Supporting Information to

Copper-catalyzed cascade annulation between α-bromocarbonyls and biaryl or (*Z*)-arylvinylacetylenes enabling a direct synthesis of dibenzocycloheptanes and related compounds

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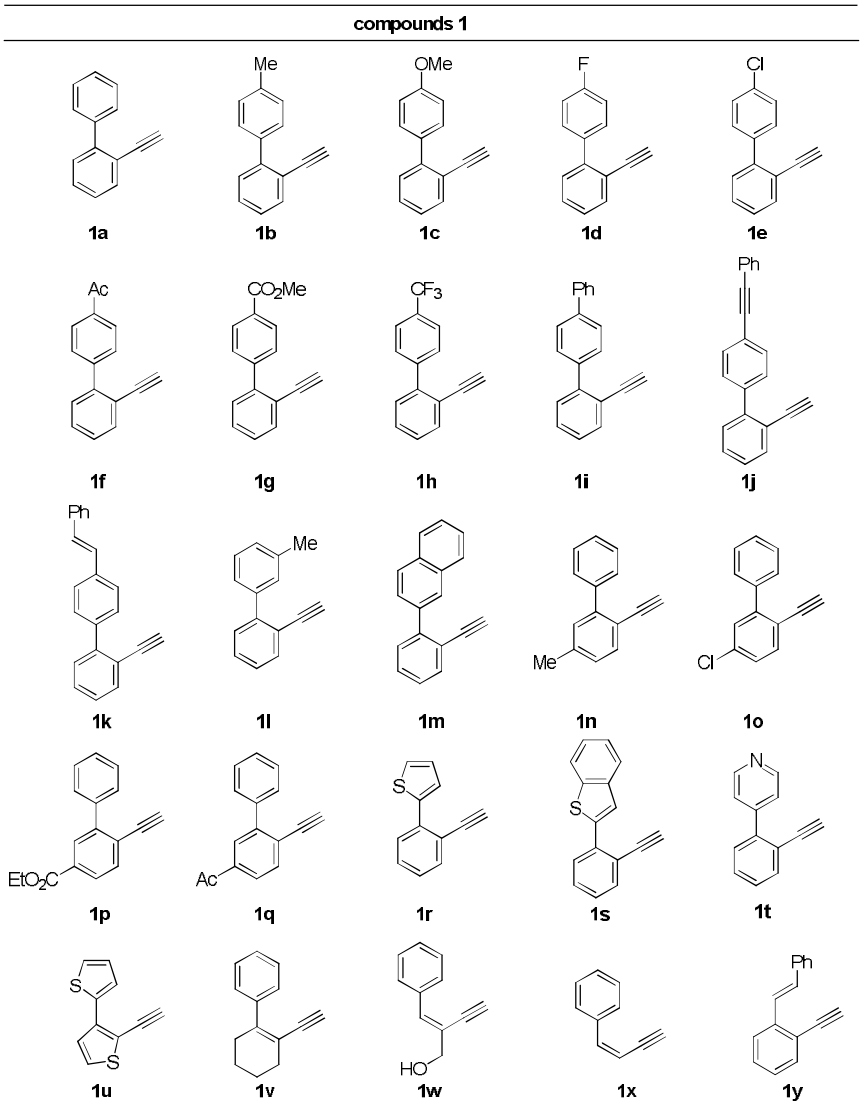
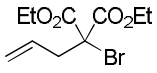
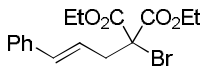
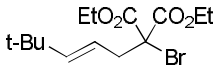
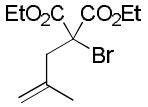
General. Unless otherwise noted, materials obtained from commercial suppliers were used directly without further purification. ^{1}H, ^{13}C, and ^{19}F NMR spectra were measured on a 600 or 400 MHz NMR spectrometer using $CDCl_3$ as the solvent with tetramethylsilane (TMS) as the internal standard. Chemical shifts (δ) are given in parts per million relative to TMS, and the coupling constants are given in hertz. High-resolution mass spectrometry (HRMS) analyses were carried out using a TOF MS instrument with ESI source. Column chromatography was performed using silica gel (300−400 mesh). The starting materials **1a-1v**[1,2] were prepared from *ortho*-bromo phenylacetylene compounds via the Suzuki-Miyaura coupling,[2] exemplified by the synthesis of **1a.** The starting materials **2** were prepared from γ,δ-unsaturated carbonyls via the $Mg(ClO_4)_2$-catalyzed α-bromination.[3]



[1] (a) M. L. Hossain, F. Ye, Z. Liu, Y. Xia, Y. Shi, L. Zhou, Y. Zhang and J. Wang, *J. Org. Chem*., 2014, **79**, 8689; (b) B. Seo, W. H. Jeon, J. Kim, S. Kim and P. H. Lee, *J. Org. Chem*., 2015, **80**, 722.

[2] J. Panteleev, K. Geyer, A. Aguilar-Aguilar, L. Wang and M. Lautens, *Org. Lett.*, 2010, **12**, 5092.

[3] (a) D. Yang, Y.-L. Yan and B. Lui, *J. Org. Chem.,* 2002, **67**, 7429; (b) W. Yang, L. Huang, H. Liu, W. Wang and H. Li, *Chem. Commun.,* 2013, **49**, 4667.

compouds 2			
			
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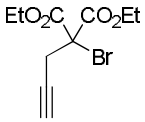	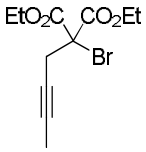	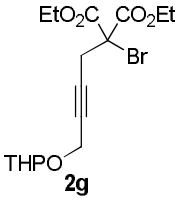	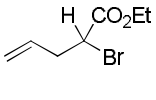
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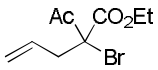
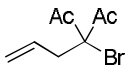
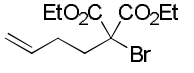
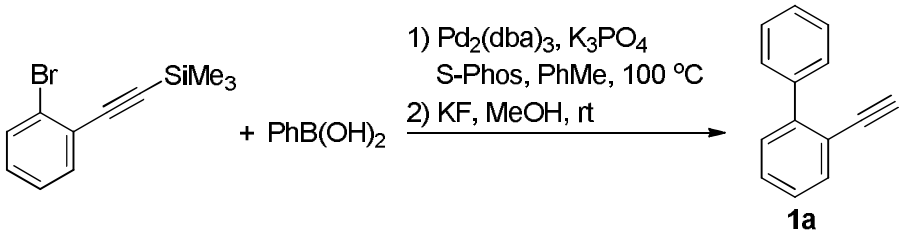
			
2i	**2j**	**2k**	

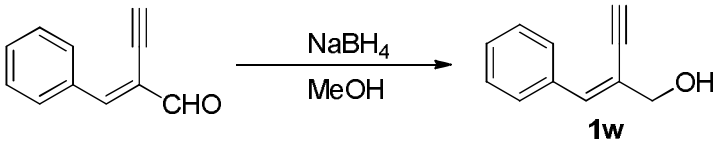
Experimental procedure[2] for the preparation of biarylacetylene 1a:



1a

To a mixture of $Pd_2(dba)_3$ (22.9 mg, 0.05 mmol), S-Phos (41 mg, 0.2 mmol), K_3PO_4 (2.1 g, 10 mmol), and $PhB(OH)_2$ (732 mg, 6.0 mmol) in 10 mL of toluene was added 1-trimethylsilylethynyl-2-bromobenzene[4] (1.27 g, 5.0 mmol). After stirring at 100 °C under N_2 for 5 h, the reaction mixture was quenched with water, then extracted with EtOAc, washed with brine, dried over Na_2SO_4, and concentrated. To the residue thus obtained in 10 mL of MeOH was added KF (320 mg, 5.5 mmol). After stirring at room temperature for 3 h, the reaction mixture was quenched with water, then extracted with EtOAc, washed with brine, dried over Na_2SO_4 and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:100) provided 710 mg of **1a**[1a] (yield: 80%) as a colorless oil. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.62–7.60 (m, 1H), 7.59–7.57 (m, 2H), 7.44–7.37 (m, 5H), 7.31–7.28 (m, 1H), 3.03 (s, 1H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 144.4, 140.2, 133.8, 129.6, 129.2, 128.9, 128.0, 127.5, 127.0, 120.4, 83.1, 80.1.

Experimental procedure for the preparation of 1w:

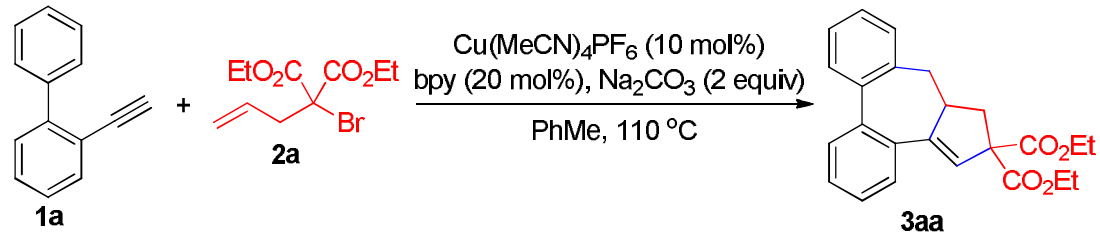


1w

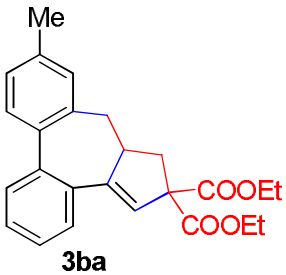
[4] A. Odedra, C.-J. Wu, T. B. Pratap, C.-W. Huang, Y.-F. Ran and R.-S. Liu, *J. Am. Chem. Soc.*, 2005, **127**, 3406.

To a solution of (*E*)-2-benzylidenebut-3-ynal[5] (780 mg, 5.0 mmol) in 10 mL of MeOH was added $NaBH_4$ (228 mg, 6.0 mmol) at 0 °C. After stirring at 0 °C for 1 h, the reaction mixture was quenched with saturated $NaHCO_3$ solution, extracted with EtOAc, washed with brine, dried over anhydrous Na_2SO_4, and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:10) gave 750 mg of **1w** (yield: 95%) as a colorless oil. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.83–7.81 (m, 2H), 7.36–7.33 (m, 2H), 7.31–7.28 (m, 1H), 6.84 (s, 1H), 4.29 (s, 2H), 3.40 (s, 1H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 135.8, 135.4, 128.7, 128.6, 128.3, 120.1, 85.2, 81.4, 67.2; HRMS (ESI) calcd for $C_{11}H_{11}O$ $(M + H)^+$ 159.0810, found 159.0805.

General procedure for the copper-catalyzed cascade annulation between α-bromocarbonyls and biaryl or (*Z*)-arylvinylacetylenes:



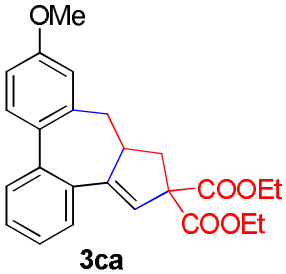
To a mixture of $Cu(MeCN)_4PF_6$ (9.0 mg, 0.025 mmol), bpy (7.8 mg, 0.05 mmol) and Na_2CO_3 (53.0 mg, 0.5 mmol) was added a solution of **1a** (44.5 mg, 0.25 mmol) and **2a** (83.4 mg, 0.30 mmol) in 5 mL of PhMe under a nitrogen atmosphere. After stirring at 110 °C for 12 h, the reaction mixture was quenched with water, extracted with EtOAc, washed with brine, dried over anhydrous Na_2SO_4, and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:10) gave 77 mg of **3aa** (yield: 82%) as a white solid, mp 86–88 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.46–7.40 (m, 2H), 7.34–7.28 (m, 4H), 7.25–7.21 (m, 1H), 7.18–7.14 (m, 1H), 5.67–5.64 (m, 1H), 4.24–4.17 (m, 2H), 4.09–4.02 (m, 2H), 3.81–3.74 (m, 1H), 3.04–2.98 (m, 1H), 2.75–2.71 (m, 1H), 2.53–2.48 (m, 1H), 2.13–2.07 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.12 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.5, 151.3, 140.9, 139.7, 136.1, 135.9, 130.3, 130.0, 128.6, 128.5, 127.4, 127.2, 127.0, 127.0, 125.5, 65.3, 61.4, 61.2, 53.9, 37.4, 35.2, 14.0, 13.8; HRMS (ESI) calcd for $C_{24}H_{25}O_4$ $(M + H)^+$ 377.1753, found 377.1745.



*Compound **3ba***. 63 mg, 65% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.44–7.39 (m, 2H), 7.32–7.26 (m, 2H), 7.21–7.18 (m, 1H), 7.12–7.09 (m, 1H), 6.99–6.96 (m, 1H), 5.68–5.63 (m,

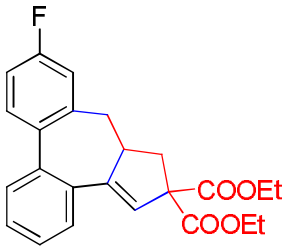
[5] W. Li and J. Zhang, *Org. Lett.*, 2014, **16**, 162.

1H), 4.24–4.18 (m, 2H), 4.12–4.04 (m, 2H), 3.79–3.73 (m, 1H), 3.02–2.97 (m, 1H), 2.74–2.70 (m, 1H), 2.49–2.45 (m, 1H), 2.35 (s, 3H), 2.14–2.08 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.14 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.0, 170.6, 151.5, 139.7, 138.0, 136.9, 136.0, 135.9, 131.1, 129.9, 128.6, 128.5, 127.7, 127.1, 127.0, 125.3, 65.3, 61.5, 61.2, 53.7, 37.5, 35.2, 21.1, 14.1, 13.9; HRMS (ESI) calcd for $C_{25}H_{27}O_4$ $(M + H)^+$ 391.1909, found 391.1905.



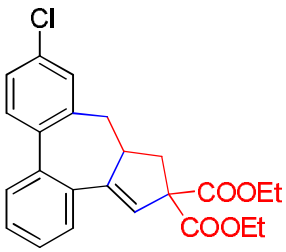
3ca

Compound ***3ca***. 74 mg, 73% yield; white solid, mp 102–104 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.41–7.38 (m, 2H), 7.30–7.26 (m, 2H), 7.24–7.20 (m, 1H), 6.85–6.81 (m, 1H), 6.74–6.71 (m, 1H), 5.67–5.65 (m, 1H), 4.24–4.18 (m, 2H), 4.12–4.05 (m, 2H), 3.82 (s, 3H), 3.78–3.74 (m, 1H), 3.03–2.98 (m, 1H), 2.76–2.71 (m, 1H), 2.50–2.45 (m, 1H), 2.13–2.07 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.5, 158.6, 151.4, 139.4, 137.6, 135.7, 133.5, 131.1, 128.5, 128.4, 127.0, 126.9, 125.2, 116.1, 111.7, 65.2, 61.4, 61.2, 55.2, 53.5, 37.6, 35.4, 14.0, 13.8; HRMS (ESI) calcd for $C_{25}H_{27}O_5$ $(M + H)^+$ 407.1858, found 407.1850.



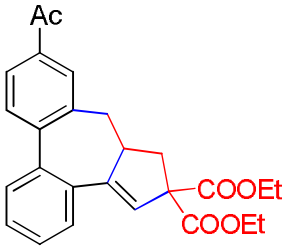
3da

Compound ***3da***. 70 mg, 71% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.44–7.39 (m, 2H), 7.34–7.31 (m, 1H), 7.29–7.26 (m, 2H), 7.01–6.97 (m, 1H), 6.92–6.89 (m, 1H), 5.68–5.65 (m, 1H), 4.25–4.18 (m, 2H), 4.13–4.06 (m, 2H), 3.81–3.73 (m, 1H), 3.02–2.97 (m, 1H), 2.77–2.73 (m, 1H), 2.52–2.46 (m, 1H), 2.10–2.04 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.8, 170.4, 161.2 (d, J = 246.7 Hz),150.9, 138.8, 138.4 (d, J = 7.6 Hz), 137.0 (d, J = 3.1 Hz), 135.8, 131.5 (d, J = 8.2 Hz), 128.6, 128.6, 127.5, 127.1, 125.7, 117.0 (d, J = 21.1 Hz), 113.7 (d, J = 20.9 Hz), 65.3, 61.5, 61.3, 53.6, 37.4, 35.2, 14.1, 13.9; ^{19}F NMR (565 MHz, $CDCl_3$): δ -115.9; HRMS (ESI) calcd for $C_{24}H_{24}O_4F$ $(M + H)^+$ 395.1659, found 395.1649.



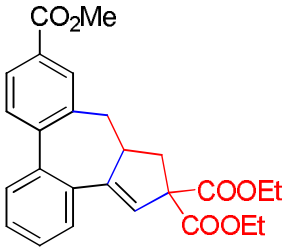
3ea

Compound ***3ea***. 75 mg, 73% yield; white solid, mp 100–102 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.45–7.39 (m, 2H), 7.36–7.33 (m, 1H), 7.29–7.27 (m, 2H), 7.24–7.21 (m, 1H), 7.19–7.15 (m, 1H), 5.70–5.65 (m, 1H), 4.26–4.18 (m, 2H), 4.15–4.05 (m, 2H), 3.83–3.76 (m, 1H), 3.01–2.95 (m, 1H), 2.79–2.74 (m, 1H), 2.51–2.46 (m, 1H), 2.09–2.03 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.16 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.3, 150.7, 139.4, 138.5, 138.0, 135.8, 132.7, 131.2, 130.0, 128.6, 128.5, 127.7, 127.1, 127.0, 125.8, 65.2, 61.5, 61.3, 53.6, 37.3, 35.0, 14.0, 13.8; HRMS (ESI) calcd for $C_{24}H_{24}O_4Cl$ $(M + H)^+$ 411.1363, found 411.1358.



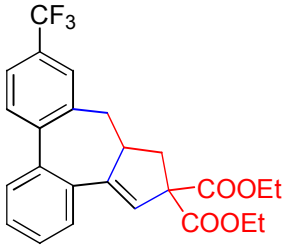
3fa

Compound ***3fa***. 73 mg, 70% yield; white solid, mp 111–113 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92–7.86 (m, 1H), 7.81–7.72 (m, 1H), 7.49–7.44 (m, 2H), 7.41–7.37 (m, 2H), 7.32–7.29 (m, 1H), 5.71–5.67 (m, 1H), 4.26–4.20 (m, 2H), 4.13–4.01 (m, 2H), 3.88–3.77 (m, 1H), 3.07–3.00 (m, 1H), 2.79–2.72 (m, 1H), 2.63 (s, 3H), 2.63–2.59 (m, 1H), 2.10–2.03 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 198.0, 170.7, 170.3, 150.6, 146.1, 138.6, 136.7, 136.0, 135.7, 130.3, 129.9, 128.8, 128.7, 128.3, 127.4, 127.2, 126.2, 65.2, 61.5, 61.3, 53.7, 37.4, 35.2, 26.7, 14.1, 13.9; HRMS (ESI) calcd for $C_{26}H_{27}O_5$ $(M + H)^+$ 419.1858, found 419.1844.



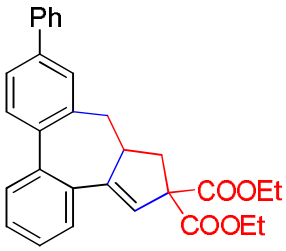
3ga

Compound ***3ga***. 76 mg, 70% yield; white solid, mp 96–98 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.99–7.95 (m, 1H), 7.86–7.84 (m, 1H), 7.47–7.44 (m, 2H), 7.38–7.36 (m, 2H), 7.31–7.29 (m, 1H), 5.69–5.67 (m, 1H), 4.24–4.19 (m, 2H), 4.10–4.02 (m, 2H), 3.93 (s, 3H), 3.83–3.79 (m, 1H), 3.05–3.01 (m, 1H), 2.77–2.73 (m, 1H), 2.62–2.59 (m, 1H), 2.05–2.10 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.4, 167.0, 150. 7, 145.8, 138.6, 136.4, 136.0, 131.3, 130.1, 128.8, 128.7, 128.6, 128.3, 128.2, 127.2, 126.1, 65.2, 61.5, 61.3, 53.7, 52.1, 37.3, 35.1, 14.0, 13.8; HRMS (ESI) calcd for $C_{26}H_{27}O_6$ $(M + H)^+$ 435.1808, found 435.1804.



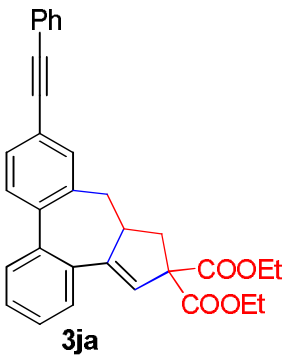
3ha

Compound ***3ha***. 84 mg, 76% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.57–7.54 (m, 1H), 7.47–7.44 (m, 2H), 7.43–7.37 (m, 3H), 7.32–7.30 (m, 1H), 5.72–5.65 (m, 1H), 4.26–4.18 (m, 2H), 4.11–4.03 (m, 2H), 3.85–3.79 (m, 1H), 3.06–3.02 (m, 1H), 2.82–2.77 (m, 1H), 2.61–2.57 (m, 1H), 2.07–2.01 (m, 1H), 1.28 (t, J = 7.1 Hz, 3H), 1.11 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.3, 150.3, 144.7, 138.3, 137.1, 136.0, 130.3, 129.1 (q, J = 32.3 Hz), 128.8, 128.7, 128.3, 127.2, 126.8 (q, J = 4.0 Hz), 126.2, 124.1 (q, J = 272.2 Hz), 123.9 (q, J = 4.2 Hz), 65.3, 61.6, 61.3, 53.7, 37.3, 35.2, 14.0, 13.8; ^{19}F NMR (565 MHz, $CDCl_3$): δ -62.2; HRMS (ESI) calcd for $C_{25}H_{24}O_4F_3$ $(M + H)^+$ 445.1627, found 445.1624.



3ia

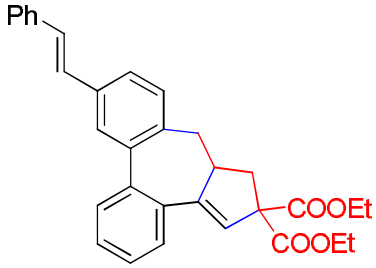
Compound ***3ia***. 87 mg, 77% yield; white solid, mp 153–155 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.66–7.60 (m, 2H), 7.56–7.52 (m, 1H), 7.51–7.47 (m, 1H), 7.47–7.42 (m, 3H), 7.42–7.32 (m, 4H), 7.32–7.28 (m, 1H), 5.72–5.65 (m, 1H), 4.27–4.17 (m, 2H), 4.10–4.00 (m, 2H), 3.85–3.78 (m, 1H), 3.11–3.02 (m, 1H), 2.79–2.73 (m, 1H), 2.65–2.55 (m, 1H), 2.17–2.10 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.10 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.5, 151.2, 140.7, 140.0, 140.0, 139.3, 136.6, 136.0, 130.5, 128.9, 128.7, 128.7, 128.6, 127.5, 127.3, 127.1, 127.1, 125.7, 125.6, 65.3, 61.5, 61.2, 53.8, 37.5, 35.5, 14.1, 13.8; HRMS (ESI) calcd for $C_{30}H_{29}O_4$ $(M + H)^+$ 453.2066, found 453.2062.



3ja

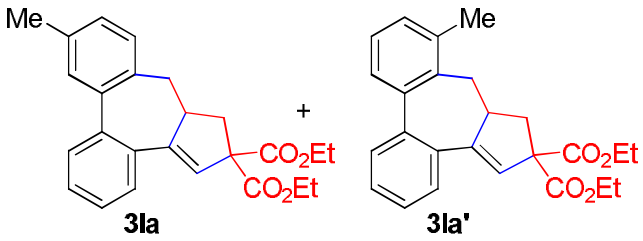
Compound ***3ja***. 62 mg, 52% yield; white solid, mp 152–154 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.56–7.54 (m, 2H), 7.48–7.43 (m, 3H), 7.37–7.34 (m, 5H), 7.30–7.28 (m, 2H), 5.70–5.67 (m, 1H),

4.24–4.18 (m, 2H), 4.12–4.04 (m, 2H), 3.83–3.78 (m, 1H), 3.03–2.98 (m, 1H), 2.80–2.73 (m, 1H), 2.56–2.51 (m, 1H), 2.14–2.07 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.8, 170.5, 150.9, 141.2, 139.0, 136.4, 136.0, 133.3, 131.6, 130.3, 130.1, 128.7, 128.6, 128.3, 128.2, 127.8, 127.1, 125.9, 123.3, 122.0, 89.7, 89.4, 65.3, 61.5, 61.3, 53.7, 37.5, 35.1, 14.1, 13.9; HRMS (ESI) calcd for $C_{32}H_{29}O_4$ $(M + H)^+$ 477.2066, found 477.2043.



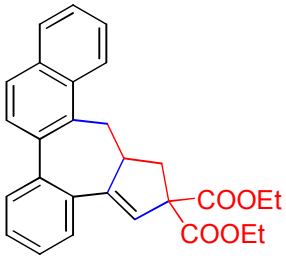
3ka

*Compound **3ka***. 68 mg, 57% yield; white solid, mp 107–119 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.54–7.52 (m, 2H), 7.47–7.45 (m, 2H), 7.44–7.41 (m, 1H), 7.39–7.34 (m, 4H), 7.32–7.28 (m, 3H), 7.14–7.10 (m, 2H), 5.71–5.66 (m, 1H), 4.23–4.19 (m, 2H), 4.09–4.02 (m, 2H), 3.82–3.77 (m, 1H), 3.06–3.02 (m, 1H), 2.80–2.75 (m, 1H), 2.57–2.53 (m, 1H), 2.16–2.11 (m, 1H), 1.28 (t, J = 7.1 Hz, 3H), 1.12 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.5, 151.2, 140.4, 139.4, 137.3, 136.5, 136.3, 135.9, 130.4, 128.7, 128.7, 128.6, 128.6, 128.5, 128.3, 127.6, 127.5, 127.1, 126.5, 125.6, 125.1, 65.3, 61.5, 61.2, 53.7, 37.6, 35.4, 14.1, 13.9; HRMS (ESI) calcd for $C_{32}H_{31}O_4$ $(M + H)^+$ 479.2222, found 479.2213.



3la **3la'**

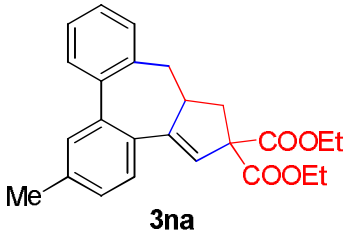
*Compound **3la** and **3la'***. 75 mg, 77% yield (**3la**:**3la'** = 2.3:1); colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$) data of **3la**: δ 7.44–7.40 (m, 2H), 7.33–7.31 (m, 1H), 7.28–7.26 (m, 1H), 7.18–7.15 (m, 1H), 7.14–7.11 (m, 2H), 5.68–5.66 (m, 1H), 4.23–4.20 (m, 2H), 4.08–4.05 (m, 2H), 3.81–3.76 (m, 1H), 2.92–2.87 (m, 1H), 2.75–2.73 (m, 1H), 2.73–2.71 (m, 1H), 2.37 (s, 3H), 2.03–1.98 (m, 1H), 1.28–1.26 (m, 3H), 1.14–1.12 (m, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) data of **3la**: δ 170.9, 170.5, 151.6, 141.5, 140.3, 136.0, 135.8, 134.5, 129.3, 128.9, 128.4, 128.2, 127.3, 126.7, 126.5, 124.9, 65.3, 61.5, 61.2, 54.2, 37.3, 29.3, 20.8, 14.1, 13.8; HRMS (ESI) calcd for $C_{25}H_{27}O_4$ $(M + H)^+$ 391.1909, found 391.1901.



3ma

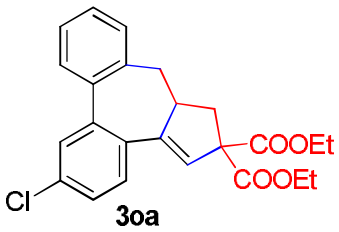
Compound ***3ma***. 75 mg, 70% yield; white solid, mp 107–119 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.12–8.09 (m, 1H), 7.84–7.82 (m, 1H), 7.79–7.77 (m, 1H), 7.56–7.52 (m, 2H), 7.48–7.44 (m, 3H), 7.37–7.32 (m, 2H), 5.68–5.64 (m, 1H), 4.24–4.18 (m, 2H), 4.00–3.96 (m, 1H), 3.93–3.85 (m, 2H), 3.53–3.47 (m, 1H), 3.03–2.98 (m, 1H), 2.85–2.81 (m, 1H), 1.96–1.91 (m, 1H), 1.26 (t, J = 7.1 Hz, 3H), 0.92 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.4, 151.5, 140.3, 138.5, 136.4, 132.8, 132.8, 132.3, 129.2, 128.5, 128.5, 128.1, 127.5, 127.1, 126.9, 126.4, 125.4, 124.8, 123.8, 65.5, 61.4, 61.0, 55.8, 37.7, 28.1, 14.0, 13.6; HRMS (ESI) calcd for $C_{28}H_{26}O_4Na$ $(M + Na)^+$ 449.1729, found 449.1723.

Crystal data for **3ma** ($C_{28}H_{26}O_4$, 426.49): monoclinic, space group $P2/c$, a = 31.220(4) Å, b = 10.5893(12) Å, c =13.5925(15) Å, U = 4493.6(9) Å^3, Z = 4, T = 296(2) K, absorption coefficient 0.042 mm^{-1}, reflections collected 82914, independent reflections 7873 [R(int) = 0.0842], refinement by full-matrix least-squares on F^2, data/restraints/parameters 7873/0/289, goodness-of-fit on F^2 = 2.859, final R indices [I>2s(I)] R_1 = 0.1764, wR_2 = 0.4273, R indices (all data) R_1 = 0.1945, wR_2 = 0.4324, largest diff peak and hole 0.462 and –0.605 e·Å^{-3}. Crystallographic data for the structure **3ma** have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication No. CCDC 1498312.



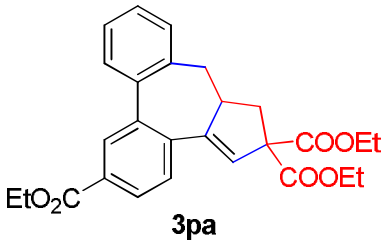
3na

Compound ***3na***. 76 mg, 78% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.30–7.27 (m, 3H), 7.23–7.20 (m, 1H), 7.19–7.17 (m, 1H), 7.16–7.13 (m, 2H), 5.64–5.61 (m, 1H), 4.24–4.17 (m, 2H), 4.09–4.03 (m, 2H), 3.76–3.71 (m, 1H), 3.02–2.98 (m, 1H), 2.74–2.70 (m, 1H), 2.52–2.49 (m, 1H), 2.42 (s, 3H), 2.10–2.05 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.12 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.6, 151.3, 141.0, 139.5, 138.2, 136.2, 133.1, 130.2, 129.9, 129.4, 128.1, 127.1, 127.0, 126.9, 125.2, 65.2, 61.4, 61.1, 53.7, 37.4, 35.2, 21.3, 14.1, 13.9; HRMS (ESI) calcd for $C_{25}H_{27}O_4$ $(M + H)^+$ 391.1909, found 391.1905.



