Electronic Supplementary Information

for

Azetidines-derived dinuclear zinc catalyzed asymmetric phospha-Michael addition of dialkyl phosphite to α,β-unsaturated carbonyl compounds

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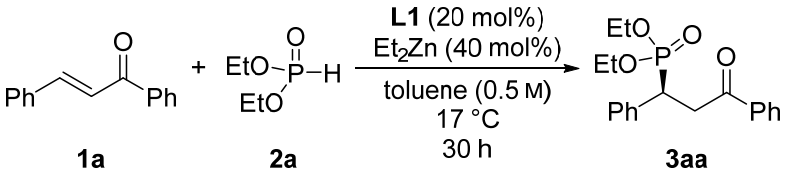
1. Materials

L1–**L4** were synthesized according to literature procedures respectively.[1] Diethylzinc was prepared from EtI with Zn and then diluted with toluene to 1.0 mol/L. Diethyl phsophite and dimethyl phosphite were purchased from *Alfa Aesar* or *TCI*. Chalcone and its deravitives were synthesized according to literature procedures.[2] α,β-Unsaturated acylpyrroles were prepared according to the known method.[3] All the racemic *γ*-oxo phosphonates were obtained according to literature procedure.[4]

2. Non-linear Effects Experiments

Table S1. Non-linear effects experiments



1a **2a** **3aa**

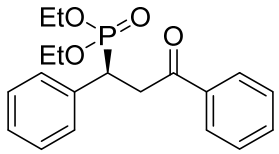
Entry	*ee* of **L1** (%)	Yield (%)	*ee* of product (%)
1	0	72	0
2	20	68	33
3	40	69	58
4	60	59	87
5	80	62	94
6	100	63	96

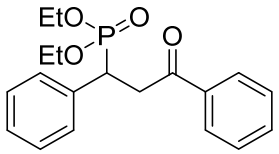
[a] Reaction conditions: **1a** (0.5 mmol), **2a** (2.0 equiv), **L1** (20 mol%), Et_2Zn (40 mol%) in toluene. All reactions were processed under argon for indicated reaction time. Isolated yield reported. The *ee* values were determined by HPLC analysis. In all cases, the product chromatogram was compared against a known racemic mixture. The absolute configuration was assigned by comparison to literature values.

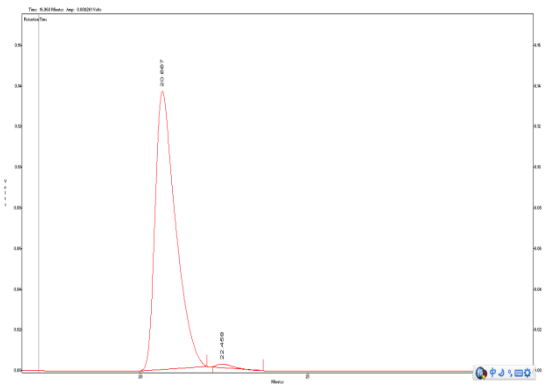
When nonenantiopure **L1** was employed as chiral ligand, there exhibited a positive non-linear effect. The phosphonate **3aa** was generated in 33% *ee* using 20% *ee* **L1** (Table S1). Using >60% *ee* **L1** provided moderate reactivity (nearly 60% yield) with high enantioselectivity (96% *ee*).

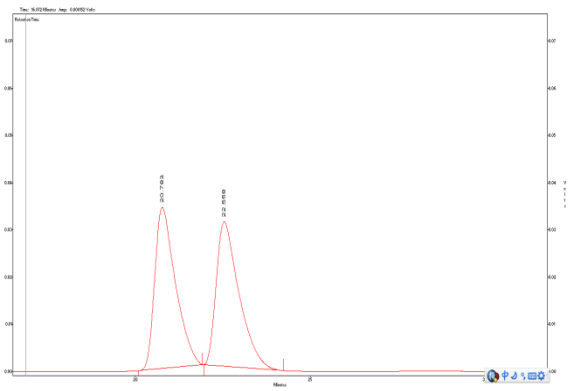
3. Chiral HPLC Spectra of the Phospha-Michael Addition Products

(*S*)-Diethyl 3-oxo-1,3-diphenylpropylphosphonate (**3aa**):



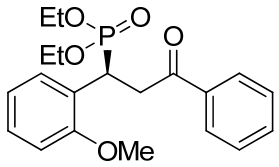


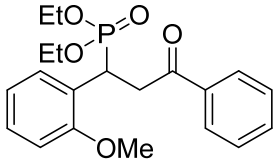


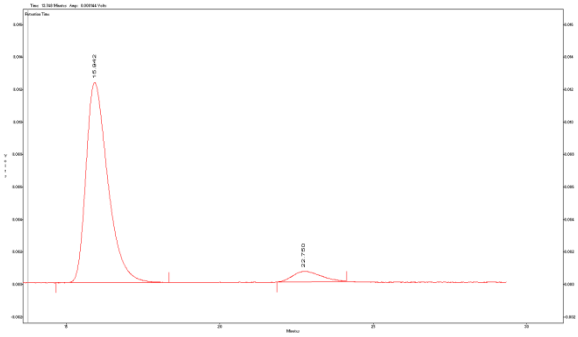


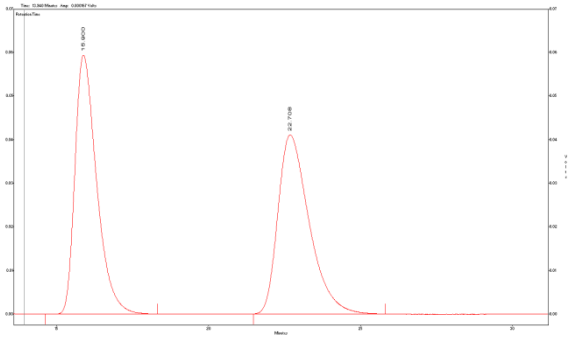
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
20.667	5815624	99.845	20.783	1409089	50.287
22.458	9022	0.155	22.558	1392997	49.713

(*S*)-Diethyl 1-(2-methoxyphenyl)-3-oxo-3-phenylpropylphosphonate (**3ba**):



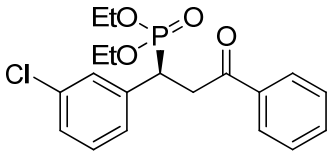


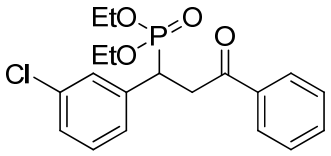


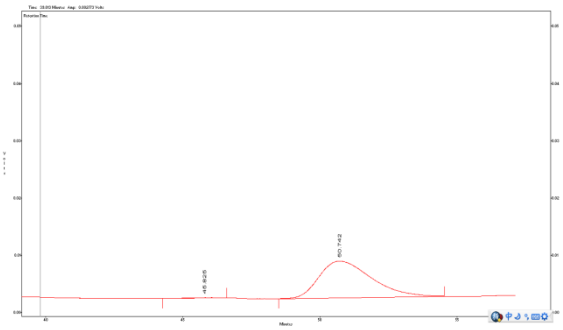


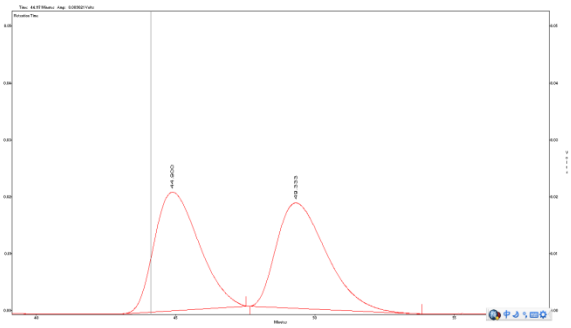
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
15.942	608045	93.515	15.900	2941298	50.062
22.750	42168	6.485	22.708	2934070	49.938

(*S*)-Diethyl 1-(3-chlorophenyl)-3-oxo-3-phenylpropylphosphonate (**3ca**):



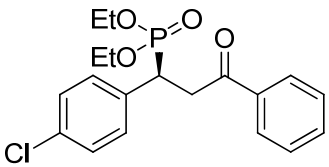


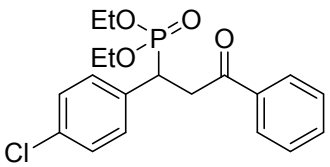


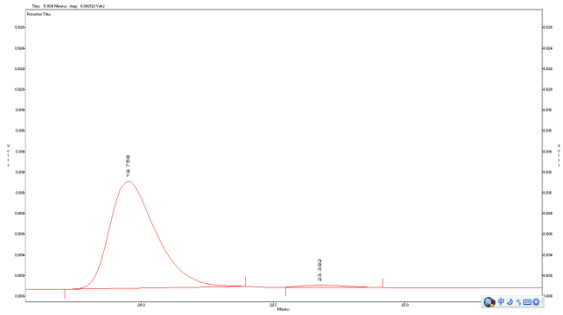


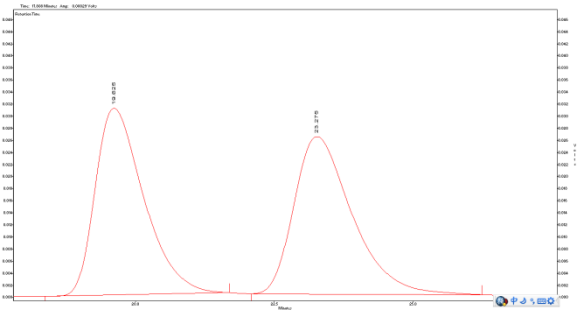
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
44.850	1015	0.123	44.900	2317268	50.061
50.742	824963	99.877	49.333	2311657	49.939

(*S*)-Diethyl 1-(4-chlorophenyl)-3-oxo-3-phenylpropylphosphonate (**3da**):



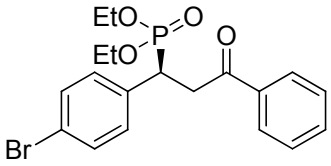


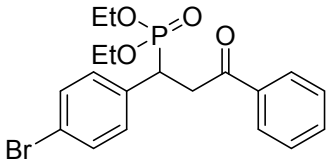


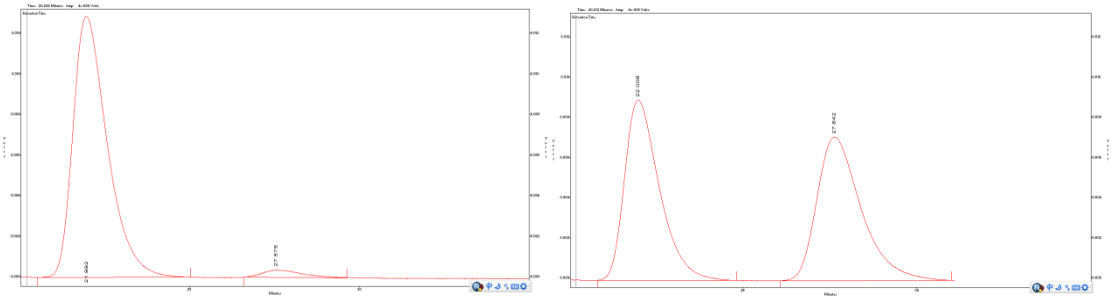


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
19.758	633486	98.694	19.625	1880888	49.808
23.392	8383	1.306	23.275	1895426	50.192

(*S*)-Diethyl 1-(4-bromophenyl)-3-oxo-3-phenylpropylphosphonate (**3ea**):

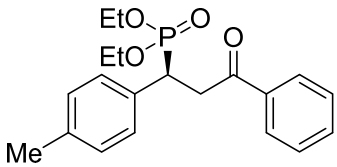


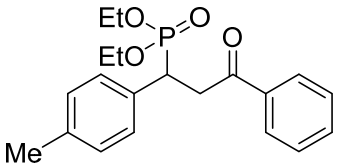


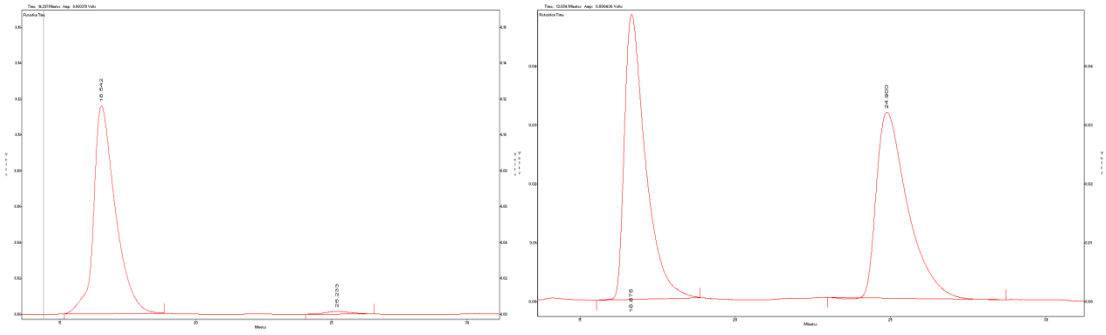


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
21.992	900837	97.512	22.008	625884	49.759
27.575	22985	2.488	27.642	631954	50.241

(*S*)-Diethyl 3-oxo-3-phenyl-1-*p*-tolylpropylphosphonate (**3fa**):

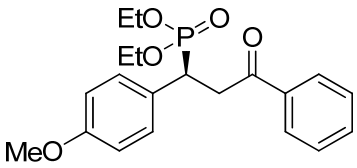


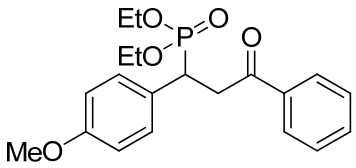


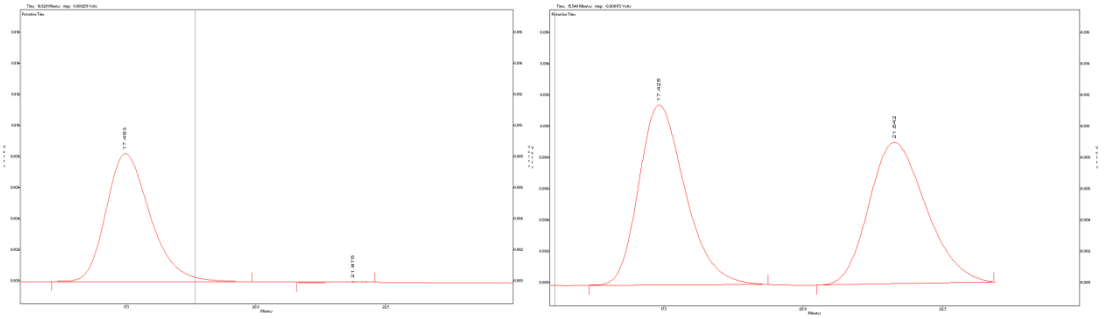


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
16.542	6537997	98.563	16.675	2283513	50.994
25.233	95334	1.437	24.900	2194470	49.006

(*S*)-Diethyl 1-(4-methoxyphenyl)-3-oxo-3-phenylpropylphosphonate (**3ga**):

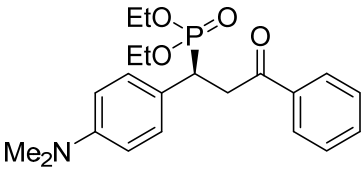


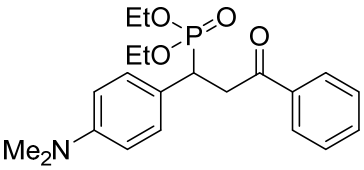


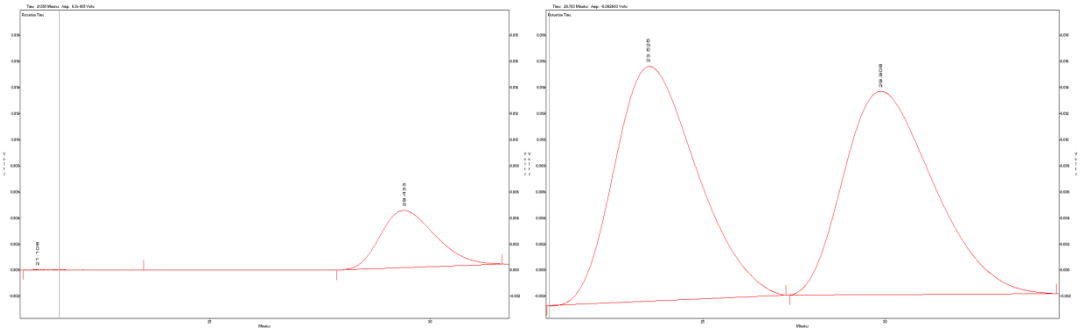


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
17.488	488609	99.645	17.425	666841	50.927
21.875	1741	0.355	21.642	642556	49.073

(*S*)-Diethyl 1-(4-dimethylamino)-3-oxo-3-phenylpropylphosphonate (**3ha**):

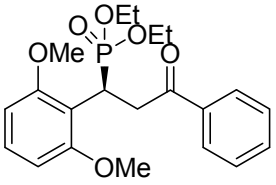


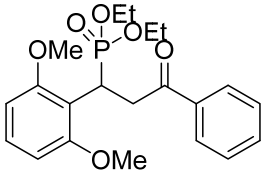


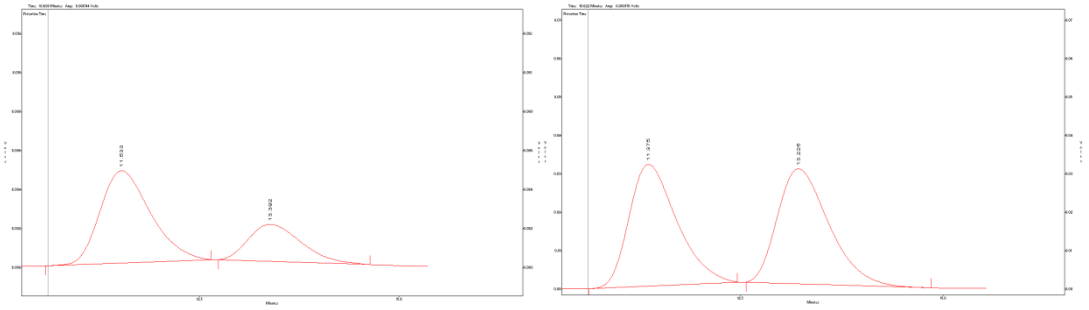


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
23.475	683	0.176	23.525	2828030	51.409
29.433	387282	99.824	29.908	2672974	48.591

(*S*)-Diethyl 1-(2,6-dimethoxyphenyl)-3-oxo-3-phenylpropylphosphonate (**3ia**):

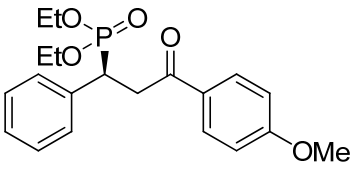


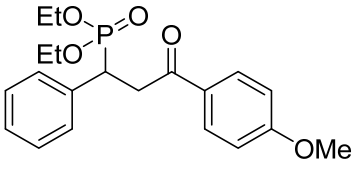


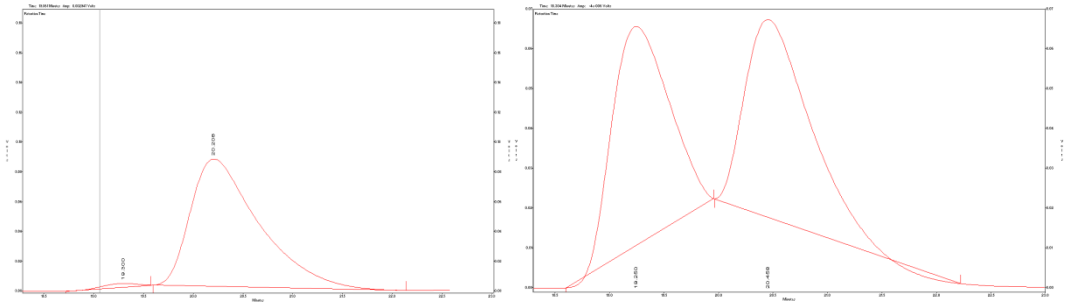


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
11.533	208527	73.860	11.375	1296395	49.568
13.392	77675	27.140	13.225	1318965	50.432

(*S*)-Diethyl 3-(4-methoxyphenyl)-3-oxo-1-phenylpropylphosphonate (**3ja**):

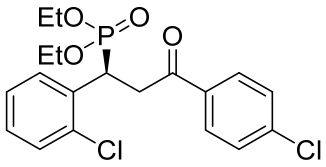


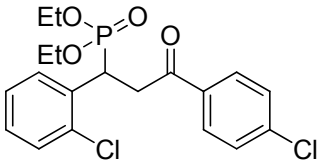


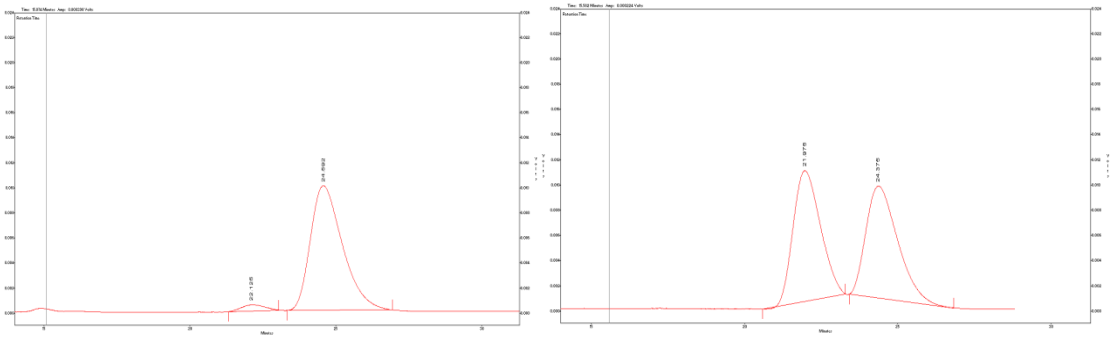


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
19.300	43062	1.042	19.250	1985167	48.862
20.208	4089078	98.958	20.458	2077615	51.138

(*S*)-Diethyl 1-(2-chlorophenyl)-3-(4-chlorophenyl)-3-oxopropylphosphonate (**3ka**):

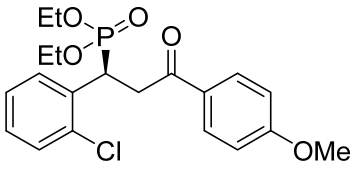


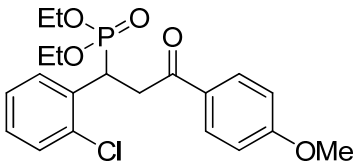


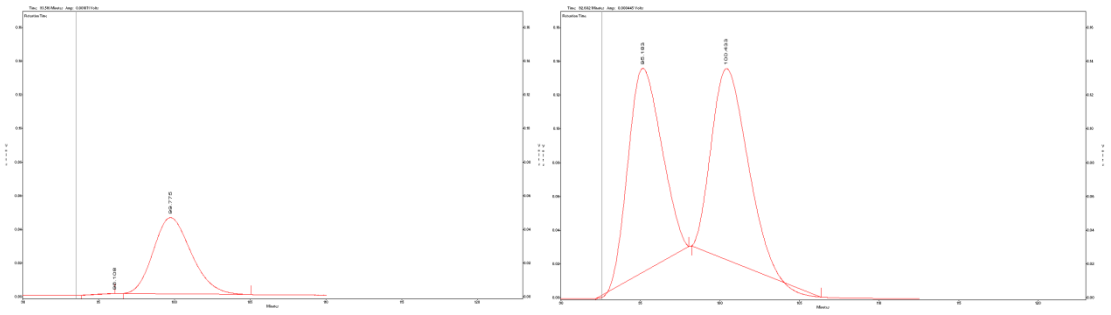


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
22.125	26522	3.346	21.975	640982	50.027
24.592	766081	96.654	24.375	640298	49.973

(*S*)-Diethyl 1-(2-chlorophenyl)-3-(4-methoxyphenyl)-3-oxopropylphosphonate (**3la**):

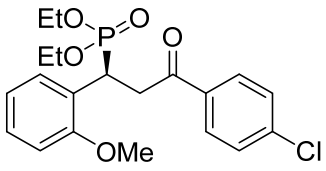


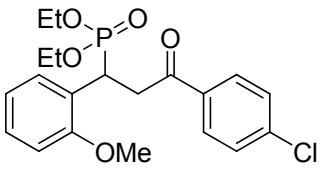


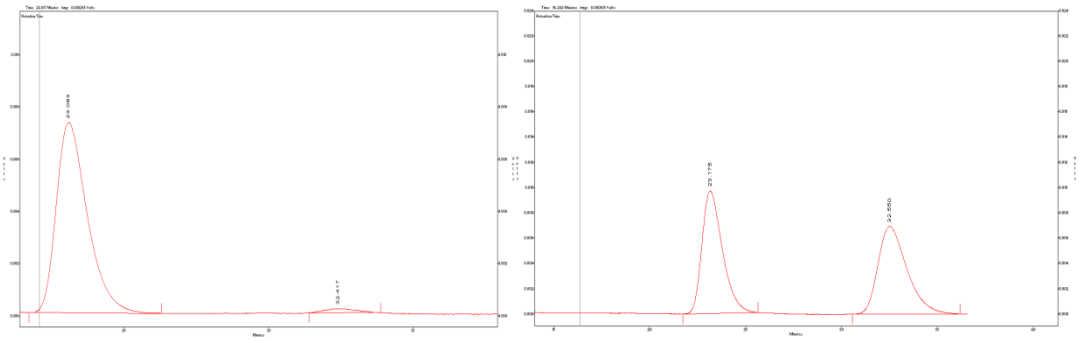


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
96.192	14938	0.189	95.183	17680952	49.881
99.775	7902311	99.811	100.433	17765228	50.119

(*S*)-Diethyl 3-(4-chlorophenyl)-1-(2-methoxyphenyl)-3-oxopropylphosphonate (**3ma**):

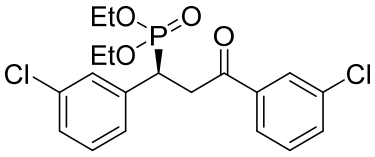


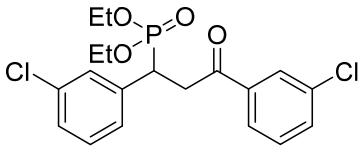


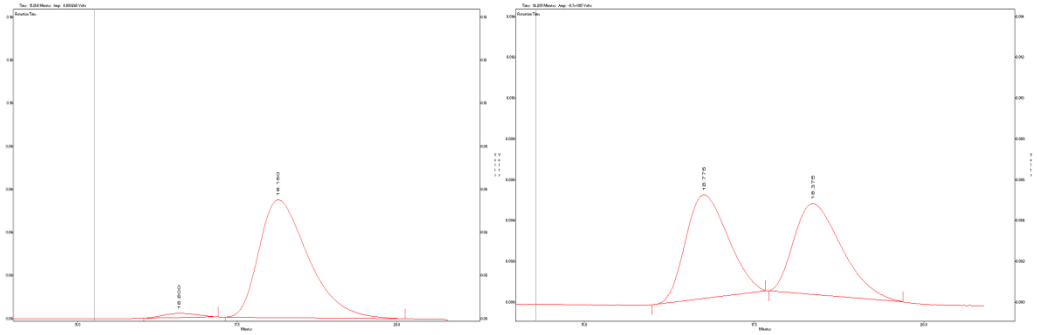


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
23.083	544231	97.746	23.175	717875	49.737
32.417	12551	2.254	32.550	725397	50.263

(*S*)-Diethyl 1,3-bis(3-chlorophenyl)-3-oxopropylphosphonate (**3na**):

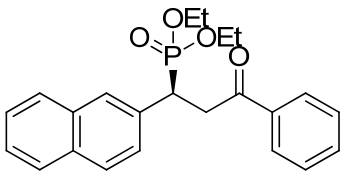


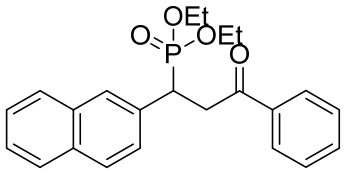


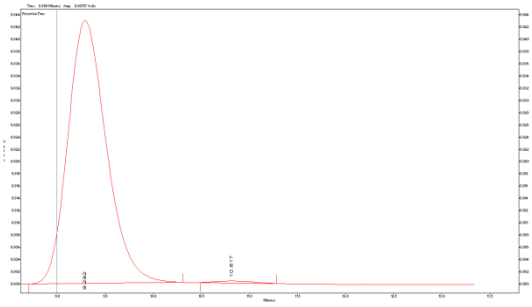


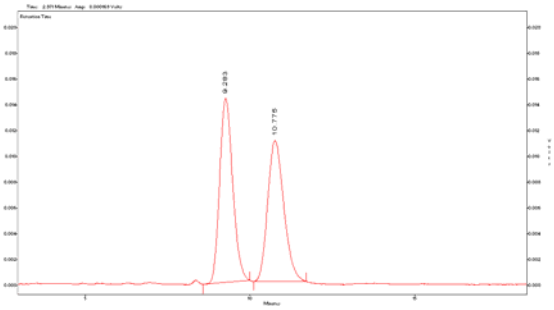
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
16.600	78333	2.597	16.775	219548	50.173
18.150	2938054	97.403	18.375	218032	49.827

(*S*)-Diethyl 1-(naphthalen-3-yl)-3-oxo-3-phenylpropylphosphonate (**3oa**):



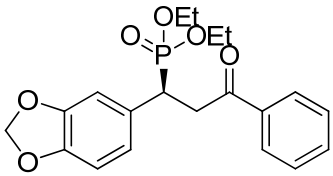


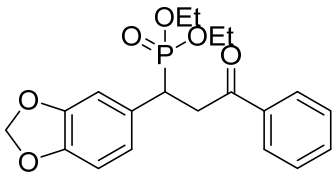


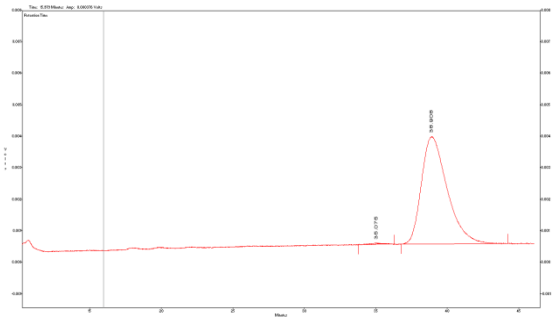


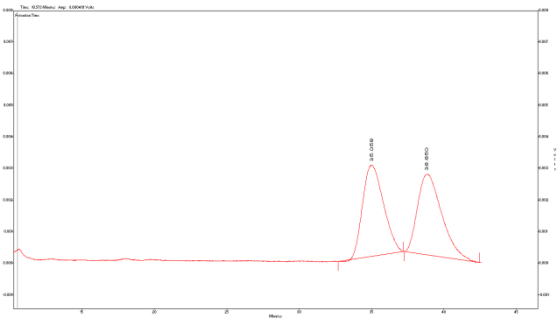
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
9.292	1178776	99.494	9.283	393737	50.981
10.817	597	0.506	10.775	378583	49.019

(*S*)-Diethyl 1-(benzo[*d*][1,3]dioxol-6-yl)-3-oxo-3-phenylpropylphosphonate (**3pa**):



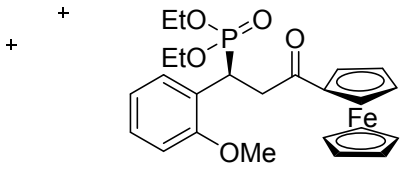


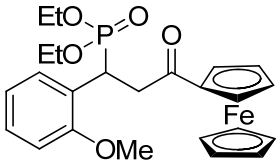


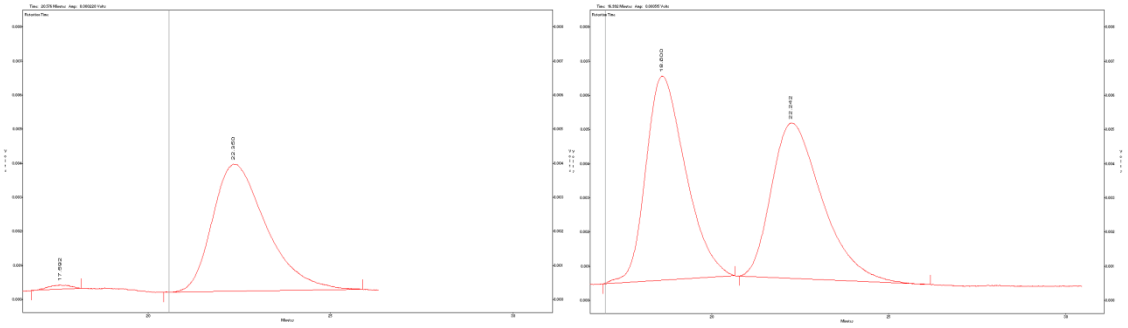


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
35.075	719	0.175	35.058	288549	49.424
38.908	409907	99.825	38.850	295278	50.567

(*S*)-Diethyl 3-(ferrocene)-1-(2-methoxyphenyl)-3-oxopropylphosphonate (**3qa**):

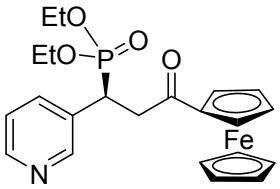


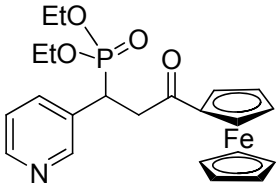


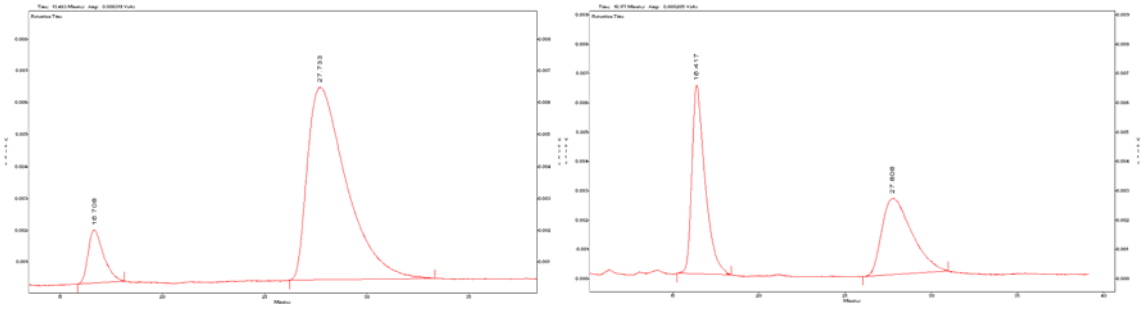


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
17.592	5585	1.472	18.600	466178	50.689
22.350	373771	98.528	22.242	453501	49.311

(*S*)-Diethyl 3-(ferrocene)-1-(2-pyridinyl)-3-oxopropylphosphonate (**3ra**):

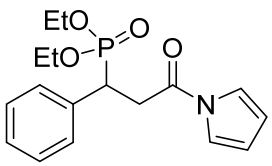


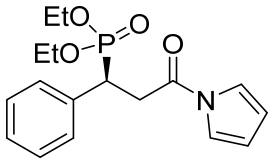


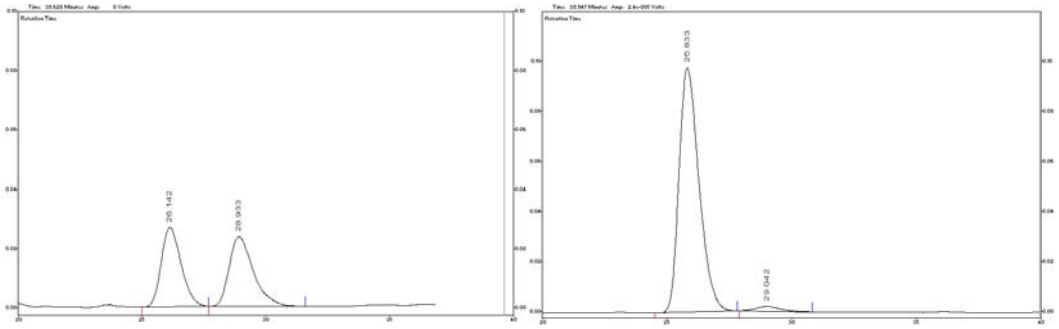


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
16.708	90761	10.062	16.417	355447	50.943
27.733	811219	89.938	27.808	332655	49.057

(*S*)-Diethyl 1-phenyl-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5aa**):

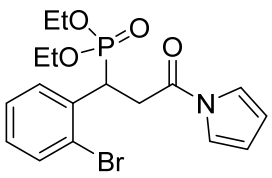


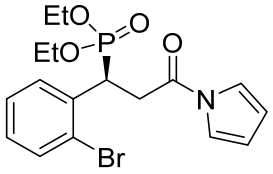


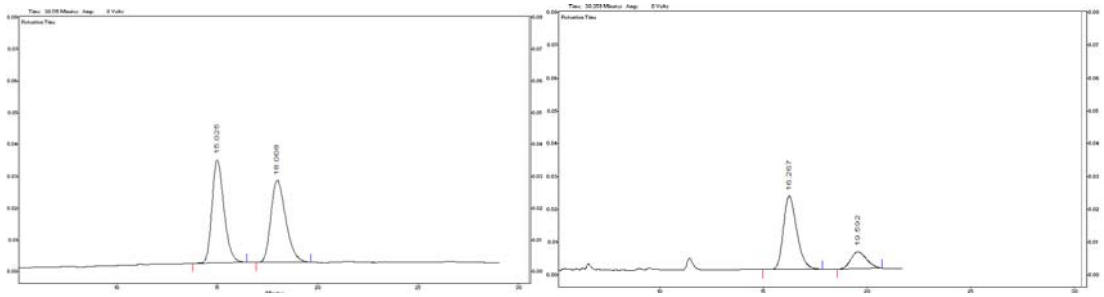


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
26.142	1504260	48.532	25.833	5440417	98.005
28.933	1595289	51.468	29.042	110735	1.995

(*S*)-Diethyl 1-(2-bromophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ba**):

