Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Efficient Catalytic Enantioselective Nazarov Cyclizations of Divinyl Ketoesters

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Supporting Information

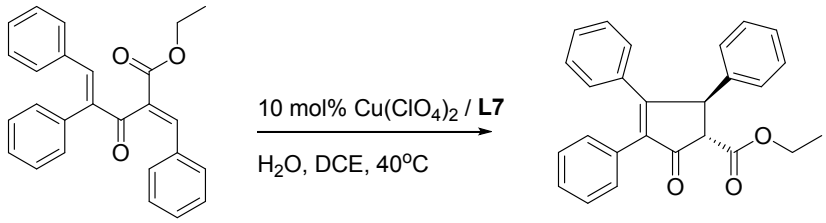
Contents

1. General information

Unless stated otherwise, all reactions were carried out under an atmosphere of Ar using standard Schlenk techniques. All solvents and reagents were obtained from commercial sources and were purified according to standard procedures before use. ^{1}H NMR spectra were recorded on a VarianMercury 300 MHz or Varian Mercury 400 MHz or Agilent Mercury 400 MHz spectrometer in chloroform-d. All signals were reported in ppm with the internal TMS signal at 0.0 ppm or chloroform signal at 7.26 ppm as a standard. Data for ^{1}H NMR were recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, coupling constant(s) in Hz, integration). ^{13}C NMR spectra were recorded on a Varian Mercury 75 MHz or Agilent Mercury 100 MHz spectrometer in chloroform-d. All signals are reported in ppm with the internal chloroform signal at 77.0 ppm as a standard. Enantiomeric ratios were obtainedusing a PerkinElmer series 200 equipped with an UV-VIS detector using one of the following chiral HPLC columns: Chiralcel AD-3 and Chiralcel AD-H column. Infrared spectra were recorded on a Perkin-Elmer Spectrum One FT-IR spectrometer. Chromatography: Flash chromatography was performed on silica gel (Merck Silica Gel 60, 300-400 mesh). TLC was performed on aluminium backed silica plates (60F254, 0.2 mm) which were developed using standard visualising agents. High resolution mass spectra were recorded on a Micromass Analytical Autospec spectrometer.

The substrates **1a-1n** were synthesized according to the literature with similar methods. [1-2]

2. Screening the amount of water



1a **2a**

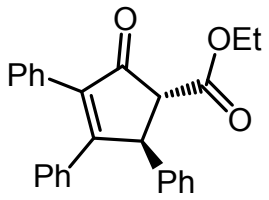
Entry	H_2O (uL)	time (h)	con. (%)[b]	ee (%)[c]
1	0	11	>99	85
2	2.3	11	99	90
3	5	15	93	90.5
4	10	15	47	90
5	15	15	16	89

[a] All reactions were carried out with 10 mol% $Cu(ClO_4)_2$ and ligand **L7** under Ar atmosphere; [b] Determined by ^1H NMR; [c] Determined by chiral HPLC;

3. Typical Procedure for the Asymmetric Nazarov Cyclization

A solution of $Cu(ClO_4)_2 \cdot 6H_2O$ (7.4 mg, 0.02 mmol) and Ligand (9.2 mg, 0.02 mmol) in anhyd DCE (4.0 mL) was stirred at r.t. for 3 h, then 2-benzyliden-3-oxo-4,5-diphenylpent-4-enoic acid ethyl ester (**1a**, 76.5 mg, 0.20 mmol) was added, then stirred at 40 °C for 20 h. The reaction mixture was concentrated under reduced pressure and the residue was purified by flash chromatography to afford **2a** (70.4 mg), as a white solid, EtOAc/petroleum ether 1/20, 92% yield with 90 % *ee* (Chiralcel AD—3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 295 nm: t_R (major) = 7.9 min, t_R (minor) = 10.9 min); $[a]_D^{20}$ = + 276.7° (*c* = 1.050, $CHCl_3$); The absolute configuration of the major enantiomer is (1*R*, 5*S*) by the comparison of its rotation with the data reported.[1-2] The product **2a** was unstable in the air and it is better to store under low temperature in Ar atmosphere.

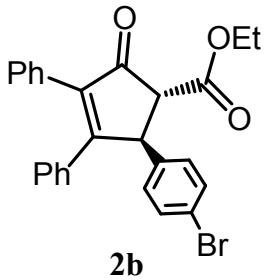
(1*R*, 5*S*)-ethyl 2-oxo-3,4,5-triphenylcyclopent-3-enecarboxylate 2a



2a

92% yield with 90 % *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 295 nm: t_R (major) = 7.9 min, t_R (minor) = 10.9 min); $[\alpha]_D^{25}$ = + 276.7° (c = 1.0500, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31-7.11 (m, 15H), 5.02 (d, J = 2.0 Hz, 1H), 4.29-4.24 (m, 2H), 3.64 (d, J = 2.4 Hz, 1H), 1.32 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) : δ 199.2, 169.8, 168.1, 140.2, 138.4, 133.7, 131.0, 129.5, 129.4, 128.8, 128.7, 128.1, 128.0, 127.4, 127.0, 62.3, 61.6, 50.7, 13.9; IR (Film) *v*: 1704, 1634, 1144 cm^{-1}; HRMS (ESI) calcd for $C_{26}H_{23}O_3^+$: 383.1642. Found: 383.1654.

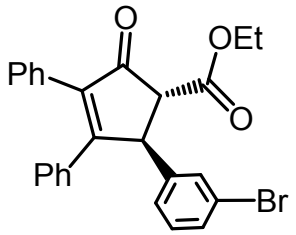
(1*R*, 2*S*)-ethyl 2-(4-bromophenyl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2b



2b

81% yield with 88% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 20/80, 1.0 mL/min^{-1}, λ = 300 nm: t_R (major) = 7.3 min, t_R (minor)= 8.6 min); $[\alpha]_D^{25}$ = + 112.7° (*c* = 1.4870, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37-7.31 (m, 5H), 7.27-7.20 (m, 3H), 7.17-7.15 (m, 4H), 7.03 (d, *J* = 8.4 Hz, 2H), 5.00 (d, *J* = 2.8 Hz, 1H), 4.31-4.25 (m, 2H), 3.57 (d, *J* = 3.2 Hz, 1H), 1.32 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.9, 169.2, 168.0, 139.5, 138.9, 133.7, 132.1, 130.9, 129.8, 129.7, 129.4, 128.8, 128.4, 128.3(4), 128.3(2), 121.2, 62.2, 62.0, 50.2, 14.2; IR (Film) *v*: 1705, 1488, 1177 cm^{-1}; HRMS (ESI) calcd for $C_{26}H_{22}BrO_3^+$: 461.0747. Found: 461.0744.

(1*R*, 2*S*)-ethyl 2-(3-bromophenyl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2c

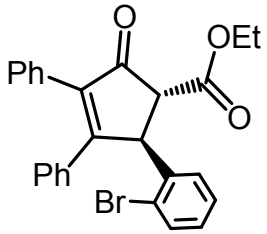


2c

80% yield with 85 % *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes= 20/80, 1.0 mL/min^{-1}, λ = 300 nm: t_R (major) = 9.3 min, t_R (minor) = 13.6 min); $[\alpha]_D^{25}$ = + 288.2° (*c* = 0.9700, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31-7.06 (m, 12H), 6.72 (d, *J* = 7.6 Hz, 1H), 6.62 (d, *J* = 7.2 Hz, 2H), 4.95 (d, *J* = 2.4 Hz, 1H), 4.29-4.24 (m, 2H), 3.63 (d, *J* = 2.8 Hz, 1H), 1.30 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 200.4, 170.8, 168.5, 156.6, 141.6, 138.5, 133.5, 130.8, 129.9, 129.6, 129.4, 128.7, 128.2, 128.1, 128.0,

119.1, 114.4, 114.3, 62.2, 62.0, 50.7, 13.8; IR (Film) *v*: 1729, 1690, 1614, 1143 cm^{-1}; HRMS (ESI) calcd for $C_{26}H_{22}BrO_3^+$: 461.0747. Found: 461.0748.

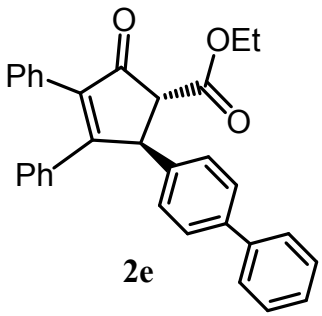
(1*R*, 2*S*)-ethyl 2-(2-bromophenyl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2d



2d

78% yield with 86% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes= 10/90, 1.0 mL/min^{-1}, λ = 297 nm: t_R (major) = 9.7 min, t_R (minor)= 15.7 min); $[\alpha]_D^{25}$ = + 280.3° (*c* = 0.7450, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.54 (d, *J* = 7.2 Hz, 1H), 7.33-7.09 (m, 11H), 7.04-6.93 (m, 2H), 5.62 (s, 1H), 4.33-4.26 (m, 2H), 3.47 (s, 1H), 1.33 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 199.4, 169.5, 168.1, 140.3, 139.5, 133.5, 133.0, 131.2, 130.0, 129.6, 128.9, 128.7, 128.4, 128.3, 128.2, 128.1, 124.8, 61.9, 61.7, 49.6, 14.2; IR (Film) *v*: 1731, 1693, 1368, 1143, 1017 cm^{-1}; HRMS (ESI) calcd for $C_{26}H_{22}BrO_3^+$: 461.0747. Found: 461.0748.

(1*R*, 2*S*)-ethyl 2-([1,1'-biphenyl]-4-yl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2e

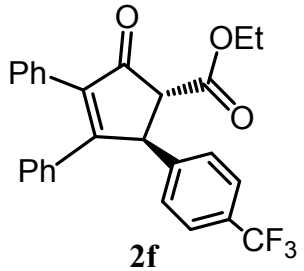


2e

92% yield with 83% ee (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ =

300 nm: t_R (major) = 12.8 min, t_R (minor) = 17.5 min); $[\alpha]_D^{25}$ = + 250.5° (*c* = 1.1400, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$): δ 7.52-7.15 (m, 19H), 5.07 (d, *J* = 2.7 Hz, 1H), 4.33-4.24 (m, 2H), 3.67 (d, *J* = 2.7 Hz, 1H), 1.33 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) : δ 199.3, 169.8, 168.3, 140.2, 140.0, 139.5, 138.7, 134.0, 131.2, 129.7, 129.6, 128.9, 128.7, 128.3, 128.2, 128.1(9), 128.1, 127.6, 127.3, 126.8, 62.4, 61.9, 50.5, 14.1; IR (Film) *v*: 1725, 1698, 1340, 1250, 1138 cm^{-1}; HRMS (ESI) calcd for $C_{32}H_{27}O_3^+$: 459.1955. Found: 459.1956.

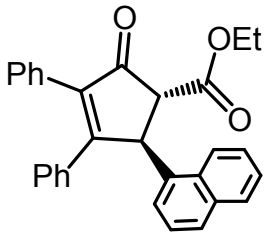
(1*R*, 5*S*)-ethyl 2-oxo-3,4-diphenyl-5-(4-(trifluoromethyl)phenyl)cyclopent-3-enecarboxylate 2f



2f

83% yield with 84 % *ee* (SFC, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 214 nm: t_R (major) = 6.6 min, t_R (minor) = 8.8 min); $[\alpha]_D^{25}$ = + 258.8° (*c* = 0.6500, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$): δ 7.49 (d, *J* = 8.1 Hz, 2H), 7.32-7.18 (m, 12H), 5.12 (d, *J* = 3.0 Hz, 1H), 4.31-4.26 (m, 2H), 3.58 (d, *J* = 3.0 Hz, 1H), 1.32 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 198.6, 168.8, 167.9, 144.6 (d, *J* = 1.1 Hz), 139.1, 133.6, 130.9, 129.9, 129.7, 128.8, 128.4, 128.1, 126.0 (q, *J* = 3.6 Hz), 62.1, 50.4, 14.2; ^{19}F NMR (282 MHz, $CDCl_3$) : δ -63.0; IR (Film) *v*: 1731, 1703, 1322, 1110 cm^{-1}; HRMS (ESI) calcd for $C_{27}H_{22}F_3O_3^+$: 451.1516. Found: 451.1518.

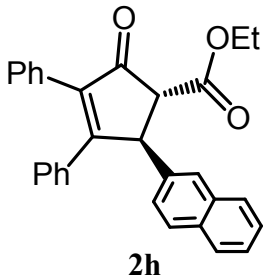
(1*R*,2*S*)-ethyl 2-(naphthalen-1-yl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2g



2g

89% yield with 86% *ee* (Chiralcel AD-H, ^{i}PrOH/hexanes= 10/90, 0.7 mL/min^{-1}, λ = 296 nm: t_R (major) = 9.5 min, t_R (minor)= 11.3 min); $[\alpha]_D^{25}$ = + 296.5° (*c* = 0.5000, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.29 (d, *J* = 8.4 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.70-7.54 (m, 3H), 7.36-7.30 (m, 6H), 7.23-7.04 (m, 6H), 5.94 (s, 1H), 4.31-4.29 (m, 2H), 3.56 (s, 1H), 1.30 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) : δ 199.4, 169.8, 168.6, 139.5, 137.5, 134.0, 133.9, 131.7, 131.5, 129.8, 129.7, 129.0, 128.9, 128.5, 128.2(7), 128.2(5), 127.7, 126.8, 126.0, 125.6, 124.6, 122.8, 62.4, 62.0, 45.3, 14.1; IR (Film) *v*: 1729, 1700, 1140 cm^{-1}; HRMS (ESI) calcd for $C_{30}H_{25}O_3^+$: 433.1798. Found: 433.1800.

(1*R*, 2*S*)-ethyl 2-(naphthalen-2-yl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2h

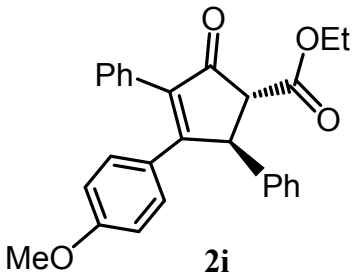


2h

93% yield with 87% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 290 nm: t_R (major) = 11.0 min, t_R (minor)= 13.4 min); $[\alpha]_D^{25}$ = + 217.7° (*c* = 0.8050, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75-7.68 (m, 4H), 7.43-7.32 (m, 7H), 7.22 (d, *J* = 7.5 Hz, 3H), 7.12-7.06 (m, 3H), 5.20 (d, *J* = 2.7 Hz, 1H), 4.36-4.21 (m, 2H), 3.71 (d, *J* = 2.7 Hz, 1H), 1.30 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 199.4,

169.8, 168.3, 138.9, 137.8, 134.0, 133.4, 132.5, 131.2, 129.8, 129.6, 129.1, 128.9, 128.4, 128.2, 127.6, 127.1, 126.3, 126.0, 124.9, 62.4, 61.9, 51.1, 14.2; IR (Film) *v*: 1703, 1626, 1332, 1141 cm^{-1}; HRMS (ESI) calcd for $C_{30}H_{25}O_3^+$: 433.1798. Found: 433.1798.

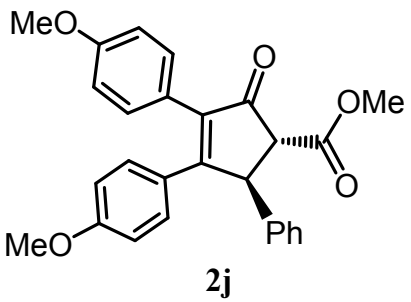
(1*R*, 2*S*)-ethyl 3-(4-methoxyphenyl)-5-oxo-2,4-diphenylcyclopent-3-enecarboxyla -te 2i



2i

91% yield with 78% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 300 nm: t_R (major) = 11.5 min, t_R (minor) = 15.3 min); $[\alpha]_D^{25}$ = + 195.3° (*c* = 1.0000, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.26-7.13 (m, 12H), 6.84 (d, *J* = 8.7 Hz, 2H), 4.97 (d, *J* = 3.0 Hz, 1H), 4.29-4.24 (m, 2H), 3.80 (s, 3H), 3.61 (d, *J* = 2.7 Hz, 1H), 1.31 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 199.8, 168.9, 168.3, 159.5, 140.6, 138.1, 134.3, 131.0, 129.4, 129.0, 128.8, 128.2, 127.7, 127.2, 123.3, 113.8, 62.4, 61.8, 55.1, 50.9, 14.2; IR (Film) *v*: 1718, 1657, 1511, 1249 cm^{-1}. HRMS (ESI) calcd for $C_{27}H_{25}IO_4^+$: 413.1747. Found: 413.1747.

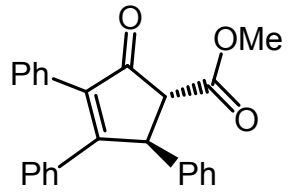
(1*R*, 5*S*)-ethyl 3,4-bis(4-methoxyphenyl)-2-oxo-5-phenylcyclopent-3-enecarboxy late 2j



2j

90% yield with 82% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 327 nm: t_R (major) = 22.2 min, t_R (minor) = 25.7 min); $[\alpha]_D^{25}$ = + 261.6° (*c* = 0.8200, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.26-7.22 (m, 4H), 7.19-7.14 (m, 5H), 6.88 (d, *J* = 8.8 Hz, 2H), 6.65 (d, *J* = 8.8 Hz, 2H), 4.96 (d, *J* = 2.8 Hz, 1H), 4.28-4.24 (m, 2H), 3.82 (s, 3H), 3.72 (s, 3H), 3.56 (d, *J* = 2.8 Hz, 1H), 1.31 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 199.5, 168.5, 168.3, 160.5, 159.3, 141.2, 137.0, 131.0, 130.9, 129.0, 127.6, 127.1, 126.3, 123.9, 113.9, 113.6, 62.5, 61.7, 55.1, 55.0, 50.5, 14.2; IR (Film) *v*: 1732, 1699, 1602, 1505, 1252, 1177 cm^{-1}; HRMS (ESI) calcd for $C_{28}H_{27}O_5^+$: 443.1853. Found: 443.1854.

