Supporting Information

Transforming an Azaarene into the Spine of Fused Bicyclics via Cycloaddition-Induced Scaffold Hopping of 5-Hydroxypyrazoles

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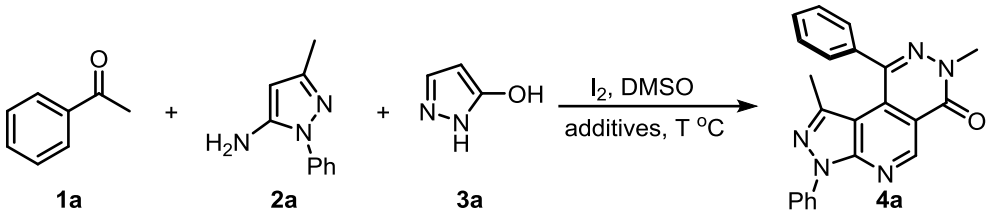
1. General

All substrates and reagents were commercially available and used without further purification. TLC analysis was performed using pre-coated glass plates. Column chromatography was performed using silica gel (200–300 mesh). ^{1}H, ^{13}C, ^{19}F and ^{31}P spectra were recorded in $CDCl_3$ or DMSO-d_6 on Bruker 400 MHz NMR (AVANCE III HD 400) spectrometers and chemical shifts of ^{1}H NMR are reported in ppm, relative to the internal standard of tetramethylsilane ($CDCl_3$, $\delta_{(TMS)} = 0.00$ ppm; DMSO-d_6, $\delta = 2.50$ ppm). Chemical shifts of ^{13}C NMR were reported in ppm with the solvent as the internal standard ($CDCl_3$, $\delta = 77.0$ ppm; DMSO-d_6, $\delta = 39.5$ ppm). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet), coupling constants (Hz) and integration. ^{13}C spectra were recorded in $CDCl_3$ on 100 MHz NMR spectrometers and resonances (δ) are given in ppm. ^{19}F spectra were recorded in $CDCl_3$ on 376 MHz NMR spectrometers and resonances (δ) are given in ppm. ^{31}P spectra were recorded in $CDCl_3$ on 162 MHz NMR spectrometers and resonances (δ) are given in ppm. The high resolution mass spectrometers were obtained on an Agilent LC1290-TOF 6224 or German Thermo Fisher Q Exactive equipped with an electrospray source. The *X-ray* crystal-structure determinations of **4e** and **7b** were obtained on a Bruker APEX DUO CCD The crystals were mounted on a glass fiber for diffraction experiments. Intensity data were collected on a Bruker SMART APEX CCD diffractometer with Mo Kα radiation (0.71073 Å) at room temperature. Melting points were determined using XT-4 apparatus and not corrected.

2. Screening of the reaction conditions

Supplementary Table 1: Screening of the reaction conditions[a]

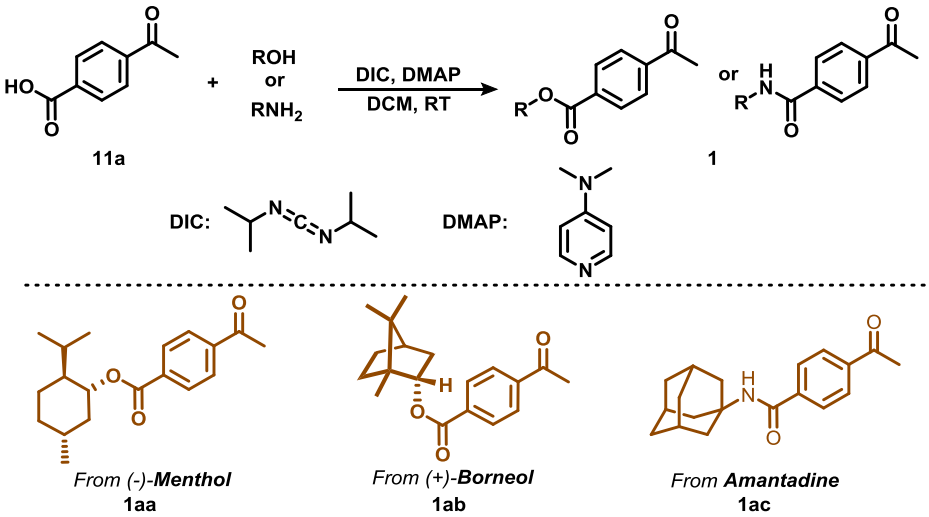


Entry	I_2 (equiv.)	Additives (equiv.)	Temp (℃)	Yield (%)[b]
1	1.0	-	100	47
2	1.0	*t*-BuCOOH (1.0)	100	45
3	1.0	CF_3COOH (1.0)	100	38
4	1.0	50% HI (1.0)	100	46
5	1.0	TfOH (1.0)	100	50
6	1.0	Tf_2NH (1.0)	100	48
7	1.0	TsOH (1.0)	100	47
8	1.0	$FeCl_3$ (1.0)	100	45
9	1.0	$CuCl_2$ (1.0)	100	39
10	1.0	$Cu(OTf)_2$ (1.0)	100	63
11	1.0	$ZnCl_2$ (1.0)	100	58
12	1.0	$NiCl_2$ (1.0)	100	60
13	1.0	$K_2S_2O_8$ (1.0)	100	19
14	1.0	$PhI(OAc)_2$ (1.0)	100	12
15	1.0	70% TBHP (1.0)	100	43
16	**1.0**	DTBP (1.0)	100	72
17	1.0	AIBN (1.0)	100	70
18	1.0	DCP (1.0)	100	67
19	**0.5**	DTBP (1.0)	100	60
20	**1.5**	DTBP (1.0)	100	63
21	**2.0**	DTBP (1.0)	100	57
22	1.0	**DTBP (2.0)**	**100**	**75**
23	1.0	**DTBP (3.0)**	100	70
24	1.0	DTBP (2.0)	**80**	59
25	1.0	DTBP (2.0)	**90**	68
26	1.0	DTBP (2.0)	**110**	72
27	1.0	DTBP (2.0)	**120**	62

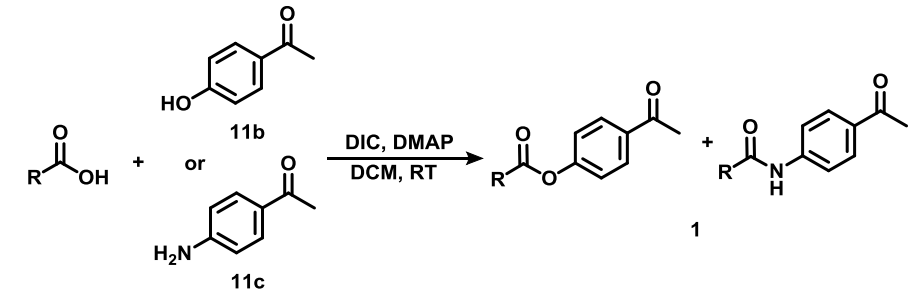
[a]Reaction conditions: **1a** (1.2 mmol), **2a** (1.0 mmol), **3a** (1.0 mmol) ,I_2 (x mmol) and Additives (x mmol) at T ℃ for 4 h under air. [b]Isolated yields.

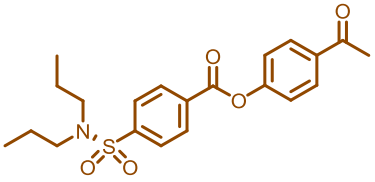
3. Synthetic operation method of target product and substrate

Synthesis of Acetophenone derived from active molecules (1aa-1af)[1-2]

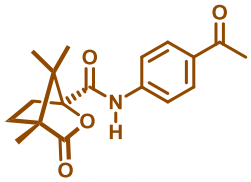


4-Acetylbenzoic acid (**11a**, 10 mmol, 1642 mg), (-)-menthol (10 mmol, 1563 mg), [or (+)-borneol (10 mmol, 1543 mg), 1-adamantanamine (10 mmol, 1513 mg)] and 4-dimethylaminopyridine (DMAP, 3 mmol, 366 mg) were added to a 100 mL round-bottomed flask, then 50 mL of dichloromethane was added and mixed well to form a solution, and add the condensation reagent *N*, *N*-diisopropylcarbodiimide (DIC, 15 mmol, 1890 mg) while stirring the solution. Keep the mixture stirred at room temperature for 6 hours using a magnetic stirrer to complete the reaction. At the end of the reaction, the organic phase was extracted and partitioned with ethyl acetate and NaCl aqueous solution, and the crude product mixture was obtained after rotary evaporation under reduced pressure. Finally, the pure target product was obtained by column chromatography separation with a yield higher than 90%.

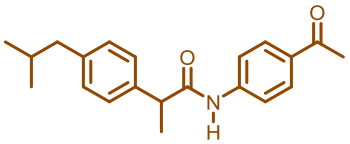




From **Probenecid**
1ad



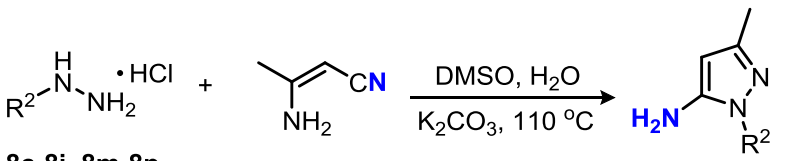
From ***(1S)-(-)-Camphanic Acid***
1ae



From ***(±)-Ibuprofen***
1af

Carboxylic acid (10 mmol), 4-hydroxyacetophenone(**11b**, 10 mmol, 1362 mg), [or 4-aminoacetophenone (**11c**, 10 mmol, 1352 mg)] and 4-dimethylaminopyridine (DMAP, 3 mmol, 366 mg) were added to a 100 mL round-bottomed flask, then 50 mL of dichloromethane was added and mixed well to form a solution, and add the condensation reagent *N*, *N*-diisopropylcarbodiimide (DIC, 15 mmol, 1890 mg) while stirring the solution. Keep the mixture stirred at room temperature for 6 hours using a magnetic stirrer to complete the reaction. At the end of the reaction, the organic phase was extracted and partitioned with ethyl acetate and NaCl aqueous solution, and the crude product mixture was obtained after rotary evaporation under reduced pressure. Finally, the pure target product was obtained by column chromatography separation with a yield higher than 90%.

Synthesis method of 5-aminopyrazole (2)[3-5]



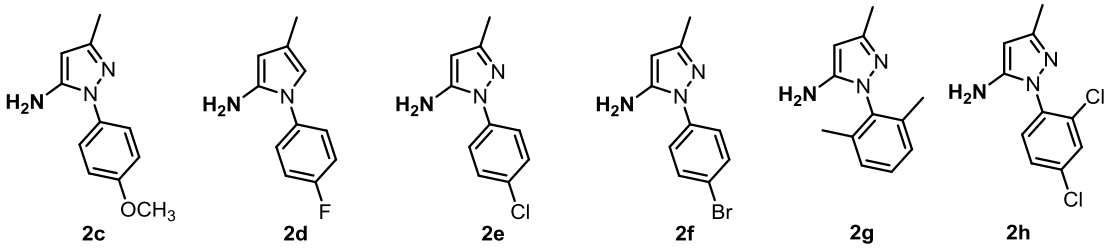
8c-8j, 8m-8p
R^2 = Aryl or alkyl

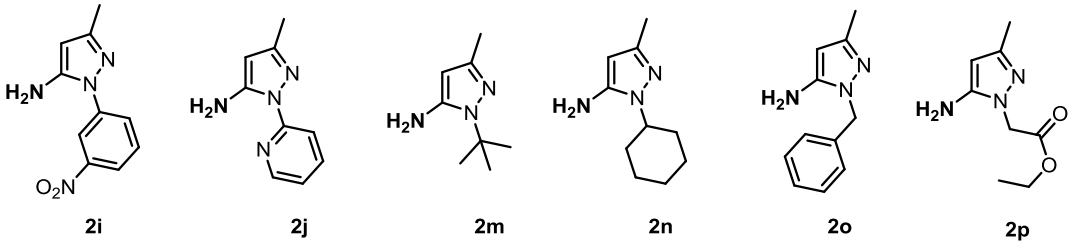
9a

2c-2j, 2m-2p

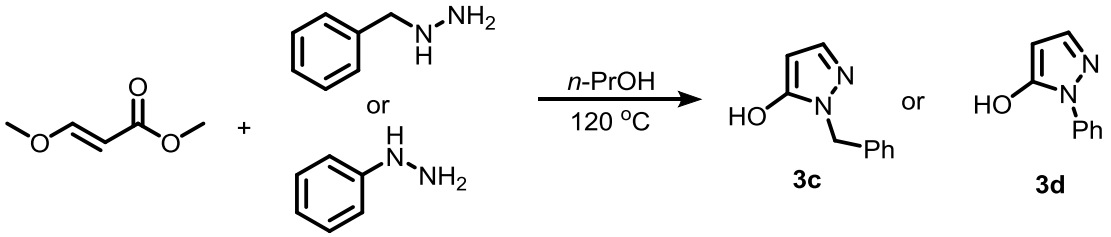
General procedure for 3-methyl-5-aminopyrazole: The substituted hydrazine hydrochloride (**8**, 5.0 mmol) was placed in a 38 mL glass reaction tube, and then K_2CO_3 (5.0 mmol, 690 mg) was added separately, followed by 15 mL of DMSO and 2 mL of H_2O as solvent, so that the mixture was stirred well on the reaction pot, and then 3-aminocrotononitrile (**9**, 6.0 mmol, 492 mg) was added, and finally the reaction was carried out at 110 ℃ for 5h. The target product in the reaction solution could be detected by TLC, and after the reaction was completed, the fraction was extracted with NaCl aqueous solution and ethyl acetate, and the combined

organic phases were spun dry, and finally the pure target product was obtained by column chromatography (eluent polarity, EA:PE=5:1-3:1, yield above 90%).



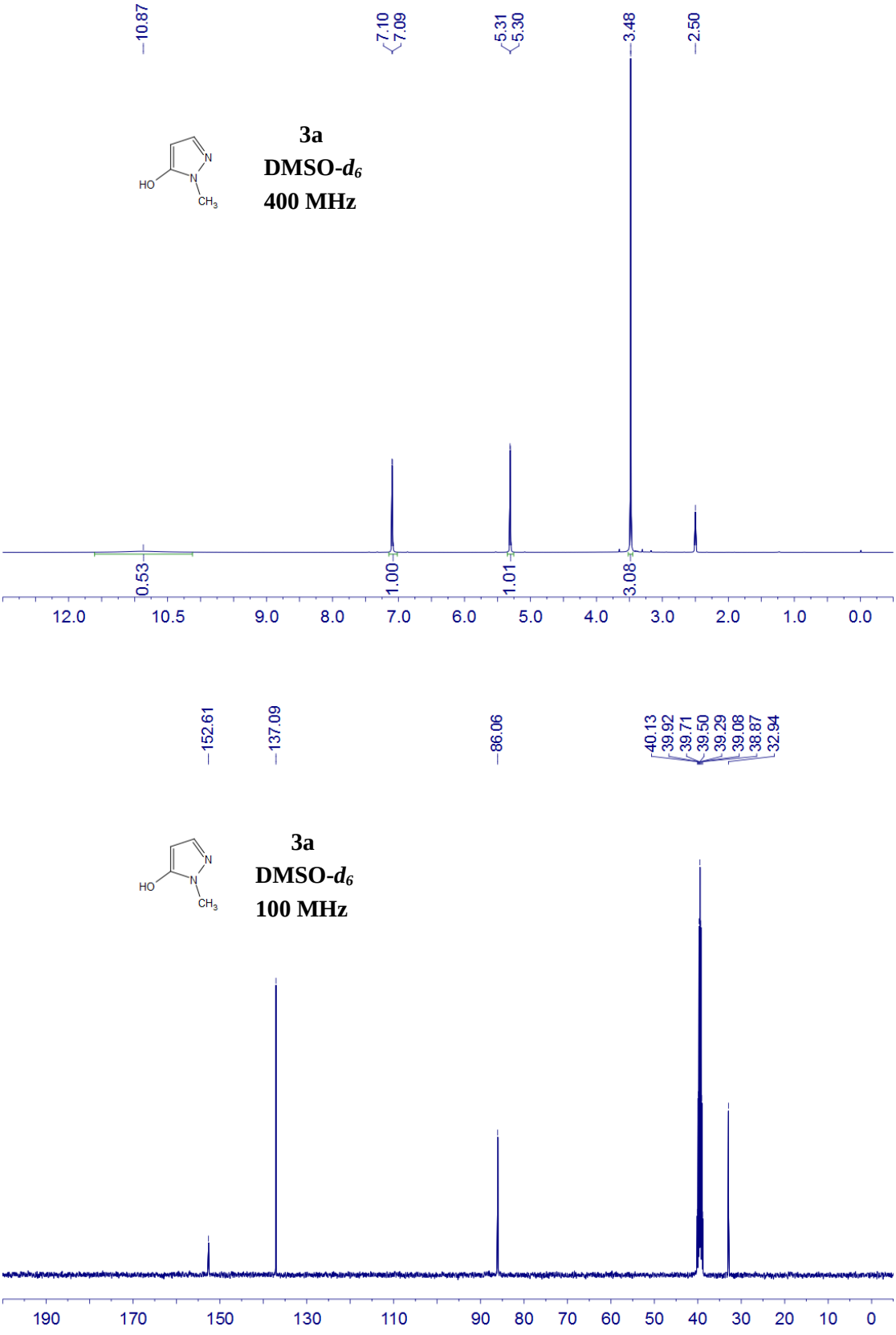


Synthesis method of 5-hydroxypyrazole (3)[6-7]

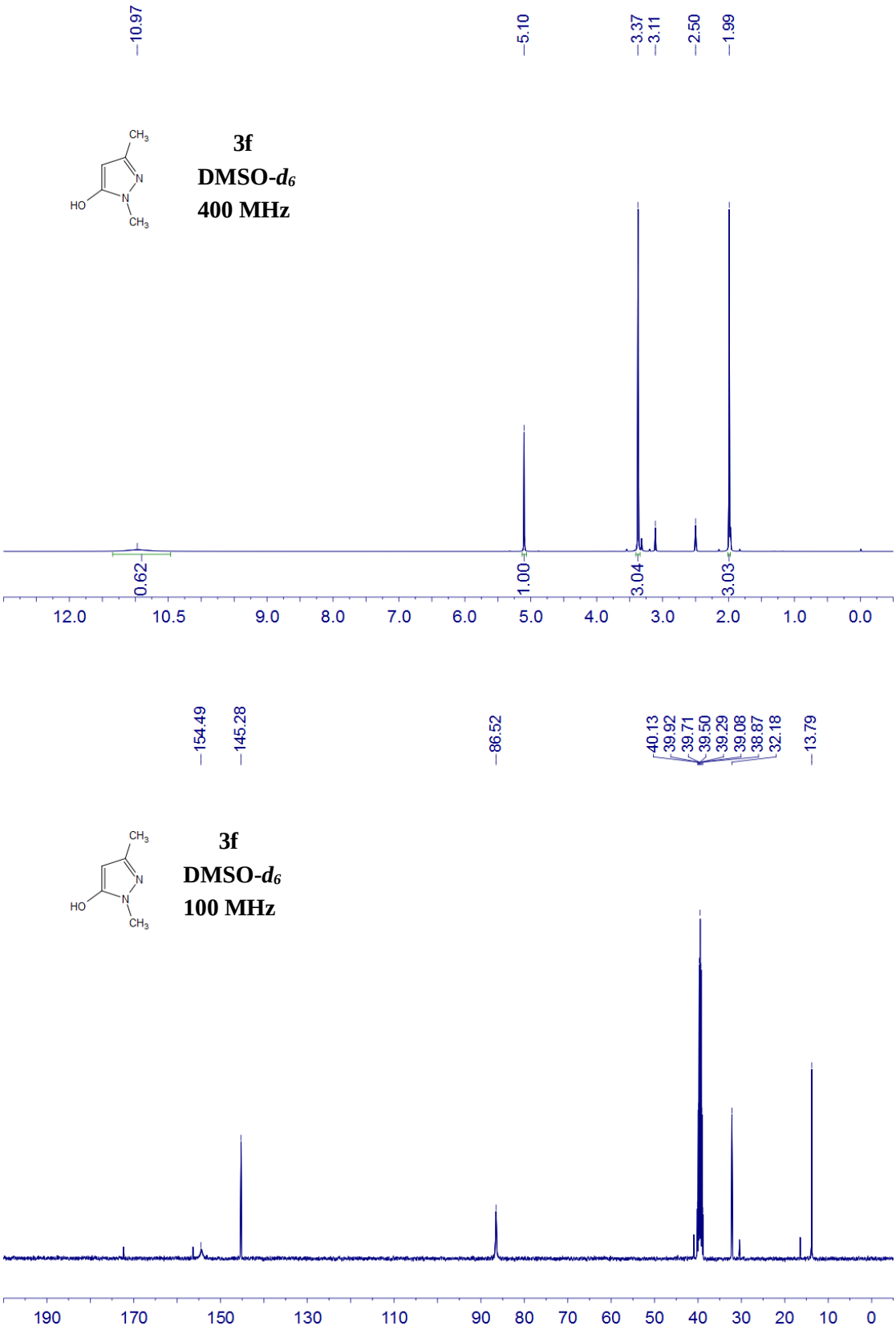


General procedure for 5-hydroxypyrazole: Add methyl 3-methoxyacrylate (10 mmol, 1160 mg) and phenylhydrazine (10 mmol, 1080 mg) [or benzylhydrazine (10 mmol, 1220 mg)] to a 38mL glass tube, and add 20mL n-propanol as the reaction solvent, and finally the reaction was carried out at 120 ℃ for 8h. The target product in the reaction solution could be detected by TLC, and after the reaction was completed, the fraction was extracted with NaCl aqueous solution and ethyl acetate, and the combined organic phases were spun dry, and finally the pure target product was obtained by column chromatography (eluent polarity, EA, yield above 60%).

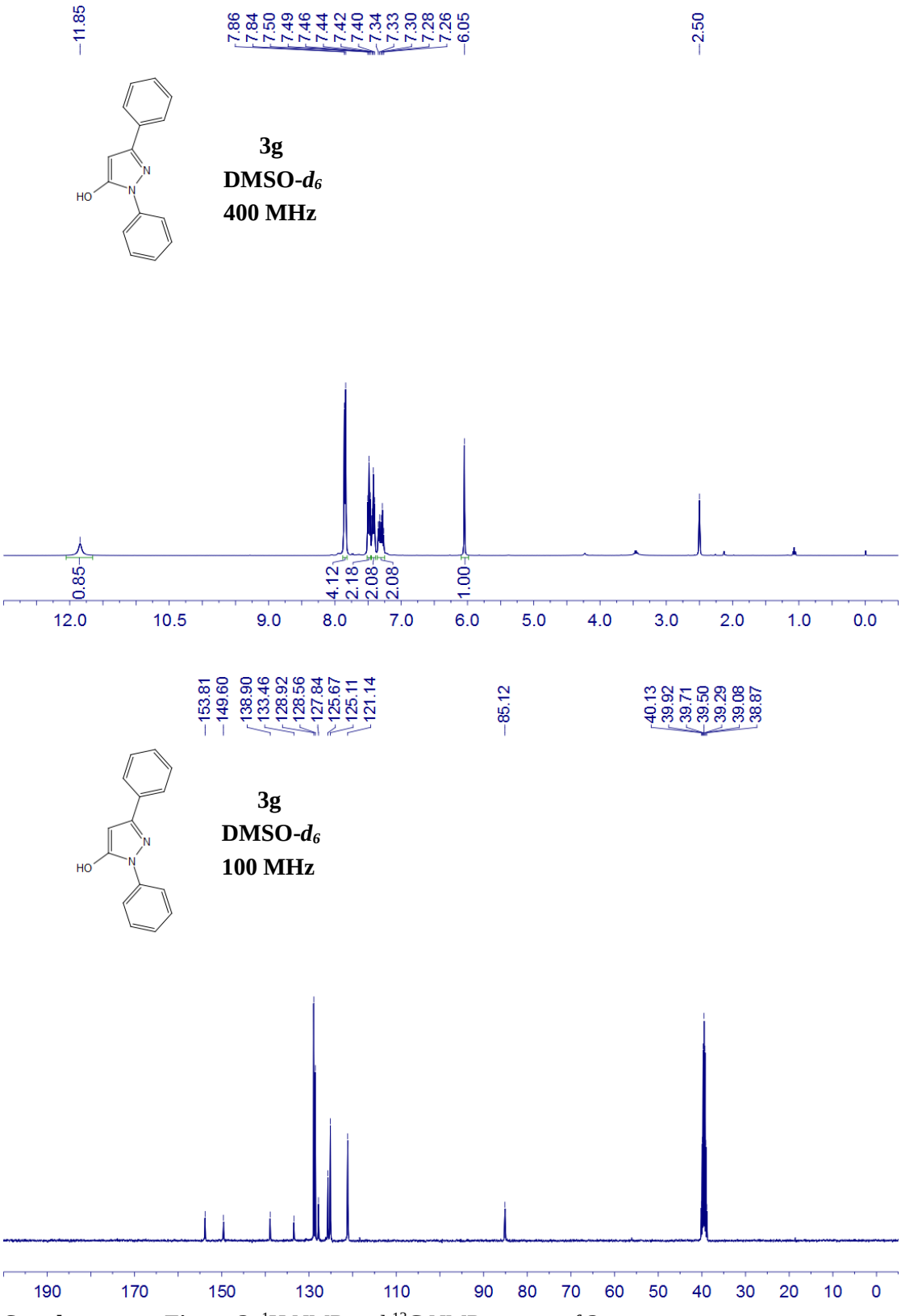
NMR spectra of 3-hydroxypyrazole in DMSO-*d*$_6$



Supplementary Figure 1. ^{1}H NMR and ^{13}C NMR spectra of **3a**.

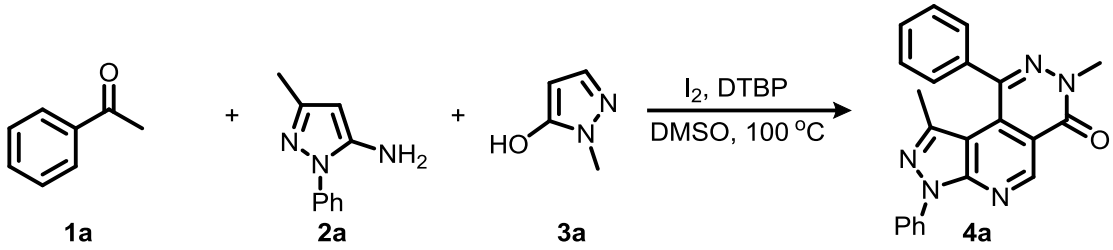


Supplementary Figure 2. ^{1}H NMR and ^{13}C NMR spectra of **3f**.

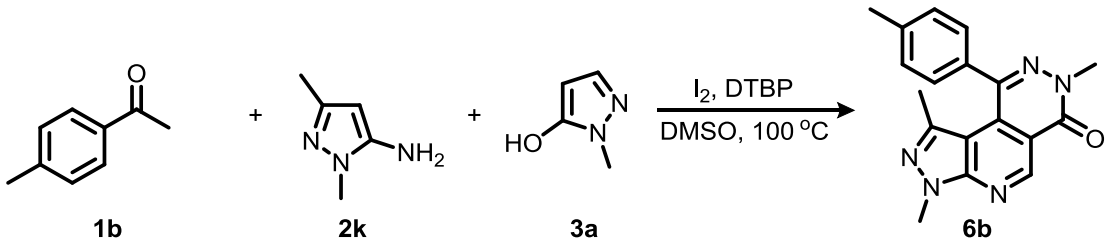


Supplementary Figure 3. ^{1}H NMR and ^{13}C NMR spectra of **3g**.

General procedure for the synthesis of 4-7 (4a or 6b as example)

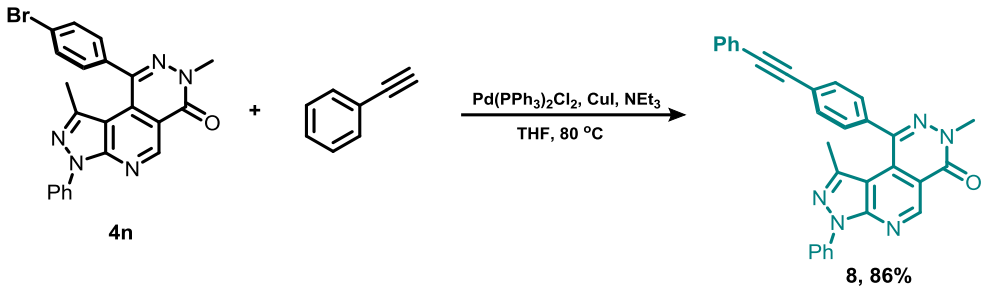


1.0 mmol scale (4a): The reactions did not require the protection of inert gases. In a 35 mL sealed tube were added acetophenone (**1a**) (144 mg, 1.2 mmol), iodine (254 mg, 1.0 mmol) and dimethyl sulfoxide (5 mL) and the resulting mixture was stirred at 100 ℃ (heating block), the reaction tube was removed after about 1 hour. Then additional **2a** (173 mg, 1.0 mmol), **3a** (98 mg, 1.0 mmol) and DTBP (292 mg, 2.0 mmol) were added at room temperature, followed by reaction at 100 ℃ for 4 hours until substrate conversion was almost complete by TLC analysis. After the reaction stopped and cooled at room temperature, the reaction mixture was quenched with saturated $Na_2S_2O_3$ solution (50 mL) and NaCl solution (200 mL). The mixture was then extracted with EtOAc (150mL × 2), and the organic layers were separated and merged. The mixture was dried with anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc = 12:1) to afford the product **4a** (275 mg, 75% yield).

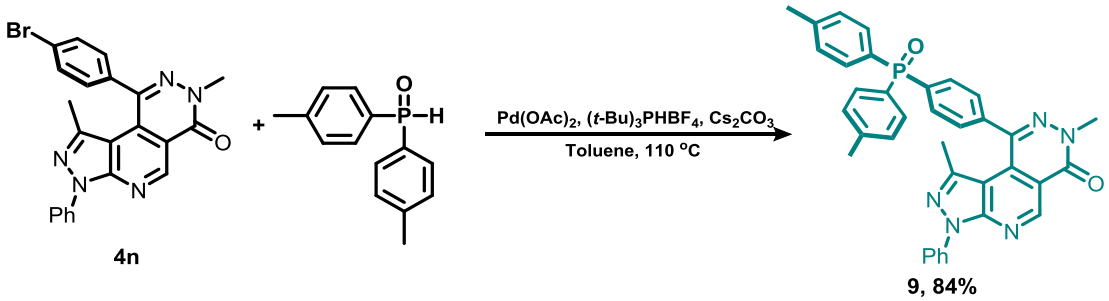


8.0 mmol scale (6b): The reactions did not require the protection of inert gases. In a 100 mL round flask were added *p*-methylacetophenone (**1b**) (1.29 g, 9.6 mmol), iodine (2.03 g, 8 mmol) and dimethyl sulfoxide (30 mL) and the resulting mixture was stirred in oil bath heating at 100 ℃, the round flask was removed after about 1.5 hour. Then additional **2k** (0.89 g, 8.0 mmol), **3a** (0.78 g, 8.0 mmol) and DTBP (2.34 g, 16 mmol) were added at room temperature, followed by reaction at 100 ℃ for 6 hours until substrate conversion was almost complete by TLC analysis. After the reaction stopped and cooled at room temperature, the reaction mixture was quenched with saturated $Na_2S_2O_3$ solution (150 mL) and NaCl solution (450 mL). The mixture was then extracted with EtOAc (300mL × 3), and the organic layers were separated and merged. The mixture was dried with anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc = 8:1) to afford the product **6b** (1.81 g, 71% yield).

Post-modification methods of 4n molecules

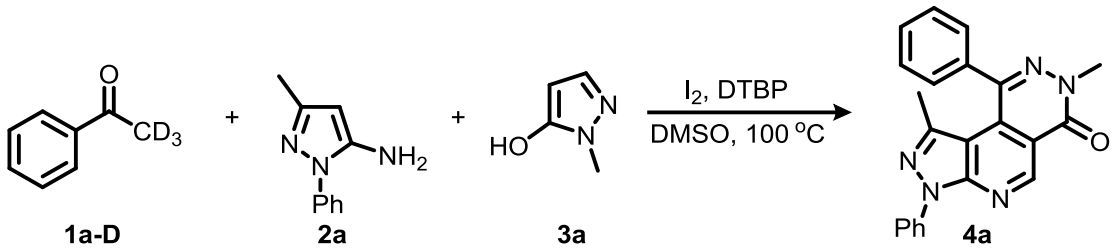


Product of *para*-bromine **4n** (134 mg, 0.3 mmol), phenylacetylene (46 mg, 0.45 mmol), $Pd(PPh_3)_2Cl_2$(9.8 mg, 0.015 mmol), CuI (5.7 mg, 0.03 mmol), NEt_3 (2 mL) and THF (2 mL). The vial was then purged with argon and sealed, and heated under an argon atmosphere 80 ℃ for 10 h. Until the disappearance of starting material was observed, as monitored by thin layer chromatography. After cooling to room temperature, the reaction solution was mixed with NaCl solution 300 mL), and then the mixture was extracted twice with EtOAc (100 mL x 2). The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated using a rotary evaporator under reduced pressure. The crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc = 12:1) to afford the product **8** (120 mg, 86% yield).[8]

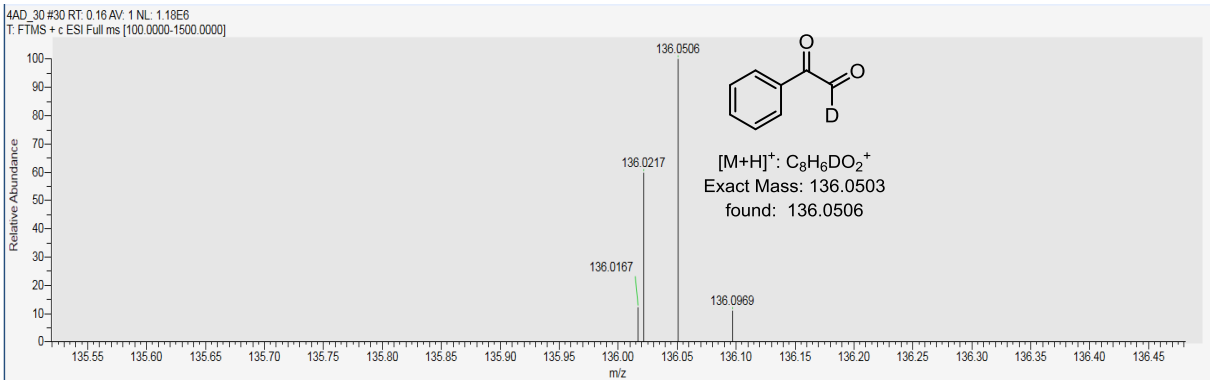


A mixture of **4n** (134 mg, 0.3 mmol), di-*p*-tolylphosphine oxide (104 mg, 0.45 mmol), palladium (II) acetate (4.5 mg, 0.02 mmol), (*t*-Bu_3)$PHBF_4$ (12.0 mg, 0.04 mmol), Cs_2CO_3 (196 mg, 0.6 mmol) and dry-toluene (4 mL), and heated under an argon atmosphere 110 ℃ for 10 h. After cooling to room temperature, the reaction solution was mixed with NaCl solution (300 mL), and then the mixture was extracted twice with EtOAc (100 mL x 2). The organic layer was separated and washed with brine, dried over anhydrous Na_2SO_4 and evaporated to dryness under reduced pressure. The crude product was purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc = 2:1) to afford the product **9** (149 mg, 84% yield).[9, 10]

4. Mechanistic studies



HRMS experiments were conducted to study the mechanisms. The reactions did not require the protection of inert gases. In a 35 mL sealed tube were added deuterated acetophenone-d_3 (**1a-D**) (148 mg, 1.2 mmol), iodine (254 mg, 1.0 mmol) and dimethyl sulfoxide (5 mL) and the resulting mixture was stirred at 100 ℃ (heating block), the reaction tube was removed after about 1 hour. Then additional **2a** (173 mg, 1.0 mmol), **3a** (98 mg, 1.0 mmol) and DTBP (292 mg, 2.0 mmol) were added at room temperature, followed by reaction at 100 ℃ for 40 mins, then wait for the reaction to cool to room temperature. Take 0.5 mL of reaction solution and dilute it with 4 mL of EtOAc. Then 1.5 mL of the extraction solution was added into the test bottle, the samples were immediately monitored by German Thermo Fisher Q Exactive high resolution mass spectrometers.



Supplementary Figure 4. High-resolution mass spectrometry of intermediate **1ab-D.**

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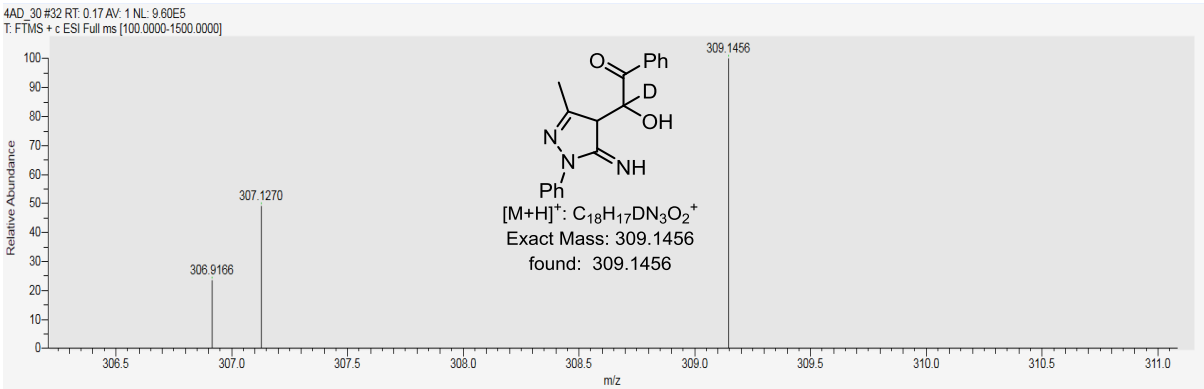
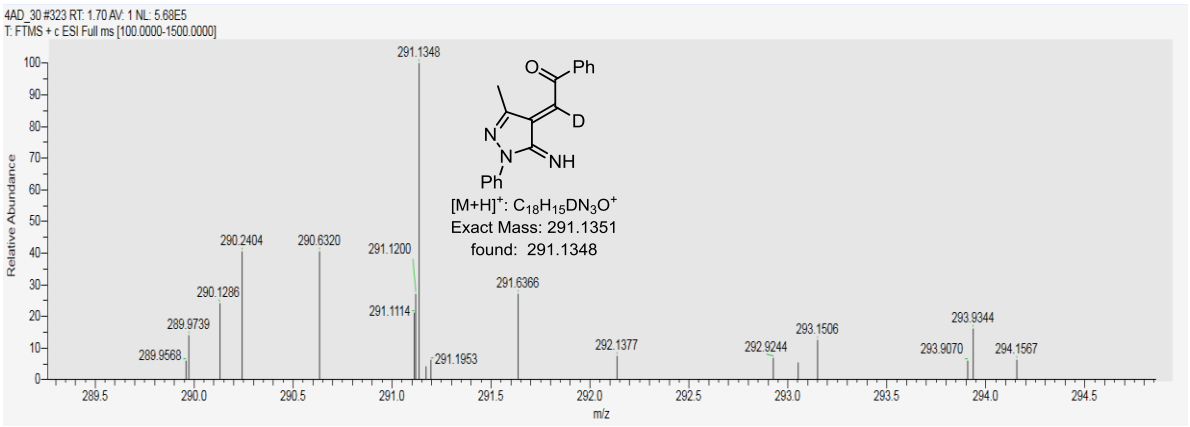
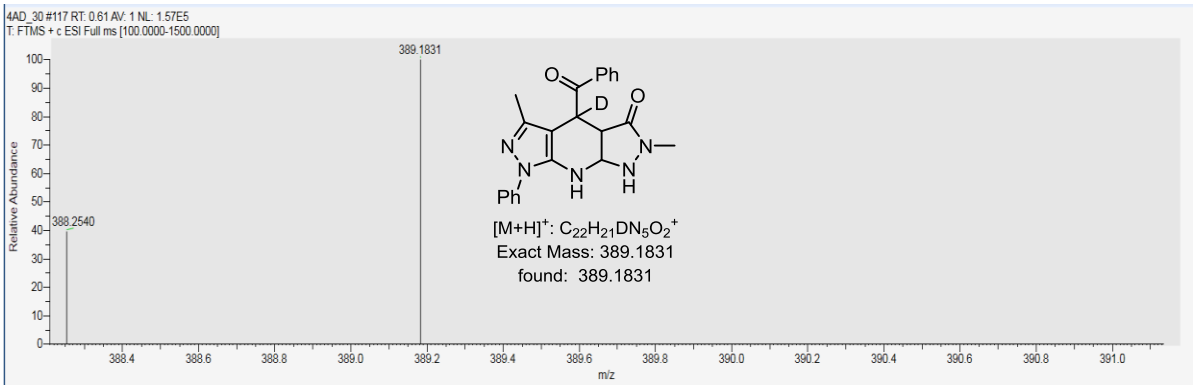


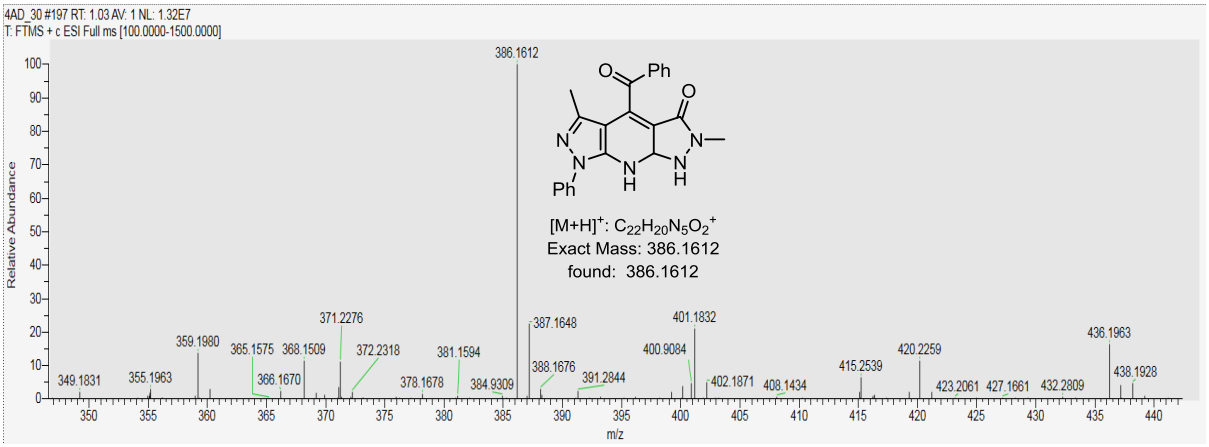
Supplementary Figure 5. High-resolution mass spectrometry of intermediate **A.**



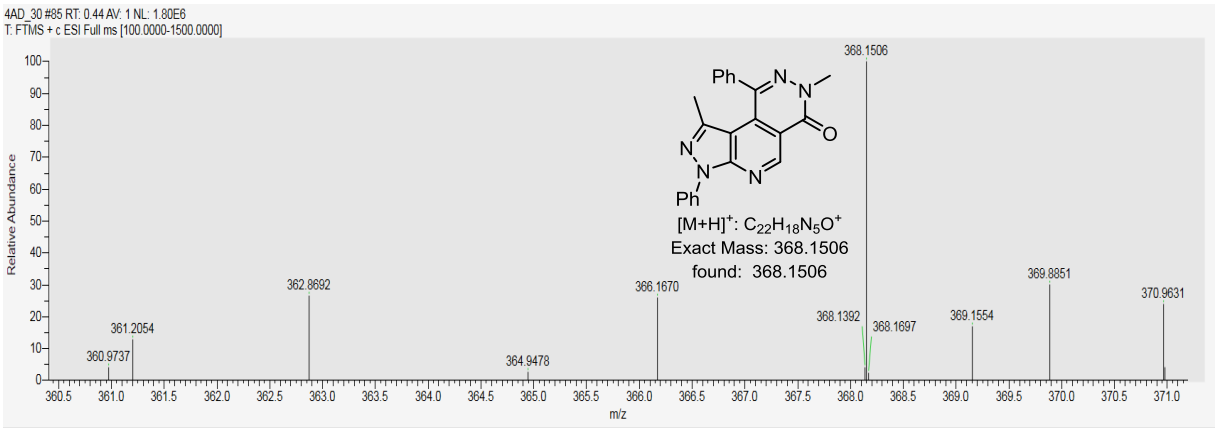
Supplementary Figure 6. High-resolution mass spectrometry of intermediate **B.**



Supplementary Figure S7. High-resolution mass spectrometry of intermediate **C.**

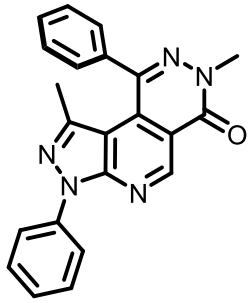


Supplementary Figure 8. High-resolution mass spectrometry of intermediate **D.**



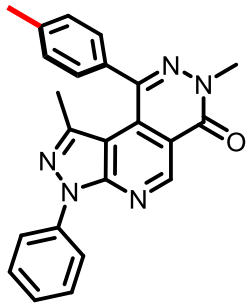
Supplementary Figure 9. High-resolution mass spectrometry of product **4a.**

6. Characterization data for compounds



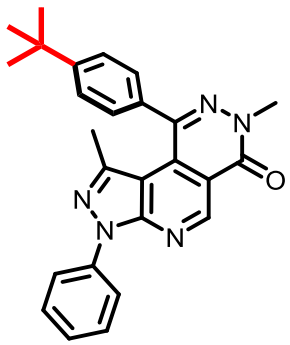
1,7-dimethyl-3,9-diphenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4a):

Yield 75%; 275 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 235–237 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.70 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.60-7.50 (m, 7H), 7.37 (t, *J* = 7.2 Hz, 1H), 3.95 (s, 3H), 1.59 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.4, 150.1, 144.3, 143.7, 138.3, 138.2, 130.7, 129.6, 129.3, 129.12, 129.09, 127.0, 122.4, 117.7, 107.6, 39.6, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{18}N_5O^+$: 368.1506; found: 368.1505.



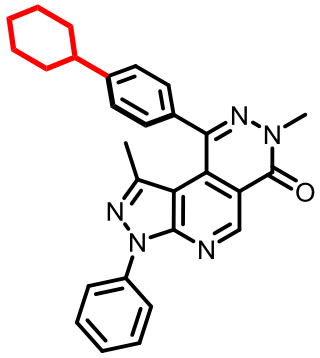
1,7-dimethyl-3-phenyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (4b):

Yield 74%; 281 mg; white solid; column chromatography, silica gel (PE:EA, 12:1); mp 211–213 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.6 Hz, 2H), 7.46 (d, *J* = 7.6 Hz, 2H), 7.38-7.33 (m, 3H), 3.94 (s, 3H), 2.47 (s, 3H), 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 152.4, 150.1, 144.4, 143.8, 139.7, 138.3, 135.3, 130.8, 129.7, 129.13, 129.10, 126.9, 122.4, 117.8, 107.7, 39.6, 21.4, 15.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O^+$: 382.1662; found: 382.1662.



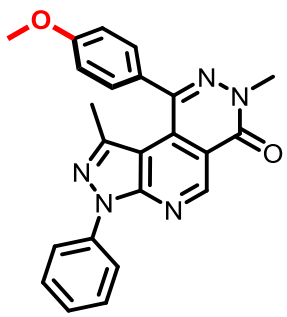
9-(4-(*tert*-butyl)phenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4c):

Yield 77%; 325 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 223–225 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.68 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 2H), 7.56-7.48 (m, 6H), 7.36 (t, *J* = 7.2 Hz, 1H), 3.94 (s, 3H), 1.57 (s, 3H), 1.39 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 153.1, 152.4, 150.0, 144.4, 143.8, 138.3, 135.2, 130.9, 129.1, 128.9, 126.9, 126.1, 122.3, 117.7, 107.8, 39.6, 34.8, 31.2, 14.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{26}H_{26}N_5O^+$: 424.2132; found: 424.2130.



9-(4-cyclohexylphenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4d):

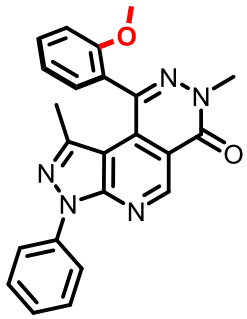
Yield 72%; 323 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 204–206 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.36 (d, *J* = 7.6 Hz, 3H), 3.93 (s, 3H), 2.64-2.57 (m, 1H), 1.94-1.87 (m, 4H), 1.78 (d, *J* = 12.4 Hz, 1H), 1.56 (s, 3H), 1.52-1.38 (m, 4H), 1.32-1.25 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.3, 150.0, 149.9, 144.5, 143.8, 138.3, 135.5, 130.8, 129.1, 129.0, 127.6, 126.8, 122.3, 117.7, 107.7, 44.4, 39.6, 34.3, 26.7, 26.0, 14.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{28}H_{28}N_5O^+$: 450.2288; found: 450.2288.



9-(4-methoxyphenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4e):

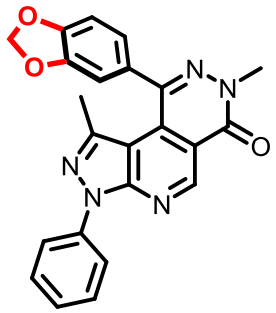
Yield 70%; 278 mg; light yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 183–185 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.13 (d, *J* = 7.2 Hz, 2H), 7.58-7.47 (m, 4H), 7.37 (t, *J* = 6.4 Hz, 1H), 7.06 (d, *J* = 7.6 Hz, 2H), 3.94 (s, 3H), 3.90 (s, 3H), 1.70 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7, 158.4, 152.4, 150.1, 144.2, 143.7, 138.3, 130.8,

130.7, 130.5, 129.1, 126.9, 122.4, 117.8, 114.5, 107.8, 55.5, 39.6, 15.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O_2^+$: 398.1612; found: 398.1612.



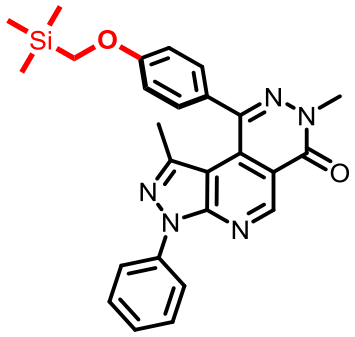
9-(2-methoxyphenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4f):

Yield 72%; 285 mg; light yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 220–222 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.71 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 2H), 7.56-7.48 (m, 4H), 7.34 (t, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 7.2 Hz, 1H), 7.02 (d, *J* = 8.4 Hz, 1H), 3.94 (s, 3H), 3.64 (s, 3H), 1.64 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 158.5, 152.3, 150.2, 143.5, 141.9, 138.4, 132.2, 131.5, 131.4, 129.0, 127.2, 126.8, 122.4, 121.0, 117.2, 111.2, 107.6, 55.5, 39.6, 15.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O_2^+$: 398.1612; found: 398.1611.



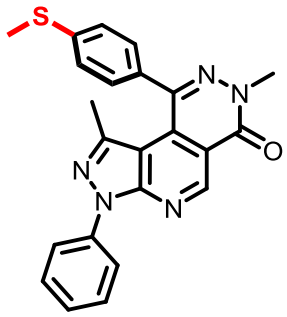
9-(benzo[d][1,3]dioxol-5-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (4g):

Yield 70%; 287 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 246–248 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.65 (s, 1H), 7.88 (d, *J* = 8.0 Hz, 2H), 7.55 (t, *J* = 7.6 Hz, 2H), 7.44 (t, *J* = 7.2 Hz, 1H), 7.10 (s, 1H), 6.98 (dd, *J* = 19.6 Hz, 8.0 Hz, 2H), 6.13 (s, 1H), 6.07 (s, 1H), 3.99 (s, 3H), 1.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.2, 151.8, 150.4, 149.2, 148.5, 145.6, 144.4, 136.9, 131.5, 131.0, 129.3, 128.3, 123.7, 123.5, 117.6, 109.5, 108.9, 107.5, 101.8, 40.3, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{18}N_5O_3^+$: 412.1404; found: 412.1401.



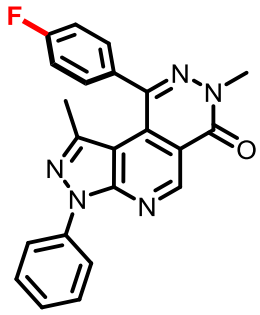
1,7-dimethyl-3-phenyl-9-(4-((trimethylsilyl)methoxy)phenyl)-3,7-dihydro-6H-pyrazolo [4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4h):

Yield 74%; 347 mg; gray solid; column chromatography, silica gel (PE:EA, 10:1); mp 133–135 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 2H), 7.46 (d, *J* = 8.4 Hz, 2H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.09 (d, *J* = 8.8 Hz, 2H), 3.92 (s, 3H), 3.67 (s, 2H), 1.70 (s, 3H), 0.19 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7, 158.4, 152.4, 150.0, 144.3, 143.8, 138.3, 130.8, 130.3, 130.2, 129.0, 126.8, 122.3, 117.7, 114.7, 107.8, 61.5, 39.5, 15.6, -3.14. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{26}H_{28}N_5O_2Si^+$: 470.2007; found: 470.2006.



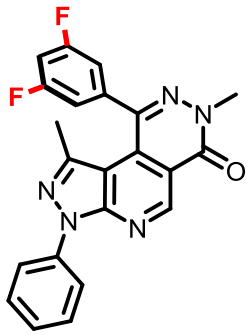
1,7-dimethyl-9-(4-(methylthio)phenyl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (4i):

Yield 73%; 301 mg; light yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 210–212 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.53 (t, *J* = 8.0 Hz, 2H), 7.48 (d, *J* = 8.4 Hz, 2H), 7.40-7.34 (m, 3H), 3.93 (s, 3H), 2.55 (s, 3H), 1.70 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.4, 150.0, 143.8, 143.5, 141.0, 138.3, 134.6, 130.6, 129.5, 129.1, 126.9, 126.4, 122.3, 117.7, 107.6, 39.6, 15.7, 15.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5OS^+$: 414.1383; found: 414.1381.



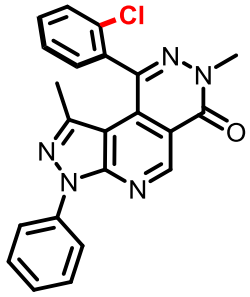
9-(4-fluorophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4j):

Yield 71%; 273 mg; white solid; column chromatography, silica gel (PE:EA, 12:1); mp 193–195 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.12 (d, *J* = 7.6 Hz, 2H), 7.65-7.47 (m, 4H), 7.38 (t, *J* = 7.2 Hz, 1H), 7.28-7.19 (m, 2H), 3.94 (s, 3H), 1.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5 (d, *J* = 249.0 Hz, $^{1}J_{CF}$), 158.4, 152.4, 150.1, 143.3, 143.2, 138.3, 134.4, 131.2 (d, *J* = 9.0 Hz, $^{3}J_{CF}$), 130.5, 129.1, 127.0, 122.4, 117.7, 116.3 (d, *J* = 22.0 Hz, $^{2}J_{CF}$), 107.5, 39.6, 15.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -110.62. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_5OF^+$: 386.1412; found: 386.1415.



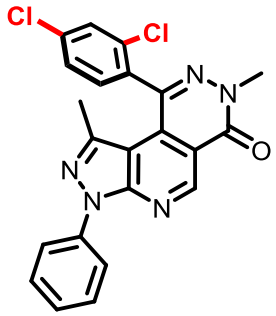
9-(3,5-difluorophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4k):

Yield 72%; 290 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 257–259 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.70 (s, 1H), 7.87 (d, *J* = 7.6 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 2H), 7.47 (t, *J* = 7.2 Hz, 1H), 7.17 (d, *J* = 4.8 Hz, 2H), 7.07 (t, *J* = 8.4 Hz, 1H), 4.04 (s, 3H), 1.83 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 163.4 (dd, $^{1}J_{CF}$ = 250.0 Hz, $^{3}J_{CF}$ = 12.0 Hz), 159.2, 151.7, 150.7, 143.9, 143.4, 140.1 (t, $^{3}J_{CF}$ = 9.0 Hz), 136.7, 130.8, 129.4, 128.6, 123.9, 117.6, 112.8 (dd, $^{2}J_{CF}$ = 19.0 Hz, $^{4}J_{CF}$ = 8.0 Hz), 107.0, 105.7 (t, $^{2}J_{CF}$ = 25.0 Hz), 40.6, 15.2. ^{19}F NMR (376 MHz, $CDCl_3$, CF_3COOD) δ -107.45. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{16}N_5OF_2^+$: 404.1317; found: 404.1313.



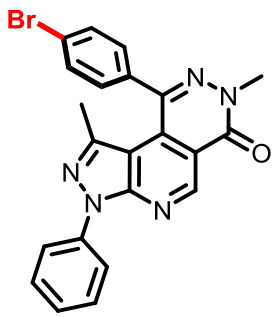
9-(2-chlorophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4l):

Yield 69%; 277 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 244–246 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.72 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.63-7.43 (m, 6H), 7.36 (t, *J* = 7.6 Hz, 1H), 3.95 (s, 3H), 1.64 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 152.3, 150.3, 143.3, 141.7, 138.3, 137.0, 135.0, 132.2, 131.3, 130.1, 129.1, 127.3, 127.0, 122.5, 117.1, 107.1, 39.7, 14.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_5OCl^+$: 402.1116; found: 402.1114.



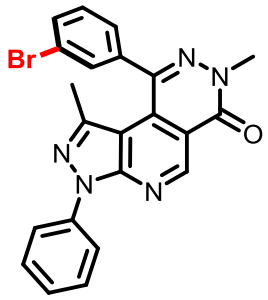
9-(2,4-dichlorophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4m):

Yield 72%; 313 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 178–180 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.11 (d, *J* = 7.6 Hz, 2H), 7.60-7.45 (m, 5H), 7.36 (t, *J* = 7.2 Hz, 1H), 3.93 (s, 3H), 1.73 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.3, 150.2, 142.8, 140.6, 138.2, 136.7, 135.9, 135.6, 132.9, 131.0, 129.8, 129.0, 127.7, 127.0, 122.5, 117.0, 106.9, 39.7, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{16}N_5OCl_2^+$: 436.0726; found: 436.0729.



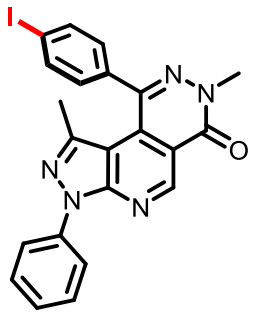
9-(4-bromophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4n):

Yield 69%; 307 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 222–224 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.11 (d, *J* = 7.6 Hz, 2H), 7.67 (d, *J* = 7.6 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 7.2 Hz, 1H), 3.92 (s, 3H), 1.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.3, 150.0, 143.2, 143.0, 138.2, 137.0, 132.2, 130.8, 130.1, 129.0, 126.9, 123.9, 122.2, 117.6, 107.3, 39.6, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_5OBr^+$: 446.0611; found: 446.0613.



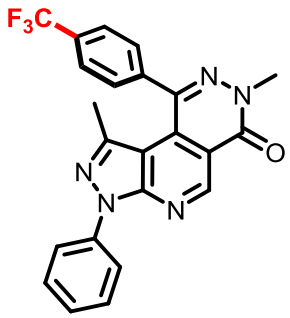
9-(3-bromophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4o):

Yield 65%; 289 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 229–231 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.12 (d, *J* = 7.2 Hz, 2H), 7.75 (s, 1H), 7.69 (d, *J* = 7.2 Hz, 1H), 7.57-7.48 (m, 3H), 7.43-7.35 (m, 2H), 3.94 (s, 3H), 1.68 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.3, 150.1, 143.2, 142.6, 140.0, 138.2, 132.7, 132.2, 130.6, 130.2, 129.1, 127.9, 127.0, 123.1, 122.4, 117.6, 107.3, 39.7, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_5OBr^+$: 446.0611; found: 446.0611.



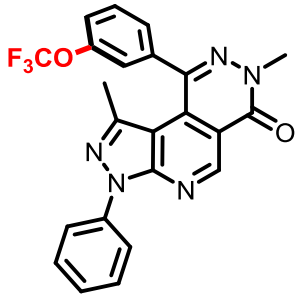
9-(4-iodophenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (4p):

Yield 73%; 359 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 239–241 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.87 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 2H), 7.37-7.30 (m, 3H), 3.92 (s, 3H), 1.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.3, 150.0, 143.2, 143.1, 138.21, 138.17, 137.6, 130.9, 130.1, 129.0, 126.9, 122.3, 117.6, 107.4, 95.6, 39.6, 15.8. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_5OI^+$: 494.0472; found: 494.0468.



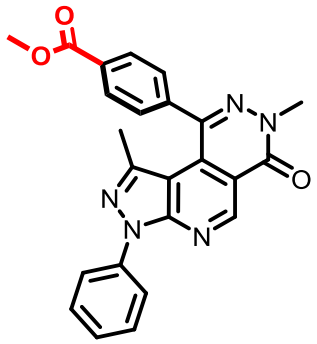
1,7-dimethyl-3-phenyl-9-(4-(trifluoromethyl)phenyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (4q):

Yield 70%; 304 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 188–190 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.81 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 1H), 3.94 (s, 3H), 1.58 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.3, 150.0, 143.0, 142.6, 141.6, 138.2, 131.7 (q, *J* = 32.0 Hz, $^{2}J_{CF}$), 130.0, 129.7, 129.1, 127.0, 126.0 (q, *J* = 3.0 Hz, $^{4}J_{CF}$), 123.7 (q, *J* = 271.0 Hz, $^{1}J_{CF}$), 122.3, 117.6, 107.2, 39.7, 15.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.66. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{17}N_5OF_3^+$: 436.1380; found: 436.1378.



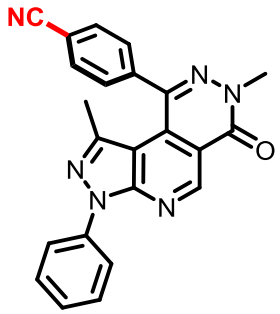
1,7-dimethyl-3-phenyl-9-(3-(trifluoromethoxy)phenyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (4r):

Yield 71%; 320 mg; light yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 190–192 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.57 (t, *J* = 8.0 Hz, 1H), 7.54-7.45 (m, 4H), 7.42 (d, *J* = 8.0 Hz, 1H), 7.33 (t, *J* = 7.2 Hz, 1H), 3.91 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.1, 152.2, 149.8, 149.59, 149.57, 143.0, 142.3, 140.0, 138.2, 130.5, 130.0, 128.9, 127.8, 126.8, 122.04, 121.96, 121.9, 120.3 (q, *J* = 257.0 Hz, $^{1}J_{CF}$), 117.5, 107.2, 39.6, 15.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -57.65. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{17}N_5O_2F_3^+$: 452.1329; found: 452.1326.



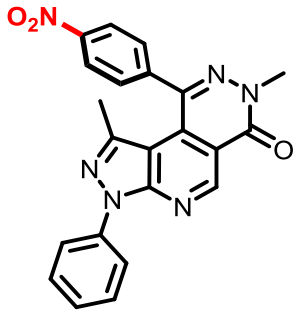
methyl 4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-9-yl)benzoate (4s):

Yield 67%; 284 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 228–230 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.20 (d, *J* = 7.6 Hz, 2H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.66 (d, *J* = 7.6 Hz, 2H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.34 (t, *J* = 7.2 Hz, 1H), 3.99 (s, 3H), 3.93 (s, 3H), 1.58 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.2, 158.2, 152.2, 149.9, 143.1, 143.0, 142.3, 138.2, 130.9, 130.2, 130.0, 129.3, 129.0, 126.8, 122.1, 117.5, 107.3, 52.3, 39.6, 15.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{20}N_5O_3^+$: 426.1561; found: 426.1560.



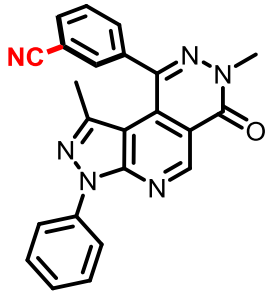
4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-9-yl)benzonitrile (4t):

Yield 66%; 258 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 275–277 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.72 (s, 1H), 7.92 (d, *J* = 7.6 Hz, 2H), 7.85 (d, *J* = 7.6 Hz, 2H), 7.78 (d, *J* = 7.6 Hz, 2H), 7.57 (t, *J* = 7.2 Hz, 2H), 7.52-7.45 (m, 1H), 4.05 (s, 3H), 1.69 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.2, 151.6, 150.8, 143.8, 143.6, 141.9, 136.6, 133.1, 130.7, 130.1, 129.5, 128.8, 124.1, 117.7, 117.4, 113.4, 107.0, 40.6, 15.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{17}N_6O_3^+$: 393.1458; found: 393.1457.



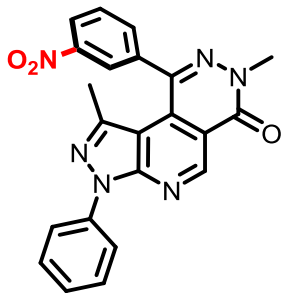
1,7-dimethyl-9-(4-nitrophenyl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (4u):

Yield 70%; 288 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 262–264 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.82 (s, 1H), 8.48 (d, *J* = 8.4 Hz, 2H), 7.89 (d, *J* = 8.4 Hz, 2H), 7.68-7.58 (m, 5H), 4.10 (s, 3H), 1.76 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.4, 151.4, 150.8, 148.8, 144.5, 143.9, 143.3, 135.2, 131.9, 130.6, 130.4, 129.9, 125.5, 124.7, 118.2, 107.5, 40.9, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_6O_3^+$: 413.1357; found: 413.1355.



3-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-9-yl)benzonitrile (4v):

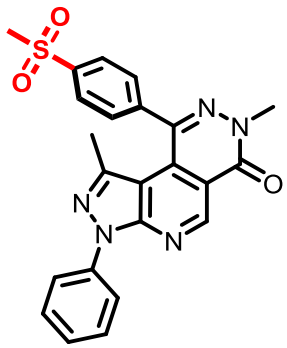
Yield 68%; 266 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 253–255 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.70 (s, 1H), 7.98 (s, 1H), 7.90 (t, *J* = 7.2 Hz, 3H), 7.85 (d, *J* = 7.6 Hz, 1H), 7.73 (t, *J* = 7.6 Hz, 1H), 7.56 (t, *J* = 7.6 Hz, 2H), 7.46 (t, *J* = 7.2 Hz, 1H), 4.03 (s, 3H), 1.66 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.1, 151.8, 150.5, 143.3, 138.8, 136.9, 133.8, 133.5, 132.7, 130.6, 130.2, 129.4, 128.4, 123.6, 117.5, 117.4, 113.3, 106.9, 40.5, 15.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{17}N_6O_3^+$: 393.1458; found: 393.1455.



1,7-dimethyl-9-(3-nitrophenyl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (4w):

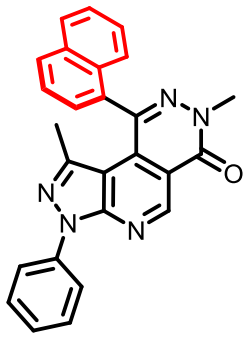
Yield 67%; 276 mg; light yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 249–251 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.51 (s, 1H), 8.41 (d, *J* = 8.0 Hz, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.89 (d, *J* = 7.6 Hz, 1H), 7.74 (t, *J* = 8.0 Hz, 1H), 7.53 (t, *J* = 8.0 Hz, 2H), 7.37 (t, *J* = 7.2 Hz, 1H), 3.95 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.3, 150.1, 148.6, 142.5, 141.5, 139.8, 138.2, 135.2, 130.1, 129.8, 129.1, 127.1, 124.3, 124.2,

122.3, 117.6, 107.0, 39.7, 16.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{17}N_6O_3^+$: 413.1357; found: 413.1359.



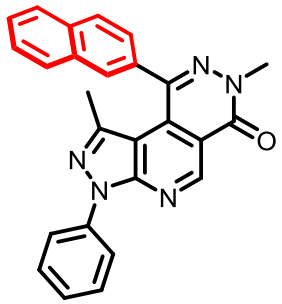
1,7-dimethyl-9-(4-(methylsulfonyl)phenyl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (4x):

Yield 73%; 324 mg; yellow solid; column chromatography, silica gel (PE:EA, 3:1); mp 265–267 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.78 (s, 1H), 8.20 (d, *J* = 8.0 Hz, 2H), 7.91 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 7.6 Hz, 2H), 7.62-7.53 (m, 3H), 4.08 (s, 3H), 3.26 (s, 3H), 1.68 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.3, 151.24, 151.21, 144.0, 143.9, 142.9, 141.1, 135.8, 131.4, 130.7, 129.7, 128.4, 125.0, 118.0, 107.2, 44.4, 40.8, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O_3S^+$: 446.1281; found: 446.1275.



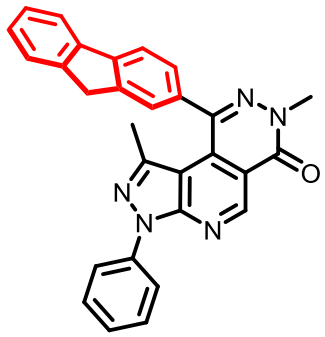
1,7-dimethyl-9-(naphthalen-1-yl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4y):

Yield 68%; 283 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 251–253 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.82 (s, 1H), 8.11 (dd, *J* = 6.8 Hz, 2.8 Hz, 1H), 8.00 (d, *J* = 8.4 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 2H), 7.67-7.61 (m, 2H), 7.60-7.50 (m, 4H), 7.48-7.41 (m, 2H), 4.06 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.4, 151.8, 151.0, 145.0, 144.4, 136.7, 134.3, 133.7, 133.1, 132.7, 130.8, 129.3, 128.8, 128.6, 128.5, 127.7, 126.9, 125.4, 124.4, 124.1, 117.3, 107.0, 40.6, 14.3. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{26}H_{20}N_5O^+$: 418.1662; found: 418.1661.



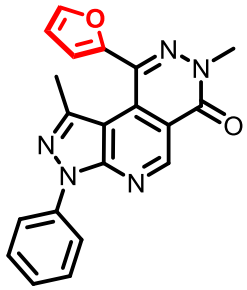
1,7-dimethyl-9-(naphthalen-2-yl)-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (4z):

Yield 72%; 300 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 191–193 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.73 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 2H), 8.02 (d, *J* = 11.6 Hz, 2H), 7.95 (d, *J* = 7.2 Hz, 1H), 7.88 (d, *J* = 7.2 Hz, 1H), 7.69 (d, *J* = 8.4 Hz, 1H), 7.61-7.50 (m, 4H), 7.37 (t, *J* = 7.2 Hz, 1H), 3.98 (s, 3H), 1.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 152.4, 150.2, 144.3, 143.6, 138.3, 135.4, 133.4, 133.1, 130.7, 129.1, 129.0, 128.8, 128.3, 127.9, 127.2, 127.00, 126.99, 126.4, 122.4, 117.8, 107.7, 39.7, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{26}H_{20}N_5O^+$: 418.1662; found: 418.1660.



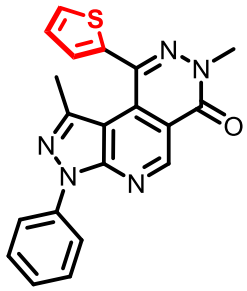
9-(9H-fluoren-2-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5a):

Yield 70%; 318 mg; white solid; column chromatography, silica gel (PE:EA, 12:1); mp 242–244 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.70 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 2H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.87 (d, *J* = 7.6 Hz, 1H), 7.76 (s, 1H), 7.61-7.51 (m, 4H), 7.44 (t, *J* = 7.2 Hz, 1H), 7.37 (dd, *J* = 13.6 Hz, 6.8 Hz, 2H), 4.00 (s, 2H), 3.96 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.4, 150.1, 144.6, 144.0, 143.7, 143.6, 143.0, 140.7, 138.3, 136.4, 130.8, 129.1, 128.1, 127.5, 127.0, 126.9, 125.8, 125.2, 122.4, 120.40, 120.38, 117.8, 107.8, 39.6, 36.9, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{29}H_{22}N_5O^+$: 456.1819; found: 456.1820.



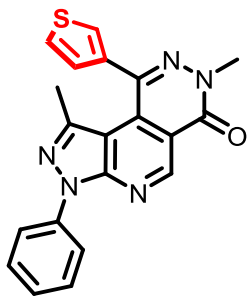
9-(furan-2-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5b):

Yield 60%; 214 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 191–193 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.60 (s, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 7.2 Hz, 1H), 6.84 (s, 1H), 6.65 (s, 1H), 3.92 (s, 3H), 1.96 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.3, 149.8, 149.6, 143.9, 143.2, 138.3, 135.1, 130.4, 129.0, 126.9, 122.3, 117.1, 112.3, 111.3, 107.3, 39.7, 13.1. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{16}N_5O_2^+$: 358.1299; found: 358.1296.



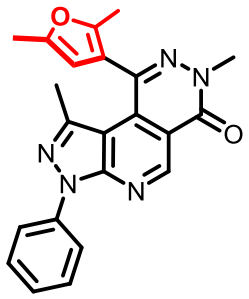
1,7-dimethyl-3-phenyl-9-(thiophen-2-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5c):

Yield 66%; 246 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 218–220 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.61 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 2H), 7.54-7.49 (m, 3H), 7.35 (t, *J* = 6.8 Hz, 1H), 7.23 (s, 1H), 7.16 (d, *J* = 3.2 Hz, 1H), 3.92 (s, 3H), 1.85 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.4, 149.8, 143.8, 138.5, 138.2, 138.1, 131.1, 129.7, 129.0, 127.8, 127.5, 126.8, 122.2, 117.4, 107.5, 39.6, 14.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{16}N_5OS^+$: 374.1070; found: 374.1069.



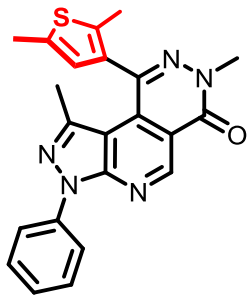
1,7-dimethyl-3-phenyl-9-(thiophen-3-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5d):

Yield 68%; 253 mg; white solid; column chromatography, silica gel (PE:EA, 8:1); mp 204–206 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.60-7.50 (m, 4H), 7.38 (d, *J* = 7.2 Hz, 1H), 7.33 (d, *J* = 4.8 Hz, 1H), 3.93 (s, 3H), 1.81 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.4, 150.0, 143.8, 140.0, 138.6, 138.3, 131.0, 129.1, 128.7, 127.1, 127.0, 126.4, 122.4, 117.5, 107.6, 39.6, 14.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{16}N_5OS^+$: 374.1070; found: 374.1070.



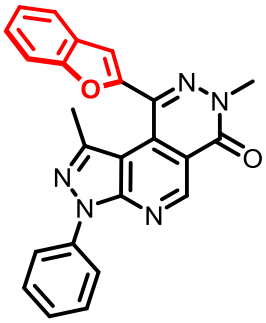
9-(2,5-dimethylfuran-3-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (5e):

Yield 67%; 357 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 226–228 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.14 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 7.2 Hz, 1H), 6.18 (s, 1H), 3.92 (s, 3H), 2.37 (s, 3H), 2.13 (s, 3H), 2.08 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.3, 150.8, 150.0, 149.2, 143.4, 138.3, 138.1, 131.4, 128.9, 126.8, 122.2, 118.9, 117.4, 108.5, 107.5, 39.5, 15.5, 13.3, 12.3. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{20}N_5O_2^+$: 386.1612; found: 386.1606.



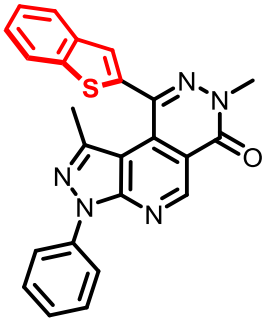
9-(2,5-dimethylthiophen-3-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (5f):

Yield 73%; 292 mg; light yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 202–204 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.68 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 2H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 1H), 6.75 (s, 1H), 3.93 (s, 3H), 2.49 (s, 3H), 2.26 (s, 3H), 1.95 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 152.3, 150.1, 143.9, 140.0, 138.3, 137.8, 137.3, 134.4, 131.5, 129.0, 127.4, 126.9, 122.4, 117.3, 107.5, 39.6, 15.1, 14.2, 13.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{20}N_5OS^+$: 402.1383; found: 402.1381.



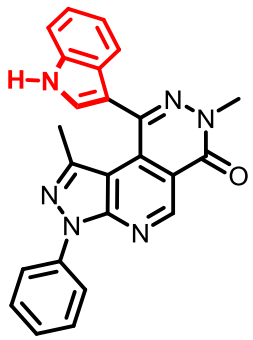
9-(benzofuran-2-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (5g):

Yield 66%; 268 mg; white solid; column chromatography, silica gel (PE:EA, 8:1); mp 210–212 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.12 (d, *J* = 7.6 Hz, 2H), 7.71 (d, *J* = 7.2 Hz, 1H), 7.56-7.50 (m, 3H), 7.43-7.33 (m, 3H), 7.23 (s, 1H), 3.96 (s, 3H), 1.86 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 154.8, 152.3, 151.5, 149.9, 143.8, 138.2, 135.0, 130.2, 129.1, 128.1, 127.0, 125.8, 123.7, 122.4, 121.9, 117.2, 111.8, 107.6, 107.3, 39.9, 13.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{18}N_5O_2^+$: 408.1455; found: 408.1443.



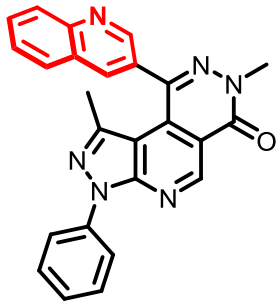
9-(benzo[b]thiophen-2-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (5h):

Yield 62%; 262 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 192–194 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.12 (d, *J* = 7.2 Hz, 2H), 7.92 (s, 1H), 7.80 (s, 1H), 7.53 (t, *J* = 6.8 Hz, 2H), 7.46-7.40 (m, 3H), 7.36 (t, *J* = 6.8 Hz, 1H), 3.95 (s, 3H), 1.88 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.4, 149.9, 143.7, 140.0, 139.2, 138.4, 138.2, 130.6, 129.1, 127.0, 126.4, 125.6, 125.0, 124.2, 122.4, 122.3, 117.5, 107.5, 39.8, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{18}N_5OS^+$: 424.1227; found: 424.1225.



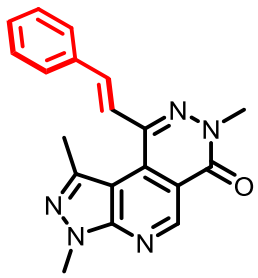
9-(1H-indol-3-yl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5i):

Yield 59%; 239 mg; yellow solid; column chromatography, silica gel (PE:EA, 3:1); mp 272–274 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.75 (s, 1H), 8.87 (s, 1H), 7.80 (d, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 2H), 7.50-7.43 (d, *J* = 8.4 Hz, 4H), 7.30 (t, *J* = 7.6 Hz, 1H), 7.16 (t, *J* = 7.2 Hz, 1H), 4.05 (s, 3H), 1.56 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.3, 151.6, 150.9, 144.9, 141.5, 136.3, 135.5, 133.2, 129.5, 128.9, 126.6, 125.2, 124.3, 123.7, 121.6, 119.0, 117.9, 113.4, 111.9, 108.0, 40.6, 14.8. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{19}N_6O^+$: 407.1615; found: 407.1617.



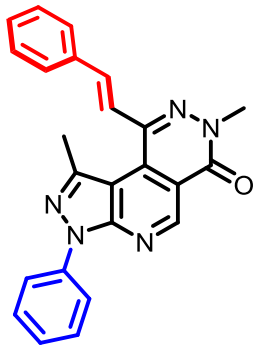
1,7-dimethyl-3-phenyl-9-(quinolin-3-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5j):

Yield 52%; 217 mg; light yellow solid; column chromatography, silica gel (PE:EA, 4:1); mp 235–237 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.70 (s, 1H), 9.14 (s, 1H), 8.37 (s, 1H), 8.24 (d, *J* = 8.4 Hz, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.85 (t, *J* = 7.6 Hz, 1H), 7.67 (t, *J* = 7.6 Hz, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 1H), 3.98 (s, 3H), 1.47 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.3, 150.1, 150.0, 147.9, 142.7, 141.1, 138.2, 136.2, 131.2, 130.8, 130.3, 129.5, 129.1, 128.1, 127.8, 127.3, 127.0, 122.3, 117.6, 107.2, 39.8, 16.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{25}H_{19}N_6O^+$: 419.1615; found: 419.1613.



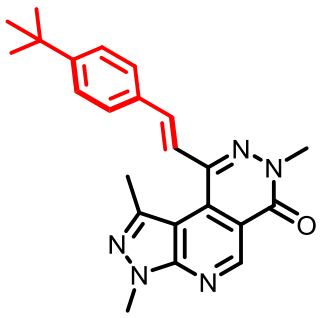
(*E*)-1,3,7-trimethyl-9-styryl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5k):

Yield 65%; 215 mg; light yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 174–176 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.54 (s, 1H), 7.59 (d, *J* = 7.6 Hz, 2H), 7.48 (d, *J* = 16.0 Hz, 1H), 7.45-7.38 (m, 3H), 7.36 (t, *J* = 6.0 Hz, 1H), 4.18 (s, 3H), 3.94 (s, 3H), 2.76 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 152.5, 149.7, 140.9, 140.8, 135.8, 134.1, 130.8, 128.9, 127.1, 124.0, 116.5, 105.5, 39.8, 34.1, 18.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{19}H_{18}N_5O^+$: 332.1506; found: 332.1505.



