Electronic Supplementary Material (ESI) for Green Chemistry.

Aqueous 1,3-dipolar cycloadditions promoted by copper nanoparticles in polydiacetylene micelles

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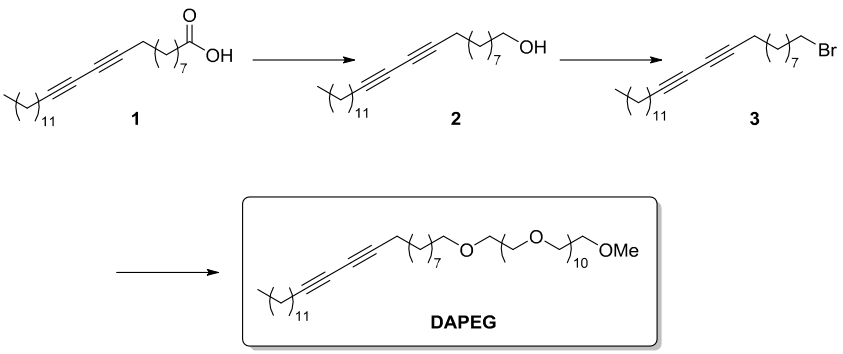
A. Catalyst preparation

1. General

Unless otherwise specified, chemicals were purchased from Sigma-Aldrich and used without further purification. Tetrahydrofuran (THF) and diethyl ether were distilled from sodium/benzophenone before use. Flash chromatography was carried out on Kieselgel 60 (230–240 mesh, Merck). ^{1}H and ^{13}C NMR spectra were recorded on a Bruker Avance DPX 400 spectrometer at 400 and 100 MHz respectively. Chemical shifts (δ) are given in ppm relative to the NMR solvent residual peak and coupling constants (J) in hertz.

2. Synthesis of DAPEG amphiphiles



a. *Synthesis of pentacosa-10,12-diyn-1-ol (**2**).*

Under nitrogen, a solution of pentacosa-10,12-diynoic acid (**1**, 1 g – 2.7 mmol – 1 equiv.) in diethyl ether (50 mL) was cooled at 4 °C before lithium aluminium hydride (205 mg – 2 equiv.) was added portionwise. After stirring for 1.5 h at room temperature, the reaction was cooled to 4 °C and 15% sodium hydroxide (200 µL) was added, followed by water (600 µL). The resulting pink precipitate was filtered off on Celite. The organic phase was washed with 10% hydrochloric acid (2 × 20 mL), dried on magnesium sulfate, filtered, and concentrated under vacuum. Product **2** was obtained as a white solid (938 mg – 2.6 mmol – 96% yield).

^{1}H NMR (400 MHz, $CDCl_3$, δ): 3.63 (t, J = 7 Hz, 2H; CH_2−OH), 2.23 (t, J = 7 Hz, 4H; CH_2−C≡), 1.60-1.45 (M, 6H; CH_2), 1.44-1.24 (M, 28H; CH_2), 0.86 ppm (t, J = 7 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, δ): 77.5 (−C≡), 77.4 (−C≡), 65.2 (−C≡), 65.2 (−C≡), 63.1 (CH_2−OH), 32.7 (CH_2), 31.9 (CH_2), 29.6 (3 CH_2), 29.4 (CH_2), 29.3 (3 CH_2), 29.1 (CH_2), 29.0 (CH_2), 28.8 (CH_2), 28.7 (CH_2), 28.3 (CH_2), 28.2 (2 CH_2), 25.7 (CH_2), 22.6 (CH_2), 19.2 (CH_2), 14.1 ppm (CH_3).

*b. Synthesis of 1-bromopentacosa-10,12-diyne (**3**).*

Under nitrogen, triphenylphosphine (550 mg – 1.5 equiv.) and compound **2** (500 mg – 1.4 mmol – 1 equiv.) were solubilized in dichloromethane (3 mL). Tetrabromomethane (700 mg – 21.5 equiv.) was added in portions and the reaction was stirred at room temperature for 15 min. After addition of cold water (2 mL) the organic phase was separated, dried over magnesium sulfate, filtered, and concentrated under vacuum. Purification on a silica plug (elution with dichloromethane) afforded the desired product **3** as a yellowish varnish (585 mg – 1.38 mmol – quantitative yield).

^{1}H NMR (400 MHz, $CDCl_3$, δ): 3.40 (t, J = 7 Hz, 2H; CH_2–Br), 2.24 (t, J = 7 Hz, 4H; CH_2–C≡), 1.85 (td, J = 7 Hz, 2H; CH_2), 1.60-1.45 (M, 6H; CH_2), 1.45-1.25 (M, 26H; CH_2), 0.88 ppm (t, J = 7 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, δ): 77.6 (−C≡), 77.4 (−C≡), 65.3 (−C≡), 65.1 (−C≡), 34.0 (CH_2–Br), 32.8 (CH_2), 31.9 (CH_2), 29.6 (3 CH_2), 29.4 (CH_2), 29.3 (CH_2), 29.2 (CH_2), 29.1 (2 CH_2), 28.9 (CH_2), 28.8 (CH_2), 28.7 (CH_2), 28.6 (CH_2), 28.3 (CH_2), 28.2 (CH_2), 28.1 (CH_2), 22.7 (CH_2), 19.2 (CH_2), 14.1 ppm (CH_3).

c. Synthesis of DAPEG.

Under nitrogen, polyethyleneglycol monomethyl ether (MW = 550, 70 mg – 0.13 mmol – 1 equiv.) in anhydrous acetonitrile (5 mL) was added to a suspension of sodium hydride (6 mg – 2 equiv.) in anhydrous acetonitrile (2 mL). The mixture was refluxed for 30 min and allowed to cool down to room temperature. Compound **3** (211 mg – 4 equiv.) in tetrahydrofurane (2 mL) was then slowly added and the reaction was stirred at room temperature for 96 h. After concentration under vacuum, purification by column chromatography (silica gel, dichloromethane/methanol 95:5) afforded the desired product as a yellowish solid (115 mg – 0.12 mmol – 92% yield).

^{1}H NMR (400 MHz, $CDCl_3$, δ): 3.80-3.45 (M, 44H; CH_2–O), 3.33 (s, 3H, O–CH_3), 2.19 (t, J = 7 Hz, 4H; CH_2−C≡), 1.57-1.45 (M, 6H; CH_2), 1.37-1.17 (M, 28H; CH_2), 0.83 ppm (t, J = 7 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, δ): 77.4 (−C≡), 77.3 (−C≡), 72.5 (CH_2−O), 71.9 (CH_2−O), 70.7-70.2 (86 CH_2−O), 70.3 (CH_2−O), 70.0 (CH_2−O), 65.3 (−C≡), 65.2 (−C≡), 61.6 (CH_2−OH), 58.9 (O–CH_3), 31.8 (CH_2), 29.6 (CH_2), 29.5 (3 CH_2), 29.4 (CH_2), 29.3 (3 CH_2), 29.2 (CH_2), 29.1 (CH_2), 29.0 (CH_2), 28.8 (CH_2), 28.7 (CH_2), 28.3 (2 CH_2), 26.0 (CH_2), 22.6 (CH_2), 19.1 (CH_2), 14.0 ppm (CH_3).

3. Synthesis and characterization of polymerized micelles (pDAPEG)

DAPEG (10 mg) was dissolved in deionized water (1 mL) yielding a solution that was sonicated with an ultrasonic probe (300 ms pulses per second, 25 W output power) for 10 min. The solution was then subjected to UV light (254 nm, low pressure mercury UV lamp, Heraeus) irradiation for 6 h to yield pDAPEG micelles. The micelles displayed a mean hydrodynamic diameter of *ca.* 9 nm, as determined by dynamic light scattering (DLS) measurements.