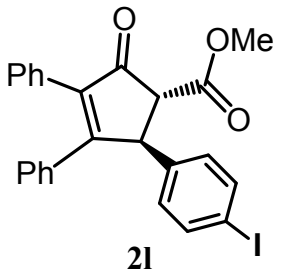
(1*R*, 5*S*)-methyl 2-oxo-3,4,5-triphenylcyclopent-3-enecarboxylate 2k



2k

95% yield with 90% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 10/90, 1.0 mL/min^{-1}, λ = 295 nm: t_R (major) = 9.1 min, t_R (minor) = 11.6 min); $[\alpha]_D^{25}$ = +278.4° (*c* = 0.99, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.30-7.14 (m, 15H), 5.02 (d, *J* = 1.5 Hz, 1H), 3.80 (s, 3H), 3.66 (d, *J* = 1.5 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 199.2, 170.0, 168.7, 140.4, 138.7, 134.0, 131.2, 129.7, 129.6, 129.0, 128.9, 128.3, 128.2, 127.7, 127.3, 62.3, 52.8, 51.0; IR (Film) *v*: 1725, 1695, 1341, 1139 cm^{-1}; HRMS (ESI) calcd for $C_{25}H_{21}O_3^+$: 369.1485. Found: 369.1486.

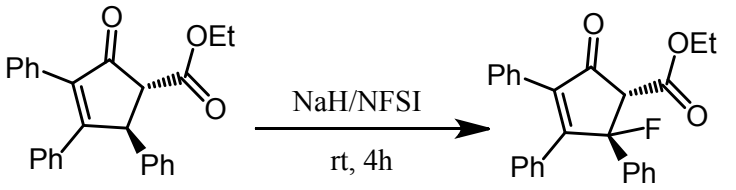
(1*R*, 2*S*)-methyl 2-(4-iodophenyl)-5-oxo-3,4-diphenylcyclopent-3-enecarboxylate 2l



2l

87% yield with 90% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 3/97, 1.0 mL/min^{-1}, λ = 320 nm: t_R (major) = 28.1 min, t_R (minor) = 32.6 min); $[\alpha]_D^{25}$ = +221.1° (*c* = 0.6450, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.56 (d, *J* = 8.0 Hz, 2H), 7.31-7.16 (m, 10H), 6.91 (d, *J* = 8.0 Hz, 2H), 4.99 (d, *J* = 2.0 Hz, 1H), 3.82 (s, 3H), 3.58 (d, *J* = 2.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.8, 169.2, 168.5, 140.1, 138.9, 138.1, 133.6, 130.9, 129.9, 129.7, 129.6, 128.9, 128.3(9), 128.3(7), 92.8, 62.0, 53.0, 50.3; IR (Film) *v*: 1728, 1703, 1345, 1139 cm^{-1}; HRMS (ESI) calcd for $C_{25}H_{20}IO_3^+$: 495.0452. Found: 495.0452.

4. Chemical transformations of 2a to 3a



90% ee

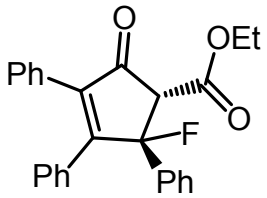
2a

87% yield, 90%ee

3a

A solution of **2a** (76.5 mg, 0.20 mmol) in anhyd THF (4.0 mL) was charged in a schlenk falsk, then NaH (0.21 mmol, 5.0 mg) was added in one portion. After that, NFSI (0.2 mmol) was added and the solution was stirred at rt 4h. Pure product was obtained by flash chromatography to afford **3a** (70.4 mg, 87% yield), as a white solid.

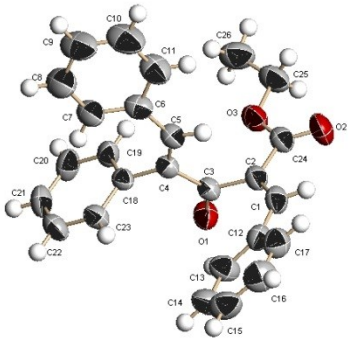
(1*R*, 2*R*)-ethyl 2-fluoro-5-oxo-2,3,4-triphenylcyclopent-3-enecarboxylate 3a [3]

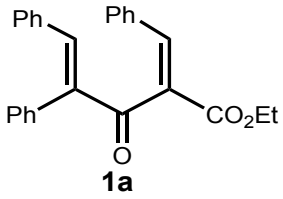


3a

87% yield with 90% *ee* (Chiralcel AD-3, ^{i}PrOH/hexanes = 3/97, 1.0 mL/min^{-1}, λ = 300 nm: t_R (major) = 16.0 min, t_R (minor) = 18.4 min); $[\alpha]_D^{25}$ = +301.8° (*c* = 0.4, $CHCl_3$) ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.38-7.36 (m, 3H), 7.30-7.27 (m, 2H), 7.25-7.11 (m, 10H), 4.98 (d, *J* = 24.4 Hz, 1H), 3.87 (q, *J* = 3.2 Hz, 1H), 3.66 (q, *J* = 3.2 Hz, 1H), 0.94 (t, *J* = 7.2 Hz, 3H).

5. Crystal data of 1a (ccdc 1029676)





1a

Table 1. Crystal data and structure refinement for cd212116.

Identification code	cd212116
Empirical formula	C26 H22 O3
Formula weight	382.44
Temperature	293(2) K
Wavelength	0.71073 A
Crystal system, space group	Monoclinic, Cc
Unit cell dimensions	a = 10.6608(8) A alpha = 90 deg. b = 20.7410(15) A beta = 102.307(2) deg. c = 9.9455(7) A gamma = 90 deg.
Volume	2148.6(3) A^3
Z, Calculated density	4, 1.182 Mg/m^3
Absorption coefficient	0.076 mm^-1
F(000)	808
Crystal size	0.275 x 0.211 x 0.159 mm
Theta range for data collection	1.96 to 25.99 deg.
Limiting indices	-13<=h<=10, -25<=k<=25, -12<=l<=11
Reflections collected / unique	6373 / 2862 [R(int) = 0.0184]
Completeness to theta = 25.99	100.0 %
Absorption correction	Empirical
Max. and min. transmission	1.00000 and 0.58997
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2862 / 2 / 263
Goodness-of-fit on F^2	1.048
Final R indices [I>2sigma(I)]	R1 = 0.0371, wR2 = 0.0969
R indices (all data)	R1 = 0.0404, wR2 = 0.0994
Absolute structure parameter	0.4(11)
Largest diff. peak and hole	0.122 and -0.176 e.A^-3

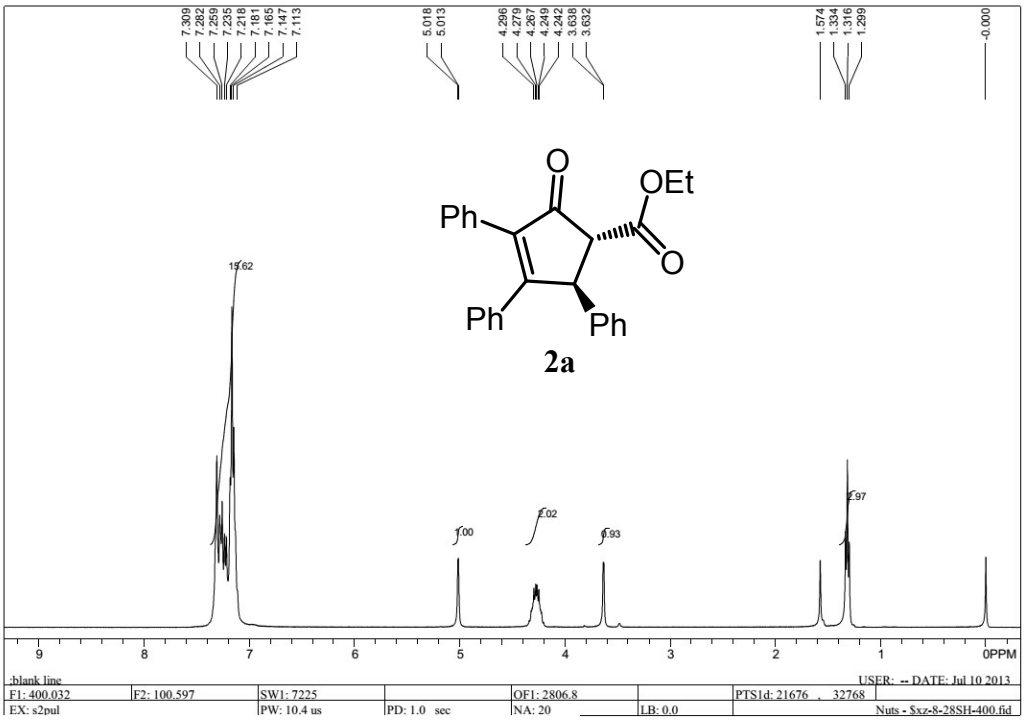
6. Reference

1. Aggarwal, V. K.; Belfield, A. J. *Org. Lett.* **2003**, *5*(26), 5075-5078.

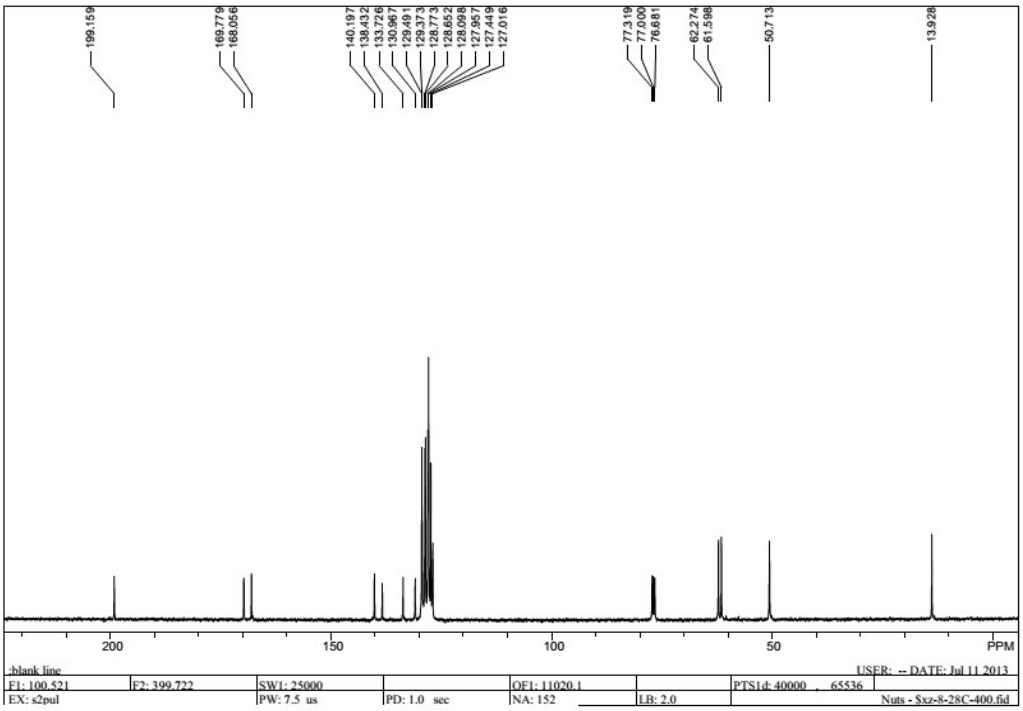
2. Walz, I.; Togni, A. *Chem. Commun.* **2008**, 4315–4317.

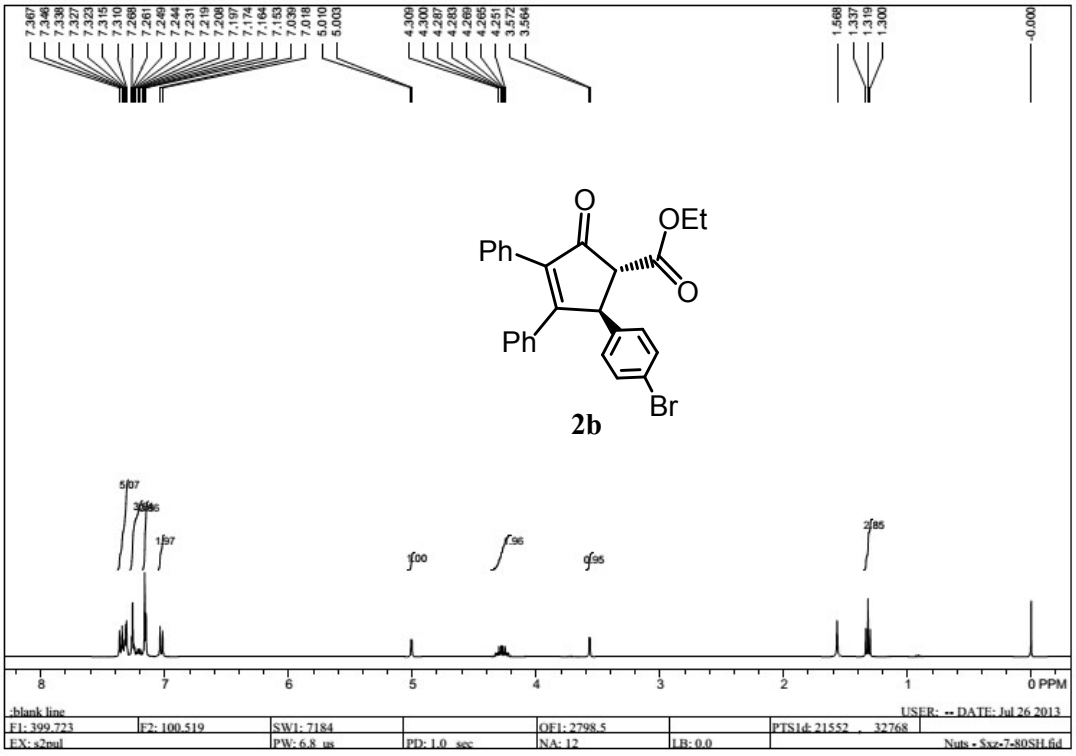
3. Kawatsura, M.; Kajita, K.; Hayase, S.; Itoh, T. *Synlett* **2010**, *8*, 1243–1246.

6. ^{1}H NMR and ^{13}C NMR Spectra of Compounds



2a

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7.323
7.315
7.310
7.268
7.261
7.249
7.244
7.231
7.219
7.209
7.197
7.174
7.164
7.153
7.039
7.018
5.010
5.003
4.309
4.300
4.287
4.283
4.269
4.265
4.251
3.572
3.564
1.568
1.337
1.319
1.300
-0.000
O
OEt
Ph
O
Ph
Br
5.07
1.97
1.00
0.96
0.95
2.85
8
7
6
5
4
3
2
1
0 PPM
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PTS1d: 21552 , 32768
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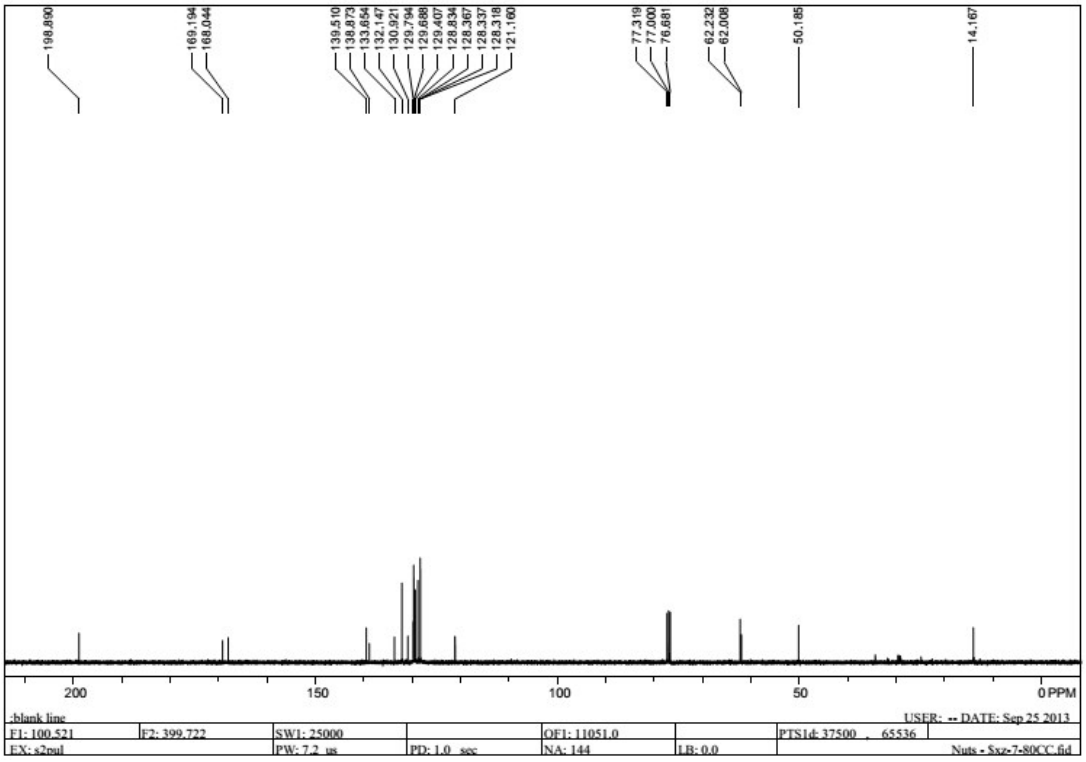
PD: 1.0 sec
NA: 12
LB: 0.0
Nuts - Sxz-7-80SH.fid

