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Electronic Supplementary Information

Design of C_2-symmetric alkaloidal chiral amphiphiles and configurational effects on self-assembly

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General methods and materials

All reactions were performed under nitrogen atmosphere unless otherwise specified. Reactions were monitored by thin layer chromatography using Merck Millipore TLC Silica gel F254 plates (0.25 mm) which were visualized using UV light, phosphomolybdic acid (PMA) stain, PMS stain and *p*-anisaldehyde strain and cerium ammonium molybdate stain (CAM). Flash column chromatography was performed using Kanto Silica Gel 60N.The medium pressure liquid chromatography (MPLC) purifications were performed on a YAMAZEN YFLC-AI-580 and Biotage® Isolera. ^{1}H and ^{13}C nuclear magnetic resonance (NMR) spectra were recorded on JEOL JNM-ECA 500 spectrometer (^{1}H/500 MHz, ^{13}C/125 MHz), JEOL JNM-ECX 400 spectrometer (^{1}H/400 MHz, ^{13}C/100 MHz) JEOL JNM-ECP 300 (^{1}H/300 MHz, ^{13}C/75 MHz) spectrometer. Chemical shifts are reported in δ (ppm) using chloroform and dimethyl sulfoxide as an internal standard of δ 7.26, 2.50 and 77.16, 39.52 for ^{1}H and ^{13}C-NMR, respectively. Data for ^{1}H-NMR are reported as follows: chemical shift (number of hydrogens, multiplicity, coupling constant). Multiplicity is abbreviated as follows: s (singlet), d (doublet), t (triplet), q (quartet), quin (quintet), m (multiplet), br (broad). Electrospray ionization time-of-flight mass (ESI-TOF MS) spectra were recorded on Bruker Daltonics micrOTOF-QII. UV-vis absorption spectra were recorded on a JASCO V-650 spectrometer. Fluorescence spectra were recorded on JASCO FP-6500 and Shimadzu RF-6000 spectrometers. 11-Bromo-1-undecene (**15**) was purchased from FUJIFILM Wako Pure Chemical Co. or Tokyo Chemical Industry Co., Ltd. (TCI). Tris(2,2'-bipyridyl)ruthenium(II) hexafluorophosphate was obtained from TCI. $Pd(PPh_3)_4$ was purchased from Sigma-Aldrich or TCI. All of reagents and commercial solvents were used as received.

Molecular models of 4–7

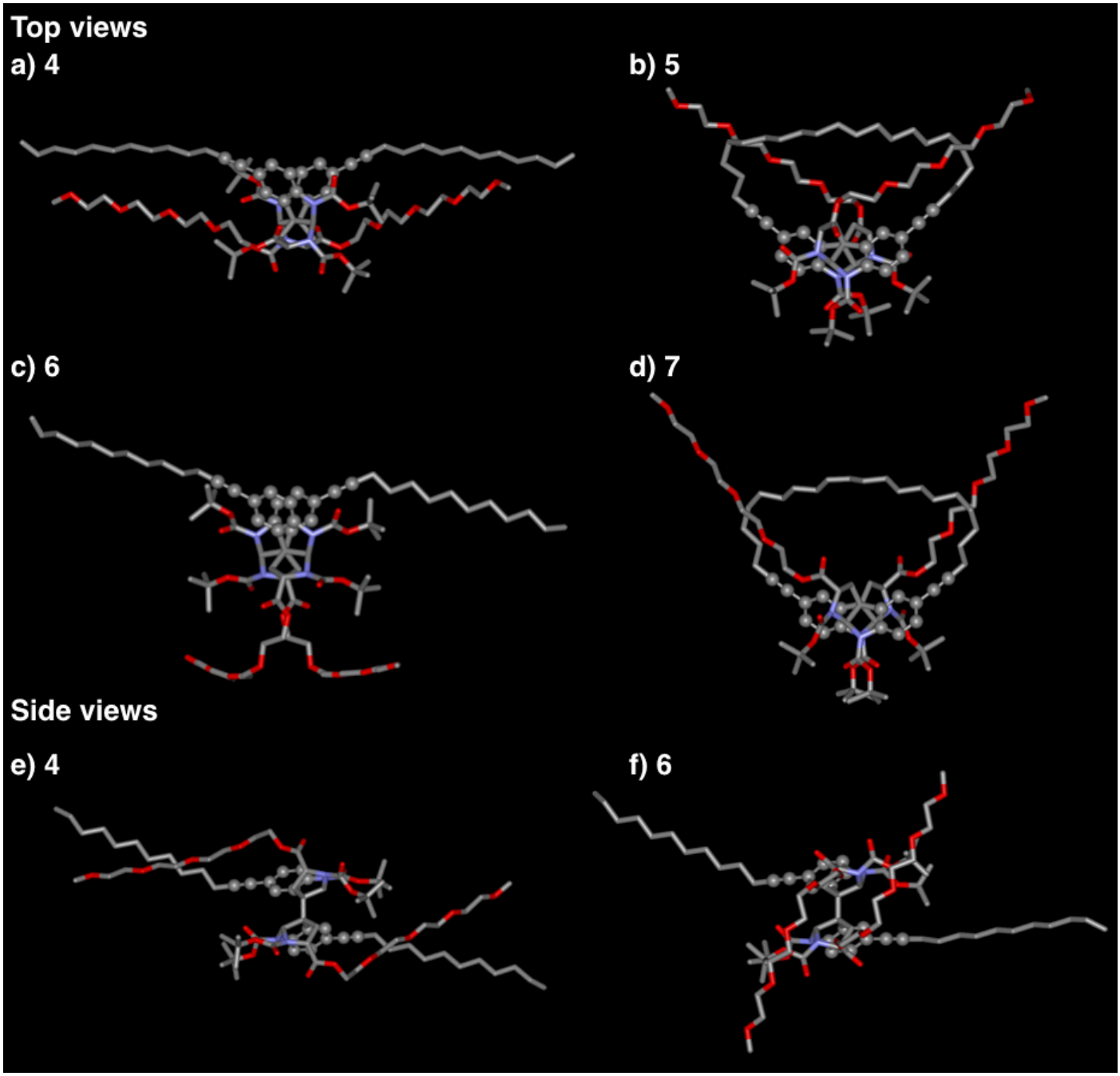


Figure S1 Molecular models of **4**–**7** calculated by the semi-empirical molecular orbital PM3 method. Top views: a) **4**, b) **5**, c) **6** and d) **7**. Side views: e) **4** and f) **6**. In the models, the alkyl links in **5** and **7** have *Z* geometries. Gray, blue and red parts depict carbon, nitrogen and oxygen atoms, respectively. Hydrogen atoms are omitted for clarity. The phenylacetylene (PA) units are drawn in a ball and stick style. The dihedral angles between the PA units: a) 40.3° for **4**, c) 36.7°for **6**.

UV-vis absorption spectra of 4–7

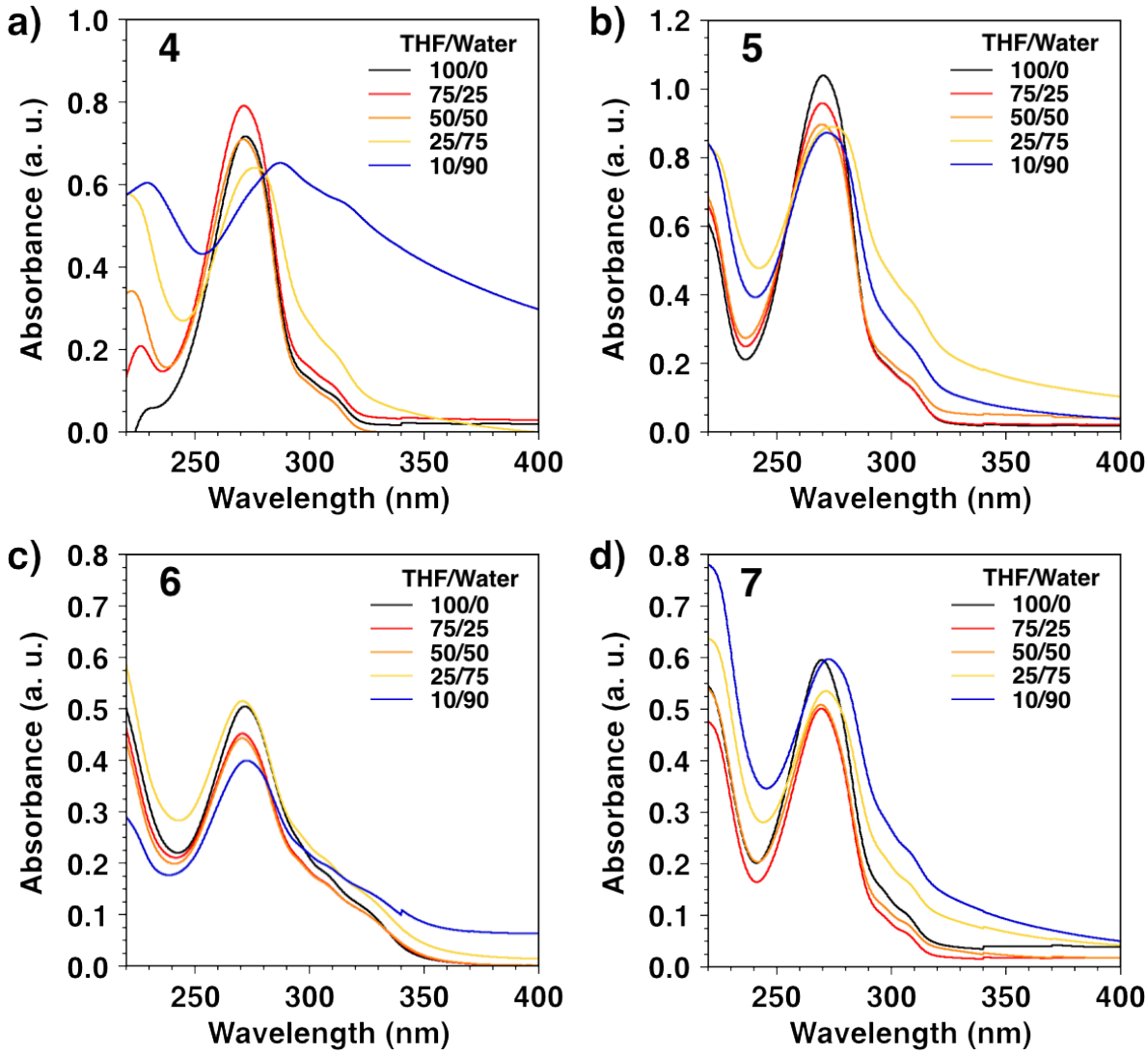


Figure S2 UV-vis absorption spectra of a) **4**, b) **5**, c) **6** and d) **7** in the mixtures of THF and water with various ratios at 20 °C. [**4**–**7**] = 20 μM.

Spectroscopic analyses of 19

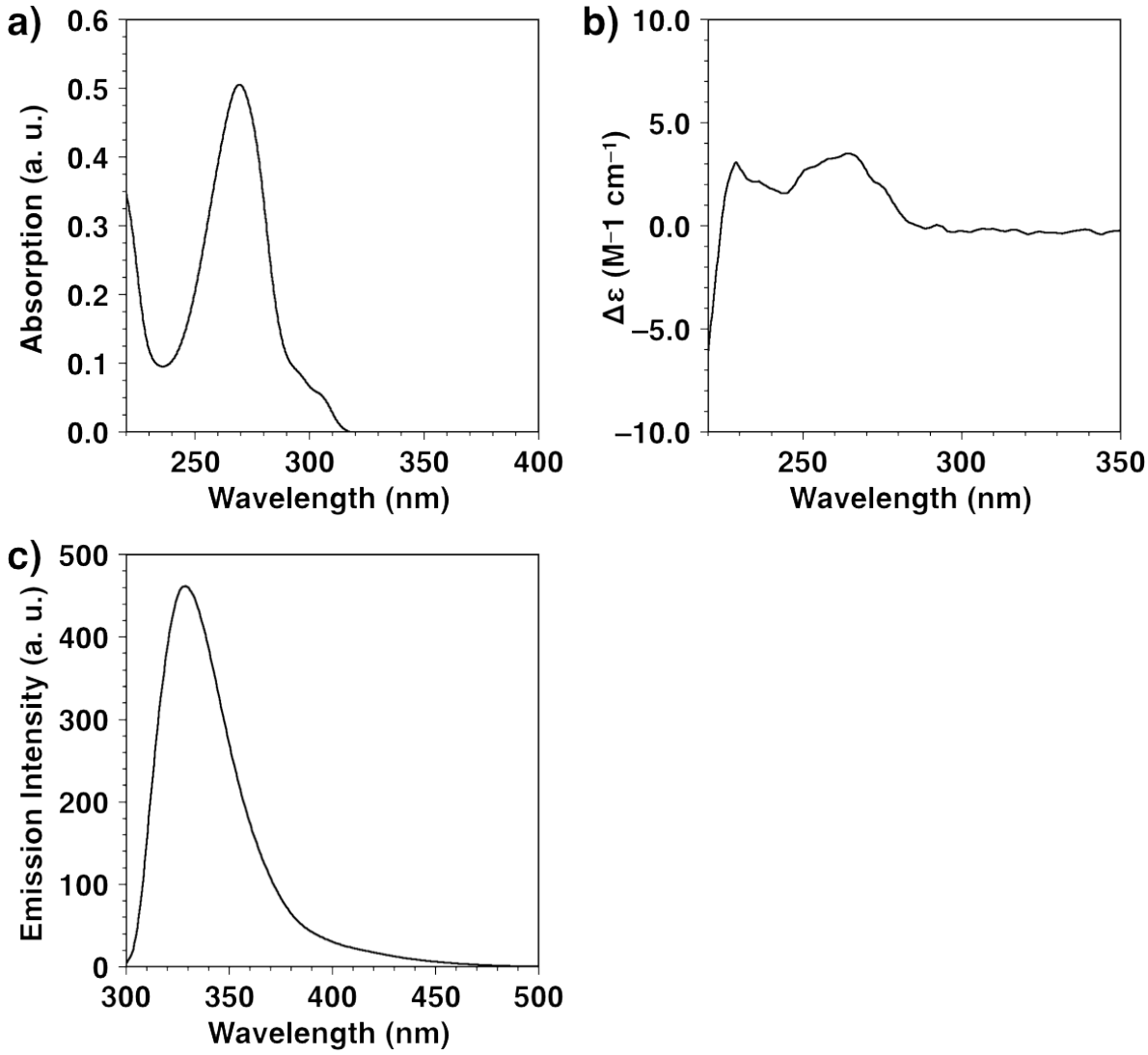


Figure S3 a) UV-vis absorption, b) circular dichroism and c) fluorescence spectra of **19** in THF at 20 °C. Excitation wavelength: 272 nm. [**19**] = 20 μM.

