Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information - Procedures and characterization data

Spirocyclization of Keto-Ynesulfonamides Promoted by Quaternary Ammonium Salts

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General information

All reactions were performed in flamed glassware under an argon atmosphere. Commercial reagents were distilled prior to use; CH_2Cl_2, THF and Et_2O were purified using a Dry Solvent Station GT S100.

Commercially available *n*-butyllithium was indicated to be 1.6 M solution in hexanes and dosed before use.

Commercially available TBAF (1 M in THF) and Triton B (40 wt. % in H_2O) were purchased from Sigma-Aldrich and used as received.

Triethylamine was distilled and stored on KOH pellets.

NMR spectra were recorded using a Bruker AV-300 or AV-400 or AV-500 spectrometer with the solvent residual peak as internal standard[1] (chloroform, δ = 7.26 ppm / δ = 77.16 ppm). Splitting patterns were reported as s, singlet; d, doublet; t, triplet; q, quartet; qu, quintet; sex, sextet; m, multiplet and br, broad singlet.

Thin layer chromatography (TLC) was performed using TLC Silica gel 60 F_{254} aluminum plates. These ones were read under UV light and revealed by sulfuric vanillin followed by a heating using a heat gun.

Merck Geduran® 40-63 µm silica gel was used for column chromatography. The deactivation of silica by triethylamine was performed as follows: silica was first conditioned with 1% of triethylamine in petroleum ether and the column was conditioned as usually. 1% of triethylamine was added in the eluent.

HRMS data were recorded on a microTOF spectrometer equipped with an orthogonal electrospray (ESI) interface.

Infrared spectra were recorded on a Bruker Alpha spectrophotometer and reported in frequency of absorption.

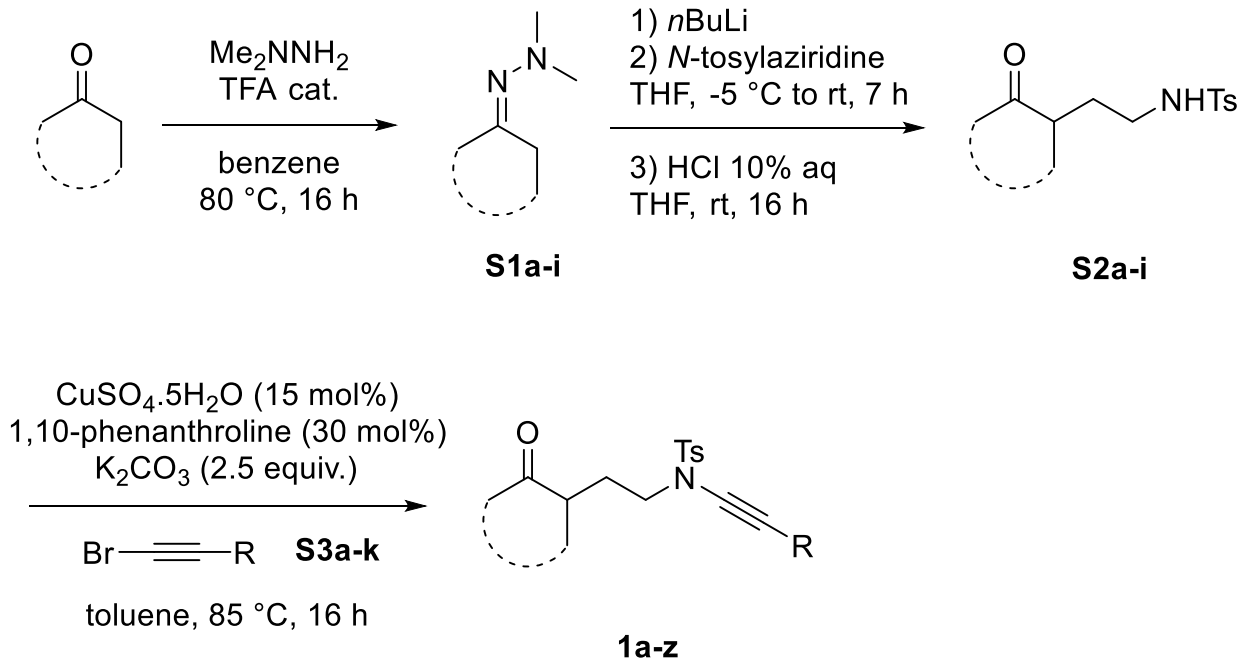
Melting points were recorded with a SMP3 Stuart Scientific microscope in open capillary tubes and are uncorrected.

X-ray structures were recorded using a KappaCCD diffractometer. The structure was solved and refined using the Bruker SHELXTL Software Package.

Ozonolysis reactions were performed using a Fisher 502 ozone generator and an ozone flow rate of 0.1 mol/h.

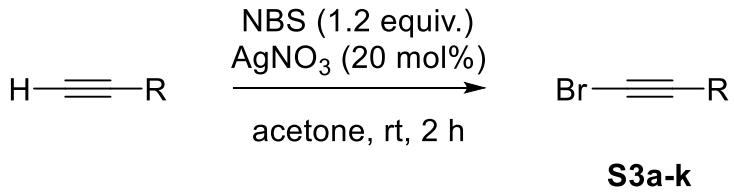
[1] Gottlieb, H. E.; Kotlyar, V.; Nudelman, A. *J. Org. Chem.* **1997**, *62*, 7512.

Preparation of starting materials



Scheme A. Synthesis of keto-sulfonylynamides **1a-z**

The bromoalkynes **S3a-k** were synthesized following literature procedure using $AgNO_3$ catalysis.[2]

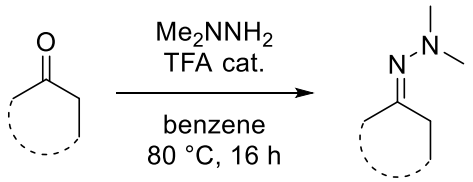


Scheme B. Synthesis of bromoalkynes **S3a-k**

Experimental procedures and characterization data for these compounds (**S1a-i**, **S2a-i** and **S3a-k**) are given thereafter.

[2] Hofmeister, H.; Annen, K.; Laurent, H.; Wiechert, R. *Angew. Chem. Int. Ed.* **1984**, *23*, 727.

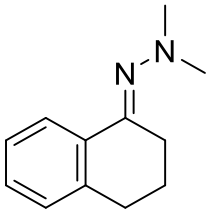
Experimental procedure and characterization data for hydrazones (S1a-i)



S1a-i

General procedure: The cycloalkanone (1 equiv, 70 mmol) was dissolved in benzene (conc = 0.45 M, 155 mL). *N,N*-dimethylhydrazine (1.5 equiv, 105 mmol) and trifluoroacetid acid (6 drops) were then added. The resulting mixture was heated to reflux overnight using a Dean-Stark device. After completion, nearly all the benzene was removed from the reaction mixture using the Dean-Stark equipment. The mixture was then diluted with Et_2O (30 mL) and hydrolyzed with a saturated aqueous solution of $NaHCO_3$ (25 mL). The aqueous layer was extracted with Et_2O (3 x 30 mL). The combined organic layers were dried (Na_2SO_4), filtered and concentrated under vacuum (15 mbar, 40 °C). The crude material was purified by distillation under reduced pressure or by recrystallization according to the case to afford the title compounds **S1**.

2-(3,4-dihydronaphthalen-1(2*H*)-ylidene)-1,1-dimethylhydrazine (S1a)

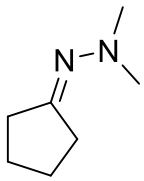


$C_{12}H_{16}N_2$
MW: 188.27 g.mol^{-1}
Yellow liquid
bp = 79 °C ; 2.1×10^{-1} torr
93% (12.26 g, 65.1 mmol)

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.15 (dd, 1H, *J* = 7.9, 1.1 Hz), 7.18-7.29 (m, 2H), 7.12 (dd, 1H, *J* = 7.4, 1.1 Hz), 2.78-2.85 (m, 4H), 2.60 (s, 6H), 1.92 (m, 2H) ppm

Spectral data were consistent with date reported in the literature.[3]

2-cyclopentylidene-1,1-dimethylhydrazine (S1b)



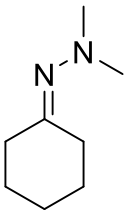
$C_7H_{14}N_2$
MW: 126.20 g.mol^{-1}
Colorless liquid
bp = 55 °C ; 15 mbar
91% (8.04 g, 63.7 mmol)

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 2.49 (s, 6H), 2.34-2.43 (m, 4H), 1.70-1.81 (m, 4H) ppm

Spectral data were consistent with date reported in the literature.[4]

[3] Murphy, J. A.; Mahesh, M.; McPheators, G.; Anand, R. V.; McGuire, T. M.; Carling, R.; Kennedy, A. R. *Org. Lett.* **2007**, *9*, 3233.

