Electronic Supplementary Material (ESI) for Chemical Communications.

High Pressure promoted Dearomatization of Nitroarenes by [4+2] Cycloadditions with Silyloxydienes

Batoul Rkein, Romain Coffinier, Marian Powderly, Maxime Manneveau, Morgane Sanselme, Muriel Durandetti, Muriel Sebban, Ghanem Hamdoun, Hassan Oulyadi, David Harrowven, Julien Legros, and Isabelle Chataigner*

E-mail: isabelle.chataigner@univ-rouen.fr

Supporting information:

Unless otherwise noted, all chemicals were used as received from commercial sources without further purification. Anhydrous MeOH was purchased from Sigma Aldrich and stored over 4Å molecular sieves. THF was dried on sodium and freshly distilled over Na/benzophenone before use. Dichloromethane was dried over calcium hydride. Filtration was performed on Celite SDS 545 from Acros Organic. RP-HPLC gradient-grade acetonitrile (CH_3CN) was obtained from VWR. Mobile layers for RP-HPLC were prepared with ultrapure water (18.2 MΩ.cm) provided by a PURELAB® flex 1 (Elga Veolia).

Chromatographic purifications were performed on silica gel (mesh size 60-80 µm) using the procedure described by Still.[1] Analytical thin layer chromatography was performed on silica gel plates (Merck® TLC Silica gel 60 F254) and the spots were visualized by illumination with a UV lamp (λ = 254/365 nm) and/or staining with $KMnO_4$.

RP-HPLC (Synchronis C_{18} column, 3 µm, 100 × 2.1 mm) was performed with CH_3CN and 0.1% trifluoroacetic acid (aq. TFA 0.1%, pH 2.0) as eluents [100% TFA then linear gradient from 0% to 100% of CH_3CN] at a flow rate of 0.25 mL/min. Detection was achieved in the range of 400-800 nm.

^1H, ^{13}C and ^{19}F NMR spectra were recorded with a Bruker DPX 300, an AVIIHD 400 equipped with a 5 mm BBFO probe including shielded z gradients or Bruker AVIII 600 spectrometers equipped with a 5 mm CPTXI probe including shielded z gradients (Bruker, Wissembourg, France) equipped with a 5 mm BBFO probe including shielded z gradients. Chemical shifts are expressed in parts per million (ppm) using the residual solvent peak for calibration. Coupling constants (J) are expressed in Hz. The following abbreviations were used in the spectral description: s (singlet), d (doublet), t (triplet), q (quartet), dd (doublet of doublet), ddd (doublet of doublet of doublet), dt (doublet of triplet), br (broad signal), m (multiplet).

Infrared spectra (IR) were obtained on Perkin-Elmer spectrum 100 FT-IR. Wavelength (ν) were reported in cm^{-1} and only the strongest or structurally most important peaks are listed.

High-resolution mass spectrometry (HRMS) were recorded either on a Thermo LTQ Orbitrap XL apparatus equipped with an ESI source or on a LCT Premier XE bench top orthogonal acceleration time-of-flight (oa-TOF) mass spectrometer (Waters Micromass) equipped with an ESI source.

Melting points (mp) were measured with a Kofler apparatus from Wagner and Munz.

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

High pressure reactions were performed with UNIPRESS U22 Pressure Systems Ltd. apparatus.

General Procedure for the cycloaddition reactions

To a stirred solution of the requisite nitroarene (0.1 mmol or 0.2 mmol, 1 equiv) in dry CH_2Cl_2 (0.9 mL) was added the diene (0.4 mmol, 0.6 mmol or 1.2 mmol, 3 equiv, 4 equiv or 6 equiv). The resultant mixture was transferred into a 0.9 mL Teflon reactor. The reactor was then sealed and allowed to react for the required time at room temperature under 16 kbar pressure. The solvent was then removed under reduced pressure. The reaction residue was dissolved in 2 mL dry methanol and NH_4F (1.2 mmol, 6 equiv) was added at -25°C. The reaction mixture was stirred for 30 min after which methanol was evaporated. The reaction residue was dissolved in EtOAc (10 mL), extracted with saturated aqueous $NaHCO_3$ solution (3*4 mL) and brine (2*4 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude was purified by flash chromatography on silica gel or reverse phase HPLC (Cyclohexane/EtOAc or water + 0.1% formic acid/ACN).

4-methoxy-4a-nitro-1,2,4a,10a-tetrahydrophenanthren-2(3*H*)-one (3a)

3a Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol), 1-nitronaphthalene (**2a**) (35 mg, 0.2 mmol) in 0.9 mL CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 50:50) was chromatographed on silica (Cyclohexane/EtOAc: 90/10) to afford **3a** as yellow oil (53 mg, 96%). (4*R**,4a*S**,10a*R**) diastereomer*:* **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 8.27 (dd, *J* = 7.6, 1.3 Hz, 1H), 7.49 (ddd≈td, *J* = 7.6, 7.6, 1.4 Hz, 1H), 7.40 (ddd≈td, *J* = 7.6, 7.6, 1.4 Hz, 1H), 7.29 (dd, *J* = 7.6, 1.3 Hz, 1H), 6.59 (d, *J* = 9.5 Hz, 1H), 6.00 (dd, *J* = 9.5, 5.9 Hz, 1H), 4.51 (dd, *J* = 13.0, 4.7 Hz, 1H), 3.48 (ddd, *J* = 13.8, 5.9, 4.8 Hz, 1H), 3.43 (s, 3H), 3.01 (ddd, *J* = 14.4, 4.7, 2.1 Hz, 1H), 2.83 (dd, *J* = 14.4, 13.0 Hz, 1H), 2.54 (ddd, *J* = 15.5, 4.8, 2.1 Hz, 1H), 1.92 (dd, *J* = 15.5, 13.8 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 203.7, 134.7, 131.0, 130.8, 129.0, 128.5, 128.2, 126.7, 126.0, 94.1, 83.5, 58.1, 43.3, 42.9, 38.8. (4*S**, 4a*S**,10a*R**) *diastereomer:* **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.75 – 7.55 (m, 1H), 7.52 – 7.34 (m, 2H), 7.20 – 7.13 (m, 1H), 6.45 (d, *J* = 9.6 Hz, 1H), 6.23 (dd, *J* = 9.6, 5.9 Hz, 1H), 5.00 (dd≈t, *J* = 2.9, 2.9 Hz, 1H), 4.06 (ddd≈dt, *J* = 13.2, 5.9, 5.6 Hz, 1H), 3.39 (s, 3H), 2.95 – 2.71 (m, 2H), 2.59 (ddd, *J* = 15.0, 5.6, 2.4 Hz, 1H), 1.98 (dd, *J* = 15.0, 13.2 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 204.4, 133.7, 131.1, 130.9, 128.7, 128.2, 127.9, 126.7, 125.4, 92.1, 81.6, 57.9, 42.3, 40.3, 34.7. **HRMS** (AP^-): m/z Calcd. for $C_{15}H_{14}NO_4$ $[M-H]^-$: 272.0923; Found: 272.0915. **IR** (neat) ν = 1621, 1458, 1263, 1075, 746, 439 cm^{-1}.

9-Fluoro-4-methoxy-4a-nitro-1,4,4a,10a-tetrahydrophenanthren-2(3*H*)-one diastereomers (3b)

3b was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol), 1-fluoro-4-nitronaphthalene (**2a**) (38 mg, 0.2 mmol) in 0.9 mL CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 60:40) was chromatographed on silica (Cyclohexane/EtOAc: 90/10) to afford **3b** as an orange solid (56 mg, 96%). (4*R**,4a*S**,10a*R**) major *diastereomer* (mp 132 °C) **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 8.33 (ddd≈dt, *J* = 7.6, 1.0, 1.0 Hz, 1H), 7.69 – 7.43 (m, 3H), 5.51 (dd, *J* = 11.2, 6.6 Hz, 1H), 4.51 (dd, *J* = 13.1, 4.6 Hz, 1H), 3.53 (dddd, *J* = 13.4, 6.6, 4.8, 3.5 Hz, 1H), 3.43 (s, 3H), 3.02 (ddd, *J* = 14.5, 4.6, 2.1 Hz, 1H), 2.88 – 2.74 (m, 1H), 2.61 (ddd, *J* = 15.5, 4.8, 2.1 Hz, 1H), 1.97 (dd, *J* = 15.5, 13.4 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ δ 203.0, 156.7 (d, *J* = 257.8 Hz), 131.2 (d, *J* = 3.6 Hz), 130.9, 130.0, 129.7 (d, *J* = 25.1 Hz), 127.0 (d, *J* = 5.8 Hz), 122.8 (d, *J* = 5.3 Hz), 102.3 (d, *J* = 17.8 Hz), 94.6, 83.3, 59.0, 43.7 (d, *J* = 3.5 Hz), 43.1, 37.8 (d, *J* = 8.2 Hz). **^{19}F{^{1}H} NMR (282 MHz, $CDCl_3$)**: δ -123.1. (4*S**, 4a*S**,10a*R**) minor *diastereomer* (mp = 159 °C) **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.76 – 7.64 (m, 1H), 7.63 – 7.42 (m, 3H), 5.76 (dd, *J* = 11.7, 6.6 Hz, 1H), 4.96 (dd≈t, *J* = 2.8, 2.8 Hz, 1H), 4.16 (dddd, *J* = 12.9, 11.7, 5.3, 3.2 Hz, 1H), 3.40 (s, 3H), 2.88 (ddd, *J* = 15.2, 3.8, 2.5 Hz, 1H), 2.75 (dd, *J* = 15.2, 2.5 Hz, 1H), 2.67 (ddd, *J* = 15.2, 5.3, 2.5 Hz, 1H), 2.04 (dd≈t, *J* = 15.2, 12.9 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 203.6 (d, *J* = 1.2 Hz), 154.6 (d, *J* = 253.6 Hz), 131.2, 130.1, 129.0 (d, *J* = 26.2 Hz), 128.3 (d, *J* = 3.8 Hz), 127.8 (d, *J* = 5.6 Hz), 122.7 (d, *J* = 5.4 Hz), 106.3 (d, *J* = 17.0 Hz), 91.7 (d, *J* = 1.3 Hz), 81.3, 57.9, 43.1 (d, *J* = 3.6 Hz), 40.2, 34.0 (d, *J* = 8.3 Hz). **^{19}F NMR{^{1}H} (282 MHz, $CDCl_3$)**: δ -127.5. **HRMS**: m/z Calcd. for $C_{15}H_{13}NO_4F$ $[M-H]^-$: 290.0829; Found: 290.0829. **IR** (neat) ν = 1723, 1548, 1113, 772, 427 cm^{-1}.

1-Methoxy-6,10a-dinitro-1,4,4a,10a-tetrahydrophenanthren-3(2*H*)-one (3c)

3c Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 2,7-dinitronaphthalene (**2c**) (44 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 50:50) was purified by reverse phase HPLC of the residue (water+0.1% formic acid/ACN: 50/50 to 0/100 over 22 min) to afford **3c** (41 mg, 65%) as a brown solid. (1*S**,4a*S**,10a*S**) *diastereomer:* **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 8.17 (dd, *J* = 8.3, 2.2 Hz, 1H), 8.01 (d, *J* = 2.2 Hz, 1H), 7.45 (d, *J* = 8.3 Hz, 1H), 7.25 (d, *J* = 9.6 Hz, 1H), 6.63 (dd, *J* = 9.6, 1.0 Hz, 1H), 4.37 (dd, *J* = 12.6, 4.8 Hz, 1H), 3.98 (ddd, *J* = 13.6, 4.8, 1.0 Hz, 1H), 3.40 (s, 3H), 2.99 (ddd, *J* = 14.0, 4.8, 2.1 Hz, 1H), 2.72 – 2.46 (m, 2H), 2.25 (dd≈t, *J* = 14.0, 12.6 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 202.0, 147.9, 136.1, 135.27, 134.7, 129.2,

124.1, 122.9, 122.8, 91.9, 80.5, 58.2, 45.8, 42.6, 41.6. (1*R**,4a*S**,10a*S**) minor *diastereomer:* **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 8.22 – 8.01 (m, 2H), 7.36 (dd, *J* = 7.1, 2.0 Hz, 1H), 7.00 (d, *J* = 9.4 Hz, 1H), 6.24 (dd, *J* = 9.4, 1.3 Hz, 1H), 4.60 – 4.47 (m, 2H), 3.38 (s, 3H), 2.92 (ddd, *J* = 15.1, 3.7, 2.4 Hz, 1H), 2.77 (dd, *J* = 15.1, 2.4 Hz, 1H), 2.66 (ddd, *J* = 15.1, 6.1, 2.4 Hz, 1H), 2.27 (dd, *J* = 15.1, 12.9 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, CDCl3): δ 202.6, 148.6, 138.5, 134.4, 133.4, 129.3, 125.2, 123.4, 122.5, 89.2, 83.2, 57.7, 44.8, 39.8, 38.9. **HRMS** (ESI$^-$): m/z Calcd. for $C_{15}H_{13}N_2O_6$ $[M-H]^-$: 317.0774; Found: 317.0774. **IR** (neat) ν = 1719, 1518, 1344, 1097, 807, 407 cm^{-1}.

4,8-dimethoxy-4a,8a-dinitro-4,4a,4b,5,8,8a,12b-octahydrotriphenylene-2,6(3*H*,7*H*)-dione (3d)

3d was prepared according to the general procedure using **1a** (230 μL, 1.2 mmol) and 1,3-dinitronaphthalene (**2d**) (44 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24h. After hydrolysis, the residue (*dr* ~ 55:25:20) was purified by reverse phase HPLC (Water+ 0.1% formic acid/ACN: 90/10 to 0/100 over 55 min) to afford **3d** (77 mg, 92%) as a yellow solid of separable diastereomers. Major diastereomer (4*S**, 4a*R**, 4b*R**, 8*S**, 8a*S**, 12b*S**)[2] (mp 82°C) **^{1}H NMR** (600 MHz, CDCl3) : δ 7.92-7.90 (m, 1H), 7.47-7.46 (m, 2H), 7.23 (m, 1H), 5.10 (dd, *J*= 8.6, 6.4 Hz, 1H), 4.86 (dd, *J*= 3.9, 1.8 Hz, 1H), 4.52 (dd, *J*= 6.4, 3.5 Hz, 1H), 4.08 (dd, *J*= 9.3, 8.0 Hz, 1H), 3.43 (s, 3H), 3.10 (s, 3H), 3.03 (dd, *J*= 16.3, 8.0 Hz, 1H), 2.84 (dd, *J*= 17.5, 6.4 Hz, 1H), 2.84-2.72 (m, 2H), 2.65 (dd, *J*= 16.3, 9.3 Hz, 1H), 2.53 (dd, *J*= 17.5, 3.5 Hz, 1H), 2.47 (dd, *J*= 17.5, 6.4 Hz, 1H), 2.42 (dd, *J*= 16.9, 1.8 Hz, 1H). **^{13}C{^{1}H} NMR** (150 MHz, $CDCl_3$): δ 203.60, 203.39, 138.23, 131.16, 128.77, 128.3, 128.22, 127.36, 93.91, 92.59, 83.06, 80.45, 58.16, 55.62, 44.51, 40.01, 39.51, 38.82, 36.73, 29.77. *Second major diasteromer* (4*R**, 4a*S**, 4b*R**, 8*S**, 8a*S**, 12b*R**)[2] **^{1}H NMR** (600 MHz, CDCl3) : δ 7.83 (d, *J*= 8.2 Hz, 1H), 7.50 (dd≈t, *J*= 7.8, 7.5 Hz, 1H), 7.39 (dd≈t, *J*= 8.2, 7.5 Hz, 1H), 7.23 (d, *J*= 7.8 Hz, 1H), 4.54 (dd, *J*= 3.8, 2.4 Hz, 1H), 4.49 (dd, *J*= 8.2, 2.3 Hz, 1H), 4.39 (dd, *J*= 12.2, 5.8 Hz, 1H), 3.86 (dd, *J*= 8.6, 4.8 Hz, 1H), 3.35 (s, 3H), 3.25 (s, 3H), 3.04 (dd, *J*= 17.2, 8.6, 1H), 2.96 (dd, *J*= 17.6, 2.3, 1H), 2.91 (ddd≈dt, *J* = 16.0, 2.4, 1.8 Hz, 1H), 2.84 (ddd, *J*= 16.4, 5.8, 1.8 Hz, 1H), 2.79 (dd, *J* = 17.6, 8.2 Hz, 1H), 2.63 (dd, *J*= 17.2, 4.8 Hz, 1H), 2.54-2.61 (m, 2H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 202.50, 201.50, 137.90, 131.42, 130.05, 128.49, 127.82, 127.30, 93.20, 91.70, 80.73, 79.69, 59.07, 57.91, 46.28, 41.27, 39.89, 38.81, 38.37, 36.13. *Minor diastereomer*[3] **^{1}H NMR (300 MHz, $CDCl_3$)**: δ 7.76 (d, *J* = 7.6 Hz, 1H), 7.47 (dd, *J* = 7.5, 1.2 Hz, 1H), 7.41 – 7.33 (m, 1H), 7.28 (d, *J* = 7.5 Hz, 1H), 4.96 – 4.90 (m, 1H), 4.83 (dd≈t, *J* = 8.2, 8.2 Hz, 1H), 4.55 – 4.48 (m, 1H), 4.33 (dd, *J* = 12.4, 6.7 Hz, 1H), 3.57 (dd, *J* = 15.3, 6.8 Hz, 1H), 3.35 (s, 3H), 2.99 (s, 3H), 2.83 – 2.59 (m, 7H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 203.1, 203.0, 139.8, 131.6, 129.0,

[2] For the relative stereochemistry assignment, see below.
[3] The relative stereochemistries could not be assigned for this minor diastereomer.

128.0, 127.8, 126.3, 93.1, 90.8, 81.8, 81.2, 58.7, 58.1, 46.8, 41.1, 39.1, 39.5, 38.2, 36.0. **HRMS** (ESI$^-$): m/z Calcd. for $C_{20}H_{21}N_2O_8$ [M-H]$^-$: 417.1298; Found: 417.1304. **IR** (neat) ν = 1724, 1546, 1085, 800, 729, 422 cm^{-1}.

4,8-dimethoxy-4a,8a-dinitro-1,4,4a,4b,5,8,8a,10a-octahydrophenanthrene-2,6(3*H*,7*H*)-dione (3e)

3e Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 1,3-dinitrobenzene (**2e**) (33 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24h. After hydrolysis, the residue (*dr* ~ 55:25:20), was chromatographed on silica gel (cyclohexane/ EtOAc 95/5 to 80/20) to afford **3e** (33 mg, 45 %) as yellow oil. (4*S**,4a*R**,4b*S**,8*S**,8a*R**,10a*S**) major *diastereomer* **^{1}H NMR (300 MHz, $CDCl_3$):** δ 6.21 (ddd, *J*=10.4, 3.2, 1.1 Hz, 1H), 5.91 (dd, *J*=10.4, 2.4 Hz, 1H), 4.35 (ddd, *J* = 11.2, 5.7, 1.1 Hz, 1H), 4.27 (ddd, *J*=3.7, 2.6, 1.1 Hz, 1H), 3.97 (dd, *J* = 6.4, 3.3 Hz, 1H), 3.81 – 3.73 (m, 1H), 3.34 (s, 3H), 3.06 (s, 3H), 3.01 (dd, *J* = 16.4, 8.9 Hz, 1H), 2.83 (dd, *J* = 16.6, 3.3 Hz, 1H), 2.74 (ddd, *J* = 16.6, 3.7, 1.5 Hz, 1H), 2.66 (dd, *J* = 16.6, 6.4 Hz, 1H), 2.52 (ddd, *J* = 16.4, 3.3, 1.1 Hz, 1H), 2.37 (dd, *J* = 16.2, 11.2 Hz, 1H), 2.24 (dd, *J* = 16.2, 5.7 Hz, 1H), 2.20 (dd, *J* = 16.6, 2.6 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 203.8, 203.3, 133.6, 121.0, 92.5, 91.1, 82.8, 81.1, 58.5, 55.2, 42.0, 40.3, 40.0, 39.3, 38.1, 33.2. (4*R**,4a*R**,4b*S**,8*R**,8a*R**,10a*S**) *diastereomer* **^{1}H NMR (300 MHz, $CDCl_3$):** δ 5.79 (d, *J* = 10.0 Hz, 1H), 5.05 (d, *J* = 10.0 Hz, 1H), 4.34 (dd, *J* = 9.4, 5.5 Hz, 1H), 3.74 (dd, *J* = 9.8, 5.9 Hz, 1H), 3.52 (dd, *J* = 10.8, 4.5 Hz, 1H), 2.90-2.85 (m, 1H), 2.79 (dd, *J* = 16.1, 8.5 Hz, 1H), 2.72 (s, 3H), 2.68 (s, 3H), 2.29 (dd, *J* = 15.7, 4.5 Hz, 1H), 2.16 (dd, *J* = 15.5, 9.4 Hz, 1H), 2.13 (dd, *J* = 17.0, 5.9 Hz, 1H), 1.83-1.73 (m, 3H), 1.68 (dd, *J* = 16.1, 3.9 Hz, 1H). **^{13}C{^{1}H} NMR (75 MHz, $CDCl_3$)**: δ 202.1, 201.8, 138.0, 120.2, 93.8, 91.5, 79.9, 74.6, 57.5, 55.6, 42.9, 40.4, 40.2, 38.9, 37.1, 33.7. **HRMS** ESI+ m/z Calcd for $C_{16}H_{21}N_2O_8$: 369.1298 [M+H]$^+$; found: 369.1302.

10-methoxy-10a-nitro-6a,7,8,9,10,10a-tetrahydrobenzo[*f*]quinolin-8(9*H*)-one (5a)

5a Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 5-nitroquinoline (**4a**) (35 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 55:45), was chromatographed (Cyclohexane/EtOAc: 20/80) to afford **5a** (49 mg, 92%) as a brown oil of separable diastereomers. (6a*R**,10*R**,10a*S**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): *δ* 8.69 (dd, *J* = 4.9, 1.6, 1H), 8.58 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.31 (dd, *J* = 8.0, 4.9 Hz, 1H), 6.78 (d, *J* = 9.7 Hz, 1H), 6.29 (dd, *J* = 9.7, 5.8 Hz, 1H), 4.53 (dd, *J* = 13.4, 4.5 Hz, 1H), 3.51 (ddd, *J* = 13.6, 5.8, 4.9 Hz, 1H), 3.43 (s, 3H), 3.04 (ddd, *J* =

14.4, 4.5, 2.0 Hz, 1H), 2.70 (dd, *J* = 14.4, 13.4 Hz, 1H), 2.61 (ddd, *J* = 15.5, 4.9, 2.0 Hz, 1H), 1.90 (dd, *J* = 15.5, 13.6 Hz, 1H).**^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): *δ* 202.5, 153.5, 151.3, 138.6, 131.4, 130.6, 122.8, 122.7, 94.8, 83.2, 59.0, 43.1, 43.1, 38.4. (6a*R**,10*S**,10a*S**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): 8.63 (dd, *J* = 4.9, 1.5 Hz, 1H), 7.94 (ddd, *J* = 7.9, 1.5, 0.7 Hz, 1H), 7.32 (dd, *J* = 7.9, 4.9 Hz, 1H), 6.66 (dd, *J* = 9.8, 0.7 Hz, 1H), 6.52 (ddd, *J* = 9.8, 5.6, 0.7 Hz, 1H), 4.92 (bdd, *J* = 3.9, 2.1 Hz, 1H), 4.12 (ddd, *J* = 13.2, 5.6, 4.0 Hz, 1H), 3.39 (s, 3H), 2.88 (ddd, *J* = 15.1, 2.5, 2.1 Hz, 1H), 2.69 (ddd, *J* = 15.1, 3.9, 2.5 Hz, 1H), 2.67 (ddd, *J* = 15.1, 4.0, 2.3 Hz, 1H), 1.98 (ddd, *J* = 15.1, 13.2, 0.7 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): *δ* 203.2, 152.5, 151.7, 135.8, 135.7, 127.4, 123.2, 123.1, 92.1, 81.1, 57.9, 42.4, 39.9, 34.6. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{15}N_2O_4$ $[M+H]^+$: 275.1032; Found: 275.1024. **IR** (neat) ν = 1716, 1551, 1462, 1366, 1231, 1104, 793 cm^{-1}.

7-methoxy-6a-nitro-7,8,10,10a-tetrahydrobenzo[*f*]quinolin-9(6a*H*)-one (5b)

5b was prepared according to the general procedure using **1a** (230 μL, 1.2 mmol) and 6-nitroquinoline (**4b**) (35 g, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 50:50) was chromatographed on silica (Cyclohexane/Acetone: 85/15) to afford **5b** (40 mg, 73%) as a yellow oil of separable diastereomers. (6a*R**,7*S**,10a*S**) *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.53 (dd, *J* = 4.9, 1.8 Hz, 1H), 7.42 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.34 (d, *J* = 9.8 Hz, 1H), 7.16 (dd, *J* = 7.6, 4.9 Hz, 1H), 6.67 (dd, *J* = 9.8, 1.4 Hz, 1H), 4.34 (dd, *J* = 12.7, 4.8 Hz, 1H), 3.89 (ddd, *J* = 13.3, 5.6, 1.4 Hz, 1H), 3.39 (s, 3H), 2.96 (ddd, *J* = 13.9, 4.8, 2.1 Hz, 1H), 2.60 – 2.50 (m, 2H), 2.30 (dd, *J* = 14.5, 13.3 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.7, 149.9, 149.8, 137.5, 135.0, 130.0, 123.8, 123.0, 91.9, 80.7, 58.2, 46.0, 42.6, 41.5. (6a*S**,7*R**,10a*S**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.50 (dd, *J* = 4.9, 1.5 Hz, 1H), 7.54 (dd, *J* = 7.6, 1.5 Hz, 1H), 7.23 (dd, *J* = 7.6, 4.9 Hz, 1H), 7.10 (d, *J* = 9.5 Hz, 1H), 6.30 (dd, *J* = 9.5, 1.4 Hz, 1H), 4.53 (dd, *J* = 3.6, 2.5 Hz, 1H), 4.46 (ddd, *J* = 12.8, 6.1, 1.4 Hz, 1H), 3.37 (s, 3H), 2.84 (ddd, *J* = 15.1, 3.6, 2.3 Hz, 1H), 2.79 (dd, *J* = 15.1, 2.5 Hz, 1H), 2.61 (ddd, *J* = 15.1, 6.1, 2.3 Hz, 1H), 2.31 (dd, *J* = 15.1, 12.8 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 203.2, 149.1, 148.5, 136.7, 134.7, 133.1, 125.5, 124.5, 89.2, 83.4, 57.7, 45.1, 39.8, 38.7. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{15}N_2O_4$ $[M+H]^+$: 275.1032; Found: 275.1038. **IR** (neat) ν = 1723, 1543, 1458, 1377, 1092, 814 cm^{-1}.

7-methoxy-6a-nitro-7,8,10,10a-tetrahydrobenzo[*h*]quinolin-9(6a*H*)-one (5c)

5c was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 7-nitroquinoline (**4a**) (35 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24h. After hydrolysis, the residue (*dr* ~ 53:47), flash chromatography of the residue (Cyclohexane/Acetone: 50/50) afforded **5c** as an orange oil of separable diastereomers (49 mg, 89 %). (6a*S**,7*R**,10a*S**) *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): *δ* 8.54 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.42 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.34 (ddd, *J* = 9.8, 0.8, 0.7 Hz, 1H), 7.17 (dd, *J* = 7.7, 4.9 Hz, 1H), 6.68 (dd, *J* = 9.8, 1.6 Hz, 1H), 4.34 (dd, *J* = 12.6, 4.8 Hz, 1H), 3.89 (ddd, *J* = 13.5, 5.3, 1.6 Hz, 1H) 3.39 (s, 3H), 2.96 (ddd, *J* = 13.9, 4.8, 2.1 Hz, 1H), 2.66 (ddd, *J* = 13.9, 12.6, 0.7 Hz, 1H), 2.53 (ddd, *J* = 15.1, 5.3, 2.1 Hz, 1H), 2.30 (ddd, *J* = 15.1, 13.5, 0.8 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.7, 149.9, 149.8, 137.5, 135.0, 130.0, 123.7, 123.0, 91.9, 80.7, 58.2, 40.0, 42.6, 41.5. (6a*R**,7*S**,10a*S**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): *δ* 8.50 (dd, *J* = 4.9, 1.6 Hz, 1H), 7.54 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.23 (dd, *J* = 7.7, 4.9 Hz, 1H), 7.10 (dd, *J* = 9.5, 0.6 Hz, 1H), 6.30 (dd, *J* = 9.5, 1.6 Hz, 1H), 4.53 (dd, *J* = 3.7, 2.5 Hz, 1H), 4.46 (ddd, *J* = 12.7, 6.1, 1.6 Hz, 1H) 3.37 (s, 3H), 2.91 (ddd, *J* = 15.1, 3.7, 2.4 Hz, 1H), 2.79 (dd, *J* = 15.1, 2.5 Hz, 1H), 2.61 (ddd, *J* = 15.1, 6.1, 2.4 Hz, 1H), 2.32 (dd, *J* = 15.1, 12.7 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): *δ* 203.2, 149.1, 148.5, 136.7, 134.8, 133.1, 125.5, 124.5, 89.2, 83.4, 57.7, 45.1, 39.8, 38.7. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{15}N_2O_4$ $[M+H]^+$: 275.1032; Found: 275.1044. **IR** (neat) ν = 1718, 1541, 1442, 1237, 1093, 816 cm^{-1}.

10-methoxy-10a-nitro-6a,9,10,10a-tetrahydrobenzo[*h*]quinolin-8(7*H*)-one (5d)

5d was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 8-nitroquinoline (**4e**) (35 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 62 : 38) was purified by flash chromatography on silica gel (Cyclohexane/Acetone: 90/10) to afford **5d** (43 mg, 78%) as an orange oil of separable diastereomers (the major diastereomer proved unstable). (6a*S**,10*S**,10a*R**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.63 (dd, *J* = 4.8 Hz, 1H), 7.54 (dd, *J* = 7.7, 1.6 Hz, 1H), 7.36 (dd, *J* = 7.7, 4.8 Hz, 1H), 6.52 (d, *J* = 9.6, 1.3 Hz, 1H), 6.01 (dd, *J* = 9.6, 4.9 Hz, 1H), 4.66 (dd, *J* = 8.5, 4.1 Hz, 1H), 3.80 (ddd, *J* = 11.2, 5.7, 4.9 Hz, 1H), 3.29 (s, 3H), 3.11 (dd, *J* = 15.7, 8.5 Hz, 1H), 3.00 (ddd, *J* = 15.7, 4.1, 1.3 Hz, 1H), 2.60 (ddd, *J* = 16.2, 5.7, 1.3 Hz, 1H), 2.17 (dd, *J* = 16.2, 11.2 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 204.8, 148.5, 148.0, 134.6, 130.2, 128.7, 125.9, 124.9, 93.8, 82.1, 59.4, 42.7, 42.1, 39.8. (6a*S**,10*R**,10a*R**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.61 (dd, *J* = 4.8, 1.7 Hz, 1H), 7.49 (dd, *J* = 7.7, 1.7 Hz, 1H), 7.37 (dd, *J* = 7.7, 4.8 Hz, 1H), 6.45 (d, *J* = 9.6 Hz, 1H),

6.32 (dd, *J* = 9.6, 5.6 Hz, 1H), 5.37 (dd≈t, *J* = 3.1, 3.1 Hz, 1H), 4.19 (ddd≈dt, *J* = 13.4, 5.6, 5.6 Hz, 1H), 3.39 (s, 3H), 2.97 – 2.75 (m, 2H), 2.63 (ddd, *J* = 14.9, 5.6, 1.6 Hz, 1H), 1.92 (dd, *J* = 14.9, 13.4 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 204.9, 148.8, 146.1, 134.7, 132.8, 129.3, 125.8, 123.8, 93.0, 81.3, 57.9, 41.7, 40.8, 35.5. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{15}N_2O_4$ $[M+H]^+$: 275.1032; Found: 275.1024. **IR** (neat) ν = 1718, 1544, 1358, 1099, 1081, 821 cm^{-1}.

10-methoxy-10a-nitro-6a,9,10,10a-tetrahydrobenzo[*f*]isoquinolin-8(7*H*)-one (5e)

5e Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 5-nitroisoquinoline (**4e**) (35 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24h. After hydrolysis, the residue (*dr* ~ 53:47) was chromatographed on silica gel (Cyclohexane/EtOAc: 30/70) to afford **5e** (54 mg, 99%) as an orange oil of separable diastereomers. (6a*R**,10*R**,10a*S**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.65 (d, *J* = 5.2 Hz, 1H), 8.57 (s, 1H), 8.16 (d, *J* = 5.2 Hz, 1H), 6.65 (d, *J* = 9.5 Hz, 1H), 6.12 (dd, *J* = 9.5, 5.9 Hz, 1H), 4.51 (dd, *J* = 13.8, 4.6 Hz, 1H), 3.50 (ddd, *J* = 13.8, 5.9, 4.6 Hz, 1H), 3.43 (s, 3H), 3.03 (ddd, *J* = 15.5, 4.6, 2.1 Hz, 1H), 2.71 (dd, *J* = 15.5, 4.6 Hz, 1H), 2.57 (ddd, *J* = 15.5, 13.8, 2.1 Hz, 1H), 1.84 (dd, *J* = 15.5, 13.8 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.4, 150.0, 148.8, 134.1, 129.6, 128.9, 125.5, 124.9, 93.3, 82.9, 59.0, 43.1, 42.5, 38.3. (6a*R**,10*S**,10a*S**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.68 (d, *J* = 5.1 Hz, 1H), 8.50 (s, 1H), 7.54 (d, *J* = 5.1 Hz, 1H), 6.53 (d, *J* = 9.6 Hz, 1H), 6.36 (dd, *J* = 9.6, 5.8 Hz, 1H), 4.95 – 4.92 (m, 1H), 4.13 (ddd≈dt, *J* = 13.1, 5.8, 5.8 Hz, 1H), 3.40 (s, 3H), 2.96 – 2.80 (m, 1H), 2.74 – 2.52 (m, 2H), 2.02 – 1.80 (m, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 203.1, 150.2, 149.0, 134.6, 133.0, 128.5, 122.1, 122.0, 90.8, 81.1, 58.0, 41.9, 40.2, 34.5. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{15}N_2O_4$ $[M+H]^+$: 275.1032; Found: 275.1035. **IR** (neat) ν = 1716, 1193, 1103, 1083, 702, 480 cm^{-1}.

10-methoxy-5-methyl-10a-nitro-6a,9,10,10a-tetrahydrobenzo[f]quinolin-8(7H)-one (5f)

5f Was prepared according to the general procedureusing **1a** (230 µL, 1.2 mmol) and 8-methyl-5-nitroquinoline (**4f**) (37 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 56:44) was purified by flash chromatography (Cyclohexane/EtOAc: 50/50) to afford **5f** (38 mg, 68%) as separable diastereomers. (6a*R**, 10*R**, 10a*S**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): 8.73 (dd, *J* = 4.7, 1.6 Hz, 1H), 8.59 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.31 (dd, *J* = 7.9, 4.7 Hz, 1H), 6.07 (d, *J* = 6.1 Hz, 1H), 4.50 (dd, *J* = 13.0, 4.6 Hz, 1H), 3.42 (s, 3H), 3.36 – 3.42 (m, 1H), 3.02 (ddd, *J* = 14.4, 4.6, 2.0 Hz, 1H), 2.69 (dd≈t, *J* = 14.4, 13.0

Hz, 1H), 2.57 (ddd, *J* = 15.2, 4.8, 2.0 Hz, 1H), 2.15 (s, 3H), 1.86 (dd≈t, *J* = 15.2, 14.1 Hz, 1H). **$^{13}C\{^1H\}$ NMR** (75 MHz, $CDCl_3$): 203.0, 154.5, 150.7, 138.3, 136.7, 126.6, 122.7, 122.5, 95.0, 83.2, 59.0, 43.5, 43.2, 38.0, 18.2. (*6aR**, 10*S**, 10a*S**) minor *diastereomer* (mp 110 °C): **^1H NMR** (300 MHz, $CDCl_3$): 8.69 (dd, *J* = 4.7, 1.5 Hz, 1H), 7.95 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.33 (dd, *J* = 8.1, 4.7 Hz, 1H), 6.31 (d, *J* = 5.4 Hz, 1H), 4.90 (dd≈t, *J* = 3.5, 2.2 Hz, 1H), 4.05 (ddd≈dt, *J* = 13.0, 6.1, 5.4 Hz, 1H), 3.39 (s, 3H), 2.87 (ddd, *J* = 15.1, 3.5, 2.5 Hz, 1H), 2.67 (dd, *J* = 15.1, 2.2 Hz, 1H), 2.63 (ddd, *J* = 14.9, 6.1, 2.5 Hz, 1H), 2.13 (s, 3H), 1.96 (dd, *J* = 14.9, 13.0 Hz, 1H). **$^{13}C\{^1H\}$ NMR** (75 MHz, $CDCl_3$): 203.6, 153.5, 151.2, 135.5, 133.2, 131.2, 123.4, 122.7, 92.3, 81.3, 57.9, 42.9, 40.0, 34.2, 18.1. **HRMS** (ESI^+): m/z Calcd. for $C_{15}H_{17}N_2O_4$ $[M+H]^+$: 289.1188 ; Found: 289.1199. **IR** (neat) ν = 2923, 1720, 1551, 1236, 1101, 793, 406 cm^{-1}.

5-(benzyloxy)-10-methoxy-10a-nitro-6a,9,10,10a-tetrahydrobenzo[*f*]quinolin-8(7*H*)-one (5g)

5g Was prepared according to the general procedure using **1a** (465 µL, 2.4 mmol) and 8-benzyl-5-nitroquinoline (**4g**) (112 mg, 0.4 mmol) in 1.8 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue (*dr* ~ 70:30), was purified by flash chromatography (Cyclohexane/EtOAc: 50/50) to afford **5g** (113 mg, 74%) as a red oil of separable diastereomers. (6a*R**, 10*R**, 10a*S**) major *diastereomer:* **^1H NMR** (300 MHz, $CDCl_3$): 8.80 (dd, *J* = 4.7, 1.6 Hz, 1H), 8.63 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.26-7.38 (m, 6H), 5.20 (d, *J* = 7.0 Hz, 1H), 5.04 (d, *J* = 12.7 Hz, 1H), 4.99 (d, *J* = 12.7 Hz, 1H), 4.74 (dd, *J* = 13.4, 4.5 Hz, 1H), 3.40 – 3.46 (m, 4H), 2.99 (ddd, *J* = 14.0, 4.5, 1.8 Hz, 1H), 2.64 (dd≈t, *J* = 14.0, 13.4 Hz, 1H), 2.52 (ddd, *J* = 15.2, 4.8, 1.8 Hz, 1H), 1.85 (dd, *J* = 15.2, 13.6 Hz, 1H). **$^{13}C\{^1H\}$ NMR** (75 MHz, $CDCl_3$): 202.7, 151.6, 151.1, 150.2, 138.5, 135.9, 128.6 (2C), 128.0, 127.2 (2C), 123.7, 123.3, 100.6, 94.3, 83.1, 70.2, 58.9, 44.8, 43.0, 36.5. (6a*R**, 10*S**, 10a*S**) minor *diastereomer:* **^1H NMR** (300 MHz, $CDCl_3$): 8.79 (dd, *J* = 4.7, 1.1 Hz, 1H), 7.98 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.28-7.43 (m, 6H), 5.49 (d, *J* = 6.6 Hz, 1H), 5.09 (d, *J* = 12.3 Hz, 1H), 5.03 (d, *J* = 12.3 Hz, 1H), 4.90-4.80 (m, 1H), 4.11 (ddd, *J* = 12.4, 6.6, 5.9 Hz, 1H), 3.38 (s, 3H), 2.86 (ddd, *J* = 14.9, 5.9, 2.9 Hz, 1H), 2.56 – 2.66 (m, 2H), 1.95 (dd, *J* = 14.9, 12.4 Hz, 1H). **$^{13}C\{^1H\}$ NMR** (75 MHz, $CDCl_3$): 203.3, 151.6, 149.5, 149.2, 136.2, 135.9, 128.7 (2C), 128.1, 127.4 (2C), 124.5, 123.6, 105.4, 91.5, 81.1, 70.2, 57.9, 44.2, 40.0, 33.7. **HRMS** (ESI^+): m/z Calcd. for $C_{21}H_{21}N_2O_5$ $[M+H]^+$: 381.1450 ; Found: 381.1454. **IR** (neat) ν = 2921, 1715, 1544, 1455, 1367, 1095, 733, 437 cm^{-1}.

5-fluoro-10-methoxy-10a-nitro-6a,9,10,10a-tetrahydrobenzo[*f*]quinolin-8(7*H*)-one (5h)

5h was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 8-fluoro-5-nitroquinoline (**4h**) (38 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 63:37) was purified by flash chromatography (Cyclohexane/EtOAc: 30/70) to afford **5h** (51 mg, 88%) as a yellow solid of separable diastereomers. (6a*R**, 10*R**, 10a*S**) major *diastereomer* (mp = 138 °C) **^{1}H NMR** (300 MHz, $CDCl_3$): 8.78 (dd, *J* = 4.8 Hz, 1H), 8.65 (d, *J* = 8.0 Hz, 1H), 7.42 (dd, *J* = 8.0, 4.8 Hz, 1H), 5.83 (dd, *J* = 10.4, 6.5 Hz, 1H), 4.51 (dd, *J* = 13.1, 4.5 Hz, 1H), 3.53 – 3.63 (m, 1H), 3.42 (s, 3H), 3.04 (ddd, *J* = 14.4, 4.5, 2.0 Hz, 1H), 2.63-2.72 (m, 2H), 1.95 (dd≈t, *J* = 14.4, 14.4 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 201.7 (d ,*J* = 1 Hz), 155.5 (d, *J* = 262 Hz), 151.3 (s), 147.7 (d, *J* = 21 Hz), 138.9 (d, *J* = 3 Hz), 124.1 (s), 124.0 (s), 107.3 (d, *J* = 17 Hz), 94.2 (s), 82.9 (s), 59.1 (s), 43.8 (d, *J* = 4 Hz), 42.9 (s), 37.1 (d, *J* = 7 Hz). **^{19}F{^{1}H} NMR (282 MHz, $CDCl_3$)**: δ -125.3. (6aR*, 10*S**, 10a*S**) minor *diastereomer* (mp = 144 °C). **^{1}H NMR** (300 MHz, $CDCl_3$): 8.76 (d, *J* = 4.8 Hz, 1H), 8.01 (d, *J* = 8.0 Hz, 1H), 7.46 (dd, *J* = 8.0, 4.8 Hz, 1H), 6.07 (dd, *J* = 11.7, 6.6 Hz, 1H), 4.90 (dd≈t, *J* = 3.6, 2.5 Hz, 1H), 4.18 – 4.27 (m, 1H), 3.40 (s, 3H), 2.90 (ddd, *J* = 15.3, 3.6, 2.5 Hz, 1H), 2.74 (ddd, *J* = 15.0, 5.4, 2.5 Hz, 1H), 2.65 (dd, *J* = 15.3, 2.5 Hz, 1H), 2.05 (dd, *J* = 15.0, 13.4 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.3 (d, *J* = 1 Hz), 153.9 (d, *J* = 258 Hz) 151.7 (s), 146.9 (d, *J* = 22 Hz), 136.1 (d, *J* = 4 Hz),124.7 (d, *J* = 3 Hz), 124.3 (s), 111.5 (d, *J* = 16 Hz), 91.5 (d, *J* = 1 Hz), 80.8 (s), 58.0 (s), 43.1 (d, *J* = 4 Hz), 39.8 (s), 33.6 (d, *J*= 7 Hz). **^{19}F{^{1}H} NMR (282 MHz, $CDCl_3$)**: δ -129.8. **HRMS** (ESI$^+$): m/z Calcd. for $C_{14}H_{14}N_2O_4F$ $[M+H]^+$: 293.0938 ; Found: 293.0927. **IR** (neat) ν = 2923, 1714, 1552, 1102, 1082, 799, 485 cm^{-1}.

8-methoxy-8a-nitro-4b,5,8,8a-tetrahydrobenzo[*f*][1.10]phenanthrolin-6(5*H*)-one (5i)

5i Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmoL) and 5-nitro-1,10-phenanthroline (45 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 60:40) was purified by reverse phase chromatography (Water + 0.1% formic acid/ACN: 90/10 to 0/100 over 45 min) to afford **5i** (57 mg, 88%) as a pink oil of separable diastereomers. (4b*R**,8*R**,8aS*) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.98 (dd, *J* = 4.7, 1.5 Hz, 1H), 8.80 (dd, *J* = 4.7, 1.5 Hz, 1H), 8.76 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.55 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.48 (dd, *J* = 8.1, 4.7 Hz, 1H), 7.30 (dd, *J* = 7.7, 4.7 Hz, 1H), 4.65 (dd, *J* = 13.2, 4.7 Hz, 1H), 3.98 (dd, *J* = 13.7, 5.0 Hz, 1H), 3.47 (s, 3H), 3.11 (ddd, *J* = 14.7, 4.7, 1.9 Hz, 1H), 2.81 – 2.67 (m, 1H), 2.61 (ddd, *J* = 15.6, 5.0, 1.9 Hz,

1H), 2.24 – 2.10 (m, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 201.7, 152.4, 152.4, 151.2, 149.0, 139.1, 135.7, 130.2, 124.9, 124.4, 124.4, 93.8, 83.3, 59.2, 45.9, 43.2, 42.7. (4b*R**,8*S**,8aS*) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.96 (dd, *J* = 4.6, 1.2 Hz, 1H), 8.77 (dd, *J* = 4.7, 1.5 Hz, 1H), 8.11 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.69 (dd, *J* = 7.7, 1.5 Hz, 1H), 7.52 (dd, *J* = 8.0, 4.6 Hz, 1H), 7.38 (dd, *J* = 7.7, 4.7 Hz, 1H), 5.15 – 4.97 (m, 1H), 4.61 (dd, *J* = 13.4, 5.4 Hz, 1H), 3.44 (s, 3H), 3.02 – 2.90 (m, 1H), 2.79 – 2.58 (m, 2H), 2.28 – 2.09 (m, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.6, 153.0, 151.3, 150.4, 147.6, 136.4, 135.7, 134.0, 125.6, 125.0, 124.8, 90.9, 81.2, 58.1, 45.5, 40.0, 38.8. **HRMS** (ESI^+): m/z Calcd. for $C_{17}H_{16}N_3O_4$ $[M+H]^+$: 326.1141; Found: 326.1132. **IR** (neat) ν = 1714, 1547, 1082, 1008, 801, 408 cm^{-1}.

