DBU-Catalyzed [3 + 2] Cycloaddition and Michael Addition Reactions of 3-Benzylidene Succinimides with 3-Ylidene Oxindoles and Chalcones

Piyush Tehri and Rama Krishna Peddinti*
Department of Chemistry, Indian Institute of Technology Roorkee
Roorkee-247 667, Uttarakhand, India

SUPPORTING INFORMATION

Table of contents

General information:

Unless otherwise noted, chemicals were purchased from commercial suppliers at the highest purity grade available and were used without further purification. The 3-(2-oxo-2-arylethylidene) oxindoles **1a**–**f** and 3-benzylidene succinimides **2a**–**f** were synthesized by literature methods.[14] Thin layer chromatography was performed on pre-coated 0.25 mm silica gel plates (60F-254) using UV light as visualizing agent. Silica gel (100–200 mesh) was used for column chromatography. IR spectra of the compounds were recorded on FT-IR and are expressed as wave number (cm^{-1}). NMR spectra were recorded in $CDCl_3$ and DMSO-d_6 using TMS as an internal standard on 500 MHz and 400 MHz instruments. Chemical shifts (δ) were reported as parts per million (ppm) in δ scale downfield from TMS. ^1H NMR spectra were referenced to $CDCl_3$ (7.26 ppm) and ^{13}C NMR spectra were referenced to $CDCl_3$ (77.0 ppm, the middle peak). Coupling constants were expressed in Hz. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, dt = doublet of triplets, m = multiplet. High-resolution mass spectra (HRMS) were obtained on a micrOTOF™-Q II mass spectrometer (ESI-MS).

NMR studies of 3a:

The structures of spiroxindoles were confirmed by detailed spectral analysis obtained from ^1H and ^{13}C NMR, and HRMS experiments of isolated products. For instance, in the 1H NMR of 3a, the protons H_a and H_d appear as doublets at δ 4.10 and 4.90 ppm, respectively, and the protons H_b and H_c appear as doublet of doublets at δ 4.21 and 5.04 ppm, respectively (Figure S1).

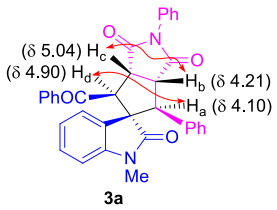


Figure S1. Selected ^1H NMR chemical shifts (ppm) and NOE correlations in **3a**.

The connectivity of the protons that are coupled with each other and between protons and carbons of **3a** was identified by two-dimensional ^1H–^1H COSY and ^1H–^{13}C COSY experiments, respectively (see Figures S5 and S6). To gain more insight into the stereochemistry of these products and to understand the spatial correlation between H_a, H_d, H_c and H_d protons, we performed NOESY experiment. The presence of correlation between the protons 'H_a and H_d'and 'H_b and H_c' and the absence of correlation between 'H_a and H_c' and 'H_b and H_d' establishes the showed geometry (Figure S7). The correlation between the proton H_d and benzoyl carbonyl in HMBC spectrum ascertains their germinal relationship unambiguously.

NMR studies of 5b:

The structure of Michael adducts were confirmed by detailed analysis obtained from ^{1}H and ^{13}C NMR, and HRMS spectral data of isolated products. For instance, in the ^{1}H NMR of Michael adduct **5b**, the protons H_a and H_a' appear at δ 3.27 and 4.68 ppm, respectively, each as doublet of doublets and the proton H_b appears at δ 4.14 as doublet of triplet and the proton H_c appears at 4.51 ppm as doublet of doublet (Figure S2).

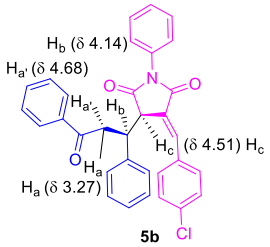


Figure S2. Selected ^{1}H NMR chemical shifts (ppm) in **5b**.

The connectivity of the protons that are coupled with each other and between protons and carbons of Michael adduct **5b** was identified by two-dimensional ^{1}H–^{1}H COSY and ^{1}H–^{13}C COSY experiments, respectively (Figures S9 and S10). To gain better insight on the stereochemistry of these products through the spatial correlation between H_a, H_a', H_b and H_c protons, we performed NOESY experiment of Michael adduct **5b**. The presence of correlation between the protons 'H_a and H_b', 'H_a and H_a'', 'H_b and H_c' and 'H_b and H_a'', the absence of correlation between 'H_a and H_c' establishes the geometry depicted in Figure S2. The results obtained from NMR studies were further confirmed by the single crystal X-ray analysis of compound **5h** (Figure S4).

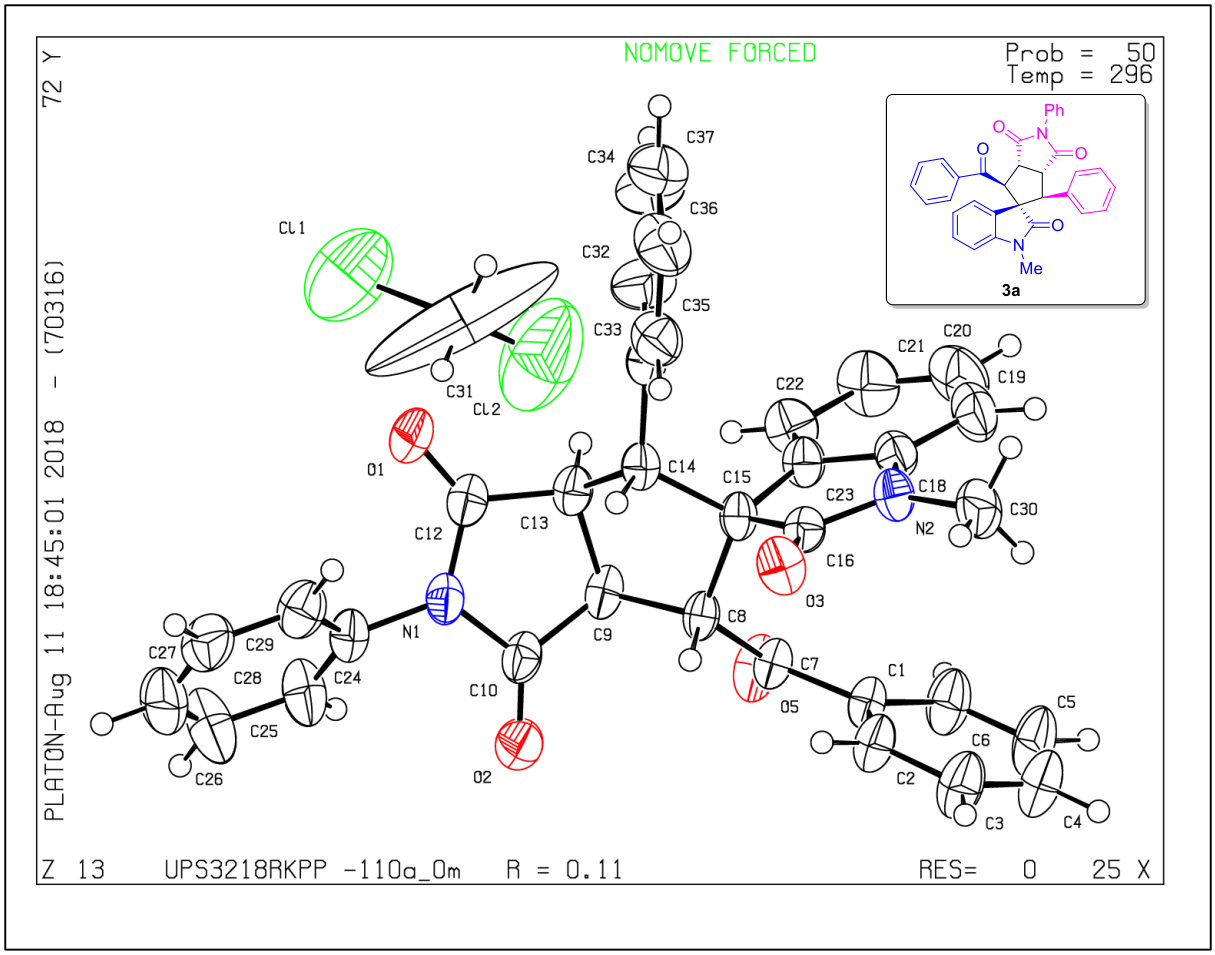


Figure S3. The ORTEP plot of the crystal structure of **3a** (The trapped dichloromethane solvent is also shown).

Table S1: Crystallographic data for spirooxindole derivative **3a**:

Empirical formula	$C_{35}H_{28}Cl_2N_2O_4$	
Formula weight	611.49	
Temperature	296(2) K	
Wavelength	0.71073Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 11.156(5) Å	α= 100.51(2)°.
	b = 11.456(5) Å	β= 108.58(2)°.
	c = 13.201(6) Å	γ =100.45(2)°.
Volume	1519.5(11) $Å^3$	

Z	30
Density (calculated)	3.735 mg/m^3
Absorption coefficient	2.804 mm^{-1}
F(000)	1680
Crystal size	0.28 x 0.24 x 0.20 mm^3
Theta range for data collection	1.684 to 28.697°
Reflections collected	25896
Independent reflections	7505 [R(int) = 0.0356]
Completeness to theta = 25.242°	99.0 %
Absorption correction type	multi-scan
Max. and min. transmission	0.970 and 0.953
Refinement method	Full-matrix least-square on F^2
Data / restraints / parameters	7505 / 0 / 390
Goodness-of-fit on F^2	1.474
Final R indices [I>2sigma(I)]	R1 = 0.1081, wR2 = 0.3387
R indices (all data)	R1 = 0.1441, wR2 = 0.3861
Large diff. peak and hole	1.397 and -1.137e.$Å^{-3}$

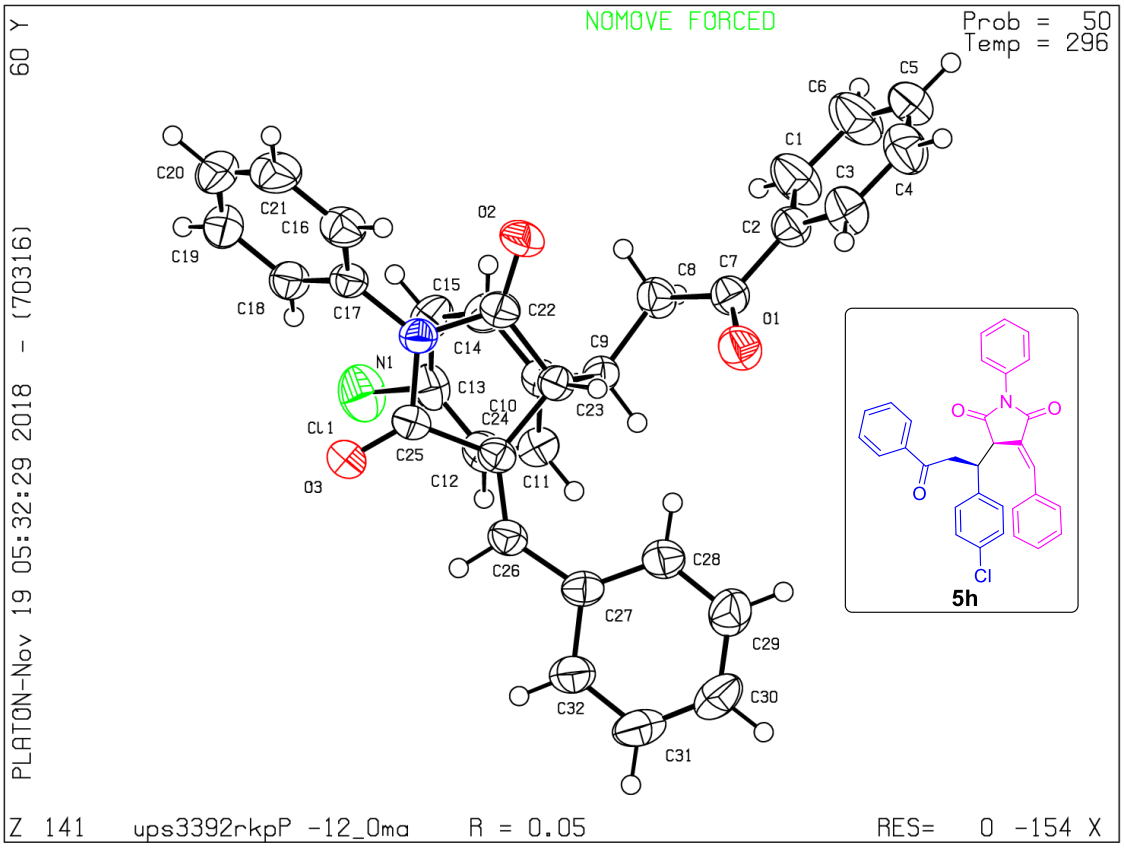


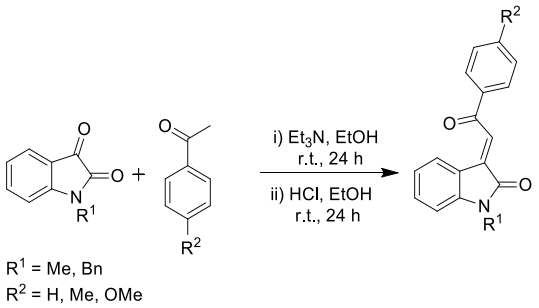
Figure S2-4. The ORTEP plot of the crystal structure of **5h**.

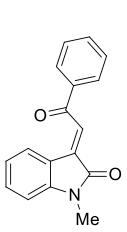
Table S2: Crystallographic data for Michael adduct **5h**:

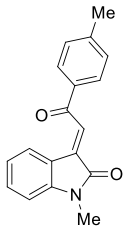
Empirical formula	$C_{32}H_{24}ClNO_3$	
Formula weight	505.97	
Temperature	296(2) K	
Wavelength	0.71073Å	
Crystal system	Triclinic	
Space group	P-1	
Unit cell dimensions	a = 10.6788(6) Å	α= 114.4170(10)°.
	b = 11.5046(3) Å	β= 103.953(2)°.
	c = 12.2981(3) Å	γ = 96.855(2)°.
Volume	1293.50(9) $Å^3$	
Z	17	
Density (calculated)	1.713 mg/m^3	

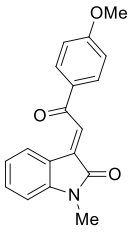
Absorption coefficient	0.975 mm^{-1}
F(000)	663
Crystal size	0.27 x 0.22 x 0.20 mm^3
Theta range for data collection	1.92 to 28.350°
Reflections collected	20574
Independent reflections	6421 [R(int) = 0.0253]
Completeness to theta = 28.35°	99.3 %
Absorption correction type	multi-scan
Refinement method	Full-matrix least-square on F^2
Data / restraints / parameters	6421 / 0 / 335
Goodness-of-fit on F^2	1.052
Final R indices [I>2sigma(I)]	R1 = 0.0480, wR2 = 0.1407
R indices (all data)	R1 = 0.0740, wR2 = 0.1803
Largest diff. peak and hole	0.460 and -0.389 $e.Å^{-3}$

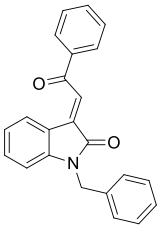
Synthesis of 3-ylideneoxindoles 1a–f:

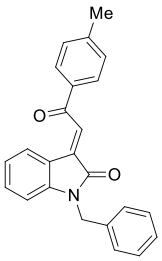


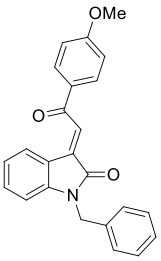

1a, 73%


1b, 70%


1c, 68%


1d, 72%


1e, 68%


1f, 64%

References:

1. (a) G. Kazemi, M. Seifi, H. Sheibani, *Heterocycl. Lett.* 2013, **3**, 141; (b) Y. Lin, Y. Wenguo, L. Lixin, S. Yang, J. Zhiyong, *Chin. J. Chem.* 2011, **29**, 1906.

General procedures:

General procedure for the synthesis of 3a-x:

To a stirred solution of 3-ylidene oxindole derivative **1** (0.1 mmol) in 2 mL of EtOH was added benzylidene-1-phenylpyrrolidine-2,5-dione **2** (0.1 mmol). Then DBU (0.02 mmol) was added, and the mixture was allowed to stir at room temperature for 40 min. After completion of the reaction as judged by TLC, the product started to settle down on the basement of the round bottom flask, reaction contents were filtered off. The product was obtained by washing with EtOH followed by drying.

Note: The ^{1}H NMR data of major diastereomers of **3i-k,r,t,v,x** is shown, wherever the spectra were recorded for the mixture of diastereomers.

General procedure for the synthesis of 5a-s and 7a:

To a stirred solution of chalcone derivative **4** or **6a** (0.1 mmol) in 2 mL of EtOH was added benzylidene-1-phenylpyrrolidine-2,5-dione **2** (0.1 mmol). Then DBU (0.02 mmol) was added, and the mixture was allowed to stir at room temperature for 8 h (5 h in case of **6a**). After completion of the reaction as judged by TLC, the product started to settle down in the round bottom flask. Then the reaction contents were filtered off, washed with EtOH and dried under vacuum.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-methyl-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3a):

Yield: 0.037 g (70%) as white solid; MP: 258–260 °C; IR (KBr) ν_{max}: 3134, 1779, 1715, 1705, 1677, 1611, 1598, 1496, 1471, 1449, 1400, 1384, 1235, 1153, 1138, 1099, 763, 753, 717, 698, 691, 645, 617, 595, 515, 488 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.56 (s, 3H), 4.1 (d, *J* = 9.6 Hz, 1H), 4.21 (dd, *J* = 7.6, 9.6 Hz, 1H), 4.90 (d, *J* = 5.2 Hz, 1H), 5.04 (dd, *J* = 5.6, 7.6 Hz, 1H), 6.15 (d, *J* = 5.6 Hz, 1H), 6.95–6.97 (m, 2H), 6.10–7.06 (m, 5H), 7.16 (dd, *J* = 0.8, 5.6 Hz, 1H), 7.21 (t, *J* = 6.4 Hz, 2H), 7.31 (d, *J* = 5.6 Hz, 2H), 7.37 (t, *J* = 6.0 Hz, 1H), 7.40 (d, *J* = 6.4 Hz, 3H), 7.49 (t, *J* = 6.0 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 25.9, 45.3, 48.1, 56.5, 59.15, 65.8, 107.9, 122.5, 124.8, 125.6, 126.4, 127.9, 127.9, 127.9, 128.2, 128.6, 129.0, 129.1, 131.8, 132.7, 132.9, 136.3, 142.8, 175.0, 175.5, 177.0, 195.9 ppm; HRMS (ESI): *m/z* calcd for $C_{34}H_{27}N_2O_4$ $[M + H]^+$: 527.1965; found 527.1978.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-methyl-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3b):

Yield: 0.034 g (63%) as off white solid; MP: 269–271 °C; IR (KBr) ν_{max}: 3135, 1778, 1708, 1676, 1610, 1494, 1400, 1384, 1190, 1137, 1112, 1097, 907, 758, 749, 728, 691, 655, 645, 602 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.13 (s, 3H), 2.56 (s, 3H), 4.06 (d, *J* = 12.0 Hz, 1H), 4.17 (dd, *J* = 9.2, 12.0 Hz, 1H), 5.02 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.16–6.18 (m, 1H), 6.83 (q, *J* = 8.4, 5.2 Hz, 4H), 7.0–7.08 (m, 2H), 7.15–7.23 (m, 3H), 7.28–7.30 (m, 2H), 7.35–7.41 (m, 4H), 7.47–7.51 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.0, 25.9, 45.2, 48.3, 56.6, 58.9, 65.7, 108.0, 122.4, 124.9, 125.6, 126.4, 127.8, 127.9, 128.1, 128.5, 128.7, 128.9, 129.1, 129.8, 131.8, 132.7, 136.3, 137.5, 142.8, 175.0, 175.6, 177.0, 195.9 ppm; HRMS (ESI): *m/z* calcd for $C_{35}H_{29}N_2O_4$ $[M + H]^+$: 541.2122; found 541.2145.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-6-(4-chlorophenyl)-1'-methyl-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3c):

Yield: 0.032 g (57%) as off white solid; MP: 221–223 °C; IR (KBr) ν_{max}: 3133, 1779, 1715, 1708, 1679, 1610, 1494, 1470, 1451, 1400, 1384, 1289, 1257, 1191, 1138, 1094, 905, 751, 737, 730, 722, 692, 655, 646, 614, 600 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.57 (s, 3H), 4.06 (d, *J* = 12.0 Hz, 1H), 4.13 (dd, *J*

= 9.2, 12.0 Hz, 1H), 4.87 (d, *J* = 6.4 Hz, 1H), 5.04 (dd, 6.8, 9.2 Hz, 1H), 6.20 (d, *J* = 7.6 Hz, 1H), 6.90 (d, *J* = 8.8 Hz, 2H), 6.99–7.04 (m, 3H), 7.08 (td, *J* = 1.2, 7.6 Hz, 1H), 7.15 (dd, *J* = 0.8, 7.6 Hz, 1H), 7.19–7.23 (m, 2H), 7.27–7.30 (m, 2H), 7.36–7.43 (m, 4H), 7.50 (t, *J* = 7.6 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 25.9, 45.1, 48.2, 56.5, 58.3, 65.6, 108.2, 122.6, 124.4, 125.4, 126.4, 128.0, 128.1, 128.2, 128.6, 129.1, 129.2, 129.3, 131.5, 131.6, 132.8, 133.8, 136.2, 142.7, 174.8, 175.3, 176.8, 195.7 ppm; HRMS (ESI): *m/z* calcd for $C_{34}H_{25}ClN_2O_4Na$ $[M + Na]^+$: 583.1395; found 583.1397.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-6-(3-methoxyphenyl)-1'-methyl-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3d):

Yield: 0.039 g (70%) as white solid; MP: 244–245 °C; IR (KBr) ν_{max}: 3134, 1778, 1715, 1675, 1610, 1493, 1400, 1385, 1190, 1137, 1101, 757, 732, 692, 655, 644, 603 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.56 (s, 3H), 3.55 (s, 3H), 4.07 (d, *J* = 12.0 Hz, 1H), 4.17 (dd, *J* = 9.2, 11.6 Hz, 1H), 4.88 (d, *J* = 6.8 Hz, 1H), 5.03 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.18–6.20 (m, 1H), 6.47 (t, *J* = 2.0 Hz, 1H), 6.57–6.60 (m, 2H), 6.94 (t, *J* = 8.0 Hz, 1H), 7.0–7.04 (m, 1H), 7.08 (td, *J* = 1.6, 7.6 Hz, 1H), 7.15–7.18 (m, 1H), 7.21 (t, *J* = 8.0 Hz, 2H), 7.29–7.31 (m, 2H), 7.36–7.42 (m, 4H), 7.48–7.51 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 25.9, 45.2, 48.3, 55.0, 56.6, 59.0, 65.7, 108.1, 113.1, 113.9, 120.6, 122.4, 124.8, 125.6, 126.4, 127.9, 128.1, 128.6, 128.9, 2129.1, 129.1, 129.2, 131.7, 132.8, 134.4, 136.3, 142.8, 159.0, 174.9, 175.5, 176.9, 195.8 ppm. HRMS (ESI): *m/z* calcd for $C_{35}H_{29}N_2O_5$ $[M + H]^+$: 557.2071; found 557.2082.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-methyl-4-(4-methylbenzoyl)-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3e):

Yield: 0.039 g (72%) as off white solid; MP: 233–235 °C; IR (KBr) ν_{max}: cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.29 (s, 3H), 2.58 (s, 3H), 4.10 (d, *J* = 12.0 Hz, 1H), 4.21 (dd, *J* = 9.6, 12.0 Hz, 1H), 4.88 (d, *J* = 6.8 Hz, 1H), 5.04 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.16–6.18 (m, 1H), 6.95–7.06 (m, 9H), 7.16–7.19 (m, 1H), 7.25 (s, 1H), 7.26 (d, *J* = 2.4 Hz, 1H), 7.37–7.41 (m, 3H), 7.47–7.50 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.5, 25.9, 45.3, 48.1, 56.2, 59.1, 65.9, 107.9, 122.4, 124.7, 125.6, 126.4, 127.8, 127.9, 127.9, 128.3, 128.5, 128.6, 128.9, 129.1, 131.7, 132.9, 133.6, 142.7, 143.7, 175.1, 175.5, 177.0, 195.2 ppm; **HRMS (ESI): *m/z* calcd for $C_{35}H_{29}N_2O_4$ $[M + H]^+$: 541.2122, found: 541.2119.**

(3aS*,3'S*,4S*,6S*,6aR*)-1'-methyl-4-(4-methylbenzoyl)-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3f):

Yield: 0.038 g (69%) as off white solid; MP: 263–266 °C; IR (KBr) ν_{max}: 3134, 1778, 1714, 1668, 1611, 1495, 1471, 1400, 1384, 1286, 1240, 1186, 1155, 1136, 1097, 825, 725, 710, 690, 655, 617, 597, 518, 495 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.13 (s, 3H), 2.29 (s, 3H), 2.59 (s, 3H), 4.06 (d, *J* = 9.6 Hz, 1H), 4.16 (dd, *J* = 7.6, 9.6 Hz, 1H), 4.86 (d, *J* = 5.2 Hz, 1H), 5.01 (dd, *J* = 5.2, 7.2 Hz, 1H), 6.20 (d, *J* = 6.0 Hz, 1H), 6.83 (q, *J* = 6.4 Hz, 4H), 6.99–7.07 (m, 4H), 7.17 (d, *J* = 5.6 Hz, 1H), 7.24 (s, 2H), 7.38–7.41 (m, 3H), 7.47–7.50 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.0, 21.5, 25.9, 45.3, 48.3,

56.4, 59.0, 65.9, 108.0, 122.4, 124.9, 125.7, 126.4, 127.8, 128.4, 128.5, 128.6, 128.7, 128.8, 129.1, 129.9, 131.8, 133.7, 137.4, 142.8, 143.6, 175.1, 175.6, 177.0, 195.3 ppm; HRMS (ESI): *m/z* calcd for $C_{36}H_{31}N_2O_4$ $[M + H]^+$: 555.2278, found: 555.2281.

(3aR*,3'S*,4S*,6S*,6aS*)-4-(4-chlorophenyl)-1'-methyl-6-(4-methylbenzoyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3g):

Yield: 0.029 g (51%) as off white solid; MP: 238–240 °C; IR (KBr) ν_{max}: 3133, 1778, 1716, 1703, 1679, 1609, 1494, 1470, 1400, 1384, 1290, 1256, 1189, 1138, 1092, 909, 833, 780, 751, 740, 729, 655, 645, 616, 603, 527, 495 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.30 (s, 3H), 2.60 (s, 3H), 4.05 (d, *J* = 12.0 Hz, 1H), 4.13 (dd, *J* = 9.2, 11.6 Hz, 1H), 4.86 (d, *J* = 6.8 Hz, 1H), 5.03 (dd, 6.8, 9.2 Hz, 1H), 6.23 (d, *J* = 7.6 Hz, 1H), 6.90 (d, *J* = 8.8 Hz, 2H), 6.99–7.03 (m, 5H), 7.08 (td, *J* = 1.2, 7.6 Hz, 1H), 7.16 (d, *J* = 7.6 Hz, 1H), 7.24 (d, *J* = 8.4 Hz, 2H), 7.39–7.42 (m, 3H), 7.49 (t, *J* = 7.6 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.5, 26.0, 45.2, 48.2, 56.3, 58.4, 65.754, 108.2, 122.6, 124.4, 125.5, 126.4, 128.2, 128.3, 128.6, 128.6, 129.1, 129.1, 129.3, 131.6, 133.6, 133.8, 142.7, 143.8, 174.9, 175.3, 176.8, 195.0 ppm; HRMS (ESI): *m/z* calcd for $C_{35}H_{28}ClN_2O_4$ $[M + H]^+$: 575.1732, found: 575.1731.

(3aR*,3'S*,4S*,6S*,6aS*)-4-(3-methoxyphenyl)-1'-methyl-6-(4-methylbenzoyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3h):

Yield: 0.034 g (60%) as off white solid; MP: 250–251 °C; IR (KBr) ν_{max}: 3138, 1775, 1703, 1677, 1609, 1494, 1400, 1385, 1137, 1123, 750, 689, 656, 644, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.29 (s, 3H), 2.59 (s, 3H), 3.56 (s, 3H), 4.07 (d, *J* = 11.6 Hz, 1H), 4.16 (dd, *J* = 9.2, 11.6 Hz, 1H), 4.86 (d, *J* = 6.8 Hz, 1H), 5.03 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.21 (d, *J* = 8.0 Hz, 1H), 6.47 (s, 1H), 6.57–6.59 (m, 2H), 6.94 (t, *J* = 8.0 Hz, 1H), 7.0–7.08 (m, 5H), 7.18 (d, *J* = 7.2 Hz, 1H), 7.24 (s, 1H), 7.38–7.42 (m, 3H), 7.47–7.51 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.5, 25.9, 45.3, 48.3, 55.0, 56.3, 59.0, 65.8, 108.0, 113.1, 113.9, 120.6, 122.4, 124.8, 125.6, 126.4, 128.3, 128.5, 128.6, 128.9, 128.9, 129.1, 131.7, 133.6, 134.5, 142.8, 143.7, 159.0, 175.0, 175.5, 177.0, 195.2 ppm; HRMS (ESI): *m/z* calcd for $C_{36}H_{31}N_2O_5$ $[M + H]^+$: 571.2227, found: 571.2224.

(3aS*,3'S*,4S*,6S*,6aR*)-4-(4-methoxybenzoyl)-1'-methyl-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3i):

Yield: 0.034 g (61%) as off white solid; MP: 158–159 °C; IR (KBr) ν_{max}: 3135, 1716, 1702, 1678, 1601, 1400, 1385, 1138, 1123, 749, 732, 656, 644, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.65 (s, 3H), 3.78 (s, 3H), 4.10 (d, *J* = 12.0 Hz, 1H), 4.21 (dd, *J* = 9.2, 12.0 Hz, 1H), 4.87 (d, *J* = 6.8 Hz, 1H), 5.05 (dd, *J* = 6.8, 9.6 Hz, 1H), 6.19–6.22 (m, 1H), 6.72 (d, *J* = 8.8 Hz, 2H), 6.95–6.99 (m, 2H), 6.99–7.06 (m, 5H), 7.18–7.20 (m, 1H), 7.33–7.43 (m, 5H), 7.47–7.53 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 26.0, 45.5, 48.1, 55.4, 55.7, 59.3, 66.1, 107.9, 113.2, 122.4, 124.7, 125.7, 126.4, 127.9, 127.9, 128.5,

128.8, 128.9, 129.1, 130.7, 131.7, 132.9, 142.6, 163.4, 175.1, 175.7, 177.1, 193.7 ppm; HRMS (ESI): *m/z* calcd for $C_{35}H_{29}N_2O_5$ $[M + H]^+$: 557.2071, found: 557.2059.

(3aS*,3'S*,4S*,6S*,6aR*)-4-(4-methoxybenzoyl)-1'-methyl-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3*j*):

Yield: 0.33 g (58%) as off white solid; MP: 277–279 °C; IR (KBr) ν_{max}: 3133, 1779, 1716, 1670, 1599, 1574, 1494, 1470, 1400, 1384, 1169, 1136, 1114, 750, 713, 692, 656, 604, 517 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.13 (s, 3H), 2.66 (s, 3H), 3.78 (s, 3H), 4.06 (d, *J* = 12.0 Hz, 1H), 4.16 (dd, *J* = 9.2, 12.0 Hz, 1H), 4.85 (d, *J* = 6.4 Hz, 1H), 5.02 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.23 (d, *J* = 7.2 Hz, 1H), 6.72 (d, *J* = 8.8 Hz, 2H), 6.83 (dd, *J* = 8.4, 12.8 Hz, 4H), 6.99–7.07 (m, 2H), 7.19 (d, *J* = 7.2 Hz, 1H), 7.29 (d, *J* = 7.6, 1H), 7.39–7.42 (m, 4H), 7.46–7.50 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.0, 26.0, 45.5, 48.3, 55.4, 55.9, 59.1, 66.1, 107.9, 113.2, 122.4, 124.9, 125.7, 126.4, 127.8, 128.5, 128.6, 128.8, 129.0, 129.9, 130.7, 131.8, 137.4, 142.7, 175.1, 175.8, 177.1, 193.7 ppm; HRMS (ESI): *m/z* calcd for $C_{36}H_{31}N_2O_5$ $[M + H]^+$: 571.2227, found: 571.2231.

(3aR*,3'S*,4S*,6S*,6aS*)-4-(4-chlorophenyl)-6-(4-methoxybenzoyl)-1'-methyl-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3k):

Yield: 0.031 g (53%) as off white solid; MP: 293–294 °C; IR (KBr) ν_{max}: cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.67 (s, 3H), 3.79 (s, 3H), 4.05 (d, *J* = 12.0 Hz, 1H), 4.13 (dd, *J* = 9.2, 12.0 Hz, 1H), 4.85 (d, *J* = 6.4 Hz, 1H), 5.05 (dd, *J* = 6.8, 9.2 Hz, 1H), 6.26 (d, *J* = 8.0 Hz, 1H), 6.72 (d, *J* = 8.8 Hz, 2H), 6.91 (d, *J* = 8.4 Hz, 2H), 6.99–7.10 (m, 4H), 7.18 (d, *J* = 7.2 Hz, 1H), 7.39–7.42 (m, 4H), 7.47–7.51 (m, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 26.1, 45.4, 48.3, 55.4, 55.8, 58.6, 66.0, 108.2, 113.3, 122.6, 124.4, 125.6, 126.4, 128.2, 128.6, 128.9, 129.1, 129.3, 130.7, 131.7, 133.8, 142.6, 163.5, 174.9, 175.5, 176.9, 193.5 ppm; HRMS (ESI): *m/z* calcd for $C_{35}H_{28}ClN_2O_5$ $[M + H]^+$: 591.1681, found: 591.1683.

(3aS*,3'S*,4S*,6S*,6aR*)-4-(4-methoxybenzoyl)-6-(3-methoxyphenyl)-1'-methyl-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3l):

Yield: 0.034 g (58%) as off white solid; MP: 201–204 °C; IR (KBr) ν_{max}: 3133, 1779, 1716, 1671, 1601, 1493, 1400, 1384, 1246, 1172, 1136, 1099, 750, 712, 693, 655, 604, 486 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.66 (s, 3H), 3.56 (s, 3H), 3.78 (s, 3H), 4.07 (d, *J* = 12.0 Hz, 1H), 4.17 (dd, *J* = 9.2, 12.0 Hz, 1H), 4.85 (d, *J* = 6.8 Hz, 1H), 5.04 (dd, *J* = 6.8, 9.6 Hz, 1H), 6.24 (d, *J* = 7.6 Hz, 1H), 6.47 (t, *J* = 2.0 Hz, 1H), 6.58 (dd, *J* = 2.0, 8.4 Hz, 2H), 6.71 (d, *J* = 8.8 Hz, 2H), 6.94 (t, *J* = 7.6 Hz, 1H), 6.99–7.08 (m, 2H), 7.19 (dd, *J* = 1.2, 7.2 Hz, 1H), 7.37–7.43 (m, 5H), 7.47–7.51 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 26.0, 45.5, 48.3, 55.0, 55.4, 55.9, 59.2, 66.0, 108.0, 113.1, 113.2, 113.9, 120.6, 122.4, 124.8, 125.7, 126.4, 128.5, 128.9, 129.1, 130.7, 131.7, 134.5, 142.7, 159.0, 163.4, 175.0, 175.7, 177.0, 193.6 ppm; HRMS (ESI): *m/z* calcd for $C_{36}H_{31}N_2O_6$ $[M + H]^+$: 587.2177, found: 587.2194.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-benzyl-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3m):

Yield: 0.037 g (62%) as white solid; MP: 247–249 °C; IR (KBr) ν_{max}: 3134, 1782, 1720, 1707, 1680, 1610, 1496, 1466, 1400, 1384, 1156, 1124, 1105, 745, 716, 690, 656, 615, 303 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.75 (d, *J* = 16.4 Hz, 1H), 4.11–4.19 (m, 2H), 4.69 (d, *J* = 16.0 Hz, 1H), 4.98 (d, *J* = 6.8 Hz, 1H), 5.08 (dd, *J* = 7.2, 9.2 Hz, 1H), 5.96 (d, *J* = 8.0 Hz, 1H), 6.37 (d, *J* = 7.6 Hz, 2H), 6.93–7.06 (m, 8H), 7.09–7.15 (m, 2H), 7.25 (s, 1H), 7.27–7.28 (m, 2H), 7.39–7.46 (m, 6H), 7.47–7.52 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.5, 45.4, 48.7, 56.4, 59.9, 65.9, 109.4, 122.5, 124.6, 125.8, 126.2, 126.4, 127.2, 128.1, 128.1, 128.2, 128.3, 128.5, 128.6, 129.1, 129.1, 131.7, 132.8, 133.0, 134.2, 136.3, 142.2, 174.9, 175.5, 176.9, 195.7 ppm; HRMS (ESI): *m/z* calcd for $C_{40}H_{31}N_2O_4$ $[M + H]^+$: 603.2278, found: 603.2276.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-benzyl-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3n):

Yield: 0.045 g (73%) as off white solid; MP: 292–295 °C; IR (KBr) ν_{max}: 3136, 1778, 1716, 1684, 1612, 1495, 1400, 1385, 1148, 1118, 755, 693, 656, 643, 603, 518 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.21 (s, 3H), 3.71 (d, *J* = 16.0 Hz, 1H), 4.07 – 4.17 (m, 2H), 4.74 (d, *J* = 16.0 Hz, 1H), 4.96 (d, *J* = 6.8 Hz, 1H), 5.06 (dd, *J* = 6.8, 8.4 Hz, 1H), 5.97 (d, *J* = 7.6 Hz, 1H), 6.38 (d, *J* = 7.6 Hz, 2H), 6.84 (s, 4H), 6.94–7.05 (m, 5H), 7.09–7.12 (m, 1H), 7.24 (s, 1H), 7.27 (s, 1H), 7.38–7.52 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.1, 43.4, 45.4, 48.9, 56.5, 59.7, 65.8, 109.4, 122.5, 124.8, 125.8, 126.2, 126.4, 127.2, 128.1, 128.3, 128.3, 128.4, 128.5, 128.9, 129.0, 129.1, 129.7, 131.8, 132.9, 134.3, 136.3, 137.7, 142.2, 174.9, 175.5, 176.9, 195.8 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{33}N_2O_4$ $[M + H]^+$: 617.2435, found: 617.2438.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-benzyl-6-(4-chlorophenyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3o):

Yield: 0.032 g (50%) as off white solid; MP: 252–254 °C; IR (KBr) ν_{max}: 3137, 1777, 1715, 1687, 1612, 1495, 1400, 1385, 1113, 757, 692, 656, 645, 603, 524 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.74 (d, *J* = 16.0 Hz, 1H), 4.05–4.14 (m, 2H), 4.72 (d, *J* = 16.4 Hz, 1H), 4.95 (d, *J* = 6.8 Hz, 1H), 5.08 (t, *J* = 7.2 Hz, 1H), 6.03 (d, *J* = 7.6 Hz, 1H), 6.38 (d, *J* = 7.2 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 2H), 6.97–7.03 (m, 3H), 7.07 (t, *J* = 7.2 Hz, 3H), 7.15 (t, *J* = 7.6 Hz, 1H), 7.24 (s, 1H), 7.28 (s, 2H), 7.38–7.44 (m, 5H), 7.46–7.52 (m, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.4, 45.3, 48.8, 56.3, 59.2, 65.7, 109.6, 122.7, 124.3, 125.7, 126.2, 126.4, 127.4, 128.1, 128.3, 128.4, 128.5, 128.7, 129.1, 129.8, 131.4, 131.6, 133.0, 134.1, 134.1, 136.2, 142.2, 174.7, 175.2, 176.7, 195.5 ppm; HRMS (ESI): *m/z* calcd for $C_{40}H_{30}ClN_2O_4$ $[M + H]^+$: 637.1889, found: 637.1887.

(3aS*,3'S*,4S*,6S*,6aR*)-4-benzoyl-1'-benzyl-6-(3-methoxyphenyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3p):

Yield: 0.050 g (79%) as off white solid; MP: 236–239 °C; IR (KBr) ν_{max}: 3135, 1778, 1716, 1683, 1611, 1488, 1400, 1385, 1193, 1108, 750, 690, 655, 644, 603, 486 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.48 (d, *J* = 16.0 Hz, 1H), 4.10 (d, *J* = 12.0 Hz, 1H), 4.16 (dd, *J* = 9.2, 12.4 Hz, 1H), 4.74 (d, *J* = 16.0 Hz, 1H), 4.97 (d, *J* = 6.8 Hz, 1H), 5.08 (dd, *J* = 6.8, 8.8 Hz, 1H), 5.98 (d, *J* = 7.6 Hz, 1H), 6.37 (d, *J* = 7.6 Hz, 2H), 6.47 (t, *J* = 1.6 Hz, 1H), 6.60 (d, *J* = 7.6 Hz, 1H), 6.70 (dd, *J* = 2.4, 8.4 Hz, 1H), 6.94–7.06 (m, 5H), 7.11 (t, *J* = 7.6 Hz, 1H), 7.28 (d, *J* = 7.6 Hz, 2H), 7.39–7.44 (m, 5H), 7.46–7.52 (m, 3H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.4, 45.3, 48.9, 54.9, 56.4, 59.8, 65.7, 109.4, 113.3, 114.4, 121.1, 122.5, 124.7, 125.7, 126.0, 126.4, 127.2, 128.1, 128.3, 128.5, 128.6, 129.1, 129.2, 131.7, 133.0, 134.1, 134.2, 136.2, 142.2, 159.1, 174.8, 175.4, 176.9, 195.7 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{33}N_2O_5$ $[M + H]^+$: 633.2384, found: 633.2390.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-benzyl-4-(4-methylbenzoyl)-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3q):

Yield: 0.040 g (65%) as white solid; MP: 149–151 °C; IR (KBr) ν_{max}: 3134, 1717, 1673, 1637, 1400, 1385, 1192, 1123, 750, 656, 644, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.35 (s, 3H), 3.91 (d, *J* = 16.0 Hz, 1H), 4.12 (d, *J* = 12.0 Hz, 1H), 4.19 (dd, *J* = 9.2, 12.4 Hz, 1H), 4.63 (d, *J* = 16.0 Hz, 1H), 4.98 (d, *J* = 6.8 Hz, 1H), 5.07 (dd, *J* = 6.8, 8.8 Hz, 1H), 5.99 (d, *J* = 7.6 Hz, 1H), 6.39 (d, *J* = 7.6 Hz, 2H), 6.93–7.04 (m, 7H), 7.05–7.15 (m, 5H), 7.28 (d, *J* = 7.2, 1H), 7.38–7.42 (m, 5H), 7.48–7.52 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.6, 43.5, 45.6, 48.7, 55.9, 60.0, 66.0, 109.4, 122.5, 124.6, 125.9, 126.2, 126.4, 127.2, 128.1, 128.1, 128.4, 128.6, 128.9, 129.1, 131.8, 132.9, 133.6, 134.3, 142.1, 144.0, 175.0, 175.5, 176.910, 194.9 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{33}N_2O_4$ $[M + H]^+$: 617.2435, found: 617.2437.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-benzyl-4-(4-methylbenzoyl)-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3r):

Yield: 0.046 g (73%) as off white solid; MP: 241–243 °C; IR (KBr) ν_{max}: 3138, 1781, 1718, 1715, 1609, 1402, 1384, 1125, 1101, 758, 743, 722, 695, 656, 613, 598 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.2 (s, 3H), 2.35 (s, 3H), 3.86 (d, *J* = 16.0 Hz, 1H), 4.09 (d, *J* = 12.0 Hz, 1H), 4.15 (dd, *J* = 8.8, 12.0 Hz, 1H), 4.70 (d, *J* = 16.0 Hz, 1H), 4.96 (d, *J* = 6.8 Hz, 1H), 5.07 (dd, *J* = 7.2, 8.8 Hz, 1H), 5.99 (d, *J* = 7.6 Hz, 1H), 6.39 (d, *J* = 7.6 Hz, 2H), 6.85 (s, 4H), 6.94–7.03 (m, 4H), 7.05–7.13 (m, 3H), 7.28 (d, *J* = 7.2 Hz, 1H), 7.36–7.42 (m, 5H), 7.47–7.51 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.1, 21.6, 43.4, 45.5, 48.9, 56.0, 59.8, 66.0, 109.4, 122.4, 124.8, 125.9, 126.2, 126.4, 127.1, 128.3, 128.5, 128.6, 128.8, 128.9, 128.9, 129.1, 129.8, 131.8, 133.6, 134.3, 137.7, 142.1, 143.9, 175.0, 175.5, 177.0, 195.0 ppm; HRMS (ESI): *m/z* calcd for $C_{42}H_{35}N_2O_4$ $[M + H]^+$: 631.2591, found: 631.2614.

(3aR*,3'S*,4S*,6S*,6aS*)-1'-benzyl-4-(4-chlorophenyl)-6-(4-methylbenzoyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3s):

Yield: 0.033 g (51%) as orange solid; MP: 239–241°C; IR (KBr) ν_{max}: 3135, 1780, 1715, 1678, 1610, 1494, 1467, 1400, 1385, 1189, 1112, 748, 656, 644, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.35 (s, 3H), 3.89 (d, *J* = 16.0 Hz, 1H), 4.05–4.13 (m, 2H), 4.68 (d, *J* = 16.0 Hz, 1H), 4.95 (d, *J* = 6.8 Hz, 1H), 5.05 – 5.09 (m, 1H), 6.05 (d, *J* = 7.6 Hz, 1H), 6.40 (d, *J* = 7.6 Hz, 2H), 6.88 (d, *J* = 8.8 Hz, 2H), 6.97–7.09 (m, 8H), 7.15 (t, *J* = 7.2 Hz, 1H), 7.27 (s, 1H), 7.36–7.42 (m, 5H), 7.48–7.52 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.6, 43.5, 45.5, 48.8, 55.9, 59.3, 65.8, 109.5, 122.6, 124.3, 125.8, 126.2, 126.4, 127.4, 128.4, 128.5, 128.6, 128.6, 128.9, 129.1, 129.3, 129.8, 131.5, 131.7, 133.5, 134.1, 134.1, 142.1, 144.1, 174.8, 175.2, 176.7, 194.7 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{32}ClN_2O_4$ $[M + H]^+$: 651.2045, found: 651.2063.

(3aR*,3'S*,4S*,6S*,6aS*)-1'-benzyl-4-(3-methoxyphenyl)-6-(4-methylbenzoyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3t):

Yield: 0.045 g (69%) as off white solid; MP: 215–218 °C; IR (KBr) ν_{max}: 3135, 1717, 1677, 1633, 1620, 1400, 1385, 1192, 1123, 749, 656, 644, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.35 (s, 3H), 3.49 (s, 3H), 3.87 (d, *J* = 16.4 Hz, 1H), 4.09 (d, *J* = 12.0 Hz, 1H), 4.15 (dd, *J* = 8.8, 12.0 Hz, 1H), 4.68 (d, *J* = 16.4 Hz, 1H), 4.96 (d, *J* = 6.8 Hz, 1H), 5.07 (dd, *J* = 6.8, 8.8 Hz, 1H), 6.01 (d, *J* = 7.6 Hz, 1H), 6.39 (d, *J* = 7.2 Hz, 2H), 6.46 (t, *J* = 2.0 Hz, 1H), 6.59 (d, *J* = 8.0 Hz, 1H), 6.69 (dd, *J* = 2.4, 8.4 Hz, 1H), 6.95–7.04 (m, 5H), 7.07–7.13 (m, 3H), 7.29 (d, *J* = 7.2 Hz, 1H), 7.40 (dd, *J* = 8.4, 16.0 Hz, 5H), 7.48–7.52 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.6, 43.5, 45.5, 48.9, 55.0, 56.0, 60.0, 65.9, 109.5, 113.3, 114.5, 121.1, 122.4, 124.8, 125.9, 126.1, 126.4, 127.2, 128.5, 128.6, 128.6, 128.9, 129.0, 129.1, 129.1, 131.8, 133.6, 134.3, 134.4, 142.2, 144.0, 159.2, 174.9, 175.5, 176.9, 194.9 ppm; HRMS (ESI): *m/z* calcd for $C_{42}H_{35}N_2O_5$ $[M + H]^+$: 647.2540, found: 647.2544.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-benzyl-4-(4-methoxybenzoyl)-2,6-diphenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3u):

Yield: 0.040 g (63%) as off white solid; MP: 241–244 °C; IR (KBr) ν_{max}: 3137, 1781, 1716, 1663, 1598, 1495, 1467, 1455, 1400, 1384, 1244, 1171, 1155, 1123, 842, 749, 698, 656, 615, 603, 582, 512 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.81 (s, 3H), 4.07–4.14 (m, 2H), 4.20 (dd, *J* = 8.8, 12.0 Hz, 1H), 4.61 (d, *J* = 16.4 Hz, 1H), 4.98 (d, *J* = 6.8 HZ, 1H), 5.10 (dd, *J* = 7.2, 8.8 Hz, 1H), 6.01 (d, *J* = 8.0 Hz, 1H), 6.37 (d, *J* = 7.6 Hz, 2H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.93–6.98 (m, 3H), 7.0–7.06 (m, 5H), 7.12 (dd, *J* = 7.6, 16.8 Hz, 2H), 7.30 (d, *J* = 7.6 Hz, 1H), 7.38 –7.42 (m, 3H), 7.48–7.55 (m, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.5, 45.7, 48.6, 55.3, 55.5, 60.1, 66.2, 109.3, 113.5, 122.5, 124.5, 125.9, 126.1, 126.4, 127.2, 128.1, 128.1, 128.4, 128.5, 128.6, 128.8, 128.9, 129.1, 130.9, 131.7, 132.8, 134.2, 141.9, 163.6,

175.0, 175.5, 177.0, 193.4 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{33}N_2O_5$ $[M + H]^+$: 633.2384, found: 633.2401.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-benzyl-4-(4-methoxybenzoyl)-2-phenyl-6-(*p*-tolyl)-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3v):

Yield: 0.042 g (65%) as off white solid; MP: 258–260 °C; IR (KBr) ν_{max}: 3136, 1779, 1716, 1669, 1597, 1489, 1400, 1385, 1239, 1171, 1115, 831, 757, 695, 656, 603 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 2.21 (s, 3H), 3.81 (s, 3H), 4.04 (d, *J* = 16.0 Hz, 1H), 4.09 (s, 1H), 4.15 (dd, *J* = 9.2, 12.0 Hz, 1H), 4.67 (d, *J* = 16.0 Hz, 1H), 4.95 (d, *J* = 6.8 Hz, 1H), 5.07 (dd, *J* = 7.2, 9.2 Hz, 1H), 6.03 (d, *J* = 8.0 Hz, 1H), 6.39 (d, *J* = 7.2 Hz, 2H), 6.76 (d, *J* = 8.8 Hz, 2H), 6.84 (s, 4H), 6.93–7.05 (m, 4H) , 7.09–7.13 (m, 1H), 7.29 (d, *J* = 7.2 Hz, 1H), 7.38–7.42 (m, 3H), 7.47–7.54 (m, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.1, 43.4, 45.6, 48.8, 55.4, 55.5, 59.9, 66.1, 109.3, 113.4, 122.4, 124.7, 125.9, 126.2, 126.4, 127.2, 128.3, 128.3, 128.5, 128.9, 129.1, 129.7, 130.9, 131.7, 134.3, 137.7, 142.0, 163.6, 175.0, 175.6, 177.1, 193.5 ppm; HRMS (ESI): *m/z* calcd for $C_{42}H_{35}N_2O_5$ $[M + H]^+$: 647.2540, found: 647.2541.

(3aR*,3'S*,4S*,6S*,6aS*)-1'-benzyl-4-(4-chlorophenyl)-6-(4-methoxybenzoyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3w):

Yield: 0.035 g (52%) as off white solid; MP: 240–242 °C; IR (KBr) ν_{max}: 3136, 1779, 1717, 1669, 1598, 1494, 1467, 1311, 1267, 1241, 1171, 1112, 1093, 1017, 837, 758, 694, 656, 616, 603, 590, 524 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.81 (s, 3H), 4.05–4.13 (m, 3H), 4.66 (d, *J* = 12.8 Hz, 1H), 4.95 (d, *J* = 5.6, 1H), 5.09 (dd, *J* = 5.6, 6.8 Hz, 1H), 6.08 (d, *J* = 6.0 Hz, 1H), 6.4 (d, *J* = 6.0 Hz, 2H), 6.77 (d, *J* = 6.8 Hz, 2H), 6.88 (d, *J* = 6.8 Hz, 2H), 6.97–7.01 (m, 3H), 7.05 (dd, *J* = 5.6, 11.6 Hz, 3H), 7.15 (t, *J* = 6.0 Hz, 1H), 7.29 (d, *J* = 6.0 Hz, 1H), 7.39–7.42 (m, 3H), 7.48–7.54 (m, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.5, 45.7, 48.8, 55.4, 55.5, 59.5, 66.0, 109.5, 113.5, 122.6, 124.3, 125.9, 126.2, 126.4, 127.4, 128.4, 128.5, 128.6, 128.8, 129.1, 129.2, 129.7, 130.9, 131.5, 131.7, 134.1, 134.2, 142.1, 163.7, 174.8, 175.4, 176.8, 193.2 ppm; HRMS (ESI): *m/z* calcd for $C_{41}H_{31}ClN_2O_5Na$ $[M + Na]^+$: 689.1814, found: 689.1814.

(3aS*,3'S*,4S*,6S*,6aR*)-1'-benzyl-4-(4-methoxybenzoyl)-6-(3-methoxyphenyl)-2-phenyl-3a,4,6,6a-tetrahydro-1*H*-spiro[cyclopenta[*c*]pyrrole-5,3'-indoline]-1,2',3(2*H*)-trione (3x):

Yield: 0.045 g (68%) as off white solid; MP: 247–249 °C; IR (KBr) ν_{max}: 3133, 1778, 1714, 1675, 1599, 1489, 1467, 1400, 1384, 1243, 1172, 1119, 758, 747, 695, 656, 604 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 3.49 (s, 3H), 3.81 (s, 3H), 4.03–4.18 (m, 3H), 4.66 (d, *J* = 16.0 Hz, 1H), 4.96 (d, *J* = 6.8 Hz, 1H), 5.09 (dd, *J* = 7.2, 9.2 Hz, 1H), 6.04 (d, *J* = 7.6 Hz, 1H), 6.38 (d, *J* = 7.2 Hz, 2H), 6.45 (t, *J* = 2.0 Hz, 1H), 6.59 (d, *J* = 8.0 Hz, 1H), 6.69 (dd, *J* = 2.4, 8.4 Hz, 1H), 6.77 (d, *J* = 8.8 Hz, 2H), 6.94–7.06 (m, 5H), 7.11 (t, *J* = 7.2 Hz, 1H), 7.31 (d, *J* = 7.6 Hz, 1H), 7.41 (d, *J* = 8.0 Hz, 3H), 7.49 (d, *J* = 7.2 Hz, 2H), 7.54 (d, *J* = 9.2 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 43.5, 45.6, 48.9, 55.0, 55.4, 55.5, 60.1,

66.1, 109.4, 113.2, 113.5, 114.4, 121.0, 122.5, 124.7, 125.9, 126.0, 126.4, 127.2, 128.5, 128.6, 128.9, 129.0, 129.1, 130.9, 134.2, 134.3, 142.1, 159.1, 163.6, 174.9, 175.5, 177.0, 193.4 ppm; HRMS (ESI): *m/z* calcd for $C_{42}H_{35}N_2O_6$ $[M + H]^+$: 663.2490, found: 663.2489.