[4] Sharma, S. D.; Pandhi, S. B *J. Org. Chem.* **1990**, *55*, 2196.

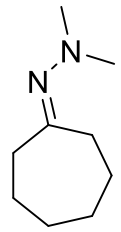


$C_{11}H_{14}N_2$
MW: 174.25 g.mol^{-1}
Yellow liquid
bp = 68 °C ; 6.0 ×10^{-2} torr
95% (9.33 g, 66.5 mmol)

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 2.50 (t, 2H, J = 6.1 Hz), 2.43 (s, 6H), 2.24 (m, 2H), 1.61-1.73 (m, 6H) ppm

Spectral data were consistent with date reported in the literature.[4]

2-cycloheptylidene-1,1-dimethylhydrazine (S1d)

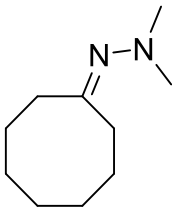


$C_9H_{18}N_2$
MW: 154.26 g.mol^{-1}
Colorless liquid
bp = 78 °C ; 9 mbar
90% (9.72 g, 63 mmol)

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 2.61 (t, 2H, *J* = 6.1 Hz), 2.37-2.41 (m, 8H), 1.55-1.66 (m, 8H) ppm

Spectral data were consistent with date reported in the literature.[5]

2-cyclooctylidene-1,1-dimethylhydrazine (S1e)

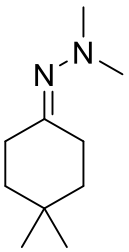


$C_{10}H_{20}N_2$
MW: 168.28 g.mol^{-1}
Colorless liquid
bp = 96 °C ; 15 mbar
84% (9.9 g, 58.8 mmol)

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 2.49 (t, 2H, *J* = 6.3 Hz), 2.40 (s, 6H), 2.32 (t, 2H, *J* = 6.3 Hz), 1.71-1.83 (m, 4H), 1.38-1.55 (m, 6H) ppm

Spectral data were consistent with date reported in the literature.[6]

2-(4,4-dimethylcyclohexylidene)-1,1-dimethylhydrazine (S1f)



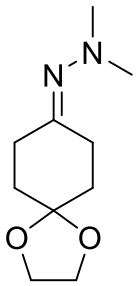
$C_{10}H_{20}N_2$
MW: 168.28 g.mol^{-1}
Colorless liquid
bp = 52 °C ; 1.6×10^{-1} torr
94% (11.07 g, 65.8 mmol)

[5] MacLeod, F.; Lang, S.; Murphy, J. A. *Synlett* **2010**, 529.
[6] Heinrich, C. F.; Fabre, I.; Miesch, L. *Angew. Chem. Int. Ed.* **2016**, *55*, 5170.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 2.52 (t, 2H, *J* = 6.8 Hz), 2.44 (s, 6H), 2.27 (t, 2H, *J* = 6.8 Hz), 1.50 (t, 2H, *J* = 6.7 Hz), 1.44 (t, 2H, *J* = 6.7 Hz), 1.00 (s, 6H) ppm

Spectral data were consistent with date reported in the literature.[7]

1,1-dimethyl-2-(1,4-dioxaspiro[4.5]decan-8-ylidene)hydrazine (S1g)



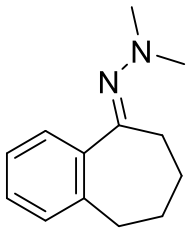
$C_{10}H_{18}N_2O_2$
MW: 198.27 g.mol^{-1}
Colorless liquid
bp = 123 °C ; 10 mbar
87% (12.07 g, 60.9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 3.95-3.97 (m, 4H), 2.66 (t, 2H, *J* = 6.9 Hz), 2.40-2.43 (m, 8H), 1.82 (t, 2H, *J* = 6.9 Hz), 1.77 (t, 2H, *J* = 6.9 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 168.0, 108.3, 64.8 (CH_2), 47.8 (2x CH_3), 35.0 (CH_2), 34.2 (CH_2), 32.8 (CH_2), 25.1 (CH_2) ppm

Spectral data were consistent with date reported in the literature.[8]

1,1-dimethyl-2-(6,7,8,9-tetrahydro-5*H*-benzo[7]annulen-5-ylidene)hydrazine (S1h)

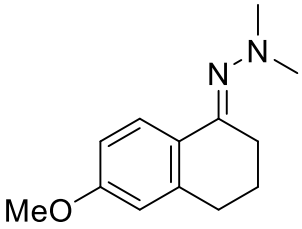


$C_{13}H_{18}N_2$
MW : 202.30 g.mol^{-1}
Yellow liquid
bp = 125 °C ; 8.0 ×10^{-2} torr
80% (11.33 g, 56 mmol)

^{1}H NMR (C_6D_6, 300 MHz): δ = 7.87-7.94 (m, 1H), 7.08-7.13 (m, 2H), 6.87-6.93 (m, 1H), 2.65-2.72 (m, 2H), 2.55 (s, 6H), 2.47-2.54 (m, 2H), 1.40-1.54 (m, 4H) ppm

Spectral data were consistent with date reported in the literature.[9]

2-(6-methoxy-3,4-dihydronaphthalen-1(2*H*)-ylidene)-1,1-dimethylhydrazine (S1i)



$C_{13}H_{18}N_2O$
MW : 218.30 g.mol^{-1}
Yellow liquid
bp = 124 °C ; 6.5×10^{-2} torr
91% (13.91 g, 63.7 mmol)

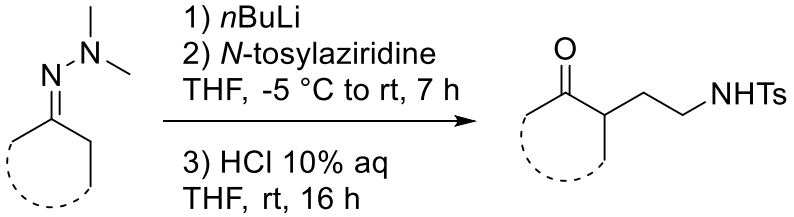
[7] Chou, H.-H.; Wu, H.-M.; Wu, J.-D.; Ly, T. W.; Jan, N.-W.; Shia, K.-S.; Liu, H.-J. *Org. Lett.* **2008**, *10*, 121.
[8] Brummond, K. M.; Chen, D.; Davis, M. M. *J. Org. Chem.* **2008**, *73*, 5064.
[9] Beltran, F.; Fabre, I.; Ciofini, I.; Miesch, L. *Org. Lett.* **2017**, *19*, 5042.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.10 (d, 1H, *J* = 8.9 Hz), 6.75 (dd, 1H, *J* = 8.9, 2.7 Hz), 6.62 (d, 1H, *J* = 2.7 Hz), 3.80 (s, 3H), 2.77-2.81 (m, 4H), 2.56 (s, 6H), 1.90 (qu, 2H) ppm

Spectral data were consistent with date reported in the literature.[10]

[10] Surendra, K.; C., E. J. *J. Am. Chem. Soc.* **2008**, *130*, 8865.

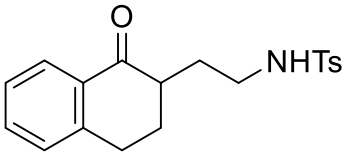
Experimental procedure and characterization data for keto-sulfonamides (S2a-i)



S1a-i **S2a-i**

General procedure: The corresponding hydrazone **S1** (1 equiv, 10 mmol) was dissolved in dry THF (conc = 0.15 M, 50 mL) and the resulting mixture was cooled to -5 °C, then *n*BuLi (1.34 M in hexanes, 1.1 equiv, 11 mmol, 8.2 mL) was added dropwise. The resulting mixture was stirred for 1 h at -5 °C and a solution of *N*-tosylaziridine (1.1 equiv, 11 mmol) in dry THF (17 mL) was added. After 1 h, the reaction mixture was warmed up and stirred at rt for 6 h and hydrolyzed with a 10% aqueous solution of HCl (60 mL) and stirred overnight. The aqueous layer was extracted with EtOAc (5 x 30 mL). The organic layers were washed with a saturated aqueous solution of $NaHCO_3$ (50 mL) and brine (50 mL), dried (Na_2SO_4), filtered and concentrated under vacuum (15 mbar, 40 °C). The crude material was purified by column chromatography using a step gradient of EtOAc in petroleum ether (0 to 50%) to afford the title compounds **S2**.