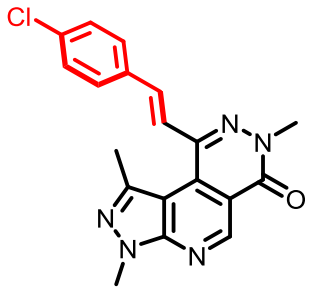
(*E*)-1,7-dimethyl-3-phenyl-9-styryl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5l):

Yield 56%; 220 mg; yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 206–208 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.54 (s, 1H), 8.12 (d, *J* = 7.8 Hz, 2H), 7.57 (d, *J* = 7.3 Hz, 2H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.44-7.34 (m, 6H), 3.91 (s, 3H), 2.78 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.1, 150.0, 142.4, 140.5, 138.3, 135.7, 134.0, 130.6, 129.0, 128.9, 127.1, 126.9, 124.0, 122.2, 117.0, 107.2, 39.7, 19.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{20}N_5O^+$: 394.1662; found: 394.1664.



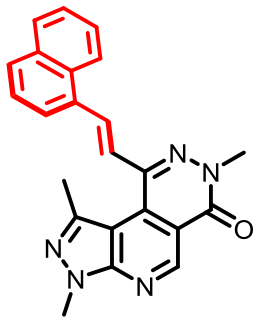
(*E*)-9-(4-(*tert*-butyl)styryl)-1,3,7-trimethyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5m):

Yield 67%; 259 mg; light yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 194–196 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.50 (s, 1H), 7.52 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 2H), 7.40-7.34 (m, 2H), 4.16 (s, 3H), 3.92 (s, 3H), 2.77 (s, 3H), 1.36 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 152.4, 152.2, 149.6, 140.9, 140.8, 133.8, 132.9, 130.7, 126.9, 125.8, 122.9, 116.4, 105.4, 39.7, 34.7, 34.1, 31.2, 19.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{26}N_5O^+$: 388.2132; found: 388.2129.



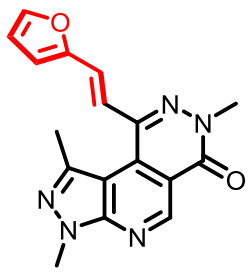
(*E*)-9-(4-chlorostyryl)-1,3,7-trimethyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (5n):

Yield 60%; 219 mg; light yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 200–202 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.55 (s, 1H), 7.51 (d, *J* = 7.6 Hz, 2H), 7.46 (d, *J* = 16.0 Hz, 1H), 7.41 (d, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 16.0 Hz, 1H), 4.18 (s, 3H), 3.94 (s, 3H), 2.75 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 152.6, 149.7, 140.8, 140.5, 134.7, 134.3, 132.7, 130.7, 129.2, 128.2, 124.7, 116.5, 105.4, 39.8, 34.1, 18.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{19}H_{17}N_5OCl^+$: 366.1116; found: 366.1117.



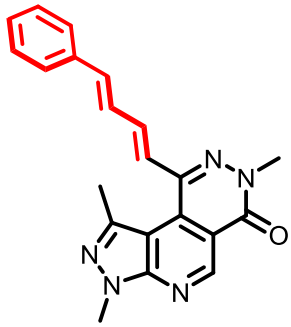
(*E*)-1,3,7-trimethyl-9-(2-(naphthalen-1-yl)vinyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (5o):

Yield 63%; 240 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 231–233 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 8.25 (t, *J* = 12.8 Hz, 2H), 7.88 (t, *J* = 7.6 Hz, 2H), 7.83 (d, *J* = 7.2 Hz, 1H), 7.61-7.50 (m, 4H), 4.17 (s, 3H), 3.99 (s, 3H), 2.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 152.5, 149.6, 140.9, 140.8, 133.7, 133.1, 131.3, 130.8, 130.6, 129.3, 128.7, 126.54, 126.47, 126.0, 125.5, 123.7, 123.3, 116.5, 105.5, 39.9, 34.1, 19.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O^+$: 382.1662; found: 382.1662.



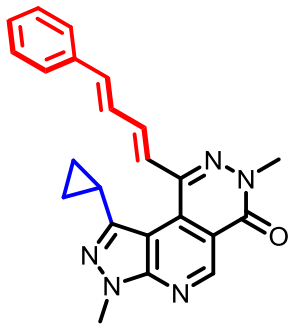
(*E*)-9-(2-(furan-2-yl)vinyl)-1,3,7-trimethyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5p):

Yield 58%; 186 mg; yellow solid; column chromatography, silica gel (PE:EA, 5:1); mp 195–197 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.56 (s, 1H), 7.51-7.47 (m, 2H), 7.27 (d, *J* = 3.2 Hz, 1H), 6.53 (d, *J* = 3.2 Hz, 1H), 6.49 (dd, *J* = 3.2 Hz, 2.0 Hz, 1H), 4.19 (s, 3H), 3.94 (s, 3H), 2.87 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.8, 152.7, 152.3, 149.7, 143.5, 141.3, 140.3, 131.0, 122.0, 120.8, 116.6, 112.0, 111.5, 105.6, 39.8, 34.1, 19.1. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{17}H_{16}N_5O_2^+$: 322.1299; found: 322.1299.



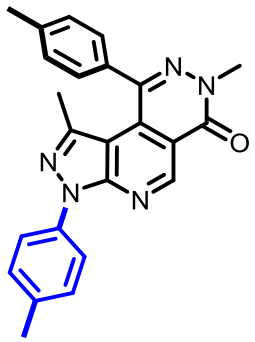
1,3,7-trimethyl-9-((1E,3E)-4-phenylbuta-1,3-dien-1-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5q):

Yield 64%; 228 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 224–226 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.52 (s, 1H), 7.48 (d, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.31-7.22 (m, 2H), 7.06 (d, *J* = 15.2 Hz, 1H), 7.03-6.97 (m, 1H), 6.86 (d, *J* = 15.6 Hz, 1H), 4.18 (s, 3H), 3.93 (s, 3H), 2.84 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 152.5, 149.6, 140.8, 140.5, 136.8, 136.5, 134.1, 130.8, 128.7, 128.3, 127.33, 127.26, 126.7, 116.5, 105.5, 39.8, 34.1, 19.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{21}H_{20}N_5O^+$: 358.1662; found: 358.1661.



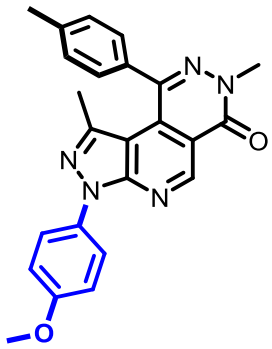
1-cyclopropyl-3,7-dimethyl-9-((1E,3E)-4-phenylbuta-1,3-dien-1-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5r):

Yield 61%; 233 mg; yellow solid; column chromatography, silica gel (PE:EA, 7:1); mp 201–203 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.55 (s, 1H), 7.64 (d, *J* = 15.2 Hz, 1H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.38-7.34 (m, 3H), 7.32-7.28 (m, 1H), 6.98 (dd, *J* = 15.6 Hz, 10.8 Hz, 1H), 6.85 (d, *J* = 15.6 Hz, 1H), 4.16 (s, 3H), 3.95 (s, 3H), 2.42-2.36 (m, 1H), 1.32-1.28 (m, 2H), 1.18-1.13 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 152.6, 149.6, 145.6, 140.5, 136.7, 136.4, 133.3, 130.9, 128.8, 128.3, 127.7, 127.4, 126.6, 116.5, 105.8, 39.9, 34.2, 13.3, 9.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{22}N_5O^+$: 384.1819; found: 384.1820.



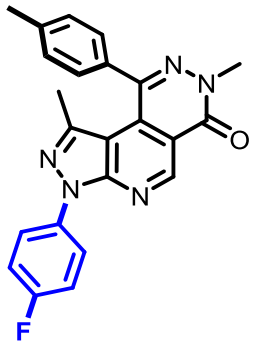
1,7-dimethyl-3,9-di-p-tolyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5s):

Yield 79%; 312 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 240–242 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 7.95 (d, *J* = 8.0 Hz, 2H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.33 (d, *J* = 7.6 Hz, 4H), 3.93 (s, 3H), 2.47 (s, 3H), 2.42 (s, 3H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 152.3, 150.0, 144.4, 143.5, 139.7, 136.9, 135.9, 135.4, 130.8, 129.7, 129.6, 129.2, 122.5, 117.7, 107.5, 39.6, 21.4, 21.1, 15.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{22}N_5O^+$: 396.1819; found: 396.1821.



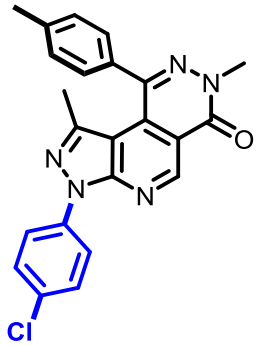
3-(4-methoxyphenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5t):

Yield 73%; 300 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 201–203 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 7.93 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 7.2 Hz, 2H), 7.38-7.28 (m, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.91 (s, 3H), 3.84 (s, 3H), 2.46 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 151.9, 149.8, 144.3, 143.1, 139.5, 135.3, 131.4, 130.6, 129.6, 129.0, 123.8, 117.4, 114.0, 107.1, 55.4, 39.4, 21.3, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{22}N_5O_2^+$: 412.1768; found: 412.1770.



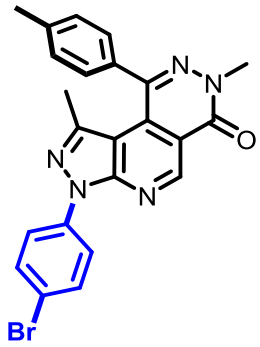
3-(4-fluorophenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (5u):

Yield 69%; 275 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 216–218 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.13-8.07 (m, 2H), 7.44 (d, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 7.6 Hz, 2H), 7.19 (t, *J* = 8.4 Hz, 2H), 3.92 (s, 3H), 2.47 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.0 (d, *J* = 245.0 Hz, $^{1}J_{CF}$), 158.3, 152.1, 150.0, 144.2, 143.7, 139.7, 135.2, 134.5 (d, *J* = 3.0 Hz, $^{4}J_{CF}$), 130.7, 129.7, 129.1, 123.8 (d, *J* = 8.0 Hz, $^{3}J_{CF}$), 117.7, 115.8 (d, *J* = 23.0 Hz, $^{2}J_{CF}$), 107.6, 39.5, 21.3, 15.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -114.91. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{19}N_5OF^+$: 400.1568; found: 400.1568.



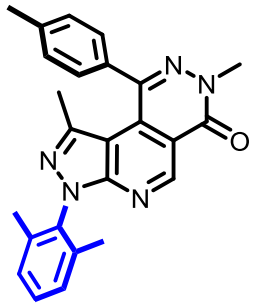
3-(4-chlorophenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (5v):

Yield 71%; 295 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 219–221 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 8.15 (d, *J* = 8.4 Hz, 2H), 7.45 (t, *J* = 8.0 Hz, 4H), 7.34 (d, *J* = 7.6 Hz, 2H), 3.93 (s, 3H), 2.47 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.3, 150.1, 144.3, 144.1, 139.8, 137.0, 135.3, 132.1, 130.7, 129.7, 129.10, 129.07, 123.0, 117.8, 108.0, 39.6, 21.4, 15.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{19}N_5OCl^+$: 416.1273; found: 416.1271.



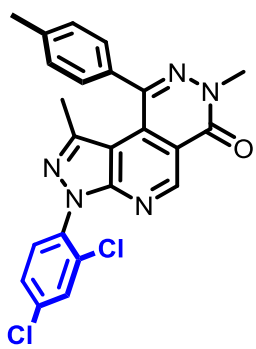
3-(4-bromophenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (5w):

Yield 66%; 303 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 215–217 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.09 (d, *J* = 8.0 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 7.6 Hz, 2H), 7.33 (d, *J* = 7.6 Hz, 2H), 3.93 (s, 3H), 2.47 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.3, 150.1, 144.2, 144.1, 139.8, 137.5, 135.3, 132.0, 130.7, 129.7, 129.1, 123.2, 119.9, 117.8, 108.0, 39.6, 21.4, 15.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{19}N_5OBr^+$: 460.0767; found: 460.0766.



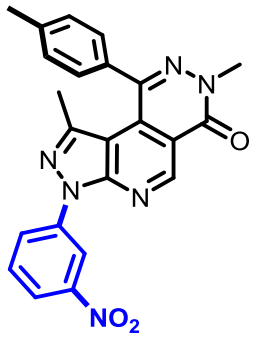
3-(2,6-dimethylphenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (5x):

Yield 78%; 319 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 147–149 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 7.51 (d, *J* = 7.6 Hz, 2H), 7.38 (d, *J* = 7.6 Hz, 2H), 7.31 (q, *J* = 7.6 Hz, 1H), 7.21 (d, *J* = 7.6 Hz, 2H), 3.94 (s, 3H), 2.48 (s, 3H), 1.92 (s, 6H), 1.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 153.2, 150.5, 144.4, 143.7, 139.6, 136.7, 135.4, 135.3, 131.0, 129.6, 129.1, 128.3, 117.4, 105.6, 39.5, 21.3, 17.5, 15.3. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{25}H_{24}N_5O^+$: 410.1975; found: 410.1973.



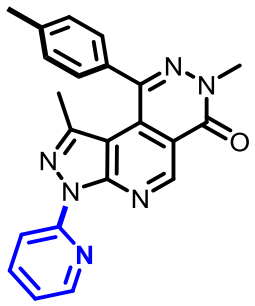
3-(2,4-dichlorophenyl)-1,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido [3,4-d]pyridazin-6-one (5y):

Yield 72%; 324 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 210–212 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 7.62 (s, 1H), 7.51-7.41 (m, 4H), 7.36 (d, *J* = 7.2 Hz, 2H), 3.93 (s, 3H), 2.48 (s, 3H), 1.64 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 153.6, 150.6, 144.7, 144.2, 139.7, 135.8, 135.1, 133.8, 133.0, 131.0, 130.4, 130.3, 129.7, 129.1, 127.8, 117.8, 106.7, 39.5, 21.3, 15.3. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{18}N_5OCl_2^+$: 450.0883; found: 450.0882.



1,7-dimethyl-3-(3-nitrophenyl)-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (5z):

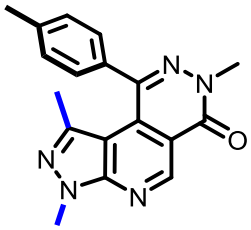
Yield 68%; 289 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 226–228 ℃. ^{1}H NMR (400 MHz, $CDCl_3$, CF_3COOD) δ 9.61 (s, 1H), 9.08 (s, 1H), 8.68 (d, *J* = 8.0 Hz, 1H), 8.10 (d, *J* = 8.0 Hz, 1H), 7.64 (t, *J* = 8.4 Hz, 1H), 7.45 (d, *J* = 8.0 Hz, 2H), 7.36 (d, *J* = 8.0 Hz, 2H), 3.95 (s, 3H), 2.49 (s, 3H), 1.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, CF_3COOD) δ 159.0, 152.5, 150.3, 148.4, 145.9, 145.3, 140.4, 139.0, 134.5, 131.0, 129.95, 129.86, 129.1, 127.1, 121.0, 117.8, 116.5, 108.4, 40.2, 21.3, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{19}N_6O_3^+$: 427.1513; found: 427.1515.



1,7-dimethyl-3-(pyridin-2-yl)-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6a):

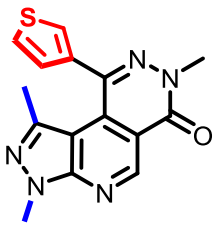
Yield 56%; 213 mg; white solid; column chromatography, silica gel (PE:EA, 3:1); mp 226–228 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.75 (s, 1H), 8.70 (d, *J* = 3.6 Hz, 1H), 8.37 (d, *J* = 8.4 Hz, 1H), 7.94 (t, *J* = 7.6 Hz, 1H), 7.45 (d, *J* = 7.6 Hz, 2H), 7.36-7.30 (m, 3H), 3.94 (s, 3H), 2.47 (s, 3H), 1.68 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.7, 150.5, 150.3, 149.1, 145.1,

144.2, 139.8, 138.3, 135.2, 130.7, 129.7, 129.0, 122.1, 118.1, 117.1, 108.5, 39.5, 21.3, 15.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{19}N_6O^+$: 383.1615; found: 383.1613.0



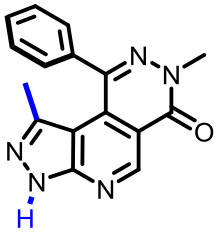
1,3,7-trimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6b):

Yield 83%; 264 mg; white solid; column chromatography, silica gel (PE:EA, 7:1); mp 188–190 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.60 (s, 1H), 7.42 (d, *J* = 7.6 Hz, 2H), 7.32 (d, *J* = 7.6 Hz, 2H), 4.16 (s, 3H), 3.93 (s, 3H), 2.46 (s, 3H), 1.54 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 152.7, 149.5, 144.4, 142.1, 139.5, 135.3, 130.7, 129.6, 129.1, 116.9, 105.8, 39.5, 34.0, 21.3, 15.1. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{18}H_{18}N_5O^+$: 320.1506; found: 320.1508.



1,3,7-trimethyl-9-(thiophen-3-yl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6c):

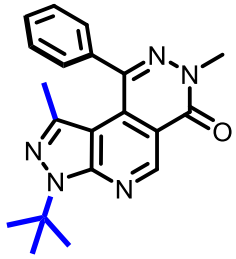
Yield 76%; 236 mg; white solid; column chromatography, silica gel (PE:EA, 6:1); mp 195–197 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.53 (s, 1H), 7.56 (s, 1H), 7.51-7.48 (s, 1H), 7.30 (d, *J* = 4.4 Hz, 1H), 4.14 (s, 3H), 3.91 (s, 3H), 1.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 152.7, 149.3, 142.1, 139.9, 138.6, 130.9, 128.7, 126.8, 126.3, 116.6, 105.5, 39.5, 33.9, 14.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{15}H_{14}N_5OS^+$: 312.0914; found: 312.0913.



1,7-dimethyl-9-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6d):

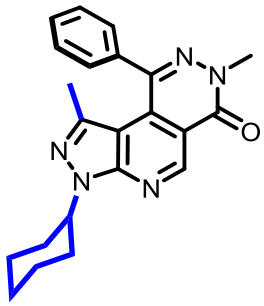
Yield 69%; 200 mg; yellow solid; column chromatography, silica gel (PE:EA, 3:1); mp 261–263 ℃. ^{1}H NMR (400 MHz, DMSO-d_6) δ 14.08 (s, 1H), 9.32 (s, 1H), 7.55-7.50 (m, 5H), 3.76

(s, 3H), 1.33 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 157.7, 154.5, 148.6, 143.8, 142.2, 138.1, 130.2, 129.5, 129.3, 128.8, 116.4, 104.5, 39.1, 14.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{16}H_{14}N_5O^+$: 292.1193; found: 292.1191.



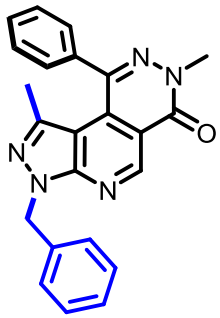
3-(tert-butyl)-1,7-dimethyl-9-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6e):

Yield 76%; 263 mg; white solid; column chromatography, silica gel (PE:EA, 10:1); mp 256–258 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.60 (s, 1H), 7.56-7.48 (m, 5H), 3.93 (s, 3H), 1.84 (s, 9H), 1.50 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 152.6, 147.6, 144.5, 139.9, 138.4, 130.2, 129.3, 129.2, 128.9, 116.4, 106.9, 60.5, 39.4, 29.1, 15.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{22}N_5O^+$: 348.1819; found: 348.1817.



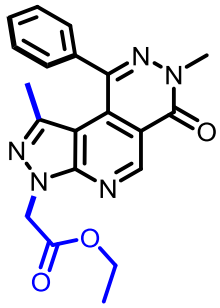
3-cyclohexyl-1,7-dimethyl-9-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6f):

Yield 79%; 294 mg; white solid; column chromatography, silica gel (PE:EA, 10:1); mp 220–222 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 7.56-7.50 (m, 5H), 5.04-4.96 (m, 1H), 3.92 (s, 3H), 2.12-1.98 (m, 4H), 1.96-1.90 (m, 2H), 1.77 (d, J = 12.8 Hz, 1H), 1.60-1.49 (m, 2H), 1.52 (s, 3H), 1.39-1.28 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.5, 151.7, 148.8, 144.3, 141.6, 138.2, 130.5, 129.3, 129.2, 128.8, 116.9, 105.6, 55.8, 39.4, 32.1, 25.4, 25.1, 14.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{24}N_5O^+$: 374.1975; found: 374.1976.



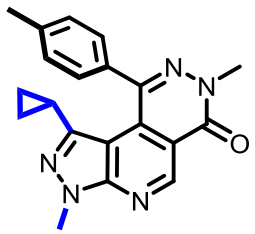
3-benzyl-1,7-dimethyl-9-phenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6g):

Yield 76%; 289 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 175–177 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (s, 1H), 7.53-5.49 (m, 5H), 7.36 (d, *J* = 7.2 Hz, 2H), 7.29-7.23 (m, 3H), 5.70 (s, 2H), 3.92 (s, 3H), 1.50 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 152.6, 149.7, 144.3, 142.6, 138.1, 136.3, 130.6, 129.4, 129.2, 128.9, 128.5, 128.0, 127.8, 117.2, 105.9, 50.7, 39.5, 15.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{23}H_{20}N_5O^+$: 382.1662; found: 382.1662.



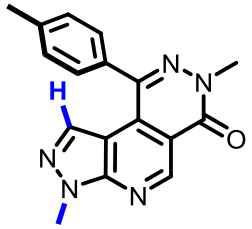
ethyl 2-(1,7-dimethyl-6-oxo-9-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-3-yl)acetate (6h):

Yield 62%; 233 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 173–175 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 7.57-7.50 (m, 5H), 5.32 (s, 2H), 4.24 (q, *J* = 7.2 Hz, 2H), 3.94 (s, 3H), 1.52 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.6, 158.6, 153.3, 150.0, 144.3, 143.4, 138.1, 130.8, 129.6, 129.3, 129.0, 117.5, 106.2, 61.8, 48.2, 39.6, 15.0, 14.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{20}N_5O_3^+$: 378.1561; found: 378.1559.



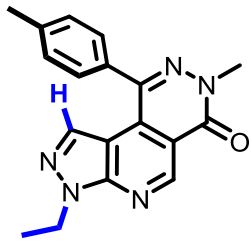
1-cyclopropyl-3,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6i):

Yield 73%; 251 mg; white solid; column chromatography, silica gel (PE:EA, 10:1); mp 210–212 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 7.47 (d, *J* = 7.6 Hz, 2H), 7.29 (d, *J* = 7.6 Hz, 2H), 4.12 (s, 3H), 3.94 (s, 3H), 2.42 (s, 3H), 0.74-0.69 (m, 2H), 0.57-0.50 (m, 1H), 0.39-0.33 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 152.4, 149.3, 147.2, 144.4, 139.0, 135.4, 130.4, 129.5, 128.6, 117.0, 106.0, 39.5, 34.0, 21.2, 10.2, 10.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{20}H_{20}N_5O^+$: 346.1662; found: 346.1662.



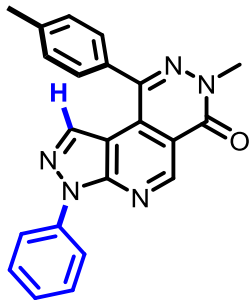
3,7-dimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6j):

Yield 82%; 250 mg; white solid; column chromatography, silica gel (PE:EA, 8:1); mp 183–185 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 7.46 (d, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 7.6 Hz, 2H), 7.18 (s, 1H), 4.21 (s, 3H), 3.96 (s, 3H), 2.51 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.8, 151.3, 149.6, 144.8, 140.0, 133.0, 132.7, 130.0, 129.6, 128.8, 116.7, 107.2, 39.8, 34.4, 21.4. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{17}H_{16}N_5O^+$: 306.1349; found: 306.1346.



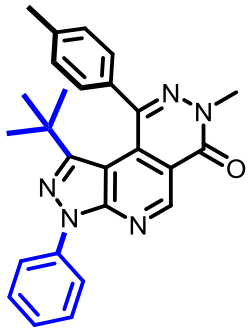
3-ethyl-7-methyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6k):

Yield 77%; 245 mg; yellow solid; column chromatography, silica gel (PE:EA, 8:1); mp 177–179 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 7.46 (d, *J* = 7.6 Hz, 2H), 7.39 (d, *J* = 7.6 Hz, 2H), 7.17 (s, 1H), 4.65 (q, *J* = 7.2 Hz, 2H), 3.96 (s, 3H), 2.50 (s, 3H), 1.54 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.9, 150.8, 149.5, 144.9, 140.0, 133.1, 132.8, 130.1, 129.7, 128.9, 116.8, 107.4, 42.6, 39.8, 21.4, 14.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{18}H_{18}N_5O^+$: 320.1506; found: 320.1504.



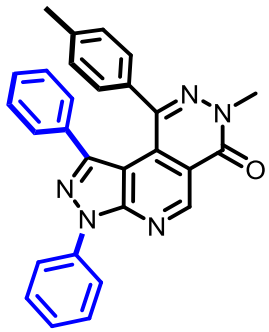
7-methyl-3-phenyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6l):

Yield 72%; 264 mg; yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 177–179 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.71 (s, 1H), 8.15 (d, *J* = 8.0 Hz, 2H), 7.55 (t, *J* = 7.6 Hz, 2H), 7.49 (d, *J* = 7.6 Hz, 2H), 7.44-7.36 (m, 3H), 7.32 (s, 1H), 3.97 (s, 3H), 2.52 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6, 151.1, 150.2, 144.7, 140.2, 138.5, 134.5, 132.6, 130.1, 129.8, 129.2, 128.9, 127.2, 122.2, 117.3, 109.0, 39.9, 21.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{18}N_5O^+$: 368.1506; found: 368.1504.



1-(tert-butyl)-7-methyl-3-phenyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6m):

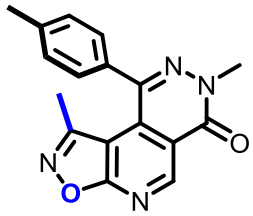
Yield 54%; 228 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 266–268 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 8.21 (d, *J* = 8.0 Hz, 2H), 7.55 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 1H), 7.30 (d, *J* = 7.6 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 2H), 3.92 (s, 3H), 2.37 (s, 3H), 0.99 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 154.6, 152.4, 149.0, 145.4, 139.6, 138.6, 135.7, 130.3, 129.7, 129.0, 128.9, 126.8, 122.4, 118.8, 107.3, 39.1, 35.1, 29.9, 21.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{26}H_{26}N_5O^+$: 424.2132; found: 424.2128.



7-methyl-1,3-diphenyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6n):

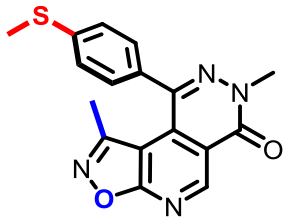
Yield 65%; 287 mg; light yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 225–227 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.74 (s, 1H), 8.22 (d, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.6 Hz, 2H), 7.37 (t, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 8.0 Hz, 4H), 7.10-7.05 (m, 1H), 7.02 (t, *J* = 7.2 Hz, 2H), 6.69 (d, *J* = 7.6 Hz, 2H), 3.95 (s, 3H), 2.11 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.5, 150.4, 147.4, 144.1, 138.8, 138.3, 134.2, 133.8, 130.0, 129.2, 129.0, 128.6,

128.2, 127.4, 127.3, 127.2, 122.6, 118.8, 106.2, 39.6, 20.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{28}H_{22}N_5O^+$: 444.1819; found: 444.1818.



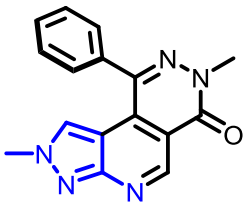
1,7-dimethyl-9-(p-tolyl)isoxazolo[4',5':5,6]pyrido[3,4-d]pyridazin-6(7H)-one (6o):

Yield 61%; 186 mg; white solid; column chromatography, silica gel (PE:EA, 8:1); mp 217–219 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.74 (s, 1H), 7.43 (d, *J* = 7.2 Hz, 2H), 7.38 (d, *J* = 7.2 Hz, 2H), 3.93 (s, 3H), 2.49 (s, 3H), 1.55 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.4, 157.6, 155.9, 152.9, 143.4, 140.3, 134.3, 132.1, 129.9, 129.2, 119.5, 105.1, 39.6, 21.3, 12.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{17}H_{15}N_4O_2^+$: 307.1190; found: 307.1191.



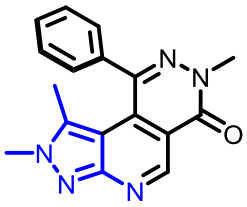
1,7-dimethyl-9-(p-tolyl)isoxazolo[4',5':5,6]pyrido[3,4-d]pyridazin-6(7H)-one (6p):

Yield 63%; 213 mg; yellow solid; column chromatography, silica gel (PE:EA, 7:1); mp 193–195 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.75 (s, 1H), 7.45 (d, *J* = 8.0 Hz, 2H), 7.41 (d, *J* = 8.0 Hz, 2H), 3.94 (s, 3H), 2.57 (s, 3H), 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.5, 157.7, 155.8, 153.1, 142.9, 141.9, 133.4, 132.0, 129.6, 126.4, 119.6, 105.1, 39.8, 15.3, 13.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{17}H_{15}N_4O_2S^+$: 339.0910; found: 339.0909.



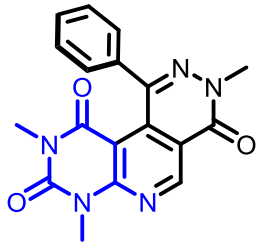
2,7-dimethyl-9-phenyl-2,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6q):

Yield 32%; 93 mg; white solid; column chromatography, silica gel (PE:EA, 1:1); mp 279–281 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.68 (s, 1H), 7.65-7.55 (m, 5H), 6.95 (s, 1H), 4.11 (s, 3H), 3.96 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.4, 158.9, 150.8, 144.5, 135.8, 130.5, 129.9, 129.0, 128.9, 125.7, 117.2, 106.3, 41.2, 40.0. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{16}H_{14}N_5O^+$: 292.1193; found: 292.1192.



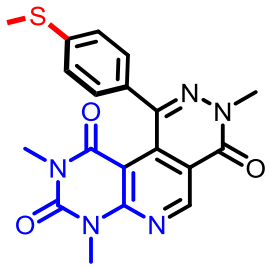
1,2,7-trimethyl-9-phenyl-2,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6r):

Yield 57%; 174 mg; white solid; column chromatography, silica gel (PE:EA, 1:1); mp 292–294 ℃. ^{1}H NMR (400 MHz, $CDCl_3$ + CF_3CO_2D) δ 9.67 (s, 1H), 7.66-7.50 (m, 5H), 4.10 (s, 3H), 3.99 (s, 3H). 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$ + CF_3CO_2D) δ 158.3, 153.9, 149.2, 144.2, 137.6, 137.4, 133.6, 130.1, 129.5, 128.9, 117.7, 106.4, 40.3, 38.8, 12.1. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{17}H_{16}N_5O^+$: 306.1349; found: 306.1350.



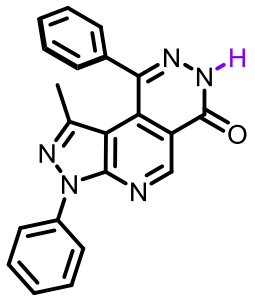
3,7,9-trimethyl-1-phenylpyrimido[5',4':5,6]pyrido[3,4-d]pyridazine-4,8,10(3H,7H,9H)-trione (6s):

Yield 72%; 251 mg; yellow solid; column chromatography, silica gel (DCM:EA, 6:1); mp 267–269 ℃. ^{1}H NMR (400 MHz, $CDCl_3$ + CF_3CO_2D) δ 8.06 (s, 1H), 7.47-7.36 (m, 5H), 3.67 (s, 3H), 3.55 (s, 3H), 3.53 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$ + CF_3CO_2D) δ 167.0, 161.2, 159.7, 158.9, 148.2, 143.2, 135.7, 131.2, 129.7, 124.3, 102.6, 99.3, 97.0, 33.2, 31.9, 29.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{18}H_{16}N_5O_3^+$: 350.1248; found: 350.1246.



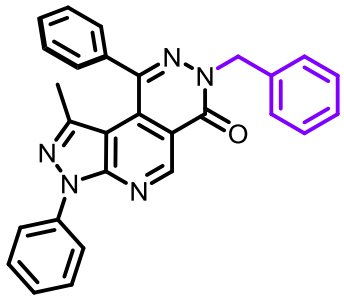
3,7,9-trimethyl-1-(4-(methylthio)phenyl)pyrimido[5',4':5,6]pyrido[3,4-d]pyridazine-4,8,10(3H,7H,9H)-trione (6t):

Yield 75%; 296 mg; yellow solid; column chromatography, silica gel (DCM:EA, 5:1); mp 244-246 ℃. ^{1}H NMR (400 MHz, $CDCl_3$ + CF_3CO_2D) δ 8.08 (s, 1H), 7.28 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 3.67 (s, 3H), 3.55 (s, 3H), 3.52 (s, 3H), 2.46 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$ + CF_3CO_2D) δ 166.9, 161.2, 159.6, 159.0, 148.2, 143.3, 143.2, 131.8, 126.5, 124.8, 102.7, 99.1, 97.0, 33.2, 31.9, 29.9, 14.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{19}H_{18}N_5O_3S^+$: 396.1125; found: 396.1124.



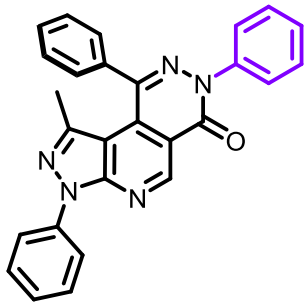
1-methyl-3,9-diphenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6u):

Yield 66%; 332 mg; yellow solid; column chromatography, silica gel (DCM:EA, 3:1); mp 292–294 ℃. ^{1}H NMR (400 MHz, DMSO-d_6) δ 13.40 (s, 1H), 9.47 (s, 1H), 8.09 (d, J = 8.0 Hz, 2H), 7.62-7.54 (m, 7H), 7.41 (t, J = 7.6 Hz, 1H), 1.46 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 158.5, 152.2, 149.2, 144.2, 143.3, 138.4, 138.0, 131.1, 129.4, 129.3, 129.2, 128.9, 126.9, 122.1, 118.0, 107.7, 14.8. HRMS (ESI-TOF): m/z [M+H]$^+$ calcd for $C_{21}H_{16}N_5O^+$: 354.1349; found: 354.1341.



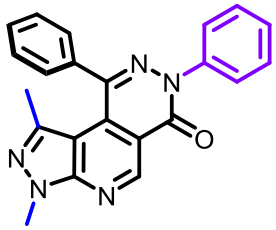
7-benzyl-1-methyl-3,9-diphenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d] pyridazin-6-one (6v):

Yield 73%; 323 mg; light yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 204–206 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.10 (d, J = 7.6 Hz, 2H), 7.60-7.49 (m, 9H), 7.37-7.32 (m, 3H), 7.30 (d, J = 7.2 Hz, 1H), 5.49 (s, 2H), 1.57 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.0, 152.4, 150.3, 144.5, 143.7, 138.3, 138.2, 136.2, 130.6, 129.6, 129.3, 129.09, 129.07, 128.8, 128.6, 127.9, 127.0, 122.4, 118.1, 107.7, 55.1, 15.2. HRMS (ESI-TOF): m/z [M+H]$^+$ calcd for $C_{28}H_{22}N_5O^+$: 444.1819; found: 444.1818.



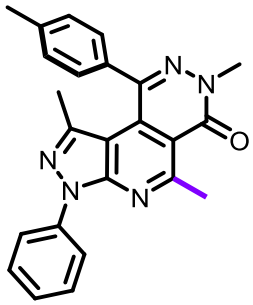
1-methyl-3,7,9-triphenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6w):

Yield 65%; 278 mg; yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 191–193 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.75 (s, 1H), 8.14 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.64-7.59 (m, 2H), 7.56-7.47 (m, 7H), 7.42-7.33 (m, 2H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.9, 152.6, 150.5, 144.9, 143.8, 141.1, 138.3, 138.1, 130.5, 129.7, 129.3, 129.1, 128.7, 128.0, 127.0, 125.3, 122.3, 118.6, 107.8, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{27}H_{20}N_5O^+$: 430.1662; found: 430.1663.



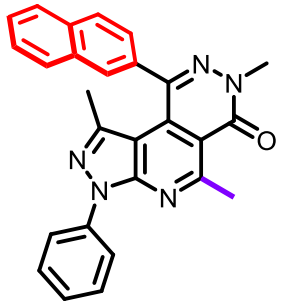
1,3-dimethyl-7,9-diphenyl-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6x):

Yield 71%; 260 mg; white solid; column chromatography, silica gel (PE:EA, 6:1); mp 206–208 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.69 (s, 1H), 7.73 (d, *J* = 8.0 Hz, 2H), 7.61-7.56 (m, 2H), 7.54-7.46 (m, 5H), 7.39 (t, *J* = 7.6 Hz, 1H), 4.18 (s, 3H), 1.53 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 153.0, 150.0, 145.1, 142.3, 141.1, 138.1, 130.5, 129.6, 129.3, 129.0, 128.7, 128.0, 125.4, 117.9, 106.0, 34.1, 14.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{22}H_{18}N_5O^+$: 368.1506; found: 368.1505.



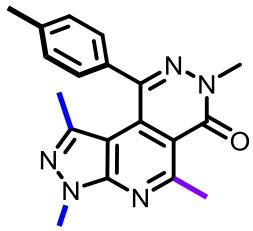
1,5,7-trimethyl-3-phenyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6y):

Yield 59%; 233 mg; yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 201–203 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.21 (d, *J* = 8.0 Hz, 2H), 7.51 (t, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 2H), 7.34-7.29 (m, 3H), 3.90 (s, 3H), 3.27 (s, 3H), 2.45 (s, 3H), 1.56 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.0, 158.9, 151.1, 144.1, 143.6, 139.5, 138.6, 135.8, 132.4, 129.7, 128.9, 126.4, 121.8, 117.0, 107.4, 40.1, 28.1, 21.4, 15.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{24}H_{22}N_5O^+$: 396.1819; found: 396.1817.



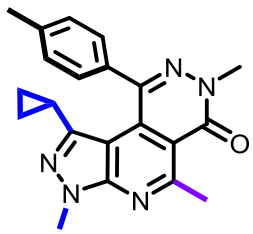
1,3,5,7-tetramethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (6z):

Yield 61%; 262 mg; white solid; column chromatography, silica gel (PE:EA, 10:1); mp 206–208 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, *J* = 7.6 Hz, 2H), 8.04-7.95 (m, 2H), 7.91 (d, *J* = 6.8 Hz, 1H), 7.84 (d, *J* = 6.8 Hz, 1H), 7.67 (d, *J* = 8.0 Hz, 1H), 7.58-7.48 (m, 4H), 7.32 (t, *J* = 6.8 Hz, 1H), 3.93 (s, 3H), 3.29 (s, 3H), 1.36 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 162.1, 158.9, 151.1, 143.9, 143.4, 138.6, 135.8, 133.3, 133.1, 132.3, 128.9, 128.5, 128.3, 127.8, 127.1, 126.8, 126.4, 126.3, 121.8, 117.1, 107.3, 40.1, 28.1, 15.8. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{27}H_{22}N_5O^+$: 432.1819; found: 432.1819.



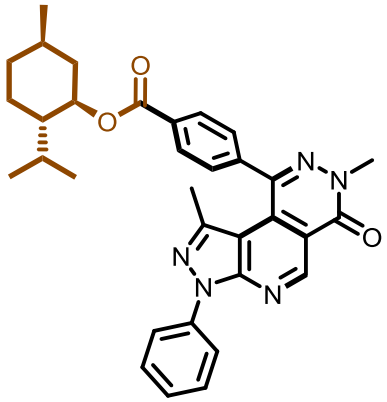
1,3,5,7-tetramethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (7a):

Yield 65%; 216 mg; white solid; column chromatography, silica gel (PE:EA, 7:1); mp 198–200 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (d, *J* = 7.6 Hz, 2H), 7.28 (d, *J* = 7.2 Hz, 2H), 4.10 (s, 3H), 3.89 (s, 3H), 3.23 (s, 3H), 2.44 (s, 3H), 1.47 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 161.4, 159.1, 151.4, 144.2, 142.0, 139.3, 135.8, 132.5, 129.6, 129.0, 116.3, 105.3, 40.0, 33.6, 27.9, 21.3, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{19}H_{20}N_5O^+$: 334.1662; found: 334.1661.



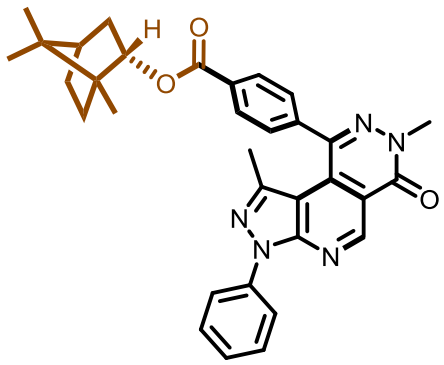
1-cyclopropyl-3,5,7-trimethyl-9-(p-tolyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-6-one (7b):

Yield 60%; 215 mg; white solid; column chromatography, silica gel (PE:EA, 10:1); mp 232–234 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.2 Hz, 2H), 7.24 (d, *J* = 7.2 Hz, 2H), 4.07 (s, 3H), 3.90 (s, 3H), 3.23 (s, 3H), 2.40 (s, 3H), 0.67-0.62 (m, 2H), 0.53-0.46 (m, 1H), 0.35-0.30 (m, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ 161.3, 159.1, 151.2, 147.0, 144.2, 138.9, 135.9, 132.2, 129.6, 128.6, 116.4, 105.7, 40.0, 33.7, 27.8, 21.2, 10.2, 9.5. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{21}H_{22}N_5O^+$: 360.1819; found: 360.1818.



(1R,5R)-2-isopropyl-5-methylcyclohexyl 4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)benzoate (7c):

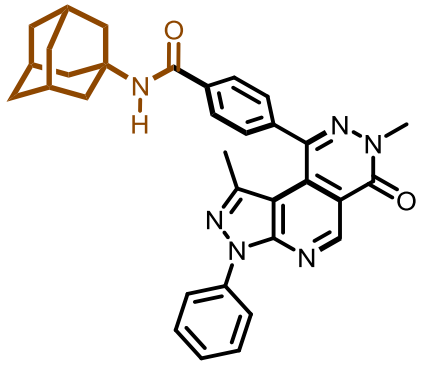
Yield 67%; 367 mg; yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 239–241 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.21 (d, *J* = 8.0 Hz, 2H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.66 (dd, *J* = 16.4 Hz, 7.6 Hz, 2H), 7.52 (t, *J* = 8.0 Hz, 2H), 7.35 (t, *J* = 7.2 Hz, 1H), 4.99 (td, J = 10.8 Hz, 4.0 Hz, 1H), 3.93 (s, 3H), 2.19 (d, J = 11.6 Hz, 1H), 2.03-1.95 (m, 1H), 1.75 (d, J = 11.6 Hz, 2H), 1.61 (s, 3H), 1.60-1.51 (m, 2H), 1.17 (q, *J* = 12.0 Hz, 2H), 0.95 (t, *J* = 6.4 Hz, 7H), 0.83 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 158.2, 152.2, 149.9, 143.2, 143.1, 142.1, 138.2, 131.6, 130.1, 130.0, 129.24, 129.16, 129.0, 126.8, 122.1, 117.5, 107.3, 75.3, 47.1, 40.8, 39.6, 34.1, 31.3, 26.5, 23.6, 21.9, 20.6, 16.5, 15.8. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{33}H_{36}N_5O_3^+$: 550.2813; found: 550.2810.



(2S,4R)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)benzoate (7d):

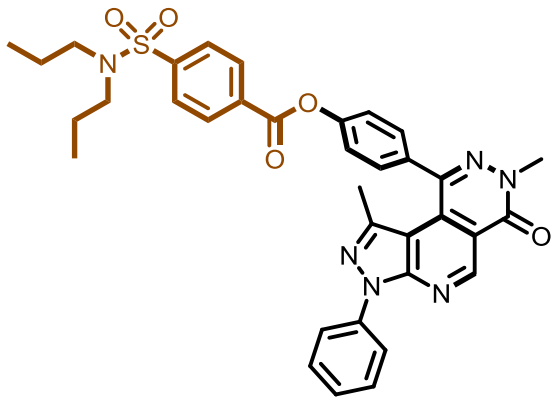
Yield 60%; 328 mg; light yellow solid; column chromatography, silica gel (PE:EA, 6:1); mp 286–288 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.67 (s, 1H), 8.22 (d, *J* = 8.0 Hz, 2H), 8.13 (d, *J* =

8.0 Hz, 2H), 7.68 (d, *J* = 6.4 Hz, 2H), 7.53 (t, *J* = 8.0 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 1H), 5.18 (d, *J* = 9.2 Hz, 1H), 3.94 (s, 3H), 2.56-2.48 (m, 1H), 2.22-2.07 (m, 1H), 1.90-1.81 (m, 1H), 1.80-1.76 (m, 1H), 1.63 (s, 3H), 1.48-1.41 (m, 1H), 1.38-1.31 (m, 1H), 1.18 (dd, J = 14.0 Hz, 3.2 Hz, 1H), 1.00 (s, 3H), 0.95 (s, 3H), 0.94 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 158.3, 152.3, 150.0, 143.23, 143.15, 142.3, 138.3, 131.8, 130.1, 129.3, 129.1, 127.0, 122.3, 117.7, 107.4, 81.0, 49.1, 47.9, 44.9, 39.7, 36.8, 28.0, 27.4, 19.7, 18.9, 15.9, 13.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{33}H_{34}N_5O_3^+$: 548.2656; found: 548.2658.



***N*-((*1s,3R,5r,7S*)-adamantan-1-yl)-4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)benzamide (7e):**

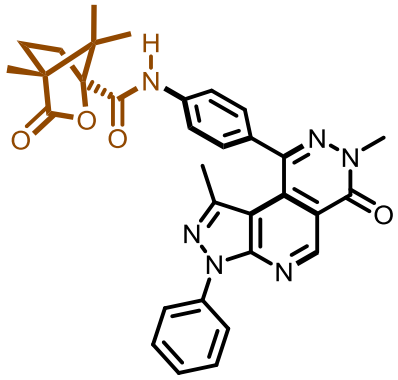
Yield 57%; 310 mg; light yellow solid; column chromatography, silica gel (PE:EA, 4:1); mp 298–300 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.64 (s, 1H), 8.10 (d, *J* = 7.6 Hz, 2H), 7.89 (d, *J* = 7.6 Hz, 2H), 7.61 (d, *J* = 7.6 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 1H), 6.00 (s, 1H), 3.92 (s, 3H), 2.22-2.12 (m, 9H), 1.78-1.70 (m, 6H), 1.60 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.5, 158.2, 152.2, 149.9, 143.24, 143.15, 140.6, 138.2, 136.8, 130.1, 129.3, 129.0, 127.4, 126.9, 122.2, 117.5, 107.3, 41.5, 39.6, 36.2, 29.4, 15.9. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{33}H_{33}N_6O_2^+$: 545.2662; found: 545.2656.



4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)phenyl 4-(*N,N*-dipropylsulfamoyl)benzoate (7f):

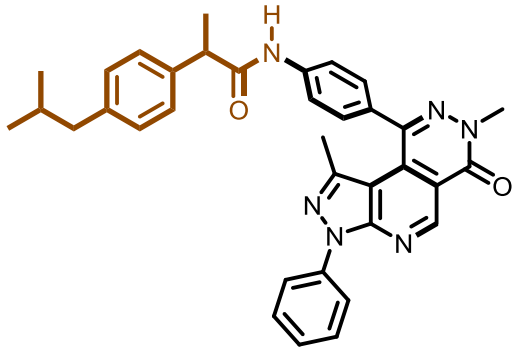
Yield 65%; 422 mg; yellow solid; column chromatography, silica gel (PE:EA, 4:1); mp 209–211 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.70 (s, 1H), 8.37 (d, *J* = 7.6 Hz, 2H), 8.14 (d, *J* = 7.6 Hz, 2H), 7.98 (d, *J* = 8.0 Hz, 2H), 7.68 (d, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.2 Hz, 2H), 7.46-7.35 (m, 3H), 3.96 (s, 3H), 3.15 (t, *J* = 7.6 Hz, 4H), 1.75 (s, 3H), 1.58 (q, *J* = 7.6 Hz, 4H), 0.90 (t, *J*

= 7.2 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5, 158.3, 152.3, 151.5, 149.9, 145.0, 143.4, 143.2, 138.2, 136.1, 132.3, 130.8, 130.6, 130.4, 129.0, 127.1, 126.9, 122.3, 122.2, 117.6, 107.5, 49.8, 39.6, 21.8, 15.5, 11.1. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{35}H_{35}N_6O_5S^+$: 651.2384; found: 651.2384.



(4S)-*N*-(4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)phenyl)-4,7,7-trimethyl-3-oxo-2-oxabicyclo[2.2.1]heptane-1-carboxamide (7g):

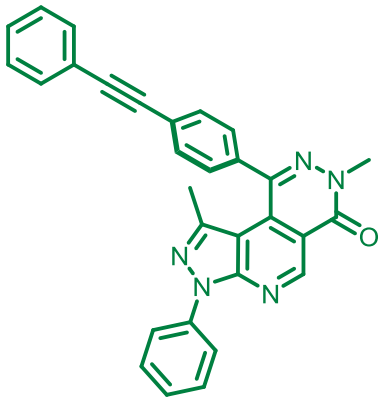
Yield 69%; 387 mg; yellow solid; column chromatography, silica gel (PE:EA, 4:1); mp 260–262 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.50 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.91 (d, *J* = 7.6 Hz, 1H), 7.76 (d, *J* = 7.6 Hz, 1H), 7.57 (d, *J* = 8.0 Hz, 2H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.35 (d, *J* = 7.2 Hz, 1H), 3.92 (s, 3H), 2.67-2.61 (m, 1H), 2.09-1.99 (m, 2H), 1.80-0.73 (m, 1H), 1.70 (s, 3H), 1.19 (s, 3H), 1.16 (s, 3H), 1.03 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.6, 165.4, 158.2, 152.2, 149.8, 143.4, 143.3, 138.2, 138.0, 134.5, 130.3, 129.95, 129.90, 128.9, 126.7, 122.0, 120.1, 120.0, 117.5, 107.5, 92.2, 55.3, 54.3, 39.5, 30.3, 28.9, 16.6, 16.4, 15.7, 9.6. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{32}H_{31}N_6O_4^+$: 563.2401; found: 563.2403.



(R)-N-(4-(1,7-dimethyl-6-oxo-3-phenyl-6,7-dihydro-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazin-9-yl)phenyl)-2-(4-isobutylphenyl)propanamide (7h):

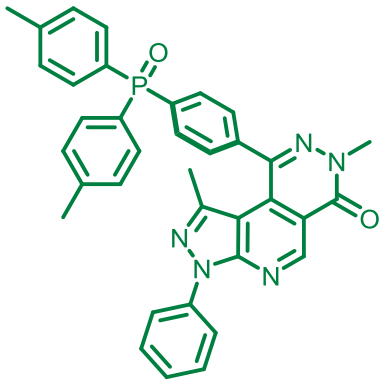
Yield 74%; 421 mg; light yellow solid; column chromatography, silica gel (PE:EA, 4:1); mp 206–208 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.10 (d, *J* = 8.0 Hz, 2H), 7.84 (s, 1H), 7.73 (d, *J* = 7.6 Hz, 1H), 7.64 (d, *J* = 7.6 Hz, 1H), 7.52-7.44 (m, 4H), 7.34 (t, *J* = 7.2 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.14 (d, *J* = 7.6 Hz, 2H), 3.88 (s, 3H), 3.77 (q, J = 6.4 Hz, 1H), 2.45

(d, J = 7.2 Hz, 2H), 1.88-1.81 (m, 1H), 1.66 (s, 3H), 1.60 (d, *J* = 6.8 Hz, 3H), 0.89 (d, *J* = 6.4 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.9, 158.3, 152.3, 149.9, 143.8, 143.5, 141.0, 139.5, 138.2, 137.9, 133.6, 130.5, 129.7, 129.0, 127.3, 126.8, 122.2, 119.6, 117.6, 107.6, 47.6, 44.9, 39.5, 30.0, 22.3, 18.6, 15.8. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{35}H_{35}N_6O_2^+$: 571.2816; found: 571.2815.



1,7-dimethyl-3-phenyl-9-(4-(phenylethynyl)phenyl)-3,7-dihydro-6H-pyrazolo[4',3':5,6] pyrido[3,4-d]pyridazin-6-one (8):

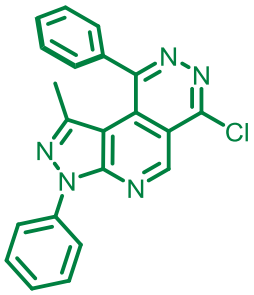
Yield 86%; 120 mg; yellow solid; column chromatography, silica gel (PE:EA, 12:1); mp 165–167 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 2H), 7.68 (d, *J* = 8.0 Hz, 2H), 7.58-7.48 (m, 6H), 7.37-7.32 (m, 4H), 3.93 (s, 3H), 1.69 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 152.2, 149.9, 143.4, 143.3, 138.2, 137.7, 132.1, 131.5, 130.2, 129.2, 129.0, 128.5, 128.3, 126.8, 124.6, 122.6, 122.2, 117.6, 107.5, 91.1, 88.5, 39.6, 15.7. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{30}H_{22}N_5O^+$: 468.1819; found: 468.1819.



9-(4-(di-p-tolylphosphoryl)phenyl)-1,7-dimethyl-3-phenyl-3,7-dihydro-6H-pyrazolo [4',3':5,6]pyrido[3,4-d]pyridazin-6-one (9):

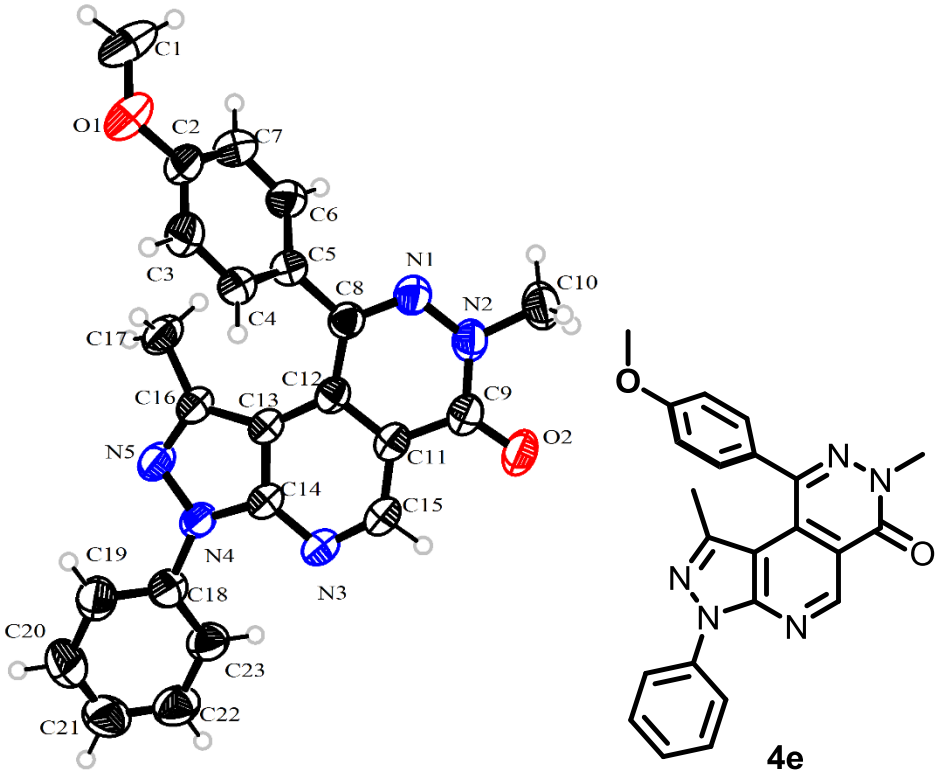
Yield 84%; 149 mg; yellow solid; column chromatography, silica gel (PE:EA, 2:1); mp 258–260 ℃. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.62 (s, 1H), 8.10 (d, *J* = 7.6 Hz, 2H), 7.92-7.81 (m, 2H), 7.68 (d, *J* = 6.8 Hz, 2H), 7.64-7.55 (m, 4H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.34-7.28 (m, 5H), 3.92 (s, 3H), 2.42 (s, 6H), 1.60 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.1, 152.1, 149.9, 142.9, 142.6 (d, *J* = 3.0 Hz, $^4J_{CP}$), 141.1 (d, *J* = 3.0 Hz, $^4J_{CP}$), 138.1, 134.9 (d, *J* = 101.0 Hz, $^1J_{CP}$), 132.6 (d, *J* = 10.0 Hz, $^3J_{CP}$), 131.9 (d, *J* = 10.0 Hz, $^3J_{CP}$), 130.0, 129.2 (d, *J* = 12.0 Hz, $^2J_{CP}$), 129.1 (d, *J* = 12.0 Hz, $^2J_{CP}$), 128.9, 128.2, 126.9, 122.1, 117.5, 107.2, 39.6, 21.5, 15.5. ^{31}P NMR (162

MHz, $CDCl_3$) δ 28.53. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{36}H_{31}N_5O_2P^+$: 596.2210; found: 596.2208.



6-chloro-1-methyl-3,9-diphenyl-3H-pyrazolo[4',3':5,6]pyrido[3,4-d]pyridazine (10):
Yield 91%; 67 mg; light yellow solid; column chromatography, silica gel (PE:EA, 10:1); mp 286-288 ℃. ^1H NMR (400 MHz, $CDCl_3$) δ 9.63 (s, 1H), 8.10 (d, *J* = 8.0 Hz, 2H), 7.73-7.66 (m, 2H), 7.62-7.50 (m, 5H), 7.39 (t, *J* = 7.6 Hz, 1H), 1.67 (s, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 152.9, 151.1, 149.3, 144.2, 138.6, 138.0, 130.1, 129.8, 129.13, 129.07, 127.4, 126.8, 122.5, 117.3, 105.7, 15.2. HRMS (ESI-TOF): m/z $[M+H]^+$ calcd for $C_{21}H_{15}N_5Cl^+$: 372.1010; found: 372.1009.

7. Crystallographic data and molecular structure of 4e and 7b



Supplementary Figure 10. Molecular structure of 4e with 50% probability ellipsoids

Crystal Data for Compound **4e**: CCDC 2344553 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic.

Sample preparation: In a 10 mL glass bottle, 8 mg of pure **4e** was completely dissolved in the mixed solvent of 3 mL EtOAc, 1 mL EtOH, 1 mL $CHCl_3$; 1 mL MeCN and then 2 mL of n-hexane was added slowly. After a week of solvent evaporation, some colorless transparent crystals were obtained. The crystals were mounted on a glass fiber for diffraction experiments. Intensity data were collected on a Bruker SMART APEX CCD diffractometer with Mo Kα radiation (0.71073 Å) at room temperature.

Datablock: y

Bond precision: C-C = 0.0030 A Wavelength=0.71073

Cell: a=7.563(3) b=11.483(4) c=13.531(4)
alpha=76.835(5) beta=78.866(5) gamma=77.227(5)
Temperature: 296 K

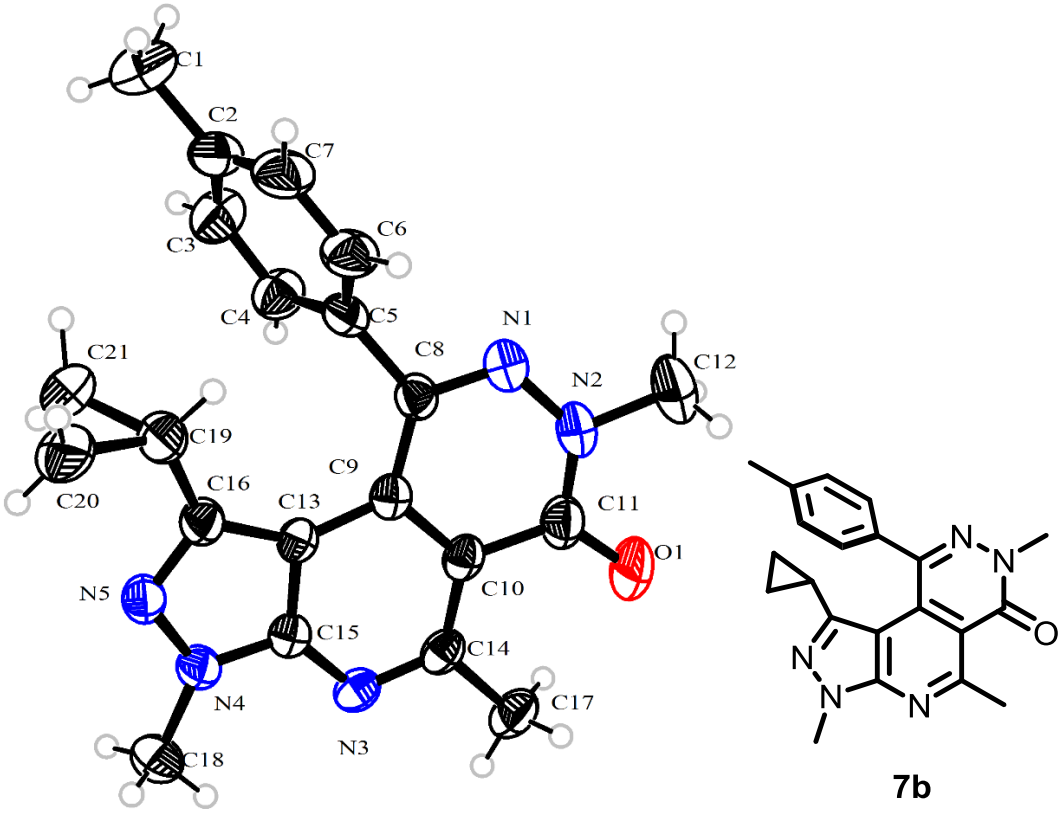
	Calculated	Reported
Volume	1103.2(7)	1103.2(6)
Space group	P -1	P -1
Hall group	-P 1	-P 1
Moiety formula	C23 H19 N5 O2 [+ solvent]	C23 H19 N5 O2
Sum formula	C23 H19 N5 O2 [+ solvent]	C23 H19 N5 O2
Mr	397.43	397.43
Dx,g cm-3	1.196	1.196
Z	2	2
Mu (mm-1)	0.080	0.080
F000	416.0	416.0
F000'	416.16	
h,k,lmax	9,13,16	9,13,16
Nref	4106	4059
Tmin,Tmax	0.984,0.992	0.636,0.746
Tmin'	0.984	

Correction method= # Reported T Limits: Tmin=0.636 Tmax=0.746
AbsCorr = MULTI-SCAN

Data completeness= 0.989 Theta(max)= 25.499

R(reflections)= 0.0532(3134) wR2(reflections)= 0.1748(4059)

S = 1.026 Npar= 274



Supplementary Figure 11. Molecular structure of 7b with 50% probability ellipsoids

Crystal Data for Compound **7b**: CCDC 2344669 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic.

Sample preparation: In a 10 mL glass bottle, 8 mg of pure **7b** was completely dissolved in the mixed solvent of 3 mL EtOAc, 1 mL EtOH, 1 mL $CHCl_3$; 1 mL MeCN and then 2 mL of n-hexane was added slowly. After a week of solvent evaporation, some colorless transparent crystals were obtained. The crystals were mounted on a glass fiber for diffraction experiments. Intensity data were collected on a Bruker SMART APEX CCD diffractometer with Mo Kα radiation (0.71073 Å) at room temperature.

Datablock: mo_220107d_0m

Bond precision: C-C = 0.0046 A Wavelength=0.71073

Cell: a=7.260(4) b=21.655(12) c=23.676(13)
alpha=90 beta=90 gamma=90
Temperature: 296 K

	Calculated	Reported
Volume	3722(4)	3722(4)
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Hall group	-P 2ac 2ab	-P 2ac 2ab
Moiety formula	C21 H21 N5 O	C21 H21 N5 O
Sum formula	C21 H21 N5 O	C21 H21 N5 O
Mr	359.43	359.43
Dx,g cm-3	1.283	1.283
Z	8	8
Mu (mm-1)	0.083	0.083
F000	1520.0	1520.0
F000'	1520.52	
h,k,lmax	8,26,28	8,26,28
Nref	3464	3448
Tmin,Tmax	0.990,0.992	0.395,0.746
Tmin'	0.984	

Correction method= # Reported T Limits: Tmin=0.395 Tmax=0.746
AbsCorr = MULTI-SCAN

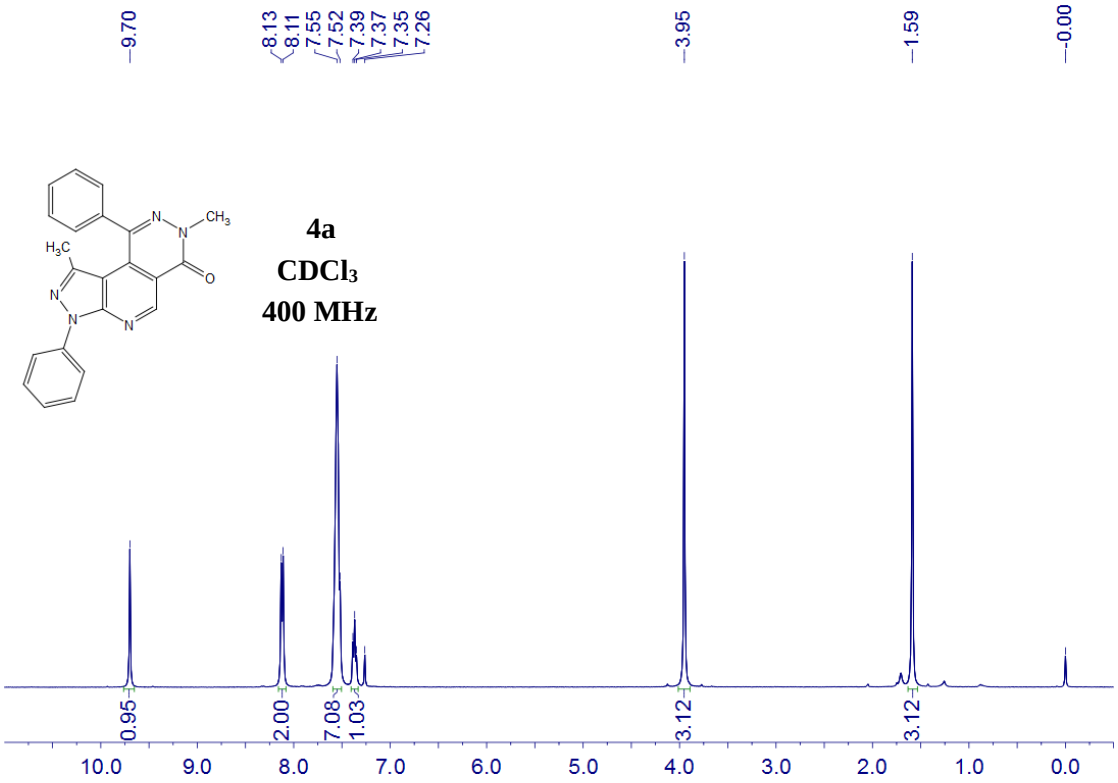
Data completeness= 0.995 Theta(max)= 25.500

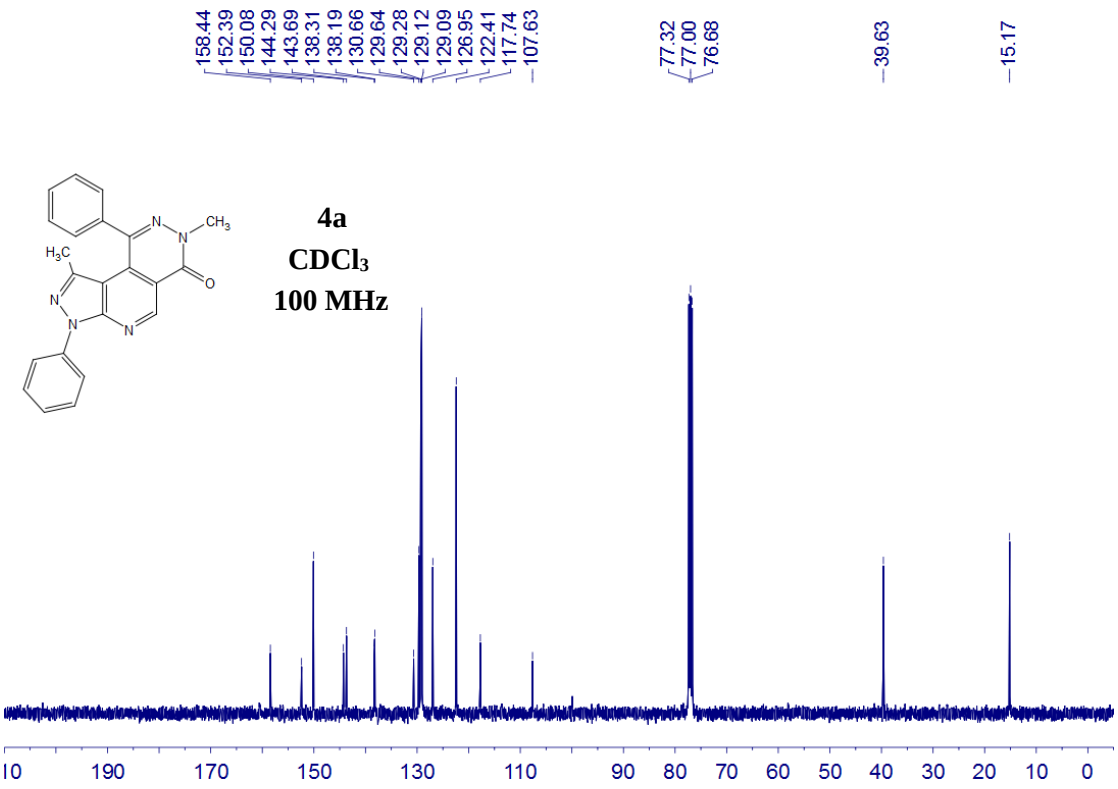
R(reflections)= 0.0796(2371) wR2(reflections)= 0.2259(3448)

S = 1.078 Npar= 260

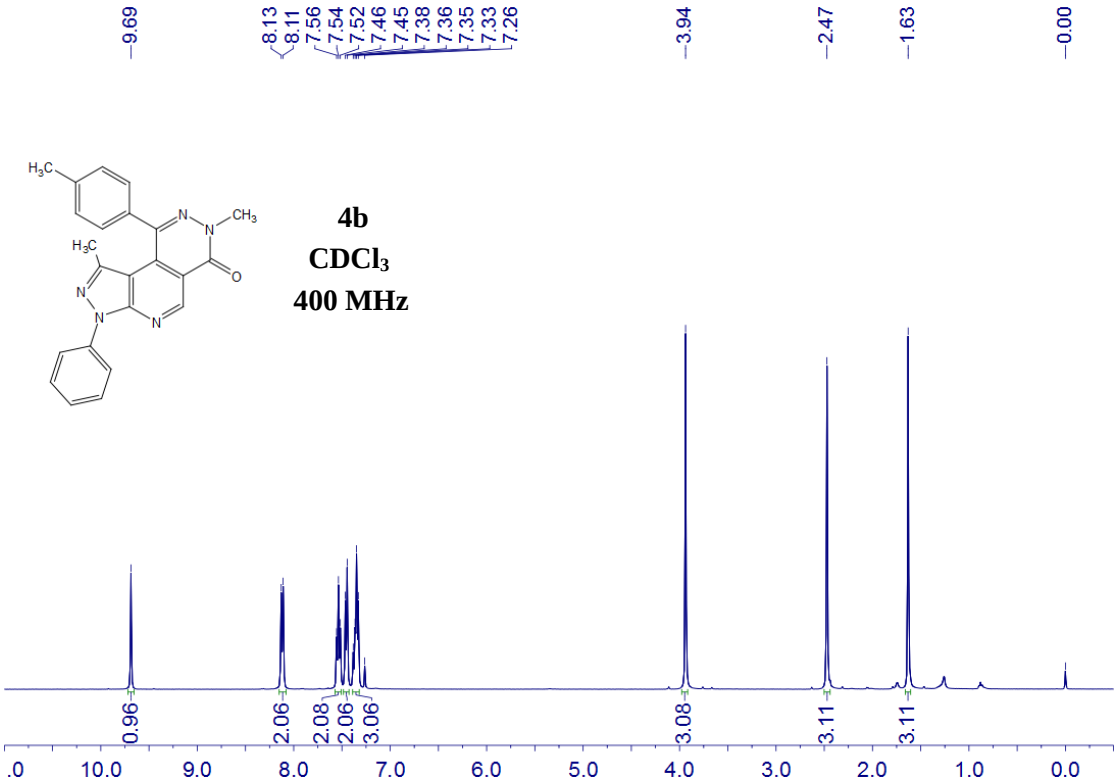
8. ^{1}H, ^{13}C ^{19}F and ^{31}P NMR spectra of compounds