2b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168.044
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138.873
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132.147
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129.688
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128.367
128.337
128.318
121.160
77.319
77.000
76.681
62.232
62.008
50.185
14.167
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150
100
50
0 PPM
:blank line
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PW: 7.2 us
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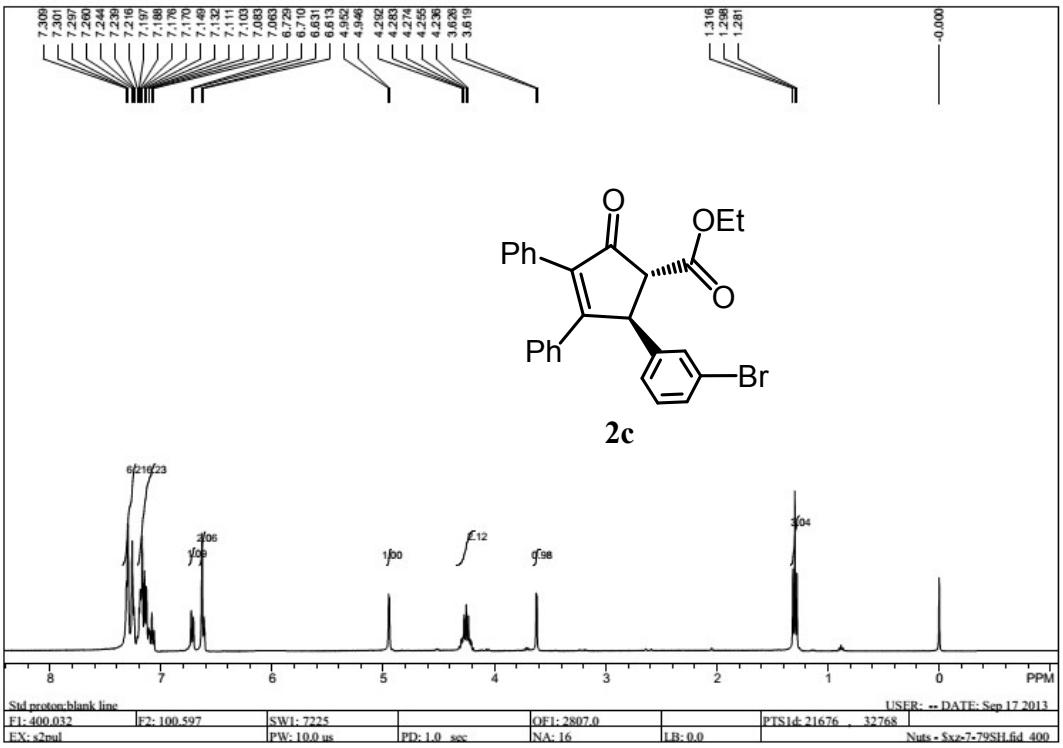
Nuts - Sxz-7-80CC.fid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7.297
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7.244
7.239
7.216
7.197
7.188
7.176
7.170
7.149
7.132
7.111
7.103
7.083
7.063
6.729
6.710
6.631
6.613
4.952
4.946
4.292
4.283
4.274
4.255
4.236
3.626
3.619
1.316
1.298
1.281
-0.000
O
OEt
Ph
O
Ph
Br
6.21
6.23
2.06
1.09
1.00
2.12
0.98
3.04
8
7
6
5
4
3
2
1
0
PPM
Std proton:blank line
USER: -- DATE: Sep 17 2013
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PTS1d: 21676 , 32768
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LB: 0.0
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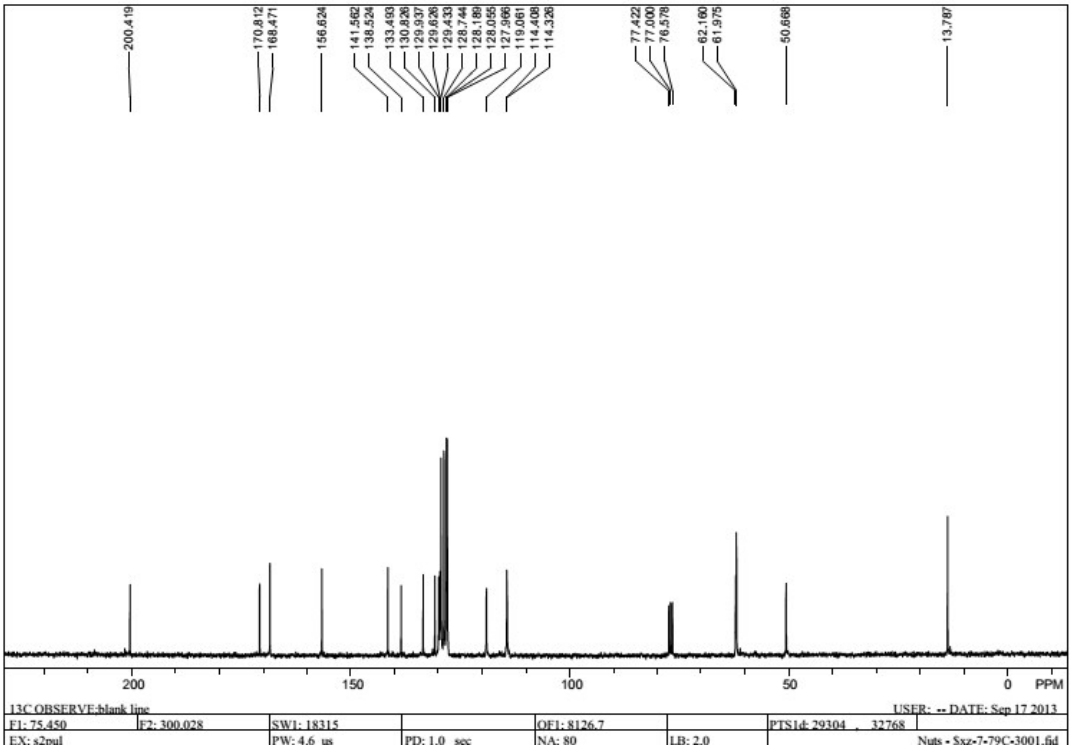
2c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129.937
129.626
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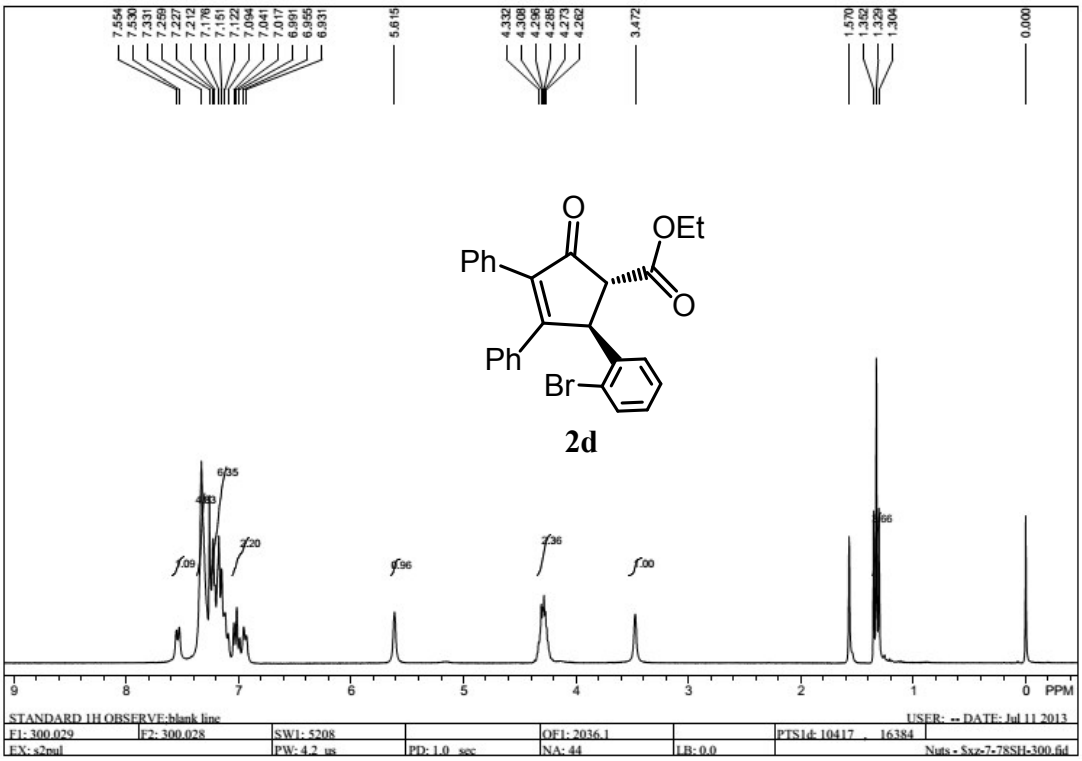
128.744
128.189
128.055
127.966
119.061
114.408
114.326
77.422
77.000
76.578
62.160
61.975
50.668
13.787
200
150
100
50
0
PPM
13C OBSERVE:blank line
USER: -- DATE: Sep 17 2013
F1: 75.450
F2: 300.028
SW1: 18315
OF1: 8126.7
PTS1d: 29304 , 32768
EX: s2pul
PW: 4.6 us
PD: 1.0 sec
NA: 80
LB: 2.0
Nuts - Sxz-7-79C-3001.fid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7.212
7.176
7.151
7.122
7.094
7.041
7.017
6.991
6.955
6.931
5.615
4.332
4.308
4.296
4.285
4.273
4.262
3.472
1.570
1.352
1.329
1.304
0.000
O
OEt
Ph
O
Ph
Br
6.35
4.83
2.20
1.09
0.96
2.36
1.00
3.66
9
8
7
6
5
4
3
2
1
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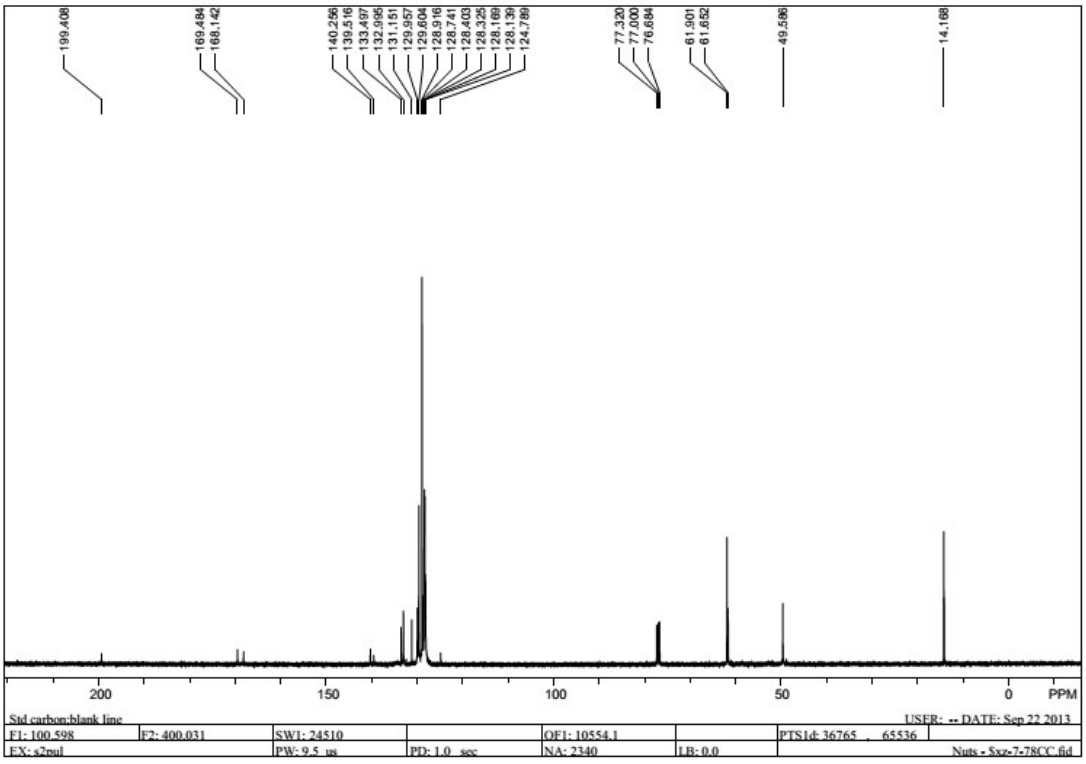
PPM
STANDARD 1H OBSERVE:blank line
USER: -- DATE: Jul 11 2013
F1: 300.029
F2: 300.028
SW1: 5208
OF1: 2036.1
PTS1d: 10417 , 16384
EX: s2pul
PW: 4.2 us
PD: 1.0 sec
NA: 44
LB: 0.0
Nuts - Sxz-7-78SH-300.fid

2d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128.169
128.139
124.789
77.320
77.000
76.684
61.901
61.652
49.586
14.168
200
150
100
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F2: 400.031
SW1: 24510
OF1: 10554.1
PTS1d: 36765 , 65536
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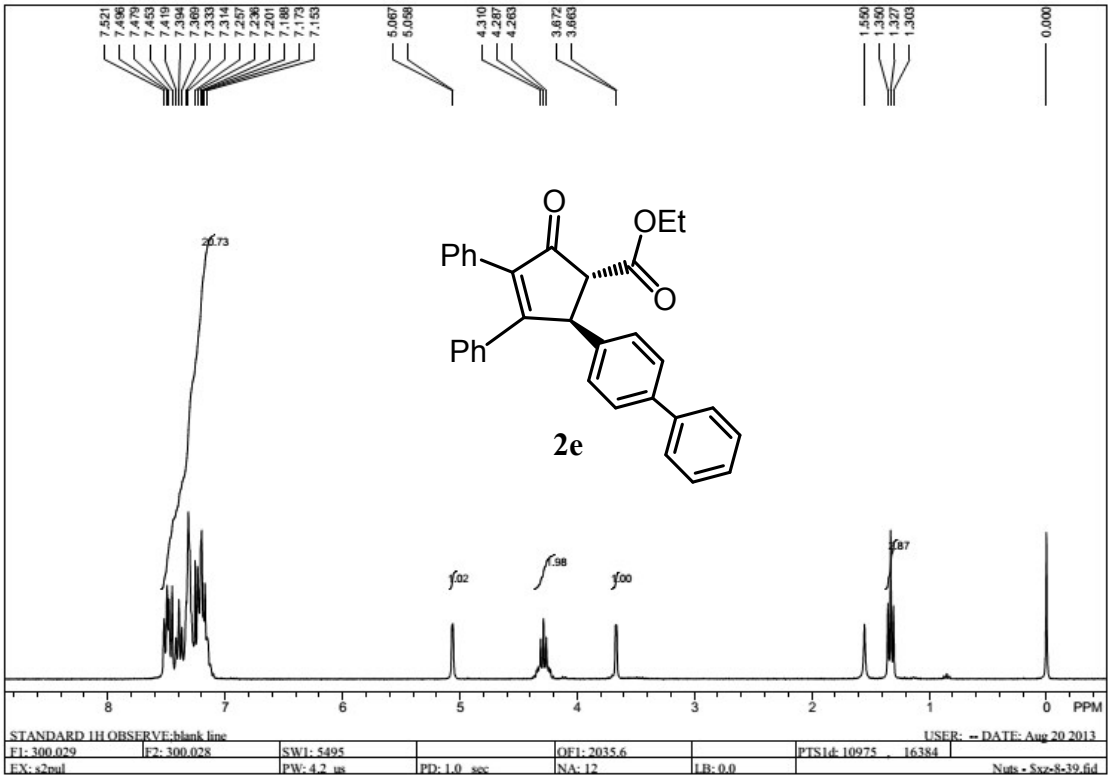
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7.394
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7.333
7.314
7.257
7.236
7.201
7.188
7.173
7.153
5.067
5.058
4.310
4.287
4.263
3.672
3.663
1.550
1.390
1.327
1.303
0.000
20.73
1.02
1.98
1.00
3.87
O
OEt
Ph
O
Ph
8
7
6
5
4
3
2
1
0
PPM
STANDARD 1H OBSERVE:blank line
USER: -- DATE: Aug 20 2013
F1: 300.029
F2: 300.028
SW1: 5495
OF1: 2035.6
PTS1d: 10975 , 16384
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PW: 4.2 us
PD: 1.0 sec
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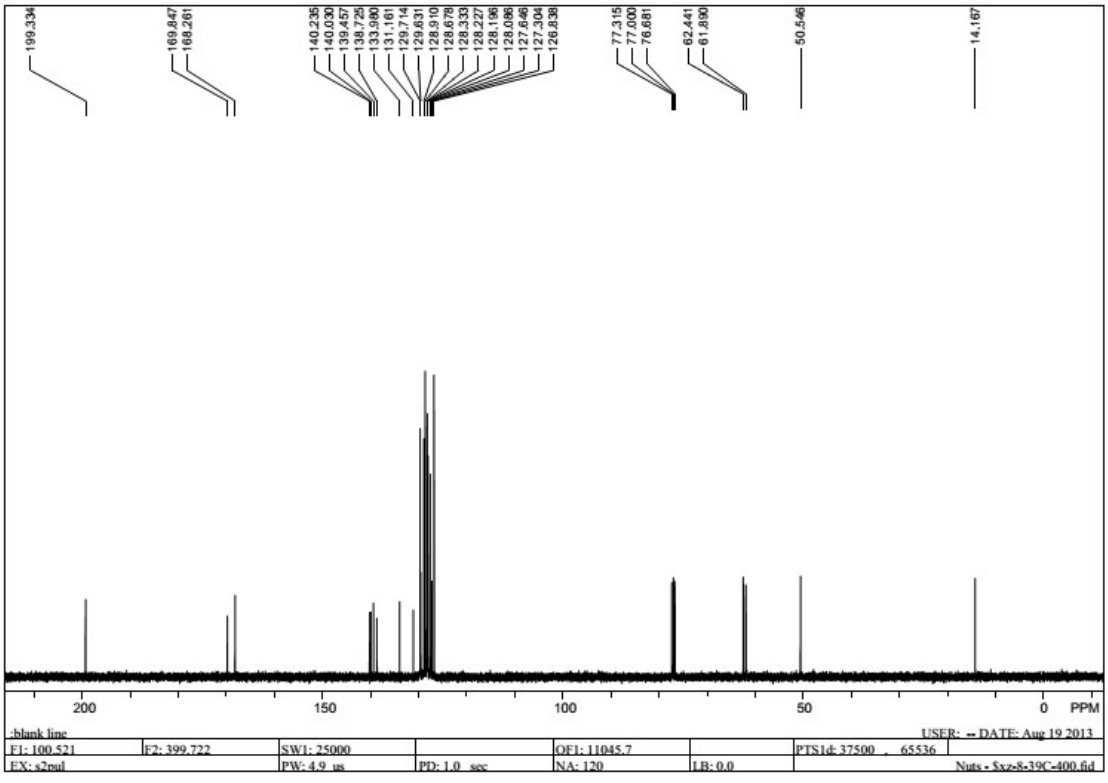
LB: 0.0
Nuts - $xz-8-39.fid

