'}$*), 150.1 (**C**$_{7a}$), 150.0 (**C**$_{7a}$*) 142.9 (**C**$_{7a'}$*), 142.7 (**C**$_{7a'}$), 141.6 (**C**$_4$*), 140.6 (**C**$_4$), 137.9 (**C**$_{11}$*), 136.1 (**C**$_{11}$), 132.9 (**C**$_{4a'}$*), 132.7 (**C**$_{4a'}$), 131.5 (**C**$_{4a}$*), 131.3 (**C**$_{4a}$), 128.3 (**C**$_6$), 128.1 (**C**$_6$*), 127.3 (**C**$_{6'}$), 127.1 (**C**$_{4'*/5'*/7'*}$), 124.6 (**C**$_{10}$), 124.5 (**C**$_{10}$*), 123.5 (**C**$_{4'*/5'*/7'*}$), 123.2 (**C**$_{4'/5'/7'}$), 120.7 (**C**$_{4'*/5'*/7'*}$), 120.6 (**C**$_{4'/5'/7'}$), 116.99 (**C**$_{6'}$*), 116.97 (**C**$_{4'/5'/7'}$), 115.4 (**C**$_5$*), 114.7 (**C**$_5$), 100.7 (**C**$_7$), 100.6 (**C**$_7$*), 83.0 (**C**$_{8a}^*$), 82.6 (**C**$_{8a}$), 79.5 (**C**$_{8a'}$), 78.1 (**C**$_{8a'}$*), 64.5 (**C**$_9$*), 64.4 (**C**$_9$), 51.8 (**C**$_{3a}$), 51.2 (**C**$_{3a'}$), 51.1 (**C**$_{3a*/3a'*}$), 49.9 (**C**$_{3a*/3a'*}$), 46.0 (**C**$_{2'}$*), 44.2 (**C**$_{2'}$), 38.1 (**C**$_3$*), 37.8 (**C**$_3$), 36.7 (**C**$_2$*), 36.3 (**C**$_2$), 32.4 (**C**$_{3'}$*), 30.8 (**C**$_{3'}$), 29.9 (N_8-**C**H_3*), 29.7 (N_8-**C**H_3), 26.0 (**C**$_{12/13}$), 25.9 (**C**$_{12*/13*}$), 23.1 (**C**$_{10'}$*), 22.7 (**C**$_{10'}$), 18.5 (**C**$_{12/13}$), 18.4 (**C**$_{12*/13*}$).

FTIR (thin film) cm^{-1}: 3315 (br-m), 2927 (m), 1636 (s), 1597 (s), 1492 (m).

HRMS (ESI) (*m/z*): calc'd for $C_{28}H_{33}N_4O$ $[M+H]^+$: 441.2649, found: 441.2633.

$[\alpha]_D^{24}$: –249 (c = 0.13 $CHCl_3$).

TLC (50% acetone in hexanes), R*f*: 0.37 (UV, CAM).

Table S1. Comparison of our ^{1}H NMR data for (–)-communesin F (1) with literature data ($CDCl_3$, major atropisomer):

Assignment	**Hayashi's Isolation Report**[19], (–)-**1** ^{1}H NMR 500 MHz, $CDCl_3$	**Qin's Report**[20] (±)-**1** ^{1}H NMR 500 MHz, $CDCl_3$	**Weinreb's Report**[21] (±)-**1** ^{1}H NMR 300 MHz, $CDCl_3$	**Ma's Report**[22] (–)-**1** ^{1}H NMR 400 MHz, $CDCl_3$	**Funk's Report**[23] (±)-**1** ^{1}H NMR 400 MHz, $CDCl_3$	**This Work** (–)-**1** ^{1}H NMR, 500 MHz, $CDCl_3$
C2	3.14 (ddd, *J* = 15.5, 12.2, 8.5 Hz, 1H) 3.34 (dd, *J* = 15.5, 9.1 Hz, 1H)	3.14 (ddd, *J* = 15.6, 12.2, 8.8 Hz, 1H) 3.34 (dd, *J* = 15.4, 9.2 Hz, 1H)	3.25–3.17 (m, 1H) 3.34–3.27 (m, 1H)	3.14 (ddd, *J* = 15.6, 12.2, 8.8 Hz, 1H) 3.33 (dd, *J* = 15.4, 9.2 Hz, 1H)	3.15 (m, 1H) 3.34 (dd, *J* = 15.7, 9.4 Hz, 1H)	3.17–3.10 (m, 1H) 3.34 (dd, *J* = 15.4, 9.4 Hz, 1H)
C2'	3.03 (app-td, *J* = 11.6, 7.6 Hz, 1H) 3.85 (dd, *J* = 11.6, 8.8 Hz, 1H)	3.03 (app-td, *J* = 11.6, 7.6 Hz, 1H) 3.85 (dd, *J* = 11.6, 9.2 Hz, 1H)	3.04–2.96 (m, 1H) 3.83 (dd, *J* = 11.4, 8.8 Hz, 1H)	3.03 (app-td, *J* = 11.6, 7.6 Hz, 1H) 3.84 (dd, *J* = 12.0, 8.8 Hz, 1H)	3.03 (app-td, *J* = 11.5, 7.5 Hz, 1H) 3.85 (dd, *J* = 11.5, 9.1 Hz, 1H)	3.03 (td, *J* = 11.4, 7.5 Hz, 1H) 3.85 (dd, *J* = 11.8, 8.8 Hz, 1H)
C3	2.22 (app-dt, *J* = 12.2, 9.1 Hz, 1H) 2.29 (dd, *J* = 12.2, 8.5 Hz, 1H)	2.22 (m, 1H) 2.29 (m, 1H)	2.30–2.18 (m, 2H)	2.29–2.16 (m, 2H)	2.32–2.19 (m, 2H)	2.33–2.19 (m, 2H)
C3'	1.96 (dd, *J* = 12.8, 7.6 Hz, 1H) 2.74 (ddd, *J* = 12.8, 11.6, 8.8 Hz, 1H)	1.96 (dd, *J* = 13.2, 7.6 Hz, 1H) 2.74 (ddd, *J* = 13.2, 11.6, 8.8 Hz, 1H)	1.97–1.91 (m, 1H) 2.75–2.70 (m, 1H)	1.96–1.90 (m, 1H) 2.76–2.70 (m, 1H)	1.99–1.94 (m, 1H) 2.78–2.70 (m, 1H)	1.99–1.95 (m, 1H) 2.78–2.71 (m, 1H)
C4'	6.68 (dd, *J* = 7.3, 1.5 Hz, 1H)	6.68 (dd, *J* = 7.3, 1.5 Hz, 1H)	6.72–6.64 (m, 1H)	6.73–6.65 (m, 1H)	6.73–6.65 (m, 1H)	6.74–6.66 (m, 1H)
C5	6.08 (d, *J* = 7.6 Hz)	6.08 (d, *J* = 7.6 Hz)	6.06 (d, *J* = 7.7 Hz)	6.07 (d, *J* = 7.6 Hz)	6.08 (d, *J* = 7.7 Hz)	6.08 (d, *J* = 7.8 Hz, 1H)
C5'	6.70 (app-td, *J* = 7.3, 1.5 Hz, 1H)	6.70 (app-td, *J* = 7.3, 1.5 Hz, 1H)	6.72–6.64 (m, 1H)	6.73–6.65 (m, 1H)	6.73–6.65 (m, 1H)	6.74–6.66 (m, 1H)
C6	6.82 (app-t, *J* = 7.6 Hz, 1H)	6.82 (app-t, *J* = 7.6 Hz, 1H)	6.80 (app-t, *J* = 7.7 Hz, 1H)	6.82 (app-t, *J* = 7.6 Hz, 1H)	6.82 (app-t, *J* = 7.7 Hz, 1H)	6.82 (app-t, *J* = 7.7 Hz, 1H)
C6'	7.00 (app-td, *J* = 7.3, 1.5 Hz, 1H)	7.00 (app-td, *J* = 7.3, 1.5 Hz, 1H)	6.68 (dd, *J* = 7.7, 1.7 Hz, 1H)	6.98 (app-td, *J* = 7.6, 1.6 Hz, 1H)	7.00 (app-t, *J* = 7.2 Hz, 1H)	7.00 (td, *J* = 7.5, 1.5 Hz, 1H)
C7	5.86 (d, *J* = 7.6 Hz, 1H)	5.86 (d, *J* = 7.6 Hz, 1H)	5.84 (d, *J* = 7.6 Hz, 1H)	5.86 (d, *J* = 7.2 Hz, 1H)	5.86 (d, *J* = 7.4 Hz, 1H)	5.86 (d, *J* = 7.4 Hz, 1H)

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C7'	6.68 (dd, *J* = 7.3, 1.5 Hz, 1H)	6.68 (dd, *J* = 7.3, 1.5 Hz, 1H)	6.72–6.64 (m, 1H)	6.73–6.65 (m, 1H)	6.73–6.65 (m, 1H)	6.74–6.66 (m, 1H)
N8-C**H**$_3$	2.82 (s, 3H)	2.82 (s, 3H)	2.80 (s, 3H)	2.82 (s, 3H)	2.82 (s, 3H)	2.82 (s, 3H)
N8'-**H**	4.60 (br-s, 1H)	4.60 (br-s, 1H)	3.76 (br-s, 0.5H)	4.57 (br-s, 1H)	4.57 (br-s, 1H)	4.57 (br s, 1 H)
C8a	4.66 (s, 1H)	4.66 (s, 1H)	4.64 (s, 1H)	4.67 (s, 1H)	4.67 (s, 1H)	4.67 (s, 1H)
C8a'	5.11 (s, 1H)	5.11 (s, 1H)	5.09 (s, 1H)	5.10 (s, 1H)	5.11 (s, 1H)	5.10 (s, 1H)
C9	5.05 (d, *J* = 8.8 Hz, 1H)	5.05 (d, *J* = 8.8 Hz, 1H)	5.03 (d, *J* = 8.8 Hz, 1H)	5.04 (d, *J* = 9.2 Hz, 1H)	5.05 (d, *J* = 8.8 Hz, 1H)	5.05 (d, *J* = 8.9 Hz, 1H)
C10	5.22 (d, *J* = 8.8 Hz, 1H)	5.22 (d, *J* = 8.8 Hz, 1H)	5.21 (d, *J* = 8.9 Hz, 1H)	5.22 (d, *J* = 8.8 Hz, 1H)	5.23 (d, *J* = 8.7 Hz, 1H)	5.23 (d, *J* = 8.8 Hz, 1H)
C10'	2.41 (s, 3H)	2.41 (s, 3H)	2.38 (s, 3H)	2.40 (s, 3H)	2.40 (s, 3H)	2.40 (s, 3H)
C12	1.79 (d, *J* = 0.6 Hz, 3H)	1.79 (d, *J* = 0.8 Hz, 3H)	1.76 (d, *J* = 1.1 Hz, 3H)	1.79 (d, *J* = 0.8 Hz, 3H)	1.77 (s, 3H)	1.79 (d, *J* = 0.9, 3H)
C13	1.85 (d, *J* = 0.6 Hz, 3H)	1.85 (d, *J* = 0.8 Hz, 3H)	1.83 (d, *J* = 1.2 Hz, 3H)	1.85 (d, *J* = 0.8 Hz, 3H)	1.85 (s, 3H)	1.85 (d, *J* = 1.1 Hz, 3H)

Table S2. Comparison of our ^{13}C NMR data for (–)-communesin F (1) with literature data ($CDCl_3$, major atropisomer):

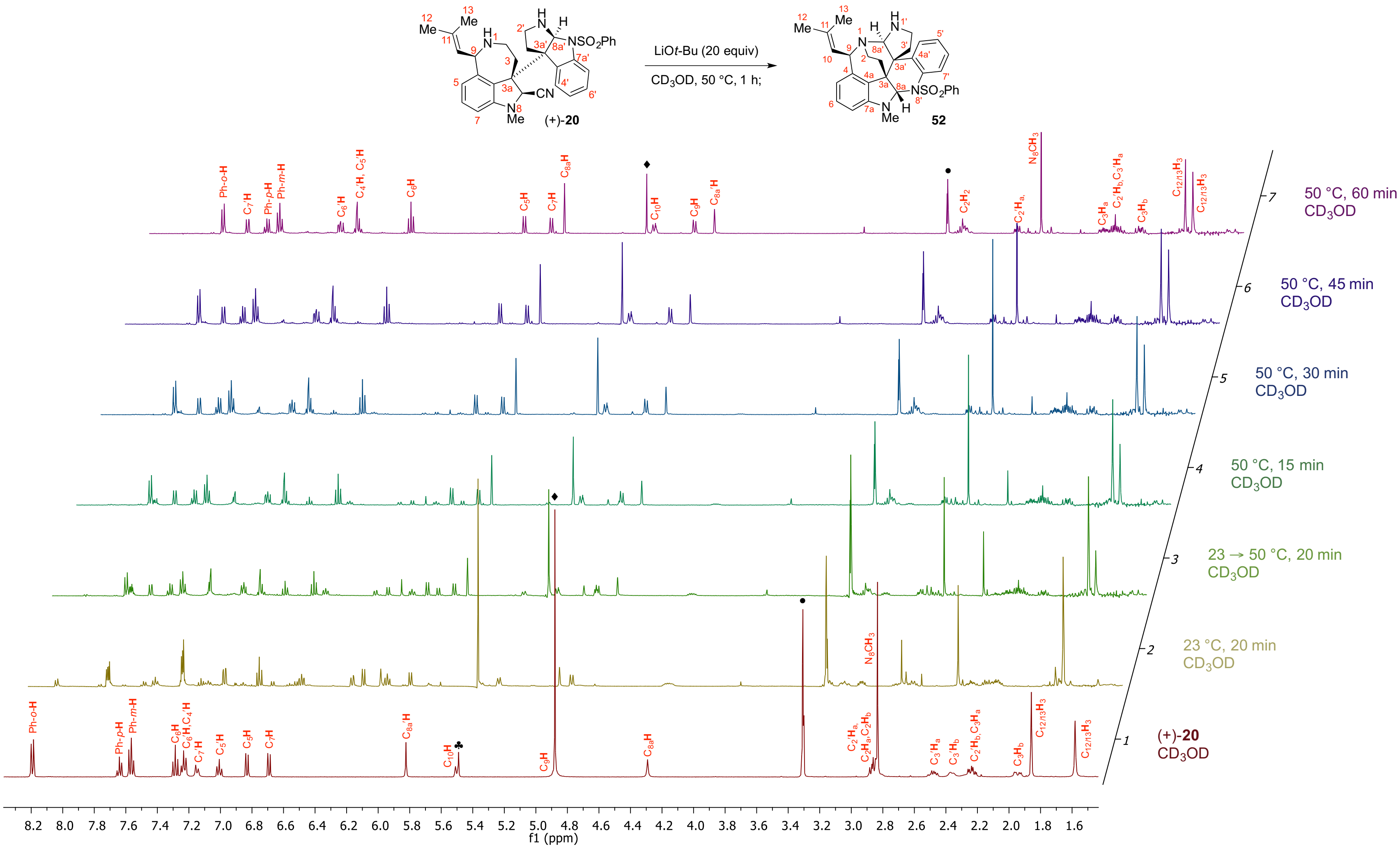
Assignment	**Hayashi's Isolation Report**[19] (–)-**1** ^{13}C NMR 500 MHz, $CDCl_3$	**Qin's Report** (±)-**1**[20] ^{13}C NMR 500 MHz,$CDCl_3$	**Weinreb's Report** (±)-**1**[21] ^{13}C NMR 300 MHz,$CDCl_3$	**Ma's Report** (–)-**1**[22] ^{13}C NMR 400 MHz $CDCl_3$	**Funk's Report** (±)-**1**[23] ^{13}C NMR 400 MHz $CDCl_3$	**This Work** (–)-**1** ^{13}C NMR, 500 MHz $CDCl_3$	**Chemical Shift Difference** Δδ = δ (this work) – δ (ref 19)
C2	36.3	36.3	36.2	36.3	36.2	36.3	0.0
C2'	44.3	44.2	44.2	44.2	44.2	44.2	–0.1
C3	37.7	37.8	37.8	37.8	37. 8	37.8	0.1
C3'	30.9	30.9	30.8	30.8	30.8	30.8	–0.1
C3a	51.2	51.2	51.2	51.2	51.2	**51.8**[24]	**0.6**[24]
C3a'	51.8	51.8	51.8	51.8	51.8	**51.2**[24]	**–0.6**[24]
C4a	131.3	131.3	131.3	131.3	131.3	131.3	0.0
C4a'	132.7	132.7	132.7	132.7	132.7	132.7	0.0
C4	140.6	140.6	140.6	140.7	140.6	140.6	0.0
C4'	123.2	123.2	123.2	123.2	123.2	123.2	0.0
C5	114.7	114.7	114.7	114.7	114.7	114.7	0.0
C5'	120.6	120.6	120.6	120.6	120.6	120.6	0.0
C6	128.4	128.4	128.3	128.4	128.4	128.3	–0.1
C6'	127.3	127.3	127.3	127.3	127.3	127.3	0.0
C7	100.8	100.8	100.7	100.7	100.7	100.7	–0.1
C7'	117.0	117.0	117.0	117.0	117.0	117.0	0.0
C7a	150.1	150.1	150.1	150.1	150.1	150.1	0.0
C7a'	142.7	142.7	142.7	142.7	142.7	142.7	0.0
N8-CH_3	29.6	29.6	29.6	29.7	29.7	29.7	0.1
C8a	82.6	82.6	82.6	82.7	82.6	82.6	0.0
C8a'	79.6	79.6	79.5	79.6	79.6	79.5	–0.1

[24] Detailed analysis of key gHSQC and gHMBC correlations are most consistent with our revised assignment of C3a and C3a' resonances.

C9	64.4	64.4	64.4	64.4	64.4	64.4	0.0
C9'	171.6	171.6	171.6	171.6	171.6	171.6	0.0
C10	124.6	124.6	124.6	124.6	124.6	124.6	0.0
C10'	22.6	22.6	22.6	22.6	22.6	22.7	0.1
C11	136.1	136.0	136.1	136.1	136.1	136.1	0.0
C12	26.0	26.0	26.0	26.0	26.0	26.0	0.0
C13	18.5	18.4	18.5	18.5	18.5	18.5	0.0

In Situ [1]H NMR Monitoring of the Conversion of Diamine (+)-20 to Heptacycle 52:

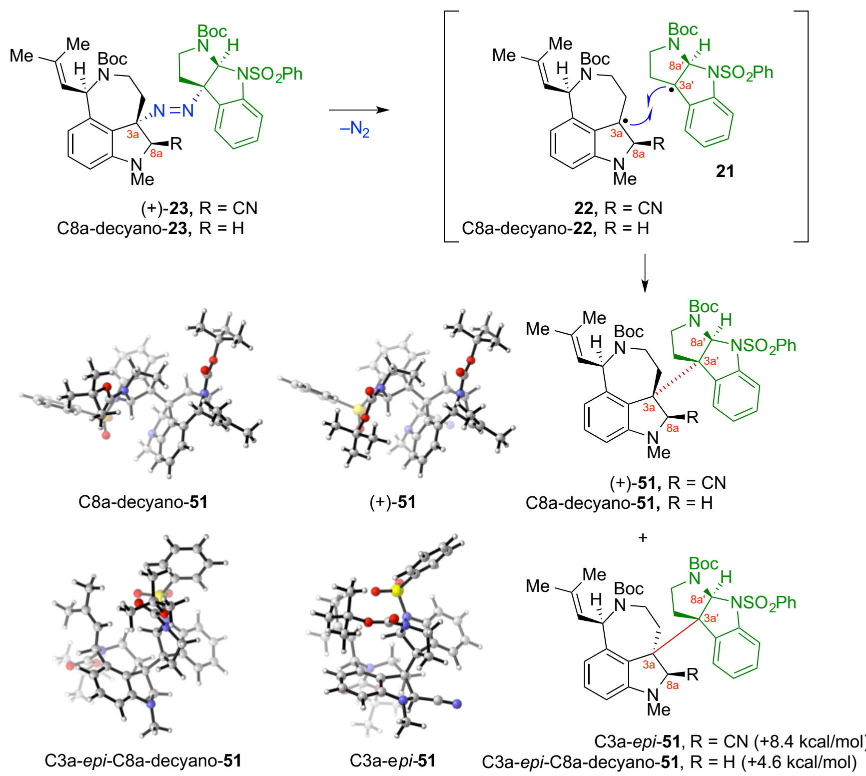
Treatment of heterodimer (+)-**20** with lithium *tert*-butoxide in methanol provided clean and complete conversion to the desired heptacyclic structure **52** within 1 h at 50° C as observed by in situ [1]H-NMR spectroscopy. Trace1: [1]H NMR (500 MHz) of heterodimer (+)-**20** in CD_3OD with assignments for reference. Trace2–7: [1]H NMR (500 MHz) monitoring of the conversion of heterodimer (+)-**20** to communesin core **52**. Legend: • = CD_2HOD, ♦ = HDO, ♣ = CH_2Cl_2.



Calculations Related to Formation of Heterodimer (+)-51:

The conformation distribution and equilibrium geometries (gas phase) in the ground state of heterodimers (+)-**51**, C3a-*epi*-**51** and the corresponding decyano variants C8a-decyano-**51** and C3a-*epi*-C8a-decayno-**51** were optimized with Merck Molecular Force Field (MMFF)[25] followed by density functional theory at B3LYP level with 6-31G(d) as basis set (Spartan ′14, Version 1.1.1, by Wavefunction, Inc.)[26]. The 3D representations of the molecular structures were generated from CYLview.[27]

Photoextrusion of dinitrogen from diazene (+)-**23** provided the heterodimer (+)-**51** as a single diastereomer. Consistent with this observation, the corresponding undesired diastereomer C3a-*epi*-**51** was calculated to be significantly less stable (+8.4 kcal/mol). The contribution of the C8a-nitrile stereochemistry to the energy difference between the two hypothetical C3a epimers, C3a-*epi*-**51** and C3a-*epi*-C8a-decyano-**51**, is noticeable ($\Delta\Delta E$ = 3.8 kcal/mol). Thus, the C8a-stereochemistry of radical **22** reinforces the approach of radical **21** from the opposite face with respect to the C8a-nitrile. The formation of the C3a-*epi*-heterodimer is intrinsically more difficult as illustrated by radical combination of C8a-decyano-**22** and cyclotryptamine **21** to afford C3a-*epi*-C8a-decyano-**51** (+4.6 kcal/mol). Our prior studies concerning the radical dimerization of cyclotryptamines indicate that the configuration of C3a′ is governed by the C8a′-stereogenic center of the tricyclic system.[28] These confluent factors contribute to the exclusive formation of the desired C3a–C3a' linkage by union of tricyclic radicals **21** and **22**.



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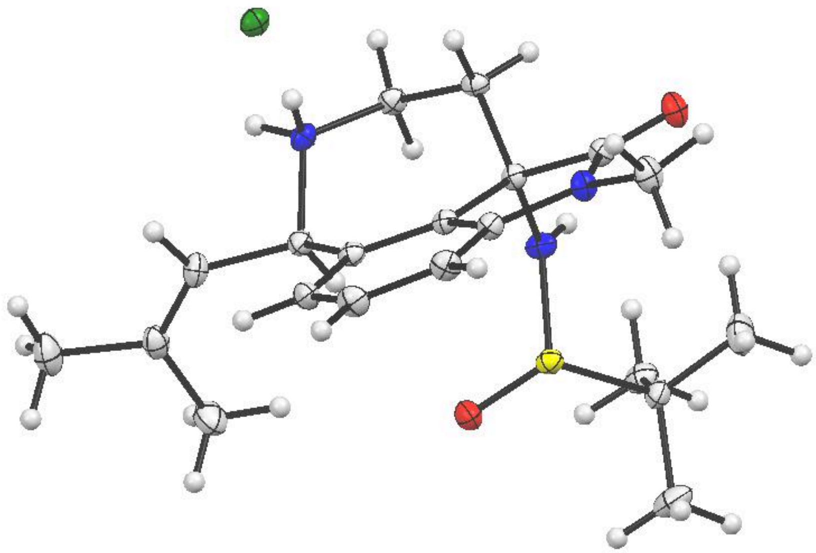
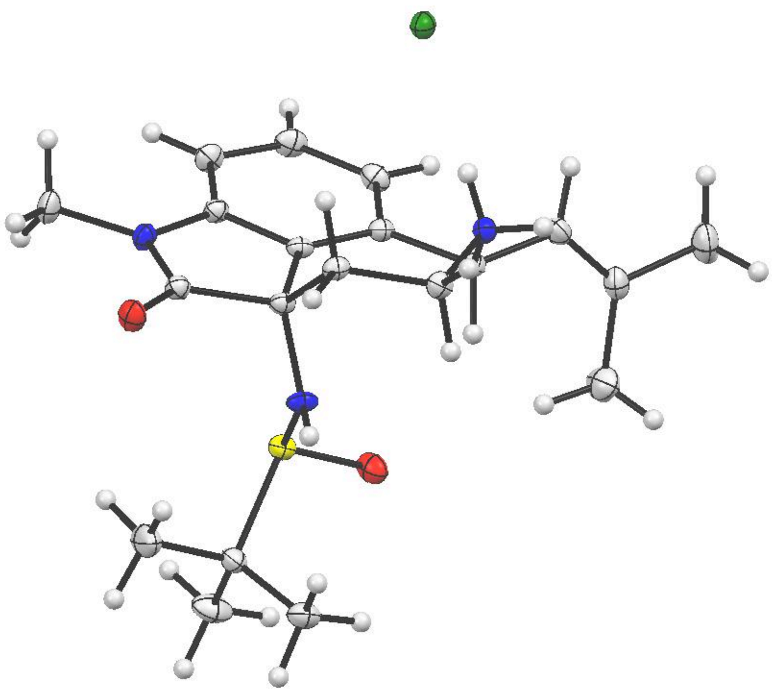
Crystal structure of azepane (+)-48.[29,30]

Structural parameters for azepane (+)-**48** are freely available from the Cambridge Crystallographic Data Center (CCDC 1471570).





[29] The MIT Department of Chemistry diffractometer was purchased with the help of funding from the National Science Foundation (NSF) under Grant Number CHE-0946721.
[30] Solvent molecules (chloroform) are omitted for clarity.

Table S3. Crystal data and structure refinement for azepane (+)-**48**.

Identification code	x8_11213	
Empirical formula	C23 H33 Cl10 N3 O2 S	
Formula weight	770.08	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P2(1)2(1)2(1)	
Unit cell dimensions	a = 12.4064(6) Å	α = 90°.
	b = 13.3489(7) Å	β = 90°.
	c = 20.4516(10) Å	γ = 90°.
Volume	3387.0(3) Å^3	
Z	4	
Density (calculated)	1.510 Mg/m^3	
Absorption coefficient	0.912 mm^{-1}	
F(000)	1576	
Crystal size	0.30 x 0.05 x 0.05 mm^3	
Theta range for data collection	1.82 to 30.27°.	
Index ranges	–17<=h<=17, -18<=k<=18, -29<=l<=29	
Reflections collected	76009	
Independent reflections	10104 [R(int) = 0.0459]	
Completeness to theta = 30.27°	100.0 %	
Absorption correction	None	
Max. and min. transmission	0.9558 and 0.7715	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	10104 / 3 / 367	
Goodness-of-fit on F^2	1.041	
Final R indices [I>2sigma(I)]	R1 = 0.0270, wR2 = 0.0594	
R indices (all data)	R1 = 0.0325, wR2 = 0.0617	
Absolute structure parameter	–0.03(3)	
Largest diff. peak and hole	0.433 and –0.393 e.Å^{-3}	

Table S4. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^2 x 10^3) for azepane (+)-**48**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	3364(1)	1739(1)	1836(1)	14(1)
O(1)	2686(1)	838(1)	-25(1)	20(1)
O(2)	4028(1)	2325(1)	2308(1)	21(1)
N(1)	3828(1)	-198(1)	542(1)	15(1)
N(2)	6356(1)	2708(1)	637(1)	15(1)
N(3)	3586(1)	2162(1)	1085(1)	15(1)
C(2)	3461(1)	705(1)	332(1)	14(1)
C(3)	4191(1)	1530(1)	627(1)	13(1)
C(4)	5038(1)	917(1)	980(1)	13(1)
C(5)	5954(1)	1216(1)	1311(1)	13(1)
C(6)	6573(1)	468(1)	1609(1)	17(1)
C(7)	6288(1)	-535(1)	1555(1)	19(1)
C(8)	5390(1)	-842(1)	1201(1)	17(1)
C(9)	4774(1)	-92(1)	919(1)	14(1)
C(10)	3359(1)	-1151(1)	358(1)	20(1)
C(11)	4651(1)	2173(1)	75(1)	14(1)
C(12)	5335(1)	3040(1)	313(1)	16(1)
C(13)	6277(1)	2313(1)	1336(1)	14(1)
C(14)	7356(1)	2528(1)	1640(1)	18(1)
C(15)	7529(1)	3036(1)	2190(1)	19(1)
C(16)	8659(2)	3305(1)	2397(1)	28(1)
C(17)	6672(2)	3381(2)	2652(1)	27(1)
C(18)	1966(1)	2167(1)	1953(1)	17(1)
C(19)	1284(2)	1652(2)	1437(1)	32(1)
C(20)	1673(2)	1808(1)	2640(1)	26(1)
C(21)	1895(1)	3299(1)	1909(1)	20(1)
C(1S)	11155(2)	5709(1)	1041(1)	24(1)
Cl(1)	11132(1)	6846(1)	608(1)	41(1)
Cl(2)	11599(1)	5912(1)	1847(1)	33(1)
Cl(3)	9859(1)	5162(1)	1047(1)	31(1)
C(2S)	5900(1)	575(1)	5840(1)	21(1)
Cl(4)	4618(1)	527(1)	5471(1)	30(1)
Cl(5)	6523(1)	1738(1)	5698(1)	38(1)
Cl(6)	5772(1)	359(1)	6687(1)	28(1)
C(3S)	4862(2)	781(1)	3422(1)	26(1)
Cl(7)	5692(1)	1445(1)	3971(1)	34(1)
Cl(8)	3614(1)	477(1)	3797(1)	36(1)
Cl(9)	5508(1)	-328(1)	3175(1)	31(1)
Cl(10)	7554(1)	1070(1)	-146(1)	16(1)

Table S5. Bond lengths [Å] and angles [°] for azepane (+)-**48**.

S(1)-O(2)	1.4910(12)
S(1)-N(3)	1.6578(13)
S(1)-C(18)	1.8422(16)
O(1)-C(2)	1.2205(19)
N(1)-C(2)	1.3586(19)
N(1)-C(9)	1.4119(19)
N(1)-C(10)	1.4490(19)
N(2)-C(12)	1.496(2)
N(2)-C(13)	1.527(2)
N(3)-C(3)	1.4681(19)
C(2)-C(3)	1.548(2)
C(3)-C(4)	1.515(2)
C(3)-C(11)	1.528(2)
C(4)-C(5)	1.381(2)
C(4)-C(9)	1.392(2)
C(5)-C(6)	1.399(2)
C(5)-C(13)	1.519(2)
C(6)-C(7)	1.389(2)
C(7)-C(8)	1.391(2)
C(8)-C(9)	1.386(2)
C(11)-C(12)	1.516(2)
C(13)-C(14)	1.504(2)
C(14)-C(15)	1.329(2)
C(15)-C(17)	1.496(2)
C(15)-C(16)	1.508(2)
C(18)-C(21)	1.516(2)
C(18)-C(19)	1.518(2)
C(18)-C(20)	1.528(2)
C(1S)-Cl(1)	1.7576(18)
C(1S)-Cl(2)	1.7600(19)
C(1S)-Cl(3)	1.7659(19)
C(2S)-Cl(5)	1.7584(18)
C(2S)-Cl(4)	1.7626(18)
C(2S)-Cl(6)	1.7627(17)
C(3S)-Cl(9)	1.7572(19)
C(3S)-Cl(7)	1.7610(19)
C(3S)-Cl(8)	1.774(2)
O(2)-S(1)-N(3)	109.23(7)
O(2)-S(1)-C(18)	105.89(7)
N(3)-S(1)-C(18)	99.87(7)
C(2)-N(1)-C(9)	111.23(12)
C(2)-N(1)-C(10)	124.26(13)
C(9)-N(1)-C(10)	124.33(13)
C(12)-N(2)-C(13)	117.56(12)
C(3)-N(3)-S(1)	118.73(10)
O(1)-C(2)-N(1)	125.55(14)
O(1)-C(2)-C(3)	126.25(13)
N(1)-C(2)-C(3)	108.20(12)
N(3)-C(3)-C(4)	111.12(12)
N(3)-C(3)-C(11)	109.88(12)
C(4)-C(3)-C(11)	113.37(12)
N(3)-C(3)-C(2)	110.96(12)
C(4)-C(3)-C(2)	101.97(11)
C(11)-C(3)-C(2)	109.31(12)
C(5)-C(4)-C(9)	121.11(14)
C(5)-C(4)-C(3)	130.40(13)
C(9)-C(4)-C(3)	108.48(13)
C(4)-C(5)-C(6)	117.30(14)
C(4)-C(5)-C(13)	120.79(13)
C(6)-C(5)-C(13)	121.90(14)
C(7)-C(6)-C(5)	120.93(14)
C(6)-C(7)-C(8)	121.96(14)
C(9)-C(8)-C(7)	116.43(14)
C(8)-C(9)-C(4)	122.19(14)
C(8)-C(9)-N(1)	127.84(14)
C(4)-C(9)-N(1)	109.97(13)
C(12)-C(11)-C(3)	113.58(12)
N(2)-C(12)-C(11)	112.97(12)
C(14)-C(13)-C(5)	115.65(13)
C(14)-C(13)-N(2)	105.36(12)
C(5)-C(13)-N(2)	108.58(12)
C(15)-C(14)-C(13)	126.28(15)
C(14)-C(15)-C(17)	125.15(15)
C(14)-C(15)-C(16)	120.67(16)
C(17)-C(15)-C(16)	114.17(15)
C(21)-C(18)-C(19)	112.26(15)
C(21)-C(18)-C(20)	110.70(14)
C(19)-C(18)-C(20)	111.40(15)
C(21)-C(18)-S(1)	110.81(11)
C(19)-C(18)-S(1)	107.09(11)
C(20)-C(18)-S(1)	104.23(11)
Cl(1)-C(1S)-Cl(2)	110.07(10)
Cl(1)-C(1S)-Cl(3)	110.25(10)
Cl(2)-C(1S)-Cl(3)	110.03(10)
Cl(5)-C(2S)-Cl(4)	110.96(9)
Cl(5)-C(2S)-Cl(6)	110.25(9)
Cl(4)-C(2S)-Cl(6)	109.51(10)
Cl(9)-C(3S)-Cl(7)	109.86(10)
Cl(9)-C(3S)-Cl(8)	109.25(10)
Cl(7)-C(3S)-Cl(8)	110.48(10)

Symmetry transformations used to generate equivalent atoms

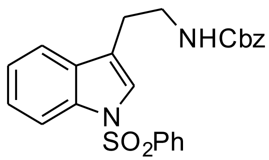
Table S6. Anisotropic displacement parameters ($Å^2$x 10^3) for azepane (+)-**48**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$.