Fluorescence spectra of 4–7

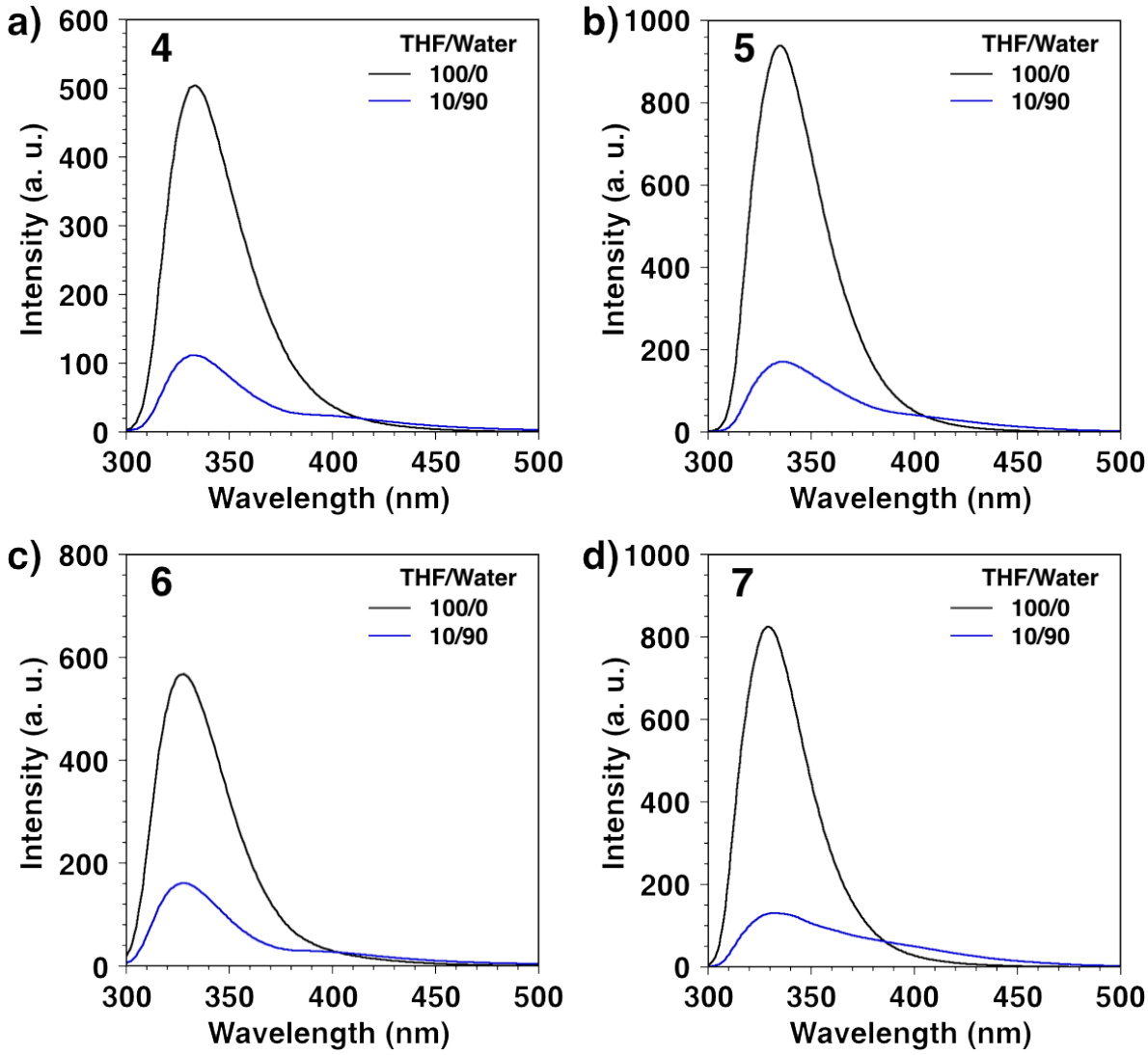
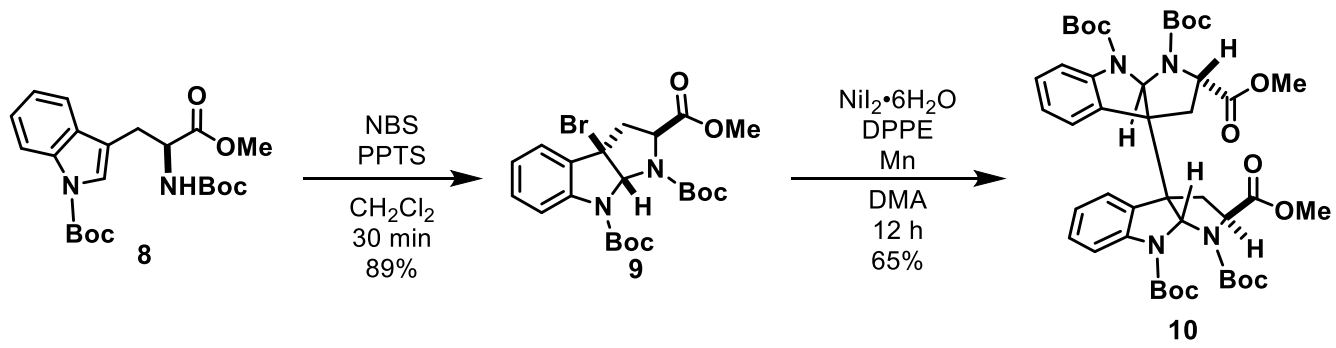


Figure S4 Fluorescence spectra of a) **4**, b) **5**, c) **6** and d) **7** in THF (black lines) and a mixture of THF and water at 10/90 (blue lines) at 20 °C. [**4**–**7**] = 20 μM. Excitation wavelengths: a) 272, b) 278, c) 272 and d) 278 nm in THF, a) 273 b) 269, c) 274 and d) 271 nm in the mixture of THF and water.

Synthetic procedures

Synthesis of C_2 dimer 10



Compound 9:[1] To a solution of **8** (9.00 g, 21.5 mmol) in CH_2Cl_2 (200 mL, 0.11 M) were successively added PPTS (5.40 g, 21.5 mmol, 1.0 eq.) and NBS (3.83 g, 21.5 mmol, 1.0 eq.) at room temperature. After being stirred for 30 min at room temperature, the resulting mixture was treated with brine. The organic layer was separated, washed with aqueous solutions of $NaHCO_3$, Na_2SO_3, and brine, and dried over Na_2SO_4. After filtration and concentration *in vacuo*, the residue was purified by silica-gel chromatography (hexane/AcOEt) to afford **9** (9.49 g, 19.1 mmol, 89%).

9: R_f = 0.44 (Hex–AcOEt = 3 : 1); ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.55 (1H, br-s), 7.37–7.29 (2H, m), 7.12 (1H, dd, J = 8.1, 7.4 Hz), 6.40 (1H, s), 3.89 (1H, dd, J = 10.4, 6.3 Hz), 3.75 (3H, s), 3.21 (1H, dd, J = 12.6, 6.3 Hz), 2.82 (1H, dd, J = 12.6, 10.4 Hz), 1.59 (9H, s), 1.40 (9H, br-s).

Compound 10:[2] A mixture of **9** (5.00 g, 10.1 mmol), DPPE (602 mg, 1.51 mmol, 15 mol%), NiI_2 •$6H_2O$ (634 mg, 1.51 mmol, 15 mol%) in DMA (8.2 mL, 1.23 M) was degassed by four cycles of gentle pumping and argon replacement. After addition of manganese (762 mg, 11.6 mmol, 1.15 eq.), the mixture was then degassed by four cycles in the almost identical manner. The mixture was then allowed to be stirred for 12 h at room temperature under argon. The mixture was diluted with AcOEt, treated with 1 M HCl and then extracted with AcOEt. The organic extracts were washed with 1 M HCl, H_2O, saturated aqueous solution of Na_2SO_3 and brine, and then dried over Na_2SO_4. Drying agent was filtered off and the solvent was removed under reduced pressure. During the concentration, white solid was precipitated and filtered off. The resulting residue was purified by silica-gel chromatography (hexane/AcOEt) to afford **10** (2.73 g, 3.27 mmol, 65%).

10: R_f = 0.42 (Hex–AcOEt = 2 : 1); ^{1}H NMR (400 MHz, DMSO-d_6, 95 °C): δ 7.37 (2H, d, J = 8.0 Hz), 7.21–7.11 (4H, m), 6.91 (2H, m), 6.09 (2H, s), 3.70 (2H, m), 3.68 (6H, s), 2.64 (2H, dd, J = 12.7, 7.0 Hz), 2.25 (2H, dd, J = 12.7, 9.5 Hz), 1.57 (18H, s), 1.33 (18H, s).

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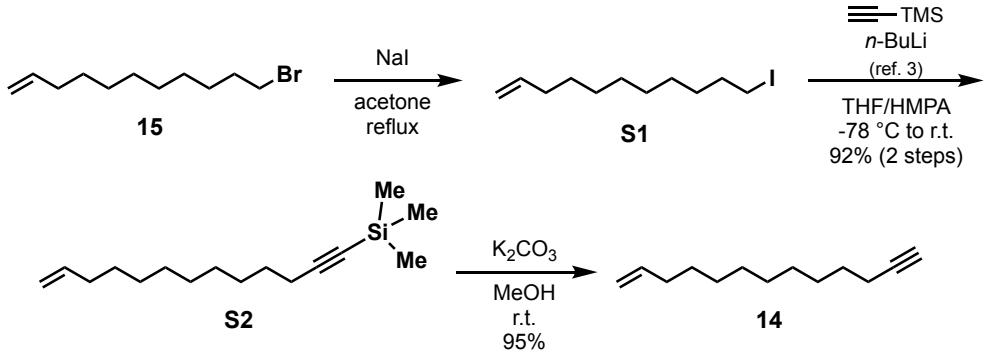
[1] C. Pérez-Balado, P. Rodriguez-Grana and A. R. de Lera, *Chem. Eur. J.*, 2009, **15**, 9928–9937.[2] M. Wada, T. Murata, H. Oikawa and H. Oguri, *Org. Biomol. Chem.*, 2014, **12**, 298–306.

Syntheses of enyne 14



Compound S2:[3] To a stirred solution of 11-bromo-1-undecene (**15**) (3.06 g, 13.1 mmol) in acetone (10 mL, 1.3 M) was added NaI (2.42 g, 16.1 mmol, 1.2 eq.) and the resulting solution was refluxed for 5 h. The resulting mixture was treated with H_2O (40 mL) and extracted with CH_2Cl_2 (25 mL × 4). The combined organic extracts were washed with saturated aqueous solution of Na_2SO_3, dried over Na_2SO_4, filtered and concentrated *in vacuo* to afford **S1** (3.92 g) as a colorless liquid, which was used without further purification. To a solution of trimethylsilylacetylene (2.75 mL, 19.9 mmol, 1.5 eq.) in THF (53 mL) was added *n*-BuLi (1.55 M in hexane, 11.0 mL, 17.1 mmol, 1.3 eq.) over 5 min at –78 °C. After being stirred for 30 min, HMPA (10.4 mL) was added to the mixture. A solution of **S1** (3.92 g) in THF (13 mL) was added dropwise at –78 ºC and then mixture was allowed to warm up to room temperature. After being stirred for 5 h, saturated aqueous solution of NH_4Cl (50 mL) was added to the resulting mixture. The layers were separated, and the aqueous layer was extracted with AcOEt (130 mL × 3). The combined organic extracts were washed with brine (150 mL), dried over Na_2SO_4, filtered and concentrated *in vacuo*. The crude residue was purified by silica-gel column chromatography (hexane) to afford **S2** (3.03 g, 12.1 mmol, 92% for 2 steps) as a colorless liquid.

S2:[4] R_f = 0.41 (Hex); ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.81 (1H, ddt, J = 18.1, 10.6, 6.8 Hz), 4.99 (1H, ddt, J = 18.1, 2.3, 1.7 Hz), 4.93 (1H, br-d, J = 10.6 Hz), 2.21 (2H, t, J = 7.2 Hz), 2.04 (2H, dt, J = 7.5, 7.2 Hz), 1.54–1.48 (2H, m), 1.41–1.32 (4H, m), 1.31–1.26 (8H, m), 0.14 (9H, s).

Compound 14: To a solution of **S2** (3.56 g, 14.2 mmol) in MeOH (284 mL, 0.05 M) was added potassium carbonate (5.90 g, 42.7 mmol, 3.0 eq.) at room temperature. The suspension was stirred at room temperature for 10.5 h and then solvent was evaporated under reduced pressure. The resulting mixture was treated with brine (60 mL) and H_2O (40 mL) extracted with Et_2O (160 mL × 3). The combined organic extracts were washed with brine, dried over Na_2SO_4, filtered, and concentrated *in vacuo* to afford **14** (2.41 g, 13.5 mmol, 95%) as a colorless liquid.

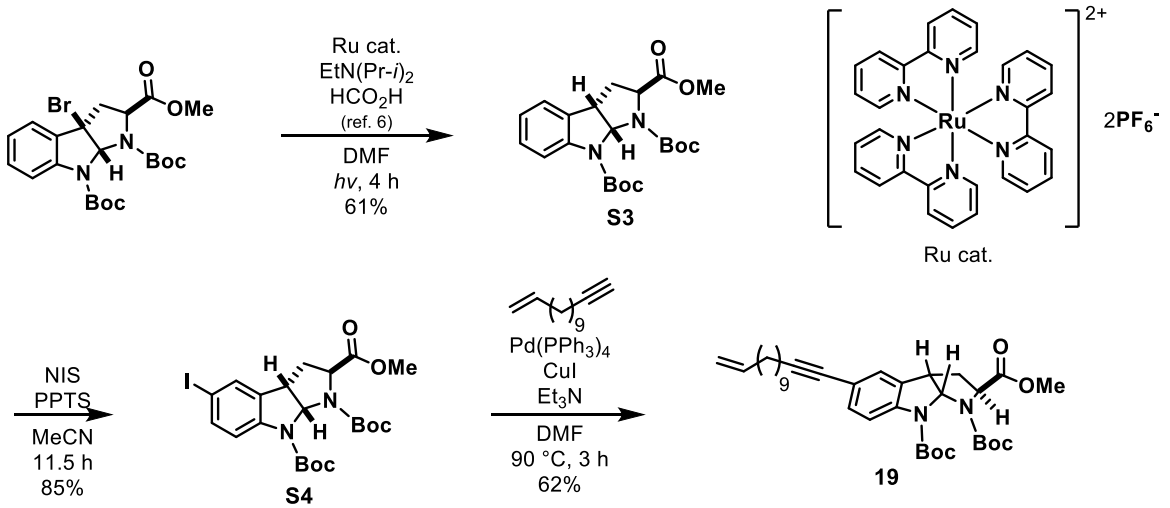
14:[5] R_f = 0.59 (Hex); ^{1}H NMR (500 MHz, $CDCl_3$): δ 5.81 (1H, ddt, J = 17.2, 10.3, 6.8 Hz), 4.99 (1H, ddt, J = 17.2, 2.3, 1.7 Hz), 4.94–4.92 (1H, m), 2.18 (2H, td, J = 7.2, 2.7 Hz), 2.04 (2H, dt, J = 7.5, 6.8 Hz), 1.94 (1H, t, J = 2.7 Hz), 1.56–1.49 (2H, m), 1.40-1.34 (4H, m), 1.28 (8H, s).

[3] X. Lu and R. Bittman, *J. Org. Chem.*, 2005, **70**, 4746–4750.

[4] A. V. Predeus, V. Gopalsamuthiram, R. J. Staples and W. D. Wulff, *Angew. Chem. Int. Ed.*, 2013, **52**, 911–915.

[5] W. Su, T.-J. Gong, Q. Zhang, Q. Zhang, B. Xiao and Y. Fu, *ACS Catal.*, 2016, **6**, 6417–6421.