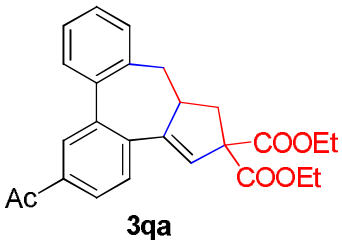
3oa

Compound ***3oa***. 79 mg, 77% yield; white solid, mp 99–101 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.45–7.43 (m, 1H), 7.32–7.28 (m, 3H), 7.28–7.26 (m, 1H), 7.23–7.20 (m, 1H), 7.18–7.15 (m, 1H), 5.67–5.64 (m, 1H), 4.23–4.18 (m, 2H), 4.10–4.04 (m, 2H), 3.78–3.72 (m, 1H), 3.01–2.96 (m, 1H), 2.75–2.70 (m, 1H), 2.54–2.50 (m, 1H), 2.10–2.04 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.4, 150.2, 141.5, 139.7, 136.2, 134.4, 134.3, 130.4, 129.9, 128.6, 128.3, 127.8, 127.3, 127.2, 126.1, 65.3, 61.5, 61.3, 53.7, 37.4, 35.1, 14.1, 13.9; HRMS (ESI) calcd for $C_{24}H_{24}O_4Cl$ $(M + H)^+$ 411.1363, found 411.1357.



3pa

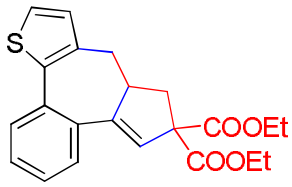
Compound ***3pa***. 90 mg, 80% yield; white solid, mp 97–109 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.16–8.11 (m, 1H), 8.02–7.99 (m, 1H), 7.37–7.33 (m, 3H), 7.28–7.26 (m, 1H), 7.20–7.15 (m, 1H), 5.74–5.69 (m, 1H), 4.43–4.38 (m, 2H), 4.24–4.19 (m, 2H), 4.11–4.05 (m, 2H), 3.83–3.75 (m, 1H), 3.00–2.95 (m, 1H), 2.78–2.72 (m, 1H), 2.55–2.50 (m, 1H), 2.14–2.09 (m, 1H), 1.41 (t, J = 7.1 Hz, 3H), 1.27 (t, J = 7.1 Hz, 3H), 1.14 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.7, 170.3, 166.4, 150.5, 140.4, 140.0, 140.0, 136.0, 130.7, 130.3, 130.2, 129.8, 128.5, 127.7, 127.2, 126.4, 65.4, 61.6, 61.3, 61.1, 53.8, 37.5, 35.1, 14.3, 14.1, 13.9; HRMS (ESI) calcd for $C_{27}H_{28}O_6Na$ $(M + Na)^+$ 471.1784, found 471.1788.



3qa

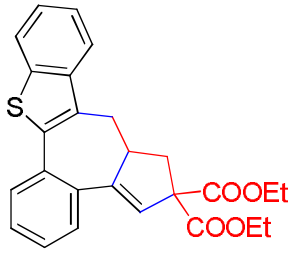
Compound ***3qa***. 75 mg, 72% yield; white solid, mp 109–111 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.05–8.03 (m, 1H), 7.93–7.91 (m, 1H), 7.40–7.38 (m, 1H), 7.35–7.32 (m, 2H), 7.29–7.27 (m, 1H), 7.20–7.16 (m, 1H), 5.73–5.70 (m, 1H), 4.24–4.20 (m, 2H), 4.10–4.04 (m, 2H), 3.82–3.76 (m, 1H), 3.00–2.96 (m, 1H), 2.78–2.73 (m, 1H), 2.65 (s, 3H), 2.56–2.52 (m, 1H), 2.14–2.09 (m, 1H), 1.28 (t, J = 7.1 Hz, 3H), 1.14 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 197.7, 170.6, 170.3, 150.4, 140.7, 140.2, 134.0, 137.3, 136.0, 130.4, 130.1, 128.7, 127.8, 127.4, 127.3, 127.2, 126.5,

65.4, 61.6, 61.3, 53.8, 37.5, 35.0, 26.7, 14.0, 13.9; HRMS (ESI) calcd for $C_{26}H_{27}O_5$ $(M + H)^+$ 419.1858, found 419.1851.



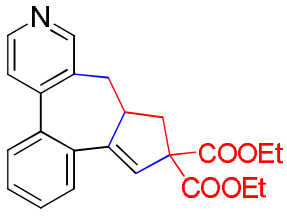
3ra

Compound ***3ra***. 67 mg, 70% yield; white solid, mp 106–108 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.61–7.59 (m, 1H), 7.54–7.51 (m, 1H), 7.32–7.29 (m, 1H), 7.23–7.20 (m, 1H), 7.17–7.13 (m, 1H), 6.88–6.85 (m, 1H), 6.00–5.97 (m, 1H), 4.23–4.15 (m, 4H), 3.54–3.48 (m, 1H), 3.03–2.99 (m, 1H), 2.84–2.80 (m, 1H), 2.76–2.72 (m, 1H), 2.30–2.25 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.23 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.7, 151.7, 138.4, 137.5, 133.4, 132.6, 130.9, 128.8, 128.6, 126.9, 125.5, 123.6, 64.8, 61.6, 61.5, 49.3, 39.5, 33.3, 14.1, 14.0; HRMS (ESI) calcd for $C_{22}H_{23}O_4$ S $(M + H)^+$ 383.1317, found 383.1311.



3sa

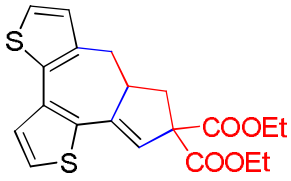
Compound ***3sa***. 86 mg, 80% yield; white solid, mp 134–136 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.86–7.83 (m, 1H), 7.76–7.71 (m, 2H), 7.61–7.57 (m, 1H), 7.43–7.38 (m, 2H), 7.37–7.35 (m, 1H), 7.34–7.30 (m, 1H), 6.05–6.02 (m, 1H), 4.29–4.23 (m, 2H), 4.19–4.13 (m, 2H), 3.70–3.63 (m, 1H), 3.26–3.22 (m, 1H), 3.02–2.96 (m, 1H), 2.94–2.89 (m, 1H), 2.36–2.30 (m, 1H), 1.32 (t, J = 7.1 Hz, 3H), 1.21 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.8, 170.7, 151.5, 140.9, 138.6, 138.6, 134.5, 132.7, 131.6, 129.5, 128.9, 128.7, 127.7, 125.7, 124.5, 124.2, 122.0, 121.7, 65.0, 61.6, 61.5, 49.5, 39.7, 30.5, 14.1, 13.9; HRMS (ESI) calcd for $C_{26}H_{25}O_4S$ $(M + H)^+$ 433.1474, found 433.1468.



3ta

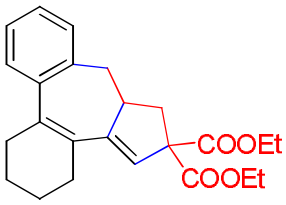
Compound ***3ta***. 76 mg, 81% yield; white solid, mp 104–106 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.57–8.54 (m, 1H), 8.42–8.39 (m, 1H), 7.49–7.46 (m, 2H), 7.43–7.40 (m, 1H), 7.35–7.32 (m, 1H), 7.24–7.22 (m, 1H), 5.73–5.70 (m, 1H), 4.26–4.18 (m, 2H), 4.12–4.05 (m, 2H), 3.90–3.84 (m, 1H), 2.98–2.94 (m, 1H), 2.82–2.77 (m, 1H), 2.60–2.56 (m, 1H), 2.08–2.03 (m, 1H), 1.27 (t, J = 7.1 Hz,

3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.5, 170.2, 150.5, 150.0, 148.8, 148.8, 136.9, 136.1, 131.4, 128.9, 128.8, 128.5, 127.5, 126.9, 123.9, 65.2, 61.6, 61.3, 53.8, 37.4, 32.0, 14.0, 13.9; HRMS (ESI) calcd for $C_{23}H_{24}O_4N$ $(M + H)^+$ 378.1705, found 378.1700.



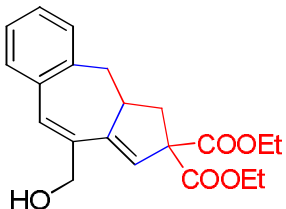
3ua

Compound ***3ua***. 41 mg, 42% yield; white solid, mp 109–111 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.20–7.17 (m, 1H), 7.16–7.12 (m, 1H), 7.11–7.08 (m, 1H), 6.84–6.79 (m, 1H), 6.13–6.09 (m, 1H), 4.26–4.22 (m, 2H), 4.21–4.13 (m, 2H), 3.29–3.22 (m, 1H), 3.09–3.00 (m, 2H), 2.75–2.67 (m, 1H), 2.14–2.07 (m, 1H), 1.30 (t, J = 7.1 Hz, 3H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.9, 170.4, 144.6, 137.7, 134.1, 132.7, 131.6, 130.5, 128.2, 125.3, 122.7, 122.4, 64.7, 61.7, 61.6, 44.5, 40.3, 34.9, 14.1, 14.0; HRMS (ESI) calcd for $C_{20}H_{21}O_4S_2$ $(M + H)^+$ 389.0881, found 389.0898.



3va

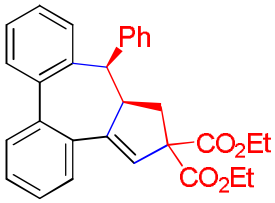
Compound ***3va***. 84 mg, 88% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.36–7.31 (m, 1H), 7.20–7.15 (m, 1H), 7.11–7.04 (m, 2H), 5.72–5.69 (m, 1H), 4.18–4.07 (m, 4H), 3.27–3.16 (m, 1H), 2.82–2.73 (m, 2H), 2.67–2.60 (m, 2H), 2.55–2.48 (m, 1H), 2.44–2.36 (m, 2H), 2.01–1.92 (m, 1H), 1.84–1.77 (m, 2H), 1.74–1.67 (m, 1H), 1.64–1.58 (m, 1H), 1.23–1.18 (m, 6H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.3, 170.4, 152.4, 141.9, 138.5, 134.8, 129.8, 128.5, 127.3, 126.3, 126.1, 122.7, 64.3, 61.3, 61.2, 51.4, 39.8, 38.1, 32.4, 29.5, 23.0, 22.8, 14.0; HRMS (ESI) calcd for $C_{24}H_{29}O_4$ $(M + H)^+$ 381.2066, found 381.2055.



3wa

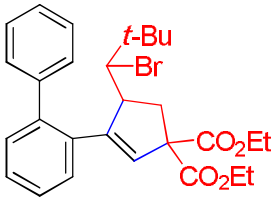
Compound ***3wa***. 66 mg, 74% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.25–7.22 (m, 1H), 7.21–7.14 (m, 2H), 7.14–7.10 (m, 1H), 6.80–6.68 (m, 1H), 6.02–5.92 (m, 1H), 4.55–4.46 (m, 2H), 4.25–4.21 (m, 2H), 4.19–4.09 (m, 2H), 3.17–3.06 (m, 1H), 3.03–2.97 (m, 1H), 2.89–2.80 (m, 2H), 2.14–2.06 (m, 1H), 2.06–2.00 (m, 1H), 1.28 (t, J = 7.1 Hz, 3H), 1.21 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.0, 170.3, 147.8, 139.5, 135.2, 133.2, 132.4, 130.9, 129.2, 127.8,

126.4, 124.0, 66.1, 64.7, 61.6, 61.6, 45.7, 41.0, 40.6, 14.0, 14.0; HRMS (ESI) calcd for $C_{21}H_{25}O_5$ $(M + H)^+$ 357.1702, found 357.1696.



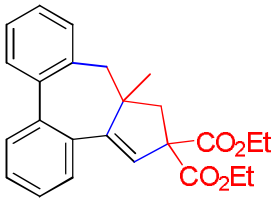
3ab

Compound ***3ab***. 79 mg, 70% yield; *cis/trans* = 6.7:1; white solid, mp 108–110 °C; ^{1}H NMR (600 MHz, $CDCl_3$) data of *cis*-isomer: δ 7.46–7.42 (m, 3H), 7.39–7.36 (m, 3H), 7.35–7.32 (m, 3H), 7.12–7.10 (m, 2H), 6.98–6.95 (m, 2H), 6.11–6.07 (m, 1H), 4.76–4.71 (m, 1H), 4.29 (q, J = 7.1 Hz, 2H), 4.22–4.18 (m, 2H), 2.85–2.80 (m, 1H), 2.74–2.69 (m, 1H), 2.35–2.31 (m, 1H), 1.32 (t, J = 7.1 Hz, 3H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) data of *cis*-isomer: δ 170.7, 170.4, 150.7, 141.0, 140.1, 139.4, 133.7, 131.7, 129.7, 129.7, 129.2, 129.0, 128.4, 128.3, 128.1, 128.1, 127.7, 127.6, 127.5, 127.4, 64.8, 61.6, 61.6, 58.6, 52.8, 34.0, 14.1, 14.1; HRMS (ESI) calcd for $C_{30}H_{29}O_4$ $(M + H)^+$ 453.2066, found 453.2062. The *cis*-diastereoselectivity of major isomer was determined by NOE analysis.



3ac'

Compound ***3ac'***. 78 mg, 92% yield; white solid, mp 98–100 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.48–7.45 (m, 1H), 7.42–7.39 (m, 3H), 7.37–7.31 (m, 5H), 5.99–5.97 (m, 1H), 4.29–4.22 (m, 4H), 3.54–3.49 (m, 1H), 3.02–2.95 (m, 1H), 2.56–2.48 (m, 2H), 1.30 (t, J = 7.1 Hz, 6H), 0.69 (s, 9H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.8, 170.6, 152.1, 140.8, 139.1, 133.9, 132.1, 129.8, 129.1, 128.4, 128.3, 127.4, 127.3, 72.1, 65.7, 61.6, 61.4, 47.5, 36.2, 34.8, 28.1, 14.1, 14.1; HRMS (ESI) calcd for $C_{28}H_{33}O_4BrNa$ $(M + Na)^+$ 535.1460, found 535.1452.

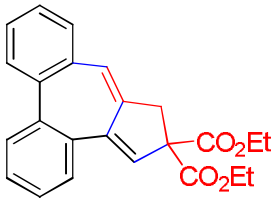


3ad

Compound ***3ad***. 74% yield (72 mg); white solid, mp 85–87 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.48–7.45 (m, 1H), 7.44–7.41 (m, 1H), 7.34–7.32 (m, 1H), 7.31–7.28 (m, 2H), 7.27–7.23 (m, 2H), 7.18–7.14 (m, 1H), 5.43–5.38 (m, 1H), 4.25–4.20 (m, 2H), 4.00–3.93 (m, 2H), 2.61–2.45 (m, 4H), 1.28 (t, J = 7.1 Hz, 3H), 1.19 (s, 3H), 1.02 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.5, 171.0, 154.7, 141.0, 139.8, 136.8, 135.2, 130.0, 129.5, 128.3, 128.0, 127.4, 127.2, 127.1,

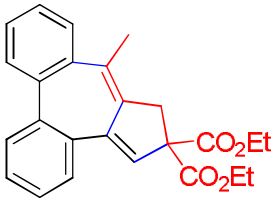
126.9, 123.7, 64.9, 61.5, 61.2, 59.4, 44.1, 41.9, 26.7, 14.0, 13.7; HRMS (ESI) calcd for $C_{25}H_{27}O_4$ $(M + H)^+$ 391.1909, found 391.1901.

Crystal data for **3ad** ($C_{25}H_{26}O_4$, 390.46): monoclinic, space group *P*21, *a* = 8.8392(5) Å, *b* = 12.7460(7) Å, *c* =9.5979(5) Å, *U* = 1066.00(10) Å^3, *Z* = 2, *T* = 296(2) K, absorption coefficient 0.081 mm^{-1}, reflections collected 17528, independent reflections 4929 [*R*(int) = 0.0782], refinement by full-matrix least-squares on F^2, data/restraints/parameters 4929/1/262, goodness-of-fit on F^2 = 0.896, final *R* indices [$I>2s(I)$] R_1 = 0.0637, wR_2 = 0.1444, *R* indices (all data) R_1 = 0.1355, wR_2 = 0.1847, largest diff peak and hole 0.164 and –0.178 e·Å^{-3}. Crystallographic data for the structure **3ad** have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication No. CCDC 1498313.



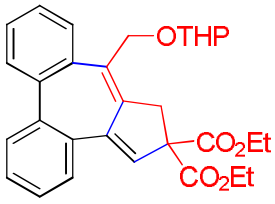
3ae

*Compound **3ae***. 42 mg, 45% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.59–7.53 (m, 2H), 7.49–7.46 (m, 1H), 7.39–7.32 (m, 2H), 7.27–7.23 (m, 2H), 7.14–7.08 (m, 1H), 6.43–6.39 (m, 1H), 6.38–6.35 (m, 1H), 4.25–4.16 (m, 4H), 3.37–3.25 (m, 2H), 1.26 (t, *J* = 7.1 Hz, 6H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.1, 147.7, 147.6, 138.3, 137.5, 136.3, 134.3, 131.9, 131.5, 130.5, 129.6, 129.2, 128.9, 128.2, 127.9, 126.9, 123.7, 62.9, 61.8, 42.4, 14.0; HRMS (ESI) calcd for $C_{24}H_{22}O_4Na$ $(M + Na)^+$ 397.1416, found 397.1412.



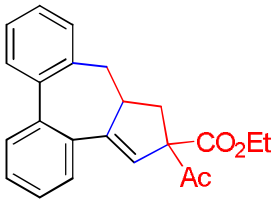
3af

*Compound **3af***. 57 mg, 58% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.52–7.49 (m, 1H), 7.4–7.41 (m, 3H), 7.38–7.36 (m, 1H), 7.33–7.28 (m, 2H), 7.26–7.24 (m, 1H), 6.46–6.45 (m, 1H), 4.17–4.23 (m, 4H), 3.32 (s, 2H), 2.23 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 6H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.2, 147.7, 146.5, 139.7, 139.0, 137.5, 135.4, 132.1, 131.4, 129.2, 128.7, 128.5, 127.8, 127.5, 127.3, 126.5, 125.8, 62.8, 61.7, 42.6, 20.3, 14.0; HRMS (ESI) calcd for $C_{25}H_{24}O_4Na$ $(M + Na)^+$ 411.1572, found 411.1581.



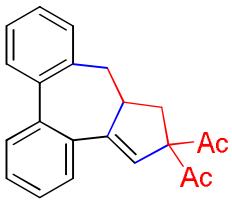
3ag

Compound ***3ag***. 73 mg, 60% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.58–7.55 (m, 1H), 7.53–7.50 (m, 1H), 7.46–7.43 (m, 1H), 7.41–7.37 (m, 2H), 7.34–7.30 (m, 2H), 7.26–7.23 (m, 1H), 6.56–6.51 (m, 1H), 4.82–4.79 (m, 1H), 4.79–4.77 (m, 1H), 4.39–4.34 (m, 1H), 4.24–4.18 (m, 4H), 3.99–3.93 (m, 1H), 3.62–3.58 (m, 1H), 3.46 (s, 2H), 1.88–1.81 (m, 1H), 1.77–1.71 (m, 1H), 1.66–1.56 (m, 4H), 1.27–1.23 (m, 6H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 170.1, 170.0, 150.9, 147.9, 139.1, 138.1, 137.6, 135.3, 132.1, 131.4, 130.5, 129.4, 128.8, 128.5, 127.8, 127.6, 126.6, 126.5, 98.9, 68.3, 63.2, 62.5, 61.8, 61.8, 41.9, 30.7, 25.5, 19.4, 14.0, 14.0; HRMS (ESI) calcd for $C_{30}H_{33}O_6$ $(M + H)^+$ 489.2277, found 489.2270.



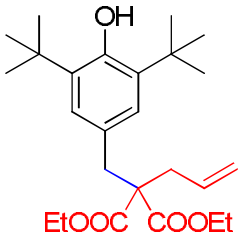
3ai

Compound ***3ai***. 61 mg, 70% yield; dr = 1.4:1; white solid, mp 89–91 °C; ^{1}H NMR (600 MHz, $CDCl_3$) data of the major isomer: δ 7.48–7.45 (m, 2H), 7.31–7.29 (m, 3H), 7.25–7.23 (m, 2H), 7.18–7.16 (m, 1H), 5.72–5.69 (m, 1H), 4.09–4.03 (m, 2H), 3.66–3.59 (m, 1H), 3.02–2.99 (m, 1H), 2.76–2.73 (m, 1H), 2.52–2.50 (m, 1H), 2.24 (s, 3H), 2.08–2.04 (m, 1H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) data of the major isomer: δ 202.3, 171.3, 152.0, 140.9, 139.7, 136.1, 135.9, 130.3, 129.9, 128.6, 128.5, 127.4, 127.3, 127.0, 126.8, 125.4, 72.3, 61.3, 53.8, 35.9, 35.2, 26.7, 13.9; HRMS (ESI) calcd for $C_{23}H_{23}O_3$ $(M + H)^+$ 347.1647, found 347.1632.



3aj

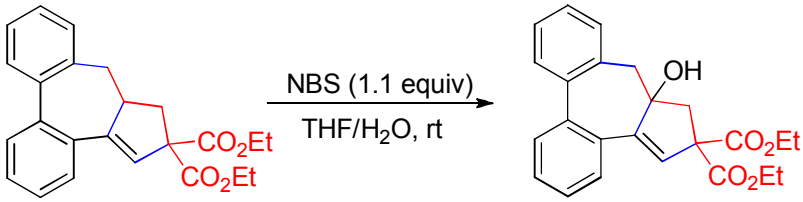
Compound ***3aj***. 58% yield (46 mg); white solid, mp 91–93 °C; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.48–7.44 (m, 2H), 7.36–7.34 (m, 1H), 7.33–7.30 (m, 2H), 7.28–7.26 (m, 1H), 7.24–7.22 (m, 1H), 7.20–7.17 (m, 1H), 5.75–5.67 (m, 1H), 3.68–3.62 (m, 1H), 3.03–2.99 (m, 1H), 2.90–2.86 (m, 1H), 2.53–2.50 (m, 1H), 2.17 (s, 3H), 1.89–1.85 (m, 1H), 1.75 (s, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 207.2, 203.6, 153.1, 140.9, 139.7, 135.9, 135.8, 130.3, 130.0, 128.7, 128.6, 127.5, 127.4, 127.2, 126.5, 125.3, 79.2, 53.9, 35.2, 34.5, 27.4, 26.2; HRMS (ESI) calcd for $C_{22}H_{21}O_2$ $(M + H)^+$ 317.1542, found 317.1535.



4

*Compound **4***. 85 mg, 81% yield; colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 6.92–6.86 (m, 2H), 5.84–5.67 (m, 1H), 5.19–5.12 (m, 2H), 5.10–5.06 (m, 1H), 4.23–4.13 (m, 4H), 3.15 (s, 2H), 2.58–2.52 (m, 2H), 1.40 (s, 18H), 1.24 (t, J = 7.2 Hz, 6H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 171.0, 152.6, 135.5, 132.9, 126.5, 126.4, 118.9, 61.1, 58.9, 37.8, 36.2, 34.2, 30.3, 14.0; HRMS (ESI) calcd for $C_{25}H_{39}O_5$ $(M + H)^+$ 419.2797, found 419.2809.

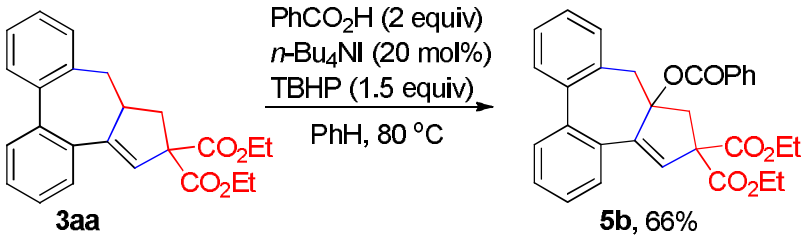
Experimental procedure for the preparation of compound 5a:



3aa **5a**, 70%

To a solution of **3aa** (94 mg, 0.25 mmol) in 1 mL of THF and 0.7 mL of H_2O was added NBS (49 mg, 0.28 mmol). After stirring at room temperature for 8 h, the reaction mixture was quenched with water, extracted with EtOAc, washed with brine, dried over anhydrous Na_2SO_4, and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:10) gave 65 mg of **5a** (yield: 70%) as a colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.49–7.44 (m, 2H), 7.37–7.34 (m, 1H), 7.32–7.29 (m, 3H), 7.25–7.22 (m, 1H), 7.22–7.19 (m, 1H), 5.73 (s, 1H), 4.31–4.25 (m, 2H), 4.12–4.06 (m, 2H), 4.05 (s, 1H), 3.01–2.95 (m, 1H), 2.92–2.86 (m, 1H), 2.57–2.53 (m, 1H), 2.51–2.46 (m, 1H), 1.30 (t, J = 7.1 Hz, 3H), 1.14 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 173.4, 169.8, 153.8, 141.0, 139.3, 134.8, 133.9, 130.1, 129.8, 128.9, 128.4, 128.1, 127.6, 127.5, 127.4, 126.9, 92.1, 64.5, 62.8, 61.4, 43.3, 42.3, 13.9, 13.8; HRMS (ESI) calcd for $C_{24}H_{24}O_5Na$ $(M + Na)^+$ 415.1521, found 415.1512.

Experimental procedure for the preparation of compound 5b:[6]

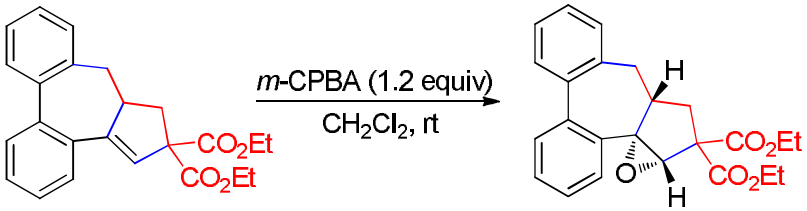


3aa **5b**, 66%

[6] E. Shi, Y. Shao, S. Chen, H. Hu, Z. Liu, J. Zhang and X. Wan, *Org. Lett.*, 2012, **14**, 3384.

To a mixture of **3aa** (94 mg, 0.25 mmol), $PhCO_2H$ (61 mg, 0.5 mmol), and *n*-Bu_4NI (18 mg, 0.05 mmol) in 2 mL of benzene was added TBHP (1.5 equiv, 70% aqueous solution, 50 μL). After stirring at 80 °C for 12 h, the reaction mixture was quenched with saturated Na_2SO_3 solution, extracted with ethyl acetate, dried over Na_2SO_4 and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:5) gave 82 mg of **5b** (yield: 66%) as a colorless oil; ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.18–8.08 (m, 2H), 7.97–7.87 (m, 2H), 7.53–7.46 (m, 6H), 7.41–7.38 (m, 2H), 7.35–7.34 (m, 1H), 6.03 (s, 1H), 4.07–3.96 (m, 3H), 3.94–3.88 (m, 2H), 3.67–3.62 (m, 1H), 3.07–3.03 (m, 1H), 2.73–2.66 (m, 1H), 1.08 (t, J = 7.1 Hz, 3H), 1.05 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 169.8, 169.6, 165.7, 148.4, 141.0, 139.4, 134.3, 133.9, 133.7, 132.8, 131.9, 130.6, 130.2, 129.7, 129.5, 129.1, 128.5, 128.3, 128.3, 128.2, 127.7, 100.3, 64.8, 61.8, 61.7, 40.5, 38.9, 13.8, 13.8; HRMS (ESI) calcd for $C_{31}H_{29}O_6$ $(M + H)^+$ 497.1964, found 497.1959.

Experimental procedure for the preparation of compound 5c:

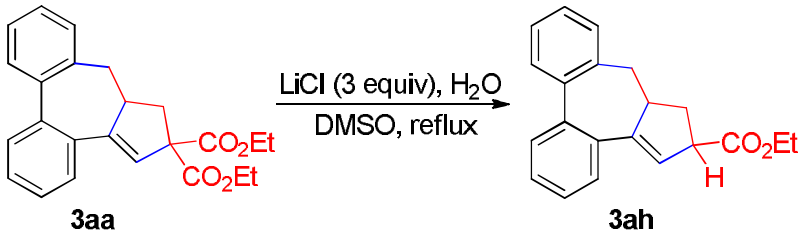


3aa **5c**, 85%

To a mixture of **3aa** (94 mg, 0.25 mmol) and $NaHCO_3$ (42 mg, 0.5 mmol) in 2 mL of DCM was added *m*-CPBA (52 mg, 0.3 mmol) at 0 °C. After stirring at 25 °C for 24 h, the reaction mixture was quenched with water, extracted with EtOAc, washed with brine, dried over anhydrous Na_2SO_4, and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:5) gave 83 mg of **5c** (yield: 85%) as a white solid, mp 160–162 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.52–7.50 (m, 1H), 7.48–7.44 (m, 1H), 7.40–7.38 (m, 1H), 7.37–7.32 (m, 3H), 7.26–7.29 (m, 1H), 7.25–7.22 (m, 1H), 4.33–4.24 (m, 2H), 4.21–4.14 (m, 2H), 4.13 (s, 1H), 3.06–3.00 (m, 1H), 2.97–2.91 (m, 1H), 2.57–2.52 (m, 1H), 2.14–2.06 (m, 2H), 1.33 (t, J = 7.1 Hz, 3H), 1.22 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$): δ 169.4, 168.5, 142.3, 140.6, 137.5, 133.3, 130.1, 129.9, 129.3, 128.9, 127.6, 127.3, 127.2, 125.5, 68.3, 61.9, 61.7, 61.4, 60.8, 47.3, 32.4, 31.1, 14.1, 13.9; HRMS (ESI) calcd for $C_{24}H_{25}O_5$ $(M + H)^+$ 393.1702, found 393.1689.

Crystal data for **5c** ($C_{24}H_{24}O_5$, 392.43): monoclinic, space group $P21/c$, a = 12.7888(4) Å, b = 15.5970(5) Å, c =11.0139(4) Å, U = 2061.73(12) Å^3, Z = 4, T = 296(2) K, absorption coefficient 0.088 mm^{-1}, reflections collected 72628, independent reflections 4736 [R(int) = 0.1094], refinement by full-matrix least-squares on F^2, data/restraints/parameters 4736/0/262, goodness-of-fit on F^2 = 1.359, final R indices [I>2s(I)] R_1 = 0.0729, wR_2 = 0.1911, R indices (all data) R_1 = 0.1245, wR_2 = 0.2224, largest diff peak and hole 0.636 and –0.333 e·Å^{-3}. Crystallographic data for the structure **5c** have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication No. CCDC 1498314.