(*R*,E*)-3-Benzylidene-4-((*S)-3-oxo-1,3-diphenylpropyl)-1-phenylpyrrolidine-2,5-dione (5a):**

Yield: 0.030 g (64%) as off white solid; MP: 171–174 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.33 (dd, *J* = 4.0, 18.4 Hz, 1H), 4.19 (dt, *J* = 4.4, 11.2 Hz, 1H), 4.55 (dd, *J* = 2.0, 4.4 Hz, 1H), 4.61 (dd, *J* = 10.4, 18.0 Hz, 1H), 6.96–7.0 (m, 5H), 7.19–7.26 (m, 3H), 7.34–7.74 (m, 7H), 7.97–7.99 (m, 2H), 8.09–8.12 (m, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 39.1, 40.0, 46.3, 126.5, 126.8, 127.8, 128.2, 128.2, 128.3, 128.5, 128.5, 128.7, 129.0, 129.3, 130.5, 131.0, 131.7, 133.3, 136.5, 137.1, 138.4, 169.4, 175.5, 199.2 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{25}KNO_3$ $[M+K]^+$: 510.1466, found: 510.1461.

(*R*,E*)-3-(4-Chlorobenzylidene)-4-((*S)-3-oxo-1,3-diphenylpropyl)-1-phenylpyrrolidine-2,5-dione (5b):**

Yield: 0.032 g (63%) as off white solid; MP: 215–218 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.27 (dd, *J* = 3.6, 18.4 Hz, 1H), 4.14 (dt, *J* = 3.6, 11.2 Hz, 1H), 4.51 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.68 (dd, *J* = 10.8, 18.0 Hz, 1H), 6.95–6.99 (m, 4H), 7.20–7.28 (m, 3H), 7.34–7.43 (m, 3H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.58–7.63 (m, 3H), 7.68 (d, *J* = 2.0 Hz, 1H), 7.97 (d, *J* = 8.8 Hz, 2H), 8.09–8.12 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 39.0, 39.9, 46.1, 126.4, 127.3, 127.9, 128.2, 128.2, 128.2, 128.3, 128.5, 128.6, 128.7, 129.0, 129.6, 131.6, 131.7, 132.2, 132.3, 132.3, 133.4, 134.9, 135.0, 135.0, 135.1, 136.6, 137.0, 138.2, 169.3, 175.3, 199.4 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{24}ClNO_3Na$ $[M+Na]^+$: 528.1337, found: 528.1359.

(*R*,E*)-3-(4-Methylbenzylidene)-4-((*S)-3-oxo-1,3-diphenylpropyl)-1-phenylpyrrolidine-2,5-dione (5c):**

Yield: 0.036 g (74%) as off white solid; MP: 235–238 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.48 (s, 3H), 3.34 (dd, *J* = 3.5, 18.0 Hz, 1H), 4.23 (dt, *J* = 4.0, 10.5 Hz, 1H), 4.51 (m, 1H), 4.62 (dd, *J* = 10.5, 18.0 Hz, 1H), 6.97–7.0 (m, 4H), 7.21–7.26 (m, 3H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.42 (dd, *J* = 8.0, 18.0 Hz, 4H), 7.49 (t, *J* = 7.5 Hz, 2H), 7.59 (t, *J* = 7.5 Hz, 1H), 7.71 (d, *J* = 1.0 Hz, 1H), 7.88 (d, *J* = 8.0 Hz, 2H), 8.12 (d, *J* = 7.5 Hz, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.6, 39.0, 40.1, 46.4, 125.7, 126.5, 127.8, 128.2, 128.4, 128.4, 128.5, 128.7, 129.0, 130.1, 130.6, 131.1, 131.8, 133.3, 136.5, 137.3, 138.5, 141.1, 169.6, 175.6, 199.3 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{31}N_2O_3$ $[M+NH_4]^+$: 503.2329, found: 503.2335.

(*R*,E*)-3-(3-Methoxybenzylidene)-4-((*S)-3-oxo-1,3-diphenylpropyl)-1-phenylpyrrolidine-2,5-dione (5d):**

Yield: 0.037 g (74%) as white solid; MP: 95–98 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.38 (dd, *J* = 4.4, 18.4 Hz, 1H), 3.99 (s, 3H), 4.19 (dt, *J* = 4.4, 10.0 Hz, 1H), 4.53 (dd, *J* = 10.4, 18.0 Hz, 1H), 4.59 (dd, *J* = 2.0, 4.0 Hz, 1H), 6.98–7.01 (m, 4H), 7.07 (dd, *J* = 1.6, 8.0 Hz, 1H), 7.20–7.25 (m, 3H), 7.34–7.44 (m, 4H), 7.46–7.50 (m, 2H), 7.53–7.63 (m, 3H), 7.70 (d, *J* = 2.0 Hz, 1H), 8.07–8.09 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 39.3, 40.1, 46.1, 55.6, 115.9, 116.6, 123.0, 126.4, 127.1, 127.8, 128.2, 128.3, 128.4, 128.6, 129.0, 130.3, 131.7, 133.3, 134.7, 136.5, 137.1, 138.4, 160.1, 169.3, 175.5, 199.0 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{27}NO_4K$ $[M+K]^+$: 540.1566, found: 540.1570.

(*R*,E*)-3-Benzylidene-4-((*S)-3-(4-fluorophenyl)-3-oxo-1-(*p*-tolyl)propyl)-1-phenylpyrrolidine-2,5-dione (5e):**

Yield: 0.035 g (70%) as off white solid; MP: 163–165 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.29 (s, 3H), 3.25 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.15 (dt, *J* = 4.0, 10.5 Hz, 1H), 4.50–4.57 (m, 2H), 6.85 (d, *J* = 7.5 Hz, 2H), 7.01 (t, *J* = 5.6 Hz, 1H), 7.15 (t, *J* = 7.2 Hz, 2H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.42–7.45 (m, 2H), 7.52 (t, *J* = 7.5 Hz, 1H), 7.63 (t, *J* = 7.5 Hz, 2H), 7.73 (d, *J* = 1.5 Hz, 1H), 7.96 (d, *J* = 8.0 Hz, 2H), 8.14 (dd, *J* = 5.5, 9.0 Hz, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.0, 38.7, 40.1, 46.2, 115.7, 115.8, 126.5, 126.9, 128.1, 128.5, 129.0, 129.1, 129.3, 130.5, 130.9, 130.9, 131.7, 133.4, 133.6, 133.6, 135.2, 136.4, 137.5, 164.9, 166.9, 169.5, 175.7, 197.7 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{26}FNO_3Na$ $[M+Na]^+$: 526.1789, found: 526.1807.

(*R*,E*)-3-(4-Chlorobenzylidene)-4-((*S)-3-(4-fluorophenyl)-3-oxo-1-(*p*-tolyl)propyl)-1-phenylpyrrolidine-2,5-dione (5f):**

Yield: 0.035 g (65%) as off white solid; MP: 176–179 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.30 (s, 3H), 3.19 (dd, *J* = 3.2, 18.0 Hz, 1H), 4.10 (dt, *J* = 3.6, 10.8 Hz, 1H), 4.48 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.62 (dd, *J* = 10.8, 18.0 Hz, 1H), 6.85 (d, *J* = 8.0 Hz, 2H), 6.98–7.04 (m, 4H), 7.16 (t, *J* = 8.8 Hz, 2H), 7.35–7.40 (m, 1H), 7.41–7.46 (m, 2H), 7.62 (d, *J* = 8.4 Hz, 2H), 7.67 (d, *J* = 2.0 Hz, 1H), 7.95 (d, *J* = 8.4 Hz, 2H), 8.11–8.16 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.0, 38.6, 40.0, 45.9, 115.7, 115.9, 126.4, 127.3, 128.1, 128.6, 129.1, 129.2, 129.6, 130.8, 130.9, 131.6, 131.7, 132.2, 133.4, 133.5, 135.0, 135.0, 136.6, 137.7, 164.6, 167.2, 169.3, 175.5, 197.9 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{25}ClFNO_3Na$ $[M+Na]^+$: 560.1399, found: 560.1396.

(*R*,E*)-3-((*S)-3-(4-Fluorophenyl)-3-oxo-1-(*p*-tolyl)propyl)-4-(4-methylbenzylidene)-1-phenylpyrrolidine-2,5-dione (5g):**

Yield: 0.038 g (73%) as white solid; MP: 195–198 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.29 (s, 3H), 2.48 (s, 3H), 3.26 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.18 (dt, *J* = 4.0, 10.4 Hz, 1H), 4.46 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.56 (dd, *J* = 10.4, 17.6 Hz, 1H), 6.86 (d, *J* = 8.0 Hz, 2H), 6.99–7.03 (m, 4H), 7.16 (t, *J* = 8.4 Hz, 2H), 7.34–7.39 (m, 1H), 7.43 (t, *J* = 7.6 Hz, 4H), 7.70 (d, *J* = 1.6 Hz, 1H), 7.86 (d, *J* = 8.0 Hz, 2H),

8.13–8.17 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.0, 21.6, 38.6, 40.1, 46.3, 115.6, 115.9, 125.7, 125.7, 126.5, 128.2, 128.5, 129.0, 129.1, 130.0, 130.6, 130.9, 131.0, 131.0, 131.8, 133.7, 135.3, 136.5, 137.5, 141.1, 164.6, 167.2, 169.6, 175.8, 197.8 ppm; HRMS (ESI): m/z calcd for $C_{34}H_{28}FNO_3K$ $[M+K]^+$: 556.1685, found: 556.1687.

(*R*,E*)-3-Benzylidene-4-((*S)-1-(4-chlorophenyl)-3-oxo-3-phenylpropyl)-1-phenylpyrrolidine-2,5-dione (5h):**

Yield: 0.038 g (75%) as off white solid; MP: 164–167 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.31 (dd, *J* = 3.5, 18.0 Hz, 1H), 4.17–4.19 (m, 1H), 4.52–4.58 (m, 2H), 6.91 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 7.5 Hz, 2H), 7.19 (d, *J* = 8.0 Hz, 2H), 7.37–7.65 (m, 9H), 7.76 (s, 1H), 7.95 (d, *J* = 7.5 Hz, 2H), 8.09 (d, *J* = 8.0 Hz, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 38.4, 40.1, 46.1, 126.3, 126.4, 128.2, 128.6, 128.6, 128.7, 129.1, 129.4, 129.6, 130.7, 130.9, 131.6, 133.2, 133.4, 133.7, 136.8, 137.0, 137.0,169.2, 175.4, 198.8 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{24}ClNO_3Na$ $[M+Na]^+$: 528.1337, found: 528.1339.

(*R*,E*)-3-(4-Chlorobenzylidene)-4-((*S)-1-(4-chlorophenyl)-3-oxo-3-phenylpropyl)-1-phenylpyrrolidine-2,5-dione (5i):**

Yield: 0.035 g (65%) as off white solid; MP: 173–176 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.24 (dd, *J* = 3.6, 18.0 Hz, 1H), 4.13 (dt, *J* = 4.0, 10.8 Hz, 1H), 4.51 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.63 (dd, *J* = 10.8, 18.4 Hz, 1H), 6.91 (d, *J* = 8.8 Hz, 2H), 6.97–7.0 (m, 2H), 7.20 (d, *J* = 8.8 Hz, 2H), 7.36–7.40 (m, 1H), 7.43–7.46 (m, 2H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.58–7.63 (m, 3H), 7.70 (d, *J* = 2.0 Hz, 1H), 7.95 (d, *J* = 8.4 Hz, 2H), 8.08–8.10 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 38.4, 39.9, 45.9, 126.3, 127.0, 128.2, 128.7, 128.7, 128.8, 129.1, 129.6, 129.7, 131.5, 131.6, 132.2, 133.5, 133.9, 135.3, 136.9, 136.9, 169.1, 175.2, 199.0 ppm; HRMS (ESI): m/z calcd for $[M+Na]^+$: , found: .

(*R*,E*)-3-((*S)-1-(4-Chlorophenyl)-3-oxo-3-phenylpropyl)-4-(4-methylbenzylidene)-1-phenylpyrrolidine-2,5-dione (5j):**

Yield: 0.039 g (75%) as white solid; MP: 178–181 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.47 (s, 3H), 3.32 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.21 (dt, *J* = 4.0, 10.4 Hz, 1H), 4.50 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.56 (dd, *J* = 10.4, 18.0 Hz, 1H), 6.91 (d, *J* = 8.4 Hz, 2H), 6.98–7.01 (m, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 7.37 (t, *J* = 7.2 Hz, 1H), 7.42–7.46 (m, 4H), 7.49 (t, *J* = 7.6 Hz, 2H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.73 (d, *J* = 2.0, 1H), 7.85 (d, *J* = 8.0 Hz, 2H), 8.08–8.11 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.6, 38.3, 40.0, 46.2, 125.2, 126.4, 128.2, 128.6, 128.7, 129.1, 129.7, 130.1, 130.4, 131.0, 131.7, 133.4, 133.7, 136.8, 137.0, 141.3, 169.4, 175.4, 198.9 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{30}ClN_2O_3$ $[M+NH_4]^+$: 537.1939, found: 537.1973.

(*R*,E*)-3-((*S)-1-(4-Chlorophenyl)-3-oxo-3-phenylpropyl)-4-(3-methoxybenzylidene)-1-phenylpyrrolidine-2,5-dione (5k):**

Yield: 0.041 g (76%) as white solid; MP: 134–137 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.36 (dd, *J* = 4.4, 18.0 Hz, 1H), 3.98 (s, 3H), 4.15–4.20 (m, 1H), 4.47 (dd, *J* = 10.0, 18.0 Hz, 1H), 4.58 (dd, *J* = 2.0, 4.0 Hz, 1H), 6.91 (d, *J* = 8.4 Hz, 2H), 7.01–7.03 (m, 2H), 7.06–7.09 (m, 1H), 7.19 (d, *J* = 8.4 Hz, 2H), 7.34–7.40 (m, 2H), 7.43–7.50 (m, 4H), 7.53–7.61 (m, 3H), 7.72 (d, *J* = 2.0 Hz, 1H), 8.05–8.07 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 38.6, 40.1, 46.0, 55.6, 115.8, 116.6, 123.0, 126.3, 126.7, 128.2, 128.6, 128.7, 129.1, 129.6, 130.4, 131.5, 133.4, 133.7, 134.5, 136.9, 136.9, 137.0, 160.1, 169.2, 175.4, 198.7 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{26}ClNO_4$ $[M]^+$: 535.1545, found: 535.1559.

(*R*,E*)-3-Benzylidene-4-((*S)-3-(4-bromophenyl)-1-(4-chlorophenyl)-3-oxopropyl)-1-phenylpyrrolidine-2,5-dione (5l):**

Yield: 0.044 g (76%) as off white solid; MP: 98–101 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 3.25 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.16 (dt, *J* = 4.0, 10.0 Hz, 1H), 4.48–4.54 (m, 2H), 6.88 (d, *J* = 8.5 Hz, 2H), 7.01 (d, *J* = 7.5 Hz, 2H), 7.19 (d, *J* = 8.0 Hz, 2H), 7.39 (t, *J* = 7.5 Hz, 1H), 7.43–7.46 (m, 2H), 7.53 (t, *J* = 7.5 Hz, 1H), 7.62–7.65 (m, 4H), 7.75 (d, *J* = 1.5 Hz, 1H), 7.93–7.96 (m, 4H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 38.3, 40.0, 46.0, 126.3, 128.7, 128.7, 129.1, 129.4, 129.6, 129.7, 130.7, 130.9, 131.5, 132.0, 133.2, 133.8, 135.7, 136.8, 136.9, 169.2, 175.4, 197.9 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{23}BrClNO_3Na$ $[M+Na]^+$: 606.0442, found: 606.047.

(*R*,E*)-3-((*S)-3-(4-Bromophenyl)-1-(4-chlorophenyl)-3-oxopropyl)-4-(4-chlorobenzylidene)-1-phenylpyrrolidine-2,5-dione (5m):**

Yield: 0.032 g (52%) as off white solid; MP: 173–175 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.18 (dd, *J* = 3.6, 18.4 Hz, 1H), 4.11 (dt, *J* = 3.6, 10.8 Hz, 1H), 4.48 (dd, *J* = 2.0, 4.0 Hz, 1H), 4.58 (dd, *J* = 10.8, 18.0 Hz, 1H), 6.88 (d, *J* = 8.4 Hz, 2H), 6.98–7.0 (m, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 7.36–7.41 (m, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.63 (t, *J* = 8.4 Hz, 4H), 7.69 (d, *J* = 2.0 Hz, 1H), 7.94 (t, *J* = 8.4 Hz, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 38.3, 39.9, 45.8, 126.3, 126.8, 128.7, 128.8, 128.8, 129.2, 129.6, 129.7, 131.4, 131.5, 132.1, 132.2, 133.9, 135.4, 135.4, 135.6, 136.6, 136.9, 169.0, 175.2, 198.0 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{22}BrCl_2NO_3K$ $[M+K]^+$: 655.9792, found: 655.9775.

(*R*,E*)-3-((*S)-3-(4-Bromophenyl)-1-(4-chlorophenyl)-3-oxopropyl)-4-(4-methylbenzylidene)-1-phenylpyrrolidine-2,5-dione (5n):**

Yield: 0.045 g (75%) as off white solid; MP: 177–180 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.48 (s, 3H), 3.26 (dd, *J* = 4.4, 18.0 Hz, 1H), 4.19 (dt, *J* = 4.0, 10.0 Hz, 1H), 4.46–4.55 (m, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.99–7.01 (m, 2H), 7.18 (d, *J* = 8.8 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 1H), 7.42–7.46 (m, 4H), 7.63 (d,

J = 8.8 Hz, 2H), 7.72 (d, *J* = 1.6 Hz, 1H), 7.83 (d, *J* = 8.4 Hz, 2H), 7.96 (d, *J* = 8.8 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.6, 38.2, 40.0, 46.0, 125.1, 126.3, 128.6, 128.6, 128.7, 129.1, 129.6, 129.7, 129.7, 129.8, 130.1, 130.4, 131.0, 131.0, 131.6, 132.0, 132.0, 133.8, 135.7, 136.8, 136.9, 141.4, 169.3, 175.4, 198.0 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{25}BrClNO_3$ $[M]^+$: 597.0701, found: 597.4141.

(*R*,E*)-3-Benzylidene-4-((*S)-1-(4-chlorophenyl)-3-oxo-3-(*p*-tolyl)propyl)-1-phenylpyrrolidine-2,5-dione (5o):**

Yield: 0.032 g (62%) as off white solid; MP: 134–137 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 2.42 (s, 3H), 3.28 (dd, *J* = 4.0, 17.5 Hz, 1H), 4.17 (dt, *J* = 4.0, 10.0 Hz, 1H), 4.49–4.54 (m, 2H), 6.91 (d, *J* = 8.5 Hz, 2H), 7.0 (d, *J* = 7.5 Hz, 2H), 7.19 (d, *J* = 8.5 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.43–7.46 (m, 2H), 7.53 (t, *J* = 7.5 Hz, 1H), 7.63 (t, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 2.0 Hz, 1H), 7.95 (d, *J* = 7.5 Hz, 2H), 7.99 (d, *J* = 8.5 Hz, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 21.7, 38.5, 39.9, 46.2, 126.3, 126.5, 128.3, 128.6, 128.6, 129.1, 129.3, 129.4, 129.6, 130.6, 130.9, 131.6, 133.2, 133.7, 134.5, 136.8, 137.1, 144.3, 169.3, 175.3, 198.4 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{26}ClNO_3Na$ $[M+Na]^+$: 542.1493, found: 542.1500.

(*R*,E*)-3-Benzylidene-4-((*S)-3-(3-chlorophenyl)-1-(4-chlorophenyl)-3-oxopropyl)-1-phenylpyrrolidine-2,5-dione (5p):**

Yield: 0.045 g (83%) as off white solid; MP: 175–178 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.27 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.16 (dt, *J* = 4.0, 10.0 Hz, 1H), 4.49–4.56 (m, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 7.0–7.02 (m, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 7.37–7.47 (m, 4H), 7.55 (q, *J* = 7.6 Hz, 2H), 7.64 (t, *J* = 7.6 Hz, 2H), 7.76 (d, *J* = 2.0 Hz, 1H), 7.94–7.97 (m, 3H), 8.04 (t, *J* = 2.0 Hz, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 38.2, 40.2, 45.9, 126.3, 126.3, 128.2, 128.3, 128.7, 128.7, 129.1, 129.4, 129.6, 130.1, 130.7, 130.9, 131.5, 133.2, 133.4, 133.8, 135.1, 136.7, 136.9, 138.4, 169.2, 175.4, 197.6 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{27}Cl_2N_2O_3$ $[M+NH_4]^+$: 557.1393, found: 557.1395.

(*R,E)-3-Benzylidene-1-(4-chlorophenyl)-4-((*S**)-3-oxo-1,3-diphenylpropyl)pyrrolidine-2,5-dione (5q):**

Yield: 0.034 g (67%) as off white solid; MP: 169–172 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 3.34 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.17 (dt, *J* = 3.6, 10.4 Hz, 1H), 4.53–4.61 (m, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 6.97 (dd, *J* = 1.6, 8.0 Hz, 2H), 7.19–7.24 (m, 3H), 7.38 (d, *J* = 8.4 Hz, 2H), 7.48–7.54 (m, 3H), 7.58–7.65 (m, 3H), 7.74 (d, *J* = 2.0 Hz, 1H), 7.98 (d, *J* = 7.6 Hz, 2H), 8.09–8.11 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 39.2, 39.9, 46.4, 126.5, 127.7, 127.9, 128.2, 128.3, 128.5, 128.7, 129.2, 129.3, 130.1, 130.7, 131.0, 133.2, 133.4, 134.3, 136.9, 137.1, 138.3, 169.2, 175.3, 199.2 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{24}ClNO_3Na$ $[M+Na]^+$: 528.1337, found: 528.1364.

(*R*,*E)-3-Benzylidene-1-(4-chlorophenyl)-4-((*S**)-1-(4-chlorophenyl)-3-oxo-3-phenylpropyl)pyrrolidine-2,5-dione (5r):**

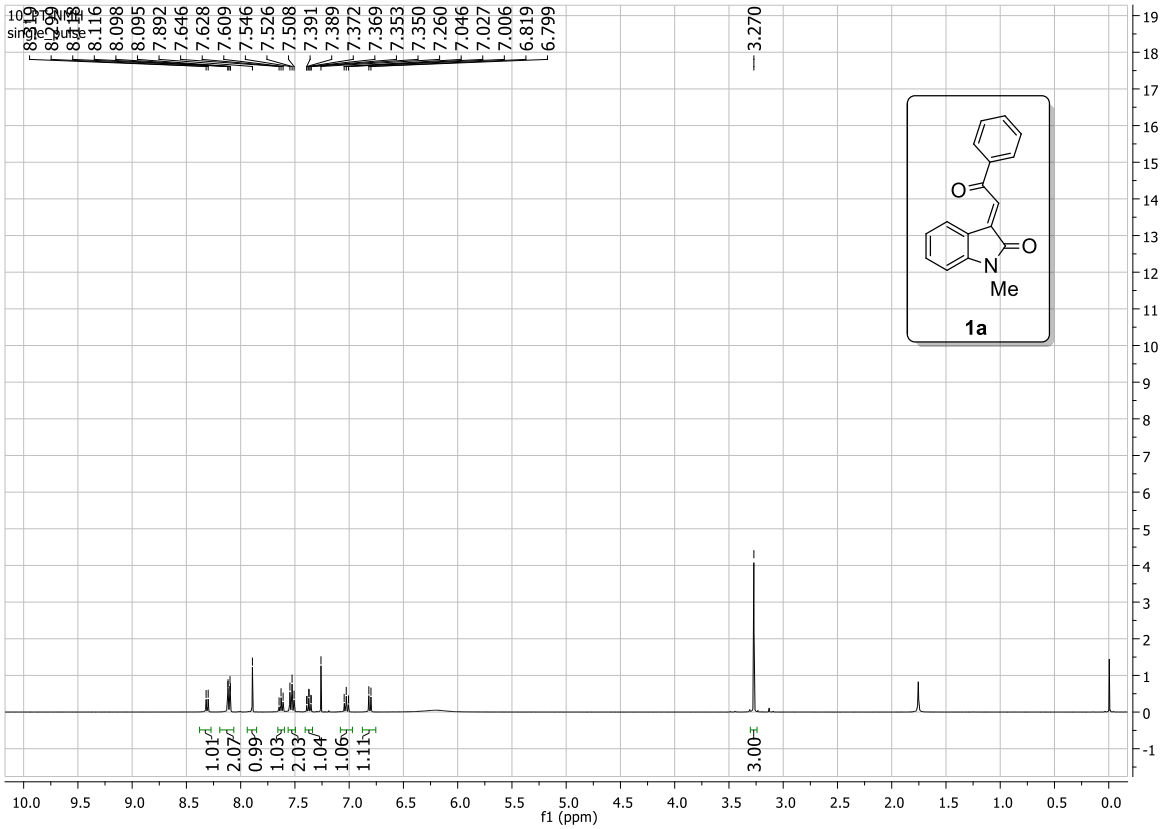
Yield: 0.036 g (67%) as off white solid; MP: 162–165 °C; ^{1}H NMR (400 MHz, CDCl3): δ 3.32 (dd, *J* = 4.0, 18.0 Hz, 1H), 4.16 (dt, *J* = 4.0, 10.4 Hz, 1H), 4.48–4.55 (m, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 6.96 (d, *J* = 8.8 Hz, 2H), 7.18 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 8.8 Hz, 2H), 7.48–7.55 (m, 3H), 7.58–7.65 (m, 3H), 7.76 (d, *J* = 2.0 Hz, 1H), 7.95 (d, *J* = 7.6 Hz, 2H), 8.07–8.09 (m, 2H) ppm; ^{13}C NMR (125 MHz, CDCl3): δ 38.5, 39.9, 46.2, 126.1, 127.5, 128.2, 128.6, 128.8, 129.3, 129.4, 129.6, 130.0, 130.8, 131.0, 133.0, 133.5, 133.8, 134.1, 134.5, 136.9, 137.0, 137.2, 169.0, 175.1, 198.8 ppm; HRMS (ESI): m/z calcd for $C_{32}H_{24}Cl_2NO_3$ $[M+H]^+$: 540.1128, found: 540.1117.

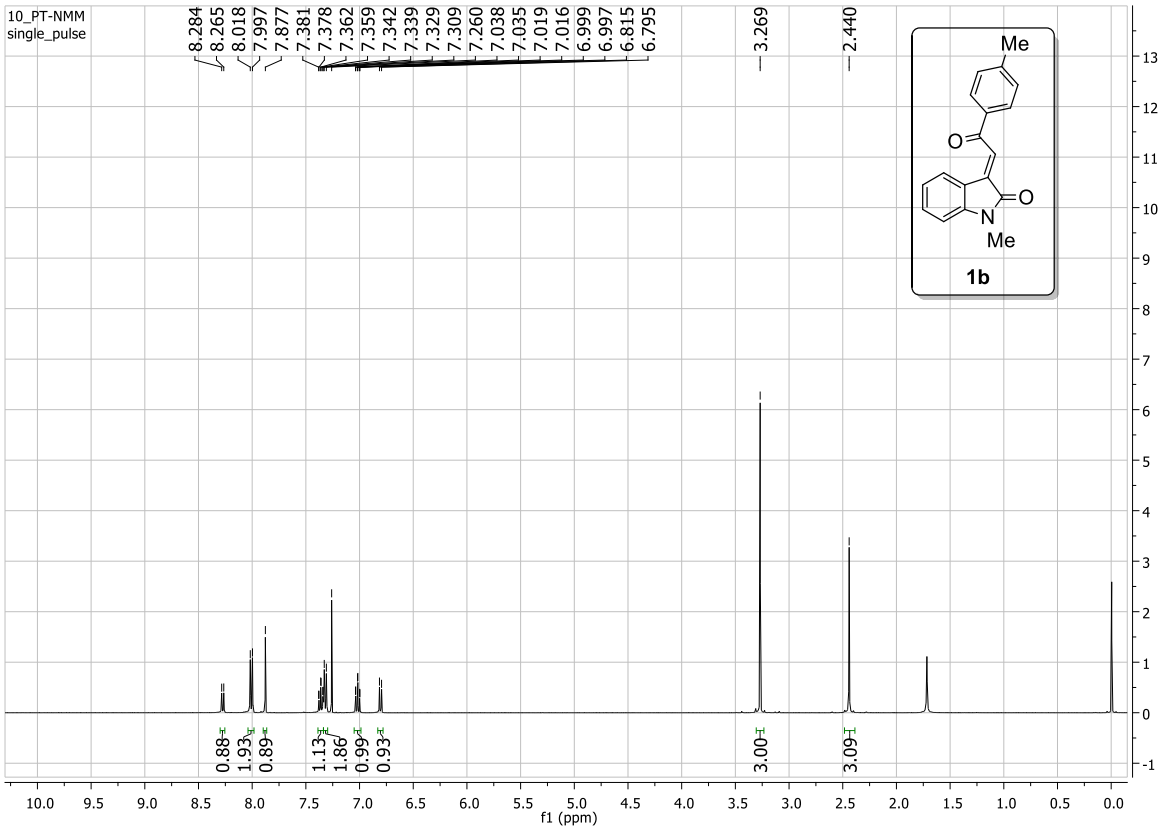
(*R*,*E)-1-Benzyl-3-benzylidene-4-((*S**)-1-(4-chlorophenyl)-3-oxo-3-phenylpropyl)pyrrolidine-2,5-dione (5s):**

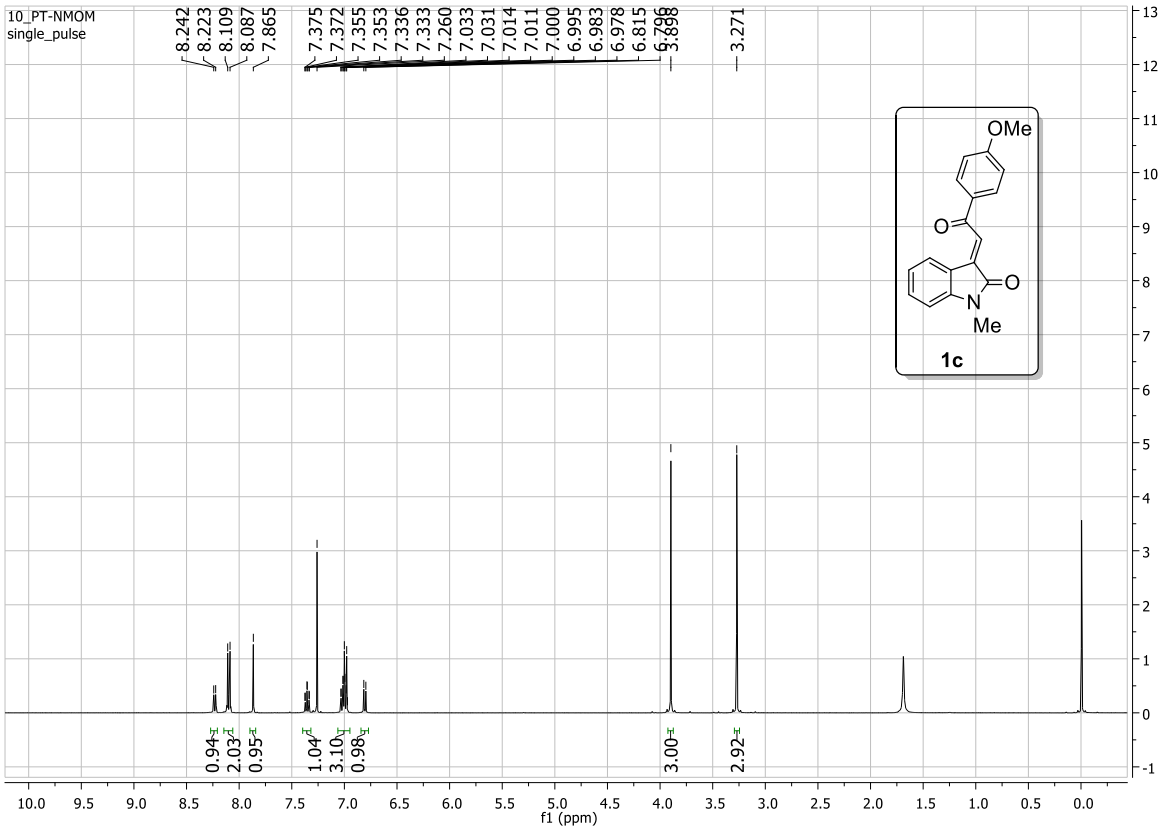
Yield: 0.034 g (65%) as off white solid; MP: 144–146 °C; ^{1}H NMR (400 MHz, CDCl3): δ 3.24 (dd, *J* = 4.4, 18.4 Hz, 1H), 4.03 (dt, *J* = 4.4, 10.4 Hz, 1H), 4.38 (dd, *J* = 2.4, 4.0 Hz, 1H), 4.44–4.64 (m, 3H), 6.57 (d, *J* = 8.4 Hz, 2H), 6.78 (d, *J* = 8.4 Hz, 2H), 7.20–7.22 (m, 2H), 7.29–7.31 (m, 3H), 7.46–7.52 (m, 3H), 7.57–7.62 (m, 3H), 7.67 (d, *J* = 2.0 Hz, 1H), 7.87 (d, *J* = 7.2 Hz, 2H), 8.05–8.07 (m, 2H) ppm; ^{13}C NMR (125 MHz, CDCl3): δ 37.6, 40.2, 42.3, 45.7, 126.6, 127.9, 128.1, 128.4, 128.6, 128.7, 129.0, 129.2, 129.2, 130.4, 130.7, 133.1, 133.2, 133.4, 135.4, 136.1, 136.6, 137.0, 170.0, 176.0, 198.8 ppm; HRMS (ESI): m/z calcd for $C_{33}H_{27}ClNO_3$ $[M+H]^+$: 520.1674, found: 520.1701.

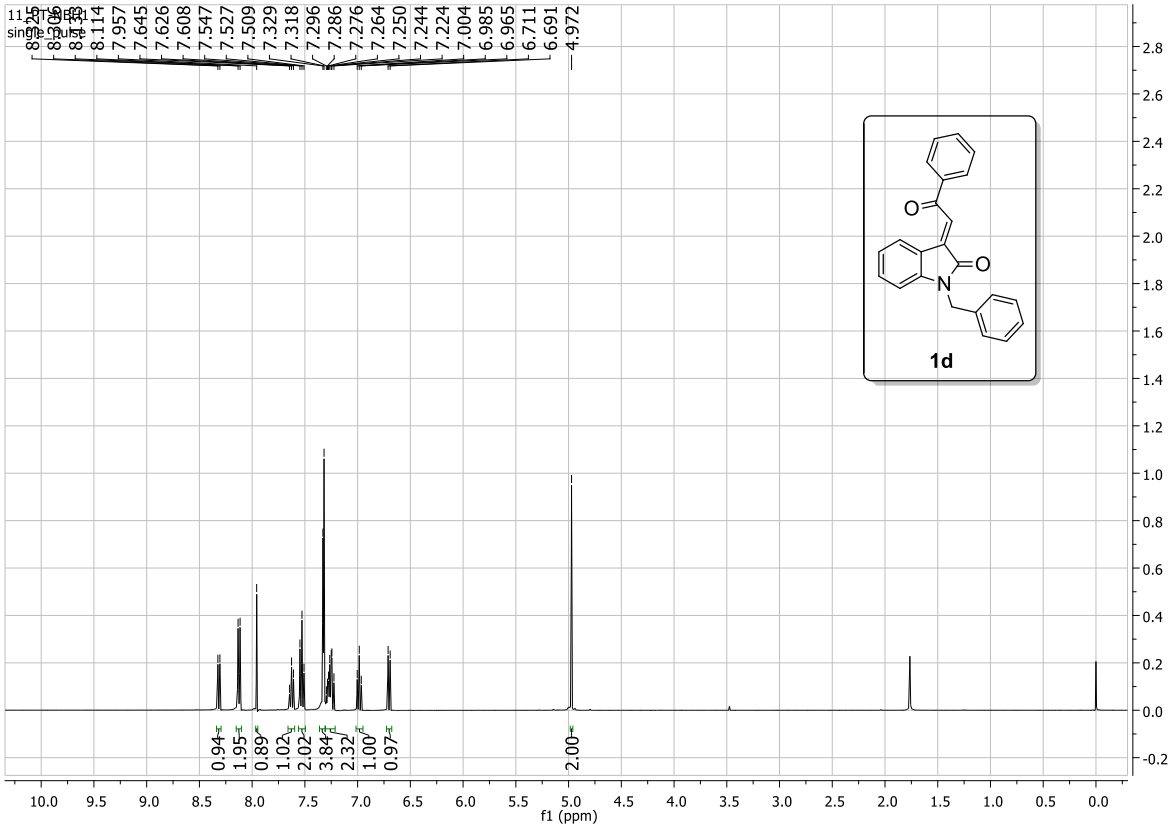
Dimethyl 2-((*S)-1-((*R*,*E**)-4-benzylidene-2,5-dioxo-1-phenylpyrrolidin-3-yl)-2-oxo-2-(*p*-tolyl)ethyl)malonate (5t):**

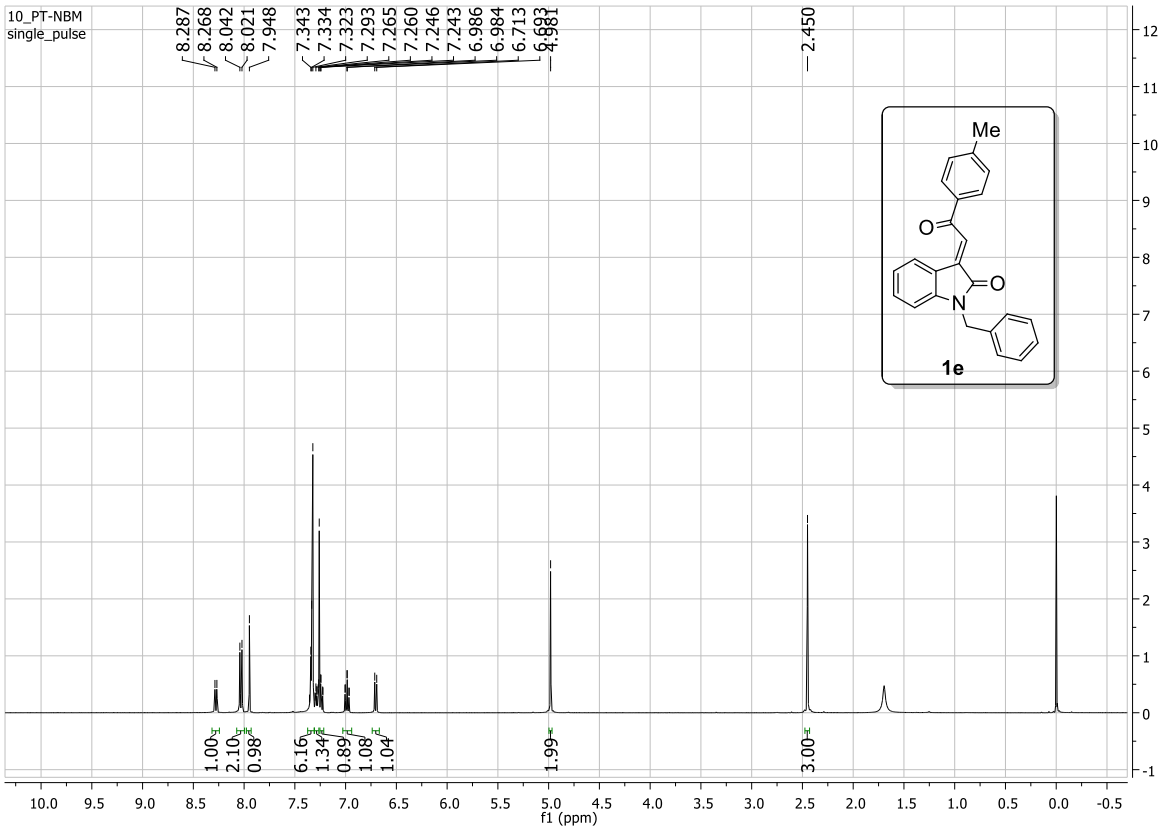
Yield: 0.043 g (81%) as white solid; MP: 197–200 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.31 (s, 3H), 3.24 (s, 3H), 3.89 (s, 3H), 4.55 (dd, *J* = 2.4, 4.8 Hz, 1H), 4.77 (d, *J* = 11.6 Hz, 1H), 5.05 (dd, *J* = 4.8, 11.6 Hz, 1H), 6.94 (d, *J* = 8.0 Hz, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 7.40–7.44 (m, 1H), 7.48–7.62 (m, 10H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 21.6, 41.6, 42.7, 51.7, 52.6, 53.1, 125.7, 126.8, 128.5, 128.6, 129.1, 129.1, 129.2, 130.4, 130.6, 132.1, 133.2, 133.9, 136.9, 144.7, 168.3, 168.8, 169.1, 174.7, 198.5 ppm; HRMS (ESI): m/z calcd for $C_{31}H_{27}NO_7Na$ $[M+Na]^+$: 548.1680, found: 548.1696.

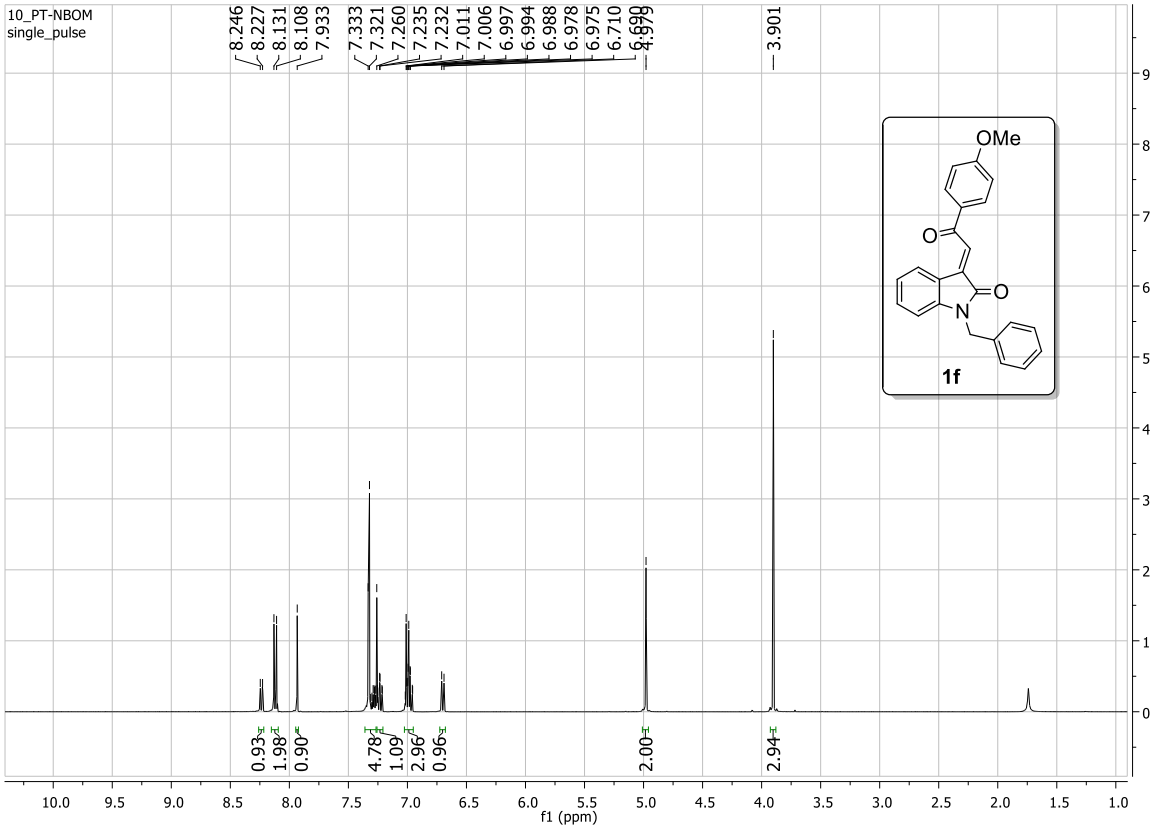

10_PT-NMM
single_pulse
8.284
8.265
8.018
7.997
7.877
7.381
7.378
7.362
7.359
7.342
7.339
7.329
7.309
7.260
7.038
7.035
7.019
7.016
6.999
6.997
6.815
6.795
3.270
1.01
2.07
0.99
1.03
2.03
1.04
1.06
1.11
3.00
O
O
N
Me
1a
f1 (ppm)

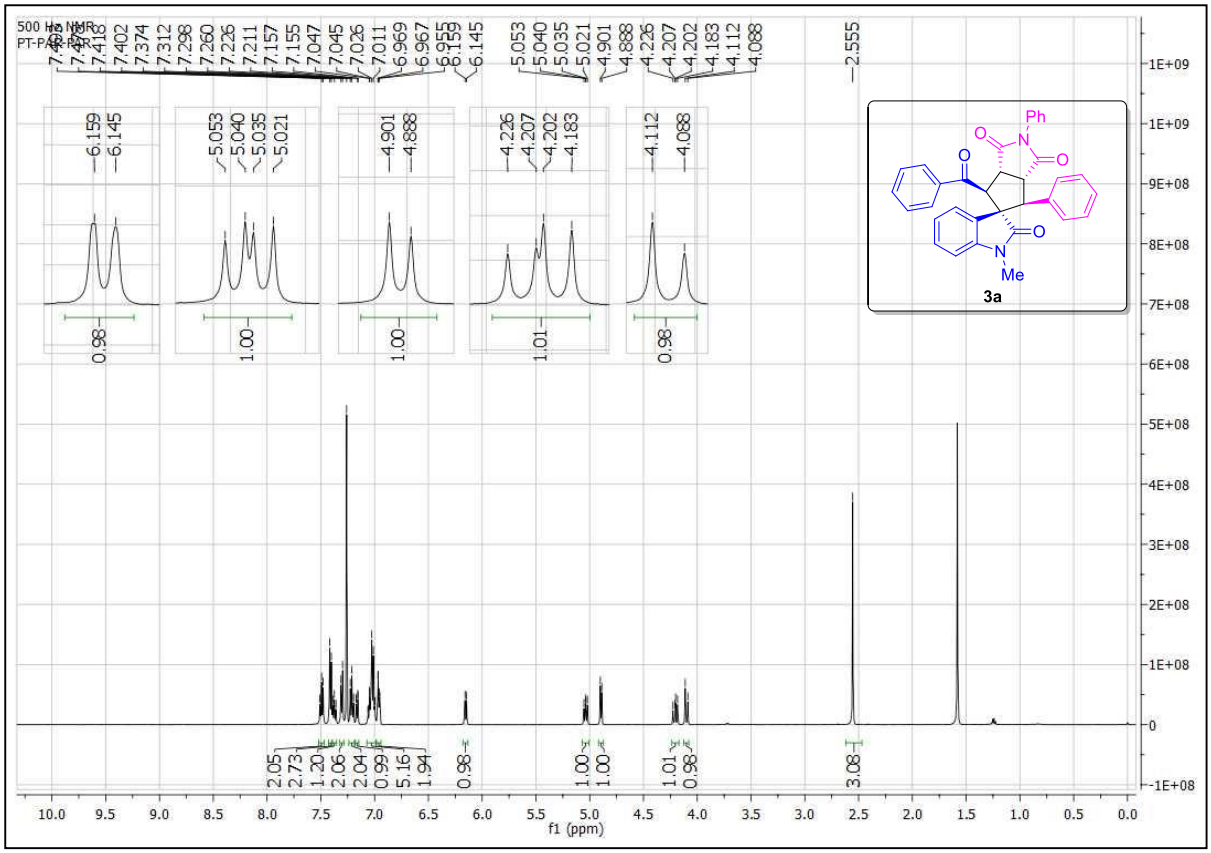

10_PT-NMM
single_pulse
8.284
8.265
8.018
7.997
7.877
7.381
7.378
7.362
7.359
7.342
7.339
7.329
7.309
7.260
7.038
7.035
7.019
7.016
6.999
6.997
6.815
6.795
3.269
2.440
0.88
1.93
0.89
1.13
1.86
0.99
0.93
3.00
3.09
Me
O
O
N
Me
1b
f1 (ppm)

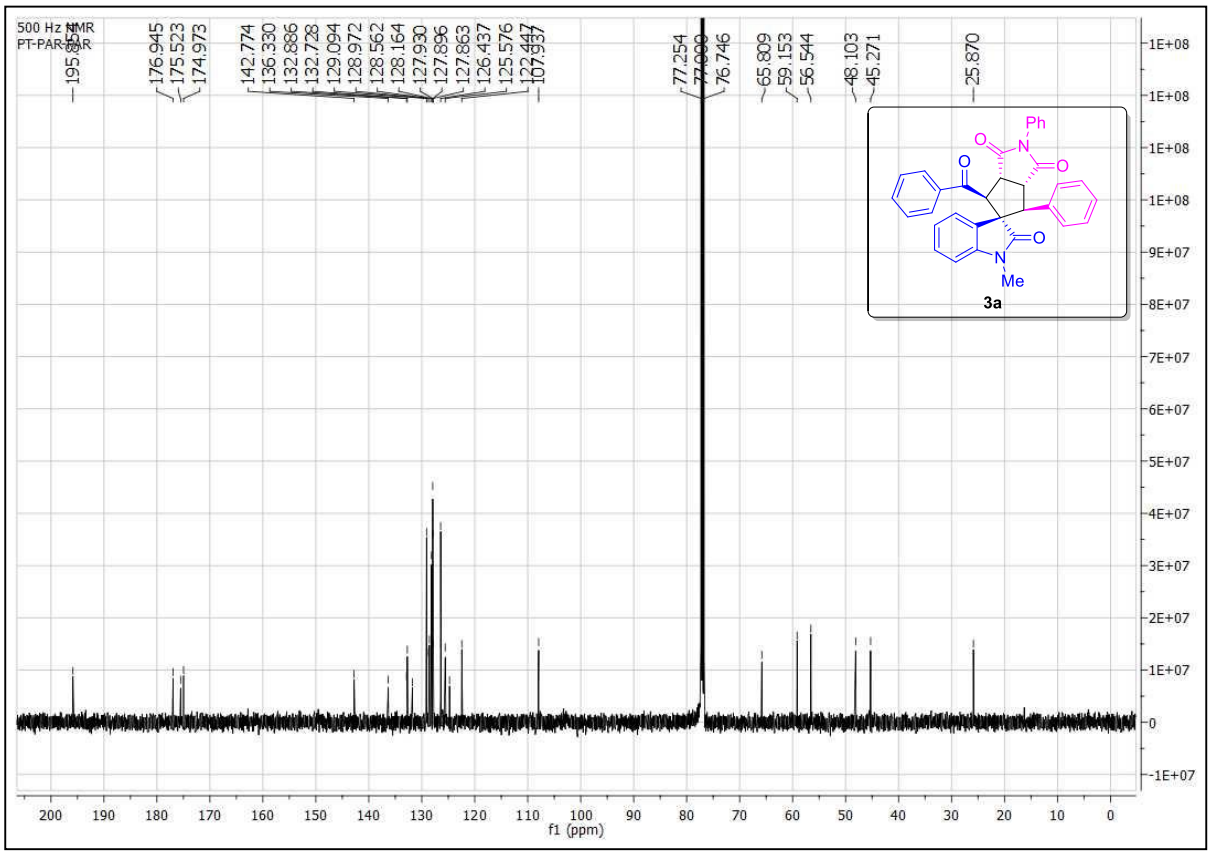

10_PT-NMOM
single_pulse
8.242
8.223
8.109
8.087
7.865
7.375
7.372
7.355
7.353
7.336
7.333
7.260
7.033
7.031
7.014
7.011
7.000
6.995
6.983
6.978
6.815
3.898
3.271
OMe
O
O
N
Me
1c
0.94
2.03
0.95
1.04
3.10
0.98
3.00
2.92
f1 (ppm)

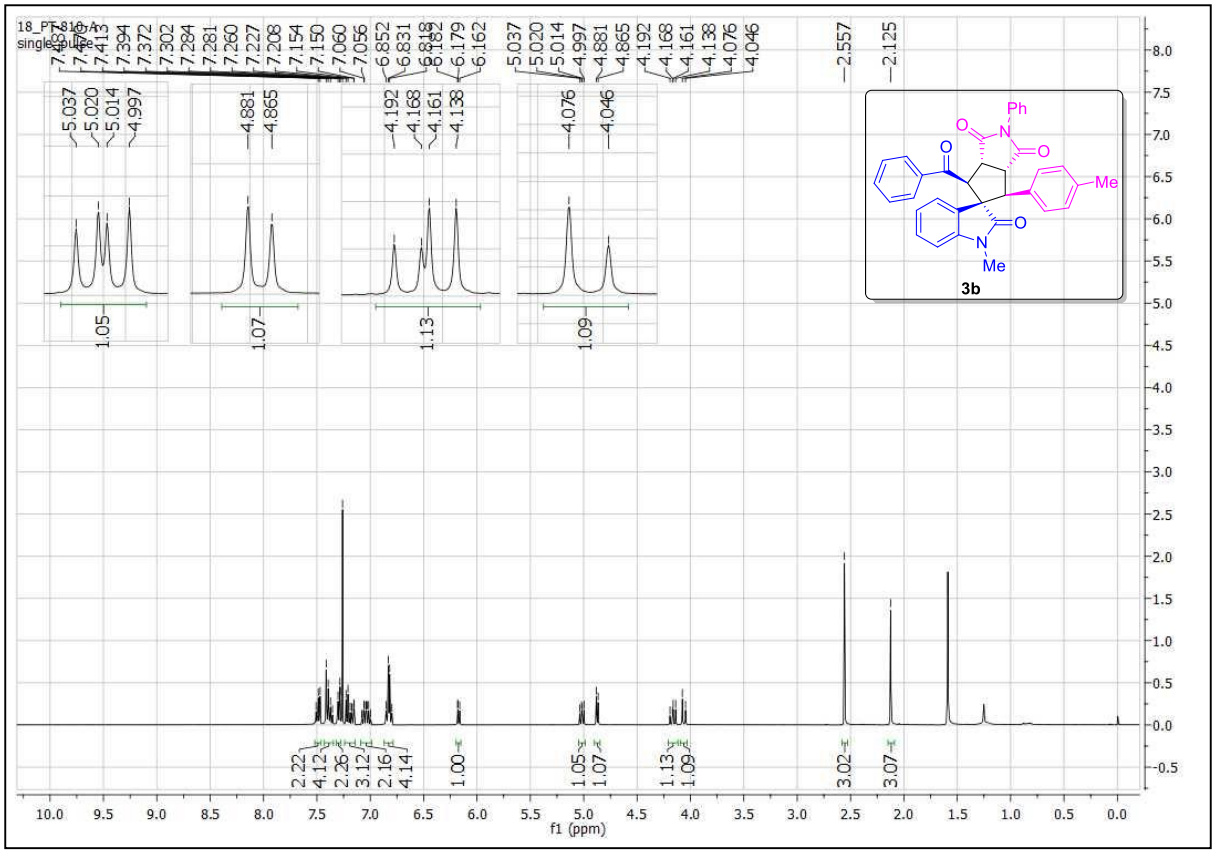

8.114
7.957
7.645
7.626
7.608
7.547
7.527
7.509
7.329
7.318
7.296
7.286
7.276
7.264
7.250
7.244
7.224
7.004
6.985
6.965
6.711
6.691
4.972
O
O
N
1d
0.94
1.95
0.89
1.02
2.02
3.84
2.32
1.00
0.97
2.00
f1 (ppm)