2e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128.196
128.086
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127.304
126.838
77.315
77.000
76.681
62.441
61.890
50.546
14.167
200
150
100
50
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PPM
:blank line
USER: -- DATE: Aug 19 2013
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F2: 399.722
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OF1: 11045.7
PTS1d: 37500 , 65536
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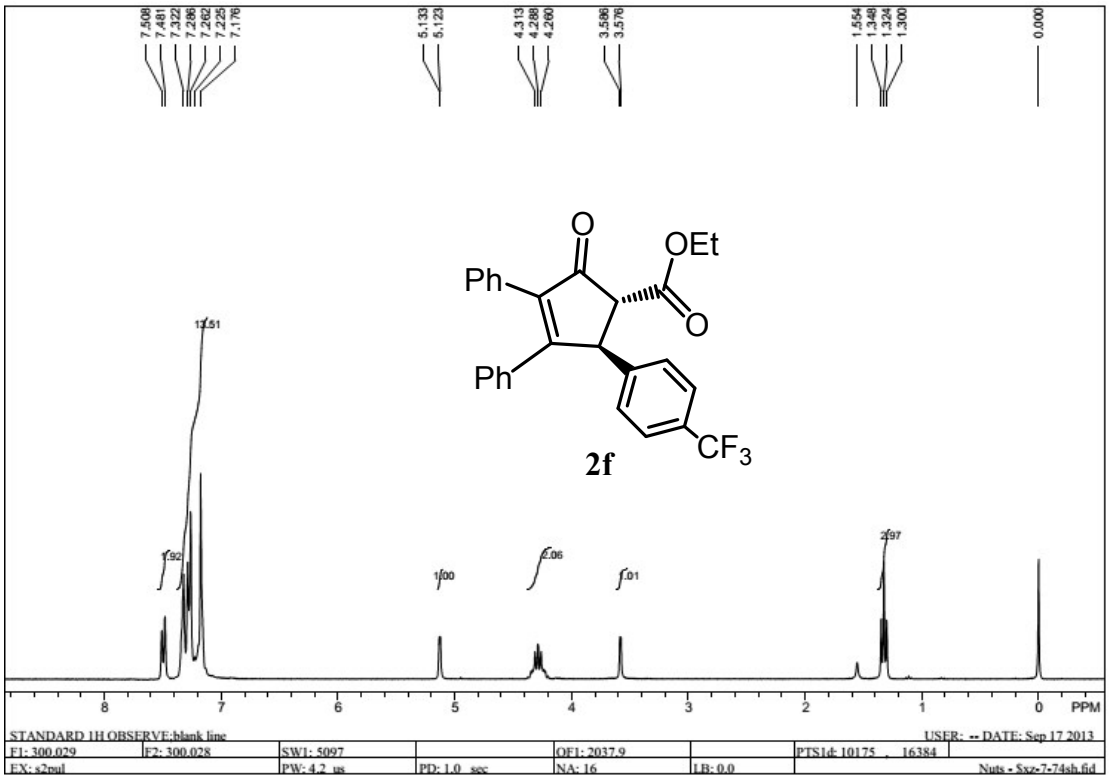
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5.133
5.123
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4.260
3.598
3.576
1.554
1.348
1.324
1.300
0.000
O
OEt
Ph
O
Ph
CF3
2f
12.51
1.92
1.00
2.06
1.01
2.97
8
7
6
5
4
3
2
1
0
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F2: 300.028
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PTS1d: 10175 , 16384
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PW: 4.2 us
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LB: 0.0
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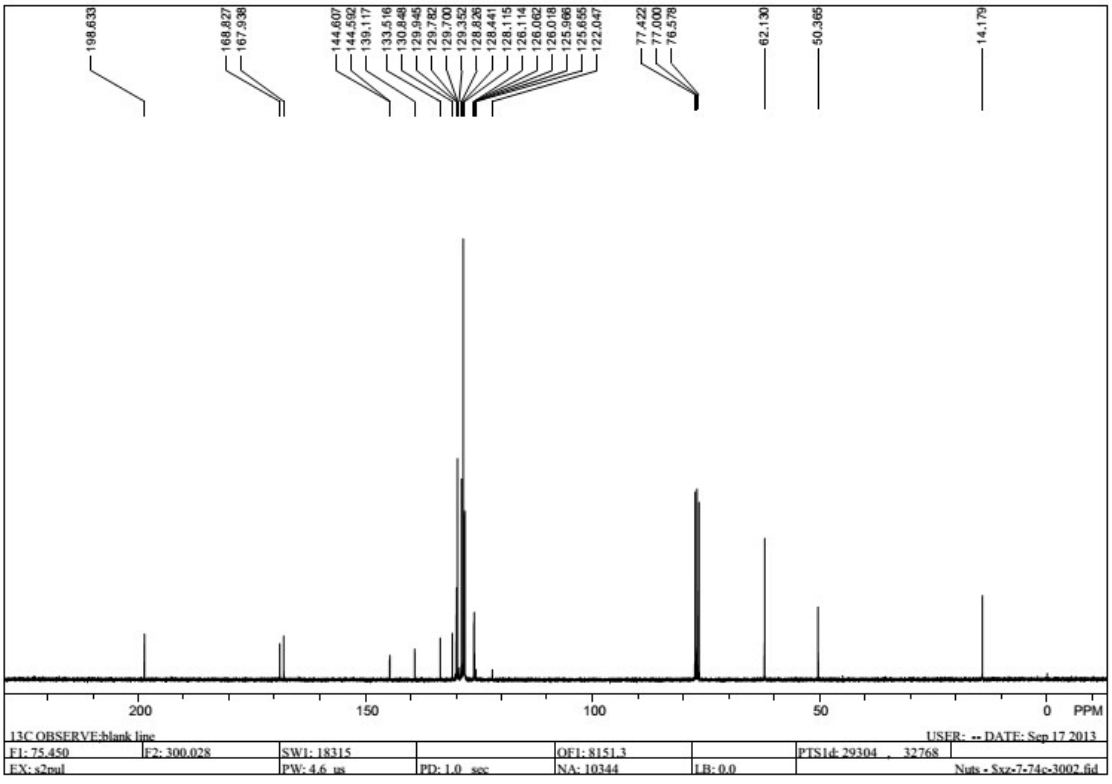
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129.352
128.826
128.441
128.115
126.114
126.062
126.018
125.966
125.655
122.047
77.422
77.000
76.578
62.130
50.365
14.179
200
150
100
50
0
PPM
13C OBSERVE:blank line
USER: -- DATE: Sep 17 2013
F1: 75.450
F2: 300.028
SW1: 18315
OF1: 8151.3
PTS1d: 29304 , 32768
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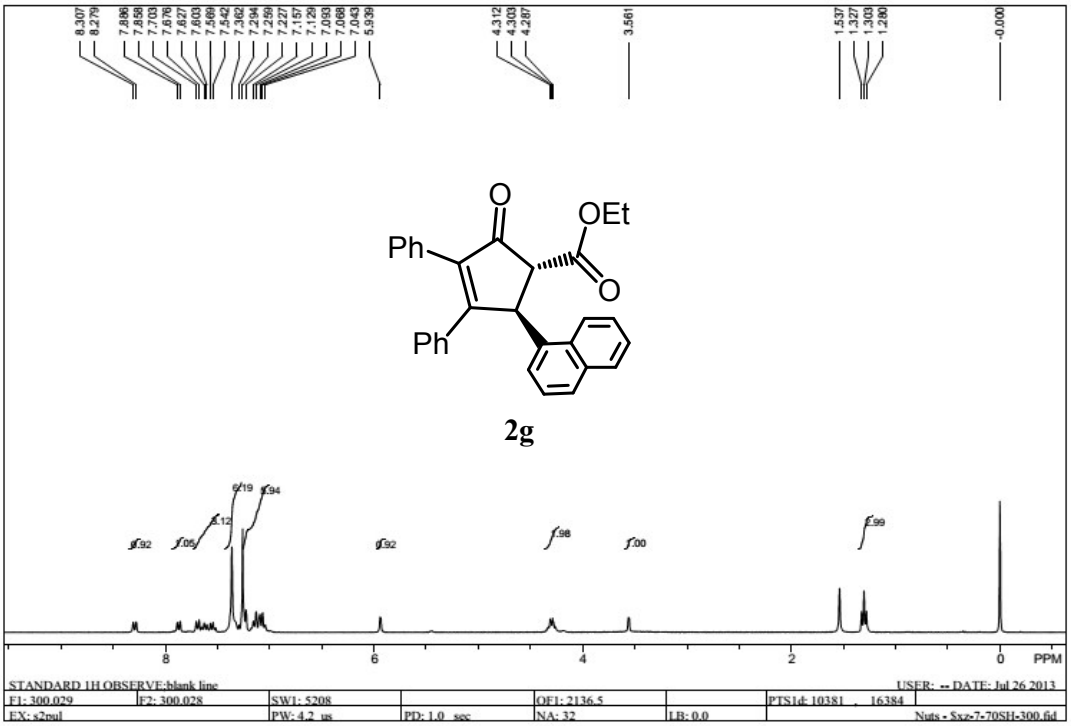
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7.603
7.569
7.542
7.362
7.294
7.259
7.227
7.157
7.129
7.093
7.068
7.043
5.939
4.312
4.303
4.287
3.561
1.537
1.327
1.303
1.280
-0.000
O
OEt
Ph
O
Ph
6.19
5.94
5.12
1.92
1.05
1.92
1.98
1.00
1.99
8
6
4
2
0
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USER: -- DATE: Jul 26 2013
F1: 300.029
F2: 300.028
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OF1: 2136.5
PTS1d: 10381 , 16384
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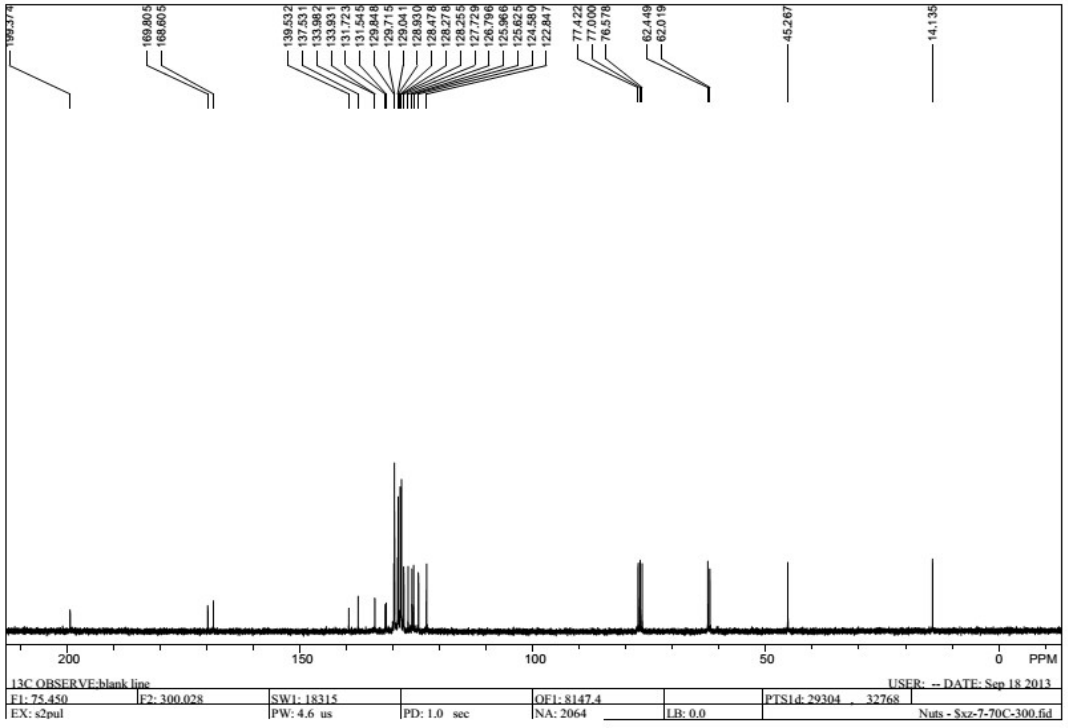
2g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128.930
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128.255
127.729
126.796
125.966
125.625
124.580
122.847
77.422
77.000
76.578
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62.019
45.267
14.135
200
150
100
50
0
PPM
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PTS1d: 29304 , 32768
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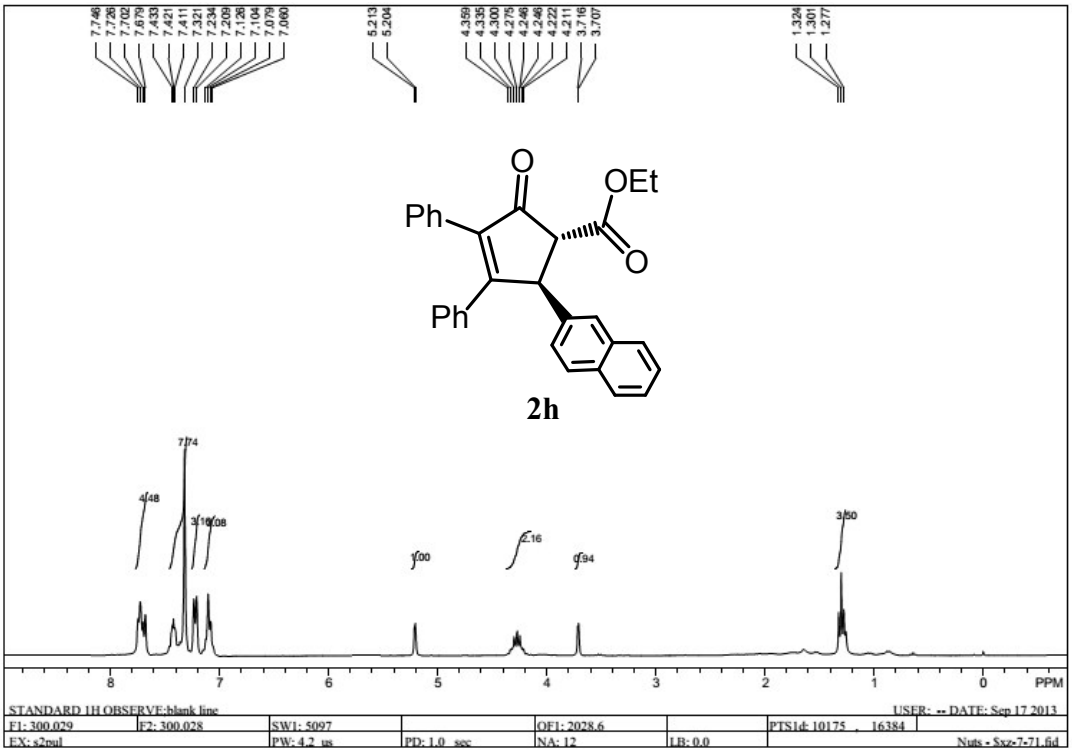
NA: 2064
LB: 0.0
Nuts - Sxz-7-70C-300.fid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7.321
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7.209
7.126
7.104
7.079
7.060
5.213
5.204
4.359
4.335
4.300
4.275
4.246
4.222
4.211
3.716
3.707
1.324
1.301
1.277
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OEt
Ph
O
Ph
2h
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3.08
1.00
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0.94
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7
6
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4
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2
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0
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STANDARD 1H OBSERVE:blank line
USER: -- DATE: Sep 17 2013
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PW: 4.2 us
PD: 1.0 sec
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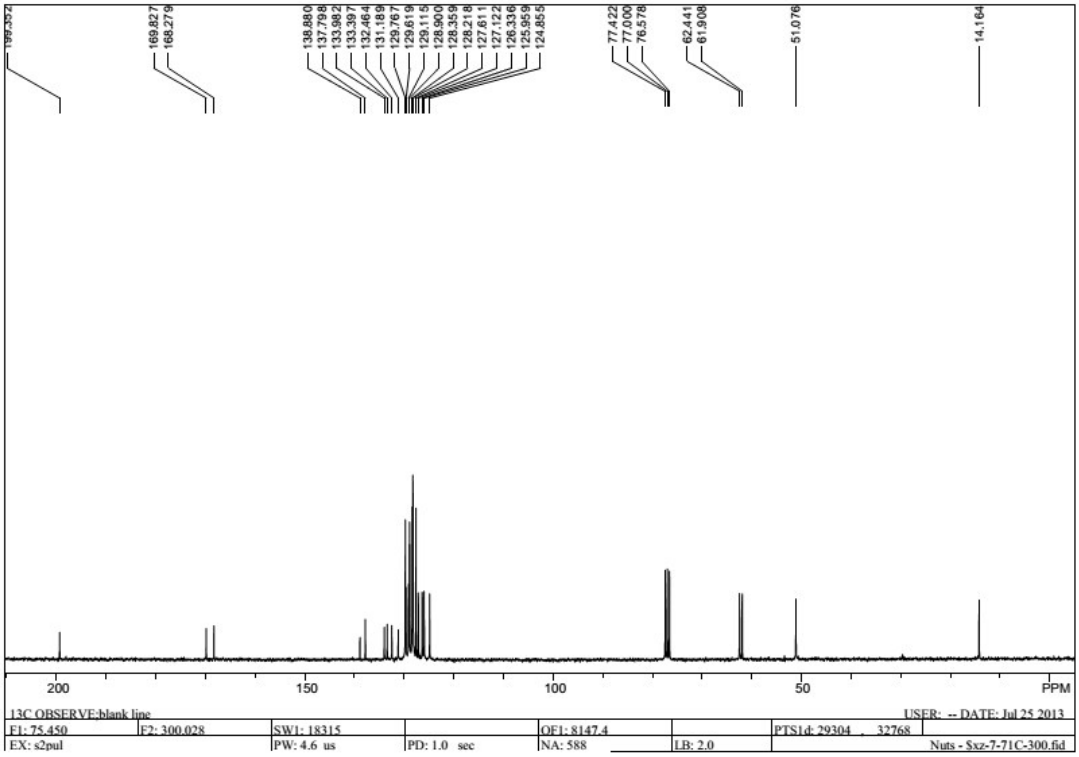
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128.900
128.359
128.218
127.611
127.122
126.336
125.989
124.855
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77.000
76.578
62.441
61.908
51.076
14.164
200
150
100
50
PPM
13C OBSERVE:blank line
USER: -- DATE: Jul 25 2013
F1: 75.450
F2: 300.028
SW1: 18315
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PTS1d: 29304 , 32768
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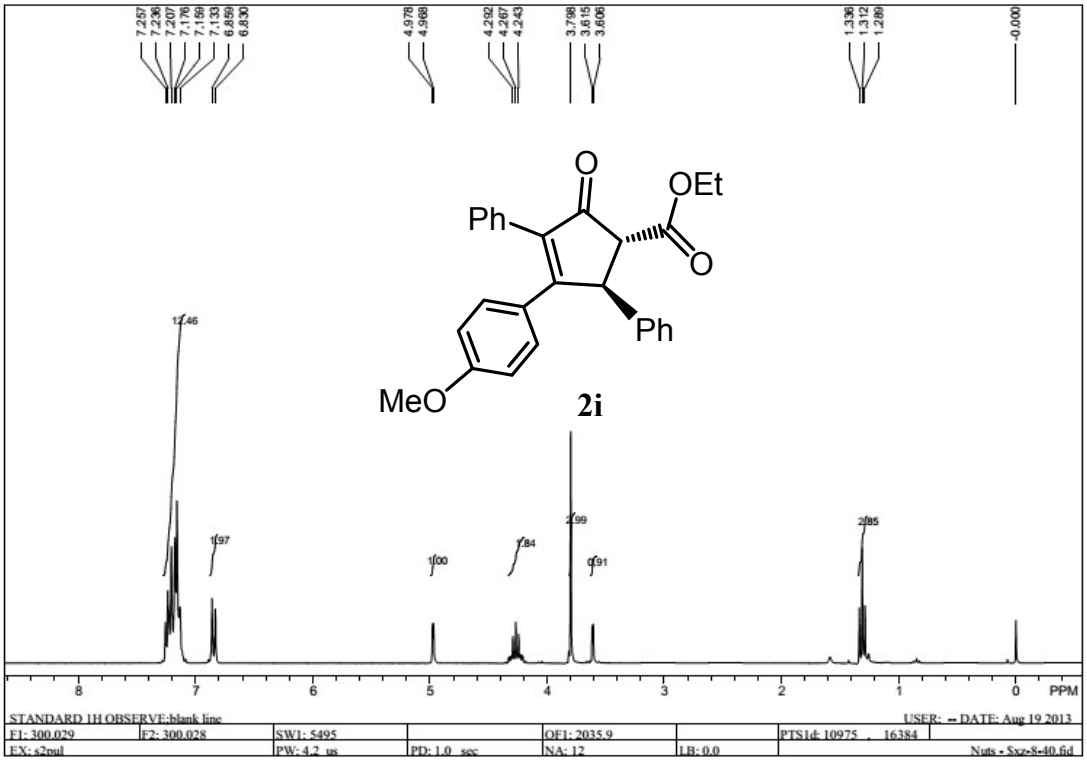
LB: 2.0
Nuts - $xz-7-71C-300.fid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7.133
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4.968
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4.243
3.798
3.615
3.606
1.336
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1.289
-0.000
O
OEt
Ph
O
Ph
MeO
2i
12.46
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1.84
2.99
0.91
2.85
8
7
6
5
4
3
2
1
0
PPM
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USER: -- DATE: Aug 19 2013
F1: 300.029
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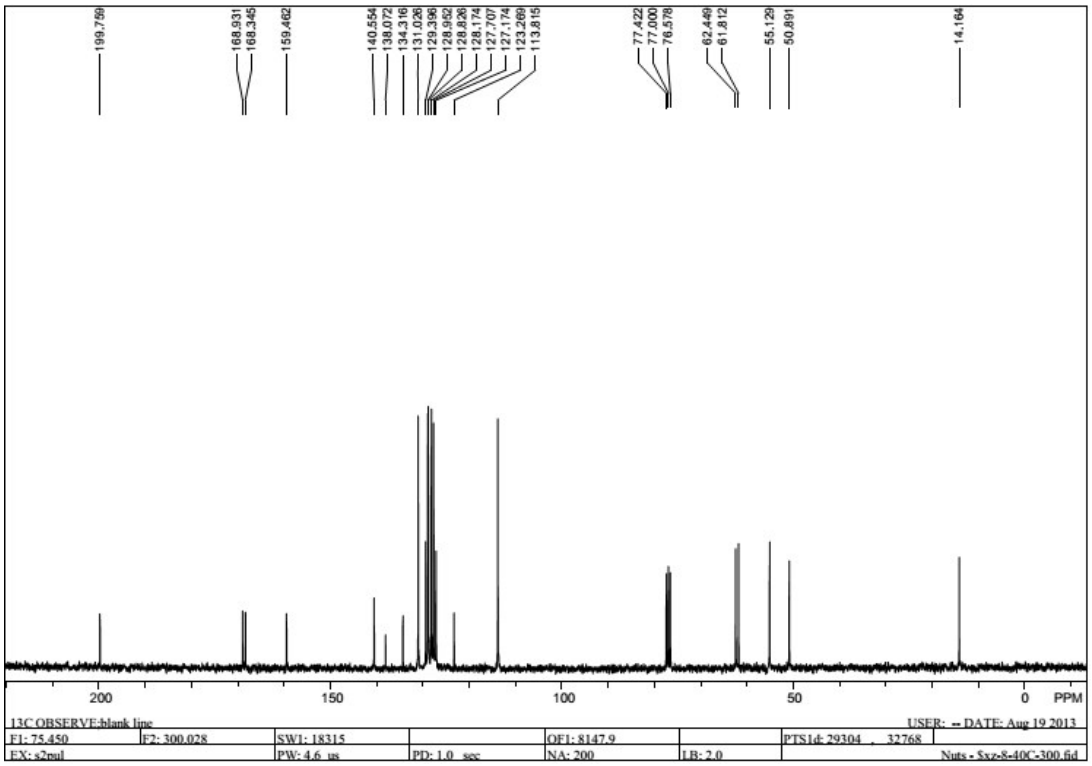
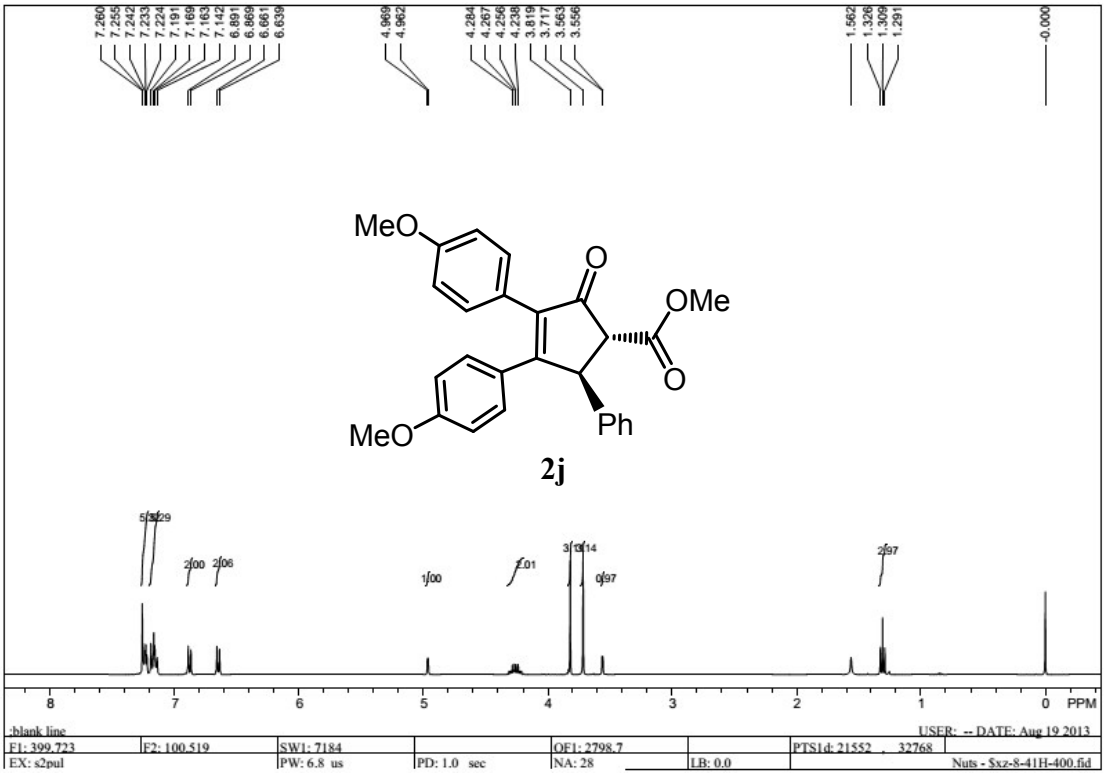
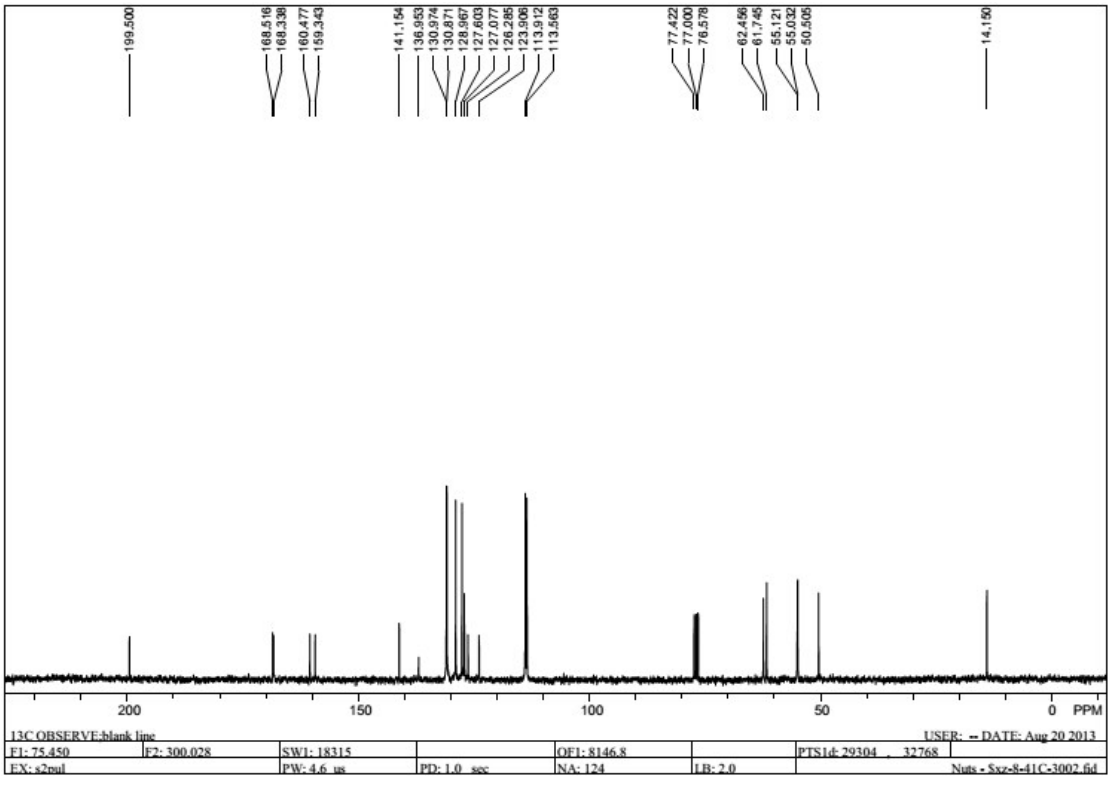
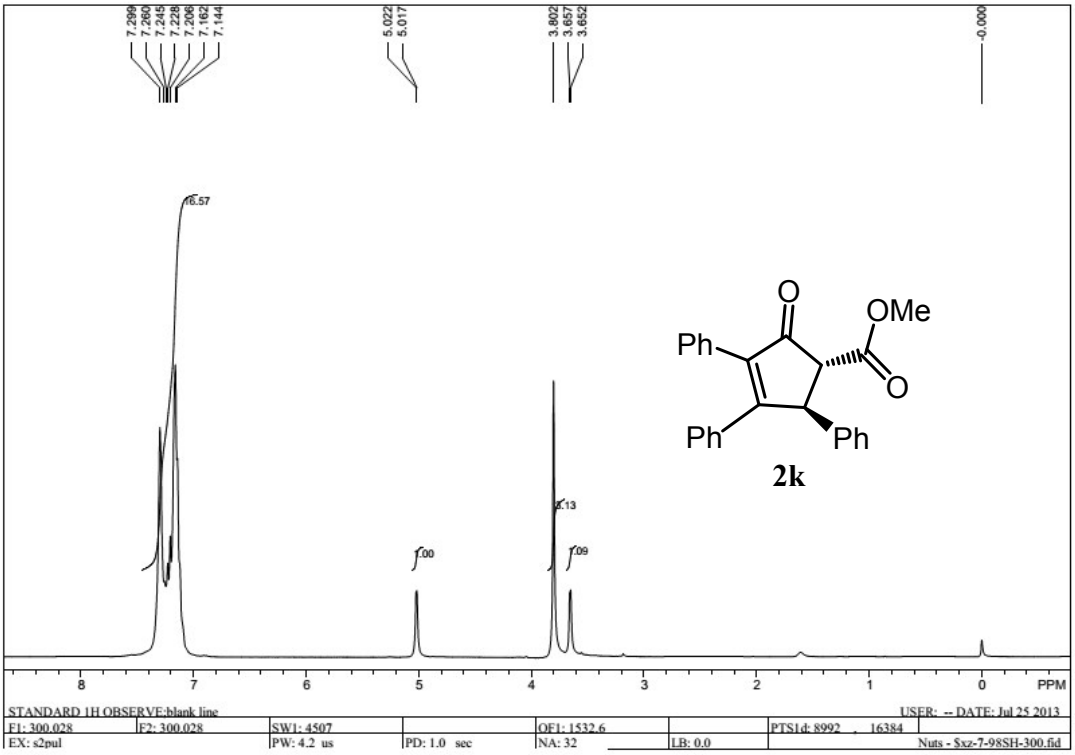
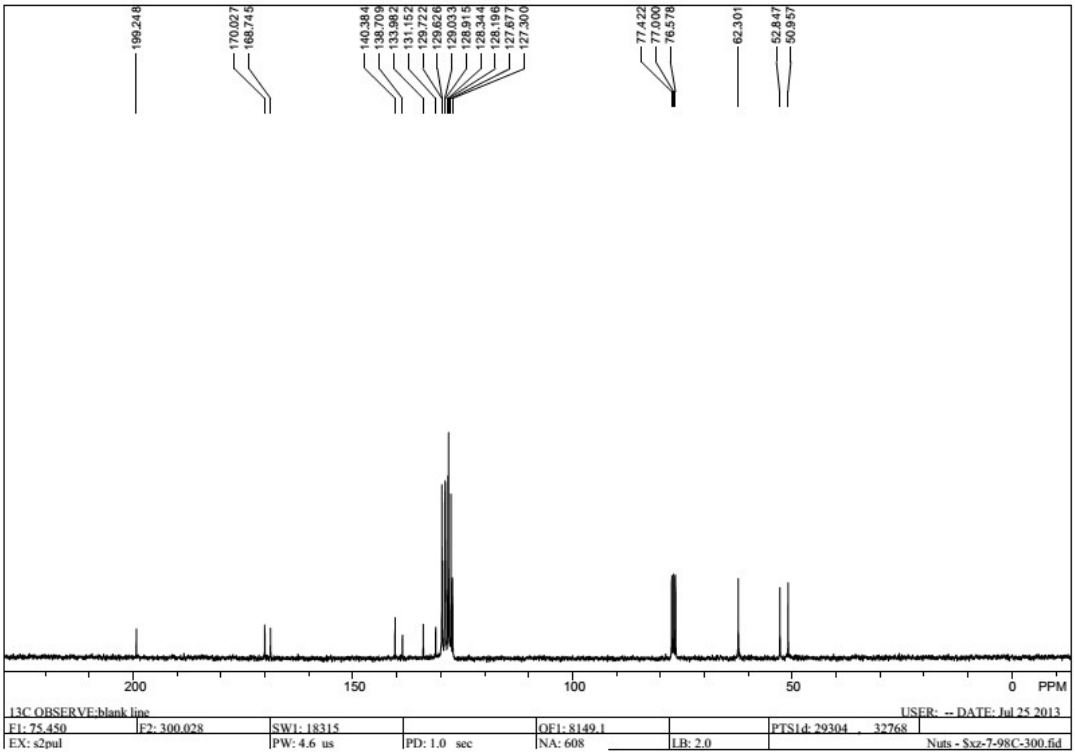
OF1: 2035.9
PTS1d: 10975 , 16384
EX: s2pul
PW: 4.2 us
PD: 1.0 sec
NA: 12
LB: 0.0
Nuts - Sxz-8-40.fid