4a





4b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8.13
8.11
7.56
7.54
7.52
7.46
7.45
7.38
7.36
7.35
7.33
7.26
3.94
2.47
1.63
0.00
4b
CDCl3
400 MHz
0.96
2.06
2.08
2.06
3.06
3.08
3.11
3.11
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
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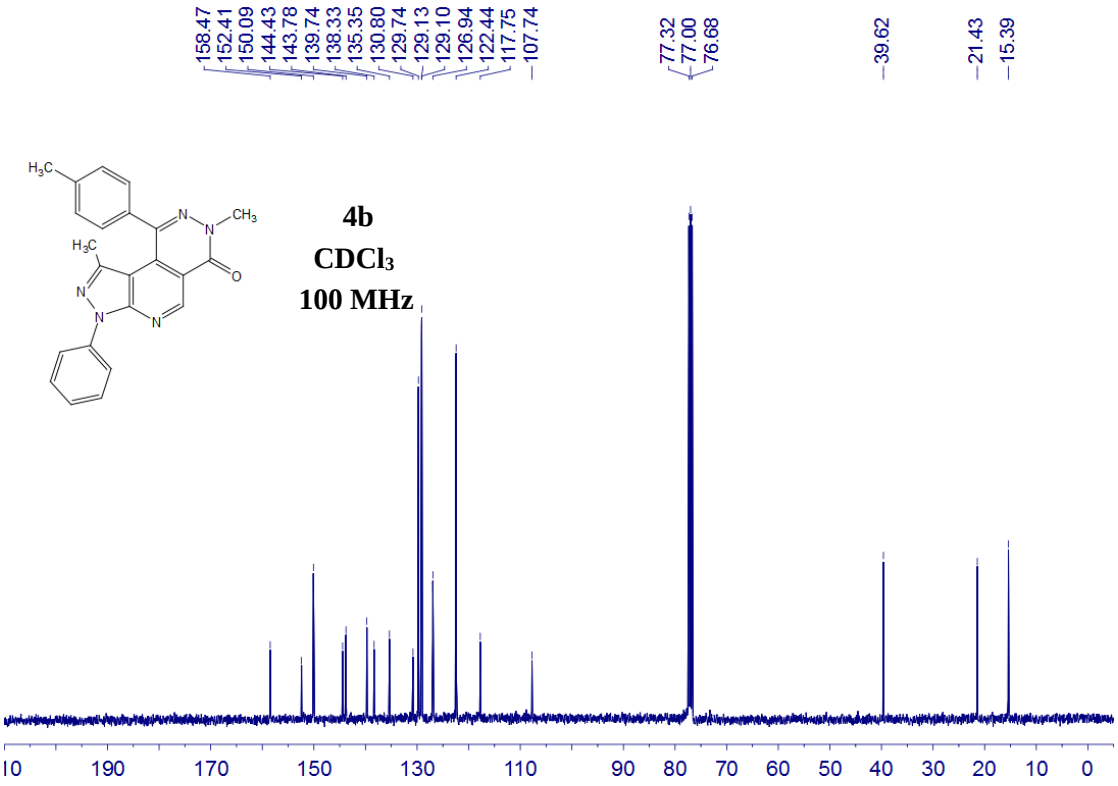
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122.44
117.75
107.74
77.32
77.00
76.68
39.62
21.43
15.39
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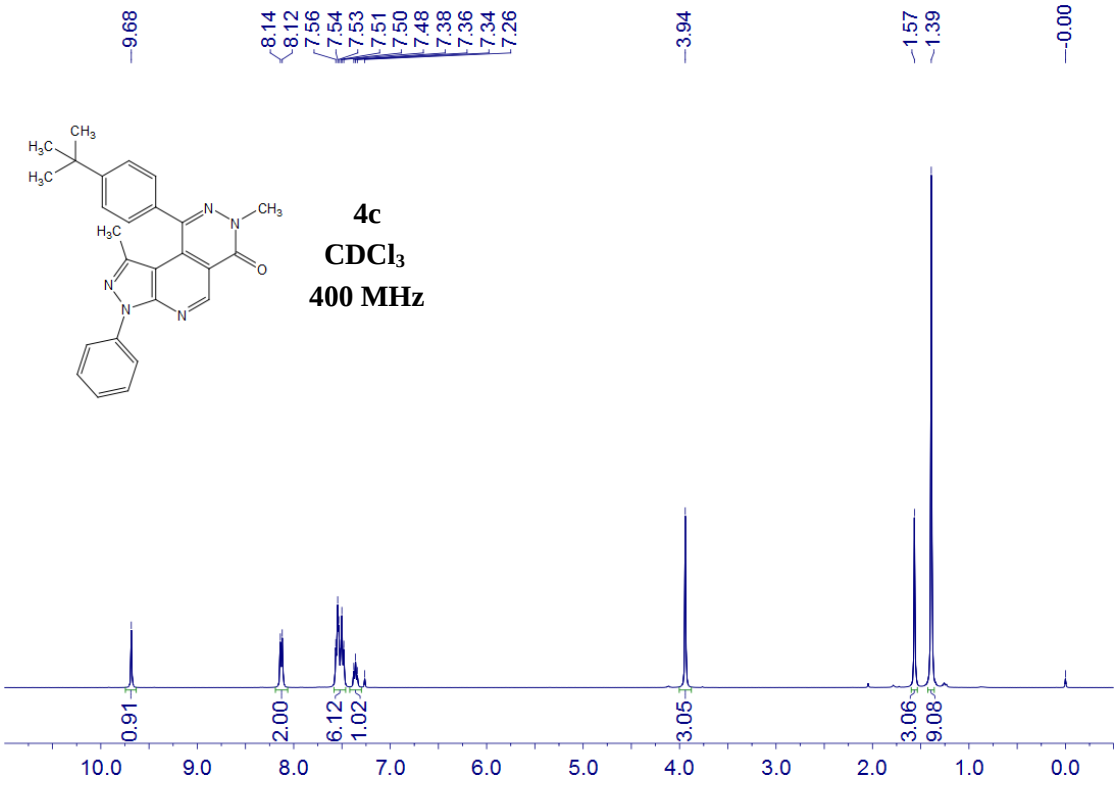
4c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7.26
3.94
1.57
1.39
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4c
CDCl3
400 MHz
0.91
2.00
6.12
1.02
3.05
3.06
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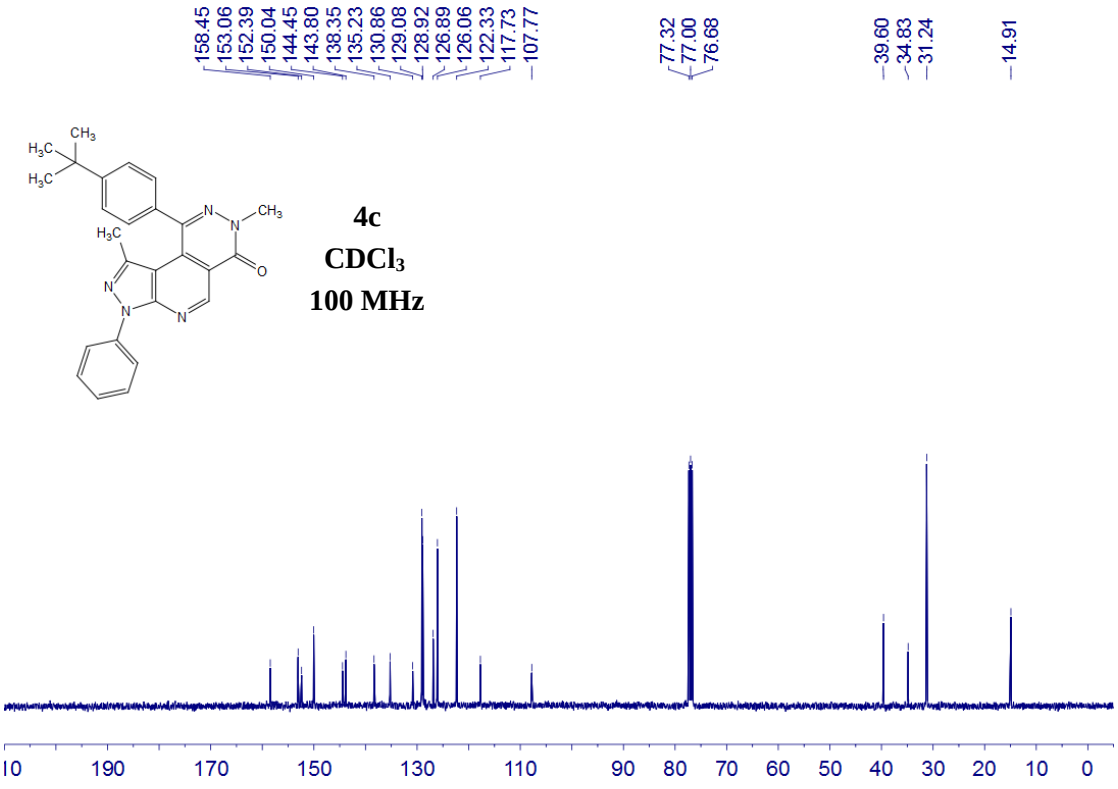
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122.33
117.73
107.77
77.32
77.00
76.68
39.60
34.83
31.24
14.91
4c
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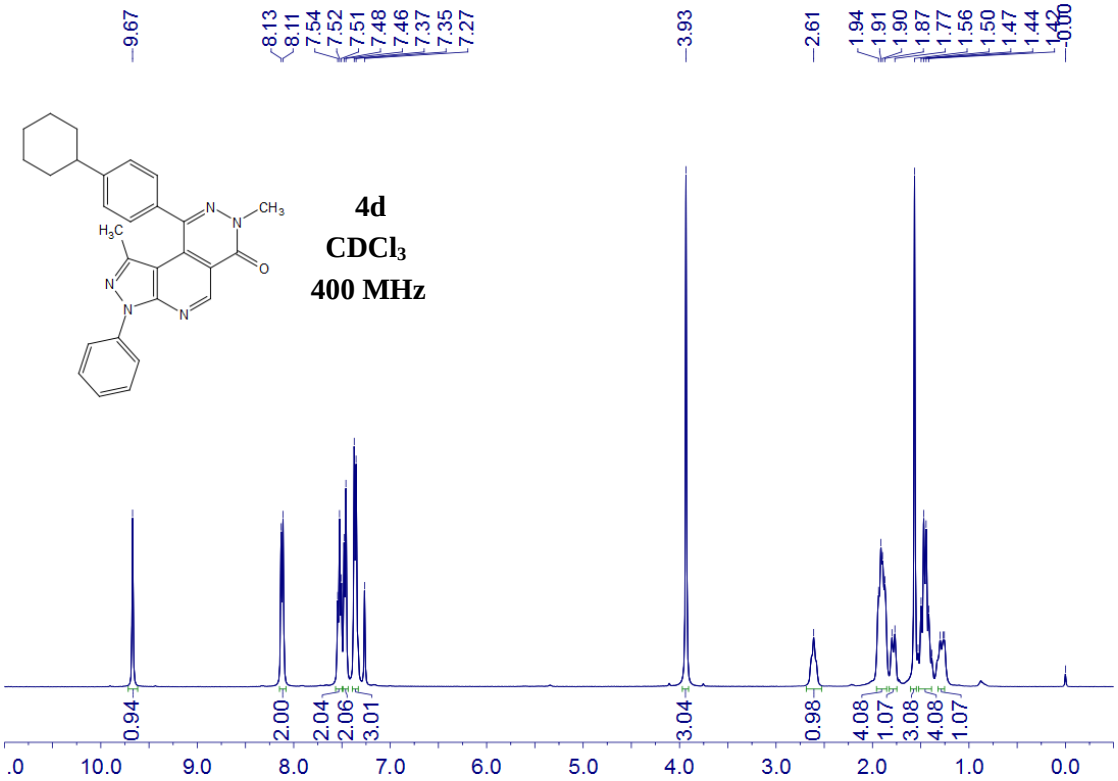
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1.91
1.90
1.87
1.77
1.56
1.50
1.47
1.44
1.42
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4d
CDCl3
400 MHz
0.94
2.00
2.04
2.06
3.01
3.04
0.98
4.08
1.07
3.08
4.08
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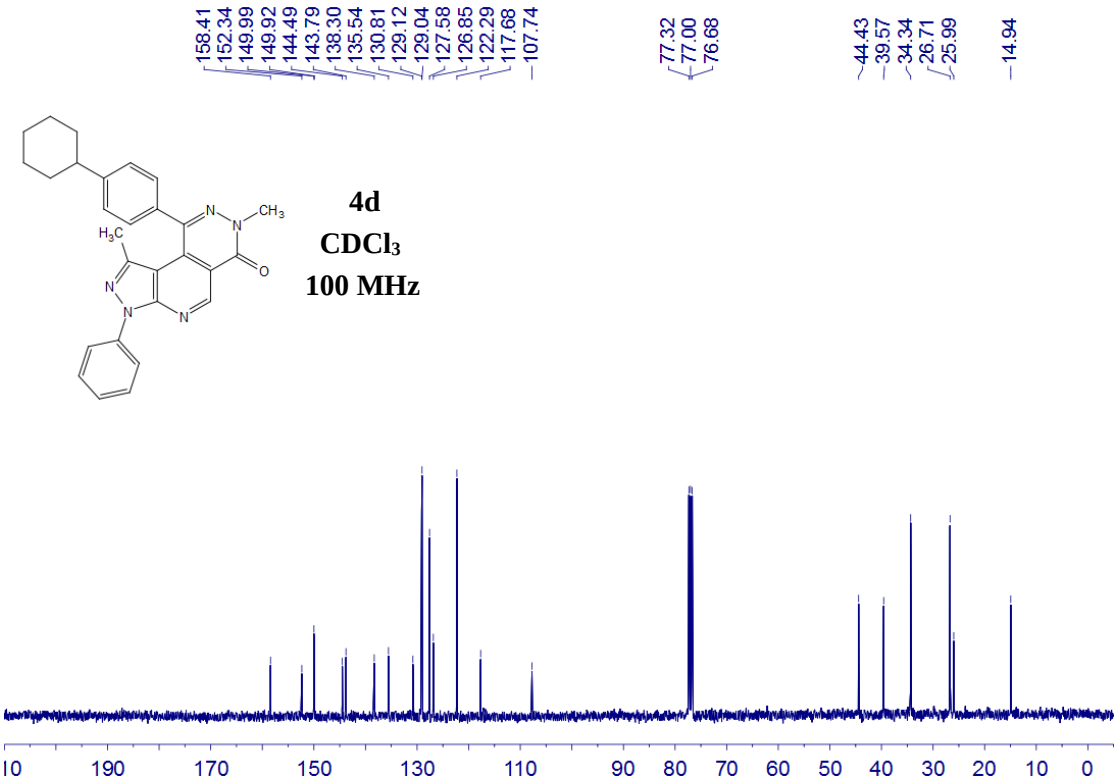
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122.29
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107.74
77.32
77.00
76.68
44.43
39.57
34.34
26.71
25.99
14.94
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110
90
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20
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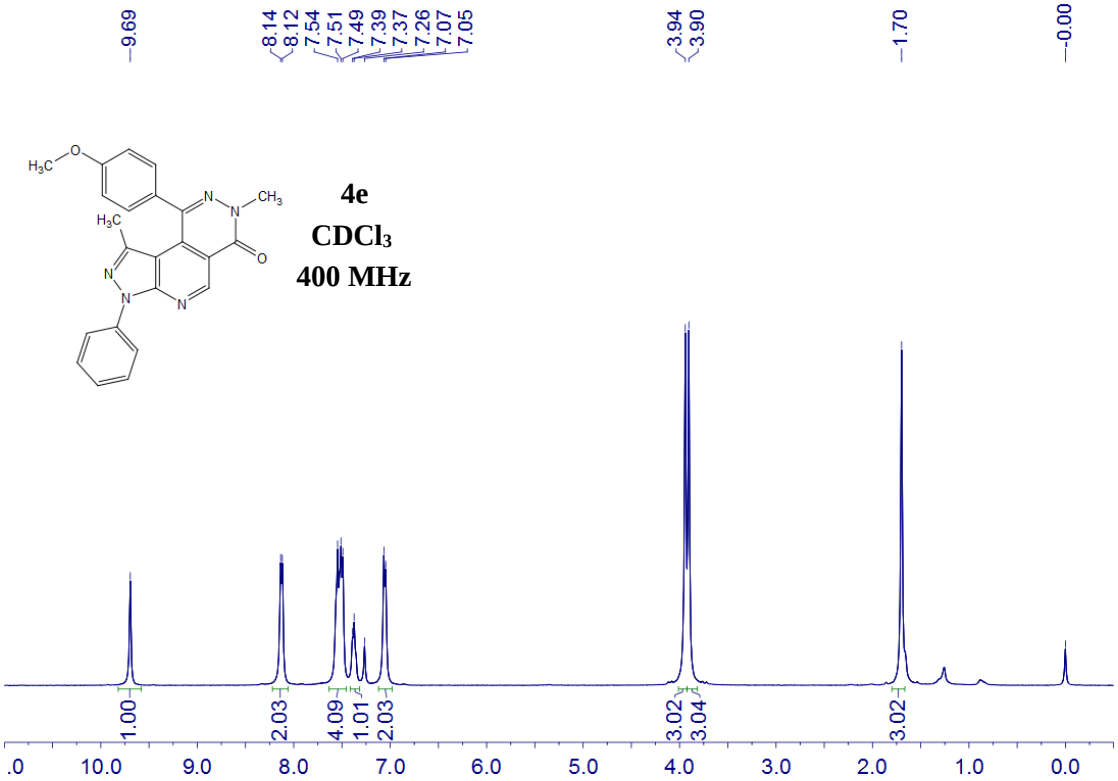
0

4e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7.37
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7.07
7.05
3.94
3.90
1.70
0.00
4e
CDCl3
400 MHz
1.00
2.03
4.09
1.01
2.03
3.02
3.04
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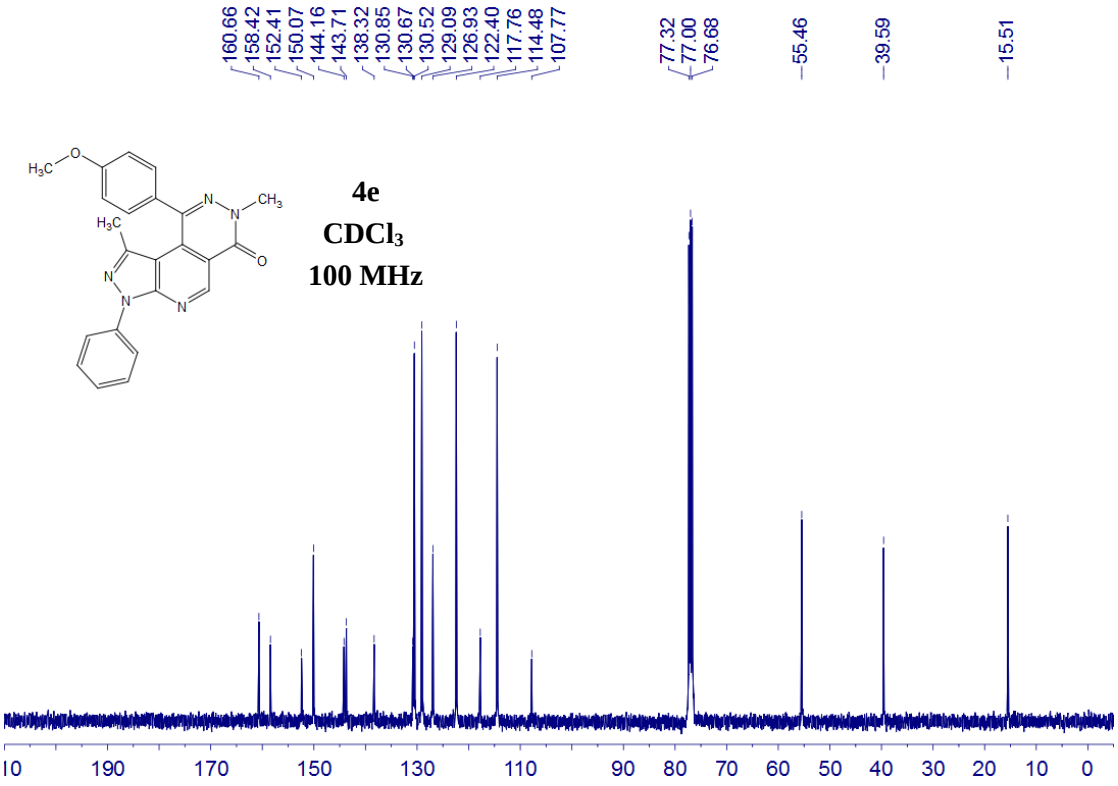
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122.40
117.76
114.48
107.77
77.32
77.00
76.68
55.46
39.59
15.51
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CDCl3
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170
150
130
110
90
80
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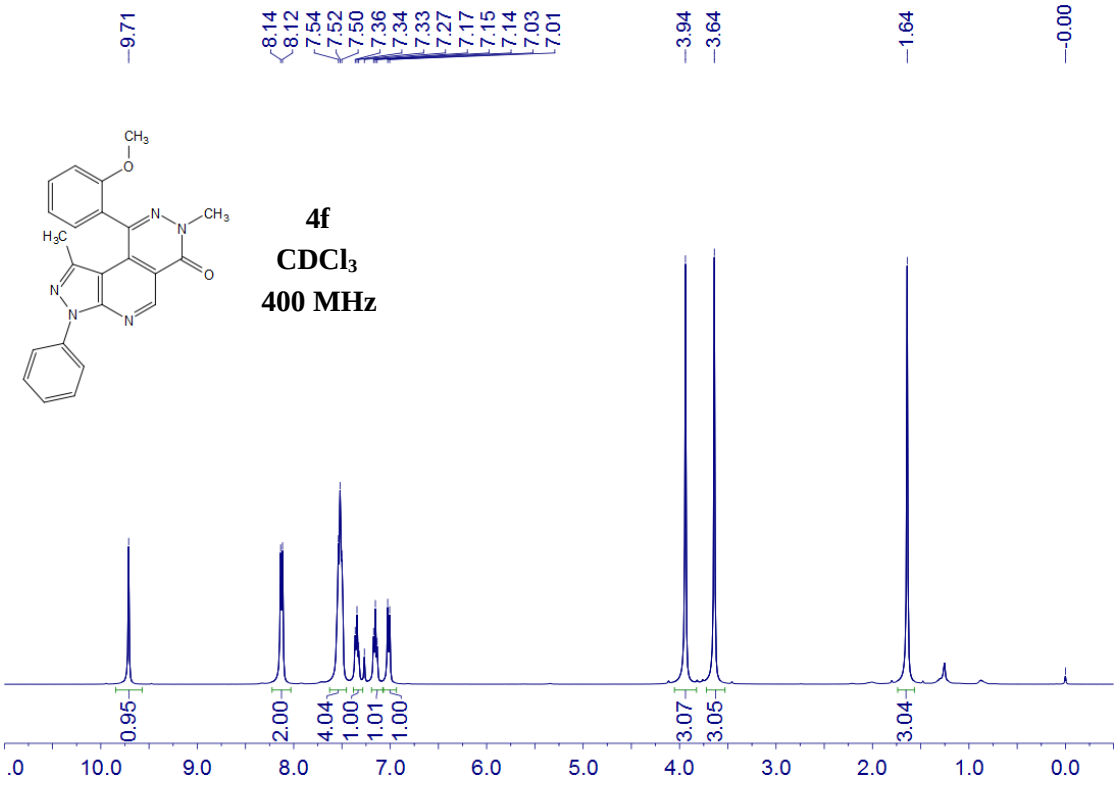
60
50
40
30
20
10
0

4f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7.50
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7.34
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7.27
7.17
7.15
7.14
7.03
7.01
3.94
3.64
1.64
0.00
4f
CDCl3
400 MHz
0.95
2.00
4.04
1.00
1.01
1.00
3.07
3.05
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8.0
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6.0
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4.0
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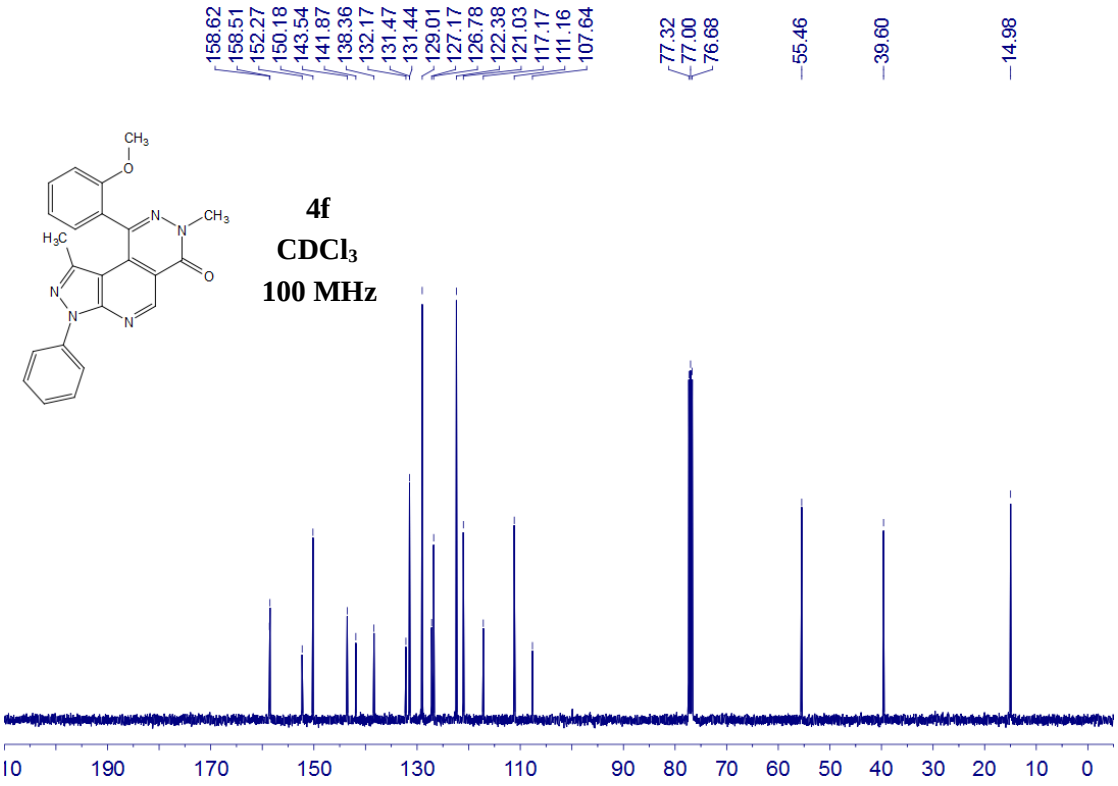
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131.44
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121.03
117.17
111.16
107.64
77.32
77.00
76.68
55.46
39.60
14.98
4f
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170
150
130
110
90
80
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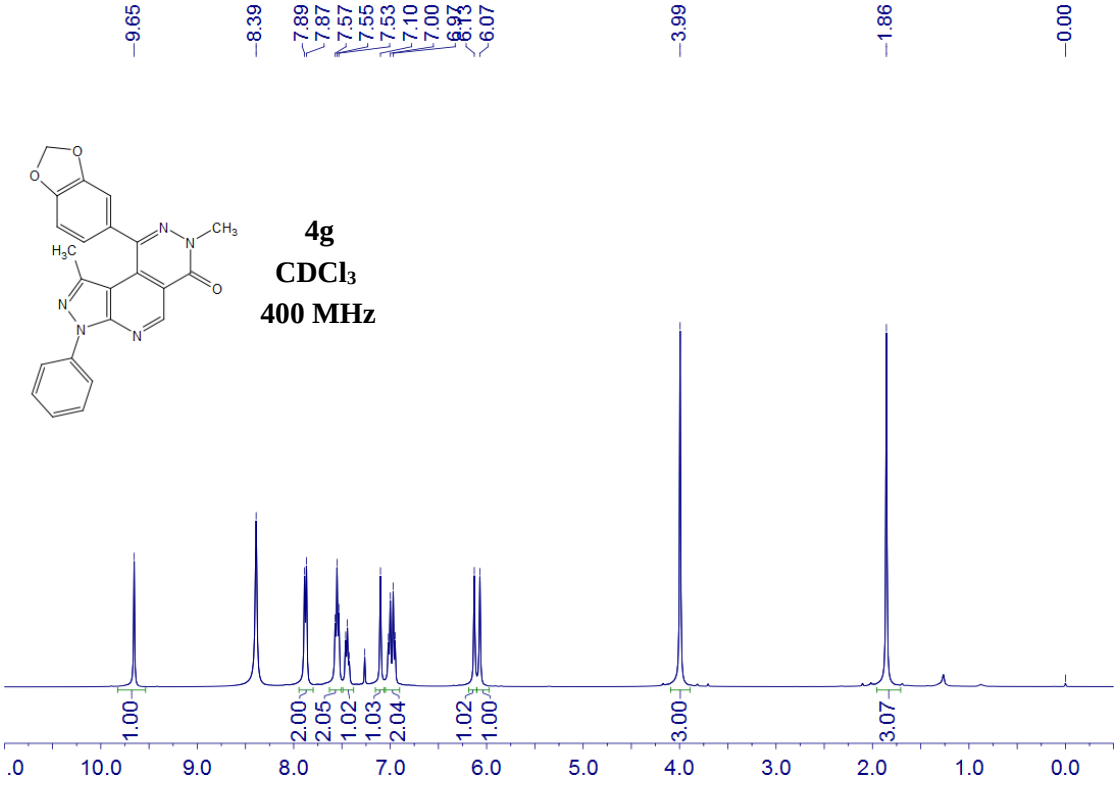
60
50
40
30
20
10
0

4g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7.10
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6.97
6.13
6.07
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1.86
0.00
4g
CDCl3
400 MHz
1.00
2.00
2.05
1.02
1.03
2.04
1.02
1.00
3.00
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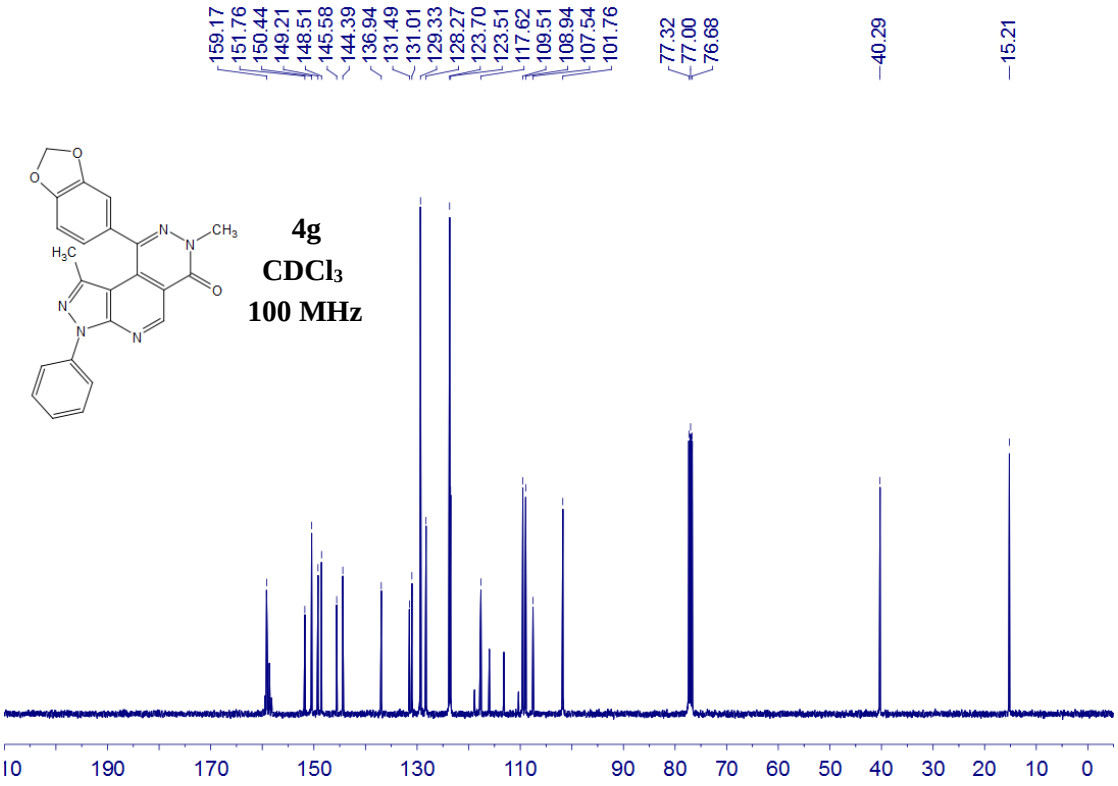
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131.01
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123.70
123.51
117.62
109.51
108.94
107.54
101.76
77.32
77.00
76.68
40.29
15.21
4g
CDCl3
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170
150
130
110
90
80
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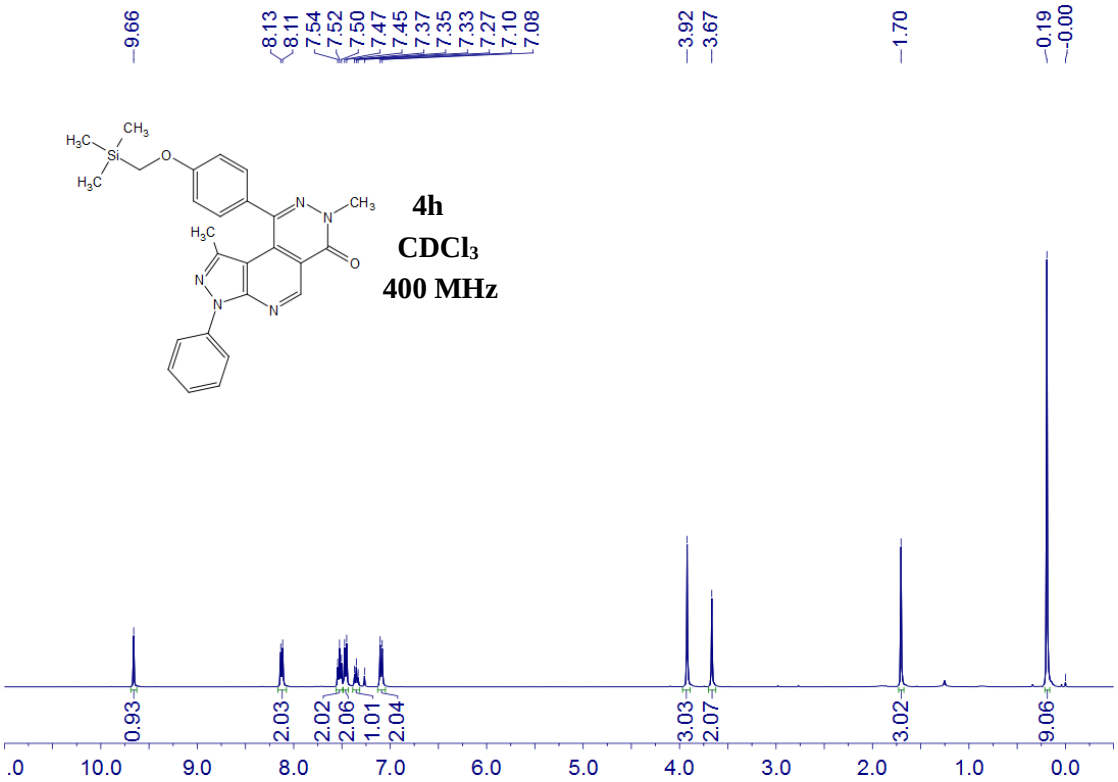
60
50
40
30
20
10
0

4h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7.33
7.27
7.10
7.08
3.92
3.67
1.70
0.19
0.00
4h
CDCl3
400 MHz
0.93
2.03
2.02
2.06
1.01
2.04
3.03
2.07
3.02
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8.0
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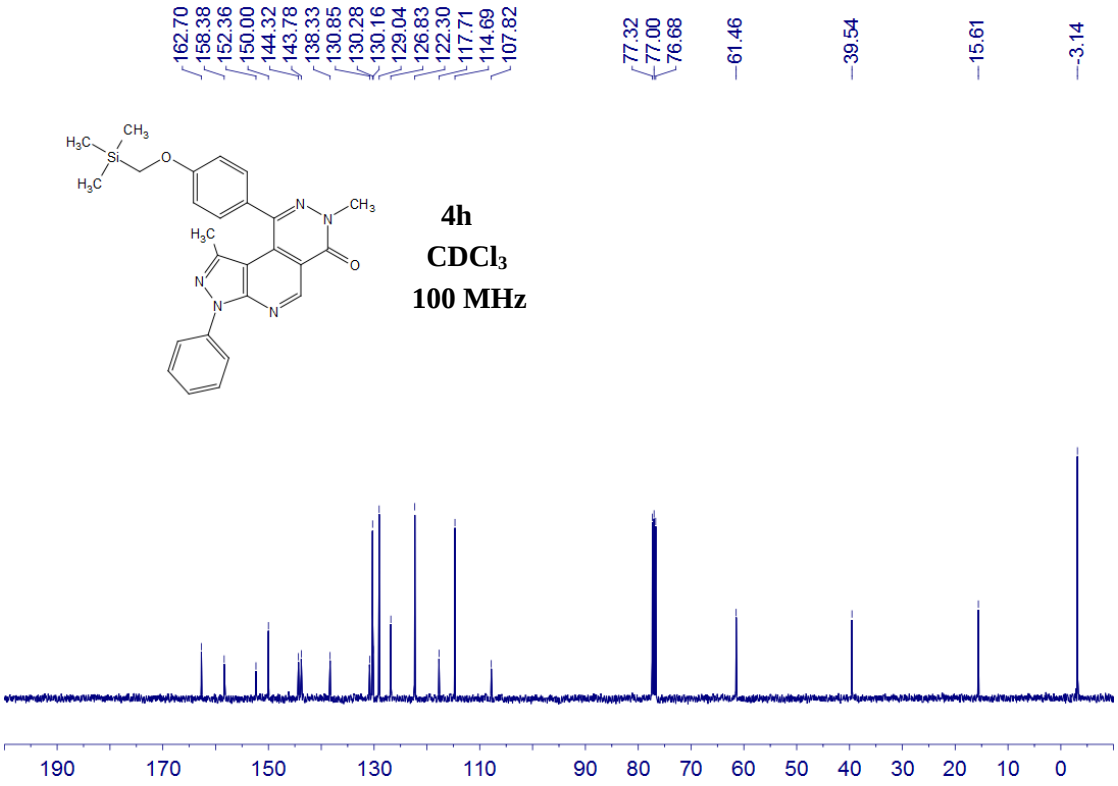
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130.28
130.16
129.04
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122.30
117.71
114.69
107.82
77.32
77.00
76.68
61.46
39.54
15.61
3.14
4h
CDCl3
100 MHz
190
170
150
130
110
90
80
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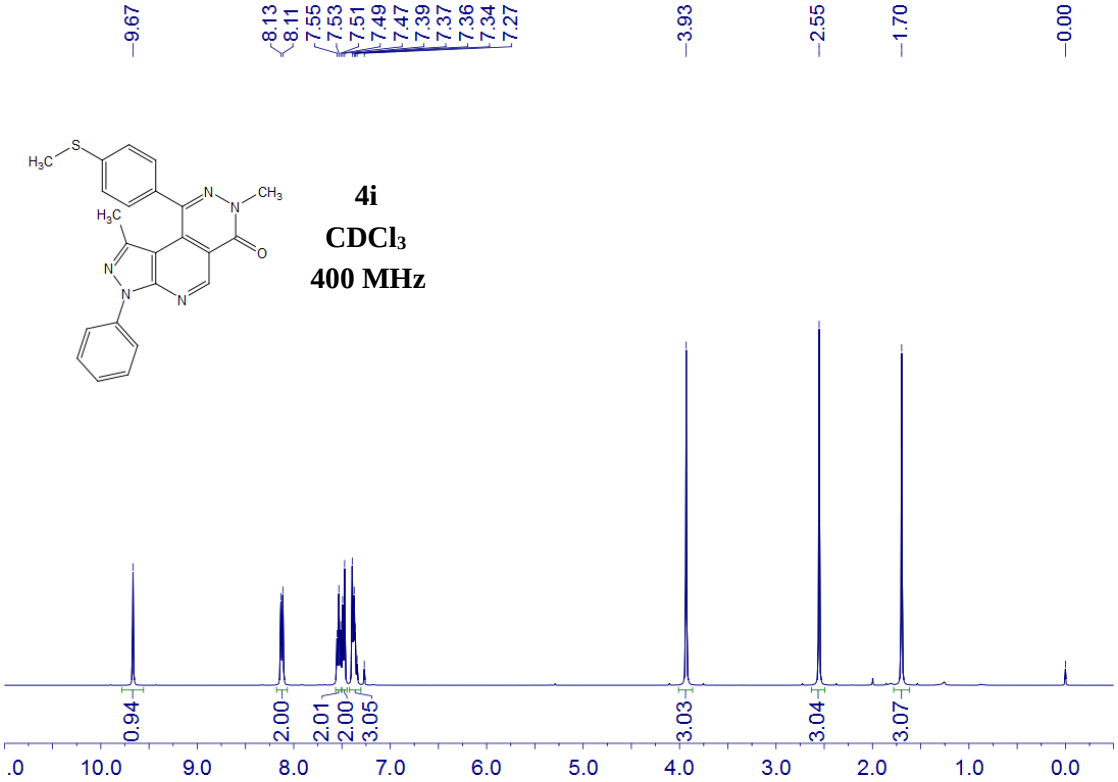
60
50
40
30
20
10
0

4i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7.55
7.53
7.51
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7.39
7.37
7.36
7.34
7.27
3.93
2.55
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CDCl3
400 MHz
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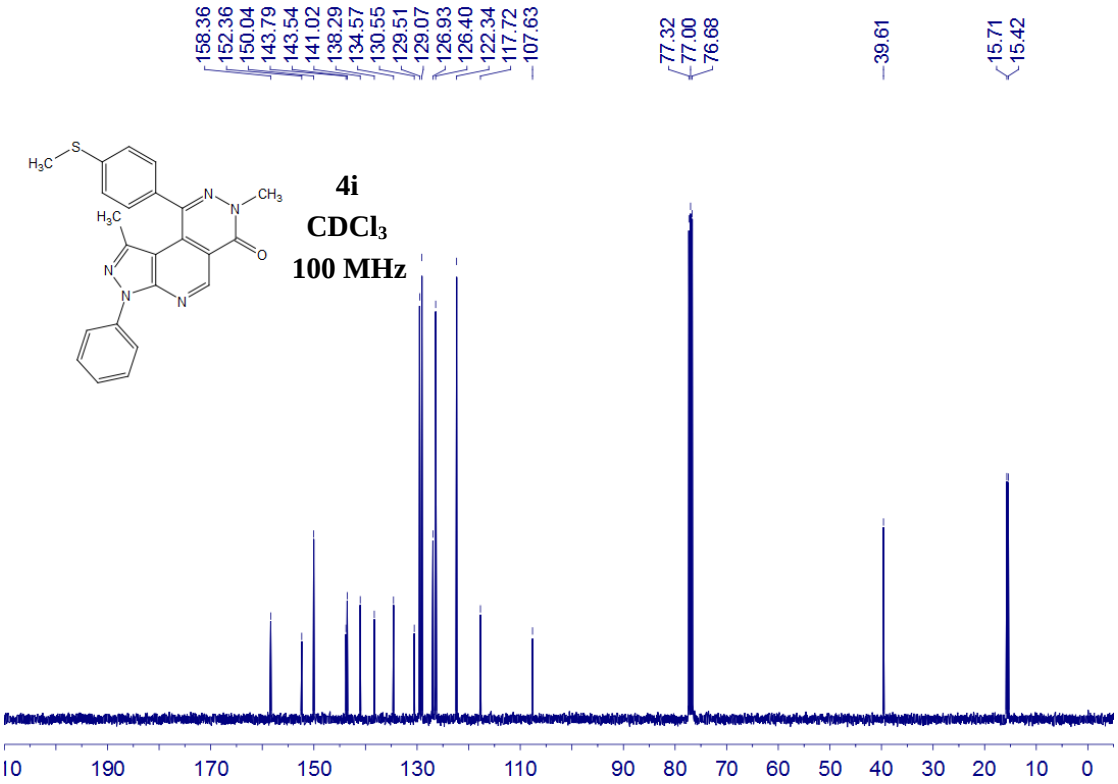
2.01
2.00
3.05
3.03
3.04
3.07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130.55
129.51
129.07
126.93
126.40
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77.32
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76.68
39.61
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15.42
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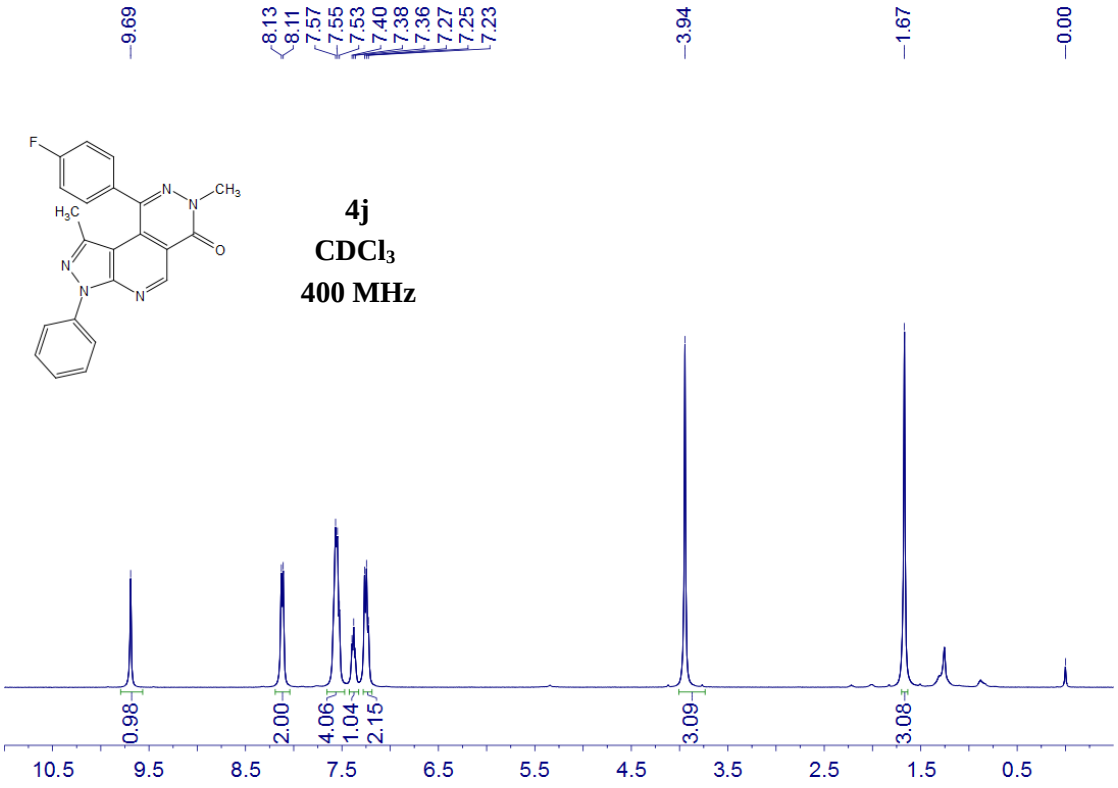
CDCl3
100 MHz

4j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8.11
7.57
7.55
7.53
7.40
7.38
7.36
7.27
7.25
7.23
3.94
1.67
0.00
4j
CDCl3
400 MHz
0.98
2.00
4.06
1.04
2.15
3.09
3.08
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9.5
8.5
7.5
6.5
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4.5
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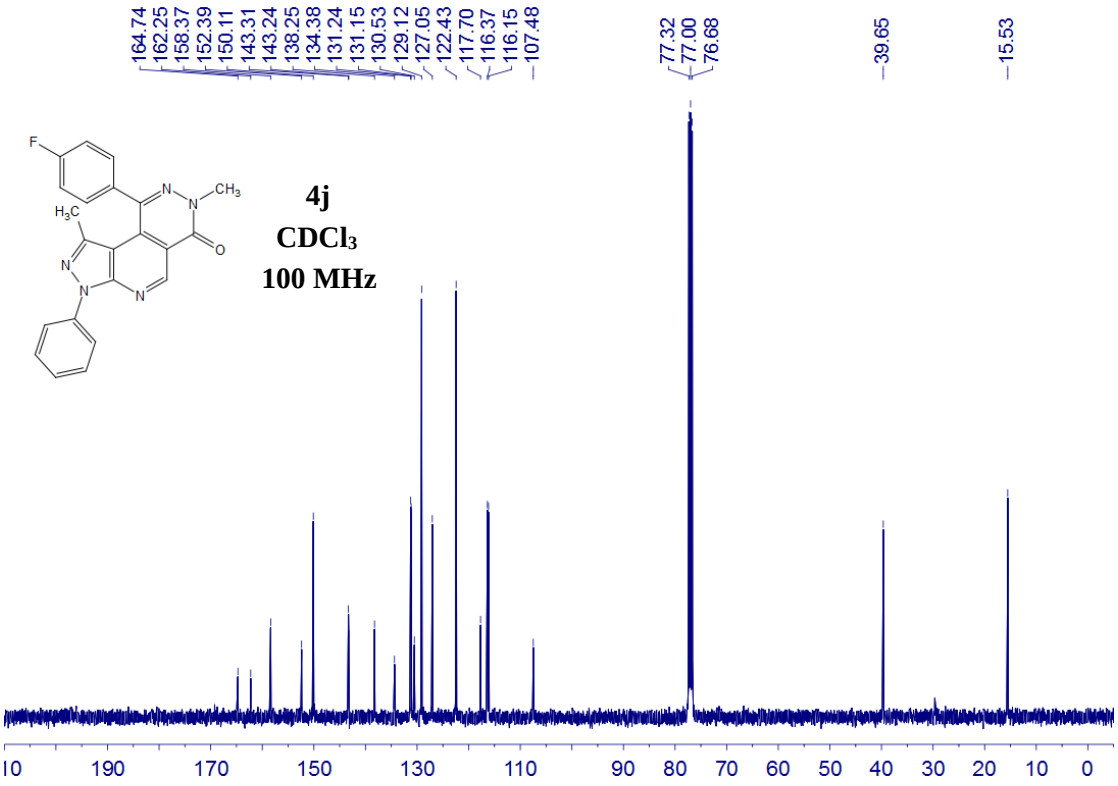
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143.24
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131.24
131.15
130.53
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127.05
122.43
117.70
116.37
116.15
107.48
77.32
77.00
76.68
39.65
15.53
4j
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
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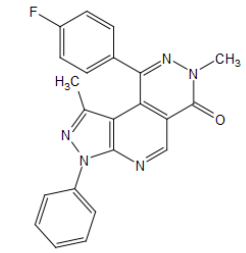
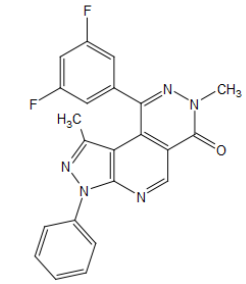
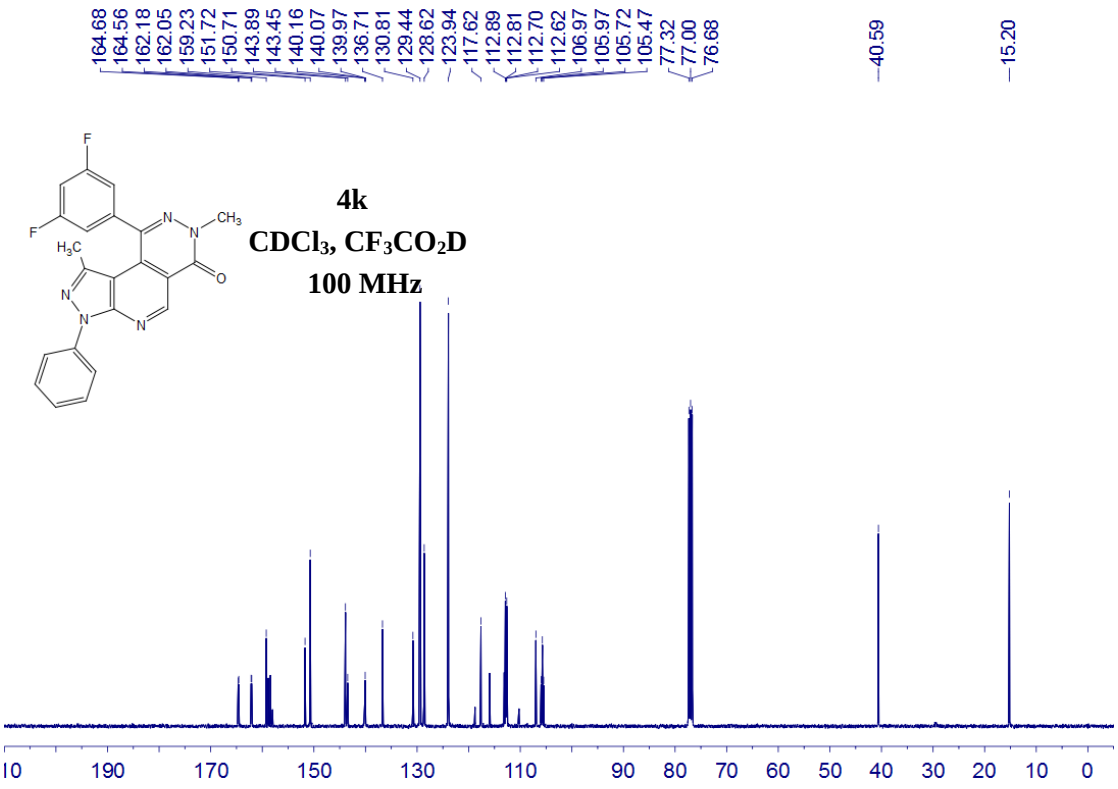


4j
$CDCl_3$
376 MHz

4k



4k
$CDCl_3$, CF_3CO_2D
400 MHz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162.05
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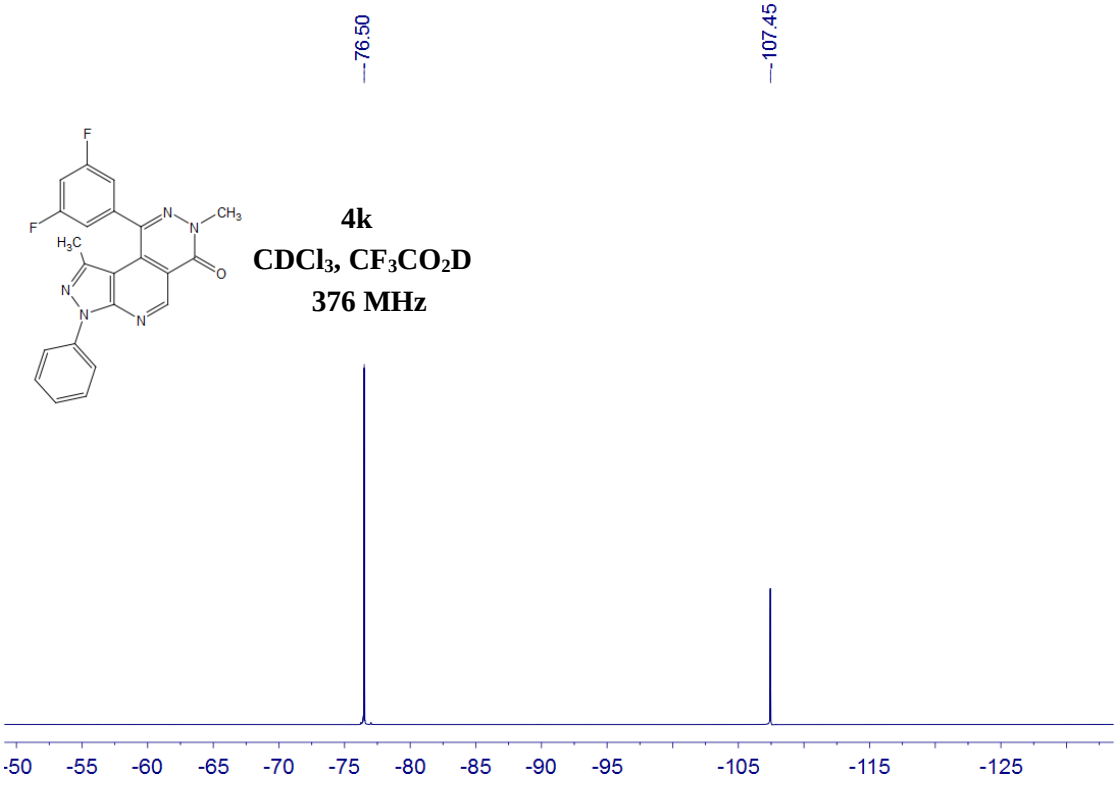
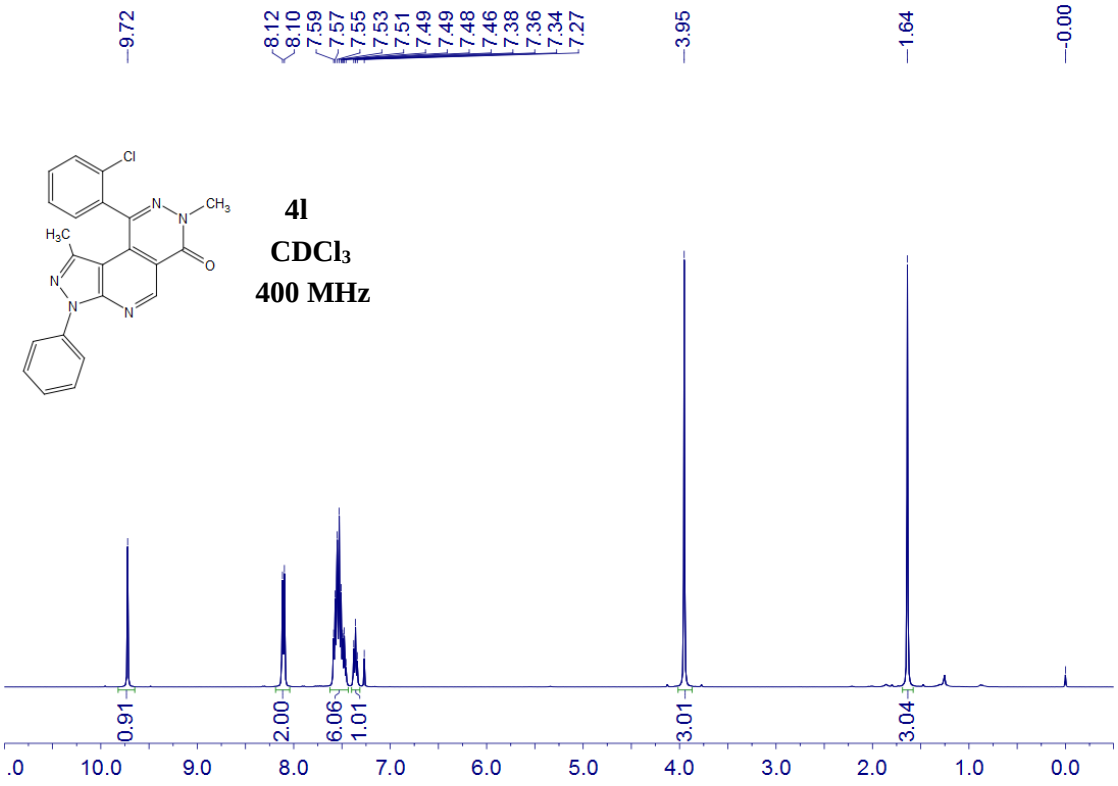
150.71
143.89
143.45
140.16
140.07
139.97
136.71
130.81
129.44
128.62
123.94
117.62
112.89
112.81
112.70
112.62
106.97
105.97
105.72
105.47
77.32
77.00
76.68
40.59
15.20
4k
CDCl3, CF3CO2D
100 MHz
10
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0


76.50
107.45
4k
CDCl3, CF3CO2D
376 MHz
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-105
-115
-125

4l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8.12
8.10
7.59
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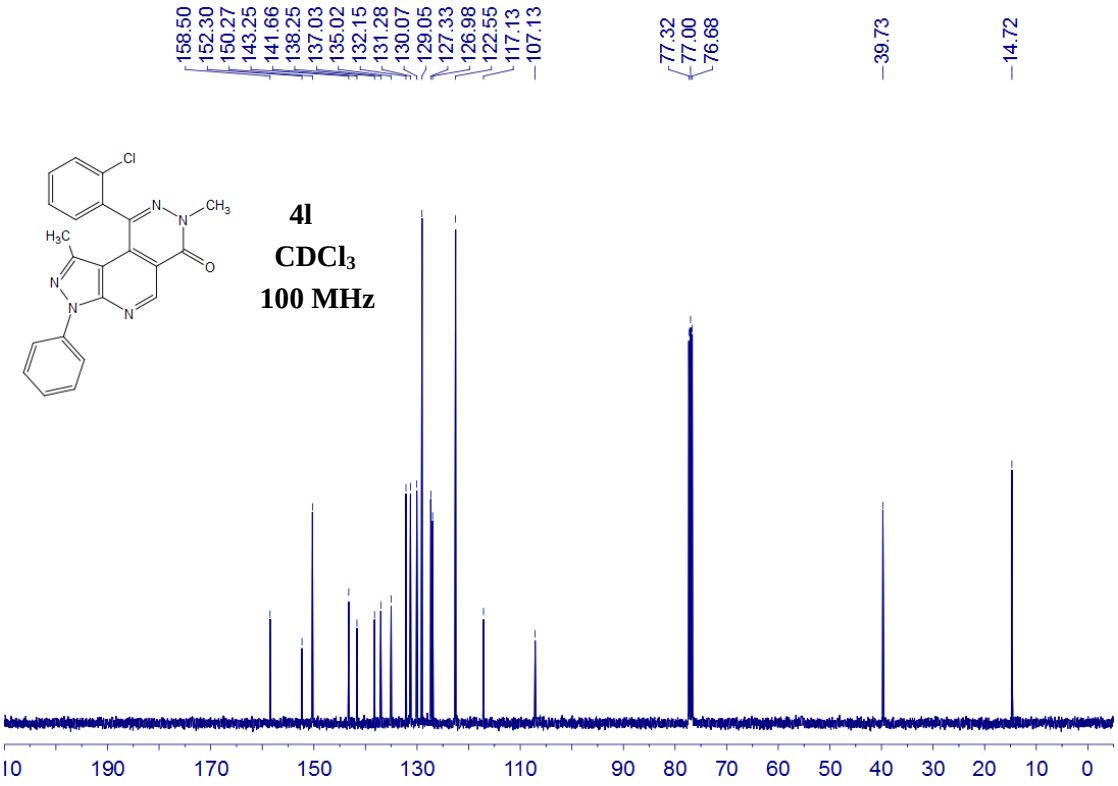
7.55
7.53
7.51
7.49
7.49
7.48
7.46
7.38
7.36
7.34
7.27
3.95
1.64
0.00
4l
CDCl3
400 MHz
0.91
2.00
6.06
1.01
3.01
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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138.25
137.03
135.02
132.15
131.28
130.07
129.05
127.33
126.98
122.55
117.13
107.13
77.32
77.00
76.68
39.73
14.72
4l
CDCl3
100 MHz
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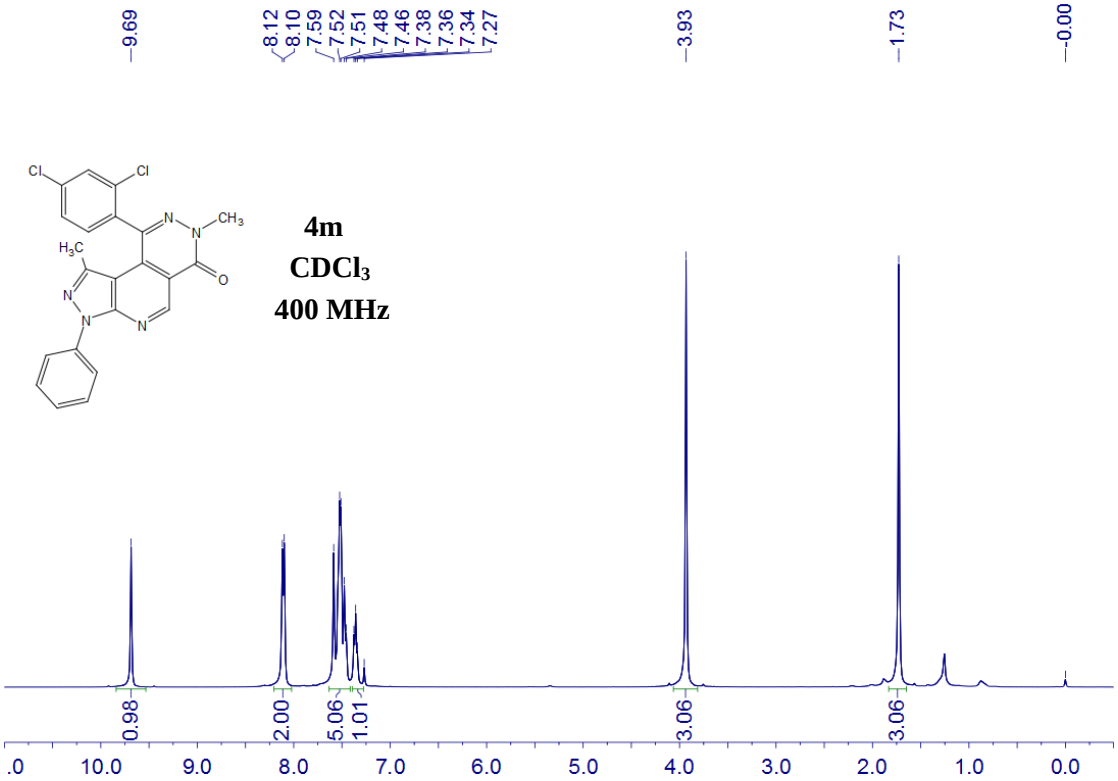
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4m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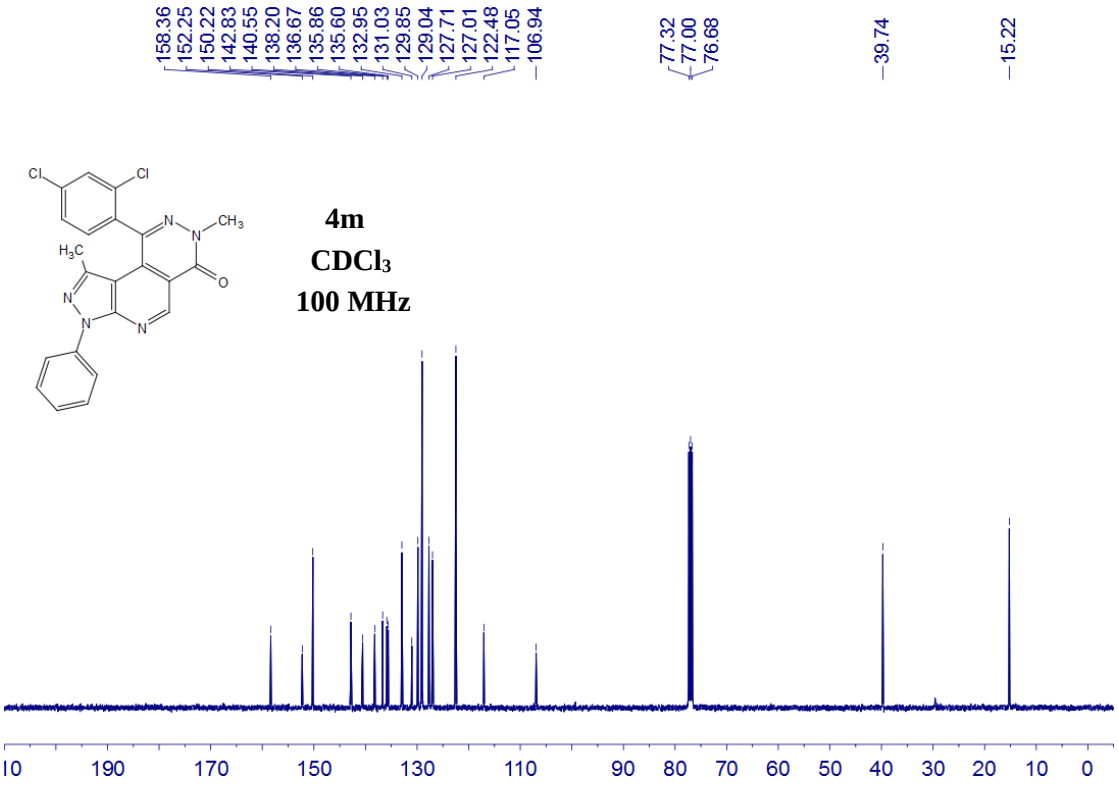
8.12
8.10
7.59
7.52
7.51
7.48
7.46
7.38
7.36
7.34
7.27
3.93
1.73
0.00
Cl
Cl
N
N
CH3
H3C
N
O
N
N
4m
CDCl3
400 MHz
0.98
2.00
5.06
1.01
3.06
3.06
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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132.95
131.03
129.85
129.04
127.71
127.01
122.48
117.05
106.94
77.32
77.00
76.68
39.74
15.22
Cl
Cl
N
N
CH3
H3C
N
O
N
N
4m
CDCl3
100 MHz
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170
150
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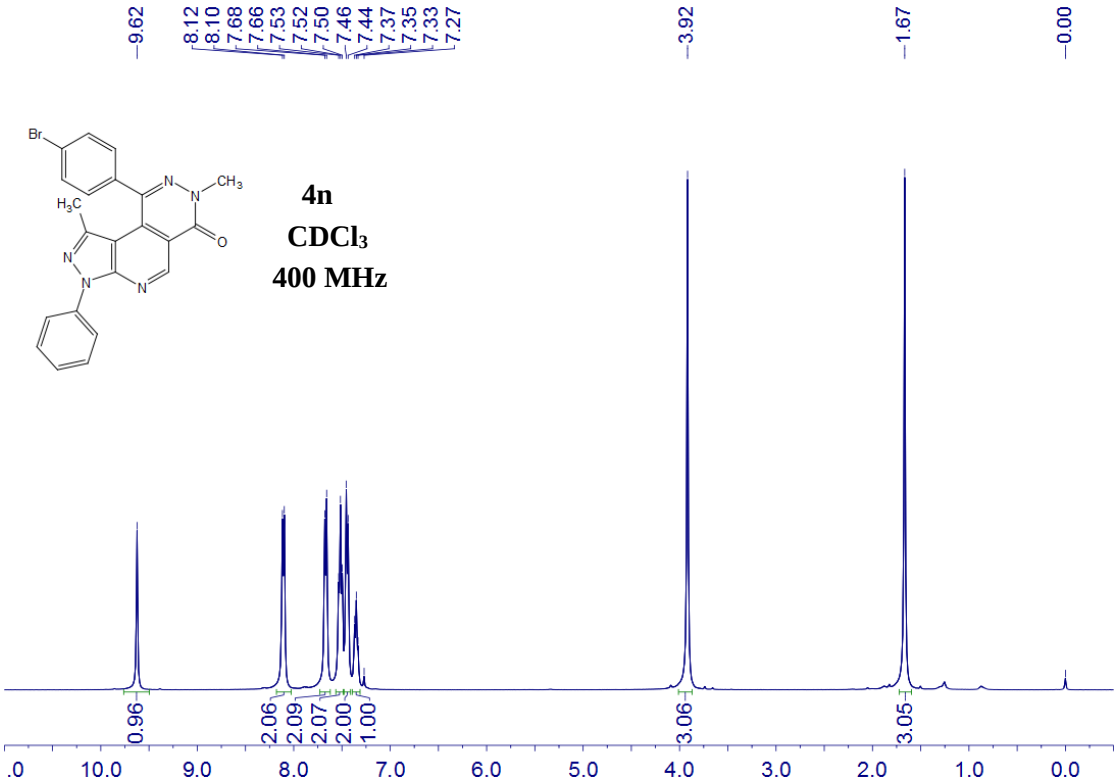
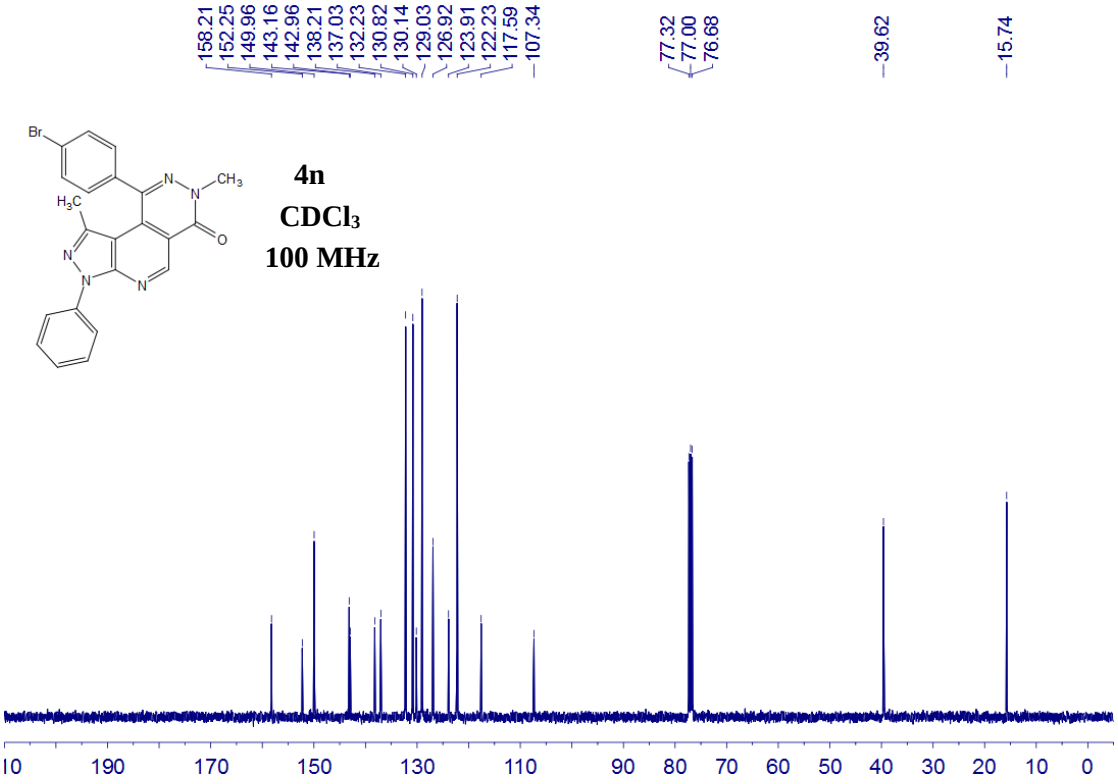
60
50
40
30
20
10
0

4n


9.62
8.12
8.10
7.68
7.66
7.53
7.52
7.50
7.46
7.44
7.37
7.35
7.33
7.27
3.92
1.67
0.00
Br
N
N
CH3
H3C
N
N
O
N
4n
CDCl3
400 MHz
0.96
2.06
2.09
2.07
2.00
1.00
3.06
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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137.03
132.23
130.82
130.14
129.03
126.92
123.91
122.23
117.59
107.34
77.32
77.00
76.68
39.62
15.74
Br
N
N
CH3
H3C
N
N
O
N
4n
CDCl3
100 MHz
190
170
150
130
110
90
80
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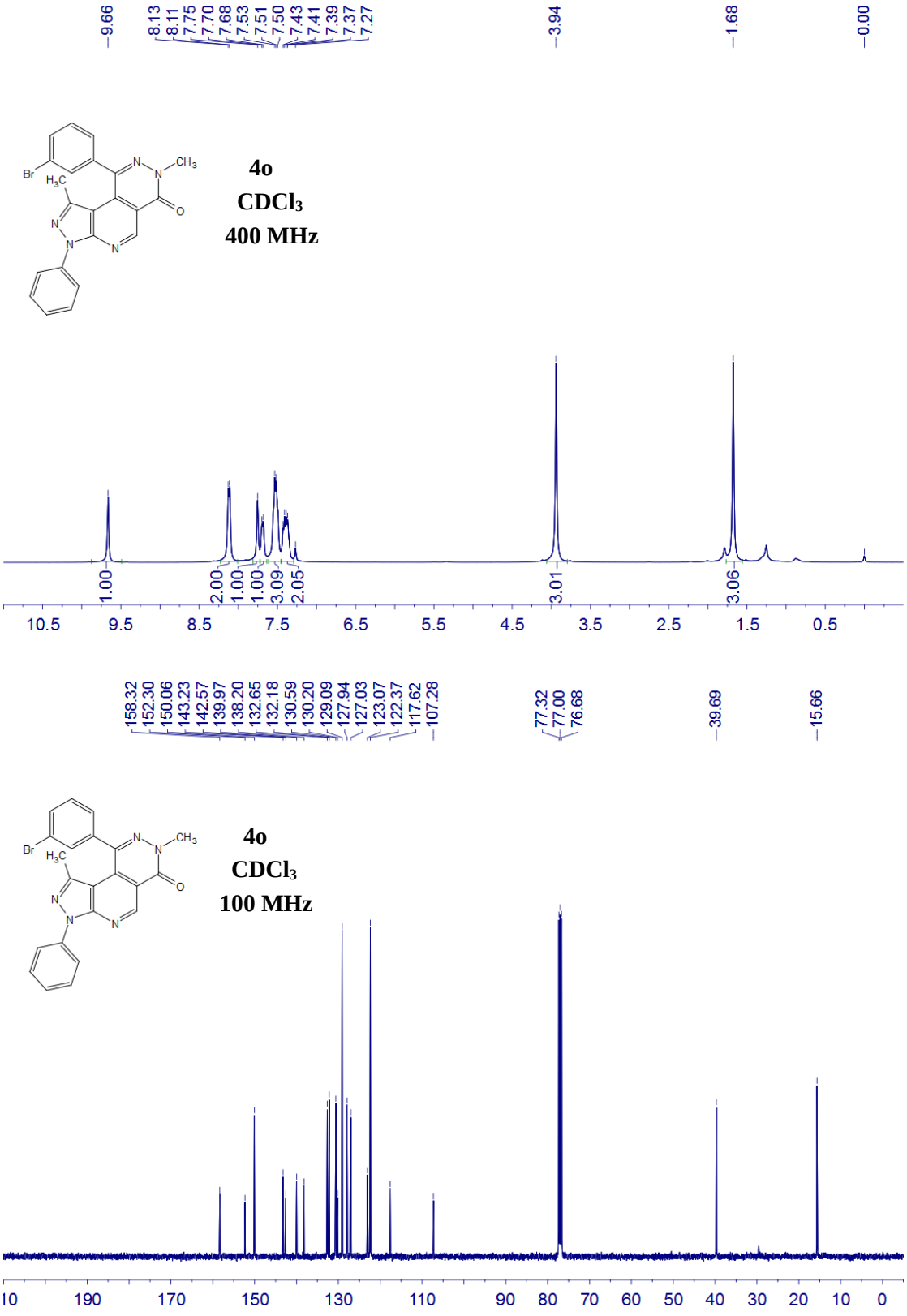
60
50
40
30
20
10
0

4o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7.70
7.68
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7.51
7.50
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7.41
7.39
7.37
7.27
3.94
1.68
0.00
Br
H3C
CH3
N
O
4o
CDCl3
400 MHz
1.00
2.00
1.00
1.00
3.09
2.05
3.01
3.06
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
158.32
152.30
150.06
143.23
142.57
139.97
138.20
132.65
132.18
130.59
130.20
129.09
127.94
127.03
123.07
122.37
117.62
107.28
77.32
77.00
76.68
39.69
15.66
4o
CDCl3
100 MHz
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170
150
130
110
90
80
70
60
50
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20
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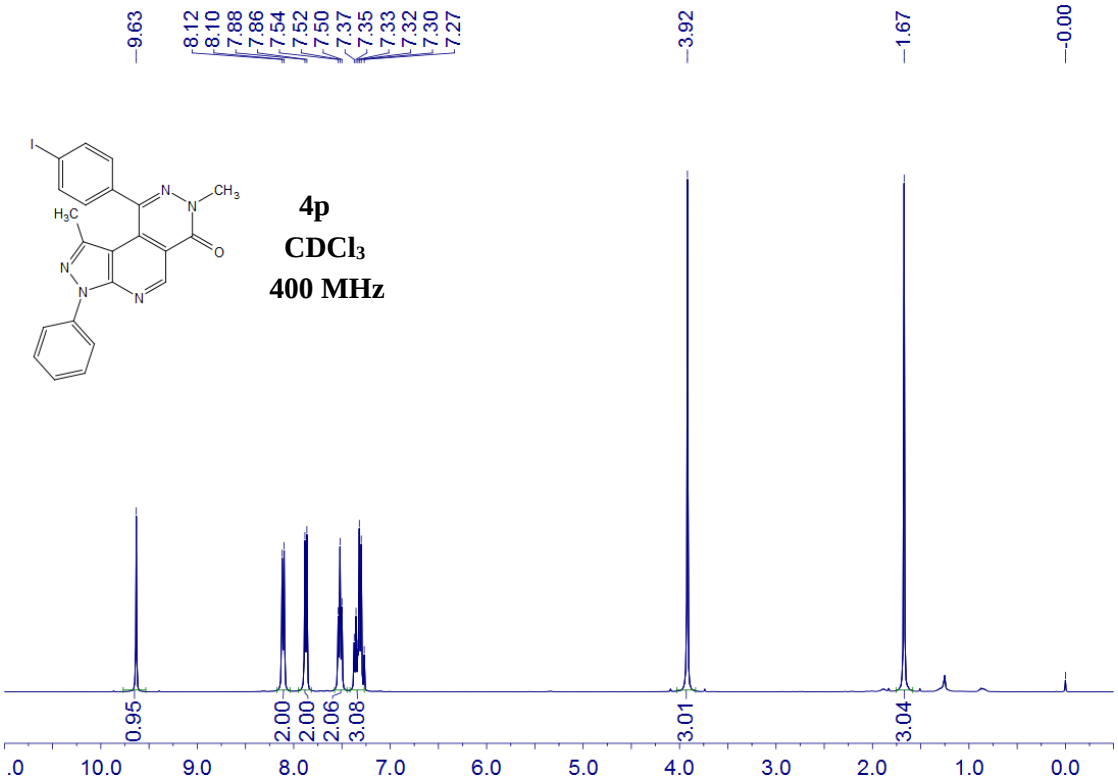
0

4p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8.10
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7.52
7.50
7.37
7.35
7.33
7.32
7.30
7.27
3.92
1.67
0.00
4p
CDCl3
400 MHz
0.95
2.00
2.00
2.06
3.08
3.01
3.04
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8.0
7.0
6.0
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4.0
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2.0
1.0
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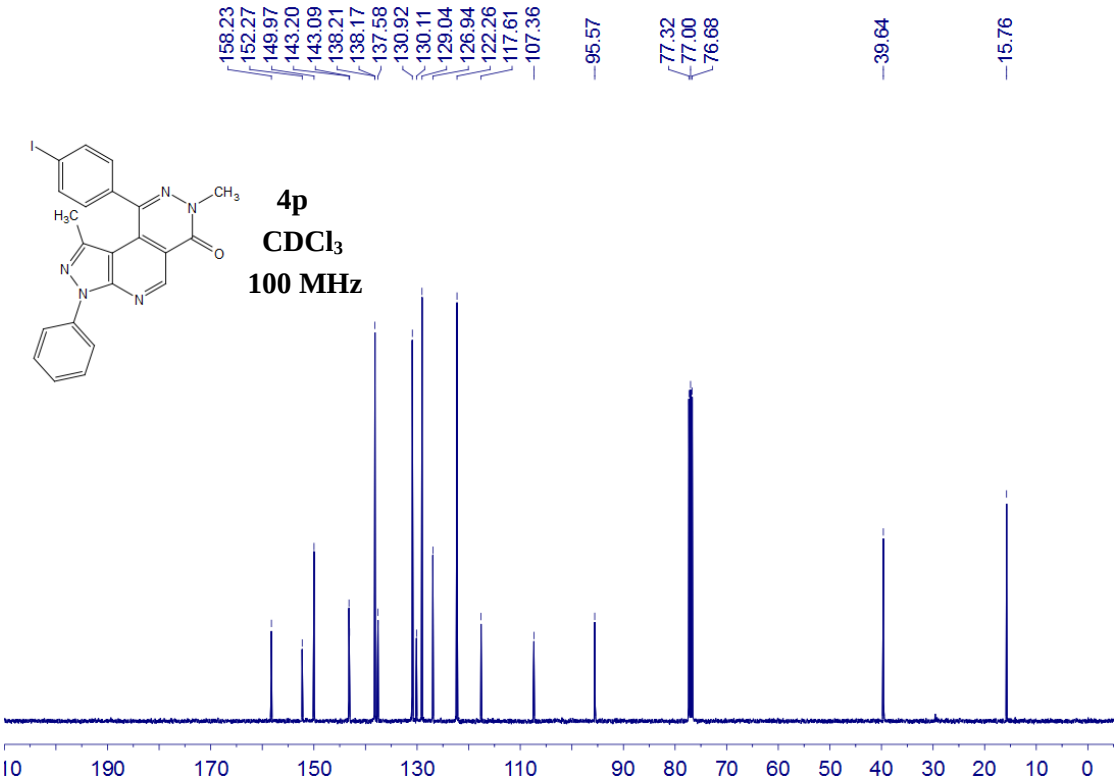
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143.09
138.21
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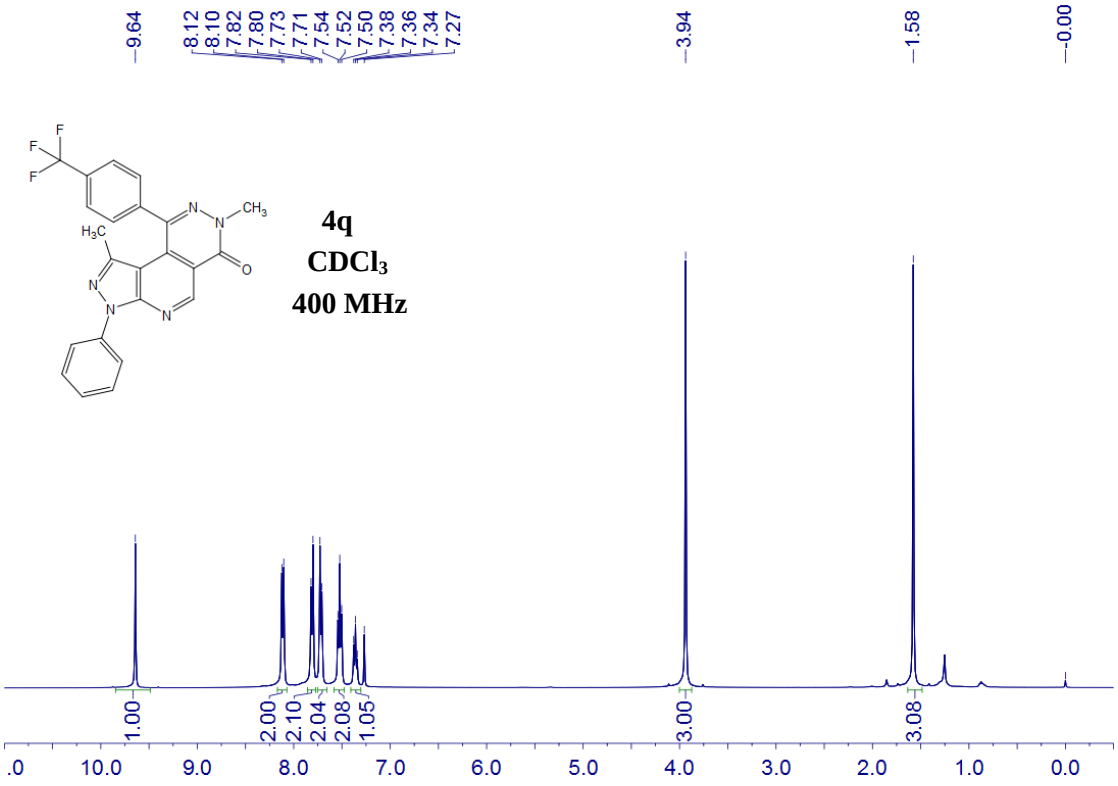
137.58
130.92
130.11
129.04
126.94
122.26
117.61
107.36
95.57
77.32
77.00
76.68
39.64
15.76
4p
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4q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8.12
8.10
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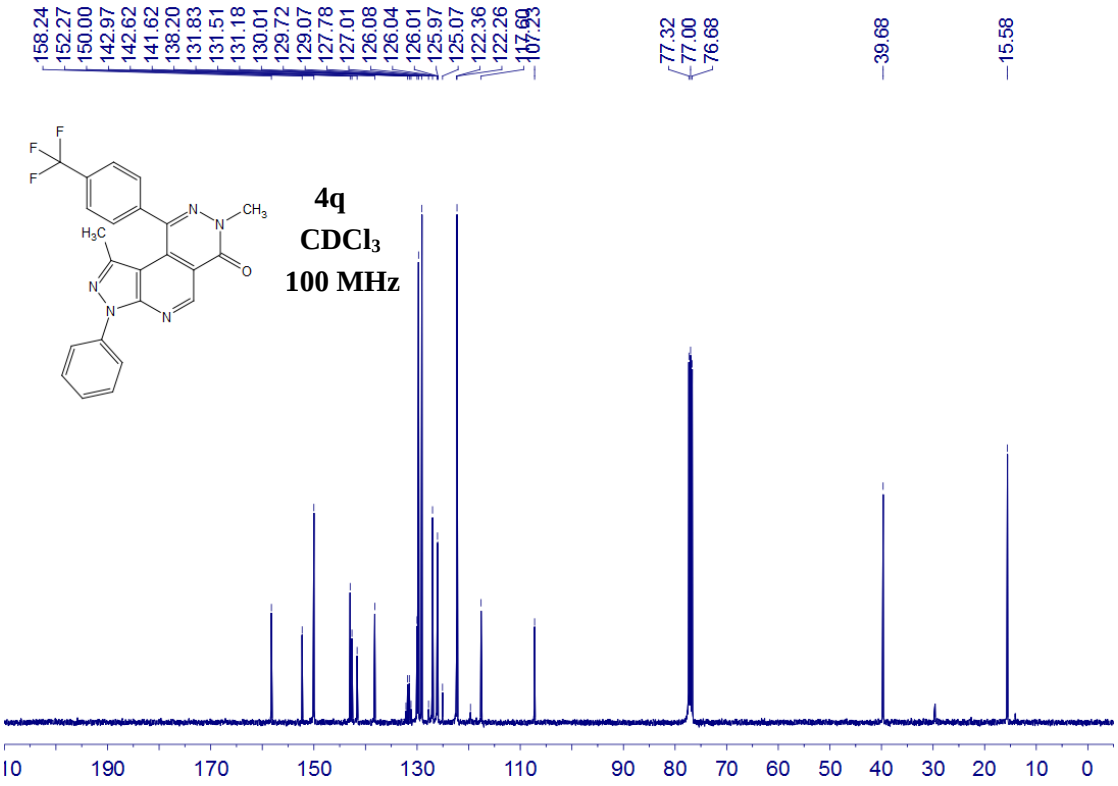
7.80
7.73
7.71
7.54
7.52
7.50
7.38
7.36
7.34
7.27
3.94
1.58
0.00
4q
CDCl3
400 MHz
1.00
2.00
2.10
2.04
2.08
1.05
3.00
3.08
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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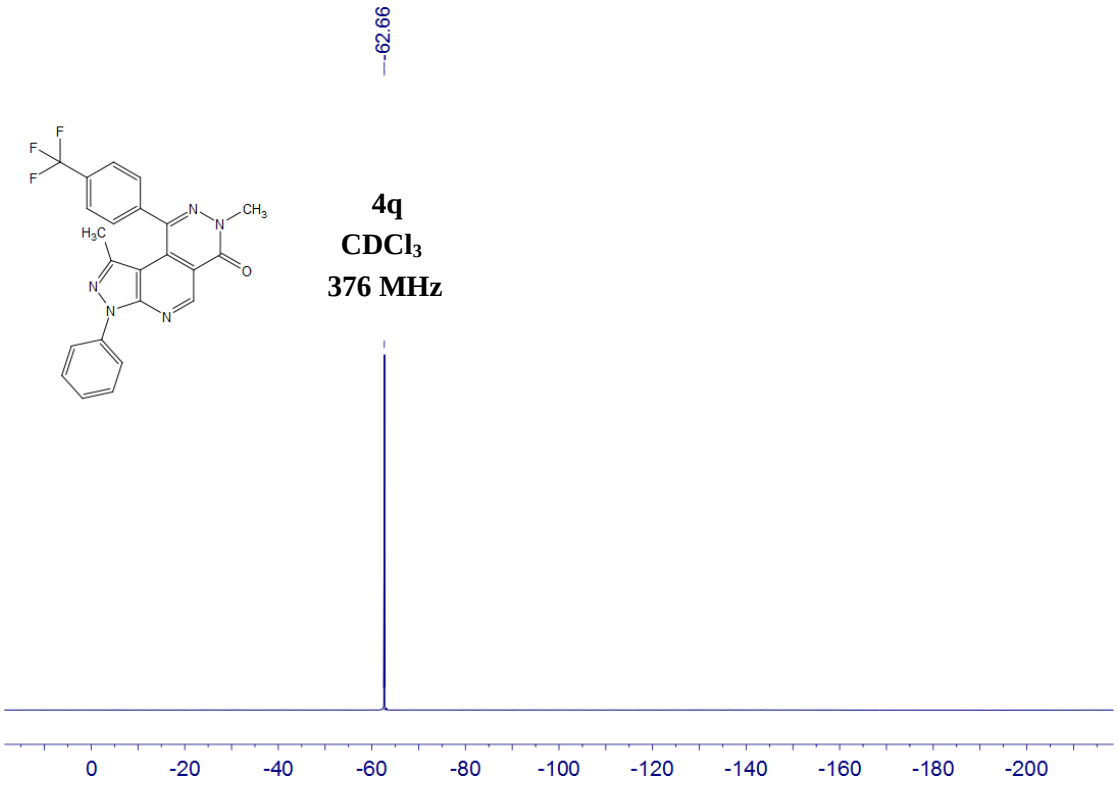
152.27
150.00
142.97
142.62
141.62
138.20
131.83
131.51
131.18
130.01
129.72
129.07
127.78
127.01
126.08
126.04
126.01
125.97
125.07
122.36
122.26
77.32
77.00
76.68
39.68
15.58
4q
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0


