

## Supporting Information

### Structure-based Design of Novel Benzoxazinorifamycins with Potent Binding Affinity to Wild-type and Rifampin-resistant Mutant *Mycobacterium Tuberculosis* RNA Polymerases

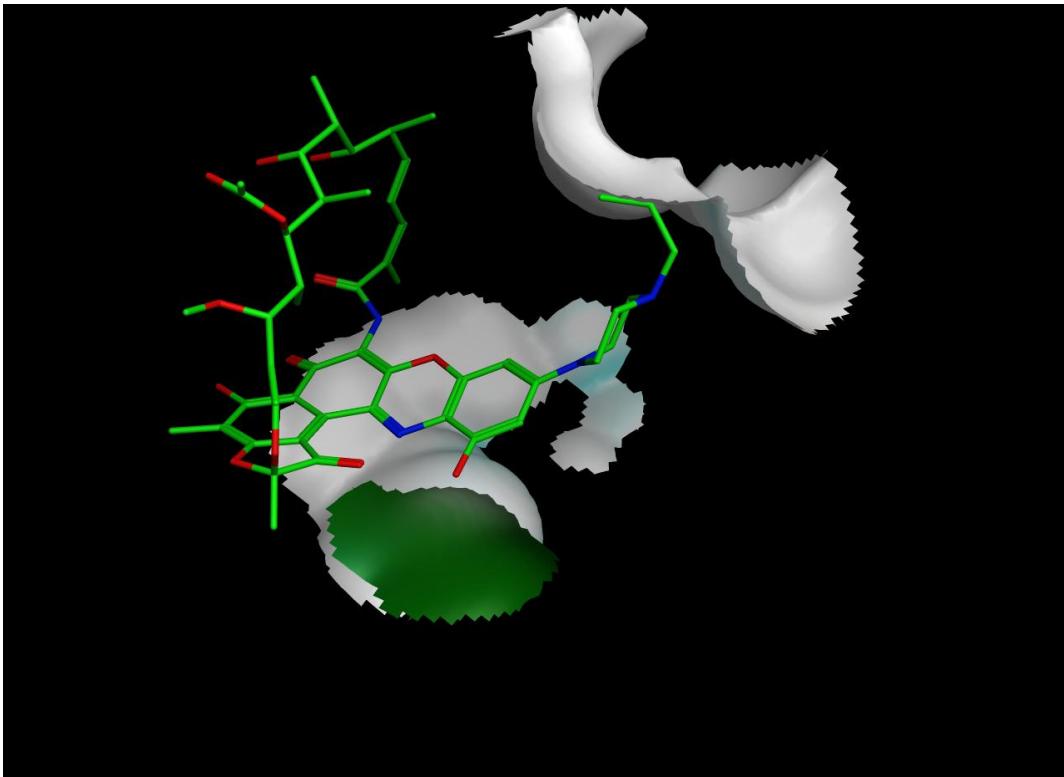
Sumandeep K. Gill<sup>#,a</sup>, Hao Xu<sup>#,b</sup>, Paul D. Kirchhoff<sup>c</sup>, Tomasz Cierpicki<sup>d</sup>, Anjanette J. Turbiak<sup>b</sup>, Baojie Wan<sup>e</sup>, Nan Zhang<sup>e</sup>, Kuan-Wei Peng<sup>e</sup>, Scott G. Franzblau<sup>e</sup>, George A. Garcia<sup>a,b</sup> and H.D. Hollis Showalter<sup>b,c \*</sup>

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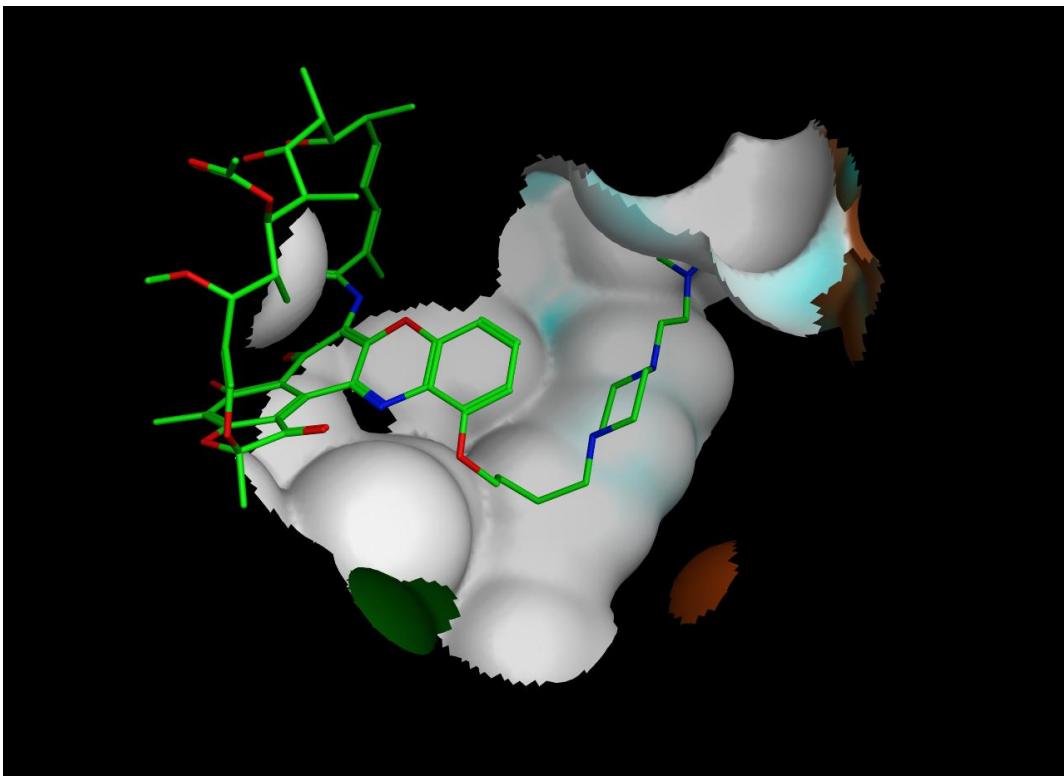
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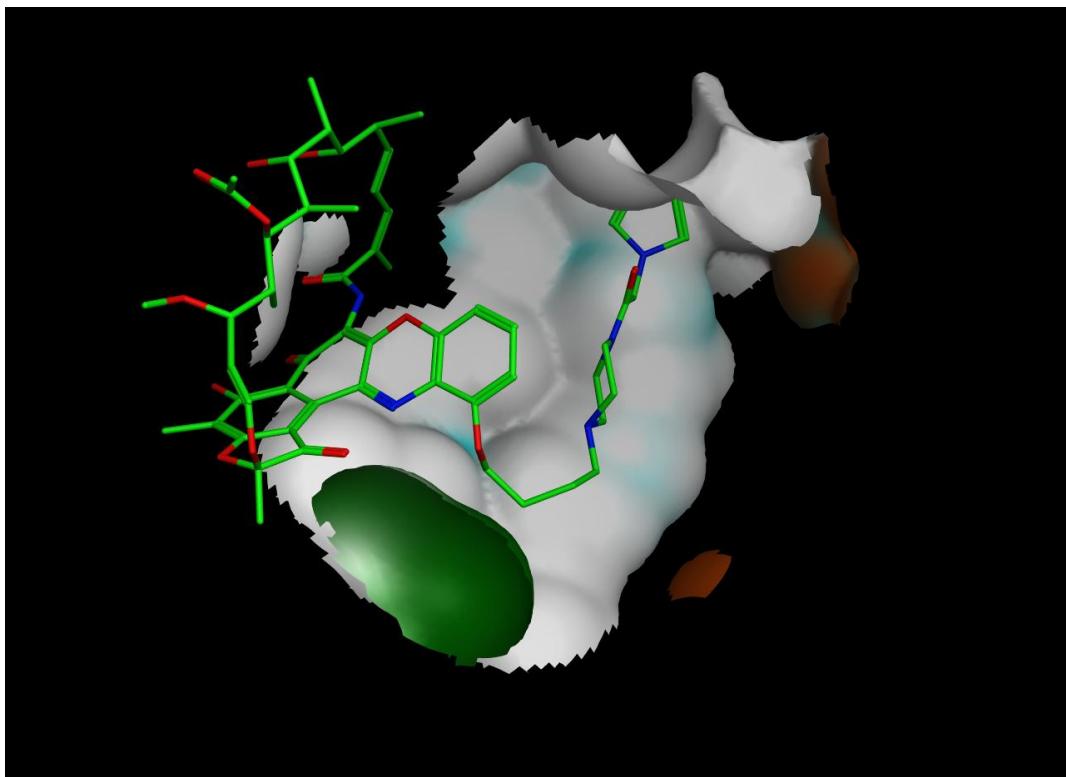
**Figure 1aSI (compound 2a)**



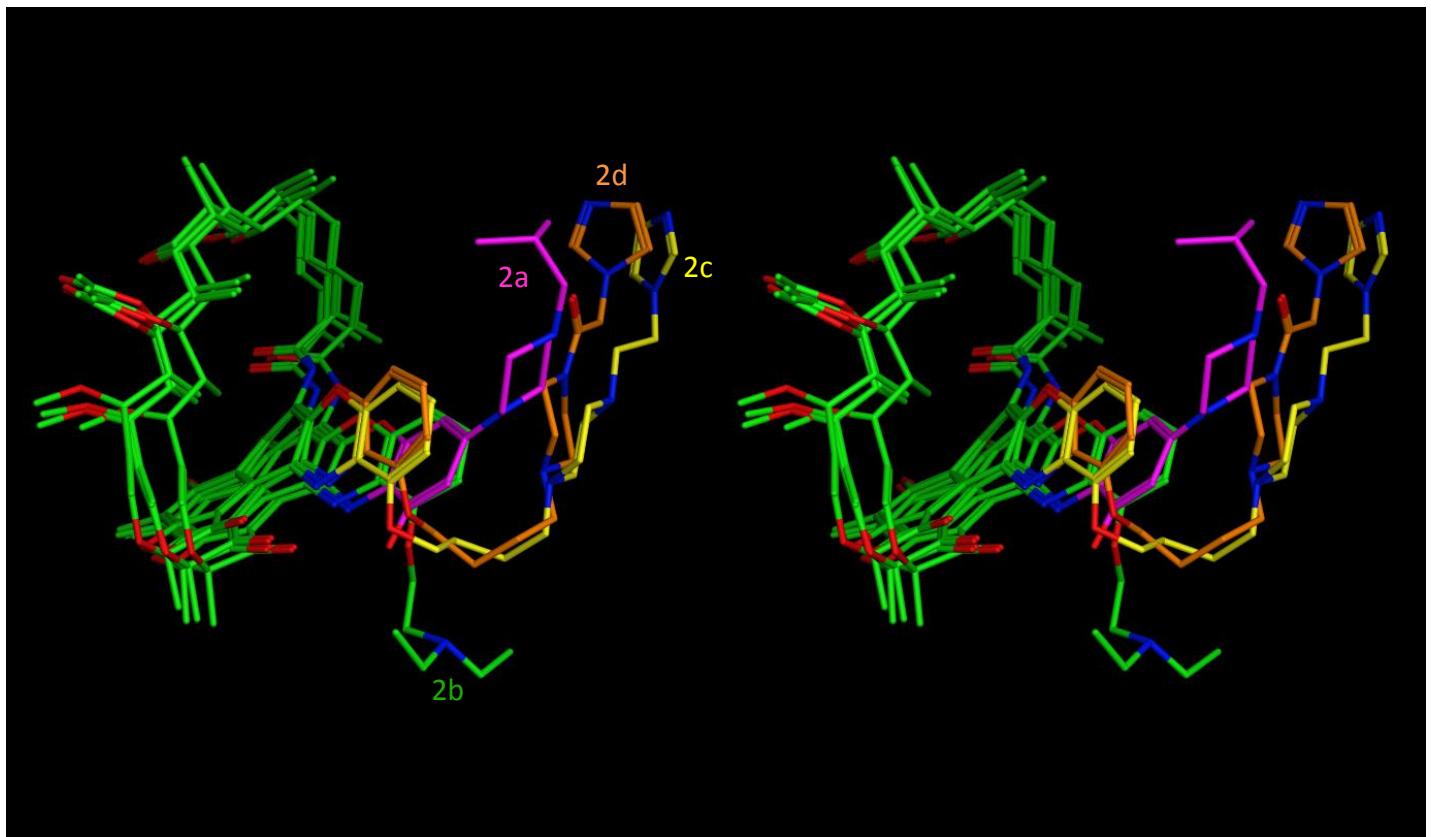
**Figure 1bSI (compound 2c)**



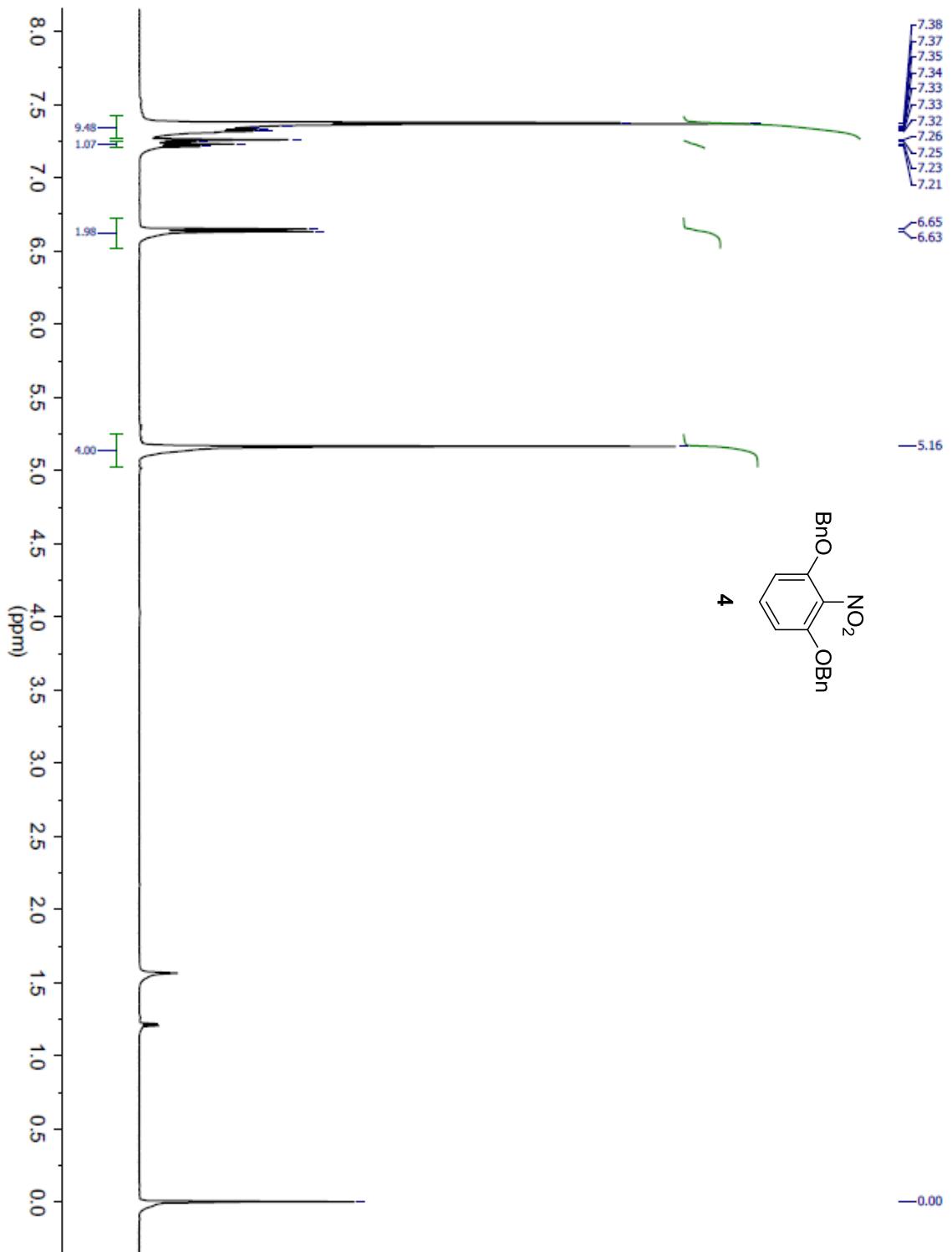
**Figure 1cSI (compound 2d)**

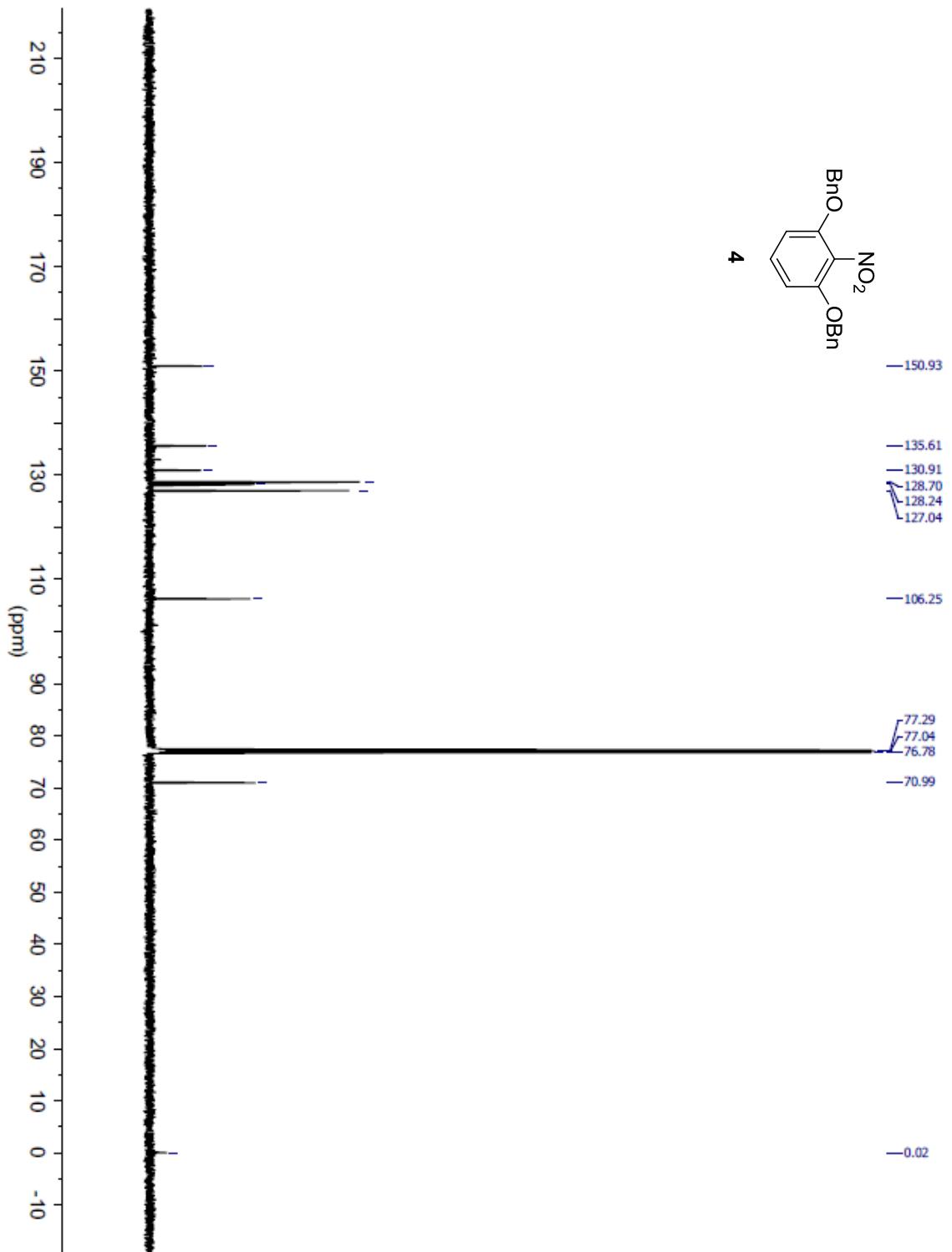


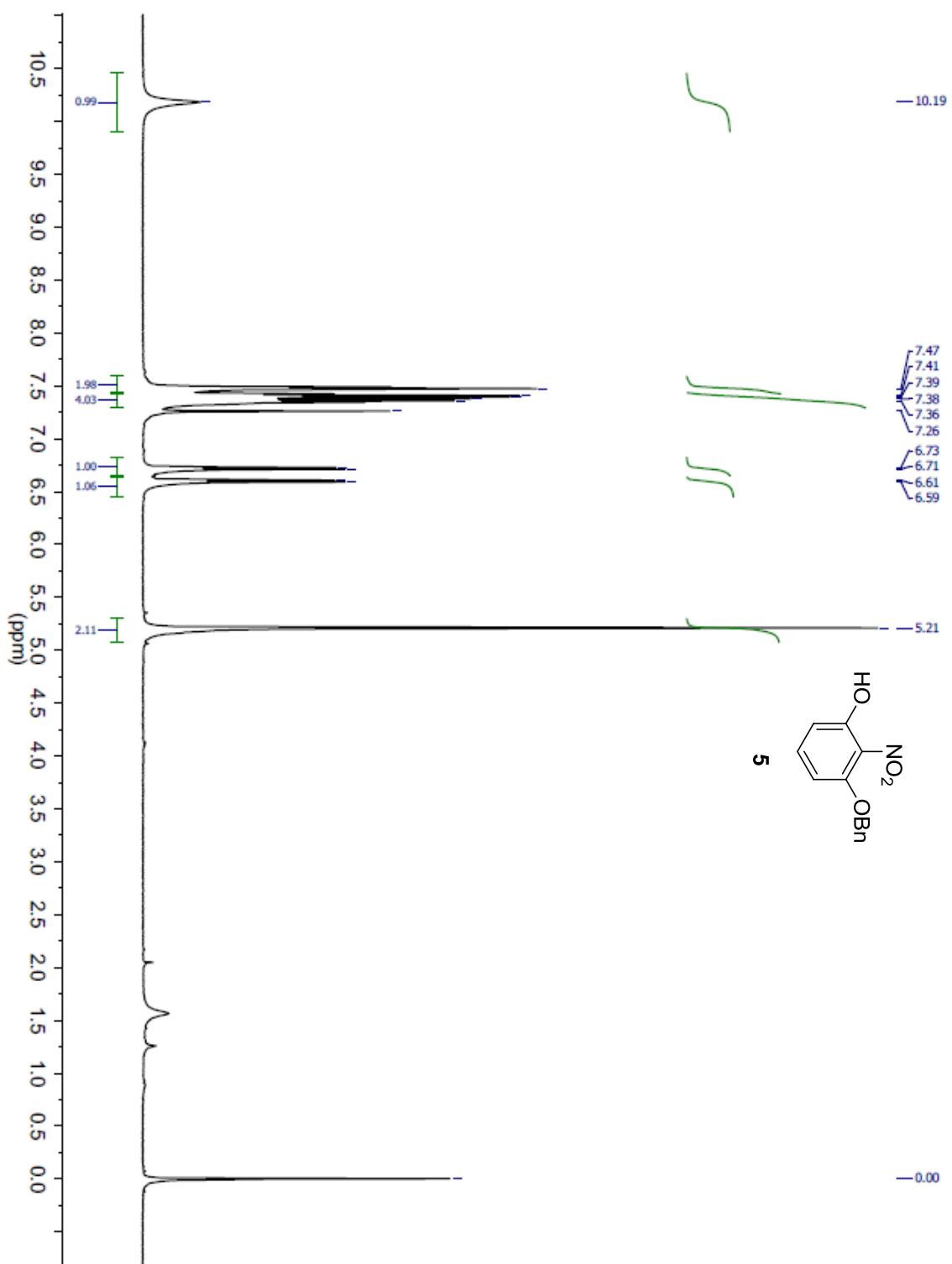
**Figure 1a-cSI.** Interaction surfaces at 4.5 Å between the compound tail and surrounding RNAP for benzoxazinorifamycins **2a** and **2c-d** in the same coloring scheme as Figure 2