Experimental procedure for the preparation of compound 3ah:[7]



3aa **3ah**

To a solution of **3aa** (188 mg, 0.5 mmol) in 0.25 mL of H_2O and 1 mL of DMSO was added LiCl (63 mg, 1.5 mmol). After refluxing for 6 h, the reaction mixture was quenched with water, extracted with EtOAc, washed with brine, dried over anhydrous Na_2SO_4, and concentrated. Column chromatography on silica gel (EtOAc/petroleum ether = 1:15) gave 116 mg of **3ah** (yield: 76%) as a colorless oil; dr = 87:13. ^{1}H NMR (600 MHz, $CDCl_3$) data of major isomer: δ 7.46–7.44 (m, 1H), 7.42–7.39 (m, 1H), 7.33–7.27 (m, 4H), 7.24–7.23 (m, 1H), 7.19–7.17 (m, 1H), 5.65–5.59 (m, 1H), 4.03 (q, J = 7.1 Hz, 2H), 3.58–3.49 (m, 2H), 3.05–3.01 (m, 1H), 2.55–2.51 (m, 1H), 2.34–2.26 (m, 1H), 1.93–1.86 (m, 1H), 1.16 (t, J = 7.1 Hz, 3H); ^{13}C NMR (151 MHz, $CDCl_3$) data of major isomer: δ 173.9, 149.0, 141.1, 139.8, 136.8, 136.7, 130.4, 130.0, 128.8, 128.3, 127.4, 127.2, 127.1, 126.9, 126.1, 60.4, 54.7, 49.8, 35.5, 33.0, 14.1; HRMS (ESI) calcd for $C_{21}H_{20}O_2Na$ $(M + Na)^+$ 327.1361, found 327.1369.

[7] C. Che, Q. Huang, H. Zheng and G. Zhu, *Chem. Sci.,* 2016, **7**, 4134.


7.6249
7.6232
7.6119
7.6105
7.5926
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7.4270
7.4166
7.4143
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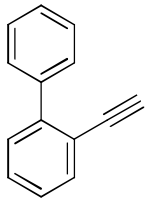

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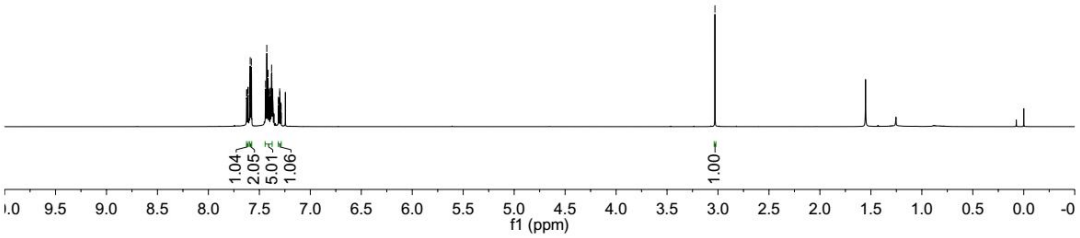
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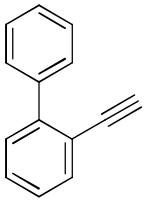

1a


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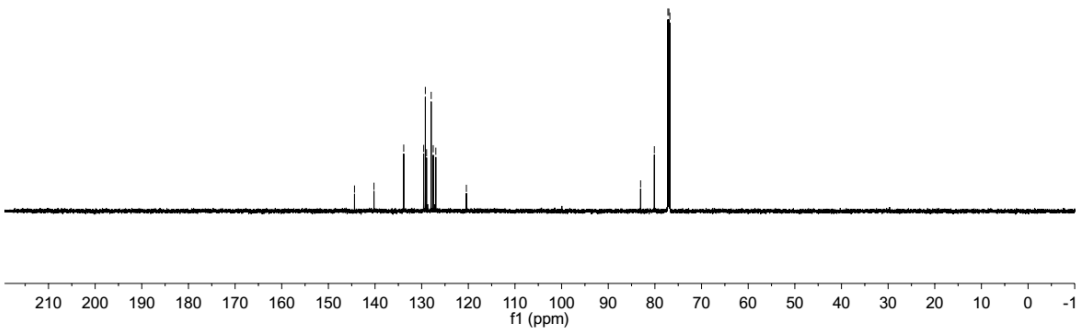
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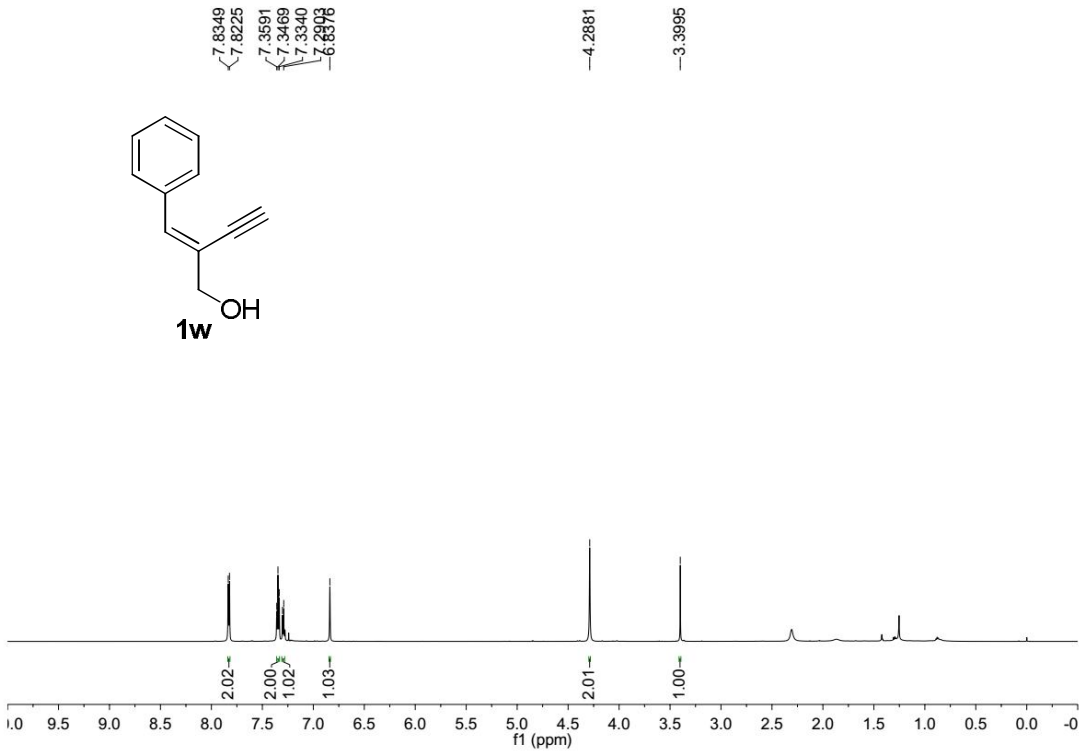
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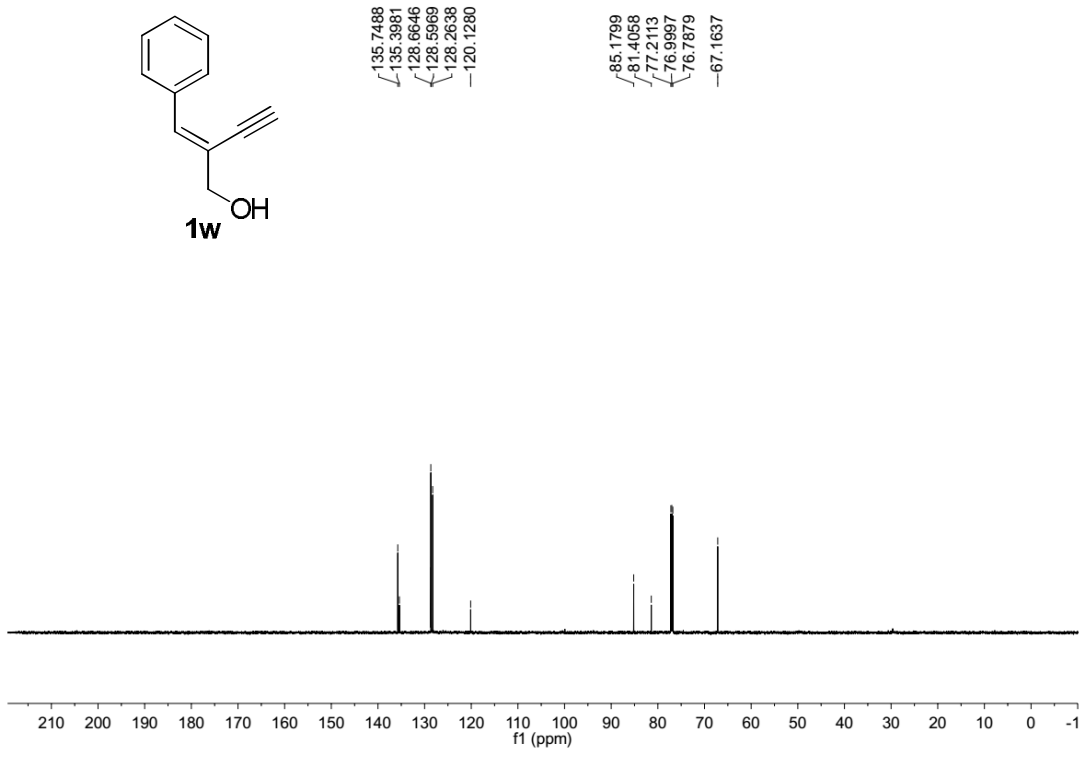
1.00
f1 (ppm)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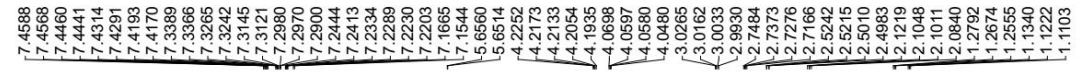
f1 (ppm)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7.2289
7.2230
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5.6514
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4.0580
4.0480
3.0265
3.0162
3.0033
2.9930
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2.7373
2.7276
2.7166
2.5242
2.5215
2.5010
2.4983
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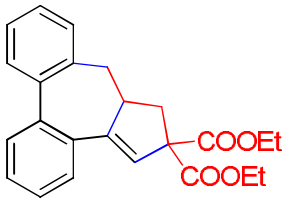
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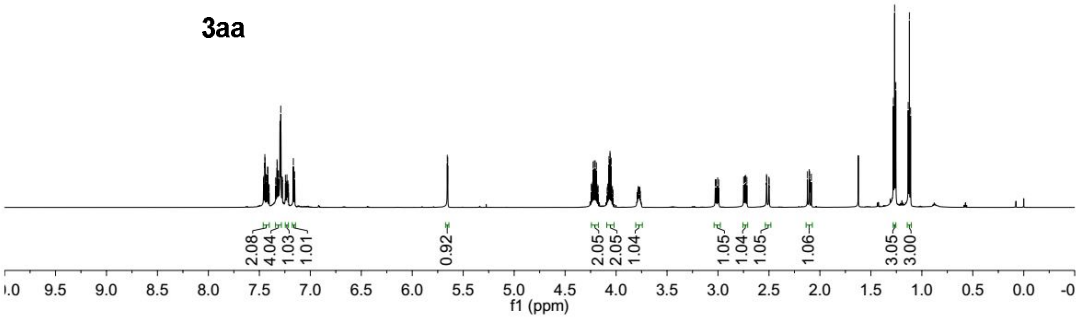
COOEt

3aa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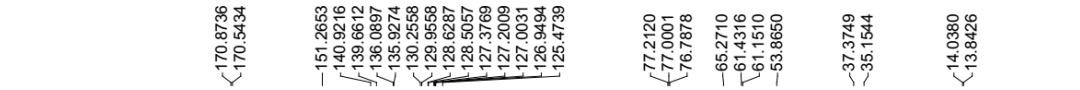
f1 (ppm)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127.0031
126.9494
125.4739
77.2120
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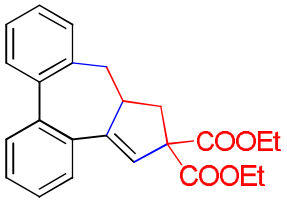
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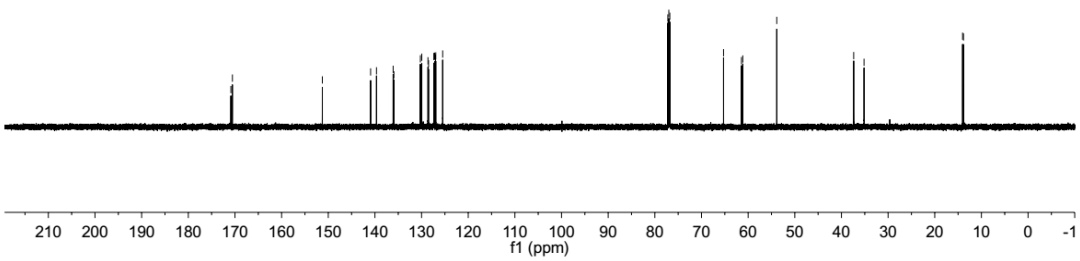
COOEt

3aa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7.2813
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7.1861
7.1095
7.0968
6.9804
5.6585
5.6540
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4.2151
4.2077
4.2031
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4.0888
4.0801
4.0769
4.0681
4.0650
3.0094
2.9992
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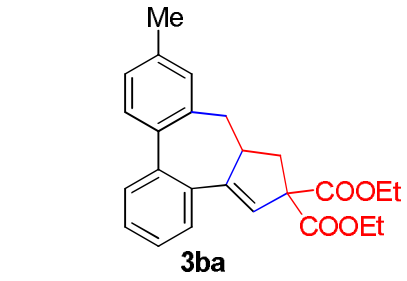
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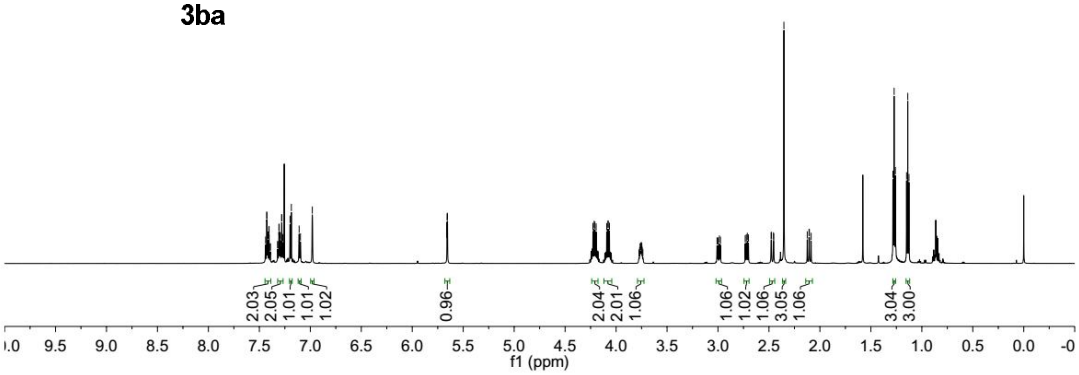
COOEt

3ba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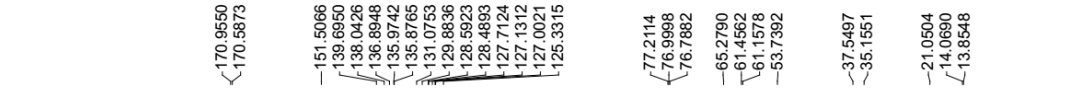
1.02
1.06
3.05
1.06
3.04
3.00
f1 (ppm)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127.1312
127.0021
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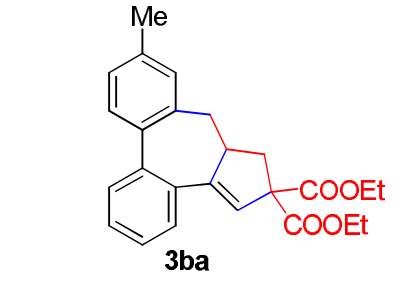
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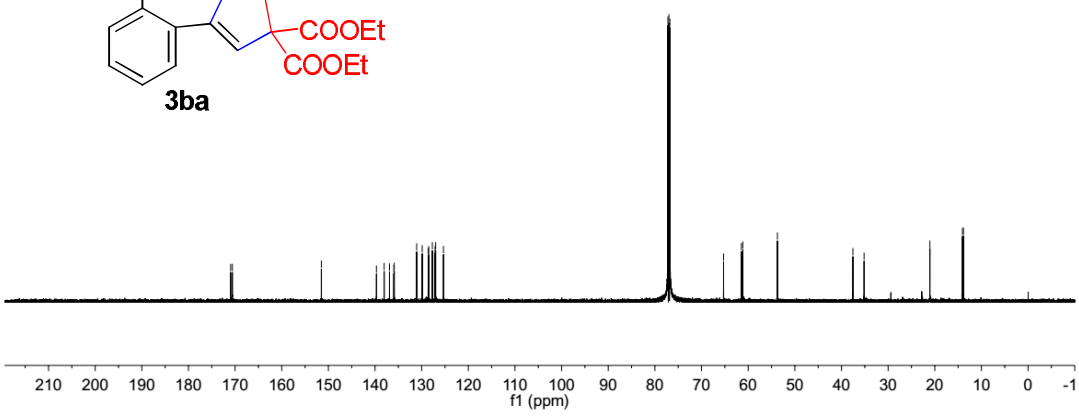
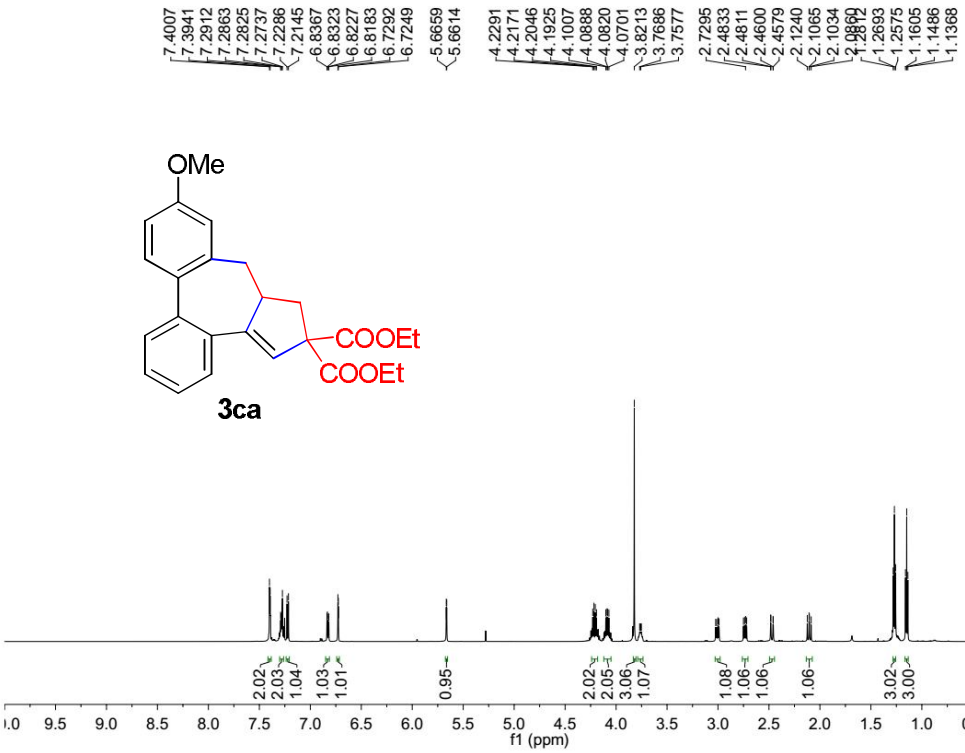
COOEt
COOEt

3ba


f1 (ppm)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6.8227
6.8183
6.7292
6.7249
5.6659
5.6614
4.2291
4.2171
4.2046
4.1925
4.1007
4.0888
4.0820
4.0701
3.8213
3.7686
3.7577
2.7295
2.4833
2.4811
2.4600
2.4579
2.1240
2.1065
2.1034
1.2693
1.2575
1.1605
1.1486
1.1368
OMe
COOEt
COOEt
3ca
2.02
2.03
1.04
1.03
1.01
0.95
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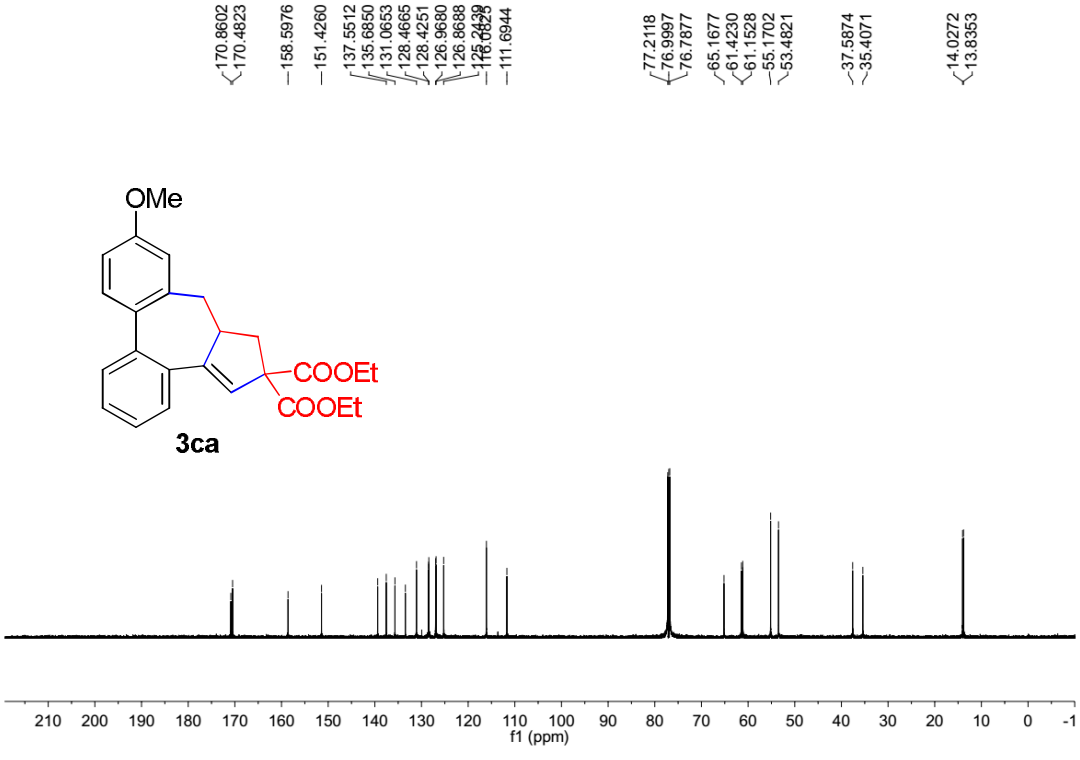
3.06
1.07
1.08
1.06
1.06
1.06
3.02
3.00
f1 (ppm)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76.7877
65.1677
61.4230
61.1528
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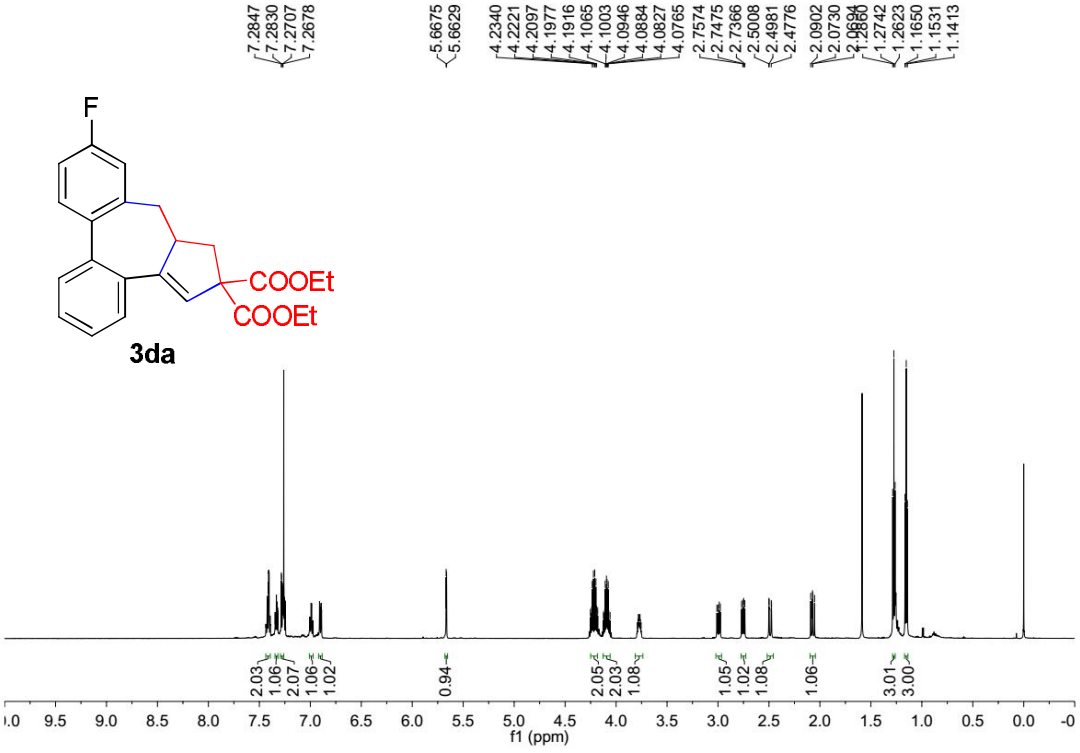
OMe
COOEt
COOEt
3ca
f1 (ppm)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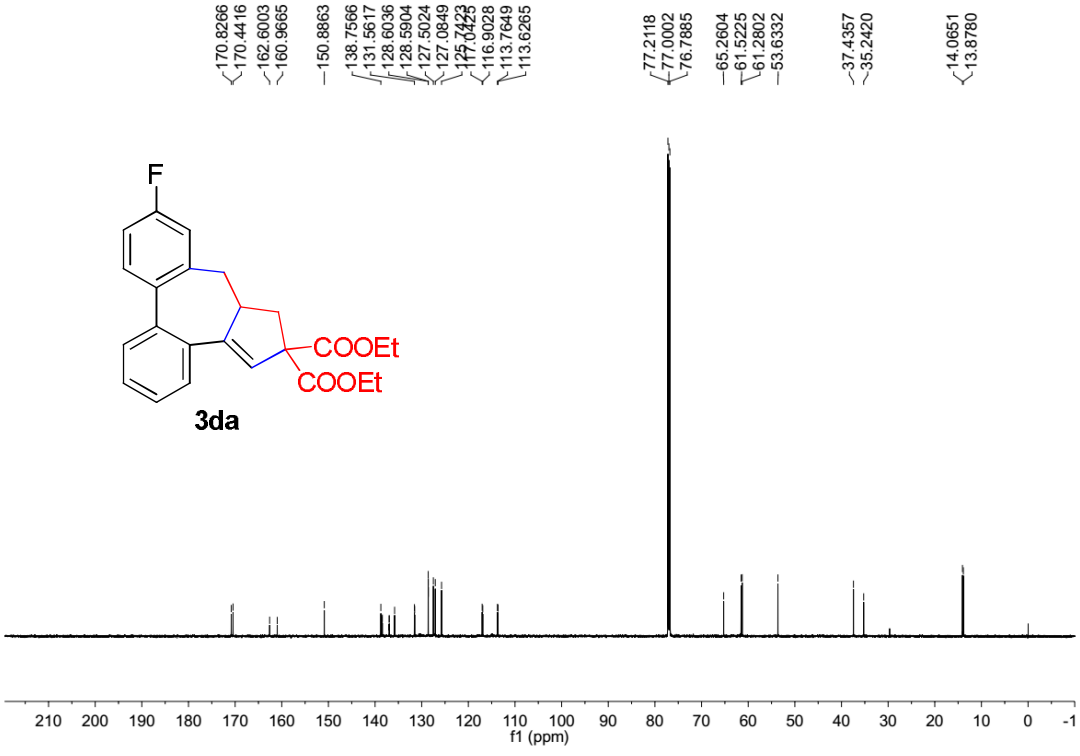
COOEt
3da
f1 (ppm)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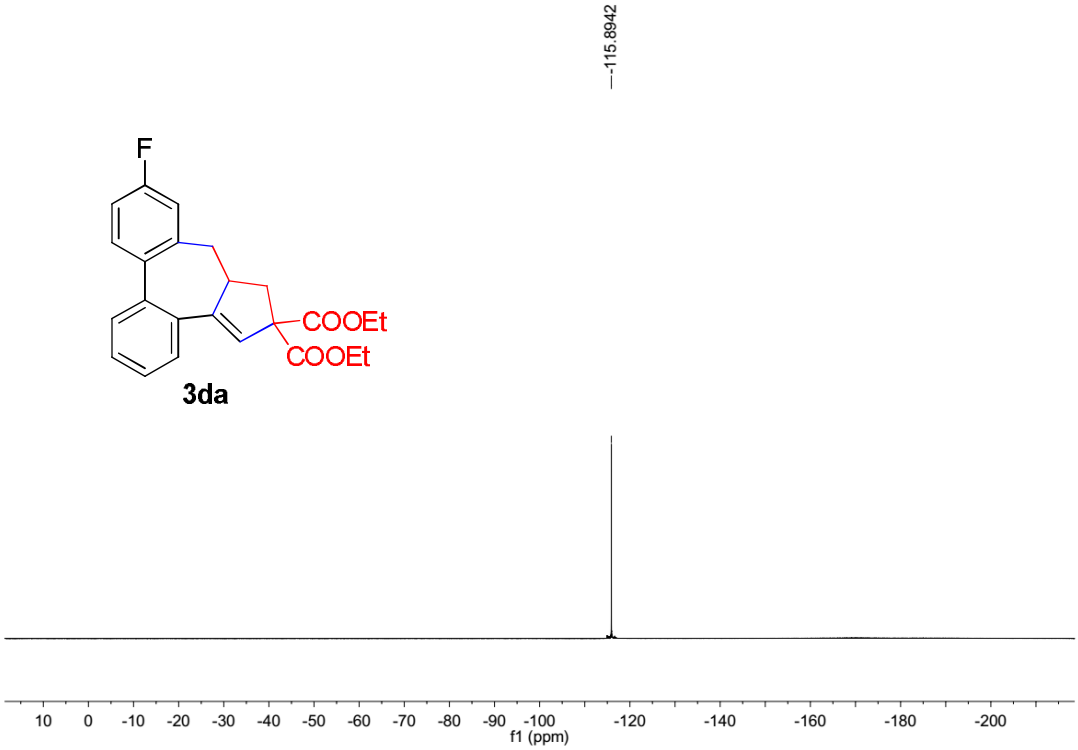
COOEt
3da
f1 (ppm)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COOEt
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-50
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-70
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-120
-140
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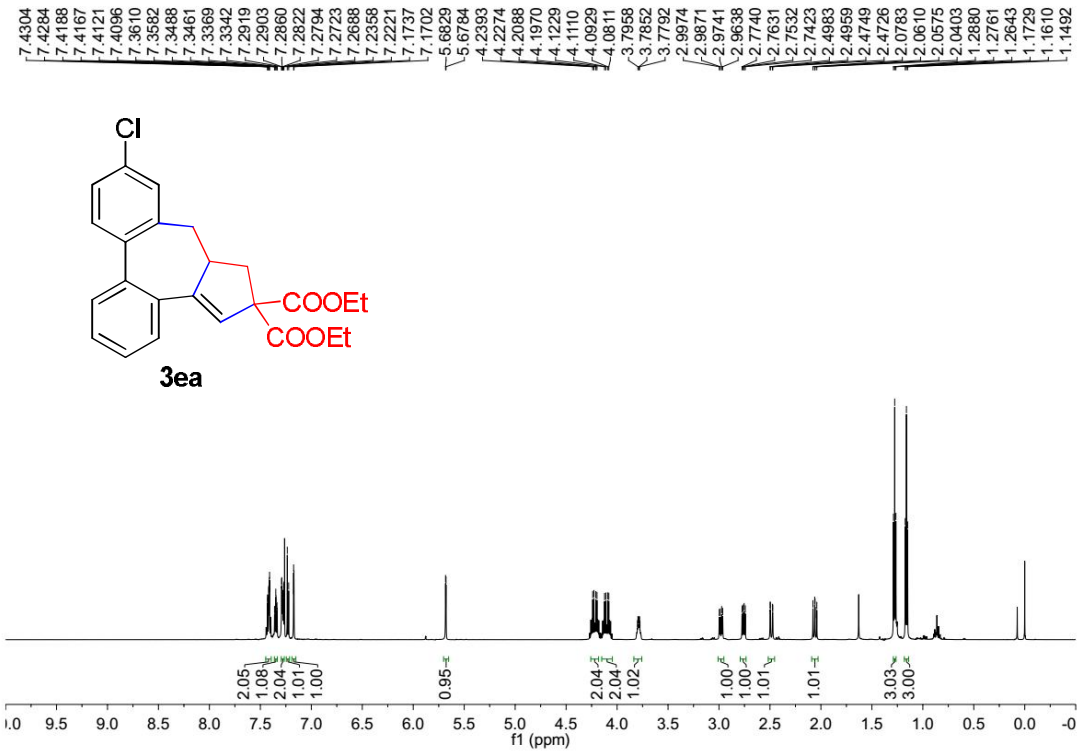
-180
-200
f1 (ppm)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7.2221
7.1737
7.1702
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2.7532
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2.0403
1.2880
1.2761
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1.1729
1.1610
1.1492
Cl
COOEt
COOEt
3ea
2.05
1.08
2.04
1.01
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1.00
1.00
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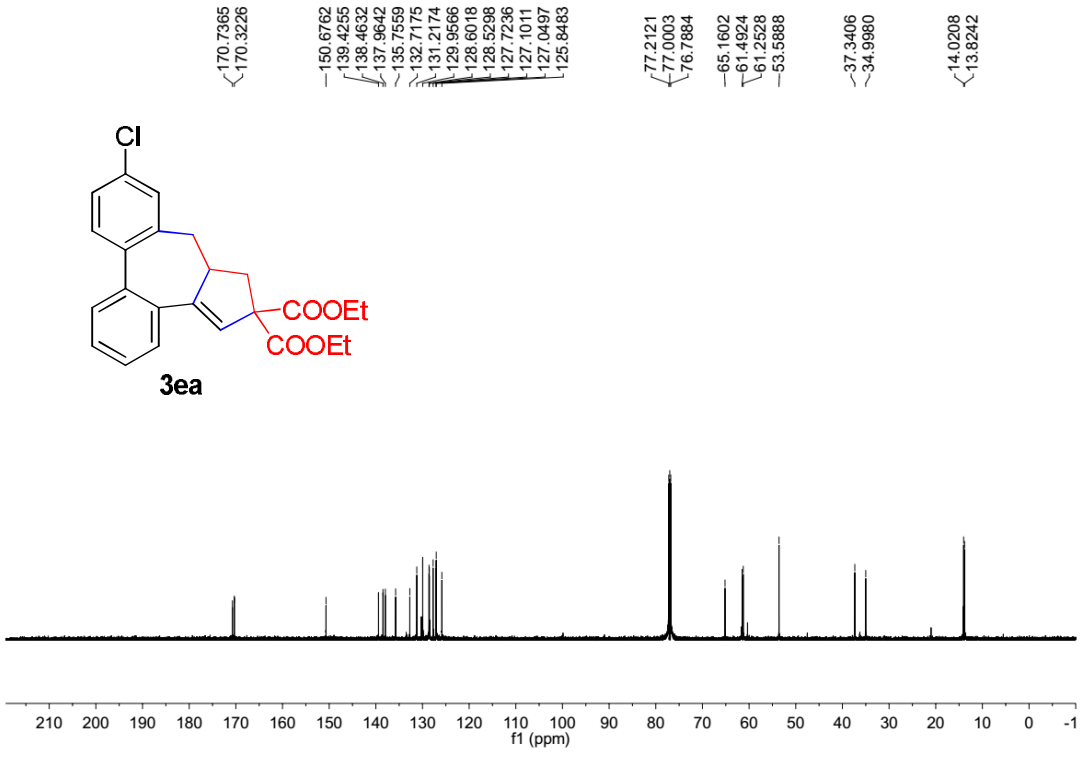
1.01
3.03
3.00
f1 (ppm)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125.8483
77.2121
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76.7884
65.1602
61.4924
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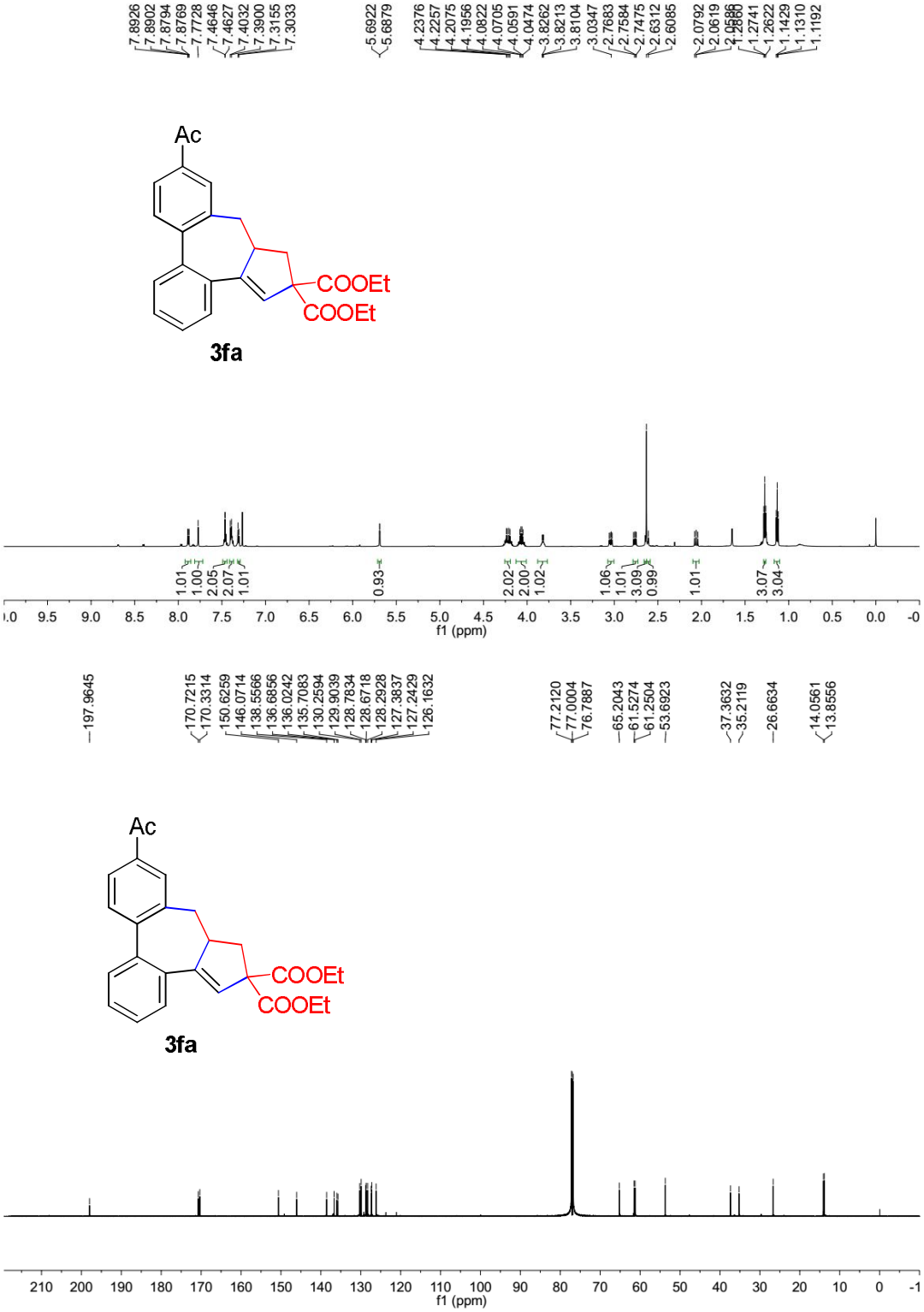
Cl
COOEt
COOEt
3ea
f1 (ppm)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5.6879
4.2376
4.2257
4.2075
4.1956
4.0822
4.0705
4.0591
4.0474
3.8262
3.8213
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3.0347
2.7683
2.7584
2.7475
2.6312
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2.0792
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1.2741
1.2622
1.1429
1.1310
1.1192
Ac
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COOEt
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1.00
2.05
2.07
1.01
0.93
2.02
2.00
1.02
1.06
1.01
3.09
0.99
1.01
3.07
3.04
f1 (ppm)
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136.6856
136.0242
135.7083
130.2594
129.9039
128.7834
128.6718
128.2928
127.3837
127.2429
126.1632
77.2120
77.0004
76.7887
65.2043
61.5274
61.2504
53.6923
37.3632
35.2119
26.6634
14.0561
13.8556
Ac
COOEt
COOEt
3fa
f1 (ppm)