-62.66
4q
CDCl3
376 MHz
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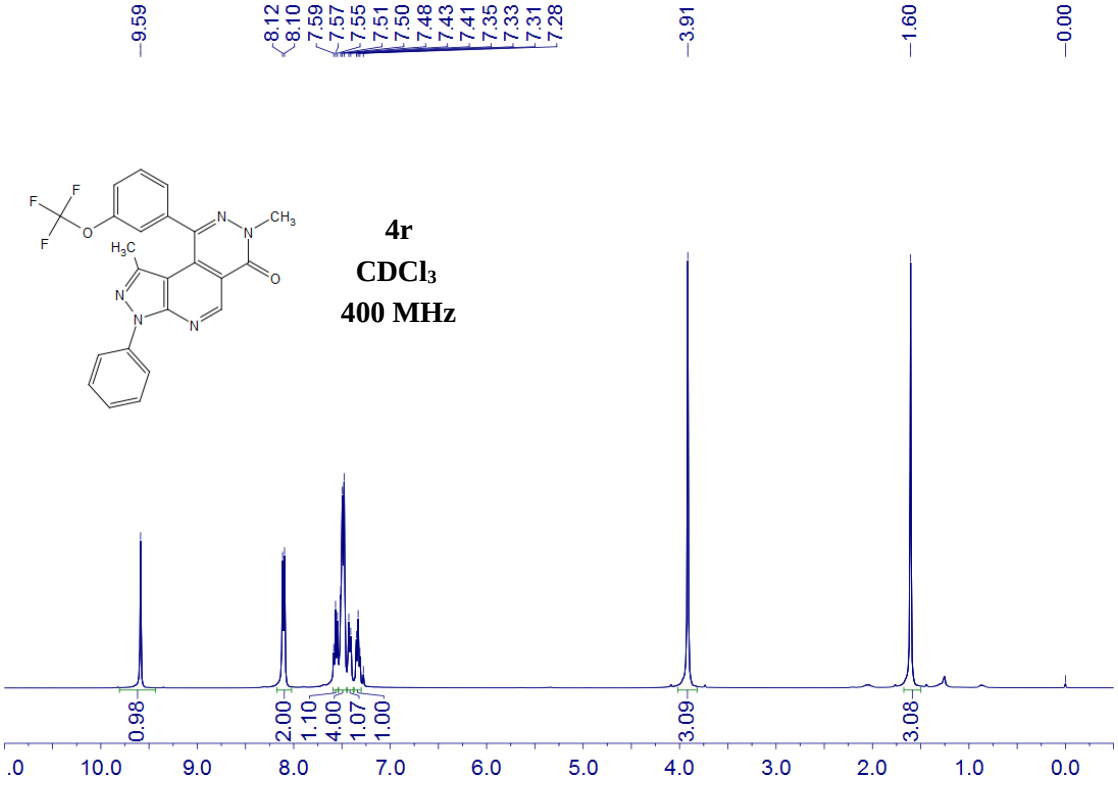
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200

4r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8.12
8.10
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7.57
7.55
7.51
7.50
7.48
7.43
7.41
7.35
7.33
7.31
7.28
3.91
1.60
0.00
4r
CDCl3
400 MHz
0.98
2.00
1.10
4.00
1.07
1.00
3.09
3.08
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
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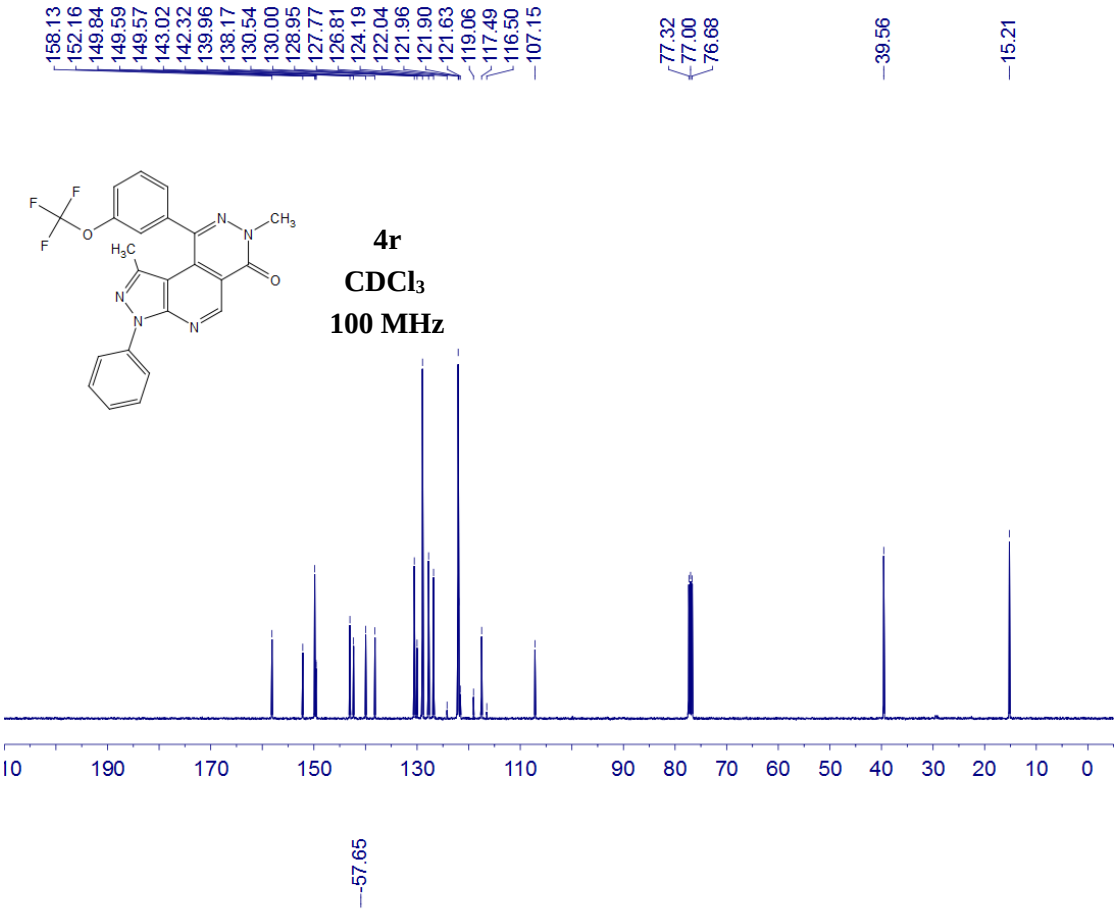
2.0
1.0
0.0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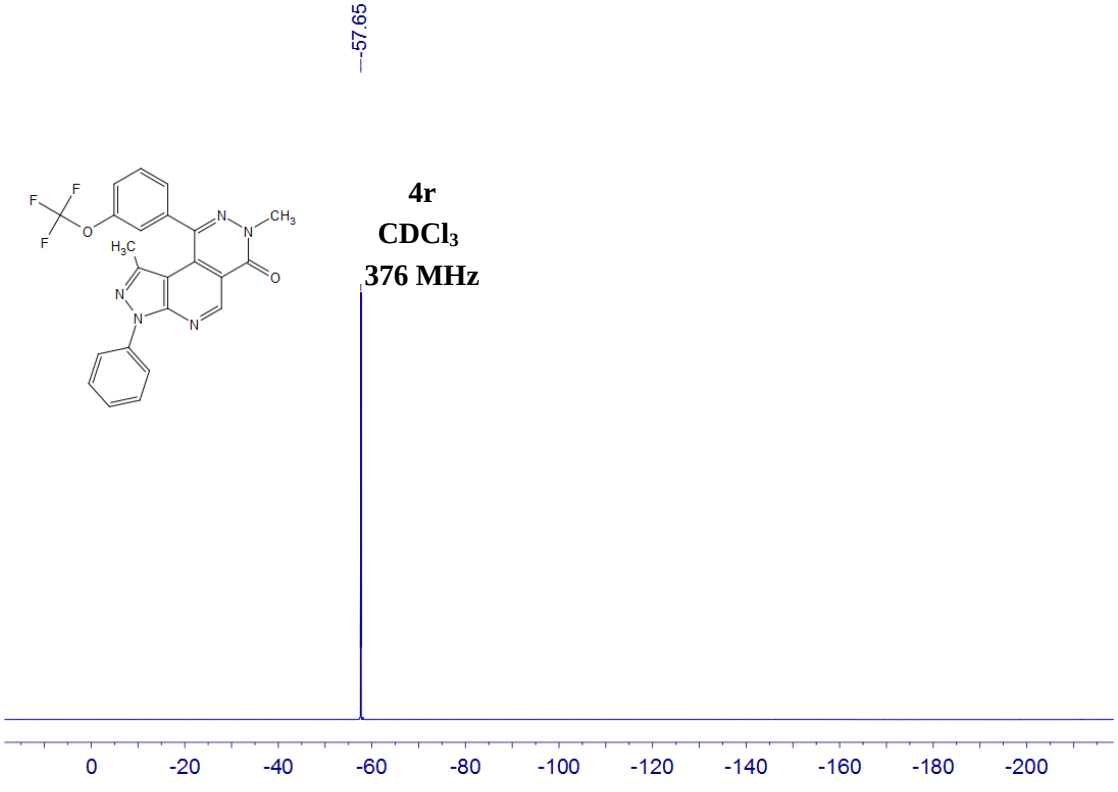
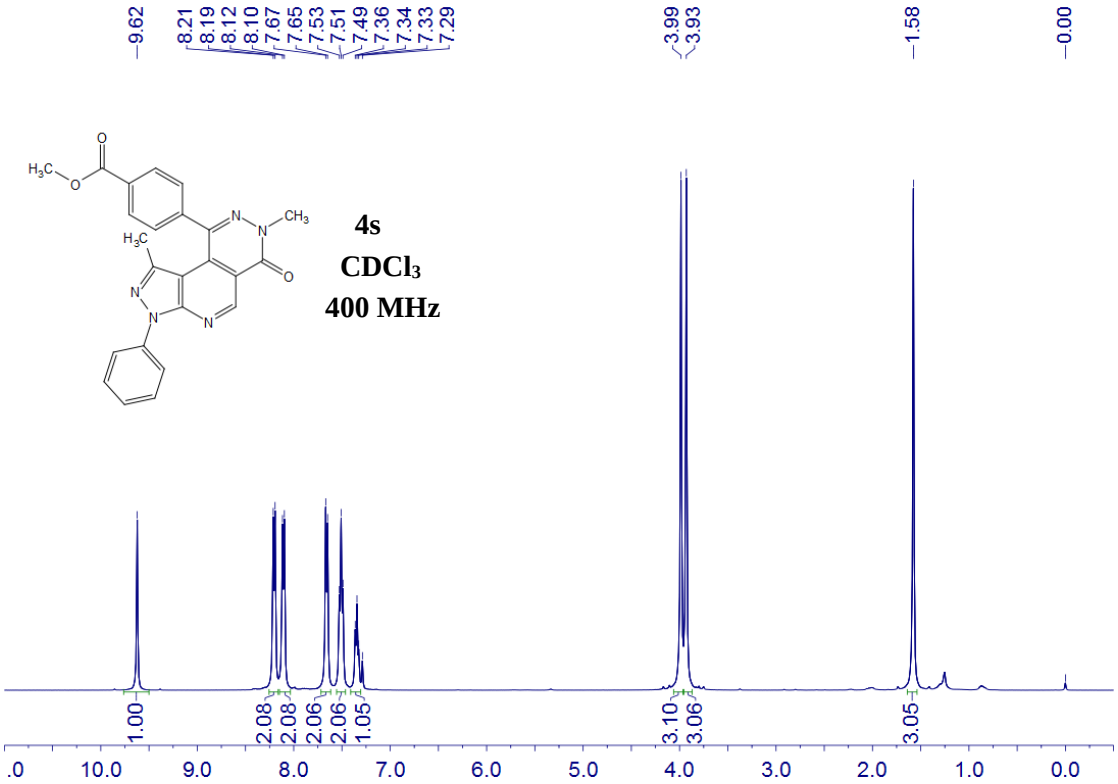
142.32
139.96
138.17
130.54
130.00
128.95
127.77
126.81
124.19
122.04
121.96
121.90
121.63
119.06
117.49
116.50
107.15
77.32
77.00
76.68
39.56
15.21
4r
CDCl3
100 MHz
10
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0


57.65
4r
CDCl3
376 MHz
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200

4s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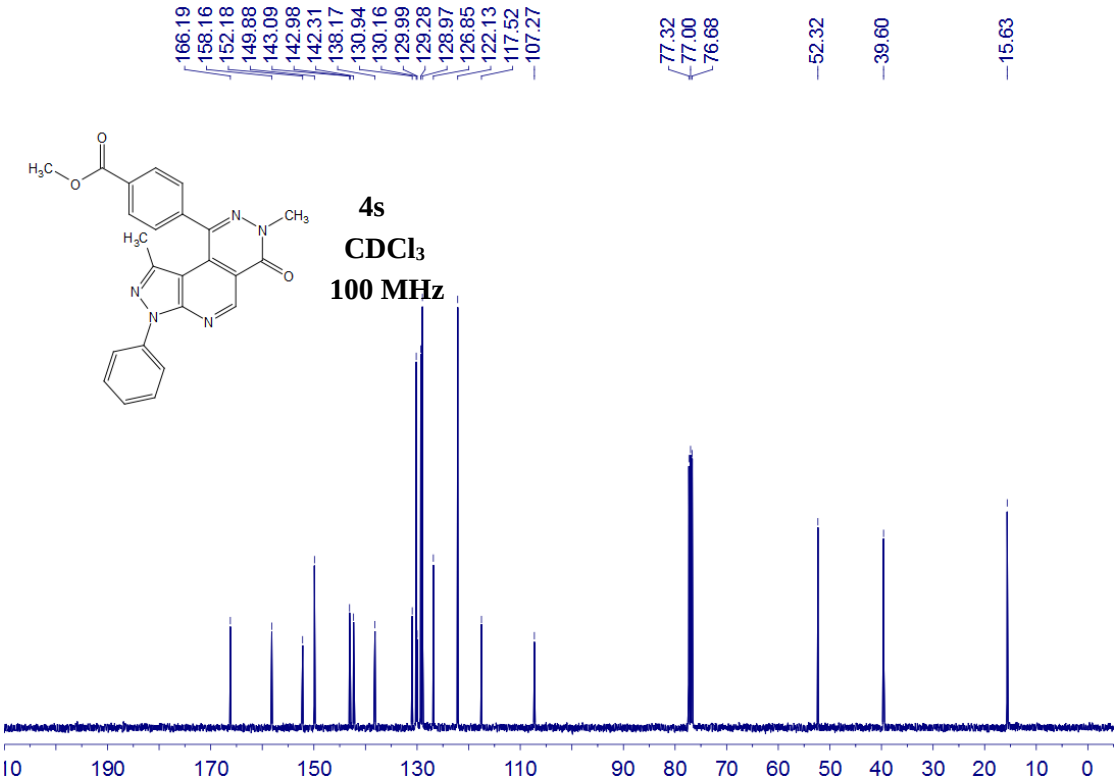
8.21
8.19
8.12
8.10
7.67
7.65
7.53
7.51
7.49
7.36
7.34
7.33
7.29
3.99
3.93
1.58
0.00
4s
CDCl3
400 MHz
1.00
2.08
2.08
2.06
2.06
1.05
3.10
3.06
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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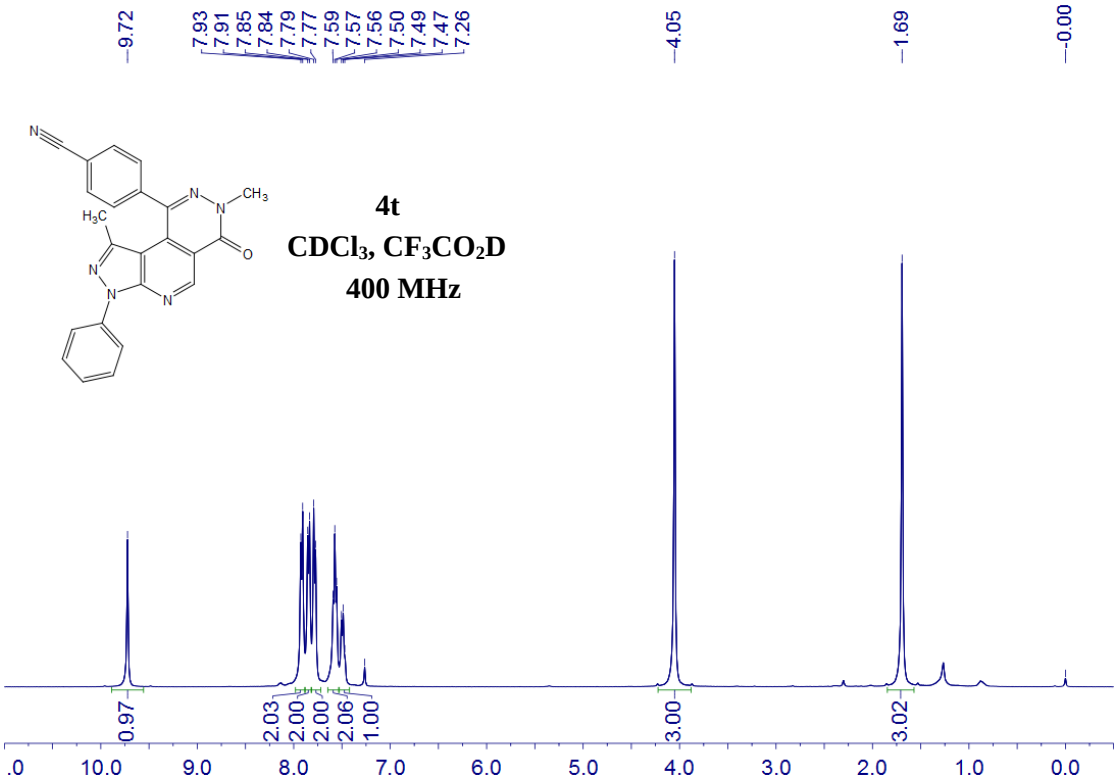
158.16
152.18
149.88
143.09
142.98
142.31
138.17
130.94
130.16
129.99
129.28
128.97
126.85
122.13
117.52
107.27
77.32
77.00
76.68
52.32
39.60
15.63
4s
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4t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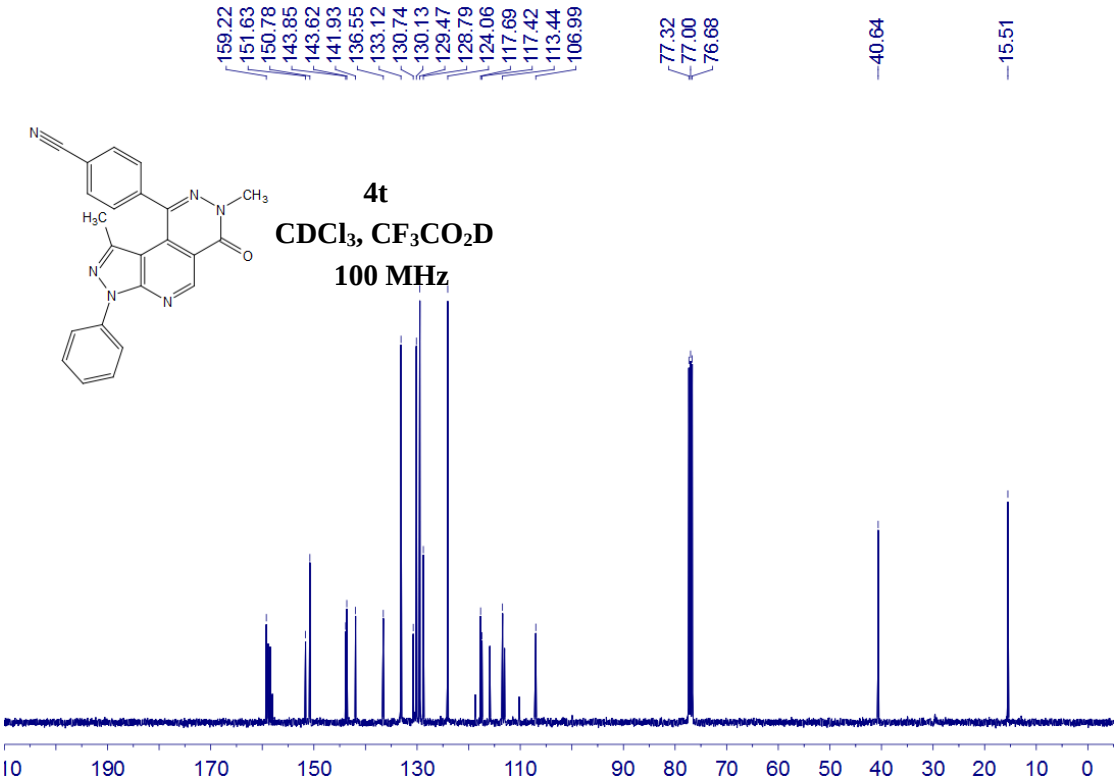
7.93
7.91
7.85
7.84
7.79
7.77
7.59
7.57
7.56
7.50
7.49
7.47
7.26
4.05
1.69
0.00
4t
CDCl3, CF3CO2D
400 MHz
0.97
2.03
2.00
2.00
2.06
1.00
3.00
3.02
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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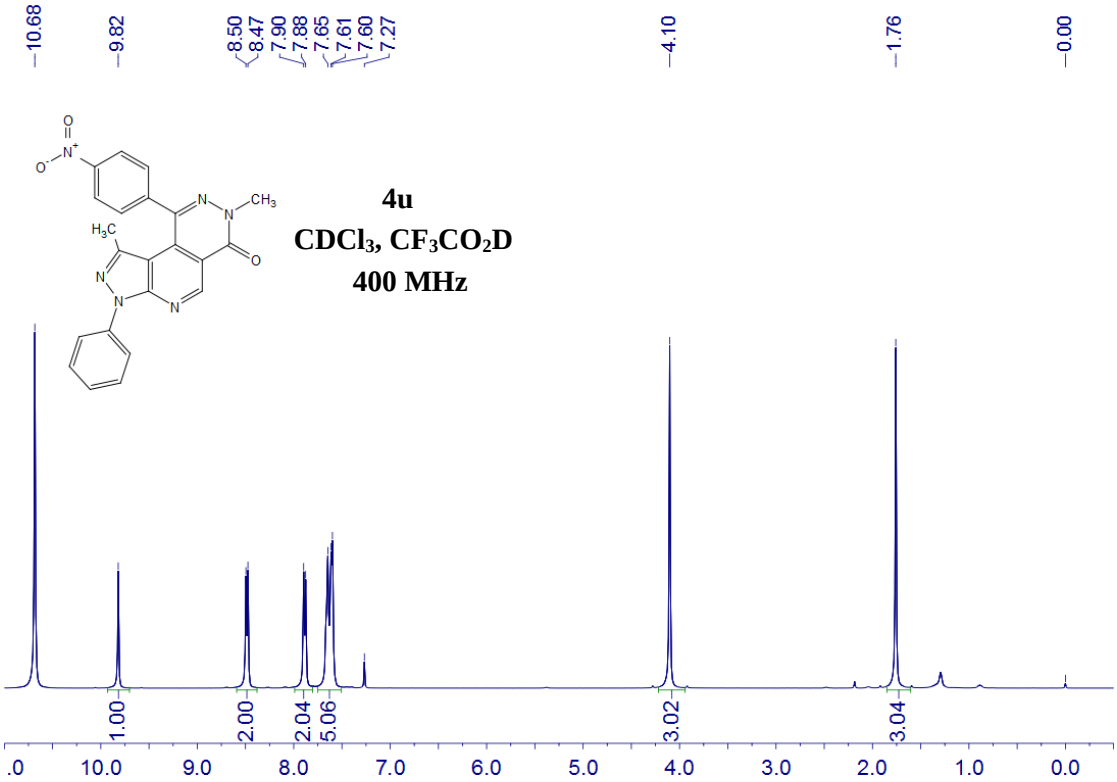
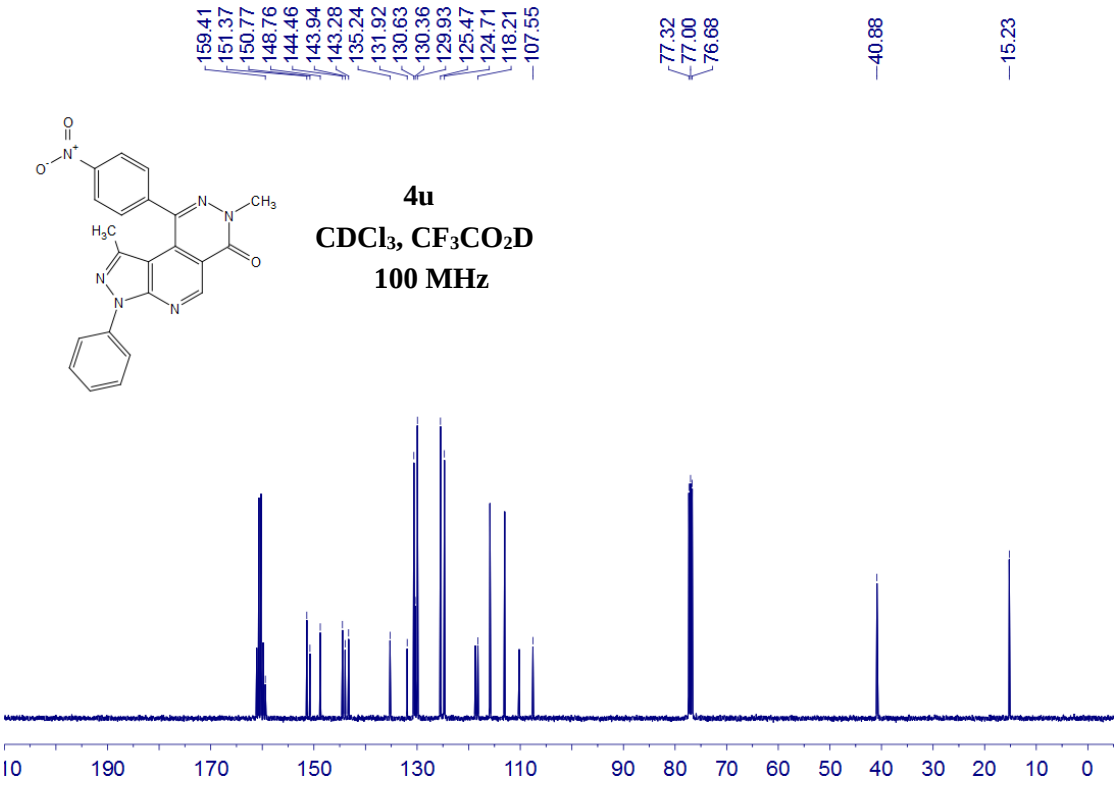
143.85
143.62
141.93
136.55
133.12
130.74
130.13
129.47
128.79
124.06
117.69
117.42
113.44
106.99
77.32
77.00
76.68
40.64
15.51
4t
CDCl3, CF3CO2D
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4u


10.68
9.82
8.50
8.47
7.90
7.88
7.65
7.61
7.60
7.27
4.10
1.76
0.00
4u
CDCl3, CF3CO2D
400 MHz
1.00
2.00
2.04
5.06
3.02
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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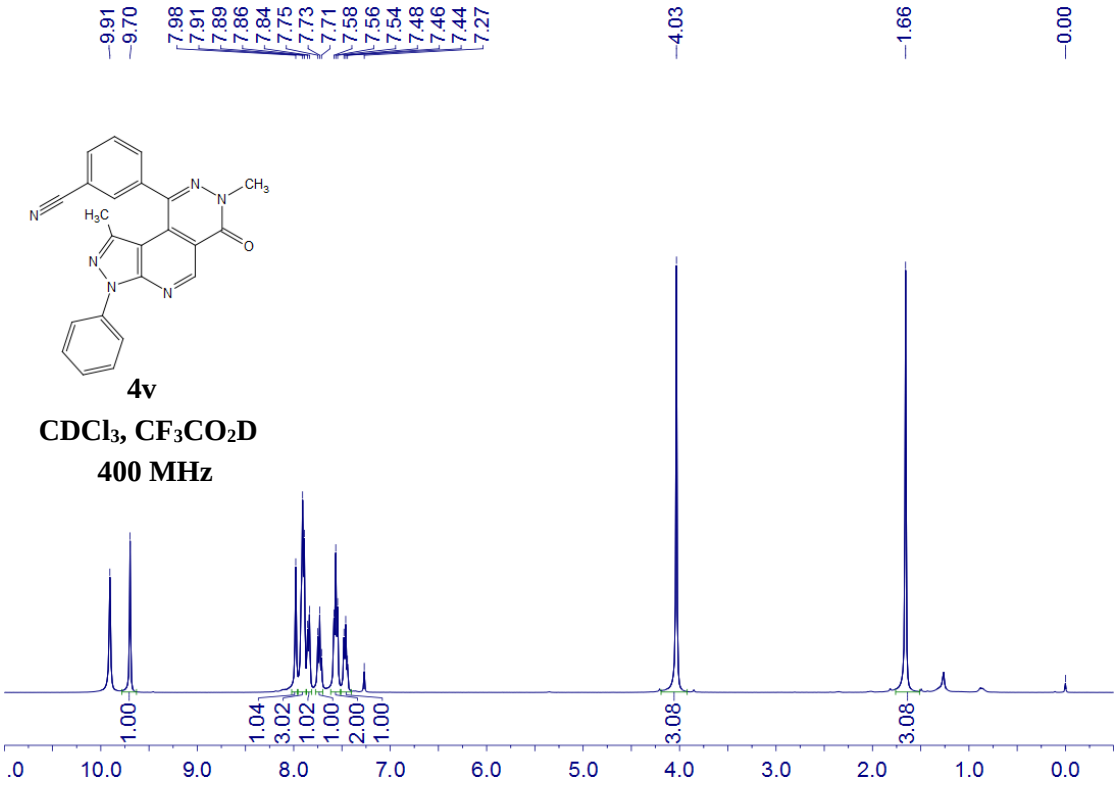
151.37
150.77
148.76
144.46
143.94
143.28
135.24
131.92
130.63
130.36
129.93
125.47
124.71
118.21
107.55
77.32
77.00
76.68
40.88
15.23
4u
CDCl3, CF3CO2D
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

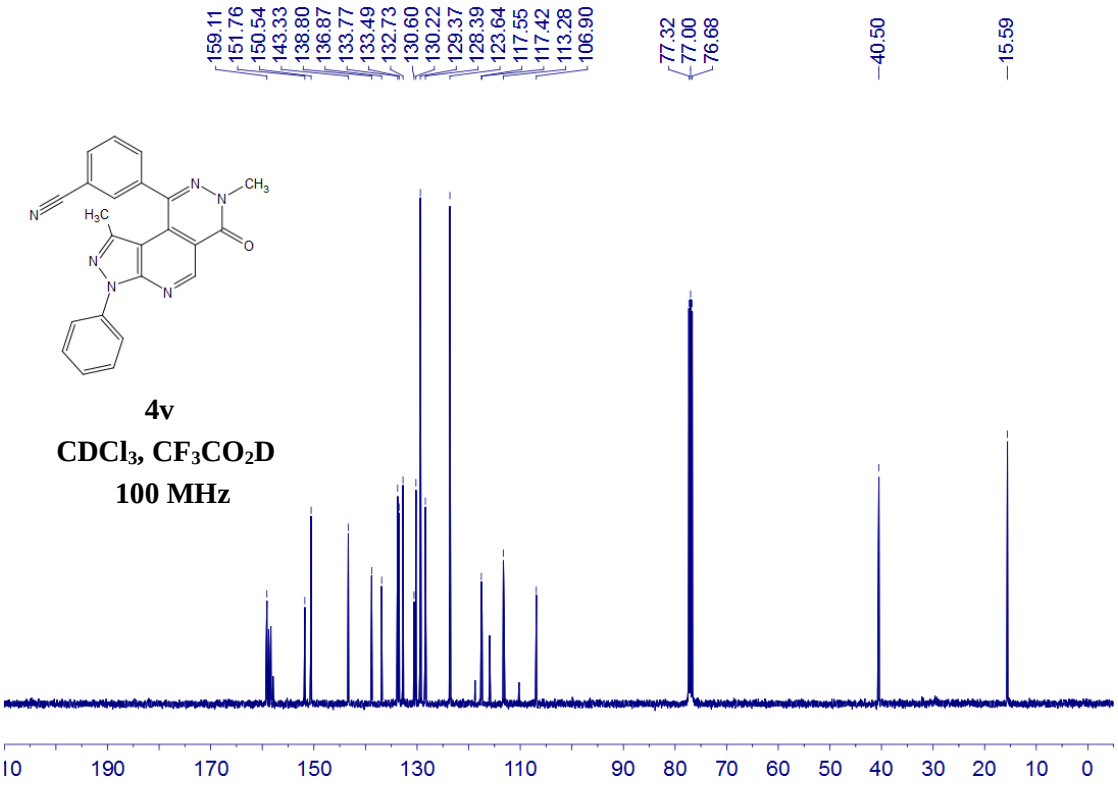
4v



4v

$CDCl_3$, CF_3CO_2D

400 MHz

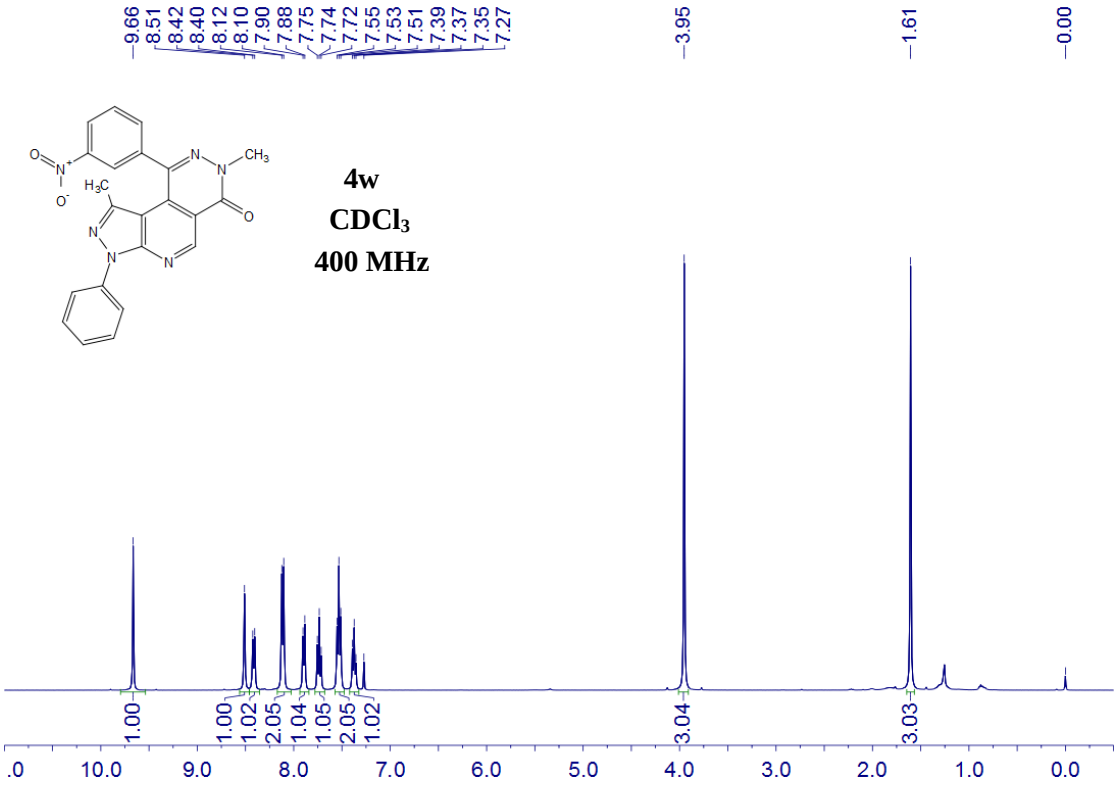


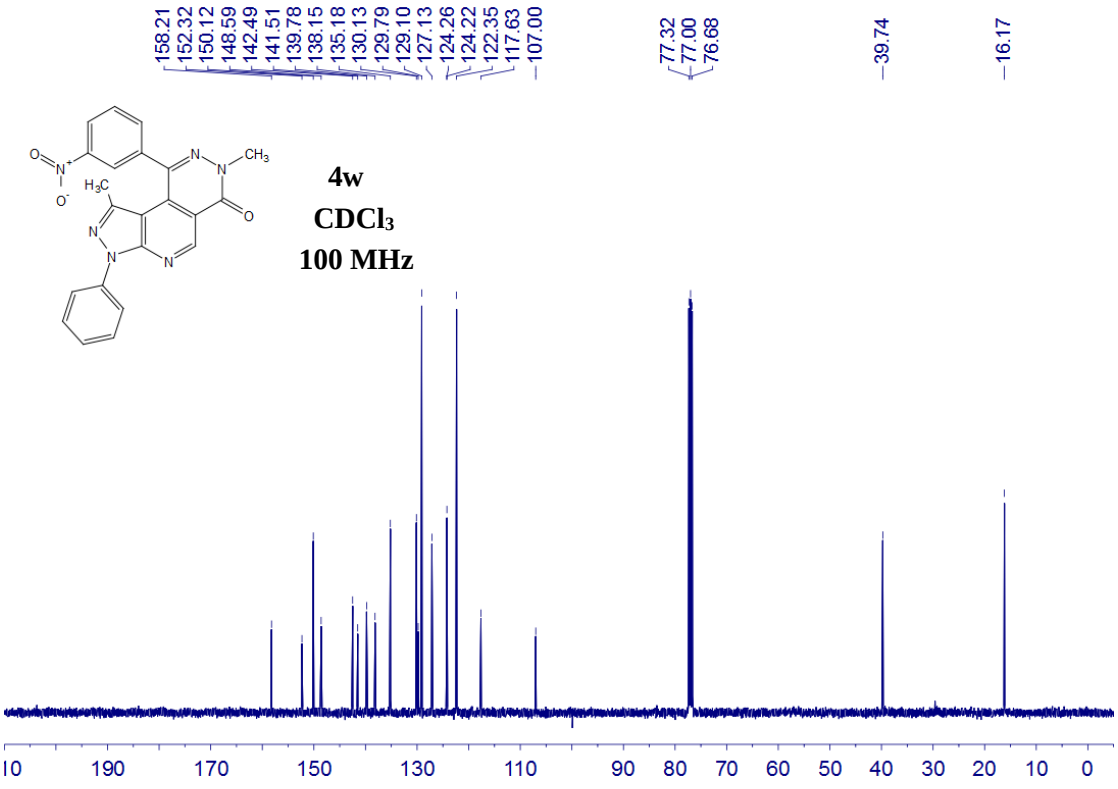
4v

$CDCl_3$, CF_3CO_2D

100 MHz

4w


9.66
8.51
8.42
8.40
8.12
8.10
7.90
7.88
7.75
7.74
7.72
7.55
7.53
7.51
7.39
7.37
7.35
7.27
3.95
1.61
0.00
4w
CDCl3
400 MHz
1.00
1.00
1.02
2.05
1.04
1.05
2.05
1.02
3.04
3.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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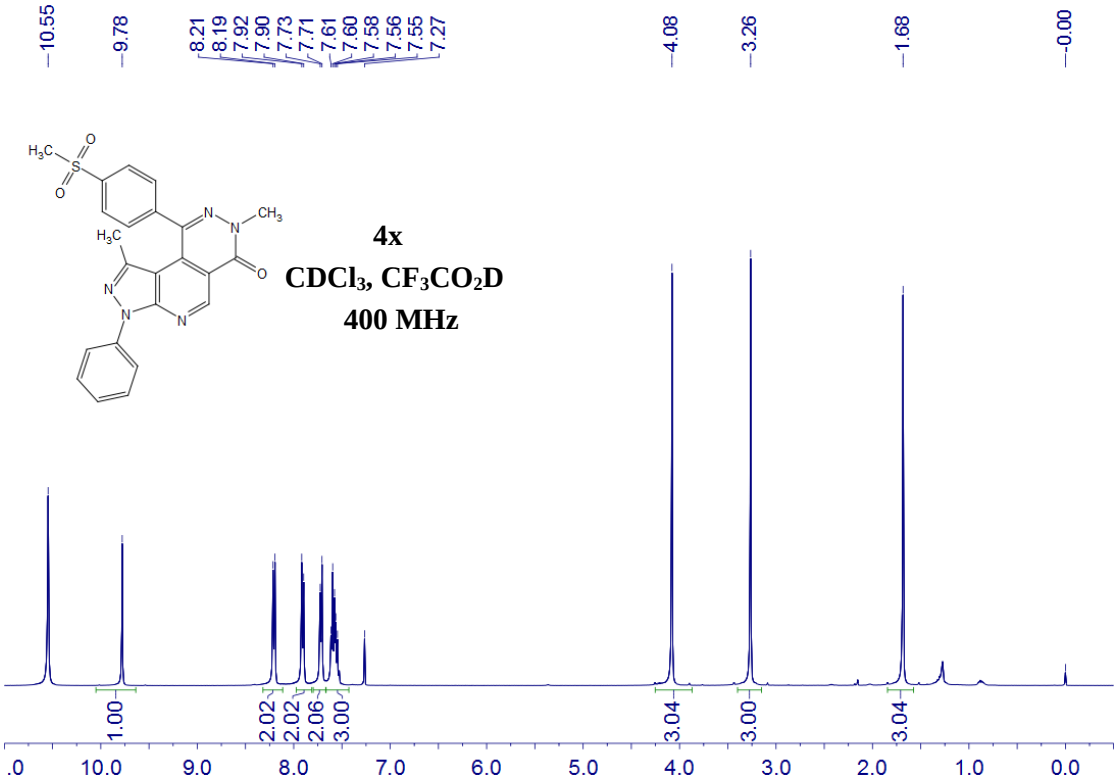
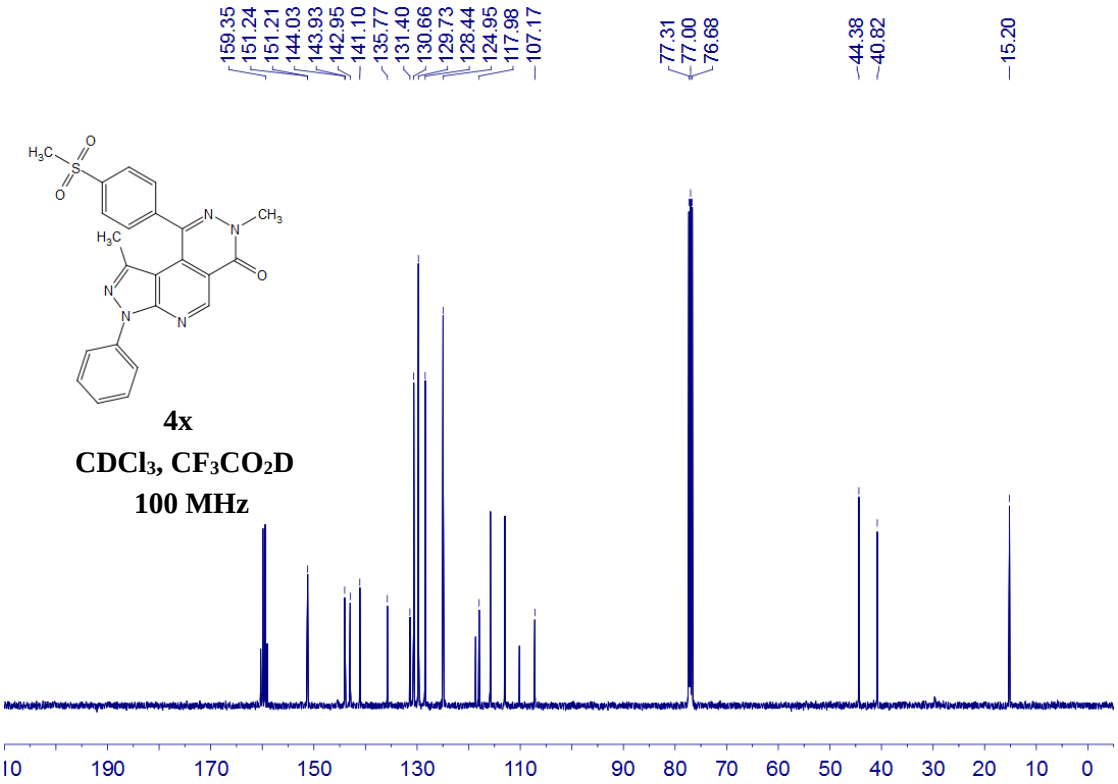
152.32
150.12
148.59
142.49
141.51
139.78
138.15
135.18
130.13
129.79
129.10
127.13
124.26
124.22
122.35
117.63
107.00
77.32
77.00
76.68
39.74
16.17
4w
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4x


10.55
9.78
8.21
8.19
7.92
7.90
7.73
7.71
7.61
7.60
7.58
7.56
7.55
7.27
4.08
3.26
1.68
0.00
4x
CDCl3, CF3CO2D
400 MHz
1.00
2.02
2.02
2.06
3.00
3.04
3.00
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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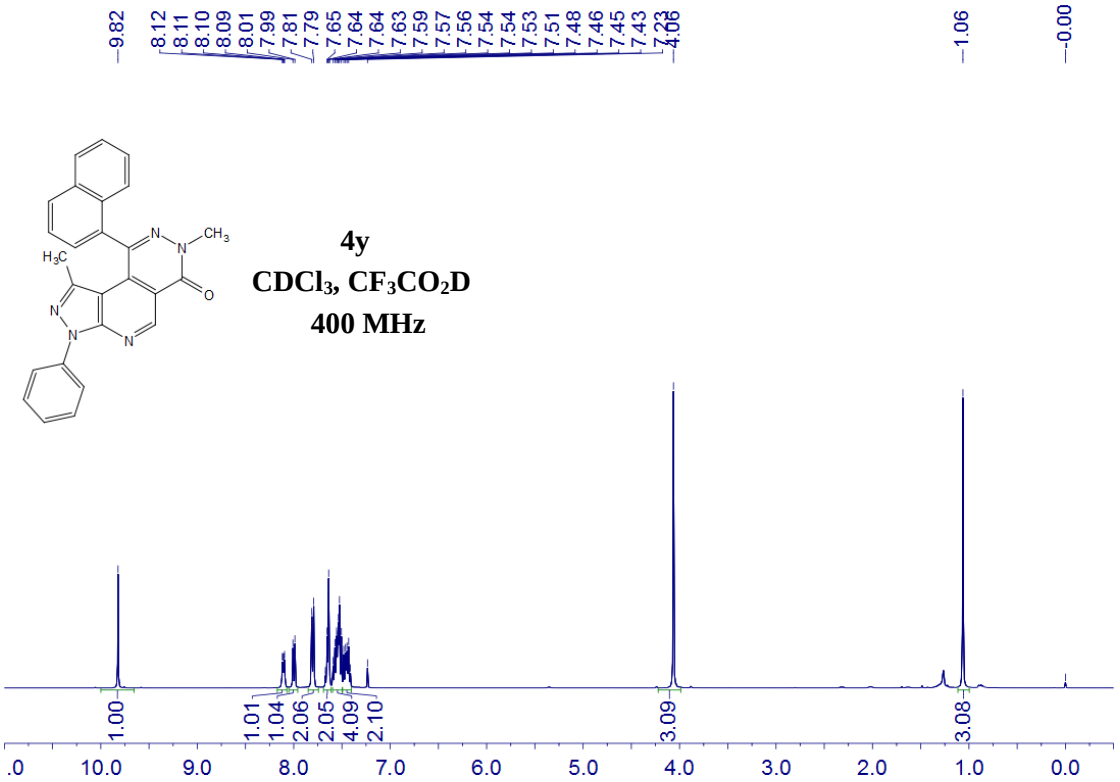
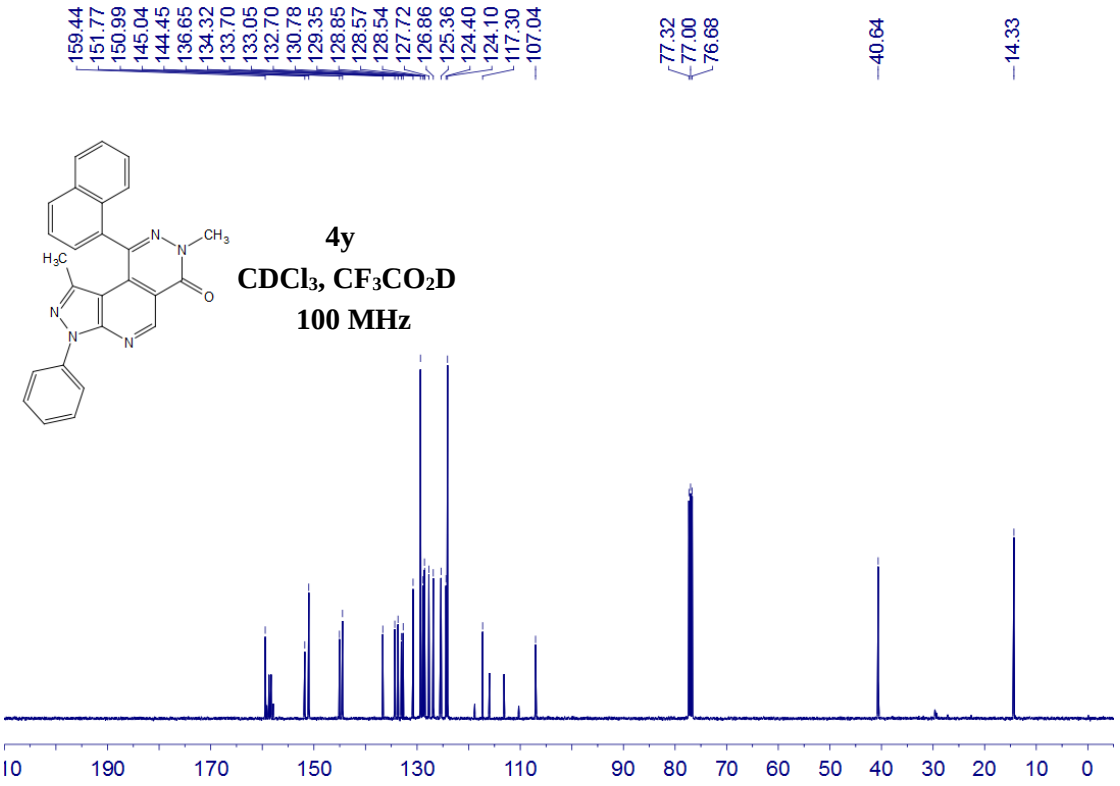
151.24
151.21
144.03
143.93
142.95
141.10
135.77
131.40
130.66
129.73
128.44
124.95
117.98
107.17
77.31
77.00
76.68
44.38
40.82
15.20
4x
CDCl3, CF3CO2D
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4y


9.82
8.12
8.11
8.10
8.09
8.01
7.99
7.81
7.79
7.65
7.64
7.64
7.63
7.59
7.57
7.56
7.54
7.54
7.53
7.51
7.48
7.46
7.45
7.43
7.23
4.06
1.06
0.00
4y
CDCl3, CF3CO2D
400 MHz
1.00
1.01
1.04
2.06
2.05
4.09
2.10
3.09
3.08
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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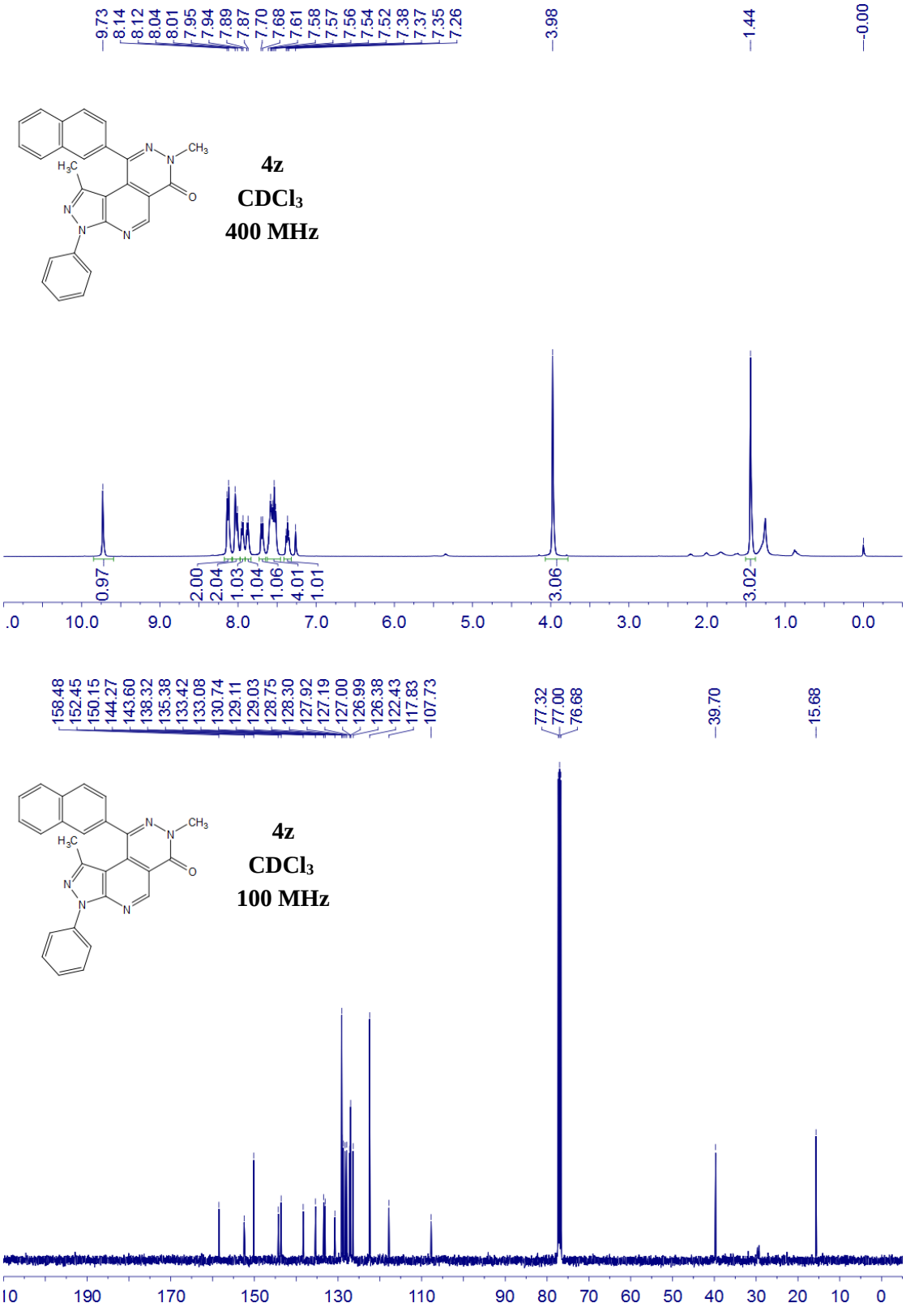
151.77
150.99
145.04
144.45
136.65
134.32
133.70
133.05
132.70
130.78
129.35
128.85
128.57
128.54
127.72
126.86
125.36
124.40
124.10
117.30
107.04
77.32
77.00
76.68
40.64
14.33
4y
CDCl3, CF3CO2D
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

4z


9.73
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8.12
8.04
8.01
7.95
7.94
7.89
7.87
7.70
7.68
7.61
7.58
7.57
7.56
7.54
7.52
7.38
7.37
7.35
7.26
3.98
1.44
0.00
4z
CDCl3
400 MHz
0.97
2.00
2.04
1.03
1.04
1.06
4.01
1.01
3.06
3.02
158.48
152.45
150.15
144.27
143.60
138.32
135.38
133.42
133.08
130.74
129.11
129.03
128.75
128.30
127.92
127.19
127.00
126.99
126.38
122.43
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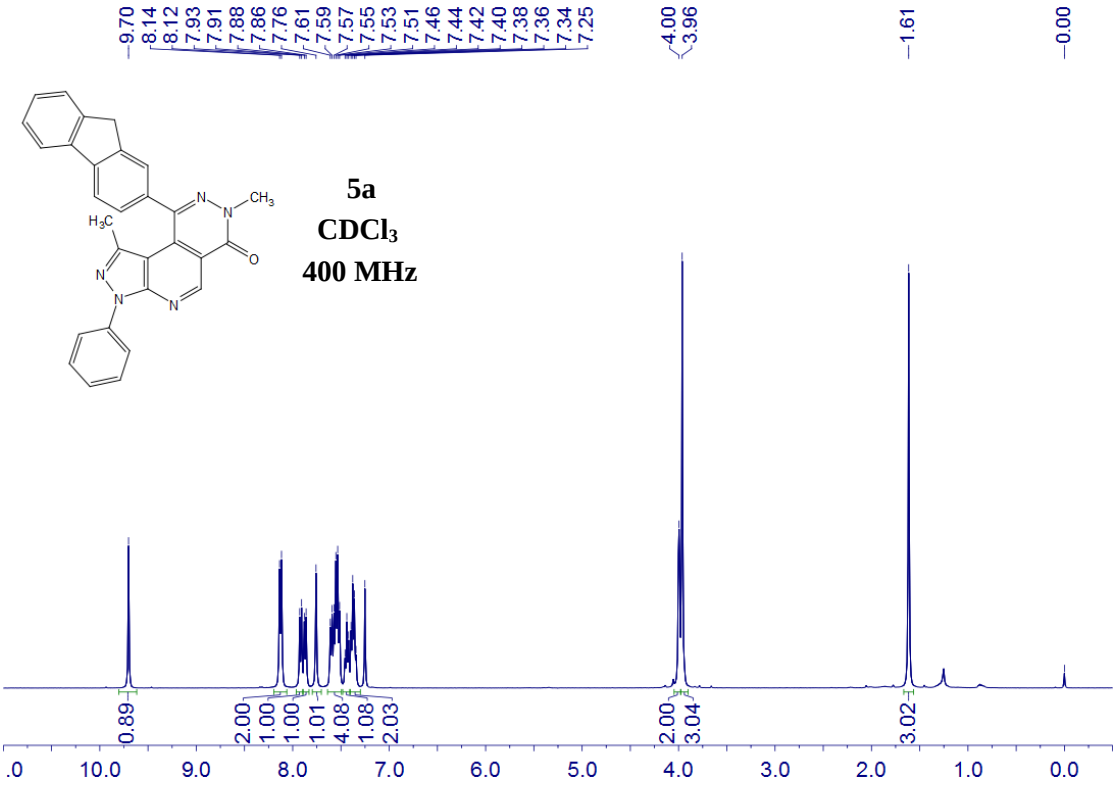
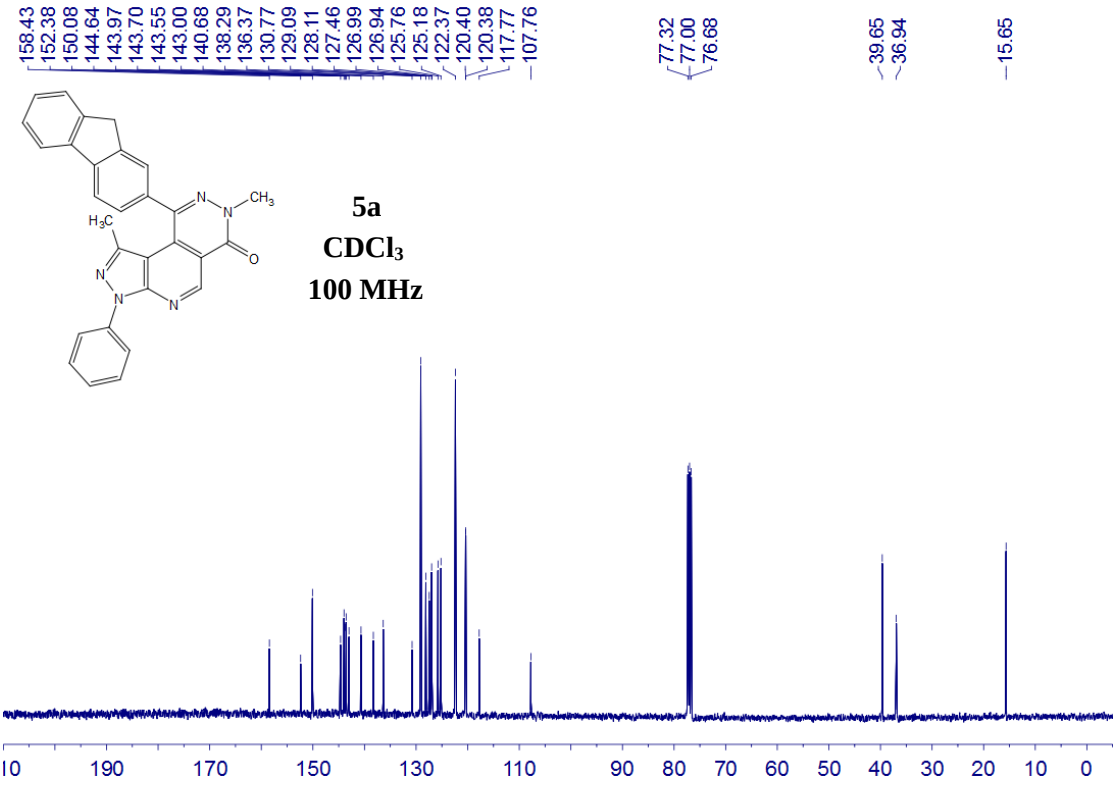
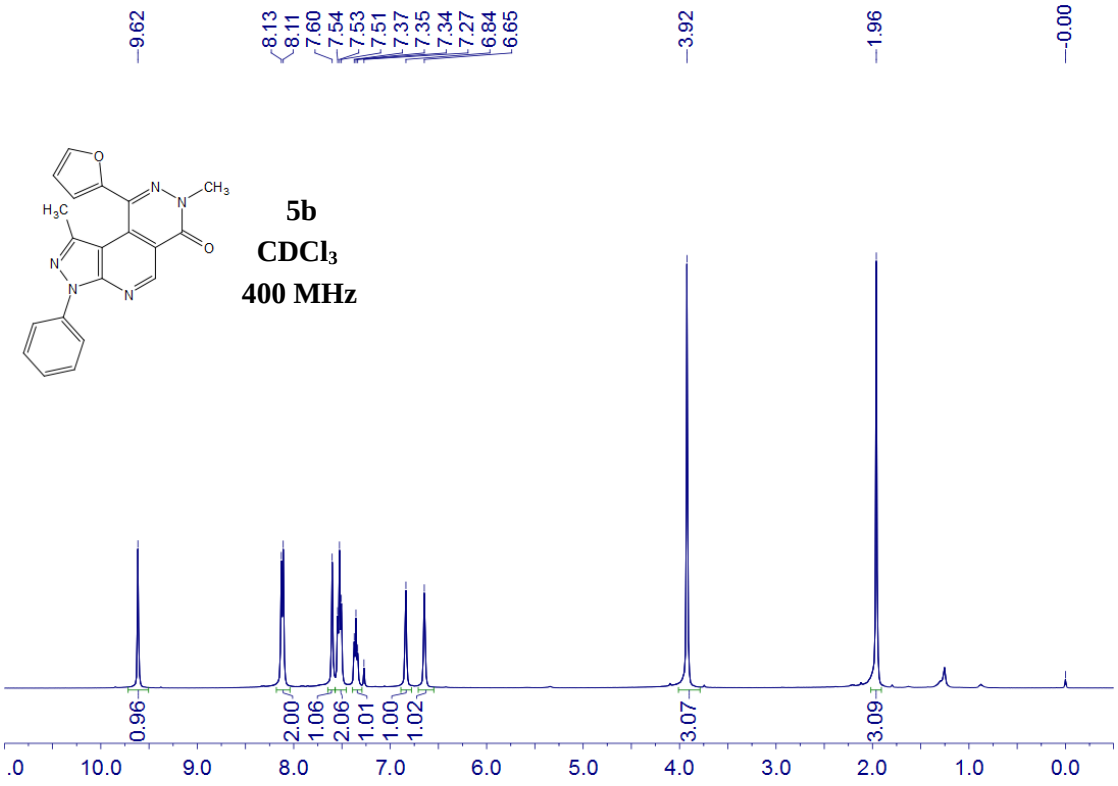
107.73
77.32
77.00
76.68
39.70
15.68
4z
CDCl3
100 MHz

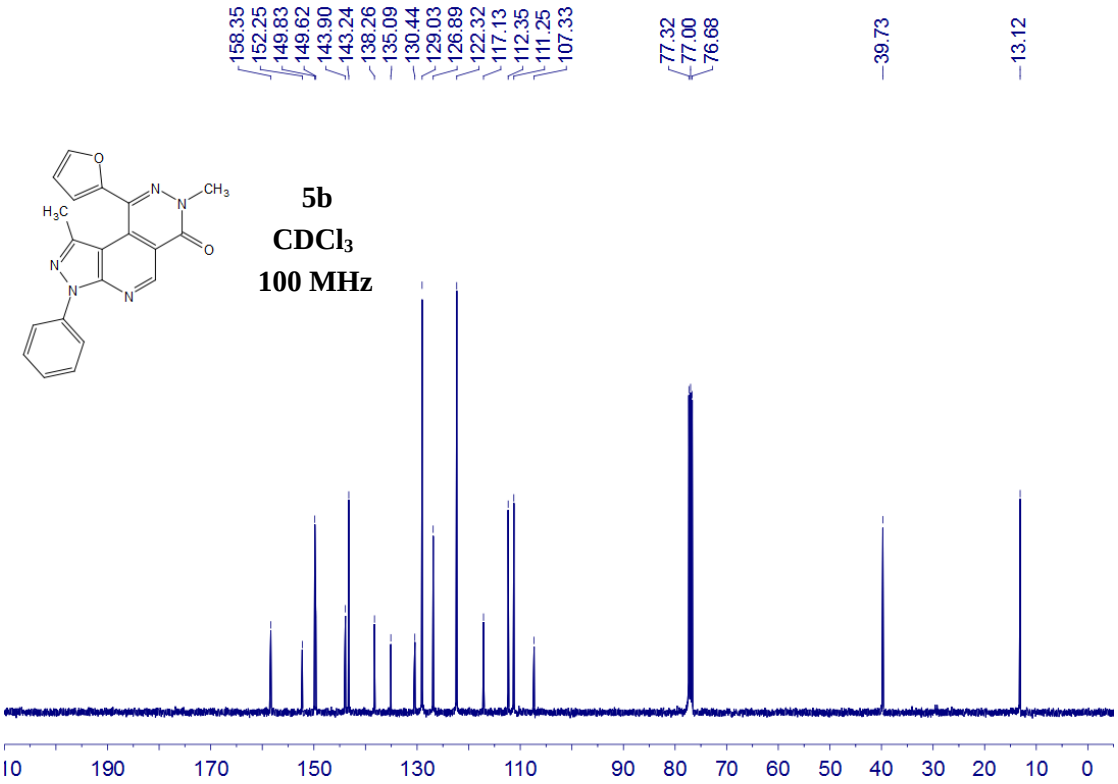
5a


9.70
8.14
8.12
7.93
7.91
7.88
7.86
7.76
7.61
7.59
7.57
7.55
7.53
7.51
7.46
7.44
7.42
7.40
7.38
7.36
7.34
7.25
4.00
3.96
1.61
0.00
5a
CDCl3
400 MHz
0.89
2.00
1.00
1.00
1.01
4.08
1.08
2.03
2.00
3.04
3.02
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

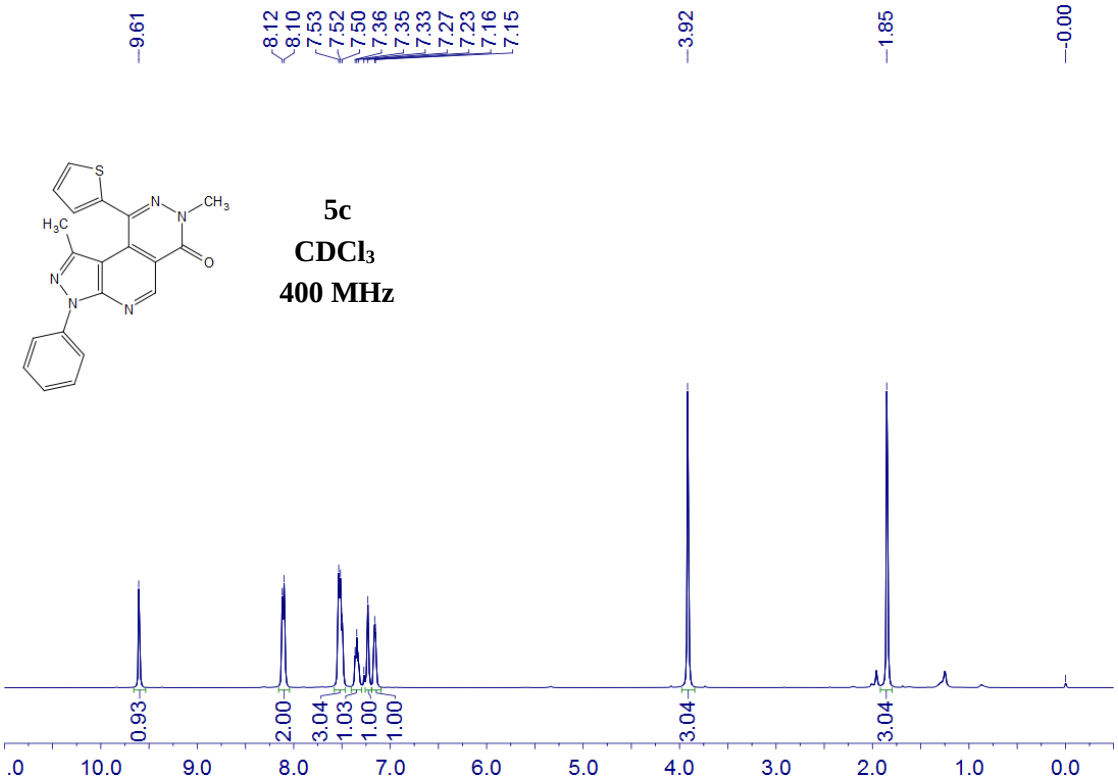

158.43
152.38
150.08
144.64
143.97
143.70
143.55
143.00
140.68
138.29
136.37
130.77
129.09
128.11
127.46
126.99
126.94
125.76
125.18
122.37
120.40
120.38
117.77
107.76
77.32
77.00
76.68
39.65
36.94
15.65
5a
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

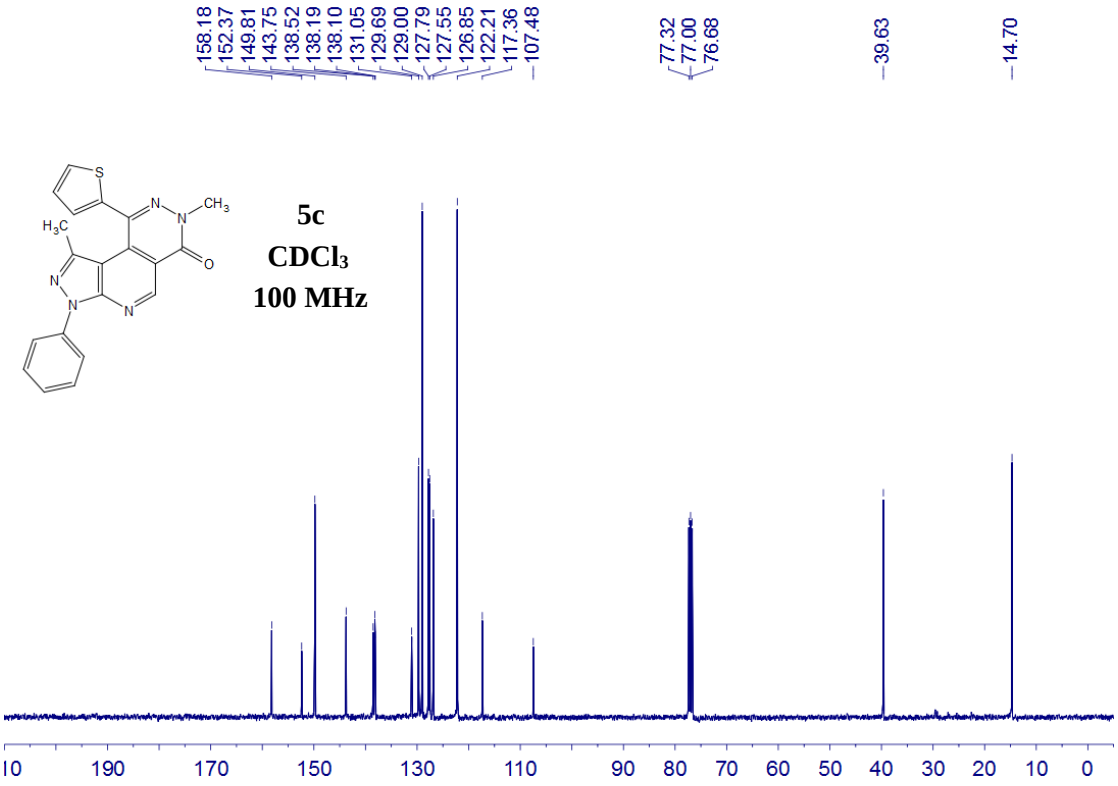
5b


9.62
8.13
8.11
7.60
7.54
7.53
7.51
7.37
7.35
7.34
7.27
6.84
6.65
3.92
1.96
0.00
5b
CDCl3
400 MHz
0.96
2.00
1.06
2.06
1.01
1.00
1.02
3.07
3.09
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

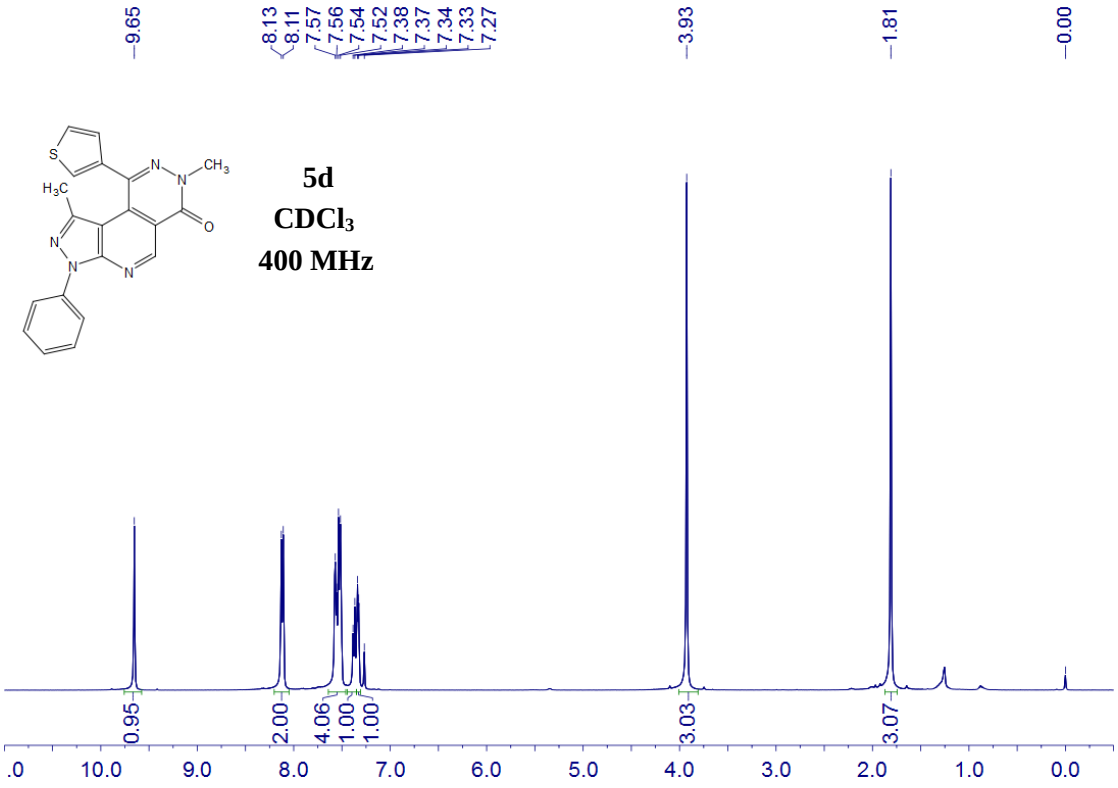

158.35
152.25
149.83
149.62
143.90
143.24
138.26
135.09
130.44
129.03
126.89
122.32
117.13
112.35
111.25
107.33
77.32
77.00
76.68
39.73
13.12
5b
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

