Total Synthesis of Dimeric Securinega Alkaloids (−)-Flueggenines D and I

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1. General Information

All reactions were performed in oven-dried or flame-dried round-bottomed flasks. Unless otherwise noted, the flasks were fitted with rubber septa and reactions were conducted under a positive pressure of argon. Stainless steel syringes or cannula were used to transfer air- and moisture-sensitive liquids. Flash column chromatography was performed as described by Still et al. using silica gel (60-Å pore size, 40–63 μm, 4-6% H_2O content, Merck).[1] Analytical thin–layer chromatography (TLC) was performed using glass plates pre-coated with 0.25 mm silica gel impregnated with a fluorescent indicator (254 nm). Thin layer chromatography plates were visualized by exposure to ultraviolet light, an aqueous ammonium cerium nitrate/ammonium molybdate (Seebach's staining),[2] and/or a basic aqueous potassium permanganate ($KMnO_4$).

Unless otherwise stated, all commercial reagents and solvents were used without additional purification with the following exceptions as indicated below. Dichloromethane and tetrahydrofuran were purchased from Merck and Daejung Inc., respectively and were purified by the method of Grubbs et al. under positive argon pressure.[3]

^1H and ^{13}C nuclear magnetic resonance spectra were recorded with Bruker Ascend 400 (400 MHz), Bruker Avance III HD Nano bay (400 MHz), Agilent Technologies DD2 (600 MHz), or Bruker AVANCE III HD (800MHz) and calibrated by using the residual undeuterated chloroform (δ_H= 7.24 ppm) and $CDCl_3$ (δ_C= 77.23 ppm) as internal references. Data are reported in the following manners: chemical shift in ppm [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, app = apparent, br = broad), coupling constant(s) in Hertz, integration]. Unless otherwise stated, all nuclear magnetic resonance experiment was carried out at room temperature. 800 MHz NMR experiments were operated by E. H. Kim at Korea Basic Science Institute. High resolution mass spectra were obtained from KAIST Analysis Center for Research (Daejeon) or Korea Basic Science Institute (SYNAPT G2, operated by J. H. Choi) by using ESI method. Specific rotation $[\alpha]_D^T$ was obtained by JASCO P-2000 polarimeter.

[1] W. C. Still, M. Kahn and A. Mitra, *J. Org. Chem*., 1978, **43**, 2923–2925.

[2] D. Seebach, R. Imwinkelried and G. Stucky, *Helv. Chim. Acta.*, 1987, **70**, 448–464.

[3] A. B. Pangborn, M. A. Giardello, R. H. Grubbs, R. K. Rosen and F. J. Timmers, *Organometallics.*, 1996, **15**, 1518–1520.

2. High-Order Securinega Alkaloids with Rauhut–Currier Reaction-based Linkages

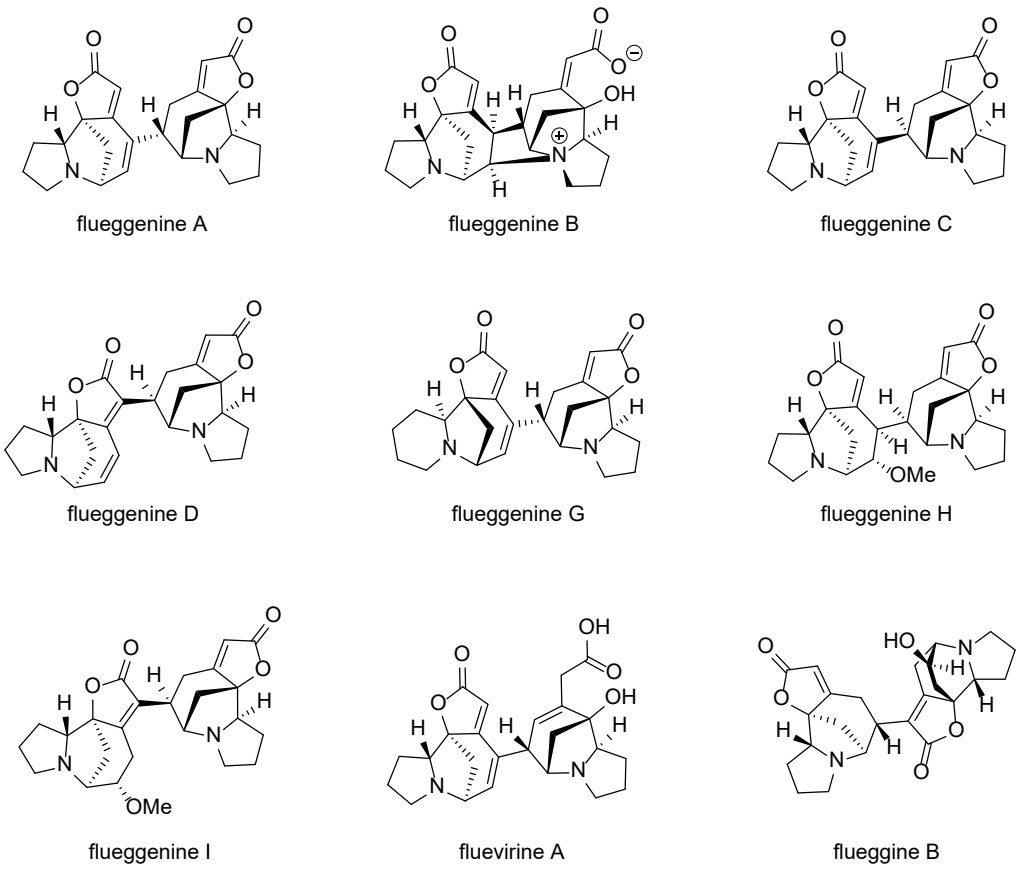


Figure S1. Dimeric Securinega Alkaloids with Rauhut–Currier Reaction-based Linkage.[4]

[4] (a) L.-S. Gan, C.-Q. Fan, S.-P. Yang, Y. Wu, L.-P. Lin, J. Ding and J.-M. Yue, *Org. Lett.*, 2006, **8**, 2285–2288. (b) B.-X. Zhao, Y. Wang, D.-M. Zhang, R.-W. Jiang, G.-C. Wang, J.-M. Shi, X.-J. Huang, W.-M. Chen, C.-T. Che and W.-C. Ye, *Org. Lett*., 2011, **13**, 3888−3891. (c) H. Zhang, W. Wei and J.-M. Yue, *Tetrahedron,* 2013, **69**, 3942–3946. (d) H. Zhang, C.-R. Zhang, Y.-S. Han, M. A. Wainberg and J.-M. Yue, *RSC Adv.,* 2015, **5**, 107045–107053. (e) X.-H. Li, M.-M. Cao, Y. Zhang, S.-L. Li, Y.-T. Di and X.-J. Hao, *Tetrahedron Lett*., 2014, **55**, 6101–6104.

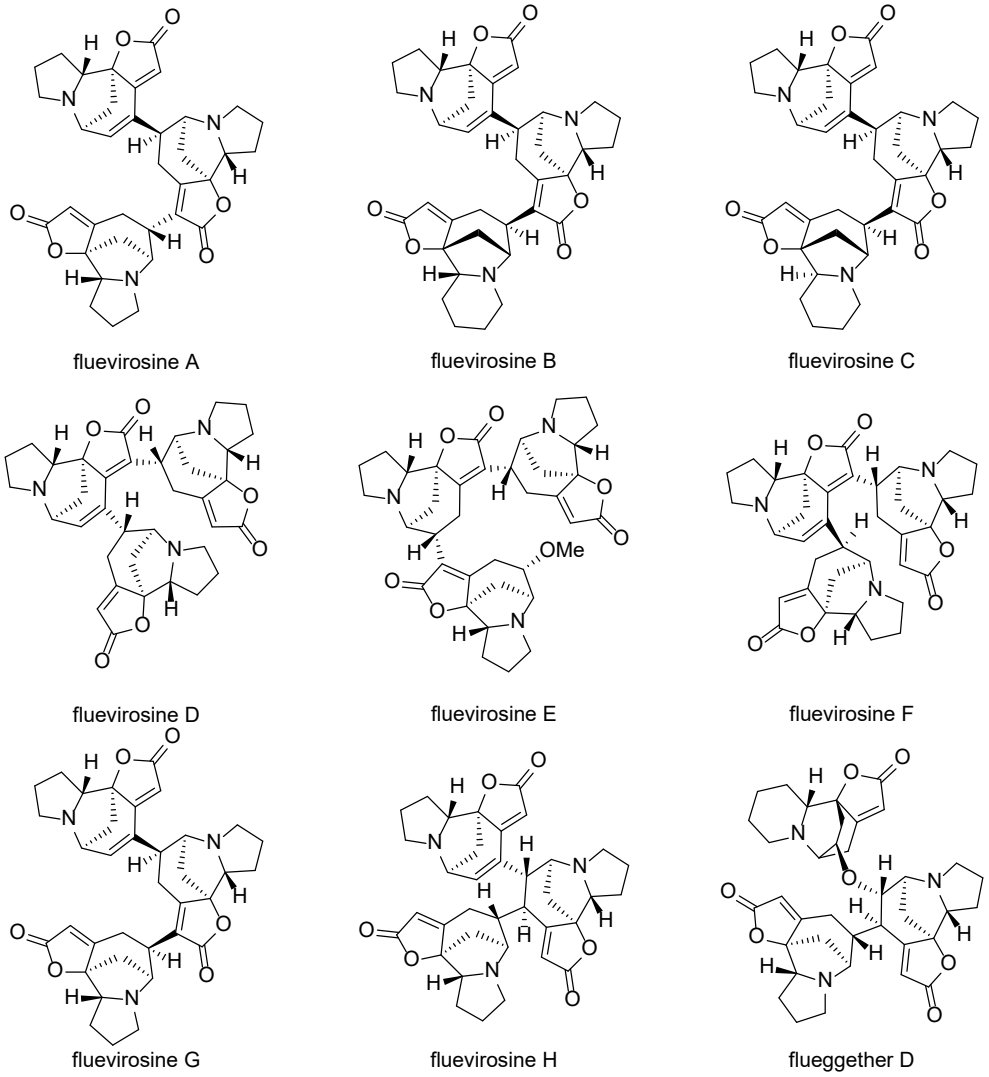


Figure S2. Trimeric Securinega Alkaloids with Rauhut–Currier Reaction-based Linkage.[4,5]

[5] (a) H. Zhang, C.-R. Zhang, K.-K. Zhu, A.-H. Gao, C. Luo, J. Li, and J.-M. Yue, *Org*. *Lett*., 2013, **15**, 120−123. (b) H. Zhang, Y.-S. Han, M. A. Wainberg, and J.-M. Yue, *Tetrahedron Lett*., 2016, **57**, 1798–1800.

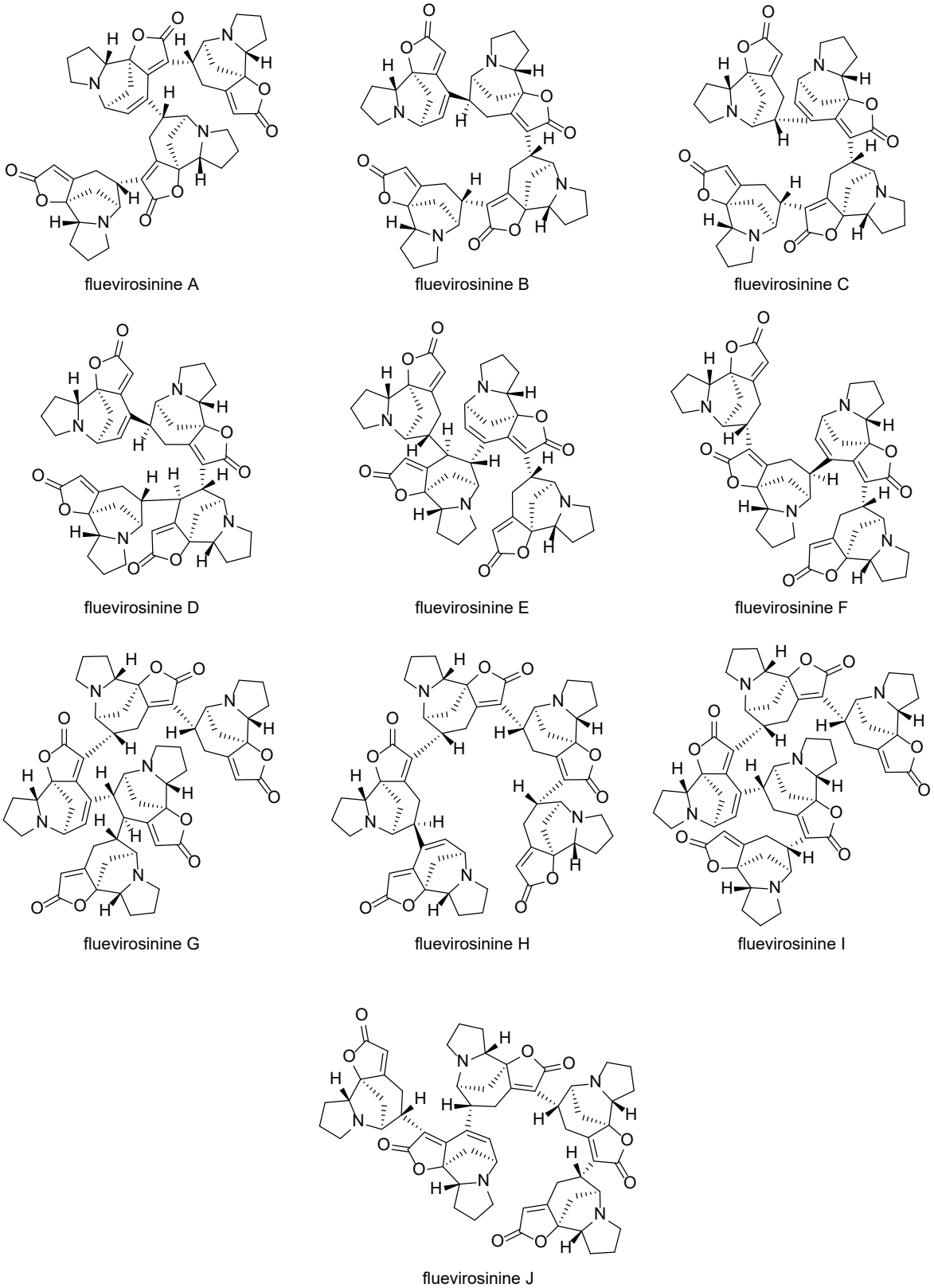
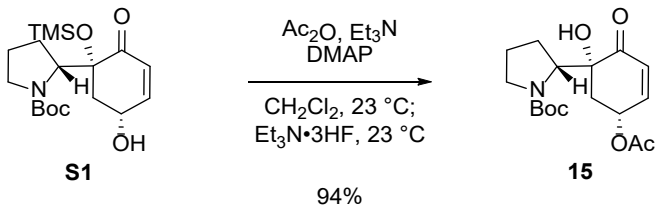


Figure S3. Tetrameric and Pentameric Securinega Alkaloids with Rauhut–Currier Reaction-based Linkage.[4,5,6]

[6] H. Zhang, Y.-S. Han, M. A. Wainberg and J.-M. Yue, *Tetrahedron*, 2015, **71**, 3671−3679.

3. Optimized Synthetic Procedure for the Preparation of γ-Acetoxy Enone 15



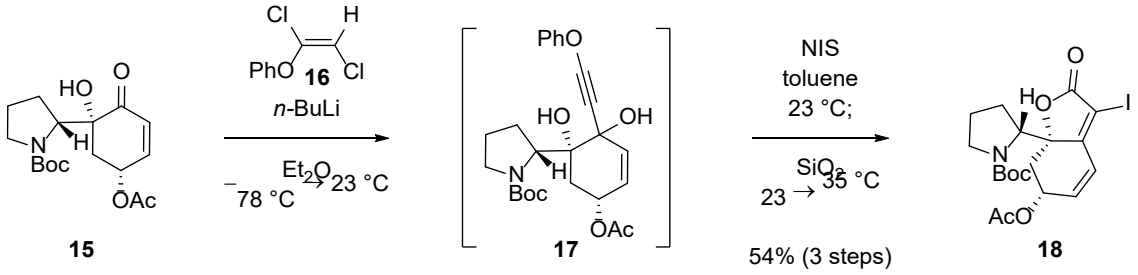
(+)-γ-Acetoxy enone 15:[7,8]

Triethylamine (2.49 mL, 17.86 mmol, 6.0 equiv.), 4-(dimethylamino)pyridine (36 mg, 0.30 mmol, 0.1 equiv.) and acetic anhydride (860 μL, 8.93 mmol, 3.0 equiv.) were added to a stirred solution of **S1**[7] (1.1 g, 2.98 mmol, 1 equiv.) in dichloromethane (30 mL) at 23 °C. After 30 min, triethylamine trihydrofluoride (2.91 mL, 17.86 mmol, 6.0 equiv.) was added. After 12 h, the reaction was quenched with saturated aqueous sodium bicarbonate solution (30 mL) and 5% aqueous copper sulfate solution (2 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 5 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 2) to afford **15** (951 mg, 94%) as a colorless oil.

[7] S. Jeon and S. Han, *J. Am. Chem. Soc.,* 2017, **139**, 6302–6305.

[8] In ref 7, γ-acetoxy enone **15** was accessed from **S1** in a two-step sequence that involves a desilylation and an acetylation. Herein, we optimized this two-step sequence to a single step procedure.

4. Experimental Procedures and Physical Data for Newly Synthesized Compounds



(–)-Iodobutenolide 18:

n-BuLi (1.8 M in cyclohexane, 2.51 mL, 4.53 mmol, 4.8 equiv.) was added to a stirred solution of 1,2-dichlorovinyl ether **16** (428 mg, 2.26 mmol, 2.4 equiv.) in anhydrous diethyl ether (5 mL) at –78 °C under an atmosphere of argon. After 10 min, the resulting mixture was warmed to –20 °C. After 2 h, the reaction mixture was cooled to –78 °C and a solution of **15** (320 mg, 0.94 mmol, 1 equiv.) in anhydrous diethyl ether (5 mL) was added. The resulting mixture was slowly warmed to 23 °C. After 1 h, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous toluene (10 mL). *N*-Iodosuccinimide (318 mg, 1.41 mmol, 1.50 equiv.) was added at 23 °C while stirring. After 1 h, excess SiO_2 (3 g) was added and the reaction mixture was heated to 35 °C. After 24 h, the resulting mixture was filtered through a pad of celite and concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 12 cm; eluent: ethyl acetate : hexanes = 1 : 4) to afford **18** as a yellow oil (250 mg, 54%).

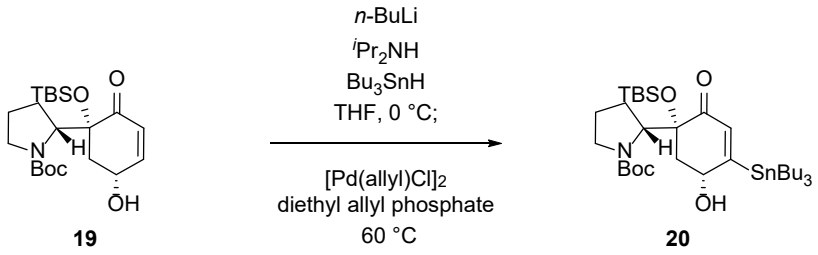
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.45 (d, *J* = 9.7 Hz, 1H), 6.35 – 6.16 (m, 2H), 4.13 (d, *J* = 8.2 Hz, 1H), 3.61 – 3.49 (m, 1H), 3.36 (ddd, *J* = 11.0, 8.7, 4.2 Hz, 1H), 2.92 (dd, *J* = 6.4, *J* = 12.0 ,1H), 2.04 (s, 3H), 1.98 – 1.88 (m, 1H), 1.86 – 1.62 (m, 3H), 1.51 – 1.43 (m, 1H), 1.45 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 170.0, 169.2, 167.2, 156.2, 139.0, 123.3, 91.9, 80.5, 79.2, 69.2, 60.4, 47.6, 37.5, 28.6 (3), 25.6, 24.8, 21.2.

HRMS (ESI): Calculated for $C_{19}H_{24}INO_6$ $[M+Na]^+$: 512.0541, found: 512.0542

TLC (ethyl acetate : hexanes= 1 : 2) R*f*: 0.57 ($KMnO_4$).

$[\alpha]_D^{25}$: –8.4 (c 1.0, CH_2Cl_2)



19 **20**

22%

(–)-β-Stannyl-γ-hydroxy enone 20:

n-BuLi (1.76 M in hexane, 1.38 mL, 2.43 mmol, 2.0 equiv.) was added to a stirred solution of diisopropylamine (360 µL, 2.55 mmol, 2.1 equiv.) in anhydrous tetrahydrofuran (5 mL) via syringe pump over 10 min at 0 °C under an atmosphere of argon. After 10 min, tributyltin hydride (645 µL, 2.43 mmol, 2.0 equiv.) was added slowly via syringe pump over 5 min. After 30 min, a solution of **19** (500 mg, 1.21 mmol, 1 equiv.) in anhydrous tetrahydrofuran (10 mL) was added slowly via syringe pump over 10 min. After 1 h, a solution of $[Pd(allyl)Cl]_2$ (22mg, 0.06 mmol, 0.05 equiv.) and diethyl allyl phosphate (433 µL, 2.43 mmol, 2.0 equiv.) in anhydrous tetrahydrofuran (1 mL) was added at once. The resulting mixture was heated to 60 °C. After 1 h, the reaction was quenched with saturated aqueous ammonium chloride solution (40 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 70 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 1 : 30) to afford **20** (188 mg, 22%) as a colorless oil.

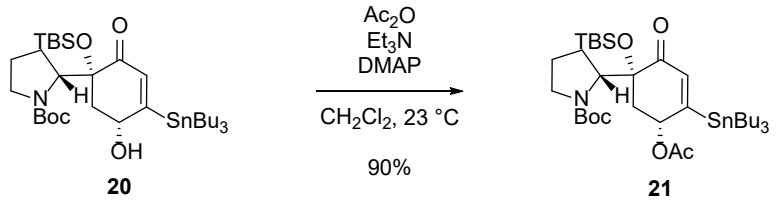
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.11 (app dd, $J_{H\text{-}Sn}$ = 25.6, J = 2.5 Hz, 1H), 5.44 (app s, 1H), 4.09 – 3.94 (m, 1H), 3.55 (app s, 1H), 3.28 (ddd, J = 10.6, 8.3, 5.4 Hz, 1H), 2.66 – 2.49 (m, 1H), 2.07 – 1.90 (m, 3H), 1.84 (dd, J = 12.2, 9.9 Hz, 1H), 1.70 – 1.40 (m, 17H), 1.37 – 1.19 (m, 6H), 1.09 – 0.91 (m, 6H), 0.87 (t, J = 7.3 Hz, 9H), 0.84 (s, 9H), 0.21 (s, 3H), -0.08 (s, 3H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 198.2, 180.7, 156.4, 135.5, 83.1, 79.4, 71.8, 59.4, 48.3, 47.0, 29.3 (3), 28.6 (3), 27.5 (3), 26.2 (3), 25.5, 24.6, 18.5, 13.9 (3), 10.6 (3), -2.8, -3.0.

HRMS (ESI): Calculated for $C_{33}H_{63}NO_5SiSn$ $[M+Na]^+$: 724.3390, found: 724.3388

TLC (ethyl acetate : hexanes = 1 : 9) R*f*: 0.52 ($KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: –54.9 (c 1.0, CH_2Cl_2)



(–)-β-Stannyl-γ-acetoxy enone 21:

Triethylamine (350 µL, 2.53 mmol, 6.0 equiv.), 4-(dimethylamino)pyridine (51 mg, 0.421 mmol, 1.0 equiv.), and acetic anhydride (122 µL, 1.26 mmol, 3.0 equiv.) were added to a stirred solution of **20** (295 mg, 0.421 mmol, 1 equiv.) in anhydrous dichloromethane (4 mL) at 23 °C. After 1 h, the reaction was quenched with saturated aqueous sodium bicarbonate solution (40 mL) and the layers were separated. The aqueous layer was extracted dichloromethane (3 × 70 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 30) to afford **21** (282 mg, 90%) as a colorless oil.

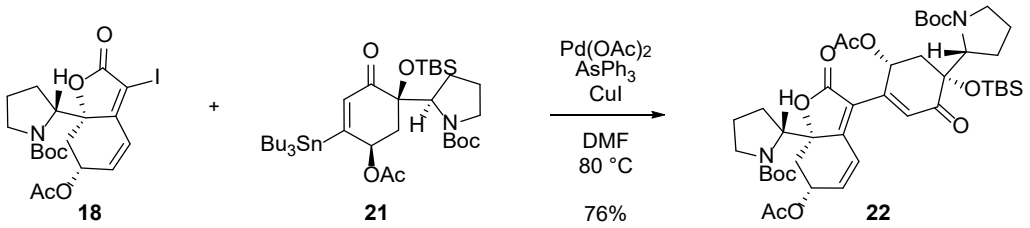
^{1}H NMR (600.0 MHz, $CDCl_3$): δ 6.23 (app t, $J_{H\text{-}Sn}$ = 26.3, 1H), 6.10 – 5.55 (m, 1H), 4.18 – 3.86 (m, 1H), 3.69 – 3.43 (m, 1H), 3.42 – 3.22 (m, 1H), 2.74 (dd, *J* = 12.8, 5.6 Hz, 1H), 2.26 – 2.01 (m, 2H), 2.06 (s, 3H), 1.82 – 1.70 (m, 3H), 1.46 (ddd, *J* = 15.9, 8.8, 6.5 Hz, 6H), 1.40 (s, 9H), 1.28 (p, *J* = 7.3 Hz, 6H), 1.01 – 0.89 (m, 6H) 0.86 (t, *J* = 7.3 Hz, 9H), 0.82 (s, 9H), 0.23 (s, 3H), -0.07 (s, 3H) (Mixture of rotamers).

^{13}C NMR (150.9 MHz, $CDCl_3$): δ 197.7, 171.2, 169.6, 156.1, 138.7, 81.0, 79.7, 74.7, 62.5, 48.5, 41.8, 29.2 (3), 28.6 (3), 27.5 (3), 26.2 (3), 25.8, 24.5, 21.4, 18.7, 13.8 (3), 10.4 (3), -2.6, -2.9 (Mixture of rotamers).

HRMS (ESI): Calculated for $C_{35}H_{65}NO_6SiSn$ $[M+Na]^+$: 766.3495, found: 766.3490

TLC (ethyl acetate : hexanes = 1 : 9) R*f*: 0.64 ($KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: –71.5 (c 1.0, CH_2Cl_2)



(+)-α′-Silyloxy-γ-acetoxy enone 22:

Palladium (II) acetate (11 mg, 0.0507 mmol, 0.2 equiv.), triphenylarsine (31 mg, 0.101 mmol, 0.4 equiv.) and copper (I) iodide (39mg, 0.203 mmol, 0.8 equiv.) were added to a stirred solution of **18** (124 mg, 0.253 mmol, 1.0 equiv.) and **21** (282 mg, 0.380 mmol, 1.5 equiv.) in anhydrous dimethylformamide (3 mL) under an atmosphere of argon. The resulting mixture was heated to 80 °C. After 10 h, the reaction mixture was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 4) to afford **22** (156 mg, 76%) as a colorless oil.

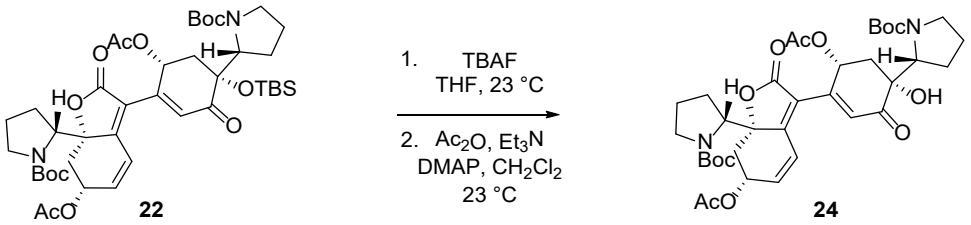
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.85 – 6.67 (m, 1H), 6.62 (s, 1H), 6.44 (app s, 1H), 6.26 (d, *J* = 10.0 Hz, 1H), 6.21 (app s, 1H), 4.15 – 3.99 (m, 2H), 3.67 – 3.46 (m, 2H), 3.46 – 3.30 (m, 2H), 2.99 (dd, J = 13.1, 6.1 Hz, 1H), 2.83 (dd, J = 13.0, 5.9 Hz, 1H), 2.24 – 2.06 (m, 2H), 2.02 (s, 3H), 1.99 – 1.91 (m, 1H), 1.94 (s, 3H), 1.89 – 1.52 (m, 7H), 1.45 (s, 9H), 1.37 (s, 9H), 0.83 (s, 9H), 0.26 (s, 3H), -0.03 (s, 3H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 198.9, 170.0, 169.9, 169.3, 160.8, 156.2, 156.1, 145.3, 139.7, 131.5, 121.6, 120.0, 87.8, 81.5, 80.4, 80.1, 68.6, 68.5, 62.8, 60.8, 48.5, 47.5, 39.9, 37.8, 28.5 (3), 28.5 (3), 26.2 (3), 26.0, 25.7, 24.8, 24.5, 21.1, 21.1, 18.7, -2.54, -2.71.

HRMS (ESI): Calculated for $C_{42}H_{62}N_2O_{12}Si$ $[M+Na]^+$: 837.3964, found: 837.3962

TLC (ethyl acetate : hexanes = 1 : 2) R*f*: 0.47 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 15.9 (c 1.0, CH_2Cl_2)



(+)-α′-Hydroxy-γ-acetoxy enone 24:

Tetrabutylammonium fluoride (1.0 M in tetrahydrofuran, 0.125 mmol, 1.0 equiv.) was added to a stirred solution of **22** (102 mg, 0.125 mmol, 1.0 equiv.) in anhydrous tetrahydrofuran (3 mL) at 23 °C under an atmosphere of argon. After 1 h, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 40 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous dichloromethane (3 mL) and triethylamine (210 μL, 1.50 mmol, 12.0 equiv.), 4-(dimethylamino)pyridine (31 mg, 0.250 mmol, 2.0 equiv.) and acetic anhydride (72 μL, 0.751 mmol, 6.0 equiv.) were added at 23 °C. After 20 min, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 40 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 2 : 3) to afford **24** (57 mg, 65% for 2 steps) as a colorless oil.

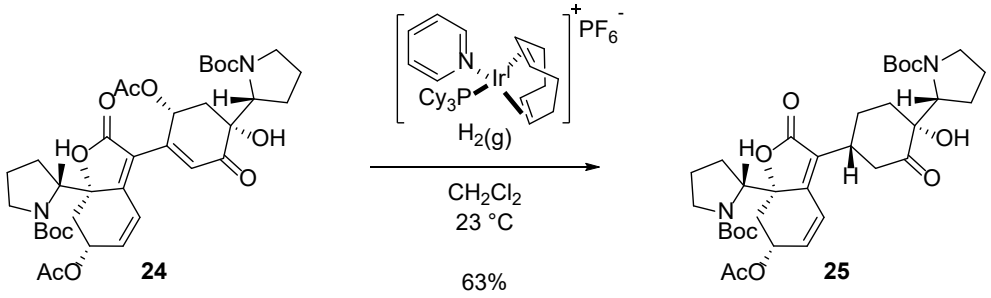
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.73 (app s, 1H), 6.70 (app s, 1H), 6.27 (app s, 1H), 6.24 (s, 1H), 6.16 (app s, 1H), 4.08 (d, J = 8.1 Hz, 1H), 3.94 – 3.87 (m, 2H), 3.59 – 3.42 (m, 3H), 3.37 (ddd, J = 11.0, 8.7, 4.1 Hz, 1H), 3.09 – 2.95 (m, 1H), 2.90 (dd, J = 13.3, 5.8 Hz, 1H), 2.34 – 2.21 (m, 1H), 2.15 – 2.06 (m, 1H), 2.03 (s, 3H), 1.98 – 1.87 (m, 3H), 1.93 (s, 3H), 1.87 – 1.68 (m, 3H), 1.63 – 1.53 (m, 2H), 1.44 (s, 9H), 1.33 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 200.3, 170.0, 169.9, 169.1, 161.3, 156.1, 156.1, 146.5, 139.7, 130.5, 121.6, 120.0, 87.8, 87.7, 80.5, 80.1, 68.4, 67.8, 63.5, 61.1, 48.5, 47.6, 38.2, 37.9, 28.5 (3), 28.4 (3), 26.4, 25.8, 24.8, 24.5, 21.1, 21.0.

HRMS (ESI): Calculated for $C_{36}H_{48}N_2O_{12}$ $[M+Na]^+$: 723.3099, found: 723.3126

TLC (ethyl acetate : hexanes = 1 : 1) R*f*: 0.30 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 22.0 (c 1.0, CH_2Cl_2)



(–)-α-Hydroxy ketone 25:

Crabtree's catalyst (57 mg, 0.0706 mmol, 1.1 equiv.) was added to a stirred solution of **24** (45 mg, 0.0642 mmol, 1.0 equiv.) in anhydrous dichloromethane (3 mL) at 23 °C with hydrogen at atmospheric pressure (using hydrogen-filled balloons). After 1 h, the reaction mixture was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 15 cm; eluent: ethyl acetate : hexanes = 2 : 3) to afford **25** (26 mg, 63%) as a yellow oil.

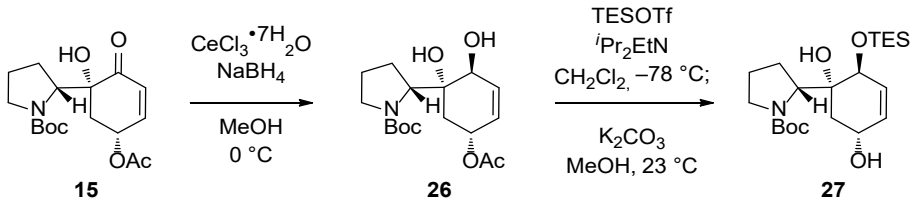
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.64 (app s, 1H), 6.31 – 6.07 (m, 2H), 4.64 (app s, 1H), 4.08 (d, J = 8.0 Hz, 1H), 3.92 (app s, 1H), 3.68 – 3.44 (m, 2H), 3.41 – 3.28 (m, 2H), 3.23 (t, J = 13.0 Hz, 1H), 3.05 – 2.88 (m, 2H), 2.84 – 2.68 (m, 1H), 2.64 – 2.46 (m, 2H), 2.04 (s, 3H), 1.99 – 1.86 (m, 2H), 1.84 – 1.64 (m, 5H), 1.63 – 1.55 (m, 1H), 1.51 – 1.38 (m, 3H), 1.45 (s, 9H), 1.44 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 211.9, 171.5, 170.0, 157.7, 156.4, 156.2, 137.2, 125.6, 120.7, 87.4, 83.2, 80.3, 79.6, 68.7, 60.4, 58.3, 48.2, 47.5, 42.2, 37.9, 37.5, 37.3, 28.6 (3), 28.6 (3), 27.2, 26.0, 25.6, 25.1, 24.9, 21.2.

HRMS (ESI): Calculated for $C_{34}H_{48}N_2O_{10}$ $[M+Na]^+$: 667.3201, found: 667.3264

TLC (ethyl acetate : hexanes = 2 : 3) R*f*: 0.64 (UV, CAM, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: –43.4 (c 1.0, CH_2Cl_2)



(+)-Cyclohexenol 27:

Cerium chloride heptahydrate (962 mg, 2.58 mmol, 2.0 equiv.) was added to a stirred solution of **15** (438 mg, 1.29 mmol, 1 equiv.) in methanol (13 mL) at 0 °C. After 30 min, sodium borohydride (59 mg, 1.55 mmol, 1.2 equiv.) was added portion wise. After 20 min, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 50 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous dichloromethane (13 mL) and cooled to –78 °C. *N*,*N*-diisopropylethylamine (450 µL, 2.58 mmol, 2.0 equiv.) was added and subsequently triethylsilyl trifluoromethanesulfonate (306 µL, 1.36 mmol, 1.05 equiv.) was added slowly via syringe pump over 20 min while stirring. After 40 min, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and 5% aqueous copper sulfate solution (5 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 50 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in methanol (13 mL). Potassium carbonate (357 mg, 2.58 mmol, 2.0 equiv.) was added at 23 °C while stirring. After 1 h, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 50 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 12 cm; eluent: ethyl acetate : hexanes = 1 : 2) to afford **27** (380 mg, 74% for 3 steps) as a colorless oil.

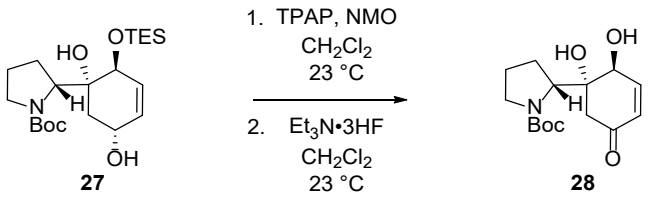
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.88 (br s, 1H), 6.00 (dd, *J* = 9.5, 5.2 Hz, 1H), 5.84 (dd, *J* = 10.5, 5.2 Hz, 1H), 4.10 (d, *J* = 10.5 Hz, 1H), 4.04 – 3.85 (m, 3H), 3.70 (dd, *J* = 10.3, 7.8 Hz, 1H), 3.21 (dt, *J* = 10.8, 5.4 Hz, 1H), 2.31 – 2.14 (m, 1H), 2.08 (ddd, *J* = 14.0, 4.8, 1.7 Hz, 1H), 2.03 – 1.92 (m, 1H), 1.82 (d, *J* = 14.0 Hz, 1H), 1.78 – 1.69 (m, 1H), 1.65 – 1.51 (m, 1H), 1.44 (s, 9H), 0.91 (t, *J* = 8.0 Hz, 9H), 0.56 (q, *J* = 8.2 Hz, 6H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 158.0, 131.6, 128.2, 80.8, 75.4, 69.2, 67.9, 64.9, 48.8, 34.0, 28.6, 28.6 (3), 24.6, 7.0 (3), 5.8 (3).