10-(tert-butyloxy)-10a-nitro-6a,7,10,10a-tetrahydrobenzo[f]quinolin-8(7*H*)-one (5j)

5j Was prepared according to the general procedure using (*E*)-((4-(*tert*-butoxy)buta-1,3-dien-2-yl)oxy)triethylsilane (**1f**) (307 mg, 1.2 mmol) and 5-nitroquinoline (**4a**) (38 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 59:41) was purified by flash chromatography (Cyclohexane/EtOAc: 30/70) to afford **5j** (45 mg, 71%) as a brown oil of separable diastereomers. (6a*R**, 10R*, 10a*S**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): 8.80 (dd, *J* = 7.9, 1.0 Hz, 1H), 8.67 (dd, *J* = 4.8, 1.0 Hz, 1H), 7.31 (dd, *J* = 7.9, 4.8 Hz, 1H), 6.75 (d, *J* = 9.7 Hz, 1H), 6.32 (dd, *J* = 9.7, 5.8 Hz, H), 4.72 (dd, *J* = 11.5, 5.8 Hz, 1H), 3.62 (ddd≈dt, *J* = 13.6, 5.8, 4.8 Hz, 1H), 2.78 – 2.88 (m, 2H), 2.59 (ddd, *J* = 15.4, 4.8, 1.7 Hz, 1H), 1.87 (dd≈t, *J* = 15.4, 13.6 Hz, 1H), 1.18 (s, 9H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): 203.5, 153.2, 150.9, 139.2, 132.1, 130.4, 123.5, 122.7, 95.7, 76.9, 74.8, 47.7, 42.6, 38.2, 28.2 (3C). (6a*R**, 10*S**, 10a*S**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): 8.66 (d, *J* = 3.9 Hz, 1H), 8.02 (d, *J* = 7.8 Hz, 1H), 7.35 (dd, *J* = 4.7, 7.8 Hz, 1H), 6.70 (d, *J* = 9.6 Hz, 1H), 6.53 (dd, *J* = 9.6, 5.7 Hz, H), 5.24 (dd≈t, *J* = 2.6, 2.6 Hz, 1H), 4.24 (ddd≈dt, *J* = 12.7, 5.7, 5.7 Hz, 1H), 2.65 – 2.72 (m, 3H), 1.92 (dd≈t, *J* = 13.2, 12.7 Hz, 1H), 1.16 (s, 9H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): 203.7, 152.5, 151.5, 136.4, 136.2, 127.6, 124.1, 122.9, 93.1, 77.3, 72.8, 44.4, 42.7, 34.3, 28.2 (3C). **HRMS** (ESI^+): m/z Calcd. for $C_{17}H_{21}N_2O_4$ $[M+H]^+$: 317.1501 ; Found: 317.1495. **IR** (neat) ν = 2979, 1717, 1545, 1444, 1184, 1104, 789, 514 cm^{-1}.

1-methoxy-9b-nitro-1,4,4a,9b-tetrahydrodibenzo[*b,d*]thiophen-3(2*H*)-one (7a)

7a Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 3-nitrobenzothiophene (**6a**) (36 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (dr ~ 50:50) was purified by flash chromatography (Cyclohexane/EtOAc: 85/15) to afford **7a** (45 mg, 80%) as an orange oil of non-separable diastereomers. (1*R**, 4a*S**, 9b*S**) & (1*S**, 4a*S**, 9b*S**) *diastereomers:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 7.92 (d, *J* = 7.9 Hz, 1/2H), 7.68 (d, *J* = 8.0 Hz, 1/2H), 7.48 – 7.11 (m, 3H), 5.38 (dd, *J* = 6.8, 5.7 Hz, 1/2H), 4.75 (dd, *J* = 3.6, 2.0 Hz, 1/2H), 4.67 (dd, *J* = 11.1, 4.1 Hz, 1/2H), 4.57 (dd, *J* = 9.9, 6.3 Hz, 1/2H), 3.42 (s, 3/2H), 3.41 (s, 3/2H), 3.28 (ddd, *J* = 16.3, 6.8, 0.9 Hz, 1/2H), 3.02 (ddd, *J* = 15.9, 6.3, 1.1 Hz, 1/2H), 2.88 (ddd, *J* = 15.6, 4.1, 1.1 Hz, 1/2H), 2.78 (dd, *J* = 17.3, 3.6 Hz, 1/2H), 2.64 – 2.52 (m, 3/2H), 2.39 (dd, *J* = 17.3, 2.0 Hz, 1/2H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 203.9 (1/2C), 202.9 (1/2C), 143.1 (1/2C), 142.9 (1/2C), 132.5 (1/2C), 132.3 (1/2C), 131.9 (1/2C), 131.0 (1/2C), 130.5 (1/2C), 127.1 (1/2C), 125.7 (1/2C), 125.5 (1/2C), 123.9 (1/2C), 123.3 (1/2C), 104.6 (1/2C), 102.1 (1/2C), 81.6 (1/2C), 80.4 (1/2C), 58.6 (1/2C), 58.1 (1/2C), 49.5 (1/2C), 46.4 (1/2C), 46.0 (1/2C), 44.7 (1/2C), 41.4 (1/2C), 38.5 (1/2C). **HRMS** (ESI^-) m/z Calcd. for $C_{13}H_{12}NO_4S$ $[M-H]^-$: 278.0487; Found: 278.0495. **IR** (neat) ν = 1723, 1548, 1090, 755, 735 cm^{-1}.

1-Ethyl-3-methyl-4-methoxy-3a-nitro-6-oxo-3a,4,5,6,7,7a-hexahydro-1*H*-indazole-1,3-dicarboxylate (7b)

7b Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 1-ethyl-3-methyl-4-nitro-1H-pyrazole-1,3-dicarboxylate (**6a**) (49 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* ~ 66:34), was purified by flash chromatography (Cyclohexane/EtOAc : 80/20) to afford **7b** (58 mg, 84%) as an orange oil of non-separable diastereomers. (3a*R**, 4*S**, 7a*R**) major *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ 5.04 (dd, *J* = 12.0, 6.8 Hz, 1H), 4.75 (dd≈t, *J* = 3.1, 2.3 Hz, 1H), 4.36 (q, *J* = 7.1 Hz, 2H), 3.92 (s, 3H), 3.28 (s, 3H), 3.19 (dd, *J* = 16.8, 6.8 Hz, 1H), 2.98 (dd, *J* = 18.9, 3.1 Hz, 1H), 2.82 (dd, *J* = 18.9, 2.3 Hz, 1H), 2.57 (dd, *J* = 16.8, 12.0 Hz, 1H), 1.36 (t, *J* = 7.1 Hz, 3H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.3, 160.7, 140.4, 98.8, 74.5, 64.2, 63.5, 61.9, 57.8, 53.2, 40.6, 38.9, 14.5. (3a*R**, 4R*, 7a*R**) minor *diastereomer:* **^{1}H NMR** (300 MHz, $CDCl_3$): δ = 5.82 (dd, *J* = 7.1, 1.5 Hz, 1H), 5.30 (dd≈t, *J* = 3.1, 2.9 Hz, 1H), 4.36 (q, *J* = 7.1 Hz, 2H), 3.90 (s, 3H), 3.40 (s, 3H), 3.25-3.25 (m, 1H), 3.00-2.75 (m, 1H), 2.85 (dd, *J* = 19.4, 3.1 Hz, 1H), 2.23 (dd, *J* = 19.4, 2.9 Hz, 1H), 1.36 (t, *J* = 7.1 Hz, 3H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 203.4, 160.6, 137.4, 96.9, 74.5, 64.4, 63.5, 61.9, 58.5, 53.5, 40.0, 38.9, 14.4. **HRMS** (ESI^+): m/z Calcd. for $C_{13}H_{21}N_4O_4$ $[M+NH_4]^+$: 361.1359; Found: 361.1350. **IR** (neat) ν = 1714, 1557, 1455, 1417, 1090, 755 cm^{-1}.

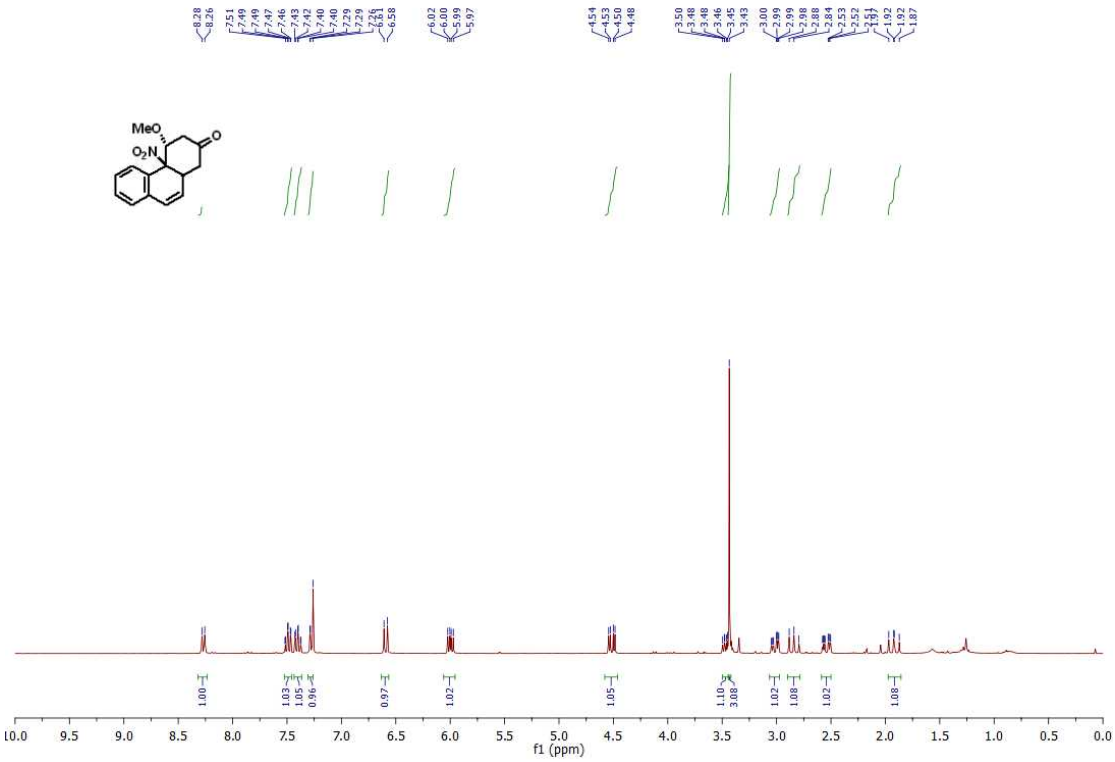
(3a*S, 7*R**, 7a*R**)-7-methoxy-7a-nitro-3a,4,7,7a-tetrahydrobenzofuran-5(4*H*)-one (7c)**

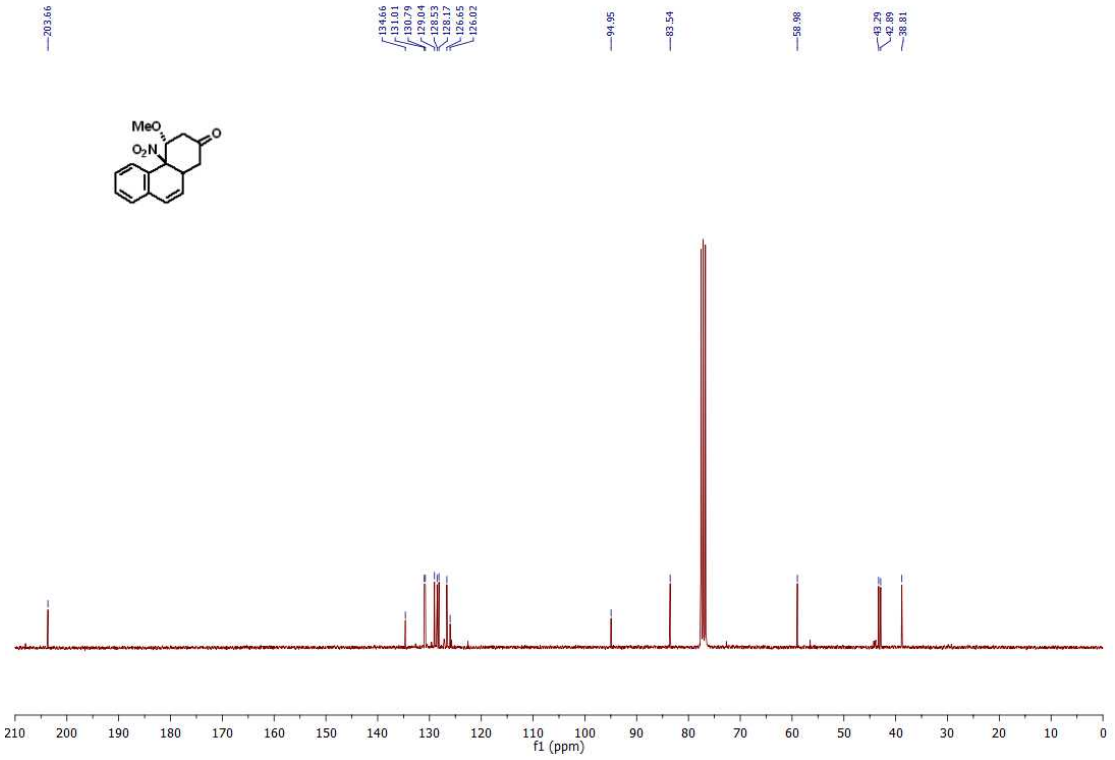
7c Was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 2-nitrofuran (**6c**) (23 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 24 h. After hydrolysis, the residue (*dr* >99:<1) was purified by flash chromatography (Cyclohexane/EtOAc: 70/30) to afford **7c** (38 mg, 90%) as an orange oil. **^{1}H NMR** (300 MHz, $CDCl_3$): δ 6.55 (dd, *J* = 6.3, 1.8 Hz, 1H), 6.37 (dd, *J* = 6.3, 1.5 Hz, 1H), 5.38 (dddd, *J* = 7.5, 1.8, 1.5, 1.5 Hz, 1H), 4.14 (dd, *J* = 8.7, 5.0 Hz, 1H), 3.38 (s, 3H), 3.15 (ddd, *J* = 15.0, 7.5, 0.9 Hz, 1H), 2.91 (ddd, *J* = 11.7, 5.0, 0.9 Hz, 1H), 2.62 (dd, *J* = 15.0, 1.5 Hz, 1H), 2.52 (dd, *J* = 11.7, 8.7 Hz, 1H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 202.4, 136.9, 125.3, 120.9, 83.1, 78.4, 58.5, 49.7, 44.4. **HRMS** (ESI^+): m/z Calcd. for $C_9H_{12}NO_5$ $[M+H]^+$: 214.0715; Found: 214.0713. **IR** (neat) ν =1706, 1553, 1371, 1092, 1005, 803 cm^{-1}.

1-Tosyl-1*H*-indol-6-ol (8)

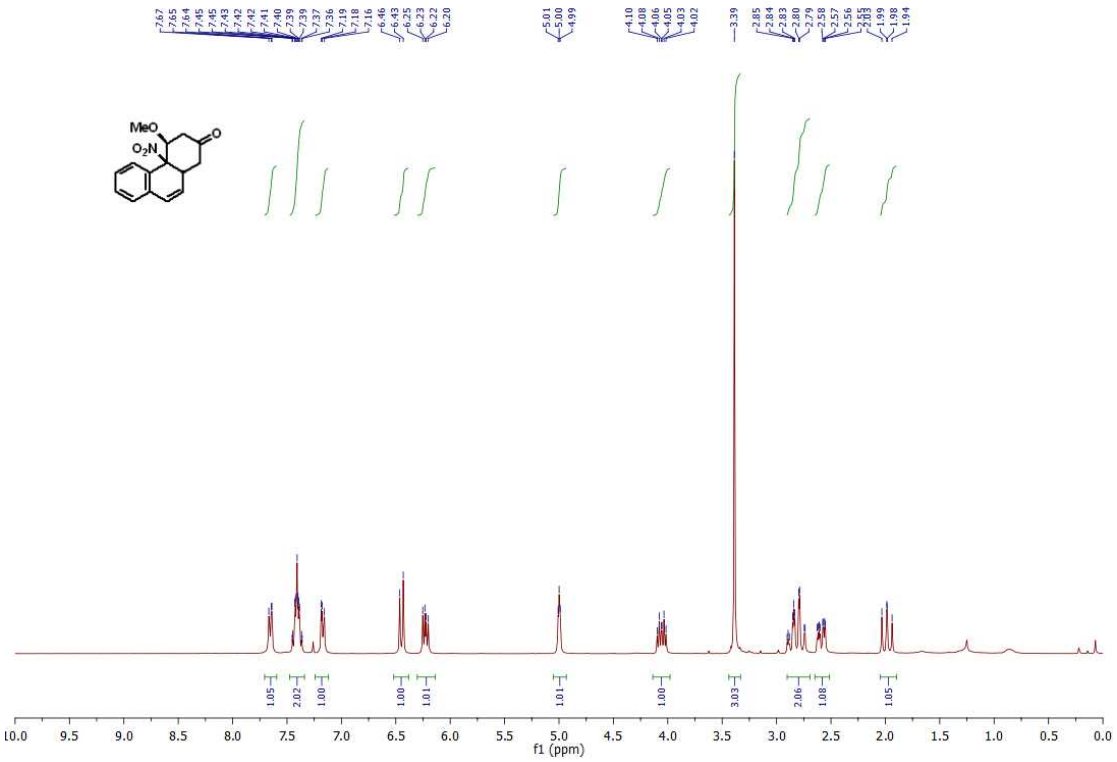
8 was prepared according to the general procedure using **1a** (230 µL, 1.2 mmol) and 3-nitropyrrole **6d** (23 mg, 0.2 mmol) in 0.9 mL dry CH_2Cl_2. The reaction mixture was compressed at 16 kbar, room temperature, for 72h. After hydrolysis, the residue was purified by flash chromatography (Cyclohexane/EtOAc: 80/20) to afford **8** (45 mg, 79%) as a white solid. (mp 114 °C). **^{1}H NMR** (300 MHz, $CDCl_3$): δ 7.73 (d, *J* = 8.4 Hz, 2H), 7.51 (d, *J* = 2.3 Hz, 1H), 7.43 (d, *J* = 3.7 Hz, 1H), 7.35 (d, *J* = 8.5, 1H), 7.18 (d, *J* = 8.4 Hz, 2H), 6.79 (dd, *J* = 8.5, 2.3 Hz, 1H), 6.56 (d, *J* = 3.7 Hz, 1H), 5.23 (bs, 1H), 2.32 (s, 3H). **^{13}C{^{1}H} NMR** (75 MHz, $CDCl_3$): δ 153.8, 145.1, 135.9, 135.3, 130.0 (2C), 126.9 (2C), 125.3, 124.8, 122.2, 112.9, 109.2, 100.4, 21.7. **HRMS** (ESI^-): m/z Calcd. for $C_{15}H_{12}NO_3S$ $[M-H]^-$: 286.0538; Found: 286.0532. **IR** (neat) ν = 1614, 1361, 1200, 1167, 1115, 671 cm^{-1}.

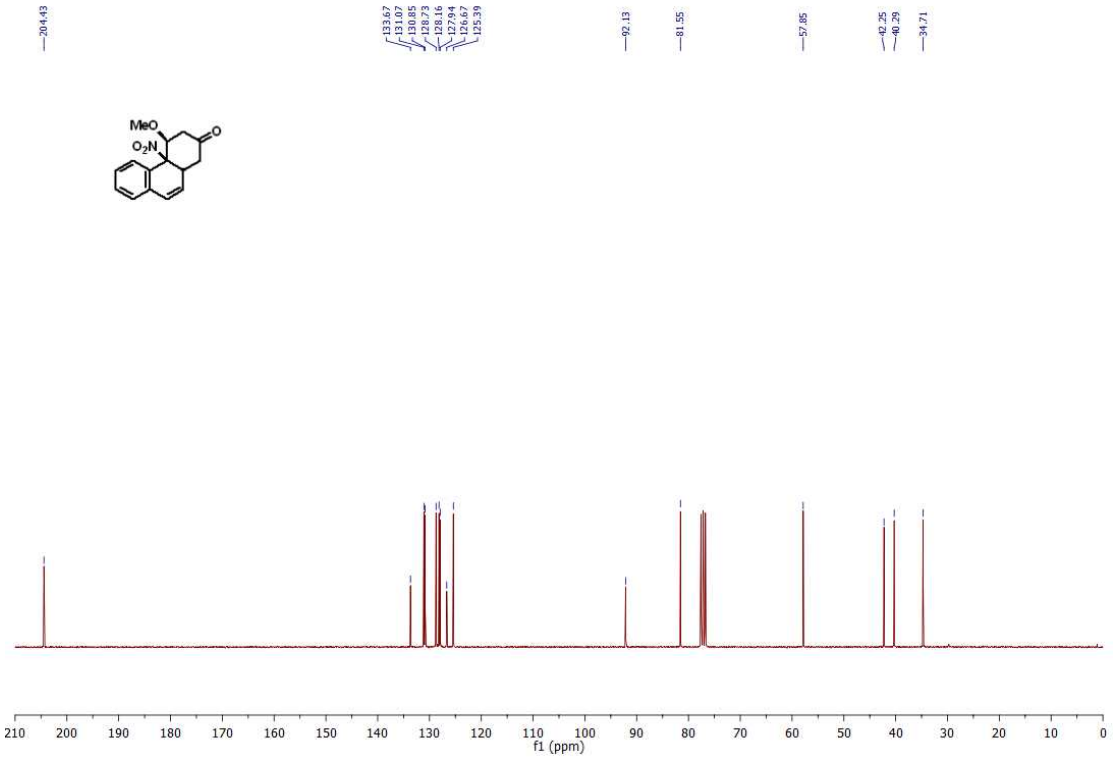
NMR spectra
3a (first diastereomer)



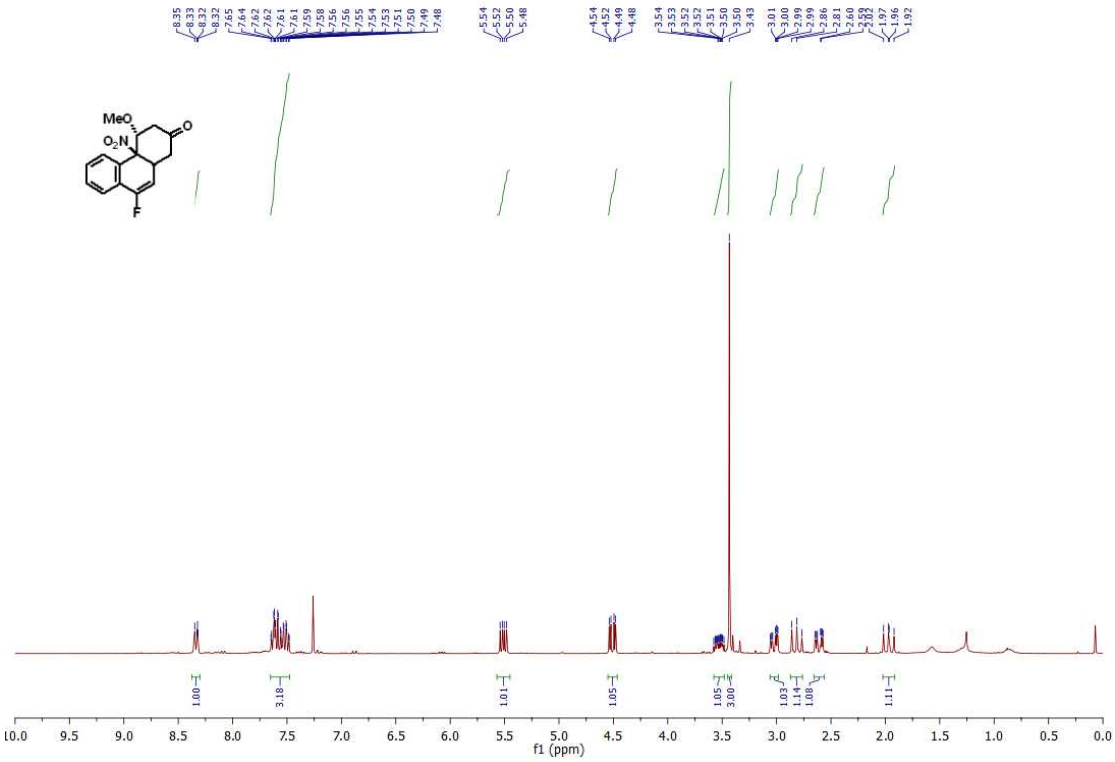


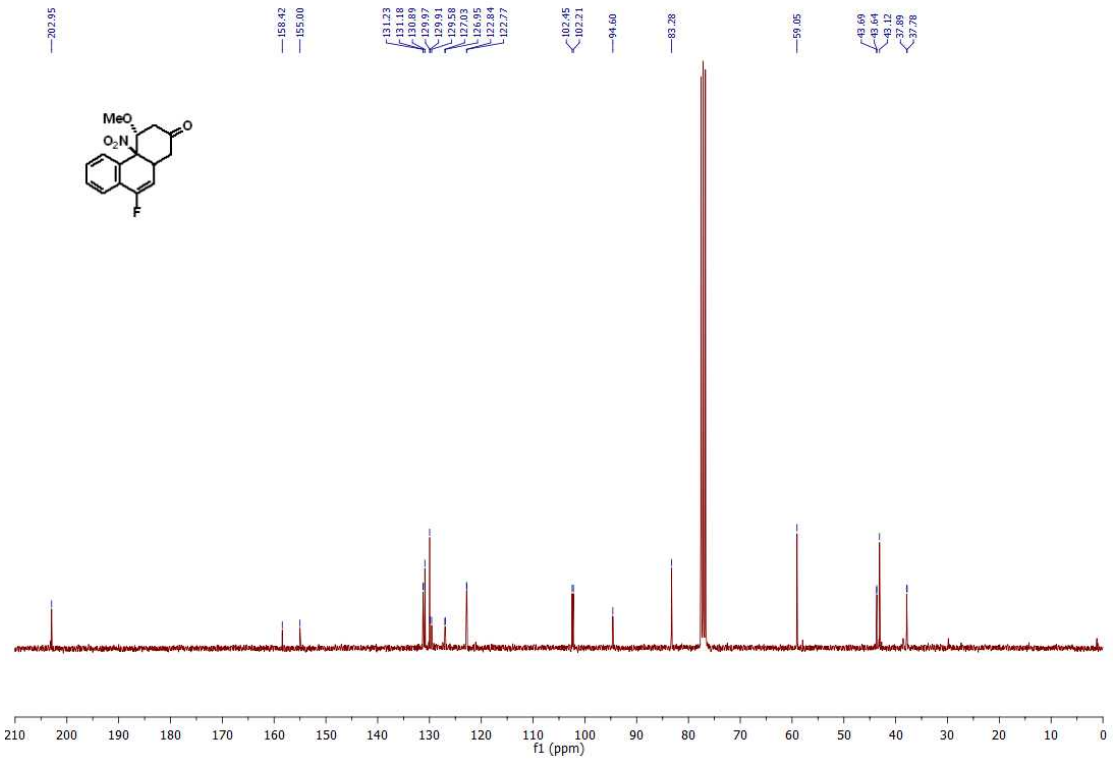
3a (second diastereomer)

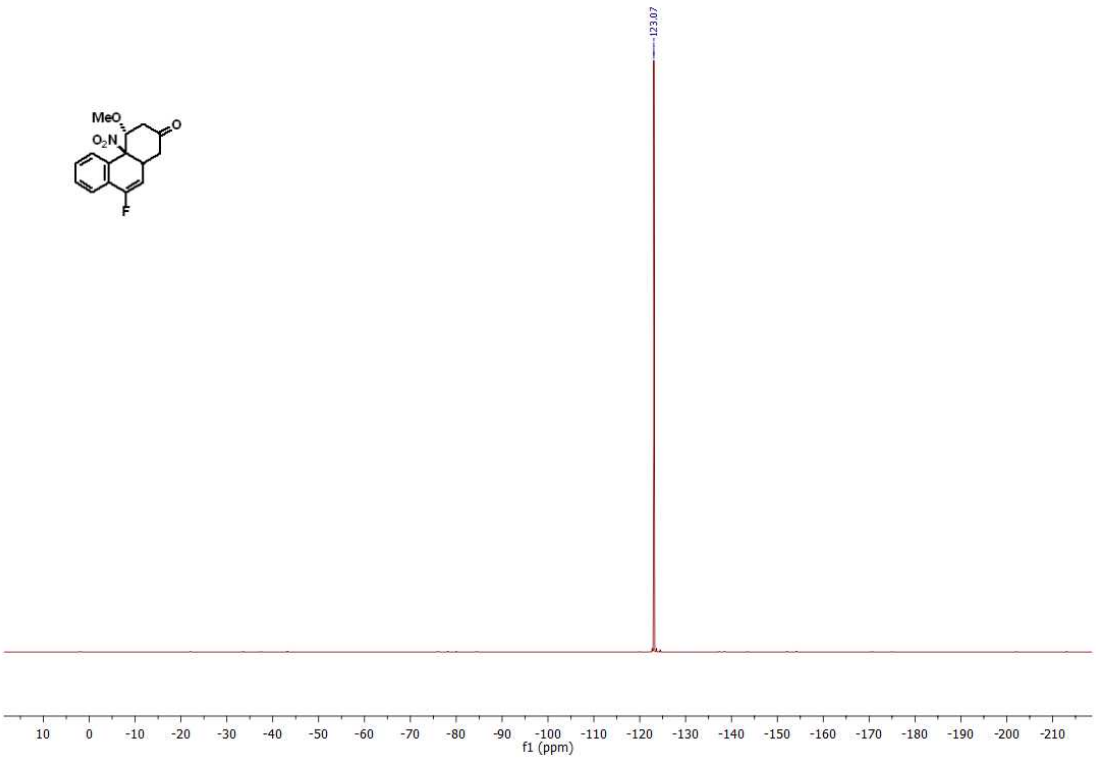




3b (major diastereomer)



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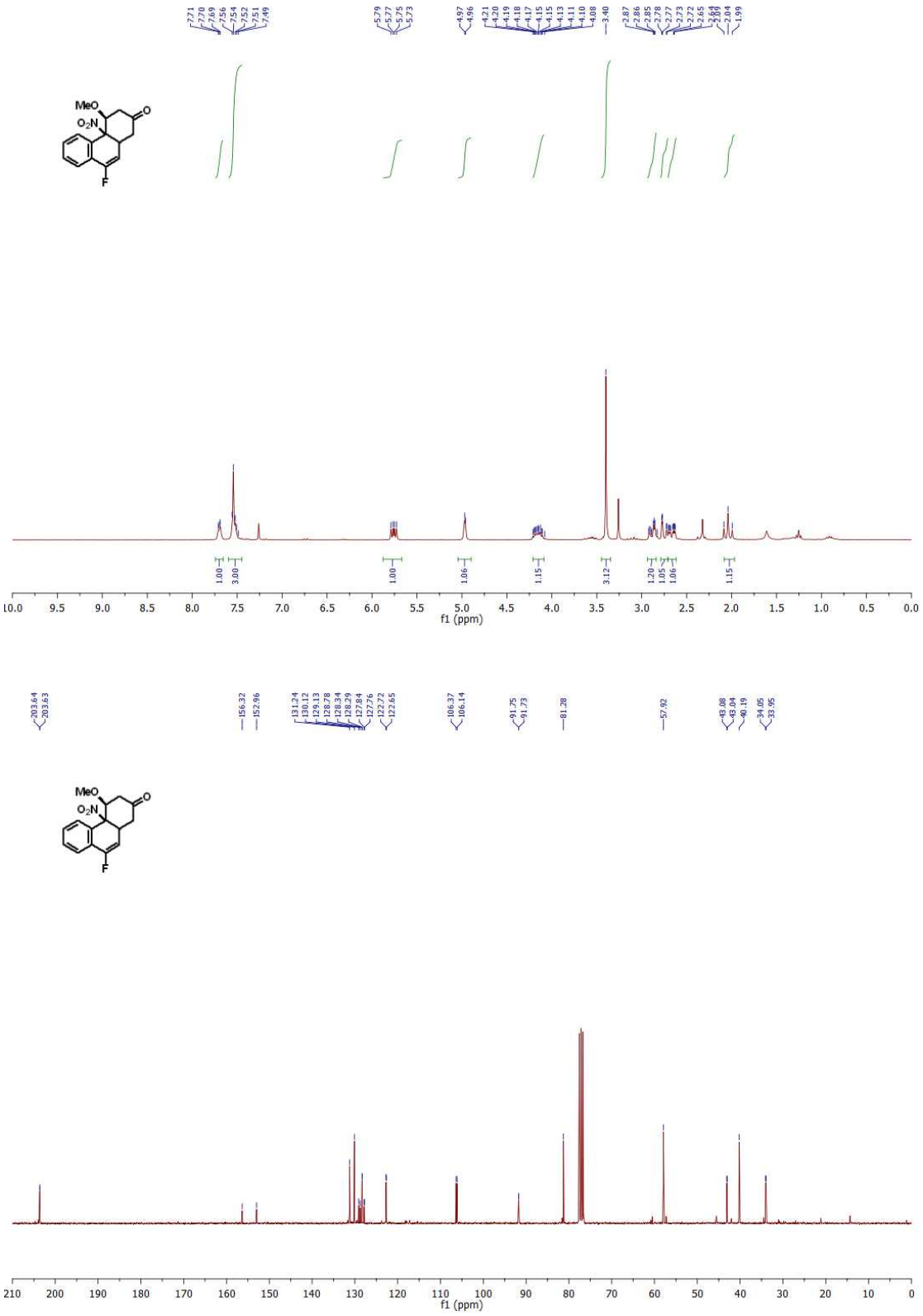
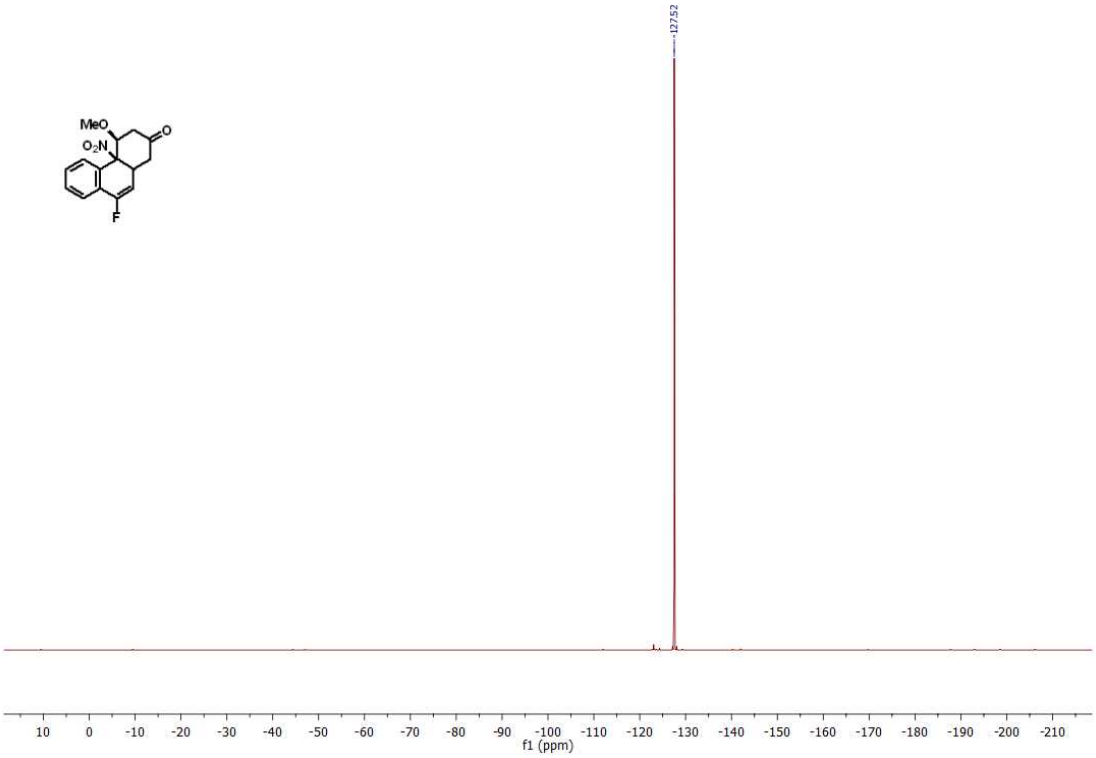
O2N
O
F
-123.07
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

3b (minor diastereomer)

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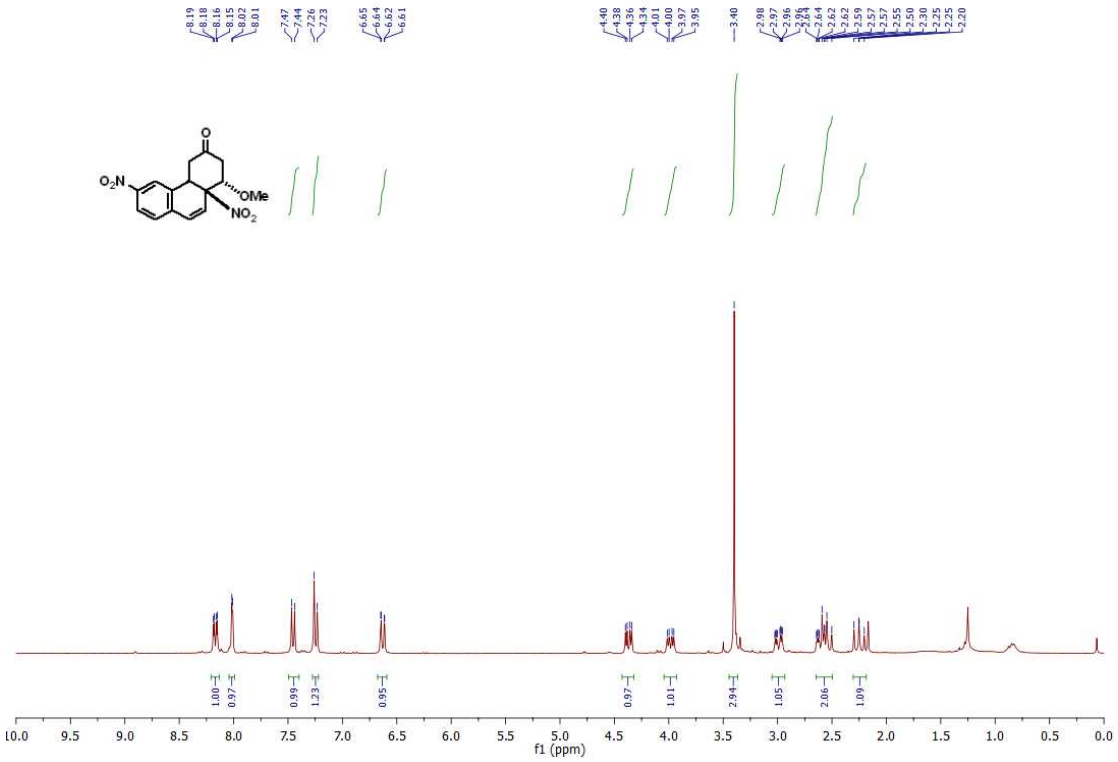
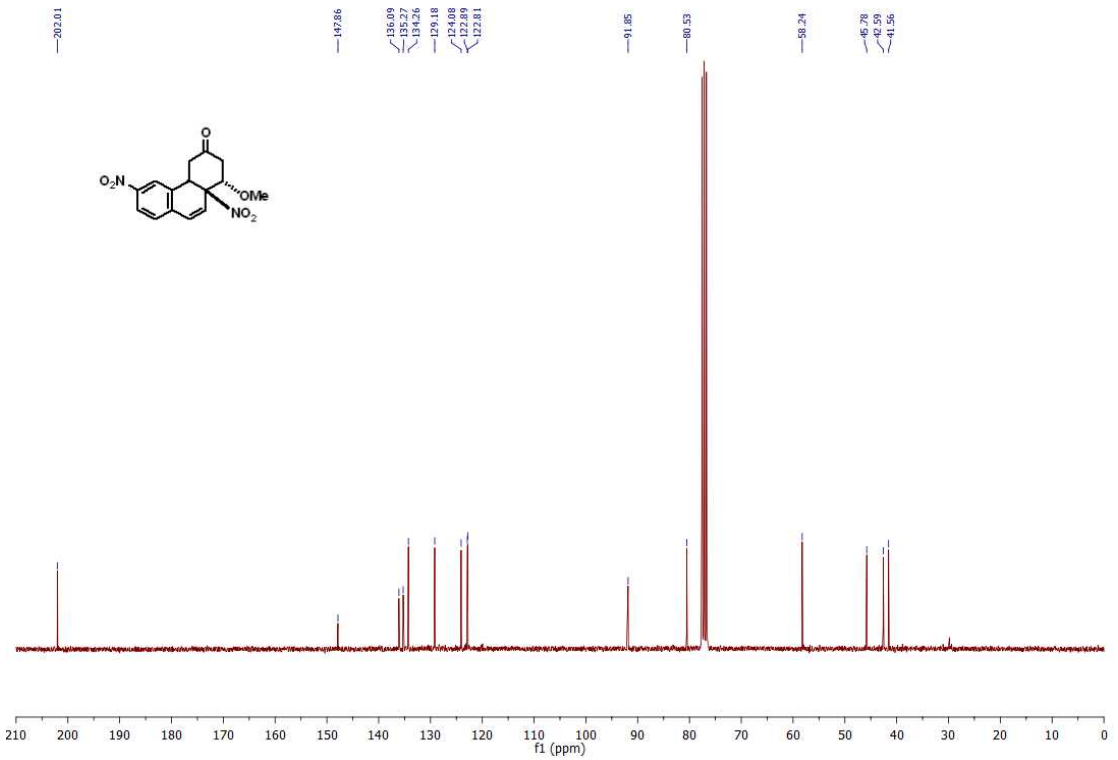
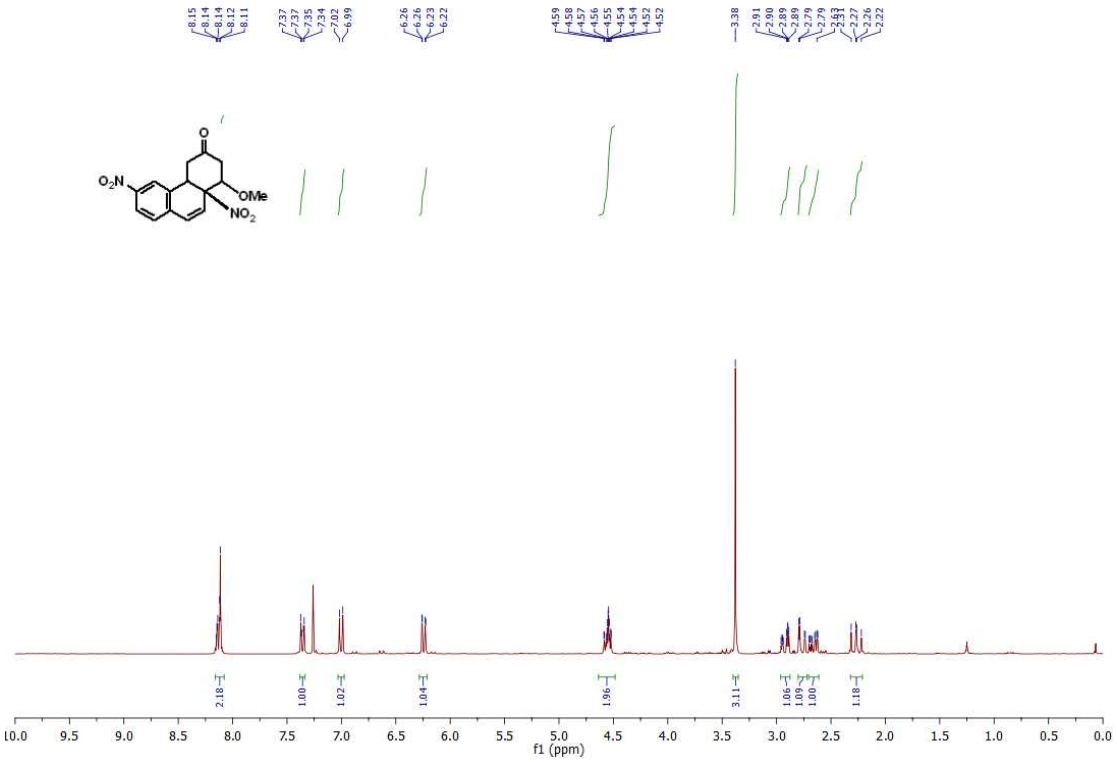
O2N
O
F
-127.52
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

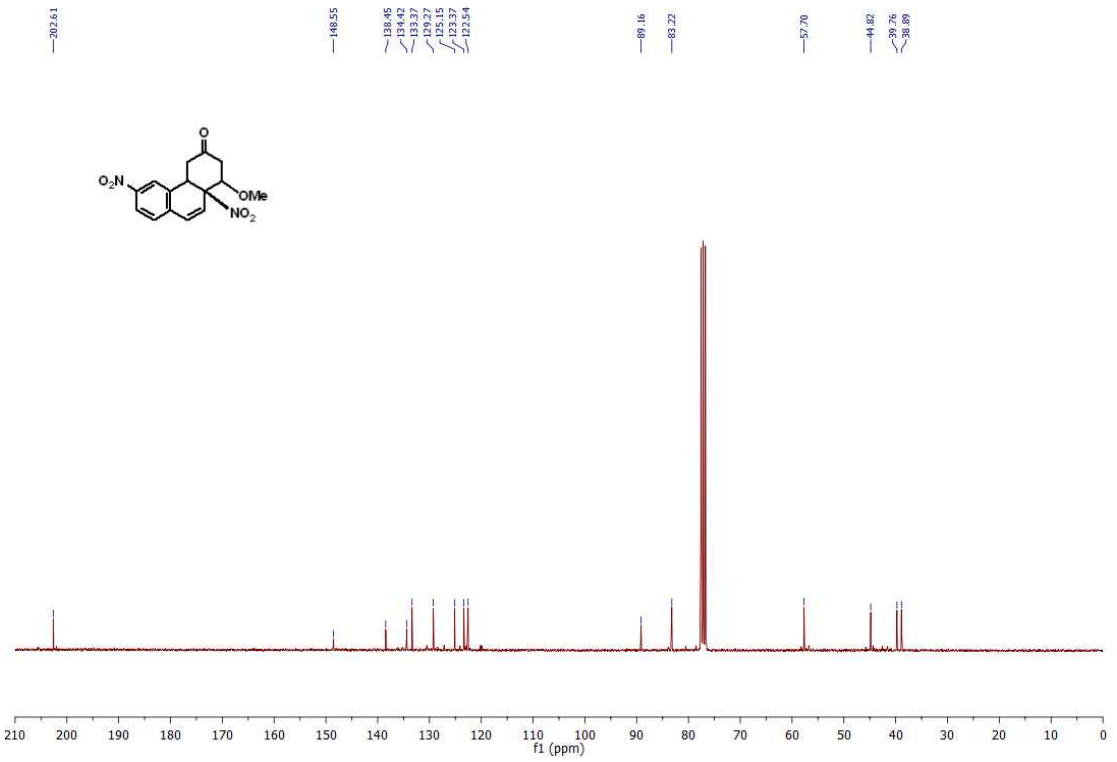
3c (first diastereomer)