Syntheses of enyne 19



Compound S3:[6] To a stirred solution of **9** (314 mg 0.631 mmol) in DMF (6.3 mL, 0.10 M) was successively added Ru cat. (tris(2,2'-bipyridyl)ruthenium(II) hexafluorophosphate) (14.1 mg, 16.4 μmol, 2.6 mol%), ethyldiisopropylamine (DIPEA) (1.08 mL, 6.31 mmol, 10 eq.) and HCO_2H (0.240 mL, 6.31 mmol, 10.0 eq.) at room temperature. The resulting mixture was placed at a distance of ~10 cm from a 15 W fluorescent lamp. After being stirred at room temperature for 4 h, the resulting mixture was poured into a separatory funnel containing 80 mL of Et_2O and 80 mL of H_2O. The layers were separated and the aqueous layer was extracted with Et_2O (100 mL × 2). The combined organic extracts were dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The crude residue was purified by silica-gel column chromatography (hexane/AcOEt) to afford **S3** (160 mg, 0.382 mmol. 61%) as a white solid.

S3:[2] R_f = 0.45 (Hex–AcOEt = 2 : 1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.54 (1H, br-s), 7.22 (1H, dd, J = 7,5, 7.5 Hz), 7.15 (1H, d, J = 7.5 Hz), 7.04 (1H, dd, J = 7.5, 7.5 Hz), 6.37 (1H, d, J = 6.3 Hz), 3.97–3.94 (2H, m), 3.72 (3H, s), 2.53 (1H, d, J = 12.7 Hz, 6.9 Hz), 2.28 (1H, ddd, J = 12.7, 9.9, 7.3 Hz), 1.57 (9H, s), 1.39 (9H, s).

Compound S4:[7] To a stirred solution of **S3** (80.2 mg 0.192 mmol) in MeCN (0.80 mL, 0.24 M) was added NIS (104 mg, 0.462 mmol, 2.4 eq.) and PPTS (25.8 mg, 0.103 mmol, 54 mol%) at room temperature. After being stirred at room temperature for 11.5 h, the mixture was diluted with AcOEt, washed with saturated aqueous solution of $NaHCO_3$ (10 mL), Na_2SO_3 (25 mL) and then brine. The organic layer was dried over Na_2SO_4, filtered, and concentrated *in vacuo*. The crude residue was purified by silica-gel column chromatography (hexane/AcOEt) to afford **S4** (88.7 mg, 0.163 mmol. 85%) as a white solid.

S4: R_f = 0.50 (Hex–AcOEt = 2 : 1); ^{1}H NMR (500 MHz, $CDCl_3$, 50 ºC): δ 7.52 (1H, d, J = 8.3 Hz), 7.44 (1H, s), 7.36 (1H, br-d, J = 8.3 Hz), 6.32 (1H, d, J = 5.7 Hz), 4.00 (1H, dd, J = 9.5, 7.2 Hz), 3.95–3.91 (1H, m), 3.73 (3H, s), 2.50–2.46 (1H, m), 2.30–2.24 (1H, m), 1.56 (9H, s), 1.39 (9H, s); ^{13}C NMR (125 MHz, $CDCl_3$, 50 ºC): δ 173.09, 152.27, 142.63, 137.49, 135.03, 132.63, 119.67, 86.10, 82.13, 81.04, 59.20, 52.19, 44.74, 33.06, 28.46, 28.38; HR-MS (ESI): calcd. for $C_{22}H_{29}IN_2O_6Na$ $[M+Na]^+$ 567.0962, found 567.0945.

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[2] M. Wada, T. Murata, H. Oikawa and H. Oguri, *Org. Biomol. Chem.*, 2014, **12**, 298–306.

[6] M. R. Narayan, J. W. Tucker and C. R. J. Stephenson, *J. Am. Chem. Soc.*, 2009, **131**, 8756–8757.

[7] Y. Wu, F. Wang, H. Song and Y. Qin, *Helv. Chim. Acta*, 2011, **94**, 1496–1505.

Compound 19:[8] $Pd(PPh_3)_4$ (21.7 mg, 18.8 μmol, 17 mol%) and CuI (4.60 mg, 24.2 μmol, 22 mol%) were placed in a flask, and a solution of the iodide **S4** (58.7 mg, 0.108 mmol), enyne **12** (61.0 mg, 0.342 mmol, 3.2 eq.) and Et_3N (2.7 mL) in DMF (1.35 mL) was added. The mixture was heated at 90 °C with stirring for 3 h. After being cooled to 0 ºC, the resulting mixture was treated with saturated aqueous solution of NH_4Cl (10 mL) and extracted with Et_2O (50 mL × 3). The combined organic extracts were washed with H_2O (40 mL × 3) and brine, dried over Na_2SO_4, filtered and concentrated *in vacuo*. The crude residue was purified by silica-gel column chromatography (hexane/AcOEt) to afford **19** (48.2 mg, 81.0 μmol, 75%) as a pale brown amorphous.

19: R_f = 0.63 (Hex–AcOEt = 2 : 1); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.47 (1H, br-s), 7.27 (1H, br d, J = 8.0 Hz), 7.19 (1H, s), 6.35 (1H, d, J = 5.7 Hz), 5.81 (1H, ddt, J = 17.2, 10.3, 6.8 Hz), 5.01–4.97 (1H, m), 4.94–4.91 (1H, m), 3.96 (1H, dd, J = 9.7, 6.9 Hz), 3.92 (1H, br-t, J = 6.3 Hz), 3.72 (3H, s), 2.51 (1H, dd, J = 12.7, 7.2 Hz), 2.38 (2H, t, J = 7.2 Hz), 2.26 (1H, ddd, J = 12.7, 9.7, 7.2 Hz), 2.04 (2H, dt, J = 7.1, 7.1 Hz), 1.62–1.25 (14H, m), 1.56 (9H, s), 1.39 (9H, s); ^{13}C-NMR (125 Hz, $CDCl_3$): δ 173.22, 152.38, 141.87, 139.38, 132.33, 132.12, 126.73, 119.24, 117.48, 114.26, 89.87, 81.95, 80.98, 80.39, 59.11, 52.27, 44.75, 33.95, 33.04, 29.85, 29.62, 29.31, 29.28, 29.09, 28.96, 28.45, 28.36, 19.57; HR-MS (ESI): calcd for $C_{35}H_{50}N_2O_6Na$ $[M+Na]^+$ 617.3561, found 617.3544.

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[8] (a) M. Laugeois, J. Ling, C. Feŕard, V. Michelet, V. Ratovelomanana-Vidal and M. R. Vitale, *Org. Lett*., 2017, **19**, 2266−2269; (b) S. Thorand and N. Krause, *J. Org. Chem.,* 1998, **63***,* 8551–8553.

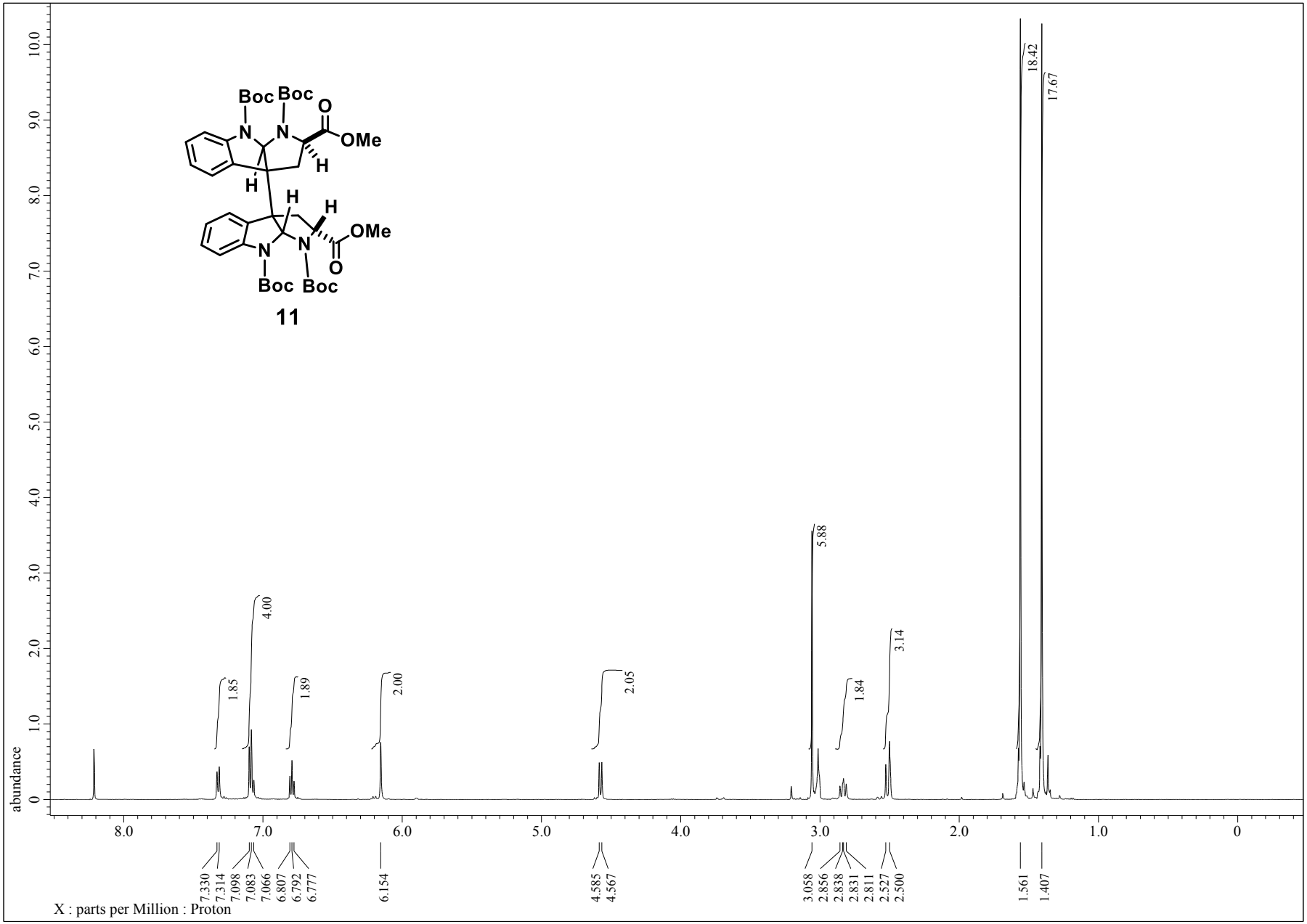

Figure S5 ^{1}H-NMR spectrum (500 MHz) of **11** in DMSO-d_6 at 90 ºC.

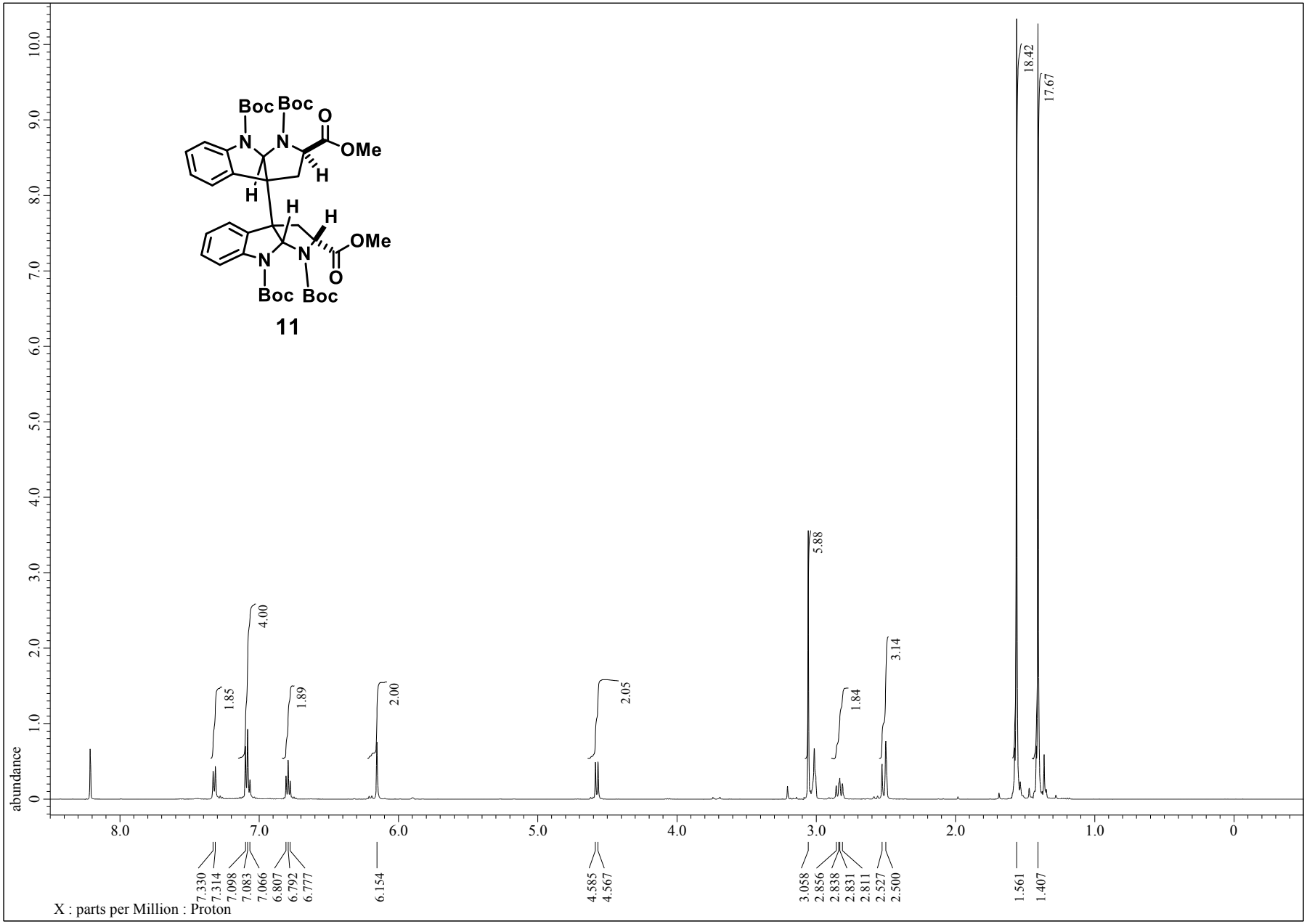

Figure S6 ^{13}C-NMR spectrum (125 MHz) of **11** in DMSO-d_6 at 90 ºC.