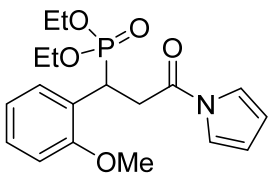


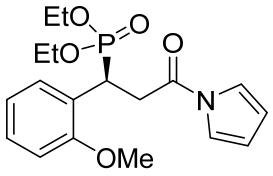


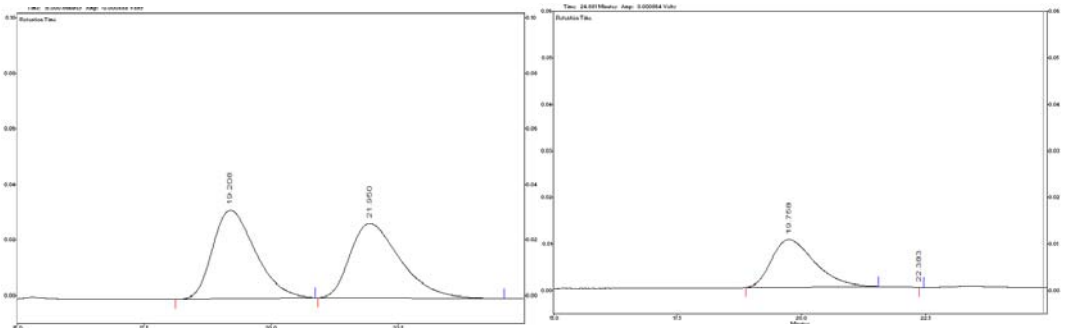


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
15.025	635178	50.530	16.267	985398	79.143
18.008	621839	49.470	19.592	259685	20.857

(*S*)-Diethyl 1-(2-methoxyphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ca**):

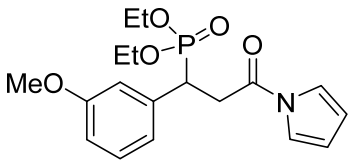


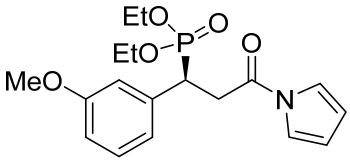


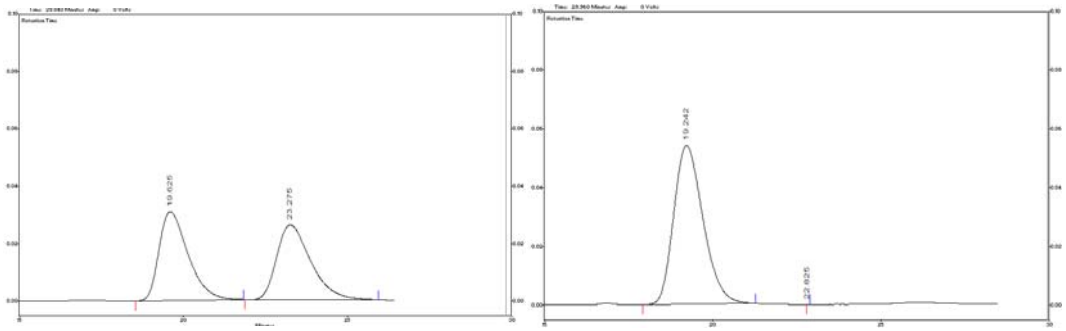


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
19.208	1841598	51.358	19.758	614303	100.000
21.950	1815395	49.642	22.375	2	0.000

(*S*)-Diethyl 1-(3-methoxyphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5da**):

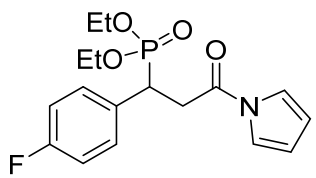


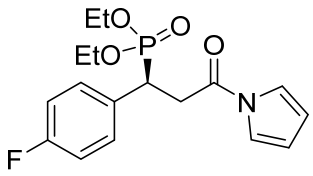


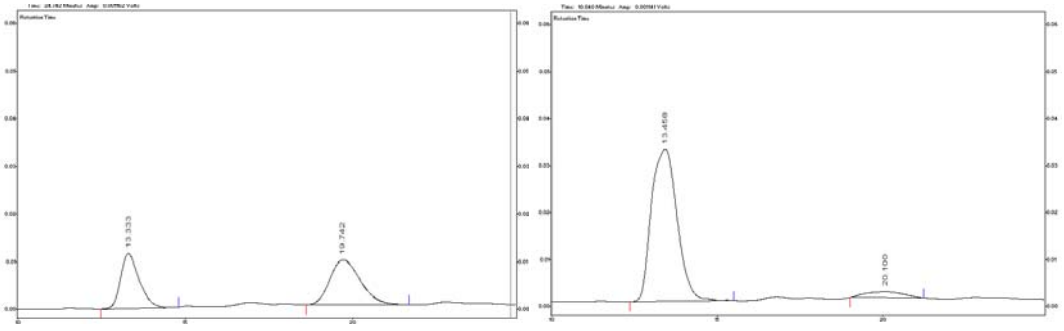


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
19.625	1887469	49.904	19.242	3273751	99.998
23.275	1894701	50.096	22.767	78	0.002

(*S*)-Diethyl 1-(4-fluorophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ea**):

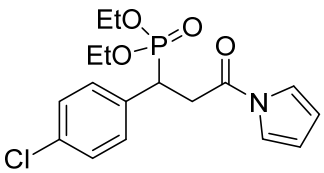


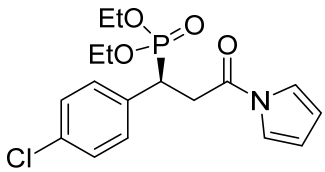


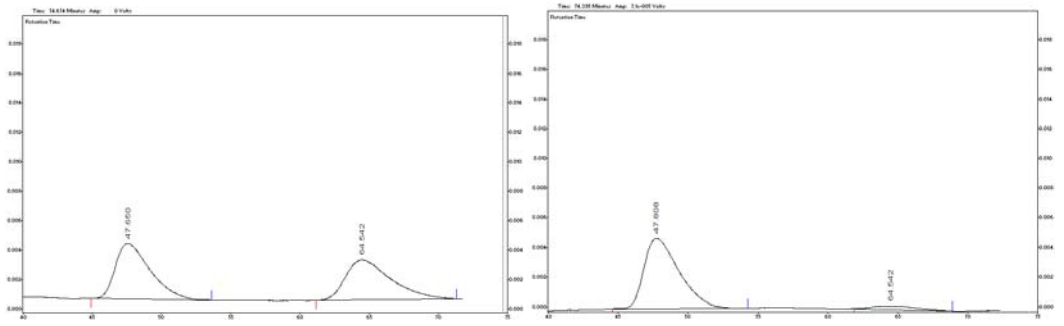


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
13.333	429299	42.837	13.458	1702266	91.871
19.742	586219	57.163	20.100	150619	8.129

(*S*)-Diethyl 1-(4-chlorophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5fa**):

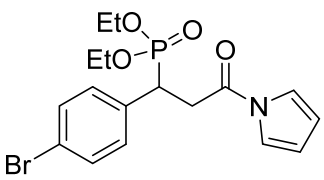


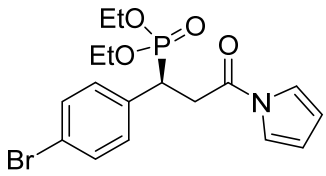


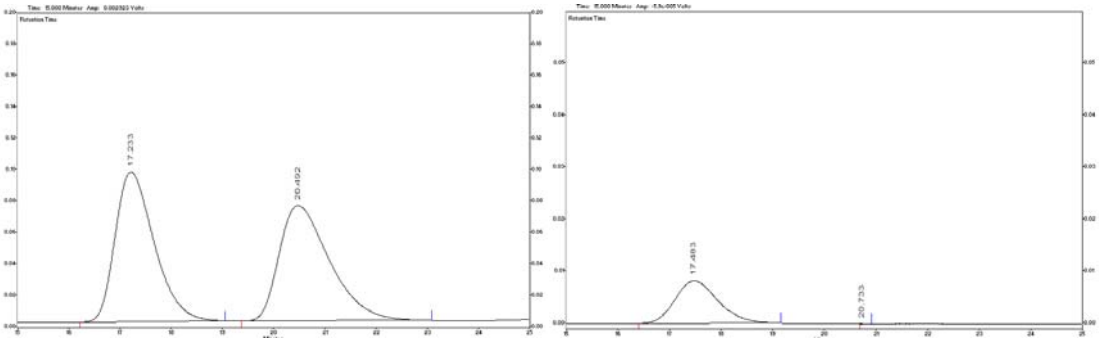


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
47.650	646560	51.876	47.808	820036	95.021
64.542	599795	48.124	64.542	42973	4.979

(*S*)-Diethyl 1-(4-bromophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ga**):

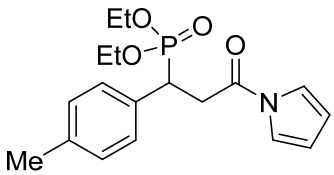


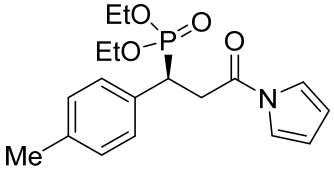


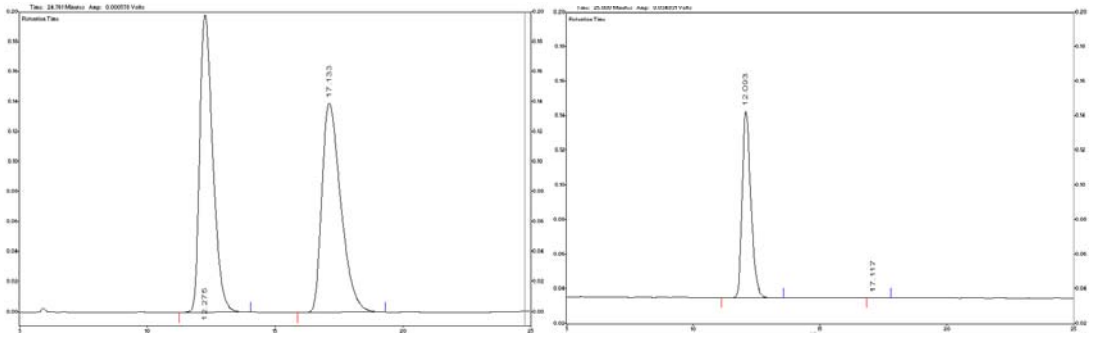


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
17.233	5040932	50.002	17.483	464780	99.997
20.492	5040527	49.998	20.608	13	0.003

(*S*)-Diethyl 1-(4-methylphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ha**):

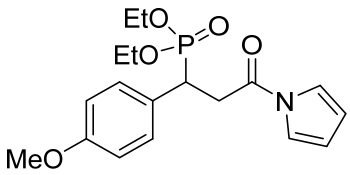


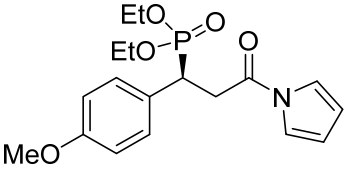


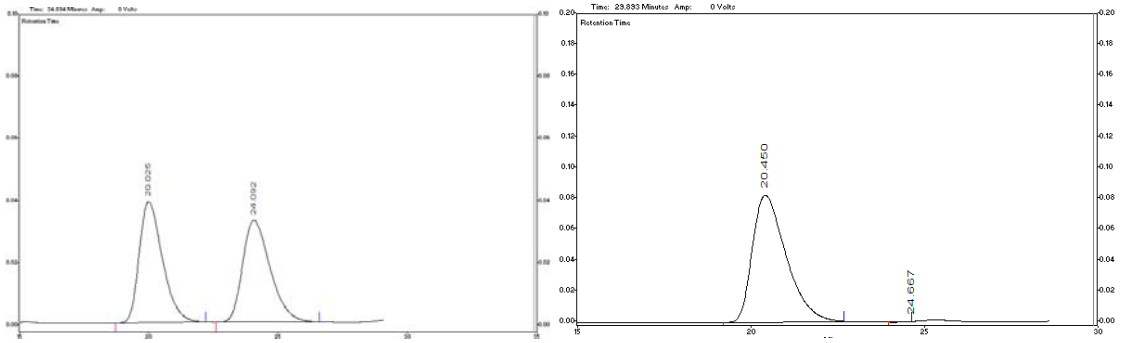


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
12.275	7058130	49.668	12.093	2565012	99.998
17.133	7152411	50.332	17.117	43	0.002

(*S*)-Diethyl 1-(4-methyoxylphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ia**):

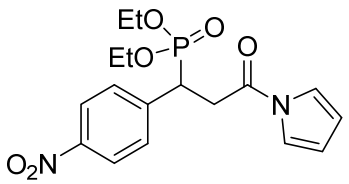


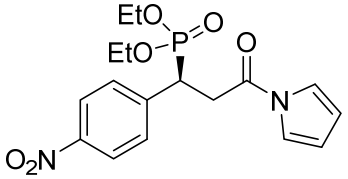


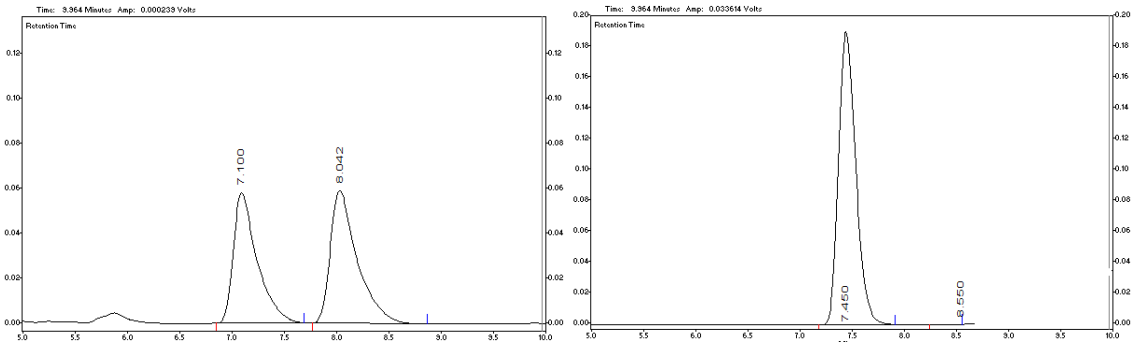


Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
20.025	2424056	50.172	20.450	5600105	98.378
24.092	2407902	49.828	25.375	92335	1.622

(*S*)-Diethyl 1-(4-nitrophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ja**):

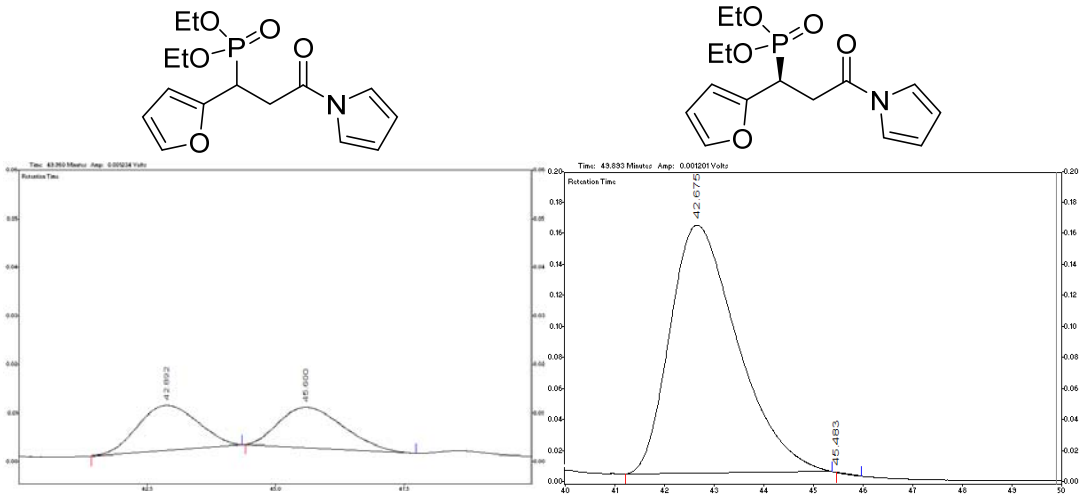






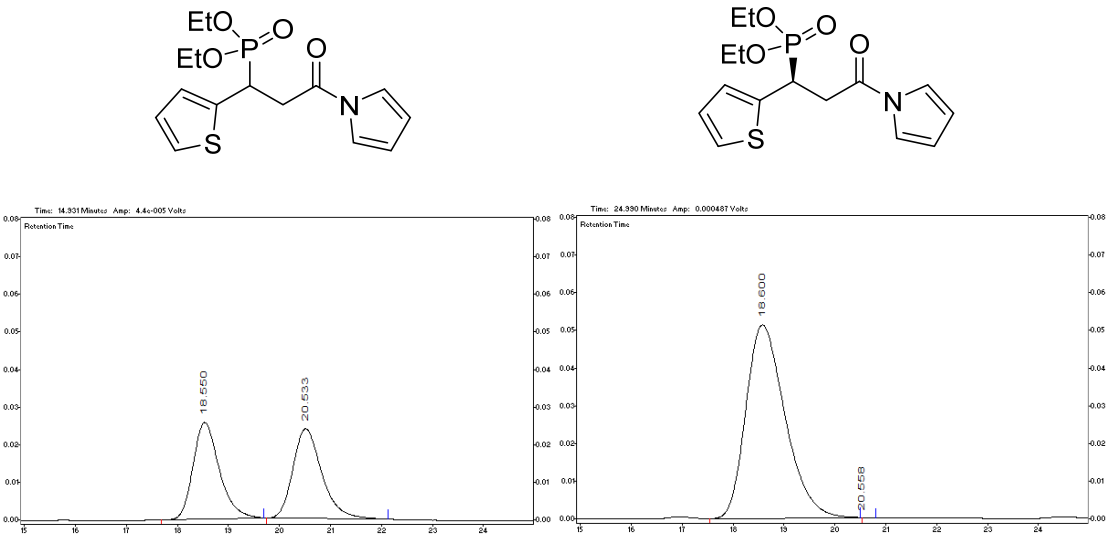
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
7.100	193322	48.002	7.450	2547478	99.992
8.042	209418	51.998	8.550	200	0.008

(*S*)-Diethyl 1-(furan-2-yl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ka**):



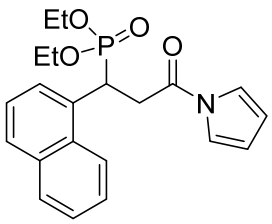
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
42.892	741165	50.231	41.492	84450	1.272
45.600	734335	49.769	43.892	6552660	98.728

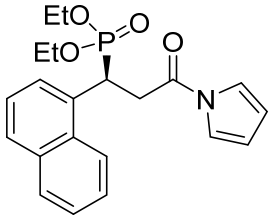
(*S*)-Diethyl 1-(thiophen-2-yl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5la**):

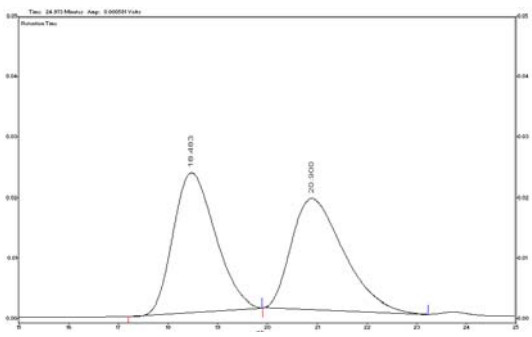


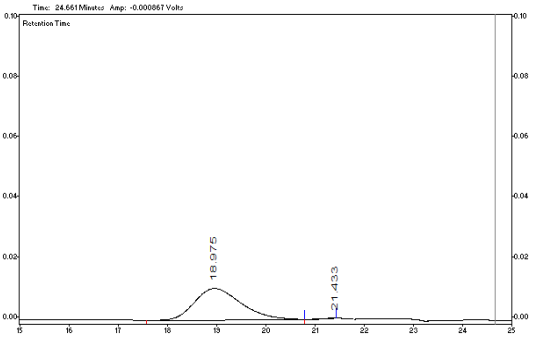
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
18.550	1011333	50.278	18.600	9501	0.346
20.533	1000143	49.722	20.558	2732858	99.654

(*S*)-Diethyl 1-(1-naphthyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ma**):



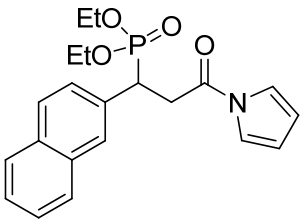


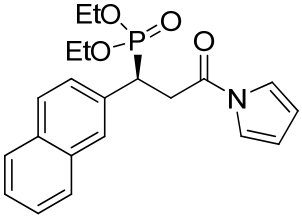


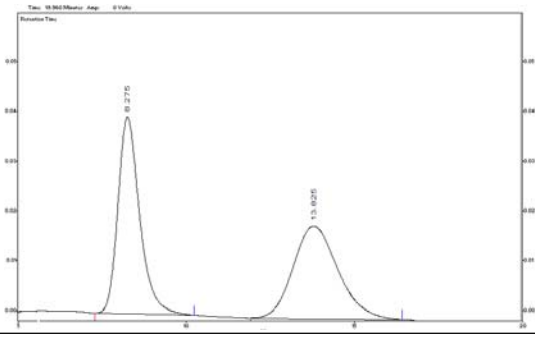


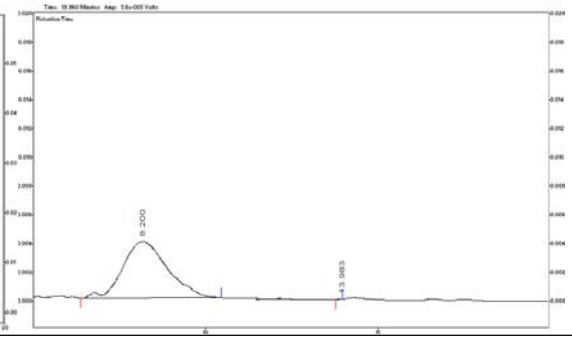
Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
18.483	1363788	50.351	18.975	674955	92.855
20.900	1344748	49.649	21.842	51937	7.145

(*S*)-Diethyl 1-(2-naphthyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5na**):









Ret. Time (min)	Area	Area (%)	Ret. Time (min)	Area	Area (%)
8.275	1788386	51.146	8.200	329275	99.952
13.825	1708212	48.854	13.908	158	0.048

4. NMR Date of the Phospha-Michael Addition Products

(*S*)-Diethyl 3-oxo-1,3-diphenylpropylphosphonate (**3aa**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.97 – 7.91 (m, 2H), 7.55 (t, *J* = 7.4 Hz, 1H), 7.45 (d, *J* = 7.8 Hz, 4H), 7.32 – 7.27 (m, 2H), 7.22 (dd, *J* = 7.3, 1.7 Hz, 1H), 4.07 (ddd, *J* = 7.7, 7.2, 2.8 Hz, 2H), 4.03 – 3.87 (m, 2H), 3.76 – 3.67 (m, 3H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.08 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 16.3 (d, *J* = 5.5 Hz), 16.5 (d, *J* = 6.2 Hz), 39.1 (d, *J* = 140.0 Hz), 39.1, 62.1 (d, *J* = 7.3 Hz), 63.1 (d, *J* = 6.9 Hz), 127.4 (d, *J* = 3.0 Hz), 128.2, 128.6 (d, *J* = 2.3 Hz), 128.7, 129.3 (d, *J* = 6.6 Hz), 133.4, 136.0 (d, *J* = 6.9 Hz), 136.0, 196.5 (d, *J* = 14.8 Hz) ppm.

(*S*)-Diethyl 1-(2-methoxyphenyl)-3-oxo-3-phenylpropylphosphonate (**3ba**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.92 (d, *J* = 8.0 Hz, 2H), 7.52 (t, *J* = 7.3 Hz, 1H), 7.41 (t, *J* = 7.7 Hz, 3H), 7.17 (t, *J* = 7.6 Hz, 1H), 6.93 – 6.82 (m, 2H), 4.60 (dt, *J* = 7.7, 6.9 Hz, 1H), 4.13 – 4.03 (m, 2H), 3.85 – 3.92 (m, 4H), 3.79 – 3.66 (m, 3H), 1.26 (t, *J* = 6.8 Hz, 3H), 1.07 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 16.3 (d, *J* = 6.0 Hz), 16.4 (d, *J* = 6.2 Hz), 30.6 (d, *J* = 141.0 Hz), 39.1, 56.0, 62.0 (d, *J* = 7.0 Hz), 62.7 (d, *J* = 7.1 Hz), 111.1 (d, *J* = 2.2 Hz), 120.8 (d, *J* = 3.1 Hz), 124.7 (d, *J* = 7.1 Hz), 128.2, 128.3 (d, *J* = 3.4 Hz), 128.6, 128.8 (d, *J* = 5.0 Hz), 133.2, 136.8, 157.5 (d, *J* = 7.1 Hz), 196.7 (d, *J* = 14.9 Hz) ppm.

(*S*)-Diethyl 1-(3-chlorophenyl)-3-oxo-3-phenylpropylphosphonate (**3ca**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.93 (d, *J* = 7.3 Hz, 2H), 7.55 (t, *J* = 7.4 Hz, 1H), 7.47 – 7.40 (m, 3H), 7.32 (d, *J* = 8.6 Hz, 1H), 7.20 (q, *J* = 9.9, 8.9 Hz, 2H), 4.07 (td, *J* = 7.7, 7.3, 3.0 Hz, 2H), 3.98 – 3.89 (m, 2H), 3.84 – 3.76 (m, 1H), 3.68 (t, *J* = 5.5 Hz, 2H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.12 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 196.1 (d, *J* = 15.0 Hz), 138.3 (d, *J* = 6.8 Hz), 136.4, 134.3 (d, *J* = 2.3 Hz), 133.5, 129.7 (d, *J* = 2.3 Hz), 129.4(d, *J* = 6.8 Hz), 128.7, 128.1, 127.6 (d, *J* = 2.3 Hz), 127.5, 63.0 (d, *J* = 7.5 Hz), 62.2 (d, *J* = 7.5 Hz), 39.0, 38.7 (d, *J* = 140.0 Hz), 16.4 (d, *J* = 6.0 Hz), 16.3 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-chlorophenyl)-3-oxo-3-phenylpropylphosphonate (**3da**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.93 (d, *J* = 7.3 Hz, 2H), 7.56 (t, *J* = 7.4 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.38 (dd, *J* = 8.5, 2.2 Hz, 2H), 7.27 (d, *J* = 8.2 Hz, 2H), 4.09 (td, *J* = 7.8, 7.3, 2.7 Hz, 2H), 3.98 – 3.89 (m, 2H), 3.76 – 3.82 (m, 1H), 3.73 – 3.64 (m, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.12 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 196.1 (d, *J* = 15.0 Hz), 136.4, 134.6 (d, *J* =6.8 Hz), 133.4, 133.1 (d, *J* =3.8 Hz), 130.5 (d, *J* = 6.8 Hz), 128.6, 128.0, 63.0 (d, *J* = 7.5 Hz), 62.1 (d, *J* = 7.5 Hz), 39.0, 38.4 (d, *J* = 140.0 Hz), 16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-bromophenyl)-3-oxo-3-phenylpropylphosphonate (**3ea**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.91 (d, *J* = 7.3 Hz, 2H), 7.53 (d, *J* = 7.2 Hz, 1H), 7.42 (dd, *J* = 13.6, 7.8 Hz, 4H), 7.30 (d, *J* = 6.5 Hz, 2H), 4.13 – 4.03 (m, 2H), 3.93 (d, *J* = 9.2 Hz, 2H), 3.82 – 3.75 (m, 1H), 3.67 (t, *J* = 9.1 Hz, 2H), 1.27 (t, *J* = 7.0 Hz, 3H), 1.11 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 196.1 (d, *J* = 15.0 Hz), 136.4, 135.2 (d, *J* = 6.8 Hz), 133.5, 133.6 (d, *J* = 2.3 Hz), 130.9 (d, *J* = 6.8 Hz), 128.7, 128.1, 121.3 (d, *J* =3.8 Hz), 63.1 (d, *J* = 7.5 Hz), 62.2 (d, *J* = 7.5 Hz), 38.9, 38.6 (d, *J* = 140.0 Hz), 16.4 (d, *J* = 6.0 Hz), 16.3 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 3-oxo-3-phenyl-1-*p*-tolylpropylphosphonate (**3fa**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.94 (d, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.3 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.31 (d, *J* = 6.2 Hz, 2H), 7.09 (d, *J* = 7.7 Hz, 2H), 4.14 – 4.02 (m, 2H), 3.92 (dd, *J* = 15.0, 8.4 Hz, 2H), 3.78 – 3.67 (m, 3H), 2.28 (s, 3H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.10 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 196.4 (d, *J* = 15.0 Hz), 136.9 (d, *J* =3.0 Hz), 136.5, 133.1, 132.7 (d, *J* =7.5 Hz), 129.1 (d, *J* = 2.3 Hz), 129.0 (d, *J* =6.0 Hz), 128.6, 128.1, 63.0 (d, *J* = 7.5 Hz), 61.9 (d, *J* = 7.5 Hz), 39.0, 37.9 (d, *J* = 140.0 Hz), 21.0, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-methoxyphenyl)-3-oxo-3-phenylpropylphosphonate (**3ga**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.92 (d, *J* = 7.2 Hz, 2H), 7.52 (t, *J* = 6.8 Hz, 1H), 7.41 (d, *J*

= 7.4 Hz, 2H), 7.33 (dd, *J* = 8.8, 2.3 Hz, 2H), 6.81 (d, *J* = 8.5 Hz, 2H), 4.10 – 4.01 (m, 2H), 3.95 – 3.85 (m, 2H), 3.74 (s, 3H), 3.71 – 3.60 (m, 3H), 1.26 (t, *J* = 7.1 Hz, 3H), 1.09 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 196.5 (d, *J* = 15.8 Hz), 158.6 (d, *J* = 3.0 Hz), 136.5, 133.2, 130.2 (d, *J* = 6.8 Hz), 128.5, 128.0, 127.7 (d, *J* = 6.8 Hz), 113.8 (d, *J* = 2.3 Hz), 62.8 (d, *J* = 6.8 Hz), 61.9 (d, *J* = 6.8 Hz), 55.2, 39.2, 37.6 (d, *J*= 140.3 Hz),16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 5.3 Hz) ppm.

(*S*)-Diethyl 3-(4-methoxyphenyl)-3-oxo-1-phenylpropylphosphonate (**3ja**): **^{1}H NMR** (400 MHz, Chloroform-*d*): *δ* = 7.92 (d, *J* = 8.6 Hz, 2H), 7.43 (d, *J* = 7.2 Hz, 2H), 7.28 (t, *J* = 7.4 Hz, 2H), 7.21 (d, *J* = 6.7 Hz, 1H), 6.90 (d, *J* = 8.5 Hz, 2H), 4.12 – 4.03 (m, 2H), 3.96 – 3.88 (m, 2H), 3.84 (s, 3H), 3.76 – 3.66 (m, 2H), 3.63 (dd, *J* = 15.8, 3.7 Hz, 1H), 1.28 (t, *J* = 7.0 Hz, 3H), 1.08 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 194.8 (d, *J* = 15.8 Hz), 163.6 (d, *J* = 3.0 Hz), 136.5, 133.2, 130.2 (d, *J* = 6.8 Hz), 128.6, 128.1, 127.7 (d, *J* = 6.8 Hz), 113.7 (d, *J* = 2.3 Hz), 62.8 (d, *J* = 6.8 Hz), 61.8 (d, *J* = 6.8 Hz), 55.5, 38.6, 38.0 (d, *J*= 140.3 Hz),16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 5.3 Hz) ppm.

(*S*)-Diethyl 1-(naphthalen-3-yl)-3-oxo-3-phenylpropylphosphonate (**3oa**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.99 – 7.87 (m, 3H), 7.79 (d, *J* = 8.1 Hz, 3H), 7.62 – 7.50 (m, 2H), 7.43 (t, *J* = 7.4 Hz, 4H), 4.21 – 4.04 (m, 4H), 3.80 – 3.78 (m, 3H), 1.29 (d, *J* = 14.1 Hz, 3H), 1.06 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 196.2 (d, *J*= 15.0 Hz), 136.5, 133.5 (d, *J* = 7.5 Hz), 133.3, 132.5 (d, *J* = 2.3 Hz), 128.6, 128.1 (d, *J* = 3.0 Hz), 128.0, 127.8, 127.5, 127.4 (d, *J* = 5.3 Hz), 126.0, 125.8, 62.9 (d, *J* = 6.8 Hz), 62.0 (d, *J* = 7.5 Hz), 39.3, 39.1 (d, *J*= 140.0 Hz), 16.4 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-phenyl-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5aa**): **^{1}H NMR** (400 MHz, Chloroform-*d*): *δ* = 7.56 – 7.28 (m, 7H), 6.27 (s, 2H), 4.09 (d, *J* = 4.5 Hz, 2H), 3.91 – 3.88 (m, 2H), 3.74 – 3.47 (m, 3H), 1.36 – 1.24 (m, 3H), 1.07 (d, *J* = 6.8 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.7 (d, *J* = 18.0 Hz), 135.2 (d, *J* = 6.8 Hz), 129.1 (d, *J* = 6.0 Hz), 128.7 (d, *J* = 2.3 Hz), 127.6 (d, *J* = 3.0 Hz), 119.1, 113.4, 63.2 (d, *J* = 7.5 Hz),

62.1 (d, *J* = 7.5 Hz), 39.5 (d, *J* =140.3 Hz), 35.5, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 5.3 Hz) ppm.

(*S*)-Diethyl 1-(2-bromophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ba**): **^{1}H NMR** (400 MHz, Chloroform-*d*): *δ* = 7.56 (d, *J* = 28.7 Hz, 2H), 7.31 – 7.29 (m, 3H), 7.11 – 7.08 (m, 1H), 6.29 – 6.27 (m, 2H), 4.60 (s, 1H), 4.13 (s, 2H), 3.93 – 3.89 (m, 1H), 3.66 (d, *J* = 37.8 Hz, 3H), 1.34 – 1.32 (m, 3H), 1.09 – 1.07 (m, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.3 (d, *J* = 18.2 Hz), 135.1 (d, *J* = 6.4 Hz), 133.3 (d, *J* = 6.8 Hz), 129.2, 128.9, 127.7, 126.3 (d, *J* = 9.2 Hz), 119.1, 113.4, 63.3 (d, *J* =7.1 Hz), 62.4 (d, *J* = 7.2 Hz), 38.1 (d, *J* = 140.3 Hz), 35.8,16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(2-methoxyphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ca**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.42 (dt, *J* = 7.6, 2.0 Hz, 1H), 7.33 – 7.28 (m, 2H), 7.26 – 7.16 (m, 1H), 7.00 – 6.81 (m, 2H), 6.29 – 6.20 (m, 2H), 4.59 (d, *J* = 4.7 Hz, 1H), 4.14 – 4.04 (m, 2H), 3.77 – 3.85 (m, 1H), 3.87 (s, 3H), 3.73 (d, *J* = 10.1 Hz, 1H), 3.64 – 3.44 (m, 2H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.08 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.9 (d, *J* = 18.0 Hz), 157.4 (d, *J* = 7.5 Hz), 128.7 (d, *J* = 5.3 Hz), 128.6 (d, *J* = 3.0 Hz), 123.8 (d, *J* = 6.8 Hz), 120.8 (d, *J* = 3.0 Hz), 119.1, 113.2, 111.1 (d, *J* = 2.3 Hz), 62.9 (d, *J* = 6.8 Hz), 62.1 (d, *J*= 6.8 Hz), 55.9, 35.4, 31.2 (d, *J* = 141.0 Hz), 16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(3-methoxyphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5da**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.31 (s, 2H), 7.23 (t, *J* = 7.9 Hz, 1H), 7.05 – 6.95 (m, 2H), 6.80 (d, *J* = 8.2 Hz, 1H), 6.32 – 6.24 (m, 2H), 4.06 (s, 2H), 3.98 – 3.82 (m, 2H), 3.79 (s, 3H), 3.76-3.68 (m, 1H), 3.47 (s, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.10 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.7 (d, *J* = 18.0 Hz), 159.6 (d, *J* = 3.0 Hz), 136.7 (d, *J* = 6.8 Hz), 129.5 (d, *J* = 2.3 Hz), 121.5 (d, *J* = 6.8Hz), 119.0, 114.9 (d, *J* = 6.0 Hz), 113.4, 113.1 (d, *J* = 3.0 Hz), 63.2 (d, *J* = 6.8 Hz), 62.1 (d, *J* = 7.5 Hz), 55.2, 39.6 (d, *J*= 140.3 Hz), 35.5, 16.4 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-fluorophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ea**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.40 (ddd, *J* = 7.6, 5.2, 2.3 Hz, 2H), 7.29 (s, 2H), 7.01 (t, *J* = 8.5 Hz, 2H), 6.33 – 6.22 (m, 2H), 4.14 – 4.03 (m, 2H), 3.97 – 3.80 (m, 2H), 3.75 – 3.67 (m, 1H), 3.48 (s, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.09 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.6 (d, *J* = 18.8 Hz), 162.1 (dd, *J* = 245.3, 3.8 Hz), 130.9 (dd, *J* = 6.8, 3.8 Hz), 130.7 (dd, *J* = 7.5, 6.8 Hz), 119.0, 115.6 (dd, *J* = 21.0, 2.3 Hz),113.4, 63.2 (d, *J* = 7.5 Hz), 63.1 (d, *J* = 7.5 Hz), 39.3 (d, *J* = 141.0 Hz), 35.6, 16.4 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-chlorophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5fa**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.37 (d, *J* = 8.3 Hz, 2H), 7.29 (s, 4H), 6.28 (s, 2H), 4.15 – 4.02 (m, 2H), 3.95 – 3.73 (m, 3H), 3.62 – 3.41 (m, 2H), 1.29 (t, *J* = 7.0 Hz, 3H), 1.11 (t, *J* = 6.9 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.4 (d, *J* = 18.8 Hz), 133.7 (d, *J* = 6.8 Hz), 133.4 (d, *J* = 3.8 Hz), 130.4 (d, *J* = 6.8 Hz), 128.8 (d, *J* = 3.0 Hz), 119.0, 113.5, 63.4 (d, *J* = 6.8 Hz), 62.2 (d, *J* = 6.8 Hz), 39.4 (d, *J* = 141.0 Hz), 35.4, 16.3 (d, *J* = 6.0 Hz), 16.2 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-bromophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ga**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 8.35 (d, *J* = 8.1 Hz, 1H), 7.51 (d, *J* = 3.8 Hz, 1H), 7.45 (d, *J* = 8.3 Hz, 2H), 7.36 (dd, *J* = 8.6, 2.2 Hz, 2H), 7.29 – 7.25 (m, 1H), 6.65 (d, *J* = 3.8 Hz, 1H), 4.16 – 4.06 (m, 2H), 3.98 – 3.88 (m, 2H), 3.83 – 3.72 (m, 1H), 3.71 – 3.61 (m, 1H), 3.60 – 3.49 (m, 1H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.12 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 168.1 (d, *J* = 18.8 Hz), 134.3 (d, *J* = 7.5 Hz), 131.7 (d, *J* = 2.3 Hz), 130.9 (d, *J* = 6.8 Hz), 123.9, 120.9, 116.6, 63.2 (d, *J* = 7.5 Hz), 62.2 (d, *J* = 6.8 Hz), 39.0 (d, *J* = 140.3 Hz), 35.3, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 5.3 Hz) ppm.