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	14(1)	15(1)	14(1)	2(1)	1(1)	2(1)
O(1)	17(1)	18(1)	23(1)	1(1)	-6(1)	1(1)
O(2)	16(1)	29(1)	17(1)	-1(1)	-3(1)	0(1)
N(1)	15(1)	11(1)	19(1)	0(1)	-2(1)	0(1)
N(2)	14(1)	13(1)	17(1)	0(1)	2(1)	-1(1)
N(3)	17(1)	13(1)	14(1)	2(1)	3(1)	6(1)
C(2)	14(1)	13(1)	16(1)	1(1)	1(1)	1(1)
C(3)	13(1)	12(1)	14(1)	0(1)	1(1)	2(1)
C(4)	13(1)	13(1)	13(1)	1(1)	1(1)	3(1)
C(5)	14(1)	13(1)	13(1)	0(1)	2(1)	2(1)
C(6)	15(1)	21(1)	16(1)	3(1)	-1(1)	1(1)
C(7)	20(1)	17(1)	21(1)	5(1)	-1(1)	5(1)
C(8)	19(1)	13(1)	20(1)	4(1)	0(1)	2(1)
C(9)	14(1)	12(1)	15(1)	1(1)	0(1)	1(1)
C(10)	22(1)	12(1)	26(1)	-1(1)	-5(1)	-3(1)
C(11)	16(1)	13(1)	13(1)	1(1)	1(1)	2(1)
C(12)	17(1)	14(1)	16(1)	3(1)	0(1)	1(1)
C(13)	13(1)	15(1)	14(1)	-1(1)	1(1)	-1(1)
C(14)	12(1)	19(1)	24(1)	0(1)	-1(1)	0(1)
C(15)	17(1)	16(1)	23(1)	3(1)	-4(1)	-3(1)
C(16)	22(1)	24(1)	36(1)	1(1)	-9(1)	-6(1)
C(17)	24(1)	34(1)	23(1)	-8(1)	-3(1)	-1(1)
C(18)	13(1)	20(1)	18(1)	-1(1)	2(1)	-1(1)
C(19)	18(1)	41(1)	36(1)	-18(1)	-2(1)	-4(1)
C(20)	25(1)	28(1)	26(1)	8(1)	12(1)	5(1)
C(21)	20(1)	20(1)	21(1)	1(1)	4(1)	5(1)
C(1S)	27(1)	20(1)	24(1)	-2(1)	0(1)	3(1)
Cl(1)	43(1)	33(1)	48(1)	18(1)	-5(1)	-3(1)
Cl(2)	42(1)	27(1)	29(1)	-4(1)	-11(1)	1(1)
Cl(3)	33(1)	29(1)	32(1)	-3(1)	-3(1)	-5(1)
C(2S)	26(1)	18(1)	20(1)	0(1)	-1(1)	2(1)
Cl(4)	36(1)	24(1)	30(1)	2(1)	-13(1)	-5(1)
Cl(5)	38(1)	27(1)	48(1)	12(1)	-14(1)	-11(1)
Cl(6)	21(1)	44(1)	19(1)	0(1)	0(1)	4(1)
C(3S)	32(1)	24(1)	22(1)	4(1)	-3(1)	-1(1)
Cl(7)	44(1)	24(1)	36(1)	-5(1)	-5(1)	-6(1)
Cl(8)	25(1)	46(1)	36(1)	1(1)	2(1)	4(1)
Cl(9)	35(1)	26(1)	31(1)	-6(1)	8(1)	-3(1)
Cl(10)	18(1)	14(1)	18(1)	0(1)	2(1)	-1(1)

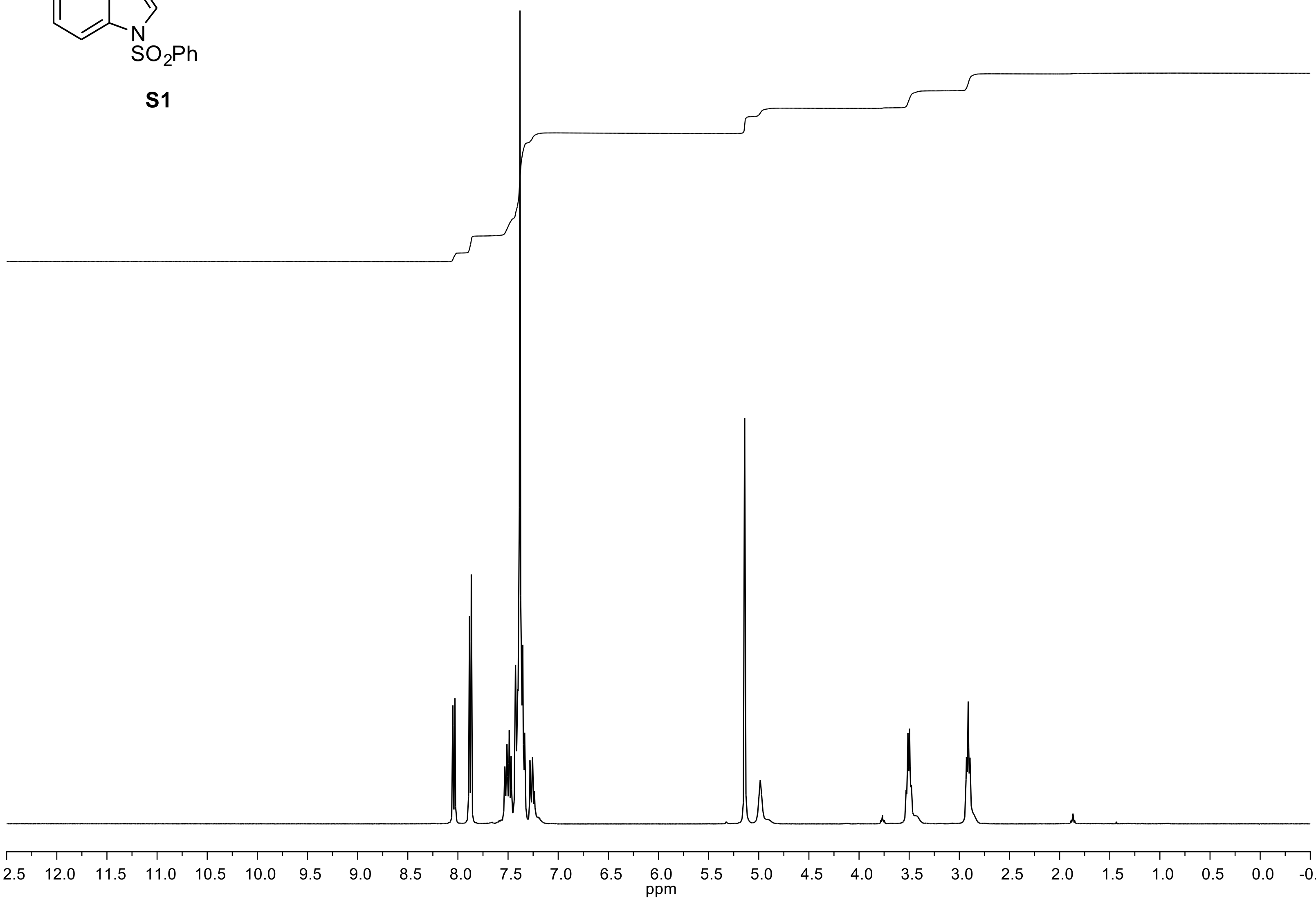
Table S7. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10 ^{3}) for azepane (+)-**48**.

	x	y	z	U(eq)
H(1N)	6799(14)	3209(13)	631(9)	18
H(2N)	6670(15)	2284(13)	382(9)	18
H(3N)	3219(15)	2647(13)	925(9)	18
H(6)	7196	649	1851	20
H(7)	6719	-1025	1767	23
H(8)	5208	-1530	1156	21
H(10A)	2796	-1042	29	30
H(10B)	3042	-1471	745	30
H(10C)	3920	-1586	176	30
H(11A)	5094	1744	-214	17
H(11B)	4047	2441	-189	17
H(12A)	5517	3475	-63	19
H(12B)	4910	3444	627	19
H(13)	5709	2698	1575	17
H(14)	7972	2277	1419	22
H(16A)	9177	2999	2096	41
H(16B)	8789	3056	2841	41
H(16C)	8745	4035	2390	41
H(17A)	5965	3162	2492	41
H(17B)	6685	4113	2681	41
H(17C)	6802	3093	3086	41
H(19A)	1410	927	1454	47
H(19B)	1481	1905	1003	47
H(19C)	520	1789	1519	47
H(20A)	924	1987	2736	40
H(20B)	2151	2126	2959	40
H(20C)	1757	1078	2664	40
H(21A)	2091	3515	1467	30
H(21B)	2393	3600	2225	30
H(21C)	1157	3514	2007	30
H(1S)	11666	5240	819	29
H(2S)	6360	35	5648	26
H(3S)	4723	1207	3029	31

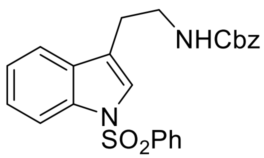
^{1}H NMR, 400 MHz, $CDCl_3$, 25 °C



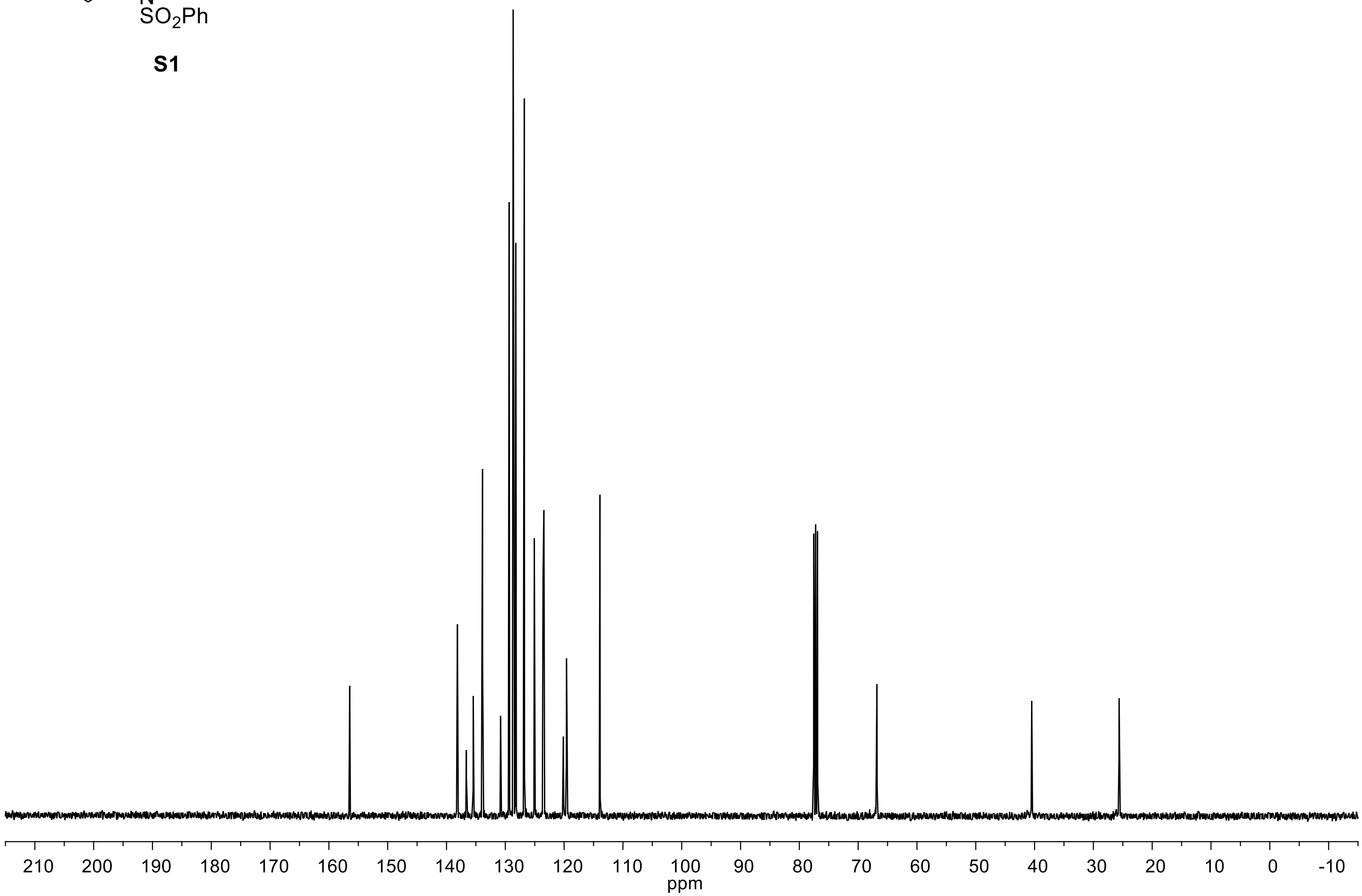
S1



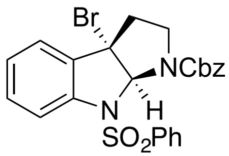
^{13}C NMR, 100 MHz, $CDCl_3$, 25 °C



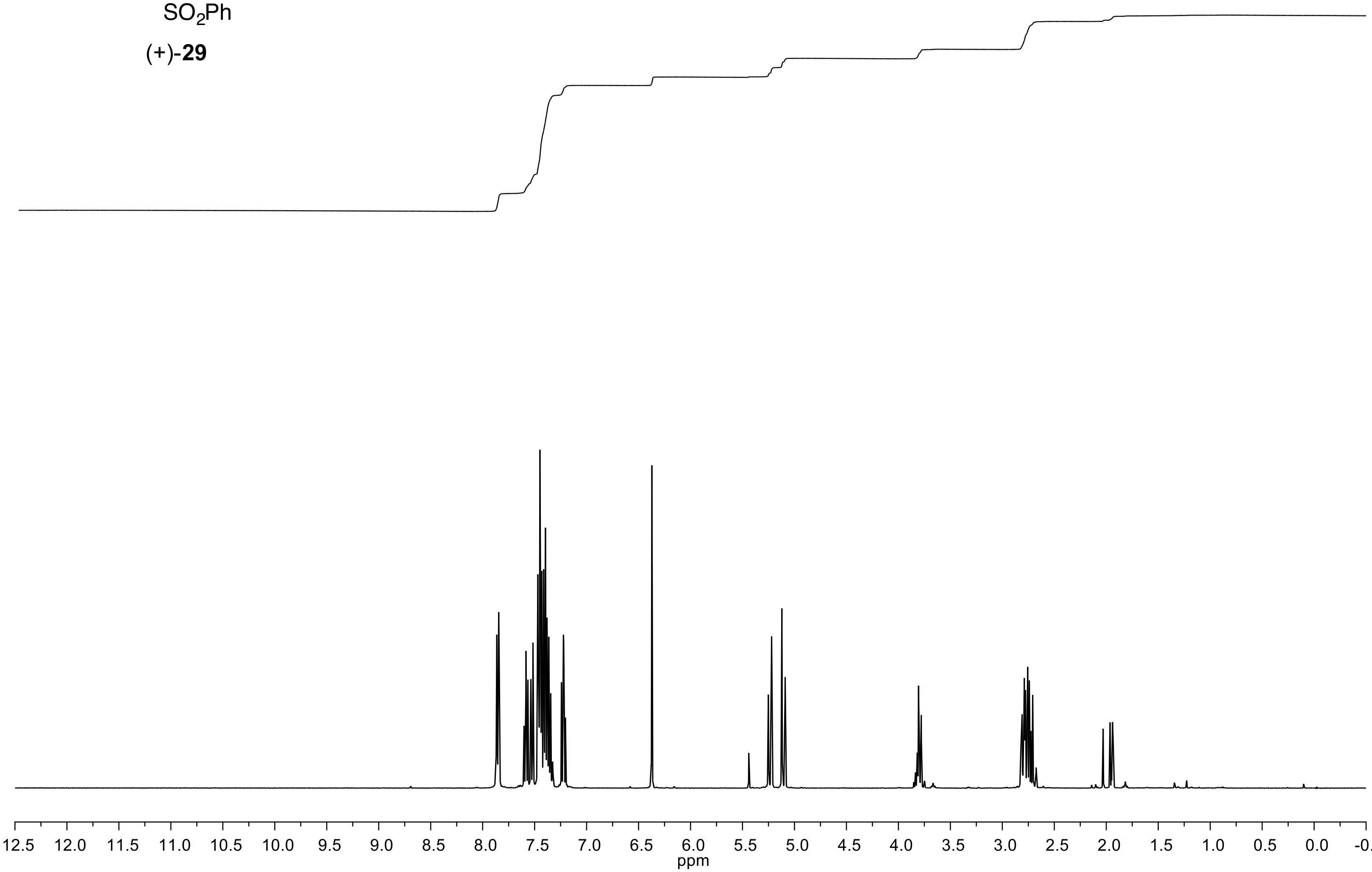
S1



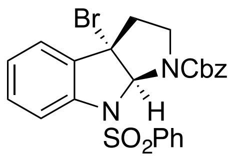
^{1}H NMR, 400 MHz, CD_3CN, 60 °C



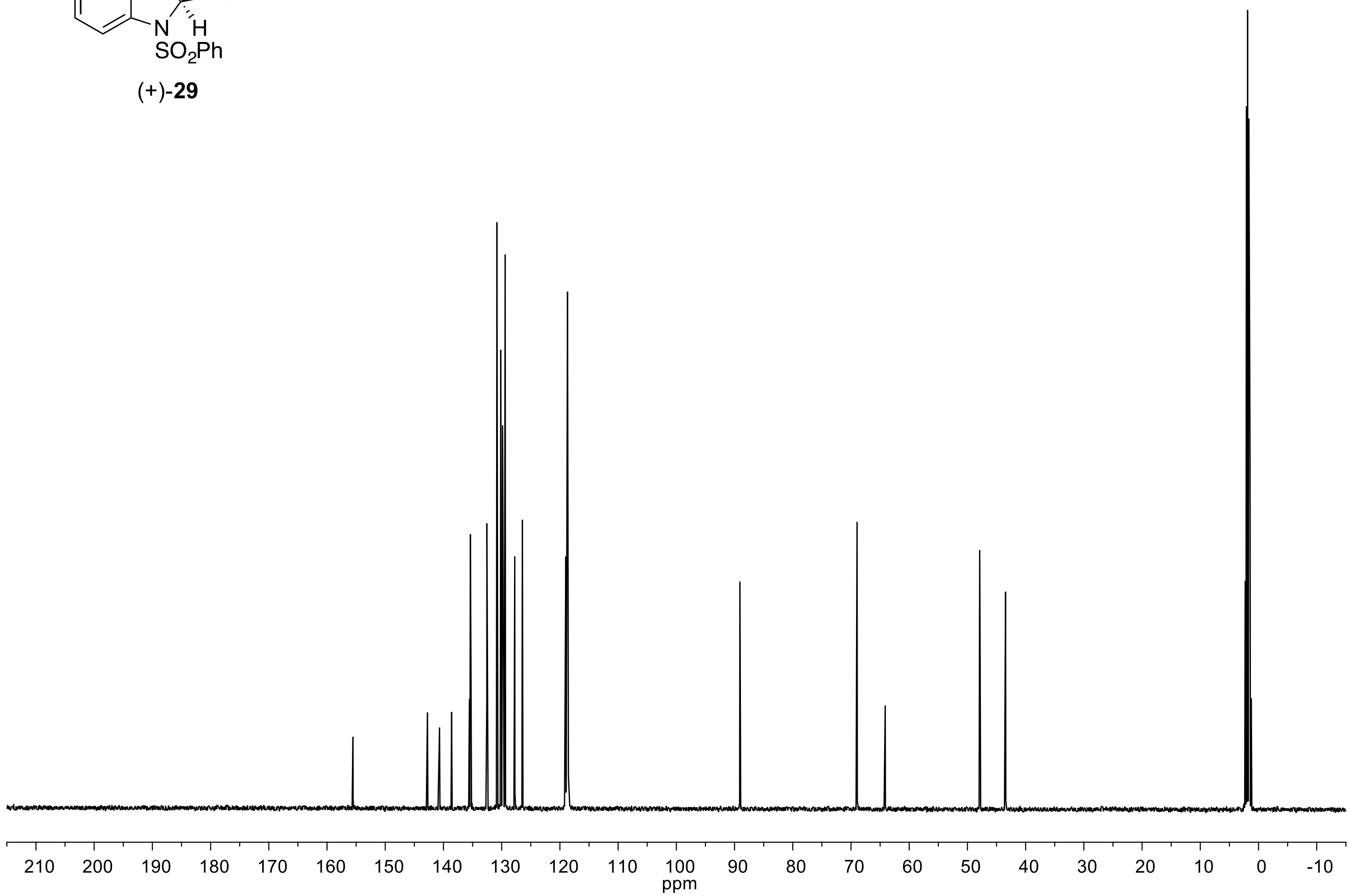
(+)-**29**

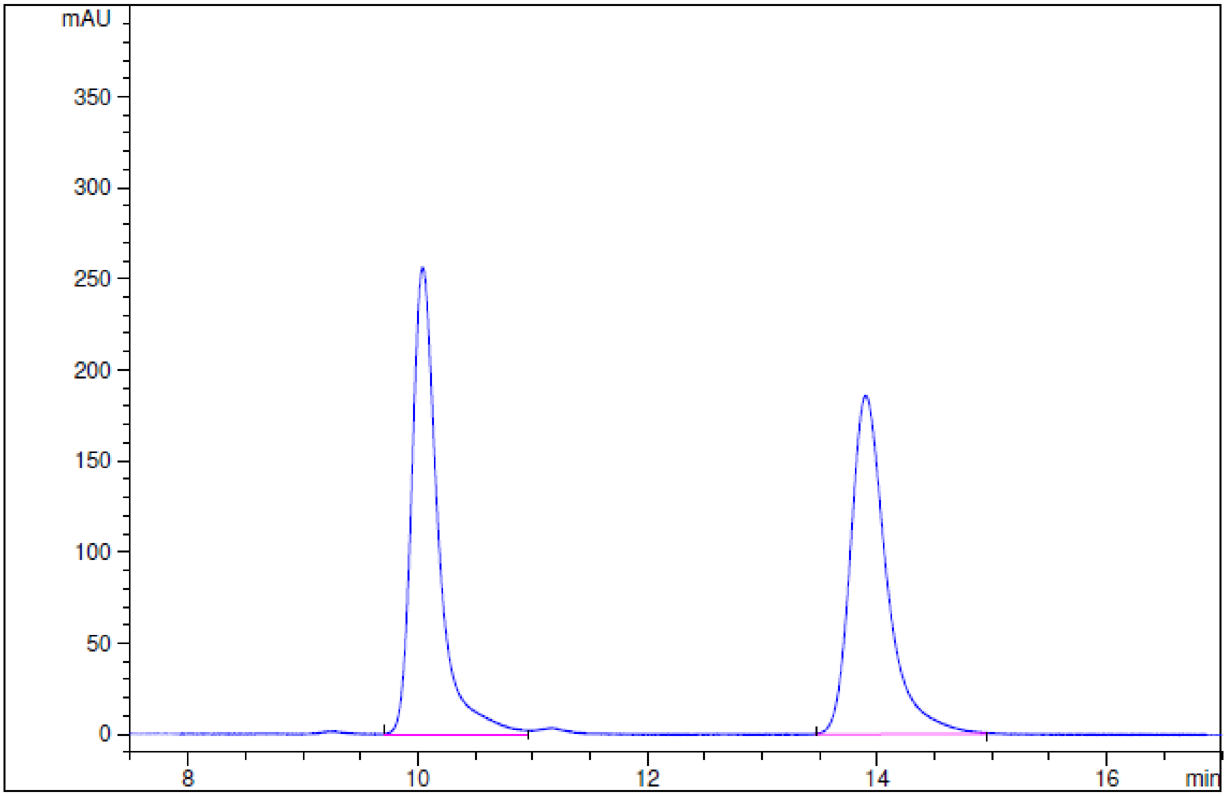


^{13}C NMR, 100 MHz, CD_3CN, 60 °C



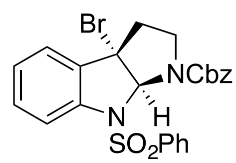
(+)-**29**





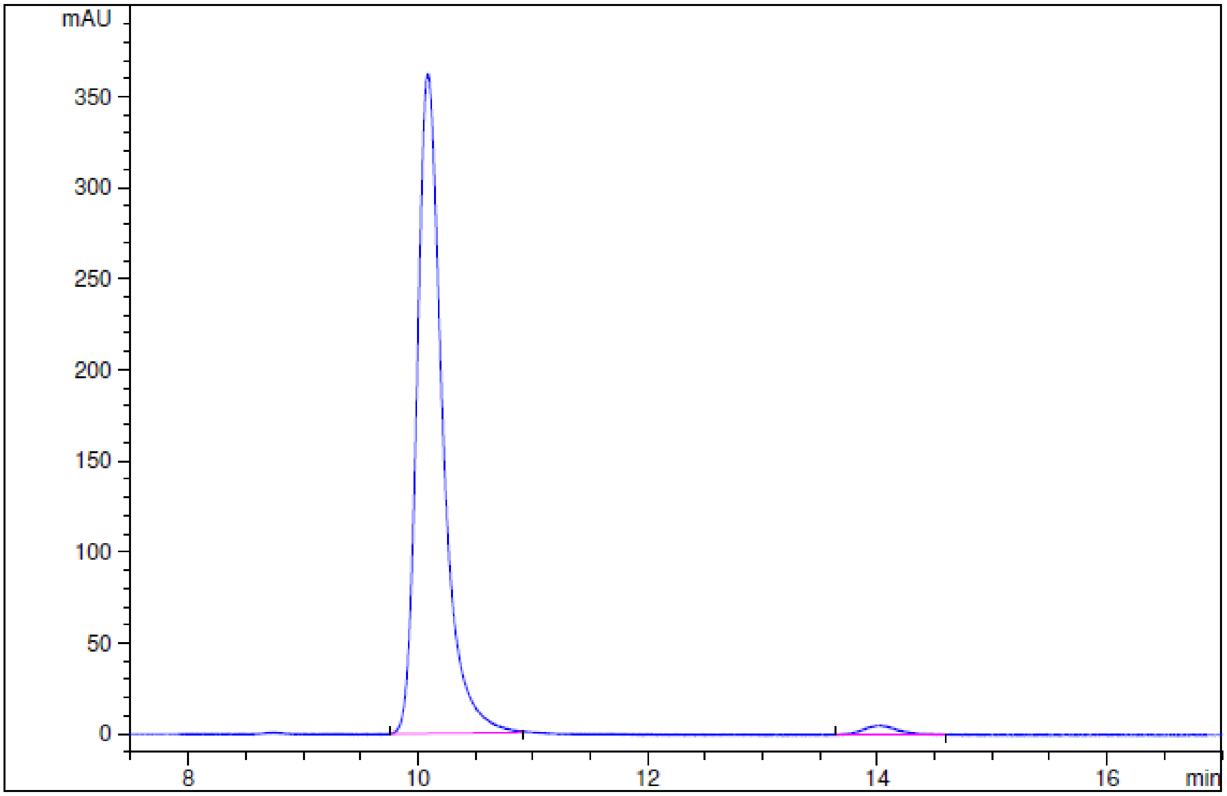
#	Meas. Ret. Time	Area %
1	10.044	50.177
2	13.901	49.823

racemate

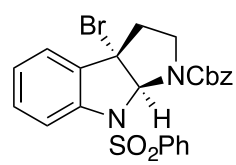


29

Chiralpak IA
40% *i*-PrOH / 60% hexanes
0.75 mL / min
254 nm



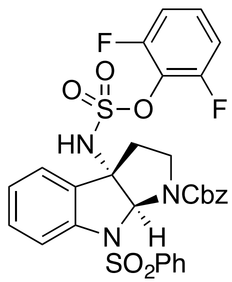
#	Meas. Ret. Time	Area %
1	10.088	98.102
2	14.024	1.898



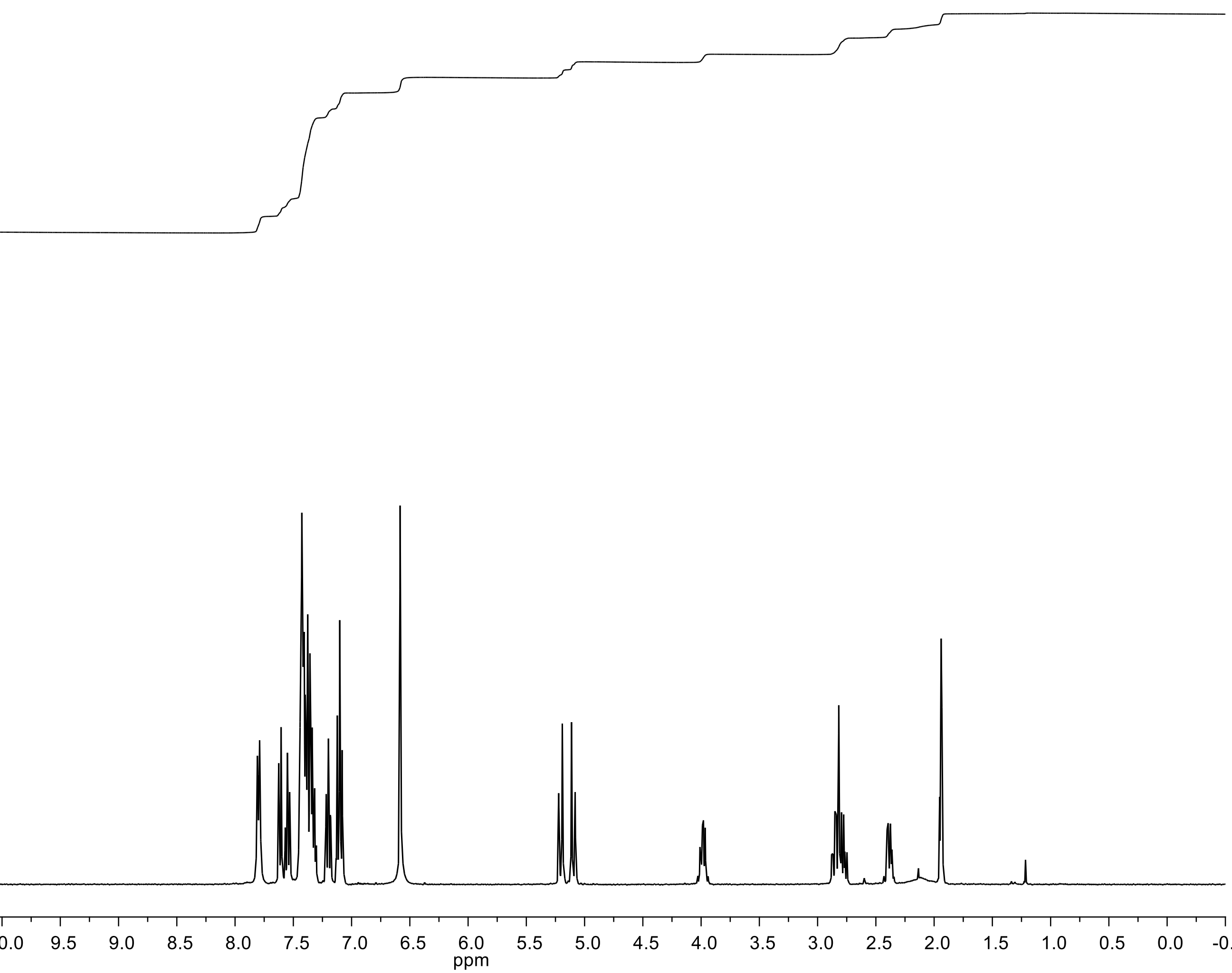
(+)-**29**

Chiralpak IA
40% *i*-PrOH / 60% hexanes
0.75 mL / min
254 nm

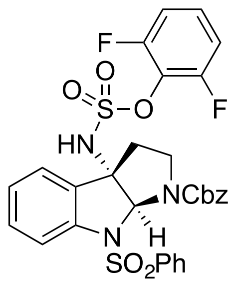
^{1}H NMR, 400 MHz, CD_3CN, 60 °C



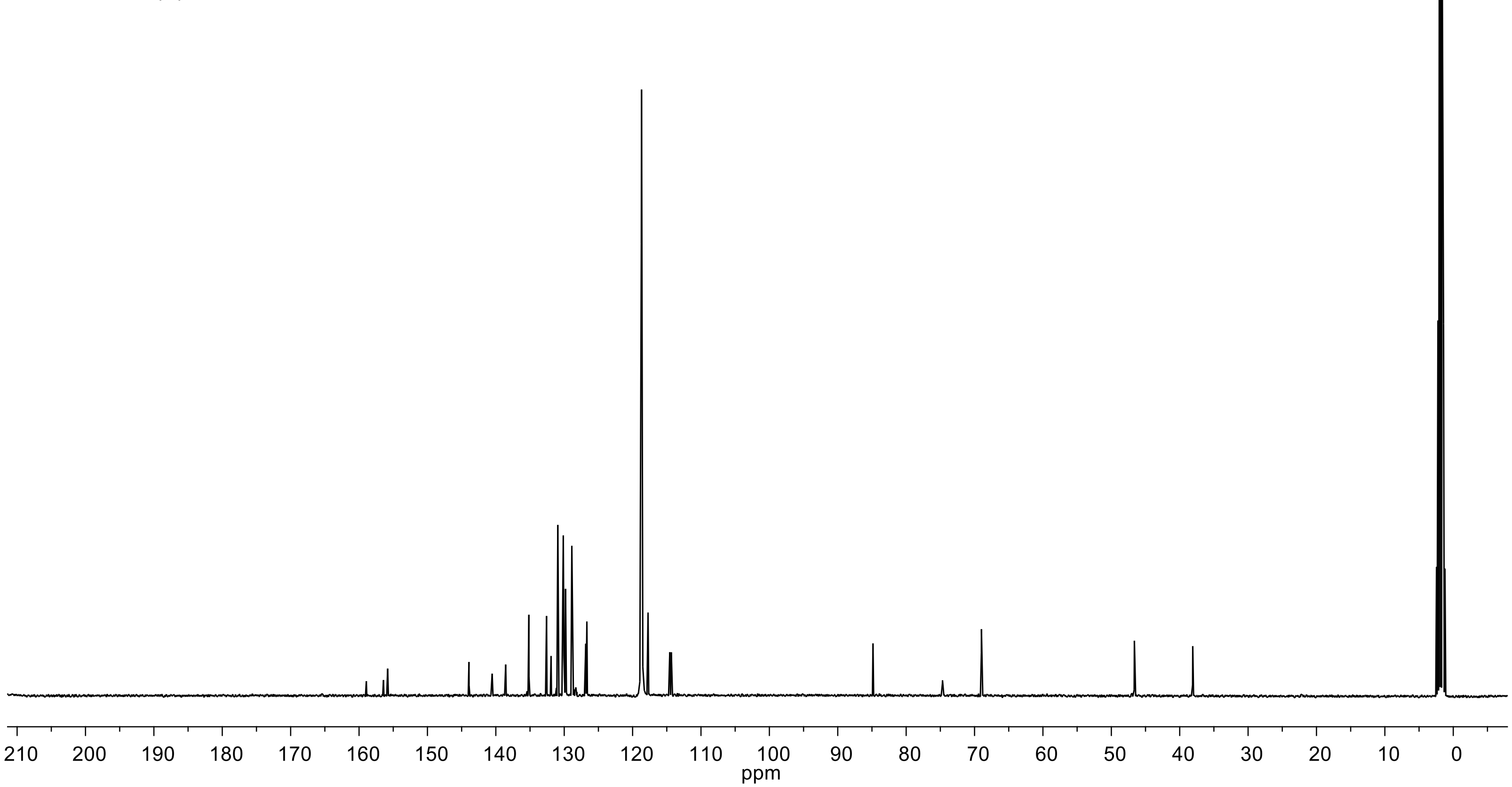
(+)-**31**



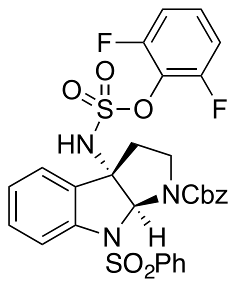
^{13}C NMR, 100 MHz, CD_3CN, 60 °C



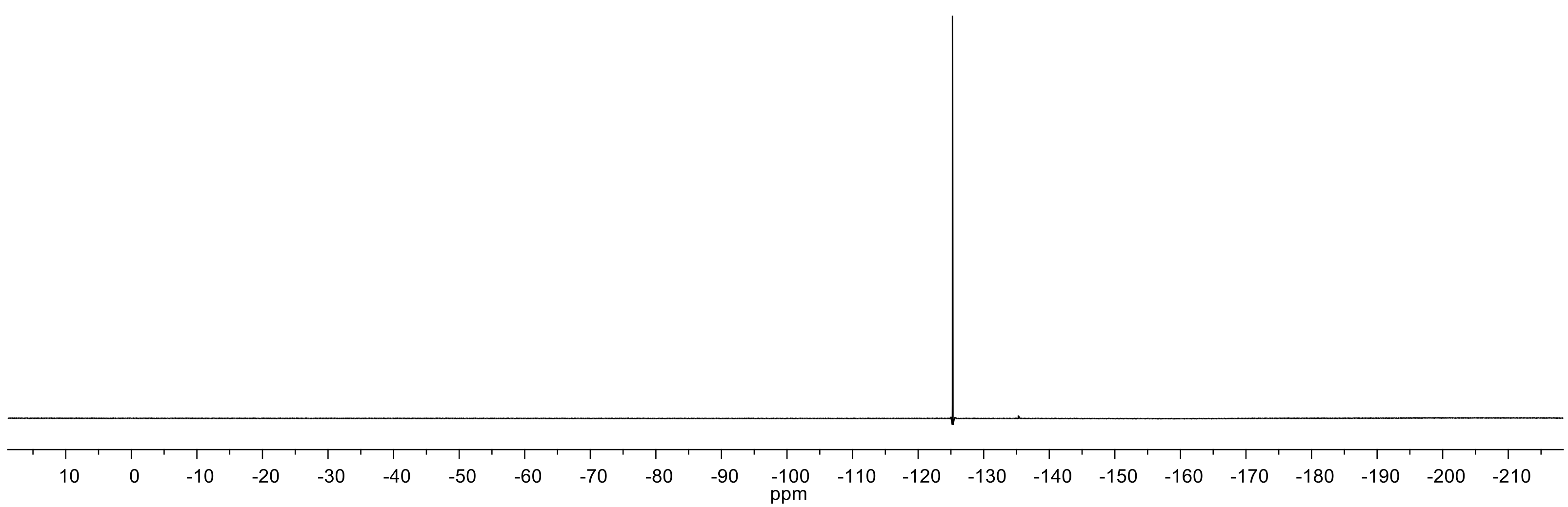
(+)-**31**



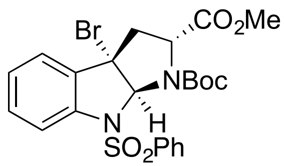
^{19}F NMR, 282 MHz, CD_3CN, 20 °C



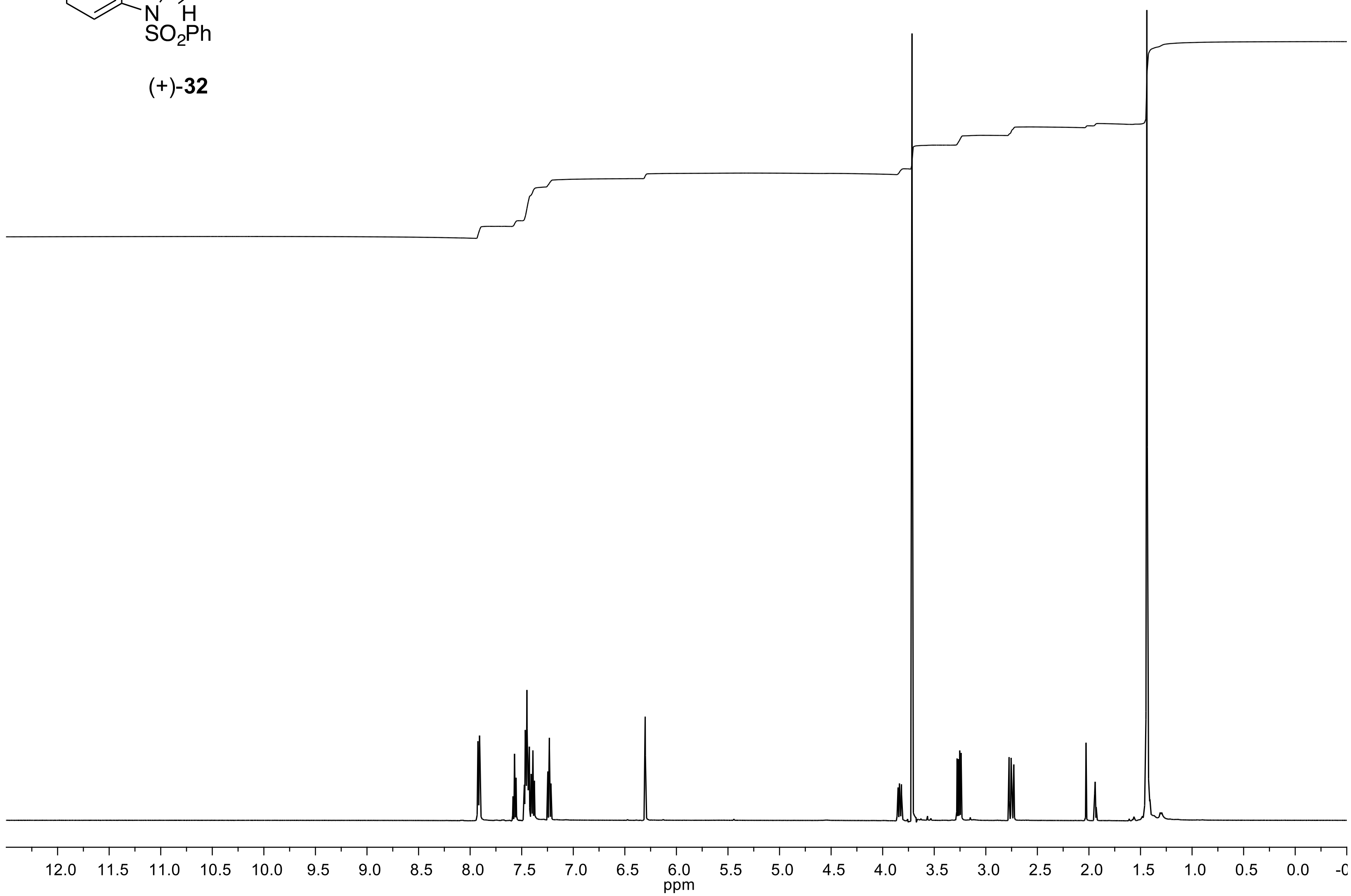
(+)-**31**



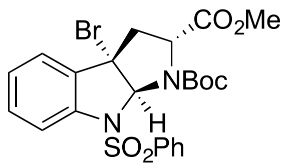
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



