

**Small-molecule, zwitterionic morpholinium sulfonates are non-cytotoxic materials
exhibiting LCST thermo-responsive phase separation in water**

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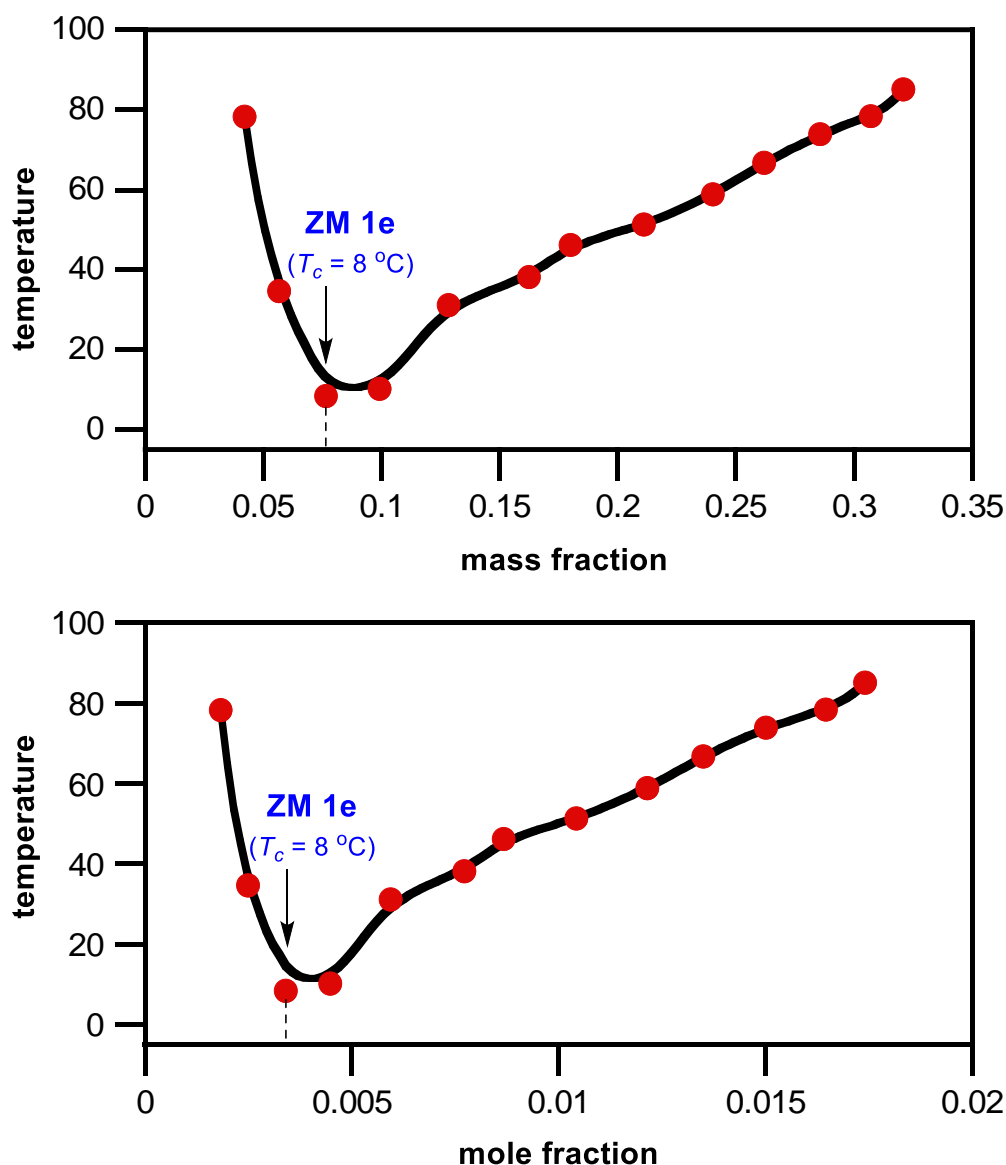


Figure S1. Phase diagrams (both T_c vs. mass fraction and T_c vs. mole fraction) of water mixtures with **ZM 1e**. Solid lines are used as the guide for the eye. This figure shows the phase diagrams of a mixture of water with **ZM 1e**, confirming a typical bowl-shaped curve with the lowest critical temperature ($T_c = 8$ °C) near its mass ratio of 1:13 and mole ratio of 1:294 (**ZM 1e** / H₂O).

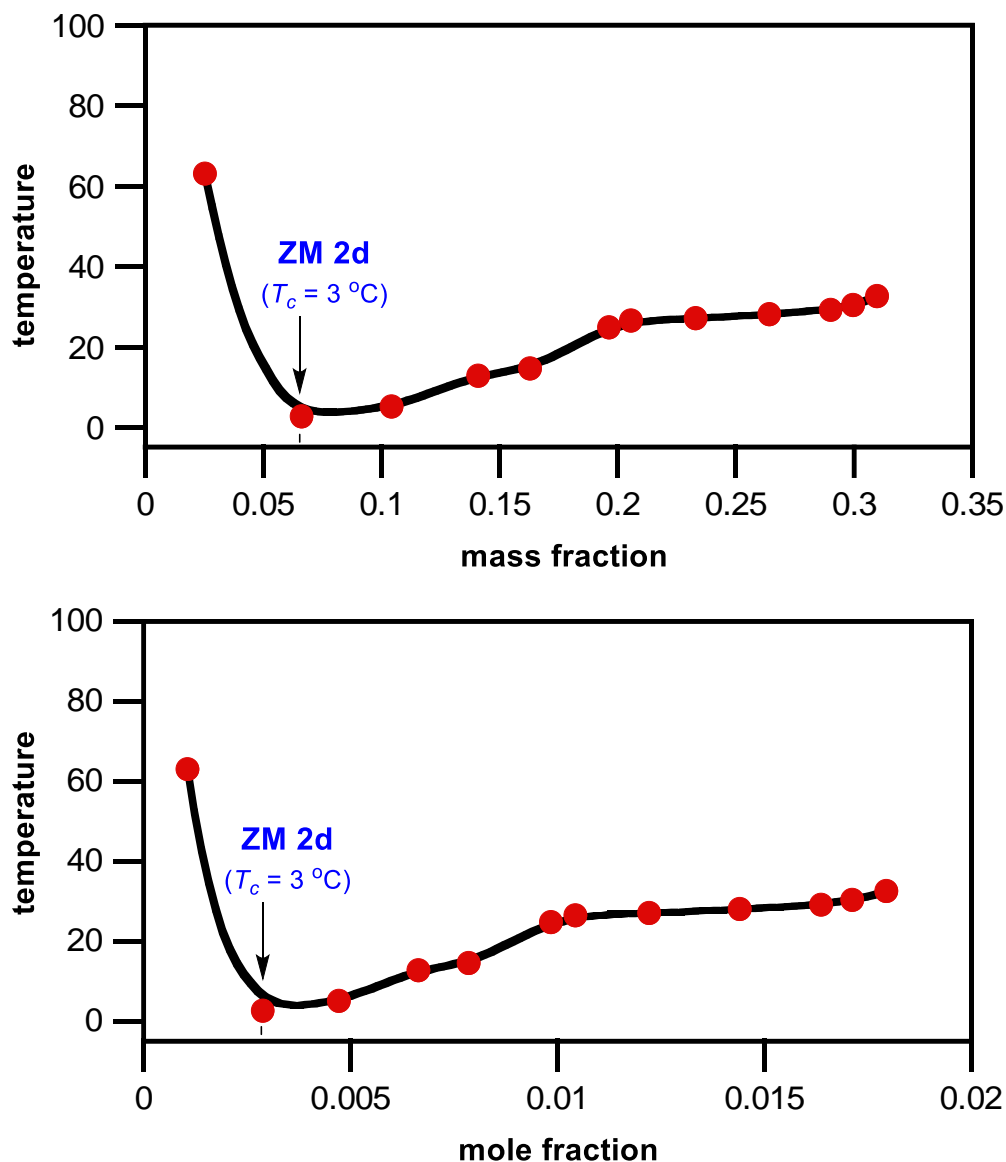


Figure S2. Phase diagrams (both T_c vs. mass fraction and T_c vs. mole fraction) of water mixtures with **ZM 2d**. Solid lines are used as the guide for the eye. This figure shows the phase diagrams of a mixture of water with **ZM 2d**, confirming a typical bowl-shaped curve with the lowest critical temperature ($T_c = 3\text{ °C}$) near its mass ratio of 1:15 and mole ratio of 1:347 (**ZM 2d** / H₂O).

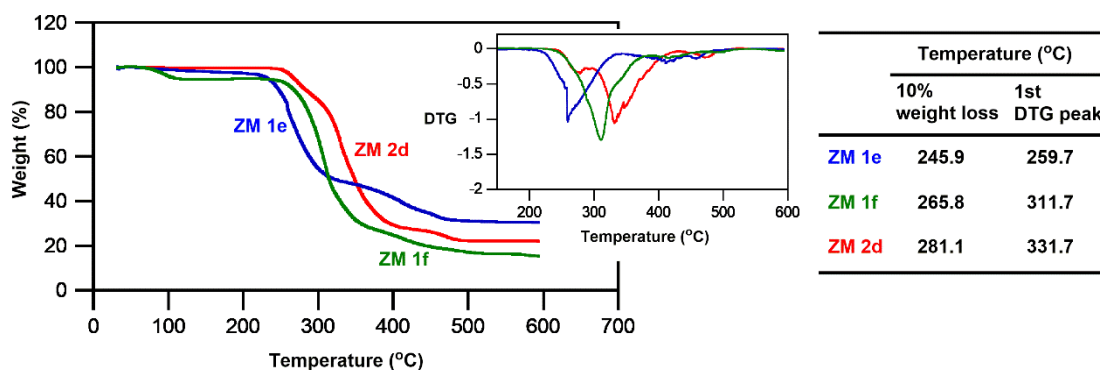
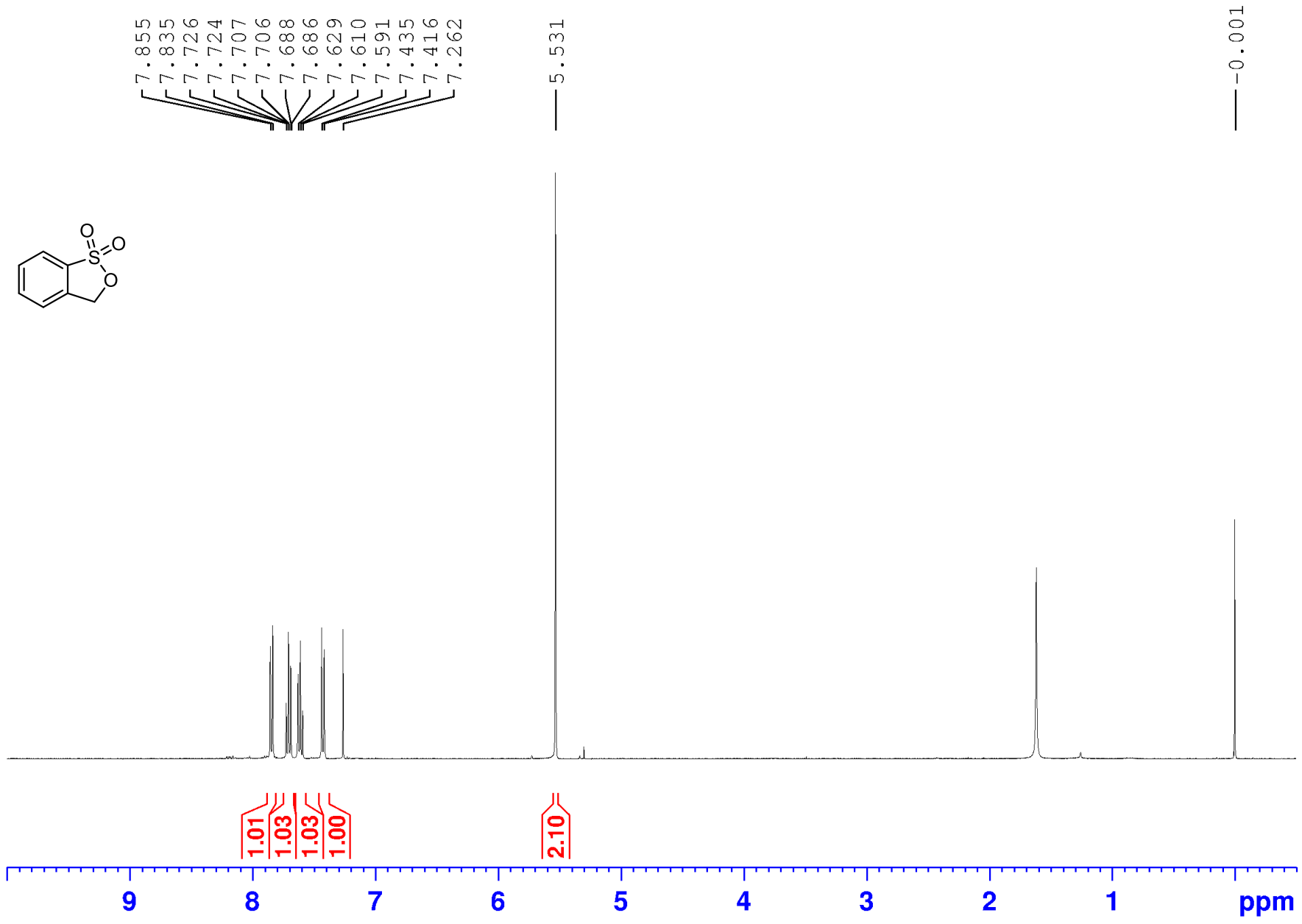
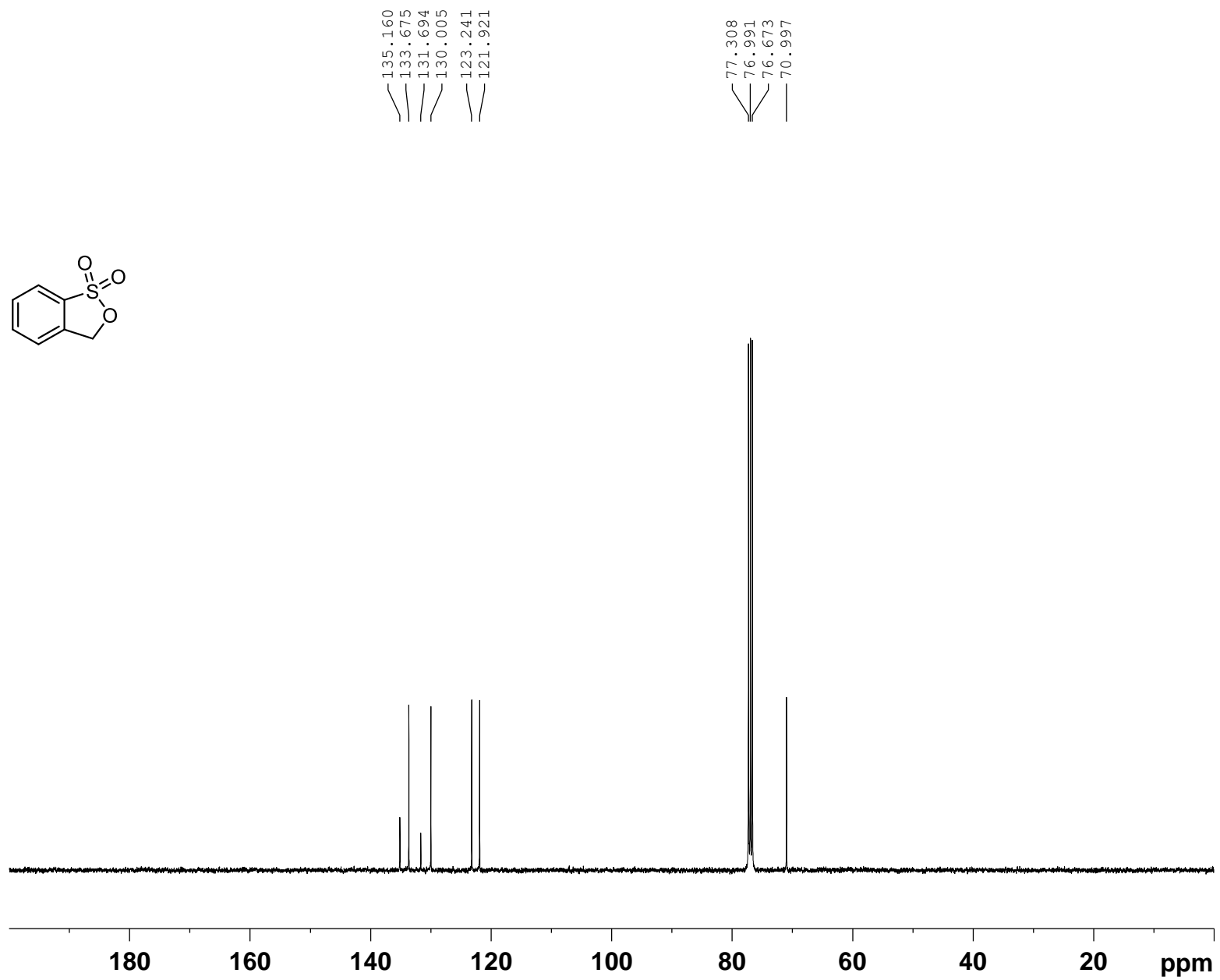
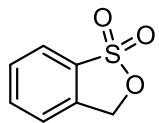
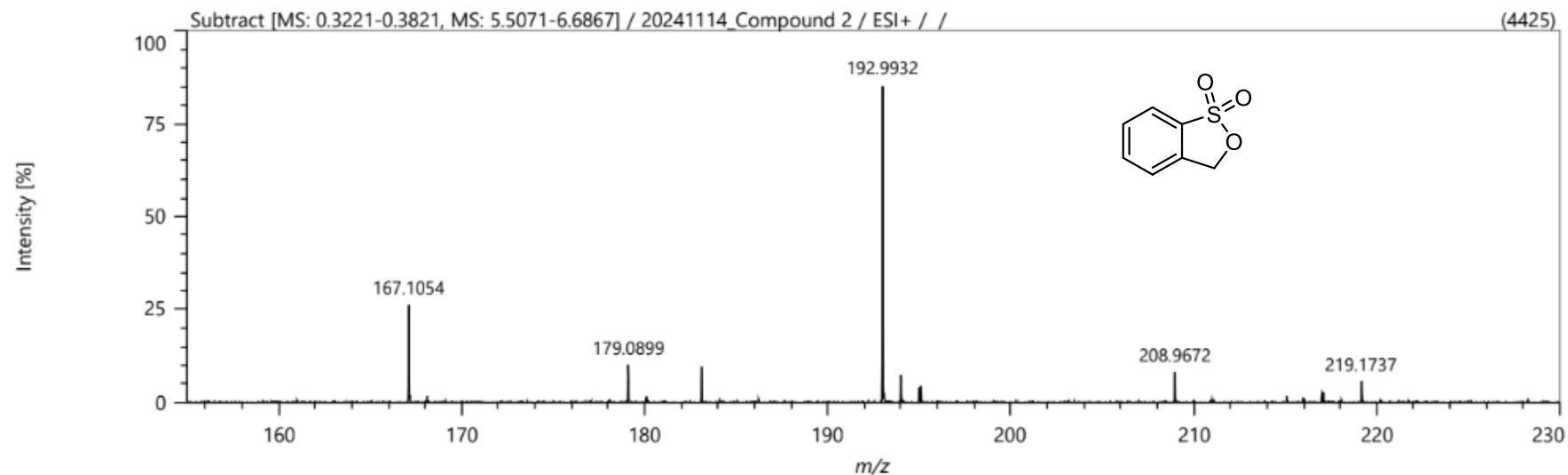


Figure S3. Thermogravimetric analysis (TGA) of representative **ZM 1e**, **ZM 1f**, and **ZM 2d** zwitterionic materials exhibiting thermoresponsiveness with water was measured under nitrogen at a heating rate of $20\text{ }^{\circ}\text{C}\cdot\text{min}^{-1}$. Inset: derivative thermogravimetry (DTG) curves of **ZM 1e**, **ZM 1f**, and **ZM 2d** with their first DTG peak at 260, 312, and 332 $^{\circ}\text{C}$, respectively. Thermal analyses were carried out using a PerkinElmer STA 6000 thermogravimetric analyzer (PerkinElmer, Waltham, MA, USA).





Spectrum



Elemental Composition

Parameters

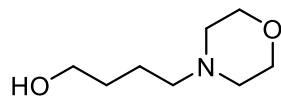
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Elements Set 2:

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Results

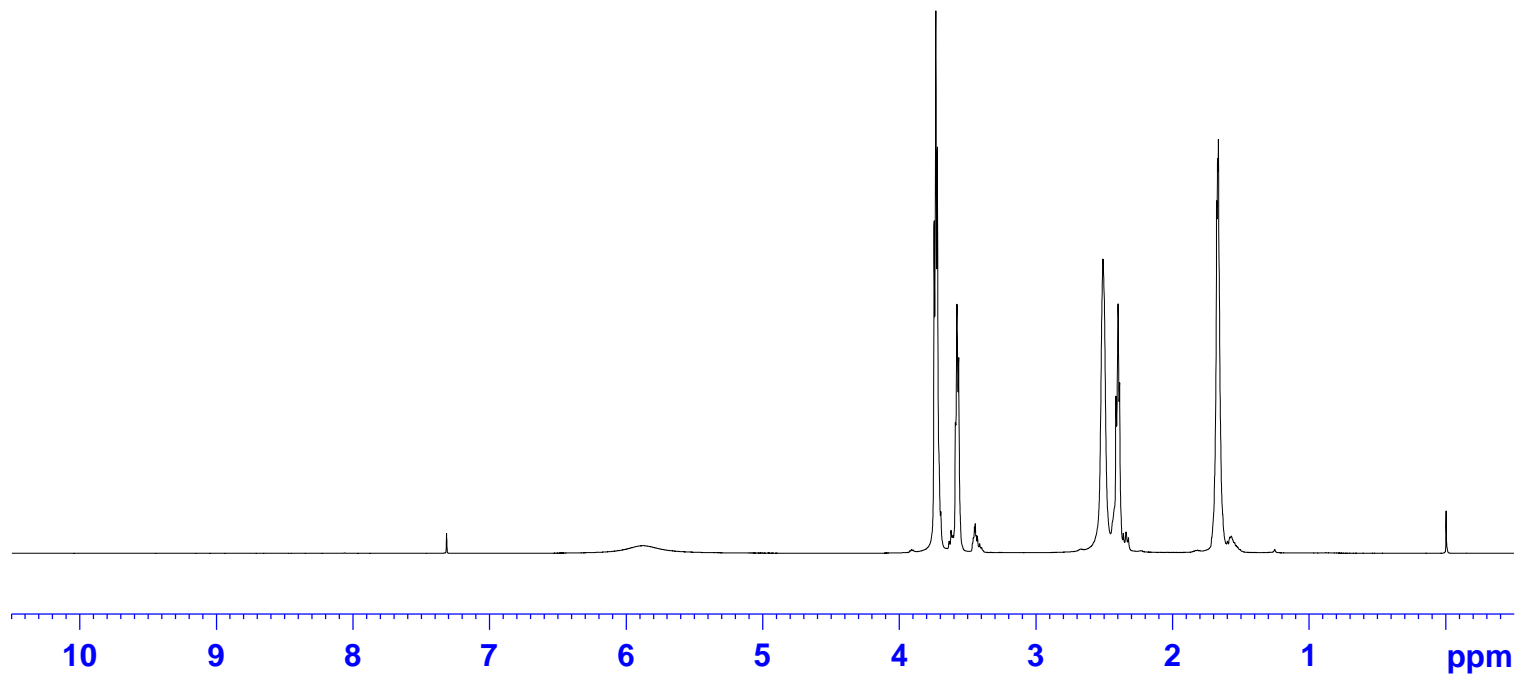
Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
192.99320	C7 H6 O3 Na S	192.99299	0.22	1.12	4.5

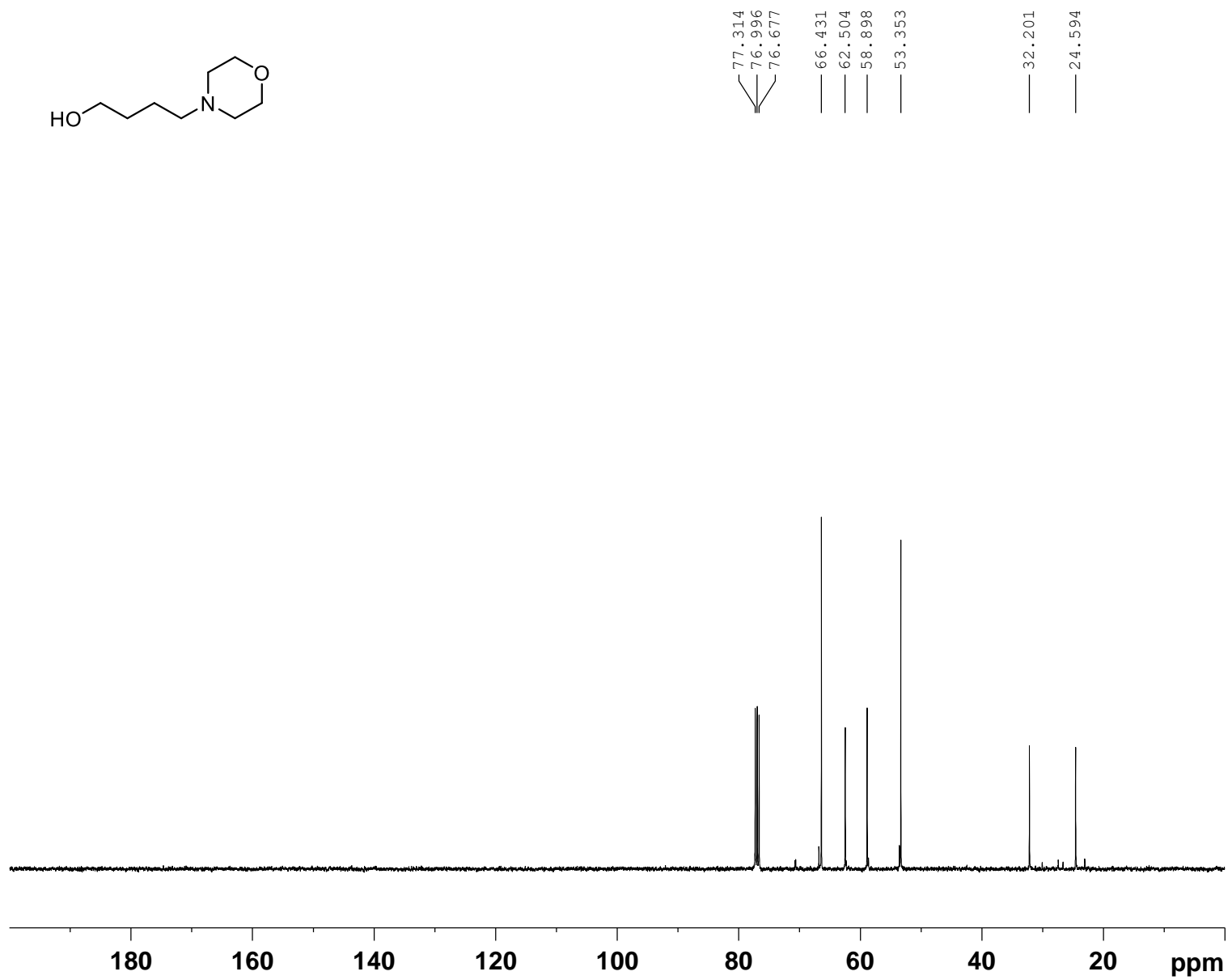
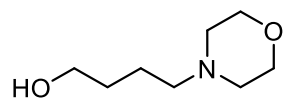