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7.9610
7.9586
7.8485
7.4702
7.4599
7.4571
7.4442
7.4430
7.3862
7.3834
7.3770
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7.3636
7.3083
7.2961
5.6837
5.6793
4.2407
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3.8126
3.8052
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3.0072
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2.7537
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2.0934
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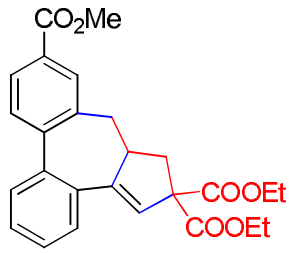
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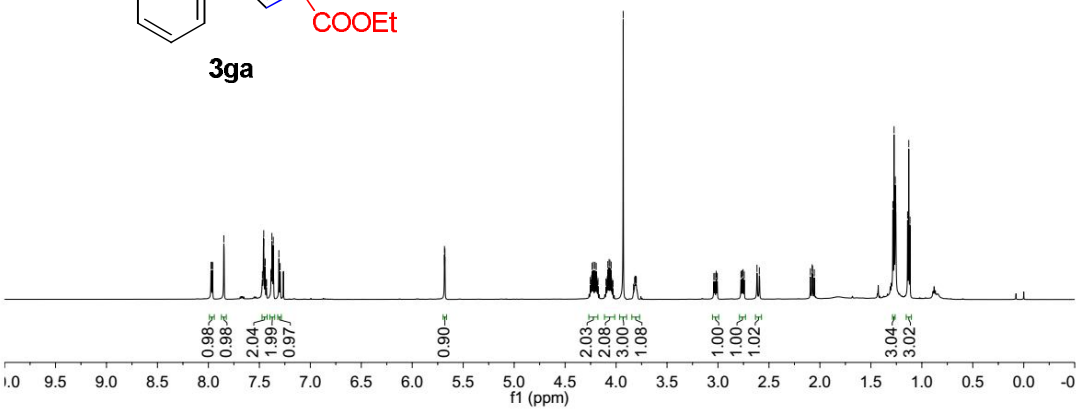
COOEt

3ga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2.08
3.00
1.08
1.00
1.00
1.02
3.04
3.02
f1 (ppm)


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167.0346
150.6708
145.8125
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136.4117
136.0078
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128.7768
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128.6391
128.3148
128.2002
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126.1003
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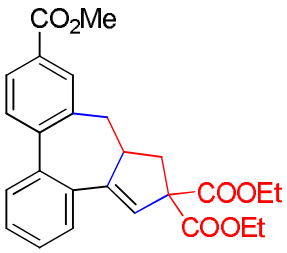
13.8360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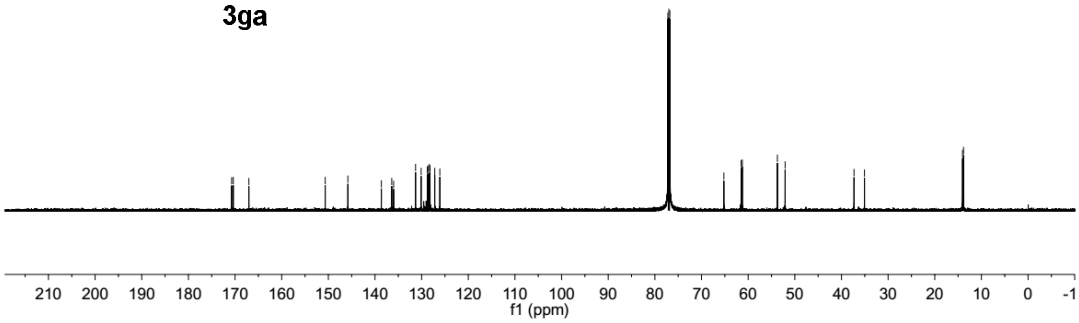
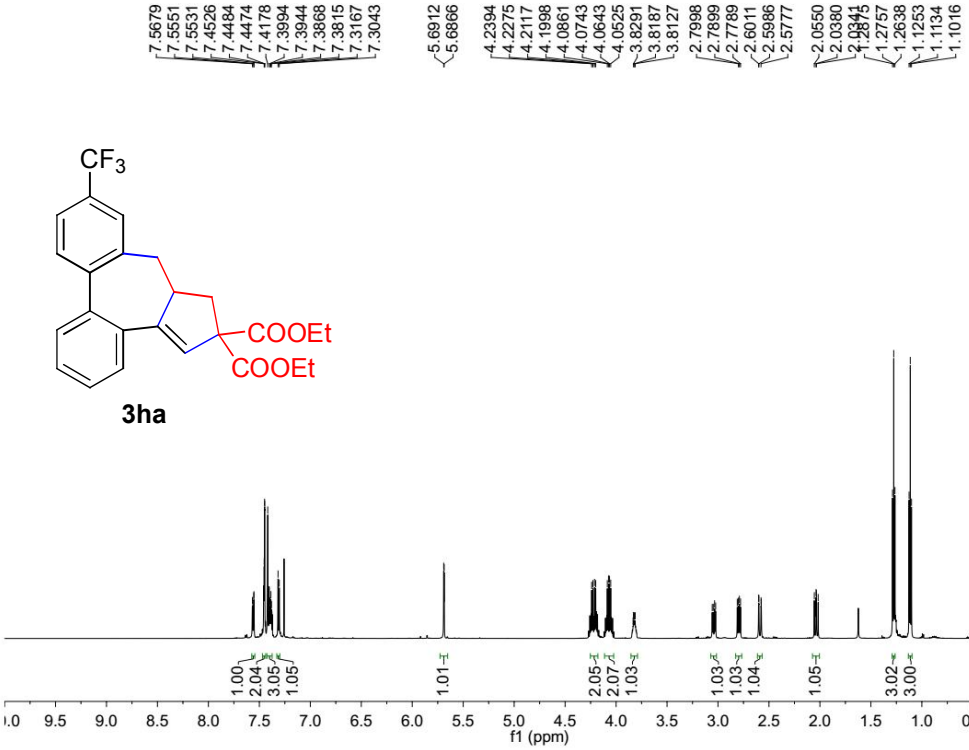
COOEt
COOEt

3ga


f1 (ppm)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7.3815
7.3167
7.3043
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5.6866
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4.2275
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4.0861
4.0743
4.0643
4.0525
3.8291
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3.8127
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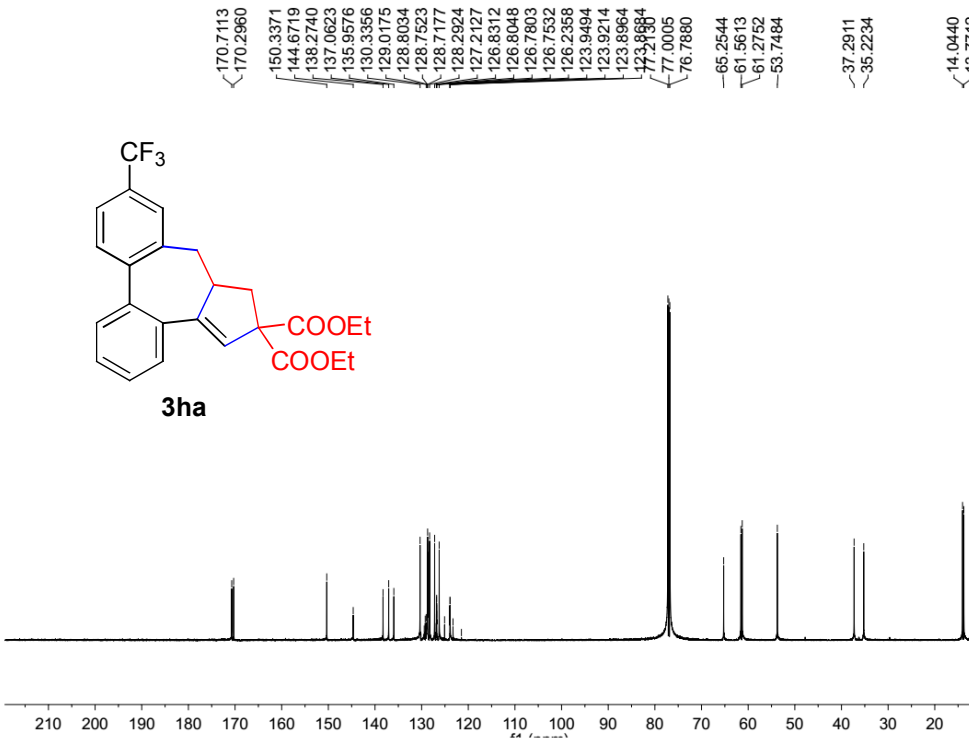
2.0550
2.0380
1.2875
1.2757
1.2638
1.1253
1.1134
1.1016
CF3
COOEt
COOEt
3ha
1.00
2.04
3.05
1.05
1.01
2.05
2.07
1.03
1.03
1.03
1.04
1.05
3.02
3.00
f1 (ppm)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128.2924
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126.8048
126.7803
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126.2358
123.9494
123.9214
123.8964
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76.7880
65.2544
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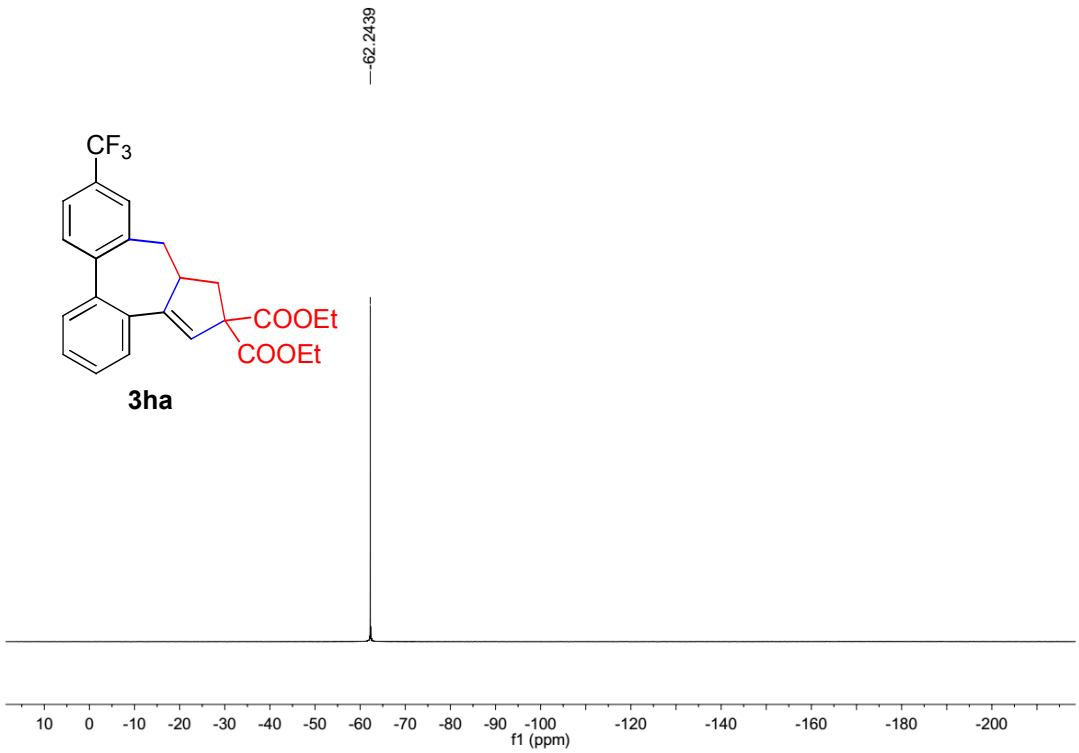
53.7484
37.2911
35.2234
14.0440
13.7712
CF3
COOEt
COOEt
3ha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COOEt
COOEt
3ha
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -120 -140 -160 -180 -200
f1 (ppm)


7.6377
7.6253
7.5453
7.5429
7.5327
7.5007
7.4882
7.4615
7.4493
7.4377
7.4271
7.4026
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7.3726
7.3621
7.3500
7.3443
7.3320
7.3125
7.3002
5.6944
5.6904
4.2390
4.2331
4.2212
4.2093
4.2040
4.1975
4.1915
4.0762
4.0703
4.0642
4.0585
4.0468
4.0366
4.0249
4.0188
3.8237
3.8189
3.8131
3.0974
3.0872
3.0742
3.0639
2.7826
2.7717
2.7619
2.7510
2.1530
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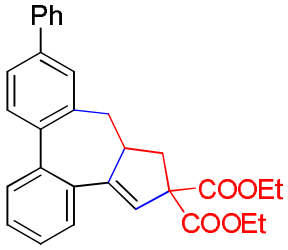
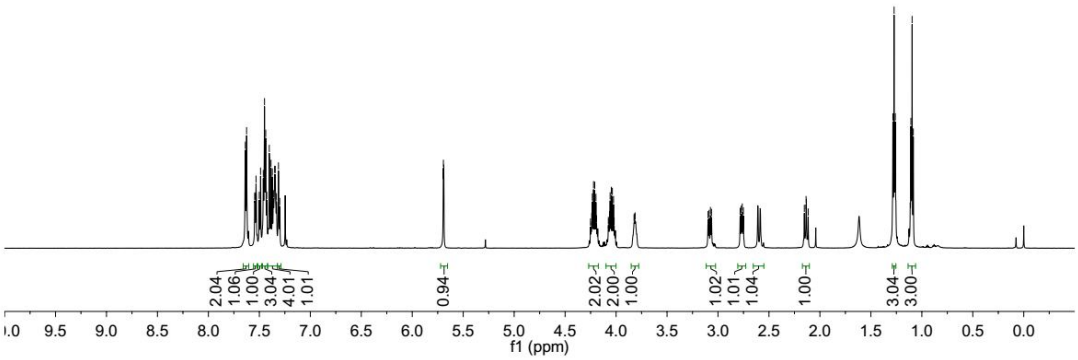
1.2722
1.2603
1.1073
1.0954
1.0836


Ph
COOEt
COOEt

3ia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1.06
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3.04
4.01
1.01
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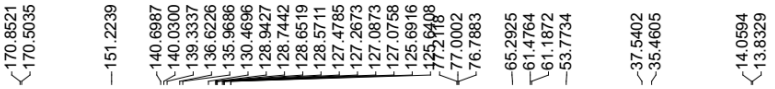
2.02
2.00
1.00
1.02
1.01
1.04
1.00
3.04
3.00
f1 (ppm)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140.6987
140.0300
139.3337
136.6226
135.9686
130.4696
128.9427
128.7442
128.6519
128.5711
127.4785
127.2673
127.0873
127.0758
125.6916
77.3180
77.0002
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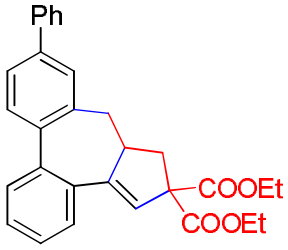
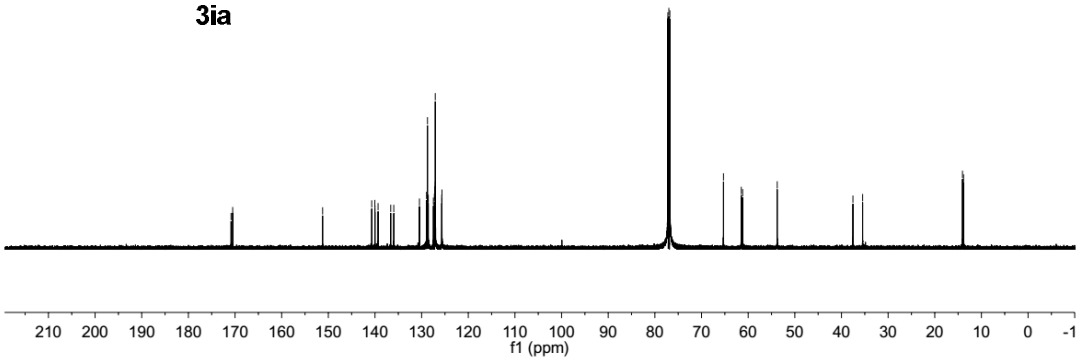
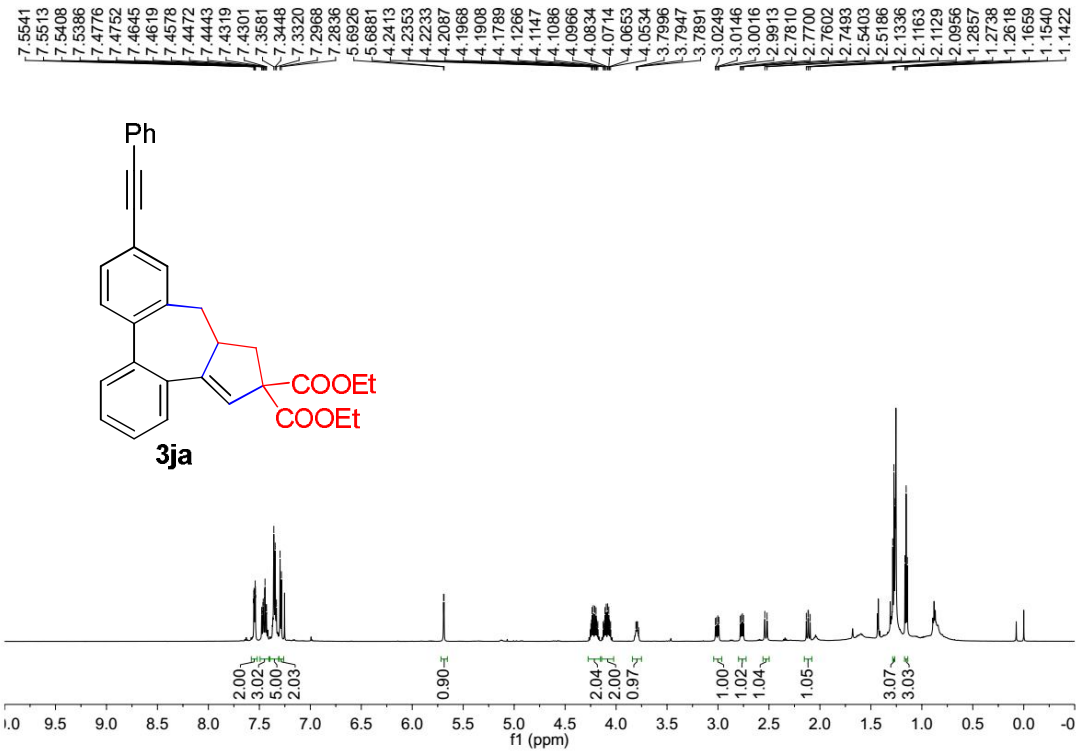
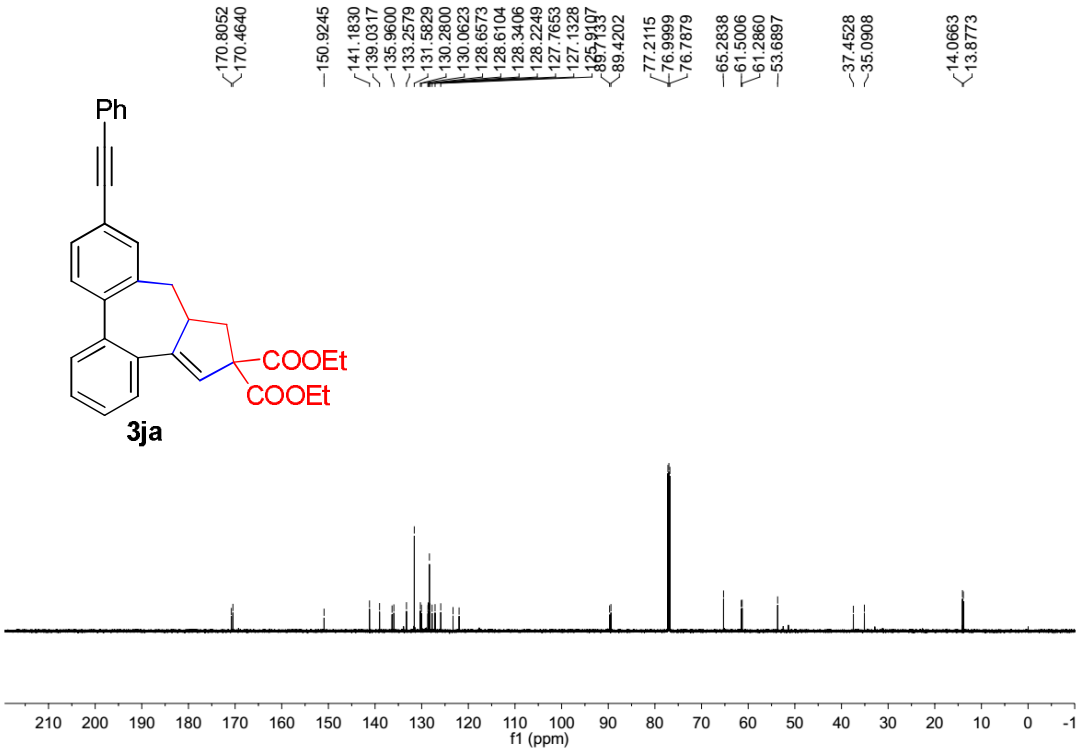
65.2925
61.4764
61.1872
53.7734
37.5402
35.4605
14.0594
13.8329