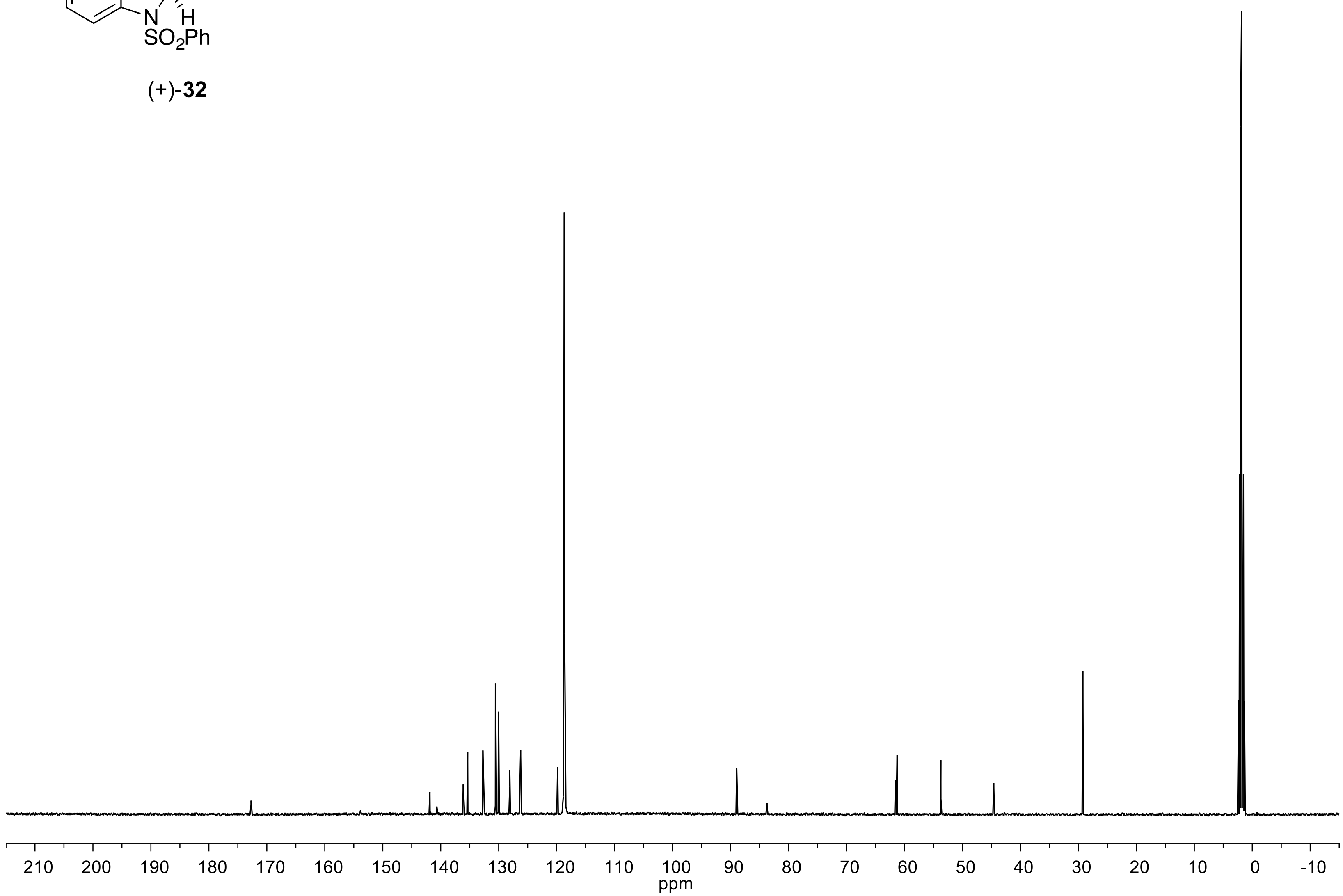
(+)-**32**



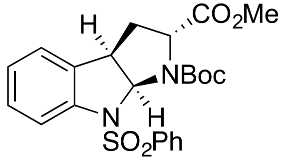
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



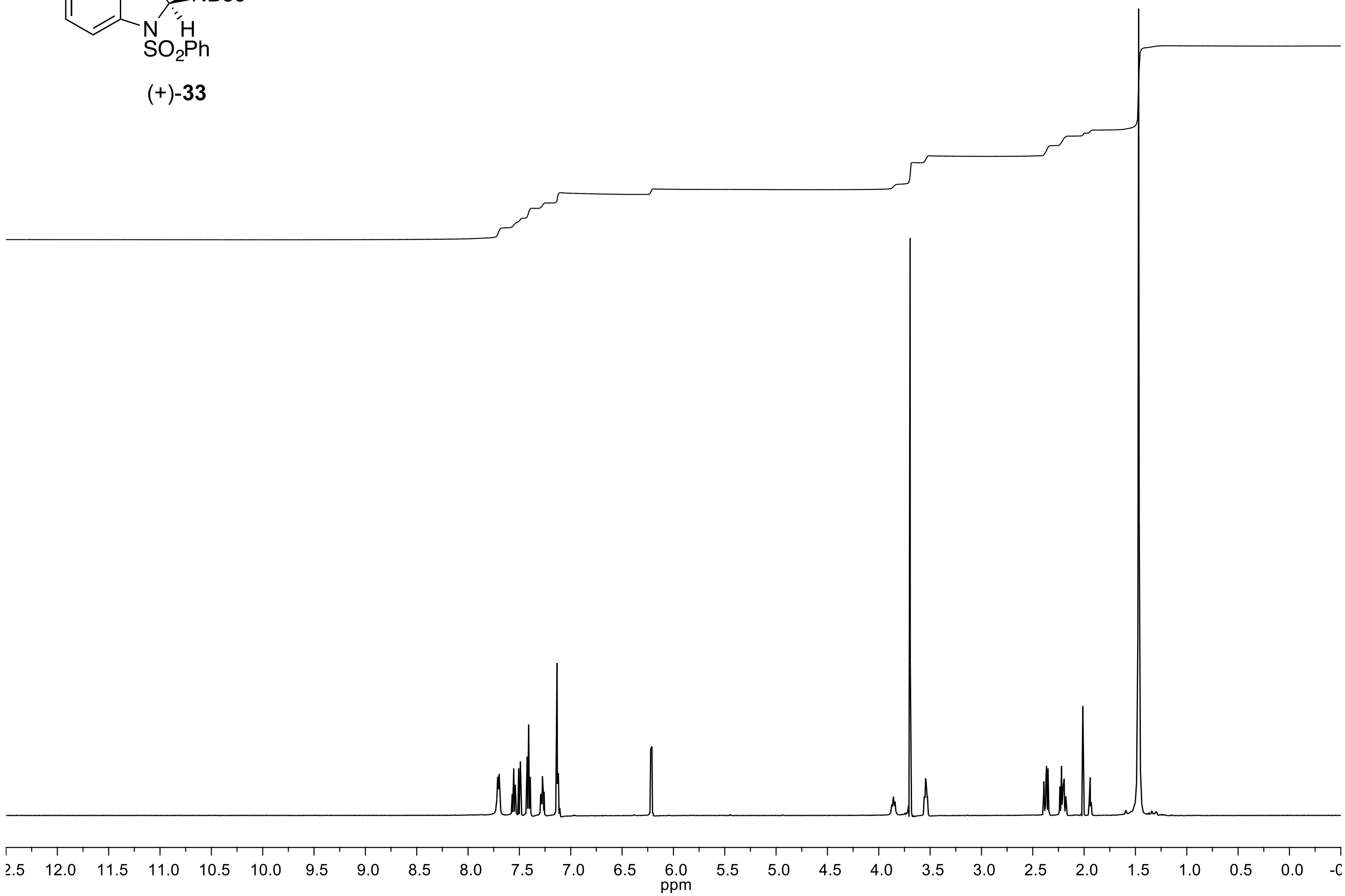
(+)-**32**



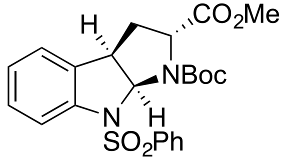
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



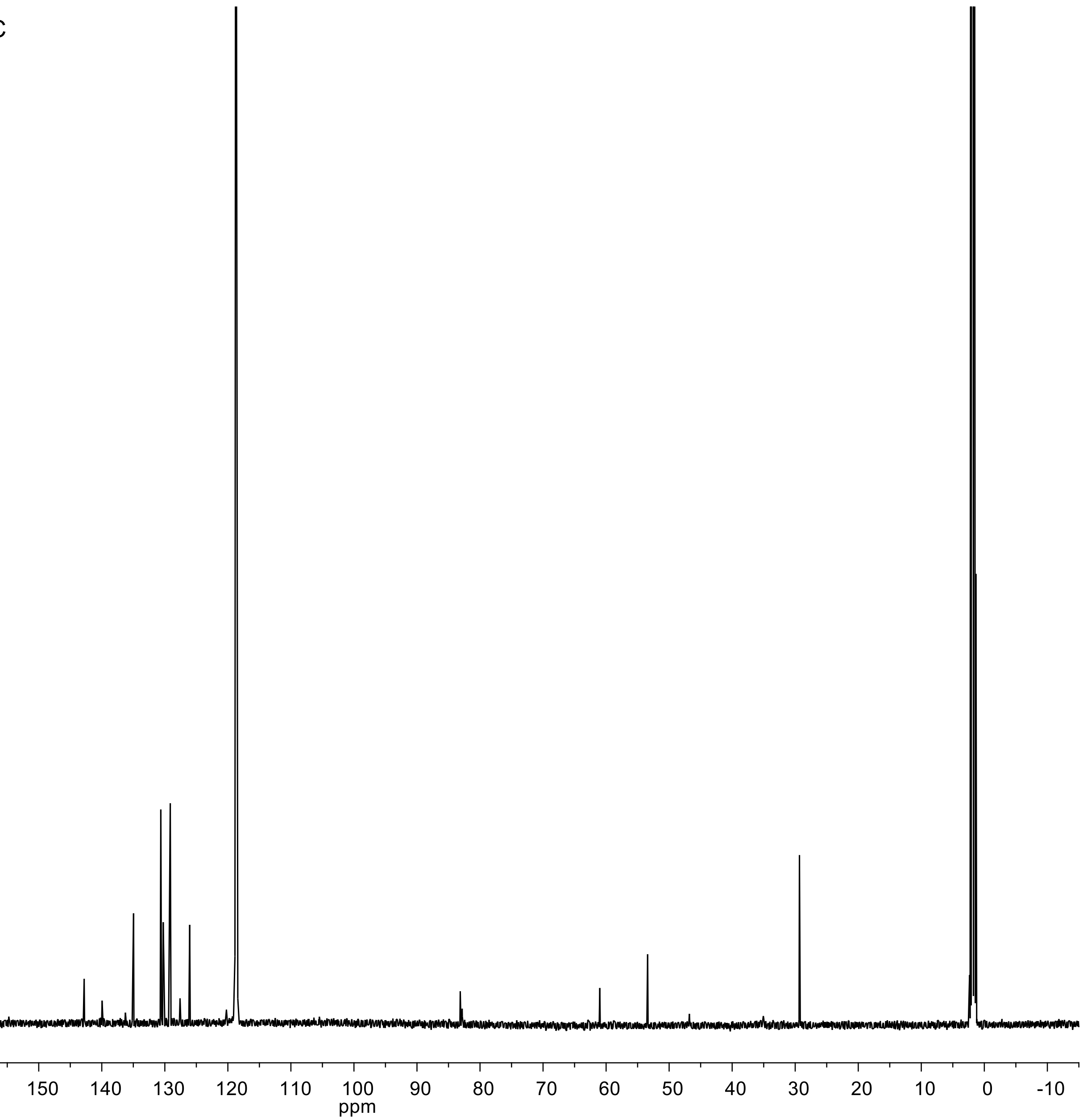
(+)-**33**



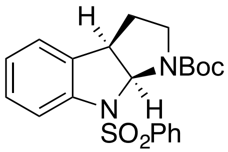
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



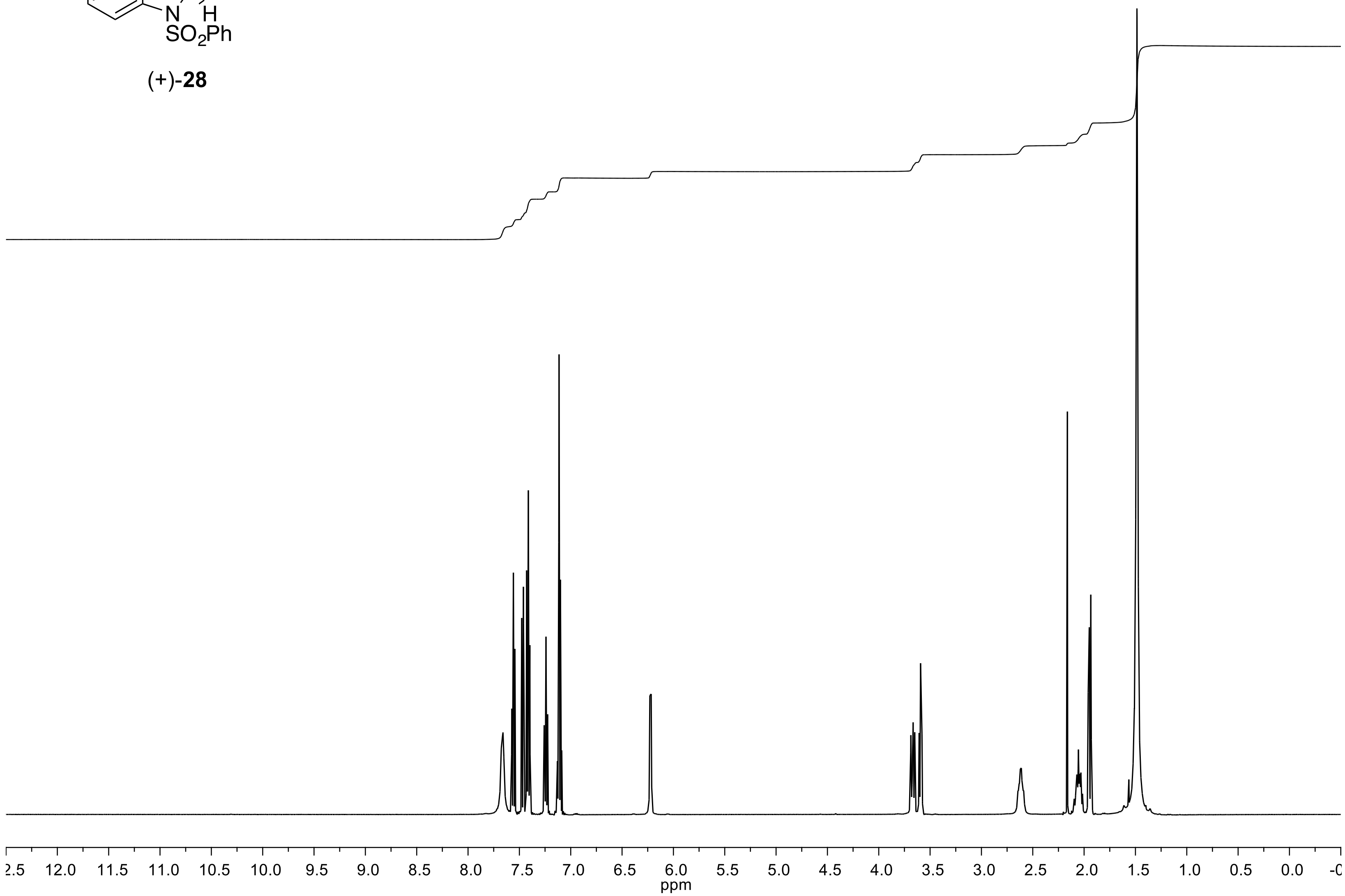
(+)-**33**



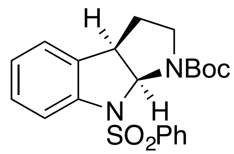
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



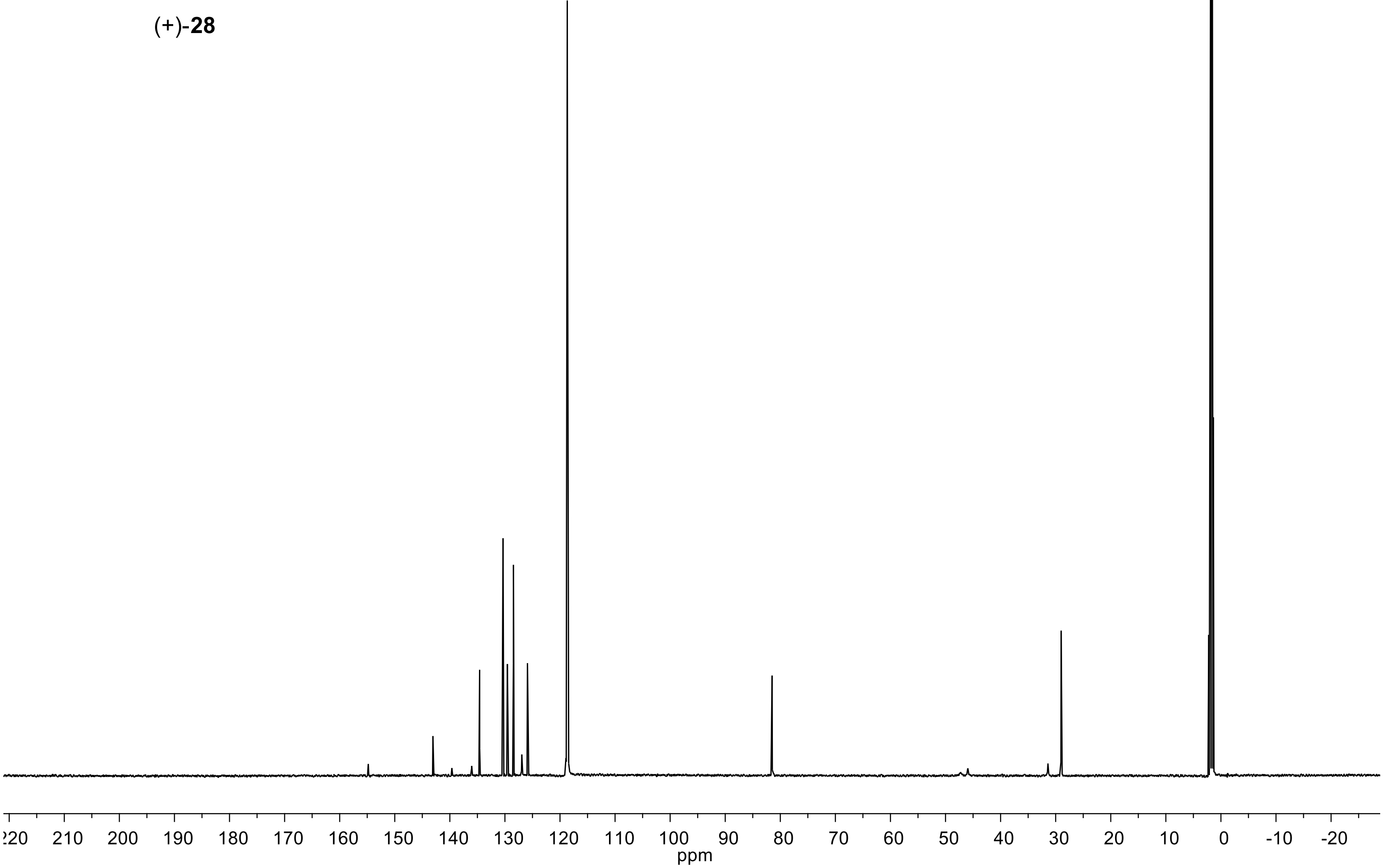
(+)-**28**



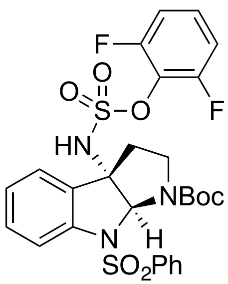
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



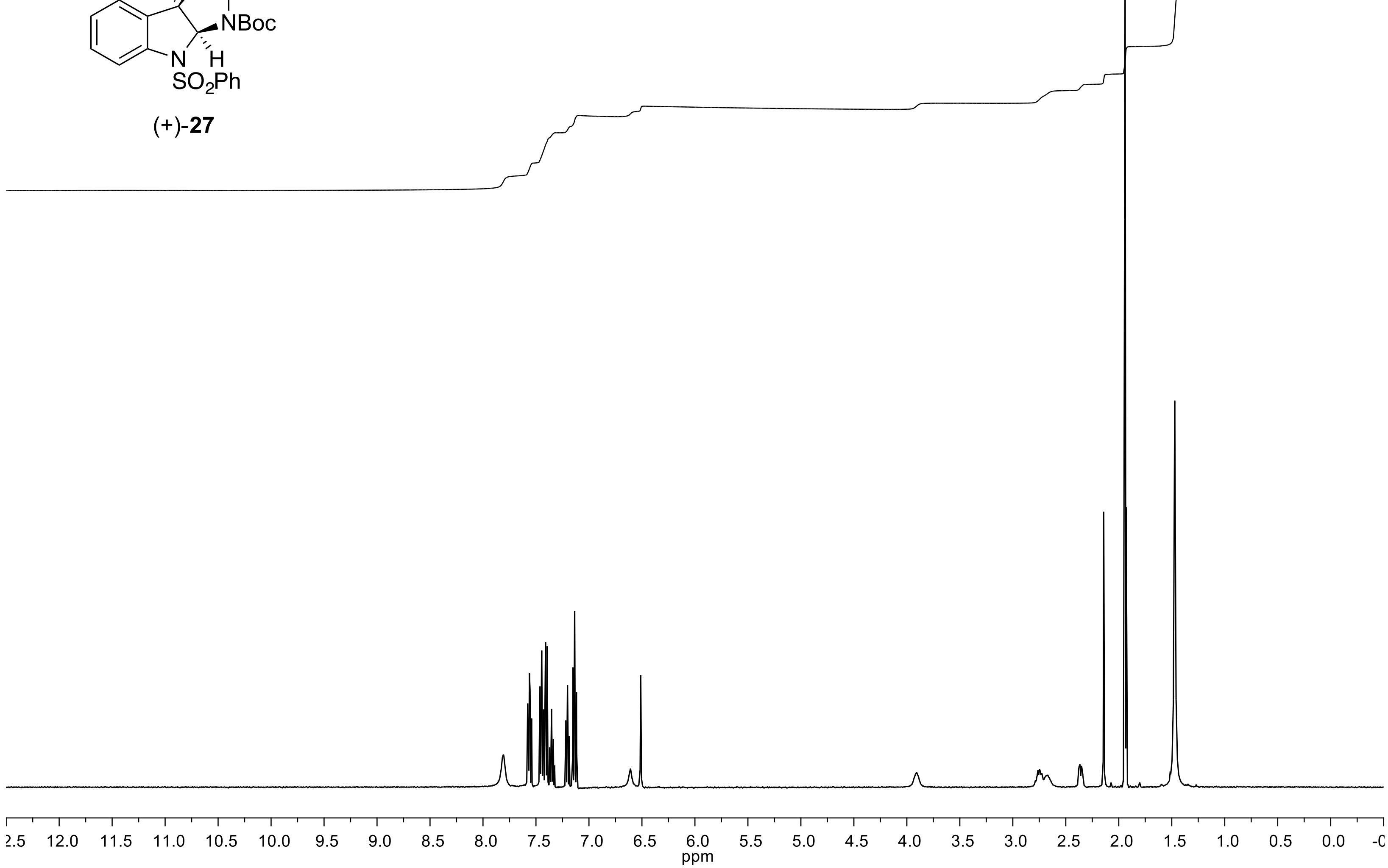
(+)-**28**



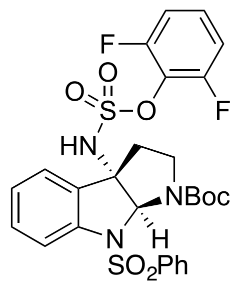
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



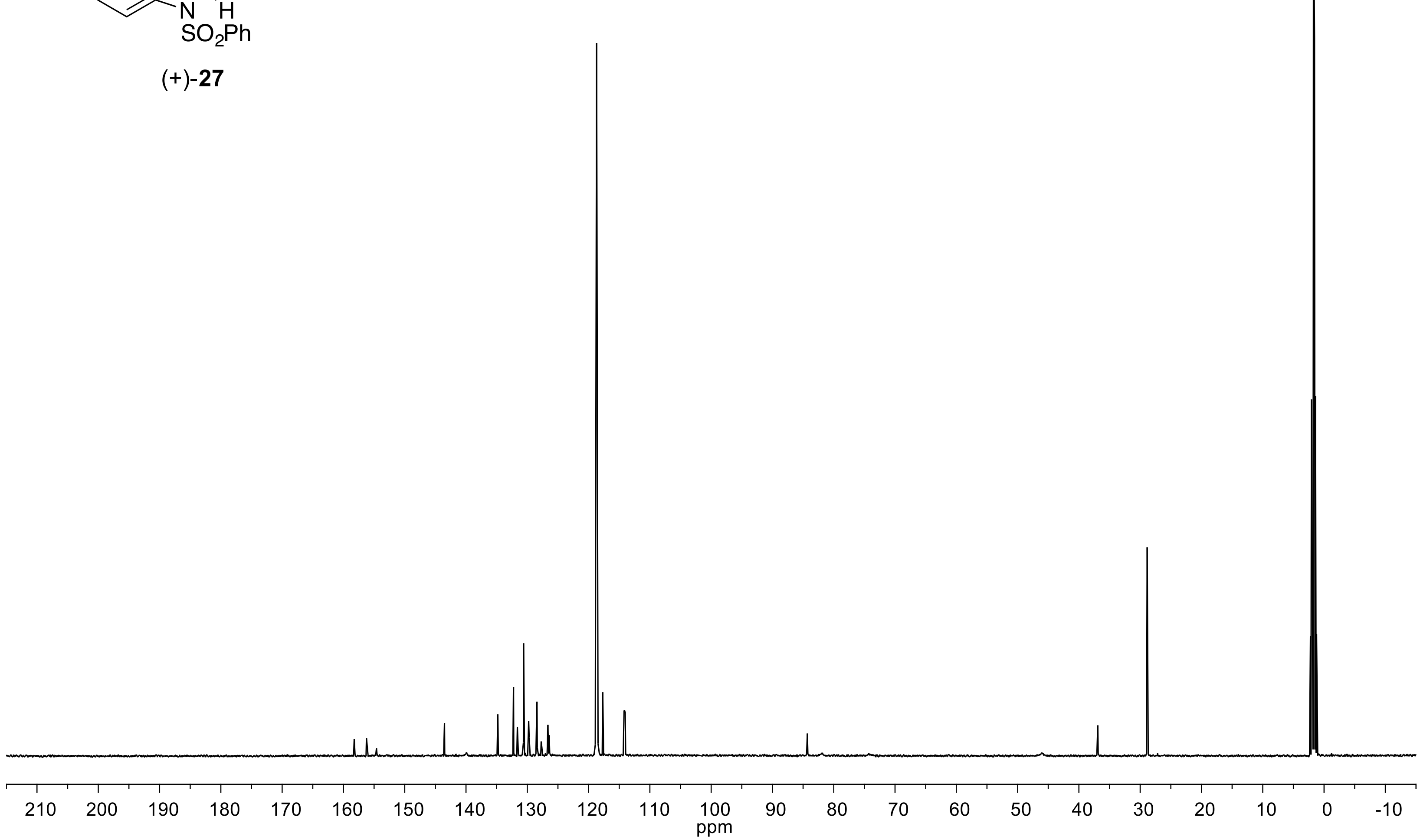
(+)-**27**



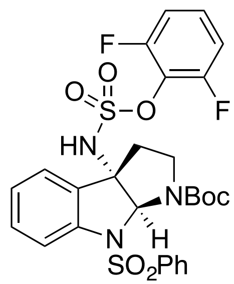
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



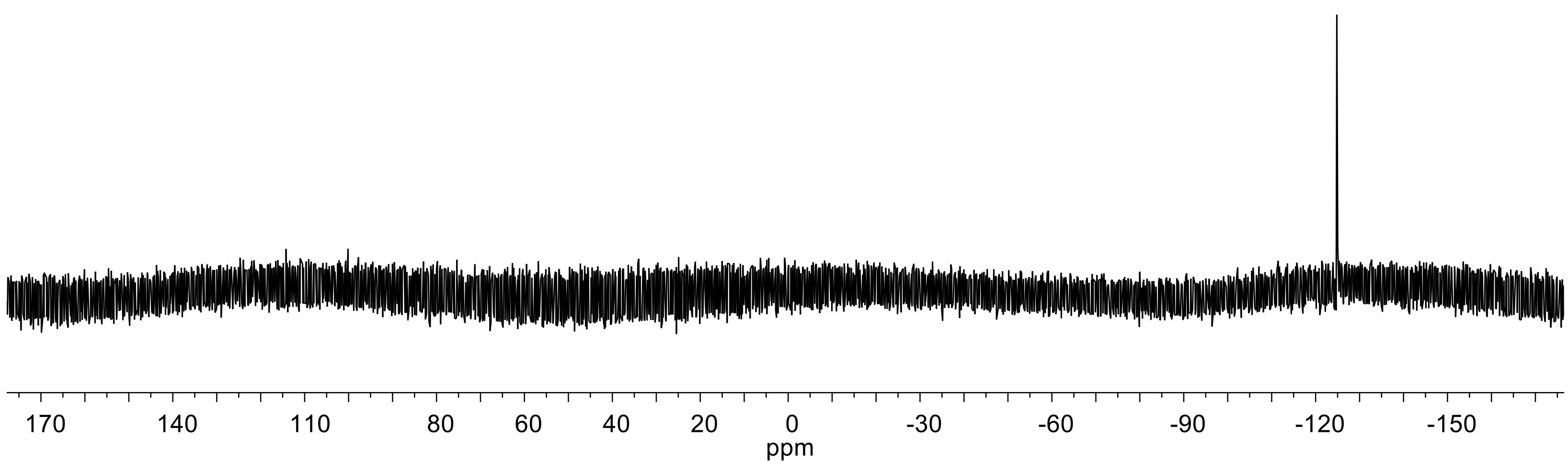
(+)-**27**



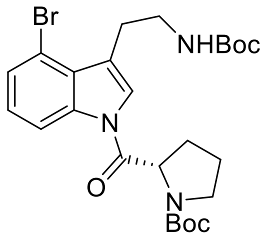
^{19}F NMR, 282 MHz, CD_3CN, 60 °C



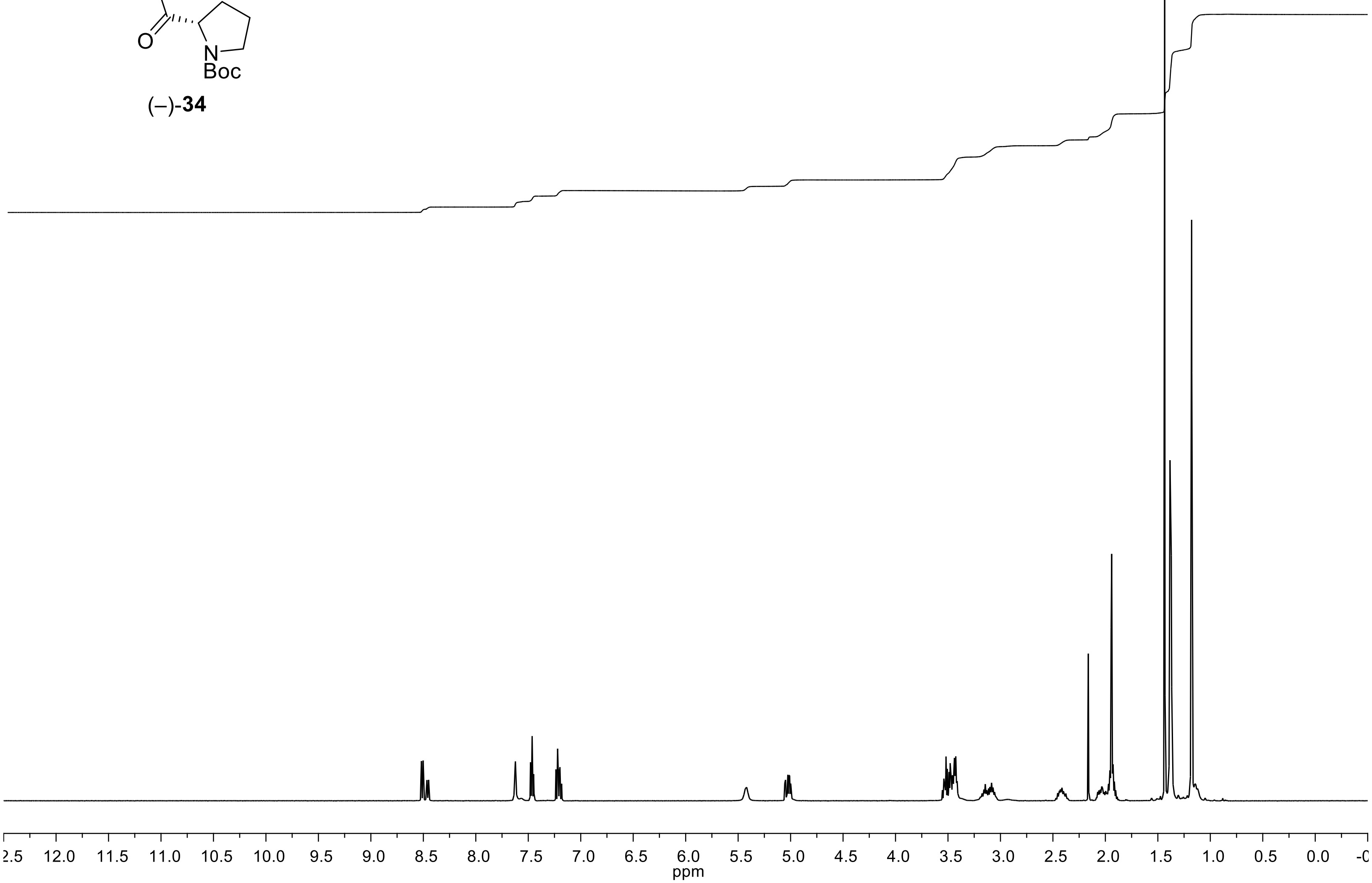
(+)-**27**



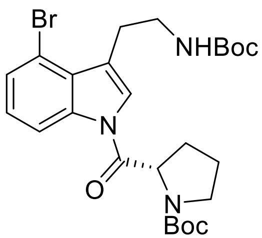
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



