Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Cycloaddition of Huisgen 1,4-dipoles: synthesis and rapid epimerization of functionalized spiropyrido[2,1-*b*][1,3]oxazine-pyrroles and related products

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1. General information

1.1. General analytical methods:

^{1}H and ^{13}C NMR spectra were recorded on a Bruker Avance III HD spectrometer (at 400, 101 MHz, respectively) at 40 °C (313K) or 30 °C (303K) in $CDCl_3$, DMSO-d_6, C_6D_6 or acetone-d_6 using the residual solvent peak ($CDCl_3$: δ_H = 7.26 ppm, δ_C = 77.16 ppm; DMSO-d_6: δ_H = 2.50 ppm; δ_C = 39.52 ppm; C_6D_6: δ_H = 7.16 ppm, δ_C = 128.06 ppm; acetone-d_6: δ_H = 2.05 ppm) as internal standards. Splitting patterns of apparent multiplets were designated as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broadened).

$CDCl_3$ was stored over Ag-foil and was protected from light. K_2CO_3-treated-$CDCl_3$ was prepared by addition of K_2CO_3 to bulk $CDCl_3$ solution (significant D/H exchange was observed after 1 month). ***Note**: for NMR analyses of compounds **5a–c**, **8a–c**, **10a, b,** $CDCl_3$ and K_2CO_3-treated-$CDCl_3$ were used from the same stock. Spectra of all compounds **3**, **5**, **8**, **10** were recorded right after complete dissolution.*

FT-IR spectra were recorded on a Perkin–Elmer Spectrum Two spectrometer from mulls in mineral oil. Melting points were measured with Mettler Toledo MP70 Melting Point apparatus or Khimlabpribor PTP apparatus. Thin-layer chromatography (TLC) was performed on silica gel 60 F_{254} plates (Merck); spots were visualized with UV light (254 nm) or iodine vapors.

HPLC analyses were performed on Hitachi Chromaster equipped with PDA detector Hitachi Chromaster 5430. The HPLC-UV conditions were as follows: wavelength 254 nm; solvent A, H_2O; solvent B, acetonitrile; NUCLEODUR C18 Gravity column 3 µm, 4 × 150 mm; column temperature, 35 °C; flow rate, 1.5 mL·min^{-1}; gradient program: 0–8.0 min, %B = 30–100% gradient, 8.0–9.5 min, %B = 100%, 9.5–11.0 min, %B = 100–30% gradient, 11.0–11.7 min, %B = 30%.

X-ray structural analyses were performed on an Xcalibur Ruby diffractometer using a Mo X-ray source (MoKα 0.71073 Å), by scanning at 295(2) K.

HRMS were recorded on Bruker MicroTOF (ESI+).

1.2. Starting materials:

1*H*-pyrrole-2,3-diones **3** [1–4], *N*-allyl isatine [5], 11*H*-indeno[1,2-*b*]quinoxalin-11-one (**6**) [6] and 2-(1-benzyl-2-oxoindolin-3-ylidene)malononitrile (**9**) [7] were synthesized according to the literature methods. Other reagents were purchased from commercial vendors (Acros, Alfa Aesar, TCI).

1.3. General remarks:

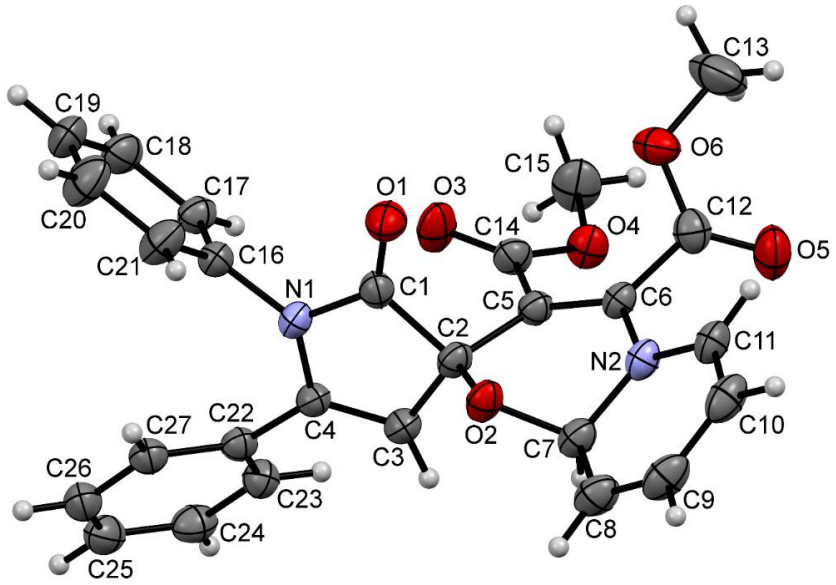
Reactions were carried out in oven-dried (120 °C) glassware, anhydrous solvent was stored under 4Å molecular sieves. All reactions were performed under ambient atmosphere, unless otherwise noted. The term *room temperature* (RT) refers to 23–27 °C, the term *concentrated* refers to solvent evaporation under vacuum on a rotary evaporator (bath temperature 40 °C), *EtOH* refers to 95%-solution of ethyl alcohol.

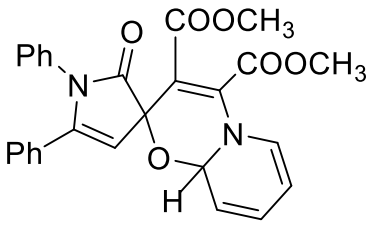
2. X-ray analysis

Single crystals of **3a** ($C_{27}H_{22}N_2O_6$) and **3f** ($C_{31}H_{28}N_2O_8$) were obtained from EtOH via slow evaporation. Single crystals of **8b** ($C_{30}H_{21}N_3O_5$) were obtained from hexane/dichloromethane mixture via slow evaporation. Single crystals of **8c** ($C_{30}H_{21}N_3O_5$) were obtained from acetonitrile via slow evaporation.

Crystal structure determination

The unit cell parameters and the X-ray diffraction intensities were measured on a Xcalibur Ruby diffractometer (Agilent Technologies). The empirical absorption correction was introduced by multi-scan method using SCALE3 ABSPACK algorithm[8]. Using OLEX2[9], the structures were solved with the SHELXS[10] program using Direct Methods and refined by the full-matrix least-squares minimization in the anisotropic approximation for all non-hydrogen atoms with the SHELXL[11] program. Hydrogen atoms were positioned geometrically and refined using a riding model.





3a

Fig. S1. *Structure of compound* ***3a*** *showing 30% probability amplitude displacement ellipsoids (CCDC 2119396).*

Table S1. Crystal data and structure refinement for **3a**.

Empirical formula	$C_{27}H_{22}N_2O_6$
Formula weight	470.46
Temperature, K	295.15
Crystal system	triclinic
Space group	P-1
a, Å	9.838(2)
b, Å	10.401(2)
c, Å	12.2553(17)
α, °	102.291(16)
β, °	100.426(16)
γ,°	103.17(2)
Volume, $Å^3$	1157.9(4)
Z	2
Density (calculated), $g·cm^{-3}$	1.349
Absorption coefficient, mm^{-1}	0.096
F(000)	492.0
Crystal size, mm^3	0.35 × 0.2 × 0.12
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection, °	6.12 to 58.944
Index ranges	-10 ≤ h ≤ 12, -14 ≤ k ≤ 11, -13 ≤ l ≤ 15
Reflections collected	9360
Independent reflections	5376 [R_{int} = 0.0542, R_{sigma} = 0.0838]
Data/restraints/parameters	5376/0/319
Goodness-of-fit on F^2	1.067
Final R indexes [I>=2σ (I)]	R_1 = 0.0672, wR_2 = 0.1540
Final R indexes [all data]	R_1 = 0.1247, wR_2 = 0.2013
Largest diff. peak/hole, $eÅ^{-3}$	0.24/-0.22

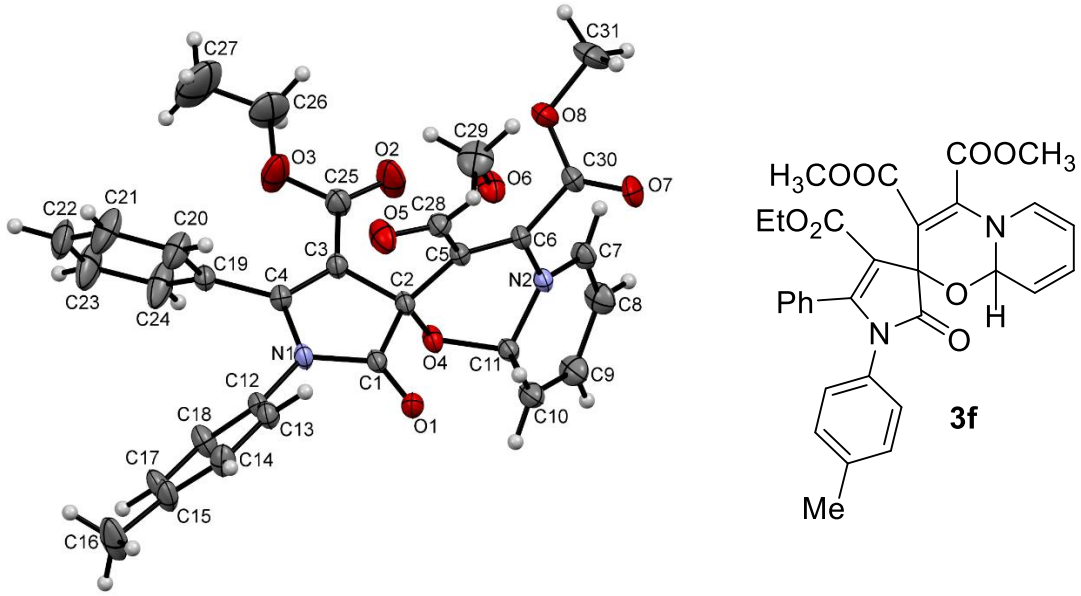
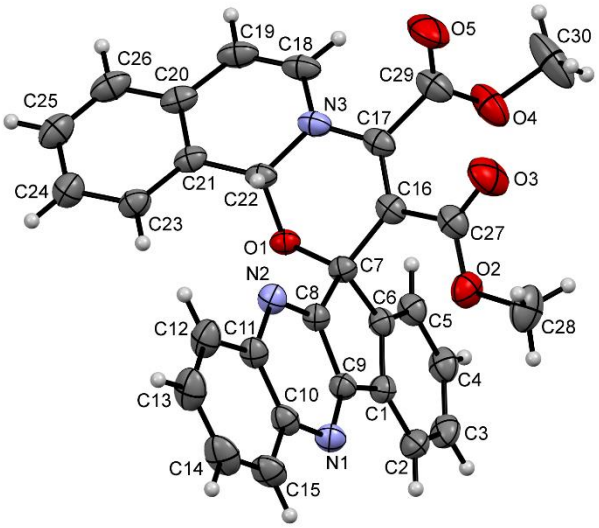
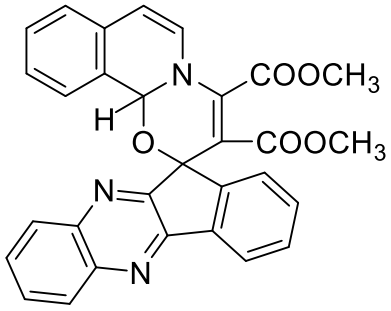


Fig. S2. *Structure of compound* ***3f*** *showing 30% probability amplitude displacement ellipsoids (CCDC 2119397).*

Table S2. Crystal data and structure refinement for **3f**.

Empirical formula	$C_{31}H_{28}N_2O_8$
Formula weight	556.55
Temperature, K	295.15
Crystal system	triclinic
Space group	P-1
a, Å	11.1868(16)
b, Å	11.4255(18)
c, Å	12.2739(16)
α, °	95.263(12)
β, °	107.966(12)
γ, °	103.507(13)
Volume, $Å^3$	1428.1(4)
Z	2
Density (calculated), $g·cm^{-3}$	1.294
Absorption coefficient, mm^{-1}	0.094
F(000)	584.0
Crystal size, mm^3	0.6 × 0.5 × 0.4
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection, °	6.85 to 58.718
Index ranges	-14 ≤ h ≤ 13, -15 ≤ k ≤ 15, -16 ≤ l ≤ 15
Reflections collected	10695
Independent reflections	6592 [R_{int} = 0.0308, R_{sigma} = 0.0530]
Data/restraints/parameters	6592/0/375
Goodness-of-fit on F^2	1.045
Final R indexes [I>=2σ (I)]	R_1 = 0.0592, wR_2 = 0.1542
Final R indexes [all data]	R_1 = 0.0870, wR_2 = 0.1804
Largest diff. peak/hole, $eÅ^{-3}$	0.24/-0.22



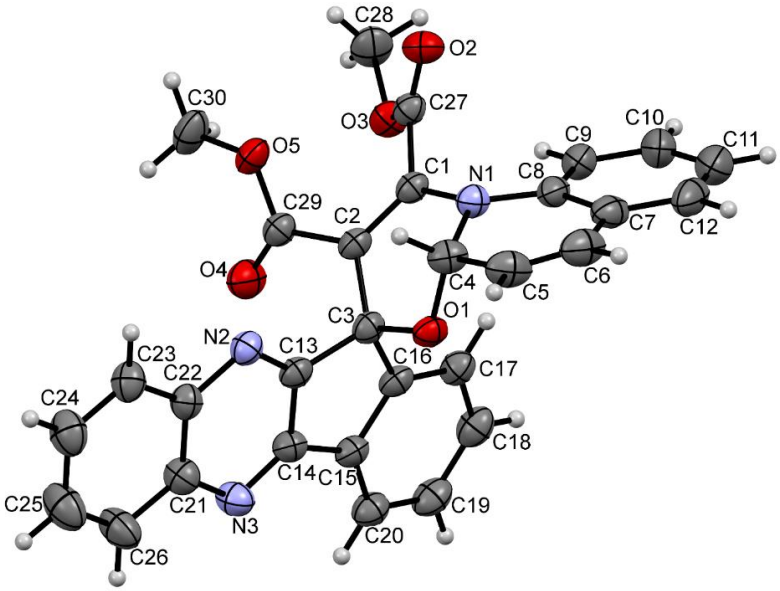


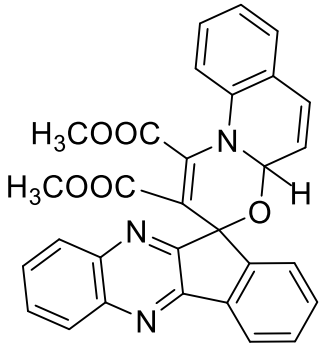
8b

Fig. S3. *Structure of compound* ***8b*** *showing 30% probability amplitude displacement ellipsoids (CCDC 2119399).*

Table S3. Crystal data and structure refinement for **8b**.

Empirical formula	$C_{30}H_{21}N_3O_5$
Formula weight	503.50
Temperature, K	295.15
Crystal system	triclinic
Space group	P-1
a, Å	11.4672(12)
b, Å	14.0604(14)
c, Å	15.6426(15)
α, °	99.666(8)
β, °	96.992(8)
γ, °	94.581(8)
Volume, $Å^3$	2454.8(4)
Z	4
Density (calculated), $g \cdot cm^{-3}$	1.362
Absorption coefficient, mm^{-1}	0.094
F(000)	1048.0
Crystal size, mm^3	0.55 × 0.3 × 0.12
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection, °	4.32 to 58.972
Index ranges	-12 ≤ h ≤ 15, -16 ≤ k ≤ 18, -20 ≤ l ≤ 20
Reflections collected	22145
Independent reflections	11448 [R_{int} = 0.0398, R_{sigma} = 0.0583]
Data/restraints/parameters	11448/0/701
Goodness-of-fit on F^2	1.020
Final R indexes [I>=2σ (I)]	R_1 = 0.0558, wR_2 = 0.1314
Final R indexes [all data]	R_1 = 0.0984, wR_2 = 0.1688
Largest diff. peak/hole, $eÅ^{-3}$	0.20/-0.24





8c

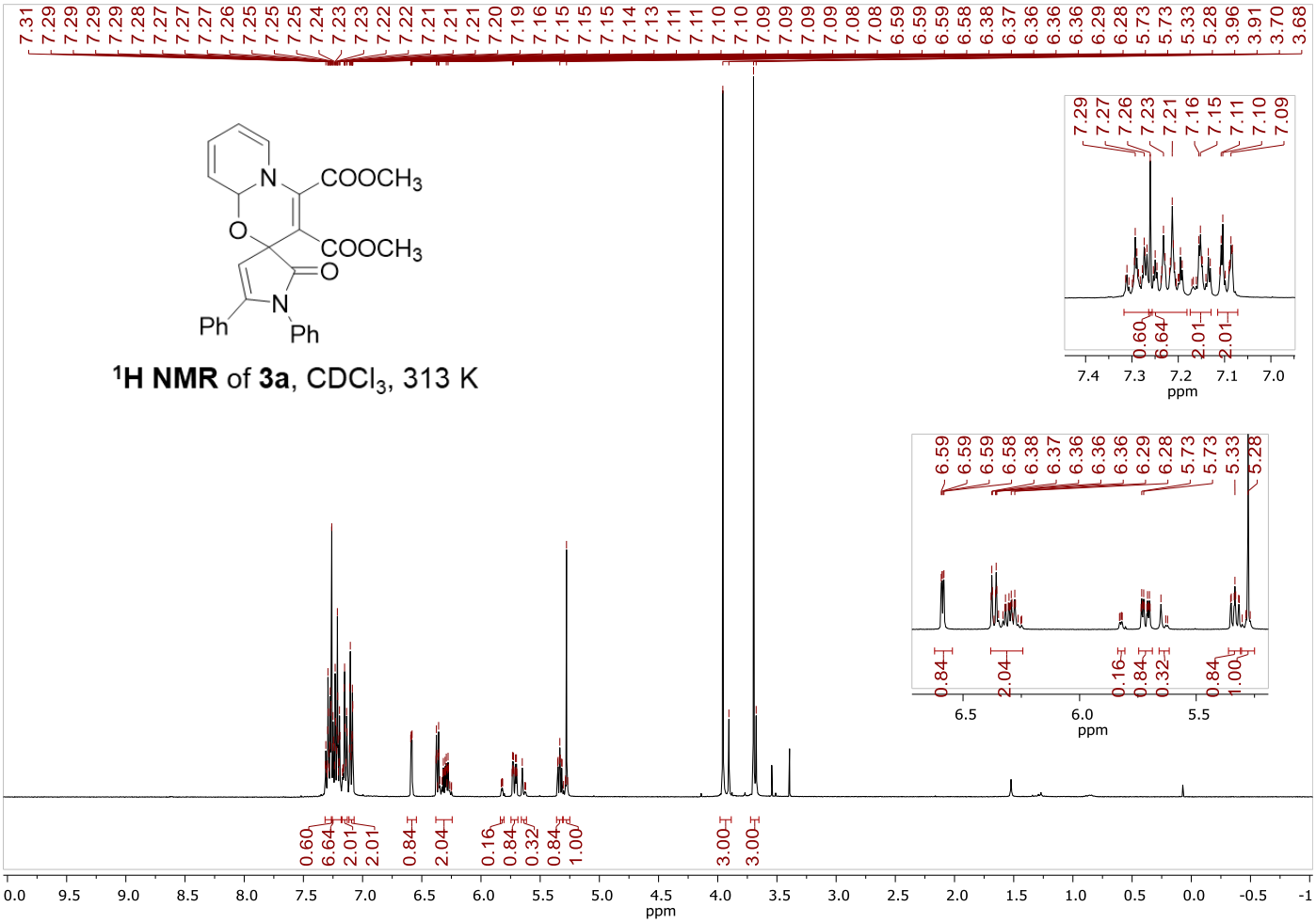
Fig. S4. *Structure of compound* ***8c*** *showing 30% probability amplitude displacement ellipsoids (CCDC 2119398).*

Table S4. Crystal data and structure refinement for **8c**.

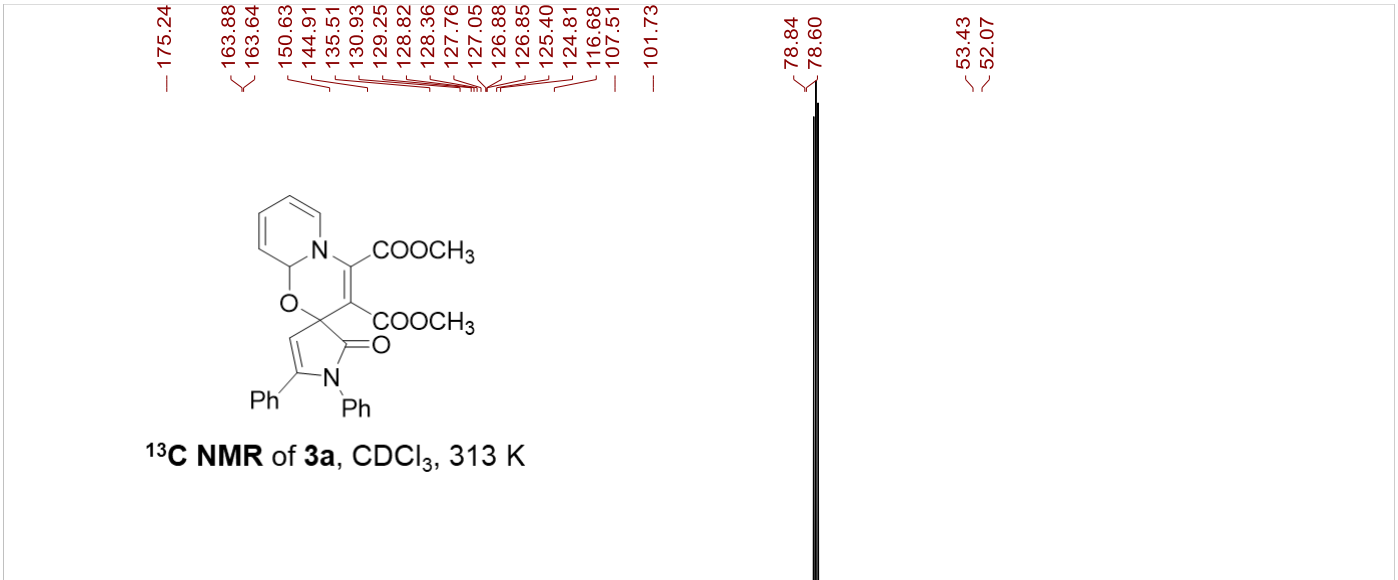
Empirical formula	$C_{30}H_{21}N_3O_5$
Formula weight	503.50
Temperature, K	295.15
Crystal system	monoclinic
Space group	$P2_1/n$
a, Å	8.7697(18)
b, Å	19.206(5)
c, Å	14.480(3)
α, °	90
β, °	94.70(2)
γ, °	90
Volume, $Å^3$	2430.7(10)
Z	4
Density (calculated), $g·cm^{-3}$	1.376
Absorption coefficient, mm^{-1}	0.095
F(000)	1048.0
Crystal size, mm^3	0.5 × 0.25 × 0.12
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection, °	5.644 to 58.886
Index ranges	-11 ≤ h ≤ 8, -24 ≤ k ≤ 26, -18 ≤ l ≤ 15
Reflections collected	16407
Independent reflections	5791 [R_{int} = 0.0548, R_{sigma} = 0.0666]
Data/restraints/parameters	5791/0/346
Goodness-of-fit on F^2	1.019
Final R indexes [I>=2σ (I)]	R_1 = 0.0652, wR_2 = 0.1616
Final R indexes [all data]	R_1 = 0.1360, wR_2 = 0.2173
Largest diff. peak/hole, $eÅ^{-3}$	0.21/-0.18

3. NMR spectra of products 3a–k

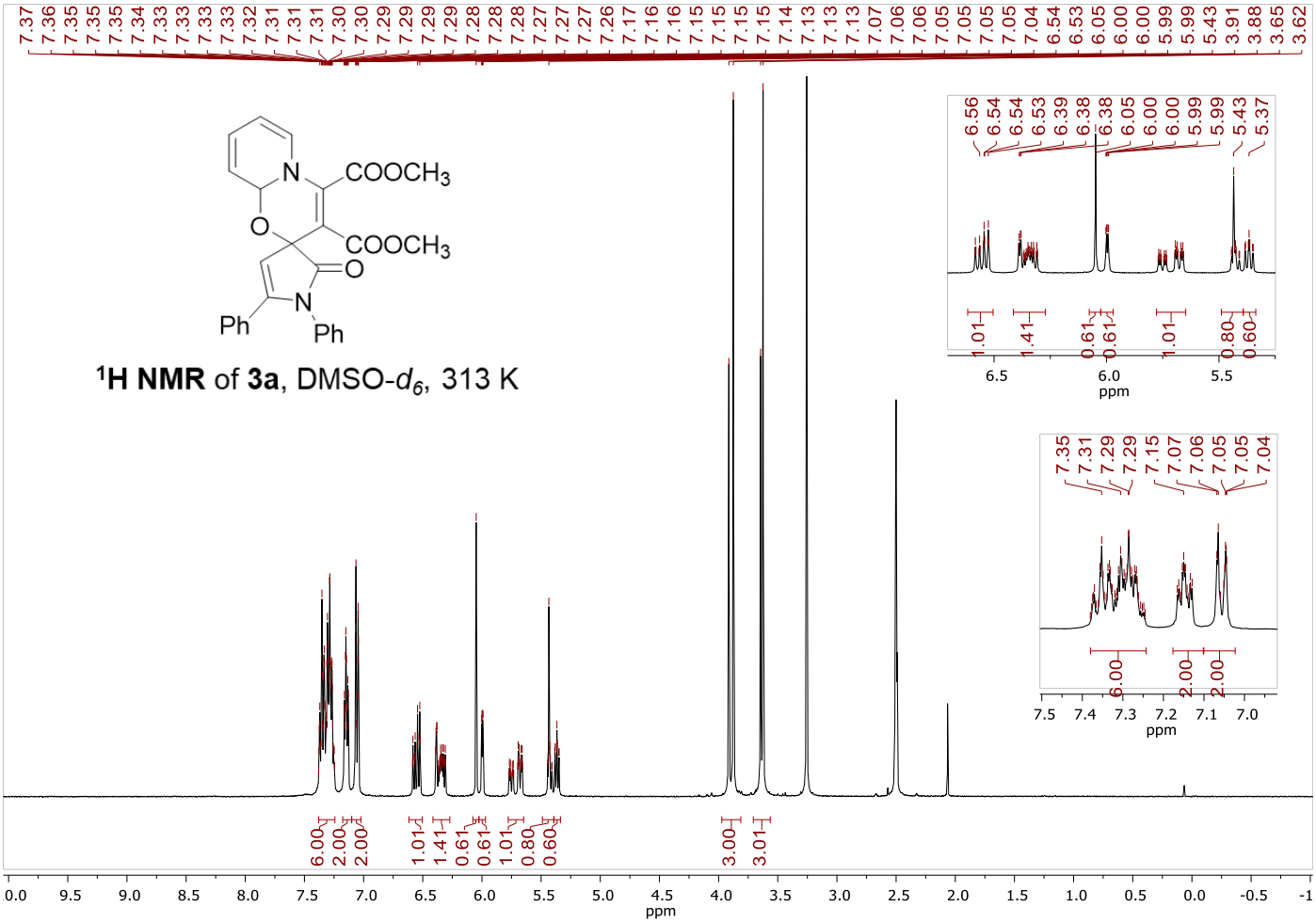
3.1. Copies of NMR spectra for product 3a



^{1}H NMR of **3a**, $CDCl_3$, 313 K



^{13}C NMR of **3a**, $CDCl_3$, 313 K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N
COOCH3
O
COOCH3
O
N
Ph
Ph
1H NMR of 3a, DMSO-d6, 313 K
6.56 6.54 6.54 6.53 6.39 6.38 6.38 6.05 6.00 6.00 5.99 5.99 5.43 5.37
1.01 1.41 0.61 0.61 1.01 0.80 0.60
6.5 6.0 5.5
ppm
7.35 7.31 7.29 7.29 7.15 7.07 7.06 7.05 7.05 7.04
6.00 2.00 2.00
7.5 7.4 7.3 7.2 7.1 7.0
ppm
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0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
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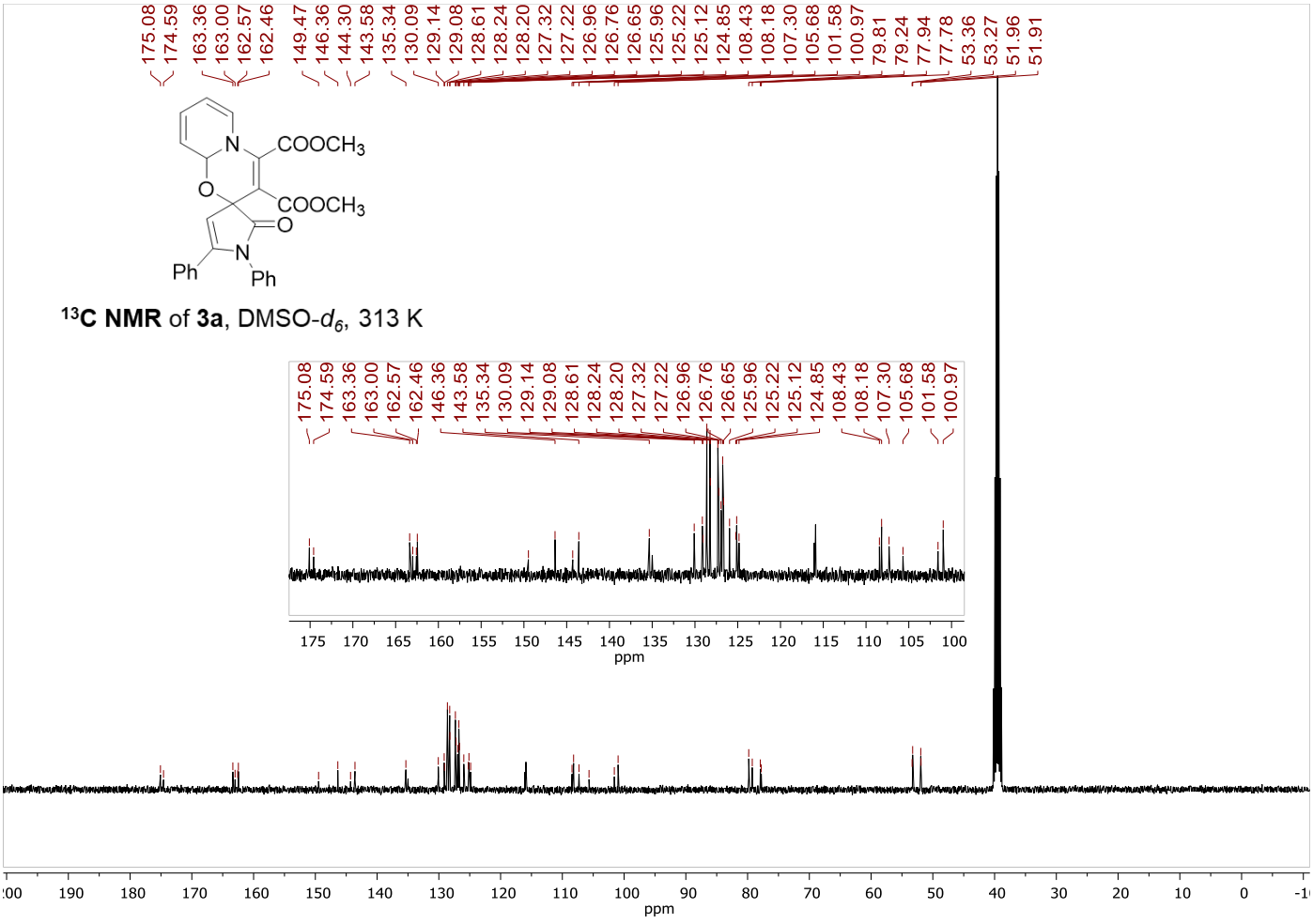
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N
COOCH3
O
COOCH3
O
N
Ph
Ph
13C NMR of 3a, DMSO-d6, 313 K
175.08 174.59 163.36 163.00 162.57 162.46 146.36 143.58 135.34 130.09 129.14 129.08 128.61 128.24 128.20 127.32 127.22 126.96 126.76 126.65 125.96 125.22 125.12 124.85 108.43 108.18 107.30 105.68 101.58 100.97
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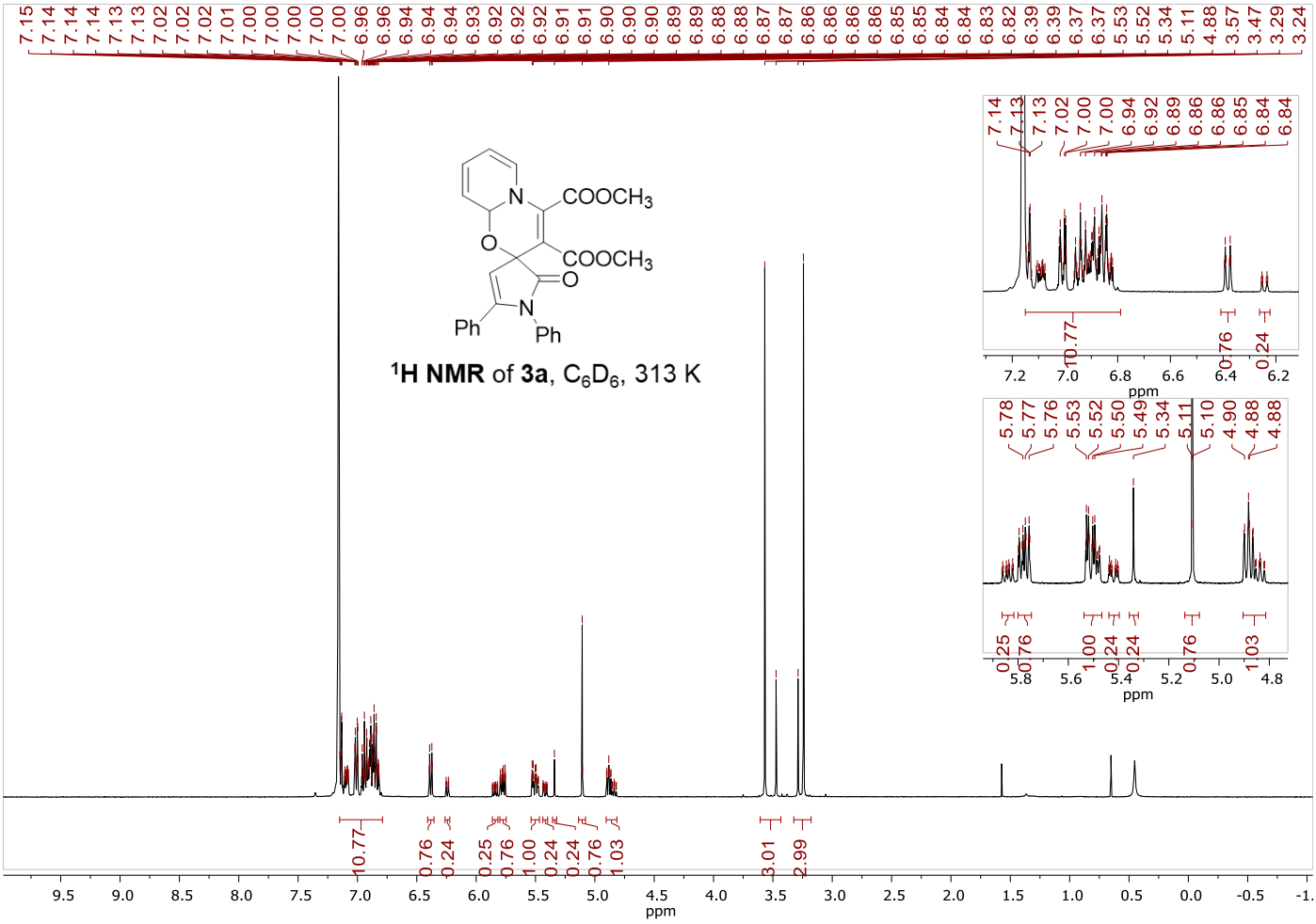
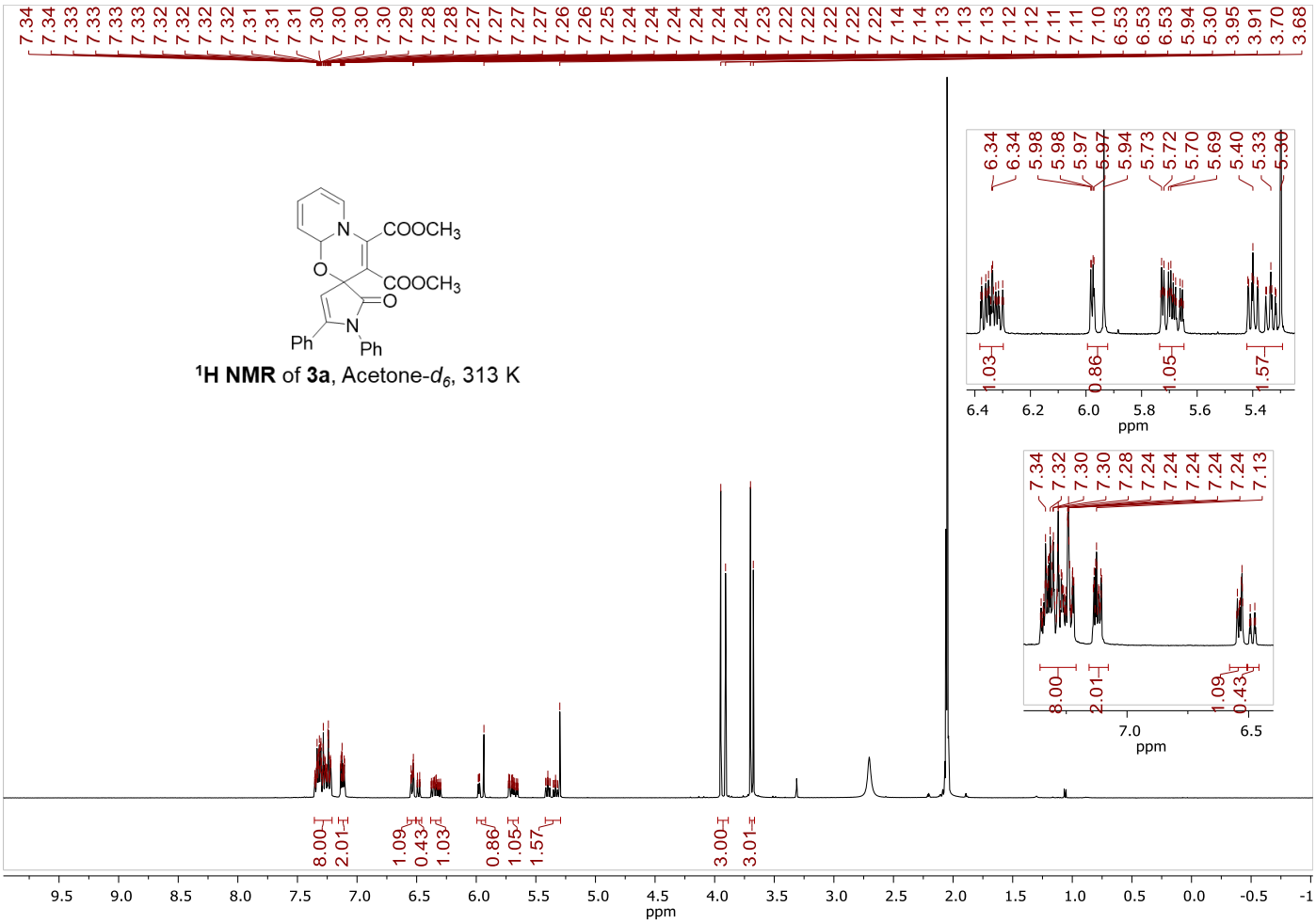
ppm