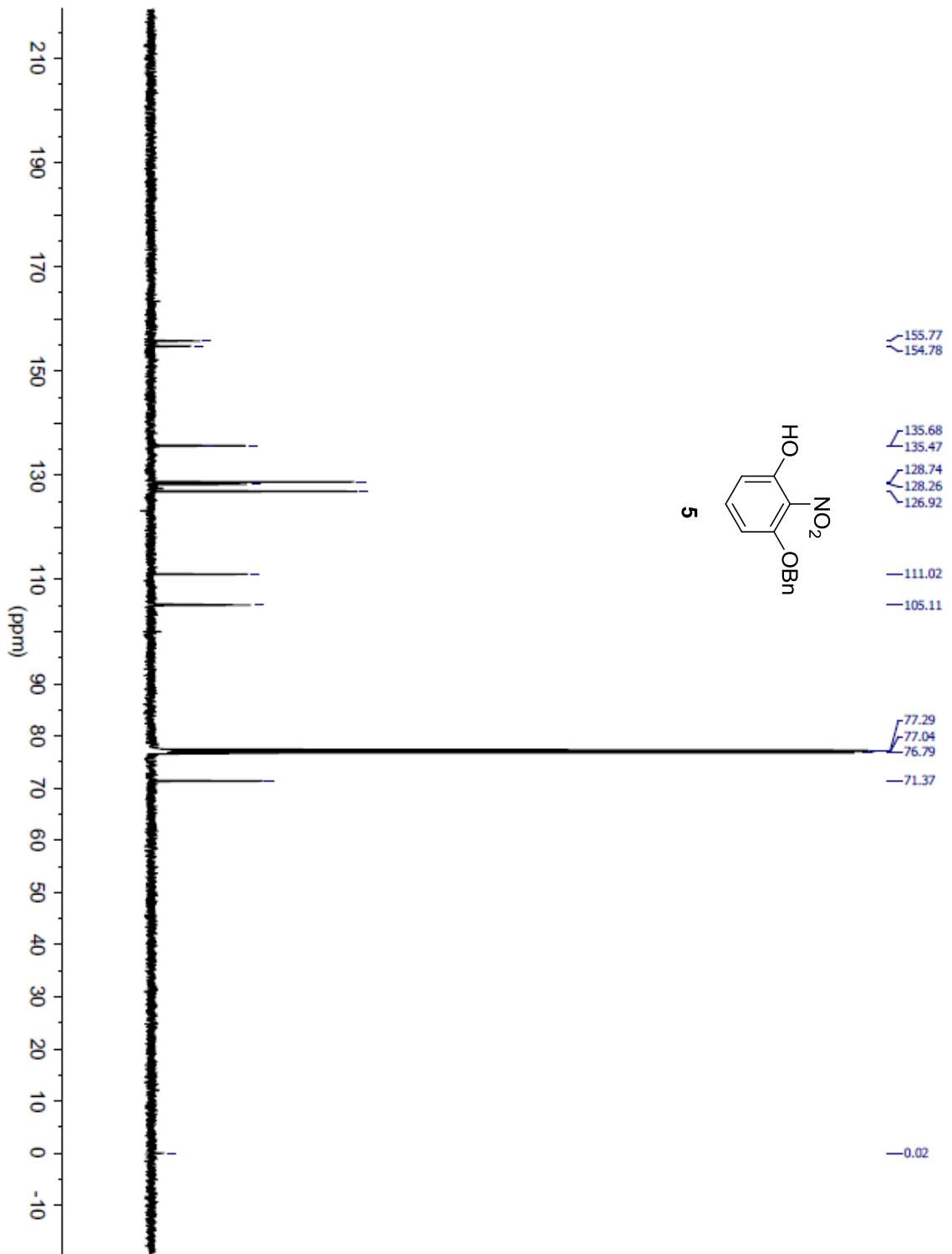


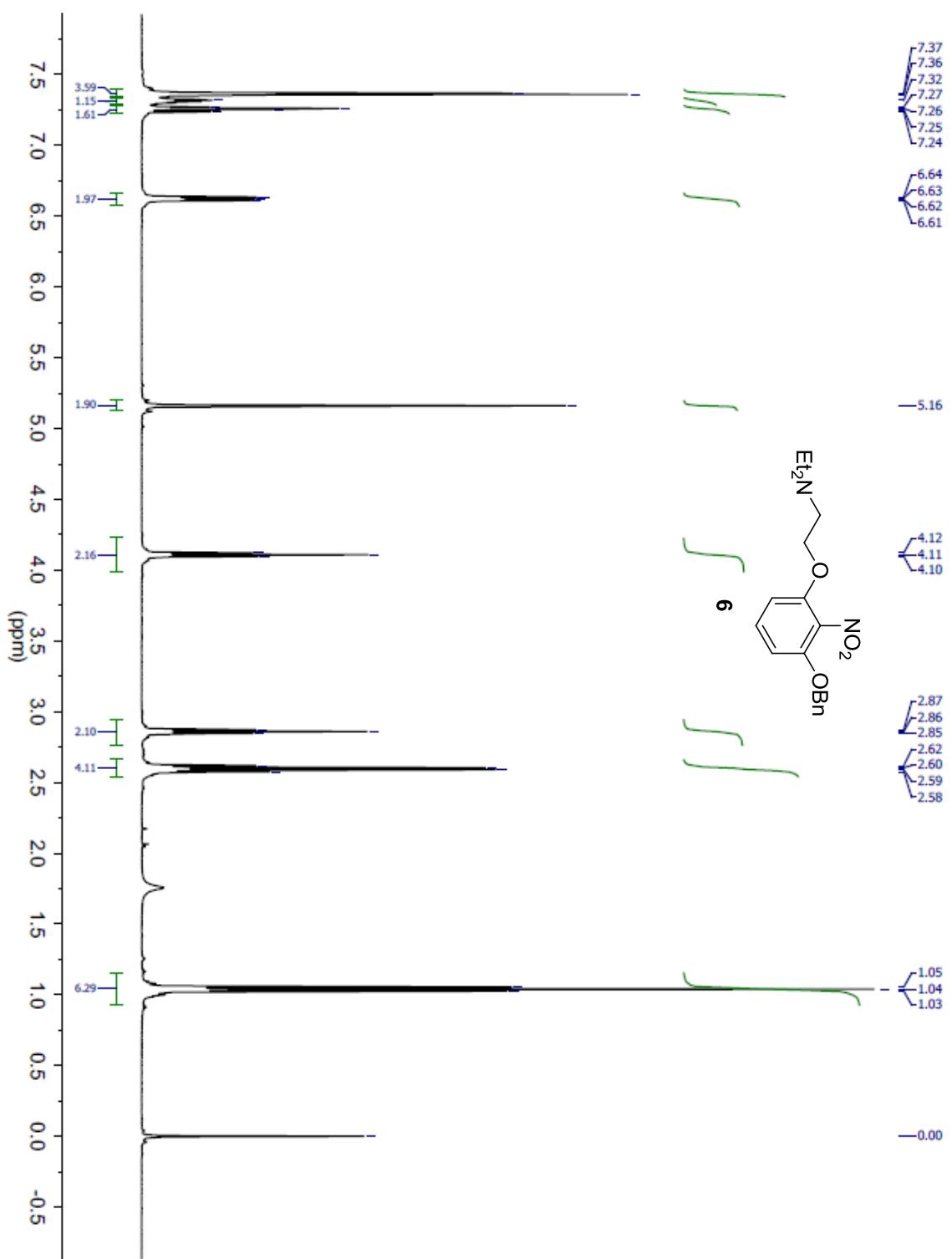
**Figure 1dSI.** Stereo view of superimposed compounds **2a-2d** in Figures 3 and 1a-cSI