Ph
COOEt
COOEt

3ia


f1 (ppm)


Ph
COOEt
COOEt
3ja
f1 (ppm)


Ph
COOEt
COOEt
3ja
f1 (ppm)


7.5379
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7.4522
7.4496
7.4291
7.4269
7.3809
7.3684
7.3553
7.3344
7.3324
7.3145
7.3122
7.3082
7.3013
7.2997
7.2949
7.1343
7.1227
5.6889
5.6844
4.2341
4.2223
4.2105
4.1986
4.0740
4.0621
4.0565
4.0446
3.8084
3.8026
3.7977
3.7919
3.0604
3.0501
3.0371
3.0268
2.7864
2.7755
2.7656
2.7547
2.5689
2.5668
2.5455
2.5433
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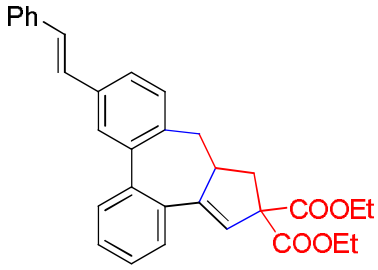
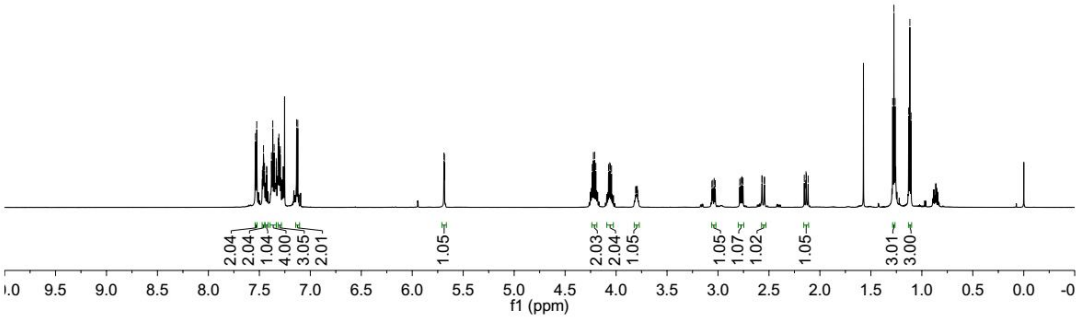
1.1175
1.1056


Ph
COOEt
COOEt

3ka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1.04
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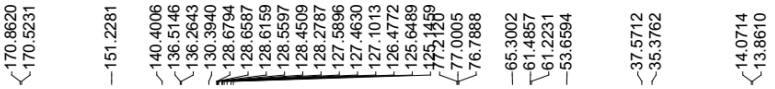
3.05
2.01
1.05
2.03
2.04
1.05
1.05
1.07
1.02
1.05
3.01
3.00
f1 (ppm)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127.5896
127.4630
127.1013
126.4772
125.6489
77.2120
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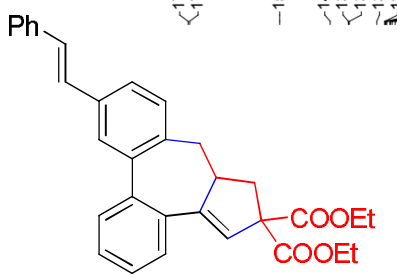
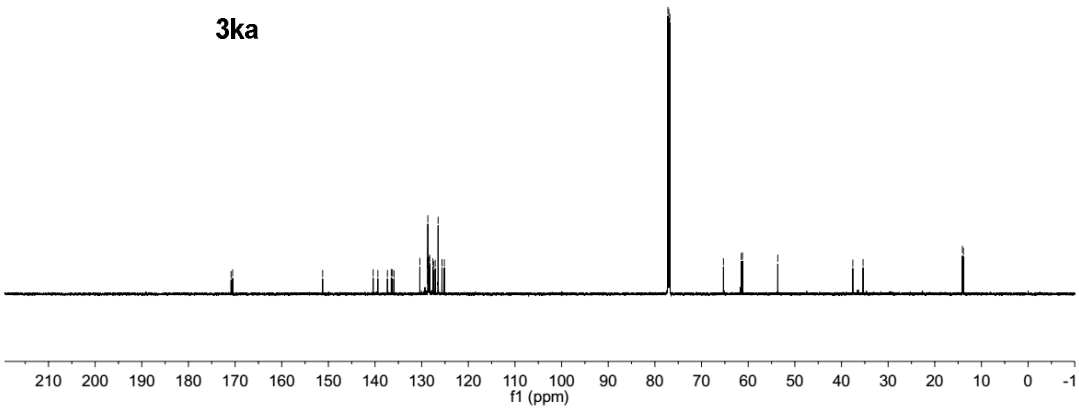
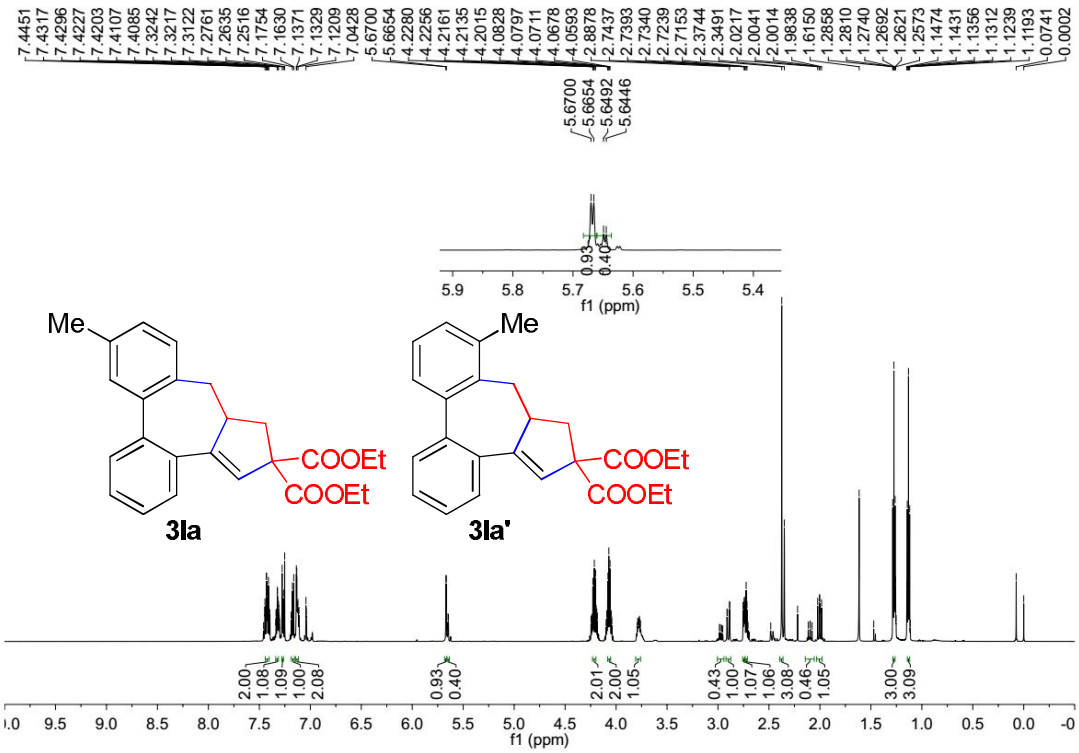
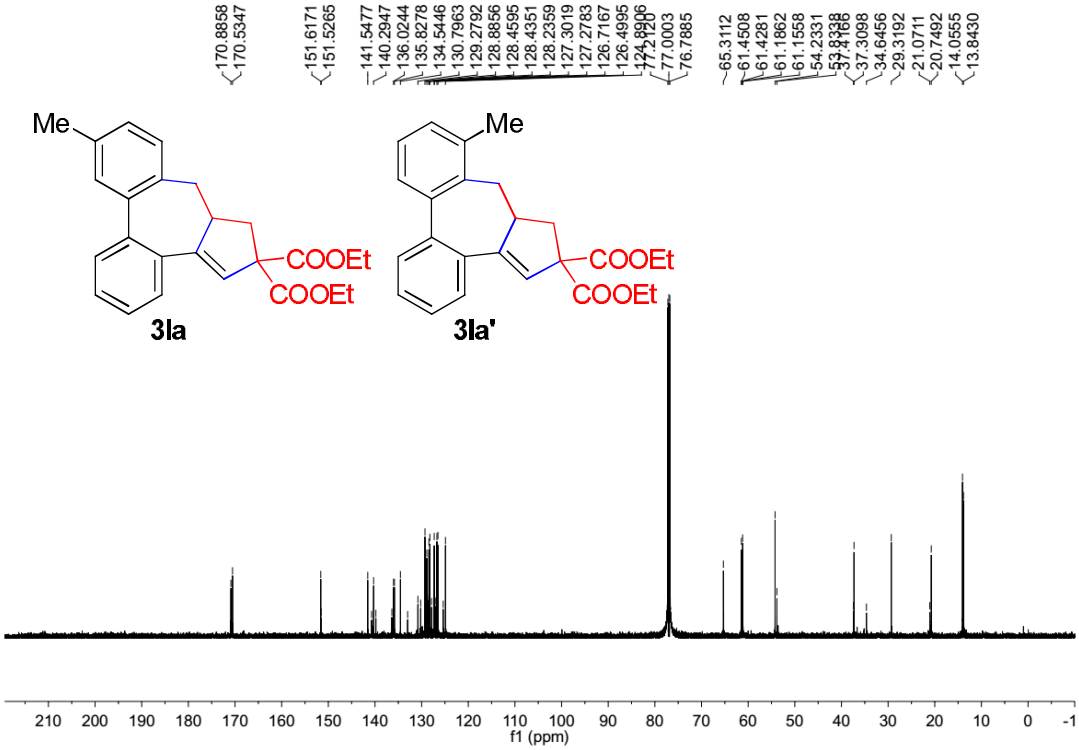
76.7888
65.3002
61.4857
61.2231
53.6594
37.5712
35.3762
14.0714
13.8610


Ph
COOEt
COOEt

3ka


f1 (ppm)


Me
COOEt
COOEt
3la
Me
COOEt
COOEt
3la'
f1 (ppm)


Me
COOEt
COOEt
3la
Me
COOEt
COOEt
3la'
f1 (ppm)


8.1164
8.1022
7.8407
7.8274
7.7926
7.7786
7.5557
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7.5345
7.5324
7.5205
7.5185
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7.4628
7.4491
7.3775
7.3758
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7.3635
7.3529
7.3513
7.3373
7.3353
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7.3231
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4.2150
4.2034
4.1916
3.9107
3.8988
3.8782
3.8663
3.5138
3.5111
3.4897
3.4871
3.0242
3.0151
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2.9908
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2.8367
2.8268
2.8160
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1.2513
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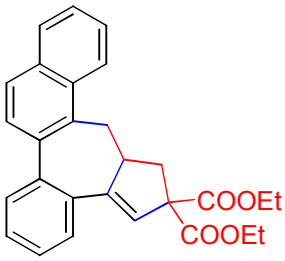
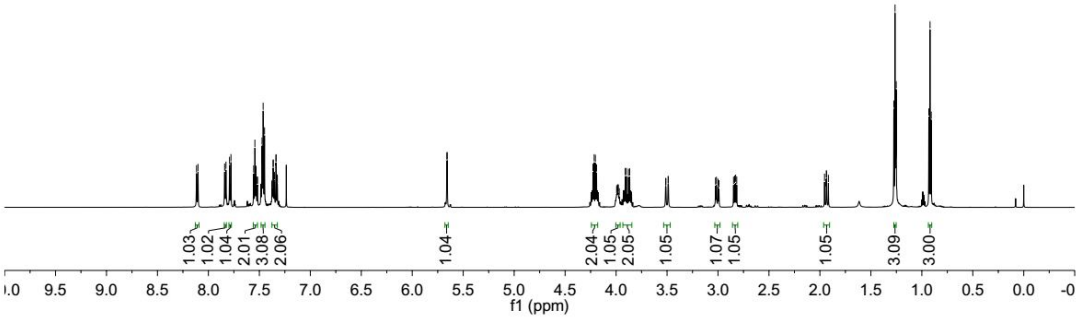
0.9077


COOEt
COOEt

3ma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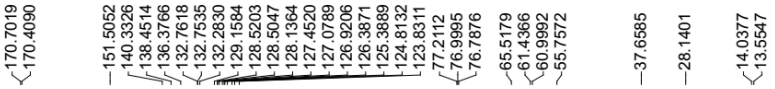
1.02
1.04
2.01
3.08
2.06
1.04
2.04
1.05
2.05
1.05
1.07
1.05
1.05
3.09
3.00
f1 (ppm)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129.1584
128.5203
128.5047
128.1364
127.4520
127.0789
126.9206
126.3871
125.3889
124.8132
123.8311
77.2112
76.9995
76.7876
65.5179
61.4366
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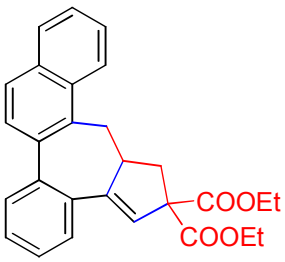
55.7572
37.6585
28.1401
14.0377
13.5547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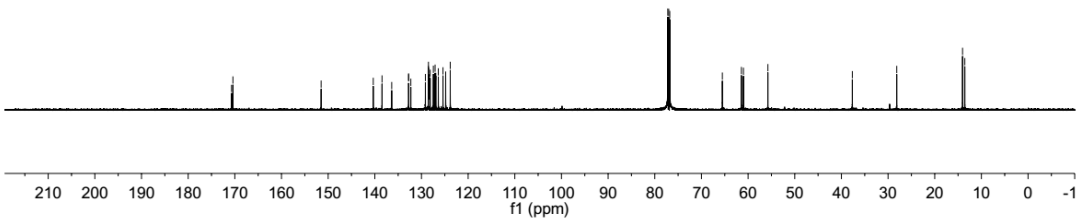
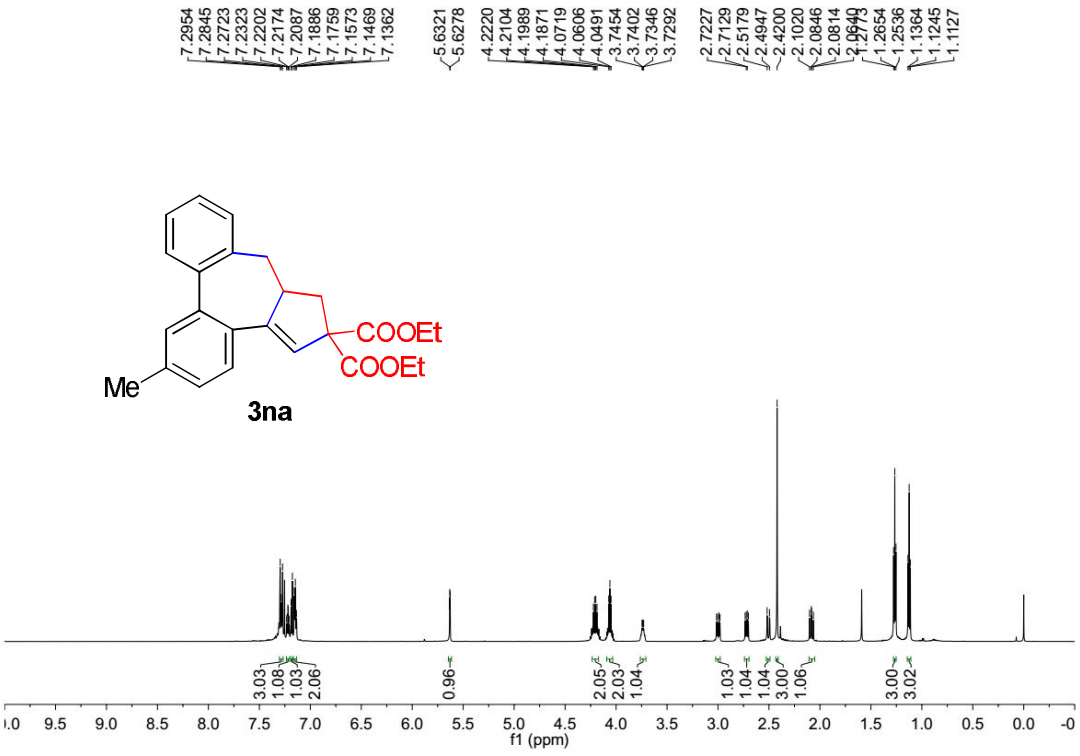
COOEt

3ma


f1 (ppm)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7.2087
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7.1759
7.1573
7.1469
7.1362
5.6321
5.6278
4.2220
4.2104
4.1989
4.1871
4.0719
4.0606
4.0491
3.7454
3.7402
3.7346
3.7292
2.7227
2.7129
2.5179
2.4947
2.4200
2.1020
2.0846
2.0814
1.2773
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1.2536
1.1364
1.1245
1.1127
COOEt
COOEt
Me
3.03
1.08
1.03
2.06
0.96
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2.03
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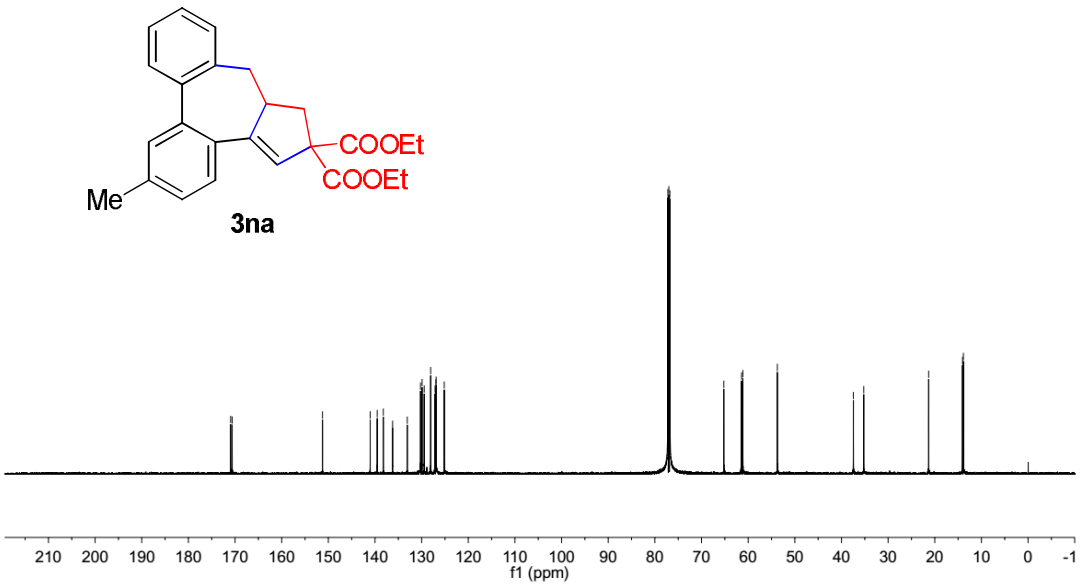
1.03
1.04
1.04
3.00
1.06
3.00
3.02
f1 (ppm)

3na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129.4452
128.0668
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125.1547
77.2118
77.0001
76.7884
65.2189
61.4212
61.1436
53.7491
37.4457
35.2247
21.3119
14.0574
13.8648
COOEt
COOEt
Me
f1 (ppm)

3na


7.4443
7.4408
7.3069
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7.2972
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7.2754
7.2724
7.2691
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7.1609
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5.6568
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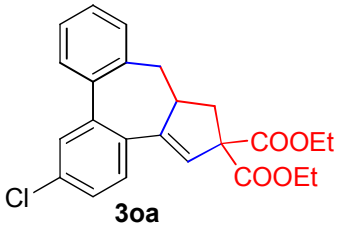
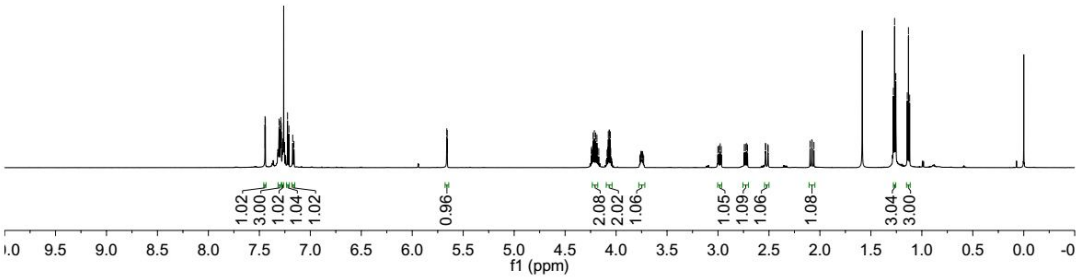
1.1195


COOEt
COOEt
Cl

3oa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2.08
2.02
1.06
1.05
1.09
1.06
1.08
3.04
3.00
f1 (ppm)


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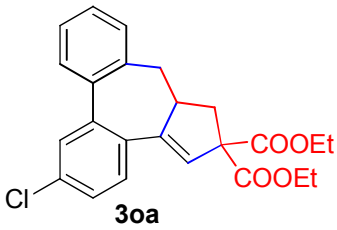
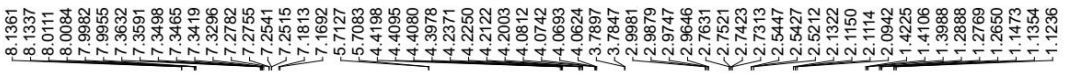
13.8707


COOEt
COOEt
Cl

3oa

f1 (ppm)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7.3296
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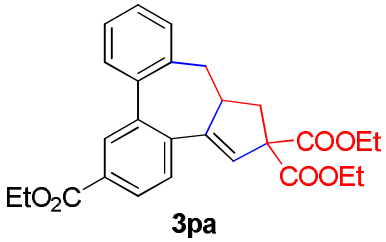
1.1236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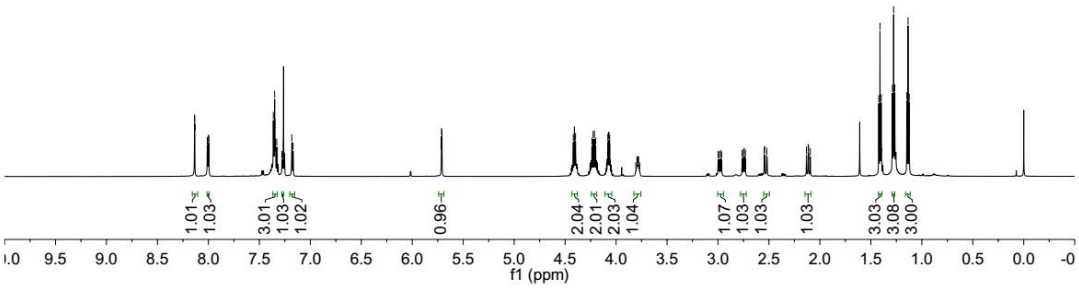
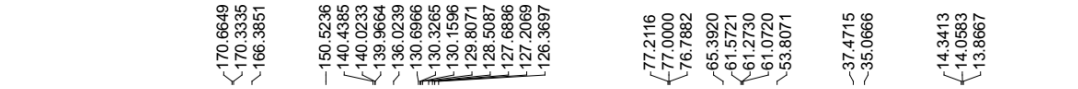
COOEt
EtO2C

3pa


1.01
1.03
3.01
1.03
1.02
0.96
2.04
2.01
2.03
1.04
1.07
1.03
1.03
1.03
3.03
3.08
3.00
f1 (ppm)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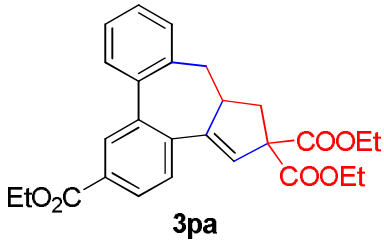
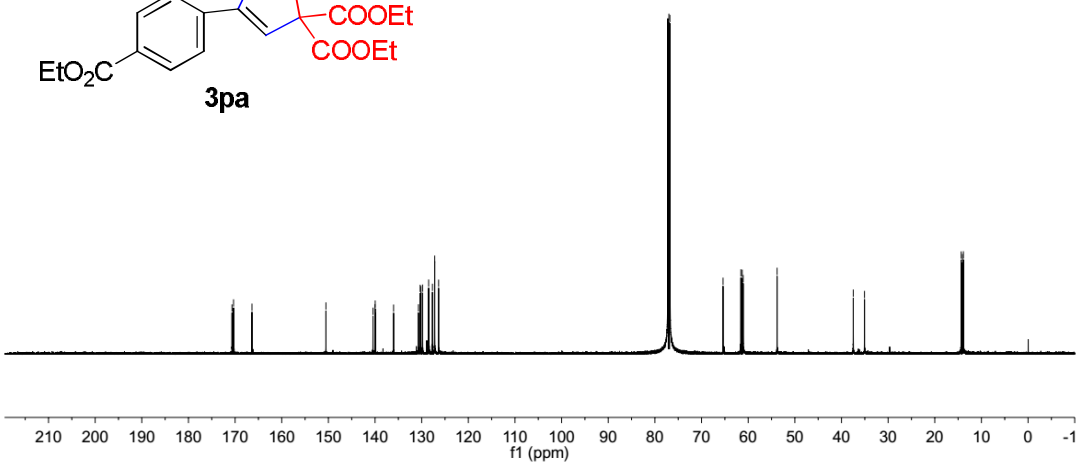
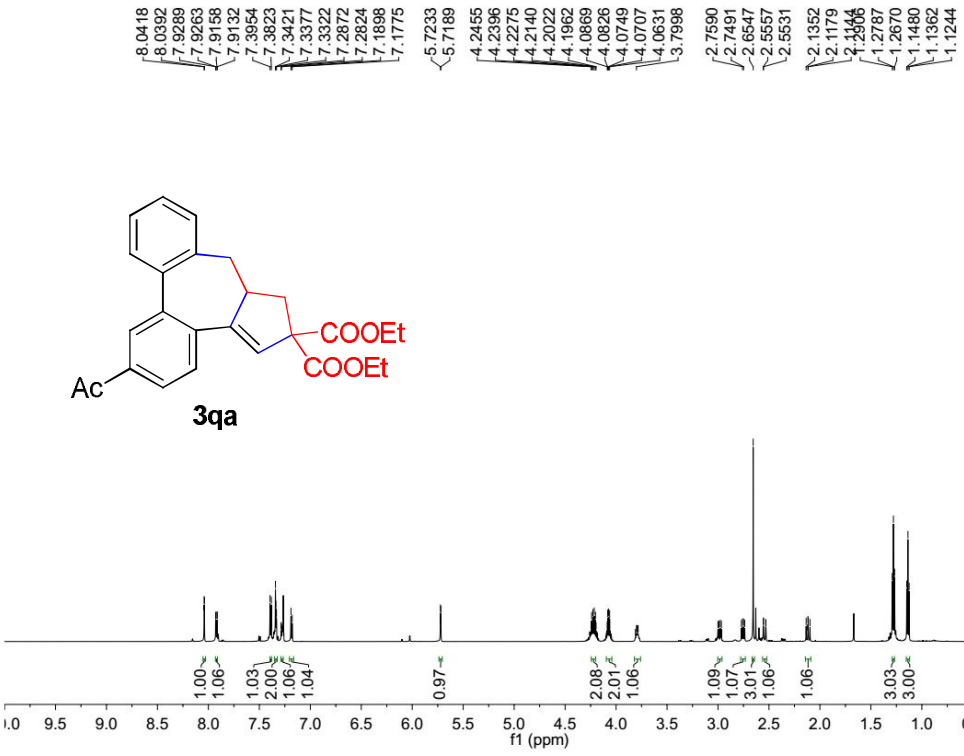
166.3851
150.5236
140.4385
140.0233
139.9664
136.0239
130.6966
130.3265
130.1596
129.8071
128.5087
127.6886
127.2069
126.3697
77.2116
77.0000
76.7882
65.3920
61.5721
61.2730
61.0720
53.8071
37.4715
35.0666
14.3413
14.0583
13.8667


COOEt
COOEt
EtO2C

3pa


f1 (ppm)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8.0392
7.9289
7.9263
7.9158
7.9132
7.3954
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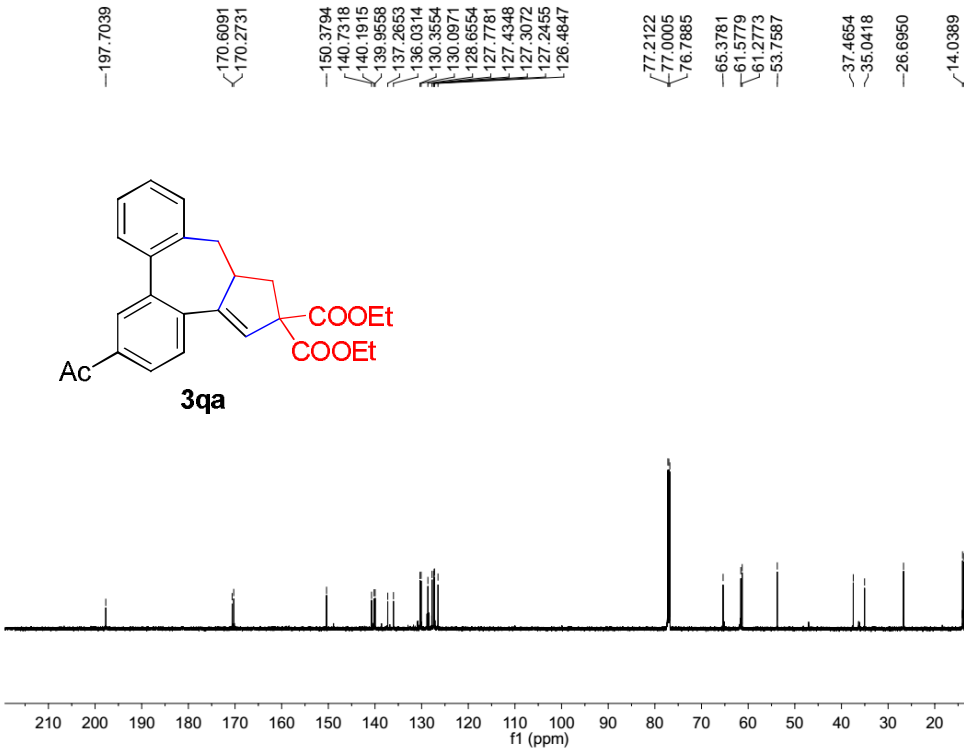
7.3421
7.3377
7.3322
7.2872
7.2824
7.1898
7.1775
5.7233
5.7189
4.2455
4.2396
4.2275
4.2140
4.2022
4.1962
4.0869
4.0826
4.0749
4.0707
4.0631
3.7998
2.7590
2.7491
2.6547
2.5557
2.5531
2.1352
2.1179
2.1144
2.0906
1.2787
1.2670
1.1480
1.1362
1.1244
COOEt
COOEt
Ac
3qa
1.00
1.06
1.03
2.00
1.06
1.04
0.97
2.08
2.01
1.06
1.09
1.07
3.01
1.06
1.06
3.03
3.00
f1 (ppm)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136.0314
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128.6554
127.7781
127.4348
127.3072
127.2455
126.4847
77.2122
77.0005
76.7885
65.3781
61.5779
61.2773
53.7587
37.4654
35.0418
26.6950
14.0389
13.8462
COOEt
COOEt
Ac
3qa
f1 (ppm)