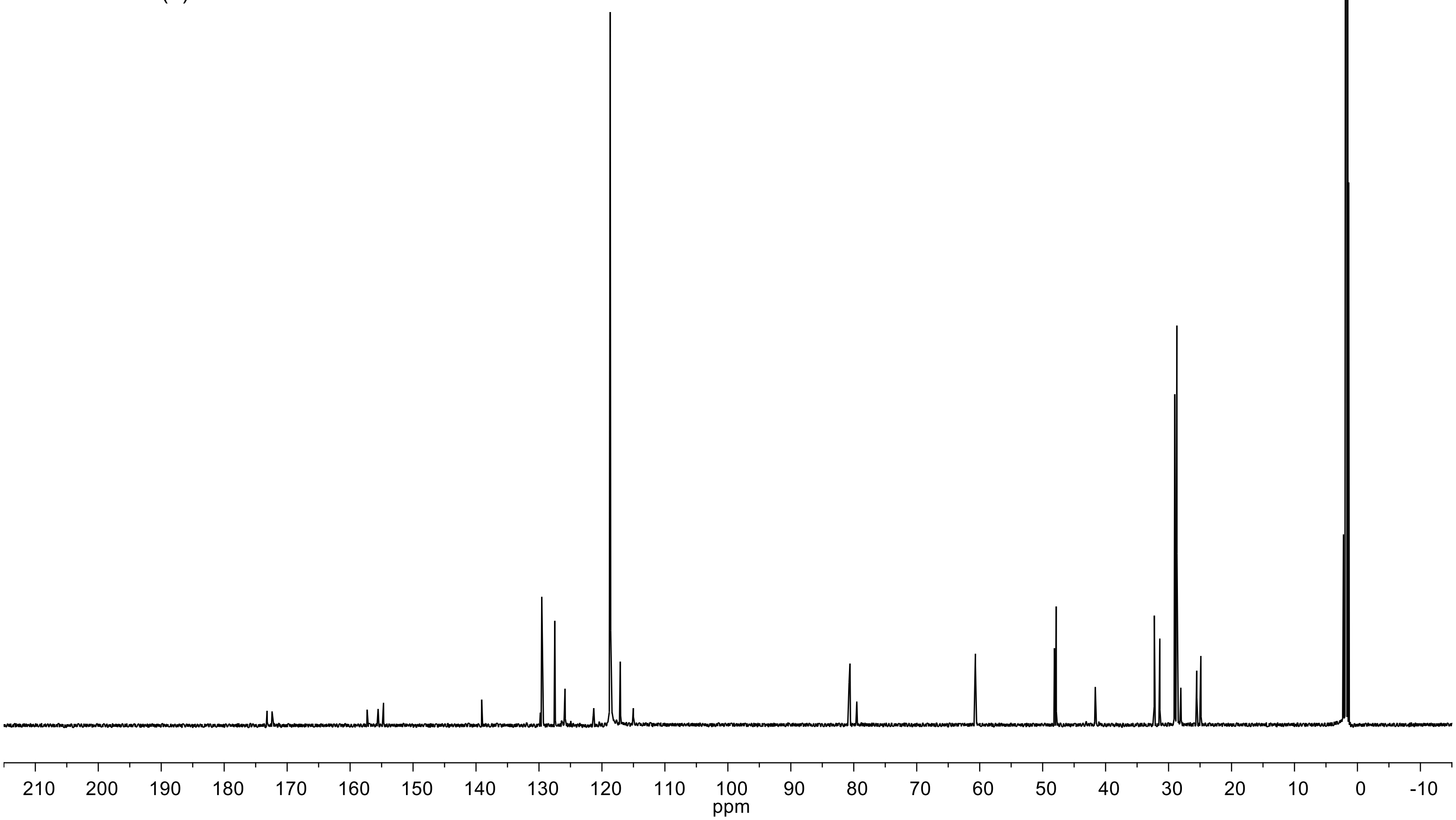
(–)-**34**



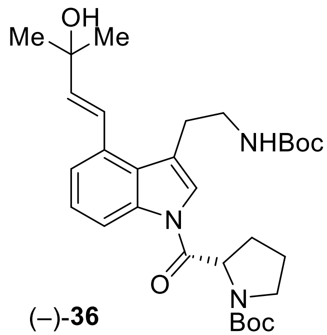
^{13}C NMR, 126 MHz, CD_3CN, 20 °C



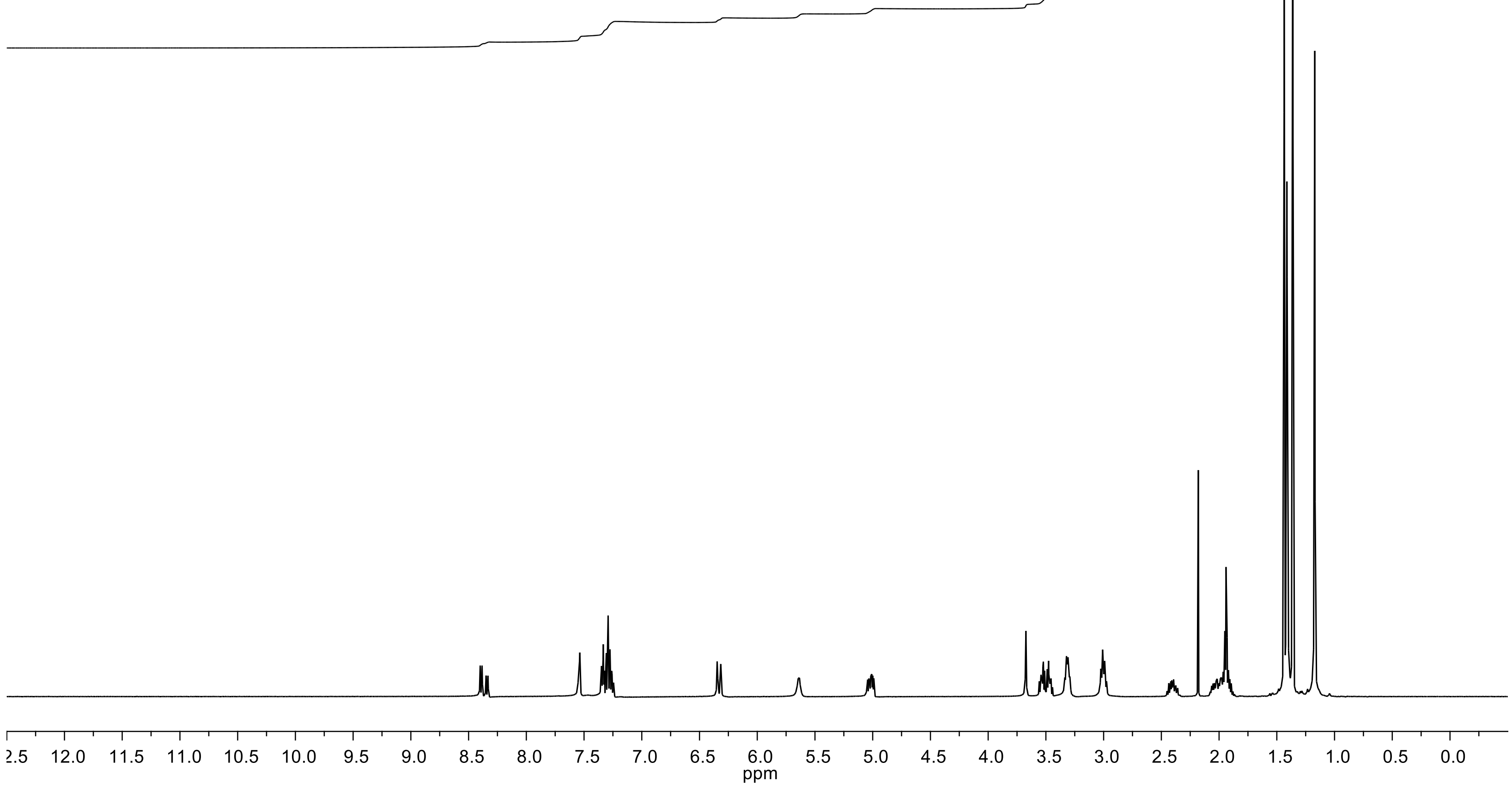
(–)-**34**



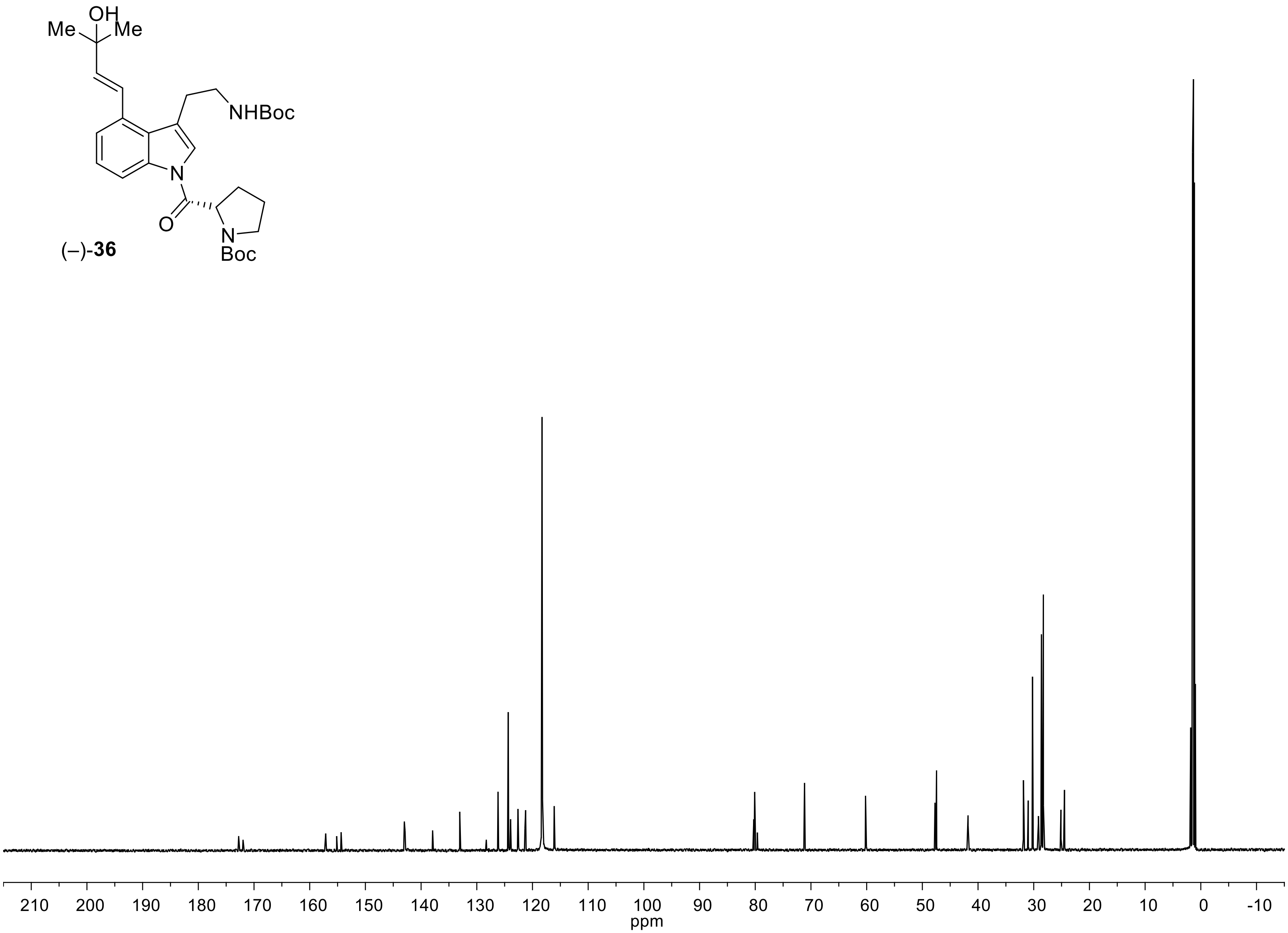
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



(–)-**36**

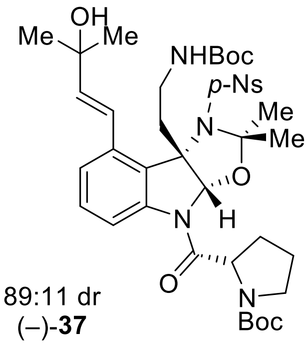


^{13}C NMR, 126 MHz, CD_3CN, 20 °C

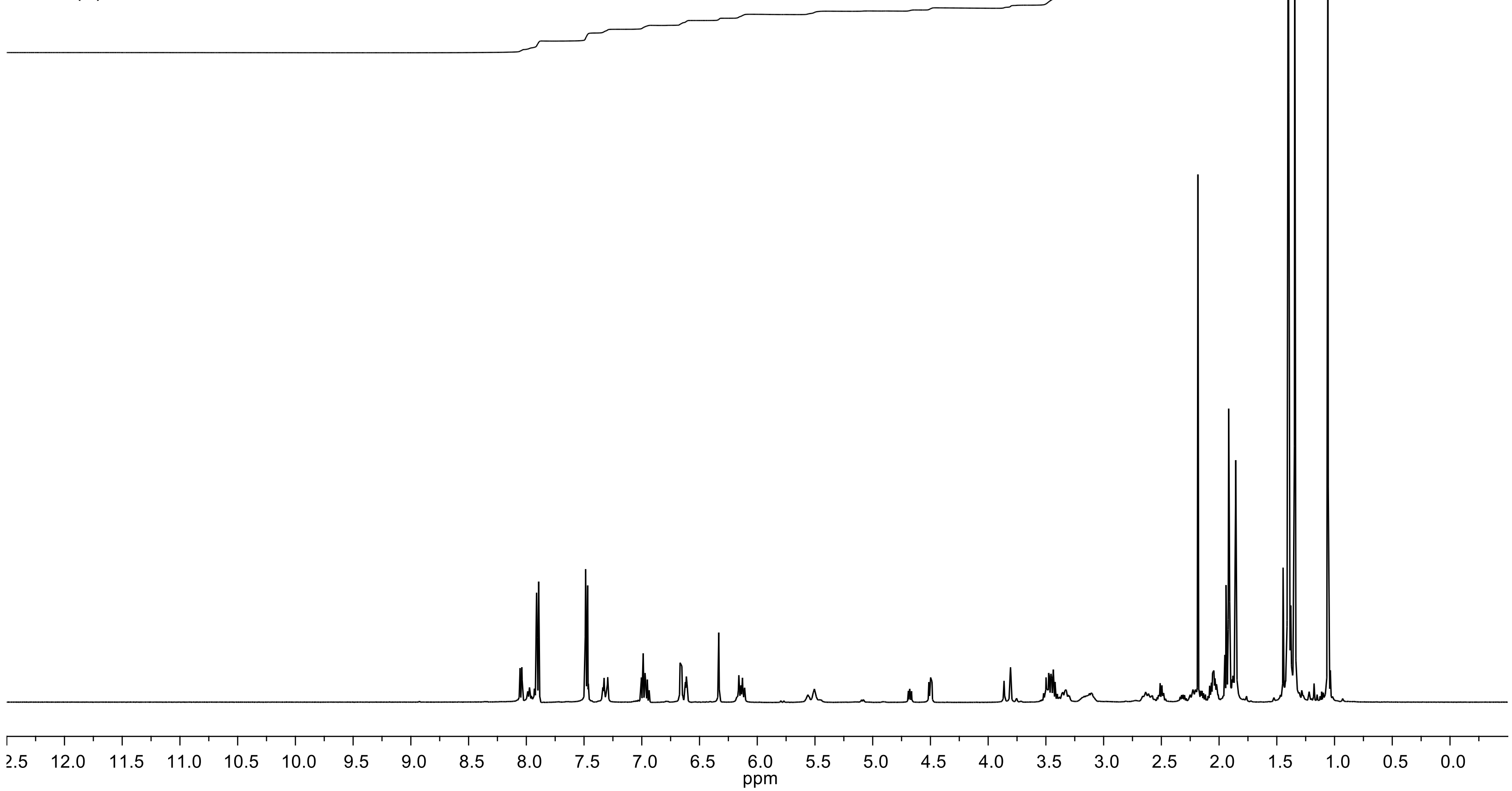


(–)-**36**

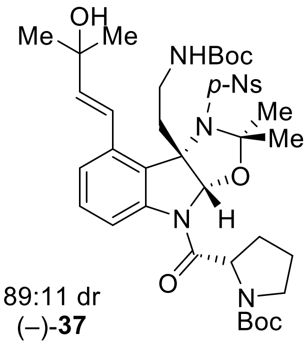
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



89:11 dr
(–)-**37**



^{13}C NMR, 126 MHz, CD_3CN, 20 °C



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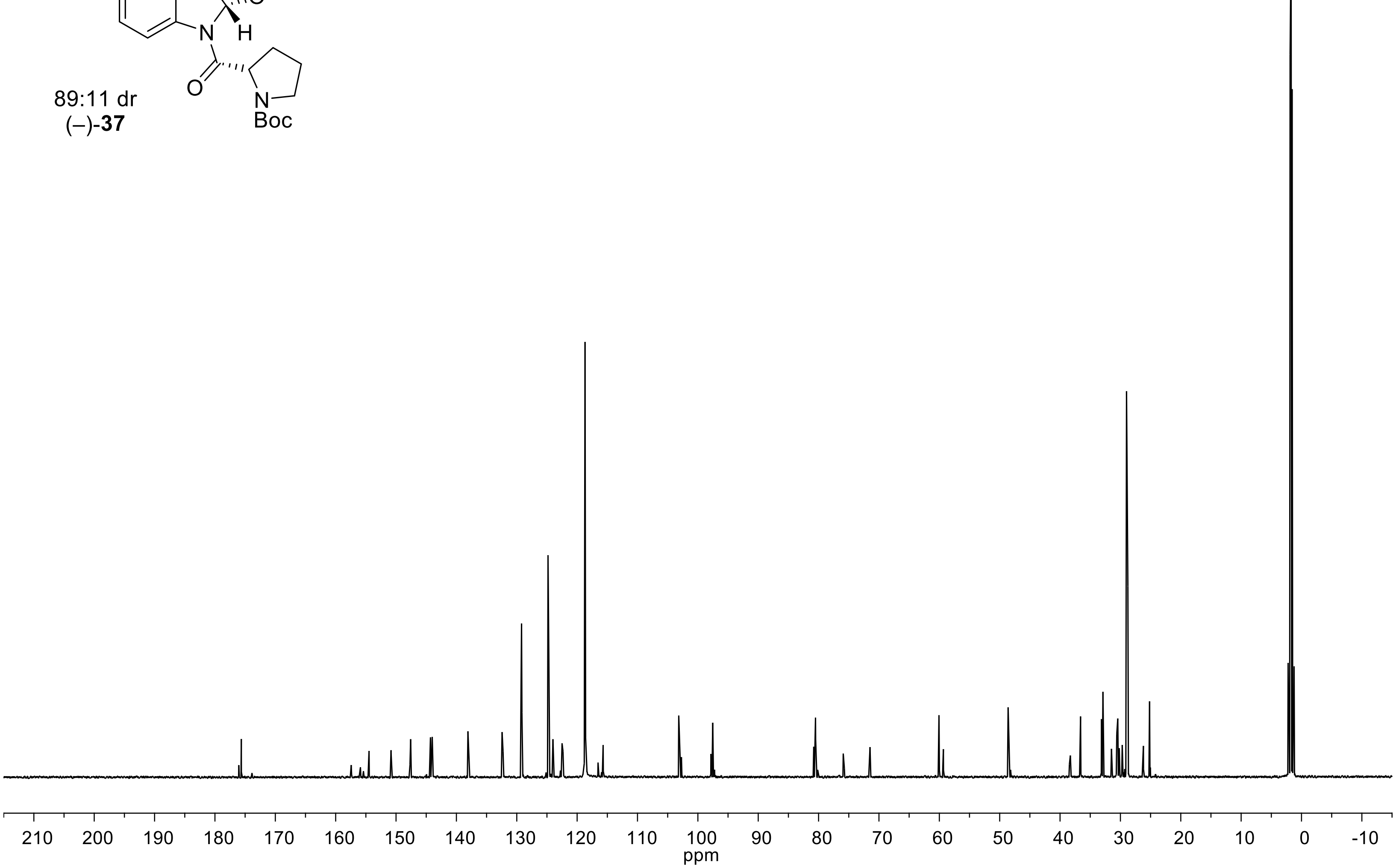
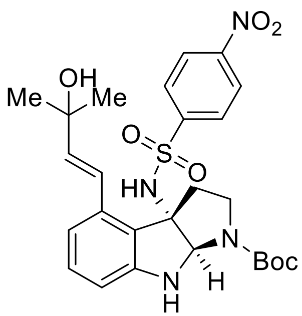
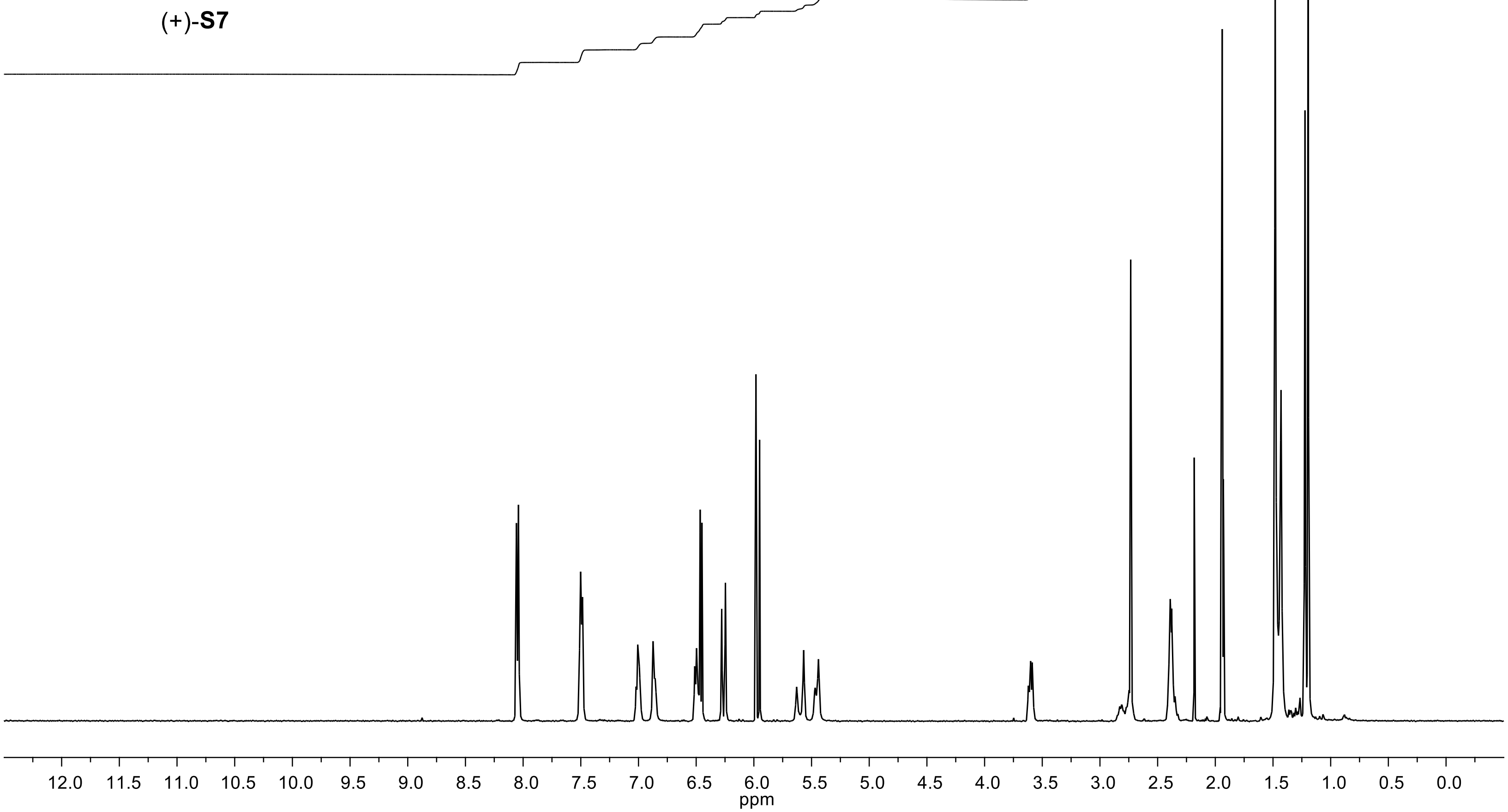
(–)-**37**



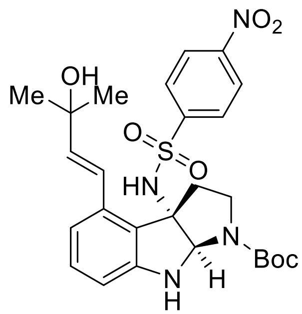
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



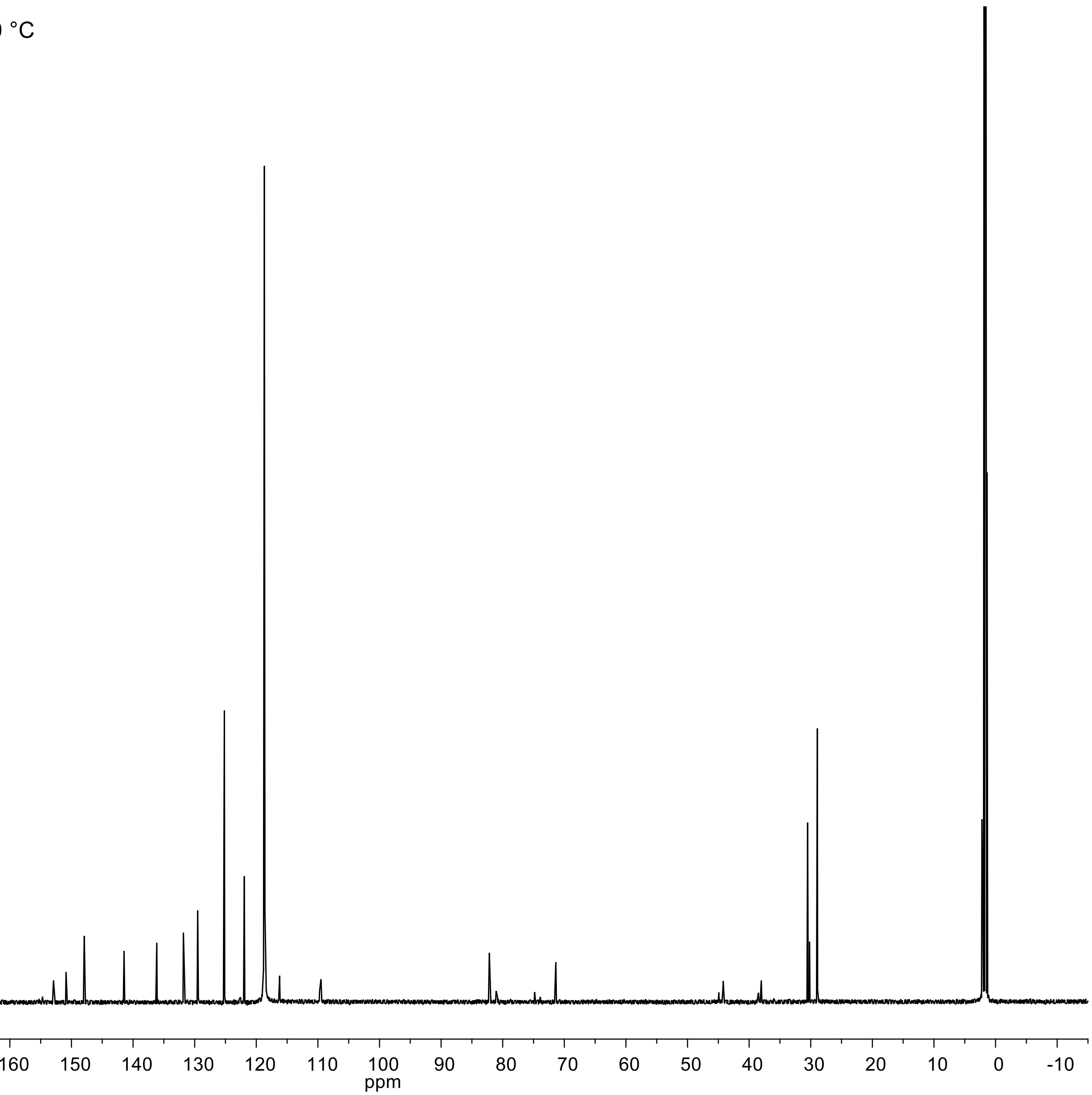
(+)-**S7**

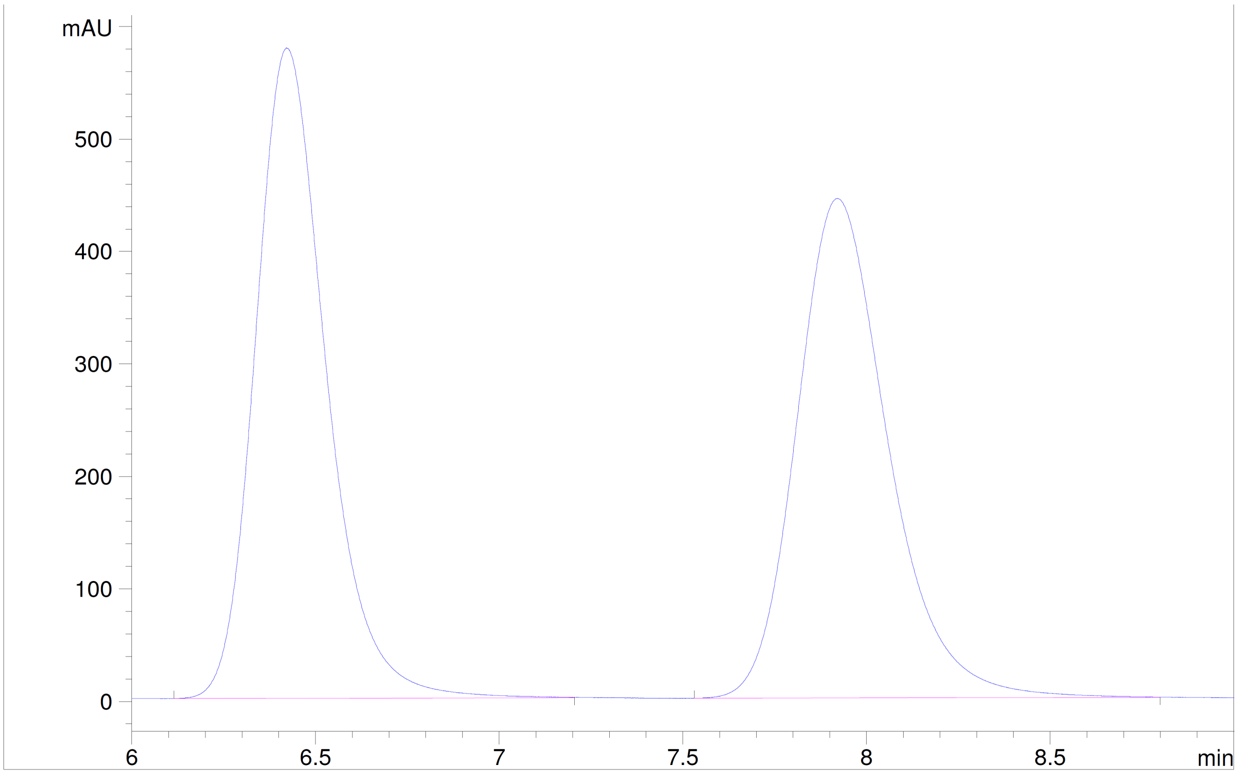


^{13}C NMR, 126 MHz, CD_3CN, 20 °C



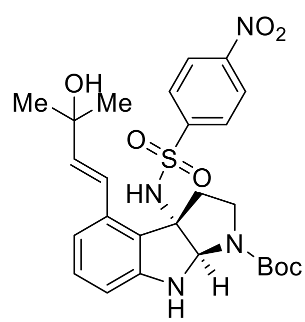
(+)-**S7**





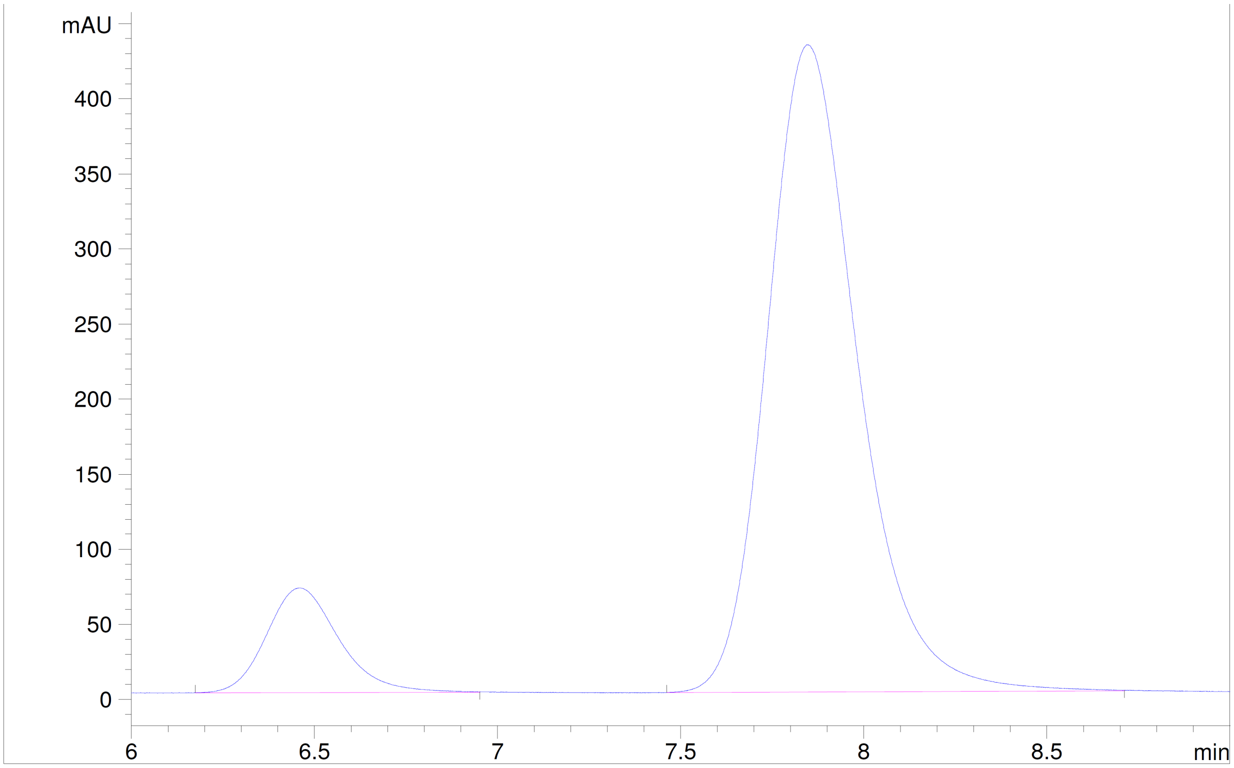
#	Meas. Ret. Time	Area %
1	6.423	50.192
2	7.921	49.808

racemate

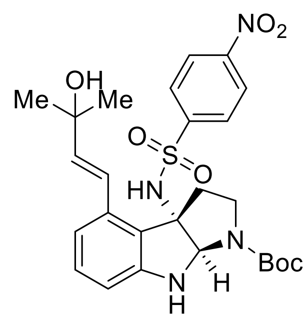


S7

Chiralpak IA
80% *i*-PrOH / 20% hexanes
1.0 mL / min
254 nm



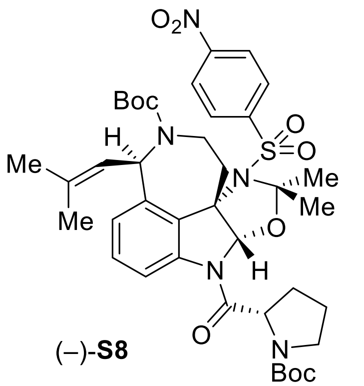
#	Meas. Ret. Time	Area %
1	6.460	11.441
2	7.847	88.559



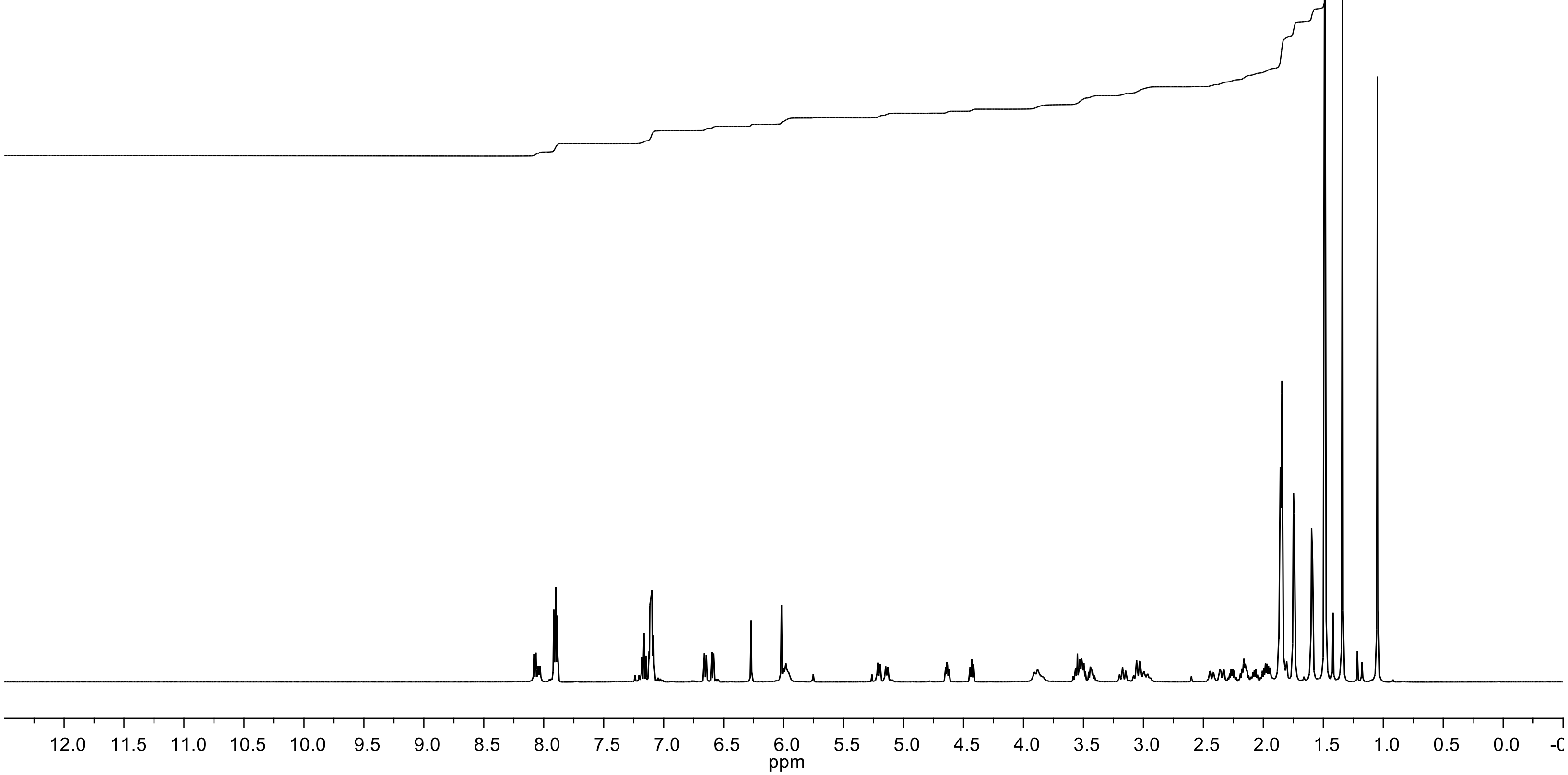
(+)-**S7**

Chiralpak IA
80% *i*-PrOH / 20% hexanes
1.0 mL / min
254 nm

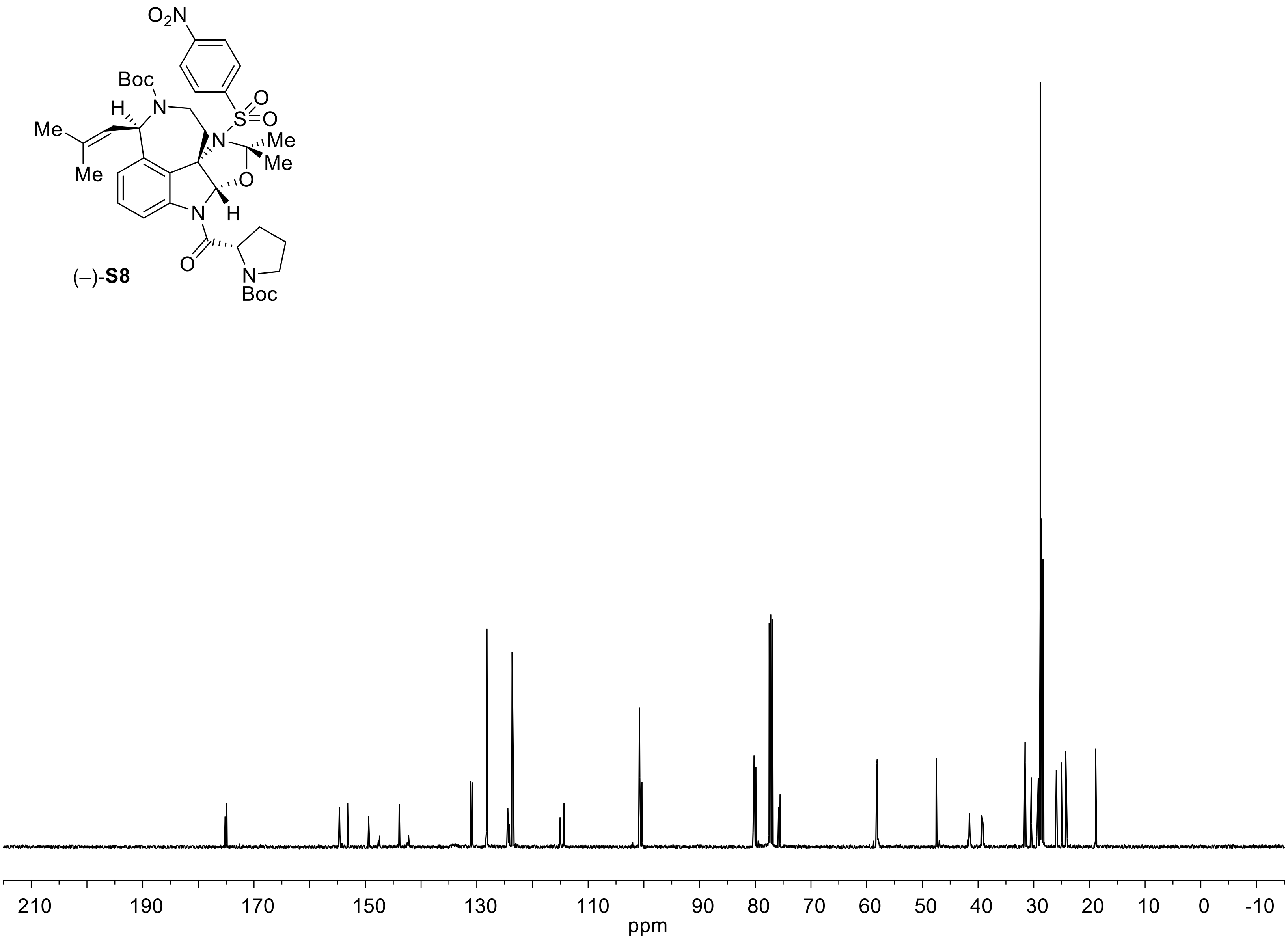
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