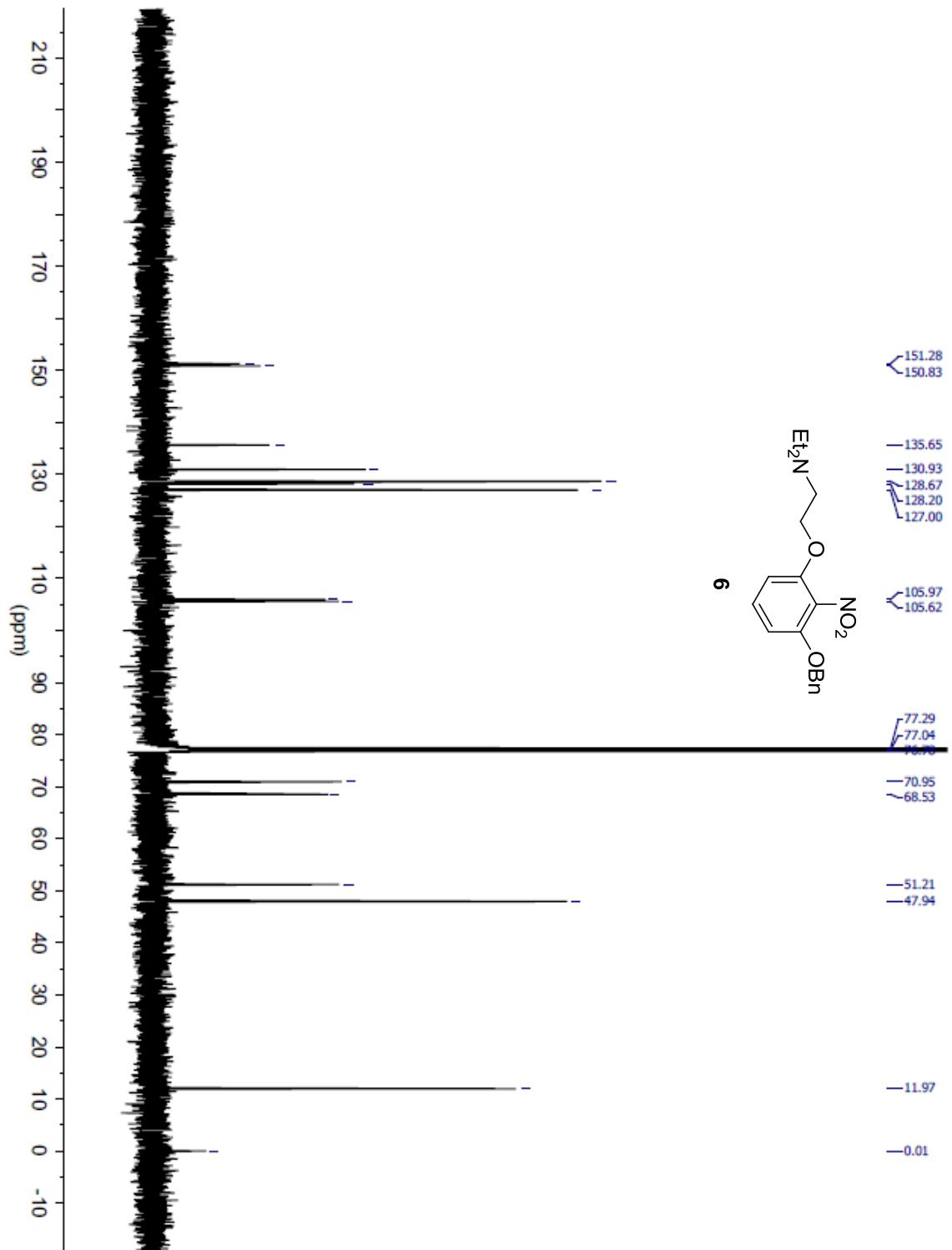


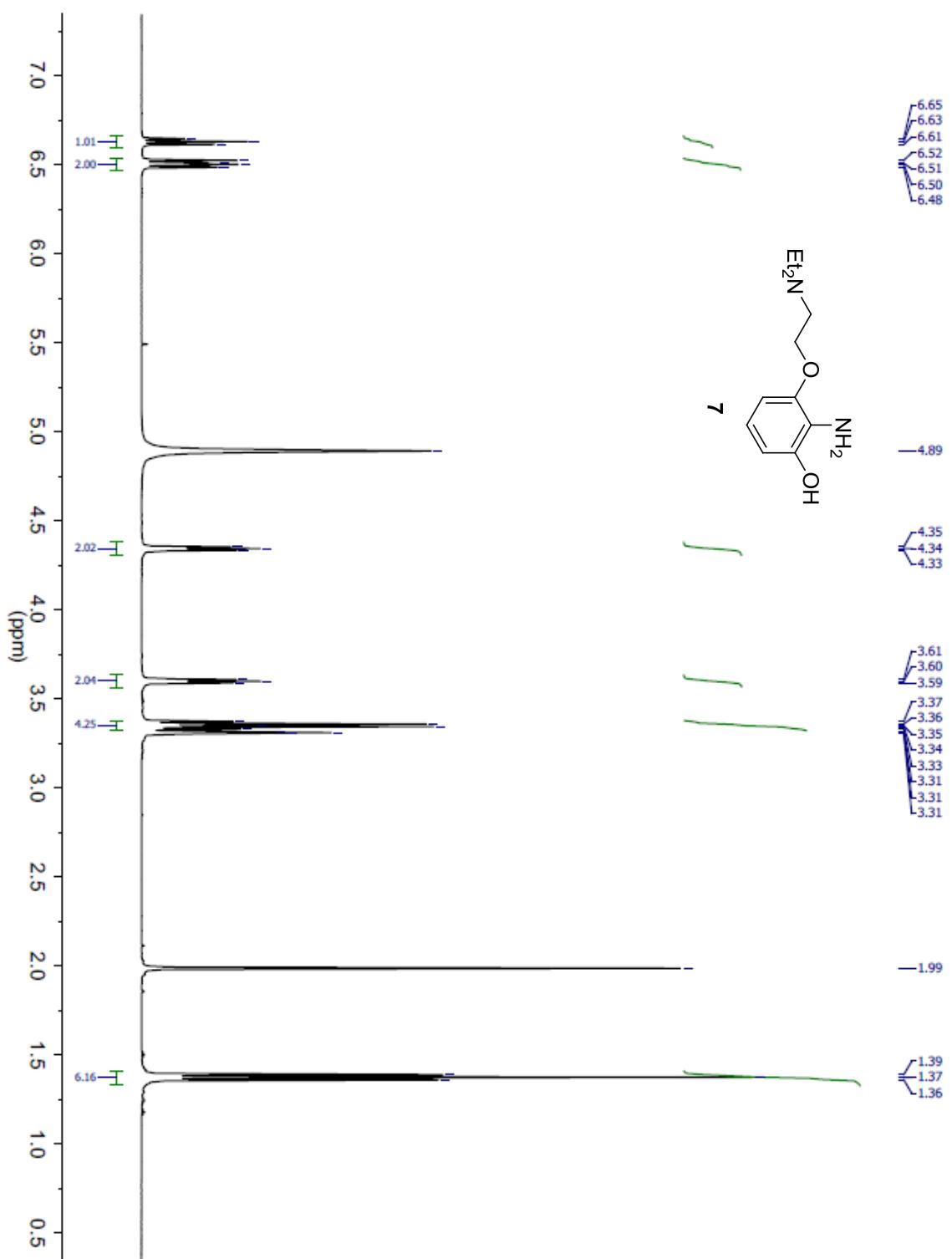


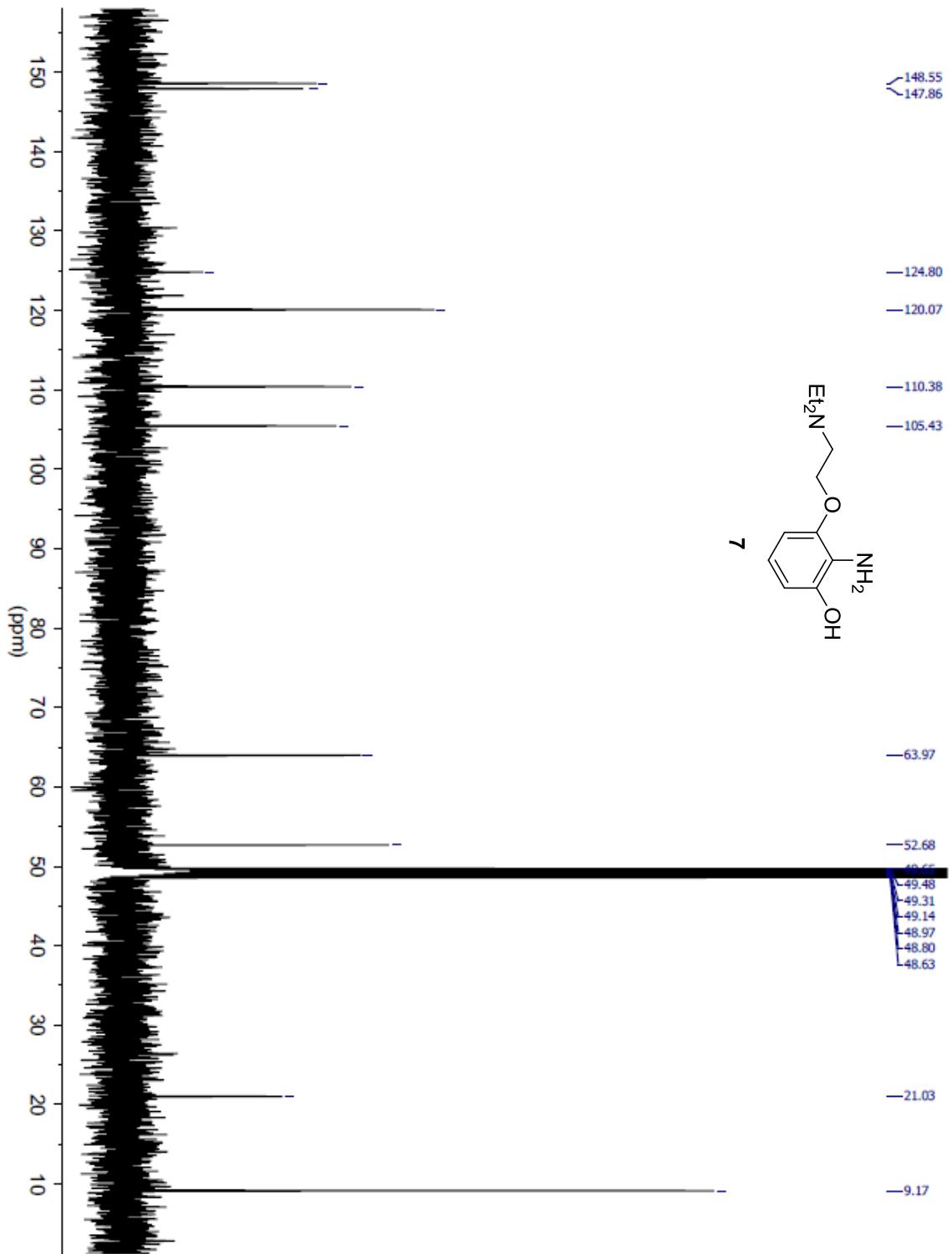


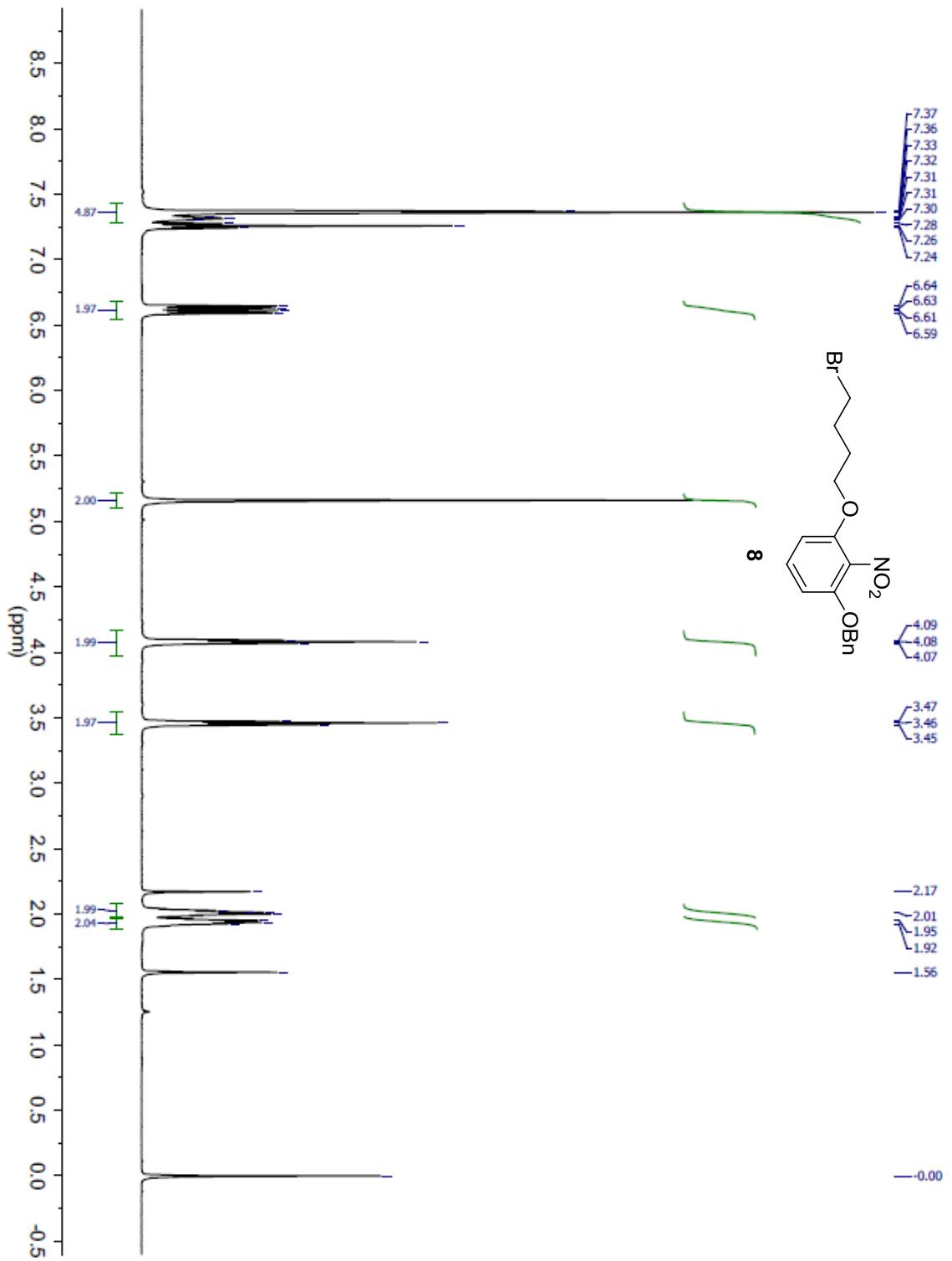


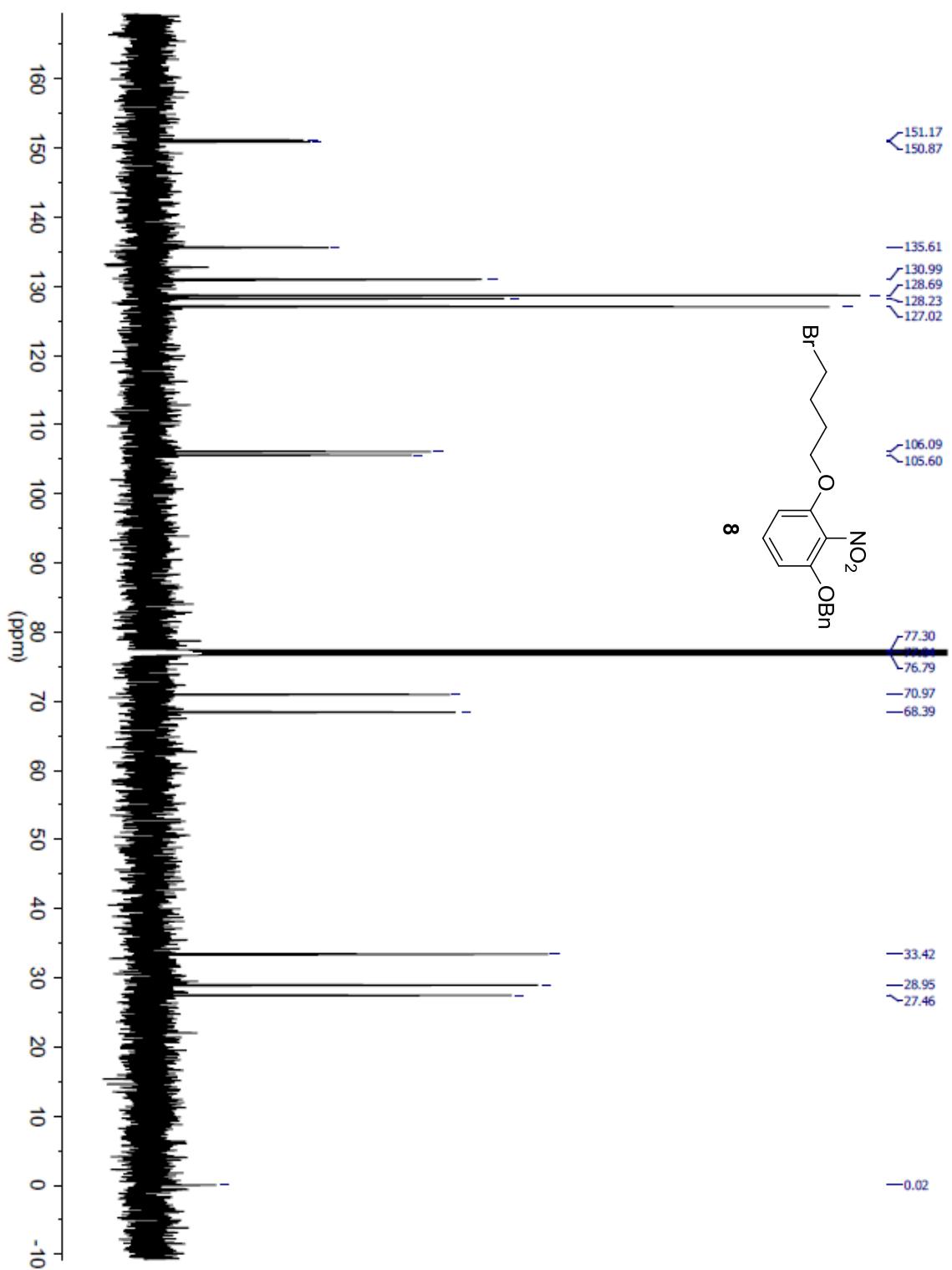


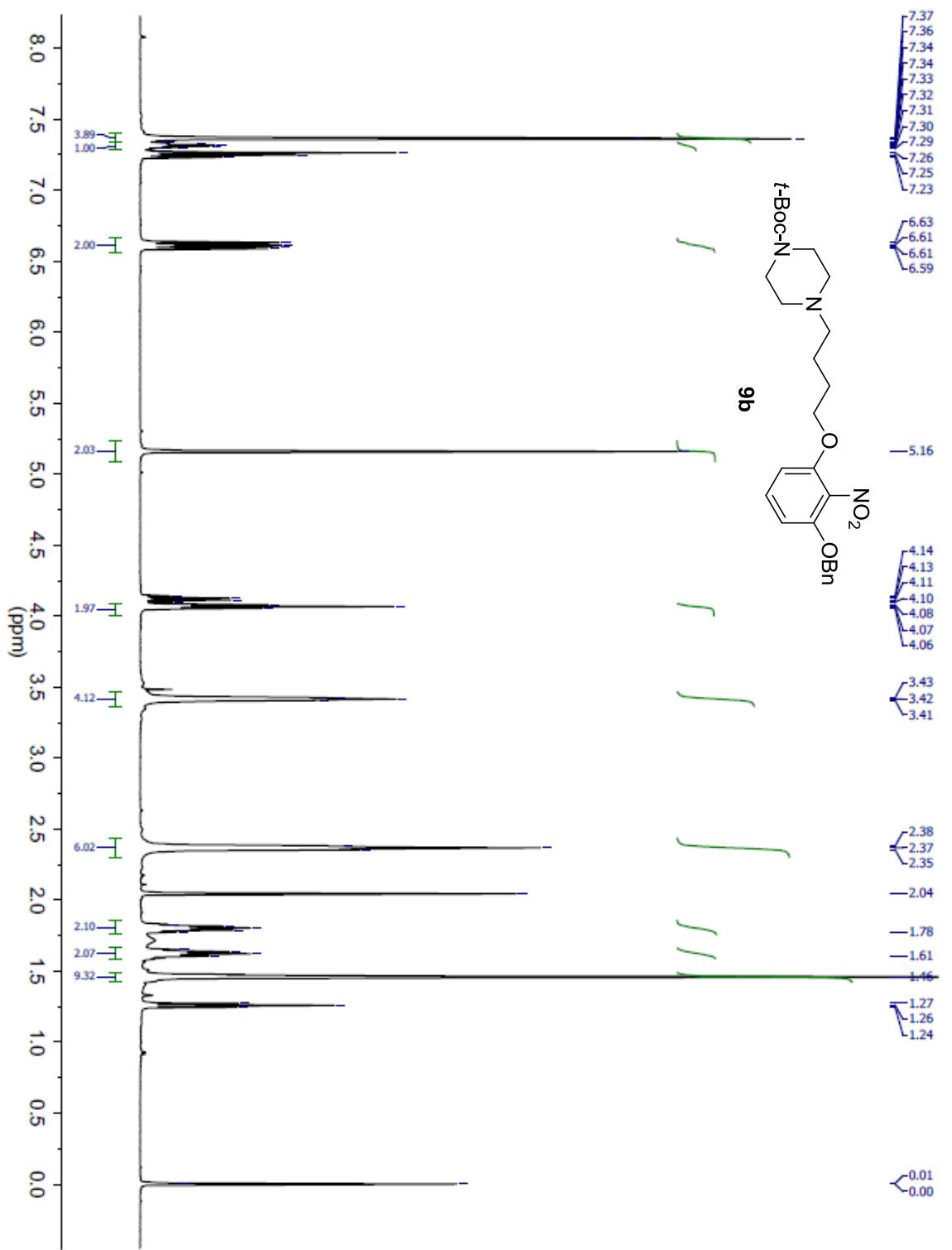


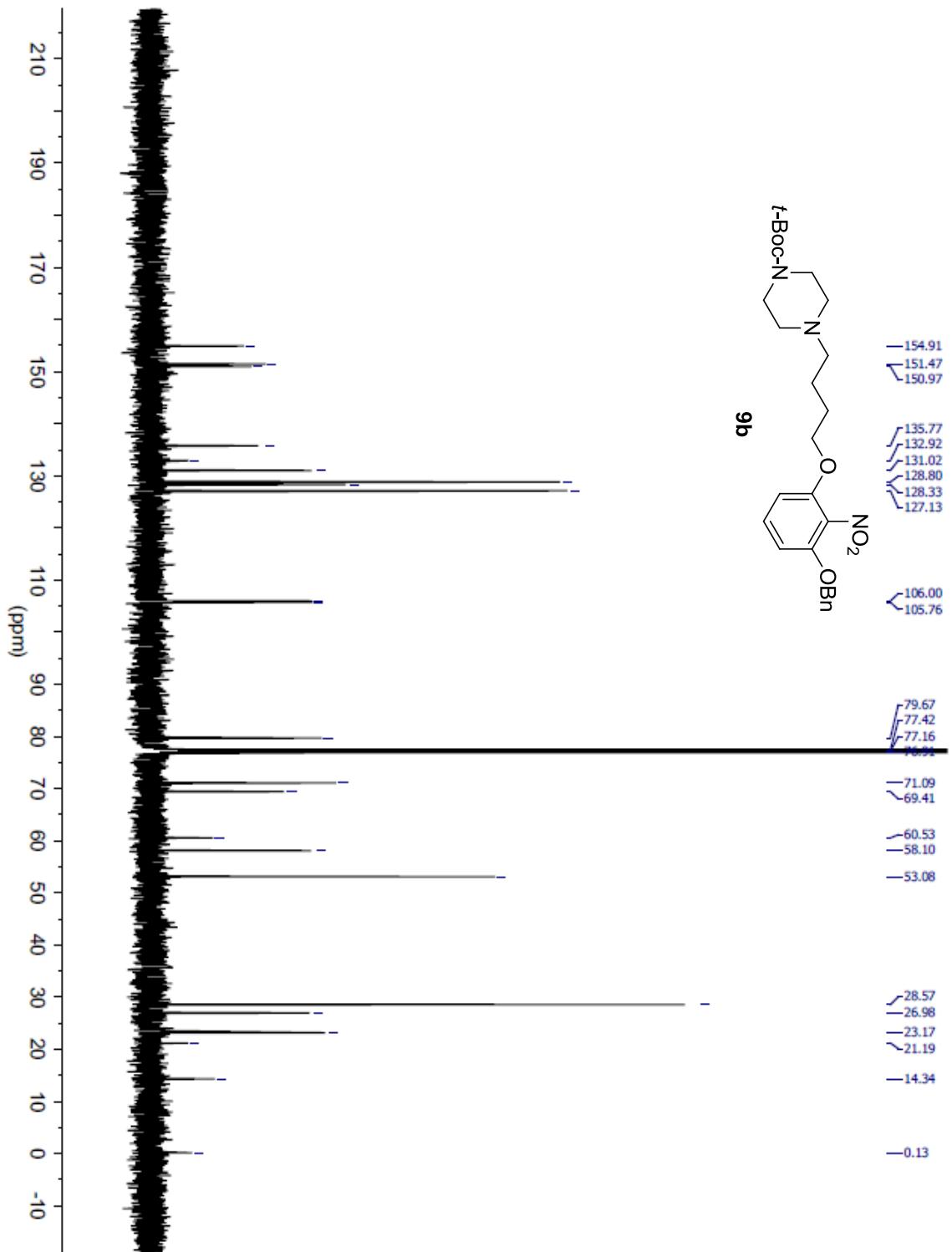


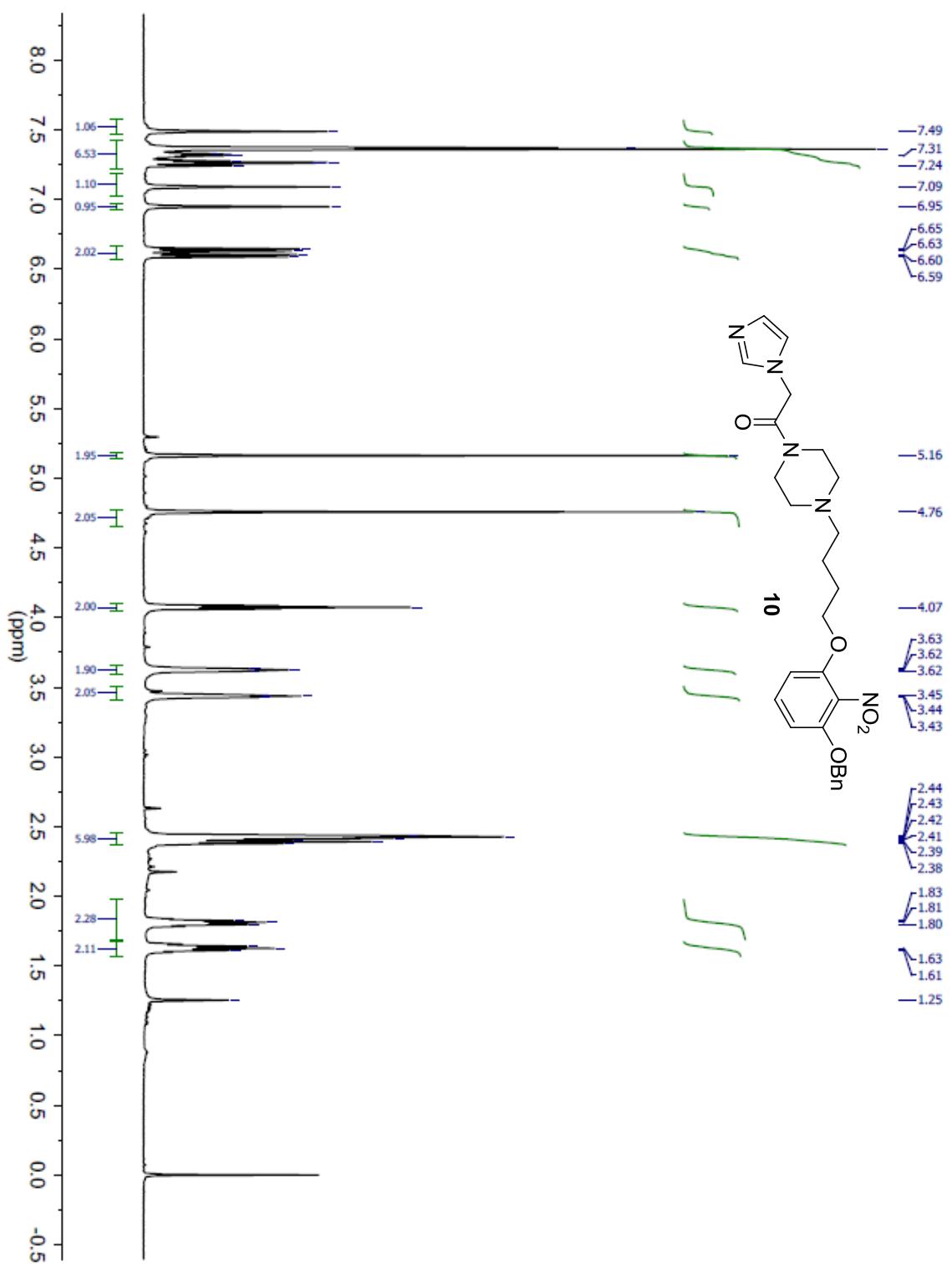


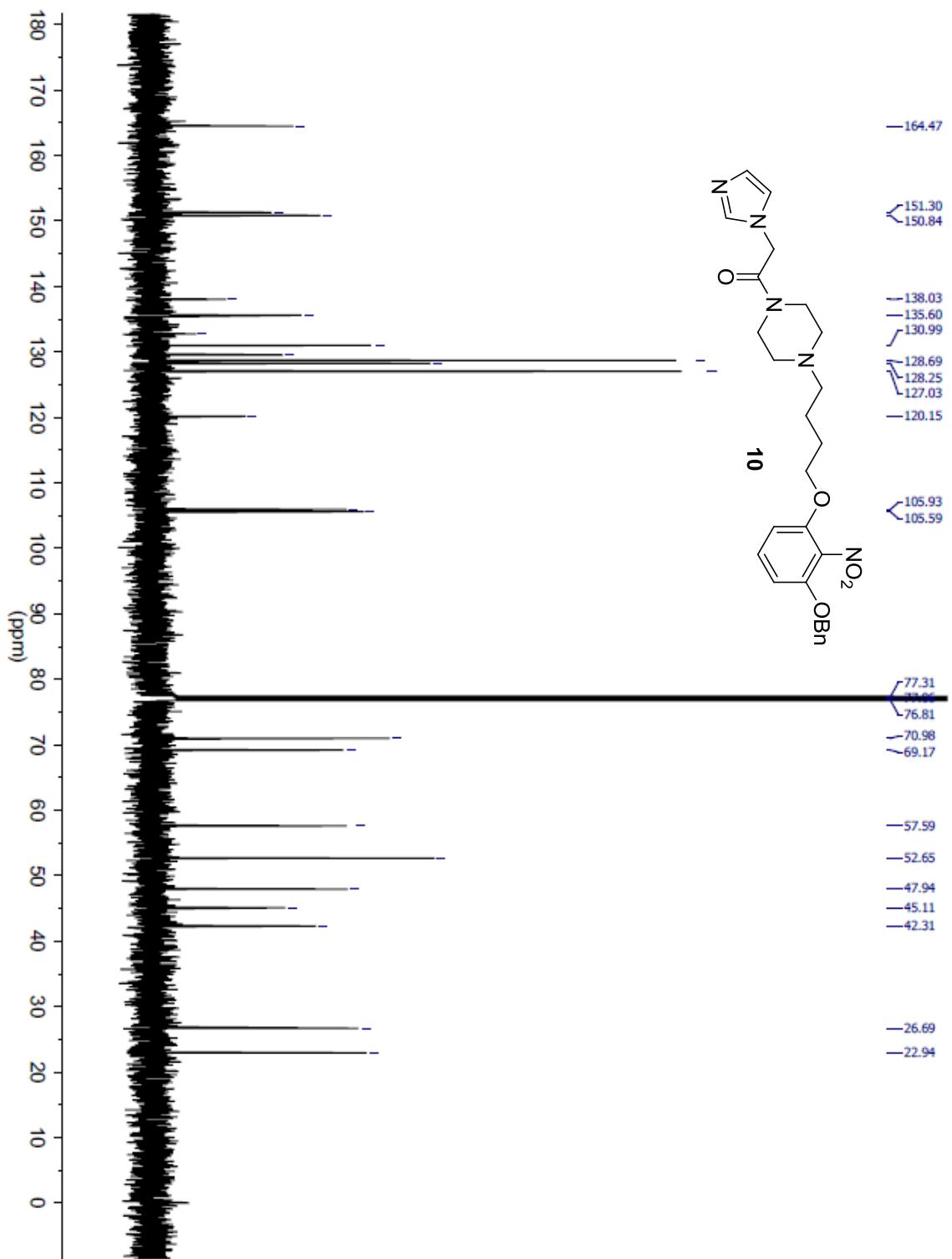


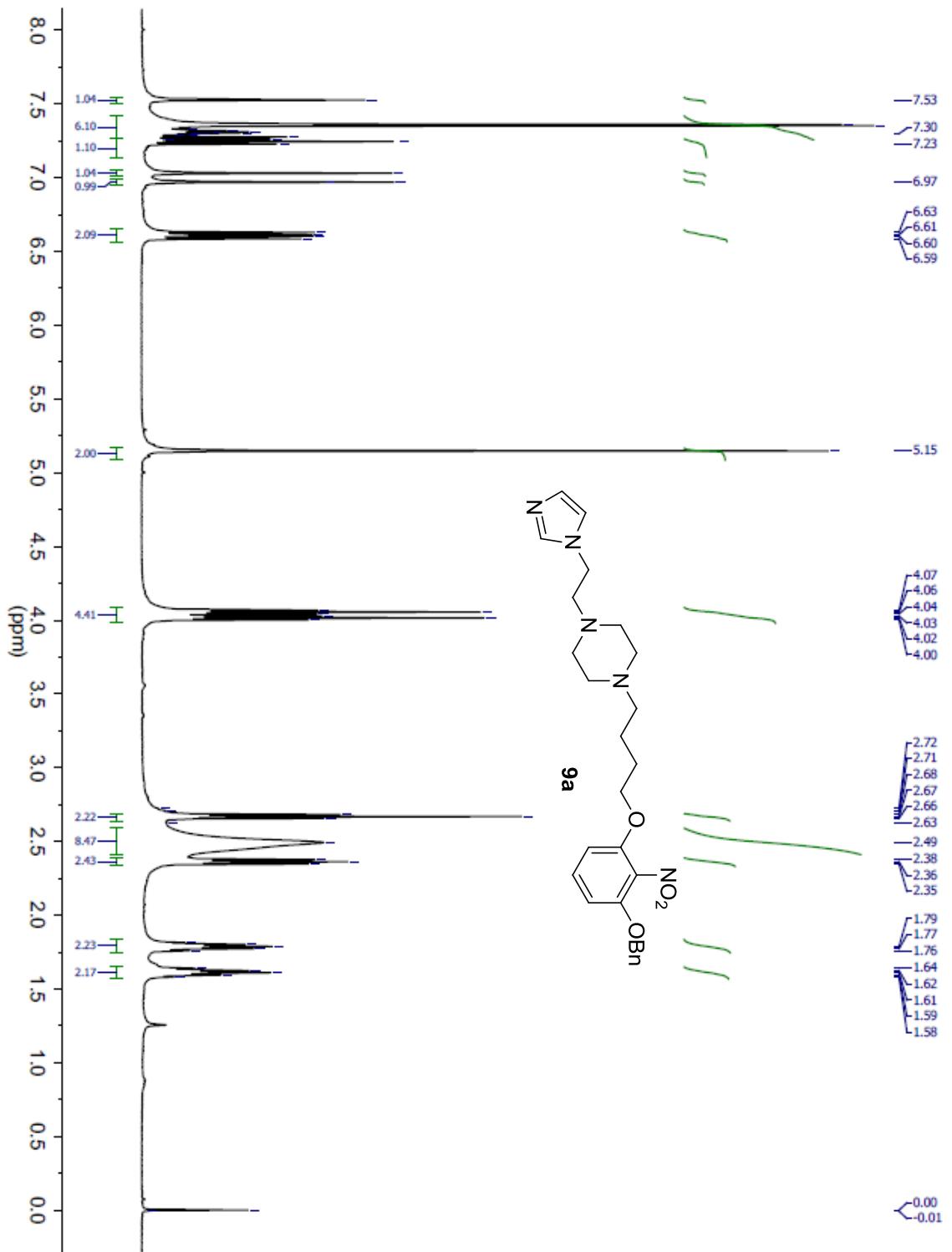


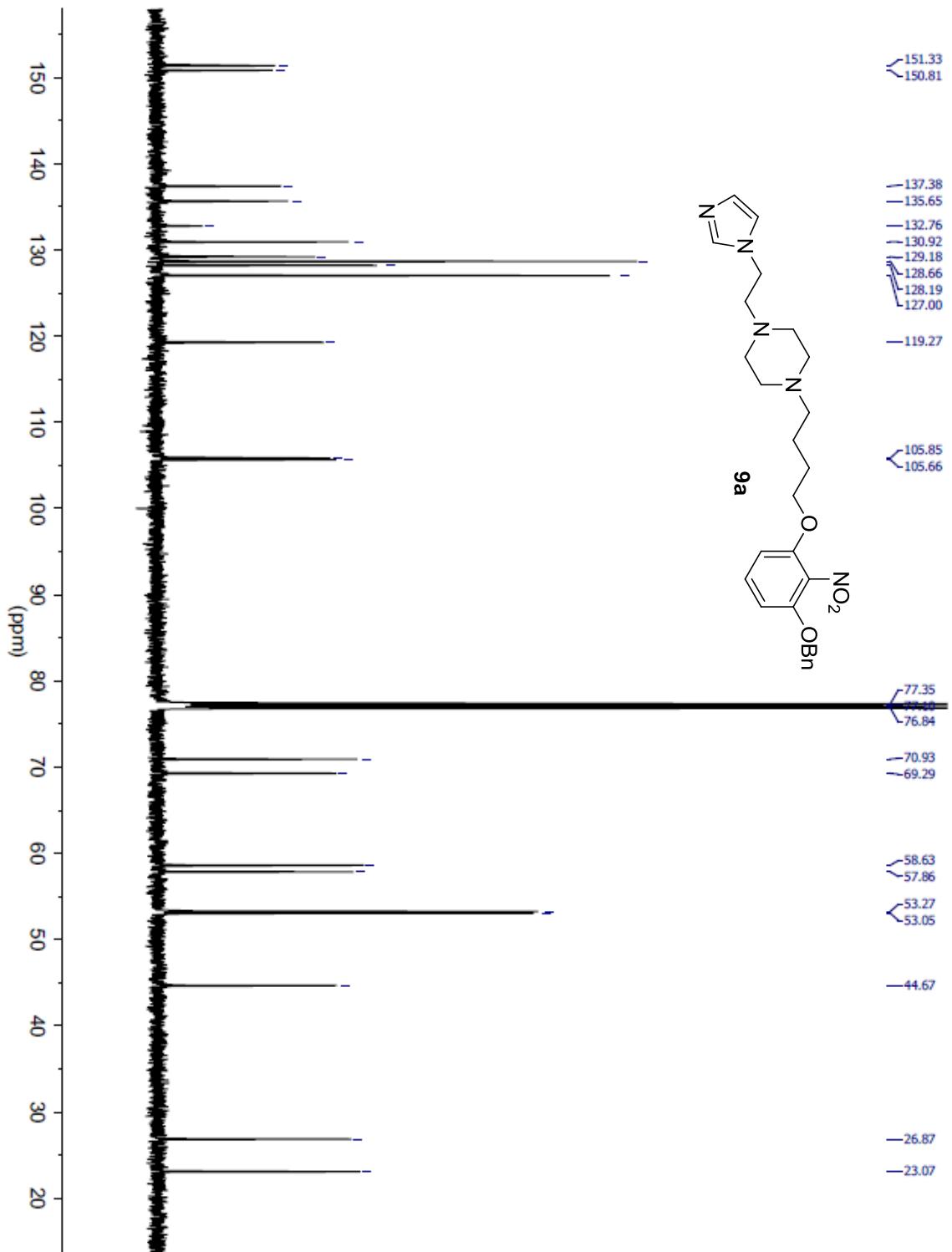