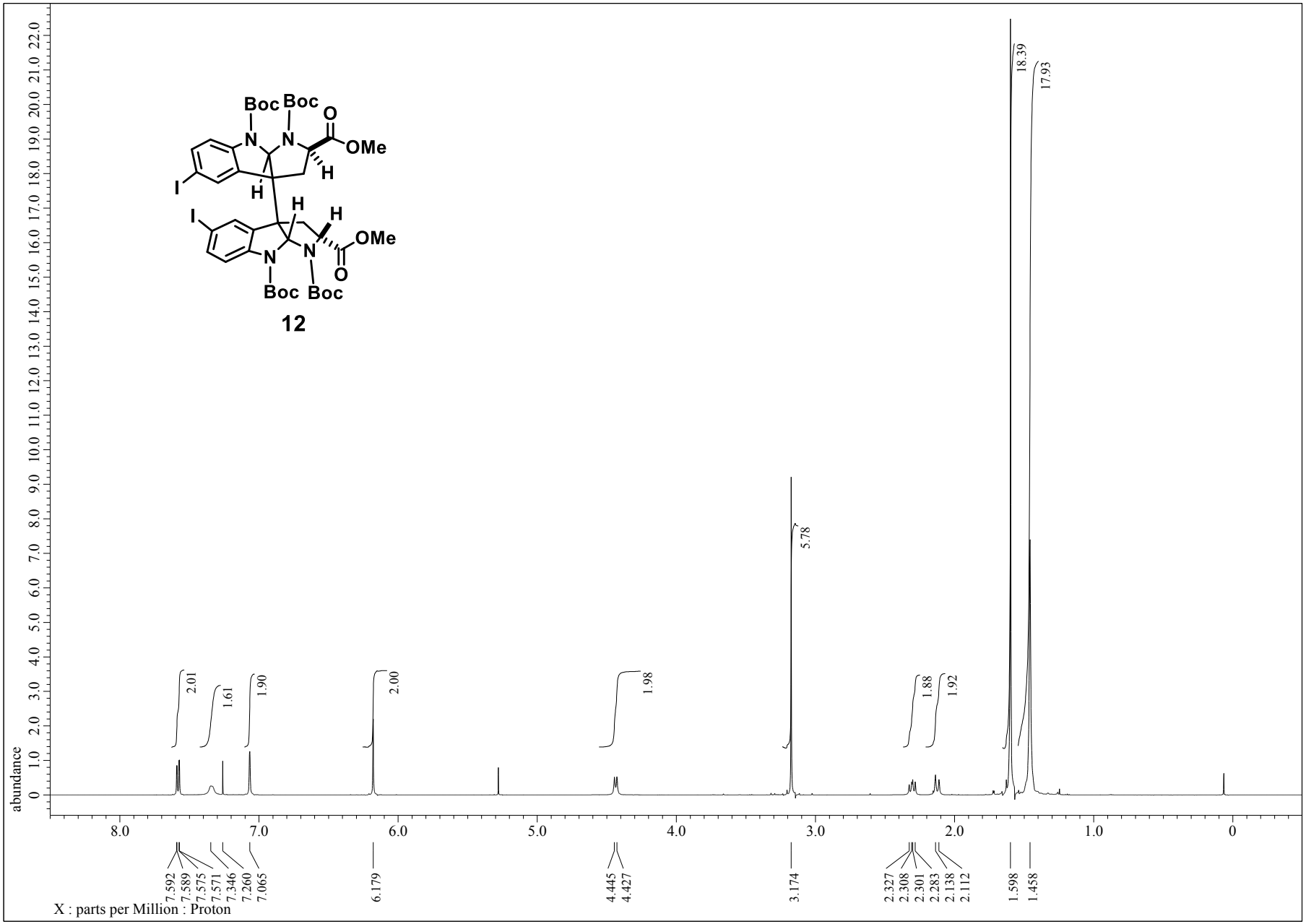

Figure S7 ^{1}H-NMR spectrum (500 MHz) of **12** in $CDCl_3$ at 50 ºC.

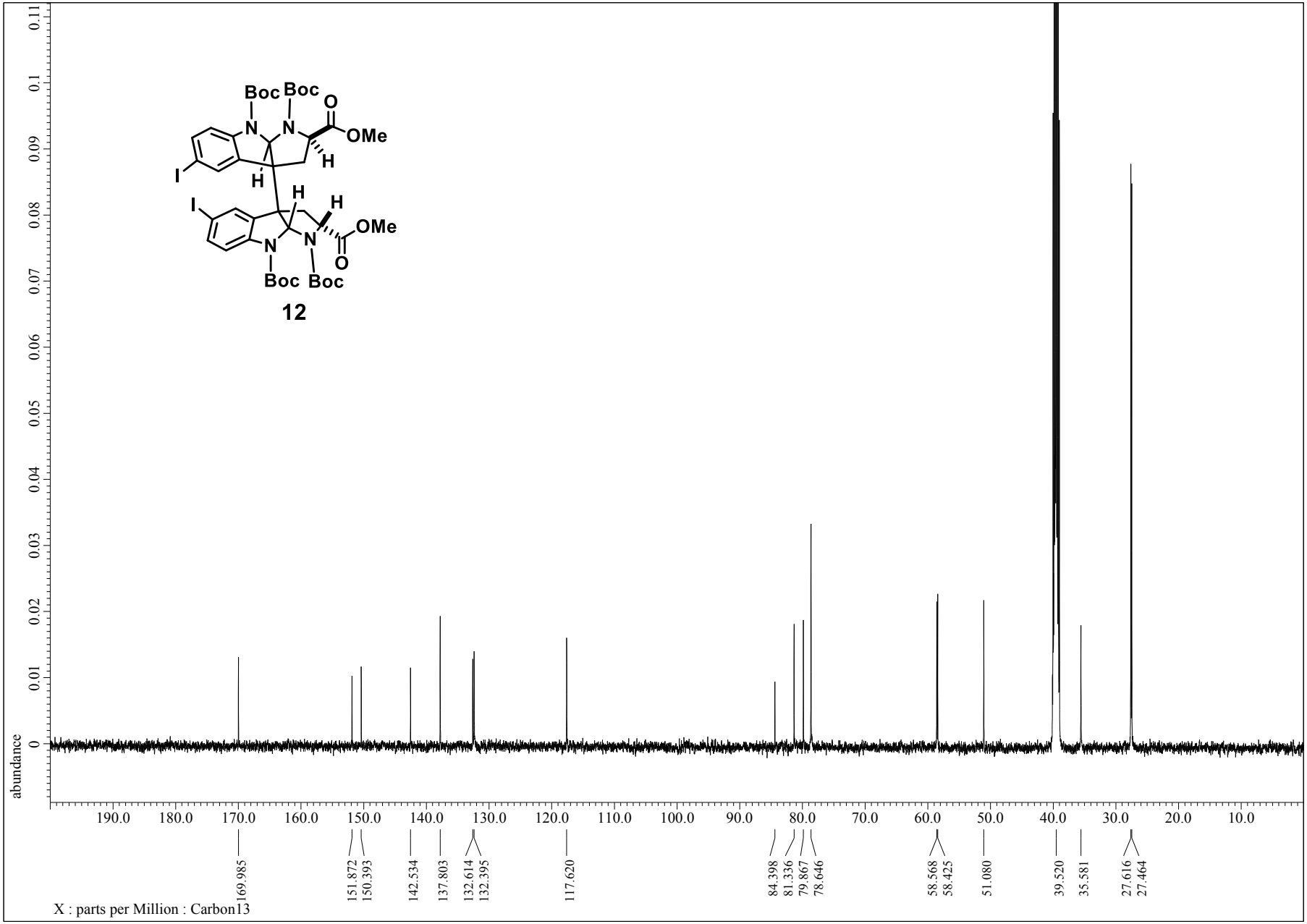

Figure S8 ^{13}C-NMR spectrum (125 MHz) of **12** in DMSO-d_6 at 90 ºC.

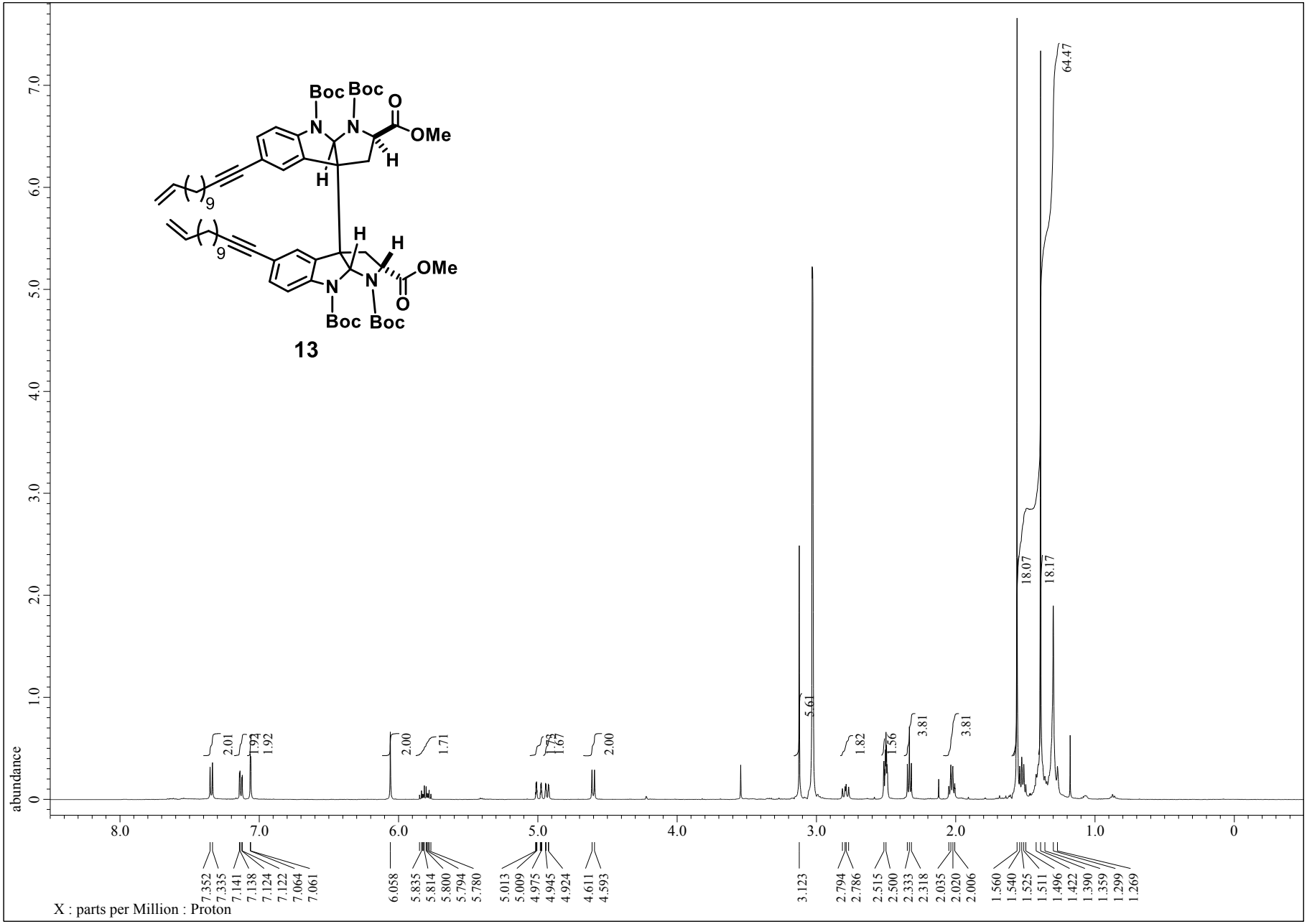

Figure S9 ^{1}H-NMR spectrum (500 MHz) of **13** in DMSO-d_6 at 90 ºC.

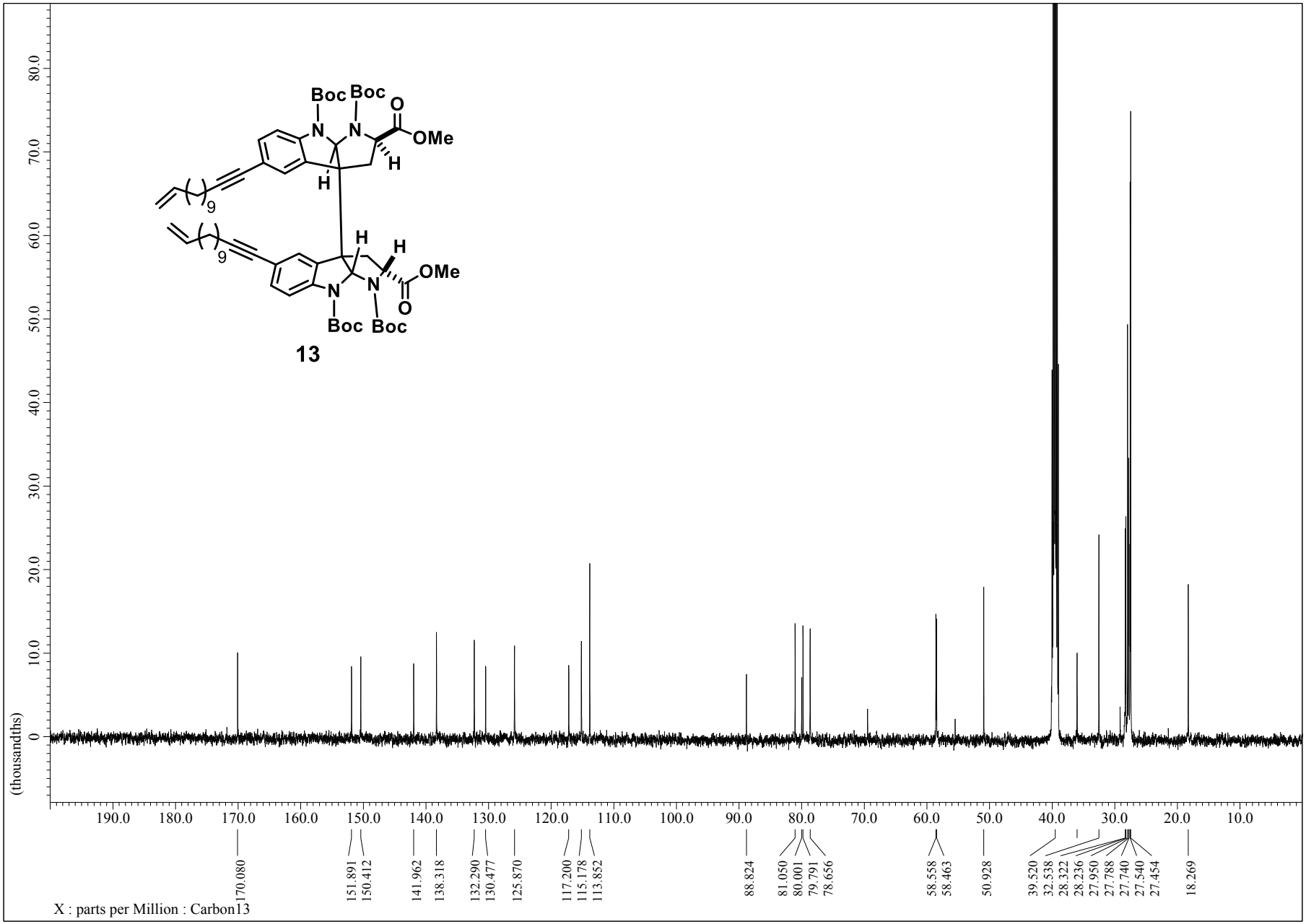

Figure S10 ^{13}C-NMR spectrum (125 MHz) of **13** in DMSO-d_6 at 90 ºC.