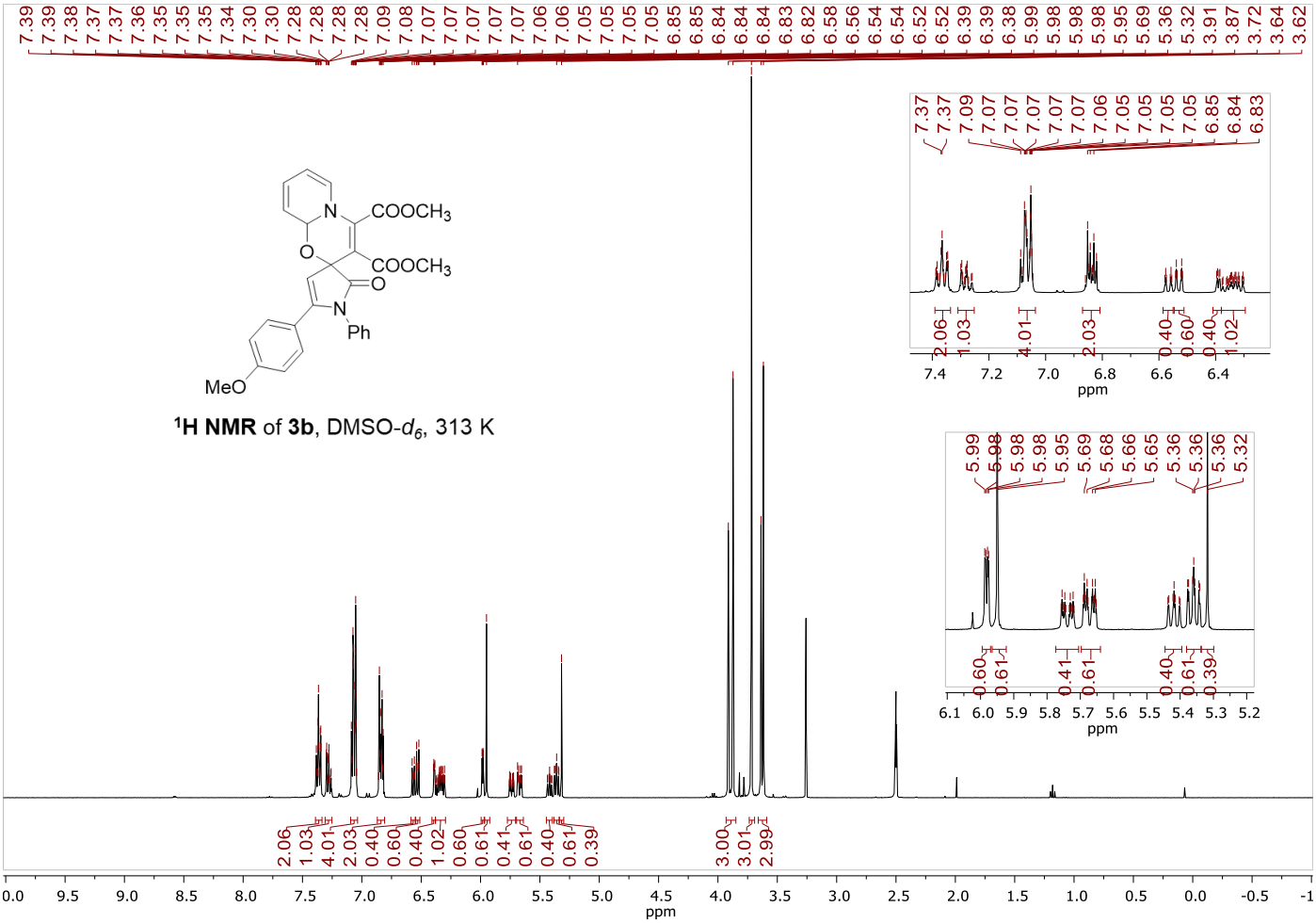


^{1}H NMR of **3a**, C_6D_6, 313 K



^{1}H NMR of **3a**, Acetone-d_6, 313 K

3.2. Copies of NMR spectra for product 3b



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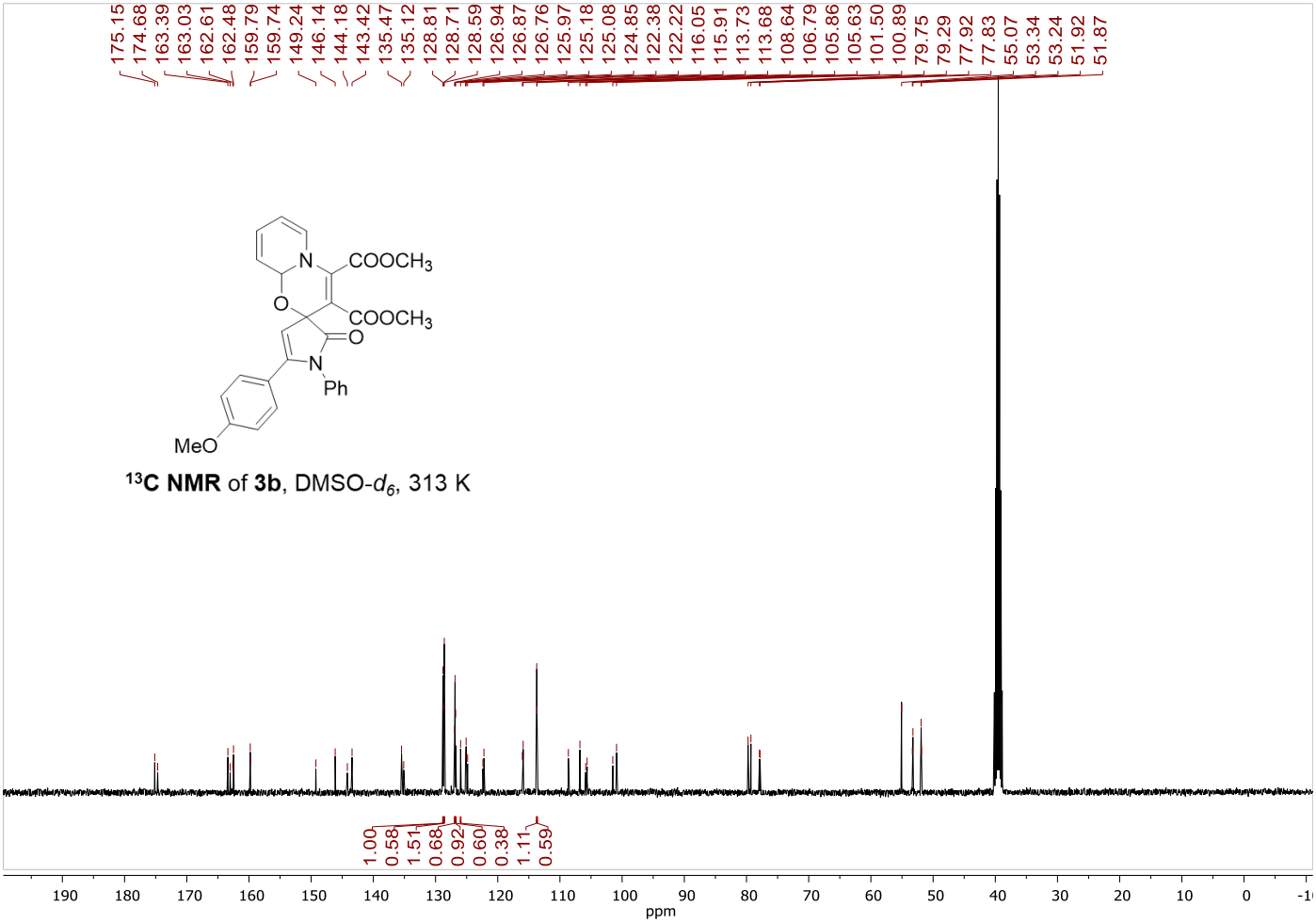

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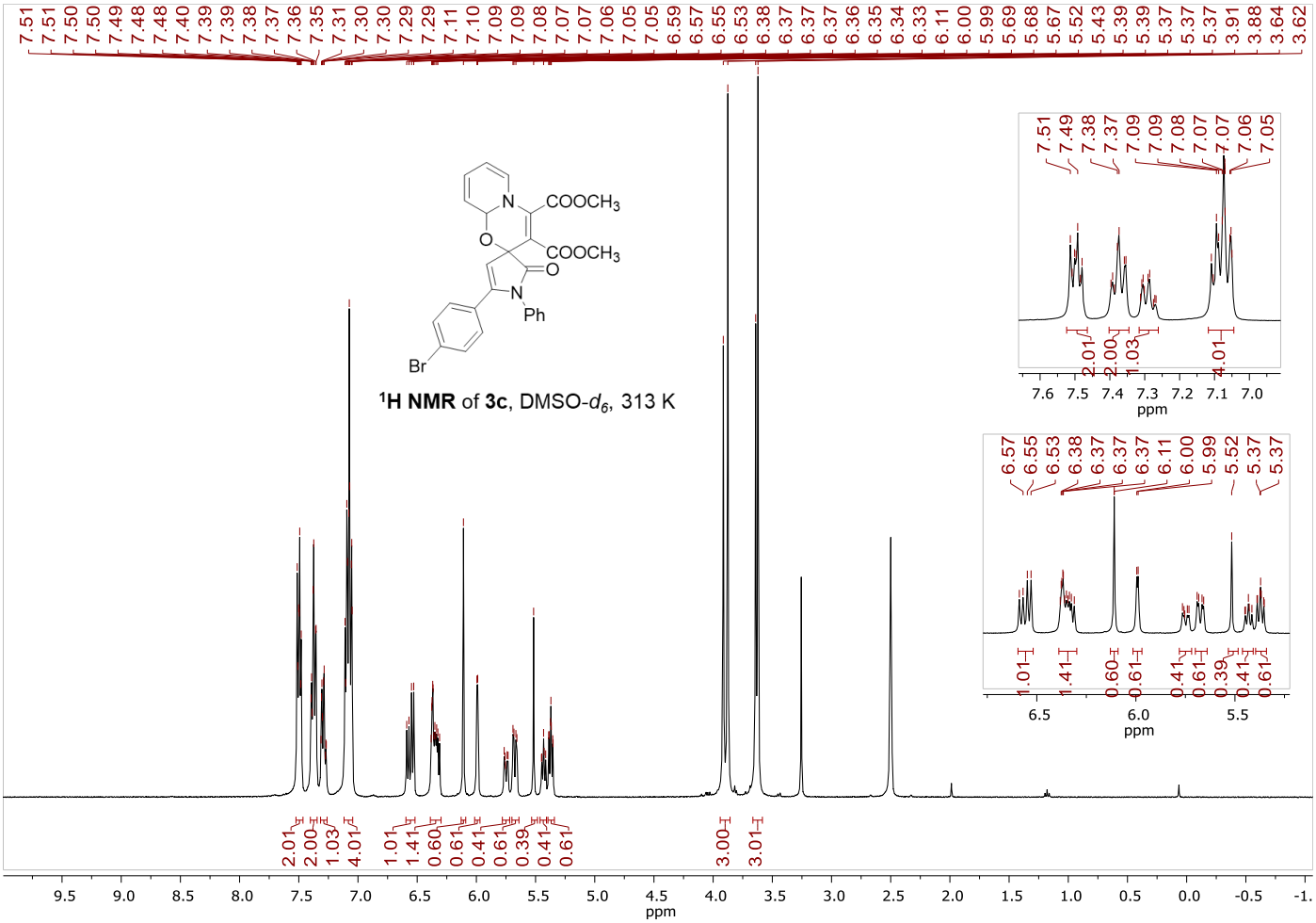
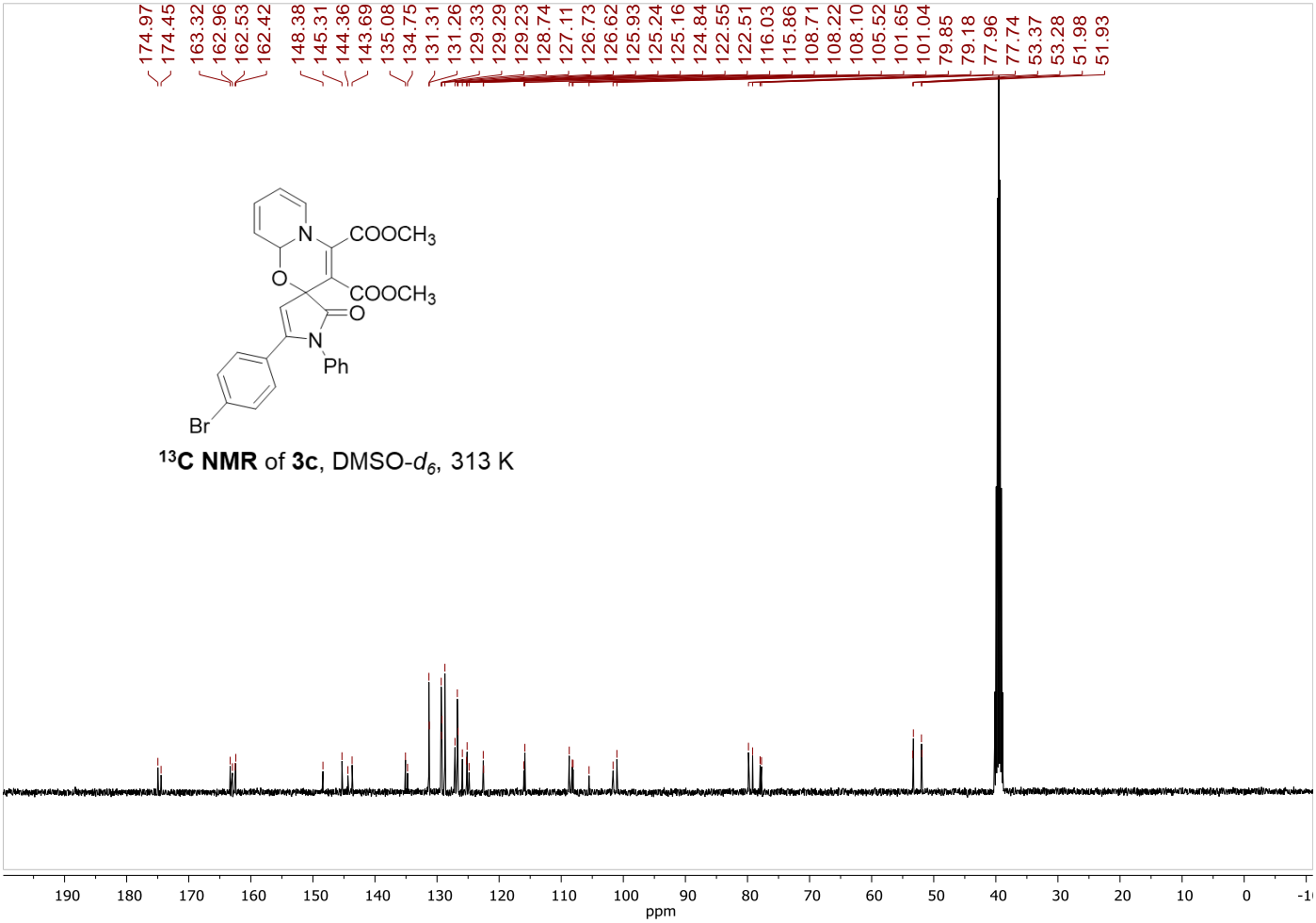
3.3. Copies of NMR spectra for product 3c





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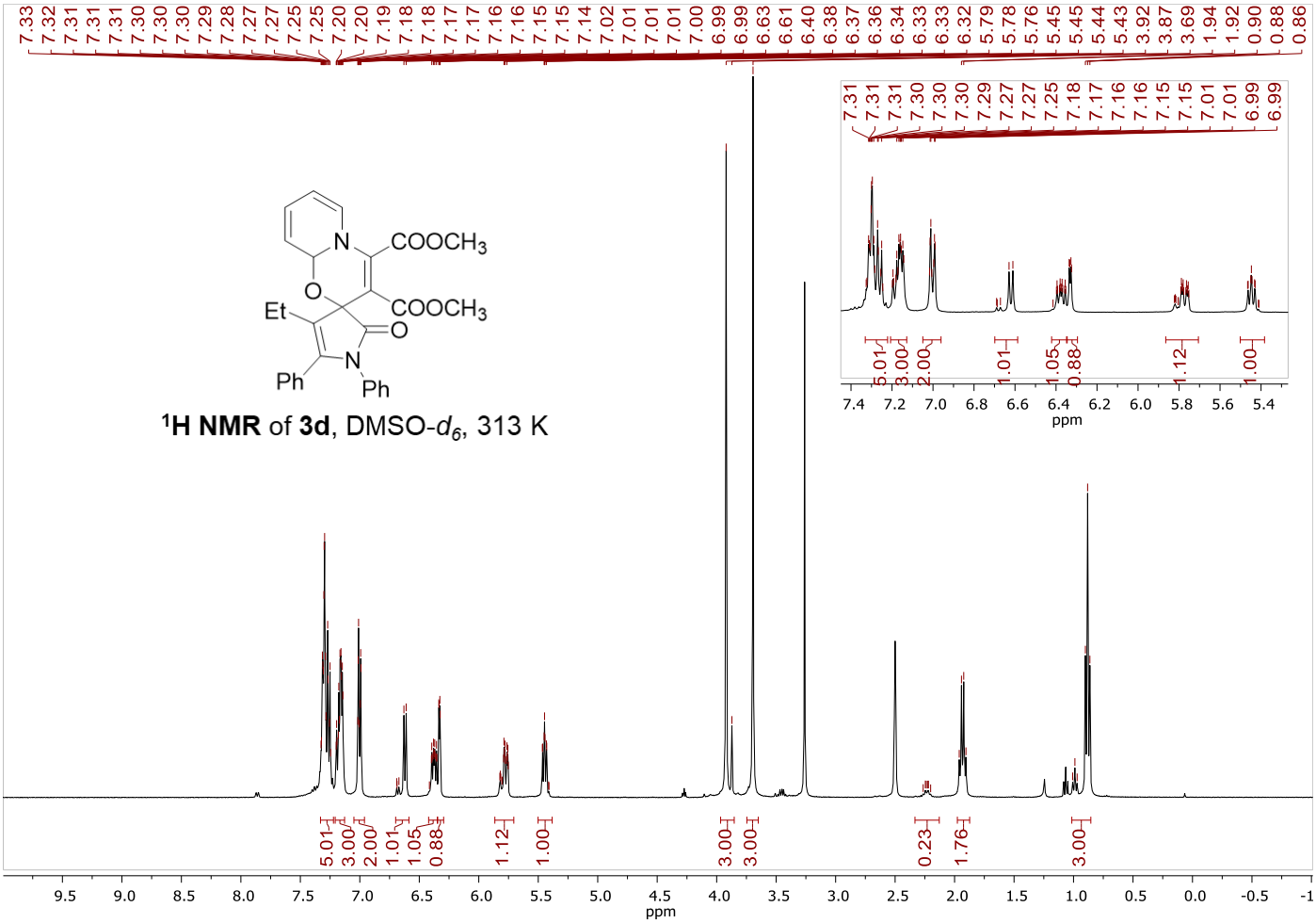
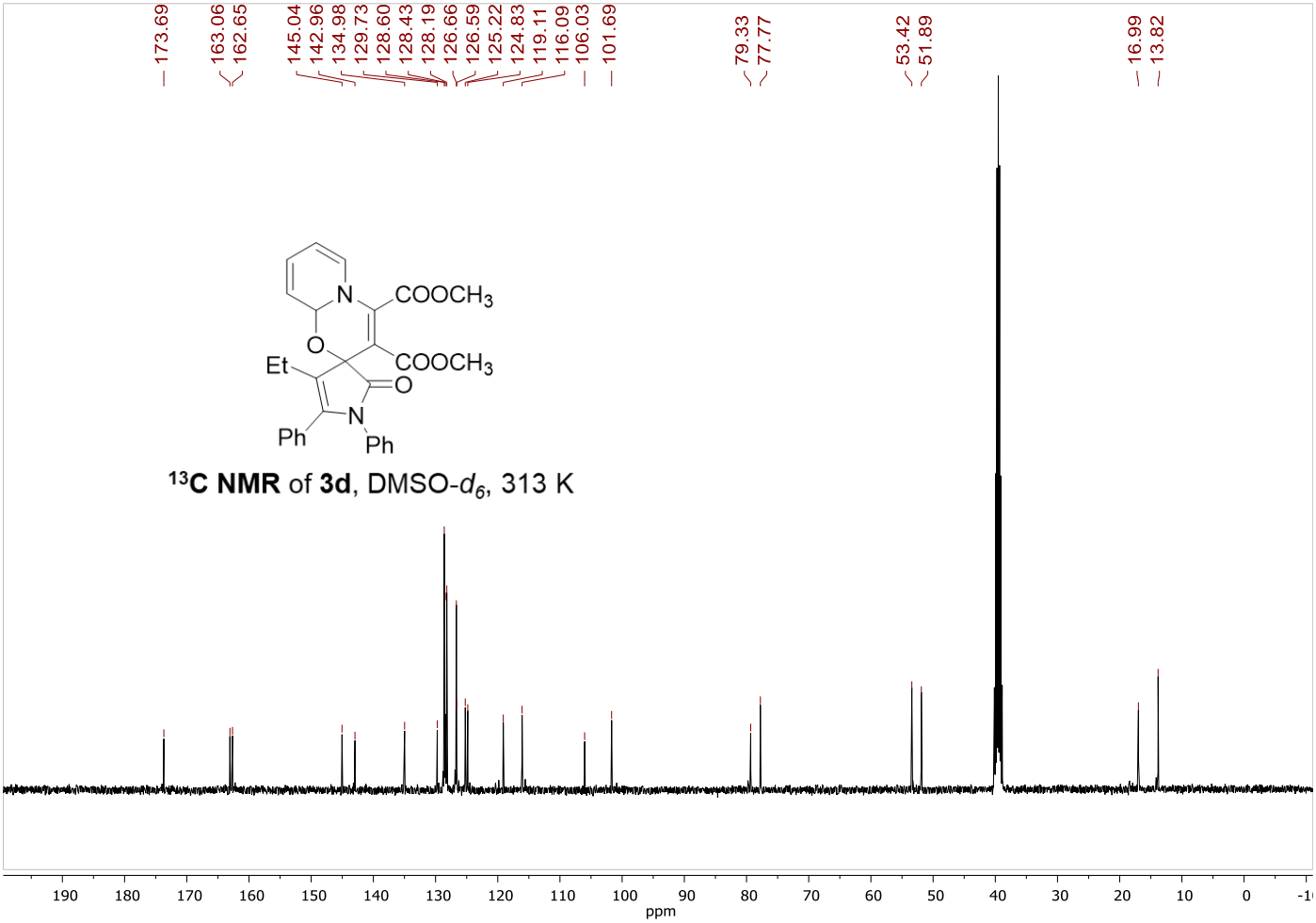
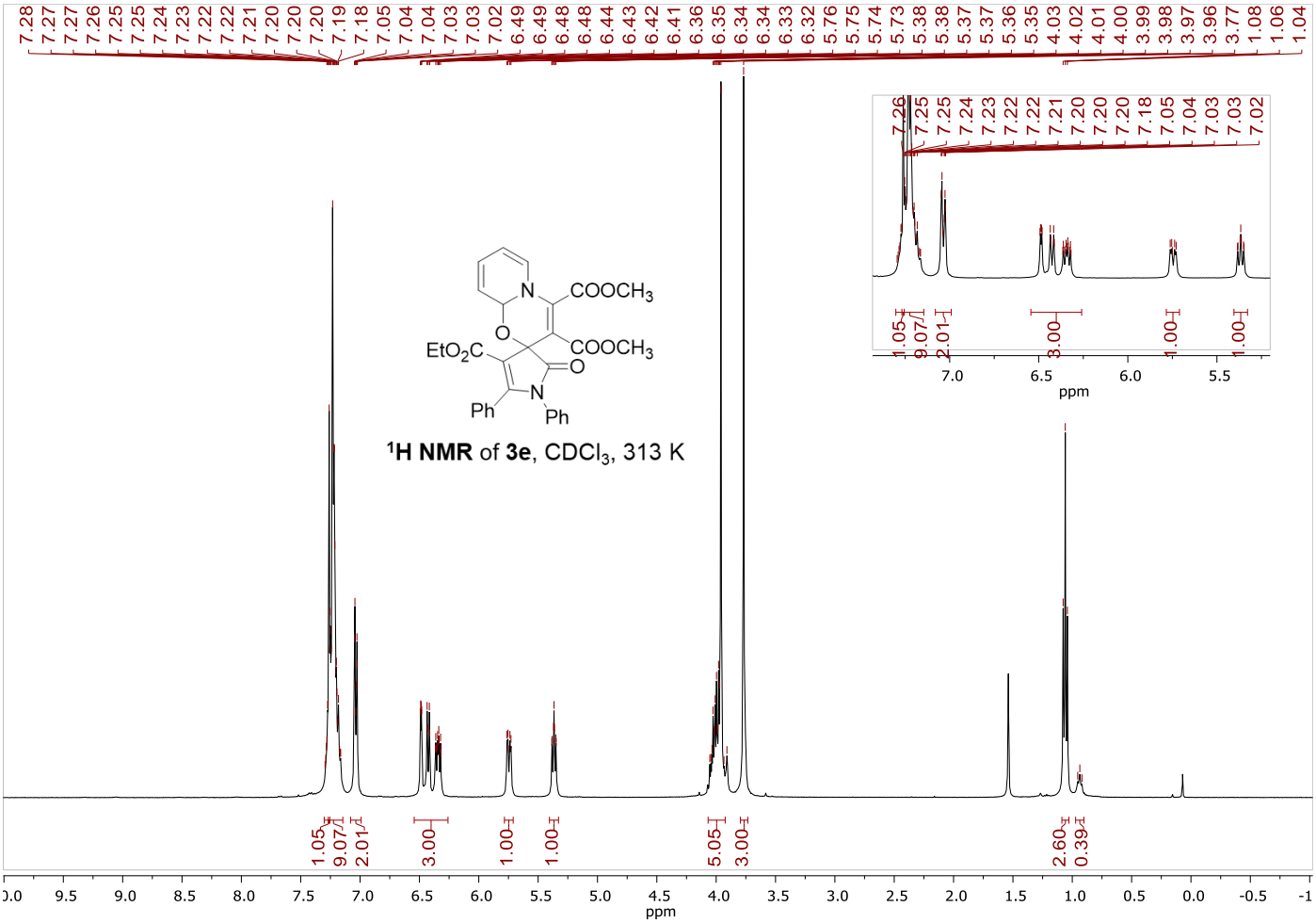
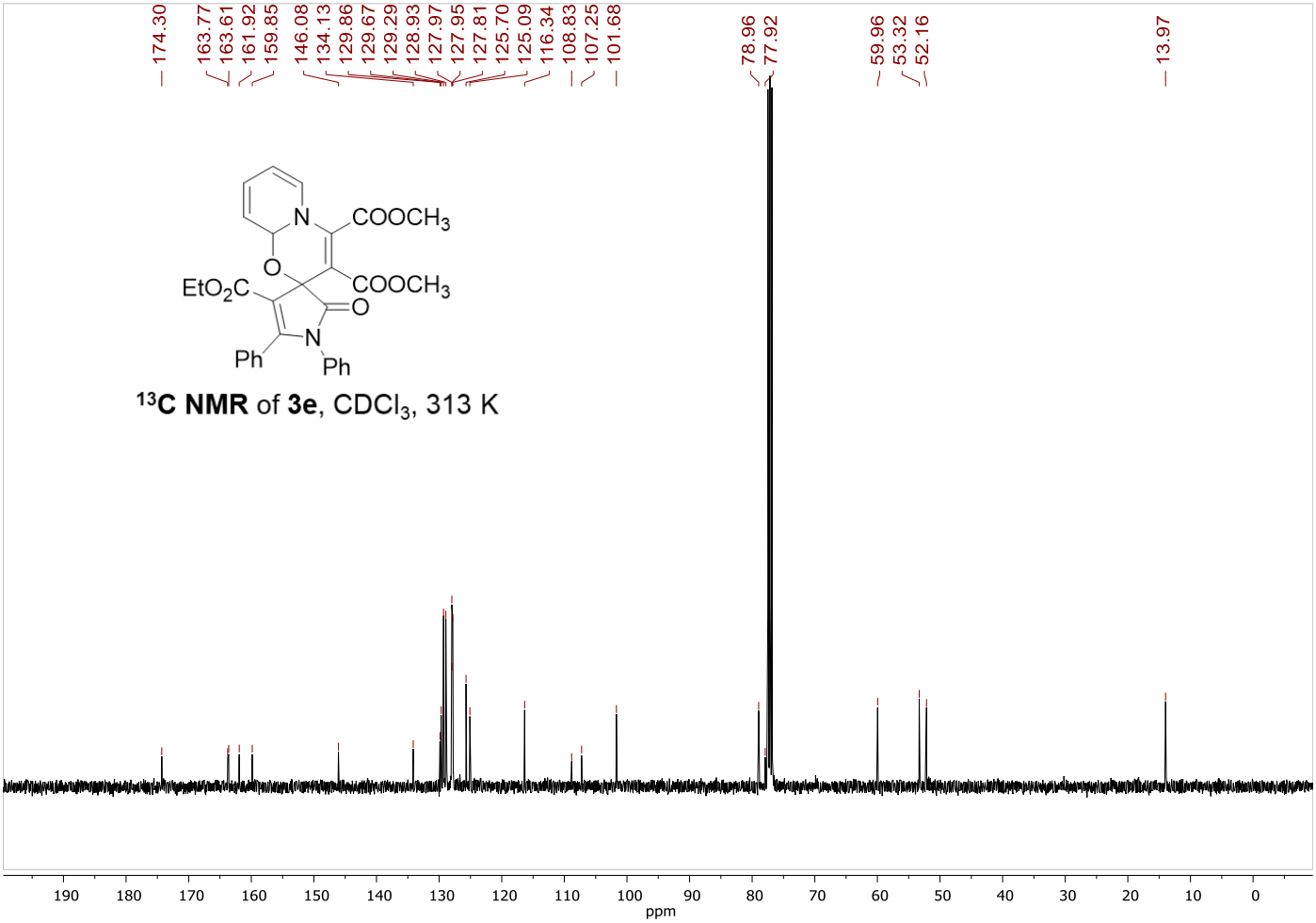
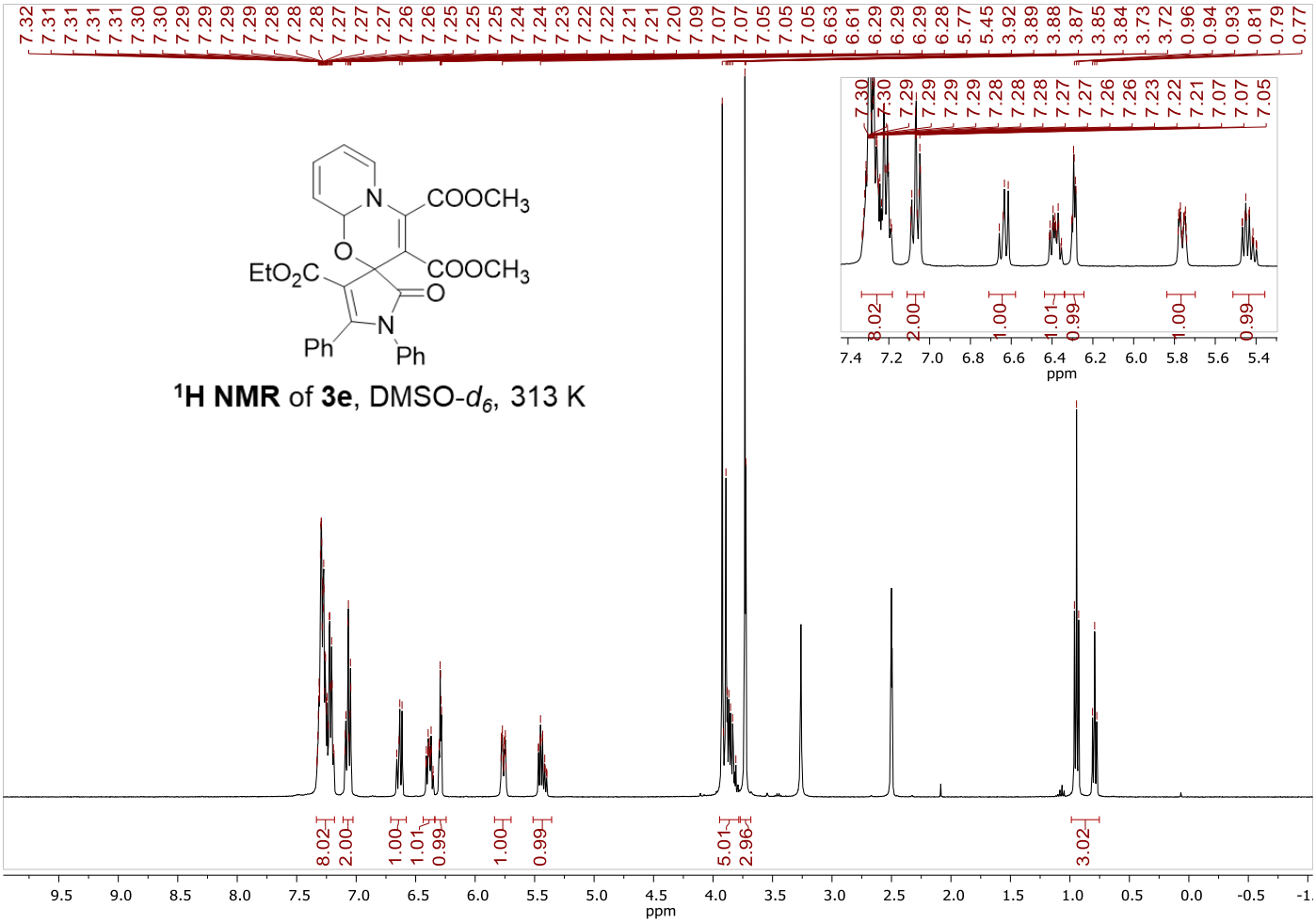




3.5. Copies of NMR spectra for product 3e



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COOCH3
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Ph
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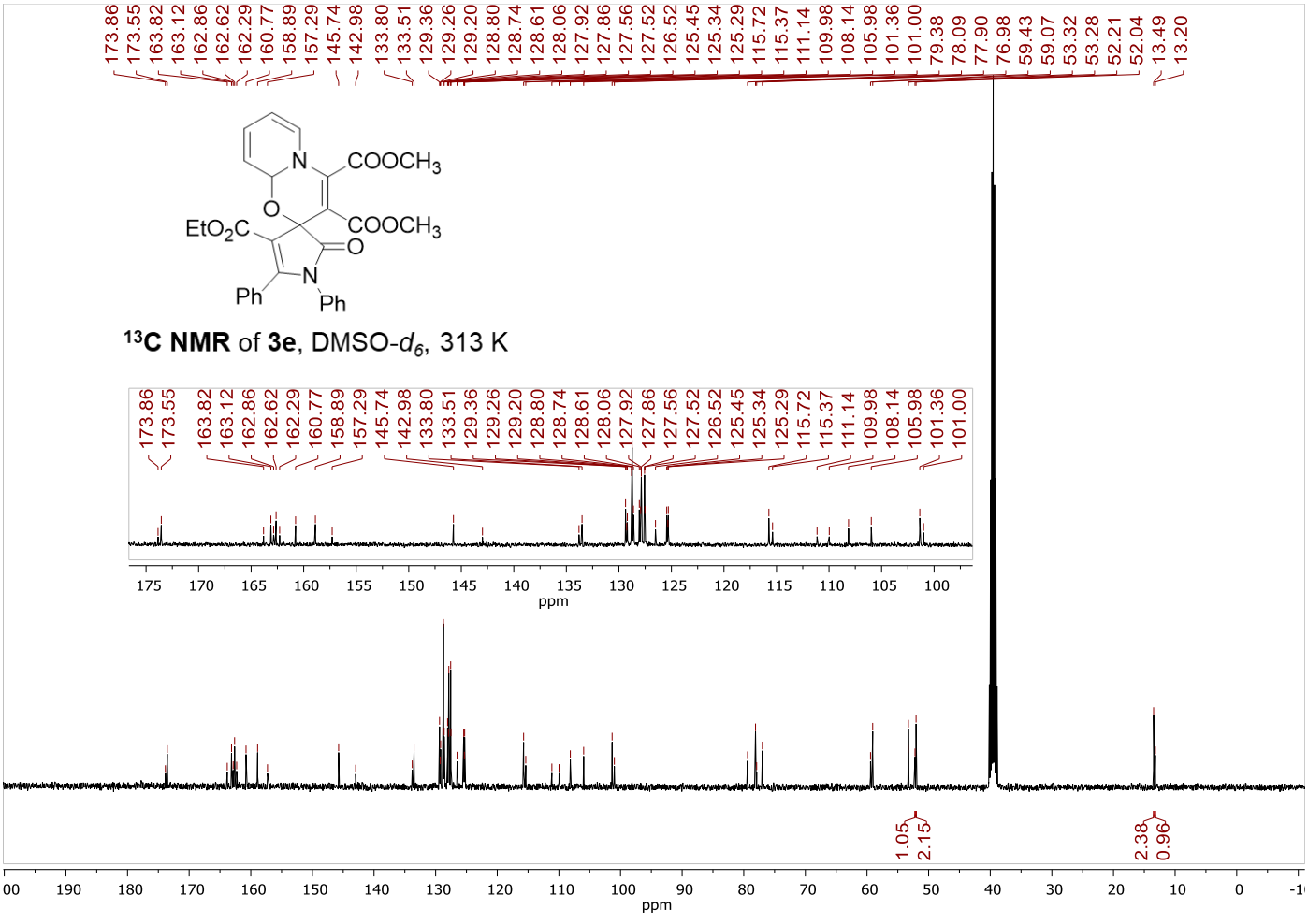
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O
N
Ph
Ph
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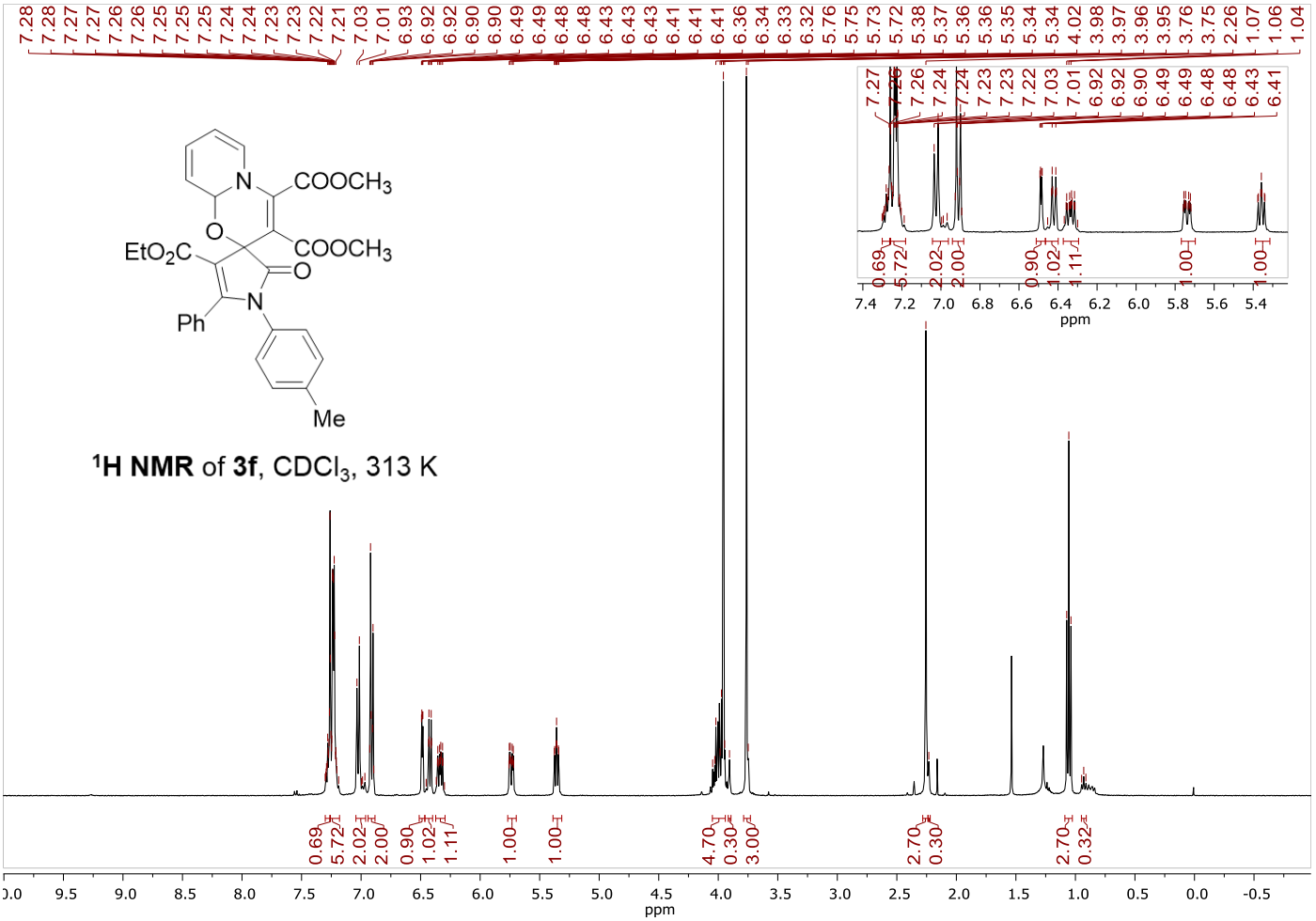
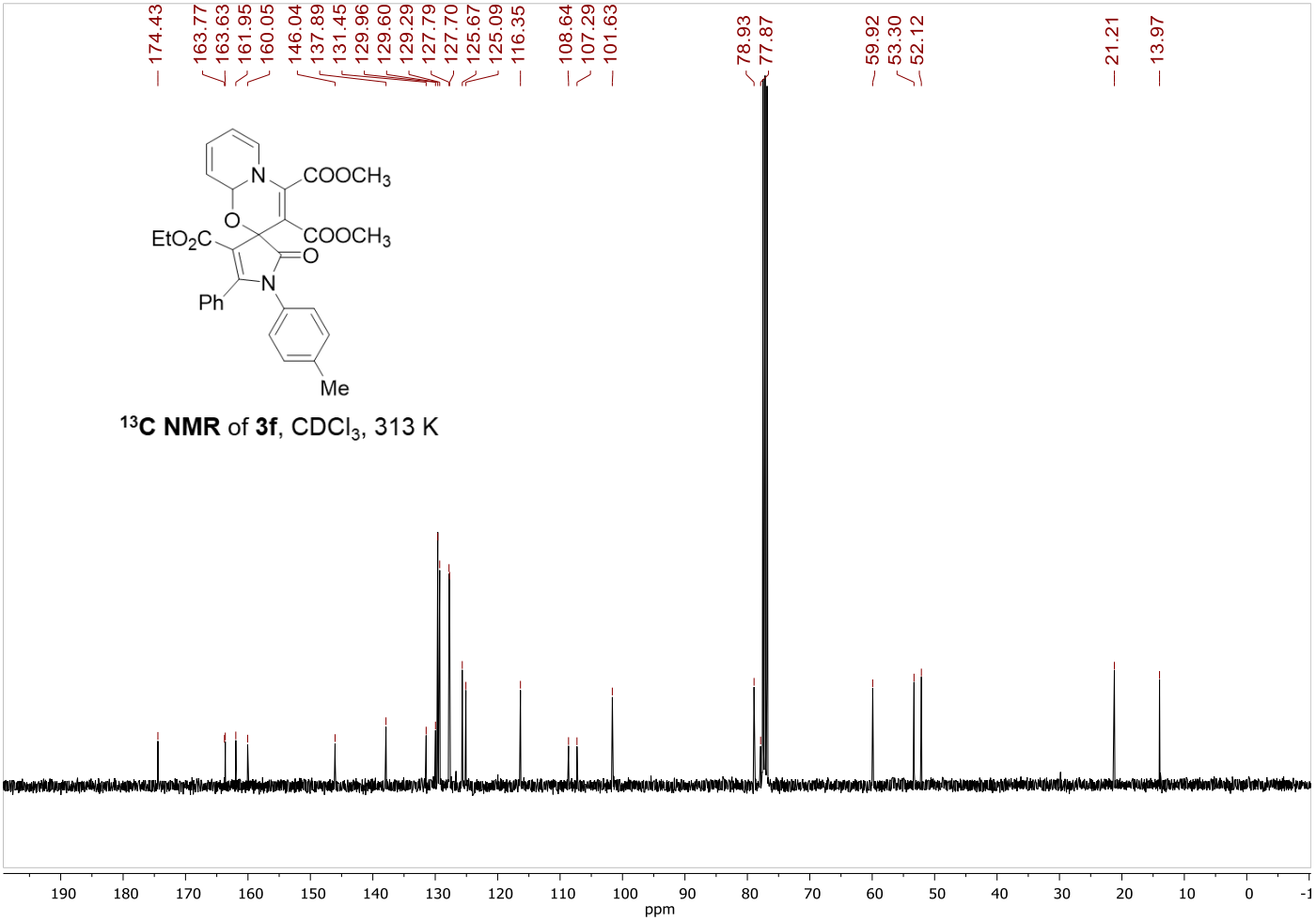
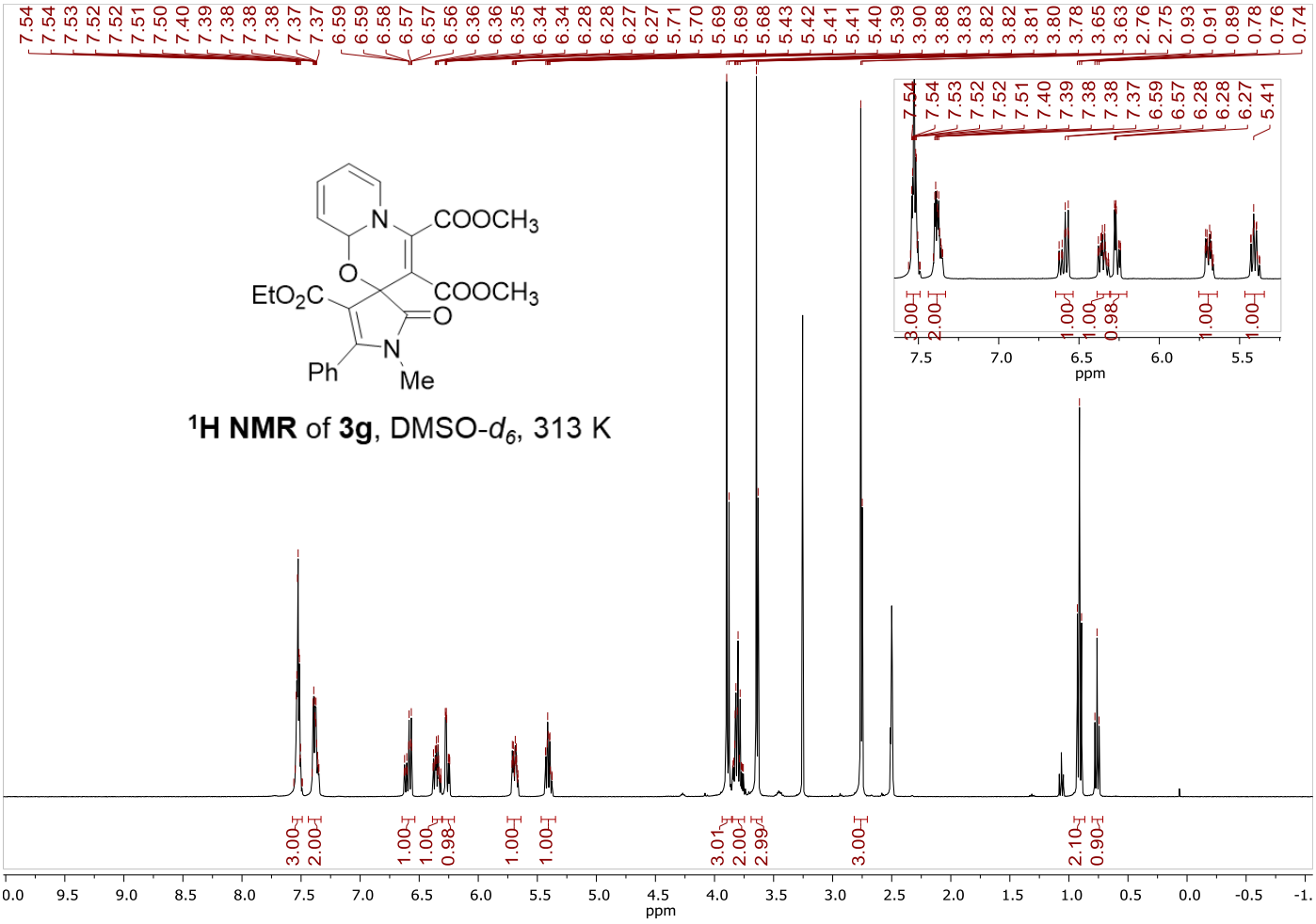
ppm