4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)benzenesulfonamide (S2a)



$C_{19}H_{21}NO_3S$
MW : 343.44 g.mol^{-1}
White solid
mp = 129 °C
92% (3.16 g, 9.2 mmol)

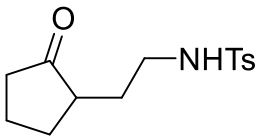
^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.98 (dd, 1H, *J* = 7.9, 1.4 Hz), 7.74 (d, 2H, *J* = 8.2 Hz), 7.47 (td, 1H, *J* = 7.4, 1.5 Hz), 7.29 (t, 1H, *J* = 7.6 Hz), 7.25 (d, 2H, *J* = 8.3 Hz), 7.22 (d, 1H, *J* = 8.0 Hz), 5.17 (t, 1H, *J* = 6.0 Hz, NH), 3.11 (qd, 2H, *J* = 6.3, 2.7 Hz), 2.90-3.01 (m, 2H), 2.49-2.53 (m, 1H), 2.38 (s, 3H), 2.05-2.17 (m, 2H), 1.79-1.84 (m, 1H), 1.62-1.69 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 200.7, 144.3, 143.6, 137.2, 133.8 (CH), 132.5, 130.0 (2x CH), 129.0 (CH), 127.7 (CH), 127.4 (2x CH), 129.9 (CH), 45.6 (CH), 41.7 (CH_3), 30.0 (CH_2), 29.3 (CH_2), 29.1 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 3277, 1677, 1325, 1154 cm^{-1}

TLC (30% ethyl acetate in petroleum ether): 0.40 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclopentyl)ethyl)benzenesulfonamide (S2b)



$C_{14}H_{19}NO_3S$
MW: 281.37 g.mol^{-1}
White solid
mp = 75 °C
86% (2.42 g, 8.6 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.72 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 5.19 (br, 1H, NH), 2.92-3.07 (m, 2H), 2.40 (s, 3H), 2.28 (dd, 1H, *J* = 18.7, 8.8 Hz), 2.15-2.20 (m, 1H), 2.04-2.12 (m, 2H), 1.94-2.00 (m, 1H), 1.81 (sex, 1H, *J* = 7.0 Hz), 1.69-1.77 (m, 1H), 1.41-1.51 (m, 2H) ppm

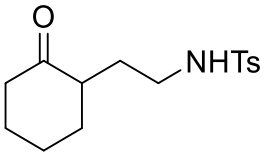
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 221.7, 143.6, 137.1, 130.0 (2x CH), 127.3 (2x CH), 47.3 (CH), 41.9 (CH_2), 38.2 (CH_2), 29.9 (CH_2), 29.5 (CH_2), 21.8 (CH_3), 21.0 (CH_2) ppm

IR (ATR): v = 3278, 1728, 1325, 1155 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 304.0978; found: 304.0974

TLC (50% ethyl acetate in petroleum ether): 0.57 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclohexyl)ethyl)benzenesulfonamide (S2c)



$C_{15}H_{21}NO_3S$
MW : 295.40 g.mol^{-1}
White solid
mp = 65 °C
90% (2.66 g, 9 mmol)

^{1}H NMR ($CDCl_3$, 400 MHz): δ = 7.71 (d, 2H, *J* = 8.4 Hz), 7.27 (d, 2H, *J* = 8.3 Hz), 5.37 (t, 1H, *J* = 6.1 Hz, NH), 2.93 (qd, 2H), 2.36-2.42 (m, 4H), 2.20-2.30 (m, 2H), 1.94-2.03 (m, 2H), 1.90 (sex, 1H, *J* = 6.9 Hz), 1.76-1.81 (m, 1H), 1.54-1.63 (m, 2H), 1.24-1.33 (m, 2H) ppm

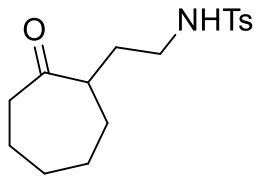
^{13}C NMR ($CDCl_3$, 100 MHz): δ = 213.4, 143.3, 137.1, 129.8 (2x CH), 127.2 (2x CH), 47.9 (CH), 42.2 (CH_2), 41.3 (CH_2), 34.3 (CH_2), 29.5 (CH_2), 28.1 (CH_2), 25.2 (CH_2), 21.6 (CH_3) ppm

IR (ATR): v = 3279, 1703, 1325, 1155 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 318.1134; found: 318.1115

TLC (40% ethyl acetate in petroleum ether): 0.48 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocycloheptyl)ethyl)benzenesulfonamide (S2d)



$C_{16}H_{23}NO_3S$
MW: 309.42 g.mol^{-1}
White solid
mp = 63 °C
90% (2.78 g, 9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.70 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 4.81-4.97 (m, 1H, NH), 2.84-2.89 (m, 2H), 2.62-2.66 (m, 1H), 2.38-2.49 (m, 5H), 1.79-1.89 (m, 4H), 1.58-1.72 (m, 2H), 1.35-1.53 (m, 2H), 1.23-1.28 (m, 2H) ppm

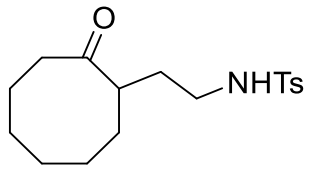
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 216.5, 143.6, 137.2, 130.0 (2x CH), 127.3 (2x CH), 49.1 (CH), 43.4 (CH_2), 41.5 (CH_2), 32.2 (CH_2), 31.9 (CH_2), 29.4 (CH_2), 29.0 (CH_2), 24.2 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 3279, 1694, 1325, 1156 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 332.1291; found: 332.1272

TLC (40% ethyl acetate in petroleum ether): 0.53 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclooctyl)ethyl)benzenesulfonamide (S2e)



$C_{17}H_{25}NO_3S$
MW: 323.45 $g.mol^{-1}$
Colorless oil
67% (2.17 g, 6.7 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.70 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 4.98 (br, 1H, NH), 2.77-2.89 (m, 2H), 2.69-2.75 (m, 1H), 2.38-2.43 (m, 5H), 2.27-2.33 (m, 1H), 1.93-2.01 (m, 1H), 1.83-1.88 (m, 2H), 1.71-1.78 (m, 2H), 1.45-1.57 (m, 4H), 1.32-1.39 (m, 1H), 1.09-1.14 (m, 1H) ppm

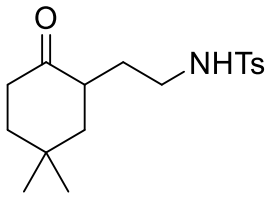
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 220.6, 143.7, 137.0, 130.0 (2x CH), 127.3 (2x CH), 47.4 (CH), 42.8 (CH_2), 41.8 (CH_2), 33.5 (CH_2), 32.2 (CH_2), 27.8 (CH_2), 25.6 (CH_2), 25.3 (CH_2), 24.9 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 3276, 1693, 1326, 1157 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 346.1447; found: 346.1463

TLC (40% ethyl acetate in petroleum ether): 0.50 (UV, Vanillin)

***N*-(2-(5,5-dimethyl-2-oxocyclohexyl)ethyl)-4-methylbenzenesulfonamide (S2f)**



$C_{17}H_{25}NO_3S$
MW: 323.45 $g.mol^{-1}$
Colorless oil
78% (2.52 g, 7.8 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.72 (d, 2H, *J* = 8.3 Hz), 7.29 (d, 2H, *J* = 8.3 Hz), 7.46 (d, 1H, *J* = 5.2 Hz, NH), 2.91-3.02 (m, 2H), 2.50-2.42 (m, 5H), 2.21 (ddd, 1H, *J* = 14.1, 4.6, 2.7 Hz), 1.87 (dq, 1H, *J* = 14.2, 7.0 Hz), 1.62-1.71 (m, 2H), 1.57 (td, 1H, *J* = 13.9, 5.2 Hz), 1.25-1.30 (m, 2H), 1.16 (s, 3H), 0.97 (s, 3H) ppm

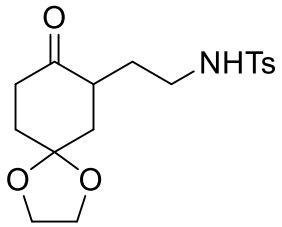
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 214.2, 143.6, 137.2, 130.0 (2x CH), 127.4 (2x CH), 47.3 (CH_2), 44.0 (CH), 41.8 (CH_2), 40.3 (CH_2), 38.7 (CH_2), 31.6 (CH_3), 31.2 (CH_2), 29.5 (CH_2), 24.7 (CH_3), 21.9 (CH_3) ppm

IR (ATR): v = 3288, 1706, 1325, 1157 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 346.1447; found: 346.1440

TLC (40% ethyl acetate in petroleum ether): 0.58 (UV, Vanillin)

4-methyl-*N*-(2-(8-oxo-1,4-dioxaspiro[4.5]decan-7-yl)ethyl)benzene sulfonamide (S2g)



$C_{17}H_{23}NO_5S$
MW: 353.43 g.mol^{-1}
Colorless oil
95% (3.36 g, 9.5 mmol)

N.B.: A saturated aqueous solution of oxalic acid was used for 30 minutes instead of a 10% hydrochloric acid solution overnight to deprotect the hydrazone.