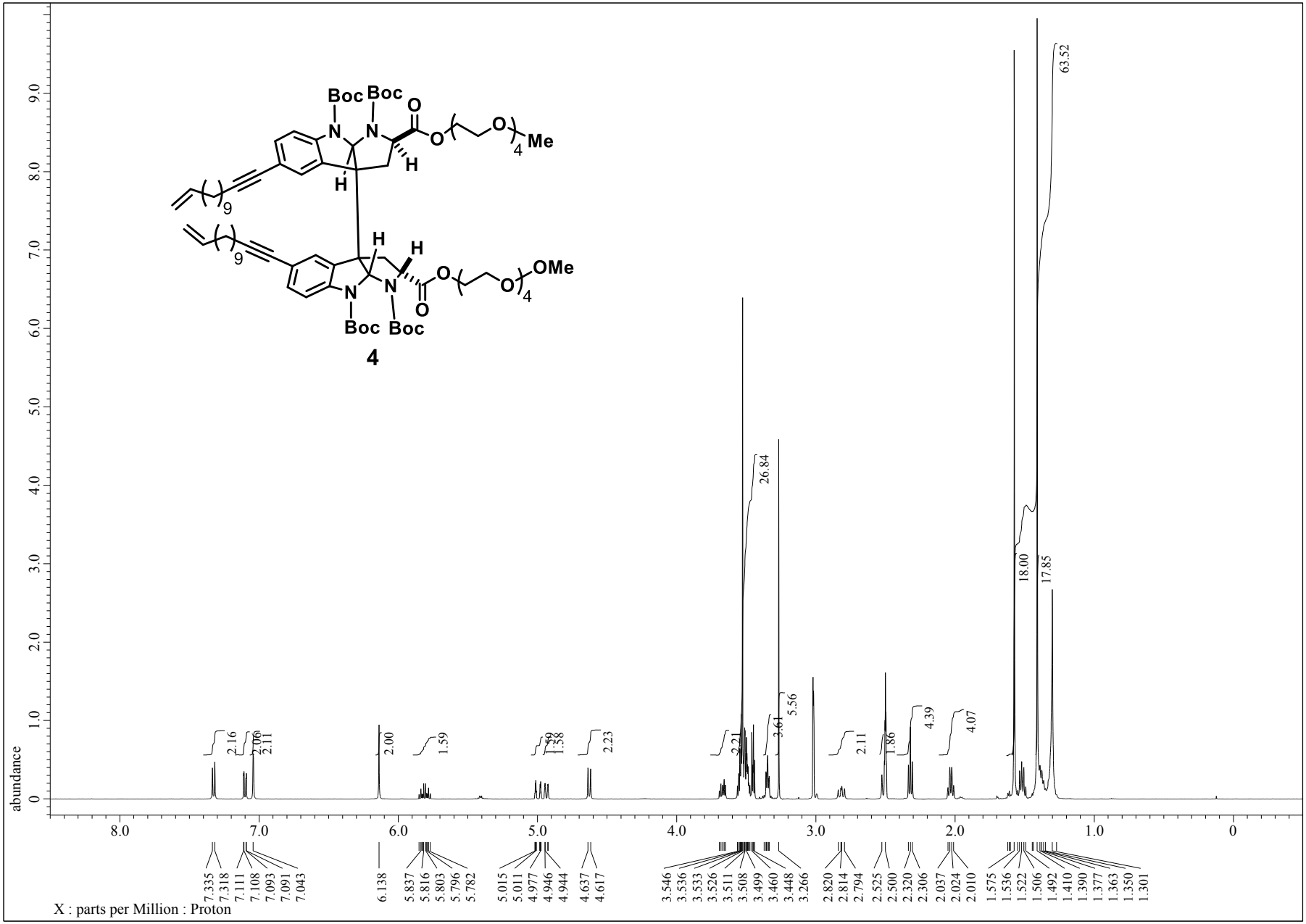

Figure S11 ^{1}H-NMR spectrum (500 MHz) of **4** in DMSO-d_6 at 90 ºC.

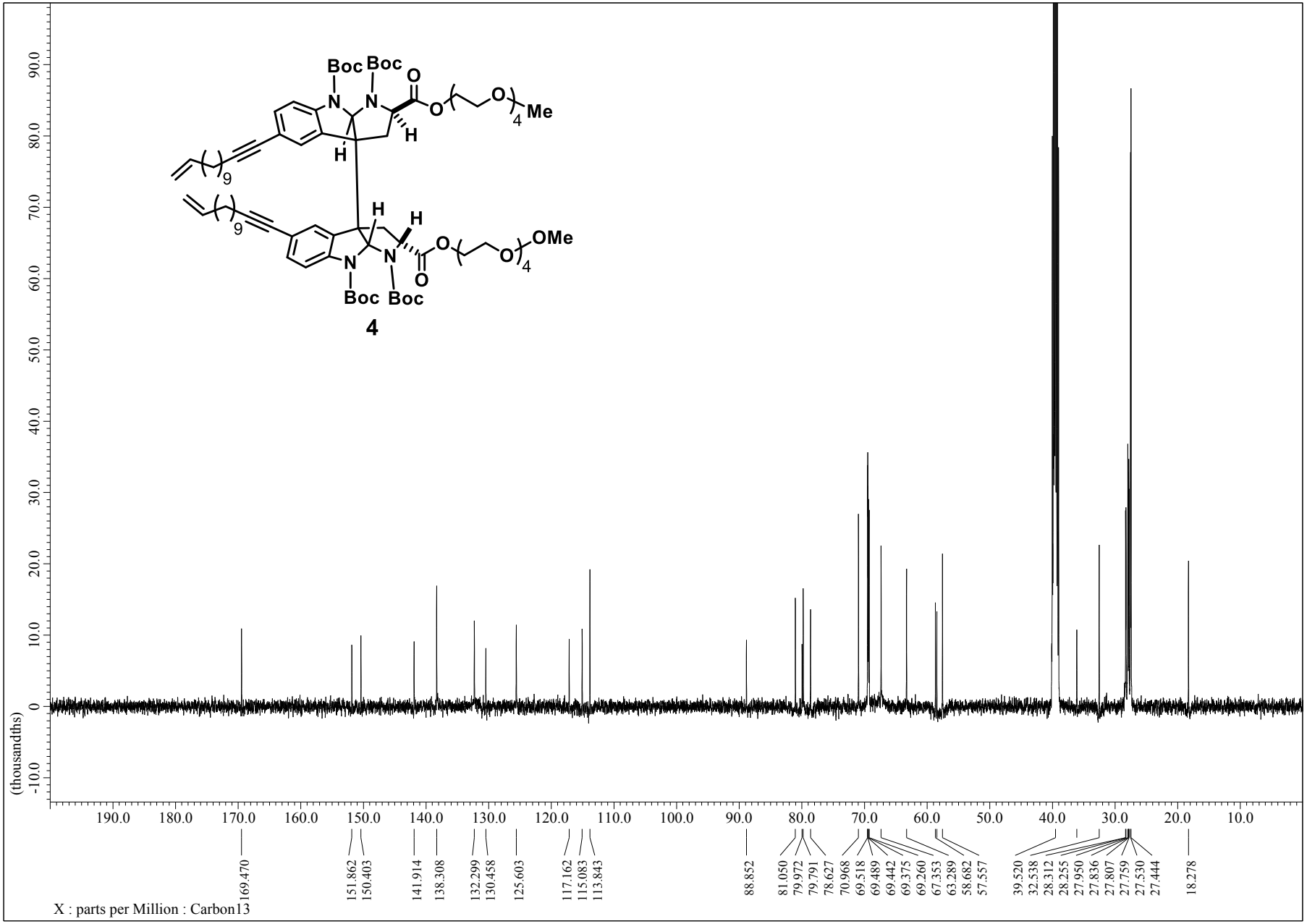

Figure S12 ^{13}C-NMR spectrum (500 MHz) of **4** in DMSO-d_6 at 90 ºC.

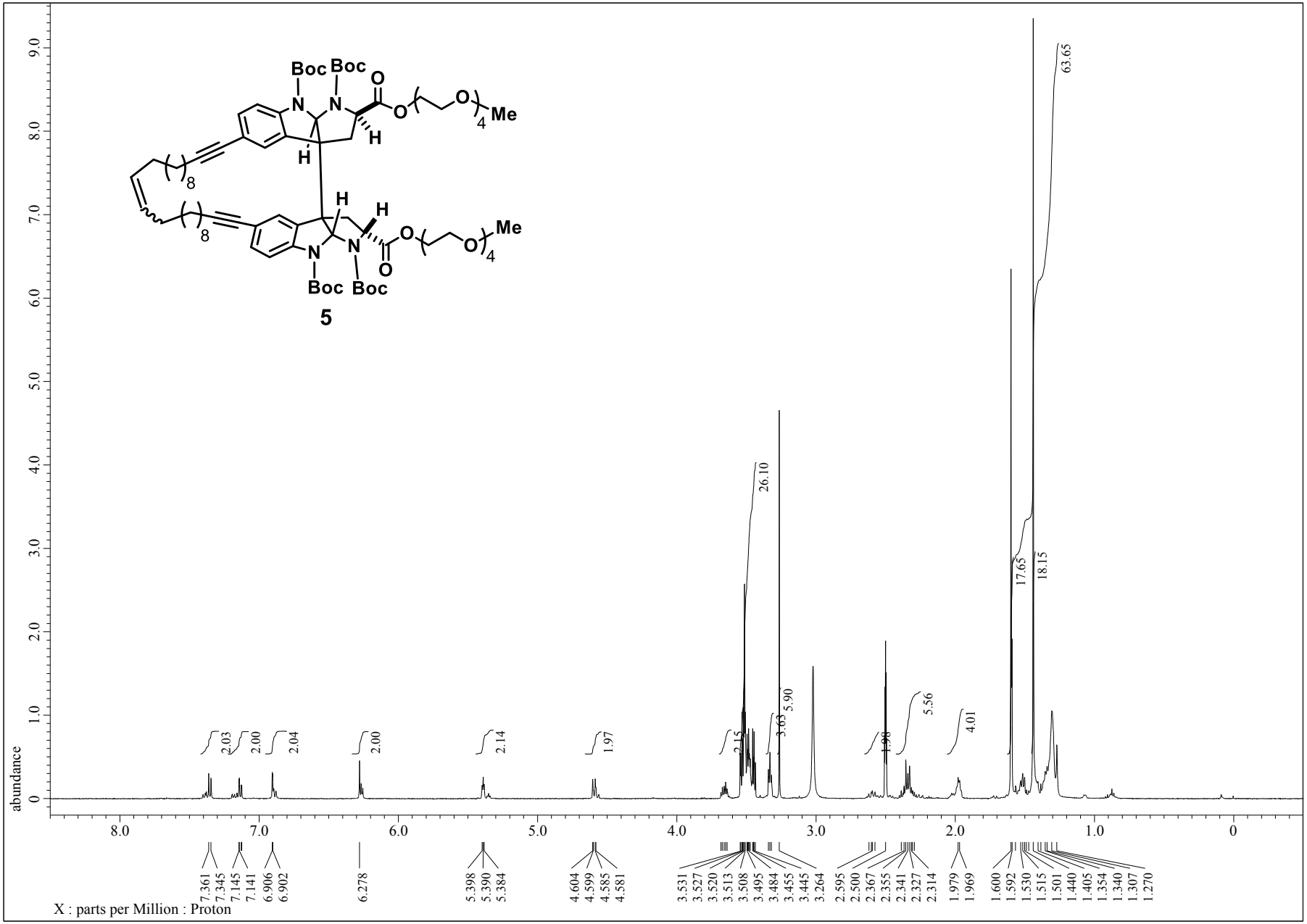

Figure S13 ^{1}H-NMR spectrum (500 MHz) of **5** in DMSO-d_6 at 90 ºC.

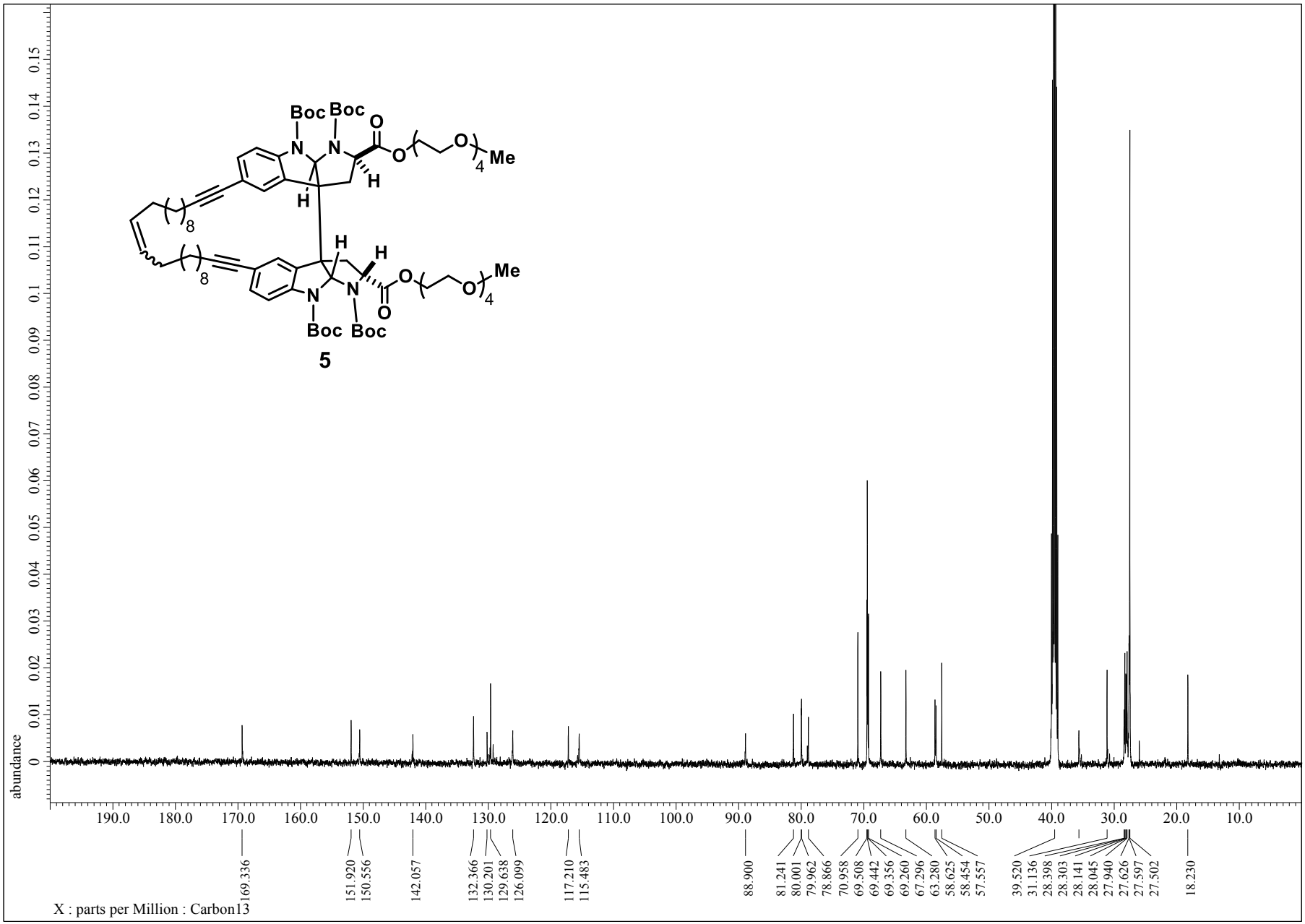

Figure S14 ^{13}C-NMR spectrum (125 MHz) of **5** in DMSO-d_6 at 90 ºC.