— 7.316

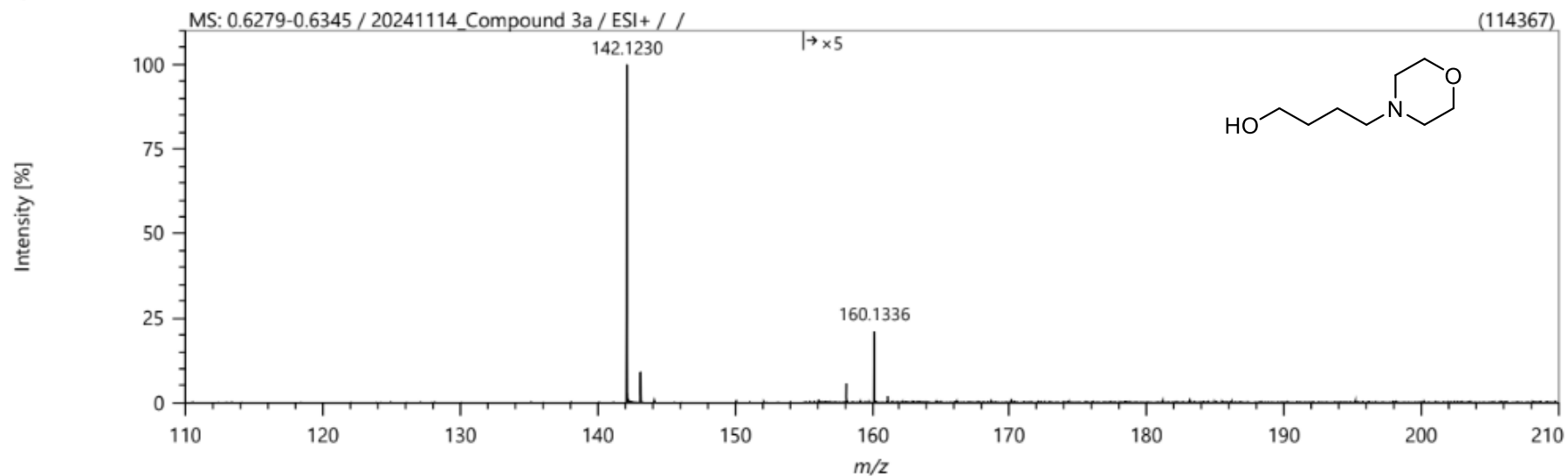
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3.724
3.591
3.580
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1.666

— -0.001





Spectrum



Elemental Composition

Parameters

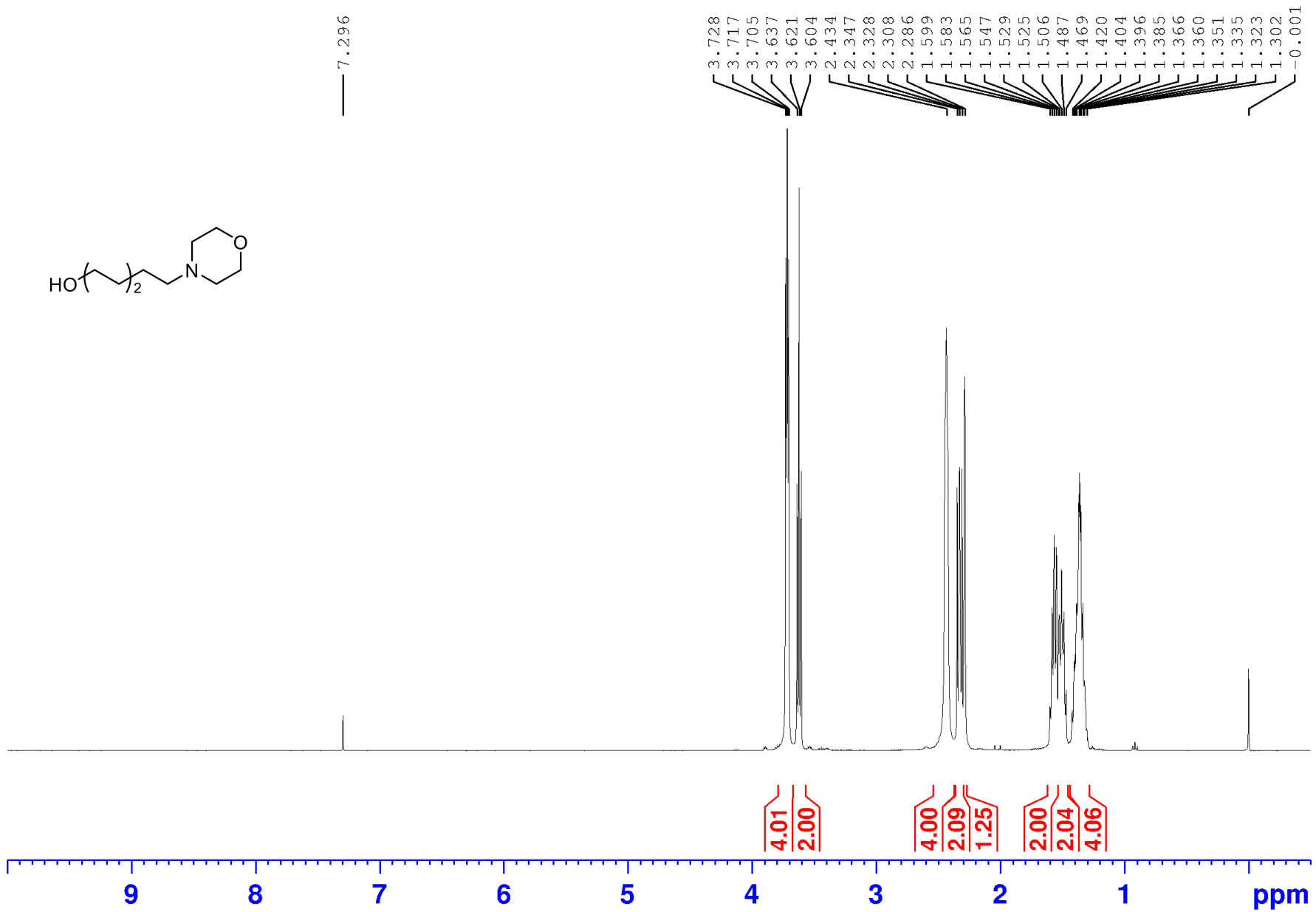
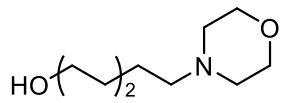
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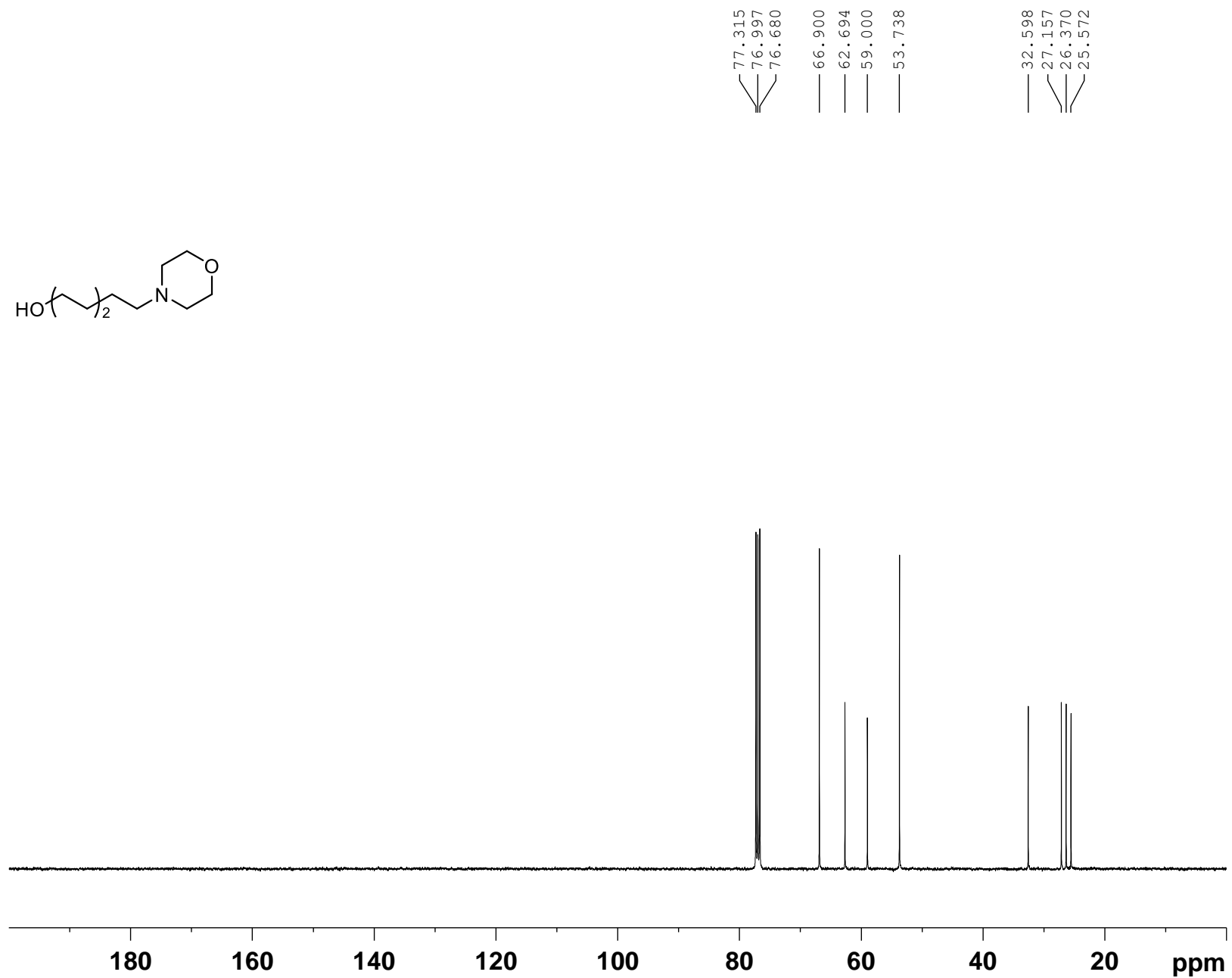
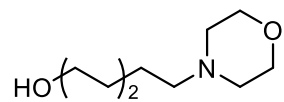
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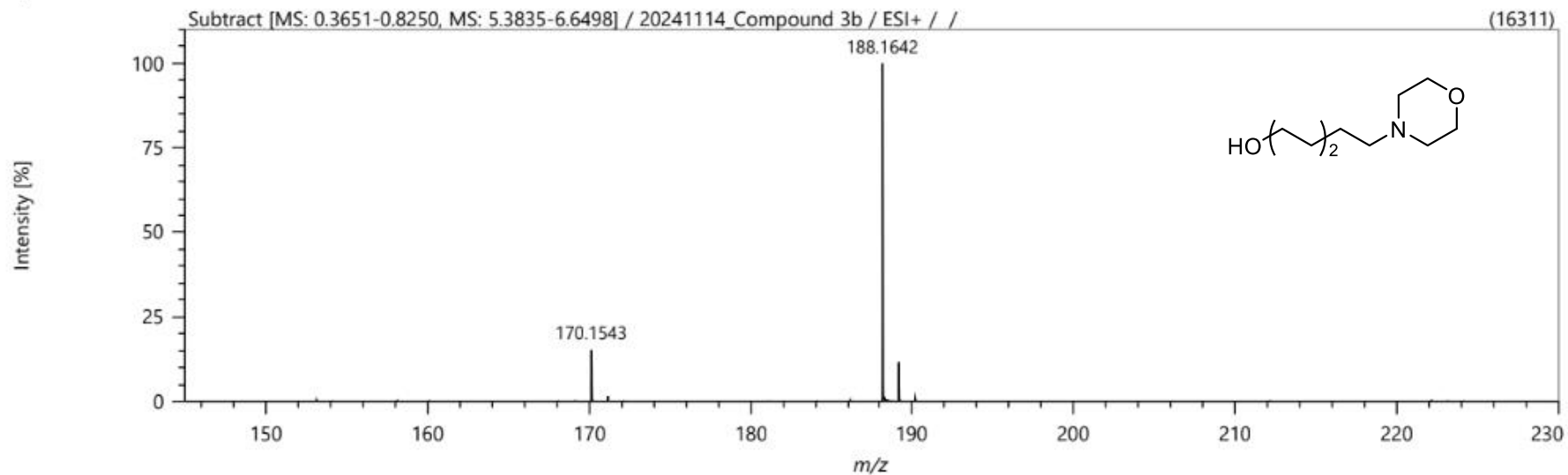
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
160.13358	C ₈ H ₁₈ N O ₂	160.13321	0.37	2.34	0.5





Spectrum



Elemental Composition

Parameters

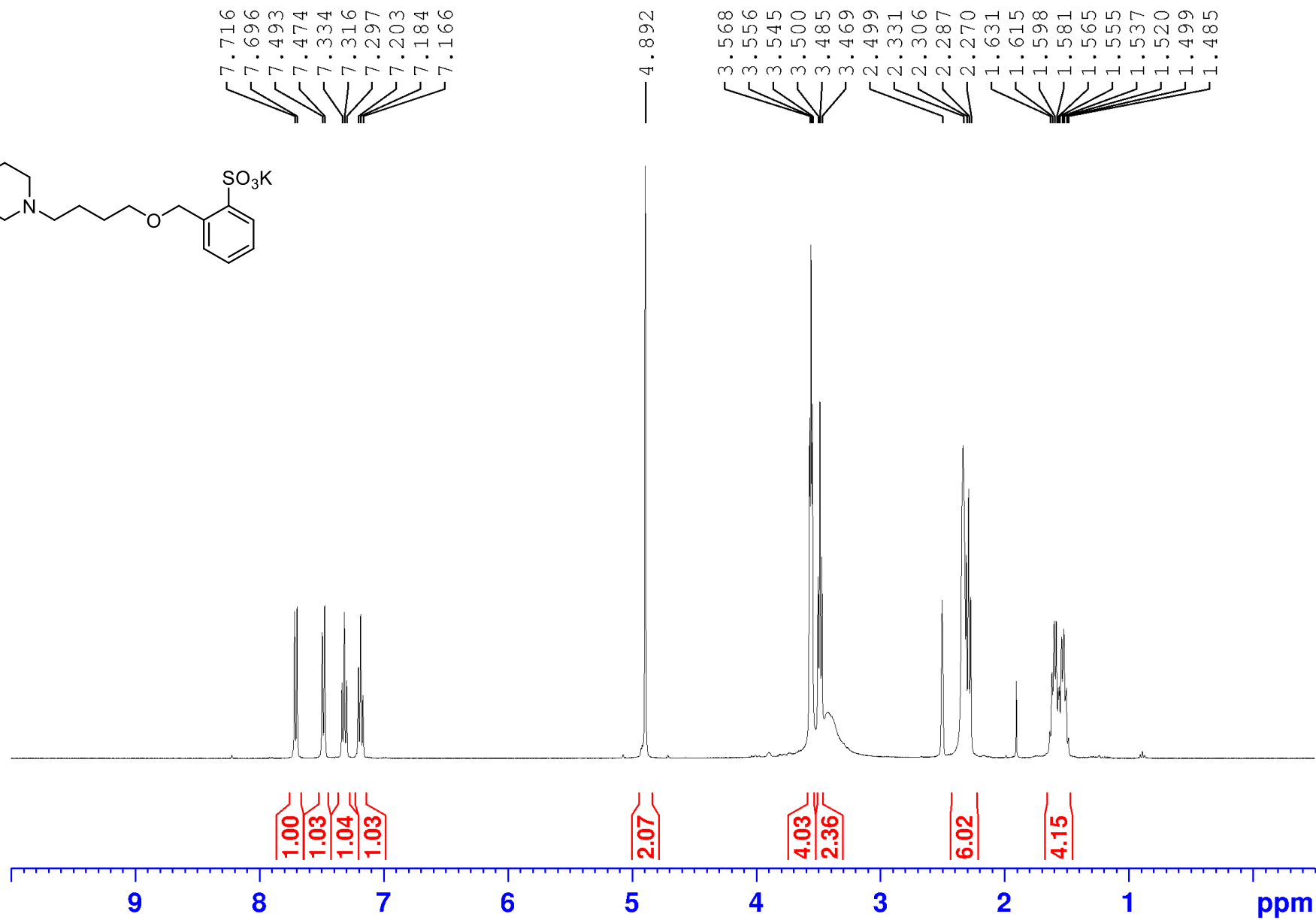
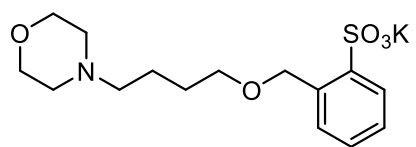
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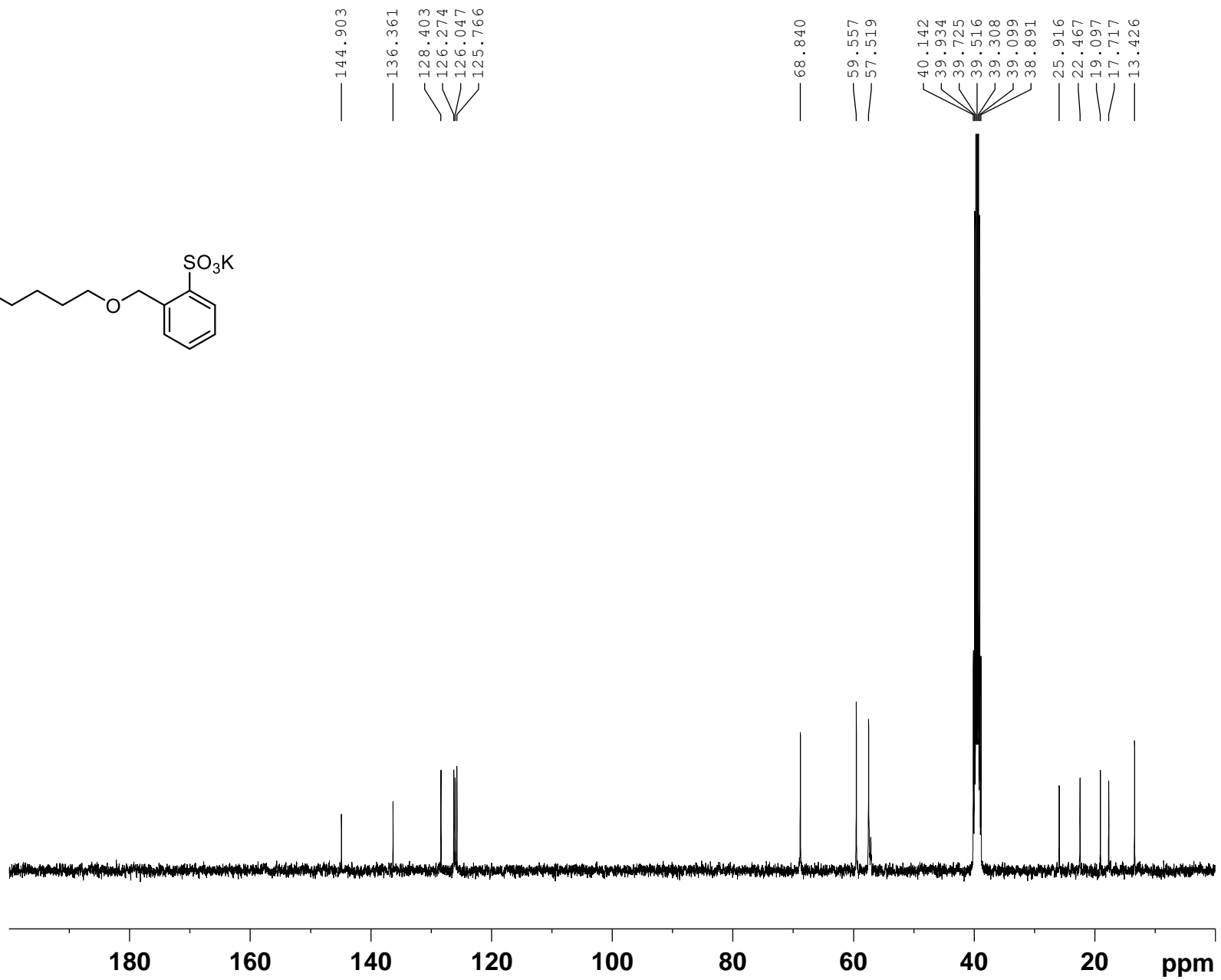
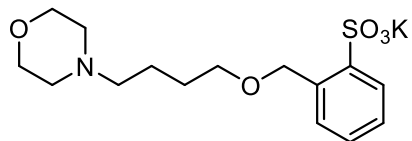
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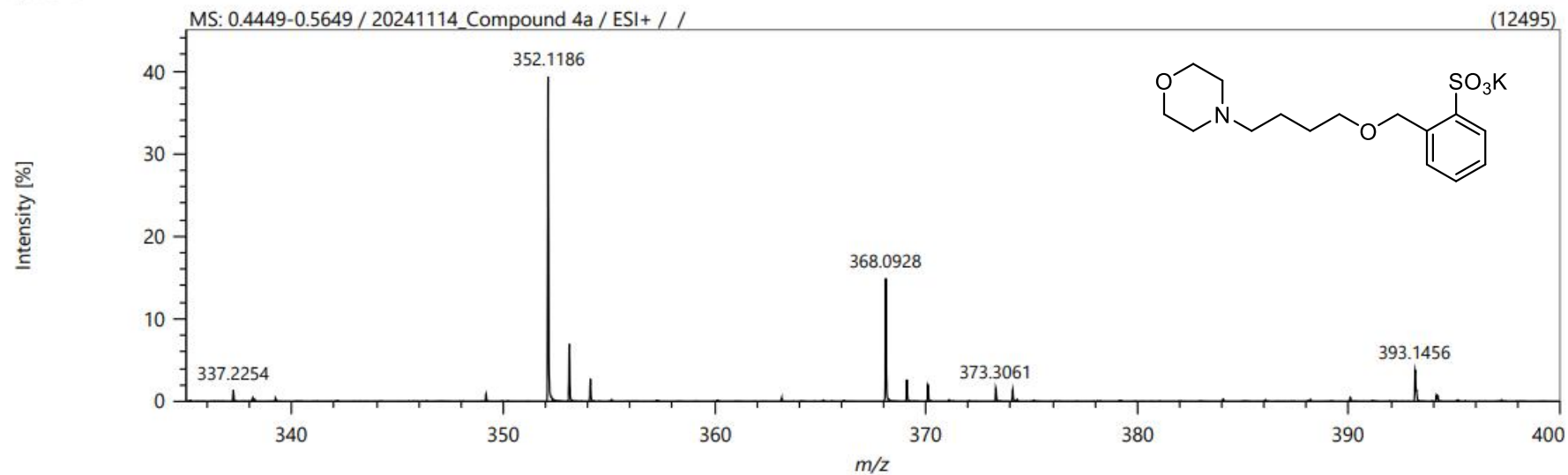
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
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Spectrum