^{1}H NMR ($CDCl_3$, 400 MHz): δ = 7.71 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 4.82 (t, 1H, *J* = 6.2 Hz, NH), 3.96-4.05 (m, 4H), 2.95 (qd, 2H, *J* = 6.5, 1.8 Hz), 2.72 (ddt, 1H, *J* = 13.3, 7.9, 5.1 Hz), 2.60 (dt, 1H, *J* = 14.2, 6.6 Hz), 2.40 (s, 3H), 2.32 (ddd, 1H, *J* = 14.1, 5.1, 3.0 Hz), 1.97-2.03 (m, 2H), 1.86-1.95 (m, 2H), 1.65 (t, 1H, *J* = 13.2 Hz), 1.31-1.39 (m, 1H) ppm

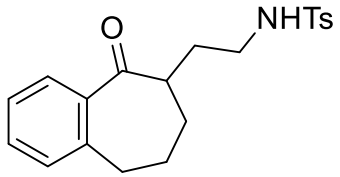
^{13}C NMR ($CDCl_3$, 100 MHz): δ = δ = 211.9, 143.6, 137.2, 130.0 (2x CH), 127.4 (2x CH), 107.4, 65.1 (CH_2), 64.9 (CH_2), 44.2 (CH), 41.5 (CH_2), 40.9 (CH_2), 38.5 (CH_2), 35.0 (CH_2), 29.3 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 3277, 1711, 1327, 1158 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 376.1189; found: 376.1178

TLC (40% ethyl acetate in petroleum ether): 0.50 (UV, Vanillin)

4-methyl-*N*-(2-(5-oxo-6,7,8,9-tetrahydro-5*H*-benzo[*7*]annulen-6-yl)ethyl)benzene sulfonamide (S2h)



$C_{20}H_{23}NO_3S$
MW : 357.47 g.mol^{-1}
Colorless oil
63% (2.25 g, 6.5 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.68 (d, 2H, *J* = 8.2 Hz), 7.60 (dd, 1H, *J* = 7.7, 1.2 Hz), 7.36 (td, 1H, *J* = 7.4, 1.5 Hz), 7.25 (t, 1H, *J* = 7.1 Hz), 7.23 (d, 2H, *J* = 8.2 Hz), 7.18 (d, 1H, *J* = 7.7 Hz), 4.97 (t, 1H, *J* = 6.2 Hz, NH), 2.88-2.96 (m, 5H), 2.38 (s, 3H), 2.01-2.13 (m, 2H), 1.81-1.88 (m, 1H), 1.56-1.66 (m, 2H), 1.46-1.54 (m, 1H) ppm

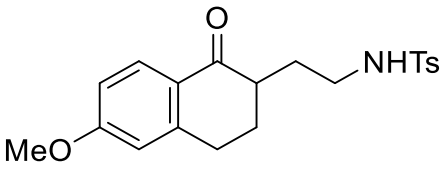
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 206.8, 143.3, 142.5, 139.5, 136.8, 131.6 (CH), 130.0 (CH), 129.7 (2x CH), 128.6 (CH), 127.1 (2x CH), 126.4 (CH), 46.9 (CH), 41.4 (CH_2), 33.5 (CH_2), 30.8 (CH_2), 30.3 (CH_2), 25.5 (CH_2), 21.6 (CH_3) ppm

IR (ATR): v = 3276, 1672, 1323, 1154 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 358.1471; found: 358.1466

TLC (30% ethyl acetate in petroleum ether): 0.30 (UV, Vanillin)

***N*-(2-(6-methoxy-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-4-methylbenzenesulfonamide (S2i)**



$C_{20}H_{23}NO_4S$
MW: 373.47 g.mol^{-1}
White solid
mp = 112 °C
63% (2.16 g, 6.3 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.95 (d, 1H, *J* = 8.7 Hz), 7.73 (d, 2H, *J* = 8.2 Hz), 7.25 (d, 2H, *J* = 8.2 Hz), 6.81 (dd, 1H, *J* = 8.7, 2.5 Hz), 6.65 (d, 1H, *J* = 2.5 Hz), 5.19 (t, 1H, *J* = 6.1 Hz, NH), 3.85 (s, 3H), 3.03-3.13 (m, 2H), 2.85-2.96 (m, 2H), 2.42-2.48 (m, 1H), 2.39 (s, 3H), 2.01-2.13 (m, 2H), 1.96-1.84 (m, 1H), 1.62-1.68 (m, 1H) ppm

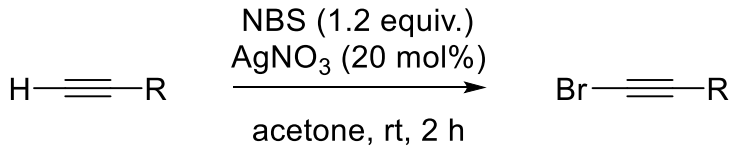
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.3, 163.8, 146.6, 143.3, 137.1, 130.1 (CH), 129.8 (2x CH), 127.2 (2x $CH_)$, 125.9, 113.4 (CH), 112.5 (CH), 55.6 (CH_3), 45.2 (CH), 41.7 (CH_2), 29.9 (CH_2), 29.3 (CH_2), 29.3 (CH_2), 21.6 (CH_3) ppm

IR (ATR): v = 1598, 1328, 1157, 1093 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 374.1421; found: 374.1411

TLC (30% ethyl acetate in petroleum ether): 0.27 (UV, Vanillin)

Experimental procedure and characterization data for bromoalkynes (S3a-k)

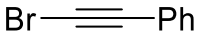


S3a-k

General procedure: To a solution of the alkyne (1 equiv, 5 mmol) in anhydrous acetone (conc = 0.30 M, 17 mL) were added *N*-bromosuccinimide (1.2 equiv, 6 mmol) and $AgNO_3$ (10 mol %, 0.5 mmol). After 1 h at room temperature, the same quantity of $AgNO_3$ (10 mol %, 0.5 mmol) was added and the mixture was stirred at room temperature for 1 h. The resulting mixture was then filtrated, and the filtrate was extracted with hexane or CH_2Cl_2 (3 x 20 mL). The combined organic layers were washed with a 10% aqueous solution of HCl (2 x 30 mL), brine (30 mL), dried (Na_2SO_4) and concentrated under vacuum (25°C, 15 mbar) to afford the title compounds **S3**.

N.B.: this reaction is carried out away from light.

(bromoethynyl)benzene (S3a)



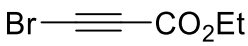
C_8H_5Br
MW: 181.03 g.mol^{-1}
Yellowish liquid
98%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.37-7.40 (m, 2H), 7.21-7.30 (m, 3H) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 132.3 (2x CH), 129.0 (CH), 128.7 (2x CH), 123.0, 80.4, 50.1 ppm

Spectral data were consistent with date reported in the literature.[11]

ethyl 3-bromopropiolate (S3b)



$C_5H_5BrO_2$
MW: 177.00 g.mol^{-1}
Colorless crystalline solid
91%

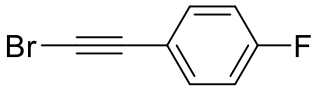
^{1}H NMR ($CDCl_3$, 300 MHz): δ = 4.24 (q, 2H, *J* = 7.2 Hz), 1.31 (t, 3H, *J* = 7.2 Hz) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 152.8, 73.1, 62.8 (CH_2), 52.8, 14.3 (CH_3) ppm

Spectral data were consistent with date reported in the literature.[12]

[11] Jiang, M. X.-W.; Rawat, M.; Wulff, W. D. *J. Am. Chem. Soc.* **2004**, *126*, 5970.
[12] Andersen, N. G.; Maddaford, S. P.; Keay, B. A. *J. Org. Chem.* **1996**, *61*, 2885.