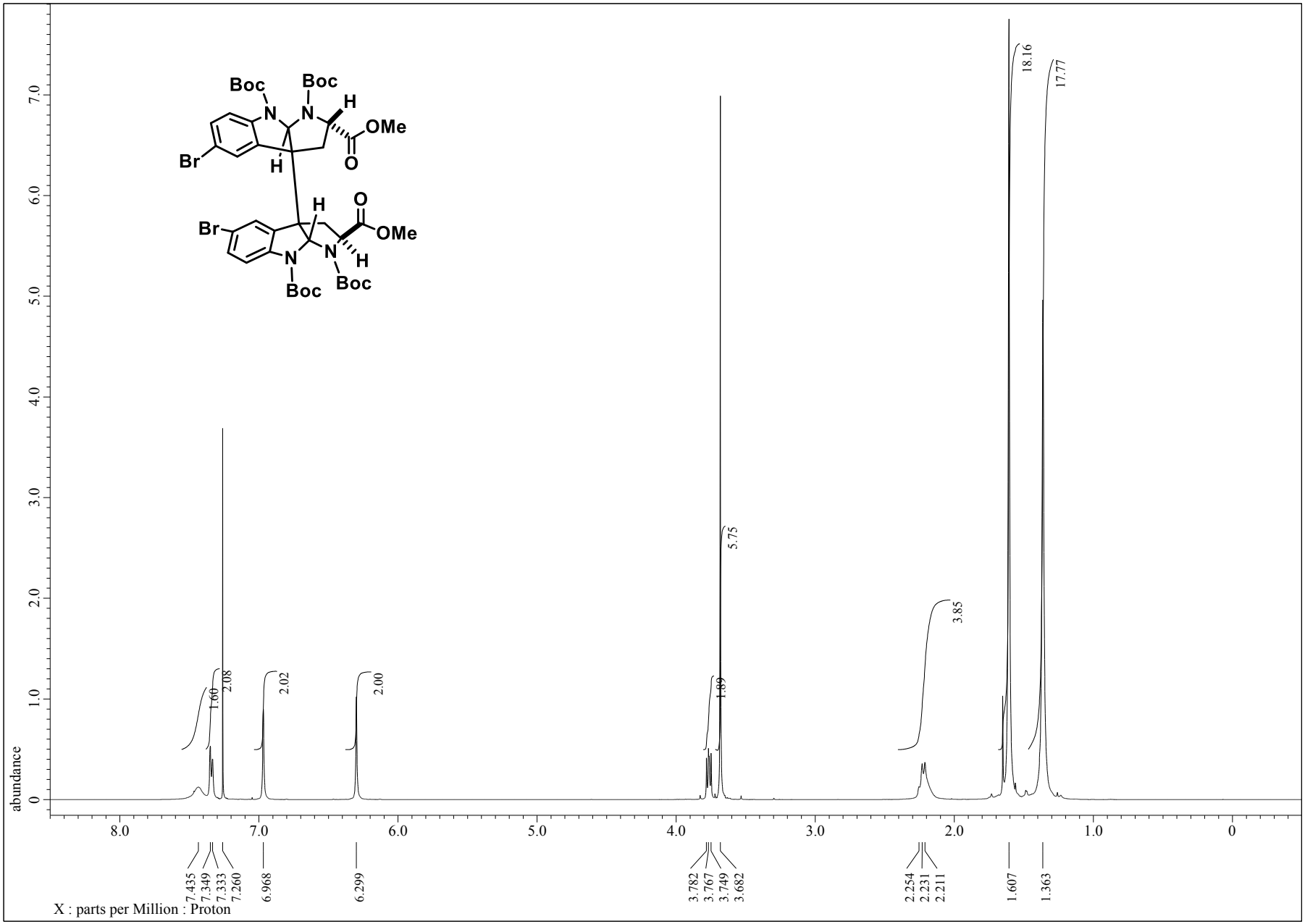

Figure S15 ^{1}H-NMR spectrum (500 MHz) of the aryl bromide (obtained through bromination of **10**) in $CDCl_3$ at 50 ºC.

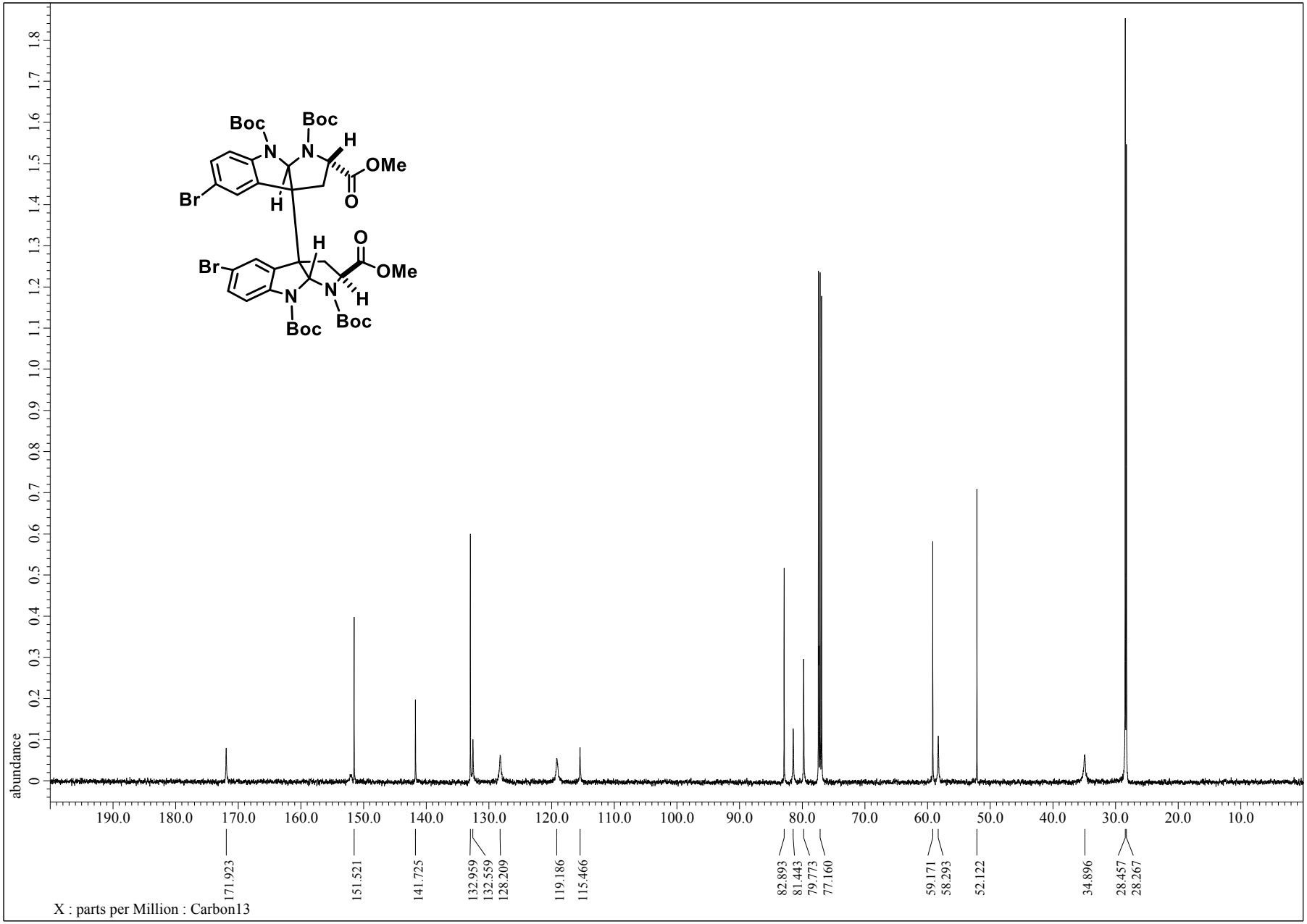

Figure S16 ^{13}C-NMR spectrum (125 MHz) of the aryl bromide (obtained through bromination of **10**) in $CDCl_3$ at 50 ºC.

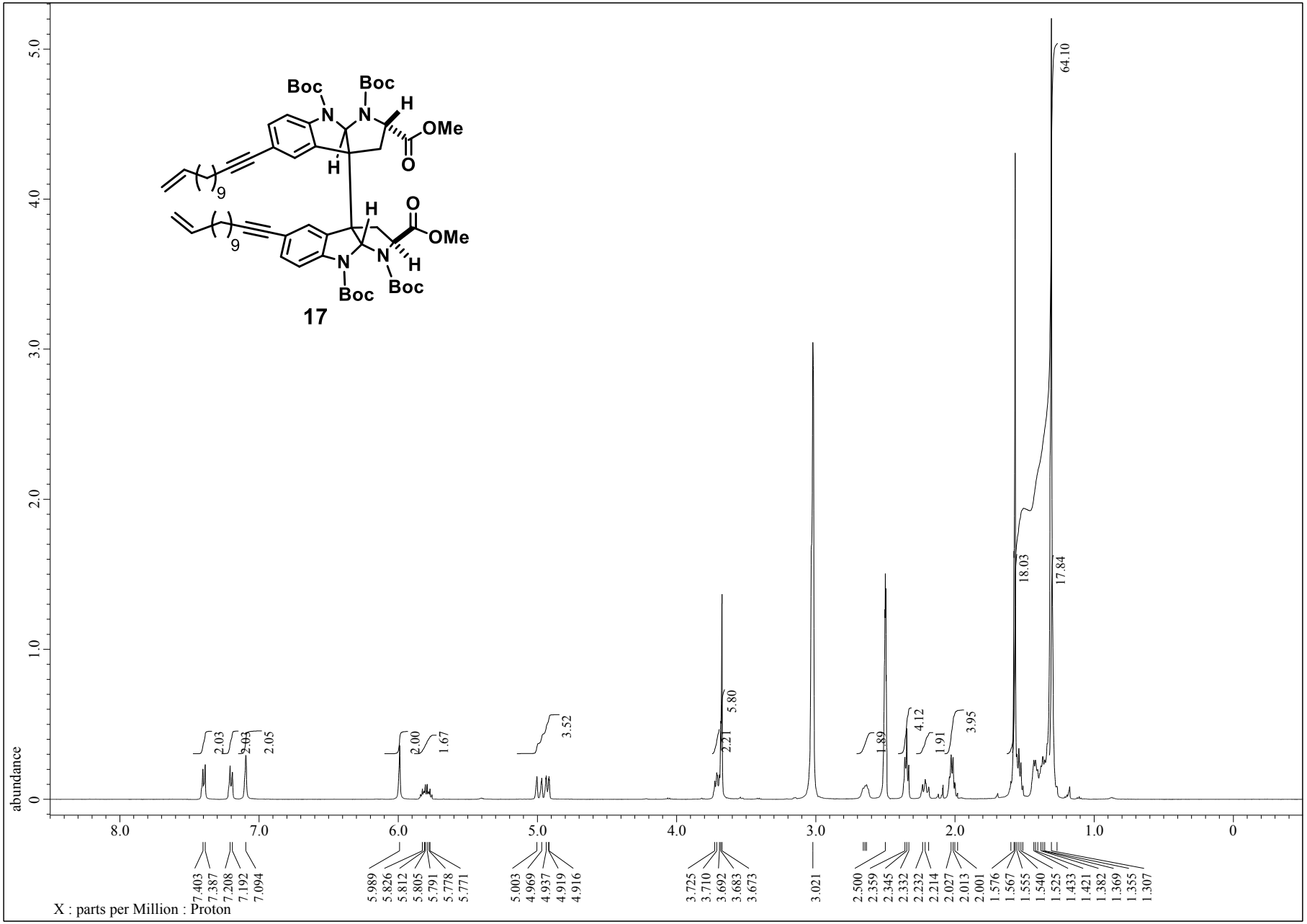

Figure S17 ^{1}H-NMR spectrum (500 MHz) of **17** in DMSO-d_6 at 90 ºC.

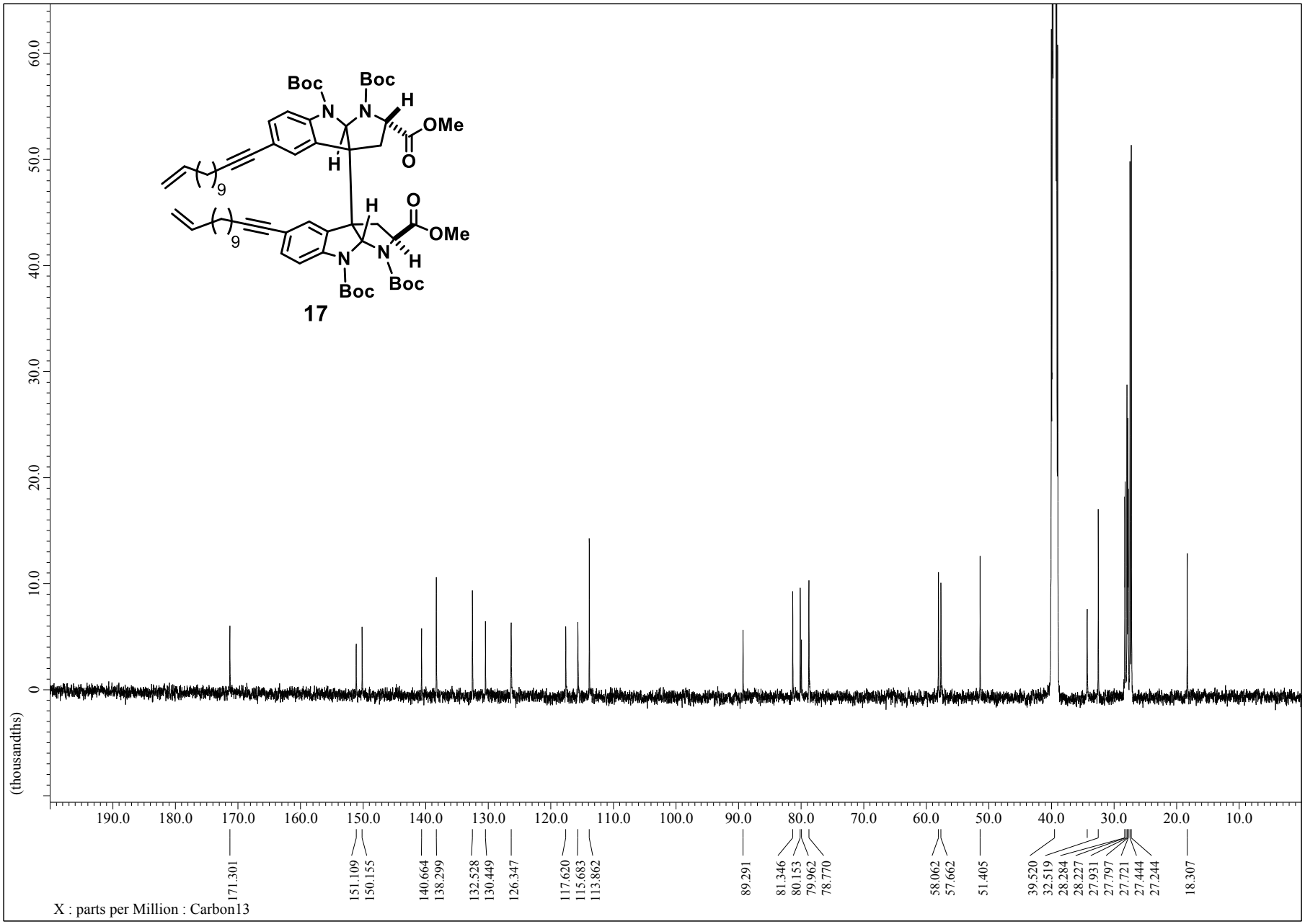

Figure S18 ^{13}C-NMR spectrum (125 MHz) of **17** in DMSO-d_6 at 90 ºC.