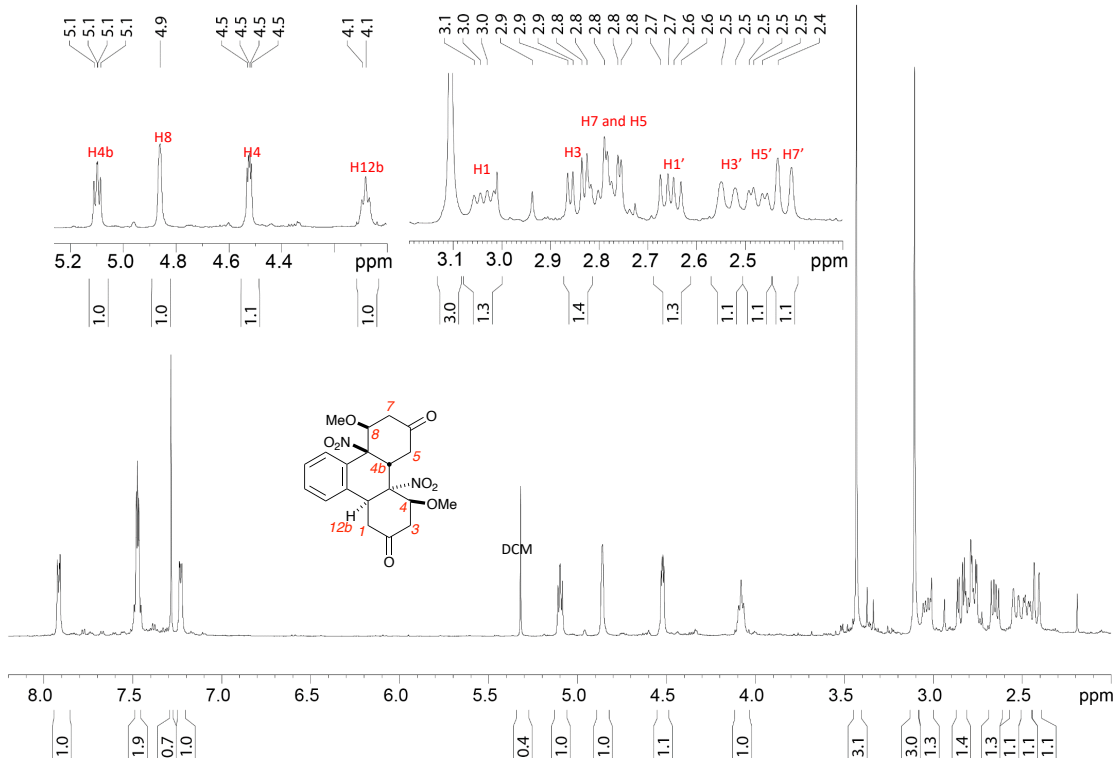


3c (second diastereomer)

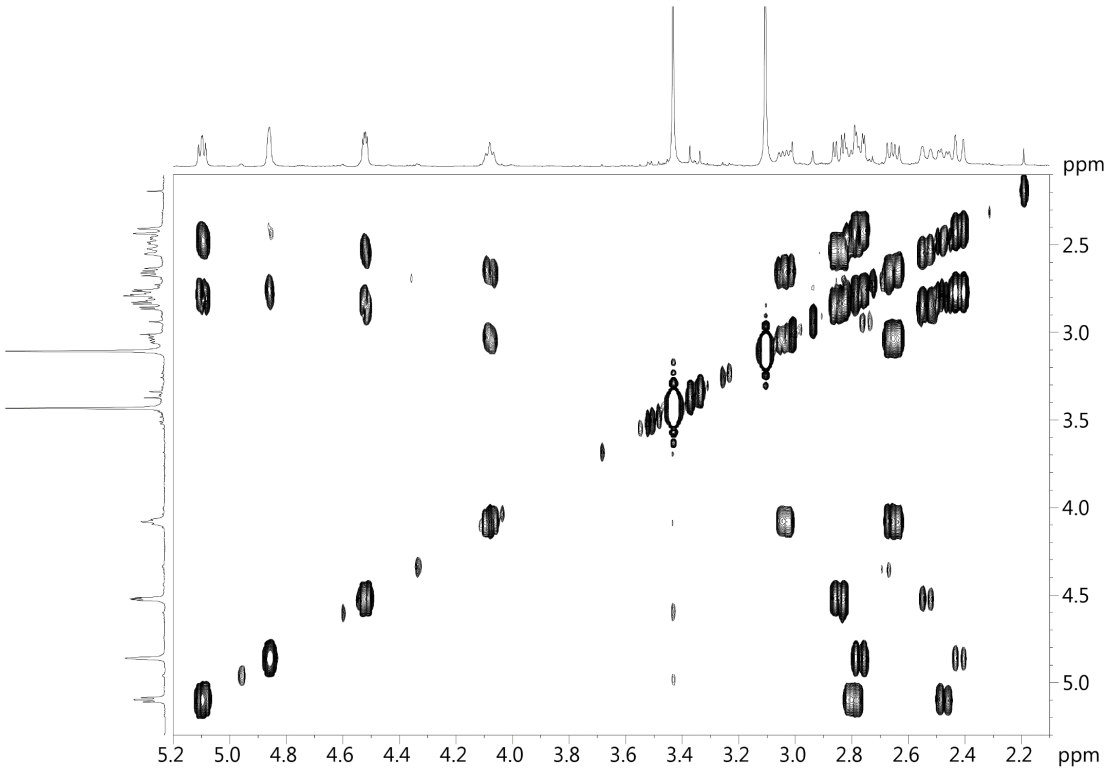




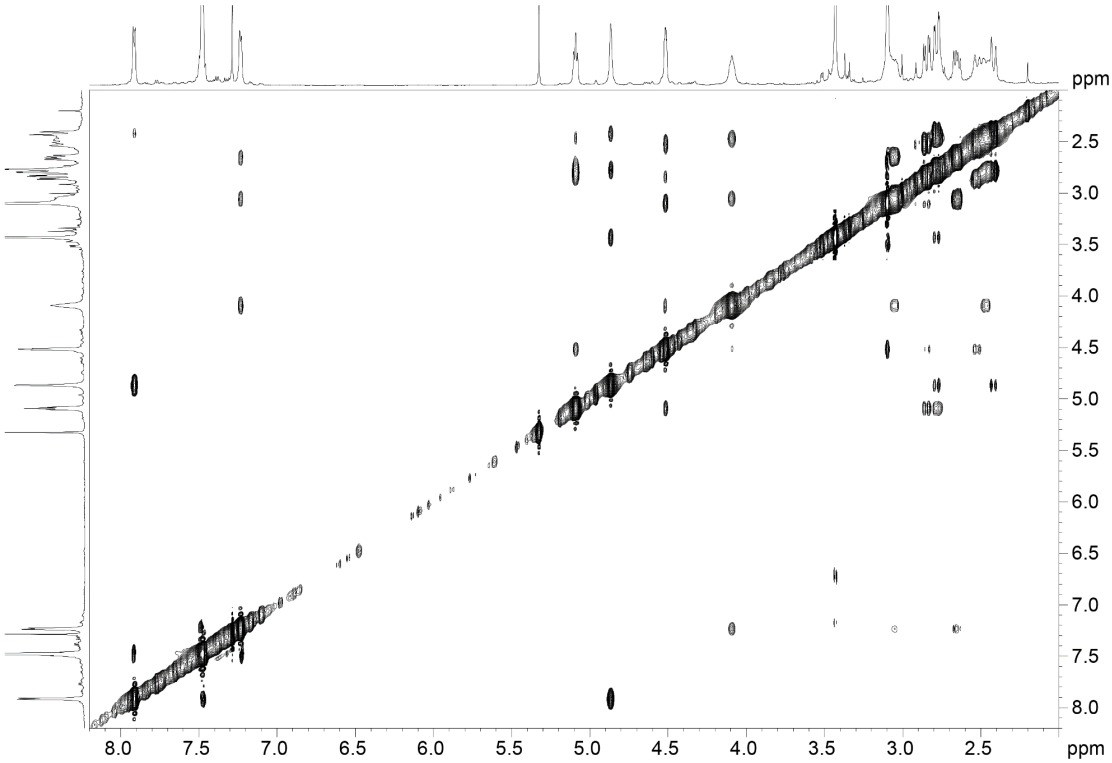
3d (F1: major diastereomer)



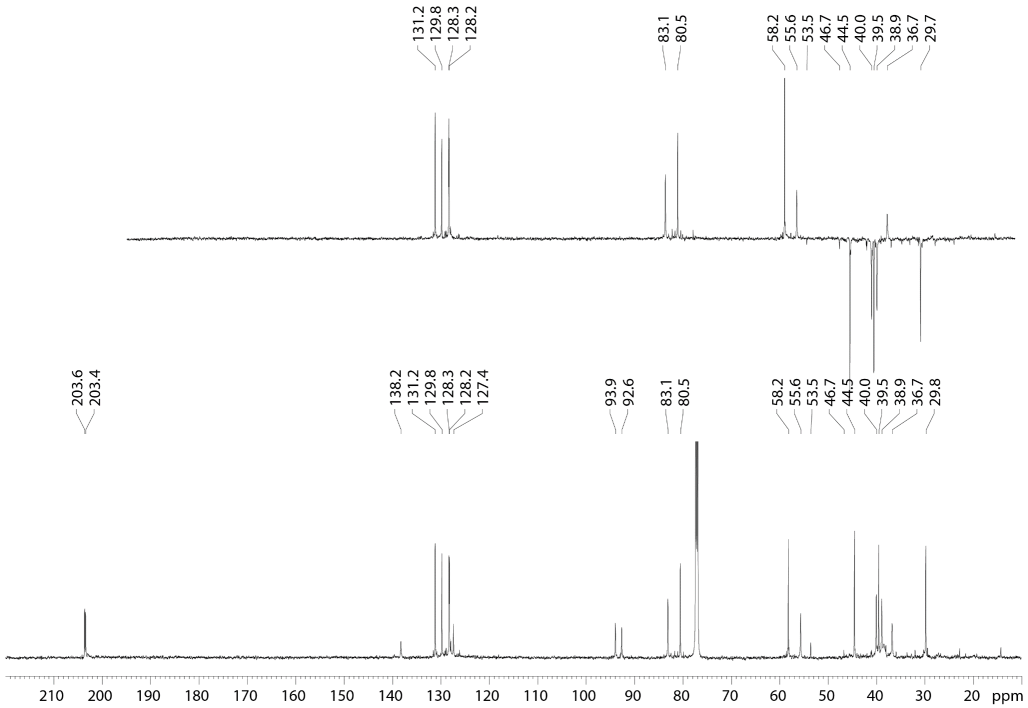
^{1}H NMR spectrum of F1 ($CDCl_3$, 600 MHz, 300K)



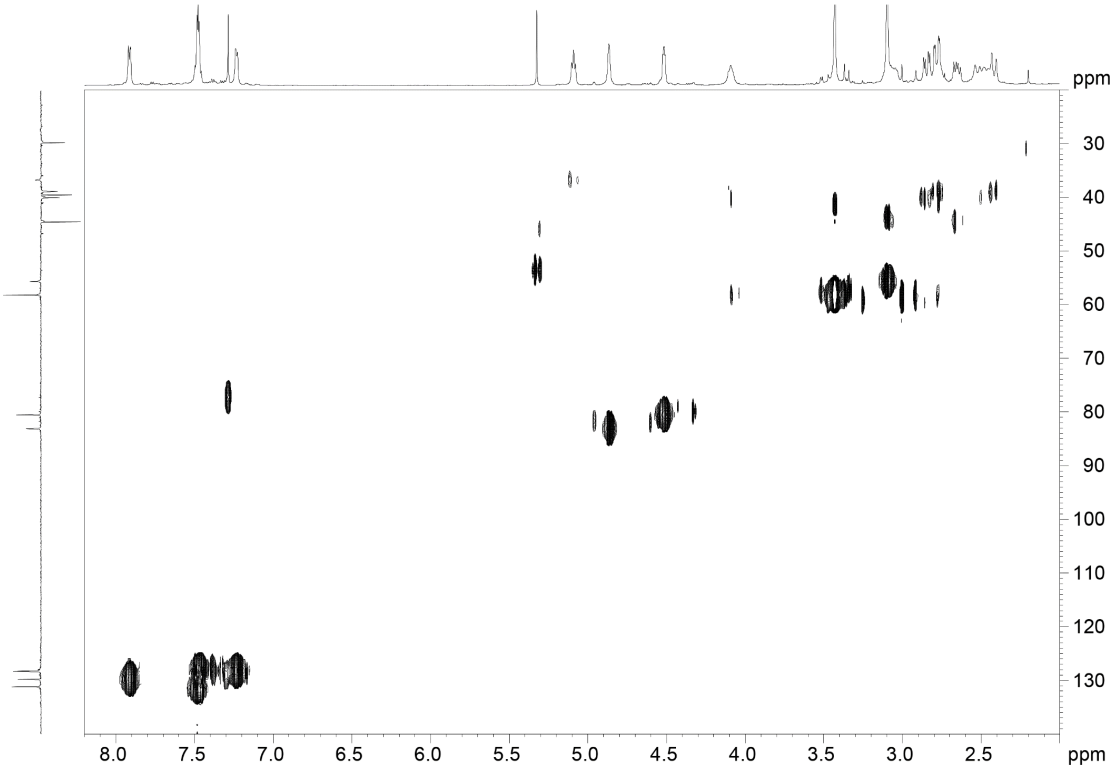
2D NMR ^{1}H-^{1}H COSY spectrum of F1 ($CDCl_3$, 600 MHz, 300K)



2D NMR ^{1}H- ^{1}H NOESY spectrum of F1 ($CDCl_3$, 600 MHz, 300K, mixing time 0.5 s)

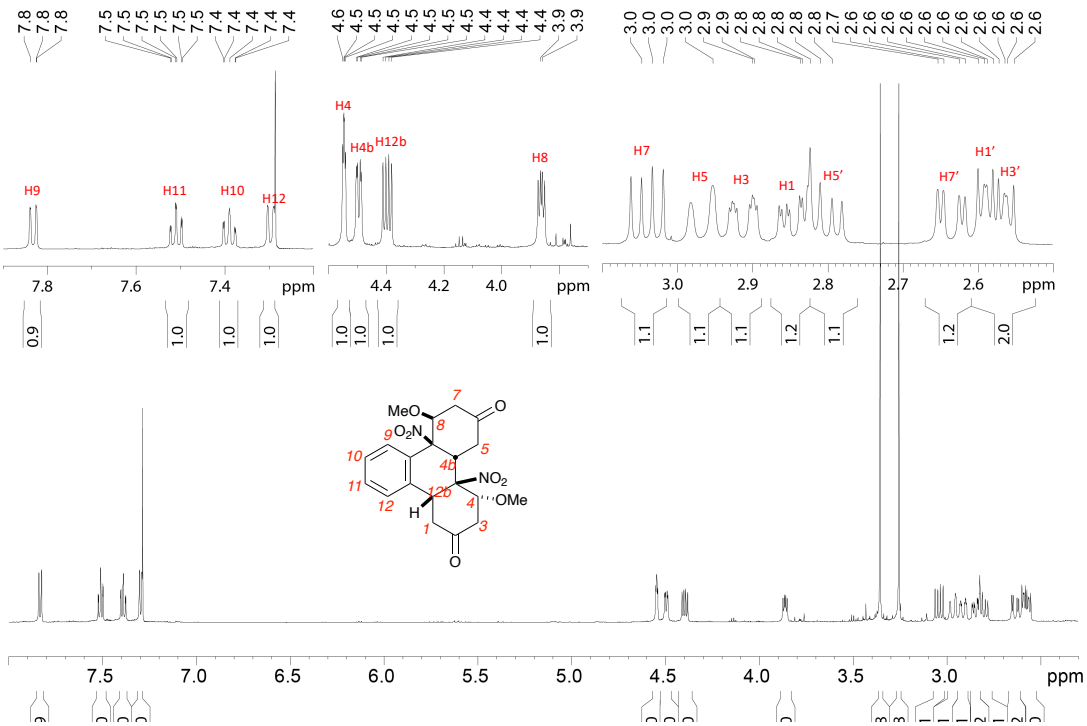


1D ^{13}C{^{1}H} NMR and Dept135 NMR spectra of F1 ($CDCl_3$, 150 MHz, 300K)

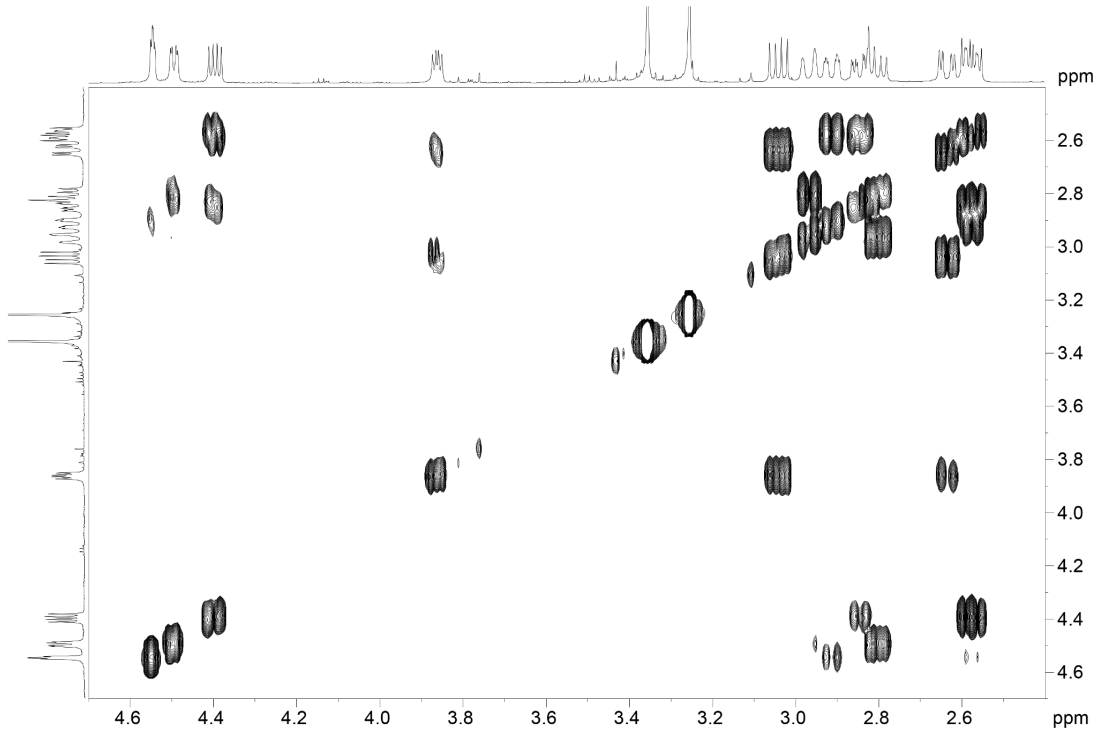


2D ^{1}H-^{13}C HSQC NMR spectrum of F1 ($CDCl_3$, 600 MHz, 300K)

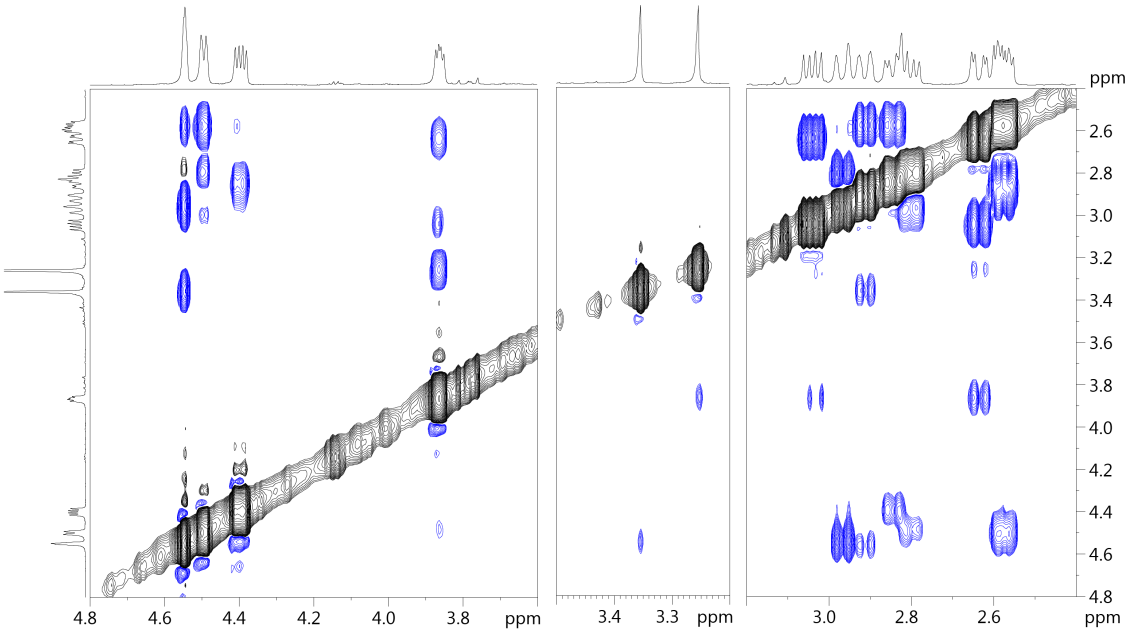
3d (F2: second major diastereomer)



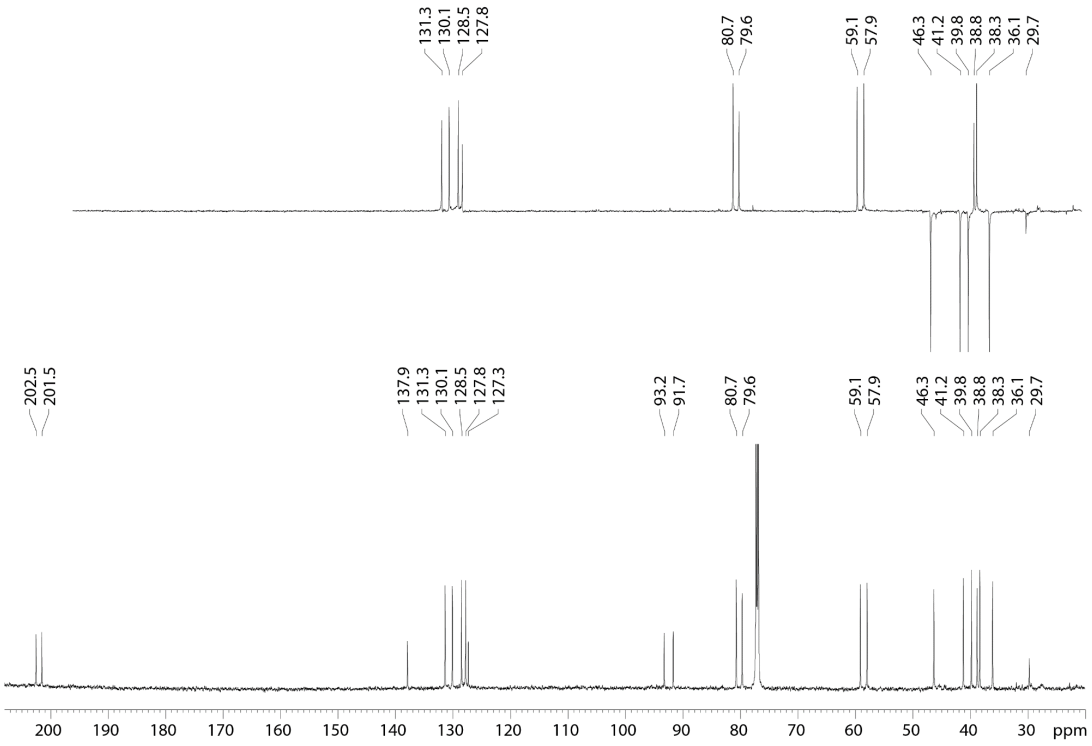
1D ^{1}H NMR spectrum of F2 ($CDCl_3$, 600 MHz, 300K)



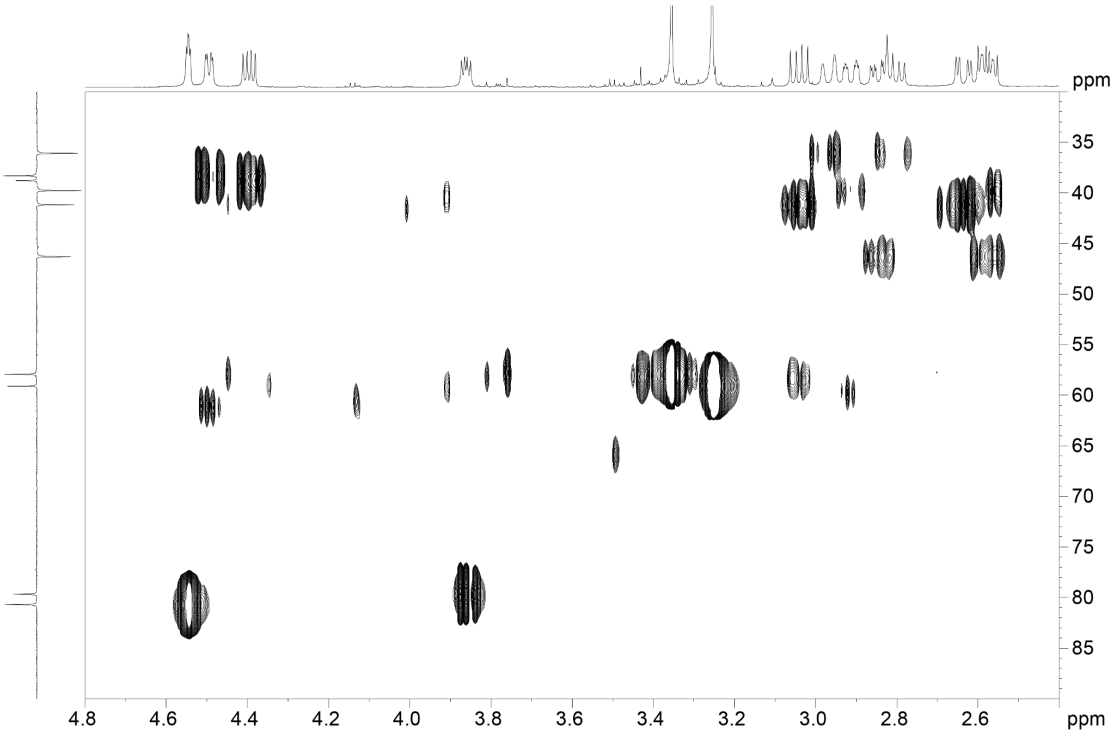
2D NMR ^{1}H-^{1}H COSY spectrum of F2 ($CDCl_3$, 600 MHz, 300K)



2D NMR ^{1}H-^{1}H NOESY spectrum of F2 ($CDCl_3$, 600 MHz, 300K, mixing time 0.5 s)

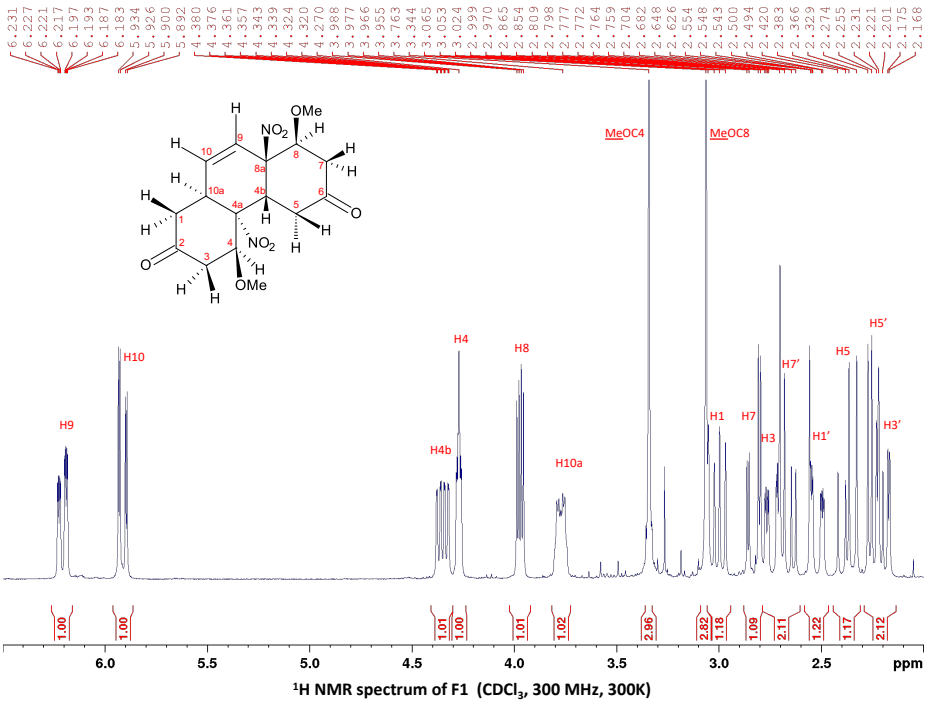


1D ^{13}C {^{1}H} and Dept135 NMR spectra of F2 ($CDCl_3$, 150 MHz, 300K)

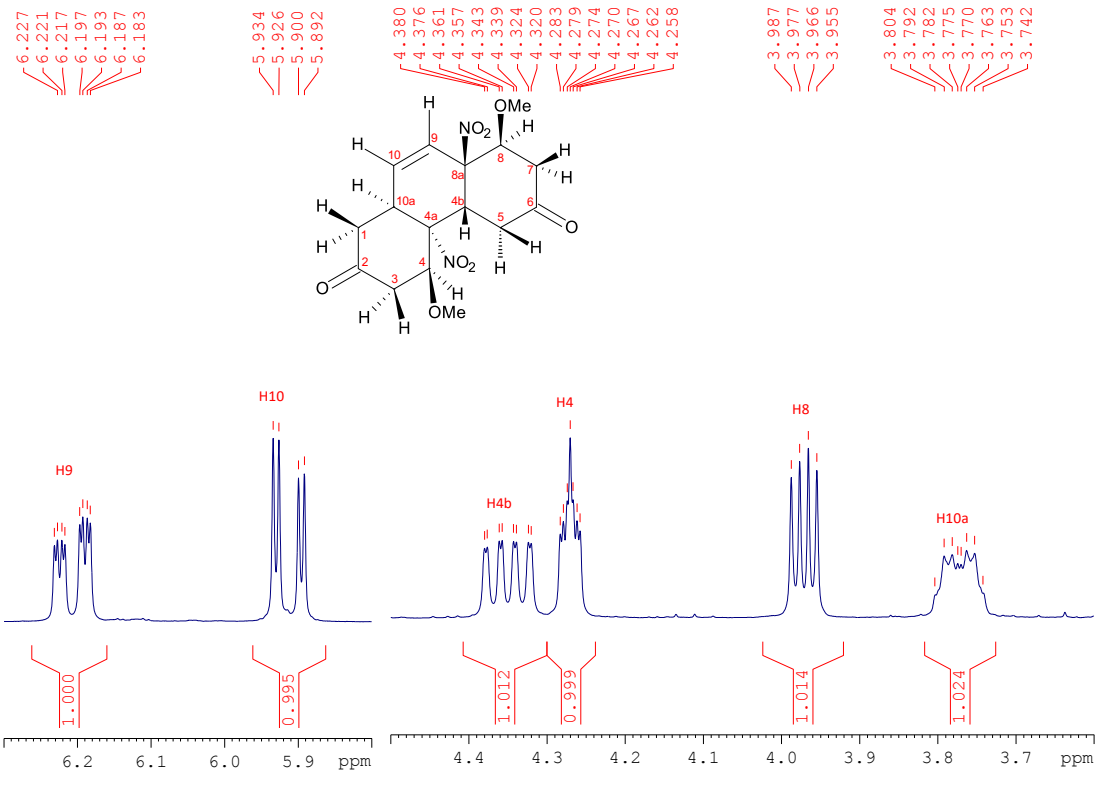


2D ^{1}H-^{13}C HSQC NMR spectrum of F2 ($CDCl_3$, 600 MHz, 300K)

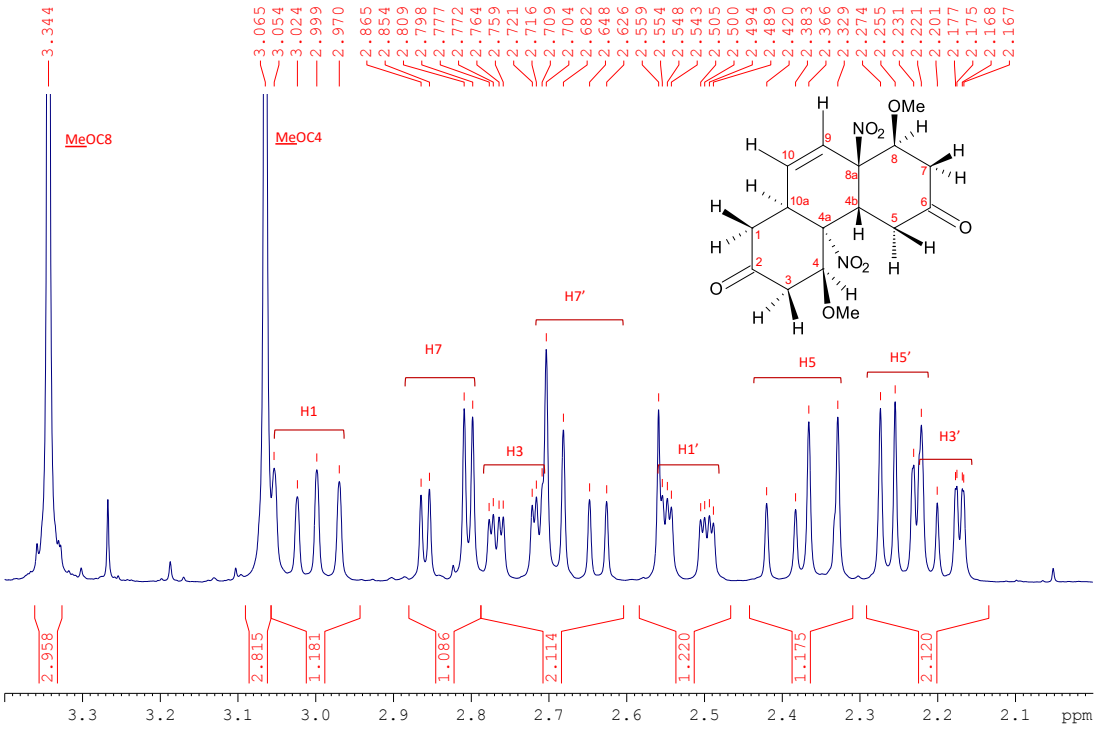
3e (F1: major diastereomer)



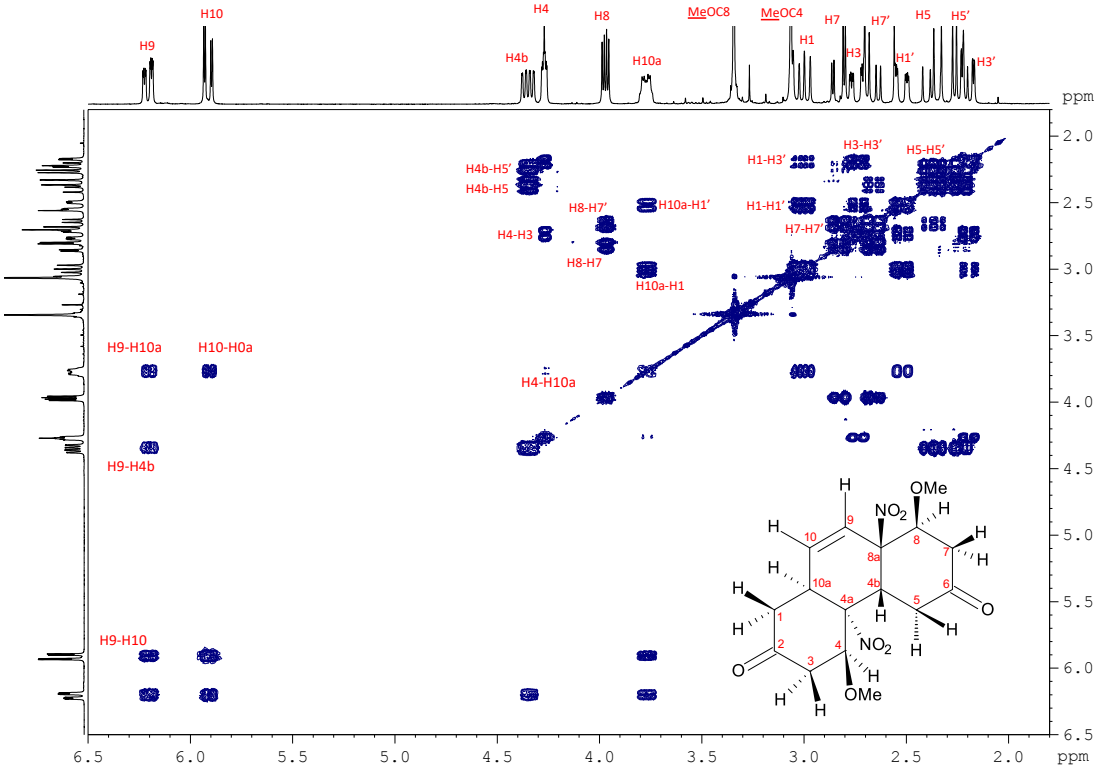
^{1}H NMR spectrum of F1 (CDCl$_3$, 300 MHz, 300K)



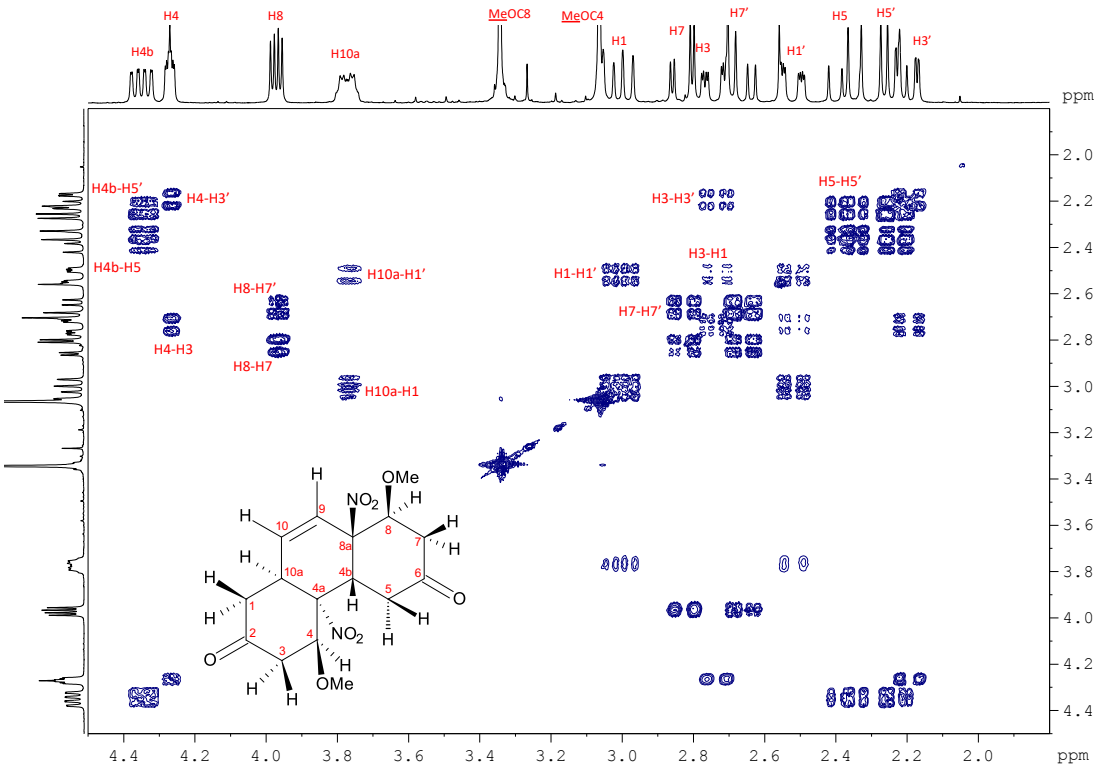
^{1}H NMR spectrum of F1 (CDCl$_3$, 300 MHz, 300K) – expansion 1



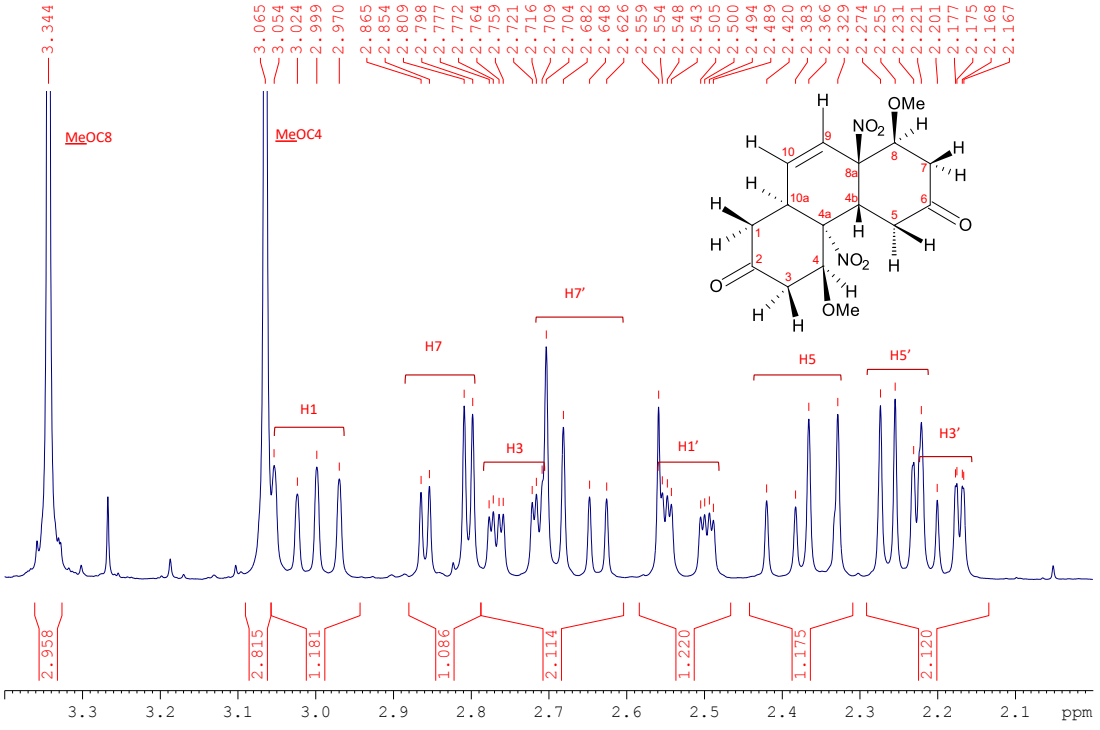
^{1}H NMR spectrum of F1 ($CDCl_3$, 300 MHz, 300K) – expansion 2



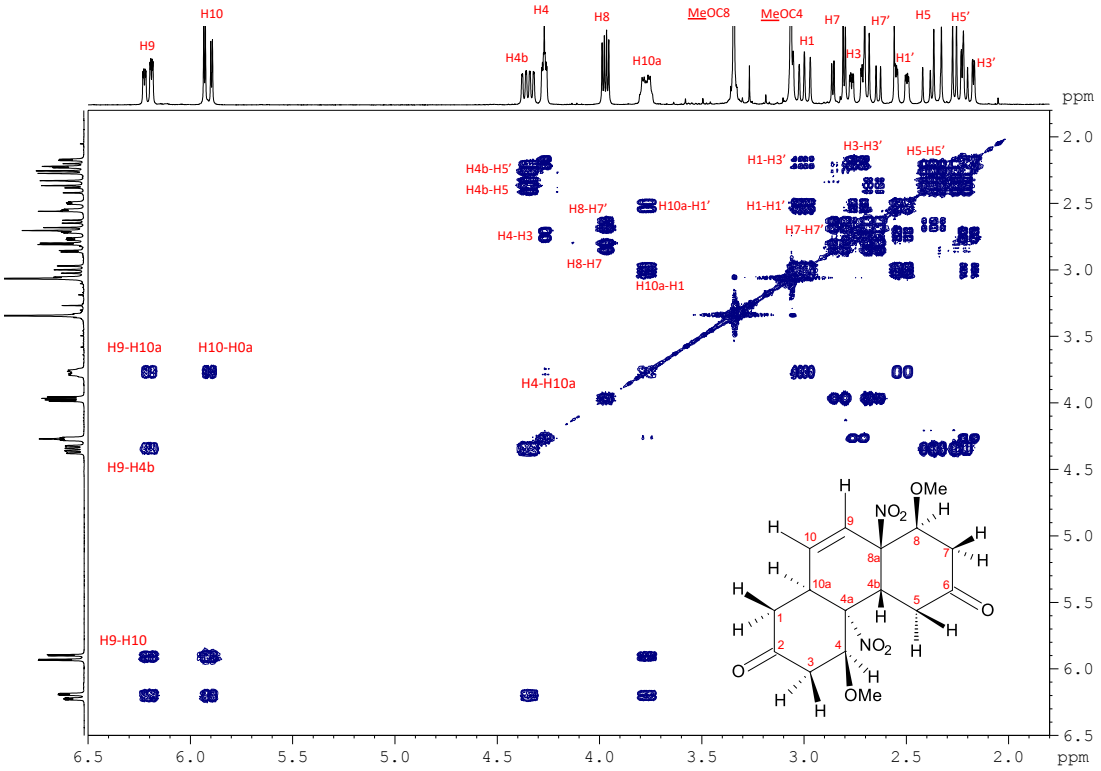
2D NMR ^{1}H-^{1}H COSY spectrum of F1 ($CDCl_3$, 300 MHz, 300K)



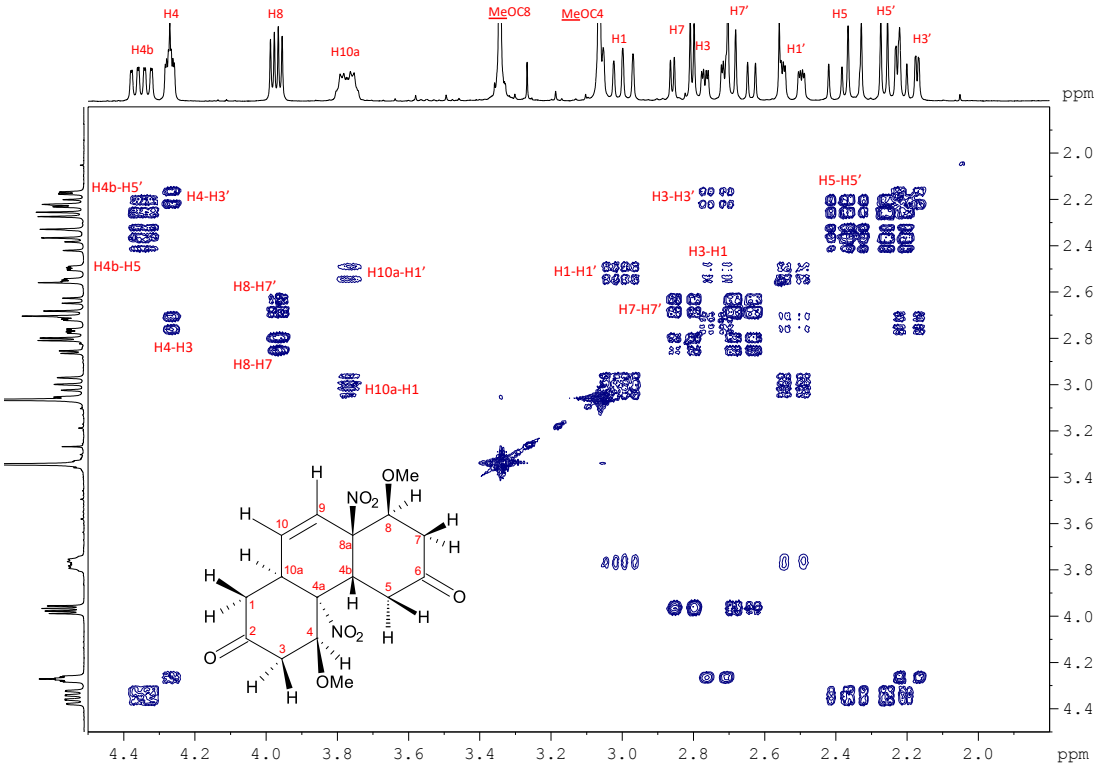
2D NMR ^{1}H-^{1}H COSY spectrum of F1 ($CDCl_3$, 300 MHz, 300K) - expansion