4. Synthesis and characterization of Cu_2O nanoparticles

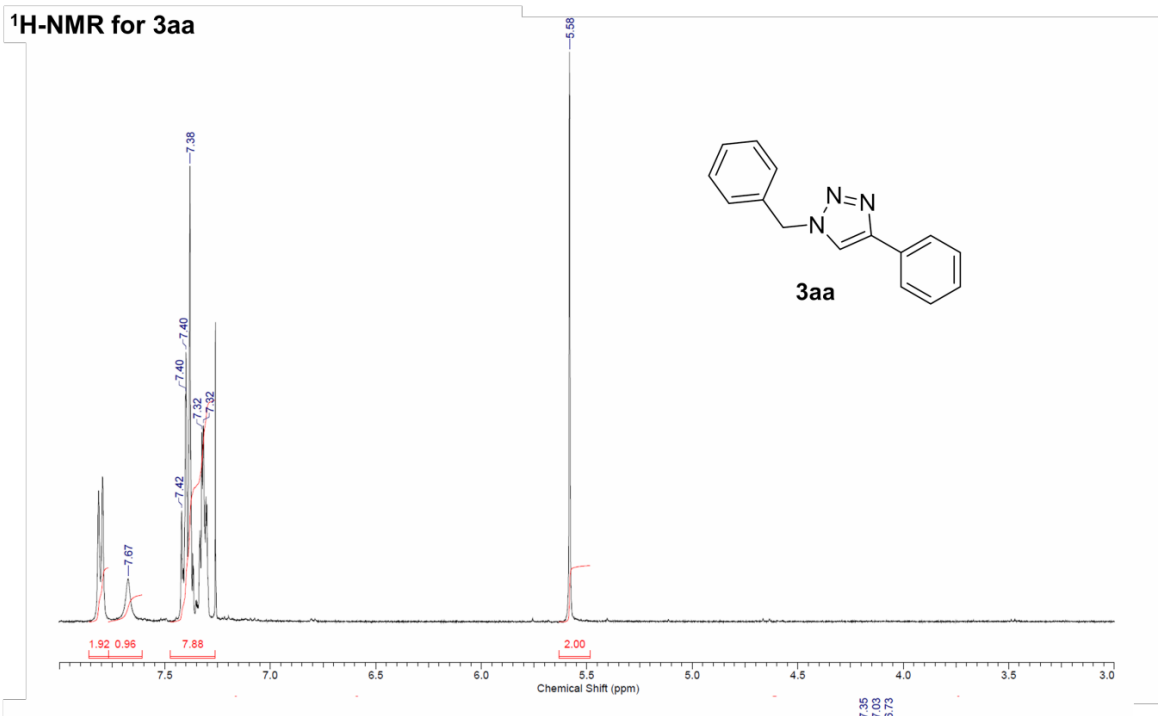
Cu_2O nanoparticles were prepared according to the procedure reported by O'Brien *et al. (J. Am. Chem. Soc.* **2005**, *127*, 9506). Briefly, 122 mg of copper(I) acetate (1 mmol) was mixed with of oleic acid (1 mL) and trioctylamine (5 mL) under a nitrogen flow. The reaction mixture was heated to 180 °C and kept at this temperature for 1 h to afford a grey colloid. This colloid was then quickly heated to 270 °C. The grey color changed to deep red and the reaction mixture was stirred at 270 °C for 1 h. After cooling to room temperature, ethanol (25 mL) was added and the precipitate was separated by centrifugation (8000 rpm, 10 min). The obtained nanoparticles were re-dispersed in hexane (15 mL) to provide a dark red solution the color of which evolved to deep green through formation of Cu_2O nanoparticles.

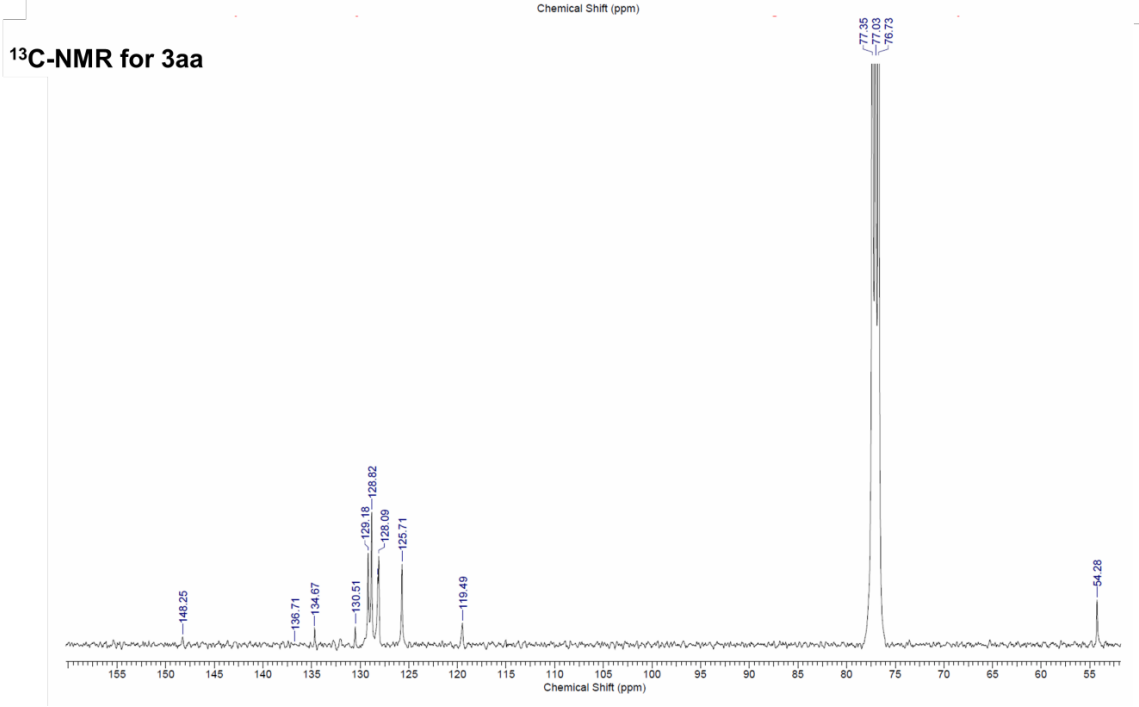
5. Encapsulation of Cu_2O nanoparticles in pDAPEG micelles

Cu_2O nanparticle in hexane (0.1 M, 500 µL) were added to a solution of pDAPEG micelles (10 mg mL^{-1}, 1 mL) and sonicatated until hexane evaporation (*ca.* 30 min). The clear deep green colloid was then filtered on a 0.22 µm membrane and submitted to diffrent analyses: ICP-MS measurements allowed the determination of a 7mM copper content; transimission electron microscopy (TEM) and dynamic light scattering (DLS) both showed an average diameter of *ca.* 30 nm.