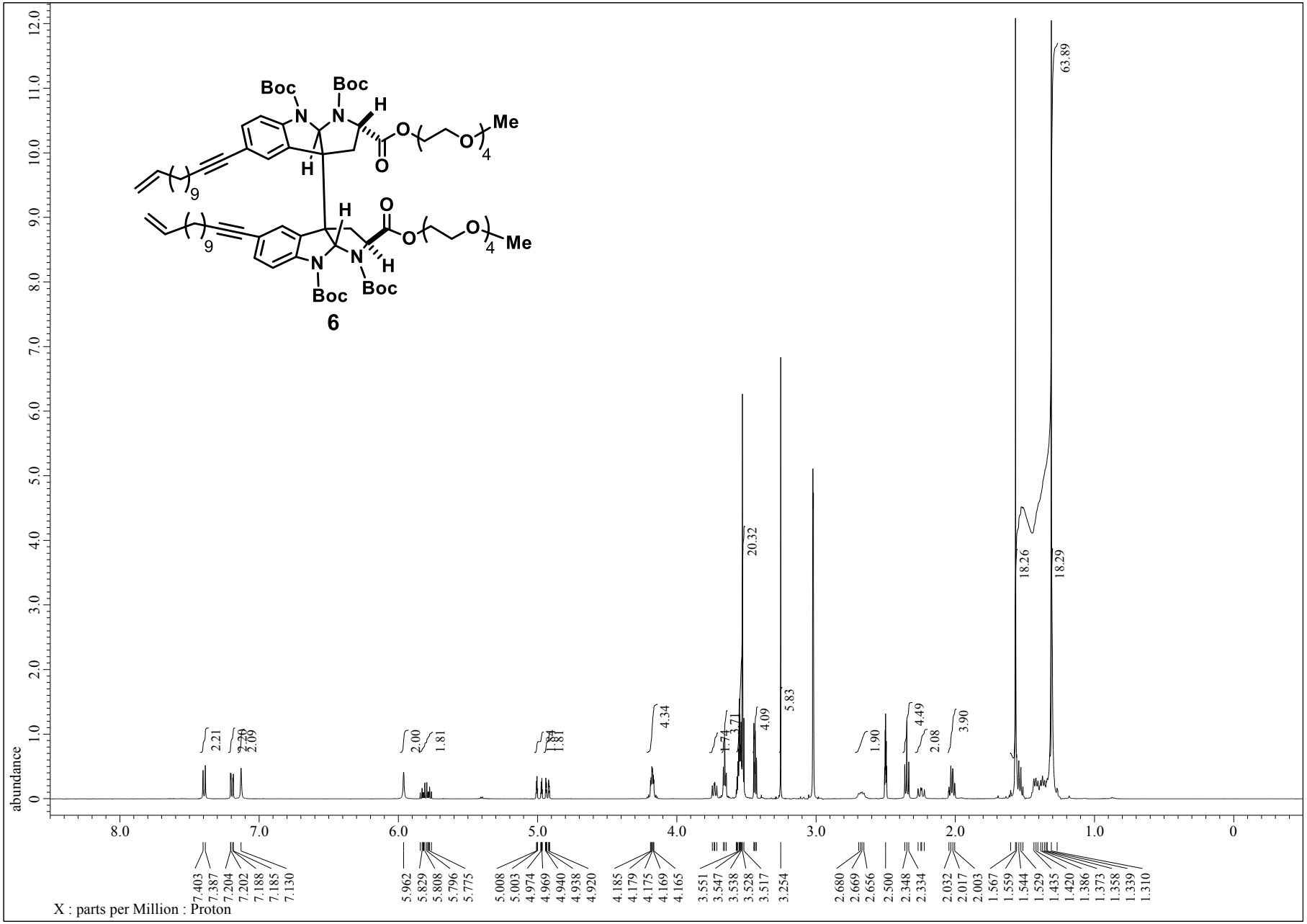

Figure S19 ^{1}H-NMR spectrum (500 MHz) of **6** in DMSO-d_6 at 90 ºC.

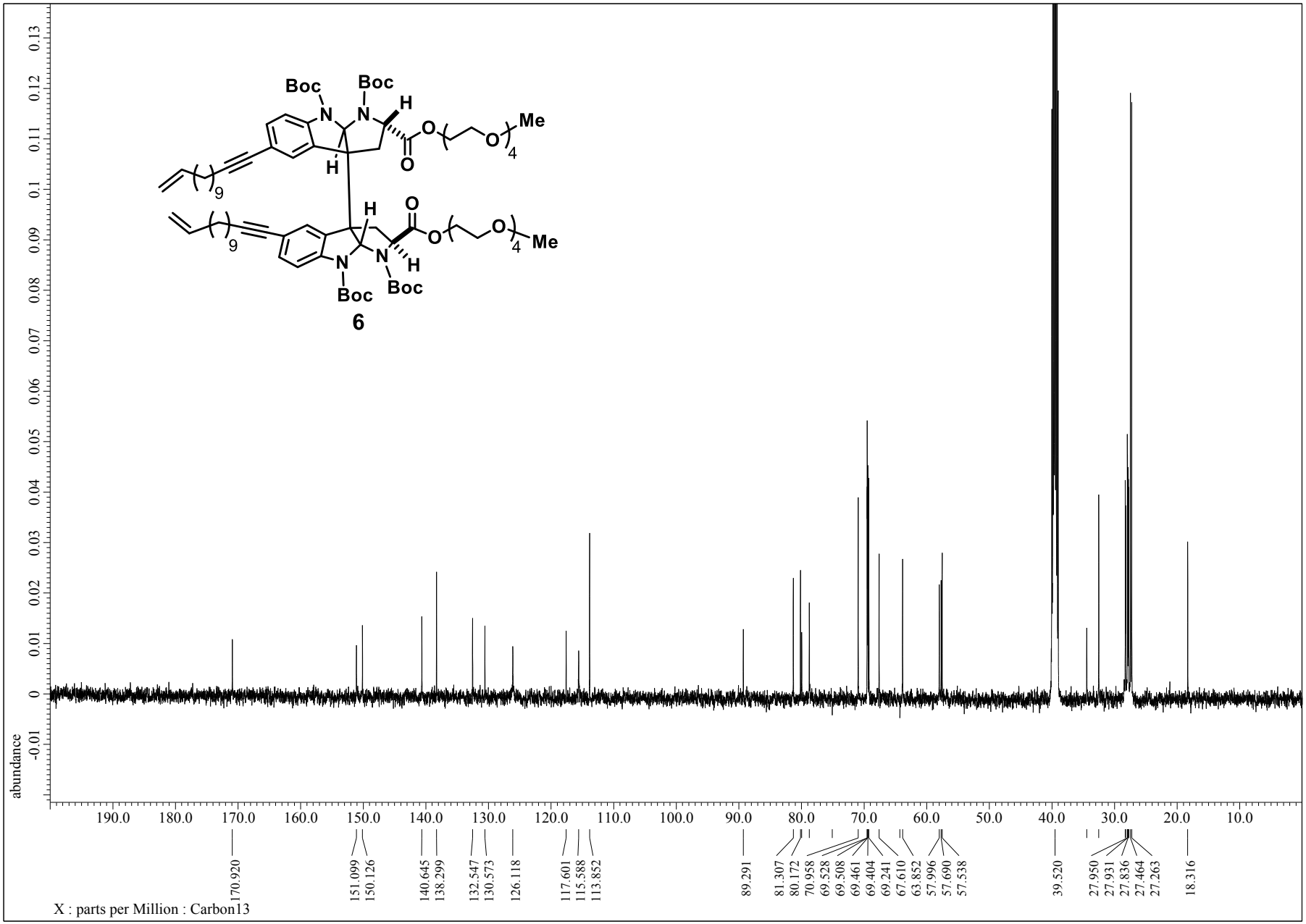

Figure S20 ^{13}C-NMR spectrum (125 MHz) of **6** in DMSO-d_6 at 90 ºC.

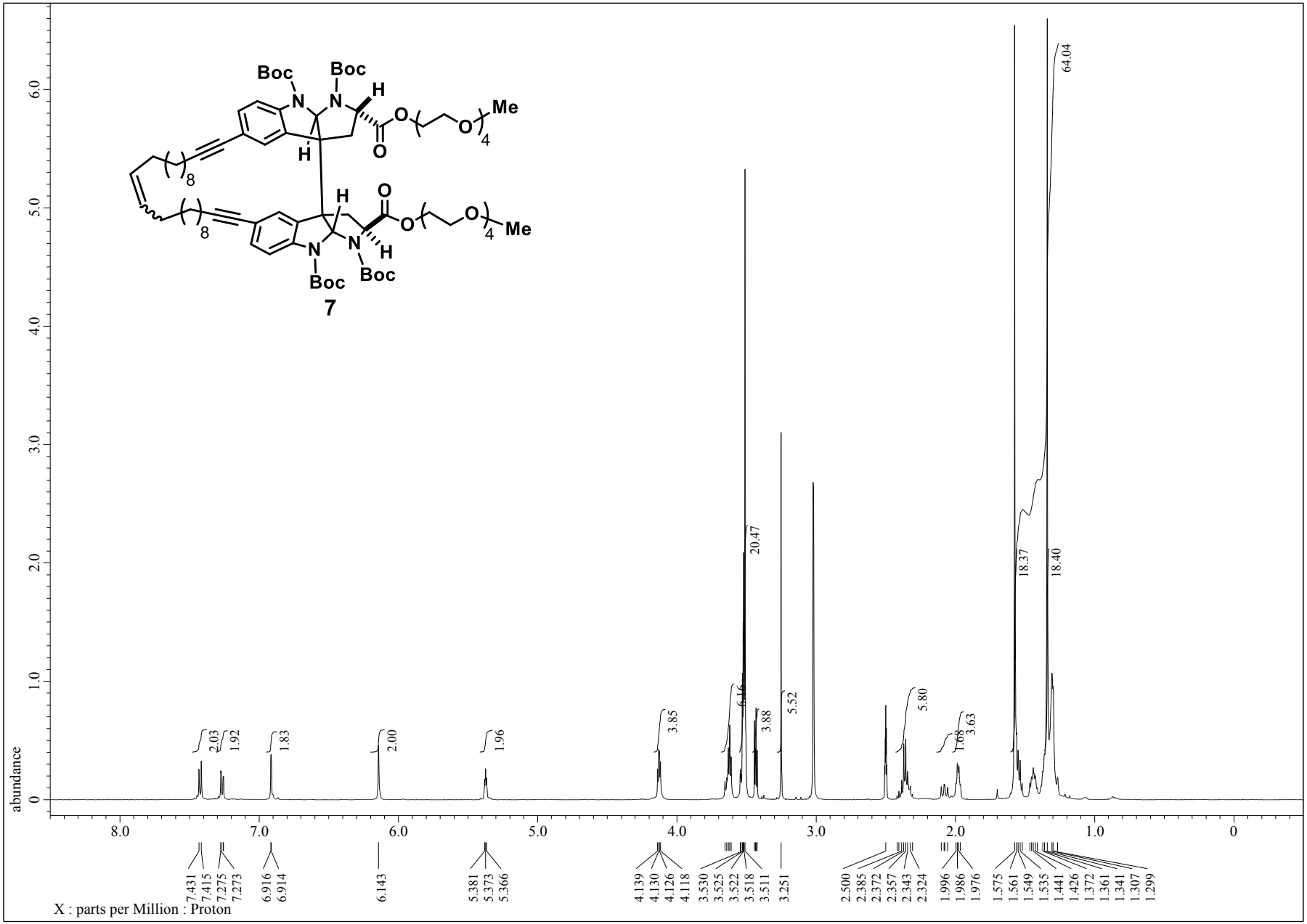

Figure S21 ^{1}H-NMR spectrum (500 MHz) of **7** in DMSO-d_6 at 90 ºC.

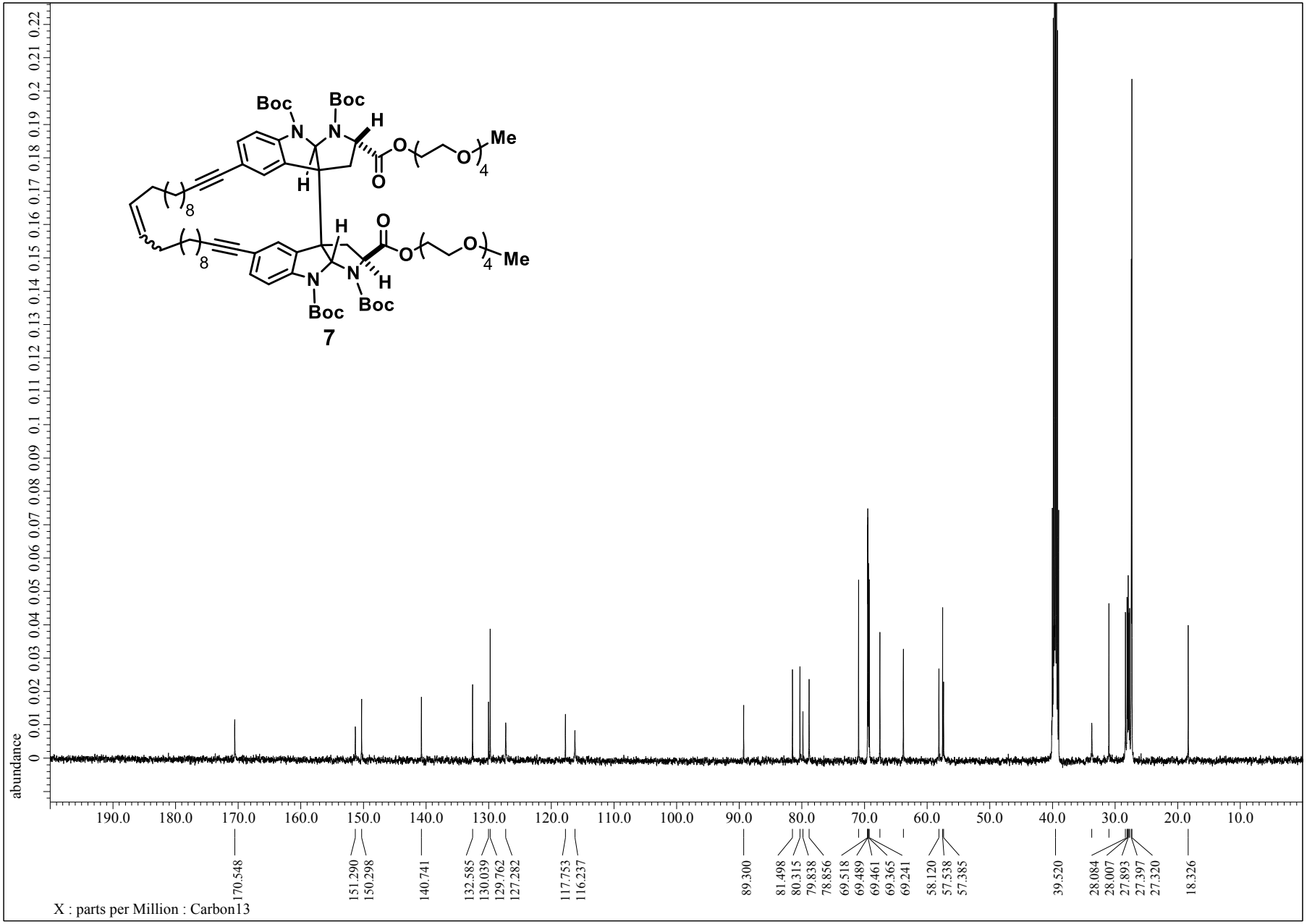

Figure S22 ^{13}C-NMR spectrum (125 MHz) of **7** in DMSO-d_6 at 90 ºC.