(*S*)-Diethyl 1-(4-methylphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ha**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.39 – 7.22 (m, 4H), 7.12 (d, *J* = 7.7 Hz, 2H), 6.27 (s, 2H), 4.13 – 4.01 (m, 2H), 3.99 – 3.79 (m, 2H), 3.76 – 3.66 (m, 1H), 3.53 (dd, *J* = 14.1, 7.0 Hz, 2H), 2.30 (s, 3H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.09 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100

MHz, Chloroform-*d*): *δ* = 167.7 (d, *J* = 18.0 Hz), 137.2 (d, *J* = 3.0 Hz), 131.9 (d, *J* = 6.8 Hz), 129.3 (d, *J* =2.3 Hz), 128.9 (d, *J* = 6.8 Hz), 119.0, 113.2, 63.1 (d, *J* = 6.8 Hz), 62.0 (d, *J* = 6.8 Hz), 39.1 (d, *J* = 140.3 Hz), 35.5, 21.0,16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-methyoxylphenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ia**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.38 – 7.32 (m, 2H), 7.32 – 7.27 (m, 2H), 6.90 – 6.80 (m, 2H), 6.30 – 6.23 (m, 2H), 4.07 (ddd, *J* = 10.9, 7.0, 3.0 Hz, 2H), 3.96 – 3.84 (m, 2H), 3.77 (s, 3H), 3.74 – 3.65 (m, 1H), 3.58 – 3.42 (m, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.09 (t, *J* = 7.0 Hz, 3H); **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.8 (d, *J* = 18.0 Hz), 158.9 (d, *J* = 3.0Hz), 130.2 (d, *J* = 6.8 Hz), 126.9 (d, *J* = 6.8 Hz), 119.1, 114.1 (d, *J* = 2.3 Hz), 113.4, 63.2 (d, *J* = 6.8 Hz), 62.1 (d, *J* =7.5 Hz), 55.2, 38.7 (d, *J* = 141.0 Hz), 35.7, 16.4 (d, *J* = 6.0 Hz), 16.3 (d, *J* = 6.0 Hz) ppm.

(*S*)-Diethyl 1-(4-nitrophenyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ja**): **^{1}H NMR** (400 MHz, Chloroform-*d*): *δ* = 8.19 (d, *J* = 8.7 Hz, 2H), 7.62 (dd, *J* = 8.9, 2.2 Hz, 2H), 7.28 (d, *J* = 4.0 Hz, 2H), 6.30 (d, *J* = 4.7 Hz, 2H), 4.19 – 4.08 (m, 2H), 4.06 – 3.92 (m, 2H), 3.89 – 3.78 (m, 1H), 3.64 – 3.54 (m, 2H), 1.32 (t, *J* = 7.1 Hz, 3H), 1.14 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.0 (d, *J* = 18.0 Hz), 147.2 (d, *J* = 3.8 Hz), 143.1 (d, *J* = 6.8 Hz), 130.0 (d, *J* = 6.0 Hz), 123.7 (d, *J* = 3.0 Hz), 118.9, 113.7, 63.3 (d, *J* = 6.8 Hz), 62.5 (d, *J* = 6.8 Hz), 39.6 (d, *J* = 139.5 Hz), 35.1, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 5.3 Hz) ppm.

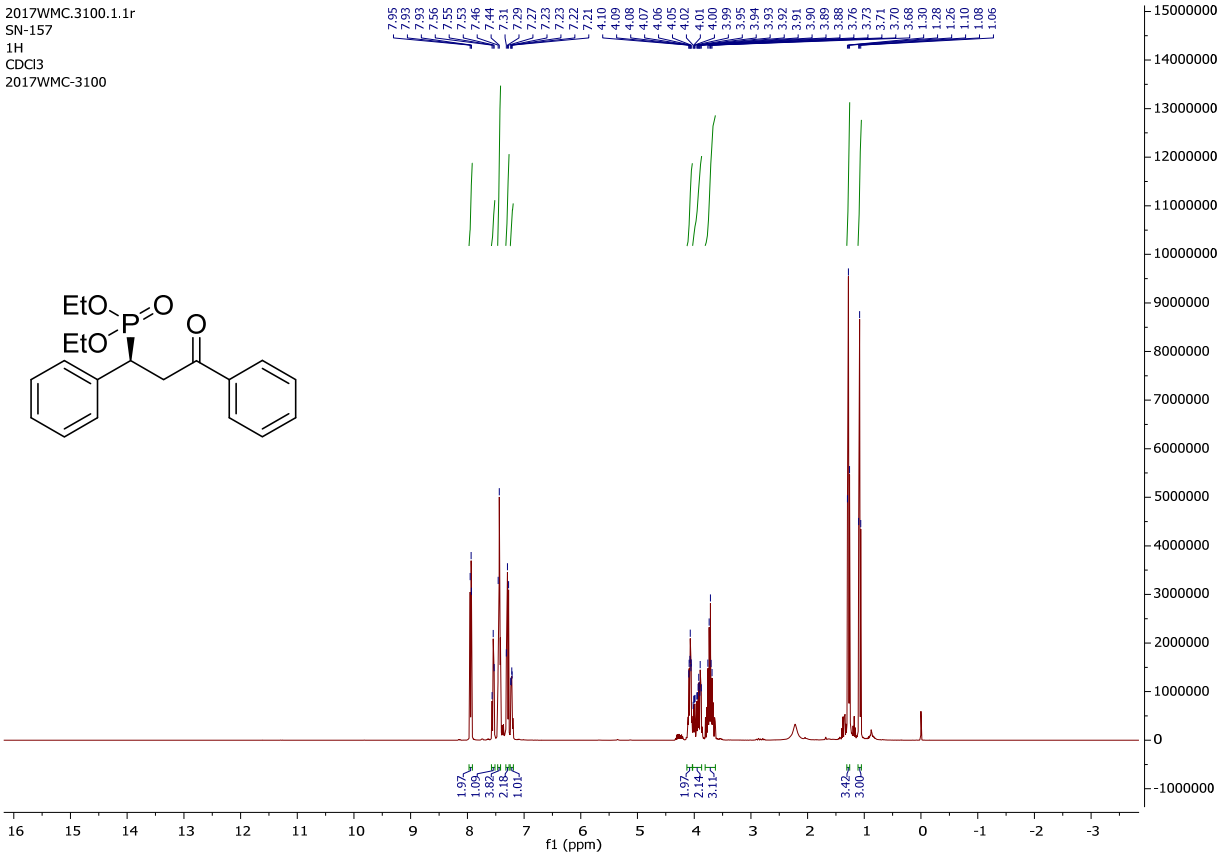
(*S*)-Diethyl 1-(furan-2-yl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ka**): **^{1}H NMR** (400 MHz, Chloroform-*d*): *δ* = 7.41 – 7.29 (m, 3H), 6.30 (dt, *J* = 8.9, 2.1 Hz, 4H), 4.12 – 4.03 (m, 4H), 3.96 – 3.89 (m, 1H), 3.60 – 3.42 (m, 2H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.21 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): *δ* = 167.6 (d, *J* = 17.3 Hz), 148.4 (d, *J* = 9.0 Hz), 142.2 (d, *J* = 3.8 Hz), 119.0, 113.5, 110.9 (d, *J* = 3.0 Hz), 108.5 (d, *J* = 7.5 Hz), 63.2(d, *J* = 6.8 Hz), 62.6 (d, *J* = 6.8 Hz), 33.8 (d, *J* = 144.0 Hz), 33.6, 16.4 (d, *J* = 3.8 Hz), 16.3 (d, *J* = 4.5 Hz) ppm.

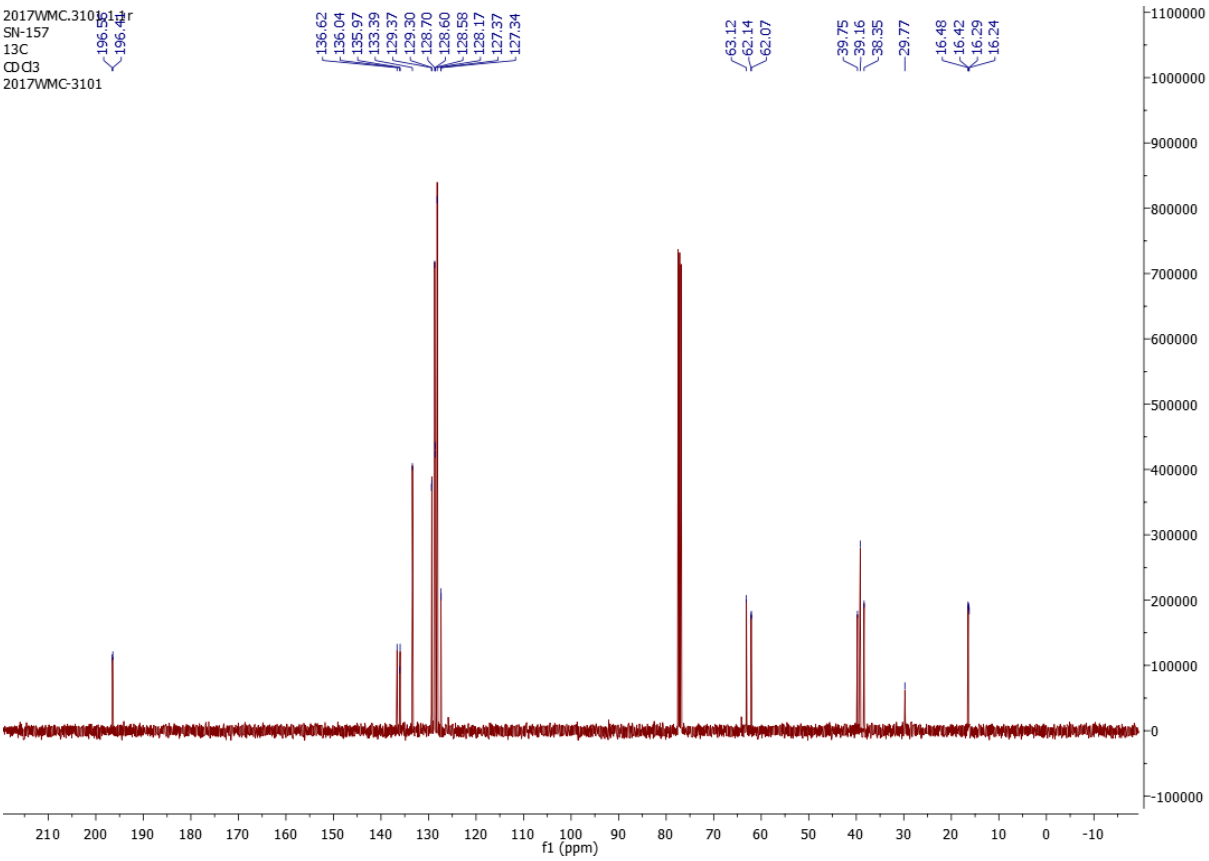
(*S*)-Diethyl 1-(thiophen-2-yl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5la**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.31 (s, 2H), 7.20 (d, *J* = 5.1 Hz, 1H), 7.11 (t, *J* = 3.1 Hz, 1H), 6.99 – 6.90 (m, 1H), 6.36 – 6.23 (m, 2H), 4.21 (ddd, *J* = 22.3, 9.7, 4.0 Hz, 1H), 4.10 (p, *J* = 7.1, 6.5 Hz, 2H), 4.05 – 3.96 (m, 1H), 3.91 – 3.80 (m, 1H), 3.65 – 3.40 (m, 2H), 1.30 (t, *J* = 7.1 Hz, 3H), 1.17 (t, *J* = 7.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.4 (d, *J* = 18.0 Hz), 135.0 (d, *J* = 6.8 Hz), 128.1 (d, *J*= 4.5 Hz), 125.8, 123.4 (d, *J* = 9.0 Hz), 119.0, 113.4, 63.2 (d, *J* = 6.8 Hz), 62.2 (d, *J* = 6.8 Hz), 34.9 (d, *J* = 143.3 Hz), 35.8, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.0 Hz) ppm.

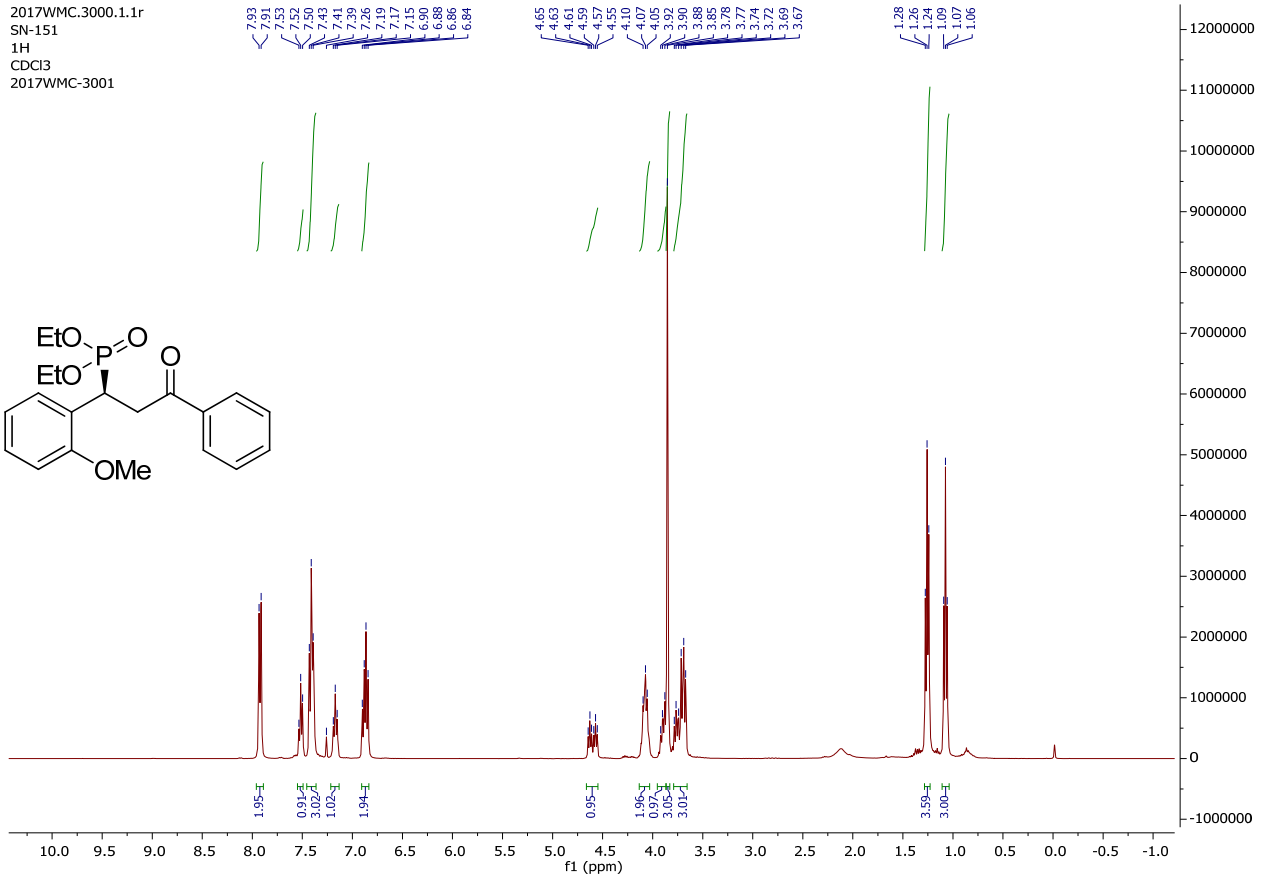
(*S*)-Diethyl 1-(1-naphthyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5ma**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 8.32 (d, *J* = 8.2 Hz, 1H), 7.84 (d, *J* = 8.1 Hz, 1H), 7.76 (d, *J* = 8.2 Hz, 2H), 7.65 – 7.40 (m, 4H), 7.34 – 7.19 (m, 2H), 6.30 – 6.22 (m, 1H), 4.99 – 4.83 (m, 1H), 4.08 (td, *J* = 7.6, 7.1, 3.5 Hz, 2H), 3.75 – 3.72 (m, 3H), 3.42 – 3.28 (m, 1H), 1.27 (t, *J* = 7.1 Hz, 3H), 0.76 (t, *J* = 7.0 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.8 (d, *J* = 16.5 Hz), 133.8, 132.0 (d, *J* = 6.8 Hz), 131.7 (d, *J* = 6.8 Hz), 128.8, 128.1 (d, *J* = 3.8 Hz), 126.4, 125.7, 125.1 (d, *J* = 3.8 Hz), 123.3, 119.0, 116.5, 113.3, 63.2 (d, *J* = 6.8 Hz), 62.1 (d, *J* = 7.5 Hz), 36.3, 33.2 (d, *J* = 140.3 Hz), 16.2 (d, *J* = 6.0 Hz), 15.8 (d, *J* = 5.3 Hz) ppm.

(*S*)-Diethyl 1-(2-naphthyl)-3-oxo-3-pyrrol-1-yl-propylphosphonate (**5na**): **^{1}H NMR** (400 MHz, Chloroform-*d*): δ = 7.91 (d, *J* = 16.5 Hz, 1H), 7.80 (t, *J* = 8.0 Hz, 3H), 7.67 – 7.49 (m, 2H), 7.44 (d, *J* = 6.4 Hz, 2H), 7.34 – 7.16 (m, 2H), 6.25 (s, 1H), 4.10 (d, *J* = 5.9 Hz, 3H), 3.93 – 3.85 (m, 1H), 3.80 – 3.59 (m, 3H), 1.29 (t, *J* = 6.0 Hz, 3H), 1.03 (t, *J* = 6.1 Hz, 3H) ppm; **^{13}C NMR** (100 MHz, Chloroform-*d*): δ = 167.6 (d, *J* = 18.8 Hz), 133.2 (d, *J* = 3.0 Hz), 132.7 (d, *J* = 2.3 Hz), 132.6 (d, *J* = 7.5 Hz), 128.3 (d, *J* = 1.5 Hz), 128.1 (d, *J* = 8.3 Hz), 127.9, 127.6, 127.0 (d, *J* = 5.3 Hz), 126.2, 126.0, 119.0, 113.4, 63.3 (d, *J* = 6.8 Hz), 62.3 (d, *J* = 6.8 Hz), 39.6 (d, *J* = 141.0 Hz), 35.6, 16.3 (d, *J* = 6.0 Hz), 16.1 (d, *J* = 6.0 Hz) ppm.

5. NMR Spectra for All Compounds



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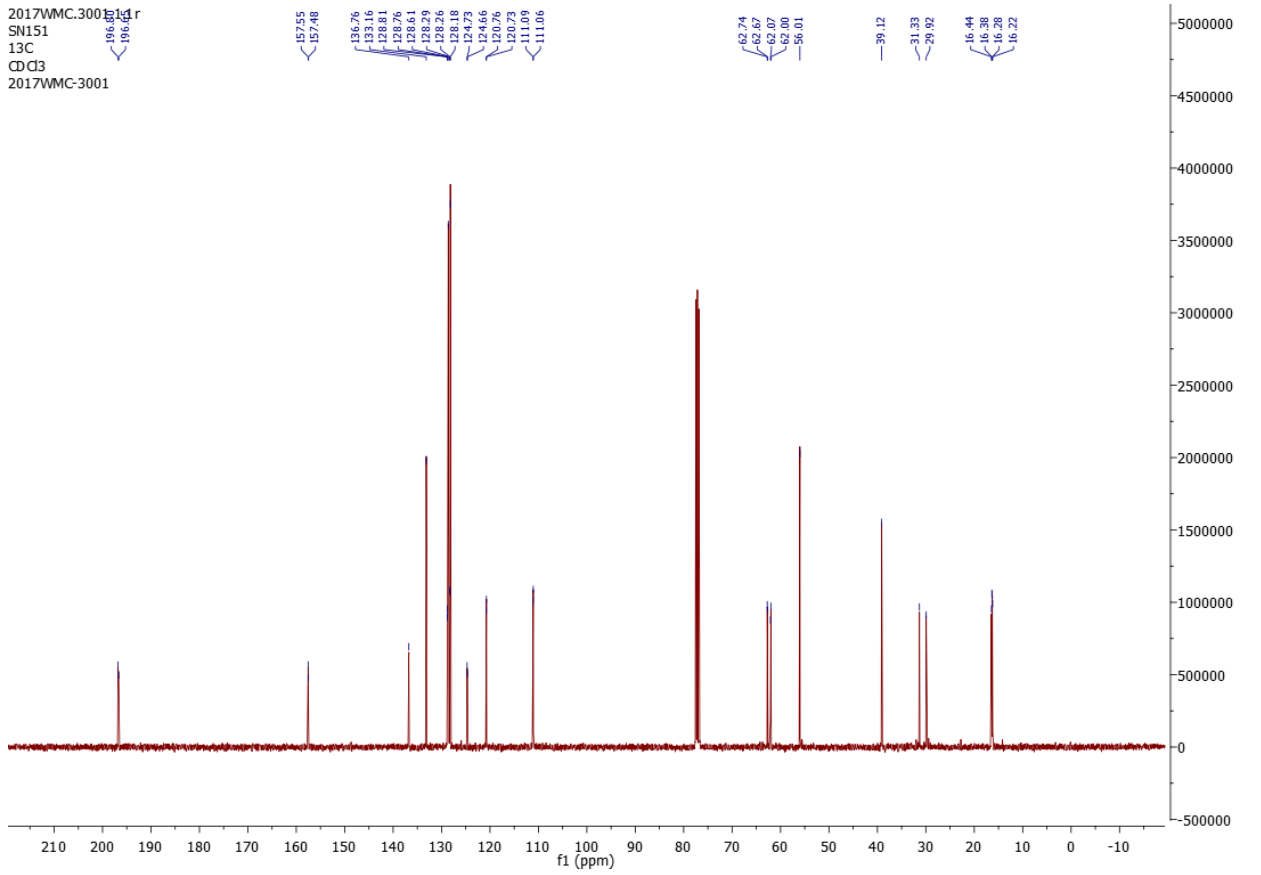
SN-151
1H
CDCl3
2017WMC-3001
EtO
EtO
P
O
O
OMe
f1 (ppm)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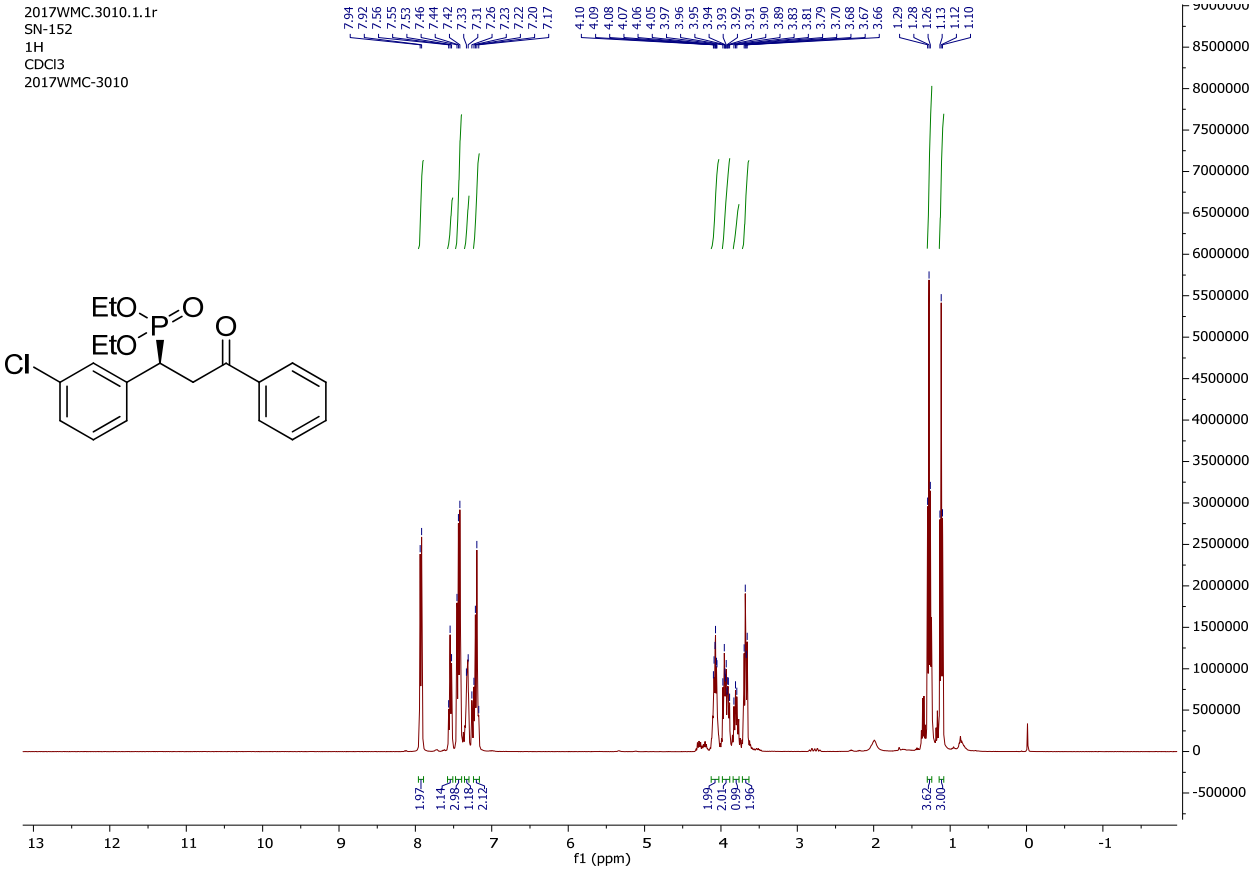
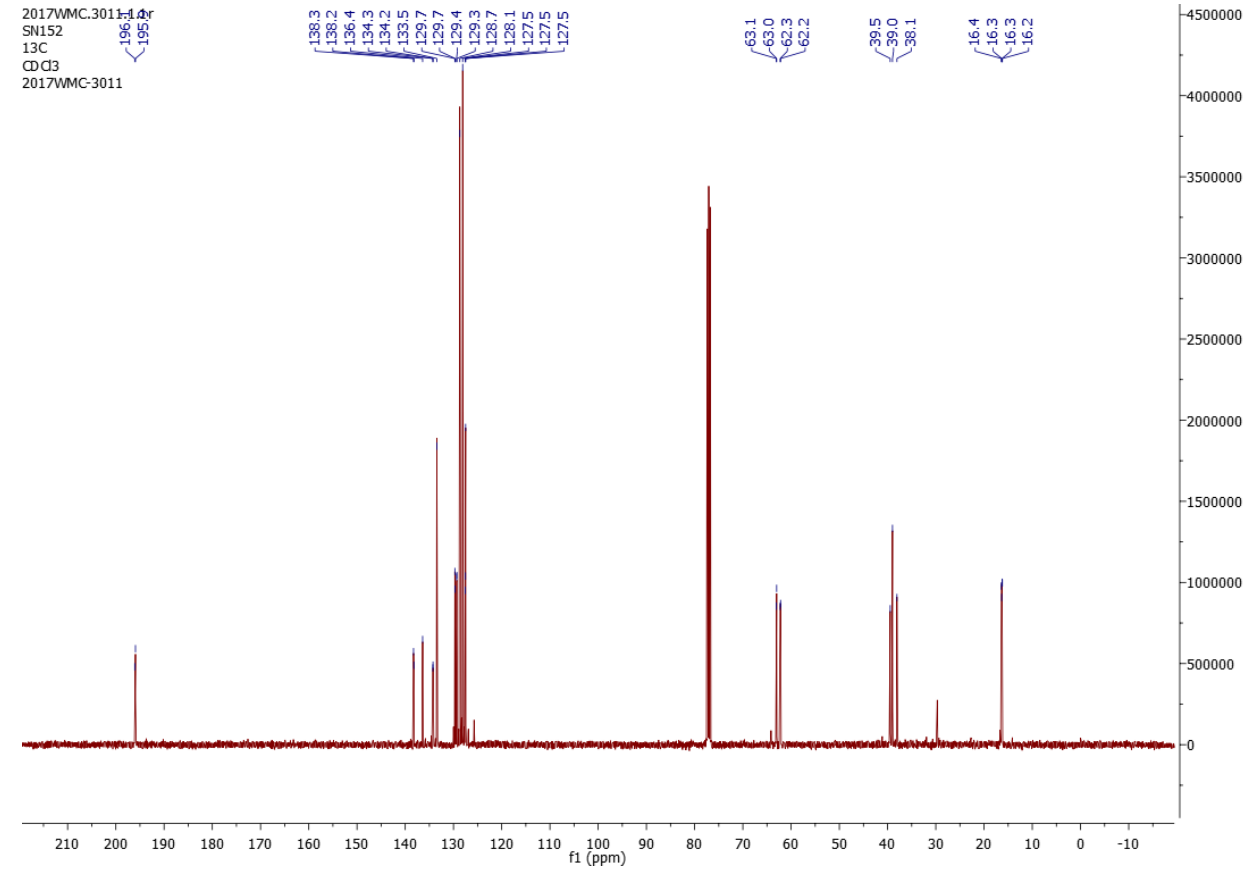
SN151
13C
CDCl3
2017WMC-3001
f1 (ppm)


2017WMC.3010.1.1r
SN-152
1H
CDCl3
2017WMC-3010
EtO
EtO
P
O
O
Cl
f1 (ppm)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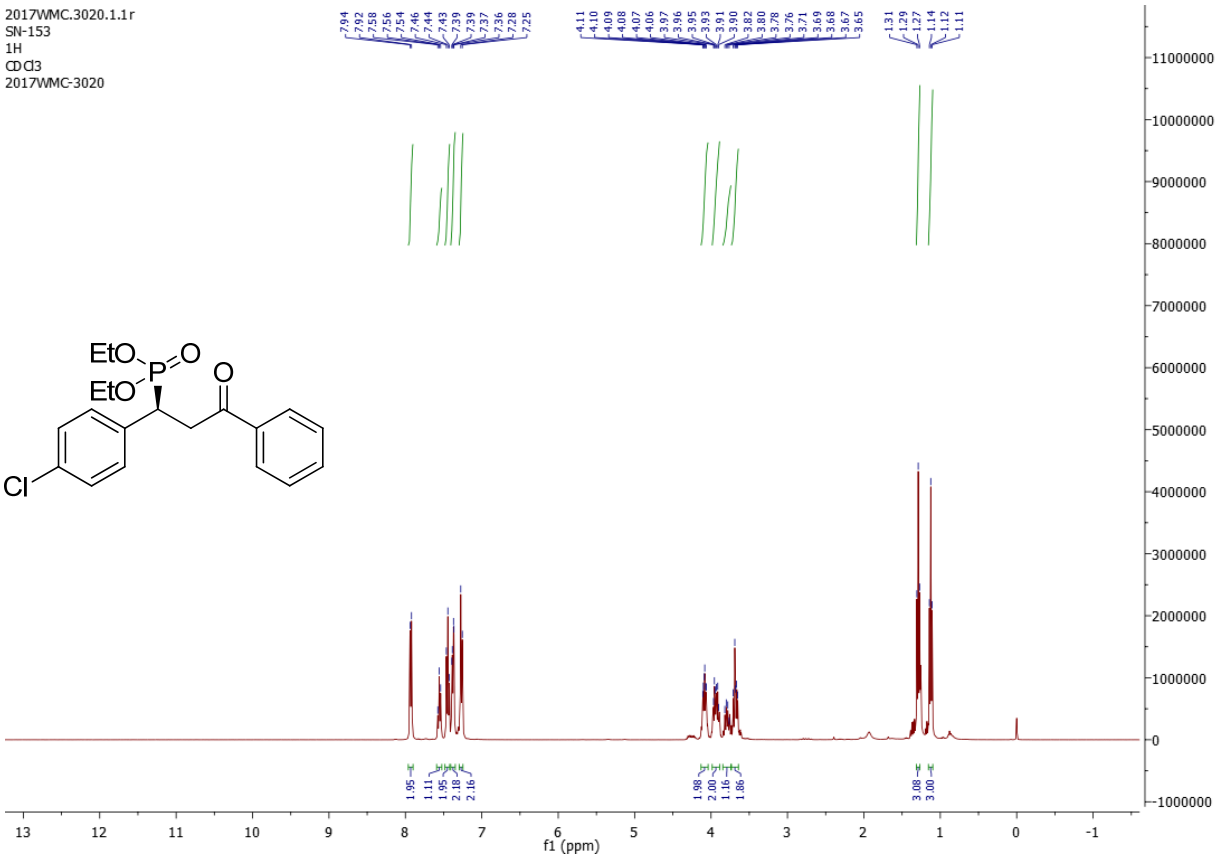
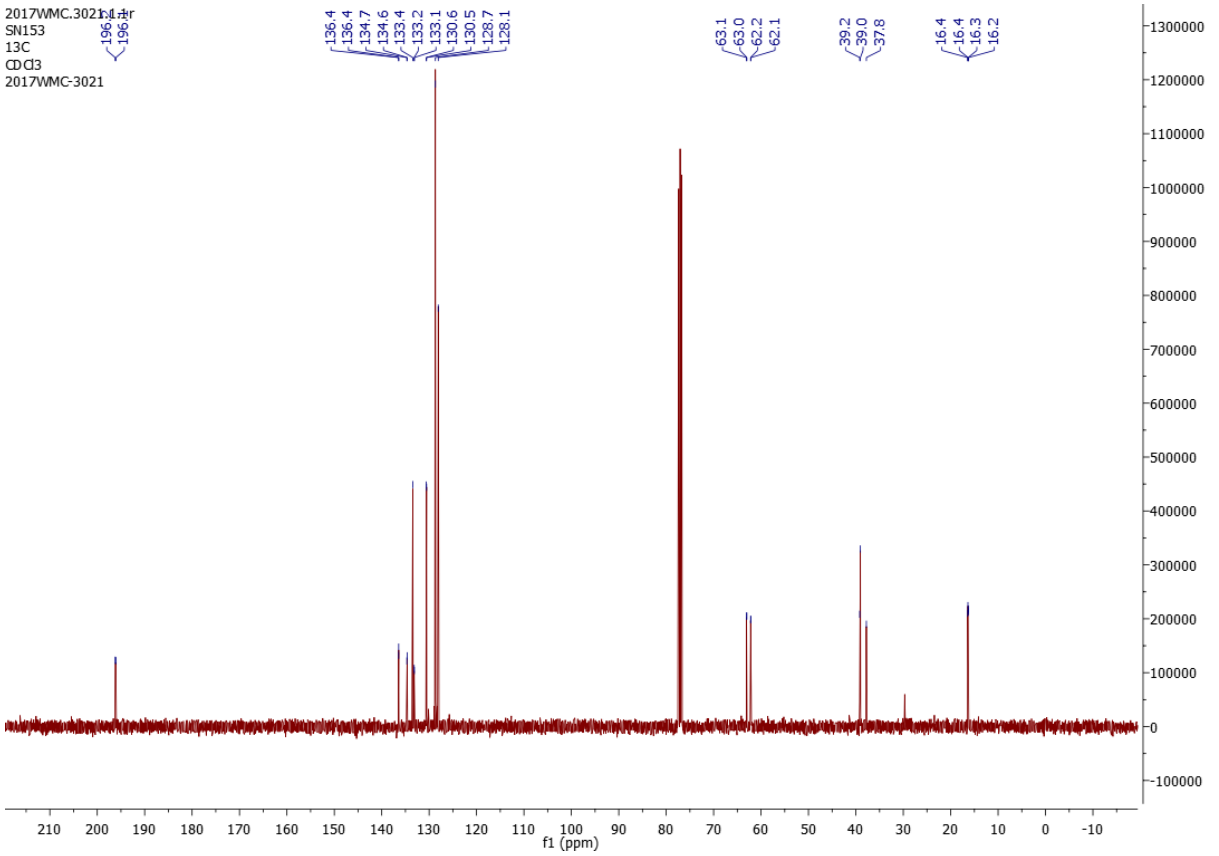
SN152
13C
CDCl3
2017WMC-3011
f1 (ppm)