1-(bromoethynyl)-4-fluorobenzene (S3c)



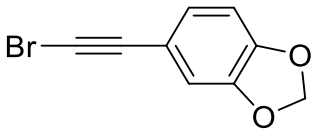
C_8H_4BrF
MW: 199.02 g.mol^{-1}
Yellow solid
96%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.40-7.46 (m, 2H), 6.97-7.04 (m, 2H) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 162.7 (d, J_{C-F} = 250 Hz), 134.0 (d, J_{C-F} = 8.4 Hz, 2x CH), 118.9 (d, J_{C-F} = 3.2 Hz), 115.7 (d, J_{C-F} = 22.2 Hz, 2x CH), 79.1, 49.6 ppm

Spectral data were consistent with date reported in the literature.[13]

5-(bromoethynyl)benzo[*d*][1,3]dioxole (S3d)



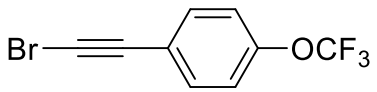
$C_9H_5BrO_2$
MW: 225.04 g.mol^{-1}
Yellow solid
93%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 6.98 (dd, 1H, *J* = 8.0, 1.6 Hz), 6.88 (d, 1H, *J* = 1.6 Hz), 6.74 (d, 1H, *J* = 8.0 Hz), 5.97 (s, 2H) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 148.6, 147.7, 127.1 (CH), 116.2, 112.2 (CH), 108.7 (CH), 101.7 (CH_2), 80.2, 48.2 ppm

Spectral data were consistent with date reported in the literature.[14]

1-(bromoethynyl)-4-(trifluoromethoxy)benzene (S3e)



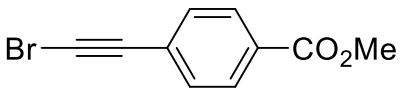
C_8H_5Br
MW: 181.03 g.mol^{-1}
Yellowish liquid
98%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.47 (d, 2H, *J* = 8.8 Hz), 7.16 (d, 2H, *J* = 8.4 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 149.3, 133.7 (2x CH), 121.6, 121.0 (2x CH), 120.5 (q, J_{C-F} = 256 Hz), 78.8, 51.2 ppm

Spectral data were consistent with date reported in the literature.[15]

methyl 4-(bromoethynyl)benzoate (S3f)



$C_{10}H_7BrO_2$
MW: 239.07 g.mol^{-1}
White solid
83%

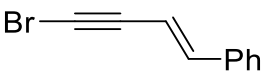
^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.98 (d, 2H, J = 8.4 Hz), 7.50 (d, 2H, J = 8.4 Hz), 3.92 (s, 3H) ppm

[13] Feng, Y.-S.; Xu, Z.-Q.; Mao, L.; Zhang, F.-F.; Xu, H.-J. *Org. Lett.* **2013**, *15*, 1472.
[14] Naskar, D.; Roy, S. *J. Org. Chem.* **1999**, *64*, 6896
[15] Gati, W.; Couty, F.; Boubaker, T.; Rammah, M. M.; Rammah, M. B.; Evano, G. *Org. Lett.* **2013**, *15*, 3122.

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 166.5, 132.1 (2x CH), 130.1, 129.6 (2x CH), 127.4, 79.5, 53.5, 52.4 (CH_3) ppm

Spectral data were consistent with date reported in the literature.[16]

(*E*)-(4-bromobut-1-en-3-yn-1-yl)benzene (S3g)



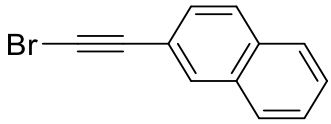
$C_{10}H_7Br$
MW: 207,07 g.mol^{-1}
Orange liquid
92%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.30-7.40 (m, 5H), 7.01 (d, 1H, *J* = 16.3 Hz), 6.13 (d, 1H, *J* = 16.3 Hz) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 142.8 (CH), 135.7, 128.8 (CH), 128.7 (2x CH), 126.2 (2x CH), 107.4 (CH), 79.3, 51.2 ppm

Spectral data were consistent with date reported in the literature.[13]

2-(bromoethynyl)naphthalene (S3h)



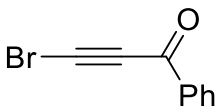
$C_{12}H_7Br$
MW: 231.09 g.mol^{-1}
Orange liquid
100%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.98 (br, 1H), 7.77-7.82 (m, 3H), 7.47-7.51 (m, 3H) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 133.1, 133.0 (CH), 132.3 (CH), 128.5 (CH), 128.2 (CH), 127.9, 127.9 (CH), 127.1 (CH), 126.8 (CH), 120.1, 80.6, 50.1 ppm

Spectral data were consistent with date reported in the literature.[17]

3-bromo-1-phenylprop-2-yn-1-one (S3i)



C_9H_5BrO
MW: 209.04 g.mol^{-1}
White solid
78%

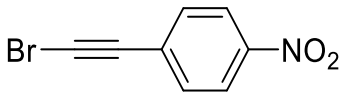
^{1}H NMR ($CDCl_3$, 400 MHz): δ = 8.12 (d, 2H, *J* = 7.9 Hz), 7.63 (t, 1H, *J* = 7.4 Hz), 7.49 (t, 2H, *J* = 8.0 Hz) ppm

^{13}C NMR ($CDCl_3$, 100 MHz): δ = 176.5, 136.1, 134.5 (CH), 129.7 (2x CH), 128.7 (2x CH), 78.9, 58.9 ppm

Spectral data were consistent with date reported in the literature.[18]

[16] Corpet, M.; Bai, X.-Z.; Gosmini, C. *Adv. Synth. Catal.* **2014**, *356*, 2937.
[17] Okutani, M.; Mori, Y. *J. Org. Chem.* **2009**, *74*, 442.
[18] Poulsen, T. B.; Bernardi, L.; Aleman, J.; Overgaard, J.; Jorgensen, K. A. *J. Am. Chem. Soc.* **2007**, *129*, 441.

1-(bromoethynyl)-4-nitrobenzene (S3j)



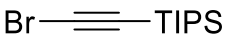
$C_8H_4BrNO_2$
MW: 226.03 g.mol^{-1}
Light yellow solid
79%

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.19 (d, 2H, *J* = 8.8 Hz), 7.60 (d, 2H, *J* = 8.8 Hz) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 147.5, 133.0 (2x CH), 129.6, 123.8 (2x CH), 78.6, 56.5 ppm

Spectral data were consistent with date reported in the literature.[19]

(bromoethynyl)triisopropylsilane (S3k)



$C_{11}H_{21}BrSi$
MW: 261.28 g.mol^{-1}
Colorless liquid
99%

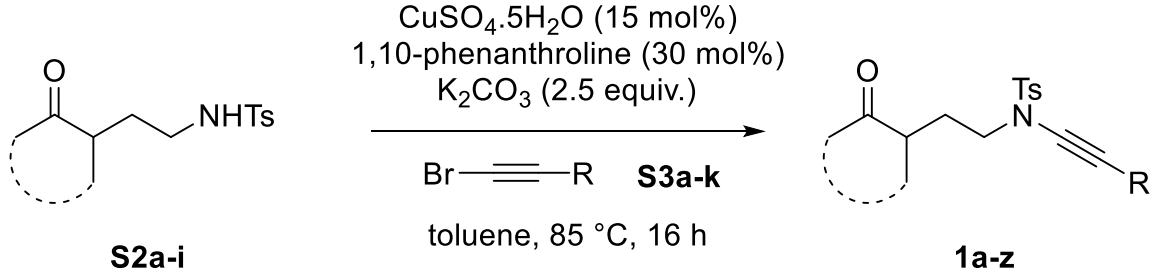
^{1}H NMR ($CDCl_3$, 300 MHz): δ = 1.08 (s, 21H) ppm

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 83.8, 62.1, 18.9 (6x CH_3), 11.7 (3x CH) ppm

Spectral data were consistent with date reported in the literature.[11]

[19] Witulski, B.; Schweikert, T.; Schollmeyer, D.; Nemkovich, N. A. *Chem. Commun.* **2010**, *46*, 2953.

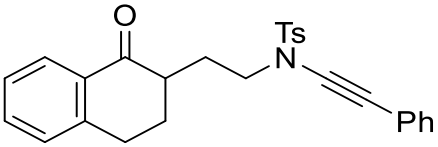
Experimental procedure and characterization data for keto-ynesulfonamides (1a-z)



S2a-i **1a-z**

General procedure: In a Schlenk tube was introduced $CuSO_4{\cdot}5H_2O$ (15 mol%, 0.3 mmol), 1,10-phenanthroline (30 mol%, 0.6 mmol), K_2CO_3 (2.5 equiv, 5 mmol), the sulfonamide **S2** (1 equiv, 2 mmol), anhydrous toluene (conc = 0.2 M, 10 mL) and the bromoalkyne **S3** (1.15 equiv, 2.3 mmol). The reaction mixture was heated to 85 °C for 16 h and then cooled down to room temperature, filtrated on a pad of silica and profusely washed with EtOAc. The filtrate was then concentrated under vacuum (40 °C, 15 mbar). The crude material was purified by column chromatography using a step gradient of EtOAc in petroleum ether (0 to 25%) to afford the title compounds **1**.