HRMS (ESI): Calculated for $C_{21}H_{39}NO_5Si$ $[M+Na]^+$: 436.2490, found: 436.2485

TLC (ethyl acetate : hexanes = 1 : 1) R*f*: 0.52 ($KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 208.7 (c 1.0, $CHCl_3$)



75% (2 steps)

(+)-γ-Hydroxy enone 28:

Tetrapropylammonium perruthenate (16 mg, 0.046 mmol, 0.05 equiv.) and *N*-methylmorpholine *N*-oxide (646 mg, 5.51 mmol, 6.0 equiv.) were added to a stirred solution of **27** (380 mg, 0.92 mmol, 1 equiv.) in anhydrous dichloromethane (9 mL) at 23 °C. After 20 h, the reaction mixture was filtered through a pad of celite. The resulting solution was washed with saturated aqueous sodium sulfite solution (10 mL) and 5% aqueous copper sulfate solution (2 mL). The combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous dichloromethane (20 mL). Triethylamine trihydrofluoride (1.5 mL, 9.19 mmol, 10.0 equiv.) was added and the resulting solution was stirred at 23 °C. After 2 h, the reaction was quenched with saturated aqueous sodium bicarbonate solution (20 mL) and 5% aqueous copper sulfate solution (5 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 15 cm; eluent: ethyl acetate : hexanes = 1.5 : 1) to afford **28** (206 mg, 75%) as a colorless oil.

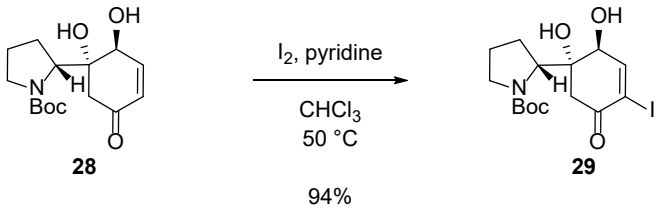
^{1}H NMR (599.0 MHz, $CDCl_3$): δ 6.82 (dd, *J* = 10.0, 2.1 Hz, 1H), 6.09 (d, *J* = 11.6 Hz, 1H), 5.78 (dt, *J* = 10.0, 2.6 Hz, 1H), 4.53 (dt, *J* = 11.6, 2.6 Hz, 1H), 4.09 (dd, *J* = 8.9, 2.8 Hz, 1H), 3.36 (dt, *J* = 11.2, 8.0 Hz, 1H), 3.07 (s, 1H), 2.95 (ddd, *J* = 11.7, 8.2, 4.5 Hz, 1H), 2.73 (d, *J* = 16.1 Hz, 1H), 2.52 (d, *J* = 16.1 Hz, 1H), 2.19 – 2.13 (m, *J* = 13.8, 6.7, 3.3 Hz, 1H), 2.04 – 1.87 (m, 2H), 1.79 (dq, *J* = 12.7, 4.2 Hz, 1H), 1.38 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 197.4, 156.6, 151.6, 127.6, 81.3, 77.6, 76.1, 59.3, 48.4, 45.9, 28.5 (3), 26.8, 24.2.

HRMS (ESI): Calculated for $C_{15}H_{23}NO_5$ $[M+Na]^+$: 320.1468, found: 320.1471

TLC (ethyl acetate : hexanes = 2 : 1) R*f*: 0.39 (UV, $KMnO_4$).

$[\alpha]_D^{25}$: 126.6 (c 1.0, $CHCl_3$)



(+)-α-Iodoenone 29:

Iodine (1.20 g, 4.73 mmol, 5.0 equiv.) was added to a stirred solution of **28** (281 mg, 0.95 mmol, 1 equiv.) in anhydrous chloroform (10 mL) and pyridine (10 mL) co-solvent at 23 °C was. The reaction temperature was raised to 50 °C. After 3 h, the reaction was quenched with saturated aqueous sodium thiosulfate solution (30 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 50 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 12 cm; eluent: ethyl acetate : hexanes = 1 : 1.5) to afford **29** (377 mg, 94%) as a yellow oil.

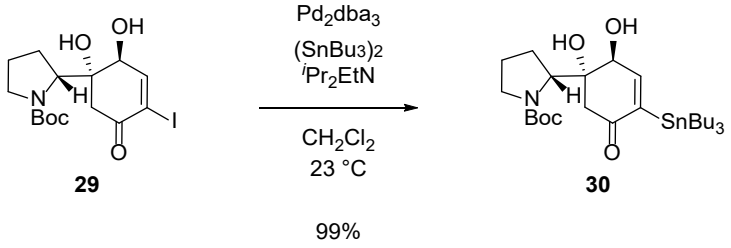
^{1}H NMR (599.0 MHz, $CDCl_3$): δ 7.56 (d, *J* = 2.3 Hz, 1H), 6.42 (d, *J* = 11.7 Hz, 1H), 4.53 (dd, *J* = 11.4, 2.4 Hz, 1H), 4.06 (dd, *J* = 9,1, 1.5 Hz, 1H), 3.34 (dt, *J* = 11.2, 8.2 Hz, 1H), 3.05 (s, 1H), 2.98 (d, *J* = 16.0 Hz, 1H), 2.90 (ddd, *J* = 11.0, 8.4, 4.0 Hz, 1H), 2.61 (dd, *J* = 16.0, 1.2 Hz, 1H), 2.14 (ddt, *J* = 10.6, 7.5, 3.0 Hz, 1H), 2.02 –1.94 (m, 1H), 1.94 – 1.85 (m, 1H), 1.79 (dtt, *J* = 12.5, 8.2, 3.7 Hz, 1H), 1.44 (s, 9H).

^{13}C NMR (150.6 MHz, $CDCl_3$): δ 190.6, 159.1, 157.0, 100.9, 82.0, 78.2, 77.8, 59.6, 48.6, 43.8, 28.5 (3), 26.7, 24.2.

HRMS (ESI): Calculated for $C_{15}H_{22}INO_5$ $[M+Na]^+$: 446.0435, found: 446.0438

TLC (ethyl acetate : hexanes = 1 : 1) R*f*: 0.43 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 15.2 (c 1.0, $CHCl_3$)



(+)-α-Stannyl enone 30:

N,*N*-Diisopropylethylamine (390 μL, 2.22 mmol, 2.5 equiv.), tris(dibenzylideneacetone)dipalladium(0) (26 mg, 0.044 mmol, 0.05 equiv.), and bis(tributyltin) (1.12 mL, 2.22 mmol, 2.5 equiv.) were added to a stirred solution of **29** (377 mg, 0.89 mmol, 1 equiv.) in anhydrous dichloromethane (9 mL) at 23 °C. After 1 h, the reaction mixture was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 2) to afford **30** as a colorless oil (516 mg, 99%).

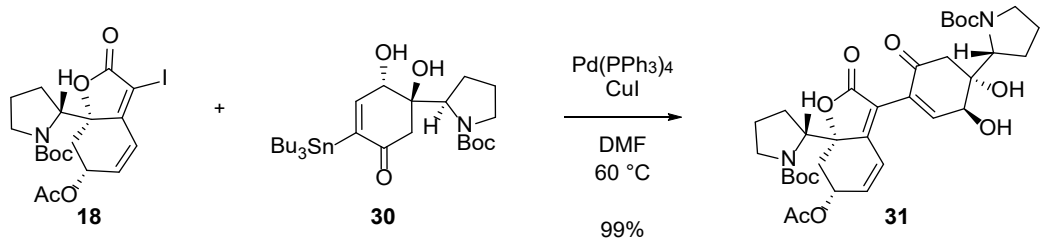
^{1}H NMR (599.0 MHz, $CDCl_3$): δ 6.93 (app t, $J_{H\text{-}Sn}$ = 26.5, 1H), 6.35 (d, J = 11.6 Hz, 1H), 4.49 (d, J = 11.6 Hz, 1H), 4.05 (d, J = 7.5 Hz, 1H), 3.30 (q, J = 9.0 Hz, 1H), 3.25 (d, J = 2.7 Hz, 1H), 2.91 – 2.84 (m, 1H), 2.72 (d, J = 15.9 Hz, 1H), 2.50 (d, J = 15.9 Hz, 1H), 2.19 – 2.11 (m, 1H), 1.97 – 1.89 (m, 2H), 1.82 – 1.74 (m, 1H), 1.51 – 1.40 (m, 6H), 1.38 (s, 9H), 1.27 (qd, J = 7.3, 1.5 Hz, 6H), 0.96 – 0.82 (m, 6H), 0.85 (t, J = 7.2 Hz, 9H).

^{13}C NMR (150.6 MHz, $CDCl_3$): δ 201.1, 160.0, 156.8, 144.9, 81.2, 77.7, 77.6, 60.2, 48.2, 45.9, 29.2 (3), 28.6 (3), 27.6 (3), 26.8, 24.2, 13.8 (3), 10.0 (3).

HRMS (ESI): Calculated for $C_{27}H_{49}NO_5Sn$ $[M+Na]^+$: 610.2525, found: 610.2526

TLC (ethyl acetate : hexanes = 1 : 2) R*f*: 0.42 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 59.6 (c 1.0, $CHCl_3$)



(+)-γ,δ-Dihydroxy enone 31:

$Pd(PPh_3)_4$ (74 mg, 0.064 mmol, 0.2 equiv.) and copper iodide (61 mg, 0.32 mmol, 1 equiv.) were added to a stirred solution of **18** (236 mg, 0.48 mmol, 1.5 equiv.) in anhydrous dimethylformamide (7 mL) at 60 °C. A solution of **30** (188 mg, 0.32 mmol, 1 equiv.) in anhydrous dimethylformamide (7 mL) was added to the resulting mixture via syringe pump over 1 h. After 20 h, the reaction mixture was warmed to 23 °C and concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 5 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 1) to afford **31** as a yellow oil (209 mg, 99%).

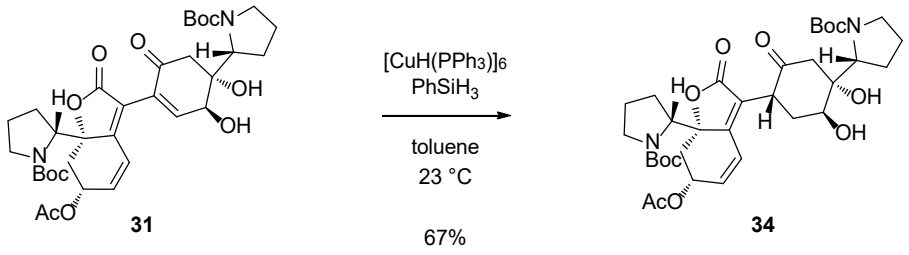
^{1}H NMR (599.0 MHz, $CDCl_3$): δ 7.40 (app s, 1H), 6.65 (d, *J* = 10.2 Hz, 1H), 6.32 (app s, 1H), 6.21 – 6.13 (m, 2H), 4.74 (dd, *J* = 11.6, 2.4 Hz, 1H), 4.22 (d, *J* = 8.2 Hz, 1H), 4.10 (dd, *J* = 9.0, 3.1 Hz, 1H), 3.58 – 3.48 (m, 1H), 3.41 (dt, *J* = 11.0, 7.9 Hz, 1H), 3.34 (dq, *J* = 14.0, 5.3, 4.7 Hz, 1H), 3.21 (s, 1H), 3.03 (dd, *J* = 12.1, 6.5 Hz, 1H), 2.98 (ddd, *J* = 11.7, 7.8, 4.7 Hz, 1H), 2.88 (d, *J* = 16.5 Hz, 1H), 2.62 (d, *J* = 16.4 Hz, 1H), 2.19 (ddd, *J* = 14.7, 7.4, 3.7 Hz, 1H), 2.08 – 2.00 (m, 1H), 2.00 – 1.90 (m, 1H), 1.97 (s, 3H), 1.85 – 1.73 (m, 2H), 1.73 – 1.65 (m, 1H), 1.62 (dt, *J* = 13.7, 9.0 Hz, 1H), 1.58 – 1.51 (m, 1H), 1.46 (s, 9H), 1.43 – 1.36 (m, 1H), 1.25 (s, 9H).

^{13}C NMR (150.6 MHz, $CDCl_3$): δ 193.4, 171.5, 169.7, 159.5, 156.8, 156.3, 154.5, 137.3, 127.7, 124.7, 116.4, 88.2, 81.5, 80.2, 76.7, 76.3, 69.0, 59.9, 59.8, 48.8, 47.4, 46.0, 37.8, 28.5 (3), 28.2 (3), 26.8, 25.3, 24.9, 24.4, 21.1.

HRMS (ESI): Calculated for $C_{34}H_{46}N_2O_{11}$ $[M+Na]^+$: 681.2994, found: 681.2993

TLC (ethyl acetate : hexanes = 3 : 2) R*f*: 0.31 (UV, $KMnO_4$)

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 73.9 (c 1.0, $CHCl_3$)



(+)-γ-hydoxy ketone 34:

Stryker's reagent (91 mg, 0.046 mmol, 0.3 equiv.) and phenylsilane (95 μL, 0.77 mmol, 5.0 equiv.) were added to a stirred solution of **31** (102 mg, 0.15 mmol, 1 equiv.) in anhydrous toluene (1.5 mL) at 23 °C in the glove box. After 3 h, the reaction mixture was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 1 : 1 → 3 : 2) to afford **34** as a colorless oil. (69 mg, 67%)

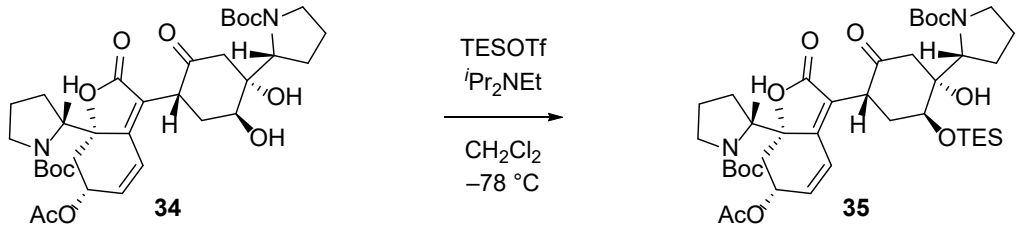
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.51 (d, *J* = 10.0 Hz, 1H), 6.21 (app s, 1H), 6.09 (d, *J* = 10.0 Hz, 1H), 5.53 (br s, 1H), 4.10 (dd, *J* = 7.2, 2.3 Hz, 1H), 4.01 (s, 1H), 3.96 (s, 1H), 3.89 (dd, *J* = 12.8, 6.6 Hz, 1H), 3.74 – 3.65 (m, 1H), 3.60 – 3.47 (m, 1H), 3.35 (td, *J* = 10.7, 9.8, 4.8 Hz, 1H), 3.27 – 3.14 (m, 1H), 3.05 – 2.75 (m, 3H), 2.66 (t, *J* = 12.7 Hz, 1H), 2.34 (d, *J* = 13.9 Hz, 1H), 2.30 – 2.21 (m, 1H), 2.02 (s, 3H), 2.00 – 1.82 (m, 4H), 1.80 – 1.69 (m, 2H), 1.68 – 1.54 (m, 3H), 1.44 (s, 18H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 205.9, 173.1, 170.2, 160.1, 158.0, 156.2, 136.3, 122.8, 122.1, 88.5, 81.1, 80.2, 79.5, 69.5, 68.9, 65.9, 60.3, 48.8, 47.4, 46.4, 40.8, 37.3, 35.8, 28.6 (3), 28.5 (3), 28.5, 25.3, 24.9, 24.7, 21.2.

HRMS (ESI): Calculated for $C_{34}H_{48}N_2O_{11}$ $[M+Na]^+$: 683.3150, found: 683.3147

TLC (ethyl acetate : hexanes = 3 : 2) R*f*: 0.31 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 81.0 (c 1.0, CH_2Cl_2)



(+)-γ-Silyloxy ketone 35:

N,*N*-diisopropylethylamine (68 μL, 0.39 mmol, 6.0 equiv.) and triethylsilyl trifluoromethanesulfonate (44 μL, 0.19 mmol, 3.0 equiv.) were added to a stirred solution of **34** (43 mg, 0.065 mmol, 1 equiv.) in anhydrous dichloromethane (5 mL) at –78 °C. After 90 min, the reaction was quenched with saturated aqueous ammonium chloride solution (10 mL) and 5% aqueous copper sulfate solution (3 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 10 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 1 : 2) to afford **35** as a yellow oil (34 mg, 67%).

^{1}H NMR (400.1 MHz, $CDCl_3$ with 1% CD_3OD): δ 6.45 (d, *J* = 10.1 Hz, 1H), 6.22 (br s, 1H), 6.09 (d, *J* = 10.1 Hz, 1H), 4.15 – 4.06 (m, 1H), 4.05 – 3.89 (m, 2H), 3.79 (dd, *J* = 12.7, 6.1 Hz, 1H), 3.73 – 3.64 (m, 1H), 3.60 – 3.46 (m, 1H), 3.39 – 3.31 (m, 1H), 3.27 – 3.15 (m, 1H), 3.05 – 2.90 (m, 2H), 2.69 (t, *J* = 13.2, 1H), 2.34 (d, *J* = 13.7 Hz, 1H), 2.22 – 2.07 (m, 1H), 2.02 (s, 3H), 1.96 – 1.53 (m, 9H), 1.44 (s, 9H), 1.42 (s, 9H), 0.98 (t, *J* = 7.9 Hz, 9H), 0.66 (q, *J* = 8.0, 6H).

^{1}H NMR (400.1 MHz, $CDCl_3$)[9]: δ 6.47 (dd, *J* = 10.1, 2.1 Hz, 1H), 6.19 (br s, 1H), 6.11 (dd, *J* = 10.1, 1.9 Hz, 1H), 4.18 – 4.11 (m, 1H), 4.11 – 4.00 (m, 2H), 3.81 (dd, *J* = 12.9, 6.3 Hz, 1H), 3.71 (t, *J* = 8.5 Hz, 1H), 3.65 – 3.55 (m, 1H), 3.37 (ddd, *J* = 11.0, 8.9, 5.0 Hz, 1H), 3.28 – 3.19 (m, 1H), 3.05 (d, *J* = 14.2 Hz, 1H), 2.99 (dd, *J* = 12.0, 6.6 Hz, 1H), 2.72 (td, *J* = 13.7, 2.2 Hz, 1H), 2.37 (d, *J* = 14.1 Hz, 1H), 2.27 – 2.10 (m, 1H), 2.03 (s, 2H), 1.99 – 1.83 (m, 4H), 1.80 – 1.56 (m, 5H), 1.47 (s, 9H), 1.45 (s, 9H), 1.02 (t, *J* = 7.9 Hz, 9H), 0.70 (qd, *J* = 8.4, 8.0, 1.7 Hz, 6H).

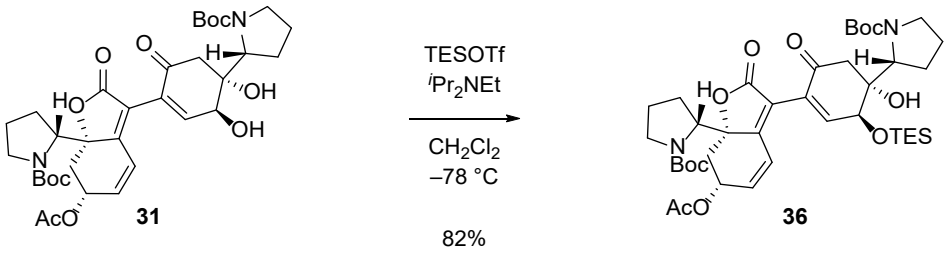
^{13}C NMR (100.6 MHz, $CDCl_3$): δ 205.7, 172.3, 170.1, 159.4, 157.4, 156.2, 136.3, 122.8, 121.7, 88.2, 80.6, 80.0, 79.7, 70.1, 68.9, 65.7, 60.2, 48.9, 47.4, 47.4, 40.9, 37.3, 35.3, 28.8, 28.5 (3), 28.5 (3), 25.2, 24.8, 24.4, 21.2, 7.1 (3), 5.3 (3).

HRMS (ESI): Calculated for $C_{40}H_{62}N_2O_{11}Si$ $[M+Na]^+$: 797.4015, found: 797.4020

TLC (ethyl acetate : hexanes = 2 : 3) R*f*: 0.57 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 52.9 (c 1.0, CH_2Cl_2)

[9] ^{1}H NMR experiment was carried out at 323K.



(+)-γ-Silyloxy-δ-hydroxy enone 36:

N,*N*-diisopropylethylamine (84 μL, 0.48 mmol, 2.0 equiv.) was added to a stirred solution of **31** (160 mg, 0.24 mmol, 1 equiv.) in anhydrous dichloromethane (8 mL) at –78 °C. A solution of triethylsilyl trifluoromethanesulfonate (55 μL, 0.24 mmol, 1 equiv.) in anhydrous dichloromethane (1 mL) was added via syringe pump over 20 min. After 20 min, the reaction was quenched with saturated aqueous ammonium chloride solution (20 mL) and 5% aqueous copper sulfate solution (5 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 13 cm; eluent: ethyl acetate : hexanes = 1 : 4 → 1 : 1) to afford **36** as a yellow oil (155 mg, 82%).

^{1}H NMR (599.0 MHz, $CDCl_3$): δ 7.24 (dd, *J* = 3.9, 2.2 Hz, 1H), 6.58 (app s, 1H), 6.25 (app s, 1H), 6.09 (dd, *J* = 10.2, 2.6 Hz, 1H), 5.24 (br s, 1H), 4.46 (app s, 1H), 4.18 (d, *J* = 8.0 Hz, 1H), 4.03 (app s, 1H), 3.67 (app s, 1H), 3.53 (app s, 1H), 3.37 (ddd, *J* = 10.9, 8.9, 4.6 Hz, 1H), 3.23 (td, *J* = 10.2, 9.8, 6.7 Hz, 1H), 3.05 – 2.94 (m, 2H), 2.50 (d, *J* = 15.9 Hz, 1H), 2.23 (app s, 1H), 2.01 (s, 3H), 1.98 – 1.92 (m, 1H), 1.89 – 1.79 (m, 2H), 1.78 – 1.62 (m, 4H), 1.56 (t, *J* = 8.7 Hz, 1H), 1.46 (s, 9H), 1.44 (s, 9H), 0.92 (t, *J* = 7.9 Hz, 9H), 0.62 (q, *J* = 7.6 Hz, 6H).

^{1}H NMR (400.1 MHz, $CDCl_3$)[10]: δ 7.24 (d, *J* = 4.8 Hz, 1H), 6.61 (d, *J* = 10.0 Hz, 1H), 6.19 (br s, 1H), 6.10 (dd, *J* = 10.2, 2.0 Hz, 1H), 4.47 (d, *J* = 4.8 Hz, 1H), 4.23 – 4.17 (m, 1H), 4.14 – 4.06 (m, 1H), 3.67 (ddd, *J* = 11.3, 8.0, 3.8 Hz, 1H), 3.60 (br s, 1H), 3.36 (ddd, *J* = 11.0, 8.8, 4.5 Hz, 1H), 3.23 (ddd, *J* = 10.9, 8.5, 6.9 Hz, 1H), 3.02 (dd, *J* = 4.2 Hz, 7.2 Hz, 1H), 3.00 (d, *J* = 16.1 Hz, 1H), 2.51 (d, *J* = 16.1 Hz, 1H), 2.21 (td, *J* = 16.5, 14.9, 8.4 Hz, 1H), 2.00 (s, 3H), 1.99 – 1.81 (m, 3H), 1.80 – 1.53 (m, 6H), 1.47 (s, 9H), 1.45 (s, 9H), 0.94 (t, J = 7.9 Hz, 9H), 0.64 (q, J = 7.8 Hz, 6H).

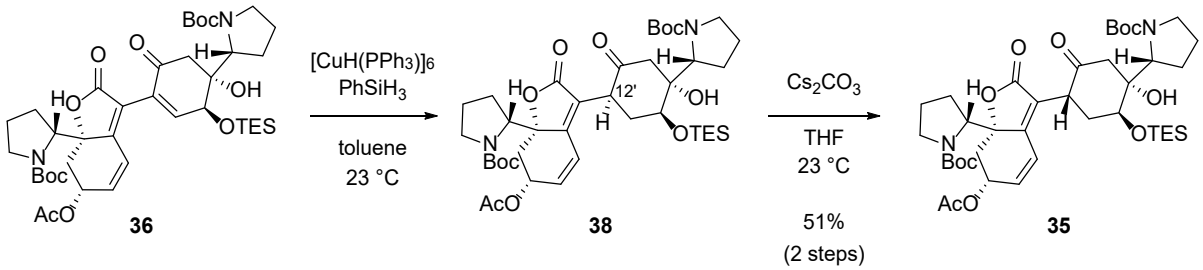
^{13}C NMR (100.6 MHz, $CDCl_3$): δ 194.4, 171.3, 170.1, 160.6, 157.5, 156.3, 147.4, 137.0, 129.7, 123.6, 117.4, 88.1, 80.8, 80.1, 76.6, 70.9, 69.0, 65.0, 60.2, 48.6, 47.5, 45.4, 37.8, 28.6, 28.6 (3), 28.6 (3), 25.6, 24.9, 24.7, 21.2, 7.0 (3), 5.6 (3).

HRMS (ESI): Calculated for $C_{40}H_{60}N_2O_{11}Si$ $[M+Na]^+$: 795.3859, found: 795.3860

TLC (ethyl acetate : hexanes = 2 : 3) R*f*: 0.68 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 63.7 (c 1.0, CH_2Cl_2)

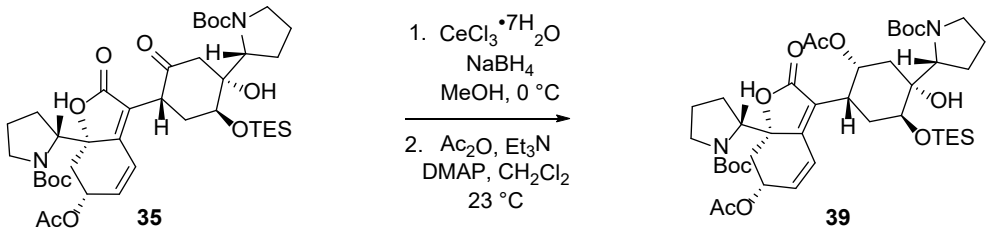
[10] ^{1}H NMR experiment was carried out at 325K.



(+)-γ-Silyloxy ketone 35:

Stryker's reagent (109 mg, 0.056 mmol, 0.3 equiv.) and phenylsilane (114 μL, 0.931 mmol, 5.0 equiv.) were added to a stirred solution of **36** (144 mg, 0.186 mmol, 1 equiv.) in anhydrous toluene (3.6 mL) at 23 °C in the glove box. After 3 h, the reaction mixture was concentrated under reduced pressure to yield **38** that was prone to air oxidation. Attempted purification of **38** resulted in at oxidation at C11' position. Hence, the crude material was directly used for the next step.

The crude mixture of **38** was dissolved in anhydrous tetrahydrofuran and cesium carbonate (182 mg, 0.559 mmol, 3.0 equiv.) was added at 23 °C. After 3 h, the reaction mixture was filtered through a pad of celite and concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 4 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 1 : 3 → 1 : 2) to afford **35** as a colorless oil. (74 mg, 51%)



(+)-Silyl ether 39:

Cerium (III) chloride heptahydrate (86 mg, 0.231 mmol, 1.3 equiv.) was added to a stirred solution of **35** (138 mg, 0.178 mmol, 1 equiv.) in anhydrous methanol (6 mL) at 0 °C. After 30 min, sodium borohydride (8.7 mg, 0.231 mmol, 1.3 equiv.) was added. After 30 min, the reaction was quenched with saturated aqueous ammonium chloride solution (10 mL) and the layers were separated. The aqueous layer was extracted with ethyl acetate (3 × 10 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous dichloromethane (6 mL) and triethylamine (496 μL, 3.561 mmol, 20 equiv.), 4-(dimethylamino)pyridine (22 mg, 0.178 mmol, 1.0 equiv.) and acetic anhydride (171 μL, 1.780 mmol, 10.0 equiv.) was added at 23 °C. After 13 h, the reaction was quenched with saturated aqueous ammonium chloride solution (10 mL) and 5% aqueous copper sulfate solution (2 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 1 : 2 → 1 : 1) to afford **39** (98 mg, 67%) as a colorless oil.

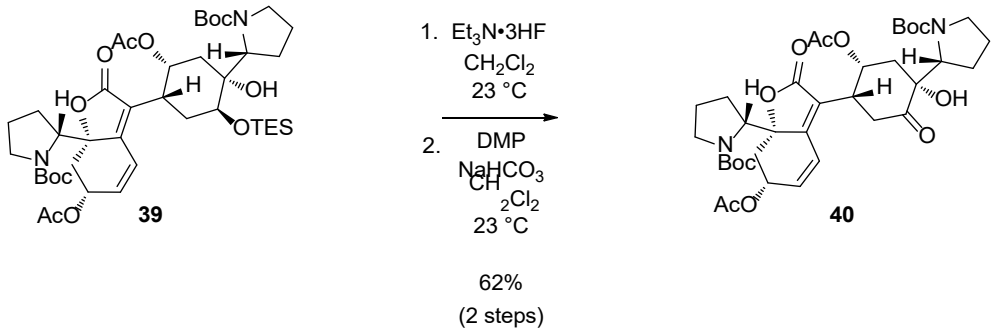
^{1}H NMR (600.0 MHz, $CDCl_3$): δ 6.69 (d, *J* = 10.2 Hz, 1H), 6.16 (app s, 1H), 6.04 (dd, *J* = 10.2, 2.7 Hz, 1H), 5.39 (app s, 1H), 4.17 (d, *J* = 8.0 Hz, 1H), 4.08 (d, *J* = 8.5 Hz, 1H), 3.93 (app s, 1H), 3.81 – 3.56 (m, 2H), 3.52 (q, *J* = 9.4, 8.9 Hz, 1H), 3.39 – 3.28 (m, 2H), 3.27 – 3.17 (m, 1H), 2.90 (dd, *J* = 12.4, 6.6 Hz, 1H), 2.77 – 2.62 (m, 1H), 2.30 (d, *J* = 15.7 Hz, 1H), 2.05 – 1.95 (m, 2H), 1.99 (s, 3H), 1.93 (s, 3H), 1.88 – 1.82 (m, 1H), 1.80 – 1.66 (m, 4H), 1.63 – 1.49 (m, 3H), 1.43 (s, 9H), 1.42 (s, 9H), 1.35 – 1.29 (m, 1H), 0.92 (t, *J* = 7.9 Hz, 9H), 0.58 (q, *J* = 7.6 Hz, 6H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 172.2, 169.8, 169.3, 157.7, 156.2, 156.0, 136.3, 125.6, 121.9, 88.0, 80.1, 79.8, 76.2, 71.0, 70.7, 68.4, 61.2, 59.9, 47.4, 47.3, 36.7, 34.0, 32.3, 28.7 (3), 28.5 (3), 27.4, 25.5, 25.3, 24.8, 24.3, 21.7, 21.1, 7.1 (3), 5.2 (3).

HRMS (ESI): Calculated for $C_{42}H_{66}N_2O_{12}Si$ $[M+Na]^+$: 841.4277, found: 841.4281

TLC (ethyl acetate : hexanes = 3 : 2) R*f*: 0.58 (UV, $KMnO_4$)

$[\alpha]_D^{25}$: 22.9 (c 1.0, CH_2Cl_2)



(–)-α-Hydroxy ketone 40:

Triethylamine trihydrofluoride (965 μL, 5.921 mmol, 50.0 equiv.) was added to a stirred solution of **39** (97 mg, 0.118 mmol, 1 equiv.) in anhydrous dichloromethane (2 mL) at 23 °C. After 8 h, the reaction was quenched with saturated aqueous sodium bicarbonate solution (20 mL) and 5% aqueous cooper sulfate solution (5 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layers were dried over anhydrous sodium sulfate and concentrated under reduced pressure.

The resulting crude residue was dissolved in anhydrous dichloromethane (2 mL) and sodium bicarbonate (199 mg, 2.368 mmol, 20.0 equiv.) and Dess–Martin periodinane (502 mg, 1.184 mmol, 10.0 equiv.) were added at 23 °C. After 15 h, the reaction was quenched with saturated aqueous sodium metabisulfite solution (20 mL) and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 10 cm; eluent: ethyl acetate : hexanes = 1 : 2 → 1 : 1) to afford **40** (52 mg, 62%) as a yellow oil.

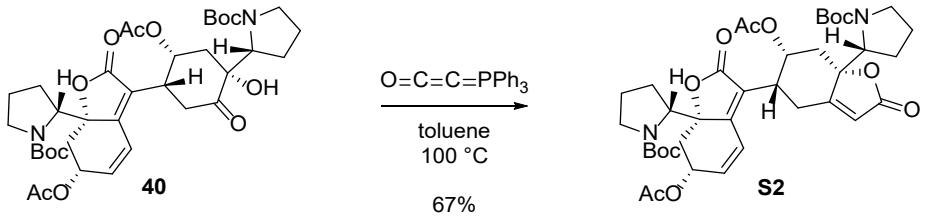
^{1}H NMR (400.1 MHz, $CDCl_3$): δ 6.68 (d, *J* = 10.1 Hz, 1H), 6.22 – 6.02 (m, 2H), 5.46 (app s, 1H), 4.90 (br s, 1H), 4.17 – 4.10 (m, 1H), 4.07 (d, *J* = 8.1 Hz, 1H), 3.66 – 3.46 (m, 3H), 3.43 – 3.28 (m, 3H), 2.95 (dd, *J* = 12.4, 6.6 Hz, 1H), 2.59 – 2.47 (m, 1H), 2.35 – 2.17 (m, 2H), 2.02 (s, 3H), 1.96 (s, 3H), 1.96 – 1.92 (m, 1H), 1.90 – 1.64 (m, 6H), 1.55 (dd, *J* = 11.9, 9.5 Hz, 1H), 1.50 – 1.46 (m, 1H), 1.44 (s, 9H), 1.42 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 208.8, 172.2, 170.3, 170.0, 160.3, 157.2, 156.2, 137.2, 123.0, 121.7, 88.2, 80.5, 80.3, 79.9, 69.9, 68.5, 62.0, 60.4, 48.2, 47.5, 38.7, 37.6, 37.2, 37.2, 28.5 (3), 28.5 (3), 27.1, 25.5, 24.8, 24.8, 21.5, 21.2.

HRMS (ESI): Calculated for $C_{36}H_{50}N_2O_{12}$ $[M+Na]^+$: 725.3256, found: 725.3263

TLC (ethyl acetate : hexanes = 1 : 1) R*f*: 0.30 (UV, $KMnO_4$).

$[\alpha]_D^{25}$:–9.7 (c 1.0, CH_2Cl_2)



(+)-ε-Acetoxy butenolide S2:

(Triphenylphosphoranylidene)ketene (71 mg, 0.234 mmol, 5.0 equiv.) was added to a stirred solution of **40** (33 mg, 0.047 mmol, 1 equiv.) in anhydrous toluene at 23 °C and the mixture was heated to 100 °C. After 3 h, the reaction mixture cooled to 23 °C and concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 2 : 3) to afford **S2** (23 mg, 67%) as a yellow oil.

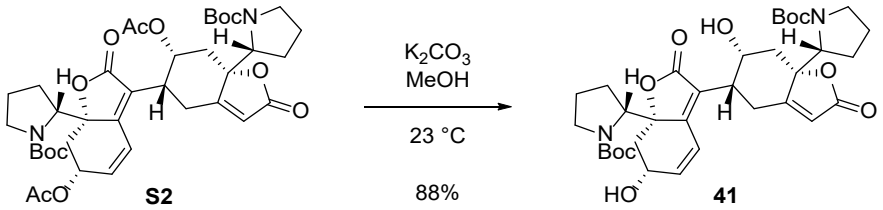
^{1}H NMR (600.0 MHz, $CDCl_3$): δ 6.78 (d, *J* = 5.0 Hz, 1H), 6.22 – 6.07 (m, 2H), 5.90 (s, 1H), 5.48 (app s, 1H), 4.36 (d, *J* = 8.4 Hz, 1H), 4.04 (d, *J* = 8.4 Hz, 1H), 3.92 (app s, 1H), 3.62 – 3.42 (m, 3H), 3.38 (ddd, *J* = 11.1, 9.1, 4.4 Hz, 1H), 3.34 (td, *J* = 10.6, 9.8, 4.1 Hz, 1H), 3.02 – 2.90 (m, 1H), 2.84 – 2.74 (m, 1H), 2.64 (dd, *J* = 16.9, 8.0 Hz, 1H), 2.08 – 1.95 (m, 2H), 2.02 (s, 3H), 1.93 (s, 3H), 1.89 – 1.70 (m, 3H), 1.70 – 1.55 (m, 3H), 1.52 – 1.39 (m, 2H), 1.45 (s, 9H), 1.44 (s, 9H).

^{13}C NMR (100.6 MHz, $CDCl_3$): δ 172.7, 171.7, 170.2, 170.0, 169.2, 161.0, 156.8, 156.1, 137.4, 123.1, 121.7, 117.3, 89.8, 87.6, 80.4, 80.2, 70.7, 68.7, 60.6, 60.1, 47.5, 47.4, 37.5, 37.5, 34.2, 28.5 (3), 28.5 (3), 25.6, 25.5, 25.0, 24.8, 24.8, 21.3, 21.2.

HRMS (ESI): Calculated for $C_{38}H_{50}N_2O_{12}$ $[M+Na]^+$: 749.3256, found: 749.3249

TLC (ethyl acetate : hexanes = 1 : 1) R*f*: 0.26 (UV, $KMnO_4$).

$[\alpha]_D^{25}$: 88.9 (c 1.0, CH_2Cl_2)



(+)-ε-Hydroxy butenolide 41:

Potassium carbonate (27 mg, 0.091 mmol, 3.0 equiv.) was added to a stirred solution of **S2** (22 mg, 0.030 mmol, 1 equiv.) in methanol, was added at 23 °C. After 1 h, the reaction was quenched with saturated aqueous ammonium chloride solution (10 mL). The aqueous layer was extracted with ethyl acetate (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 14 cm; eluent: ethyl acetate : hexanes = 4 : 1) to afford **41** (17.2 mg, 88%) as a colorless oil.