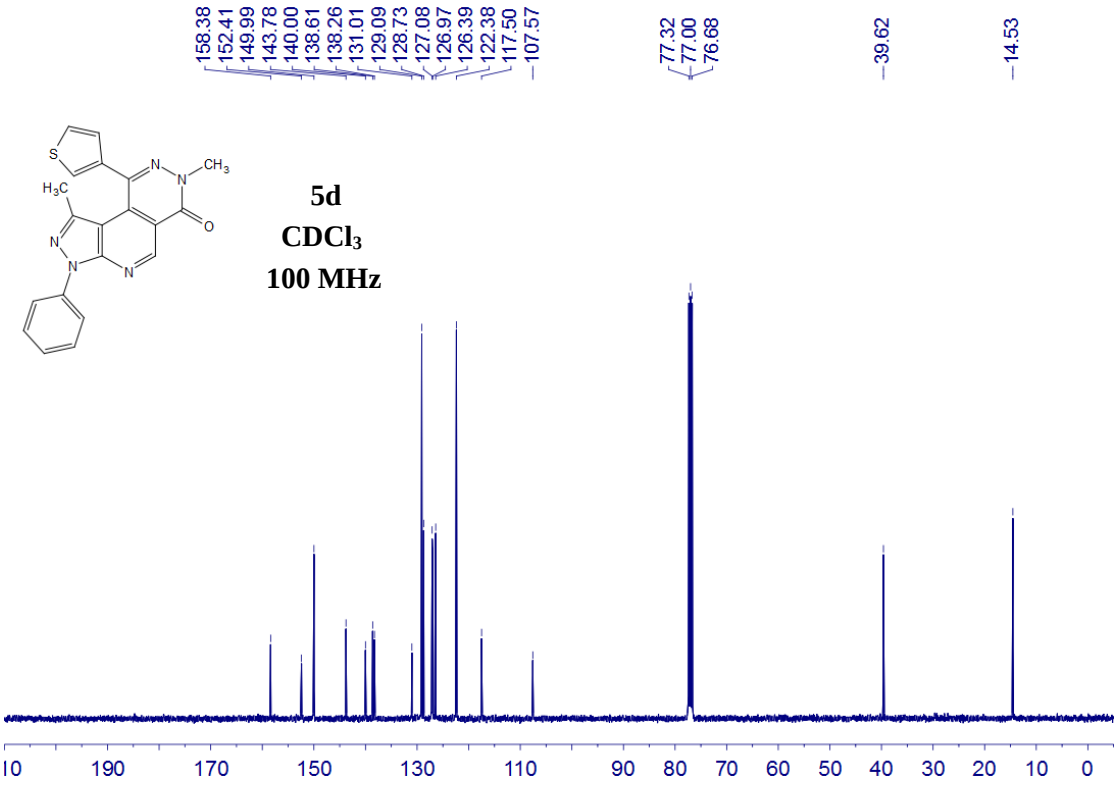
5c


9.61
8.12
8.10
7.53
7.52
7.50
7.36
7.35
7.33
7.27
7.23
7.16
7.15
3.92
1.85
0.00
5c
CDCl3
400 MHz
0.93
2.00
3.04
1.03
1.00
1.00
3.04
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

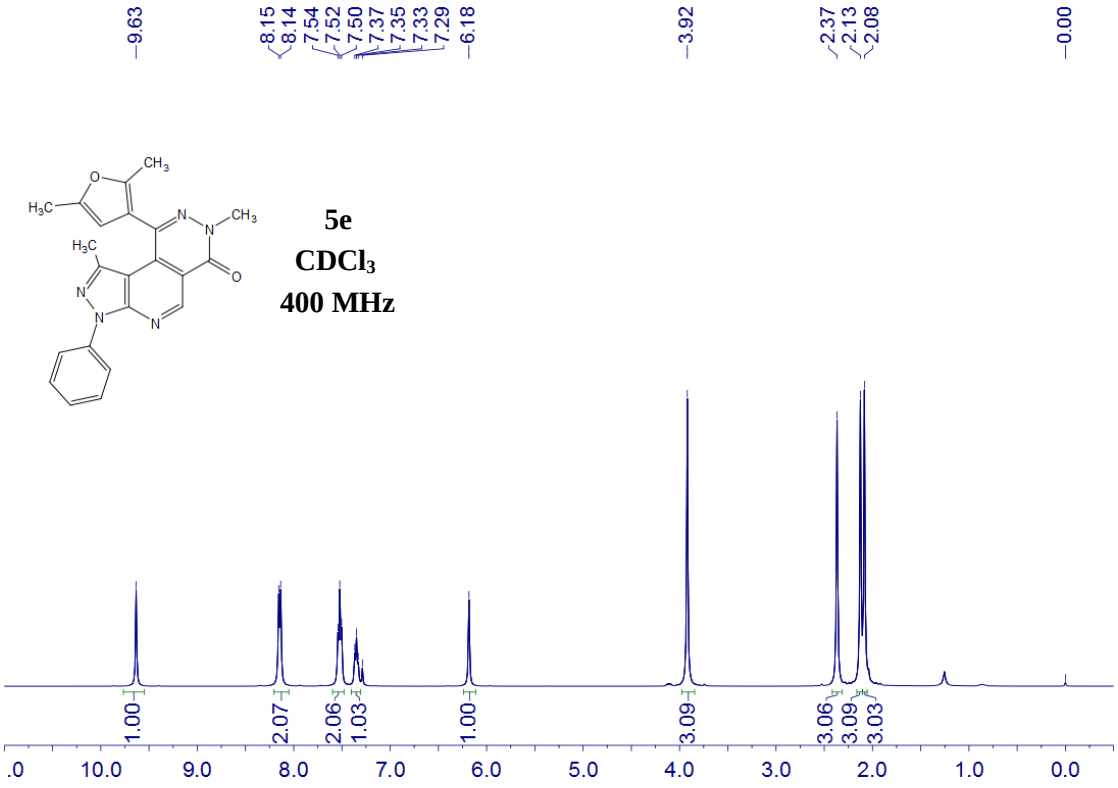

158.18
152.37
149.81
143.75
138.52
138.19
138.10
131.05
129.69
129.00
127.79
127.55
126.85
122.21
117.36
107.48
77.32
77.00
76.68
39.63
14.70
5c
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5d

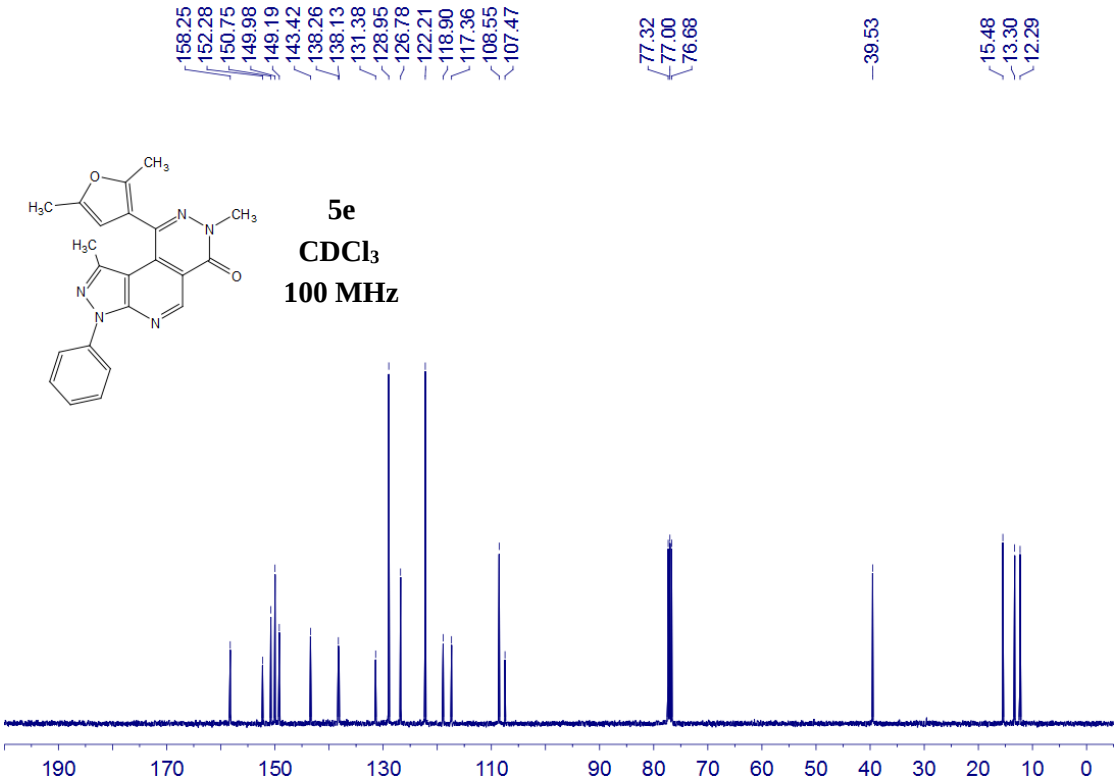

9.65
8.13
8.11
7.57
7.56
7.54
7.52
7.38
7.37
7.34
7.33
7.27
3.93
1.81
0.00
5d
CDCl3
400 MHz
0.95
2.00
4.06
1.00
1.00
3.03
3.07
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.38
152.41
149.99
143.78
140.00
138.61
138.26
131.01
129.09
128.73
127.08
126.97
126.39
122.38
117.50
107.57
77.32
77.00
76.68
39.62
14.53
5d
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5e

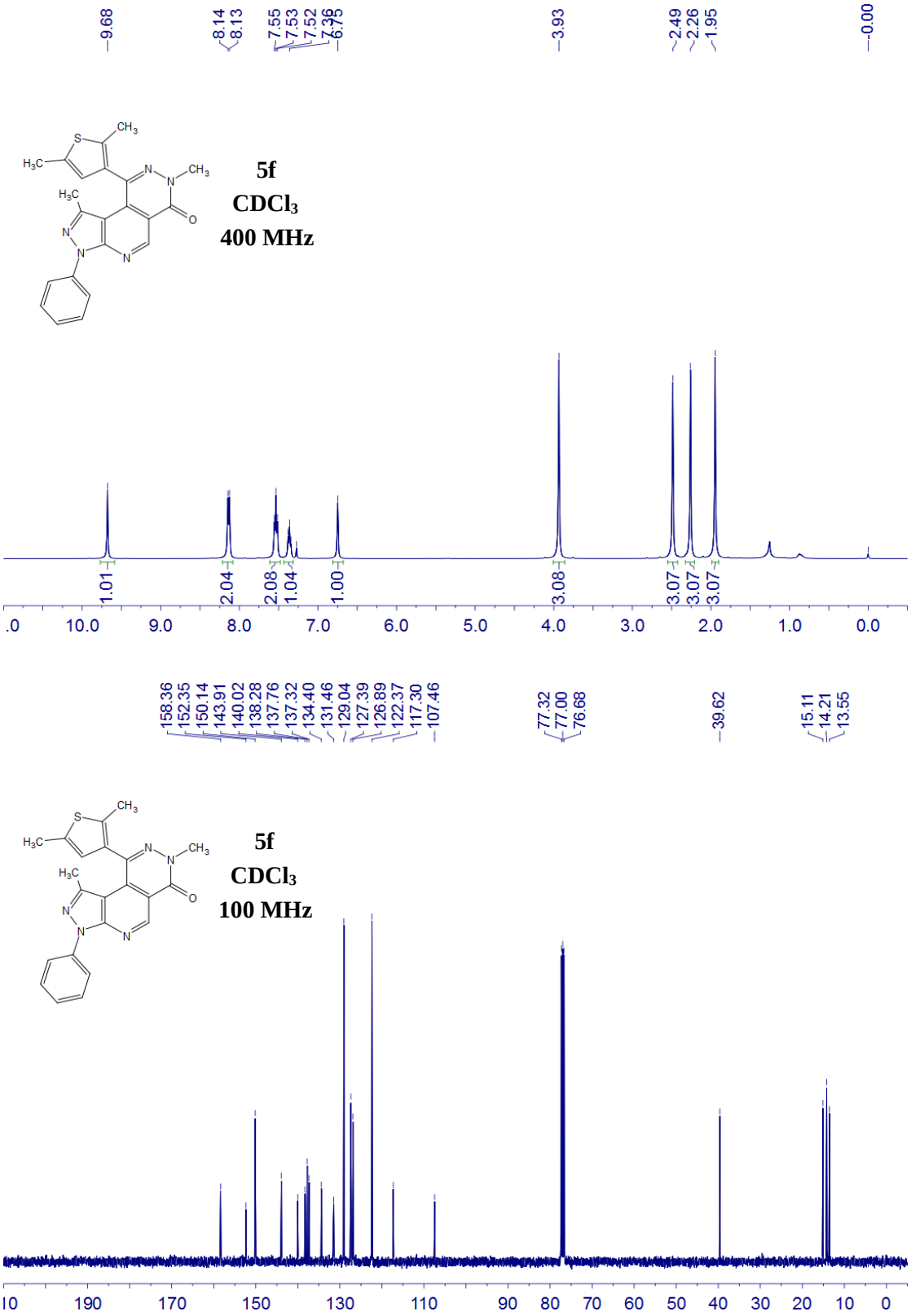


5e
$CDCl_3$
400 MHz

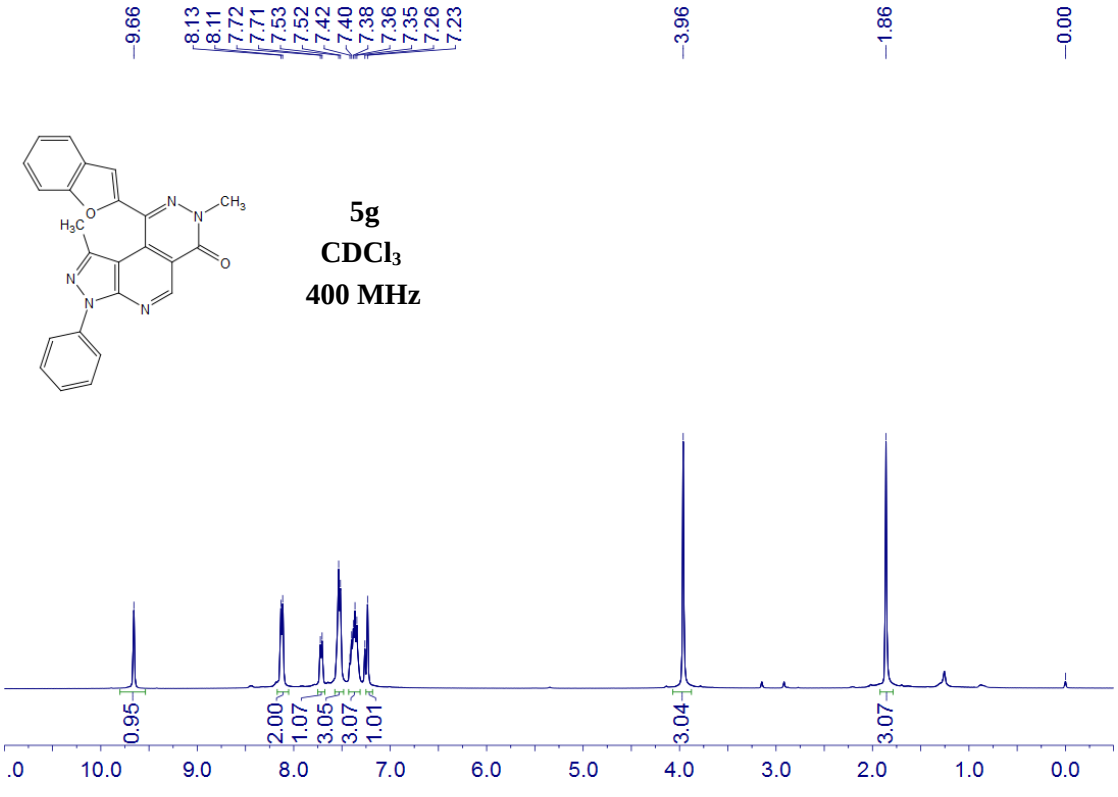


5e
$CDCl_3$
100 MHz

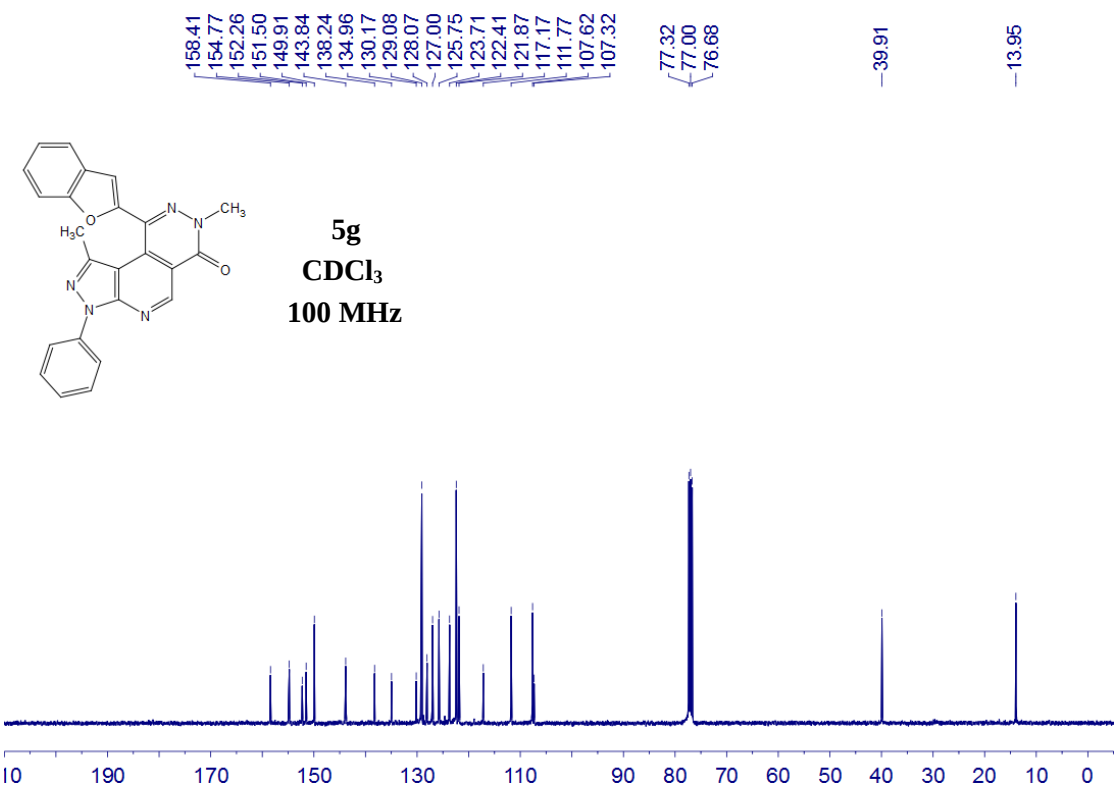
5f


9.68
8.14
8.13
7.55
7.53
7.52
7.36
6.75
3.93
2.49
2.26
1.95
0.00
5f
CDCl3
400 MHz
1.01
2.04
2.08
1.04
1.00
3.08
3.07
3.07
3.07
158.36
152.35
150.14
143.91
140.02
138.28
137.76
137.32
134.40
131.46
129.04
127.39
126.89
122.37
117.30
107.46
77.32
77.00
76.68
39.62
15.11
14.21
13.55
5f
CDCl3
100 MHz

5g

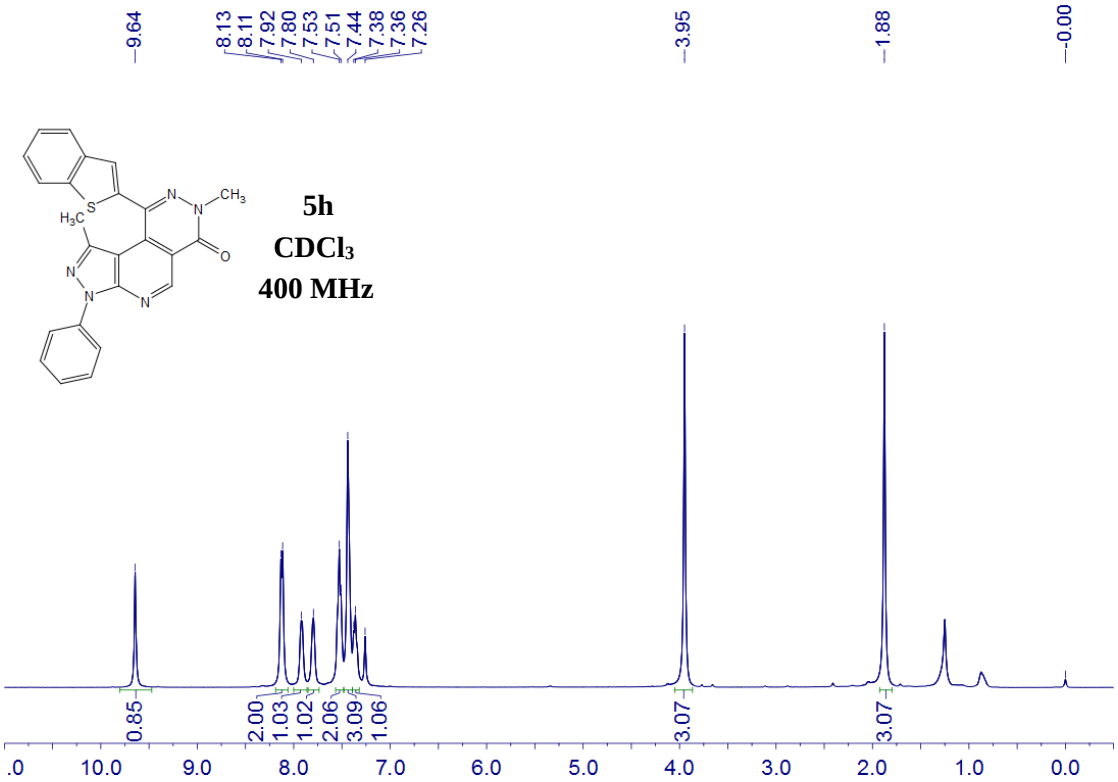


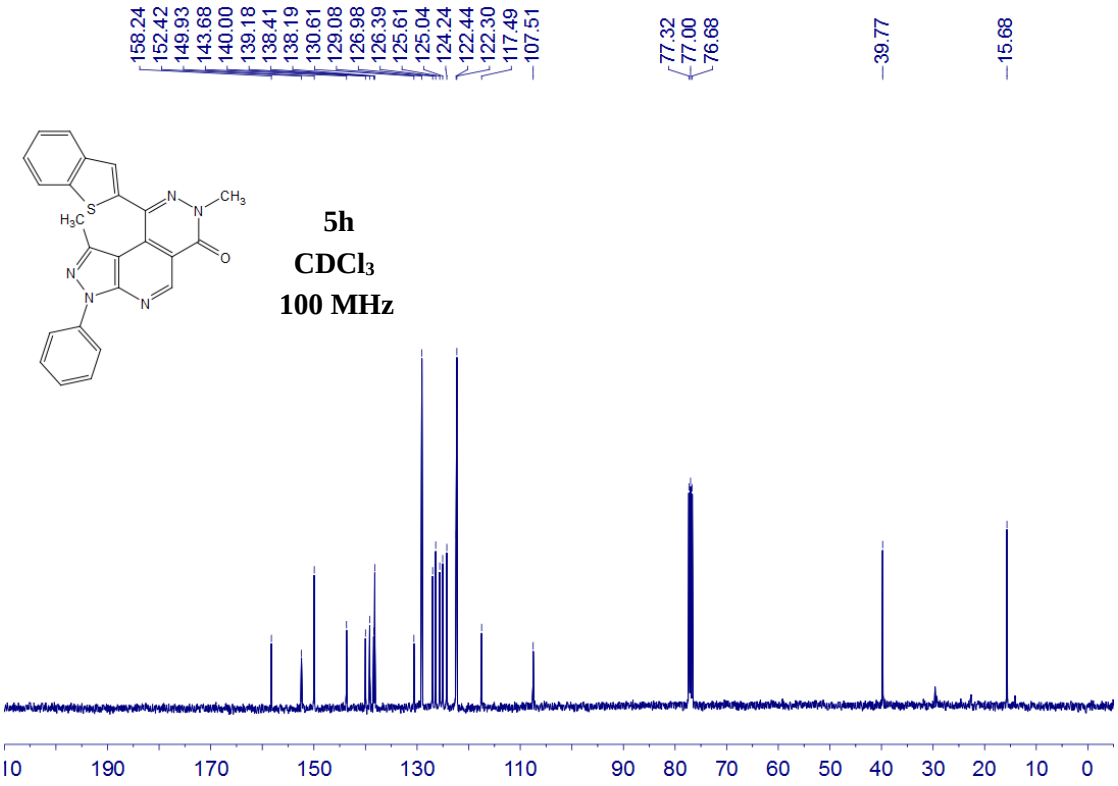
5g
$CDCl_3$
400 MHz



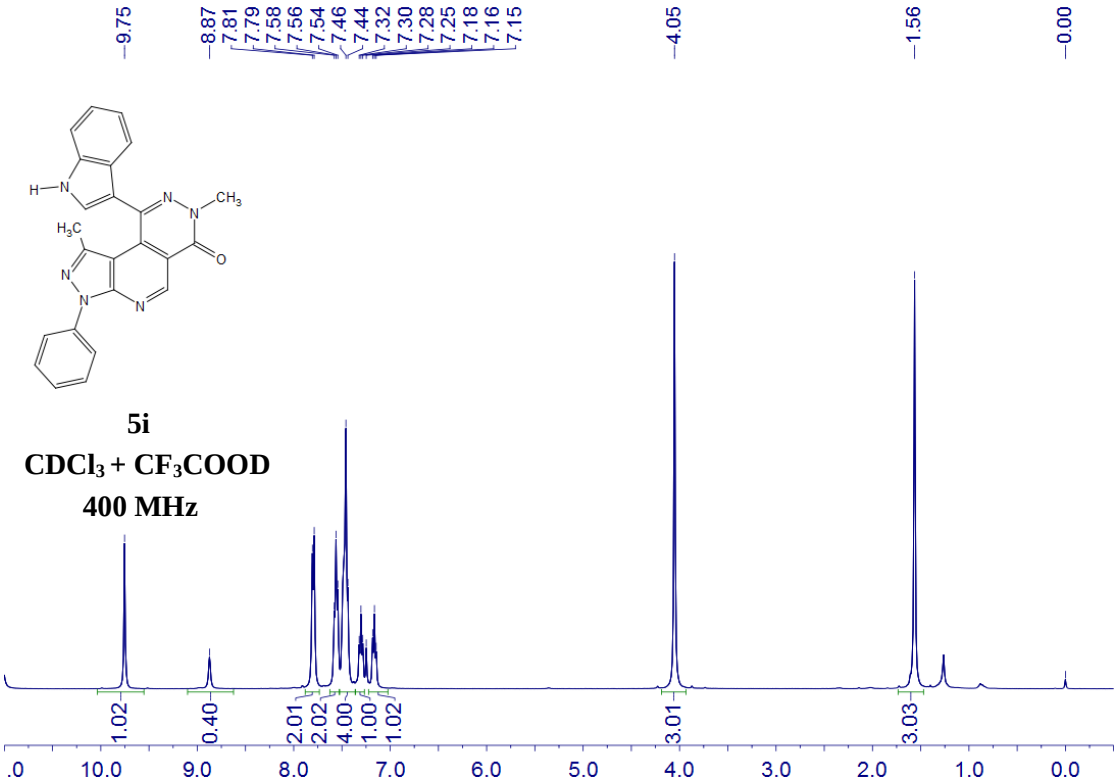
5g
$CDCl_3$
100 MHz

5h

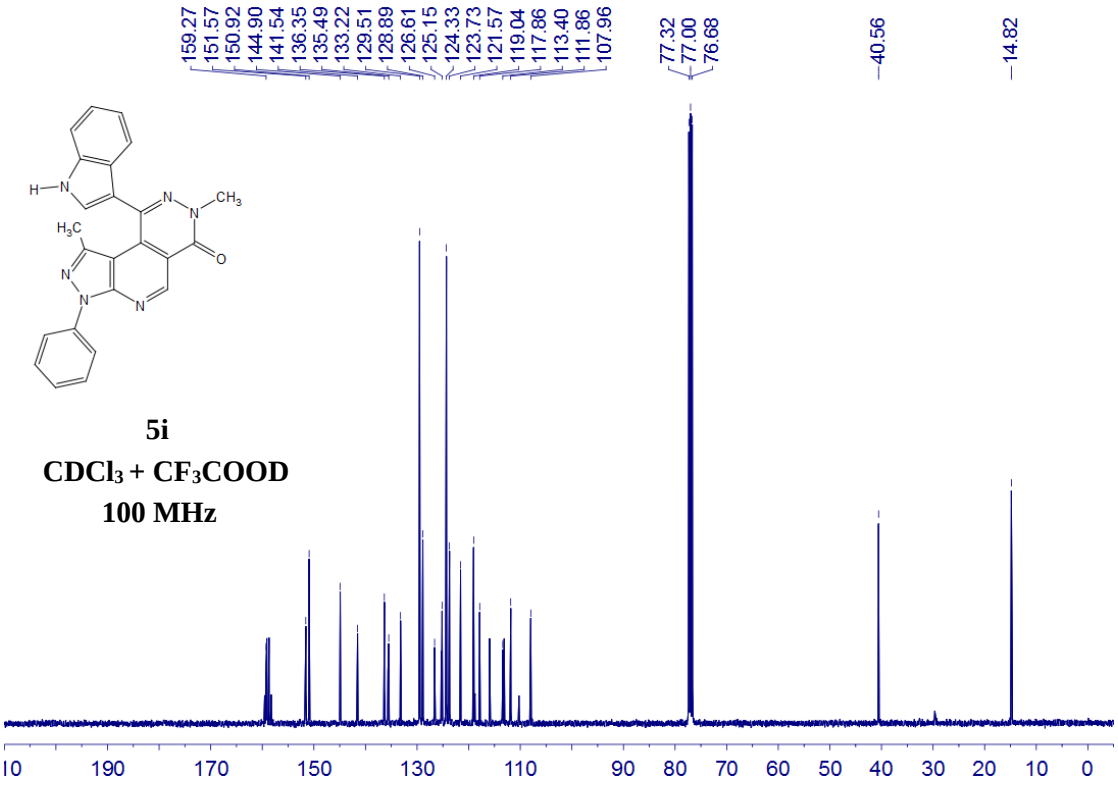

9.64
8.13
8.11
7.92
7.80
7.53
7.51
7.44
7.38
7.36
7.26
3.95
1.88
0.00
5h
CDCl3
400 MHz
0.85
2.00
1.03
1.02
2.06
3.09
1.06
3.07
3.07
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.24
152.42
149.93
143.68
140.00
139.18
138.41
138.19
130.61
129.08
126.98
126.39
125.61
125.04
124.24
122.44
122.30
117.49
107.51
77.32
77.00
76.68
39.77
15.68
5h
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5i

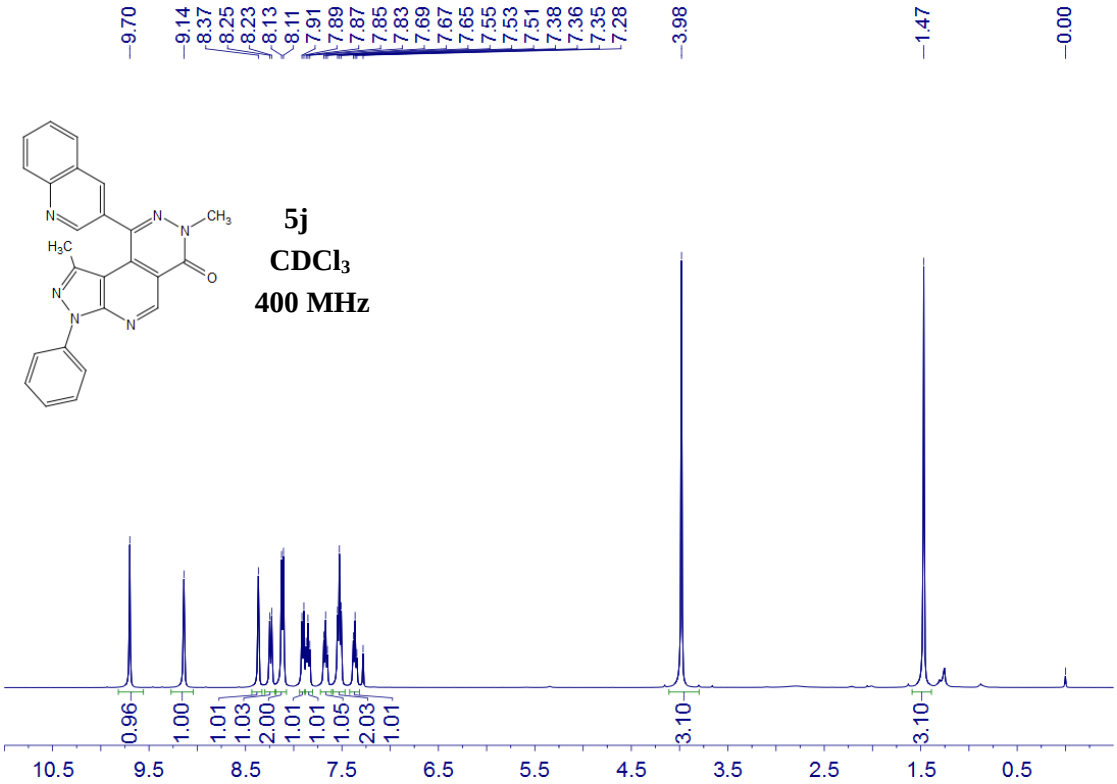


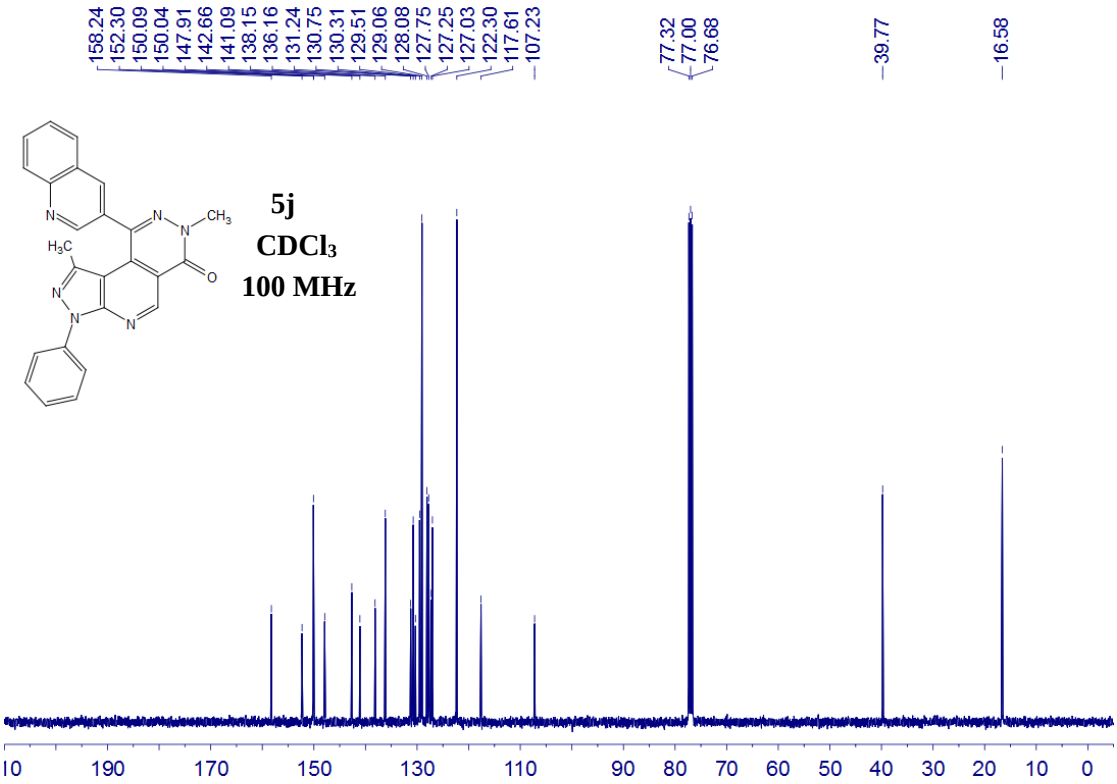
5i
$CDCl_3$ + CF_3COOD
400 MHz



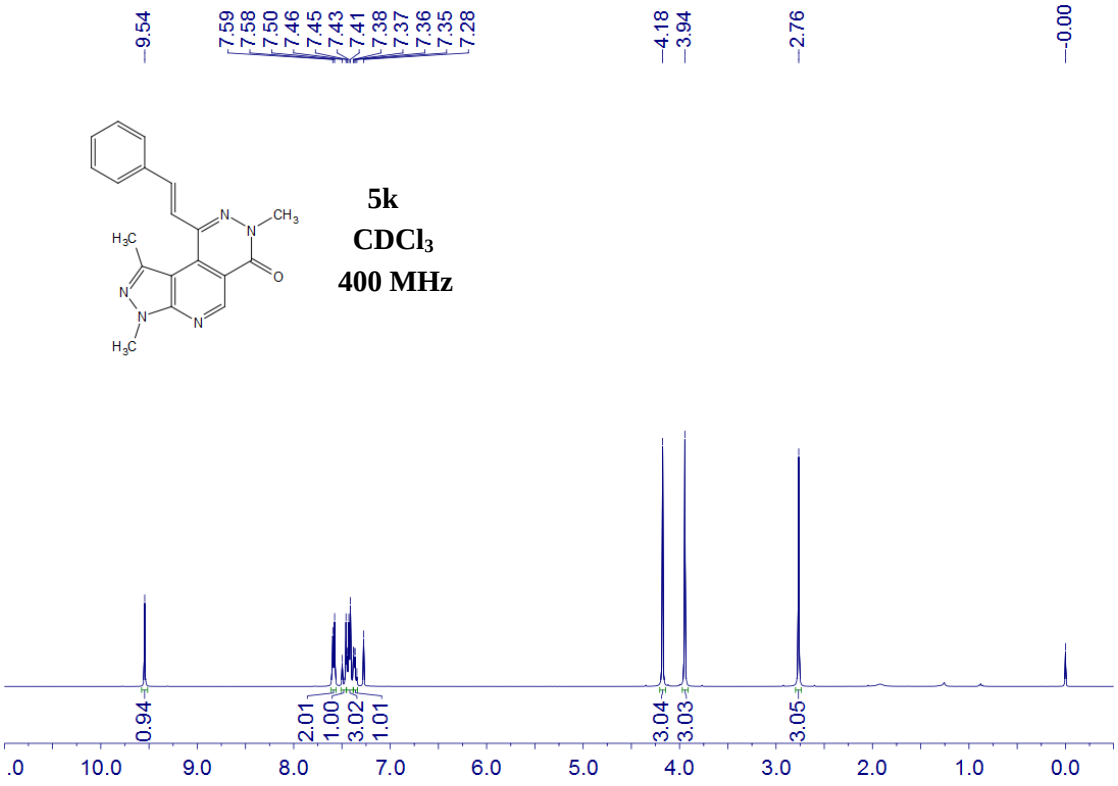
5i
$CDCl_3$ + CF_3COOD
100 MHz

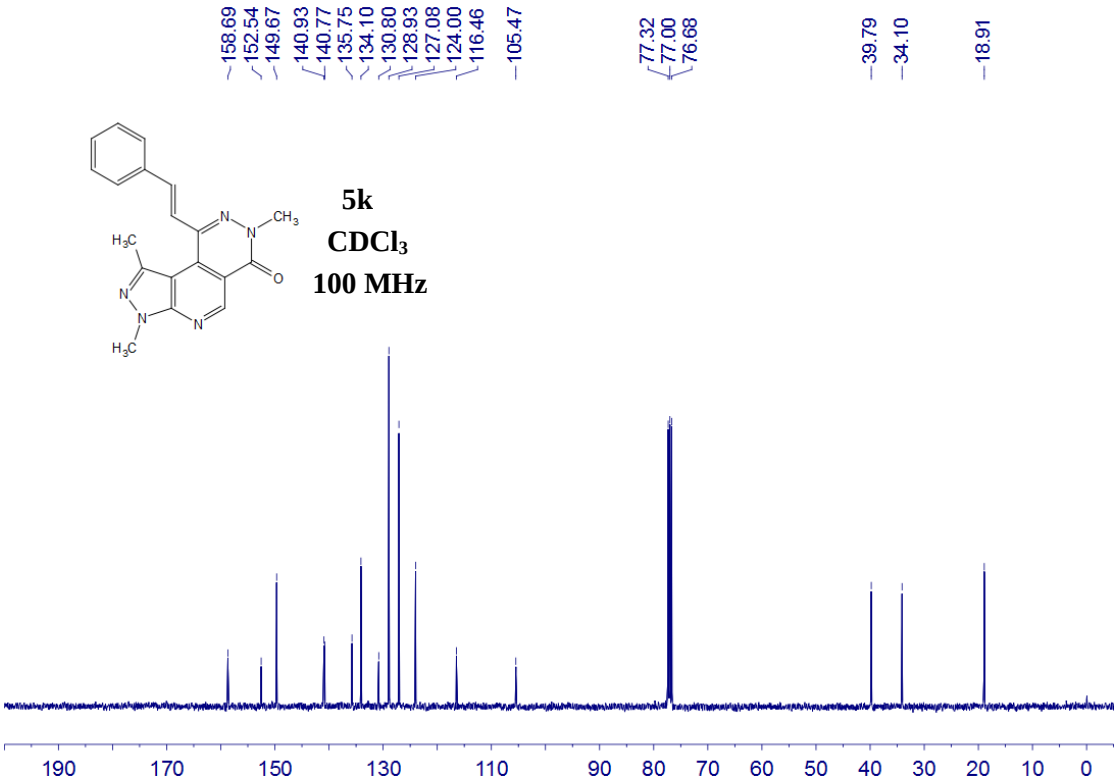
5j


9.70
9.14
8.37
8.25
8.23
8.13
8.11
7.91
7.89
7.87
7.85
7.83
7.69
7.67
7.65
7.55
7.53
7.51
7.38
7.36
7.35
7.28
3.98
1.47
0.00
5j
CDCl3
400 MHz
0.96
1.00
1.01
1.03
2.00
1.01
1.01
1.05
2.03
1.01
3.10
3.10
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5

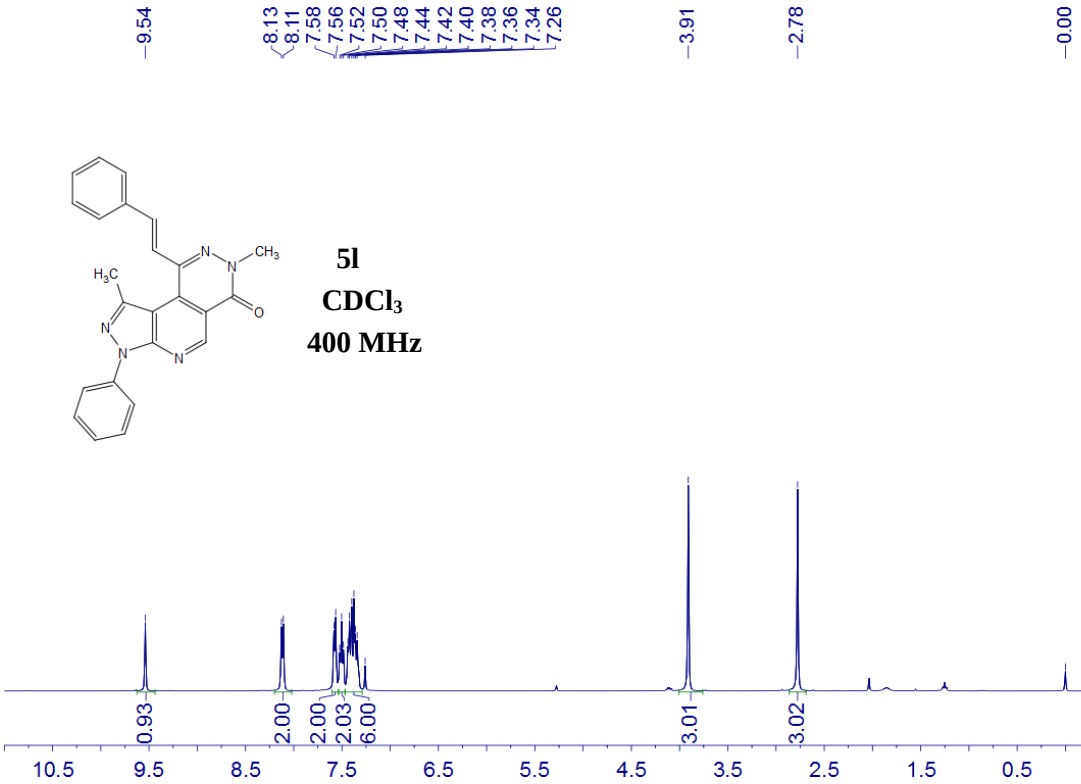

158.24
152.30
150.09
150.04
147.91
142.66
141.09
138.15
136.16
131.24
130.75
130.31
129.51
129.06
128.08
127.75
127.25
127.03
122.30
117.61
107.23
77.32
77.00
76.68
39.77
16.58
5j
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

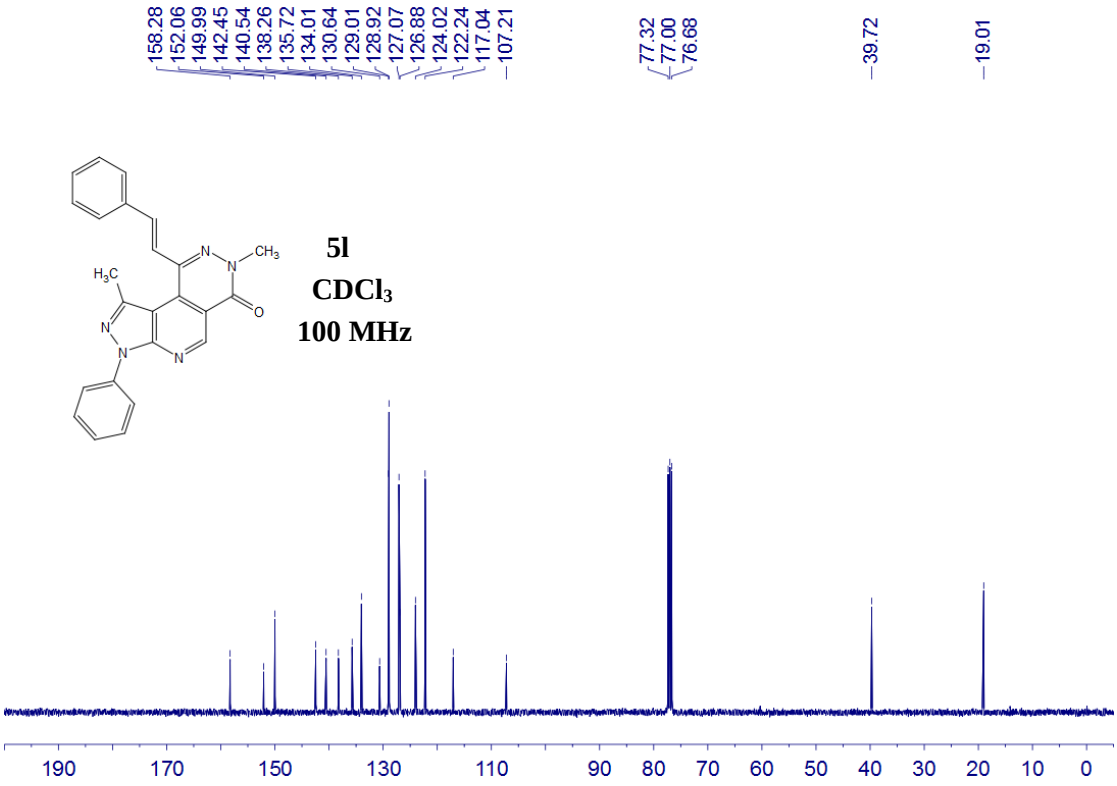
5k


9.54
7.59
7.58
7.50
7.46
7.45
7.43
7.41
7.38
7.37
7.36
7.35
7.28
4.18
3.94
2.76
0.00
5k
CDCl3
400 MHz
0.94
2.01
1.00
3.02
1.01
3.04
3.03
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

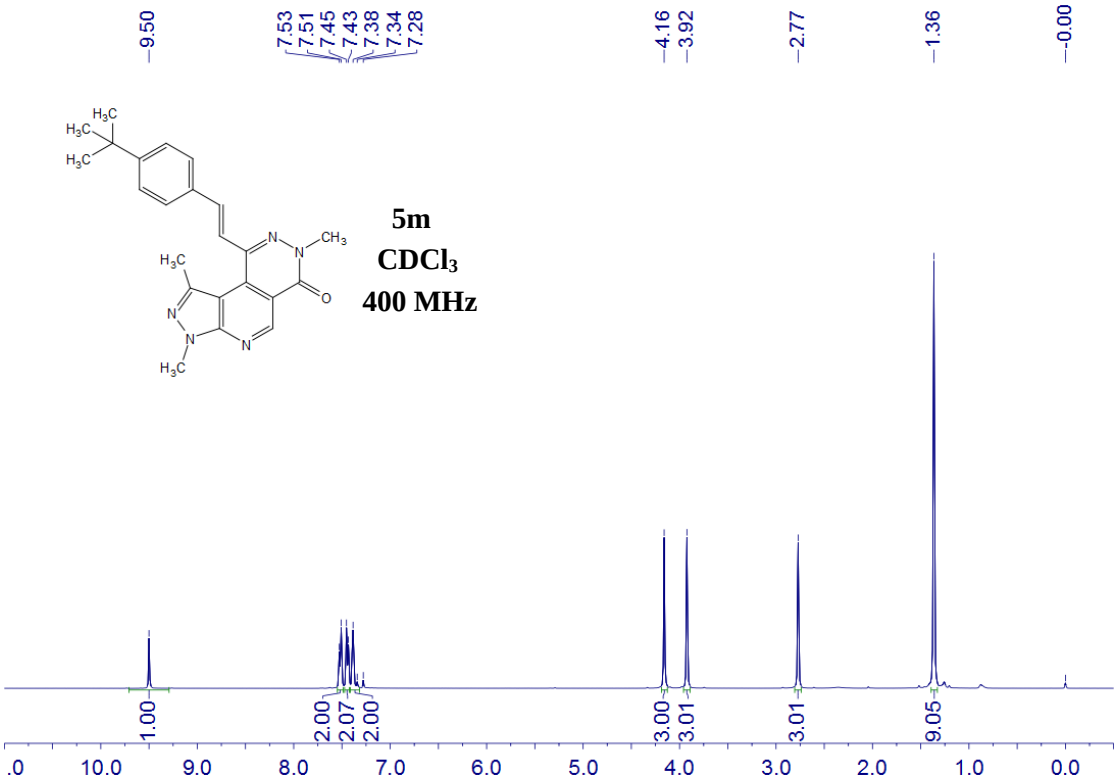

158.69
152.54
149.67
140.93
140.77
135.75
134.10
130.80
128.93
127.08
124.00
116.46
105.47
77.32
77.00
76.68
39.79
34.10
18.91
5k
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

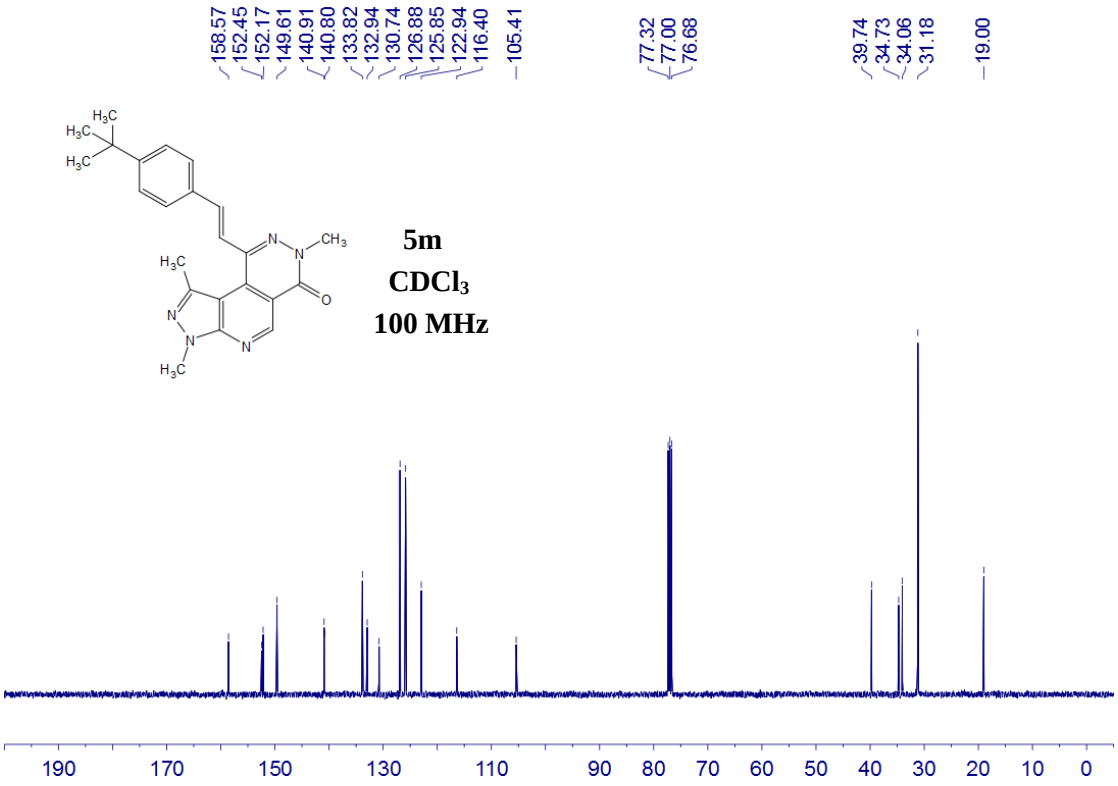
5l


9.54
8.13
8.11
7.58
7.56
7.52
7.50
7.48
7.44
7.42
7.40
7.38
7.36
7.34
7.26
3.91
2.78
0.00
5l
CDCl3
400 MHz
0.93
2.00
2.00
2.03
6.00
3.01
3.02
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5

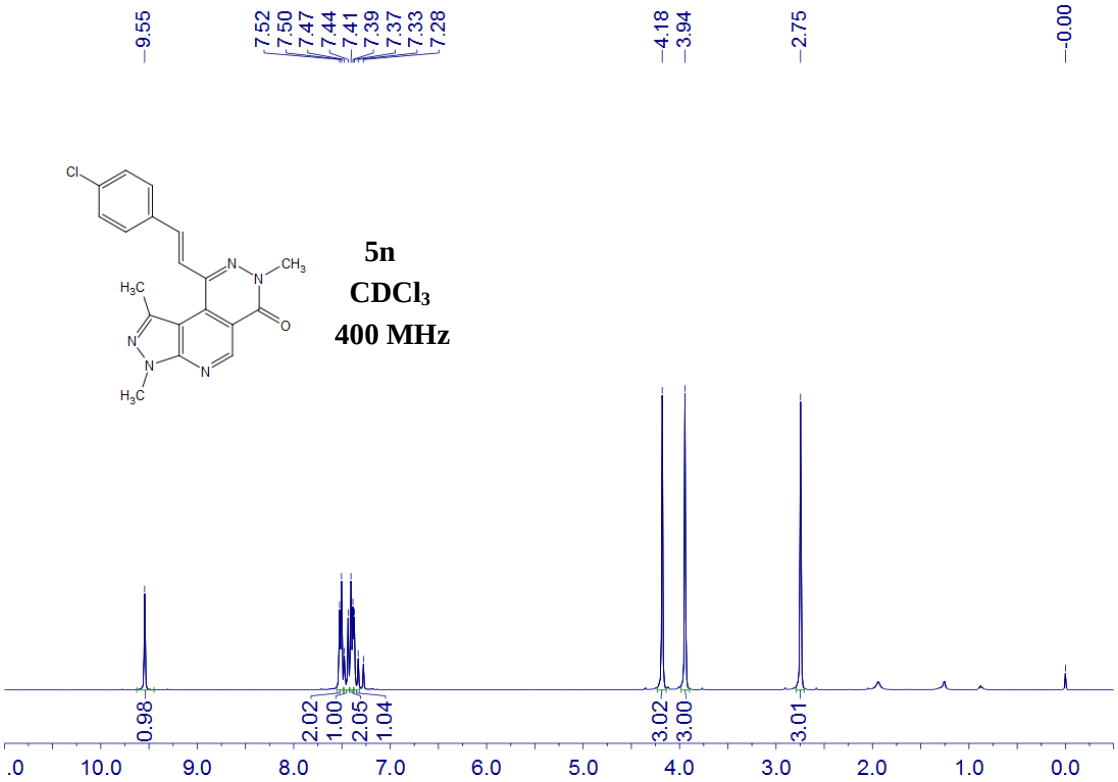

158.28
152.06
149.99
142.45
140.54
138.26
135.72
134.01
130.64
129.01
128.92
127.07
126.88
124.02
122.24
117.04
107.21
77.32
77.00
76.68
39.72
19.01
5l
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

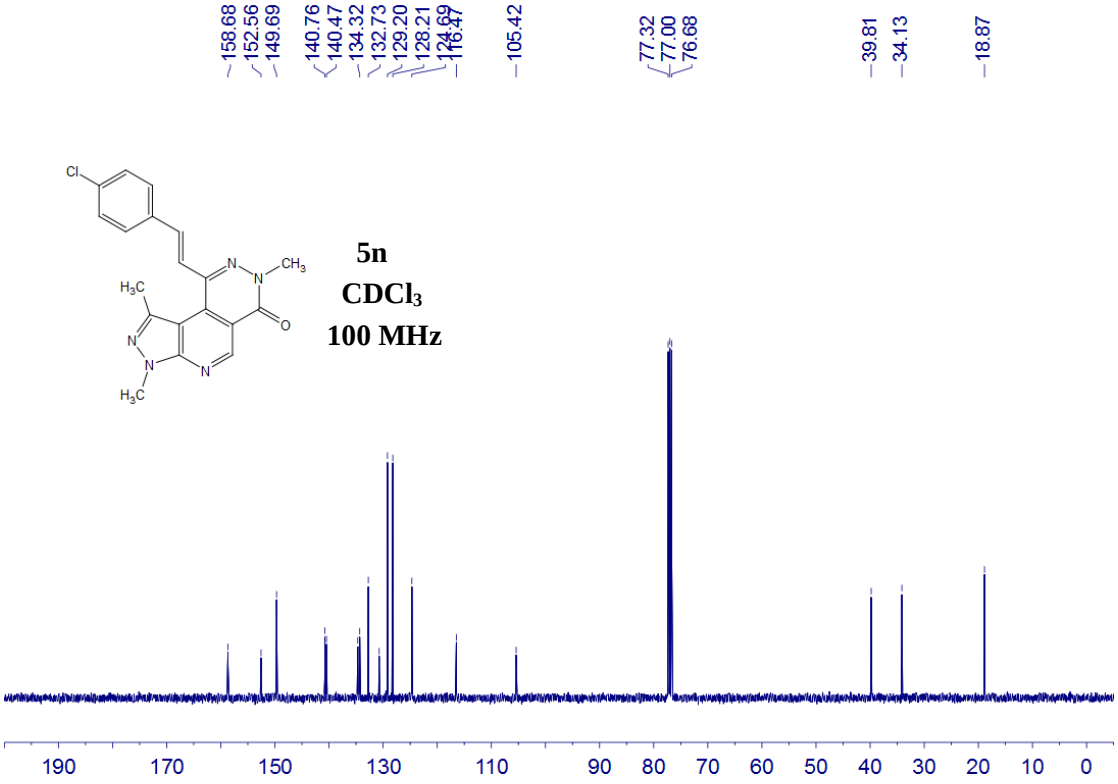
5m


9.50
7.53
7.51
7.45
7.43
7.38
7.34
7.28
4.16
3.92
2.77
1.36
0.00
5m
CDCl3
400 MHz
1.00
2.00
2.07
2.00
3.00
3.01
3.01
9.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

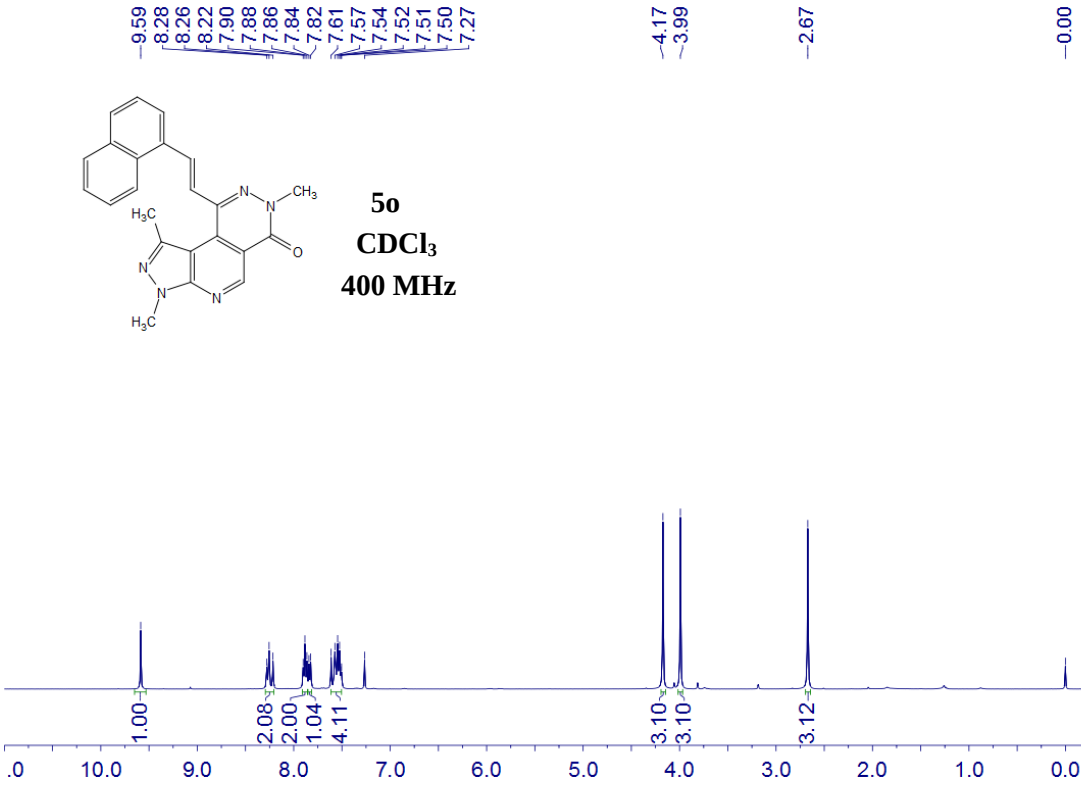

158.57
152.45
152.17
149.61
140.91
140.80
133.82
132.94
130.74
126.88
125.85
122.94
116.40
105.41
77.32
77.00
76.68
39.74
34.73
34.06
31.18
19.00
5m
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5n

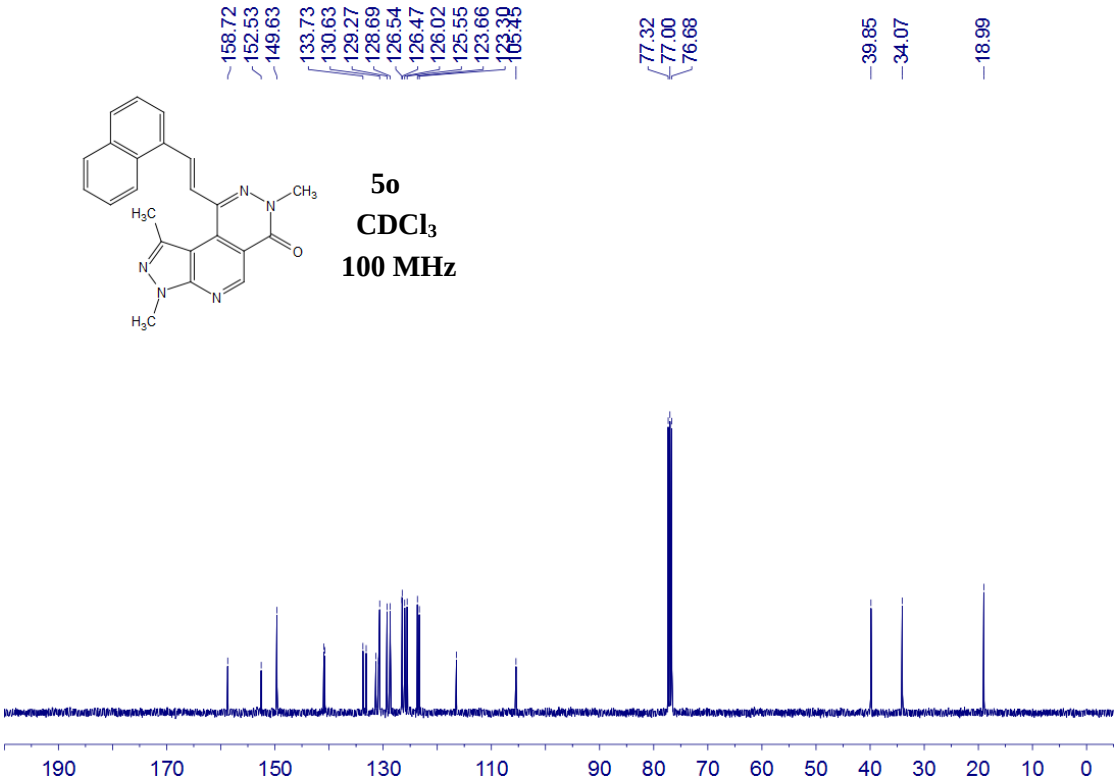

9.55
7.52
7.50
7.47
7.44
7.41
7.39
7.37
7.33
7.28
4.18
3.94
2.75
0.00
Cl
N
N
CH3
H3C
O
N
N
N
H3C
5n
CDCl3
400 MHz
0.98
2.02
1.00
2.05
1.04
3.02
3.00
3.01
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.68
152.56
149.69
140.76
140.47
134.32
132.73
129.20
128.21
124.69
116.47
105.42
77.32
77.00
76.68
39.81
34.13
18.87
Cl
N
N
CH3
H3C
O
N
N
H3C
5n
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5o

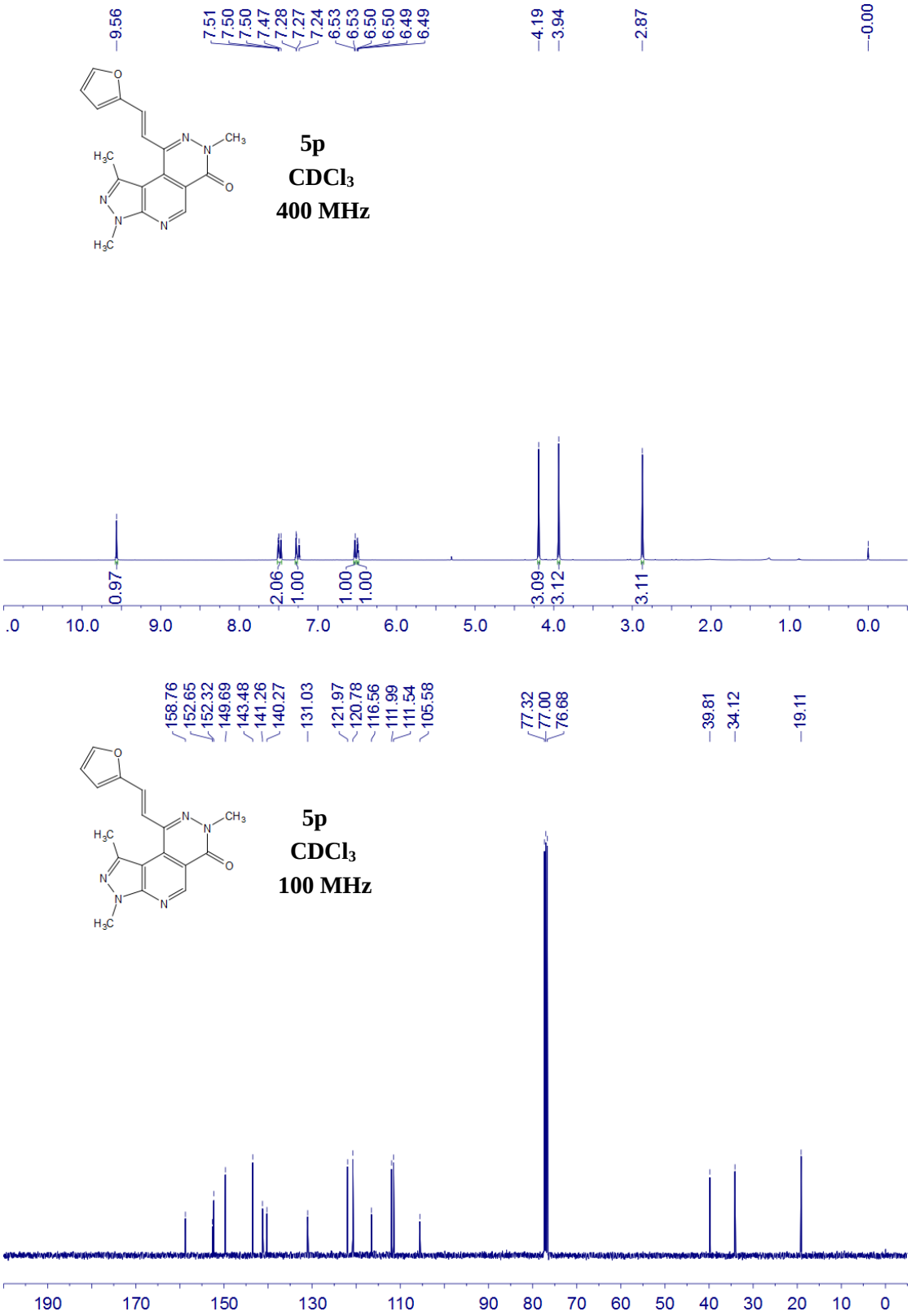


5o
$CDCl_3$
400 MHz

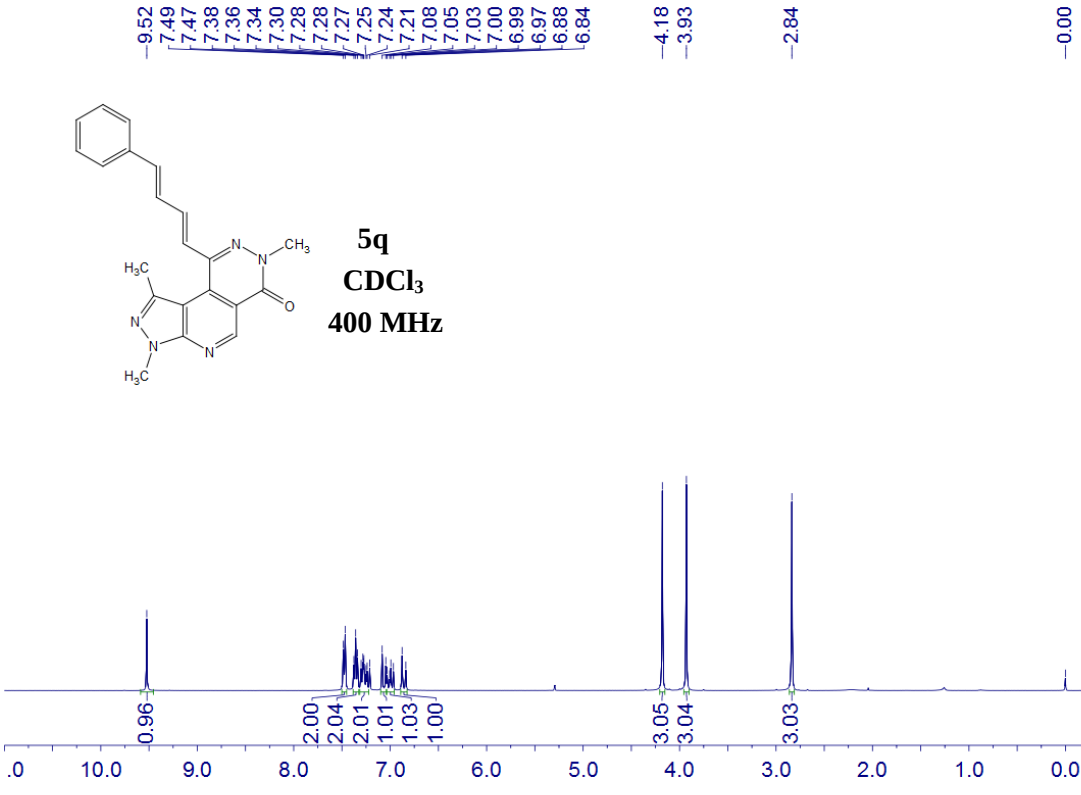


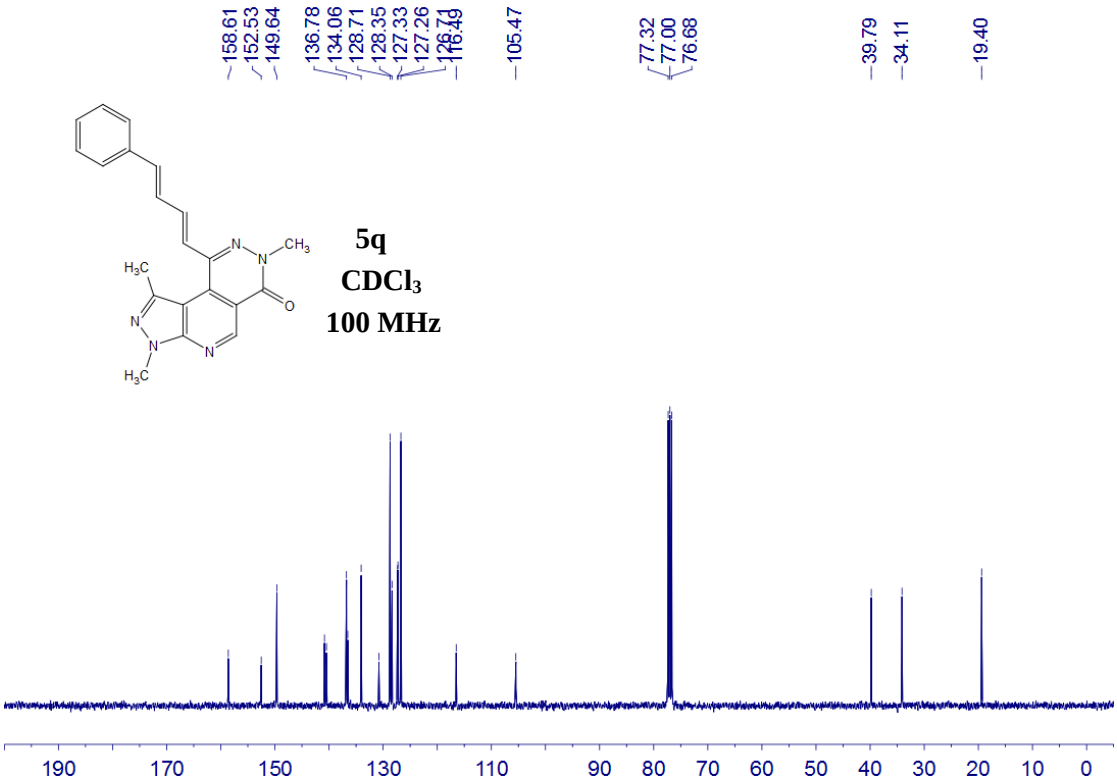
5o
$CDCl_3$
100 MHz

5p


9.56
7.51
7.50
7.50
7.47
7.28
7.27
7.24
6.53
6.53
6.50
6.50
6.49
6.49
4.19
3.94
2.87
0.00
5p
CDCl3
400 MHz
0.97
2.06
1.00
1.00
1.00
3.09
3.12
3.11
158.76
152.65
152.32
149.69
143.48
141.26
140.27
131.03
121.97
120.78
116.56
111.99
111.54
105.58
77.32
77.00
76.68
39.81
34.12
19.11
5p
CDCl3
100 MHz

5q


9.52
7.49
7.47
7.38
7.36
7.34
7.30
7.28
7.28
7.27
7.25
7.24
7.21
7.08
7.05
7.03
7.00
6.99
6.97
6.88
6.84
4.18
3.93
2.84
0.00
5q
CDCl3
400 MHz
0.96
2.00
2.04
2.01
1.01
1.03
1.00
3.05
3.04
3.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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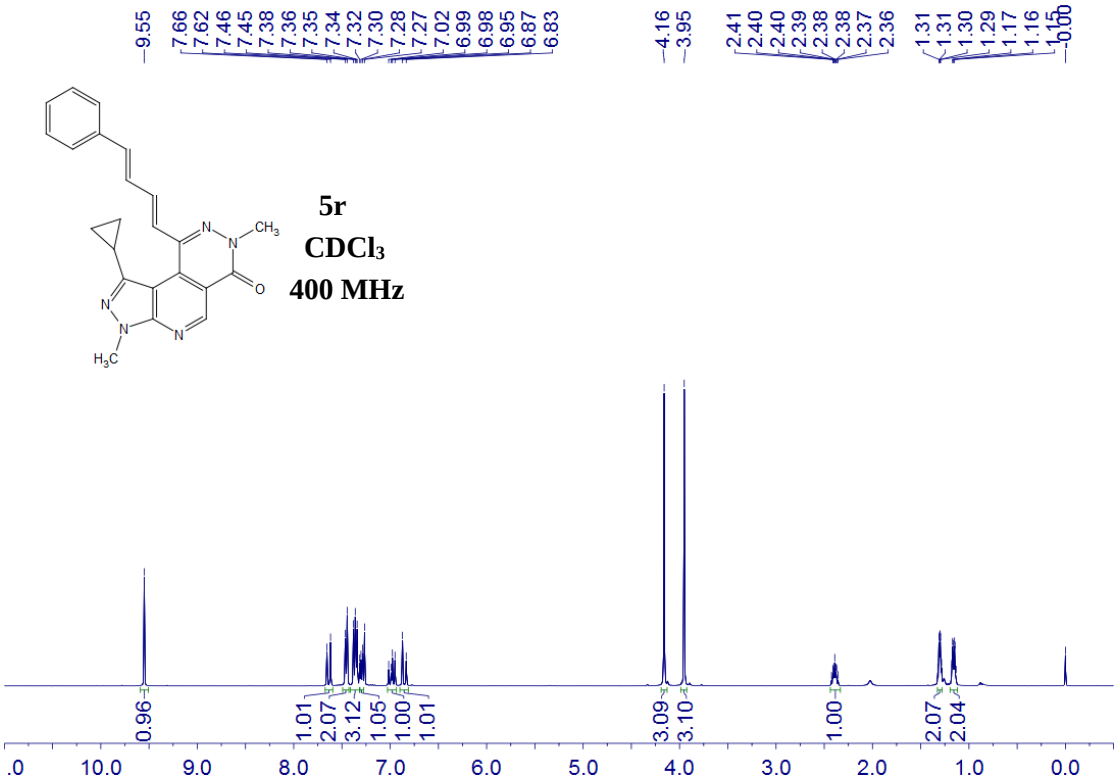
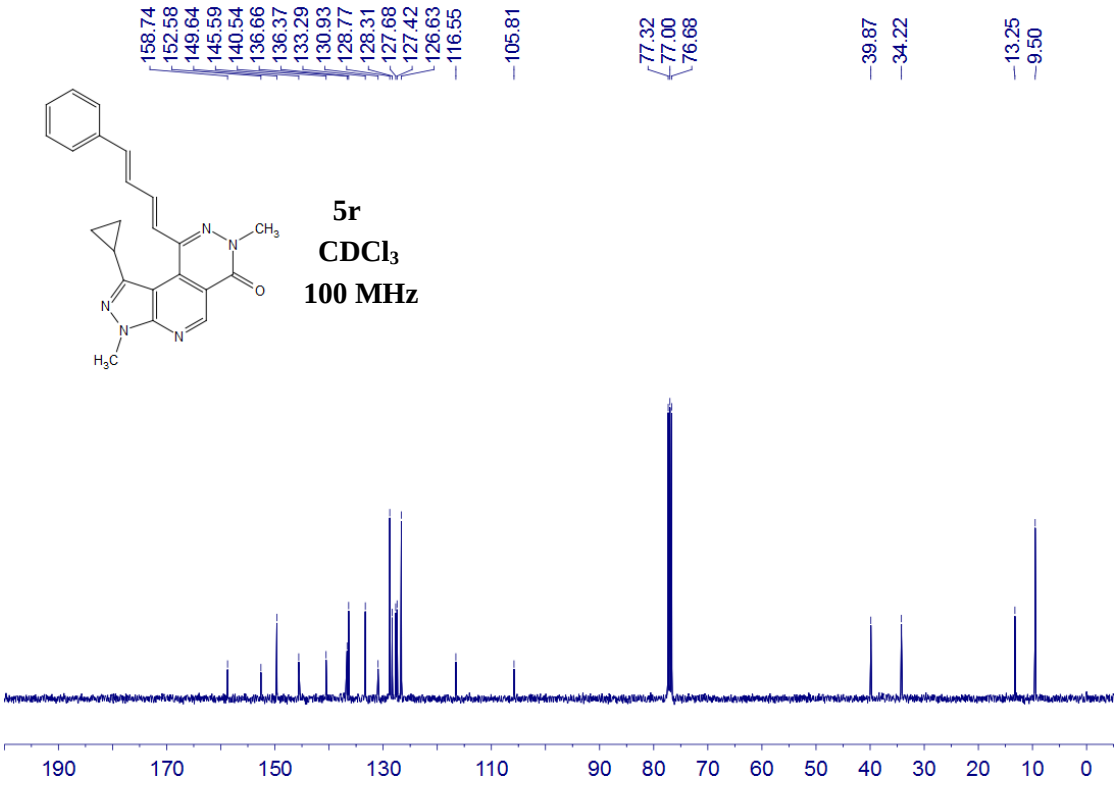
152.53
149.64
136.78
134.06
128.71
128.35
127.33
127.26
116.49
105.47
77.32
77.00
76.68
39.79
34.11
19.40
5q
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5r