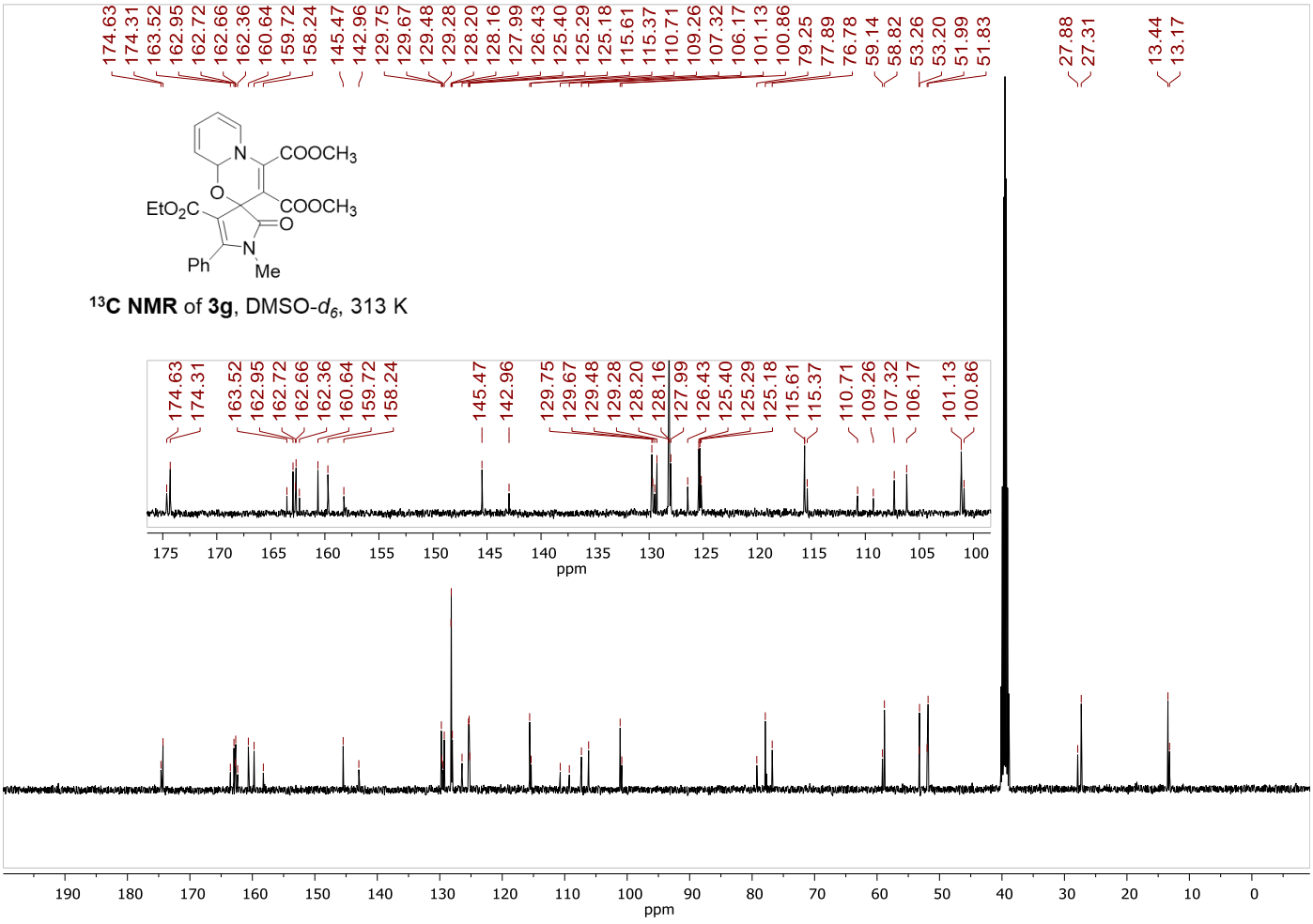
3.6. Copies of NMR spectra for product 3f



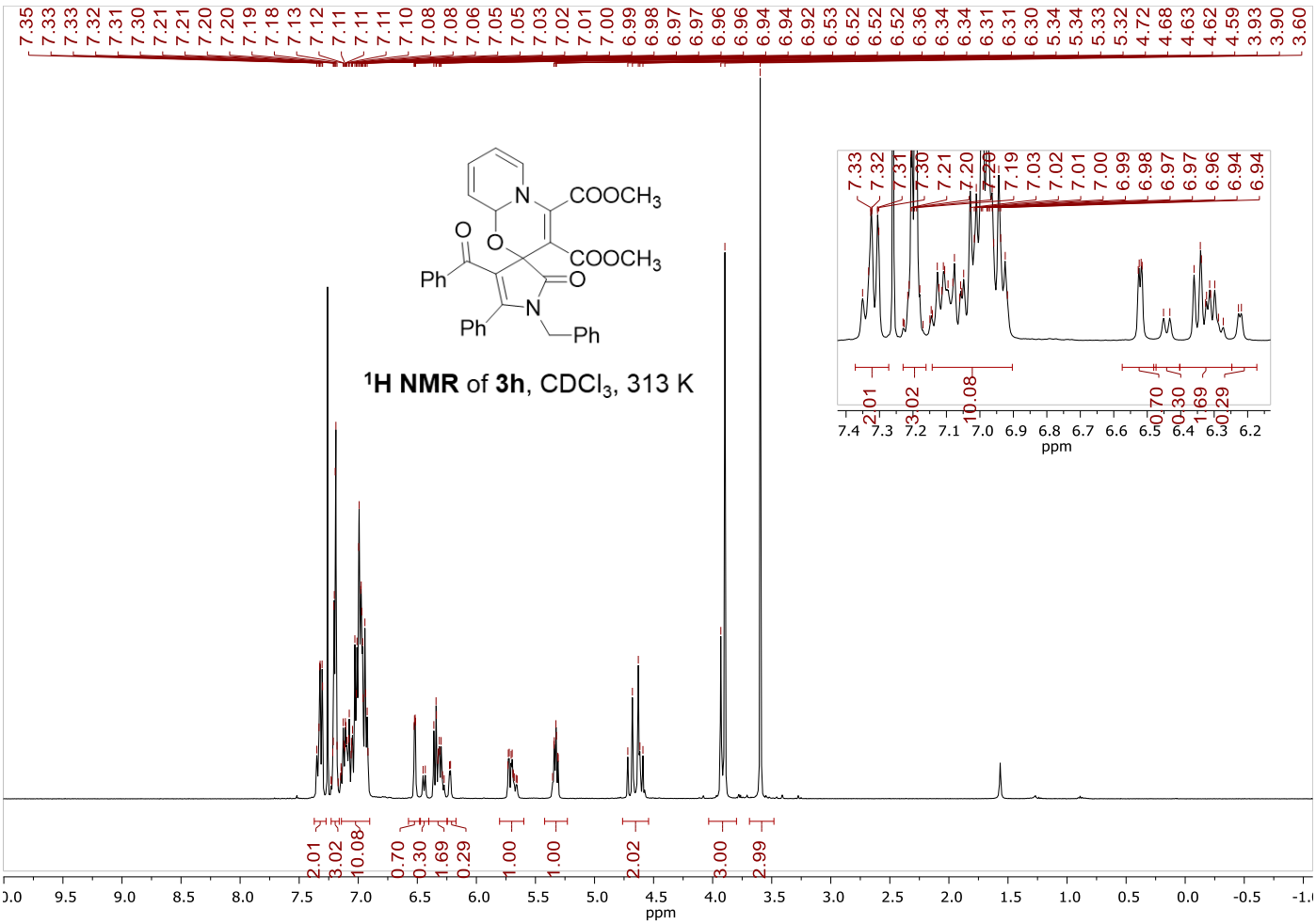


3.7. Copies of NMR spectra for product 3g

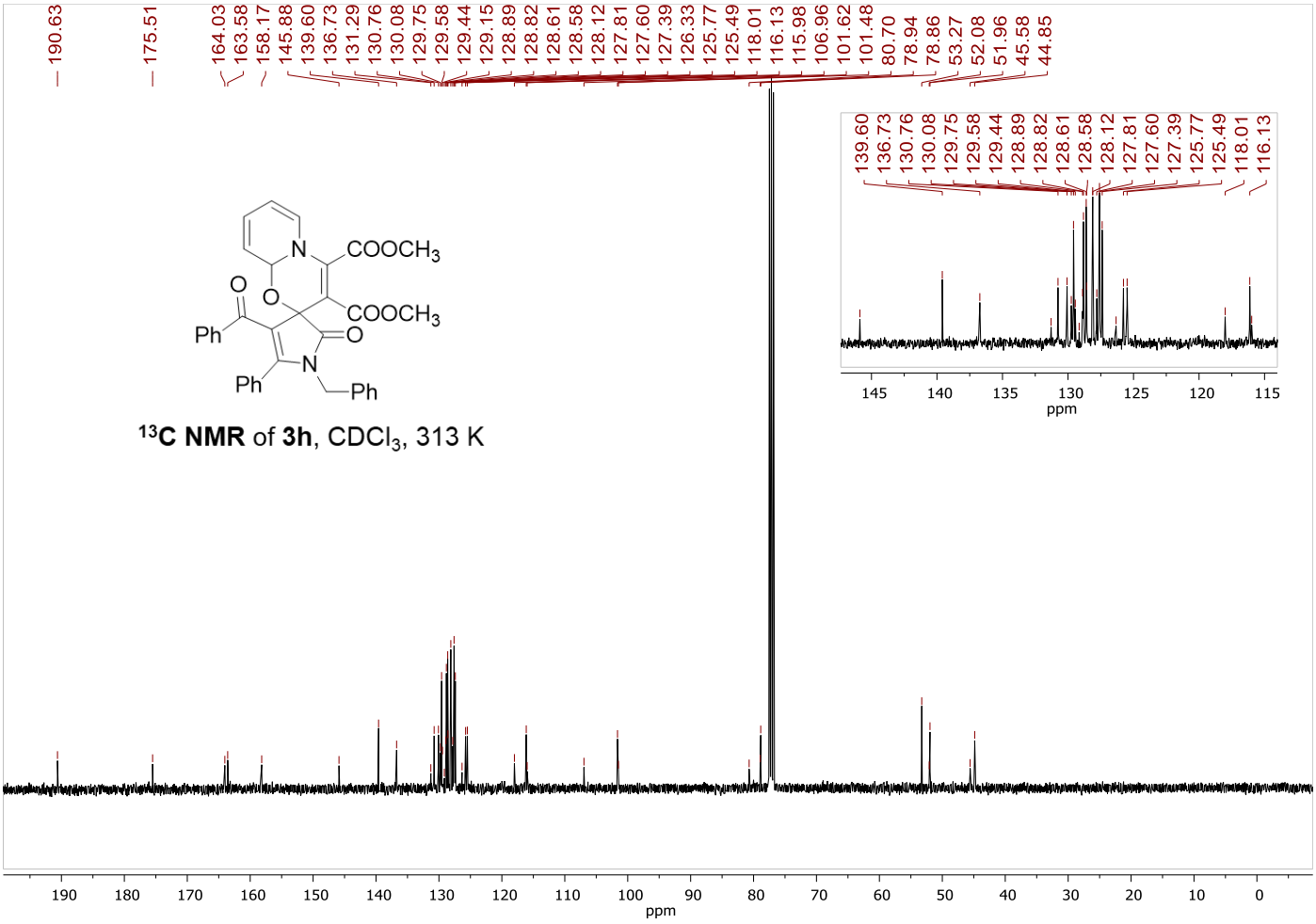




3.8. Copies of NMR spectra for product 3h

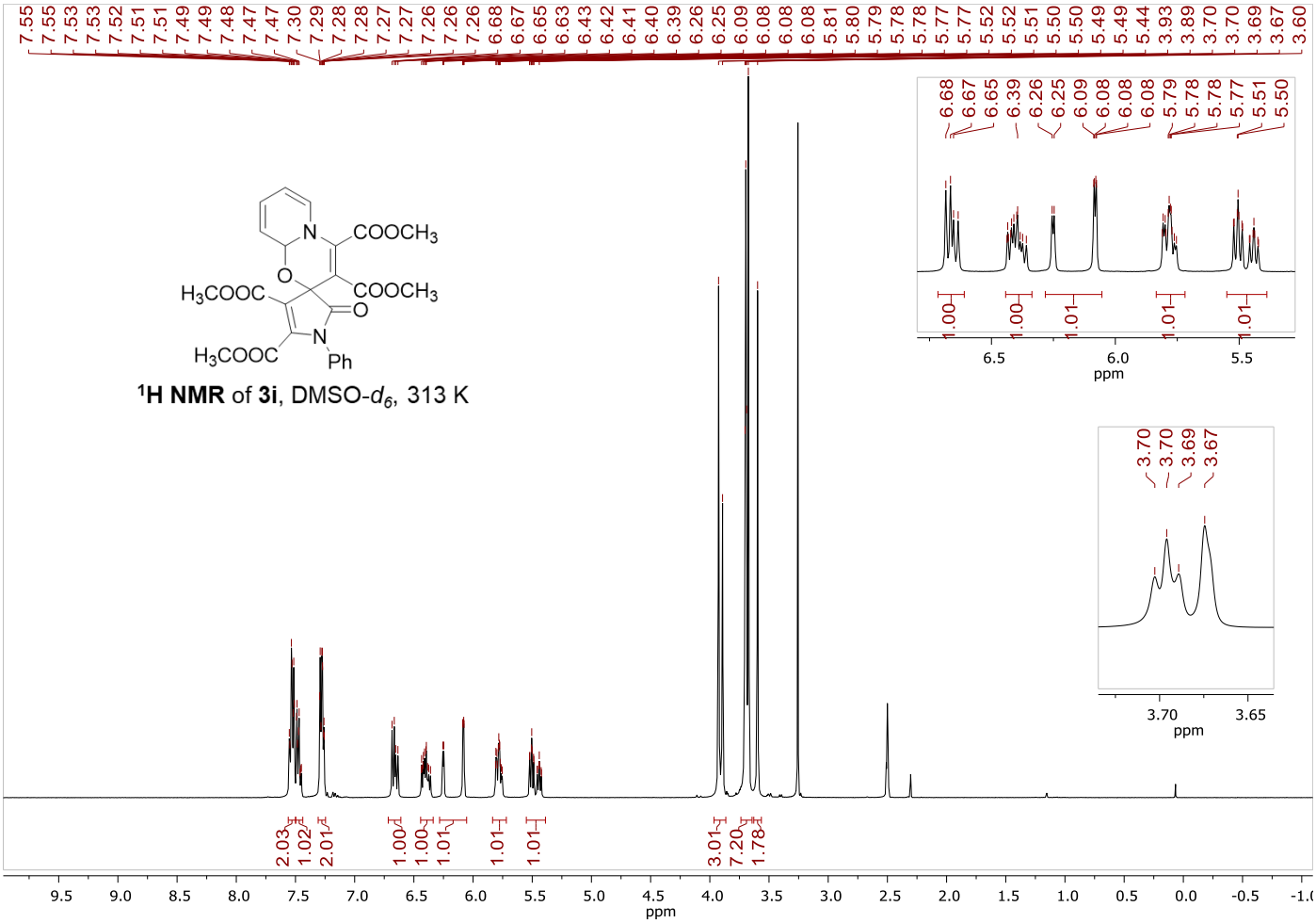


^{1}H NMR of **3h**, $CDCl_3$, 313 K

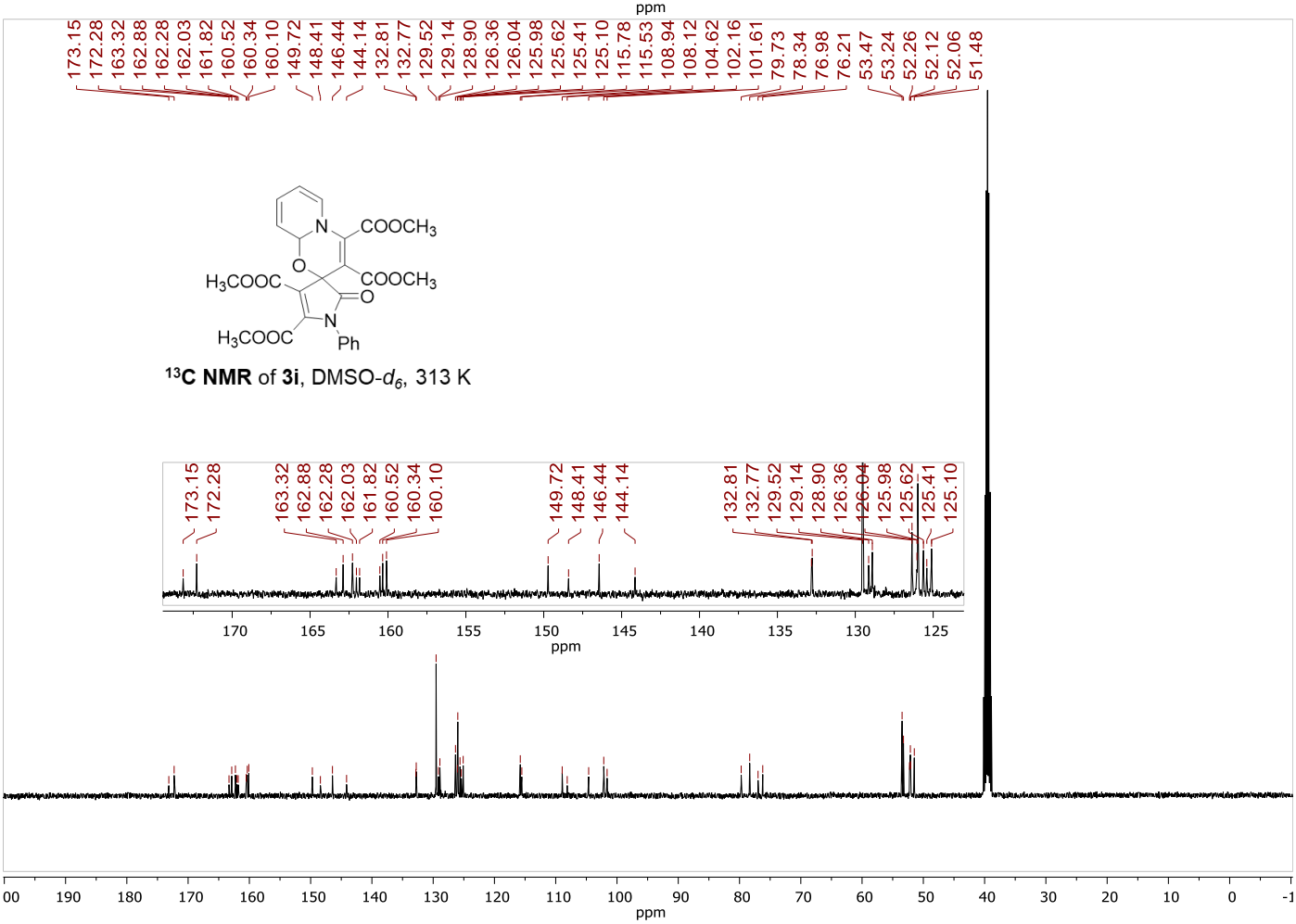


^{13}C NMR of **3h**, $CDCl_3$, 313 K

3.9. Copies of NMR spectra for product 3i

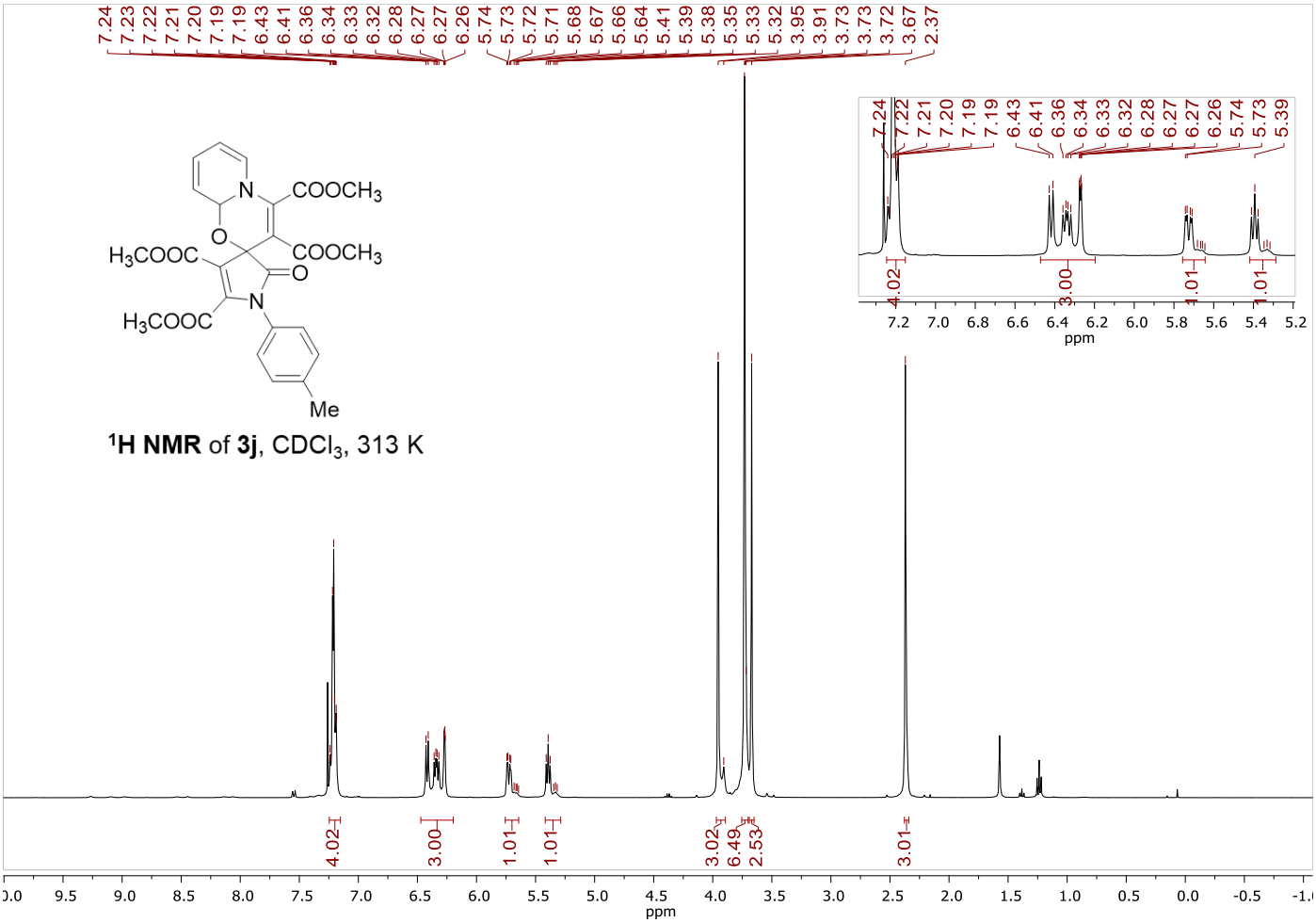


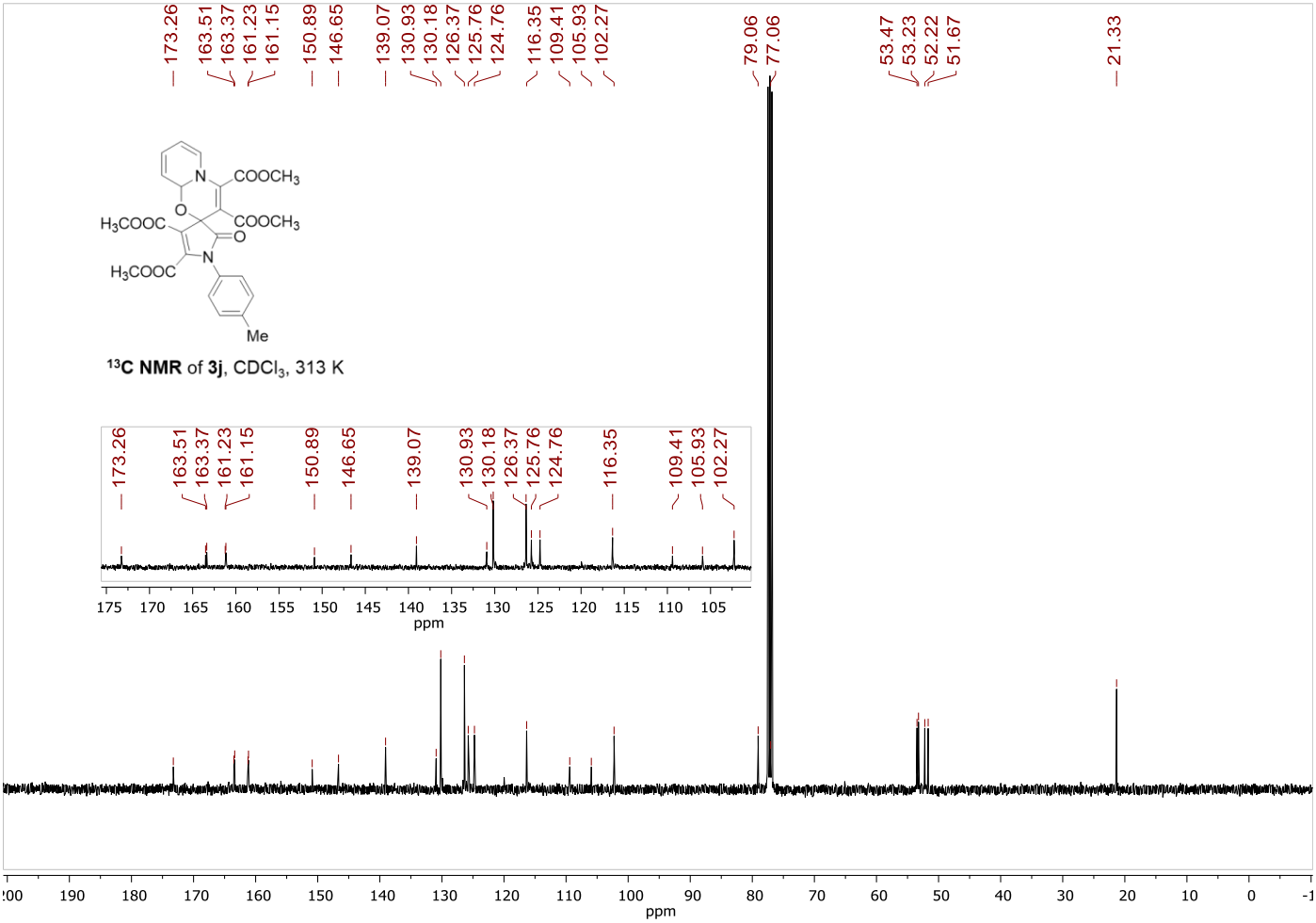
^{1}H NMR of **3i**, DMSO-d_6, 313 K



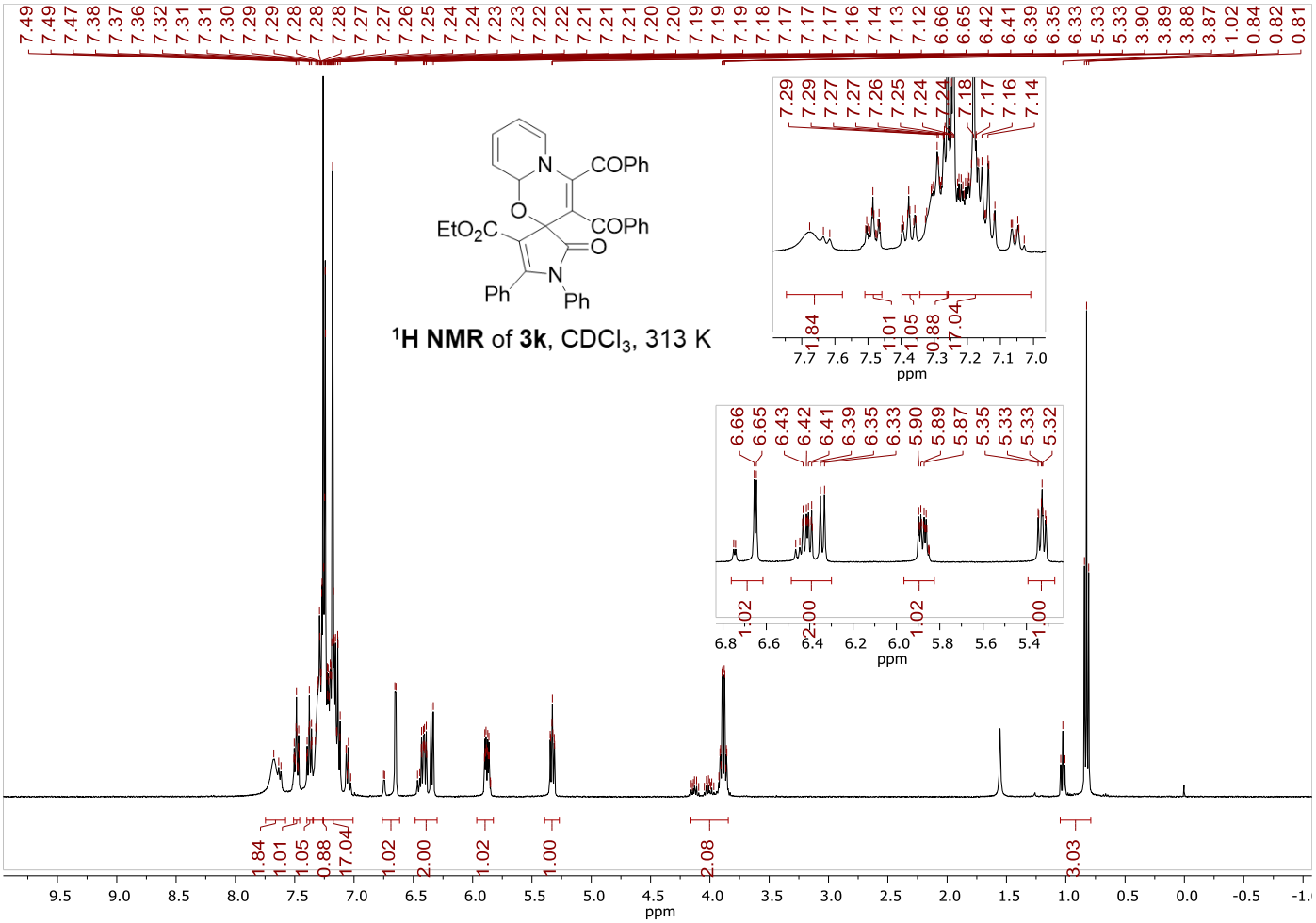
^{13}C NMR of **3i**, DMSO-d_6, 313 K

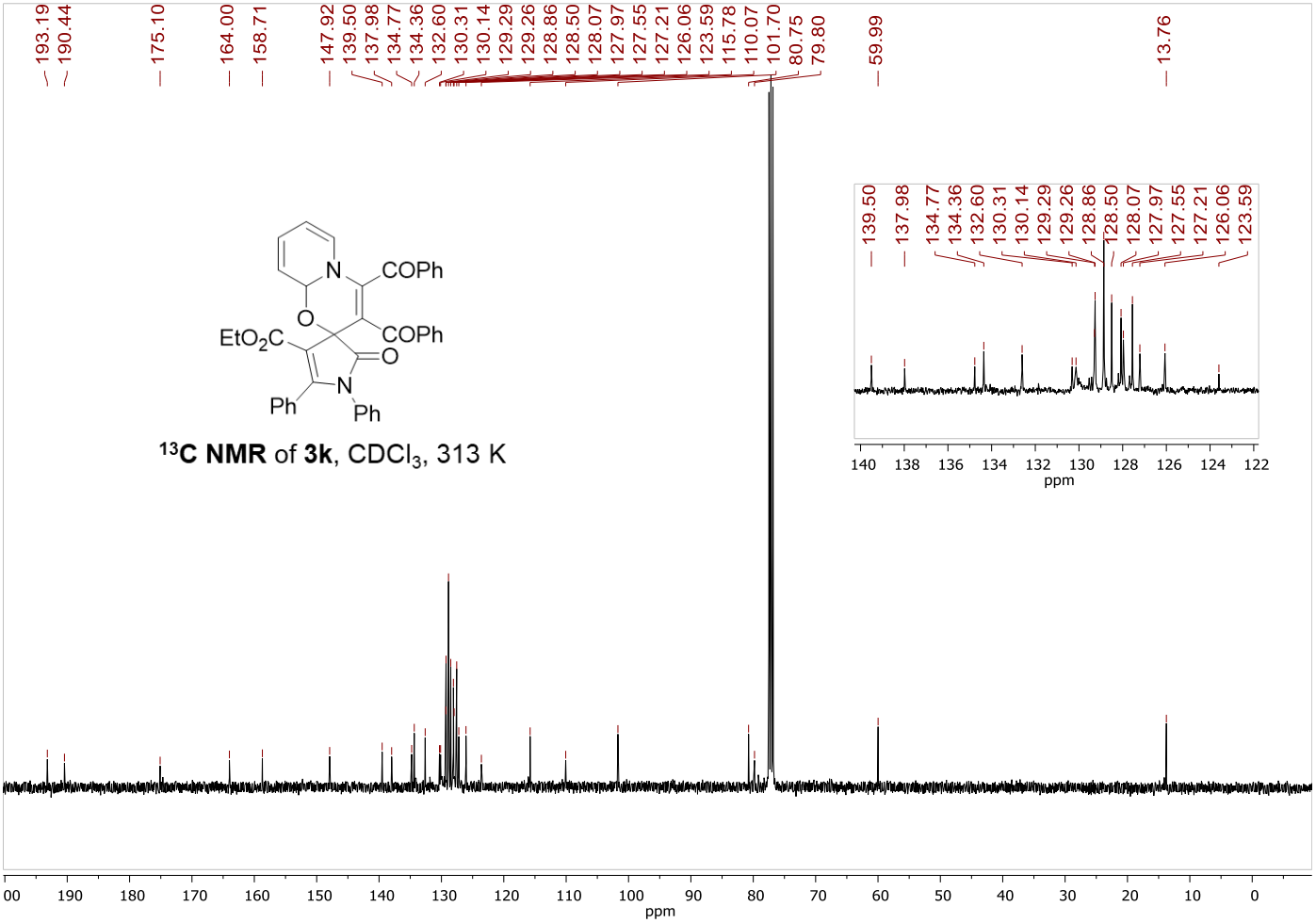
3.10. Copies of NMR spectra for product 3j





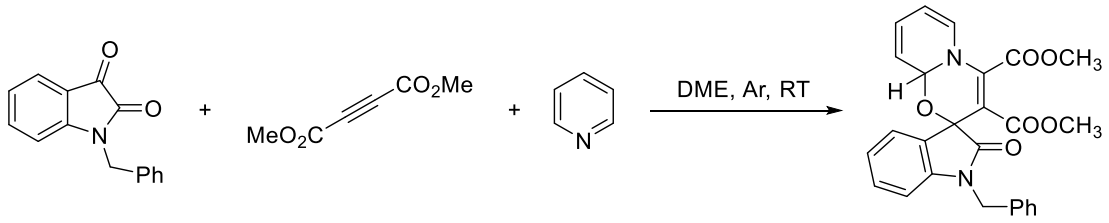
3.11. Copies of NMR spectra for product 3k





4. Synthesis, HPLC and NMR spectra of compounds 5a-c

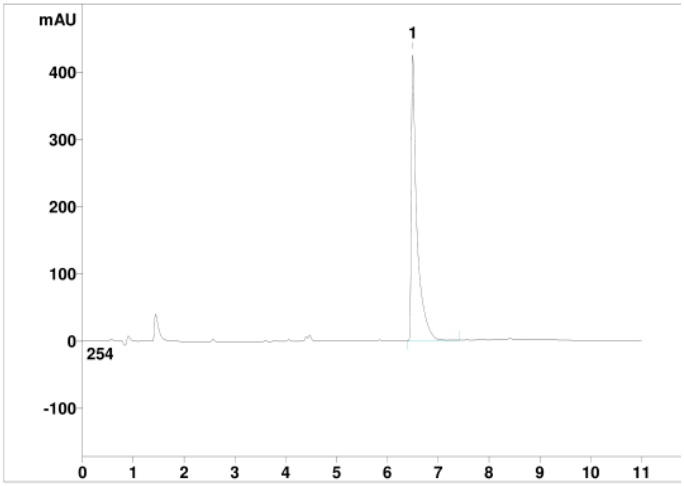
4.1. Synthesis of product 5a



2a **5a** (91%)

Dimethyl 1-benzyl-2-oxo-9a'*H*-spiro[indoline-3,2'-pyrido[2,1-*b*][1,3]oxazine]-3',4'-dicarboxylate (5a): The compound was prepared according to the modified (1.2 equiv. of DMAD and pyridine instead of 1.0 equiv.) reported procedure [12]: DMAD (78 µL, 0.64 mmol, 1.2 equiv.) and pyridine (64 µL, 0.64 mmol, 1.2 equiv.) were added to a solution of *N*-benzylisatin (126 mg, 0.53 mmol, 1 equiv.) in 1,2-dimethoxyethane (DME, 10 mL) under Ar atmosphere. The reaction mixture was stirred at RT for 1d. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH and hexane, affording a mixture of inseparable diastereomers as a pale-yellow solid (222 mg, 70% yield); R_f = 0.59 (Hex/EA 1:1); m.p. 179–181 °C (decomp.) [lit. not reported].