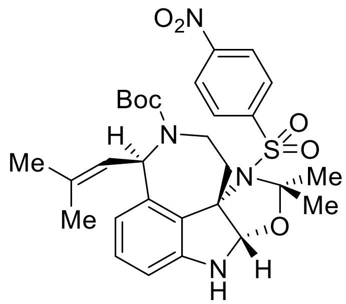
(–)-**S8**



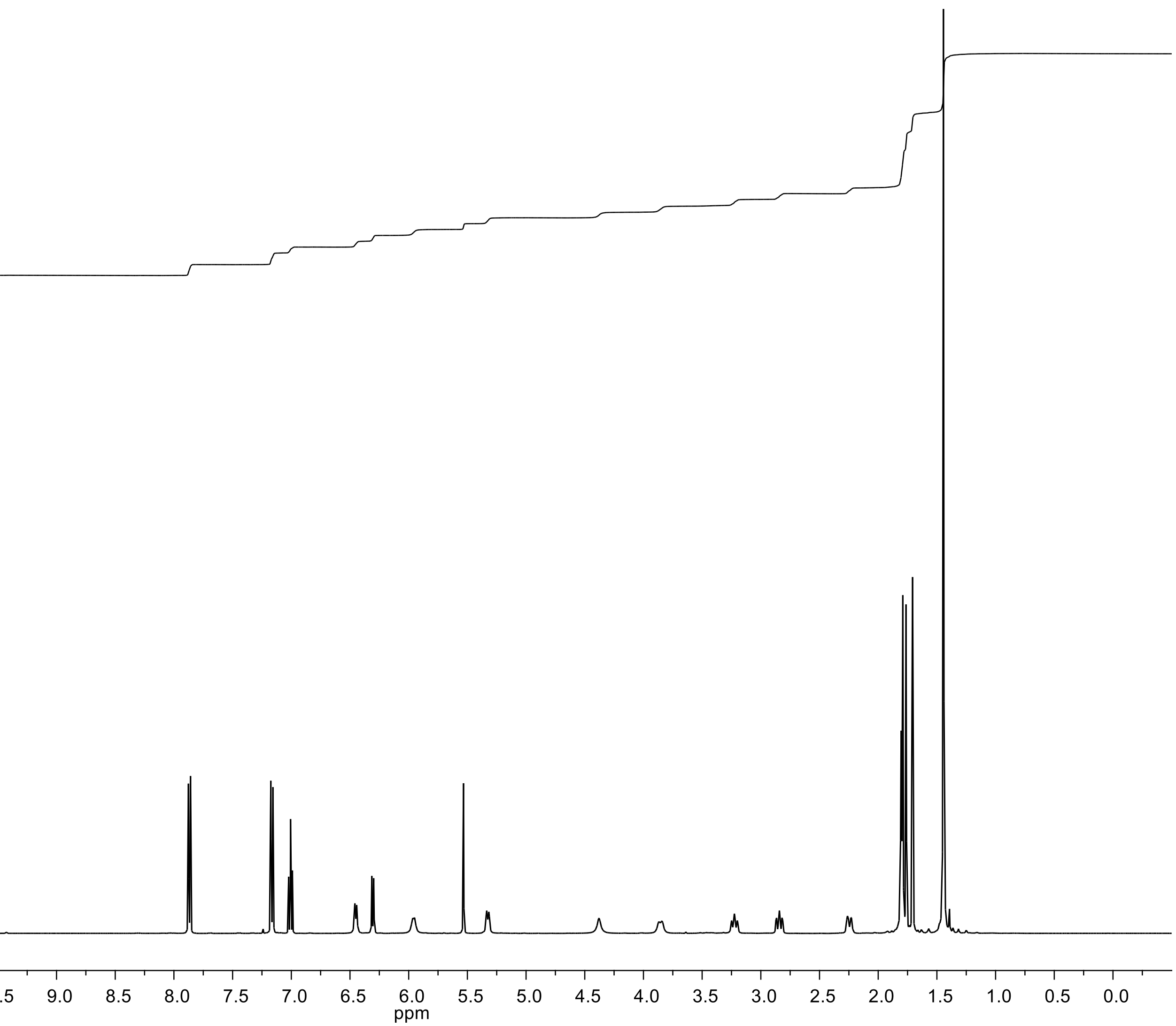
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



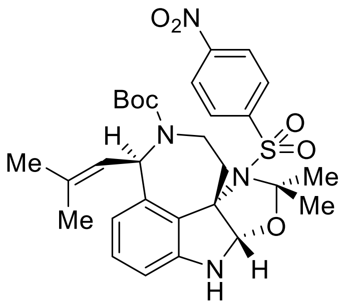
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



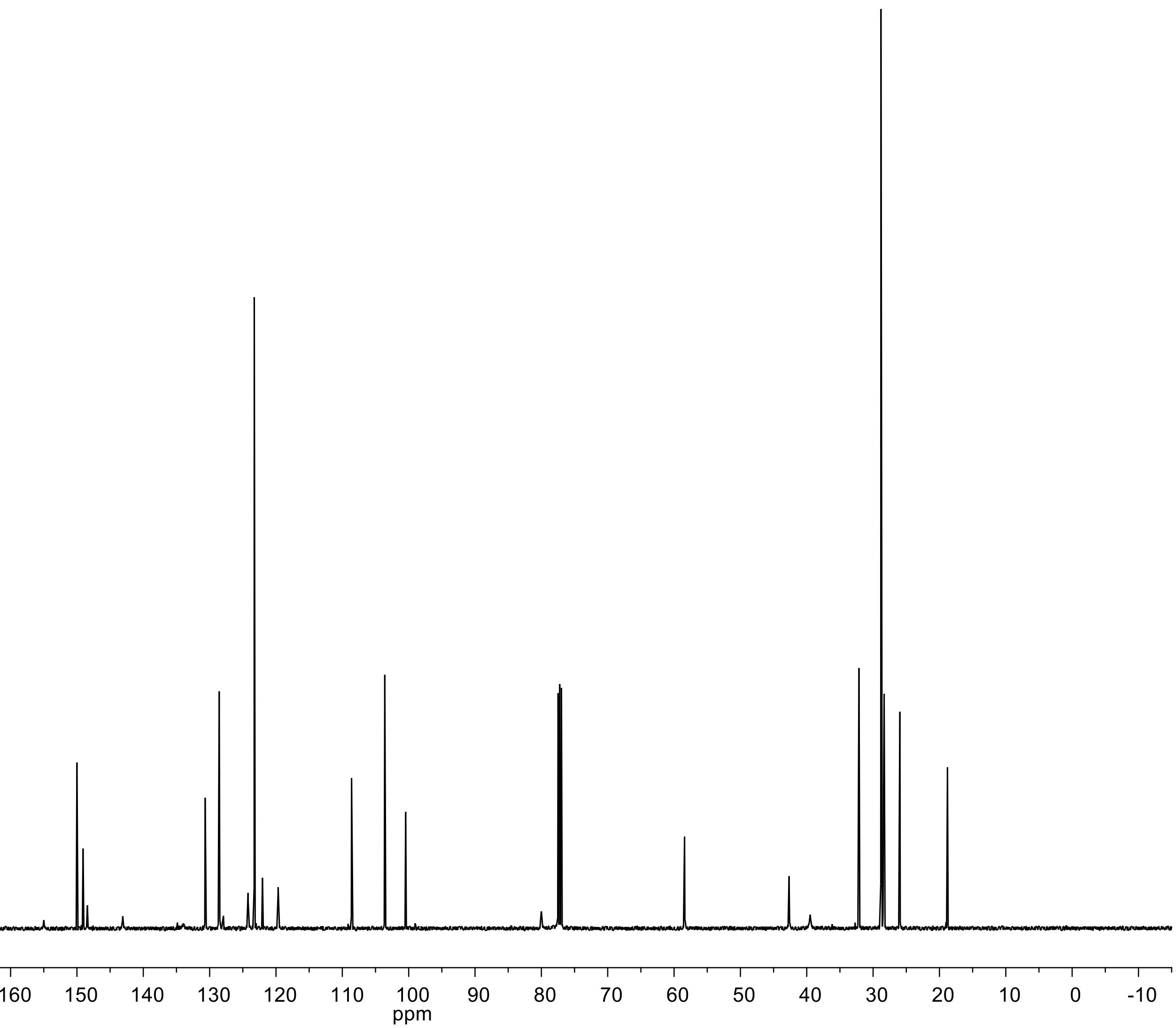
(–)-**38**



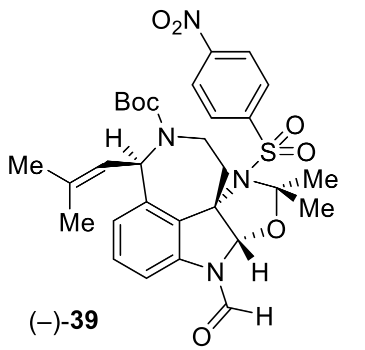
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



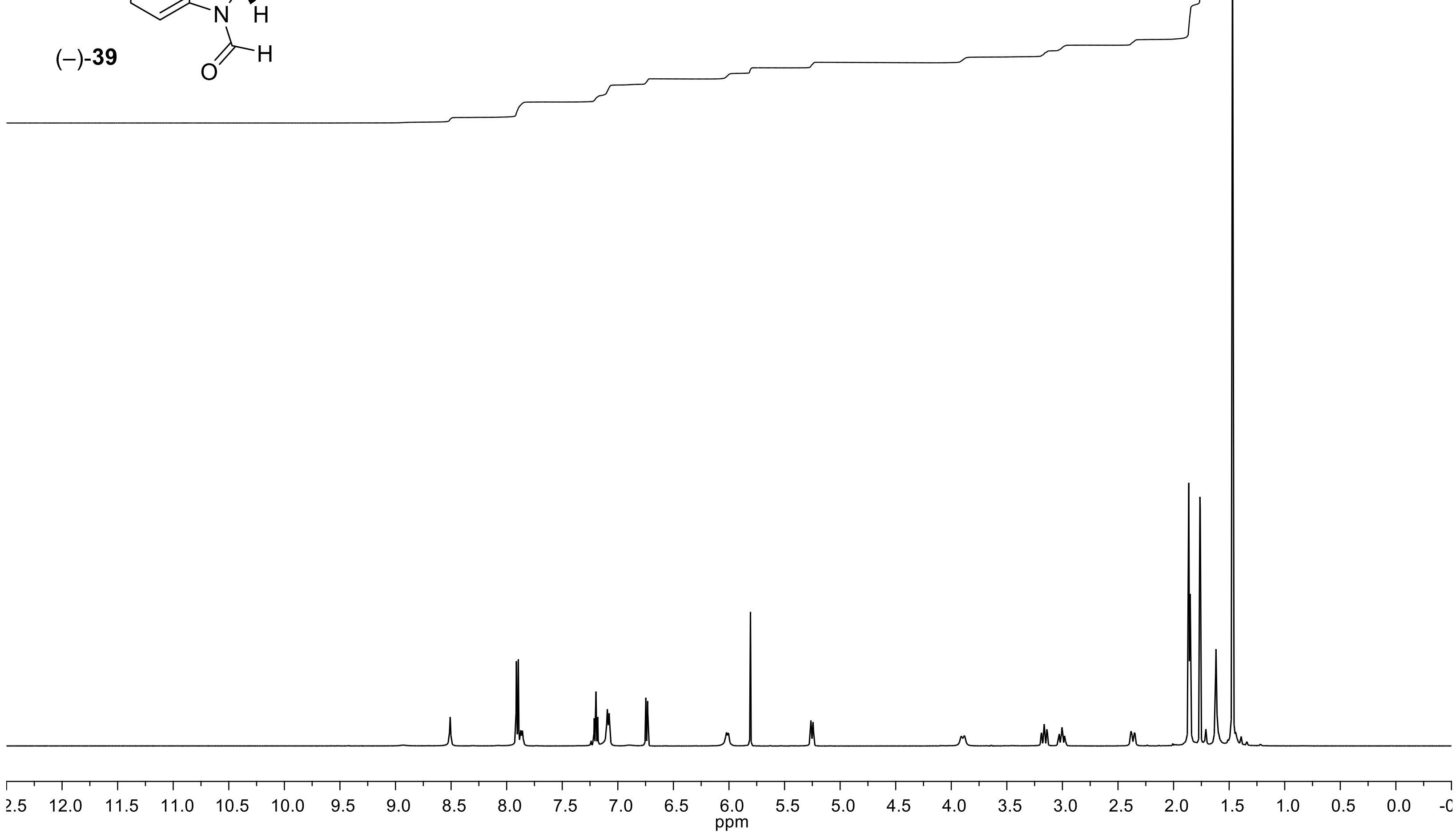
(–)-**38**



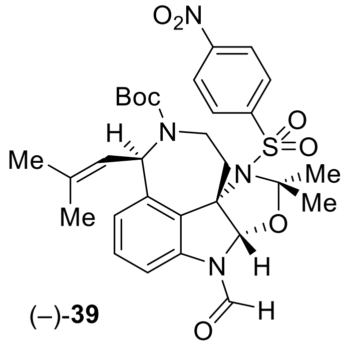
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



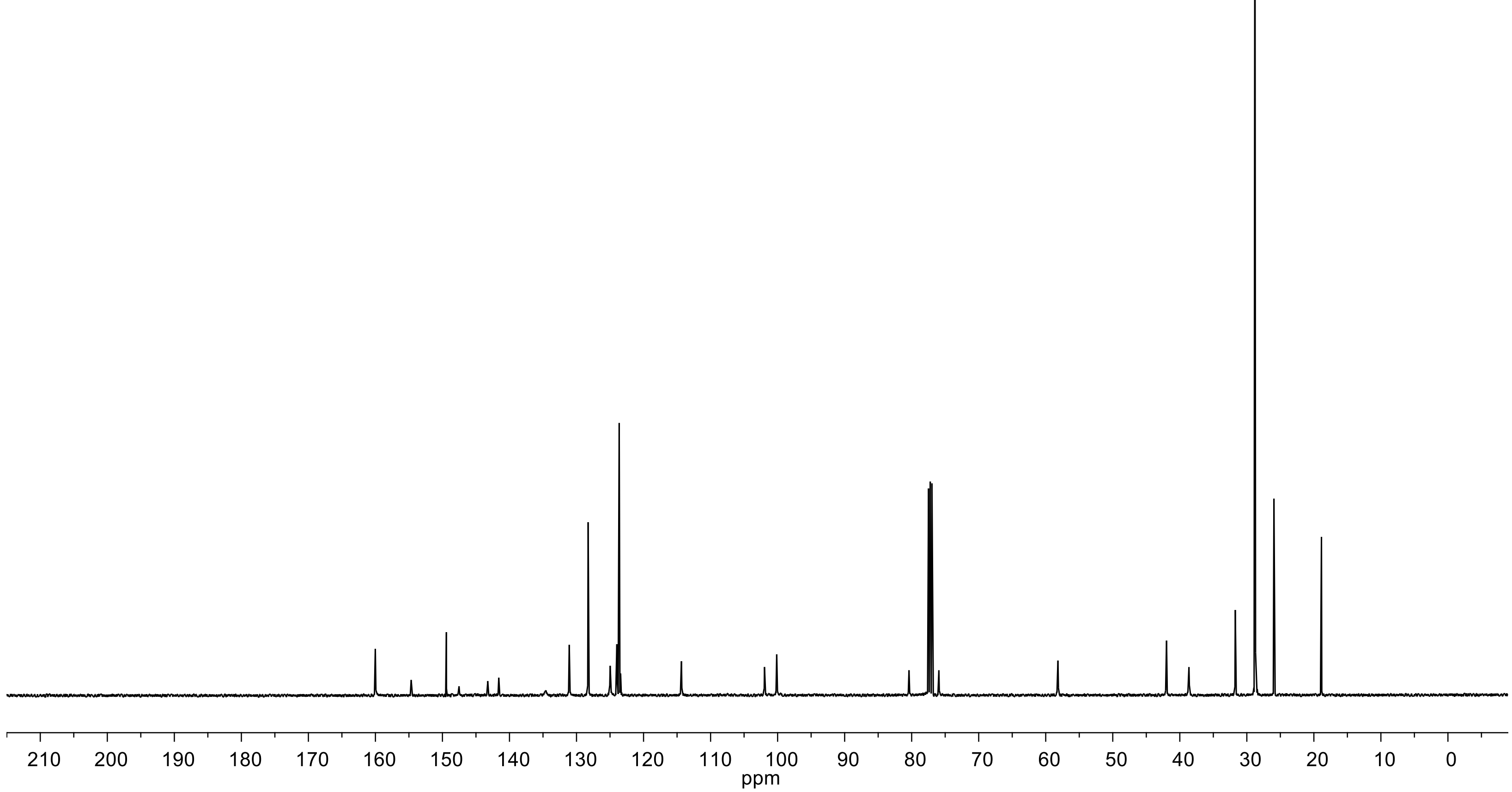
(–)-**39**



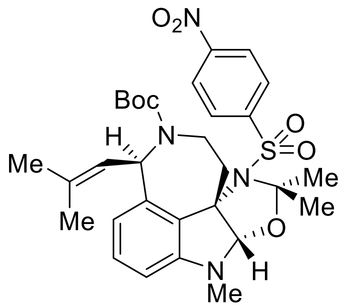
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



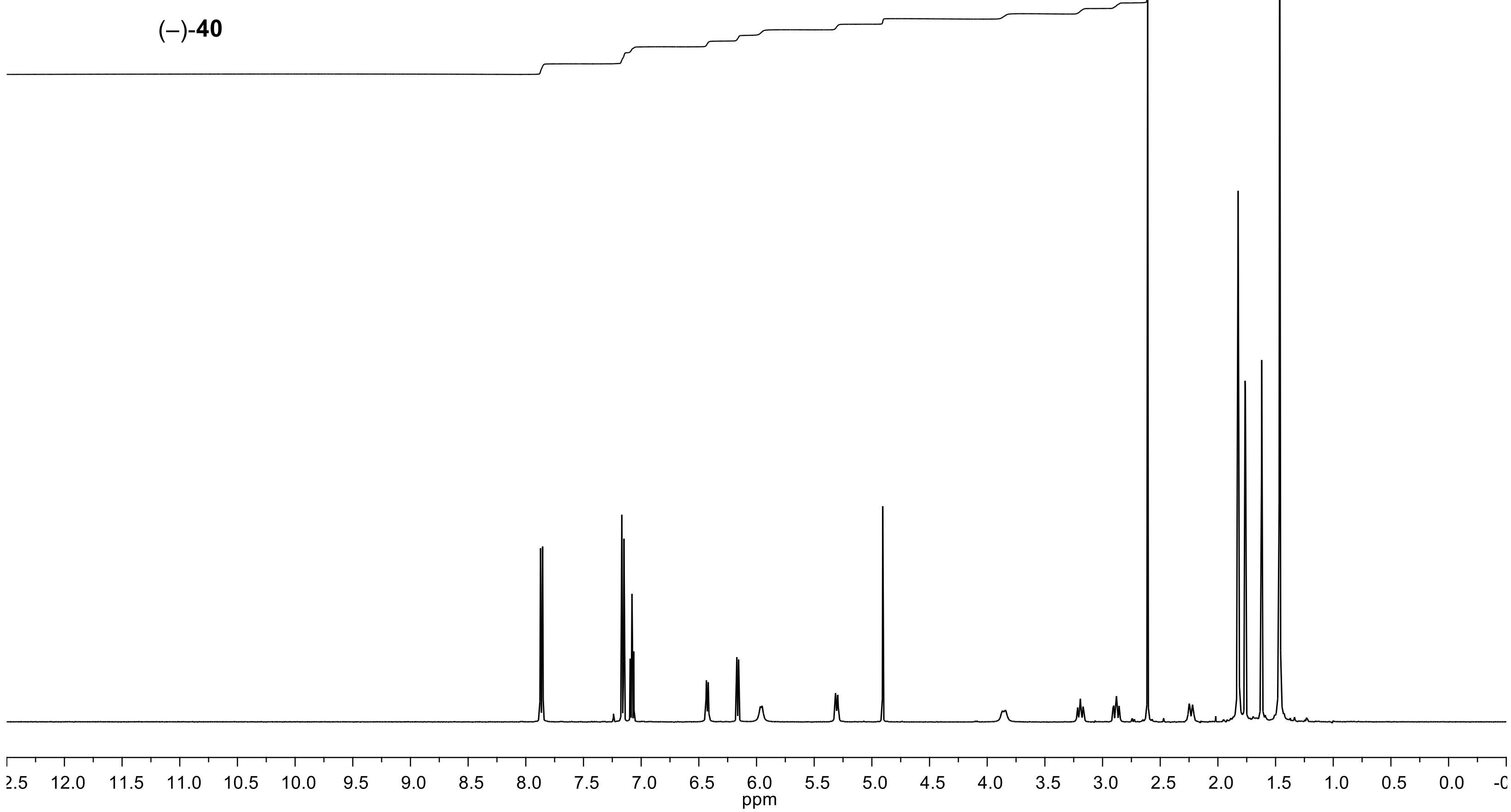
(–)-**39**



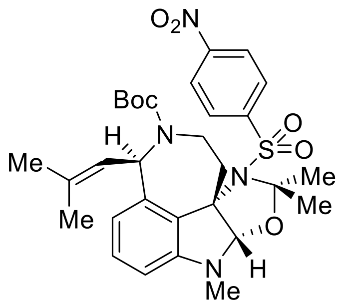
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



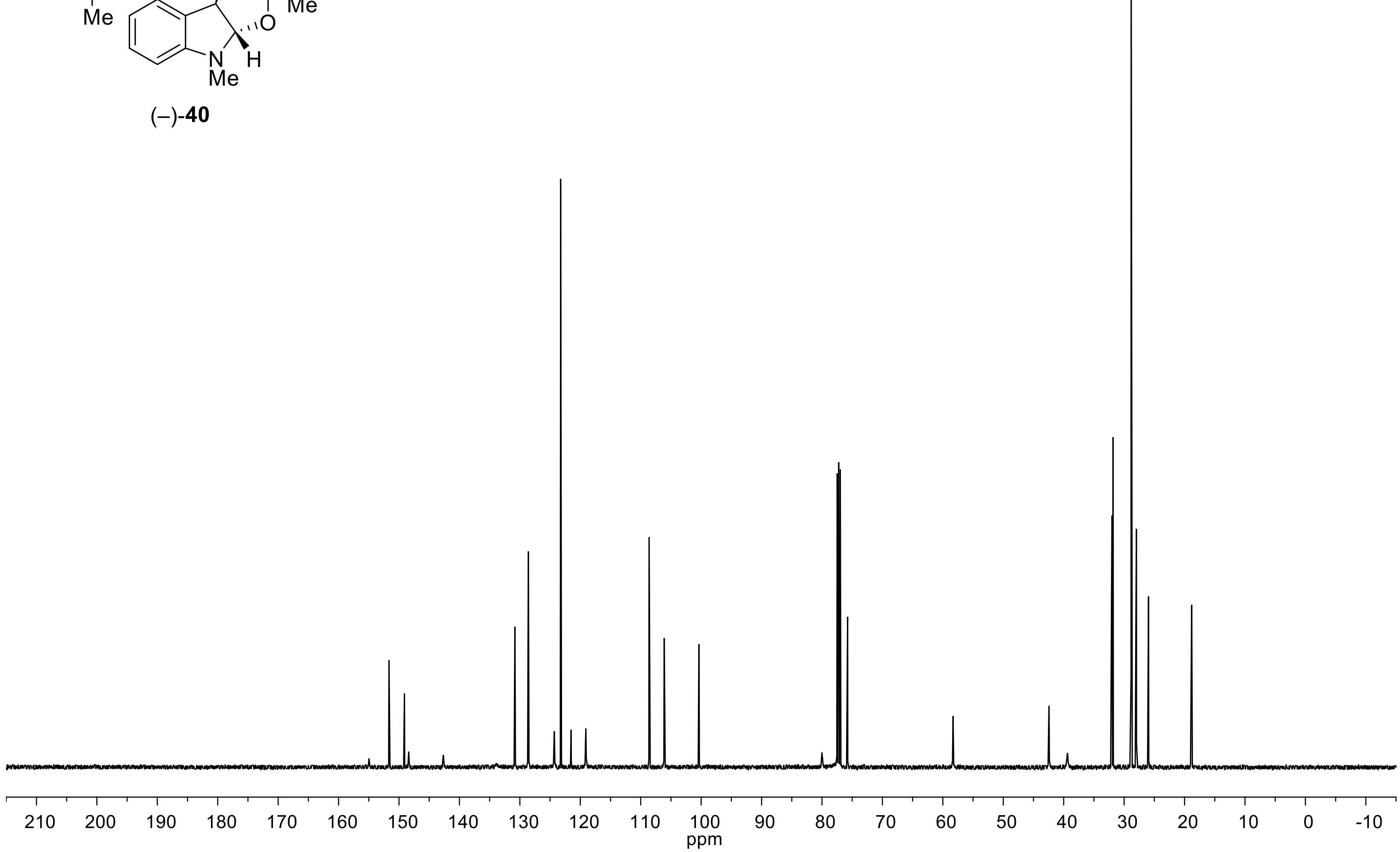
(–)-**40**



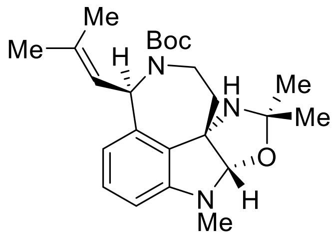
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



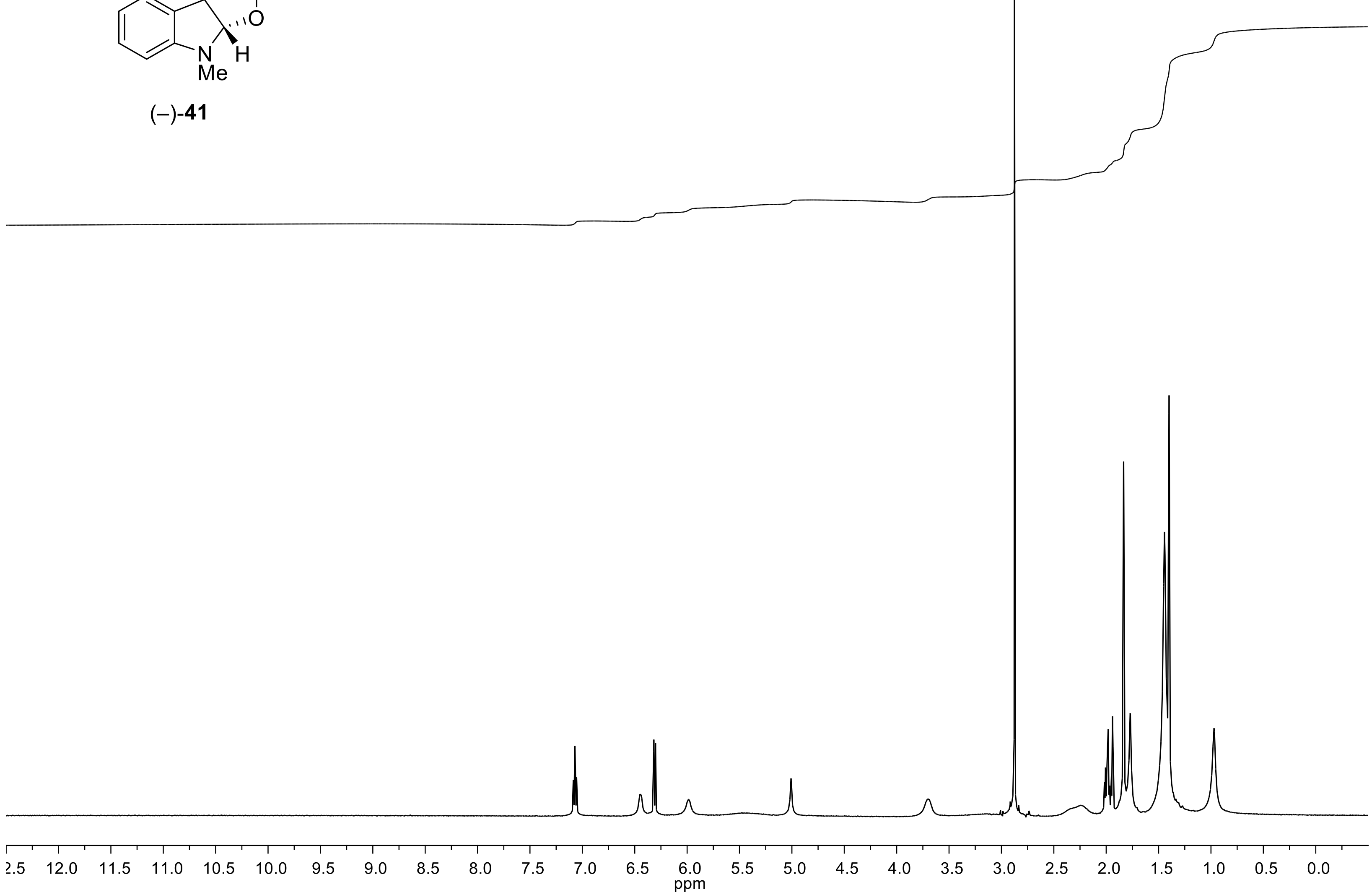
(–)-**40**



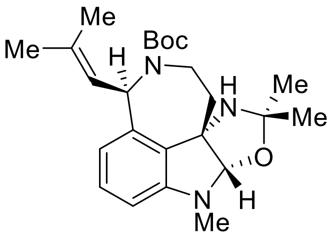
^{1}H NMR, 500 MHz, CD_3CN, 70 °C



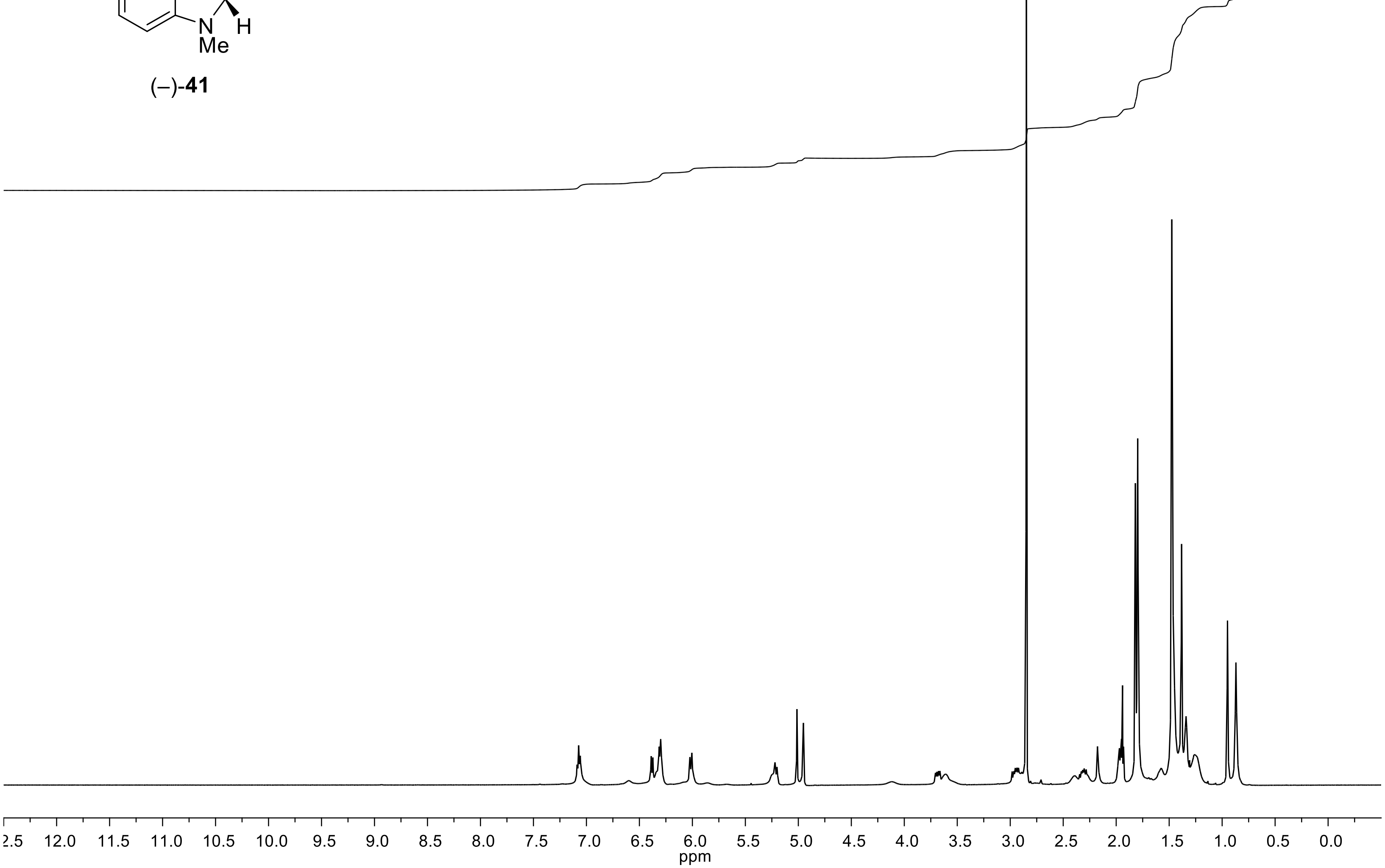
(–)-**41**



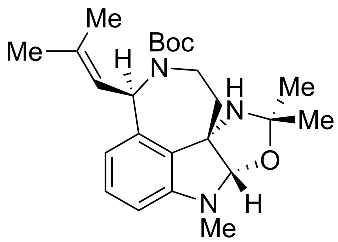
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



(–)-**41**



^{13}C NMR, 126 MHz, CD_3CN, 20 °C



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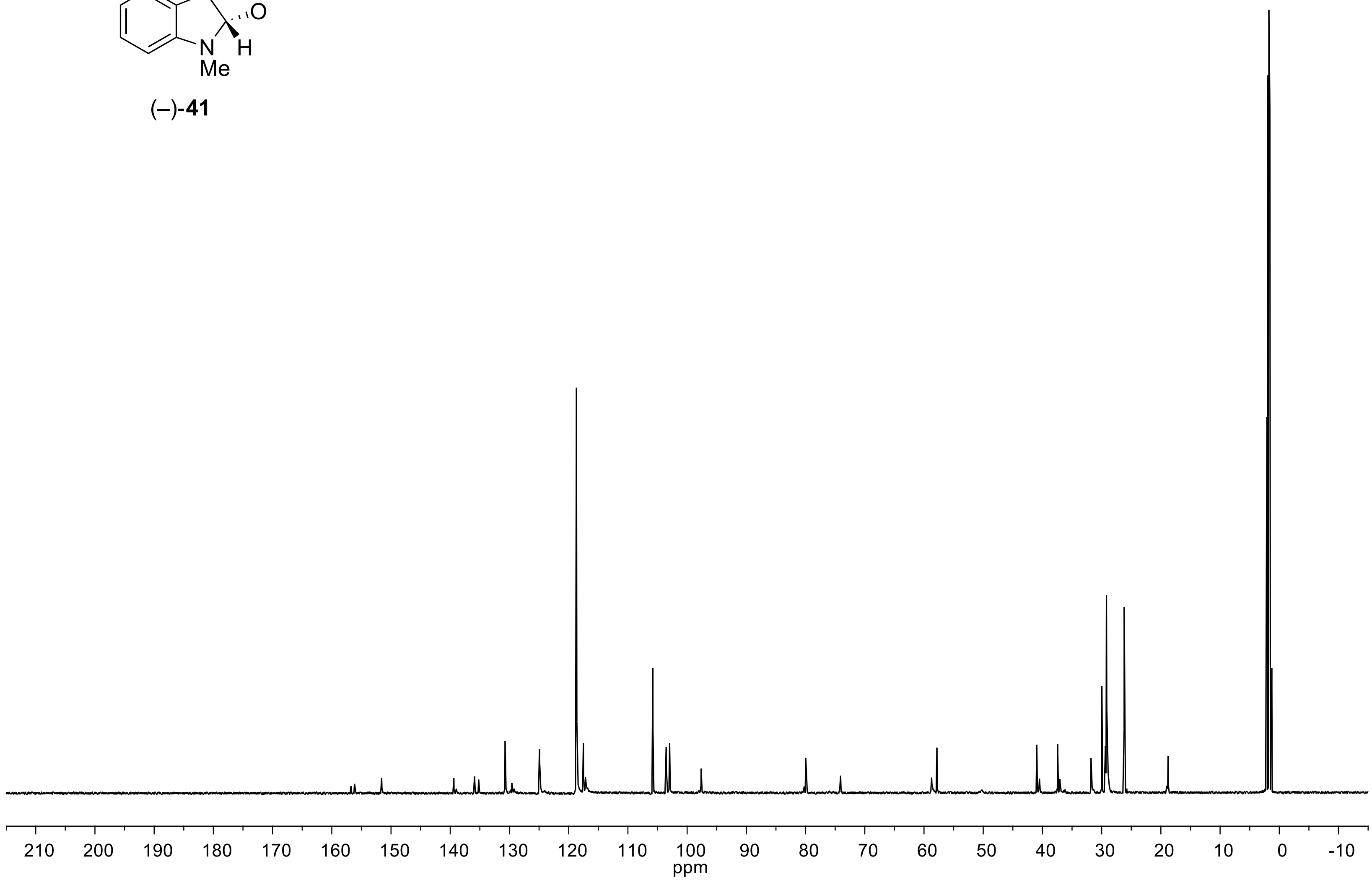
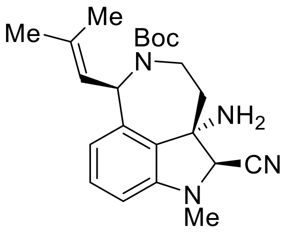
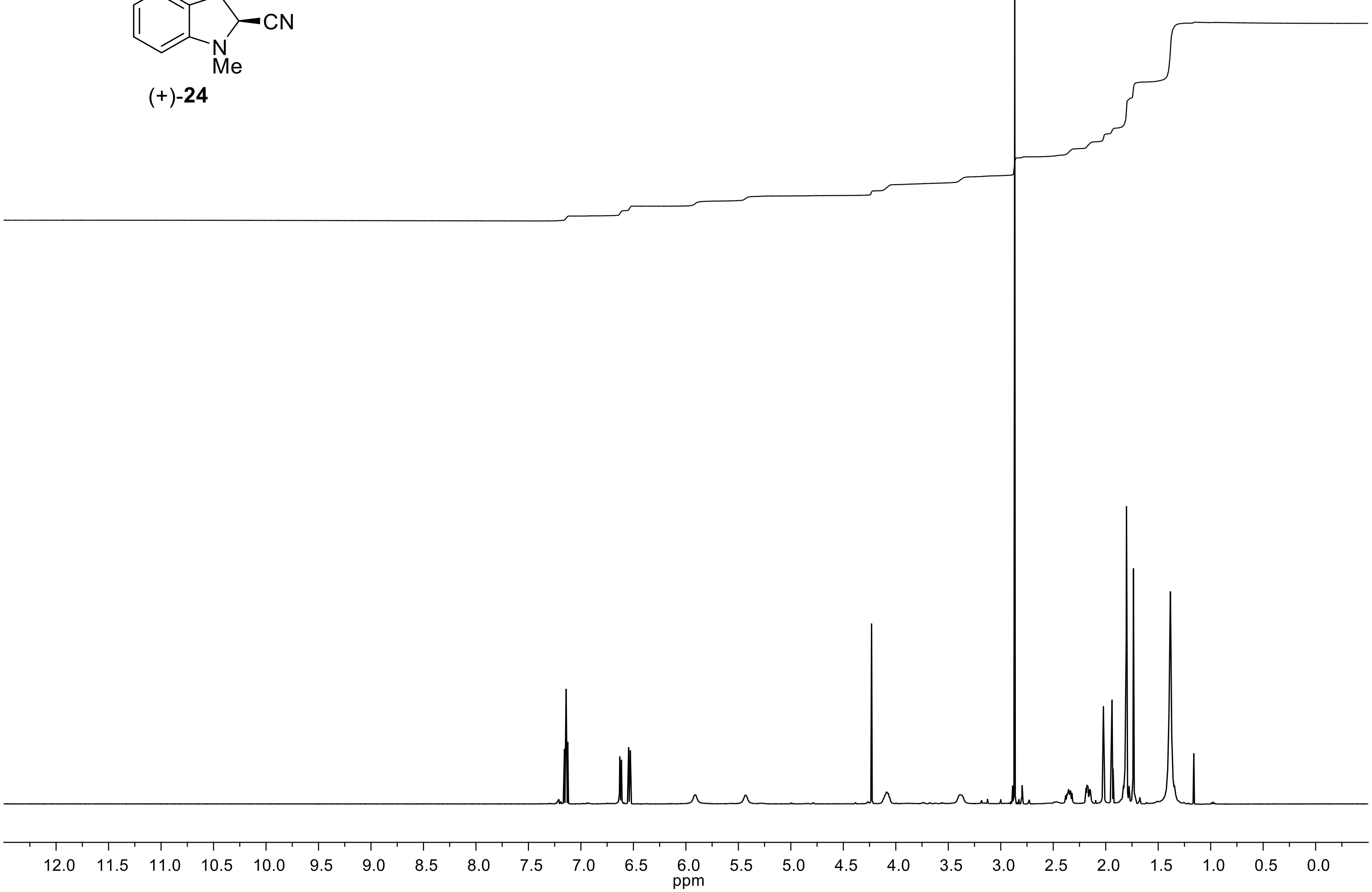