7.6064
7.6050
7.5934
7.5920
7.5389
7.5369
7.5260
7.5240
7.3172
7.3149
7.3046
7.3026
7.2919
7.2896
7.2348
7.2329
7.2222
7.2205
7.2097
7.2079
7.1627
7.1542
6.8648
6.8563
5.9835
5.9801
4.2281
4.2161
4.2040
4.1918
4.1865
4.1797
4.1752
4.1678
4.1634
3.5115
3.0285
3.0208
3.0033
2.9956
2.8386
2.8264
2.8171
2.8049
2.7614
2.7490
2.7362
2.7238
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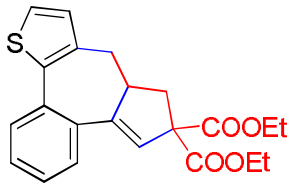
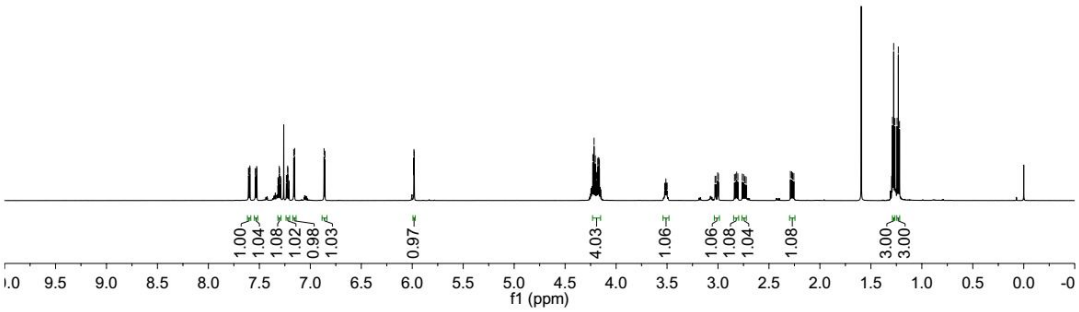
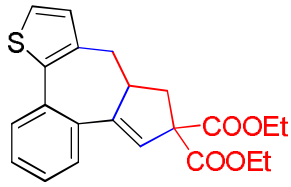
1.2880
1.2762
1.2643
1.2426
1.2307
1.2189


S
COOEt
COOEt

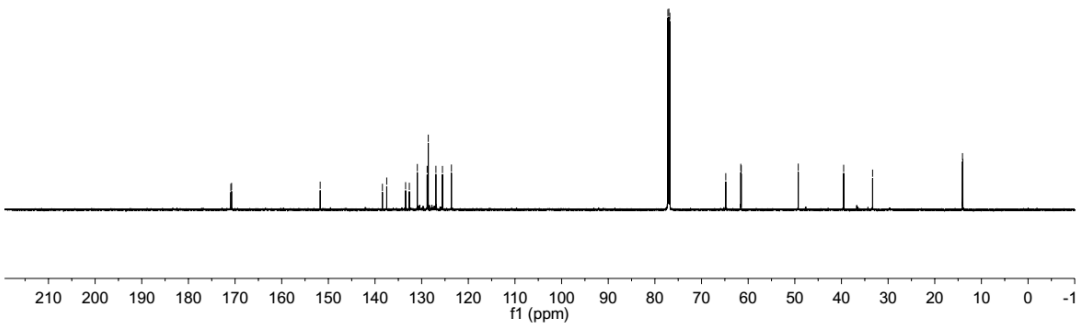
3ra


1.00
1.04
1.08
1.02
0.98
1.03
0.97
4.03
1.06
1.06
1.08
1.04
1.08
3.00
3.00
f1 (ppm)


170.9040
170.7431
151.7483
138.4066
137.4886
133.4408
132.6398
130.9212
128.8201
128.5769
126.9435
125.5401
123.6146
77.2118
77.0002
76.7885
64.8020
61.5842
61.4788
49.2614
39.5298
33.3327
14.0589
13.9828


S
COOEt
COOEt

3ra


f1 (ppm)


7.8485
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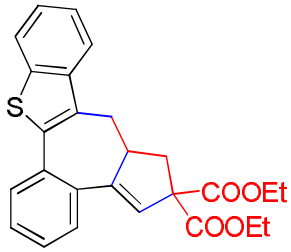
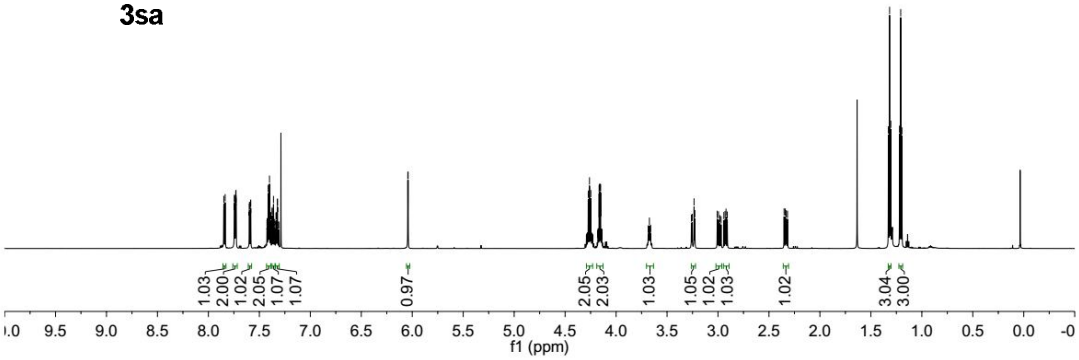
7.7419
7.7402
7.7320
7.7291
7.7273
7.5990
7.5970
7.5862
7.5842
7.4237
7.4133
7.4029
7.4005
7.3902
7.3880
7.3748
7.3730
7.3615
7.3498
7.3362
7.3343
7.3236
7.3218
6.0436
6.0402
4.2729
4.2607
4.2479
4.1665
4.1635
4.1546
4.1517
3.6730
3.2608
3.2527
3.2349
3.2270
3.0074
2.9953
2.9816
2.9695
2.9425
2.9302
2.9210
2.9088
2.3514
2.3395
2.3299
2.3180
1.3282
1.3163
1.3044
1.2191
1.2073
1.1954


S
COOEt
COOEt

3sa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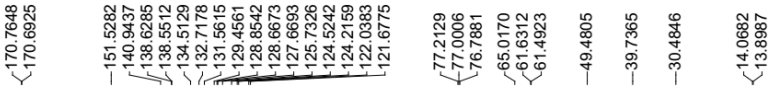
2.00
1.02
2.05
1.07
1.07
0.97
2.05
2.03
1.03
1.05
1.02
1.03
1.02
3.04
3.00
f1 (ppm)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138.6285
138.5512
134.5129
132.7178
131.5615
129.4561
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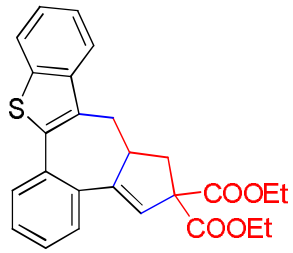
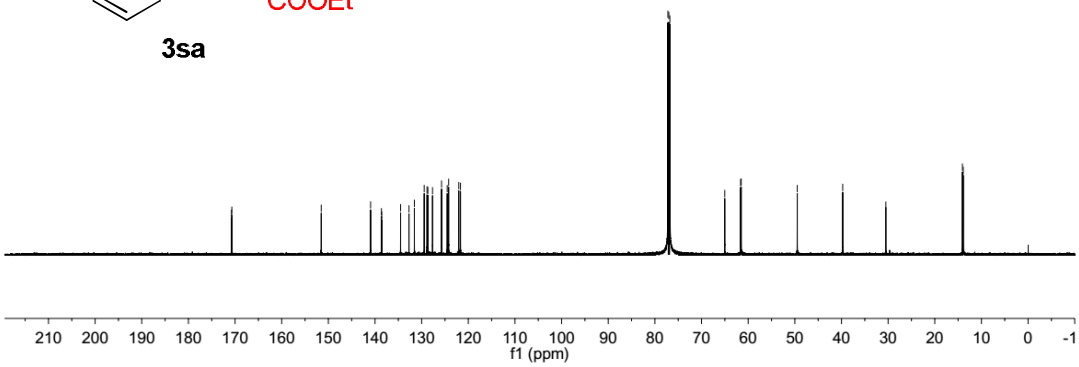
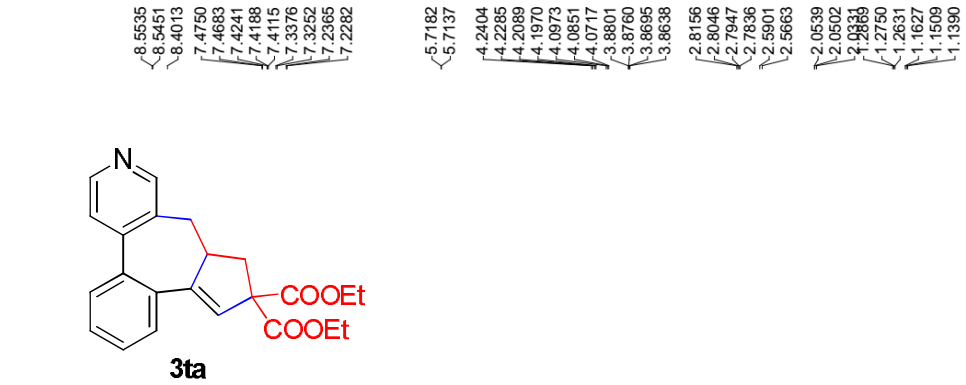
128.6673
127.6693
125.7326
124.5242
124.2159
122.0383
121.6775
77.2129
77.0006
76.7881
65.0170
61.6312
61.4923
49.4805
39.7365
30.4846
14.0682
13.8987


S
COOEt
COOEt

3sa


f1 (ppm)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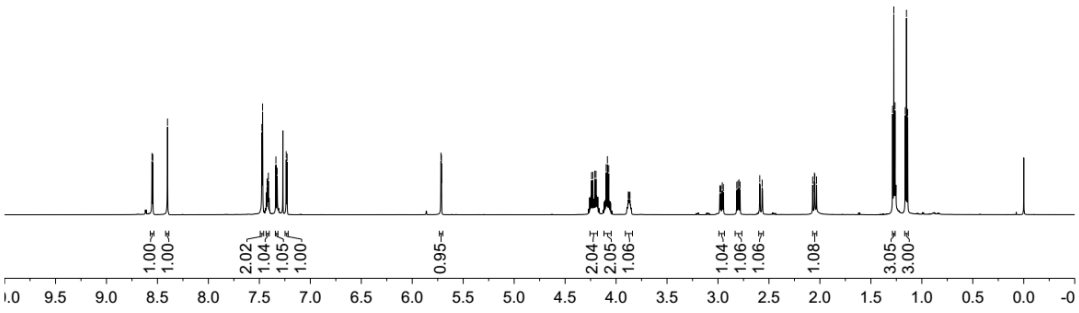
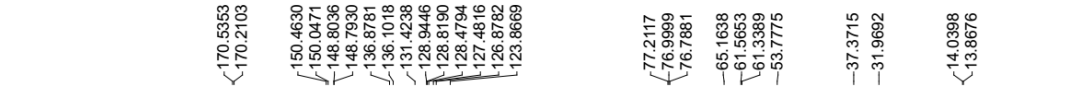
8.4013
7.4750
7.4683
7.4241
7.4188
7.4115
7.3376
7.3252
7.2365
7.2282
5.7182
5.7137
4.2404
4.2285
4.2089
4.1970
4.0973
4.0851
4.0717
3.8801
3.8760
3.8695
3.8638
2.8156
2.8046
2.7947
2.7836
2.5901
2.5663
2.0539
2.0502
1.2750
1.2631
1.1627
1.1509
1.1390

N
COOEt
COOEt

3ta


1.00
1.00
2.02
1.04
1.05
1.00
0.95
2.04
2.05
1.06
1.04
1.06
1.06
1.08
3.05
3.00
1.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0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150.4630
150.0471
148.8036
148.7930
136.8781
136.1018
131.4238
128.9446
128.8190
128.4794
127.4816
126.8782
123.8669
77.2117
76.9999
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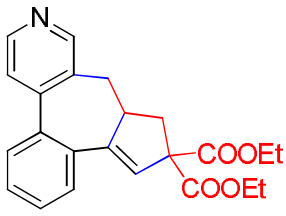
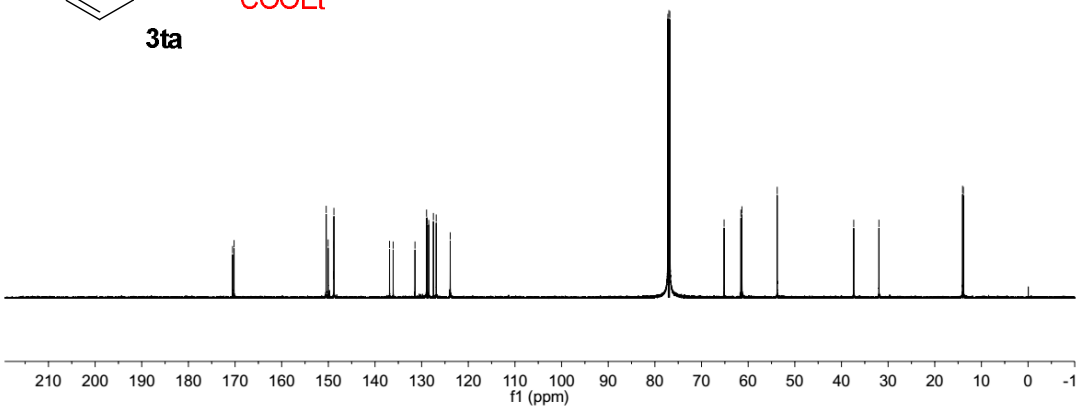
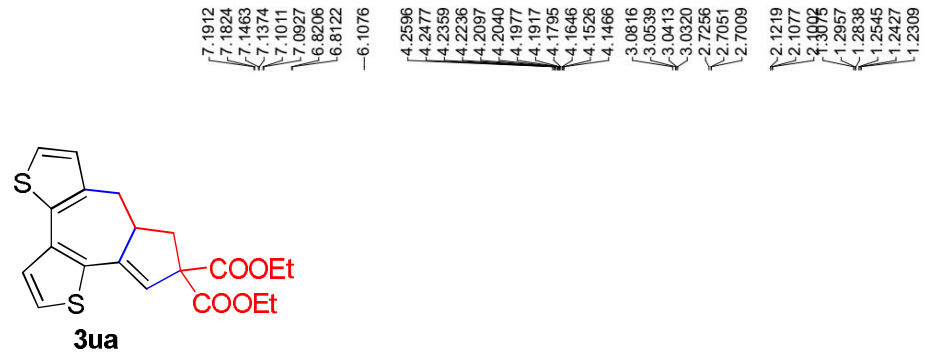
65.1638
61.5653
61.3389
53.7775
37.3715
31.9692
14.0398
13.8676


N
COOEt
COOEt

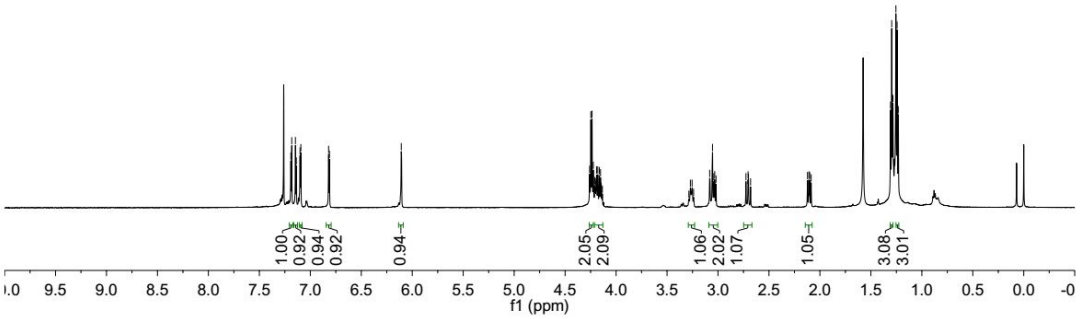
3ta


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)


7.1912
7.1824
7.1463
7.1374
7.1011
7.0927
6.8206
6.8122
6.1076
4.2596
4.2477
4.2359
4.2236
4.2097
4.2040
4.1977
4.1917
4.1795
4.1646
4.1526
4.1466
3.0816
3.0539
3.0413
3.0320
2.7256
2.7051
2.7009
2.1219
2.1077
1.2957
1.2838
1.2545
1.2427
1.2309

S
S
COOEt
COOEt

3ua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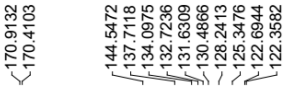
0.92
0.94
0.92
0.94
2.05
2.09
1.06
2.02
1.07
1.05
3.08
3.01
f1 (ppm)


170.9132
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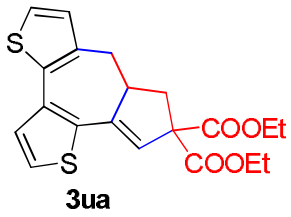
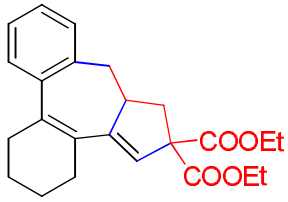
144.5472
137.7118
134.0975
132.7236
131.6309
130.4866
128.2413
125.3476
122.6944
122.3582
77.2117
76.9998
76.7881
64.7302
61.6884
61.6201
44.4685
40.3045
34.9427
14.0704
14.0344

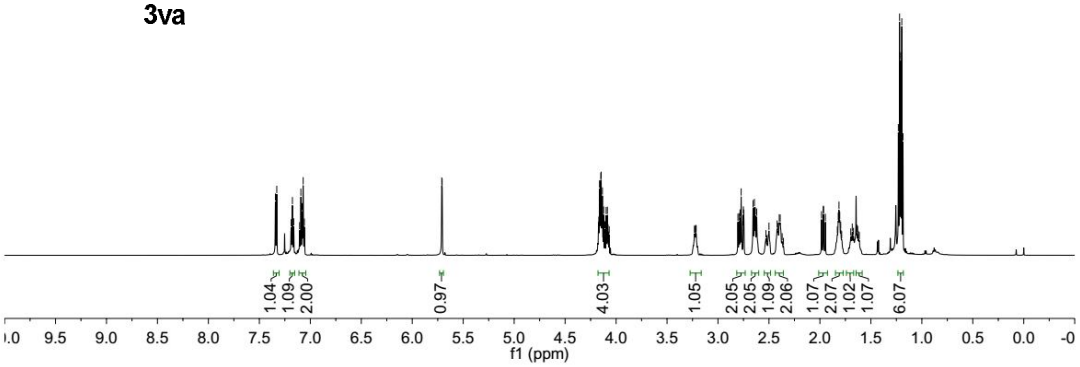

S
S
COOEt
COOEt

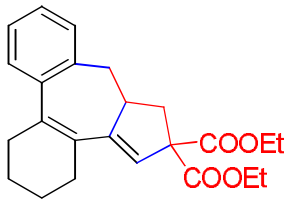
3ua

f1 (ppm)

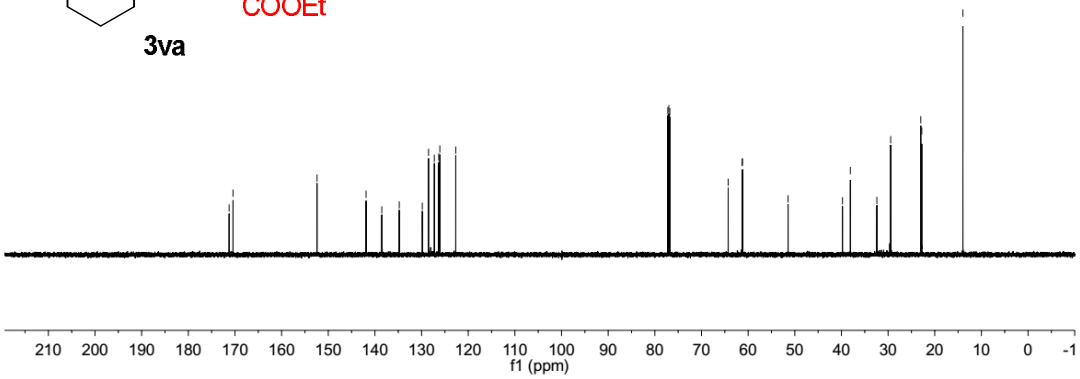

COOEt
COOEt

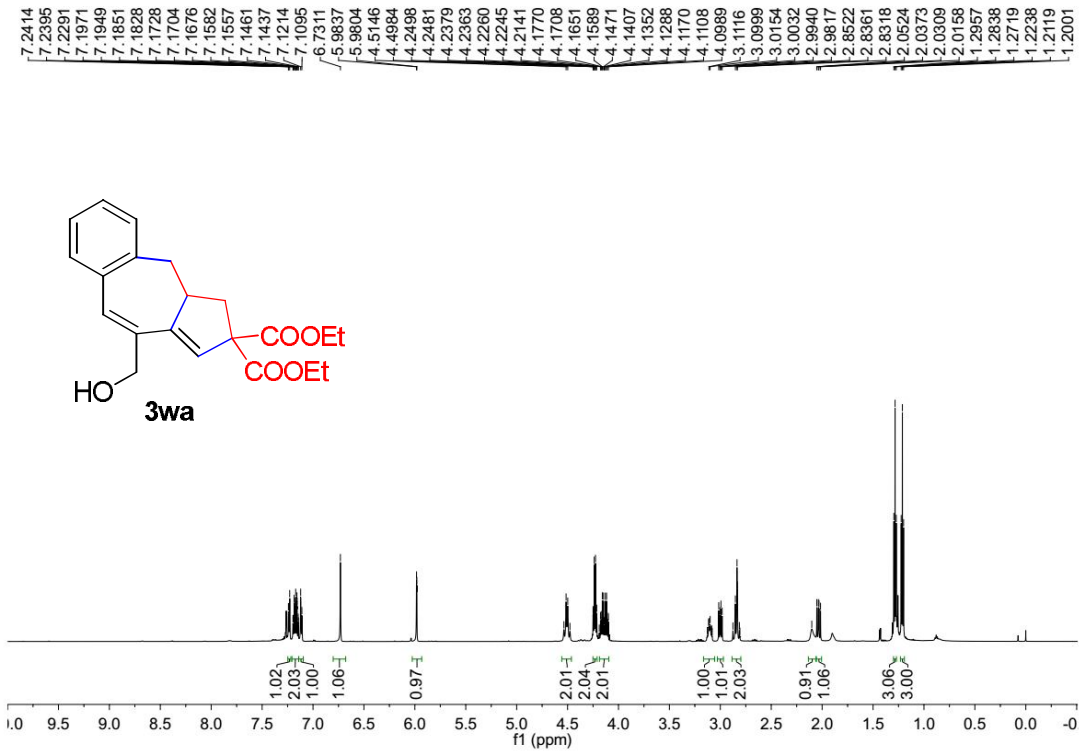
3va


1.04
1.09
2.00
0.97
4.03
1.05
2.05
2.05
1.09
2.06
1.07
2.07
1.02
1.07
6.07
f1 (ppm)


COOEt
COOEt

3va


f1 (ppm)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7.2291
7.1971
7.1949
7.1851
7.1828
7.1728
7.1704
7.1676
7.1582
7.1557
7.1461
7.1437
7.1214
7.1095
6.7311
5.9837
5.9804
4.5146
4.4984
4.2498
4.2481
4.2379
4.2363
4.2260
4.2245
4.2141
4.1770
4.1708
4.1651
4.1589
4.1471
4.1407
4.1352
4.1288
4.1170
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4.0989
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3.0999
3.0154
3.0032
2.9940
2.9817
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2.0524
2.0373
2.0309
2.0158
1.2957
1.2838
1.2719
1.2238
1.2119
1.2001
COOEt
COOEt
HO
3wa
1.02
2.03
1.00
1.06
0.97
2.01
2.04
2.01
1.00
1.01
2.03
0.91
1.06
3.06
3.00
f1 (ppm)
171.0102
170.3411
147.8014
139.4561
135.1716
133.2355
132.3926
130.9194
129.1707
127.8290
126.4320
124.0216
77.2117
76.9997
76.7880
66.1315
64.7483
61.5972
61.5651
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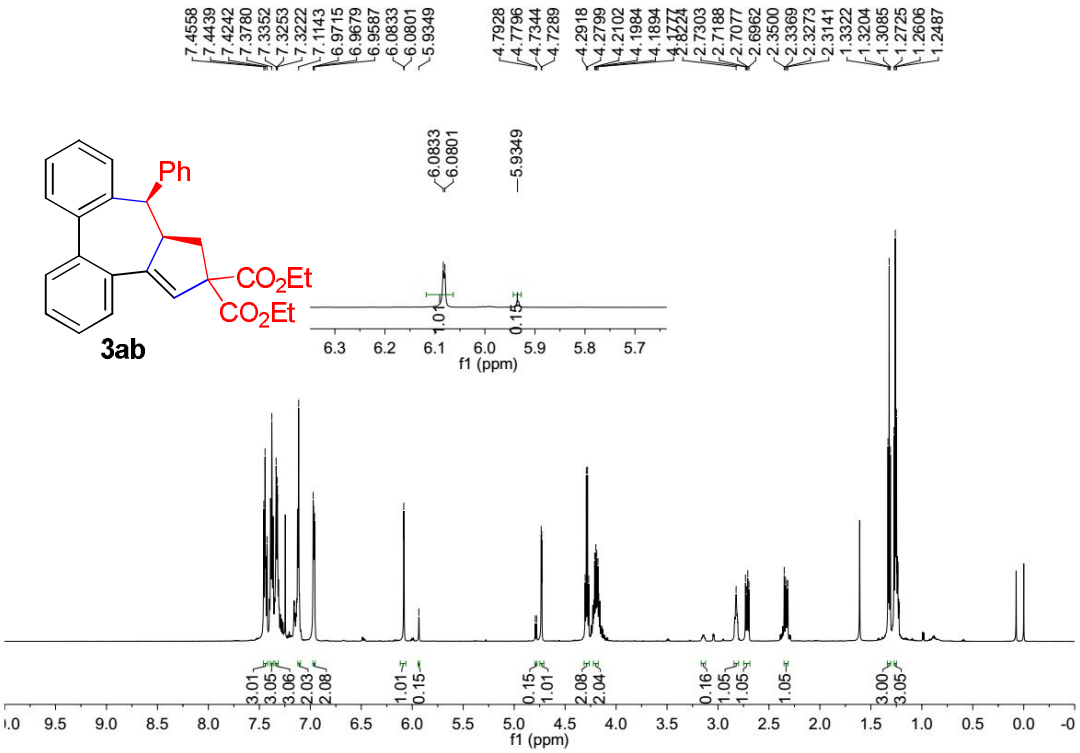
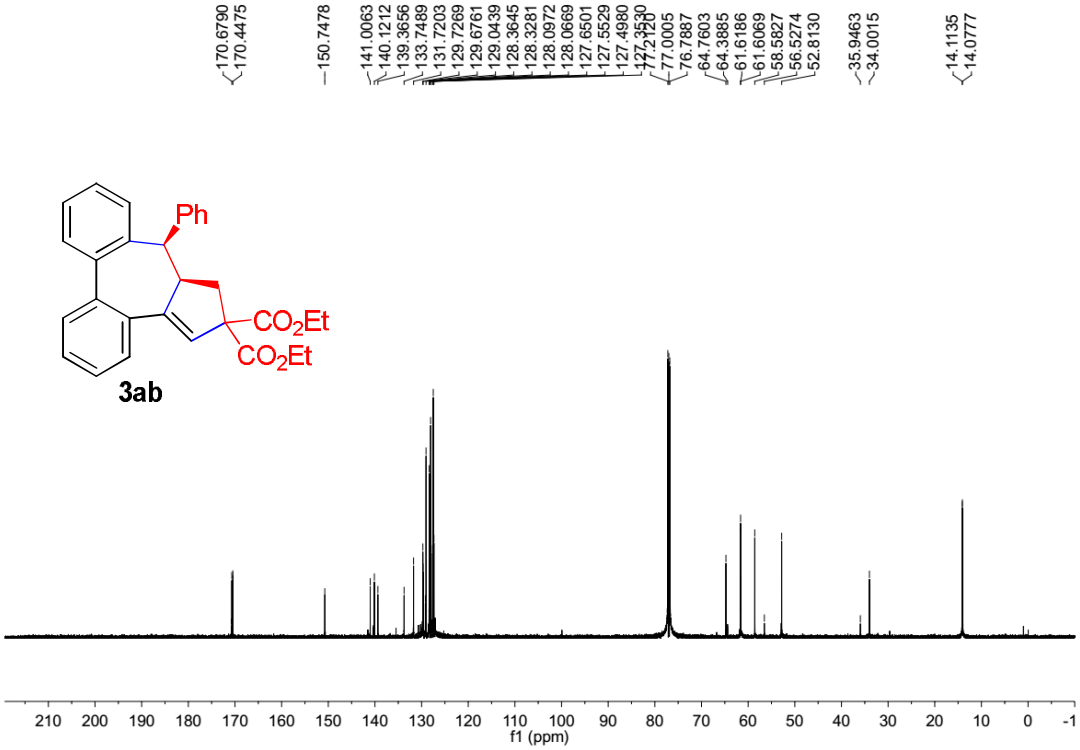
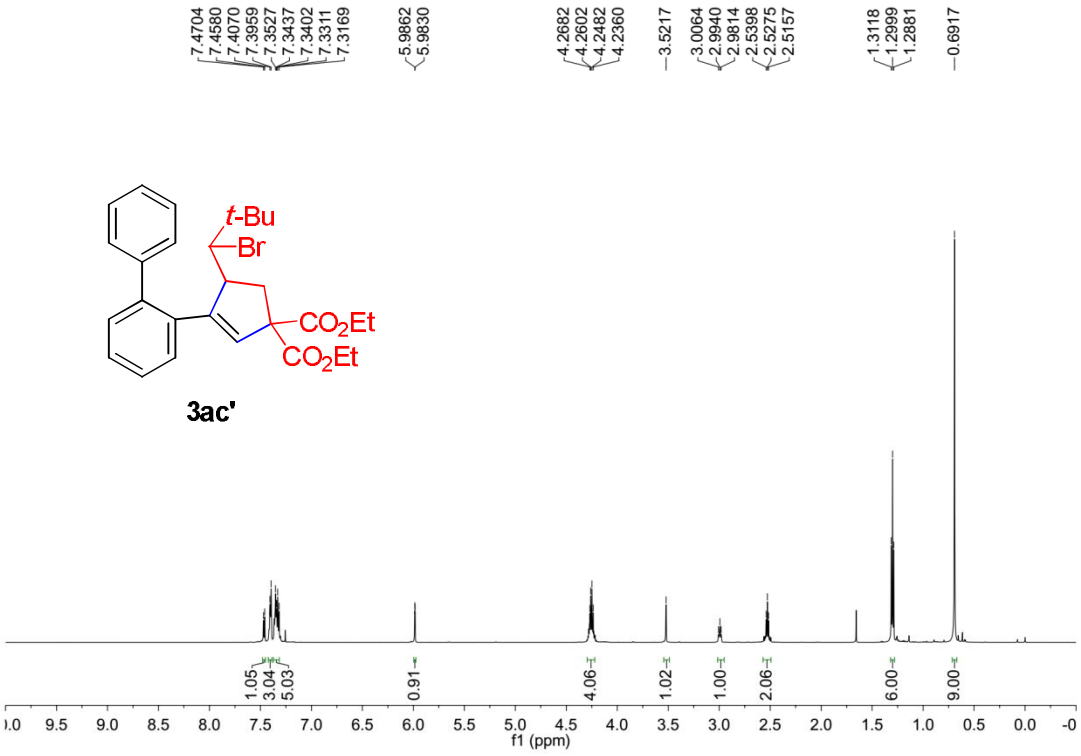
41.0157
40.5967
14.0145
13.9588
COOEt
COOEt
HO
3wa
f1 (ppm)