9.55
7.66
7.62
7.46
7.45
7.38
7.36
7.35
7.34
7.32
7.30
7.28
7.27
7.02
6.99
6.98
6.95
6.87
6.83
4.16
3.95
2.41
2.40
2.40
2.39
2.38
2.38
2.37
2.36
1.31
1.31
1.30
1.29
1.17
1.16
1.15
0.00
5r
CDCl3
400 MHz
0.96
1.01
2.07
3.12
1.05
1.00
1.01
3.09
3.10
1.00
2.07
2.04
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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152.58
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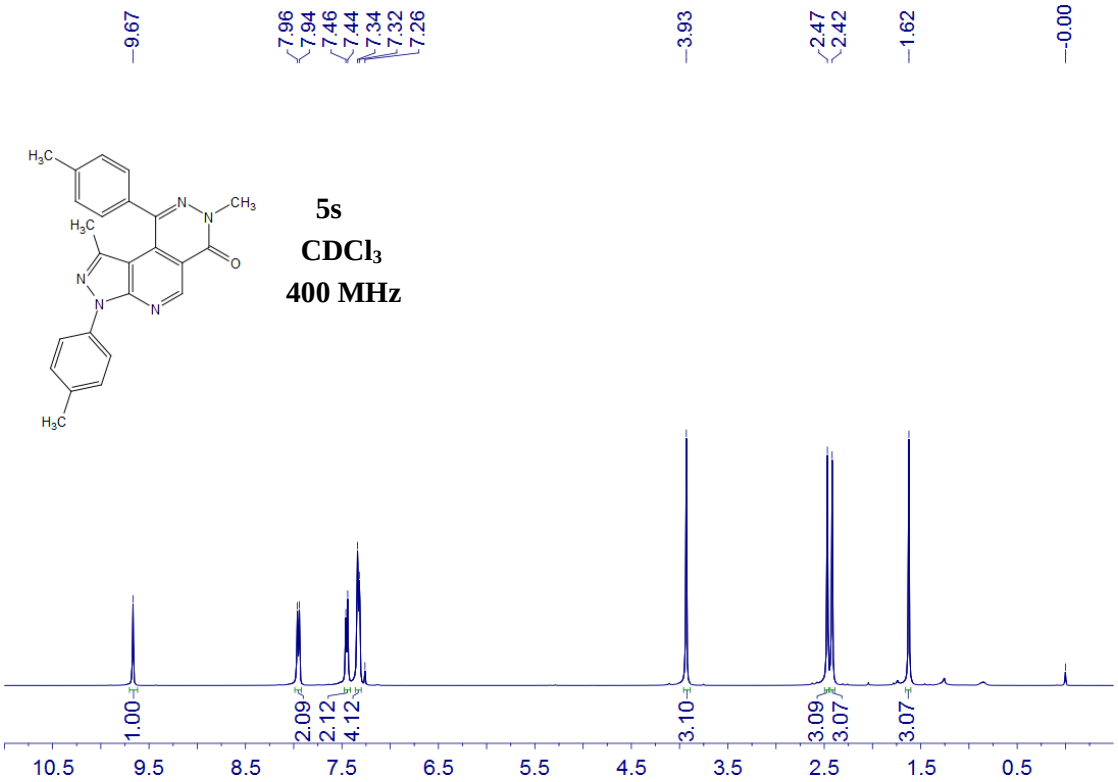
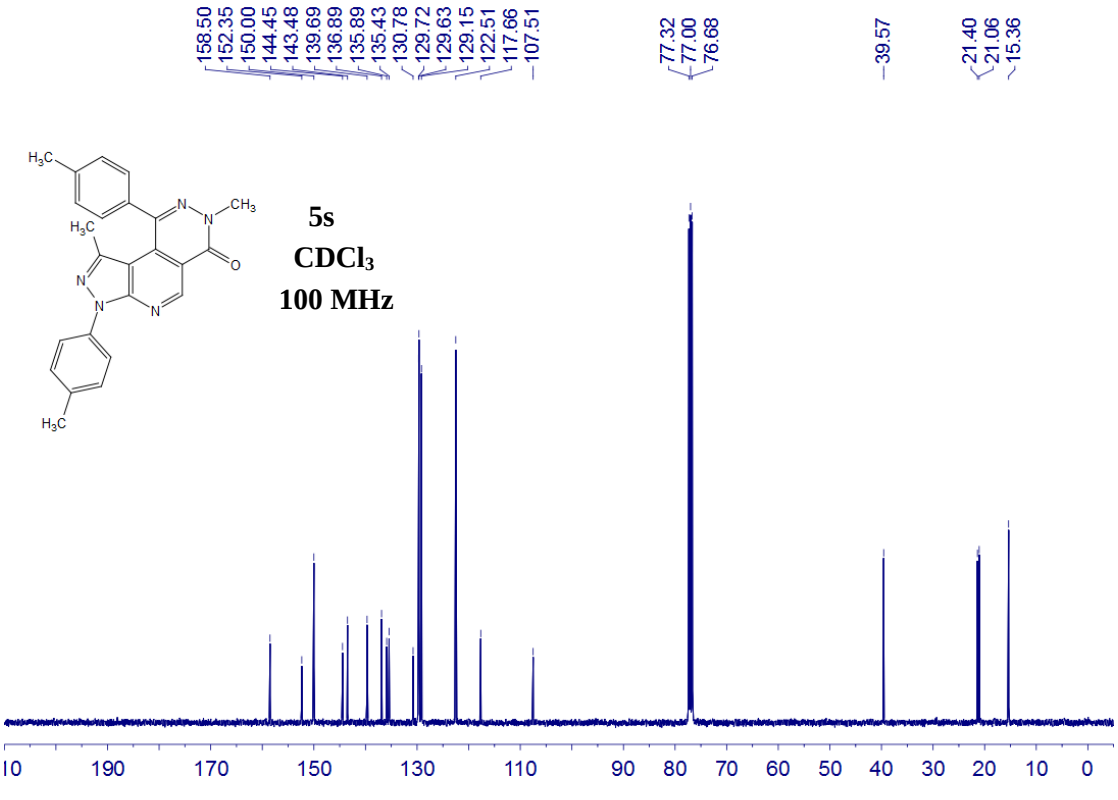
145.59
140.54
136.66
136.37
133.29
130.93
128.77
128.31
127.68
127.42
126.63
116.55
105.81
77.32
77.00
76.68
39.87
34.22
13.25
9.50
5r
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5s


9.67
7.96
7.94
7.46
7.44
7.34
7.32
7.26
3.93
2.47
2.42
1.62
0.00
5s
CDCl3
400 MHz
1.00
2.09
2.12
4.12
3.10
3.09
3.07
3.07
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5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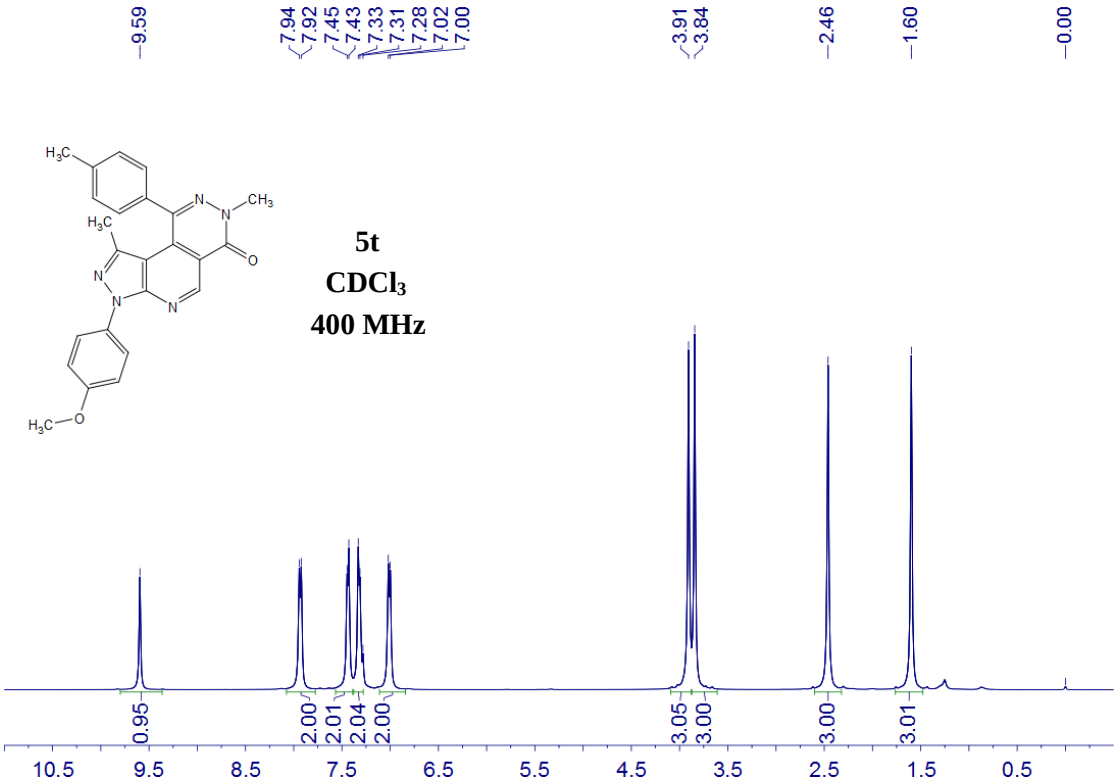
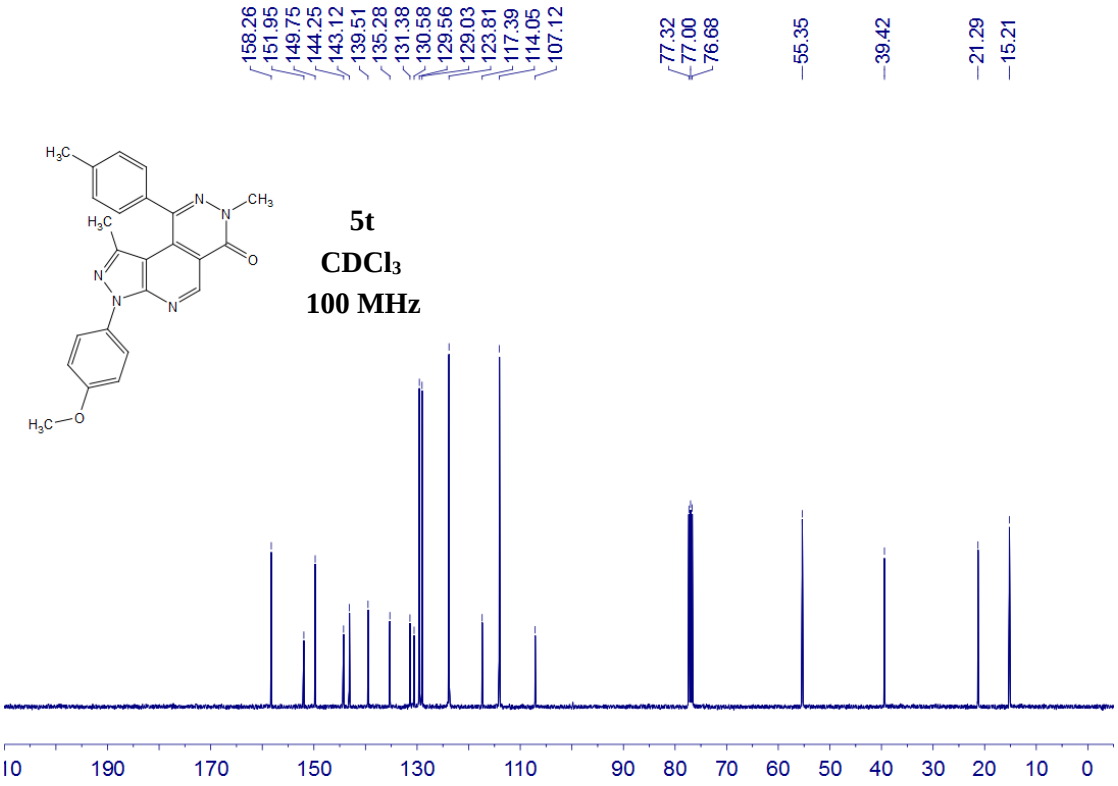
152.35
150.00
144.45
143.48
139.69
136.89
135.89
135.43
130.78
129.72
129.63
129.15
122.51
117.66
107.51
77.32
77.00
76.68
39.57
21.40
21.06
15.36
5s
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5t


9.59
7.94
7.92
7.45
7.43
7.33
7.31
7.28
7.02
7.00
3.91
3.84
2.46
1.60
0.00
5t
CDCl3
400 MHz
0.95
2.00
2.01
2.04
2.00
3.05
3.00
3.00
3.01
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5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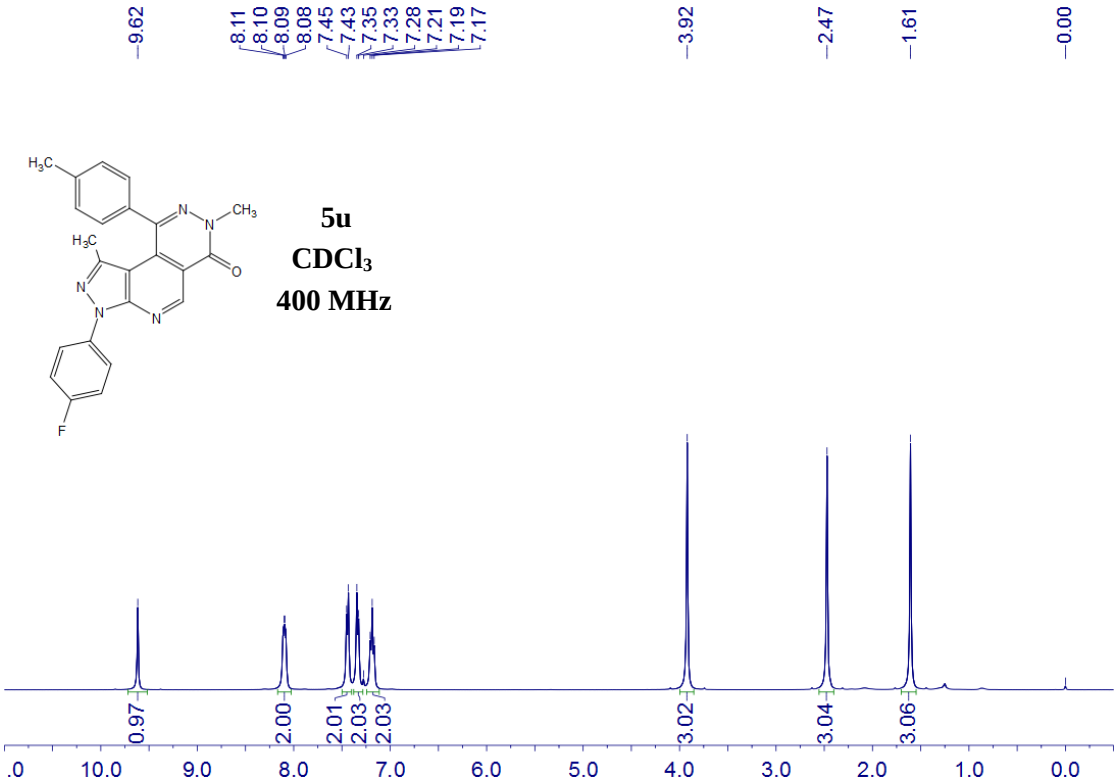
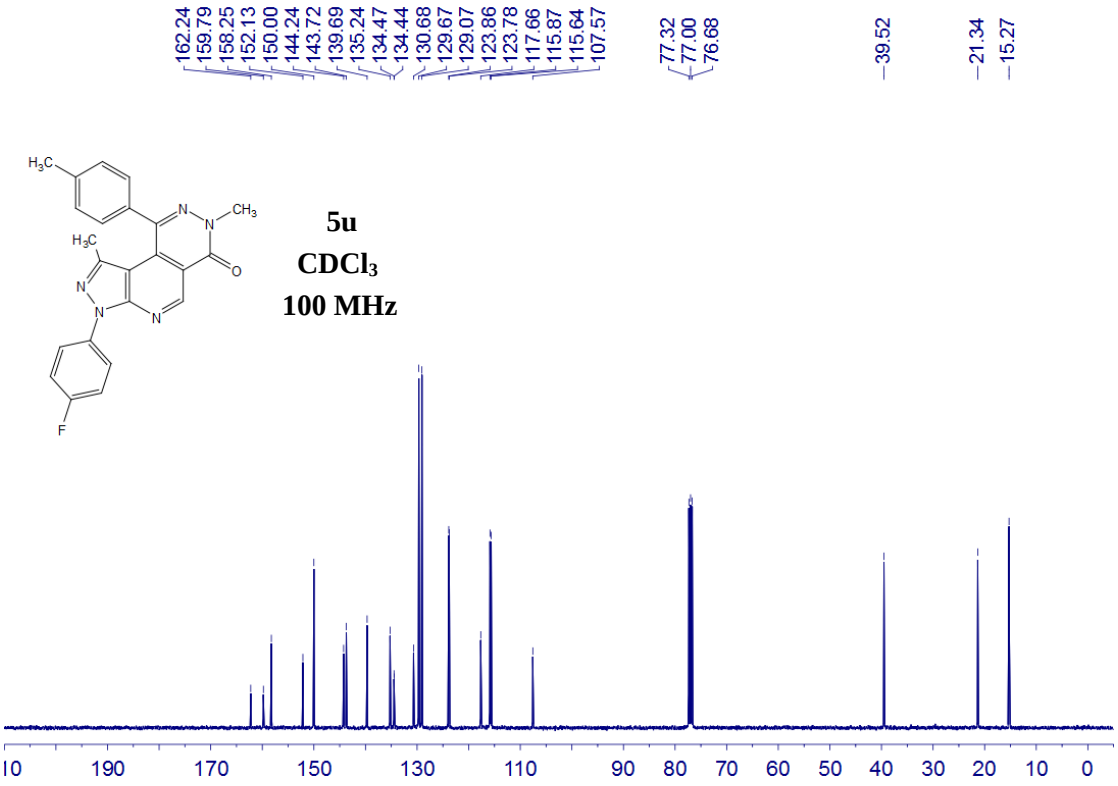
151.95
149.75
144.25
143.12
139.51
135.28
131.38
130.58
129.56
129.03
123.81
117.39
114.05
107.12
77.32
77.00
76.68
55.35
39.42
21.29
15.21
5t
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

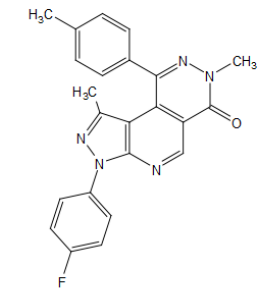
5u



5u
$CDCl_3$
400 MHz



5u
$CDCl_3$
100 MHz

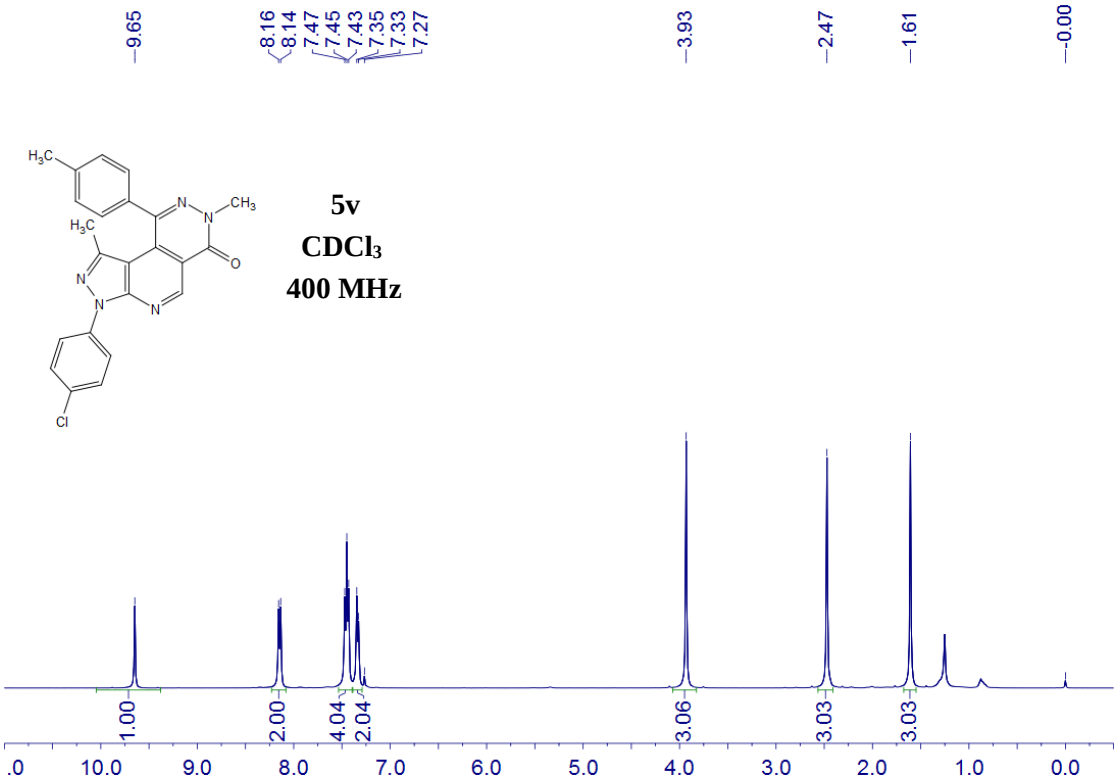


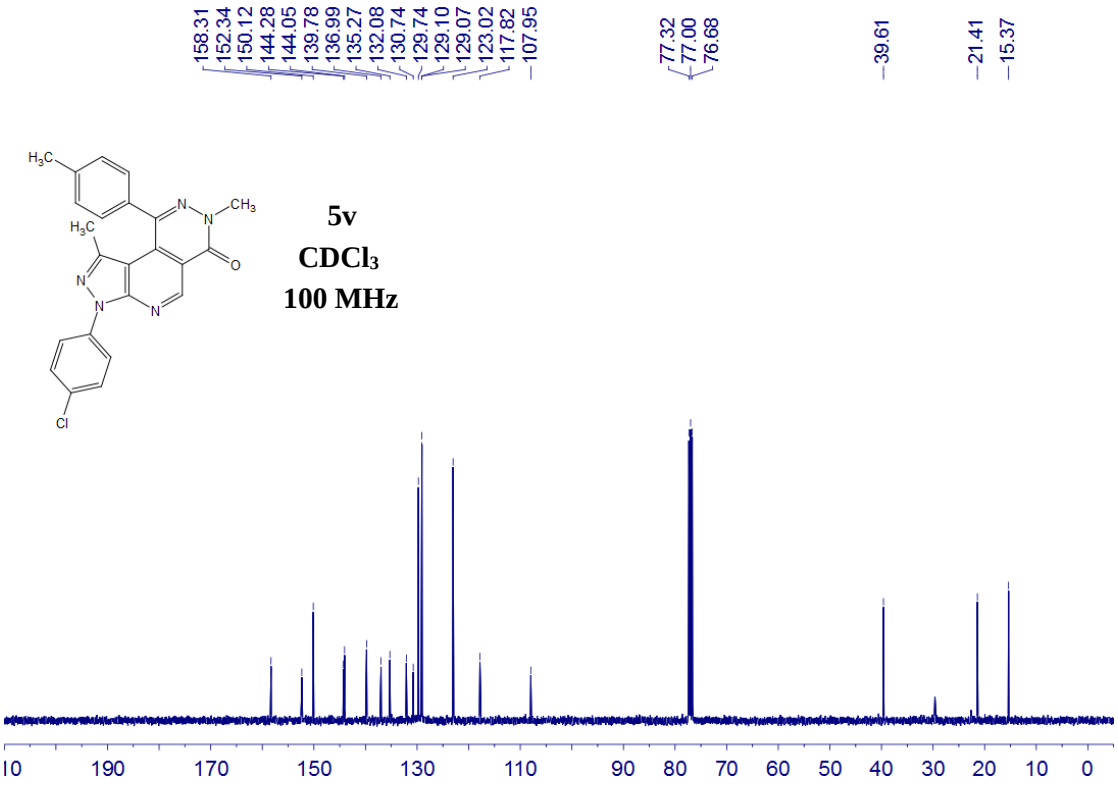
5u

$CDCl_3$

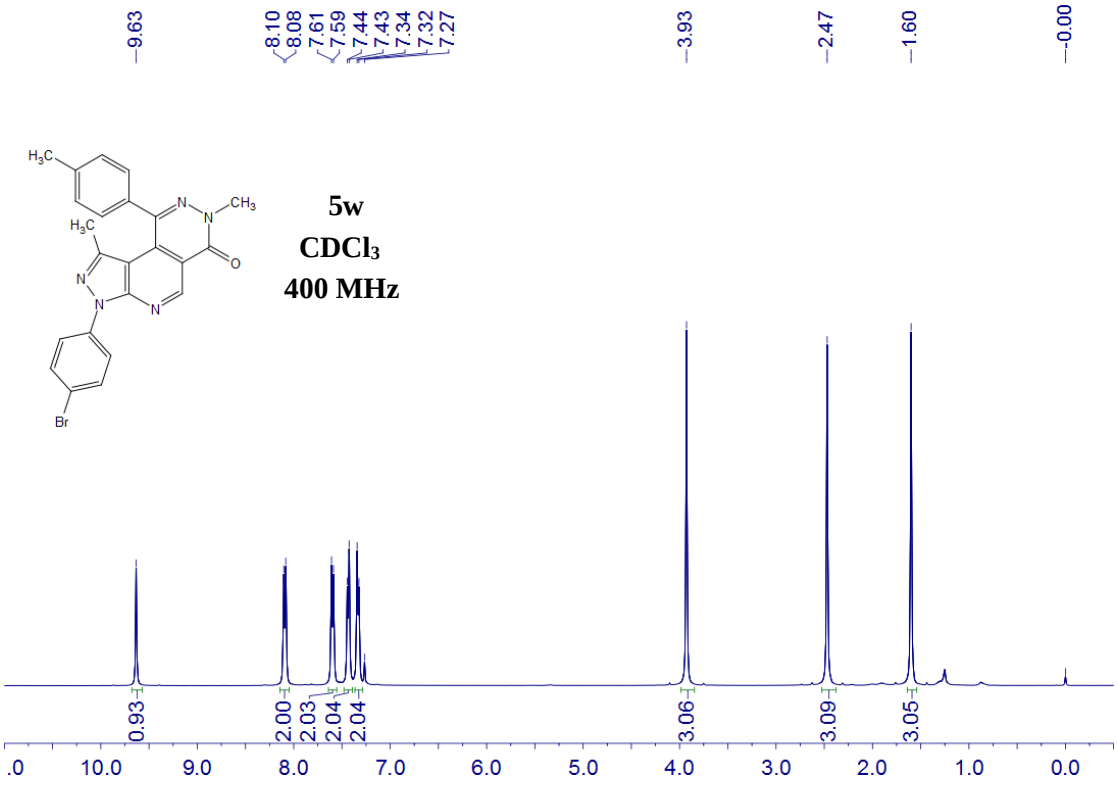
376 MHz

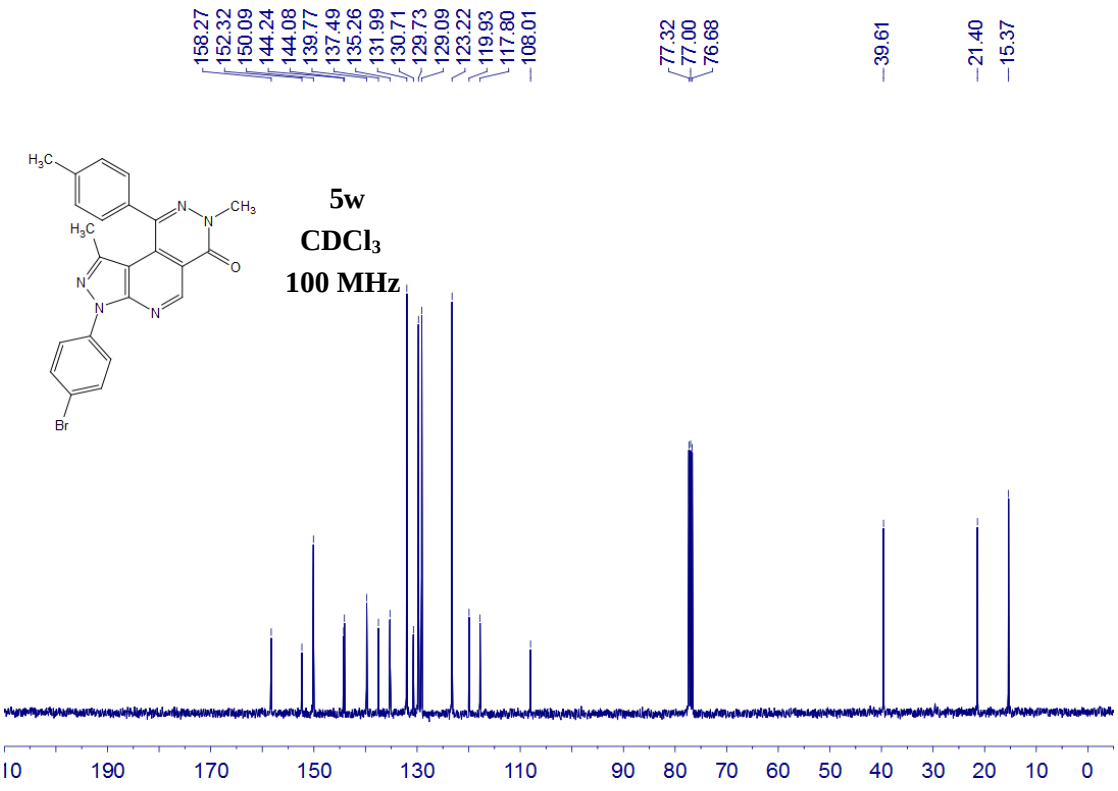
5v


9.65
8.16
8.14
7.47
7.45
7.43
7.35
7.33
7.27
3.93
2.47
1.61
0.00
5v
CDCl3
400 MHz
1.00
2.00
4.04
2.04
3.06
3.03
3.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

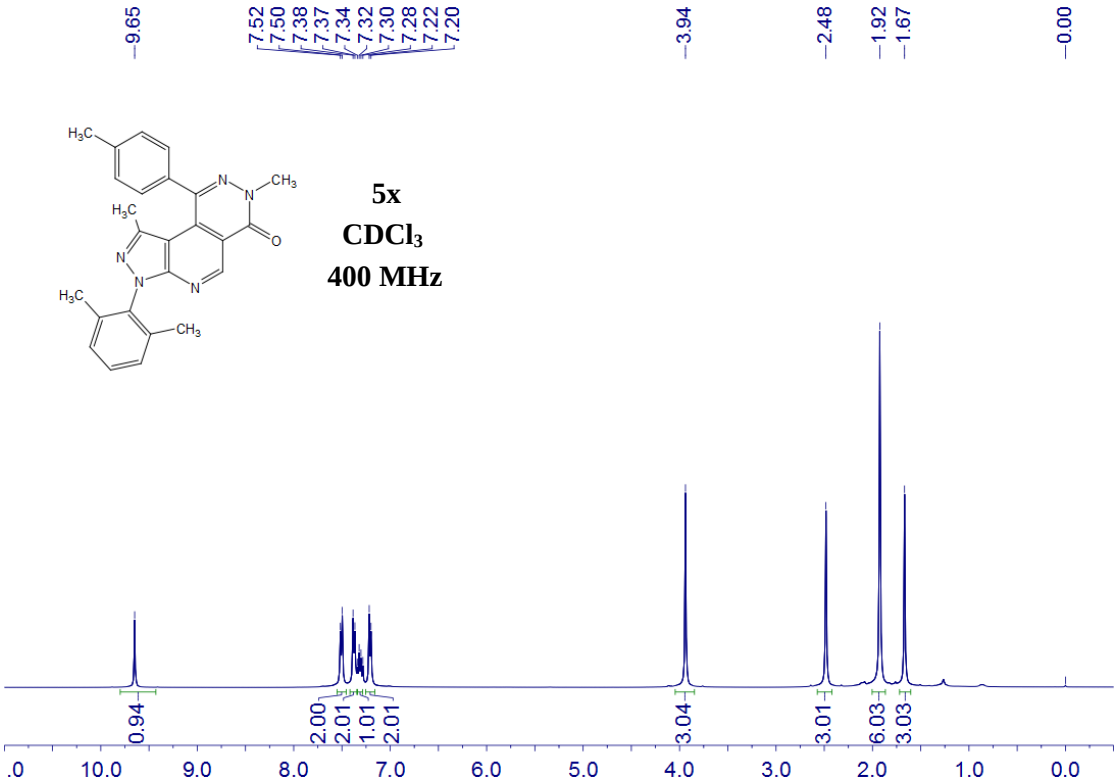

158.31
152.34
150.12
144.28
144.05
139.78
136.99
135.27
132.08
130.74
129.74
129.10
129.07
123.02
117.82
107.95
77.32
77.00
76.68
39.61
21.41
15.37
5v
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

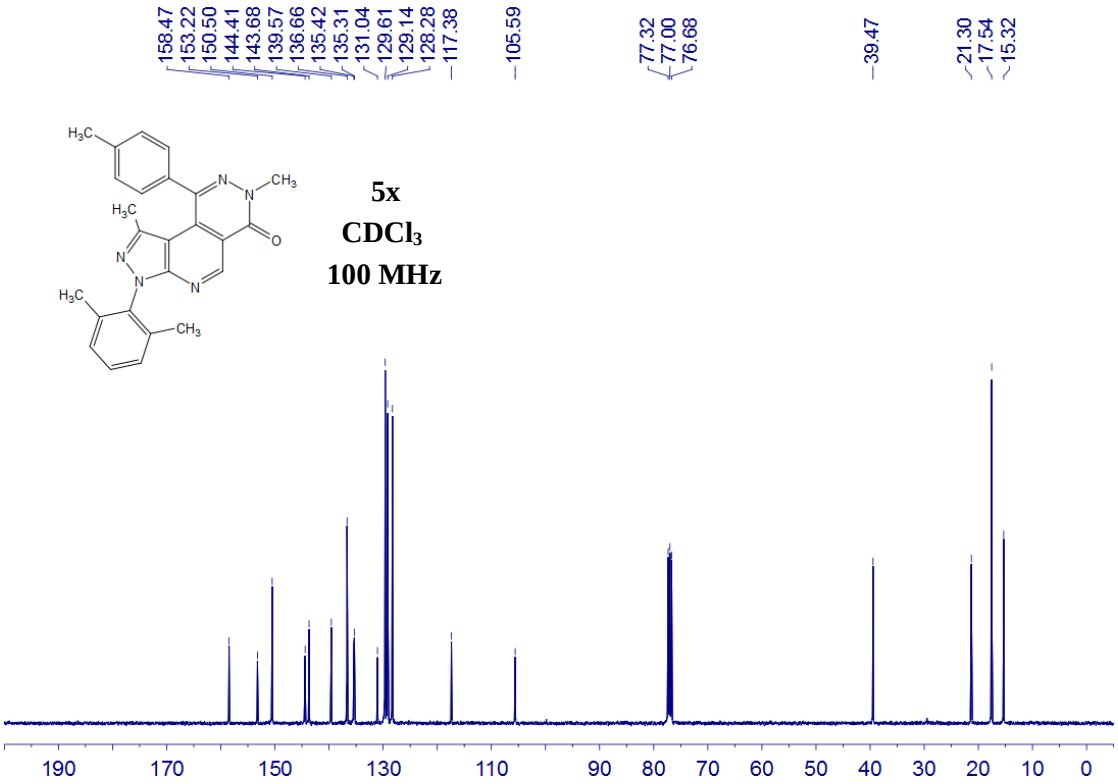
5w


9.63
8.10
8.08
7.61
7.59
7.44
7.43
7.34
7.32
7.27
3.93
2.47
1.60
0.00
5w
CDCl3
400 MHz
0.93
2.00
2.03
2.04
2.04
3.06
3.09
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

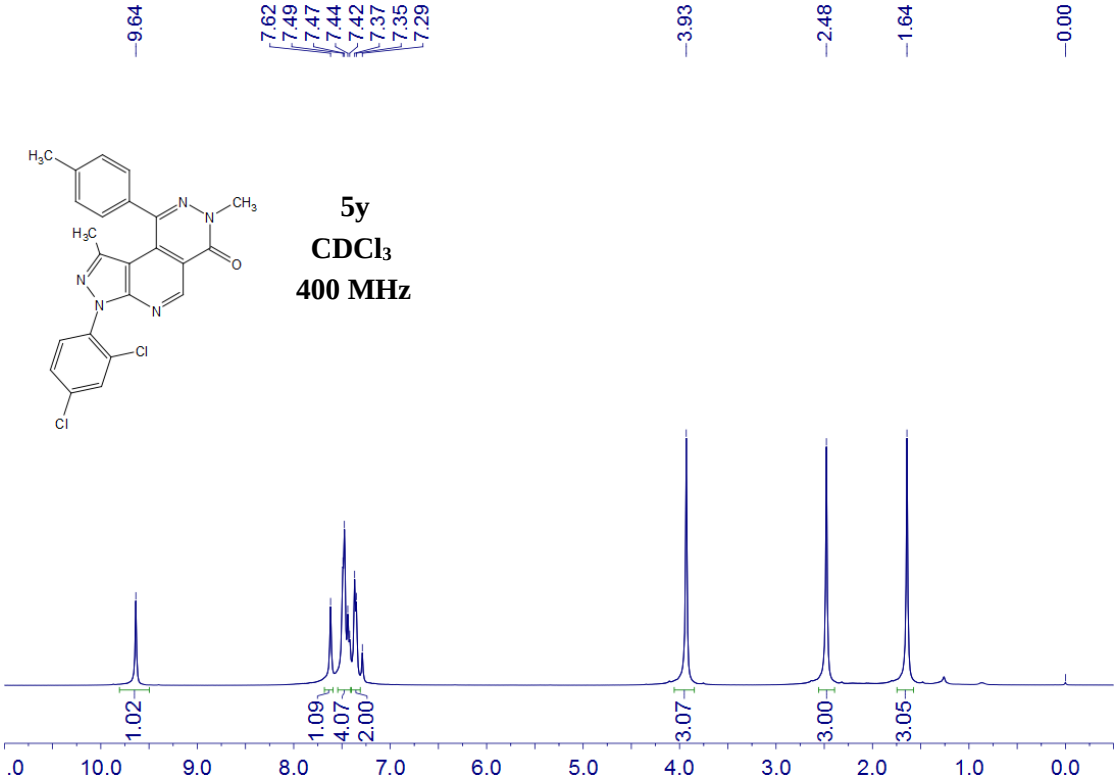

158.27
152.32
150.09
144.24
144.08
139.77
137.49
135.26
131.99
130.71
129.73
129.09
123.22
119.93
117.80
108.01
77.32
77.00
76.68
39.61
21.40
15.37
5w
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

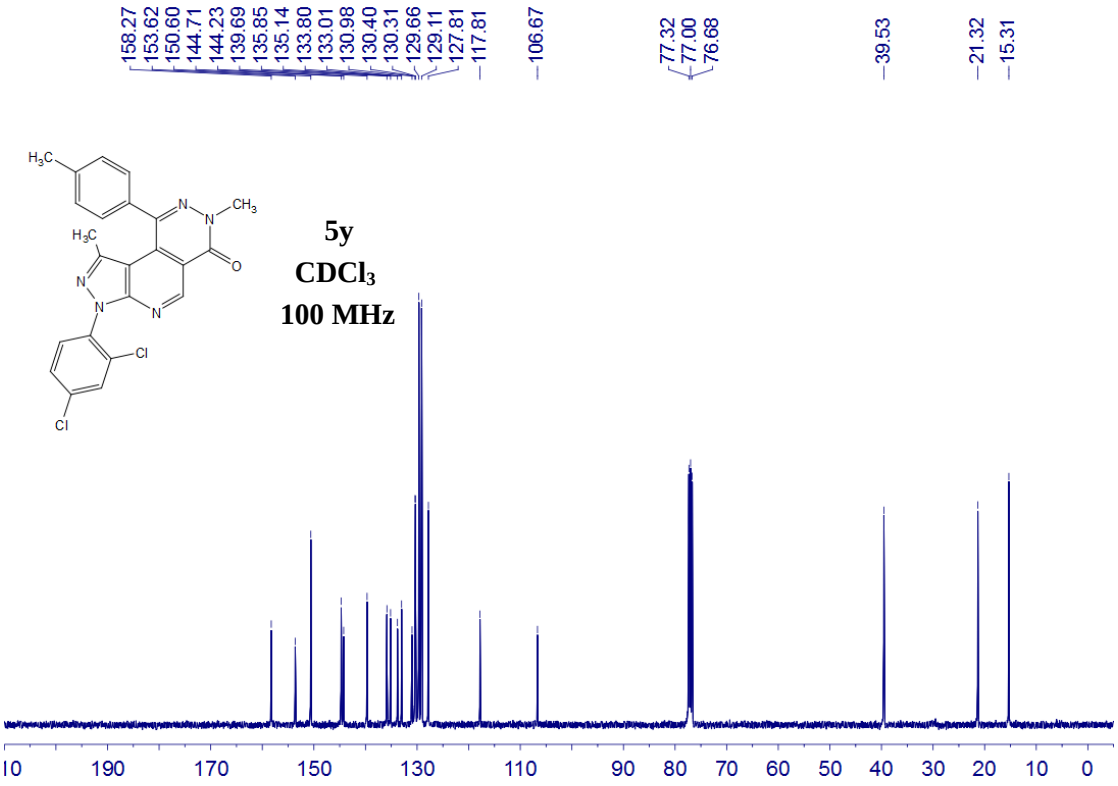
5x


9.65
7.52
7.50
7.38
7.37
7.34
7.32
7.30
7.28
7.22
7.20
3.94
2.48
1.92
1.67
0.00
5x
CDCl3
400 MHz
0.94
2.00
2.01
1.01
2.01
3.04
3.01
6.03
3.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

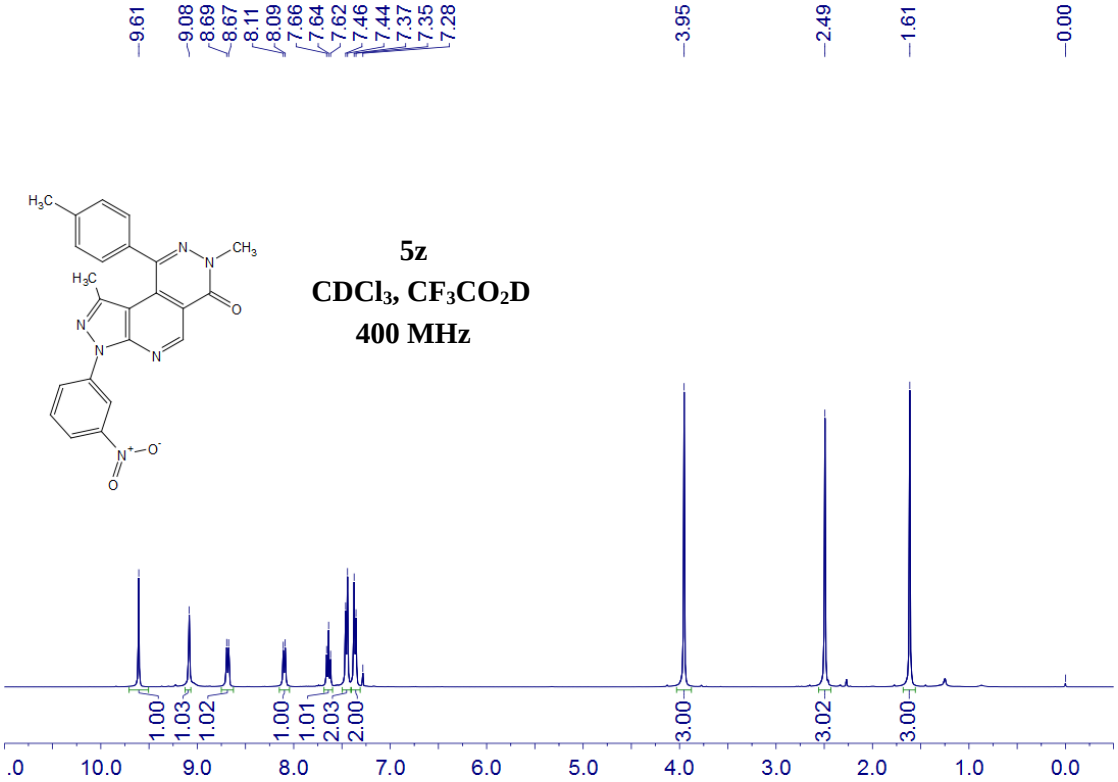

158.47
153.22
150.50
144.41
143.68
139.57
136.66
135.42
135.31
131.04
129.61
129.14
128.28
117.38
105.59
77.32
77.00
76.68
39.47
21.30
17.54
15.32
5x
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5y

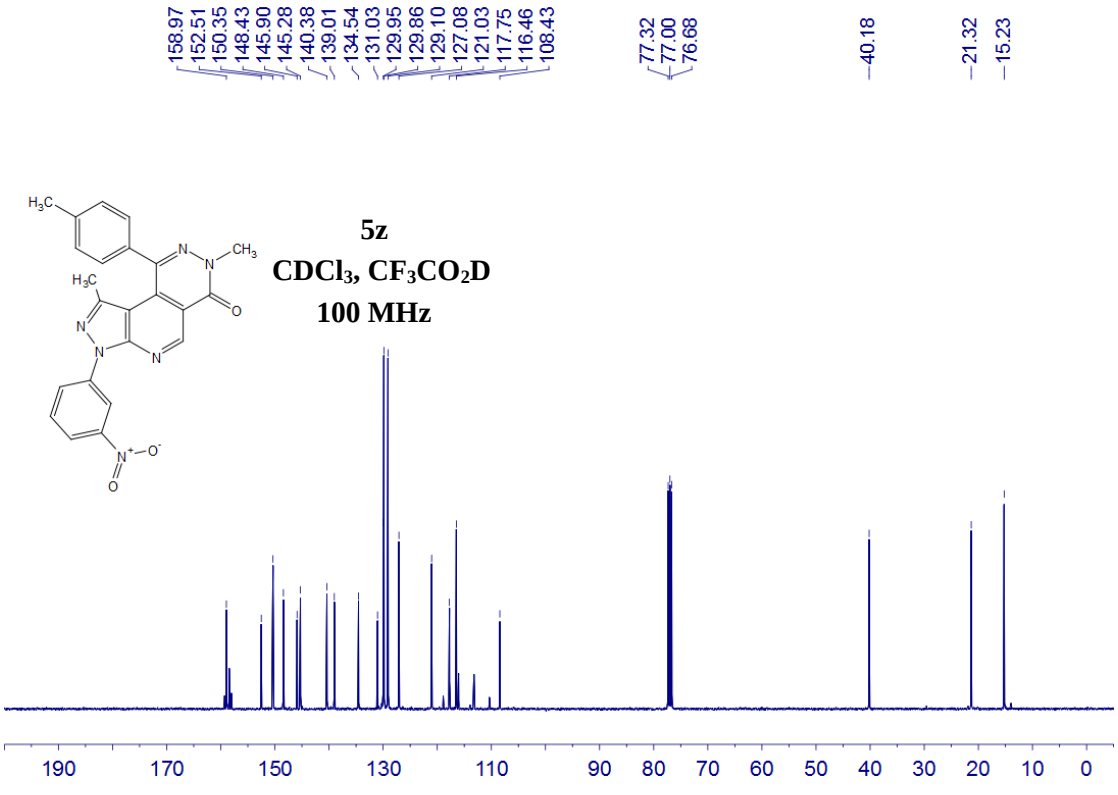

9.64
7.62
7.49
7.47
7.44
7.42
7.37
7.35
7.29
3.93
2.48
1.64
0.00
5y
CDCl3
400 MHz
1.02
1.09
4.07
2.00
3.07
3.00
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.27
153.62
150.60
144.71
144.23
139.69
135.85
135.14
133.80
133.01
130.98
130.40
130.31
129.66
129.11
127.81
117.81
106.67
77.32
77.00
76.68
39.53
21.32
15.31
5y
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

5z

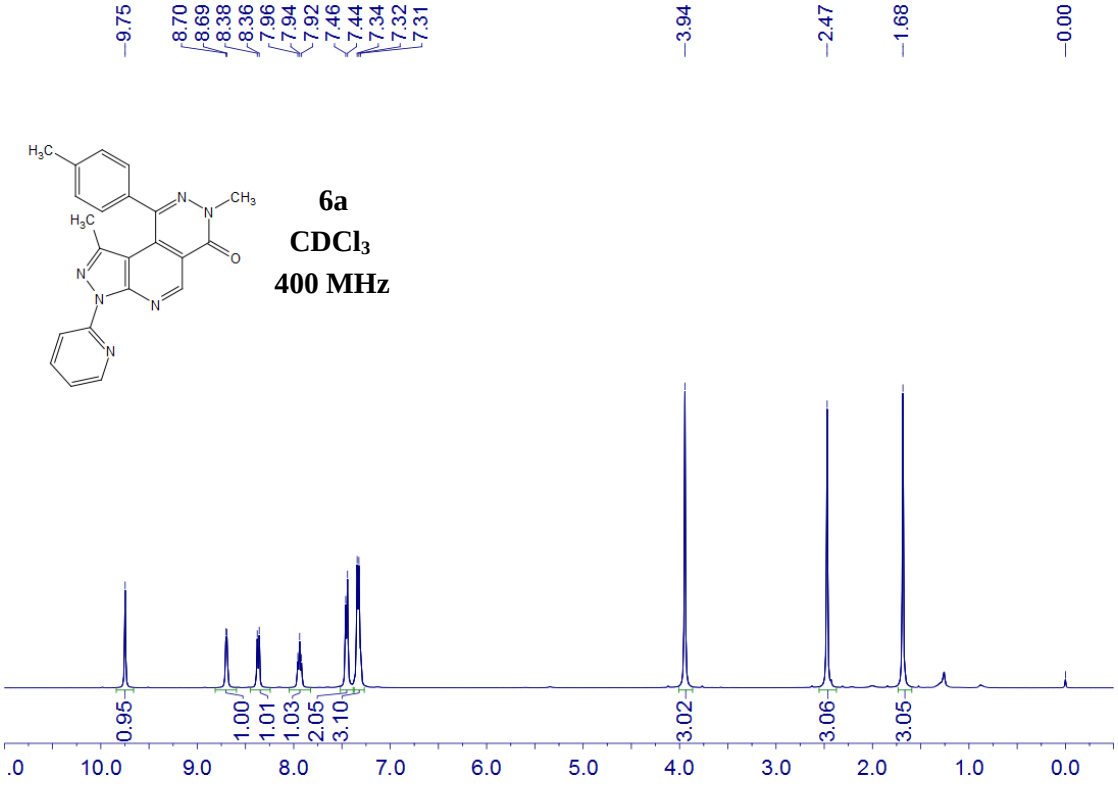


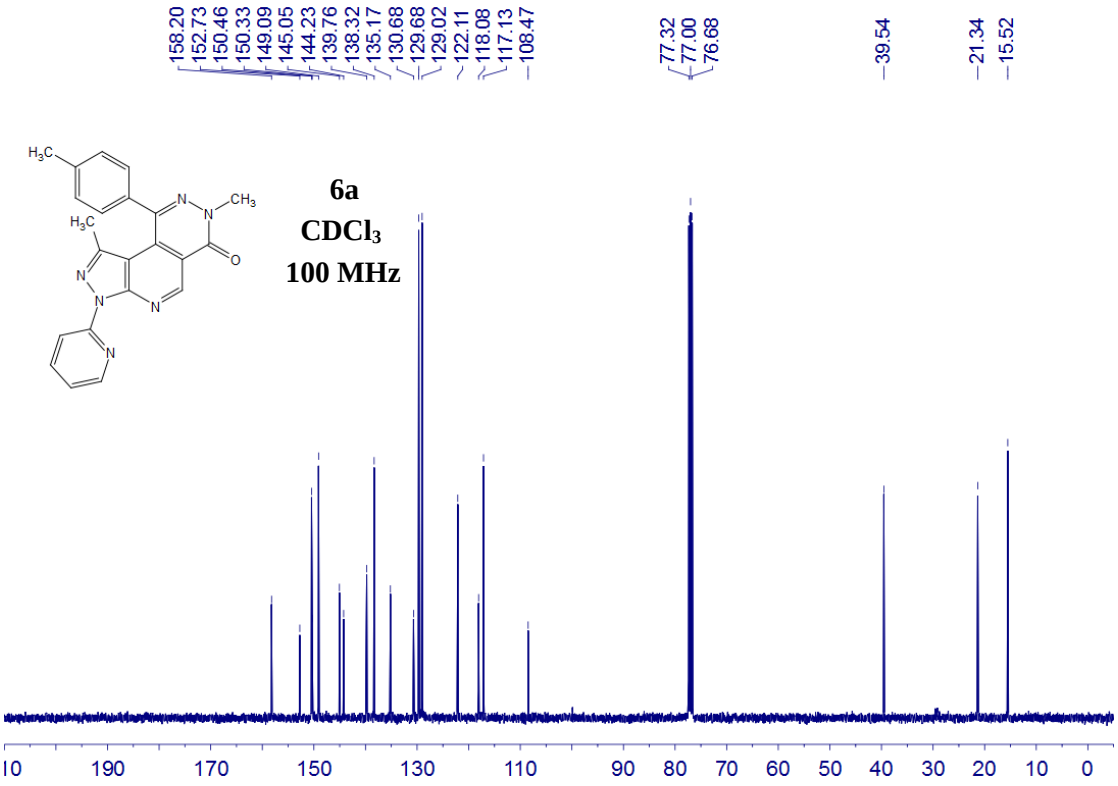
5z
$CDCl_3$, CF_3CO_2D
400 MHz



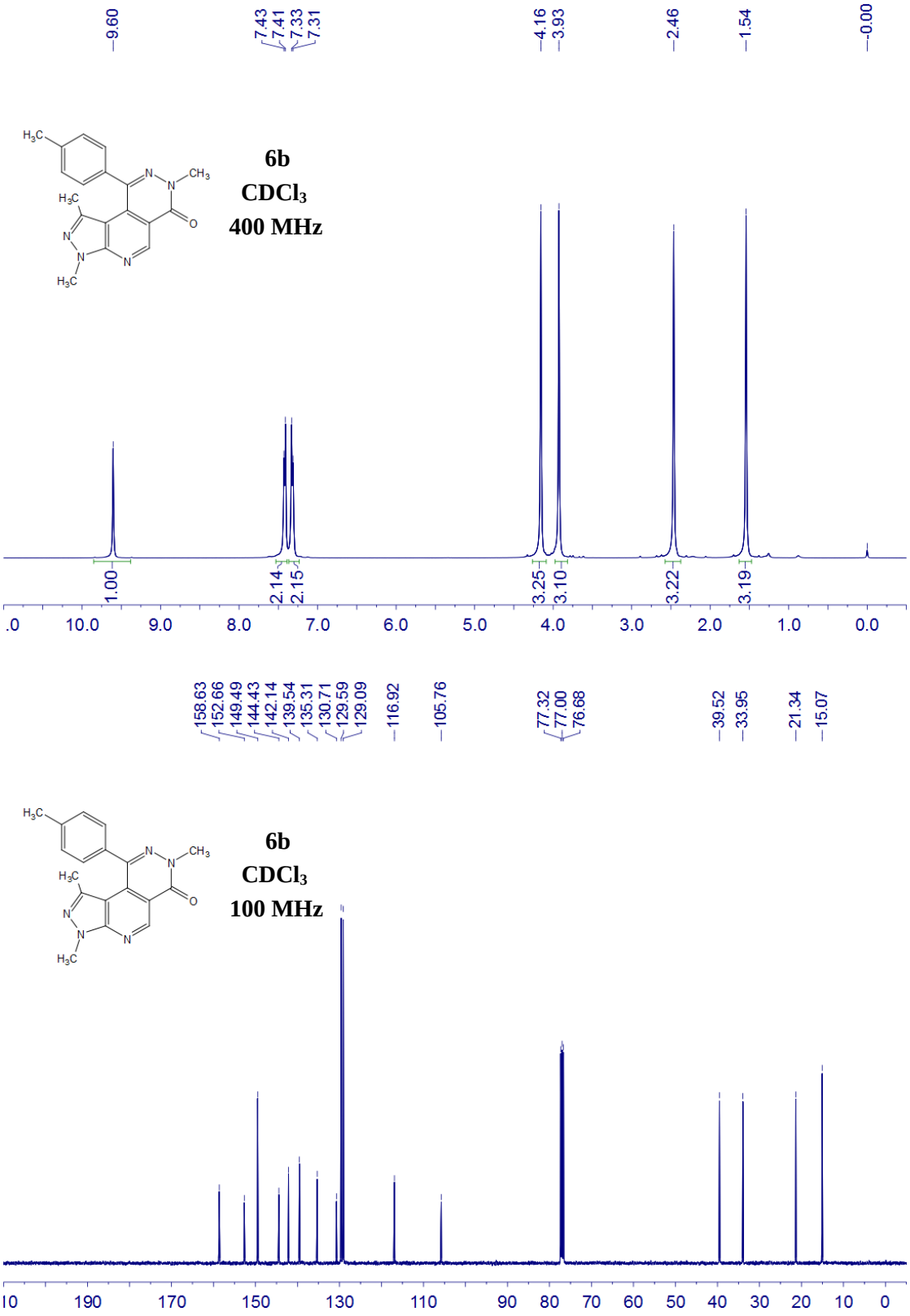
5z
$CDCl_3$, CF_3CO_2D
100 MHz

6a

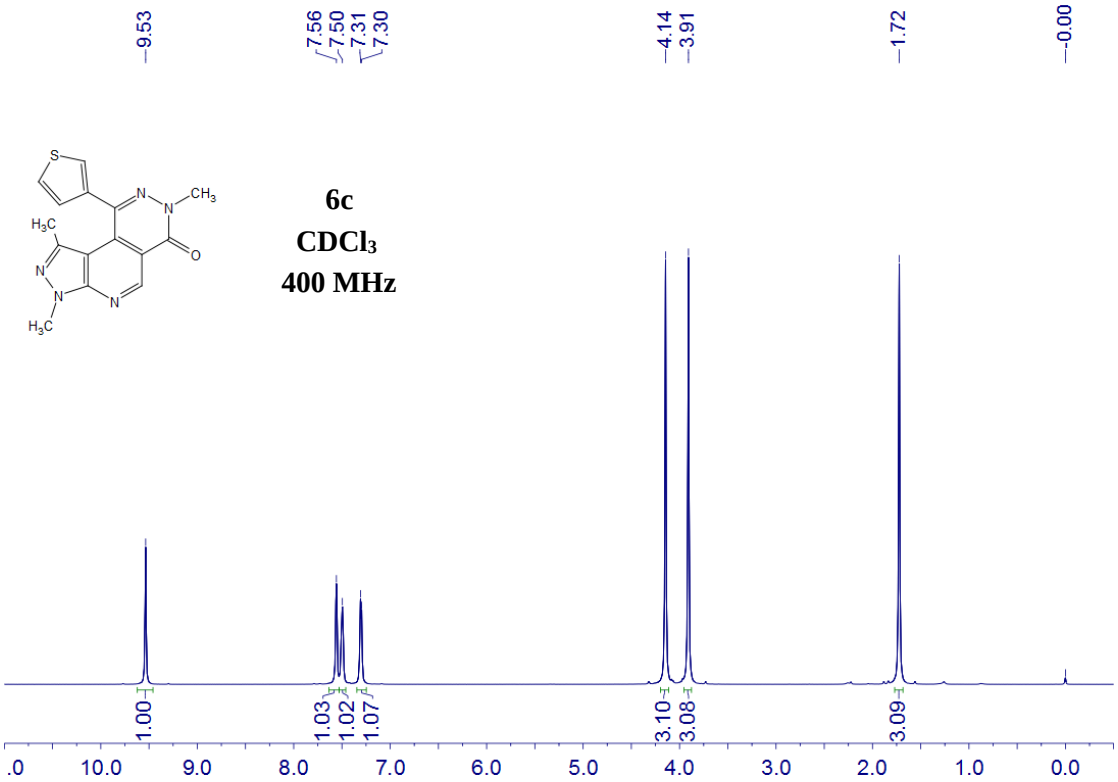

9.75
8.70
8.69
8.38
8.36
7.96
7.94
7.92
7.46
7.44
7.34
7.32
7.31
3.94
2.47
1.68
0.00
6a
CDCl3
400 MHz
0.95
1.00
1.01
1.03
2.05
3.10
3.02
3.06
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.20
152.73
150.46
150.33
149.09
145.05
144.23
139.76
138.32
135.17
130.68
129.68
129.02
122.11
118.08
117.13
108.47
77.32
77.00
76.68
39.54
21.34
15.52
6a
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

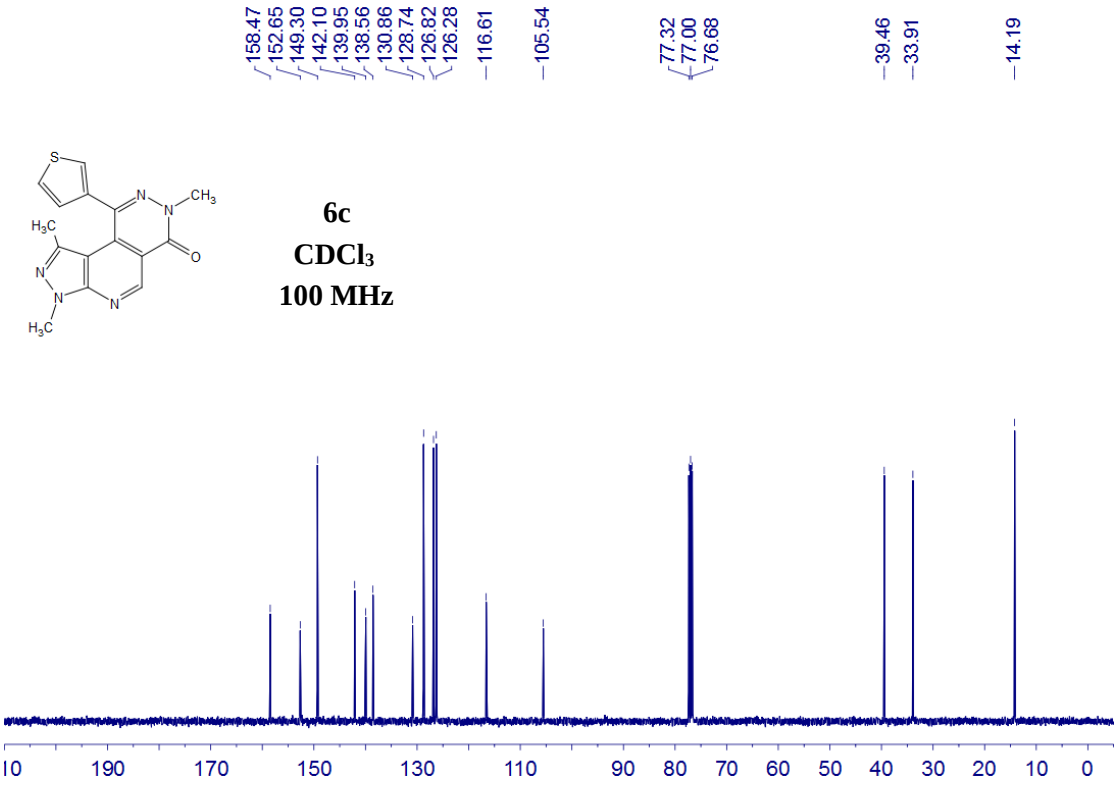
6b


9.60
7.43
7.41
7.33
7.31
4.16
3.93
2.46
1.54
0.00
6b
CDCl3
400 MHz
1.00
2.14
2.15
3.25
3.10
3.22
3.19
158.63
152.66
149.49
144.43
142.14
139.54
135.31
130.71
129.59
129.09
116.92
105.76
77.32
77.00
76.68
39.52
33.95
21.34
15.07
6b
CDCl3
100 MHz

6c

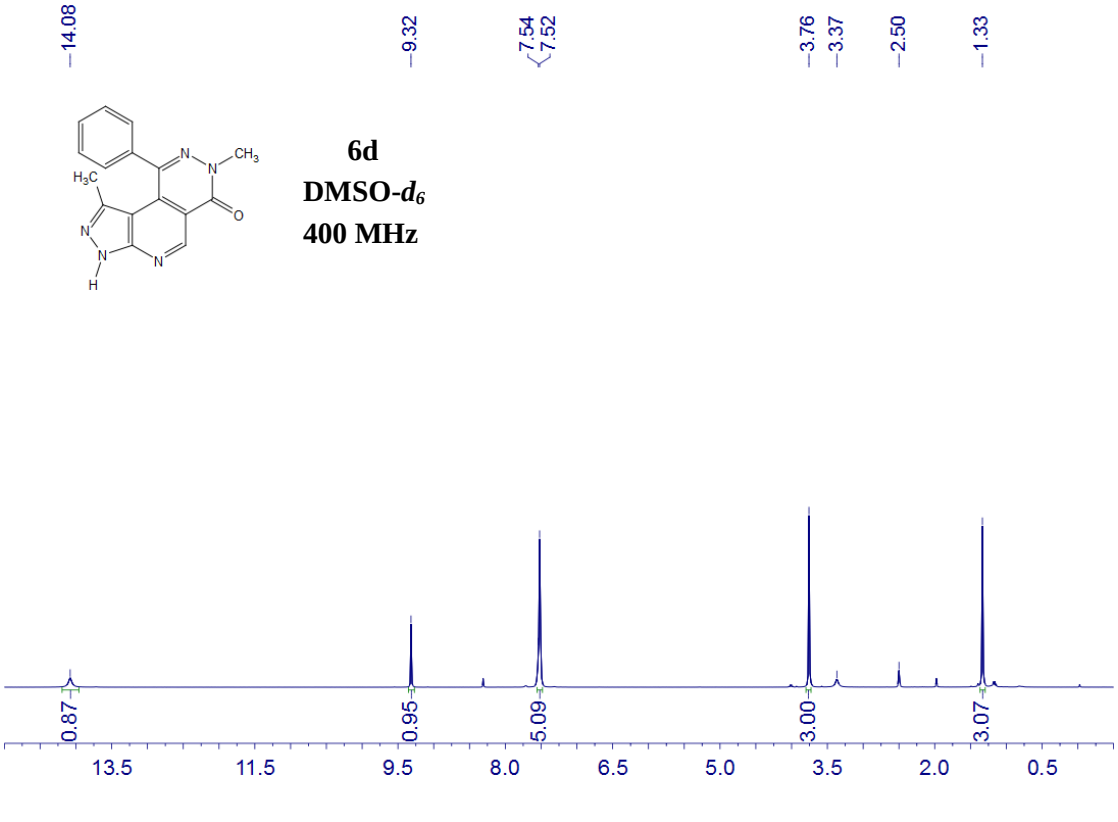


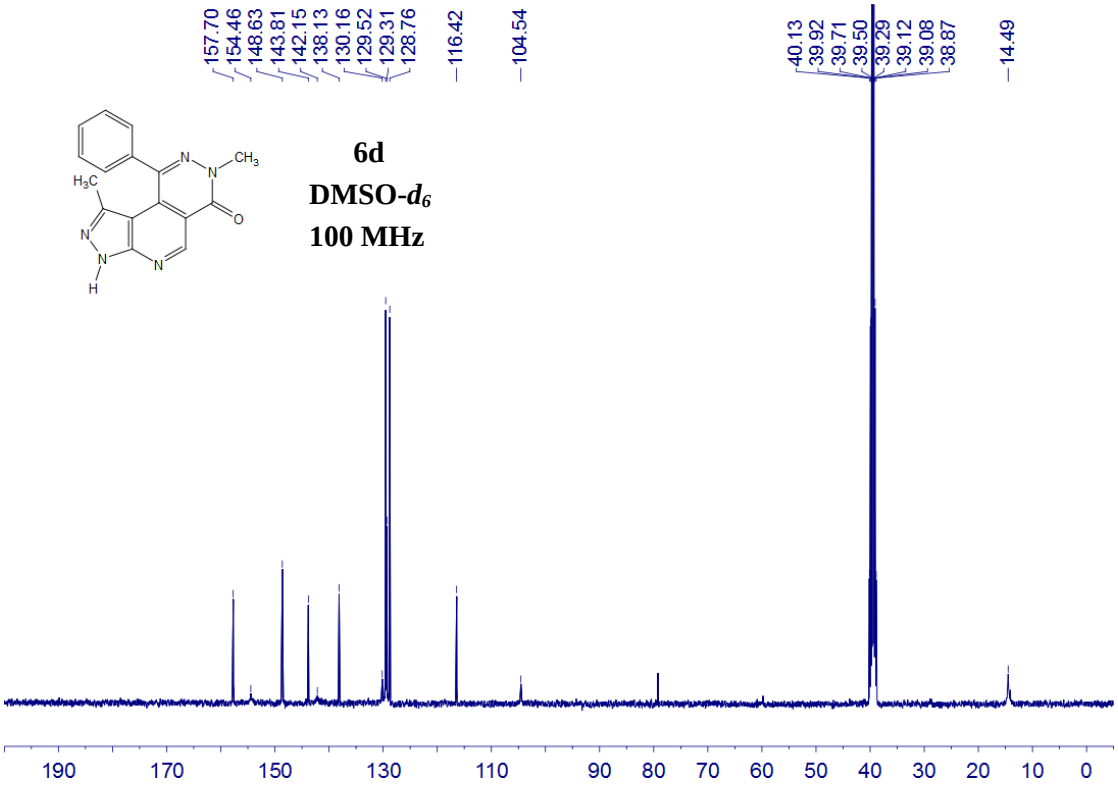
6c
$CDCl_3$
400 MHz



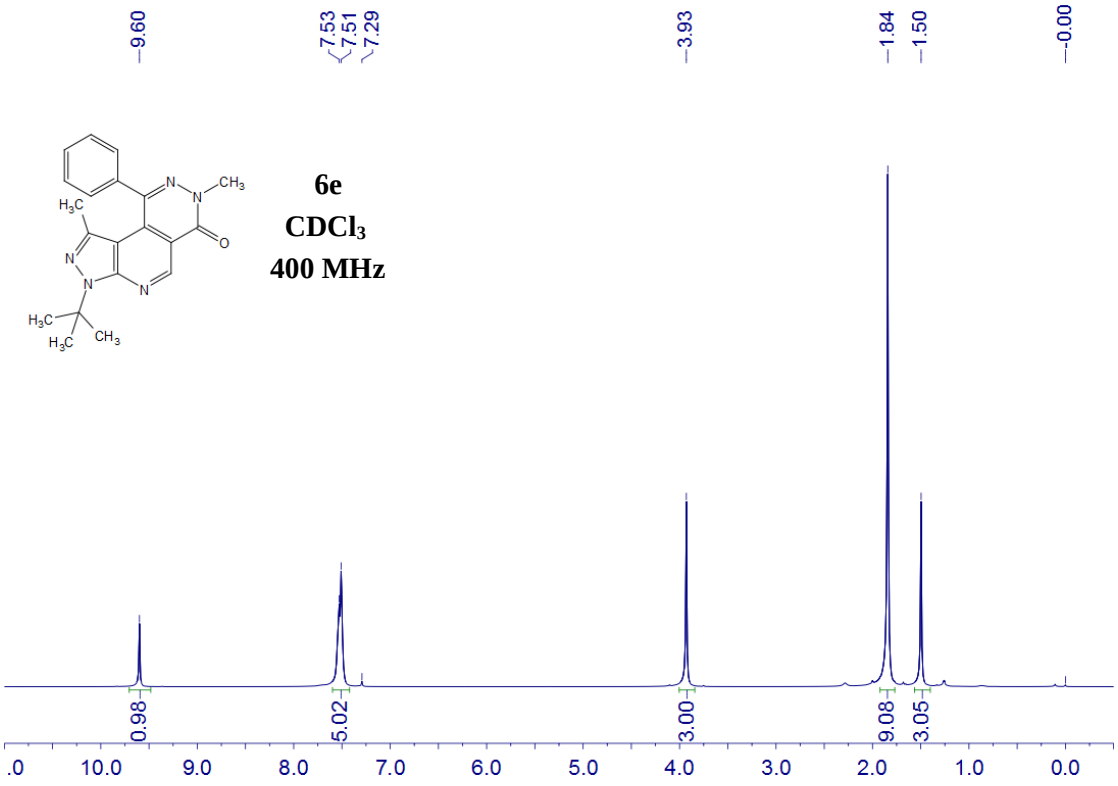
6c
$CDCl_3$
100 MHz

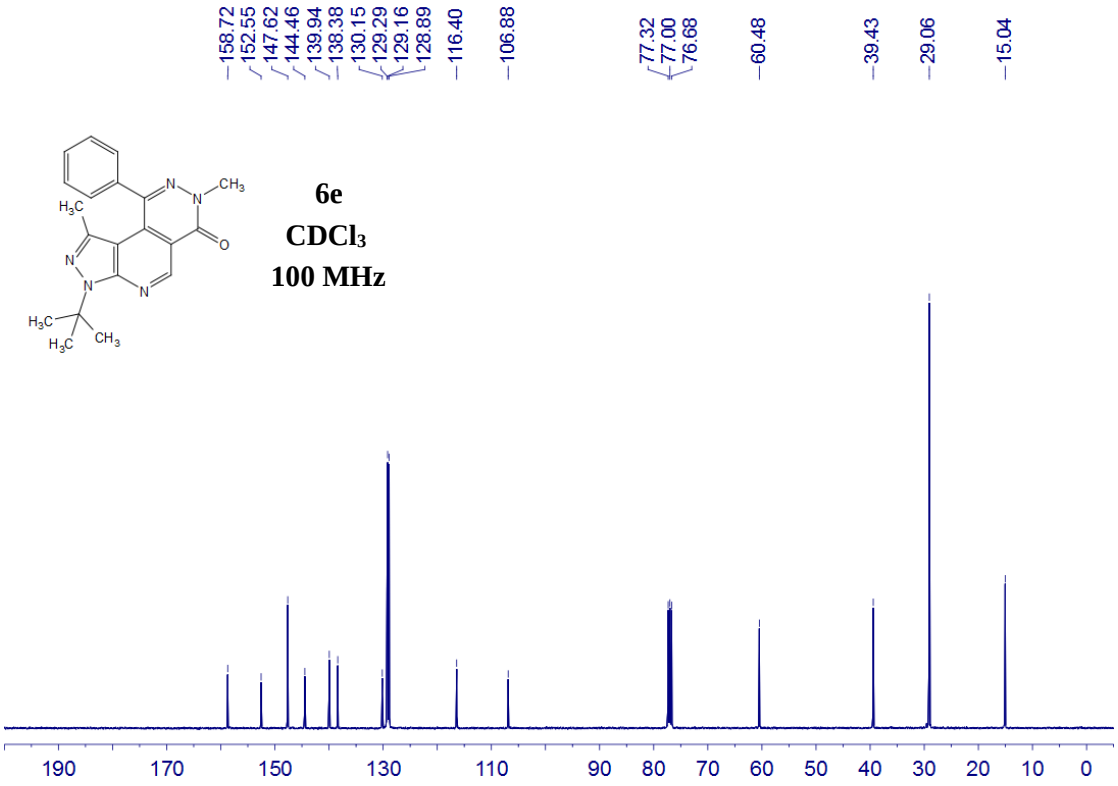
6d


14.08
9.32
7.54
7.52
3.76
3.37
2.50
1.33
6d
DMSO-d6
400 MHz
0.87
0.95
5.09
3.00
3.07
13.5
11.5
9.5
8.0
6.5
5.0
3.5
2.0
0.5

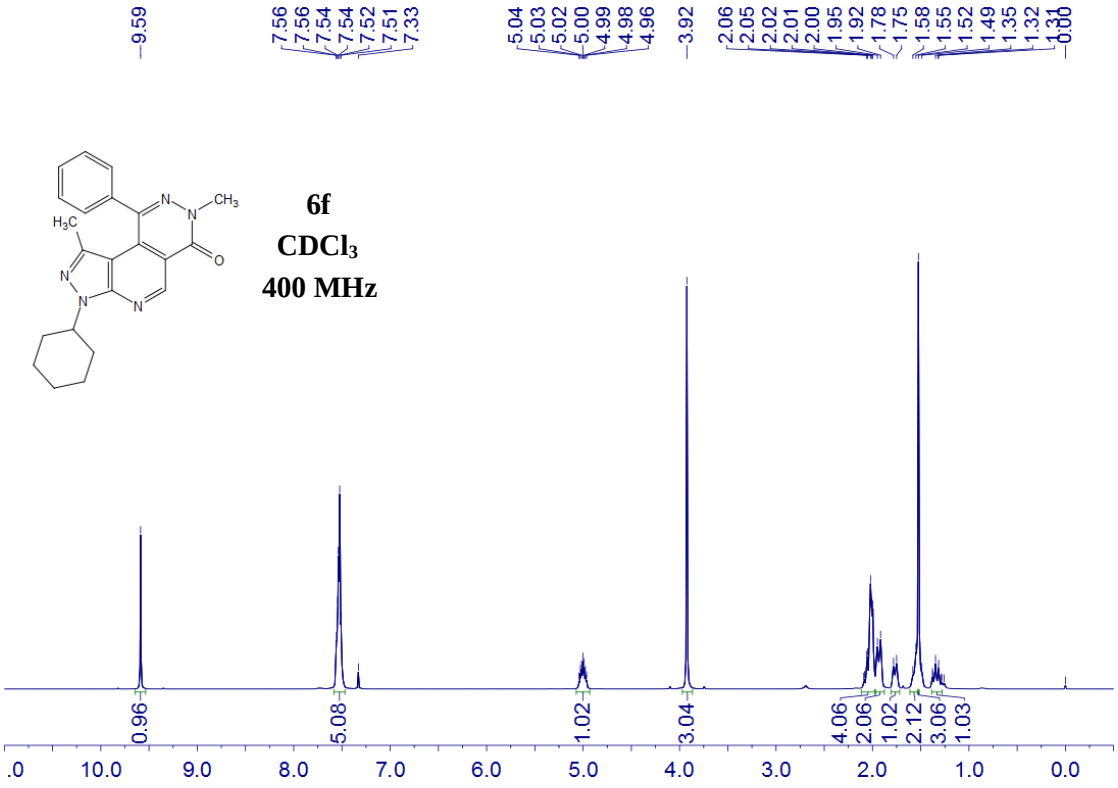

157.70
154.46
148.63
143.81
142.15
138.13
130.16
129.52
129.31
128.76
116.42
104.54
40.13
39.92
39.71
39.50
39.29
39.12
39.08
38.87
14.49
6d
DMSO-d6
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6e


9.60
7.53
7.51
7.29
3.93
1.84
1.50
0.00
6e
CDCl3
400 MHz
0.98
5.02
3.00
9.08
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


158.72
152.55
147.62
144.46
139.94
138.38
130.15
129.29
129.16
128.89
116.40
106.88
77.32
77.00
76.68
60.48
39.43
29.06
15.04
6e
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6f


9.59
7.56
7.56
7.54
7.54
7.52
7.51
7.33
5.04
5.03
5.02
5.00
4.99
4.98
4.96
3.92
2.06
2.05
2.02
2.01
2.00
1.95
1.92
1.78
1.75
1.58
1.55
1.52
1.49
1.35
1.32
1.31
0.00
6f
CDCl3
400 MHz
0.96
5.08
1.02
3.04
4.06
2.06
1.02
2.12
3.06
1.03
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9.0
8.0
7.0
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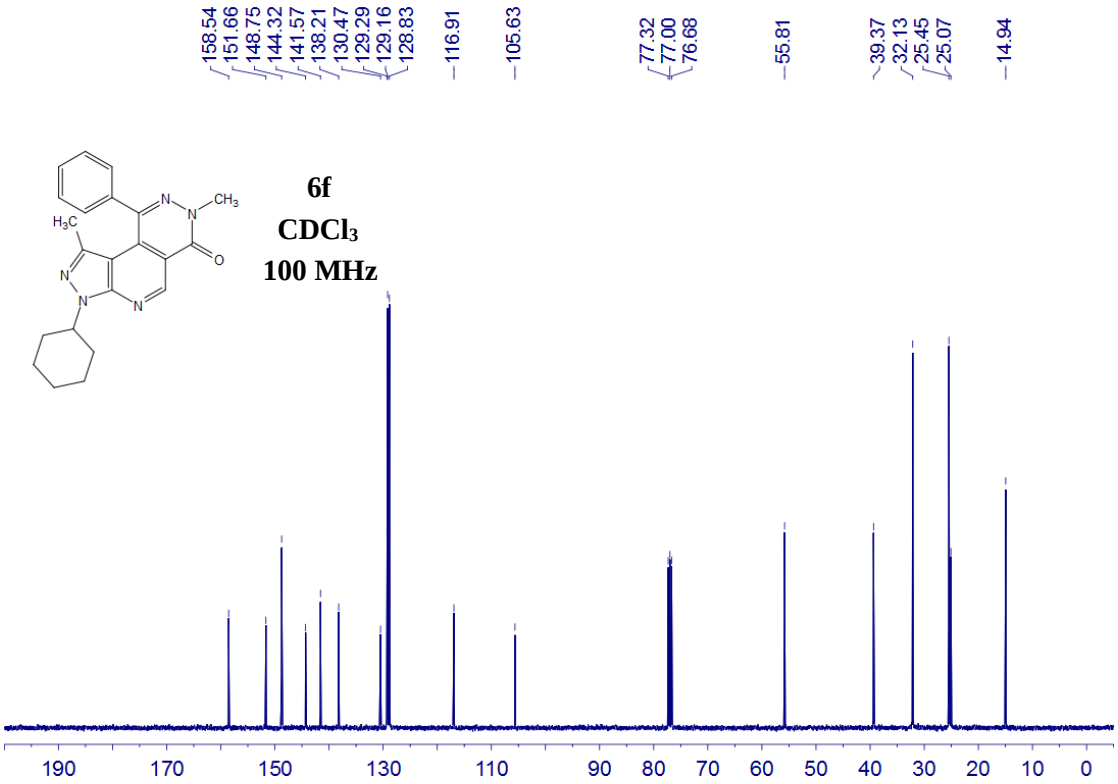
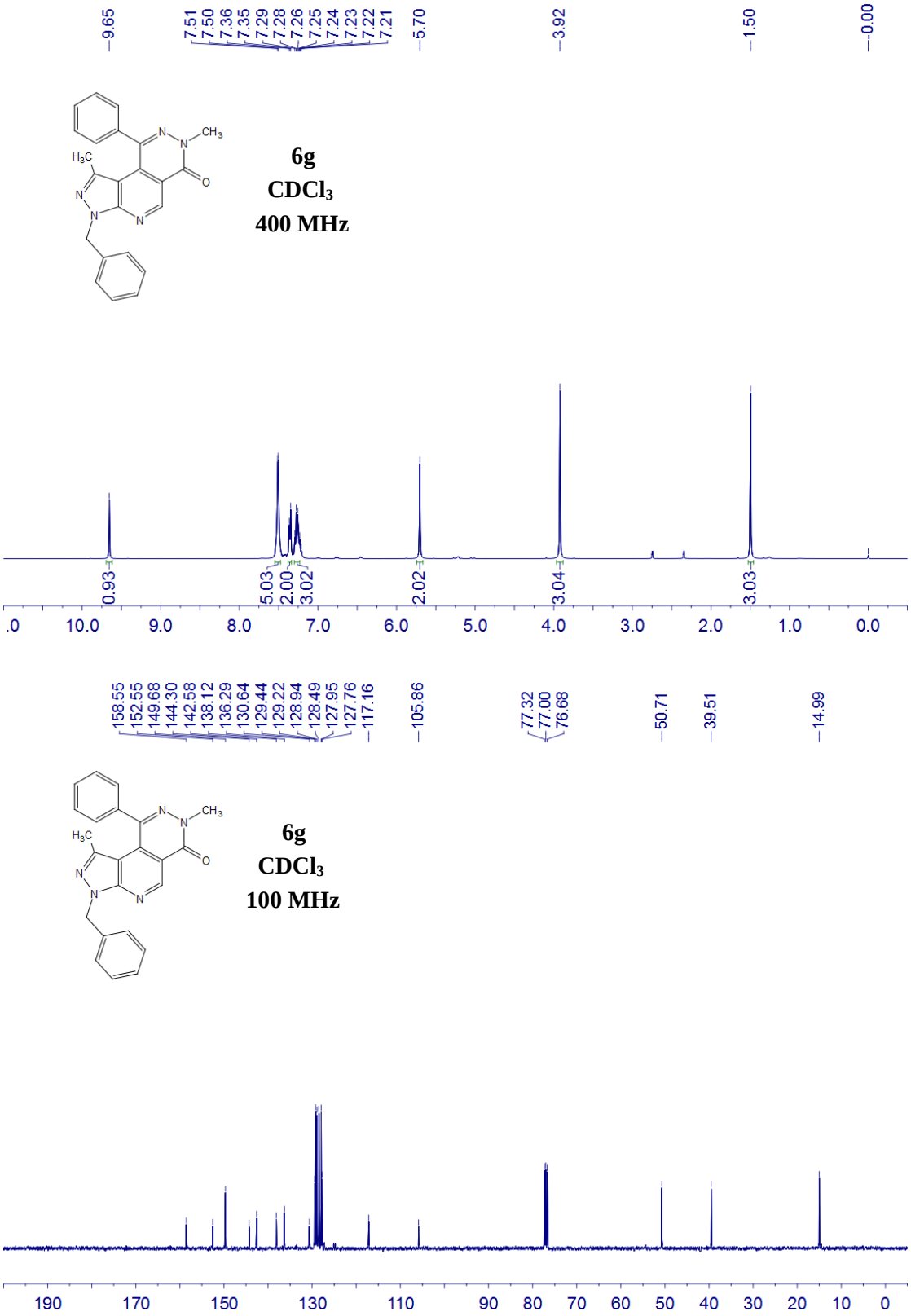
4.0
3.0
2.0
1.0
0.0