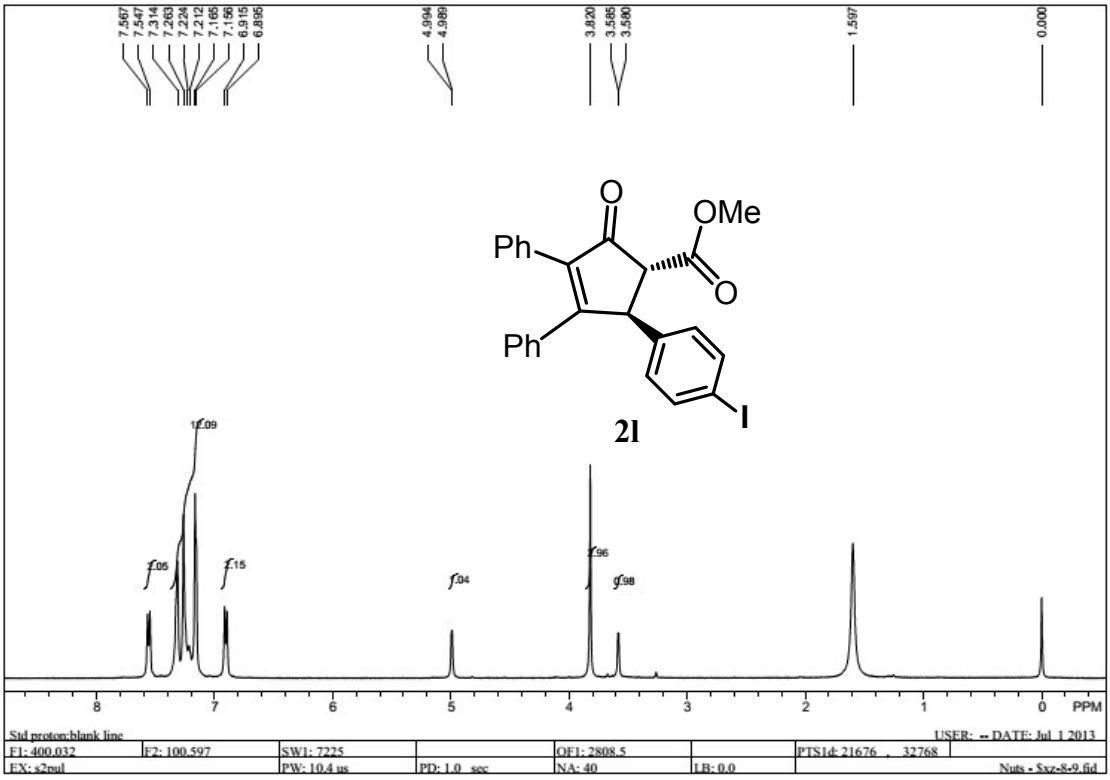

199.759
168.931
168.345
159.462
140.554
138.072
134.316
131.026
129.396
128.952
128.826
128.174
127.707
127.174
123.269
113.815
77.422
77.000
76.578
62.449
61.812
55.129
50.891
14.164
200
150
100
50
0
PPM
13C OBSERVE:blank line
USER: -- DATE: Aug 19 2013
F1: 75.450
F2: 300.028
SW1: 18315
OF1: 8147.9
PTS1d: 29304 , 32768
EX: s2pul
PW: 4.6 us
PD: 1.0 sec
NA: 200
LB: 2.0
Nuts - Sxz-8-40C-300.fid