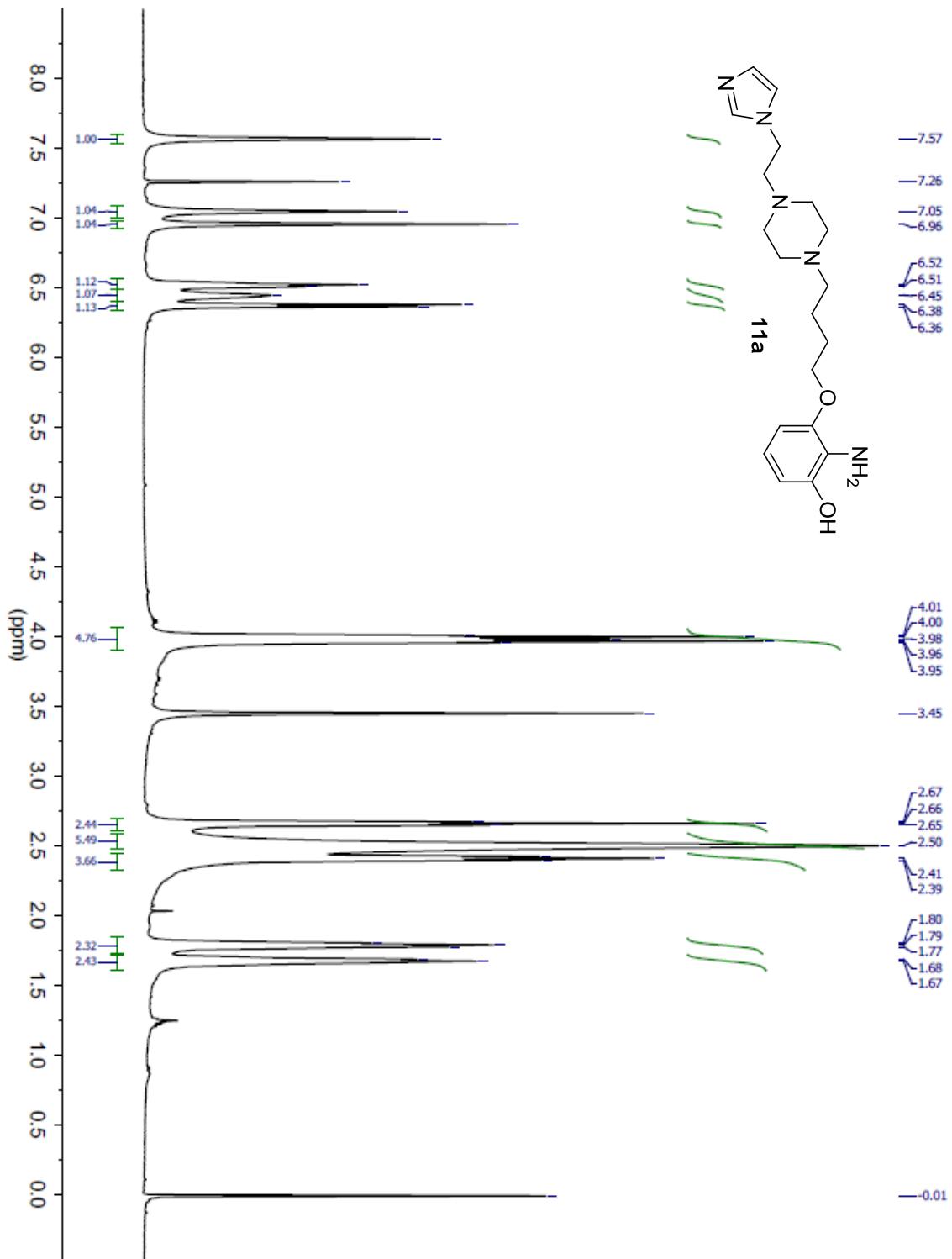


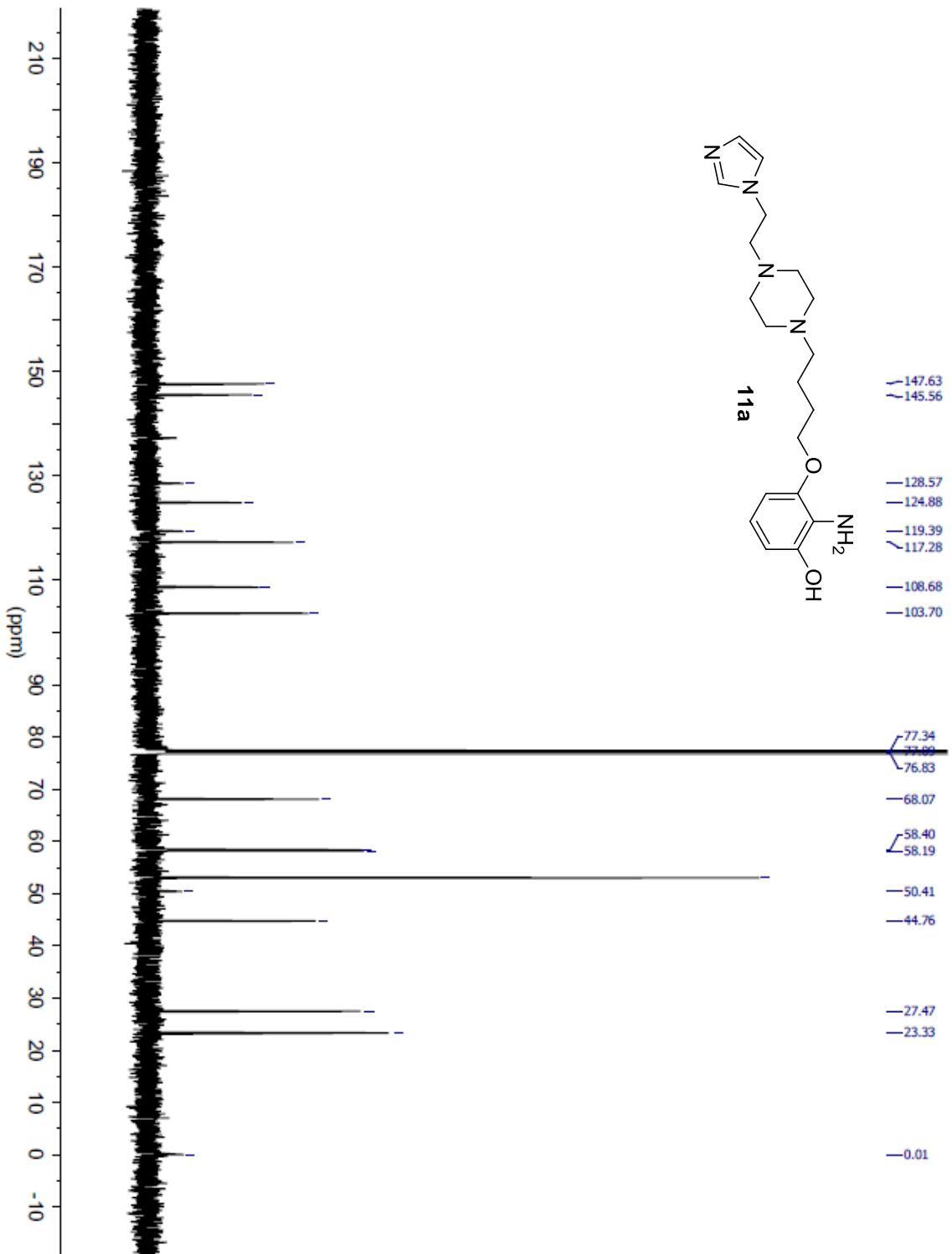


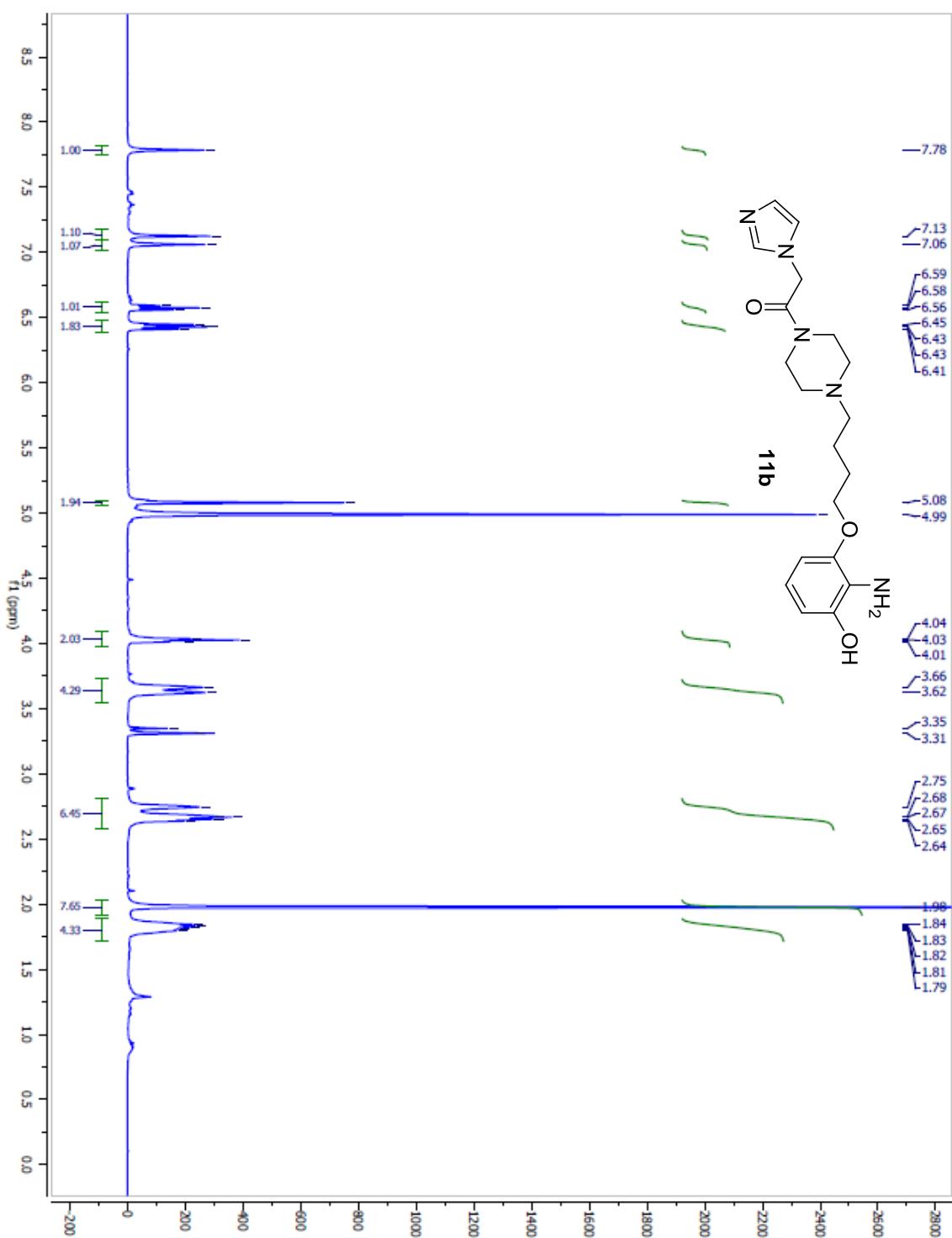


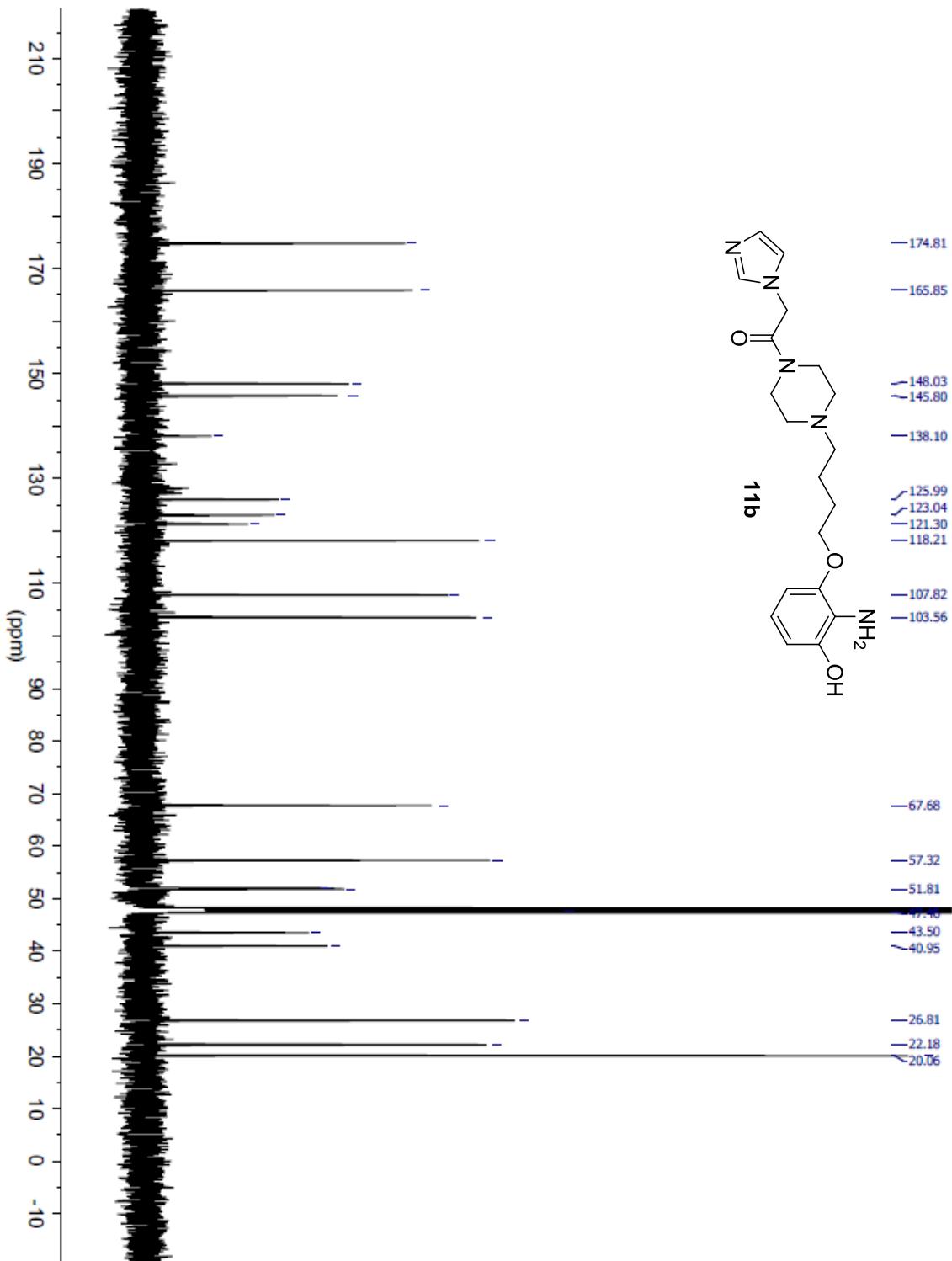








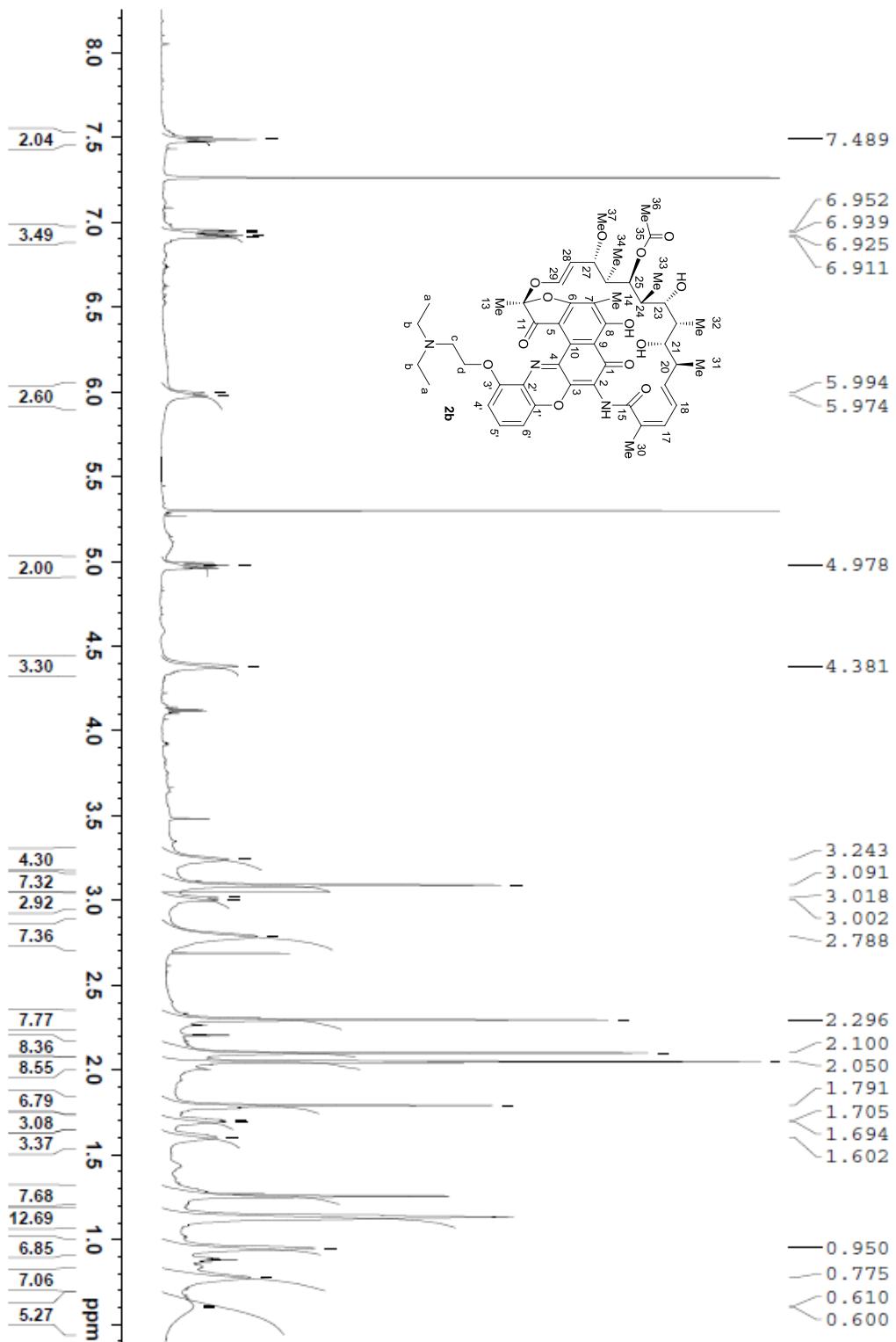




**Figure 2SI.**  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra of 2-aminoresorcinol ethers (**7**, **11a**, **11b**) and precursors

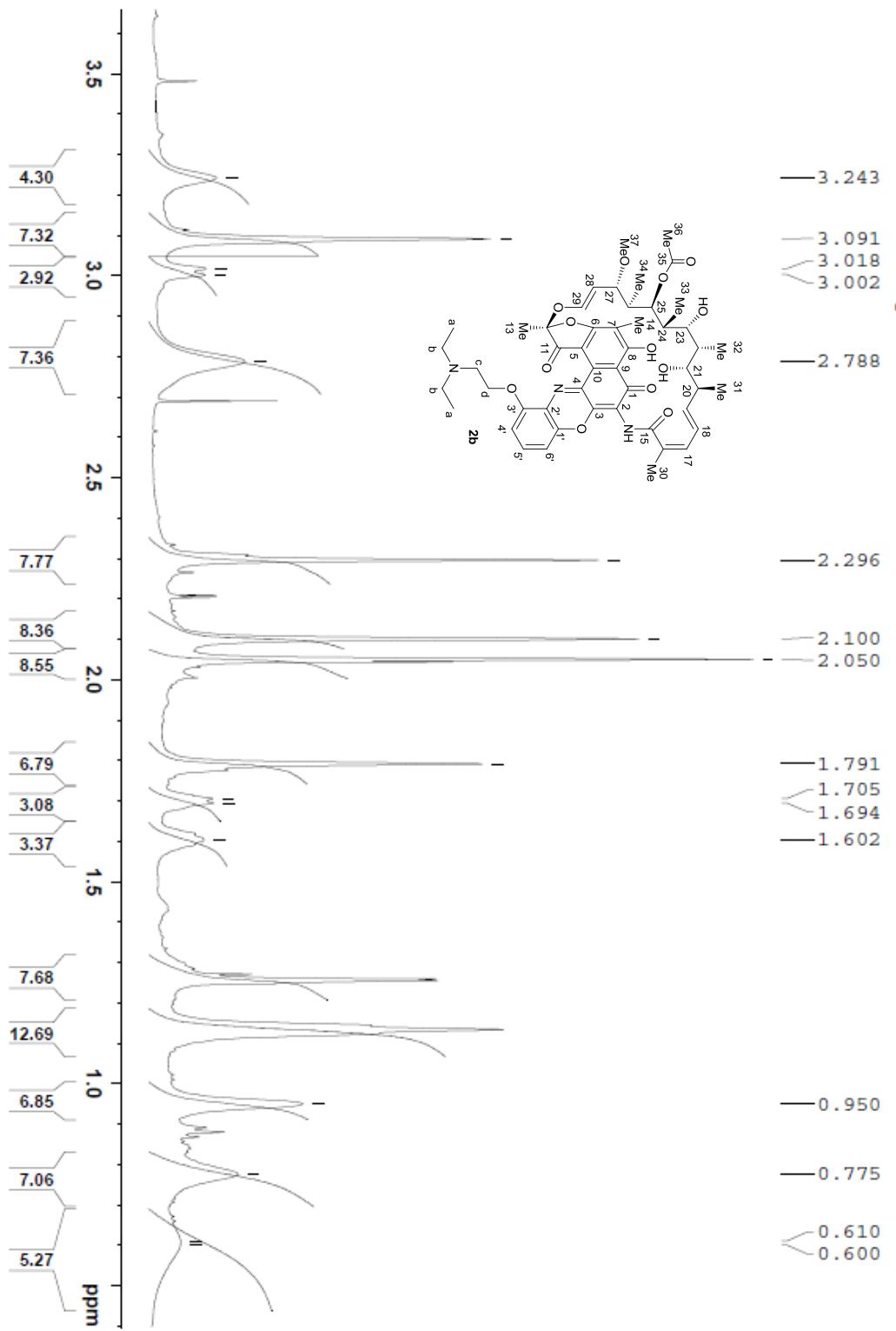
HX-2-51-1 in  $\text{CDCl}_3$ , temp=25°C