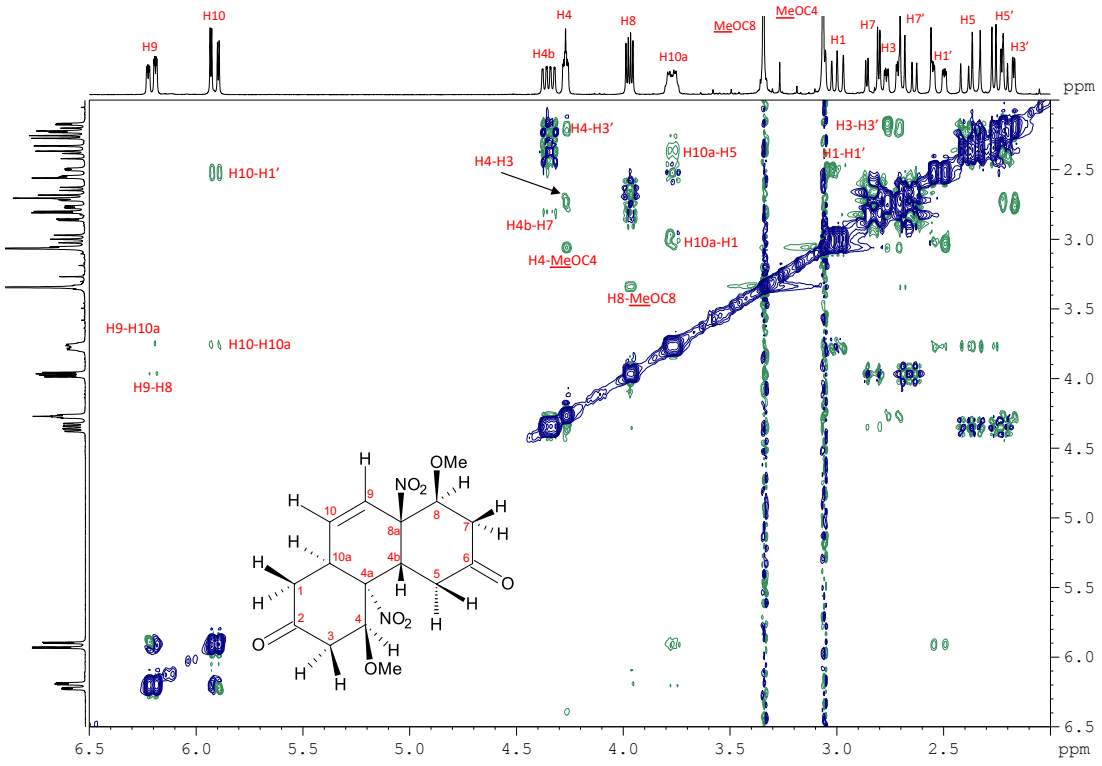
^{1}H NMR spectrum of F1 ($CDCl_3$, 300 MHz, 300K) – expansion 2



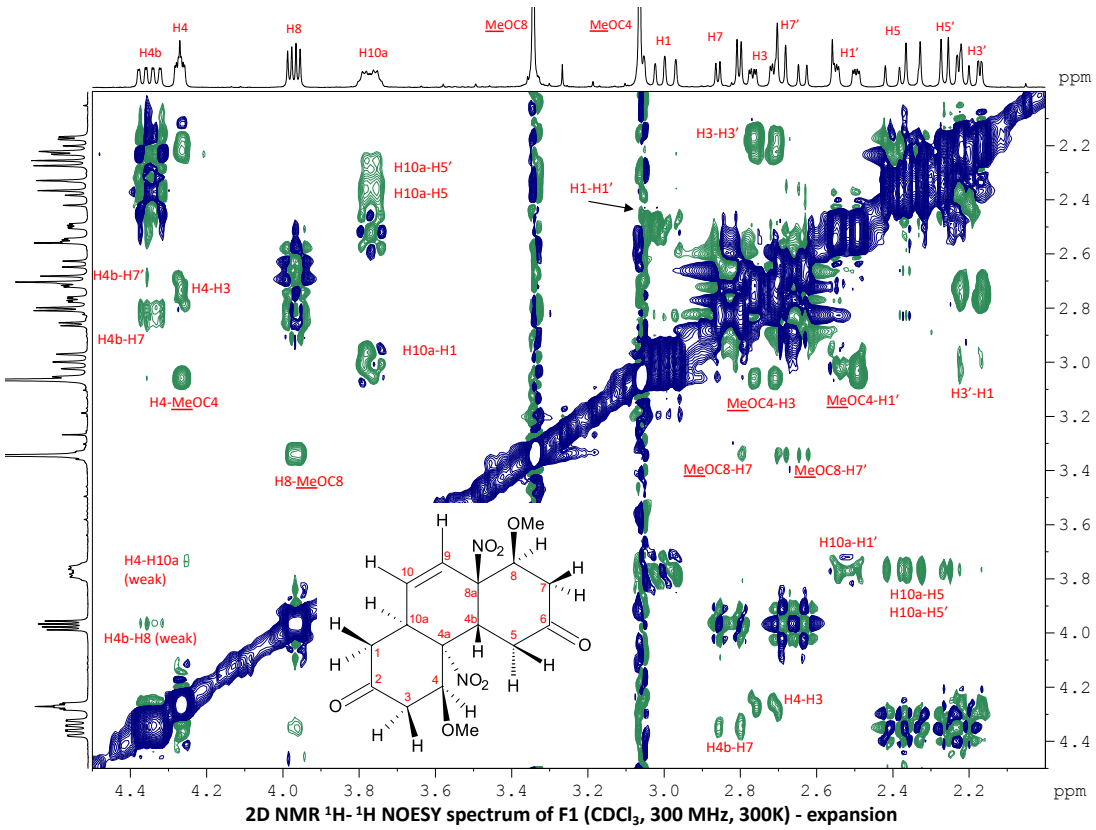
2D NMR ^{1}H-^{1}H COSY spectrum of F1 ($CDCl_3$, 300 MHz, 300K)



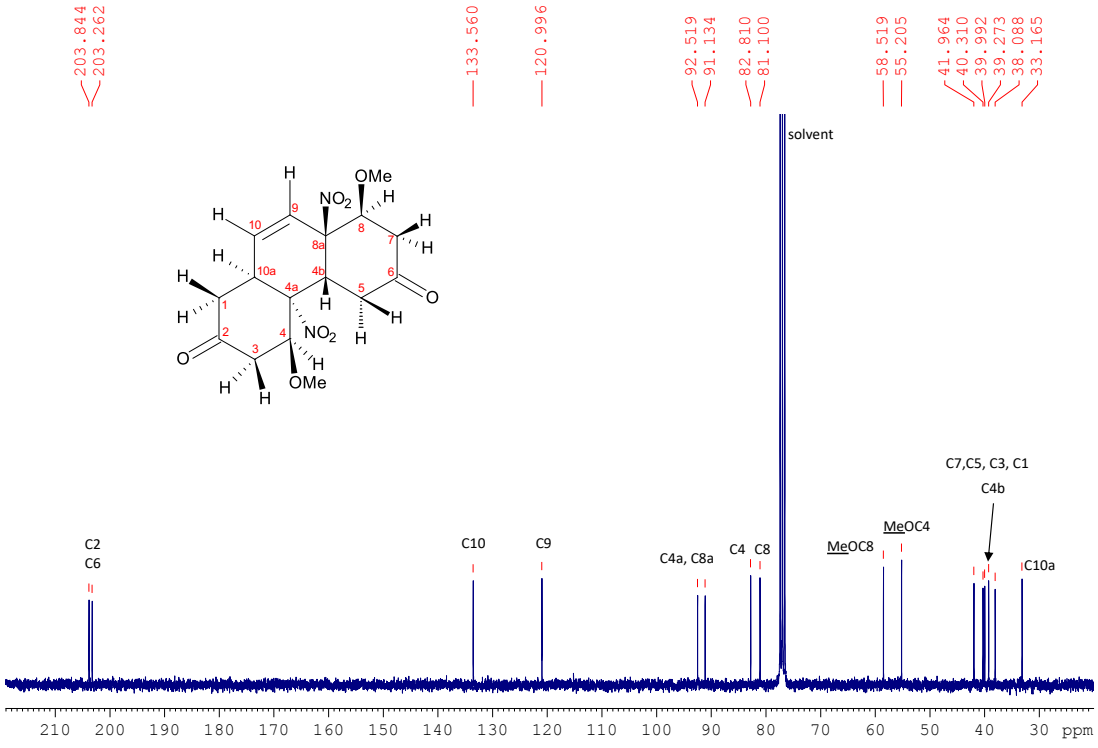
2D NMR ^{1}H-^{1}H COSY spectrum of F1 ($CDCl_3$, 300 MHz, 300K) - expansion



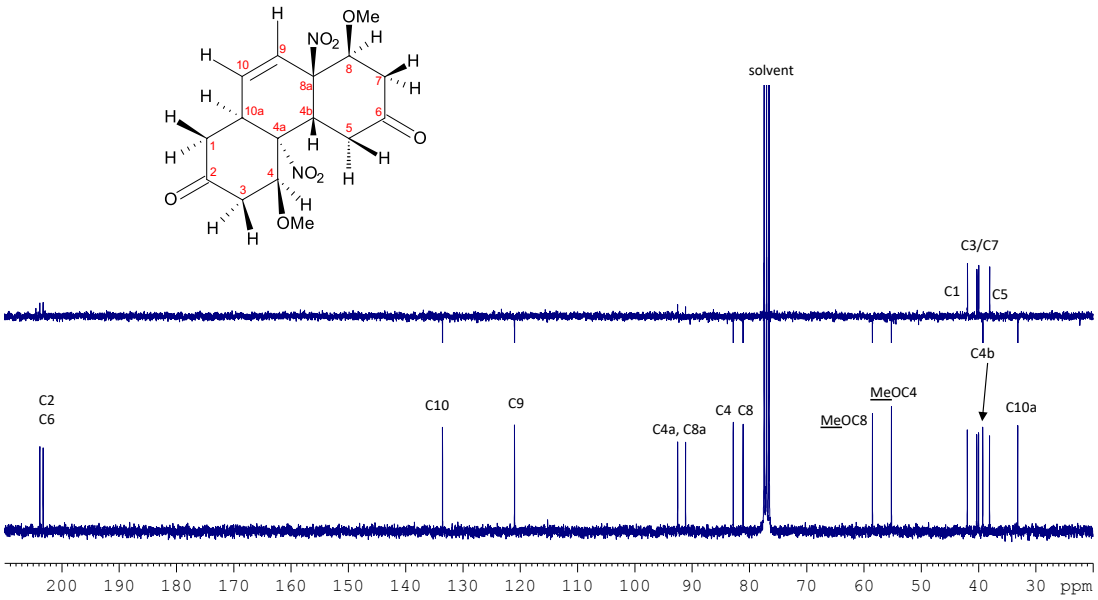
2D NMR ^{1}H-^{1}H NOESY spectrum of F1 ($CDCl_3$, 300 MHz, 300K)



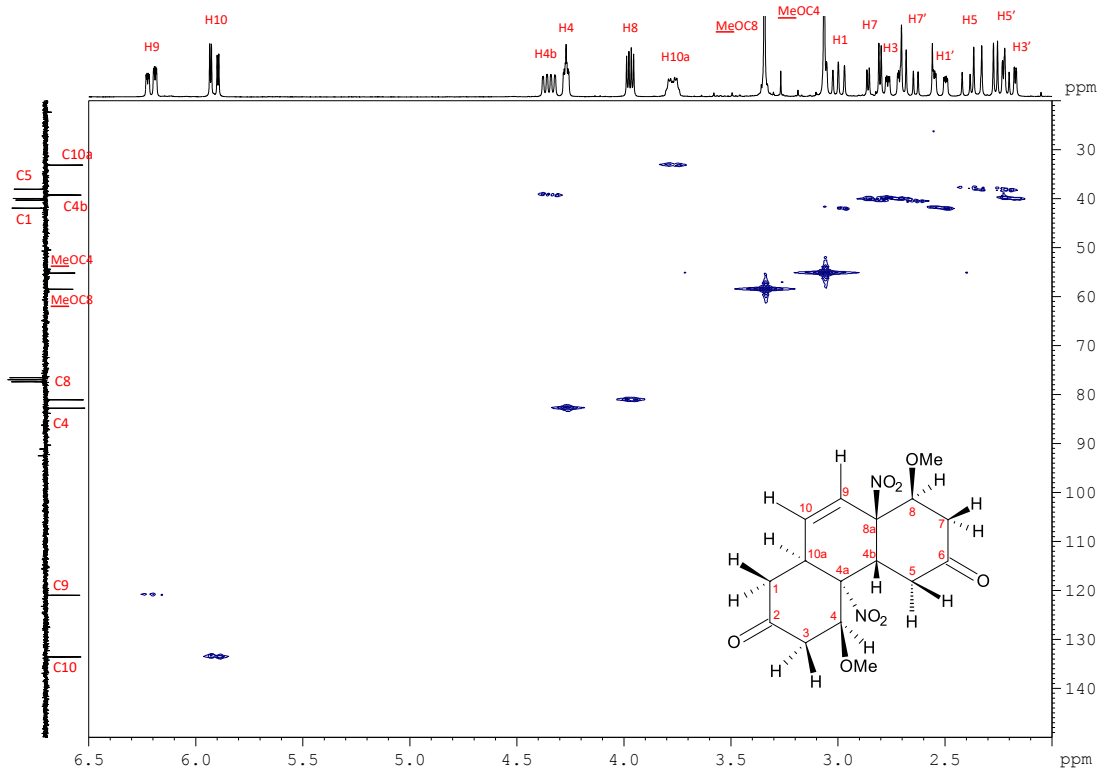
2D NMR ^{1}H-^{1}H NOESY spectrum of F1 ($CDCl_3$, 300 MHz, 300K) - expansion



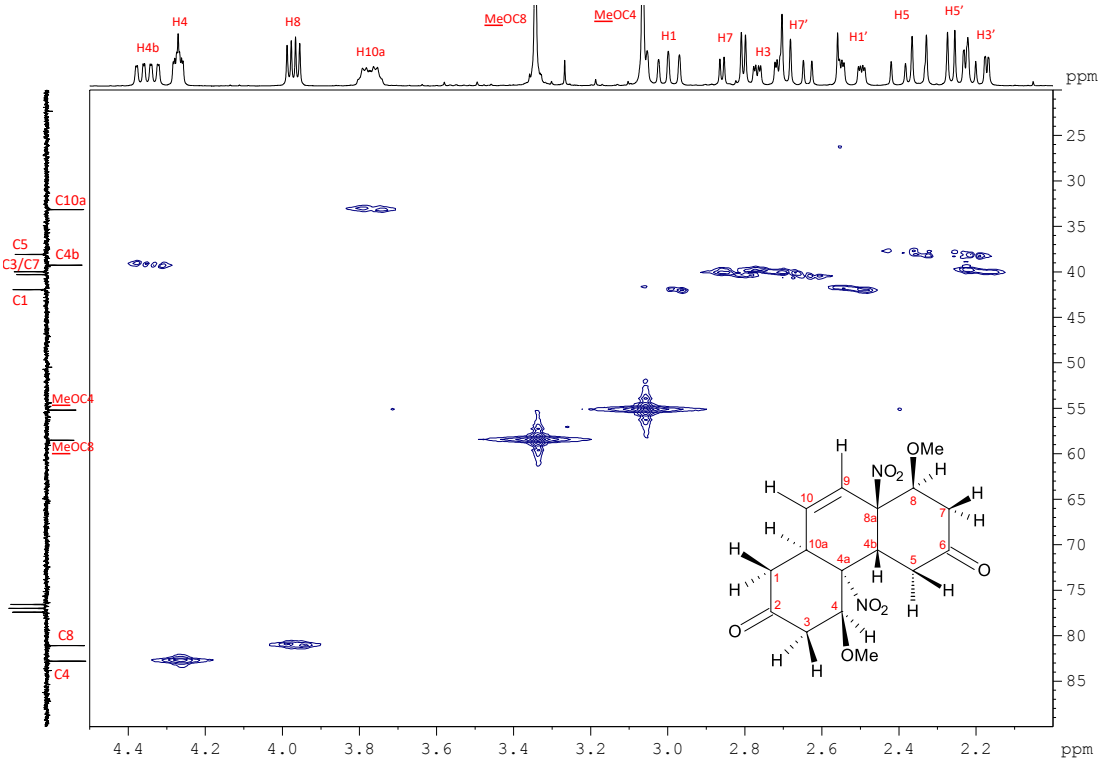
^{13}C NMR spectrum of F1 ($CDCl_3$, 75 MHz, 300K)



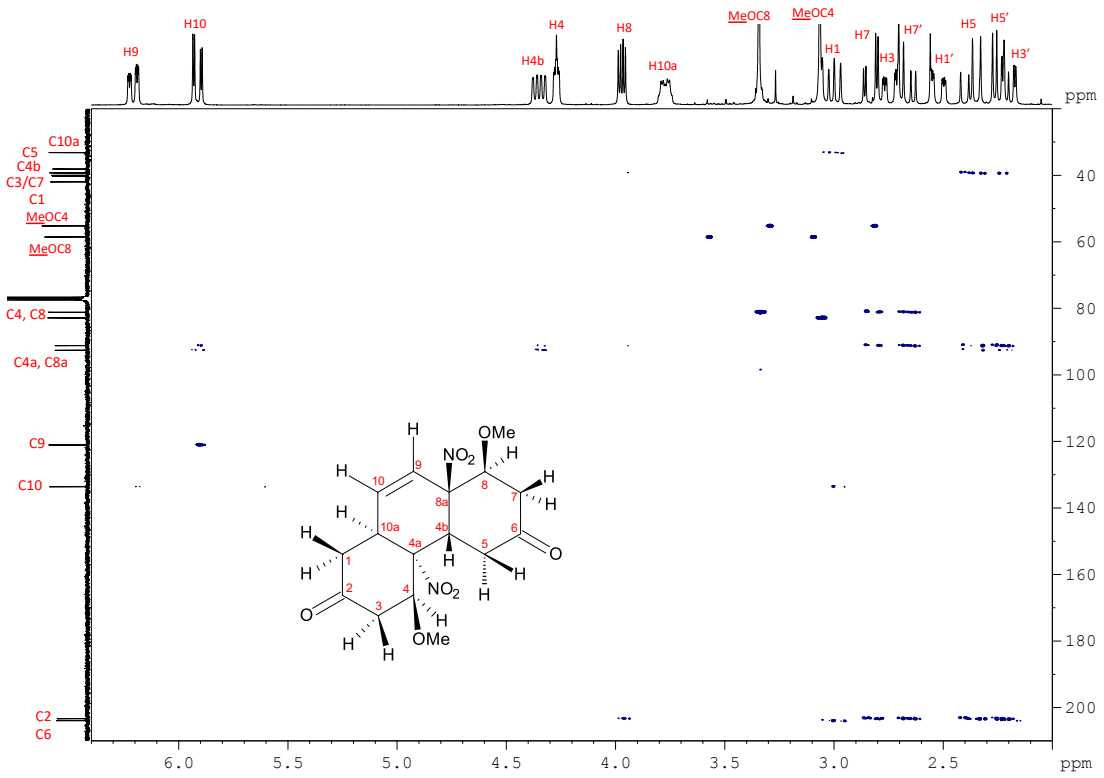
^{13}C NMR and ^{13}C Jmod spectra of F1 ($CDCl_3$, 75 MHz, 300K)



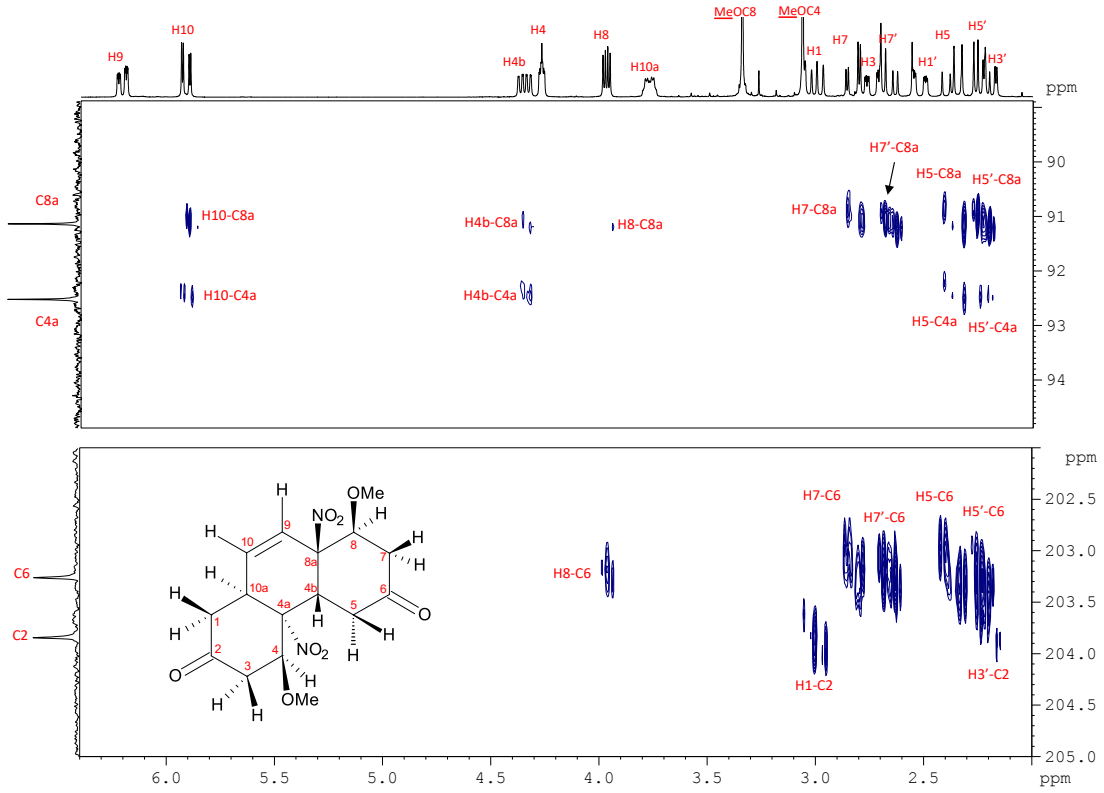
2D ^{1}H-^{13}C HMQC NMR spectrum of F1 (CDl_3, 300 MHz, 300K)



2D ^{1}H-^{13}C HMQC NMR spectrum of F1 (CDl_3, 300 MHz, 300K) - expansion

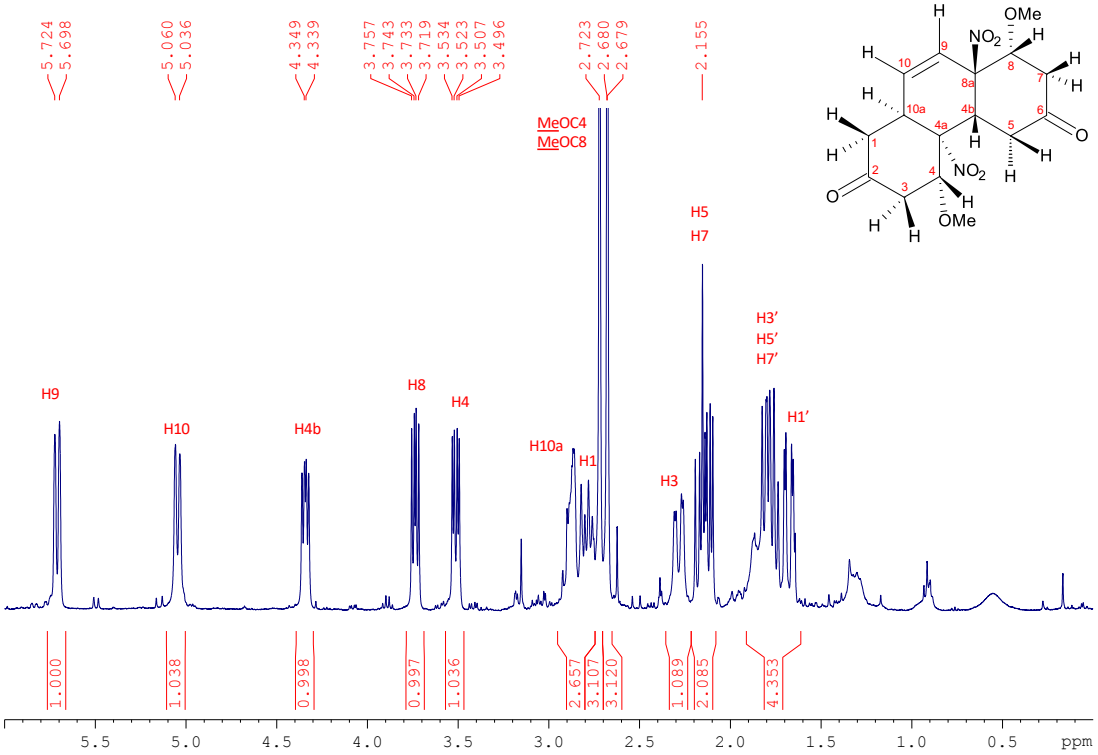


2D ^{1}H-^{13}C HMBC NMR spectrum of F1 (CDl_3, 300 MHz, 300K)

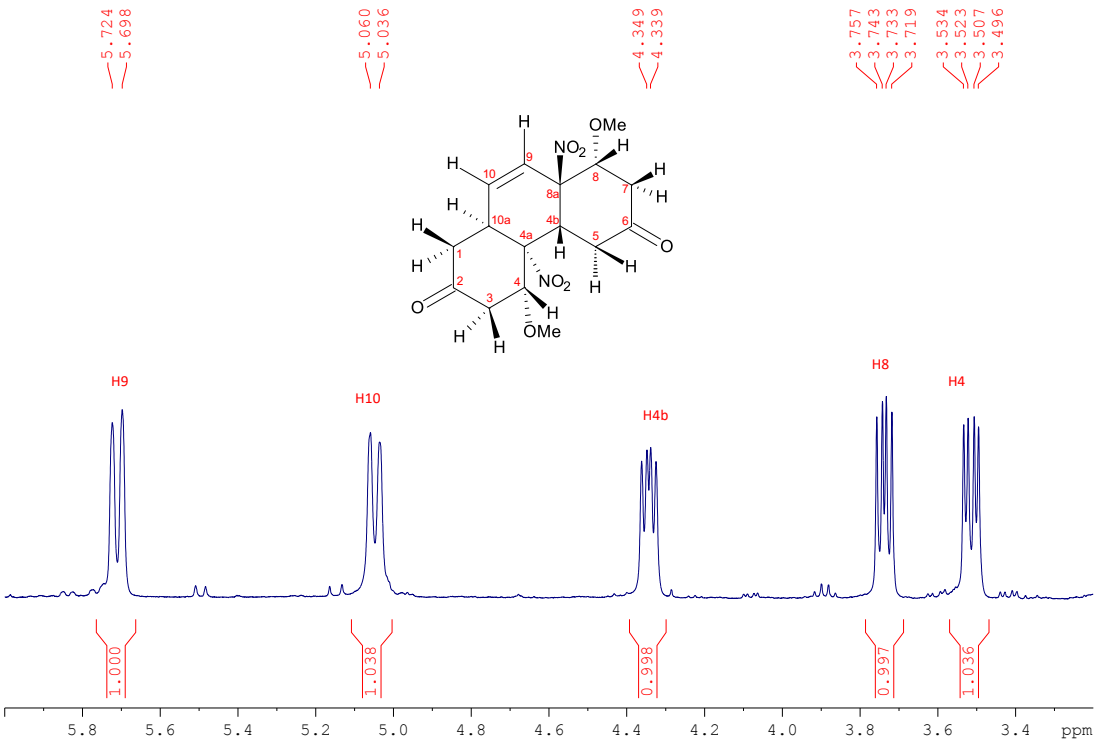


2D ^{1}H-^{13}C HMBC NMR spectrum of F1 (CDl_3, 300 MHz, 300K) - expansion

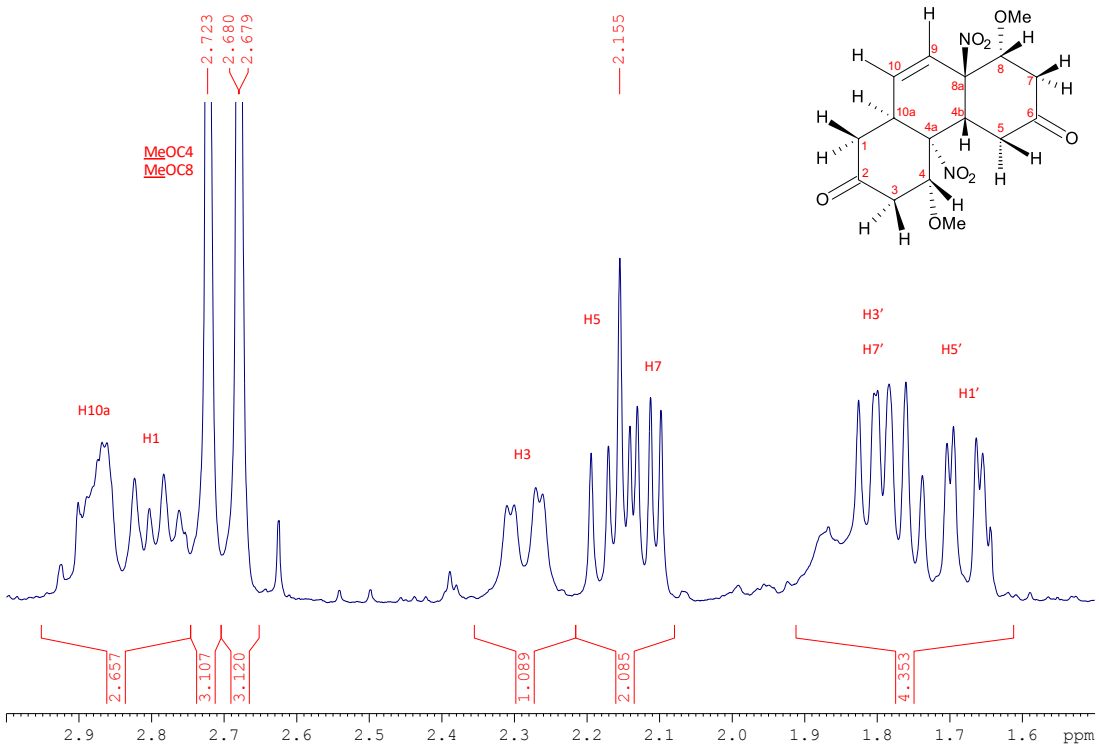
3e (F2: minor diastereomer)



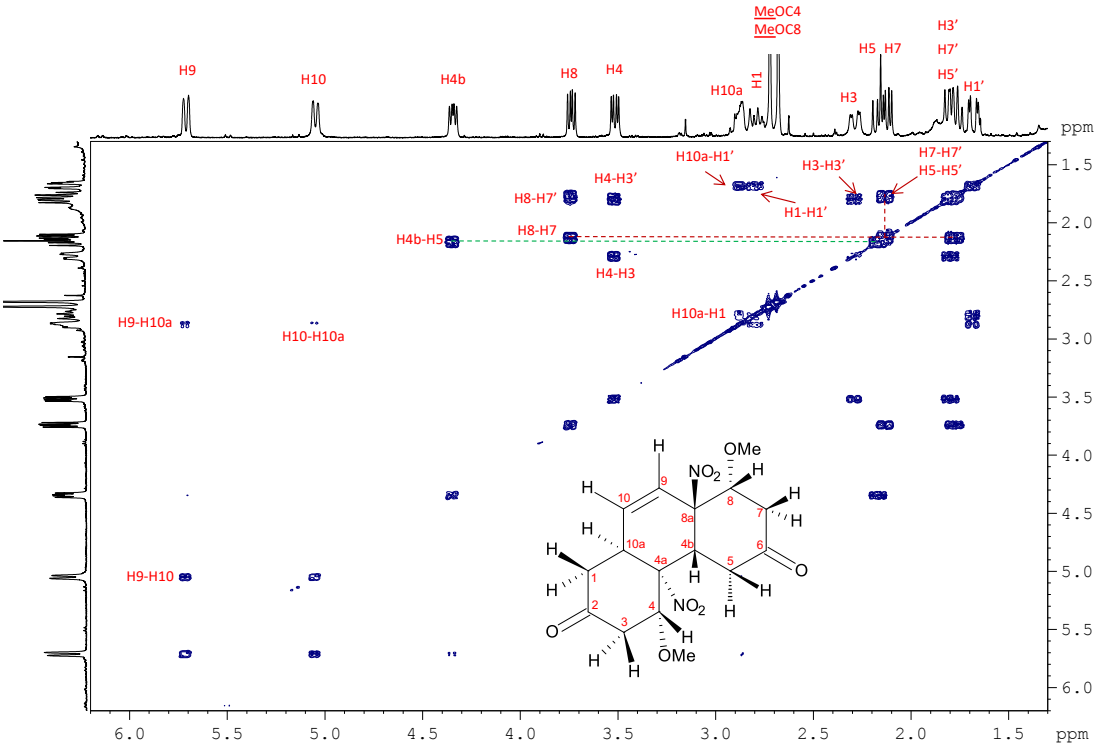
^{1}H NMR spectrum of F2 (C_6D_6, 400 MHz, 300K)



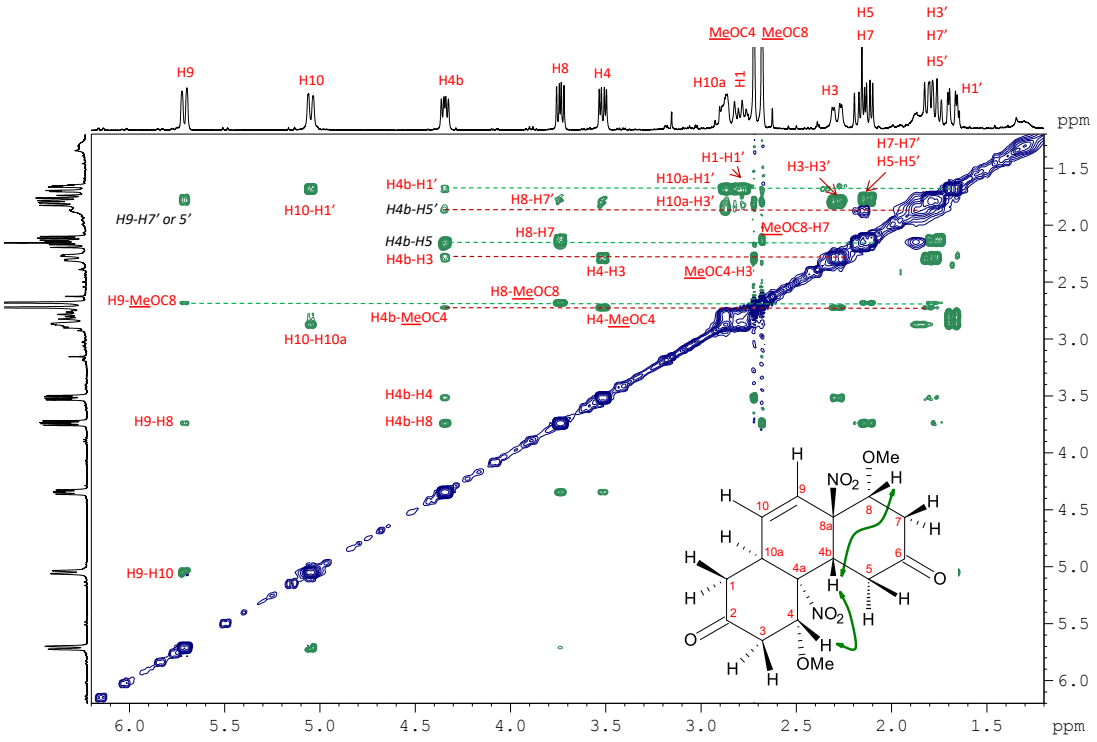
^{1}H NMR spectrum of F2 (C_6D_6, 400 MHz, 300K) - expansion



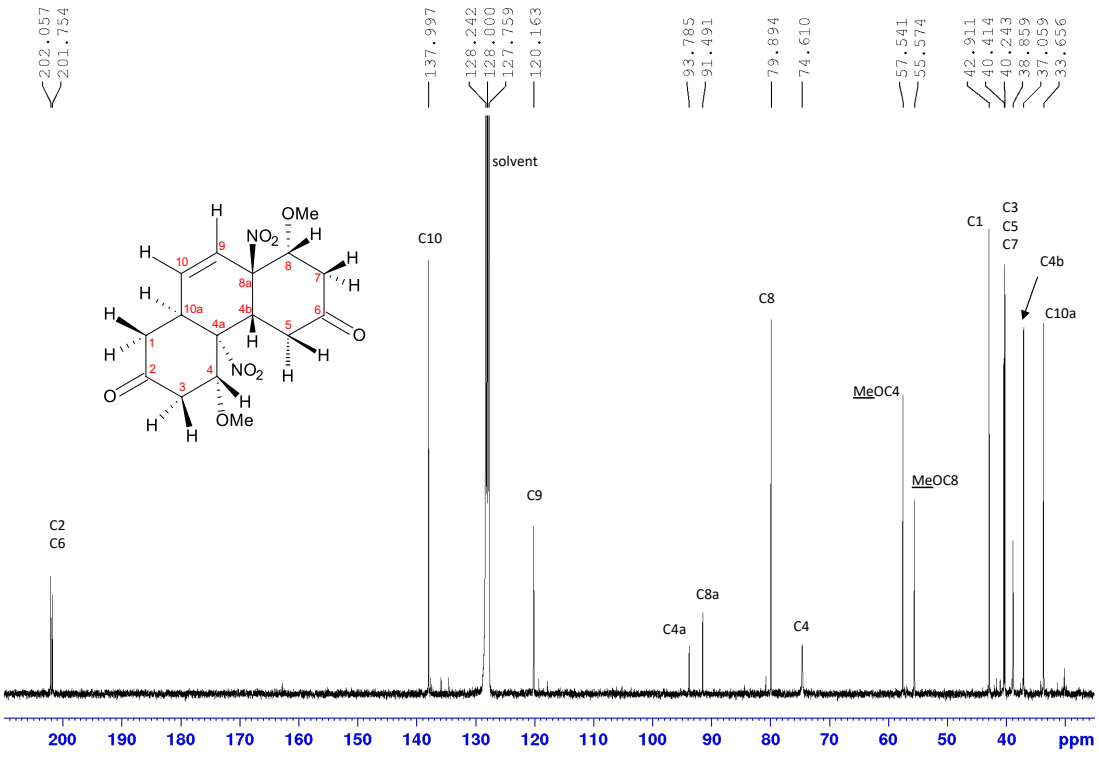
^{1}H NMR spectrum of F2 (C_6D_6, 400 MHz, 300K) - expansion



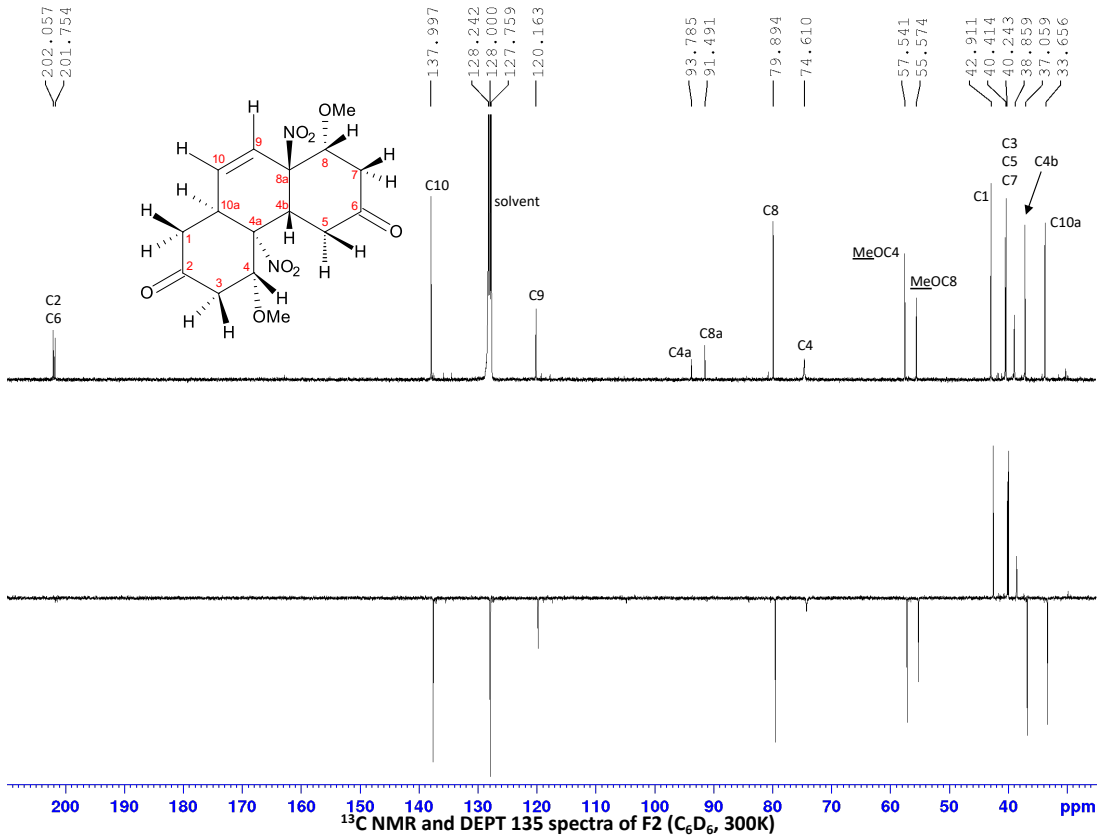
2D NMR ^{1}H-^{1}H COSY spectrum of F2 (C_6D_6, 400 MHz, 300K)



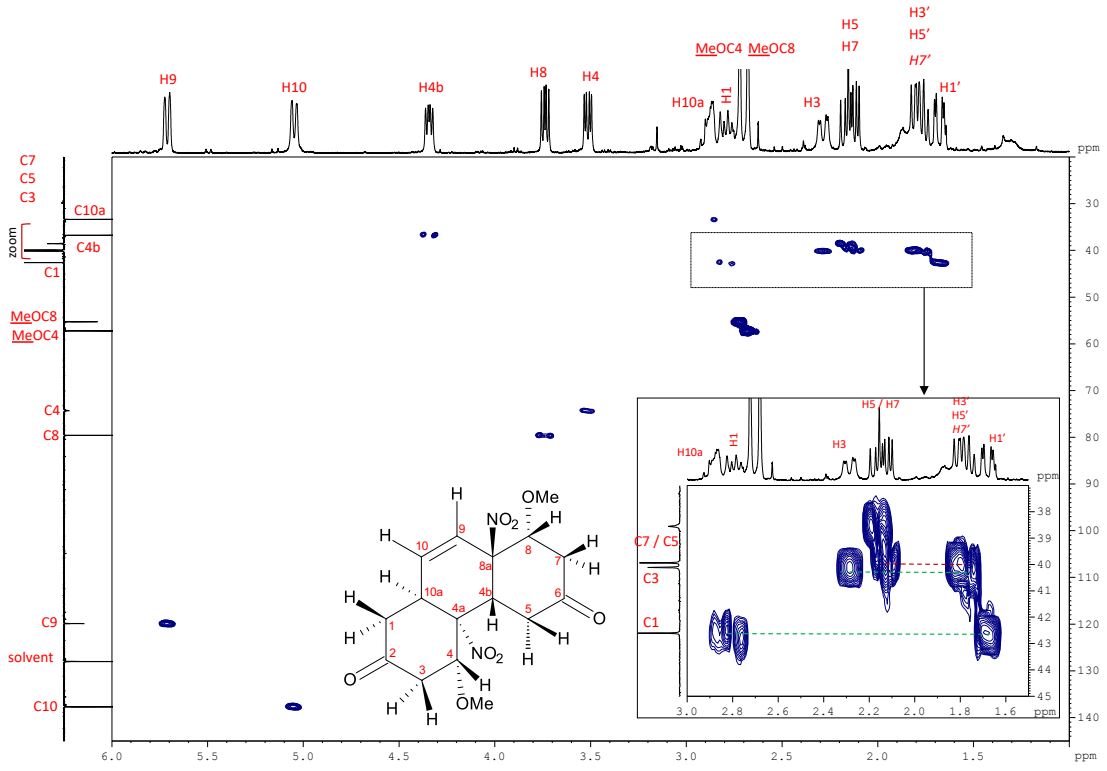
2D NMR ^{1}H-^{1}H NOESY spectrum of F2 (C_6D_6, 400 MHz, 300K) ⟷ Strong NOE : H4b-H8 and H4b-H4



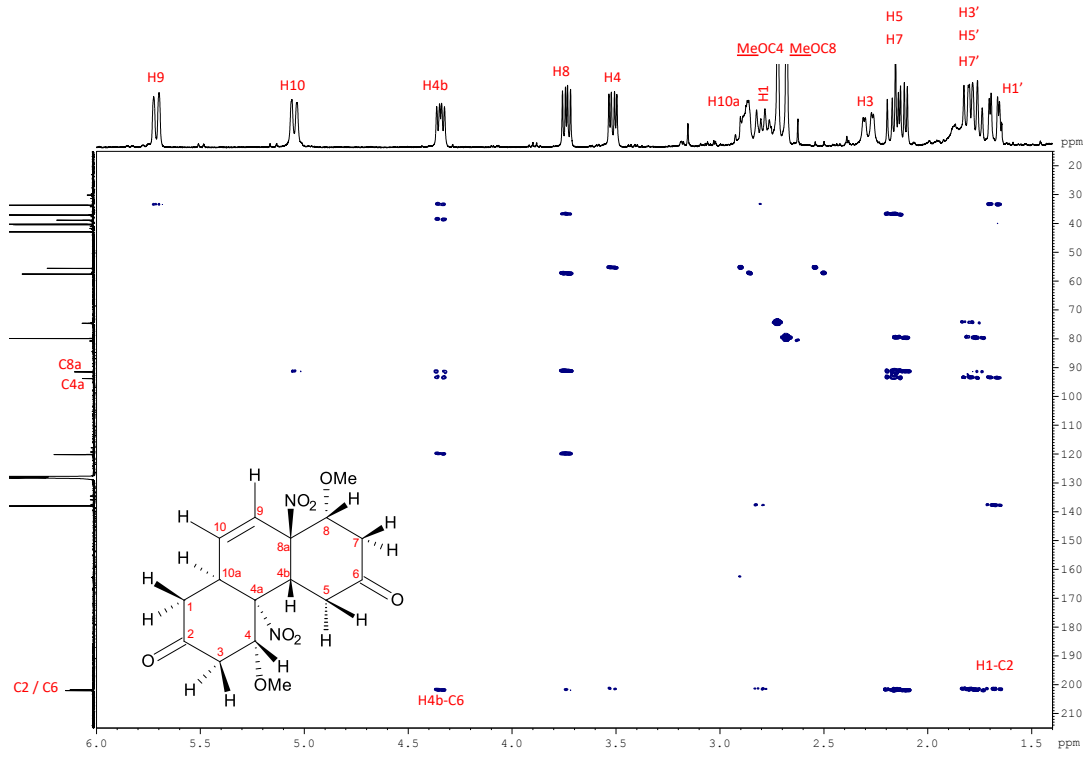
^{13}C NMR spectrum of F2 (C_6D_6, 100 MHz, 300K)