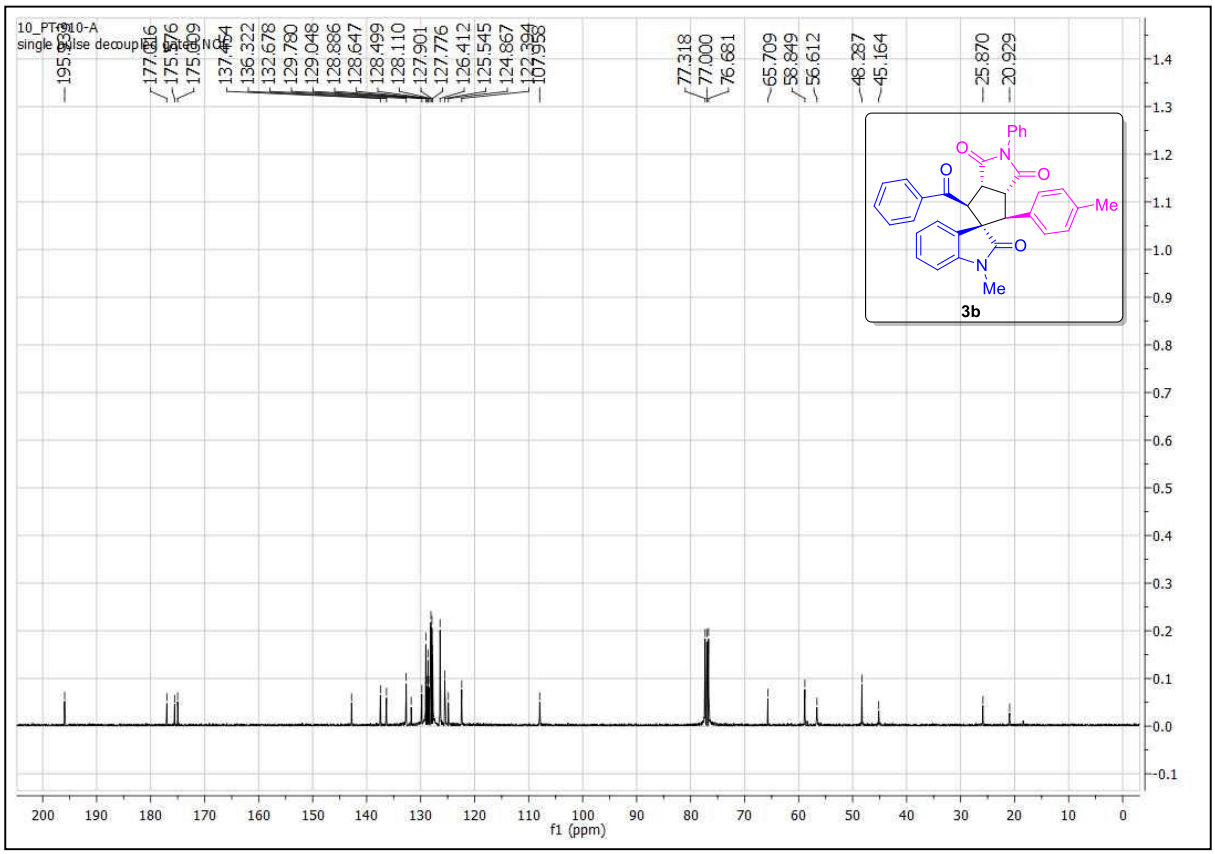

10_PT-NBM
single_pulse
8.287
8.268
8.042
8.021
7.948
7.343
7.334
7.323
7.293
7.265
7.260
7.246
7.243
6.986
6.984
6.713
6.693
4.981
2.450
Me
O
O
N
1e
1.00
2.10
0.98
6.16
1.34
0.89
1.08
1.04
1.99
3.00
f1 (ppm)

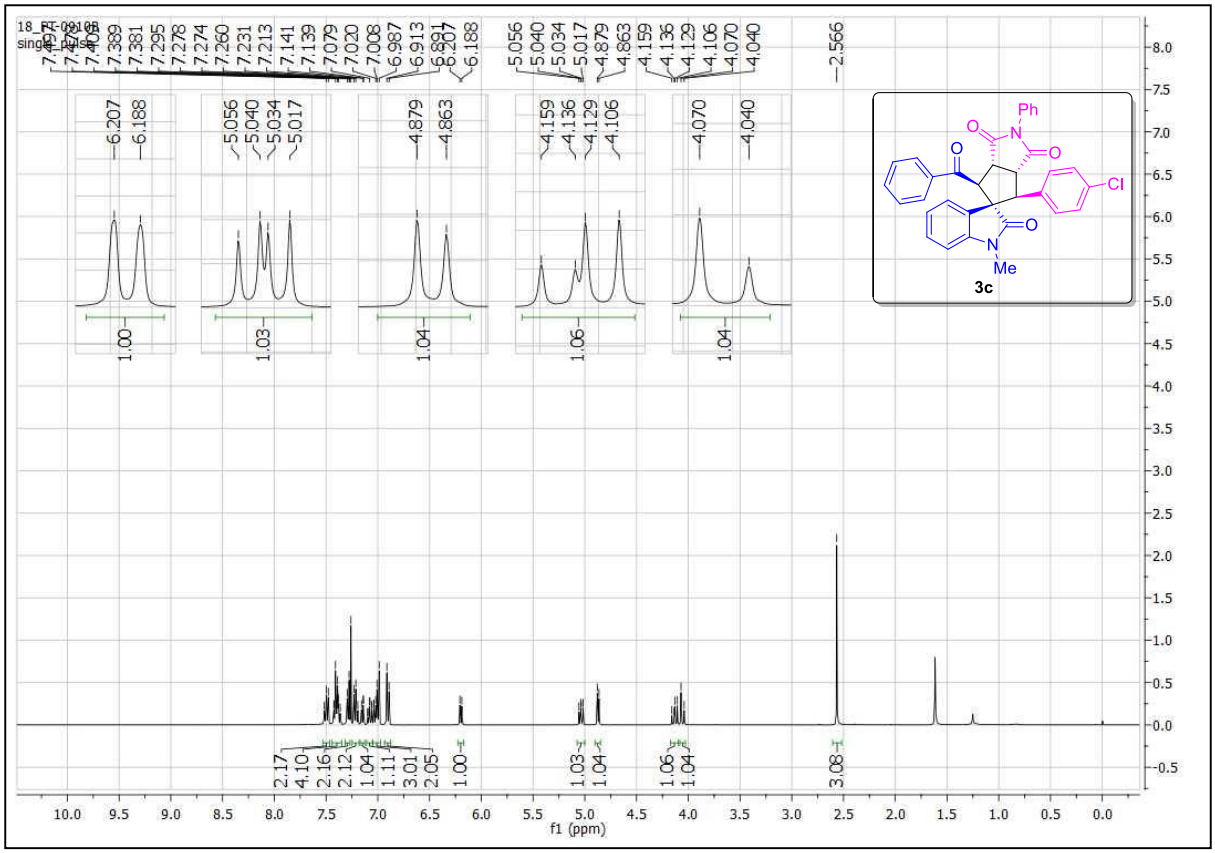

10_PT-NBOM
single_pulse
8.246
8.227
8.131
8.108
7.933
7.333
7.321
7.260
7.235
7.232
7.011
7.006
6.997
6.994
6.988
6.978
6.975
6.710
6.690
4.979
3.901
OMe
O
O
N
1f
0.93
1.98
0.90
4.78
1.09
2.96
0.96
2.00
2.94
f1 (ppm)

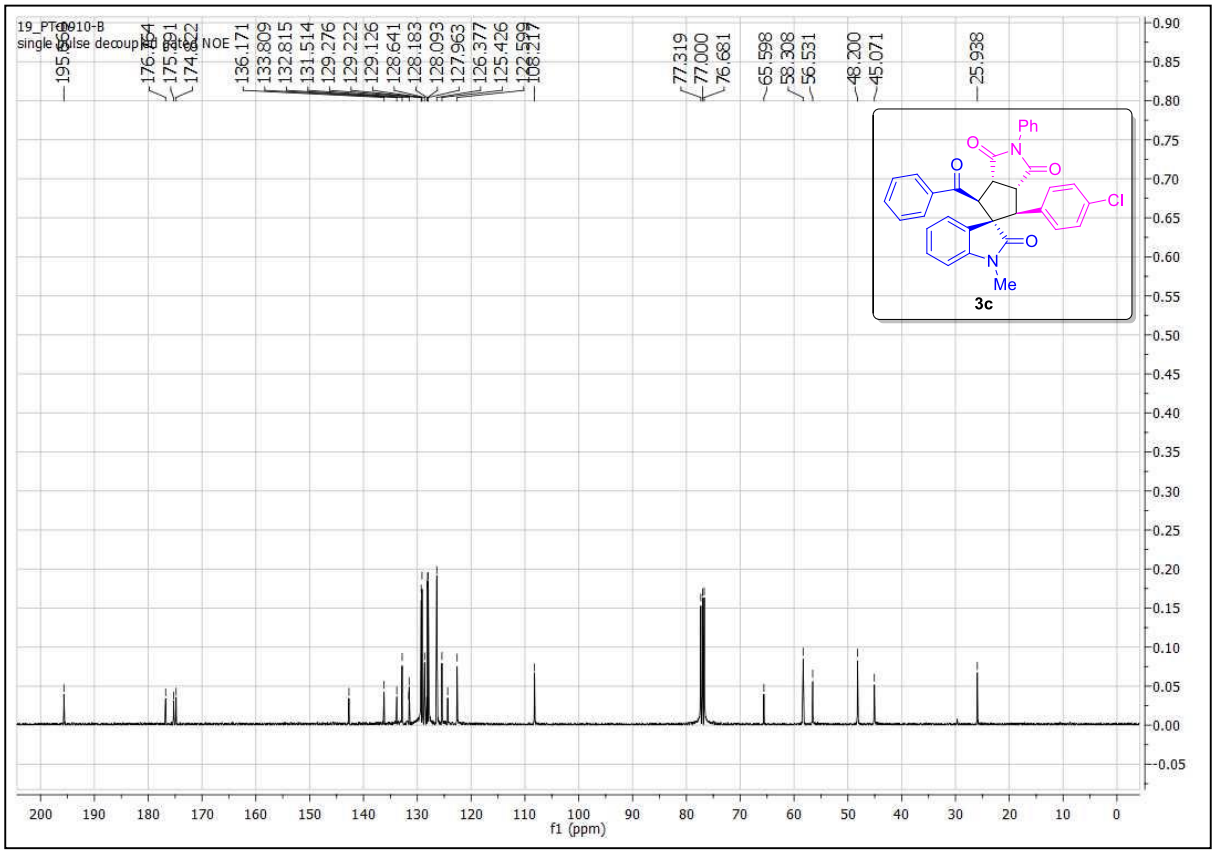

500 Hz NMR
PT-PAR-PAR
7.418
7.402
7.374
7.312
7.298
7.260
7.225
7.211
7.157
7.155
7.047
7.045
7.026
7.011
6.969
6.967
6.159
6.145
5.053
5.040
5.035
5.021
4.901
4.888
4.226
4.207
4.202
4.183
4.112
4.088
2.555
0.98
1.00
1.00
1.01
0.98
Ph
O
N
O
O
O
N
Me
3a
f1 (ppm)

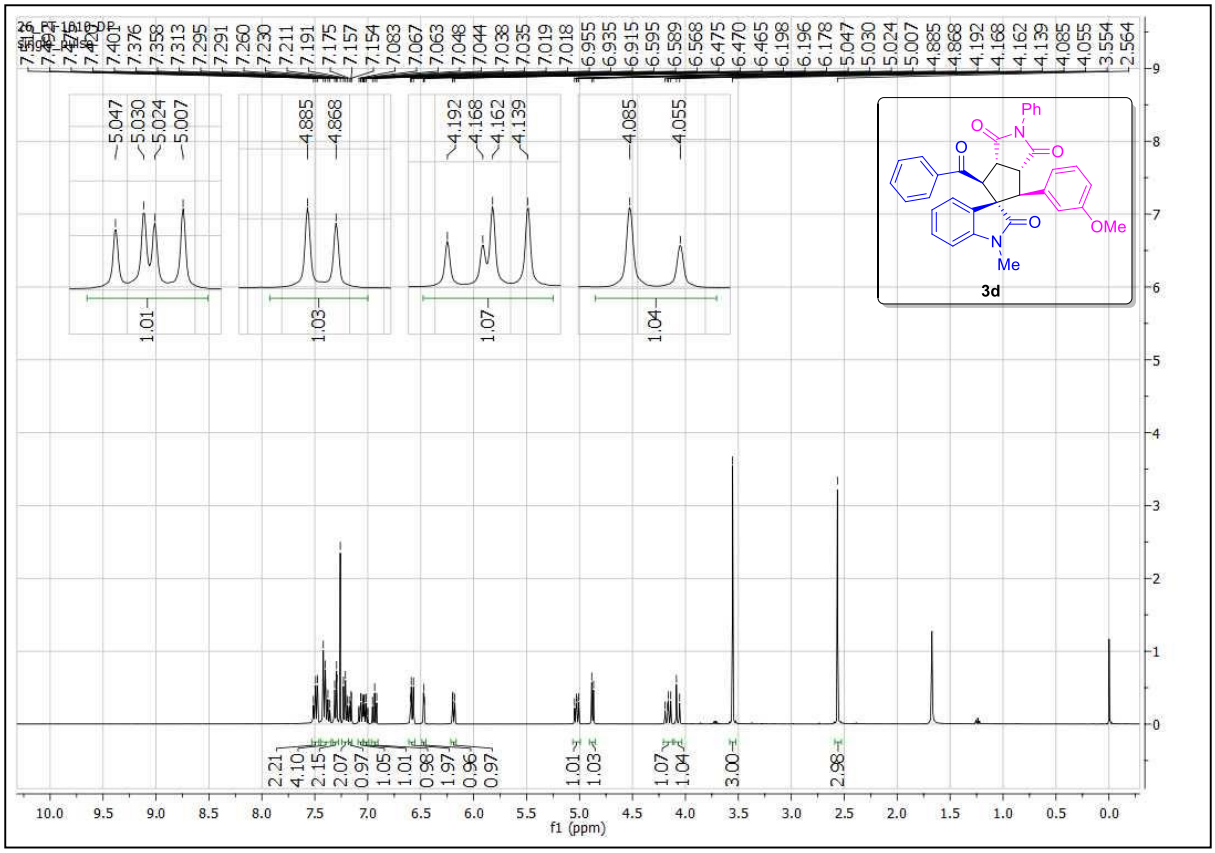

500 Hz NMR
PT-PAR-PAR
195.160
176.945
175.523
174.973
142.774
136.330
132.886
132.728
129.094
128.972
128.562
128.164
127.930
127.896
127.863
126.437
125.576
77.254
77.000
76.746
65.809
59.153
56.544
48.103
45.271
25.870
Ph
O
N
O
O
O
N
Me
3a
f1 (ppm)

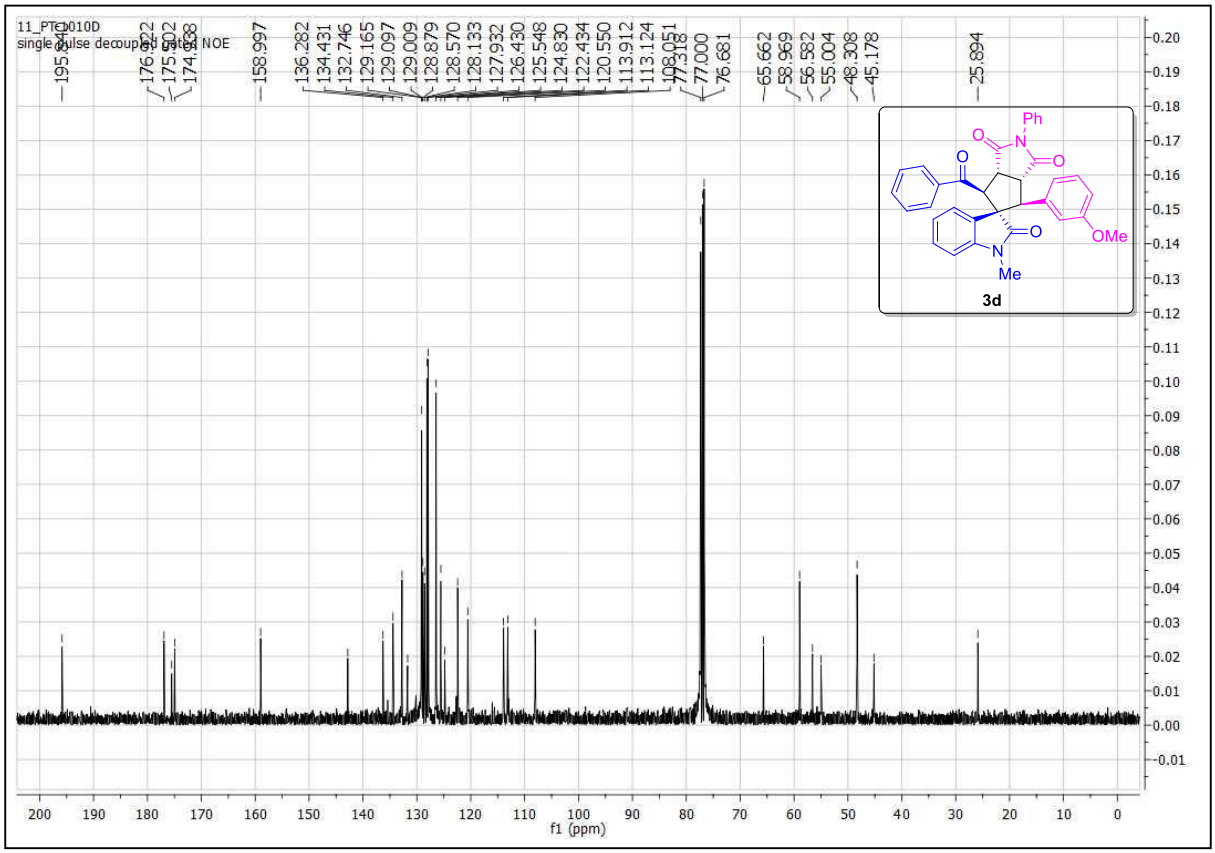

18_PT-810-A
single pulse
Ph
Me
Me
3b
f1 (ppm)

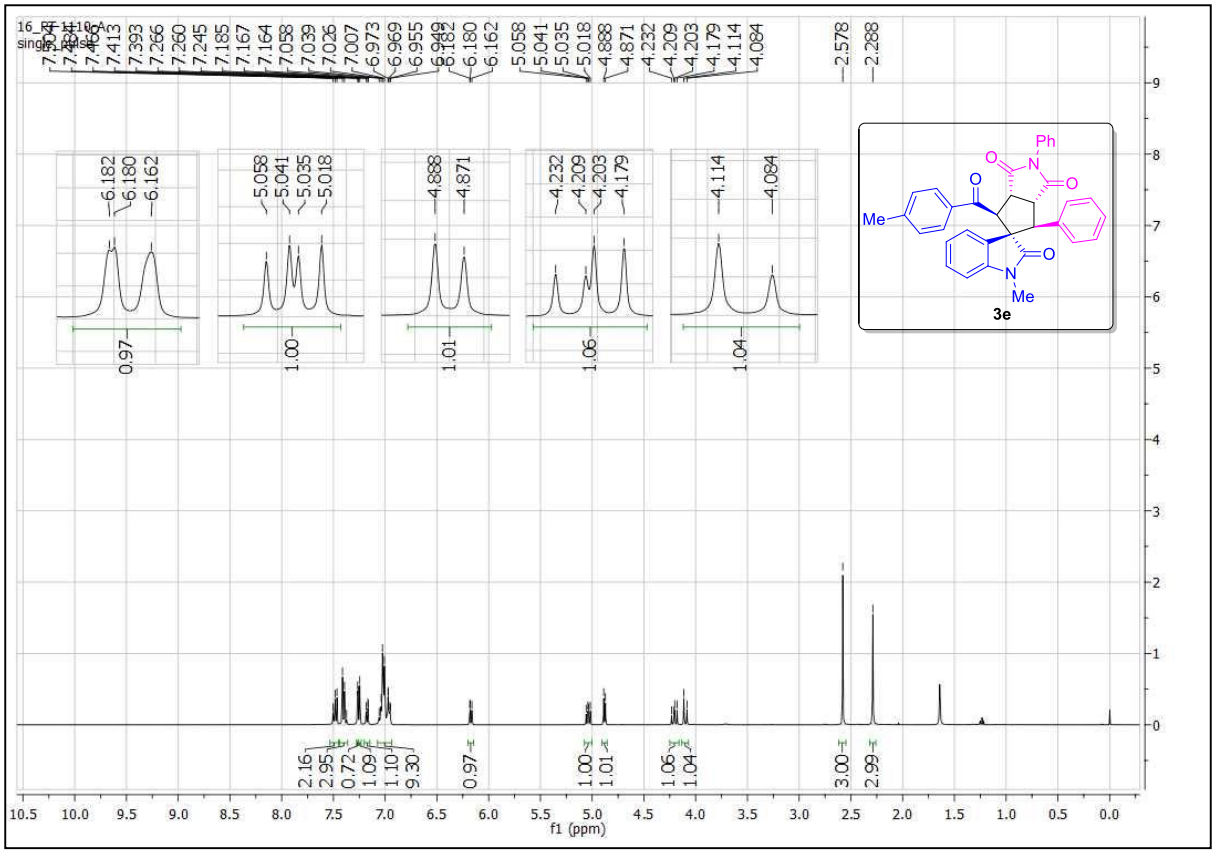

10_PT-810-A
single pulse decoupled gated NOE
Ph
Me
Me
3b
f1 (ppm)

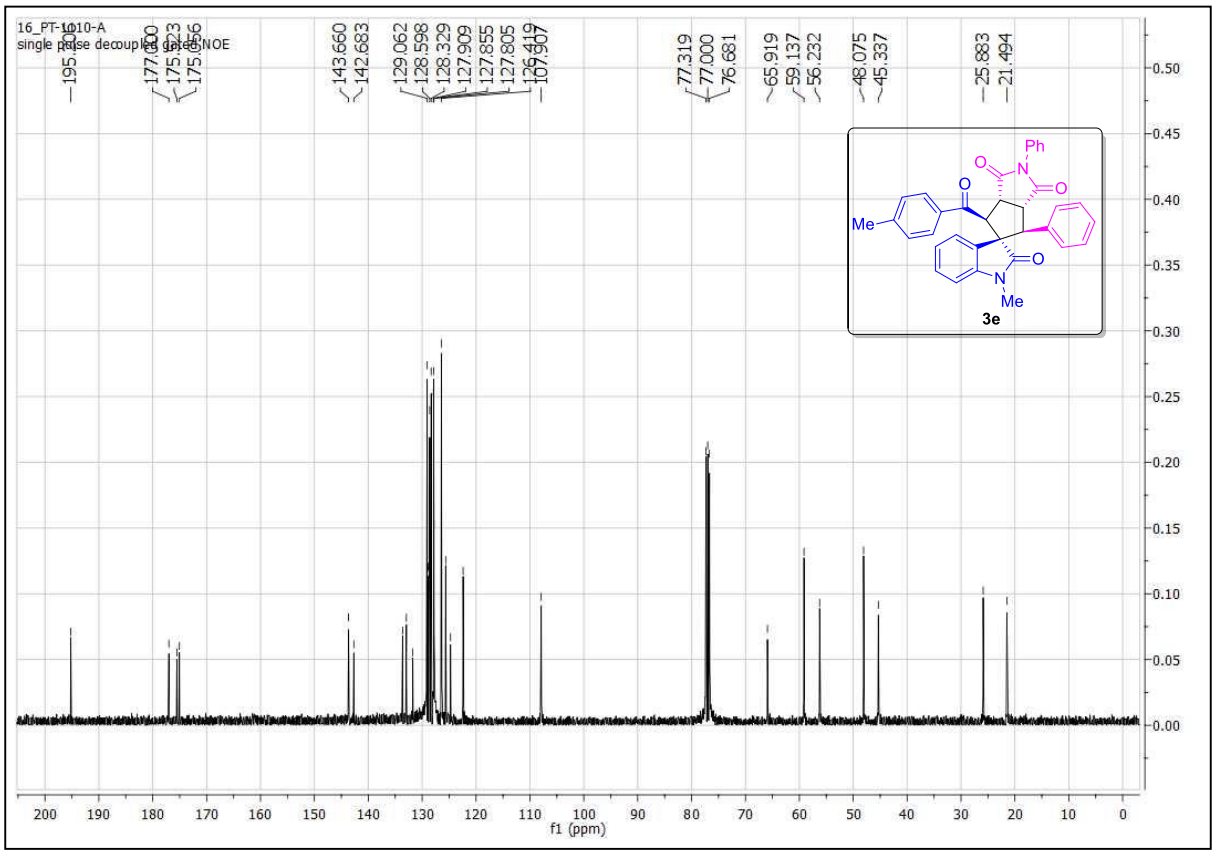

3c

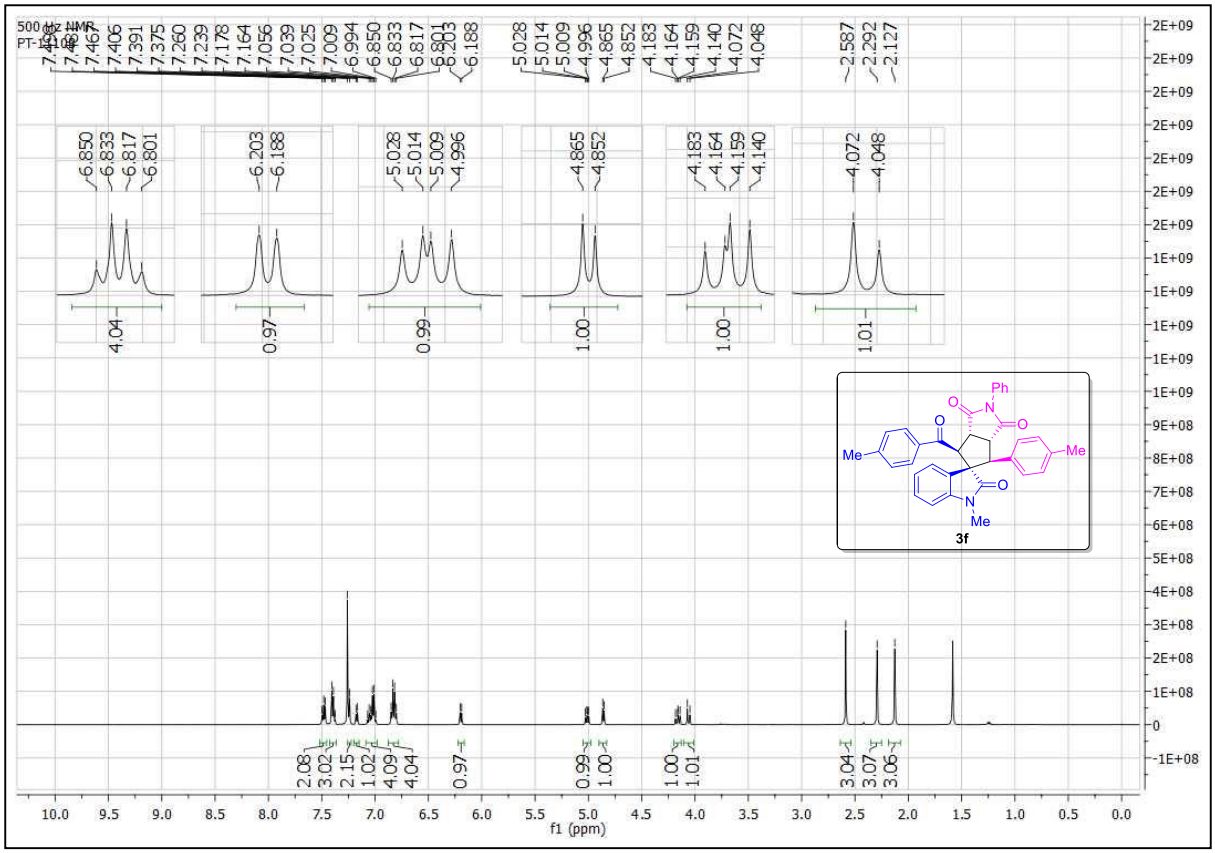

3c

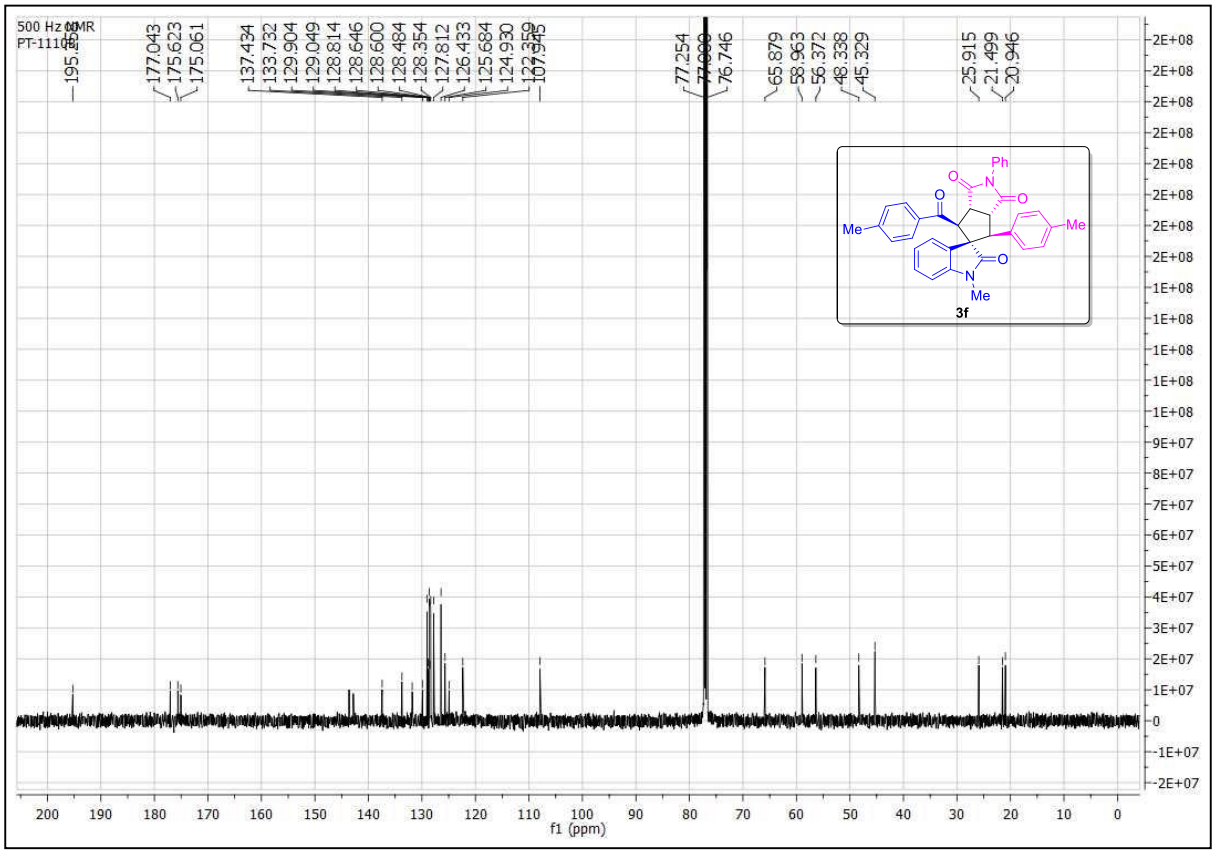

3d
f1 (ppm)

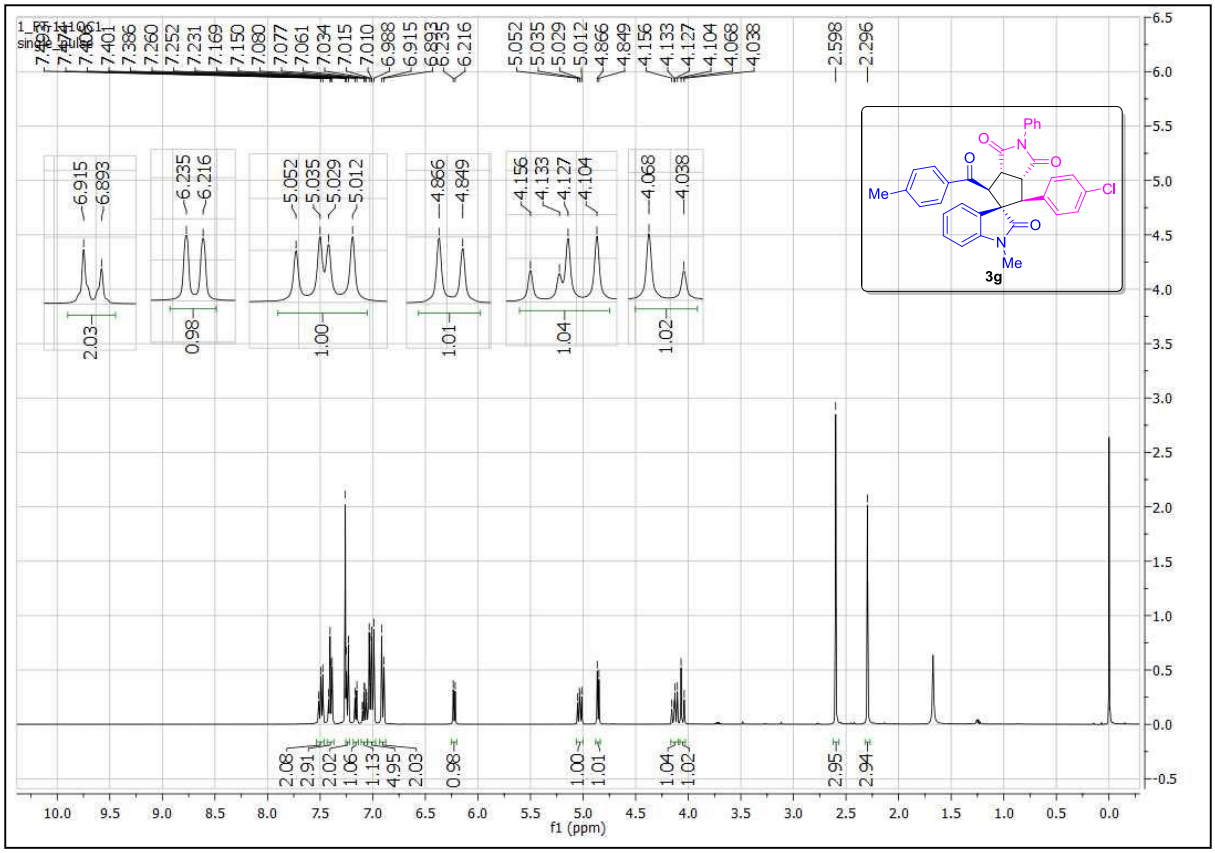

3d
f1 (ppm)

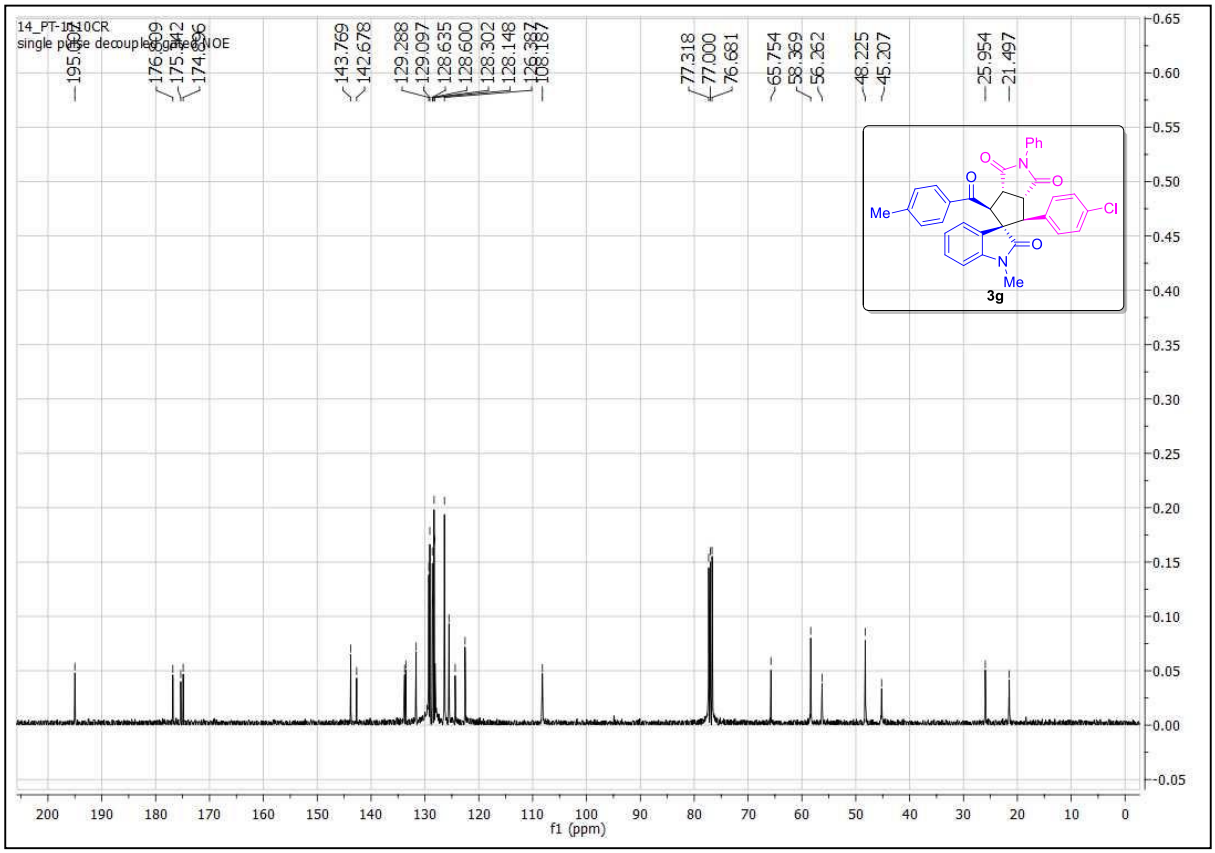

16_PT-1010-A
single pulse
7.504
7.484
7.465
7.413
7.393
7.266
7.260
7.245
7.185
7.167
7.164
7.058
7.039
7.026
7.007
6.973
6.969
6.955
6.949
6.182
6.180
6.162
5.058
5.041
5.035
5.018
4.888
4.871
4.232
4.209
4.203
4.179
4.114
4.084
2.578
2.288
0.97
1.00
1.01
1.06
1.04
Ph
Me
Me
3e
2.16
2.95
0.72
1.09
1.10
9.30
0.97
1.00
1.01
1.06
1.04
3.00
2.99
f1 (ppm)

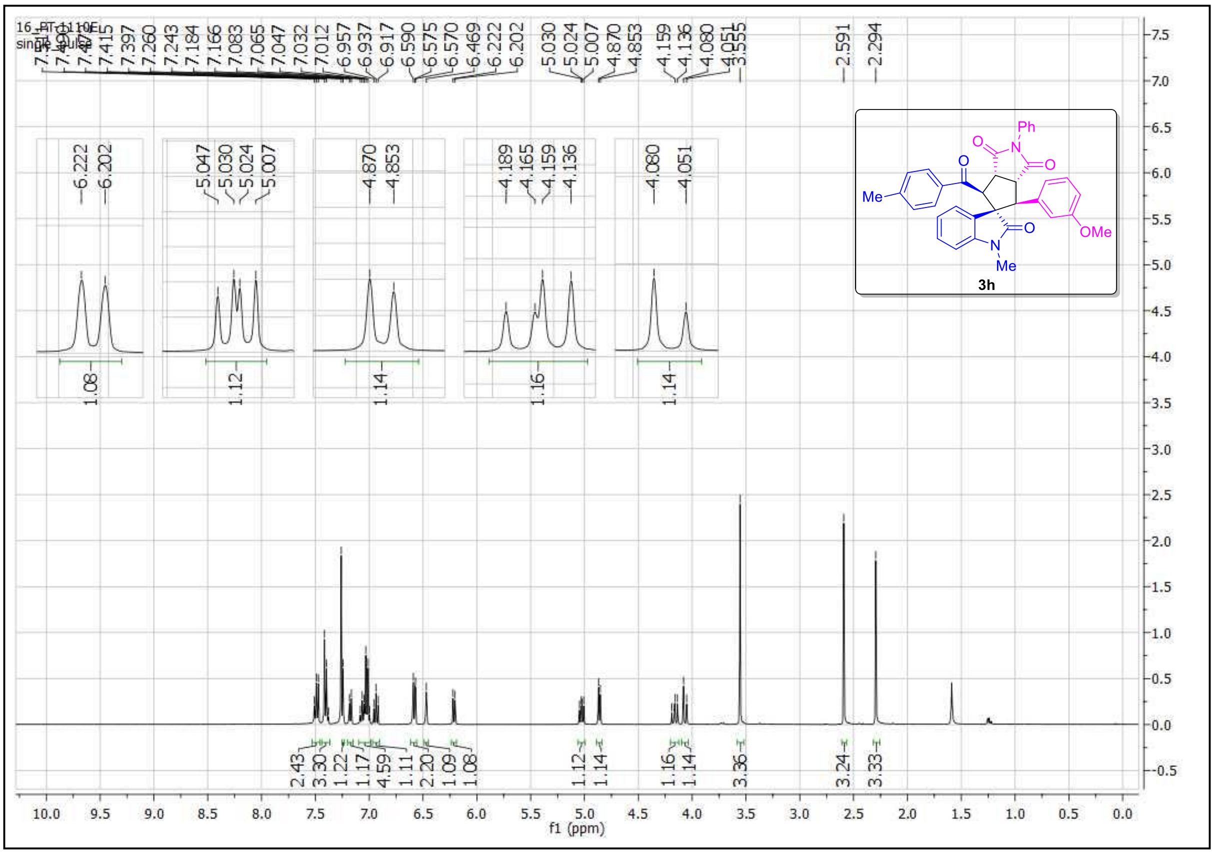

16_PT-1010-A
single pulse decoupled gated NOE
195.020
177.600
175.023
175.056
143.660
142.683
129.062
128.598
128.329
127.909
127.855
127.805
126.419
107.907
77.319
77.000
76.681
65.919
59.137
56.232
48.075
45.337
25.883
21.494
Ph
Me
Me
3e
f1 (ppm)

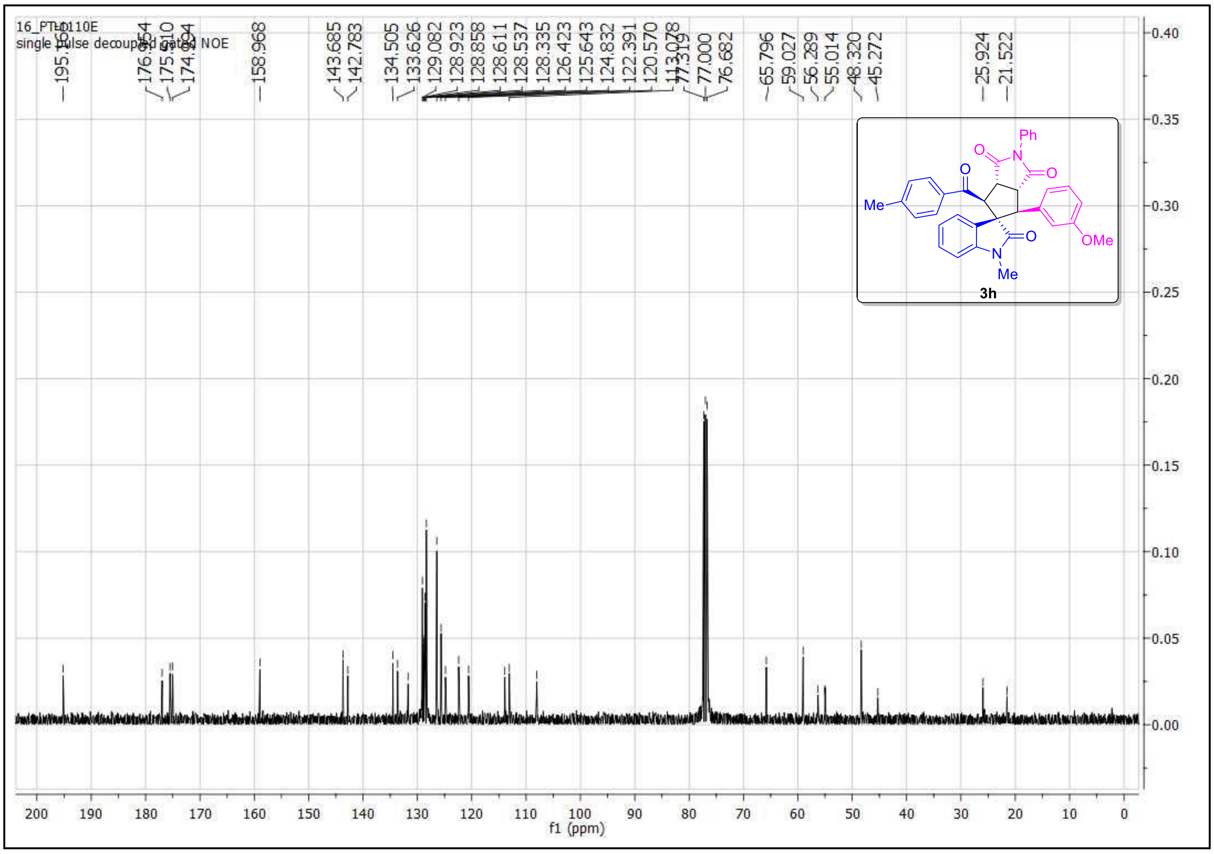

3f
f1 (ppm)

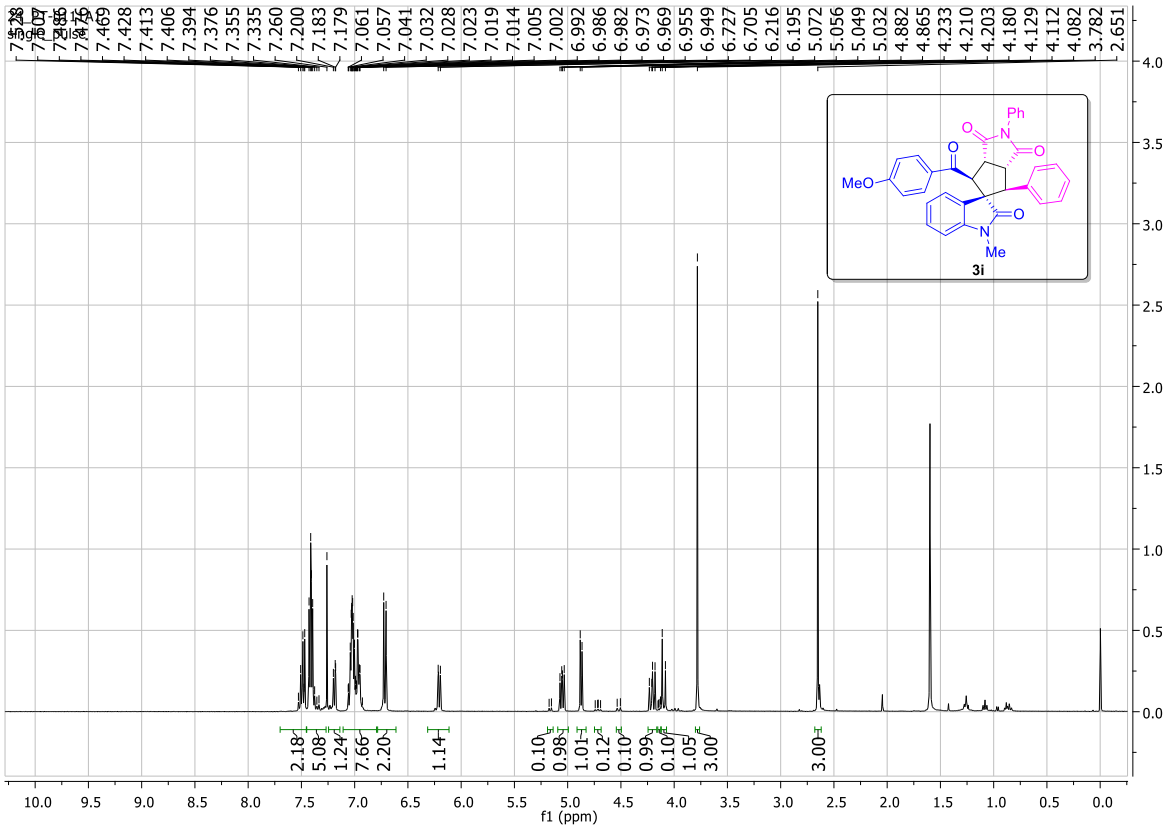

3f
f1 (ppm)