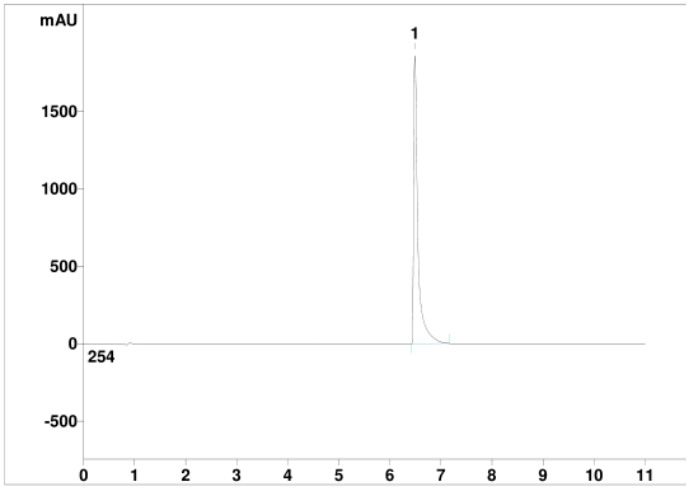
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.50	3235.044	100.00	

HPLC of the isolated product 5a



Quantitation method: Response normalization

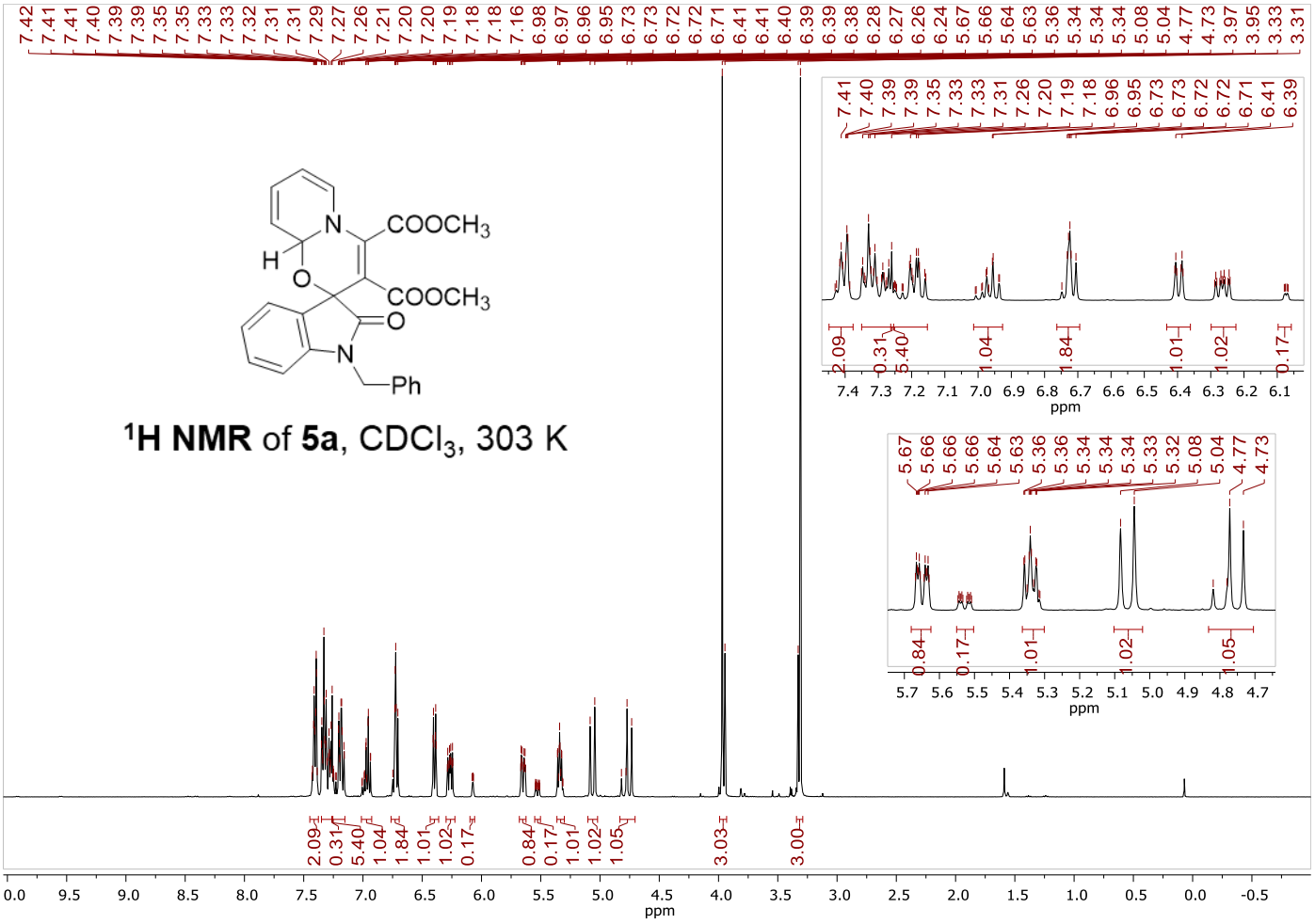
Peak	Retention min	Area mAU*sec	Area %	Component
1	6.49	10881.886	100.00	

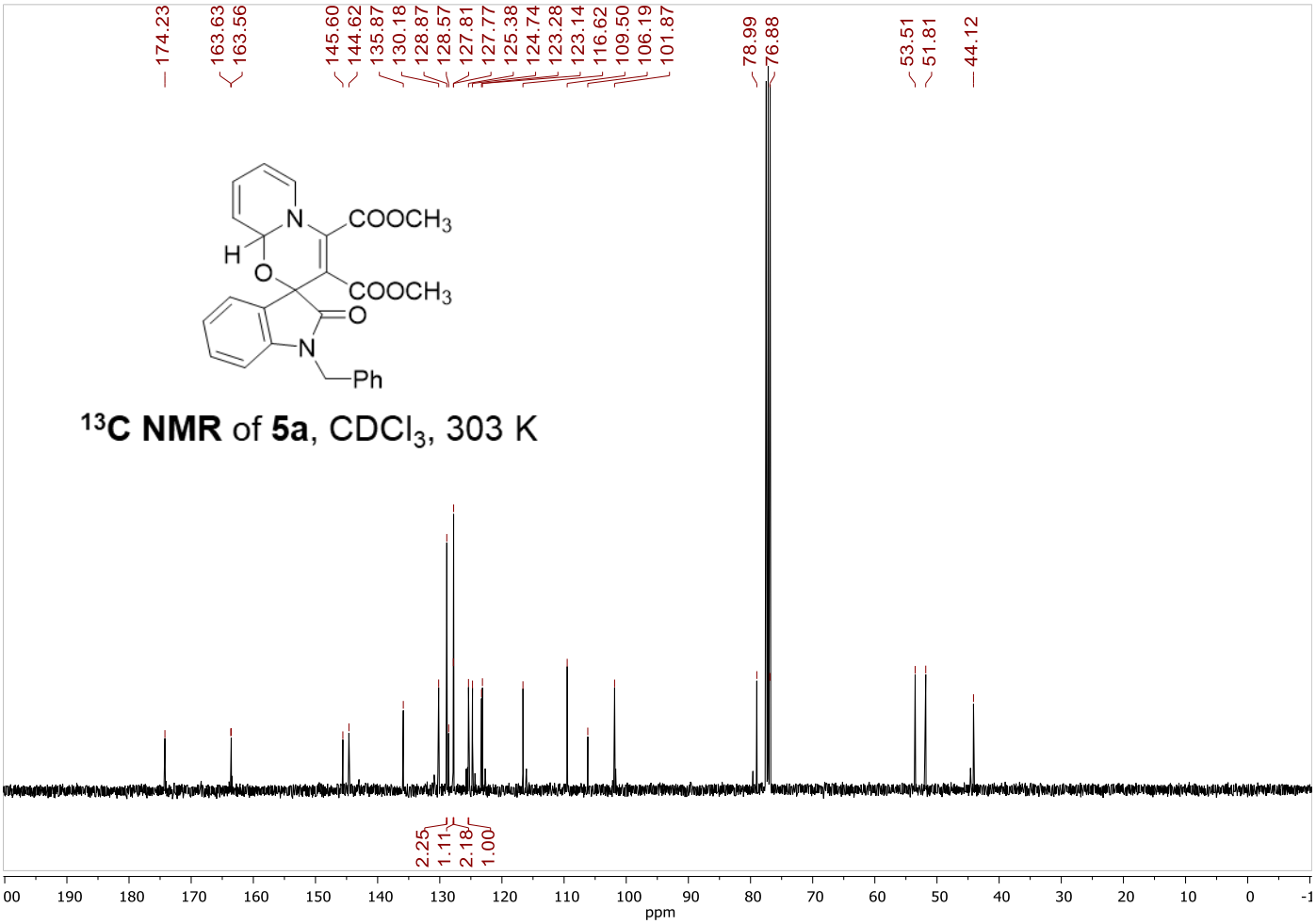
NMR spectra of 5a in $CDCl_3$: mixture of inseparable diastereomers, dr = ~ 4.8 : 1 (A : B) (the same dr was observed in K_2CO_3-treated-$CDCl_3$). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 7.43–7.38 (m, 2H, A + B), 7.36–7.13 (m, 5H, A + B), 7.01–6.89 (m, 1H, A + B), 6.76–6.68 (m, 1.83H, A + B), 6.40 (d[A], *J* = 7.5, 1H, A + B), 6.26 (dd, *J* = 10.0, 6.0 Hz, 1H, A + B), 6.07 (dd, *J* = 3.2, 1.3 Hz, 0.17H, B), 5.65 (dd, *J* = 10.0, 3.3 Hz, 0.83H, A), 5.53 (dd, *J* = 9.9, 3.3 Hz, 0.17H, B), 5.37–5.28 (m, 1H, A + B), 5.06 (d[A], *J* = 15.6 Hz, 1H, A + B), 4.80 (d, *J* = 15.6 Hz, 0.17H, B), 4.75 (d, *J* = 15.7 Hz, 0.83H, A), 3.97 (s, 2.48H, A), 3.95 (s, 0.52H, B), 3.33 (s, 0.52H, B), 3.31 (s, 2.48H, A). **^{13}C NMR (101 MHz, $CDCl_3$)**:

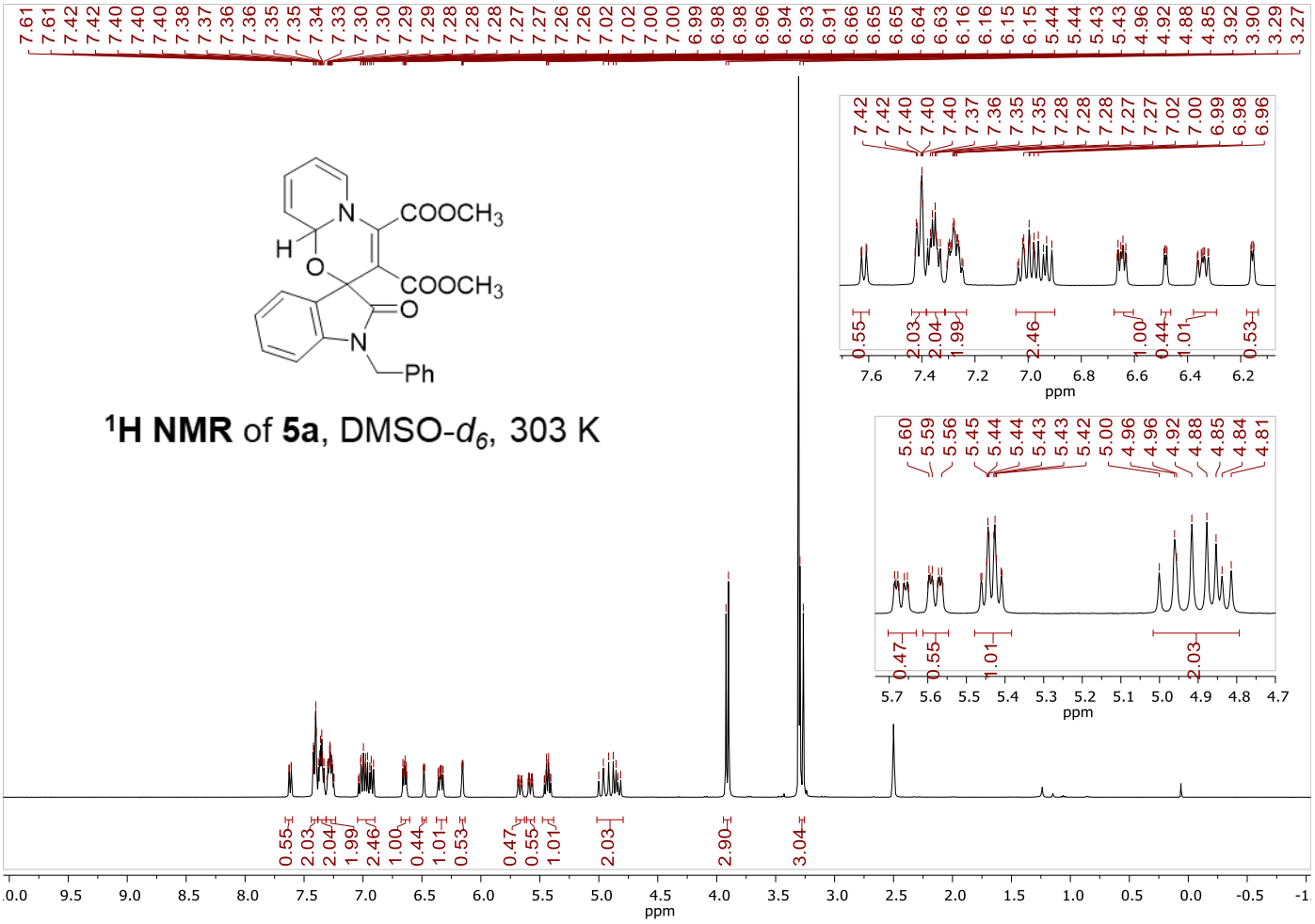
δ (A, major) = 174.2, 163.63, 163.56, 145.6, 144.6, 135.9, 130.2, 128.9 (2C), 128.6, 127.8 (2C), 127.8, 125.4, 124.7, 123.3, 123.1, 116.6, 109.5, 106.2, 101.9, 79.0, 76.9, 53.5, 51.8, 44.1.

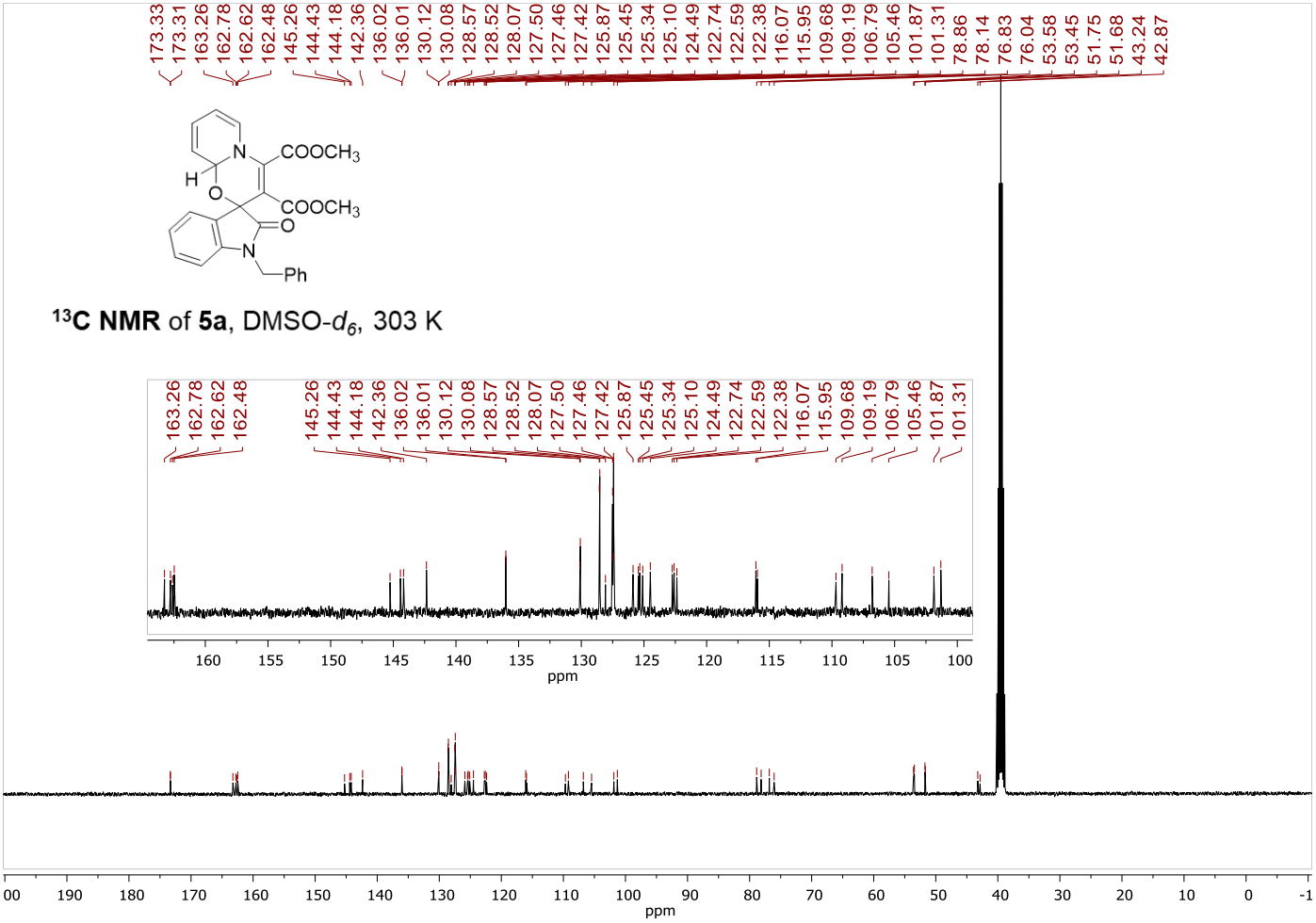
NMR spectra of 5a in DMSO-*d*$_6$: mixture of inseparable diastereomers, dr = ~ 1.2 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-*d*$_6$)**: δ = 7.62 (dd, *J* = 7.4, 1.2 Hz, 0.55H, A), 7.43–7.39 (m, 2H, A + B), 7.38–7.32 (m, 2H, A + B), 7.31–7.22 (m, 2H, A + B), 7.05–6.85 (m, 2.45H, A + B), 6.70–6.58 (m, 1H, A + B), 6.48 (dd, *J* = 3.3, 1.3 Hz, 0.45H, B), 6.41–6.25 (m, 1H, A + B), 6.16 (dd, *J* = 3.4, 1.2 Hz, 0.55H, A), 5.67 (dd, *J* = 9.9, 3.2 Hz, 0.45H, B), 5.58 (dd, *J* = 9.9, 3.4 Hz, 0.55H, A), 5.50–5.35 (m, 1H, A + B), 5.03–4.73 (m, 2H, A + B), 3.92 (s, 1.36H, B), 3.90 (s, 1.64H, A), 3.29 (s, 1.64H, A), 3.27 (s, 1.36H, B). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)**: δ (A + B) = 173.33, 173.31, 163.3, 162.8, 162.6, 162.5, 145.3, 144.4, 144.2, 142.4, 136.02, 136.01, 130.12, 130.08, 128.57 (2C), 128.52 (2C), 128.07, 127.50 (2C), 127.46, 127.42 (4C), 125.9, 125.5, 125.3, 125.1, 124.5, 122.7, 122.6, 122.4, 116.1, 116.0, 109.7, 109.2, 106.8, 105.5, 101.9, 101.3, 78.9, 78.2, 76.8, 76.0, 53.6, 53.5, 51.8, 51.7, 43.2, 42.9.

4.1.1. Copies of NMR spectra for product 5a

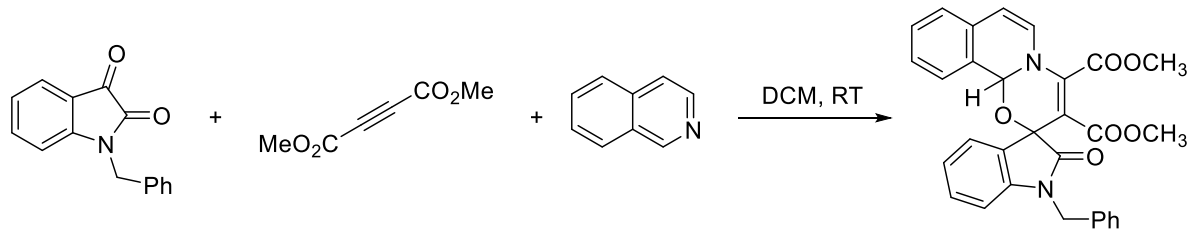





COOCH3
COOCH3
O
N
H
O
N
Ph
1H NMR of 5a, DMSO-d6, 303 K
ppm


COOCH3
COOCH3
O
N
H
O
N
Ph
13C NMR of 5a, DMSO-d6, 303 K
ppm

4.2. Synthesis of product 5b

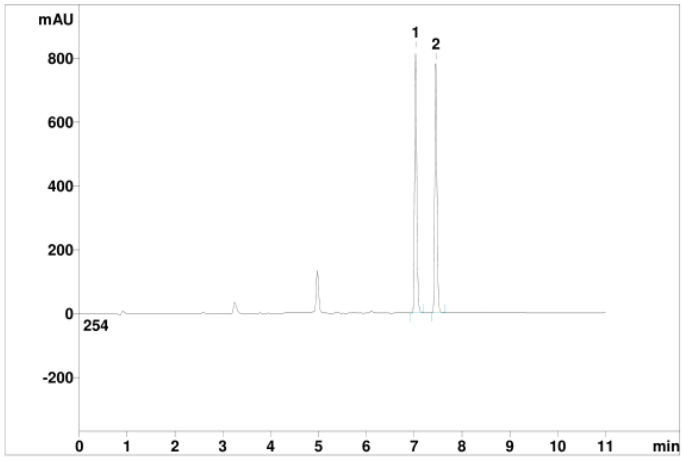


2a **5b** (86%)

Dimethyl 1-benzyl-2-oxo-11b'*H*-spiro[indoline-3,2'-[1,3]oxazino[2,3-*a*]isoquinoline]-3',4'-dicarboxylate (5b): The compound was prepared according to the reported procedure [13]: DMAD (125 µL, 1 mmol, 1.0 equiv.) and isoquinoline (120 µL, 1 mmol, 1.0 equiv.) were added to a solution of *N*-benzylisatin (237 mg, 1.0 mmol, 1 equiv.) in dichloromethane (DCM, 15 mL). The reaction was stirred at RT for 2d. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH and hexane, affording a mixture of inseparable* diastereomers as a pale-yellow solid (436 mg, 86% yield); R_f = 0.57 + 0.66 (Hex/EA 1:1); m.p. 217–219 °C (decomp.) [lit. 235–237 °C].

* *inseparable by crystallization, however separation via column chromatography is possible*

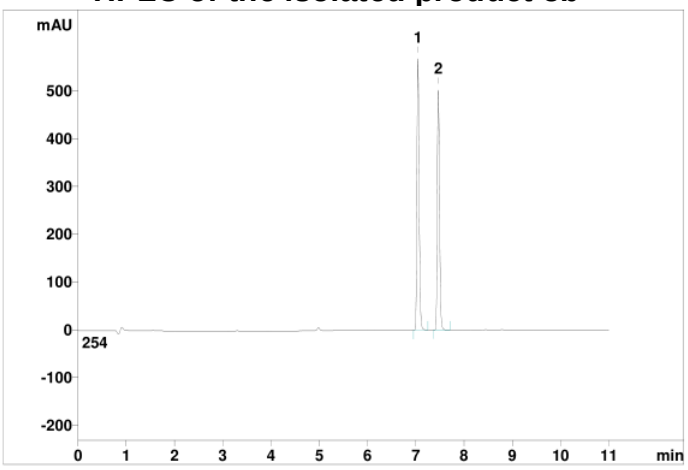
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	7.03	2607.848	50.85	
2	7.45	2520.505	49.15	
2	11.00	5128.353	100.00	

HPLC of the isolated product 5b



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	7.04	1813.654	52.88	
2	7.46	1616.168	47.12	
2	11.00	3429.822	100.00	

NMR spectra of 5b in $CDCl_3$: mixture of inseparable diastereomers, dr = ~ 4.8 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 7.47–7.40 (m, 2.17H, A + B), 7.38–7.25 (m, 5H, A + B), 7.24–6.99 (m, 4.83H, A + B), 6.94 (t, *J* = 7.5 Hz, 0.83H, A), 6.79 (d, *J* = 7.9 Hz, 0.17H, B), 6.74 (d, *J* = 7.8 Hz, 0.83H, A), 6.53 (s, 0.17H, B), 6.43 (d[A], *J* = 7.7 Hz, 1H, A + B), 5.84 (d, *J* = 7.7 Hz, 0.83H, A), 5.83 (d, *J* = 7.7 Hz, 0.17H, B), 5.09 (d, *J* = 15.6 Hz, 1H, A + B), 4.87 (d, *J* = 15.6 Hz, 0.83H, A), 4.78 (d, *J* = 15.7 Hz, 0.17H, B), 4.00 (s, 2.48H, A), 3.98 (s, 0.52H, B), 3.35 (s, 0.52H, B), 3.33 (s, 2.48H, A). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (A, major) = 174.8, 163.8, 163.7, 145.6, 144.4, 135.9, 130.2, 129.9, 129.7,

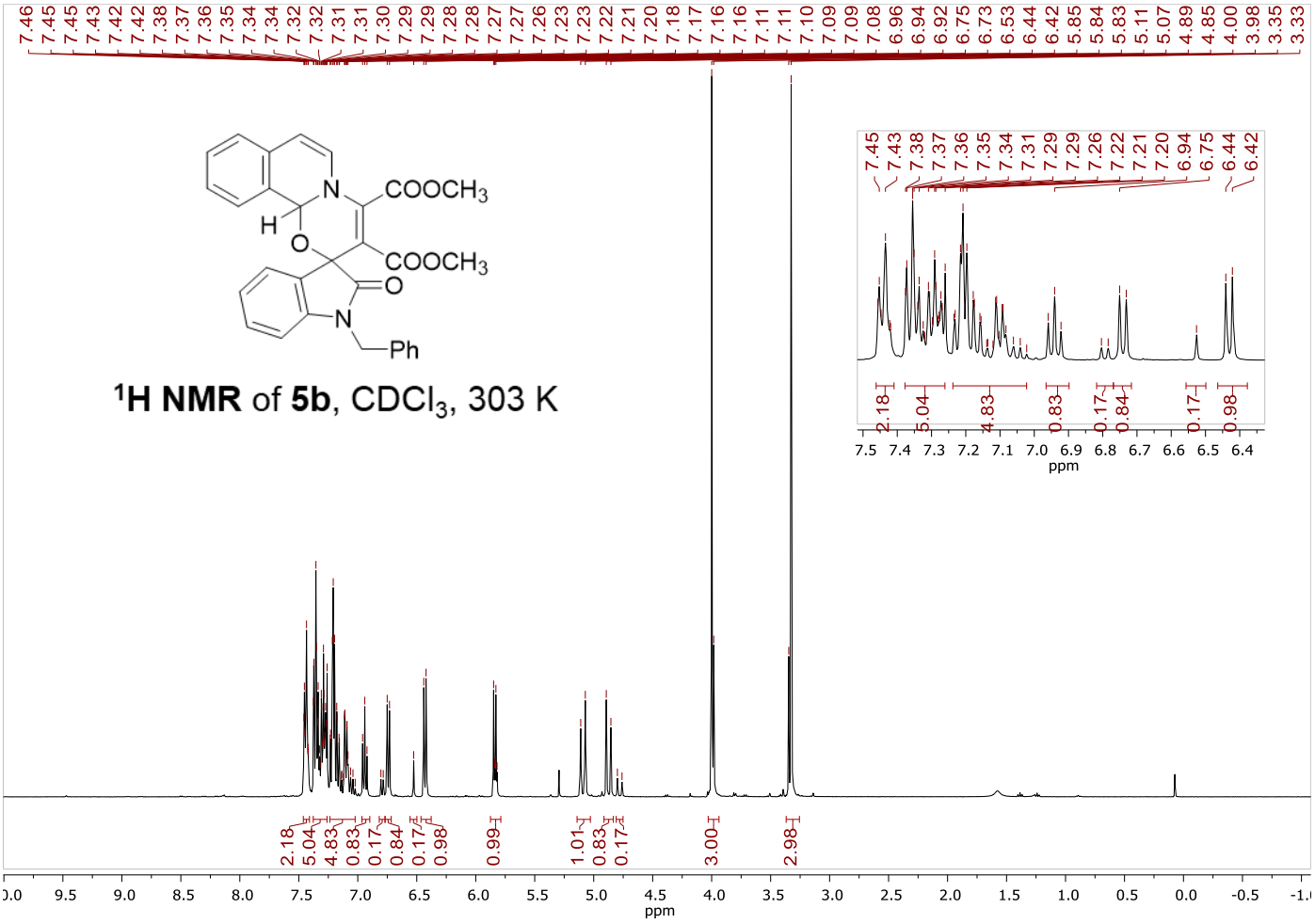
128.9 (2C), 128.7, 128.2, 127.8, 127.7 (2C), 127.3, 126.3, 125.4, 123.5, 123.3, 123.2, 109.4, 105.4, 105.1, 79.7, 77.6, 53.6, 51.8, 44.1.

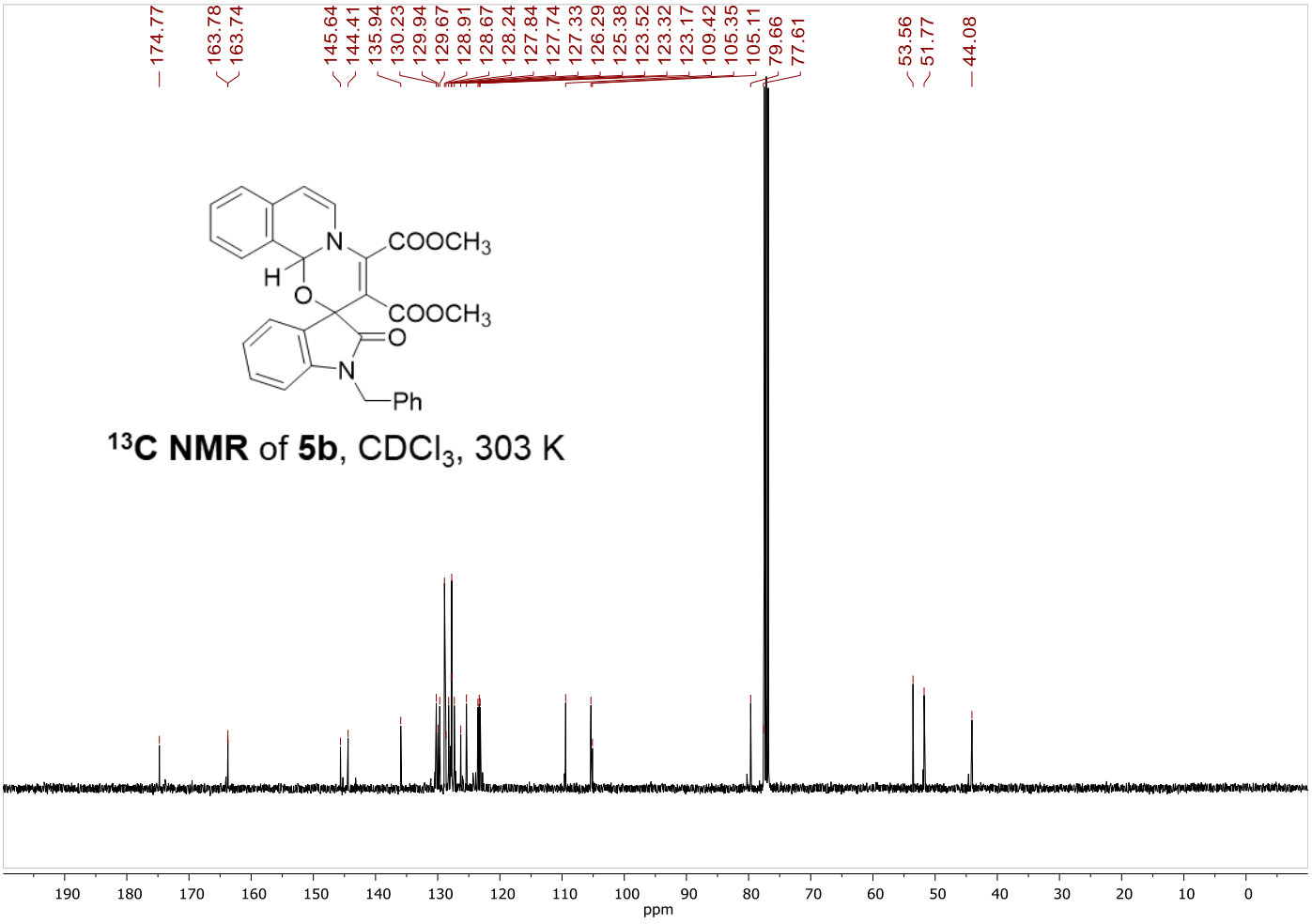
NMR spectra of 5b in K_2CO_3-treated-$CDCl_3$: mixture of inseparable diastereomers, dr = ~ 1:1 (A* : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 7.46–7.40 (m, 2.5H, A + B), 7.39–7.26 (m, 5H, A + B), 7.24–7.01 (m, 4.5H, A + B), 6.94 (t, *J* = 7.5 Hz, 0.5H, A), 6.79 (d, *J* = 7.8 Hz, 0.5H, B), 6.74 (d, *J* = 7.8 Hz, 0.5H, A), 6.53 (s, 0.5H, B), 6.43 (d, *J* = 7.7 Hz, 0.5H, A), 6.43 (d, *J* = 7.8 Hz, 0.5H, B), 5.84 (d, *J* = 7.7 Hz, 0.5H, A), 5.83 (d, *J* = 7.8 Hz, 0.5H, B), 5.10 (d, *J* = 15.7 Hz, 0.5H, B), 5.09 (d, *J* = 15.6 Hz, 0.5H, A), 4.87 (d, *J* = 15.6 Hz, 0.5H, B), 4.78 (d, *J* = 15.6 Hz, 0.5H, A), 4.00 (s, 1.5H, A), 3.98 (s, 1.5H, B), 3.35 (s, 1.5H, B), 3.33 (s, 1.5H, A). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (A*, major) = 174.8, 163.78, 163.74, 145.6, 144.4, 135.94, 130.2, 129.9, 129.7, 128.9 (2C), 128.7, 128.2, 127.84, 127.7 (2C), 127.3, 126.3, 125.38, 123.5, 123.3, 123.2, 109.4, 105.4, 105.1, 79.7, 77.6, 53.6, 51.8, 44.1. **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (B, minor) = 173.8, 164.0, 163.66, 145.2, 143.2, 135.87, 131.1, 130.4, 130.1, 129.8, 128.8 (2C), 127.9 (2C), 127.79, 127.1, 126.3, 126.0, 125.37, 124.3, 123.9, 122.8, 109.6, 105.2, 105.0, 80.3, 78.3, 53.6, 52.0, 44.6

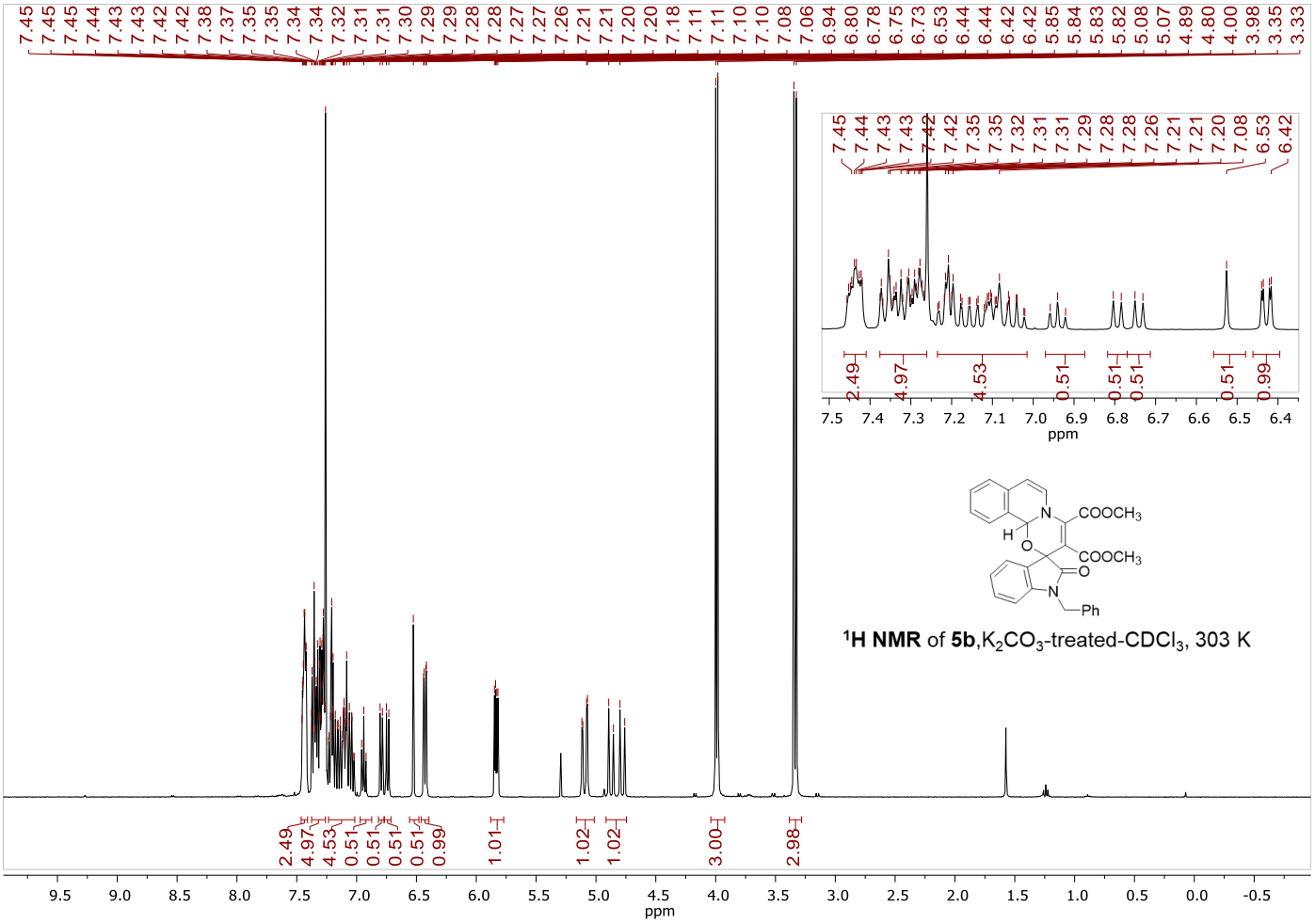
** "A" denotes major diastereomer in acidic $CDCl_3$*

NMR spectra of 5b in DMSO-d_6: mixture of inseparable diastereomers, dr = ~ 1:1 (A : B). **^{1}H NMR (400 MHz, DMSO-d_6)**: δ = 7.81 (d, *J* = 7.2 Hz, 0.5H, A / B), 7.50–7.24 (m, 8.5H, A + B), 7.23–7.16 (m, 1H, A + B), 7.10–6.94 (m, 3H, A + B), 6.93–6.86 (m, 0.5H, A), 6.71 (d, *J* = 5.2 Hz, 0.5H, A / B), 6.69 (d, *J* = 5.2 Hz, 0.5H, A / B), 6.67 (s, 0.5H, A / B), 6.01 (d, *J* = 7.8 Hz, 0.5H, A / B), 6.00 (d, *J* = 7.7 Hz, 0.5H, A / B), 5.09–4.75 (m, 2H, A + B), 3.96 (s, 1.5H, A / B), 3.93 (s, 1.5H, A / B), 3.31 (s, 1.5H, A / B), 3.30 (s, 1.5H, A / B). **^{13}C NMR (101 MHz, DMSO-d_6)**: δ (A + B) = 173.9, 173.0, 163.4, 162.9, 162.7, 162.6, 145.3, 144.5, 144.0, 142.5, 136.1, 136.0, 130.2 (2C), 129.8, 129.7, 129.6, 129.5, 128.6 (2C), 128.5 (2C), 128.0, 127.7, 127.5, 127.45 (5C), 127.4, 127.35, 127.2, 126.9, 125.5, 125.38, 125.36, 125.1, 124.7, 124.5, 123.9, 122.8, 122.7, 122.6, 109.7, 109.4, 105.8, 104.8, 104.3, 104.2, 79.4, 78.6, 77.7, 76.8, 53.6, 53.5, 51.72, 51.65, 43.3, 42.8.