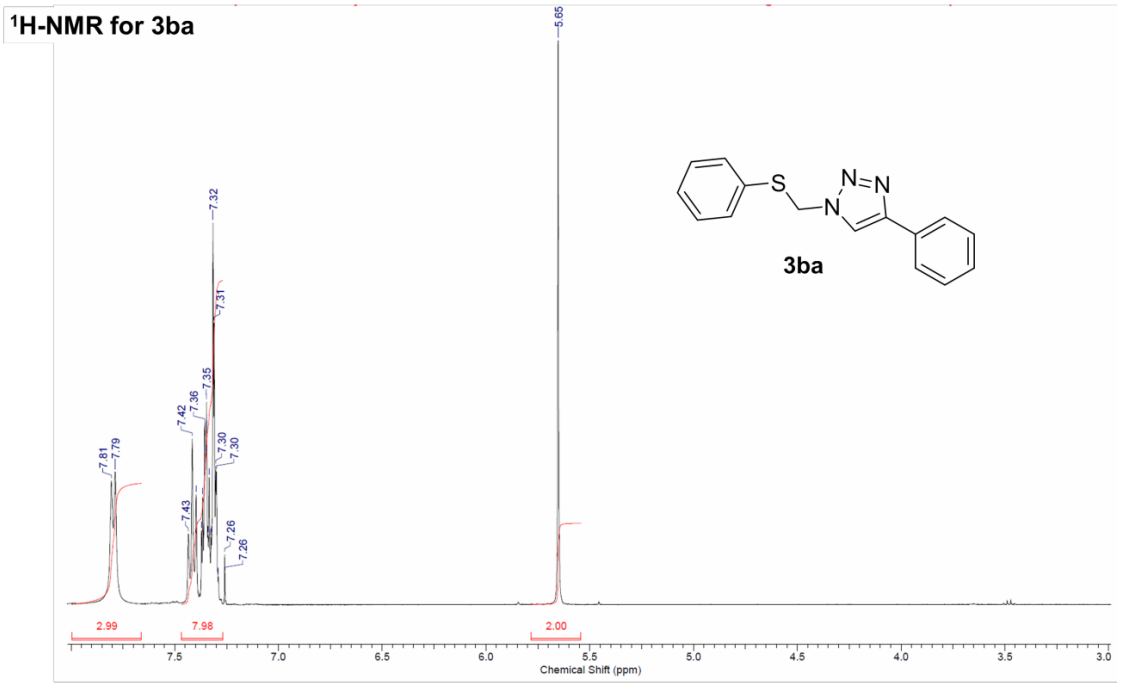
B. Copies of NMR spectra

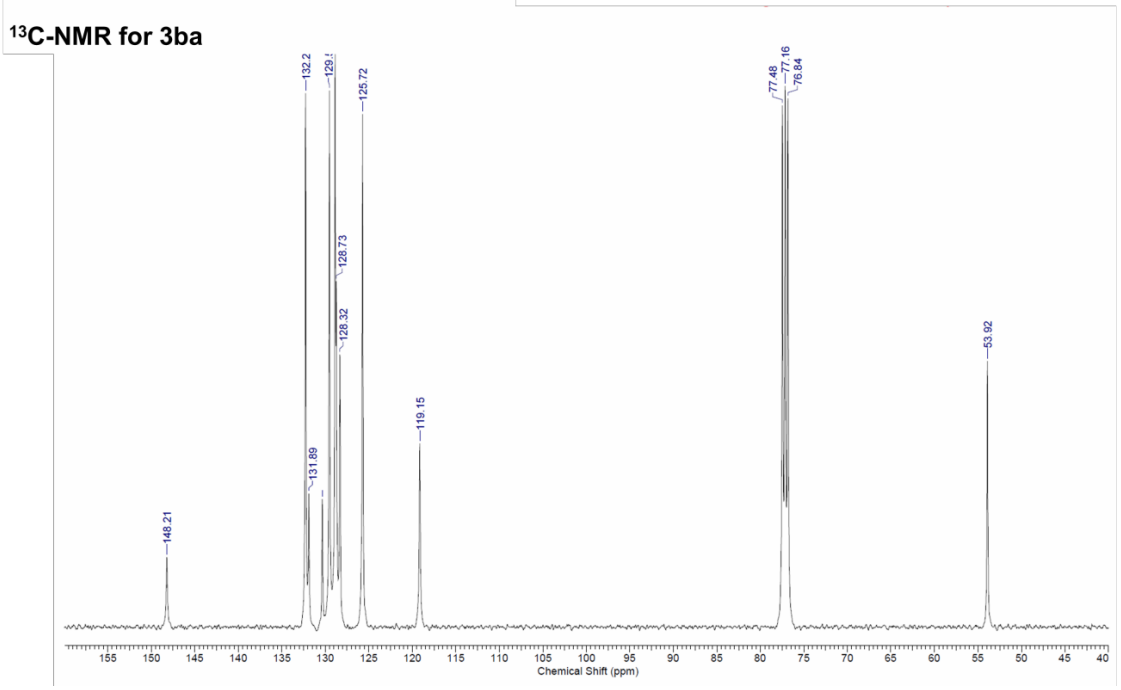
Compound **3aa** (*Adv. Synth. Catal.* 2009, **351**, 207).





Compound **3ba** (*Synthesis* 2009, **20**, 3527)



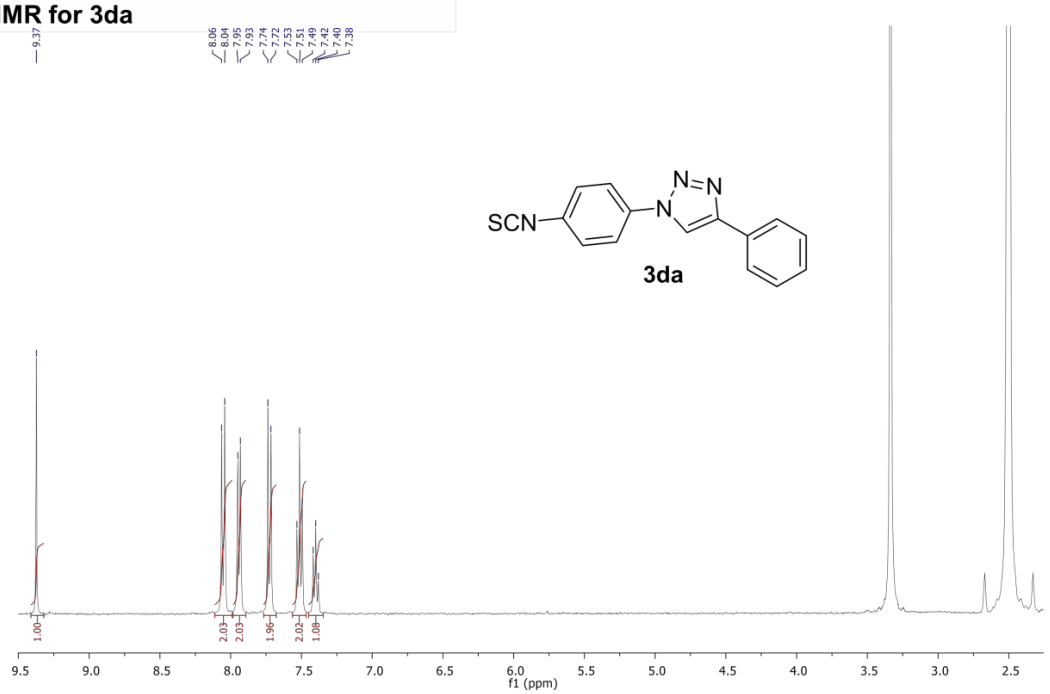


Compound **3da**

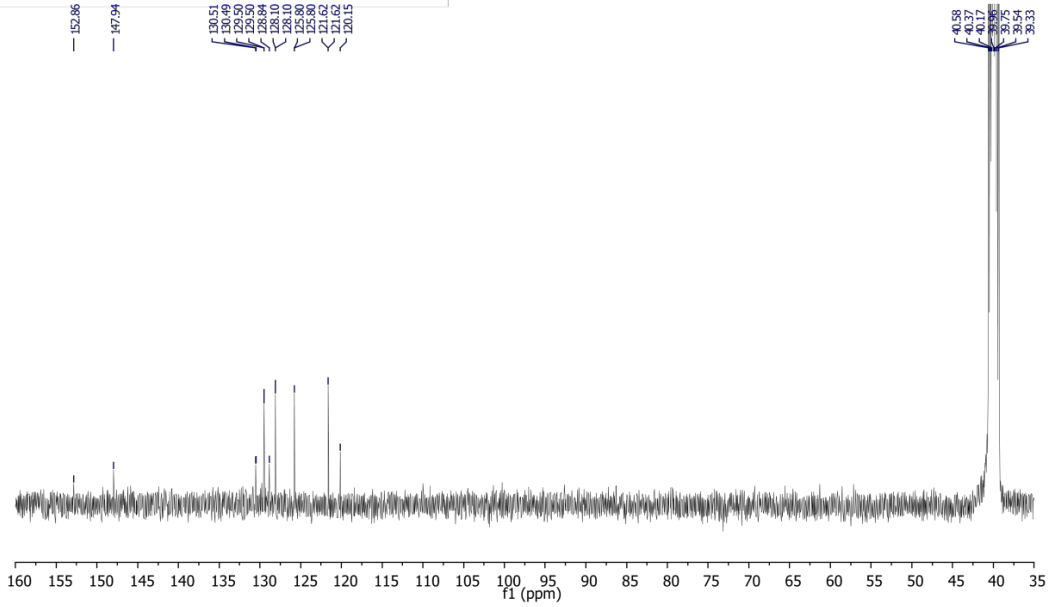
IR (film): ν 695, 768, 839, 1041, 1260, 1514, 2058, 2851, 2923 cm^{-1}.

HRMS *m/z* calcd for $C_{15}H_{11}N_4S$ $[M+H]^+$: 279.0698, found: 279.0697.