2017WMC.3020.1.1r
SN-153
1H
CDCl3
2017WMC-3020
EtO
EtO
P
O
O
Cl
f1 (ppm)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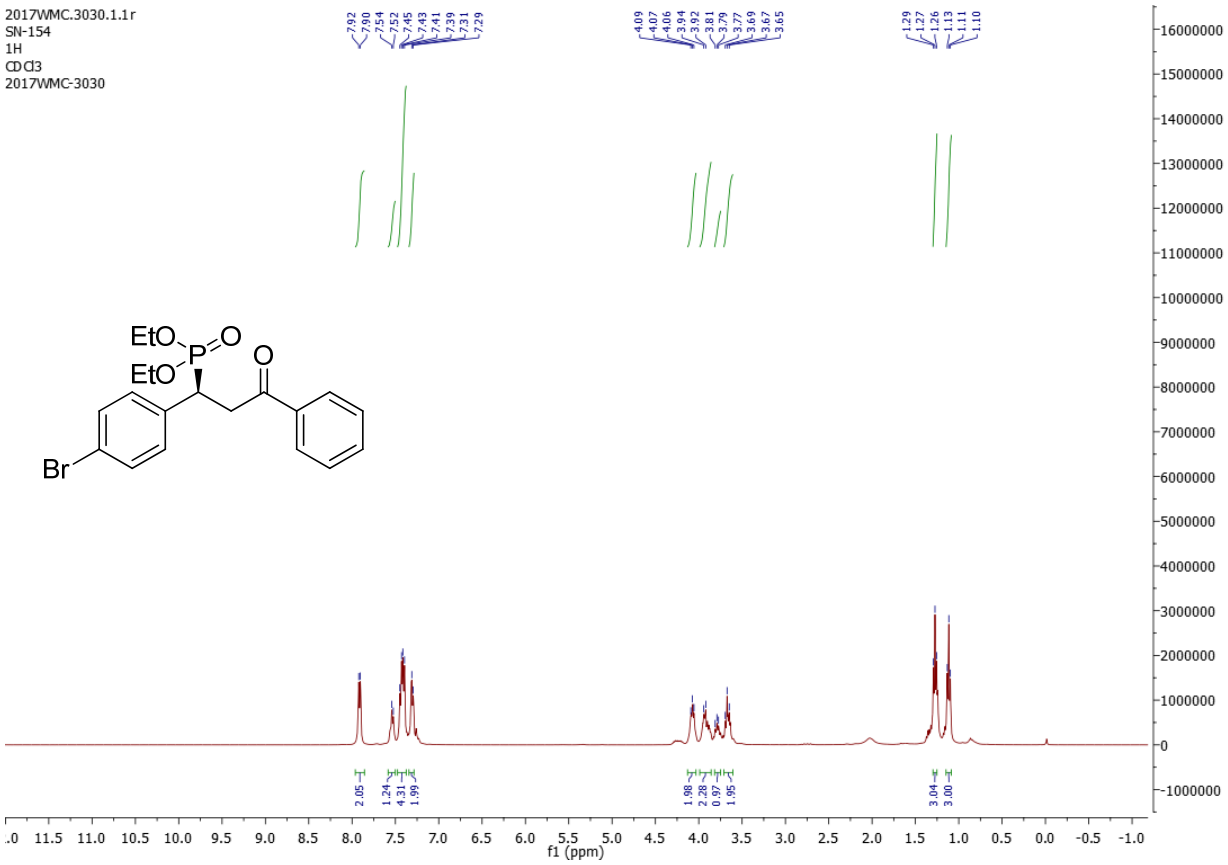
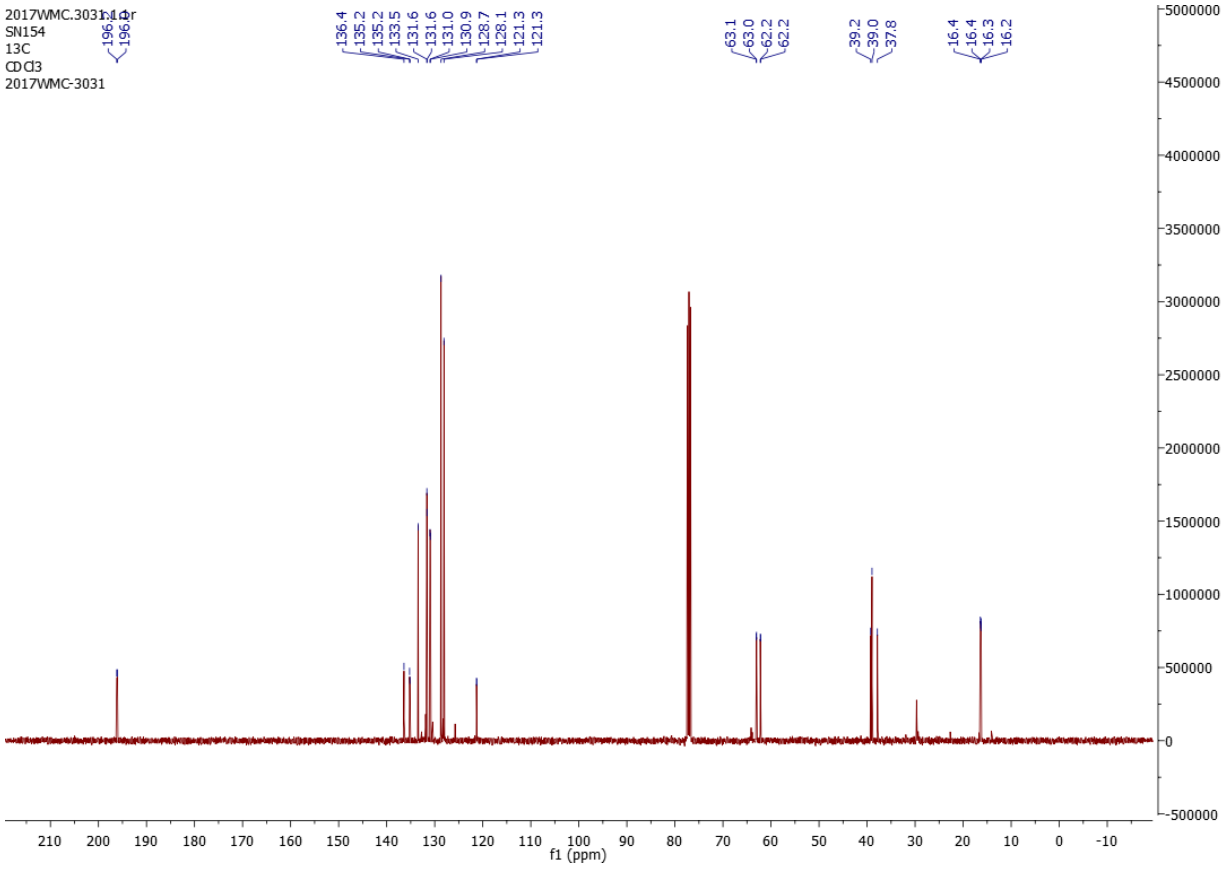
SN153
13C
CDCl3
2017WMC-3021
f1 (ppm)


2017WMC.3030.1.1r
SN-154
1H
CDCl3
2017WMC-3030
EtO
EtO
P
O
O
Br
f1 (ppm)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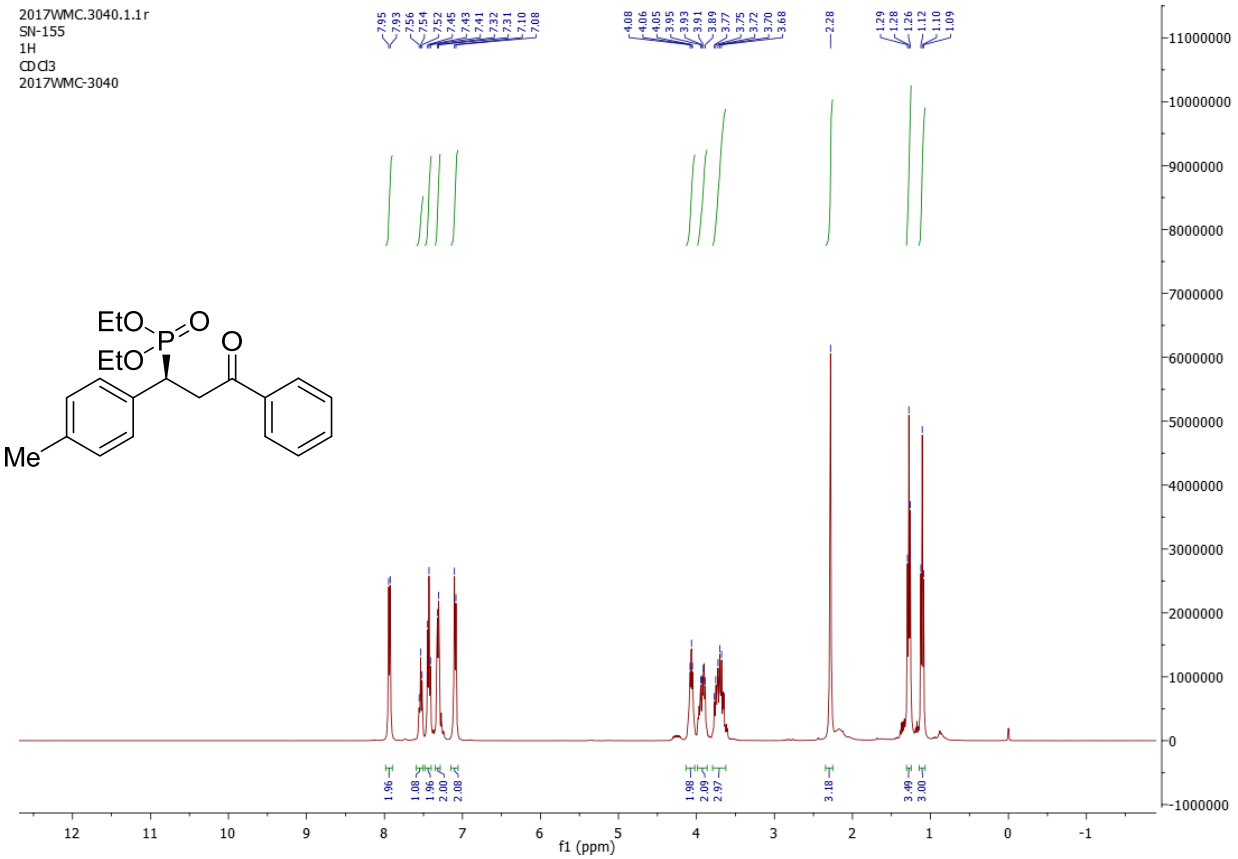
SN154
13C
CDCl3
2017WMC-3031
f1 (ppm)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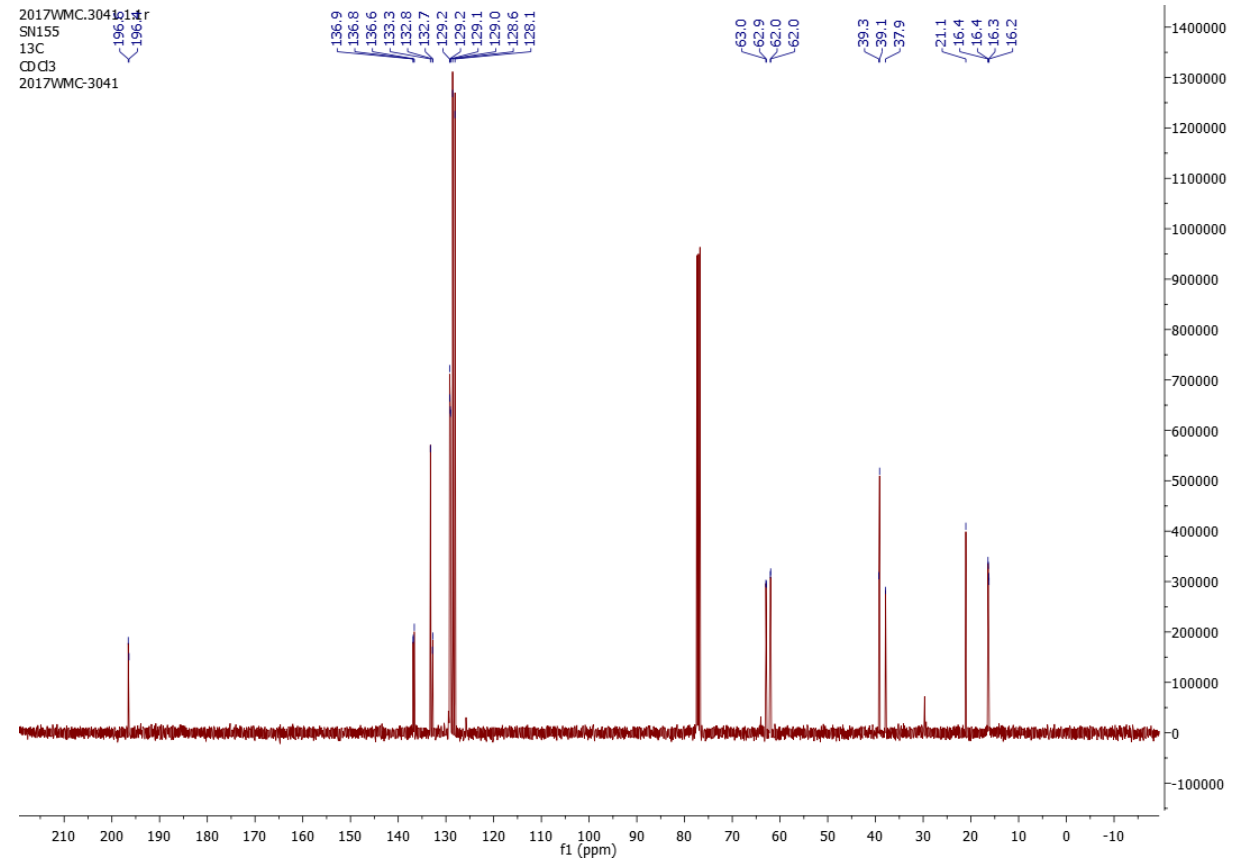
SN-155
1H
CDCl3
2017WMC-3040
EtO
EtO
P
O
O
Me
f1 (ppm)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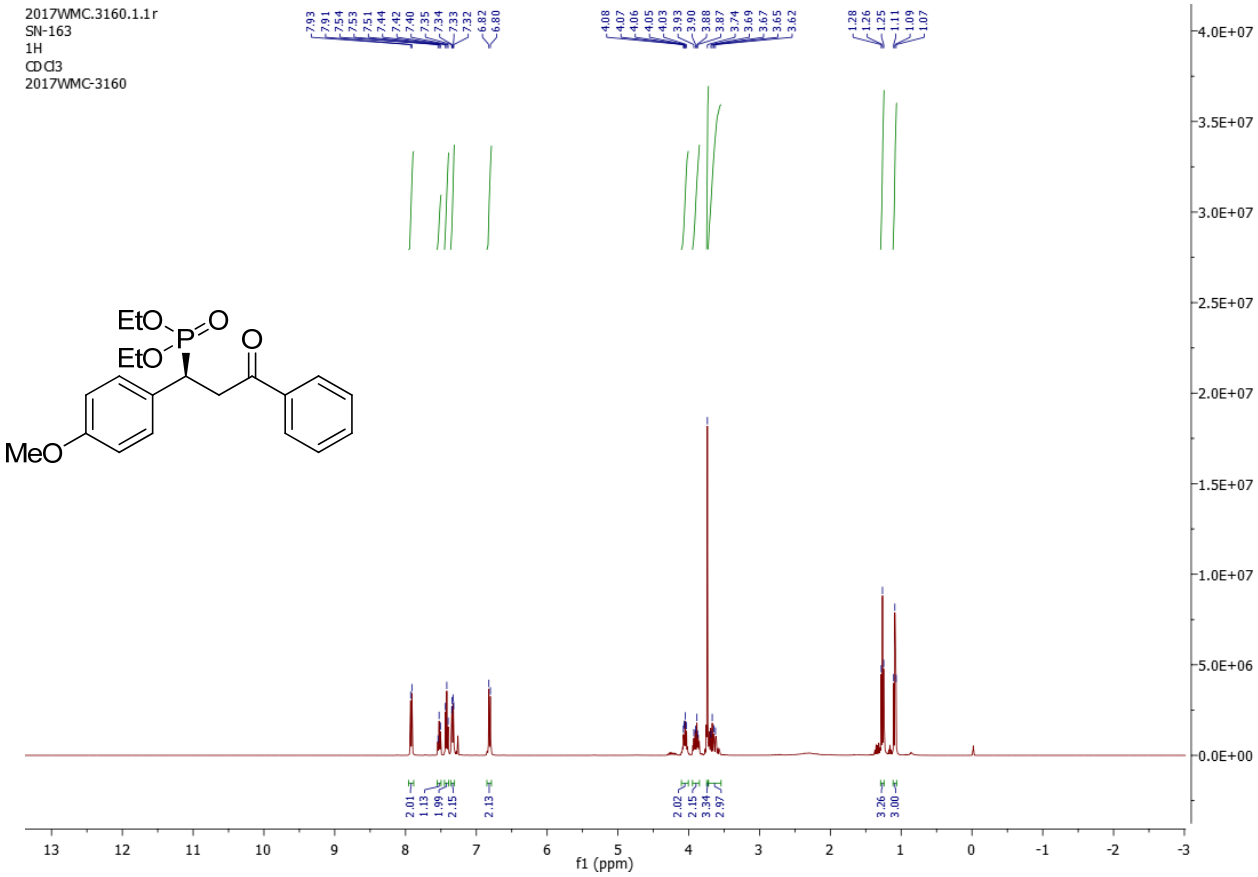
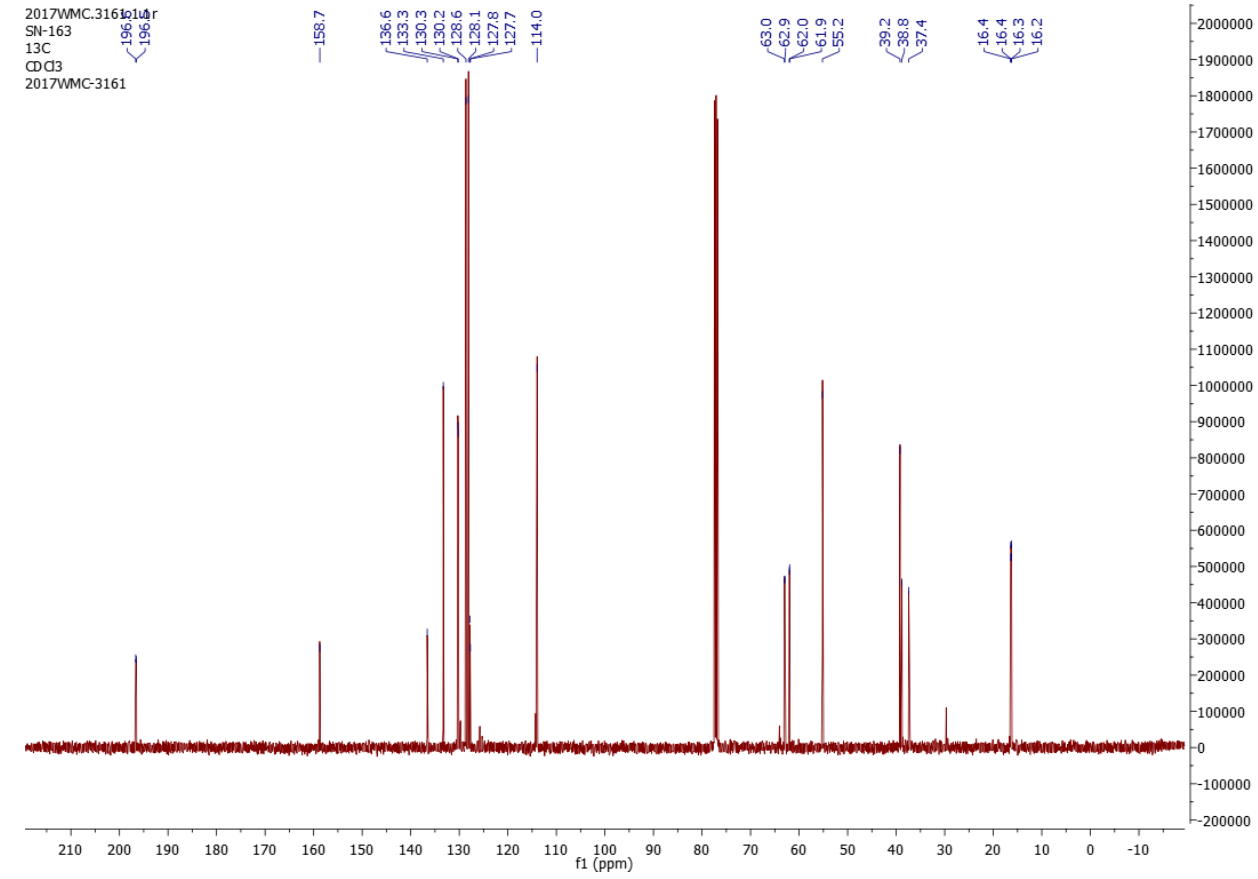
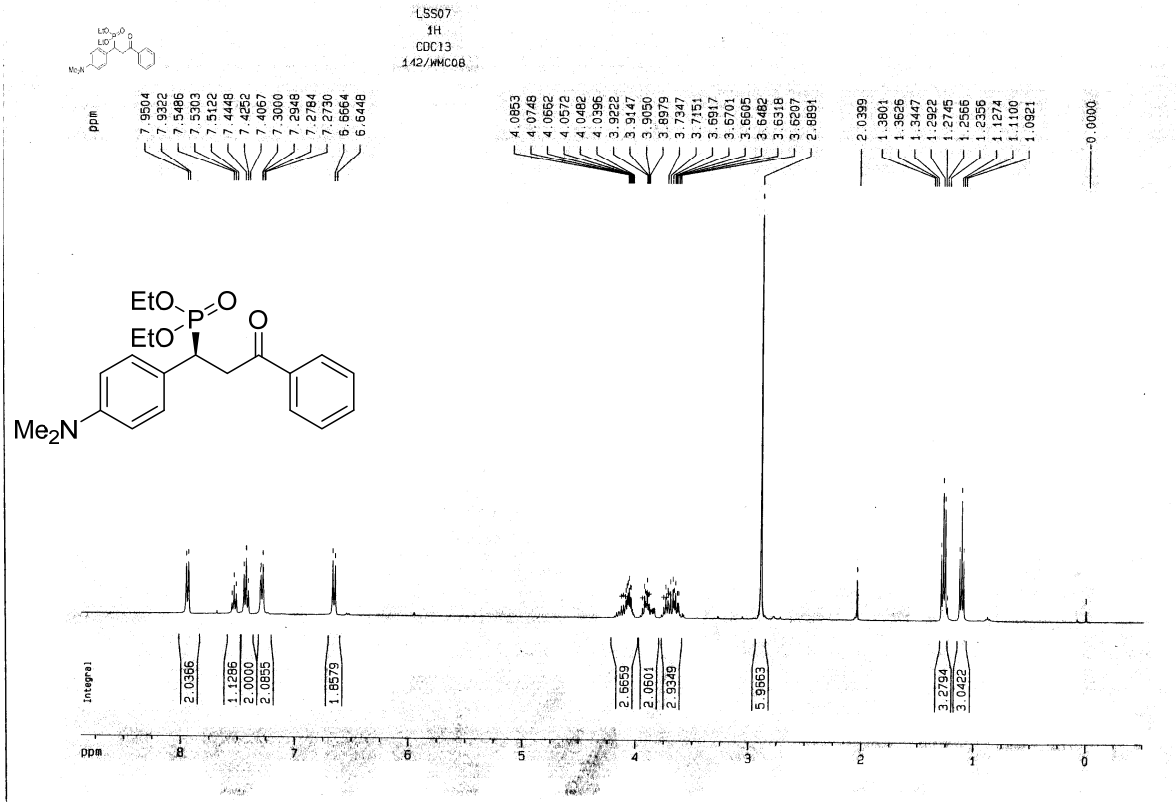
SN155
13C
CDCl3
2017WMC-3041
f1 (ppm)


2017WMC.3160.1.1r
SN-163
1H
CDCl3
2017WMC-3160
EtO
EtO
P
O
O
MeO
f1 (ppm)


2017WMC.3161.1.1r
SN-163
13C
CDCl3
2017WMC-3161
f1 (ppm)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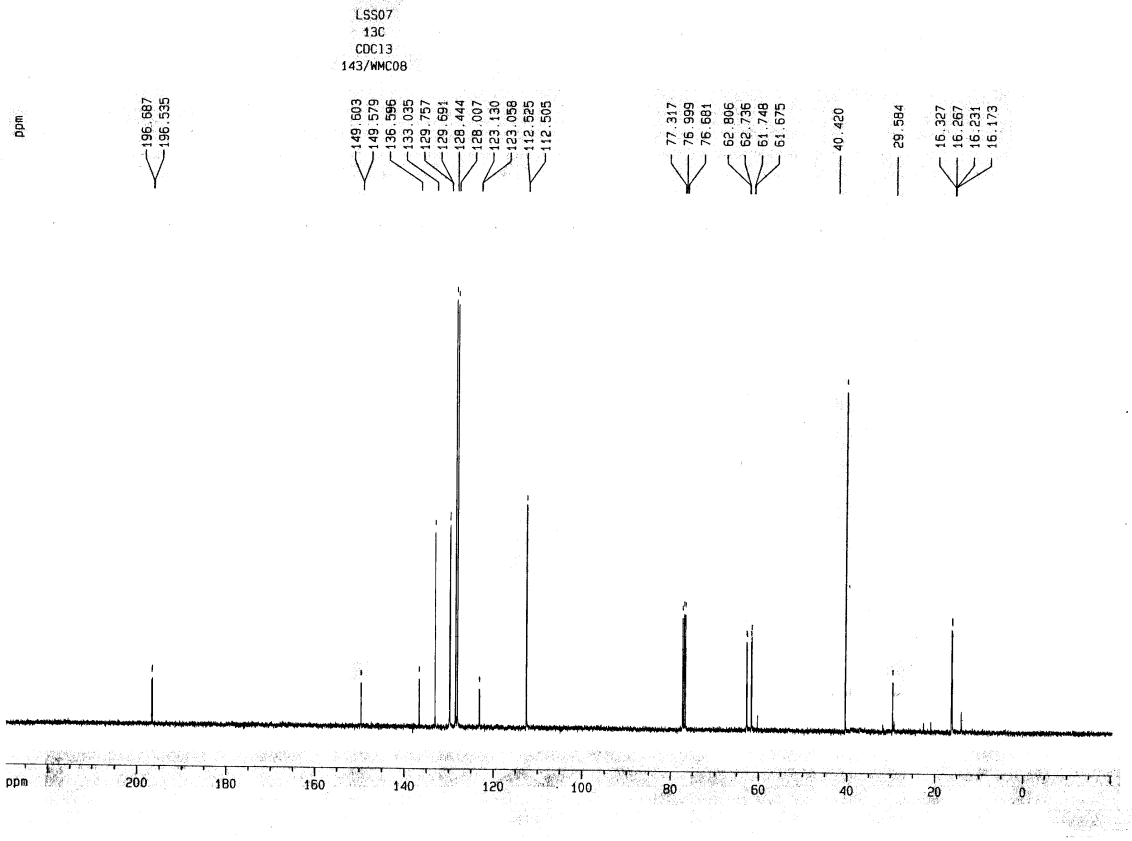
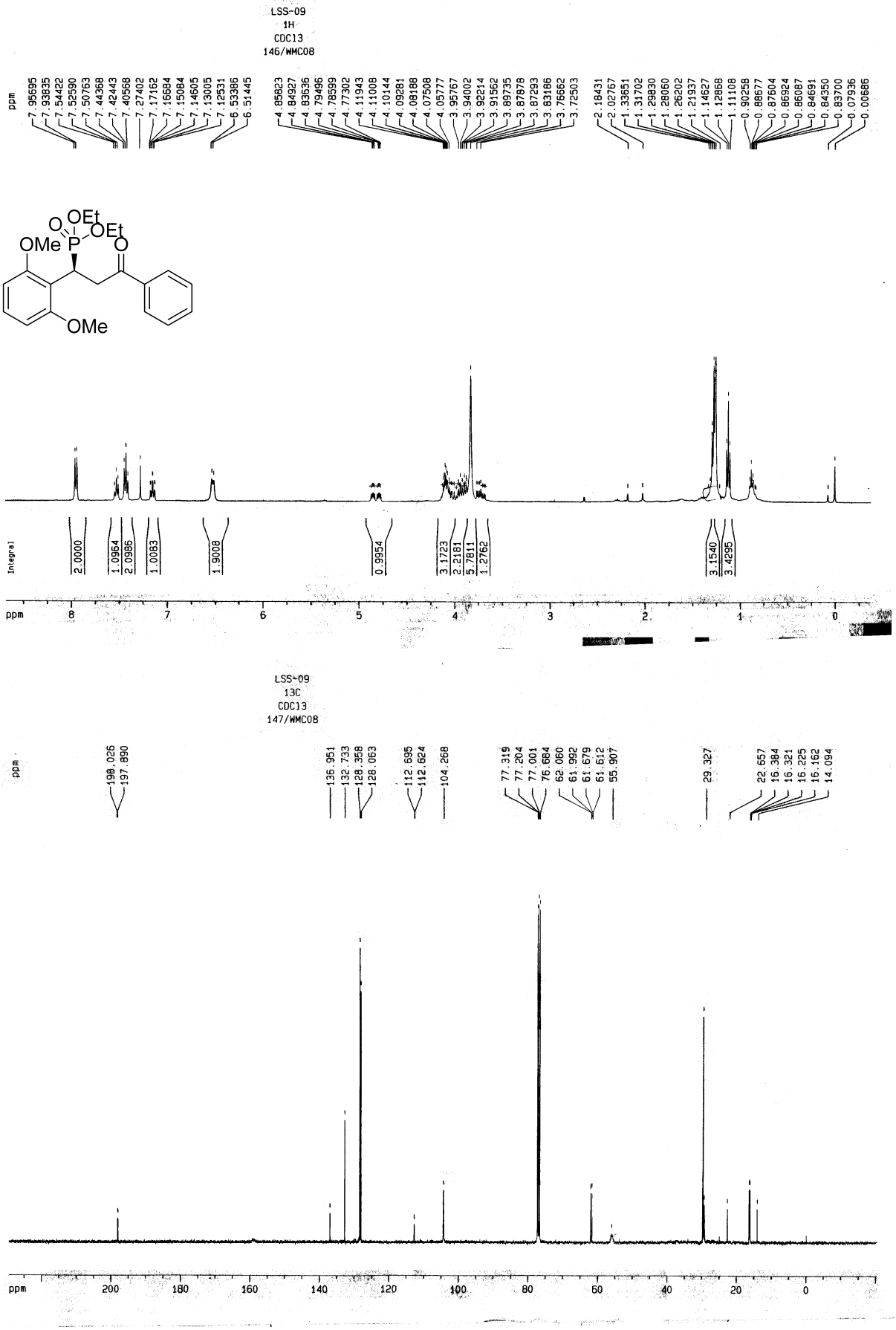
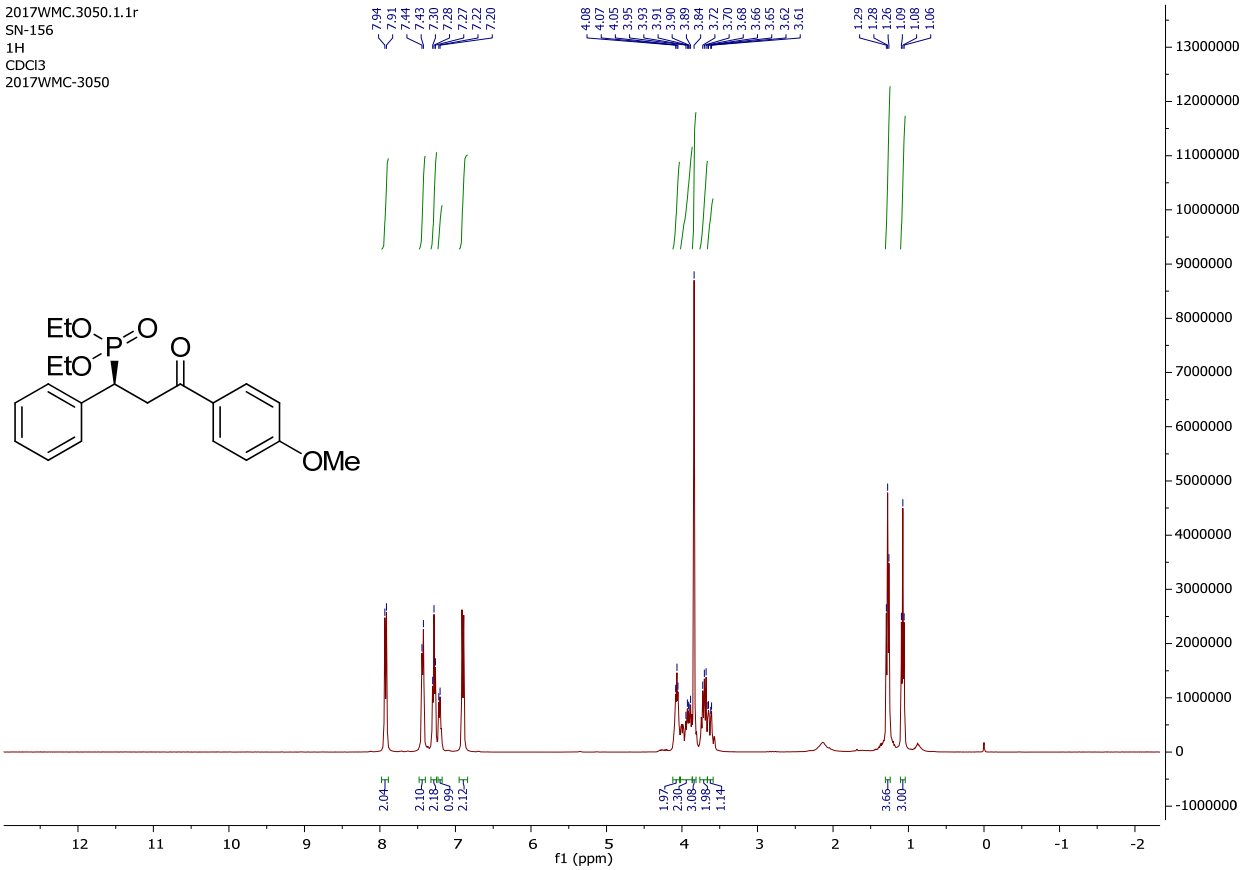
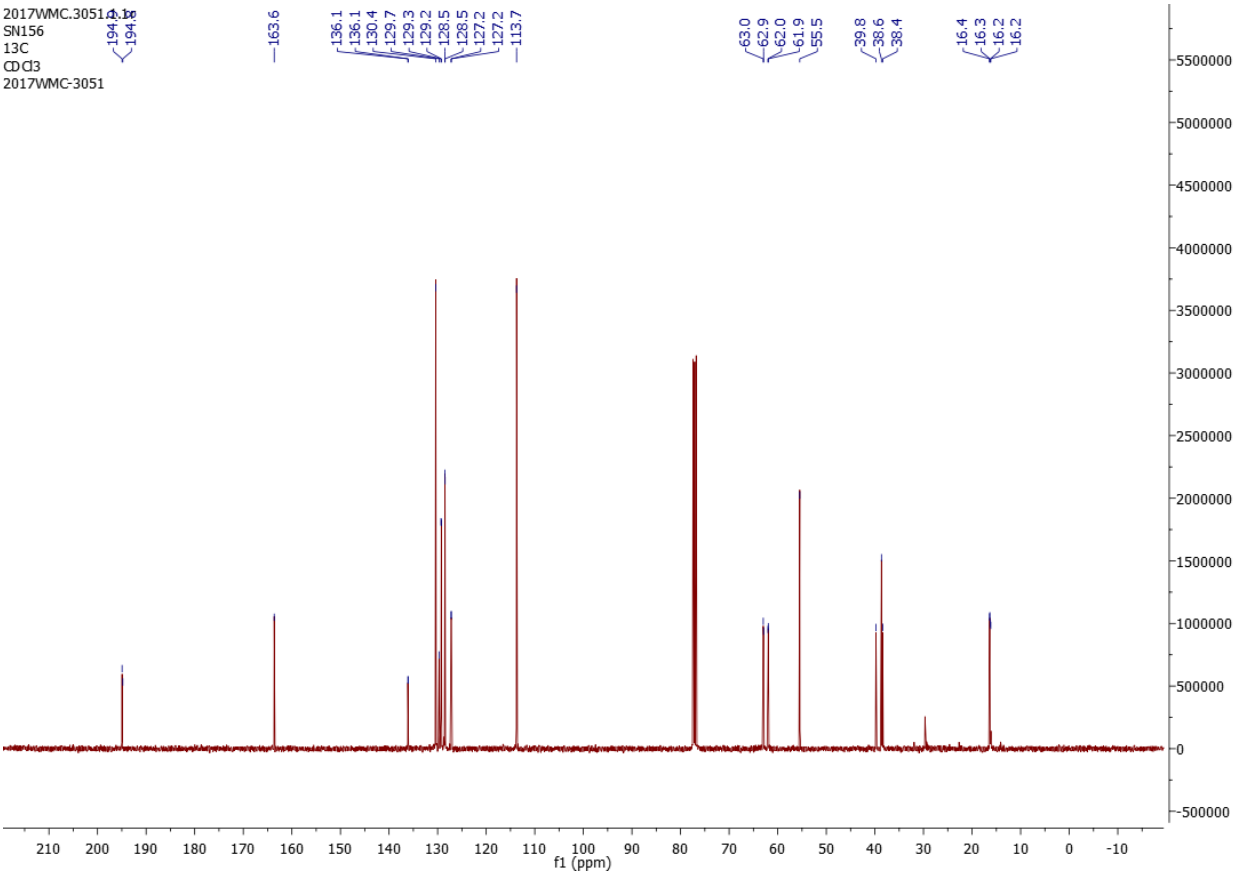
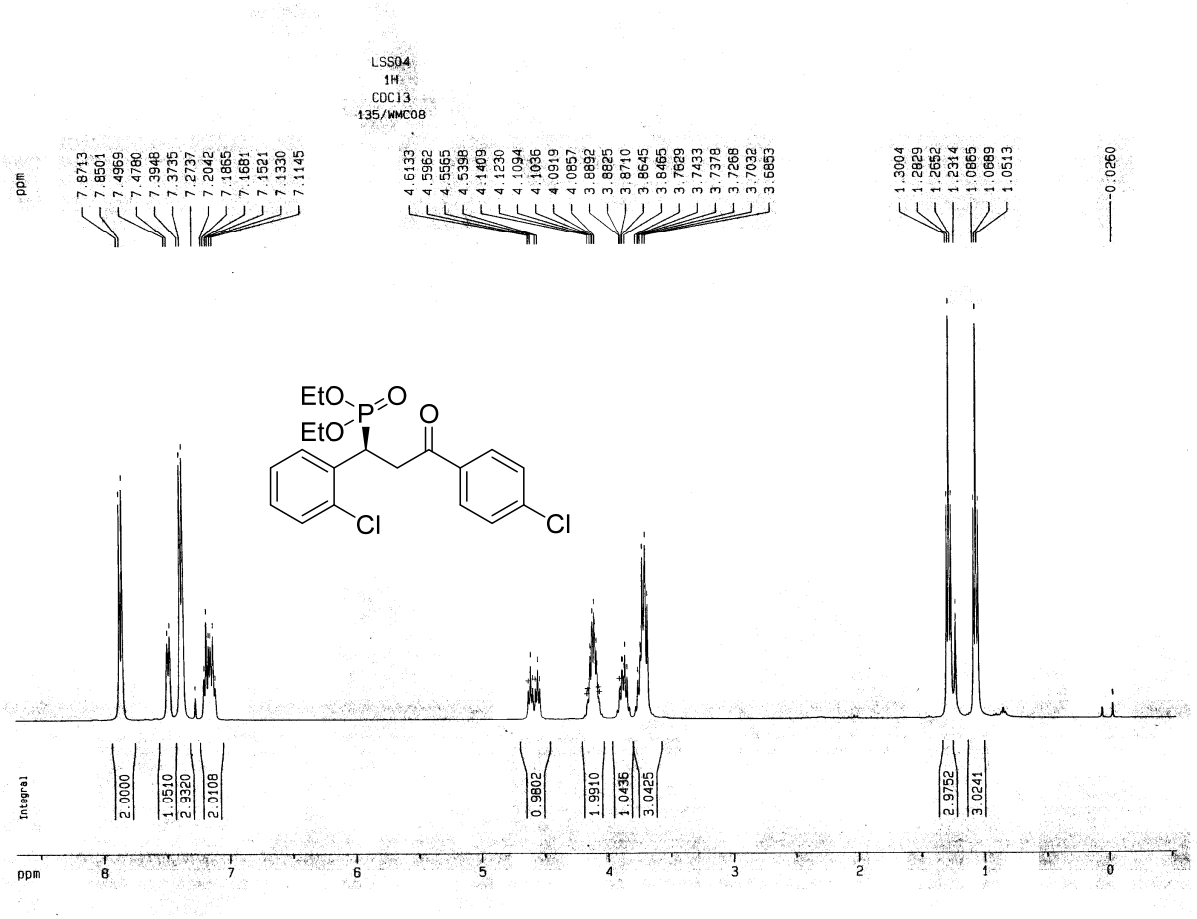
1H
CDCl3
142/WMC08
EtO
EtO
P
O
O
Me2N
ppm
integral