Elemental Composition

Parameters

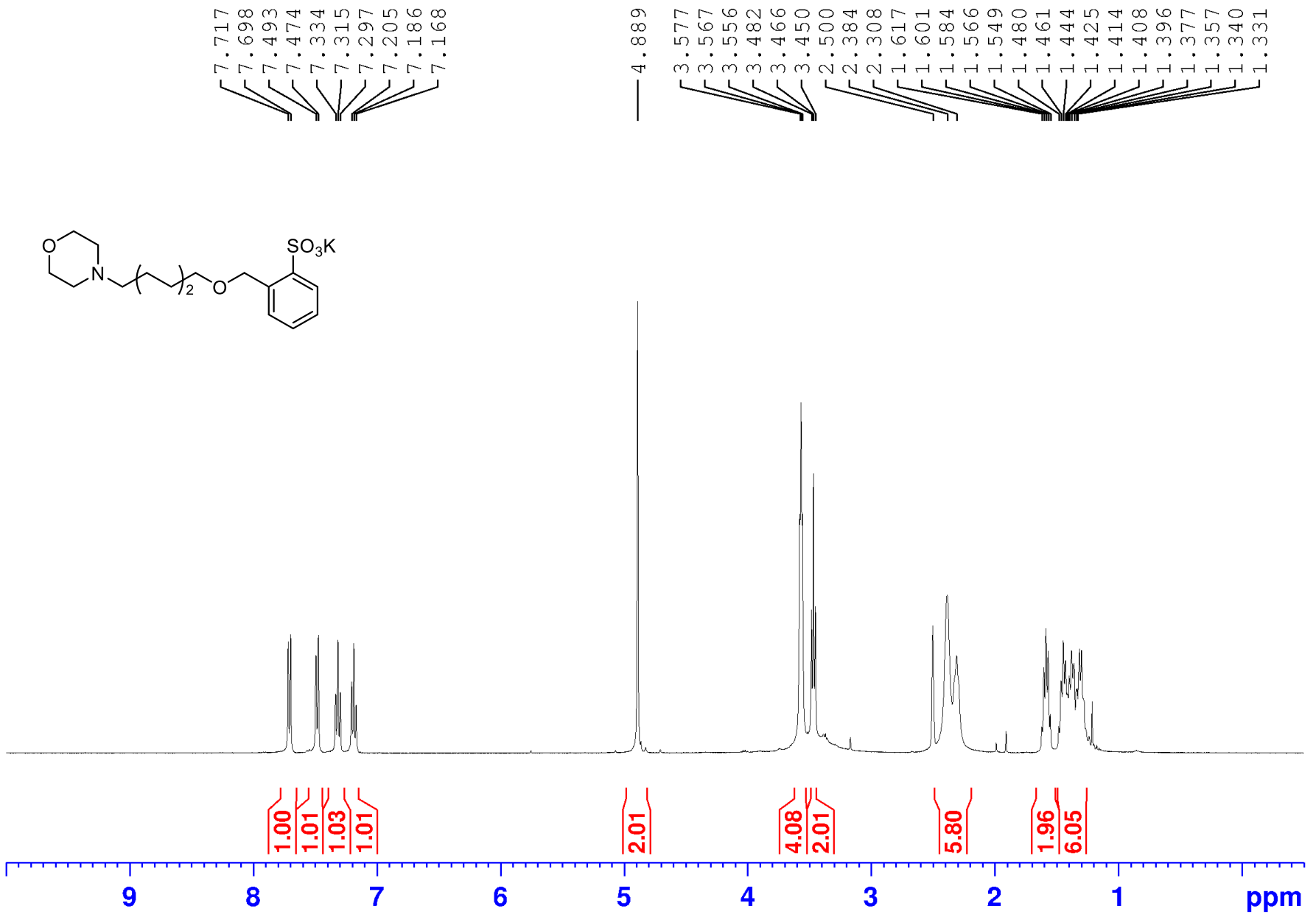
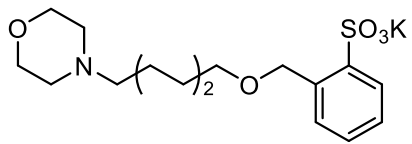
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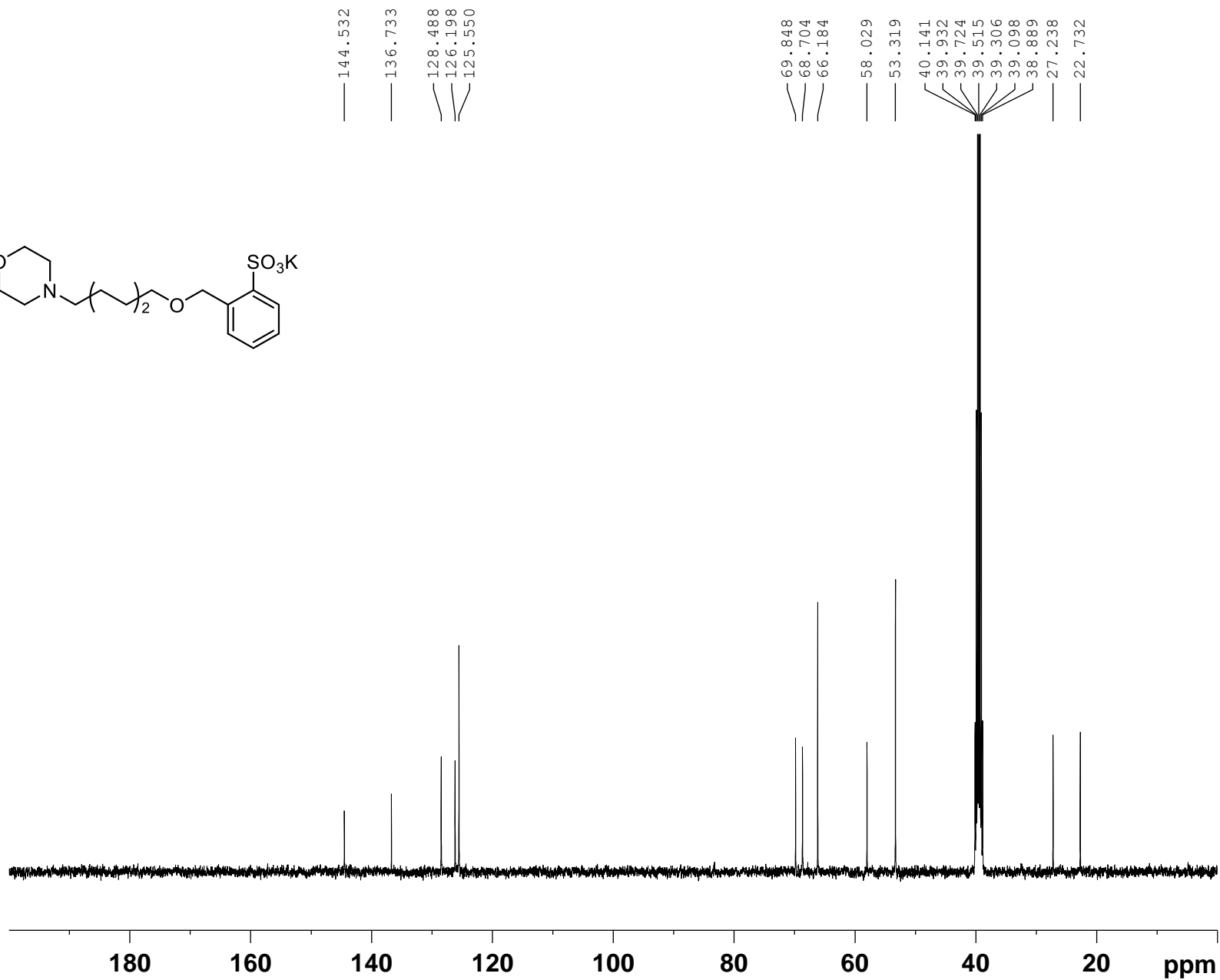
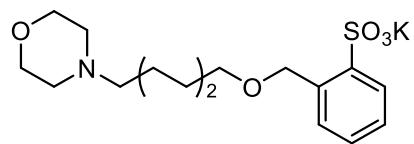
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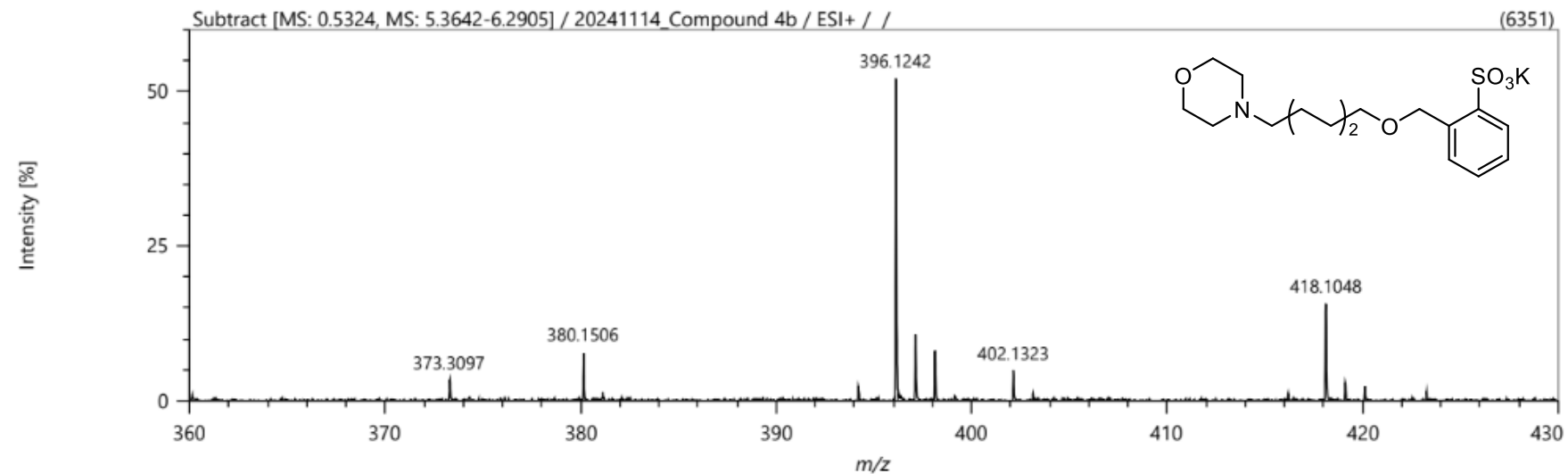
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
368.09278	C ₁₅ H ₂₃ N O ₅ S K	368.09285	-0.07	-0.19	4.5





Spectrum



Elemental Composition

Parameters

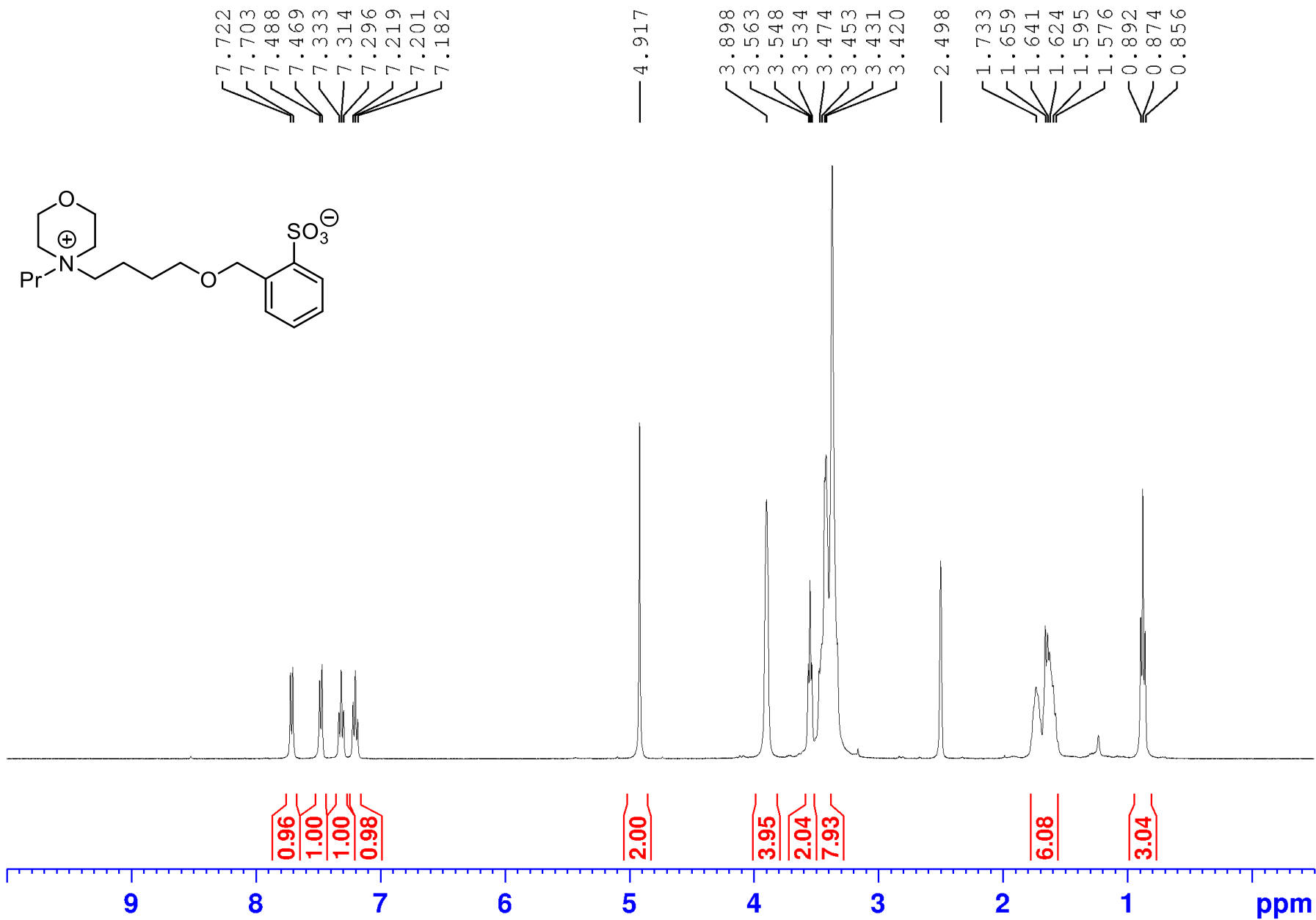
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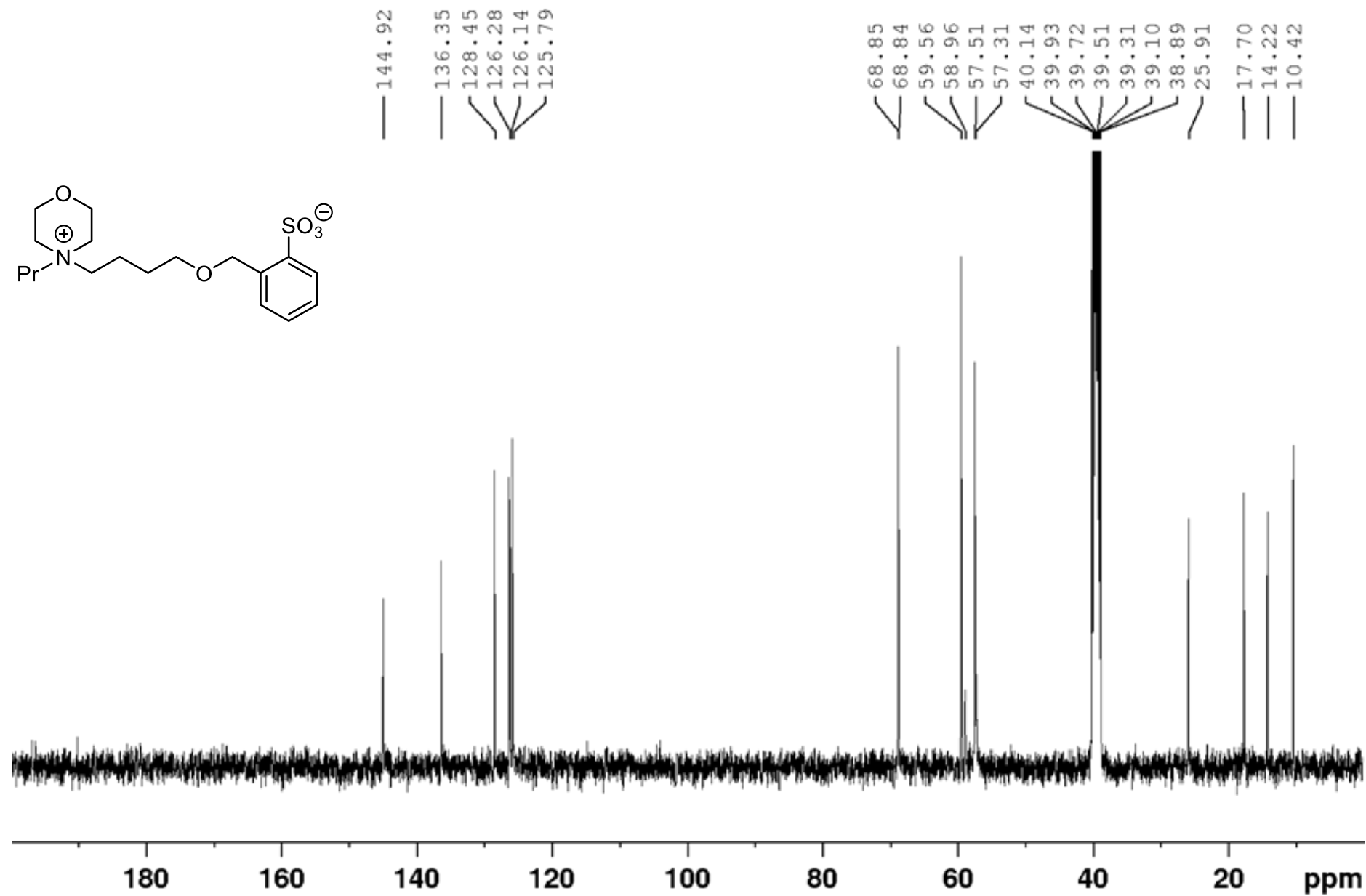
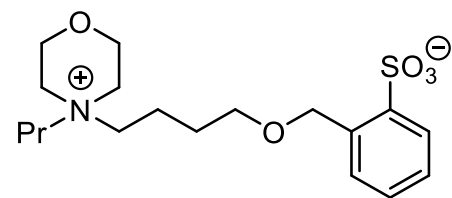
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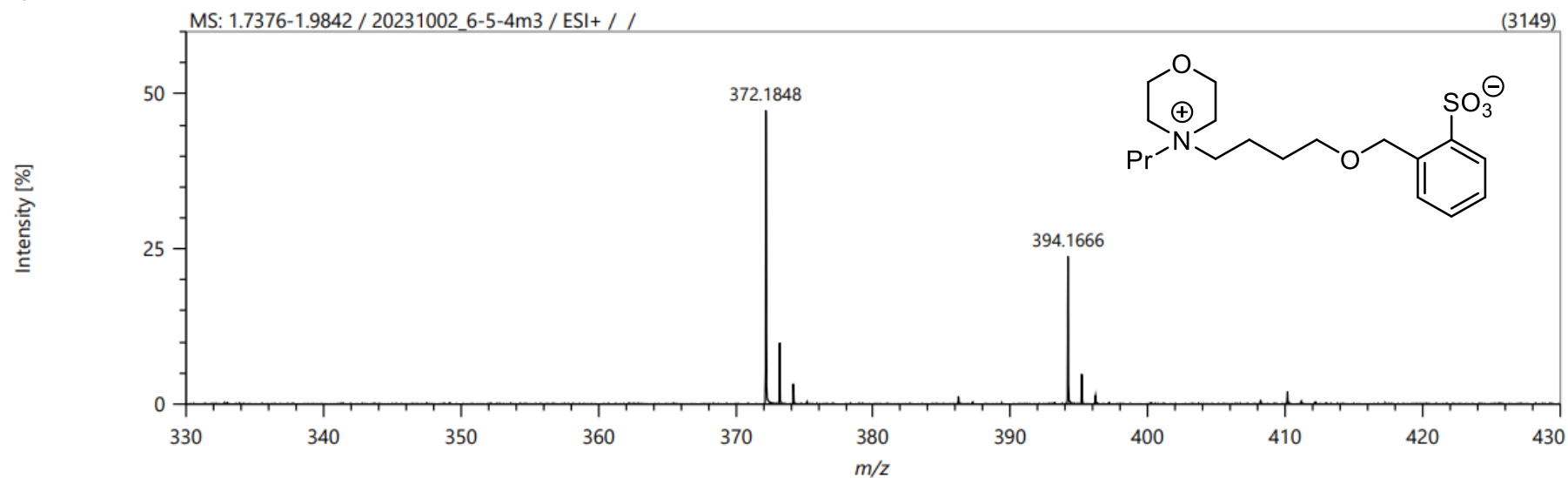
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
396.12418	C ₁₇ H ₂₇ N ₁ O ₅ S ₁ K	396.12415	0.02	0.06	4.5





Spectrum



Elemental Composition

Parameters

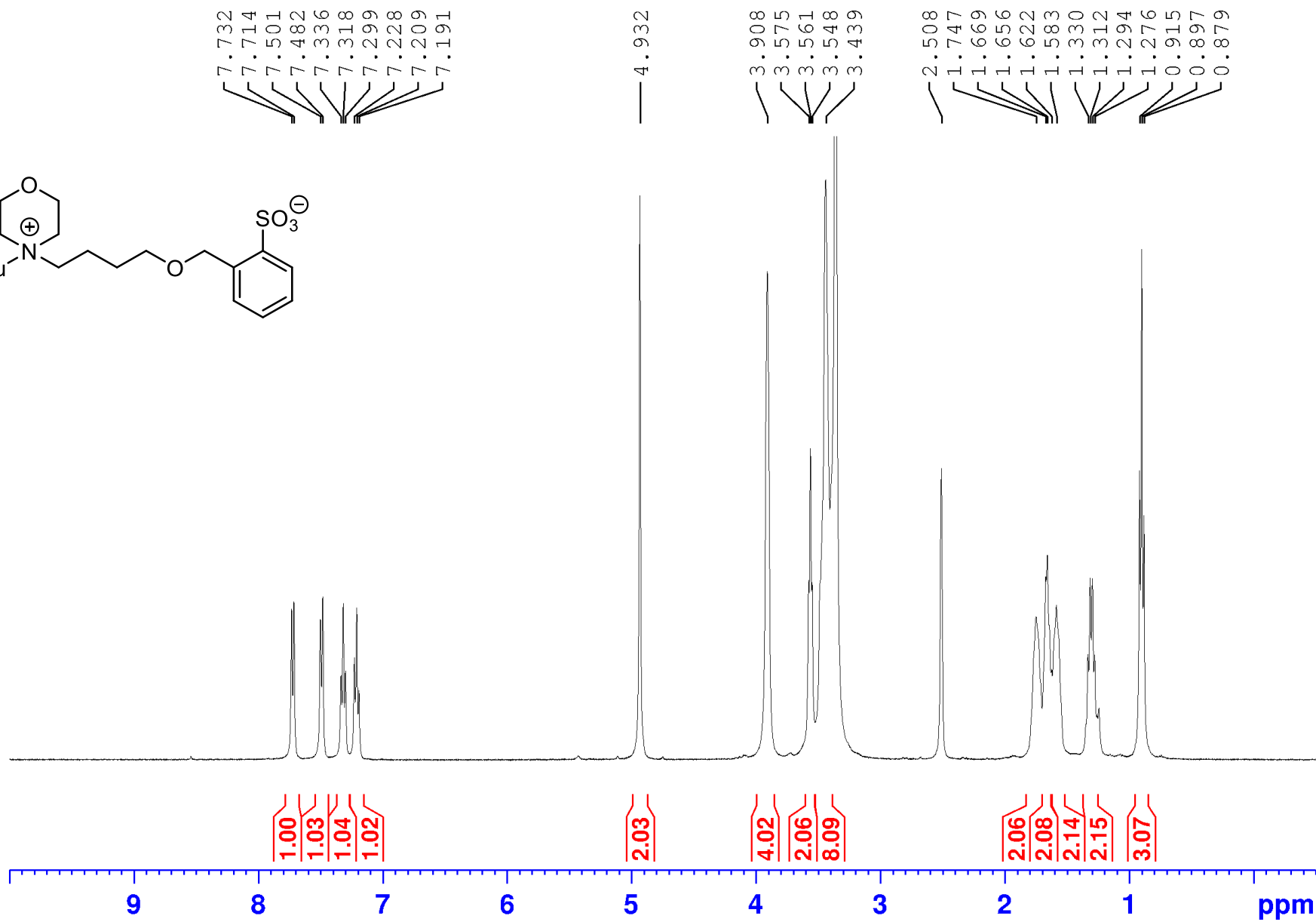
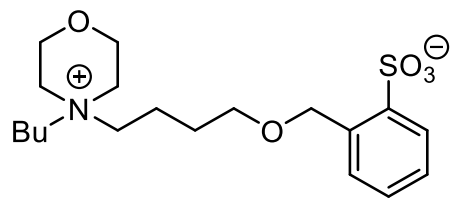
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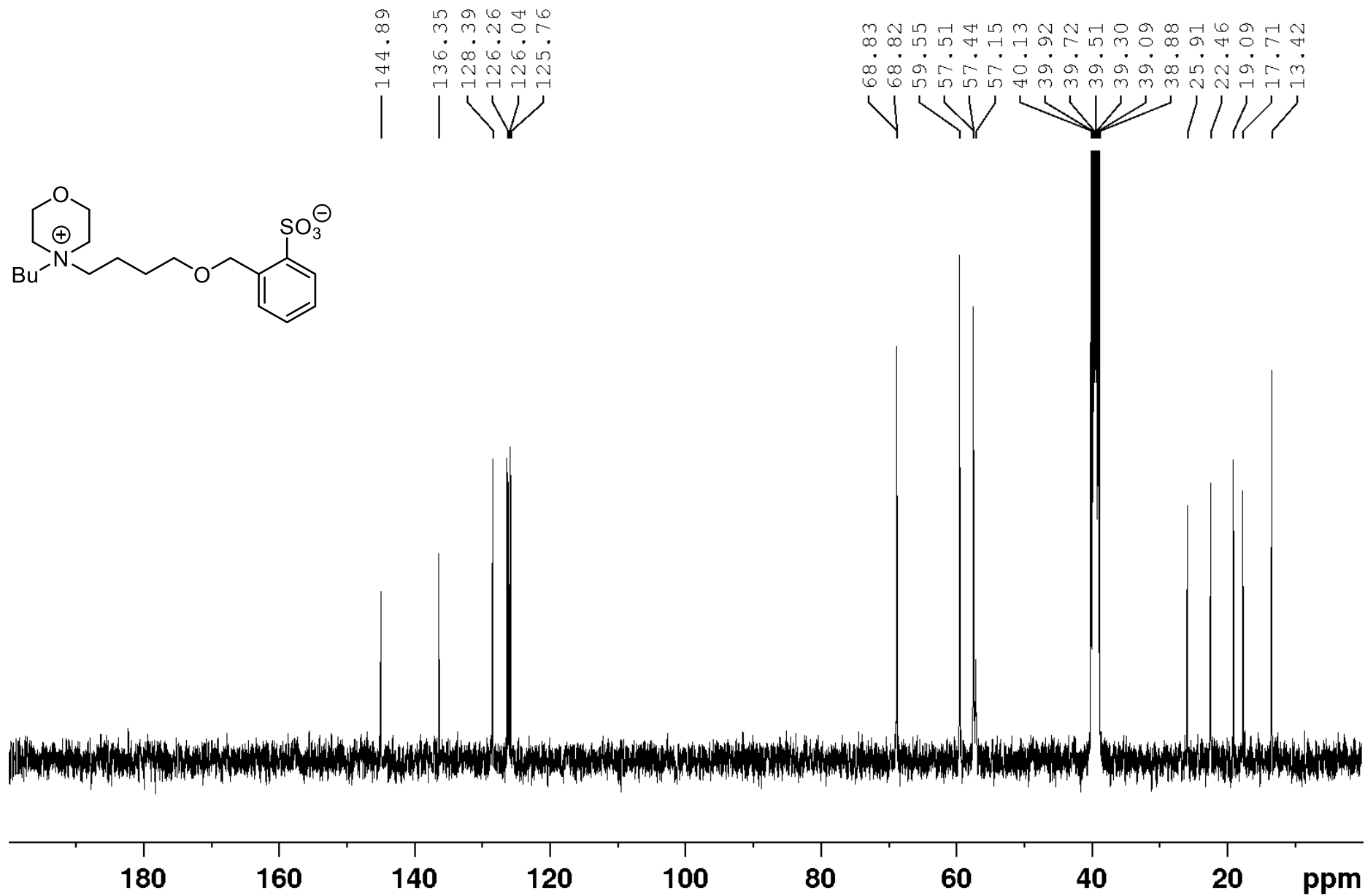
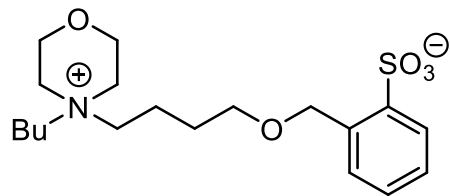
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Symbol	C	H	N	O	S	Na
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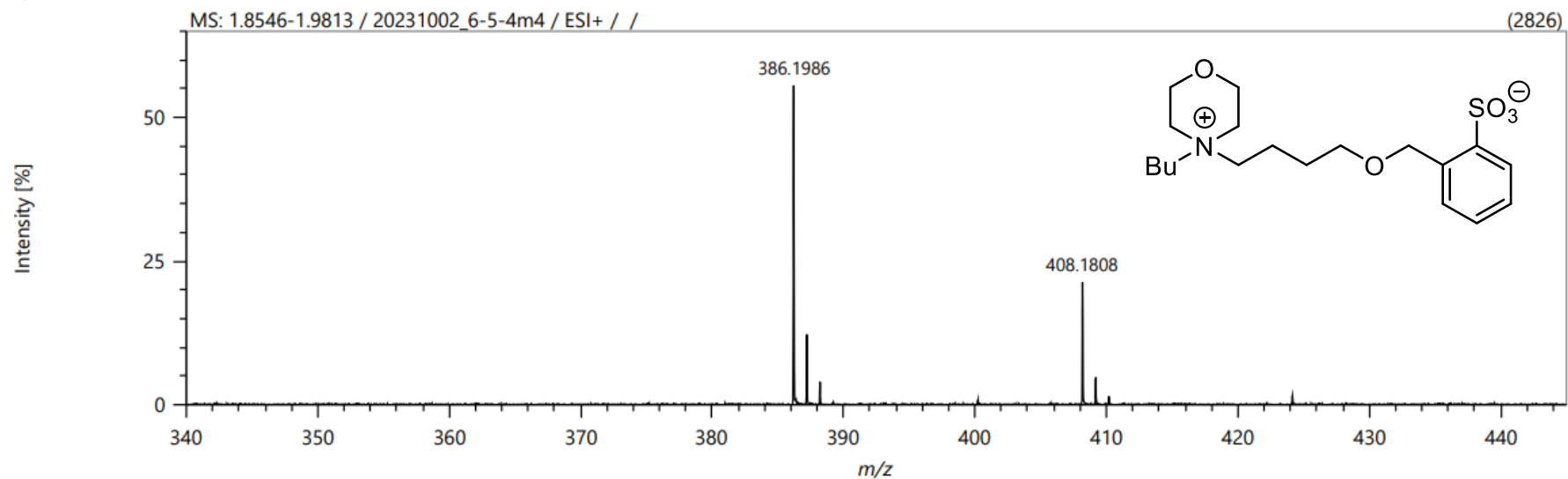
Results

