Electronic Supplementary Information

An efficient method for the synthesis of enol ethers and enecarbamates. Total syntheses of isoindolobenzazepine alkaloids, lennoxamine and chilenine.

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General remarks

All reactions were performed using oven-dried glasswares under an atmosphere of argon. Anhydrous THF was purchased from Kanto Chemicals Inc. and distilled from Na/benzophenone immediately before use. Anhydrous DMF was purchased from Kanto Chemicals Co. Inc. and used as received. CH_3CN was distilled from CaH_2 under an atmosphere of argon. HMPA was distilled from CaH_2 under reduced pressure. Tetrakis(triphenylphosphine)palladium(0) was prepared according to the literature procedure (D. R. Coulson, *Inorg. Synth.*, 1972, **13**, 121) and stored under argon at −20 °C. All other chemicals were purchased at the highest commerical grade and used as received. Analytical thin-layer chromatography (TLC) was performed using E. Merck silica gel 60 F_{254} pre-coated glass plates (0.25 mm-thickness). Flash column chromatography was carried out using Fuji Silysia silica gel BW-300 (200-400 mesh). Melting points were recorded on a Yanaco melting point apparatus MP-S3 and are uncorrected. ^{1}H and ^{13}C NMR spectra were recorded on a Varian Unity INOVA-500 spectrometer. Chemical shift values are reported in δ (ppm) downfield from tetramethylsilane with reference to internal residual solvent [^{1}H NMR C*H*Cl_3 (7.24); $C_6H D_5$ (7.15); ^{13}C NMR $CDCl_3$ (77.0); C_6D_6 (128.0)]. EI and FAB mass spectra were measured on a JEOL JMS-700 spectrometer and ESI-TOF mass spectra were recorded on a Brucker microTOFfocus spectrometer.

*Spectroscopic data for newly synthesised compounds and compounds **25** and **34**.*

Compounds **8a,b** (an inseparable mixture, data for (*Z*)-isomer **8a**): ^{1}H NMR (500 MHz, C_6D_6) δ 7.21 (d, *J* = 7.5 Hz, 2H), 6.81 (d, J = 7.5 Hz, 2H), 5.82 (apparent d, *J* = 4.0 Hz, 1H), 4.39 (apparent t, *J* = 7.0 Hz, 1H), 4.29 (s, 2H), 3.45 (m, 2H), 3.30 (s, 3H), 3.26 (m, 2H), 1.74 (d, *J* = 7.0 Hz, 3H), 1.59 (m, 4H); ^{13}C NMR (125 MHz, C_6D_6) δ 159.6, 146.1, 131.4, 129.3 (× 2), 114.0 (× 2), 100.5, 72.6, 71.8, 69.7, 54.7, 27.1, 26.6, 9.6; HRMS (EI) calcd for $C_{15}H_{22}O_3$ (M^+) 250.1569, found 250.1574.

Compound **11a**: ^{1}H NMR (500 MHz, C_6D_6) δ 7.84 (d, *J* = 7.5 Hz, 2H), 7.27 (t, *J* = 7.5 Hz, 2H), 7.05 (t, *J* = 7.5 Hz, 1H), 6.02 (d, *J* = 7.5 Hz, 1H), 5.26 (d, *J* = 7.5 Hz, 1H), 3.24 (dt, *J* = 11.0, 4.5 Hz, 1H), 2.26 (m, 1H), 1.86 (m, 1H), 1.47—1.44 (m, 2H), 1.35 (m, 1H), 1.08 (m, 1H), 0.98 (ddd, *J* = 12.0, 12.0, 11.5 Hz, 1H), 0.85 (d, *J* = 7.0 Hz, 3H), 0.80 (d, *J* = 6.0 Hz, 3H), 0.76 (d, *J* = 6.5 Hz, 3H), 0.66 (m, 1H); ^{13}C NMR (125 MHz, C_6D_6) δ 146.4, 137.1, 128.6, 128.5, 128.5, 125.8, 105.7, 83.8, 48.0, 42.1, 34.4, 31.6, 26.3, 23.7, 22.2, 20.9, 16.6 (one carbon signal is missing due to solvent overlapping); HRMS (EI) calcd for $C_{18}H_{26}O$ (M^+) 258.1984, found 258.1985.