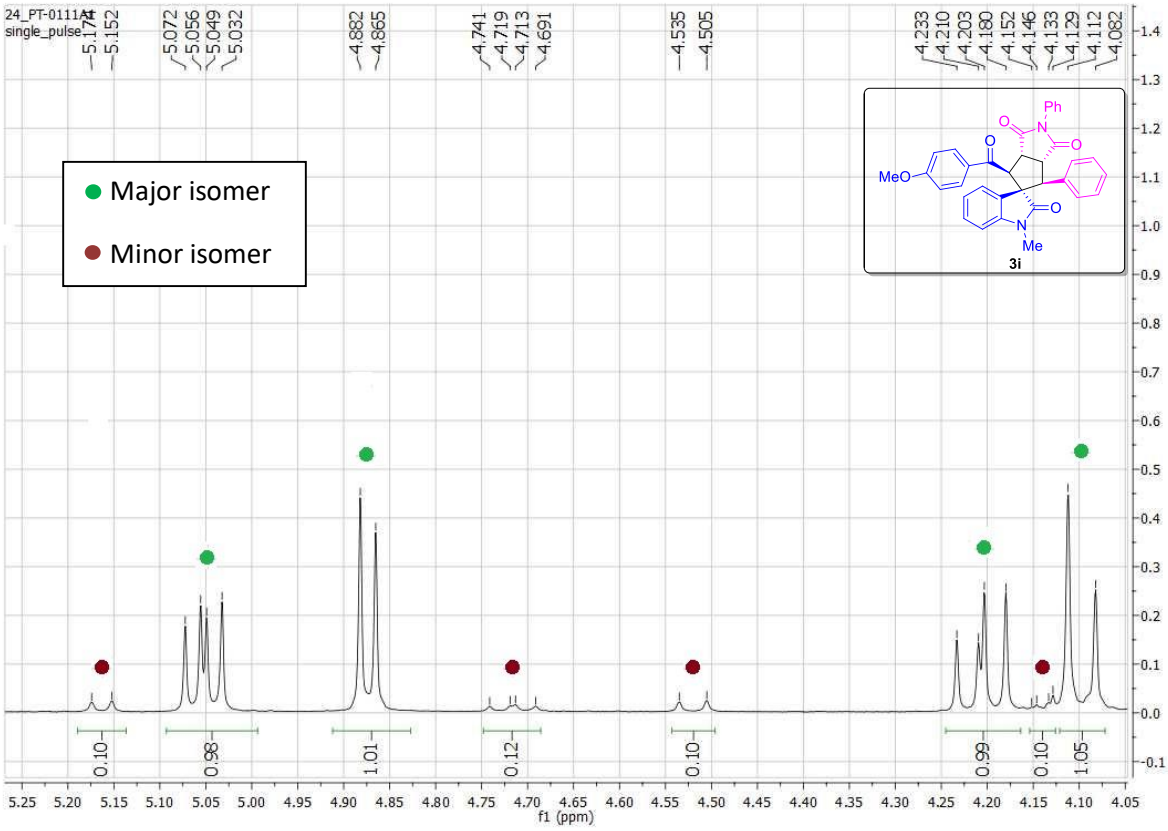

3g


3g

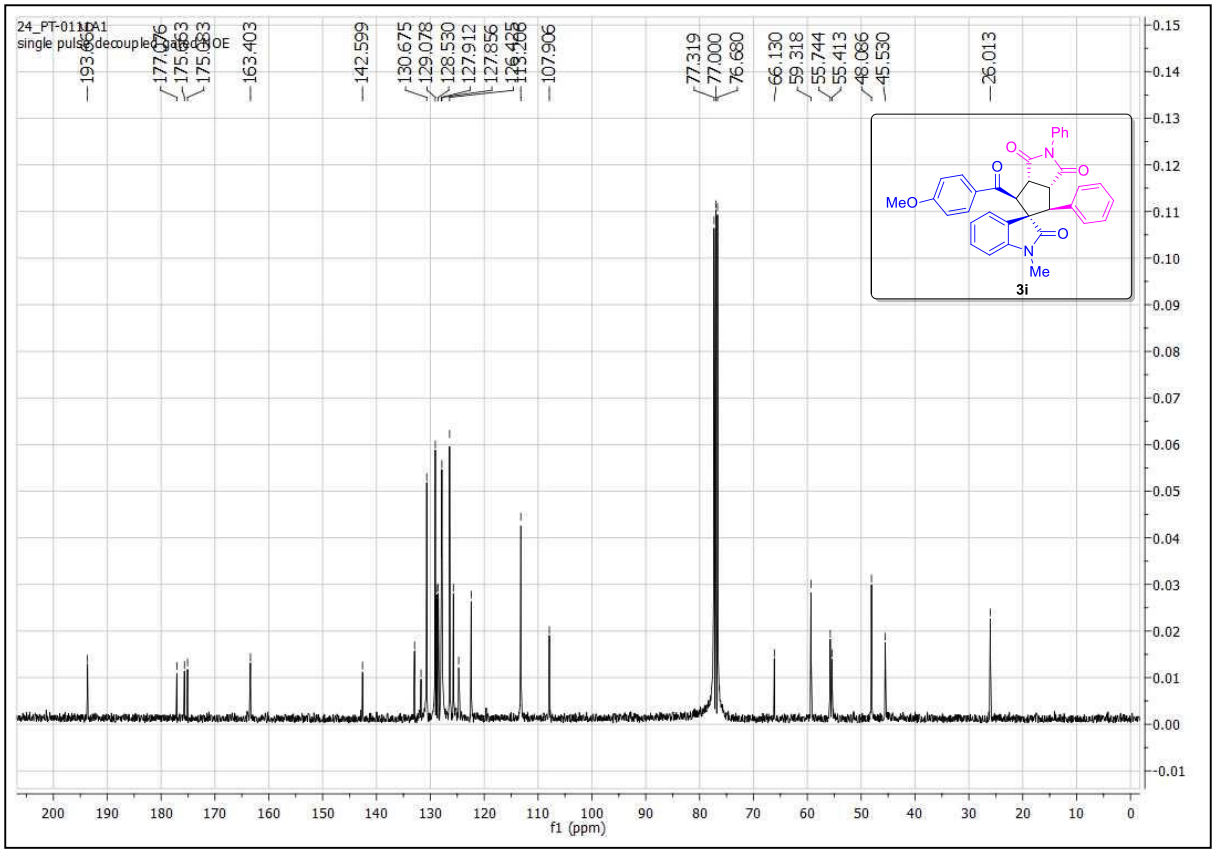

16_PT-0110E
single_pulse
f1 (ppm)
Ph
N
O
O
O
Me
OMe
N
Me
O
3h

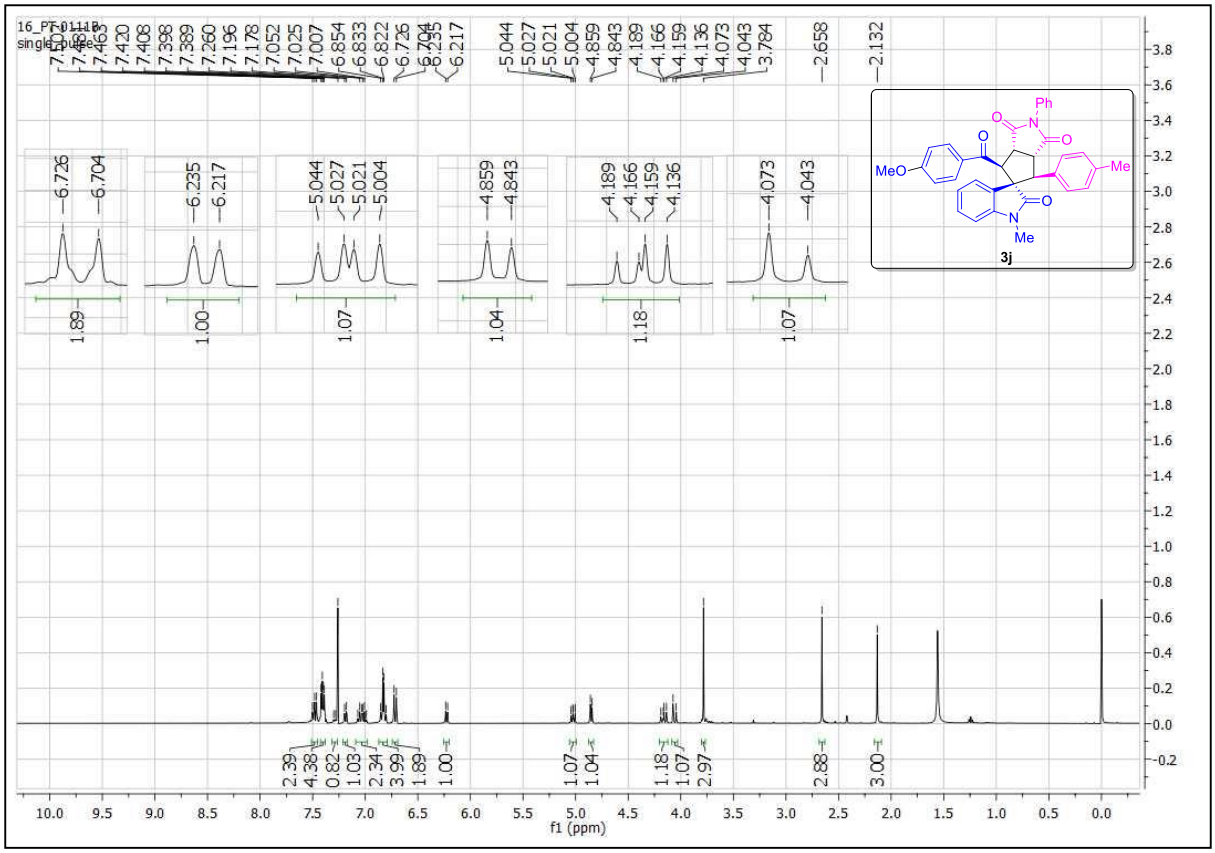

16_PT-0110E
single_pulse decoupled gated NOE
f1 (ppm)
Ph
N
O
O
O
Me
OMe
N
Me
O
3h

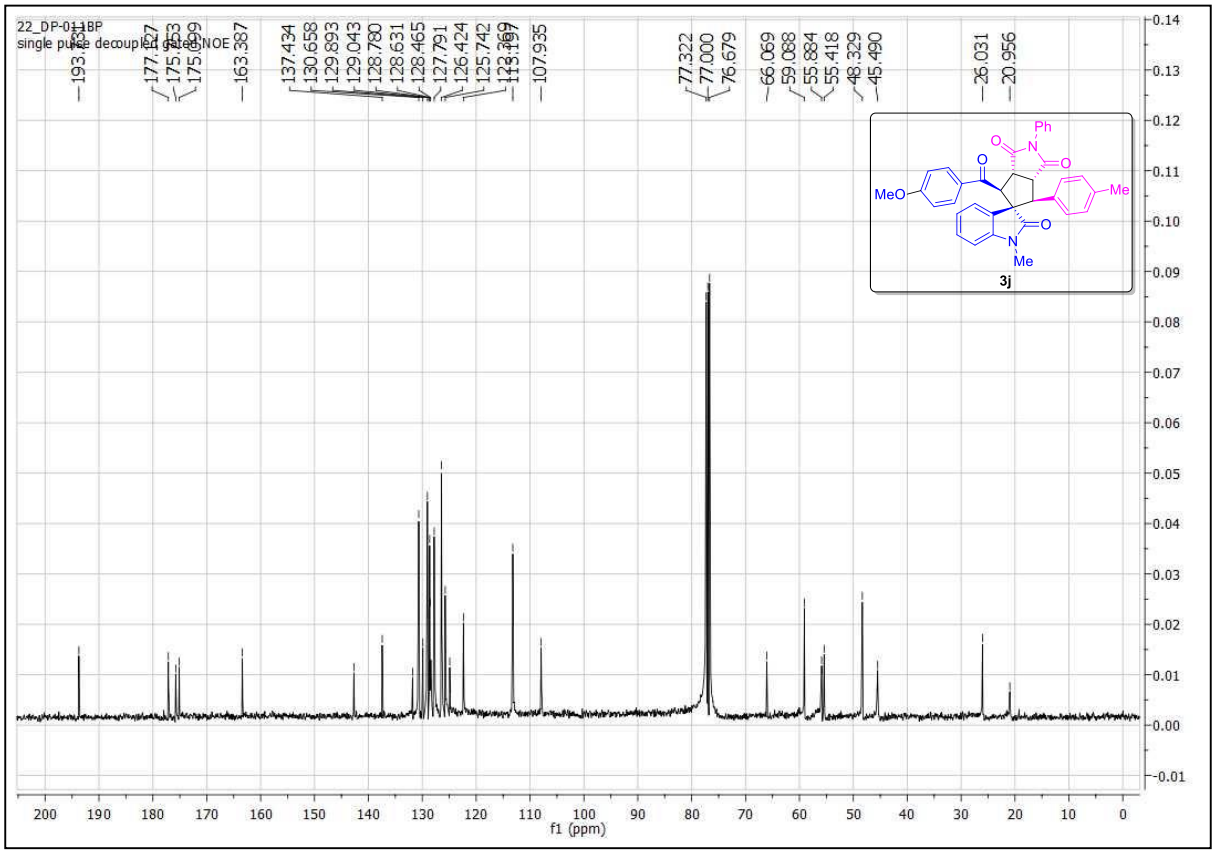


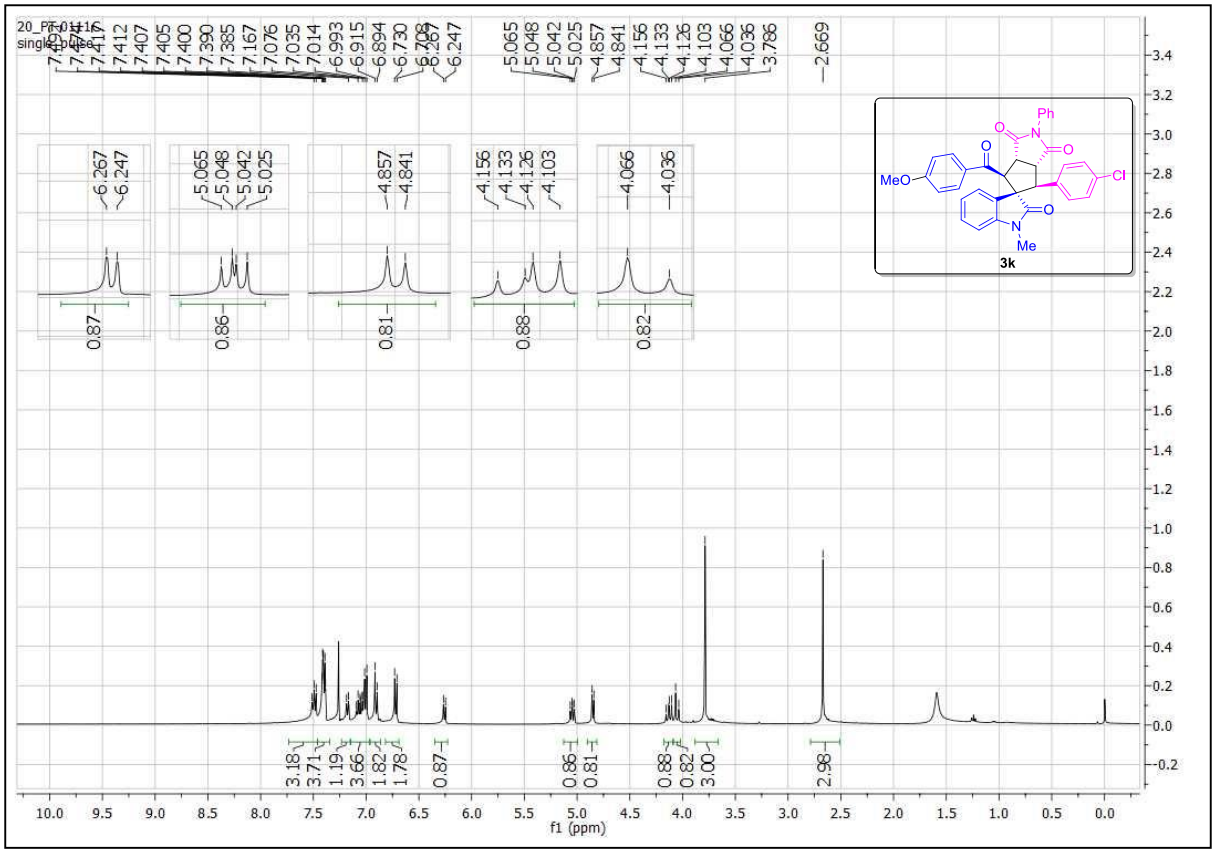


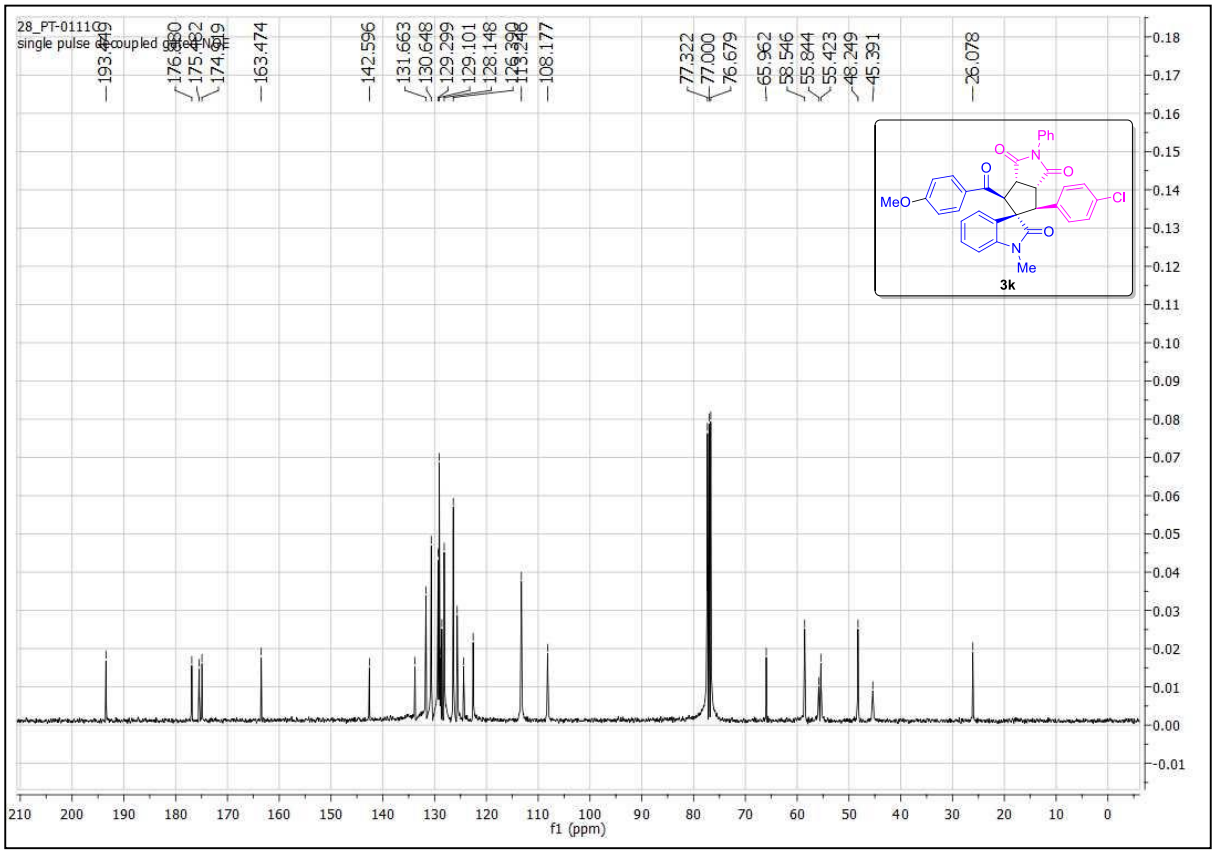
Expanded portion of ^{1}H NMR spectrum of mixture of diastereomers present in **3i**:

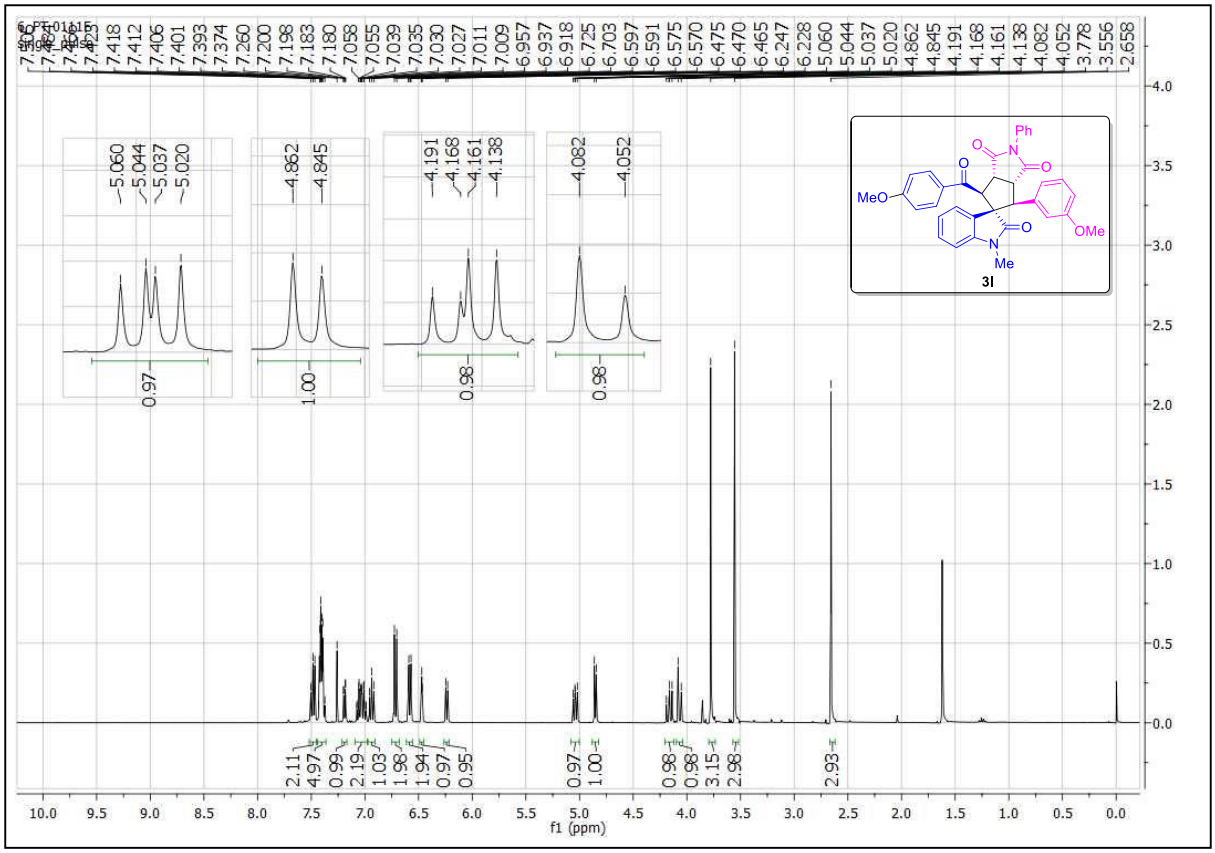

24_PT-011DA1
single pulse decoupled gated OE
193.855
177.076
175.403
175.033
163.403
142.599
130.675
129.078
128.530
127.912
127.856
126.425
115.208
107.906
77.319
77.000
76.680
66.130
59.318
55.744
55.413
48.086
45.530
26.013
Ph
O
N
O
O
MeO
O
N
Me
3i
f1 (ppm)

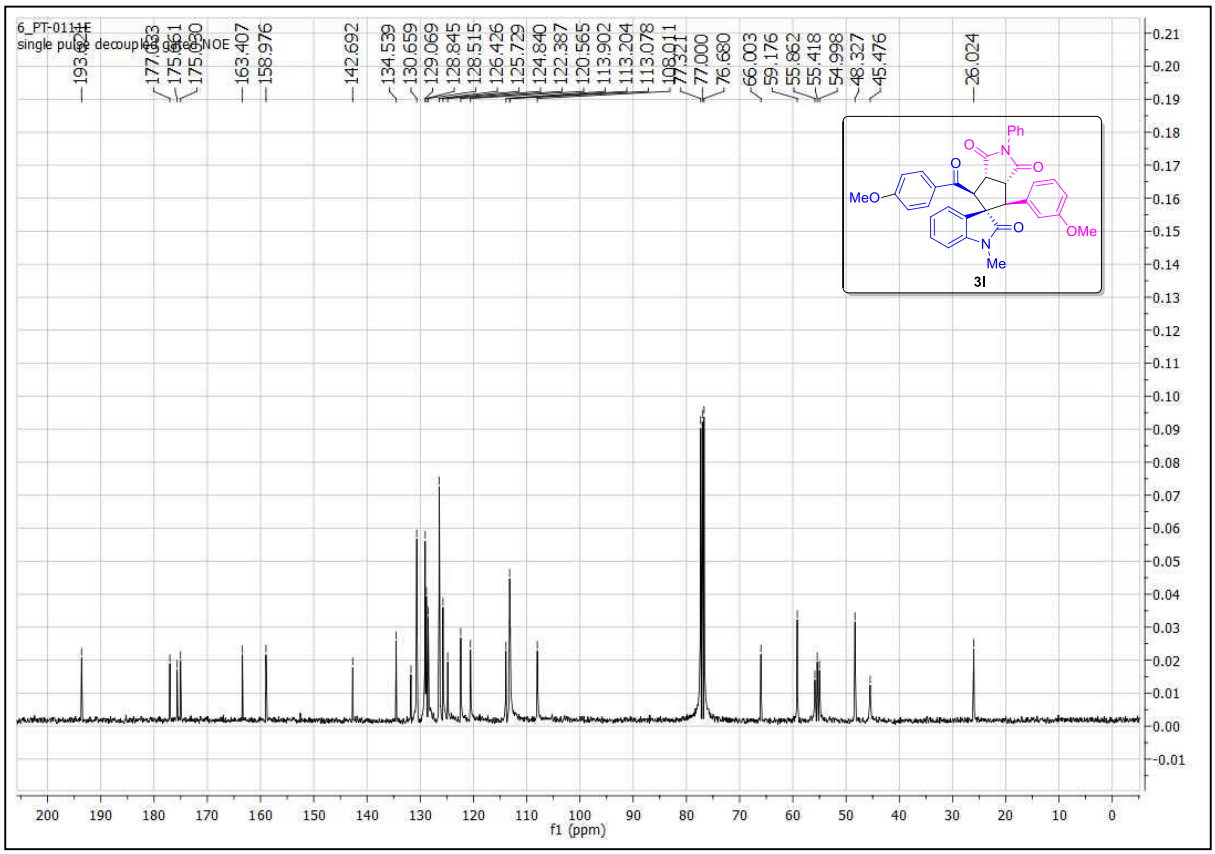

16_PT-011B
single pulse
3j

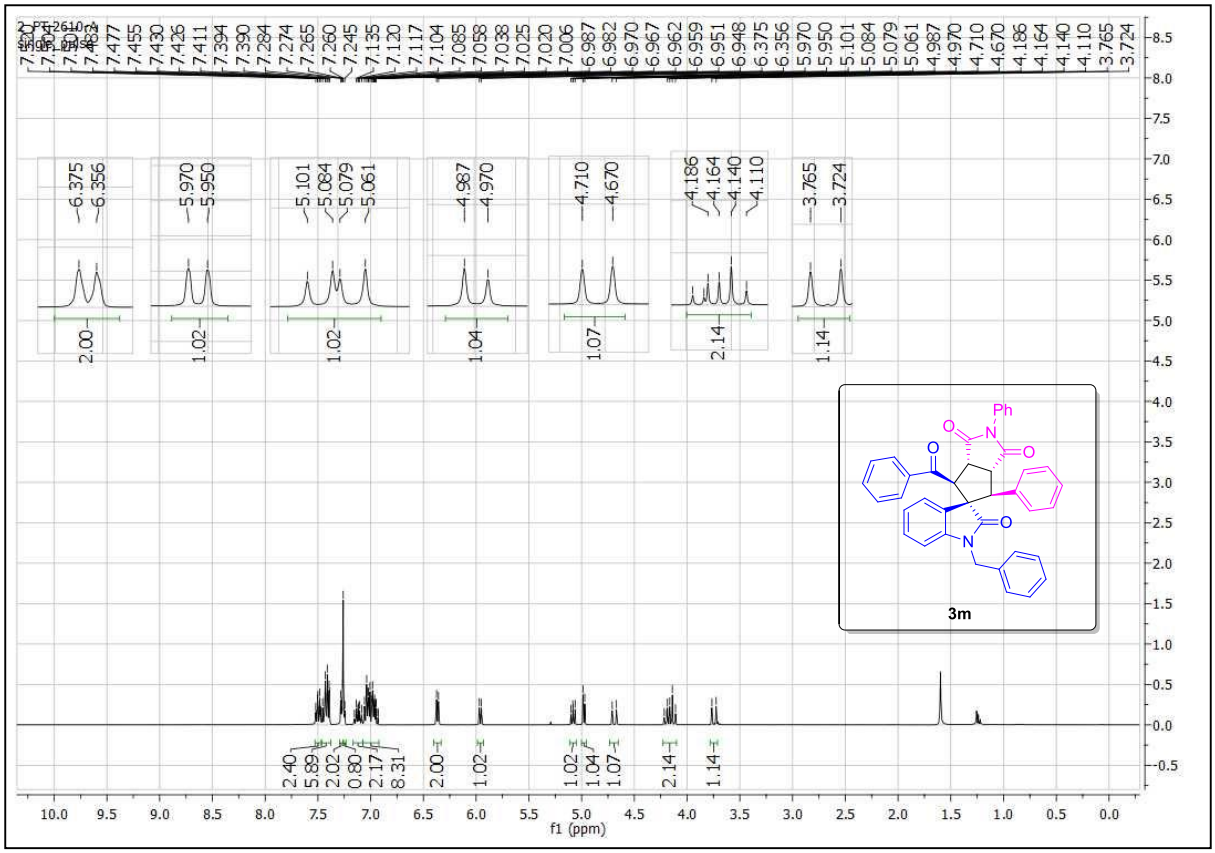

22_DP-011BP
single pulse decoupled gated NOE
3j

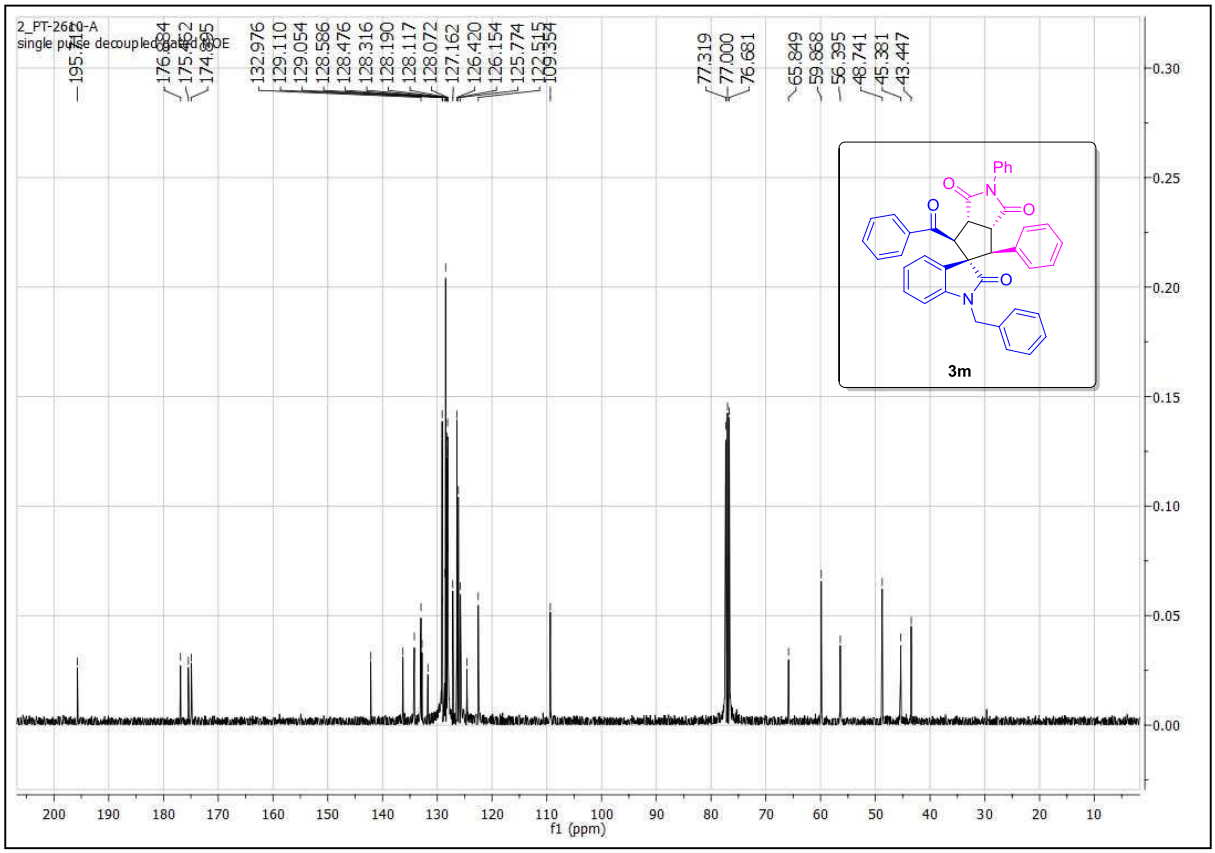

3k
f1 (ppm)

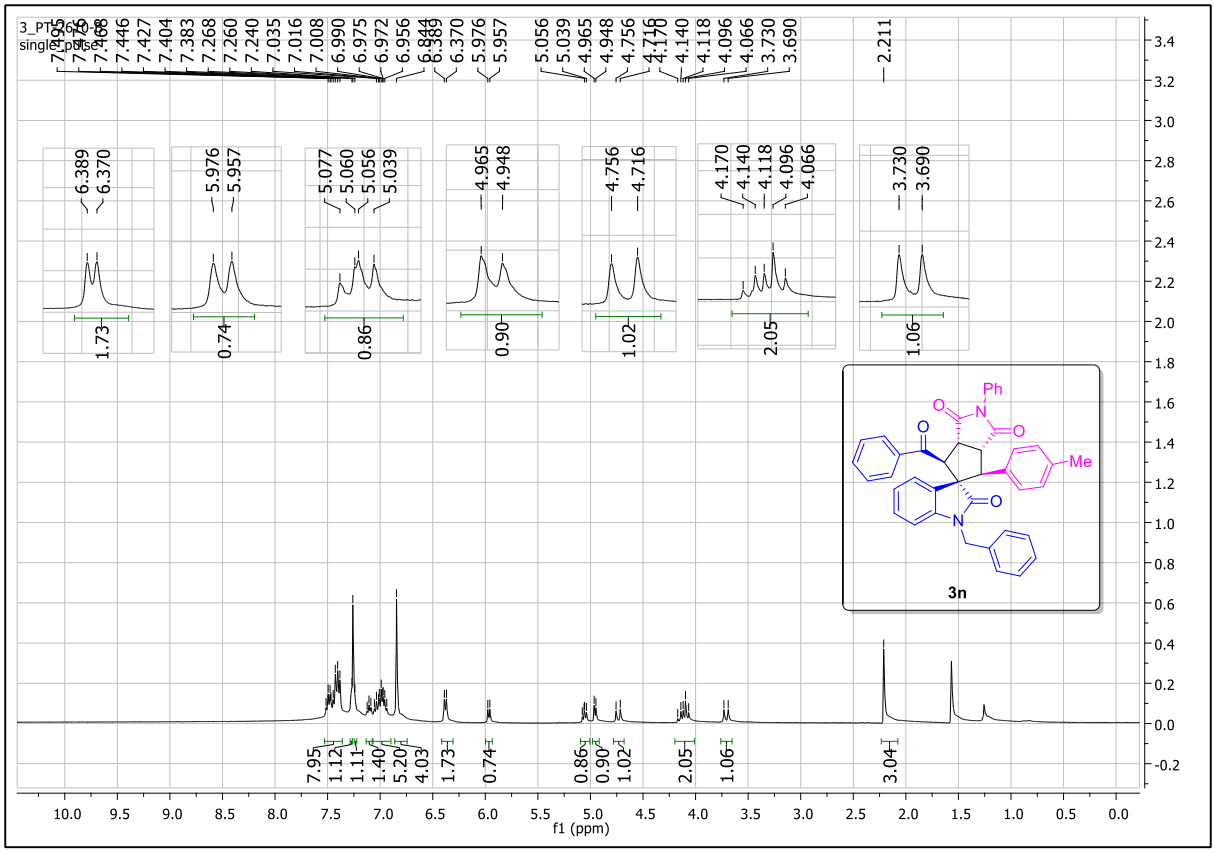

3k
f1 (ppm)

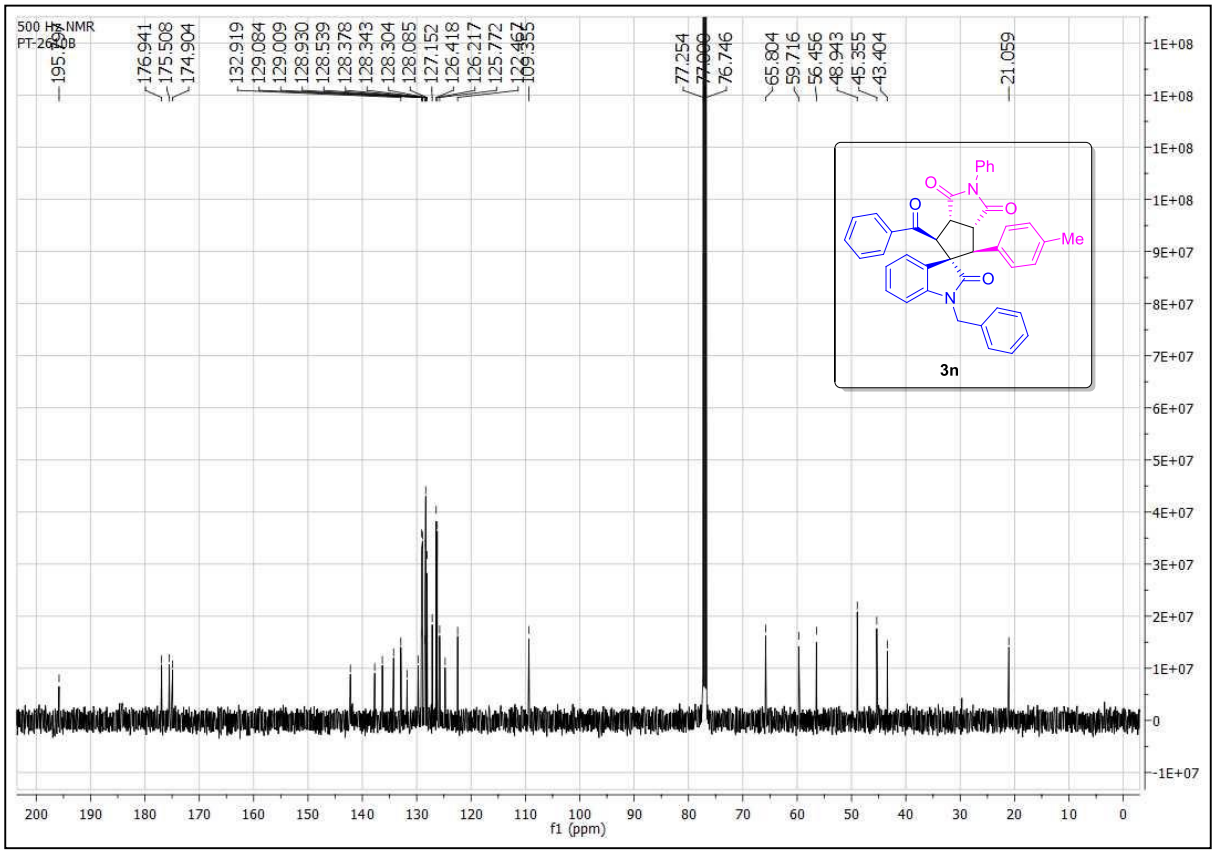

7.418
7.412
7.406
7.401
7.393
7.374
7.260
7.200
7.198
7.183
7.180
7.058
7.055
7.039
7.035
7.030
7.027
7.011
7.009
6.957
6.937
6.918
6.725
6.703
6.597
6.591
6.575
6.570
6.475
6.470
6.465
6.247
6.228
5.060
5.044
5.037
5.020
4.862
4.845
4.191
4.168
4.161
4.138
4.082
4.052
3.778
3.556
2.658
5.060
5.044
5.037
5.020
4.862
4.845
4.191
4.168
4.161
4.138
4.082
4.052
0.97
1.00
0.98
0.98
Ph
MeO
OMe
Me
3l
2.11
4.97
0.99
2.19
1.03
1.98
1.94
0.97
0.95
0.97
1.00
0.98
0.98
3.15
2.98
2.93
f1 (ppm)

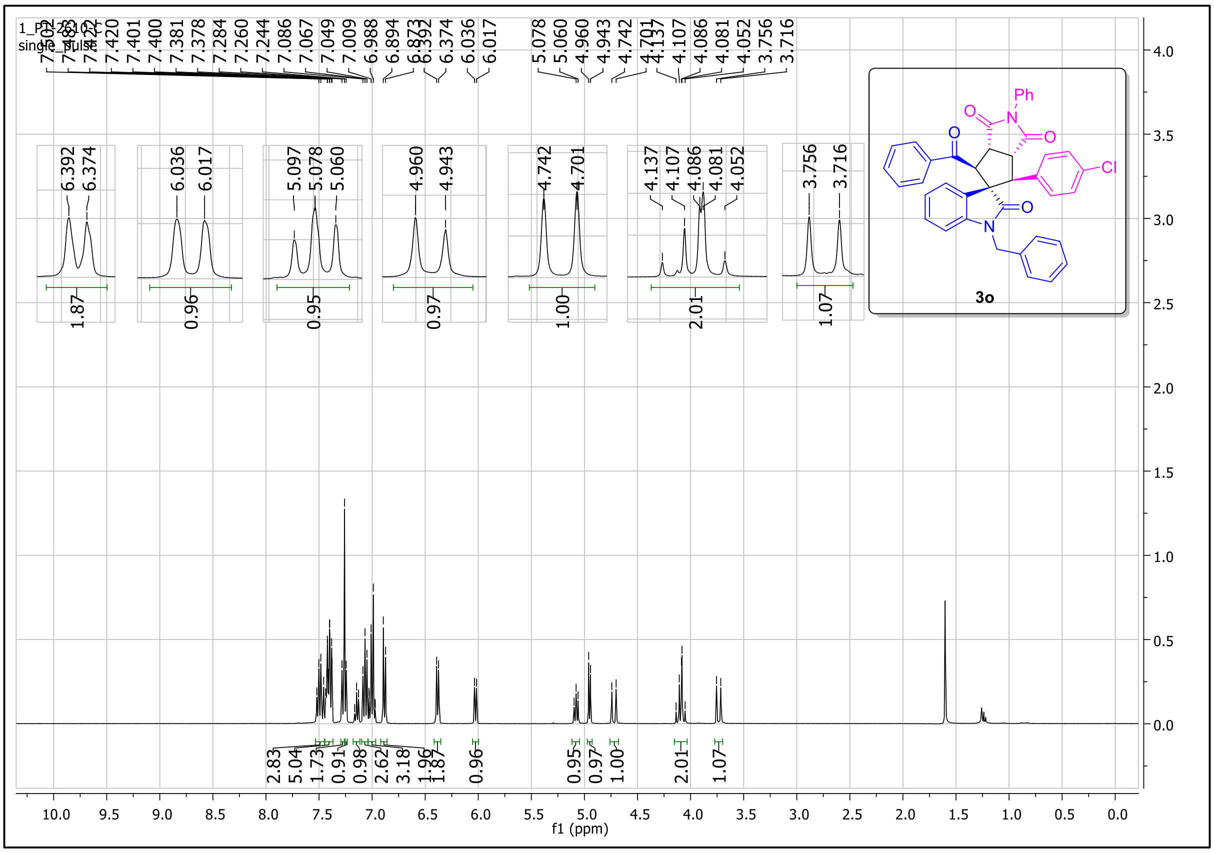

6_PT-011-E
single pulse decoupled gated NOE
193.301
177.033
175.461
175.230
163.407
158.976
142.692
134.539
130.659
129.069
128.845
128.515
126.426
125.729
124.840
122.387
120.565
113.902
113.204
113.078
108.011
77.321
77.000
76.680
66.003
59.176
55.862
55.418
54.998
48.327
45.476
26.024
Ph
MeO
OMe
Me
3l
f1 (ppm)

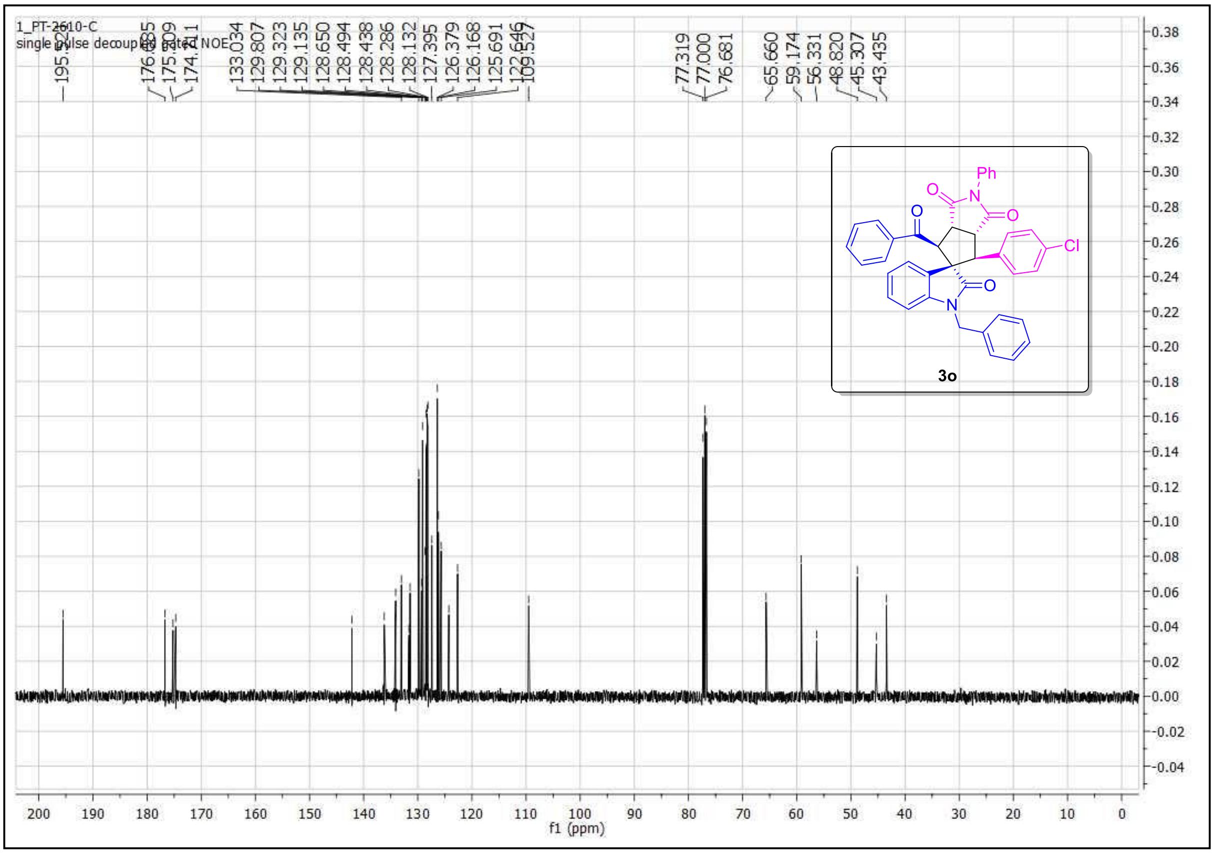

3m

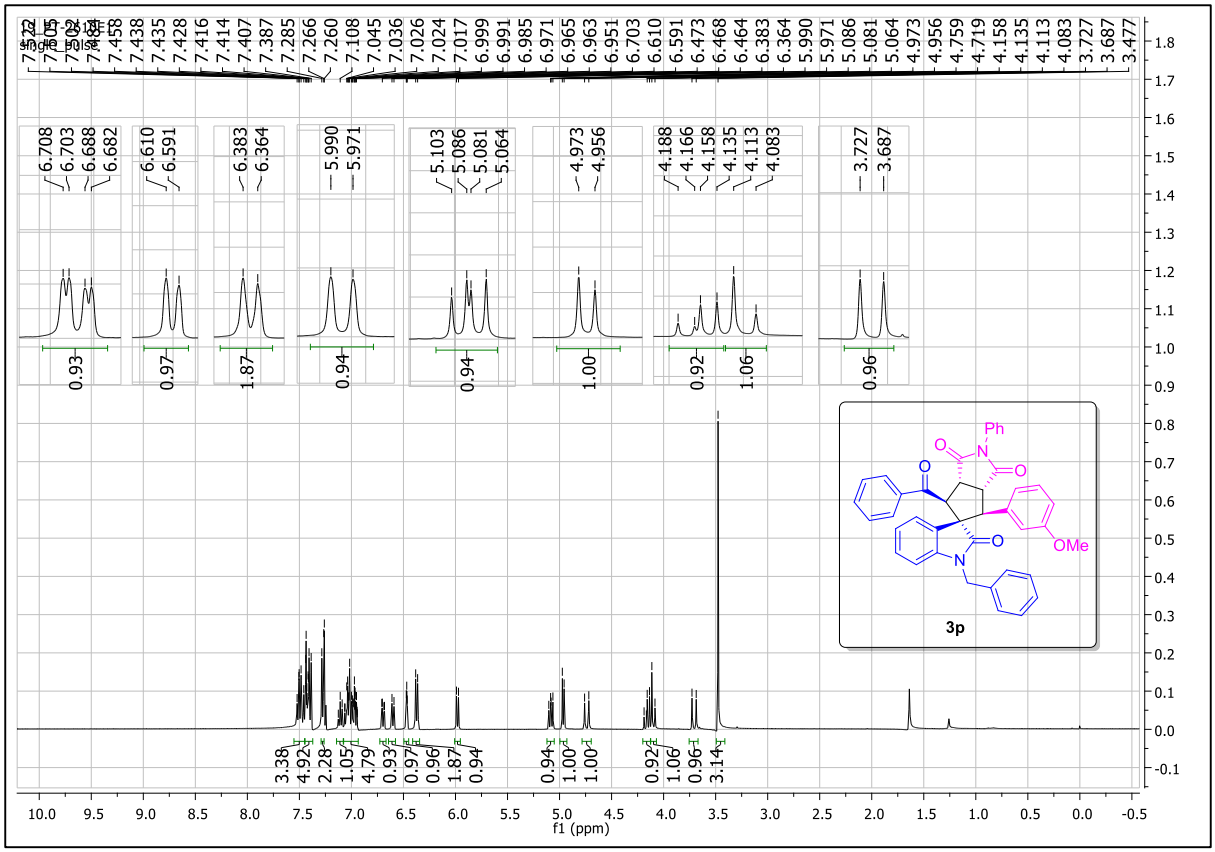

3m

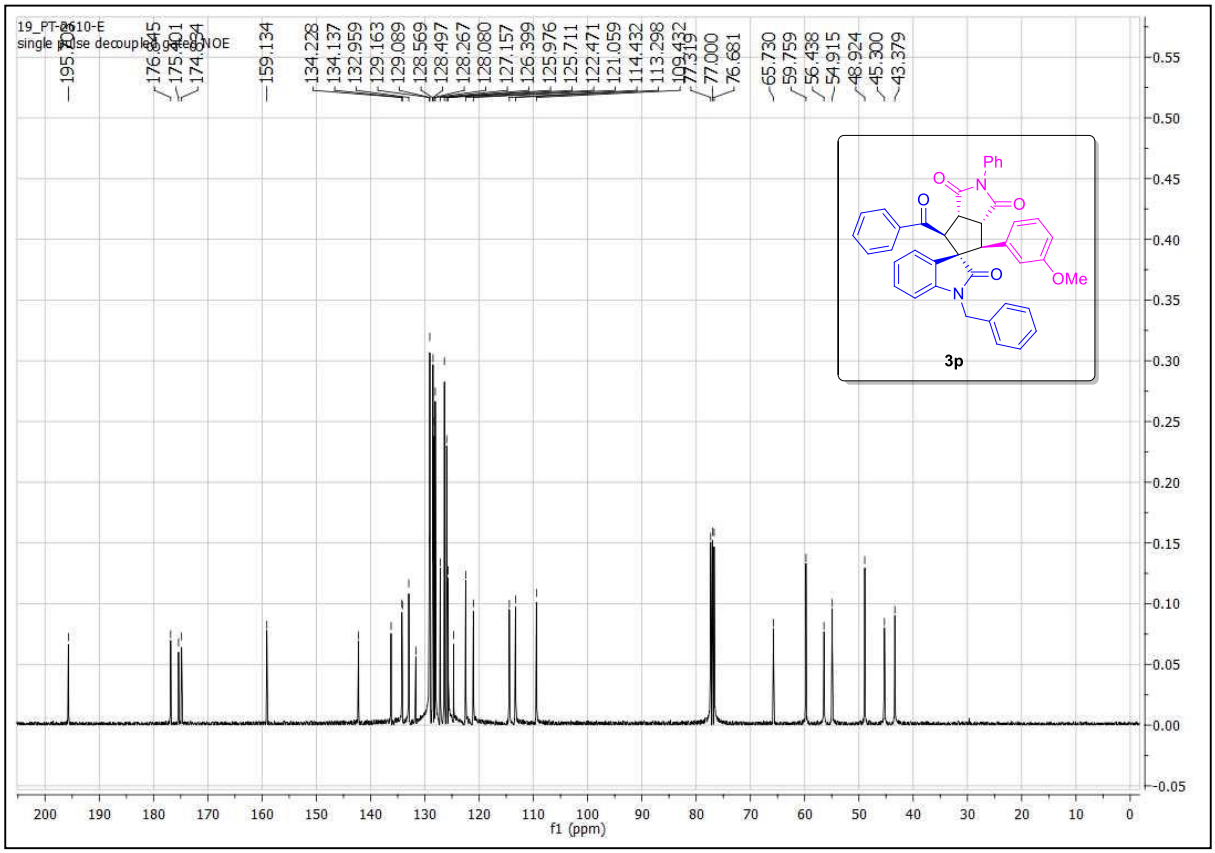

3n
f1 (ppm)

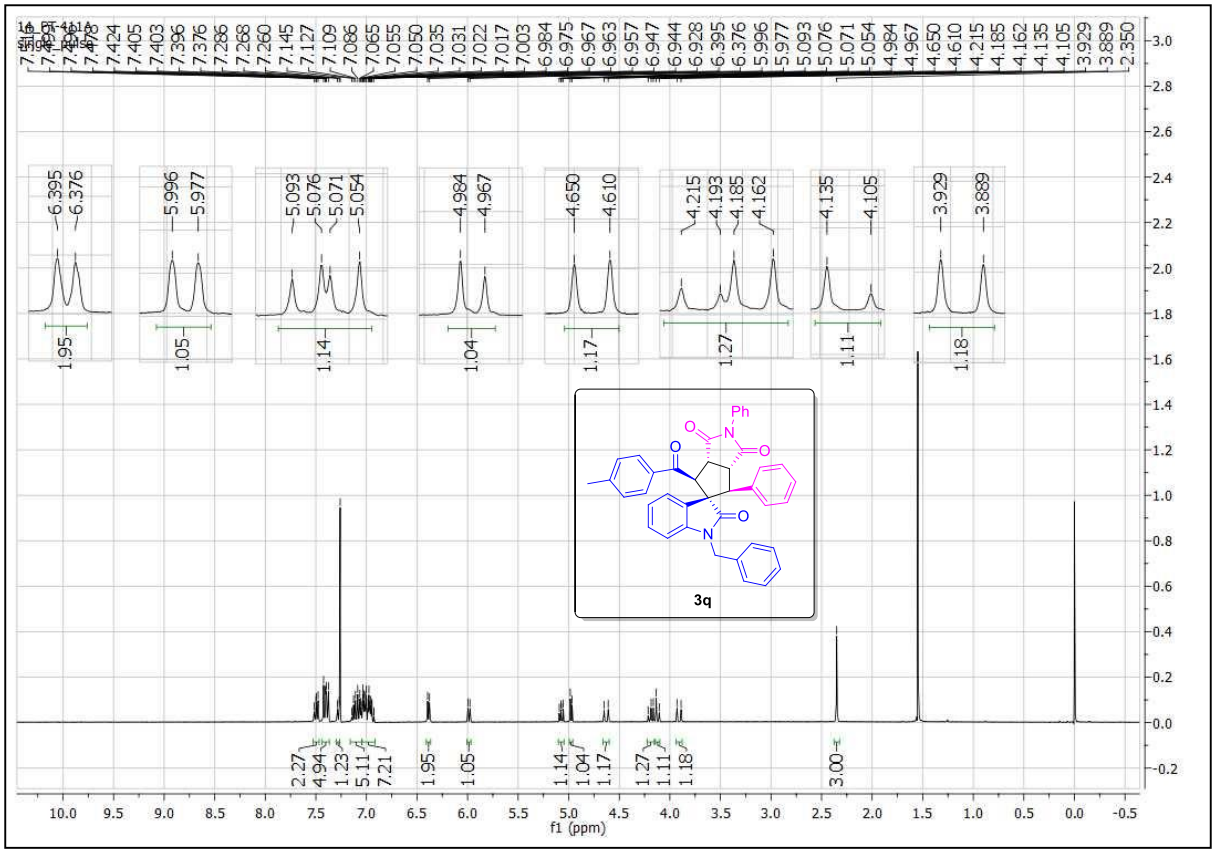

3n
f1 (ppm)