158.54
151.66
148.75
144.32
141.57
138.21
130.47
129.29
129.16
128.83
116.91
105.63
77.32
77.00
76.68
55.81
39.37
32.13
25.45
25.07
14.94
6f
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6g


9.65
7.51
7.50
7.36
7.35
7.29
7.28
7.26
7.25
7.24
7.23
7.22
7.21
5.70
3.92
1.50
0.00
6g
CDCl3
400 MHz
0.93
5.03
2.00
3.02
2.02
3.04
3.03
158.55
152.55
149.68
144.30
142.58
138.12
136.29
130.64
129.44
129.22
128.94
128.49
127.95
127.76
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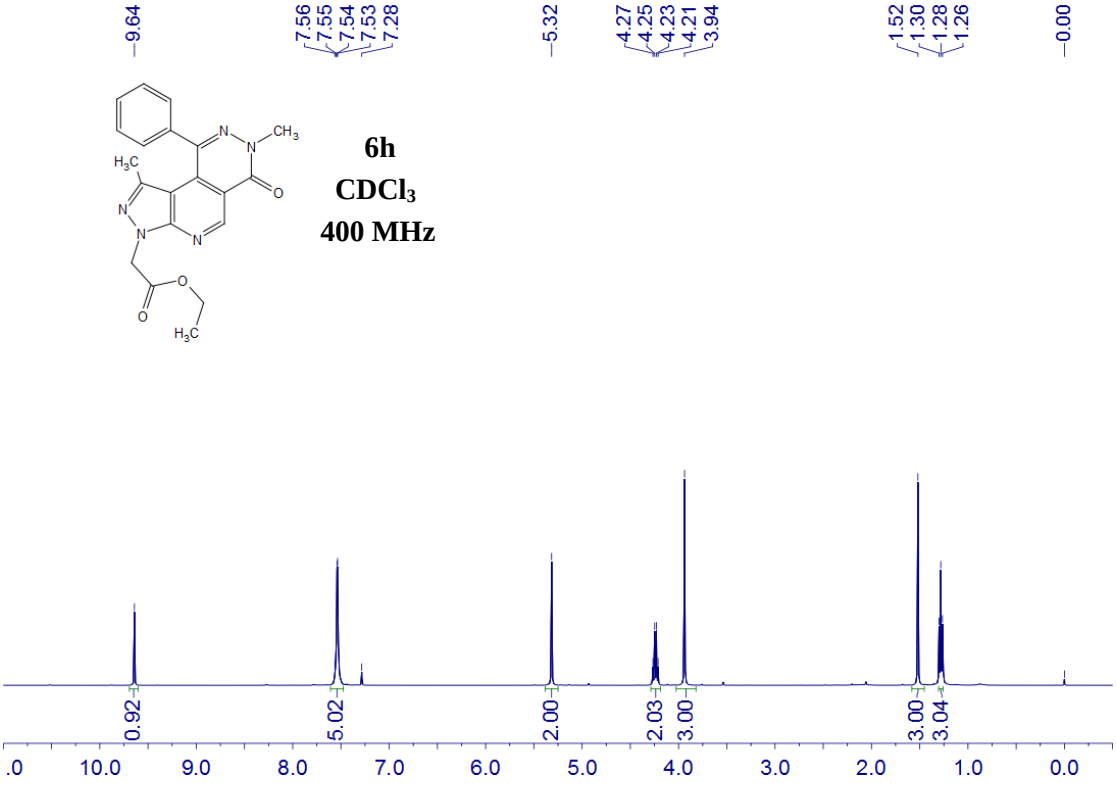
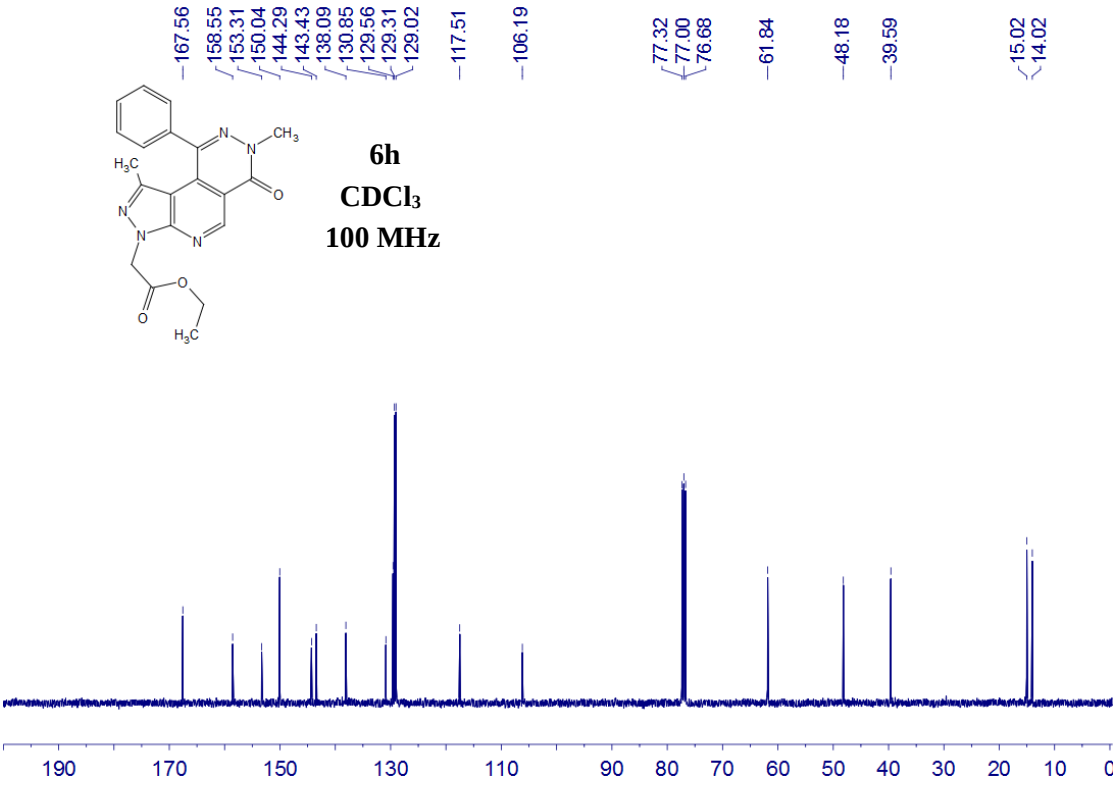
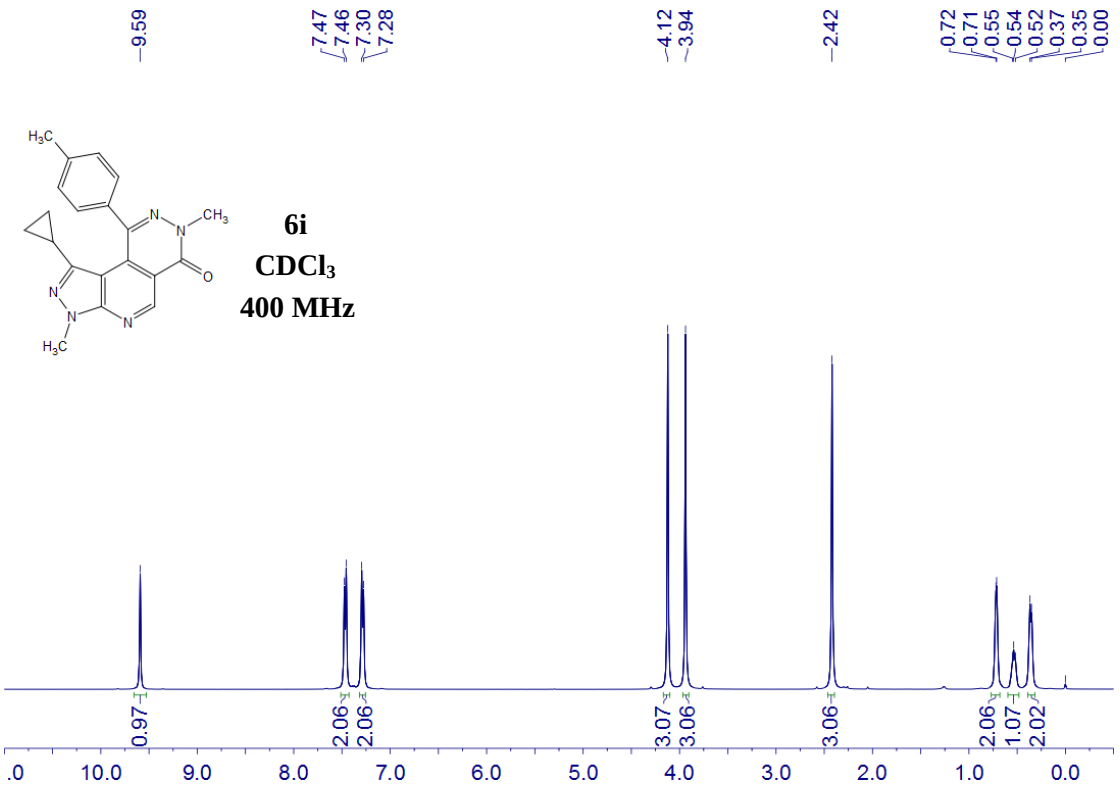
105.86
77.32
77.00
76.68
50.71
39.51
14.99
6g
CDCl3
100 MHz

6h

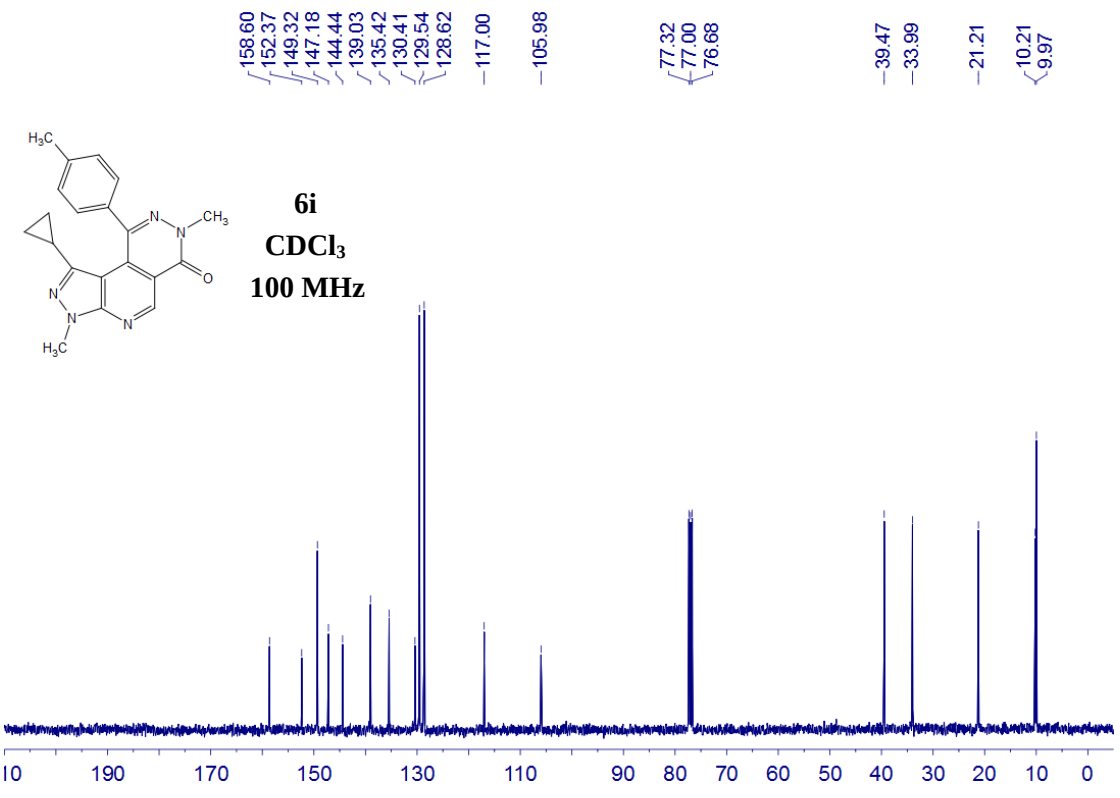

9.64
7.56
7.55
7.54
7.53
7.28
5.32
4.27
4.25
4.23
4.21
3.94
1.52
1.30
1.28
1.26
0.00
6h
CDCl3
400 MHz
0.92
5.02
2.00
2.03
3.00
3.00
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


167.56
158.55
153.31
150.04
144.29
143.43
138.09
130.85
129.56
129.31
129.02
117.51
106.19
77.32
77.00
76.68
61.84
48.18
39.59
15.02
14.02
6h
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10

6i

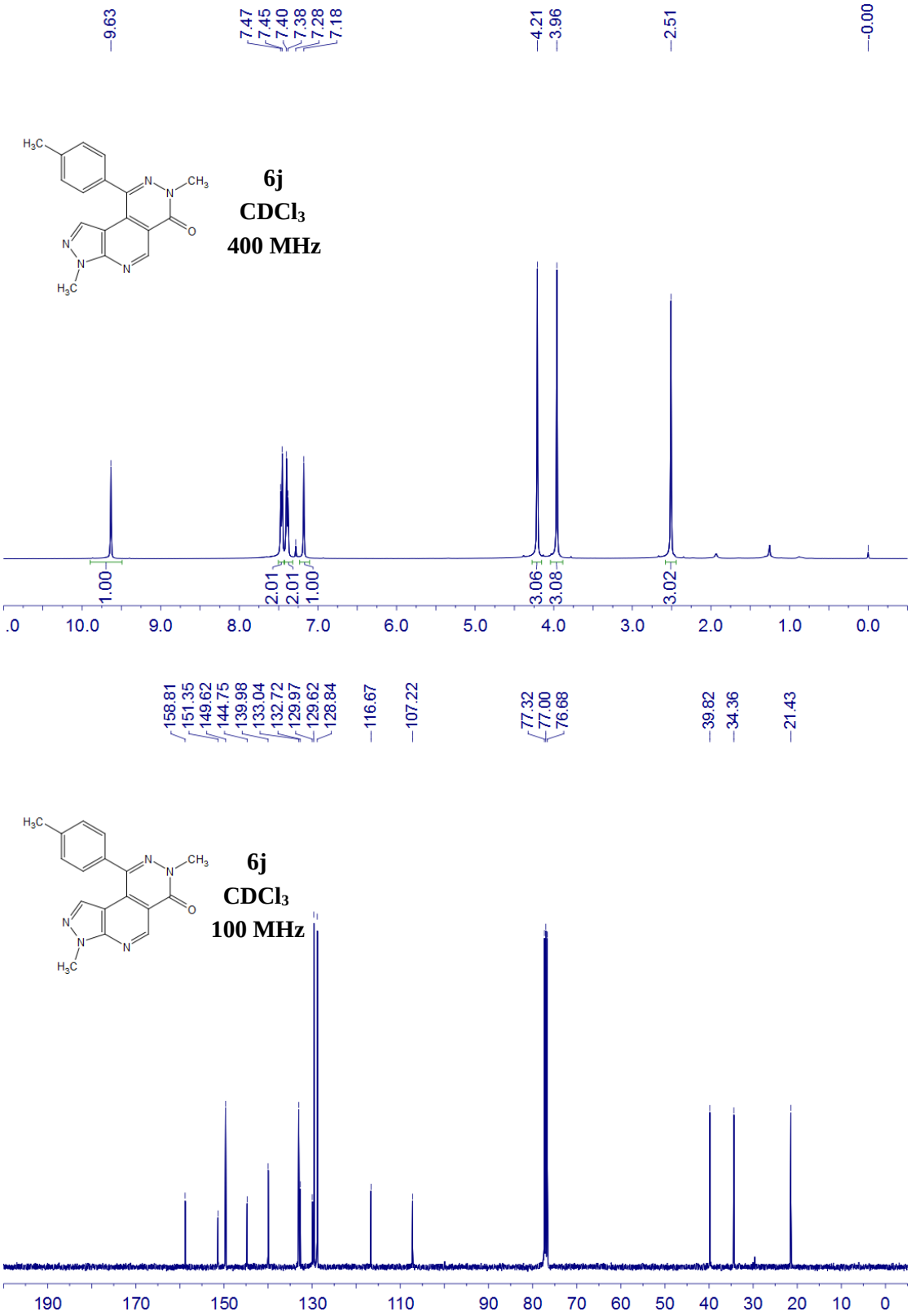


6i
$CDCl_3$
400 MHz

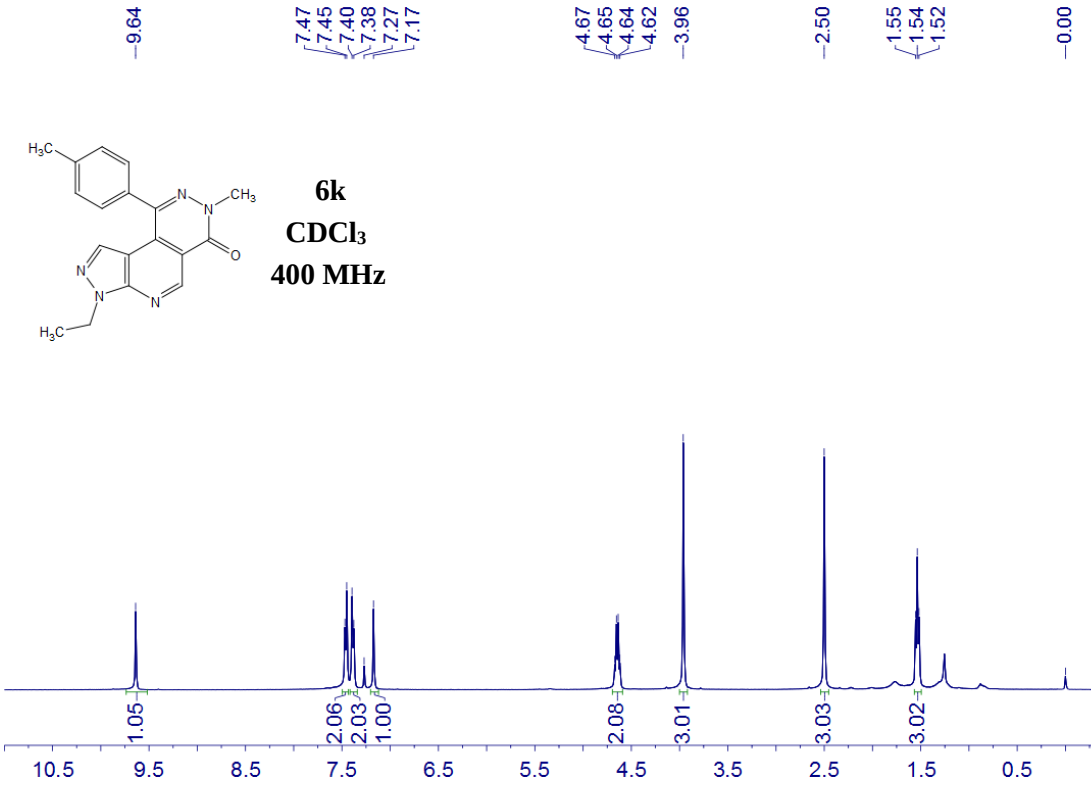


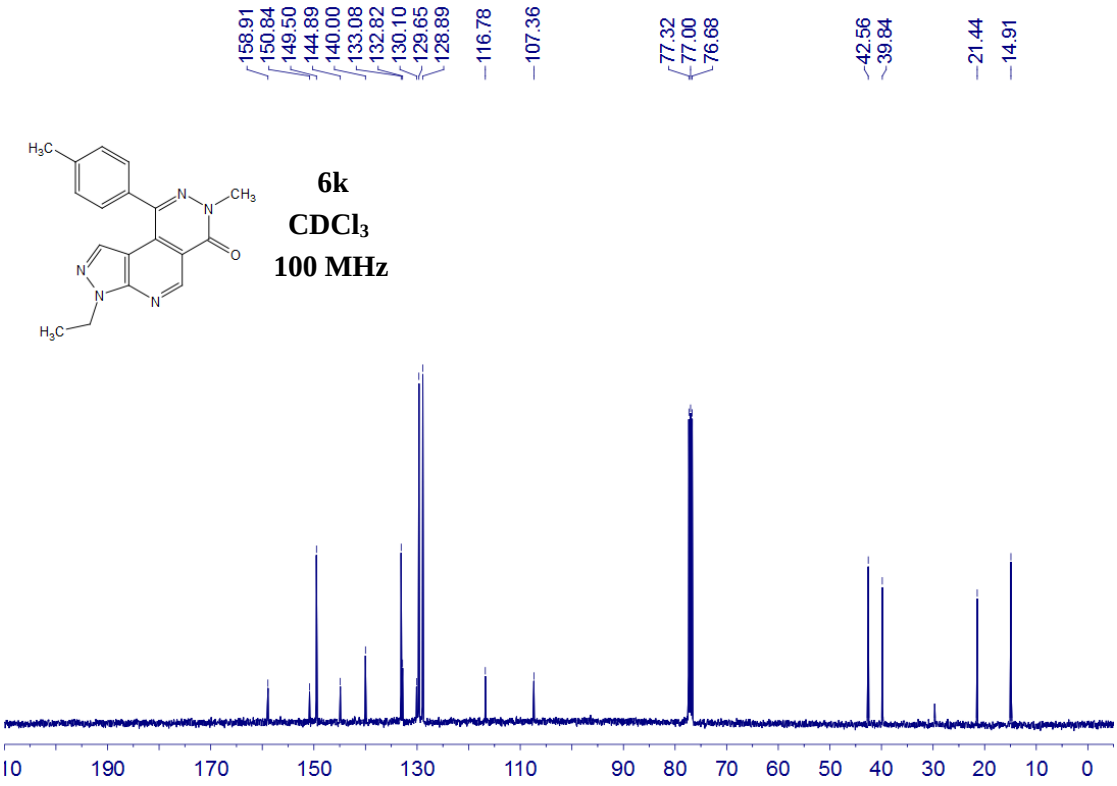
6i
$CDCl_3$
100 MHz

6j

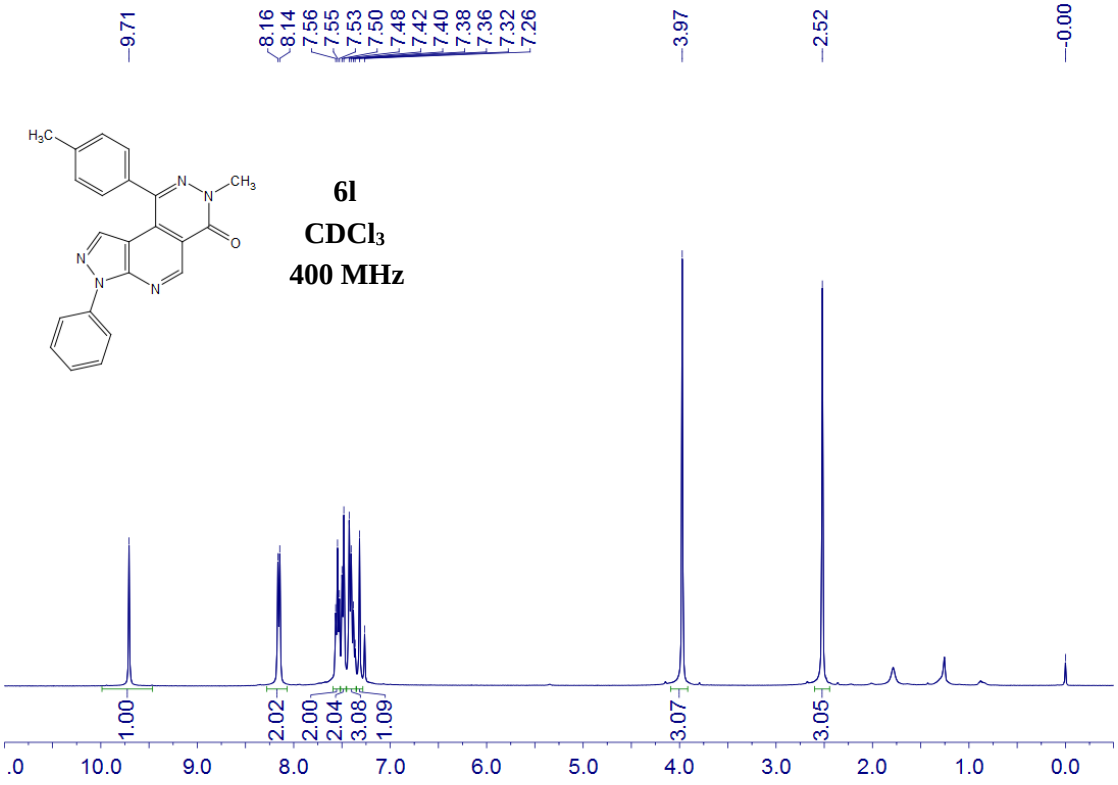

9.63
7.47
7.45
7.40
7.38
7.28
7.18
4.21
3.96
2.51
0.00
6j
CDCl3
400 MHz
1.00
2.01
2.01
1.00
3.06
3.08
3.02
158.81
151.35
149.62
144.75
139.98
133.04
132.72
129.97
129.62
128.84
116.67
107.22
77.32
77.00
76.68
39.82
34.36
21.43
6j
CDCl3
100 MHz

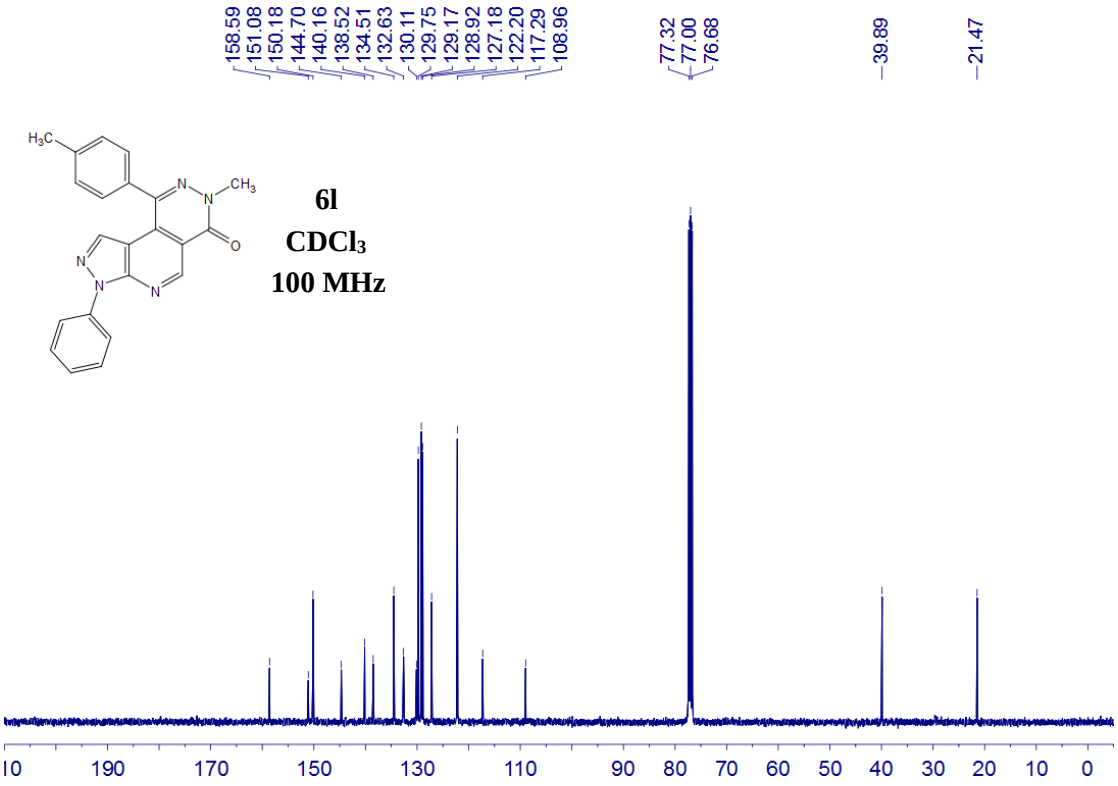
6k


9.64
7.47
7.45
7.40
7.38
7.27
7.17
4.67
4.65
4.64
4.62
3.96
2.50
1.55
1.54
1.52
0.00
6k
CDCl3
400 MHz
1.05
2.06
2.03
1.00
2.08
3.01
3.03
3.02
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5

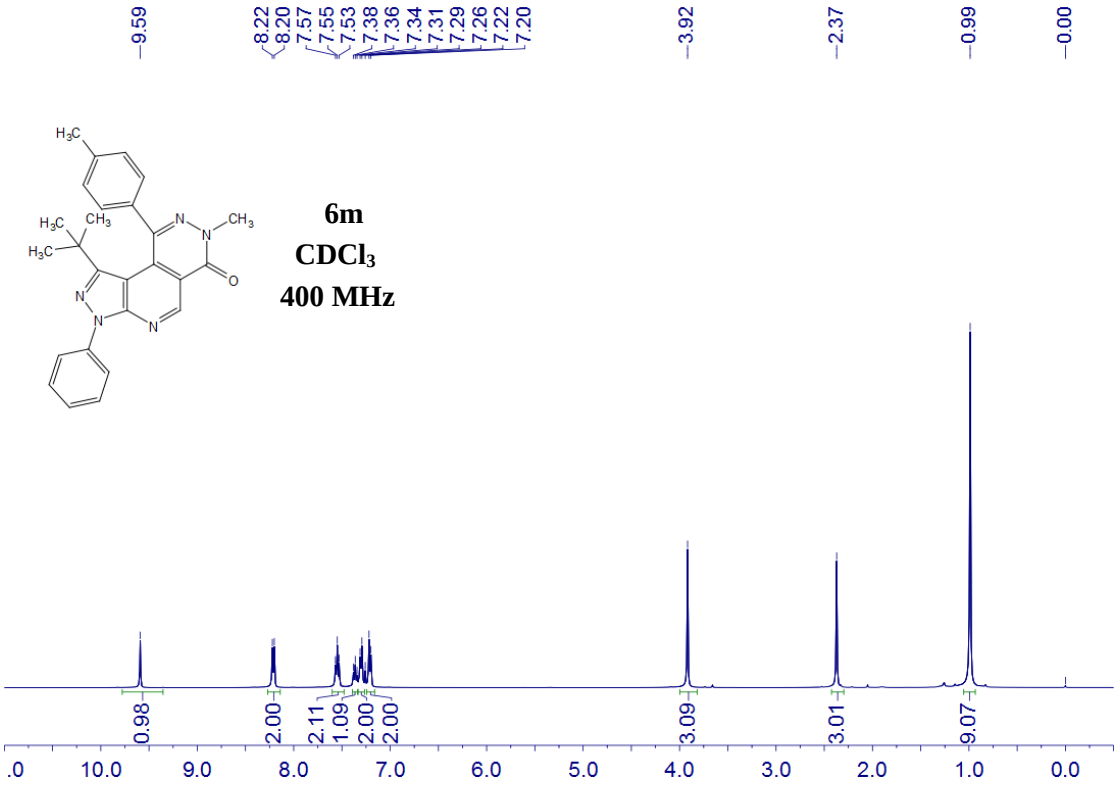

158.91
150.84
149.50
144.89
140.00
133.08
132.82
130.10
129.65
128.89
116.78
107.36
77.32
77.00
76.68
42.56
39.84
21.44
14.91
6k
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

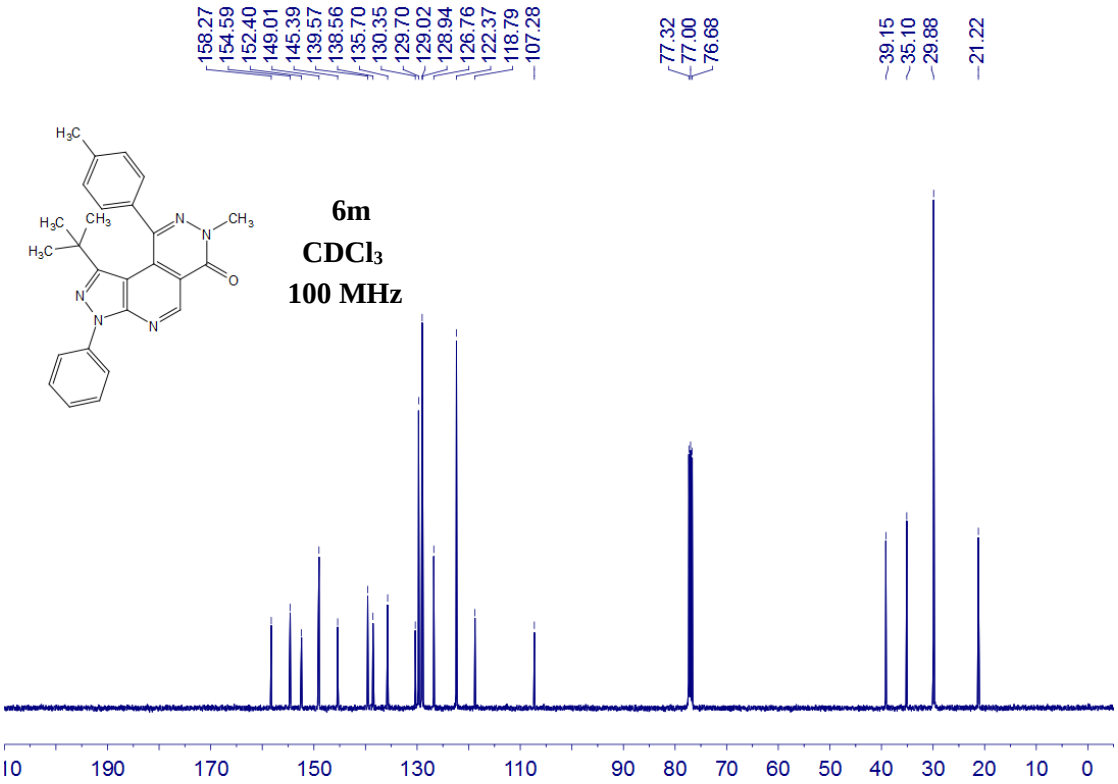
6l


9.71
8.16
8.14
7.56
7.55
7.53
7.50
7.48
7.42
7.40
7.38
7.36
7.32
7.26
3.97
2.52
0.00
6l
CDCl3
400 MHz
1.00
2.02
2.00
2.04
3.08
1.09
3.07
3.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

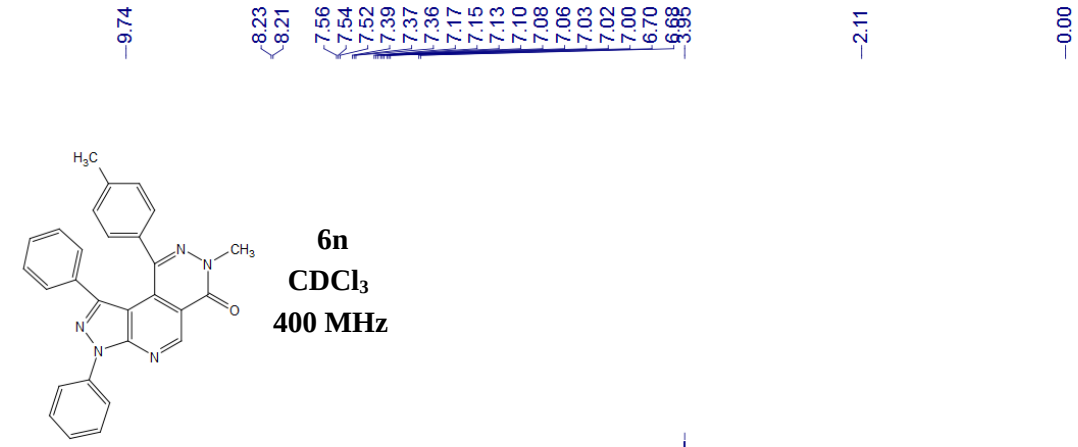

158.59
151.08
150.18
144.70
140.16
138.52
134.51
132.63
130.11
129.75
129.17
128.92
127.18
122.20
117.29
108.96
77.32
77.00
76.68
39.89
21.47
6l
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6m

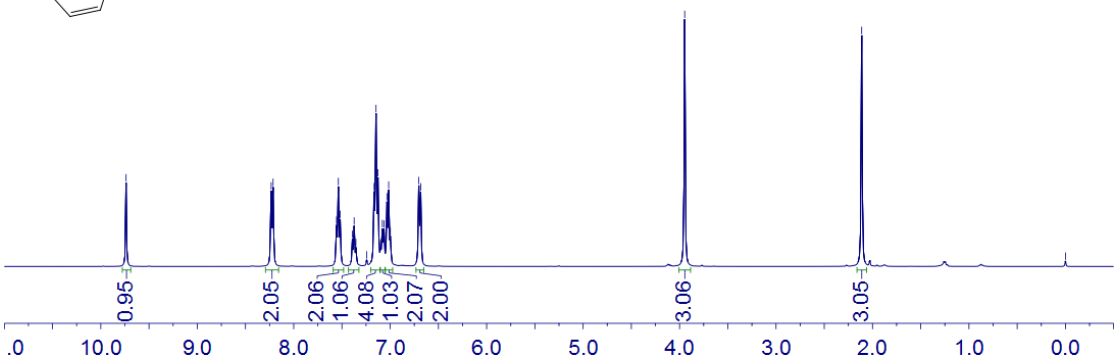

9.59
8.22
8.20
7.57
7.55
7.53
7.38
7.36
7.34
7.31
7.29
7.26
7.22
7.20
3.92
2.37
0.99
0.00
6m
CDCl3
400 MHz
0.98
2.00
2.11
1.09
2.00
2.00
3.09
3.01
9.07
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

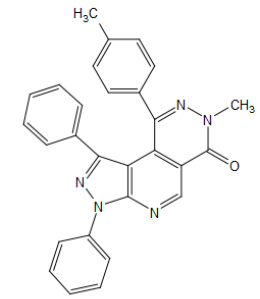

158.27
154.59
152.40
149.01
145.39
139.57
138.56
135.70
130.35
129.70
129.02
128.94
126.76
122.37
118.79
107.28
77.32
77.00
76.68
39.15
35.10
29.88
21.22
6m
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6n



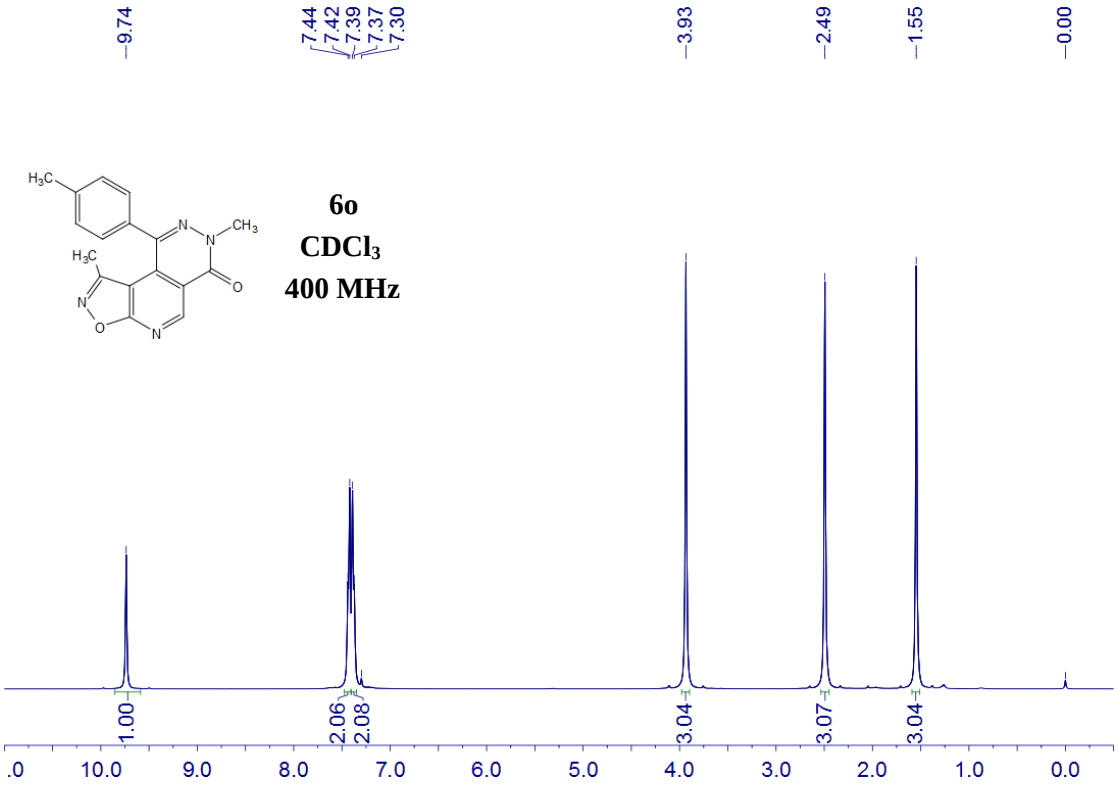
6n
$CDCl_3$
400 MHz

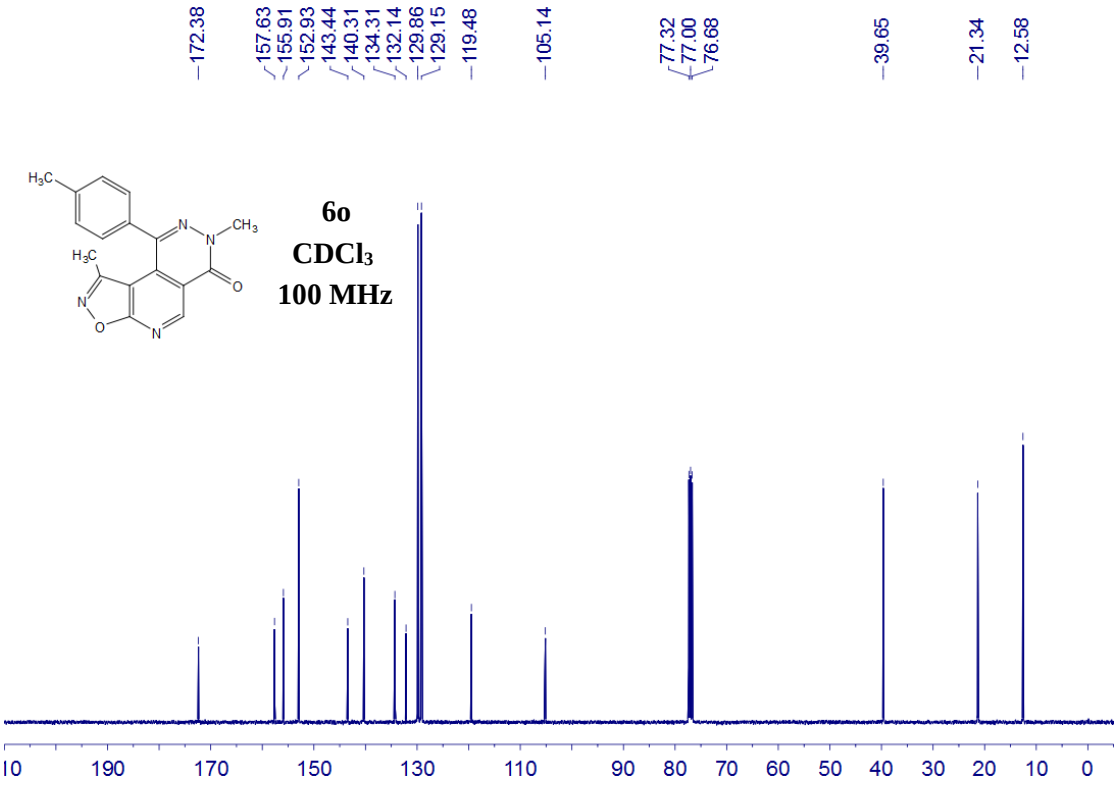




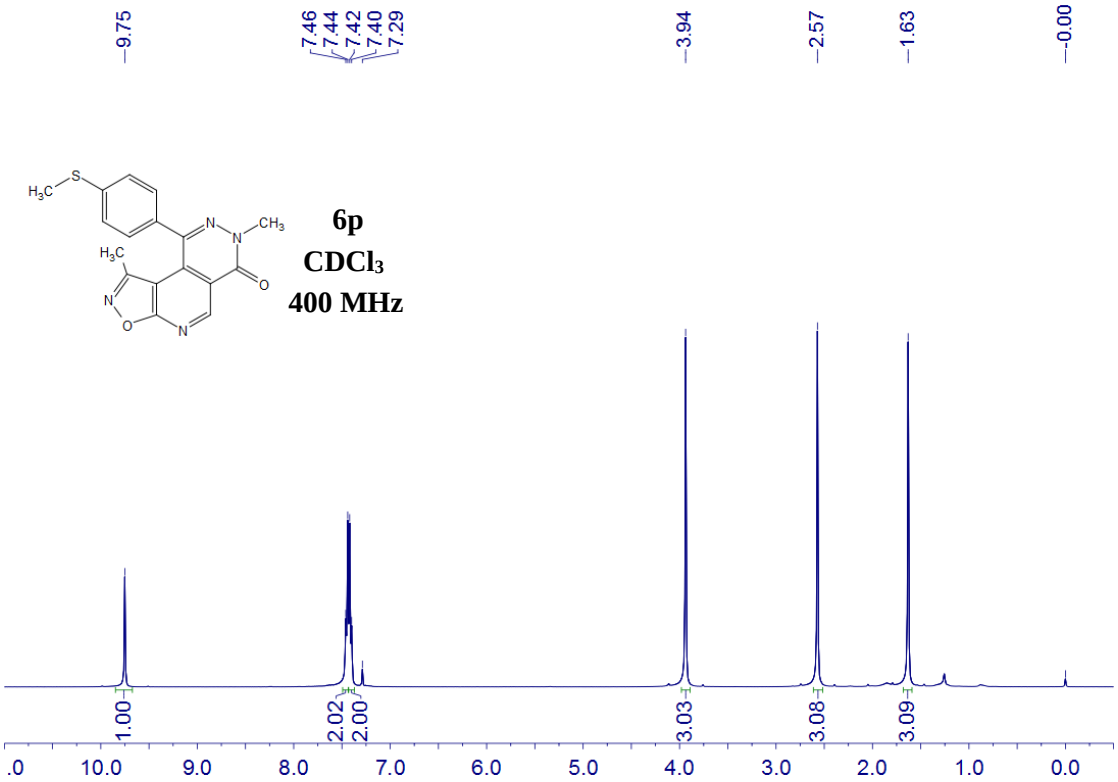
6n
$CDCl_3$
100 MHz

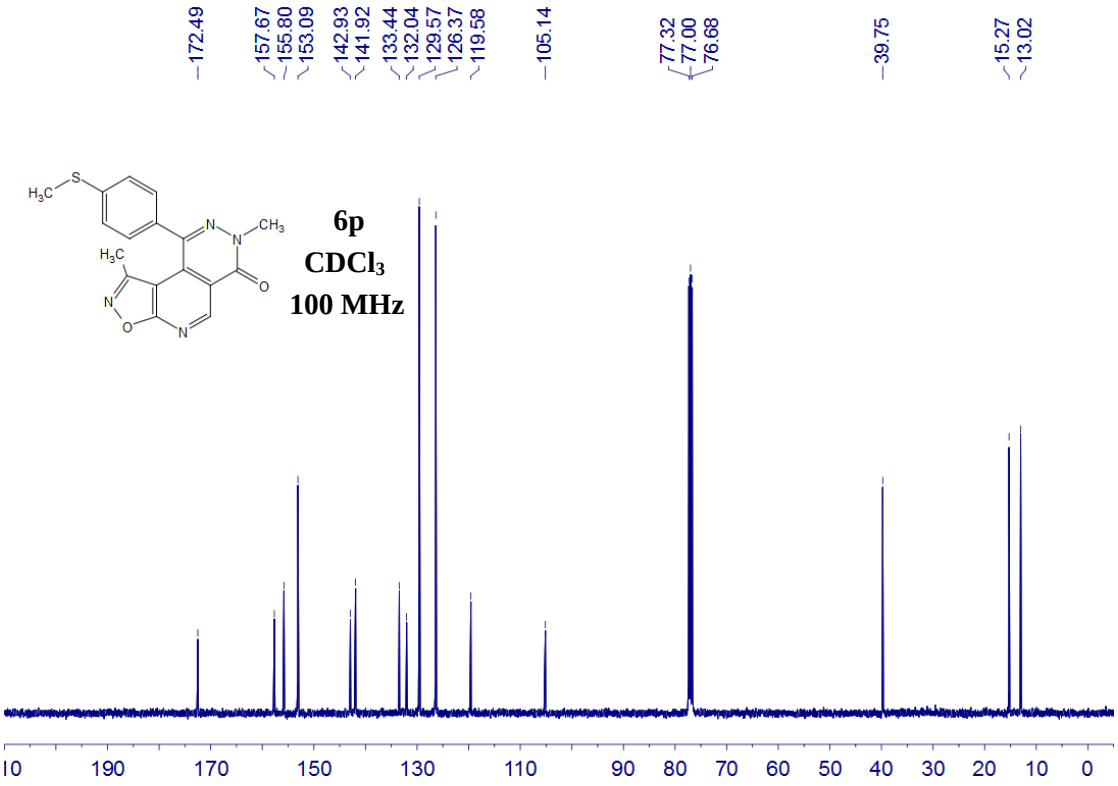
6o


9.74
7.44
7.42
7.39
7.37
7.30
3.93
2.49
1.55
0.00
6o
CDCl3
400 MHz
1.00
2.06
2.08
3.04
3.07
3.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

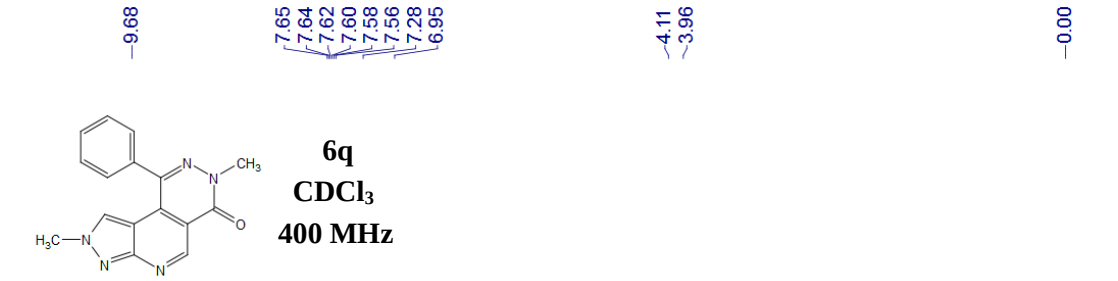

172.38
157.63
155.91
152.93
143.44
140.31
134.31
132.14
129.86
129.15
119.48
105.14
77.32
77.00
76.68
39.65
21.34
12.58
6o
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6p

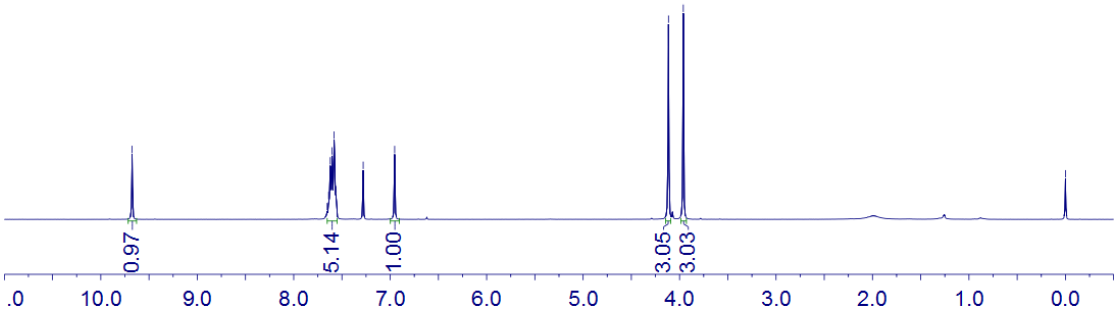

9.75
7.46
7.44
7.42
7.40
7.29
3.94
2.57
1.63
0.00
6p
CDCl3
400 MHz
1.00
2.02
2.00
3.03
3.08
3.09
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

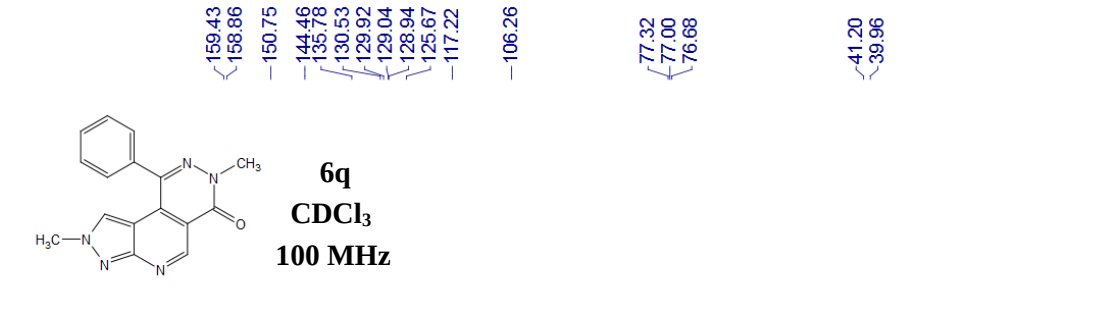

172.49
157.67
155.80
153.09
142.93
141.92
133.44
132.04
129.57
126.37
119.58
105.14
77.32
77.00
76.68
39.75
15.27
13.02
6p
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6q

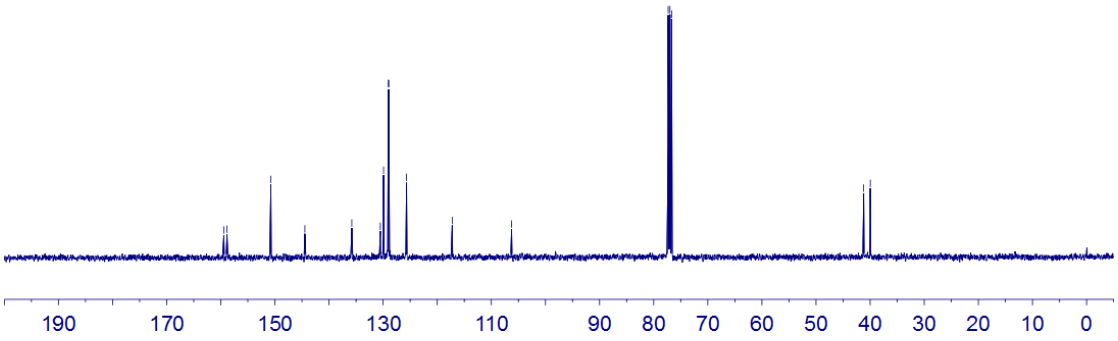


6q
$CDCl_3$
400 MHz

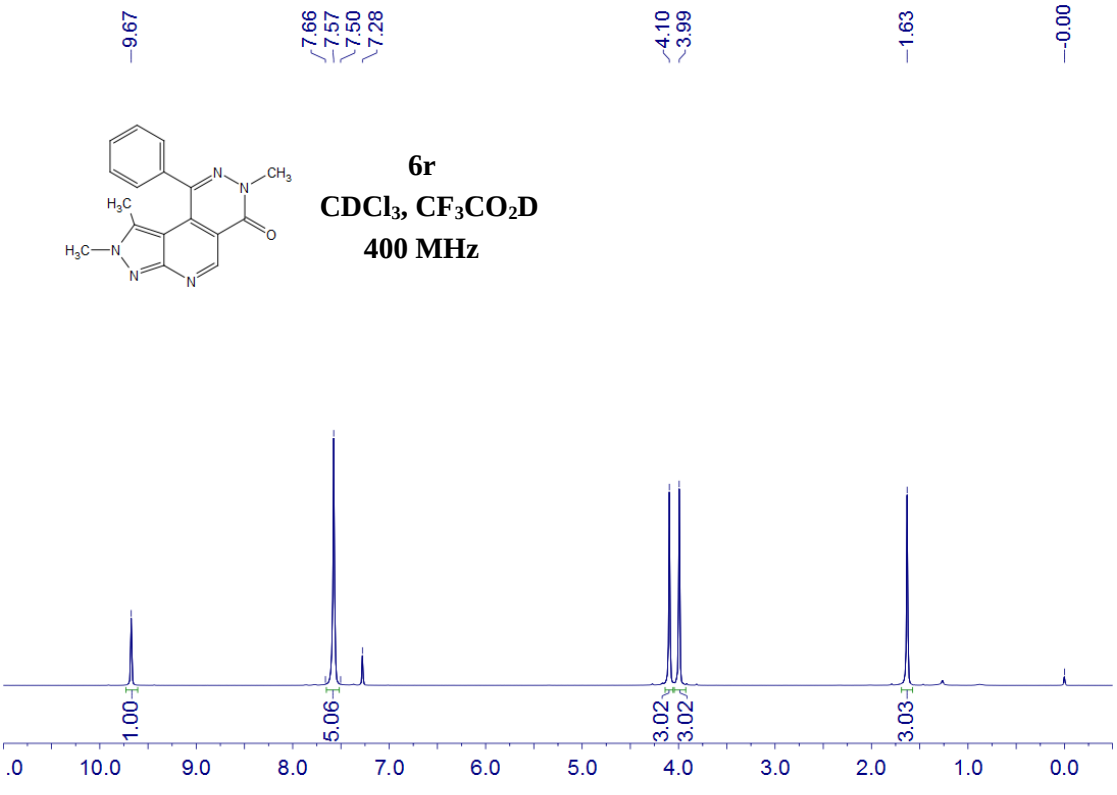


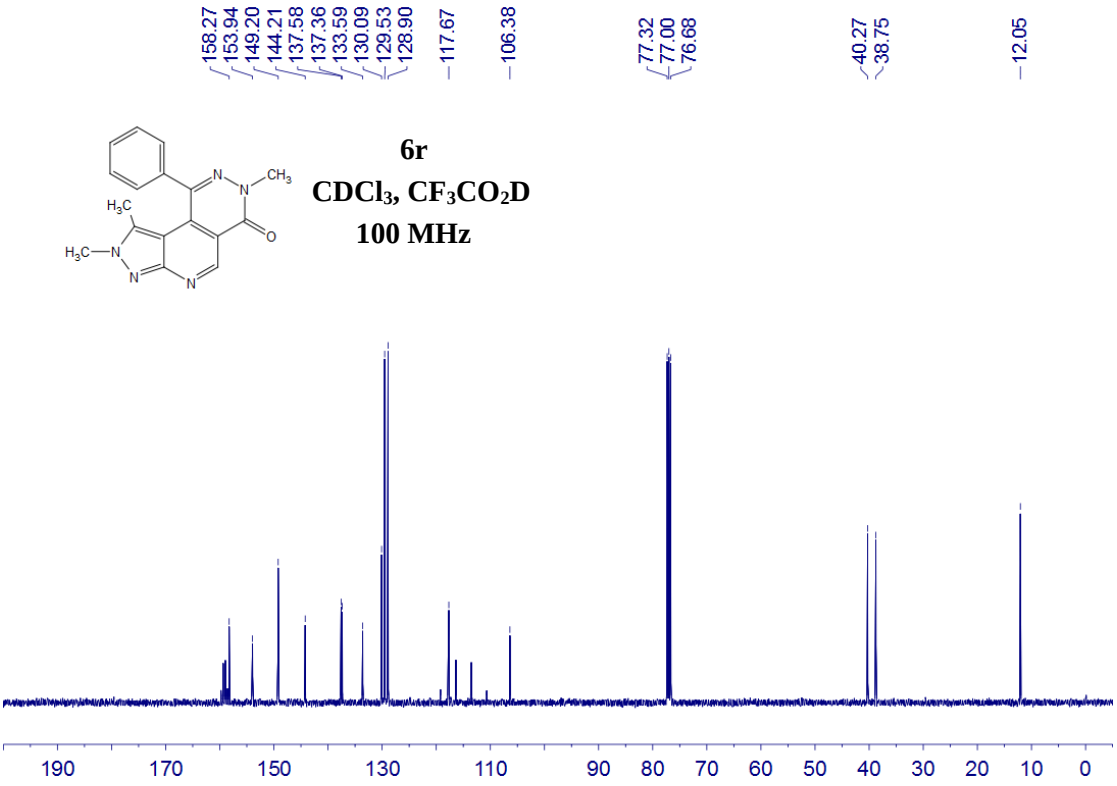


6q
$CDCl_3$
100 MHz

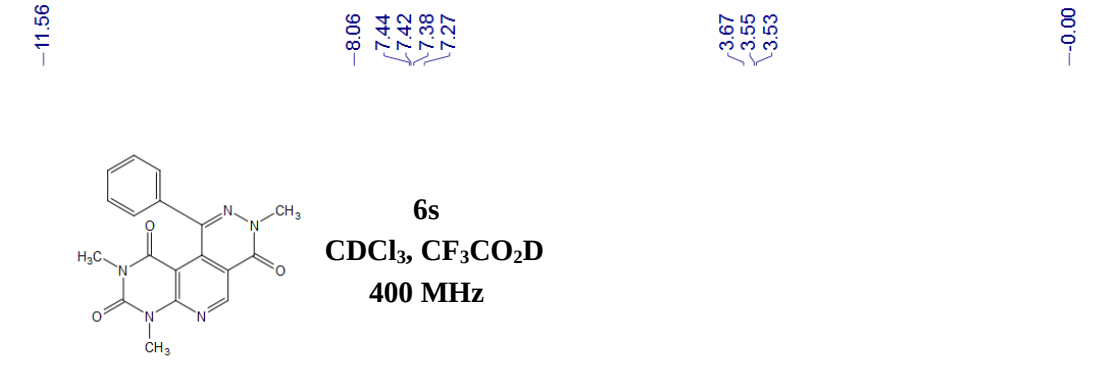


6r

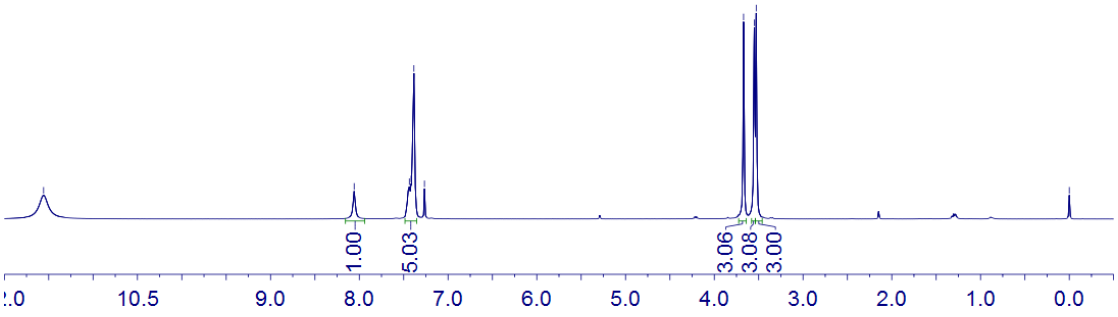

9.67
7.66
7.57
7.50
7.28
4.10
3.99
1.63
0.00
6r
CDCl3, CF3CO2D
400 MHz
1.00
5.06
3.02
3.02
3.03
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

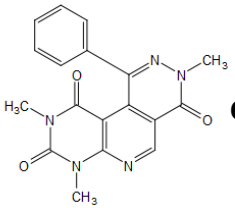

158.27
153.94
149.20
144.21
137.58
137.36
133.59
130.09
129.53
128.90
117.67
106.38
77.32
77.00
76.68
40.27
38.75
12.05
6r
CDCl3, CF3CO2D
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6s

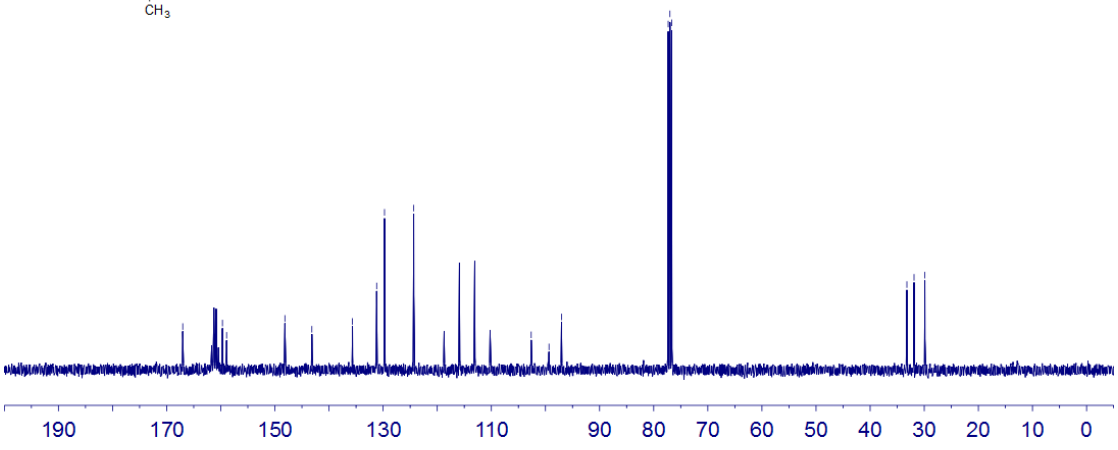


6s
$CDCl_3$, CF_3CO_2D
400 MHz

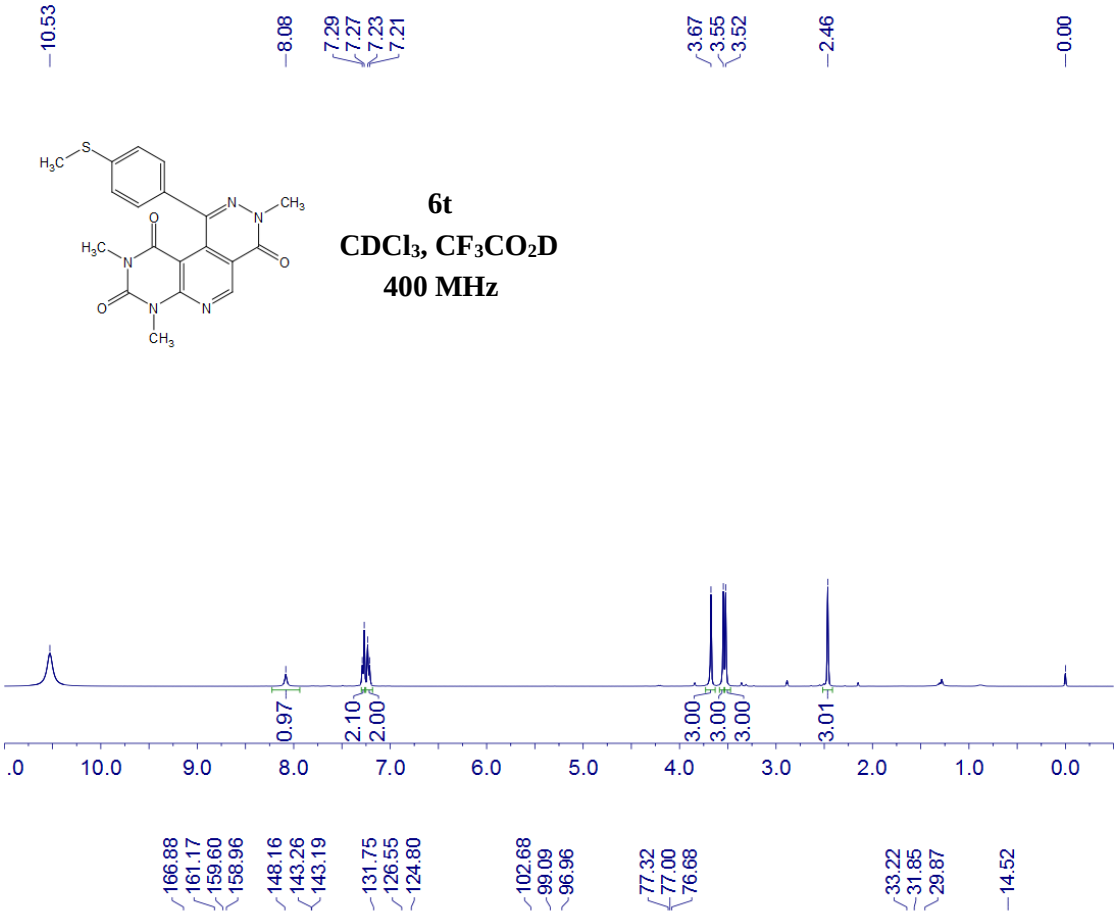




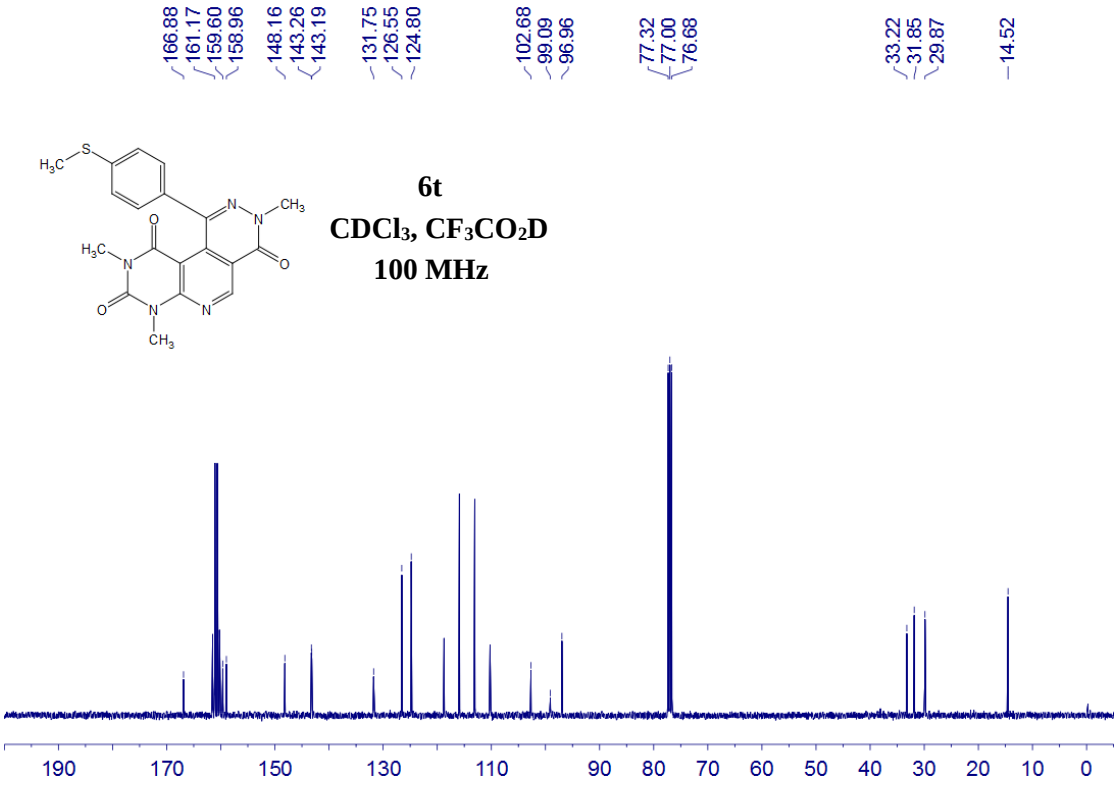
6s
$CDCl_3$, CF_3CO_2D
100 MHz



6t

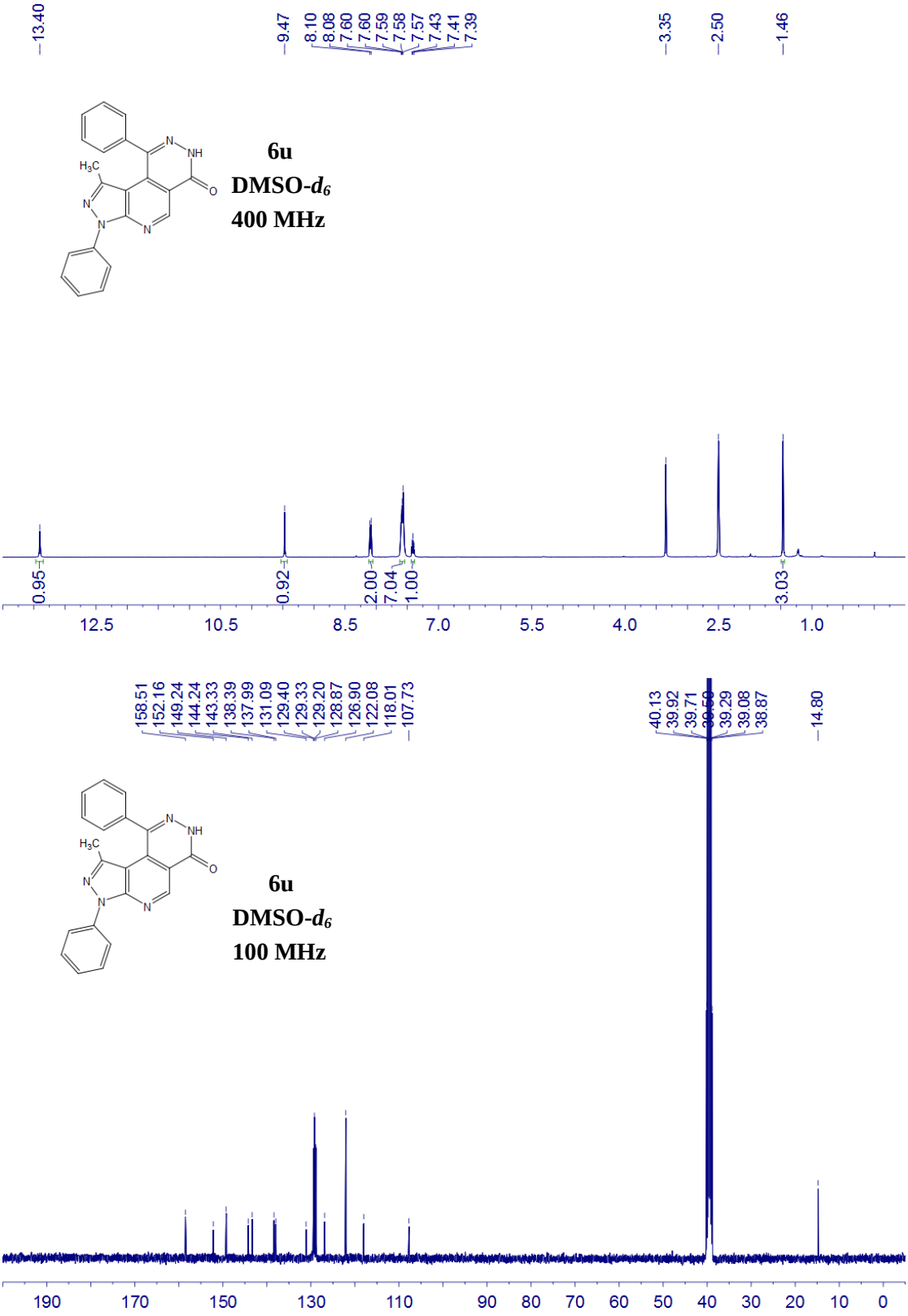


6t
$CDCl_3$, CF_3CO_2D
400 MHz

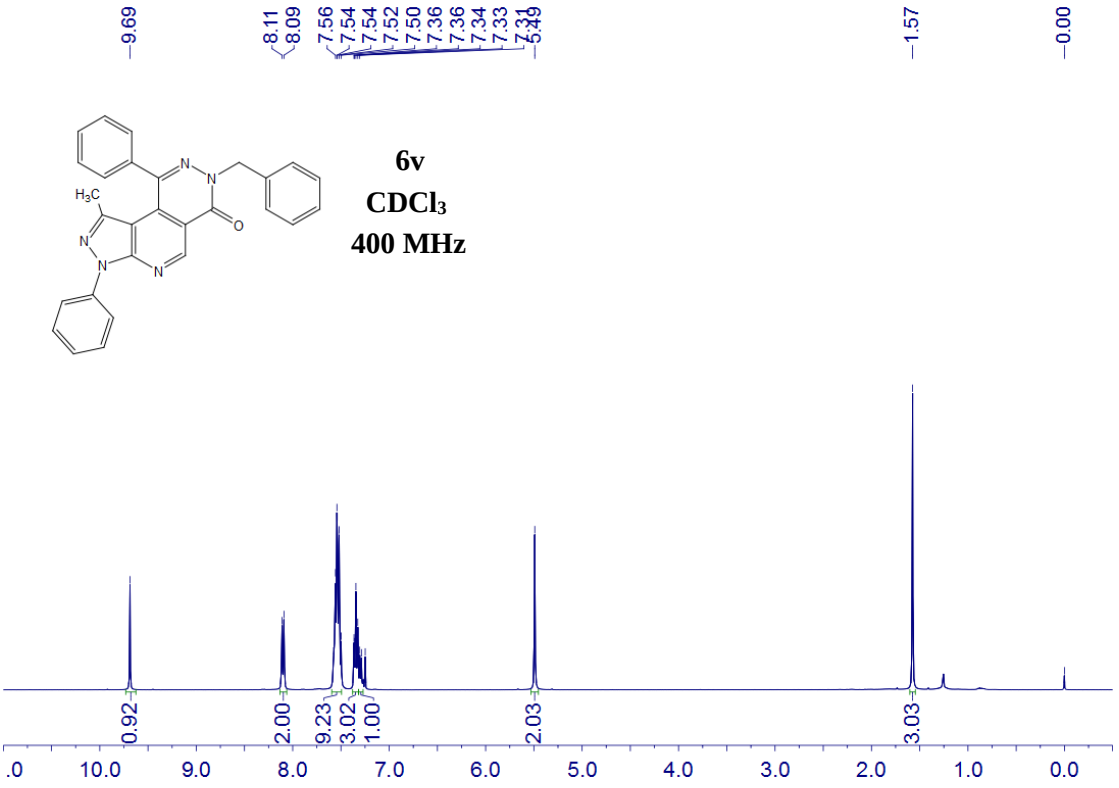


6t
$CDCl_3$, CF_3CO_2D
100 MHz

6u


13.40
9.47
8.10
8.08
7.60
7.60
7.59
7.58
7.57
7.43
7.41
7.39
3.35
2.50
1.46
6u
DMSO-d6
400 MHz
0.95
0.92
2.00
7.04
1.00
3.03
12.5
10.5
8.5
7.0
5.5
4.0
2.5
1.0
158.51
152.16
149.24
144.24
143.33
138.39
137.99
131.09
129.40
129.33
129.20
128.87
126.90
122.08
118.01
107.73
40.13
39.92
39.71
39.50
39.29
39.08
38.87
14.80
6u
DMSO-d6
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6v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8.11
8.09
7.56
7.54
7.54
7.52
7.50
7.36
7.36
7.34
7.33
7.31
5.49
1.57
0.00
6v
CDCl3
400 MHz
0.92
2.00
9.23
3.02
1.00
2.03
3.03
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8.0
7.0
6.0
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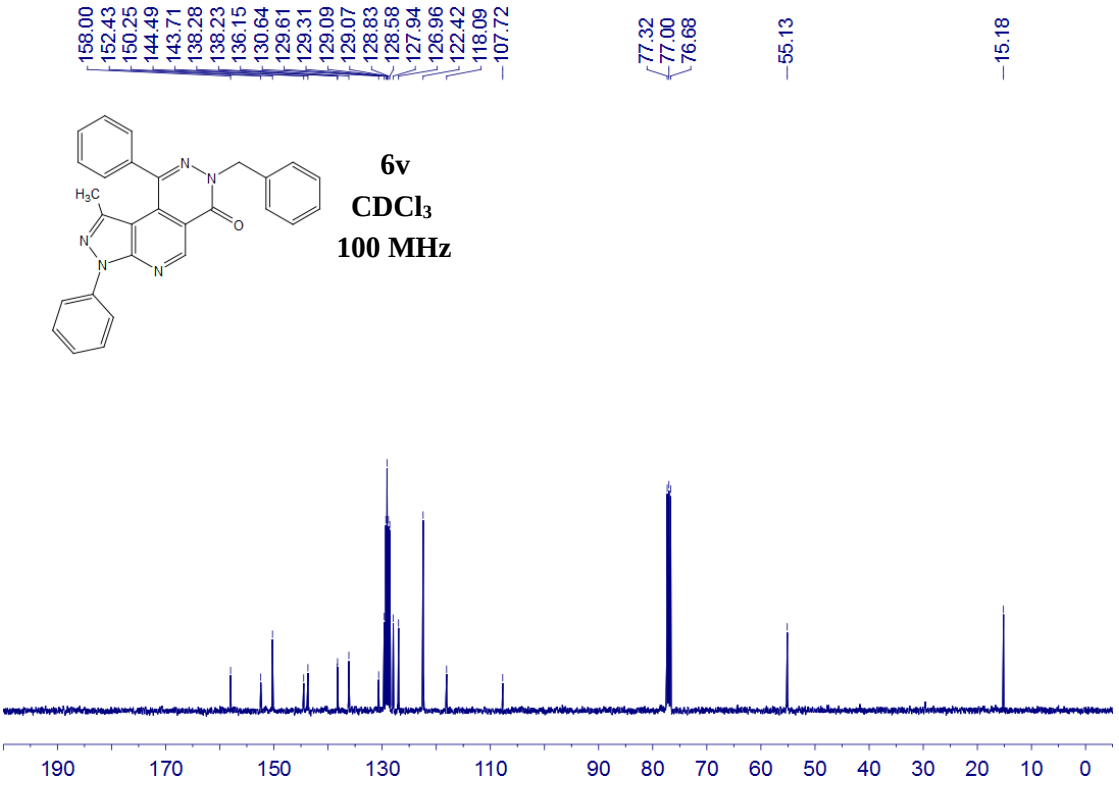
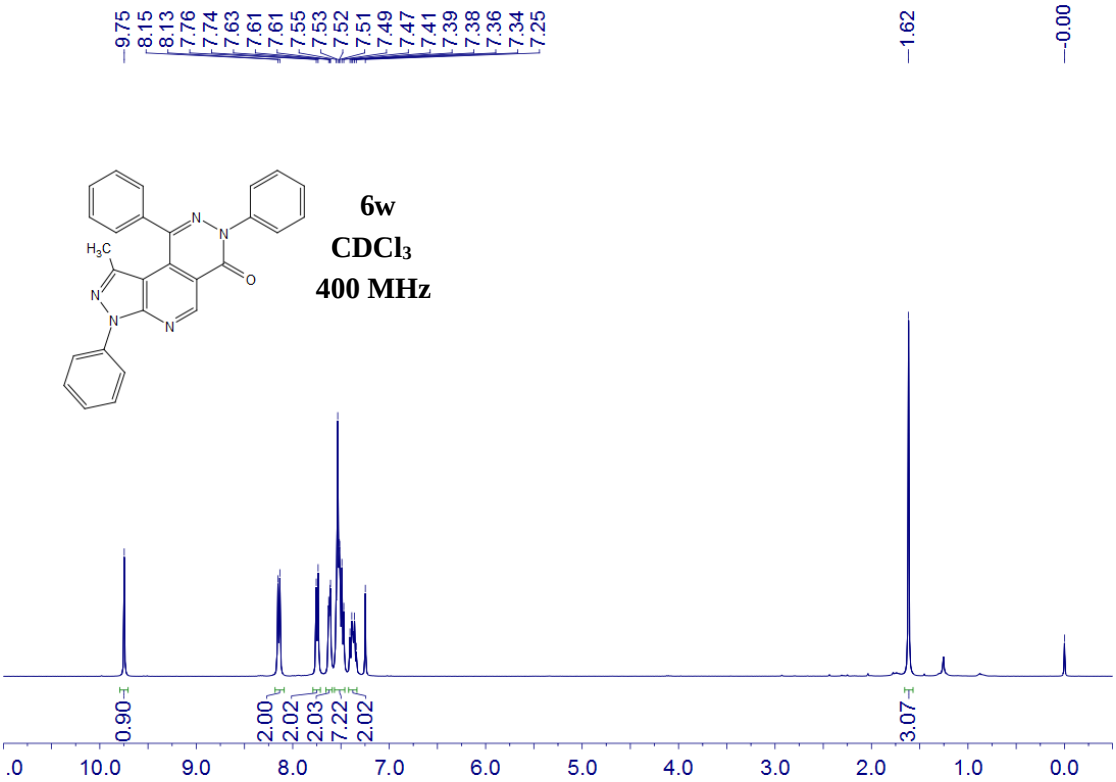
4.0
3.0
2.0
1.0
0.0