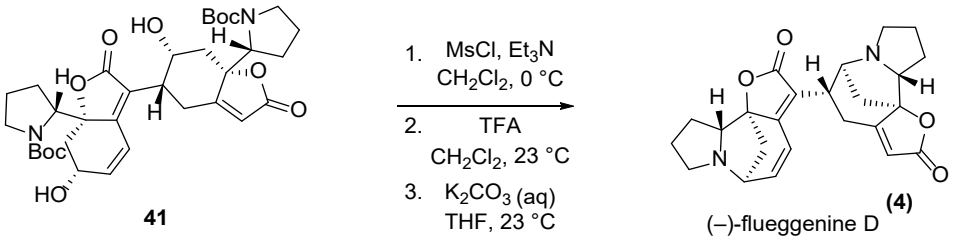
^{1}H NMR (600.0 MHz, $CDCl_3$): δ 6.74 (d, *J* = 9.9, 1H), 6.24 (dd, *J* = 10.2, 2.4 Hz, 1H), 5.88 (s, 1H), 5.24 (app s, 1H), 4.47 (app s, 1H), 4.35 (d, *J* = 8.4 Hz, 1H), 4.01 (d, *J* = 8.0 Hz, 1H), 3.64 (app s, 1H), 3.59 – 3.47 (m, 3H), 3.41 – 3.31 (m, 2H), 3.20 (dd, *J* = 16.8, 6.4 Hz, 1H), 2.97 – 2.78 (m, 1H), 2.73 (dd, *J* = 14.0, 4.6 Hz, 1H), 2.55 (dd, *J* = 16.4, 7.8 Hz, 1H), 2.43 – 2.32 (m, 1H), 1.99 (q, *J* = 9.7, 7.2 Hz, 1H), 1.90 (dd, *J* = 13.8, 6.3 Hz, 1H), 1.86 – 1.71 (m, 3H), 1.71 – 1.60 (m, 2H), 1.55 (dd, *J* = 12.2, 9.3 Hz, 1H), 1.51 – 1.34 (m, 2H), 1.47 (s, 9H), 1.44 (s, 9H).

^{13}C NMR (150.9 MHz, $CDCl_3$): δ 173.5, 172.8, 169.9, 161.8, 156.8, 156.5, 142.3, 123.5, 120.2, 117.0, 90.2, 89.3, 80.4, 80 .3, 68.4, 66.2, 60.2, 60.2, 47.7, 47.4, 41.5, 40.1, 36.7, 28.6 (3), 28.6 (3), 26.6, 25.7, 25.0, 24.8, 24.7.

HRMS (ESI): Calculated for $C_{34}H_{46}N_2O_{10}$ $[M+Na]^+$: 665.3045, found: 665.3041

TLC (ethyl acetate : hexanes = 8 : 1) R*f*: 0.22 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: 99.4 (c 1.0, CH_2Cl_2)



(–)-Flueggenine D (4):

Triethylamine (61 µL, 0.436 mmol, 20.0 equiv.) and methanesulfonyl chloride (17 µL, 0.218 mmol, 10.0 equiv.) were added to a stirred solution of **41** (14 mg, 0.022 mmol, 1 equiv.) in anhydrous dichloromethane (700 µL) at 0 °C. After 40 min, brine (10 mL) was added and the aqueous layer was extracted with dichloromethane (3 × 10 mL). The combined organic layer was dried over anhydrous sodium sulfate and the resulting filtrate concentrated under reduced pressure. The resulting crude mixture was dissolved in anhydrous dichloromethane (1 mL) and trifluoroacetic acid (1 mL) cosolvent and the mixture was stirred at 23 °C. After 30 min, the reaction mixture was concentrated under reduced pressure.

The resulting crude mixture was dissolved in a mixture of tetrahydrofuran (1 mL) and saturated aqueous potassium carbonate solution (1 mL). The reaction mixture was stirred at 23 °C. After 1 h, 1 M aqueous sodium hydroxide solution (10 mL) was added. The aqueous layer was extracted with dichloromethane (3 × 10 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash purified by flash column chromatography (silica gel: diam. 2 cm, ht. 10 cm; eluent: dichloromethane : methanol : ammonium hydroxide = 10 : 1 : 0.1) to afford flueggenine D (**4**) (4.5 mg, 51%, 3 steps) as a white amorphous solid.

^{1}H NMR (400.1 MHz, $CDCl_3$)[11]: δ 6.73 (dd, *J* = 9.2, 6.4 Hz, 1H), 6.45 (d, *J* = 9.2 Hz, 1H), 5.75 (d, *J* = 2.2 Hz, 1H), 3.61 (dd, *J* = 6.4, 4.7 Hz, 1H), 3.43 (dd *J* = 9.2 Hz, 3.3 Hz, 1H), 3.43 – 3.37 (m, 1H), 3.30 – 3.24 (m, 2H), 3.22 (dd, *J* = 8.6, 7.0 Hz, 1H), 3.14 (ddd, *J* = 17.3, 9.2, 7.0 Hz , 1H), 3.13 (dd, *J* = 8.8, 7.7 Hz, 1H), 3.03 (d, *J* = 17.3 Hz, 1H), 2.68 – 2.60 (m, 1H), 2.55 (dd, *J* = 10.6, 4.7 Hz, 1H), 2.56 – 2.48 (m, 1H), 2.30 (dd, *J* = 11.4, 5.7 Hz, 1H), 2.01 – 1.86 (m, 4H), 1.84 – 1.66 (m, 4H), 1.60 (d, *J* = 10.6 Hz, 1H), 1.37 (d, *J* = 11.4 Hz, 1H).

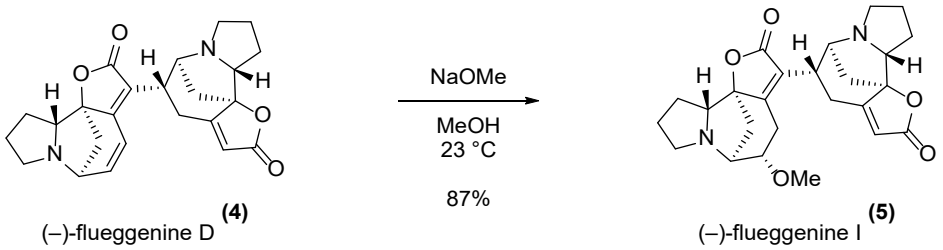
^{13}C NMR (100.6 MHz, $CDCl_3$): δ 174.1, 172.8, 172.7, 161.5, 144.3, 120.6, 119.3, 110.7, 92.4, 90.6, 66.9, 65.9, 65.0, 59.7, 57.7, 55.3, 39.8, 35.8, 30.6, 29.6, 29.3, 27.0, 26.8, 26.5.

HRMS (ESI): Calculated for $C_{24}H_{26}N_2O_4$ $[M+H]^+$: 407.1965, found: 407.1970

TLC (dichloromethane : methanol : ammonium hydroxide =10 : 1 : 0.1) R*f*: 0.26 (UV, $KMnO_4$).

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: –118.2 (c 0.11, MeOH)

[11] Proton nuclear magnetic resonance spectra are referenced from the residual protium in the NMR solvent ($CDCl_3$: δ 7.26 ($CHCl_3$)) for direct comparison with the isolation paper.



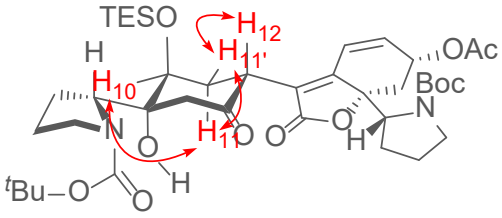
(–)-flueggenine D **(4)** (–)-flueggenine I **(5)**

(–)-Flueggenine I (5):

Sodium methoxide (5 M solution in methanol, 69 μL, 0.344 mmol, 40.0 equiv.) was added to a stirred solution of (–)-flueggenine D **(4)** (3.5 mg, 0.009 mmol, 1 equiv.) in methanol (1 mL) at 23 °C. After 2 h, saturated aqueous sodium bicarbonate solution (10 mL) was added to the reaction mixture. The aqueous layer was extracted with dichloromethane (3 × 20 mL) and the combined organic layer was dried over anhydrous sodium sulfate. The resulting filtrate was concentrated under reduced pressure. The resulting crude residue was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 10 cm; eluent: dichloromethane : methanol : ammonium hydroxide = 10 : 1 : 0.1) to afford (–)-flueggenine I **(5)** (3.3 mg, 87%) as a white amorphous solid

^{1}H NMR (400.1 MHz, $CDCl_3$)[9]: δ 5.74 (d, *J* = 2.3 Hz, 1H), 3.57 (t, *J* = 4.7 Hz, 1H), 3.43 – 3.34 (m, 1H), 3.37 (br d, *J* = 9.7 Hz, 1H), 3.34 – 3.28 (m, 1H), 3.21 (s, 3H), 3.20 (dd, *J* = 8.8, 6.8 Hz, 1H), 3.20 – 3.16 (m, 1H), 3.16 – 3.10 (m, 1H), 3.12 (ddd, *J* = 17.3, 9.7, 2.3 Hz, 1H), 3.06 (t, *J* = 8.3 Hz, 1H), 2.94 (d, *J* = 16.4 Hz, 1H), 2.92 (d, *J* = 17.3 Hz, 1H), 2.70 – 2.66 (m, 1H), 2.66 – 2.60 (m, 2H), 2.29 (dd, *J* = 11.5, 5.8 Hz, 1H), 2.27 (dd, *J* = 11.1, 5.7 Hz, 1H) 1.99 – 1.83 (m, 4H), 1.82 – 1.66 (m, 4H), 1.70 (d, *J* = 11.1 Hz, 1H), 1.55 (d, *J* = 11.5 Hz, 1H).
^{13}C NMR (201.2 MHz, $CDCl_3$): δ 174.7, 173.0, 172.7, 165.4, 122.9, 110.7, 92.5, 90.6, 78.8, 66.9, 66.3, 64.7, 63.4, 57.7, 57.3, 57.1, 39.3, 30.4, 30.0, 29.29, 29.27, 28.1, 26.9, 26.8, 26.3.
HRMS (ESI): Calculated for $C_{25}H_{30}N_2O_5$ $[M+H]^+$: 439.2227, found: 439.2234
TLC (dichloromethane : methanol : ammonium hydroxide =10 : 1 : 0.1) R*f*: 0.29 (UV, $KMnO_4$).
$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\mathbf{25}}$: –0.9 (c 0.56, MeOH)

5. Key NOE Correlations of Compounds 35 and 39



35

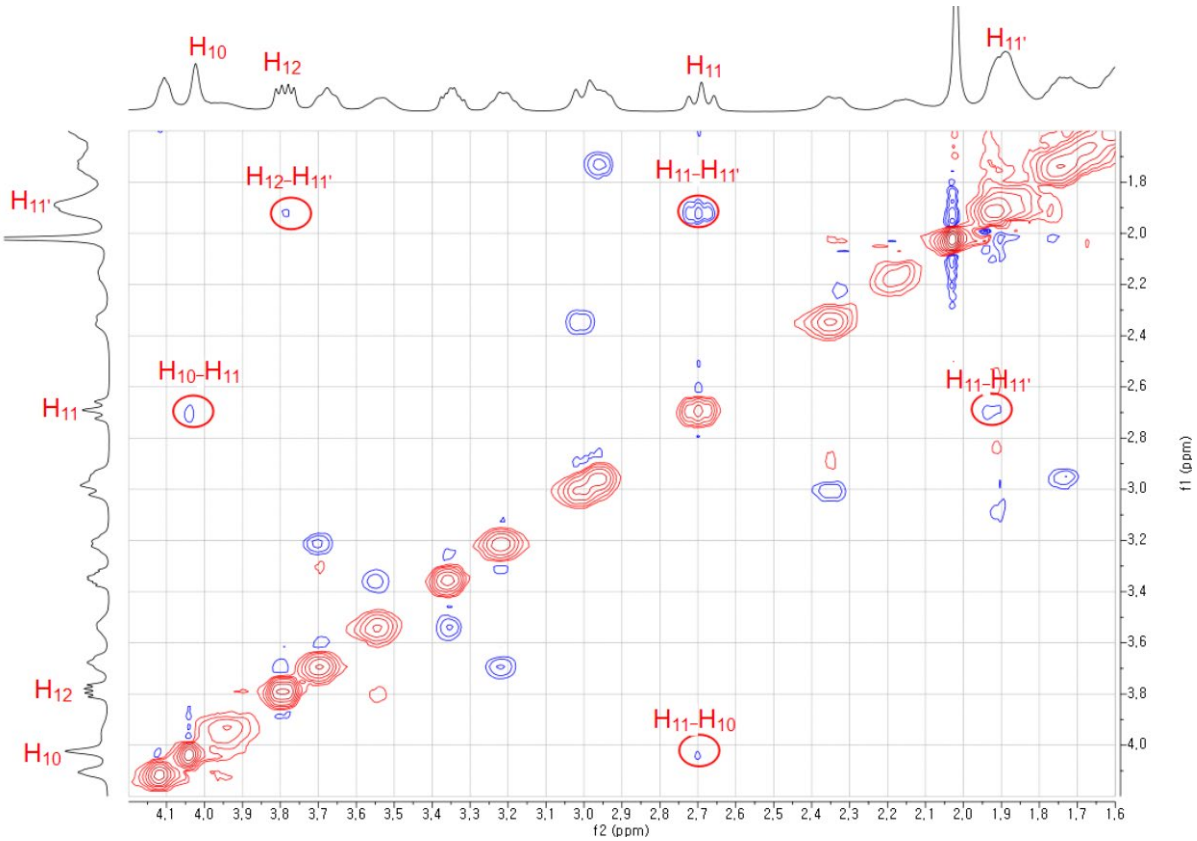
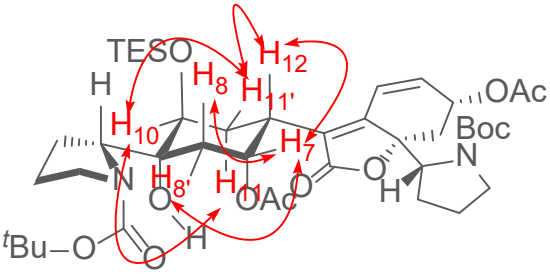


Figure S4. 2D NOESY spectrum of compound **35** (Region of interest (1.6–4.2 ppm) is magnified. See section 7 for copies of comprehensive 2D NMR spectra of compound **35**).



39

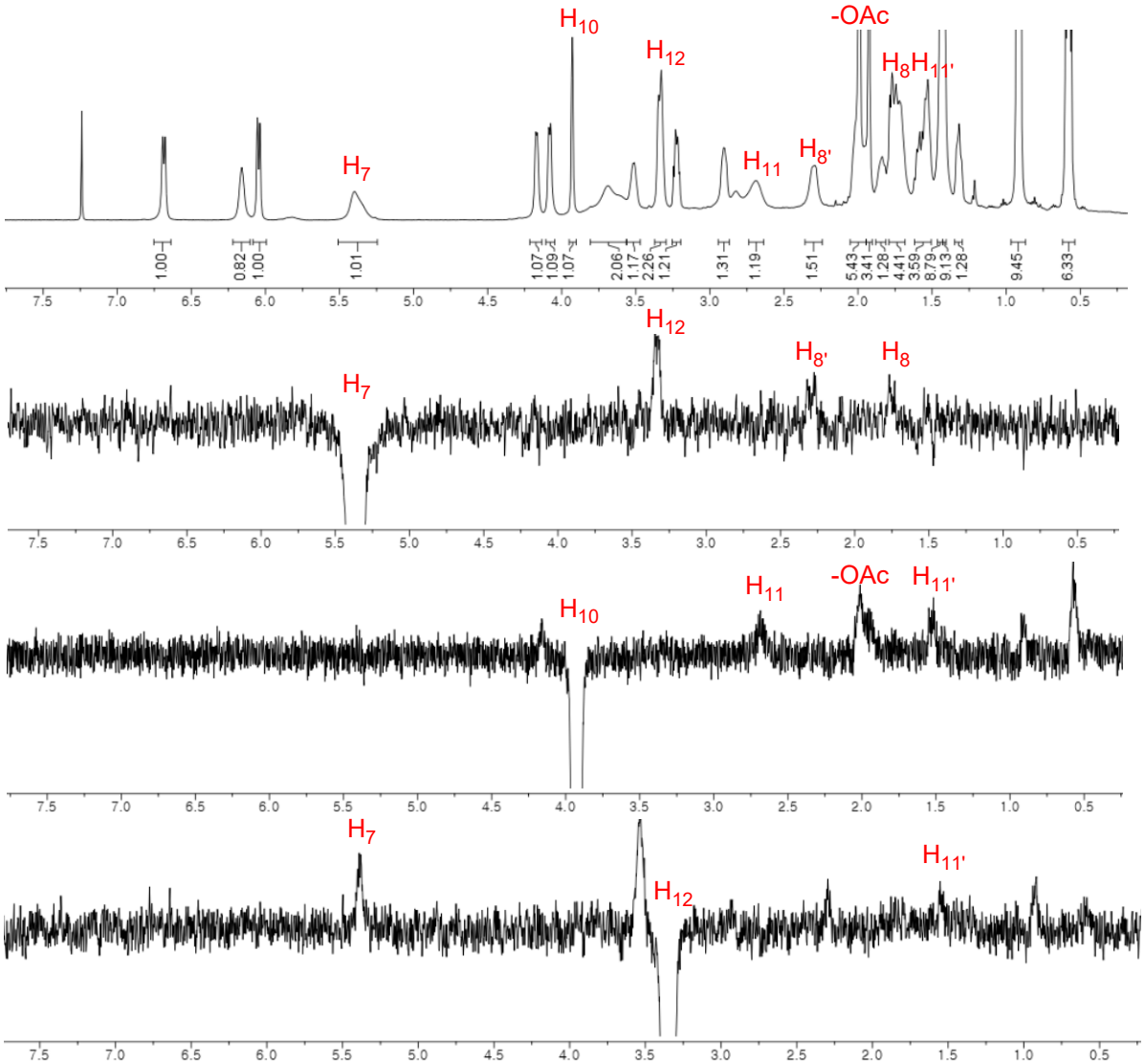


Figure S5. Selective 1D NOESY spectra of compound **39** (See section 7 for copies of comprehensive 2D NMR spectra of compound **39**).

6. Comparison of Spectroscopic Data of Our Synthetic Natural Products with Other Reports

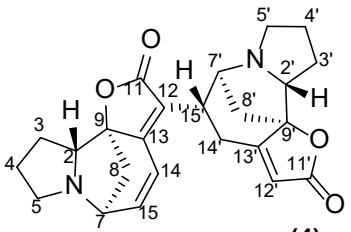
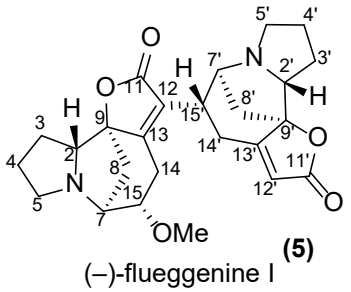


Table S1. Comparison of ^{1}H-NMR spectroscopic data of natural and synthetic flueggenine D (4)

position	natural **4**[4c] δ_1 (ppm ; multi, *J* in Hz)	synthetic **4** δ_2 (ppm ; multi, *J* in Hz)	deviation $\Delta\delta = \delta_1 - \delta_2$ (ppm)
2	3.12 (dd, 8.8, 7.7)	3.13 (dd, 8.8, 7.7)	–0.01
3	a 1.94 (m)	a 1.94 (m)	0
	b 1.77 (m)	b 1.77 (m)	0
4	a 1.96 (m)	a 1.96 (m)	0
	b 1.76 (m)	b 1.76 (m)	0
5	a 3.27 (m)	a 3.27 (m)	0
z	b 2.51 (m)	b 2.52 (m)	–0.01
7	3.61 (dd, 6.4, 4.7)	3.61 (dd, 6.4, 4.7)	0
8	a 2.55 (dd, 10.6, 4.7)	a 2.55 (dd, 10.6, 4.7)	0
	b 1.60 (d, 10.6)	b 1.60 (d, 10.6)	0
14	6.44 (d, 9.2)	6.45 (d, 9.2)	–0.01
15	6.73 (dd, 9.2, 6.4)	6.73 (dd, 9.2, 6.4)	0
2′	3.21 (dd, 8.6, 7.0)	3.22 (dd, 8.6, 7.0)	–0.01
3′	a 1.90 (m)	a 1.90 (m)	0
	b 1.74 (m)	b 1.74 (m)	0
4′	a 1.93 (m)	a 1.93 (m)	0
	b 1.73 (m)	b 1.73 (m)	0
5′	a 3.40 (m)	a 3.40 (m)	0
	b 2.63 (m)	b 2.64 (m)	–0.01
7′	3.26 (m)	3.27 (m)	–0.01
8′	a 2.29 (dd, 11.5, 5.7)	a 2.30 (dd, 11.4, 5.7)	–0.01
	b 1.37 (d, 11.5)	b 1.37 (d, 11.4)	0
12′	5.74 (d, 2.2)	5.75 (d, 2.2)	–0.01
14′	β 3.14 (ddd, 17.3, 9.2, 2.2)	β 3.14 (ddd, 17.3, 9.2, 2.2)	0
	α 3.03 (d, 17.3)	α 3.03 (d, 17.3)	0
15’	3.42 (dd, 9.2, 3.3)	3.43 (dd, 9.2, 3.3)	–0.01

Table S2. Comparison of ^{13}C NMR spectroscopic data of natural and synthetic flueggenine D (4)

position	natural **4**[4c] δ_1 (ppm)	synthetic **4** δ_2 (ppm)	deviation $\Delta\delta = \delta_1 - \delta_2$ (ppm)
2	65.8	65.9	–0.1
3	29.6	29.6	0
4	27.0	27.0	0
5	55.3	55.3	0
7	59.7	59.7	0
8	35.8	35.8	0
9	90.6	90.6	0
11	172.8	172.8	0
12	120.6	120.6	0
13	161.5	161.5	0
14	119.3	119.3	0
15	144.3	144.3	0
2′	66.8	66.9	–0.1
3′	29.3	29.3	0
4′	26.8	26.8	0
5′	57.7	57.7	0
7′	64.9	65.0	–0.1
8′	30.6	30.6	0
9′	92.4	92.4	0
11′	172.7	172.7	0
12′	110.7	110.7	0
13′	174.1	174.1	0
14′	26.5	26.5	0
15′	39.8	39.8	0



(–)-flueggenine I **(5)**

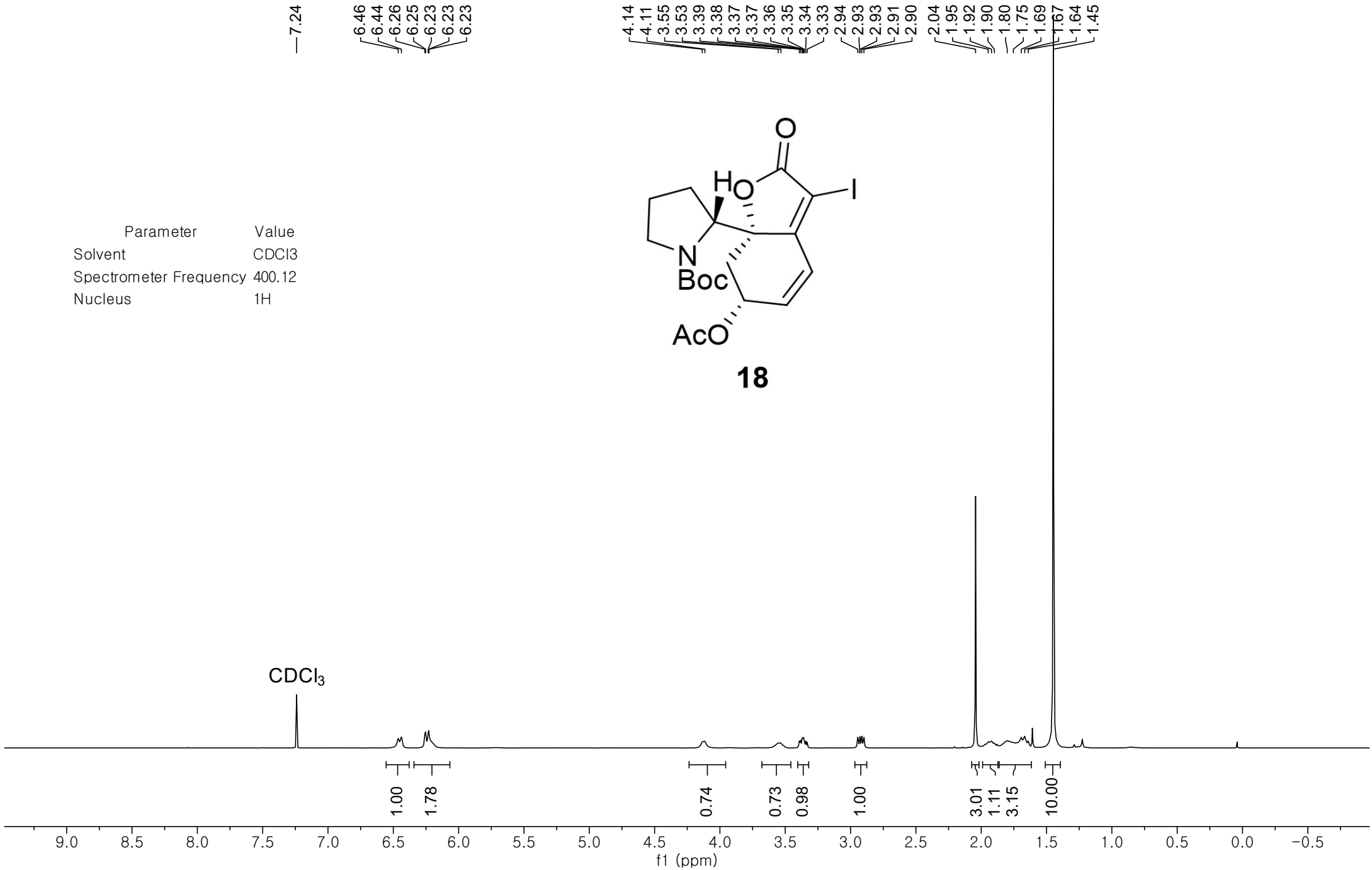
Table S3. Comparison of ^{1}H-NMR spectroscopic data of natural and synthetic flueggenine I (5)

position	natural **5**[4d] δ_1 (ppm ; multi, *J* in Hz)	synthetic **5** δ_2 (ppm ; multi, *J* in Hz)	deviation $\Delta\delta = \delta_1 - \delta_2$ (ppm)
2	3.05 (dd, 8.9, 6.9)	3.06 (t, 8.3)	-0.01
3	1.85–1.94 (m)	1.86–1.95 (m)	-0.01
	1.71–1.80 (m)	1.71–1.80 (m)	0
4	1.90–1.98 (m)	1.91–1.99 (m)	-0.01
	1.66–1.76 (m)	1.65–1.75 (m)	0.01
5	3.31 (m)	3.31 (m)	0
	2.62 (m)	2.63 (m)	-0.01
7	3.13 (m)	3.13 (m)	0
8	a 2.27 (dd, 11.1, 5.6)	a 2.27 (dd 11.1, 5.7)	0
	b 1.70 (d, 11.1)	b 1.70 (d, 11.1)	0
14	2.93 (d, 16.4)	2.94 (d, 16.4)	-0.01
	2.66 (ddd, 16.4, 5.3, 1.7)	2.68 (m)	-0.02
15	3.57 (dd, 5.3, 4.1)	3.57 (t, 4.7)	0
2′	3.20 (dd, 8.8, 6.8)	3.20 (dd, 8.8, 6.8)	0
3′	1.85–1.94 (m)	1.85–1.94 (m)	0
	1.71–1.80 (m)	1.71–1.80 (m)	0
4′	1.90–1.98 (m)	1.90–1.98 (m)	0
	1.66–1.76 (m)	1.65–1.75 (m)	0.01
5′	3.39 (m)	3.39 (m)	0
	2.64 (m)	2.65 (m)	-0.01
7′	3.17 (m)	3.18 (m)	-0.01
8′	2.29 (dd, 11.6, 5.8)	2.29 (dd, 11.5, 5.8)	0
	1.54 (d, 11.6)	1.55 (d, 11.5)	-0.01
12′	5.74 (d, 2.4)	5.74 (d, 2.3)	0
14′	3.11 (ddd, 17.3, 9.6, 2.4)	3.12 (ddd, 17.3, 9.7, 2.3)	-0.01
	2.91 (d, 17.3)	2.92 (d, 17.3)	-0.01
15′	3.36 (br d, 9.6)	3.37 (br d, 9.7)	-0.01
OMe	3.20 (s)	3.21 (s)	-0.01

Table S4. Comparison of ^{13}C NMR spectroscopic data of natural and synthetic flueggenine I (5)

position	natural **5**[4d] δ_1 (ppm)	synthetic **5** δ_2 (ppm)	deviation $\Delta\delta = \delta_1 - \delta_2$ (ppm)
2	66.2	66.3	-0.1
3	29.26	29.29	-0.03
4	26.8	26.8	0
5	57.3	57.3	0
7	63.4	63.4	0
8	30.4	30.4	0
9	90.6	90.6	0
11	173.0	173.0	0
12	122.9	122.9	0
13	165.4	165.4	0
14	28.1	28.1	0
15	78.7	78.8	-0.1
2′	66.9	66.9	0
3′	29.25	29.27	-0.02
4′	26.9	26.9	0
5′	57.7	57.7	0
7′	64.6	64.7	-0.1
8′	30.0	30.0	0
9′	92.5	92.5	0
11′	172.8	172.7	0.1
12′	110.7	110.7	0
13′	174.7	174.7	0
14′	26.3	26.3	0
15′	39.2	39.3	-0.1
OMe	57.1	57.1	0

7. Copies of ^{1}H NMR, ^{13}C NMR Spectra of Newly Synthesized Compounds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6.46
6.44
6.26
6.25
6.23
6.23
6.23
4.14
4.11
3.55
3.53
3.39
3.38
3.37
3.37
3.36
3.35
3.34
3.33
2.94
2.93
2.93
2.91
2.90
2.04
1.95
1.92
1.90
1.80
1.75
1.69
1.67
1.64
1.45
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
O
HO
I
N
Boc
AcO
18
CDCl3
1.00
1.78
0.74
0.73
0.98
1.00
3.01
1.11
3.15
10.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
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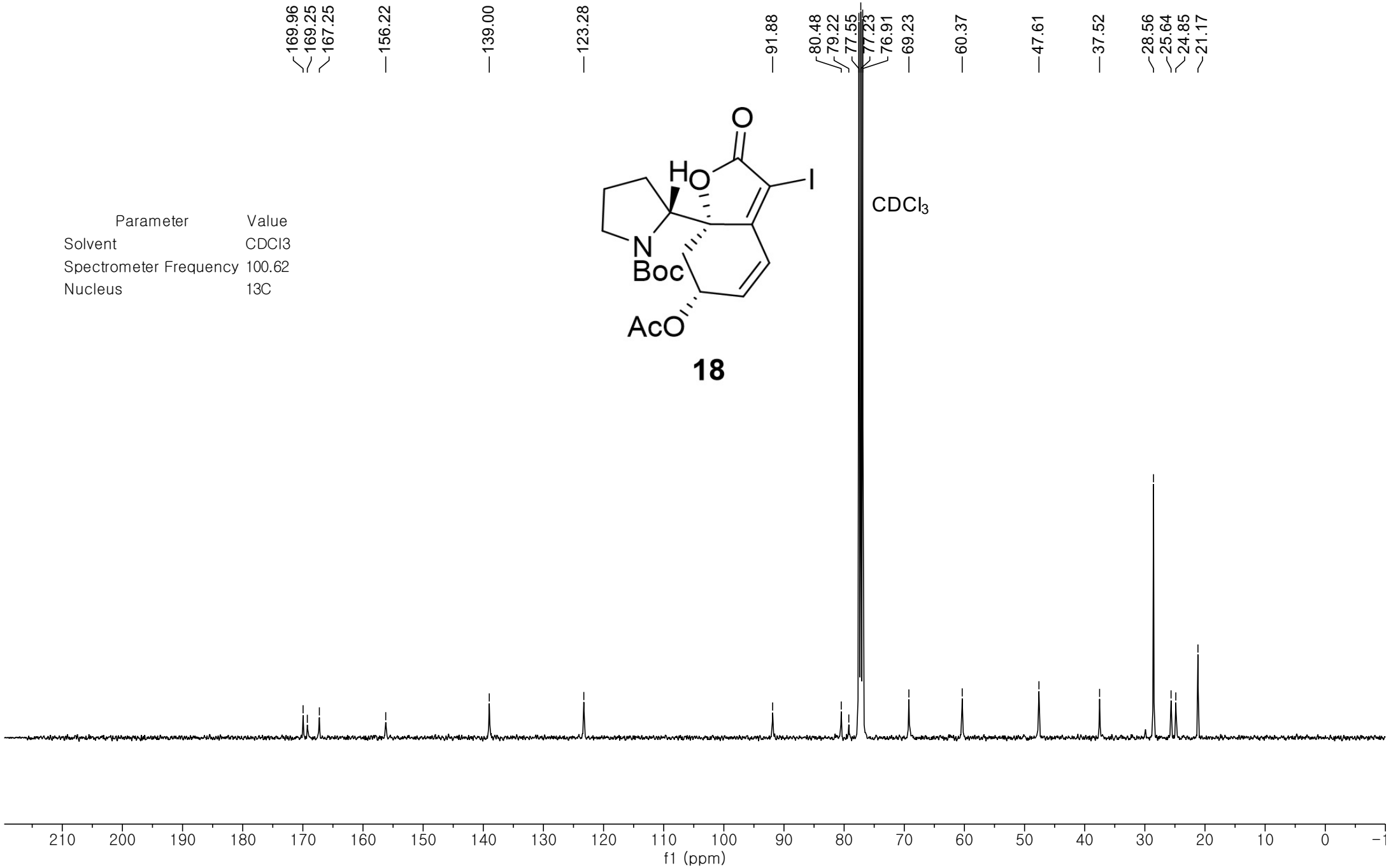
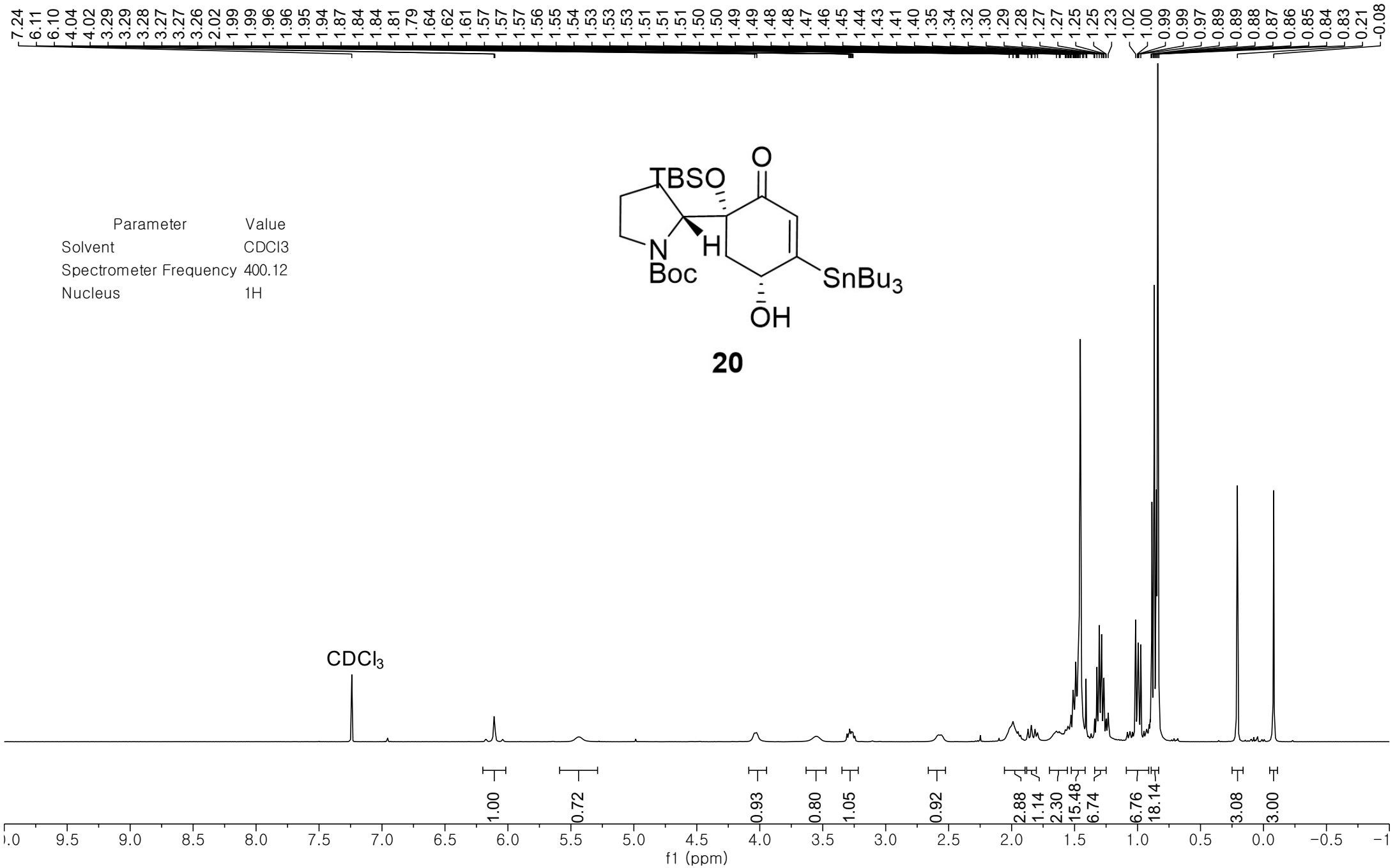
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)


169.96
169.25
167.25
156.22
139.00
123.28
91.88
80.48
79.22
77.55
77.23
76.91
69.23
60.37
47.61
37.52
28.56
25.64
24.85
21.17
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
O
HO
I
N
Boc
AcO
18
f1 (ppm)