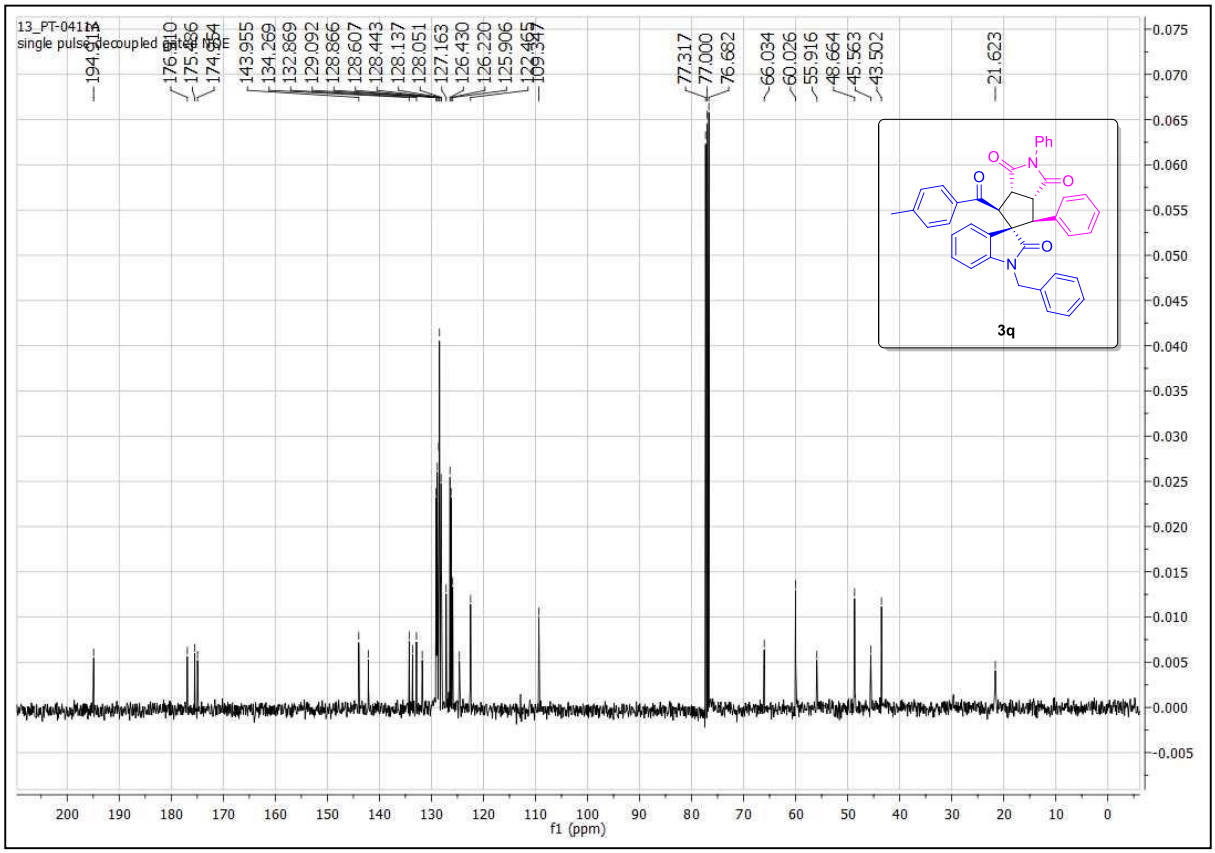

single_pulse
7.420
7.401
7.400
7.381
7.378
7.284
7.260
7.244
7.086
7.067
7.049
7.009
6.988
6.894
6.392
6.374
6.036
6.017
5.078
5.060
4.960
4.943
4.742
4.137
4.107
4.086
4.081
4.052
3.756
3.716
5.097
4.701
1.87
0.96
0.95
0.97
1.00
2.01
1.07
2.83
5.04
1.73
0.91
0.98
2.62
3.18
1.96
1.87
0.96
0.95
0.97
1.00
2.01
1.07
Ph
N
O
Cl
3o
f1 (ppm)

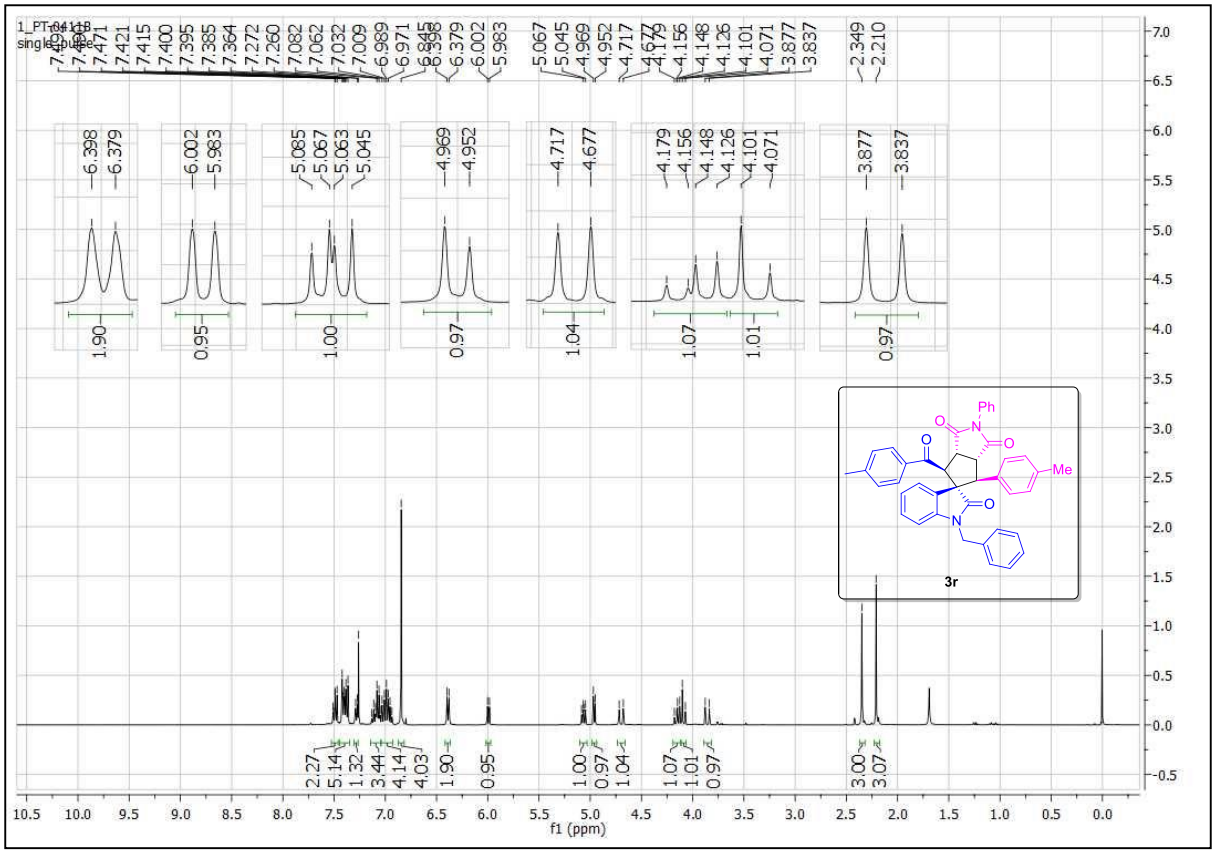

1_PT-2610-C
single pulse decoupled gated NOE
133.034
129.807
129.323
129.135
128.650
128.494
128.438
128.286
128.132
127.395
126.379
126.168
125.691
77.319
77.000
76.681
65.660
59.174
56.331
48.820
45.307
43.435
Ph
N
O
Cl
3o
f1 (ppm)

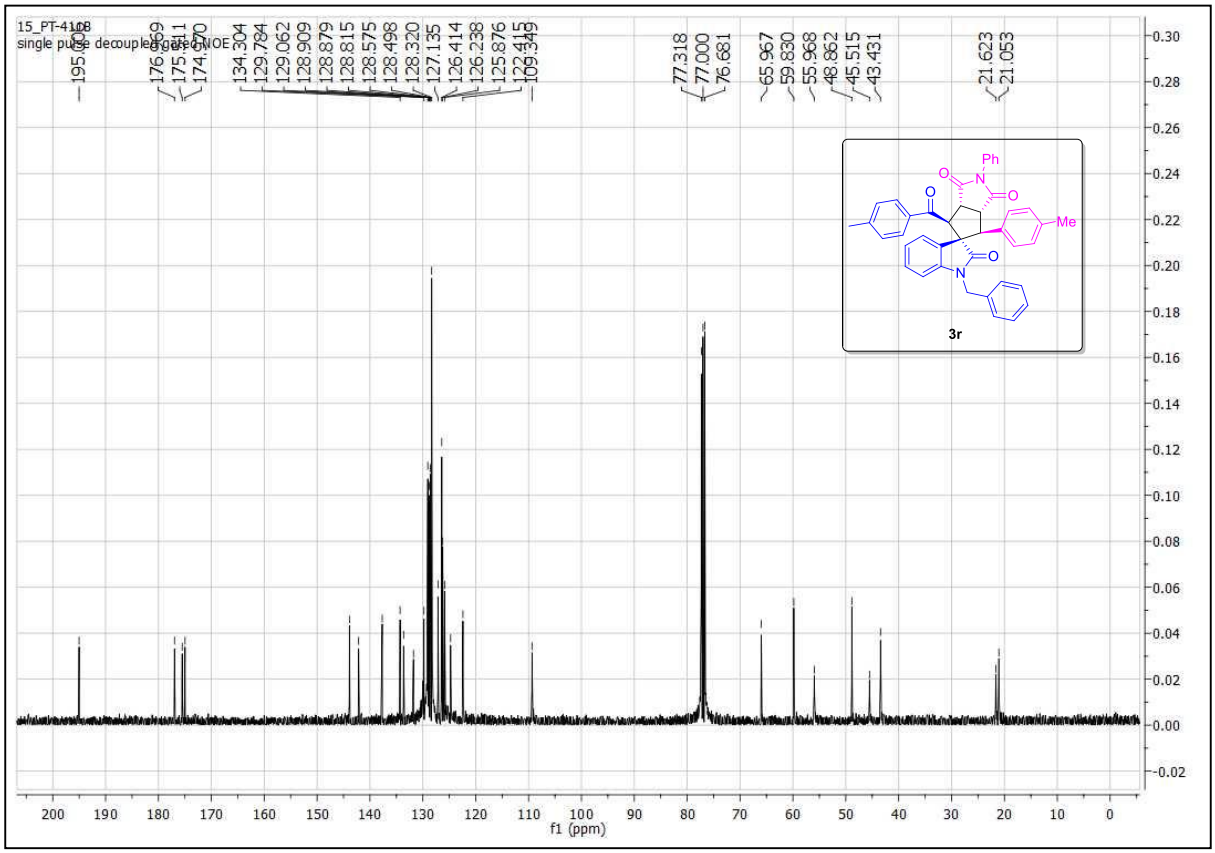

3p
Ph
OMe
f1 (ppm)

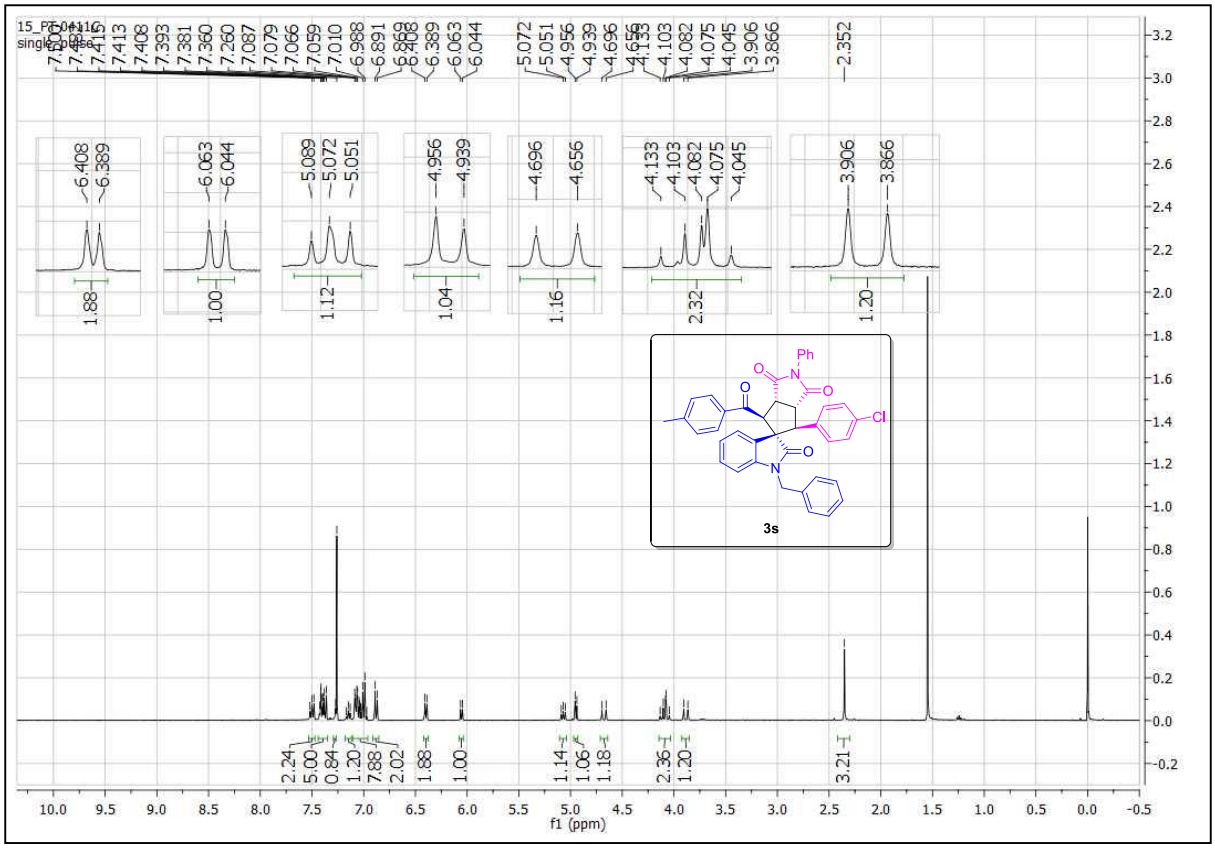

3p
Ph
OMe
f1 (ppm)

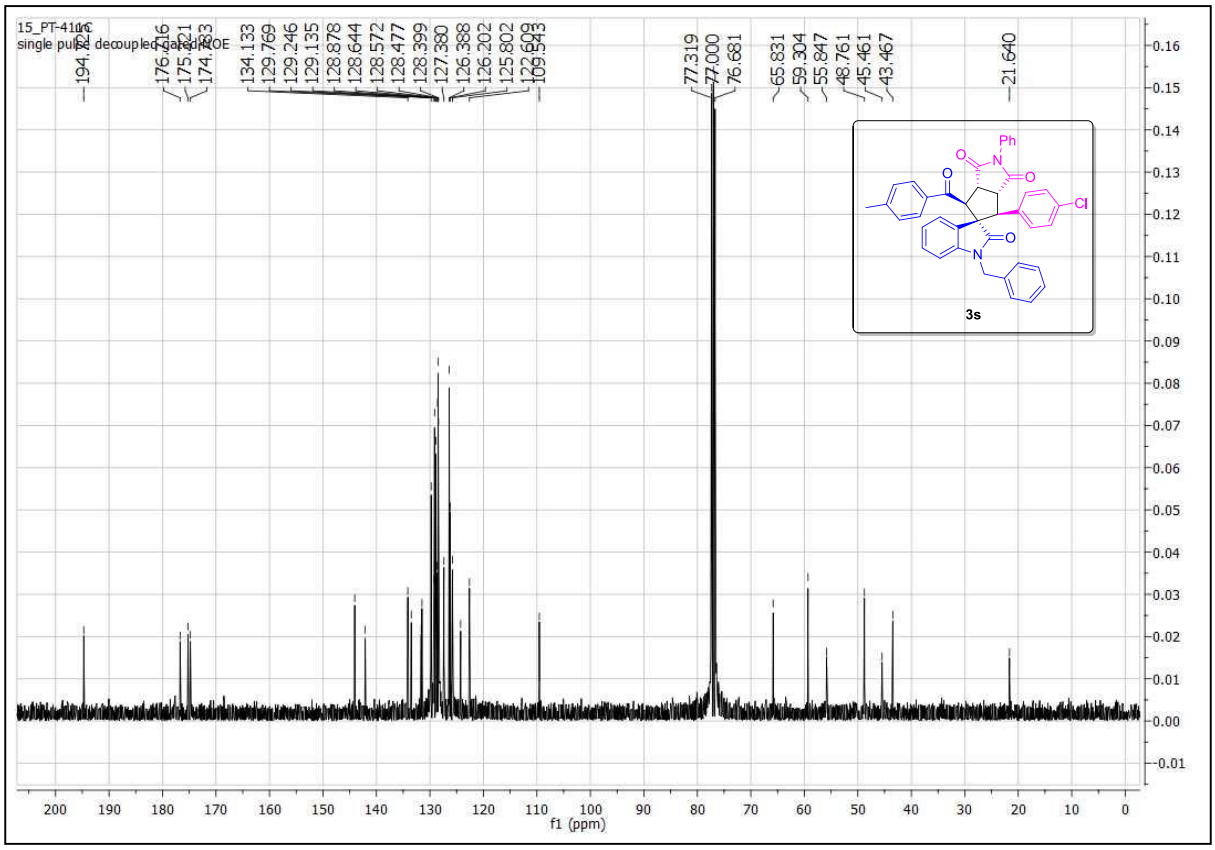

3q

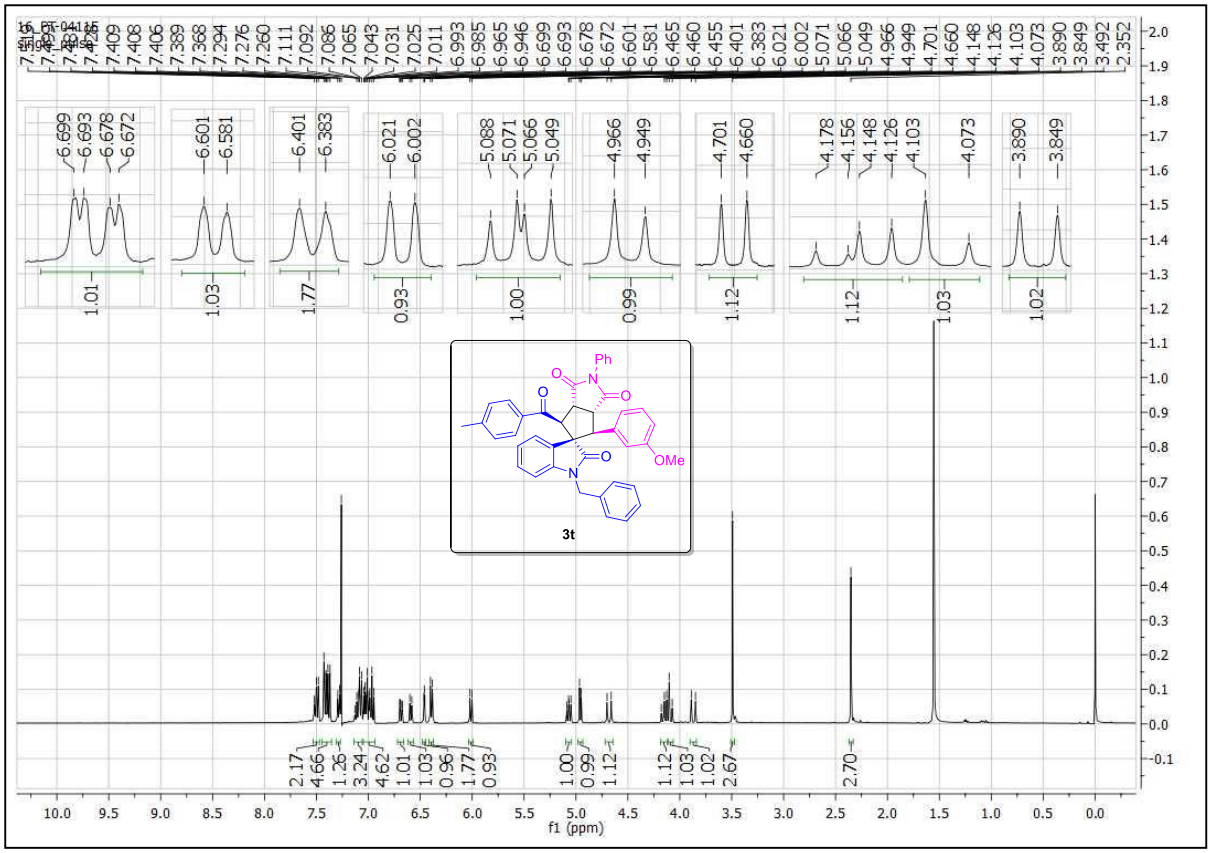

3q

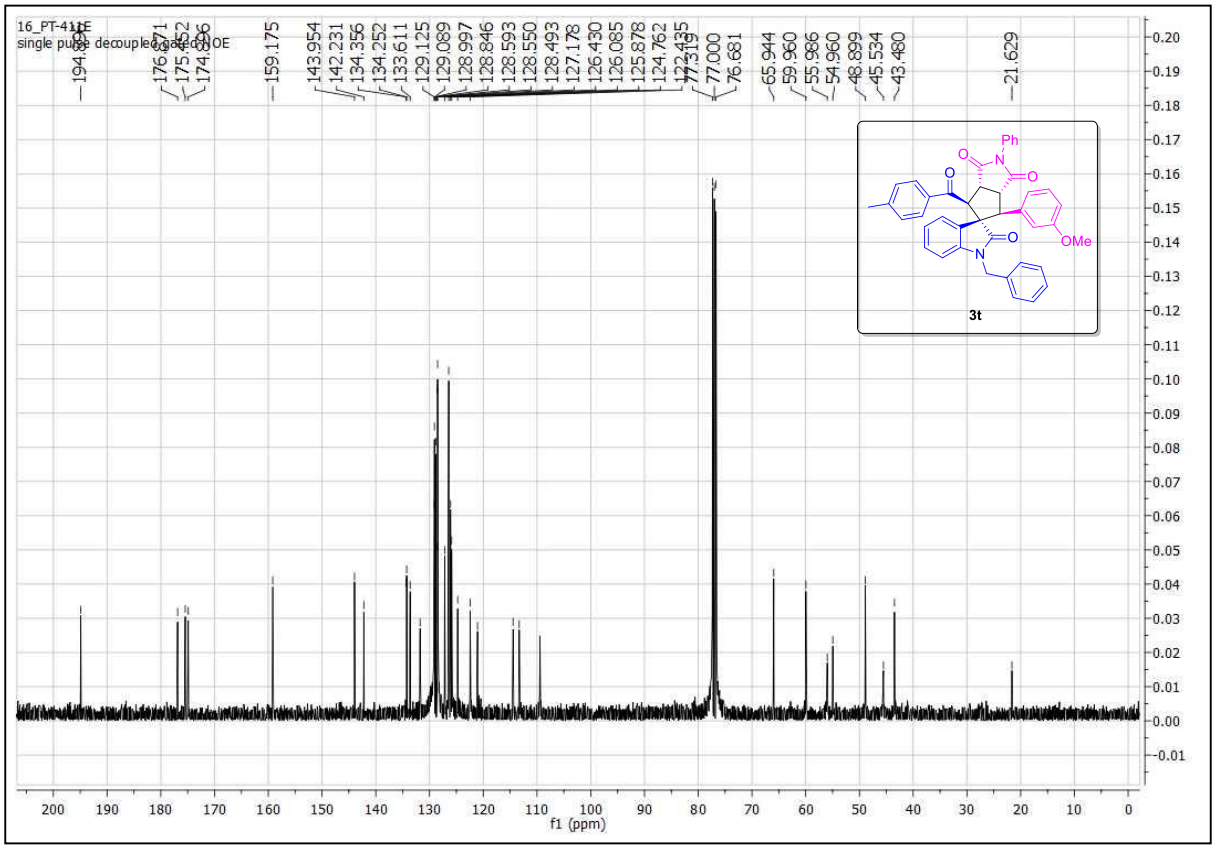

1_PT-4118
single pulse
3r
f1 (ppm)

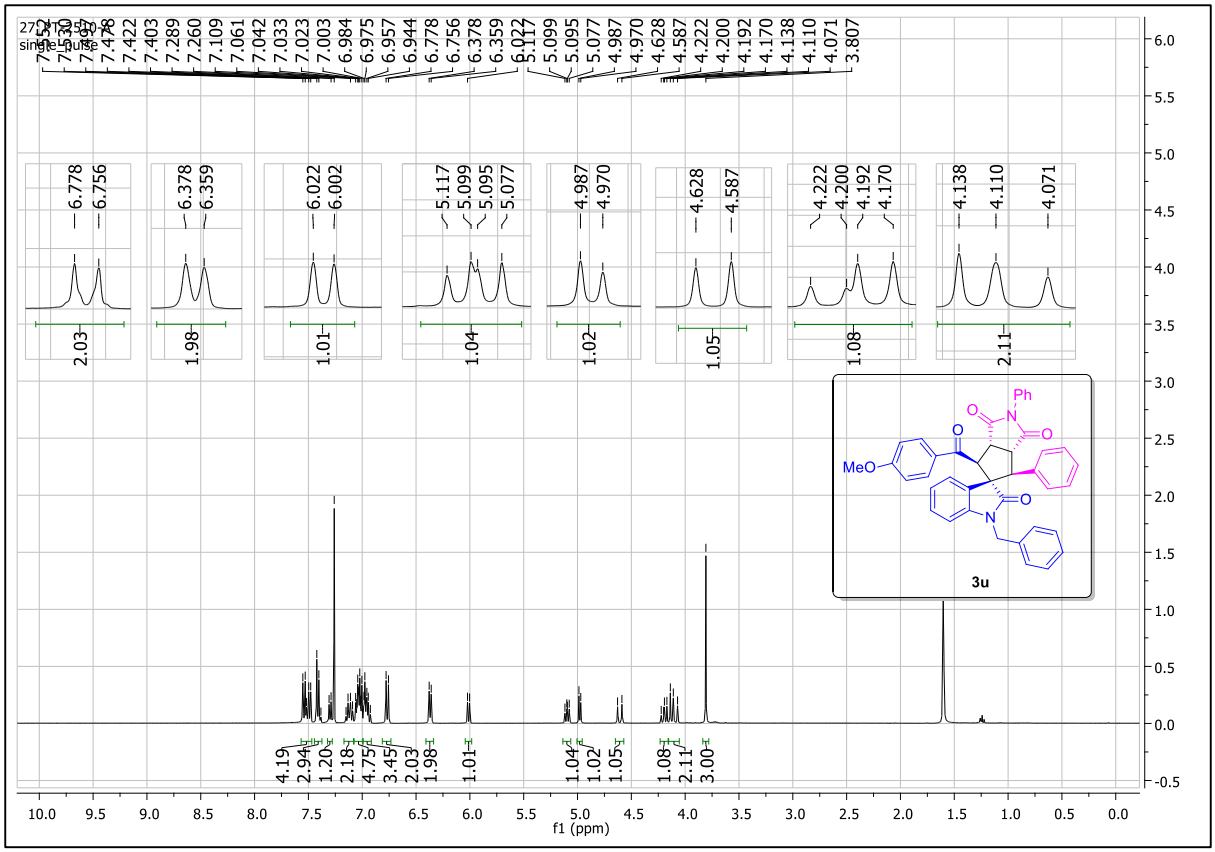

15_PT-4108
single pulse decoupled gated NOE
3r
f1 (ppm)

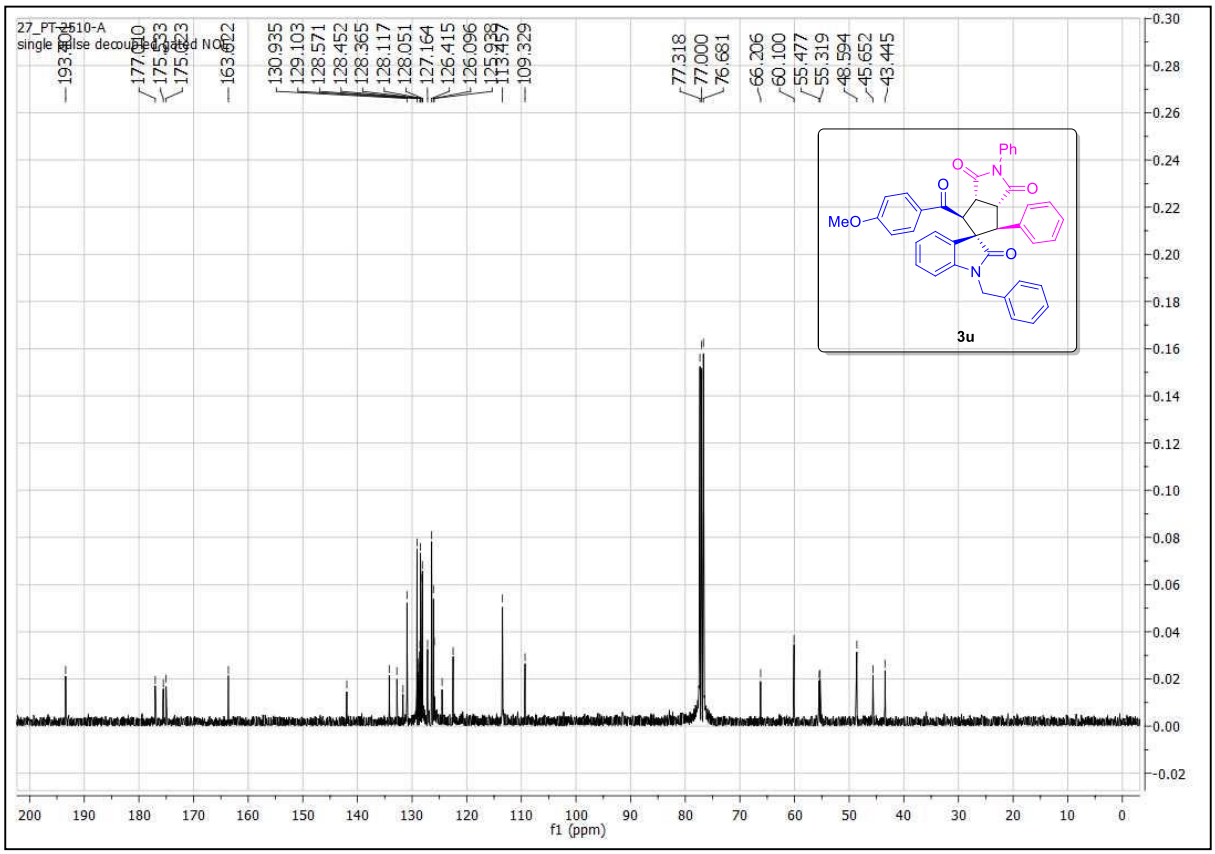

3s

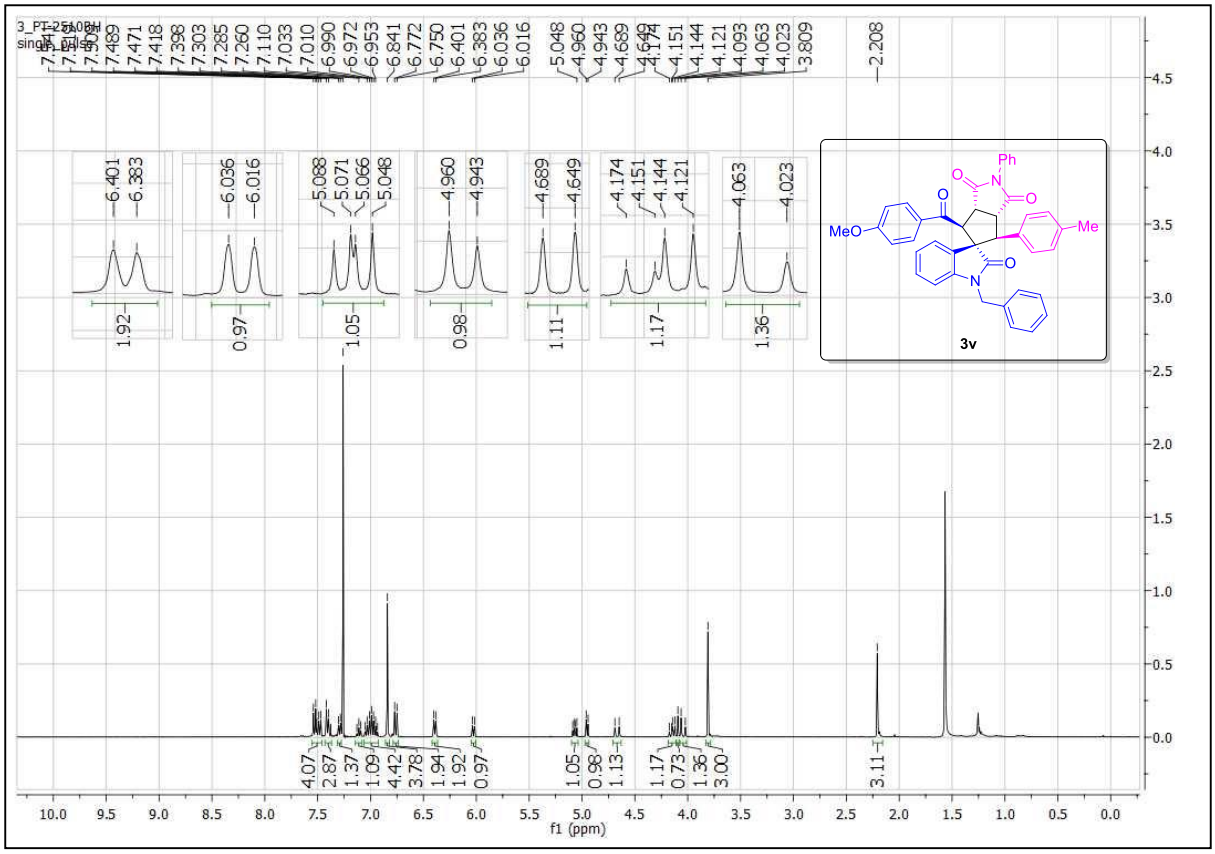

3s

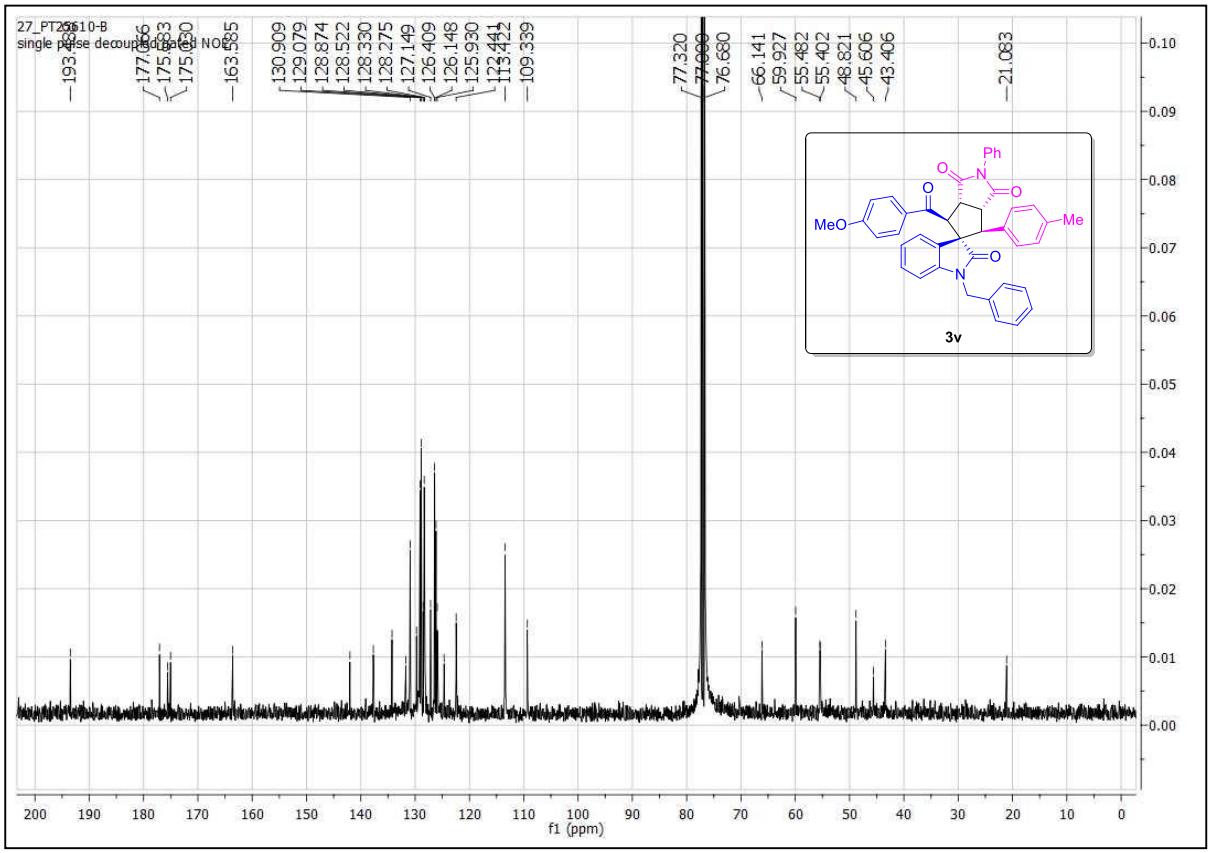

3t
f1 (ppm)

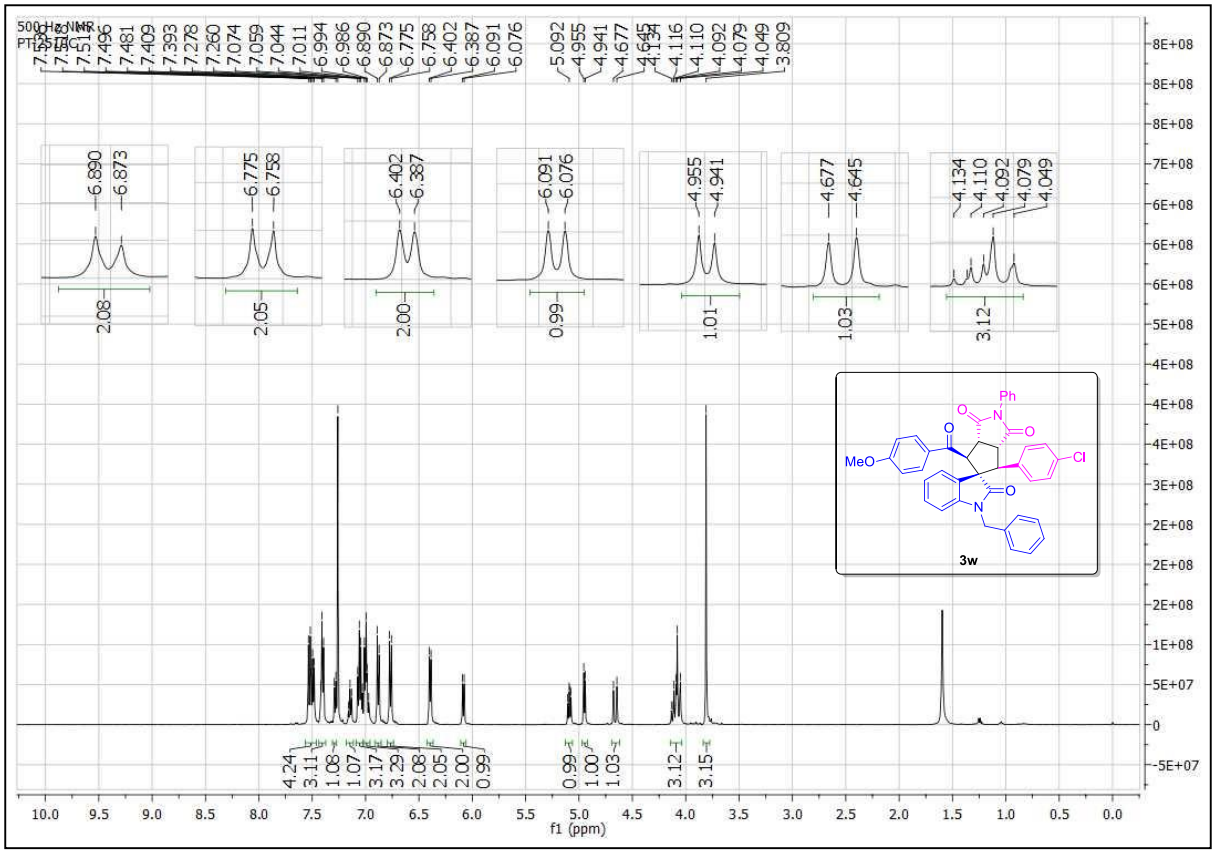

3t
f1 (ppm)

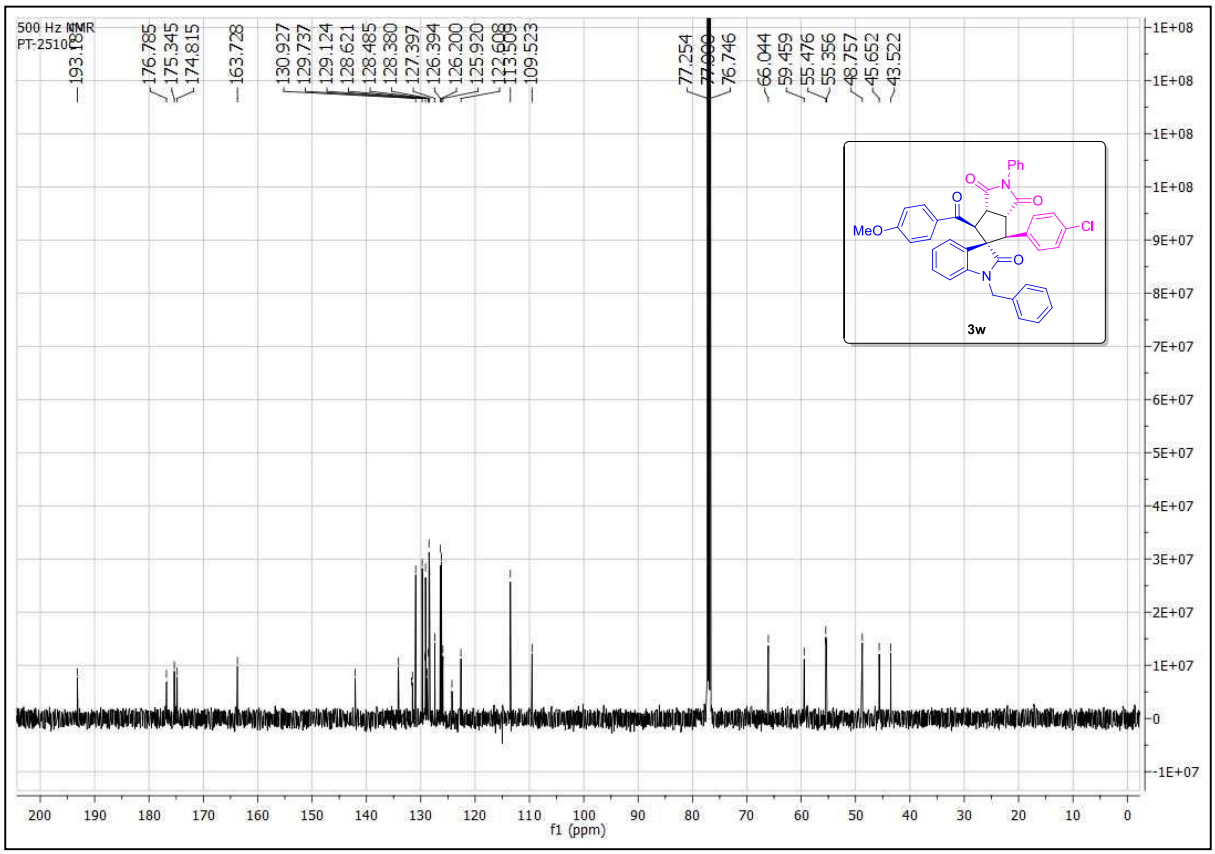

27_PT_2510-A
single pulse
7.807
7.478
7.422
7.403
7.289
7.260
7.109
7.061
7.042
7.033
7.023
7.003
6.984
6.975
6.957
6.944
6.778
6.756
6.378
6.359
6.022
5.117
5.099
5.095
5.077
4.987
4.970
4.628
4.587
4.222
4.200
4.192
4.170
4.138
4.110
4.071
2.03
1.98
1.01
1.04
1.02
1.05
1.08
2.11
4.19
2.94
1.20
2.18
4.75
3.45
2.03
1.98
1.01
1.04
1.02
1.05
1.08
2.11
3.00
MeO
Ph
3u
f1 (ppm)

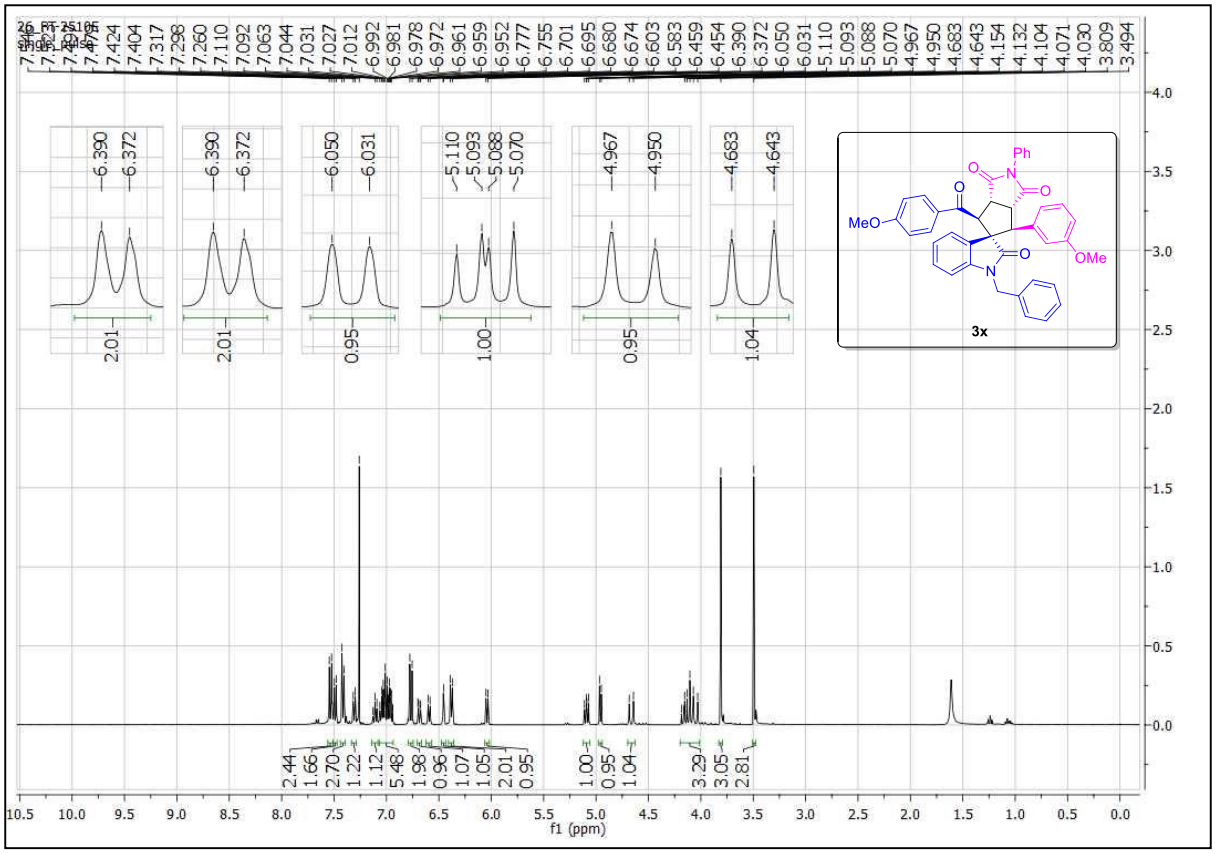

27_PT_2510-A
single pulse decoupled gated NOE
193.420
177.010
175.833
175.523
163.622
130.935
129.103
128.571
128.452
128.365
128.117
128.051
127.164
126.415
126.096
125.938
113.457
109.329
77.318
77.000
76.681
66.206
60.100
55.477
55.319
48.594
45.652
43.445
MeO
Ph
3u
f1 (ppm)

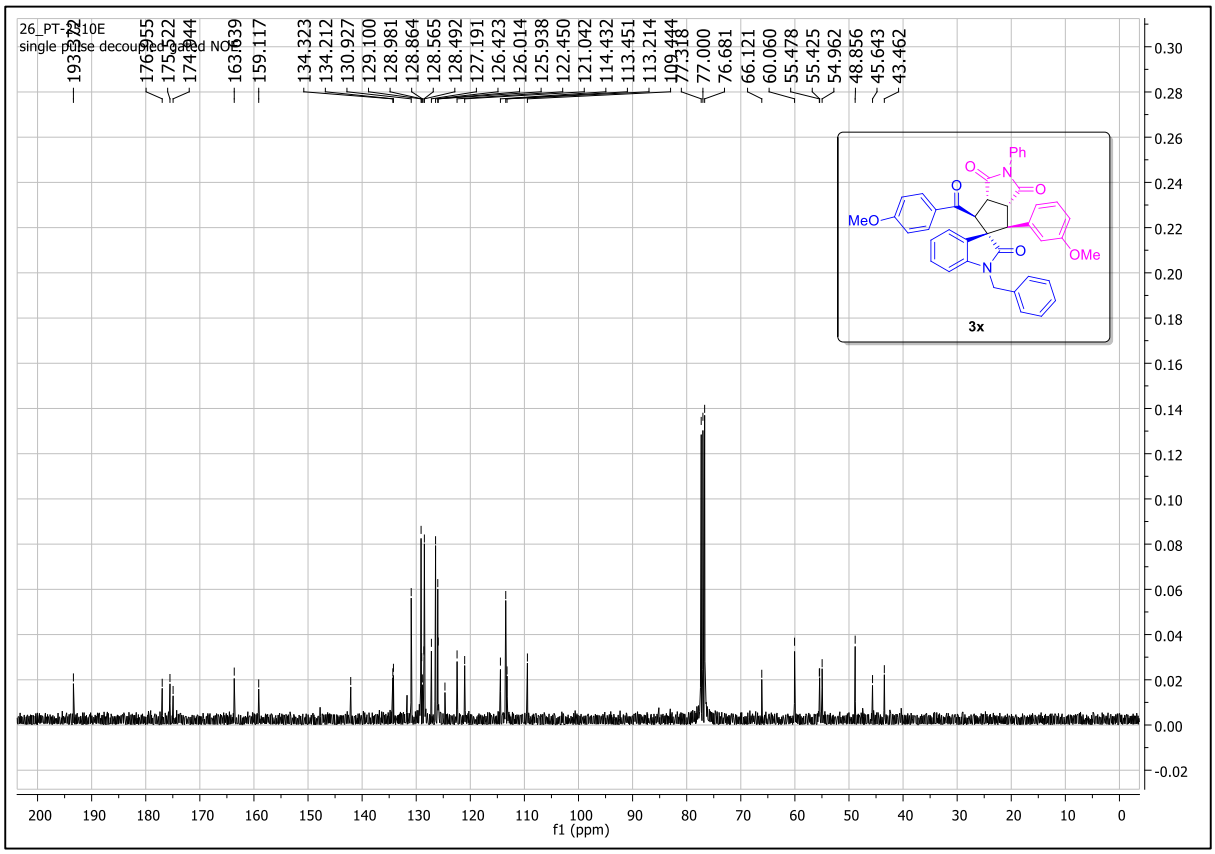

3v
f1 (ppm)


3v
f1 (ppm)


500 Hz NMR
PT-2510
7.556
7.511
7.496
7.481
7.409
7.393
7.278
7.260
7.074
7.059
7.044
7.011
6.994
6.986
6.890
6.873
6.775
6.758
6.402
6.387
6.091
6.076
5.092
4.955
4.941
4.677
4.645
4.134
4.116
4.110
4.092
4.079
4.049
3.809
2.08
2.05
2.00
0.99
1.01
1.03
3.12
4.24
3.11
1.08
1.07
3.17
3.29
2.08
2.05
2.00
0.99
0.99
1.00
1.03
3.12
3.15
Ph
MeO
Cl
3w
f1 (ppm)


500 Hz NMR
PT-2510
193.169
176.785
175.345
174.815
163.728
130.927
129.737
129.124
128.621
128.485
128.380
127.397
126.394
126.200
125.920
123.608
113.509
109.523
77.254
77.000
76.746
66.044
59.459
55.476
55.356
48.757
45.652
43.522
Ph
MeO
Cl
3w
f1 (ppm)


26_PT-2510E
single pulse
6.390
6.372
6.050
6.031
5.110
5.093
5.088
5.070
4.967
4.950
4.683
4.643
2.01
2.01
0.95
1.00
0.95
1.04
Ph
MeO
OMe
3x
f1 (ppm)


26_PT-2510E
single pulse decoupled gated NOE
193.211
176.555
175.022
174.444
163.639
159.117
134.323
134.212
130.927
129.100
128.981
128.864
128.565
128.492
127.191
126.423
126.014
125.938
122.450
121.042
114.432
113.451
113.214
109.444
77.318
77.000
76.681
66.121
60.060
55.478
55.425
54.962
48.856
45.643
43.462
Ph
MeO
OMe
3x
f1 (ppm)

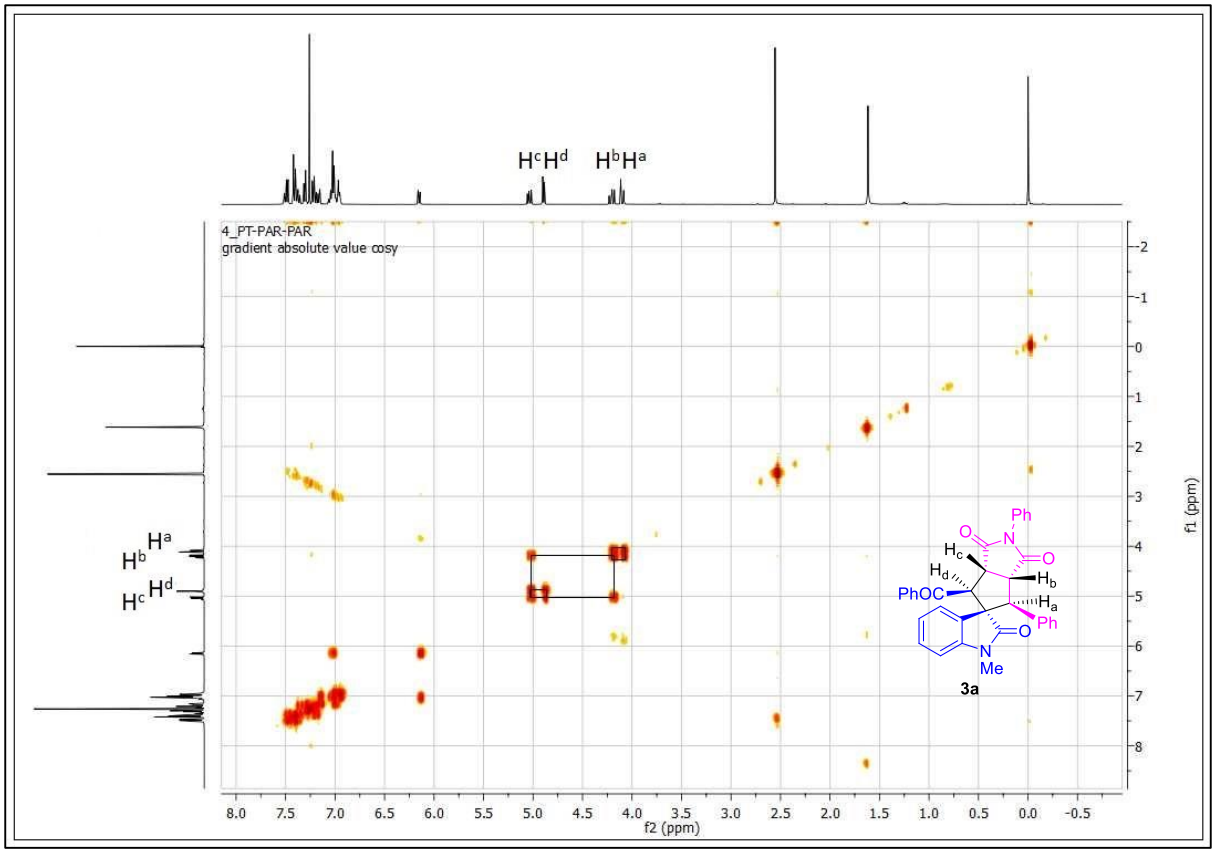


Figure S5: ^{1}H–^{1}H COSY spectrum of **3a**.