S25

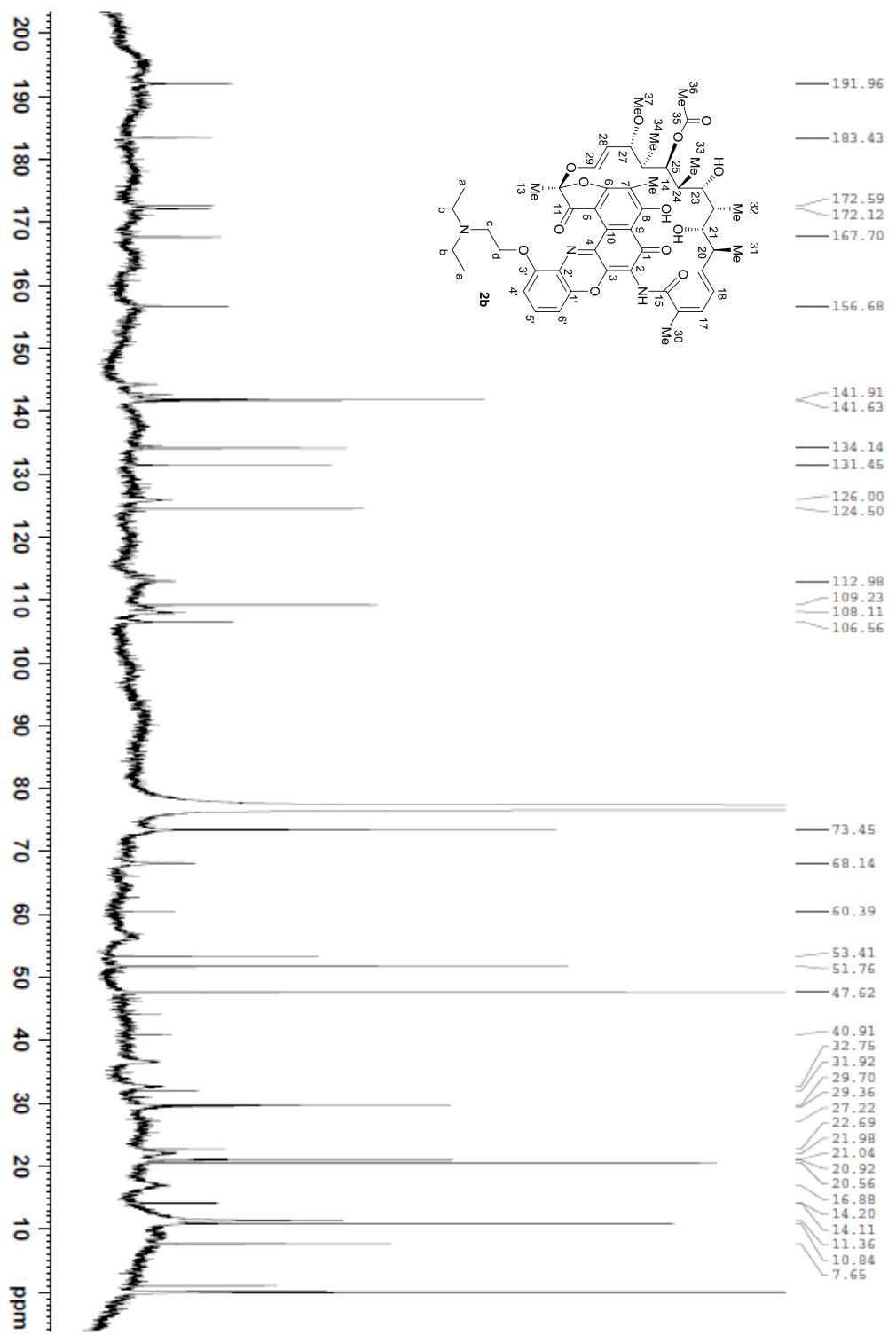


HX-2-51-1 in  $\text{CDCl}_3$ , temp=25°C

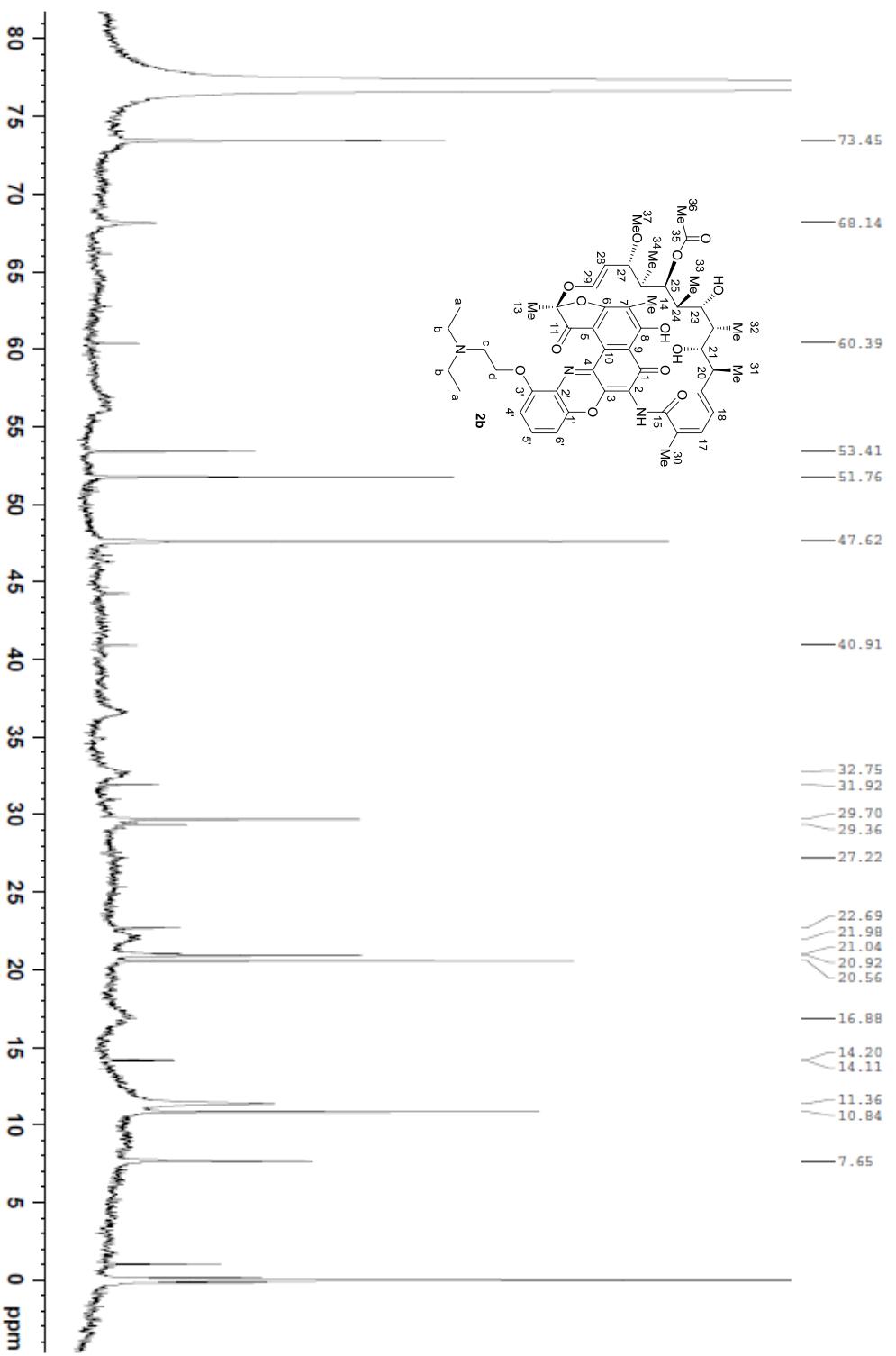
S26



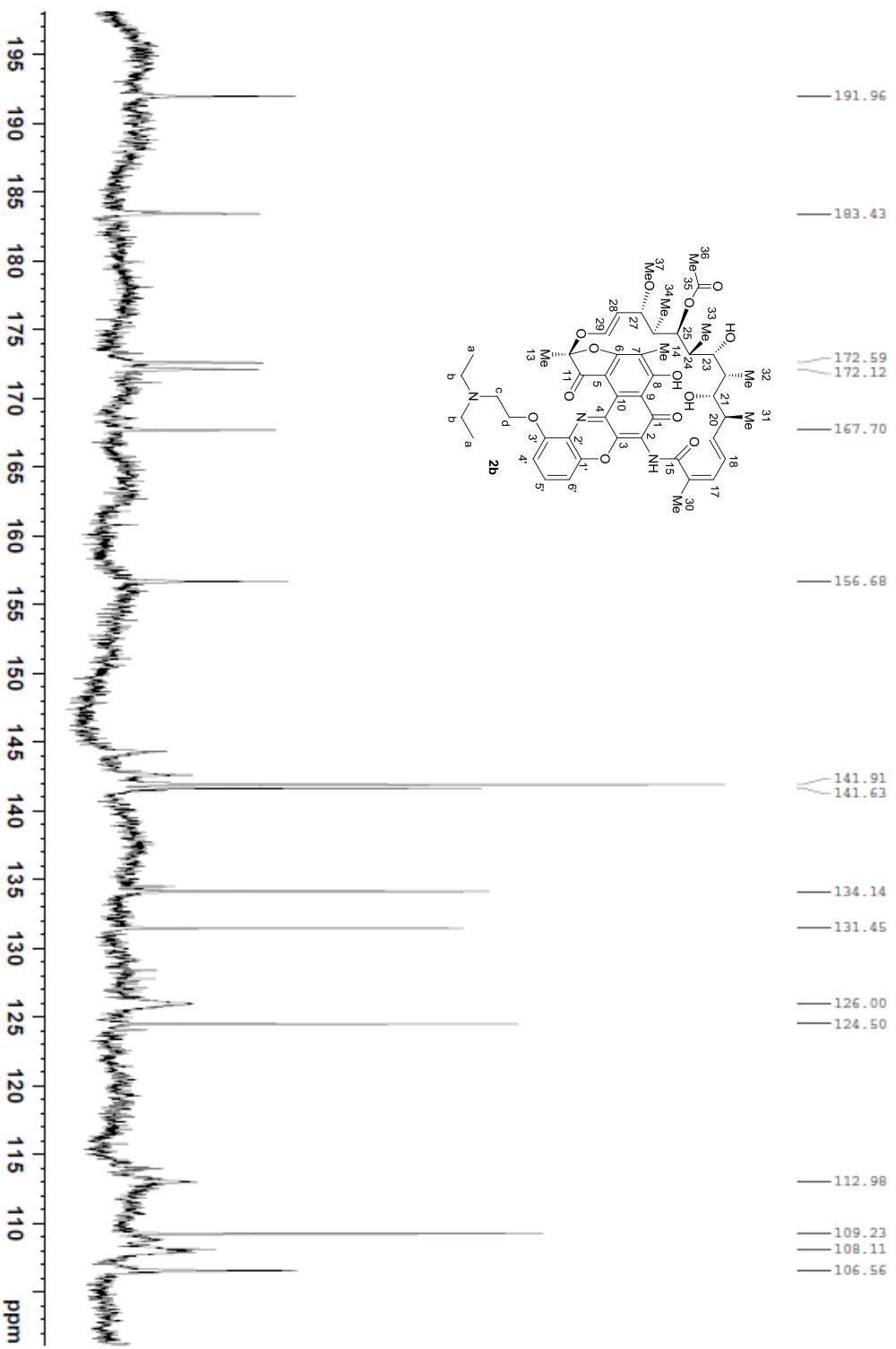
HX-2-51-1 in CDCl<sub>3</sub>, temp=25°C

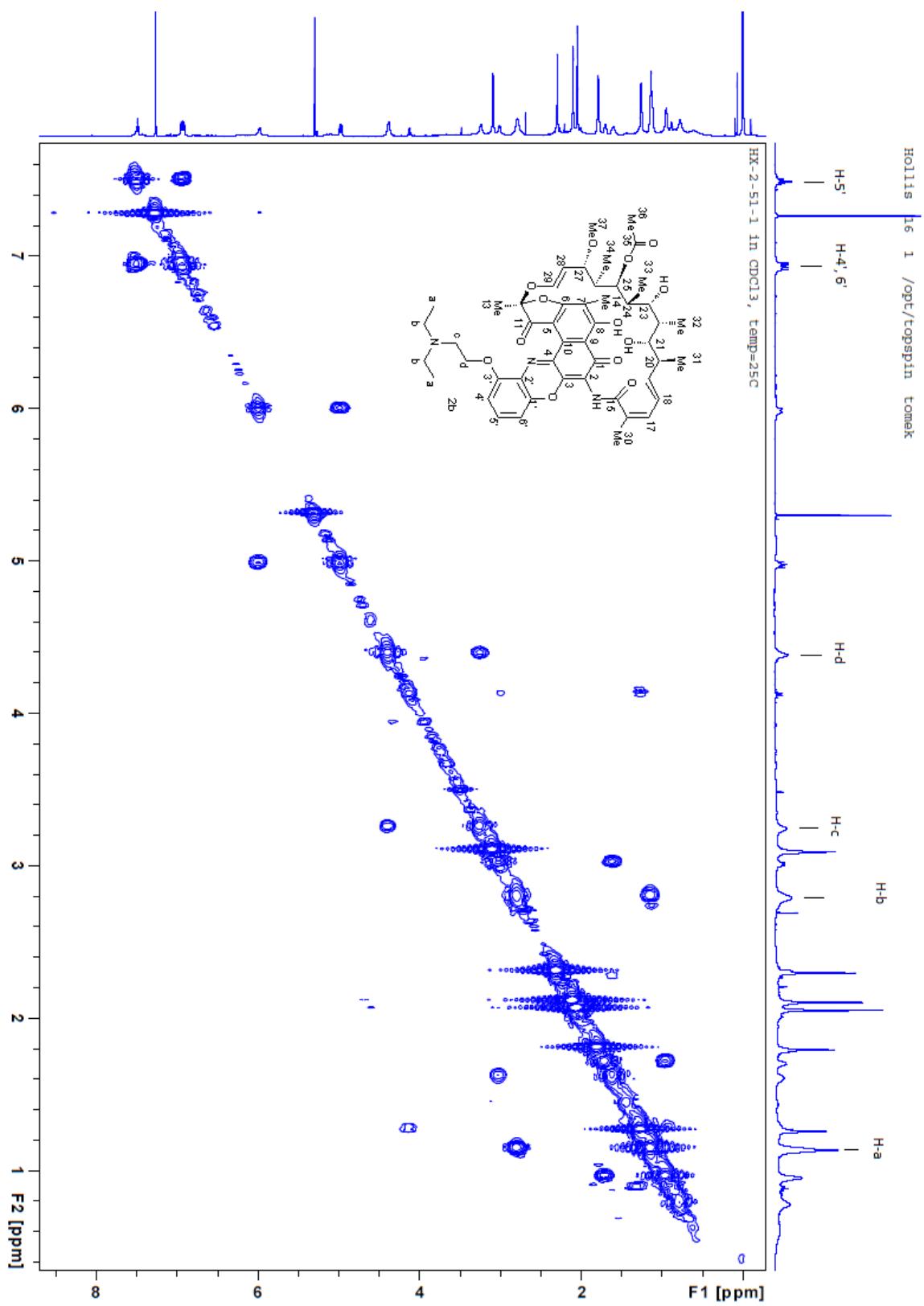


HX-2-51-1 in CDCl<sub>3</sub>, temp=25°C



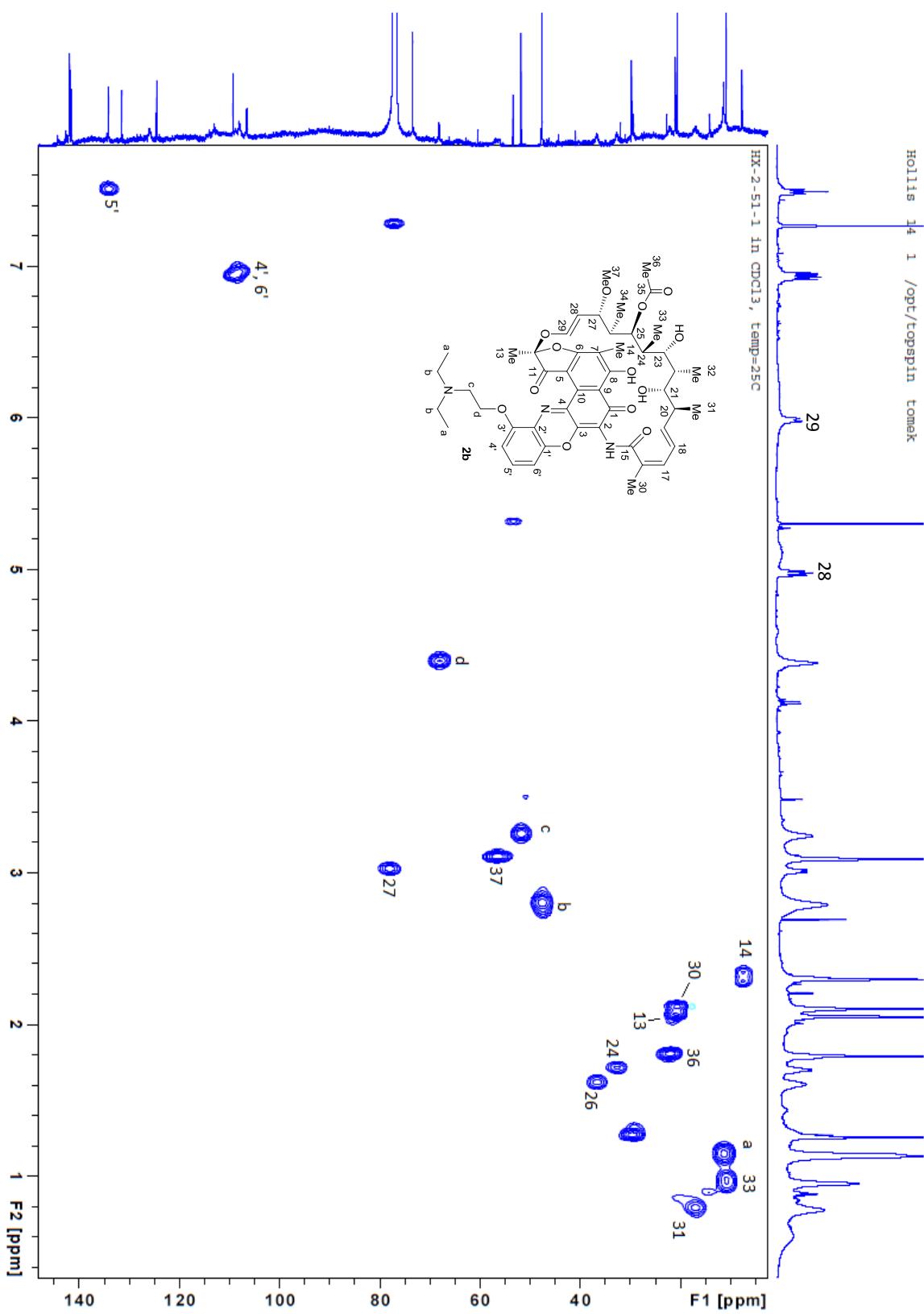
HX-2-51-1 in CDCl<sub>3</sub>, temp=25°C



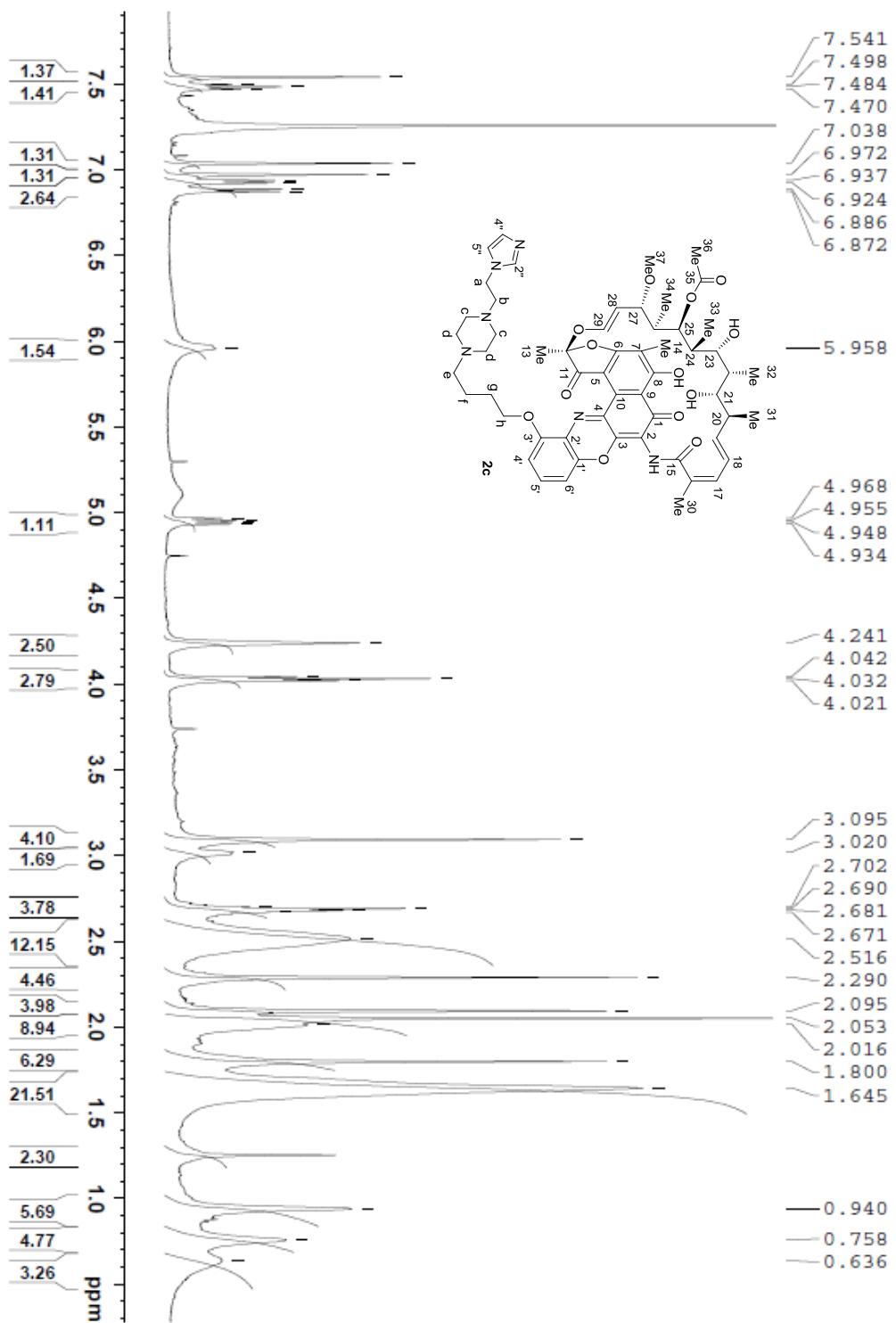


Hollis 14 1 /opt/topsin tomek

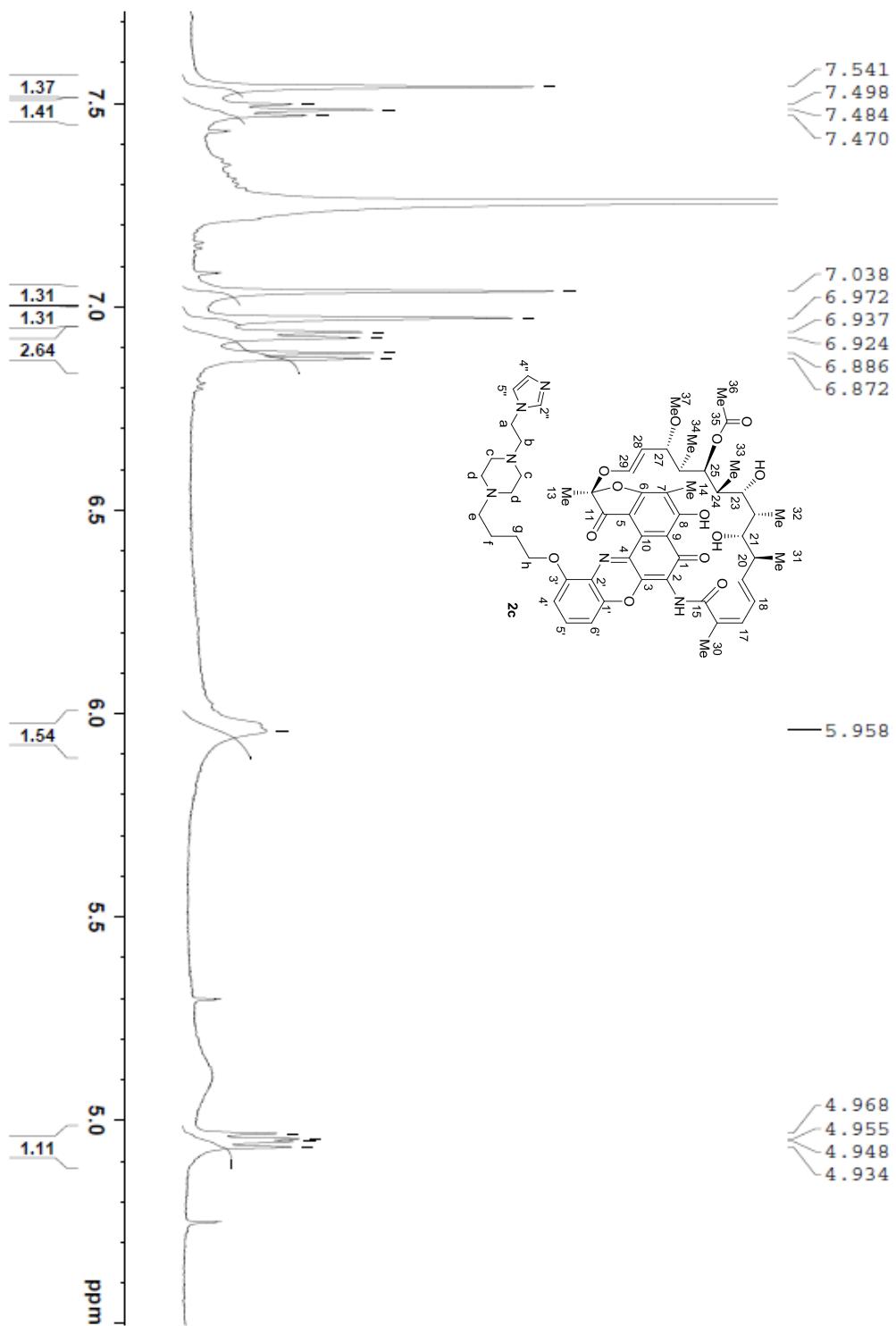
HR-2-51-1 in CDCl<sub>3</sub>, temp=25°C



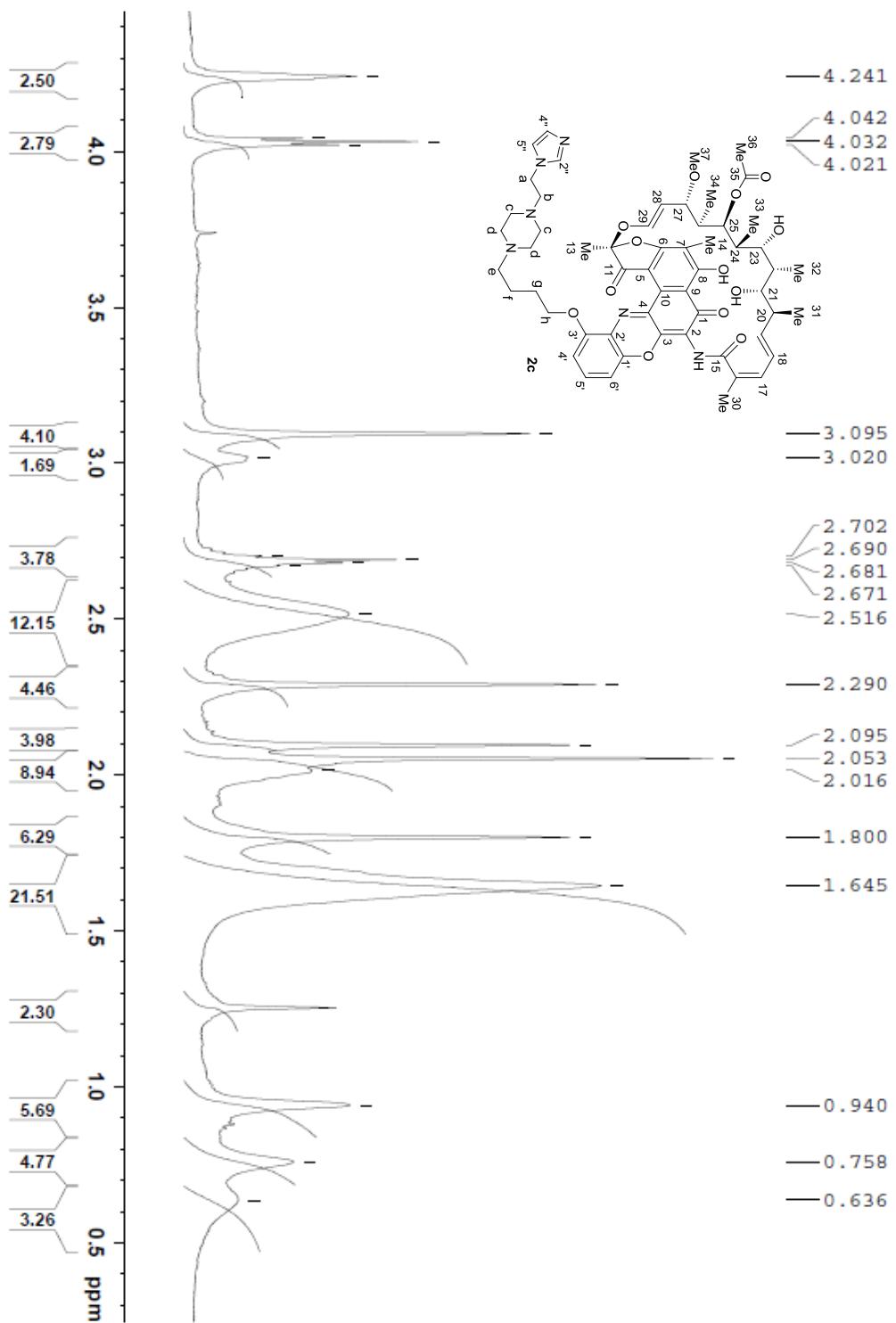
HX-2-33-1 in CDCl<sub>3</sub>, temp=25°C