7.24 6.11 6.10 4.04 4.02 3.29 3.29 3.28 3.27 3.27 3.26 2.02 1.99 1.99 1.96 1.96 1.95 1.94 1.87 1.84 1.84 1.81 1.79 1.64 1.62 1.61 1.57 1.57 1.57 1.56 1.55 1.54 1.53 1.53 1.53 1.51 1.51 1.51 1.50 1.50 1.49 1.49 1.48 1.48 1.47 1.46 1.45 1.44 1.43 1.41 1.40 1.35 1.34 1.32 1.30 1.29 1.28 1.27 1.27 1.25 1.25 1.23 1.02 1.00 0.99 0.99 0.97 0.89 0.89 0.88 0.87 0.86 0.85 0.84 0.83 0.21 -0.08
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
TBSO
O
N
H
Boc
SnBu3
OH
20
CDCl3
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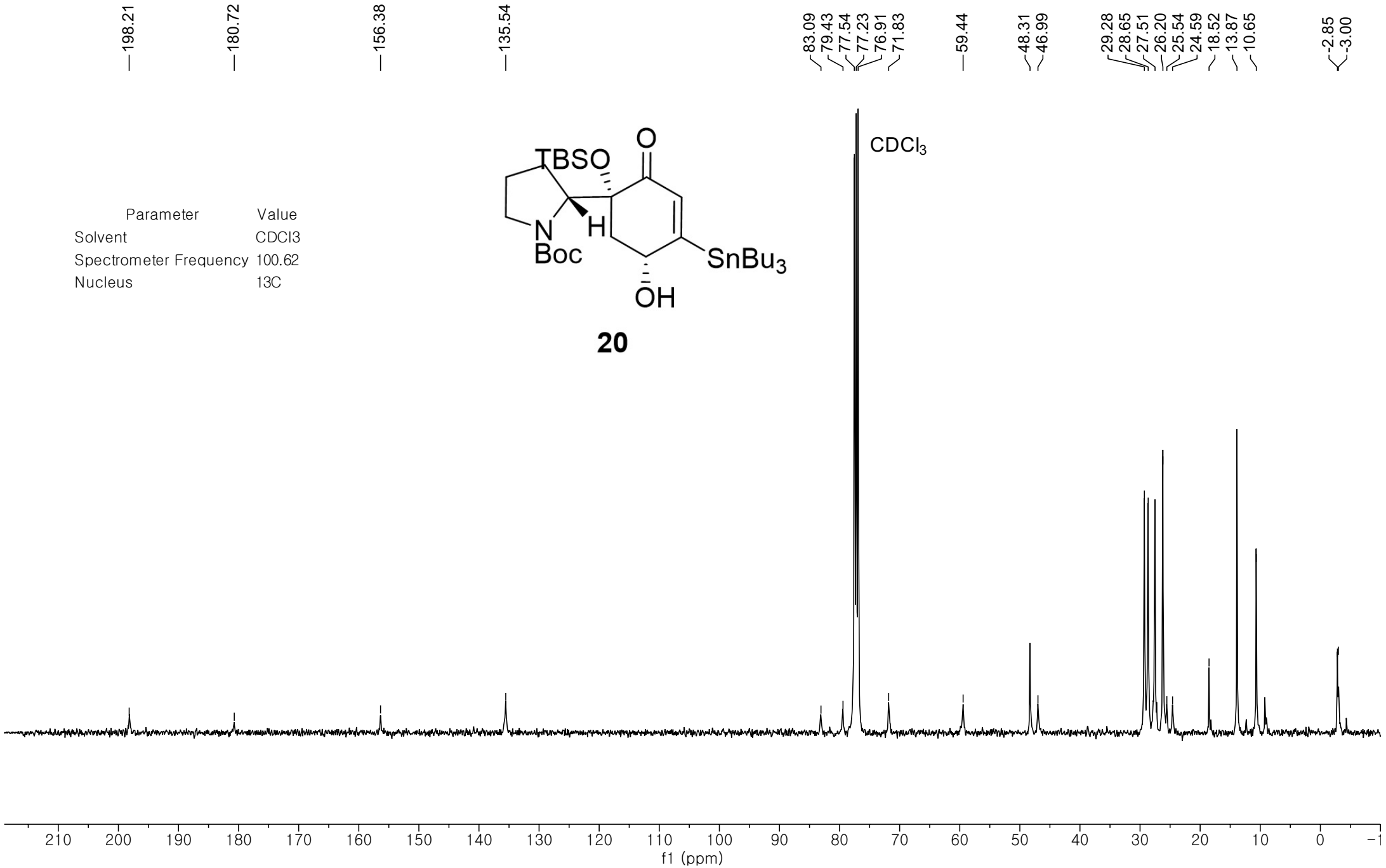
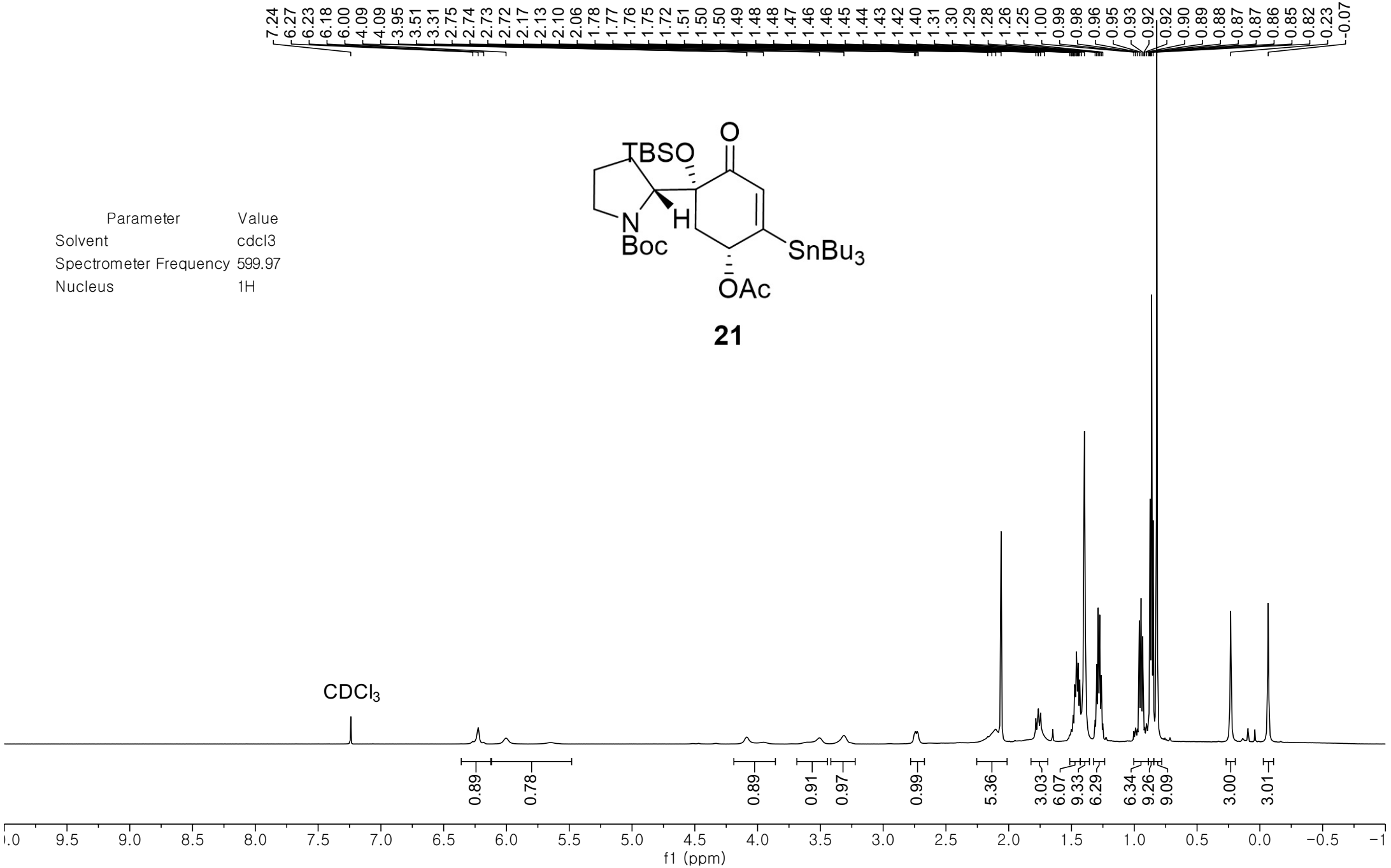
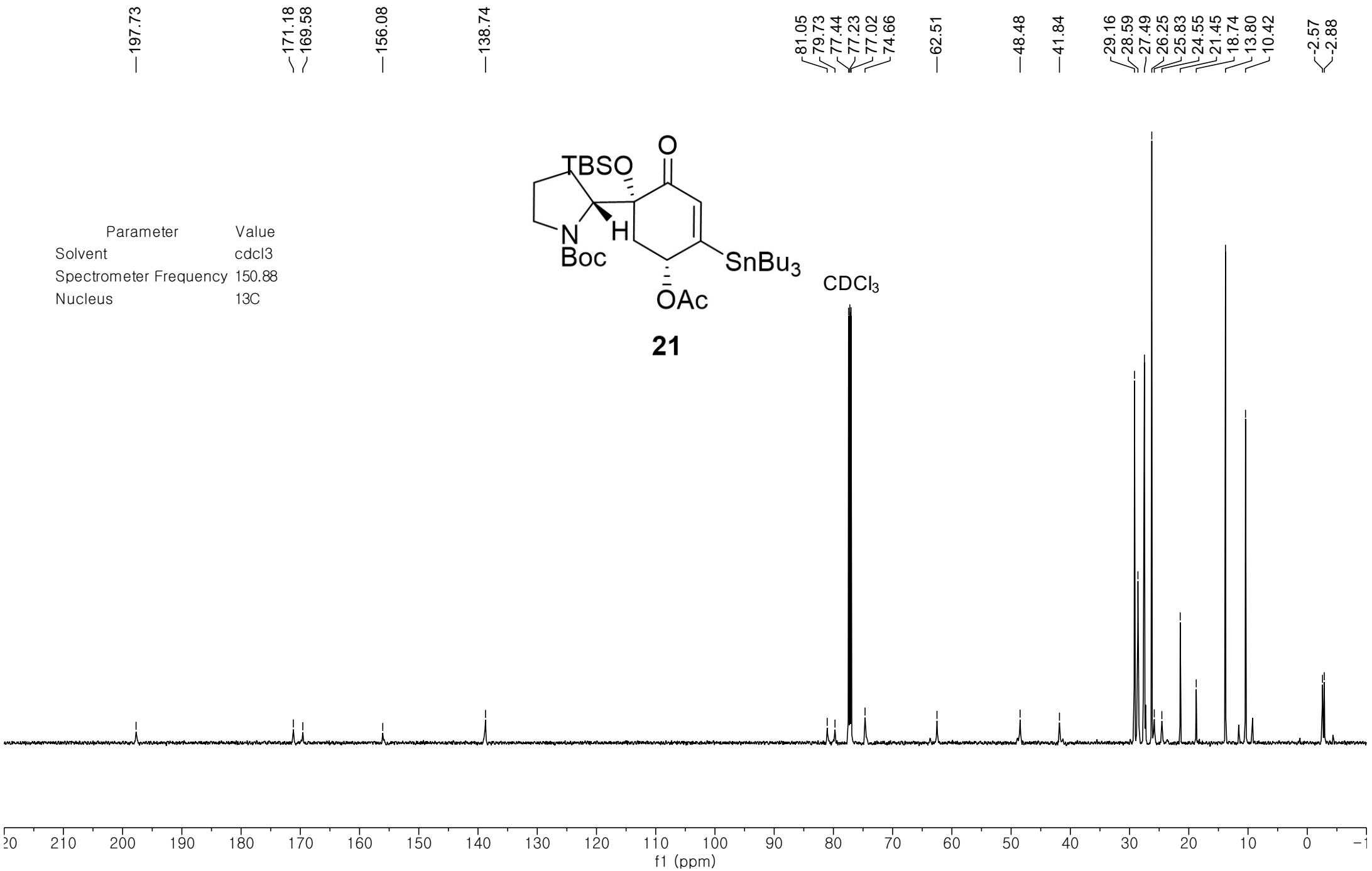
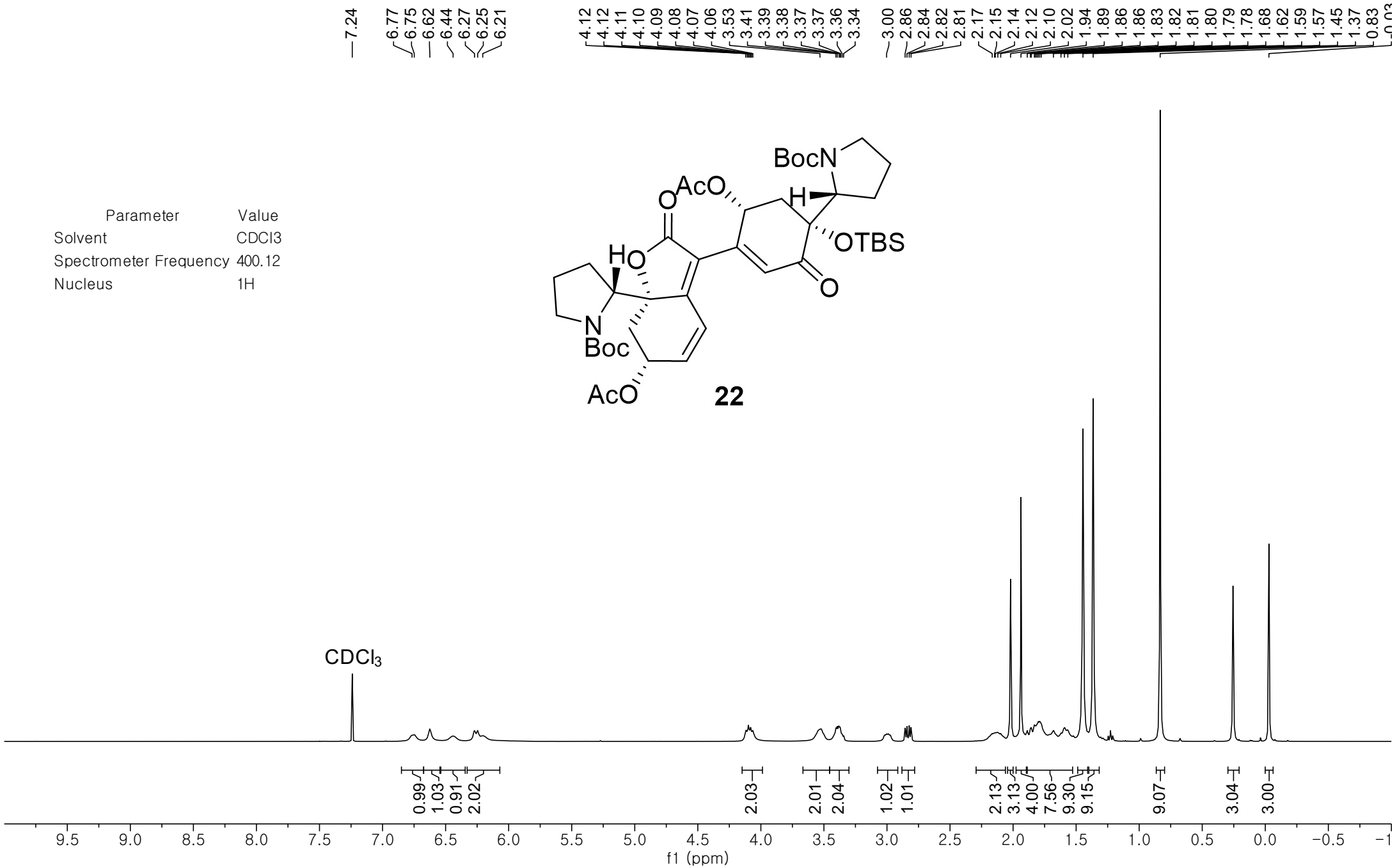
f1 (ppm)


198.21
180.72
156.38
135.54
83.09
79.43
77.54
77.23
76.91
71.83
59.44
48.31
46.99
29.28
28.65
27.51
26.20
25.54
24.59
18.52
13.87
10.65
-2.85
-3.00
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
TBSO
O
N
H
Boc
SnBu3
OH
20
f1 (ppm)


7.24 6.27 6.23 6.18 6.00 4.09 4.09 3.95 3.51 3.31 2.75 2.74 2.73 2.72 2.17 2.13 2.10 2.06 1.78 1.77 1.76 1.75 1.72 1.51 1.50 1.50 1.49 1.48 1.48 1.47 1.46 1.46 1.45 1.44 1.43 1.42 1.40 1.31 1.30 1.29 1.28 1.26 1.25 1.00 0.99 0.98 0.96 0.95 0.93 0.92 0.92 0.90 0.89 0.88 0.87 0.87 0.86 0.85 0.82 0.23 -0.07
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.97
Nucleus 1H
TBSO
O
N
Boc
H
SnBu3
OAc
21
CDCl3
0.89 0.78 0.89 0.91 0.97 0.99 5.36 3.03 6.07 9.33 6.29 6.34 9.26 9.09 3.00 3.01
f1 (ppm)


197.73
171.18
169.58
156.08
138.74
81.05
79.73
77.44
77.23
77.02
74.66
62.51
48.48
41.84
29.16
28.59
27.49
26.25
25.83
24.55
21.45
18.74
13.80
10.42
-2.57
-2.88
Parameter Value
Solvent cdcl3
Spectrometer Frequency 150.88
Nucleus 13C
TBSO
O
N
H
Boc
SnBu3
OAc
21
CDCl3
f1 (ppm)


7.24
6.77
6.75
6.62
6.44
6.27
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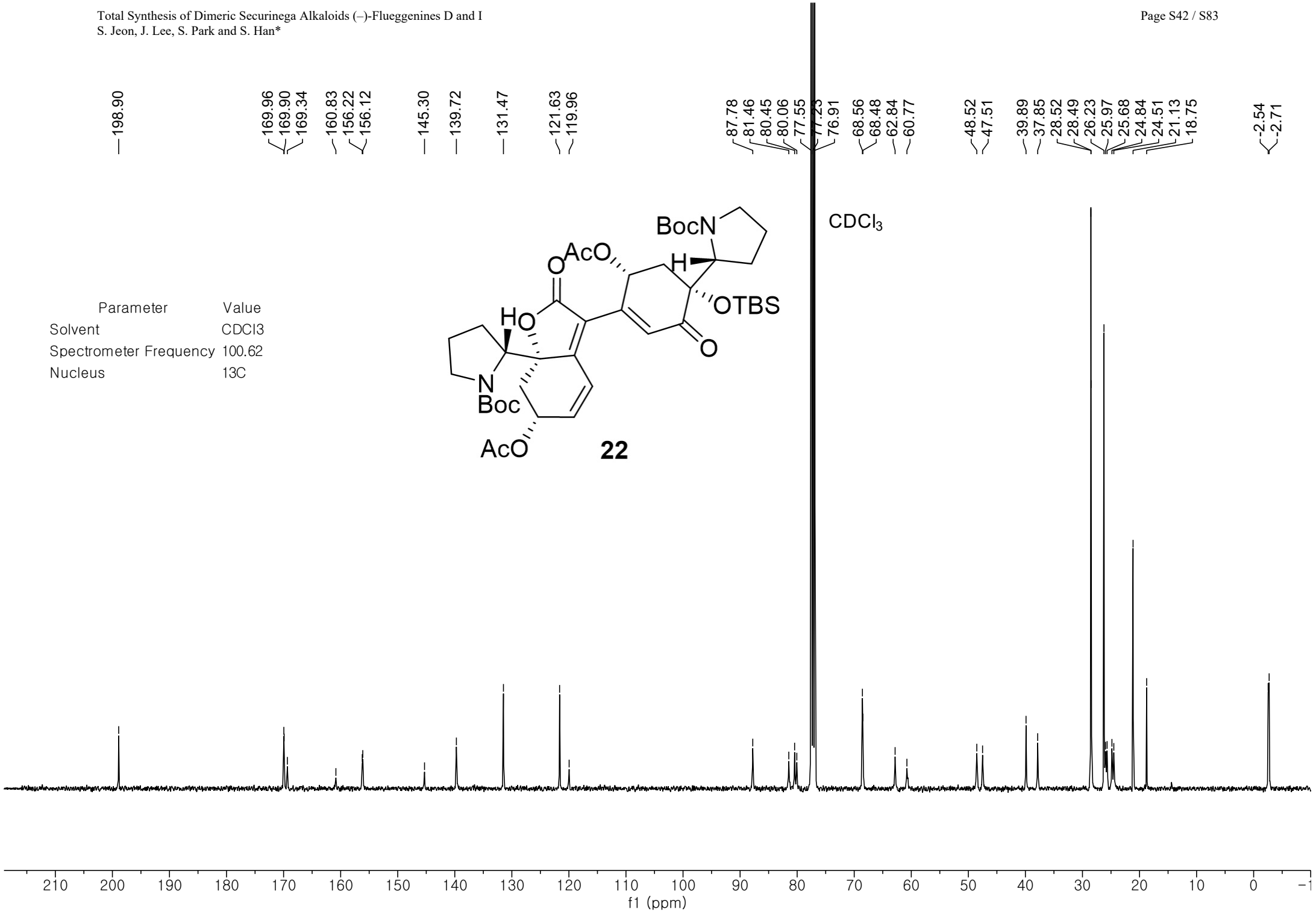
6.21
4.12
4.12
4.11
4.10
4.09
4.08
4.07
4.06
3.53
3.41
3.39
3.38
3.37
3.37
3.36
3.34
3.00
2.86
2.84
2.82
2.81
2.17
2.15
2.14
2.12
2.10
2.02
1.94
1.89
1.86
1.86
1.83
1.82
1.81
1.80
1.79
1.78
1.68
1.62
1.59
1.57
1.45
1.37
0.83
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
BocN
AcO
H
HO
OTBS
O
O
N
Boc
AcO
22
CDCl3
0.99
1.03
0.91
2.02
2.03
2.01
2.04
1.02
1.01
2.13
3.13
4.00
7.56
9.30
9.15
9.07
3.04
3.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)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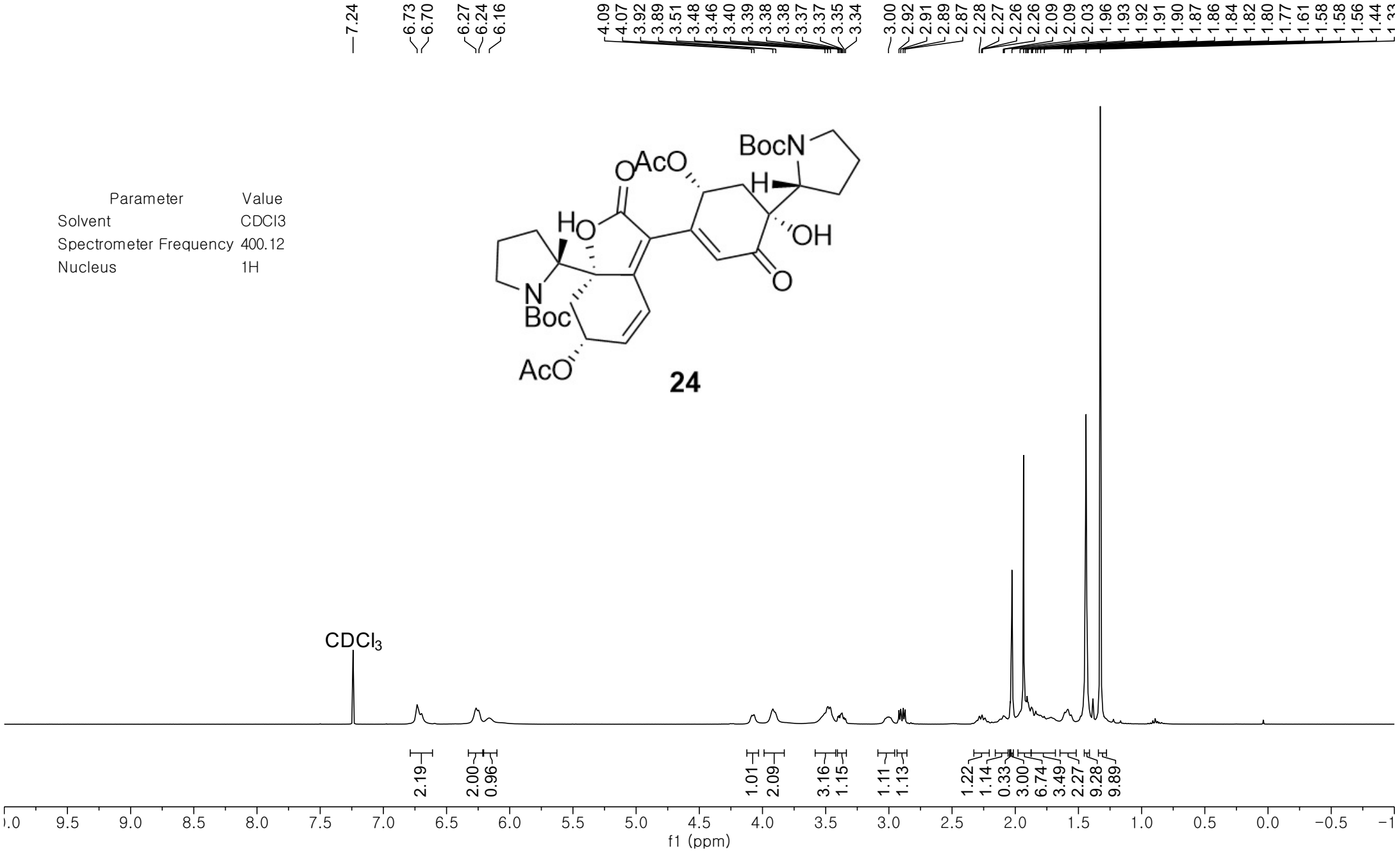
169.90
169.34
160.83
156.22
156.12
145.30
139.72
131.47
121.63
119.96
87.78
81.46
80.45
80.06
77.55
77.23
76.91
68.56
68.48
62.84
60.77
48.52
47.51
39.89
37.85
28.52
28.49
26.23
25.97
25.68
24.84
24.51
21.13
18.75
-2.54
-2.71
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
BocN
AcO
H
OTBS
HO
O
N
Boc
AcO
22
f1 (ppm)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6.73
6.70
6.27
6.24
6.16
4.09
4.07
3.92
3.89
3.51
3.48
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3.40
3.39
3.38
3.38
3.37
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3.34
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2.87
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2.26
2.09
2.09
2.03
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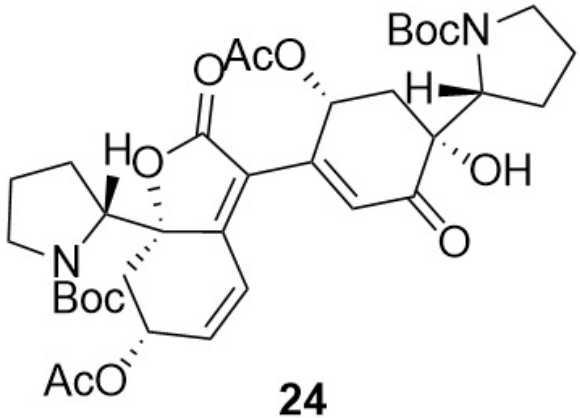
1.93
1.92
1.91
1.90
1.87
1.86
1.84
1.82
1.80
1.77
1.61
1.58
1.58
1.56
1.44
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
BocN
AcO
H
HO
OH
O
N
Boc
AcO
24
CDCl3
2.19
2.00
0.96
1.01
2.09
3.16
1.15
1.11
1.13
1.22
1.14
0.33
3.00
6.74
3.49
2.27
9.28
9.89
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

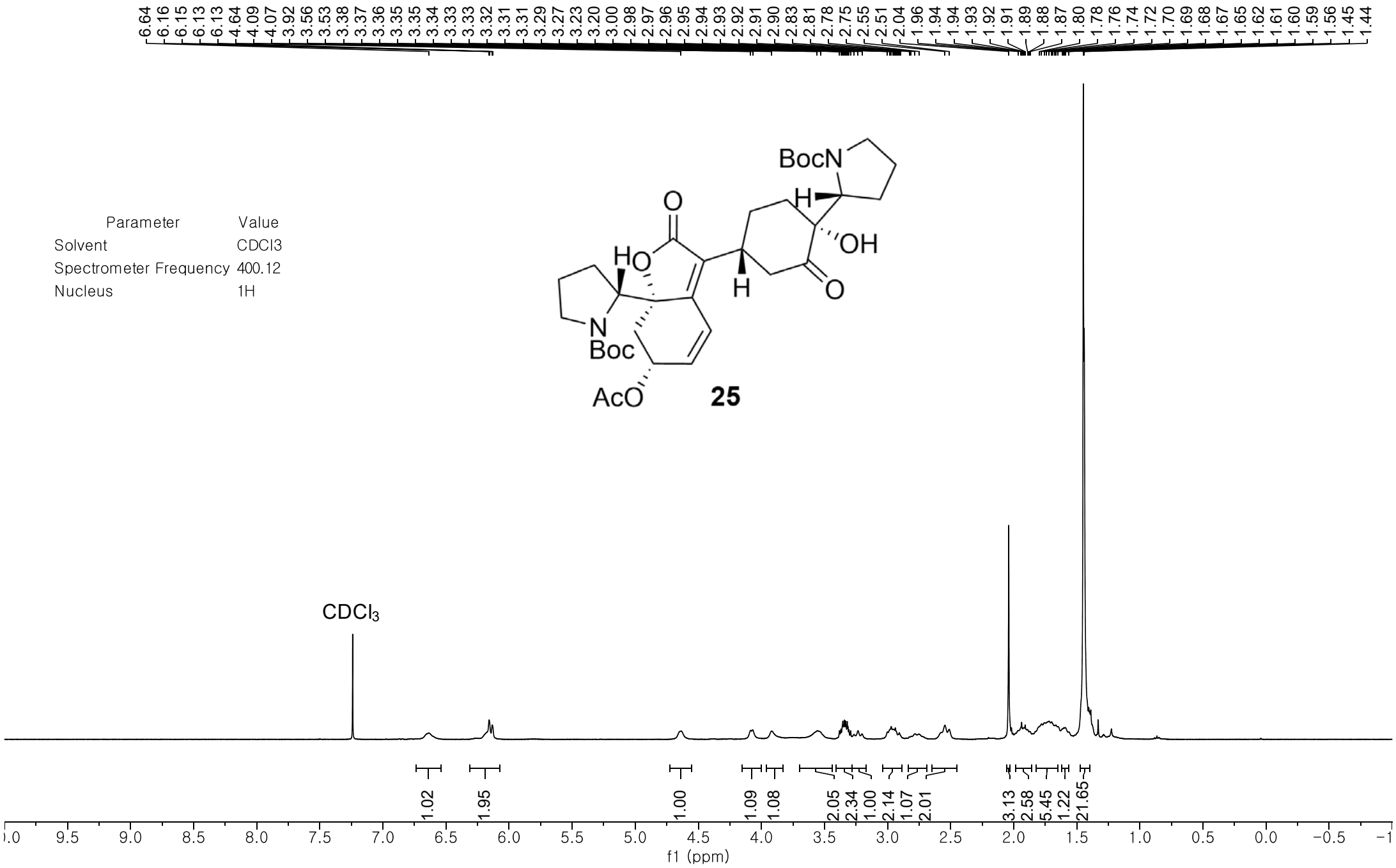
200.34
170.01
169.93
169.14
161.28
156.12
156.06
146.50
139.74
130.47
121.59
119.99
87.76
87.74
80.48
80.15
77.23
76.91
68.39
67.83
63.51
61.11
48.53
47.58
38.22
37.86
28.51
28.42
26.44
25.85
24.80
24.49
21.12
21.02

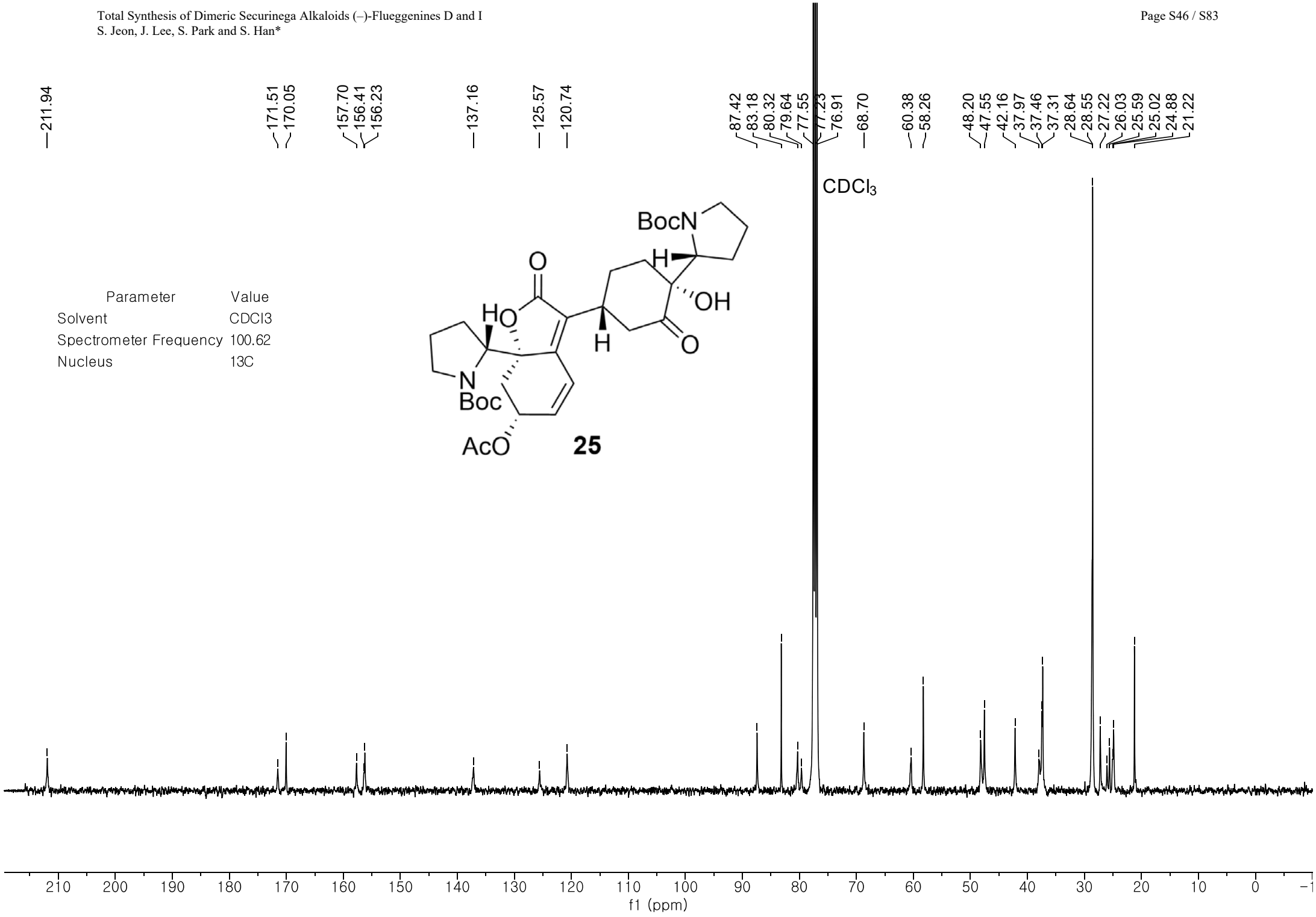
$CDCl_3$

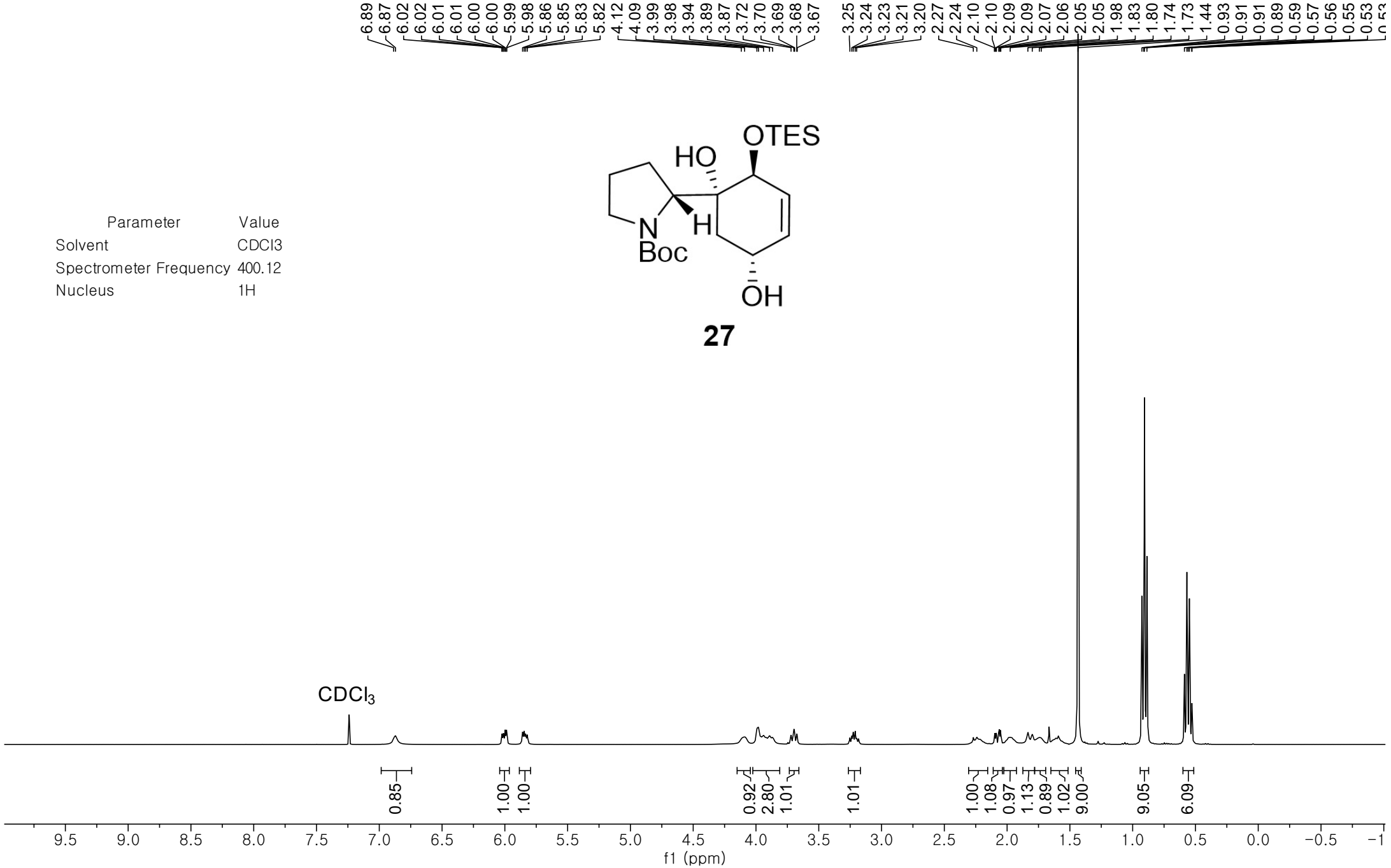
Parameter	Value
Solvent	CDCl3
Spectrometer Frequency	100.62
Nucleus	13C