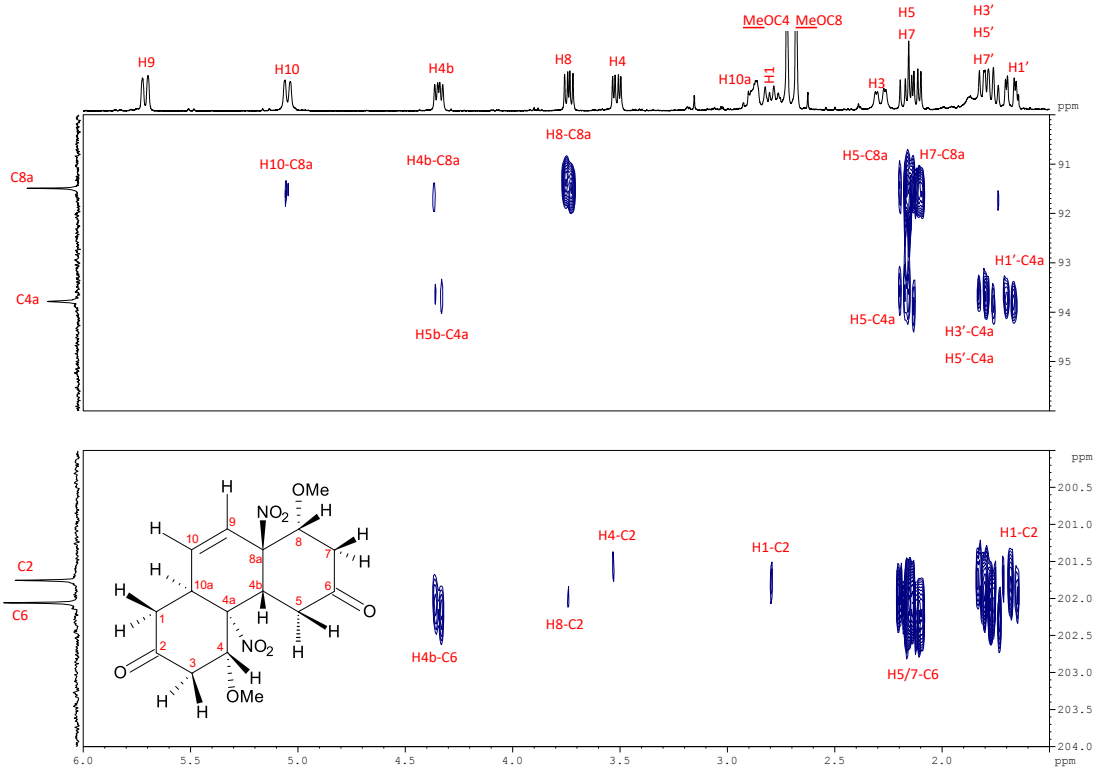
^{13}C NMR and DEPT 135 spectra of F2 (C_6D_6, 300K)



2D ^{1}H-^{13}C HMQC NMR spectrum of F2 (C_6D_6, 400 MHz, 300K)

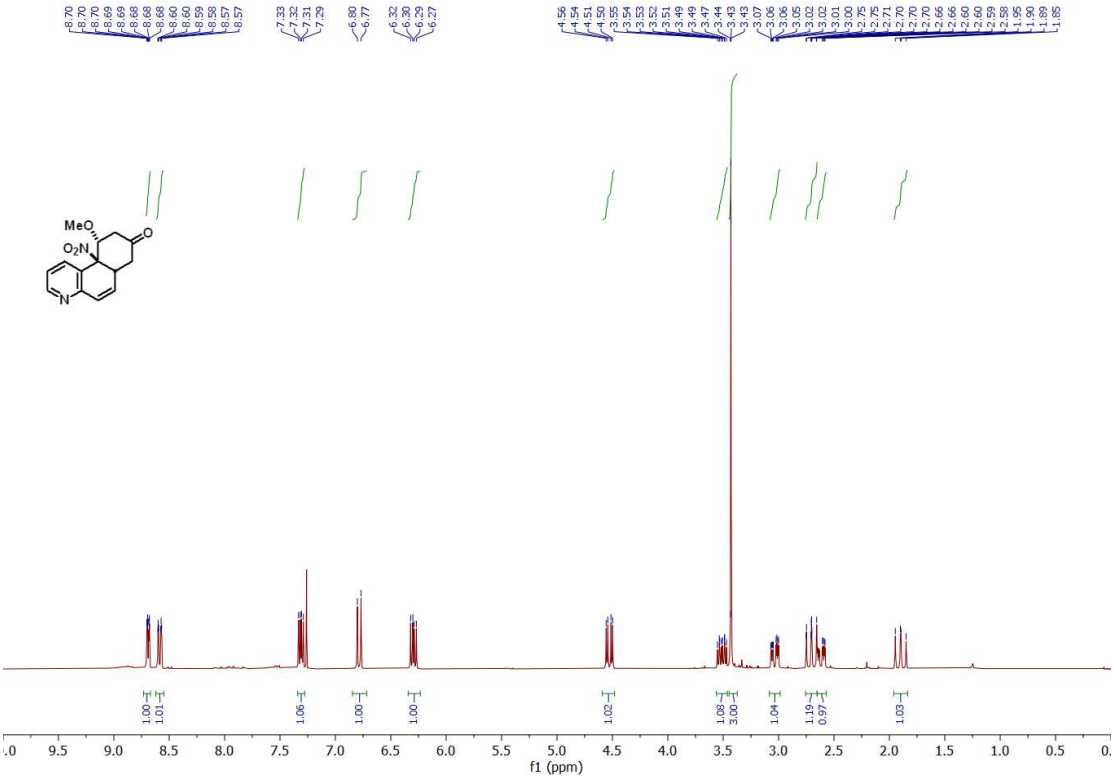


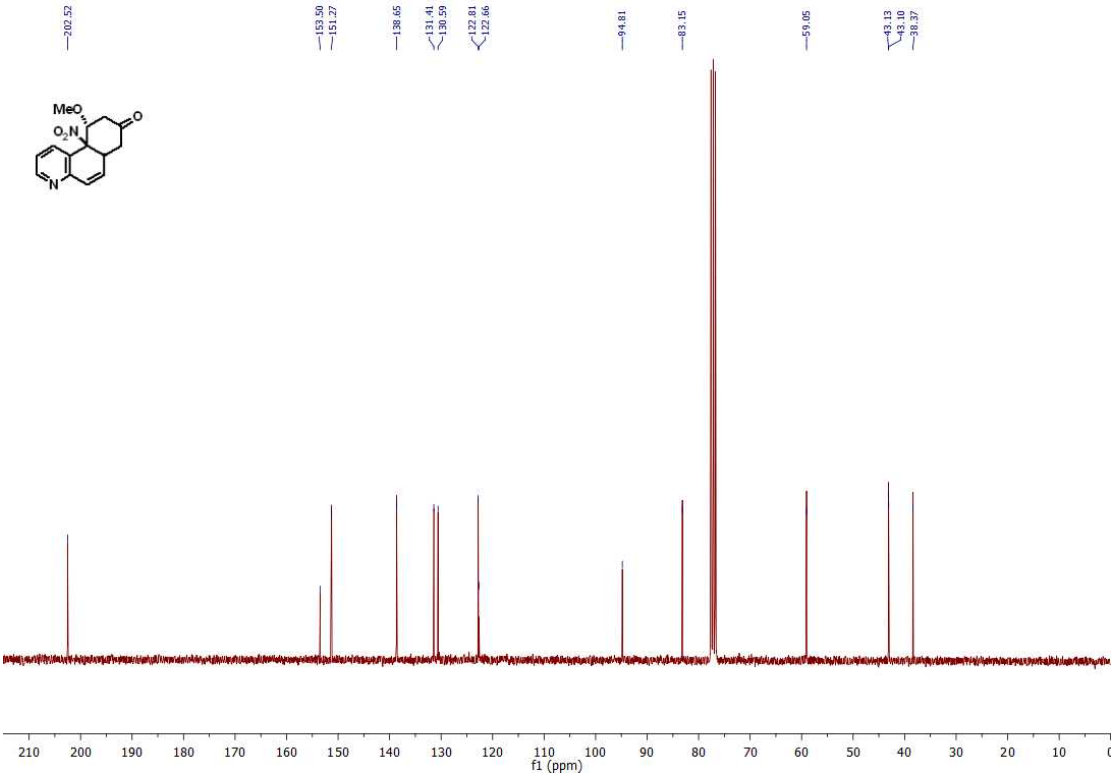
2D ^{1}H-^{13}C HMBC NMR spectrum of F2 (C_6D_6, 400 MHz, 300K)



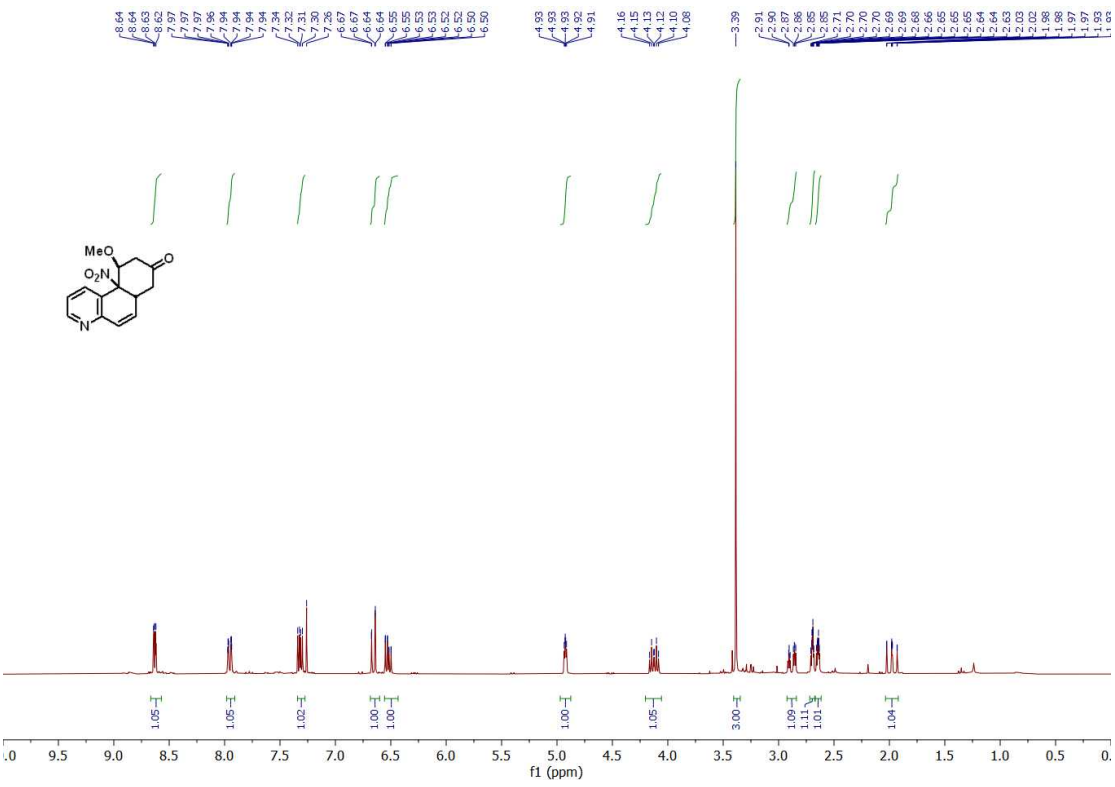
Carte RMN ^{1}H-^{13}C HMBC (C6D6, 300K) de F2 - zoom

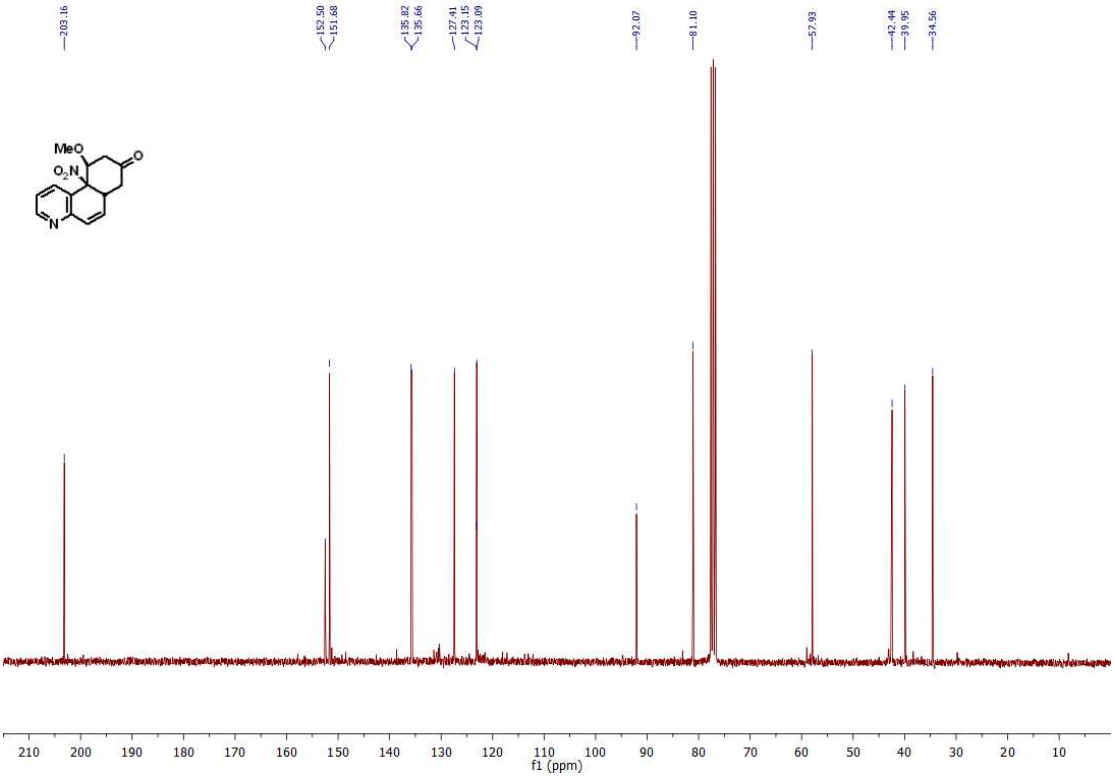
5a (first diastereomer)



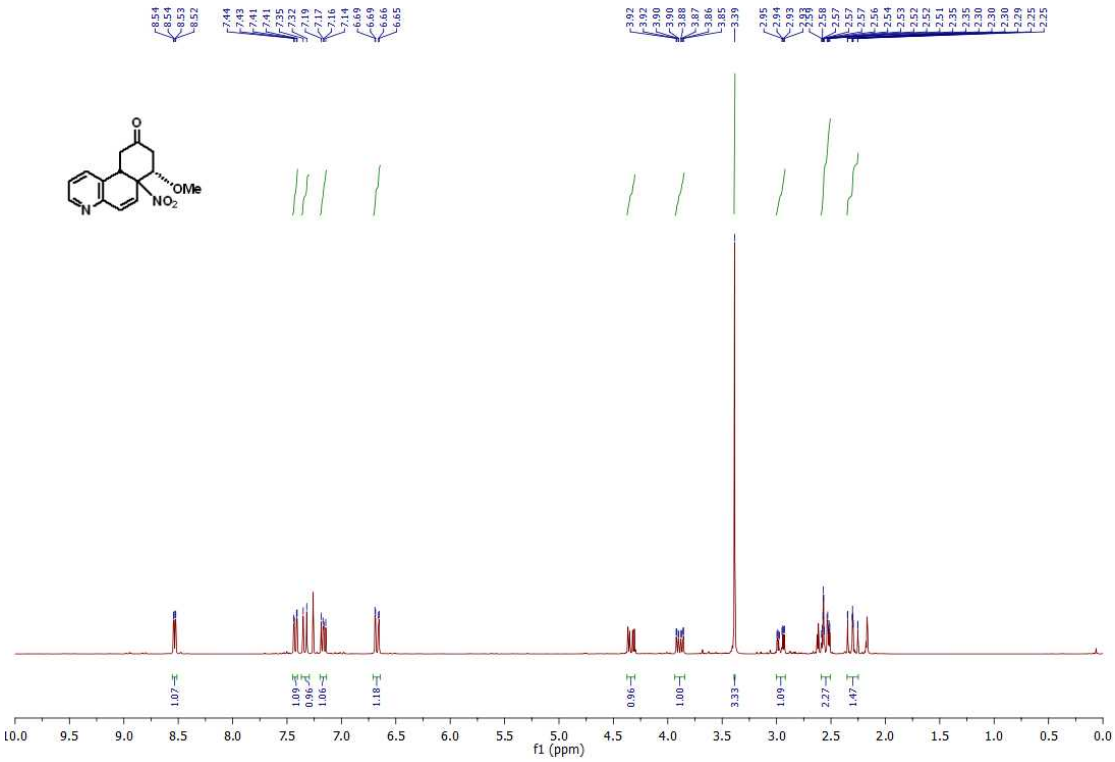


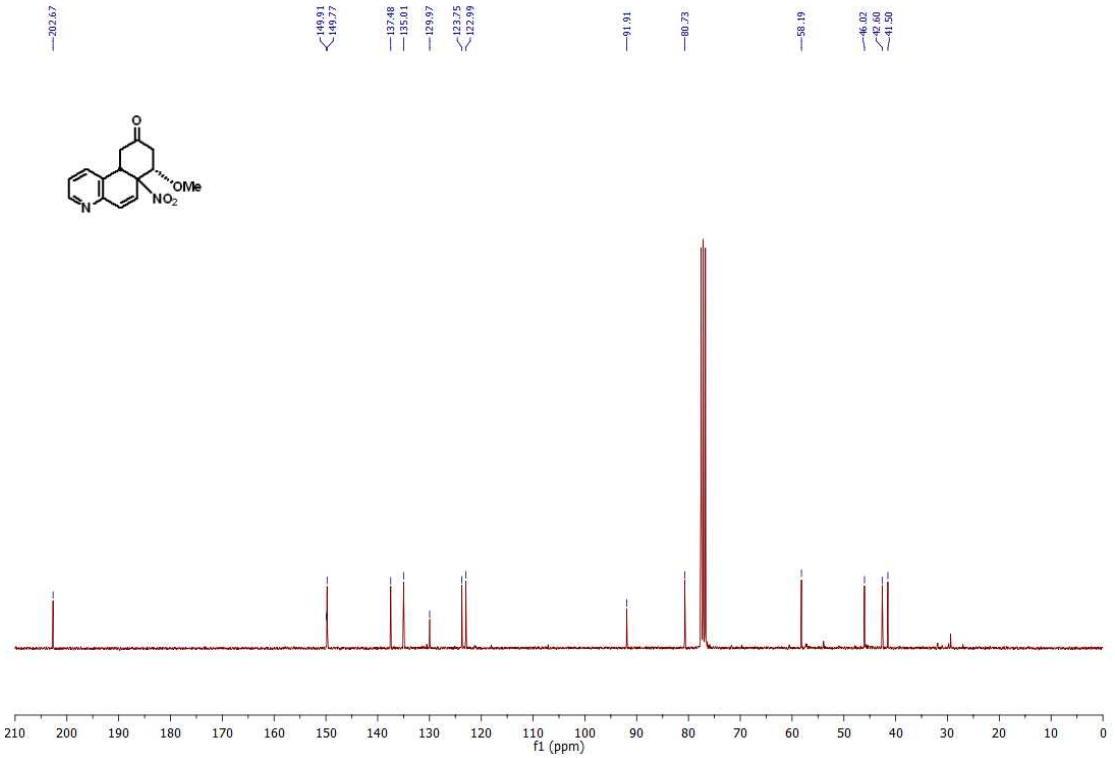
5a (second diastereomer)



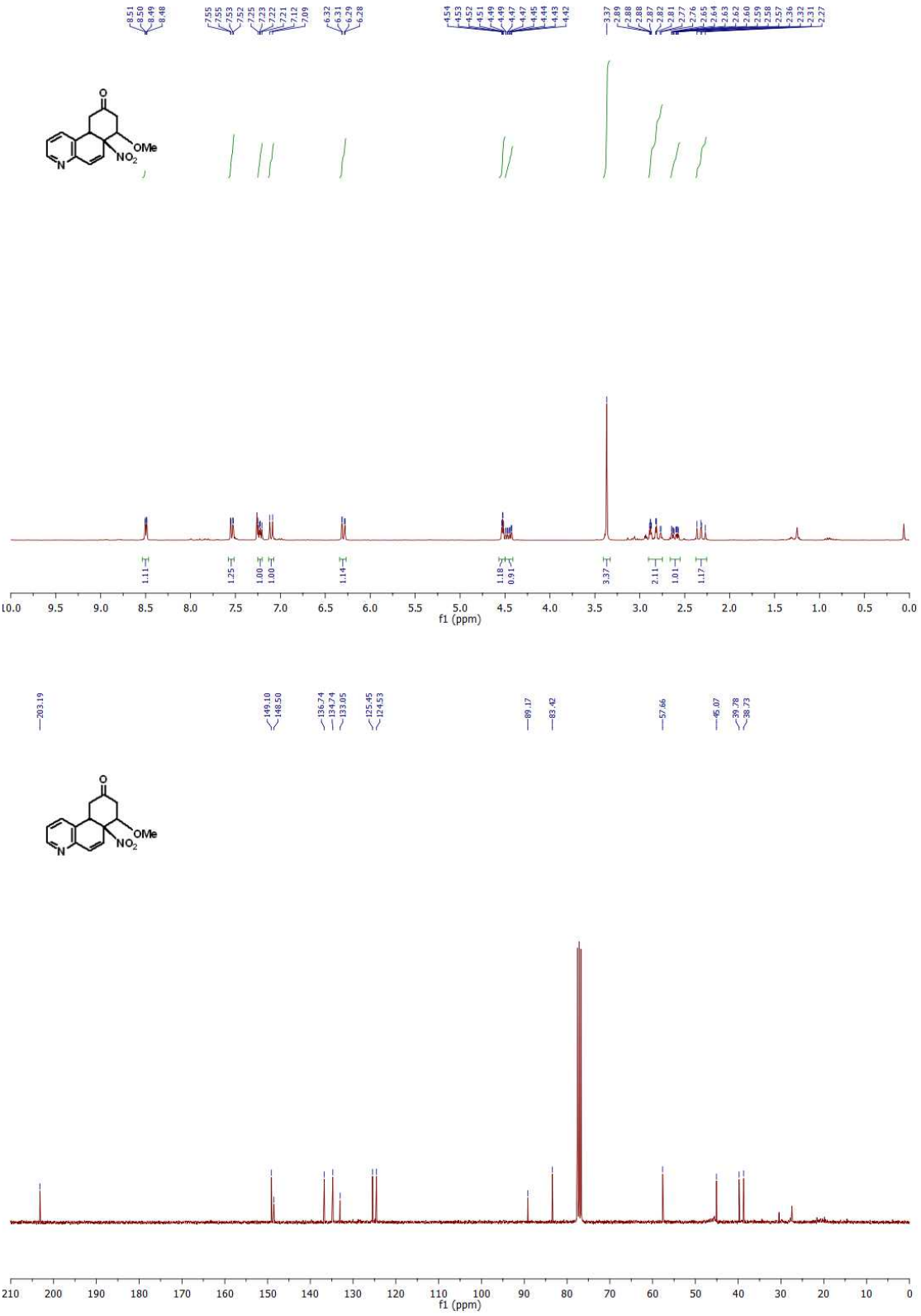


5b (first diastereomer)

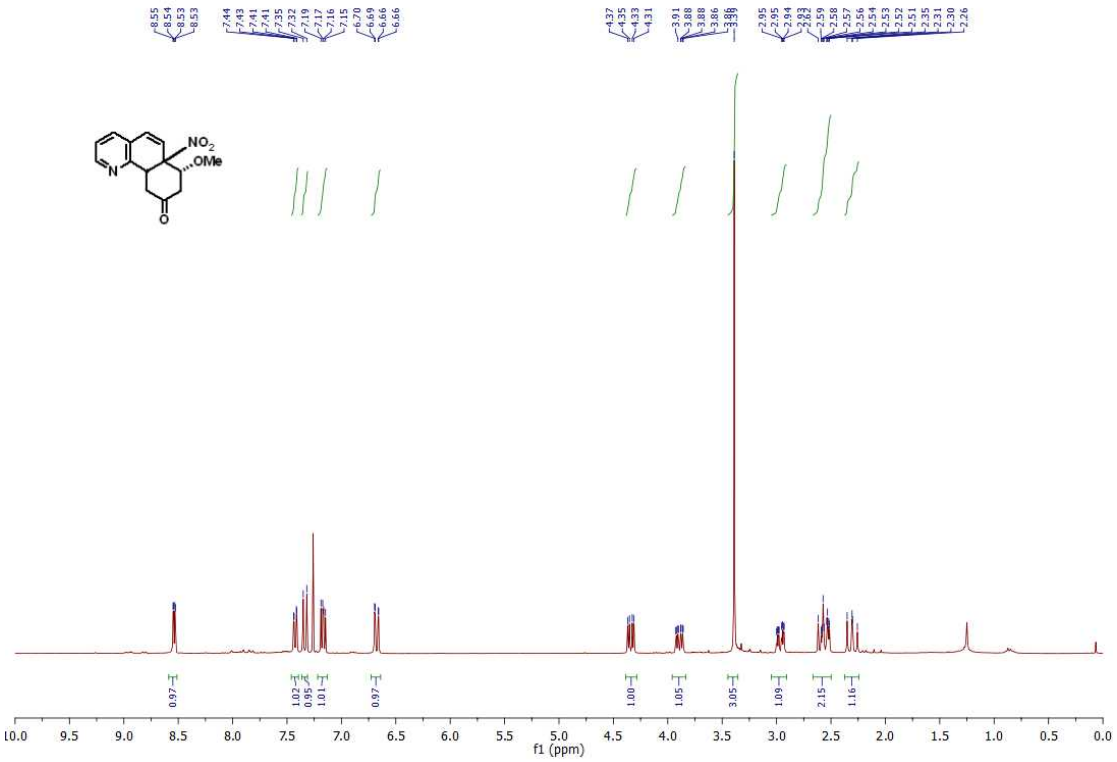


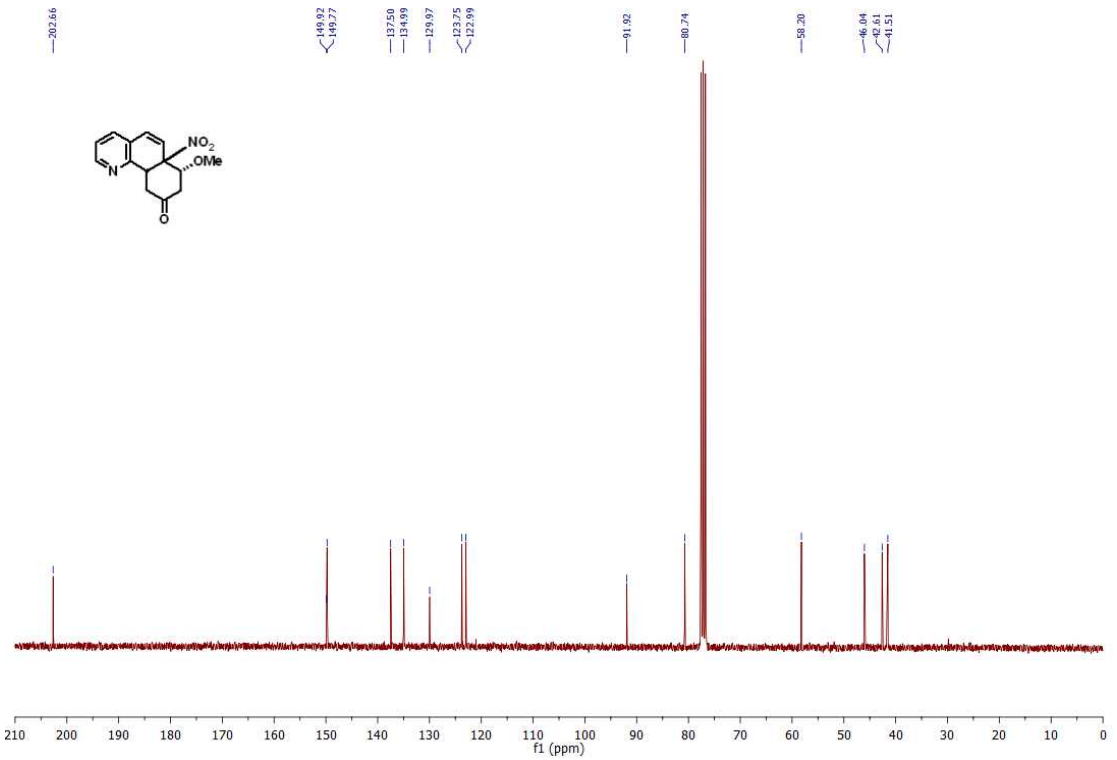


5b (second diastereomer)

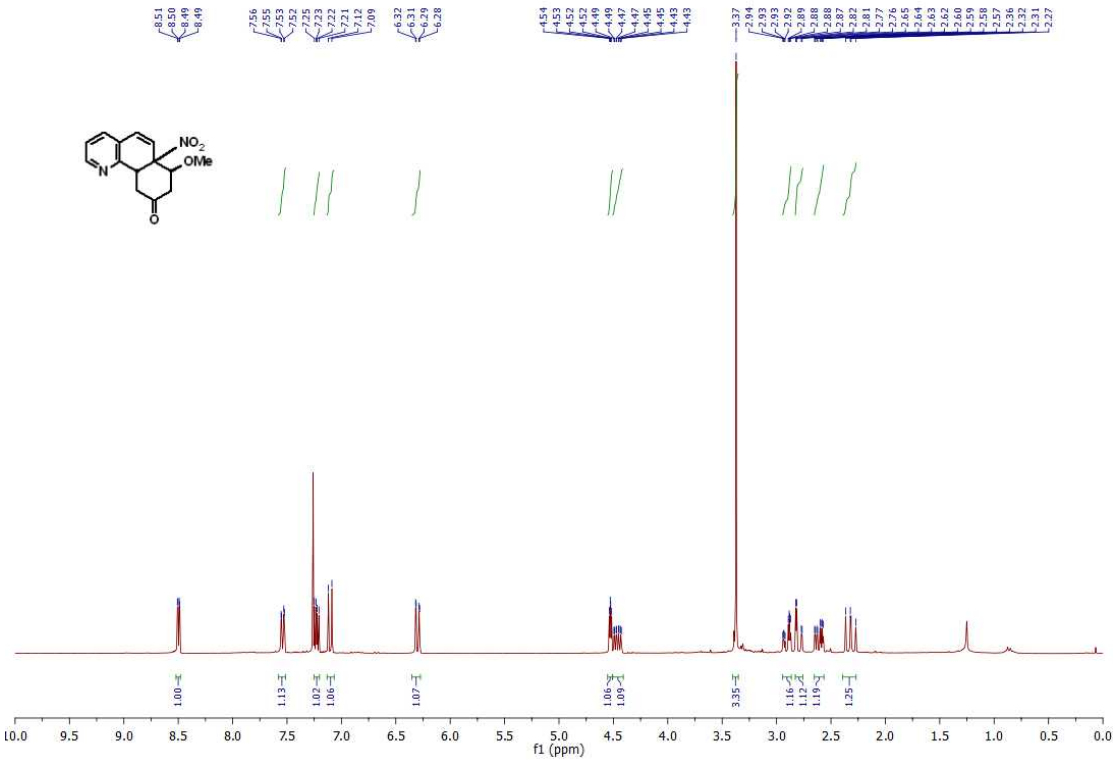


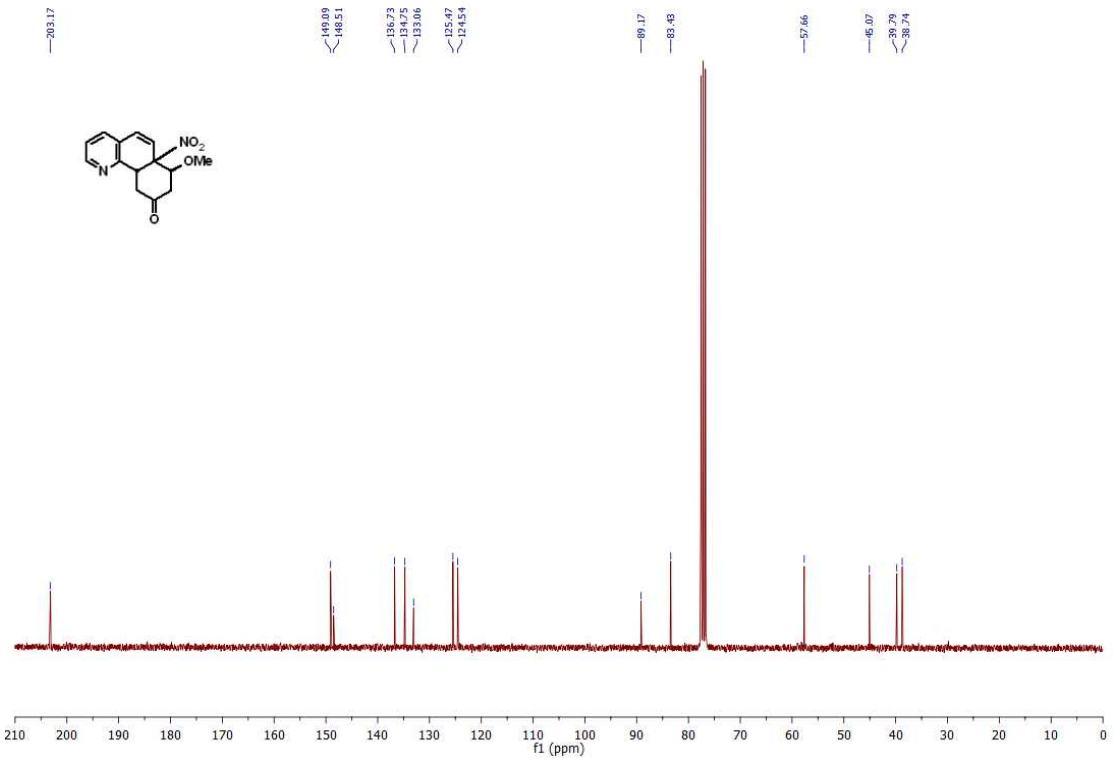
5c (major diastereomer)



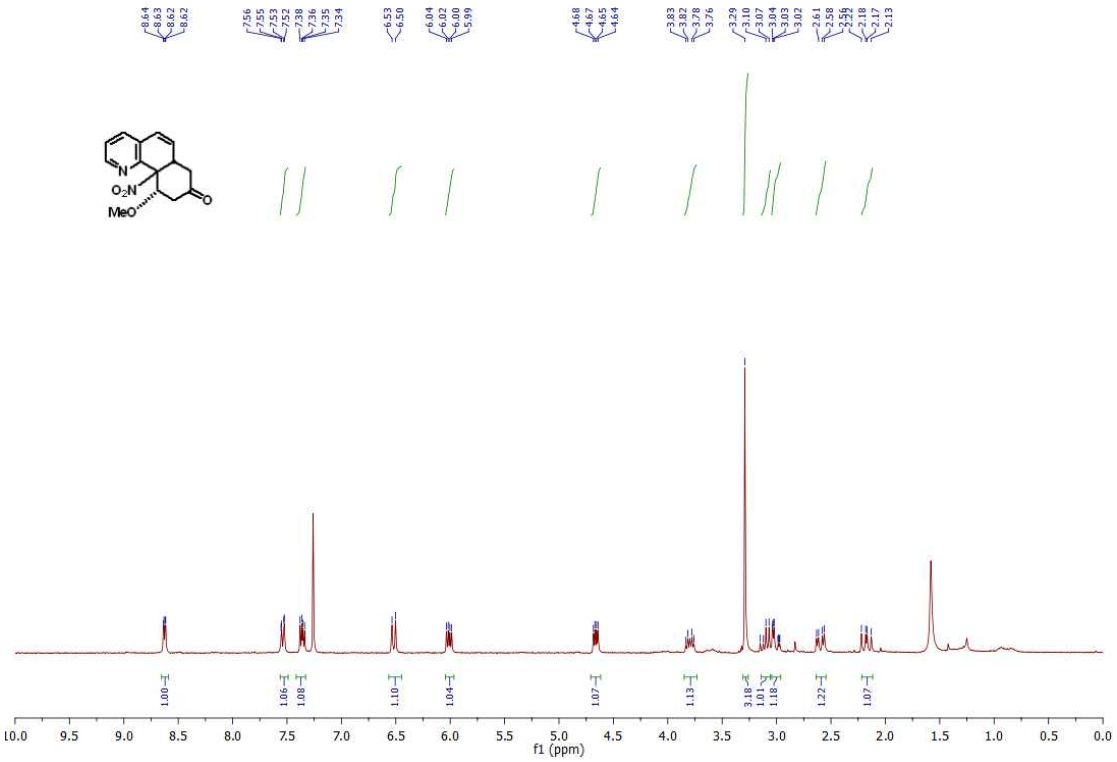


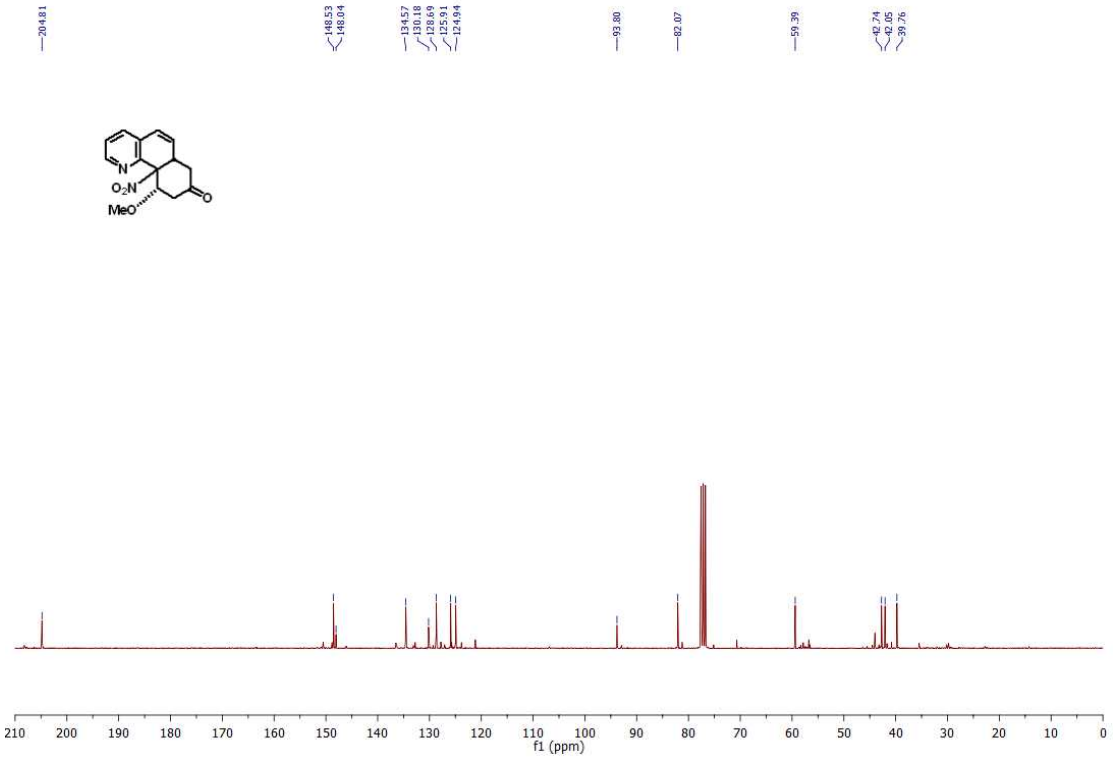
5c (minor diastereomer)



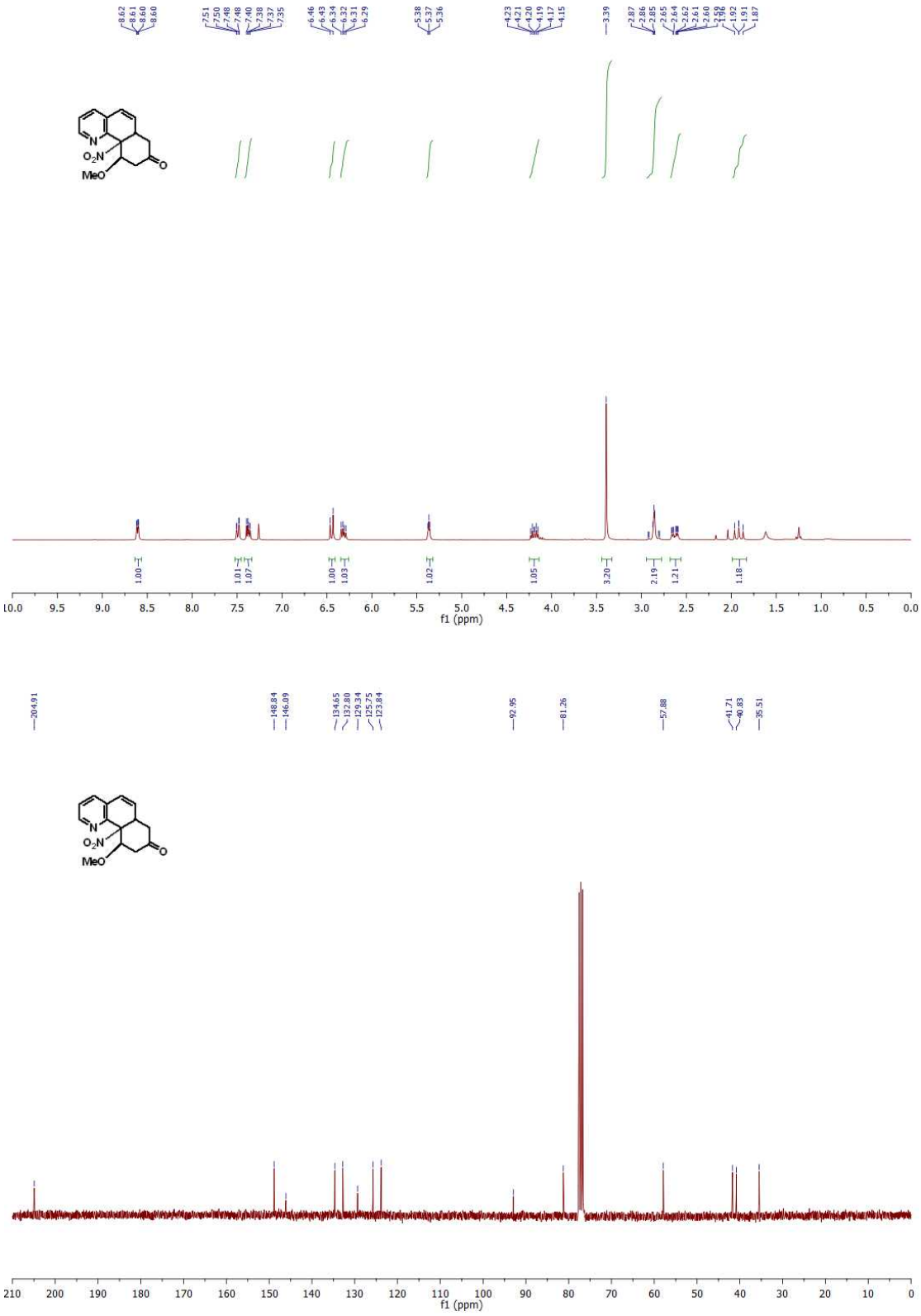


5d (major diastereomer)

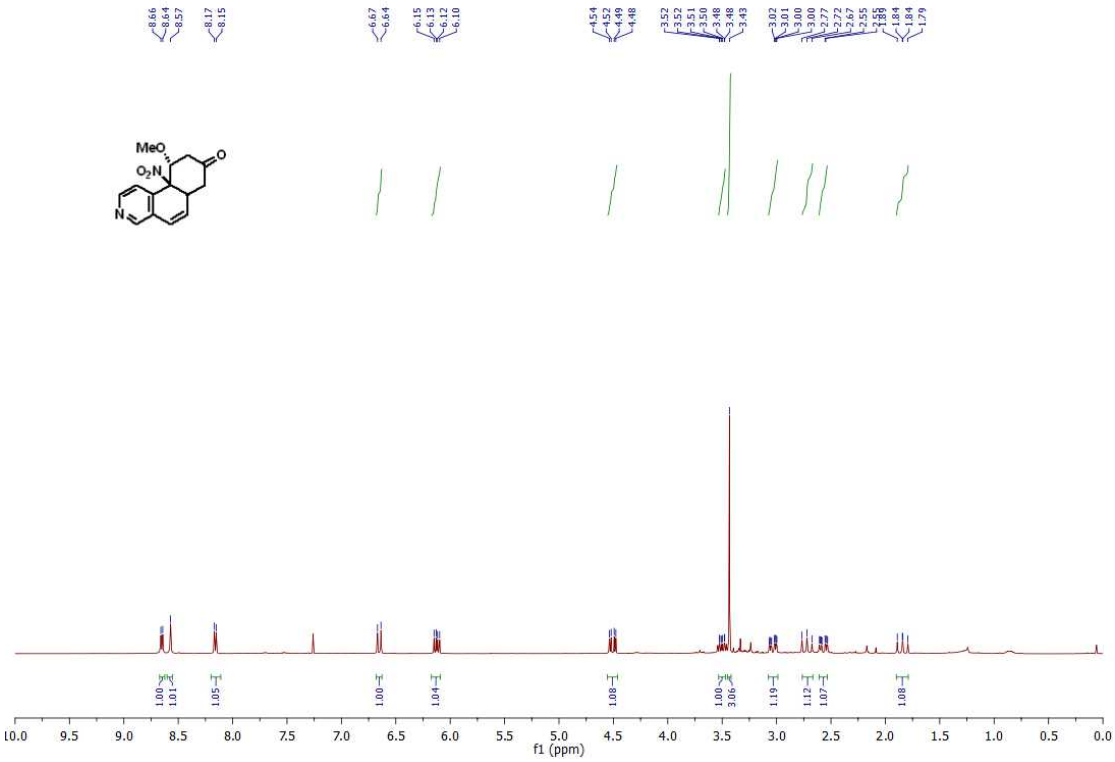


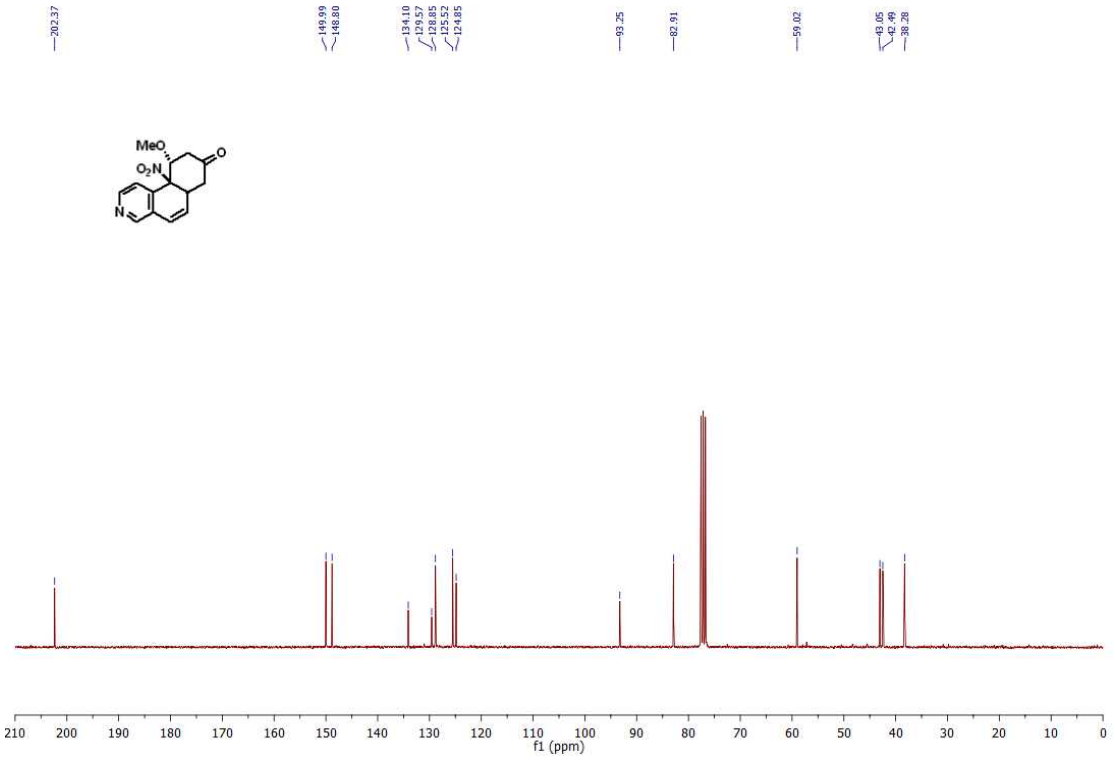


5d (minor diastereomer)