Ph
CO2Et
CO2Et
3ab
f1 (ppm)


Ph
CO2Et
CO2Et
3ab
f1 (ppm)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5.9830
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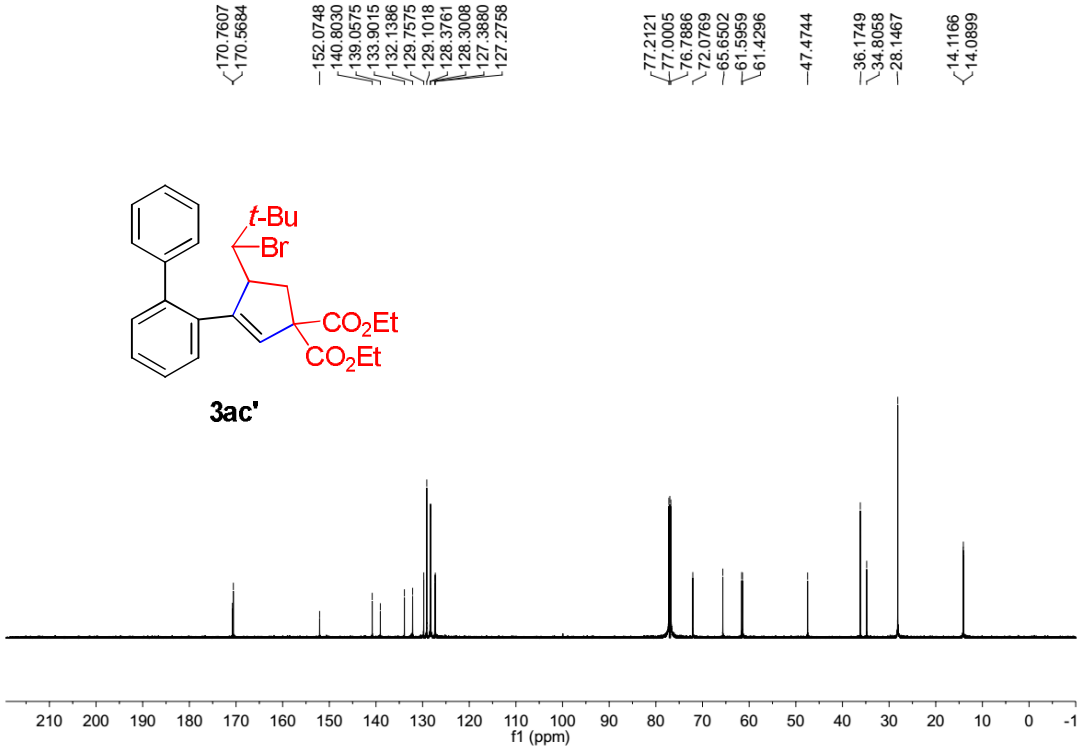
4.2602
4.2482
4.2360
3.5217
3.0064
2.9940
2.9814
2.5398
2.5275
2.5157
1.3118
1.2999
1.2881
0.6917
t-Bu
Br
CO2Et
CO2Et
3ac'
1.05
3.04
5.03
0.91
4.06
1.02
1.00
2.06
6.00
9.00
f1 (ppm)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127.3880
127.2758
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77.0005
76.7886
72.0769
65.6502
61.5959
61.4296
47.4744
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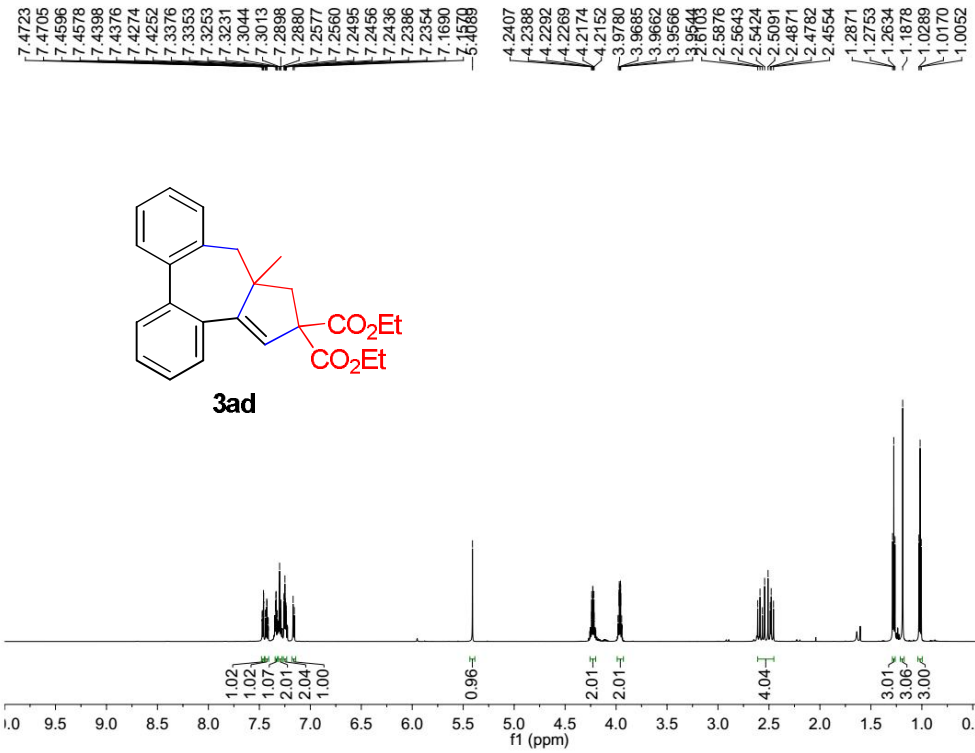
14.0899
t-Bu
Br
CO2Et
CO2Et
3ac'
f1 (ppm)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7.3231
7.3044
7.3013
7.2898
7.2880
7.2577
7.2560
7.2495
7.2456
7.2436
7.2386
7.2354
7.1690
5.4089
4.2407
4.2388
4.2292
4.2269
4.2174
4.2152
3.9780
3.9685
3.9662
3.9566
3.9544
2.5876
2.5643
2.5424
2.5091
2.4871
2.4782
2.4554
1.2871
1.2753
1.2634
1.1878
1.0289
1.0170
1.0052
CO2Et
CO2Et
3ad
1.02
1.02
1.07
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1.00
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2.01
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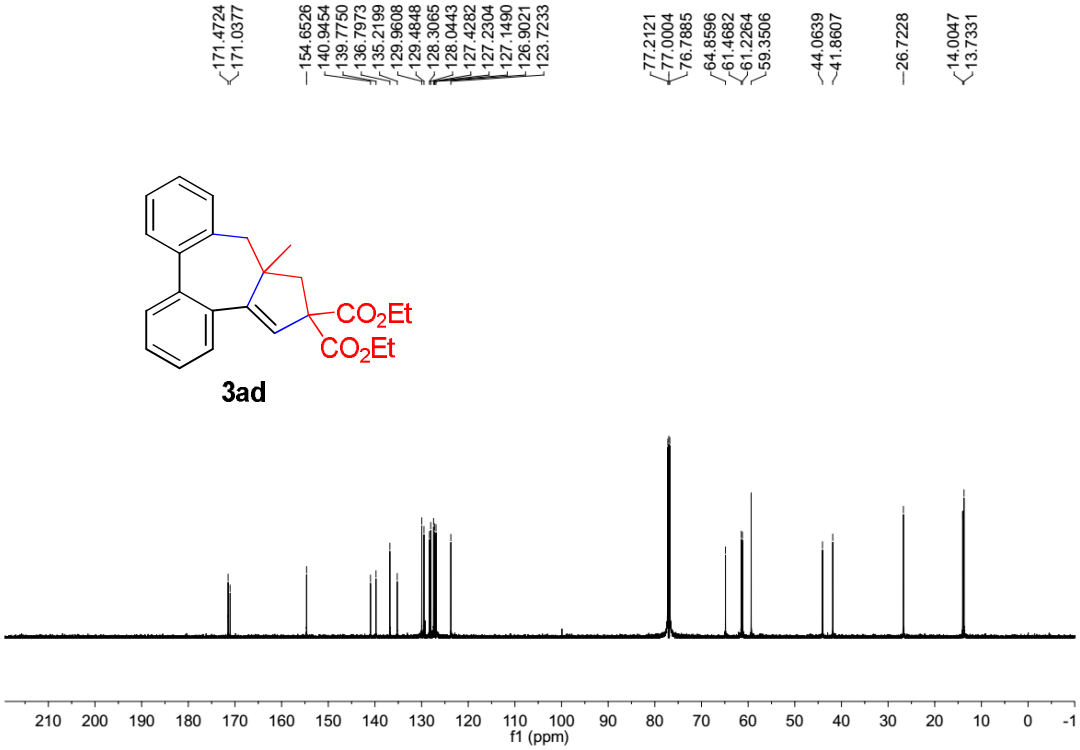
3.01
3.06
3.00
f1 (ppm)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127.4282
127.2304
127.1490
126.9021
123.7233
77.2121
77.0004
76.7885
64.8596
61.4682
61.2264
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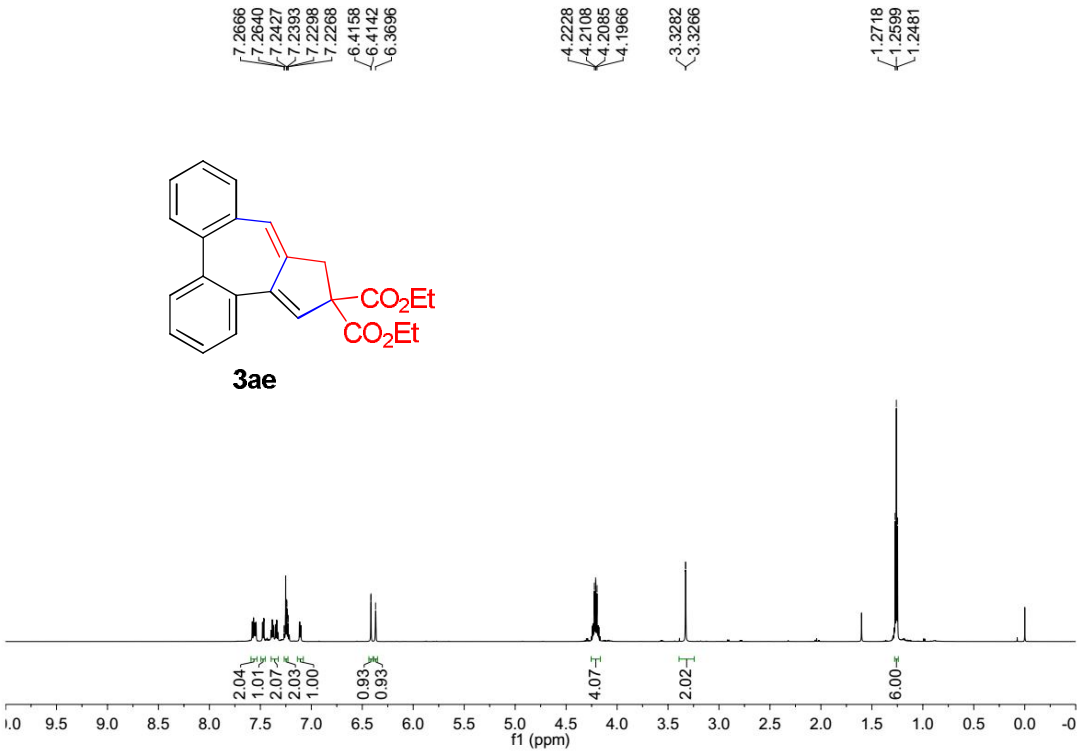
41.8607
26.7228
14.0047
13.7331
CO2Et
CO2Et
3ad
f1 (ppm)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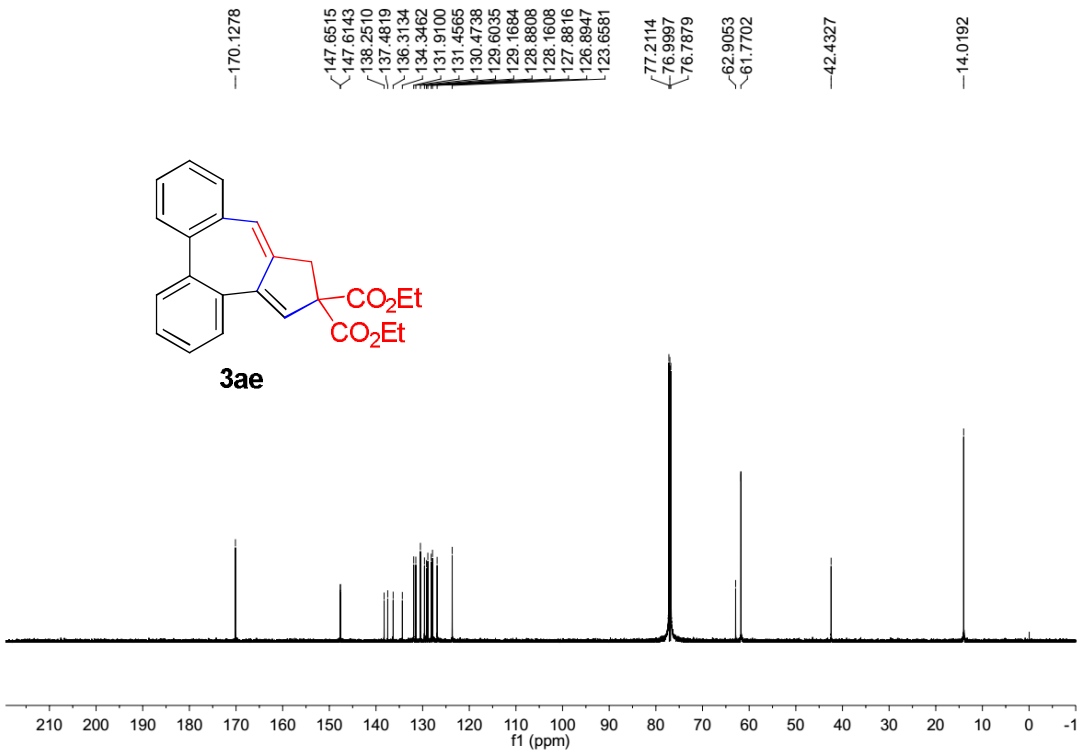
4.2085
4.1966
3.3282
3.3266
1.2718
1.2599
1.2481
CO2Et
CO2Et
3ae
2.04
1.01
2.07
2.03
1.00
0.93
0.93
4.07
2.02
6.00
f1 (ppm)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136.3134
134.3462
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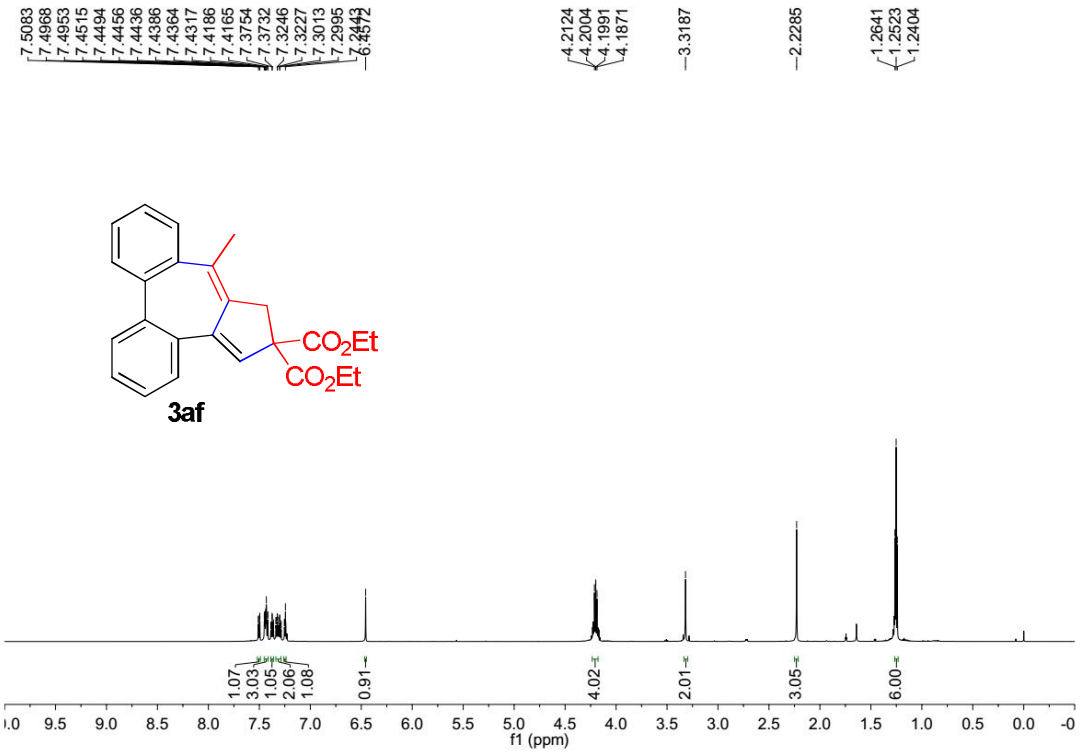
130.4738
129.6035
129.1684
128.8808
128.1608
127.8816
126.8947
123.6581
77.2114
76.9997
76.7879
62.9053
61.7702
42.4327
14.0192
CO2Et
CO2Et
3ae
f1 (ppm)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7.4436
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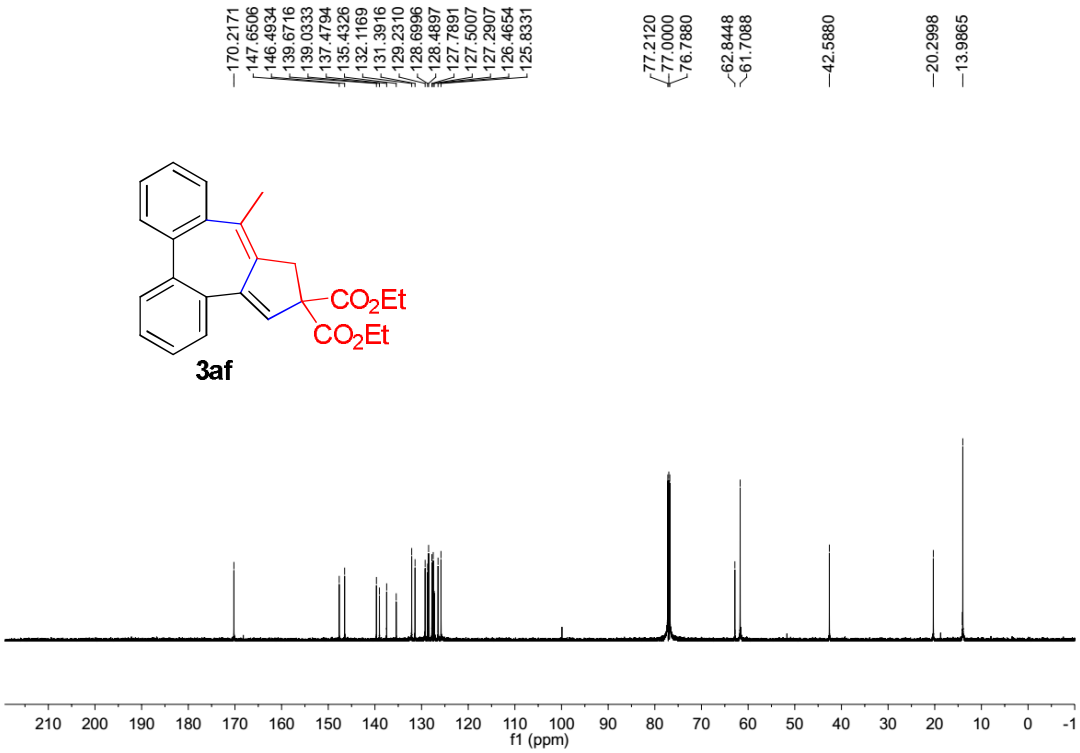
7.4186
7.4165
7.3754
7.3732
7.3246
7.3227
7.3013
7.2995
7.2443
6.4572
4.2124
4.2004
4.1991
4.1871
3.3187
2.2285
1.2641
1.2523
1.2404
CO2Et
CO2Et
3af
1.07
3.03
1.05
2.06
1.08
0.91
4.02
2.01
3.05
6.00
f1 (ppm)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137.4794
135.4326
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131.3916
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128.4897
127.7891
127.5007
127.2907
126.4654
125.8331
77.2120
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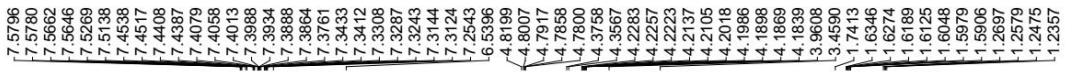
20.2998
13.9865
CO2Et
CO2Et
3af
f1 (ppm)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7.3934
7.3888
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7.3761
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7.3412
7.3308
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7.3243
7.3144
7.3124
7.2543
6.5396
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4.8007
4.7917
4.7858
4.7800
4.3758
4.3567
4.2283
4.2257
4.2223
4.2137
4.2105
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4.1986
4.1898
4.1869
4.1839
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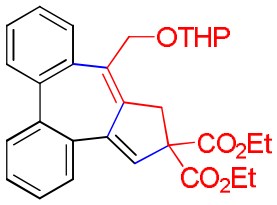
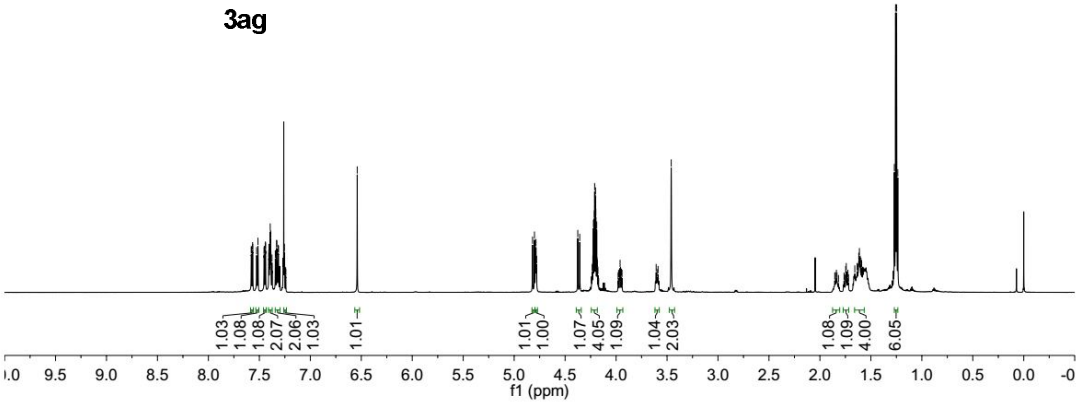
1.2579
1.2475
1.2357


OTHP
CO2Et
CO2Et

3ag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1.08
1.08
2.07
2.06
1.03
1.01
1.01
1.00
1.07
4.05
1.09
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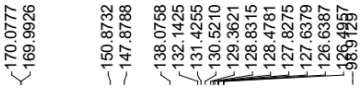
1.08
1.09
4.00
6.05
f1 (ppm)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127.8275
127.6379
126.6387
98.9129
77.2113
76.9997
76.7881
68.2808
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25.4777
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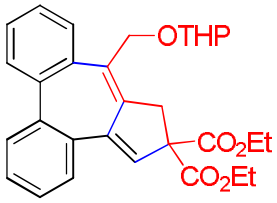
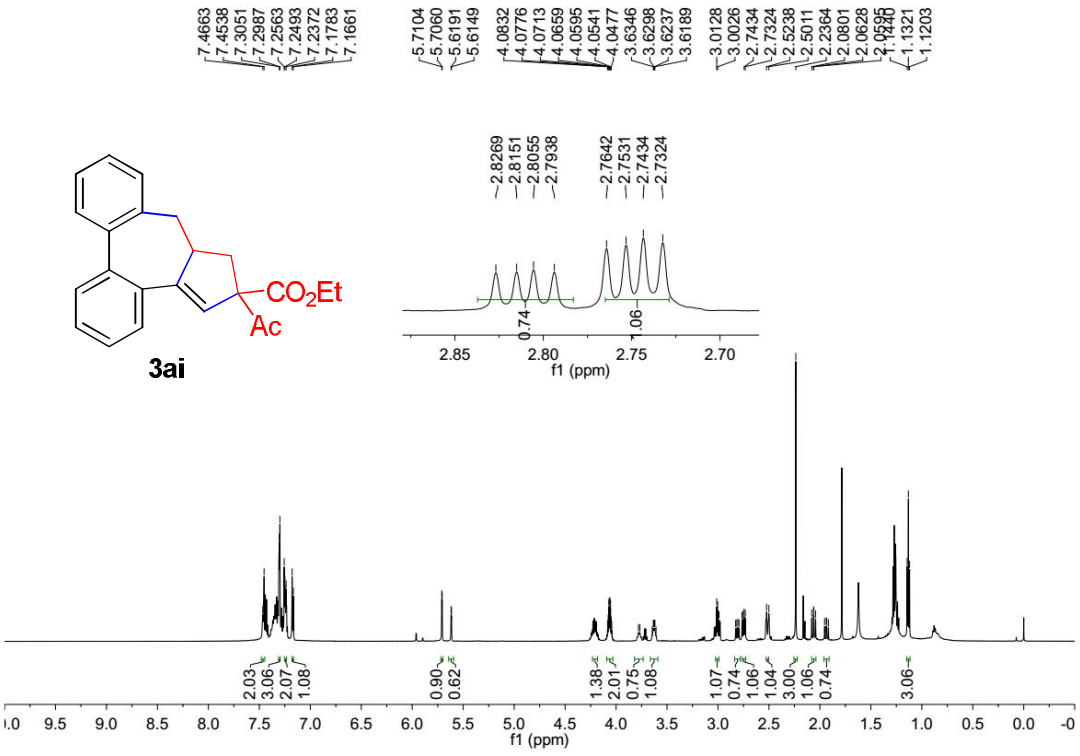
14.0136
14.0030