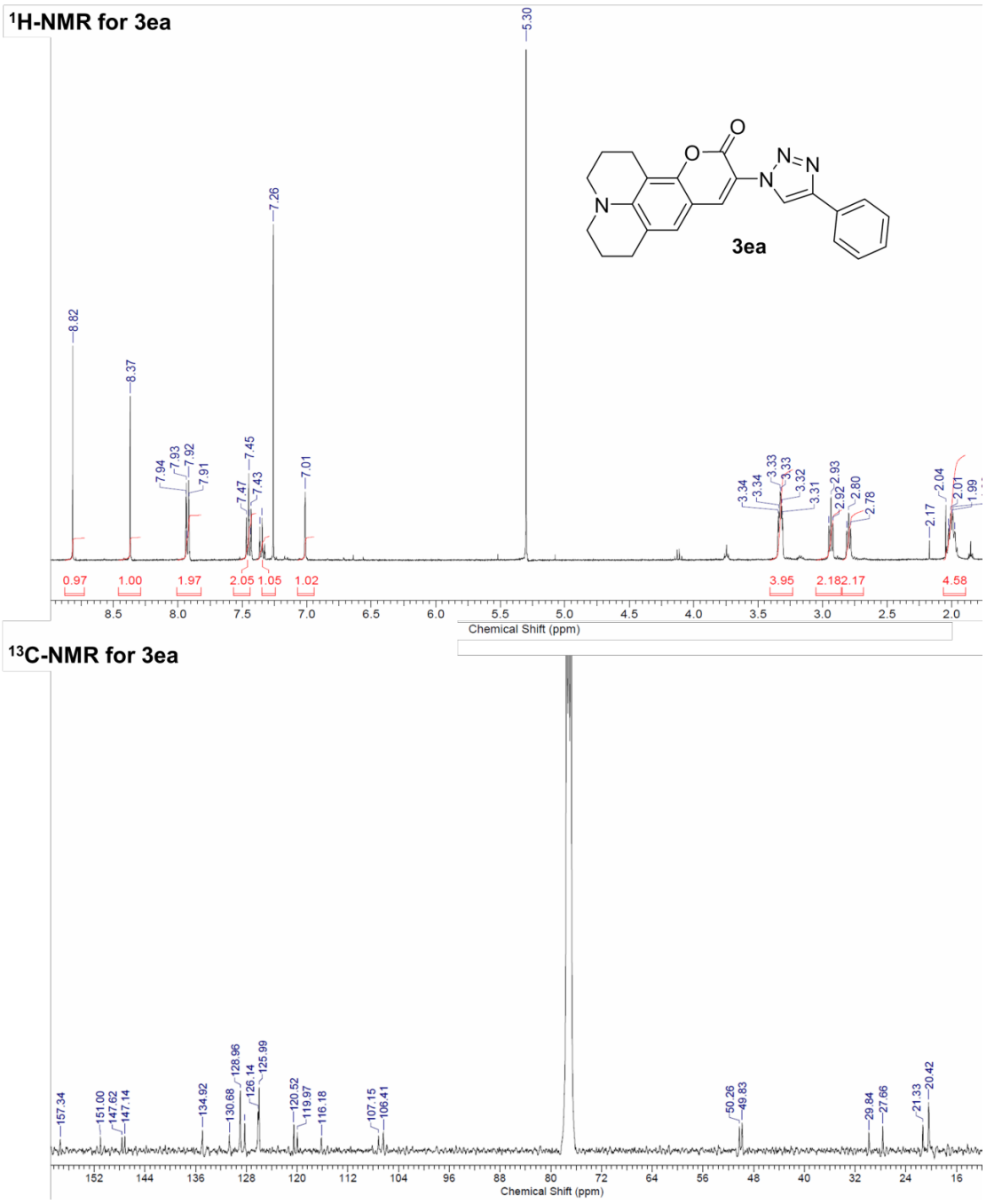
^{1}H-NMR for 3da



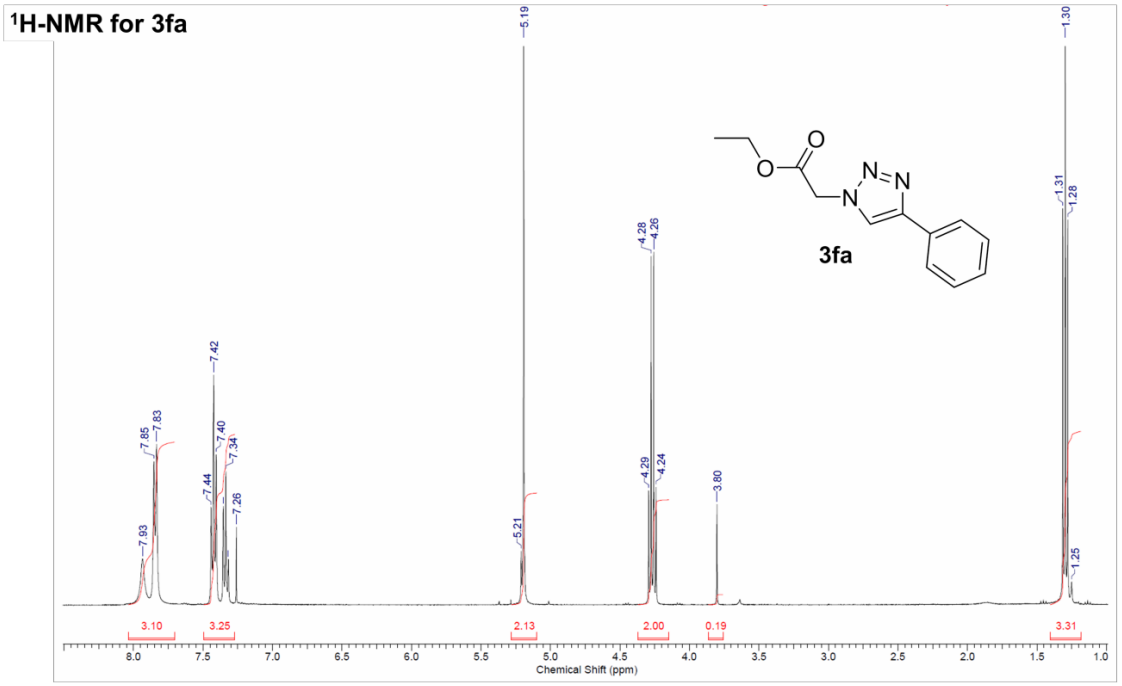
^{13}C-NMR for 3da

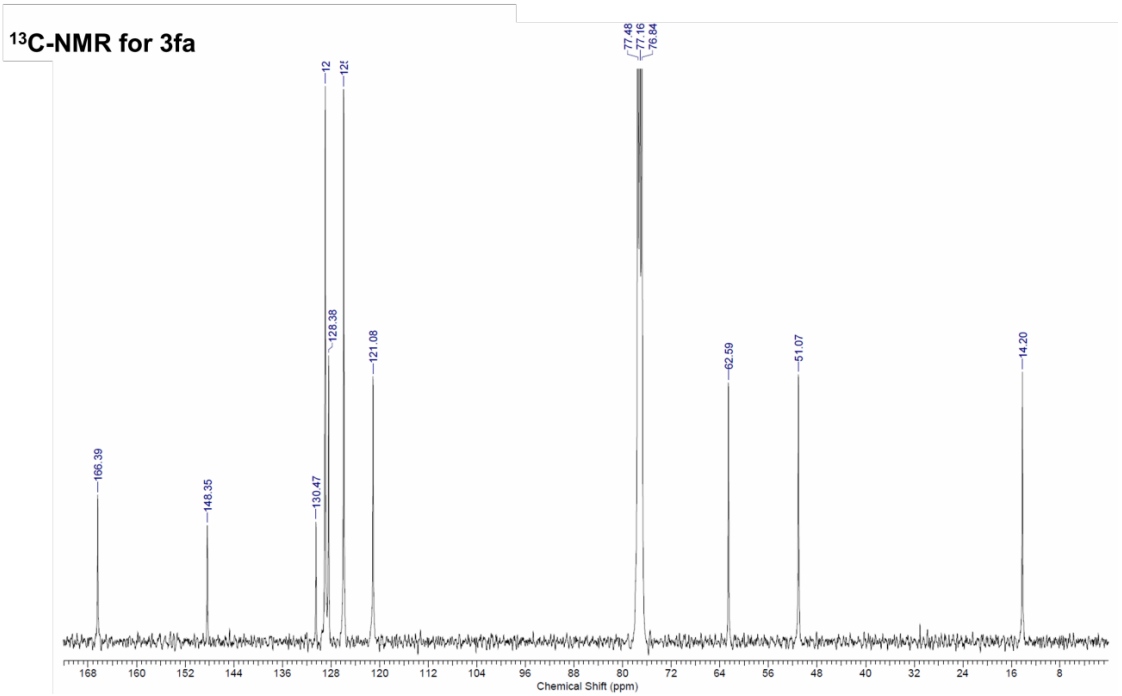


Compound **3ea** (*Org. Lett.*, 2004, **24**, 4603)