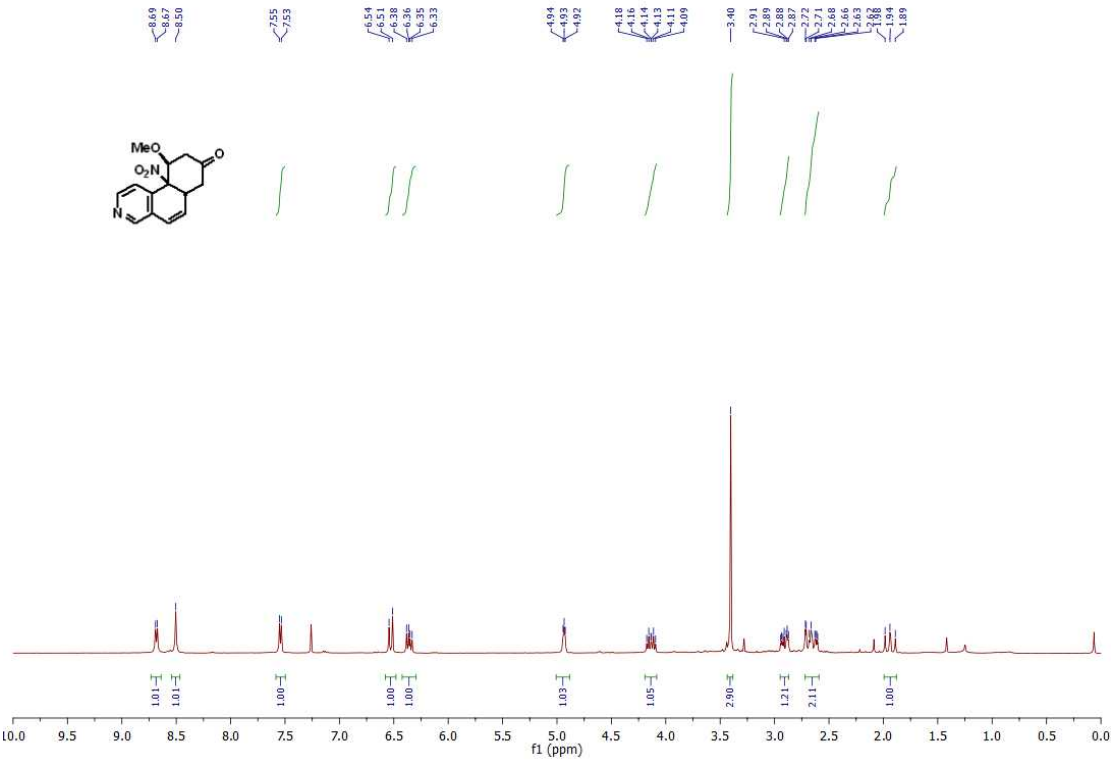


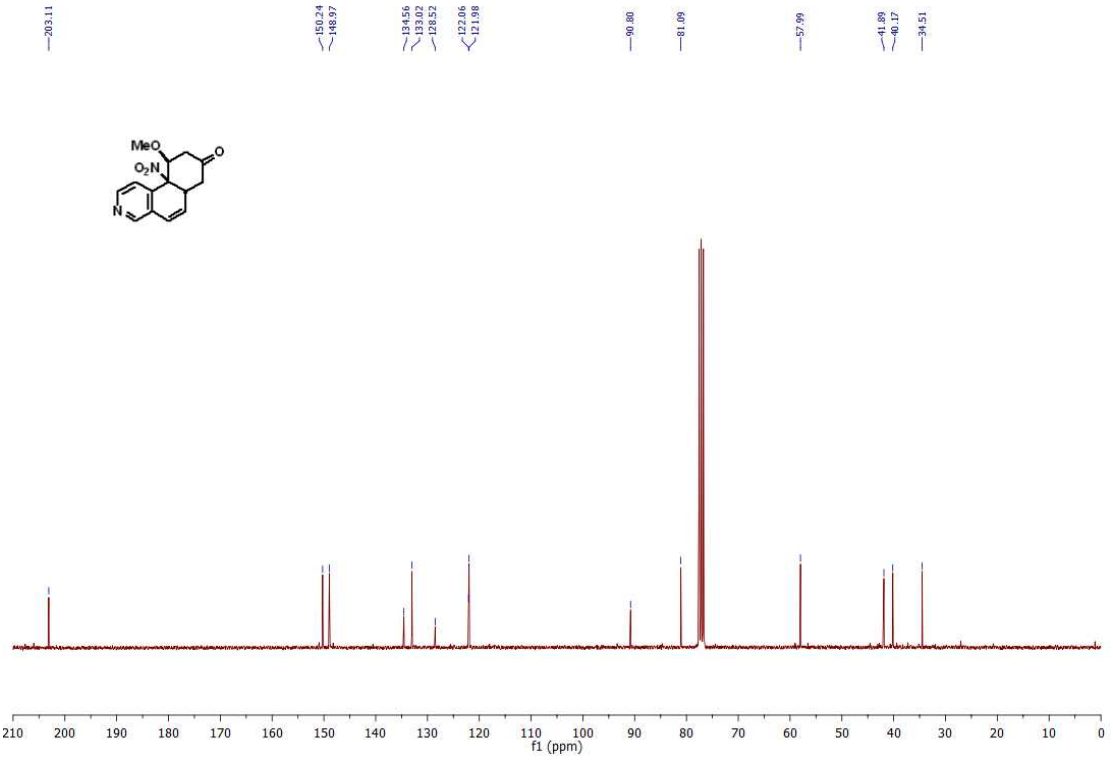
5e (major diastereomer)



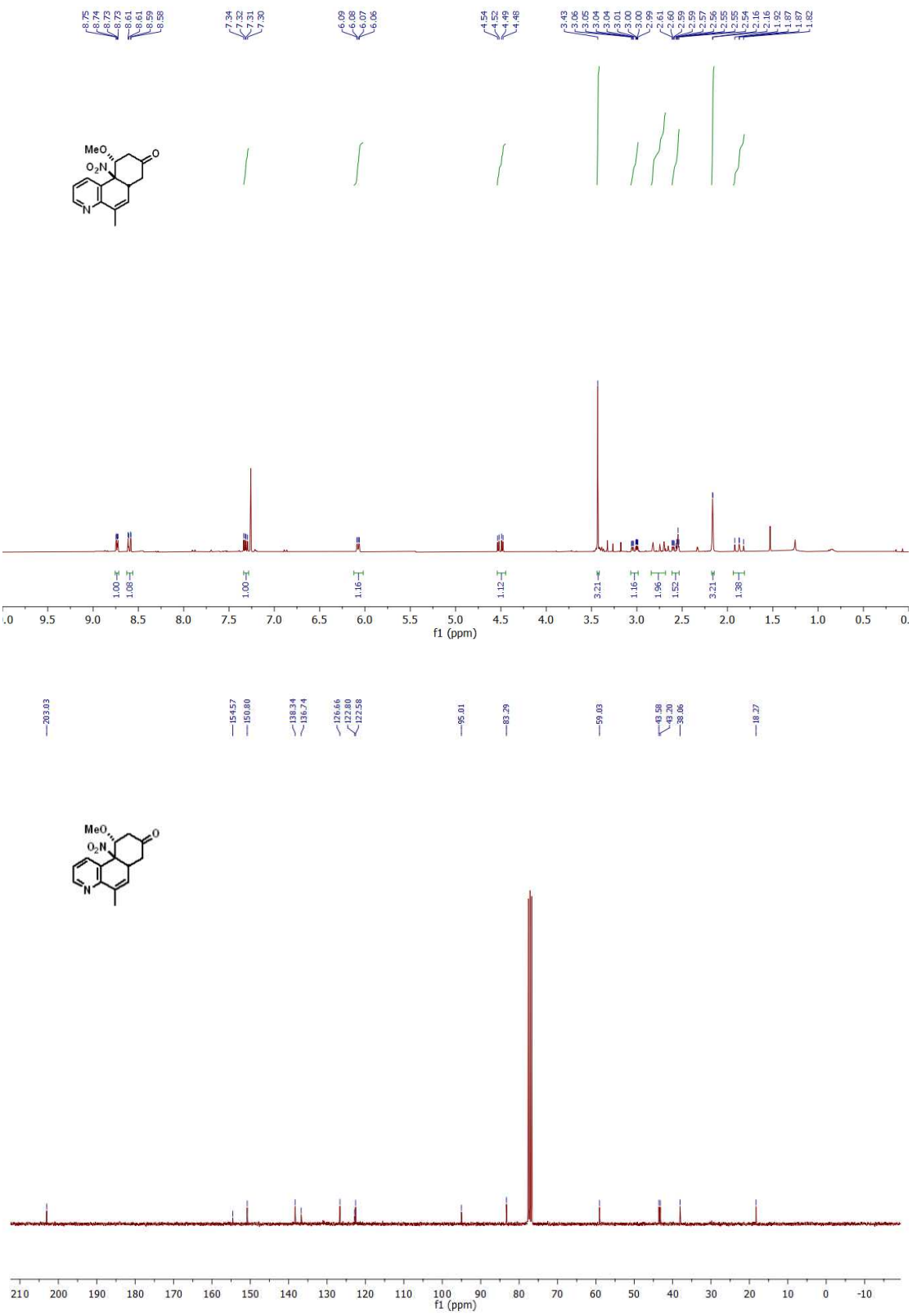


5e (minor diastereomer)

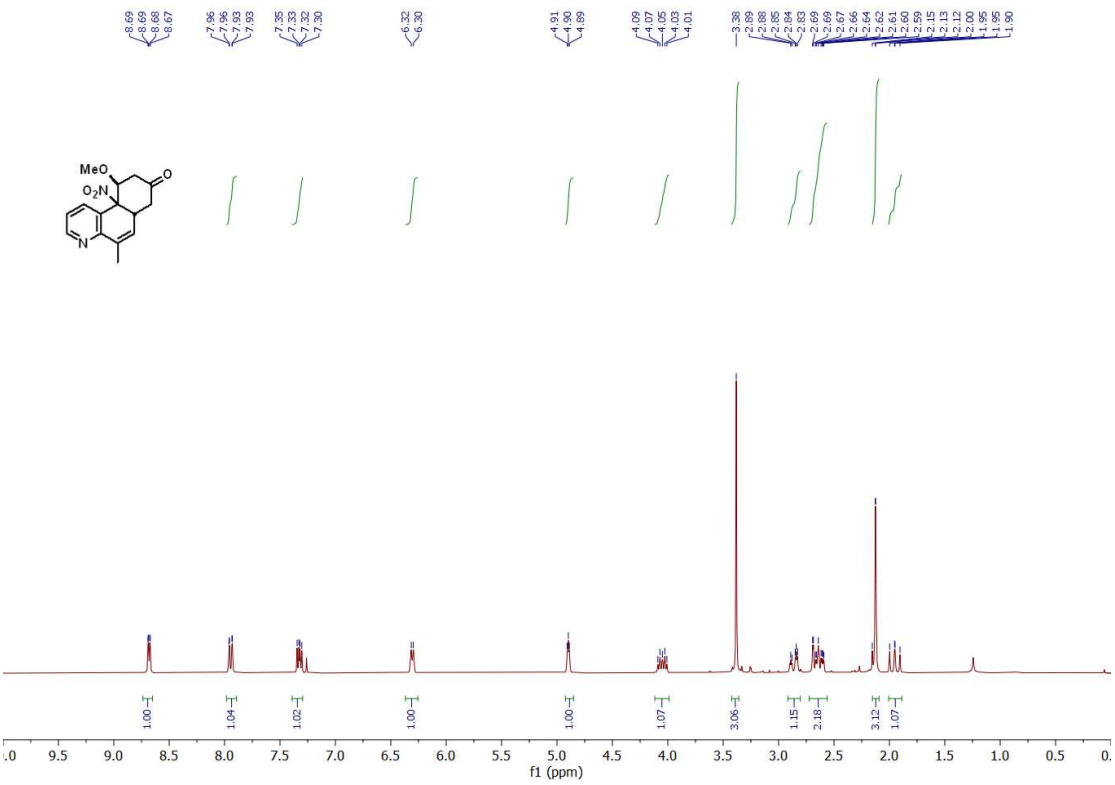


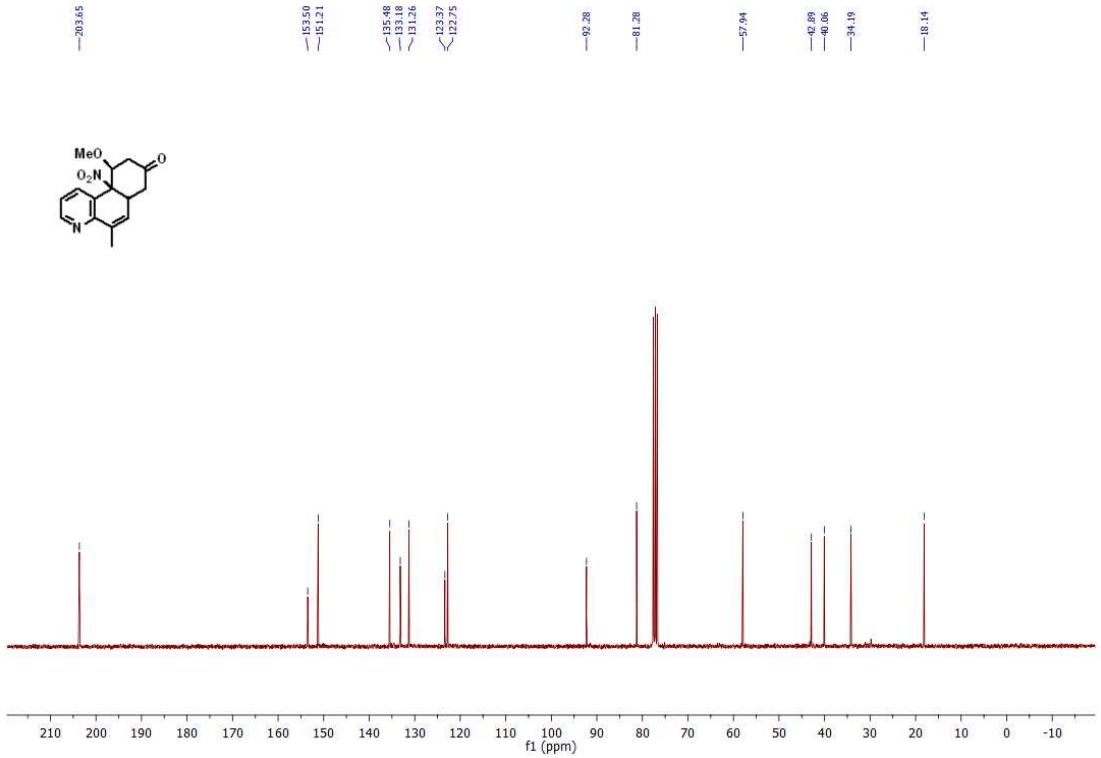


5f (major diastereomer)

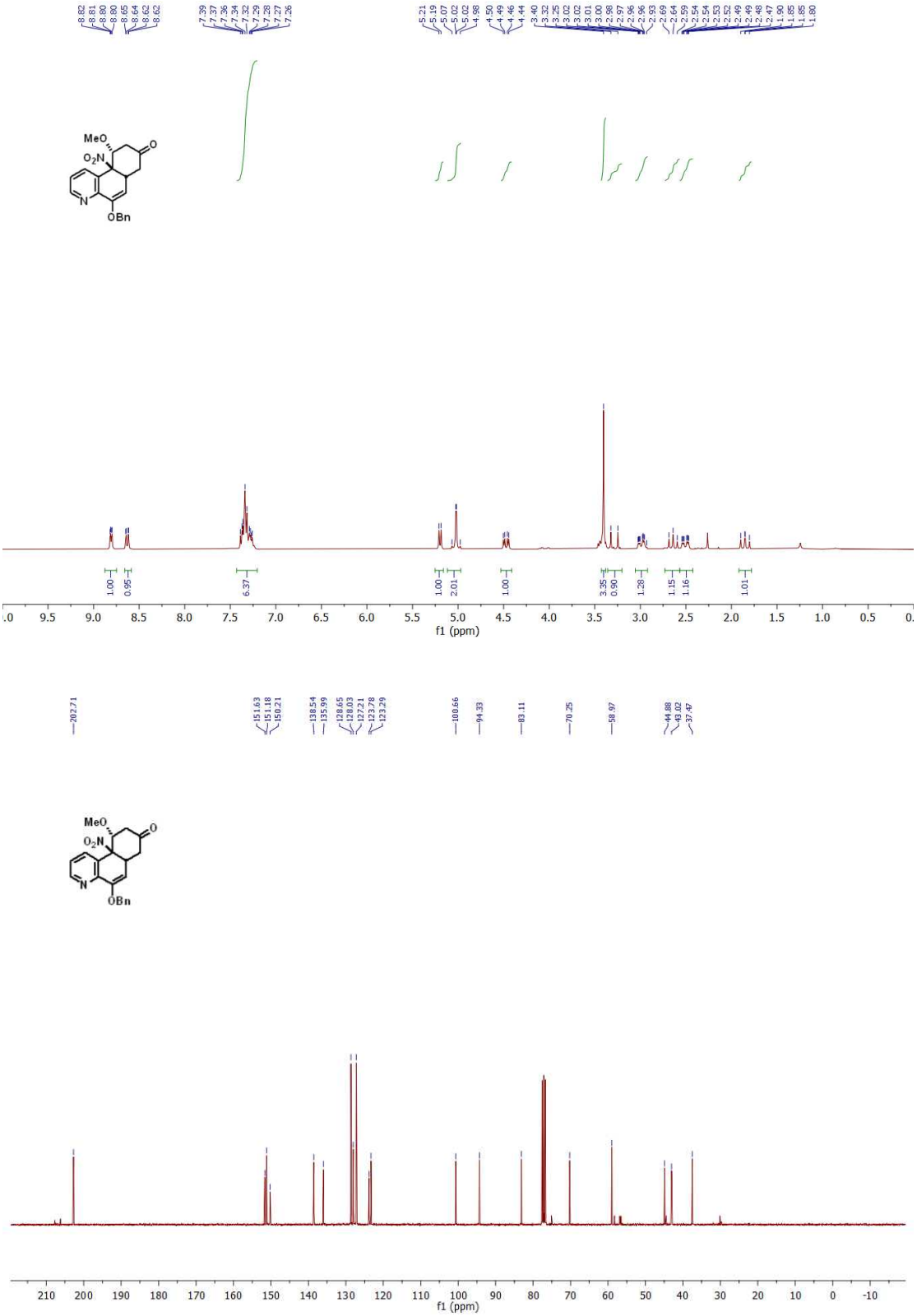


5f (minor diastereomer)

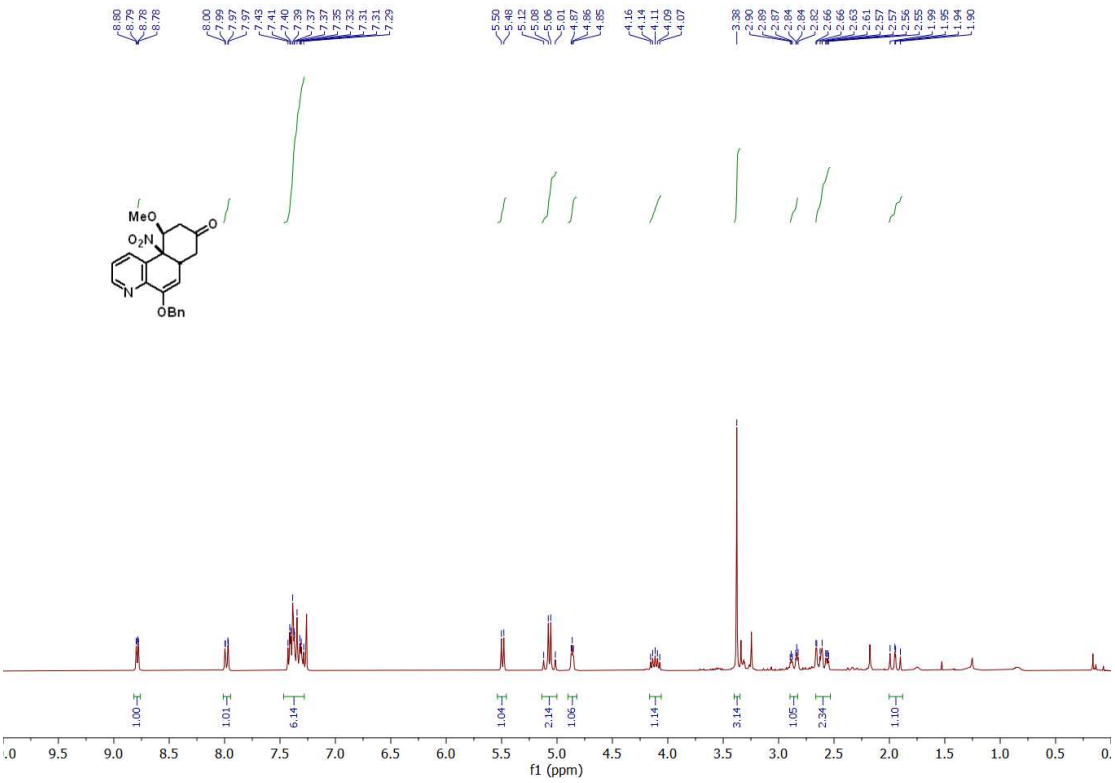


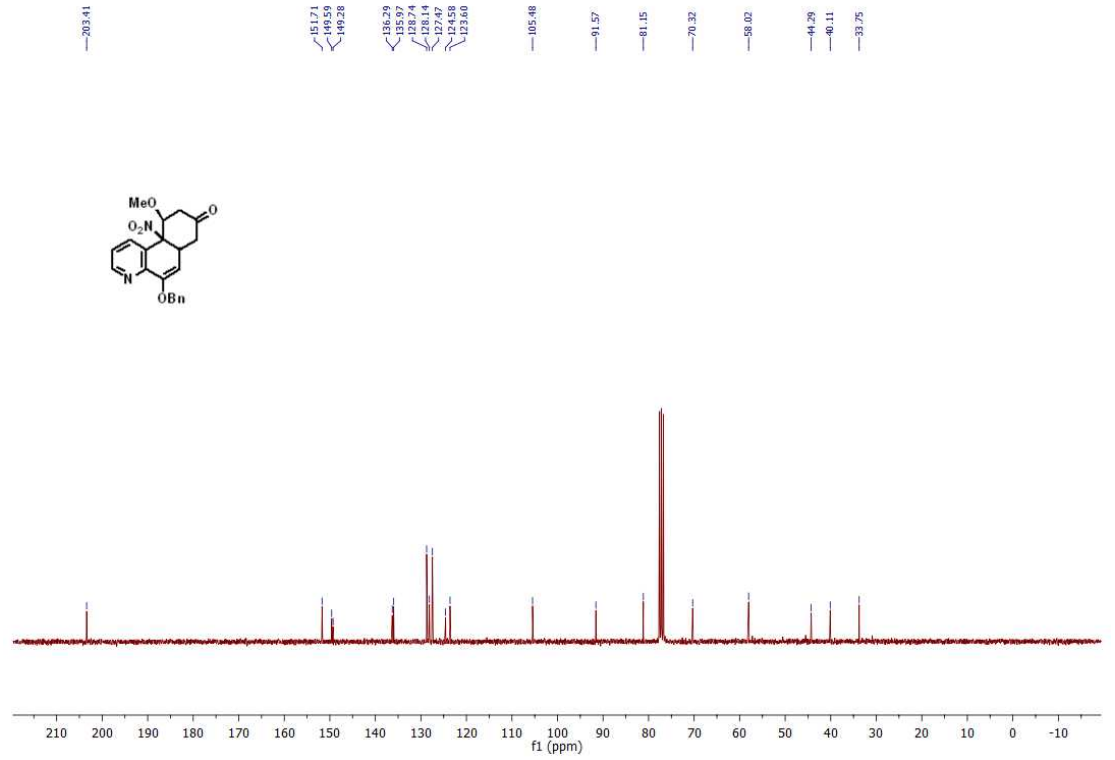


5g (major diastereomer)

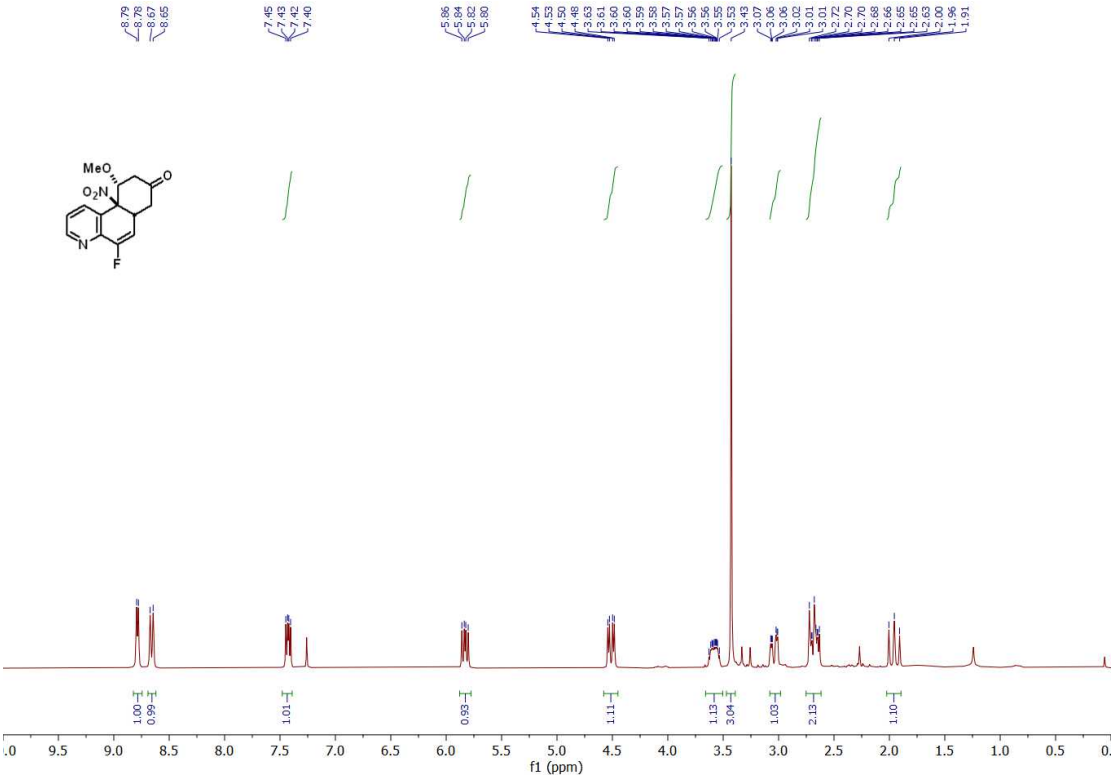


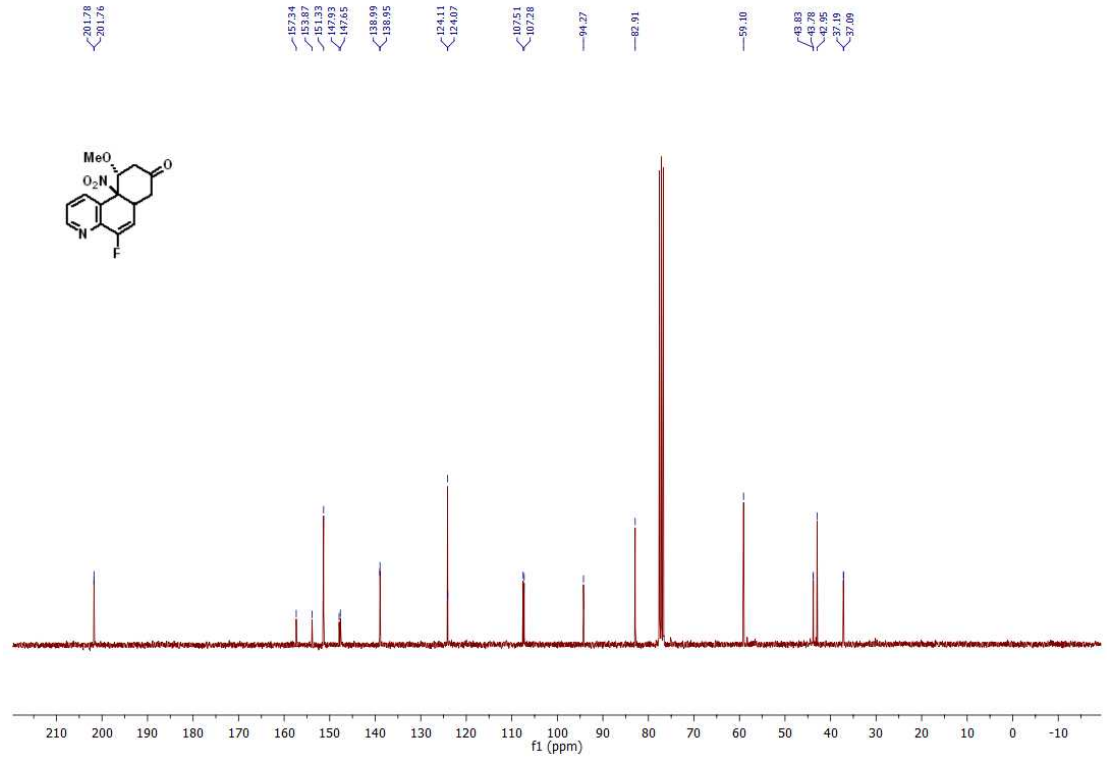
5g (minor diastereomer)

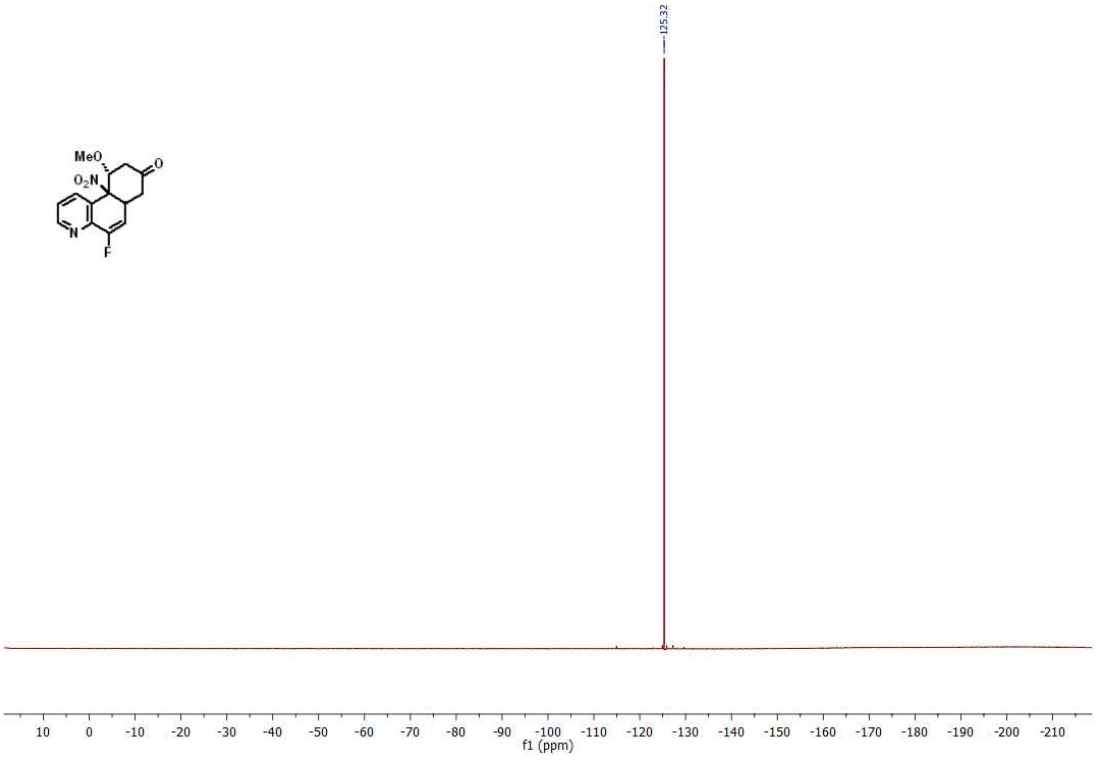




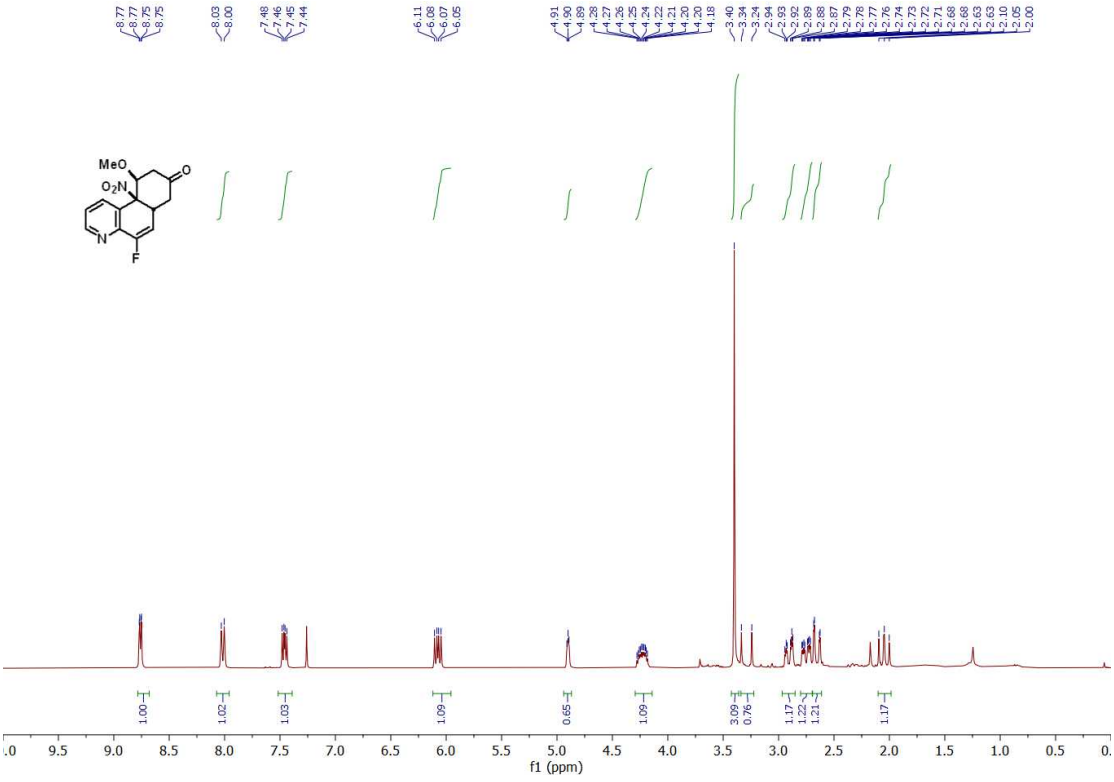
5h (major diastereomer)

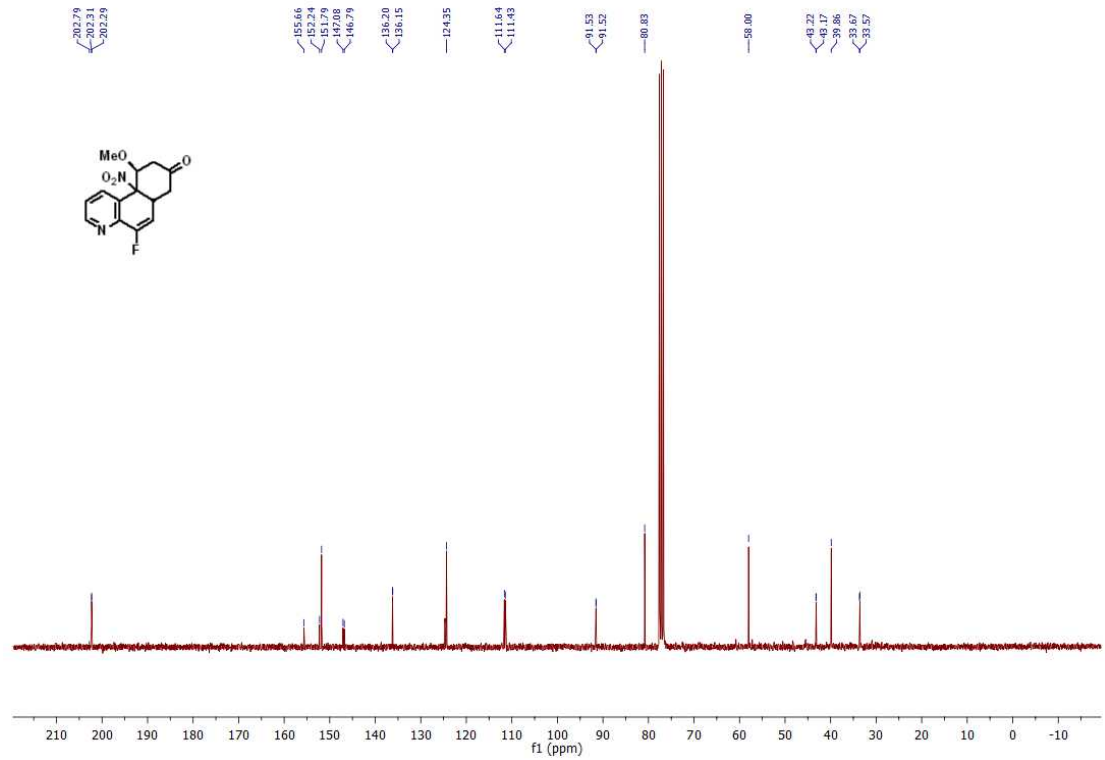


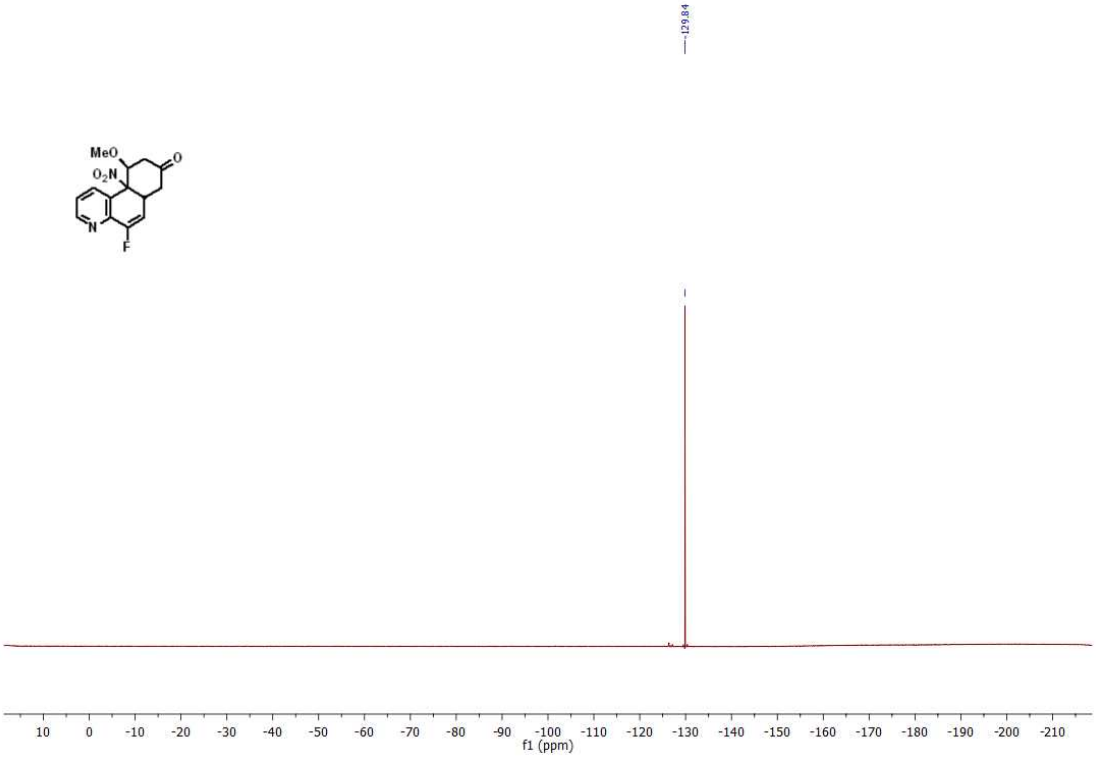



MeO
O2N
O
N
F
-125.32
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

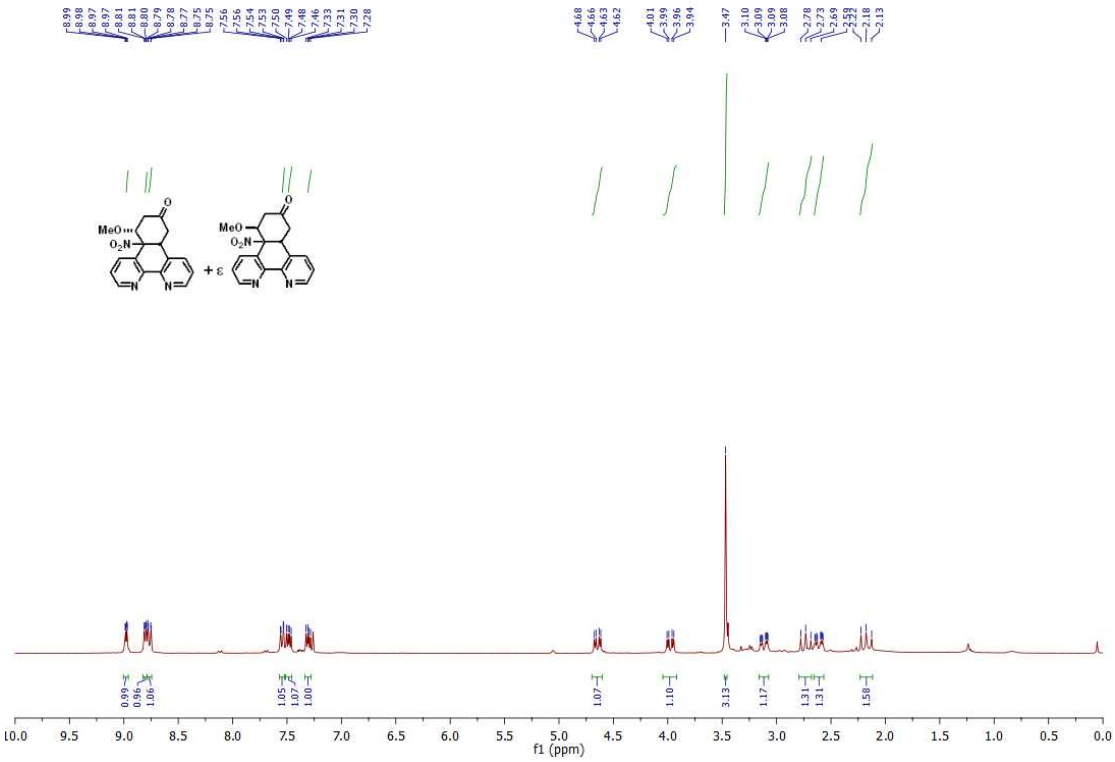
5h (minor diastereomer)

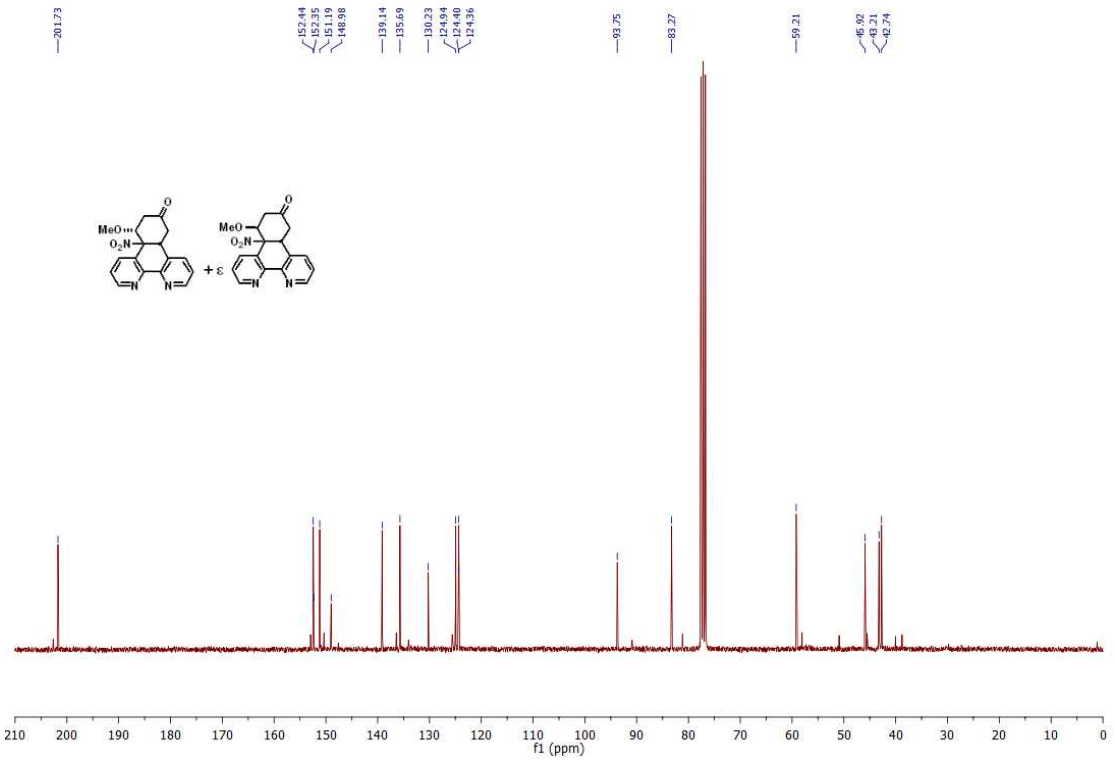




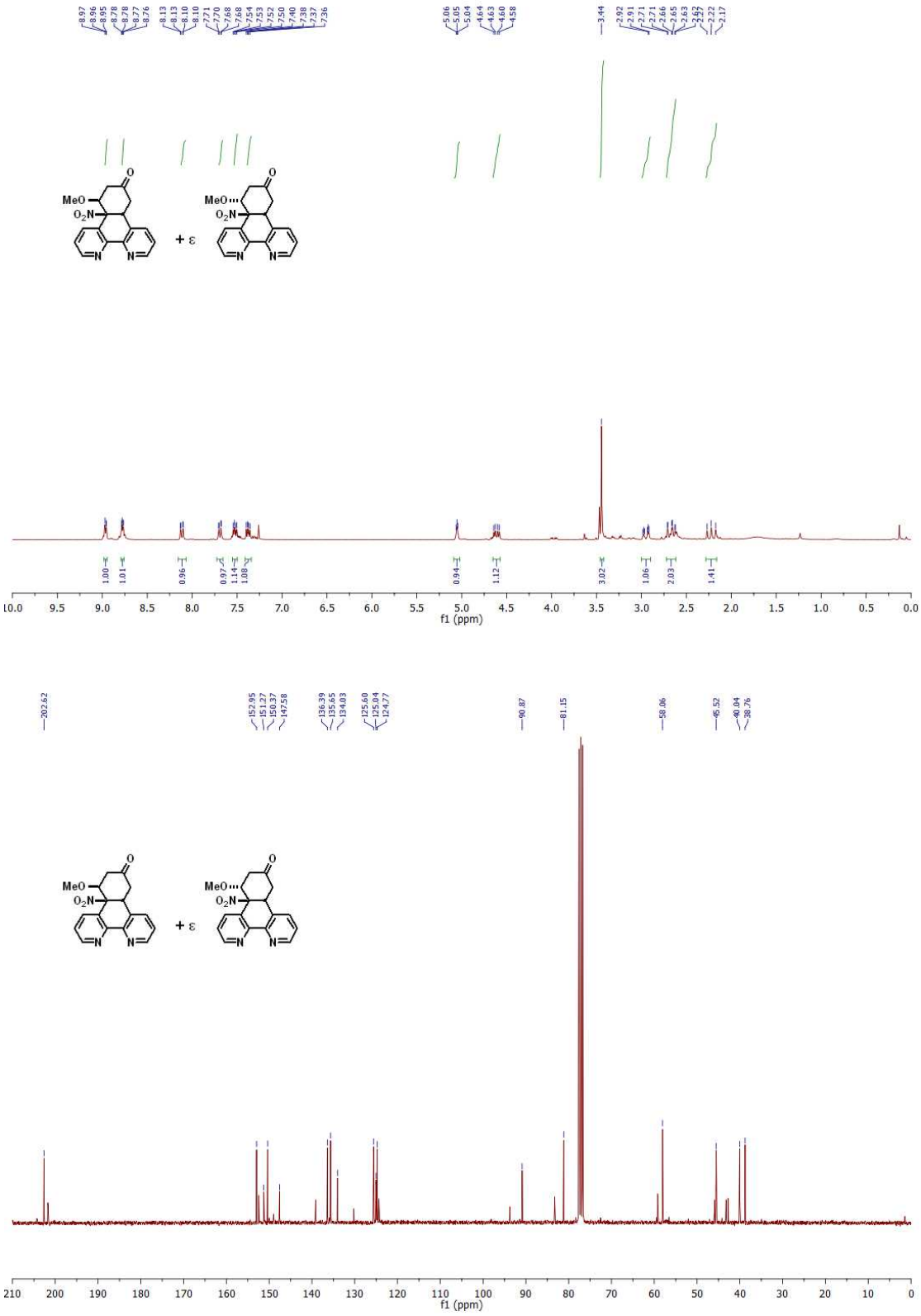

-129.84
MeO
O2N
O
N
F
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

5i (major diastereomer)