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372.18476	C ₁₈ H ₃₀ N O ₅ S	372.18392	0.84	2.27	4.5
394.16658	C ₁₈ H ₂₉ N O ₅ Na S	394.16586	0.71	1.81	4.5





Spectrum



Elemental Composition

Parameters

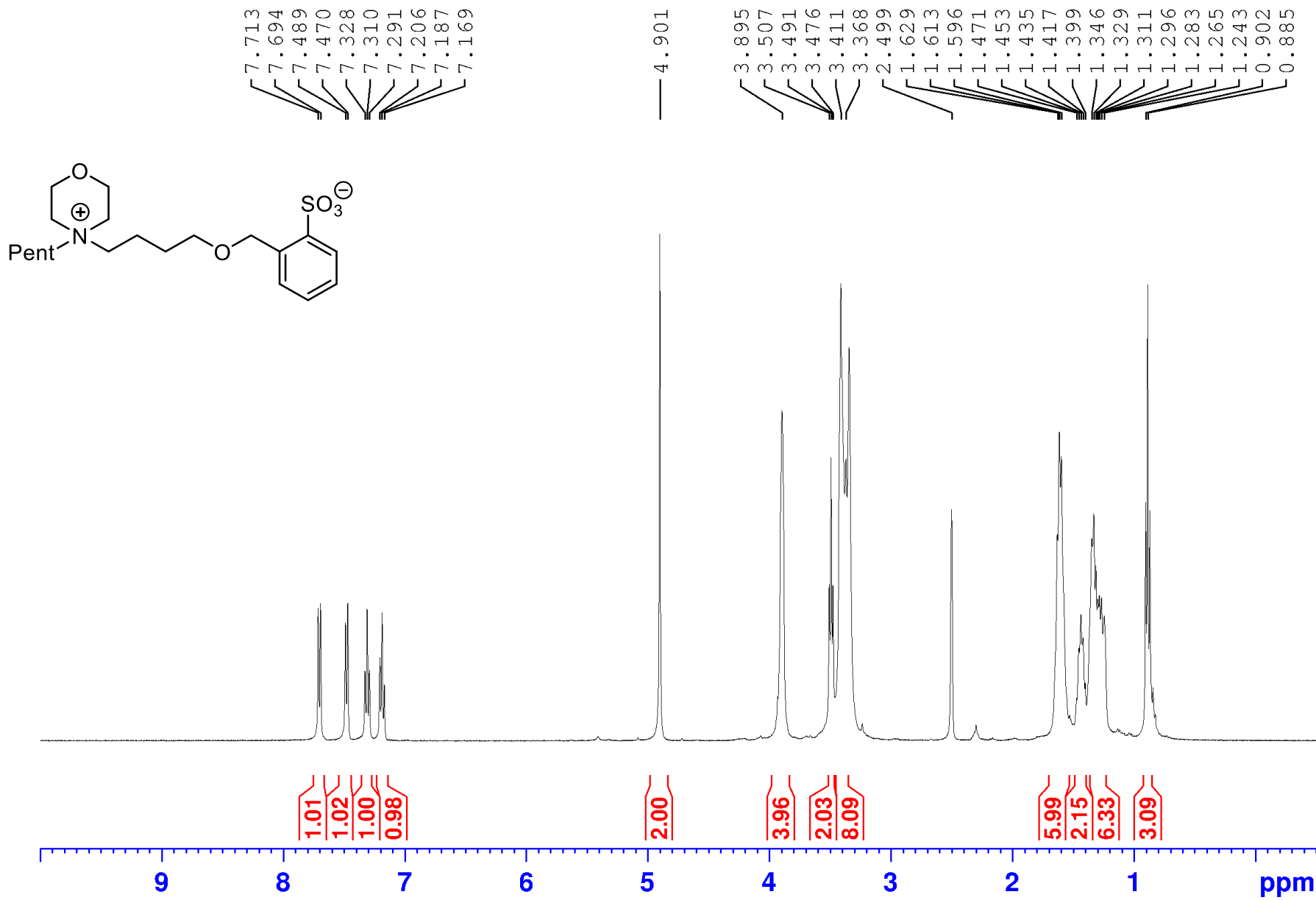
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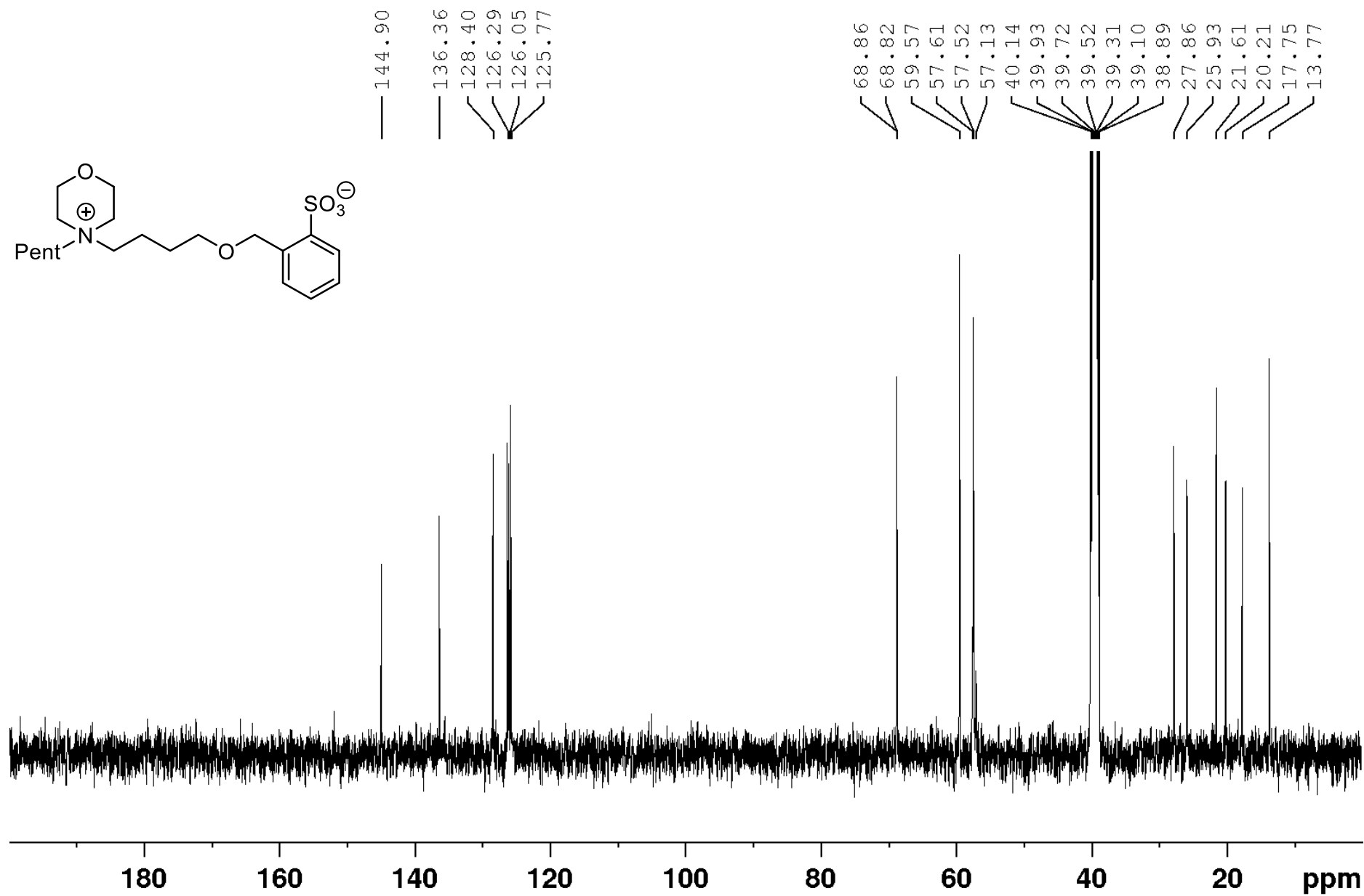
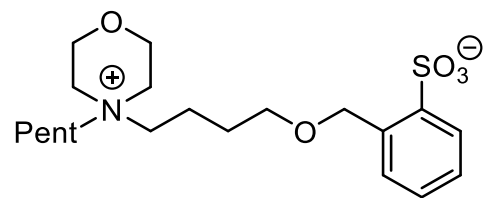
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Symbol	C	H	N	O	S	Na
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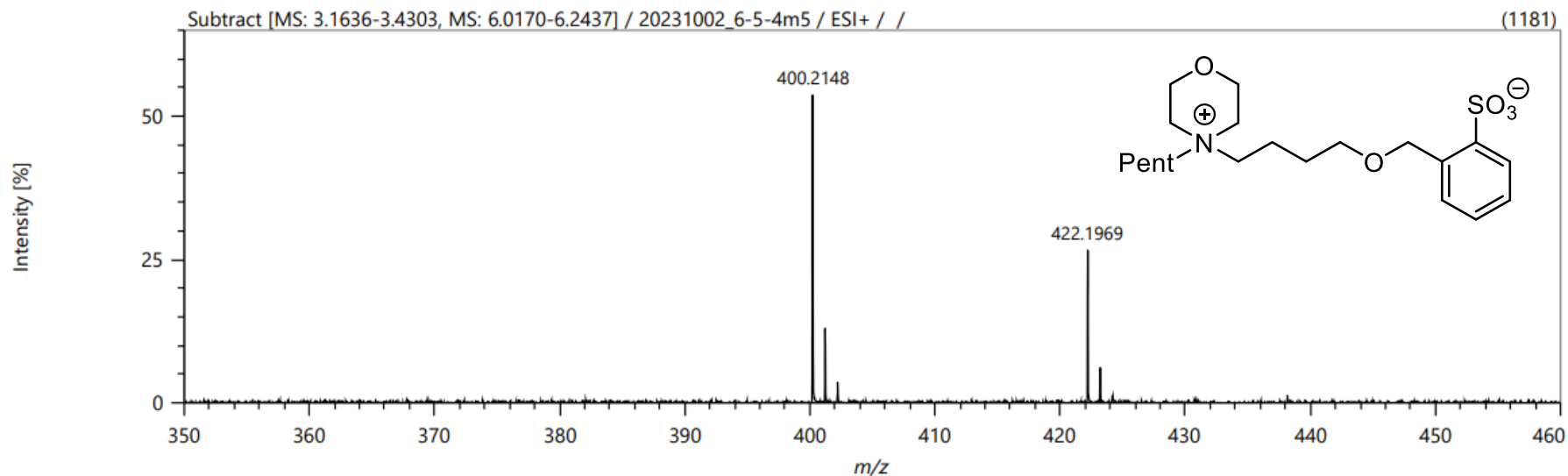
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
386.19859	C ₁₉ H ₃₂ N O ₅ S	386.19957	-0.98	-2.53	4.5
408.18084	C ₁₉ H ₃₁ N O ₅ Na S	408.18151	-0.67	-1.65	4.5





Spectrum



Elemental Composition

Parameters

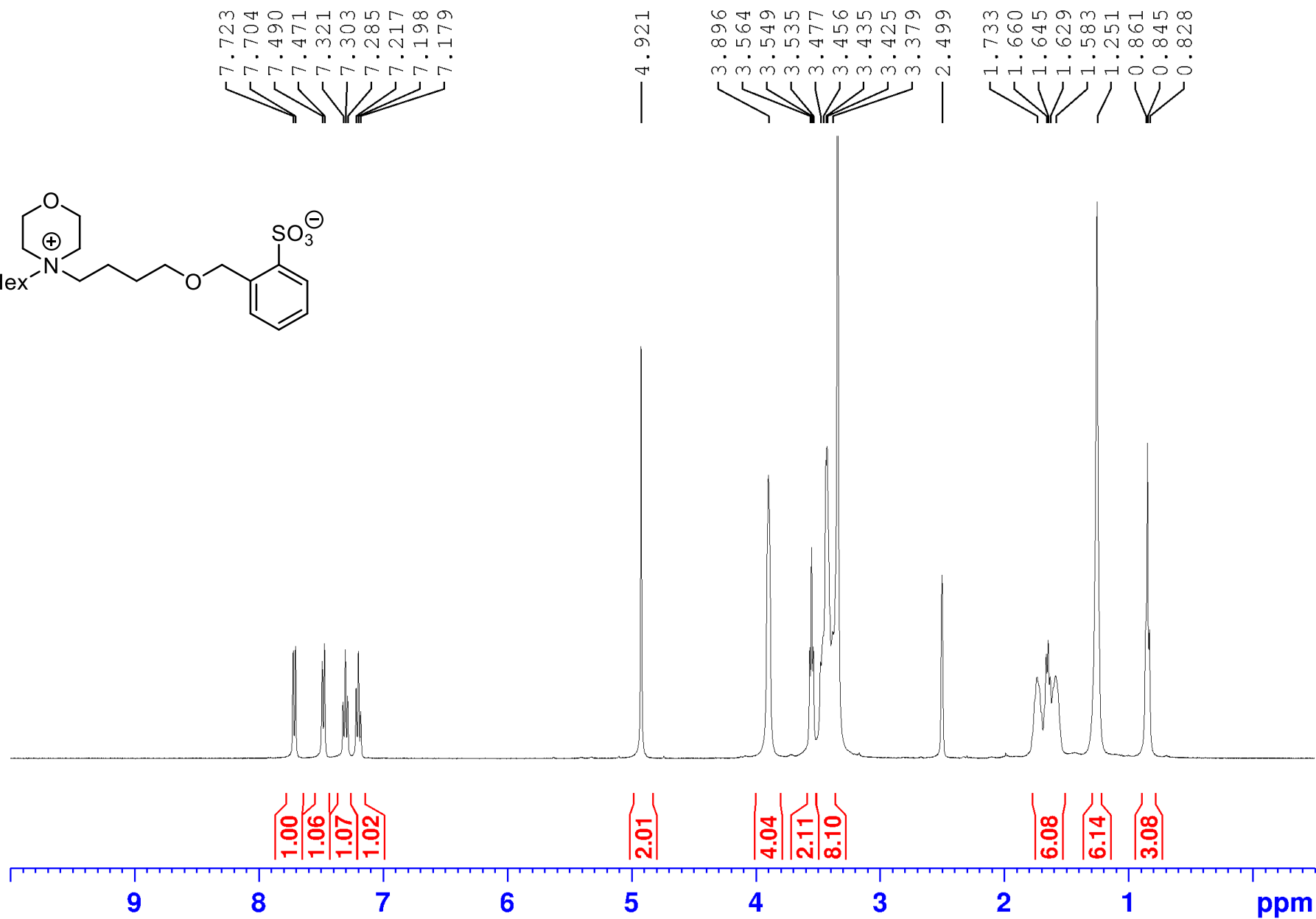
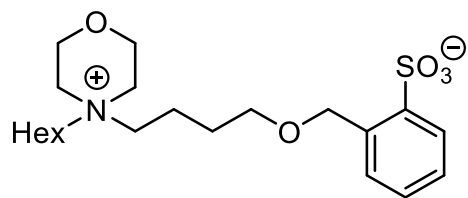
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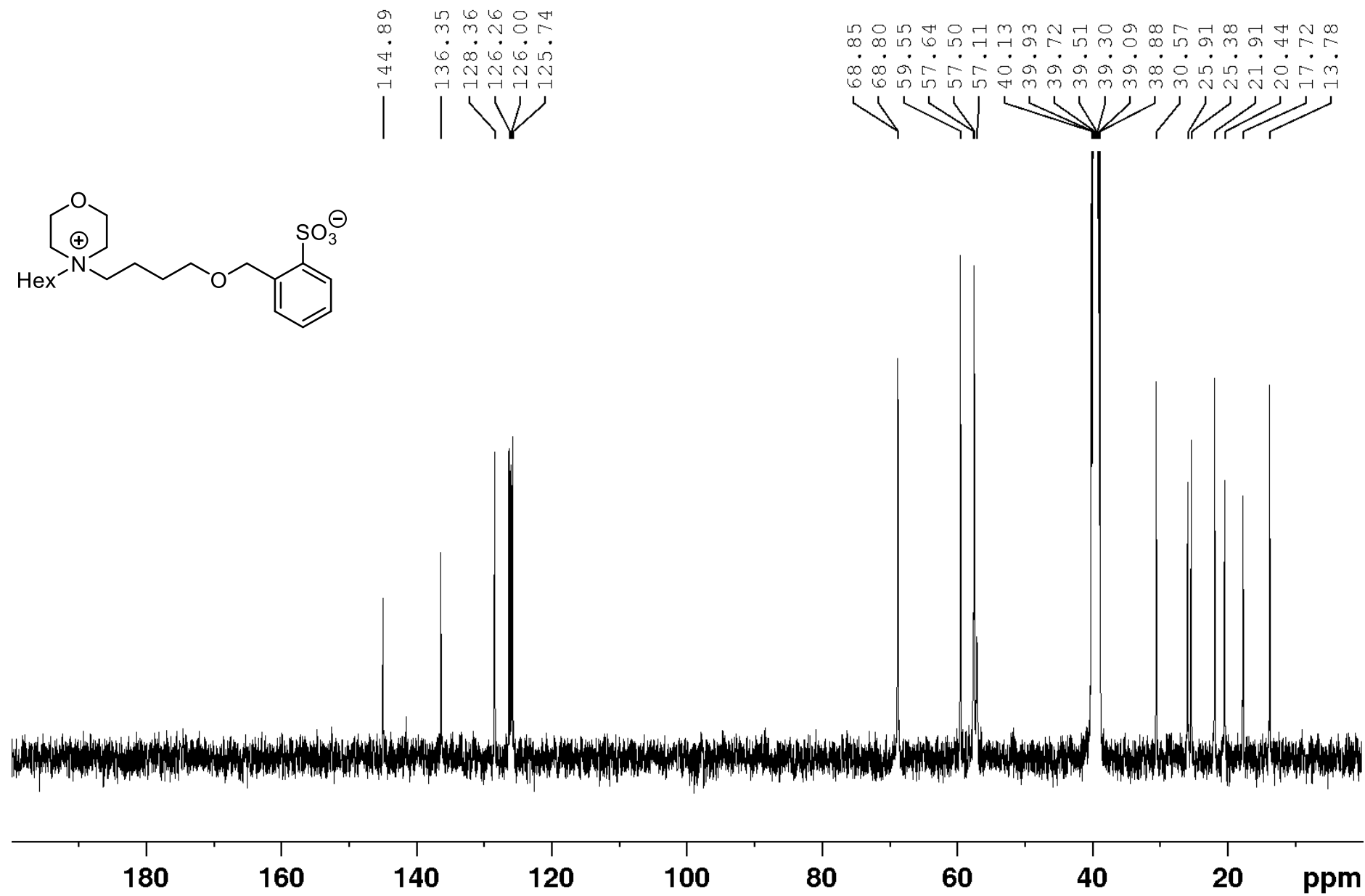
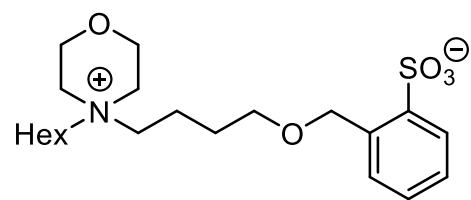
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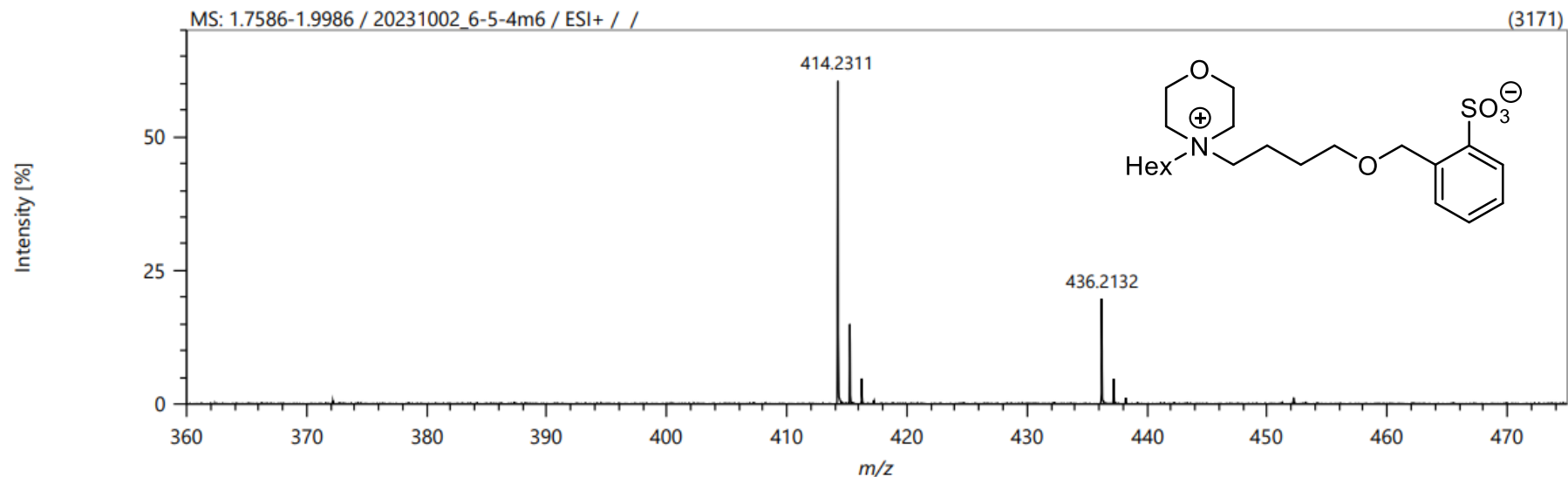
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
400.21480	C ₂₀ H ₃₄ N O ₅ S	400.21522	-0.42	-1.05	4.5
422.19692	C ₂₀ H ₃₃ N O ₅ Na S	422.19716	-0.24	-0.57	4.5