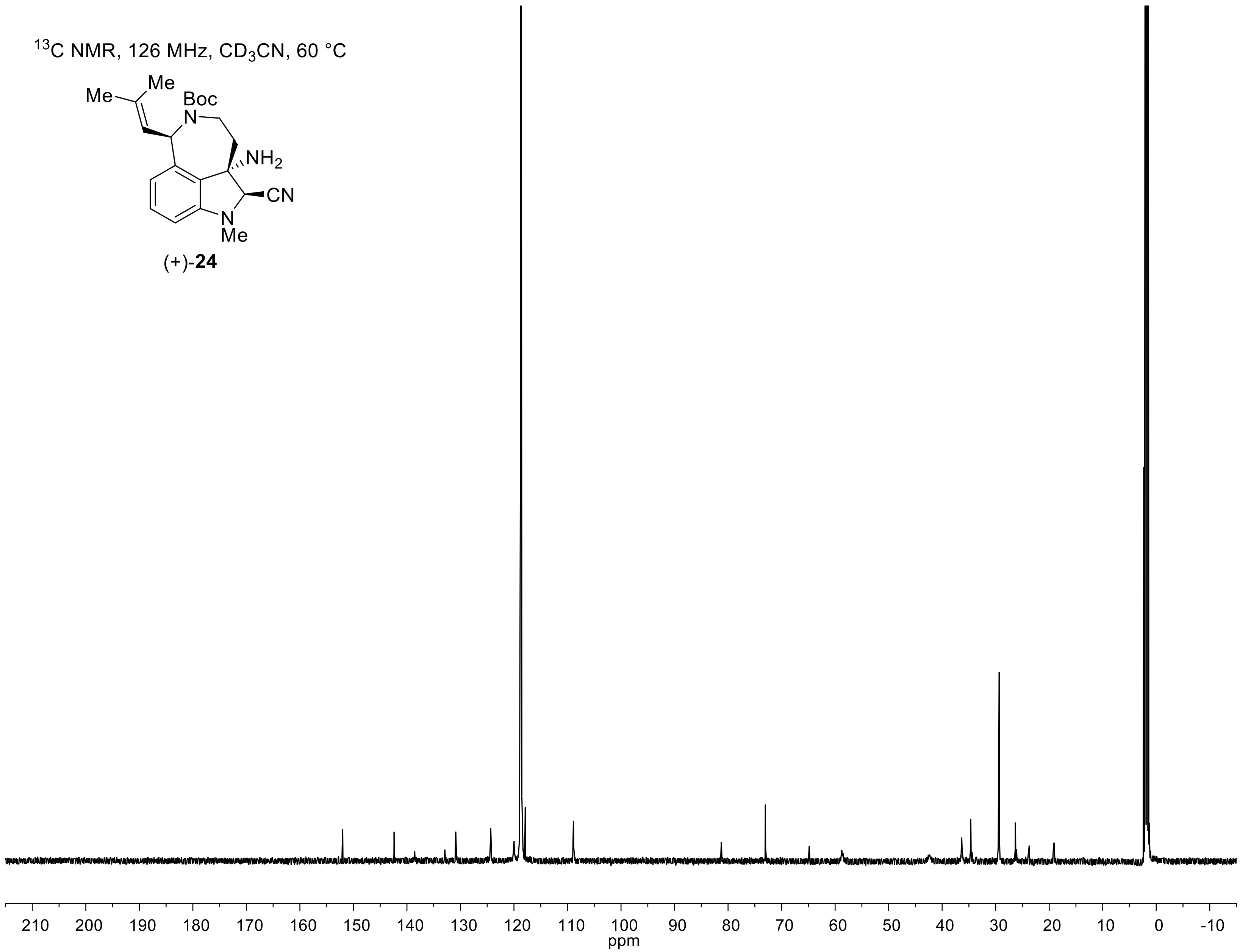
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



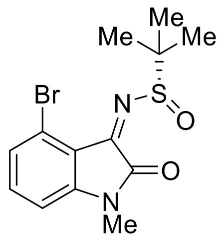
(+)-**24**



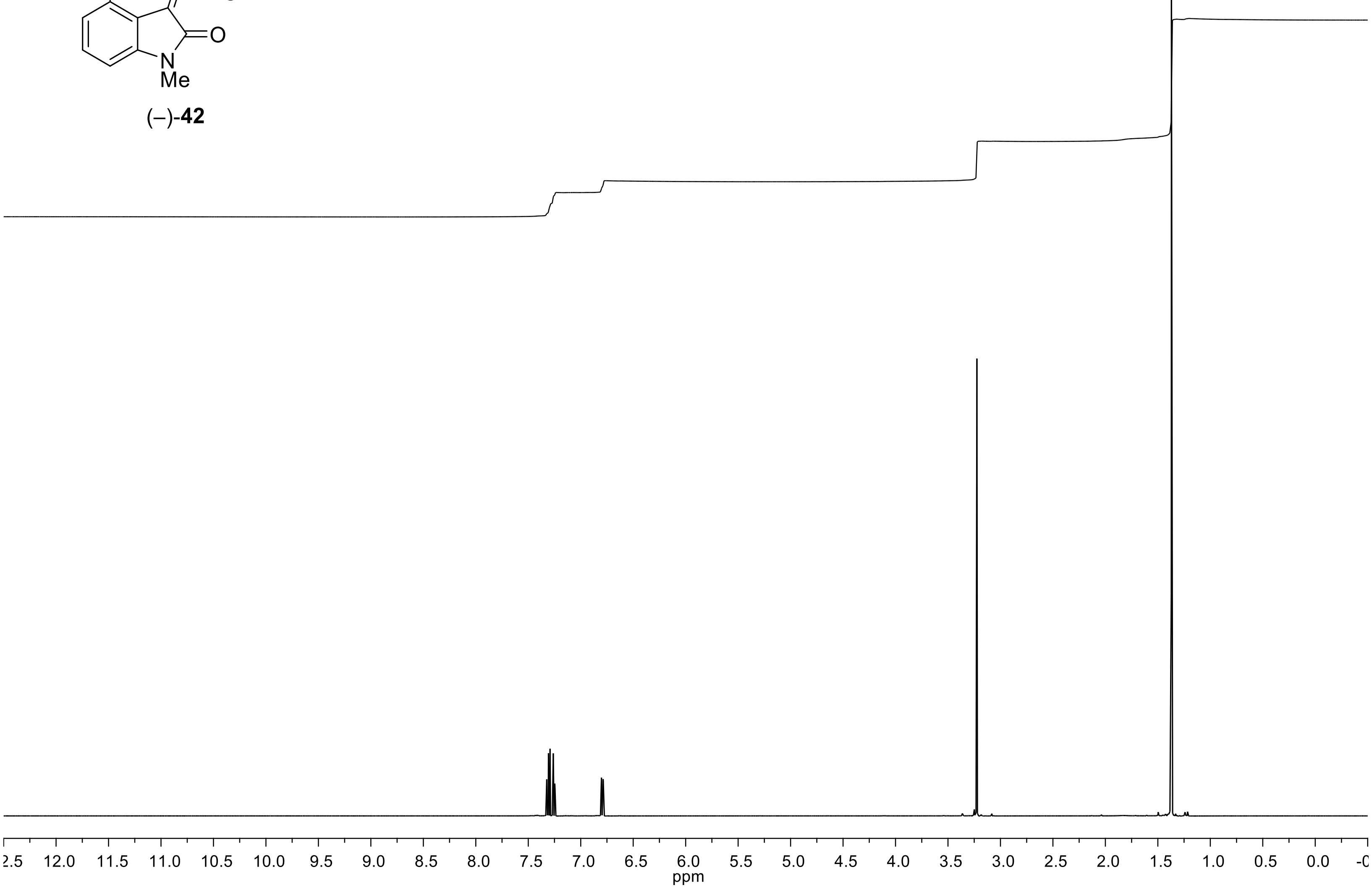
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



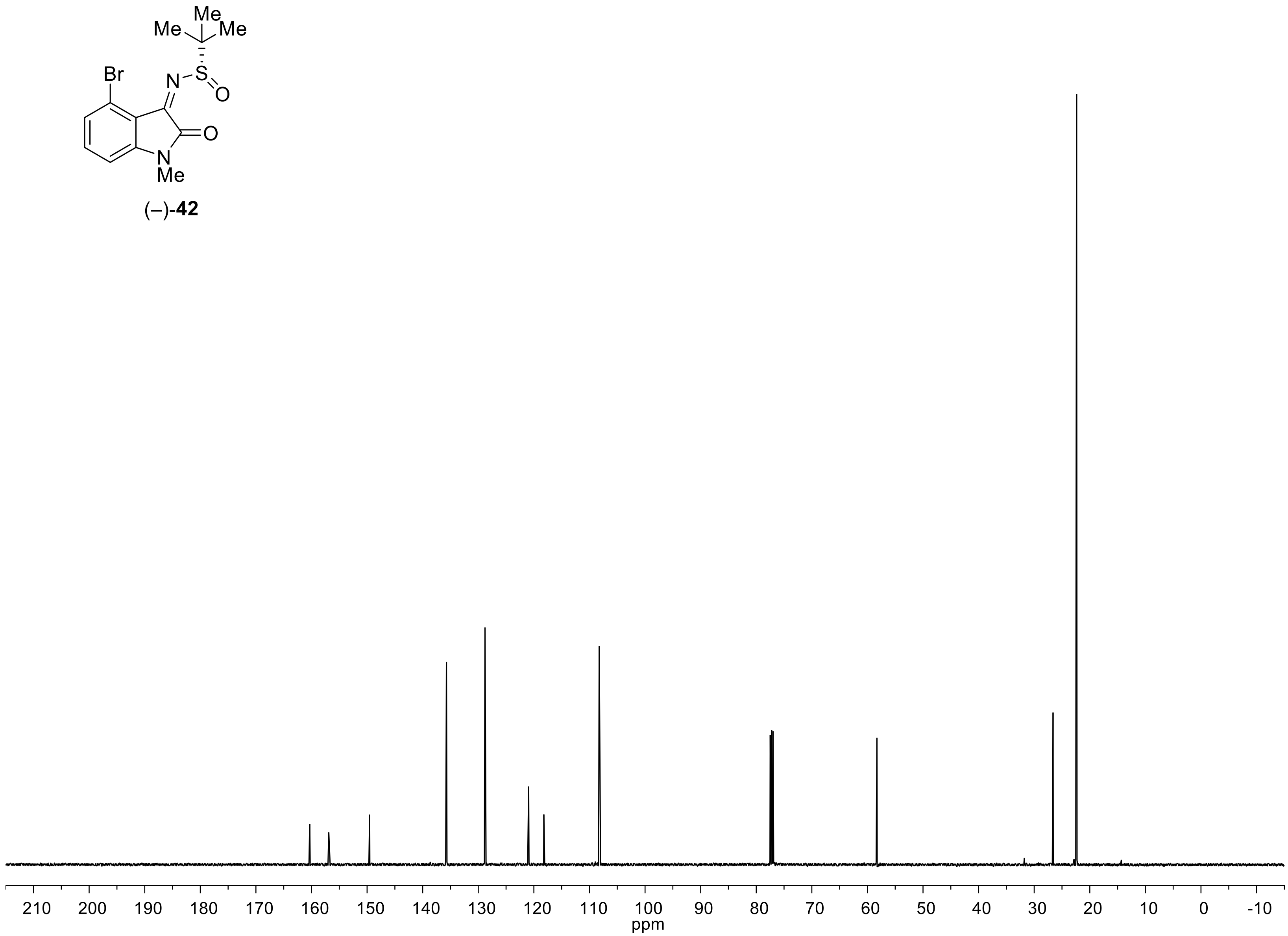
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



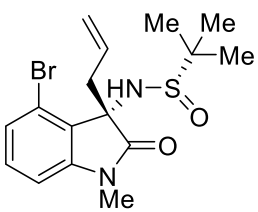
(–)-**42**



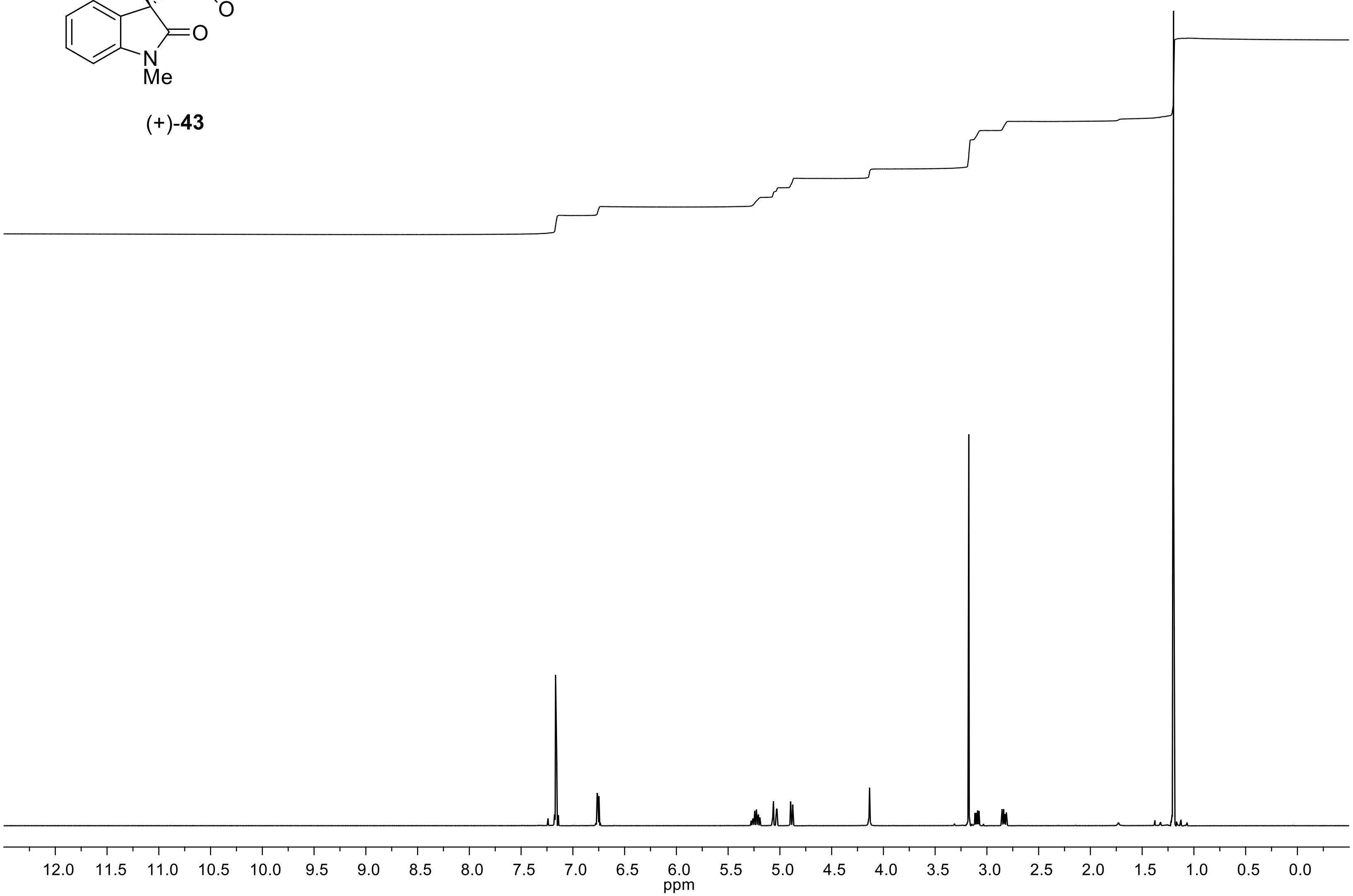
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



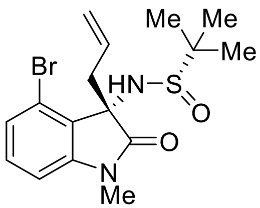
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



(+)-**43**



^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



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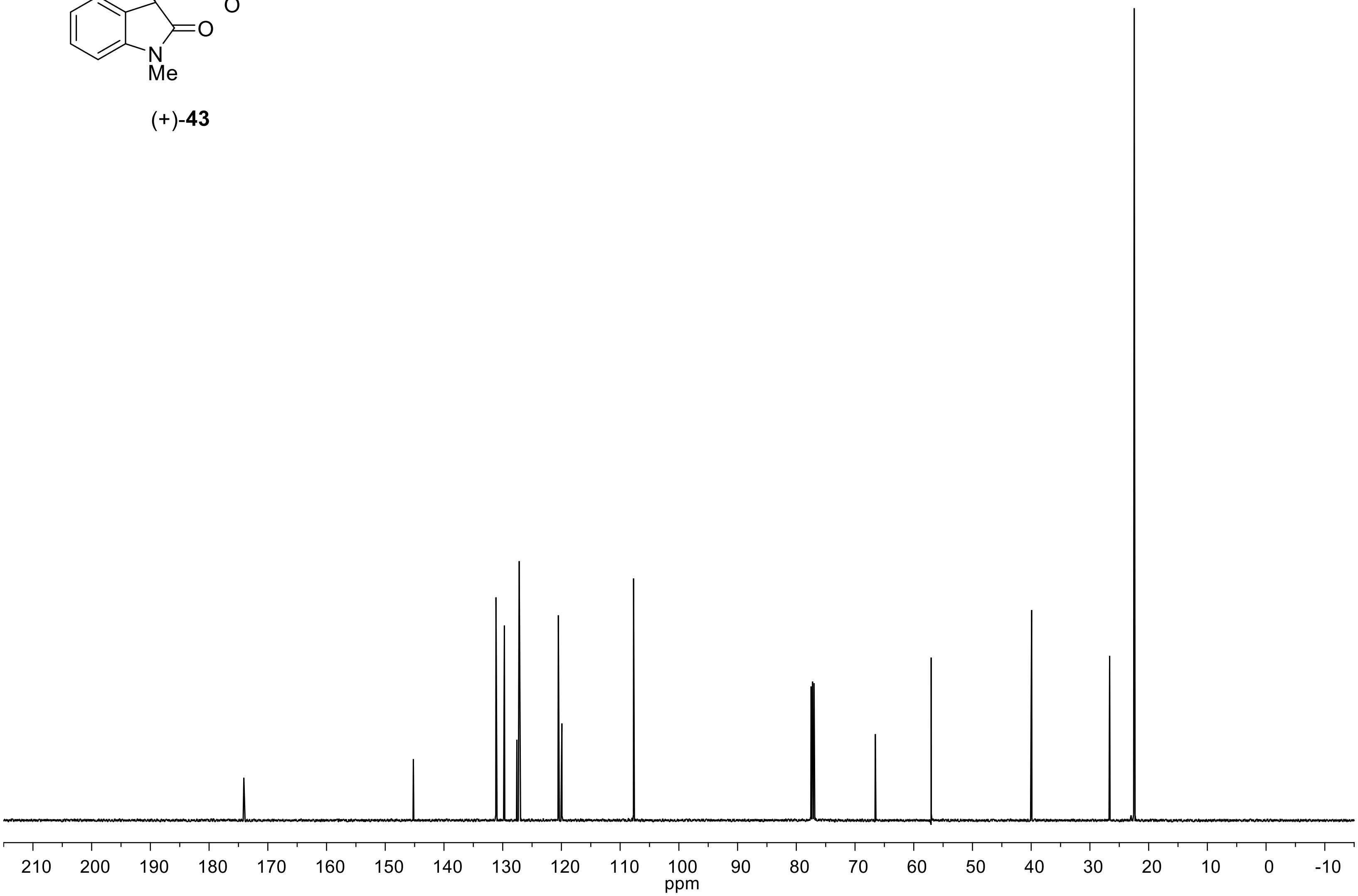
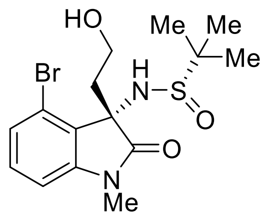


^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



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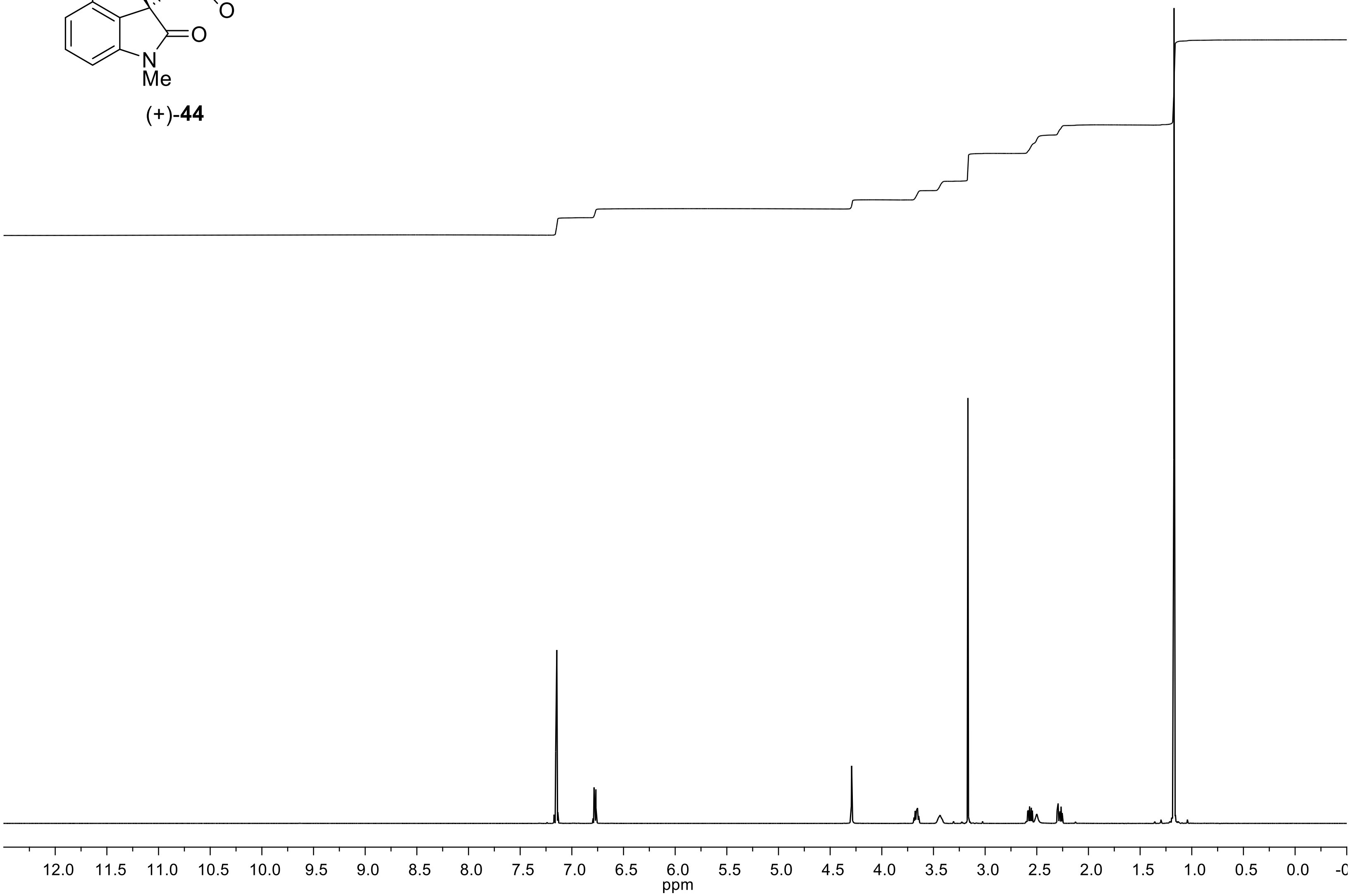
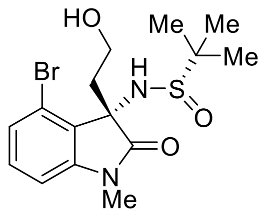
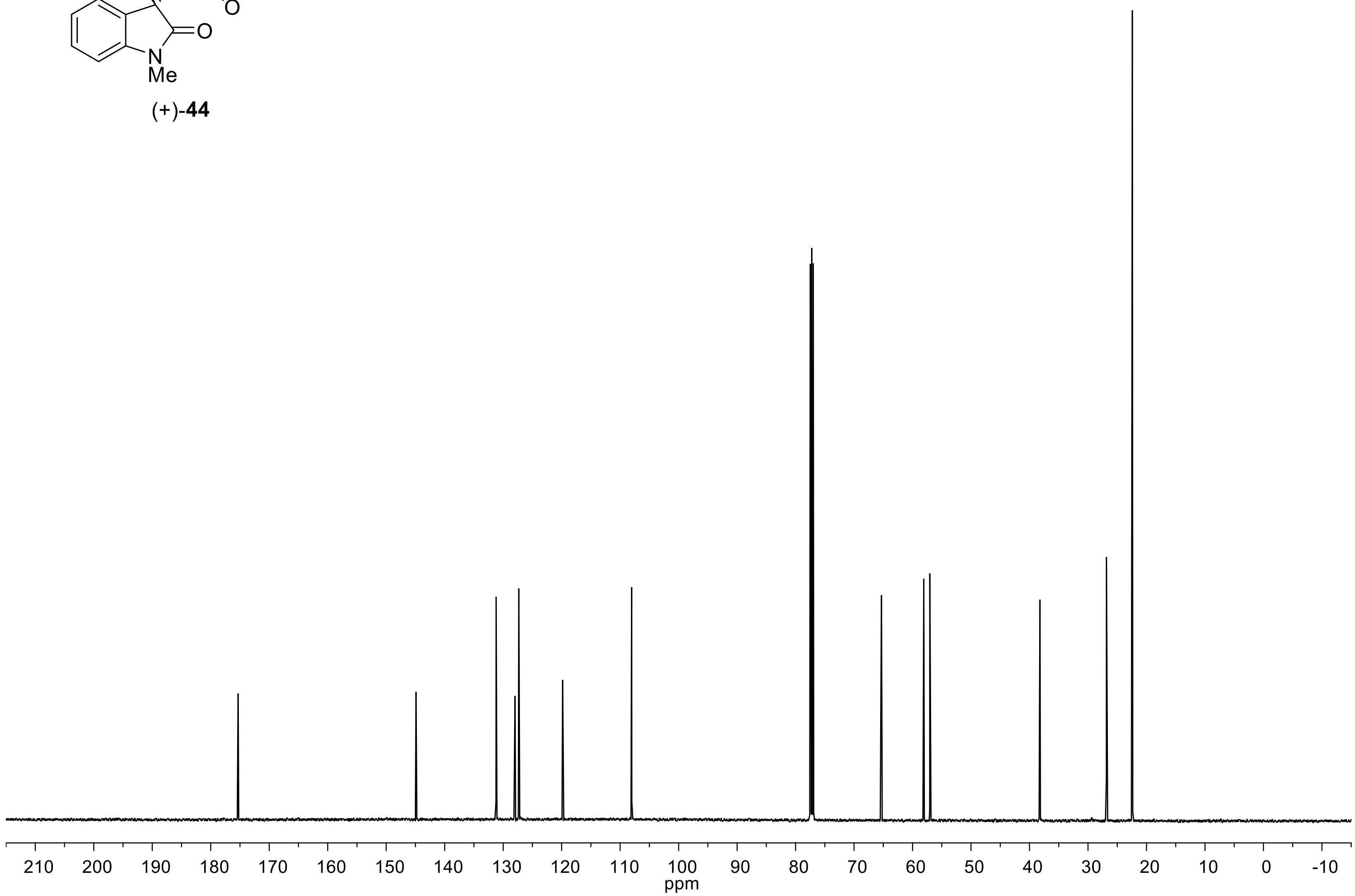


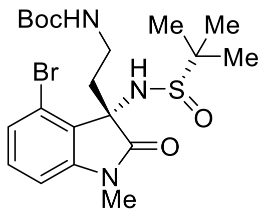
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



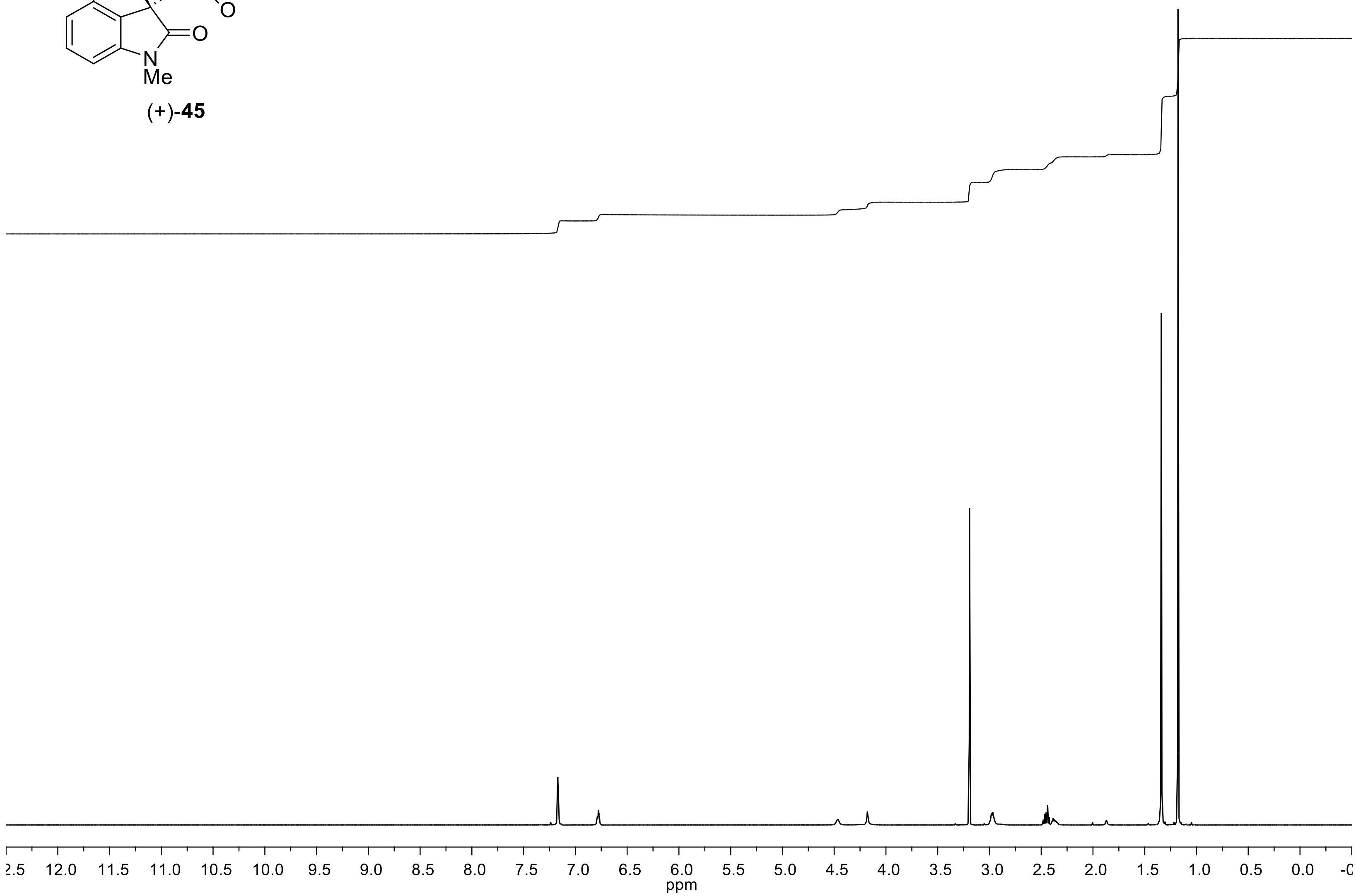
(+)-**44**



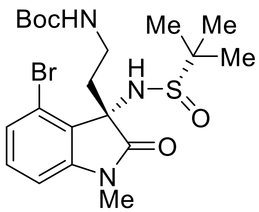
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



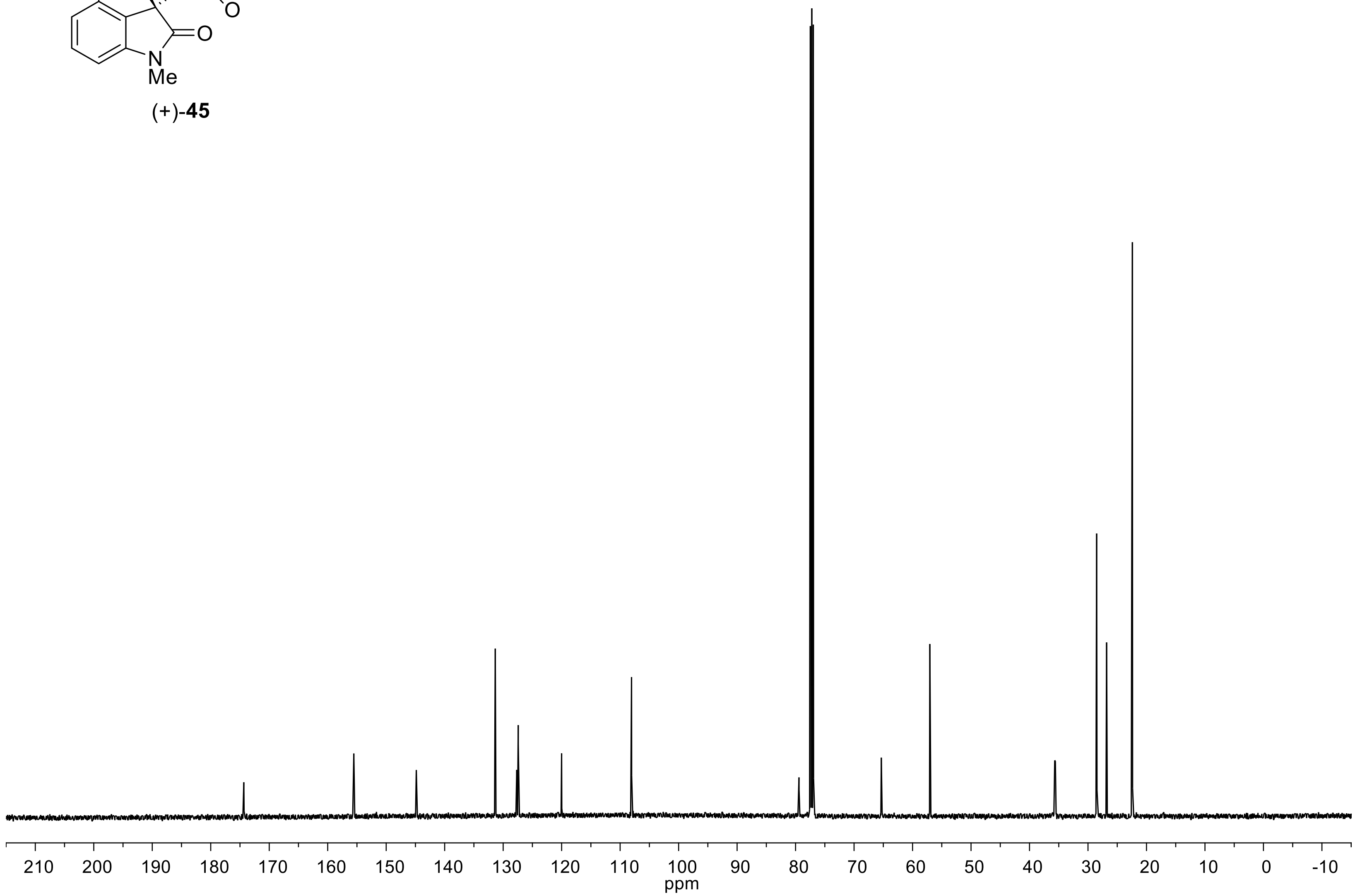
(+)-**45**



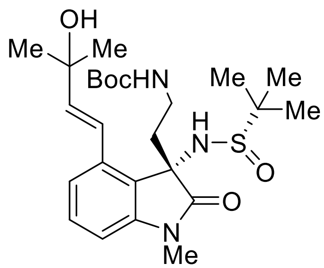
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