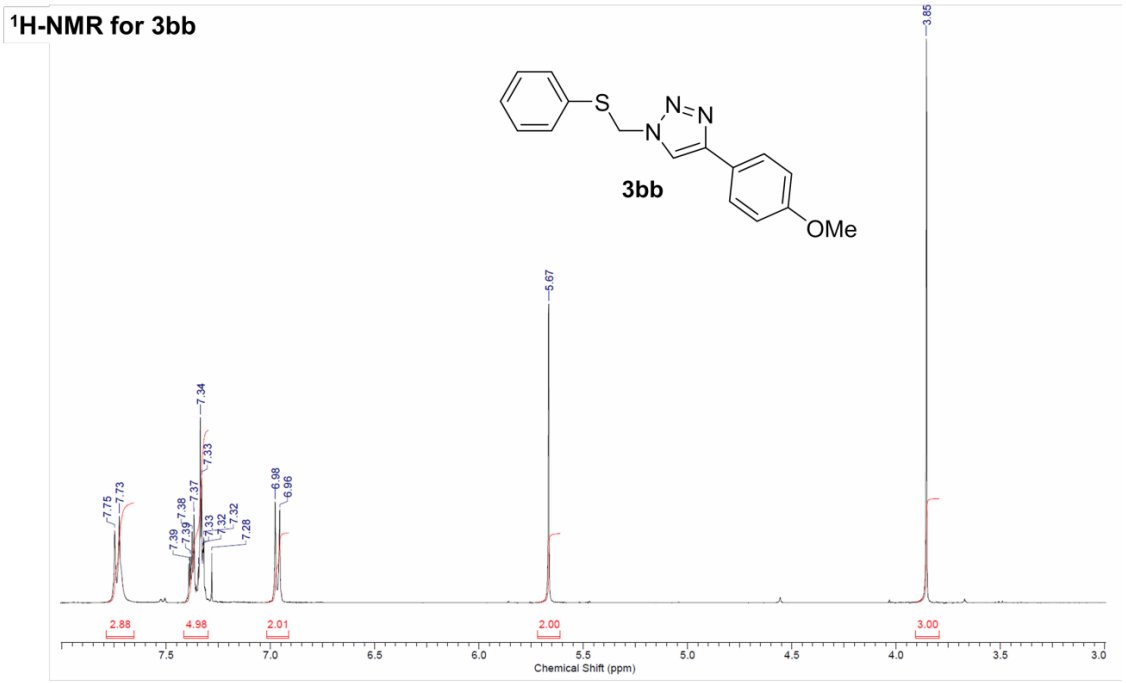


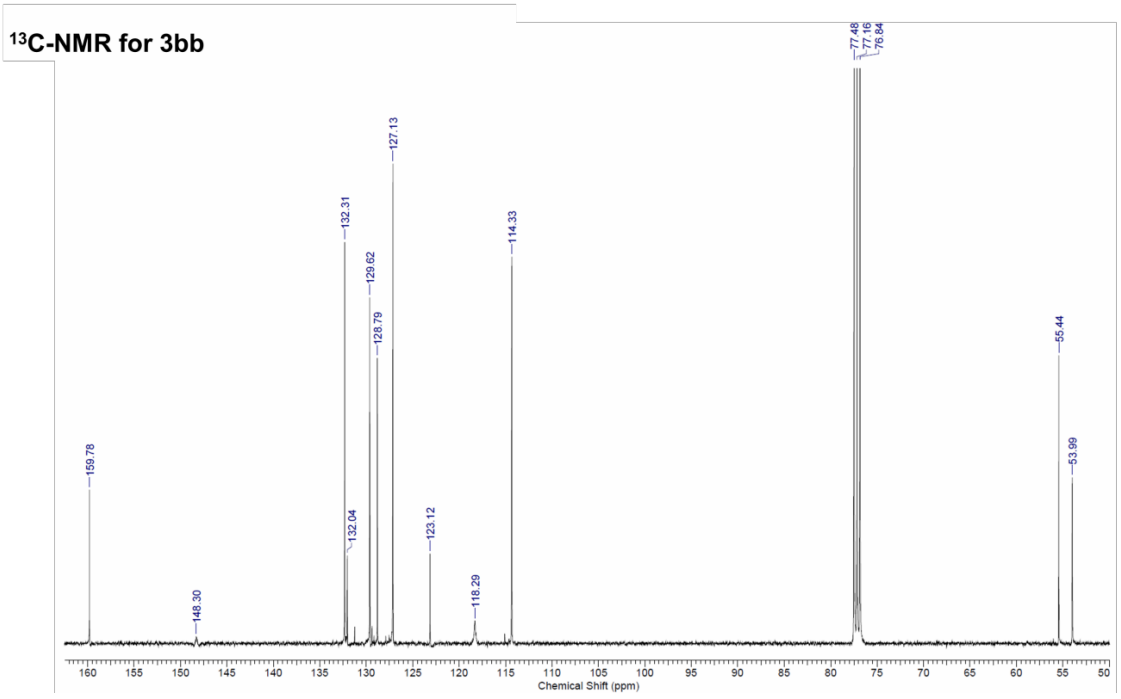
Compound **3fa** (*Molecules* 2009, **14**, 528)





Compound **3bb (***Dalton Trans.*, 2009, 9043)