Spectrum



Elemental Composition

Parameters

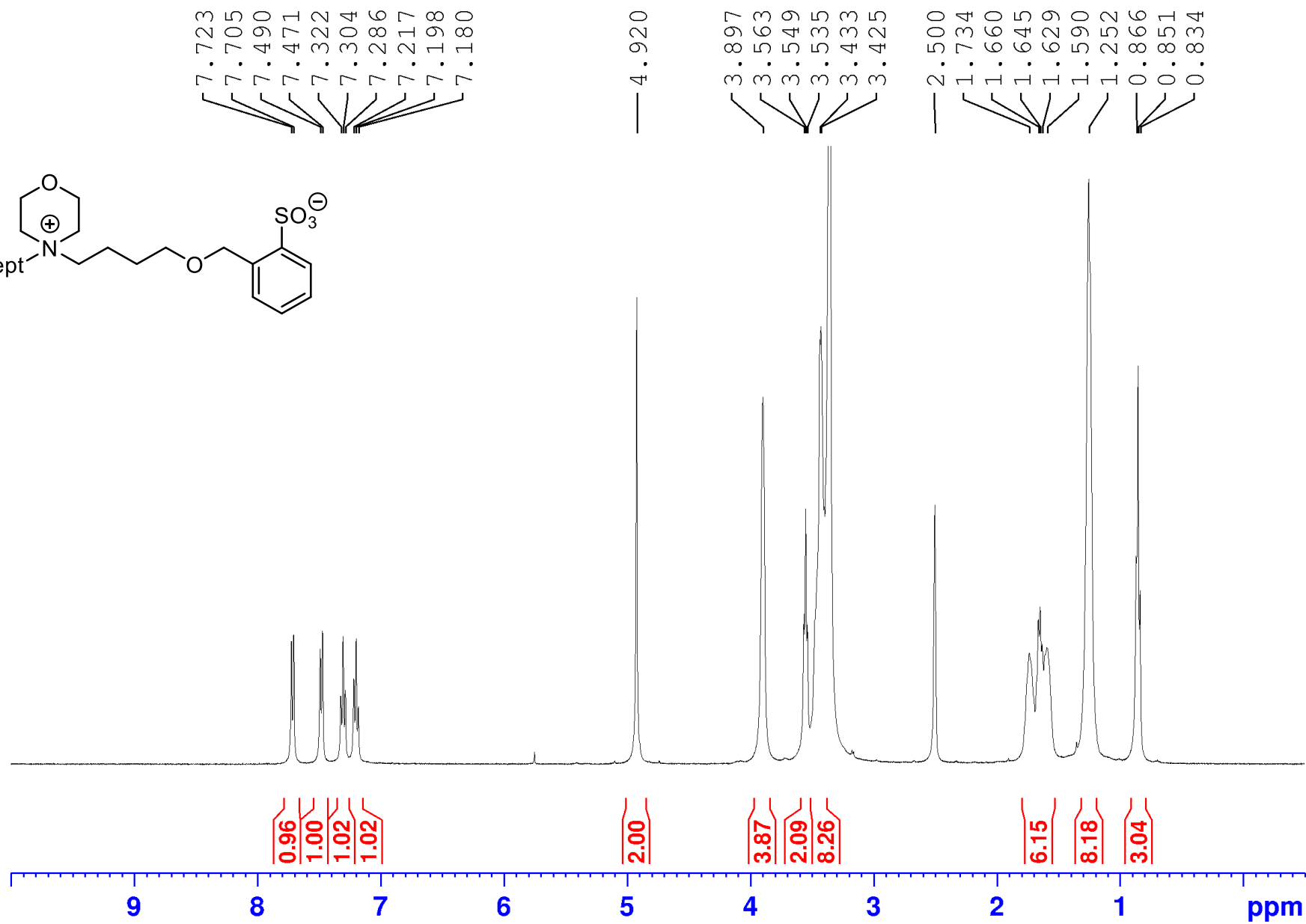
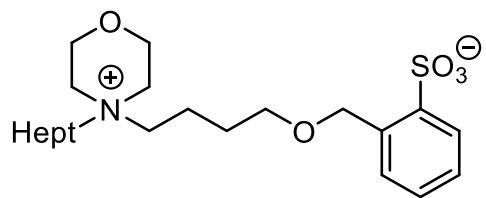
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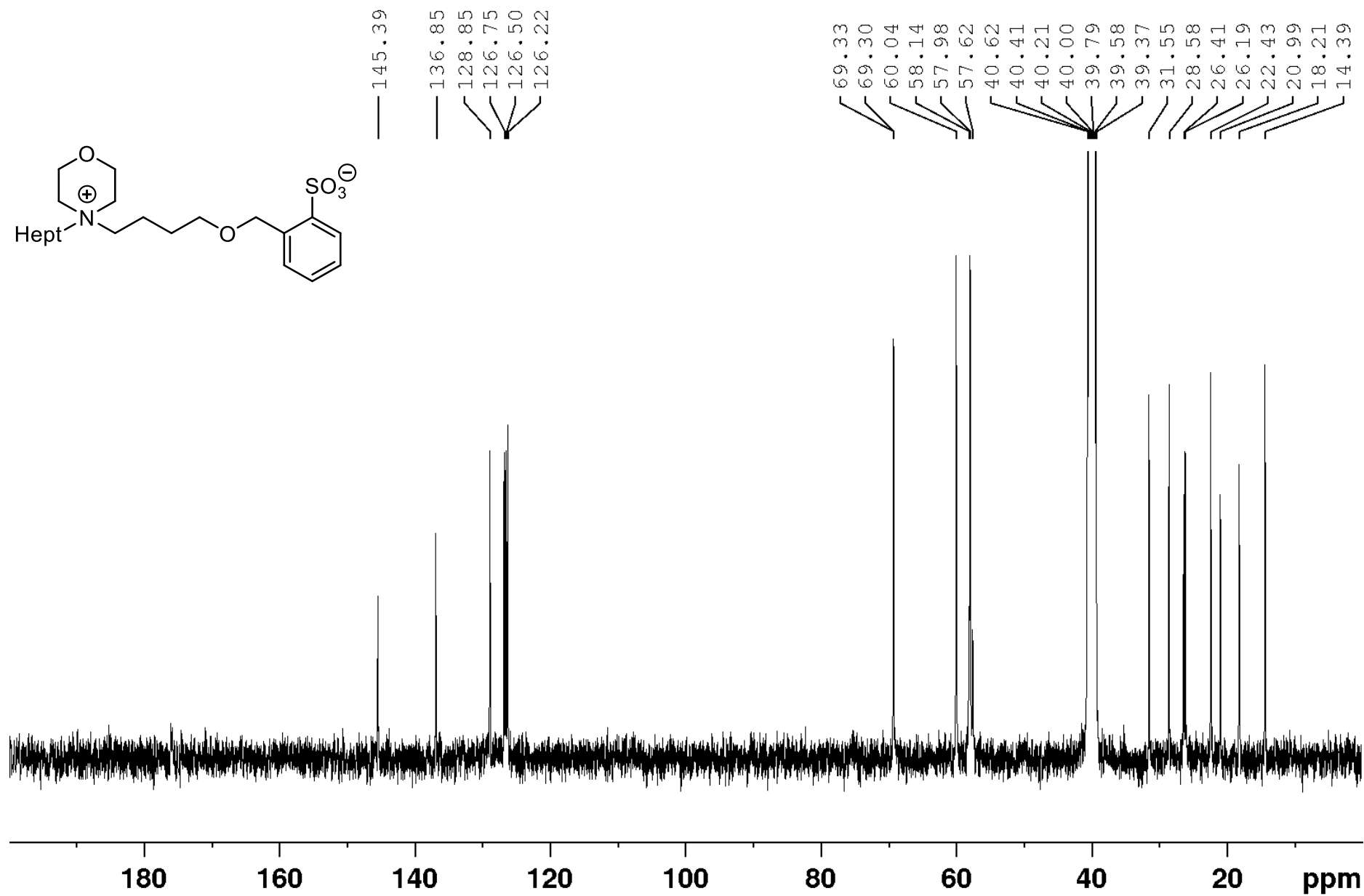
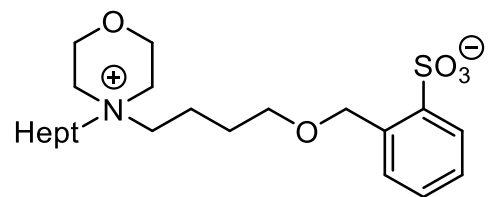
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Symbol	C	H	N	O	S	Na
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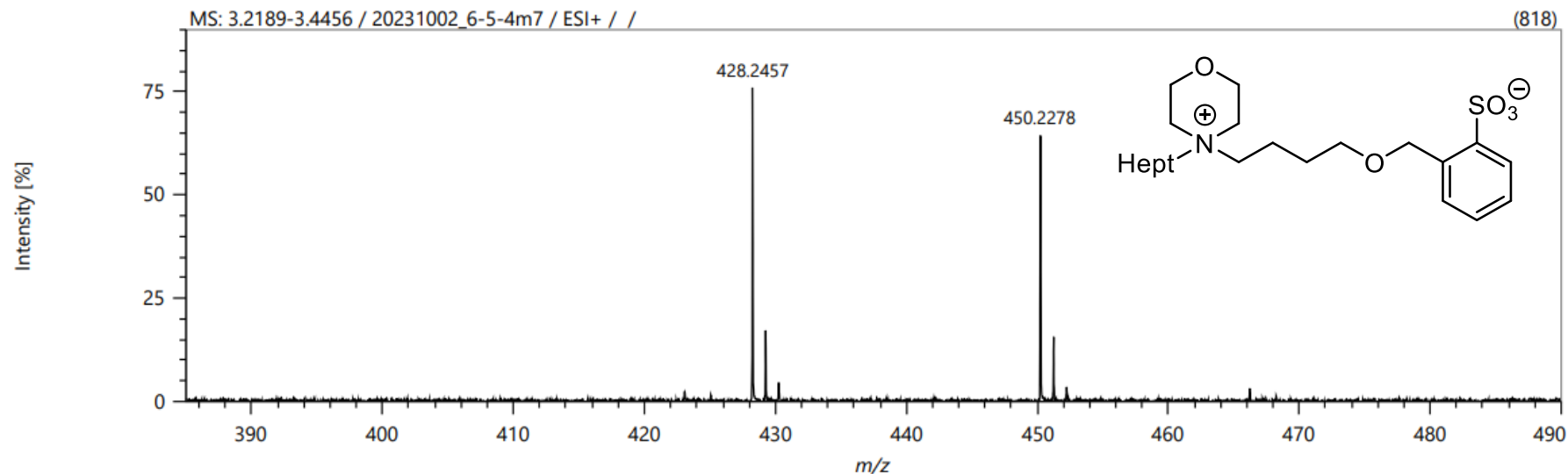
Results

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414.23111	C ₂₁ H ₃₆ N O ₅ S	414.23087	0.24	0.59	4.5
436.21323	C ₂₁ H ₃₅ N O ₅ Na S	436.21282	0.41	0.94	4.5





Spectrum



Elemental Composition

Parameters

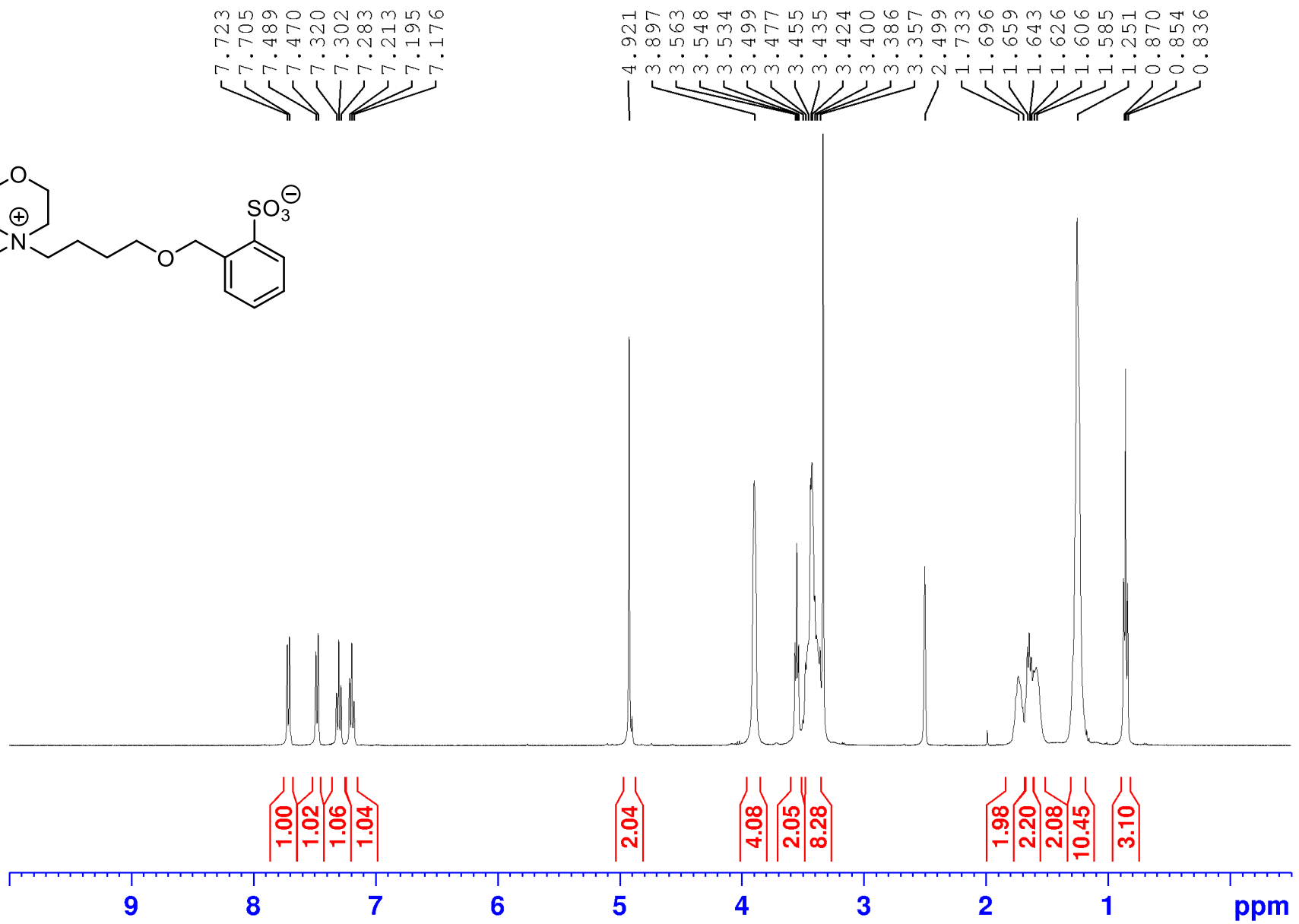
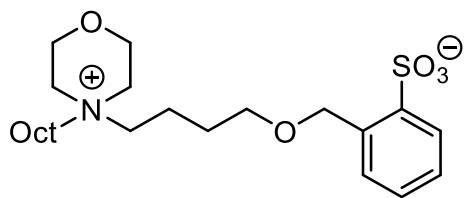
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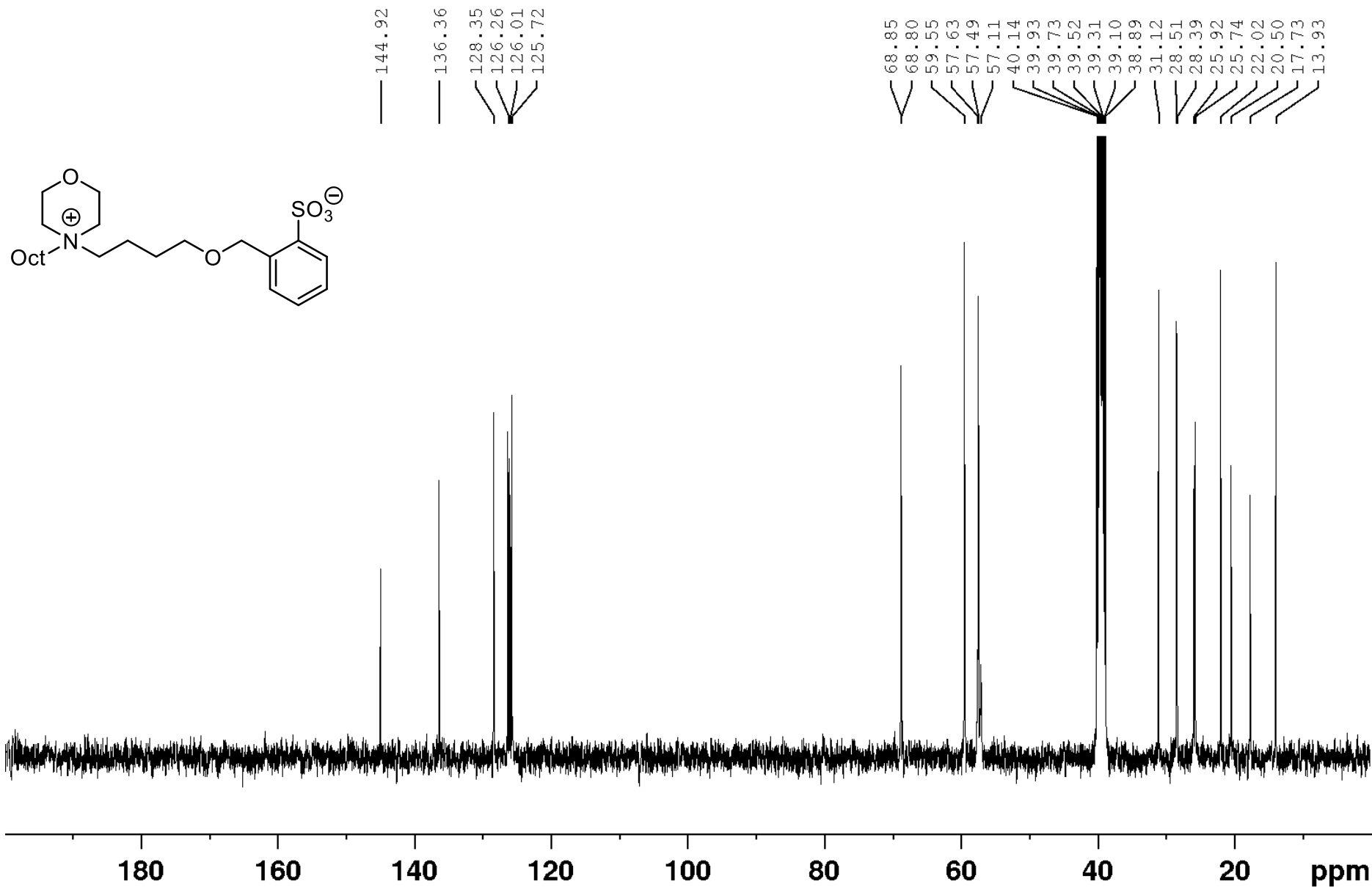
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Symbol	C	H	N	O	S	Na
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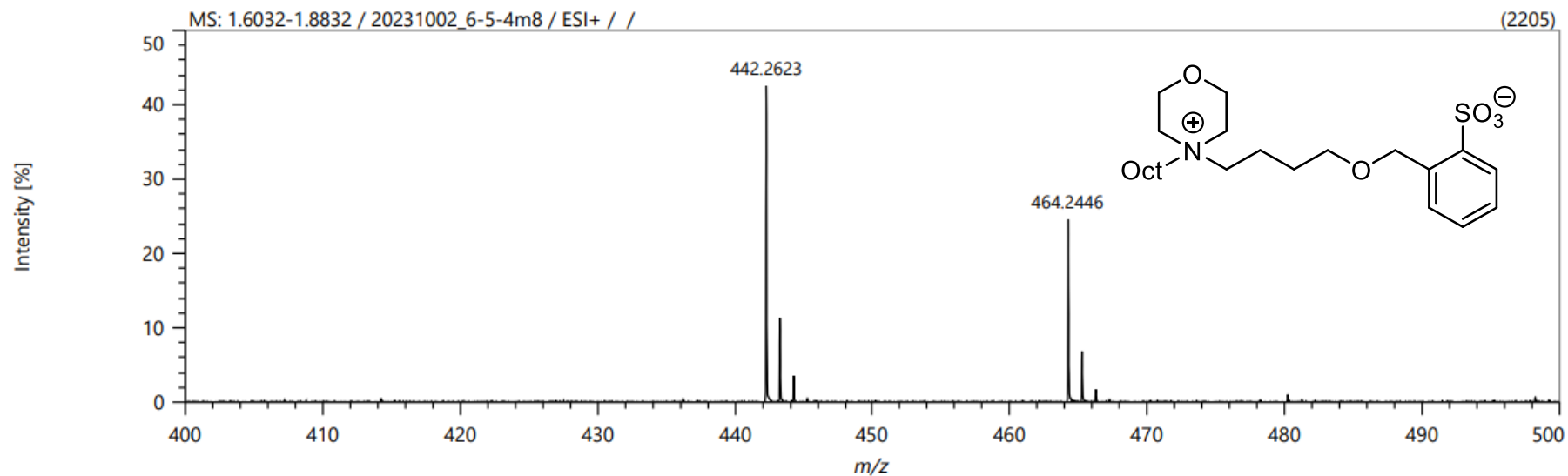
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
428.24570	C ₂₂ H ₃₈ N O ₅ S	428.24652	-0.82	-1.91	4.5
450.22784	C ₂₂ H ₃₇ N O ₅ Na S	450.22847	-0.62	-1.39	4.5





Spectrum



Elemental Composition

Parameters

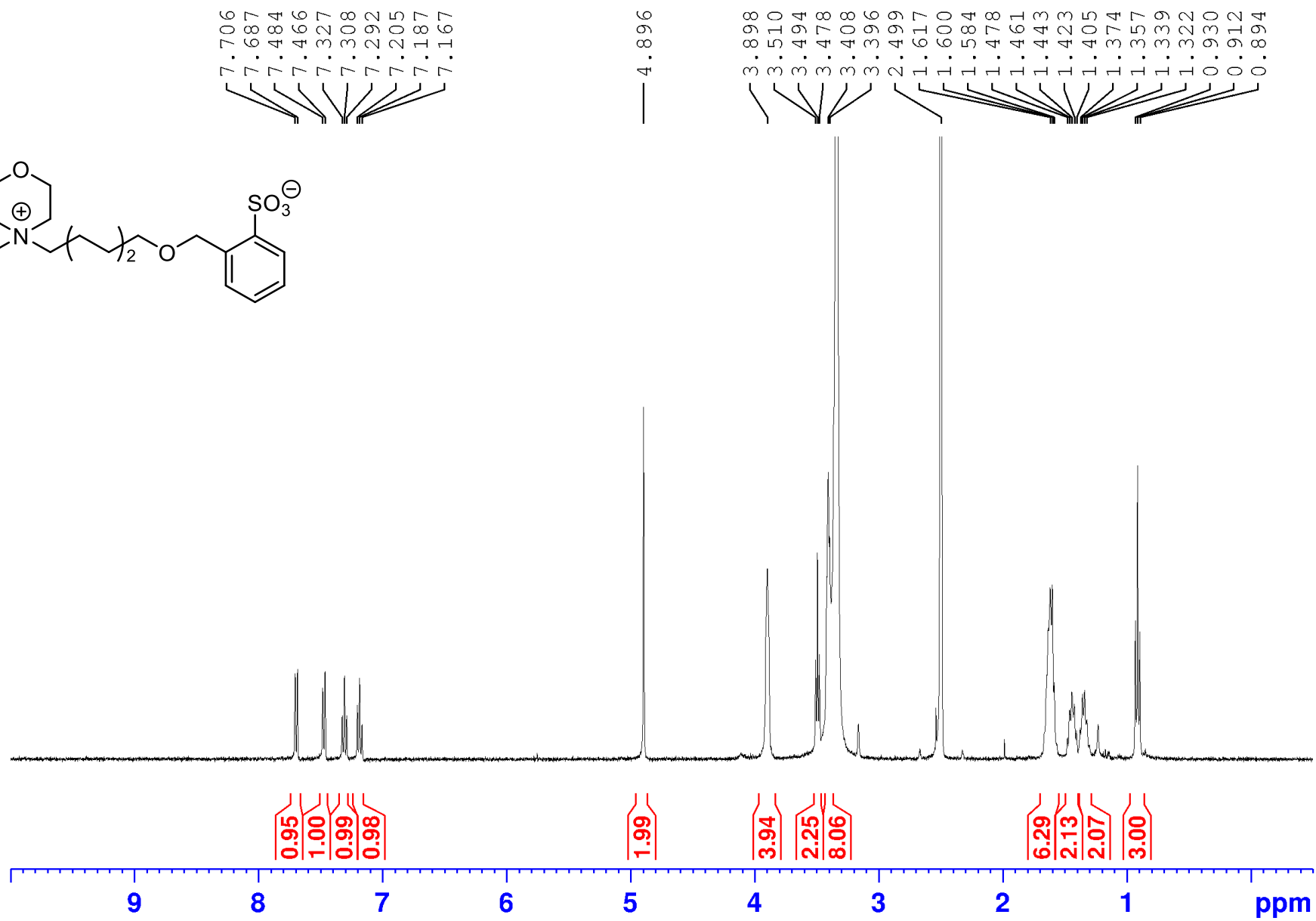
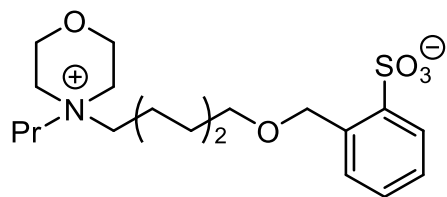
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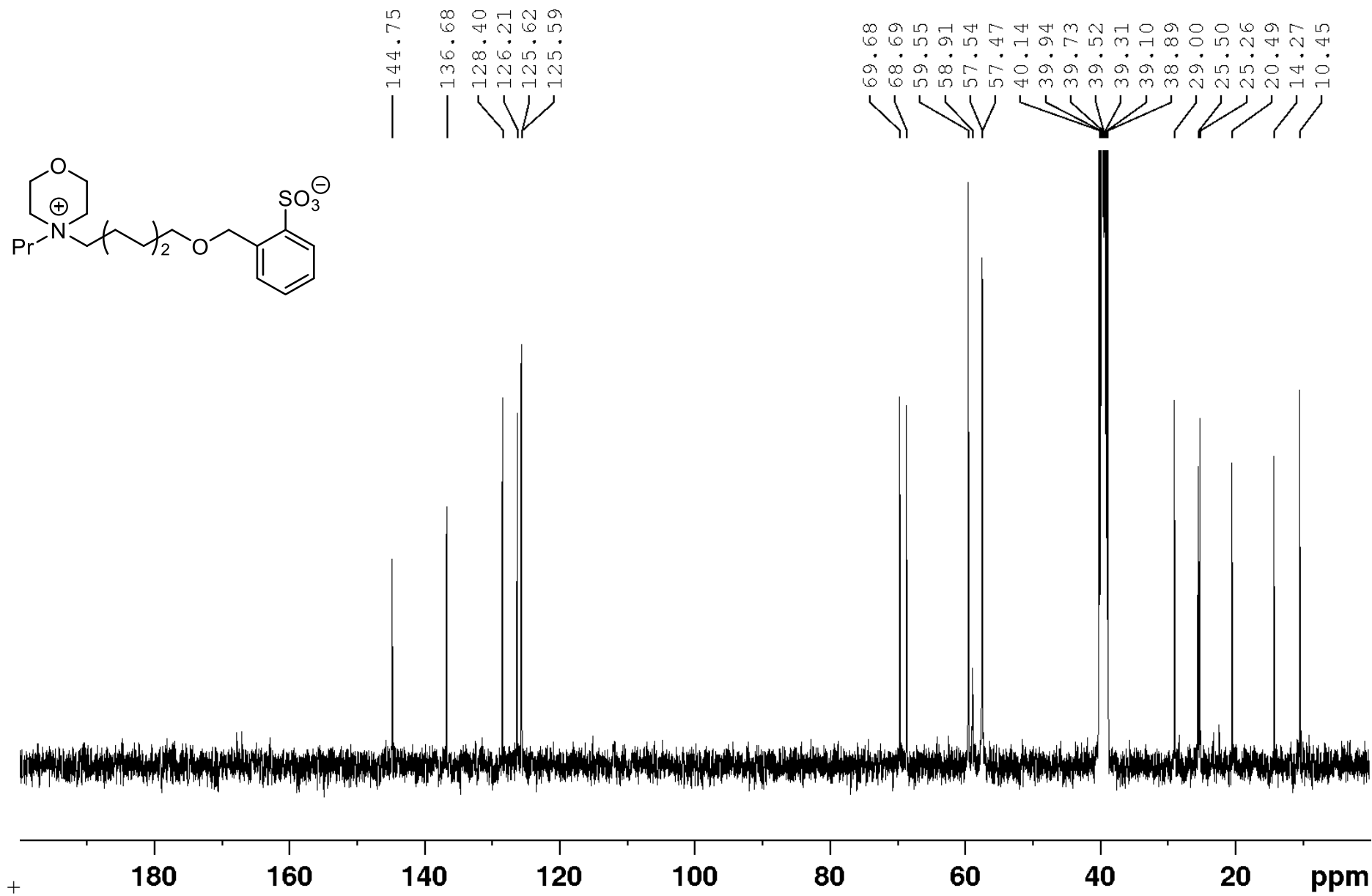
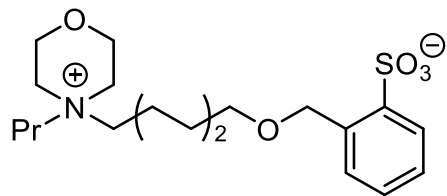
Elements Set 2:

Symbol	C	H	N	O	S	Na
Min	0	0	1	5	1	0
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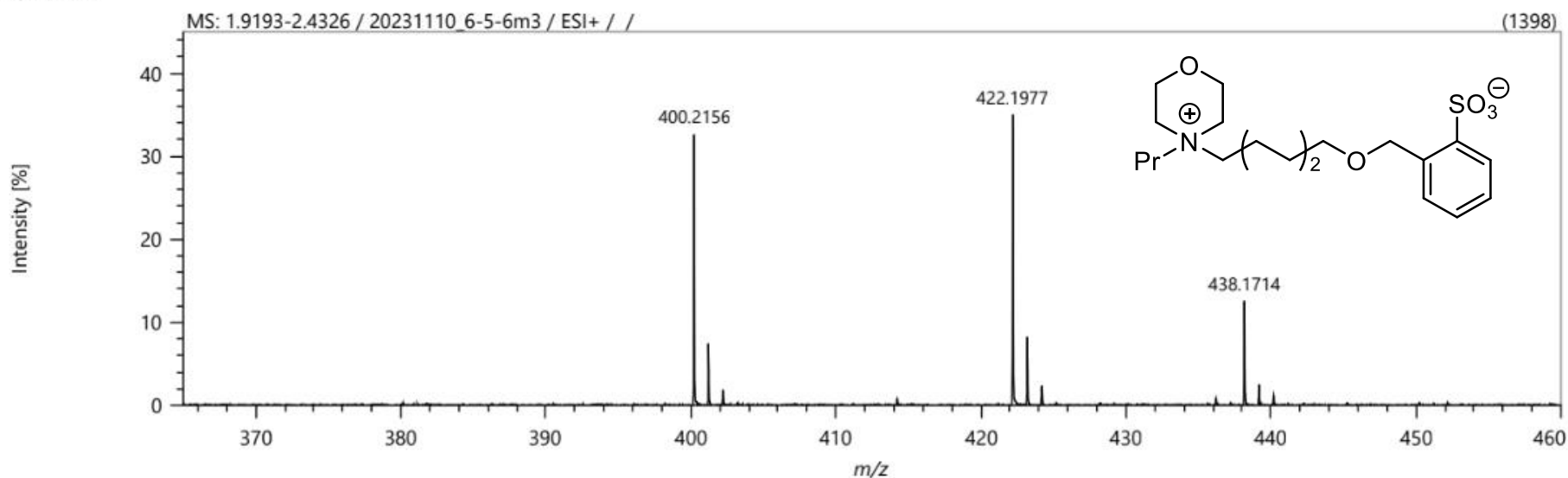
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
442.26232	C ₂₃ H ₄₀ N O ₅ S	442.26217	0.15	0.35	4.5
464.24461	C ₂₃ H ₃₉ N O ₅ Na S	464.24412	0.49	1.06	4.5





Spectrum



Elemental Composition

Parameters

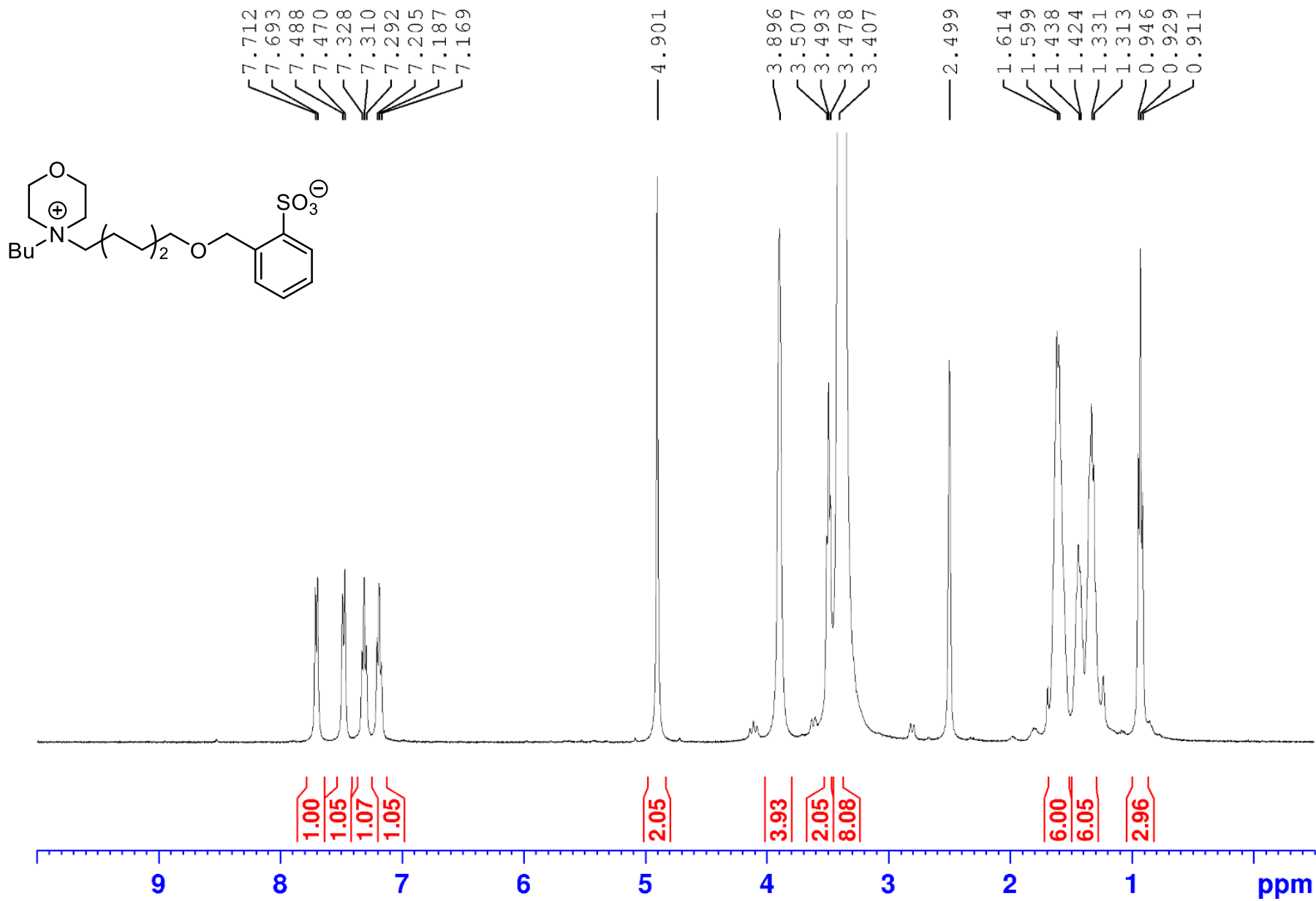
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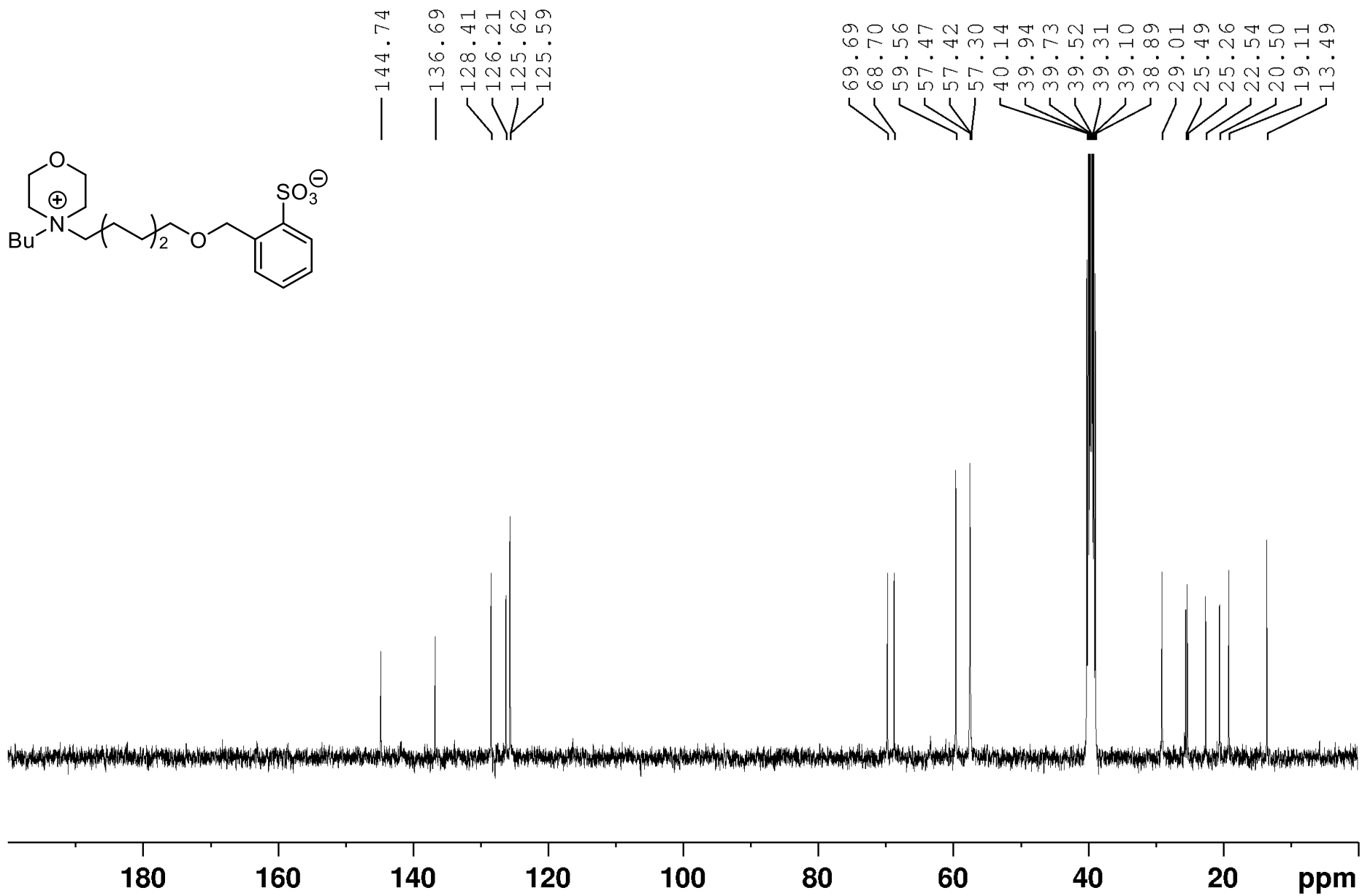
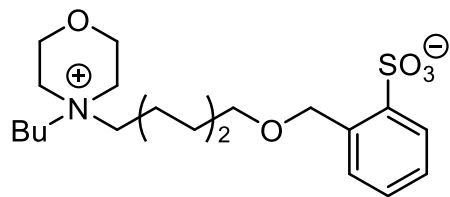
Elements Set 2:

Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

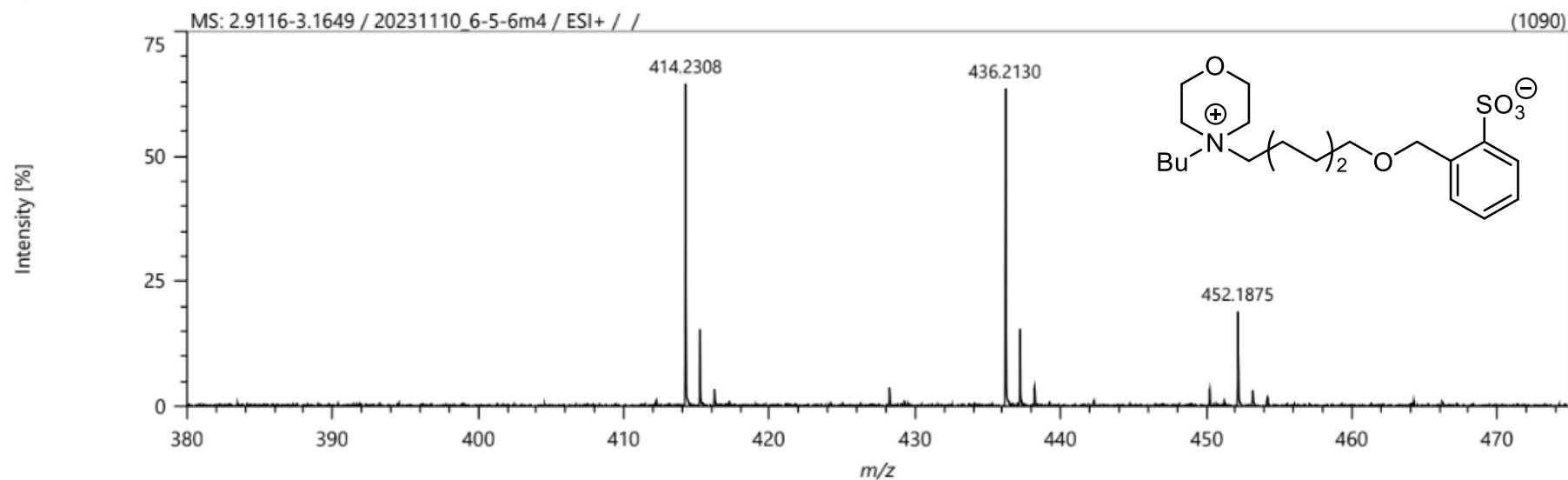
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
400.21559	C ₂₀ H ₃₄ N O ₅ S	400.21522	0.37	0.92	4.5
422.19774	C ₂₀ H ₃₃ N O ₅ Na S	422.19716	0.58	1.37	4.5
438.17141	C ₂₀ H ₃₃ N O ₅ S K	438.17110	0.31	0.70	4.5





Spectrum



Elemental Composition

Parameters

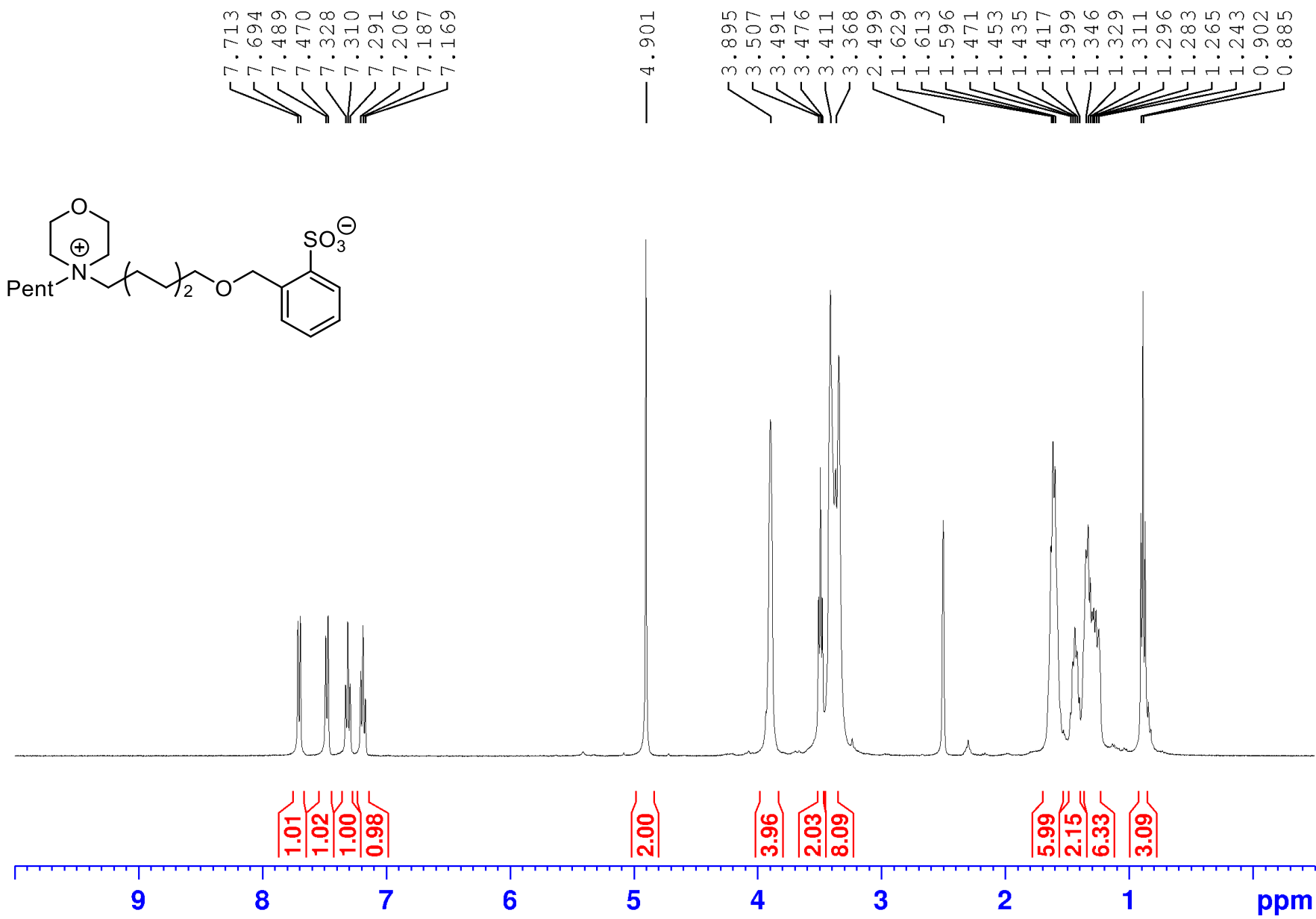
Tolerance: ± 2.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

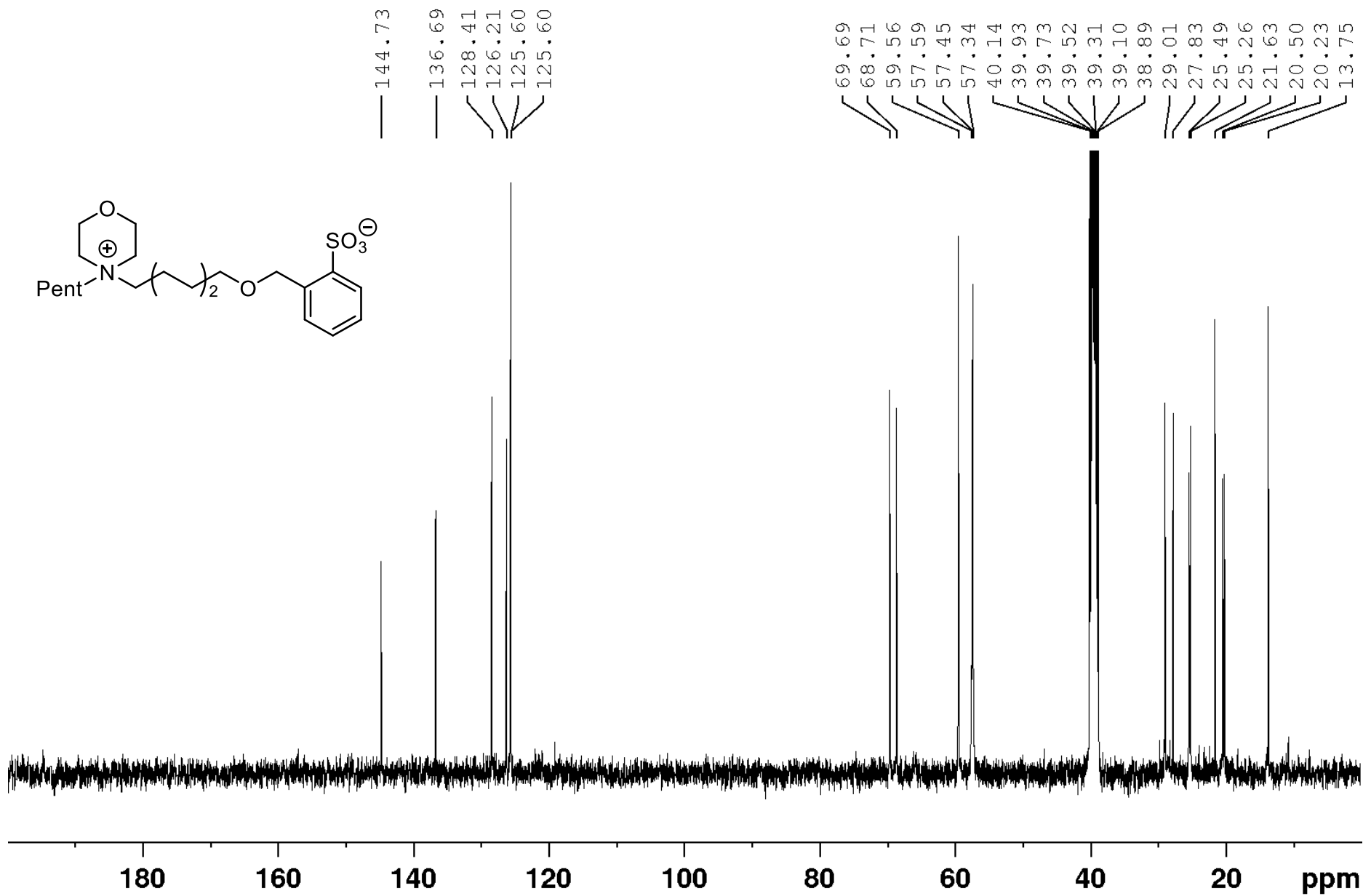
Elements Set 2:

Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

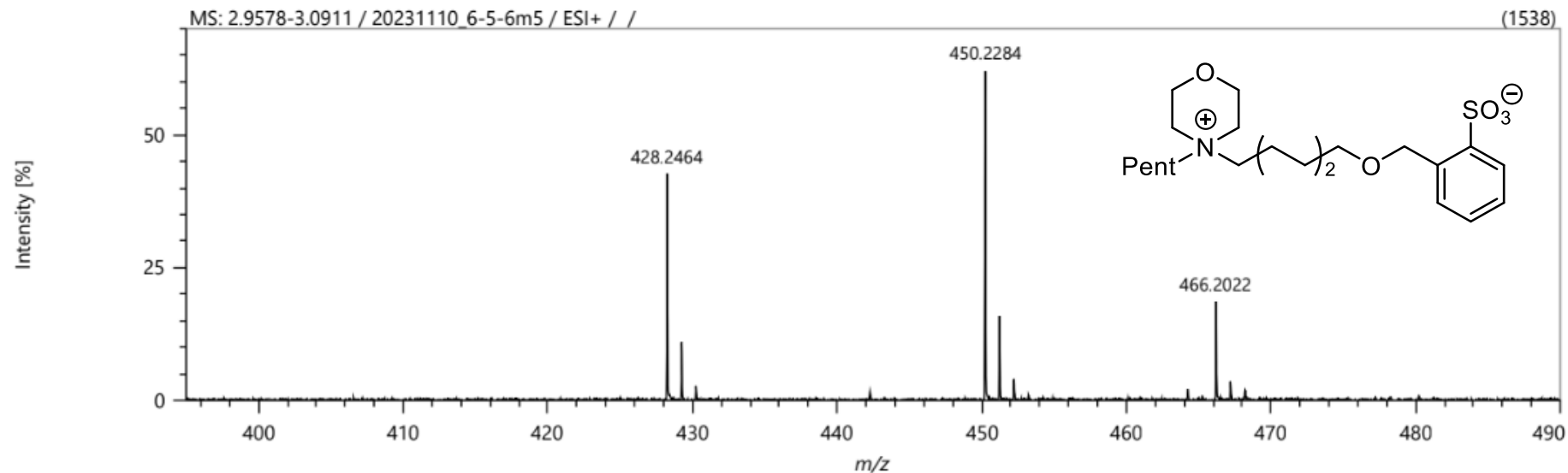
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
414.23079	C ₂₁ H ₃₆ N O ₅ S	414.23087	-0.08	-0.20	4.5
436.21299	C ₂₁ H ₃₅ N O ₅ Na S	436.21282	0.17	0.40	4.5
452.18747	C ₂₁ H ₃₅ N O ₅ S K	452.18675	0.72	1.59	4.5