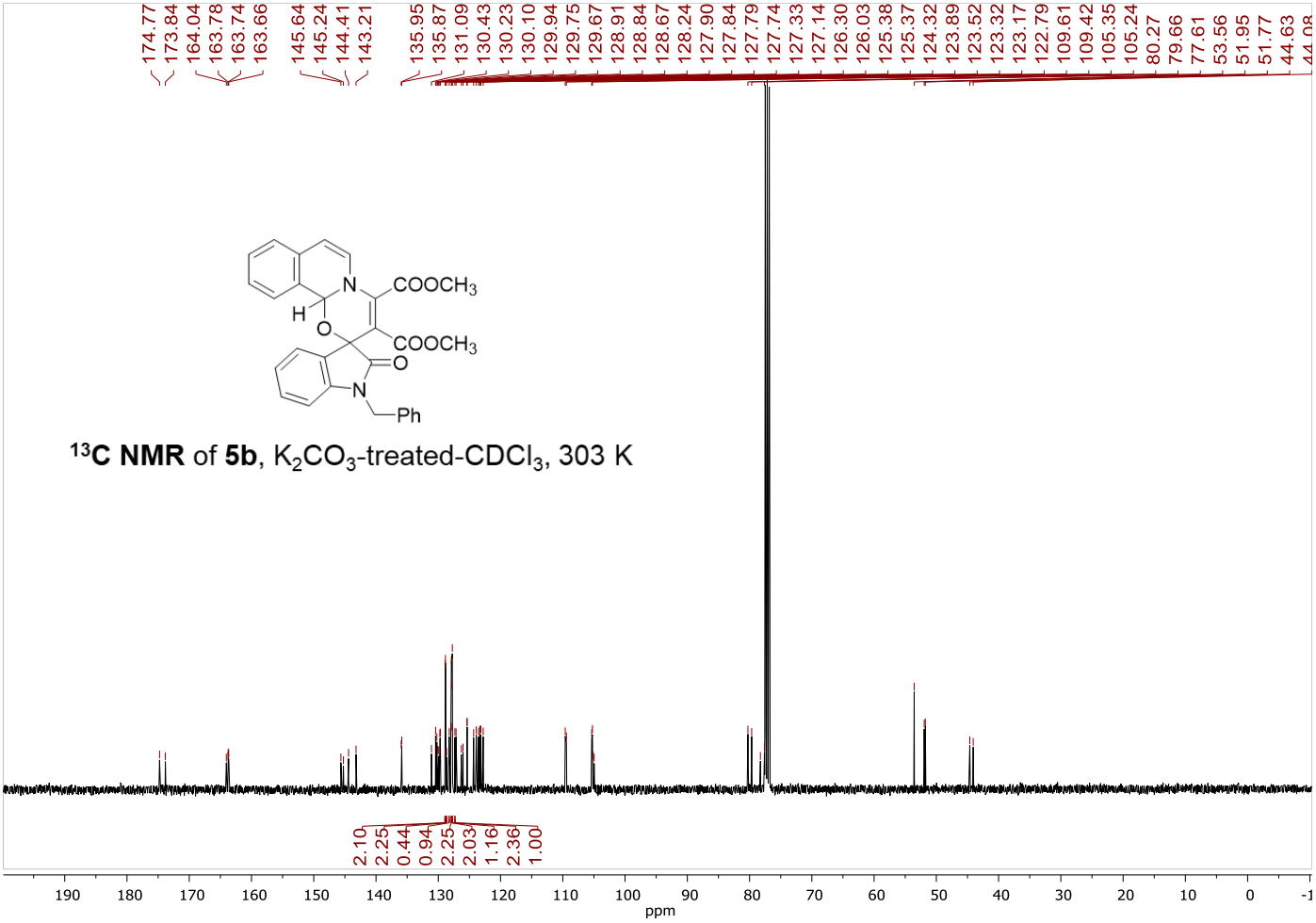
4.2.1. Copies of NMR spectra for product 5b



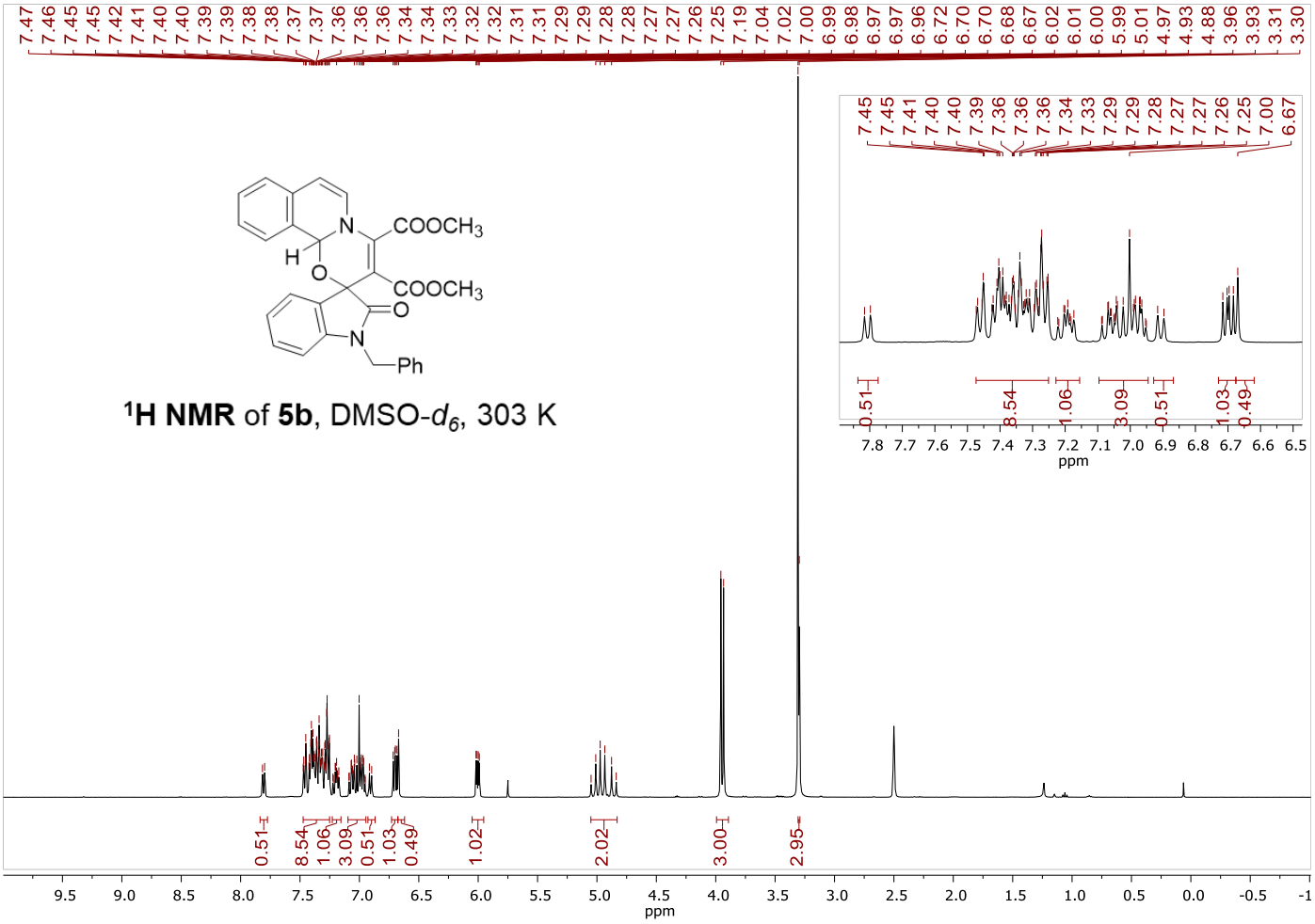




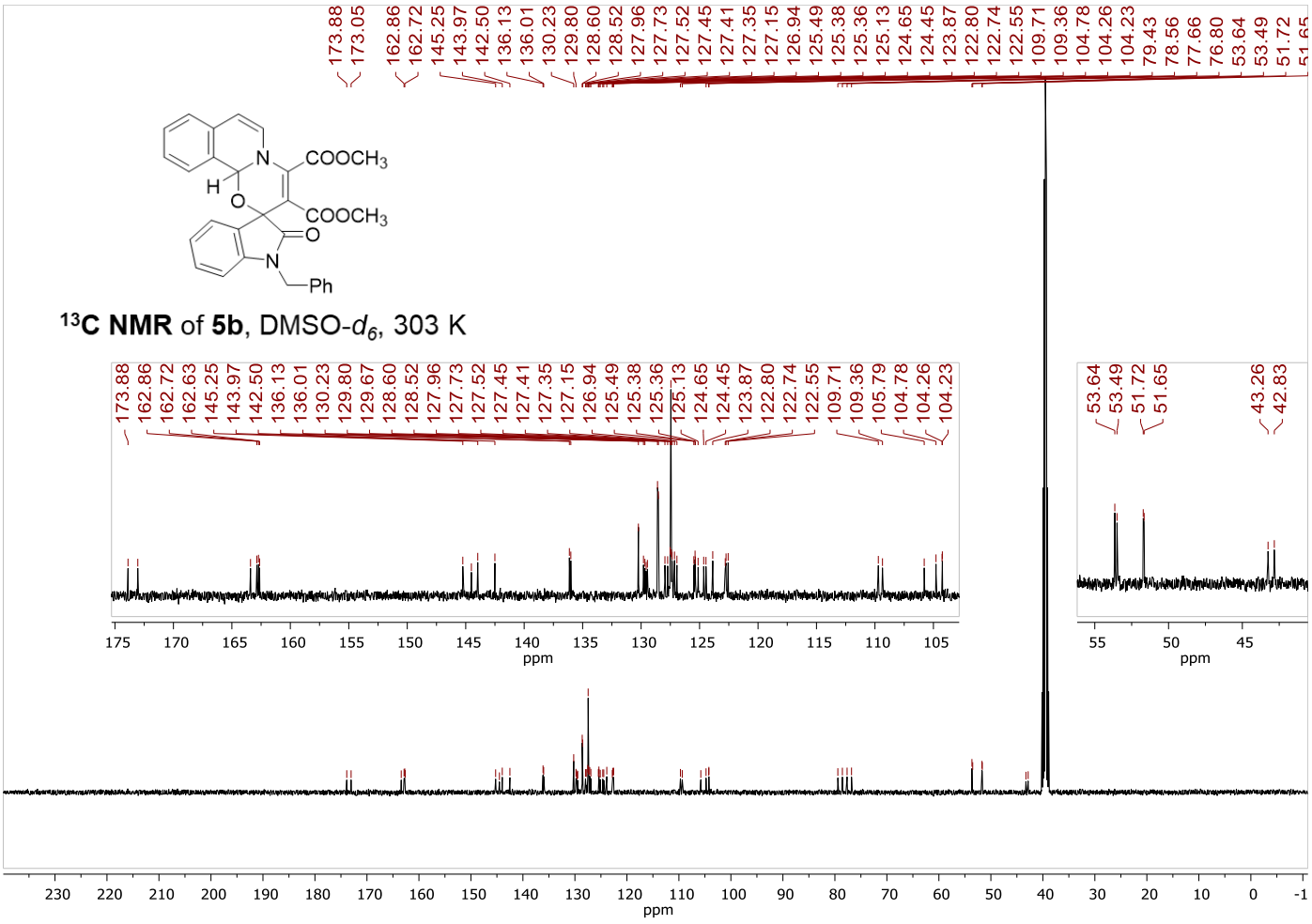
^{1}H NMR of **5b**,K_2CO_3-treated-$CDCl_3$, 303 K



^{13}C NMR of **5b**, K_2CO_3-treated-$CDCl_3$, 303 K

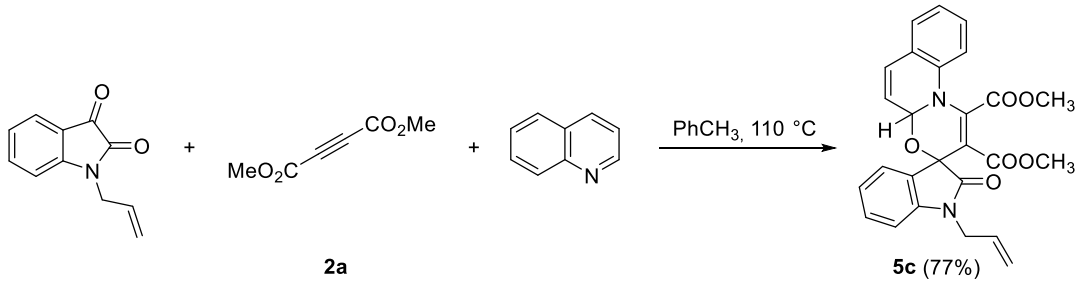


^{1}H NMR of **5b**, DMSO-d_6, 303 K



^{13}C NMR of **5b**, DMSO-d_6, 303 K

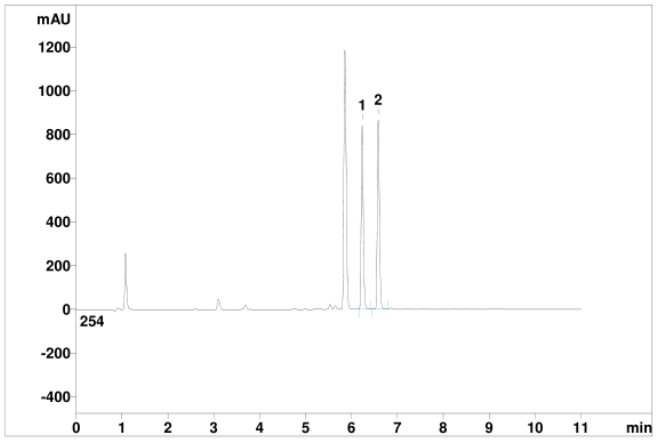
4.3. Synthesis of product 5c



Dimethyl 1-allyl-2-oxo-4a'*H*-spiro[indoline-3,3'-[1,3]oxazino[3,2-*a*]quinoline]-1',2'-dicarboxylate (5c): The compound was prepared according to the reported procedure [14]: DMAD (65 µL, 0.53 mmol, 1.2 equiv.) and quinoline (63 µL, 0.53 mmol, 1.2 equiv.) were added to a solution of *N*-allylisatin (82 mg, 0.44 mmol, 1 equiv.) in toluene (3 mL). The reaction mixture* was heated at 110 °C for 12h. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH and hexane, affording a mixture of inseparable** diastereomers as an off-white solid (156 mg, 77% yield); R_f = 0.57 + 0.61 (Hex/EA 1:1)***; m.p. 185–188 °C (decomp.) [lit. 164–166 °C].

** reaction was performed in a screw capped reaction vial placed in a preheated heating block*
*** inseparable by crystallization, however separation via column chromatography is possible*
**** in original report, compound was purified by column chromatography (Hex/EA 90:10), however R_f in this system is around zero*

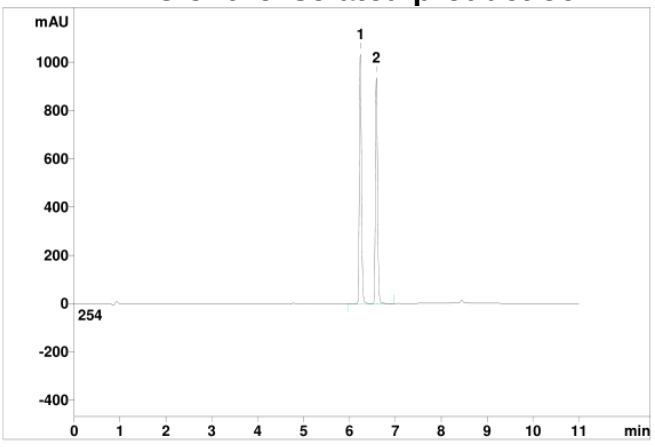
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.23	2704.001	48.72	
2	6.58	2845.784	51.28	
2	11.00	5549.785	100.00	

HPLC of the isolated product 5c



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.23	3304.880	51.94	
2	6.58	3058.291	48.06	
2	11.00	6363.172	100.00	

NMR spectra of 5c in $CDCl_3$: mixture of inseparable diastereomers, dr = ~ 1 : 1 (A : B) (the same dr was observed in K_2CO_3-treated-$CDCl_3$). **^{1}H NMR (400 MHz, $CDCl_3$):** δ = 7.38–7.17 (m, 3.5H, A + B), 7.07–6.98 (m, 2.5H, A + B), 6.97–6.87 (m, 1H, A + B), 6.86–6.74 (m, 2H, A + B), 6.15 (d, *J* = 4.3 Hz, 0.5H, A / B), 5.99 (dd, *J* = 9.9, 4.3 Hz, 0.5H, A / B), 5.92–5.77 (m, 1.5H, A + B), 5.67 (d, *J* = 4.3 Hz, 0.5H, A / B), 5.41–5.32 (m, 1H, A + B), 5.29–5.19 (m, 1H, A + B), 4.47–4.35 (m, 1H, A + B), 4.31–4.16 (m, 1H, A + B), 3.90 (s, 1.5H, A / B), 3.88 (s, 1.5H, A / B), 3.59 (s, 1.5H, A / B), 3.44 (s,

1.5H). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (A + B) = 173.7, 172.2, 164.6, 164.4, 163.8, 163.7, 144.7, 144.6, 143.3, 142.2, 135.8, 135.6, 131.3, 131.2, 130.6, 130.3, 130.0, 129.9 (2C), 129.7, 129.3, 128.8, 128.5, 128.1, 123.7, 123.2, 123.1, 123.0, 122.7, 122.5, 122.0, 121.9, 121.4, 119.8, 118.7, 118.2, 118.0, 117.8, 115.4, 114.4, 109.6, 109.6, 79.64, 79.62, 78.9, 78.6, 53.4, 53.3, 52.4, 52.3, 43.2, 42.6.

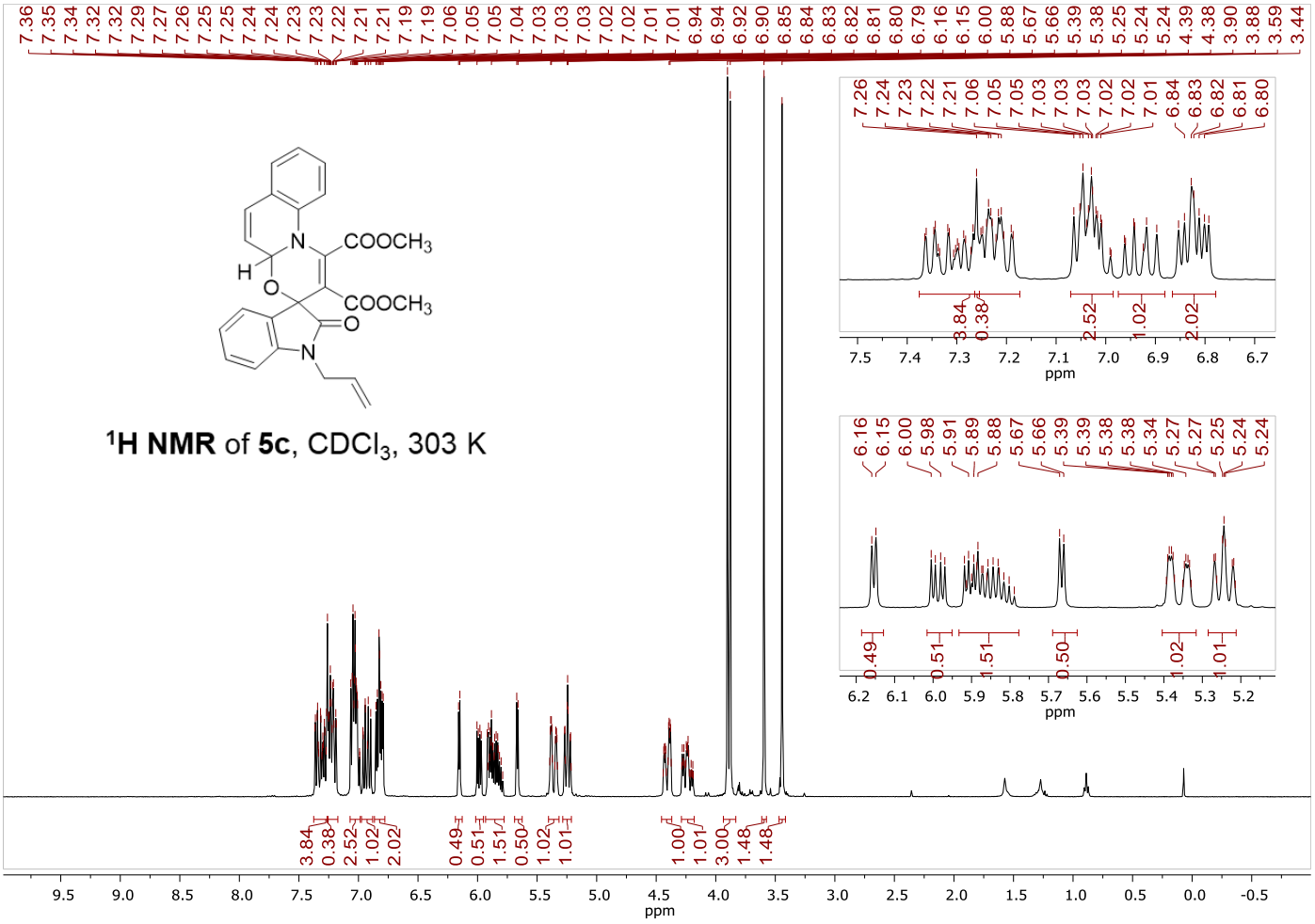
***Note**: no change in dr was observed after 12d.*

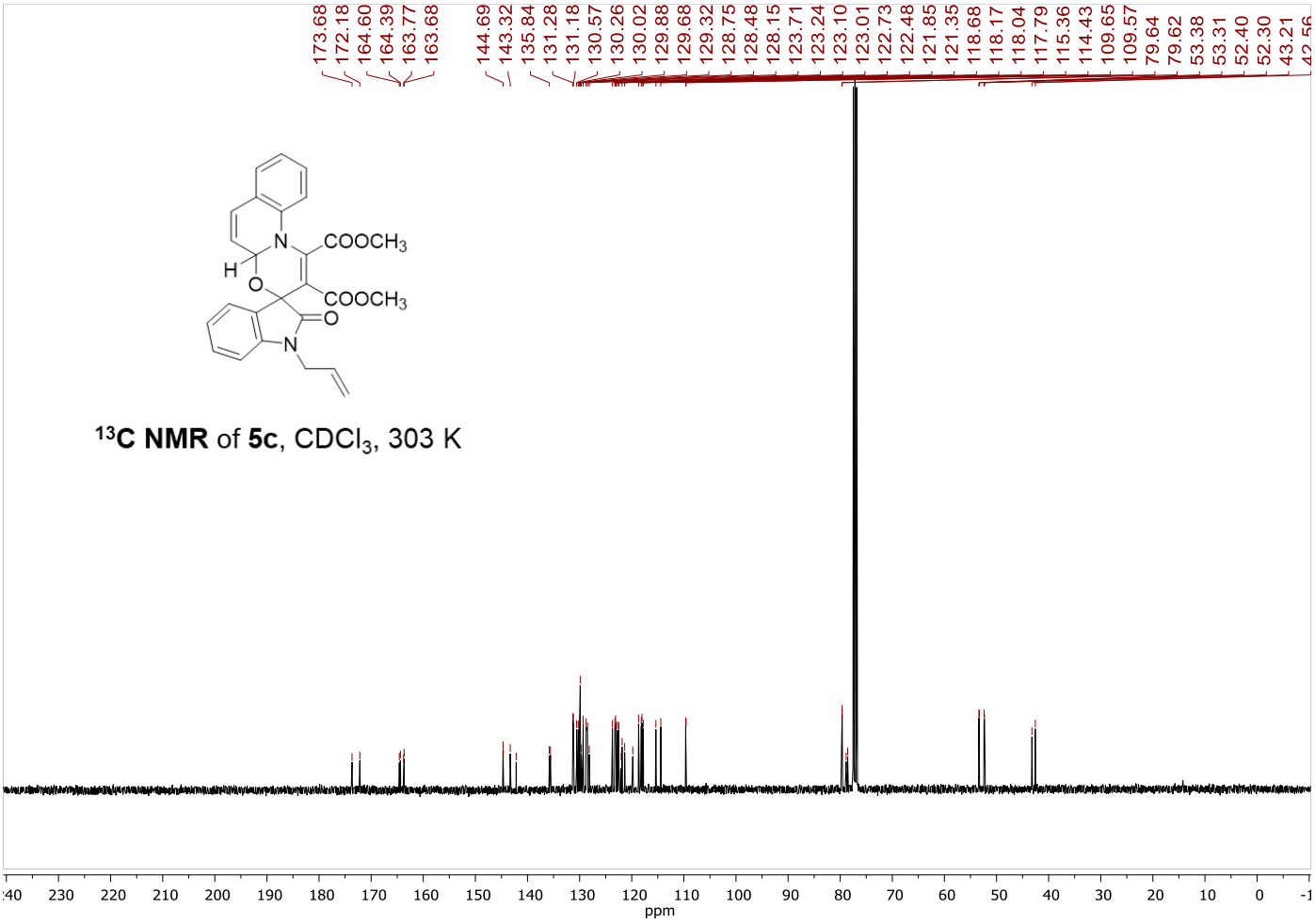
NMR spectra of 5c in DMSO-d_6: mixture of inseparable diastereomers, dr = ~ 1 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-d_6)**: δ = 7.68 (d, *J* = 7.0 Hz, 0.5H, A / B), 7.44–7.22 (m, 3H, A + B), 7.15–7.02 (m, 1.5H, A + B), 7.01–6.91 (m, 3H, A + B), 6.87 (d, *J* = 6.9 Hz, 0.5H, A / B), 6.74 (d, *J* = 8.2 Hz, 0.5H, A / B), 6.06 (dd, *J* = 9.8, 4.3 Hz, 0.5H, A / B), 5.99 (dd, *J* = 9.8, 4.4 Hz, 0.5H, A / B), 5.92 (d, *J* = 4.4 Hz, 0.5H, A / B), 5.89–5.74 (m, 1.5H, A + B), 5.35–5.25 (m, 1H, A + B), 5.24–5.10 (m, 1H, A + B), 4.41–4.12 (m, 2H, A + B), 3.88 (s, 1.5H, A / B), 3.84 (s, 1.5H, A / B), 3.54 (s, 1.5H, A / B), 3.40 (s, 1.5H, A / B). **^{13}C NMR (101 MHz, DMSO-d_6)**: δ (A + B) = 172.6, 171.3, 164.1, 163.4, 163.2, 163.1, 144.2, 143.9, 142.5, 140.8, 135.3, 134.6, 131.4, 131.3, 130.4, 130.3, 130.2, 129.8, 128.84, 128.77, 128.7, 128.6, 128.4, 127.5, 124.1, 122.80, 122.75, 122.7, 122.4, 122.3, 122.1, 121.1, 120.9, 119.8, 118.7, 118.5, 117.4, 117.2, 114.4, 114.0, 109.9, 109.4, 78.9, 78.7, 78.3, 77.7, 53.5, 53.3, 52.4, 52.2, 42.1, 41.6.

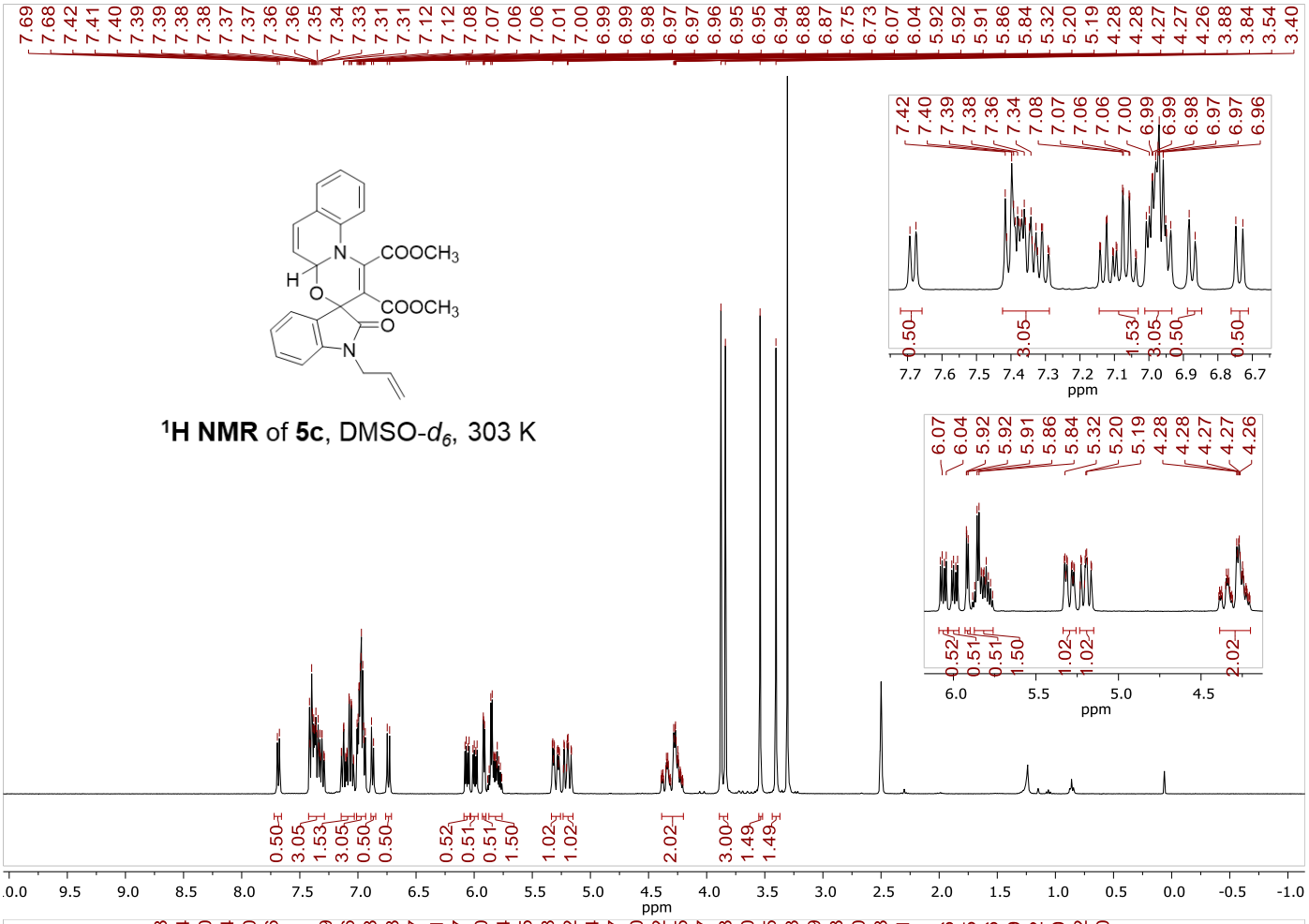
Additional experiments on acid-catalyzed isomerization.

Compound **5c** (0.05 mmol) was treated with *p*-TSA (20 mol%) or HCl_{conc} (60 mol%) in 1 mL of DCM at RT, after 6h reaction mixtures were analyzed by LC. No significant dr change was observed in either case.

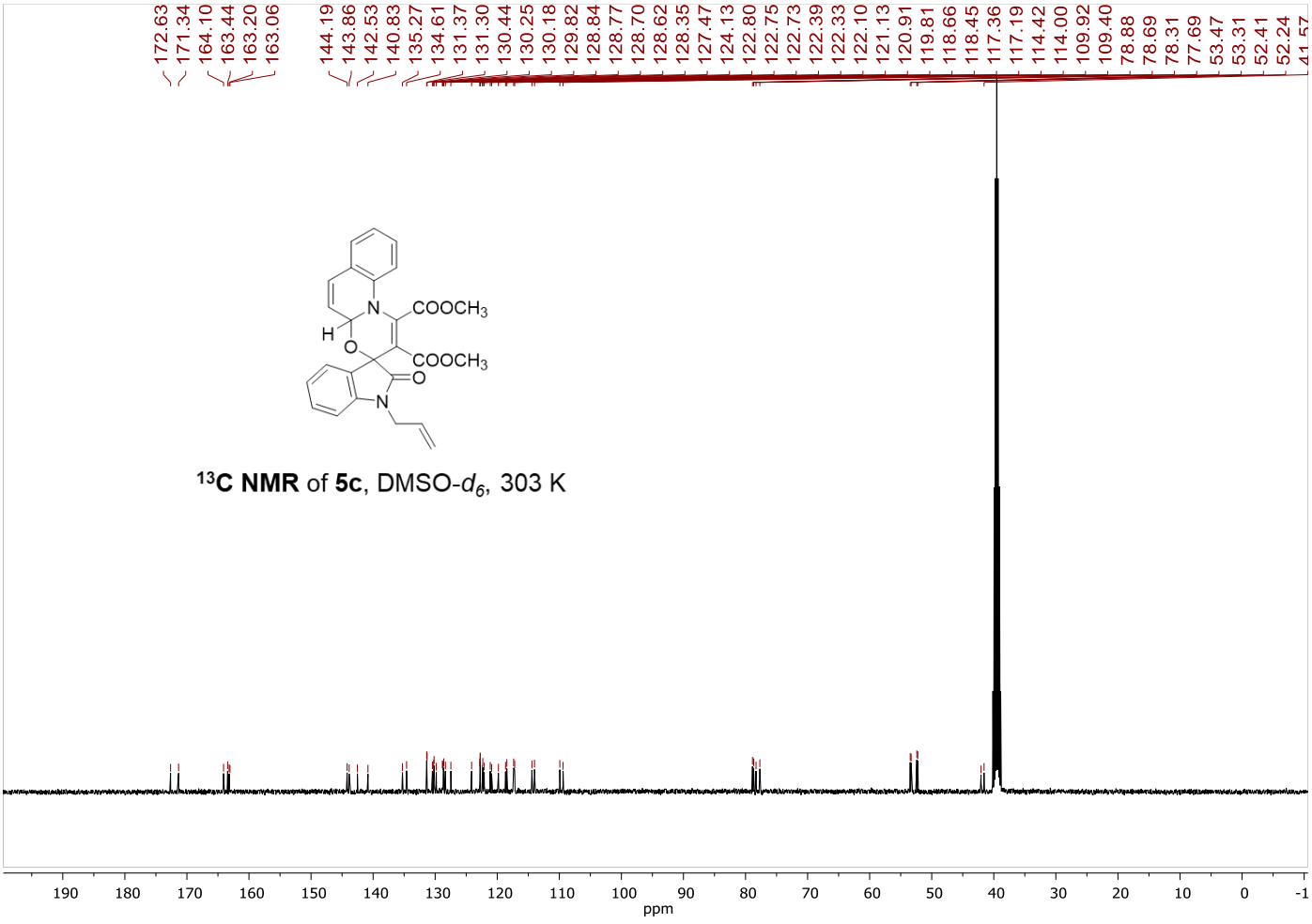
4.3.1. Copies of NMR spectra for product 5c







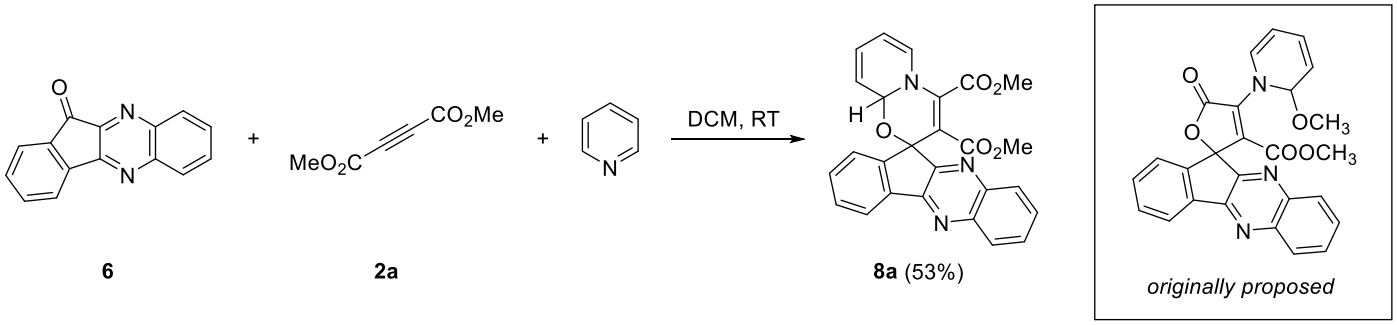
^{1}H NMR of **5c**, DMSO-d_6, 303 K



^{13}C NMR of **5c**, DMSO-d_6, 303 K

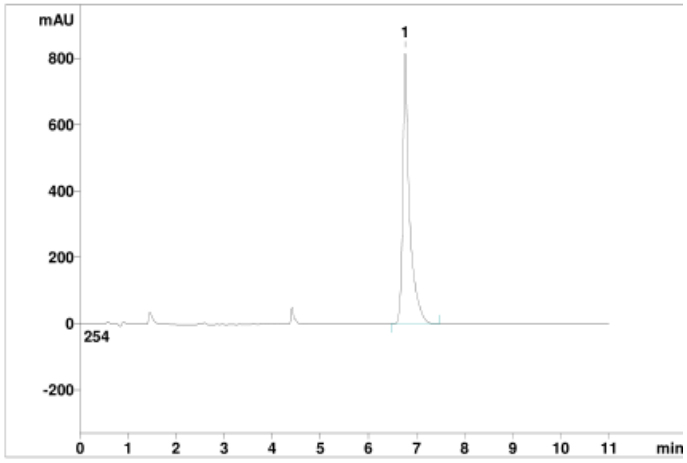
5. Synthesis, HPLC and NMR spectra of compounds 8a-c

5.1. Synthesis of product 8a



Dimethyl 9a'*H*-spiro[indeno[1,2-*b*]quinoxaline-11,2'-pyrido[2,1-*b*][1,3]oxazine]-3',4'-dicarboxylate (8a): The compound was prepared according to the modified (1.5 equiv. of DMAD and pyridine instead of 1.0 equiv.) reported procedure [15]: a solution of DMAD (185 µL, 1.5 mmol, 1.5 equiv.) in 2 mL of DCM was added to a solution of **6** (232 mg, 1.0 mmol, 1 equiv.) and pyridine (120 µL, 1.5 mmol, 1.5 equiv.) in dichloromethane (DCM, 10 mL) over 15 min (via syringe). The reaction mixture was stirred at RT for 1d. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH affording a mixture of inseparable diastereomers as a yellow solid (240 mg, 53% yield); R_f = 0.53 (Hex/EA 1:1) [lit. 0.54 (Hex/EA 1:1)]; m.p. 168–170 °C (decomp.) [lit. 167–169 °C]. HRMS (ESI): *m*/*z* calcd for $C_{26}H_{19}N_3O_5$: 454.1397 $[M+H]^+$; found: 454.1397.

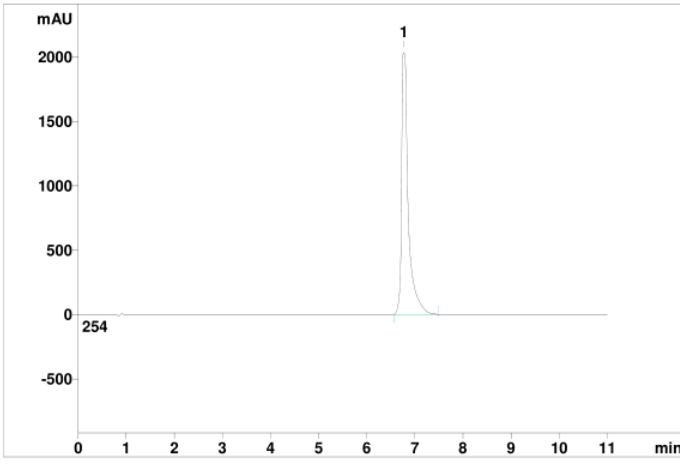
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.76	7926.253	100.00	

HPLC of the isolated product 8a



Quantitation method: Response normalization

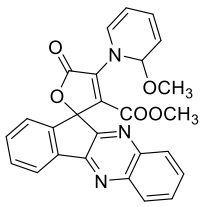
Peak	Retention min	Area mAU*sec	Area %	Component
1	6.76	19778.476	100.00	

NMR spectra of 8a in K_2CO_3-treated-$CDCl_3$: (the same dr was observed in $CDCl_3$) mixture of inseparable diastereomers, dr = ~ 16 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 8.21–8.10 (m, 2H, A + B), 8.09–8.02 (m, 1H, A + B), 7.78–7.65 (m, 2H, A + B), 7.59–7.46 (m, 3H, A + B), 7.02 (dd, *J* = 3.3, 1.3 Hz, 0.94H, A), 6.51 (d, *J* = 7.8 Hz, 0.06H, B), 6.47 (d, *J* = 7.6 Hz, 0.94H, A), 6.39 (dd, *J* = 3.2, 1.3 Hz, 0.06H, B), 6.24 (dd[A], *J* = 9.9, 6.1 Hz, 1H, A + B), 5.53 (dd[A], *J* = 10.0, 3.3 Hz, 1H, A

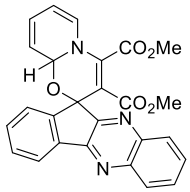
+ B), 5.41–5.29 (m, 1H, A + B), 4.00 (s, 2.82H, A), 3.98 (s, 0.18H, B), 3.17 (s, 3H, A + B). **^{13}C NMR (101 MHz, $CDCl_3$)**: (A, major) δ = 164.0, 163.7, 161.9, 154.2, 147.4, 145.6, 142.9, 141.5, 138.6, 132.2, 130.4, 130.0, 130.0, 129.4, 129.0, 125.2, 125.1, 123.9, 122.5, 116.7, 107.6, 101.8, 80.2, 79.6, 53.5, 51.6.

NMR spectra of 8a in DMSO-d_6: mixture of inseparable diastereomers, dr = ~ 3.2 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-d_6)**: δ = 8.19–8.00 (m, 3.24H, A + B), 7.90–7.73 (m, 2H, A + B), 7.68–7.55 (m, 2H, A + B), 7.42 (d, *J* = 6.7 Hz, 0.76H, A), 6.79 (dd, *J* = 3.4, 1.3 Hz, 0.76H, A), 6.76 (d, *J* = 7.6 Hz, 0.24H, B), 6.73 (d, *J* = 7.6 Hz, 0.76H, A), 6.47 (d, *J* = 2.7 Hz, 0.24H, B), 6.36–6.24 (m, 1H, A + B), 5.66–5.51 (m, 1H, A+ B), 5.51–5.40 (m, 1H, A + B), 3.95 (s, 2.29H, A), 3.92 (s, 0.71H, B), 3.20 (s, 0.71H, B), 3.19 (s, 2.29H, A). **^{13}C NMR (101 MHz, DMSO-d_6)**: (A, major) δ = 162.8, 162.7, 161.3, 153.4, 147.1, 145.3, 142.1, 140.4, 137.7, 132.4, 130.6, 130.5, 129.5, 129.5, 128.9, 125.4, 125.3, 123.3, 122.1, 116.1, 106.7, 101.9, 79.4, 78.8, 53.6, 51.6. **^{13}C NMR (101 MHz, DMSO-d_6)**: (B, minor) δ = 163.2, 162.7, 162.4, 154.5, 148.0, 144.6, 141.9, 140.8, 136.0, 132.4, 130.6, 130.2, 129.5, 129.3, 128.9, 126.2, 125.6, 125.2, 121.9, 116.2, 108.5, 101.2, 79.2, 79.0, 53.5, 51.6.