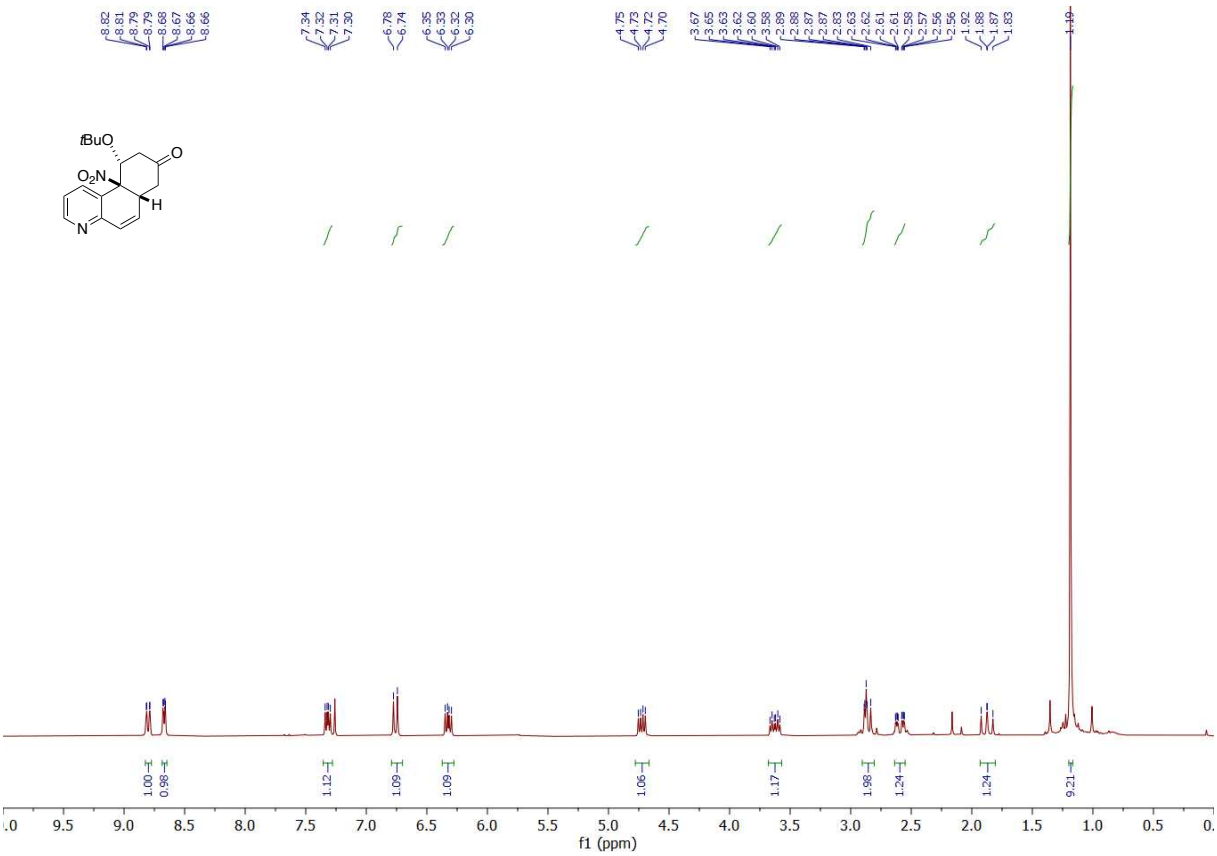


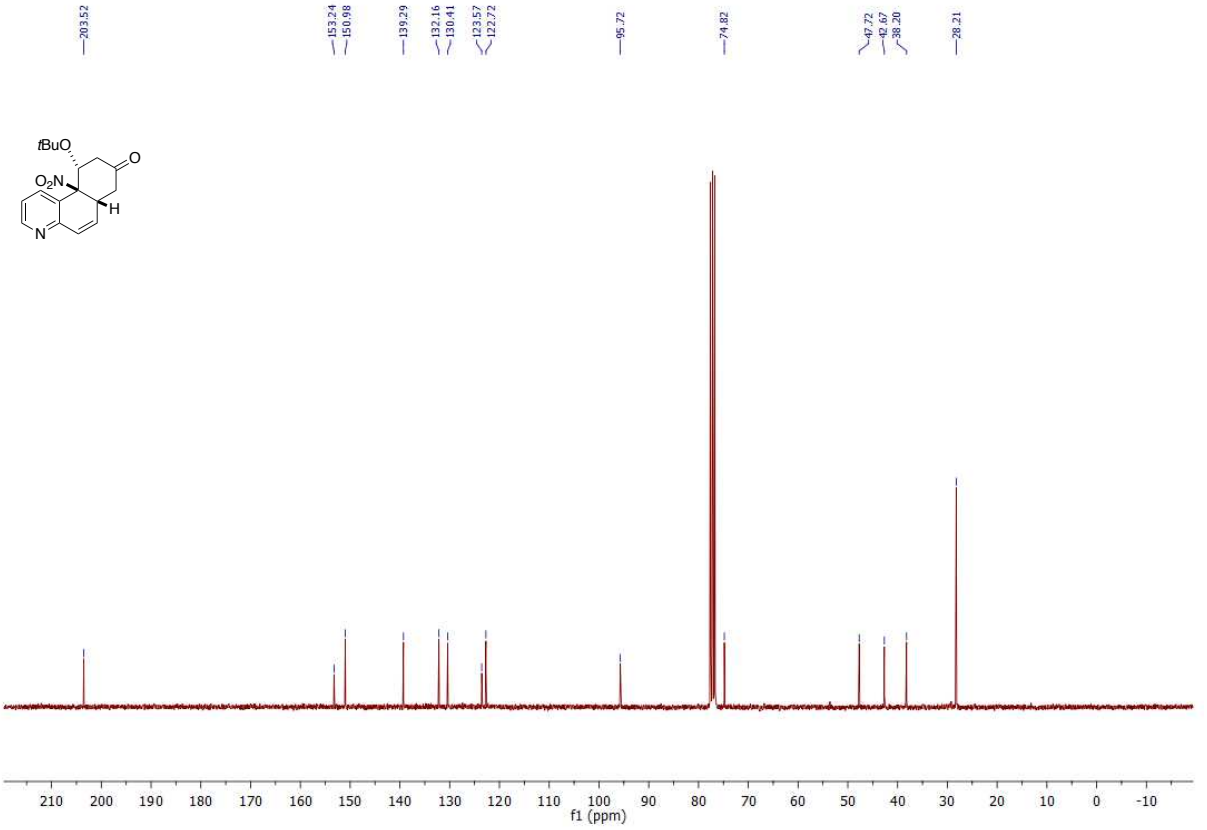


5i (minor diastereomer)

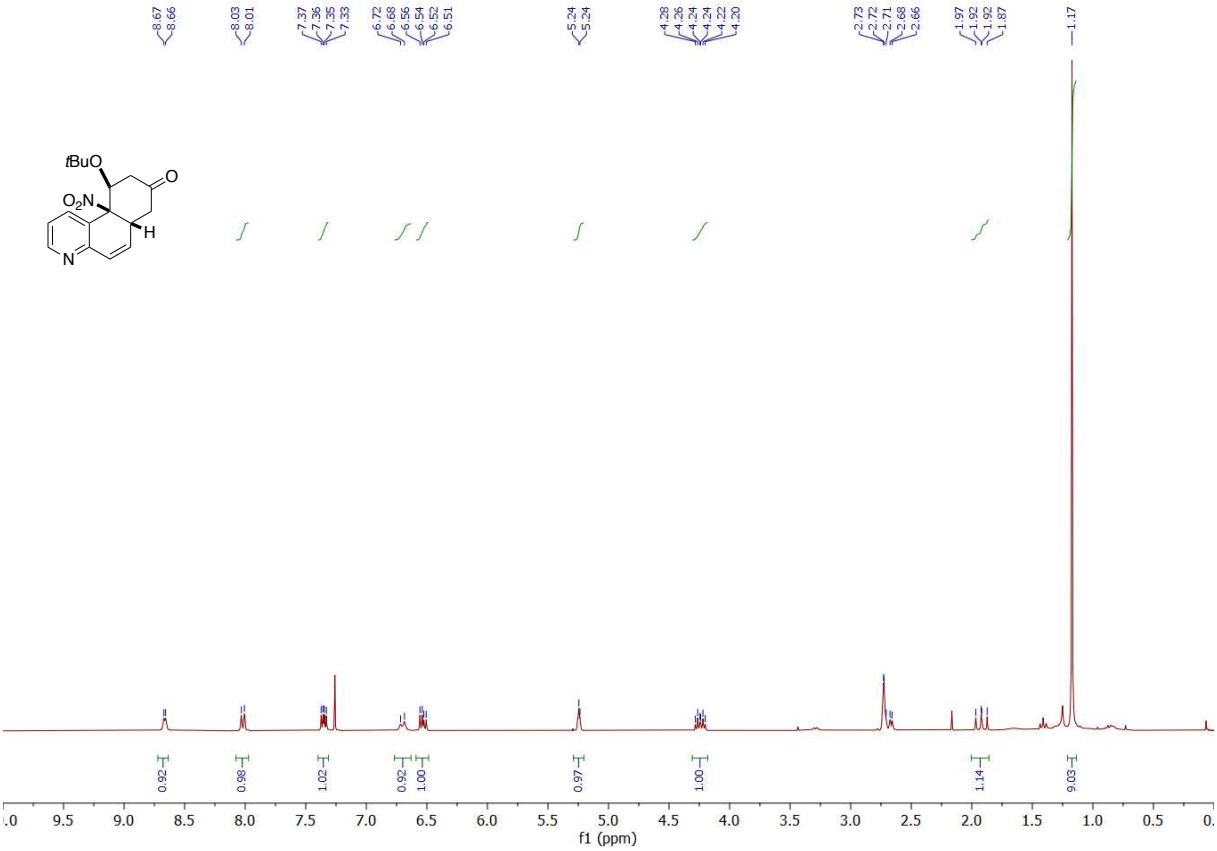


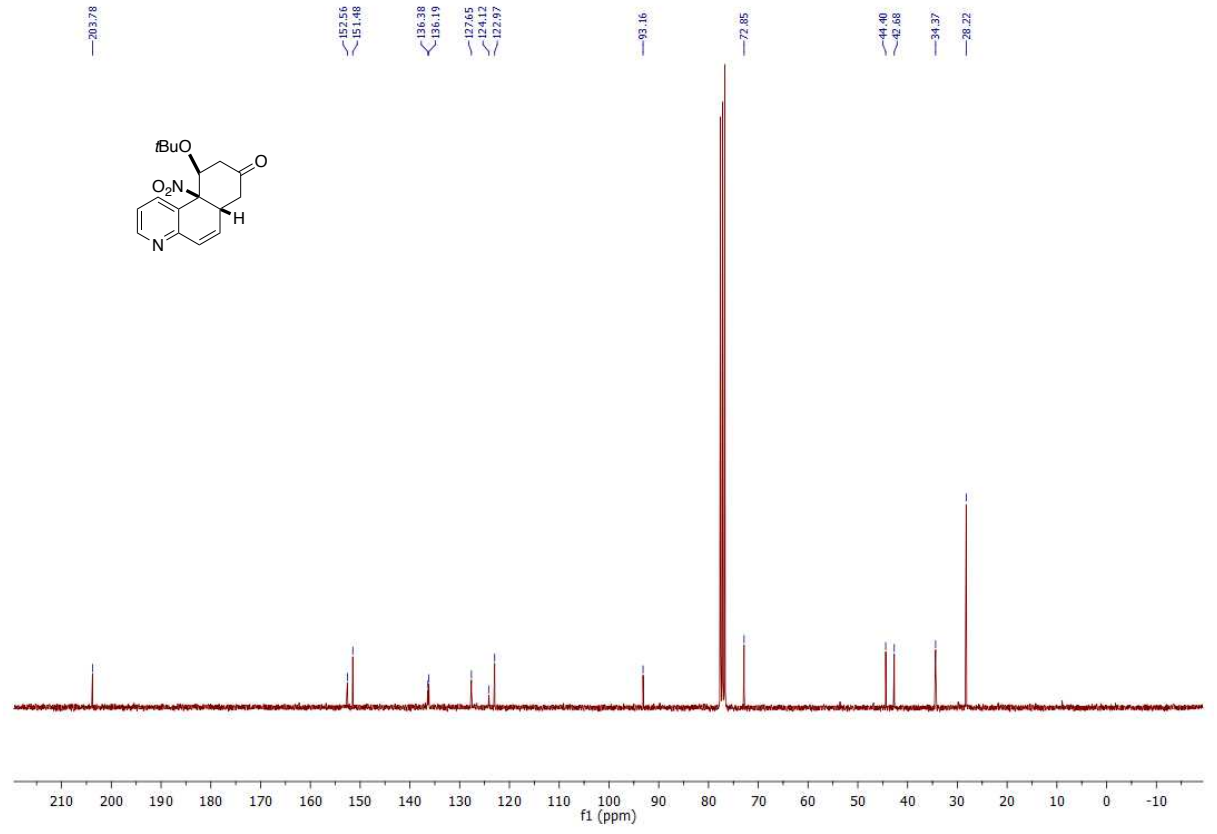
5j (major diastereomer)



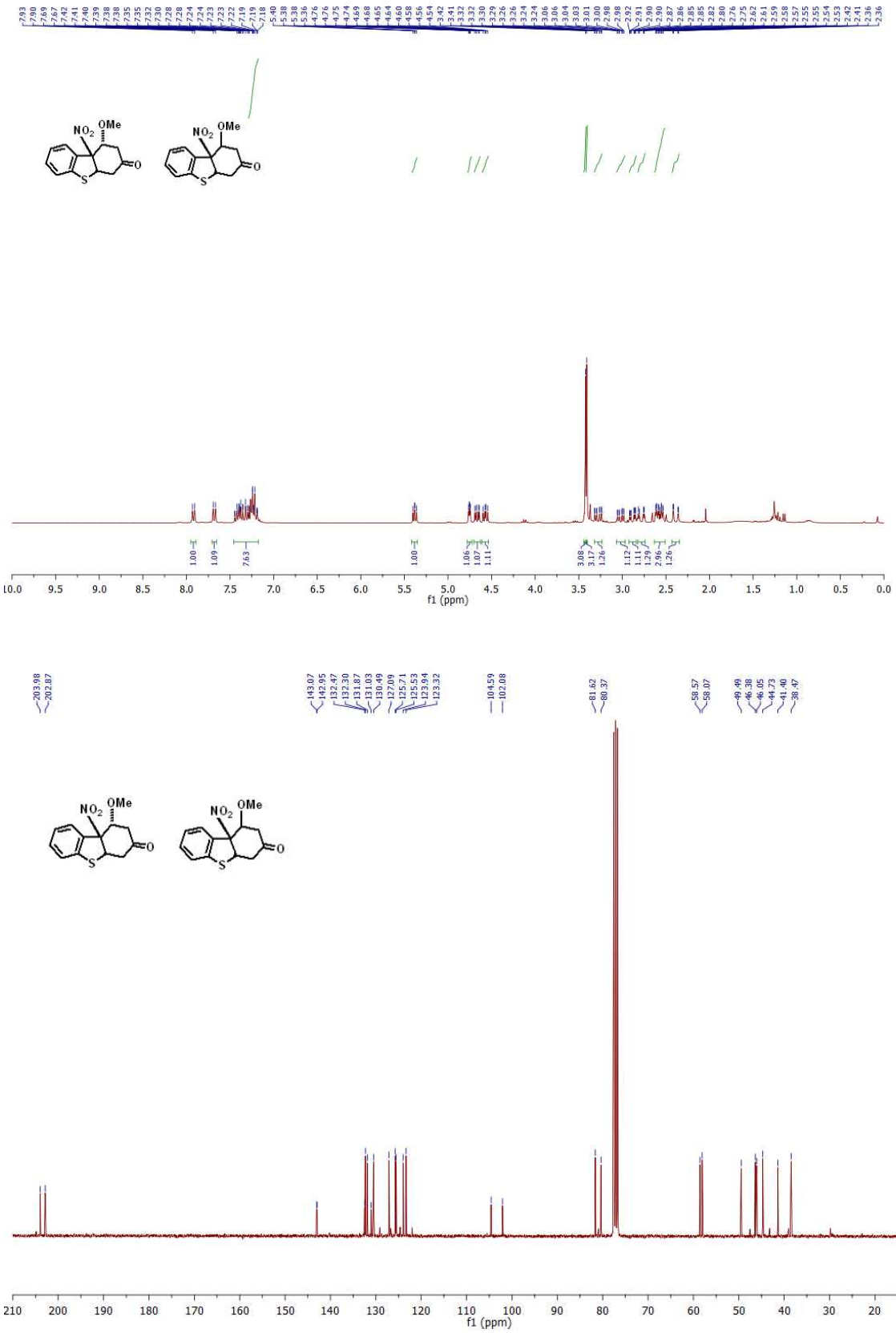


5j (minor diastereomer)

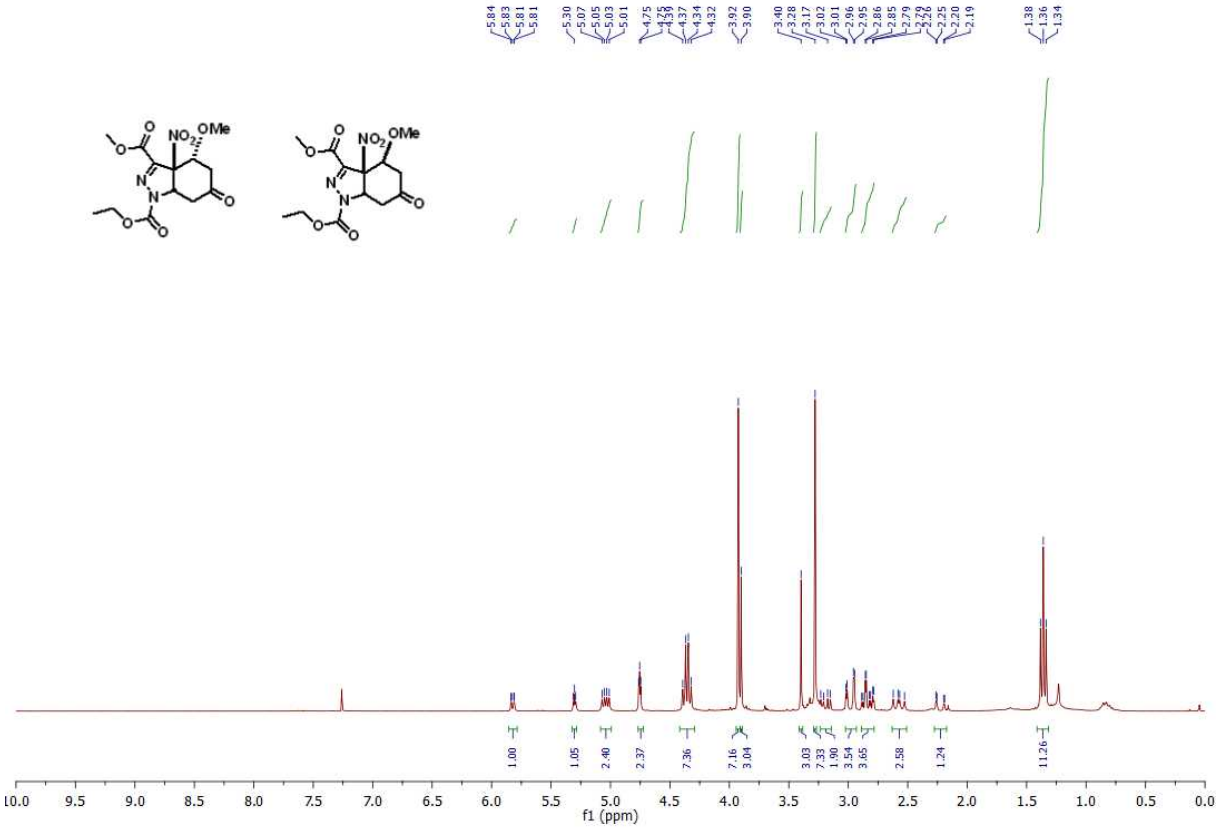


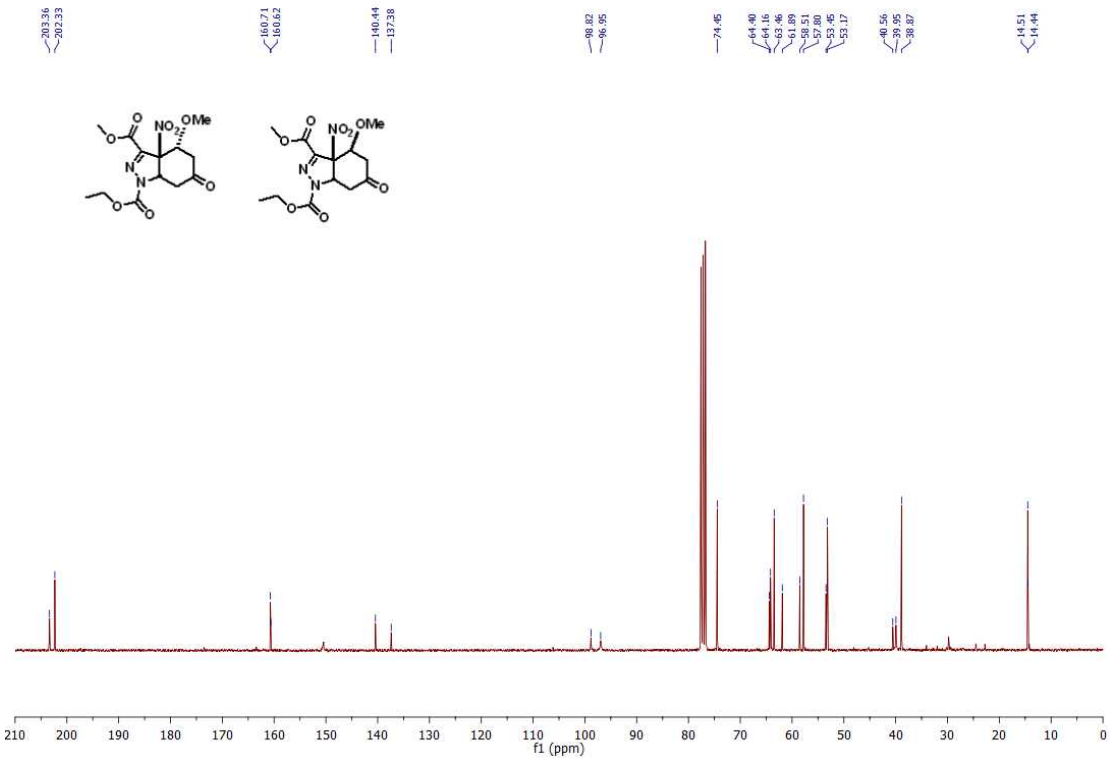


7a

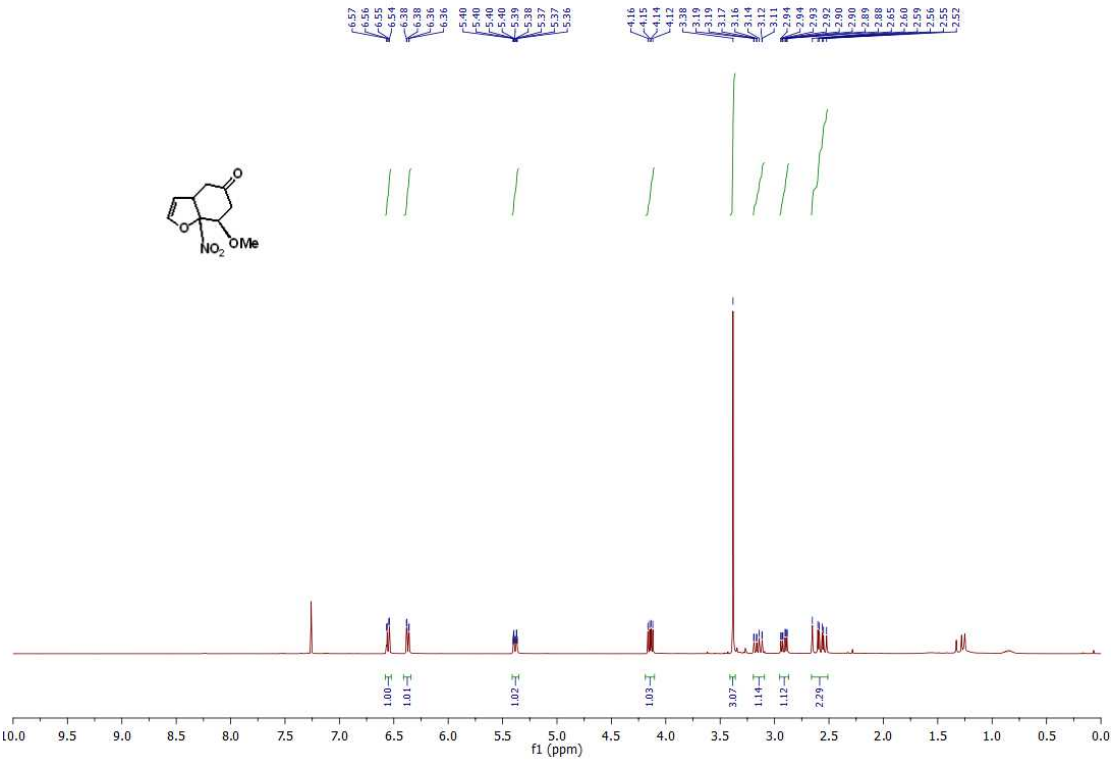


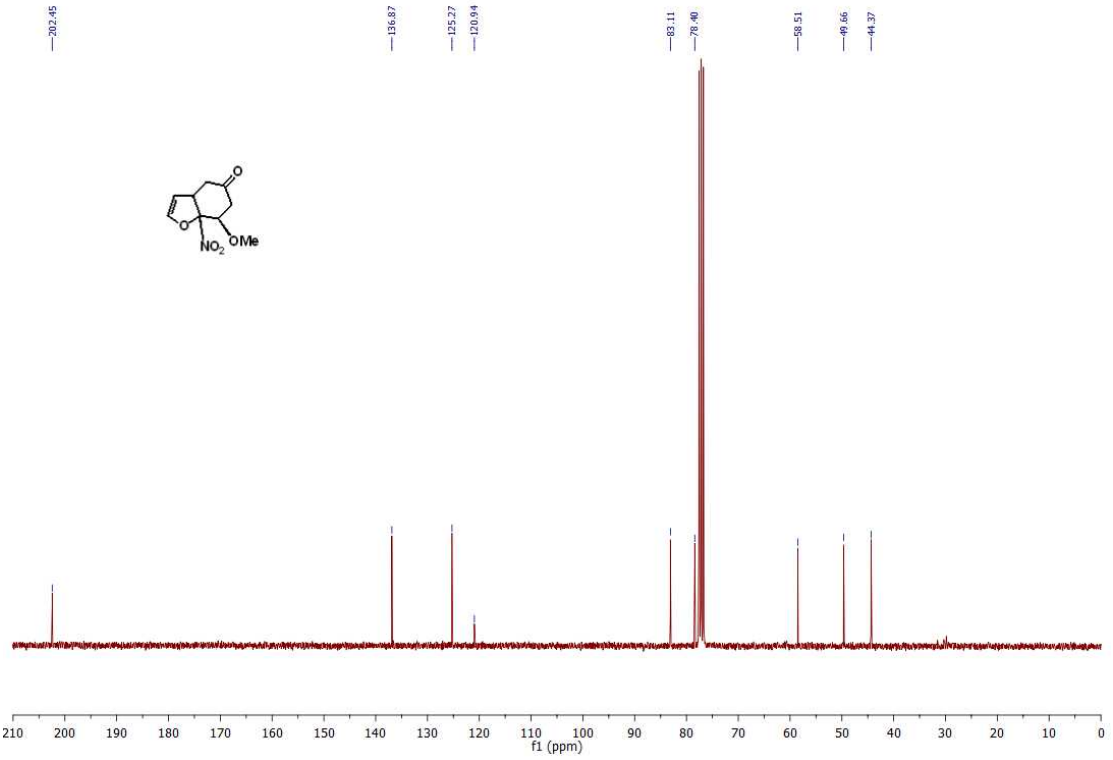
7b


5.84
5.83
5.81
5.81
5.30
5.07
5.05
5.03
5.01
4.75
4.37
4.34
4.32
3.92
3.90
3.40
3.28
3.17
3.02
3.01
2.96
2.95
2.86
2.85
2.79
2.26
2.25
2.20
2.19
1.38
1.36
1.34
NO2
OMe
1.00
1.05
2.40
2.37
7.36
7.16
3.04
3.03
7.33
1.90
3.54
3.65
2.58
1.24
11.26
f1 (ppm)

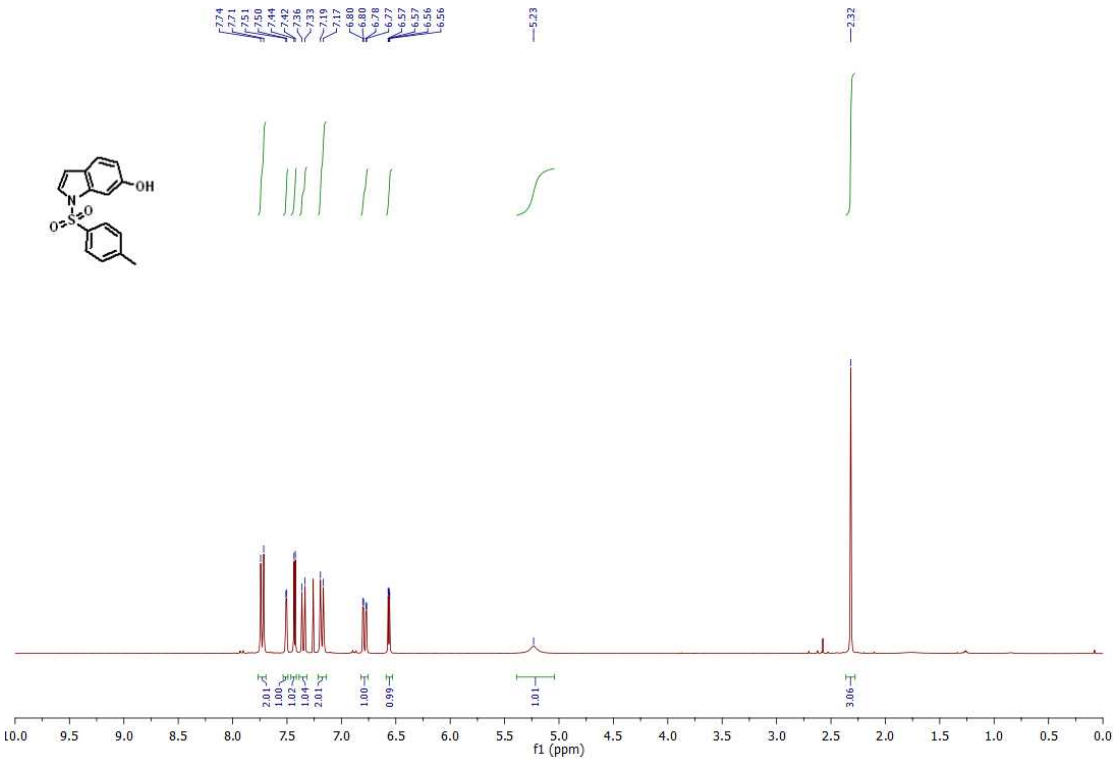

203.36
202.33
160.71
160.62
140.44
137.38
98.82
96.95
74.45
64.40
64.16
63.46
61.89
58.51
57.80
53.45
53.17
40.56
39.95
38.87
14.51
14.44
NO2
OMe
f1 (ppm)

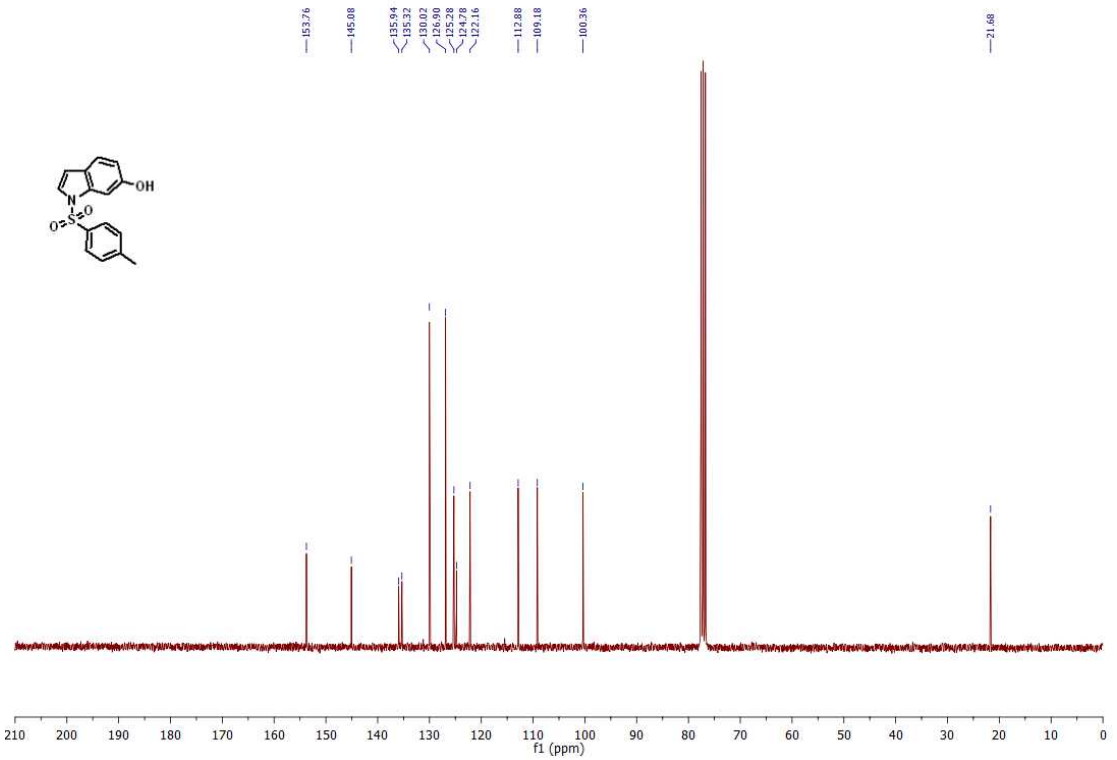
7c


6.57
6.56
6.55
6.54
6.38
6.38
6.36
6.36
5.40
5.40
5.40
5.40
5.39
5.38
5.37
5.37
5.36
4.16
4.15
4.14
4.12
3.38
3.19
3.19
3.17
3.16
3.14
3.12
3.11
2.94
2.94
2.93
2.92
2.90
2.90
2.89
2.88
2.65
2.60
2.59
2.56
2.55
2.52
O
NO2
OMe
1.00
1.01
1.02
1.03
3.07
1.14
1.12
2.29
f1 (ppm)


202.45
136.87
125.27
120.94
83.11
78.40
58.51
49.66
44.37
O
NO2
OMe
f1 (ppm)

8


7.74
7.71
7.51
7.50
7.44
7.42
7.36
7.33
7.19
7.17
6.80
6.78
6.77
6.57
6.56
6.56
5.23
2.32
OH
2.01
1.00
1.02
1.04
2.01
1.00
0.99
1.01
3.06
f1 (ppm)


153.76
145.08
135.94
135.32
130.02
126.90
125.28
124.78
122.16
112.88
109.18
100.36
21.68
OH
f1 (ppm)

Relative stereochemistry assignment for compound 3d

For the conversion of the NOE measurement to distance, the usual relationship between the NOE intensity and the distance between a pair of nuclei for an isolated pair of spin was used:

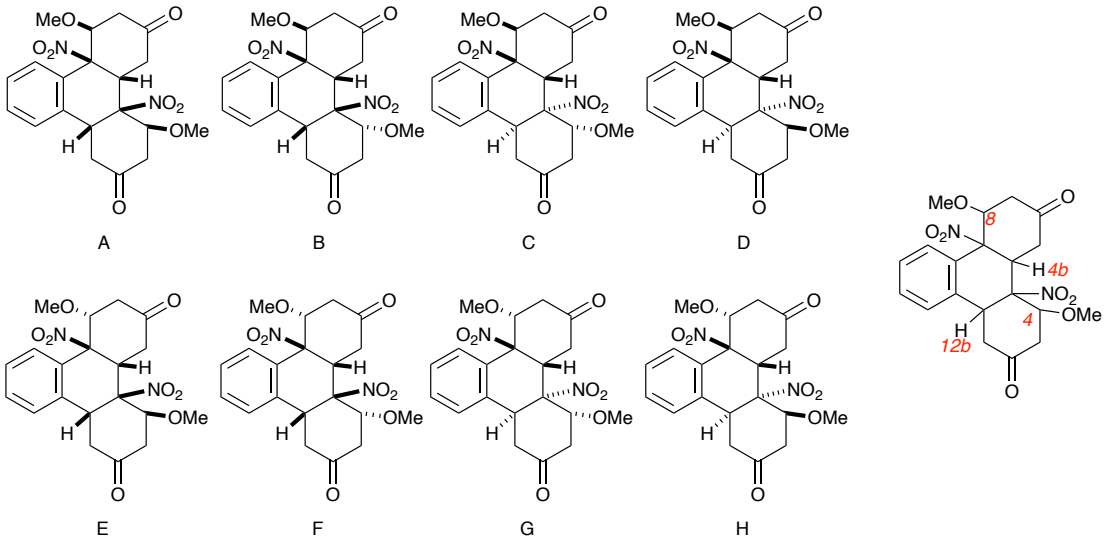
$$d_{ij} = d_{kl} * (NOE_{kl}/NOE_{ij})^{6}$$

where NOE_{ij} and NOE_{kl} are the NOEs between atoms k and l and between i and j, respectively. In the NOESY spectrum, the NOE between diastereotopic protons, corresponding to a distance of 0.18 nm, was used for interproton distance calibration. A range of 20% of the distance values was used for defining the upper and lower bonds of the constraints.

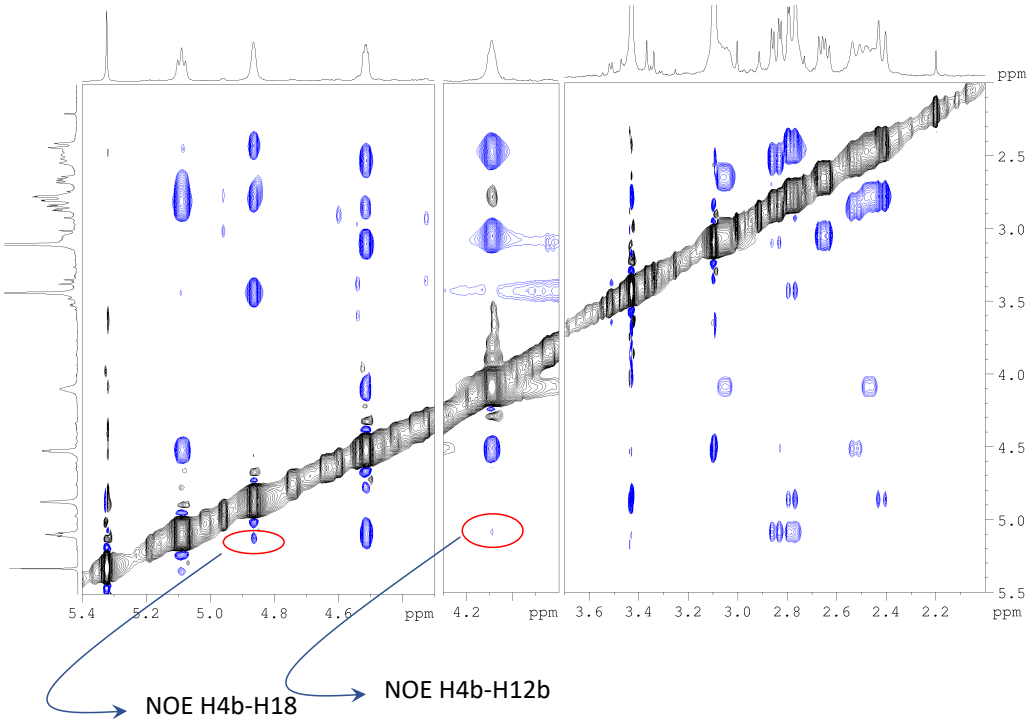
Strong, medium and weak refer to a NOE effect arising from inter-proton distances of 1.5–2.5 Å, 2.5–3.5 Å and over 3.5 Å respectively.

F1: assigned as (4*S**, 4a*R**, 4b*R**, 8*S**, 8a*S**, 12*bS**)

Considering that **3d** is formed through a *bis*-Diels-Alder cycloaddition for which the relative stereochemistries at both ring junctions is imposed by the (pseudo)pericyclic character of the cycloaddition, 8 couples (A-H) of diastereomers can theoretically be obtained:



For this fraction, the strongest NOE correlations observed on the NOESY spectrum do not allow an unambiguous assignment of the relative stereochemistries. The strong NOE correlation observed between H4 and H12b suggests that this fraction may correspond to diastereomer B, D, F or H. Noteworthy, no strong correlation is observed between H4b and H8.
Weak NOE correlations are observed between H4b and H8 on the one side and H4b and H12b (see spectrum below).



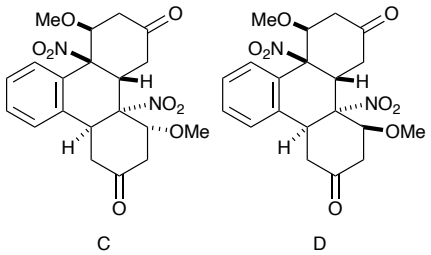
Such low intensities of the NOEs correlations mean that the distance between the hydrogen atoms considered is greater than 3.5 Å.

DFT optimizations of the different tetracyclic structures (A-H) at the M062X-6-31+G(d,p) considering a polarized continuum (SMD:chloroform) to mimic the NMR solvent effects led to the elimination of 6 over the 8 possible stereoisomers, for which the computed distances are below 3 Å (See Table below).

structures	A	B	**C**	**D**	E	F	G	H
d_{H4b-H8} (in Å)[a]	3.9	4.1	**3.7**	**3.8**	4.2	4.0	2.4	2.3
$d_{H4b-H12b}$ (in Å)[a]	2.2	2.4	**3.8**	**3.8**	2.2	2.4	3.8	3.8

[a] computed distances between H4b and H12b or H4b and H8 in the optimized structures

The remaining structures are the C and D ones. Taking into account that the D structure is the one leading to a strong NOE correlation between H4 and H12b, this fraction probably corresponds to the D one.



In order to confirm this assignment, comparison of the theoretical and measured $^3J_{H-H}$ scalar coupling constants was performed. Applying the Karplus equation to

the dihedral angles, extracted from the optimized structures, allowed us to estimate the expected scalar coupling values between H8 and H7 on the one side, H3 and H4 and H12b and H1 on the others.[4]

structures	C	D
Calc.[a]	4.2	**2.3**
^3J H_8-H_7	3.6	**4.0**
Exp. values[b]	1.8	
^3J H_8-H_7	3.9	
Calc. [a]	6.6	**1.3**
^3J H_3-H_4	11.6	**6.3**
Exp. values[b]	3.5	
^3J H_3-H_4	6.4	
Calc. [a]	11.0	**8.9**
^3J H_1-H_{12b}	7.0	**9.1**
Exp. values[b]	8.0	
^3J H_1-H_{12b}	9.3	

a: Calculated $^3J_{H\text{-}H}$ according to the dihedral angle on the optimized structures.[5] b. experimental values on the 1D 1H NMR spectra recorded at 600 MHz in CDCl3 at 300K.

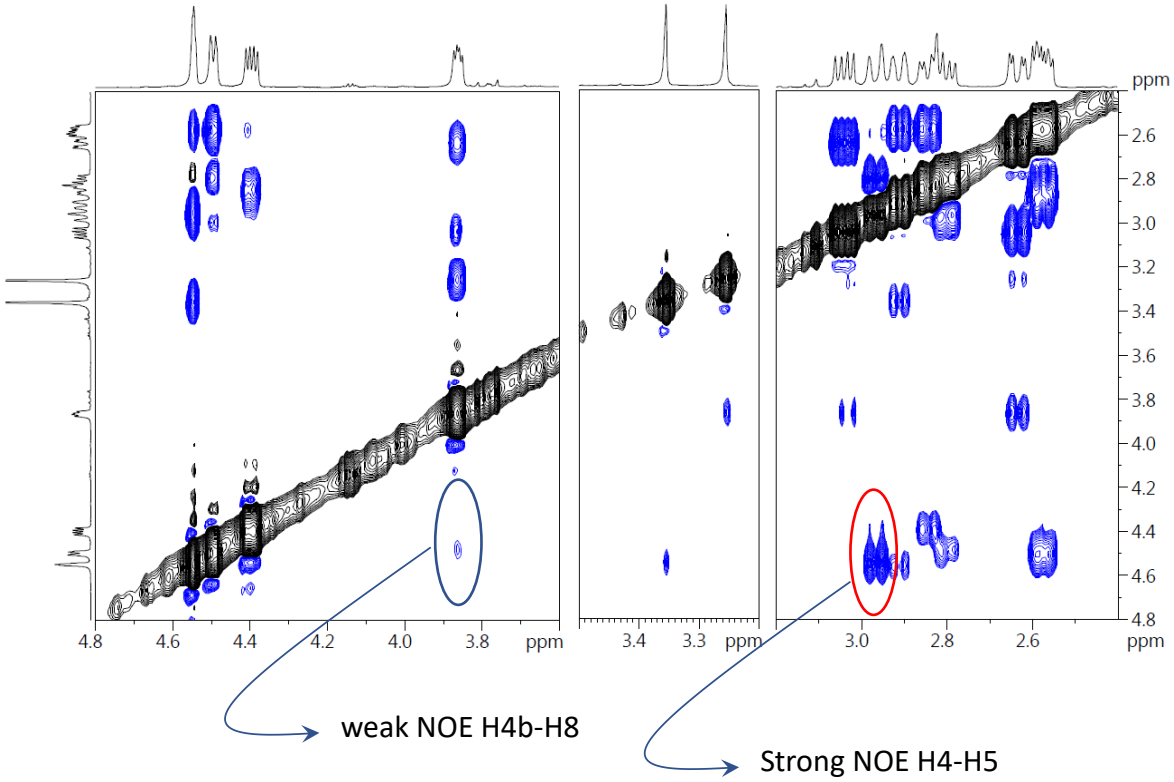
The calculated scalar couplings for structure D are in much better agreement with the experimental data and this confirms the assignment of the relative stereochemistry of structure D for this fraction.