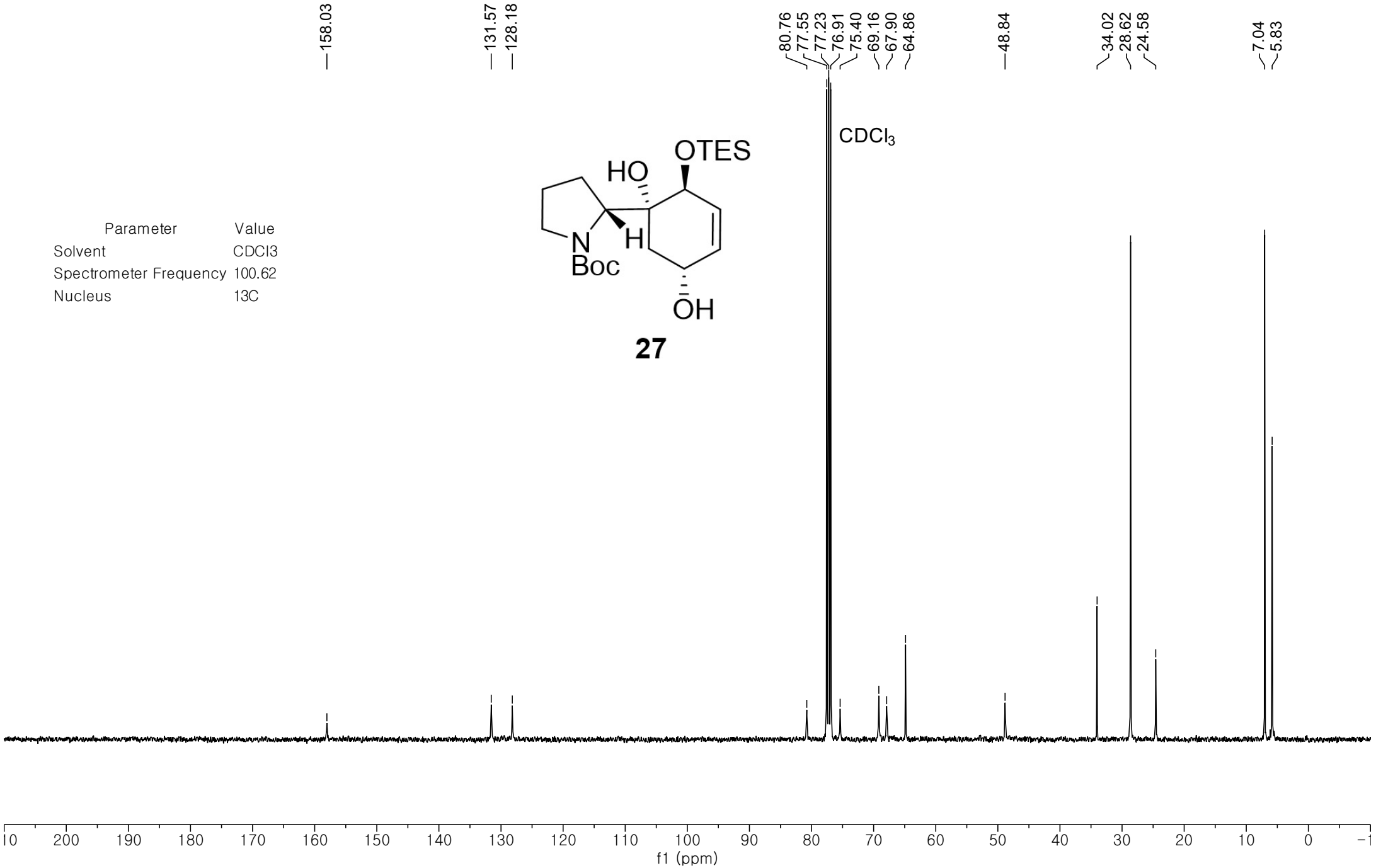


24

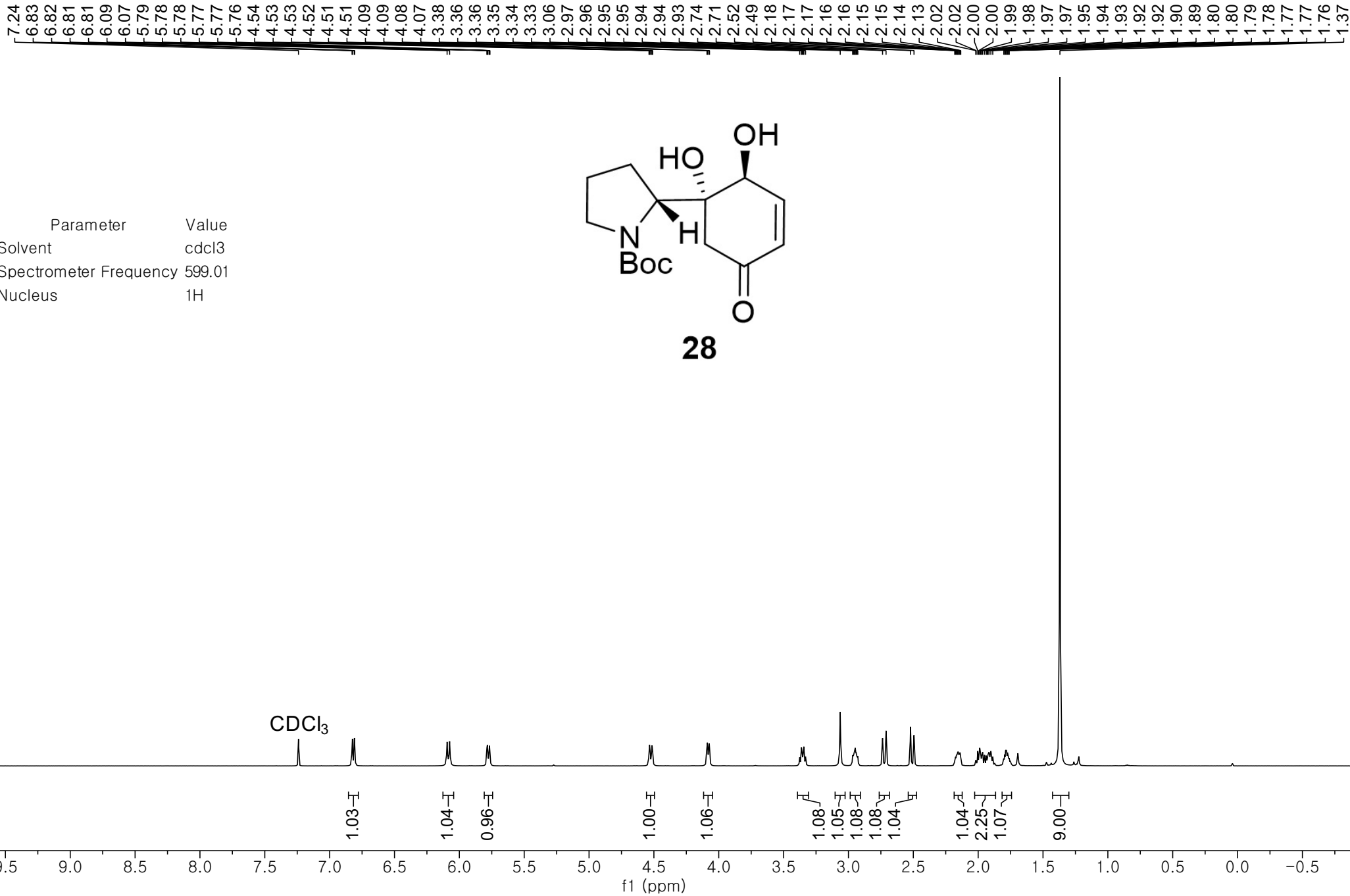

6.64 6.16 6.15 6.13 6.13 4.64 4.09 4.07 3.92 3.56 3.53 3.38 3.37 3.36 3.35 3.35 3.34 3.33 3.33 3.32 3.31 3.31 3.29 3.27 3.23 3.20 3.00 2.98 2.97 2.96 2.95 2.94 2.93 2.92 2.91 2.90 2.83 2.81 2.78 2.75 2.55 2.51 2.04 1.96 1.94 1.94 1.93 1.92 1.91 1.89 1.88 1.87 1.80 1.78 1.76 1.74 1.72 1.70 1.69 1.68 1.67 1.65 1.62 1.61 1.60 1.59 1.56 1.45 1.44
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
BocN
H
OH
O
HO
O
H
N
Boc
AcO
25
CDCl3
1.02 1.95 1.00 1.09 1.08 2.05 2.34 1.00 2.14 1.07 2.01 3.13 2.58 5.45 1.22 21.65
f1 (ppm)

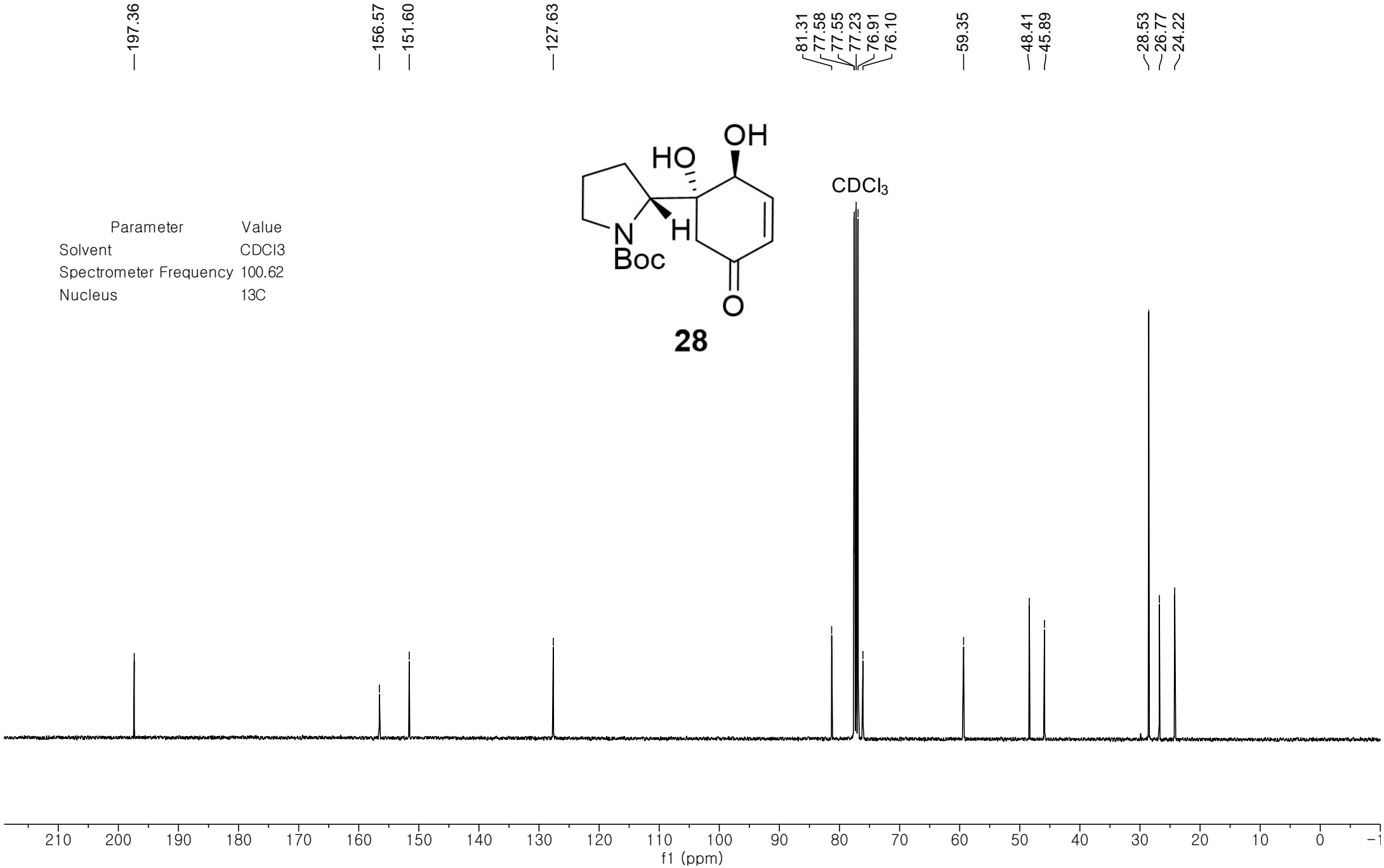

211.94
171.51
170.05
157.70
156.41
156.23
137.16
125.57
120.74
87.42
83.18
80.32
79.64
77.55
77.23
76.91
68.70
60.38
58.26
48.20
47.55
42.16
37.97
37.46
37.31
28.64
28.55
27.22
26.03
25.59
25.02
24.88
21.22
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
BocN
H
OH
O
HO
O
H
N
Boc
AcO
25
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −1
f1 (ppm)

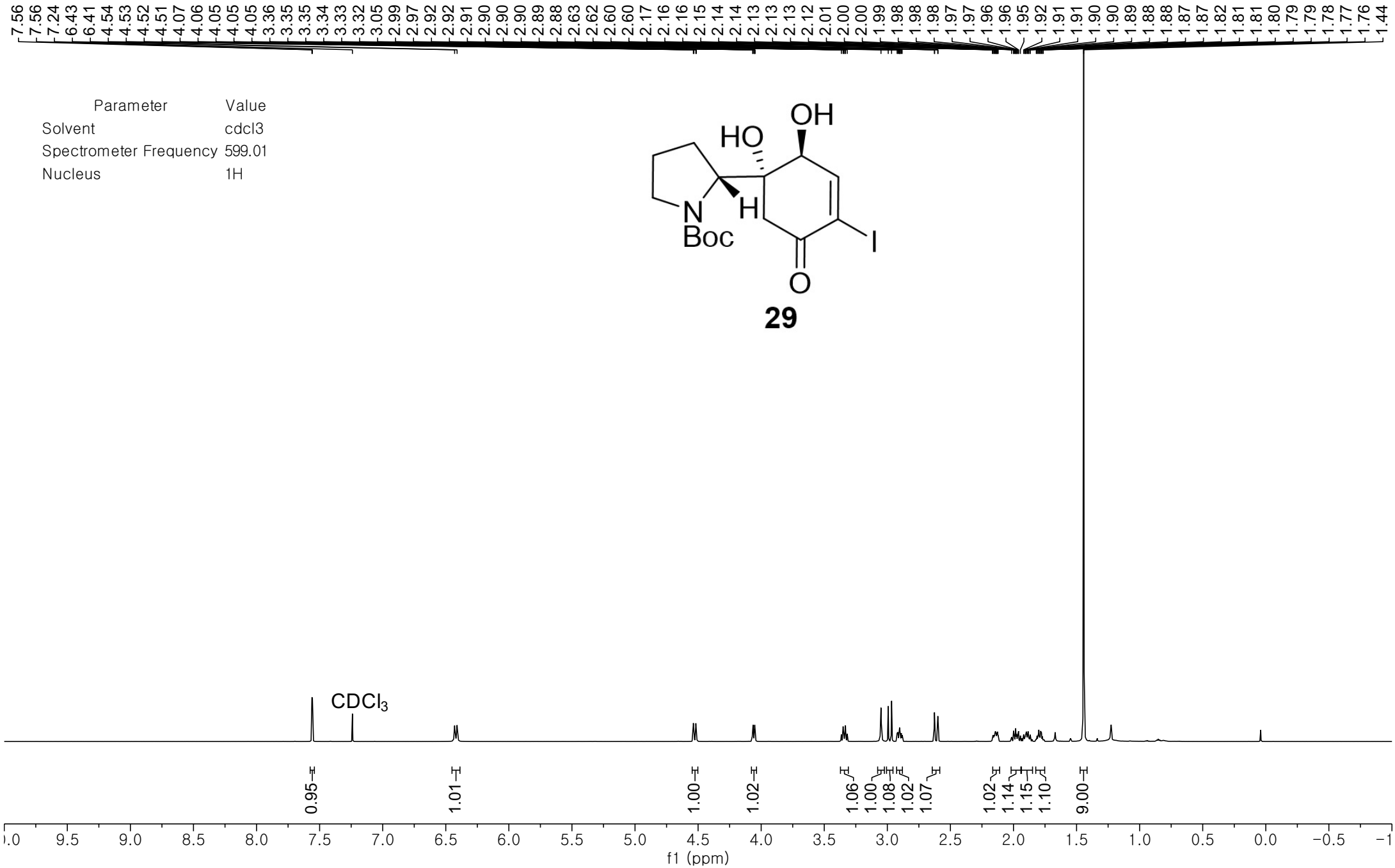

6.89 6.87 6.02 6.02 6.01 6.01 6.00 6.00 5.99 5.98 5.86 5.85 5.83 5.82 4.12 4.09 3.99 3.98 3.94 3.89 3.87 3.72 3.70 3.69 3.68 3.67
3.25 3.24 3.23 3.21 3.20 2.27 2.24 2.10 2.10 2.09 2.09 2.07 2.06 2.05 2.05 1.98 1.83 1.80 1.74 1.73 1.44 0.93 0.91 0.91 0.89 0.59 0.57 0.56 0.55 0.53
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
OTES
HO
N
H
Boc
OH
27
CDCl3
0.85 1.00 1.00 0.92 2.80 1.01 1.01 1.00 1.08 0.97 1.13 0.89 1.02 9.00 9.05 6.09
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1
f1 (ppm)

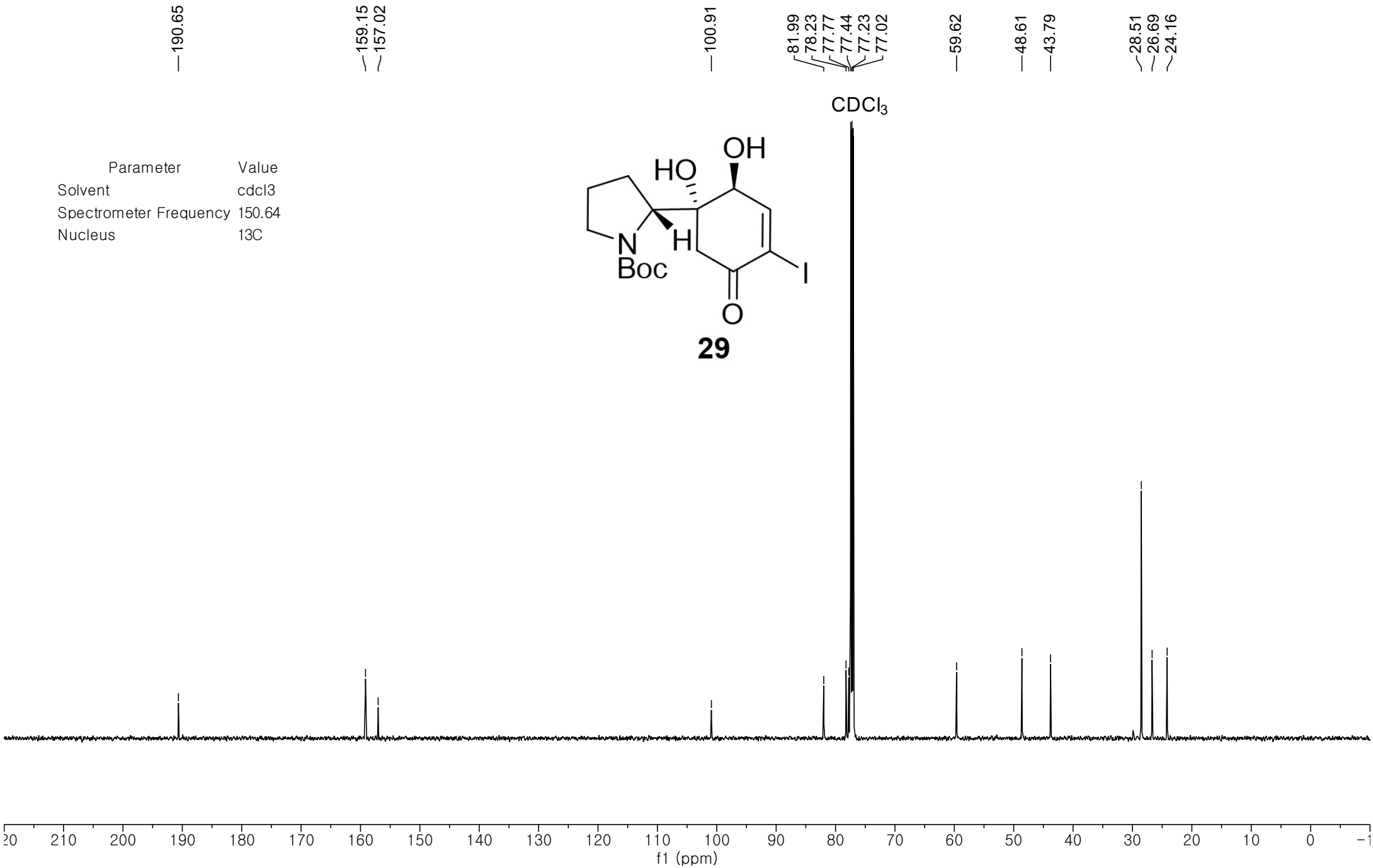

158.03
131.57
128.18
80.76
77.55
77.23
76.91
75.40
69.16
67.90
64.86
48.84
34.02
28.62
24.58
7.04
5.83
CDCl3
OTES
HO
N
H
Boc
OH
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
f1 (ppm)

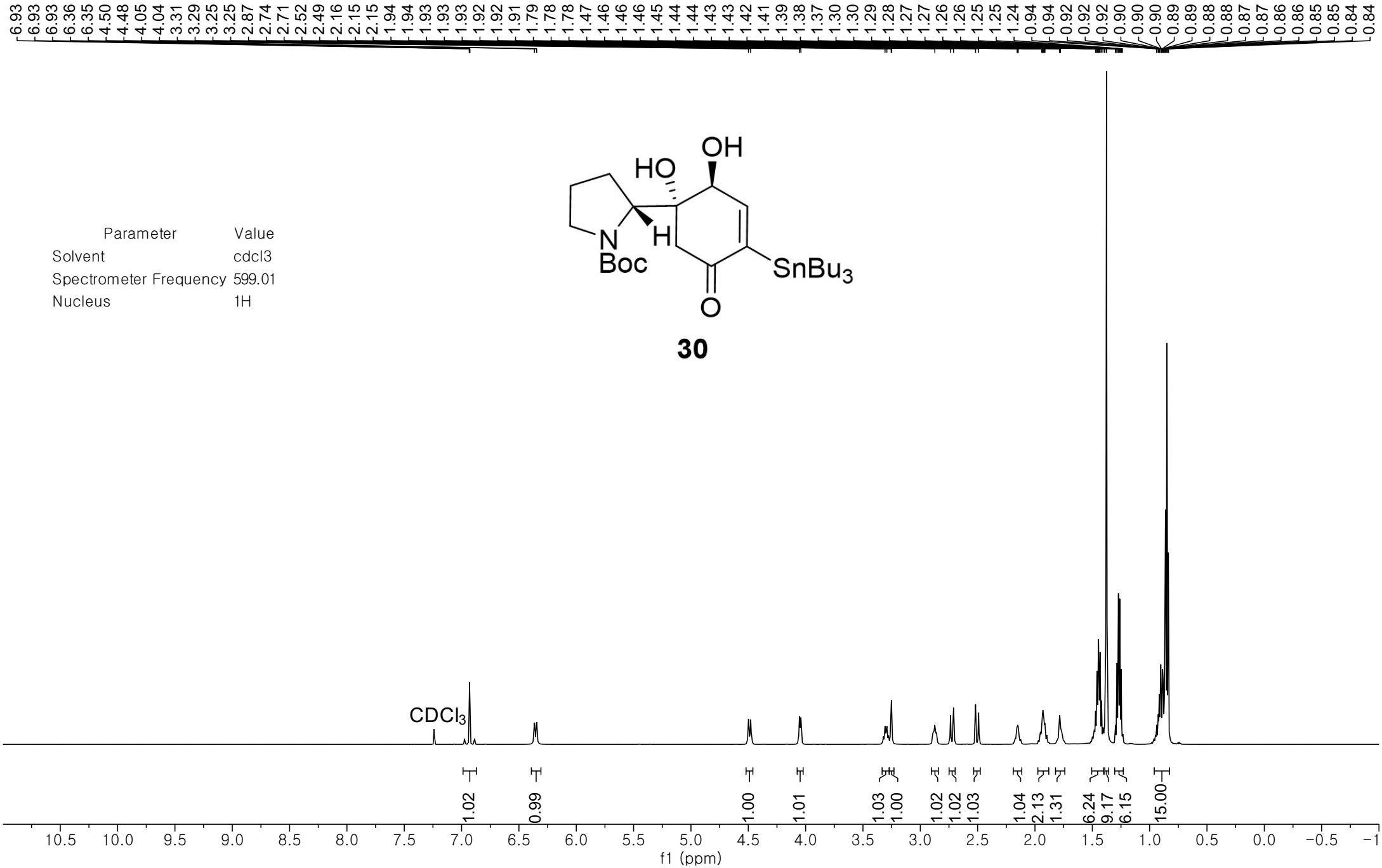
27


7.24 6.83 6.82 6.81 6.81 6.09 6.07 5.79 5.78 5.78 5.77 5.77 5.76 4.54 4.53 4.53 4.52 4.51 4.51 4.09 4.09 4.08 4.07 3.38 3.36 3.36 3.35 3.34 3.33 3.06 2.97 2.96 2.95 2.95 2.94 2.94 2.93 2.74 2.71 2.52 2.49 2.18 2.17 2.17 2.16 2.16 2.15 2.15 2.14 2.13 2.02 2.02 2.00 2.00 1.99 1.98 1.97 1.97 1.95 1.94 1.93 1.92 1.92 1.90 1.89 1.80 1.80 1.79 1.78 1.77 1.77 1.76 1.37
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.01
Nucleus 1H
HO
OH
N
H
Boc
O
28
CDCl3
1.03
1.04
0.96
1.00
1.06
1.08
1.05
1.08
1.08
1.04
1.04
2.25
1.07
9.00
f1 (ppm)


197.36
156.57
151.60
127.63
81.31
77.58
77.55
77.23
76.91
76.10
59.35
48.41
45.89
28.53
26.77
24.22
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
HO
OH
N
H
Boc
O
28
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −1
f1 (ppm)

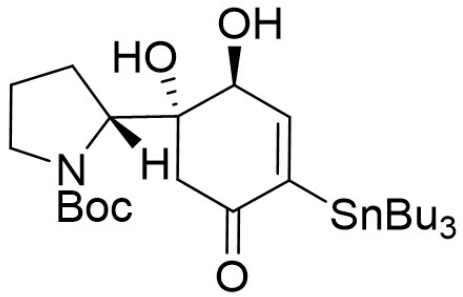

7.56 7.56 7.24 6.43 6.41 4.54 4.53 4.52 4.51 4.07 4.06 4.05 4.05 4.05 3.36 3.35 3.35 3.34 3.33 3.32 3.05 2.99 2.97 2.92 2.92 2.91 2.90 2.90 2.90 2.89 2.88 2.63 2.62 2.60 2.60 2.17 2.16 2.16 2.15 2.14 2.14 2.13 2.13 2.13 2.12 2.01 2.00 2.00 1.99 1.98 1.98 1.98 1.97 1.97 1.96 1.96 1.95 1.92 1.91 1.91 1.90 1.90 1.89 1.88 1.88 1.87 1.87 1.82 1.81 1.81 1.80 1.79 1.79 1.78 1.77 1.76 1.44
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.01
Nucleus 1H
OH
HO
N
H
Boc
I
O
29
CDCl3
0.95
1.01
1.00
1.02
1.06
1.00
1.08
1.02
1.07
1.02
1.14
1.15
1.10
9.00
f1 (ppm)


190.65
159.15
157.02
100.91
81.99
78.23
77.77
77.44
77.23
77.02
59.62
48.61
43.79
28.51
26.69
24.16
CDCl3
Parameter Value
Solvent cdcl3
Spectrometer Frequency 150.64
Nucleus 13C
HO
OH
N
H
Boc
I
O
29
f1 (ppm)

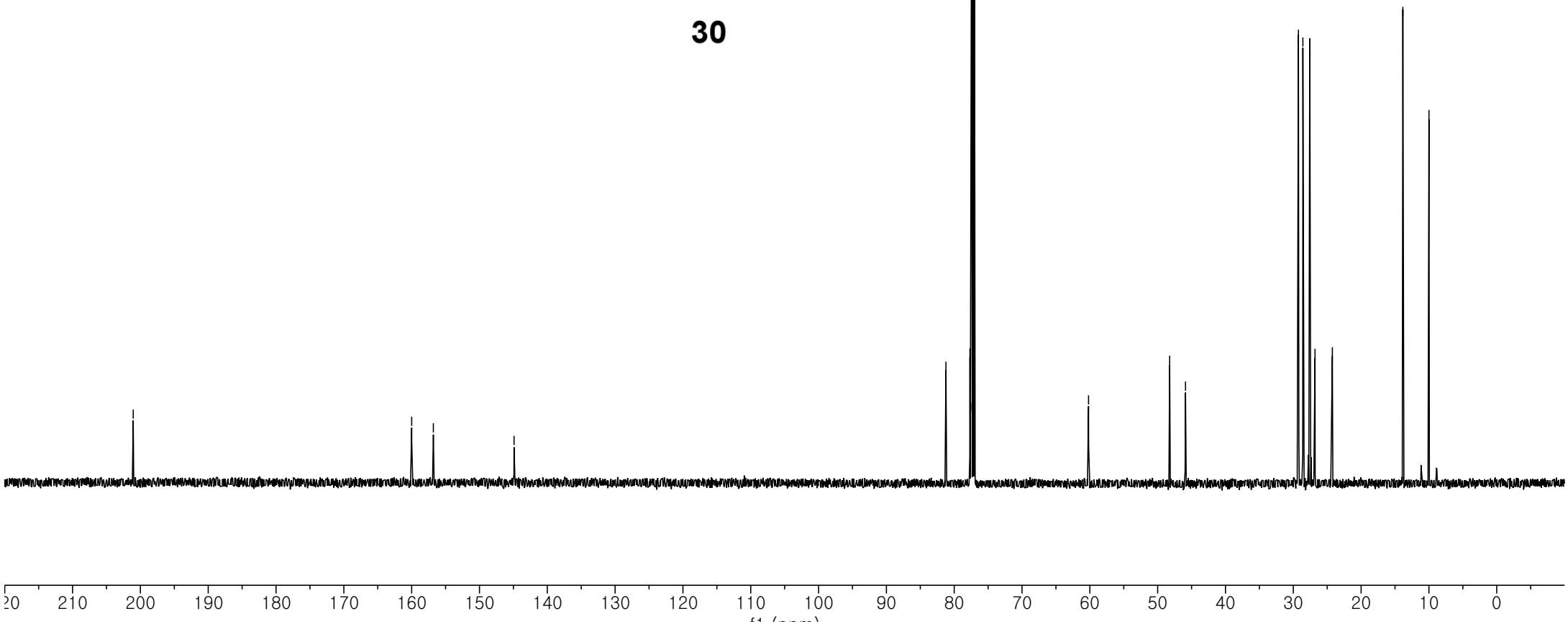

6.93 6.93 6.93 6.36 6.35 4.50 4.48 4.05 4.04 3.31 3.29 3.25 3.25 2.87 2.74 2.71 2.52 2.49 2.16 2.15 2.15 1.94 1.94 1.93 1.93 1.93 1.92 1.92 1.91 1.79 1.78 1.78 1.47 1.46 1.46 1.46 1.45 1.44 1.44 1.43 1.43 1.42 1.41 1.39 1.38 1.37 1.30 1.30 1.29 1.28 1.27 1.27 1.26 1.26 1.25 1.25 1.24 0.94 0.94 0.92 0.92 0.92 0.90 0.90 0.90 0.89 0.89 0.88 0.88 0.87 0.87 0.86 0.86 0.85 0.85 0.84 0.84
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.01
Nucleus 1H
OH
HO
N
H
Boc
SnBu3
O
30
CDCl3
1.02 0.99 1.00 1.01 1.03 1.00 1.02 1.02 1.03 1.04 2.13 1.31 6.24 9.17 6.15 15.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1
f1 (ppm)

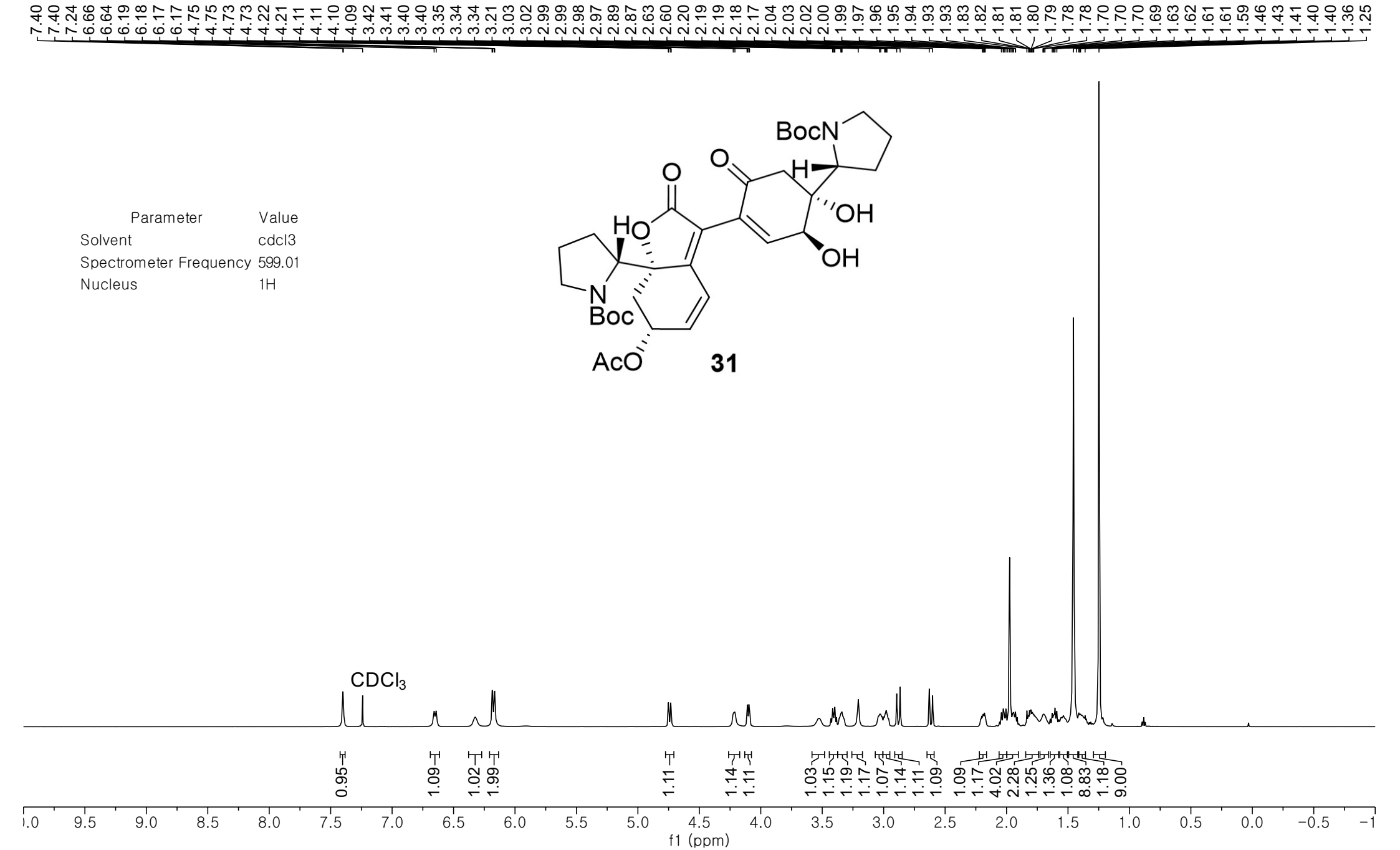
201.06
160.00
156.80
144.90
81.22
77.68
77.57
77.44
77.23
77.02
60.19
48.23
45.89
29.24
28.59
27.57
26.80
24.24
13.84
10.00

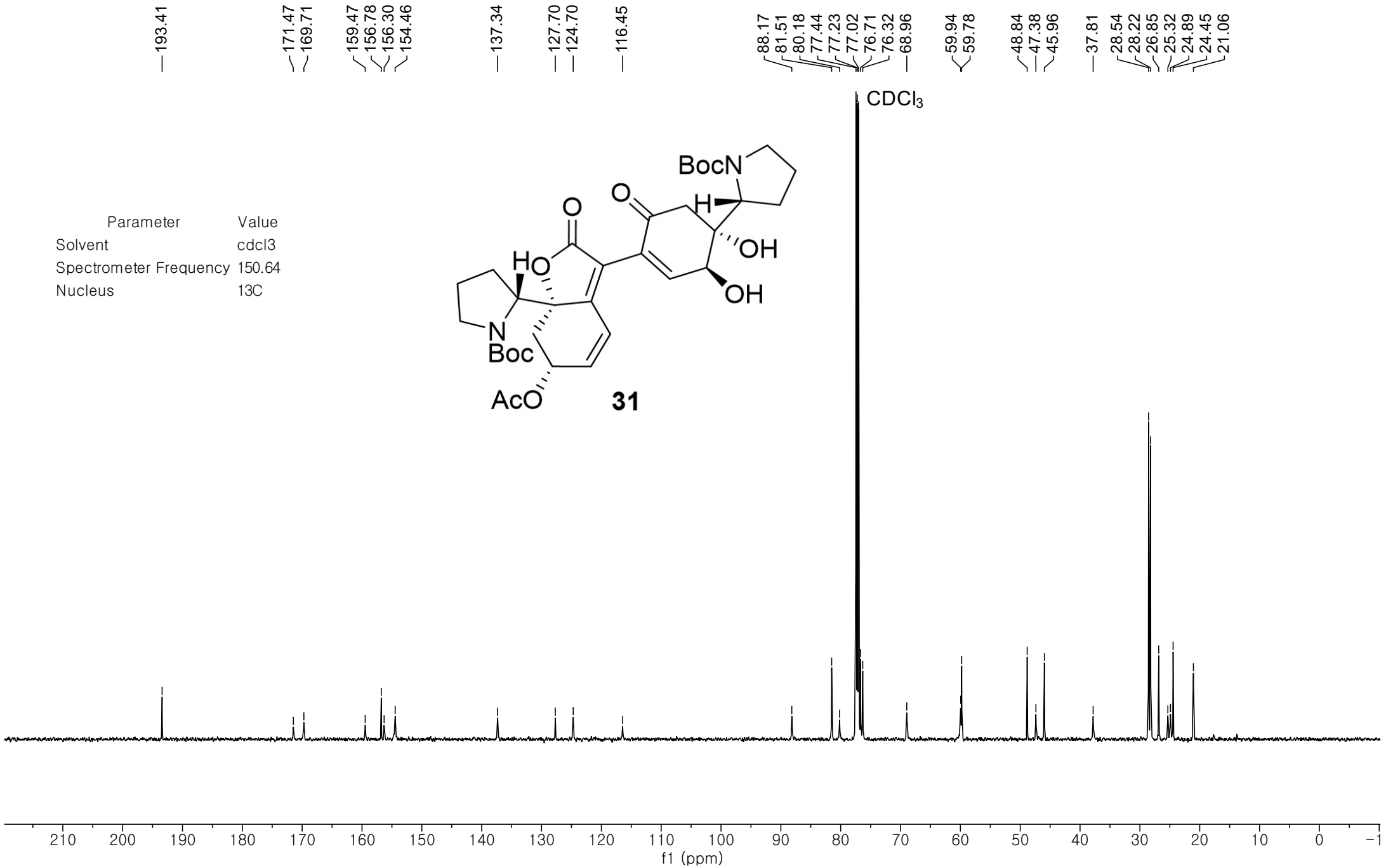
Parameter	Value
Solvent	cdcl3
Spectrometer Frequency	150.64
Nucleus	13C