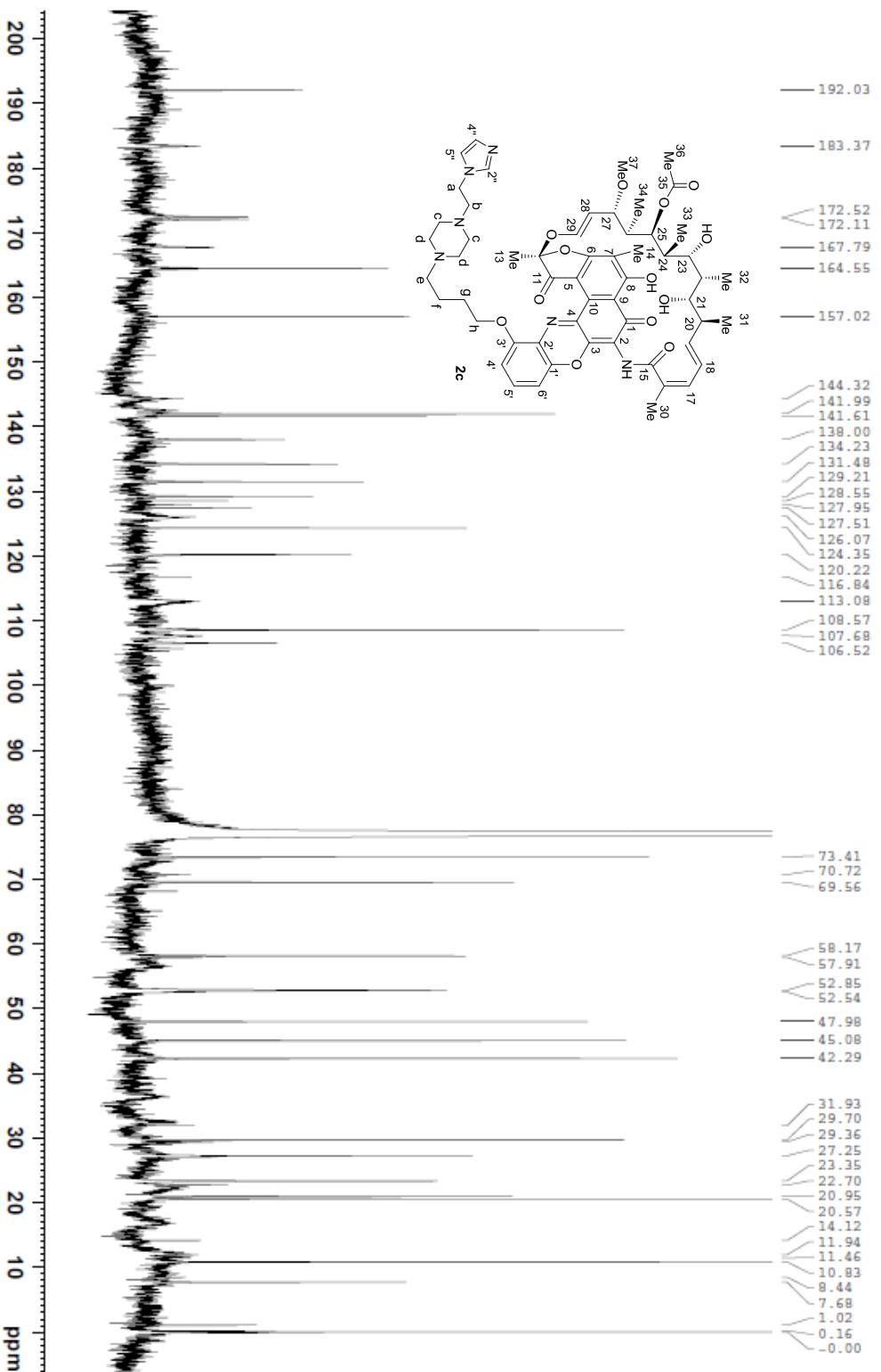
HX-2-33-1 in CDCl<sub>3</sub>, temp=25°C



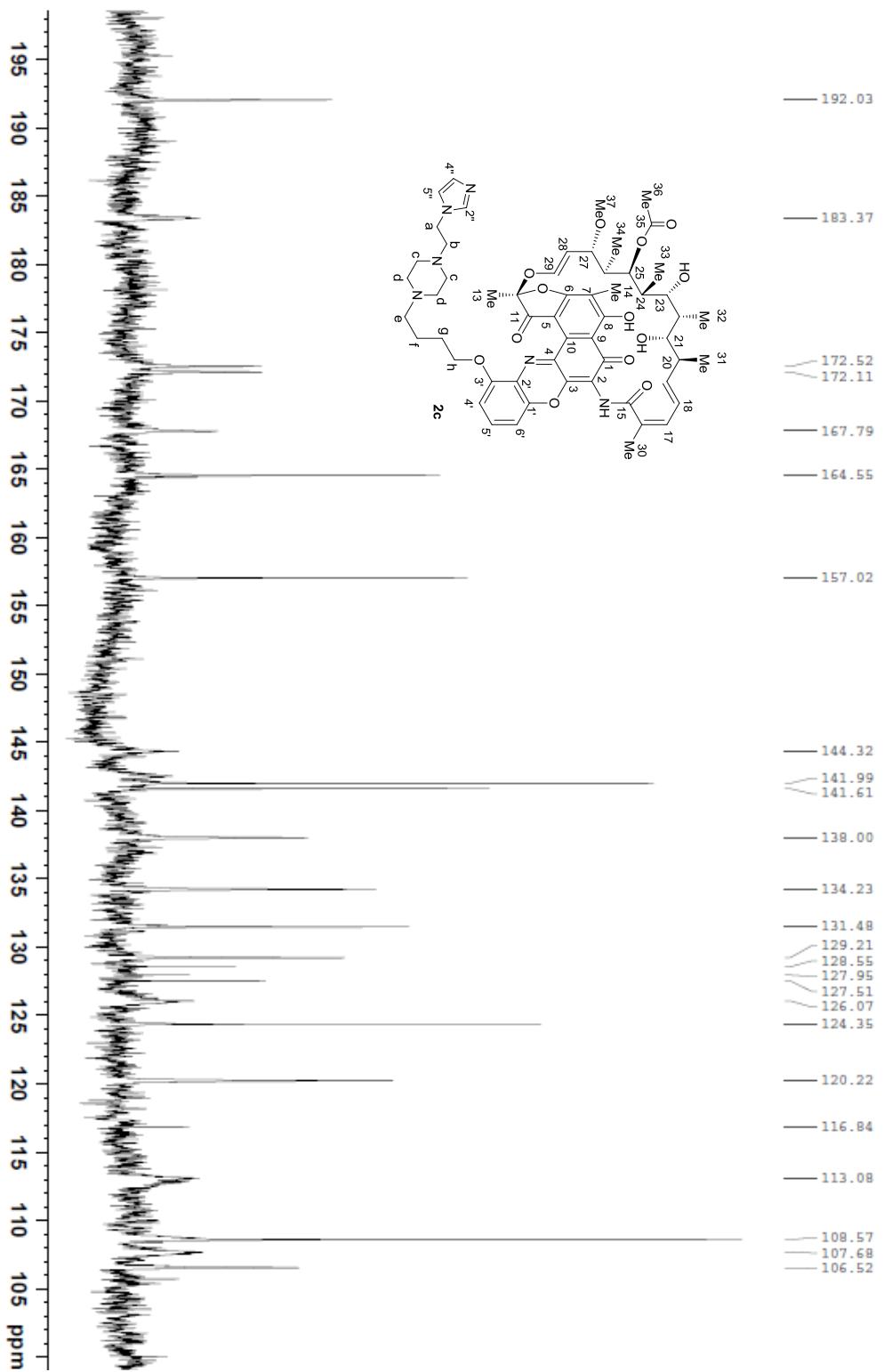
HX-2-33-1 in CDCl<sub>3</sub>, temp=25°C



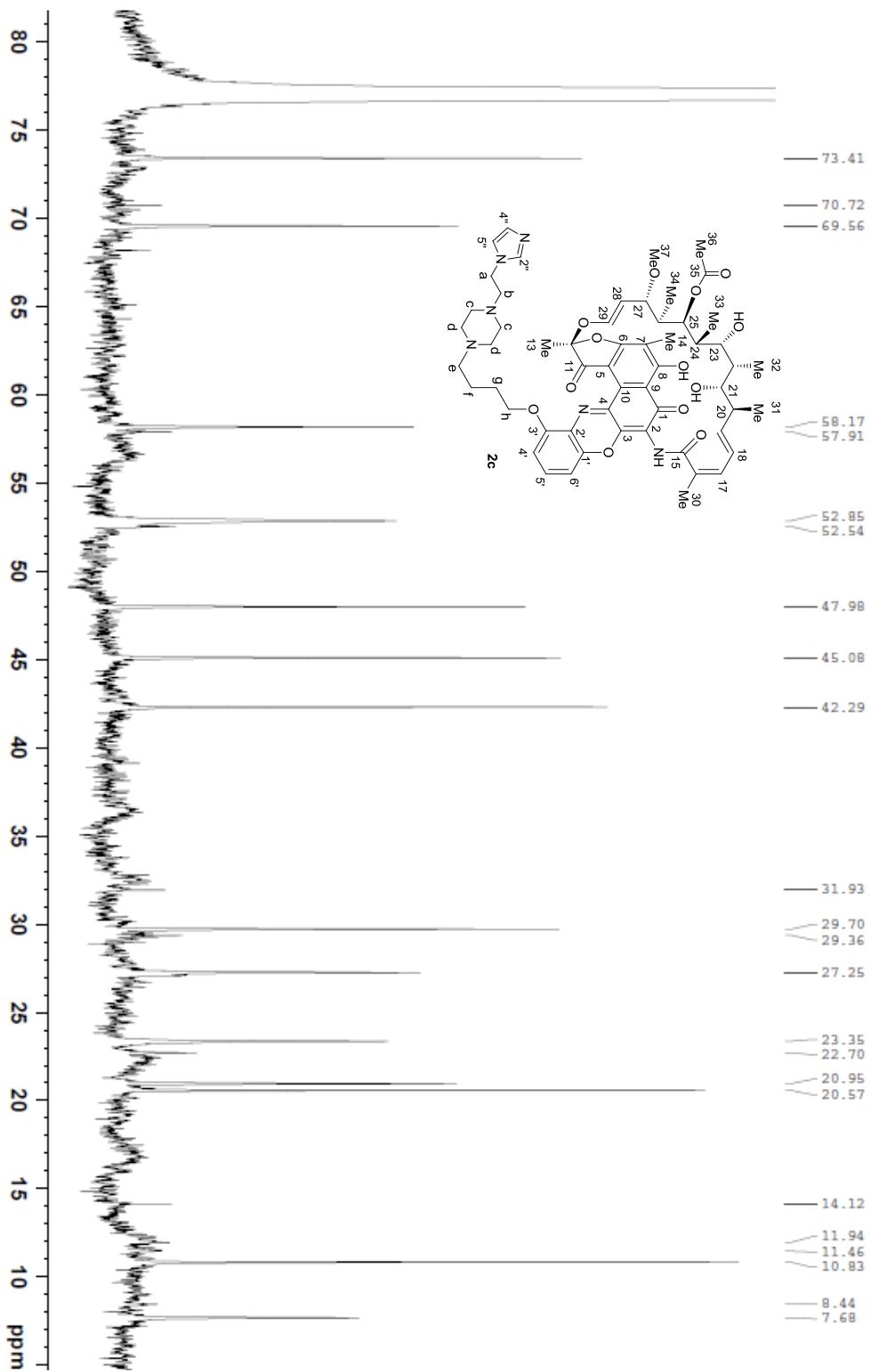
HX-2-28-1 in CDCl<sub>3</sub>  
temp=25C

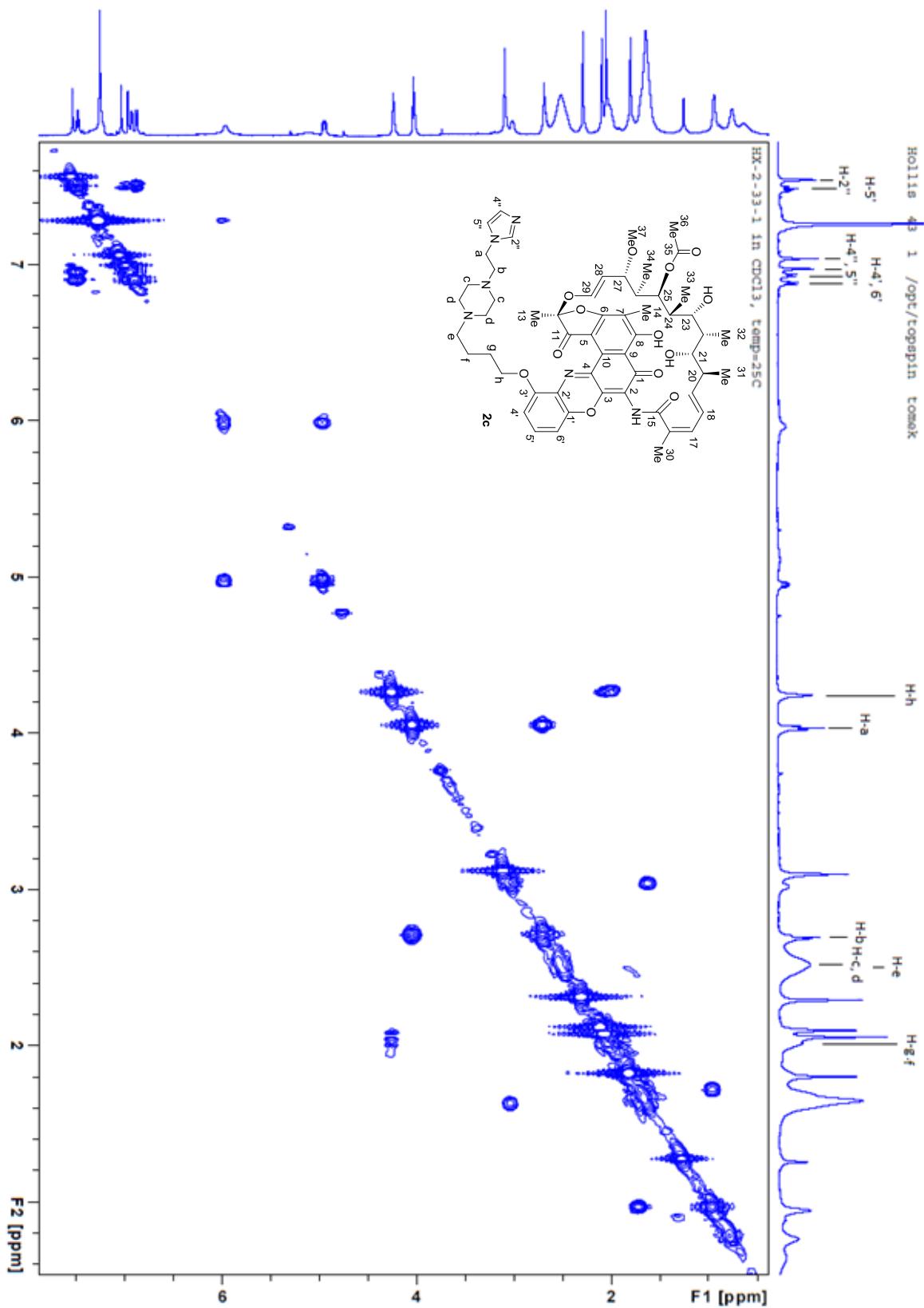


HX-2-28-1 in CDCl<sub>3</sub>  
temp=25°C



HX-2-28-1 in CDCl<sub>3</sub>  
temp=25°C





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RX-2-33-1 in CDCl<sub>3</sub>, temp=25C

29

28

14

33

a

31

30 13 36

f

24

26

c,d

b,e

g

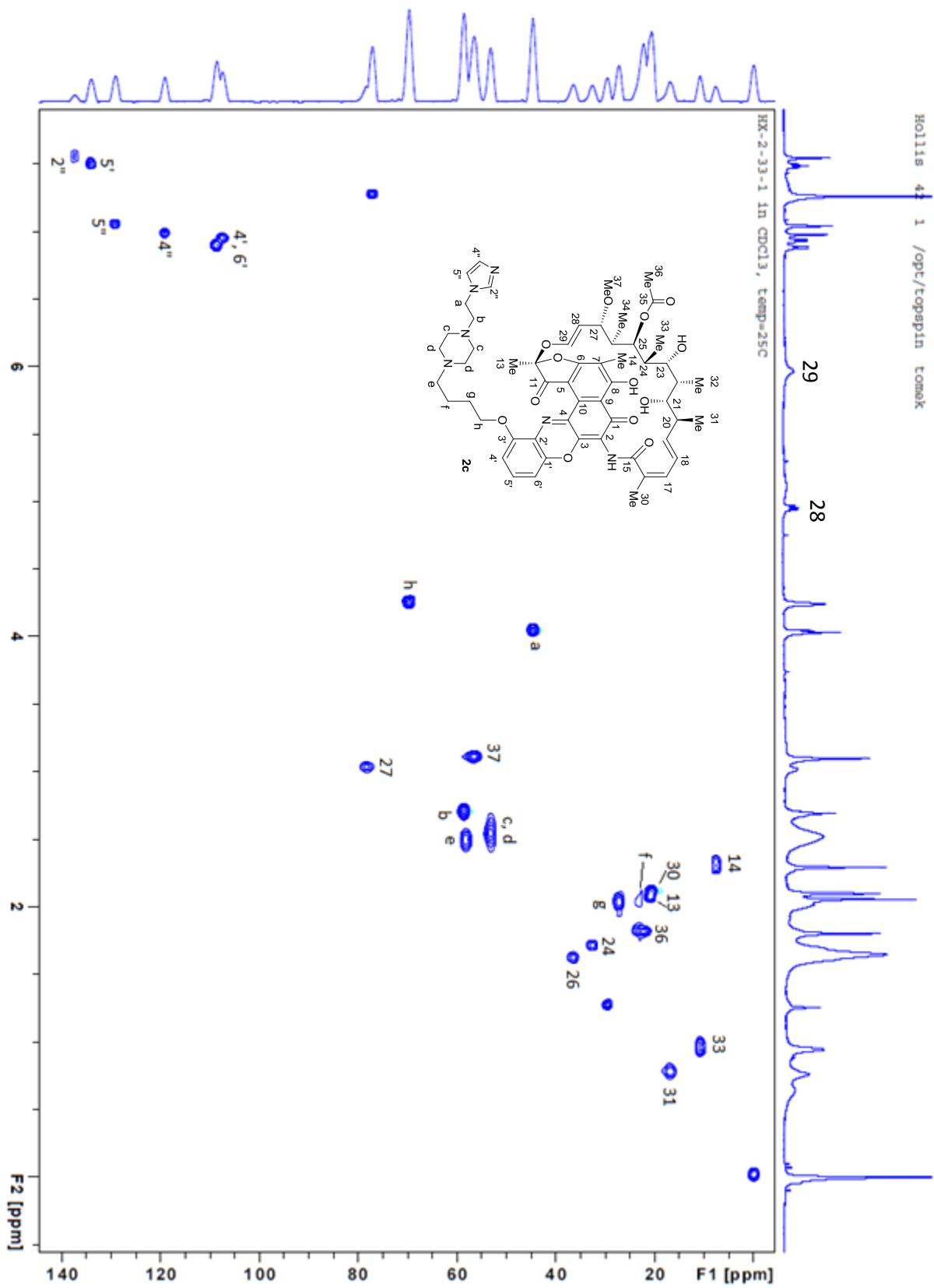
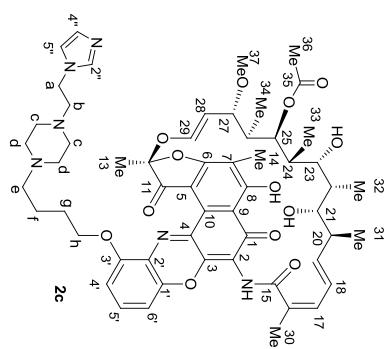
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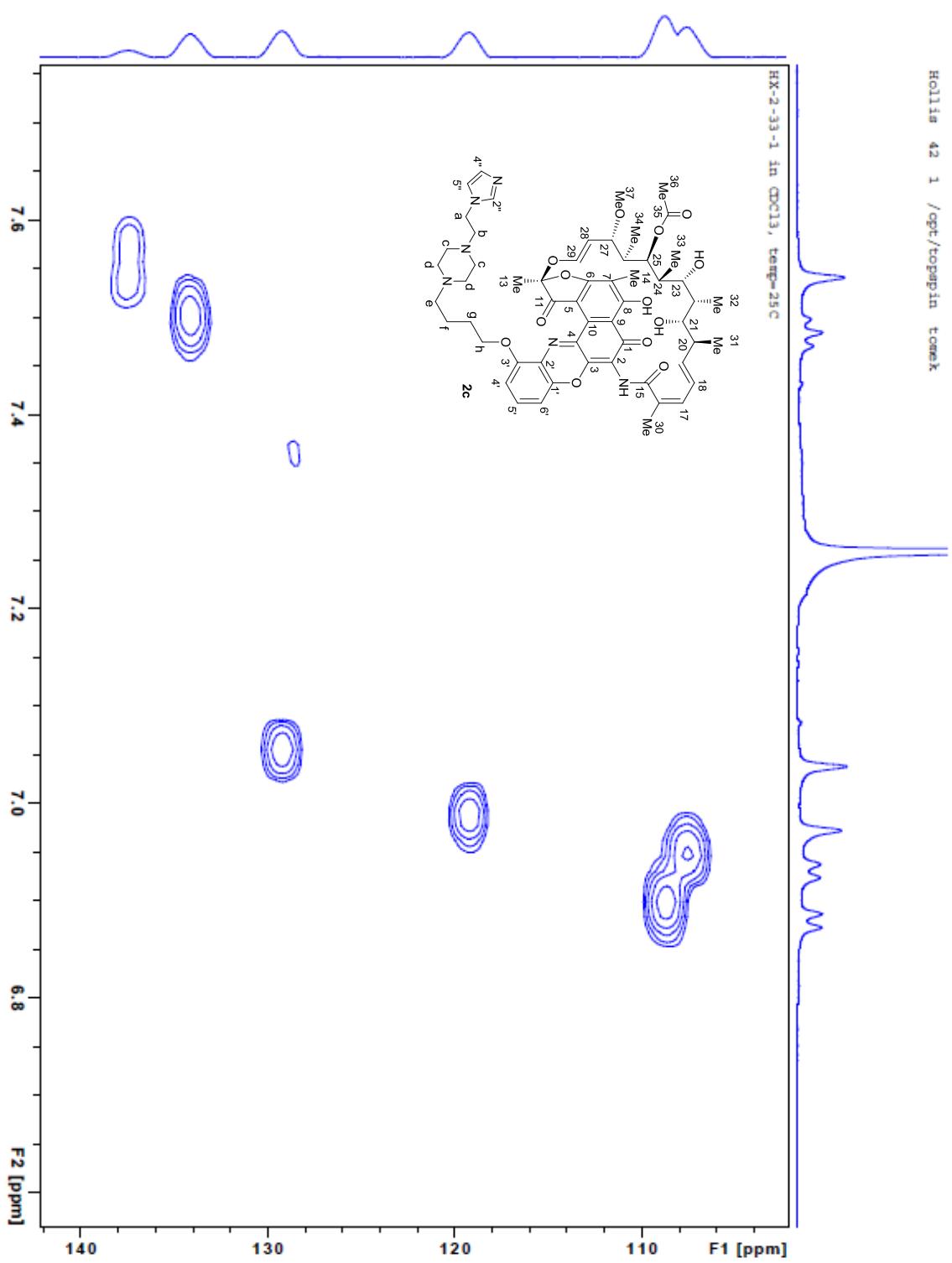
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27