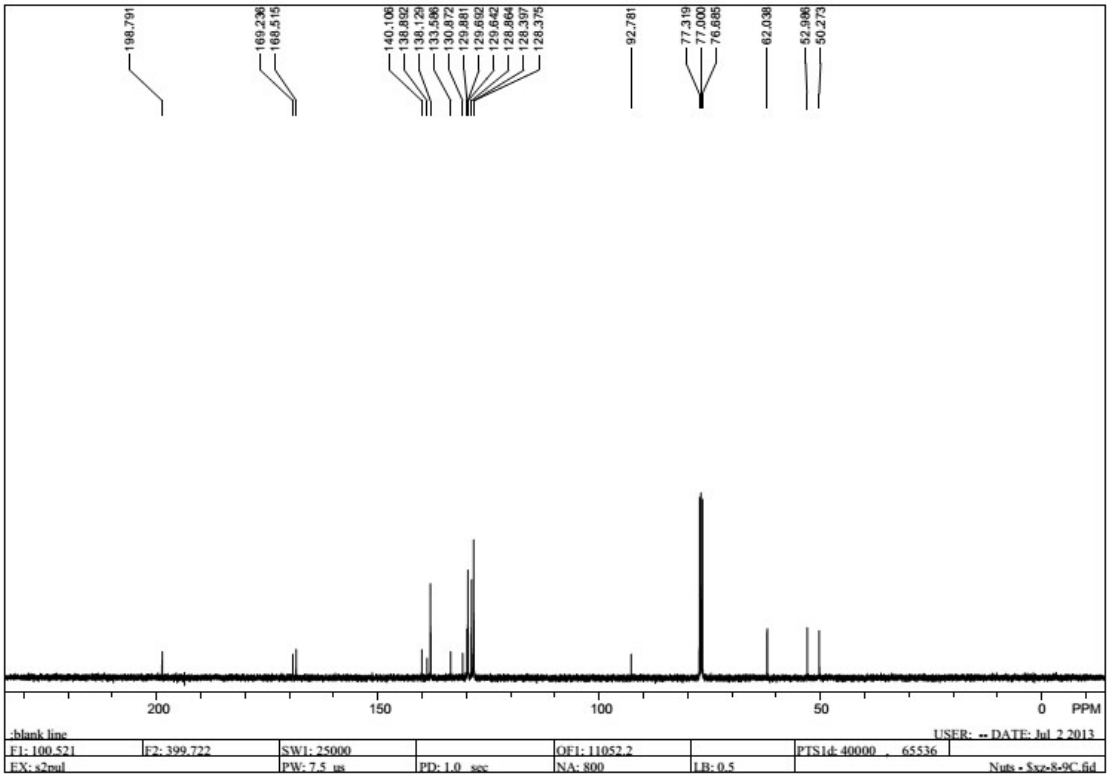

7.260
7.255
7.242
7.233
7.224
7.191
7.169
7.163
7.142
6.891
6.869
6.661
6.639
4.969
4.962
4.284
4.267
4.256
4.238
3.819
3.717
3.563
3.556
1.562
1.326
1.309
1.291
0.000
MeO
O
OMe
O
MeO
Ph
2j
2.00
2.06
1.00
1.01
3.14
0.97
2.97
8
7
6
5
4
3
2
1
0
PPM
:blank line
USER: -- DATE: Aug 19 2013
F1: 399.723
F2: 100.519
SW1: 7184
OF1: 2798.7
PTS1d: 21552 , 32768
EX: s2pul
PW: 6.8 us
PD: 1.0 sec
NA: 28
LB: 0.0
Nuts - $xz-8-41H-400.fid


199.500
168.516
168.338
160.477
159.343
141.154
136.953
130.974
130.871
128.967
127.603
127.077
126.285
123.906
113.912
113.563
77.422
77.000
76.578
62.486
61.745
55.121
55.032
50.505
14.150
200
150
100
50
0
PPM
13C OBSERVE:blank line
USER: -- DATE: Aug 20 2013
F1: 75.450
F2: 300.028
SW1: 18315
OF1: 8146.8
PTS1d: 29304 , 32768
EX: s2pul
PW: 4.6 us
PD: 1.0 sec
NA: 124
LB: 2.0
Nuts - $xz-8-41C-3002.fid

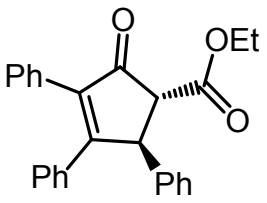

7.299
7.260
7.245
7.228
7.206
7.162
7.144
5.022
5.017
3.802
3.657
3.652
0.000
6.57
1.00
4.13
2.09
O
OMe
Ph
O
Ph
Ph
2k
8
7
6
5
4
3
2
1
0
PPM
STANDARD 1H OBSERVE:blank line
USER: -- DATE: Jul 25 2013
F1: 300.028
F2: 300.028
SW1: 4507
OF1: 1532.6
PTS1d: 8992 , 16384
EX: s2pul
PW: 4.2 us
PD: 1.0 sec
NA: 32
LB: 0.0
Nuts - $xz-7-98SH-300.fid


199.248
170.027
168.745
140.384
138.709
133.982
131.152
129.722
129.626
129.033
128.915
128.344
128.196
127.677
127.300
77.422
77.000
76.578
62.301
52.847
50.957
200
150
100
50
0
PPM
13C OBSERVE:blank line
USER: -- DATE: Jul 25 2013
F1: 75.450
F2: 300.028
SW1: 18315
OF1: 8149.1
PTS1d: 29304 , 32768
EX: s2pul
PW: 4.6 us
PD: 1.0 sec
NA: 608
LB: 2.0
Nuts - $xz-7-98C-300.fid

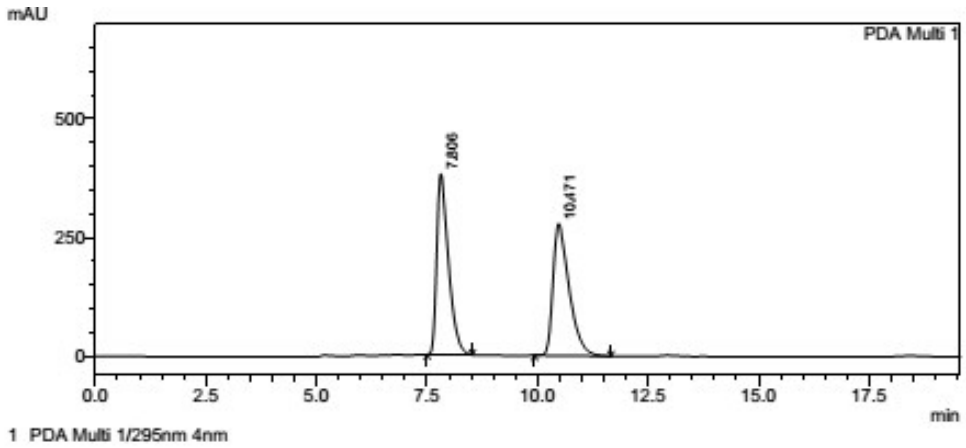

7.567
7.547
7.314
7.263
7.224
7.212
7.165
7.156
6.915
6.895
4.994
4.989
3.820
3.585
3.580
1.597
0.000
O
OMe
Ph
O
Ph
I
2l
1.09
1.05
1.15
1.04
2.96
0.98
8
7
6
5
4
3
2
1
0
PPM
Std proton:blank line
USER: -- DATE: Jul 1 2013
F1: 400.032
F2: 100.597
SW1: 7225
OF1: 2808.5
PTS1d: 21676 , 32768
EX: s2pul
PW: 10.4 us
PD: 1.0 sec
NA: 40
LB: 0.0
Nuts - $xz-8-9.fid


198.791
169.236
168.515
140.106
138.892
138.129
133.586
130.872
129.881
129.632
129.642
128.864
128.397
128.375
92.781
77.319
77.000
76.685
62.038
52.986
50.273
200
150
100
50
0
PPM
-blank line
USER: -- DATE: Jul 2 2013
F1: 100.521
F2: 399.722
SW1: 25000
OF1: 11052.2
PTS1d: 40000 , 65536
EX: s2pul
PW: 7.5 us
PD: 1.0 sec
NA: 800
LB: 0.5
Nuts - $xz-8-9C.fid

7. HPLC spectra of the products



2a

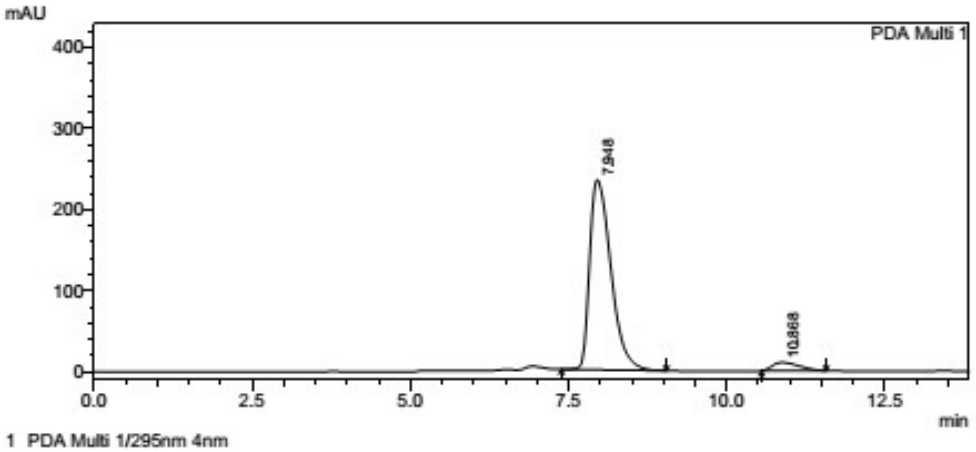


1 PDA Multi 1/295nm 4nm

PeakTable

PDA Ch1 295nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.806	7006145	380158	49.939	57.814
2	10.471	7023385	277392	50.061	42.186
Total		14029529	657550	100.000	100.000

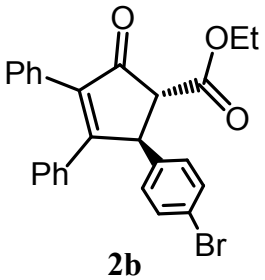


1 PDA Multi 1/295nm 4nm

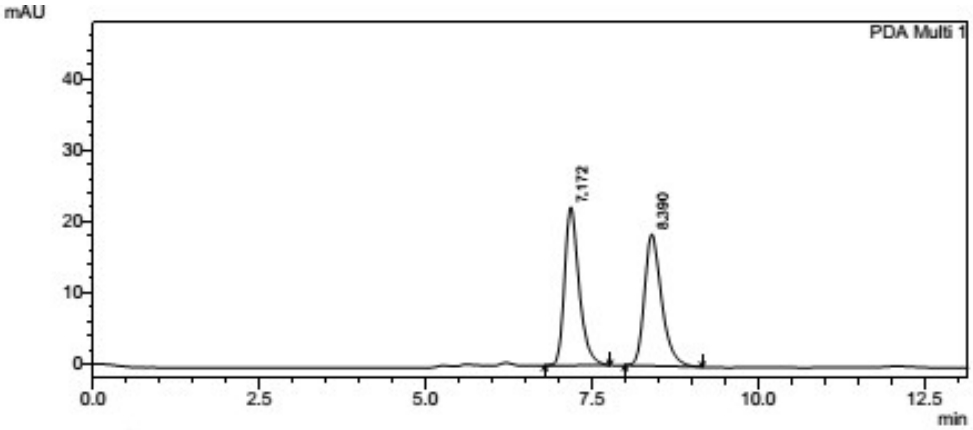
PeakTable

PDA Ch1 295nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.948	5470465	234150	94.764	95.749
2	10.868	302241	10395	5.236	4.251
Total		5772706	244546	100.000	100.000



2b

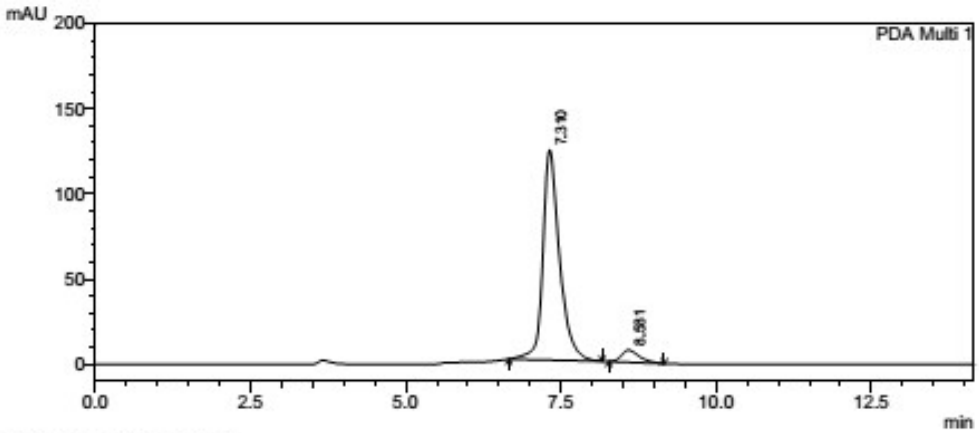


1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.172	337154	22204	50.336	54.584
2	8.390	332657	18474	49.664	45.416
Total		669811	40678	100.000	100.000

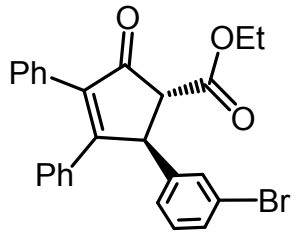


1 PDA Multi 1/300nm 4nm

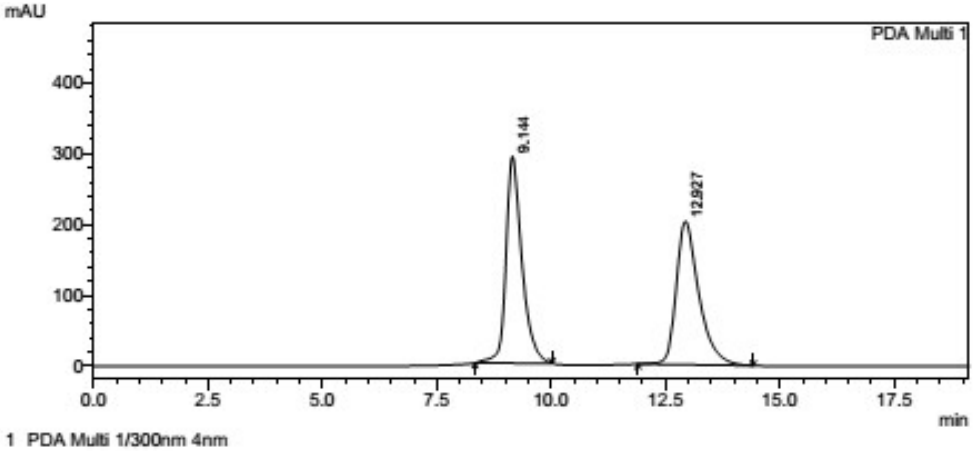
PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.310	2299642	123370	94.224	94.529
2	8.581	140967	7140	5.776	5.471
Total		2440609	130510	100.000	100.000



2c

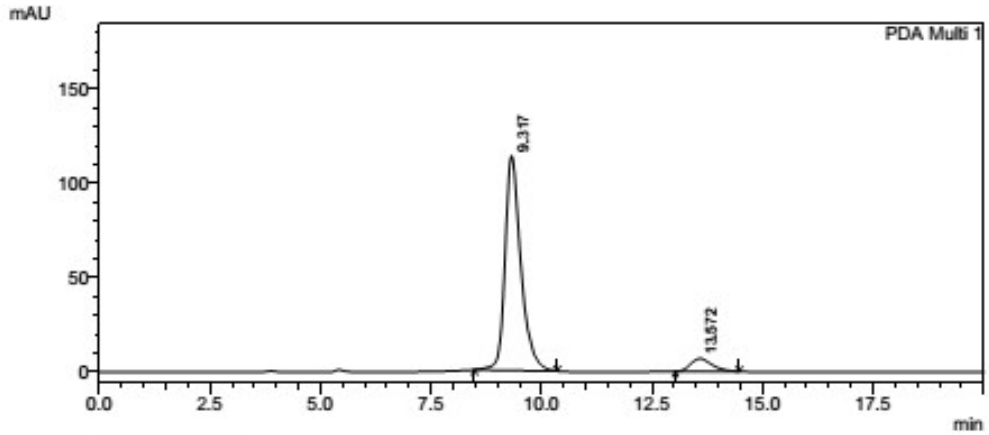


1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.144	7082378	292134	50.412	59.058
2	12.927	6966552	202525	49.588	40.942
Total		14048929	494659	100.000	100.000