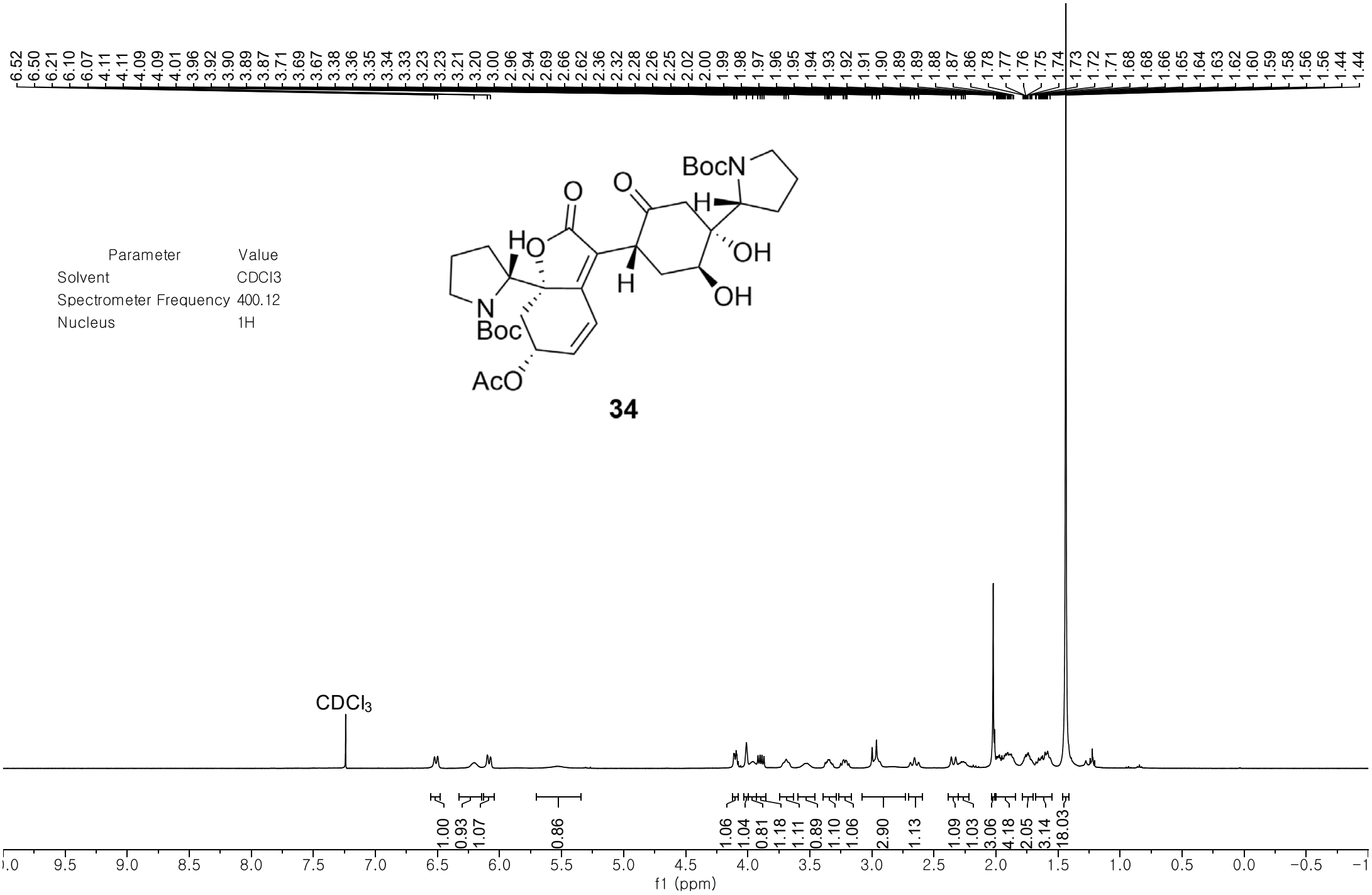


30



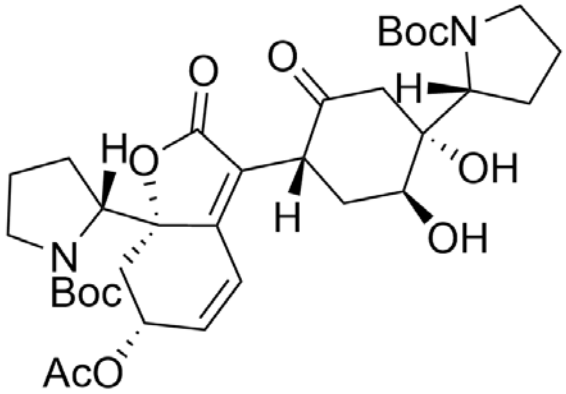

7.40 7.40 7.24 6.66 6.64 6.19 6.18 6.17 6.17 4.75 4.75 4.73 4.73 4.22 4.21 4.11 4.11 4.10 4.09 3.42 3.41 3.40 3.40 3.35 3.34 3.34 3.21 3.03 3.02 2.99 2.99 2.98 2.97 2.89 2.87 2.63 2.60 2.20 2.19 2.19 2.18 2.17 2.04 2.03 2.02 2.00 1.99 1.97 1.96 1.95 1.94 1.93 1.93 1.83 1.82 1.81 1.81 1.80 1.79 1.78 1.78 1.70 1.70 1.70 1.69 1.63 1.62 1.61 1.61 1.59 1.46 1.43 1.41 1.40 1.40 1.36 1.25
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.01
Nucleus 1H
BocN
O
O
H
HO
OH
OH
N
Boc
AcO
31
CDCl3
0.95 1.09 1.02 1.99 1.11 1.14 1.11 1.03 1.15 1.19 1.17 1.07 1.14 1.11 1.09 1.09 1.17 4.02 2.28 1.25 1.36 1.08 8.83 1.18 9.00
f1 (ppm)


193.41
171.47
169.71
159.47
156.78
156.30
154.46
137.34
127.70
124.70
116.45
88.17
81.51
80.18
77.44
77.23
77.02
76.71
76.32
68.96
59.94
59.78
48.84
47.38
45.96
37.81
28.54
28.22
26.85
25.32
24.89
24.45
21.06
CDCl3
Parameter Value
Solvent cdcl3
Spectrometer Frequency 150.64
Nucleus 13C
BocN
H
O
O
HO
OH
OH
N
Boc
AcO
31
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −1
f1 (ppm)


6.52 6.50 6.21 6.10 6.07 4.11 4.11 4.09 4.09 4.01 3.96 3.92 3.90 3.89 3.87 3.71 3.69 3.67 3.38 3.36 3.35 3.34 3.33 3.23 3.23 3.21 3.20 3.00 2.96 2.94 2.69 2.66 2.62 2.36 2.32 2.28 2.26 2.25 2.02 2.00 1.99 1.98 1.97 1.96 1.95 1.94 1.93 1.92 1.91 1.90 1.89 1.89 1.88 1.87 1.86 1.78 1.77 1.76 1.75 1.74 1.73 1.72 1.71 1.68 1.68 1.66 1.65 1.64 1.63 1.62 1.60 1.59 1.58 1.56 1.56 1.44 1.44
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.12
Nucleus 1H
BocN
O
O
H
HO
OH
H
OH
N
Boc
AcO
34
CDCl3
1.00 0.93 1.07 0.86 1.06 1.04 0.81 1.18 1.11 0.89 1.10 1.06 2.90 1.13 1.09 1.03 3.06 4.18 2.05 3.14 18.03
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

205.89
173.07
170.22
160.07
157.96
156.21
136.33
122.77
122.08
88.48
81.10
80.16
79.48
77.55
77.23
76.91
69.55
68.92
65.93
60.29
48.76
47.44
46.45
40.85
37.35
35.83
28.58
28.54
25.32
24.88
24.72
21.24

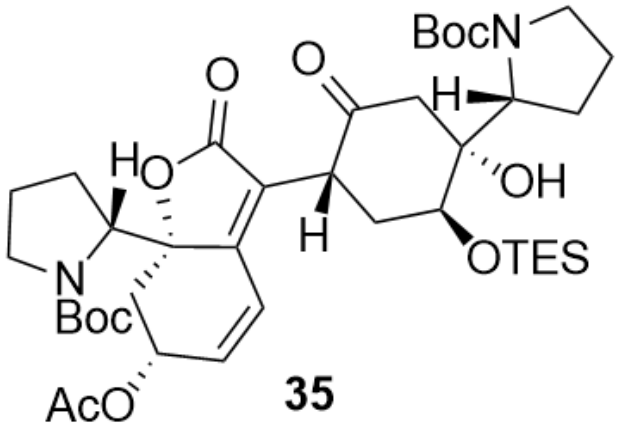
Parameter	Value
Solvent	CDCl3
Spectrometer Frequency	100.62
Nucleus	13C



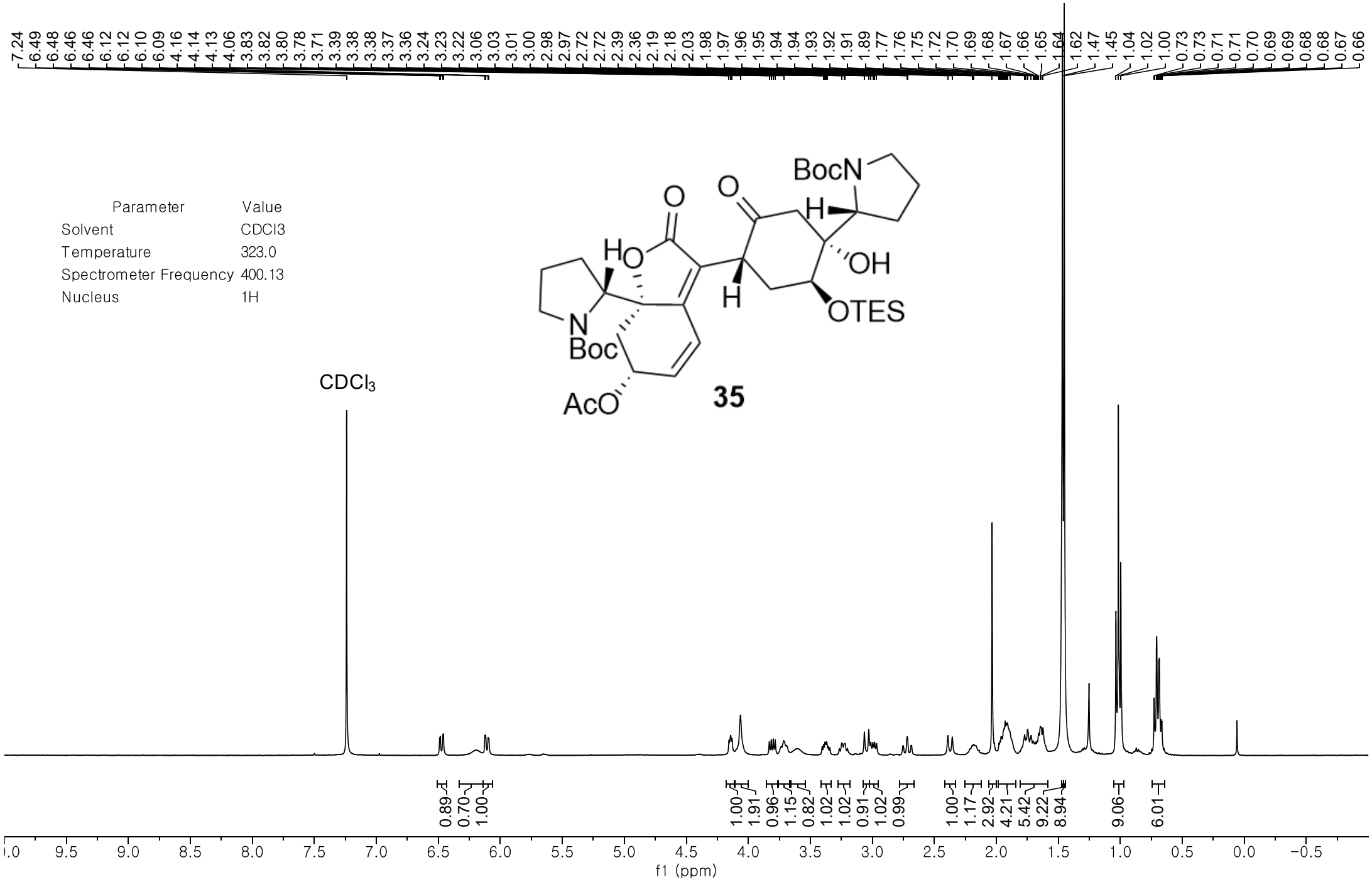
34

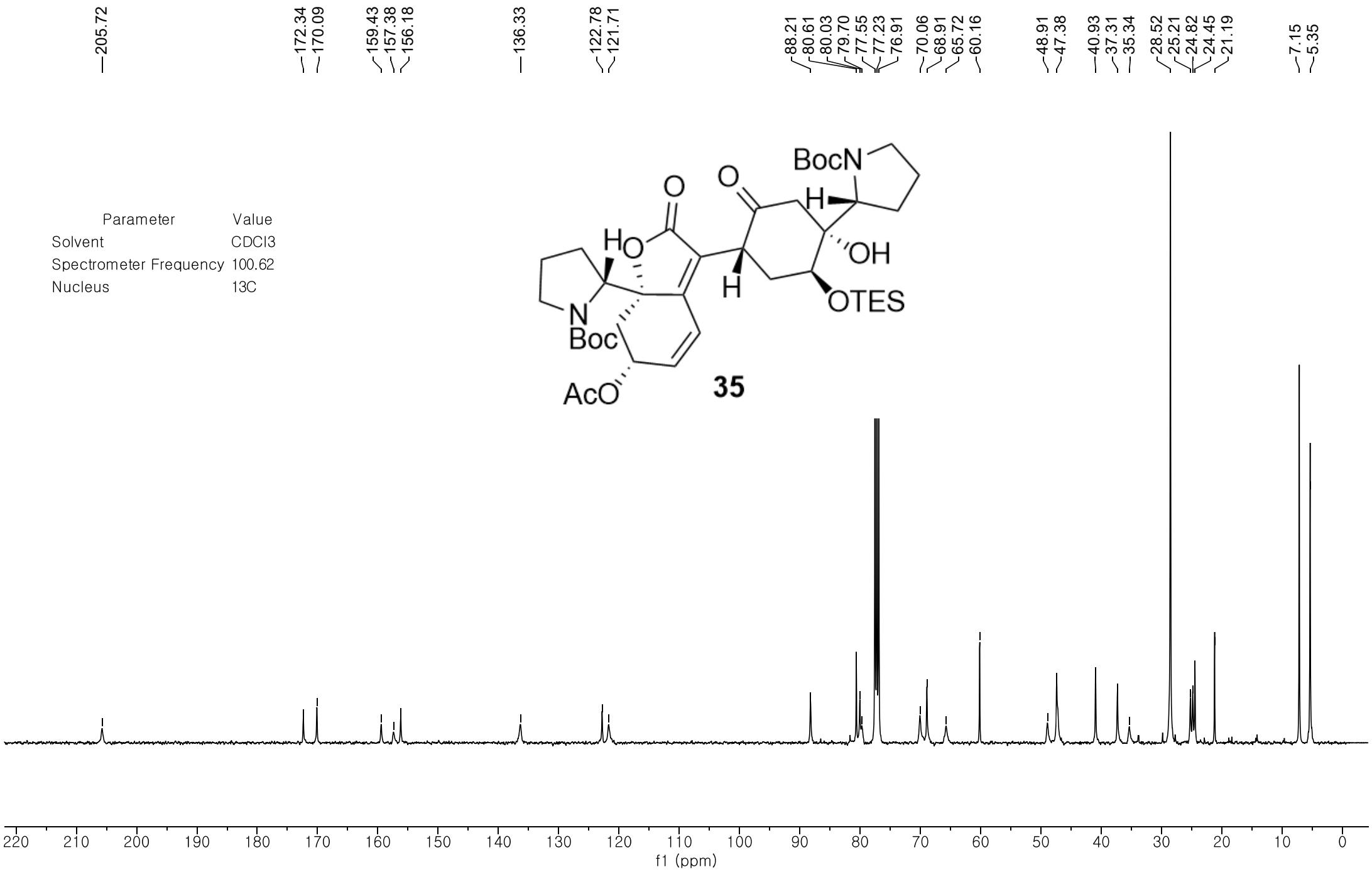
$CDCl_3$

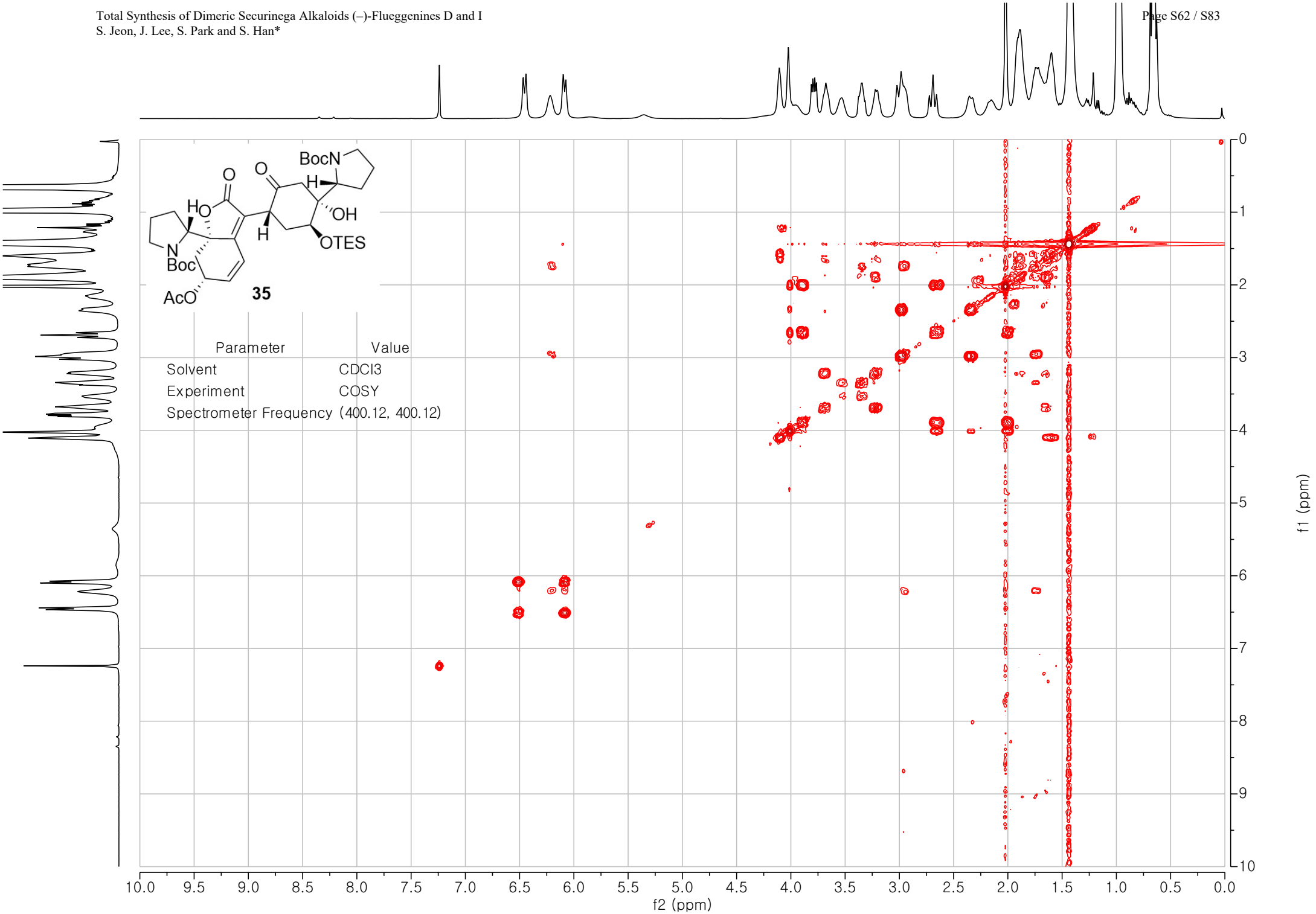
Parameter	Value
Solvent	CDCl3
Spectrometer Frequency	400.12
Nucleus	1H

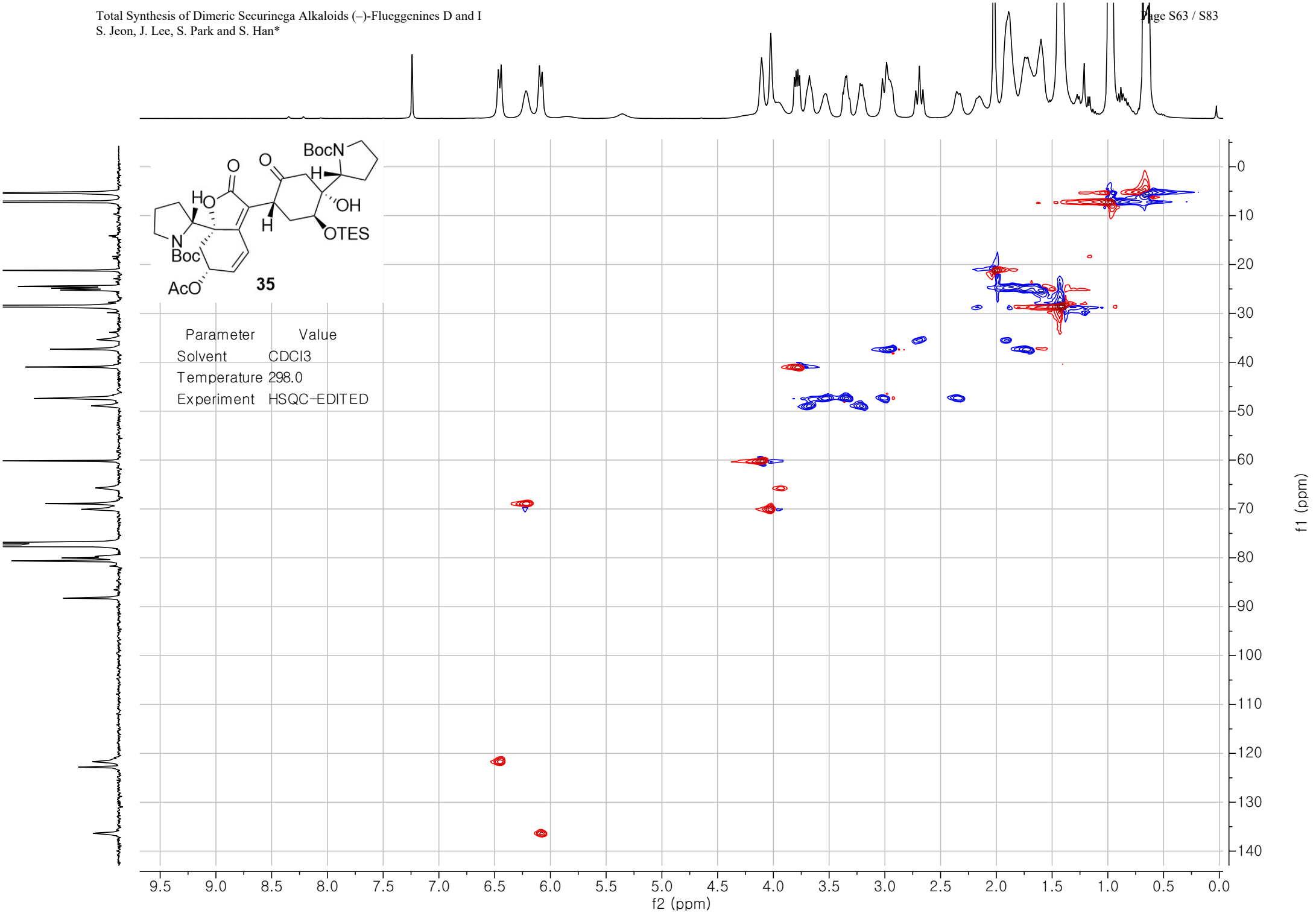


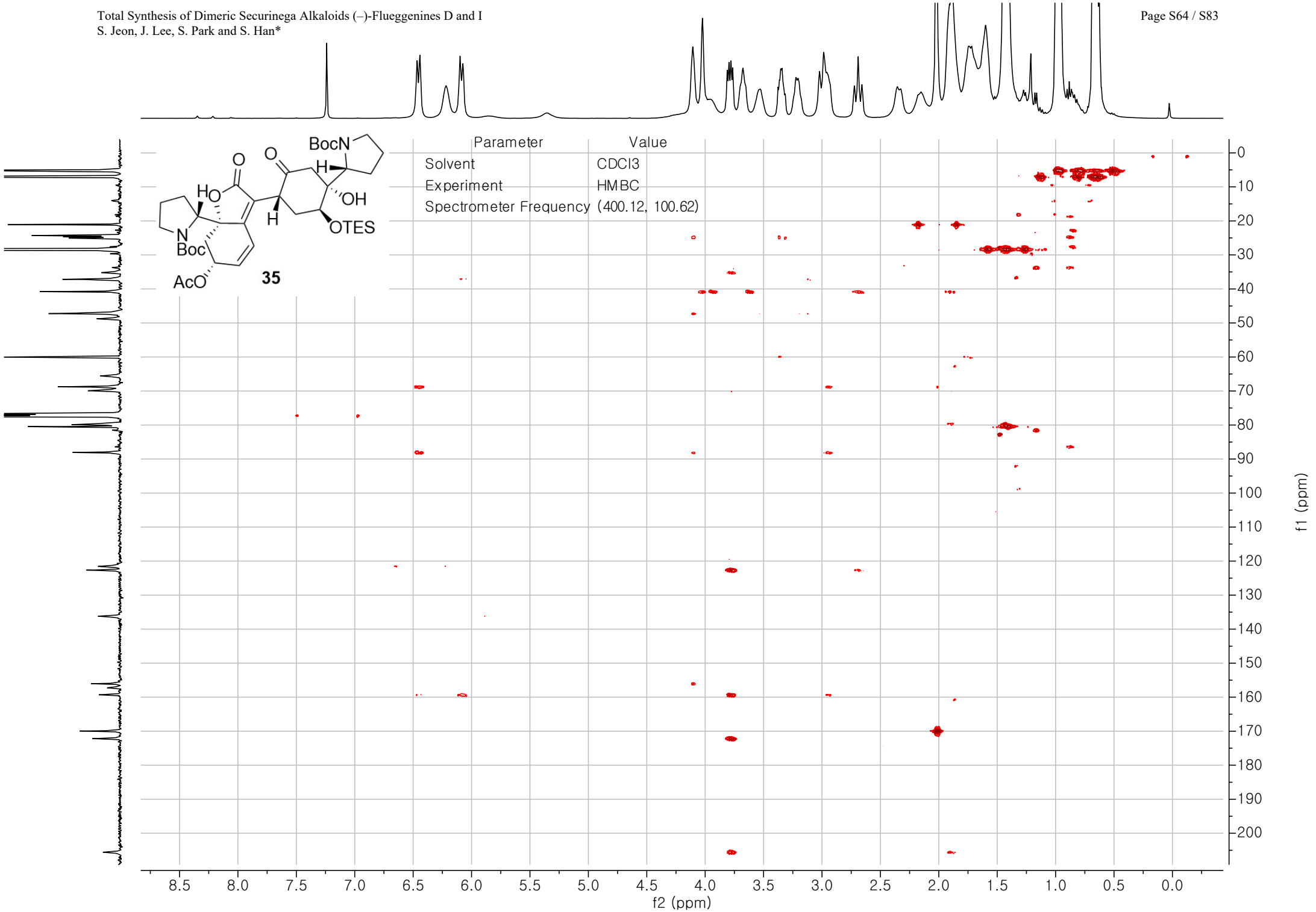
35

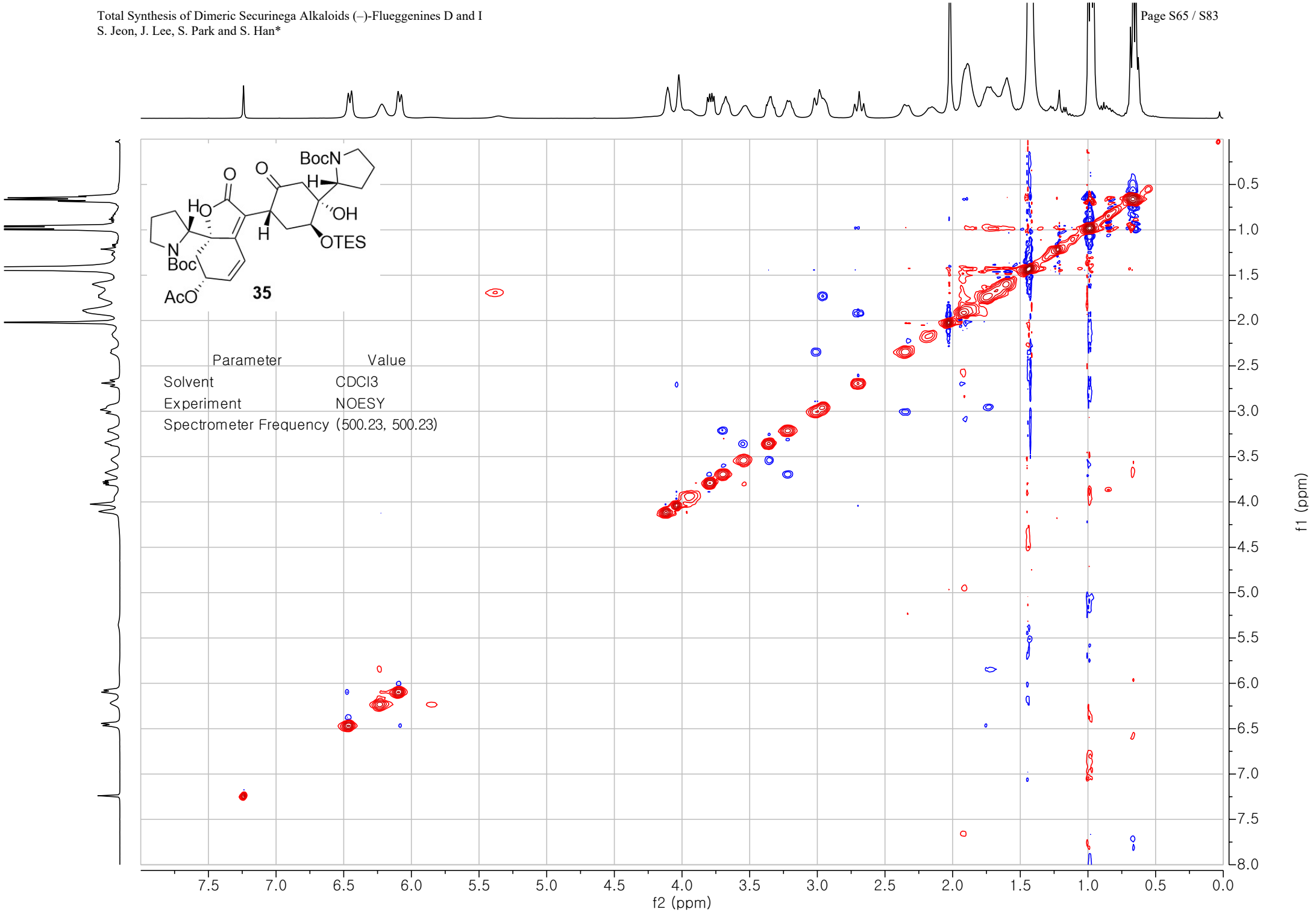

7.24 6.49 6.48 6.46 6.46 6.12 6.12 6.10 6.09 4.16 4.14 4.13 4.06 3.83 3.82 3.80 3.78 3.71 3.39 3.38 3.38 3.37 3.36 3.24 3.23 3.22 3.06 3.03 3.01 3.00 2.98 2.97 2.72 2.72 2.39 2.36 2.19 2.18 2.03 1.98 1.97 1.96 1.95 1.94 1.94 1.93 1.92 1.91 1.89 1.77 1.76 1.75 1.72 1.70 1.69 1.68 1.67 1.66 1.65 1.64 1.62 1.47 1.45 1.04 1.02 1.00 0.73 0.73 0.71 0.71 0.70 0.69 0.69 0.68 0.68 0.67 0.66
Parameter Value
Solvent CDCl3
Temperature 323.0
Spectrometer Frequency 400.13
Nucleus 1H
BocN
O
O
H
HO
OH
H
OTES
N
Boc
AcO
35
CDCl3
0.89 0.70 1.00 1.00 1.91 0.96 1.15 0.82 1.02 1.02 0.91 1.02 0.99 1.00 1.17 2.92 4.21 5.42 9.22 8.94 9.06 6.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

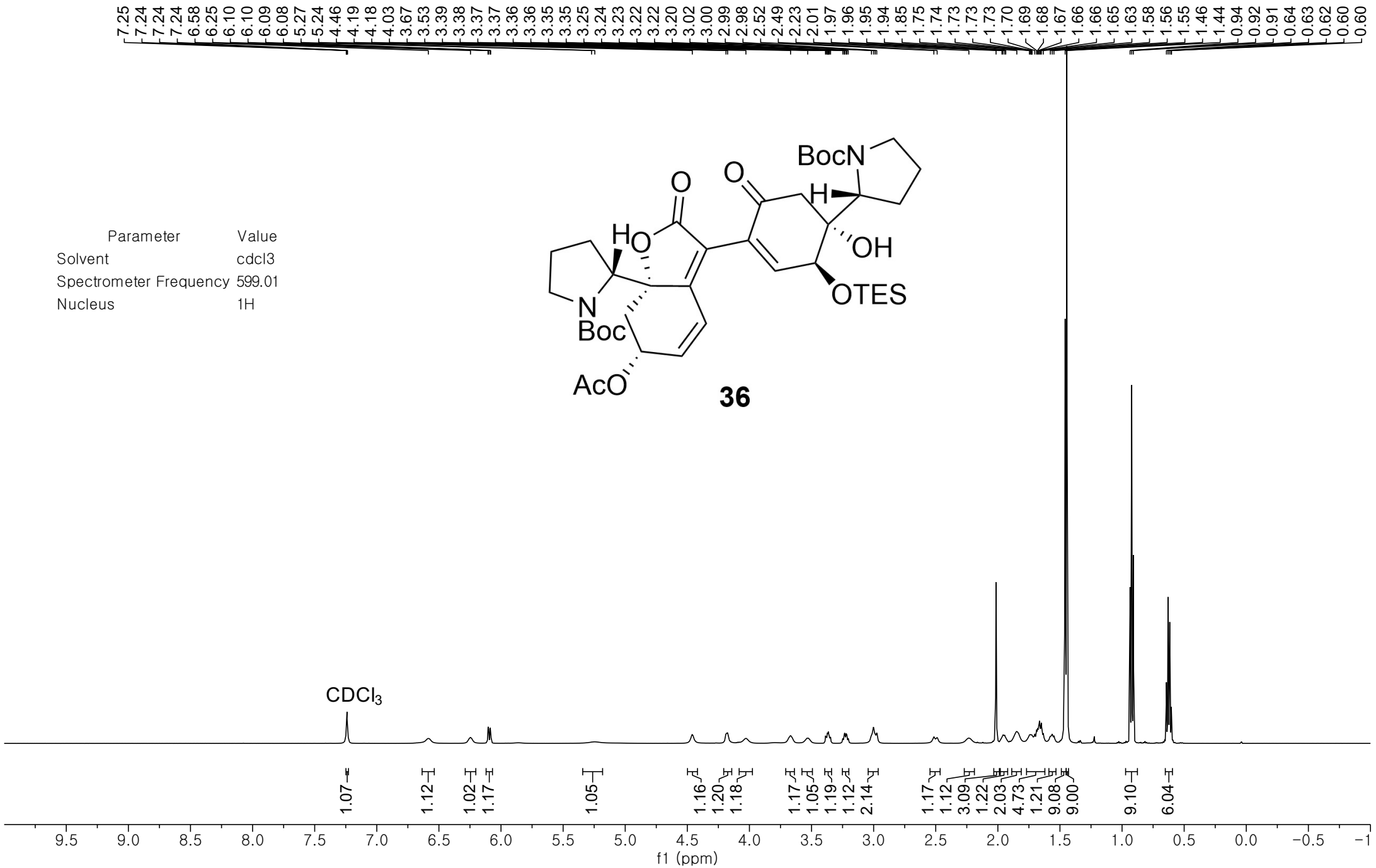

205.72
172.34
170.09
159.43
157.38
156.18
136.33
122.78
121.71
88.21
80.61
80.03
79.70
77.55
77.23
76.91
70.06
68.91
65.72
60.16
48.91
47.38
40.93
37.31
35.34
28.52
25.21
24.82
24.45
21.19
7.15
5.35
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
BocN
O
O
H
HO
OH
H
OTES
N
Boc
AcO
35
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