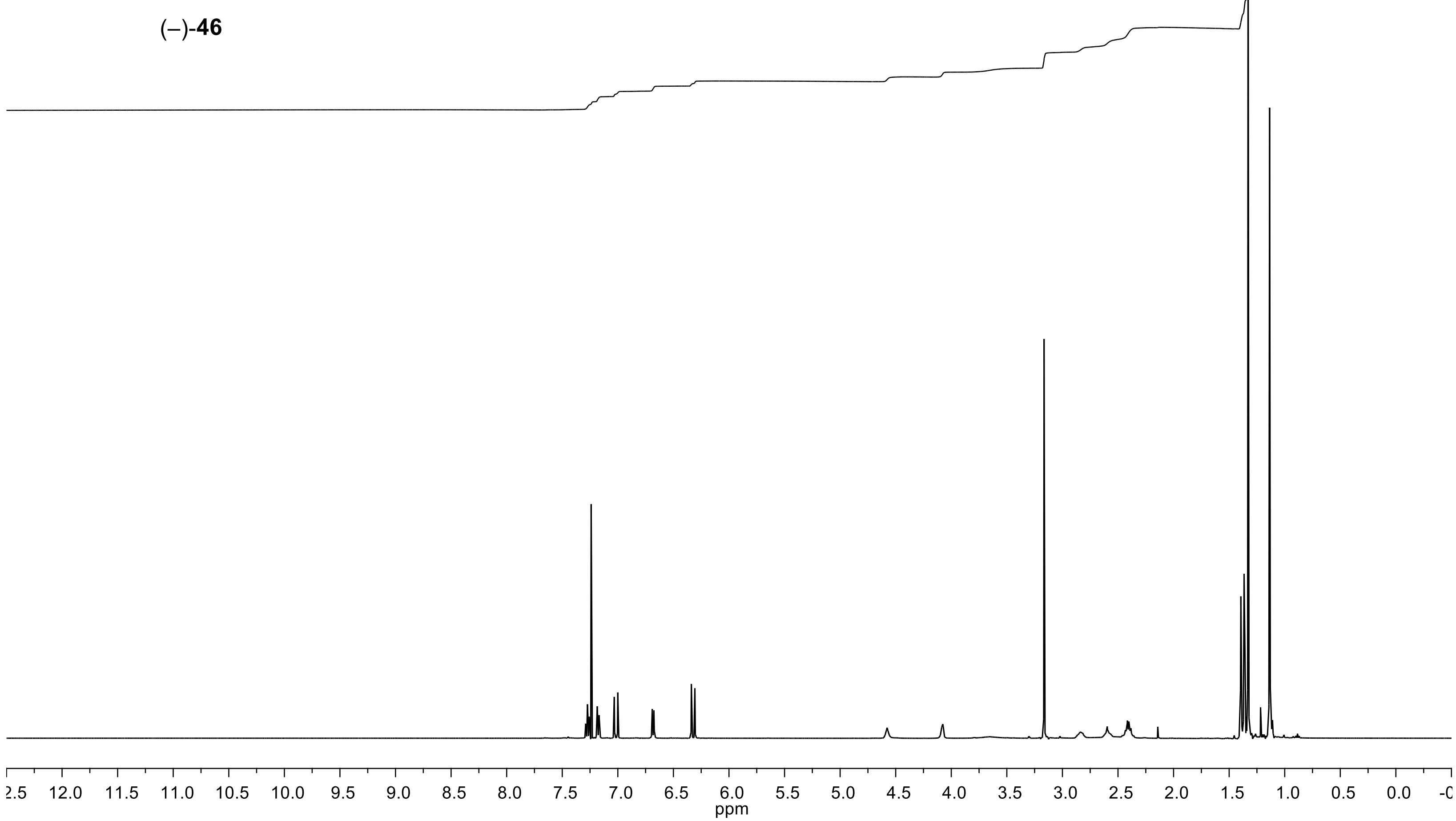
(+)-**45**



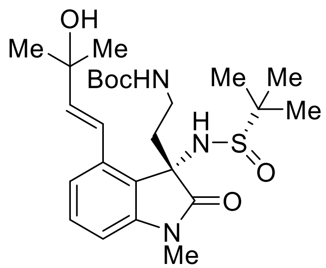
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



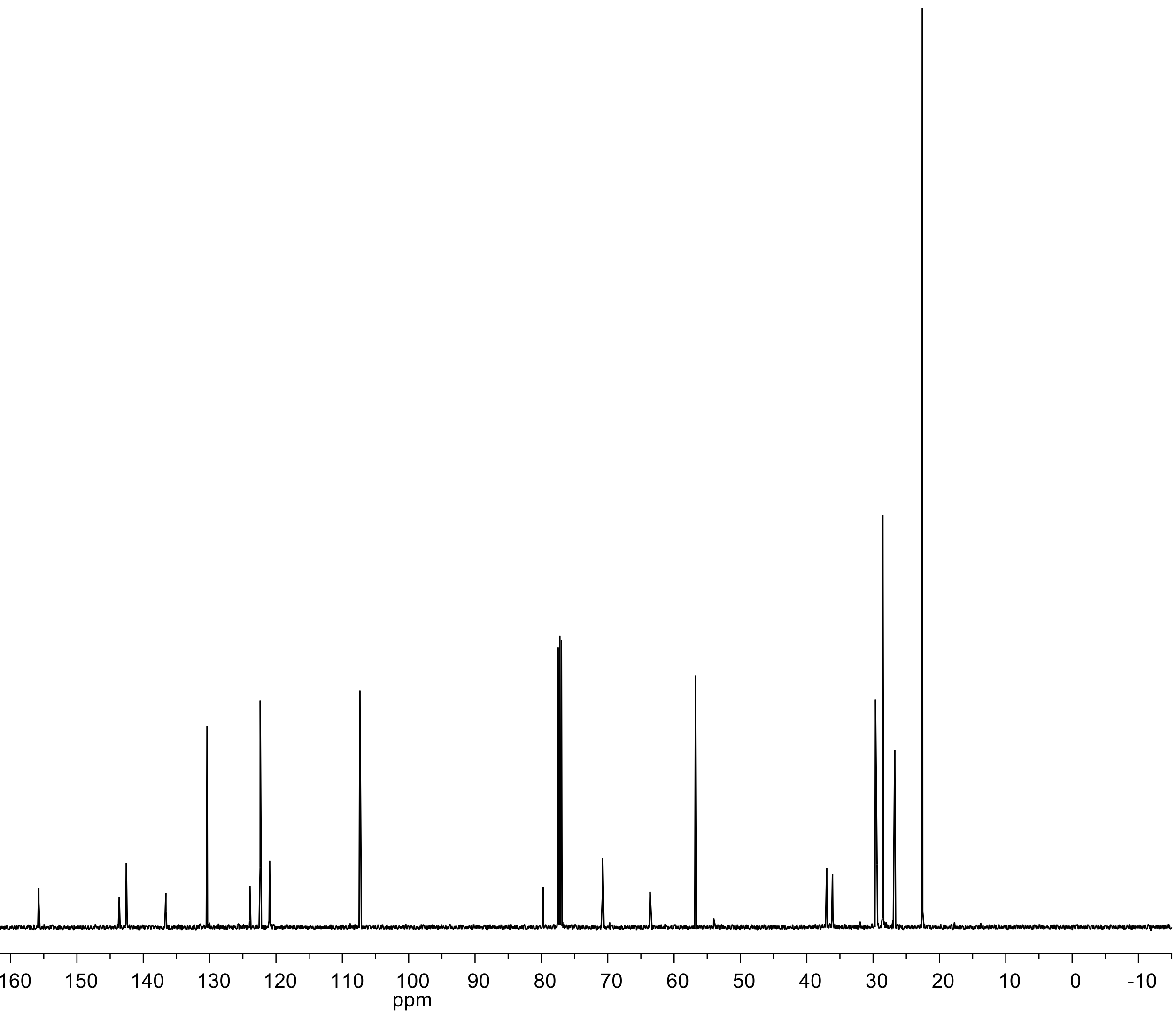
(–)-**46**



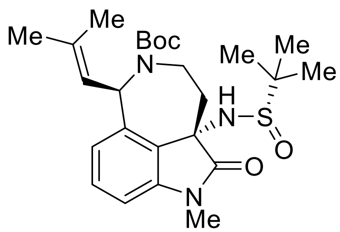
^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