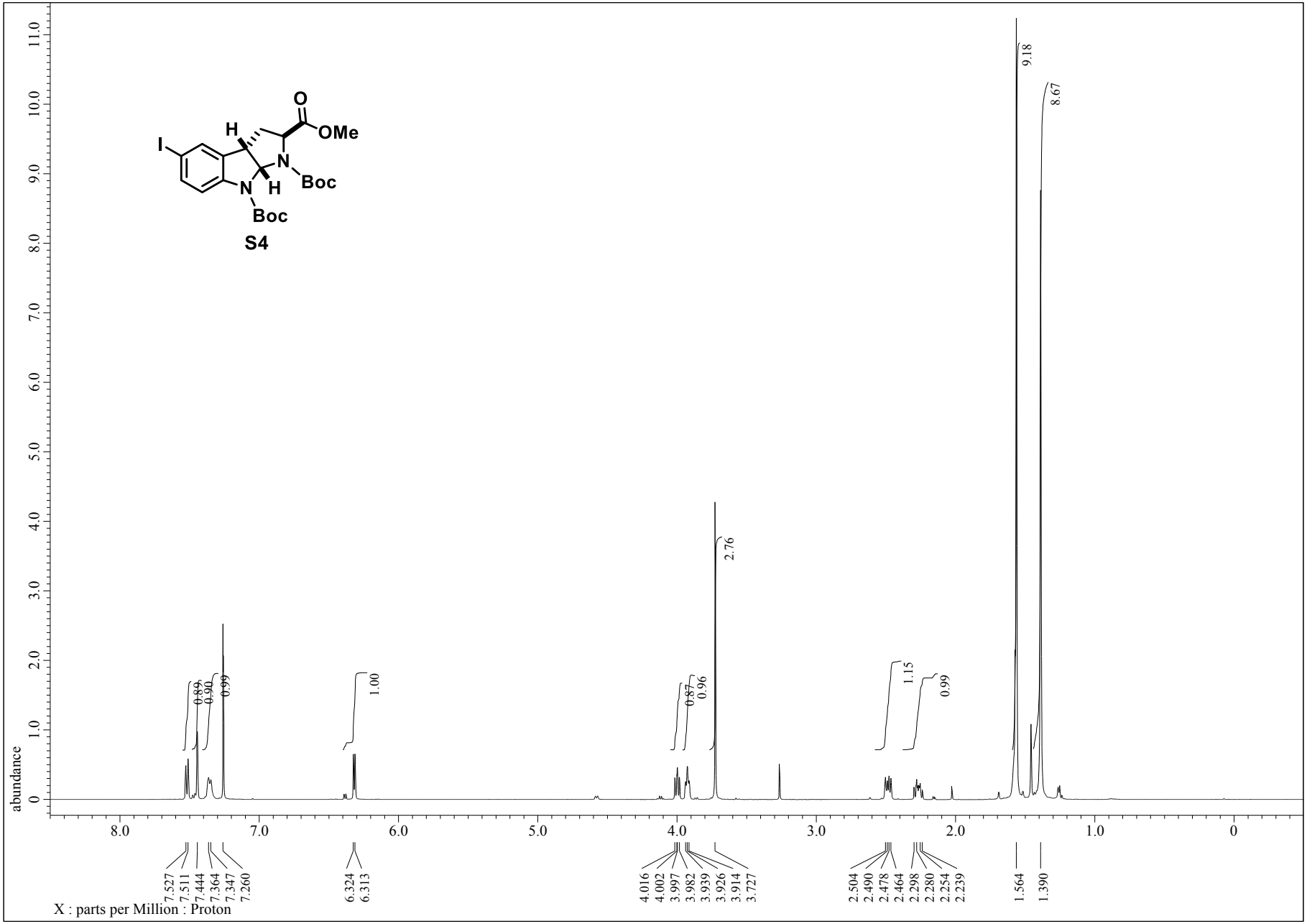

Figure S23 ^{1}H-NMR spectrum (500 MHz) of **S4** in $CDCl_3$ at 50 ºC.

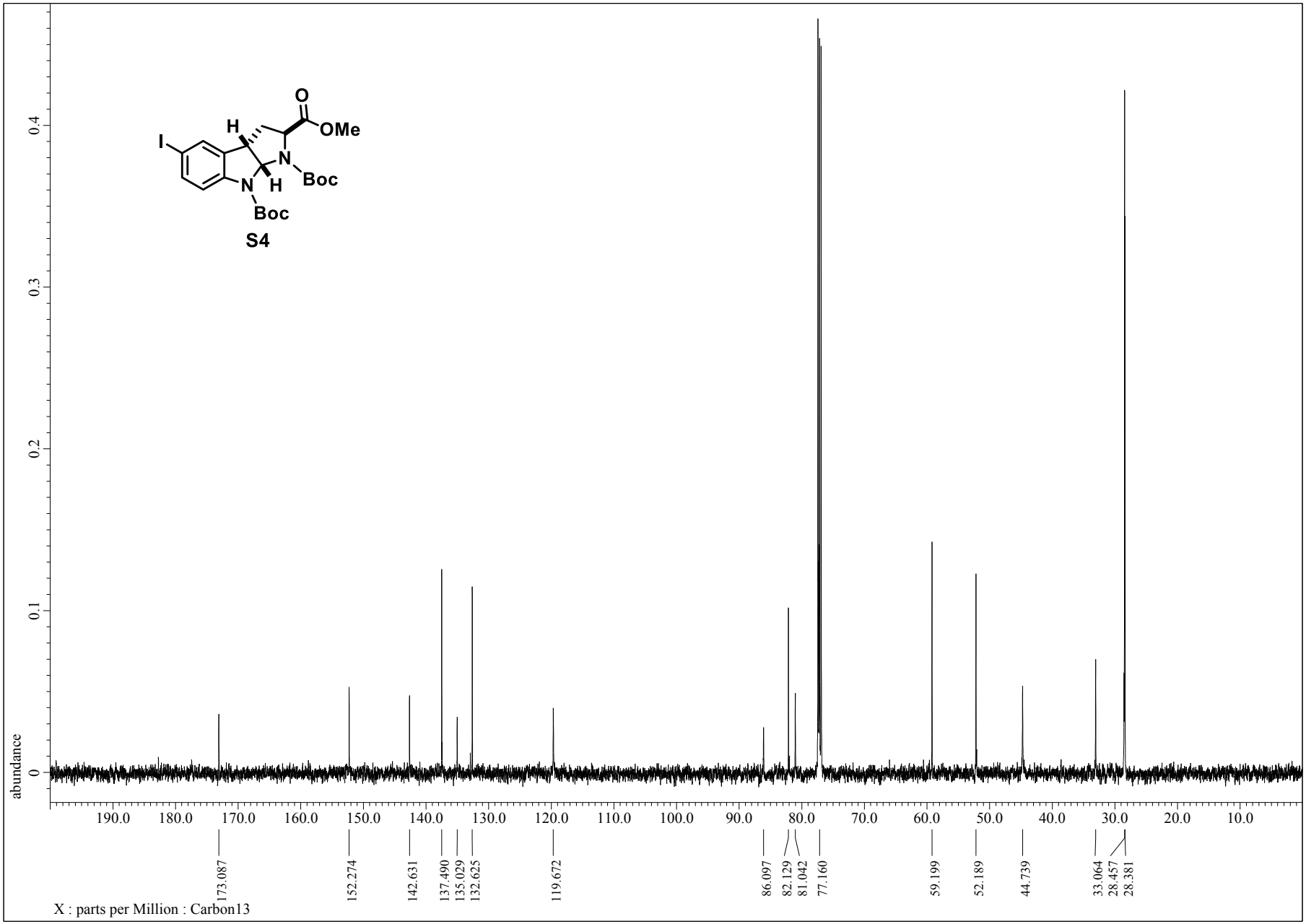

Figure S24 ^{13}C-NMR spectrum (125 MHz) of **S4** in $CDCl_3$ at 50 ºC.

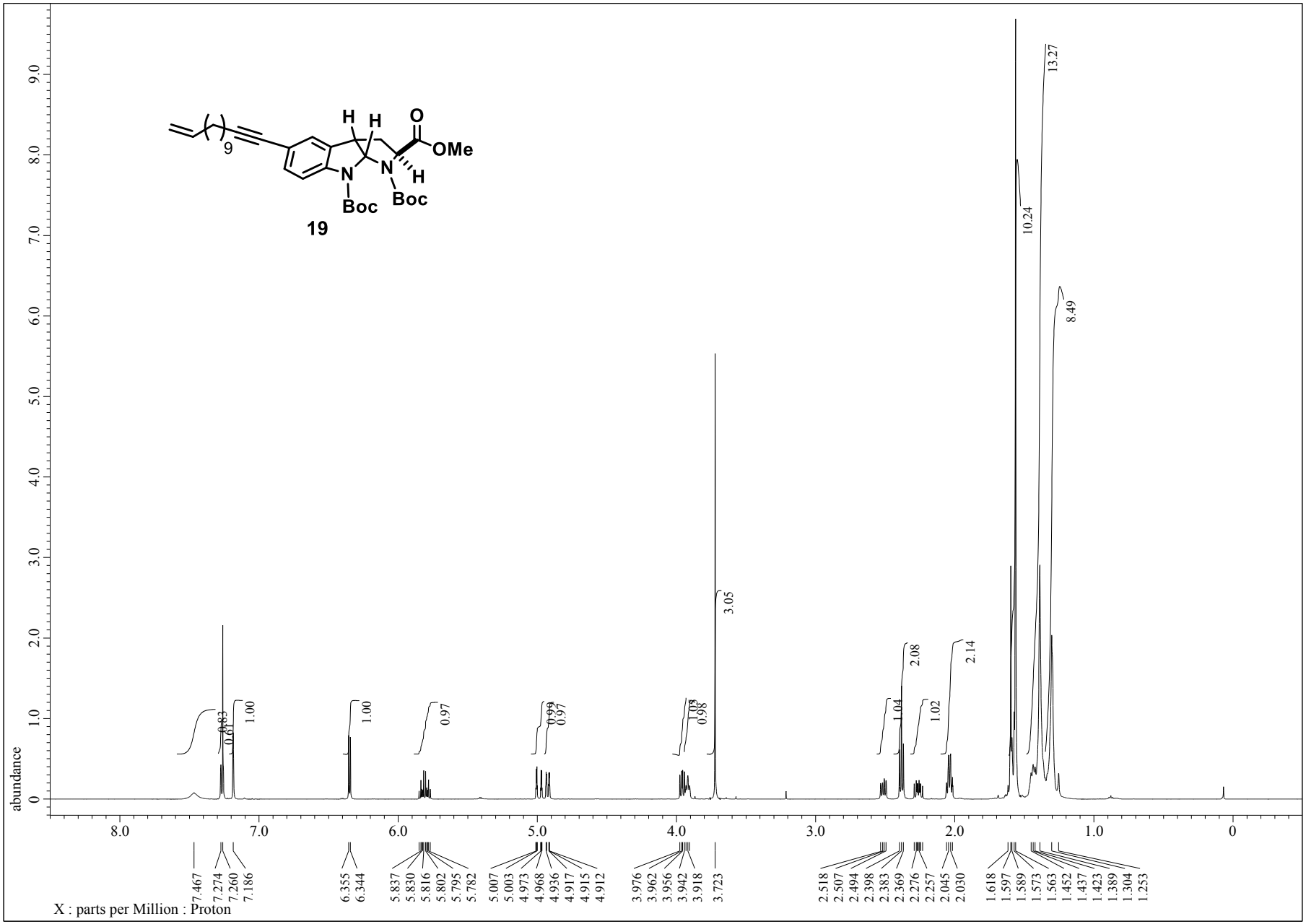

Figure S25 ^{1}H-NMR spectrum (500 MHz) of **19** in $CDCl_3$.

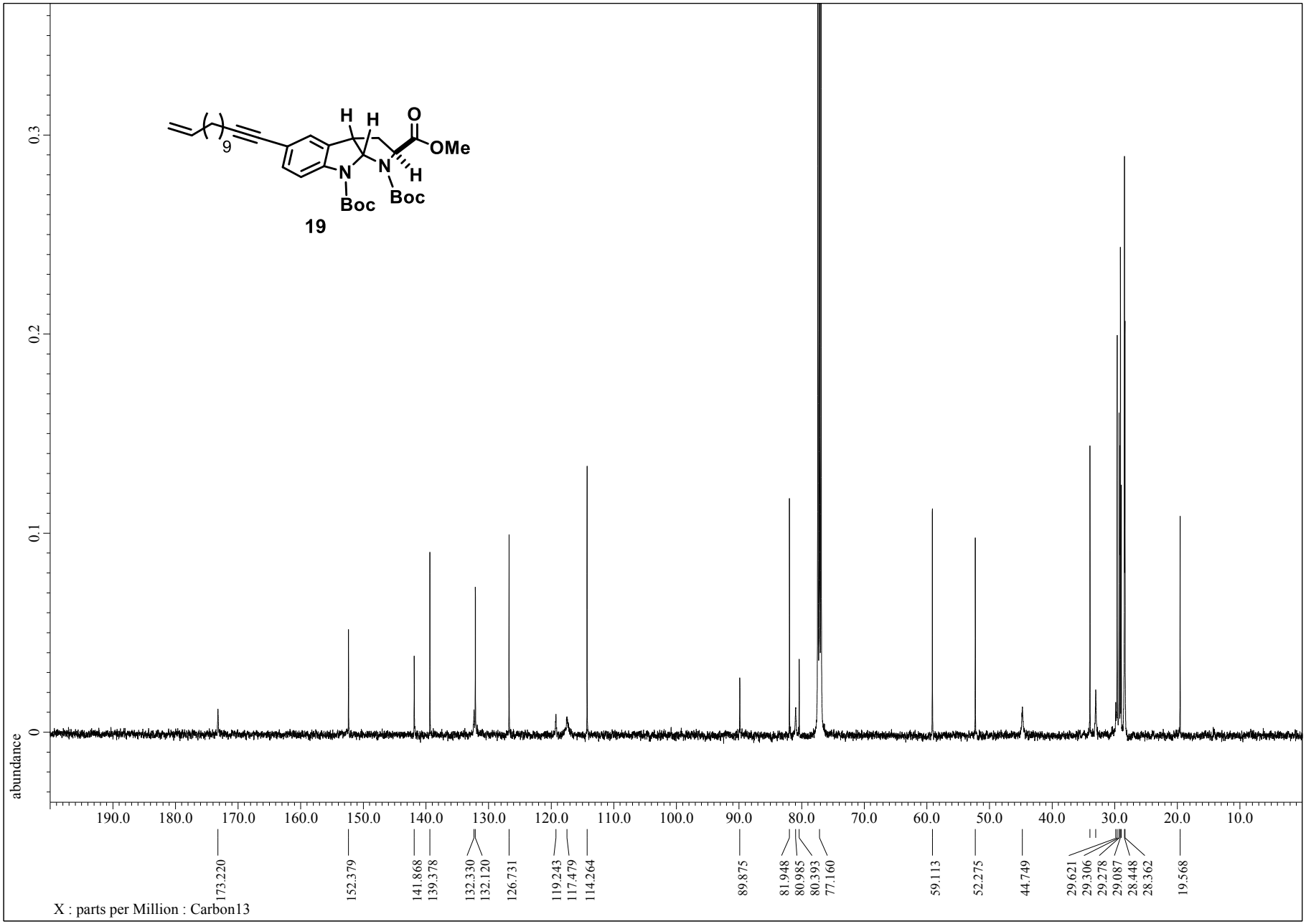

Figure S26 ^{13}C-NMR spectrum (125 MHz) of **19** in $CDCl_3$.