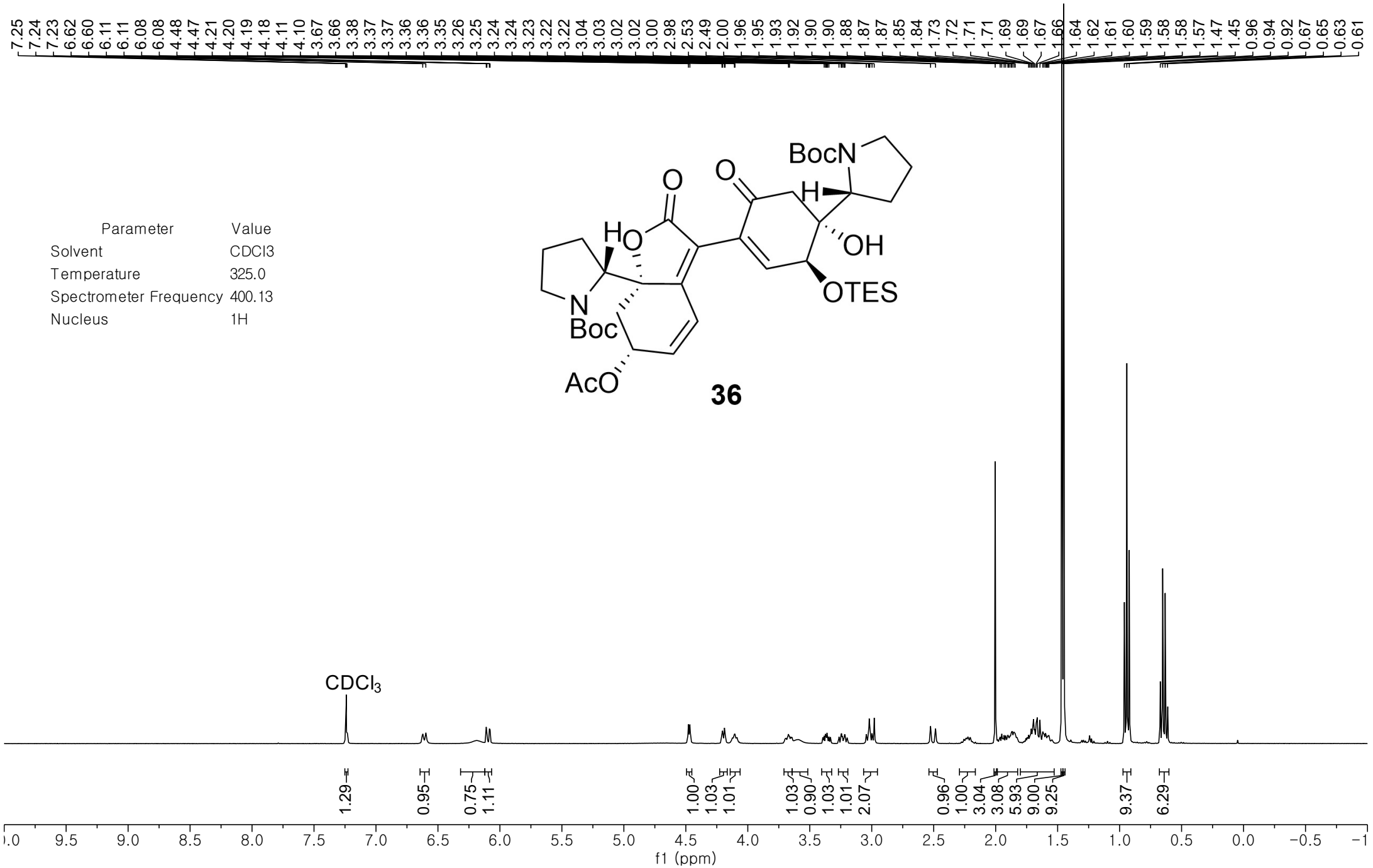

BocN
O
O
H
HO
OH
H
OTES
N
Boc
AcO
35
Parameter Value
Solvent CDCl3
Experiment COSY
Spectrometer Frequency (400.12, 400.12)
f2 (ppm)
f1 (ppm)

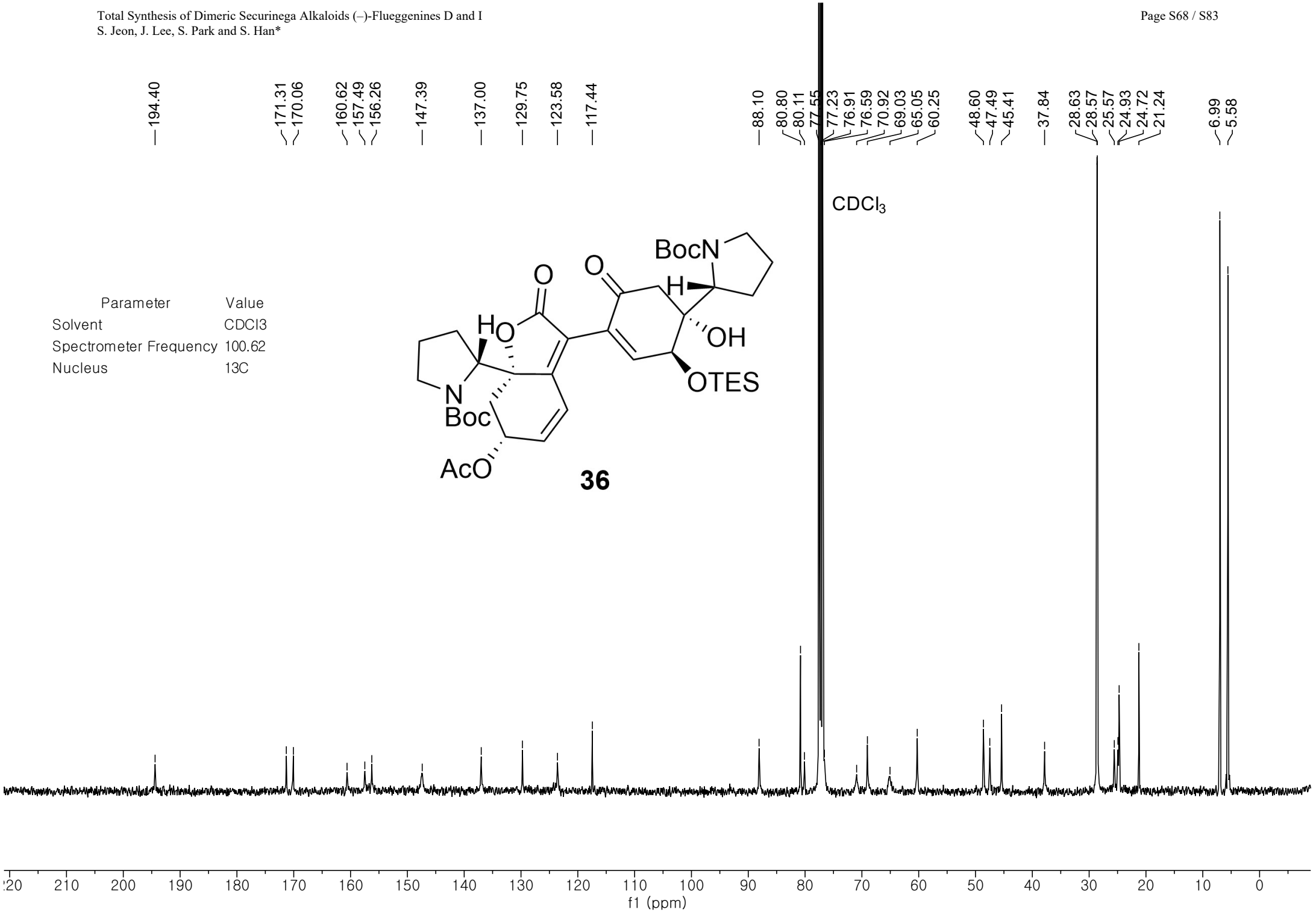

BocN
H
O
O
HO
OH
H
OTES
N
Boc
AcO
35
Parameter Value
Solvent CDCl3
Temperature 298.0
Experiment HSQC-EDITED
f2 (ppm)
f1 (ppm)

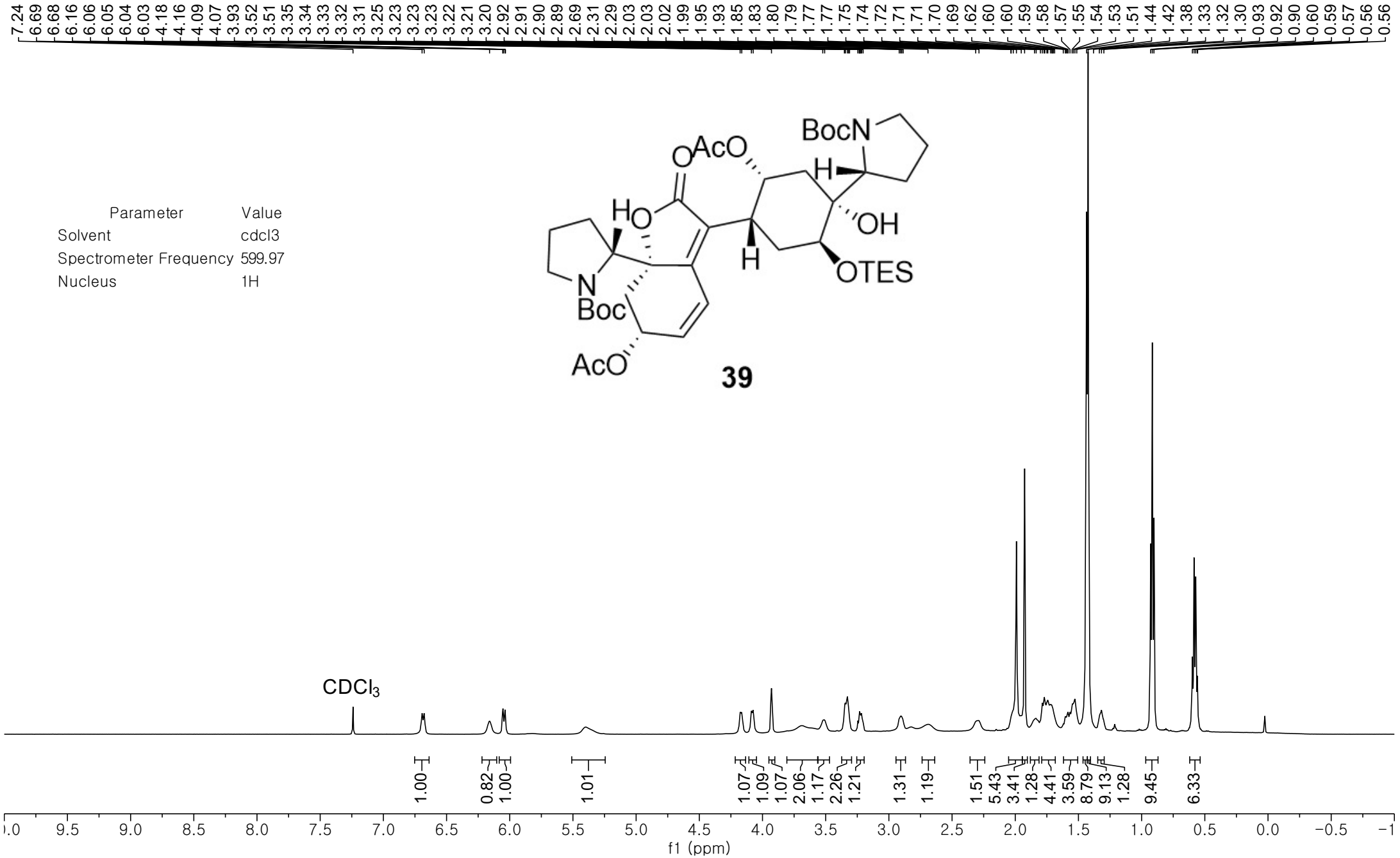

Parameter Value
Solvent CDCl3
Experiment HMBC
Spectrometer Frequency (400.12, 100.62)
BocN
H
HO
O
O
OH
H
OTES
N
Boc
AcO
35
f2 (ppm)
f1 (ppm)

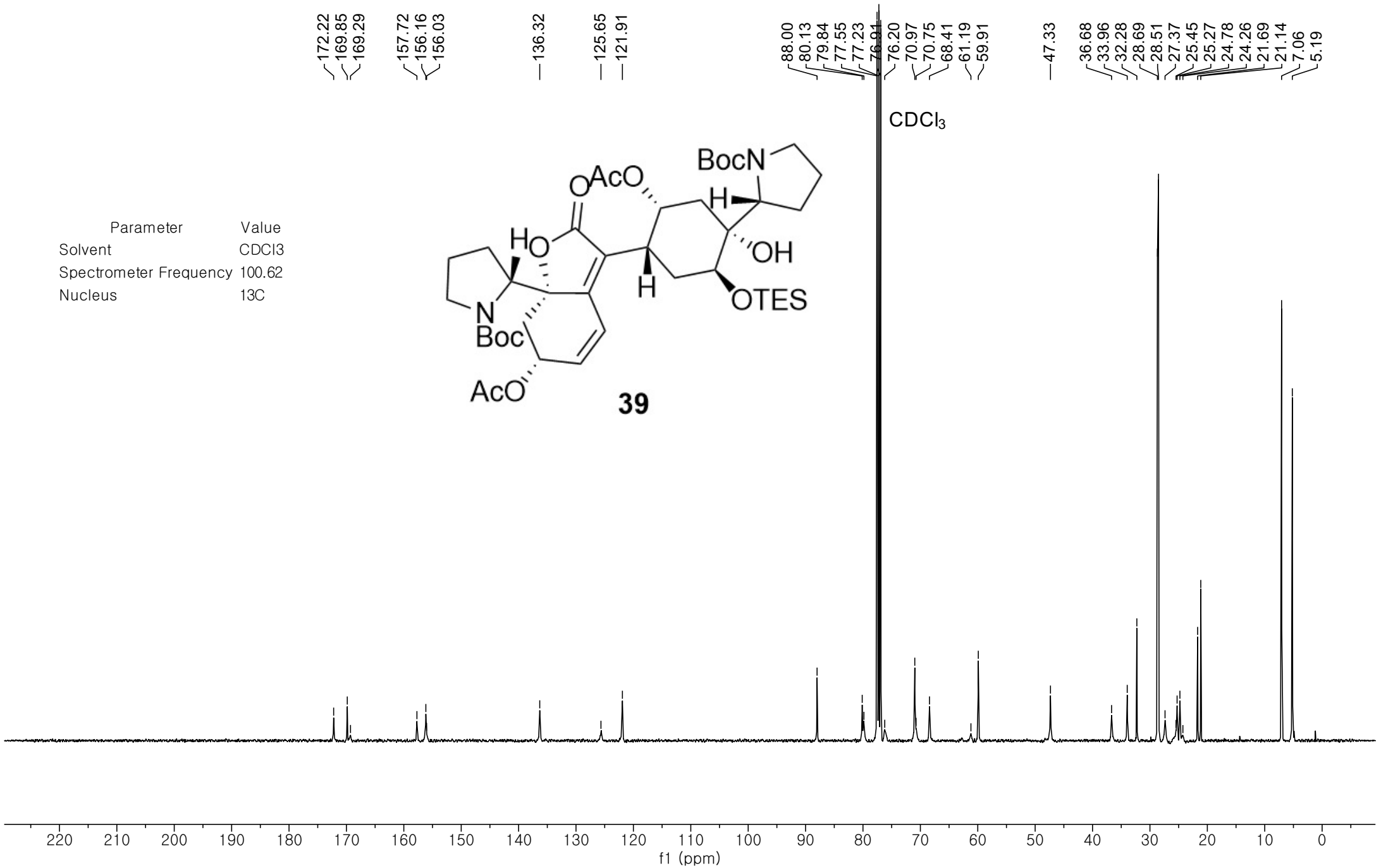

BocN
O
O
H
HO
OH
H
OTES
N
Boc
AcO
35
Parameter Value
Solvent CDCl3
Experiment NOESY
Spectrometer Frequency (500.23, 500.23)
f2 (ppm)
f1 (ppm)

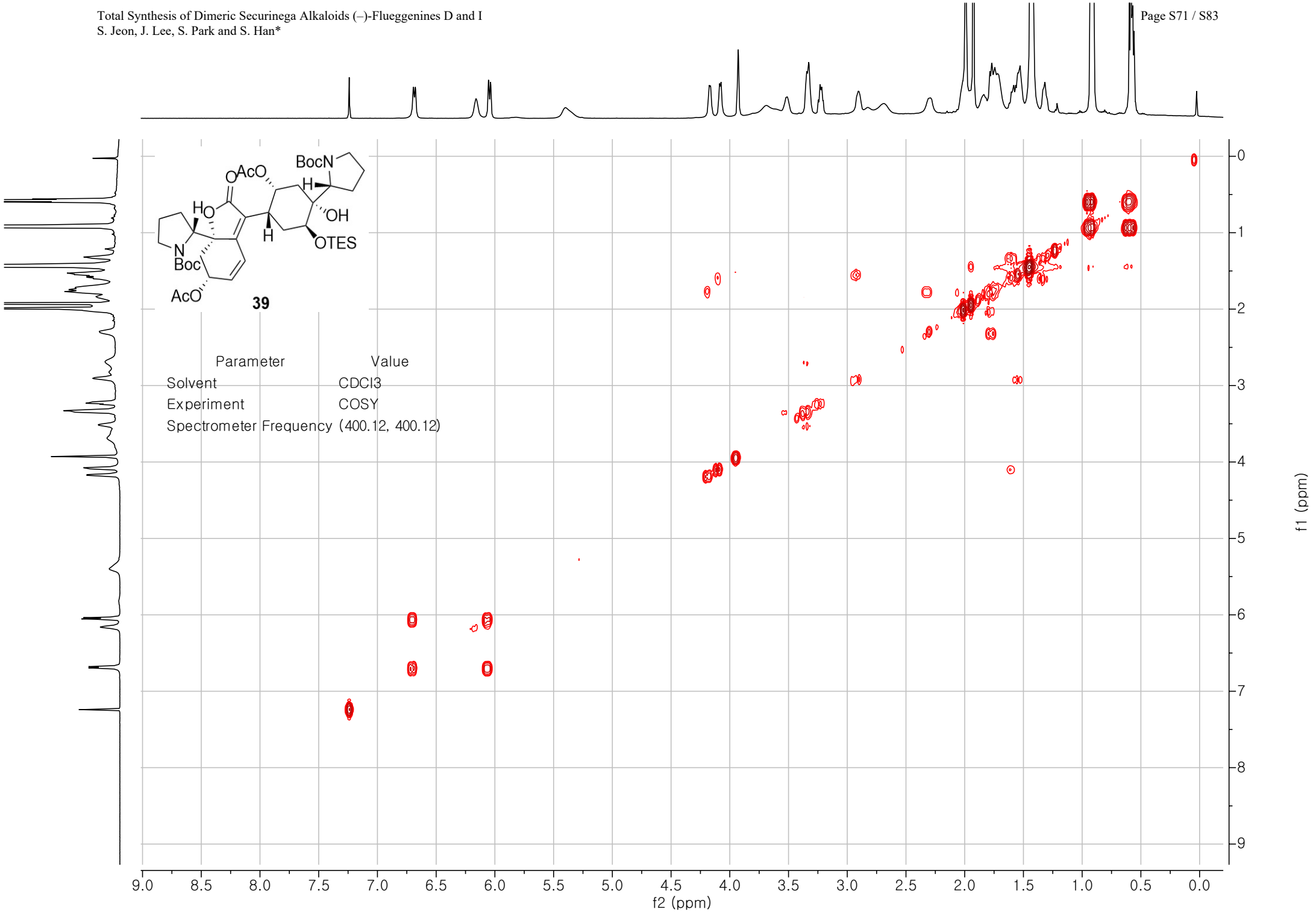

7.25 7.24 7.24 7.24 6.58 6.25 6.10 6.10 6.09 6.08 5.27 5.24 4.46 4.19 4.18 4.03 3.67 3.53 3.39 3.38 3.37 3.37 3.36 3.36 3.35 3.35 3.25 3.24 3.23 3.22 3.22 3.20 3.02 3.00 2.99 2.98 2.52 2.49 2.23 2.01 1.97 1.96 1.95 1.94 1.85 1.75 1.74 1.73 1.73 1.73 1.70 1.69 1.68 1.67 1.66 1.66 1.65 1.63 1.58 1.56 1.55 1.46 1.44 0.94 0.92 0.91 0.64 0.63 0.62 0.60 0.60
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.01
Nucleus 1H
BocN
O
O
H
HO
OH
OTES
N
Boc
AcO
36
CDCl3
1.07 1.12 1.02 1.17 1.05 1.16 1.20 1.18 1.17 1.05 1.19 1.12 2.14 1.17 1.12 3.09 1.22 2.03 4.73 1.21 9.08 9.00 9.10 6.04
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5 −1
f1 (ppm)

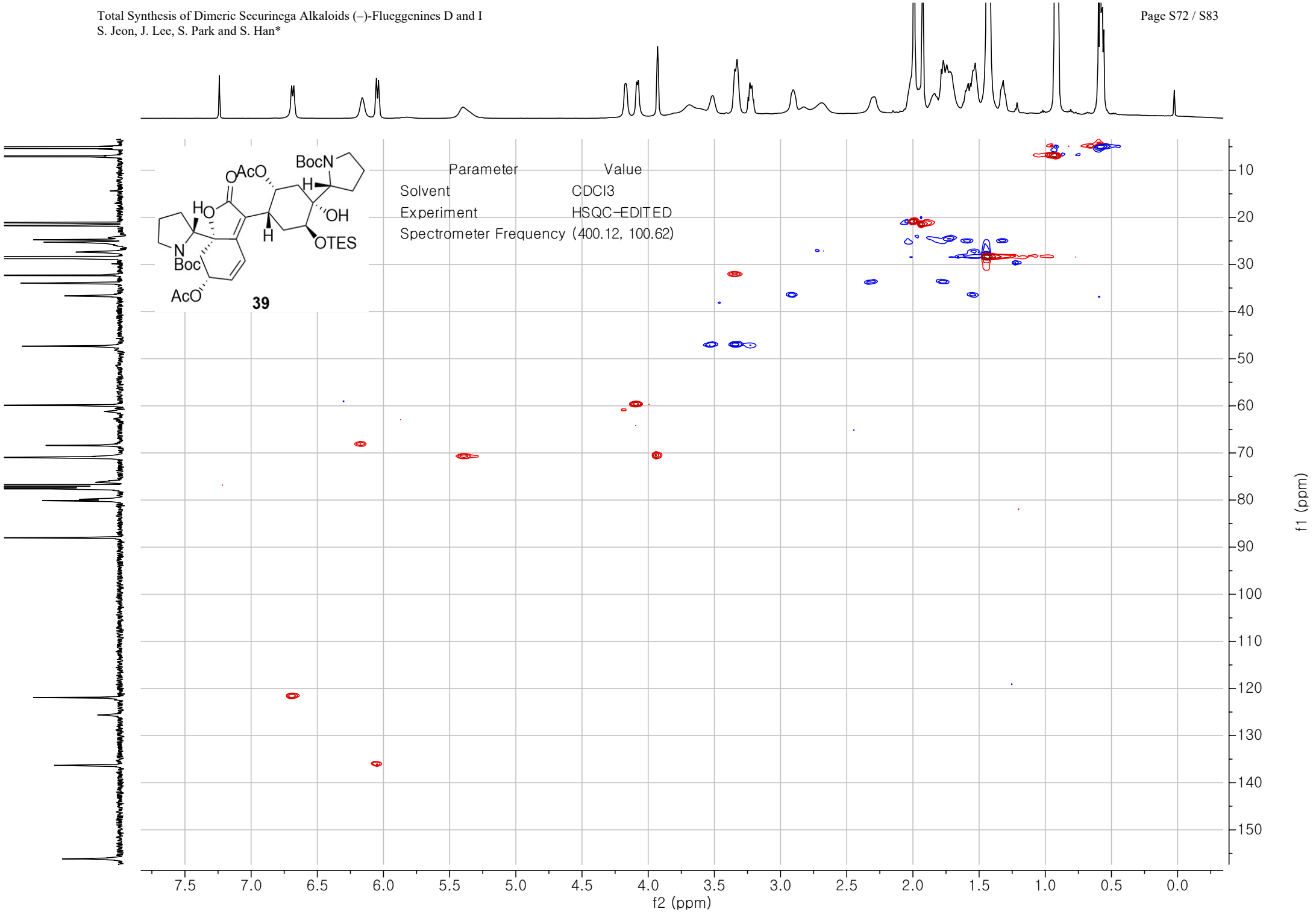

7.25 7.24 7.23 6.62 6.60 6.11 6.11 6.08 6.08 4.48 4.47 4.21 4.20 4.19 4.18 4.11 4.10 3.67 3.66 3.38 3.37 3.37 3.36 3.36 3.35 3.26 3.25 3.24 3.24 3.23 3.22 3.22 3.04 3.03 3.02 3.02 3.00 2.98 2.53 2.49 2.00 1.96 1.95 1.93 1.92 1.90 1.90 1.88 1.87 1.87 1.85 1.84 1.73 1.72 1.71 1.71 1.69 1.69 1.67 1.66 1.64 1.62 1.61 1.60 1.59 1.58 1.58 1.57 1.47 1.45 0.96 0.94 0.92 0.67 0.65 0.63 0.61
Parameter Value
Solvent CDCl3
Temperature 325.0
Spectrometer Frequency 400.13
Nucleus 1H
BocN
H
O
O
HO
OH
OTES
N
Boc
AcO
36
CDCl3
1.29 0.95 0.75 1.11 1.00 1.03 1.01 1.03 0.90 1.03 1.01 2.07 0.96 1.00 3.04 3.08 5.93 9.00 9.25 9.37 6.29
f1 (ppm)

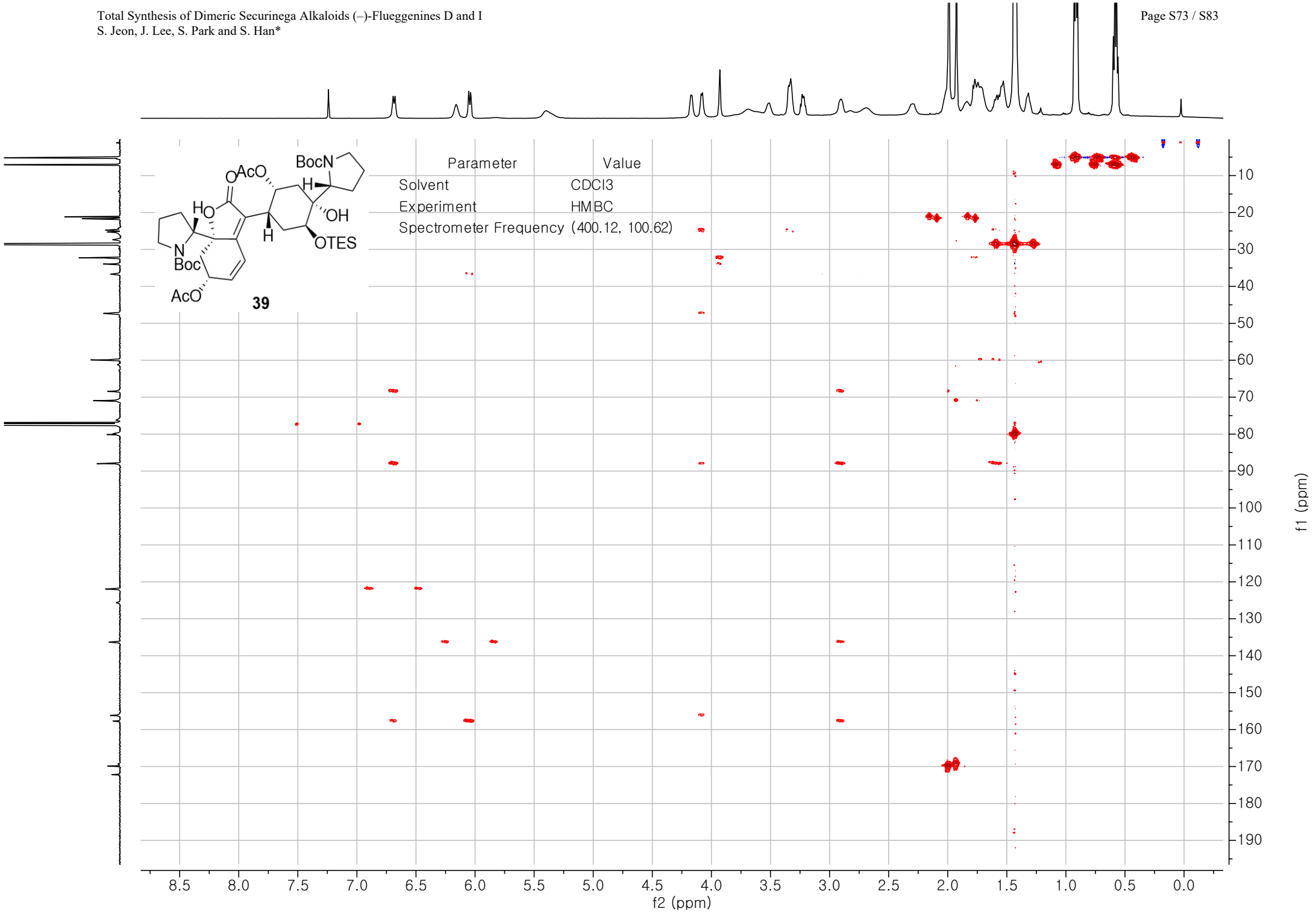

194.40
171.31
170.06
160.62
157.49
156.26
147.39
137.00
129.75
123.58
117.44
88.10
80.80
80.11
77.55
77.23
76.91
76.59
70.92
69.03
65.05
60.25
48.60
47.49
45.41
37.84
28.63
28.57
25.57
24.93
24.72
21.24
6.99
5.58
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
BocN
H
O
O
HO
OH
OTES
N
Boc
AcO
36
f1 (ppm)

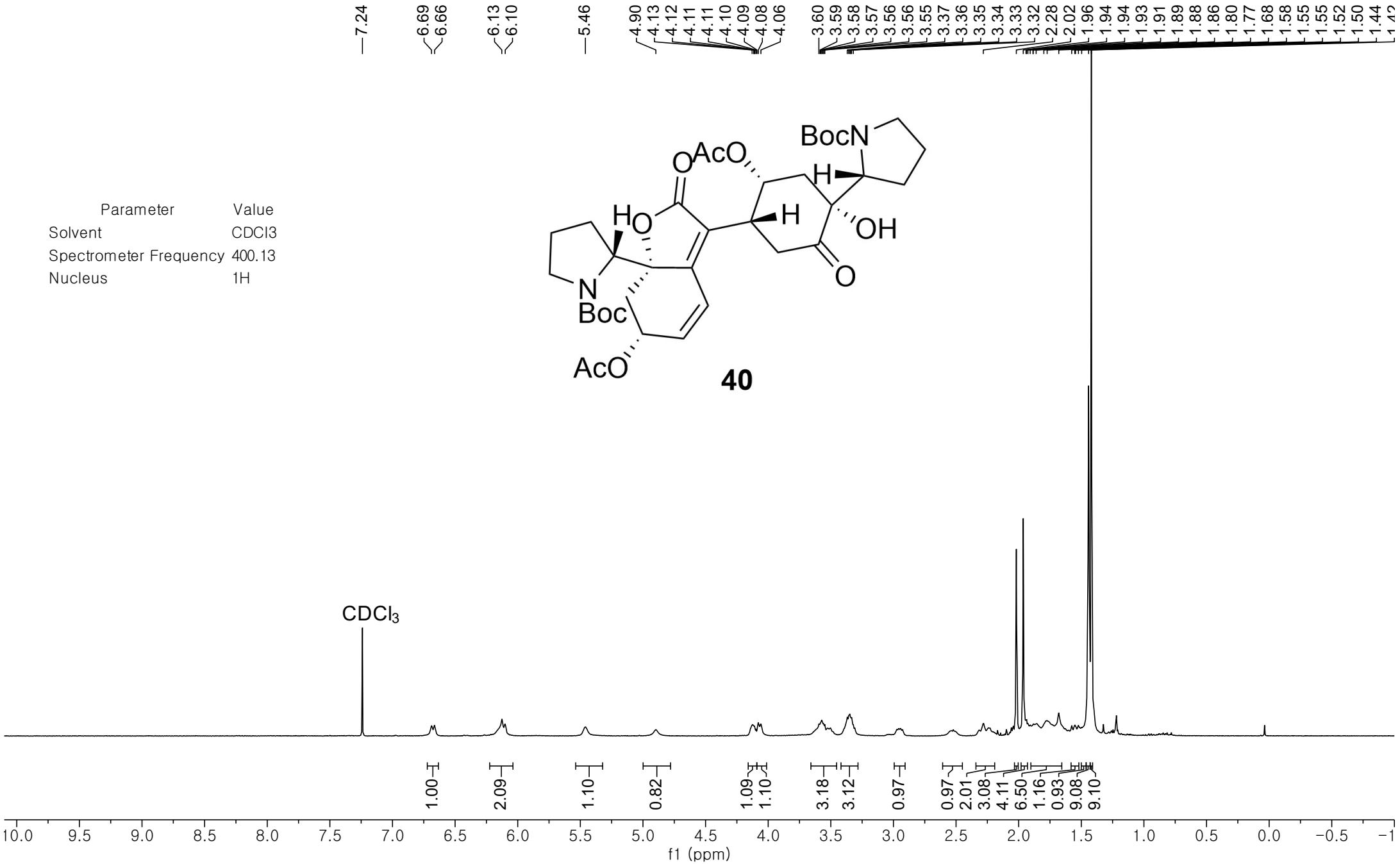

7.24 6.69 6.68 6.16 6.06 6.05 6.04 6.03 4.18 4.16 4.09 4.07 3.93 3.52 3.51 3.35 3.34 3.33 3.32 3.31 3.25 3.23 3.23 3.23 3.22 3.21 3.20 2.92 2.91 2.90 2.89 2.69 2.31 2.29 2.03 2.03 2.02 1.99 1.95 1.93 1.85 1.83 1.80 1.79 1.77 1.77 1.75 1.74 1.72 1.71 1.71 1.70 1.69 1.62 1.60 1.60 1.59 1.58 1.57 1.55 1.54 1.53 1.51 1.44 1.42 1.38 1.33 1.32 1.30 0.93 0.92 0.90 0.60 0.59 0.57 0.56 0.56
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.97
Nucleus 1H
BocN
AcO
H
HO
OH
H
OTES
N
Boc
AcO
39
CDCl3
1.00 0.82 1.00 1.01 1.07 1.09 1.07 2.06 1.17 2.26 1.21 1.31 1.19 1.51 5.43 3.41 1.28 4.41 3.59 8.79 9.13 1.28 9.45 6.33
f1 (ppm)

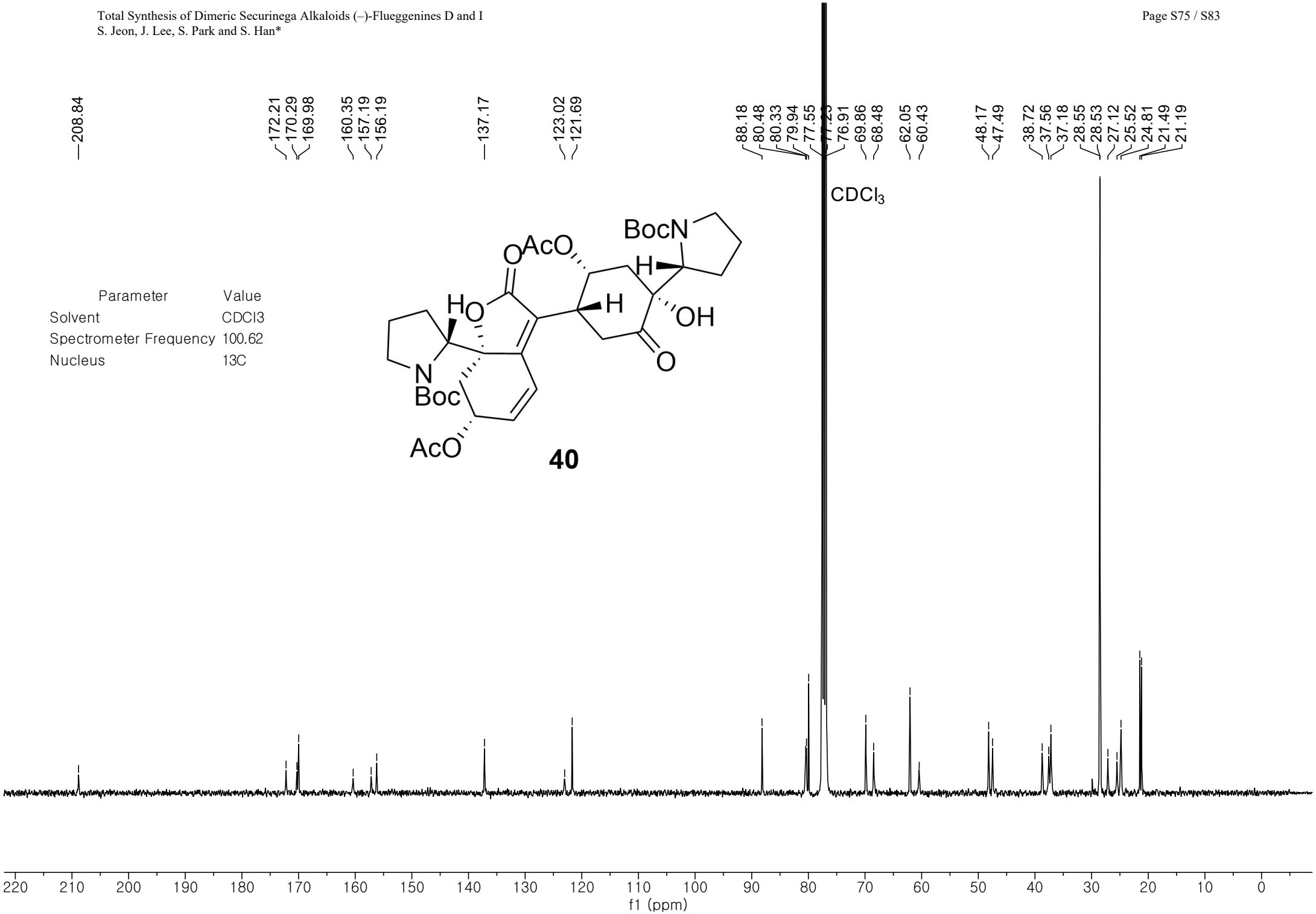

172.22
169.85
169.29
157.72
156.16
156.03
136.32
125.65
121.91
88.00
80.13
79.84
77.55
77.23
76.91
76.20
70.97
70.75
68.41
61.19
59.91
47.33
36.68
33.96
32.28
28.69
28.51
27.37
25.45
25.27
24.78
24.26
21.69
21.14
7.06
5.19
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
BocN
AcO
O
H
HO
OH
H
OTES
N
Boc
AcO
39
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