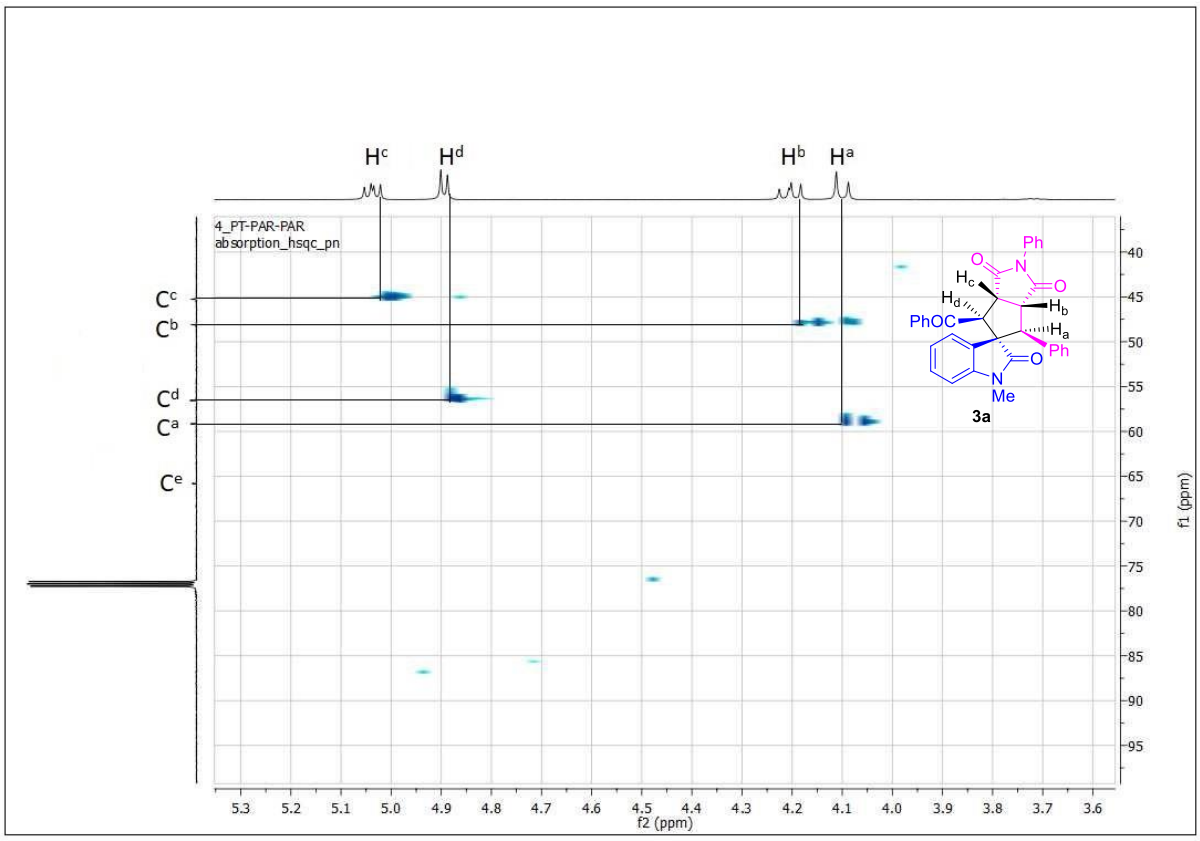


Figure S6: ^{1}H–^{13}C (HSQC) COSY spectrum of **3a**.

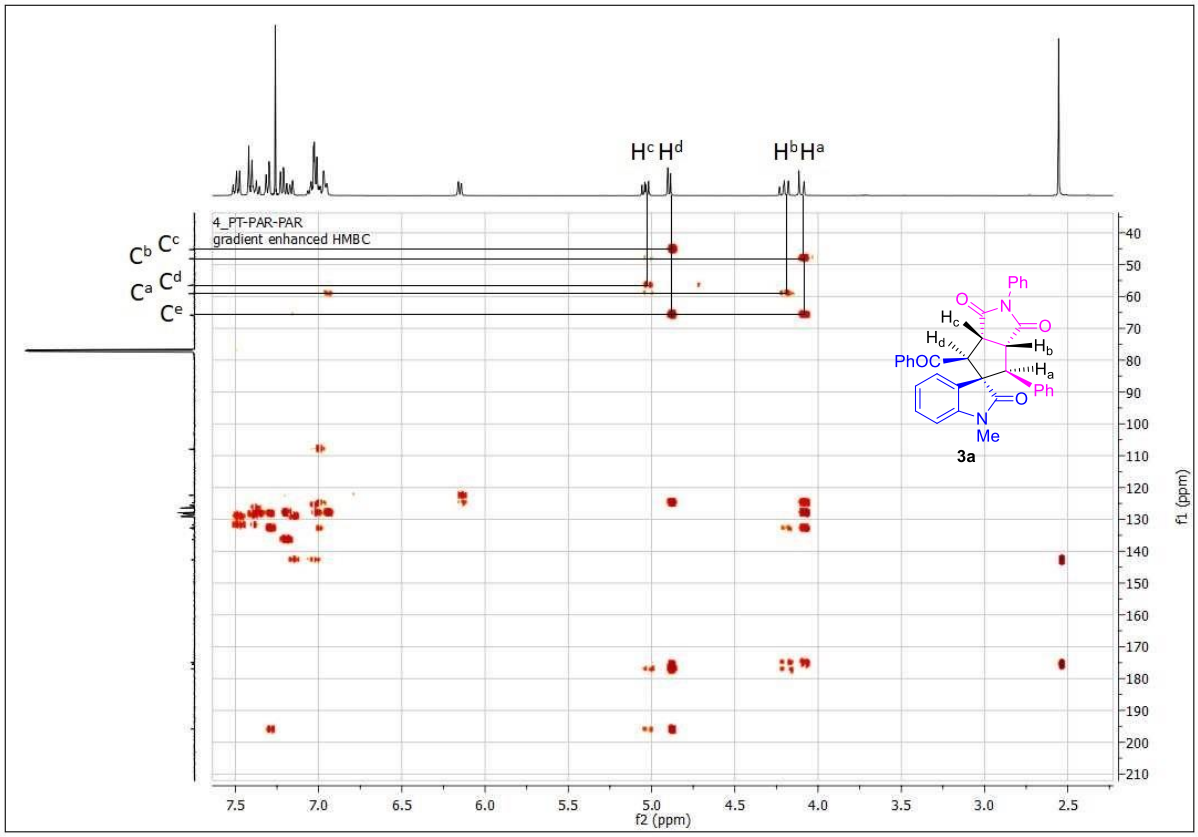


Figure S7: $^{1}H–^{13}C$ (HMBC) COSY spectrum of **3a**.

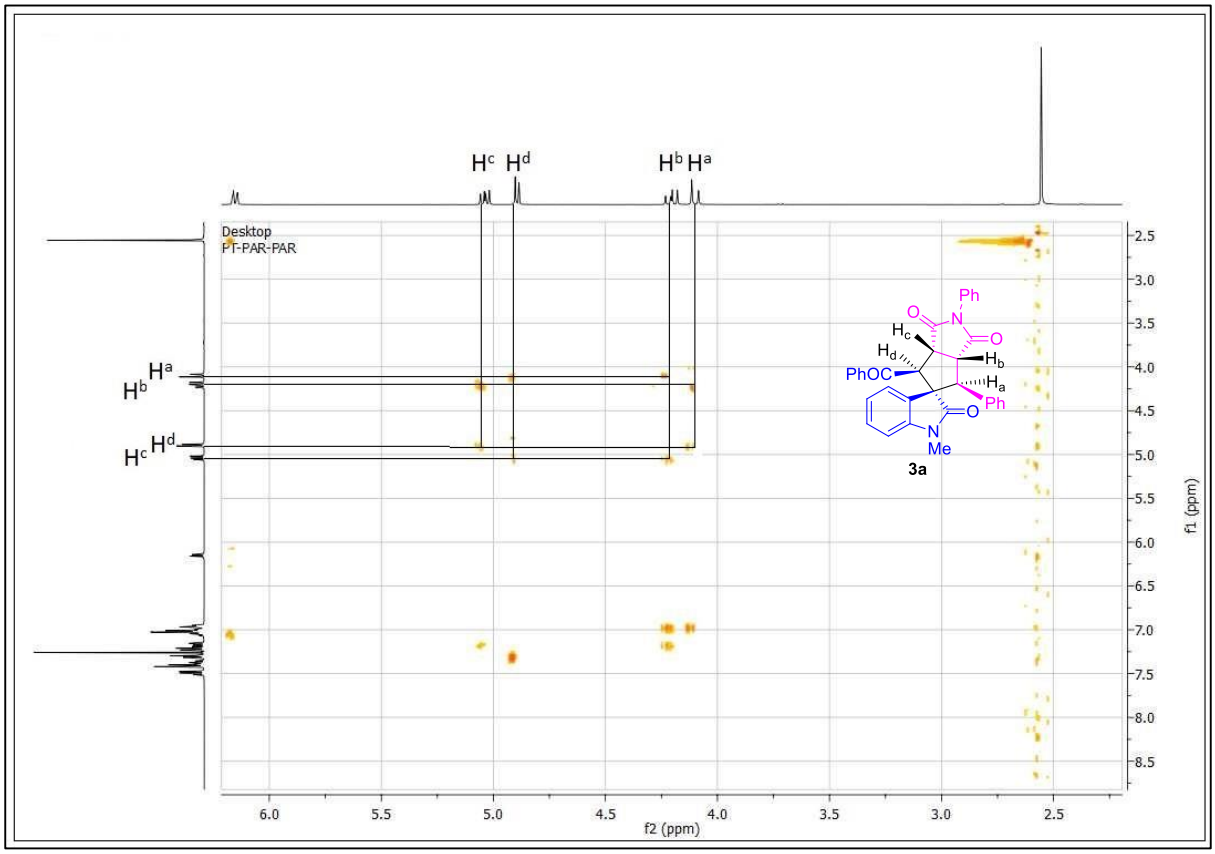
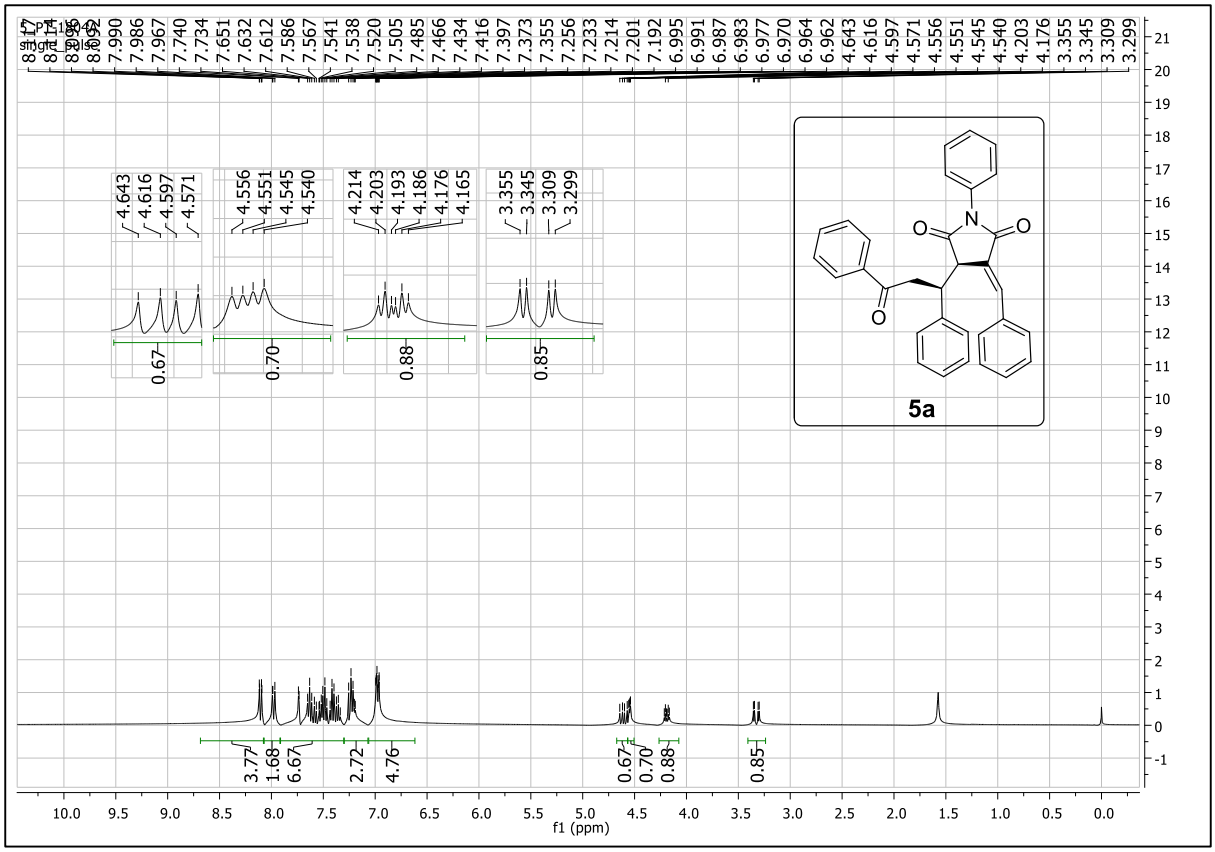
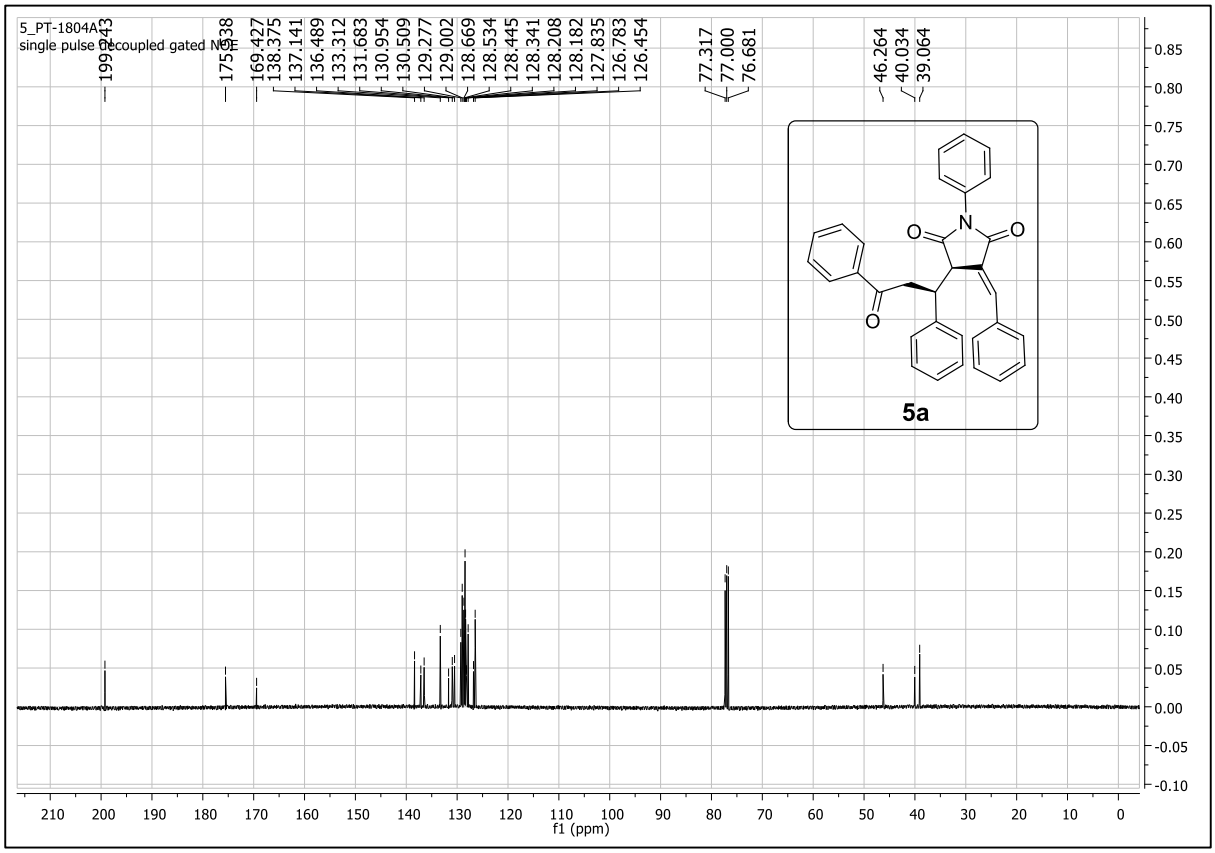
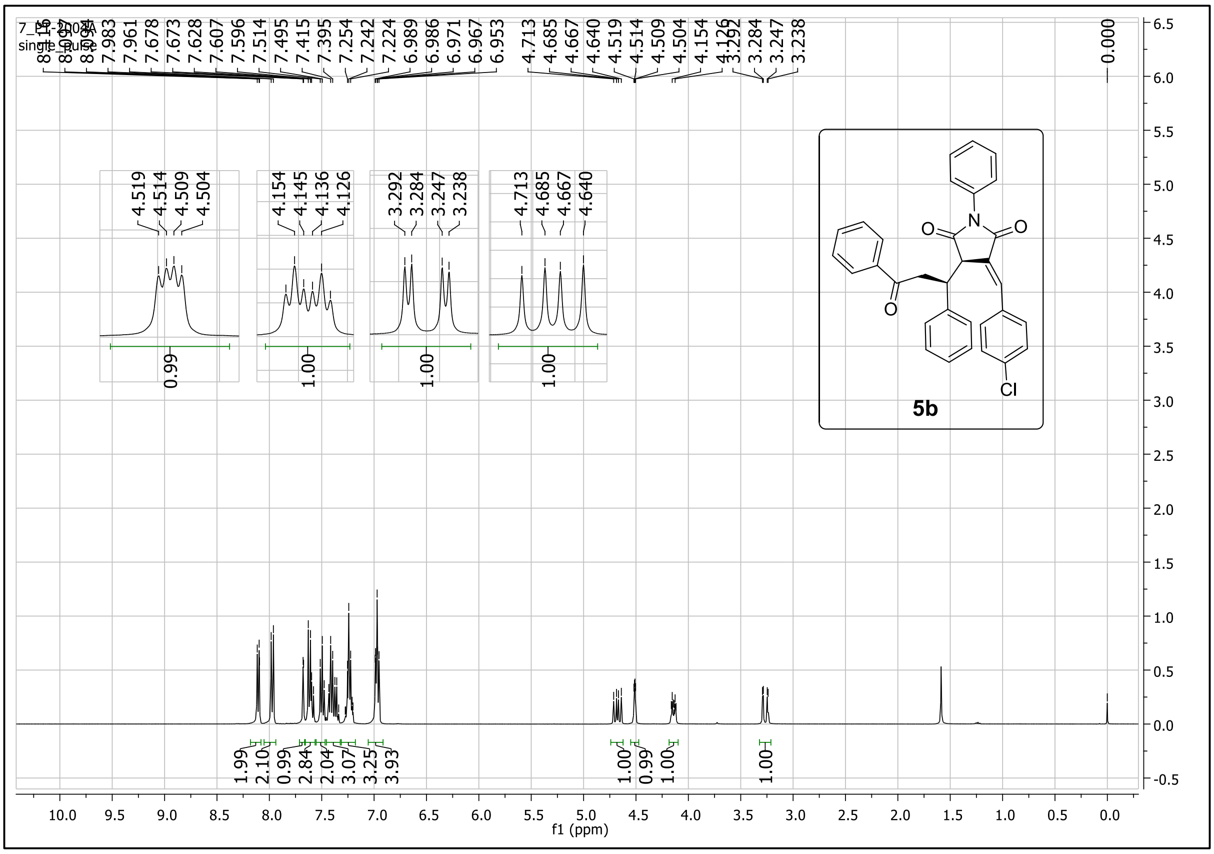


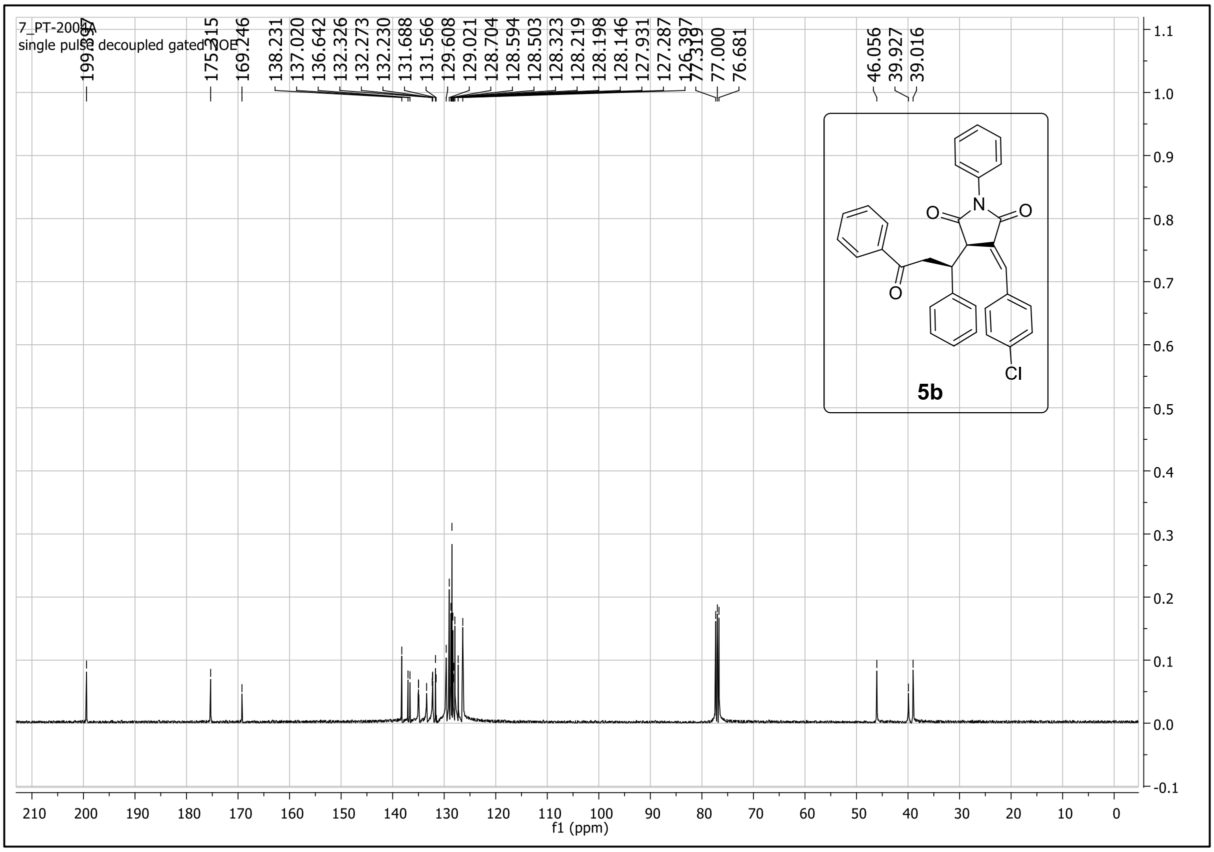
Figure S6: $^{1}H–^{1}H$ NOESY spectrum of **3a**.


5a

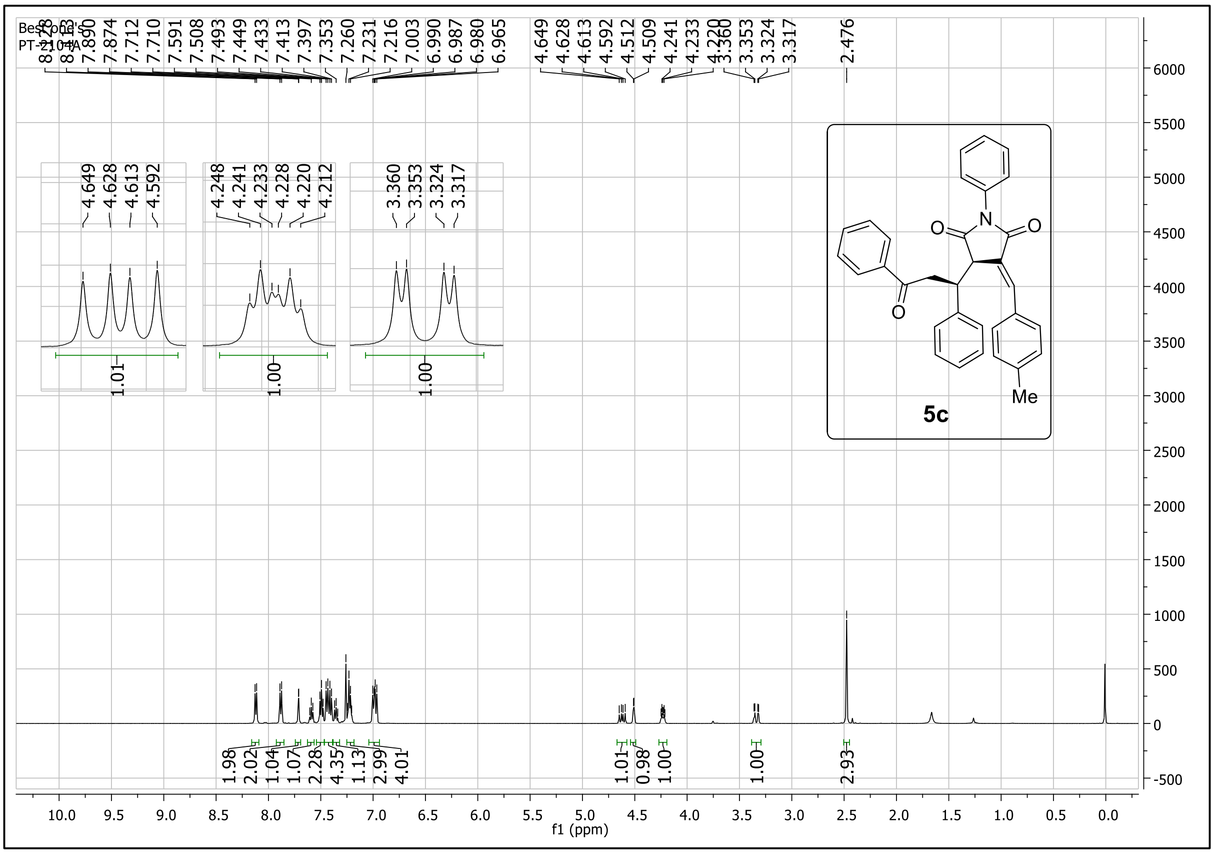

5a



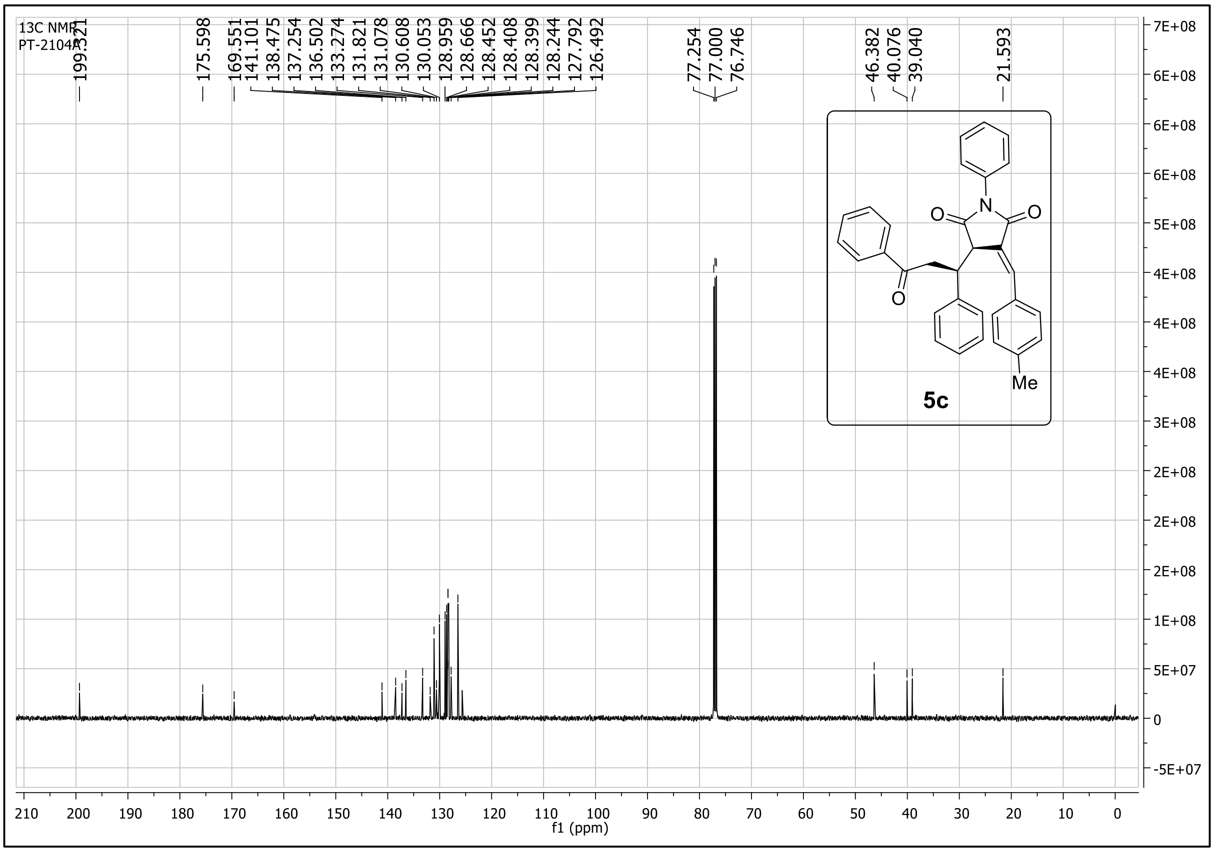
7_PT-2008A
single pulse
7.983 7.961 7.678 7.673 7.628 7.607 7.596 7.514 7.495 7.415 7.395 7.254 7.242 7.224 6.989 6.986 6.971 6.967 6.953 4.713 4.685 4.667 4.640 4.519 4.514 4.509 4.504 4.154 4.126 3.292 3.284 3.247 3.238
0.000
4.519 4.514 4.509 4.504
0.99
4.154 4.145 4.136 4.126
1.00
3.292 3.284 3.247 3.238
1.00
4.713 4.685 4.667 4.640
1.00
O
N
O
O
Cl
5b
1.99 2.10 0.99 2.84 2.04 3.07 3.25 3.93
1.00 0.99 1.00 1.00
f1 (ppm)



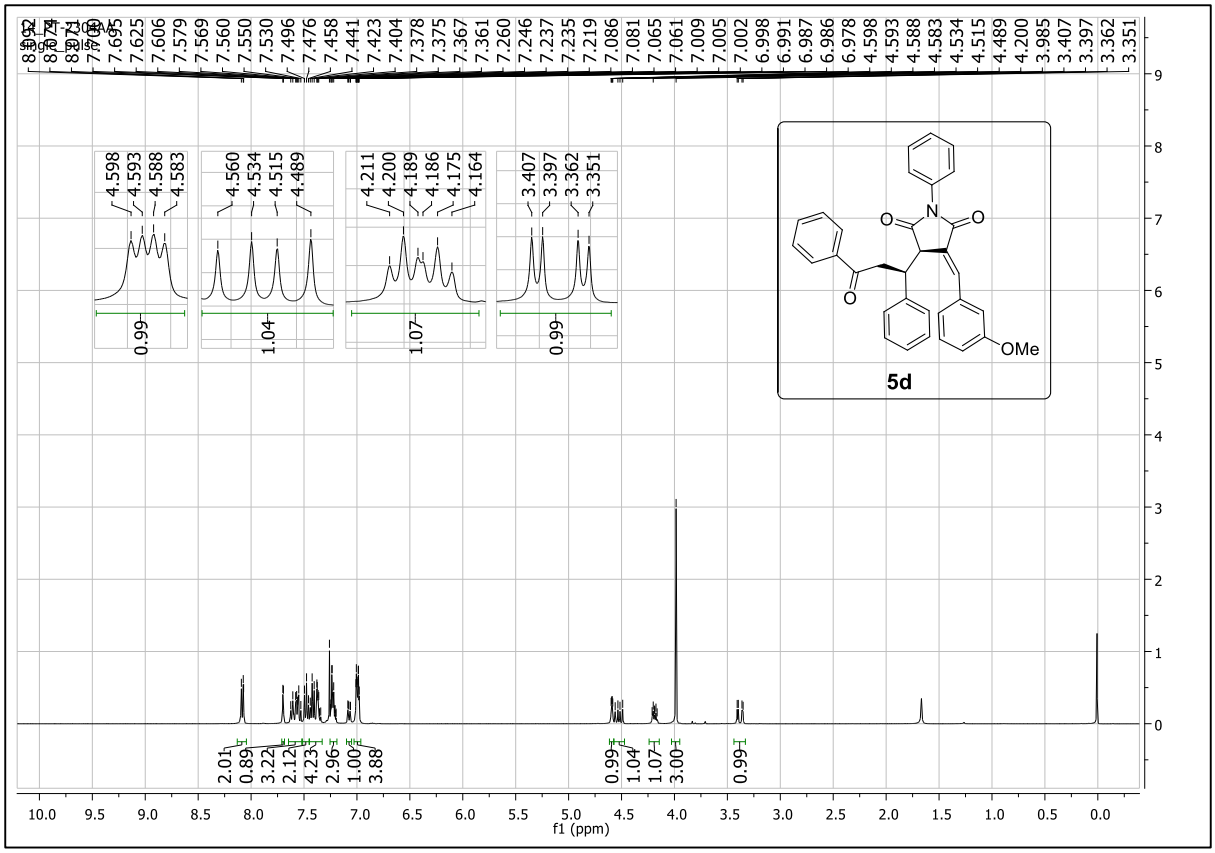
7_PT-2008A
single pulse decoupled gated NOE
175.215
169.246
138.231 137.020 136.642 132.326 132.273 132.230 131.688 131.566 129.608 129.021 128.704 128.594 128.503 128.323 128.219 128.198 128.146 127.931 126.397
77.000 76.681
46.056 39.927 39.016
O
N
O
O
Cl
5b
f1 (ppm)

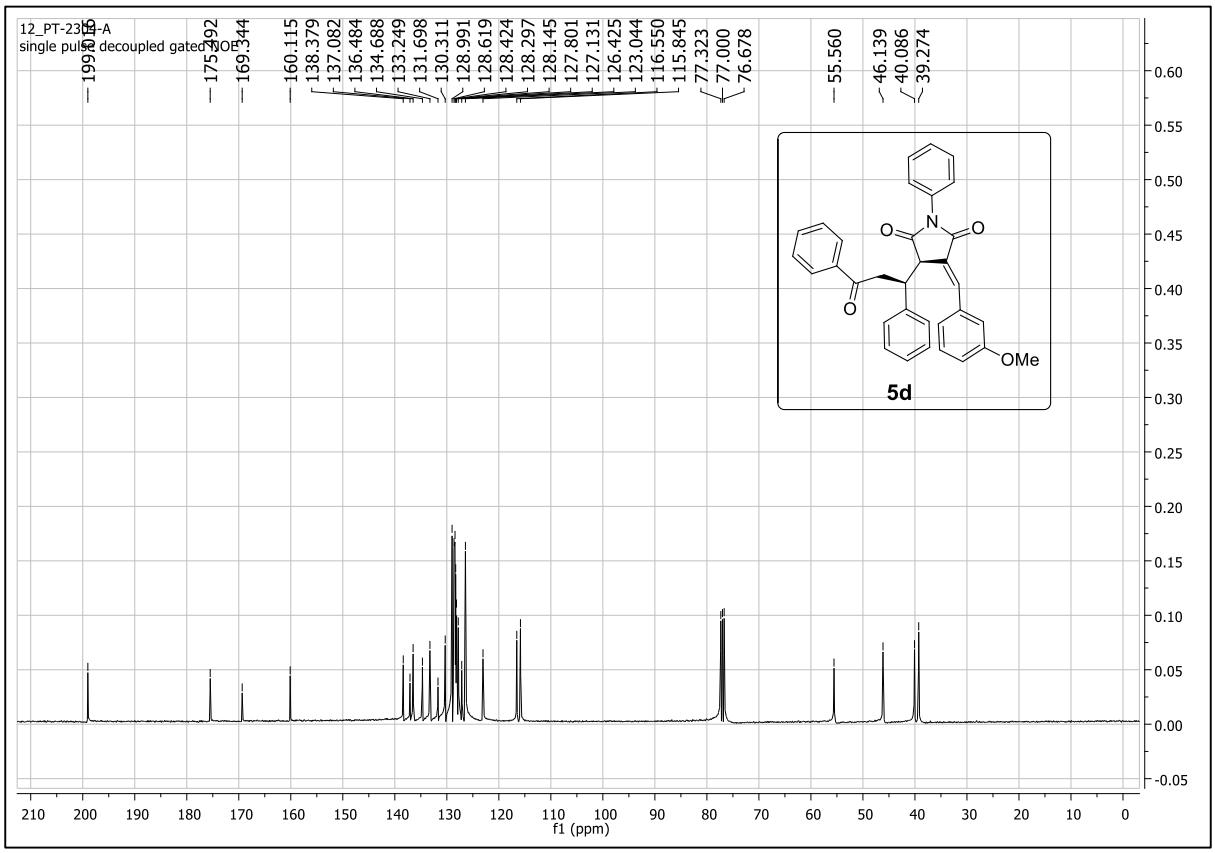


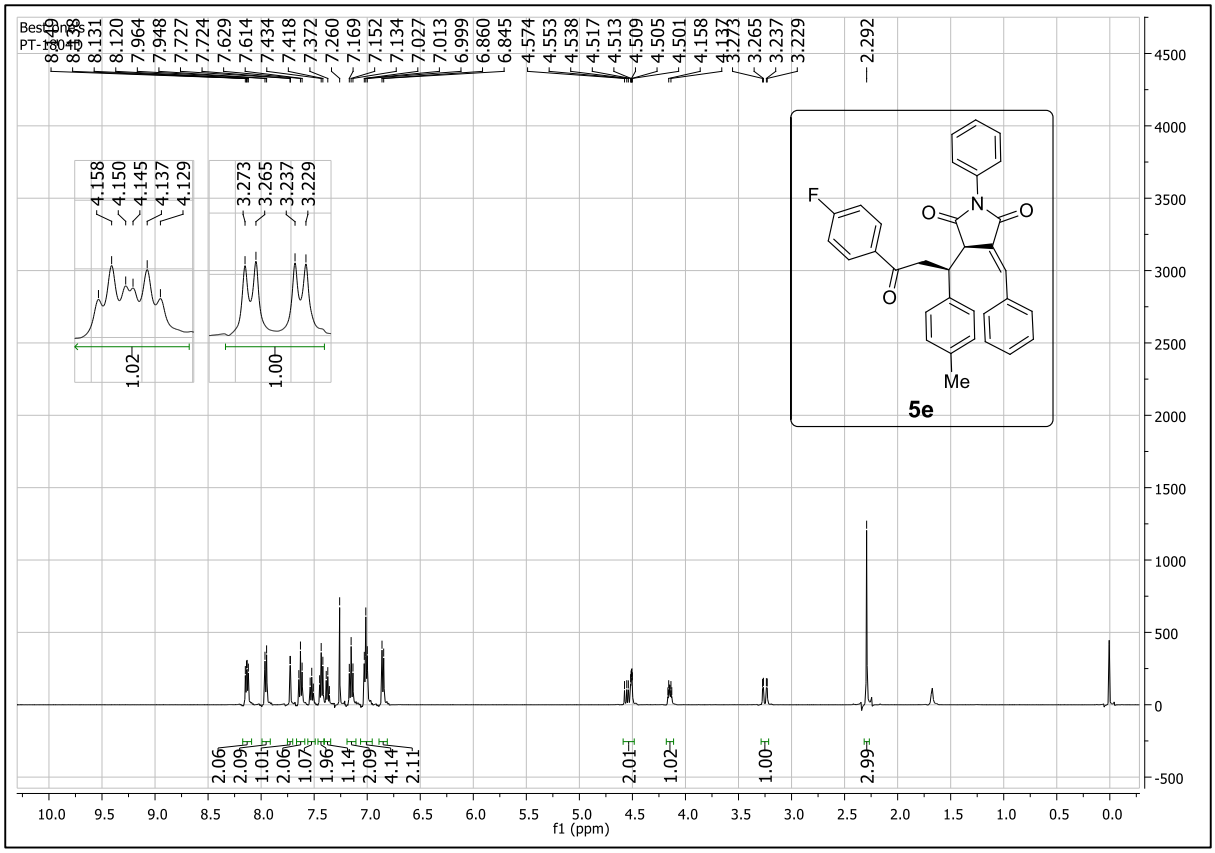
PT-2104A
2.476
1.01
1.00
5c
Me
f1 (ppm)

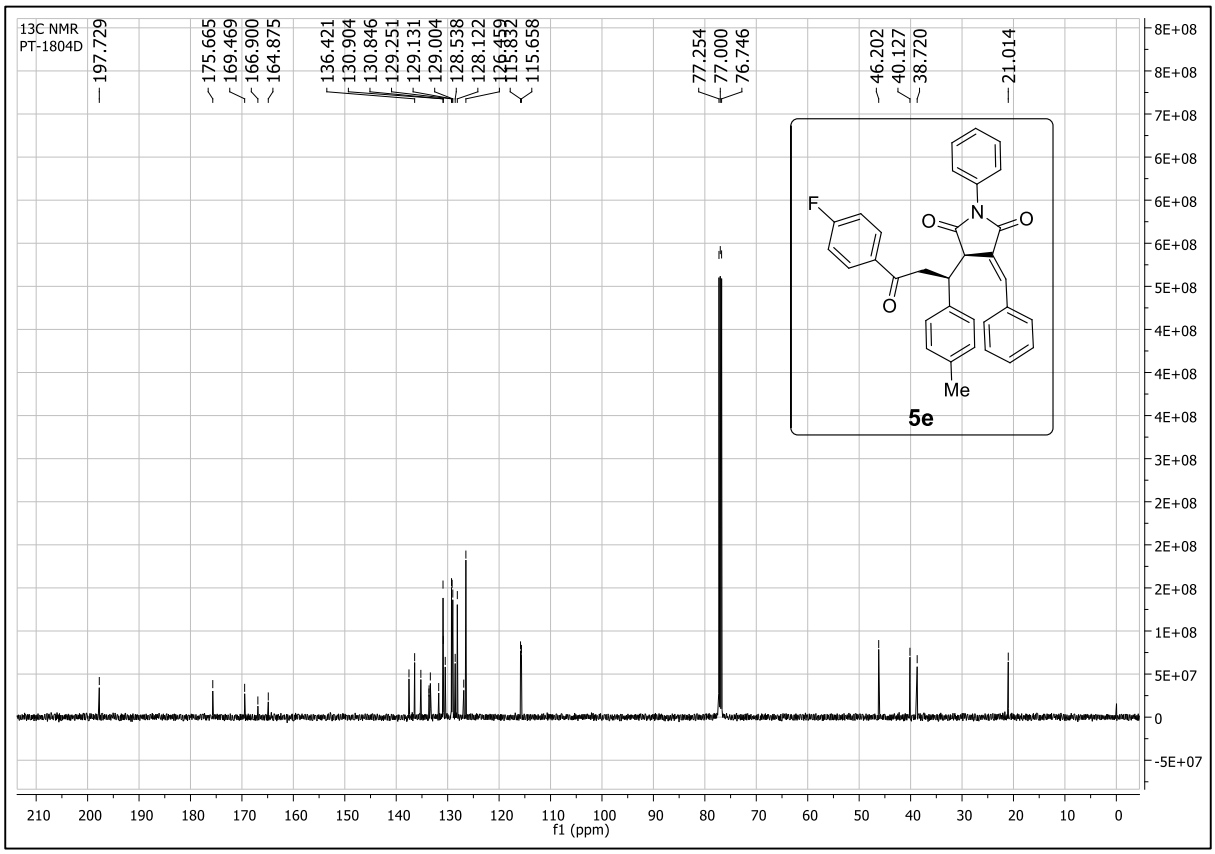


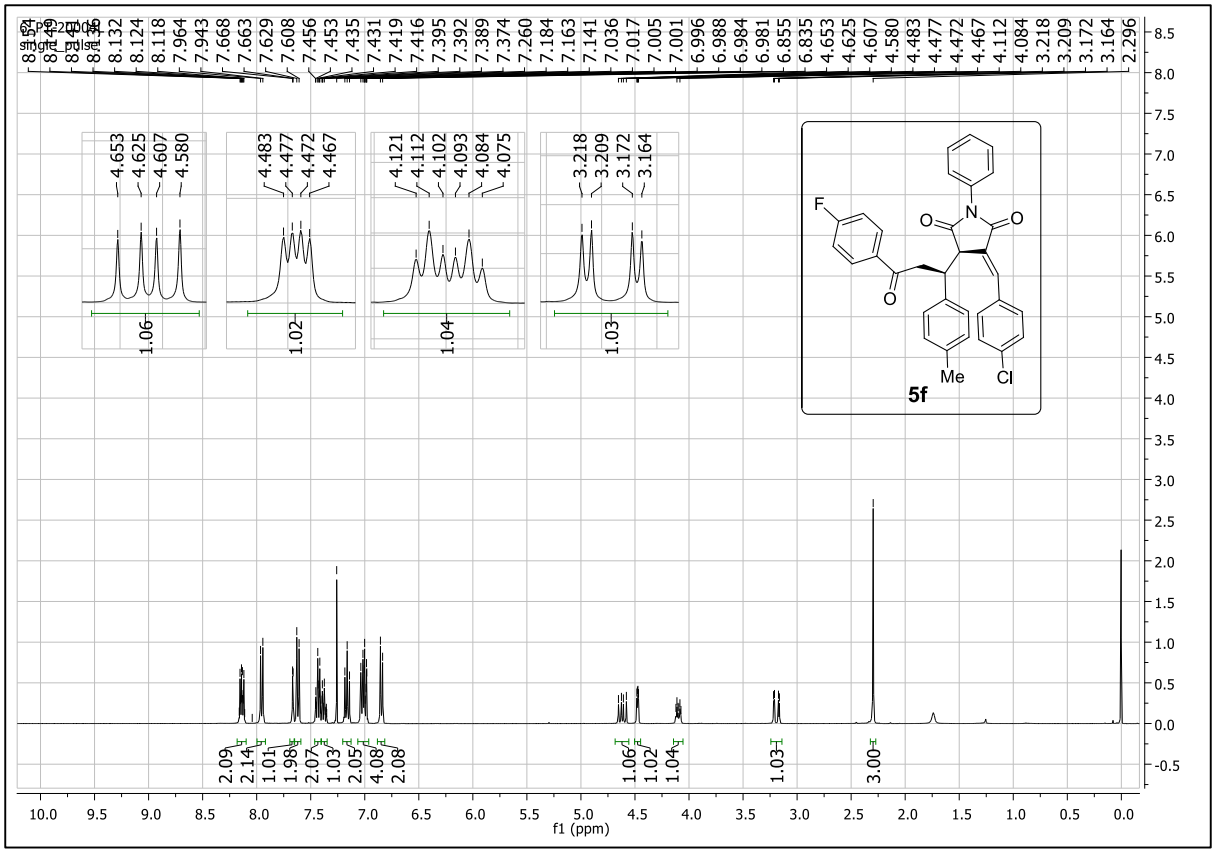
13C NMR
PT-2104A
199.321
175.598
169.551
141.101
138.475
137.254
136.502
133.274
131.821
131.078
130.608
130.053
128.959
128.666
128.452
128.408
128.399
128.244
127.792
126.492
77.254
77.000
76.746
46.382
40.076
39.040
21.593
5c
Me
f1 (ppm)

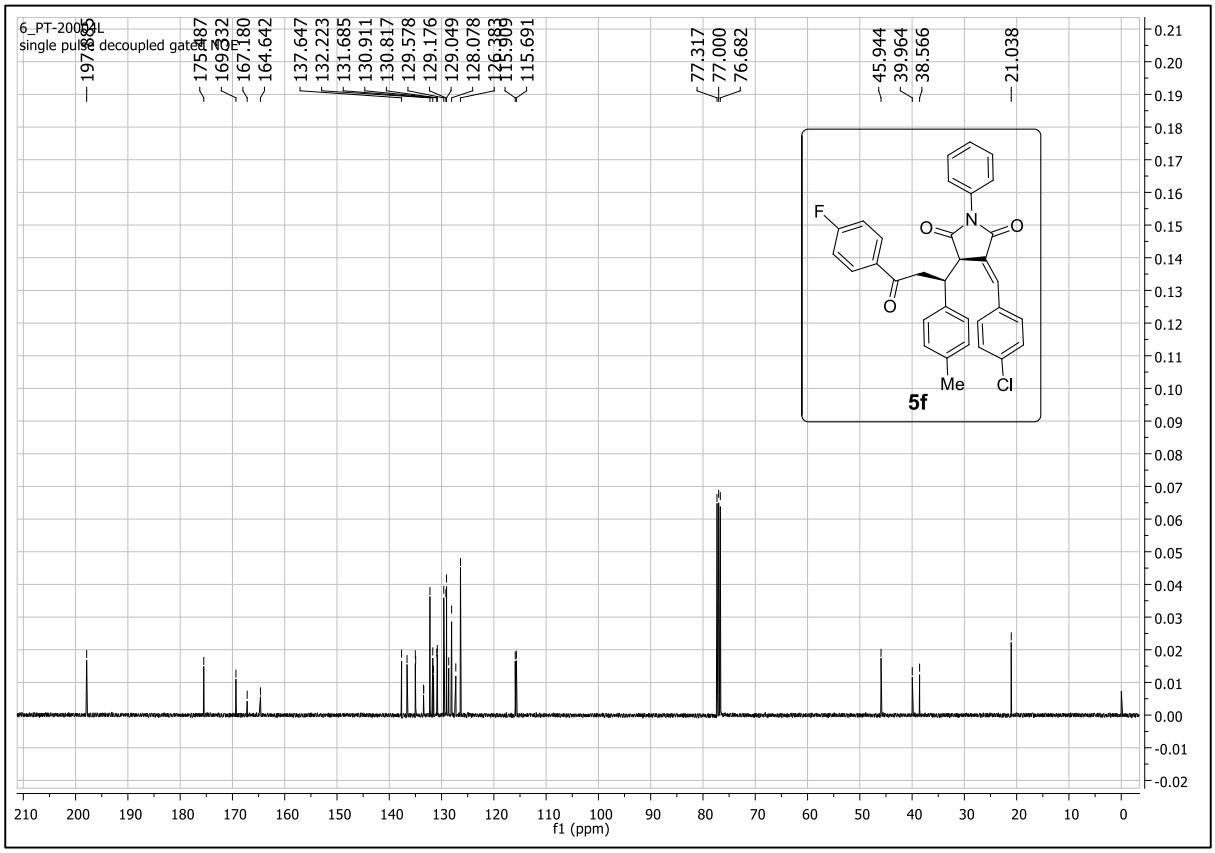

12_PT-2304-A
single pulse decoupled gated NOE
4.598
4.593
4.588
4.583
4.560
4.534
4.515
4.489
4.211
4.200
4.189
4.186
4.175
4.164
3.407
3.397
3.362
3.351
0.99
1.04
1.07
0.99
O
N
O
O
OMe
5d
2.01
0.89
3.22
2.12
4.23
2.96
1.00
3.88
0.99
1.04
3.00
0.99
f1 (ppm)

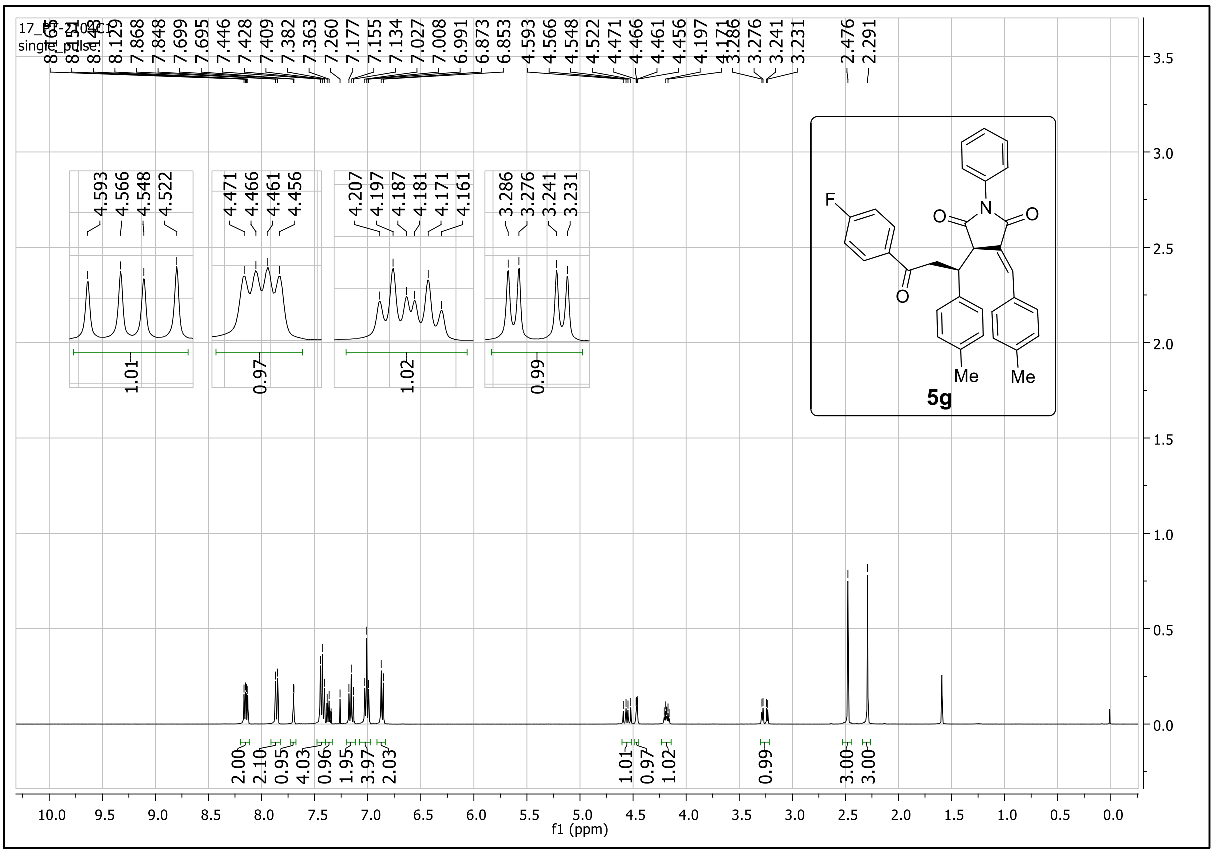

12_PT-2304-A
single pulse decoupled gated NOE
199.210
175.492
169.344
160.115
138.379
137.082
136.484
134.688
133.249
131.698
130.311
128.991
128.619
128.424
128.297
128.145
127.801
127.131
126.425
123.044
116.550
115.845
77.323
77.000
76.678
55.560
46.139
40.086
39.274
O
N
O
O
OMe
5d
f1 (ppm)