Compound **11b**: ^{1}H NMR (500 MHz, C_6D_6) δ 7.18—7.12 (m, 4H), 7.02 (m, 1H), 6.86 (d, *J* = 13.0 Hz, 1H), 6.16 (d, *J* = 13.0 Hz, 1H), 3.39 (dt, *J* = 10.5, 4.0 Hz, 1H), 2.30 (m, 1H), 1.97 (m, 1H), 1.49—1.46 (m, 2H), 1.37 (m, 1H), 1.13 (m, 1H), 1.00 (ddd, *J* = 12.0, 11.5, 11.5 Hz, 1H), 0.90 (d, *J* = 7.0 Hz, 3H), 0.82 (d, *J* = 6.5 Hz, 3H), 0.81 (d, *J* = 7.0 Hz, 3H), 0.68 (m, 1H); ^{13}C NMR (125 MHz, C_6D_6) δ 147.9, 137.3, 128.8, 125.7, 125.4, 118.1, 107.7, 81.4, 48.1, 41.6, 34.5, 31.6, 26.2, 23.8, 22.2, 20.9, 16.7 (one carbon signal is missing due to solvent overlapping); HRMS (EI) calcd for $C_{18}H_{26}O$ (M^+) 258.1984, found 258.1987.

Compound **14**: ^{1}H NMR (500 MHz, C_6D_6) δ 7.64 (d, *J* = 6.5 Hz, 2H), 6.08 (dd, *J* = 14.0, 6.0 Hz, 1H), 5.93 (m, 1H), 5.33 (s, 1H), 5.12-5.06 (m, 2H), 4.40 (dd, *J* = 14.0, 2.0 Hz, 1H), 4.18 (dd, *J* = 10.0, 4.0 Hz, 1H), 3.99 (dd, *J* = 6.5, 1.5 Hz, 1H), 3.46—3.39 (m, 2H), 3.24 (ddd, *J* = 12.0, 7.0, 3.0 Hz, 1H), 3.14—3.04 (m, 2H), 2.55 (m, 1H), 2.43 (ddd, *J* = 8.0, 4.0, 4.0 Hz, 1H), 2.23 (m, 1H), 1.62 (ddd, *J* = 11.5, 11.0, 10.0 Hz, 1H); ^{13}C NMR (125 MHz, C_6D_6) δ 150.5, 138.5, 134.5, 129.0, 128.5 (× 2), 126.7 (× 2), 117.5, 101.6, 89.2, 79.9, 76.4, 75.8, 73.4, 69.4, 36.2, 35.1; HRMS (FAB) calcd for $C_{18}H_{23}O_4$ [(M + H)$^+$] 303.1596, found 303.1597.

Compound **20**: ^{1}H NMR (500 MHz, C_6D_6) δ 7.15—6.72 (m, 6H), 4.74 (m, 1H), 3.69—3.62 (m, 2H), 2.08—2.01 (m, 2H), 1.62—1.55 (m, 2H), 1.55—1.40 (m, 4H); HRMS (FAB) calcd for $C_{14}H_{18}NO_2$ [(M + H)$^+$] 232.1337, found 232.1344.

Compound **23**: ^{1}H NMR (500 MHz, C_6D_6) δ 7.59 (dd, *J* = 15.5, 8.5 Hz, 1H), 7.15 (d, *J* = 8.0 Hz, 2H), 6.64 (d, *J* = 8.0 Hz, 2H), 4.13 (d, *J* = 8.5 Hz, 1H), 3.83 (d, *J* = 15.5 Hz, 1H), 1.26 (s, 9H); ^{13}C NMR (125 MHz, C_6D_6) δ 152.0, 137.8, 135.1, 132.6 (× 2), 130.9 (× 2), 121.4, 93.5, 81.2, 28.0 (× 3); HRMS (FAB) calcd for $C_{13}H_{18}{}^{79}BrNO_2Na$ [(M + Na)$^+$] 322.0419, found 322.0419.

Compound **30**: mp 66—67 °C (EtOAc/hexane); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.77 (d, *J* = 8.0 Hz, 1H), 6.72 (s, 1H), 6.68 (d, *J* = 8.0 Hz, 1H), 5.94 (s, 2H), 5.61 (br, 1H), 4.30 (t, *J* = 5.0 Hz, 1H), 3.46 (s, 2H), 3.35—3.33 (m, 8H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.2, 148.0, 146.9, 128.3, 122.5, 109.7, 108.6, 102.6, 101.1, 54.5, 43.3, 41.1; HRMS (FAB) calcd for $C_{13}H_{18}NO_5$ [(M + H)$^+$] 268.1185, found 268.1191.