[4] The $^3J_{H,H}$ values were calculated according to Haasnoot, C.A.G. DeLeeuw F.A.A.M. and C. Altona, *Tetrahedron* **1980**, *36*, 2783-2792.

[5] Different conformations (chair- or boat-like conformations for the cyclohexanones) have been considered in the computations and for both these C and D compounds and the scalar couplings (measured/calculated) better fit a structure with a chair-like conformation for the upper cyclohexanone and a boat-like for the lower one (upper/lower as designed on the figure above)

F2: assigned as (4*R**, 4a*S**, 4b*R**, 8*S**, 8a*S**, 12b*R**)

The same methodology was adopted for this fraction. A strong NOE correlation is observed between H4 and one H5, and a weak NOE correlation is seen between H4b and H8 (see spectrum below).



These correlations suggest that this fraction may correspond to diastereomer B or F (See Table below).

structures	A	**B**	C	D	E	**F**	G	H
$d_{H4\text{-}H5}$ (in Å)[a]	4.2	**2.4**	4.5	4.7	3.9	**2.4**	4.4	4.2
$d_{H8\text{-}H4b}$(in Å)[a]	3.9	**4.1**	3.7	3.8	4.2	**4.0**	2.3	2.3

[a] computed distances between H4 and H5 (smallest distance) or H4b and H8 in the optimized structures

The theoretical and measured $^{3}J_{H\text{-}H}$ scalar coupling constants between H8-H7, H12b-H1, H3-H4 and H4b-H5 were compared (See Table below).[6]

[6] The $^{3}J_{H,H}$ values were calculated according to Haasnoot, C.A.G. DeLeeuw F.A.A.M. Altona, C *Tetrahedron* **1980**, *36*, 2783-2792.

structures	**B**	F
Calc.[a]	**12.2**	3.6
^3J H_8-H_7	**5.2**	2.8
Exp. values[b]	8.6	
^3J H_8-H_7	4.8	
Calc. [a]	**5.0**	7.5
^3J H_3-H_4	**1.8**	0.8
Exp. values[b]	3.8	
^3J H_3-H_4	2.4	
Calc. [a]	**12.8**	9.3
^3J H_1-H_{12b}	**3.9**	8.8
Exp. values[b]	12.2	
^3J H_1-H_{12b}	5.8	
Calc. [a]	**6.3**	6.4
^3J H_{4b}-$H5_b$	**1.2**	1.1
Exp. values[b]	8.2	
^3J H_{4b}-H_5	2.3	

a: Calculated $^3J_{H\text{-}H}$ according to the dihedral angle on the optimized structures.[7] b. experimental values on the 1D 1H NMR spectra recorded at 600 MHz in CDCl3 at 300K.

The calculated scalar couplings for structure B are in better agreement with the experimental data and this prompts us to propose the relative stereochemistry of structure B for this fraction. Note that the differences between computed and experimental data are attributed to conformational flexibility in solution. An X-ray structure would allow an unambiguous assignment but efforts dedicated to the crystallization of this compound as monocrystals unfortunately failed at this time.

[7] Different conformations (chair- or boat-like conformations for the 2 cyclohexanone moieties) have been considered in the computations and for both these C and D compounds and the scalar couplings (measured/calculated) better fit a structure with a chair-like conformation for the upper cyclohexanone and a boat-like for the lower one (upper/lower as designed on the figure above)

Computations

Computational Details

Computations were run by using the Gaussian 16 set of programs.[8] Full geometry optimizations were carried out in the absence of symmetry constraints at the M062X/6-31+G(d,p) level of theory,[9,10] considering a polarized continuum (SMD:DCM) to mimic the experimental solvent effects,[11] a level which had proven adequate in previous related calculations. The nature of the minima (or TS) was checked by harmonic frequency evaluations to show the presence of no (or one and only one) imaginary frequencies. The connectivity between reactants and products was confirmed by IRC calculations and computing force constants at every step. After the IRC calculations, all adducts were optimized. The harmonic frequencies were used unscaled for the evaluation of the thermodynamic data of the reaction. They were computed by using the standard Gaussian values (T = 298.15 K and P = 1 atm). The activation/reaction Gibbs free energies were computed as the difference between the separated reactants and the TS/products.

Energy profiles

Calculations involved a 1-nitronaphthalene derivative and 1-methoxy-3-trimethylsilyloxybutadiene. Firstly, two approaches (*endo* and *exo*) and four conformations for each were considered (rotation around the OMe and O-TMS bonds) for the diene in its *s*-cis conformation. Two approaches with a *s-trans* diene conformation were also considered. This led to the evaluation of 10 different approaches, that were computed at the M062X/6-31G(d) level of theory considering a polarized continuum (SMD:DCM). Results are compiled in the Table below.

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[9] Y. Zhao and D. G. Truhlar, "The M06 suite of density functionals for main group thermochemistry, thermochemical kinetics, noncovalent interactions, excited states, and transition elements: two new functionals and systematic testing of four M06-class functionals and 12 other functionals," *Theor. Chem. Acc.*, **120** (2008) 215-41.

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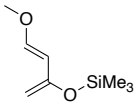
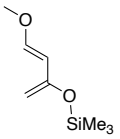
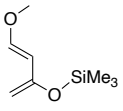
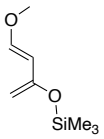
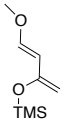
[11] J. Ho and M. Z. Ertem, *J. Phys. Chem. B*, 2016, **120**, 1319–1329.

Diene conf.					
TS *endo* $\Delta G^{\ddagger}$ [a]	29.0	29.6	28.6	29.3	30.9
TS *exo* $\Delta G^{\ddagger}$ [a]	28.6	29.2	30.5	31.1	31.3

a.TS activation free energy (in kcal.mol^{-1}) computed as the difference between the TS and separated 1-nitronaphthalene and Danisfefsky diene in its s-trans most favorable conformation

The most favoured diene conformations for both the endo and exo approaches (highlighted in the Table above) were then considered at the M062X/6-31+G(d,p) level of theory, still considering a polarized continuum (SMD:DCM) for the complete reaction paths. TS activation and adducts free energies (in kcal.mol^{-1}) were computed as the difference between the TS and separated 1-nitronaphthalene and Danisfefsky diene in its s-cis reactive conformation (since only reactive dienic s-cis conformations had to be considered here). A stepwise mechanism was calculated for this cycloaddition process, involving the formation of a zwitterionic primary adduct (**PA**) in the first step and the cyclisation via a Michael addition to generate the cycloadduct (**CA**) in the second. Considering the low energy barrier for the cyclization step compared to the first step (3.4 and 5.8 kcal.mol^{-1} compared to 26.7 and 27.1 kcal.mol^{-1}), this can be considered as an inflection point of the potential energy surface and the cycloaddition as *pseudo*-concerted pathway. The differences between the *endo* and *exo* approaches for the rate determining step is very small ($\Delta\Delta G^{\ddagger}$ = 0.2 kcal.mol^{-1}), in line with the experimental data (low *dr* between 1:1 and 2:1).

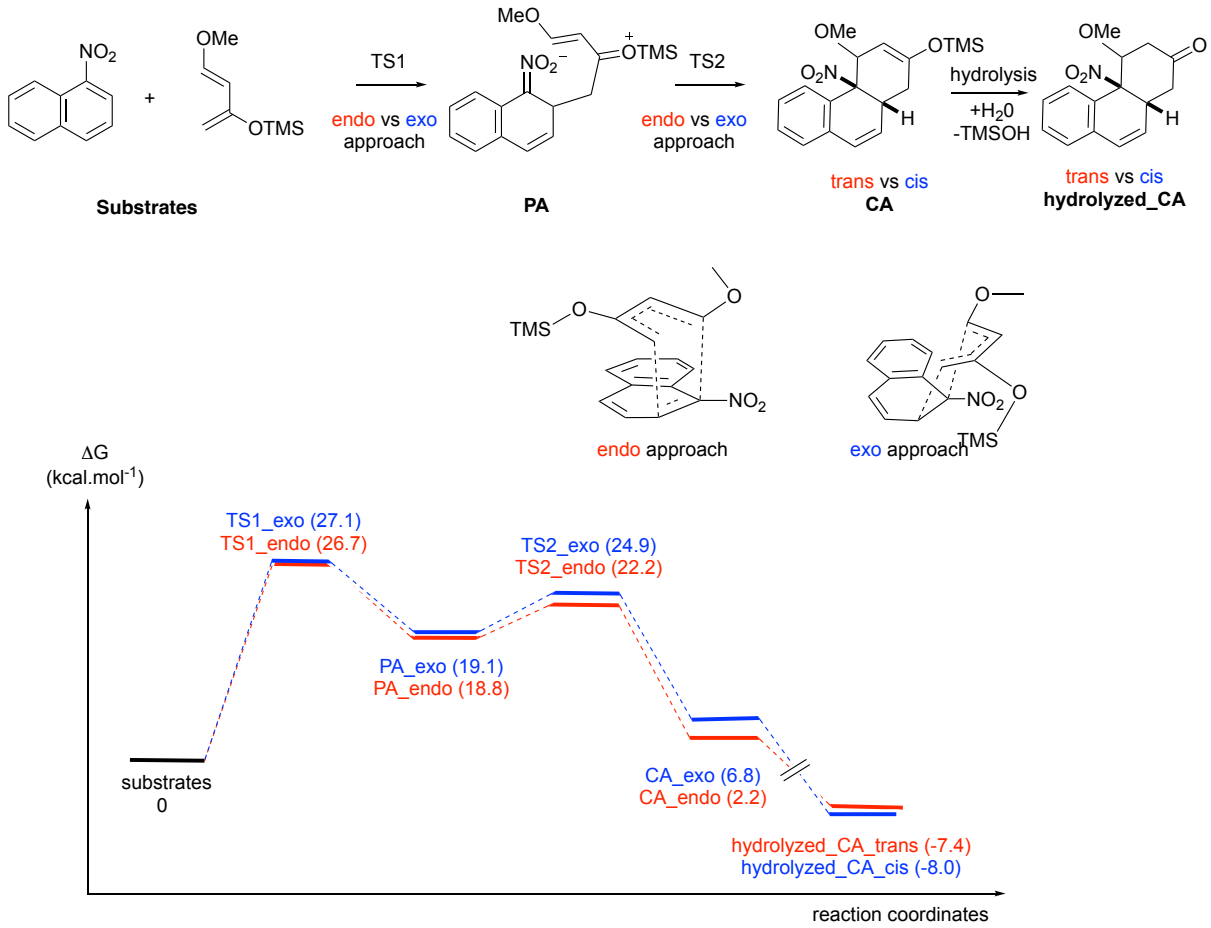


Figure: Energy profiles for the cycloaddition of *N*-methylsulfonyl-3-nitroindole with diene **4**; *endo* approach (red); *exo* approach (blue) at the SMD-M062X/6-31+G(d,p) level.

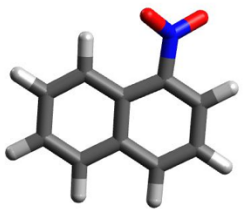
Total energy and cartesina coordinates:

- 1-nitronaphthalene

Electronic Energy = -590.186545 a.u.

Sum of electronic and thermal free energies = -590.070394 a.u.

Number of imaginary frequencies: 0



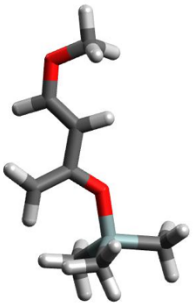
C	-0.05302	-0.07632	-0.16803
C	-0.06593	0.02015	1.20092
C	1.14183	0.07224	1.94834
C	2.40448	-0.00067	1.28384
C	2.35101	-0.11733	-0.13801
C	1.17933	-0.13567	-0.85228
C	1.10501	0.20909	3.36285
N	3.58078	-0.24519	-0.92691
C	3.59117	0.10261	2.06230
H	-1.00741	0.06496	1.74163
H	-0.97828	-0.11239	-0.73236
H	1.21013	-0.21846	-1.93294
C	3.51480	0.24528	3.42700
H	4.56044	0.06988	1.58258
H	4.43048	0.32590	4.00458
C	2.26478	0.29001	4.09024
H	0.13542	0.25567	3.85085
O	3.60882	0.28022	-2.02898
O	4.50608	-0.89079	-0.45900
H	2.22987	0.39681	5.16978

-Danishefsky diene (s-cis conformation)

Electronic Energy = -754.233002588 a.u.

Sum of electronic and thermal free energies = -754.050621a.u.

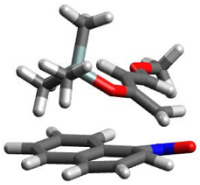
Number of imaginary frequencies: 0



C	-0.28039	-0.34465	0.20480
C	-0.12231	-0.22431	1.53456
O	1.05139	0.10525	2.14162
Si	2.59706	0.26651	1.45386
C	-1.19340	-0.44065	2.52272
C	-2.46255	-0.08152	2.27380
H	0.51454	-0.12053	-0.49741
H	-1.22925	-0.67993	-0.19620
H	-0.89329	-0.86851	3.47421
O	-3.52911	-0.24831	3.07886
H	-2.74893	0.41126	1.34798
C	3.69963	0.49052	2.94279
C	3.04932	-1.29036	0.51669
C	2.65408	1.78178	0.35680
C	-3.29962	-0.89433	4.32420
H	-4.26873	-0.95933	4.81785
H	-2.89276	-1.89965	4.16797
H	-2.60822	-0.30974	4.94111
H	4.73968	0.63893	2.63143
H	3.39370	1.36355	3.52901
H	3.66300	-0.38888	3.59464
H	4.13211	-1.30596	0.34417
H	2.79120	-2.18164	1.09946
H	2.55470	-1.36304	-0.45614
H	3.68324	1.95259	0.01920
H	2.02266	1.68510	-0.53162
H	2.33140	2.67077	0.90983

-TS1_endo

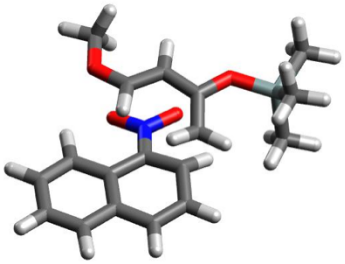
Electronic Energy = -1344.40130597 a.u. ($\Delta E_e^{\ddagger}$ = 11.4 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.078519 a.u. ($\Delta G^{\ddagger}$ = 26.7 kcal.mol^{-1})
Number of imaginary frequencies: 1 at --499.86



C	-1.23885	-2.41317	-6.43271
C	-1.49041	-2.30139	-5.07792
C	-0.44109	-2.29147	-4.13984
C	0.90999	-2.43624	-4.57041
C	1.14228	-2.53574	-5.96429
C	0.09056	-2.51613	-6.86737
C	-0.74838	-2.13414	-2.73514
C	0.22357	-2.03874	-1.80265
C	1.62120	-2.07069	-2.18823
C	1.92571	-2.42313	-3.53349
C	2.29231	-0.16192	-1.77351
C	1.61163	0.62336	-2.69711
C	1.99336	0.74599	-4.07604
C	3.12214	0.17723	-4.57045
O	3.36809	0.18520	-5.87542
C	4.65631	-0.30634	-6.27828
N	3.26937	-2.73461	-3.78393
O	4.10938	-2.53565	-2.88126
O	0.45920	1.15457	-2.28550
Si	-0.70132	2.15999	-3.05075
C	-1.59852	1.19150	-4.37051
C	0.15954	3.67405	-3.73080
C	-1.83889	2.59385	-1.64125
O	3.62091	-3.19624	-4.88377
H	1.97655	-0.08383	-0.73793
H	3.33476	-0.40672	-1.94356
H	-0.58512	4.45764	-3.91424
H	0.68084	3.48379	-4.67373
H	0.88451	4.06595	-3.00882
H	-2.25700	1.68857	-1.18807
H	-1.30863	3.15383	-0.86390
H	-2.67120	3.21077	-1.99773
H	-2.15940	0.36422	-3.92301
H	-2.31616	1.84917	-4.87603
H	-0.92815	0.77819	-5.13124
H	1.31876	1.22533	-4.77861
H	3.88221	-0.28784	-3.94154
H	4.61356	-0.41708	-7.36091
H	4.85482	-1.27498	-5.81224
H	5.42848	0.41912	-6.00726
H	2.32997	-2.40670	-1.43940
H	-0.01678	-1.91644	-0.75105
H	-1.79619	-2.10204	-2.44534
H	2.15270	-2.62453	-6.33500
H	0.30824	-2.58868	-7.92912
H	-2.05525	-2.41467	-7.14813
H	-2.51015	-2.20590	-4.71259

-TS1_exo

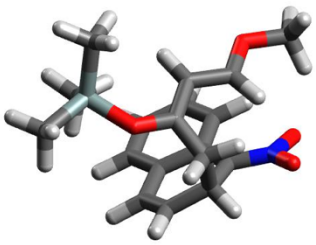
Electronic Energy = -1344.40297841 a.u. ($\Delta E_e^{\ddagger}$ = 10.4 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.077830 a.u. ($\Delta G^{\ddagger}$ = 27.1 kcal.mol^{-1})
Number of imaginary frequencies: 1 at -508.60



C	-3.36359	2.90707	-0.24655
C	-2.12560	2.82610	0.43772
C	-1.02085	3.53910	-0.11643
C	-1.18503	4.30527	-1.28600
C	-2.40552	4.37109	-1.93295
C	-3.49169	3.65884	-1.40437
C	0.27113	3.50213	0.53347
C	0.50641	2.70209	1.59422
C	-0.53391	1.81752	2.09800
C	-1.86196	2.05714	1.63942
N	-2.87563	1.48702	2.42803
O	-4.07430	1.67248	2.15355
O	-2.54305	0.80145	3.41273
C	0.12277	0.06095	1.32761
C	-0.75288	-0.92759	1.79023
C	-2.05806	-1.15280	1.23879
C	-2.51948	-0.46849	0.15980
O	-3.76114	-0.49168	-0.31253
C	-4.74267	-1.22149	0.42808
O	-0.49496	-1.66045	2.87338
Si	0.90167	-1.76460	3.86330
C	1.25408	-0.09949	4.63647
C	2.32714	-2.38631	2.82706
C	0.39225	-3.01193	5.14800
H	1.14333	0.05668	1.69775
H	0.02103	0.37834	0.29570
H	0.35665	0.30603	5.11658
H	2.01927	-0.22233	5.41257
H	1.62848	0.63543	3.91654
H	2.66428	-1.65772	2.08358
H	3.17769	-2.61609	3.47960
H	2.04877	-3.30734	2.30341
H	1.20618	-3.17848	5.86217
H	0.14330	-3.97267	4.68541
H	-0.48295	-2.66192	5.70530
H	-2.70457	-1.81229	1.80628
H	-1.88696	0.16651	-0.45298
H	-4.50689	-2.29023	0.42091
H	-4.79308	-0.84795	1.45490
H	-5.68922	-1.04674	-0.08113
H	-0.44270	1.49771	3.12898
H	1.48086	2.67499	2.07308
H	1.05375	4.14839	0.14352
H	-0.32508	4.84578	-1.67378
H	-2.52048	4.96238	-2.83595
H	-4.45480	3.69179	-1.90564
H	-4.21808	2.36705	0.13269

-PA_endo

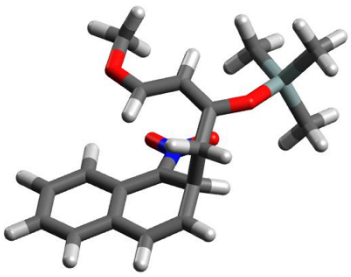
Electronic Energy = -1344.41728074 a.u. (ΔE_e = 1.4 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.091065 a.u. (ΔG = 18.8 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	0.83644	-2.14448	0.29168
C	2.00186	0.52501	-0.15732
C	0.49856	-1.94255	1.74297
C	1.00096	-0.55868	2.34334
C	0.39066	0.58765	1.63044
C	0.86212	1.06617	0.40335
C	-0.96163	-2.12361	2.03098
C	-1.88720	-2.15420	1.06565
C	-1.53980	-2.01887	-0.34920
C	-0.17572	-2.02142	-0.75439
C	0.09011	-1.84823	-2.13044
C	-0.94259	-1.69497	-3.05281
C	-2.27775	-1.72291	-2.64744
C	-2.56167	-1.88652	-1.29587
N	2.13109	-2.41988	0.03214
O	2.54995	-2.68013	-1.13951
O	2.34501	0.85707	-1.36544
C	3.60175	0.34124	-1.86884
O	-0.68958	1.05813	2.18610
Si	-1.88037	2.21531	1.64226
C	-1.00992	3.83557	1.32589
O	2.97685	-2.38595	0.98982
C	-3.01238	2.29641	3.11302
C	-2.69843	1.48399	0.13798
H	0.70310	-0.51713	3.39324
H	2.08901	-0.55626	2.27294
H	-1.73399	4.65226	1.42809
H	-0.57486	3.90128	0.32446
H	-0.21579	4.00236	2.06198
H	-3.86082	2.95668	2.90248
H	-3.40485	1.30316	3.35481
H	-2.48851	2.68554	3.99221
H	-3.24701	0.57490	0.40563
H	-3.41630	2.20379	-0.27277
H	-1.98329	1.23480	-0.65304
H	0.31106	1.80864	-0.16401
H	2.67113	-0.15251	0.37775
H	3.54891	0.44299	-2.95107
H	3.70674	-0.70852	-1.58628
H	4.41250	0.95282	-1.46795
H	1.07407	-2.66810	2.32856
H	-1.24829	-2.20321	3.07726
H	-2.94060	-2.26930	1.31312
H	1.11507	-1.84094	-2.47290
H	-0.69559	-1.56146	-4.10240
H	-3.08036	-1.61847	-3.37107
H	-3.59328	-1.90680	-0.95147

-PA_exo

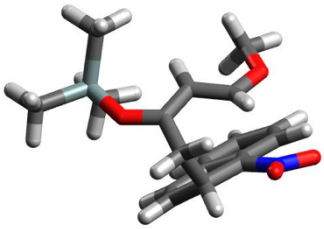
Electronic Energy = -1344.41725229 a.u. (ΔE_e = 1.4 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.090547 a.u. (ΔG = 19.1 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	-0.24075	1.28678	-0.49482
C	-0.68379	-1.67119	-0.95927
C	1.25648	1.23740	-0.39273
C	1.83749	-0.23018	-0.58584
C	1.26056	-1.19048	0.38936
C	0.05634	-1.88977	0.17627
C	1.93363	2.11645	-1.40148
C	1.29381	2.59247	-2.47575
C	-0.12158	2.31928	-2.72530
C	-0.91258	1.67823	-1.72946
C	-2.27276	1.44774	-2.02787
C	-2.81809	1.83665	-3.24978
C	-2.03795	2.47595	-4.21377
C	-0.69482	2.71343	-3.93896
N	-0.89508	0.91199	0.62266
O	-2.15982	0.87845	0.70666
O	-1.89831	-2.11019	-1.17420
C	-2.59024	-2.78162	-0.10827
O	1.96724	-1.37204	1.46394
Si	1.62872	-1.60227	3.15757
C	2.87512	-2.90327	3.63252
O	-0.20021	0.54953	1.63426
C	-0.12347	-2.15079	3.47578
C	1.99486	0.05231	3.92414
H	2.91750	-0.18713	-0.42625
H	1.64291	-0.53567	-1.61556
H	1.94468	-0.02042	5.01669
H	2.99841	0.39541	3.65129
H	1.26375	0.79284	3.58670
H	3.89327	-2.57616	3.39709
H	2.82329	-3.10059	4.70910
H	2.68485	-3.84476	3.10644
H	-0.27348	-2.14239	4.56290
H	-0.32764	-3.16773	3.12541
H	-0.83678	-1.44966	3.03188
H	-0.32591	-2.51040	0.97517
H	-0.30774	-1.12070	-1.81601
H	-2.09445	-3.72846	0.12129
H	-2.62363	-2.13462	0.77198
H	-3.59496	-2.96490	-0.48338
H	1.55466	1.53740	0.61648
H	2.98950	2.32432	-1.24467
H	1.81975	3.20449	-3.20529
H	-0.06612	3.21426	-4.67156
H	-2.46940	2.78642	-5.16040
H	-3.86868	1.63929	-3.44405
H	-2.89710	0.96320	-1.29128

-TS2_endo

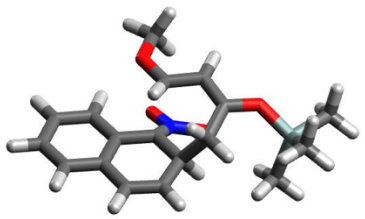
Electronic Energy = -1344.41411785 a.u. ($\Delta E_e^{\ddagger}$ = 3.4 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.085688 a.u. ($\Delta G^{\ddagger}$ = 22.2 kcal.mol^{-1})
Number of imaginary frequencies: 1 at -197.12



C	1.01759	-1.83184	0.18695
C	1.68302	0.36803	-0.14483
C	0.52195	-1.78848	1.61573
C	0.93616	-0.47591	2.40770
C	0.28660	0.69256	1.77491
C	0.61099	1.04646	0.48794
C	-0.96050	-1.96224	1.74115
C	-1.78383	-1.98106	0.68998
C	-1.29341	-1.92725	-0.68855
C	0.10259	-1.94953	-0.95885
C	0.49845	-1.98390	-2.31157
C	-0.44148	-1.97347	-3.34185
C	-1.80590	-1.92247	-3.06572
C	-2.21902	-1.90747	-1.73640
N	2.34881	-2.23998	0.08904
O	2.85821	-2.55974	-1.00059
O	1.95318	0.49221	-1.42785
C	1.00927	1.15641	-2.28285
O	-0.71166	1.22933	2.46082
Si	-1.92167	2.35479	1.96225
C	-1.09471	3.93492	1.40312
O	3.05417	-2.18772	1.12483
C	-2.89717	2.60600	3.52633
C	-2.93689	1.54988	0.61759
H	0.60245	-0.57147	3.44253
H	2.02648	-0.40875	2.38474
H	-1.82097	4.75468	1.45361
H	-0.72136	3.88580	0.37584
H	-0.25815	4.19061	2.06281
H	-3.74141	3.28014	3.34464
H	-3.29434	1.65474	3.89546
H	-2.27361	3.04679	4.31119
H	-3.46038	0.66924	1.00425
H	-3.69060	2.25845	0.25408
H	-2.32972	1.23948	-0.23946
H	0.00921	1.75111	-0.07251
H	2.55527	0.04050	0.41780
H	1.33879	0.94926	-3.29963
H	1.04118	2.23296	-2.09151
H	0.00001	0.76662	-2.13012
H	1.02519	-2.58550	2.17481
H	-1.35289	-2.03480	2.75321
H	-2.85824	-2.07530	0.83104
H	1.54783	-2.00595	-2.56085
H	-0.09327	-1.99820	-4.37063
H	-2.53594	-1.90939	-3.86928
H	-3.27866	-1.89348	-1.49175

-TS2_exo

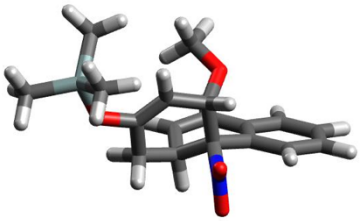
Electronic Energy = -1344.41104743 a.u. ($\Delta E_e^{\ddagger}$ = 5.3 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.081281 a.u. ($\Delta G^{\ddagger}$ = 24.9 kcal.mol^{-1})
Number of imaginary frequencies: 1 at -253.18



C	-1.99191	2.62577	1.36084
C	-2.05344	0.47745	0.77696
C	-0.59914	2.76079	1.94183
C	0.18177	1.39126	2.12815
C	-0.64951	0.29924	2.70215
C	-1.73789	-0.15601	2.00570
C	0.30096	3.66437	1.15645
C	-0.04503	4.21173	-0.01134
C	-1.36470	4.00564	-0.60826
C	-2.35971	3.26347	0.07944
C	-3.61274	3.11989	-0.54692
C	-3.87165	3.69817	-1.78857
C	-2.89027	4.43298	-2.45165
C	-1.64345	4.57954	-1.85406
N	-2.96333	2.46344	2.36114
O	-4.18067	2.54563	2.10464
O	-3.18917	0.26237	0.12307
C	-4.28216	-0.37131	0.80476
O	-0.38719	-0.21624	3.89607
Si	0.59271	0.34022	5.19297
C	2.37548	-0.06679	4.80974
O	-2.57150	2.14443	3.50154
C	-0.03863	-0.66177	6.62948
C	0.31606	2.17097	5.44376
H	1.06792	1.58812	2.73450
H	0.53096	1.08277	1.13738
H	-0.74656	2.41957	5.35028
H	0.64400	2.44870	6.45256
H	0.88016	2.78198	4.73140
H	2.76243	0.50152	3.95796
H	3.00034	0.16827	5.67944
H	2.49171	-1.13399	4.59229
H	0.53714	-0.43640	7.53392
H	0.05117	-1.73433	6.42755
H	-1.09122	-0.43671	6.83044
H	-2.43116	-0.83397	2.48887
H	-1.26883	0.78018	0.08897
H	-4.08246	-1.44228	0.90353
H	-4.45270	0.08291	1.78193
H	-5.15258	-0.21574	0.16822
H	-0.69736	3.16567	2.95401
H	1.28556	3.84677	1.58255
H	0.65166	4.84957	-0.55021
H	-0.86222	5.15278	-2.34730
H	-3.09397	4.88631	-3.41699
H	-4.85254	3.56843	-2.23659
H	-4.39166	2.55438	-0.05926

-CA_endo

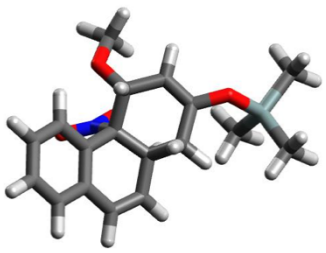
Electronic Energy = -1344.44625075 a.u. (ΔE_e = -16.8 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.117542 a.u. (ΔG = 2.2 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	-1.99191	2.62577	1.36084
C	-2.05344	0.47745	0.77696
C	-0.59914	2.76079	1.94183
C	0.18177	1.39126	2.12815
C	-0.64951	0.29924	2.70215
C	-1.73789	-0.15601	2.00570
C	0.30096	3.66437	1.15645
C	-0.04503	4.21173	-0.01134
C	-1.36470	4.00564	-0.60826
C	-2.35971	3.26347	0.07944
C	-3.61274	3.11989	-0.54692
C	-3.87165	3.69817	-1.78857
C	-2.89027	4.43298	-2.45165
C	-1.64345	4.57954	-1.85406
N	-2.96333	2.46344	2.36114
O	-4.18067	2.54563	2.10464
O	-3.18917	0.26237	0.12307
C	-4.28216	-0.37131	0.80476
O	-0.38719	-0.21624	3.89607
Si	0.59271	0.34022	5.19297
C	2.37548	-0.06679	4.80974
O	-2.57150	2.14443	3.50154
C	-0.03863	-0.66177	6.62948
C	0.31606	2.17097	5.44376
H	1.06792	1.58812	2.73450
H	0.53096	1.08277	1.13738
H	-0.74656	2.41957	5.35028
H	0.64400	2.44870	6.45256
H	0.88016	2.78198	4.73140
H	2.76243	0.50152	3.95796
H	3.00034	0.16827	5.67944
H	2.49171	-1.13399	4.59229
H	0.53714	-0.43640	7.53392
H	0.05117	-1.73433	6.42755
H	-1.09122	-0.43671	6.83044
H	-2.43116	-0.83397	2.48887
H	-1.26883	0.78018	0.08897
H	-4.08246	-1.44228	0.90353
H	-4.45270	0.08291	1.78193
H	-5.15258	-0.21574	0.16822
H	-0.69736	3.16567	2.95401
H	1.28556	3.84677	1.58255
H	0.65166	4.84957	-0.55021
H	-0.86222	5.15278	-2.34730
H	-3.09397	4.88631	-3.41699
H	-4.85254	3.56843	-2.23659
H	-4.39166	2.55438	-0.05926

-CA_exo

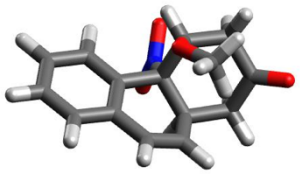
Electronic Energy = -1344.43996820 a.u. (ΔE_e = -12.8 kcal.mol^{-1})
Sum of electronic and thermal free energies = -1344.110227 a.u. (ΔG = 6.8 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	-2.10629	2.49560	1.20850
C	-2.69962	1.02443	1.21449
C	-2.11647	0.11702	2.26197
C	-0.81496	0.19343	2.55538
C	0.00997	1.31846	1.99313
C	-0.82272	2.61614	2.05500
C	0.01680	3.81320	1.71766
C	-0.06341	4.44332	0.54171
C	-0.99821	4.00121	-0.49715
C	-1.97758	3.03559	-0.20532
C	-0.91780	4.53326	-1.79121
C	-1.79588	4.11941	-2.78679
C	-2.77391	3.16809	-2.49370
C	-2.86263	2.63472	-1.20988
N	-3.17743	3.35216	1.94096
O	-3.35468	3.11279	3.12292
O	-0.20352	-0.73556	3.33818
Si	0.56722	-0.41265	4.82217
C	0.12637	-1.85659	5.91793
O	-4.11688	1.09943	1.18313
C	-4.86543	0.61884	2.29322
O	-3.79345	4.19122	1.31859
C	-0.09616	1.20606	5.48784
C	2.41482	-0.33375	4.54558
H	0.92767	1.45503	2.57359
H	0.31284	1.10658	0.95848
H	-1.19223	1.21848	5.48777
H	0.24034	1.34749	6.52151
H	0.25769	2.06455	4.90564
H	2.93493	-0.22111	5.50401
H	2.77627	-1.25370	4.07316
H	2.69739	0.51074	3.90828
H	0.62621	-1.77034	6.88916
H	0.43910	-2.80098	5.45939
H	-0.95382	-1.90230	6.09192
H	-2.71741	-0.69870	2.64917
H	-2.40906	0.61709	0.23846
H	-4.93872	-0.47451	2.27926
H	-4.44505	0.94833	3.24780
H	-5.86584	1.04102	2.17975
H	-1.14676	2.70117	3.09623
H	0.74081	4.12449	2.46706
H	0.58421	5.28569	0.31174
H	-0.15490	5.27675	-2.00697
H	-1.72226	4.53886	-3.78560
H	-3.47286	2.84680	-3.25956
H	-3.64719	1.91773	-0.98601

-Hydrolyzed_CA_trans

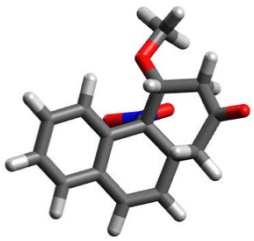
Electronic Energy = -935.841316237 a.u. (ΔE_e = -24.5 kcal.mol^{-1}) (*vs* nitronaphthalene+diene+H_2O-TMSOH)
Sum of electronic and thermal free energies = -935.605049 a.u. (ΔG = -7.4 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	0.45842	-1.42100	-0.24137
C	0.23318	-0.17966	-0.84698
C	-0.03009	0.93699	-0.03291
C	-0.05334	0.79942	1.35322
C	0.16076	-0.44636	1.94382
C	0.41835	-1.55832	1.14399
C	-0.17258	2.30043	-0.69936
C	-0.79367	2.19678	-2.10582
C	-0.15453	1.08304	-2.90086
C	0.28404	-0.03043	-2.30589
C	-0.80772	3.55336	-2.83273
C	0.50963	4.29434	-2.79319
C	1.16038	4.38146	-1.43117
C	1.19578	3.05916	-0.65616
N	-1.18464	3.08832	0.16119
O	-0.76631	3.95605	0.90737
O	2.22572	2.17138	-1.05449
C	2.82595	2.31537	-2.33157
O	0.97436	4.84637	-3.77185
O	-2.35644	2.77451	0.08156
H	-1.12308	3.42394	-3.87088
H	-1.54057	4.21258	-2.34513
H	0.55219	5.08666	-0.85038
H	1.39783	3.28100	0.39449
H	3.49407	1.45846	-2.43983
H	3.41680	3.23500	-2.40379
H	2.10006	2.28165	-3.15082
H	-1.84045	1.89861	-1.96554
H	-0.14077	1.18733	-3.98329
H	0.67447	-0.86174	-2.88724
H	-0.23747	1.66190	1.99008
H	0.13114	-0.54138	3.02458
H	0.59112	-2.52917	1.59820
H	0.66538	-2.28266	-0.87066
H	2.16114	4.80988	-1.51604

-Hydrolyzed_CA_cis

Electronic Energy = -935.844464992 a.u. (ΔE_e = -26.5 kcal.mol^{-1}) (*vs* nitronaphthalene+diene+H_2O-TMSOH)
Sum of electronic and thermal free energies = -935.606056 a.u. (ΔG = -8.0 kcal.mol^{-1})
Number of imaginary frequencies: 0



C	-2.08538	2.47512	1.15329
C	-2.64705	1.19706	1.18498
C	-2.20491	0.27053	2.14675
C	-1.20897	0.64555	3.05697
C	-0.65112	1.91947	3.01540
C	-1.08961	2.83610	2.05977
C	-3.77192	0.80575	0.24497
C	-3.85962	-0.71333	-0.02045
C	-3.52928	-1.54589	1.18538
C	-2.76755	-1.08311	2.18176
C	-2.97312	-1.09339	-1.22021
C	-3.48008	-0.43542	-2.48554
C	-4.30027	0.82380	-2.28280
C	-3.74285	1.61455	-1.09738
N	-5.11551	1.20105	0.91556
O	-5.10325	1.76264	1.98893
O	-4.33485	2.88141	-0.86033
C	-5.41784	3.30938	-1.67629
O	-3.25445	-0.88832	-3.58945
O	-6.13045	0.92976	0.29511
H	-2.95569	-2.17683	-1.36521
H	-1.93704	-0.76720	-1.05115
H	-5.34058	0.52138	-2.10968
H	-2.68017	1.79186	-1.30671
H	-5.10030	3.49211	-2.70854
H	-6.24860	2.59676	-1.66149
H	-5.75511	4.25082	-1.23965
H	-4.89390	-0.92520	-0.31013
H	-3.90029	-2.56736	1.19244
H	-2.51062	-1.71397	3.02888
H	-0.87301	-0.07653	3.79656
H	0.12143	2.19758	3.72582
H	-0.66564	3.83471	2.02350
H	-2.43985	3.20556	0.43239
H	-4.25826	1.41301	-3.20052

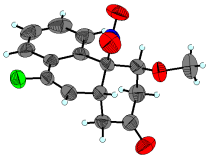
-TMSOH

Electronic Energy = -485.020814544 a.u.
Sum of electronic and thermal free energies = -484.928273 a.u.
Number of imaginary frequencies: 0

-H2O

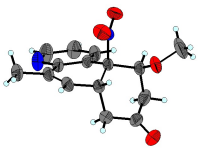
Electronic Energy = -76.4035129789 a.u.
Sum of electronic and thermal free energies = -76.400524 a.u.
Number of imaginary frequencies: 0

X-Ray data



3b-cis minor diastereomer

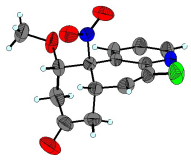
Crystal structure determination of **3b-cis**. $C_{15}H_{14}F_1N_1O_4$, M=291.3g.mol^{-1}, monoclinic, $P2_1/a$ (Nr 14), a=12.5797(2)Å, b=8.1298(1)Å, c=13.6651(2)Å, β=104.883(3)°, V=1350.7(3) Å^3, Z=4, d_{calc}=1.432. A total of 5814 reflections were collected at room temperature using a three-circle goniometer of a Bruker SMART APEX diffractometer equipped with a CCD area detector and Mo Ka radiation (λ=0.71073Å). The cell parameters and the orientation matrix of the crystal were preliminary determined by using SMART Software[1]. Data integration and global cell refinement were performed with SAINT Software[2]. Intensities were corrected for Lorentz polarisation, decay and absorption effects (SAINT and SADABS Softwares[2]) and reduced to F_O^2. The structure was solved by direct methods (SHEL-XS[3]). Anisotropic displacement parameters were refined for all non-hydrogen atoms using SHEL-XL[4] available with the WinGX[5] package. Hydrogen atoms were located by Fourier-difference synthesis and fixed geometrically according to their environment with a common isotropic factor. The final cycle of full matrix least square refinement on Fo^2 was based on 1923 observed reflections and 192 variable parameters and converged with unweighted and weighted agreement factors of R1=0.0447, wR2=0.1229 for 1542 reflections with I>2σI and R1=0.0554 , wR2=0.1334 for all data. The data have been deposited to the Cambridge Crystallographic Data Centre (Nr CCDC 2151279). ORTEP representation of compound 3b-cis is given in Fig. xx.



5f-*cis* minor diastereomer

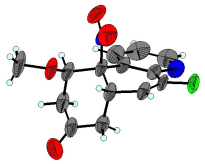
Crystal structure determination of **5f-cis**. $C_{15}H_{16}N_2O_4$, M=288.3g.mol^{-1}, orthorhombic, $P2_12_12_1$ (Nr 19), a=7.4616(1)Å, b=8.6131(1)Å, c=21.565(3)Å, ,V=1385.9(4) Å^3, Z=4, d_{calc}=1.382. A total of 6286 reflections were collected at room temperature using a three-circle goniometer of a Bruker SMART APEX diffractometer equipped with a CCD area detector and Mo Ka radiation (λ=0.71073Å). The cell parameters and the orientation matrix of the crystal were preliminary determined by using SMART Software[1]. Data integration and global cell refinement were performed with SAINT Software[2]. Intensities were corrected for

Lorentz polarisation, decay and absorption effects (SAINT and SADABS Softwares[2]) and reduced to F_O^2. The structure was solved by direct methods (SHEL-XS[3]). Anisotropic displacement parameters were refined for all non-hydrogen atoms using SHEL-XL[4] available with the WinGX[5] package. Hydrogen atoms were located by Fourier-difference synthesis and fixed geometrically according to their environment with a common isotropic factor. The final cycle of full matrix least square refinement on Fo^2 was based on 1994 observed reflections and 192 variable parameters and converged with unweighted and weighted agreement factors of R1=0.0505, wR2=0.1265 for 1738 reflections with I>2σI and R1=0.0.0570 , wR2=0.1317 for all data. The data have been deposited to the Cambridge Crystallographic Data Centre (Nr CCDC 2151281). ORTEP representation of compound 5f-cis is given in Fig. xx.



5h-*trans* major diastereomer

Crystal structure determination of **5h-trans**. $C_{14}H_{13}F_1N_2O_4$, M=292.3g.mol^{-1}, Orthorhombic, $P2_12_12_12_1$ (Nr 19), a=10.0454(1))Å, b=10.7142(1)Å, c=13.3095(1)Å, , V=1324.9(3) Å^3, Z=4, d_{calc}=1.465. A total of 5937 reflections were collected at room temperature using a three-circle goniometer of a Bruker SMART APEX diffractometer equipped with a CCD area detector and Mo Ka radiation (λ=0.71073Å). The cell parameters and the orientation matrix of the crystal were preliminary determined by using SMART Software[1]. Data integration and global cell refinement were performed with SAINT Software[2]. Intensities were corrected for Lorentz polarisation, decay and absorption effects (SAINT and SADABS Softwares[2]) and reduced to F_O^2. The structure was solved by direct methods (SHEL-XS[3]). Anisotropic displacement parameters were refined for all non-hydrogen atoms using SHEL-XL[4] available with the WinGX[5] package. Hydrogen atoms were located by Fourier-difference synthesis and fixed geometrically according to their environment with a common isotropic factor. The final cycle of full matrix least square refinement on Fo^2 was based on 1901 observed reflections and 191 variable parameters and converged with unweighted and weighted agreement factors of R1=0.0398, wR2=0.0926 for 1565 reflections with I>2σI and R1=0.0487 , wR2=0.0968 for all data. The data have been deposited to the Cambridge Crystallographic Data Centre (Nr CCDC 2151282). ORTEP representation of compound 8h-trans is given in Fig. xx.



5h-*cis* minor diastereomer

Crystal structure determination of **5h-cis**. $C_{14}H_{13}F_1N_2O_4$, M=292.3g.mol^{-1}, monoclinic, $P2_1/a$ (Nr 14), a=12.532(4)Å, b=7.904(3)Å, c=13.537(5)Å, β=103.55(7)°, V=1304.7(8) Å^3, Z=4, d_{calc}=1.488. A total of 5580 reflections were collected at room temperature using a three-circle goniometer of a Bruker SMART APEX diffractometer equipped with a CCD area detector and Mo Ka radiation (λ=0.71073Å). The cell parameters and the orientation matrix of the crystal were preliminary determined by using SMART Software[1]. Data integration and global cell refinement were performed with SAINT Software[2]. Intensities were corrected for Lorentz polarisation, decay and absorption effects (SAINT and SADABS Softwares[2]) and reduced to F_O^2. The structure was solved by direct methods (SHEL-XS[3]). Anisotropic displacement parameters were refined for all non-hydrogen atoms using SHEL-XL[4] available with the WinGX[5] package. Hydrogen atoms were located by Fourier-difference synthesis and fixed geometrically according to their environment with a common isotropic factor. The final cycle of full matrix least square refinement on Fo^2 was based on 1876 observed reflections and 191 variable parameters and converged with unweighted and weighted agreement factors of R1=0.0807, wR2=0.2174 for 1225 reflections with I>2σI and R1=0.1086 , wR2=0.2530 for all data. The data have been deposited to the Cambridge Crystallographic Data Centre (Nr CCDC 2151280). ORTEP representation of compound 8h-cis is given in Fig. xx.

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(2)- SAINT+ V6.02 (1999), Saint software reference manual, Bruker Advanced X Ray Solutions, Inc., Madison, Wisconsin, USA.

(3). SHELXS-97: Sheldrick, G. M. Acta Crystallogr. 1990, A46, 467e473.

(4). Sheldrick, G. M. SHELXL-97dA Program for Crystal Structure Refinement; University of Gottingen: Gottingen, Germany, 1997; release 97-2.

(5). Farrugia, L. J. WinGX: Version 1.70.01dAn Integrated System of Windows Programs for the Solution, Refinement and Analysis of Single Crystal X-ray Diffraction Data. Dept. of chemistry, University of Glasgow.