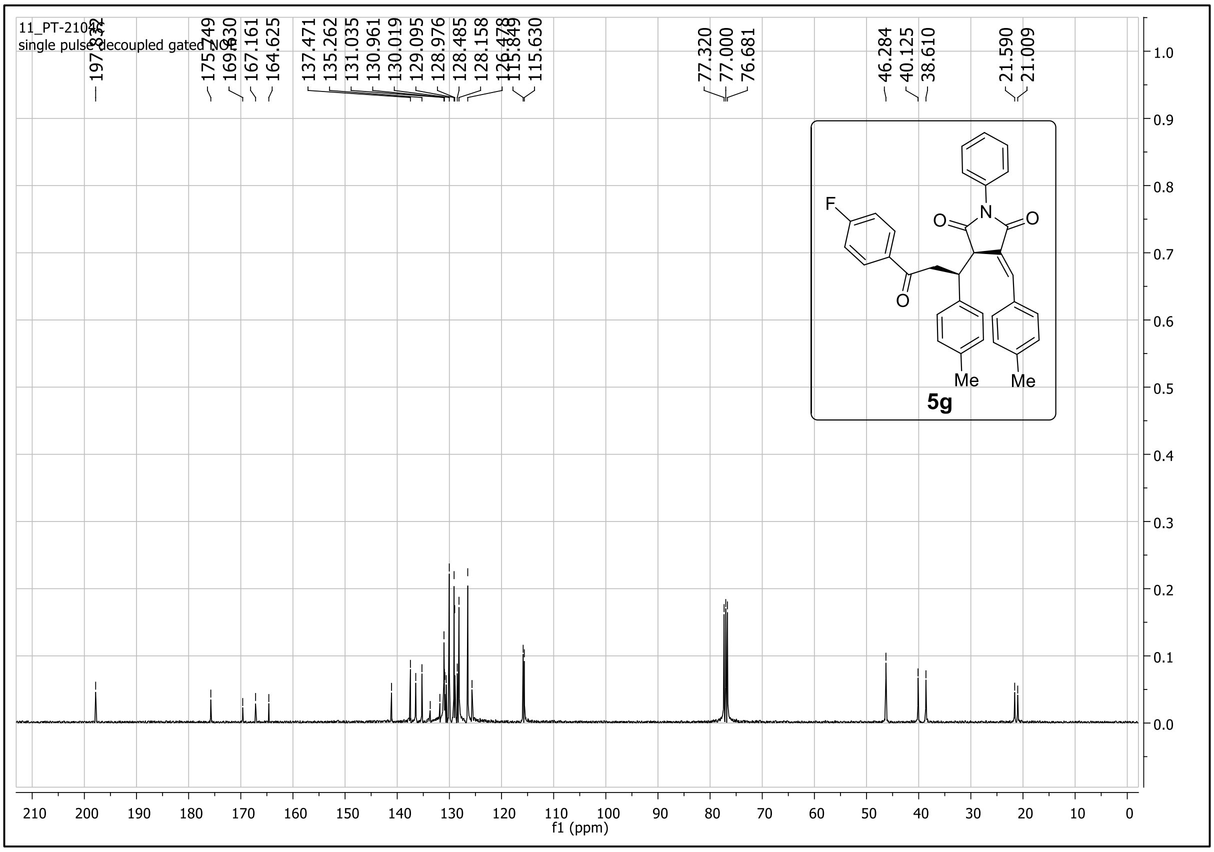

PT-1804D
8.131
8.120
7.964
7.948
7.727
7.724
7.629
7.614
7.434
7.418
7.372
7.260
7.169
7.152
7.134
7.027
7.013
6.999
6.860
6.845
4.574
4.553
4.538
4.517
4.513
4.509
4.505
4.501
4.158
4.137
3.273
3.265
3.237
3.229
2.292
4.158
4.150
4.145
4.137
4.129
3.273
3.265
3.237
3.229
1.02
1.00
F
O
N
O
O
Me
5e
2.06
2.09
1.01
2.06
1.07
1.96
1.14
2.09
4.14
2.11
2.01
1.02
1.00
2.99
f1 (ppm)

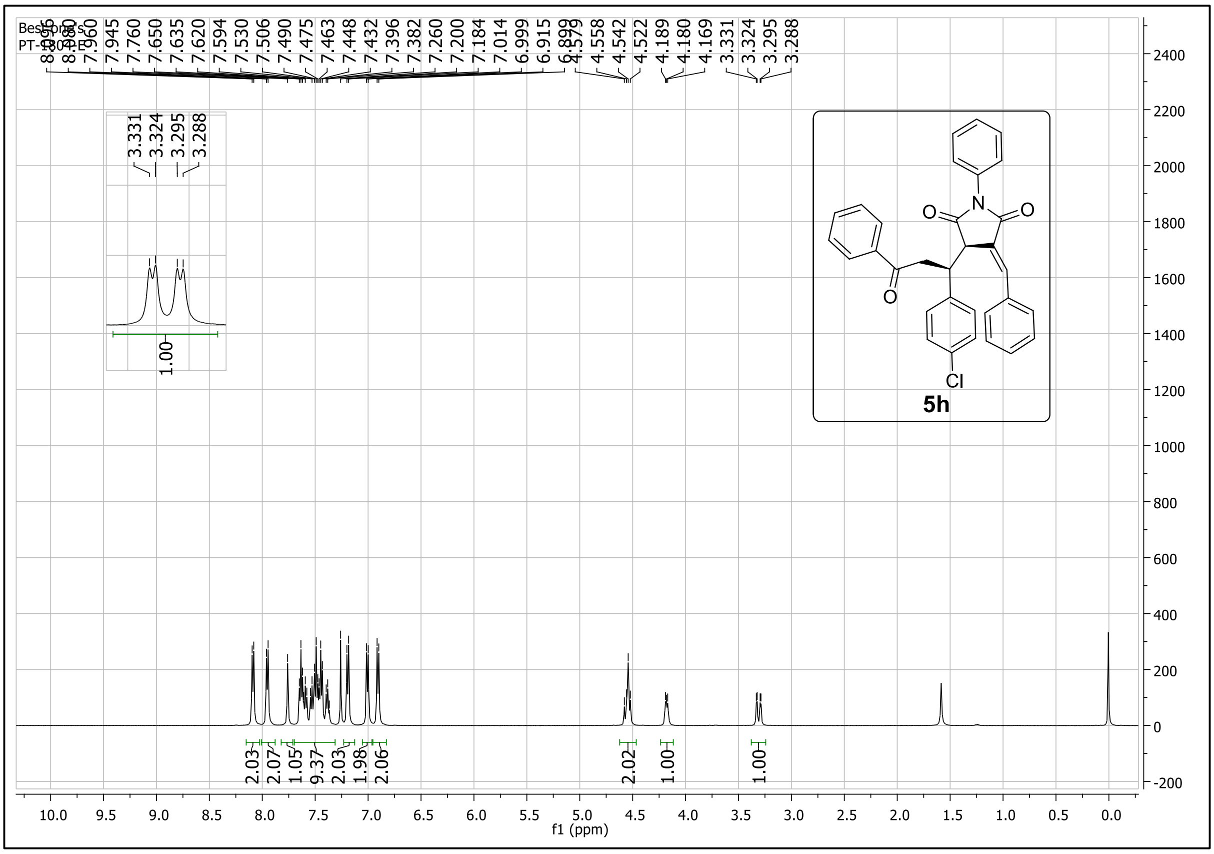

13C NMR
PT-1804D
197.729
175.665
169.469
166.900
164.875
136.421
130.904
130.846
129.251
129.131
129.004
128.538
128.122
126.459
115.832
115.658
77.254
77.000
76.746
46.202
40.127
38.720
21.014
F
O
N
O
O
Me
5e
f1 (ppm)

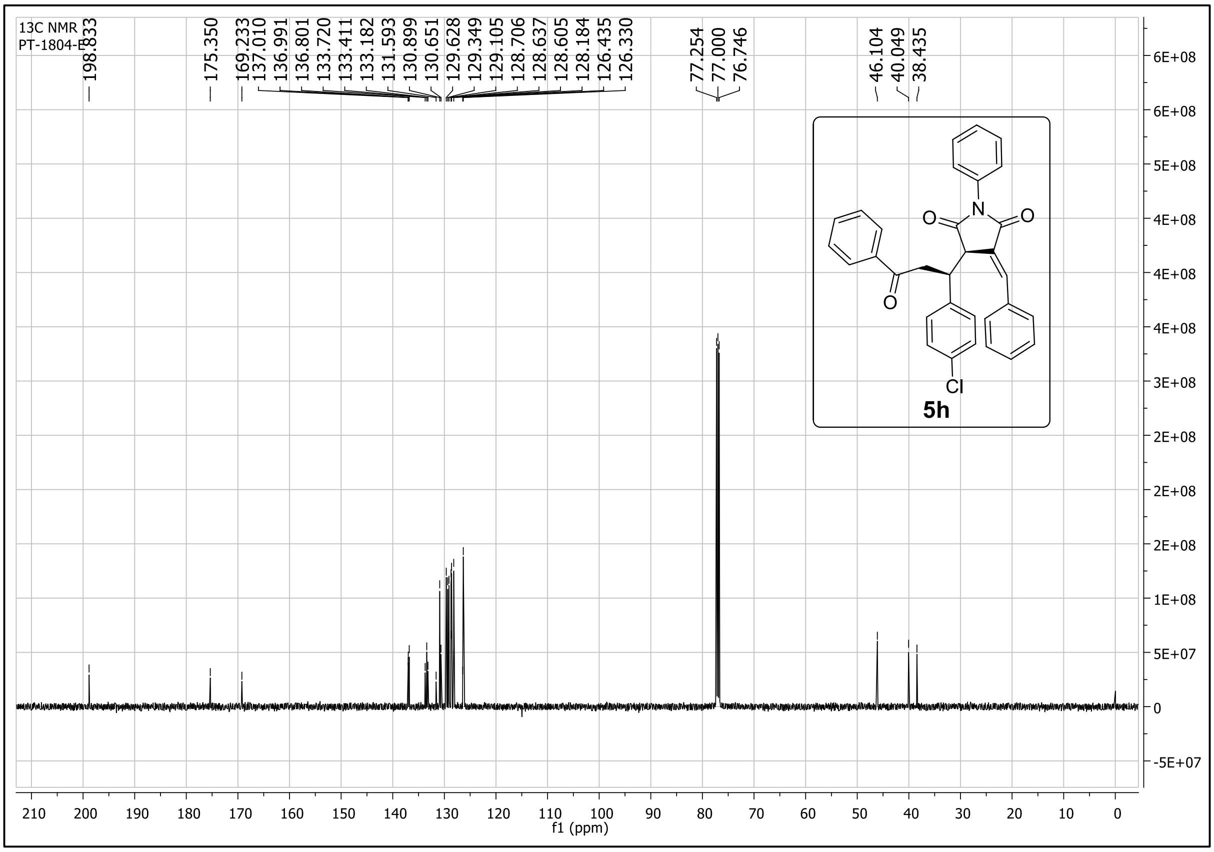

5f
F
O
N
O
O
Me
Cl
f1 (ppm)

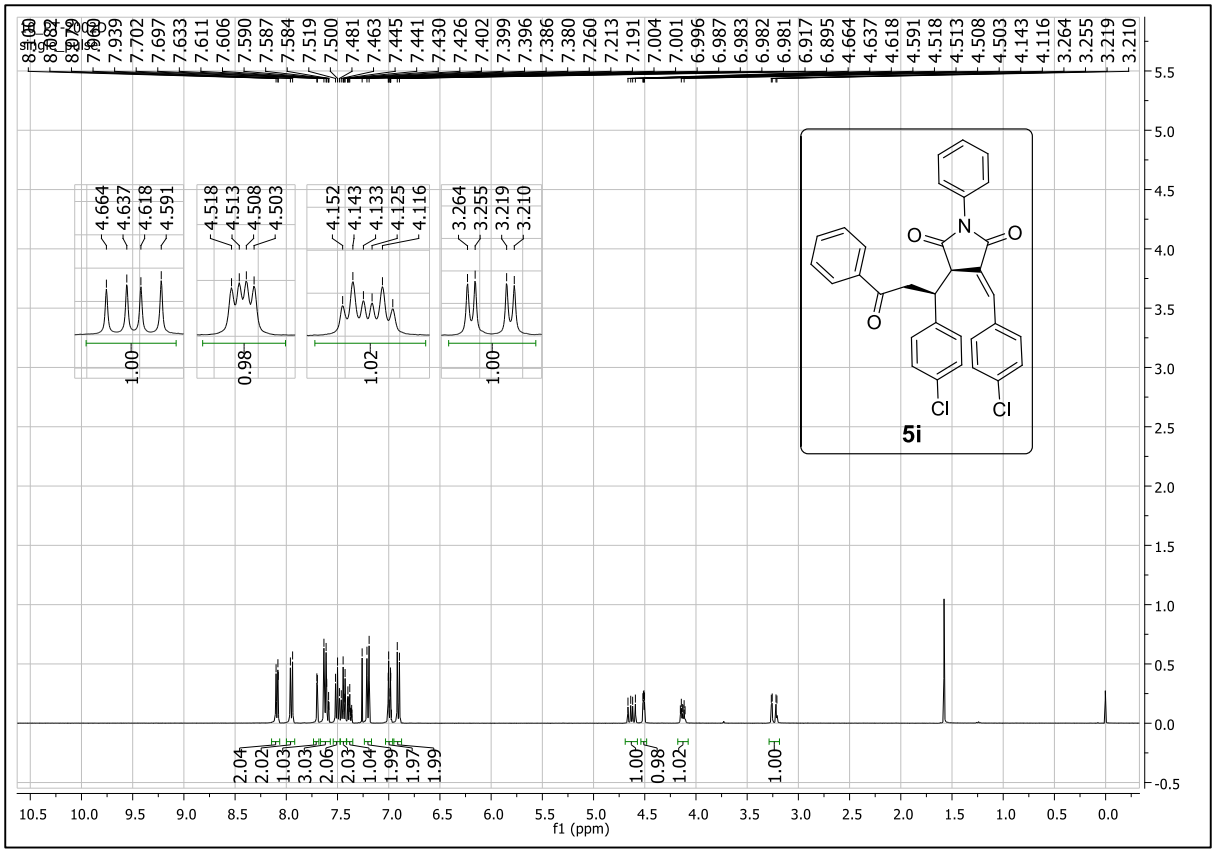

5f
F
O
N
O
O
Me
Cl
f1 (ppm)

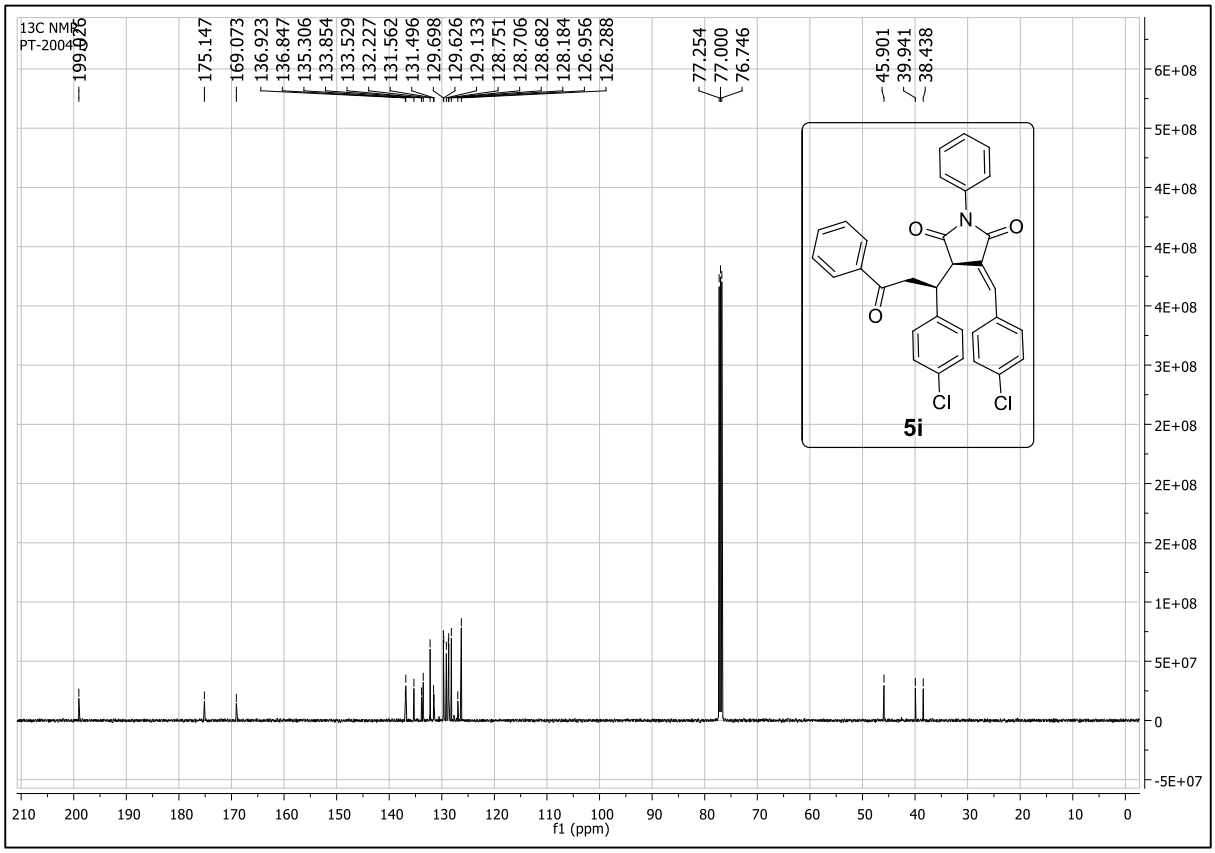

single_pulse
5g
f1 (ppm)

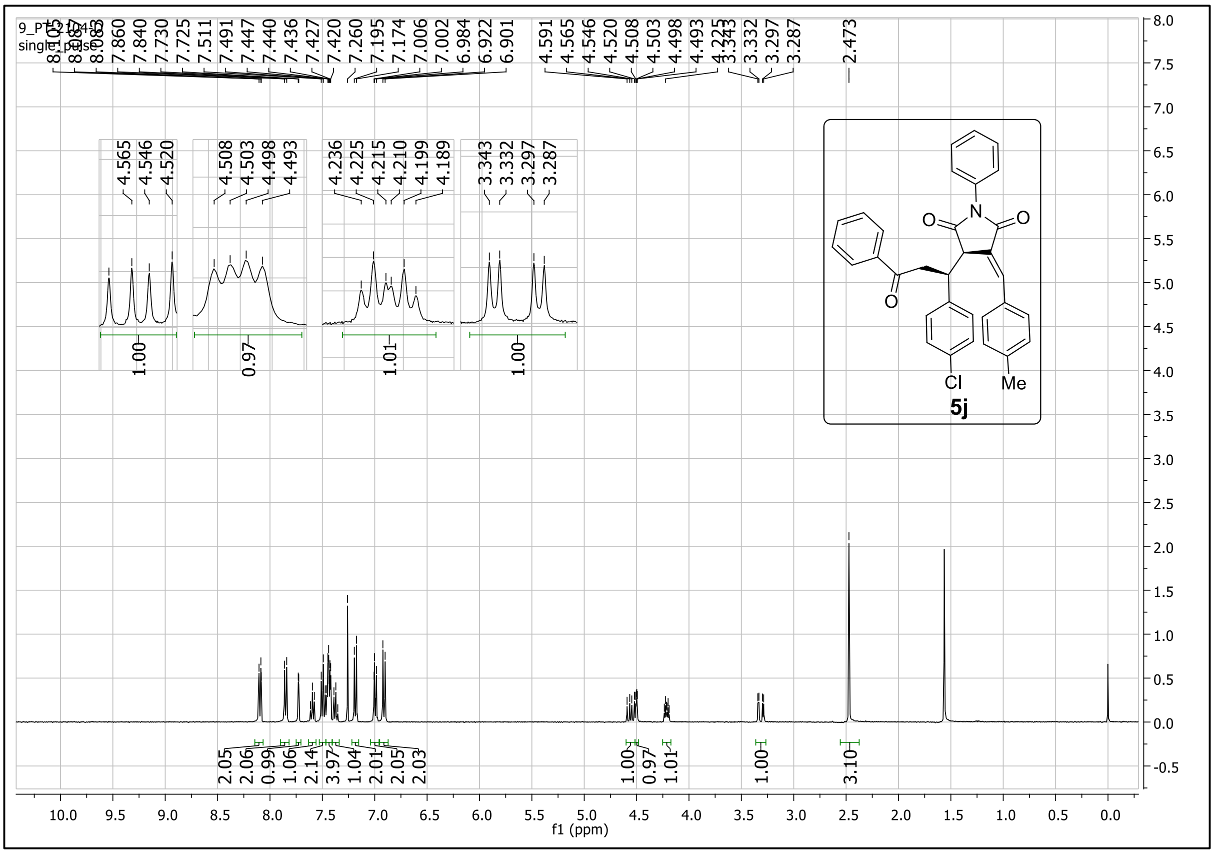

single pulse decoupled gated NOE
5g
f1 (ppm)

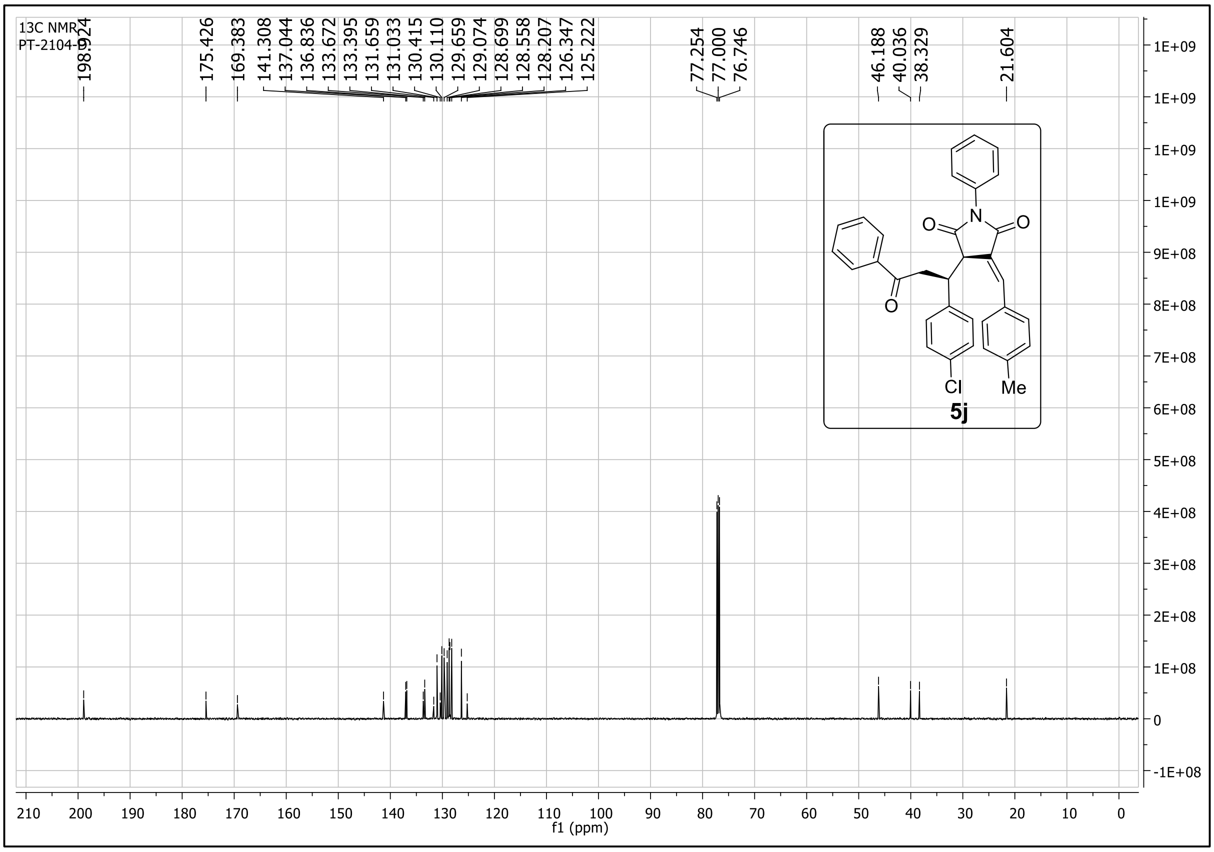

PT-1804-E
8.095, 8.080, 7.960, 7.945, 7.760, 7.650, 7.635, 7.620, 7.594, 7.530, 7.506, 7.490, 7.475, 7.463, 7.448, 7.432, 7.396, 7.382, 7.260, 7.200, 7.184, 7.014, 6.999, 6.915, 6.899, 4.579, 4.558, 4.542, 4.522, 4.189, 4.180, 4.169, 3.331, 3.324, 3.295, 3.288
2.03, 2.07, 1.05, 9.37, 2.03, 1.98, 2.06, 2.02, 1.00, 1.00
5h
f1 (ppm)

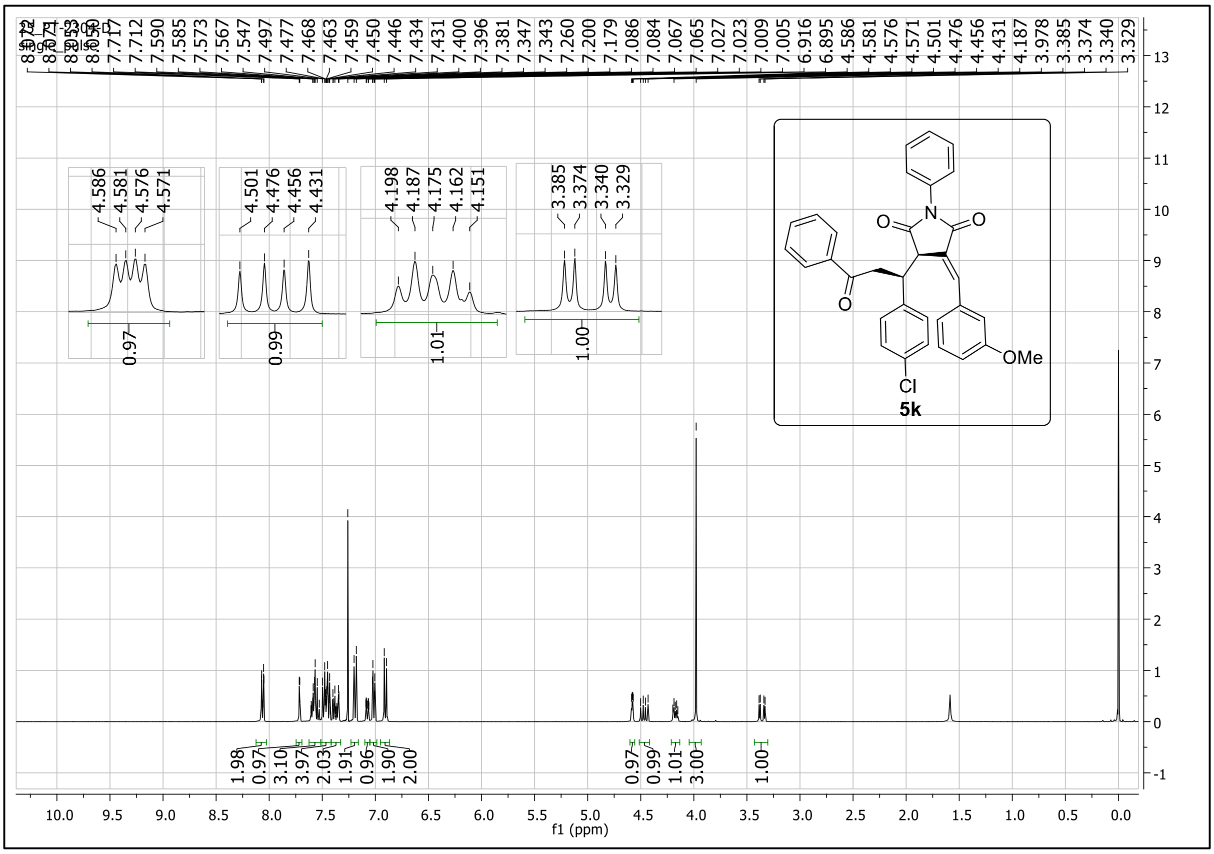

13C NMR
PT-1804-E
198.833, 175.350, 169.233, 137.010, 136.991, 136.801, 133.720, 133.411, 133.182, 131.593, 130.899, 130.651, 129.628, 129.349, 129.105, 128.706, 128.637, 128.605, 128.184, 126.435, 126.330, 77.254, 77.000, 76.746, 46.104, 40.049, 38.435
5h
f1 (ppm)

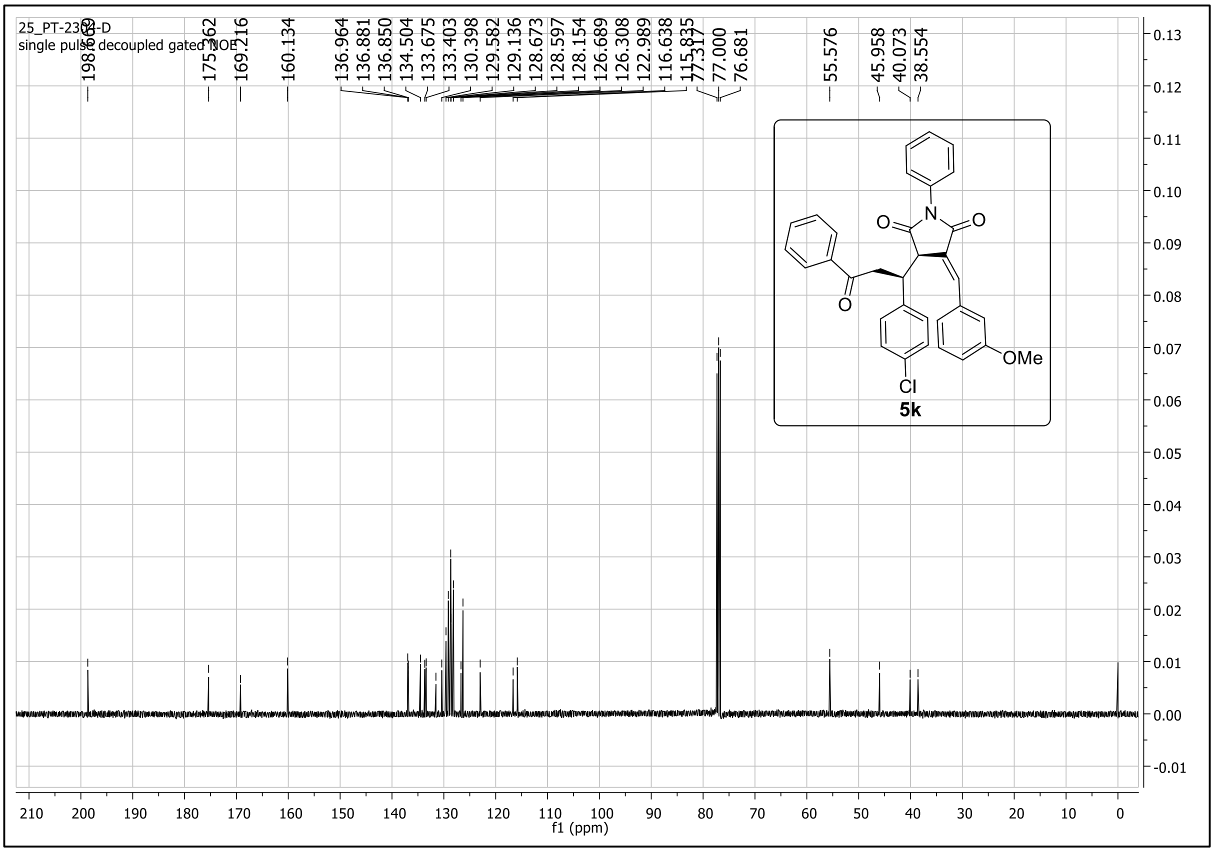

5i
f1 (ppm)

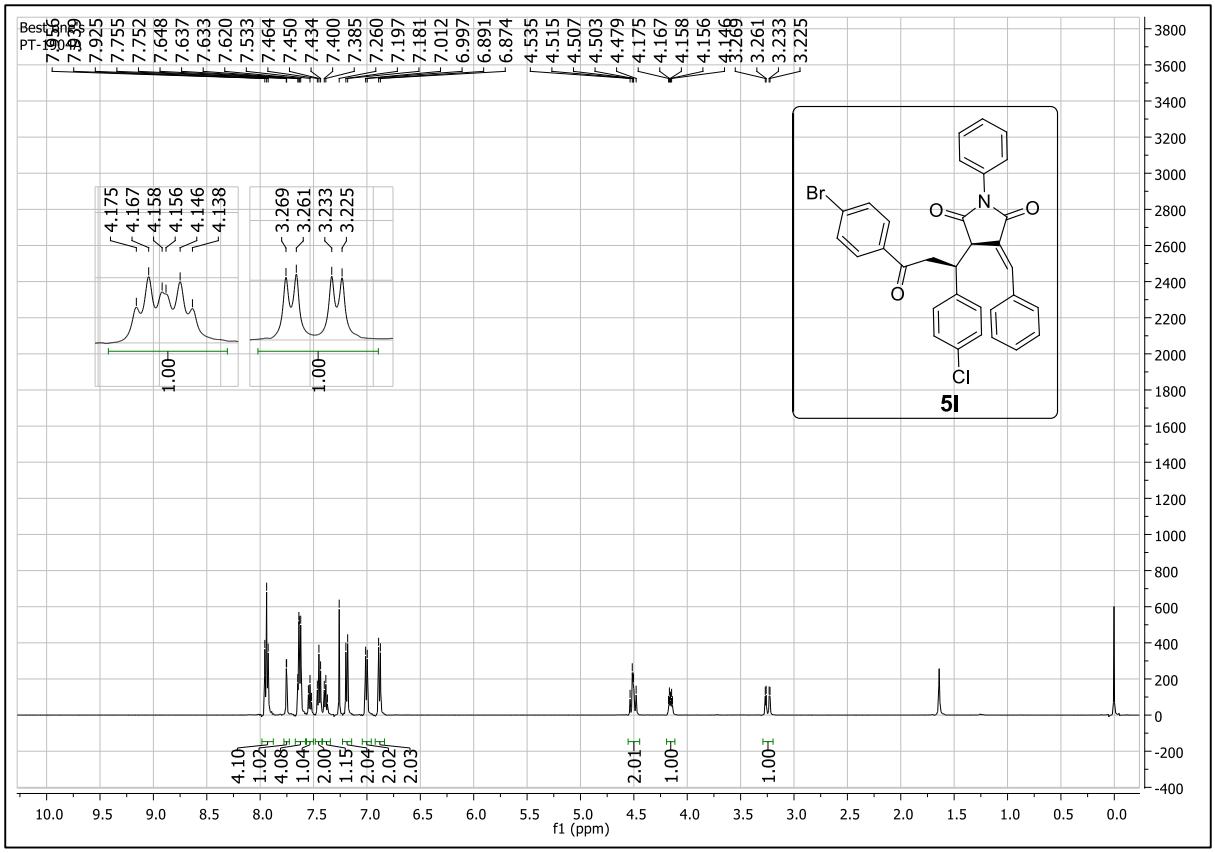

5i
f1 (ppm)

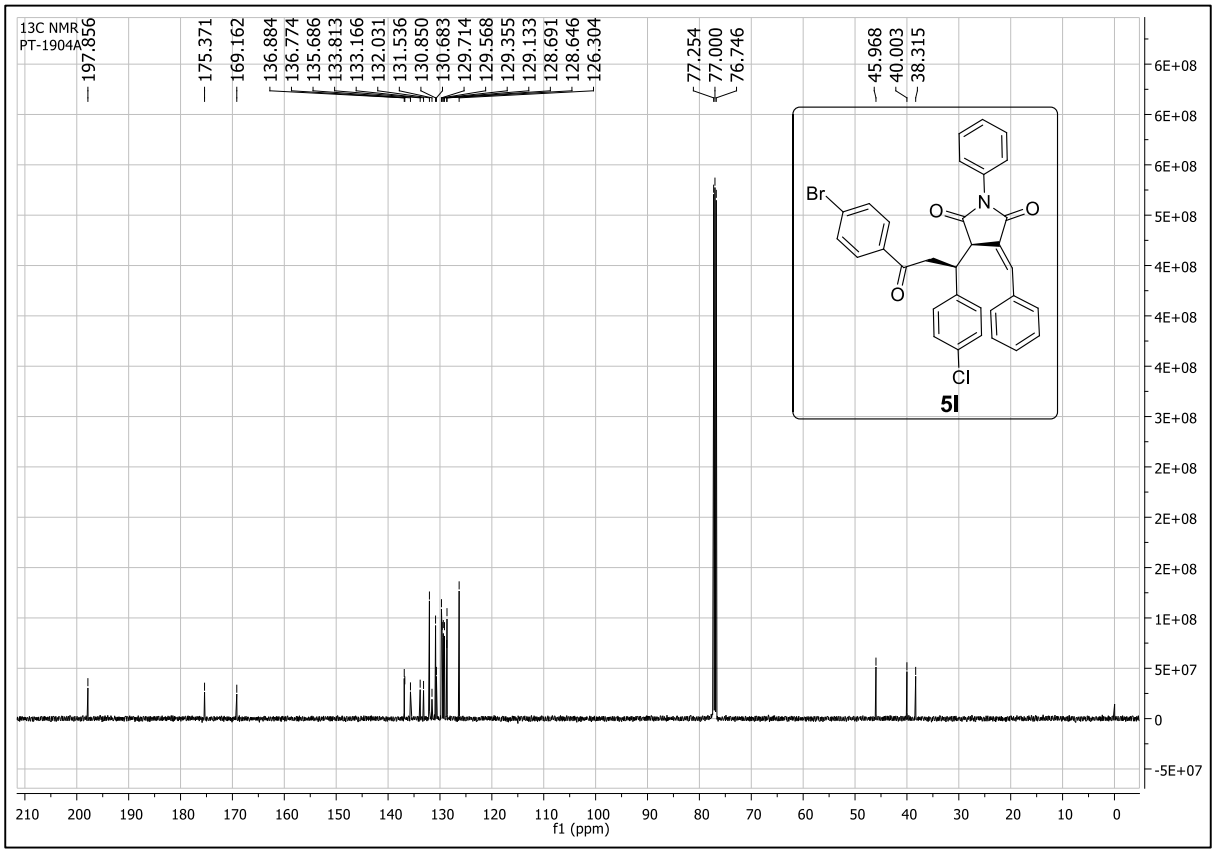

single_pulse
7.860
7.840
7.730
7.725
7.511
7.491
7.447
7.440
7.436
7.427
7.420
7.260
7.195
7.174
7.006
7.002
6.984
6.922
6.901
4.591
4.565
4.546
4.520
4.508
4.503
4.498
4.493
3.332
3.297
3.287
2.473
4.565
4.546
4.520
1.00
4.508
4.503
4.498
4.493
0.97
4.236
4.225
4.215
4.210
4.199
4.189
1.01
3.343
3.332
3.297
3.287
1.00
O
N
O
O
Cl
Me
5j
2.05
2.06
0.99
1.06
2.14
3.97
1.04
2.01
2.05
2.03
1.00
0.97
1.01
1.00
3.10
f1 (ppm)

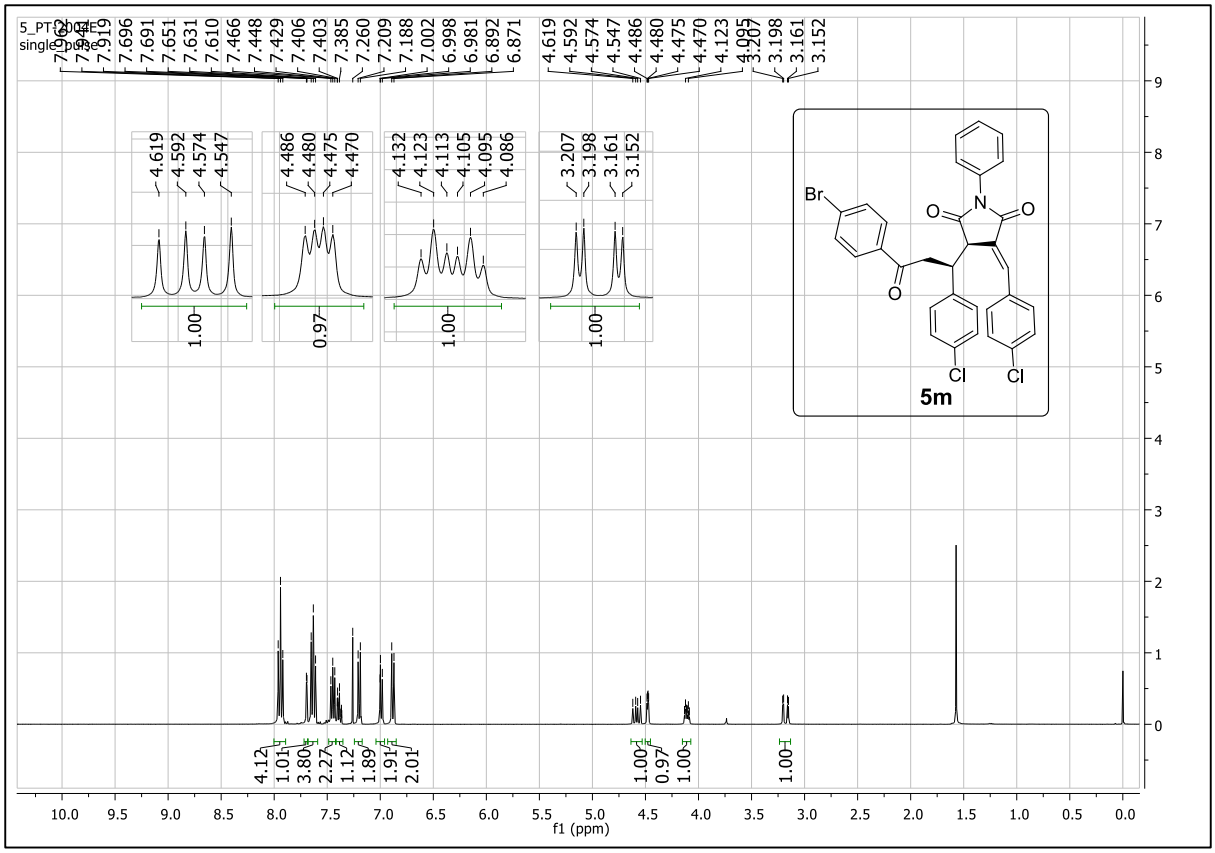

13C NMR
198.924
175.426
169.383
141.308
137.044
136.836
133.672
133.395
131.659
131.033
130.415
130.110
129.659
129.074
128.699
128.558
128.207
126.347
125.222
77.254
77.000
76.746
46.188
40.036
38.329
21.604
O
N
O
O
Cl
Me
5j
f1 (ppm)

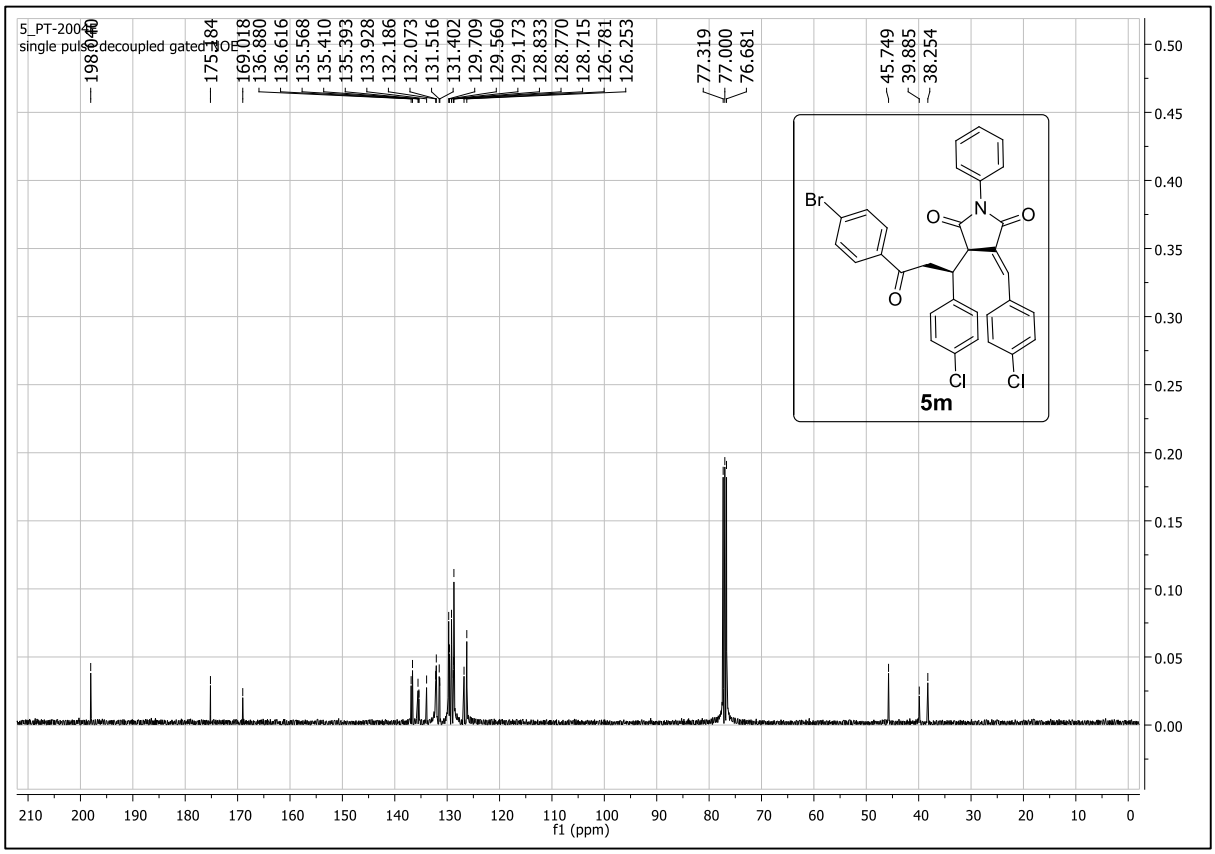


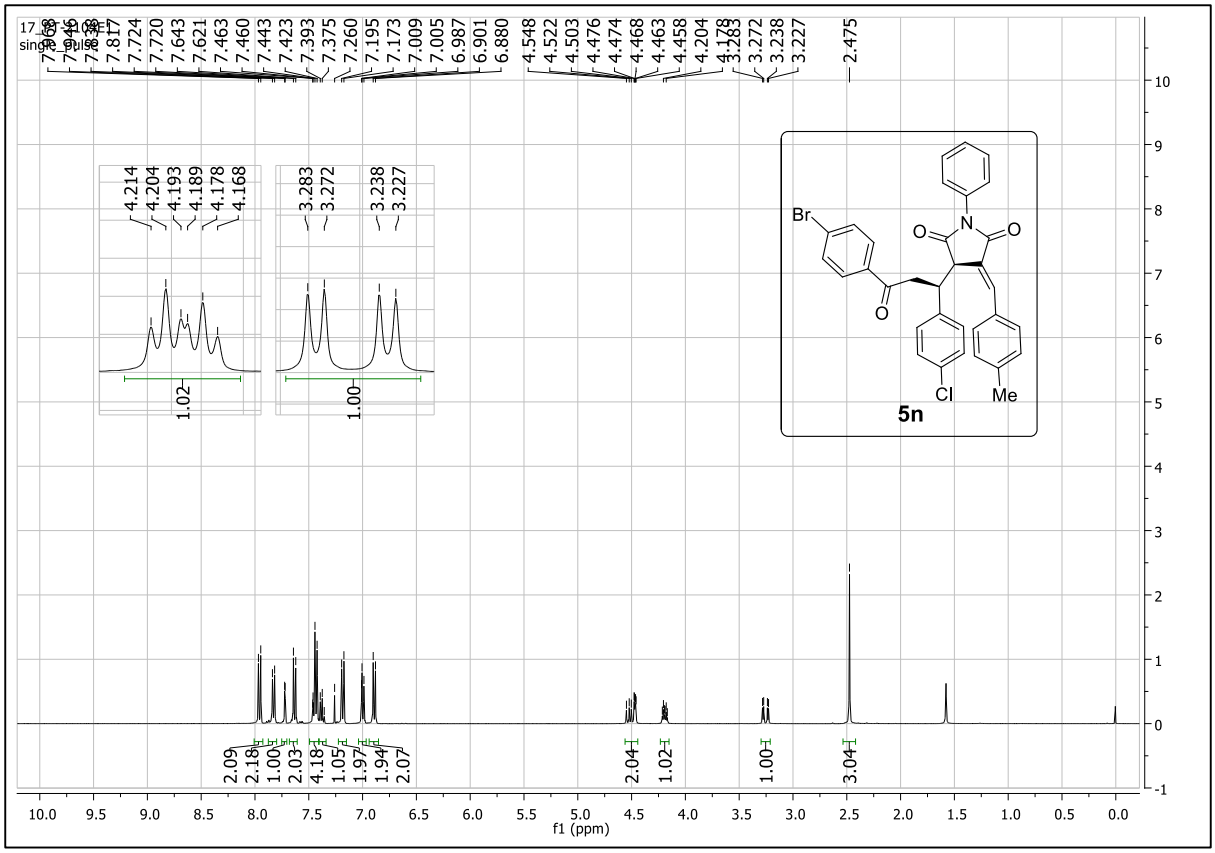


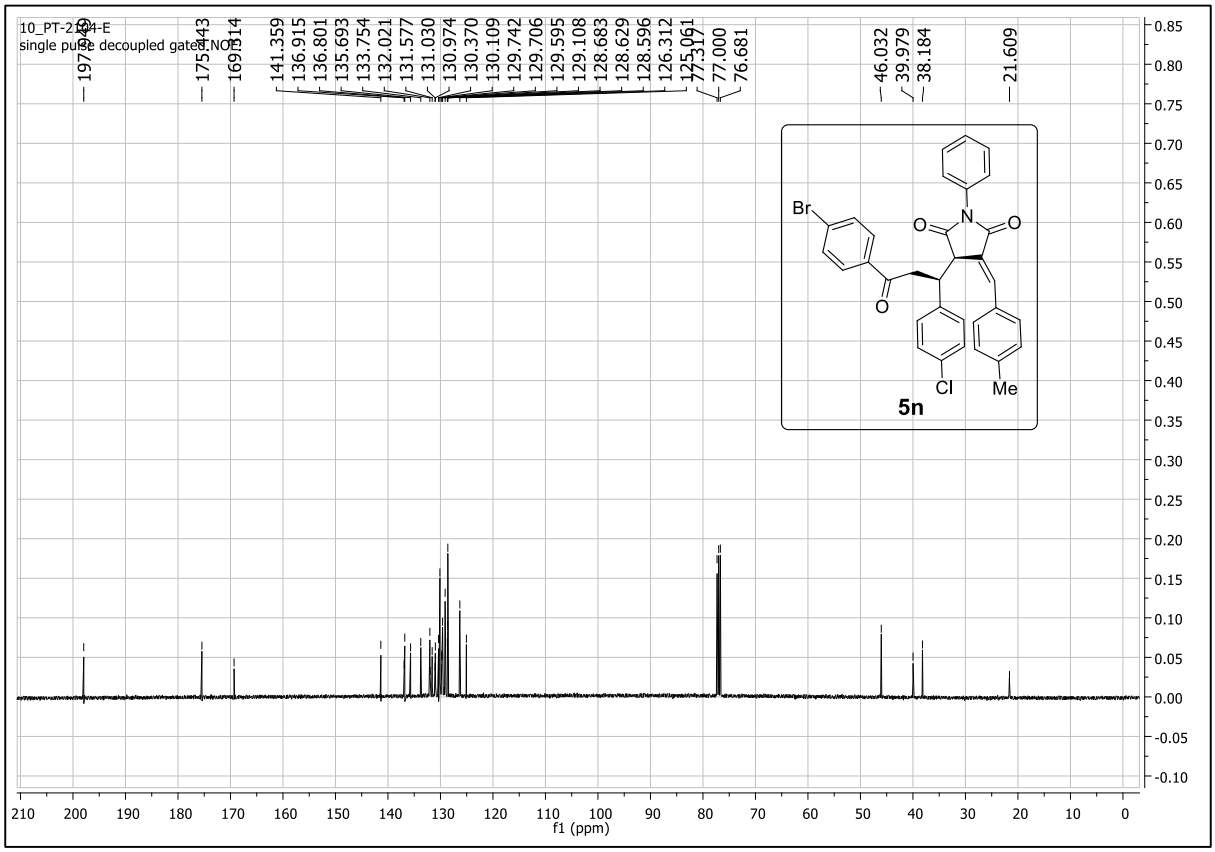

Br
O
N
O
O
Cl
5l
f1 (ppm)