5.1.1. Comparison of NMR spectra of 8a and the reported structure



*The proposed structure of compound **4a** in original publication (ref. 15)*



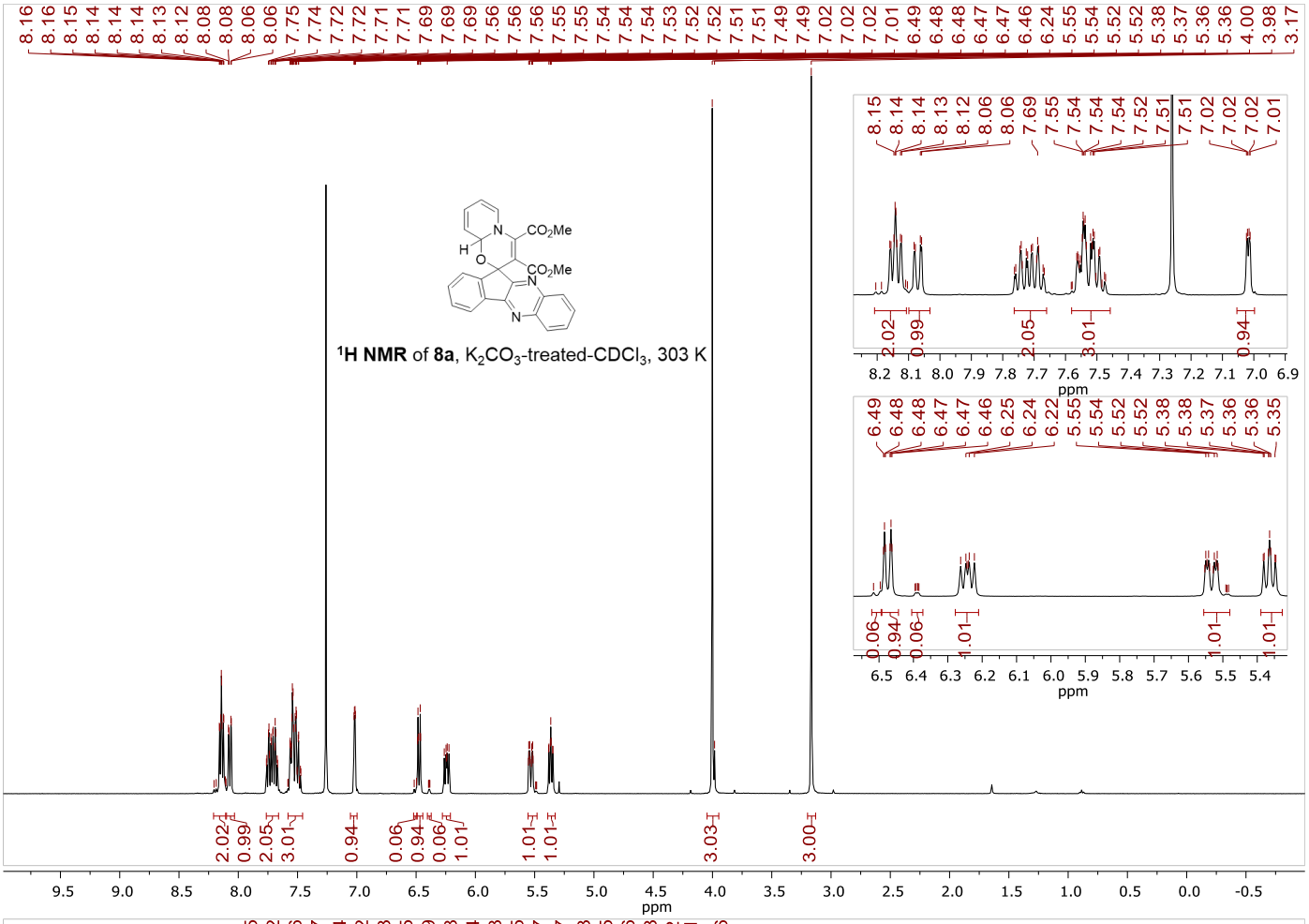
The revised structure (**8a**)

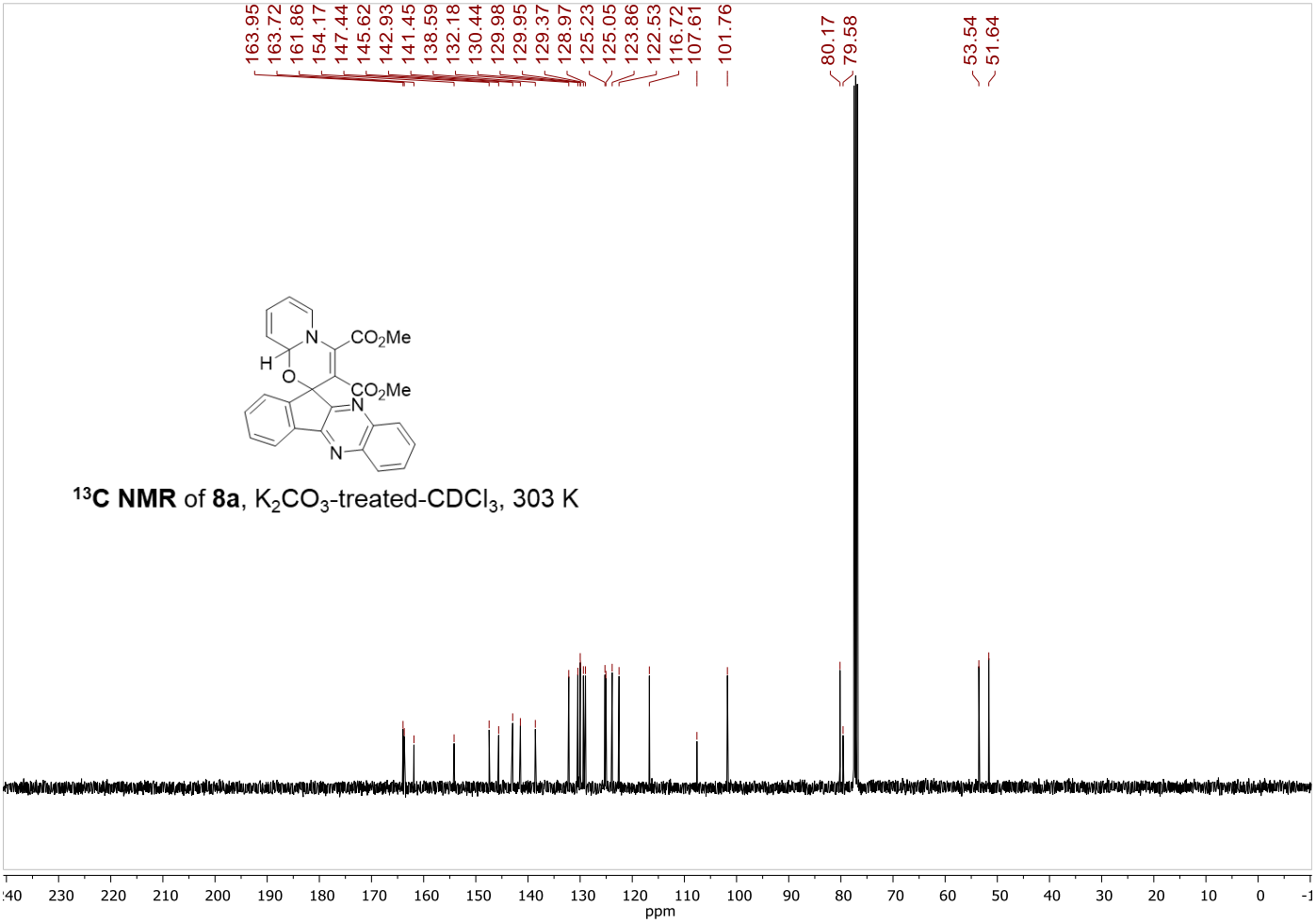
^{1}H NMR						^{13}C NMR		
Reported in [15], 4a			Observed, 8a*			Reported in [15], 4a	Observed, 8a**	Difference, ppm
δ, ppm	int., mult.	*J*, Hz	δ, ppm	int., mult.	*J*, Hz	δ, ppm	δ, ppm	
3.16	3H, s		3.16	3H, s		51.4	51.4	0
4	3H, s		3.99	3H, s		53.3	53.3	0
5.36	1H, m		5.29–5.40	1H, m		79.4	79.3	-0.1
5.53	1H, m		5.53	1H, dd	10.0, 3.3	80.0	79.9	-0.1
6.24	1H, m		6.24	1H, dd	9.9, 6.1	101.6	101.5	-0.1
6.46	1H, d	7.5	6.47	1H, d	7.6	107.4	107.4	0
7.01	1H, s		7.01	1H, dd	3.3, 1.3	116.5	116.5	0
7.46	5H, m		7.45–7.58	3H, m		123.3	122.3	-1
			7.65–7.78	2H, m		123.6	123.6	0
8.07	1H, d	7.5	8.01–8.08	1H, m		124.8	124.8	0
8.16	2H, m		8.09–8.21	2H, m		125.0	125.0	0
							128.7	
						129.2	129.1	-0.1
						129.8	129.71	-0.09
							129.73	
						130.3	130.2	-0.1
						132.0	131.9	-0.1
						138.4	138.3	-0.1
						142.2	141.2	-1
						142.7	142.7	0
						145.7	145.4	-0.3
						146.5	147.2	0.7
						147.2		
						154.0	153.9	-0.1
						161.7	161.6	-0.1
						163.6	163.5	-0.1
						163.8	163.7	-0.1

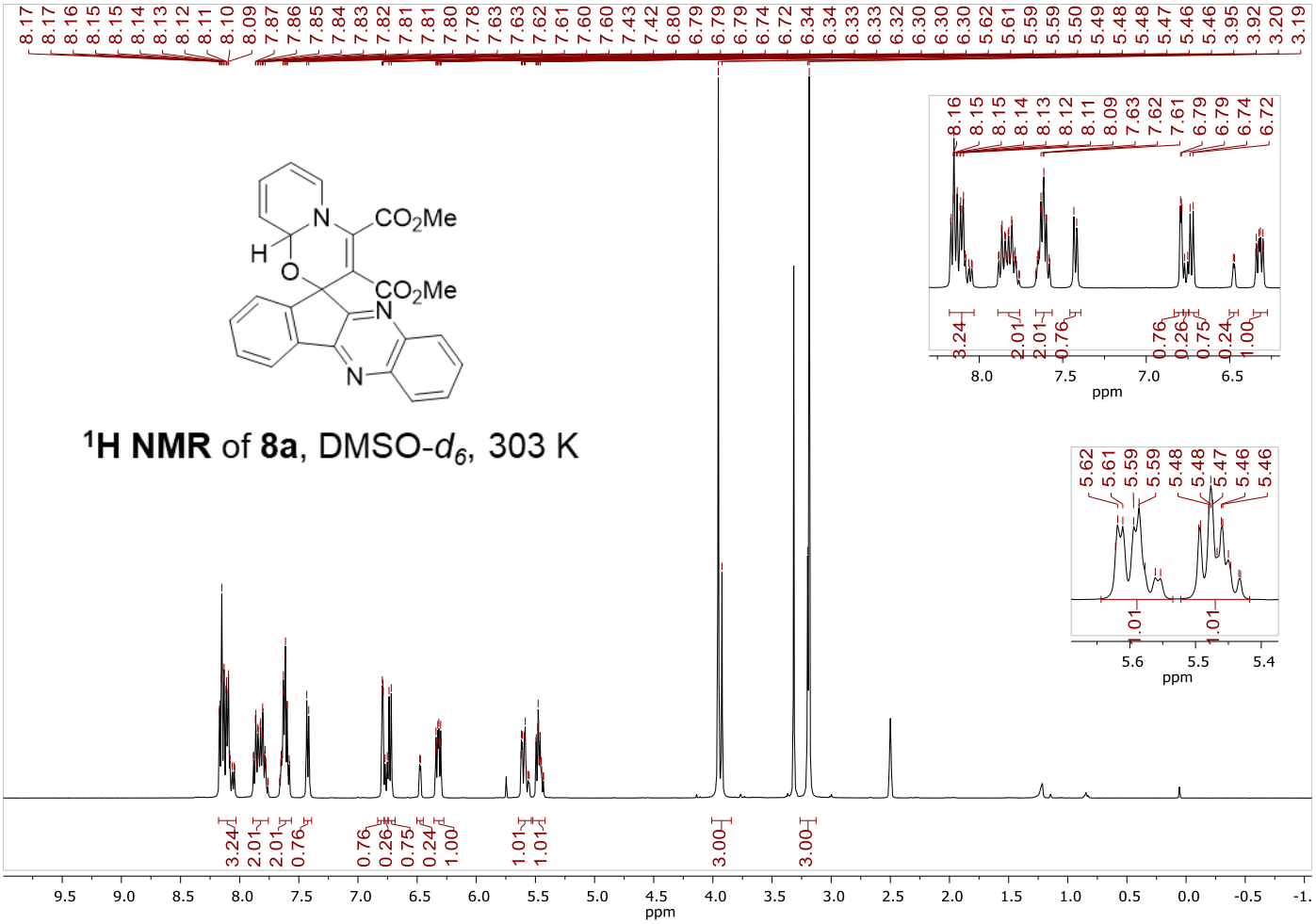
* first proton signal was set to 3.16 ppm

** first carbon signal was set to 51.4 ppm

5.1.2. Copies of NMR spectra for product 8a

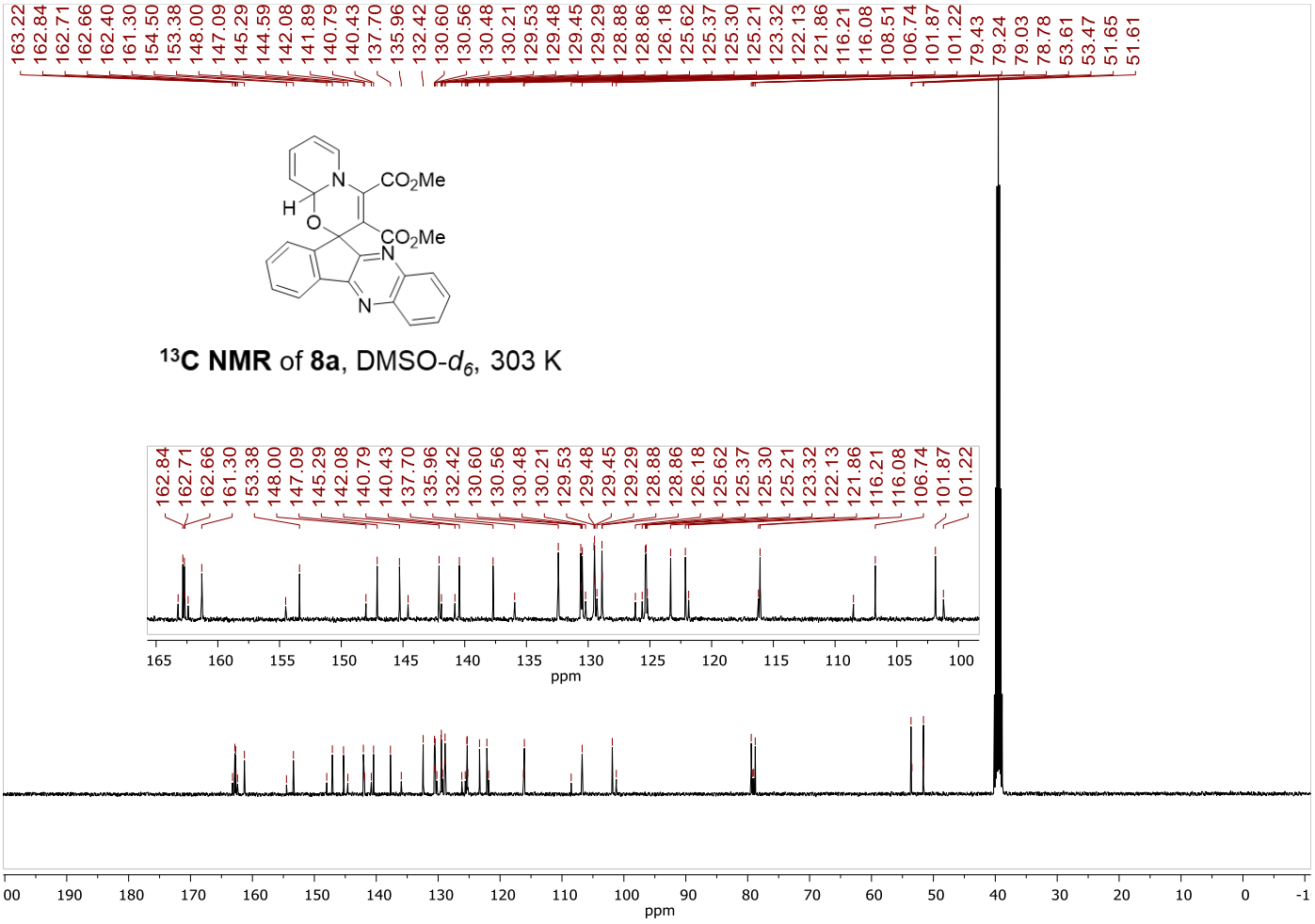




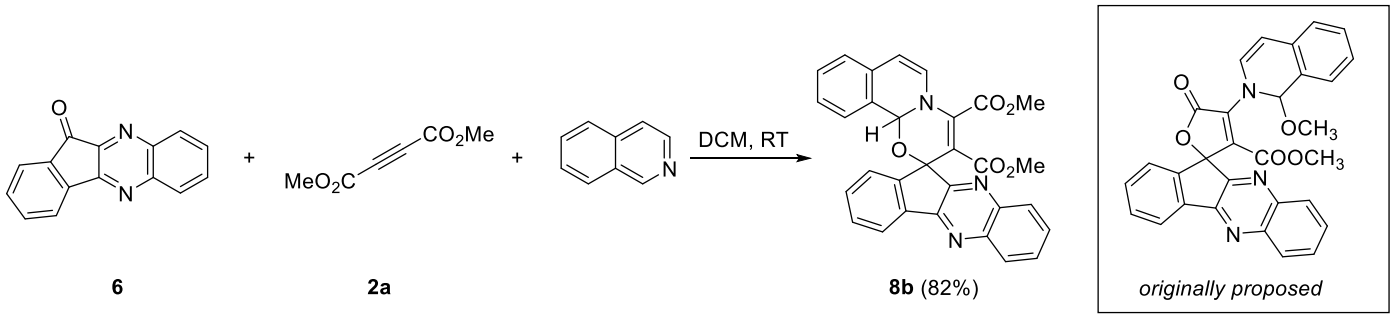

8.17 8.17 8.16 8.15 8.15 8.14 8.13 8.12 8.11 8.10 8.09 7.87 7.86 7.85 7.84 7.83 7.82 7.81 7.81 7.80 7.78 7.63 7.63 7.62 7.61 7.60 7.43 7.42 6.80 6.79 6.79 6.79 6.74 6.72 6.34 6.34 6.33 6.33 6.32 6.30 6.30 5.62 5.61 5.59 5.50 5.49 5.48 5.48 5.47 5.46 3.95 3.92 3.20 3.19
N
H
O
CO2Me
CO2Me
N
N
1H NMR of 8a, DMSO-d6, 303 K
3.24 2.01 2.01 0.76 0.76 0.26 0.75 0.24 1.00 1.01 1.01 3.00 3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
ppm

8.16 8.15 8.15 8.14 8.13 8.12 8.11 8.09 7.63 7.62 7.61 6.79 6.79 6.74 6.72
3.24 2.01 2.01 0.76 0.76 0.26 0.75 0.24 1.00
8.0 7.5 7.0 6.5
ppm

5.62 5.61 5.59 5.59 5.48 5.48 5.47 5.46 5.46
1.01 1.01
5.6 5.5 5.4
ppm


163.22 162.84 162.71 162.66 162.40 161.30 154.50 153.38 148.00 147.09 145.29 144.59 142.08 141.89 140.79 140.43 137.70 135.96 132.42 130.60 130.56 130.48 130.21 129.53 129.48 129.45 129.29 128.88 128.86 126.18 125.62 125.37 125.30 125.21 123.32 122.13 121.86 116.21 116.08 108.51 106.74 101.87 101.22 79.43 79.24 79.03 78.78 53.61 53.47 51.65 51.61
N
H
O
CO2Me
CO2Me
N
N
13C NMR of 8a, DMSO-d6, 303 K
165 160 155 150 145 140 135 130 125 120 115 110 105 100
ppm
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
ppm

5.2. Synthesis of product 8b

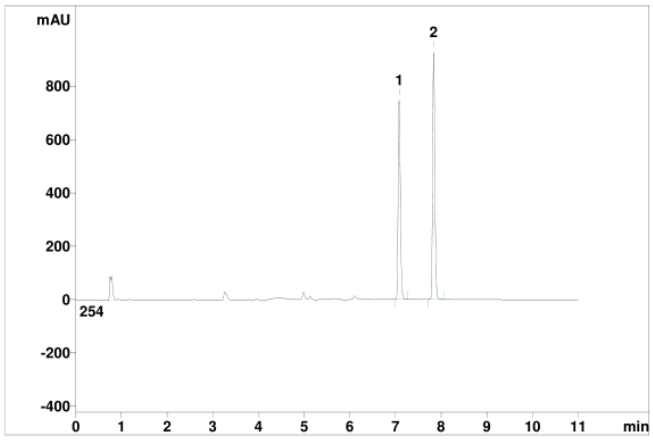


6 **2a** **8b** (82%)

Dimethyl 11b'*H*-spiro[indeno[1,2-*b*]quinoxaline-11,2'-[1,3]oxazino[2,3-*a*]isoquinoline]-3',4'-dicarboxylate (8b): The compound was prepared according to the modified (1.5 equiv. of DMAD and pyridine instead of 1.0 equiv.) reported procedure [15]: a solution of DMAD (185 µL, 1.5 mmol, 1.5 equiv.) in 2 mL of dichloromethane (DCM) was added to a solution of 11*H*-indeno[1,2-*b*]quinoxalin-11-one **6** (232 mg, 1.0 mmol, 1 equiv.) and isoquinoline (180 µL, 1.5 mmol, 1.5 equiv.) in DCM (10 mL) over 15 min (via syringe). The reaction mixture was stirred at RT for 1d. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH affording a mixture of inseparable* diastereomers as a bright-yellow solid (414 mg, 82% yield); R_f = 0.49 + 0.59 (Hex/EA 1:1) [lit. 0.59 (Hex/EA 1:1)]**; m.p. 214–217 °C (decomp.) [lit. 190–193 °C]. HRMS (ESI): *m*/*z* calcd for $C_{30}H_{21}N_3O_5$: 504.1554 $[M+H]^+$; found: 504.1554.

** inseparable by crystallization, however separation via column chromatography is possible*
*** in the original work, only one diastereomer was reported, see the manuscript*

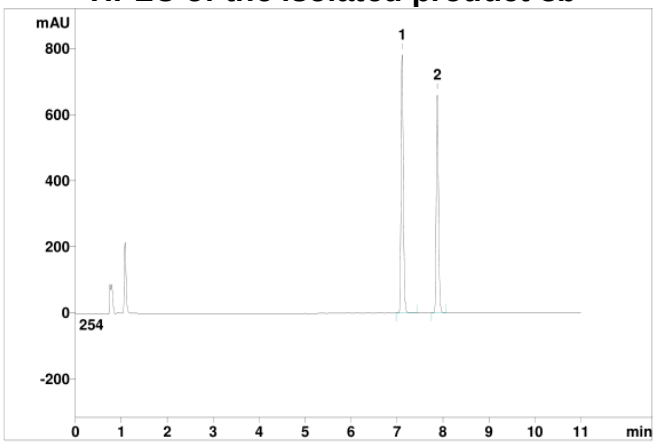
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	7.08	2545.793	44.46	
2	7.83	3180.107	55.54	
2	11.00	5725.901	100.00	

HPLC of the isolated product 8b



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	7.11	2669.849	54.23	
2	7.87	2252.989	45.77	
2	11.00	4922.838	100.00	

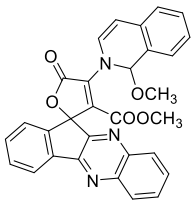
NMR spectra of 8b in $CDCl_3$: mixture of inseparable diastereomers, dr = ~ 2.6 : 1 → 12 : 1 (A : B; in 30–40 min). **^{1}H NMR (400 MHz, $CDCl_3$)**: (A, major) δ = 8.26–8.22 (m, 2H), 8.14–8.07 (m, 1H), 7.83–7.76 (m, 1H), 7.76–7.69 (m, 1H), 7.59–7.45 (m, 4H), 7.26–7.20 (m, 1H), 7.13–7.08 (m, 1H), 7.08–6.98 (m, 2H), 6.52 (d, *J* = 7.8 Hz, 1H), 5.87 (d, *J* = 7.8 Hz, 1H), 4.03 (s, 3H), 3.20 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)**: (A, major) δ = 164.1, 163.8, 162.5, 154.0, 147.7, 145.7, 142.2, 141.6,

138.0, 132.5, 130.6, 130.3, 130.0, 129.9, 129.6, 129.3, 129.0, 128.0, 127.2, 126.6, 125.4, 124.2, 123.6, 122.9, 106.4, 105.3, 81.0, 80.2, 53.6, 51.7.

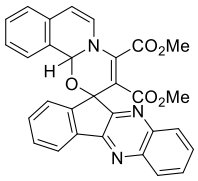
NMR spectra of 8b in K_2CO_3-treated-$CDCl_3$: mixture of inseparable diastereomers, dr = ~ 1.1 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 8.26–8.23 (m, 0.53H, A), 8.19–8.14 (m, 1H, A + B), 8.13–8.07 (m, 1.47H, A + B), 7.84–7.75 (m, 1H, A + B), 7.74–7.67 (m, 1H, A + B), 7.67–7.44 (m, 3.47H, A + B), 7.26–7.18 (m, 1H, A + B), 7.13–6.98 (m, 3H, A + B), 6.84 (s, 0.53H, A), 6.52 (d, *J* = 7.8 Hz, 0.53H, A), 6.52 (d, *J* = 7.8 Hz, 0.47H, B), 5.94–5.75 (m, 1H, A + B), 4.03 (s, 1.47H, B), 4.02 (s, 1.53H, A), 3.19 (s, 1.47H, B), 3.18 (s, 1.53H, A). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (A +B) = 164.13, 164.11, 163.95, 163.87, 162.3, 162.1, 154.8, 154.4, 148.9, 147.5, 145.6, 145.4, 143.0, 142.9, 142.0, 141.5, 138.4, 137.4, 132.2, 131.9, 130.6, 130.5, 130.3, 130.1, 130.05, 130.02, 129.94, 129.89, 129.7, 129.6, 129.4, 129.2, 129.1, 128.9, 128.0, 127.6, 127.22, 127.19, 126.6, 126.4, 125.33, 125.29, 125.1, 124.14, 124.10, 123.6, 122.8, 122.5, 106.5, 106.2, 105.24, 105.18, 81.0, 80.8, 80.4, 80.2, 53.6, 53.6, 51.7, 51.6.

NMR spectra of 8c in DMSO-*d*$_6$: mixture of inseparable diastereomers, dr = ~ 1.3 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-*d*$_6$)**: δ = 8.27–8.10 (m, 3H, A + B), 8.08–8.03 (m, 0.43H, B), 7.90 (ddd, *J* = 8.3, 7.0, 1.6 Hz, 0.57H, A), 7.86–7.80 (m, 1H, A + B), 7.76 (ddd, *J* = 8.4, 7.0, 1.5 Hz, 0.43H, B), 7.72–7.55 (m, 2H, A + B), 7.48–7.39 (m, 0.57H, A), 7.35–7.29 (m, 1.57H, A + B), 7.27–7.22 (m, 1H, A + B), 7.16–7.05 (m, 1H, A + B), 6.98 (s, 0.43H, B), 6.95–6.87 (m, 1H, A + B), 6.81 (d, *J* = 7.8 Hz, 0.43H, B), 6.78 (d, *J* = 7.8 Hz, 0.57H, A), 6.05 (d, *J* = 7.9 Hz, 0.57H, A), 6.02 (d, *J* = 8.0 Hz, 0.43H, B), 3.98 (s, 1.7H, A), 3.95 (s, 1.3H, B), 3.21 (s, 1.3H), 3.20 (s, 1.7H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)**: δ (A + B) = 163.4, 163.0, 162.8 (2C), 162.1, 161.7, 154.4, 153.6, 148.1, 146.9, 145.2, 144.6, 142.2, 141.9, 140.8, 140.6, 137.6, 136.1, 132.6, 132.4, 130.7 (2C), 130.5, 130.3, 129.7, 129.60 (2C), 129.58, 129.55, 129.5, 129.4, 129.3, 128.9, 128.8, 127.6, 127.5, 127.1, 126.9, 125.8, 125.6, 125.5, 125.2, 125.1, 125.0, 124.1, 123.5, 122.1, 122.0, 107.3, 105.7, 104.8, 104.2, 80.1, 80.0, 79.6, 79.4, 53.7, 53.5, 51.64, 51.58.

5.2.1. Comparison of NMR spectra of 8b and the reported structure



*The proposed structure of compound **4c** in original publication (ref. 15)*



The revised structure (**8b**)

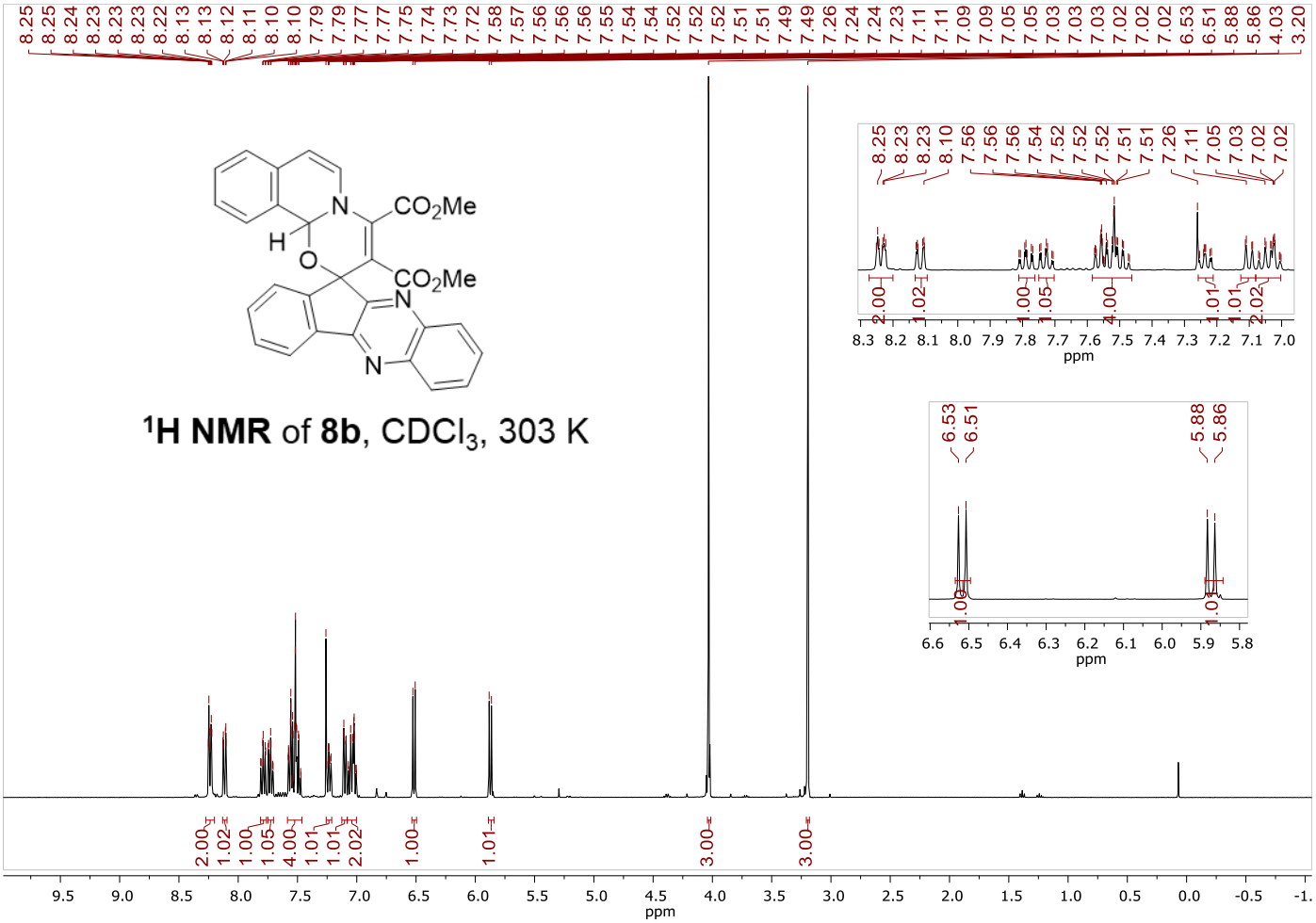
^{1}H NMR						^{13}C NMR		
Reported in [15], 4c			Observed, 8b*			Reported** in [15], 4c	Observed, 8b***	Difference, ppm
δ, ppm	int., mult.	*J*, Hz	δ, ppm	int., mult.	*J*, Hz	δ, ppm	δ, ppm	
3.19	3H, s		3.19	3H, s		51.50	51.50	0
4.03	3H, s		4.03	3H, s		53.40	53.50	-0.1
5.87	1H, d	7.5	5.87	1H, d	7.8	79.90	80.00	-0.1
6.51	1H, d	7.5	6.51	1H, d	7.8	80.80	80.90	-0.1
7.02	1H, s		6.97–7.07	2H, m		105.10	105.20	-0.1
7.11	3H, m		7.08–7.13	1H, m			106.20	
7.56	6H, m		7.19–7.25	1H, m		122.60	122.80	-0.2
			7.44–7.58	4H, m		123.40	123.50	-0.1
			7.68–7.76	1H, m		123.90	124.00	-0.1
8.17	3H, m		7.76–7.83	1H, m		125.20	125.20	0
			8.06–8.14	1H, m		126.30	126.40	-0.1
			8.21–8.25	2H, m		127.00	127.10	-0.1
						127.80	127.80	0
						128.90	128.80	0.1
						129.00	129.10	-0.1
						129.40	129.50	-0.1
						129.70	129.80	-0.1
						129.80	129.90	-0.1
						130.00	130.10	-0.1
						130.40	130.40	0
						132.20	132.40	-0.2
						137.90	137.80	0.1
						141.30	141.40	-0.1
						142.20	142.00	0.2
						145.50	145.50	0
						147.40	147.50	-0.1
						153.90	153.80	0.1
						162.20	162.40	-0.2
						163.70	163.70	0
						163.90	163.90	0

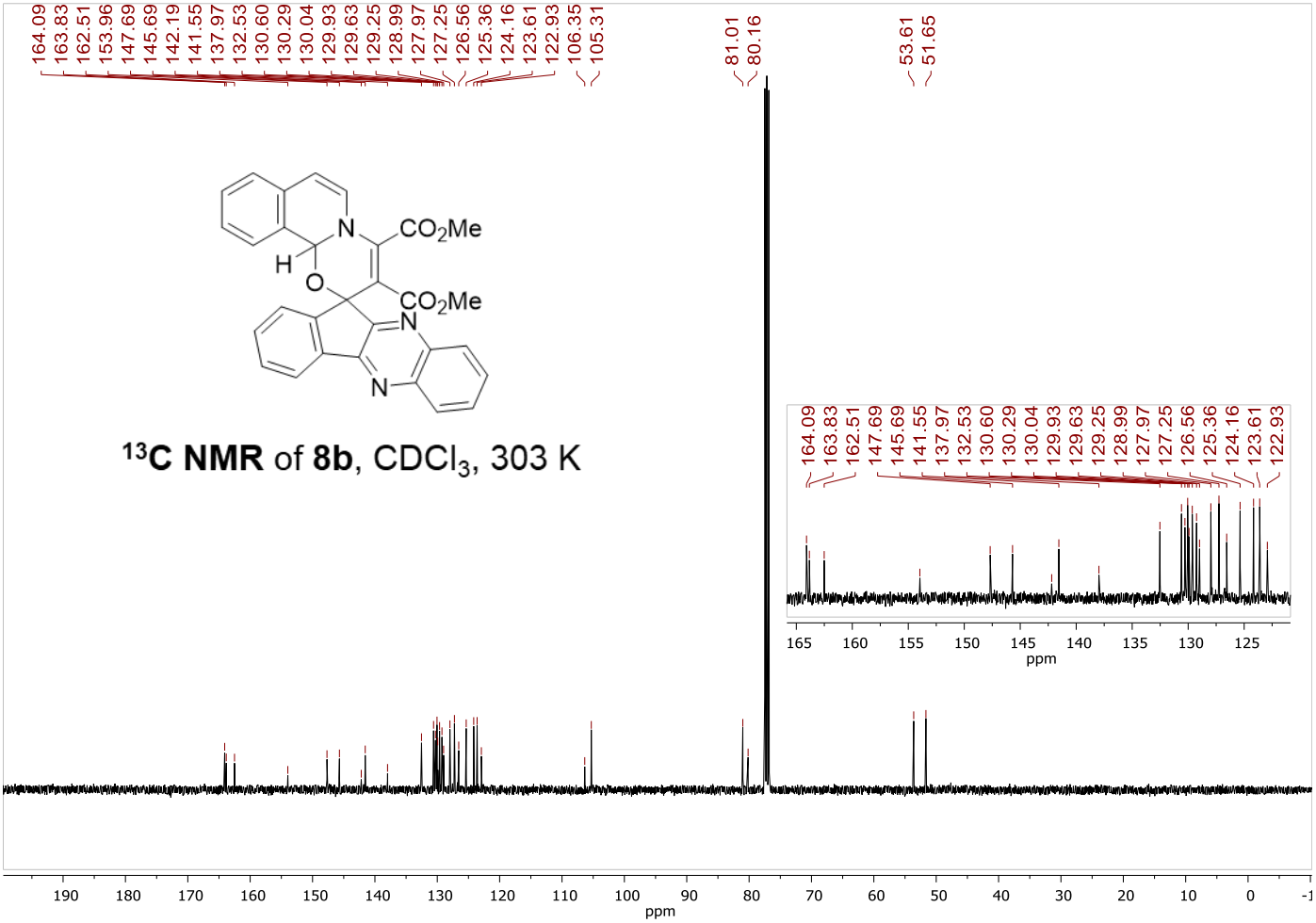
* first proton signal was set to 3.19 ppm

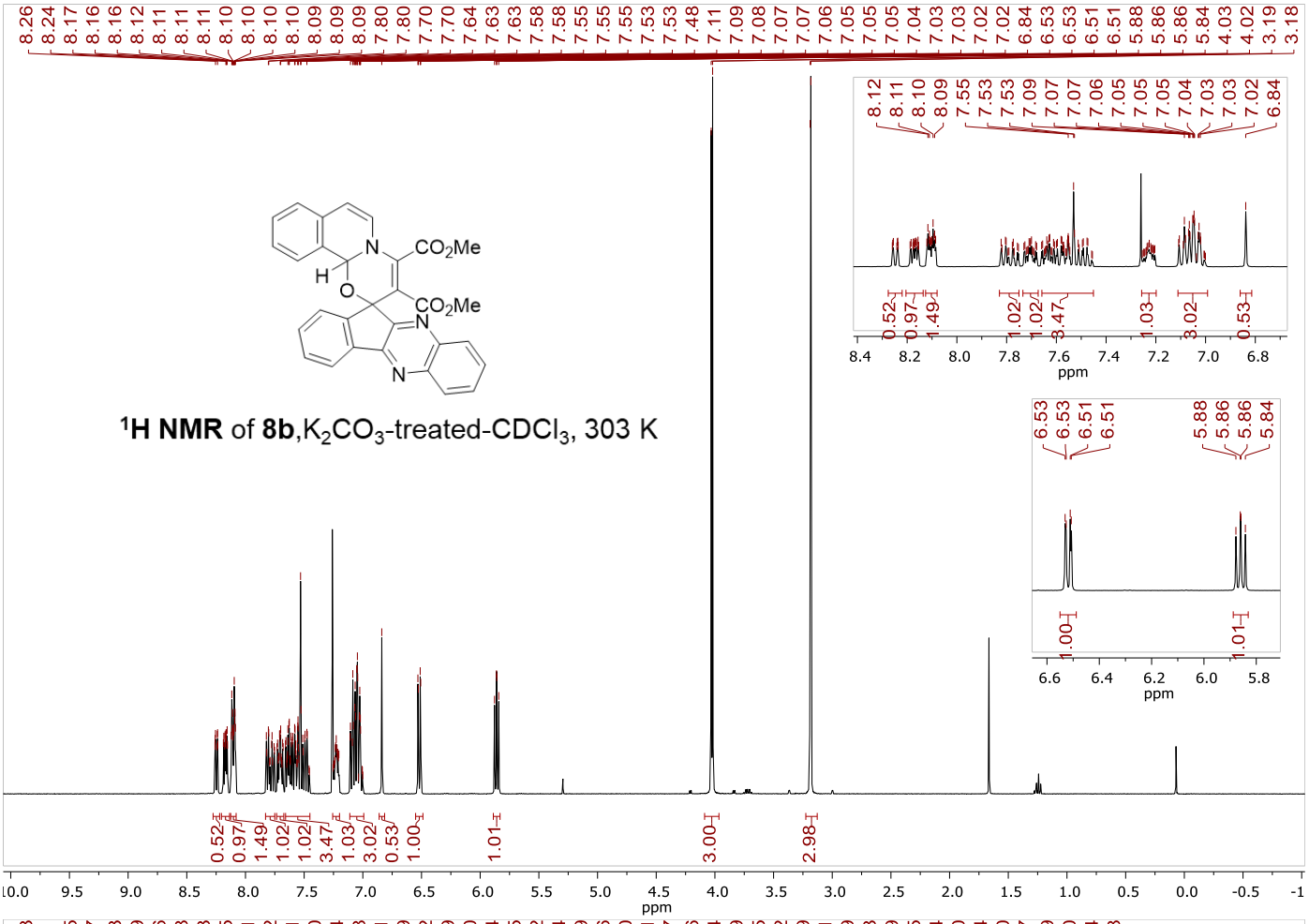
** 29 out of 30 signals were reported

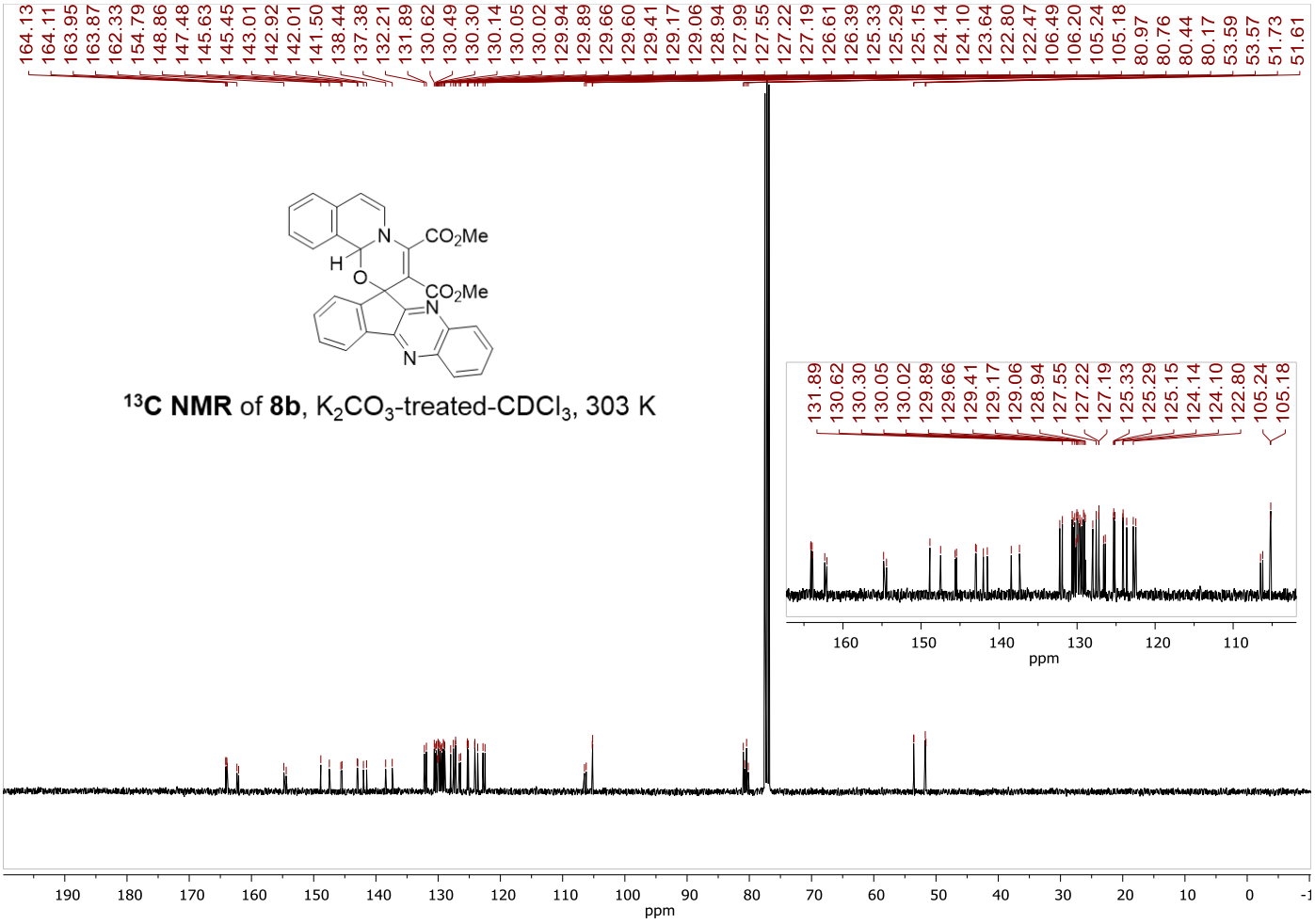
*** first carbon signal was set to 51.5 ppm, data from spectra in $CDCl_3$ (non-treated with K_2CO_3) were used