Compound **31**: mp 200—201 °C ($CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.16 (br, 1H), 6.73 (s, 1H), 6.67 (s, 1H), 6.24 (d, *J* = 9.5 Hz, 1H), 6.16 (dd, *J* = 9.5, 4.5 Hz, 1H), 5.95 (s, 2H), 3.39 (s, 2H); HRMS (EI) calcd for $C_{11}H_9NO_3$ (M^+) 203.0574, found 203.0585.

Compound **32**: mp 222—224 °C (MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.61 (s, 1H), 6.59 (s, 1H), 6.10 (br, 1H), 5.90 (s, 2H), 3.72 (s, 2H), 3.52 (q, *J* = 6.0 Hz, 2H), 3.02 (t, *J* = 6.0 Hz, 2H); HRMS (EI) calcd for $C_{11}H_{11}NO_3$ (M^+) 205.0749, found 205.0736.

Compound **33**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.13 (d, *J* = 9.0 Hz, 1H), 6.74 (d, *J* = 9.0 Hz, 1H), 6.58 (s, 1H), 6.49 (s, 1H), 5.90 (s, 2H), 4.45 (brm, 2H), 3.93—3.83 (m, 2H), 3.79 (s, 3H), 3.64 (s, 3H), 3.23 (brm, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.8, 166.6, 151.7, 147.3, 146.1, 145.3, 135.0, 128.6, 127.4,

122.1, 113.5, 110.9, 109.9, 107.7, 101.1, 61.0, 55.9, 44.7, 40.6, 32.7; HRMS (EI) calcd for $C_{20}H_{18}{}^{79}BrNO_6$ (M^+) 447.0318, found 447.0318.

Compound **27** (exists as an approximately 7:3 mixture of rotational isomers): ^{1}H NMR (500 MHz, $CDCl_3$, 293 K) δ 7.41 (d, *J* = 11.0 Hz, 0.3H), 7.26 (d, *J* = 7.0 Hz, 0.7H), 6.84 (d, *J* = 7.0 Hz, 0.7H), 6.83 (m, 0.3H), 6.68 (s, 0.3H), 6.61 (s, 0.7H), 6.59 (s, 0.7H), 6.48 (s, 0.3H), 6.18 (d, *J* = 10.0 Hz, 0.7H), 5.90 (s, 2H), 5.78 (d, *J* = 11.0 Hz, 0.3H), 5.39 (s, 0.7H), 4.30 (dd, *J* = 13.0, 7.0 Hz, 0.7H), 4.04 (dd, *J* = 13.0, 7.0 Hz, 0.7H), 3.86 (s, 3H), 3.83 (s, 3H), 3.59 (t, *J* = 4.5 Hz, 0.3H × 2), 3.05-2.96 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$, 293 K) δ 164.8, 152.3, 146.3, 146.2, 146.1, 133.8, 133.5, 132.2, 128.2, 128.1, 128.1, 128.0, 124.9, 122.6, 114.3, 114.0, 112.3, 110.1, 110.3, 110.2, 109.4, 109.2, 101.0, 61.7, 61.6, 56.0, 56.0, 48.1, 42.8, 36.8, 36.2; HRMS (ESI) $C_{20}H_{18}{}^{79}BrNO_5Na$ [$(M + Na)^+$] 454.0267, found 454.0266.

Compound **25** (lennoxamine): mp 229—230 °C (MeOH) (lit.,[1] 229—230 °C); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.15 (d, *J* = 8.5 Hz, 1H), 7.11 (d, *J* = 8.5 Hz, 1H), 6.75 (s, 1H), 6.68 (s, 1H), 5.93 (d, *J* = 5.0 Hz, 1H), 5.93 (d, *J* = 5.0 Hz, 1H), 4.72 (m, 1H), 4.28 (apparent d, *J* = 10.0 Hz, 1H), 4.08 (s, 3H), 3.89 (s, 3H), 3.09 (dd, *J* = 14.5, 1.5 Hz, 1H), 2.92—2.85 (m, 2H), 2.83—2.76 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.2, 152.6, 147.2, 146.3, 146.1, 138.2, 134.8, 130.9, 124.2, 117.1, 116.1, 110.3 (× 2), 101.0, 62.5, 60.1, 56.7, 42.7, 41.1, 35.9; HRMS (ESI) calcd for $C_{20}H_{19}NO_5Na$ [$(M + Na)^+$] 376.1161, found 376.1166.