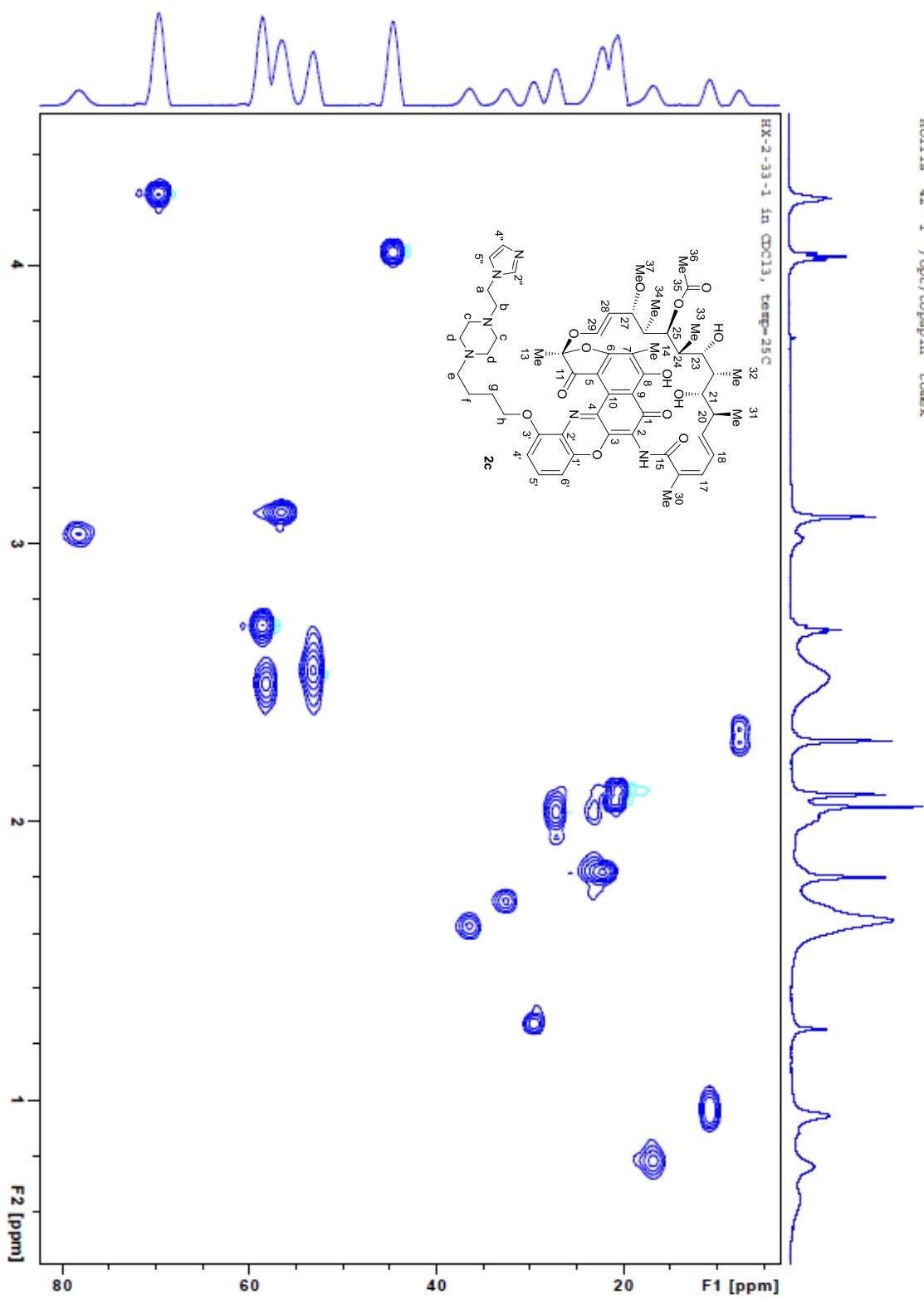
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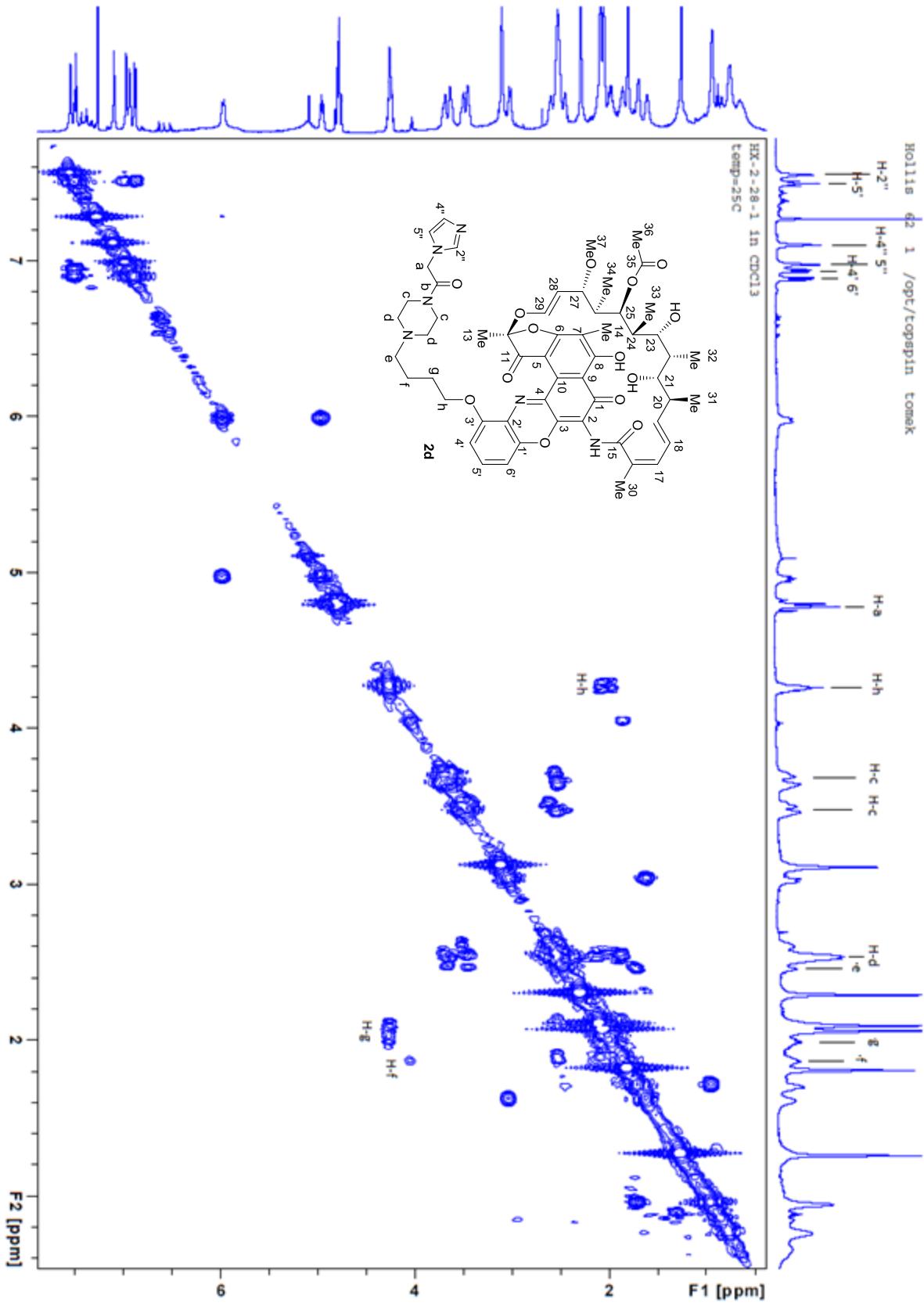


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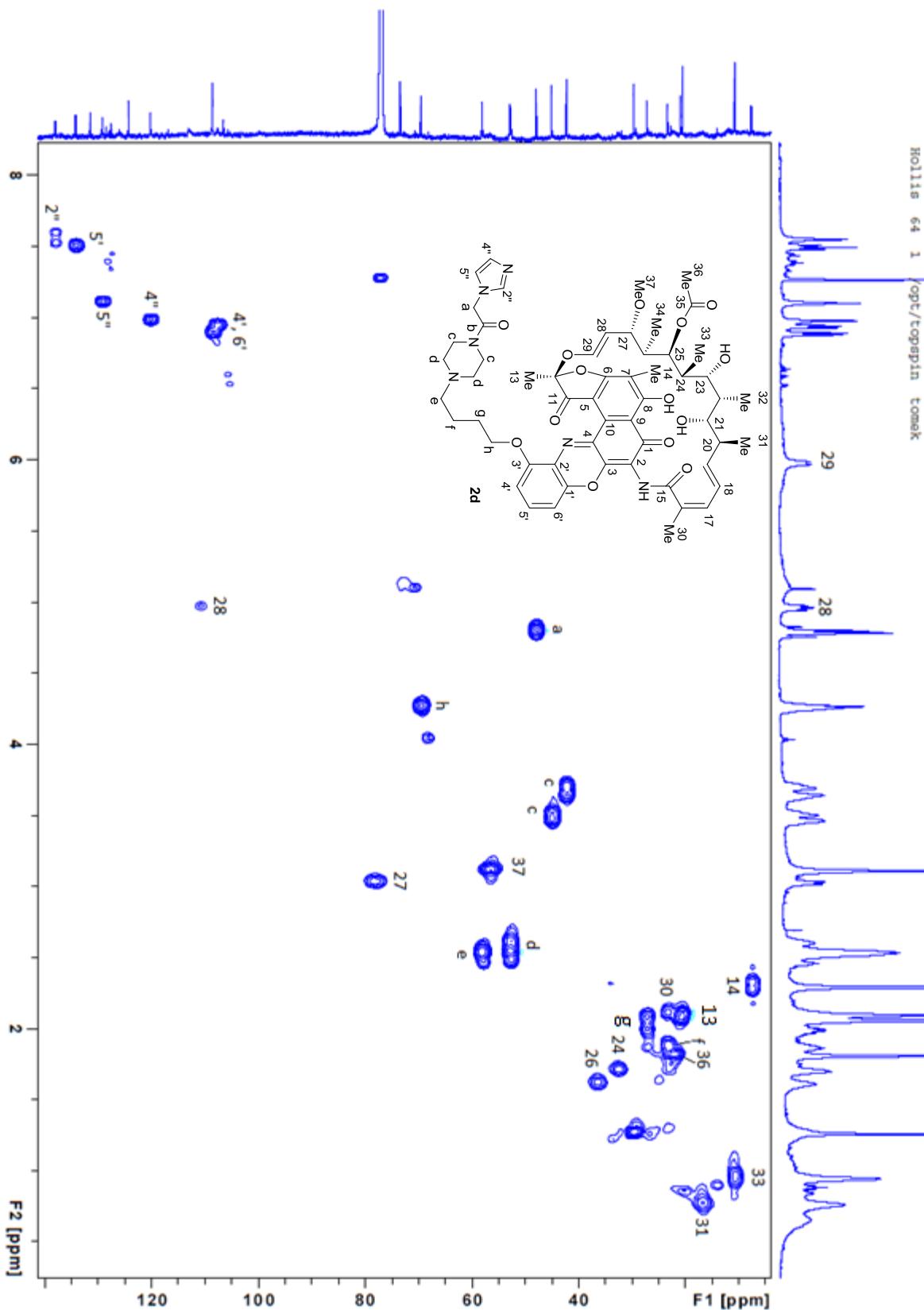


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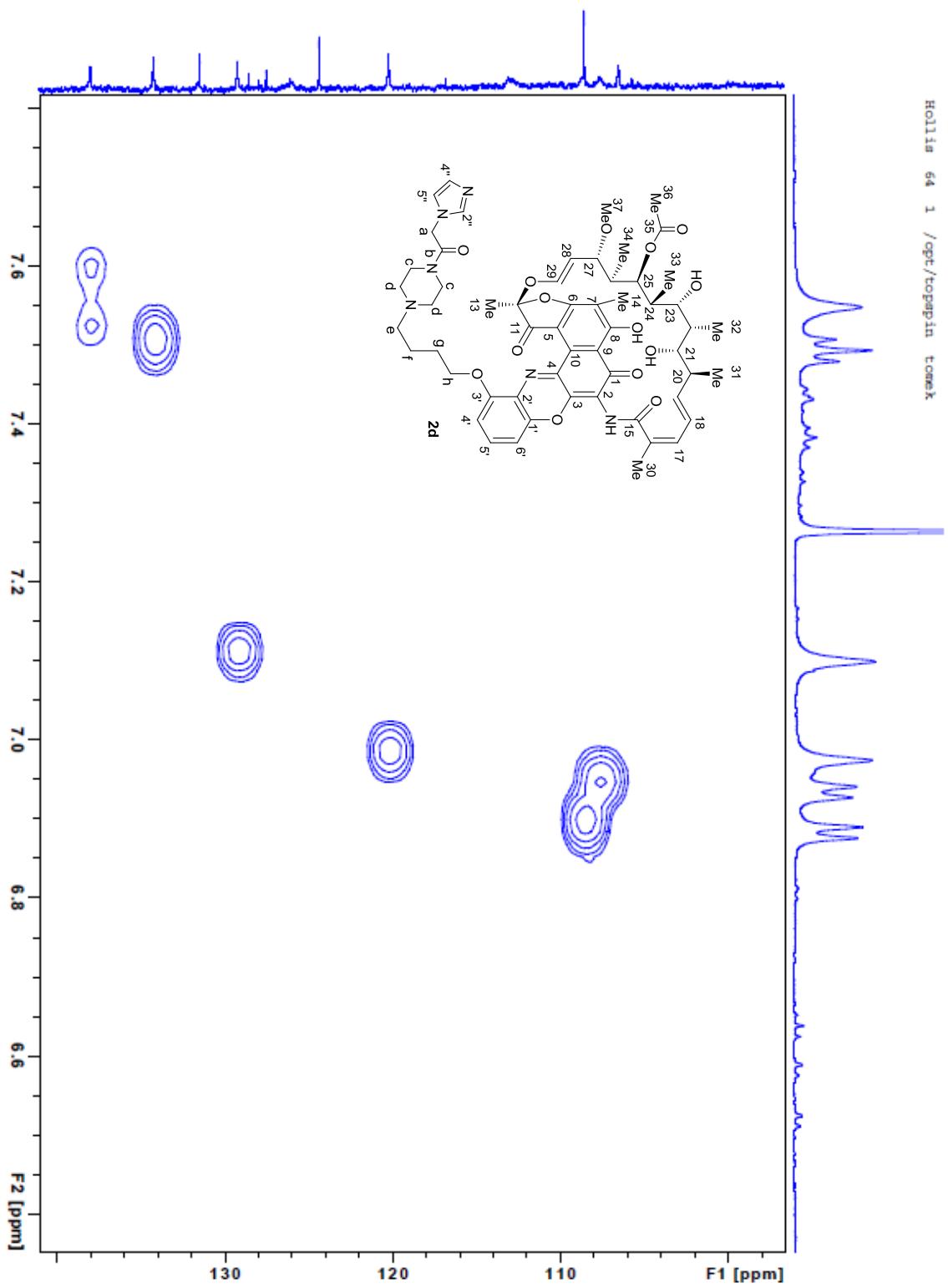


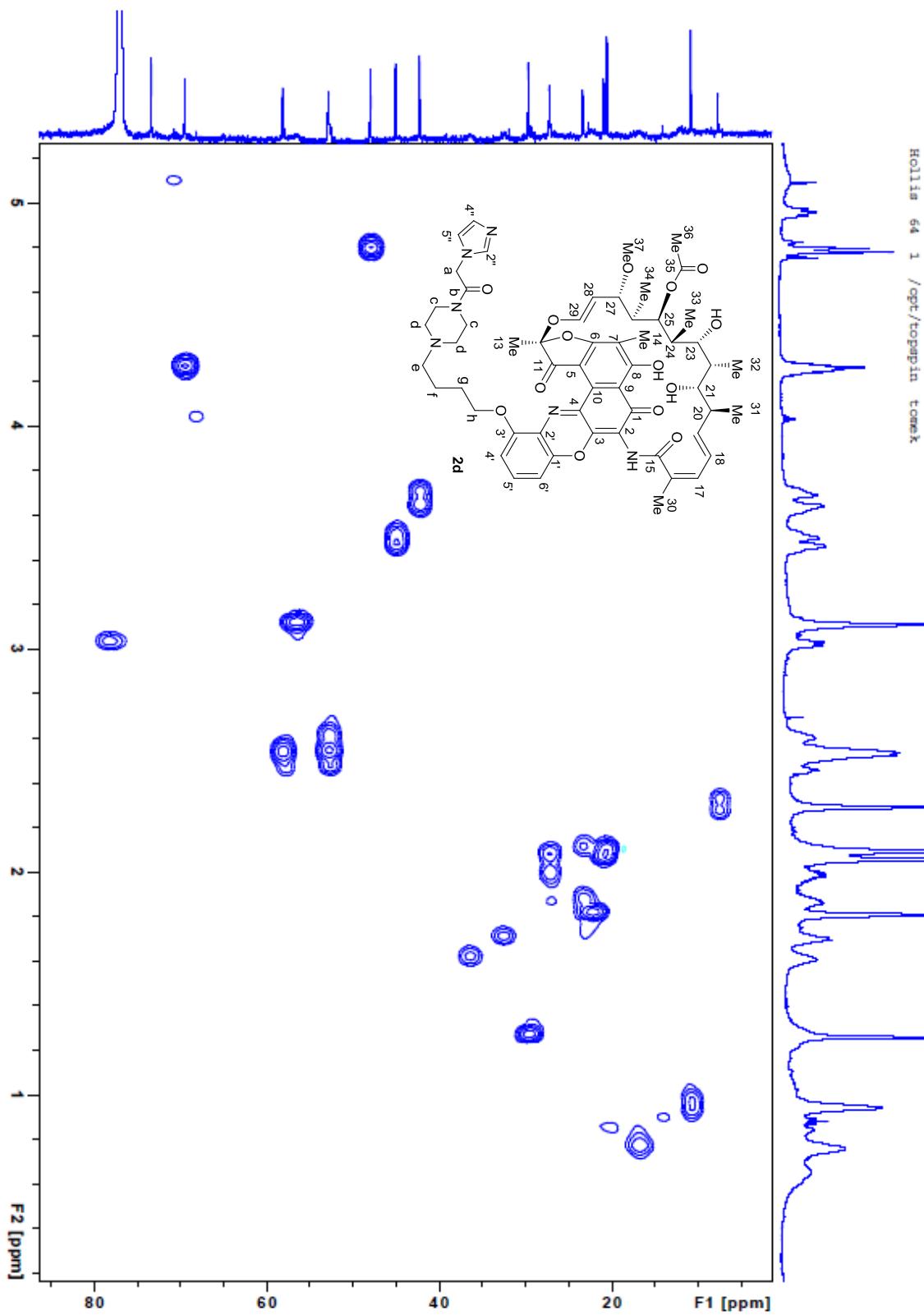


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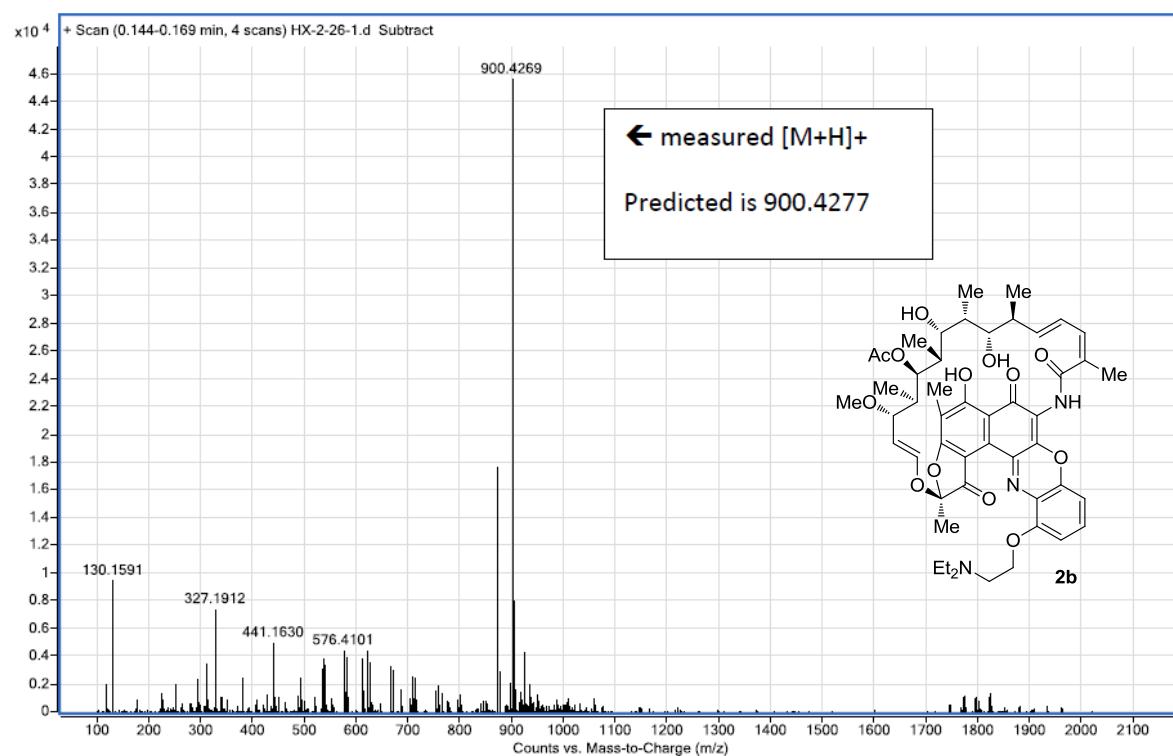
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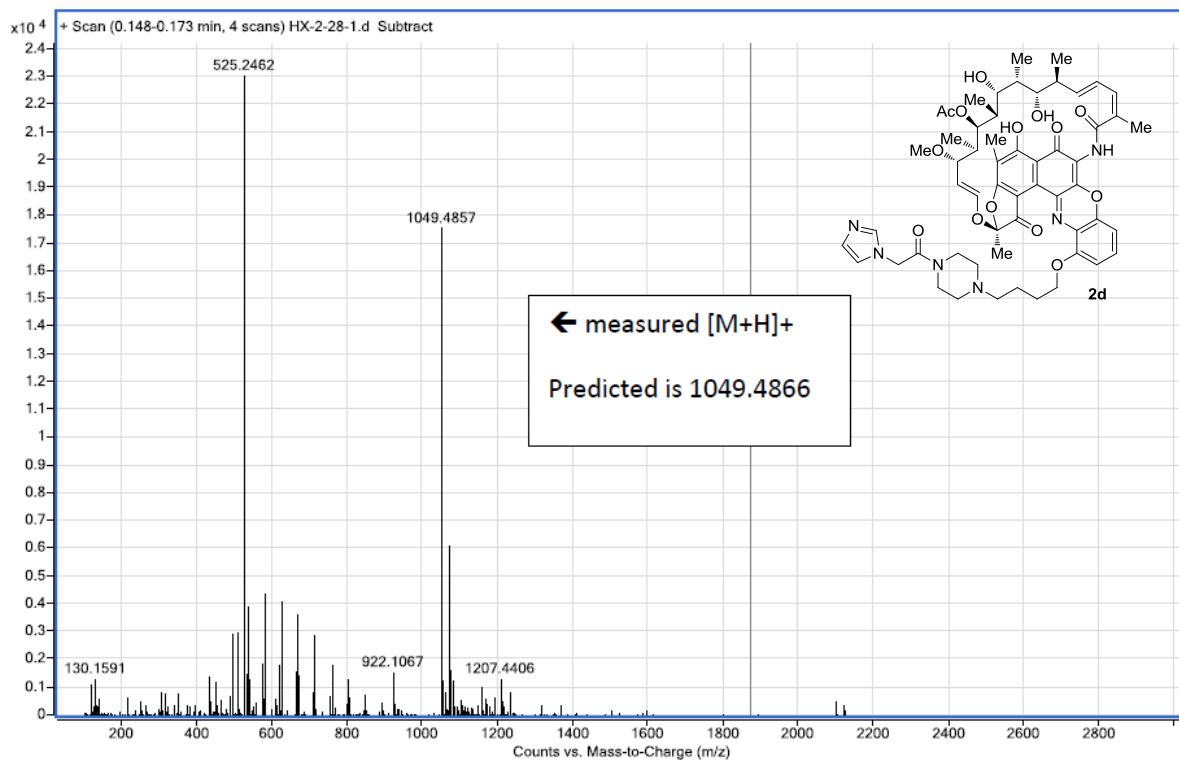