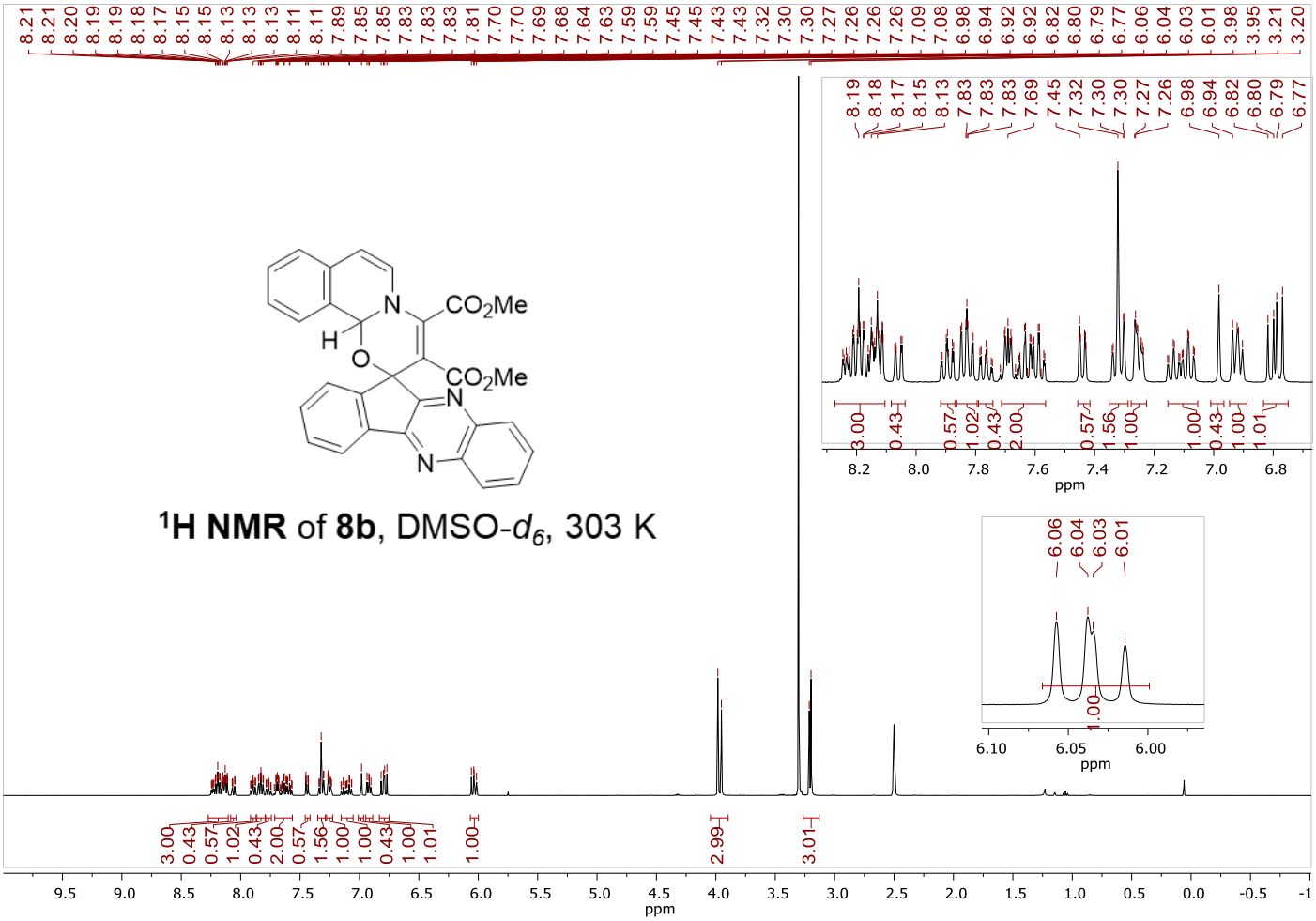
5.2.2. Copies of NMR spectra for product 8b



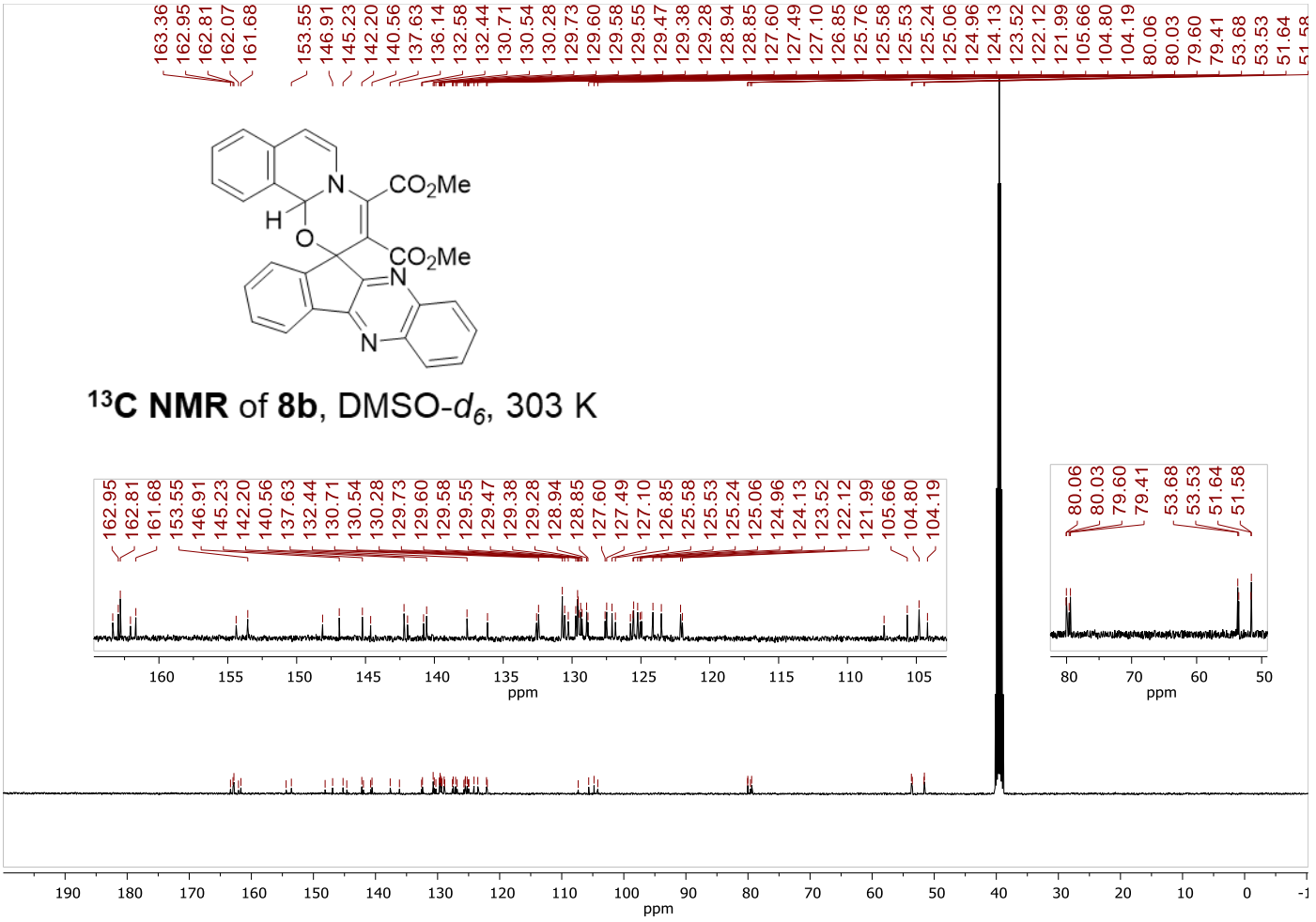



CO2Me
CO2Me
H
O
N
N
N
1H NMR of 8b,K2CO3-treated-CDCl3, 303 K
ppm


CO2Me
CO2Me
H
O
N
N
N
13C NMR of 8b, K2CO3-treated-CDCl3, 303 K
ppm

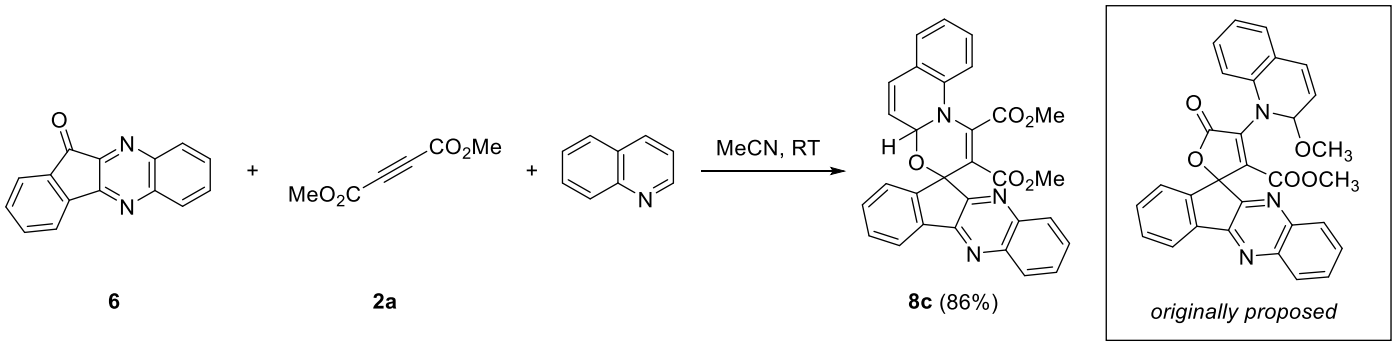


^{1}H NMR of **8b**, DMSO-d_6, 303 K



^{13}C NMR of **8b**, DMSO-d_6, 303 K

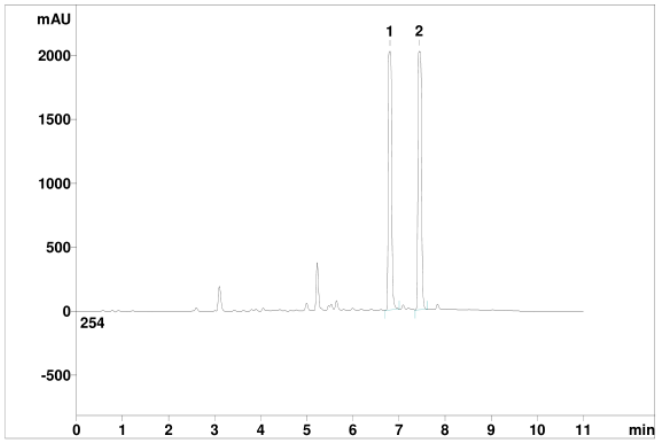
5.3. Synthesis of product 8c



Dimethyl 4a'*H*-spiro[indeno[1,2-*b*]quinoxaline-11,3'-[1,3]oxazino[3,2-*a*]quinoline]-1',2'-dicarboxylate (8c): The compound was prepared according to the modified (1.5 equiv. of DMAD and pyridine instead of 1.0 equiv.) reported procedure [15]: DMAD (185 µL, 1.5 mmol, 1.5 equiv.) was added to a solution of 11*H*-indeno[1,2-*b*]quinoxalin-11-one **6** (232 mg, 1.0 mmol, 1 equiv.) and quinoline (180 µL, 1.5 mmol, 1.5 equiv.) in acetonitrile* (5 mL). The reaction mixture was stirred at RT for 1d. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH affording a mixture of inseparable** diastereomers as a pale-yellow solid (435 mg, 86% yield); R_f = 0.54 + 0.60 (Hex/EA 1:1) [lit. not reported]; m.p. 219–220 °C (decomp.) [lit. 216–220 °C]. HRMS (ESI): *m/z* calcd for $C_{30}H_{21}N_3O_5$: 504.1554 $[M+H]^+$; found: 504.1555.

** reaction in DCM, which was used in the original method, was slow (not full conversion after 6d)*
*** inseparable by crystallization, however separation via column chromatography is possible*

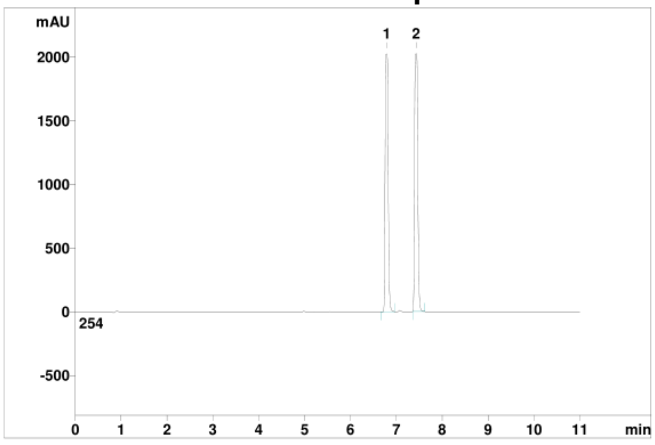
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.80	10377.450	49.03	
2	7.44	10789.888	50.97	
2	11.00	21167.338	100.00	

HPLC of the isolated product 8c



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.78	9318.622	48.83	
2	7.43	9763.534	51.17	
2	11.00	19082.156	100.00	

NMR spectra of 8c in K_2CO_3-treated-$CDCl_3$: (the same dr was observed in $CDCl_3$) mixture of inseparable diastereomers, dr = ~ 1 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 8.23–8.01 (m, 2.5H, A + B), 7.90 (dd, *J* = 8.3, 1.5 Hz, 0.5H, A / B), 7.79–7.64 (m, 2H, A + B), 7.62–7.55 (m, 1.5H, A + B), 7.52 (td, *J* = 7.5, 1.3 Hz, 0.5H, A /B), 7.45 (td, *J* = 7.5, 1.2 Hz, 0.5H, A / B), 7.40–7.30 (m, 1.5H, A + B), 7.25–7.21 (m, 1H, A + B), 7.13–7.02 (m, 2H, A + B), 6.87 (d, *J* = 9.7 Hz, 0.5H, A / B), 6.83

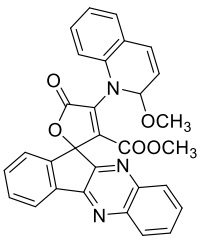
(d, *J* = 9.7 Hz, 0.5H, A / B), 6.51 (dd, *J* = 4.3, 1.0 Hz, 0.5H, A / B), 6.00 (d, *J* = 4.3 Hz, 0.5H, A / B), 6.02–5.90 (m, 1H, A + B), 3.92 (s, 1.5H, A / B), 3.88 (s, 1.5H, A / B), 3.27 (s, 1.5H, A / B), 3.24 (s, 1.5H, A / B). **^{13}C NMR (101 MHz, $CDCl_3$)**: *δ* (A + B) = 164.8, 164.6, 164.1, 163.9, 161.4, 160.7, 154.5, 154.2, 147.3, 146.6, 143.8, 143.0, 142.8, 142.3, 142.1, 141.6, 138.4, 137.4, 136.4, 136.0, 132.3, 132.2, 130.7, 130.54, 130.46, 130.05, 129.98, 129.91 (2C), 129.89, 129.8, 129.4, 129.3, 129.1 (2C), 128.83, 128.78, 128.5, 124.8, 124.5, 123.9, 122.7, 122.6 (3C), 122.3, 121.9, 121.4, 118.7, 118.1, 115.5, 114.5, 81.3, 81.2, 80.1, 79.9, 53.4, 53.3, 52.14, 52.13.

NMR spectra of 8c in DMSO-*d*$_6$: mixture of inseparable diastereomers, dr = ~ 1 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-*d*$_6$)**: *δ* = 8.21–8.07 (m, 3H, A + B), 7.93–7.79 (m, 2H, A + B), 7.77–7.70 (m, 0.5H, A / B), 7.69–7.53 (m, 2H, A + B), 7.48–7.34 (m, 2H, A + B), 7.26 (d, *J* = 7.4 Hz, 0.5H, A / B), 7.15 (t, *J* = 6.2 Hz, 0.5H, A / B), 7.11 (t, *J* = 6.1 Hz, 0.5H, A / B), 7.06–6.95 (m, 1.5H, A + B), 6.91 (d, *J* = 8.1 Hz, 0.5H, A / B), 6.28 (d, *J* = 4.4 Hz, 0.5H, A / B), 6.21 (d, *J* = 4.3 Hz, 0.5H, A / B), 6.10–5.97 (m, 1H, A + B), 3.89 (s, 1.5H, A / B), 3.84 (s, 1.5H, A / B), 3.26 (s, 3H, A + B). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)**: *δ* (A + B) = 164.2, 163.6, 163.5, 163.2, 160.8, 160.7, 154.2, 153.3, 146.7, 146.1, 143.3, 142.2, 141.9, 141.2, 140.8, 140.6, 137.5, 136.1, 135.5, 134.9, 132.7, 132.6, 130.9, 130.8, 130.7, 130.4, 130.2, 129.9, 129.7, 129.54, 129.48, 129.3, 129.0, 128.9 (2C), 128.68, 128.66, 128.4, 125.3, 124.1, 123.3, 122.7, 122.2, 122.1, 121.9, 121.8, 121.2, 121.0, 118.9, 118.5, 114.6, 114.0, 80.7, 80.3, 79.5, 79.0, 53.5, 53.3, 52.2, 52.1.

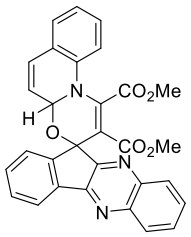
Additional experiments on acid-catalyzed isomerization.

Compound **8c** (0.1 mmol) was treated with *p*-TSA (20 mol%) or HCl_{conc} (30 mol%) in 1 mL of DCM at RT, after 6h reaction mixtures were analyzed by LC. For conditions employing *p*-TSA, dr changed from ~ 1:1.05 to 1:1.16. Conditions employing HCl_{conc} resulted in dr change from ~1:1.05 to 1:1.37.

5.3.1. Comparison of NMR spectra of 8c and the reported structure



*The proposed structure of compound **4e** in original publication (ref. 15)*

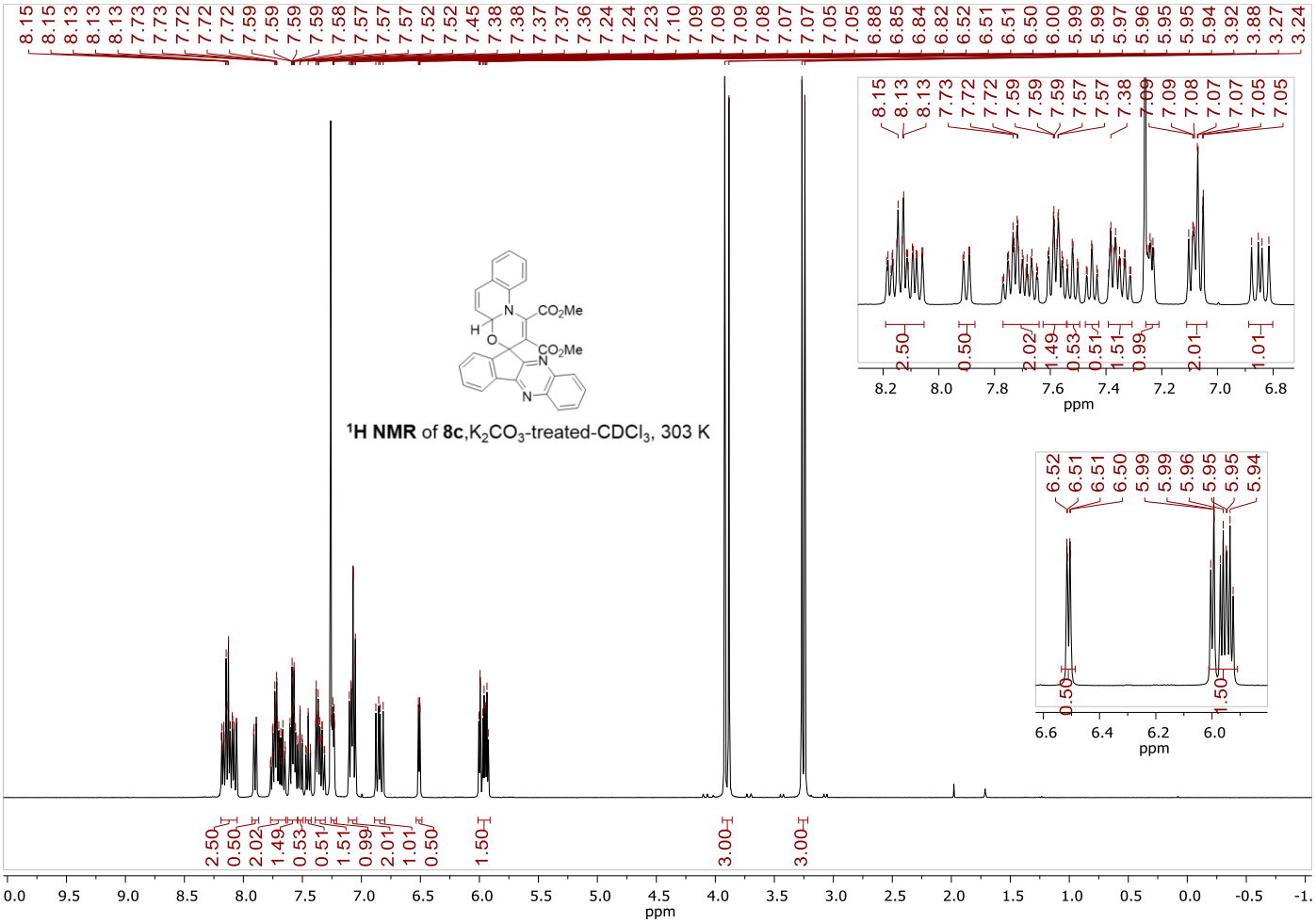


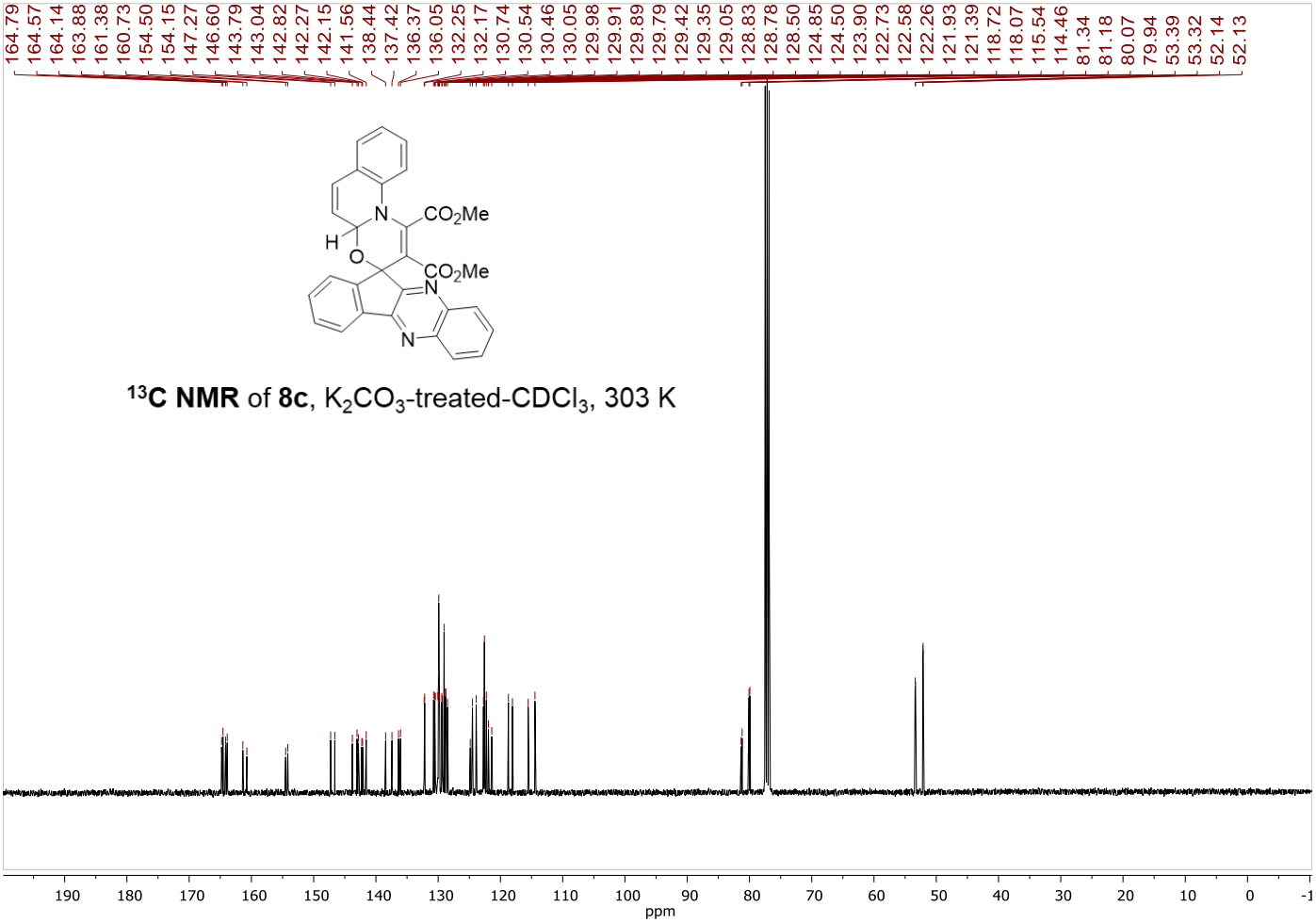
The revised structure (**8c**)

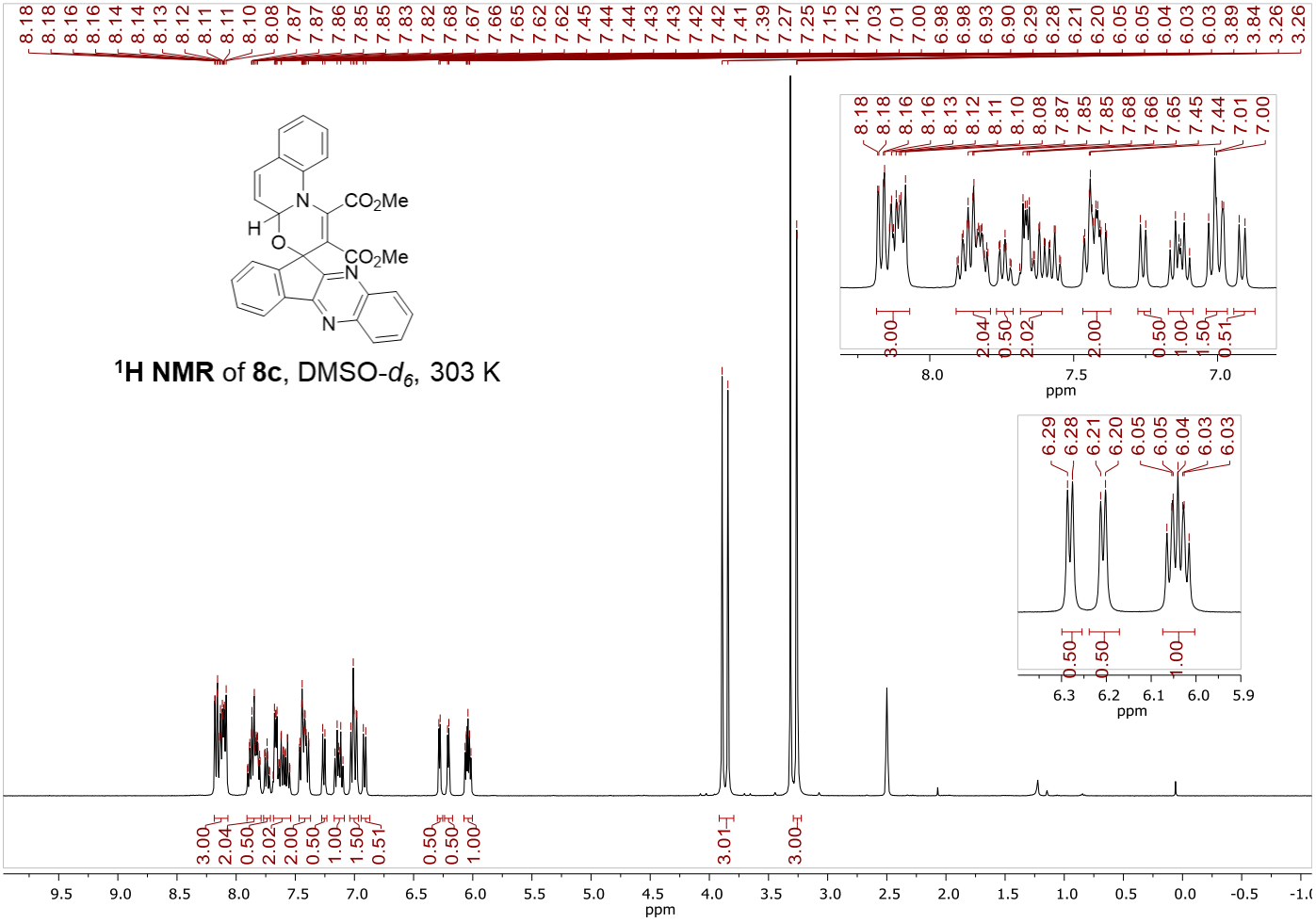
^{1}H NMR						
Reported in [15], 4e				Observed, 8c		
δ, ppm		int., mult.	*J*, Hz	δ, ppm	int., mult.	*J*, Hz
major	minor					
3.26		3H, s		3.27	3H, s	
	3.24	3H, s		3.24	3H, s	
3.92		3H, s		3.92	3H, s	
	3.89	3H, s		3.88	3H, s	
5.94		1H, m		5.90–6.02	2H, m	
	5.94	1H, m				
6.5		1H, d	4.3	6.51	1H, dd	4.3, 1.0
	5.99	1H, d	4.3	6.00	1H, d	4.3
6.87		1H, d	9.7	6.87	1H, d	9.7
	6.83	1H, d	9.7	6.83	1H, d	9.7
7.08		2H, m		7.02–7.13	4H, m	
	7.08	2H, m				
7.26-8.24	7.26-8.24	Σ20H, m		7.20–7.28	2H, m	
				7.30–7.40	3H, m	
				7.45	1H, td	7.5, 1.2
				7.52	1H, td	7.5, 1.3
				7.55–7.62	3H, m	
				7.64–7.79	4H, m	
				7.90	1H, dd	8.3, 1.5
				8.01–8.23	5H, m	

The ^{13}C NMR spectrum from the original work shows inconsistency with our data, at least 6 carbon signals do not match with literature data; for other signals, the difference with literature is 0–0.6 ppm. No copies of NMR spectra were provided in the original work, which complicated data analysis.

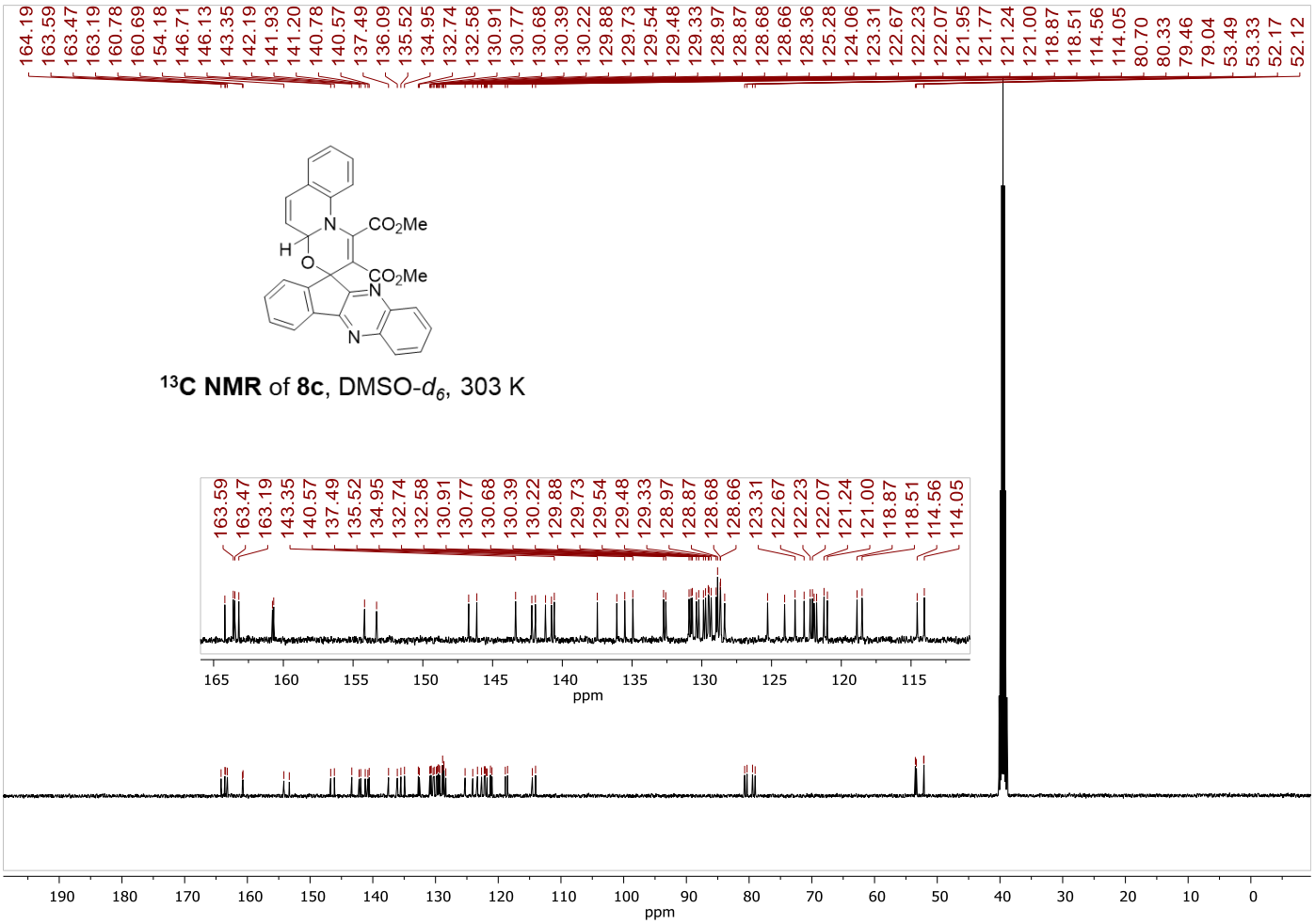
5.3.2. Copies of NMR spectra for product 8c







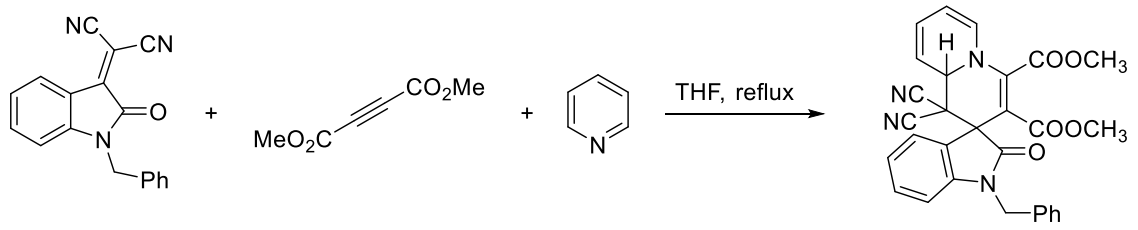
^{1}H NMR of **8c**, DMSO-d_6, 303 K



^{13}C NMR of **8c**, DMSO-d_6, 303 K

6. Synthesis, HPLC and NMR spectra of compounds 10a,b

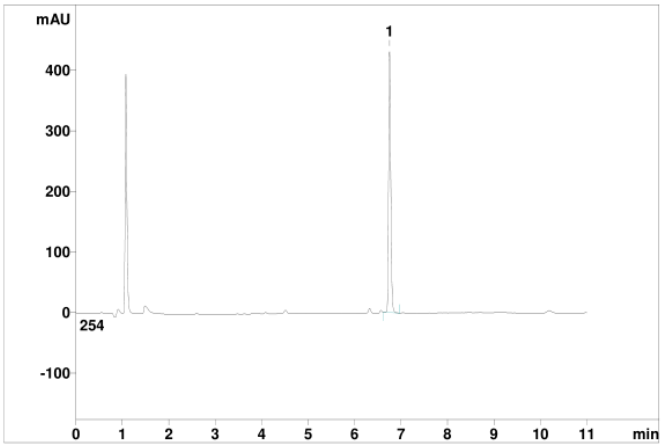
6.1. Synthesis of product 10a



9 **2a** **10a** (62%)

Dimethyl 1-benzyl-1',1'-dicyano-2-oxo-1',9a'-dihydrospiro[indoline-3,2'-quinolizine]-3',4'-dicarboxylate (10a): The compound was prepared according to the reported procedure [16]: DMAD (92 µL, 0.75 mmol, 1.5 equiv.) was added to a solution of 2-(1-benzyl-2-oxoindolin-3-ylidene)malononitrile **9** (143 mg, 0.5 mmol, 1 equiv.) and pyridine (61 µL, 0.75 mmol, 1.5 equiv.) in tetrahydrofurane (THF, 12 mL). The reaction mixture was refluxed for 2h. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH. Compound was additionally purified by recrystallization from hexane/DCM, affording a mixture of inseparable diastereomers as a pale-yellow solid (158 mg, 62% yield); R_f = 0.63 (Hex/EA 1:1); m.p. 183–185 °C (decomp.) [lit. 222–226 °C].

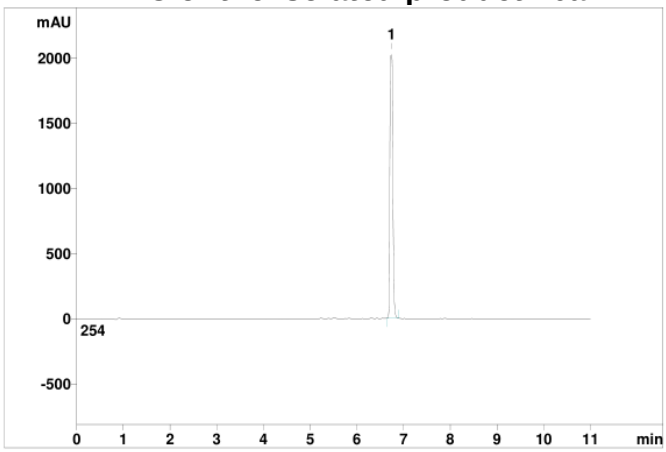
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.75	1387.107	100.00	

HPLC of the isolated product 10a



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.74	9081.375	100.00	

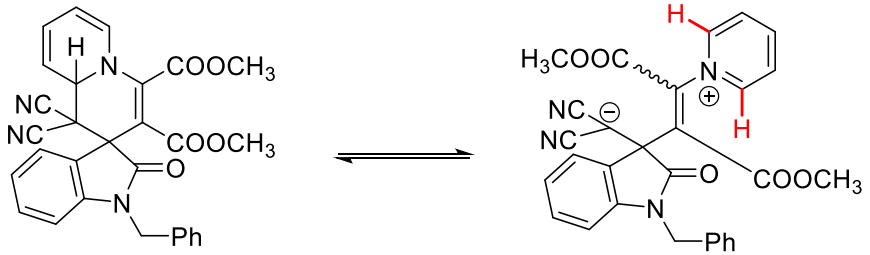
NMR spectra of 10a in $CDCl_3$: (the same dr was observed in K_2CO_3-treated-$CDCl_3$) mixture of inseparable diastereomers, d.r. = ~ 9 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 7.54–7.46 (m, 1.18H, A + B), 7.45–7.40 (m, 1.82H, 2×A), 7.37–7.27 (m, 4H, A + B), 7.15–7.05 (m, 1H, A + B), 6.92 (d, J = 7.8 Hz, 0.09H, B), 6.88 (d, J = 7.9 Hz, 0.91H, A), 6.32–6.20 (m, 3H, A + B), 5.75 (dd, J = 10.0, 3.3 Hz, 0.91H, A), 5.69 (d, J = 10.5 Hz, 0.09H, B), 5.31–5.21 (m, 1H, A + B), 5.16 (d, J = 15.6 Hz, 0.91H, A), 5.09 (d, J = 15.5 Hz, 0.09H, B), 5.00 (d, J = 15.5 Hz, 0.09H, B), 4.82 (d, J = 15.5 Hz,

0.91H, A), 3.96 (s, 3H, A + B), 3.26 (s, 0.27H, B), 3.14 (s, 2.73H, A). **^{13}C NMR (101 MHz, $CDCl_3$): δ (A, major)** = 173.5, 163.6, 163.4, 146.8, 143.7, 135.1, 130.7, 129.0 (2C), 128.1, 128.0 (2C), 126.8, 126.5, 125.2, 124.1, 123.7, 114.3, 110.9, 110.3, 110.2, 103.3, 100.4, 57.2, 53.7, 52.0, 51.9, 45.3, 44.9.

NMR spectra of 10a in DMSO-d_6: mixture of inseparable diastereomers, dr = ~ 1.5 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-d_6)**: δ = 7.68–7.56 (br. m, 0.6H, A), 7.52–7.25 (br. m, 6.4H, A + B), 7.23–7.07 (br. m, 2H, A + B), 6.51 (br. s, 1H, A + B), 6.40 (t, J = 8.0 Hz, 1H, A + B), 6.13 (br. s, 0.4H, B), 5.78 (br. s, 1H, A + B), 5.70–5.59 (br. m, 0.6H, A), 5.37 (br. s, 1H, A + B), 5.16–4.89 (br. m, 2H, A + B), 3.92 (s, 3H, A + B), 3.26 (br. s, 1.8H, A), 3.08 (br. s, 1.2H, B).

One of the possible reasons for broadening peaks in NMR spectra of **10a** in DMSO-d_6 might be the presence of ring-chain equilibrium (see ref. [17] for related example on partial unsaturated [1,3]oxazine) depicted in **A**, scheme 1. In that case, *α–CH* (shown in red) of the pyridinium fragment should have δ > 8.5 ppm (see **B** on scheme 1 for literature examples). However, no such signal can be seen in ^{1}H NMR of **10a**, indicating that two sets of signals are likely attributed to diastereomers.