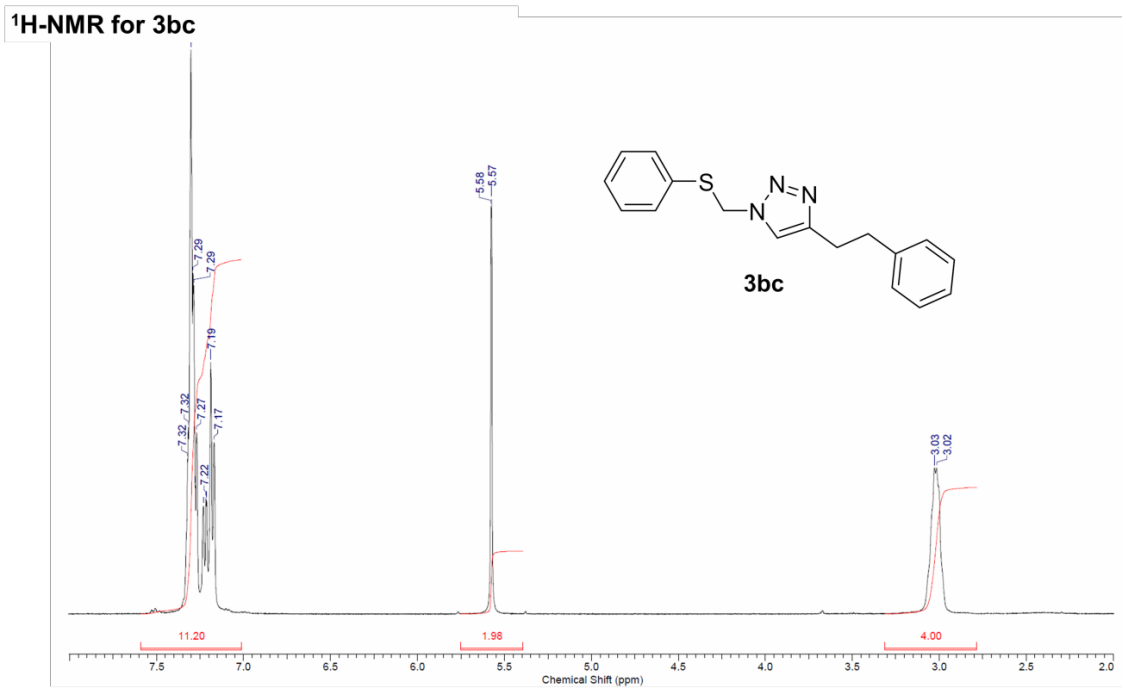


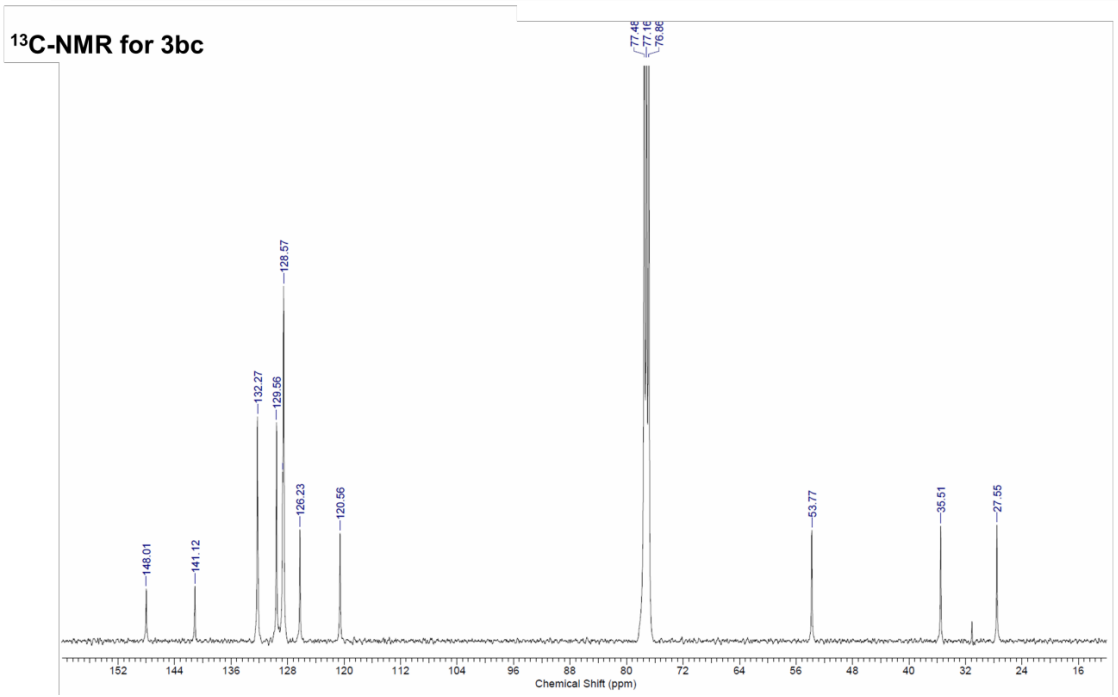


Compound **3bc**

IR (film): ν 691, 739, 1023, 1219, 1438, 2922 cm^{-1}.

HRMS *m/z* calcd for $C_{17}H_{18}N_3S$ $[M+H]^+$: 296.1216, found: 296.1215.

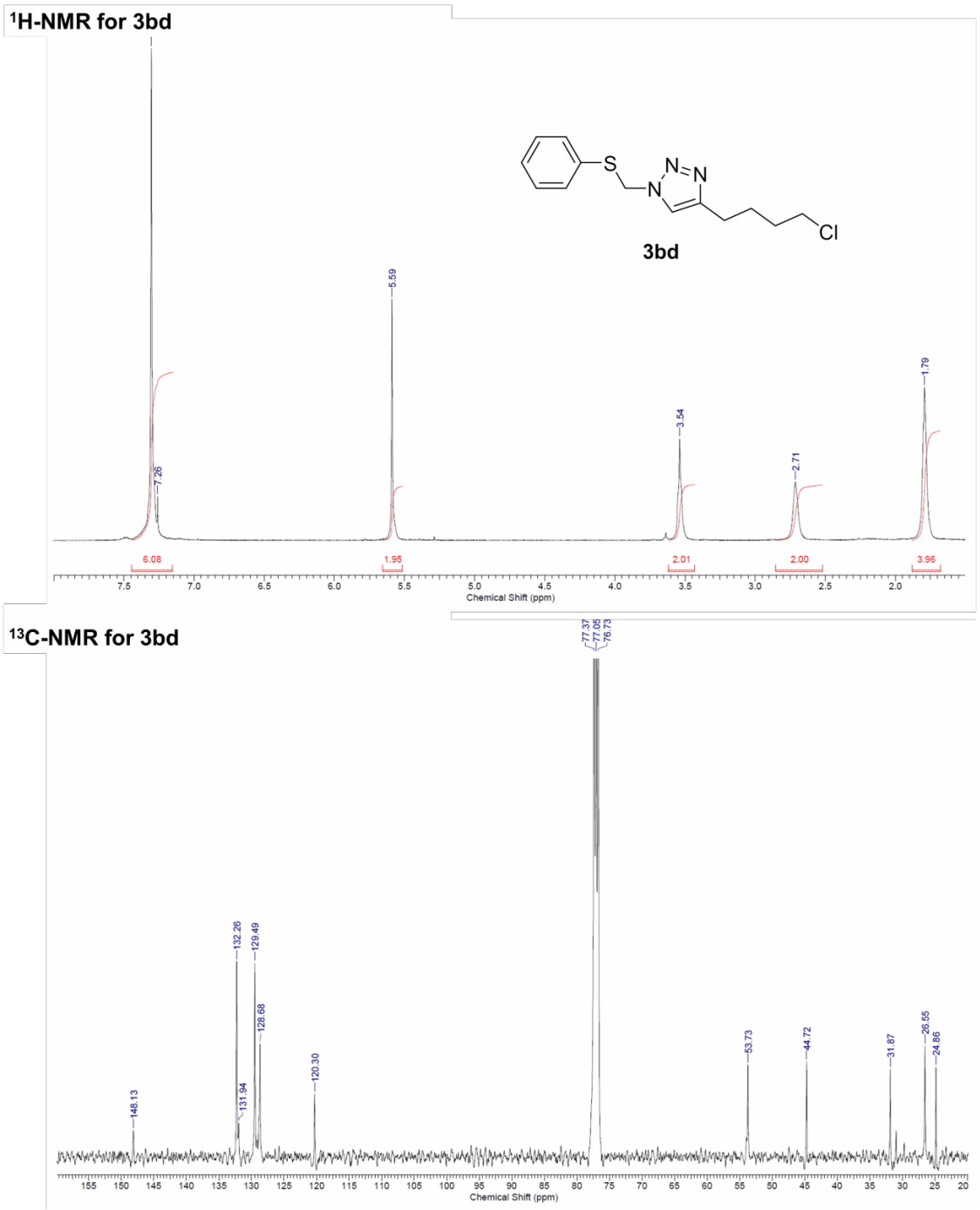




Compound **3bd**

IR (film): ν 647, 692, 745, 1044, 1219, 1439, 1582, 2862, 2927 cm^{-1}.

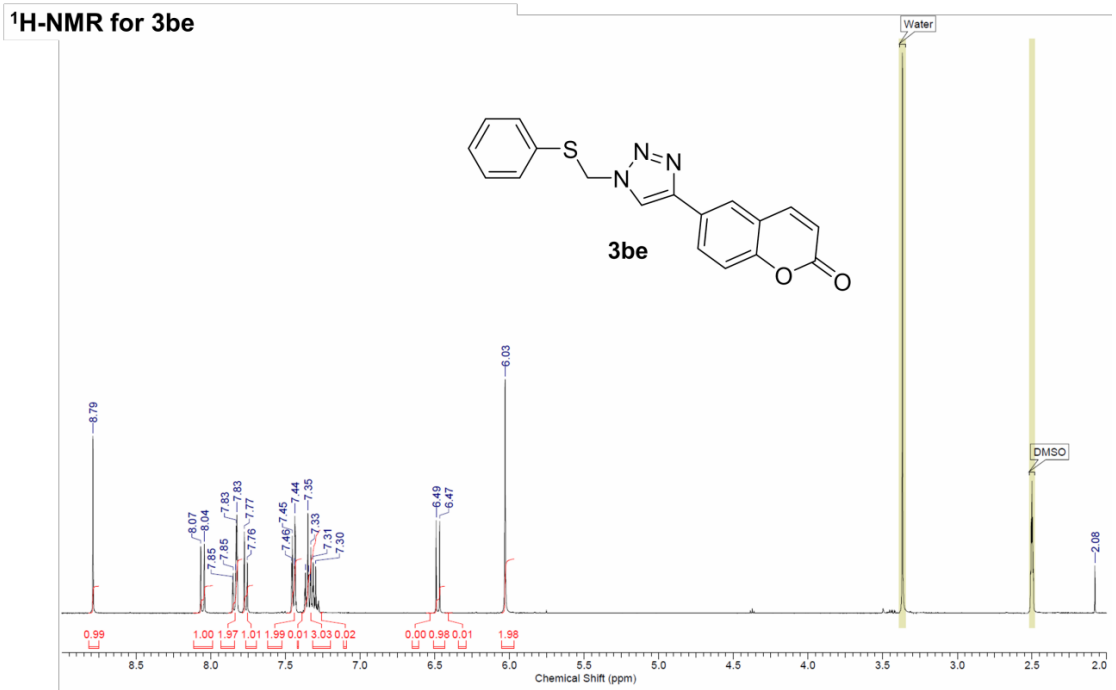
HRMS *m/z* calcd for $C_{13}H_{17}ClN_3S$ $[M+H]^+$: 282.0826, found: 282.0822.