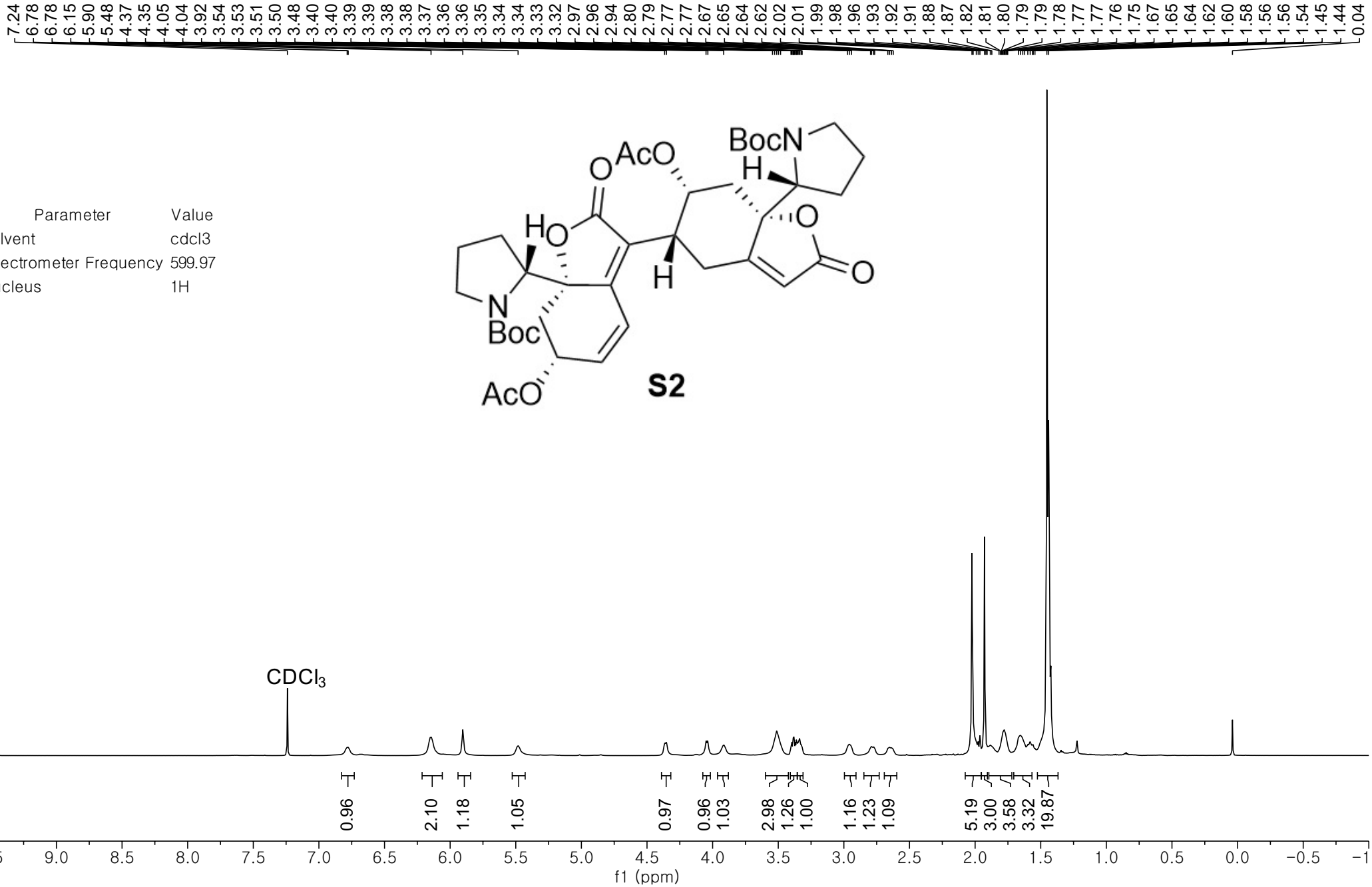

BocN
OAcO
H
HO
OH
H
OTES
N
Boc
AcO
39
Parameter Value
Solvent CDCl3
Experiment COSY
Spectrometer Frequency (400.12, 400.12)
f2 (ppm)
f1 (ppm)

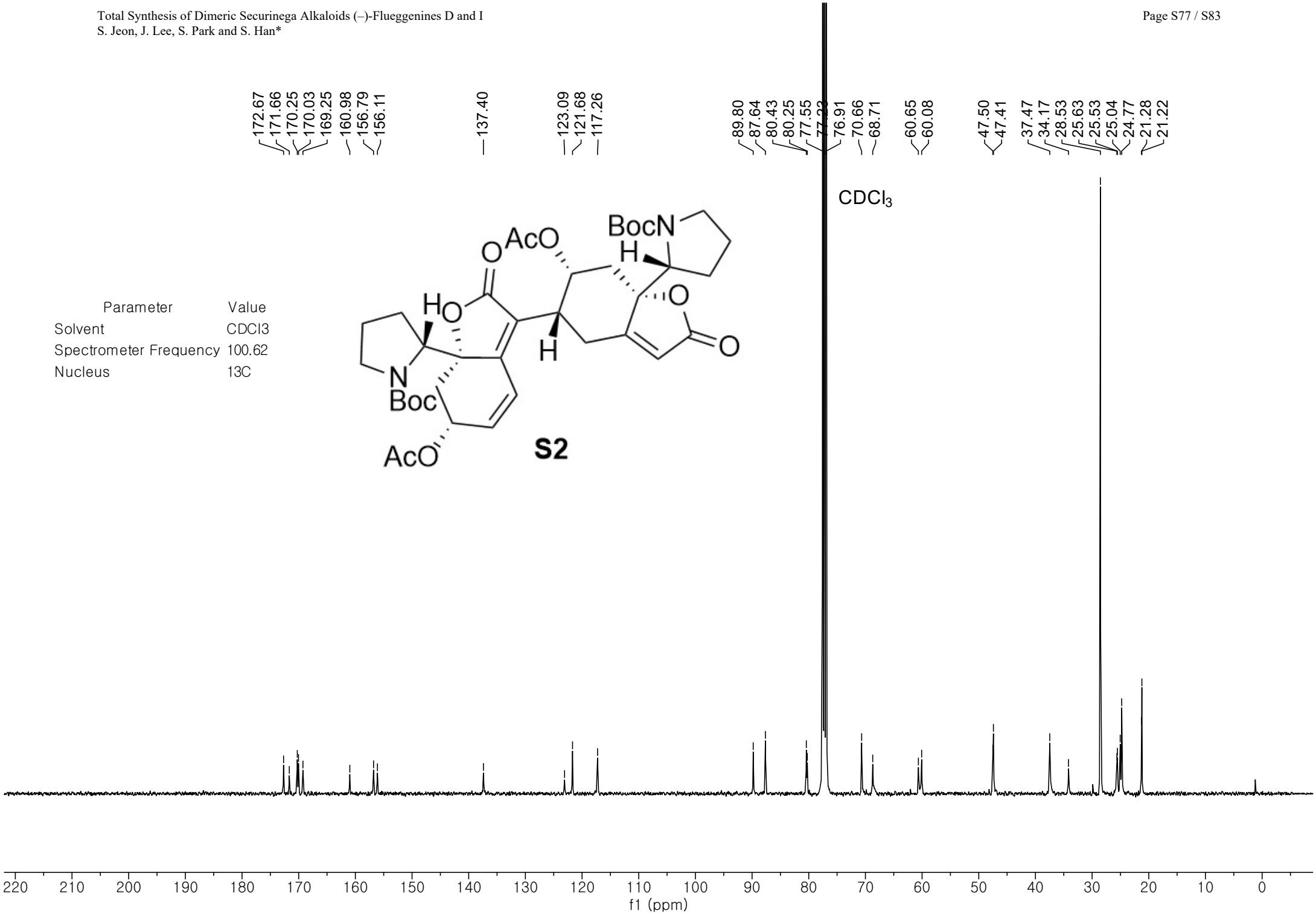

BocN
OAcO
H
HO
OH
H
OTES
N
Boc
AcO
39
Parameter Value
Solvent CDCl3
Experiment HSQC-EDITED
Spectrometer Frequency (400.12, 100.62)
f2 (ppm)
f1 (ppm)

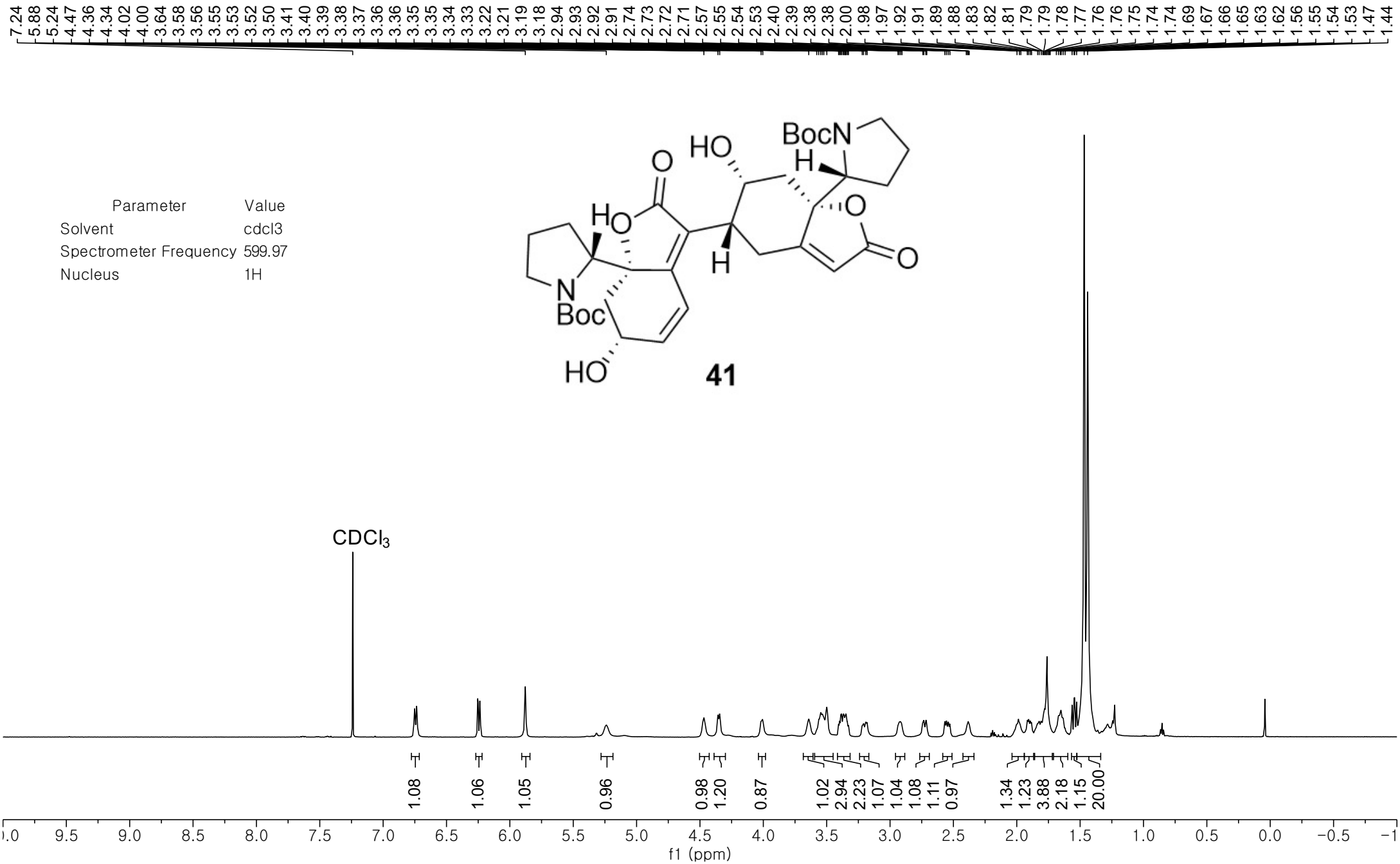

BocN
OAcO
H
HO
OH
H
OTES
N
Boc
AcO
39
Parameter Value
Solvent CDCl3
Experiment HMBC
Spectrometer Frequency (400.12, 100.62)
f2 (ppm)
f1 (ppm)

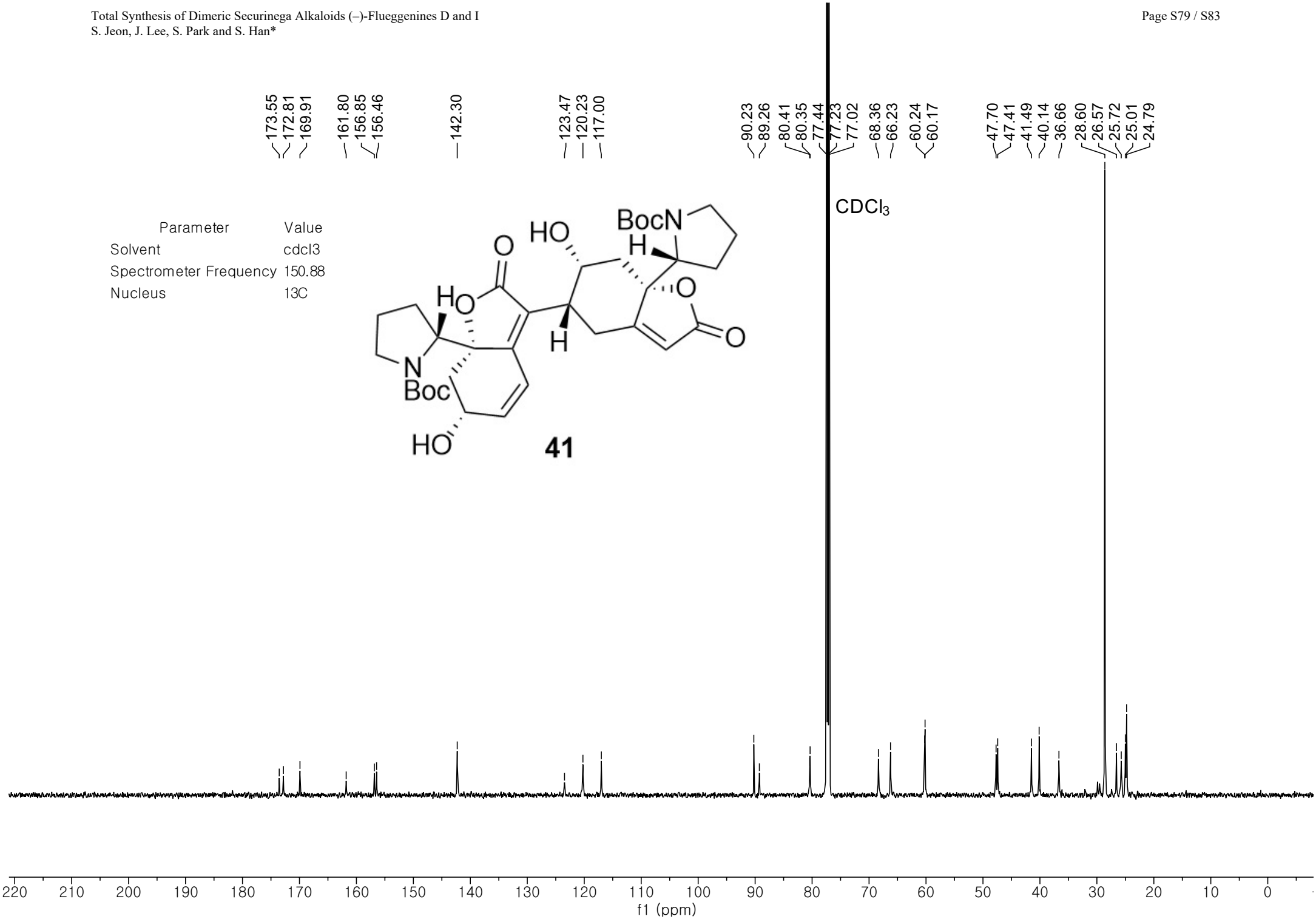

7.24
6.69
6.66
6.13
6.10
5.46
4.90
4.13
4.12
4.11
4.11
4.10
4.09
4.08
4.06
3.60
3.59
3.58
3.57
3.56
3.56
3.55
3.37
3.36
3.35
3.34
3.33
3.32
2.28
2.02
1.96
1.94
1.94
1.93
1.91
1.89
1.88
1.86
1.80
1.77
1.68
1.58
1.55
1.55
1.52
1.50
1.44
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.13
Nucleus 1H
BocN
AcO
O
H
HO
H
OH
O
N
Boc
AcO
40
CDCl3
1.00
2.09
1.10
0.82
1.09
1.10
3.18
3.12
0.97
0.97
2.01
3.08
4.11
6.50
1.16
0.93
9.08
9.10
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)

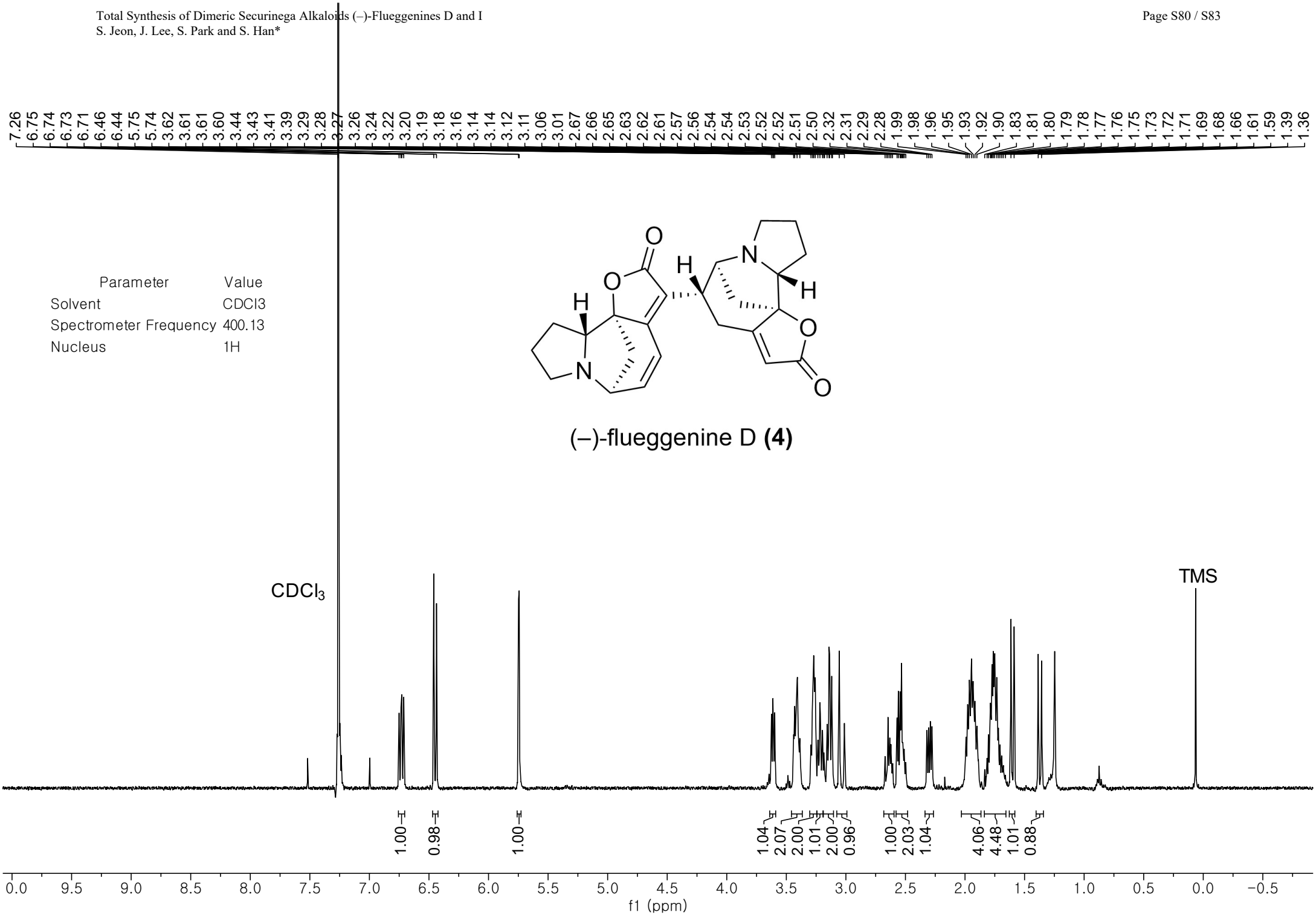

208.84
172.21
170.29
169.98
160.35
157.19
156.19
137.17
123.02
121.69
88.18
80.48
80.33
79.94
77.55
76.91
69.86
68.48
62.05
60.43
48.17
47.49
38.72
37.56
37.18
28.55
28.53
27.12
25.52
24.81
21.49
21.19
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
AcO
BocN
H
HO
H
OH
O
O
N
Boc
AcO
40
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

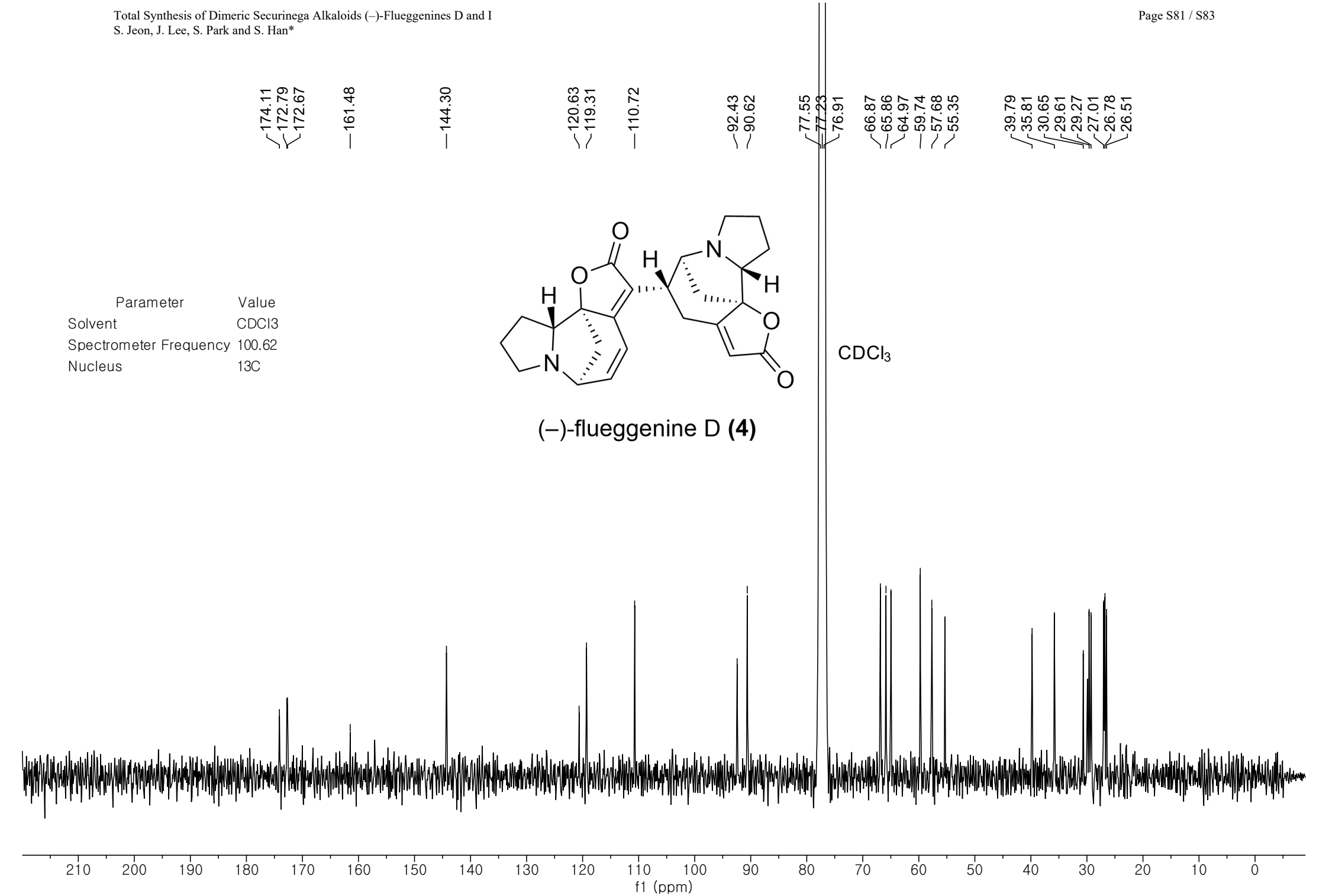

7.24 6.78 6.78 6.15 5.90 5.48 4.37 4.35 4.05 4.04 3.92 3.54 3.53 3.51 3.50 3.48 3.40 3.40 3.39 3.39 3.38 3.38 3.37 3.36 3.36 3.35 3.34 3.34 3.33 3.32 2.97 2.96 2.94 2.80 2.79 2.77 2.77 2.67 2.65 2.64 2.62 2.02 2.01 1.99 1.98 1.96 1.93 1.92 1.91 1.88 1.87 1.82 1.81 1.80 1.79 1.79 1.78 1.77 1.77 1.76 1.75 1.67 1.65 1.64 1.62 1.60 1.58 1.56 1.56 1.54 1.45 1.44 0.04
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.97
Nucleus 1H
BocN
H
AcO
O
HO
H
O
O
N
Boc
AcO
S2
CDCl3
0.96 2.10 1.18 1.05 0.97 0.96 1.03 2.98 1.26 1.00 1.16 1.23 1.09 5.19 3.00 3.58 3.32 19.87
f1 (ppm)

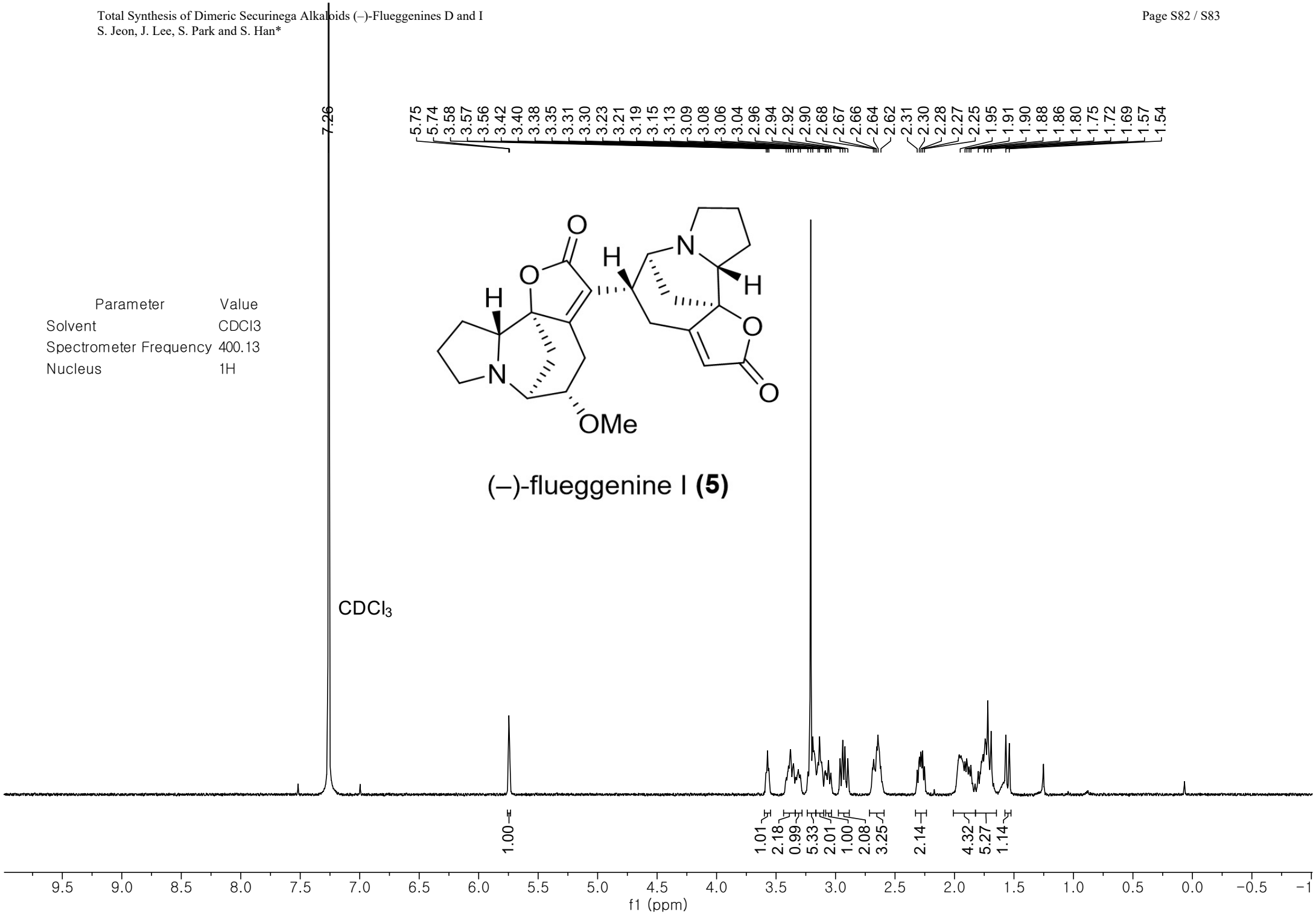

172.67
171.66
170.25
170.03
169.25
160.98
156.79
156.11
137.40
123.09
121.68
117.26
89.80
87.64
80.43
80.25
77.55
77.22
76.91
70.66
68.71
60.65
60.08
47.50
47.41
37.47
34.17
28.53
25.63
25.53
25.04
24.77
21.28
21.22
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
AcO
BocN
H
O
HO
H
O
O
N
Boc
AcO
S2
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

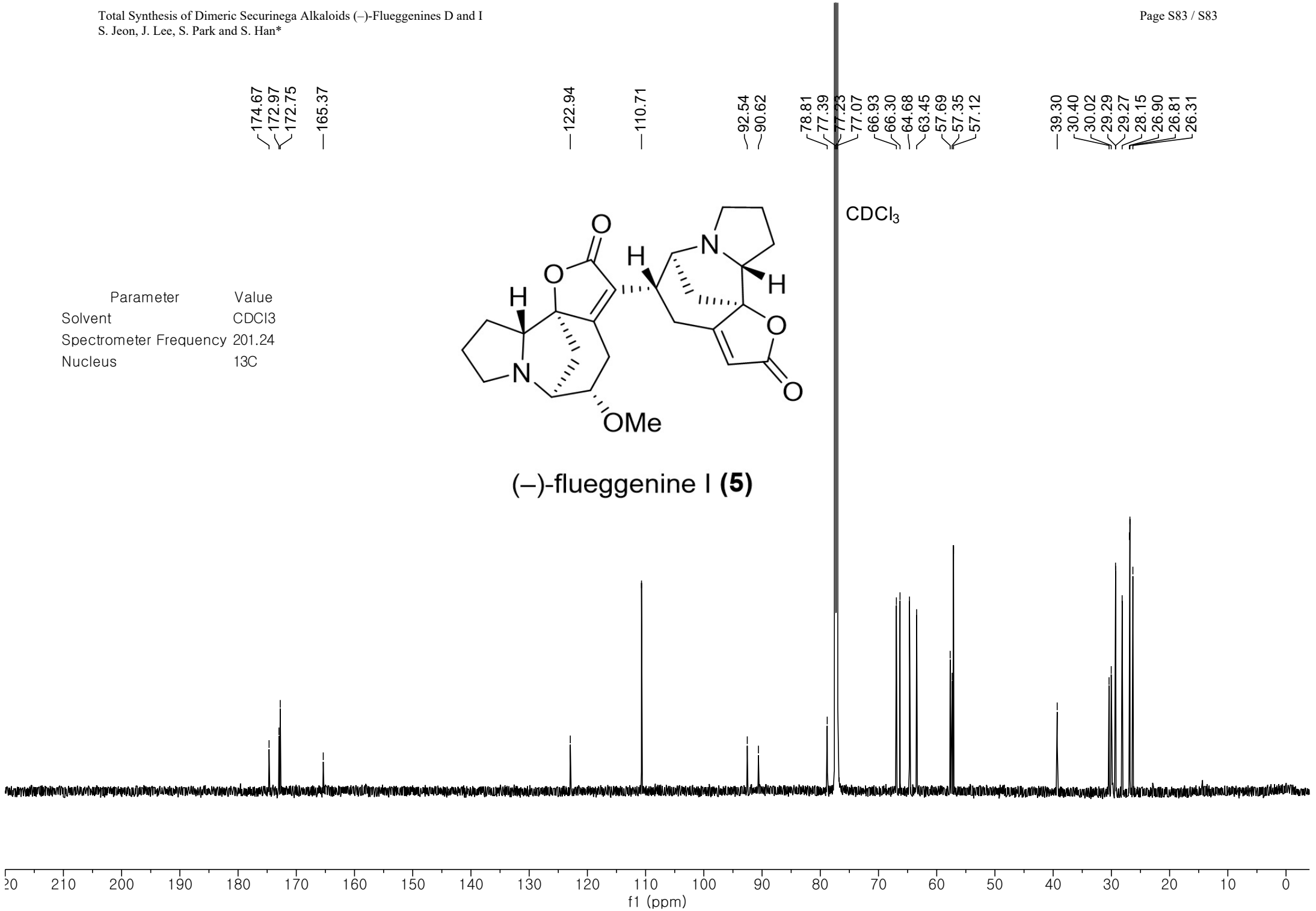

7.24 5.88 5.24 4.47 4.36 4.34 4.02 4.00 3.64 3.58 3.56 3.55 3.53 3.52 3.50 3.41 3.40 3.39 3.38 3.37 3.36 3.36 3.35 3.35 3.34 3.33 3.22 3.21 3.19 3.18 2.94 2.93 2.92 2.91 2.74 2.73 2.72 2.71 2.57 2.55 2.54 2.53 2.40 2.39 2.38 2.38 2.00 1.98 1.97 1.92 1.91 1.89 1.88 1.83 1.82 1.81 1.79 1.79 1.78 1.77 1.76 1.76 1.75 1.74 1.74 1.69 1.67 1.66 1.65 1.63 1.62 1.56 1.55 1.54 1.53 1.47 1.44
Parameter Value
Solvent cdcl3
Spectrometer Frequency 599.97
Nucleus 1H
HO
O
HO
BocN
H
O
O
H
N
Boc
HO
41
CDCl3
1.08 1.06 1.05 0.96 0.98 1.20 0.87 1.02 2.94 2.23 1.07 1.04 1.08 1.11 0.97 1.34 1.23 3.88 2.18 1.15 20.00
f1 (ppm)


173.55
172.81
169.91
161.80
156.85
156.46
142.30
123.47
120.23
117.00
90.23
89.26
80.41
80.35
77.44
77.23
77.02
68.36
66.23
60.24
60.17
47.70
47.41
41.49
40.14
36.66
28.60
26.57
25.72
25.01
24.79
CDCl3
Parameter Value
Solvent cdcl3
Spectrometer Frequency 150.88
Nucleus 13C
HO
O
BocN
H
HO
O
H
O
N
Boc
HO
41
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.26 6.75 6.74 6.73 6.71 6.46 6.44 5.75 5.74 3.62 3.61 3.61 3.60 3.44 3.43 3.41 3.39 3.29 3.28 3.27 3.26 3.24 3.22 3.20 3.19 3.18 3.16 3.14 3.14 3.12 3.11 3.06 3.01 2.67 2.66 2.65 2.63 2.62 2.61 2.57 2.56 2.54 2.54 2.53 2.52 2.52 2.51 2.50 2.32 2.31 2.29 2.28 1.99 1.98 1.96 1.95 1.93 1.92 1.90 1.83 1.81 1.80 1.79 1.78 1.77 1.76 1.75 1.73 1.72 1.71 1.69 1.68 1.66 1.61 1.59 1.39 1.36
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.13
Nucleus 1H
(–)-flueggenine D (4)
CDCl3
TMS
1.00 0.98 1.00 1.04 2.07 2.00 1.01 2.00 0.96 1.00 2.03 1.04 4.06 4.48 1.01 0.88
f1 (ppm)


174.11
172.79
172.67
161.48
144.30
120.63
119.31
110.72
92.43
90.62
77.55
77.23
76.91
66.87
65.86
64.97
59.74
57.68
55.35
39.79
35.81
30.65
29.61
29.27
27.01
26.78
26.51
Parameter Value
Solvent CDCl3
Spectrometer Frequency 100.62
Nucleus 13C
O
O
H
N
H
N
H
O
O
CDCl3
(–)-flueggenine D (4)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.26
5.75
5.74
3.58
3.57
3.56
3.42
3.40
3.38
3.35
3.31
3.30
3.23
3.21
3.19
3.15
3.13
3.09
3.08
3.06
3.04
2.96
2.94
2.92
2.90
2.68
2.67
2.66
2.64
2.62
2.31
2.30
2.28
2.27
2.25
1.95
1.91
1.90
1.88
1.86
1.80
1.75
1.72
1.69
1.57
1.54
Parameter Value
Solvent CDCl3
Spectrometer Frequency 400.13
Nucleus 1H
O
O
H
N
OMe
H
N
H
O
O
(–)-flueggenine I (5)
CDCl3
1.00
1.01
2.18
0.99
5.33
2.01
1.00
2.08
3.25
2.14
4.32
5.27
1.14
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1
f1 (ppm)


174.67
172.97
172.75
165.37
122.94
110.71
92.54
90.62
78.81
77.39
77.23
77.07
66.93
66.30
64.68
63.45
57.69
57.35
57.12
39.30
30.40
30.02
29.29
29.27
28.15
26.90
26.81
26.31
CDCl3
Parameter Value
Solvent CDCl3
Spectrometer Frequency 201.24
Nucleus 13C
O
O
H
N
OMe
H
N
H
O
O
(–)-flueggenine I (5)
f1 (ppm)