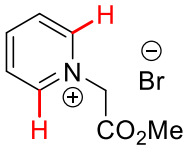
A. The possible ring-chain equilibrium



10a

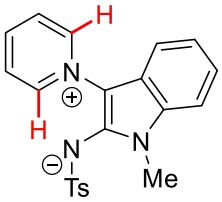
B.

9.15 ppm (DMSO-d_6)



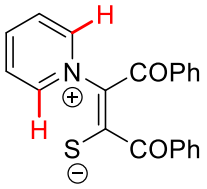
Ref. 18

9.04 ppm (DMSO-d_6)



Ref.19

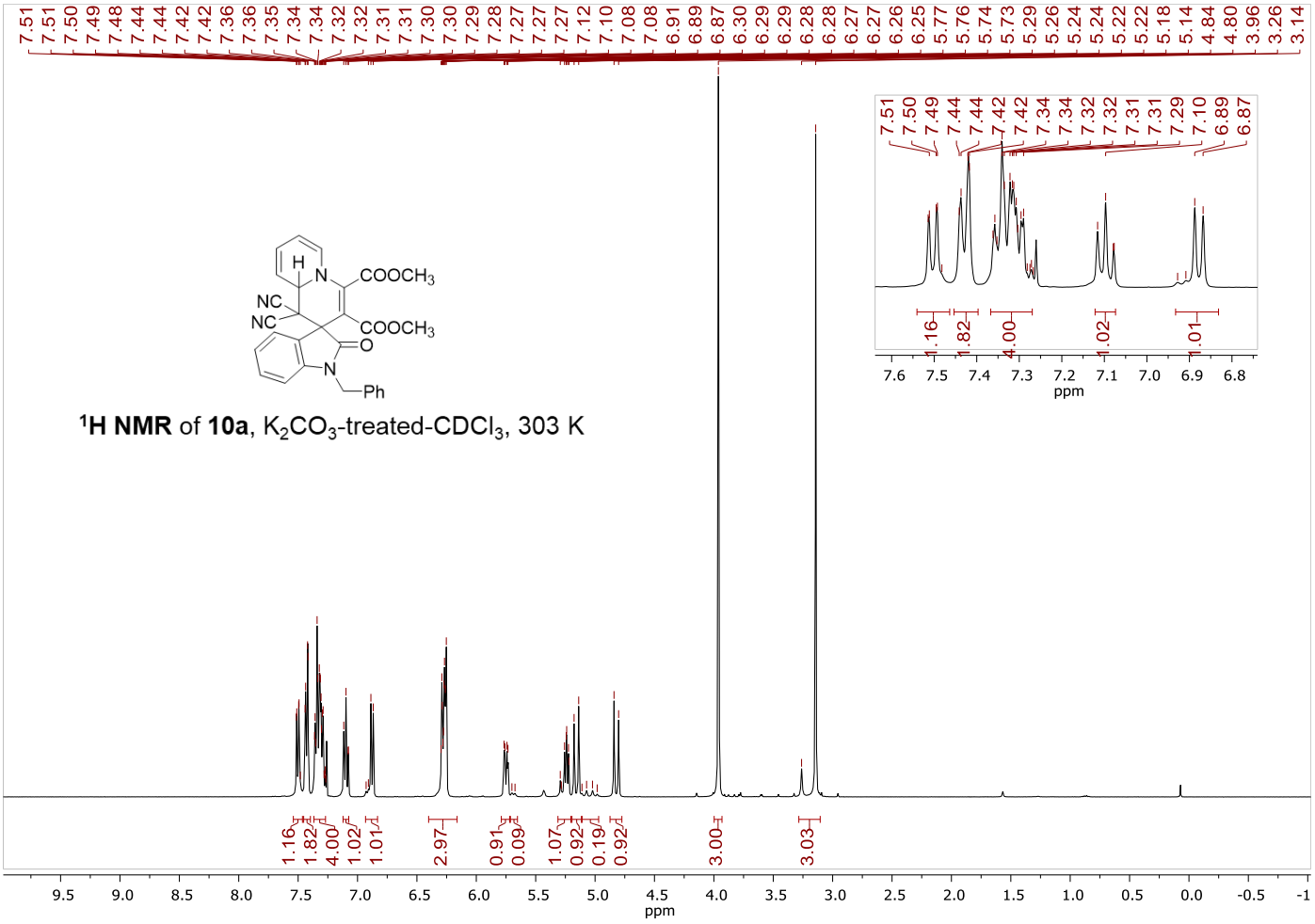
9.15 ppm (DMSO-d_6)

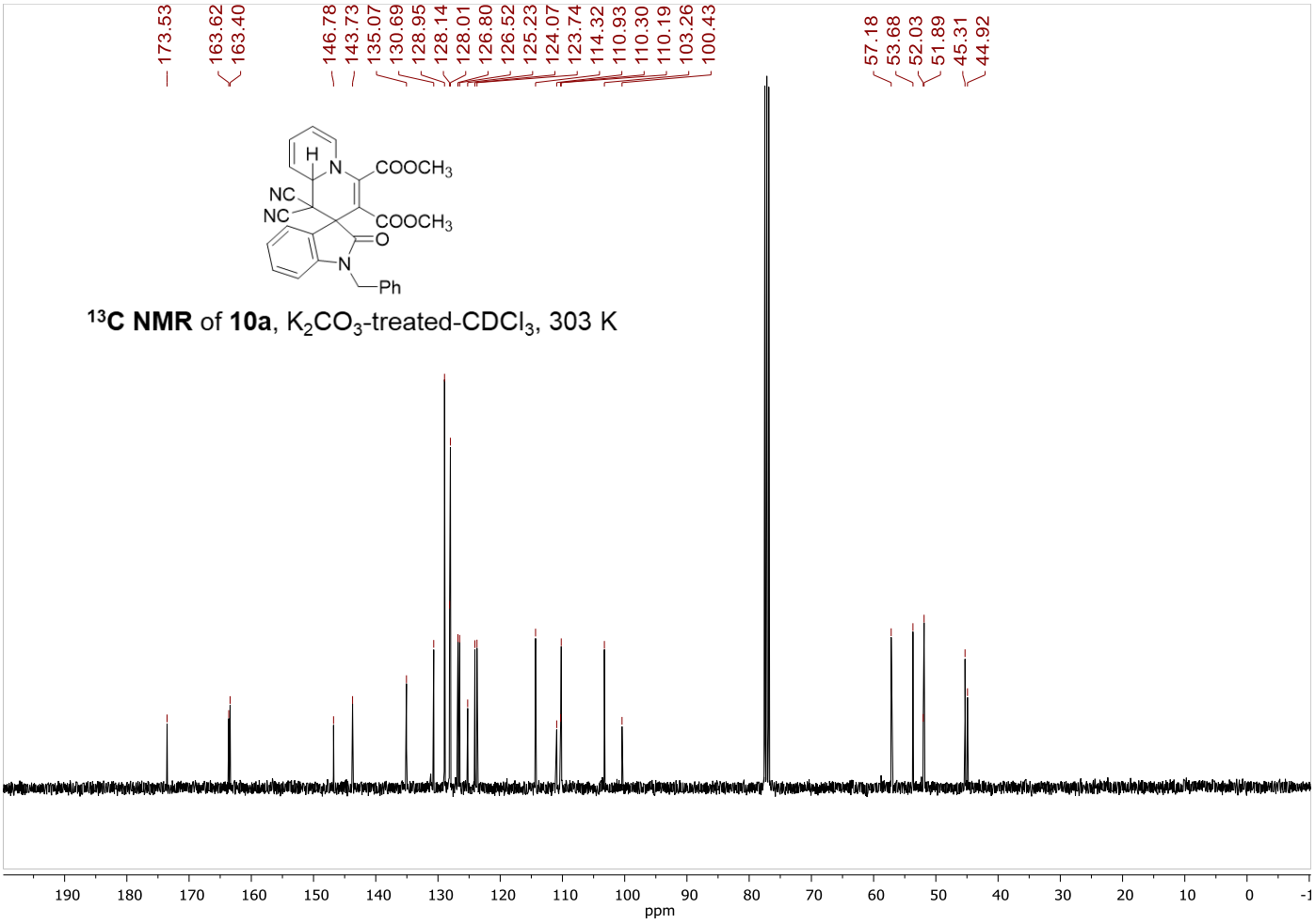


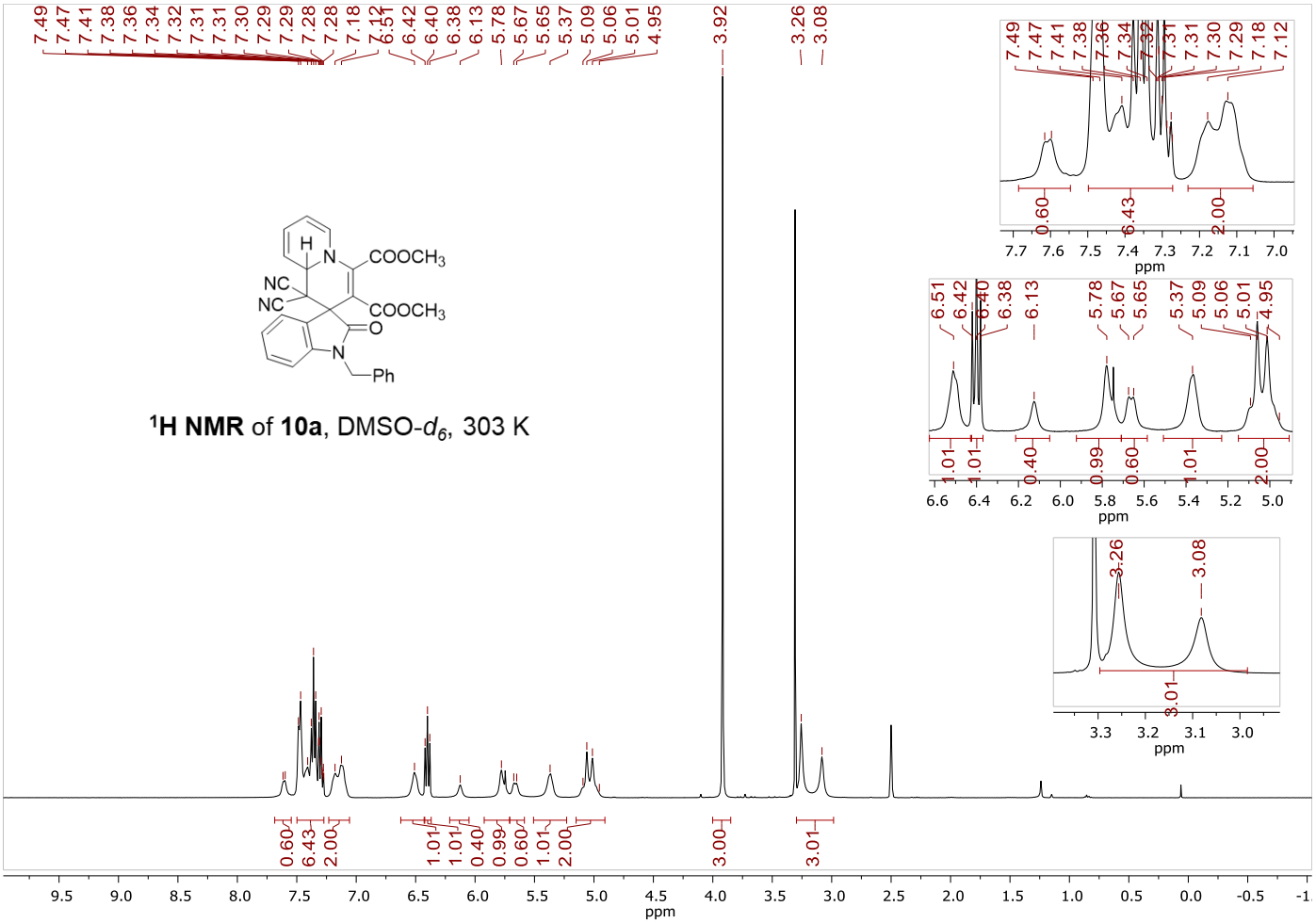
Ref.20

Scheme 1

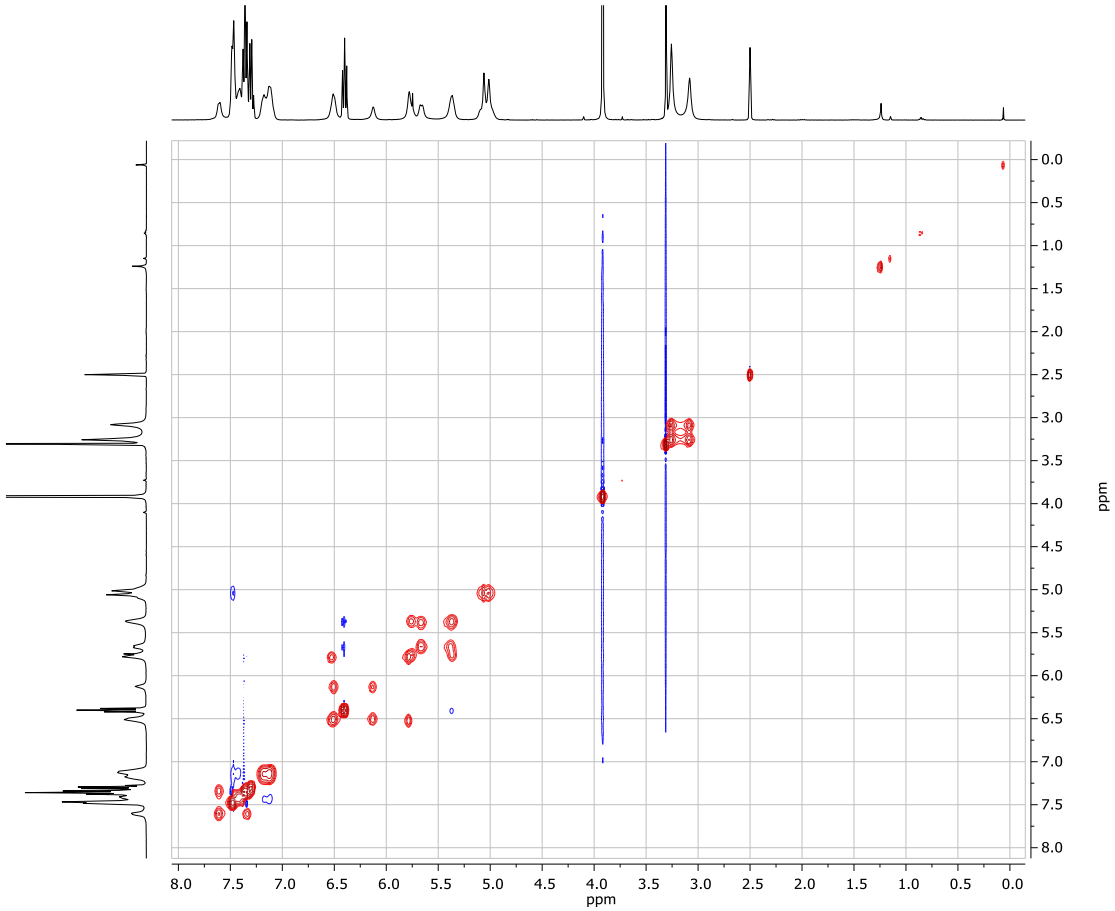
6.1.1. Copies of NMR spectra for product 10a



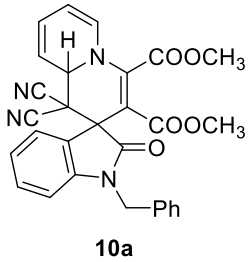



7.49 7.47 7.41 7.38 7.36 7.34 7.32 7.31 7.31 7.30 7.29 7.29 7.28 7.28 7.18 7.12 6.51 6.42 6.40 6.38 6.13 5.78 5.67 5.65 5.37 5.09 5.06 5.01 4.95 3.92 3.26 3.08
H
N
COOCH3
NC
NC
COOCH3
O
N
Ph
1H NMR of 10a, DMSO-d6, 303 K
0.60 6.43 2.00 1.01 1.01 0.40 0.99 0.60 1.01 2.00 3.00 3.01
ppm

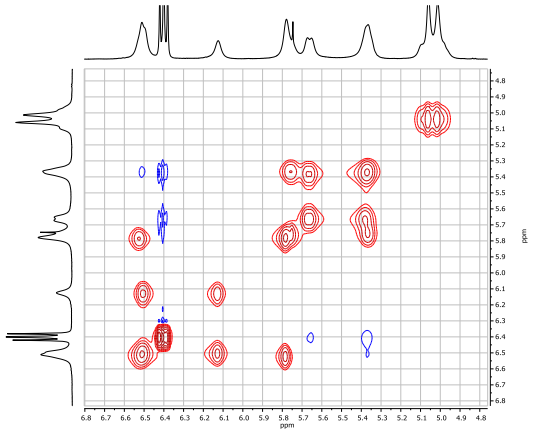
6.1.2. The NOESY/EXSY of compound 10a



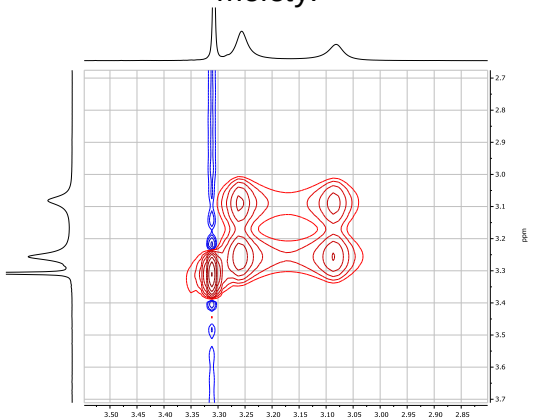
The NOESY (EXSY) spectrum of compound **10a** in DMSO-d_6 at 303K, acquired with standard Bruker program (NOESYPHSW), mixing time 0.700 sec; Off-diagonal cross-peaks in the same phase (red color) as the diagonal ones indicate chemical exchange between these peaks (protons).



10a

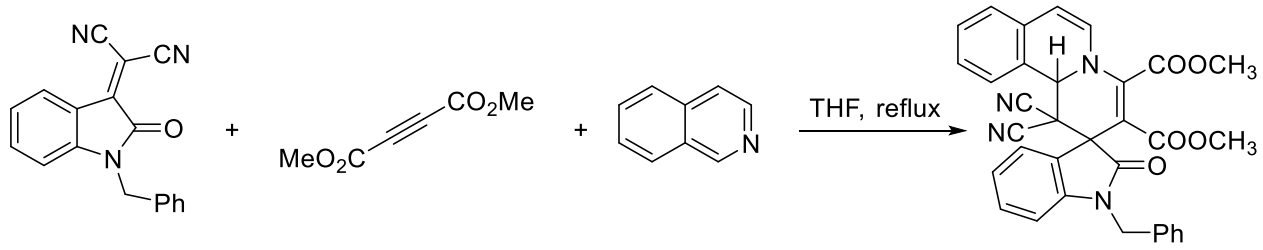


The fragment of the NOESY spectrum (region of 4.80–6.80 ppm); cross peaks indicate exchange between *CH fragments* of the dihydropyridine moiety.



The fragment of the NOESY spectrum (region of 2.85–3.50 ppm); cross-peaks indicate exchange between the methoxy groups.

6.2. Synthesis of product 10b

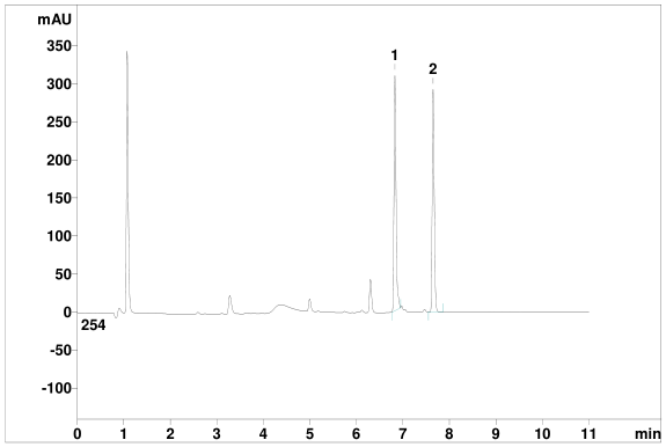


9 **2a** **10b** (76%)

Dimethyl 1-benzyl-1',1'-dicyano-2-oxo-1',11b'-dihydrospiro[indoline-3,2'-pyrido[2,1-*a*]isoquinoline]-3',4'-dicarboxylate (10b): The compound was prepared according to the adopted reported procedure [16]: DMAD (92 µL, 0.75 mmol, 1.5 equiv.) was added to a solution of 2-(1-benzyl-2-oxoindolin-3-ylidene)malononitrile **9** (143 mg, 0.5 mmol, 1 equiv.) and isoquinoline (99 µL, 0.75 mmol, 1.5 equiv.) in tetrahydrofuran (THF, 12 mL). The reaction mixture was refluxed for 8h. The reaction mixture was concentrated, the residue was triturated with EtOH, filtered and washed with EtOH. Compound was additionally purified by recrystallization from hexane/DCM, affording a mixture of inseparable* diastereomers as a yellow solid (213 mg, 76% yield); R_f = 0.53 + 0.65 (Hex/EA 1:1); m.p. 180–183 °C (decomp.); HRMS (ESI): *m/z* calcd for $C_{33}H_{24}N_4O_5$: 579.1639 [*M*+Na]$^+$; found: 579.1652.

* *inseparable by crystallization, however separation via column chromatography is possible*

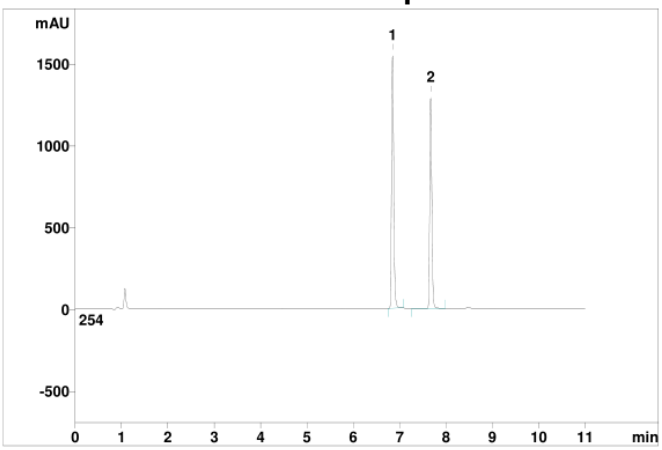
HPLC of the reaction mixture



Quantitation method: Response normalization

Peak	Retention min	Area mAU*sec	Area %	Component
1	6.83	966.860	51.85	
2	7.65	897.942	48.15	
2	11.00	1864.802	100.00	

HPLC of the isolated product 10b



Quantitation method: Response normalization

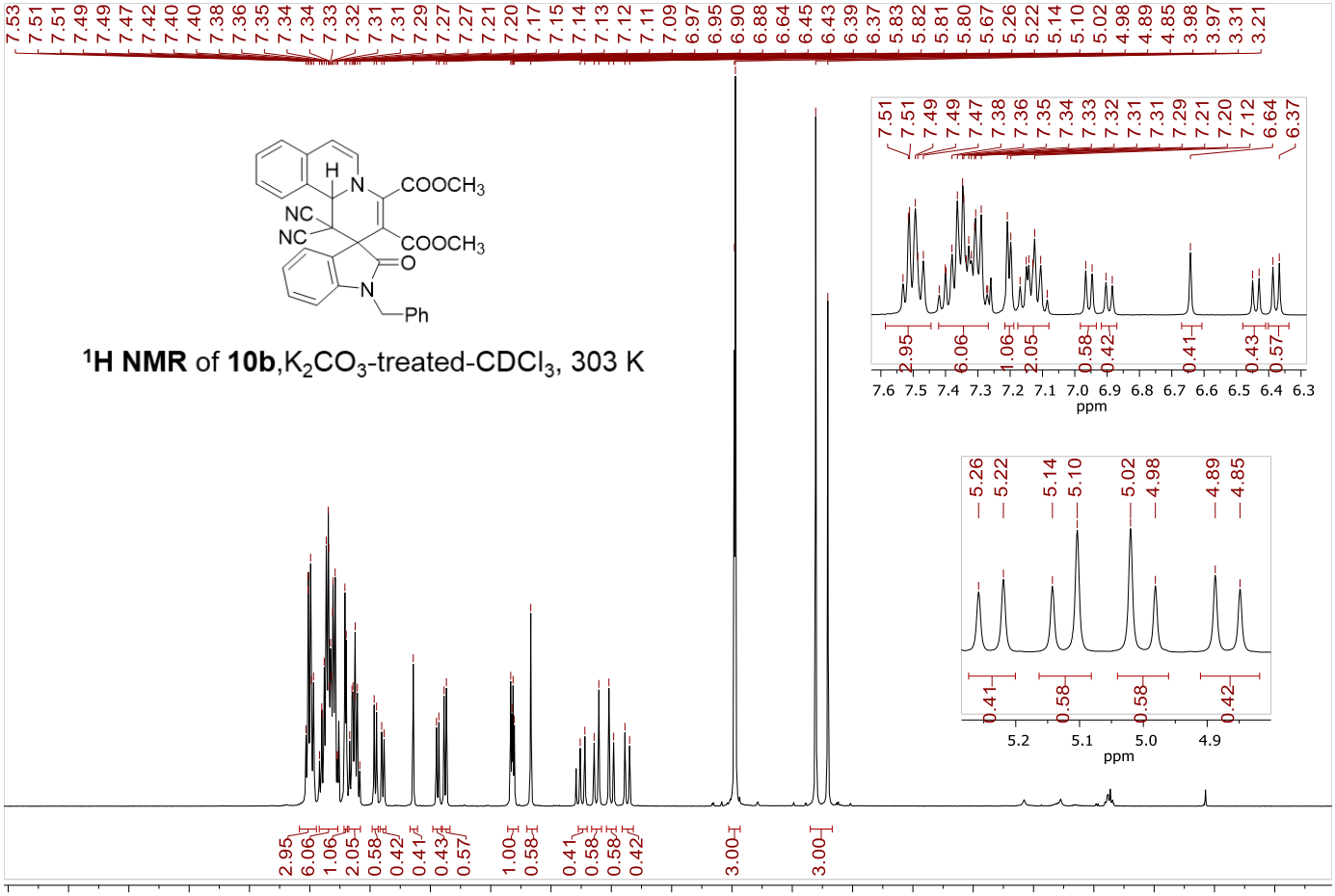
Peak	Retention min	Area mAU*sec	Area %	Component
1	6.85	5054.957	55.16	Peak1
2	7.67	4109.016	44.84	
2	11.00	9163.972	100.00	

NMR spectra of 10b in K_2CO_3-treated-$CDCl_3$: (the same dr was observed in $CDCl_3$) mixture of inseparable diastereomers, dr = ~ 1.4 : 1 (A : B). **^{1}H NMR (400 MHz, $CDCl_3$)**: δ = 7.55–7.45 (m, 3H, A+ B), 7.42–7.26 (m, 6H, A + B), 7.23–7.19 (m, 1H, A + B), 7.17–7.05 (m, 2H, A + B), 6.96 (d, *J* = 7.9 Hz, 0.58H, A), 6.89 (d, *J* = 7.9 Hz, 0.42H, B), 6.64 (s, 0.42H, B), 6.44 (d, *J* = 7.9 Hz, 0.42H, B),

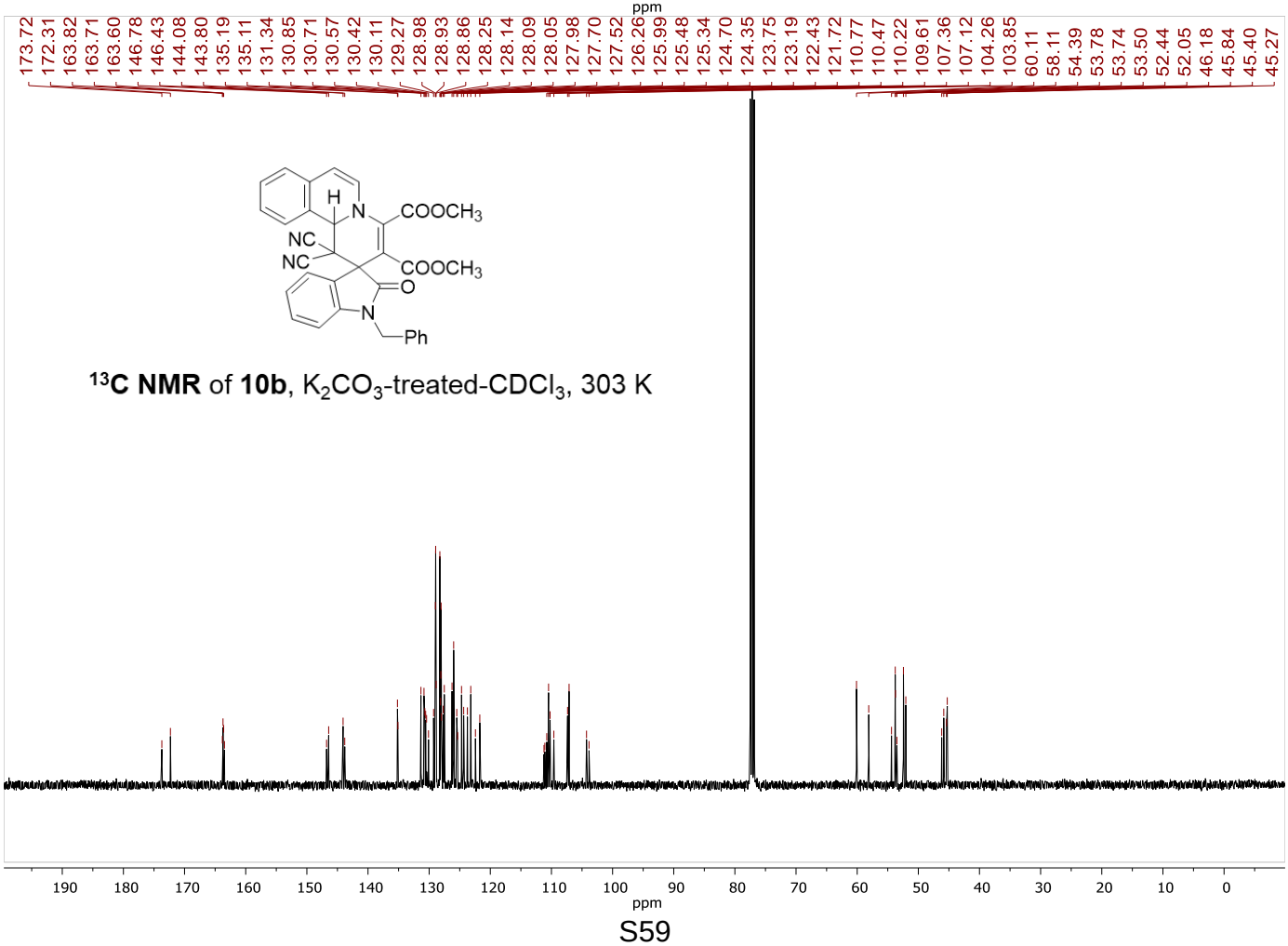
6.38 (d, *J* = 7.9 Hz, 0.58H, A), 5.82 (d, *J* = 7.9 Hz, 0.58H, A), 5.81 (d, *J* = 7.9 Hz, 0.42H, B), 5.67 (s, 0.58H, A), 5.24 (d, *J* = 15.5 Hz, 0.42H, B), 5.12 (d, *J* = 15.6 Hz, 0.58H, A), 5.00 (d, *J* = 15.6 Hz, 0.58H, A), 4.87 (d, *J* = 15.5 Hz, 0.42H, B), 3.98 (s, 1.25H, B), 3.97 (s, 1.75H, A), 3.31 (s, 1.75H, A), 3.21 (s, 1.25H, B). **^{13}C NMR (101 MHz, $CDCl_3$)**: δ (A + B) = 173.7, 172.3, 163.8, 163.7, 163.6, 163.5, 146.8, 146.4, 144.1, 143.8, 135.2, 135.1, 131.3, 130.8, 130.7, 130.6, 130.4, 130.1, 129.3, 129.0 (2C), 128.9 (2C), 128.9, 128.3 (2C), 128.14, 128.09, 128.05 (2C), 128.0, 127.7, 127.5, 126.3, 126.0 (2C), 125.5, 125.3, 124.7, 124.4, 123.7, 123.2, 122.4, 121.7, 111.2, 111.1, 110.8, 110.5, 110.2, 109.6, 107.4, 107.1, 104.3, 103.9, 60.1, 58.1, 54.4, 53.8, 53.7, 53.5, 52.4, 52.0, 46.2, 45.8, 45.4, 45.3.

NMR spectra of 10b in DMSO-d_6: mixture of inseparable diastereomers, dr = ~ 1.4 : 1 (A : B). **^{1}H NMR (400 MHz, DMSO-d_6)**: δ = 7.94 (d, *J* = 7.5 Hz, 0.6H, A), 7.54–7.41 (m, 3.8H, A + B), 7.41–7.25 (m, 6H, A + B), 7.23–7.12 (m, 2H, A + B), 7.09 (d, *J* = 7.7 Hz, 0.6H, A), 6.68 (d, *J* = 7.9 Hz, 0.4H, B), 6.64 (d, *J* = 7.9 Hz, 0.6H, A), 6.53 (s, 0.4H, B), 6.14 (s, 0.6H, A), 6.01 (d, *J* = 7.9 Hz, 0.4H, B), 5.96 (d, *J* = 7.9 Hz, 0.6H, A), 5.20–4.94 (m, 2H, A + B), 3.95 (s, 1.25H, B), 3.94 (s, 1.75H, A), 3.31 (s, 1.75H, A), 3.15 (s, 1.25H, B). **^{13}C NMR (101 MHz, DMSO-d_6)**: δ (A + B) = 172.9, 171.9, 163.3, 162.9, 162.8, 162.7, 146.4, 146.0, 143.4, 143.3, 135.6, 135.3, 131.0, 130.9, 130.7, 130.5, 130.2, 129.7, 129.0, 128.6 (2C), 128.5 (3C), 127.9 (2C), 127.7 (3C), 127.6, 127.5, 127.3, 126.9, 126.8, 126.0, 125.9, 125.7, 125.4, 124.6, 123.5, 123.2, 123.2, 121.9, 121.6, 111.0, 110.92, 110.90, 110.6, 110.02, 109.97, 106.7, 106.1, 103.8, 102.7, 59.3, 57.2, 53.9, 53.8, 53.7, 52.6, 52.2, 52.0, 45.9, 45.8, 44.2, 43.9.

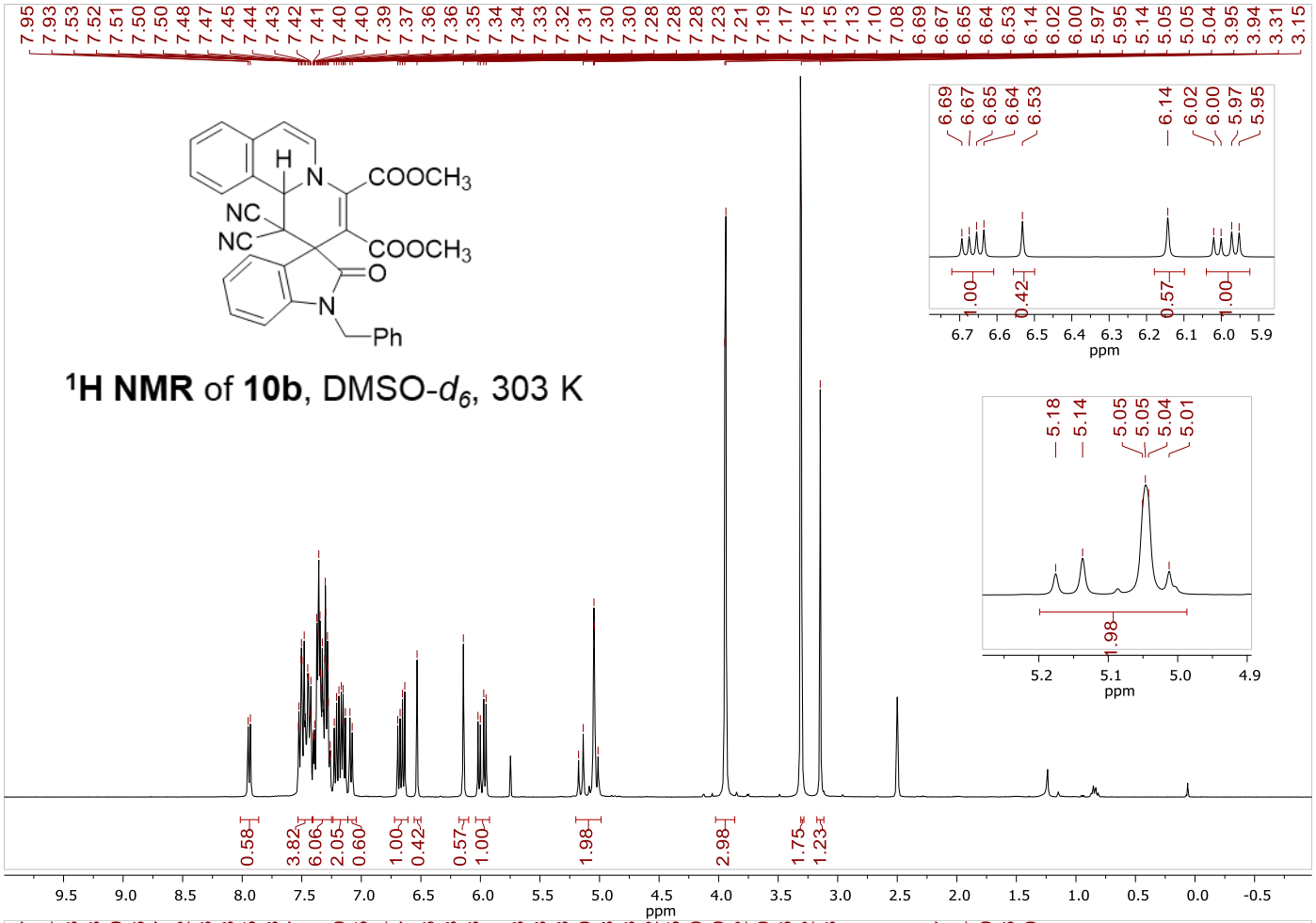
6.2.1. Copies of NMR spectra for product 10b

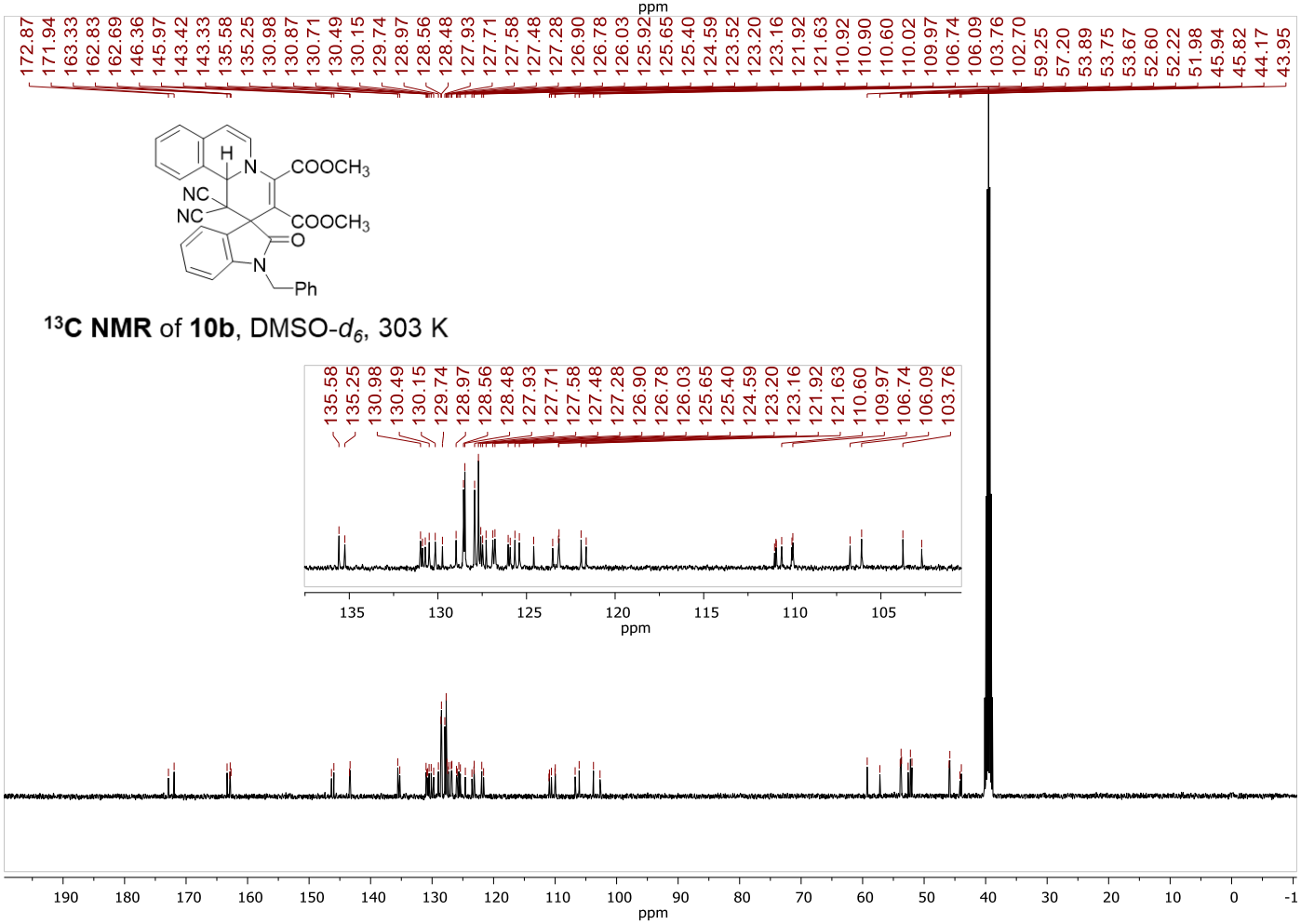


^{1}H NMR of **10b**,K_2CO_3-treated-$CDCl_3$, 303 K



^{13}C NMR of **10b**, K_2CO_3-treated-$CDCl_3$, 303 K


H
N
COOCH3
NC
NC
COOCH3
O
N
Ph
1H NMR of 10b, DMSO-d6, 303 K
ppm


H
N
COOCH3
NC
NC
COOCH3
O
N
Ph
13C NMR of 10b, DMSO-d6, 303 K
ppm

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