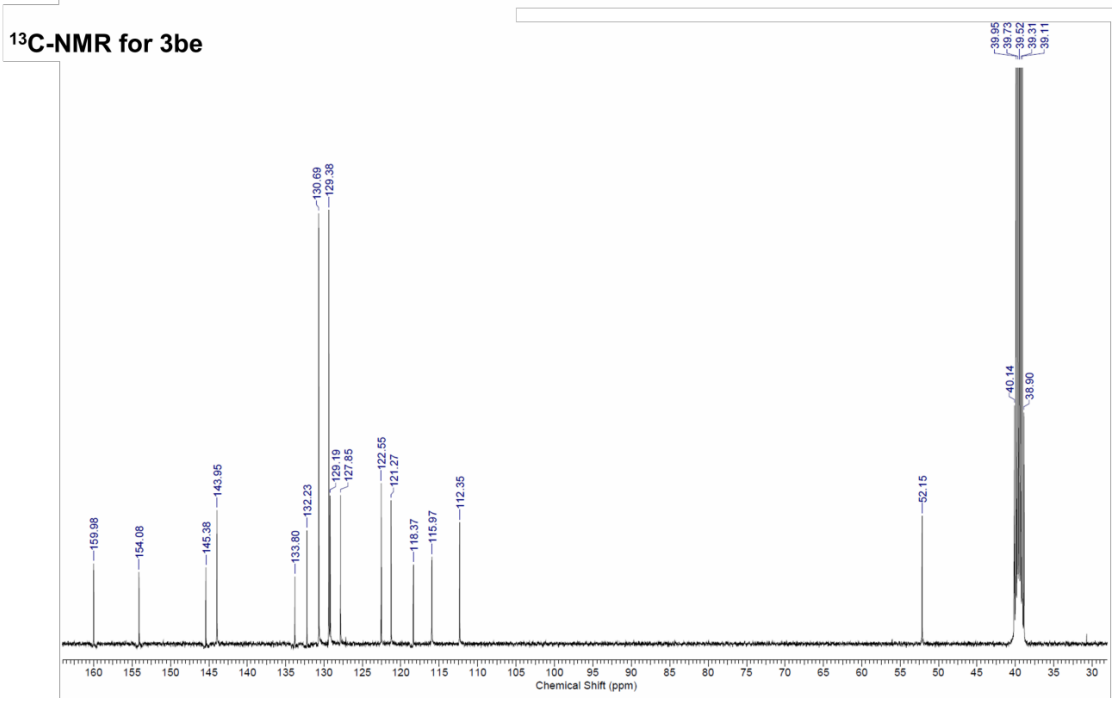


Compound **3be**

IR (film): ν 698, 761, 821, 1025, 1052, 1621, 1731, 2252, 2853, 2911 cm^{-1}.

HRMS *m/z* calcd for $C_{18}H_{14}N_3O_2S$ $[M+H]^+$: 336.0801, found: 336.0801.