LSS07
13C
CDCl3
143/WMC08
ppm


LSS-09
1H
CDCl3
146/WMC08
LSS-09
13C
CDCl3
147/WMC08
OEt
OEt
OMe
OMe
O
O
P
Integral
ppm


2017WMC.3050.1.1r
SN-156
1H
CDCl3
2017WMC-3050
EtO
EtO
P
O
O
OMe
f1 (ppm)


SN156
13C
CDCl3
2017WMC-3051
f1 (ppm)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1H
CDCl3
135/WMC08
EtO
EtO
P
O
O
Cl
Cl
Integral
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2.0108
0.9802
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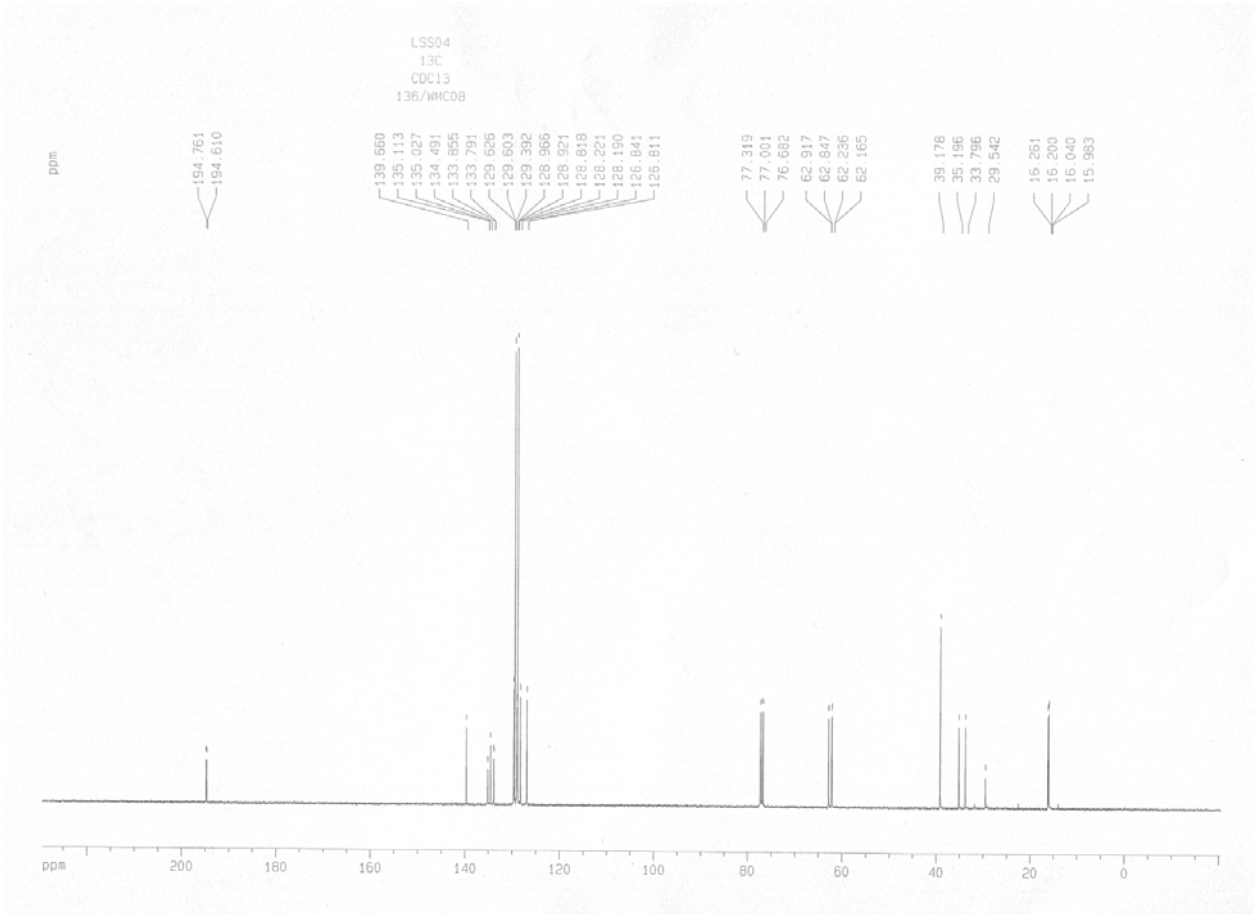
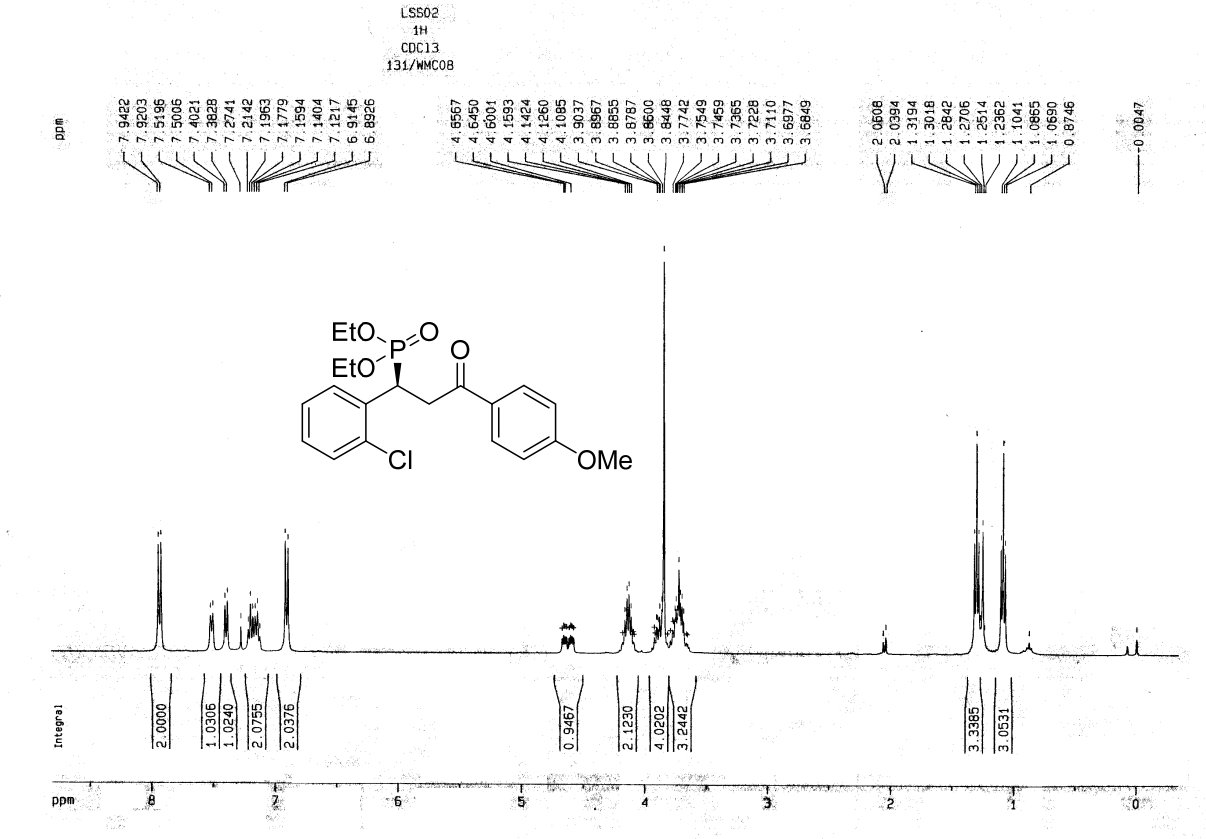
1.0436
3.0425
2.9752
3.0241
ppm


LSS04
13C
CDCl3
136/WMC08
ppm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1H
CDCl3
131/WMC08
EtO
EtO
P
O
O
Cl
OMe
Integral
2.0000
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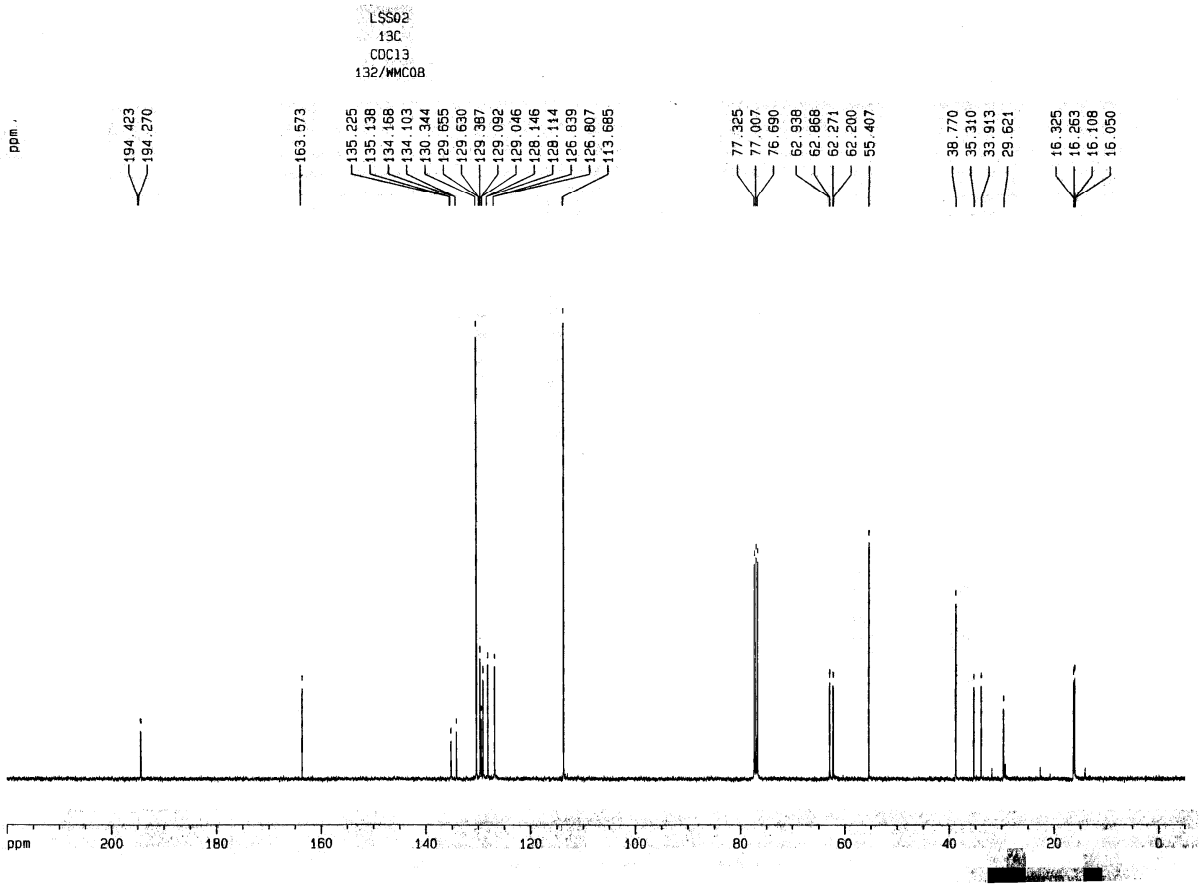
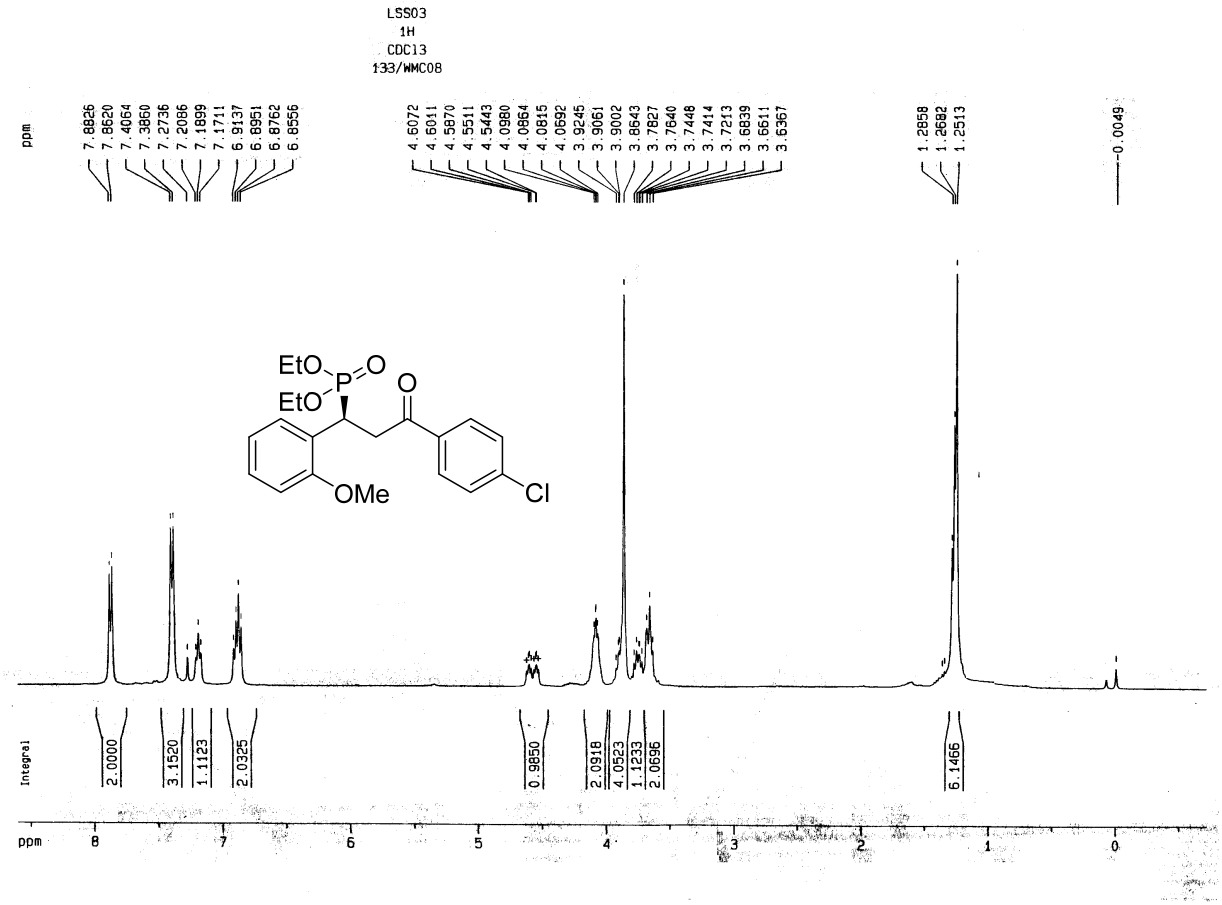
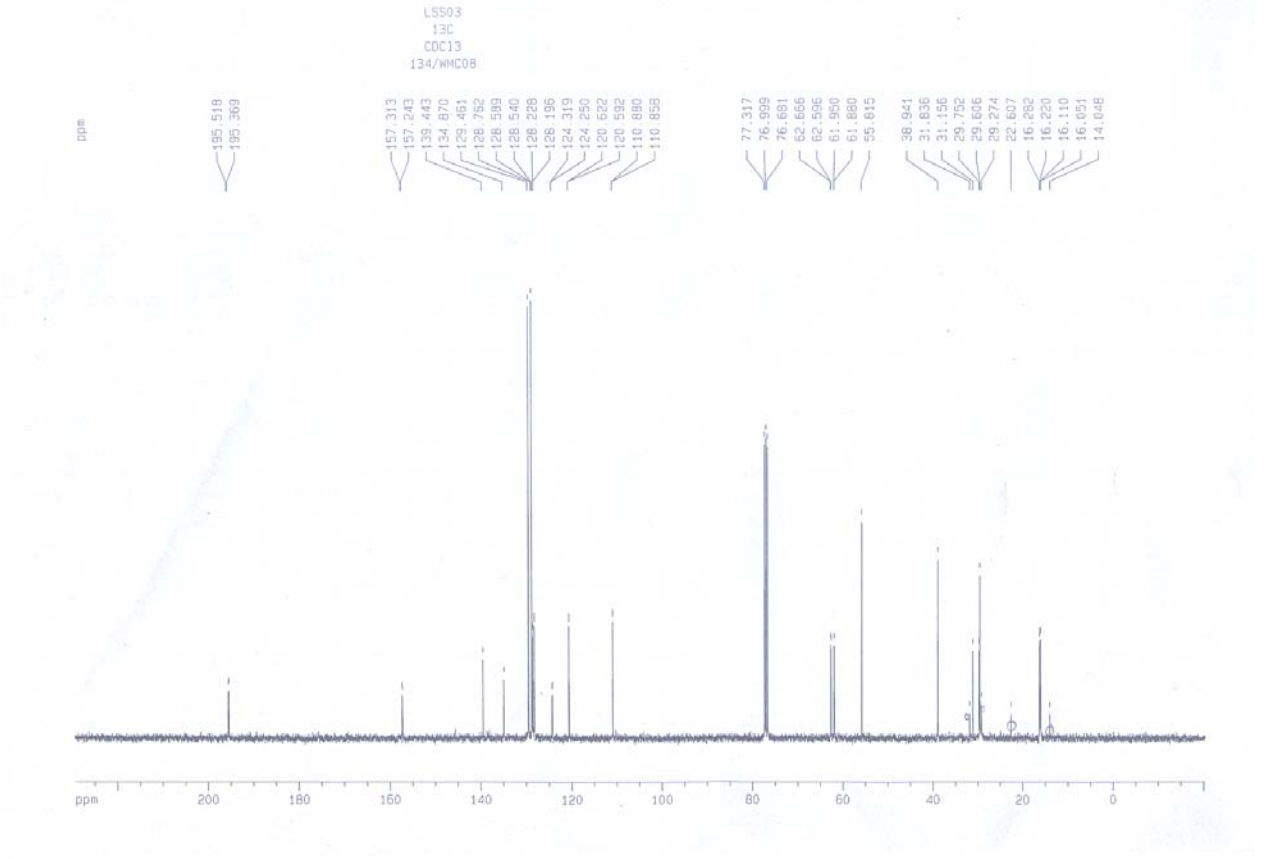
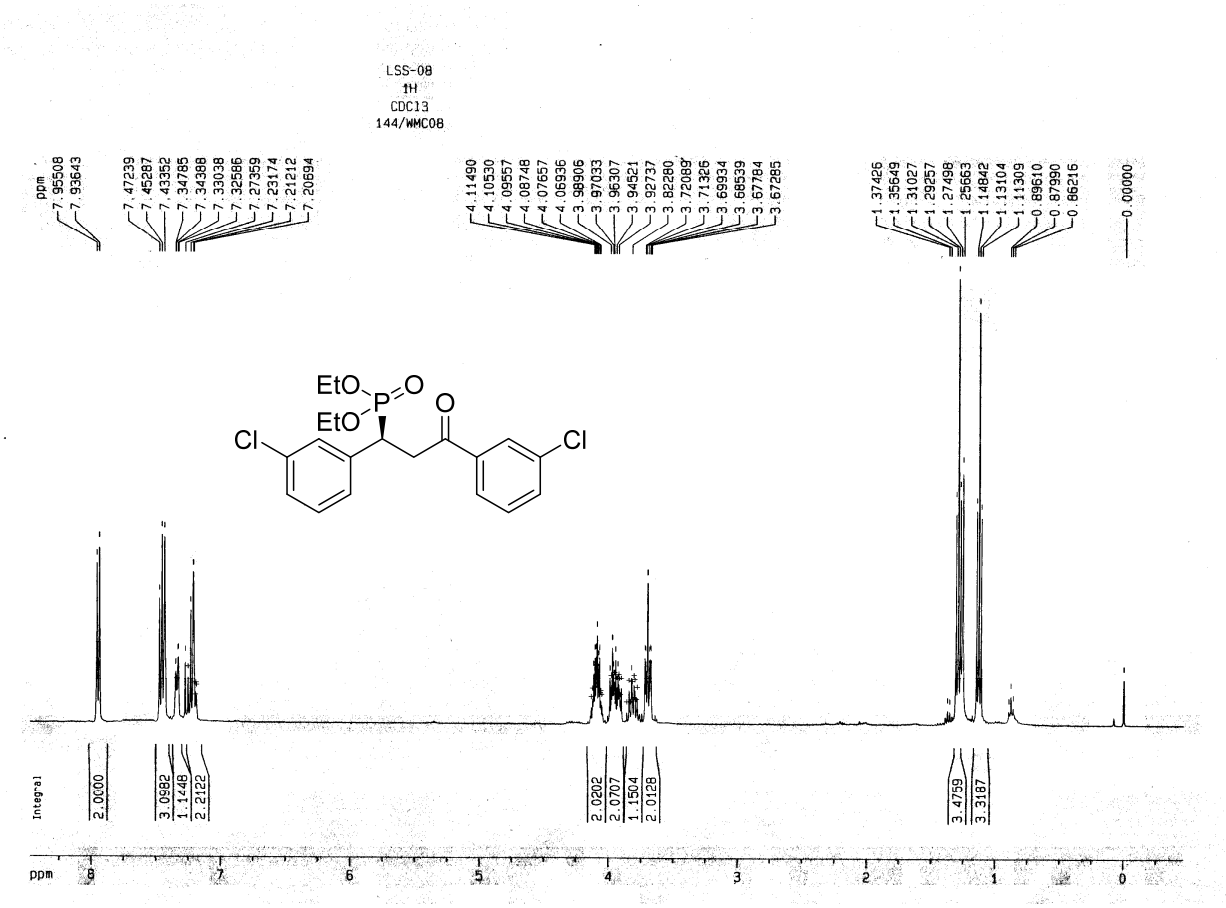
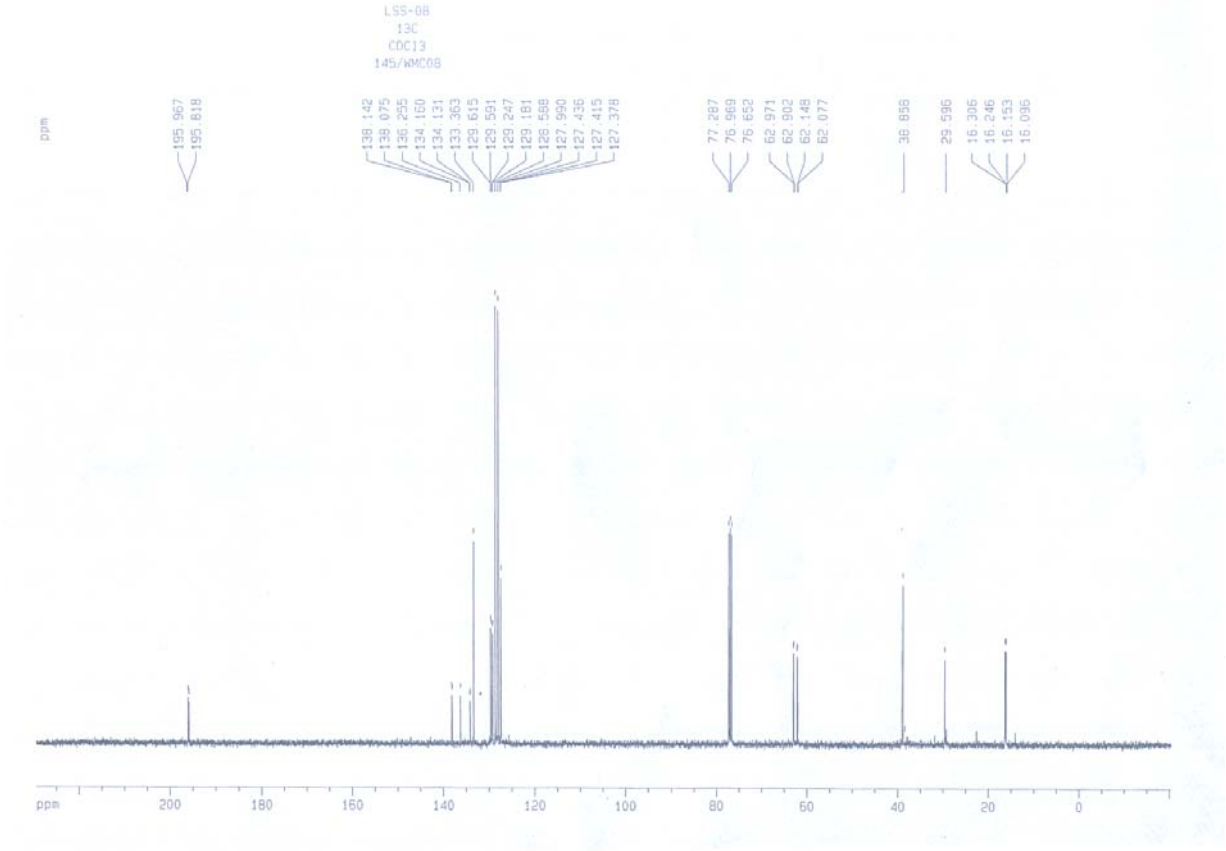
1.0240
2.0755
2.0376
0.9467
2.1230
4.0202
3.2442
3.3365
3.0531
ppm

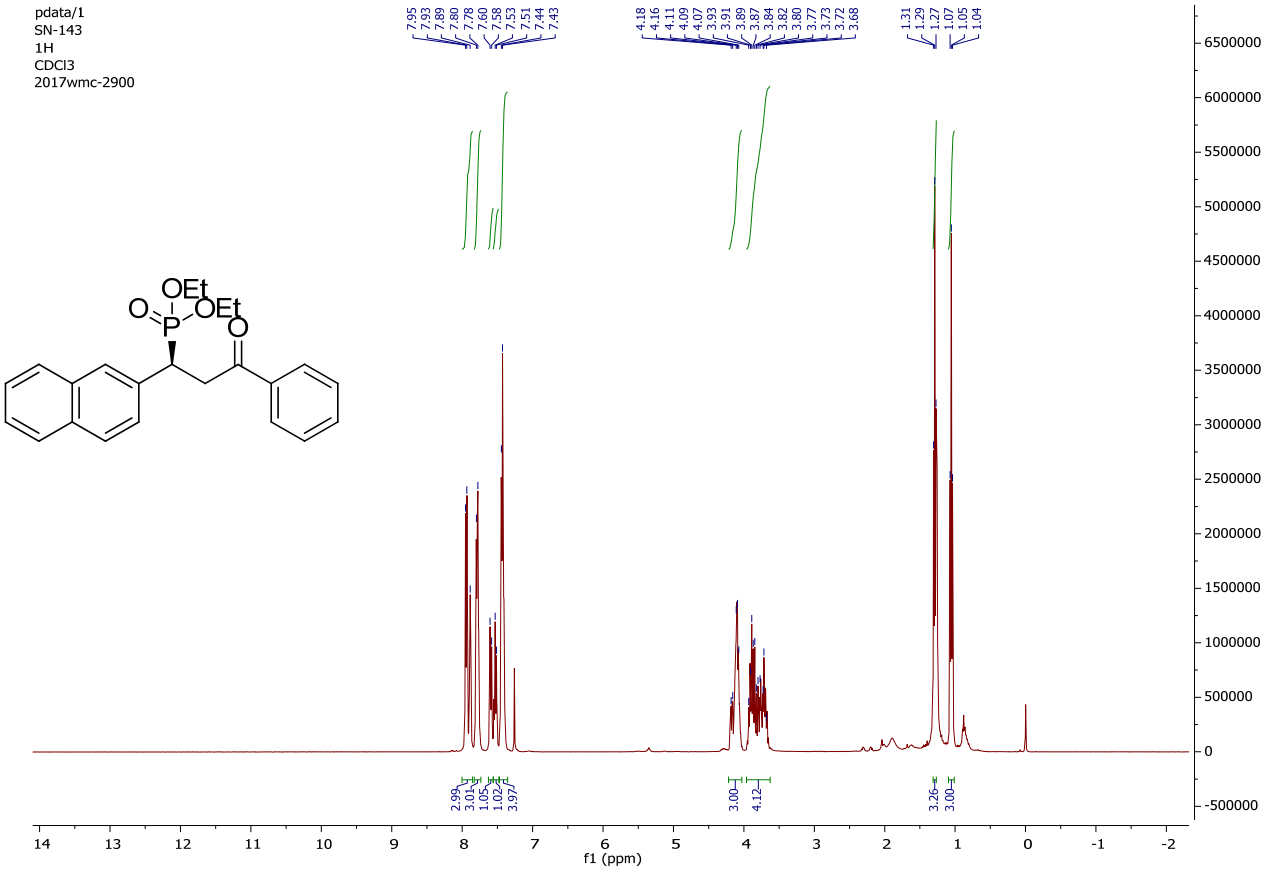

LSS02
13C
CDCl3
132/WMC08
ppm
194.423
194.270
163.573
135.225
135.138
134.168
134.103
130.344
129.655
129.630
129.387
129.092
129.046
128.146
128.114
126.839
126.807
113.685
77.325
77.007
76.690
62.938
62.868
62.271
62.200
55.407
38.770
35.310
33.913
29.621
16.325
16.263
16.108
16.050
ppm

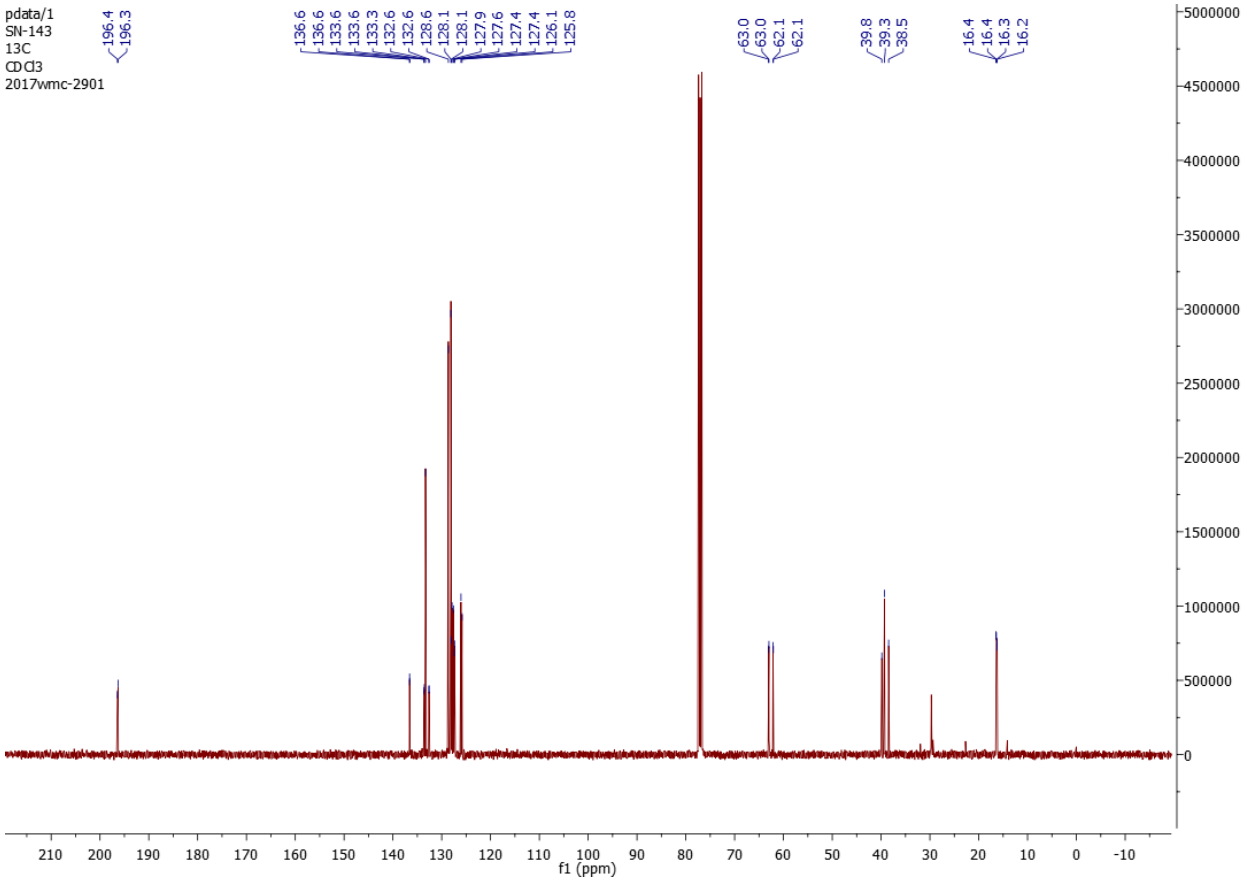

LSS03
1H
CDC13
133/WMC08
EtO
EtO
P
O
O
OMe
Cl
Integral
2.0000
3.1520
1.1123
2.0325
0.9850
2.0918
4.0523
1.1233
2.0696
6.1466
ppm

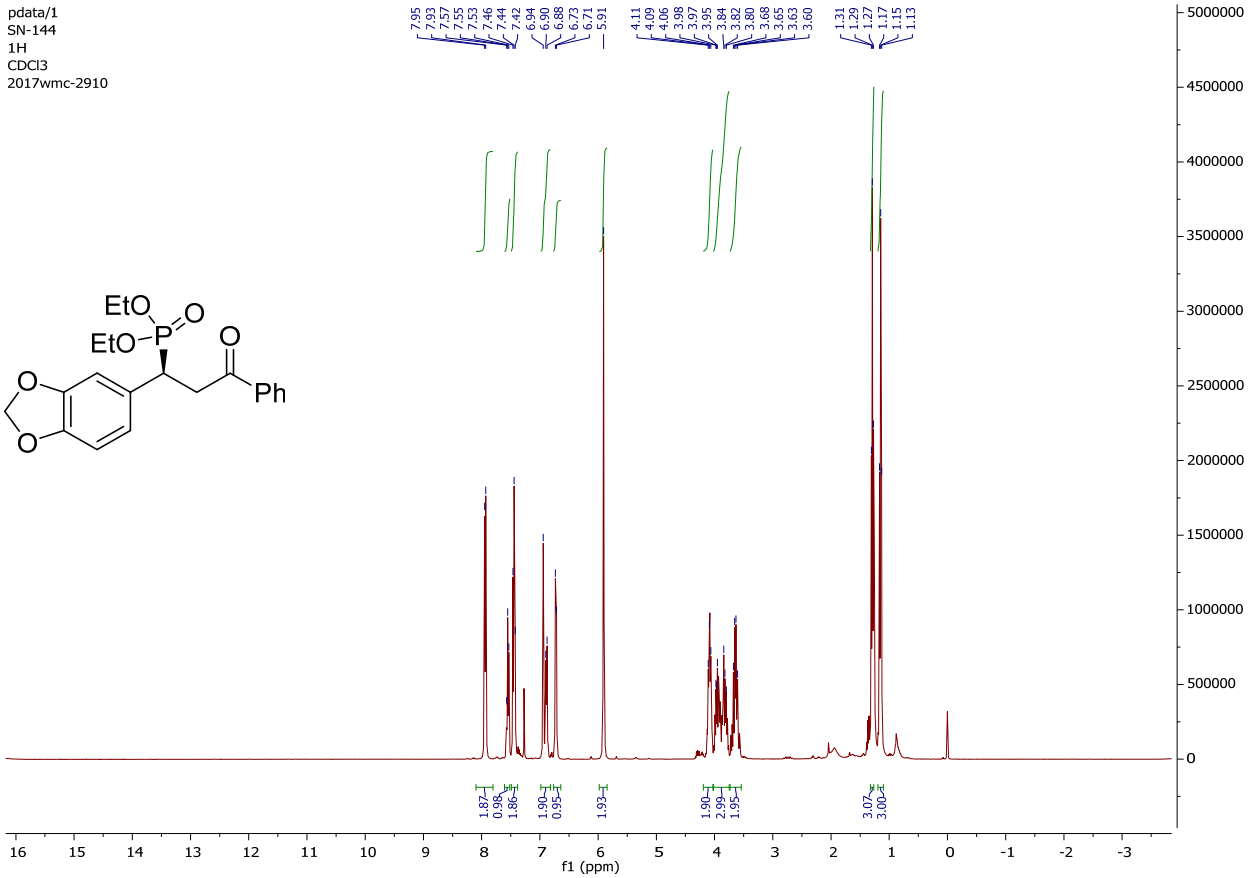

LSS03
13C
CDC13
134/WMC08
ppm

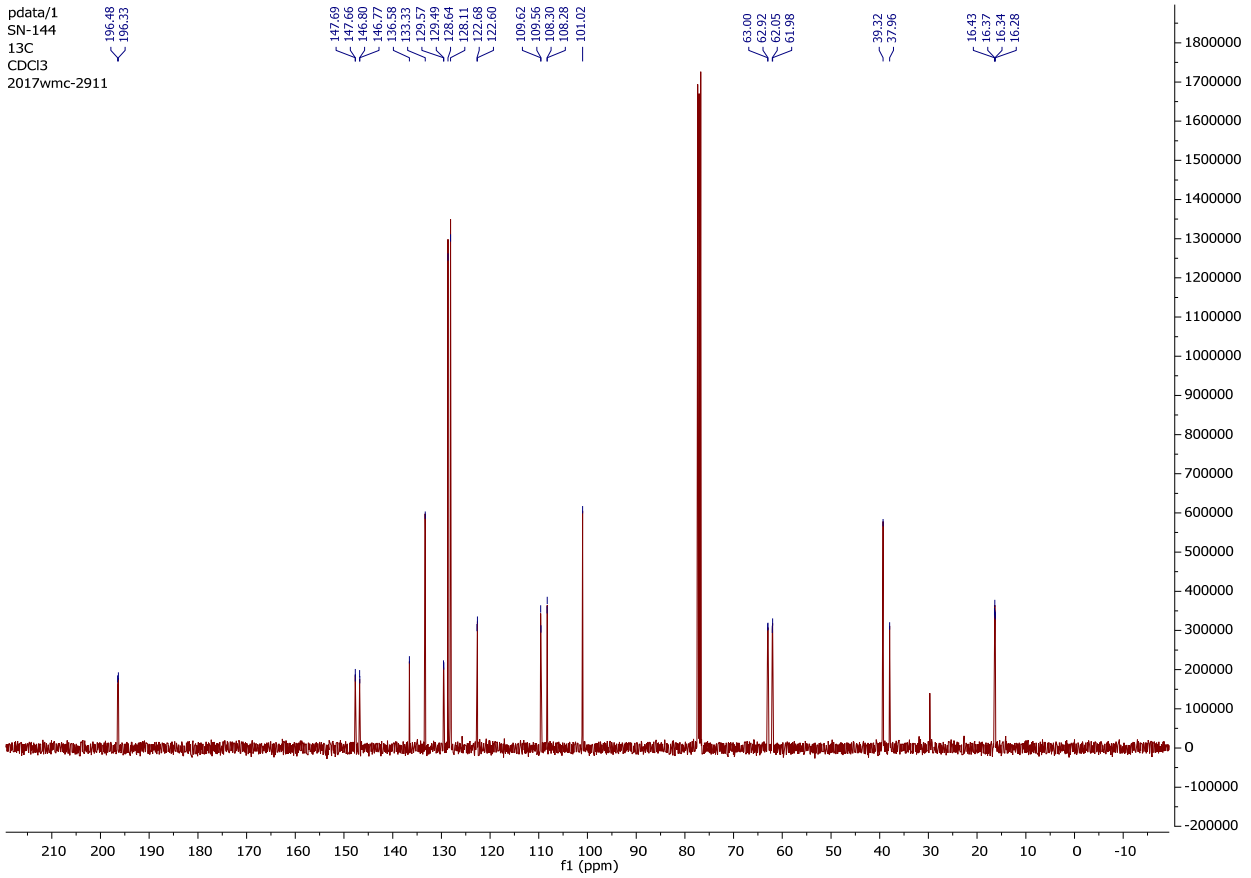

LSS-08
1H
CDCl3
144/WMC08
EtO
EtO
P
O
O
Cl
Cl
Integral
2.0000
3.0982
1.1448
2.2122
2.0202
2.0707
1.1504
2.0128
3.4759
3.3187
ppm