Compound **34** (dehydrolennoxamine): mp 212—214 °C (lit.,[1] 209—211 °C); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.0 Hz, 1H), 7.11 (d, *J* = 8.0 Hz, 1H), 6.78 (s, 1H), 6.64 (s, 1H), 6.30 (s, 1H), 5.94 (s, 2H), 4.08 (s, 3H), 3.90 (s, 3H), 4.20—3.80 (m, 2H), 3.01 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) d 163.7, 152.9, 146.91, 146.85, 146.6, 133.9, 133.3, 131.1, 127.8, 120.3, 116.3, 114.3, 110.3, 110.2, 104.9, 101.2, 62.5, 56.7, 41.8, 35.5; HRMS (ESI) calcd for $C_{20}H_{17}NO_5Na$ [$(M + Na)^+$] 374.1004, found 374.1004.

Reference

1. H. Ishibashi, H. Kawanami and M. Ikeda, *J. Chem. Soc., Perkin Trans 1*, 1997, 817.

HF21131a/CDCl3

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
INOVA-500 "varian"

Relax. delay 1.000 sec
Pulse 45.0 degrees
Acq. time 1.892 sec
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8 repetitions
OBSERVE H1, 499.8593228 MHz
DATA PROCESSING
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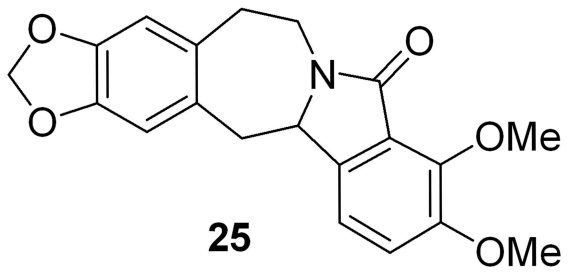
Total time 0 min, 23 sec



25

STANDARD CARBON PARAMETERS

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Solvent: CDCl3
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User: 1-14-87
INOVA-500 "varian"

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Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
512 repetitions
OBSERVE C13, 125.6897266 MHz
DECOUPLE H1, 499.8618041 MHz
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continuously on
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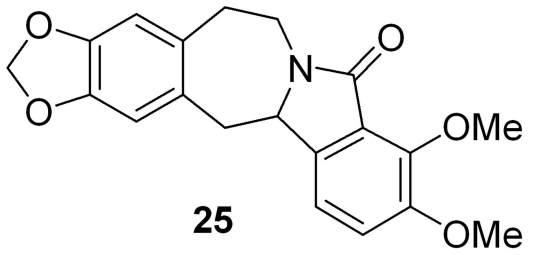

25

HF21138/CDCl3

Pulse Sequence: s2pul

Solvent: CDCl3
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INOVA-500 "varian"

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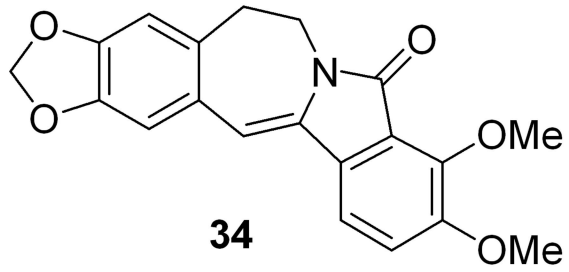
Pulse 45.0 degrees
Acq. time 1.892 sec
Width 8000.0 Hz
8 repetitions
OBSERVE H1, 499.8593228 MHz
DATA PROCESSING
FT size 32768
Total time 0 min, 23 sec