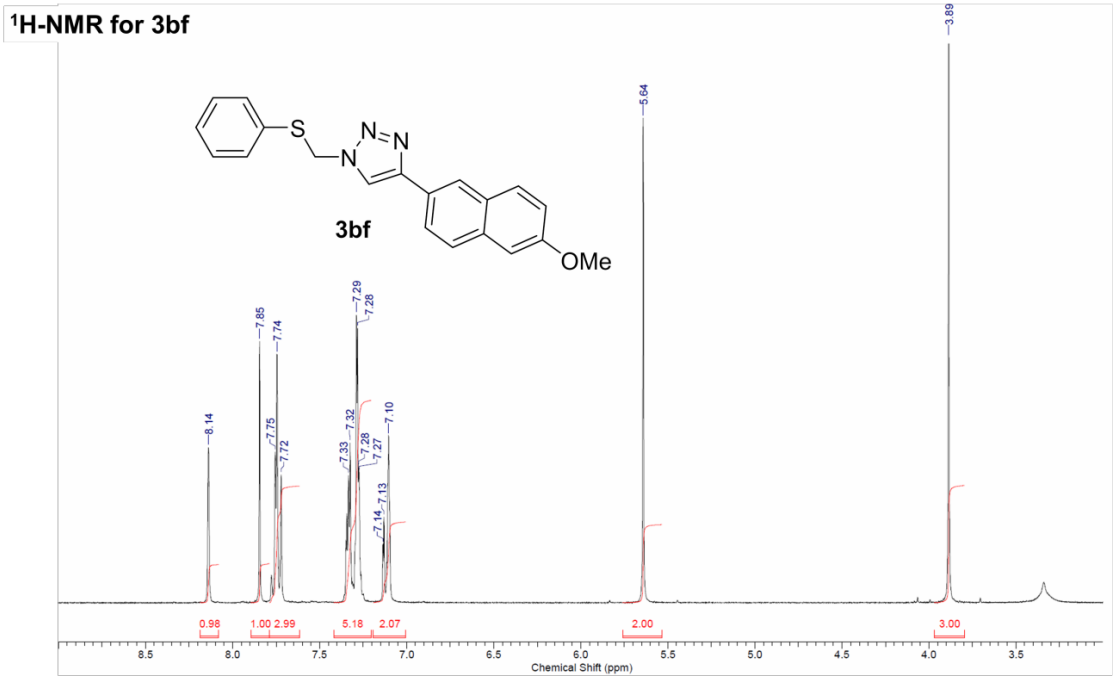


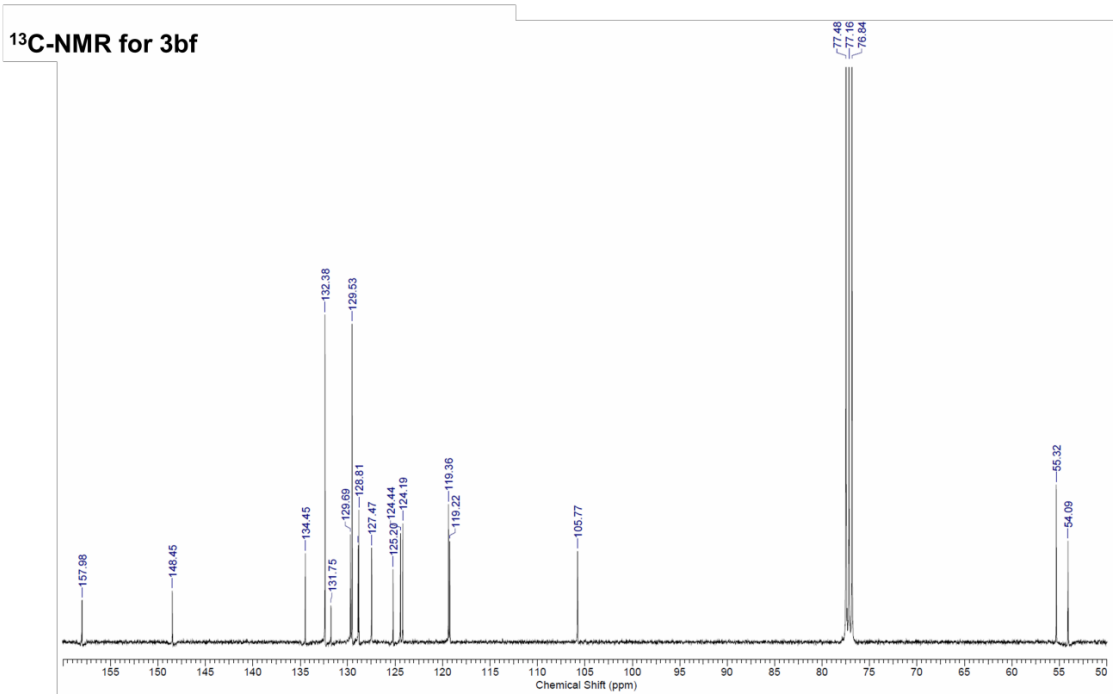


Compound **3bf**

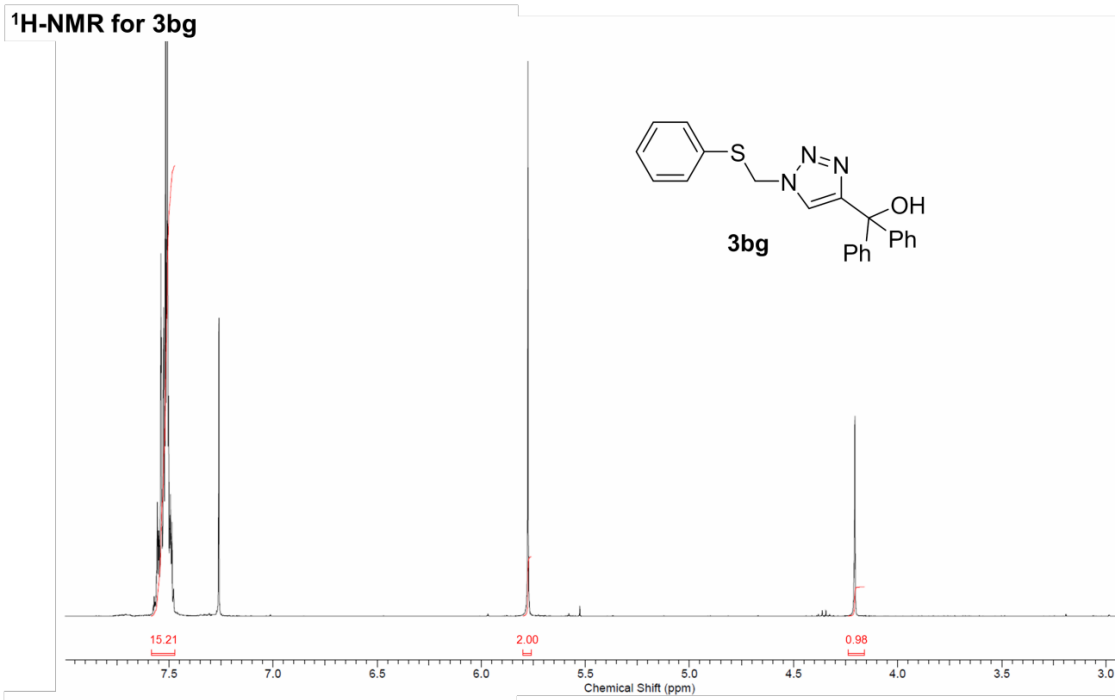
IR (film): ν 692, 751, 908, 1040, 1216, 1263, 1480, 1611, 2252, 2849, 2924 cm^{-1}

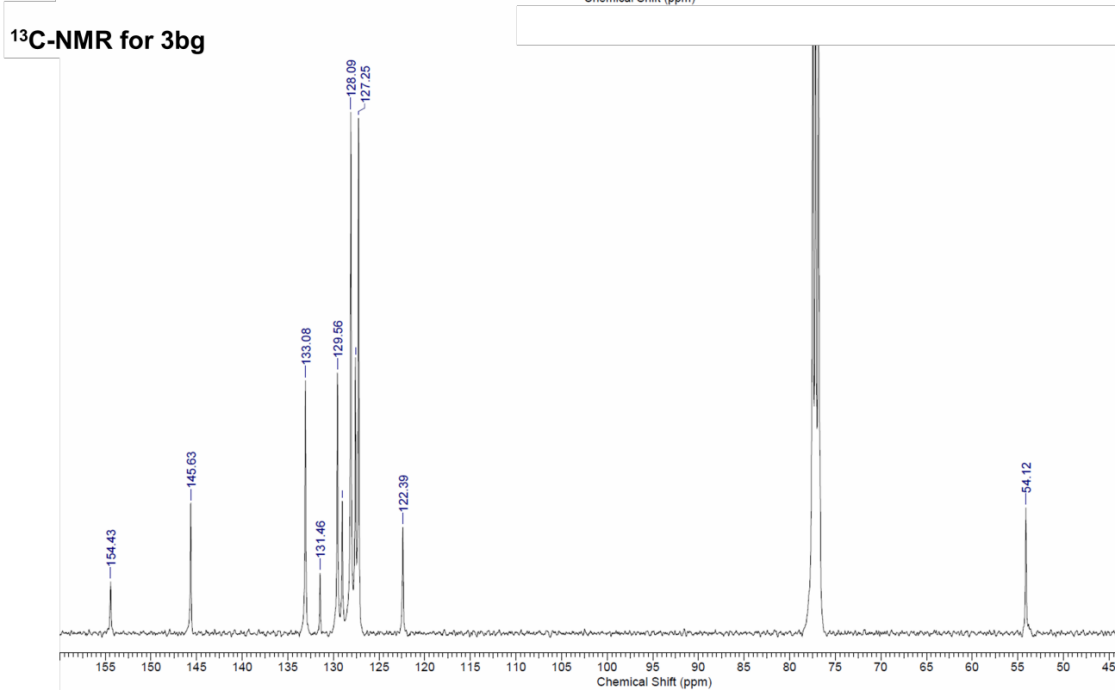
HRMS *m/z* calcd for $C_{20}H_{18}N_3OS$ $[M+H]^+$: 348.1165, found: 348.1164.





Compound **3bg** (*Green Chem.*, 2010, **12**, 2127)





C. Supplementary figures

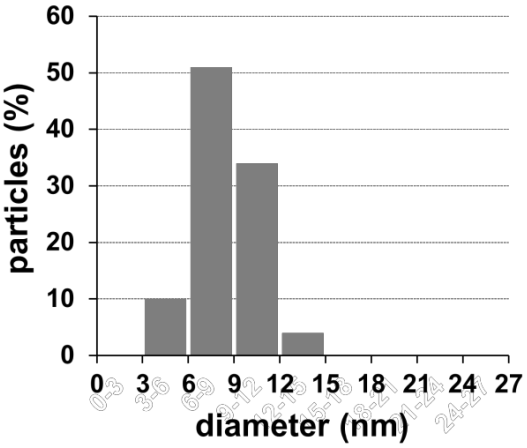


Figure S1. Size distribution of the Cu_2O NPs before encapsulation (measured on 250 particles).

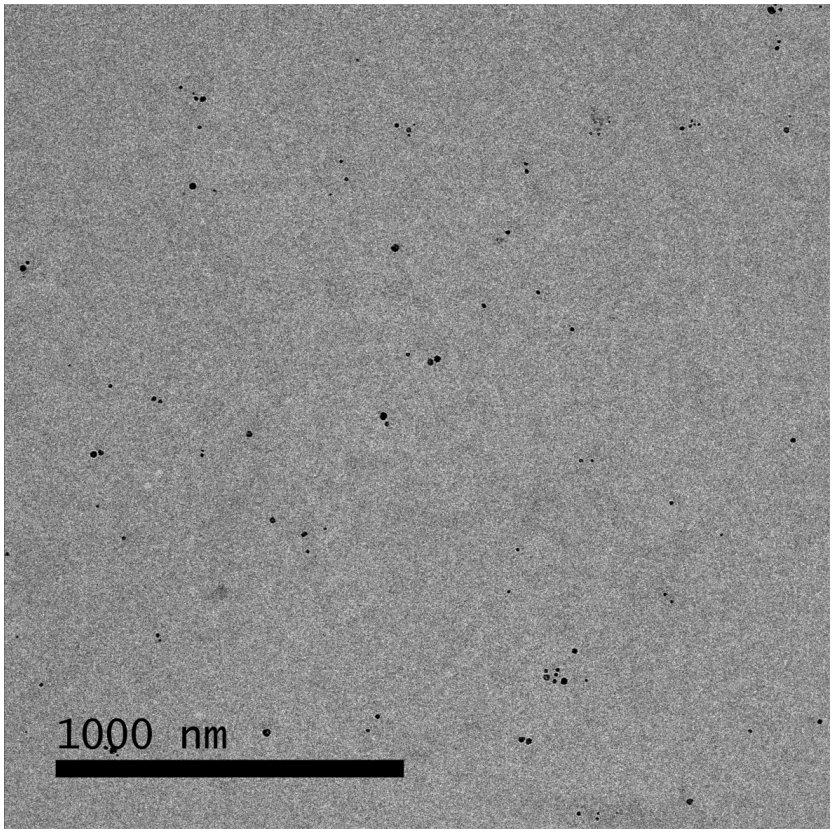


Figure S2. TEM image of the Cu_2O@pDAPEG catalyst after five runs (recycling experiments).