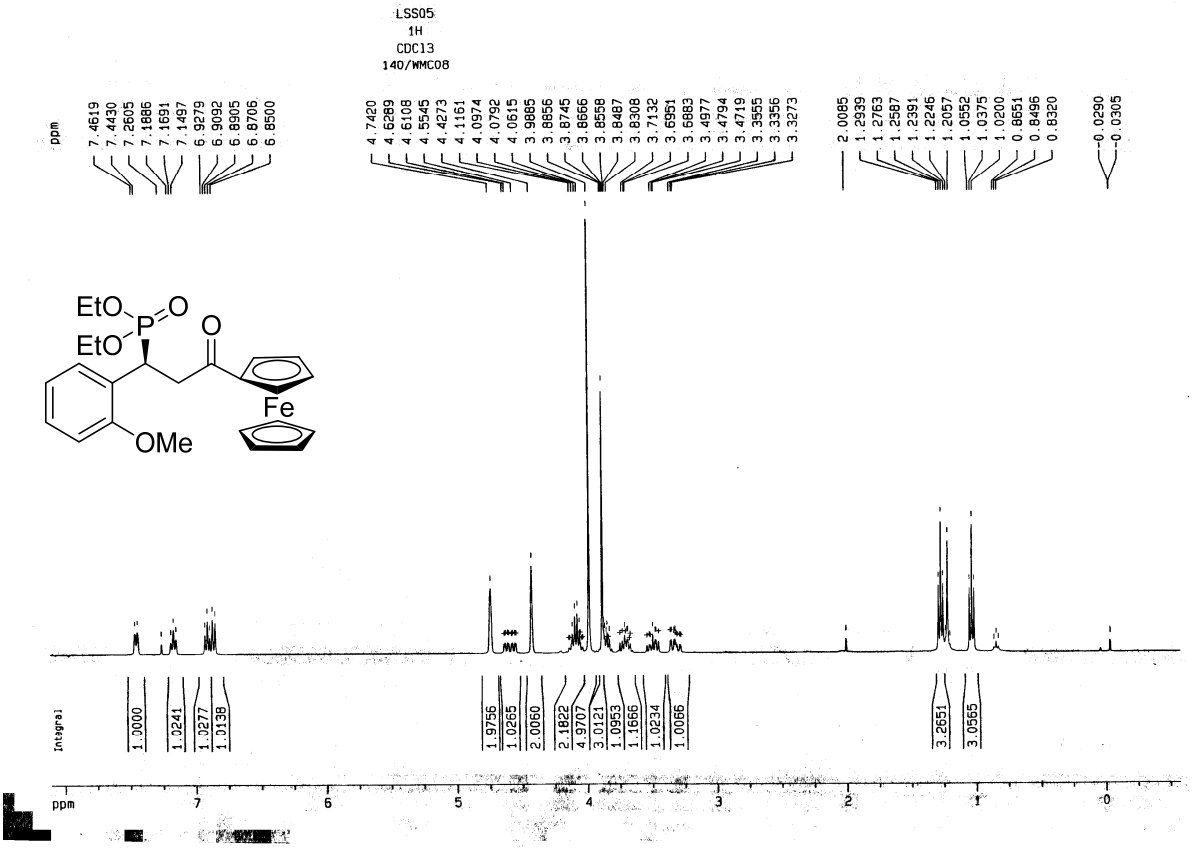

LSS-08
13C
CDCl3
145/WMC08
ppm

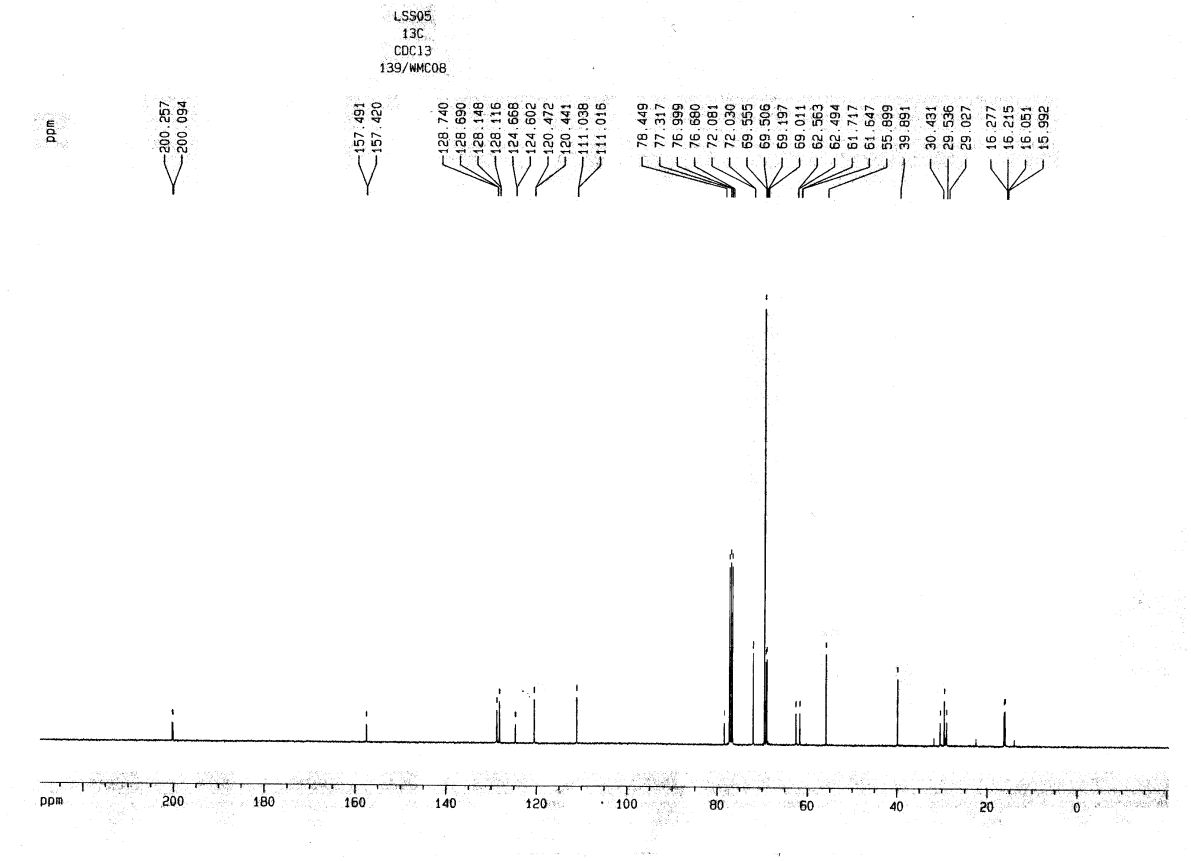

pdata/1
SN-143
1H
CDCl3
2017wmc-2900
OEt
OEt
O
P
O
O
f1 (ppm)


pdata/1
SN-143
13C
CDCl3
2017wmc-2901
f1 (ppm)

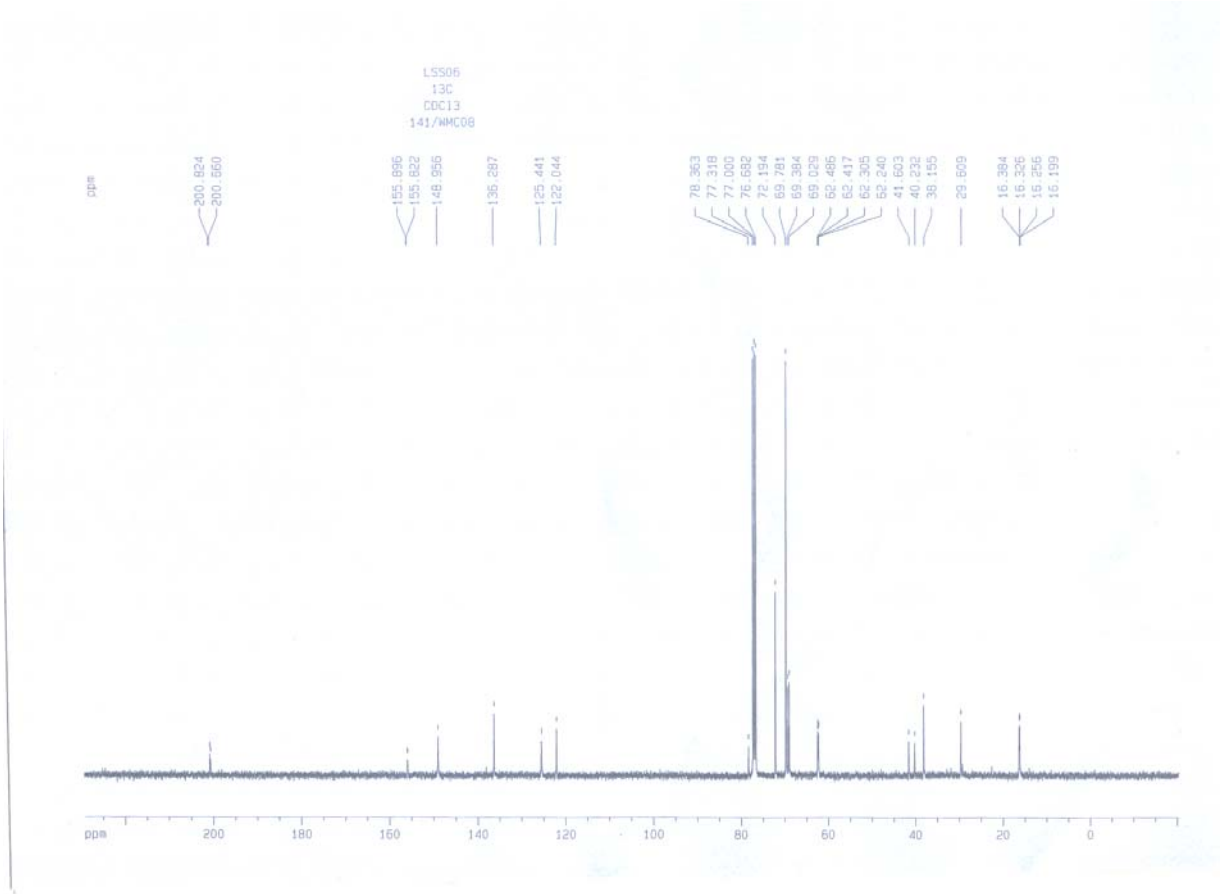

pdata/1
SN-144
1H
CDCl3
2017wmc-2910
7.95
7.93
7.57
7.55
7.53
7.46
7.44
7.42
6.94
6.90
6.88
6.73
6.71
5.91
4.11
4.09
4.06
3.98
3.97
3.95
3.84
3.82
3.80
3.68
3.65
3.63
3.60
1.31
1.29
1.27
1.17
1.15
1.13
1.87
0.98
1.86
1.90
0.95
1.93
1.90
2.99
1.95
3.07
3.00
EtO
EtO
P
O
O
O
O
Ph
f1 (ppm)

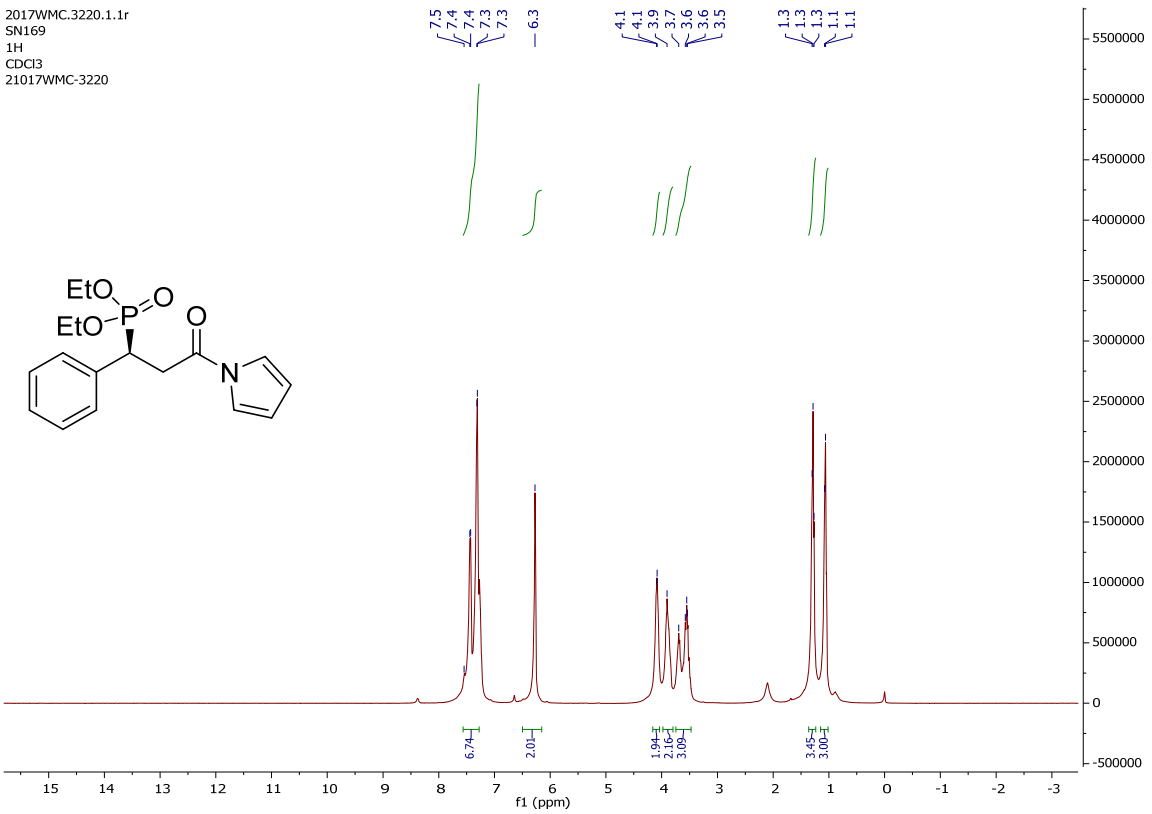

pdata/1
SN-144
13C
CDCl3
2017wmc-2911
196.48
196.33
147.69
147.66
146.80
146.77
136.58
133.33
129.57
129.49
128.64
128.11
122.68
122.60
109.62
109.56
108.30
108.28
101.02
63.00
62.92
62.05
61.98
39.32
37.96
16.43
16.37
16.34
16.28
f1 (ppm)

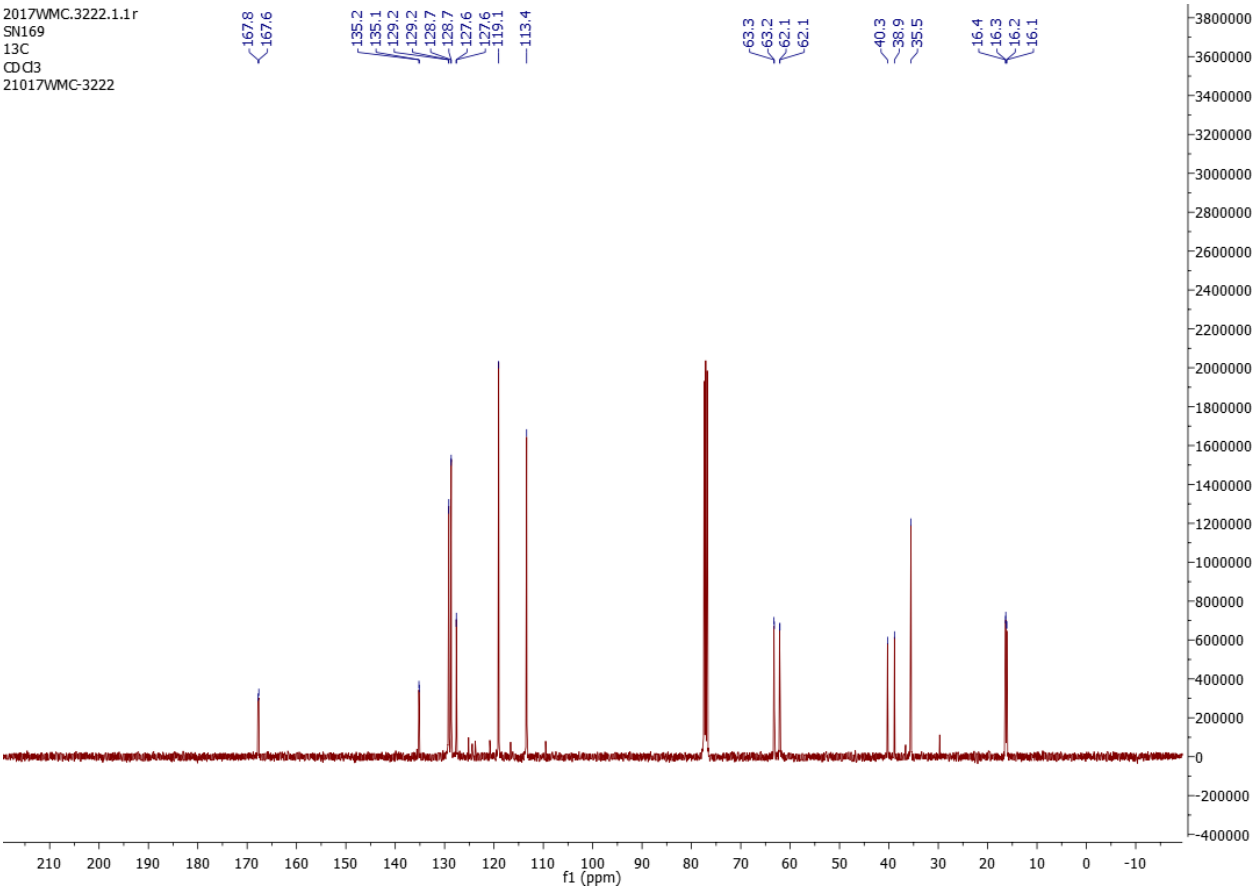

LSS05
1H
CDCl3
140/WMC08
EtO
EtO
P
O
O
Fe
OMe
ppm
Integral

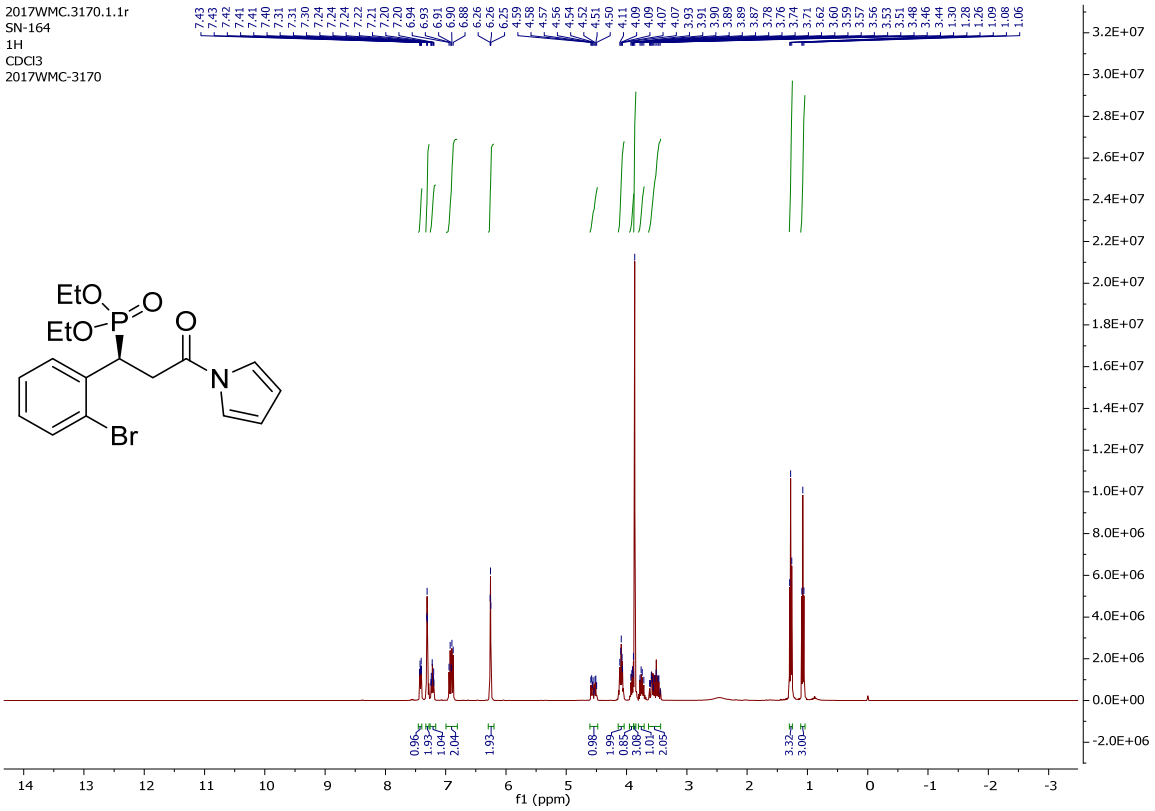

LSS05
13C
CDCl3
139/WMC08
ppm

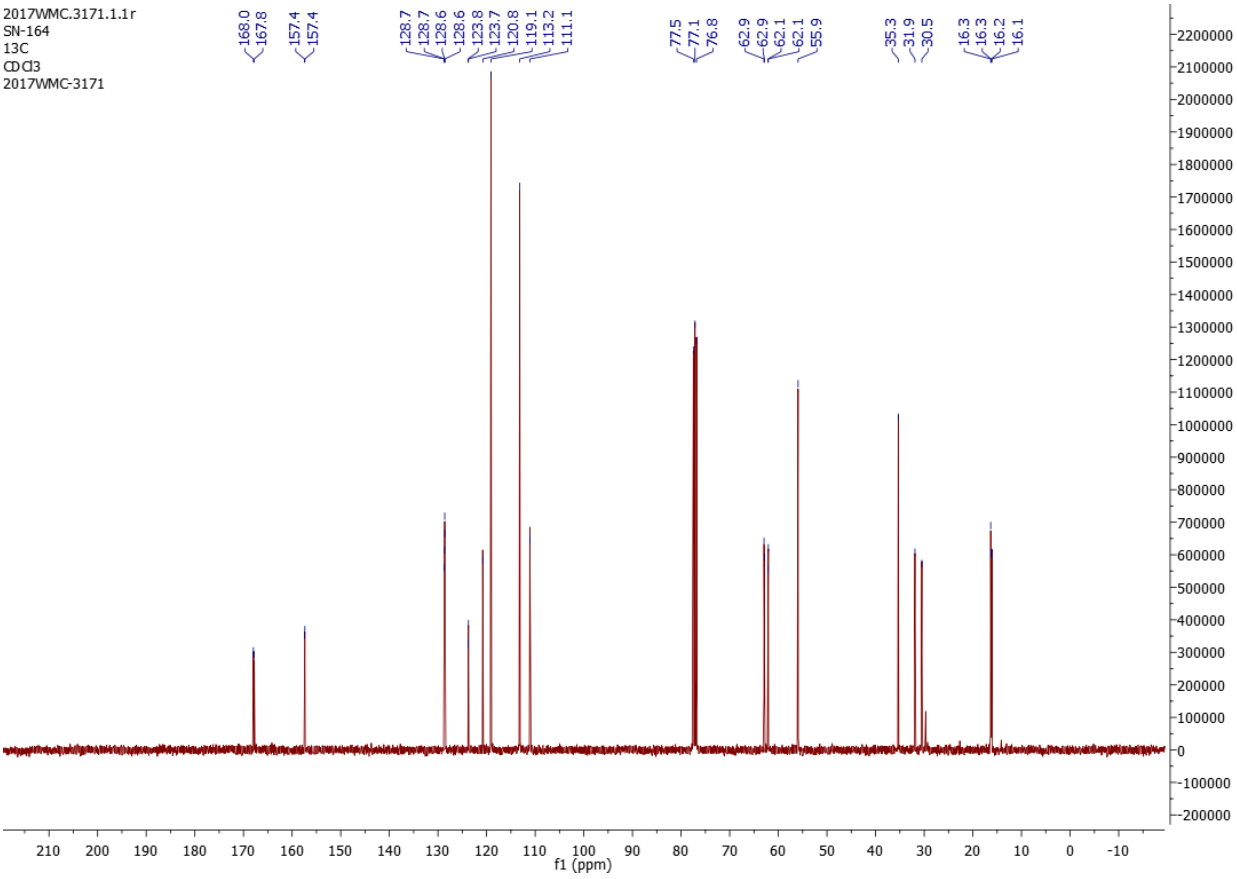

EtO
EtO
P
O
O
Fe
N

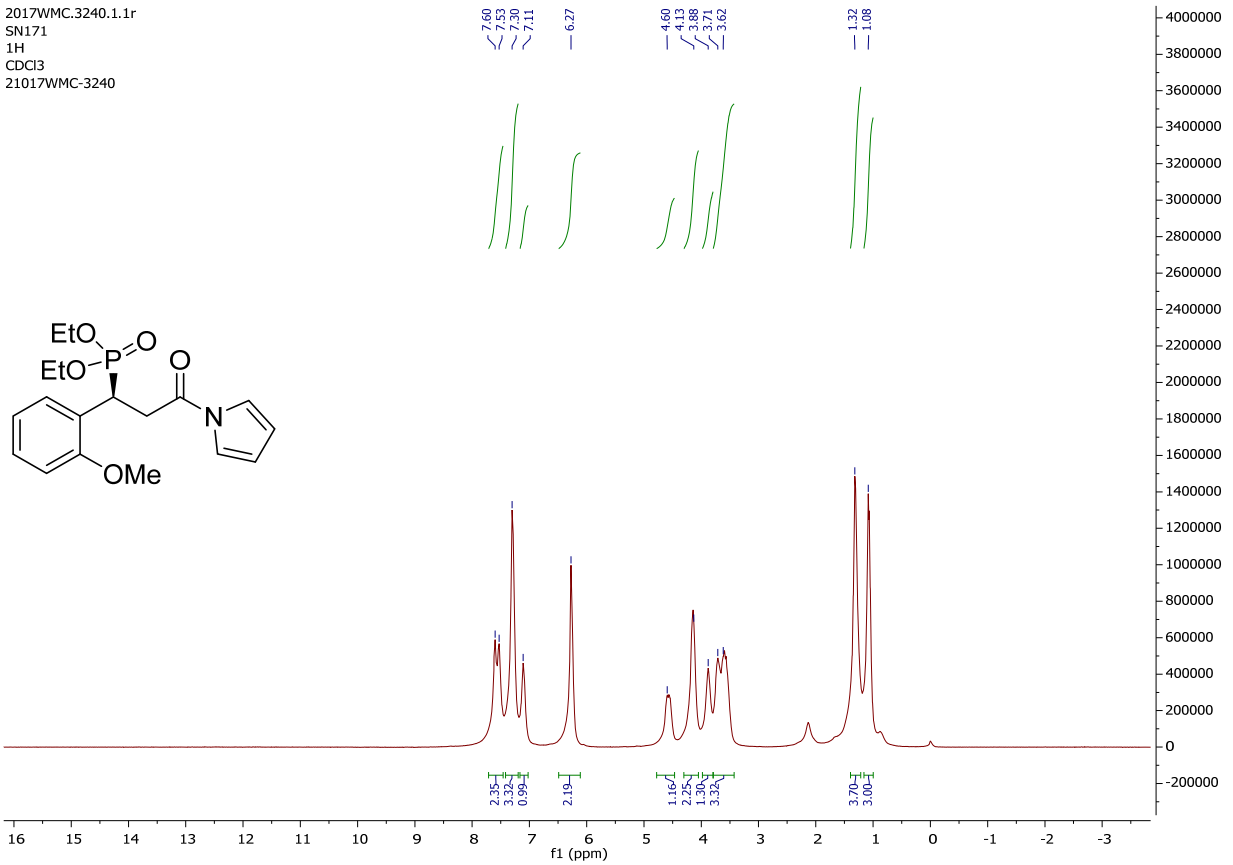


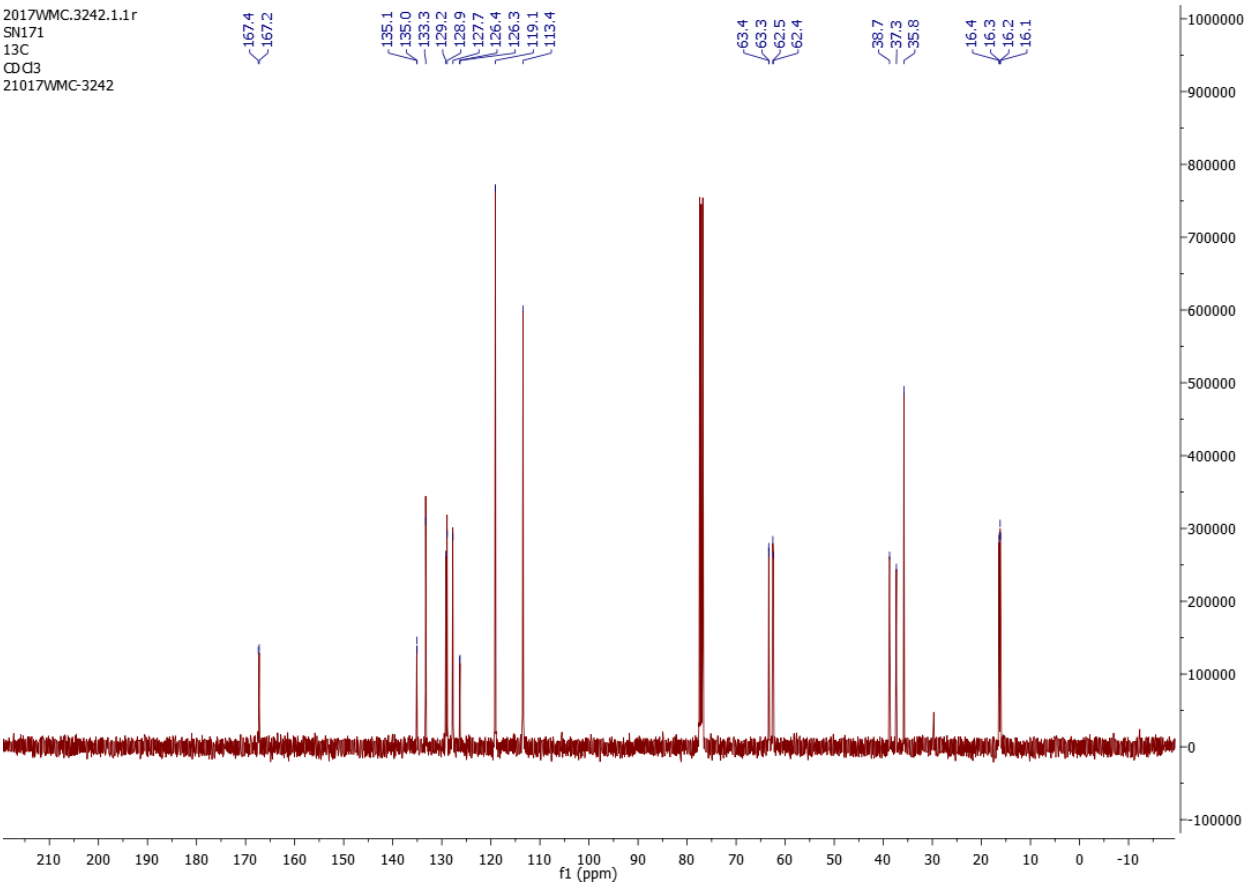

2017WMC.3220.1.1r
SN169
1H
CDCl3
21017WMC-3220
7.5
7.4
7.4
7.3
7.3
6.3
4.1
4.1
3.9
3.7
3.6
3.6
3.5
1.3
1.3
1.3
1.1
1.1
EtO
EtO
P
O
O
O
N
6.74
2.01
1.94
2.16
3.09
3.45
3.00
f1 (ppm)

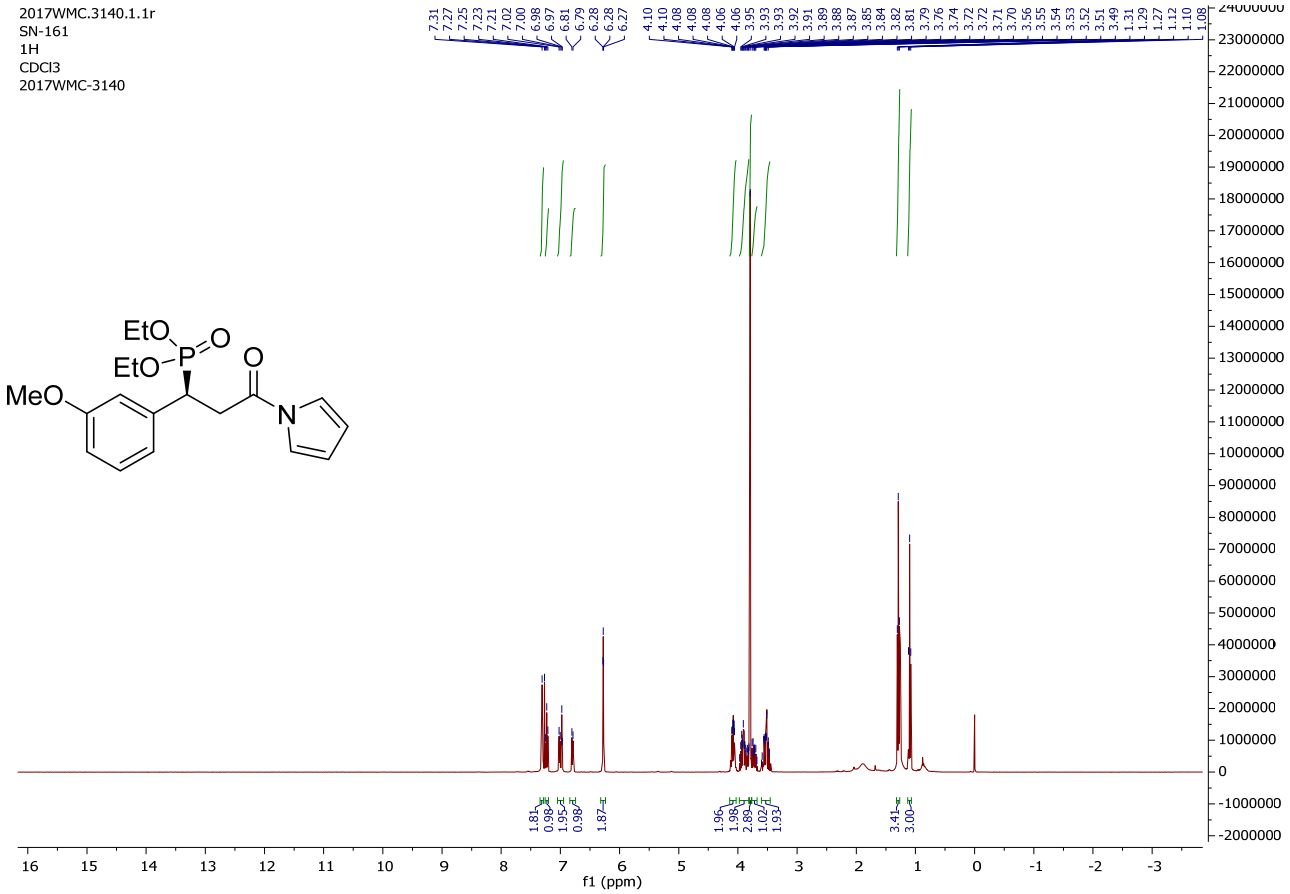

2017WMC.3222.1.1r
SN169
13C
CDCl3
21017WMC-3222
167.8
167.6
135.2
135.1
129.2
129.2
128.7
128.7
127.6
127.6
119.1
113.4
63.3
63.2
62.1
62.1
40.3
38.9
35.5
16.4
16.3
16.2
16.1
f1 (ppm)

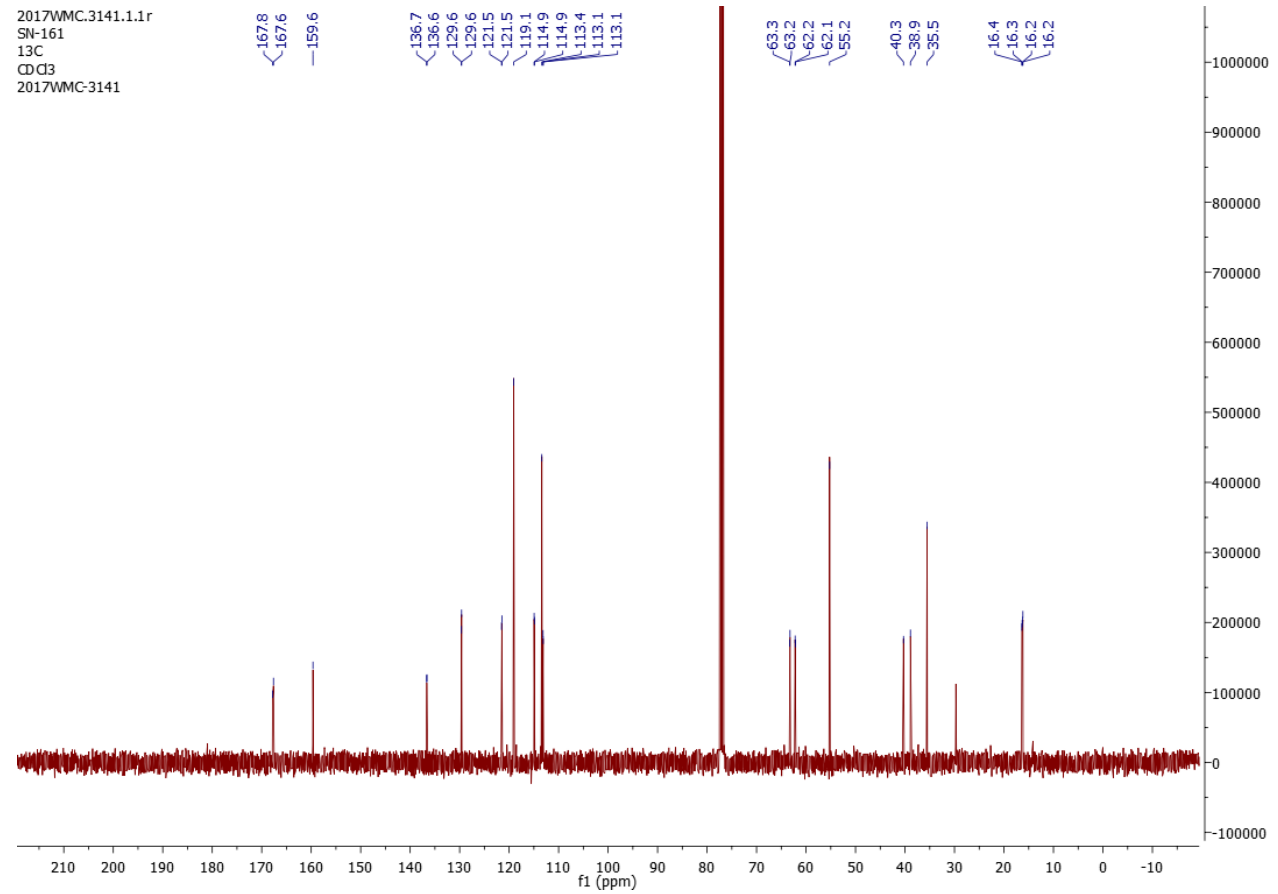

2017WMC.3170.1.1r
SN-164
1H
CDCl3
2017WMC-3170
EtO
EtO
P
O
O
N
Br
f1 (ppm)