Spectrum



Elemental Composition

Parameters

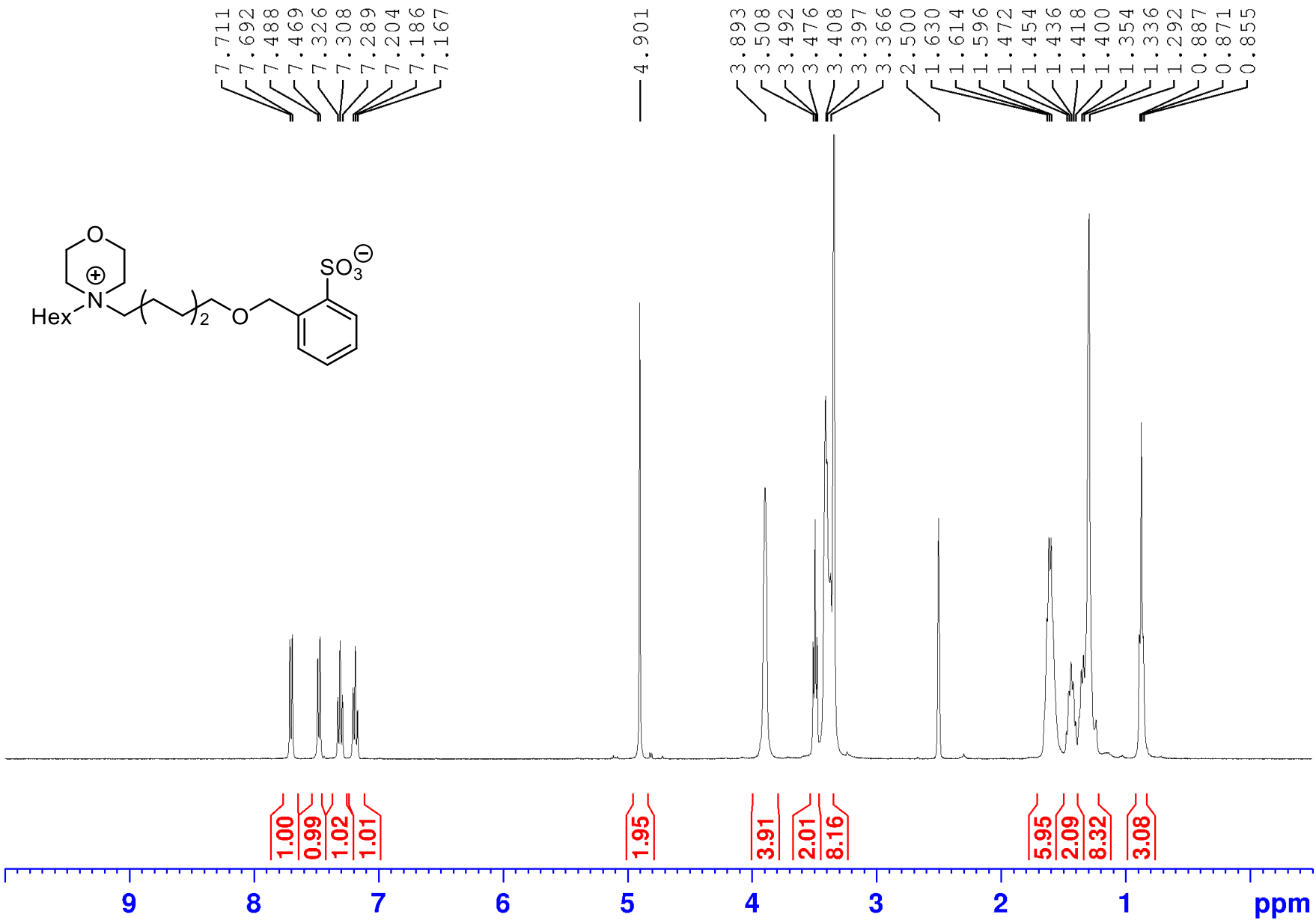
Tolerance: ±2.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

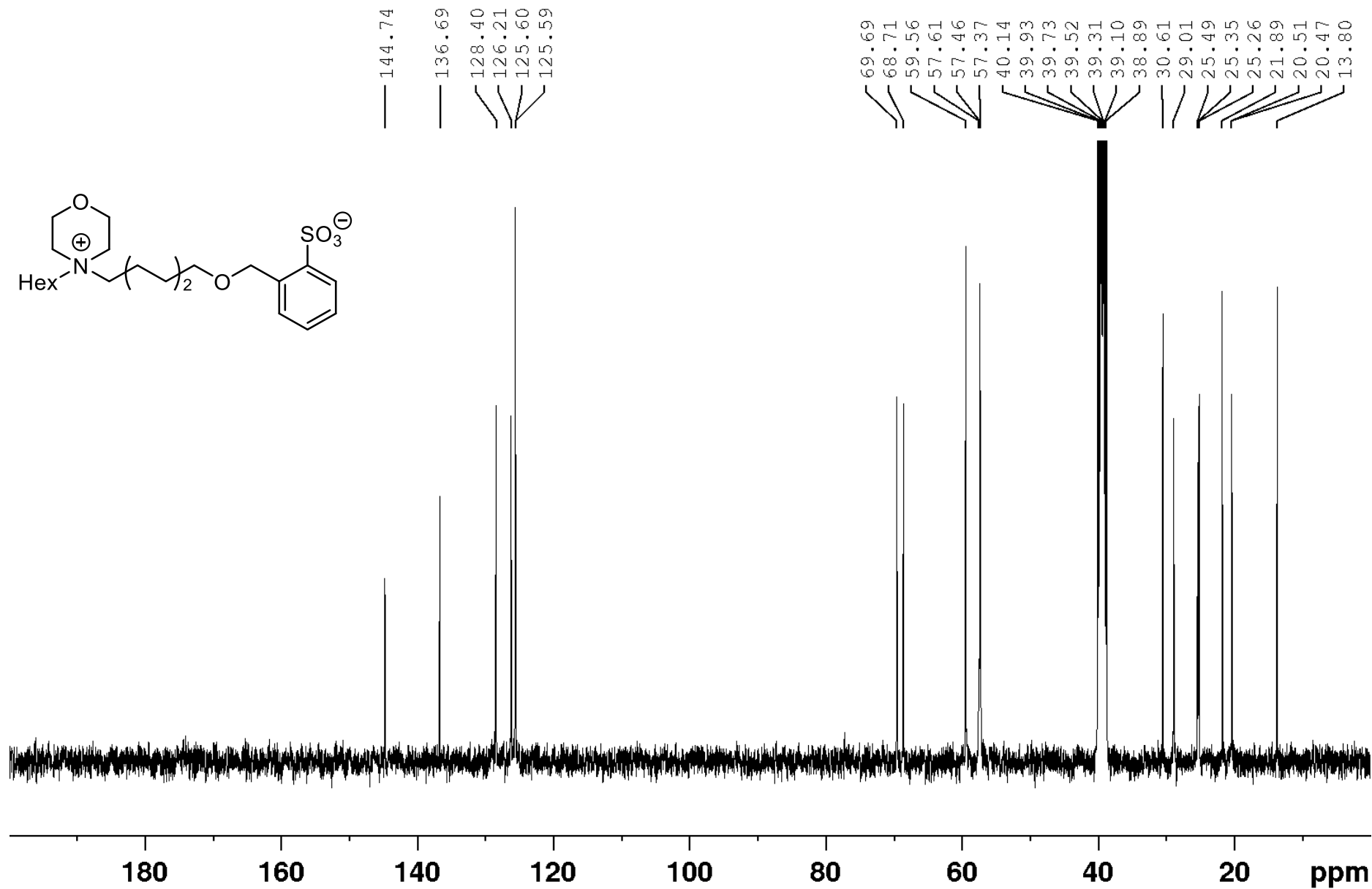
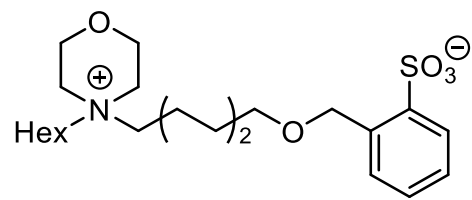
Elements Set 2:

Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

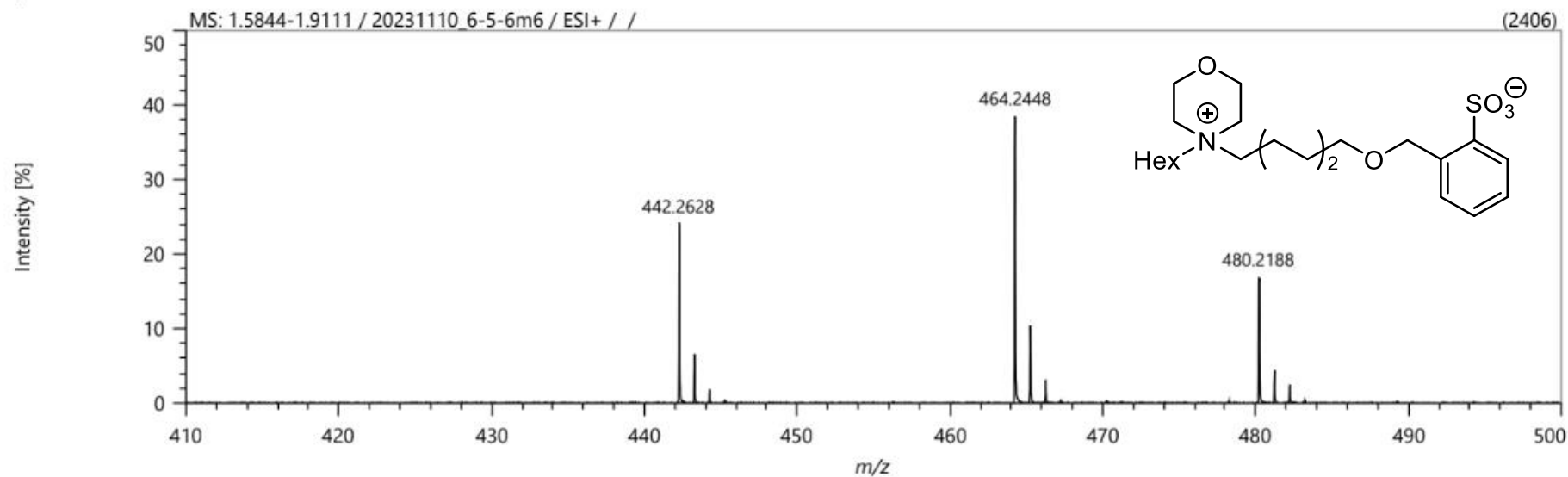
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
428.24638	C ₂₂ H ₃₈ N O ₅ S	428.24652	-0.14	-0.32	4.5
450.22842	C ₂₂ H ₃₇ N O ₅ Na S	450.22847	-0.05	-0.10	4.5
466.20221	C ₂₂ H ₃₇ N O ₅ S K	466.20240	-0.19	-0.40	4.5





Spectrum



Elemental Composition

Parameters

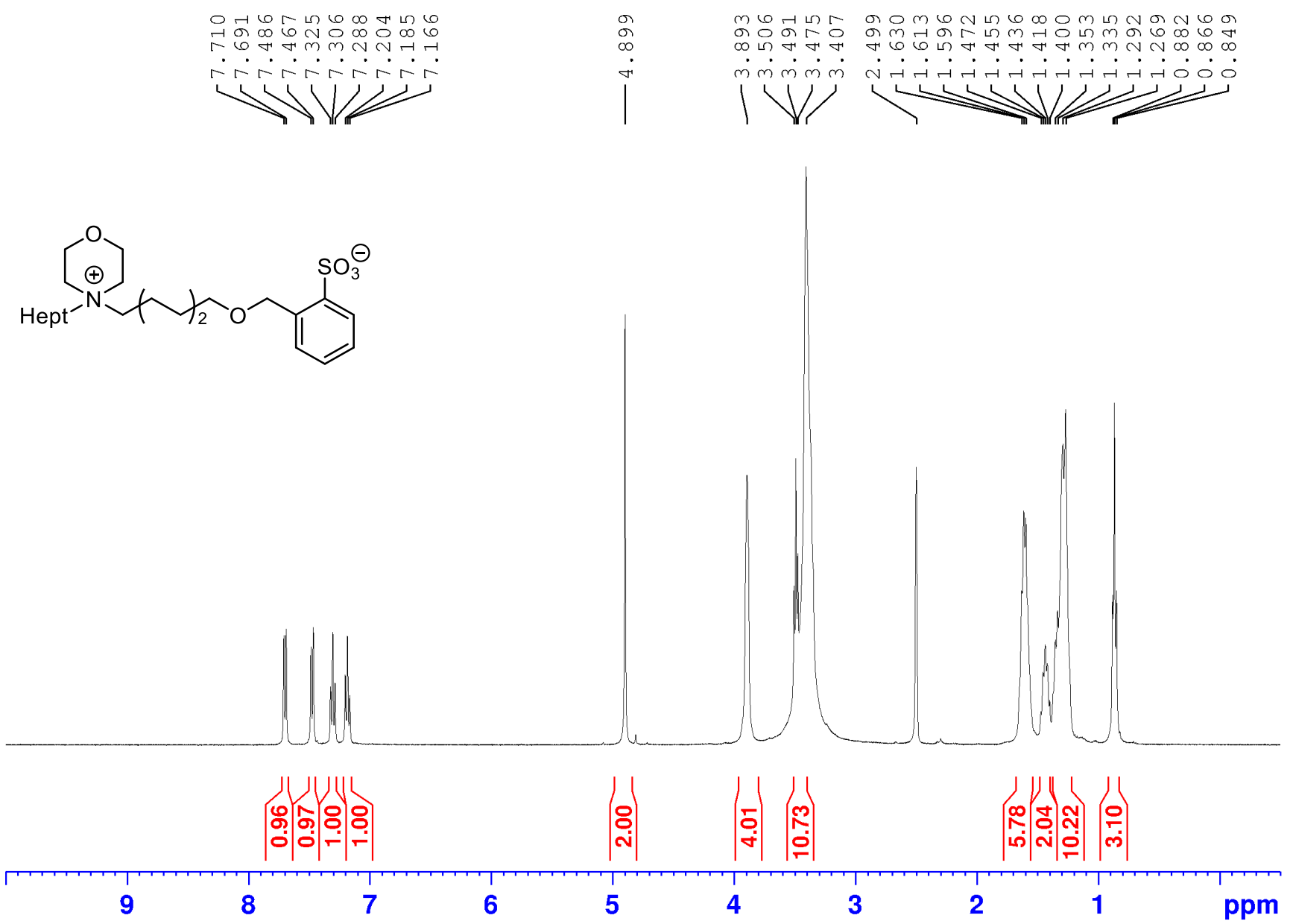
Tolerance: ± 2.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

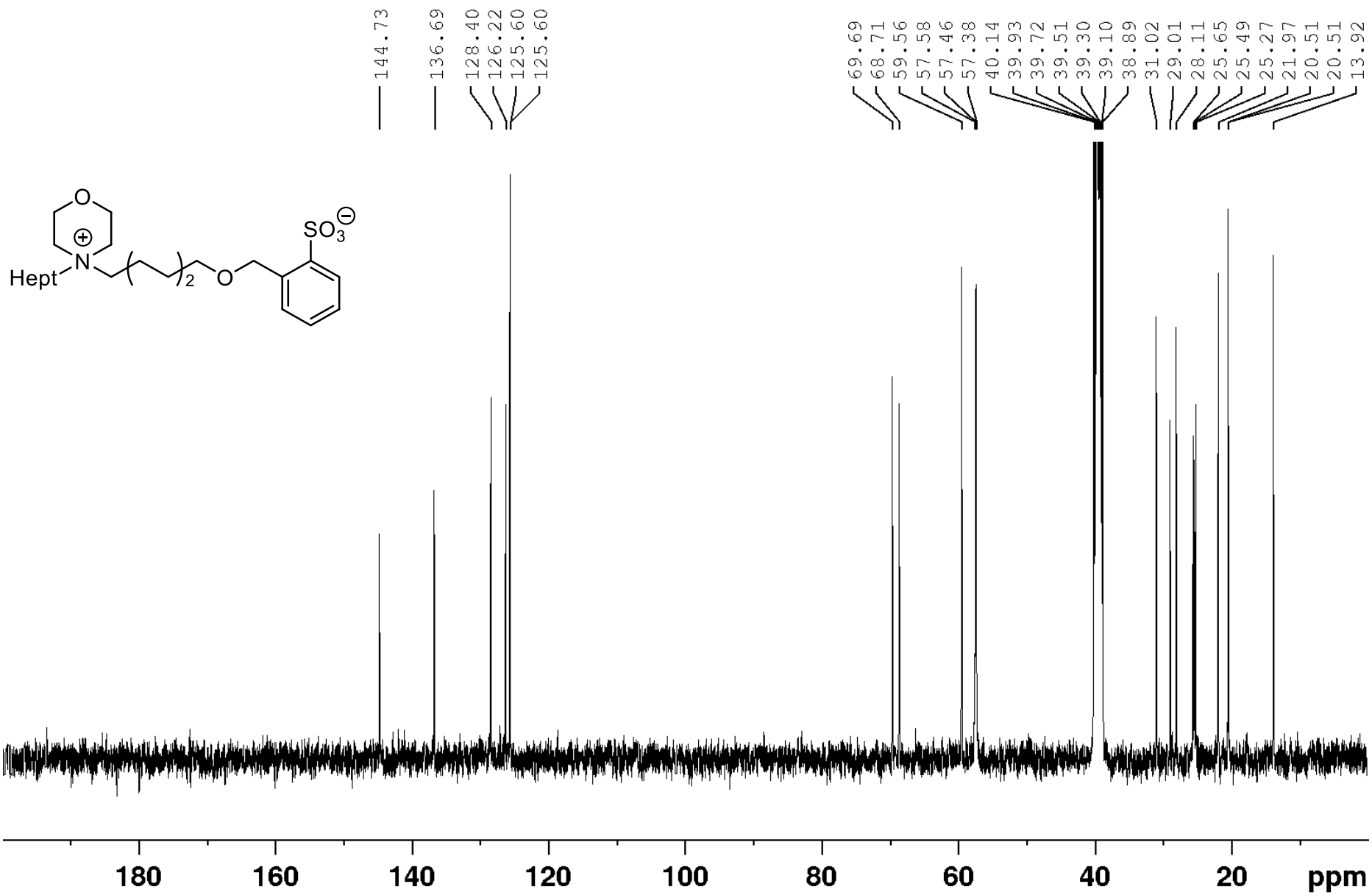
Elements Set 2:

Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

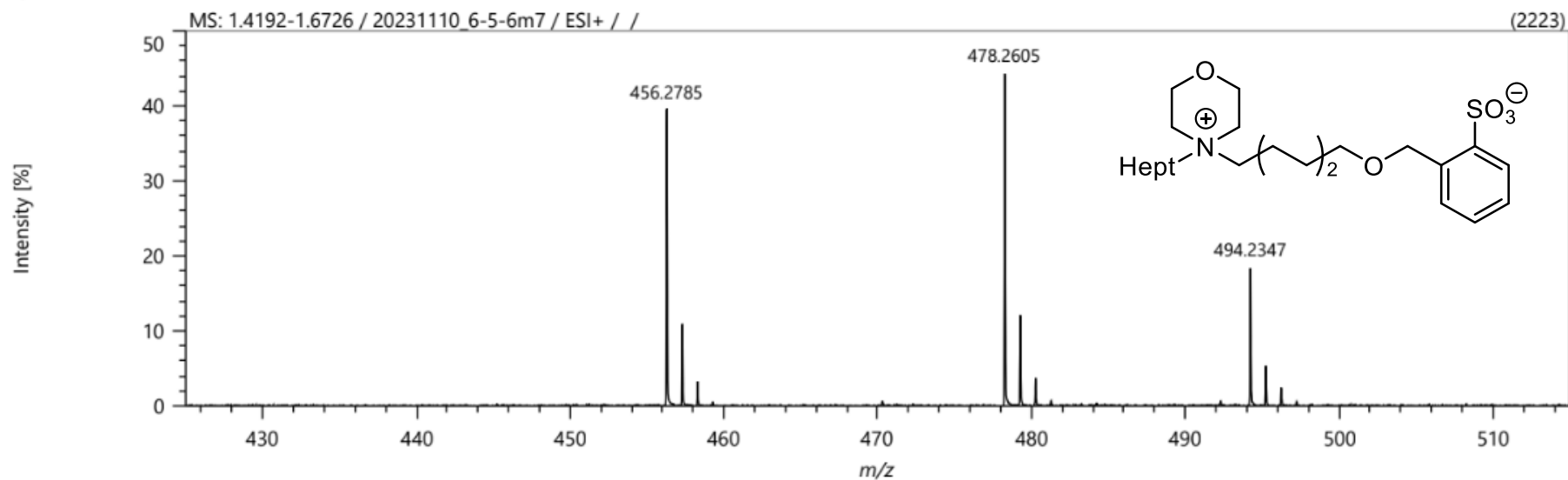
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
442.26278	C ₂₃ H ₄₀ N O ₅ S	442.26217	0.61	1.38	4.5
464.24478	C ₂₃ H ₃₉ N O ₅ Na S	464.24412	0.67	1.44	4.5
480.21876	C ₂₃ H ₃₉ N O ₅ S K	480.21805	0.70	1.47	4.5





Spectrum



Elemental Composition

Parameters

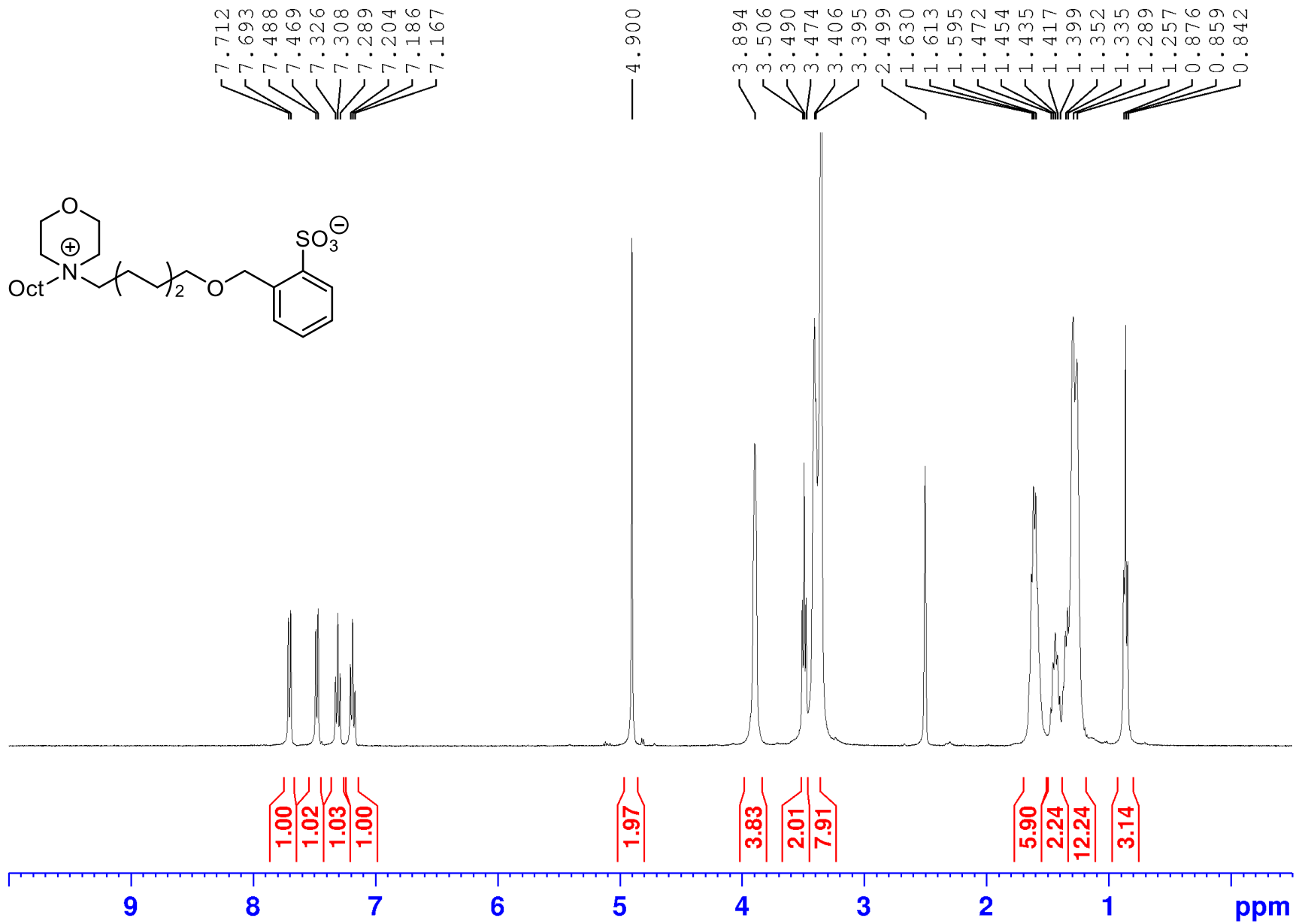
Tolerance: ±2.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

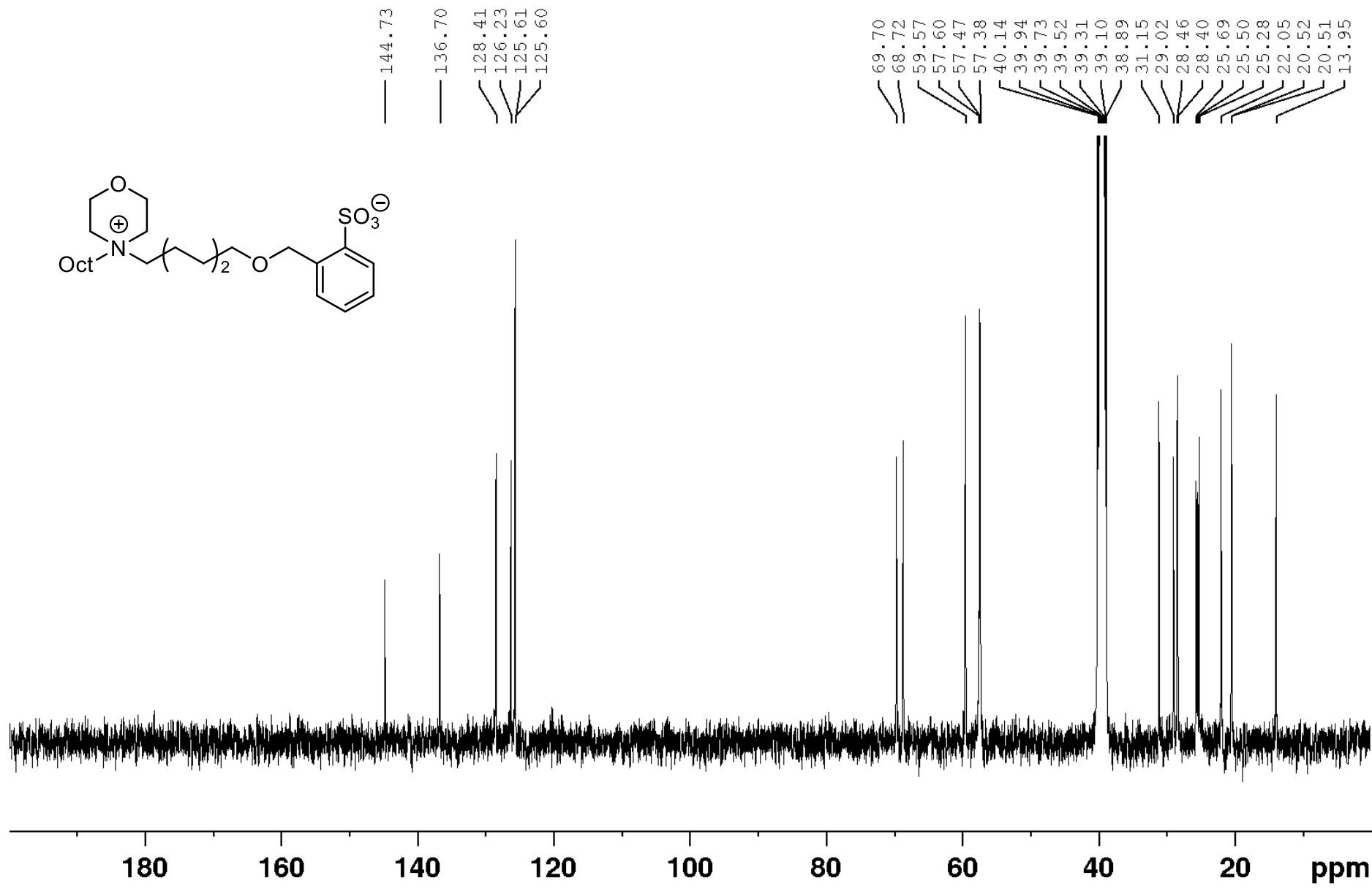
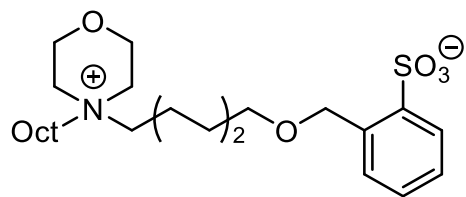
Elements Set 2:

Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

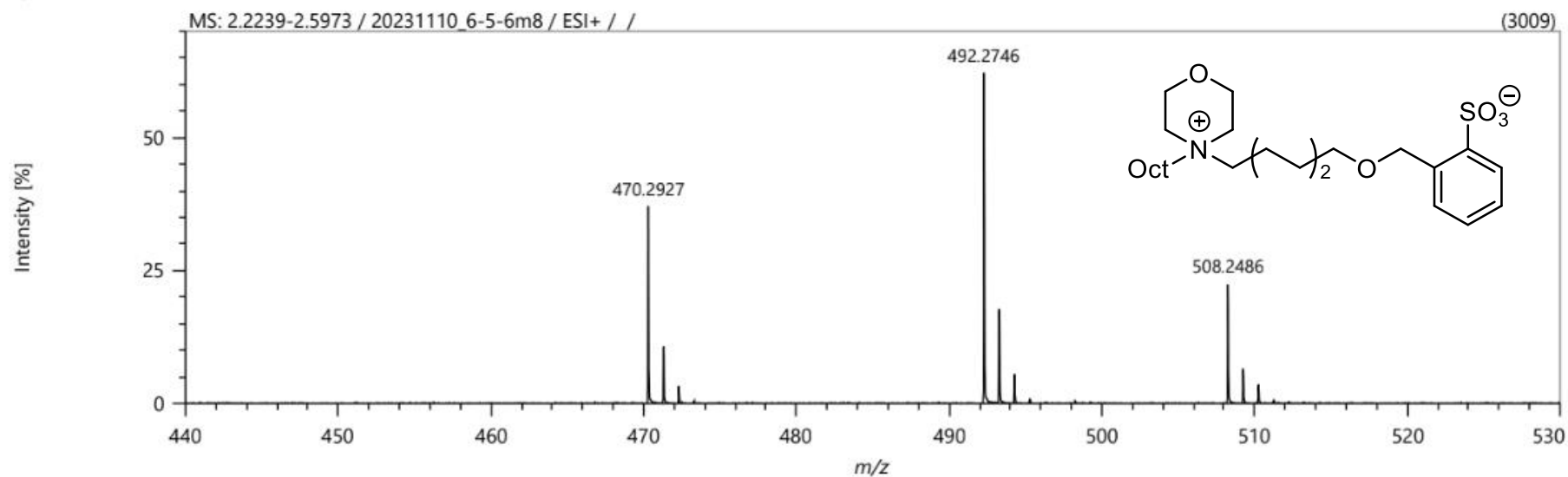
Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
456.27855	C ₂₄ H ₄₂ N O ₅ S	456.27782	0.73	1.60	4.5
478.26047	C ₂₄ H ₄₁ N O ₅ Na S	478.25977	0.71	1.48	4.5
494.23468	C ₂₄ H ₄₁ N O ₅ S K	494.23370	0.98	1.97	4.5





Spectrum



Elemental Composition

Parameters

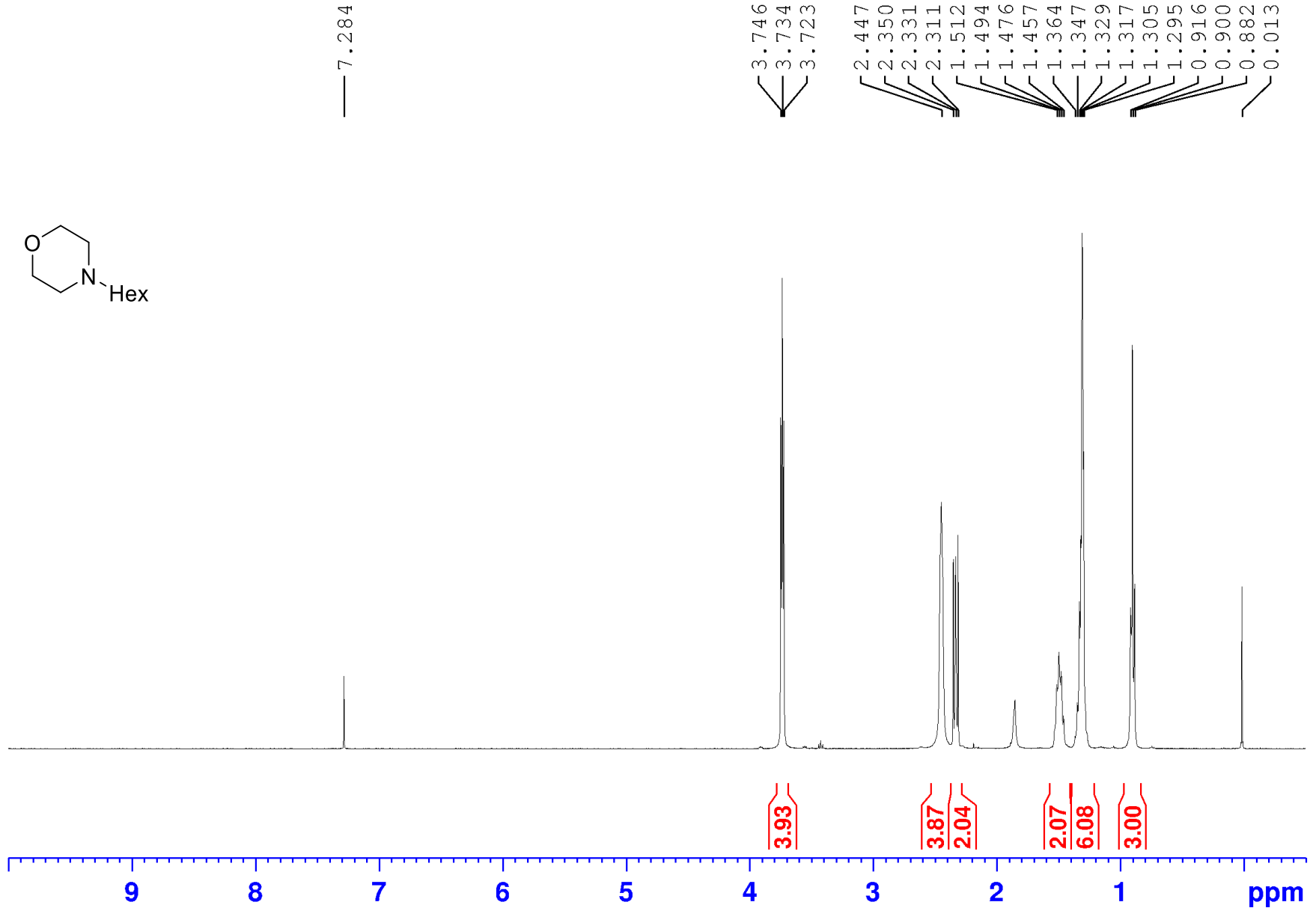
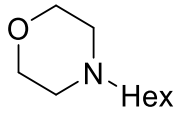
Tolerance: ±2.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

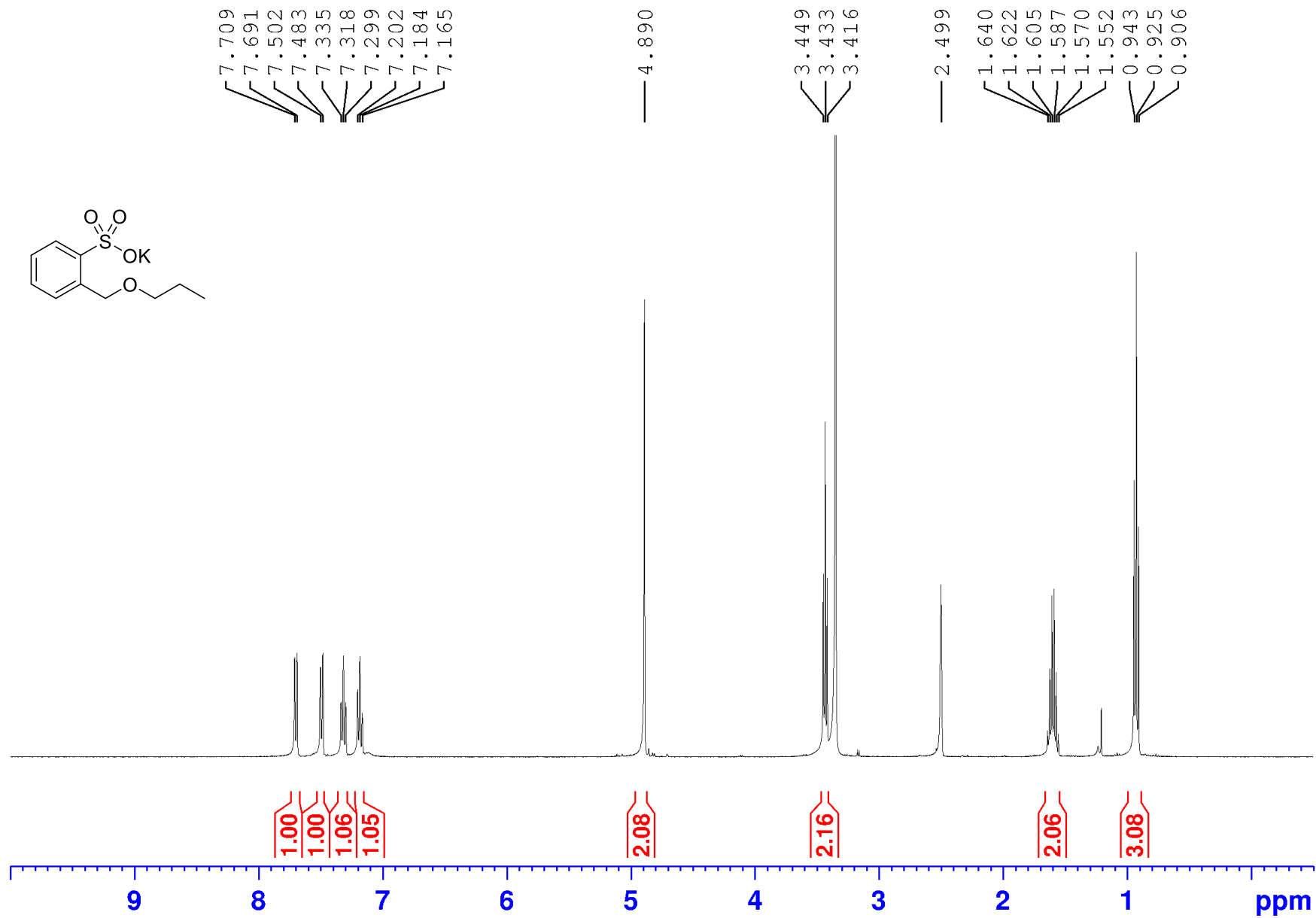
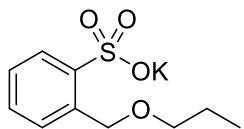
Elements Set 2:

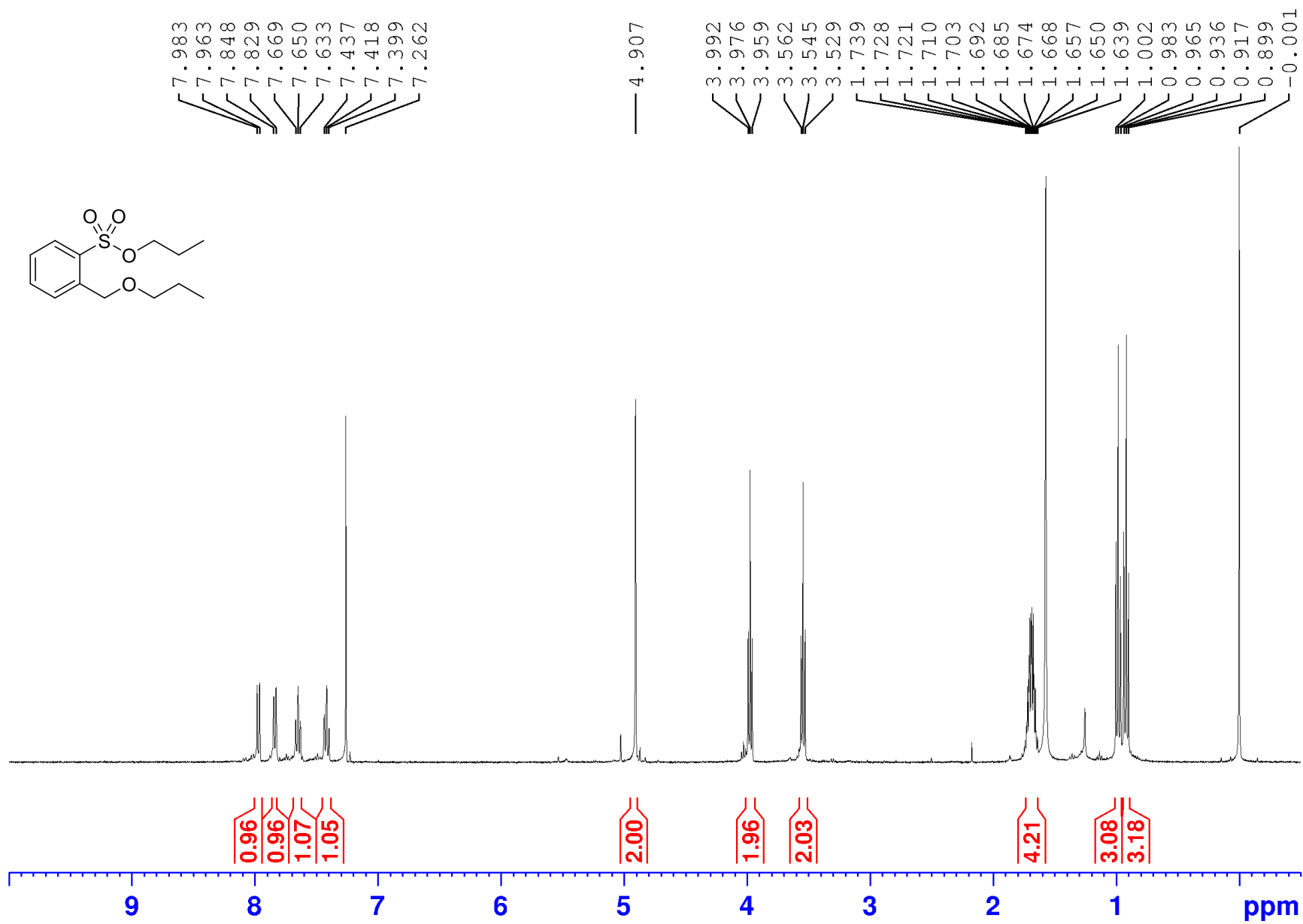
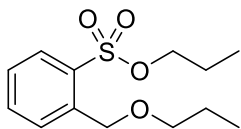
Symbol	C	H	O	N	S	Na	K
Min	0	0	5	1	1	0	0
Max	400	1000	5	1	1	1	1

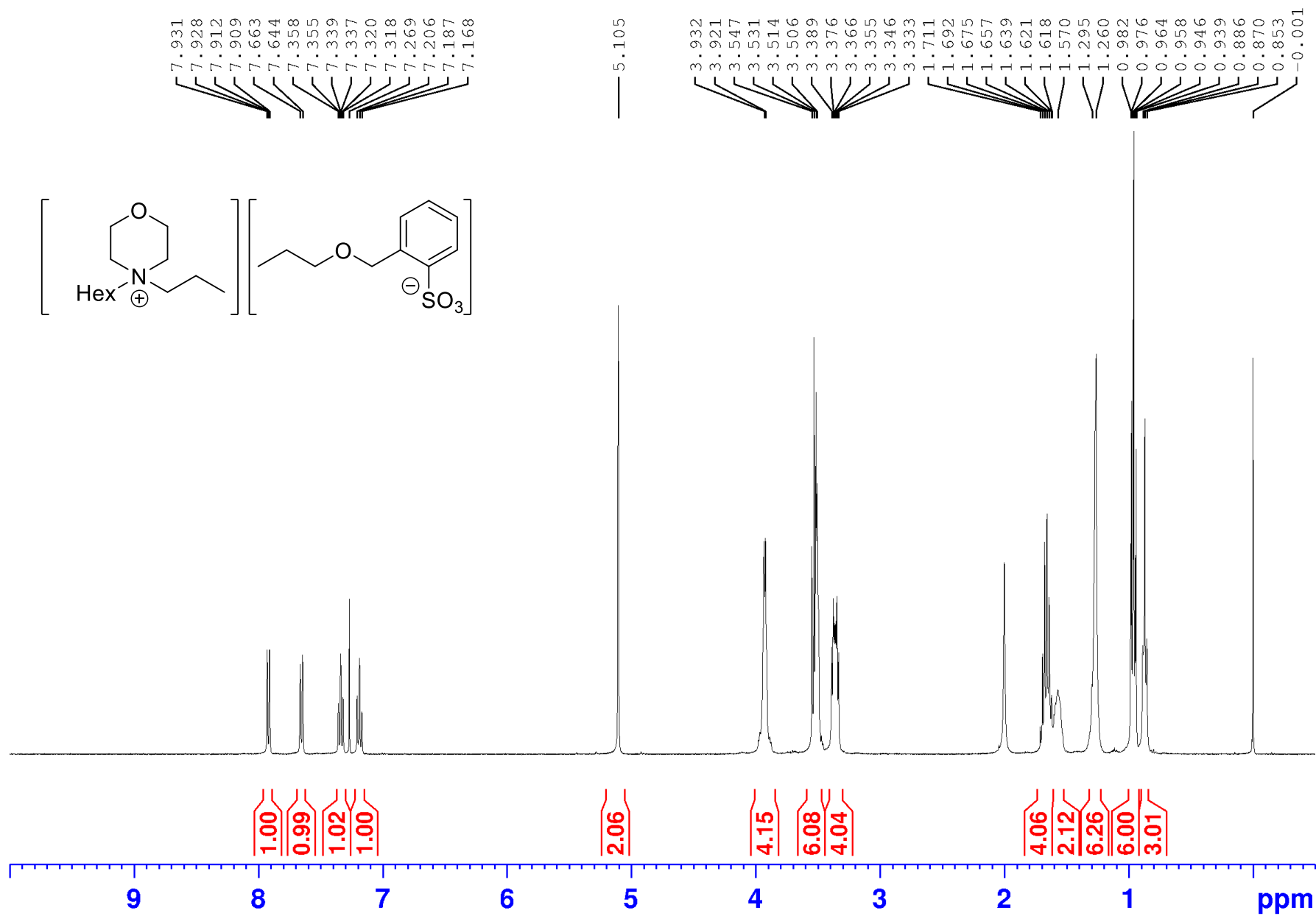
Results

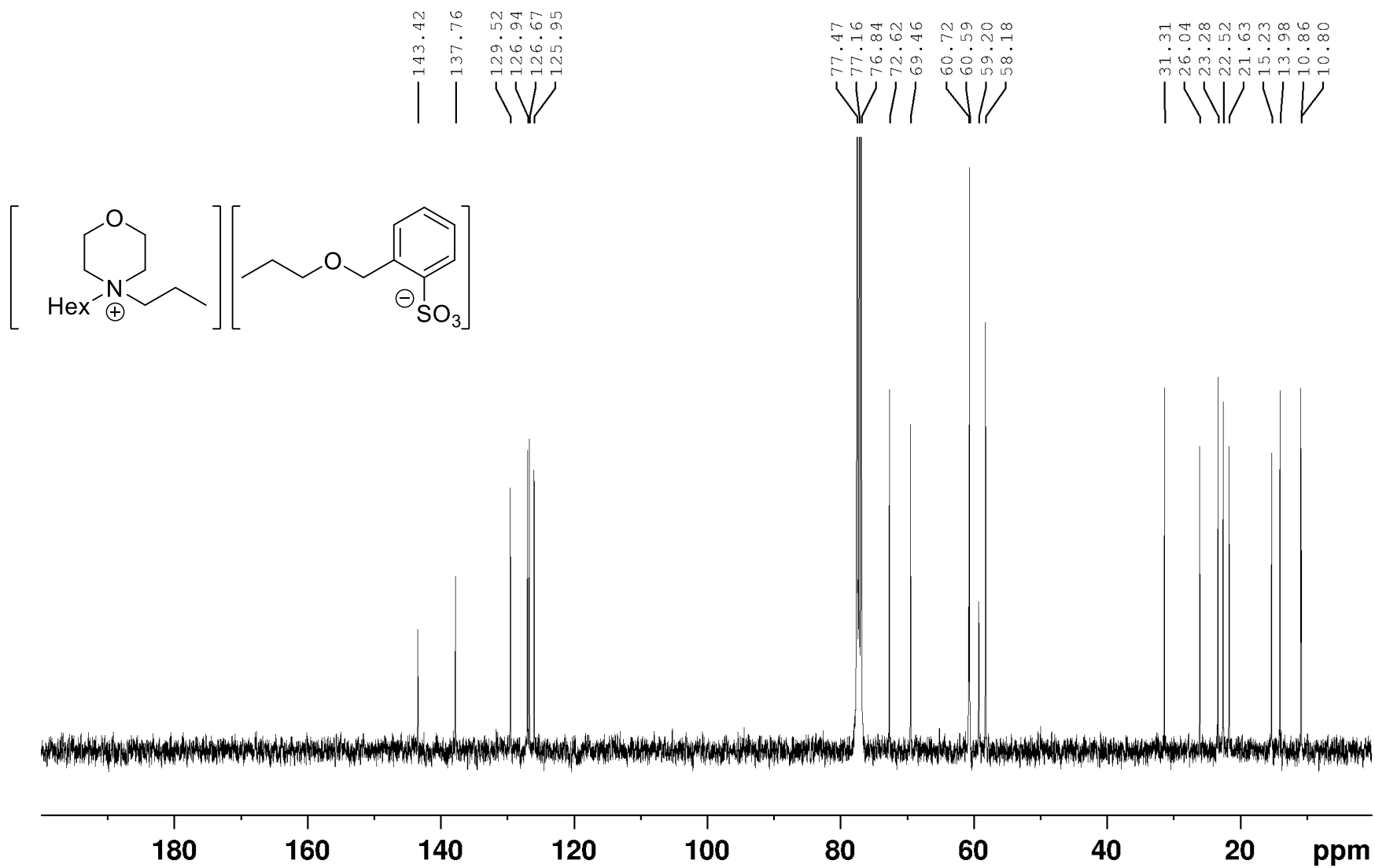
Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
470.29273	C ₂₅ H ₄₄ N O ₅ S	470.29347	-0.74	-1.57	4.5
492.27463	C ₂₅ H ₄₃ N O ₅ Na S	492.27542	-0.79	-1.60	4.5
508.24858	C ₂₅ H ₄₃ N O ₅ S K	508.24935	-0.77	-1.52	4.5



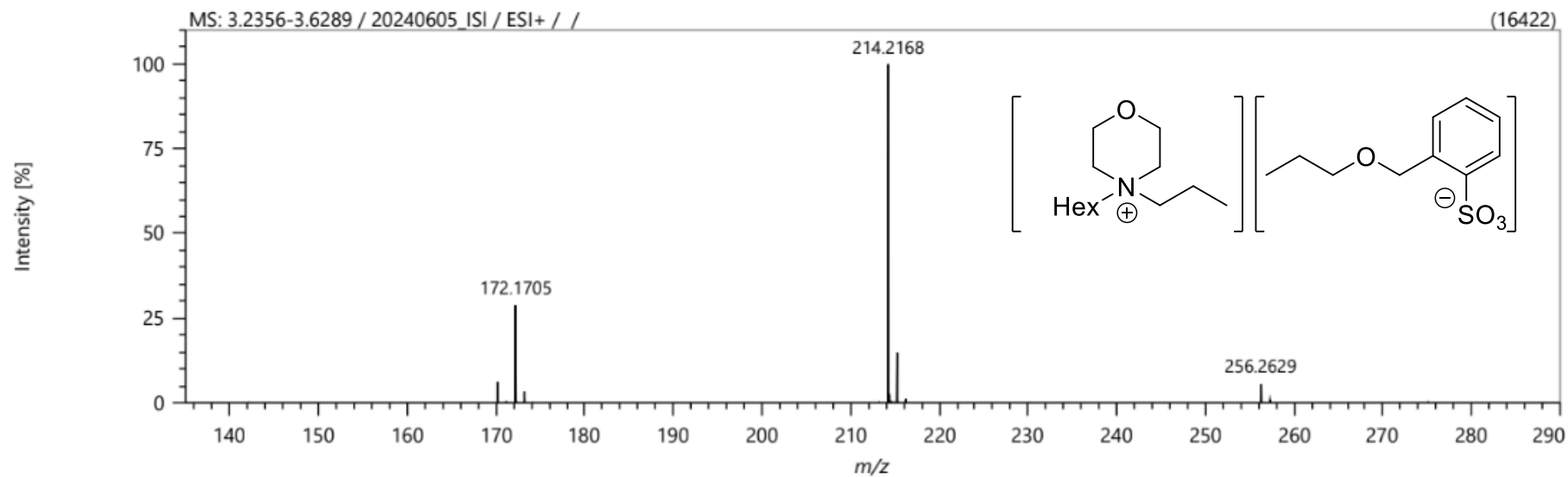








Spectrum



Elemental Composition

Parameters

Tolerance: ± 10.00 ppm
 Electron: Odd/Even
 Charge: +1
 DBE: -99.0 - 999.0

Elements Set 2:

Symbol	C	H	O	N
Min	0	0	1	1
Max	400	1000	1	1

Results

Mass	Formula	Calculated Mass	Mass Difference [mDa]	Mass Difference [ppm]	DBE
214.21678	C ₁₃ H ₂₈ N O	214.21654	0.24	1.13	0.5