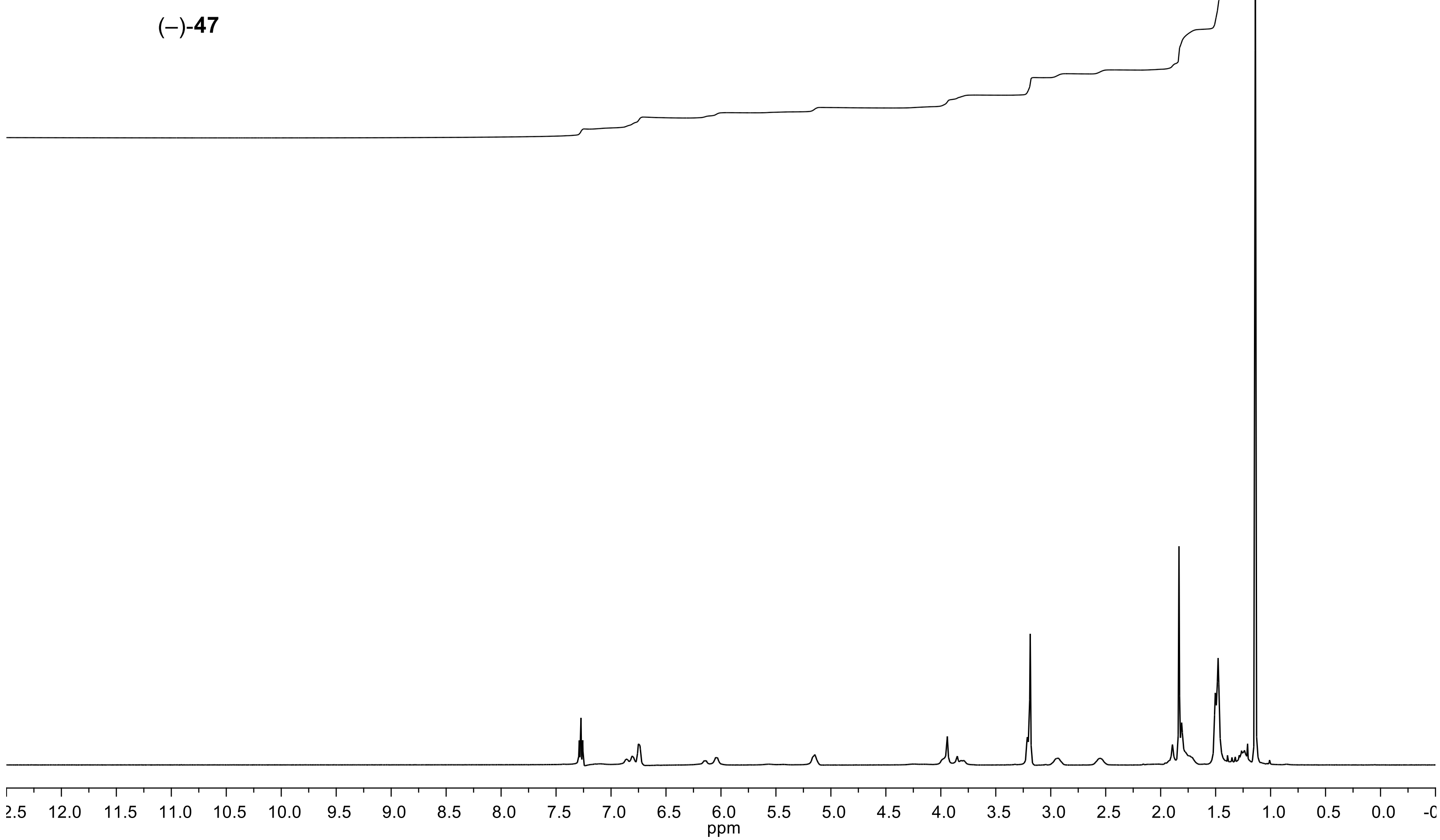
(–)-**46**



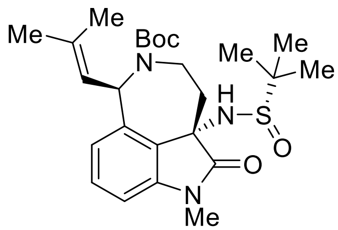
^{1}H NMR, 500 MHz, $CDCl_3$, 20 °C



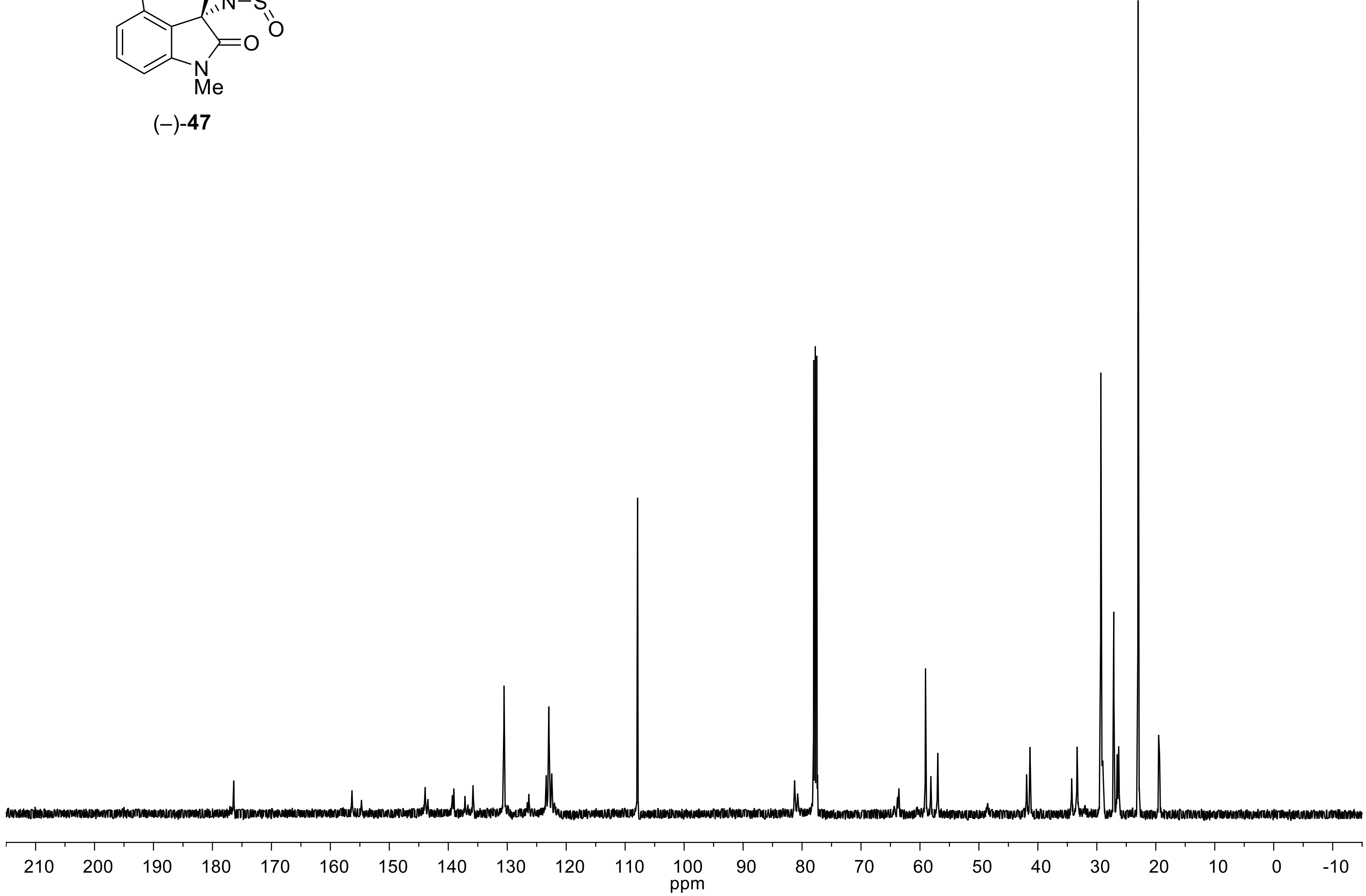
(–)-**47**



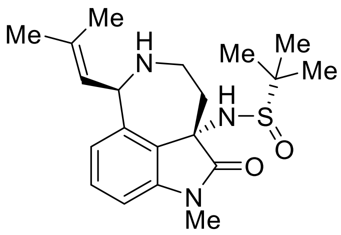
^{13}C NMR, 126 MHz, CDCl$_3$, 20 °C



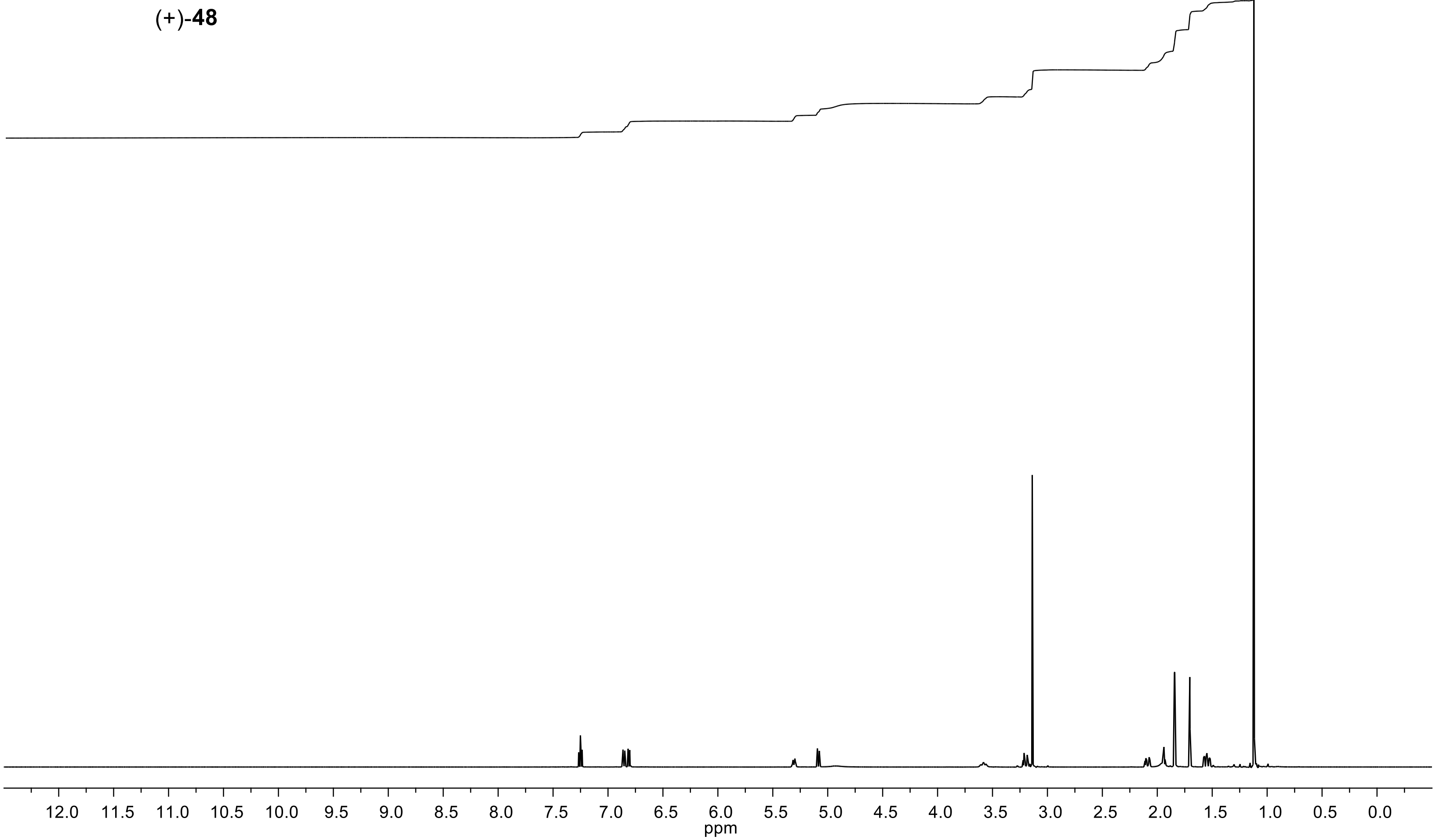
(–)-**47**



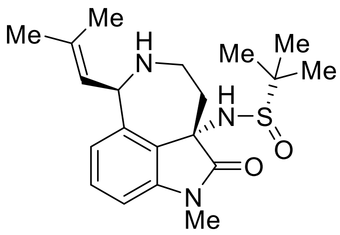
^{1}H NMR, 500 MHz, CD_3CN, 60 °C



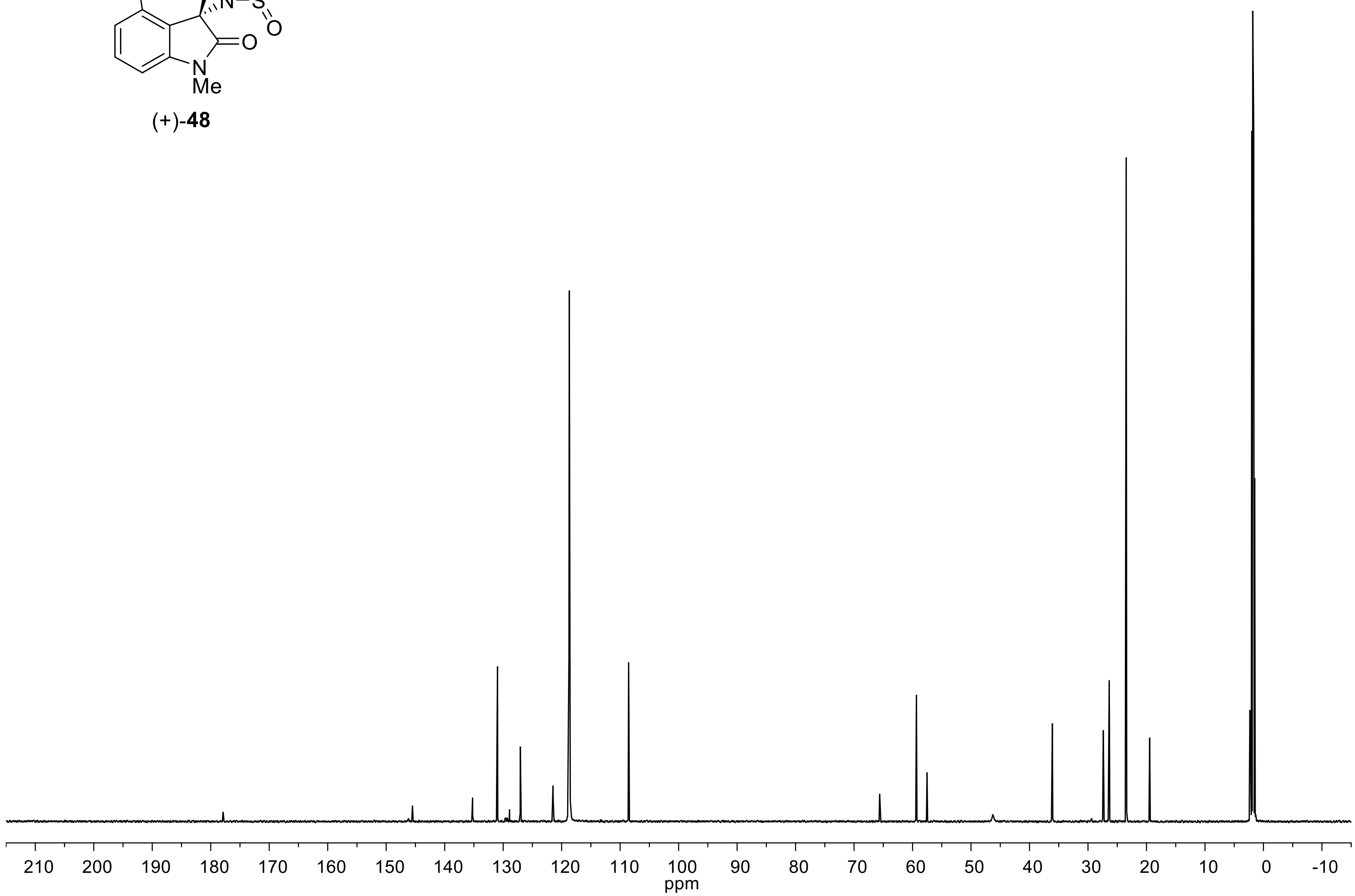
(+)-**48**



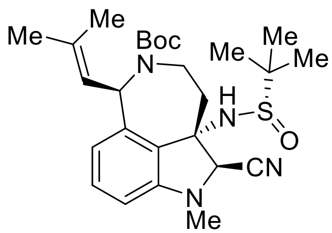
^{13}C NMR, 126 MHz, CD_3CN, 60 °C



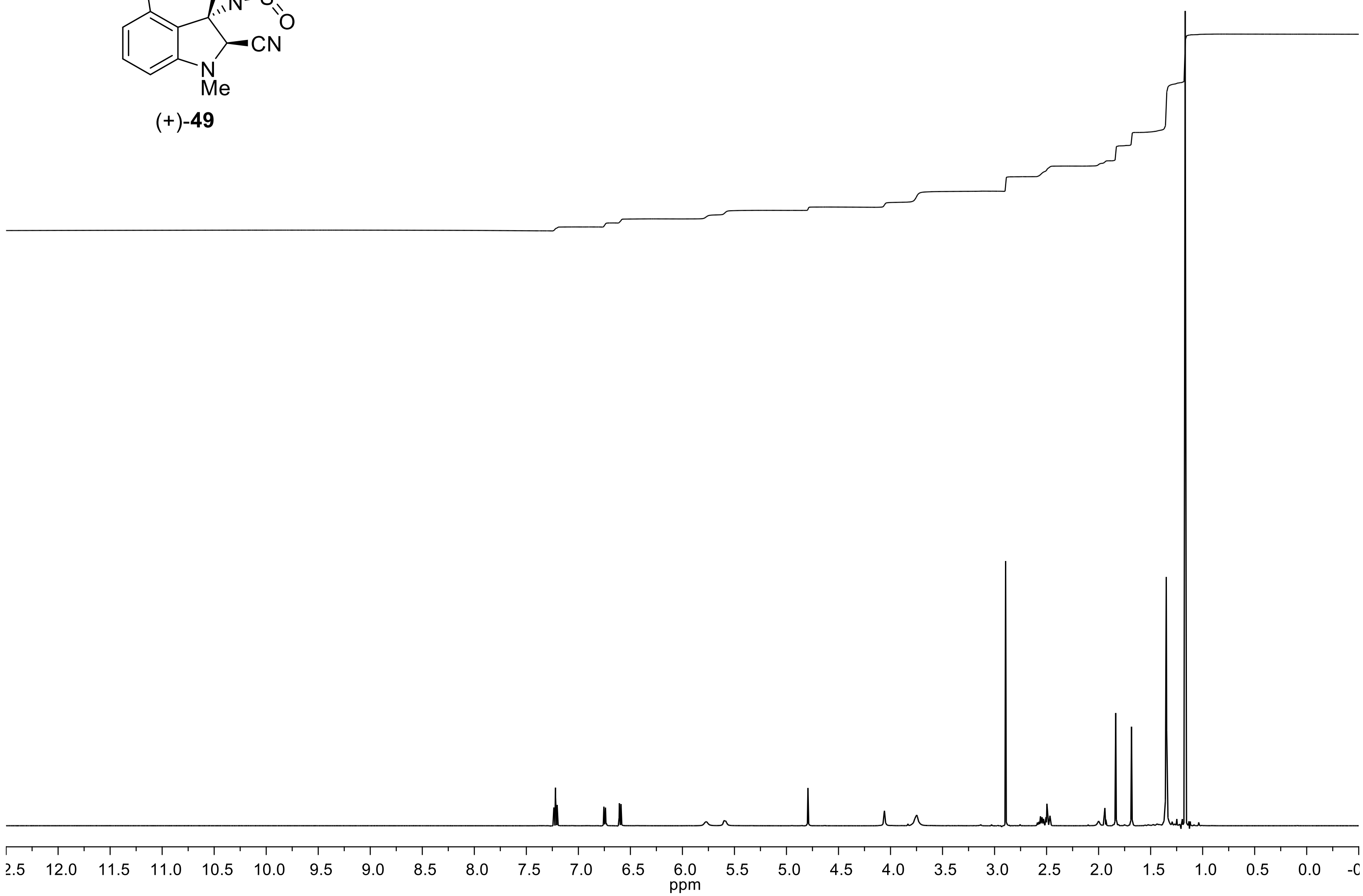
(+)-**48**



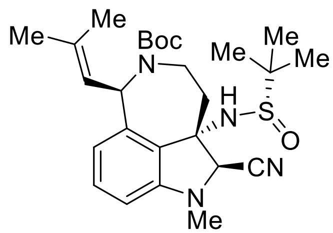
^{1}H NMR, 500 MHz, CD_3CN, 70 °C



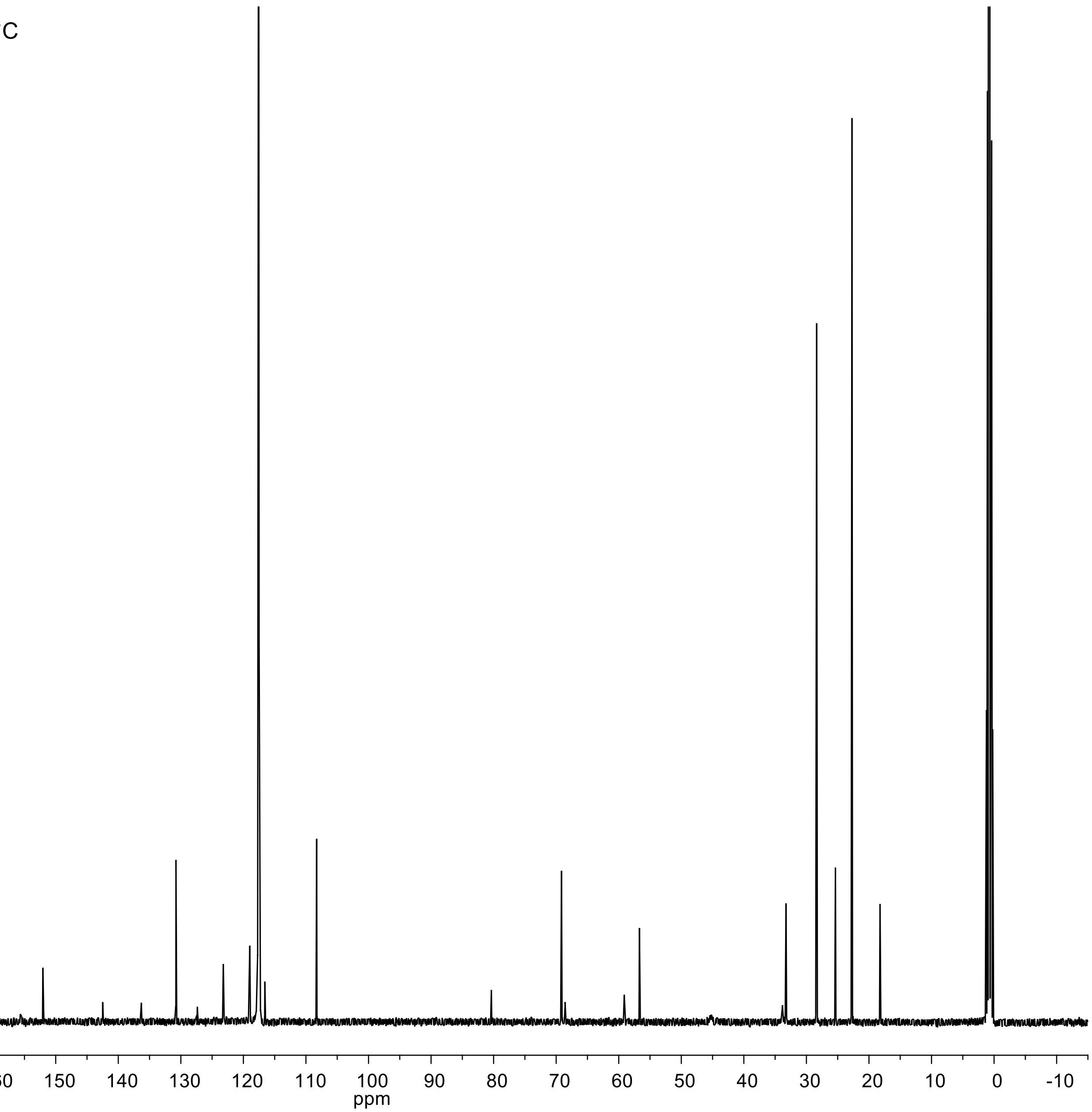
(+)-**49**



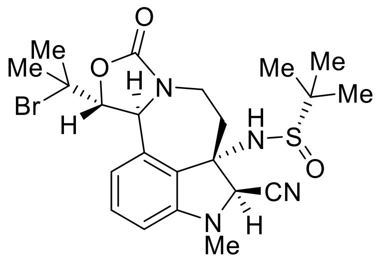
^{13}C NMR, 126 MHz, CD_3CN, 70 °C



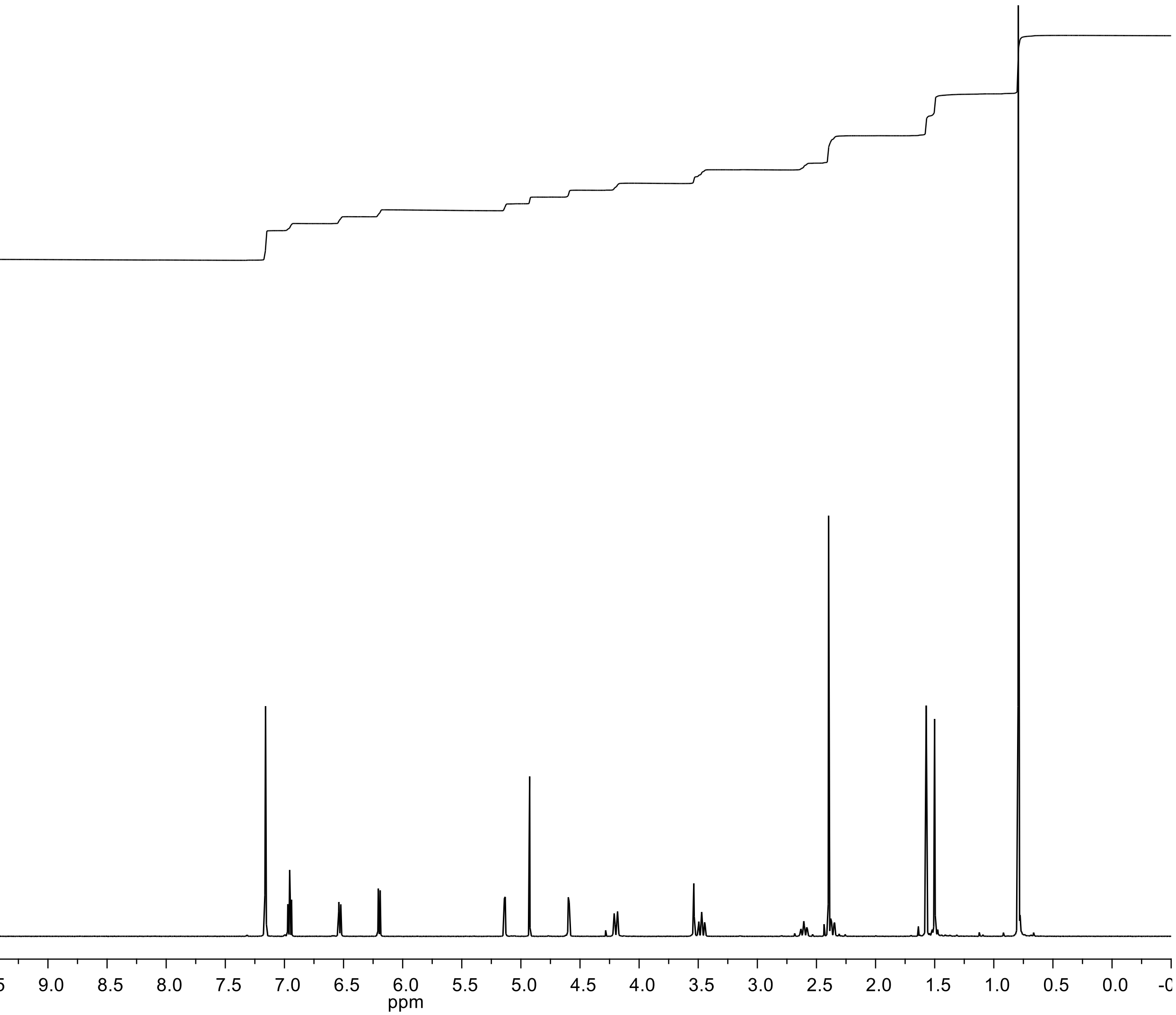
(+)-**49**



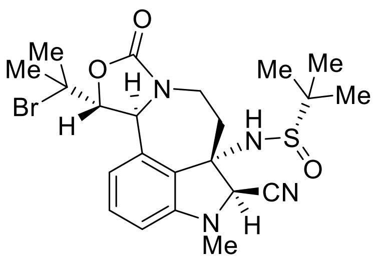
^{1}H NMR, 500 MHz, C_6D_6, 20 °C



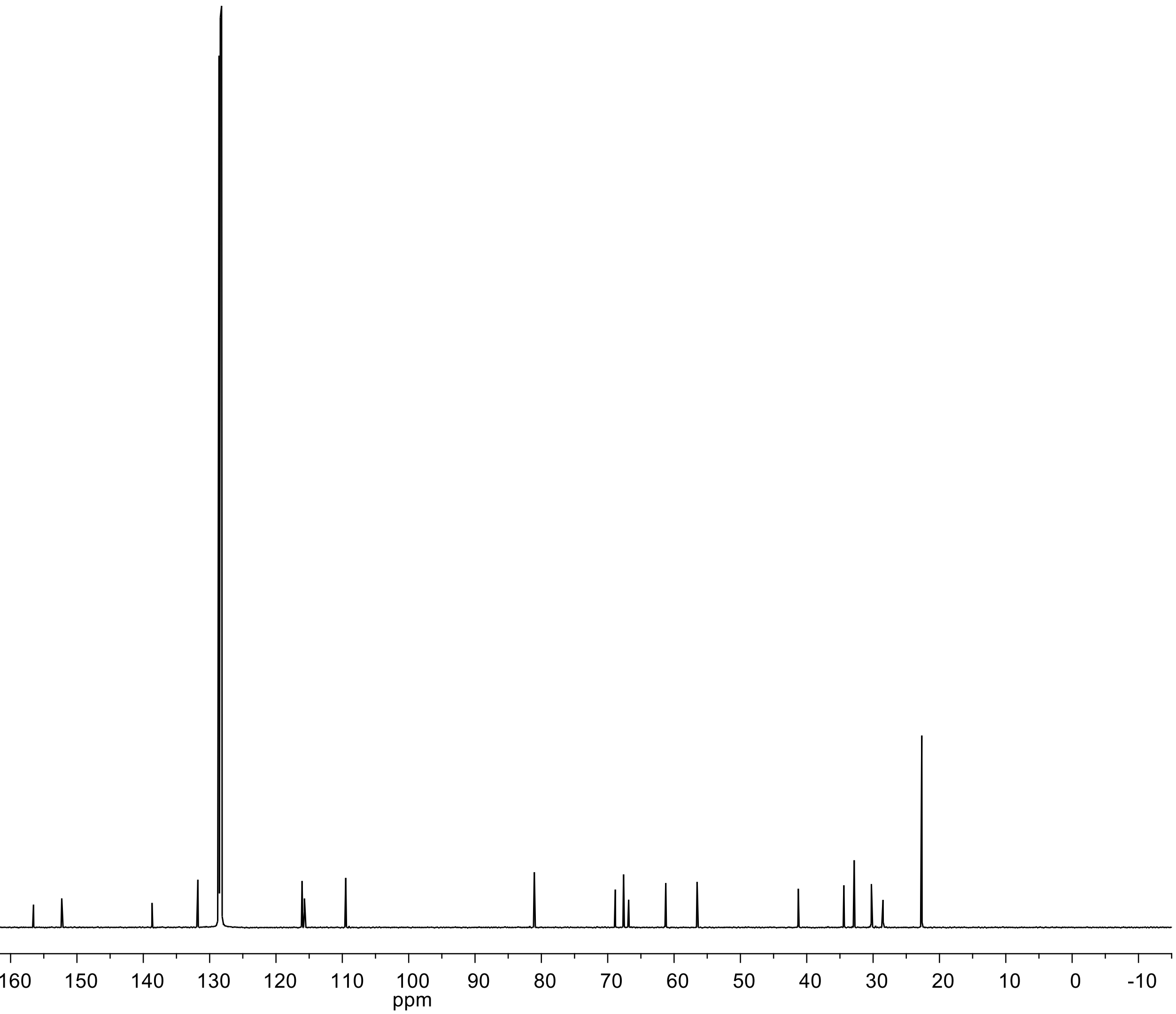
(+)-**S10**



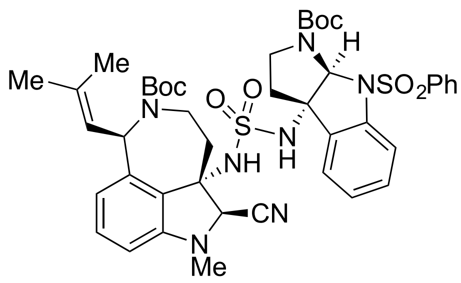
^{13}C NMR, 126 MHz, C_6D_6, 20 °C



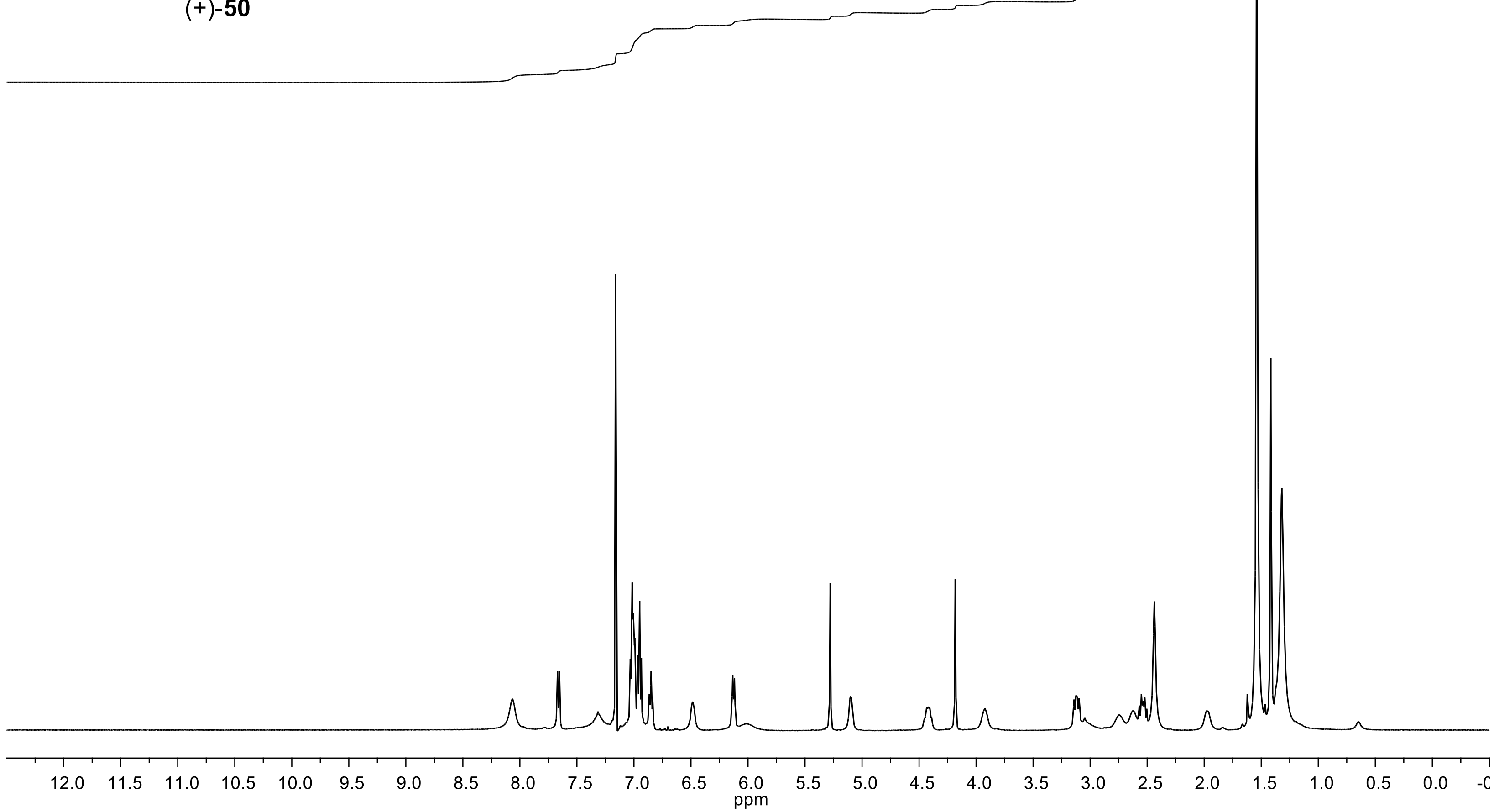
(+)-**S10**



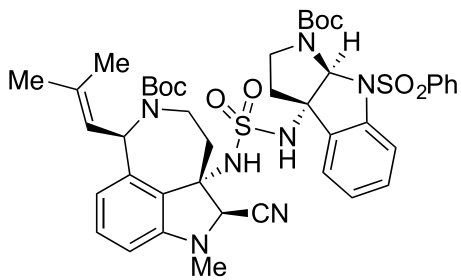
^{1}H NMR, 500 MHz, C_6D_6, 70 °C



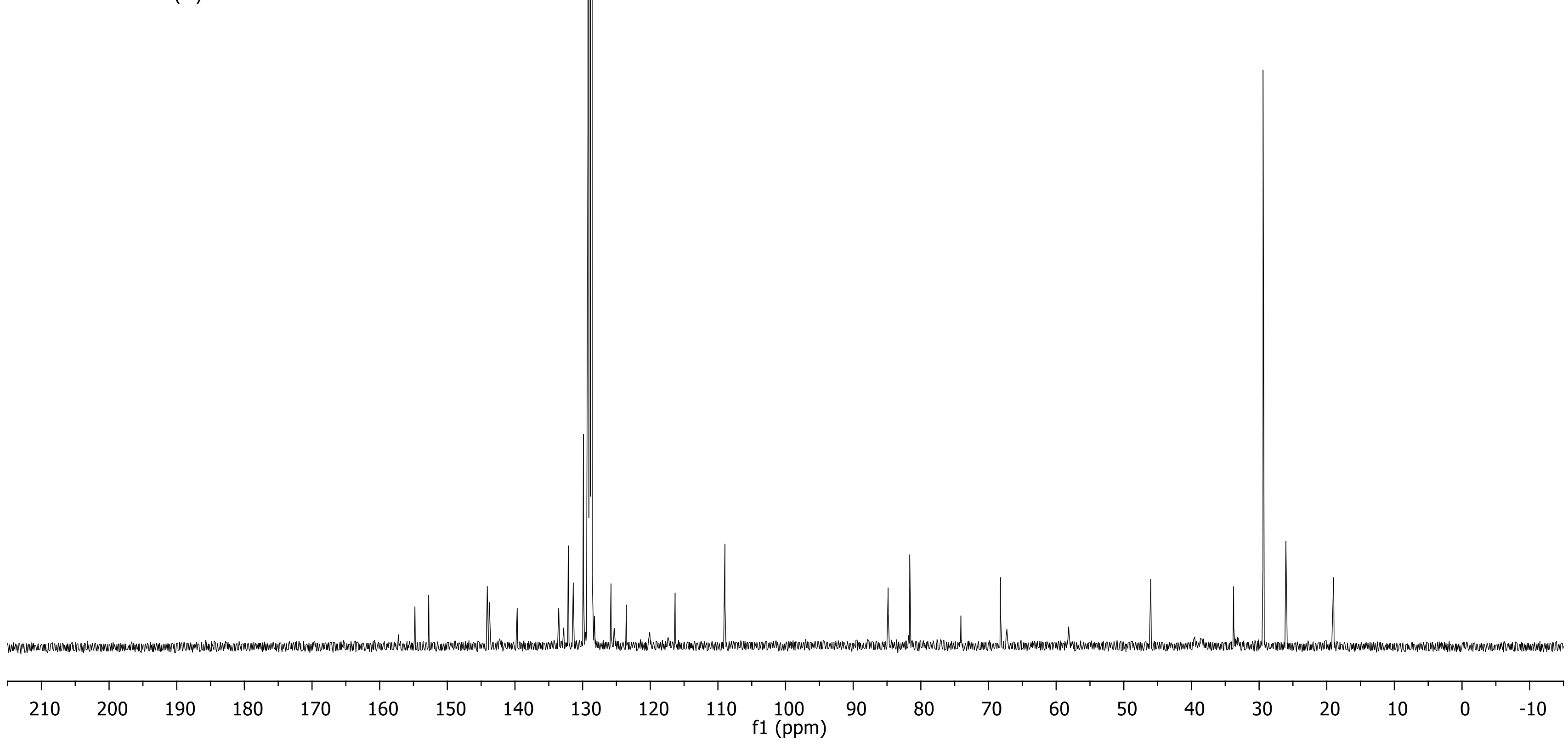
(+)-**50**



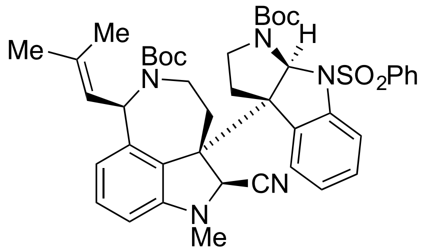
^{13}C NMR, 100 MHz, C_6D_6, 70 °C



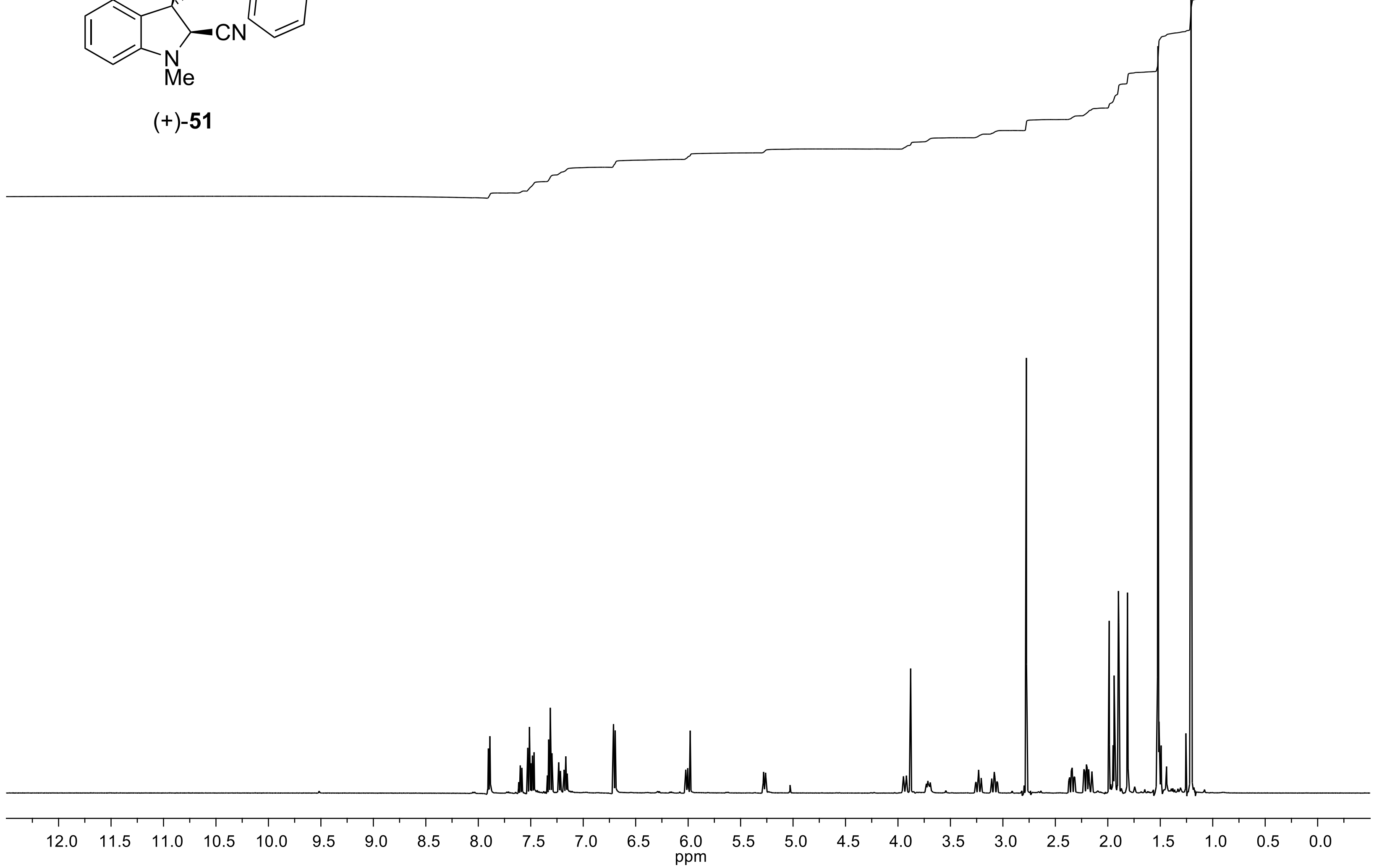
(+)-**50**



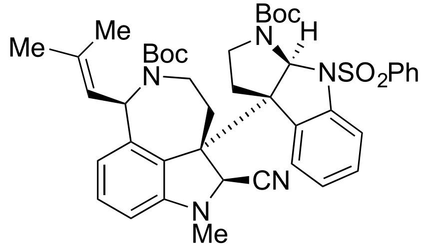
^{1}H NMR, 500 MHz, CD_3CN, 70 °C



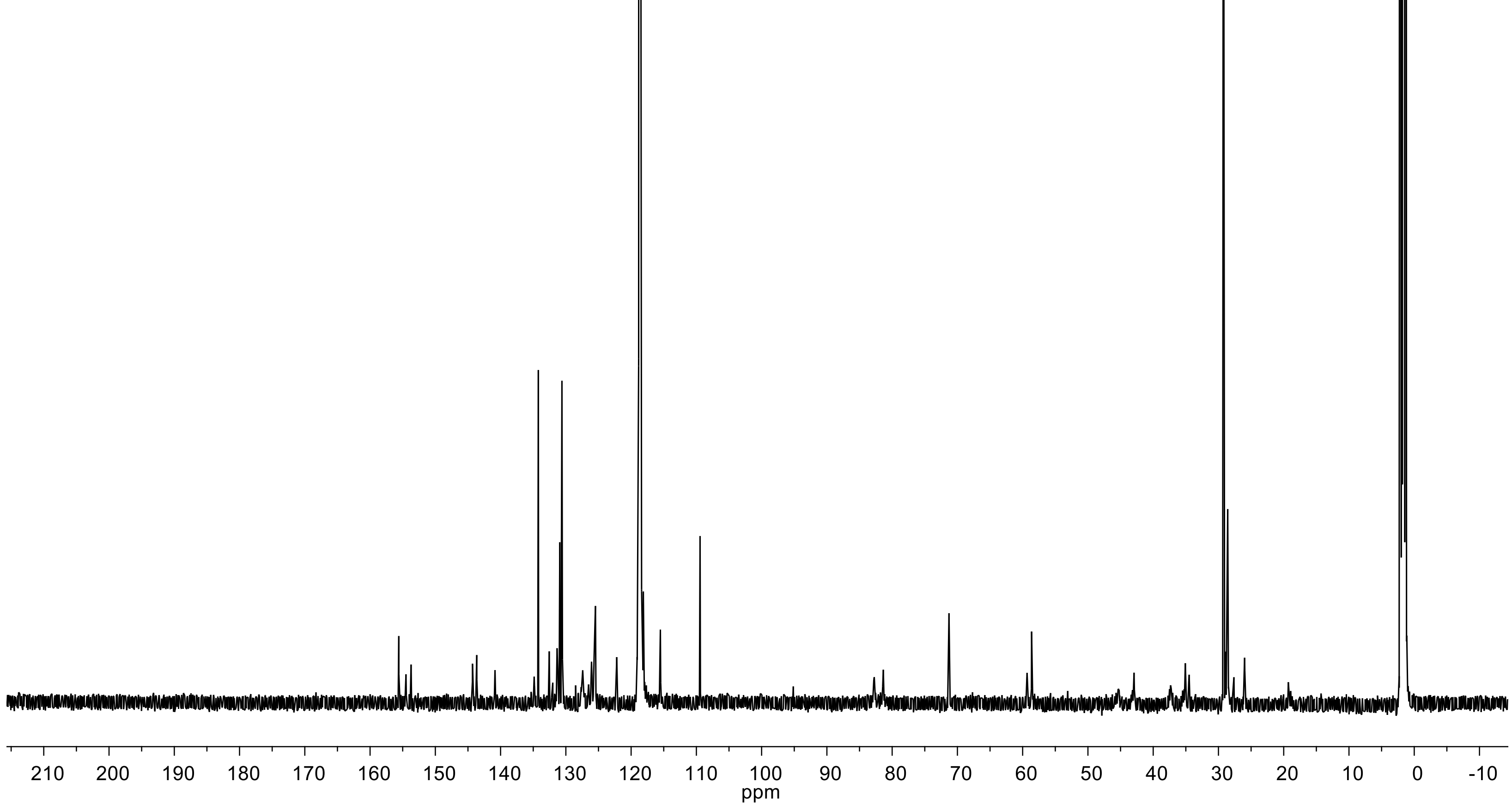
(+)-**51**



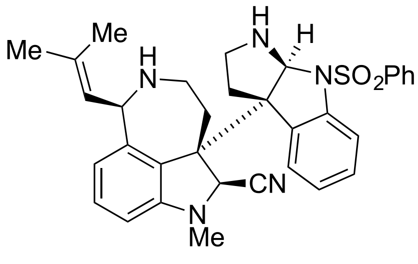
^{13}C NMR, 126 MHz, CD_3CN, 70 °C



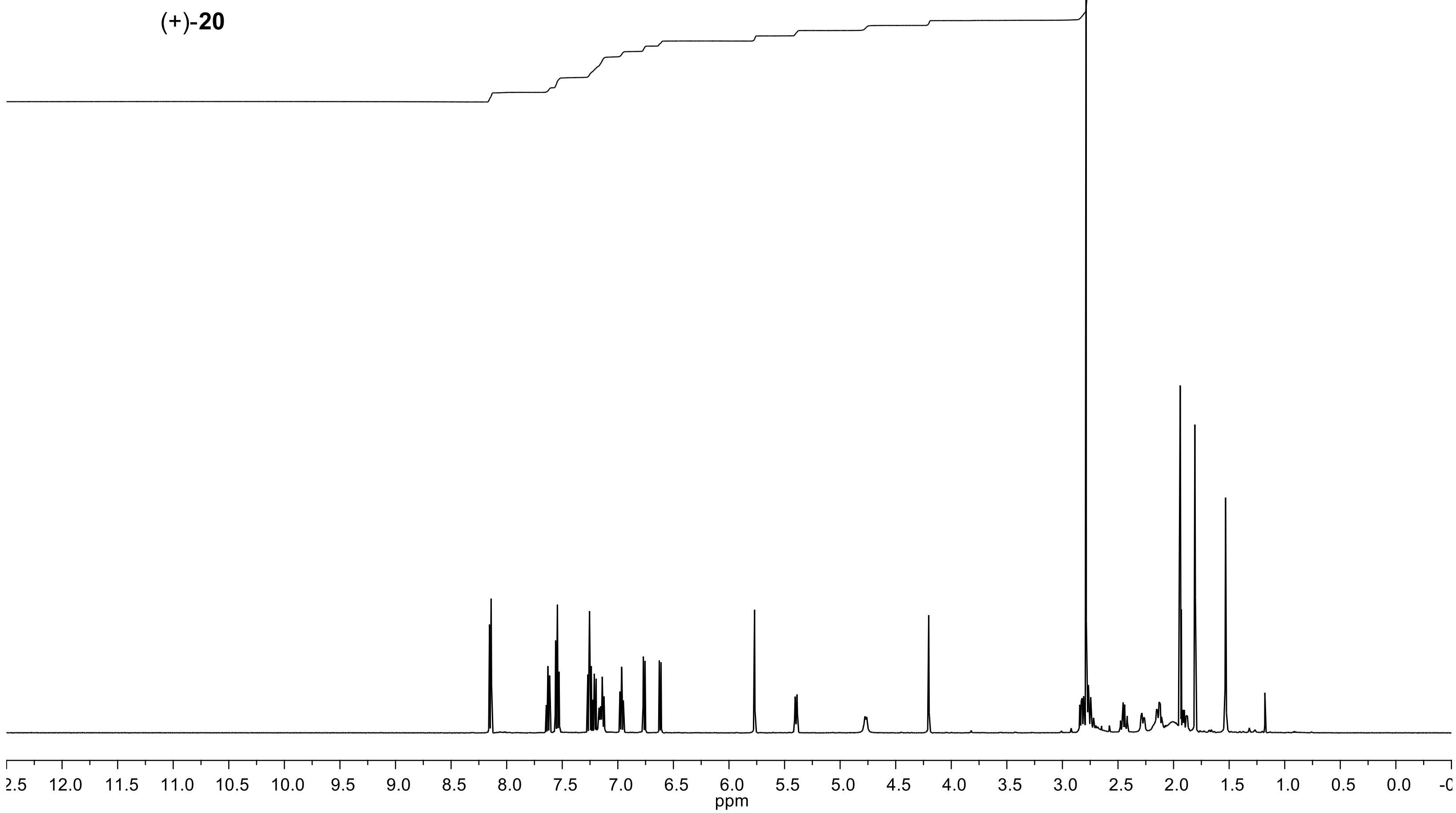
(+)-**51**



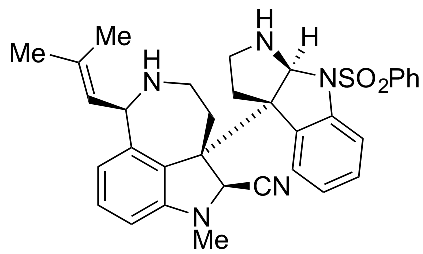
^1H NMR, 500 MHz, CD_3CN, 20 °C



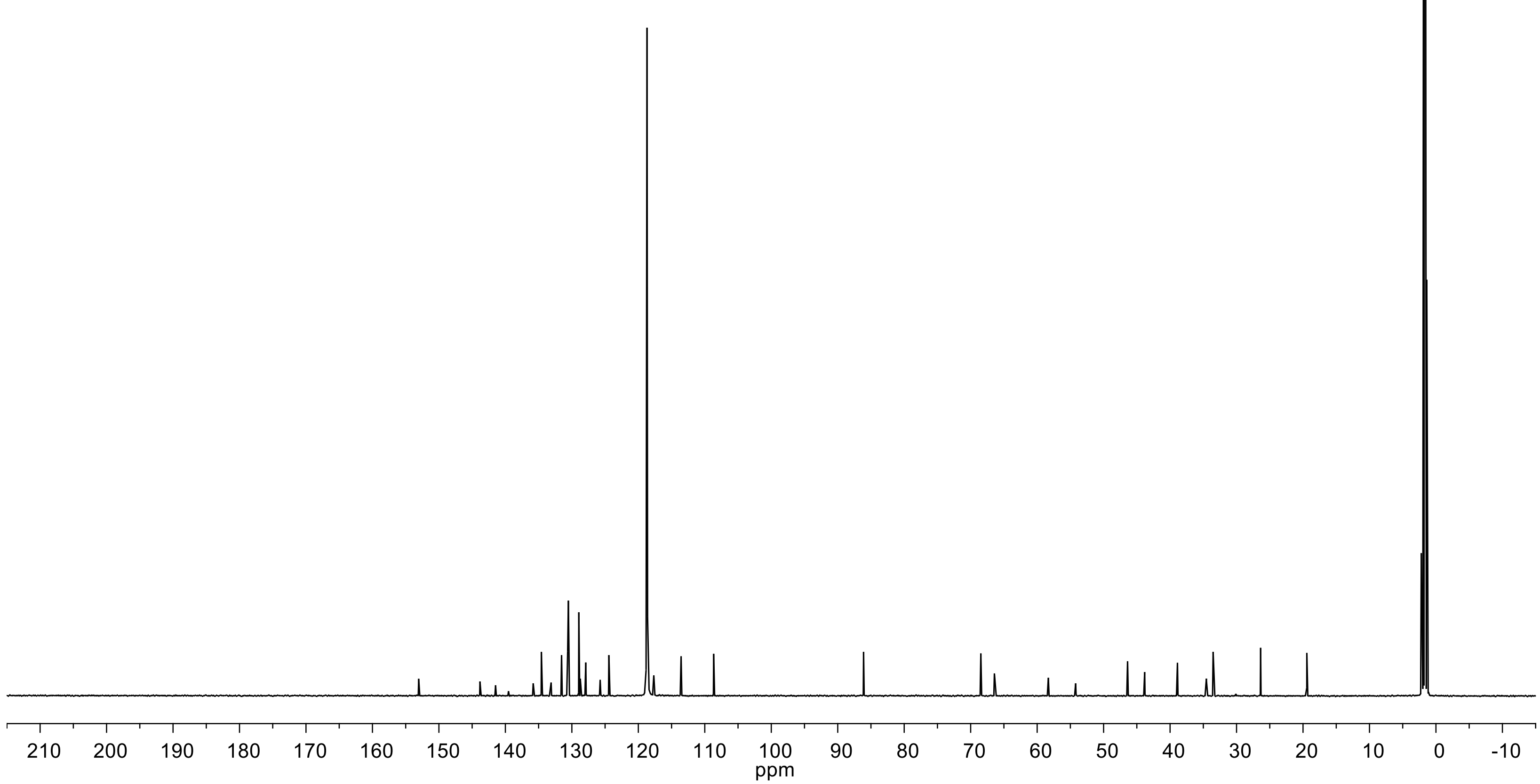
(+)-**20**



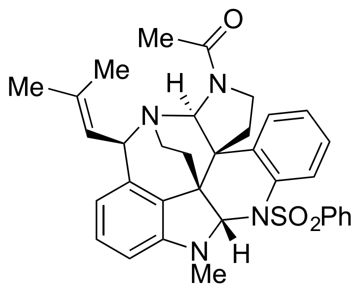
^{13}C NMR, 126 MHz, CD_3CN, 20 °C



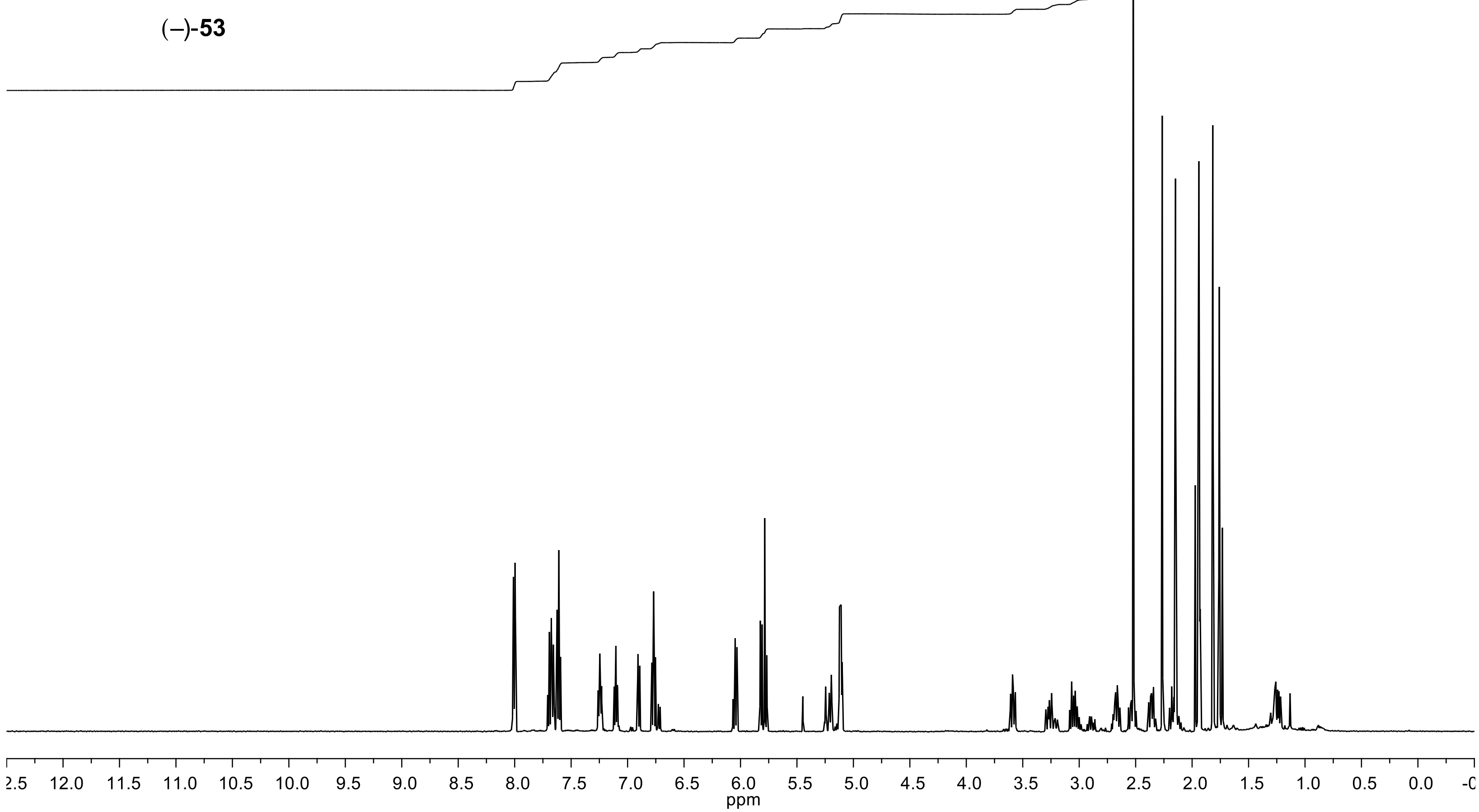
(+)-**20**



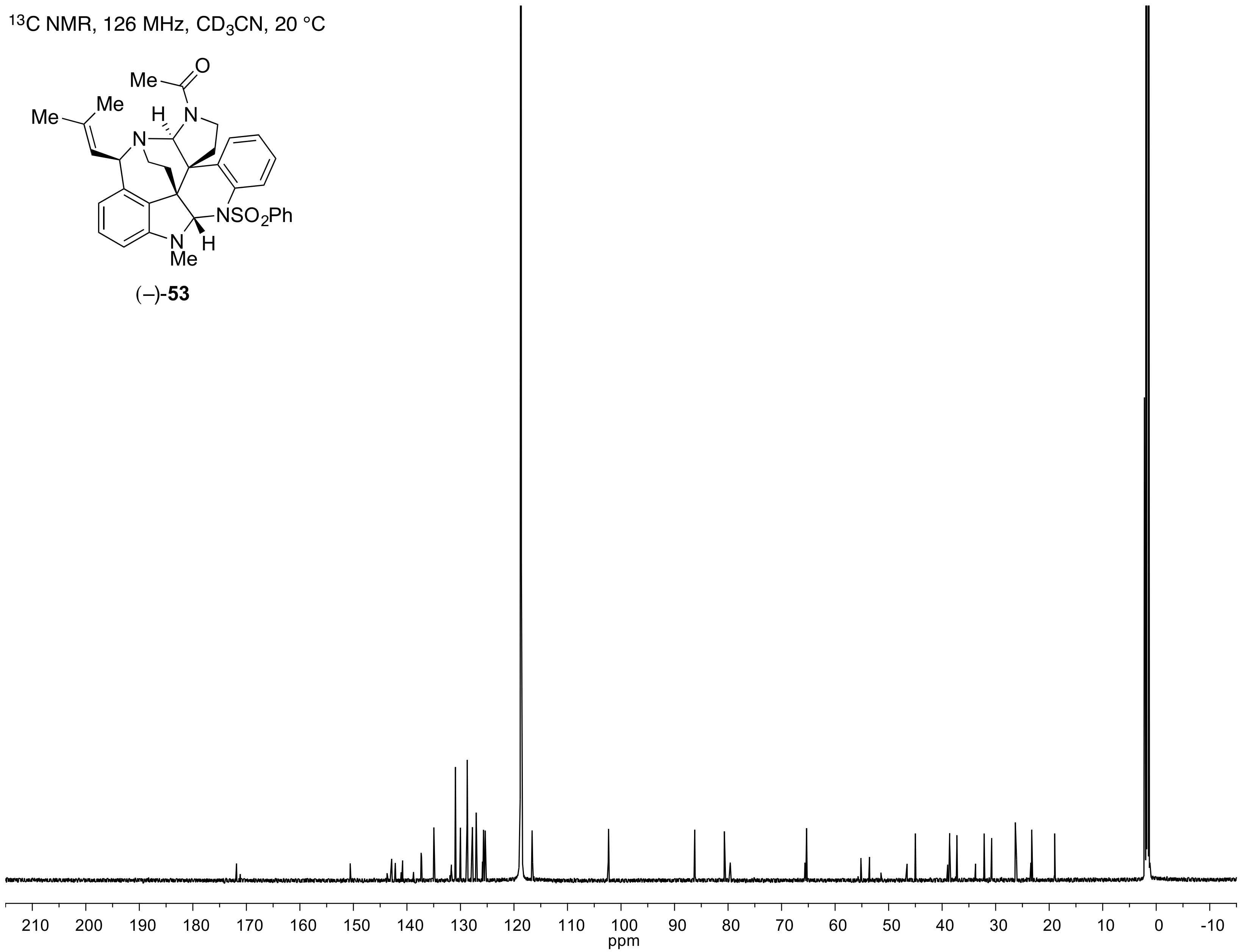
^{1}H NMR, 500 MHz, CD_3CN, 20 °C



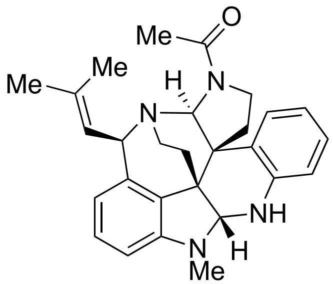
(–)-**53**



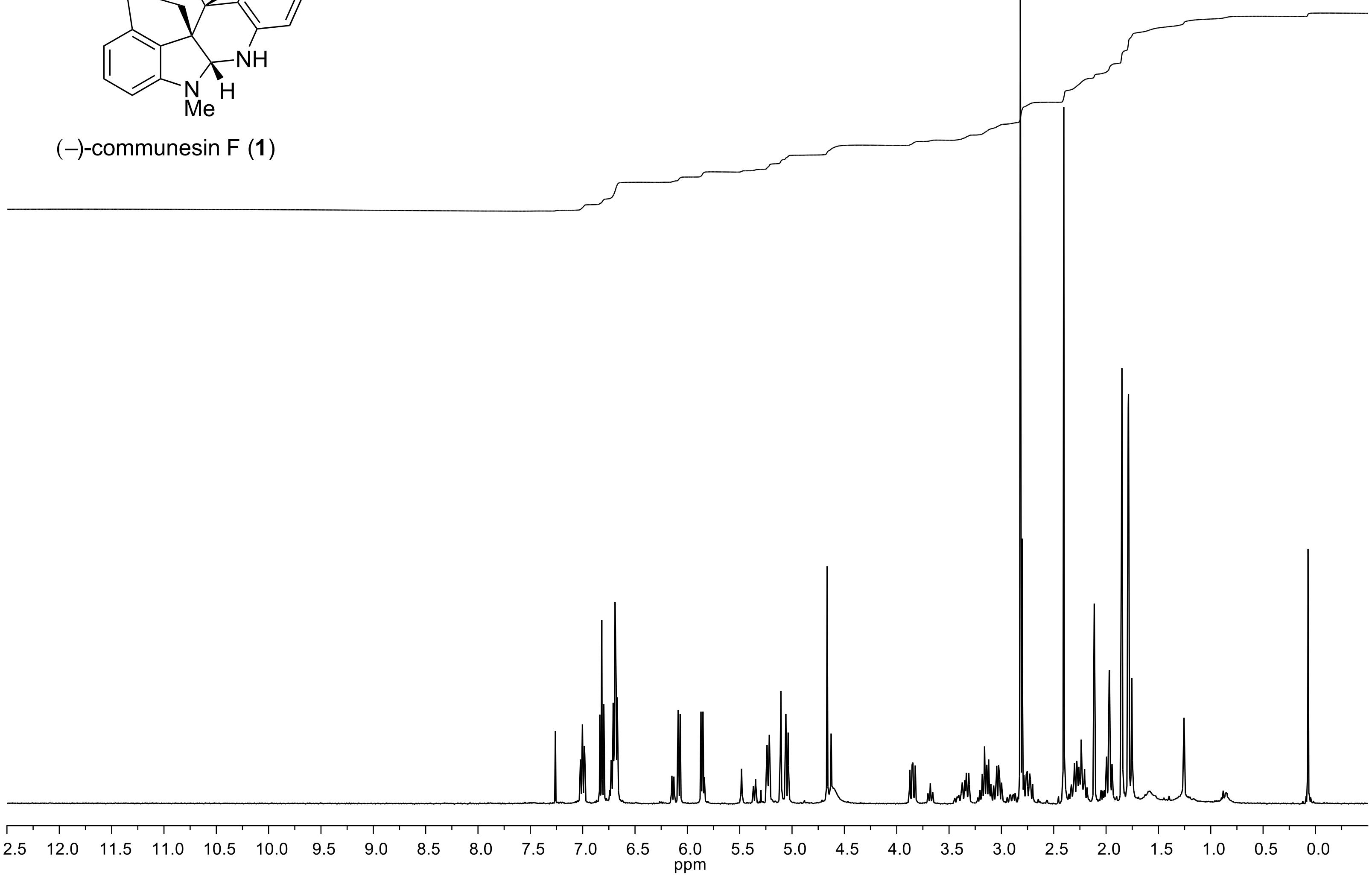
^{13}C NMR, 126 MHz, CD_3CN, 20 °C



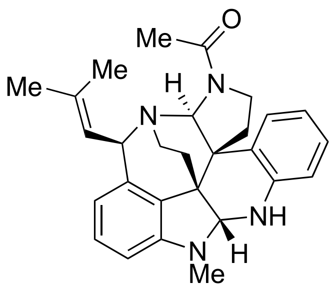
^{1}H NMR, 400 MHz, $CDCl_3$, 20 °C



(–)-communesin F (**1**)



^{13}C NMR, 126 MHz, $CDCl_3$, 20 °C



(–)-communesin F (**1**)