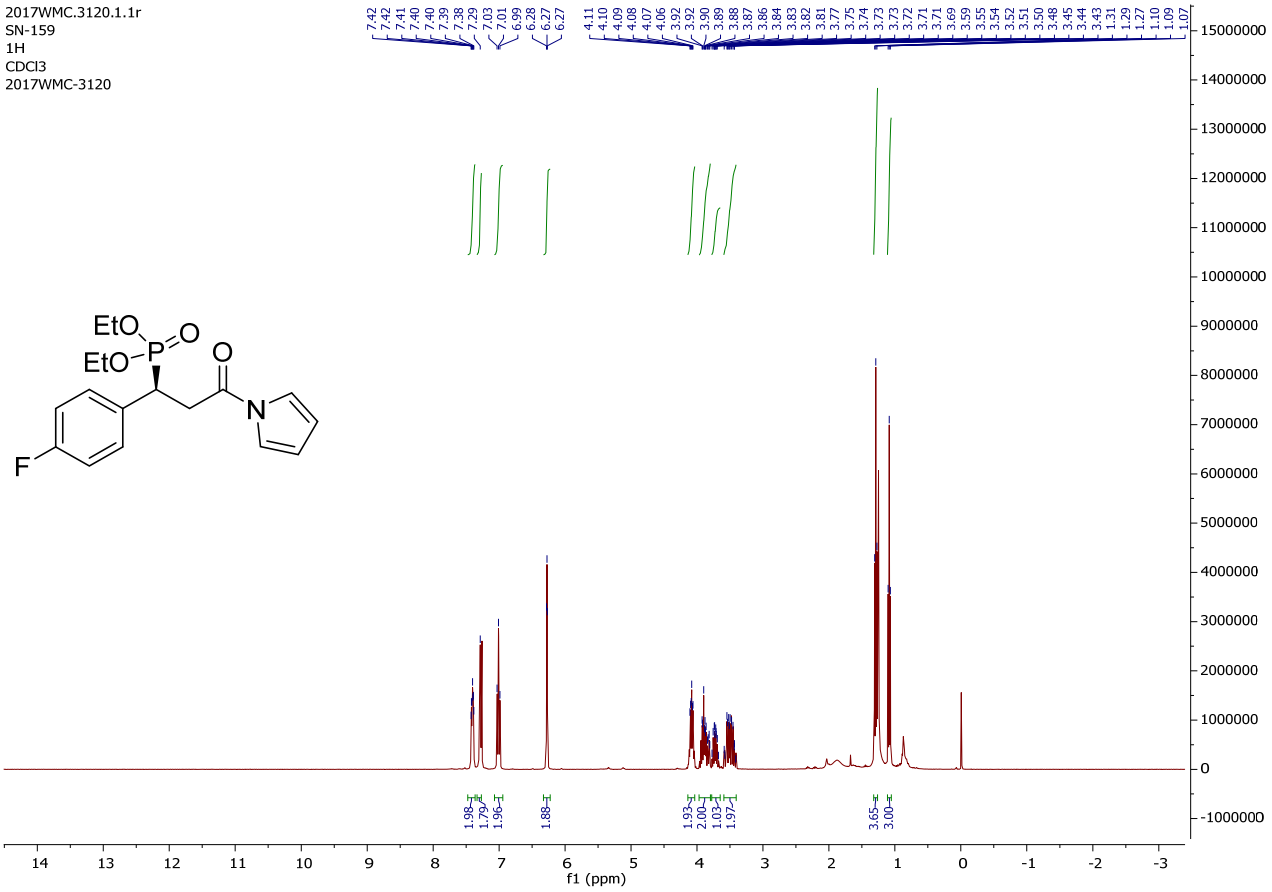

2017WMC.3171.1.1r
SN-164
13C
CDCl3
2017WMC-3171
f1 (ppm)

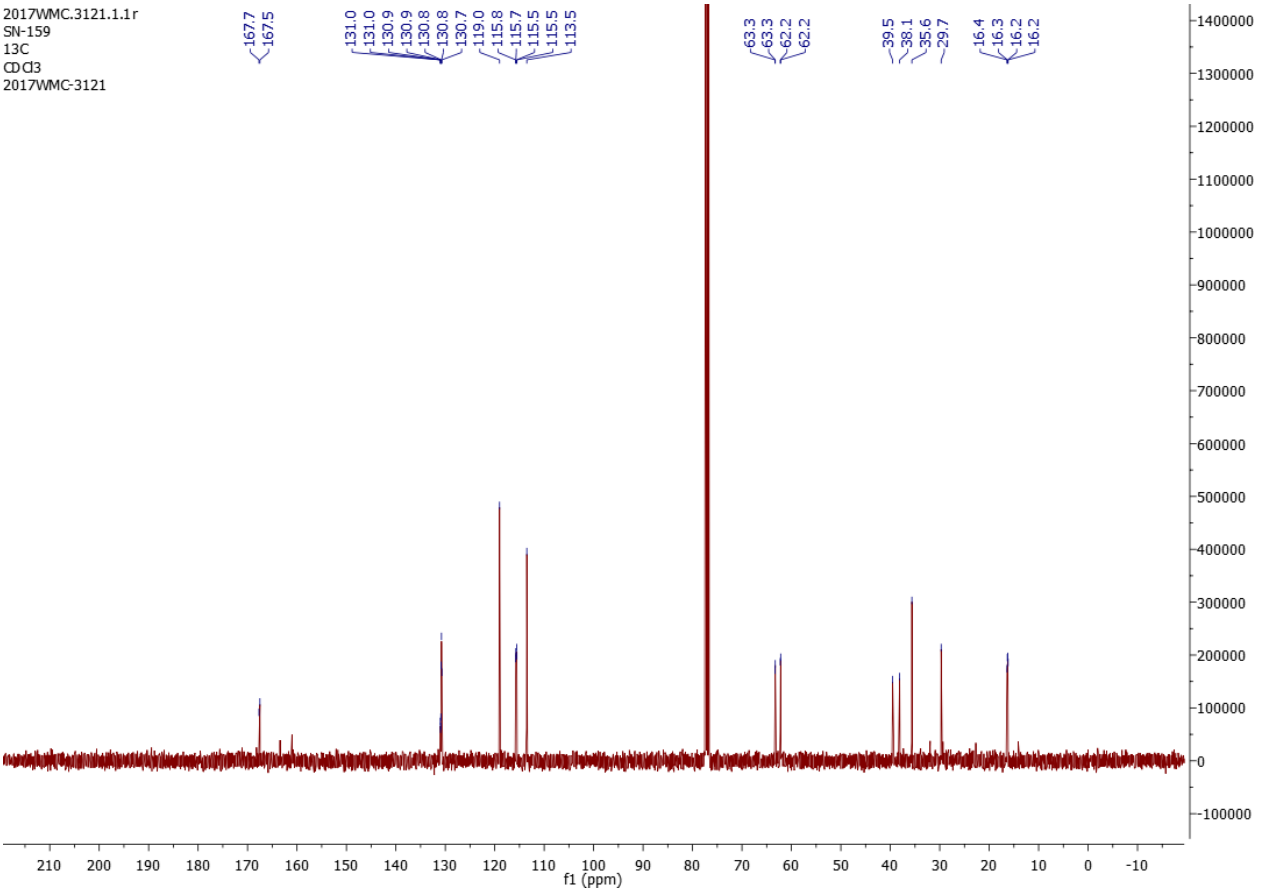

2017WMC.3240.1.1r
SN171
1H
CDCl3
21017WMC-3240
7.60
7.53
7.30
7.11
6.27
4.60
4.13
3.88
3.71
3.62
1.32
1.08
EtO
EtO
P
O
O
N
OMe
2.35
3.32
0.99
2.19
1.16
2.25
1.30
3.32
3.70
3.00
f1 (ppm)

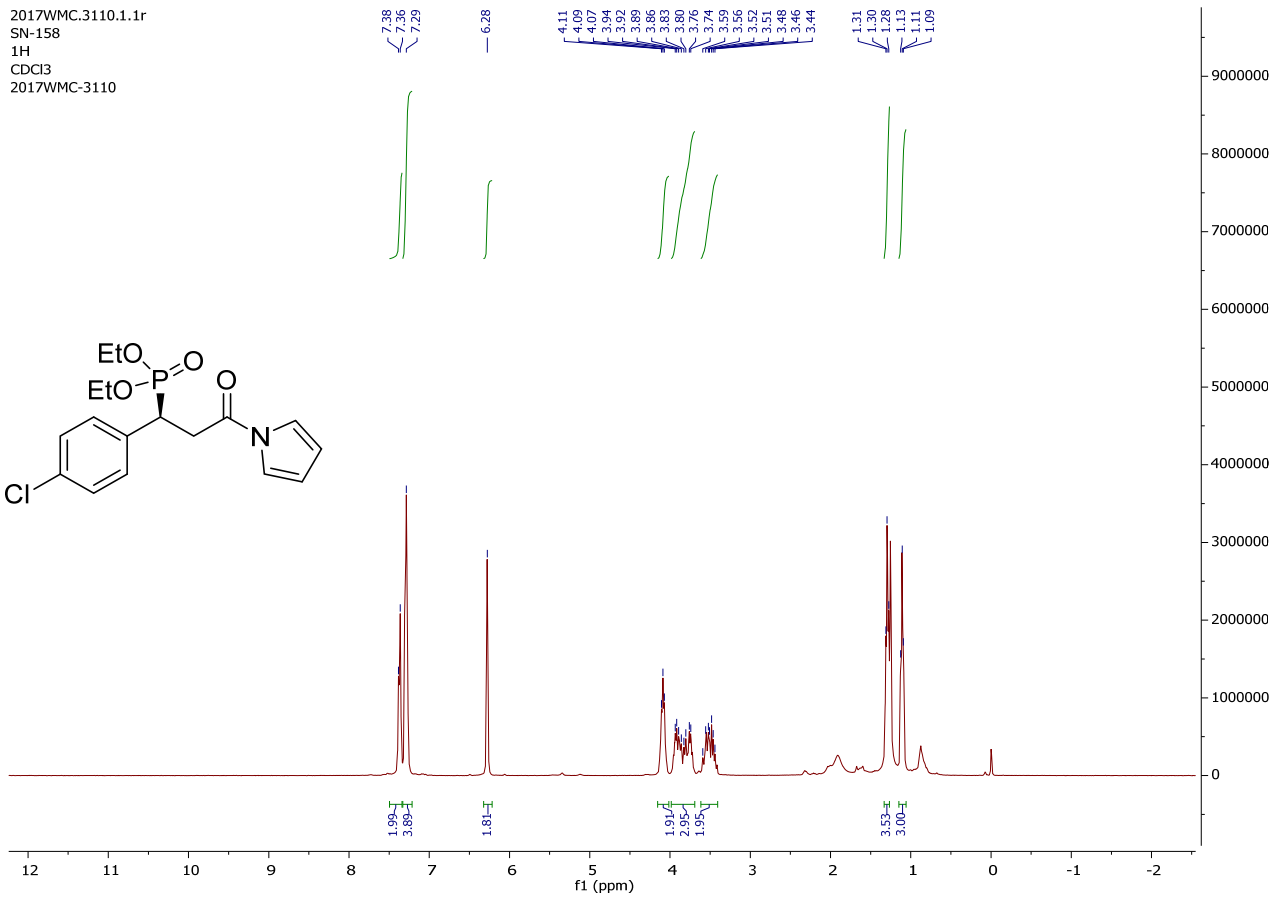

2017WMC.3242.1.1r
SN171
13C
CDCl3
21017WMC-3242
167.4
167.2
135.1
135.0
133.3
129.2
128.9
127.7
126.4
126.3
119.1
113.4
63.4
63.3
62.5
62.4
38.7
37.3
35.8
16.4
16.3
16.2
16.1
f1 (ppm)

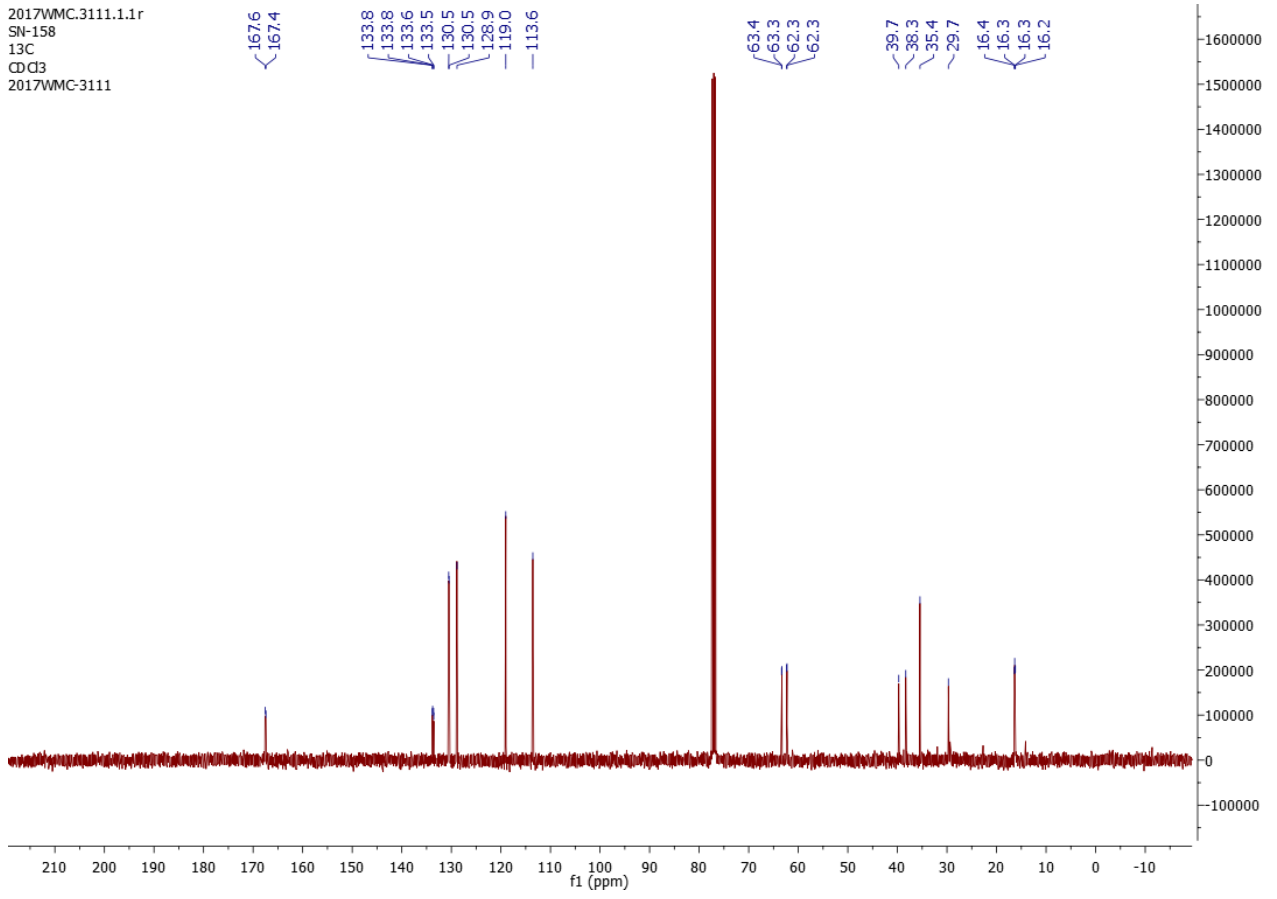

2017WMC.3140.1.1r
SN-161
1H
CDCl3
2017WMC-3140
EtO
EtO
P
O
O
MeO
N
f1 (ppm)

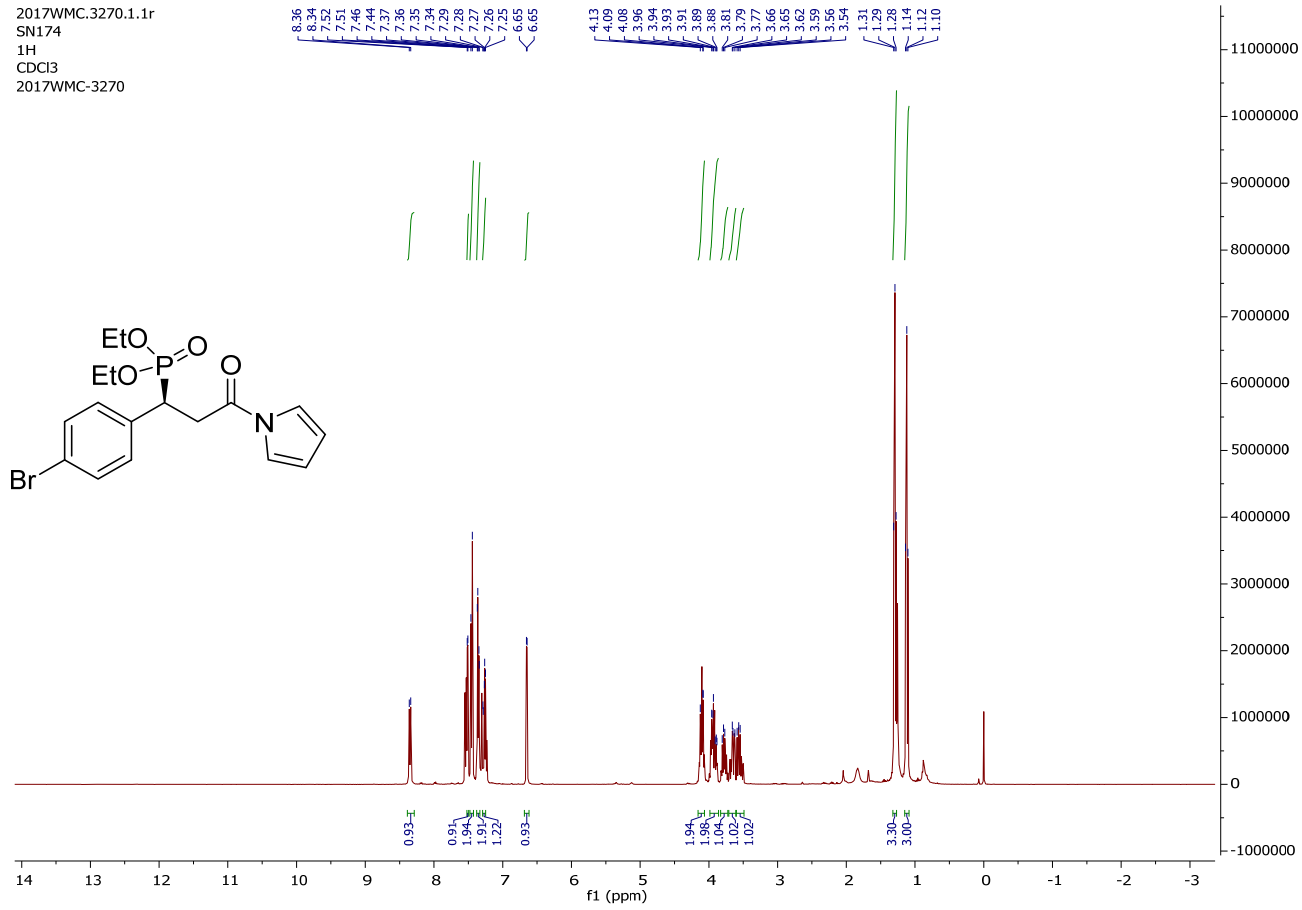

2017WMC.3141.1.1r
SN-161
13C
CDCl3
2017WMC-3141
f1 (ppm)

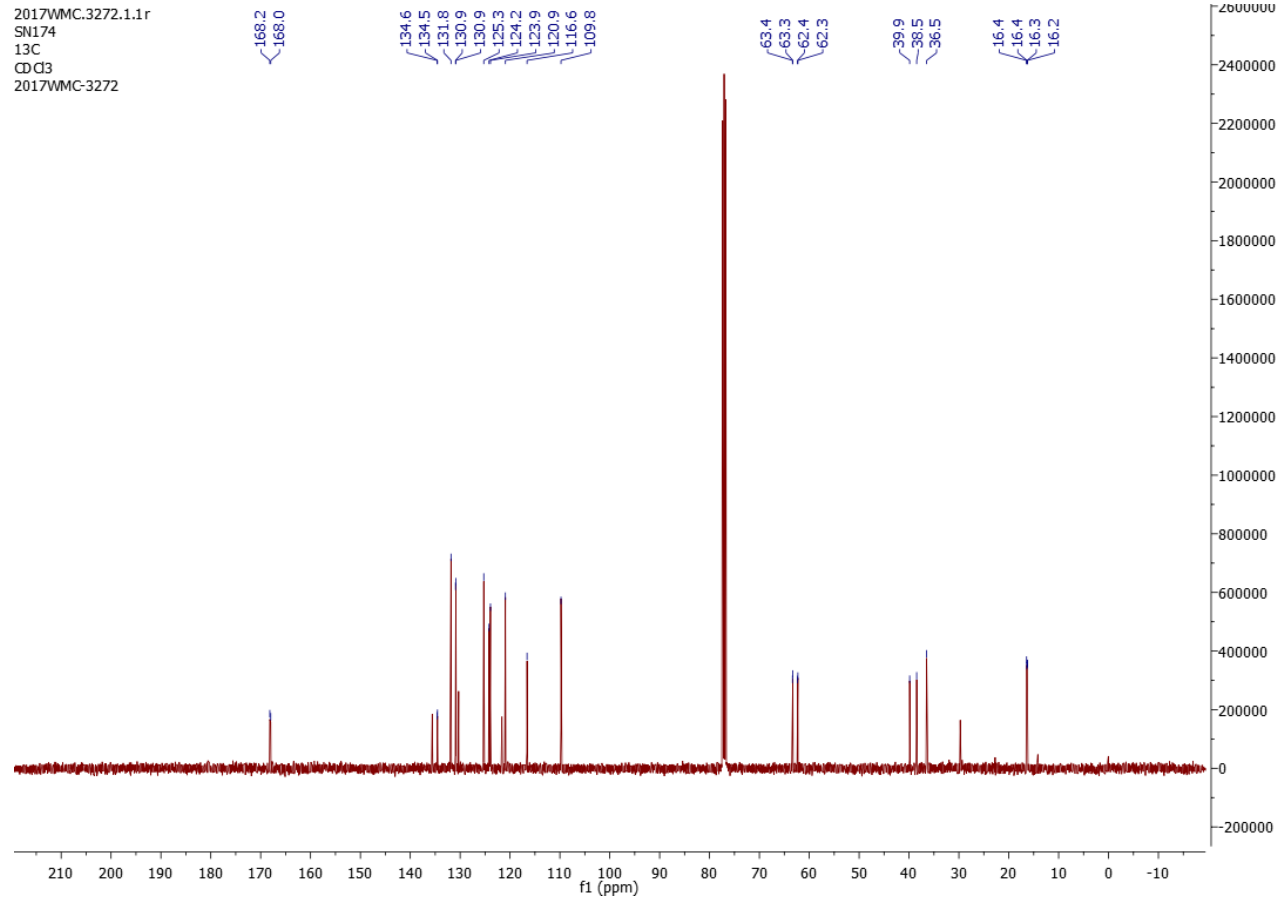

2017WMC.3120.1.1r
SN-159
1H
CDCl3
2017WMC-3120
EtO
EtO
P
O
O
N
F
f1 (ppm)

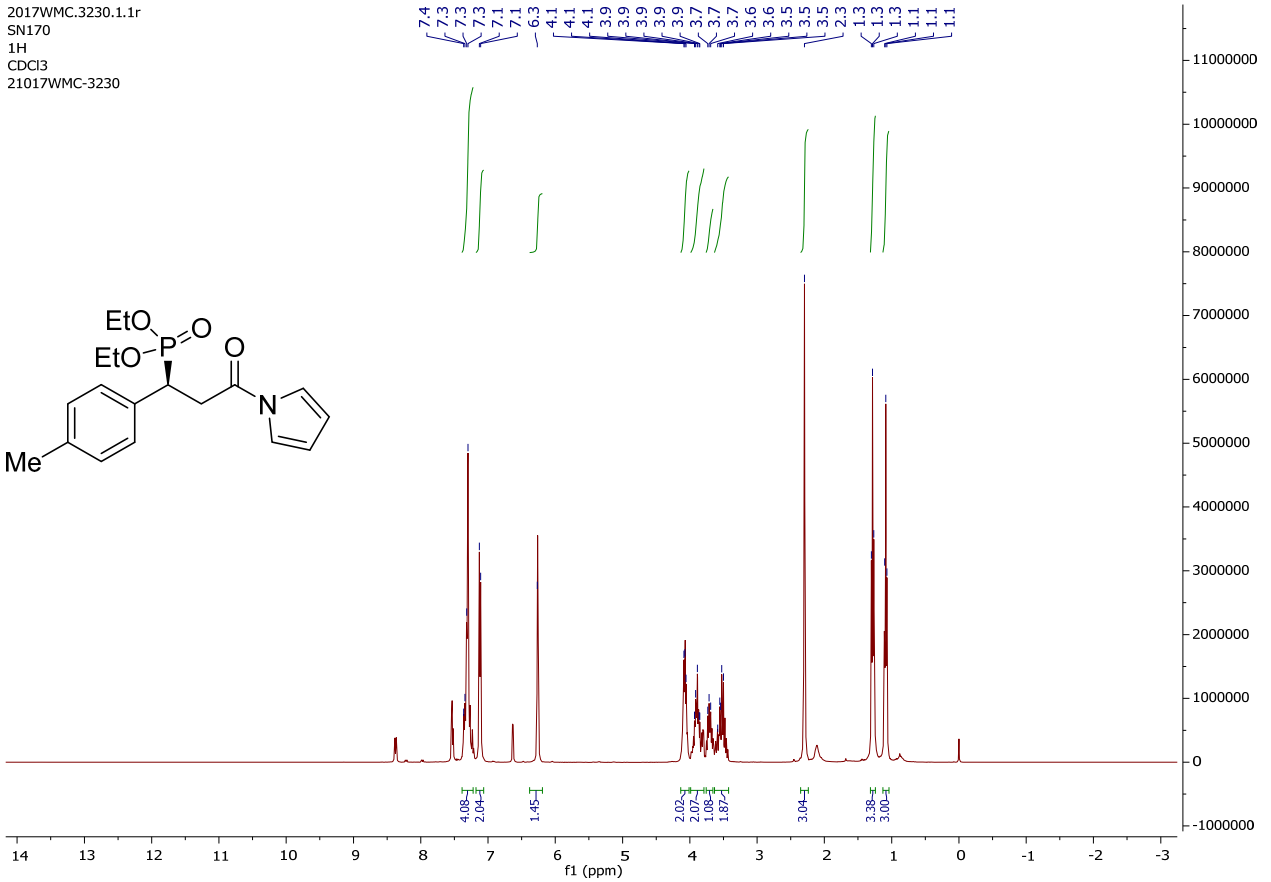

2017WMC.3121.1.1r
SN-159
13C
CDCl3
2017WMC-3121
f1 (ppm)

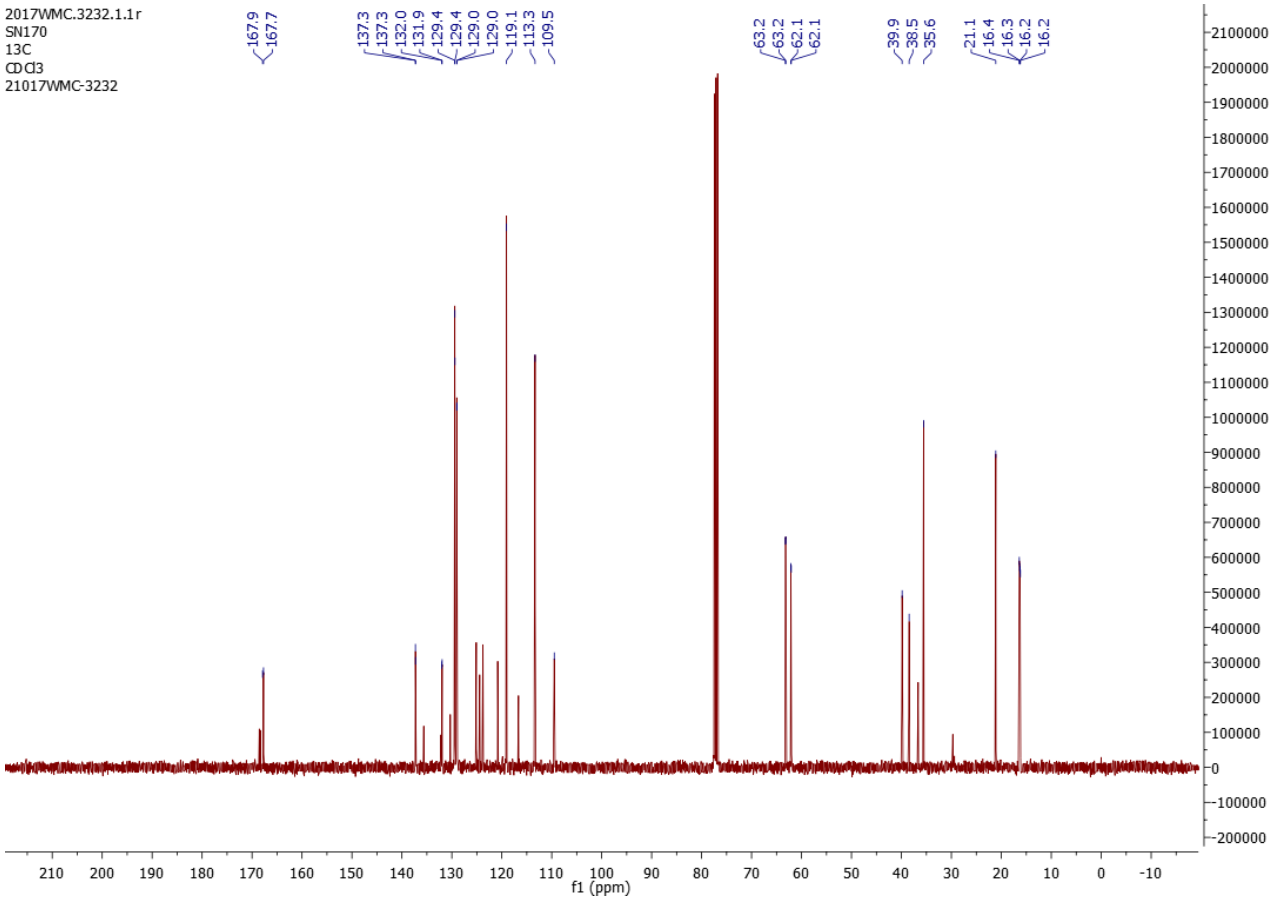

2017WMC.3110.1.1r
SN-158
1H
CDCl3
2017WMC-3110
7.38
7.36
7.29
6.28
4.11
4.09
4.07
3.94
3.92
3.89
3.86
3.83
3.80
3.76
3.74
3.59
3.56
3.52
3.51
3.48
3.46
3.44
1.31
1.30
1.28
1.13
1.11
1.09
EtO
EtO
P
O
O
N
Cl
1.99
3.89
1.81
1.91
2.95
1.95
3.53
3.00
f1 (ppm)

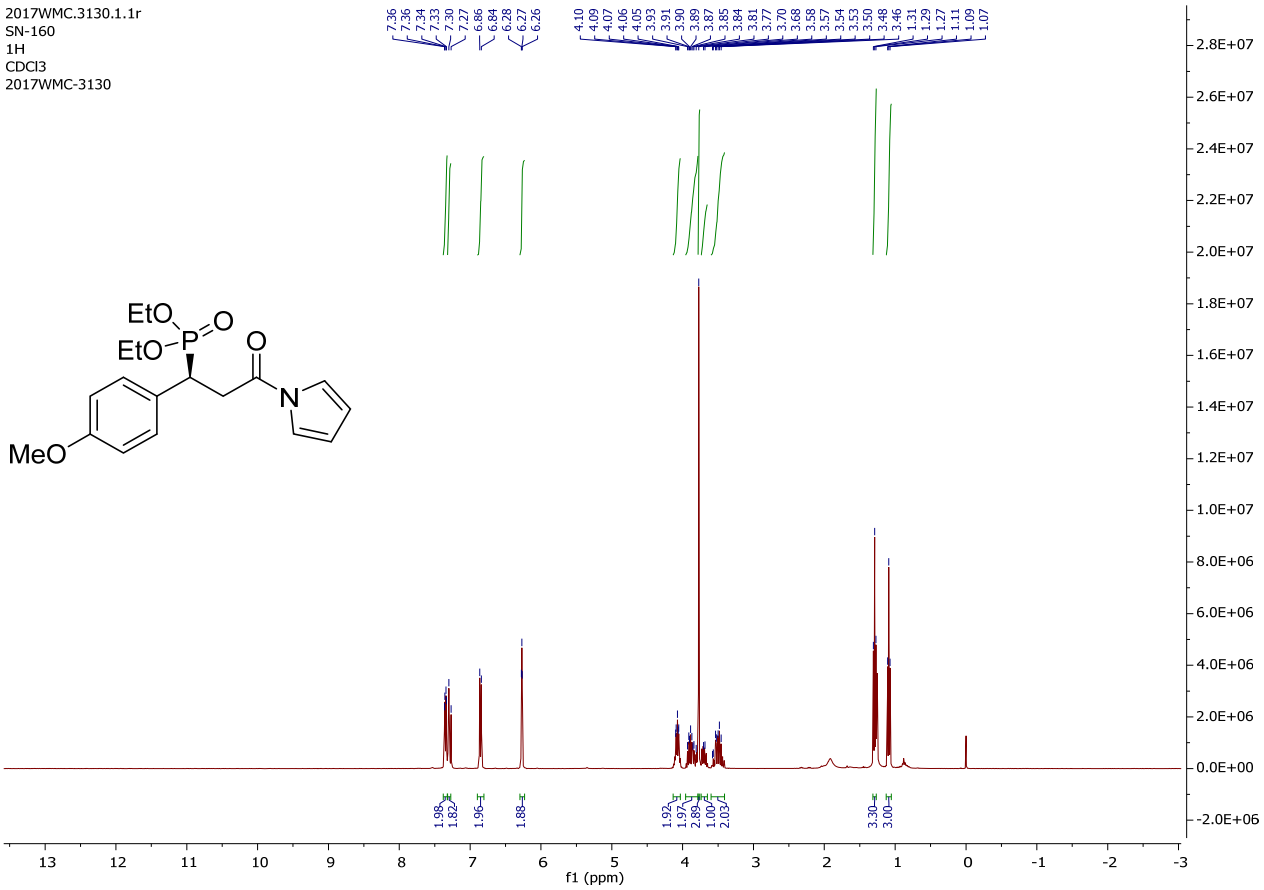

2017WMC.3111.1.1r
SN-158
13C
CDCl3
2017WMC-3111
167.6
167.4
133.8
133.8
133.6
133.5
130.5
130.5
128.9
119.0
113.6
63.4
63.3
62.3
62.3
39.7
38.3
35.4
29.7
16.4
16.3
16.3
16.2
f1 (ppm)

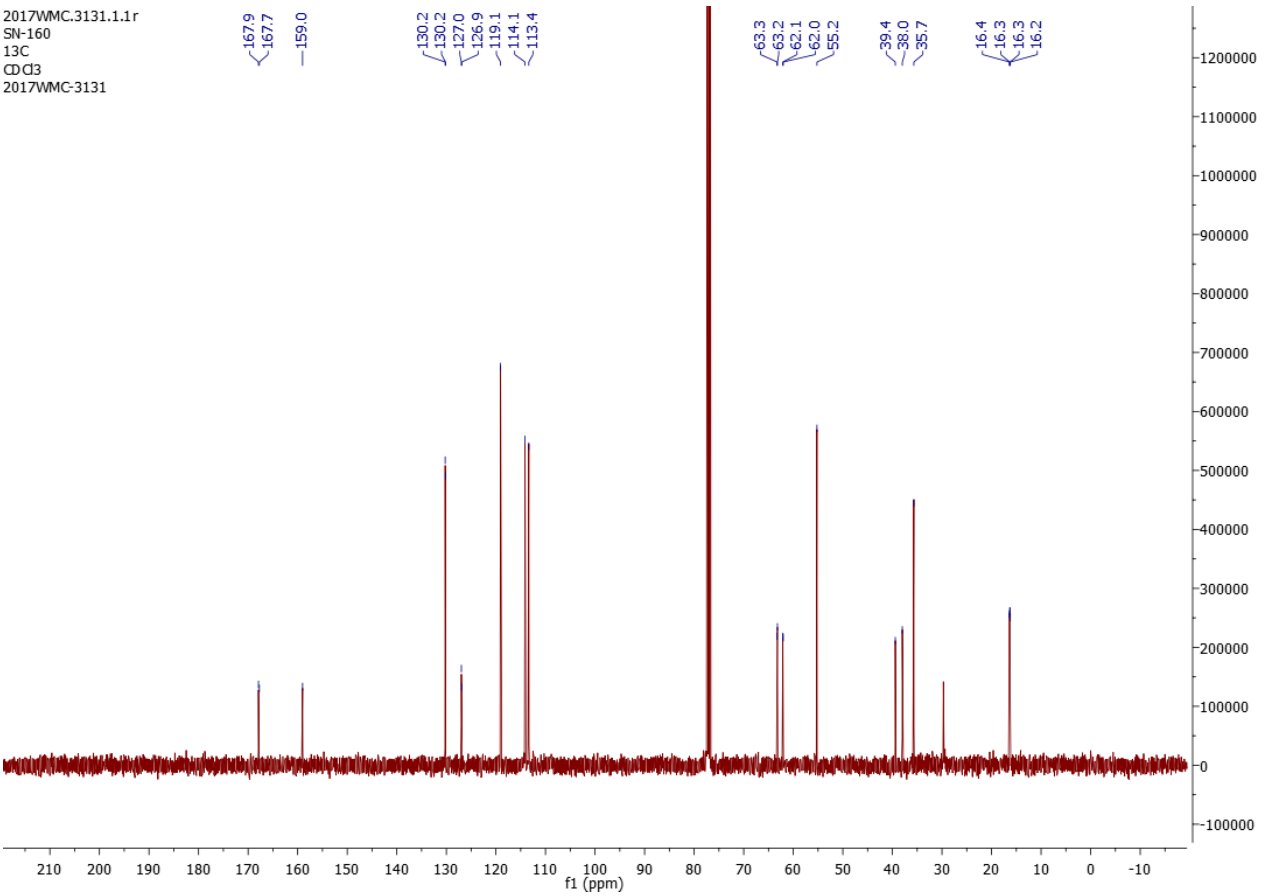

2017WMC.3270.1.1r
SN174
1H
CDCl3
2017WMC-3270
EtO
EtO
P
O
O
N
Br
f1 (ppm)