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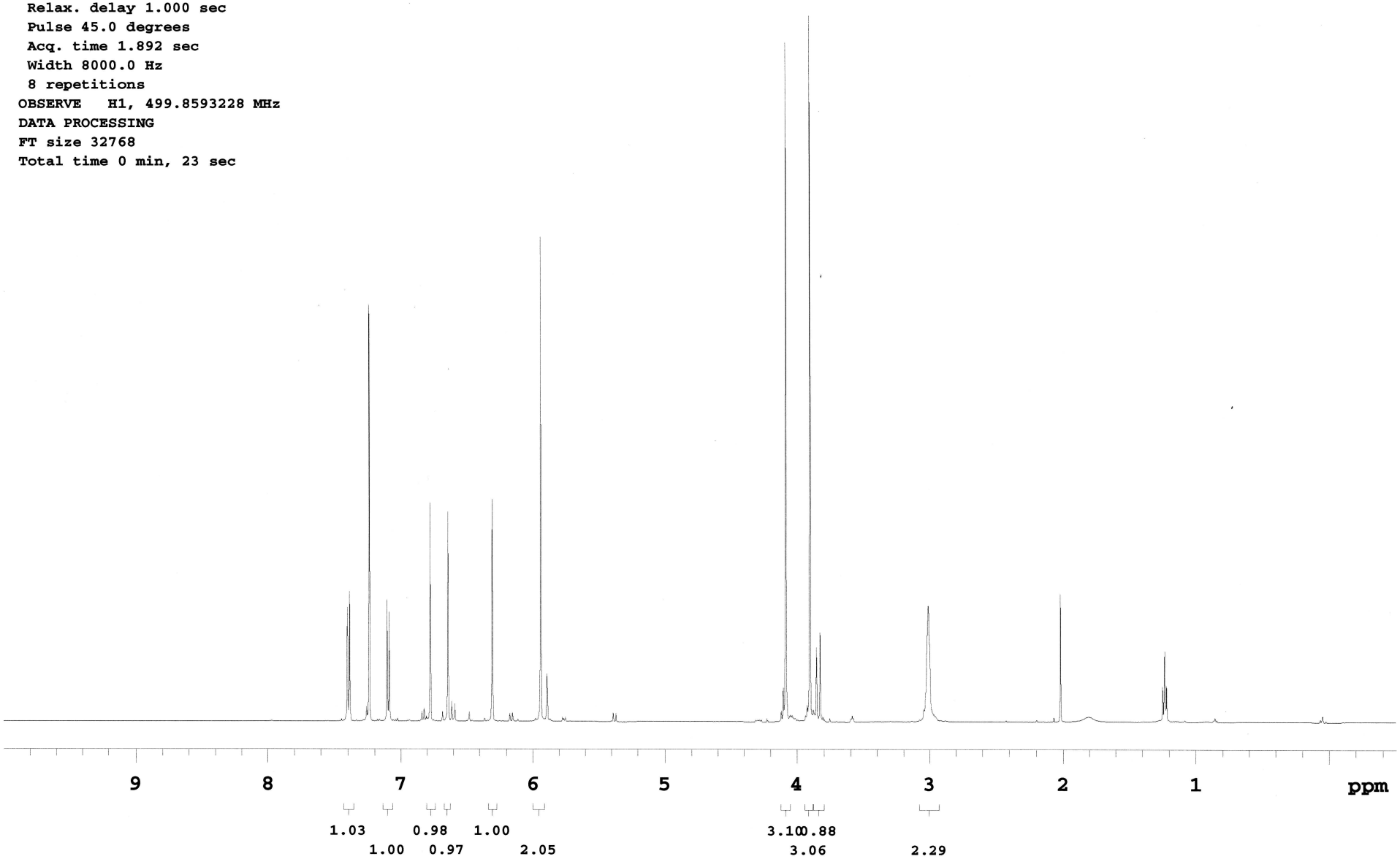
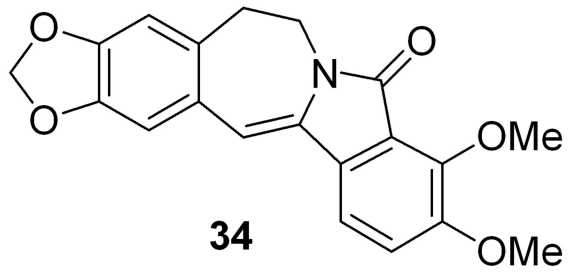


STANDARD CARBON PARAMETERS

Pulse Sequence: s2pul

Solvent: CDCl3
Temp. 20.0 C / 293.1 K
User: 1-14-87
INOVA-500 "varian"

Relax. delay 0.700 sec
Pulse 45.0 degrees
Acq. time 1.298 sec
Width 37735.8 Hz
224 repetitions
OBSERVE C13, 125.6897277 MHz
DECOUPLE H1, 499.8618041 MHz
Power 27 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 0.5 Hz
FT size 131072
Total time 2 hr, 51 min, 19 sec



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