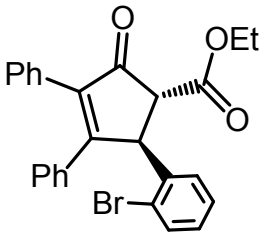


1 PDA Multi 1/300nm 4nm

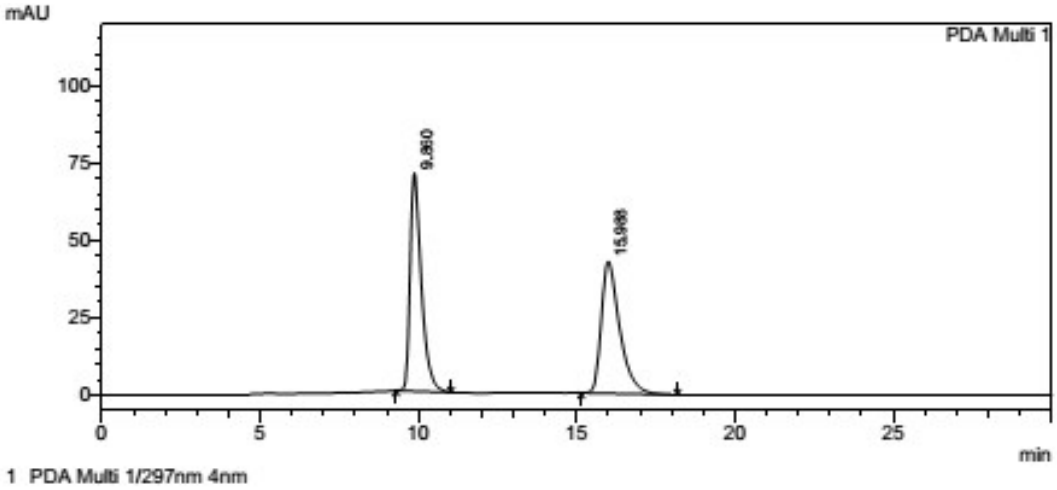
PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.317	2834901	113958	92.363	94.275
2	13.572	234409	6921	7.637	5.725
Total		3069310	120878	100.000	100.000



2d

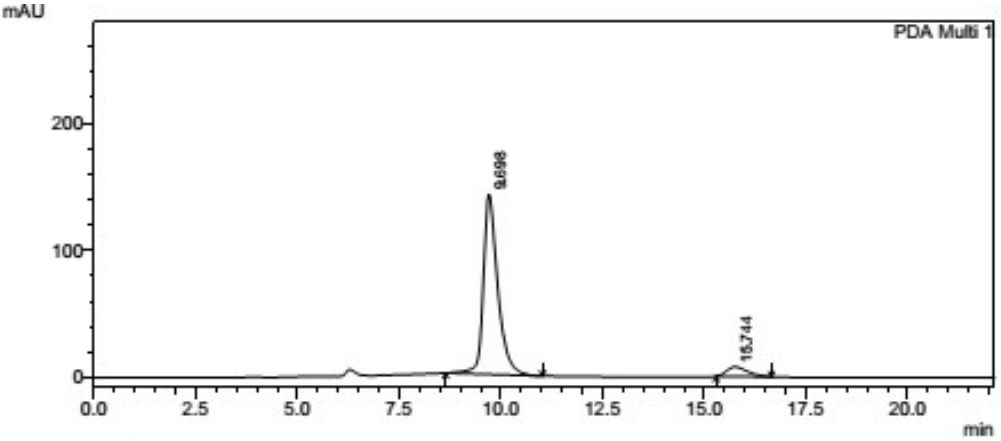


1 PDA Multi 1/297nm 4nm

PeakTable

PDA Ch1 297nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.860	1747501	70471	50.346	62.328
2	15.988	1723491	42593	49.654	37.672
Total		3470992	113064	100.000	100.000

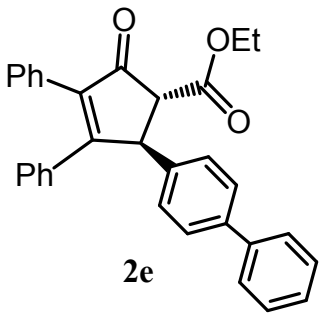


1 PDA Multi 1/297nm 4nm

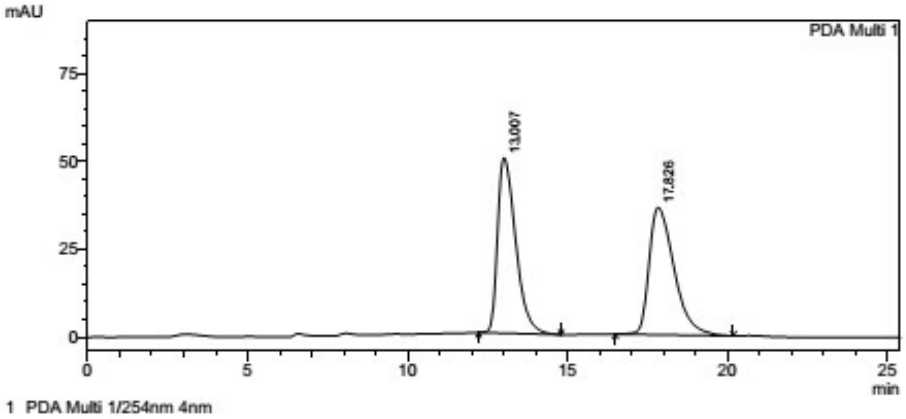
PeakTable

PDA Ch1 297nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.698	3484827	141519	92.759	94.800
2	15.744	272038	7763	7.241	5.200
Total		3756865	149282	100.000	100.000



2e

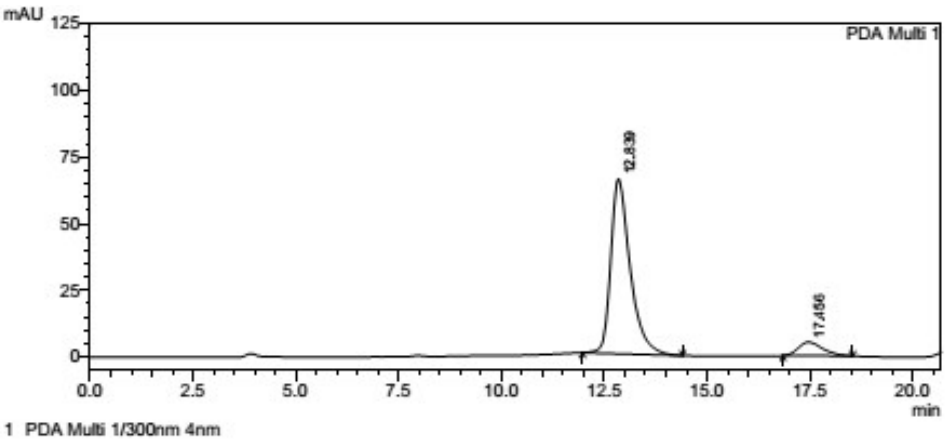


1 PDA Multi 1/254nm 4nm

PeakTable

PDA Ch1 254nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.007	1959279	49919	49.945	57.915
2	17.826	1963610	36274	50.055	42.085
Total		3922889	86192	100.000	100.000

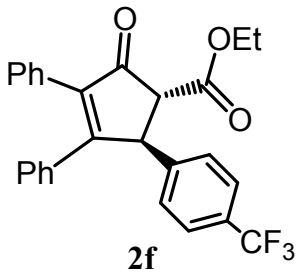


1 PDA Multi 1/300nm 4nm

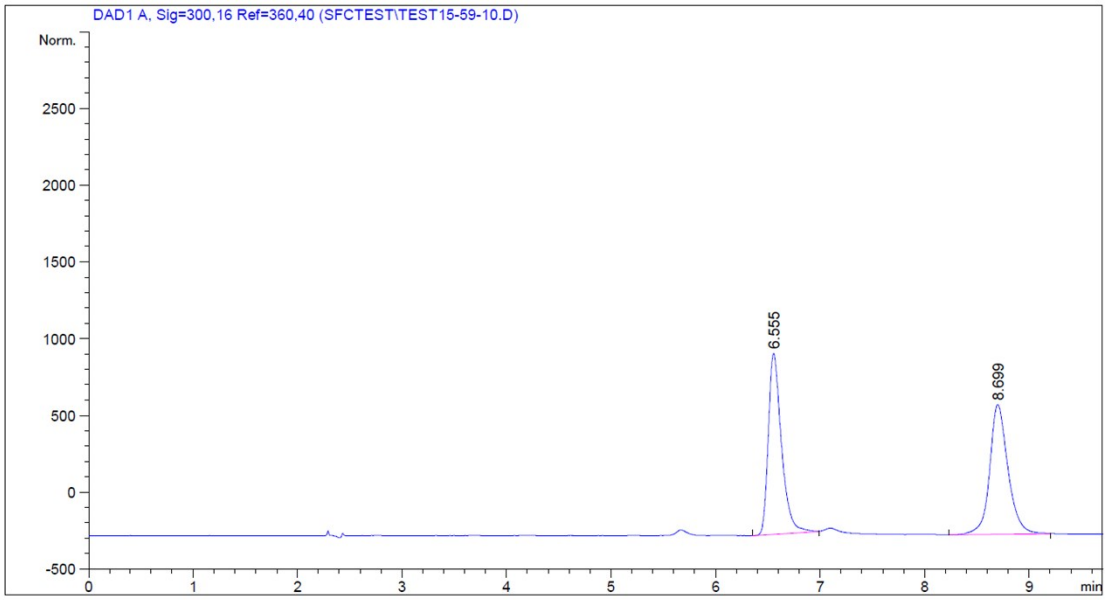
PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.839	2145644	65551	91.100	92.752
2	17.456	209609	5123	8.900	7.248
Total		2355253	70673	100.000	100.000



2f




```
=====================================================================
                      Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Do not use Multiplier & Dilution Factor with ISTDs


Signal 1: DAD1 A, Sig=300,16 Ref=360,40

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1   6.555 MM R  0.1394 5350.26758  609.96863  50.0839
   2   8.699 MM R  0.1937 5332.34863  436.94049  49.9161

Totals :                  1.06826e4  1046.90912
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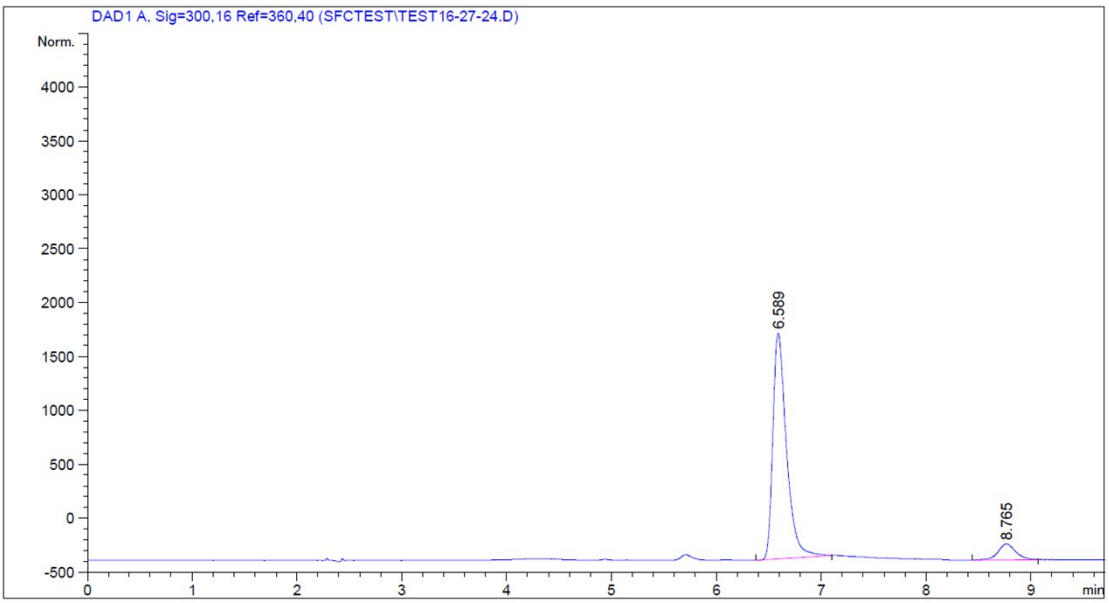


```
======================================================================
                        Area Percent Report
======================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Do not use Multiplier & Dilution Factor with ISTDs


Signal 1: DAD1 A, Sig=300,16 Ref=360,40

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1   6.589 MM R  0.1464 1.19048e4  1314.51257  91.7450
   2   8.765 MM R  0.1795 1071.16052   92.18559   8.2550

Totals :                  1.29760e4  1406.69816
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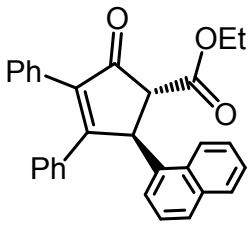
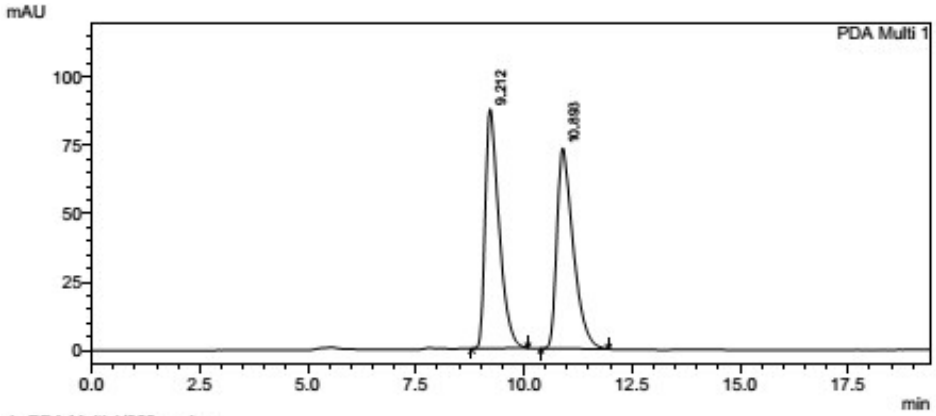


2g

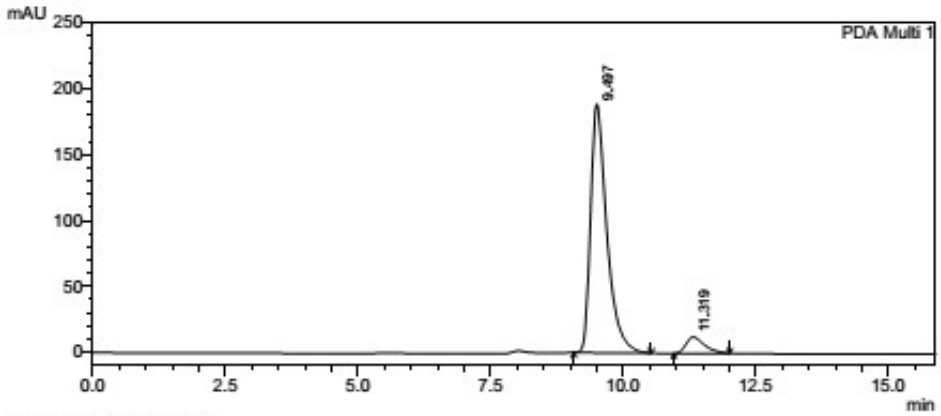


1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.212	1941670	87656	50.095	54.462
2	10.893	1934336	73293	49.905	45.538
Total		3876006	160949	100.000	100.000

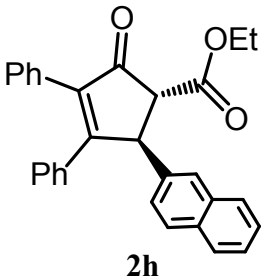


1 PDA Multi 1/296nm 4nm

PeakTable

PDA Ch1 296nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.497	3997850	188487	93.021	93.785
2	11.319	299921	12490	6.979	6.215
Total		4297770	200977	100.000	100.000



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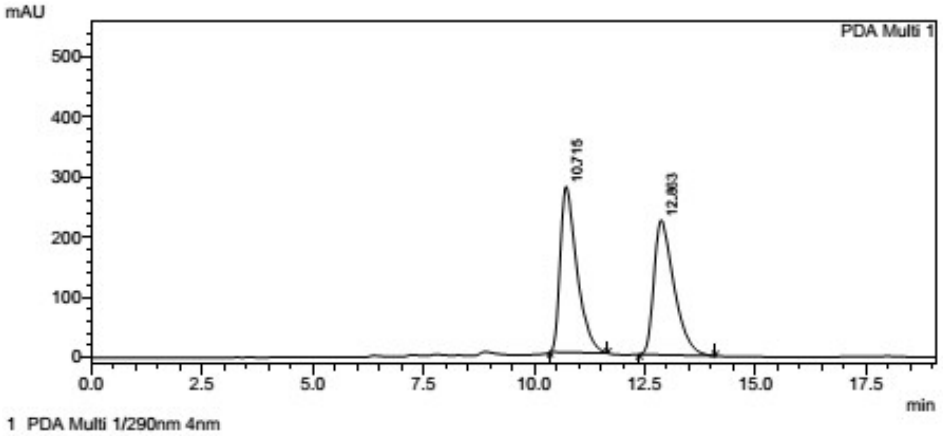
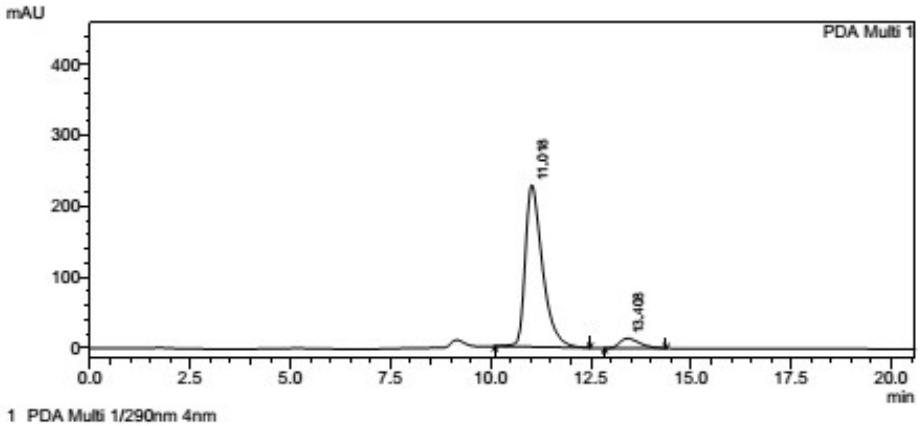