158.00
152.43
150.25
144.49
143.71
138.28
138.23
136.15
130.64
129.61
129.31
129.09
129.07
128.83
128.58
127.94
126.96
122.42
118.09
107.72
77.32
77.00
76.68
55.13
15.18
6v
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6w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8.15
8.13
7.76
7.74
7.63
7.61
7.61
7.55
7.53
7.52
7.51
7.49
7.47
7.41
7.39
7.38
7.36
7.34
7.25
1.62
0.00
6w
CDCl3
400 MHz
0.90
2.00
2.02
2.03
7.22
2.02
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8.0
7.0
6.0
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4.0
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2.0
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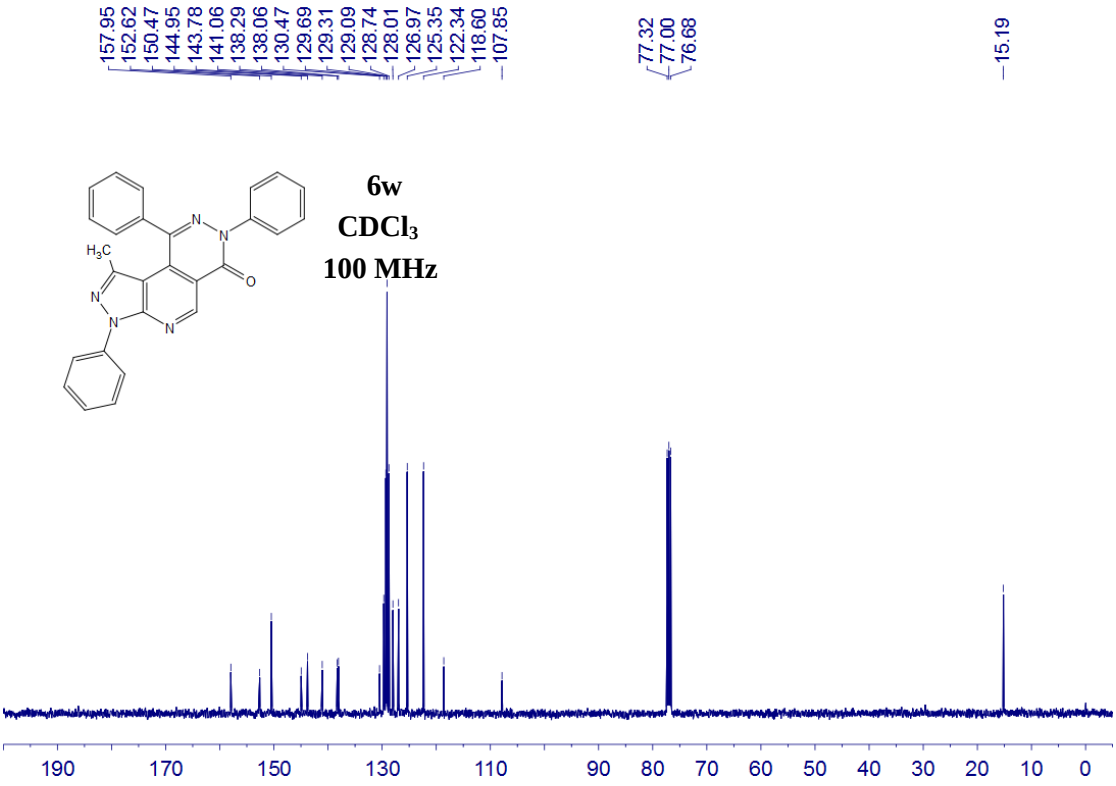
0.0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141.06
138.29
138.06
130.47
129.69
129.31
129.09
128.74
128.01
126.97
125.35
122.34
118.60
107.85
77.32
77.00
76.68
15.19
6w
CDCl3
100 MHz
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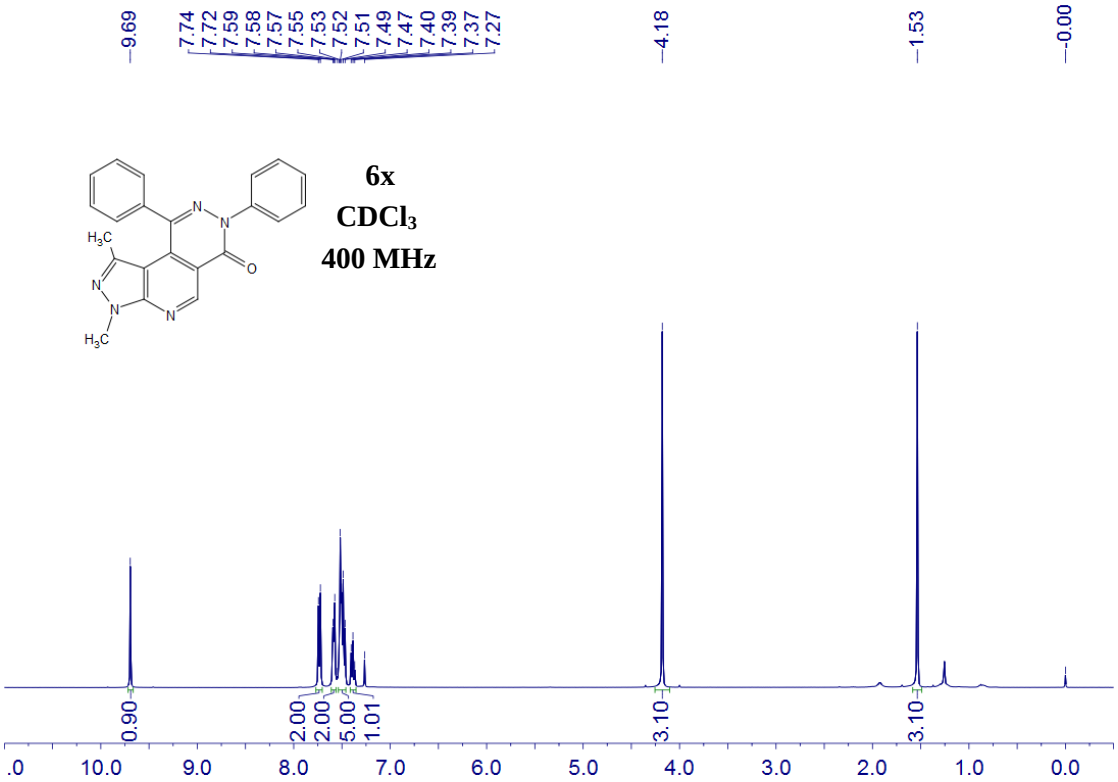
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6x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7.74
7.72
7.59
7.58
7.57
7.55
7.53
7.52
7.51
7.49
7.47
7.40
7.39
7.37
7.27
4.18
1.53
0.00
6x
CDCl3
400 MHz
0.90
2.00
2.00
5.00
1.01
3.10
3.10
10.0
9.0
8.0
7.0
6.0
5.0
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3.0
2.0
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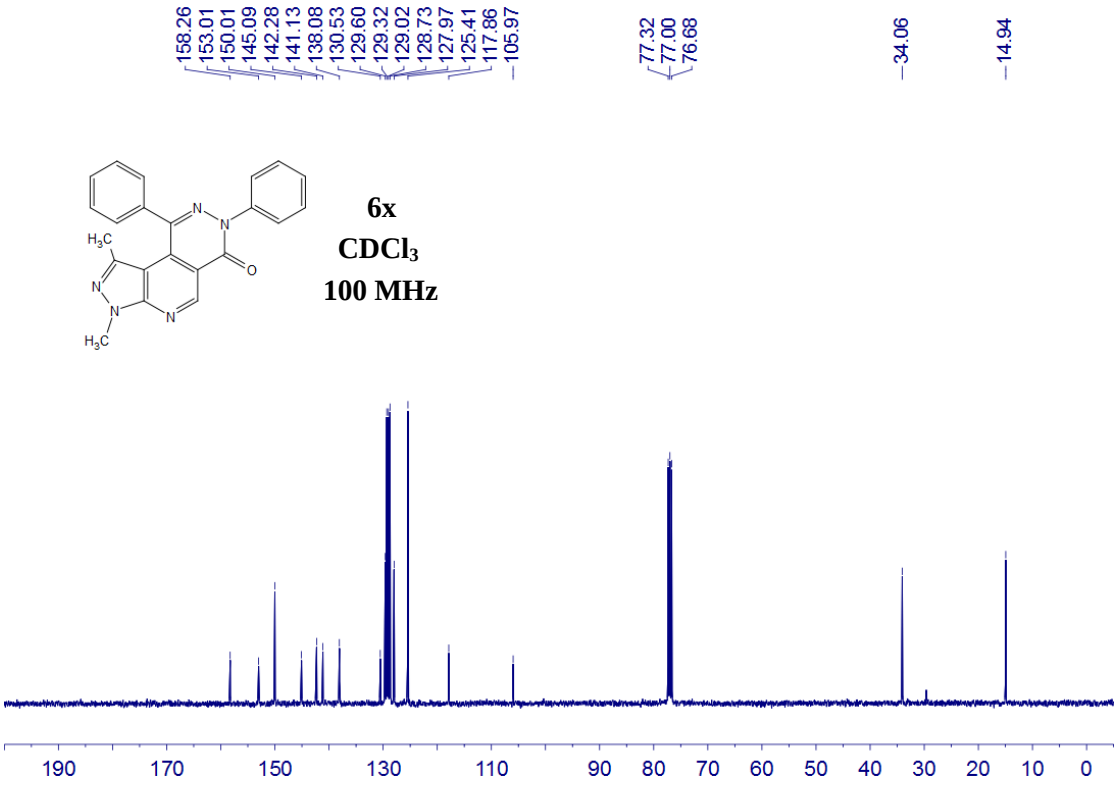
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150.01
145.09
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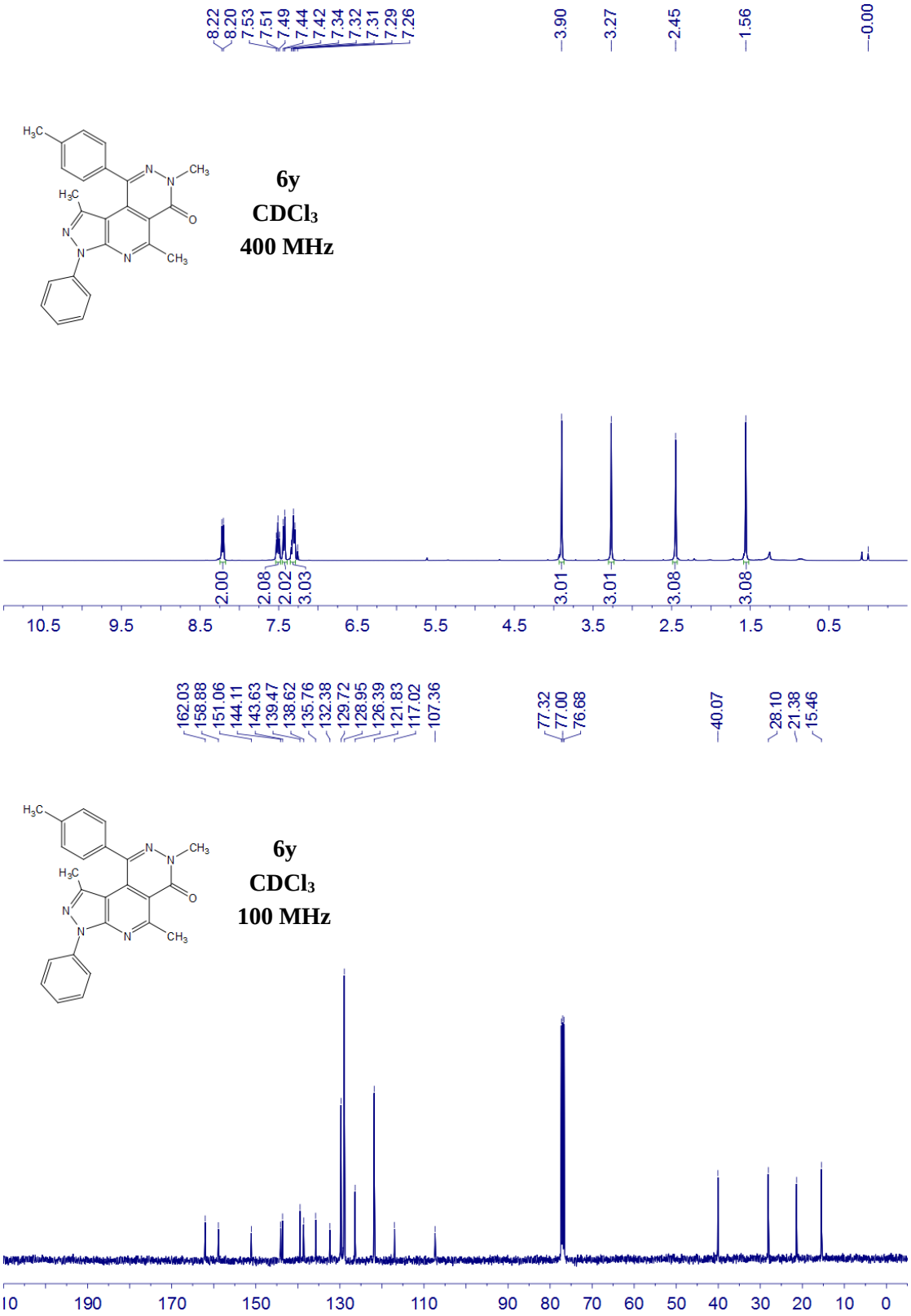
141.13
138.08
130.53
129.60
129.32
129.02
128.73
127.97
125.41
117.86
105.97
77.32
77.00
76.68
34.06
14.94
6x
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

6y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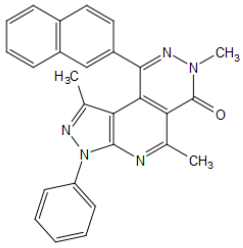
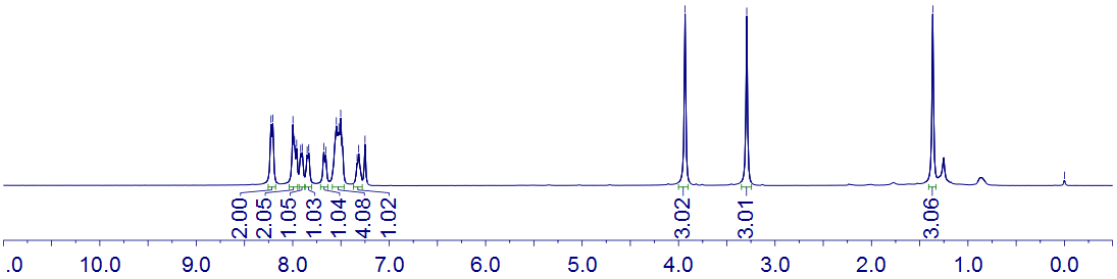
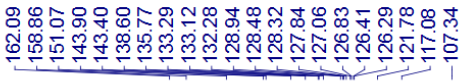
8.20
7.53
7.51
7.49
7.44
7.42
7.34
7.32
7.31
7.29
7.26
3.90
3.27
2.45
1.56
0.00
6y
CDCl3
400 MHz
2.00
2.08
2.02
3.03
3.01
3.01
3.08
3.08
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
162.03
158.88
151.06
144.11
143.63
139.47
138.62
135.76
132.38
129.72
128.95
126.39
121.83
117.02
107.36
77.32
77.00
76.68
40.07
28.10
21.38
15.46
6y
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

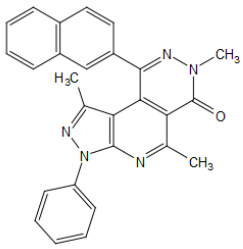
6z



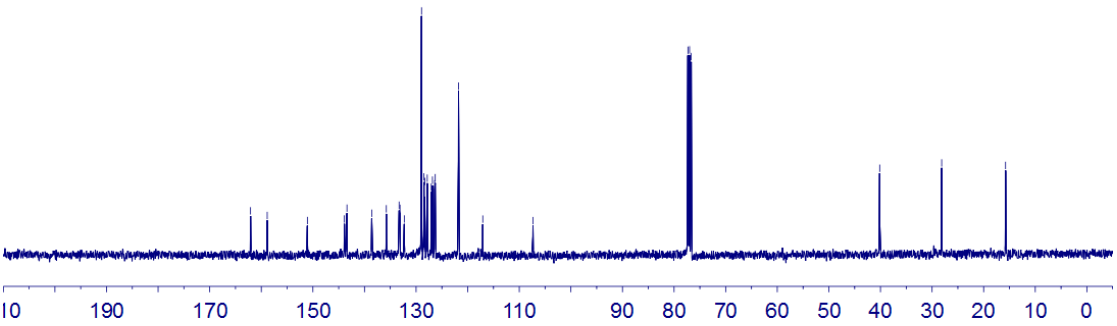
6z
$CDCl_3$
400 MHz



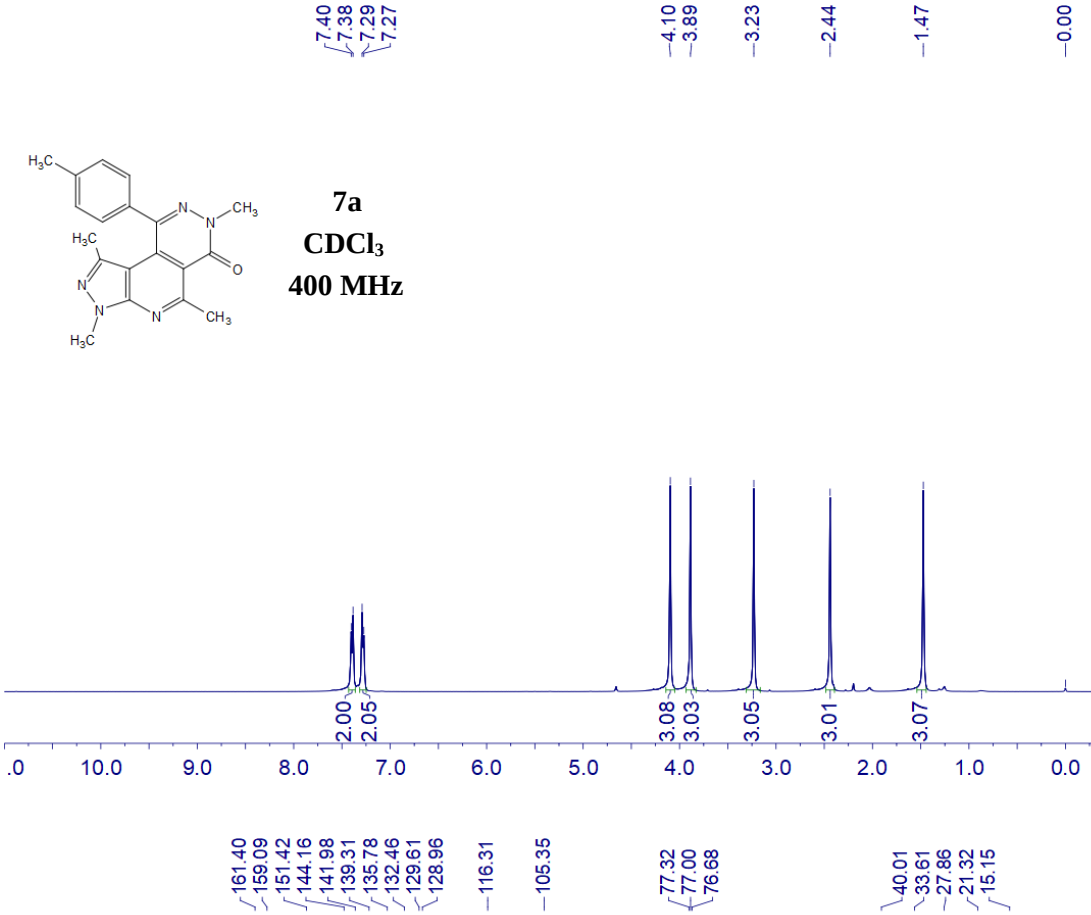


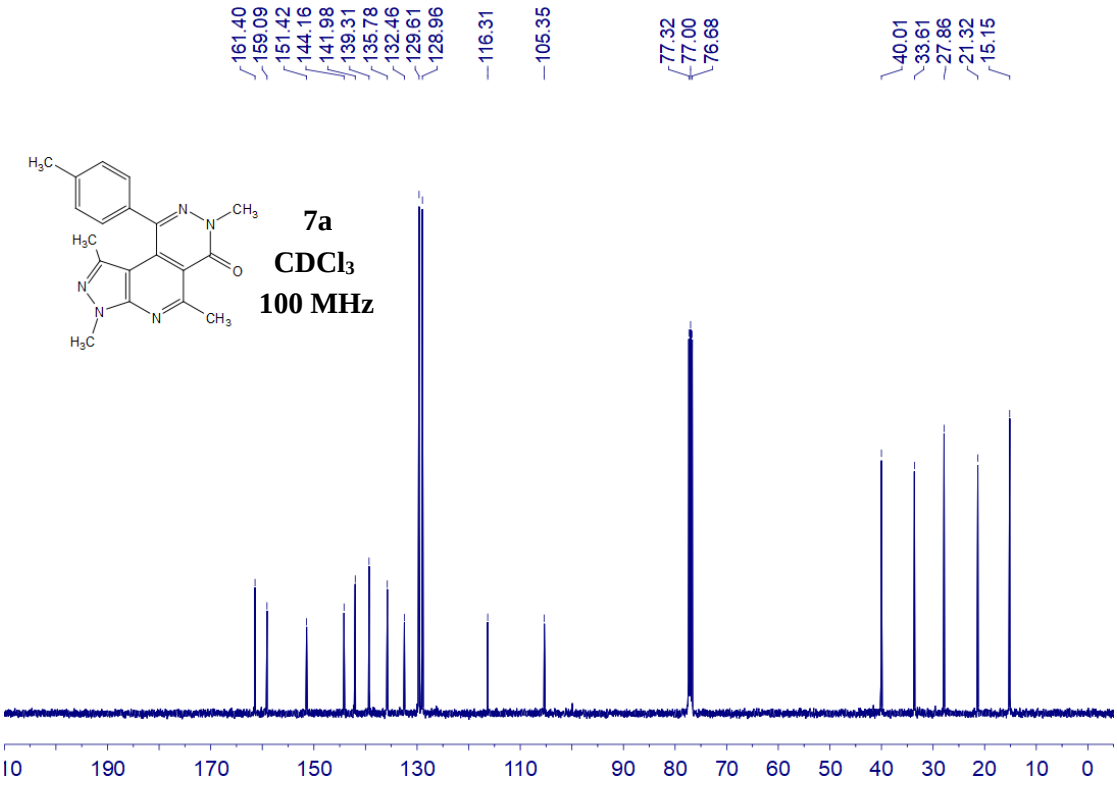


6z
$CDCl_3$
100 MHz

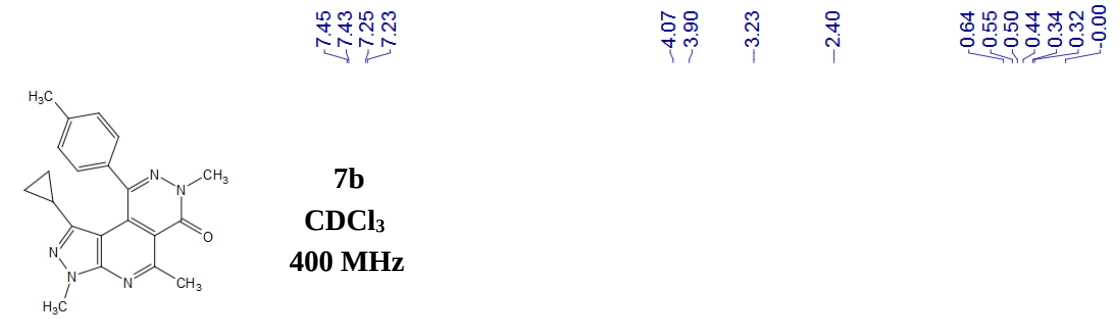


7a

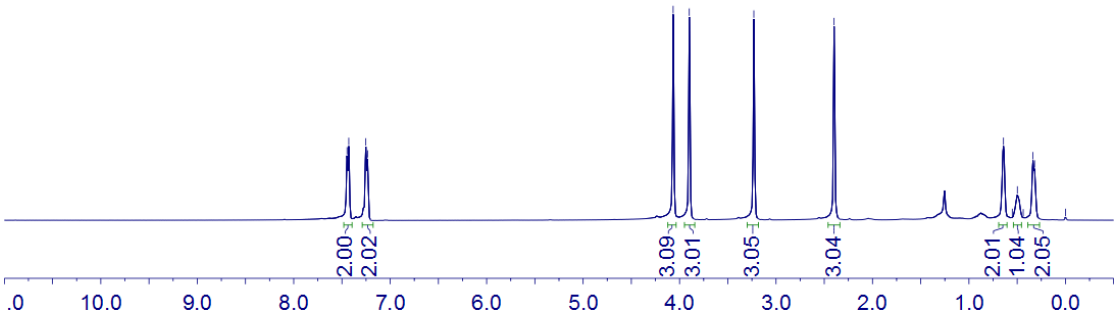

7.40
7.38
7.29
7.27
4.10
3.89
3.23
2.44
1.47
0.00
7a
CDCl3
400 MHz
2.00
2.05
3.08
3.03
3.05
3.01
3.07
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

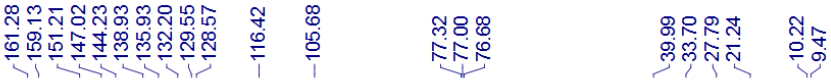

161.40
159.09
151.42
144.16
141.98
139.31
135.78
132.46
129.61
128.96
116.31
105.35
77.32
77.00
76.68
40.01
33.61
27.86
21.32
15.15
7a
CDCl3
100 MHz
10
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

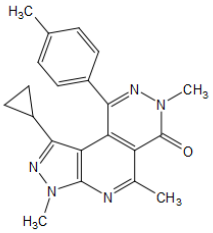
7b



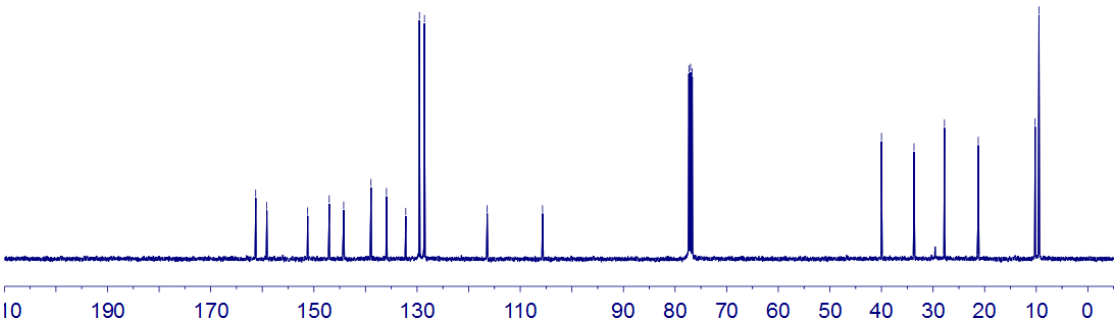
7b
$CDCl_3$
400 MHz



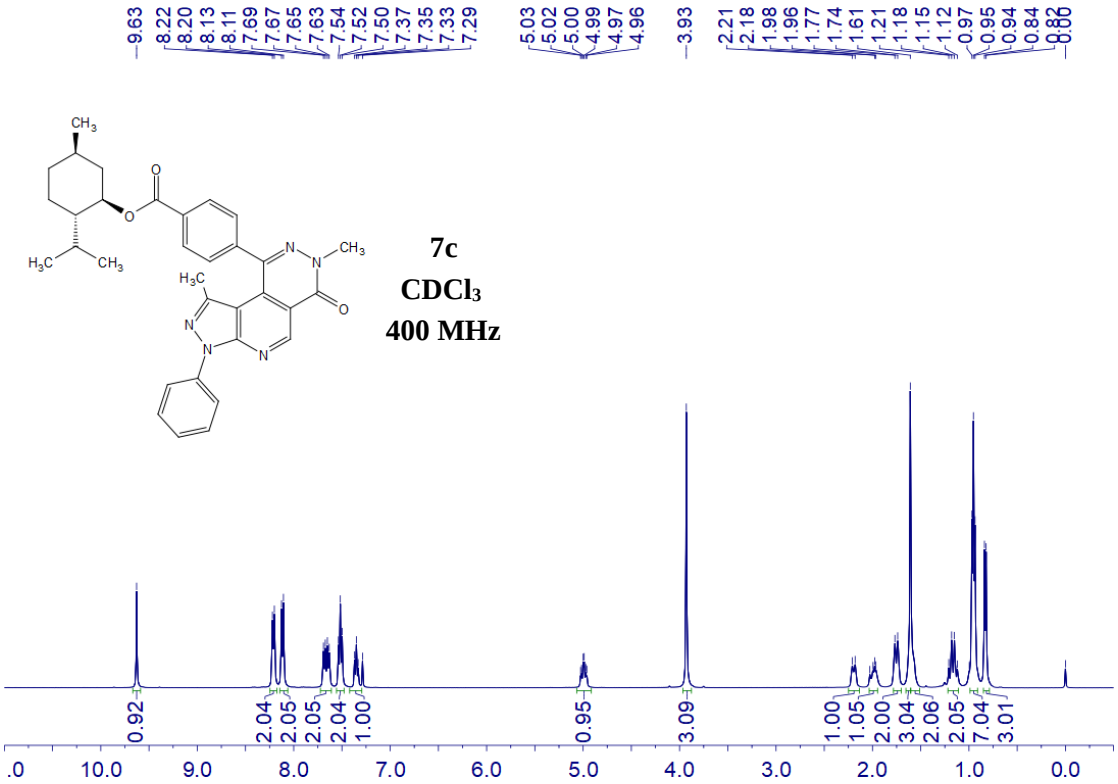


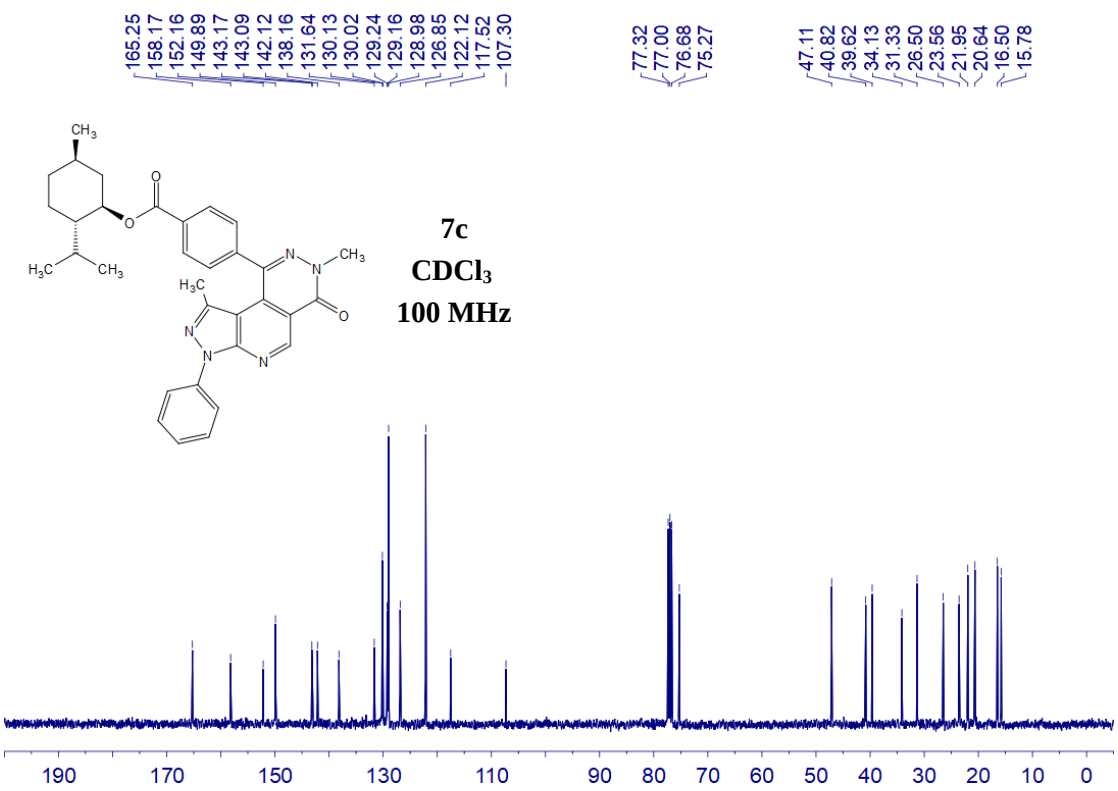


7b
$CDCl_3$
100 MHz

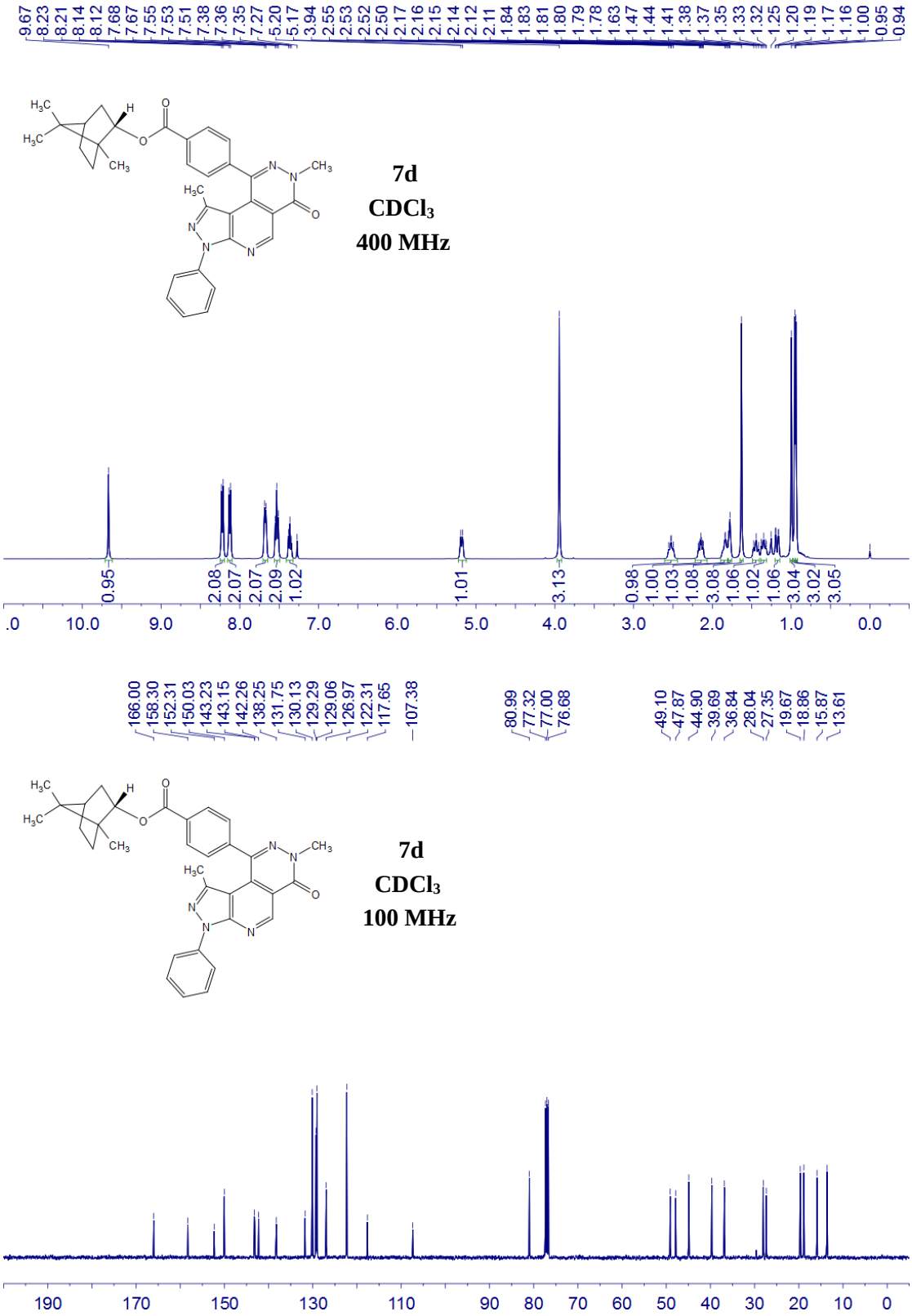


7c

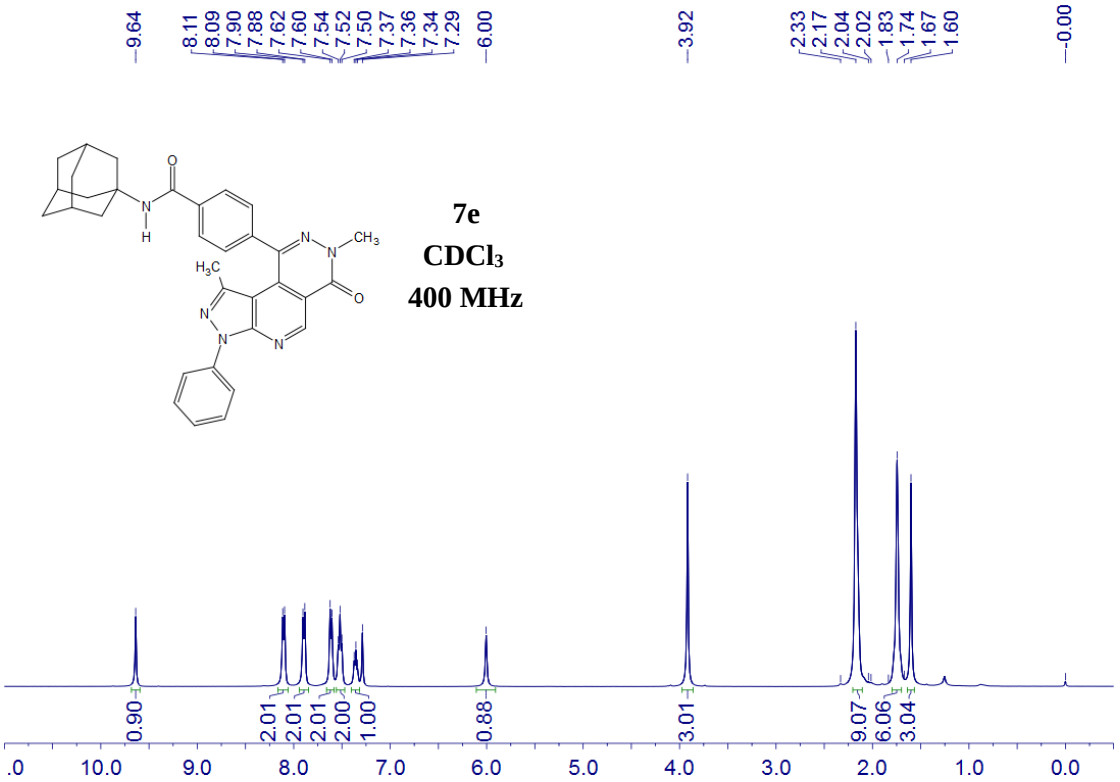

9.63
8.22
8.20
8.13
8.11
7.69
7.67
7.65
7.63
7.54
7.52
7.50
7.37
7.35
7.33
7.29
5.03
5.02
5.00
4.99
4.97
4.96
3.93
2.21
2.18
1.98
1.96
1.77
1.74
1.61
1.21
1.18
1.15
1.12
0.97
0.95
0.94
0.84
0.82
0.80
7c
CDCl3
400 MHz
0.92
2.04
2.05
2.05
2.04
1.00
0.95
3.09
1.00
1.05
2.00
3.04
2.06
2.05
7.04
3.01
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


165.25
158.17
152.16
149.89
143.17
143.09
142.12
138.16
131.64
130.13
130.02
129.24
129.16
128.98
126.85
122.12
117.52
107.30
77.32
77.00
76.68
75.27
47.11
40.82
39.62
34.13
31.33
26.50
23.56
21.95
20.64
16.50
15.78
7c
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

7d


9.67 8.23 8.21 8.14 8.12 7.68 7.67 7.55 7.53 7.51 7.38 7.36 7.35 7.27 5.20 5.17 3.94 2.55 2.53 2.52 2.50 2.17 2.16 2.15 2.14 2.12 2.11 1.84 1.83 1.81 1.80 1.79 1.78 1.63 1.47 1.44 1.41 1.38 1.37 1.35 1.33 1.32 1.25 1.20 1.19 1.17 1.16 1.00 0.95 0.94
7d
CDCl3
400 MHz
0.95 2.08 2.07 2.07 2.09 1.02 1.01 3.13 0.98 1.00 1.03 1.08 3.08 1.06 1.02 1.06 3.04 3.02 3.05
.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0
166.00 158.30 152.31 150.03 143.23 143.15 142.26 138.25 131.75 130.13 129.29 129.06 126.97 122.31 117.65 107.38 80.99 77.32 77.00 76.68 49.10 47.87 44.90 39.69 36.84 28.04 27.35 19.67 18.86 15.87 13.61
7d
CDCl3
100 MHz
190 170 150 130 110 90 80 70 60 50 40 30 20 10 0

7e


9.64
8.11
8.09
7.90
7.88
7.62
7.60
7.54
7.52
7.50
7.37
7.36
7.34
7.29
6.00
3.92
2.33
2.17
2.04
2.02
1.83
1.74
1.67
1.60
0.00
7e
CDCl3
400 MHz
0.90
2.01
2.01
2.01
2.00
1.00
0.88
3.01
9.07
6.06
3.04
10.0
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8.0
7.0
6.0
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4.0
3.0
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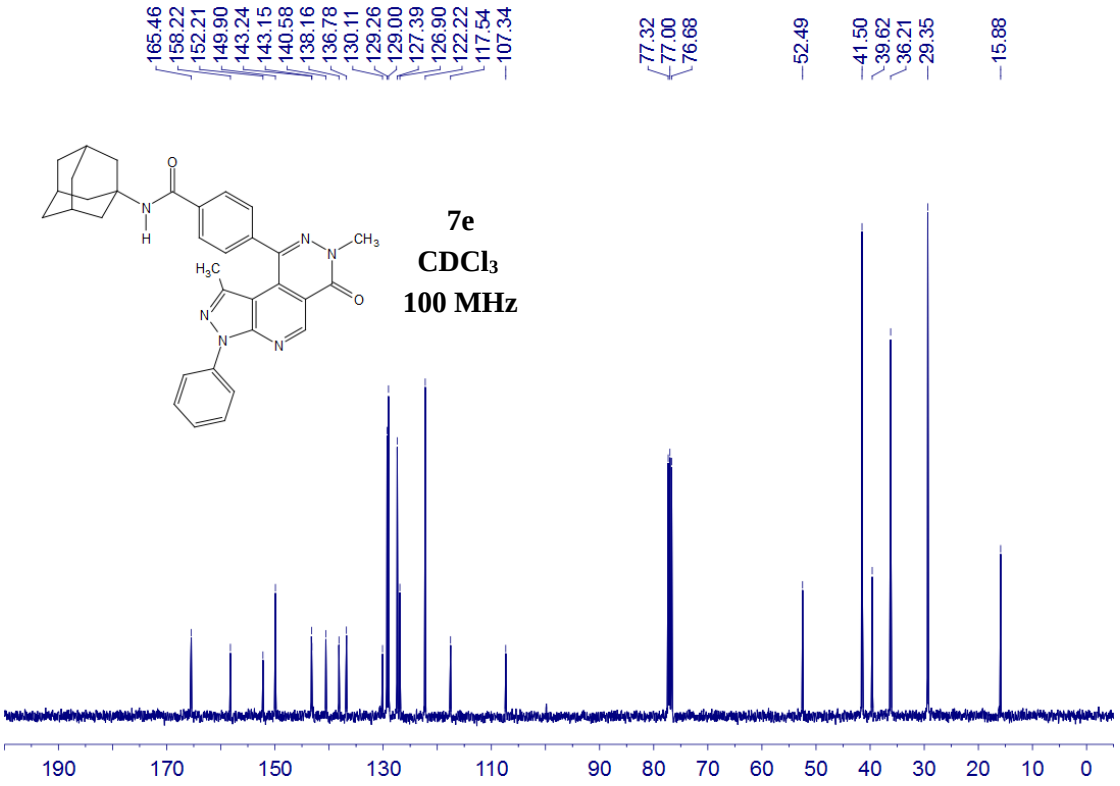
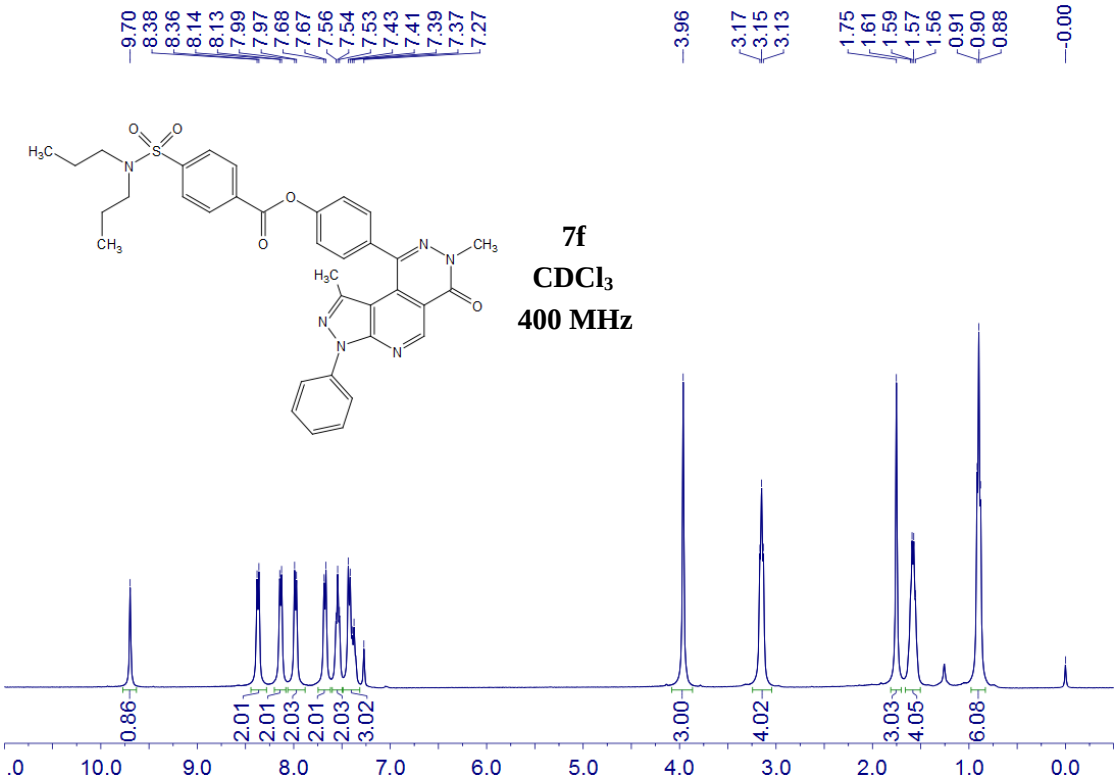
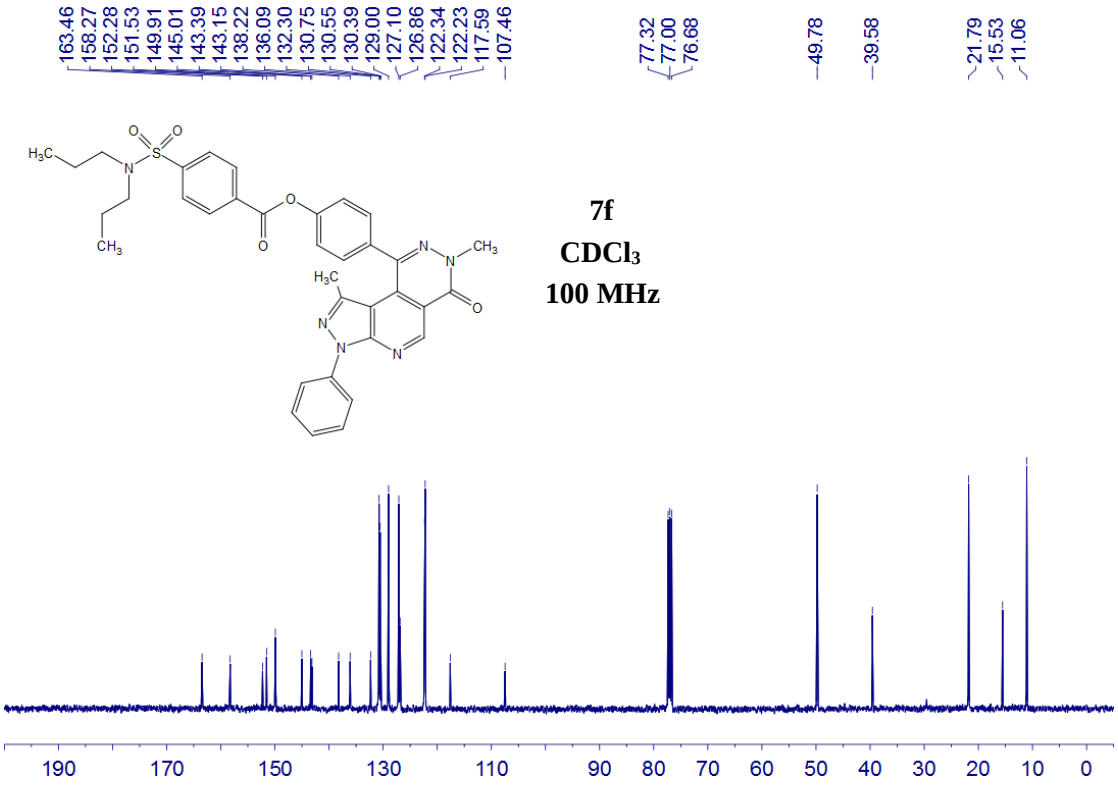
1.0
0.0


165.46
158.22
152.21
149.90
143.24
143.15
140.58
138.16
136.78
130.11
129.26
129.00
127.39
126.90
122.22
117.54
107.34
77.32
77.00
76.68
52.49
41.50
39.62
36.21
29.35
15.88
7e
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

7f

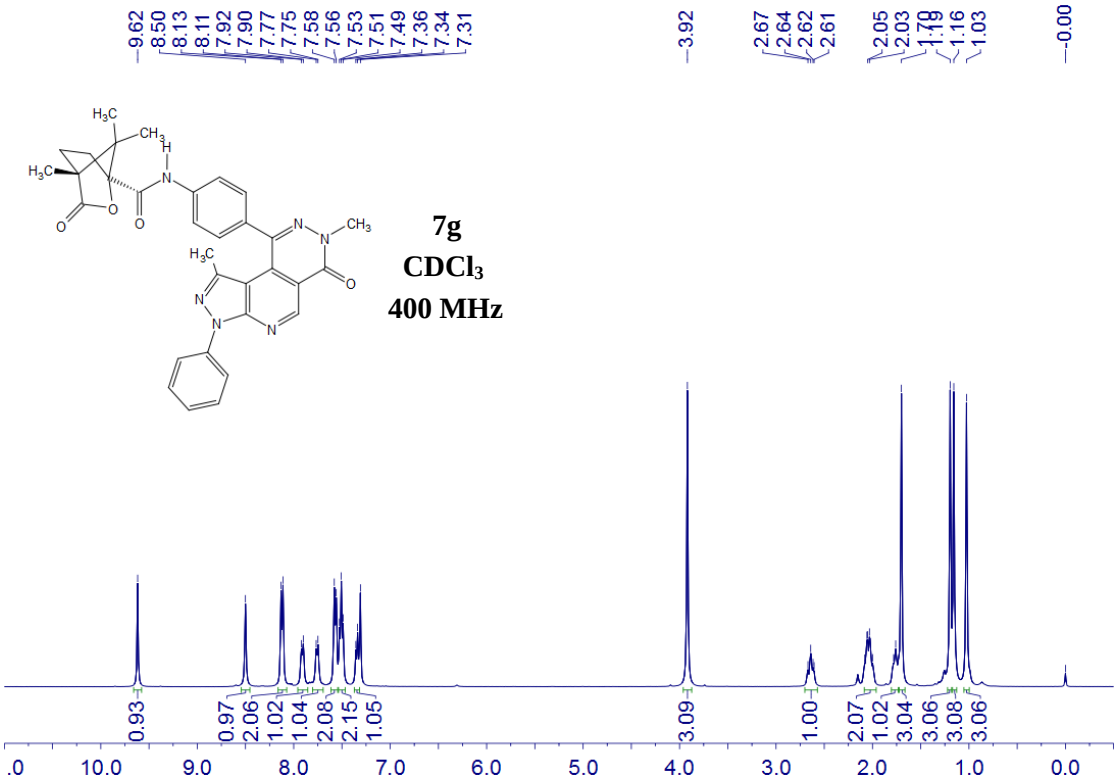


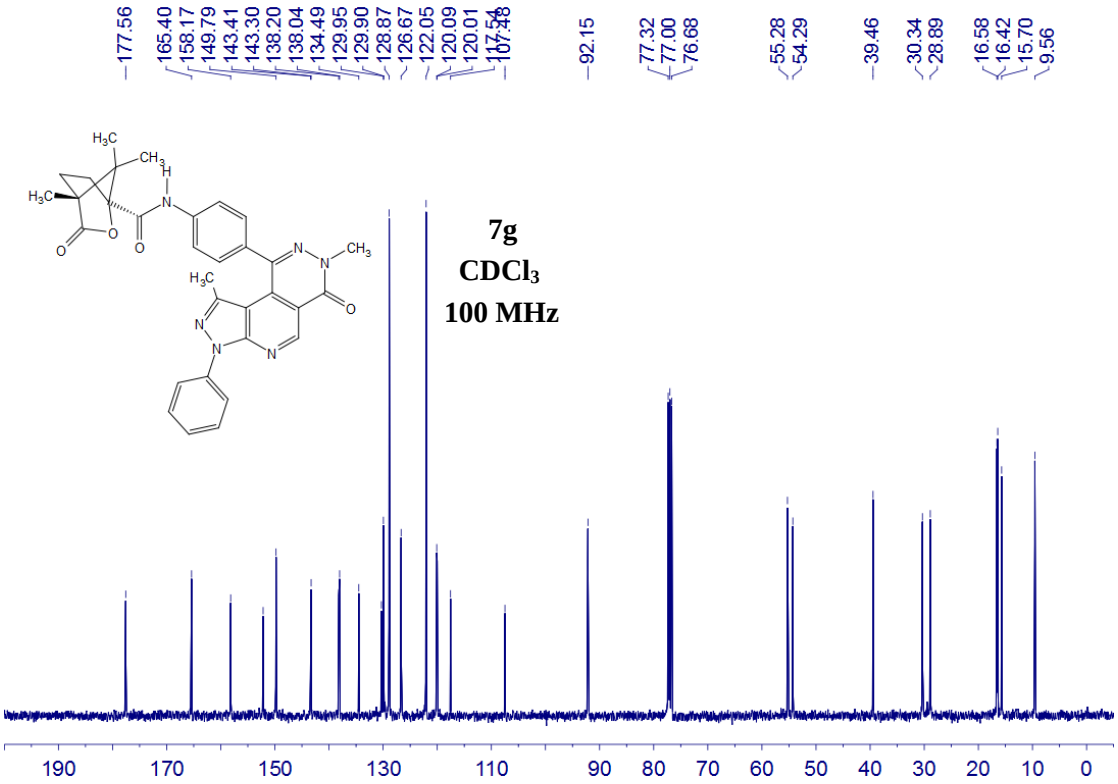
7f
$CDCl_3$
400 MHz



7f
$CDCl_3$
100 MHz

7g


9.62
8.50
8.13
8.11
7.92
7.90
7.77
7.75
7.58
7.56
7.53
7.51
7.49
7.36
7.34
7.31
3.92
2.67
2.64
2.62
2.61
2.05
2.03
1.16
1.03
0.00
7g
CDCl3
400 MHz
0.93
0.97
2.06
1.02
1.04
2.08
2.15
1.05
3.09
1.00
2.07
1.02
3.04
3.06
3.08
3.06
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0


177.56
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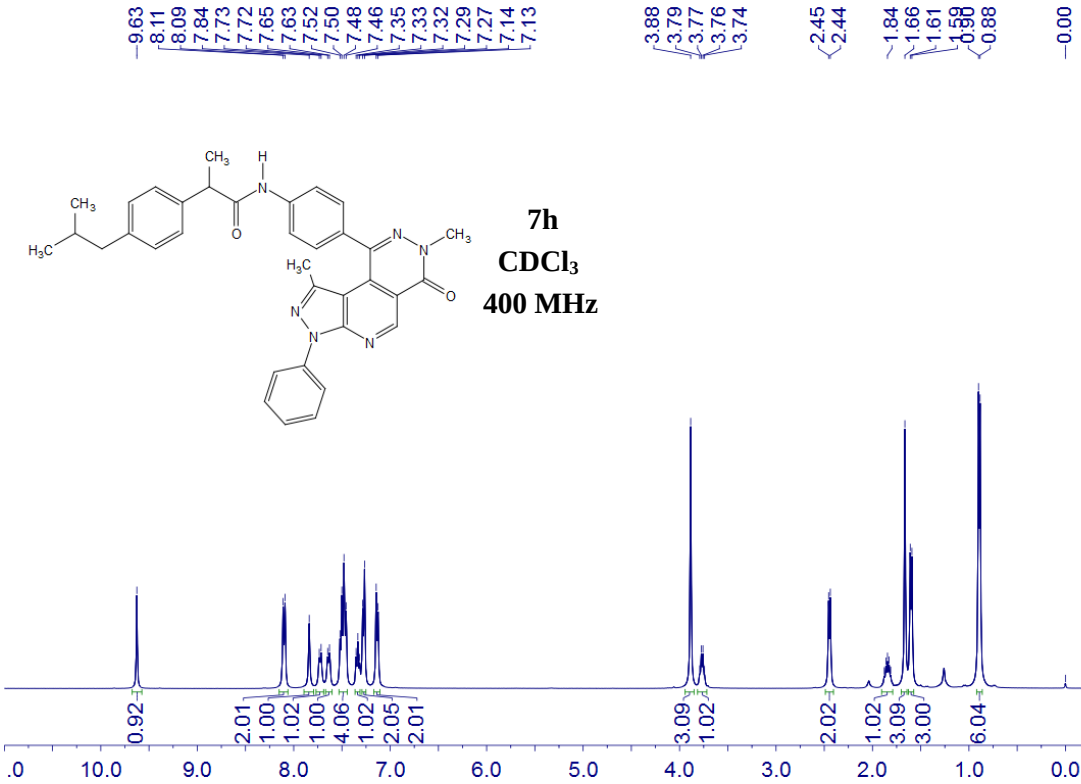
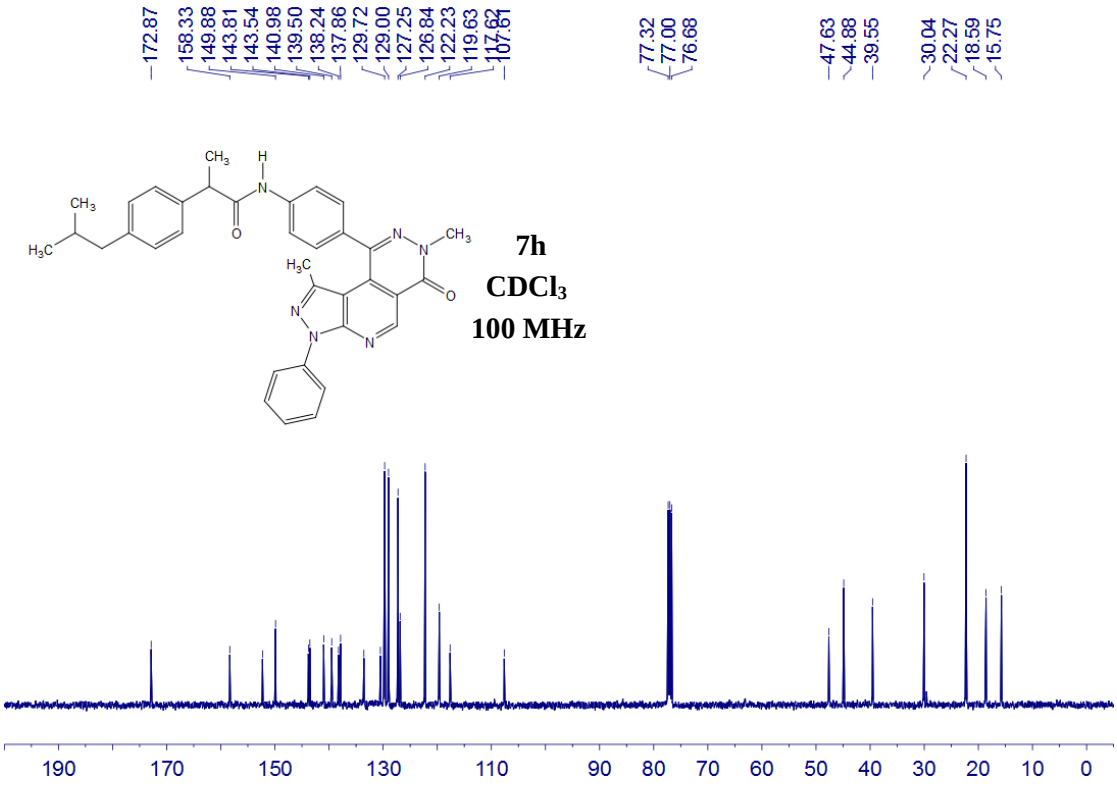
149.79
143.41
143.30
138.20
138.04
134.49
129.95
129.90
128.87
126.67
122.05
120.09
120.01
92.15
77.32
77.00
76.68
55.28
54.29
39.46
30.34
28.89
16.58
16.42
15.70
9.56
7g
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

7h


9.63
8.11
8.09
7.84
7.73
7.72
7.65
7.63
7.52
7.50
7.48
7.46
7.35
7.33
7.32
7.29
7.27
7.14
7.13
3.88
3.79
3.77
3.76
3.74
2.45
2.44
1.84
1.66
1.61
1.58
1.30
0.88
0.00
7h
CDCl3
400 MHz
0.92
2.01
1.00
1.02
1.00
4.06
1.02
2.05
2.01
3.09
1.02
2.02
1.02
3.09
3.00
6.04
.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0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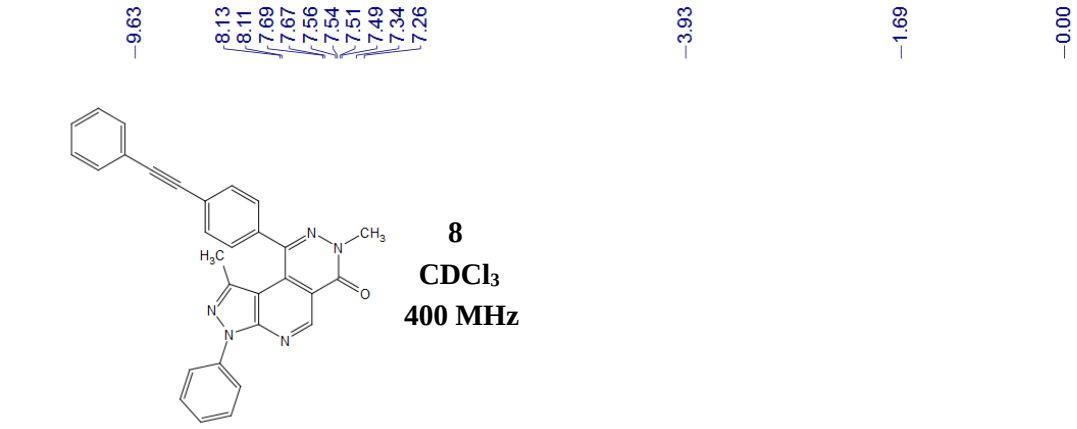
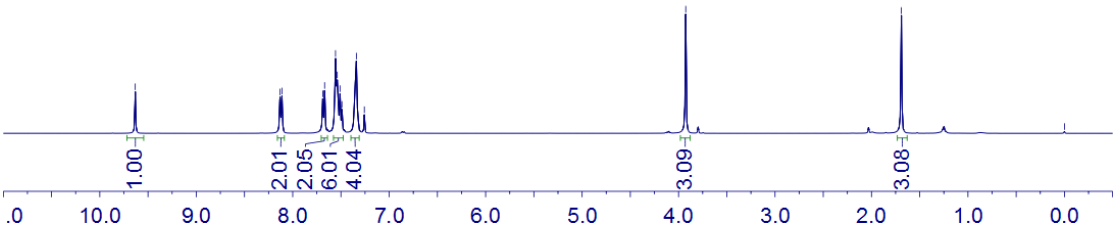
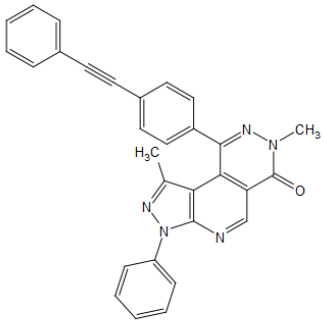
143.81
143.54
140.98
139.50
138.24
137.86
129.72
129.00
127.25
126.84
122.23
119.63
117.62
107.81
77.32
77.00
76.68
47.63
44.88
39.55
30.04
22.27
18.59
15.75
7h
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

8

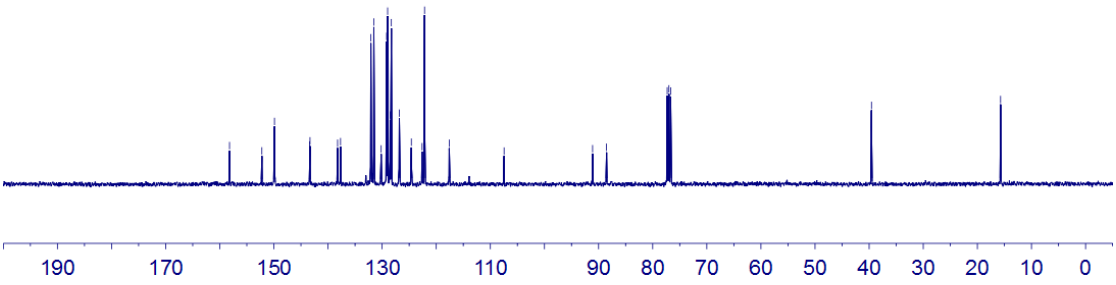


8
$CDCl_3$
400 MHz

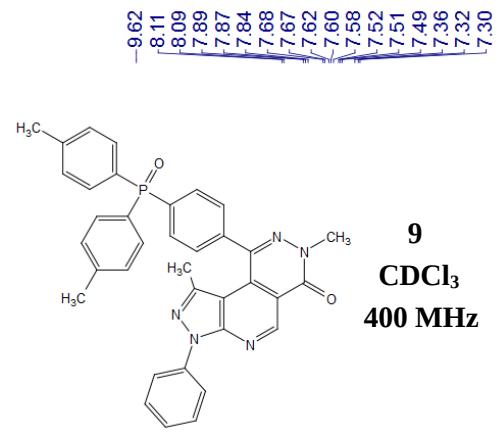




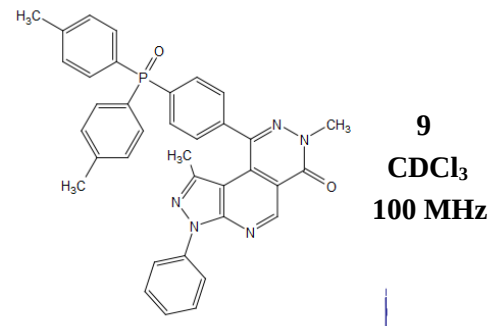
8
$CDCl_3$
100 MHz



9



9
$CDCl_3$
400 MHz



9
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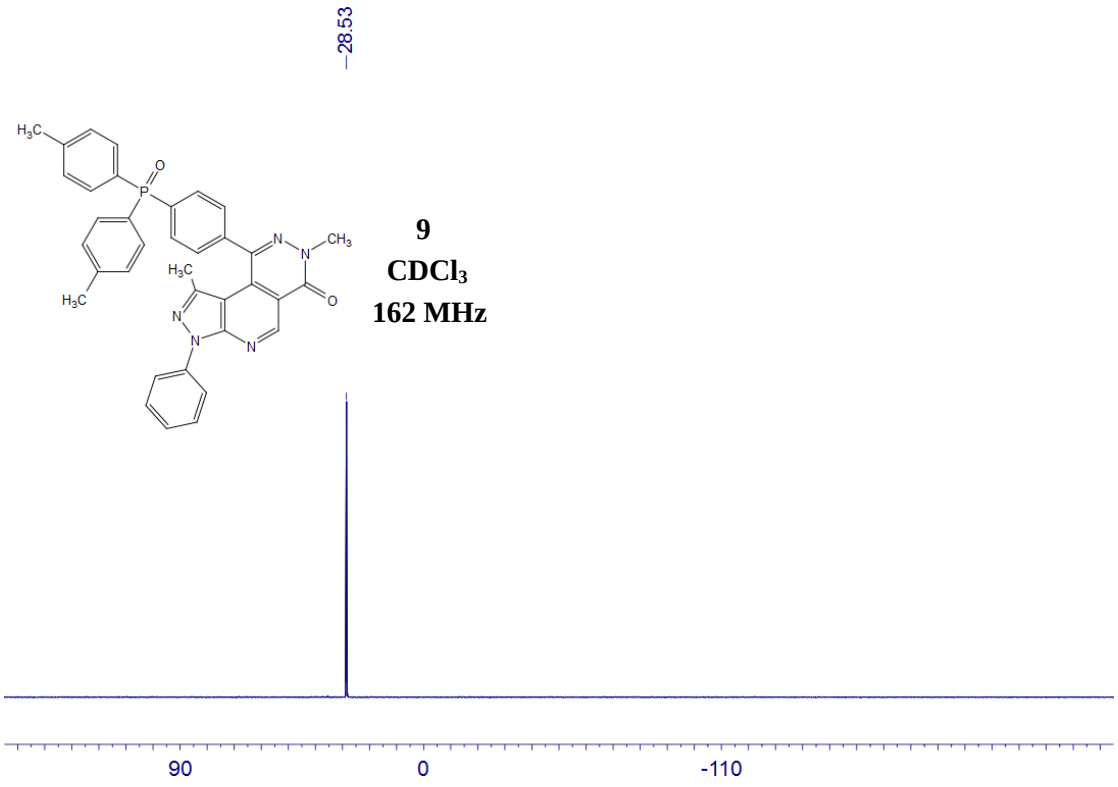
100 MHz



9
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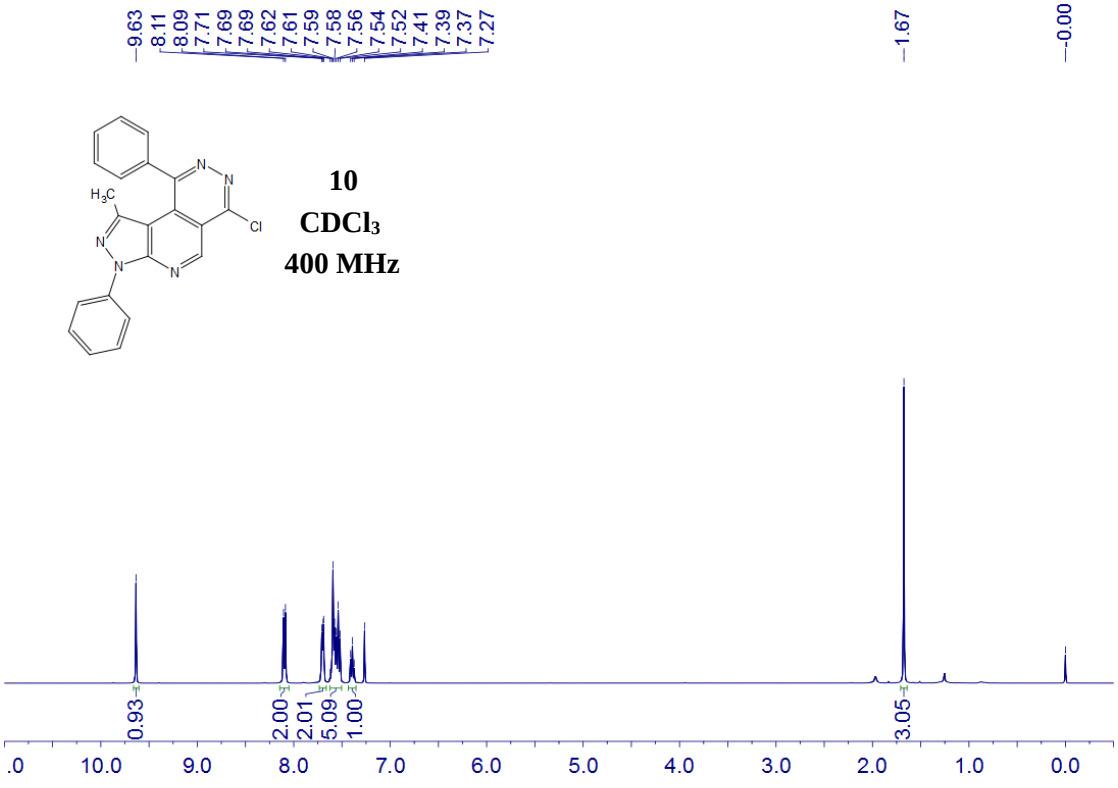
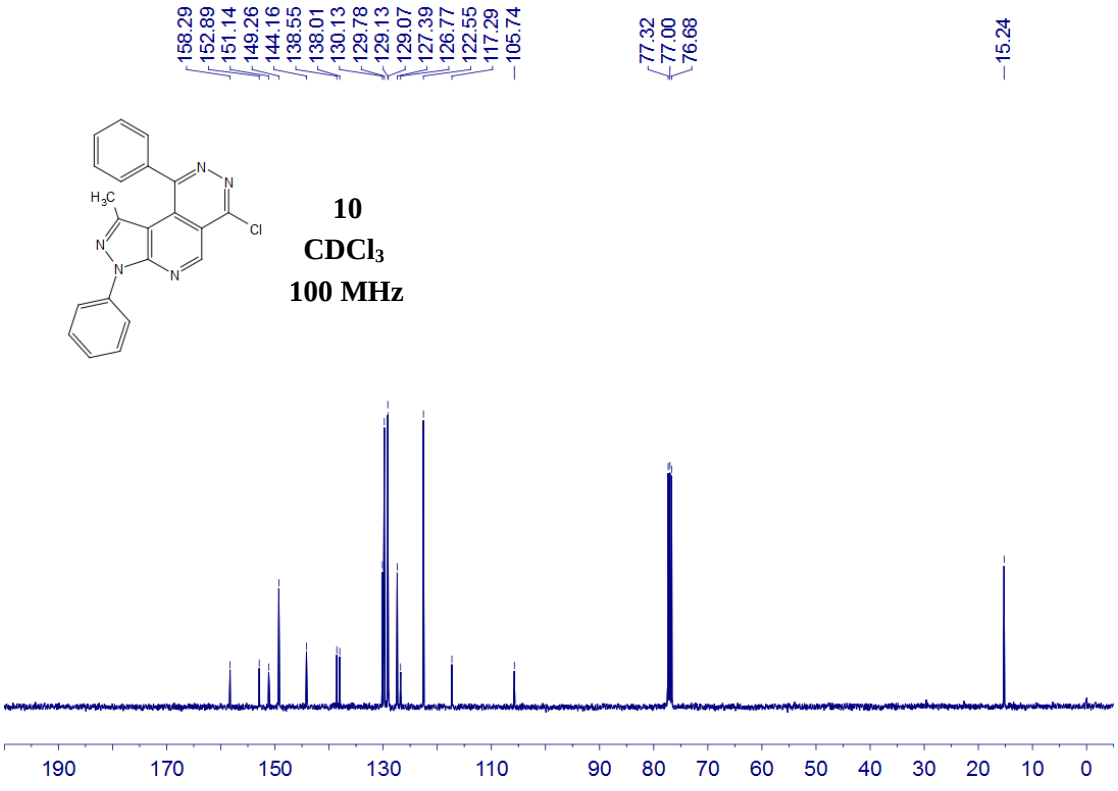
162 MHz

10



10
$CDCl_3$
400 MHz


158.29
152.89
151.14
149.26
144.16
138.55
138.01
130.13
129.78
129.13
129.07
127.39
126.77
122.55
117.29
105.74
77.32
77.00
76.68
15.24
H3C
N
N
Cl
N
N
N
10
CDCl3
100 MHz
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0

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