OTHP
CO2Et
CO2Et

3ag

f1 (ppm)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5.6191
5.6149
4.0832
4.0776
4.0713
4.0659
4.0595
4.0541
4.0477
3.6346
3.6298
3.6237
3.6189
3.0128
3.0026
2.7434
2.7324
2.5238
2.5011
2.2364
2.0801
2.0628
1.1440
1.1321
1.1203
CO2Et
Ac
3ai
2.8269
2.8151
2.8055
2.7938
2.7642
2.7531
2.7434
2.7324
0.74
1.06
2.85
2.80
2.75
2.70
f1 (ppm)
2.03
3.06
2.07
1.08
0.90
0.62
1.38
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1.07
0.74
1.06
1.04
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1.06
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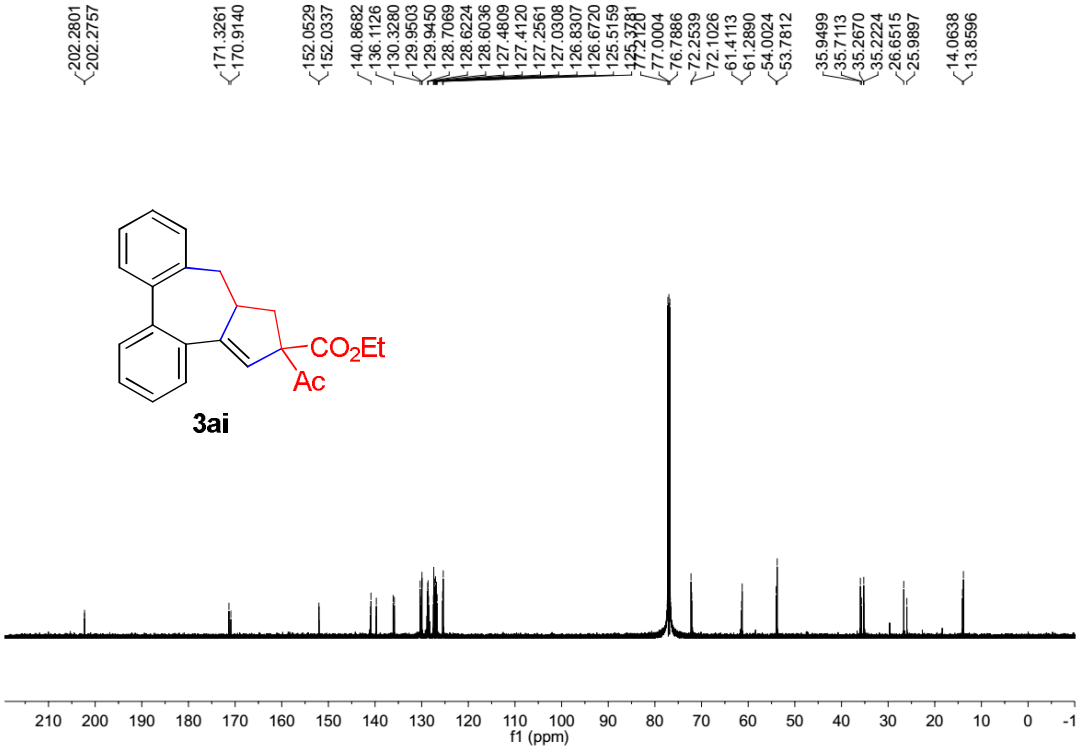
3.06
f1 (ppm)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128.7069
128.6224
128.6036
127.4809
127.4120
127.2561
127.0308
126.8307
126.6720
125.5159
77.2120
77.0004
76.7886
72.2539
72.1026
61.4113
61.2890
54.0024
53.7812
35.9499
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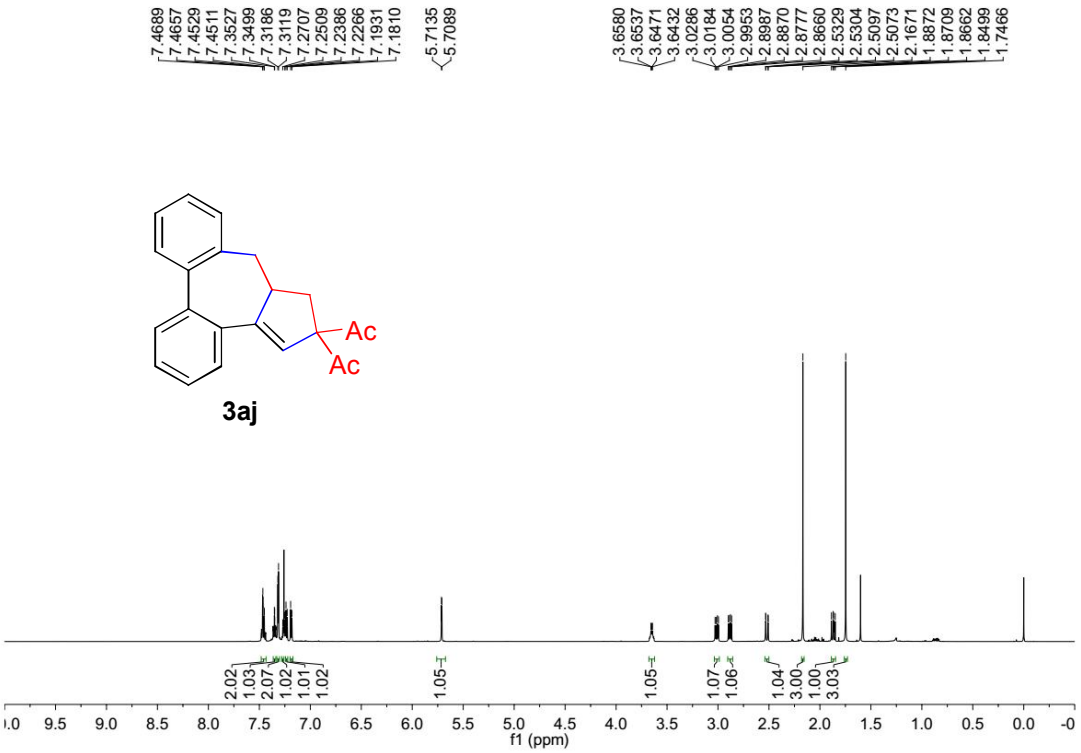
26.6515
25.9897
14.0638
13.8596
CO2Et
Ac
3ai
f1 (ppm)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7.2266
7.1931
7.1810
5.7135
5.7089
3.6580
3.6537
3.6471
3.6432
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3.0054
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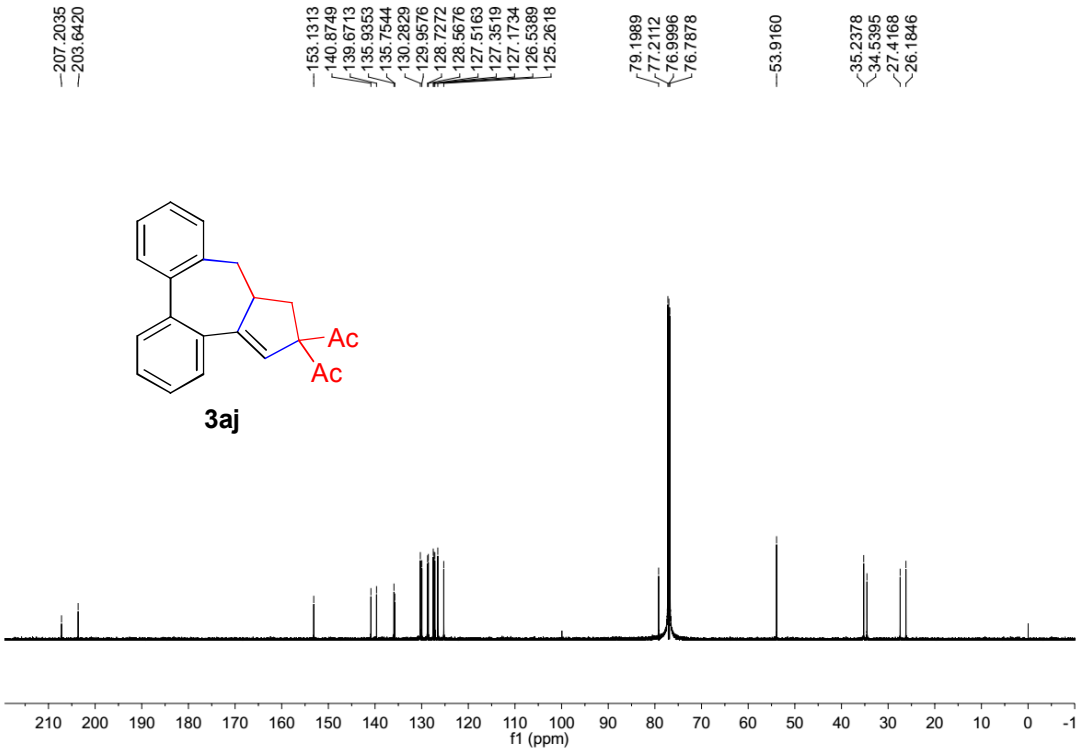
1.8709
1.8662
1.8499
1.7466
Ac
Ac
3aj
2.02
1.03
2.07
1.02
1.01
1.02
1.05
1.05
1.07
1.06
1.04
3.00
1.00
3.03
f1 (ppm)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126.5389
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79.1989
77.2112
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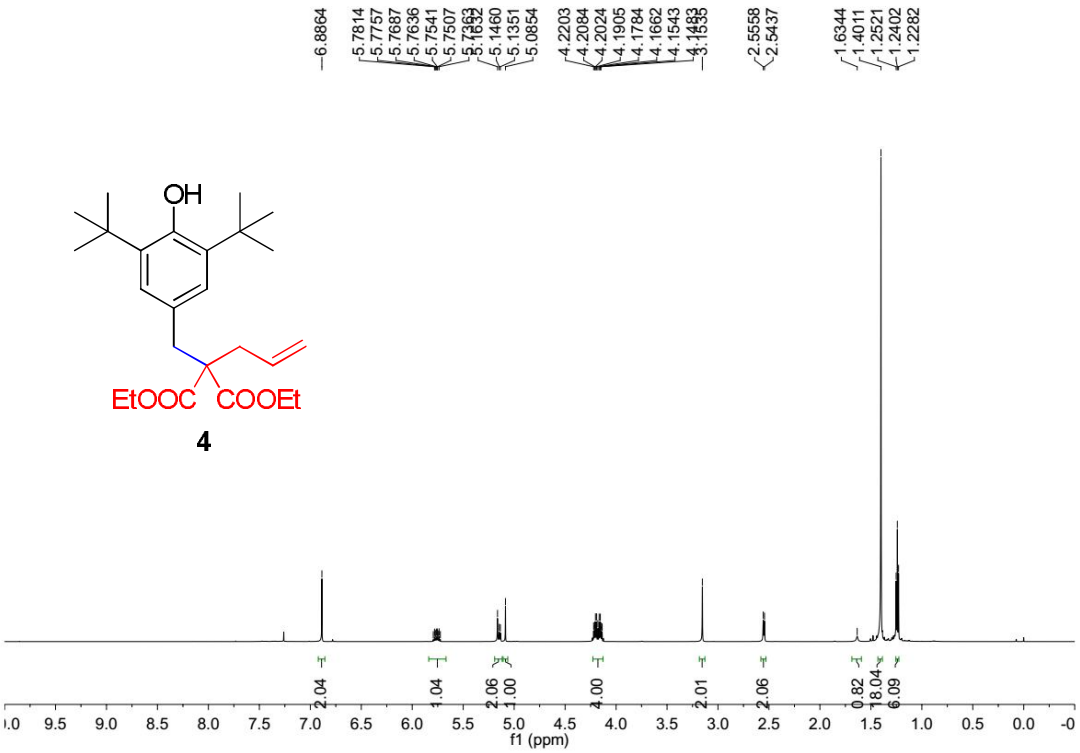
26.1846
Ac
Ac
3aj
f1 (ppm)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5.1351
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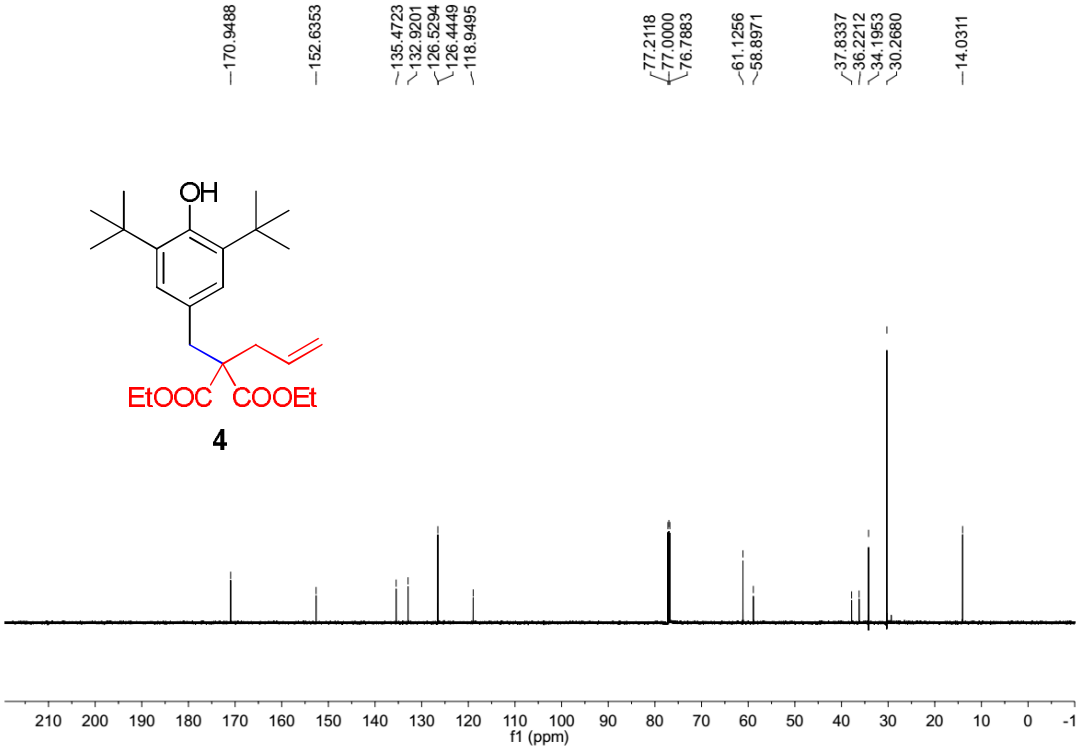
4.2084
4.2024
4.1905
4.1784
4.1662
4.1543
2.5558
2.5437
1.6344
1.4011
1.2521
1.2402
1.2282
OH
EtOOC COOEt
4
2.04
1.04
2.06
1.00
4.00
2.01
2.06
0.82
18.04
6.09
f1 (ppm)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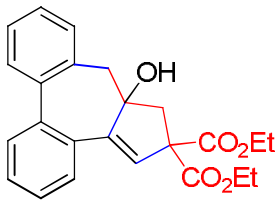
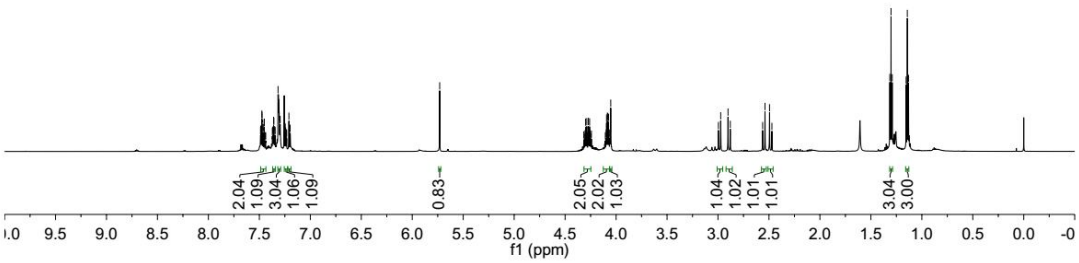
36.2212
34.1953
30.2680
14.0311
OH
EtOOC COOEt
4
f1 (ppm)


OH
CO2Et
CO2Et

5a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1.09
3.04
1.06
1.09
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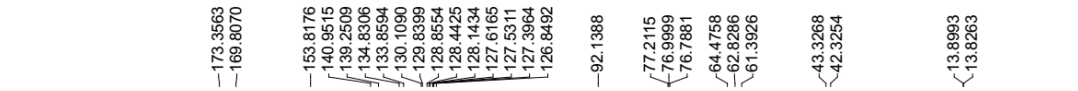
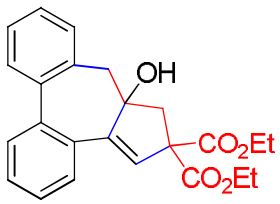
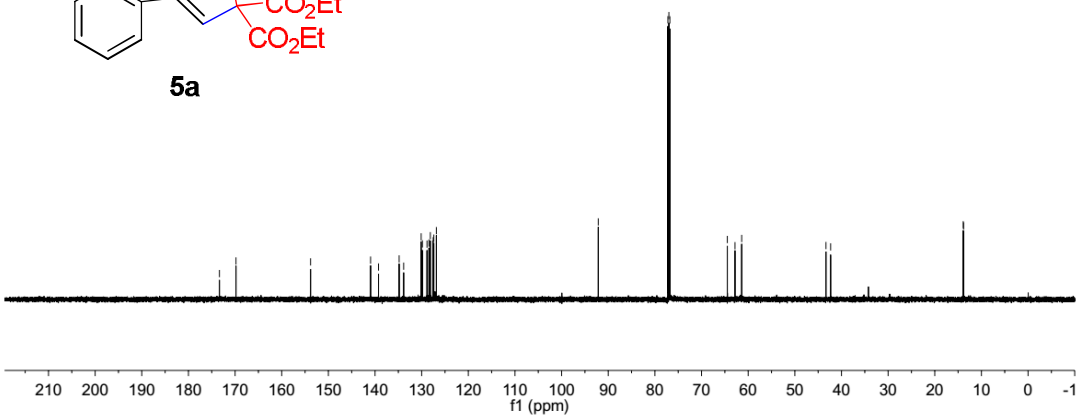
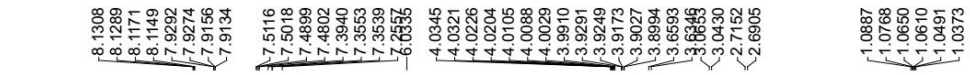
2.02
1.03
1.04
1.02
1.01
1.01
3.04
3.00
f1 (ppm)

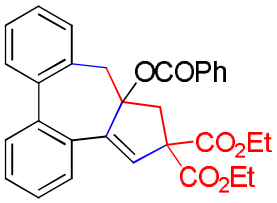



OH
CO2Et
CO2Et

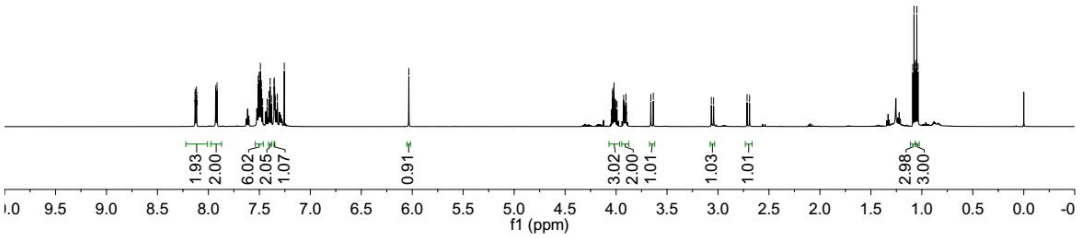
5a

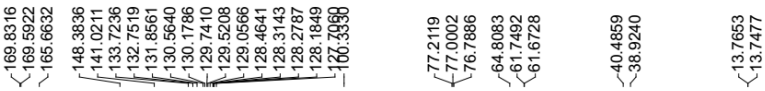

f1 (ppm)

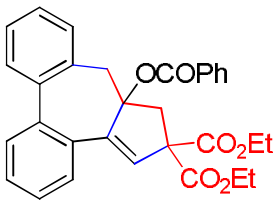




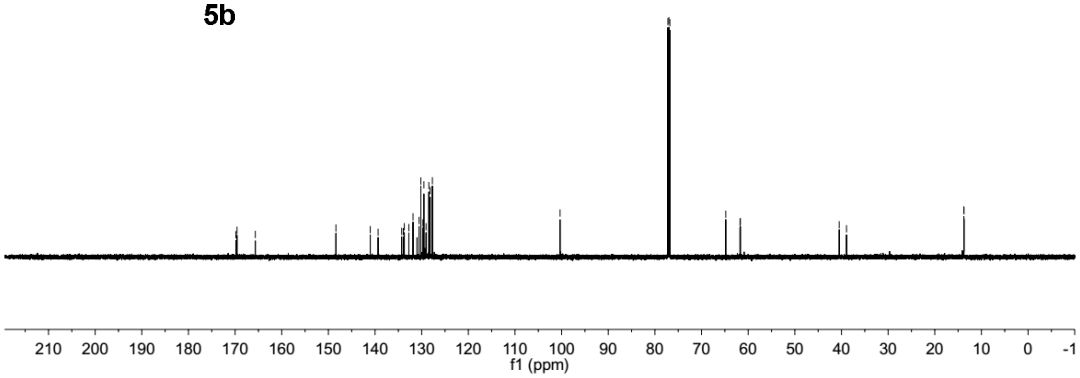
5b







5b

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7.5096
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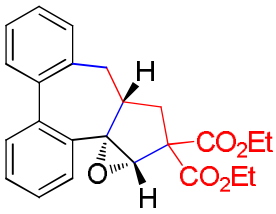
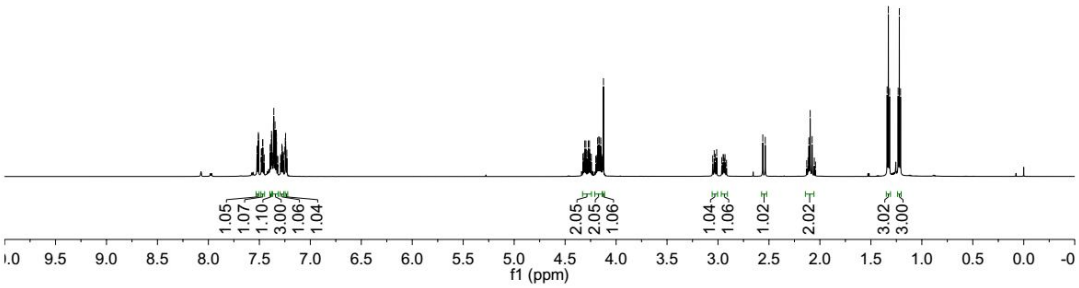
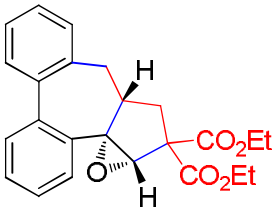
7.4683
7.4660
7.3933
7.3913
7.3809
7.3788
7.3710
7.3615
7.3585
7.3463
7.3341
7.3322
7.2910
7.2787
7.2757
7.2673
7.2641
7.2461
7.2425
7.2304
4.3257
4.3138
4.3078
4.2959
4.2842
4.2726
4.2607
4.2546
4.2428
4.1811
4.1692
4.1615
4.1574
4.1497
4.1316
4.1237
3.0368
3.0278
3.0128
2.9495
2.9305
2.5604
2.5363
2.1080
2.0954
2.0765
1.3403
1.3284
1.3165
1.2326
1.2207
1.2089


H
CO2Et
O
CO2Et
H

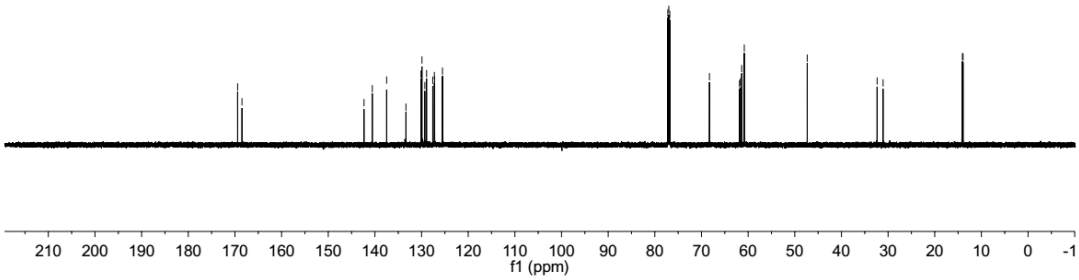
5c

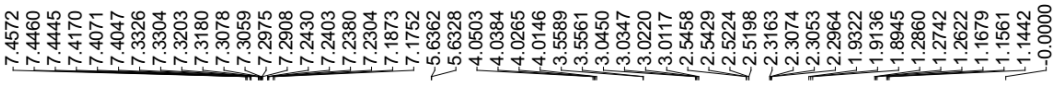

1.05
1.07
1.10
3.00
1.06
1.04
2.05
2.05
1.06
1.04
1.06
1.02
2.02
3.02
3.00
f1 (ppm)

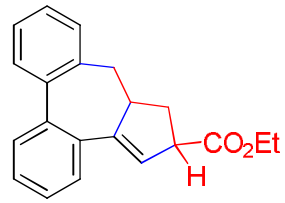

169.4279
168.4897
142.3354
140.5549
137.4859
133.3450
130.1255
129.9154
129.2964
128.9261
127.6001
127.2642
127.1961
125.5170
77.2123
77.0004
76.7884
68.2945
61.8513
61.6871
61.3813
60.8307
47.3296
32.3540
31.0762
14.0723
13.9280


H
CO2Et
O
CO2Et
H

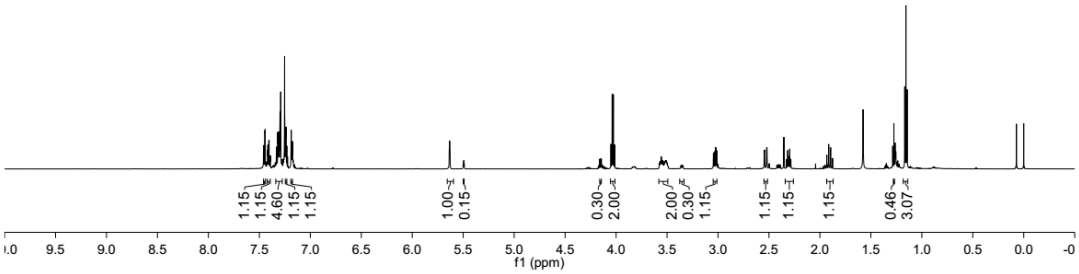
5c

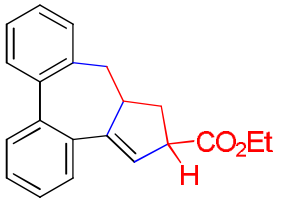

f1 (ppm)



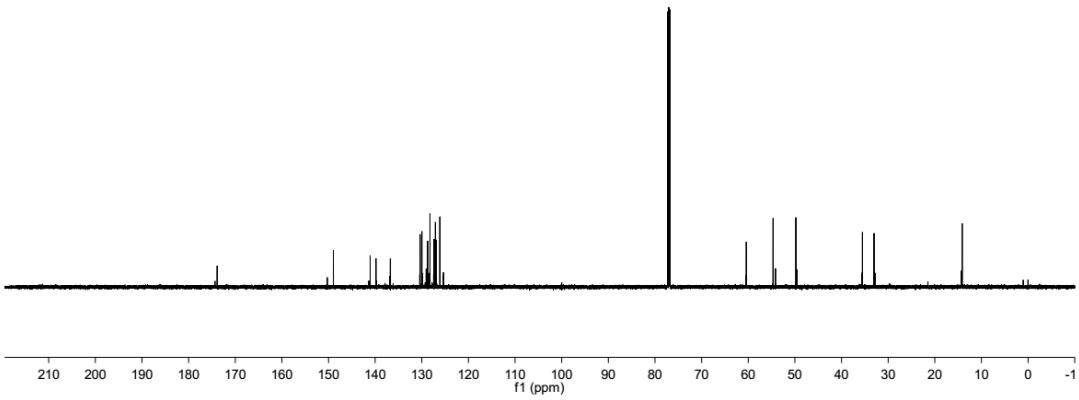


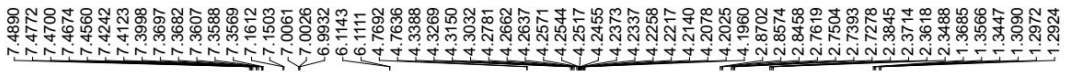
3ah (dr = 87:13)

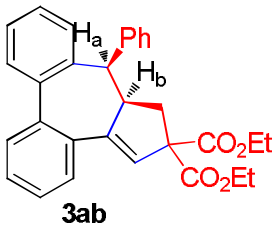




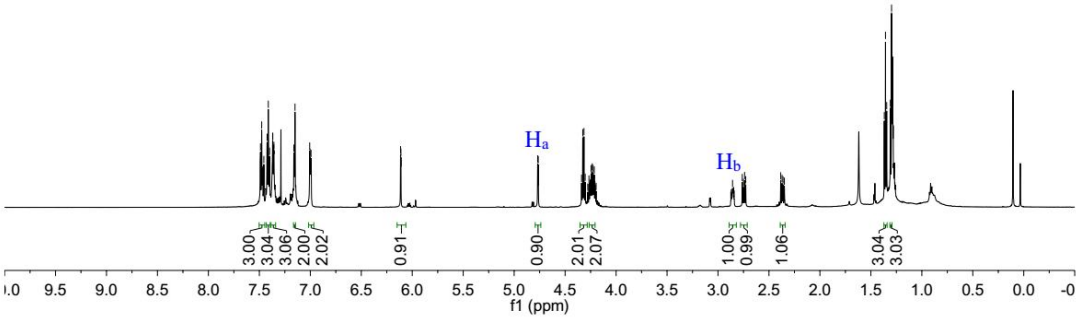
3ah (dr = 87:13)

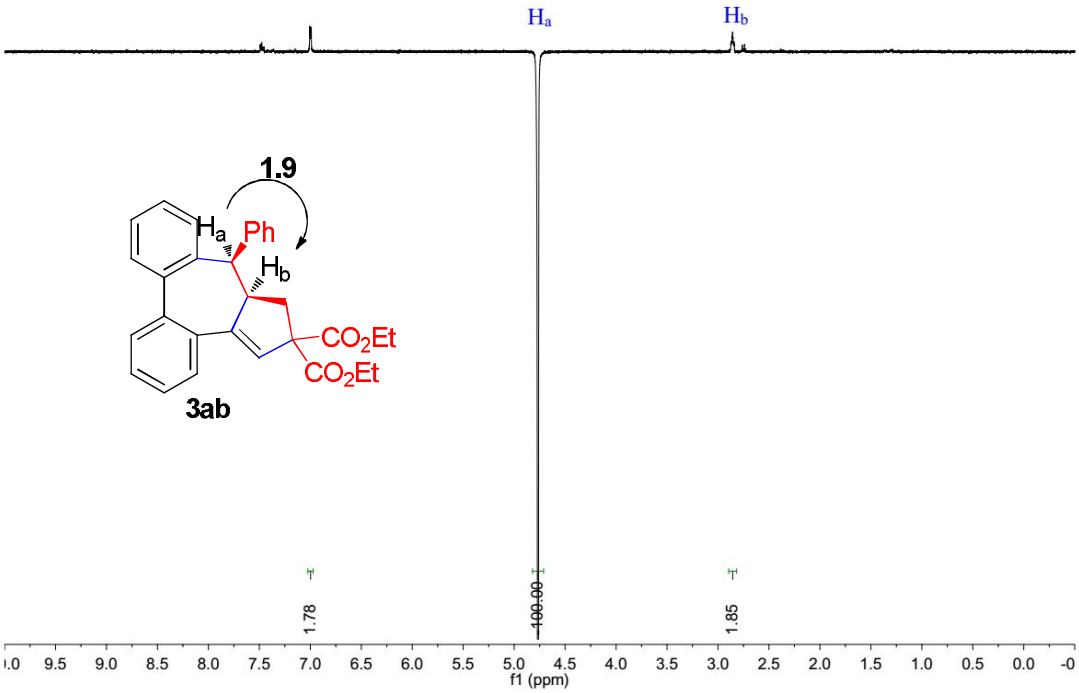



7.4890
7.4772
7.4700
7.4674
7.4560
7.4242
7.4123
7.3998
7.3697
7.3682
7.3607
7.3588
7.3569
7.1612
7.1503
7.0061
7.0026
6.9932
6.1143
6.1111
4.7692
4.7636
4.3388
4.3269
4.3150
4.3032
4.2781
4.2662
4.2637
4.2571
4.2544
4.2517
4.2455
4.2373
4.2337
4.2258
4.2217
4.2140
4.2078
4.2025
4.1960
2.8702
2.8574
2.8458
2.7619
2.7504
2.7393
2.7278
2.3845
2.3714
2.3618
2.3488
1.3685
1.3566
1.3447
1.3090
1.2972
1.2924


Ha
Ph
Hb
CO2Et
CO2Et

3ab


Ha
Hb
3.00
3.04
3.06
2.00
2.02
0.91
0.90
2.01
2.07
1.00
0.99
1.06
3.04
3.03
f1 (ppm)


Ha
Hb
1.9
Ha
Ph
Hb
CO2Et
CO2Et
1.78
100.00
1.85
f1 (ppm)

3ab