1 PDA Multi 1/290nm 4nm

PeakTable

PDA Ch1 290nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	10.715	7216231	276196	50.442	55.220
2	12.863	7089788	223977	49.558	44.780
Total		14306019	500173	100.000	100.000

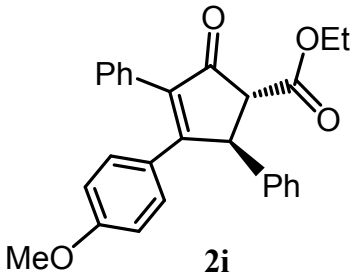


1 PDA Multi 1/290nm 4nm

PeakTable

PDA Ch1 290nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.018	6837816	228502	93.419	94.186
2	13.408	481688	14106	6.581	5.814
Total		7319504	242608	100.000	100.000



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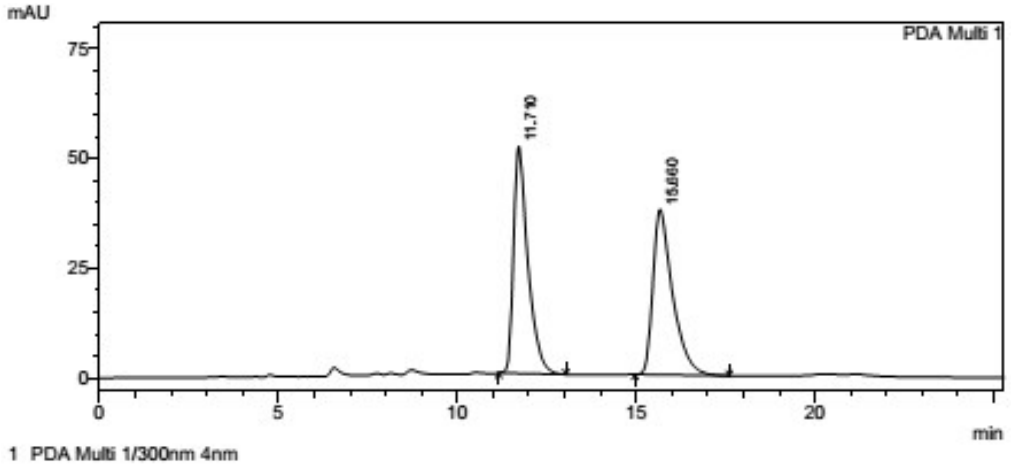
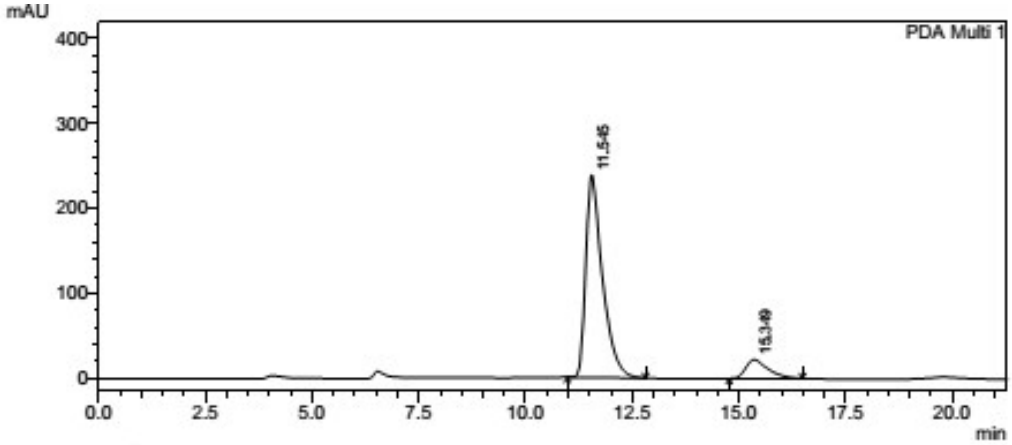


1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.710	1438458	51733	50.139	57.881
2	15.660	1430485	37645	49.861	42.119
Total		2868942	89378	100.000	100.000

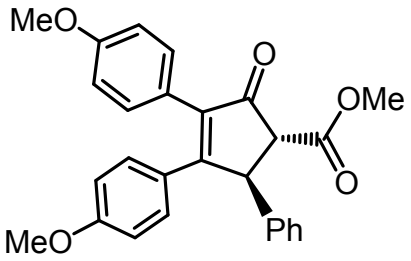


1 PDA Multi 1/300nm 4nm

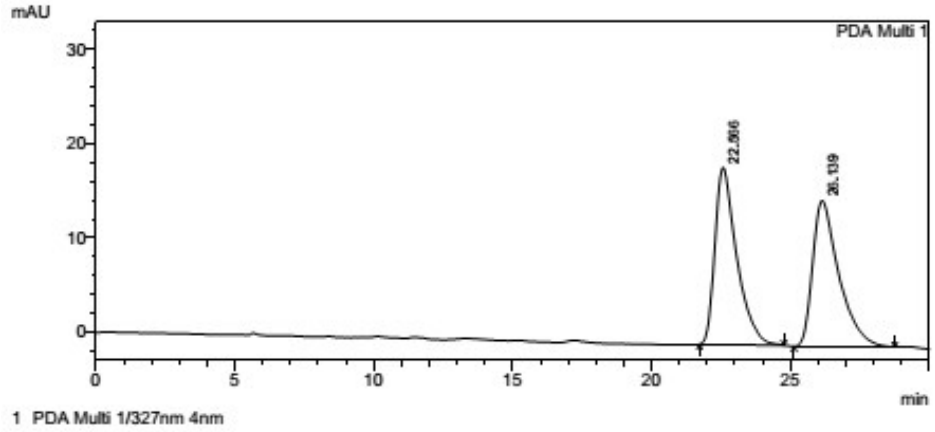
PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.545	6488496	238244	88.933	91.387
2	15.349	807474	22453	11.067	8.613
Total		7295970	260697	100.000	100.000



2j

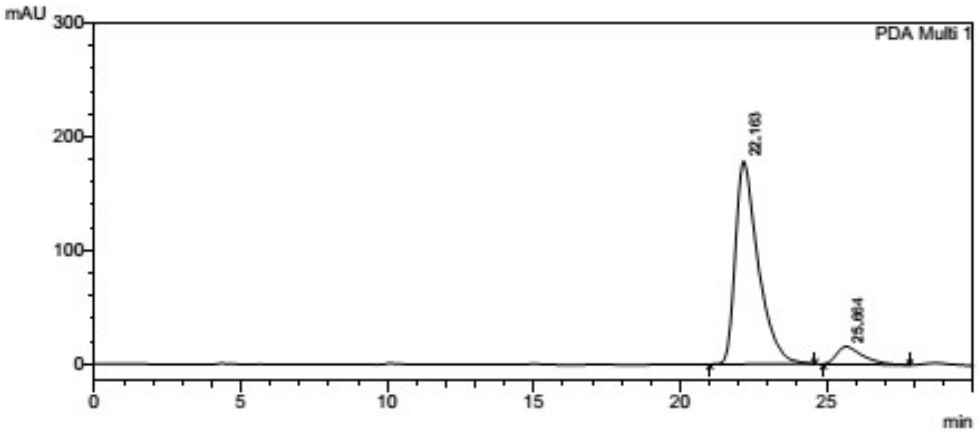


1 PDA Multi 1/327nm 4nm

PeakTable

PDA Ch1 327nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.566	1024857	18820	50.166	54.828
2	26.139	1018085	15506	49.834	45.172
Total		2042942	34326	100.000	100.000

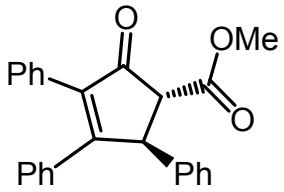


1 PDA Multi 1/320nm 4nm

PeakTable

PDA Ch1 320nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.163	9675184	178683	90.990	92.009
2	25.664	958089	15519	9.010	7.991
Total		10633273	194203	100.000	100.000



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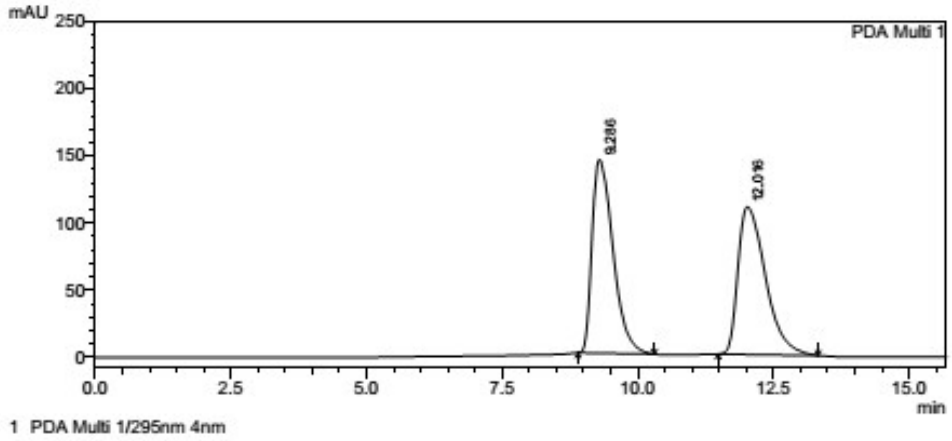
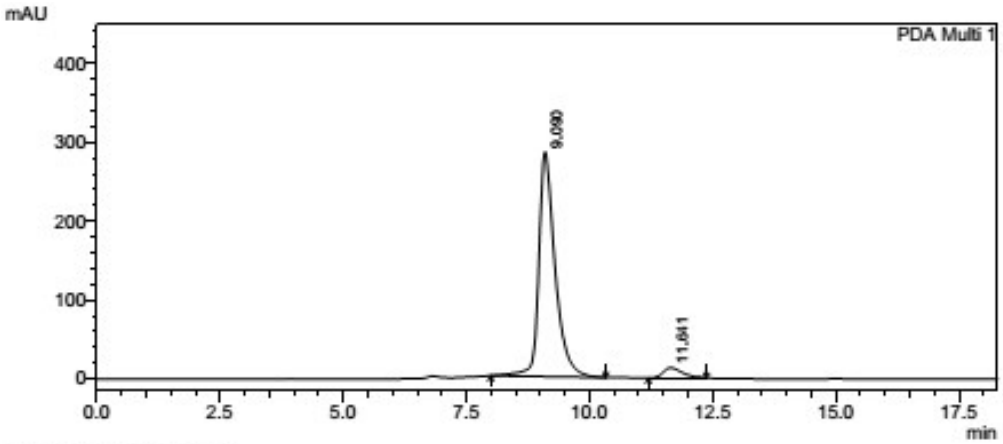


1 PDA Multi 1/295nm 4nm

PeakTable

PDA Ch1 295nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.286	3889046	144289	50.062	56.734
2	12.016	3879430	110036	49.938	43.266
Total		7768476	254325	100.000	100.000

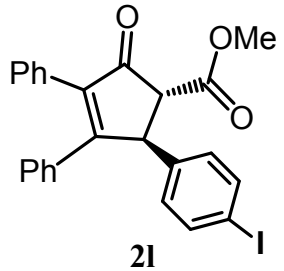


1 PDA Multi 1/295nm 4nm

PeakTable

PDA Ch1 295nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.090	6559833	284801	94.927	95.562
2	11.641	350545	13228	5.073	4.438
Total		6910378	298028	100.000	100.000



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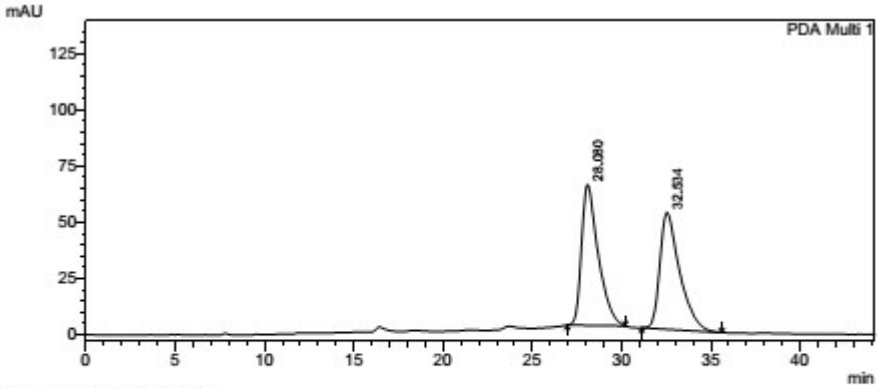
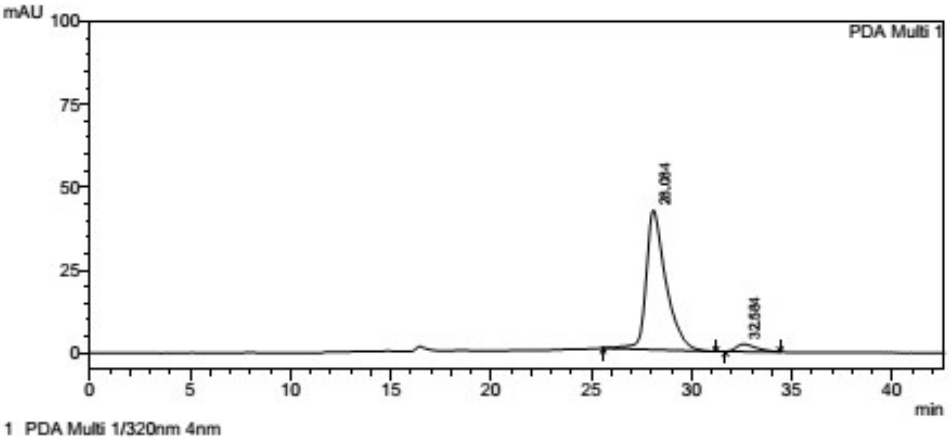


1 PDA Multi 1/320nm 4nm

PeakTable

PDA Ch1 320nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.080	4056938	62677	50.271	54.611
2	32.534	4013212	52094	49.729	45.389
Total		8070150	114771	100.000	100.000

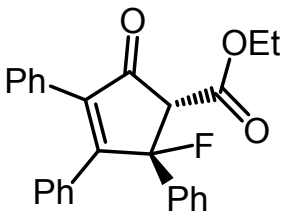


1 PDA Multi 1/320nm 4nm

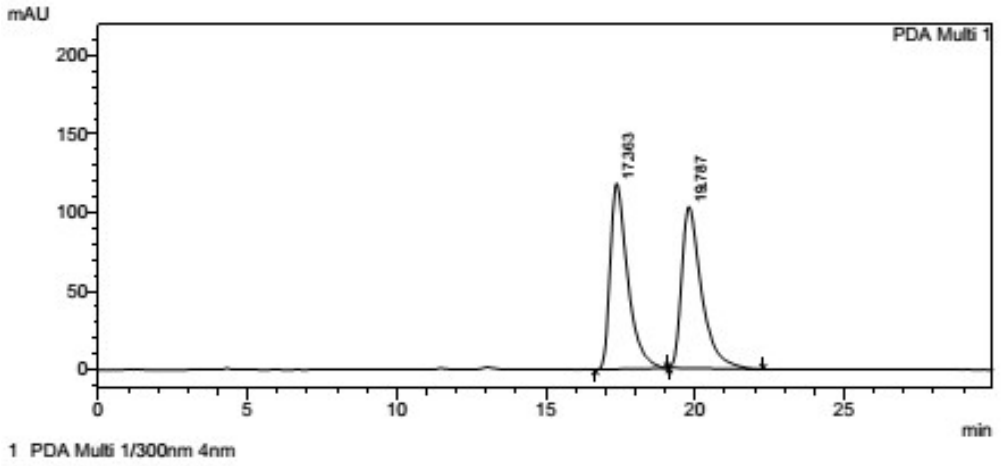
PeakTable

PDA Ch1 320nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.084	2892114	42096	94.823	94.883
2	32.584	157888	2270	5.177	5.117
Total		3050002	44366	100.000	100.000



3a

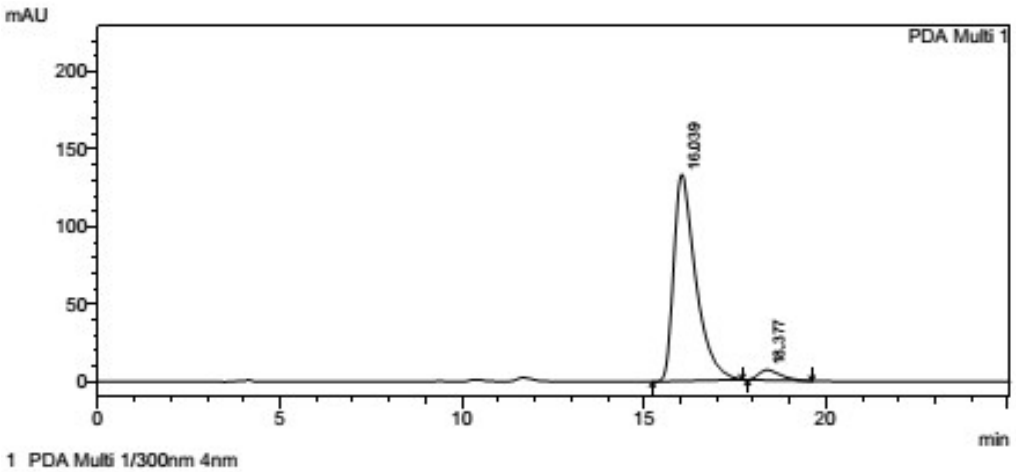


1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	17.363	4795191	118116	50.118	53.475
2	19.787	4772591	102764	49.882	46.525
Total		9567782	220881	100.000	100.000



1 PDA Multi 1/300nm 4nm

PeakTable

PDA Ch1 300nm 4nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	16.039	5604246	133516	95.269	95.264
2	18.377	278334	6637	4.731	4.736
Total		5882580	140153	100.000	100.000