**Figure 3SI.** 1D- and 2D-NMR spectra for compounds **2b-2d**

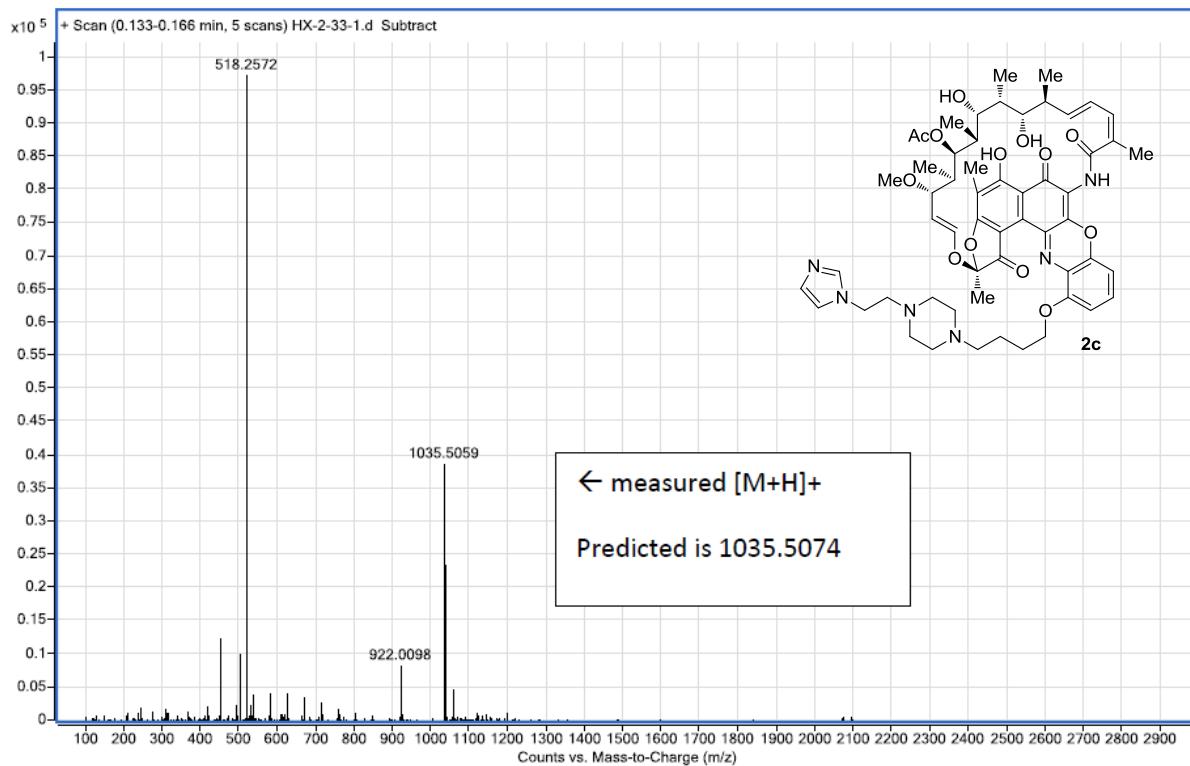
Sample HX-2-26-1



Sample HX-2-28-1



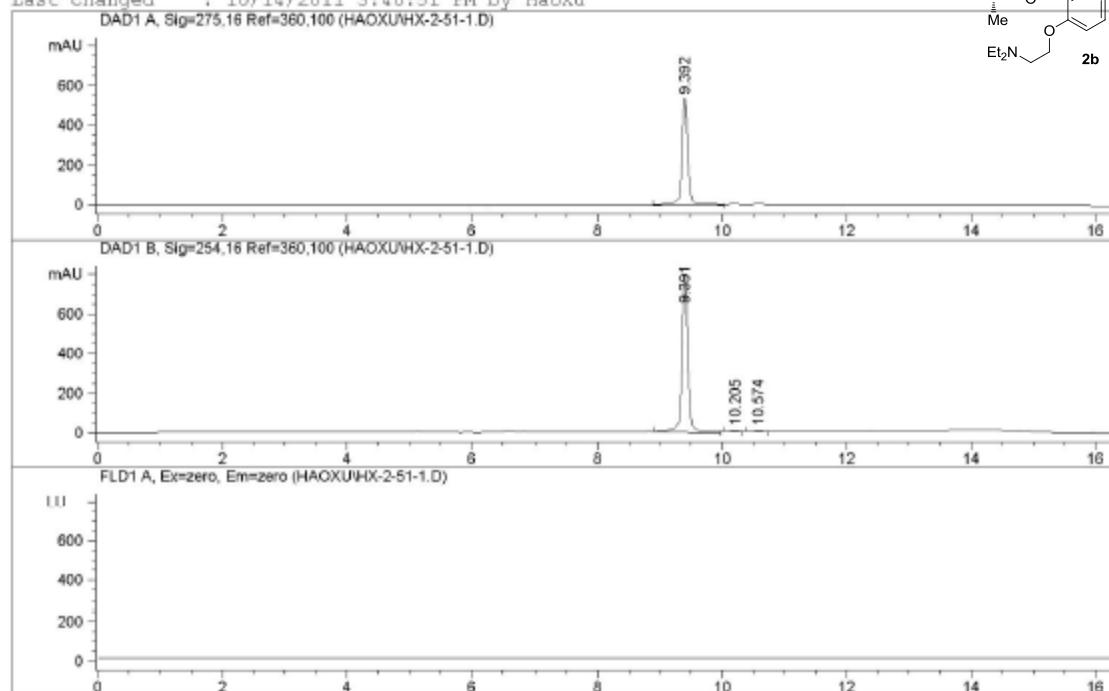
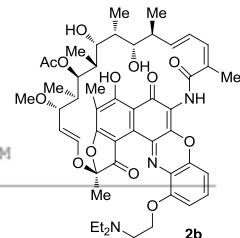
Sample HX-2-33-1



**Figure 4SI.** High resolution mass spectrometry traces for compounds **2b-2d**

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Sample Name: HX-2-51-1

Acq. Operator : hao xu Seq. Line : 1  
Acq. Instrument : Instrument 1 Location : Vial 41  
Injection Date : 2/19/2012 8:32:03 PM Inj : 1  
Inj Volume : 20  $\mu$ l  
Different Inj Volume from Sequence ! Actual Inj Volume : 10  $\mu$ l  
Method : C:\CHEM32\HPLC METHOD FILE\HAOXU\HX20111010\_OSELTAMIVIR.M  
Last changed : 10/14/2011 3:40:51 PM by HaoXu



External Standard Report

Sorted By : Signal  
Multiplier : 1.0000  
Dilution : 1.0000  
Sample Amount : 300.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

Area Percent Report

Sorted By : Signal  
Multiplier : 1.0000  
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Sample Amount : 300.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

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Sample Name: HX-2-51-1

Signal 1: DAD1 A, Sig=275,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.392	VV	0.1077	3836.46729	534.61926	100.0000
Totals :				3836.46729	534.61926	

Signal 2: DAD1 B, Sig=254,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.391	VB	0.1058	5639.96338	804.75433	98.1315
2	10.205	MM T	0.1600	54.09678	5.63606	0.9412
3	10.574	MM T	0.1521	53.29184	5.84105	0.9272
Totals :				5747.35200	816.23145	

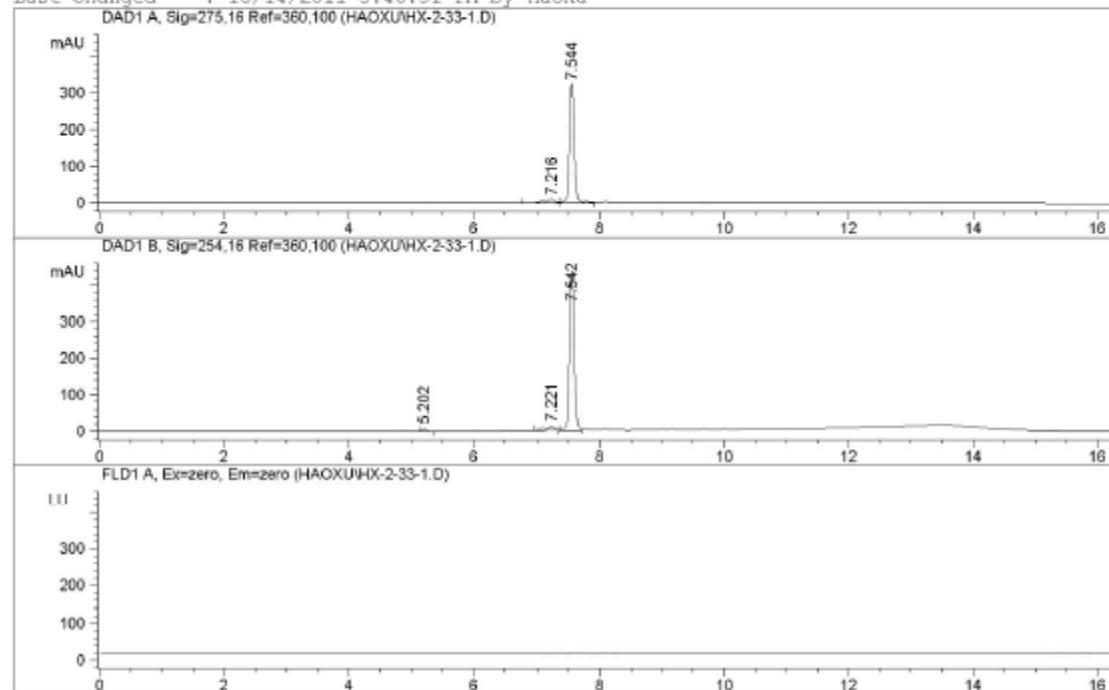
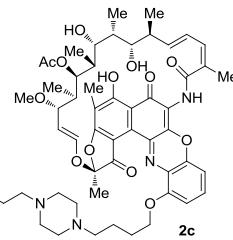
Signal 3: FLD1 A, Ex-zero, Em-zero

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\*\*\* End of Report \*\*\*

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Sample Name: HX-2-33-1

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Acq. Instrument : Instrument 1 Location : Vial 62  
Injection Date : 3/14/2012 9:35:00 PM Inj : 1  
Different Inj Volume from Sequence ! Actual Inj Volume : 10  $\mu$ l  
Method : C:\CHEM32\HPLC METHOD FILE\HAOXU\HX20111010\_OSELTAMIVIR.M  
Last changed : 10/14/2011 3:40:51 PM by HaoXu



External Standard Report

Sorted By : Signal  
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Dilution : 1.0000  
Sample Amount : 150.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

Area Percent Report

Sorted By : Signal  
Multiplier : 1.0000  
Dilution : 1.0000  
Sample Amount : 150.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

. File C:\CHEM32\1\DATA\HAOXU\HX-2-33-1.D  
Sample Name: HX-2-33-1

Signal 1: DAD1 A, Sig=275,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.216	VV	0.1776	131.26886	9.97083	7.1535
2	7.544	VV	0.0853	1703.76294	324.38193	92.8465

Total : 1835.03180 334.35275

Signal 2: DAD1 B, Sig=254,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.202	BB	0.0600	28.32638	7.18704	1.2048
2	7.221	MM T	0.1587	106.04414	11.13753	4.5105
3	7.542	VV	0.0771	2216.68555	437.60831	94.2847

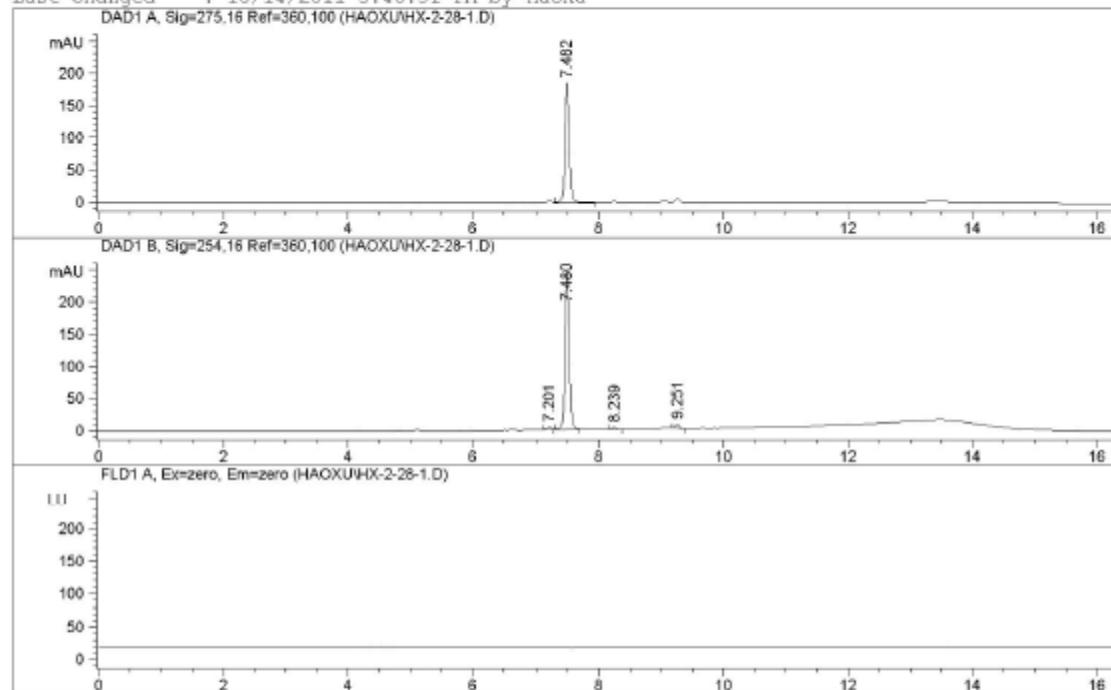
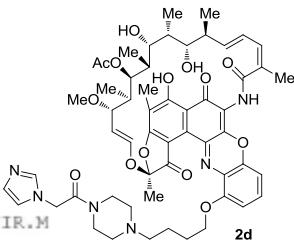
Total : 2351.05607 455.93287

Signal 3: FLD1 A, Ex-zero, Em-zero

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\*\*\* End of Report \*\*\*

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Acq. Instrument : Instrument 1 Location : Vial 61  
Injection Date : 3/14/2012 9:16:24 PM Inj : 1  
Inj Volume : 20  $\mu$ l  
Different Inj Volume from Sequence ! Actual Inj Volume : 10  $\mu$ l  
Method : C:\CHEM32\HPLC METHOD FILE\HAOXU\HX20111010\_OSELTAMIVIR.M  
Last changed : 10/14/2011 3:40:51 PM by HaoXu



External Standard Report

Sorted By : Signal  
Multiplier : 1.0000  
Dilution : 1.0000  
Sample Amount : 150.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

Area Percent Report

Sorted By : Signal  
Multiplier : 1.0000  
Dilution : 1.0000  
Sample Amount : 150.00000 [wt%] (not used in calc.)  
Use Multiplier & Dilution Factor with ISTDs

. File C:\CHEM32\1\DATA\HAOXU\HX-2-28-1.D  
Sample Name: HX-2-28-1

Signal 1: DAD1 A, Sig=275,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.482	VV	0.0823	928.80750	185.88354	100.0000
Totals :				928.80750	185.88354	

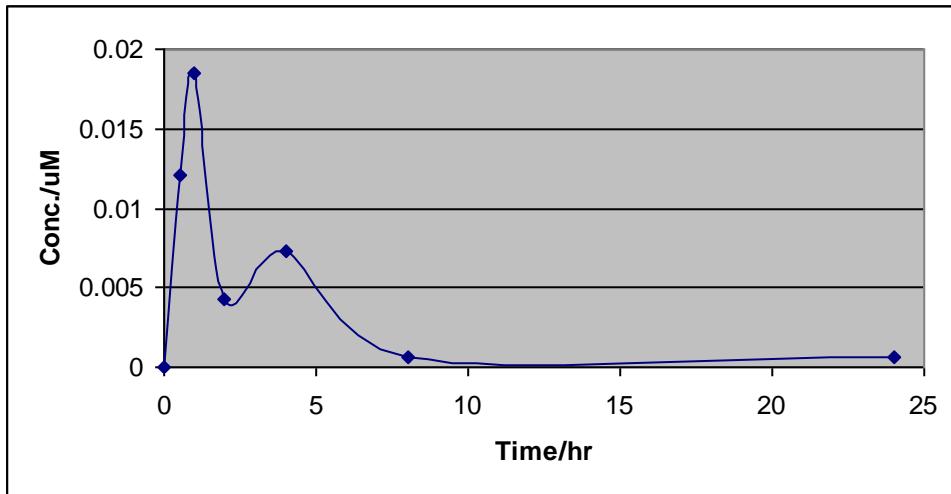
Signal 2: DAD1 B, Sig=254,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.201	MM T	0.0684	16.75931	4.08280	1.3502
2	7.480	VV	0.0718	1180.38770	246.71176	95.0980
3	8.239	BB	0.0767	16.16008	3.21078	1.3019
4	9.251	MM T	0.0749	27.92550	6.21770	2.2498
Totals :				1241.23258	260.22303	

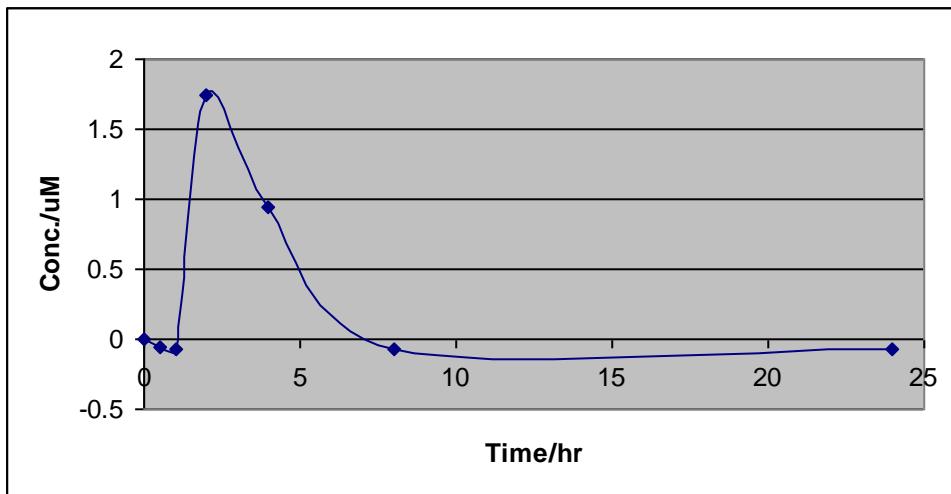
Signal 3: FLD1 A, Ex-zero, Em-zero

\*\*\* End of Report \*\*\*

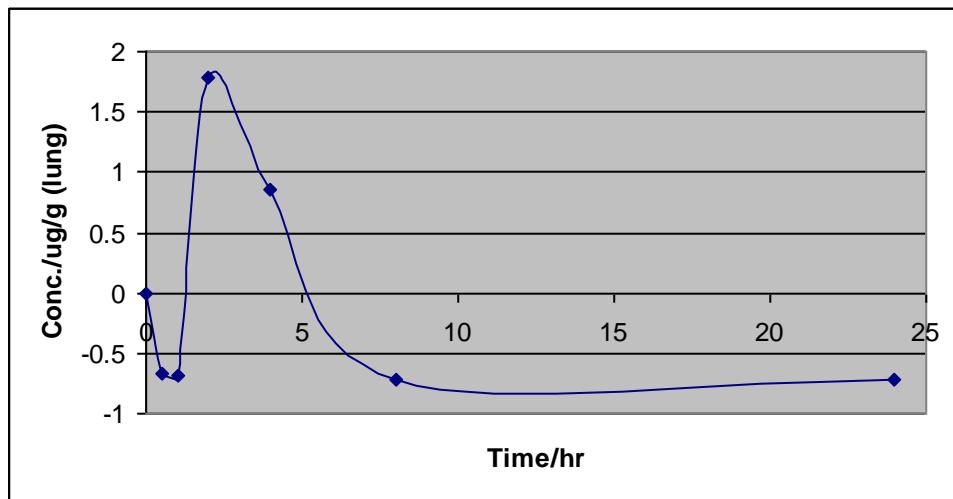
**(a) Single dose**



**(b) Multiple dose**



**Figure 6SI.** Linear plasma mean concentration vs. time profile for analog **2b** in (a) single dose and (b) multiple dose studies



**Figure 7SI.** Linear lung tissue mean concentration vs. time profile for analog **2b** in a multiple dose study.

**Table 1SI.**  $^1\text{H}$ -NMR chemical shifts of benzoxazinorifamycins

Proton atom	$\delta$ (ppm)		
	<b>2b</b>	<b>2c</b>	<b>2d</b>
H-13	2.05	2.05	2.05
H-14	2.30	2.29	2.28
H-24	1.70	1.7	1.71
H-26	1.60	1.6	1.61
H-27	3.01	3.02	3.02
H-28	4.98	4.95	4.95
H-29	5.98	5.96	5.97
H-30	2.10	2.10	2.09
H-31	0.77	0.75	0.76
H-33	0.95	0.94	0.94
H-34	0.60	0.63	0.65
H-36	1.79	1.80	1.80
H-37	3.09	3.09	3.10
H-4'	6.92	6.88	6.88
H-5'	7.49	7.48	7.49
H-6'	6.94	6.93	6.93
H-a	1.13	4.03	4.78
H-b	2.79	2.69	
H-c	3.24	2.51	3.68-3.45
H-d	4.38	2.51	2.53
H-e		2.51	2.45
H-f		2.02	1.87
H-g		2.02	1.99
H-h		4.24	4.26
H-2''		7.54	7.54
H-4''		6.97	6.97
H-5''		7.04	7.10

**Table 2SI.**  $^{13}\text{C}$ -NMR chemical shifts of benzoxazinorifamycins

Carbon atom	$\delta$ (ppm)		
	<b>2b</b>	<b>2c</b>	<b>2d</b>
C-13	21.0	20.7	20.6
C-14	7.6	7.5	7.7
C-24	32.7	32.4	32.5
C-26	36.8	36.5	36.4
C-27	78.1	78.1	78.5
C-28	113.0	113.6	113.7
C-29	142.5	142.9	142.0
C-30	20.5	21	20.9
C-31	16.7	16.8	16.8
C-33	10.6	10.8	10.8
C-34	N/A	N/A	N/A
C-36	22.0	22.4	22.0
C-37	56.5	56.5	56.9
C-4'	109.2	108.7	108.6
C-5'	134.1	134	134.2
C-6'	109.3	107.5	107.7
C-a	11.2	44.7	48.0
C-b	47.6	58.7	N/A
C-c	51.8	53.2	42.3, 44.9
C-d	68.1	53.2	52.8
C-e		58.2	58.2
C-f		23.2	22.7
C-g		27.3	27.2
C-h		69.8	69.6
C-2''		137.4	138.0
C-4''		119.1	120.2
C-5''		129.2	129.2

**Table 3SI.** Log IC<sub>50</sub>s and standard errors of the fits for RLZ (**2a**) and analogs (**2b – 2d**) against RNAP

	<b>2a (RLZ)</b>	<b>2b</b>	<b>2c</b>	<b>2d</b>
<b>WT RNAP (-σ<sup>A</sup>)</b>	-1.9407 (0.048, 1.09)	-2.5282 (0.026, 2.29)	-2.5103 (0.038, 2.38)	-2.4916 (0.066, 1.22)
<b>WT RNAP (+σ<sup>A</sup>)</b>	-2.4614 (0.068, 1.16)	-2.5442 (0.038, 1.65)	-2.5653 (0.055, 1.51)	-2.348 (0.096, 0.85)
<b>D435V (+σ<sup>A</sup>)</b>	2.7331 (0.038, 2.02)	1.2946 (0.035, 0.95)	0.94796 (0.064, 0.87)	1.1085 (0.046, 0.88)
<b>H445Y (+σ<sup>A</sup>)</b>	2.2355 (0.069, 0.71)	2.2337 (0.138, 0.41)	2.6407 (0.140, 0.64)	2.7592 (0.180, 0.53)
<b>S450L (+σ<sup>A</sup>)</b>	2.0692 (0.157, 0.63)	1.2054 (0.056, 0.81)	-2.5103 (0.038, 2.38)	2.0881 (0.069, 0.67)

<sup>a</sup> The log IC<sub>50</sub> values are such that the IC<sub>50</sub> values will be in μM. Negative log IC<sub>50</sub> values reflect IC<sub>50</sub> values less than μM (e.g., in the nM range). Values were fit to a four parameter logistic regression model with the top and bottom limits set at 100 and 0 respectively. <sup>b</sup> The average error is ~10 %, which roughly translates to 20-25% in the IC<sub>50</sub>. <sup>c</sup> The average Hill slope is 1.02.

**Table 4SI.** Mean relative fluorescence units (RFU)<sup>a</sup> for RMP (**1a**) and benzoxazinorifamycins (**2a – 2d**) in the hPXR activation assay

Conc.	<b>1a</b> (RMP)	Conc.	<b>2a</b> (RLZ)	<b>2b</b>	<b>2c</b>	<b>2d</b>
20 µM	48427	100 µM	35250	11137	10881	11625
10 µM	59067	25 µM	63418	11591	12218	43077
5 µM	61839	6.25 µM	70784	43495	49297	66941
1 µM	64852	1.56 µM	73704	68860	60314	68172
0.5 µM	59756	0.39 µM	74950	69532	63570	68936
0.1 µM	63078	0.098 µM	72399	71149	65632	68628

<sup>a</sup>RFU is a measure of cell viability in the assay. For controls, 1% DMSO = 67021 RFU; Dosing media = 59992 RFU.