4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-*N*-(phenylethynyl)benzene sulfonamide (1a)



$C_{27}H_{25}NO_3S$
MW: 443.56 g.mol^{-1}
Yellow oil
75% (665 mg, 1.5 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.00 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.85 (d, 2H, *J* = 8.3 Hz), 7.46 (td, 1H, *J* = 7.7, 1.0 Hz), 7.28-7.38 (m, 8H), 7.23 (d, 1H, *J* = 7.8 Hz), 3.64 (td, 2H, *J* = 6.7, 1.8 Hz), 2.95-3.08 (m, 2H), 2.57-2.63 (m, 1H), 2.43-2.47 (m, 1H), 2.41 (s, 3H), 2.25-2.30 (m, 1H), 1.85-1.94 (m, 1H), 1.75-1.81 (m, 1H) ppm

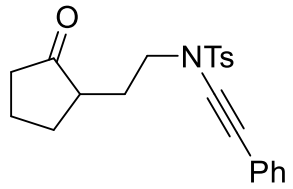
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.6, 144.8, 144.0, 134.5, 133.4 (CH), 132.5, 131.5 (2x CH), 129.9 (2x CH), 128.9 (CH), 128.4 (2x CH), 127.9 (CH), 127.8 (2x CH), 127.5 (CH), 126.7 (CH), 122.9, 82.3, 71.1, 50.0 (CH_2), 44.7 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.5 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2234, 1682, 1365, 1186 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 482.1187; found: 482.1182

TLC (30% ethyl acetate in petroleum ether): 0.58 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclopentyl)ethyl)-*N*-(phenylethynyl)benzenesulfonamide (1b)



$C_{22}H_{23}NO_3S$
MW: 381.49 g.mol^{-1}
Light yellow oil
82% (625 mg, 1.64 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.73 (d, 2H, *J* = 8.2 Hz), 7.24-7.27 (m, 4H), 7.16-7.19 (m, 3H), 3.37-3.44 (m, 2H), 2.34 (s, 3H), 2.19-2.29 (m, 2H), 1.89-2.15 (m, 4H), 1.63-1.73 (m, 1H), 1.38-1.53 (m, 2H) ppm

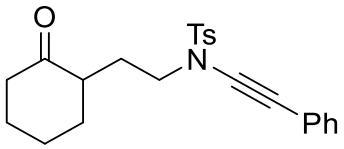
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 220.1, 144.9, 134.4, 131.5 (2x CH), 129.9 (2x CH), 128.4 (2x CH), 127.9 (CH), 127.8 (2x CH), 122.8, 82.1, 71.1, 50.1 (CH_2), 46.5 (CH), 37.8 (CH_2), 29.9 (CH_2), 28.1 (CH_2), 21.8 (CH_3), 20.8 (CH_2) ppm

IR (ATR): v = 2234, 1734, 1364, 1168 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 420.1030; found: 420.1018

TLC (30% ethyl acetate in petroleum ether): 0.38 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclohexyl)ethyl)-*N*-(phenylethynyl)benzenesulfonamide (1c)



$C_{23}H_{25}NO_3S$
MW: 395.52 g.mol^{-1}
White solid
95% (751 mg, 1.9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.80 (d, 2H, *J* = 8.2 Hz), 7.32-7.34 (m, 4H), 7-25-7.29 (m, 3H), 3.37-3.49 (m, 2H), 2.50-2.56 (m, 1H), 2.43 (s, 3H), 2.26-2.37 (m, 2H), 2.11-2.17 (m, 2H,), 2.04-2.09 (m, 1H), 1.82-1.86 (m, 1H), 1.59-1.73 (m, 2H), 1.51-1.56 (m, 1H), 1.35 (qd, 1H, *J* = 12.5, 3.8 Hz) ppm

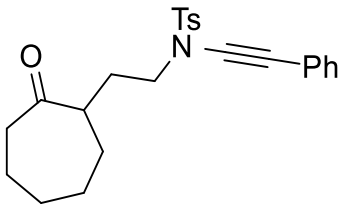
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 212.8, 145.0, 134.7, 131.6 (2x CH), 130.2 (2x CH), 128.6 (2x CH), 128.1 (CH), 128.0 (2x CH), 123.1, 82.7, 71.0, 50.2 (CH_2), 47.3 (CH), 42.6 (CH_2), 34.9 (CH_2), 28.5 (CH_2), 28.3 (CH_2), 25.6 (CH_2), 22.0 (CH_3) ppm

IR (ATR): v = 2235, 1708, 1365, 1186 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 418.1447; found: 418.1442

TLC (20% ethyl acetate in petroleum ether): 0.34 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocycloheptyl)ethyl)-*N*-(phenylethynyl)benzenesulfonamide (1d)



$C_{24}H_{27}NO_3S$
MW: 409.54 g.mol^{-1}
Light yellow oil
99% (811 mg, 1.98 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.3 Hz), 7.34-7.37 (m, 4H), 7.27-7.30 (m, 3H), 3.41 (ddd, 1H, *J* = 13.0, 8.4, 5.6 Hz), 3.33 (ddd, 1H, *J* = 13.0, 5.9, 5.7 Hz), 2.83-2.89 (m, 1H), 2.57 (ddd, 1H, *J* = 16.1, 5.1, 4.4 Hz), 2.38-2.44 (m, 4H), 2.12 (ddt, 1H, *J* = 14.2, 8.9, 5.6 Hz), 1.65-1.91 (m, 6H),

1.47-1.55 (m, 1H), 1.20-1.35 (m, 2H) ppm

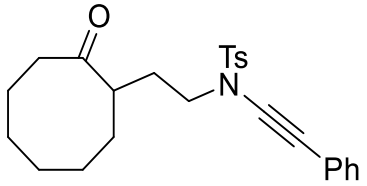
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 215.3, 144.8, 134.5, 131.4 (2x CH), 129.9 (2x CH), 128.4 (2x CH), 127.9 (CH), 127.7 (2x CH), 122.8, 82.0, 70.6, 50.2 (CH_2), 47.7 (CH), 43.6 (CH_2), 32.2 (CH_2), 30.4 (CH_2), 29.2 (CH_2), 29.0 (CH_2), 23.6 (CH_2), 21.6 (CH_3) ppm

IR (ATR): v = 2233, 1697, 1362, 1166 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 410.1784; found: 410.1776

TLC (30% ethyl acetate in petroleum ether): 0.48 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclooctyl)ethyl)-*N*-(phenylethynyl)benzenesulfonamide (1e)



$C_{25}H_{29}NO_3S$
MW: 423.57 $g.mol^{-1}$
Light yellow oil
100% (847 mg, 2 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.2 Hz), 7.34-7.37 (m, 4H), 7.28-7.30 (m, 3H), 3.34 (ddd, 1H, *J* = 13.0, 8.7, 5.4 Hz), 3.27 (ddd, 1H, *J* = 13.0, 5.9, 5.3 Hz), 2.93 (ddt, 1H, *J* = 10.4, 9.1, 4.4 Hz), 2.56 (ddd, 1H, *J* = 14.5, 7.9, 3.1 Hz), 2.45 (s, 3H), 2.33 (ddd, 1H, *J* = 14.4, 11.1, 3.2 Hz), 2.03-2.14 (m, 2H), 1.90 (ddt, 1H, *J* = 13.7, 6.8, 3.3 Hz), 1.70-1.79 (m, 2H), 1.50-1.67 (m, 5H), 1.39-1.45 (m, 1H), 1.07-1.14 (m, 1H) ppm

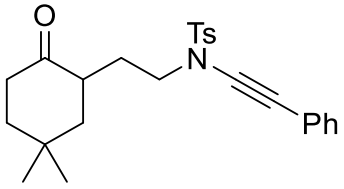
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 219.5, 144.9, 134.4, 131.5 (2x CH), 130.0 (2x CH), 128.5 (2x CH), 128.0 (CH), 127.8 (2x CH), 122.9, 82.4, 70.9, 50.2 (CH_2), 46.0 (CH), 43.4 (CH_2), 34.0 (CH_2), 30.5 (CH_2), 28.0 (CH_2), 25.2 (CH_2), 24.9 (CH_2), 24.6 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2234 (N-C≡C), 1696 (CO), 1364 (SO_2N), 1166 (SO_2) cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 424.1941; found: 424.1947

TLC (30% ethyl acetate in petroleum ether): 0.62 (UV, Vanillin)