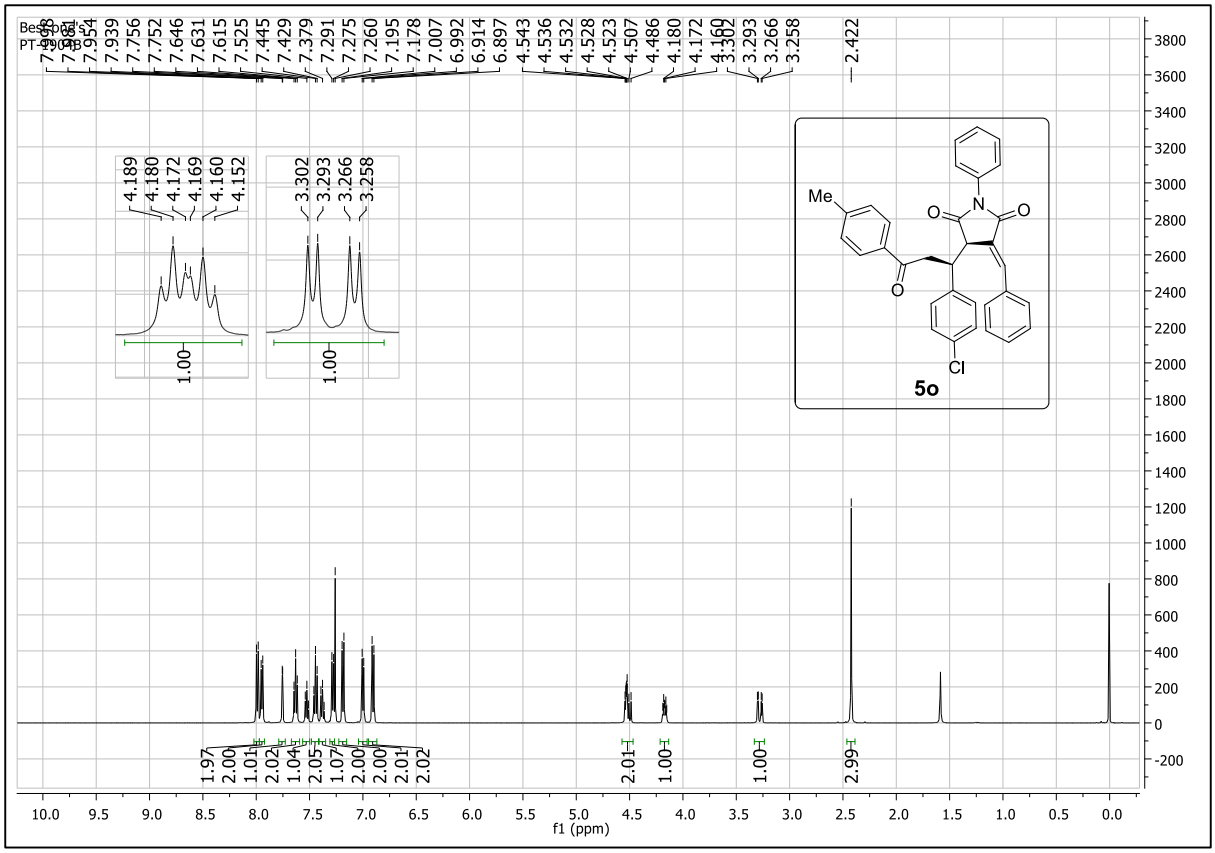

13C NMR
PT-1904A
Br
O
N
O
O
Cl
5l
f1 (ppm)

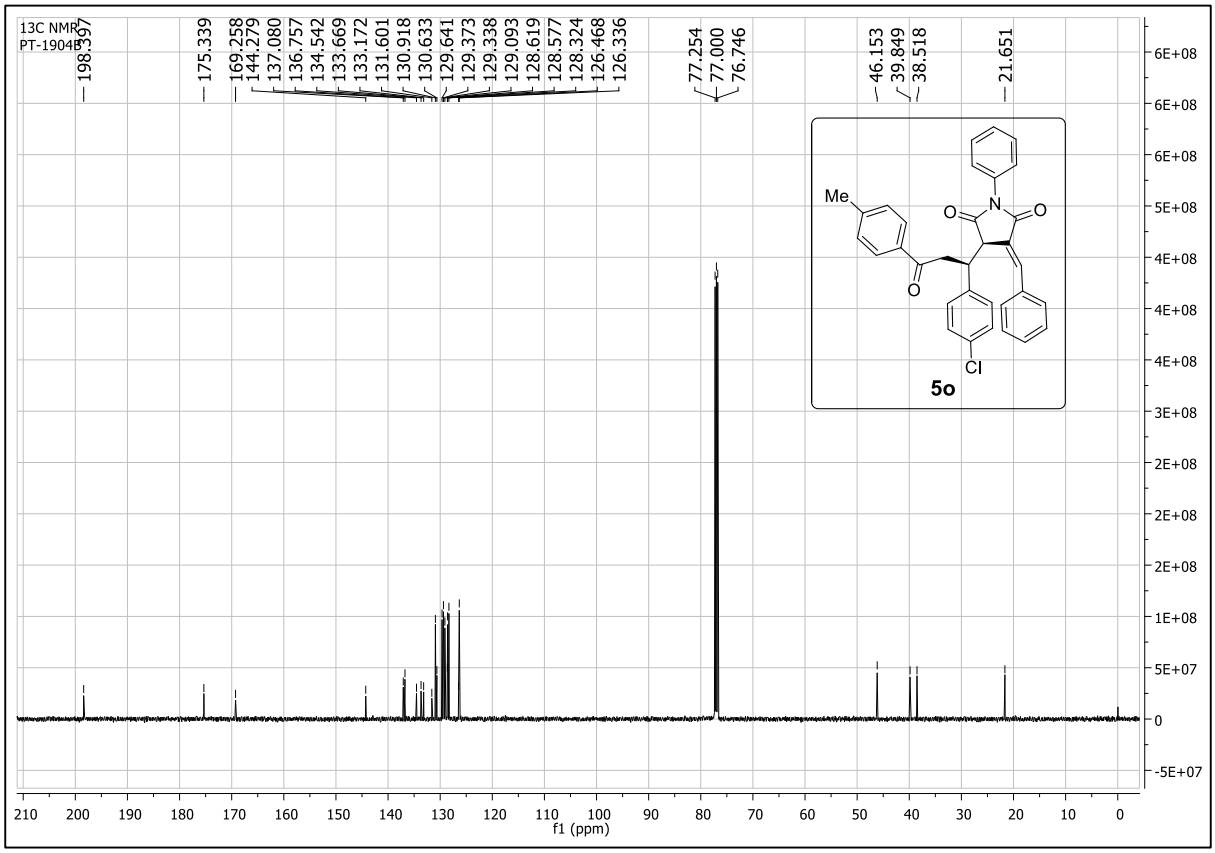

5_PT-2004-F1
single pulse
7.919
7.696
7.691
7.651
7.631
7.610
7.466
7.448
7.429
7.406
7.403
7.385
7.260
7.209
7.188
7.002
6.998
6.981
6.892
6.871
4.619
4.592
4.574
4.547
4.486
4.480
4.475
4.470
4.132
4.123
4.113
4.105
4.095
4.086
3.207
3.198
3.161
3.152
1.00
0.97
1.00
1.00
Br
O
N
O
O
Cl
Cl
5m
4.12
1.01
3.80
2.27
1.12
1.89
1.91
2.01
1.00
0.97
1.00
1.00
f1 (ppm)

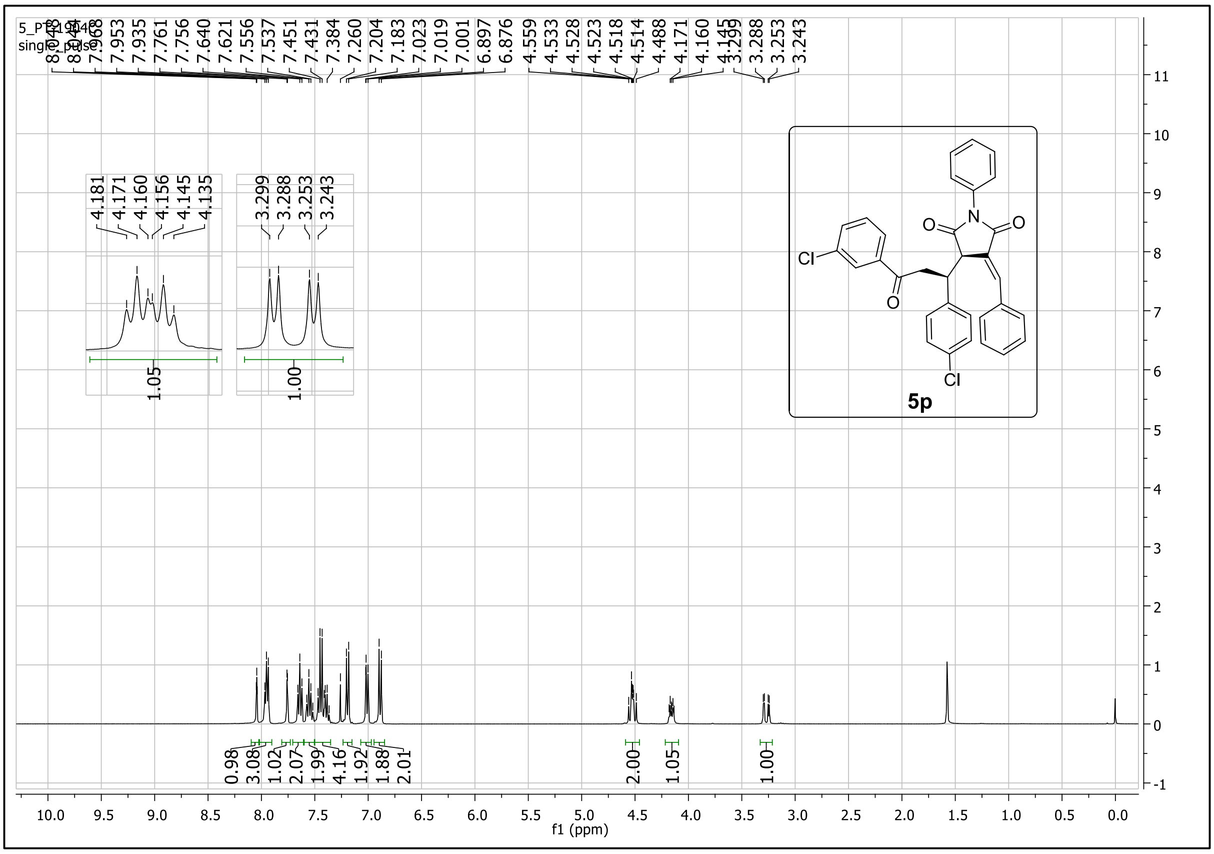

5_PT-2004-F2
single pulse decoupled gated NOE
198.040
175.184
169.018
136.880
136.616
135.568
135.410
135.393
133.928
132.186
132.073
131.516
131.402
129.709
129.560
129.173
128.833
128.770
128.715
126.781
126.253
77.319
77.000
76.681
45.749
39.885
38.254
Br
O
N
O
O
Cl
Cl
5m
f1 (ppm)

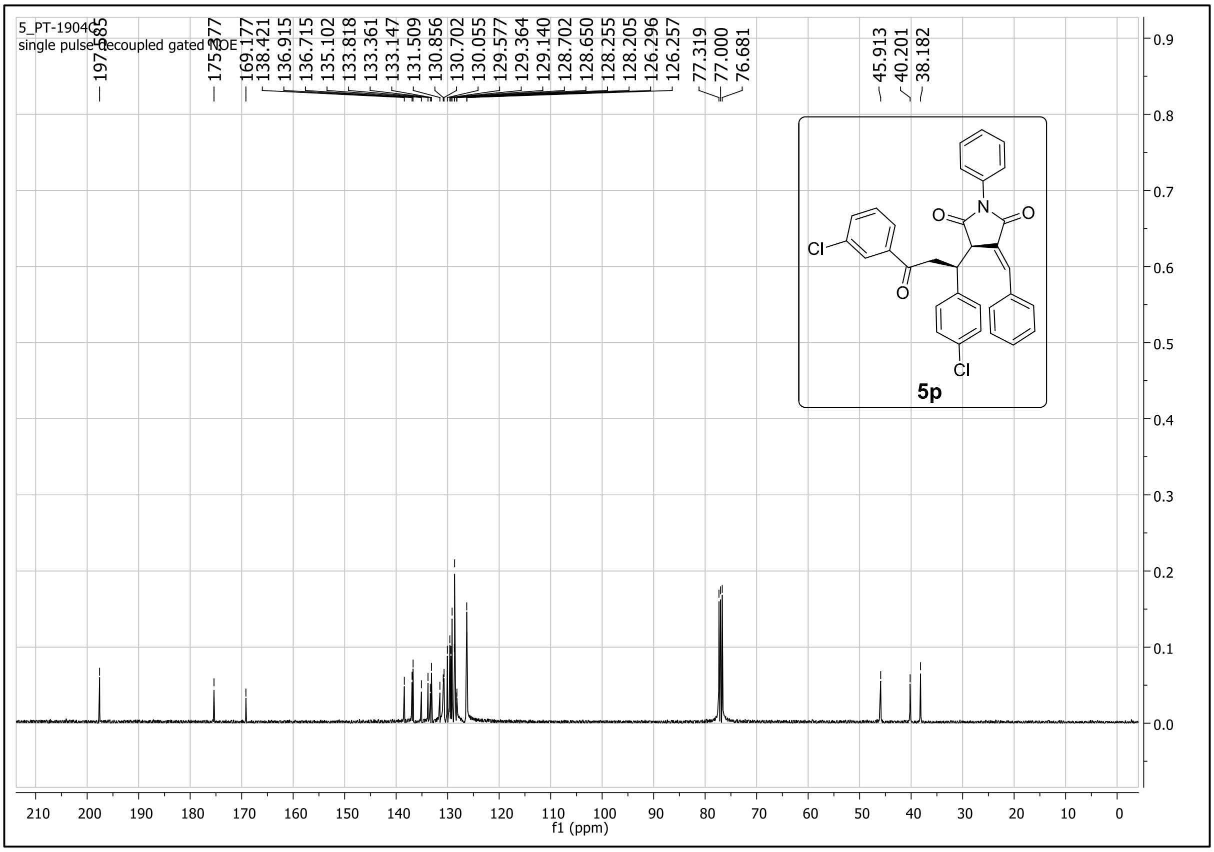

7.817
7.724
7.720
7.643
7.621
7.463
7.460
7.443
7.423
7.393
7.375
7.260
7.195
7.173
7.009
7.005
6.987
6.901
6.880
4.548
4.522
4.503
4.476
4.474
4.468
4.463
4.458
4.204
4.178
4.168
3.283
3.272
3.238
3.227
2.475
4.214
4.204
4.193
4.189
4.178
4.168
3.283
3.272
3.238
3.227
1.02
1.00
Br
O
N
O
O
Cl
Me
5n
2.09
2.18
1.00
2.03
4.18
1.05
1.97
1.94
2.07
2.04
1.02
1.00
3.04
f1 (ppm)

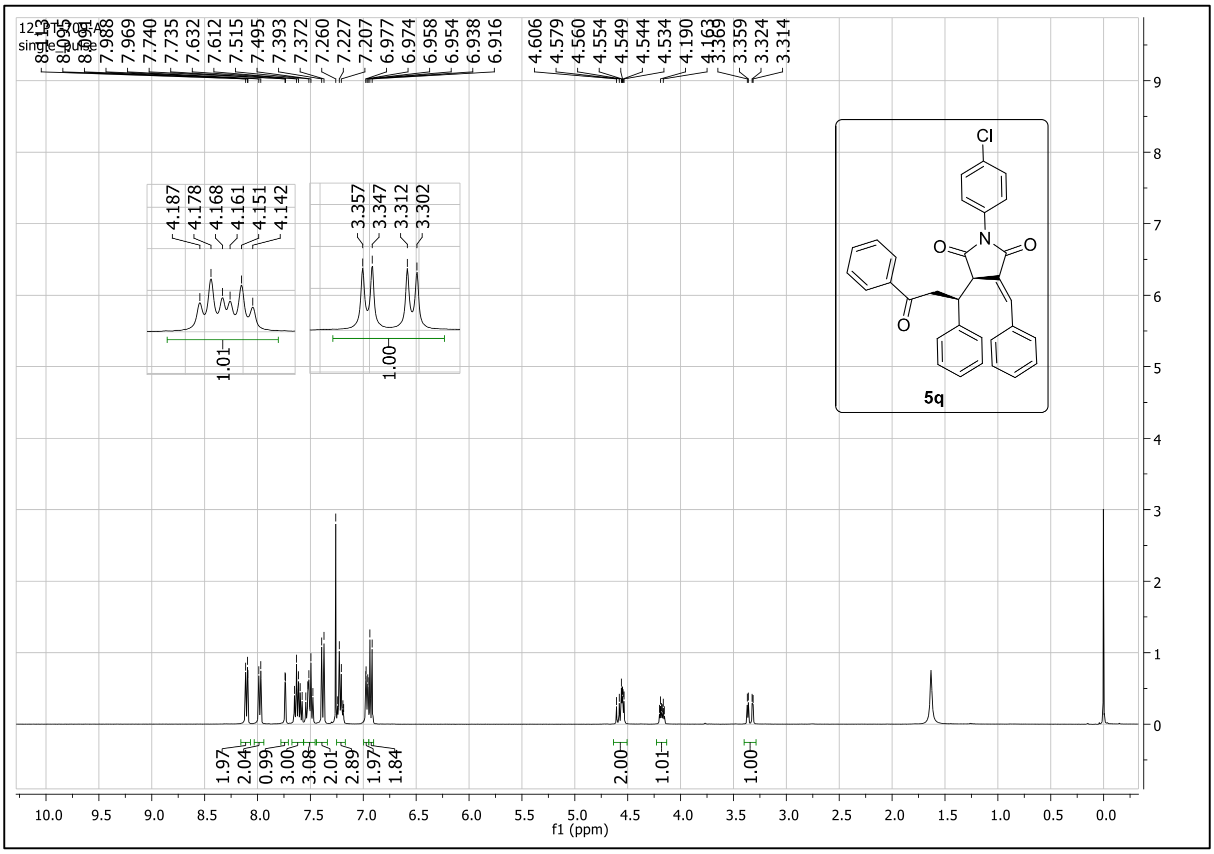

10_PT-214-E
single pulse decoupled gated_NOE
197.540
175.443
169.314
141.359
136.915
136.801
135.693
133.754
132.021
131.577
131.030
130.974
130.370
130.109
129.742
129.706
129.595
129.108
128.683
128.629
128.596
126.312
125.061
77.317
77.000
76.681
46.032
39.979
38.184
21.609
Br
O
N
O
O
Cl
Me
5n
f1 (ppm)

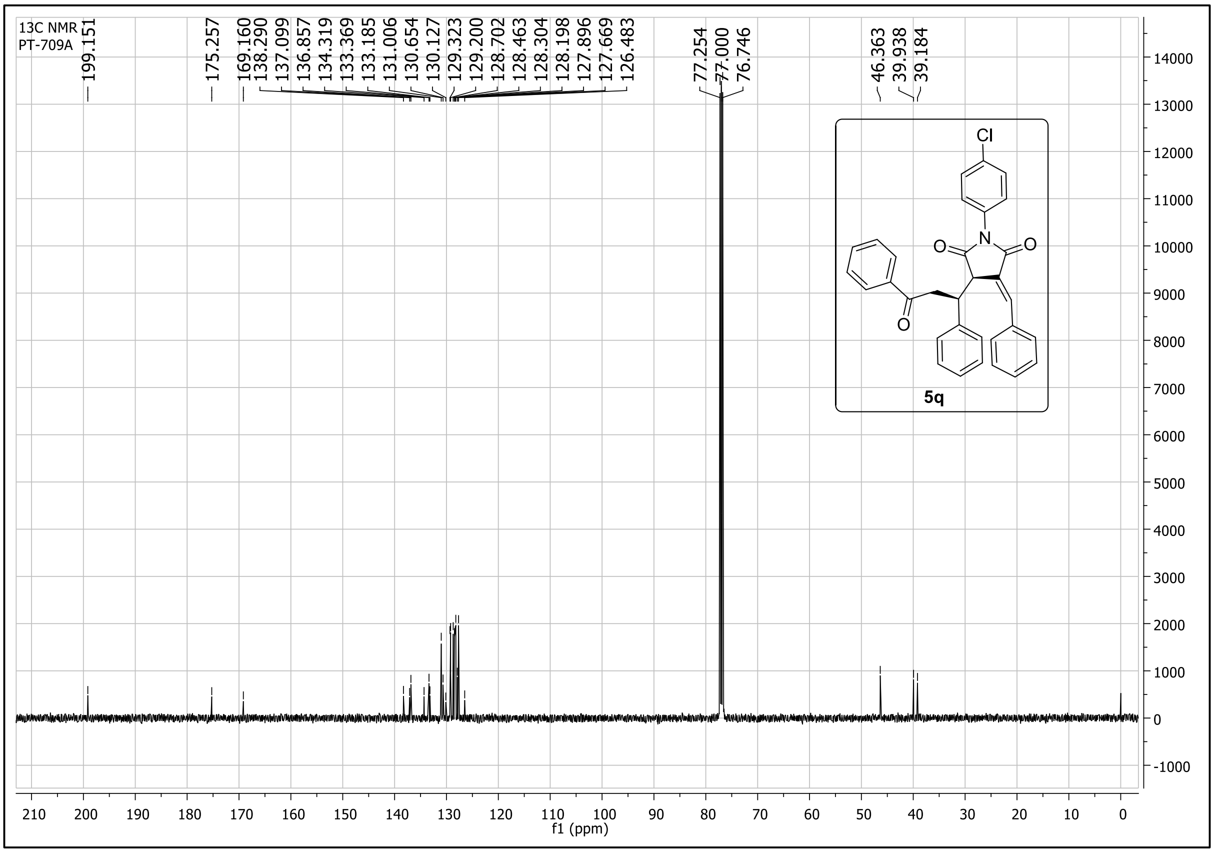

Me
O
N
O
O
Cl
5o
f1 (ppm)

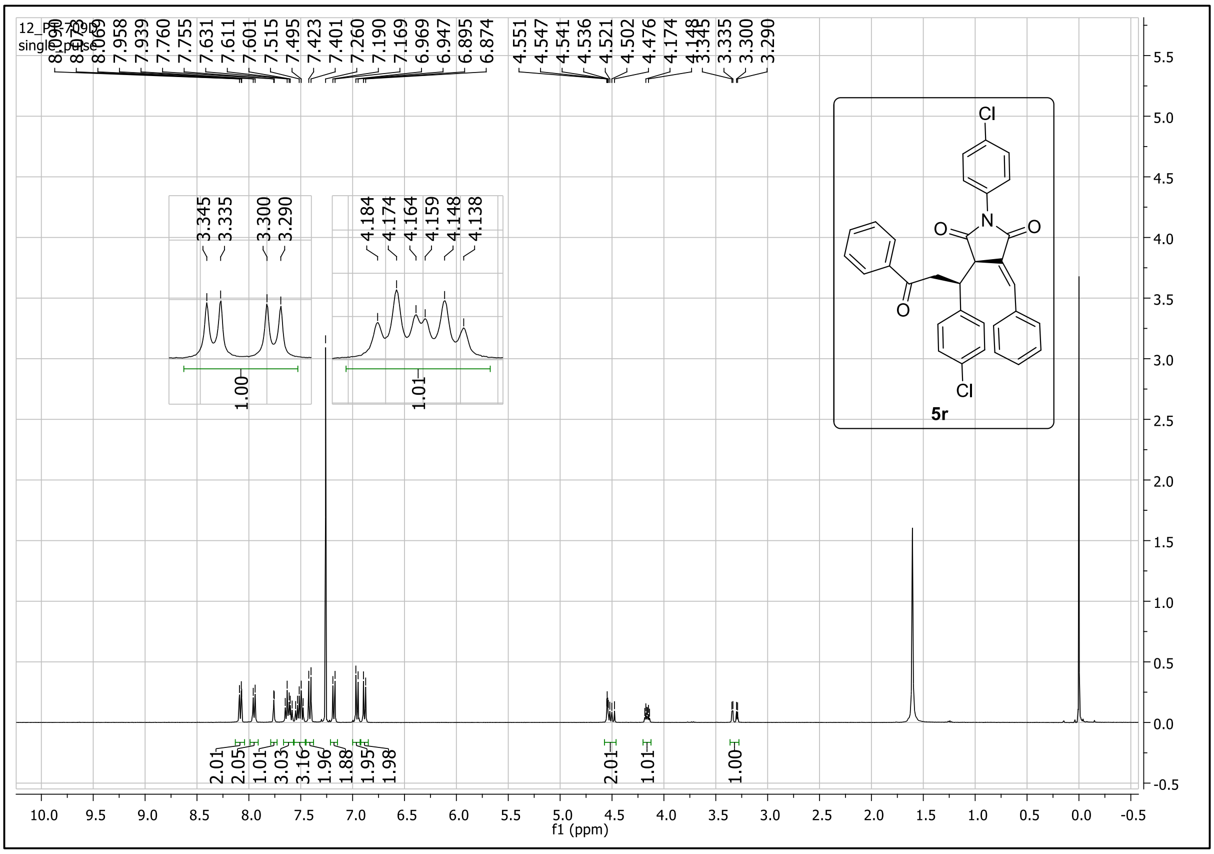

13C NMR
PT-190497
Me
O
N
O
O
Cl
5o
f1 (ppm)

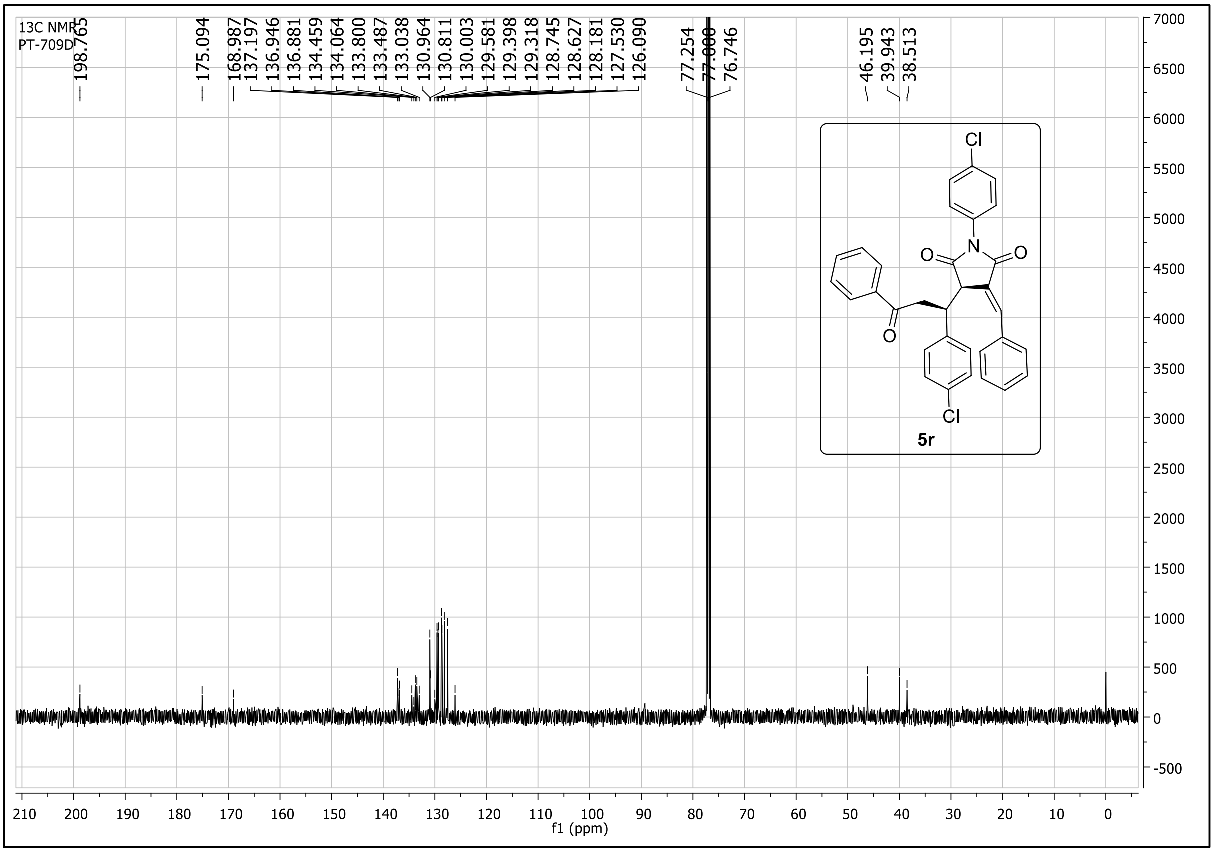


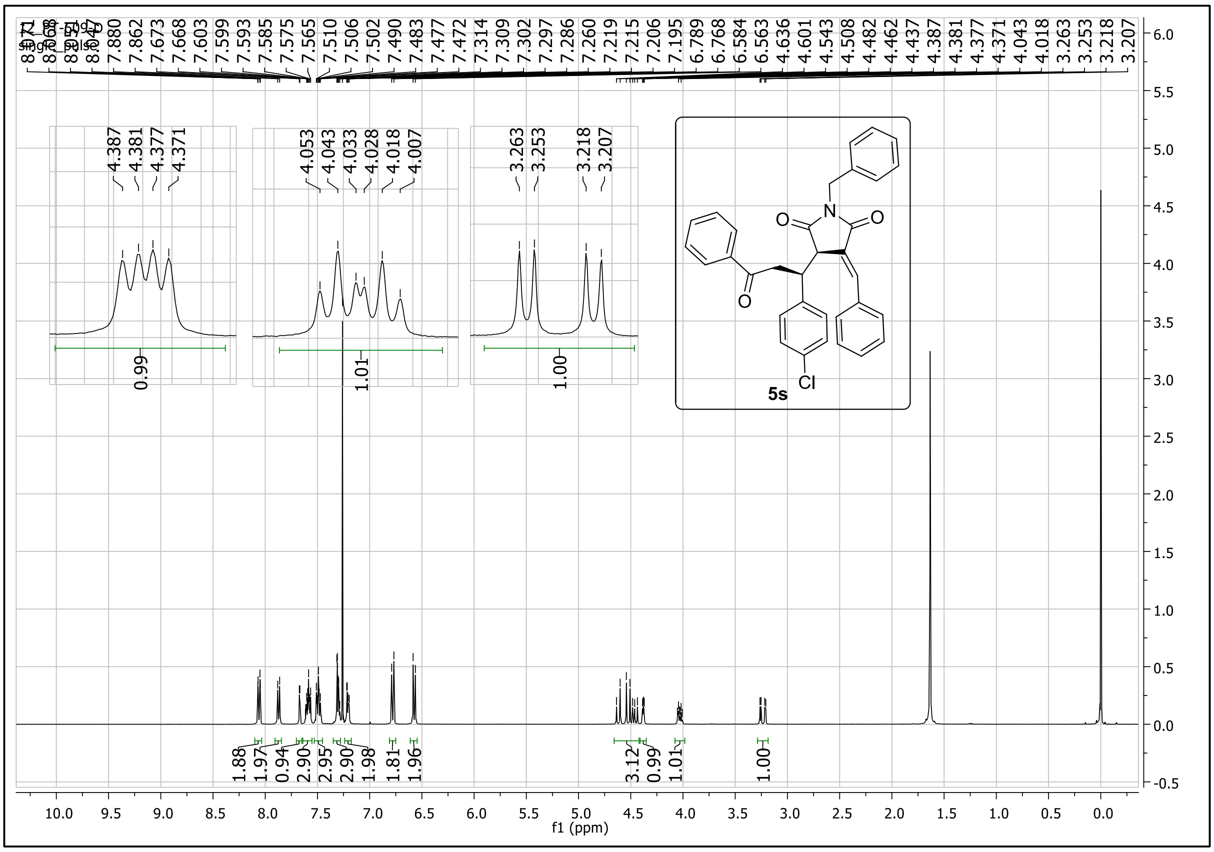


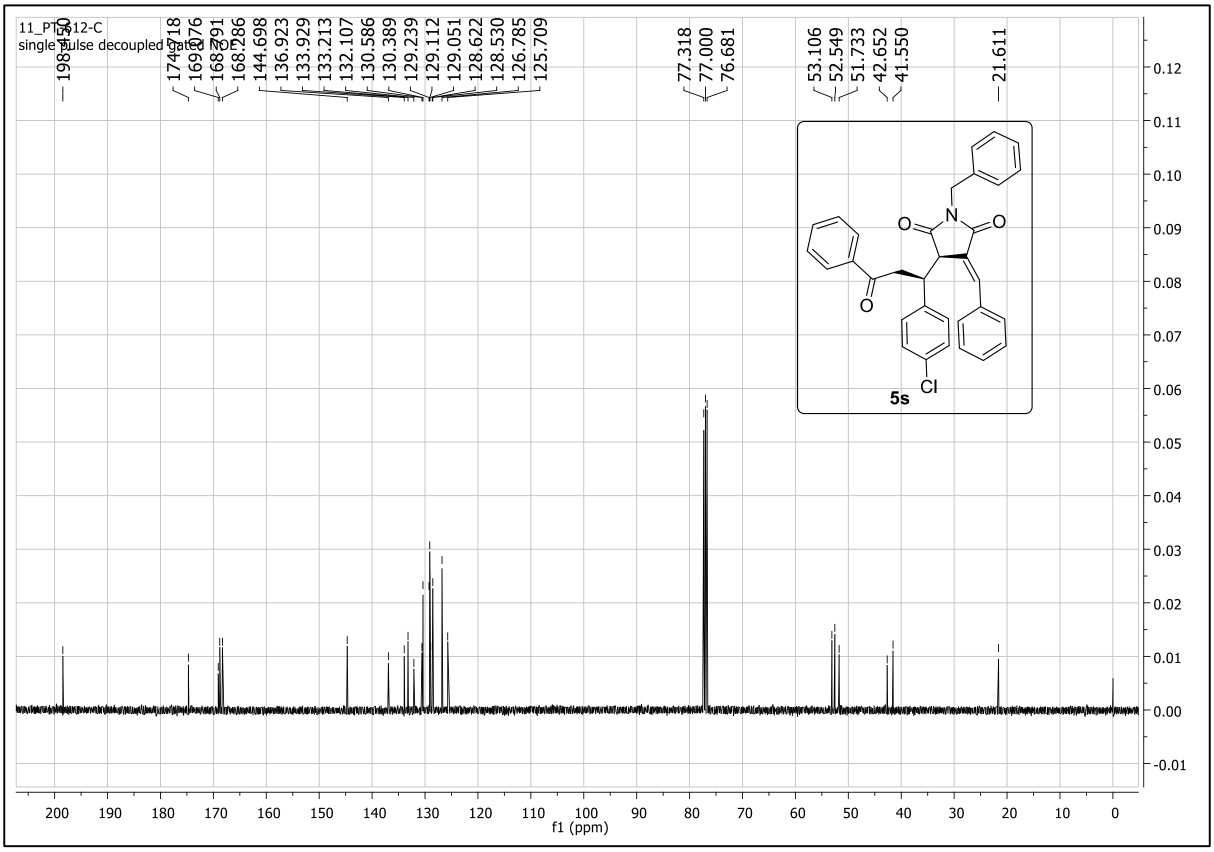

single_pulse
5q
f1 (ppm)

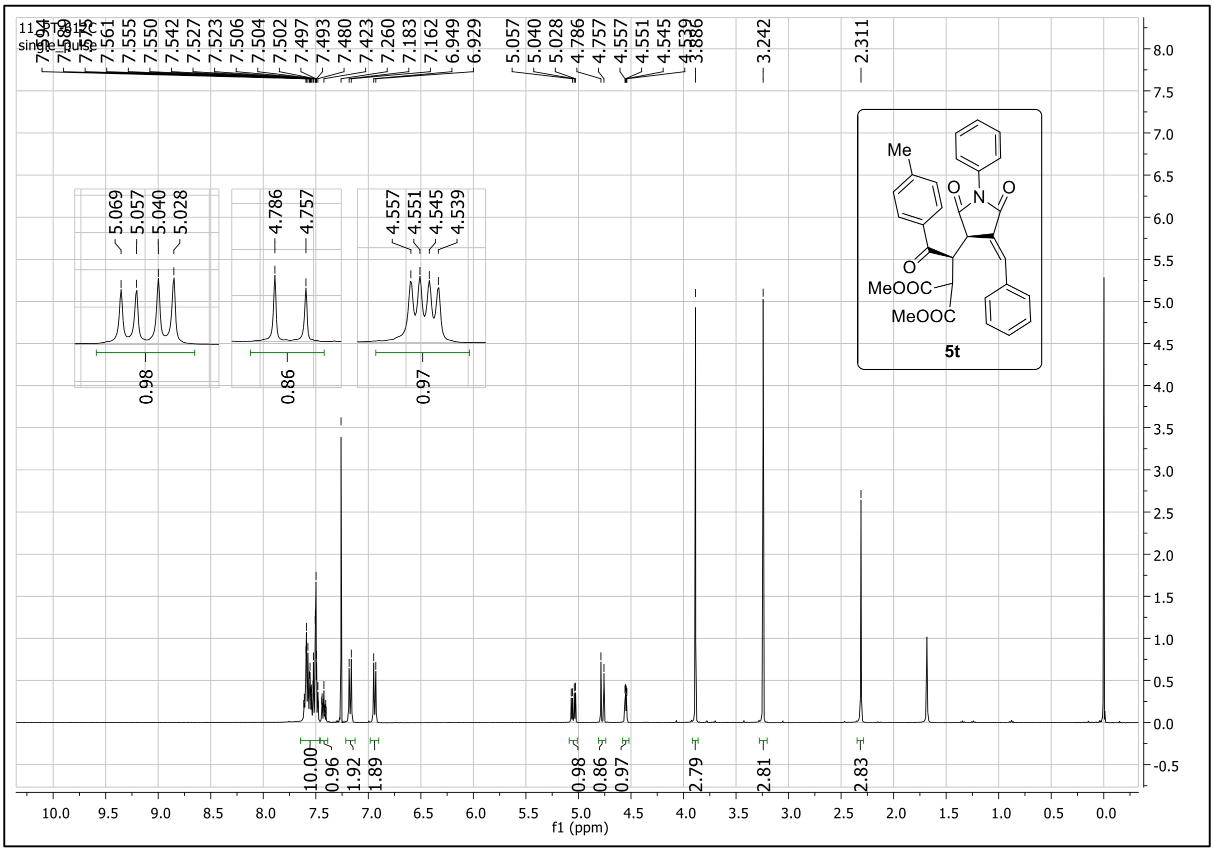

13C NMR
PT-709A
5q
f1 (ppm)

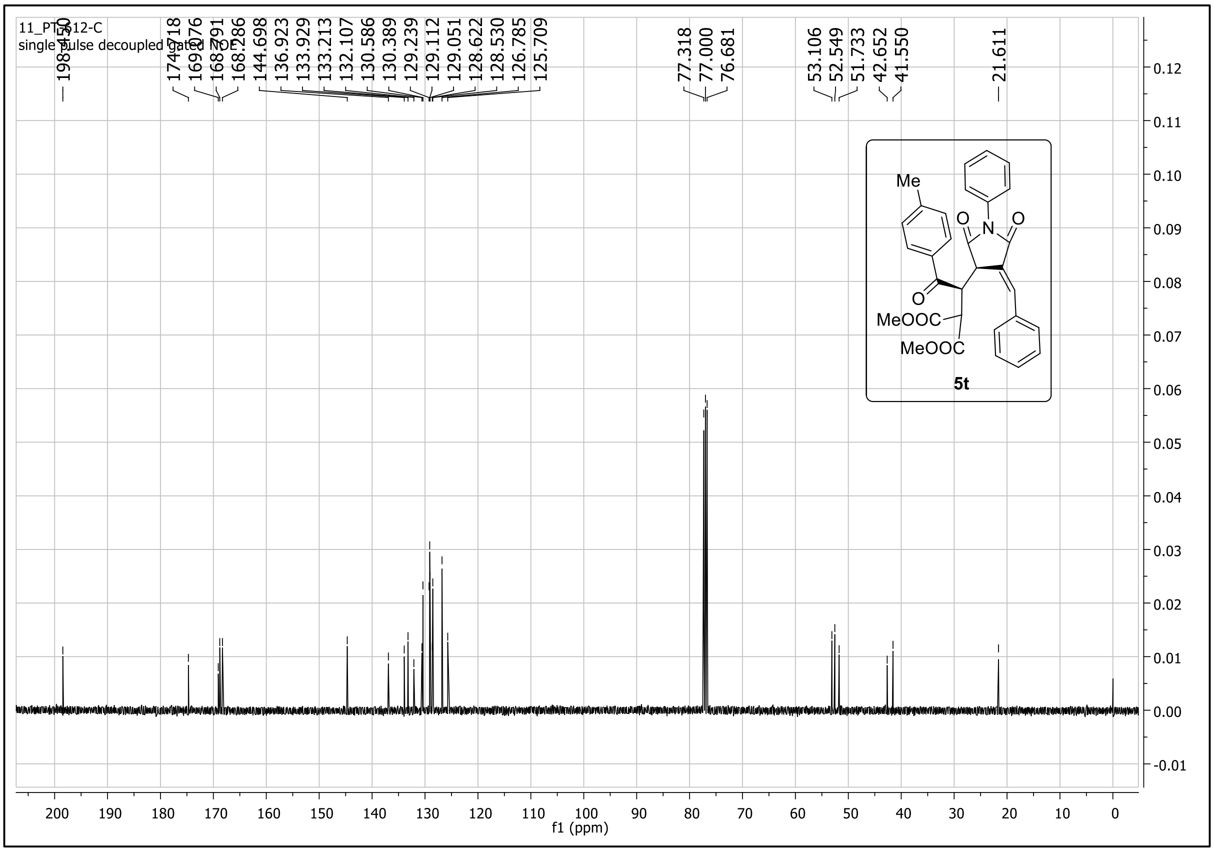

12_PT-709D
single_pulse
5r
f1 (ppm)


13C NMR
PT-709D
5r
f1 (ppm)






single_pulse
Me
O
N
O
O
MeOOC
MeOOC
5t
f1 (ppm)


single pulse decoupled gated NOE
Me
O
N
O
O
MeOOC
MeOOC
5t
f1 (ppm)

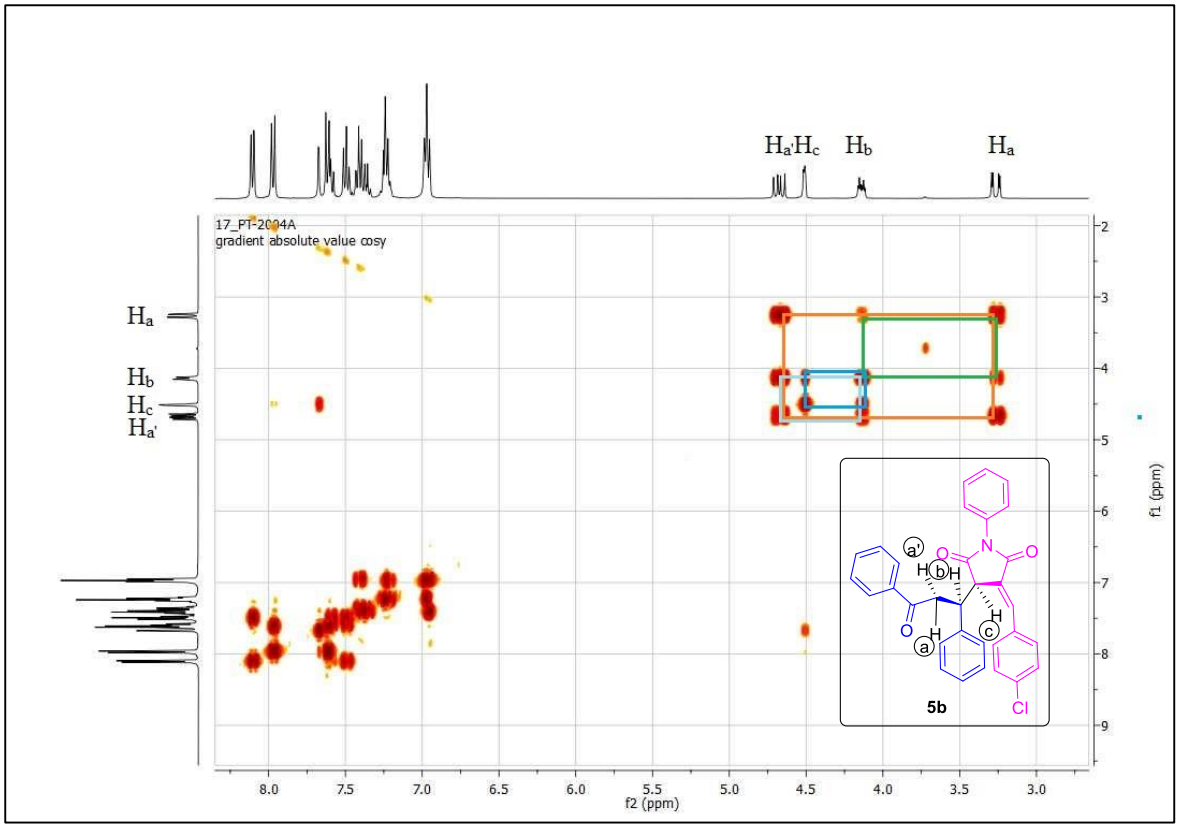


Figure S9: $^{1}H–^{1}H$ COSY spectrum of **5b**.

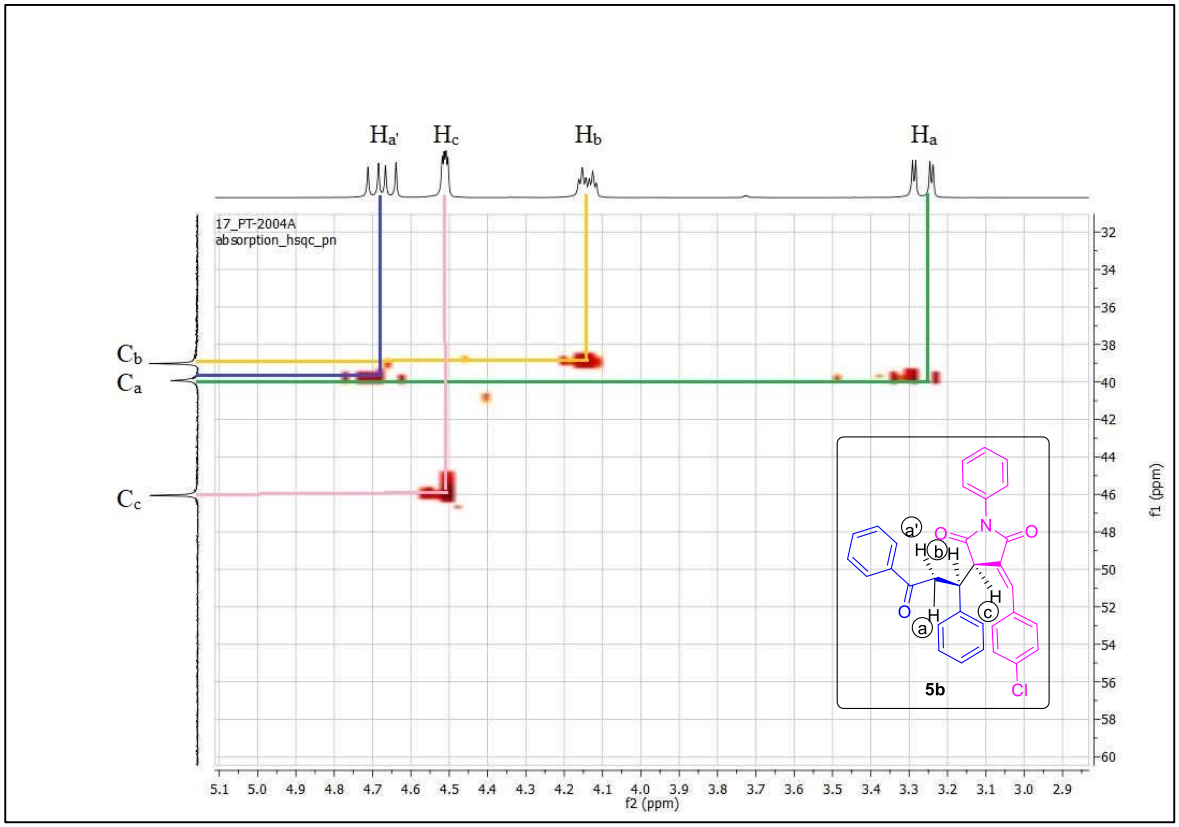


Figure S10: $^{1}H–^{13}C$ (HSQC) COSY spectrum of **5b**.

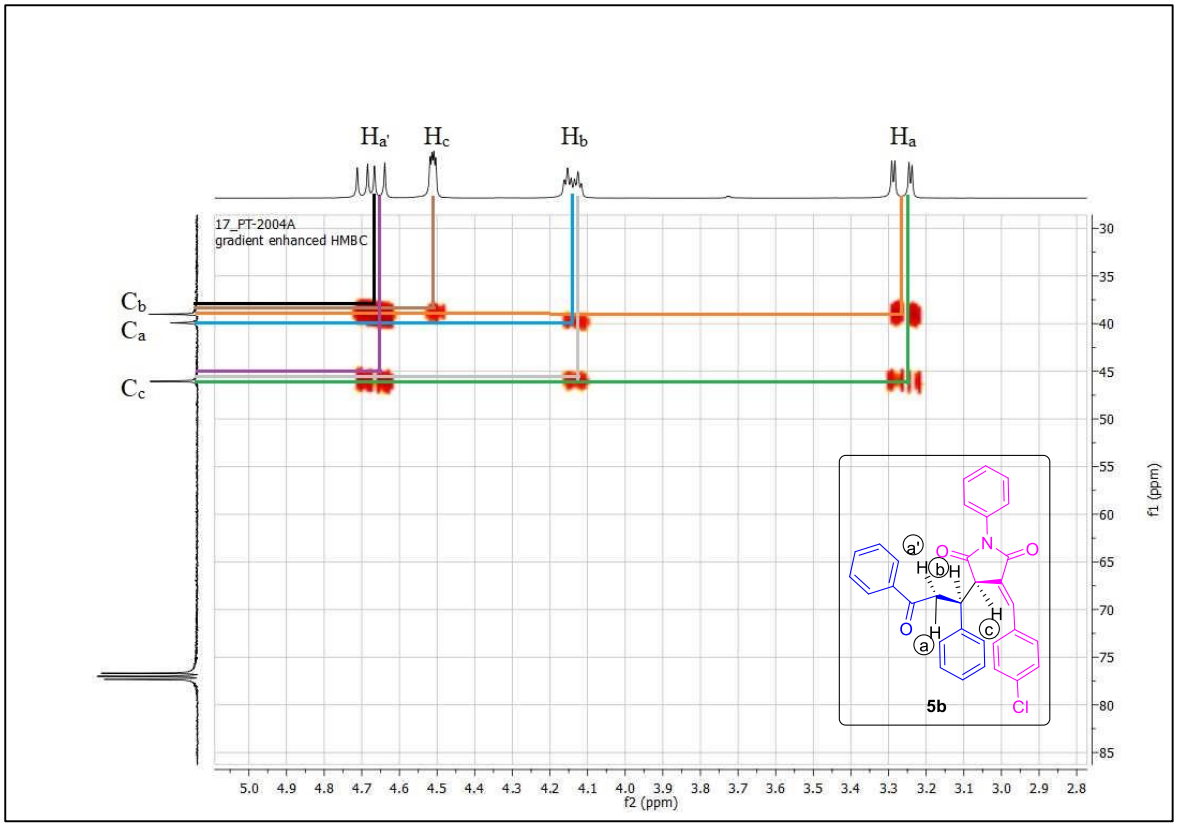


Figure S11: $^{1}H–^{13}C$ (HMBC) COSY spectrum of **5b**.

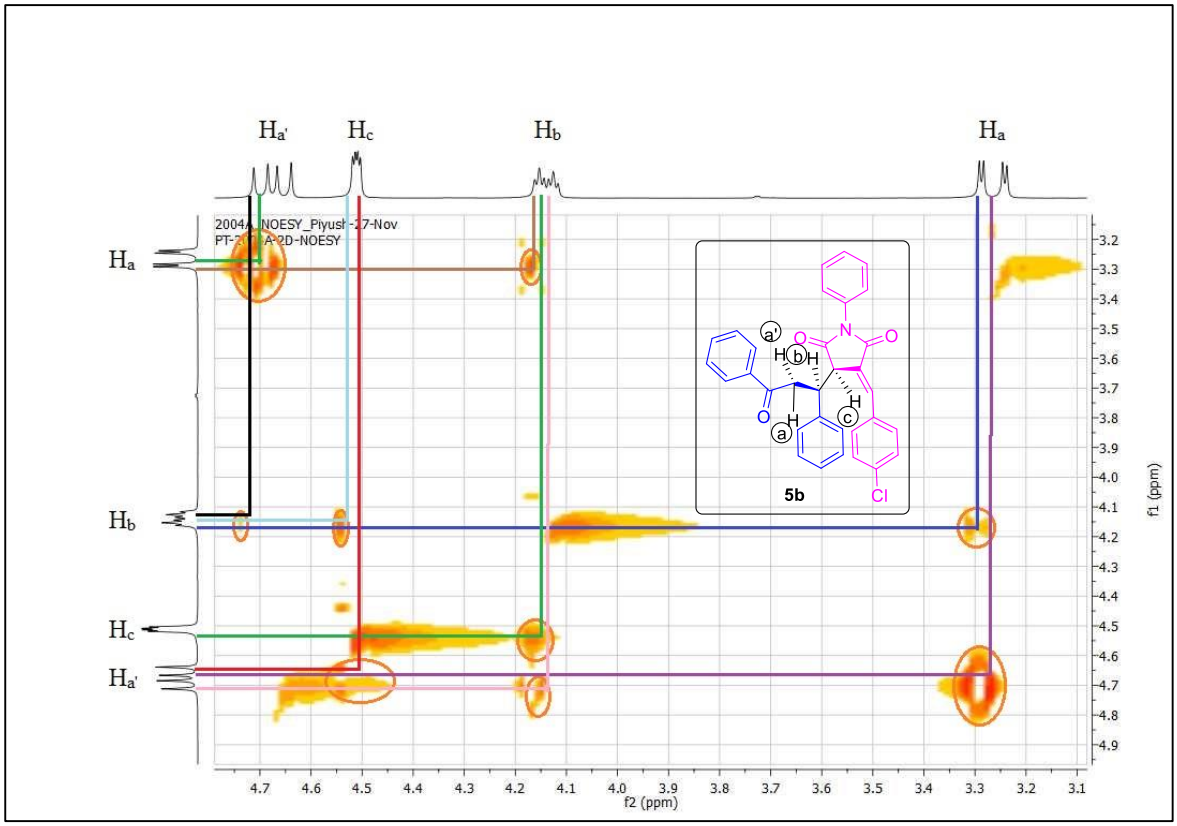


Figure S12: $^{1}H–^{1}H$ NOESY spectrum of **5b**.