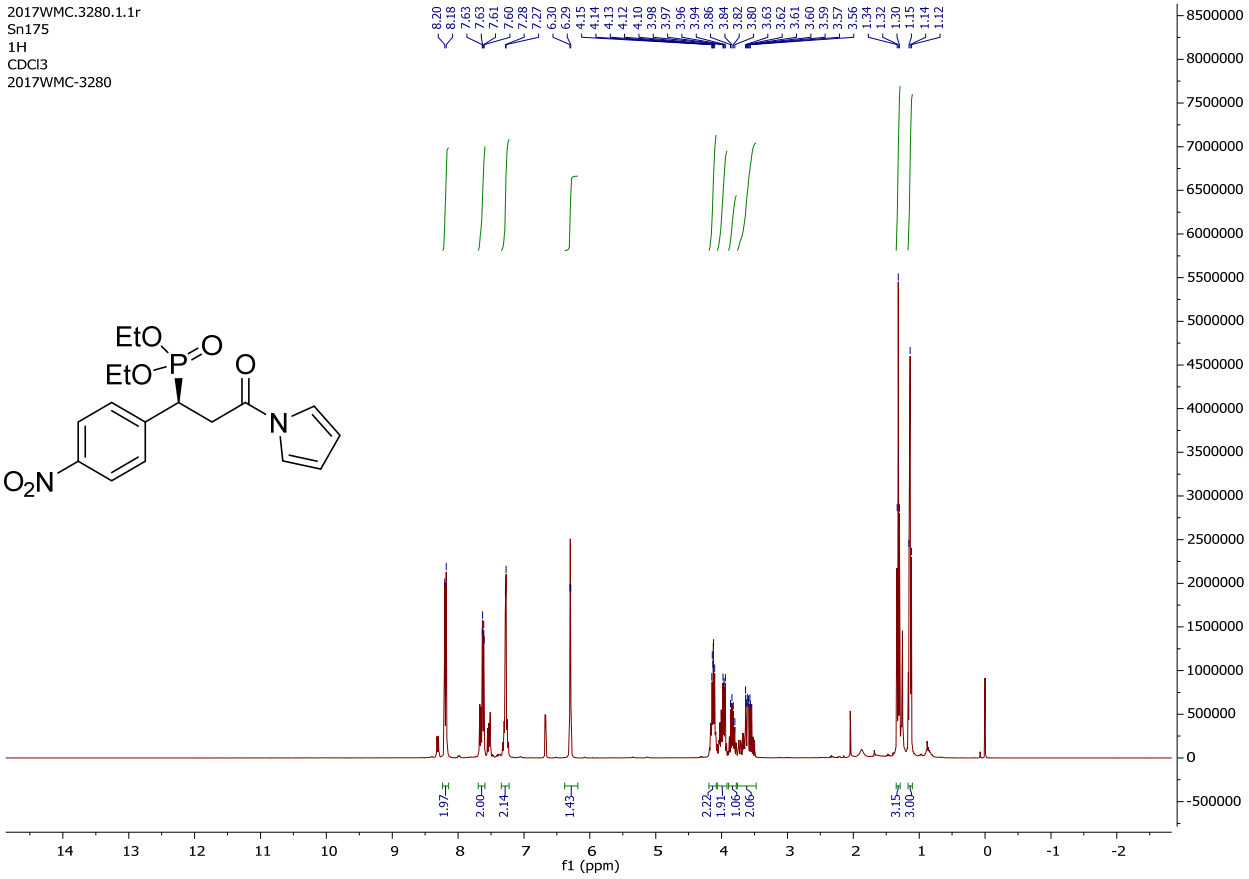

2017WMC.3272.1.1r
SN174
13C
CDCl3
2017WMC-3272
f1 (ppm)

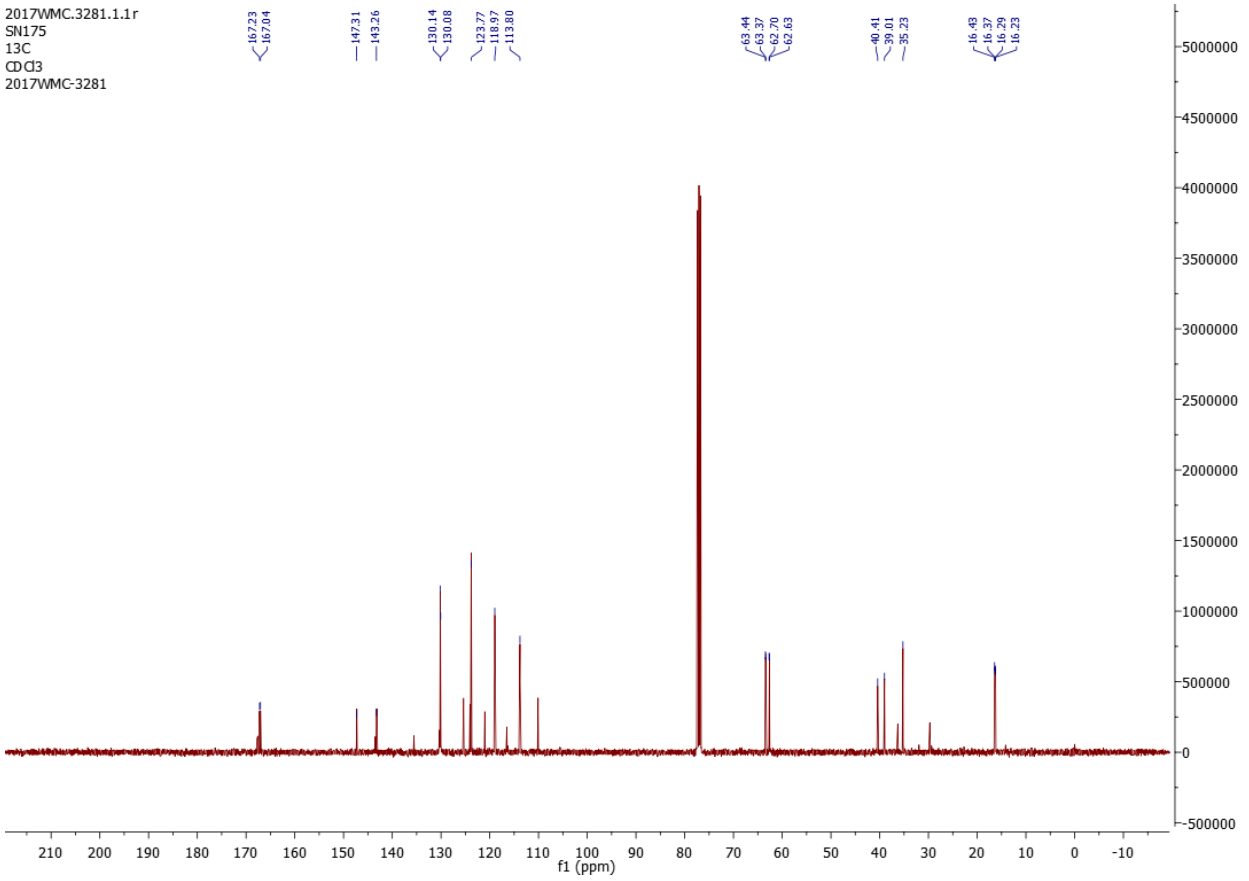

2017WMC.3230.1.1r
SN170
1H
CDCl3
21017WMC-3230
EtO
EtO
P
O
O
N
Me
f1 (ppm)


2017WMC.3232.1.1r
SN170
13C
CDCl3
21017WMC-3232
f1 (ppm)

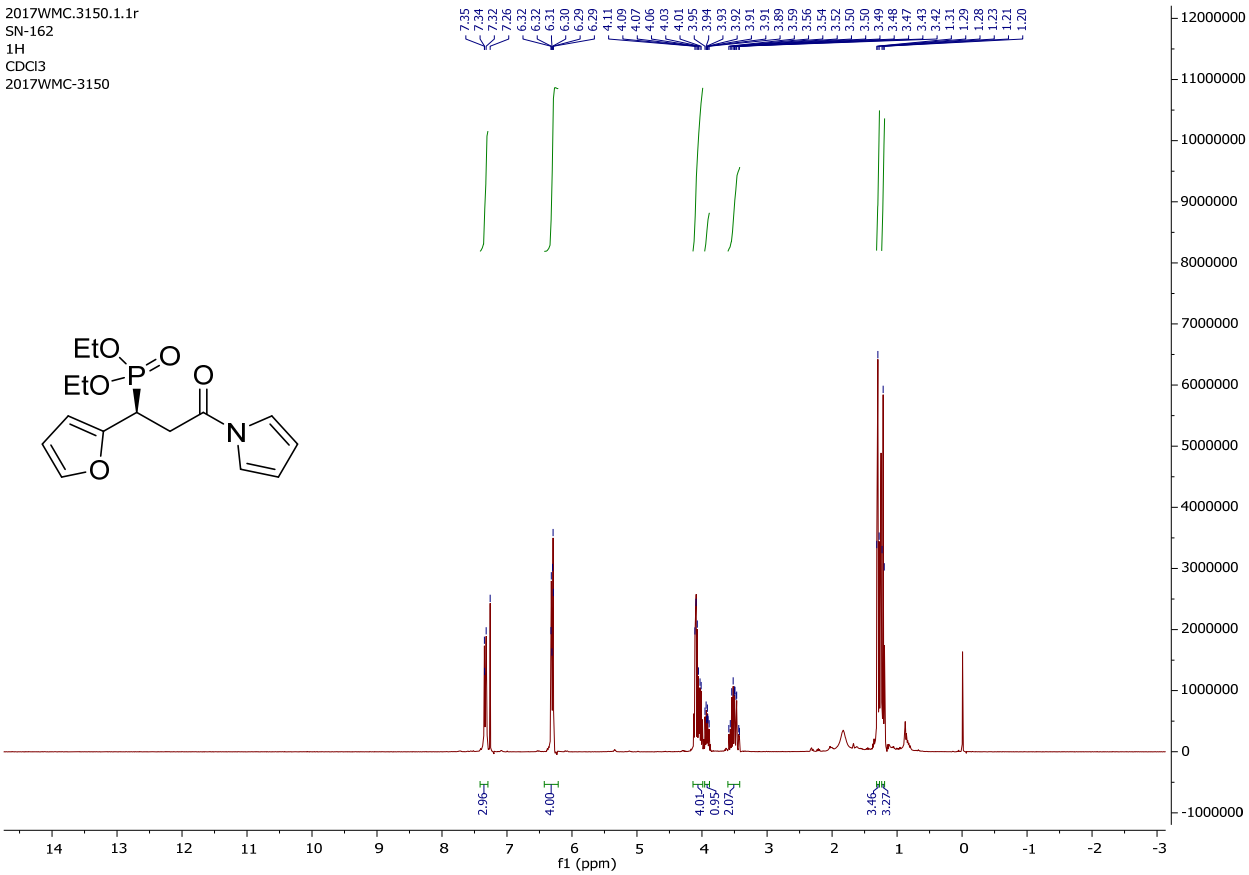

2017WMC.3130.1.1r
SN-160
1H
CDCl3
2017WMC-3130
EtO
EtO
P
O
O
N
MeO
f1 (ppm)

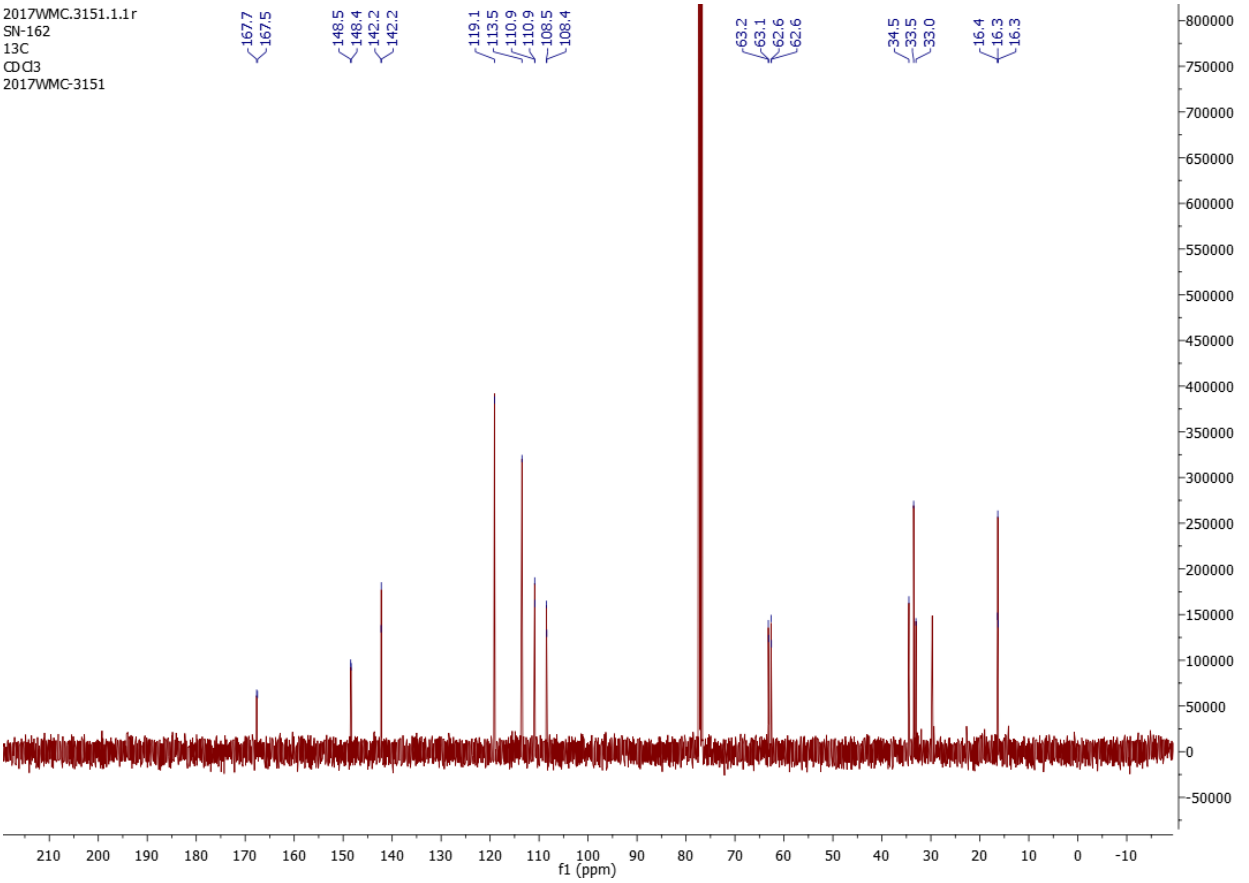

2017WMC.3131.1.1r
SN-160
13C
CDCl3
2017WMC-3131
f1 (ppm)

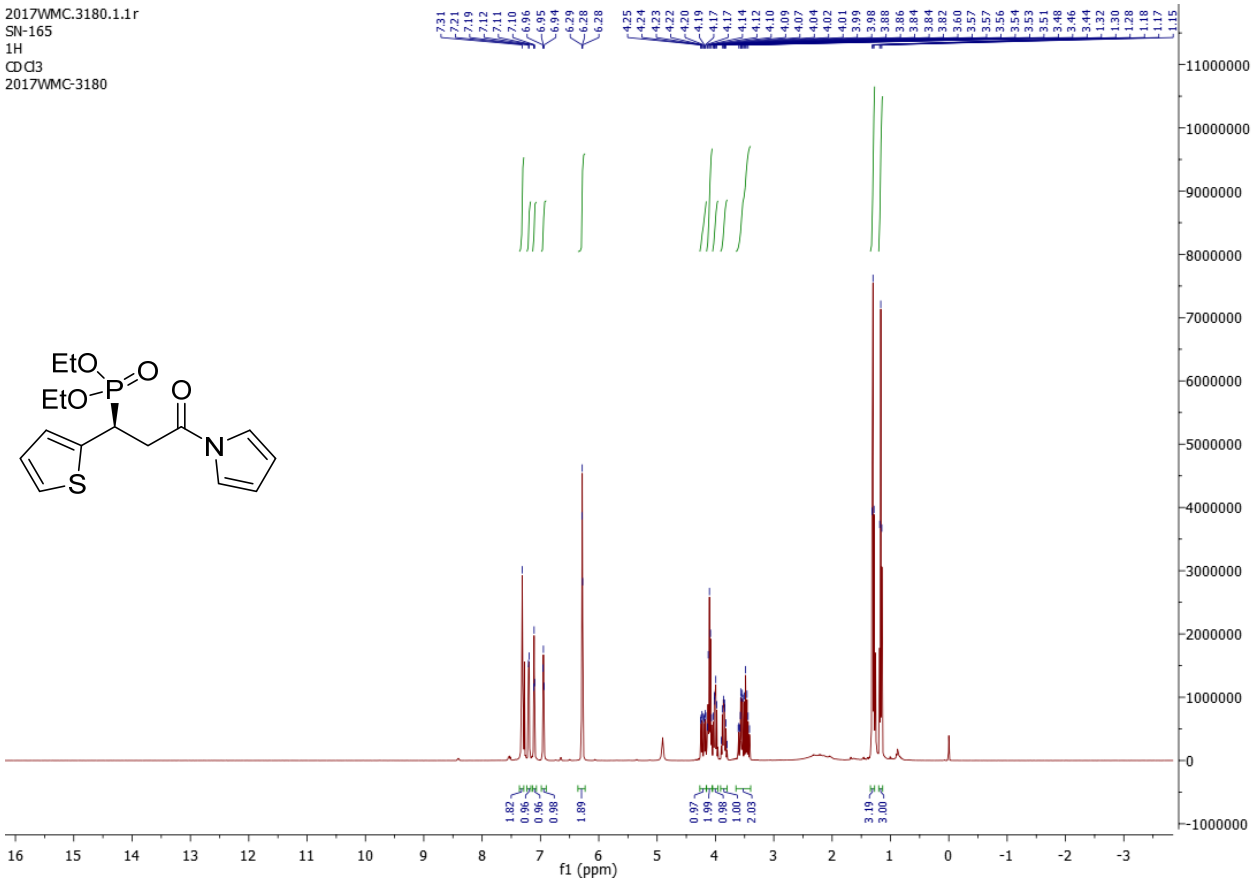

2017WMC.3280.1.1r
Sn175
1H
CDCl3
2017WMC-3280
EtO
EtO
P
O
O
N
O2N
f1 (ppm)

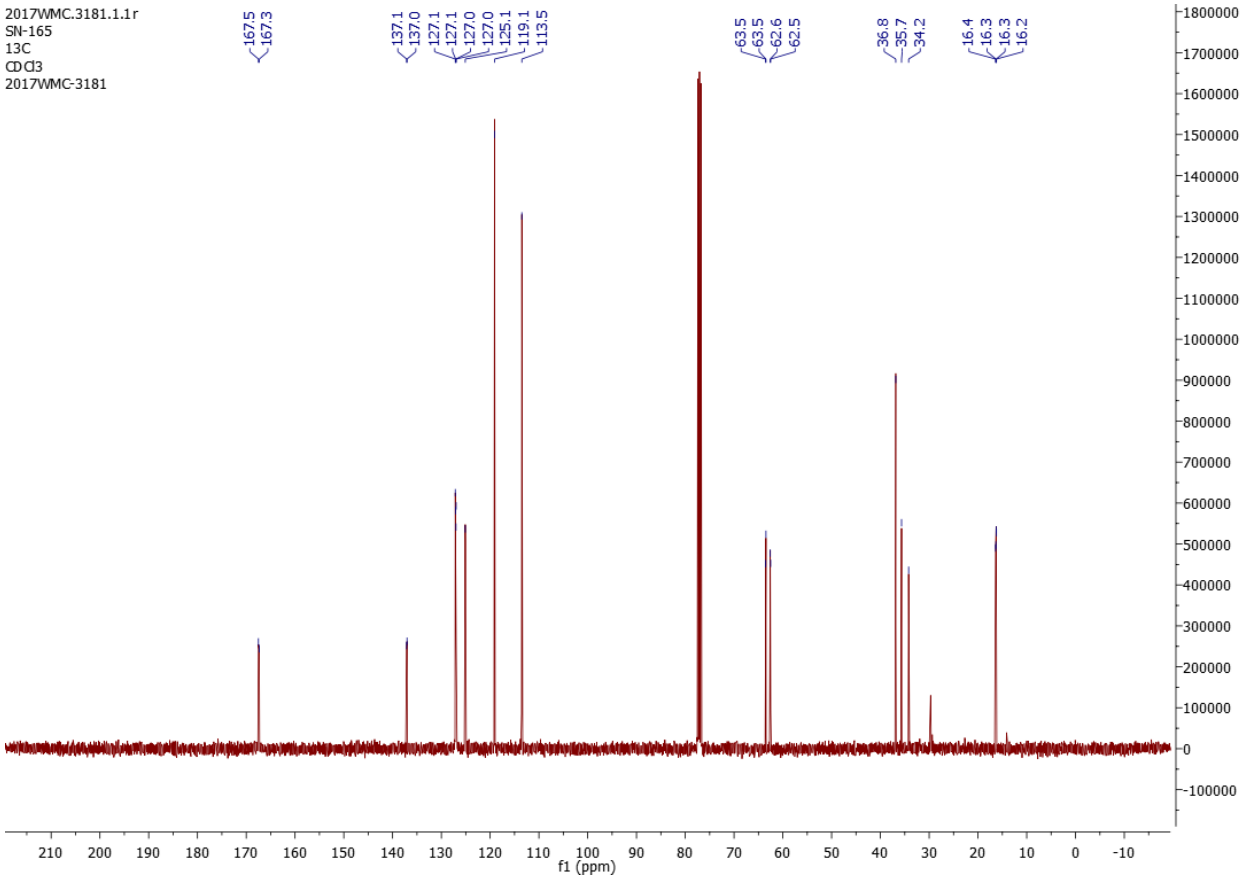

2017WMC.3281.1.1r
SN175
13C
CDCl3
2017WMC-3281
f1 (ppm)

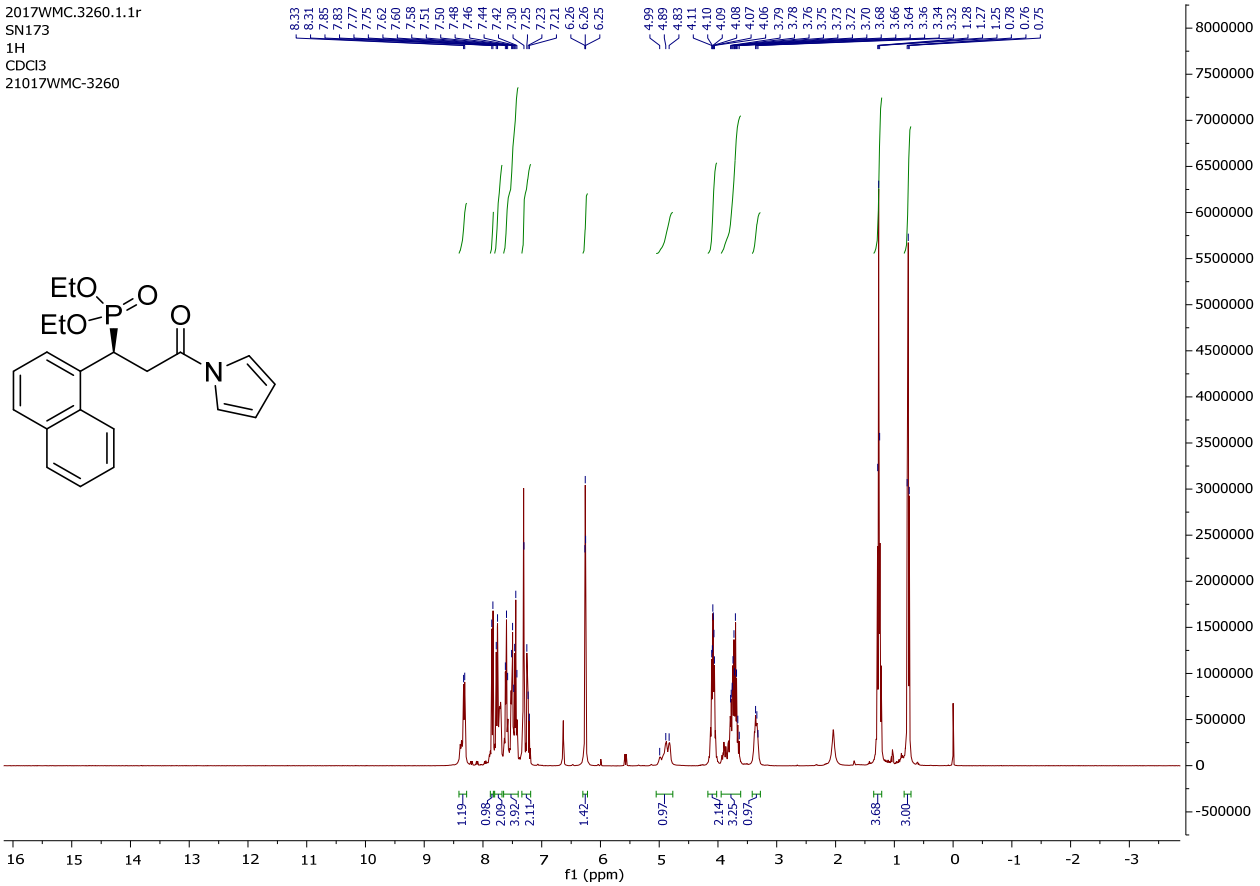
.

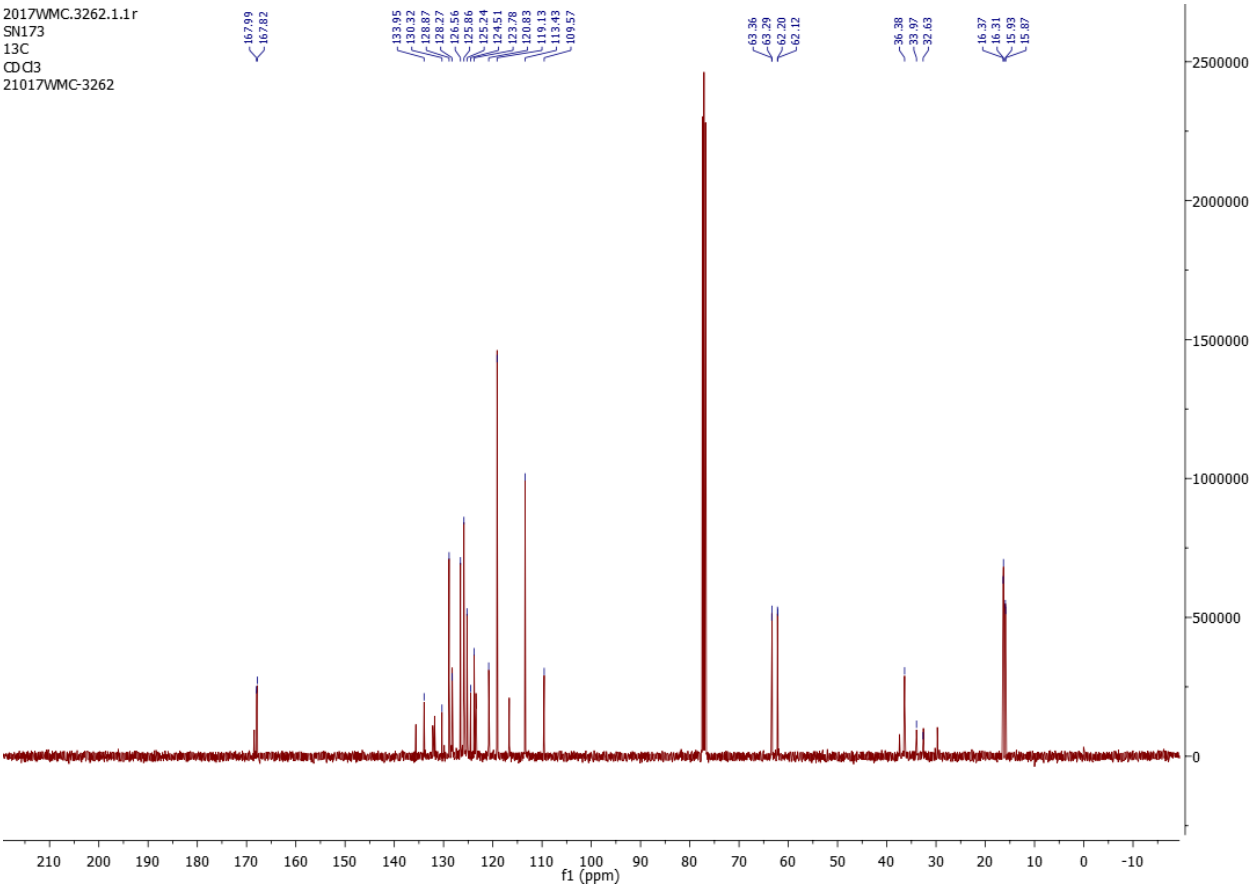

2017WMC.3150.1.1r
SN-162
1H
CDCl3
2017WMC-3150
EtO
EtO
P
O
O
N
O
f1 (ppm)

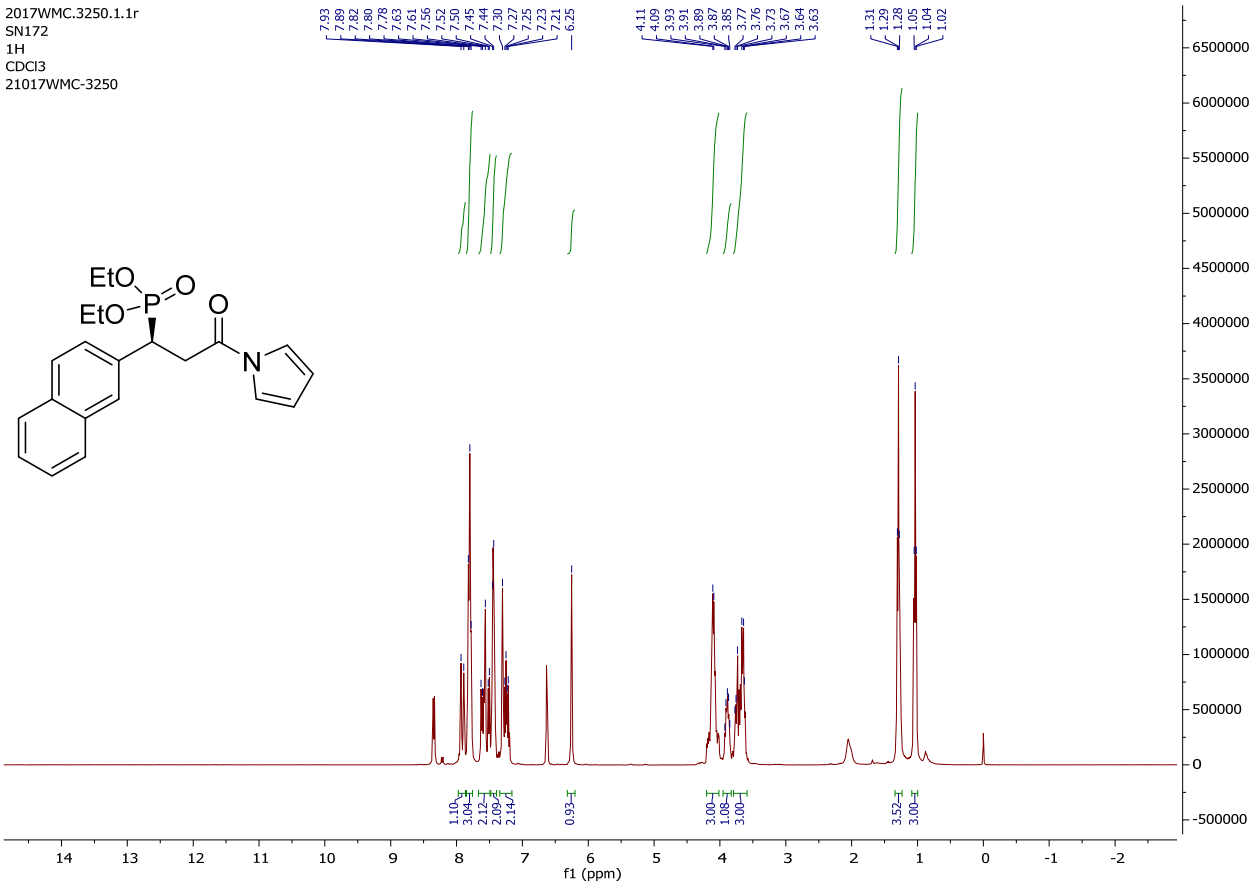

2017WMC.3151.1.1r
SN-162
13C
CDCl3
2017WMC-3151
f1 (ppm)

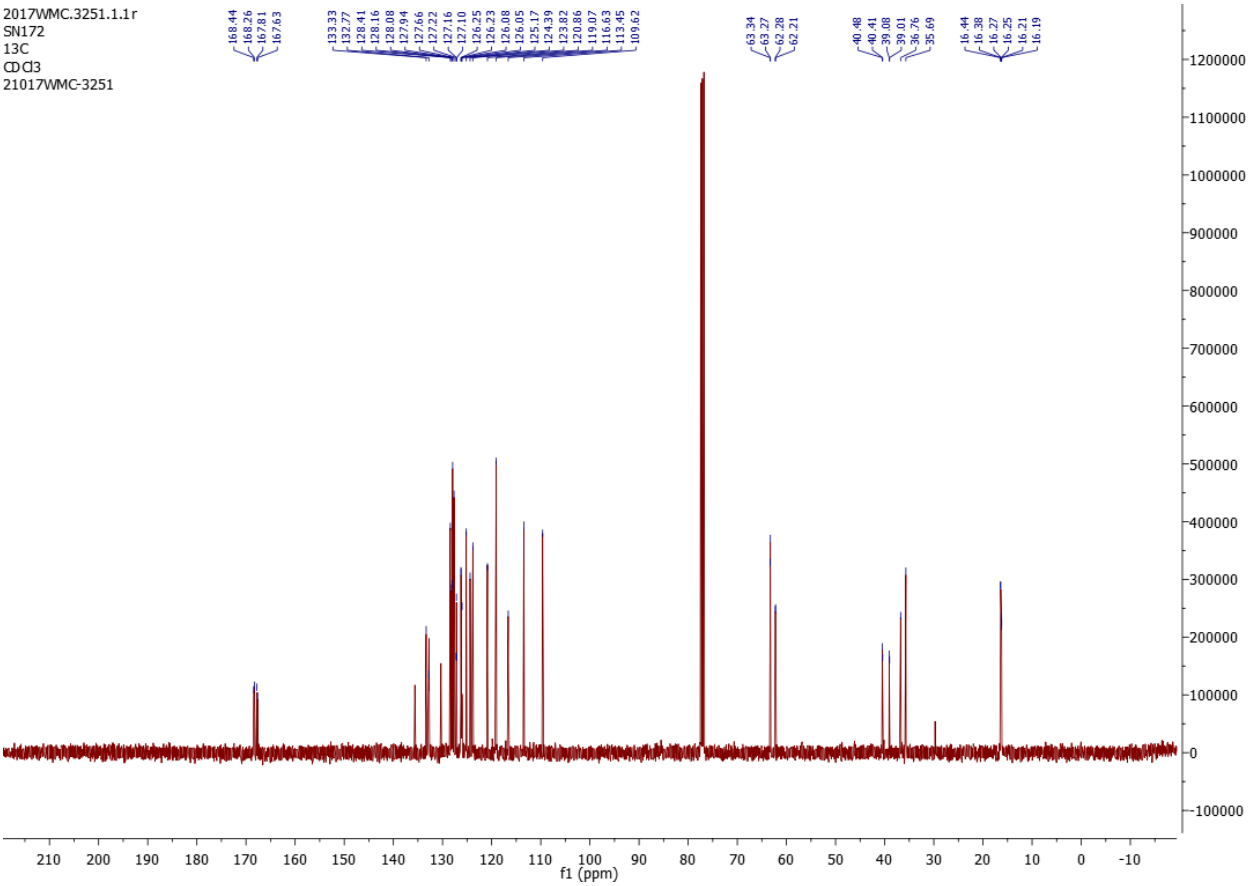

2017WMC.3180.1.1r
SN-165
1H
CDCl3
2017WMC-3180
EtO
EtO
P
O
O
N
S
f1 (ppm)


2017WMC.3181.1.1r
SN-165
13C
CDCl3
2017WMC-3181
167.5
167.3
137.1
137.0
127.1
127.1
127.0
127.0
125.1
119.1
113.5
63.5
63.5
62.6
62.5
36.8
35.7
34.2
16.4
16.3
16.3
16.2
f1 (ppm)


2017WMC.3260.1.1r
SN173
1H
CDCl3
21017WMC-3260
EtO
EtO
P
O
O
N
f1 (ppm)


2017WMC.3262.1.1r
SN173
13C
CDCl3
21017WMC-3262
f1 (ppm)


2017WMC.3250.1.1r
SN172
1H
CDCl3
21017WMC-3250
EtO
EtO
P
O
O
N
f1 (ppm)


2017WMC.3251.1.1r
SN172
13C
CDCl3
21017WMC-3251
f1 (ppm)

6. References

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