***N*-(2-(5,5-dimethyl-2-oxocyclohexyl)ethyl)-4-methyl-*N*-(phenylethynyl)benzenesulfonamide (1f)**



$C_{25}H_{29}NO_3S$
MW: 423.57 $g.mol^{-1}$
Light yellow oil
84% (712 mg, 1.68 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.73 (d, 2H, *J* = 8.2 Hz), 7.25-7.27 (m, 4H), 7.17-7.20 (m, 3H), 3.38 (td, 2H, *J* = 6.7, 1.4 Hz), 2.56 (ddt, 1H, *J* = 13.5, 7.3, 5.3 Hz), 2.33-2.40 (m, 4H), 2.03-2.15 (m, 2H), 1.69 (dt, 1H, *J* = 13.1, 4.5 Hz), 1.59-1.65 (m, 1H), 1.51 (td, 1H, *J* = 13.8, 4.5 Hz), 1.37 (dtd, 1H, *J* = 14.4, 6.8, 5.2 Hz), 1.25 (t, 1H, *J* = 13.3 Hz), 1.11 (s, 3H), 0.90 (s, 3H) ppm

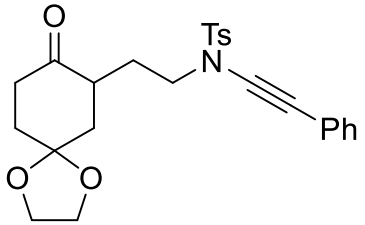
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 213.1, 144.7, 134.6, 131.4 (2x CH), 129.9 (2x CH), 128.4 (2x CH), 127.9 (CH), 127.8 (2x CH), 122.9, 82.5, 70.7, 50.0 (CH_2), 47.2 (CH_2), 42.6 (CH), 40.4 (CH_2), 38.6 (CH_2), 31.5 (CH_3), 31.0 (CH_2), 28.0 (CH_2), 24.5 (CH_3), 21.8 (CH_3) ppm

IR (ATR): v = 2234, 1708, 1598, 1363, 1167 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 462.1500; found: 462.1501

TLC (30% ethyl acetate in petroleum ether): 0.51 (UV, Vanillin)

4-methyl-*N*-(2-(8-oxo-1,4-dioxaspiro[4.5]decan-7-yl)ethyl)-*N*-(phenylethynyl)benzene sulfonamide (1g)



$C_{25}H_{27}NO_5S$
MW: 453.55 g.mol^{-1}
Light yellow oil
96% (871 mg, 1.92 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.2 Hz), 7.32-7.36 (m, 4H), 7.25-7.28 (m, 3H), 3.96-4.05 (m, 4H), 3.43 (ddd, 2H, *J* = 6.7, 6.5, 3.4 Hz), 2.88 (dtd, 1H, *J* = 13.4, 6.7, 5.1 Hz), 2.65 (ddd, 1H, *J* = 14.1, 13.4, 6.5 Hz), 2.42 (s, 3H), 2.33 (ddd, 1H, *J* = 14.1, 5.1, 2.7 Hz), 2.12-2.20 (m, 2H), 2.00-2.05 (m, 1H), 1.94 (ddd, 1H, *J* = 14.1, 13.4, 5.1 Hz), 1.68 (t, 1H, *J* = 13.4 Hz), 1.52 (dtd, 1H, *J* = 14.1, 6.7, 6.5 Hz) ppm

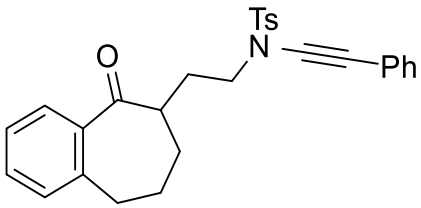
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 211.0, 144.8, 134.4, 131.4 (2x CH), 129.9 (2x CH), 128.3 (2x CH), 127.9 (CH), 127.7 (2x CH), 122.8, 107.1, 82.3, 70.7, 64.9 (CH_2), 64.7 (CH_2), 49.6 (CH_2), 43.0 (CH), 40.7 (CH_2), 38.4 (CH_2), 35.0 (CH_2), 27.7 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2234, 1712, 1362, 1167, 1120 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 476.1502; found: 476.1513

TLC (40% ethyl acetate in petroleum ether): 0.35 (UV, Vanillin)

4-methyl-*N*-(2-(5-oxo-6,7,8,9-tetrahydro-5H-benzo[*7*]annulen-6-yl)ethyl)-*N*-(phenylethynyl) benzenesulfonamide (1h)



$C_{28}H_{27}NO_3S$
MW: 457.59 g.mol^{-1}
Light yellow oil
100% (915 mg, 2 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.79 (d, 2H, *J* = 8.3 Hz), 7.70 (dd, 1H, *J* = 7.7, 1.6 Hz), 7.36 (td, 1H, *J* = 7.4, 1.6 Hz), 7.31 (d, 2H, *J* = 8.3 Hz), 7.20-7.24 (m, 7H), 3.42-3.51 (m, 2H), 2.91-3.14 (m, 3H), 2.43 (s, 3H), 2.33-2.40 (m, 1H), 2.10-2.16 (m, 1H), 1.96-2.03 (m, 1H), 1.84-1.90 (m, 1H), 1.56-1.69 (m, 2H) ppm

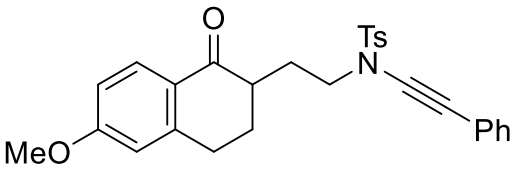
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 205.8, 144.7, 142.7, 139.6, 134.5, 131.5 (CH), 131.4 (2x CH), 130.1 (CH), 129.9 (2x CH), 128.7 (CH), 128.3 (2x CH), 127.9 (CH), 127.7 (2x CH), 126.5 (CH), 122.8, 82.5, 70.7, 50.0 (CH_2), 46.2 (CH), 33.8 (CH_2), 30.8 (CH_2), 29.7 (CH_2), 25.7 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2234, 1676, 1597, 1363, 1167 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 458.1784; found: 458.1788

TLC (30% ethyl acetate in petroleum ether): 0.46 (UV, Vanillin)

_N_-(2-(6-methoxy-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-4-methyl-_N_-(phenylethynyl) benzenesulfonamide (1i)



$C_{28}H_{27}NO_4S$
MW: 473.59 g.mol^{-1}
Light yellow oil
100% (947 mg, 2 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.98 (d, 1H, *J* = 8.8 Hz), 7.85 (d, 2H, *J* = 8.2 Hz), 7.36-7.38 (m, 2H), 7.33 (d, 2H, *J* = 8.2 Hz), 7.26-7.32 (m, 3H), 6.81 (dd, 1H, *J* = 8.7, 2.5 Hz), 6.67 (d, 1H, *J* = 2.5 Hz), 3.84 (s, 3H), 3.61-3.65 (m, 2H), 2.89-3.02 (m, 2H), 2.54 (dtd, 1H, *J* = 12.4, 6.0, 4.2 Hz), 2.41-2.47 (m, 4H), 2.24 (ddt, 1H, *J* = 13.1, 4.8, 3.9 Hz), 1.86 (tdd, 1H, *J* = 12.4, 12.1, 4.1 Hz), 1.76 (dtd, 1H, *J* = 12.9, 7.1, 6.1 Hz) ppm

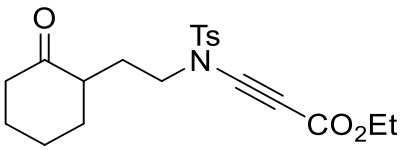
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 198.2, 163.5, 146.4, 144.8, 134.4, 131.4 (2x CH), 129.9 (2x CH), 129.9 (CH), 128.3 (2x CH), 127.8 (CH), 127.7 (2x CH), 126.1, 122.9, 113.3 (CH), 112.5 (CH), 82.3, 71.0, 55.5 (CH_3), 50.0 (CH_2), 44.3 (CH), 29.4 (CH_2), 29.2 (CH_2), 28.5 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 2235, 1597, 1362, 1167, 1089 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 474.1734; found: 474.1717

TLC (30% ethyl acetate in petroleum ether): 0.43 (UV, Vanillin)

ethyl 3-((4-methyl-_N_-(2-(2-oxocyclohexyl)ethyl)phenyl)sulfonamido)propiolate (1j)



$C_{20}H_{25}NO_5S$
MW: 391.48 g.mol^{-1}
Colorless oil
81% (634 mg, 1.62 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.79 (d, 2H, *J* = 8.3 Hz), 7.36 (d, 2H, *J* = 8.3 Hz), 4.21 (q, 2H, *J* = 7.1 Hz), 3.41-3.53 (m, 2H), 2.44 (s, 3H), 2.26-2.42 (m, 3H), 2.03-2.10 (m, 3H), 1.83-1.86 (m, 1H), 1.58-1.71 (m, 2H), 1.47-1.54 (m, 1H), 1.33-1.39 (m, 1H), 1.29 (t, 3H, *J* = 7.2 Hz) ppm

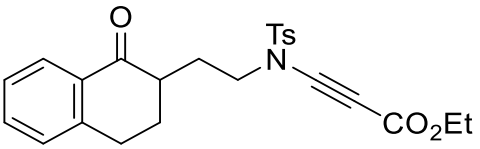
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 212.5, 154.4, 145.8, 134.4, 130.4 (2x CH), 128.0 (2x CH), 82.6, 67.9, 61.9 (CH_2), 50.0 (CH_2), 47.2 (CH), 42.5 (CH_2), 34.9 (CH_2), 28.5 (CH_2), 28.5 (CH_2), 25.6 (CH_2), 22.0 (CH_2), 14.5 (CH_3) ppm

IR (ATR): v = 2214, 1703, 1597, 1371, 1170, 1150 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 430.1085; found: 430.1037

TLC (30% ethyl acetate in petroleum ether): 0.49 (UV, Vanillin)

ethyl 3-((4-methyl-_N_-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)phenyl)sulfonamido) propiolate (1k)



$C_{24}H_{25}NO_5S$
MW: 439.53 g.mol^{-1}
Yellow oil
74% (650 mg, 1.48 mmol)

N.B.: K_3PO_4 (2 equiv) was used instead of K_2CO_3 (2.5 equiv) and the heating was reduced to 70 °C for

1 h instead of 85 °C for 16 h.

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.99 (dd, 1H, *J* = 7.5, 1.2 Hz), 7.83 (d, 2H, *J* = 8.3 Hz), 7.47 (td, 1H, *J* = 7.5, 1.2 Hz), 7.33 (d, 2H, *J* = 8.3 Hz), 7.30 (t, 1H, *J* = 7.5 Hz), 7.22 (d, 1H, *J* = 7.5 Hz), 4.22 (q, 2H, *J* = 7.1 Hz), 3.69 (t, 2H, *J* = 7.0 Hz), 2.93-3.05 (m, 2H), 2.42-2.48 (m, 1H), 2.40 (s, 3H), 2.31 (sex, 1H, *J* = 7.1 Hz), 2.17-2.22 (m, 1H), 1.83-1.92 (m, 1H), 1.72-1.79 (m, 1H), 1.30 (t, 3H, *J* = 7.1 Hz) ppm

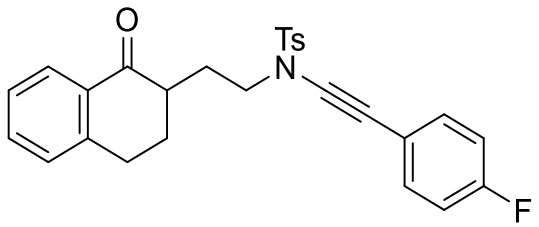
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.3, 154.3, 145.7, 143.9, 134.2, 133.5 (CH), 132.4, 130.2 (2x CH), 128.9 (CH), 127.9 (2x CH), 127.5 (CH), 126.8 (CH), 82.4, 68.0, 61.7 (CH_2), 50.0 (CH_2), 44.6 (CH), 29.5 (CH_2), 29.2 (CH_2), 28.9 (CH_2), 21.8 (CH_3), 14.3 (CH_3) ppm

IR (ATR): v = 2213, 1700, 1682,1369, 1188, 1144 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 478.1085; found: 478.1072

TLC (30% ethyl acetate in petroleum ether): 0.55 (UV, Vanillin)

***N*-((4-fluorophenyl)ethynyl)-4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl) benzenesulfonamide (1l)**



$C_{27}H_{24}FNO_3S$
MW: 461.55 $g.mol^{-1}$
Yellow oil
68% (628 mg, 1.36 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.00, dd, 1H, *J* = 7.7, 0.9 Hz), 7.83 (d, 2H, *J* = 8.3 Hz), 7.47 (td, 1H, *J* = 7.6, 1.0 Hz), 7.33-7.36 (m, 4H), 7.30 (t, 1H, *J* = 7.6 Hz), 7.23 (d, 1H, *J* = 7.7 Hz), 6.98 (t, 2H, *J* = 8.7 Hz), 3.57-3.67 (m, 2H), 2.95-3.06 (m, 2H), 2.56-2.62 (m, 1H), 2.42 (s, 3H), 2.30-2.42 (m, 1H), 1.85-1.93 (m, 1H), 1.73-1.80 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.6, 162.4 (d, J_{C-F} = 250 Hz), 144.9, 144.0, 134.5, 133.6 (d, J_{C-F} = 8 Hz, 2x CH), 133.5 (CH), 132.5, 130.0 (2x CH), 128.9 (CH), 127.8 (2x CH), 127.5 (CH), 126.8 (CH), 118.9 (d, J_{C-F} = 3 Hz), 115.7 (d, J_{C-F} = 22 Hz, 2x CH), 81.8, 70.0, 49.9 (CH_2), 44.7 (CH), 29.2 (CH_2), 29.1 (CH_2), 28.5 (CH_2), 21.8 (CH_3) ppm

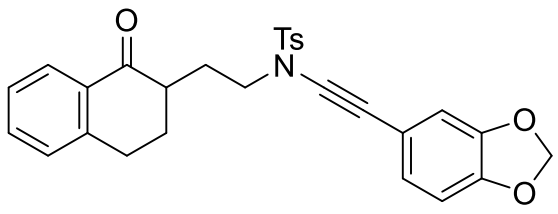
IR (ATR): v = 2236, 1680, 1362, 1186, 1090 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 500.1193; found: 500.1053

IR (ATR): v = 3277, 1677, 1325, 1154 cm^{-1}

TLC (30% ethyl acetate in petroleum ether): 0.60 (UV, Vanillin)

***N*-(benzo[*d*][1,3]dioxol-5-ylethynyl)-4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)benzenesulfonamide (1m)**



$C_{28}H_{25}NO_5S$
MW: 487.57 $g.mol^{-1}$
Yellow oil
56% (548 mg, 1.12 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.00 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.83 (d, 2H, *J* = 8.2 Hz), 7.46 (td, 1H, *J*

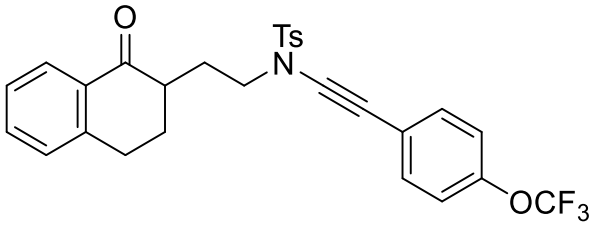
= 7.7, 1.0 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 7.30 (t, 1H, *J* = 7.6 Hz), 7.23 (d, 1H, *J* = 7.8 Hz), 6.90 (dd, 1H, *J* = 8.0, 1.6 Hz), 6.82 (d, 1H, *J* = 1.6 Hz), 6.73 (d, 1H, *J* = 8.0 Hz), 5.96 (s, 2H), 3.61 (td, 2H, *J* = 6.8, 3.5 Hz), 2.95-3.07 (m, 2H), 2.56-2.62 (m, 1H), 2.39-2.46 (m, 1H), 2.42 (s, 3H), 2.24-2.29 (m, 1H), 1.85-1.93 (m, 1H), 1.72-1.79 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.6, 147.8, 147.5, 144.8, 144.0, 134.5, 133.5 (CH), 132.5, 129.9 (2x CH), 128.9 (CH), 127.8 (2x CH), 127.5 (CH), 126.7 (CH), 126.6 (CH), 116.0, 112.0 (CH), 108.5 (CH), 101.4 (CH_2), 80.5, 70.8, 50.0 (CH_2), 44.7 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.5 (CH_2), 21.8 (CH_3) ppm

ESI-HRMS: $[M+Na]^+$ calc: 510.1346; found: 510.1336

TLC (30% ethyl acetate in petroleum ether): 0.43 (UV, Vanillin)

4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-*N*-((4-(trifluoromethoxy)phenyl) ethynyl)benzenesulfonamide (1n)



$C_{28}H_{24}F_3NO_4S$
MW: 527.56 g.mol^{-1}
Light yellow oil
70% (739 mg, 1.4 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.98 (dd, 1H, *J* = 7.8, 1.3 Hz), 7.81 (d, 2H, *J* = 8.2 Hz), 7.44 (td, 1H, *J* = 7.5, 1.3 Hz), 7.37 (d, 2H, *J* = 8.8 Hz), 7.32 (d, 2H, *J* = 8.2 Hz), 7.28 (t, 1H, *J* = 7.5 Hz), 7.21 (dd, 1H, *J* = 7.6, 1.2 Hz), 7.12 (d, 2H, *J* = 8.8 Hz), 3.59-3.69 (m, 2H), 2.95-3.07 (m, 2H), 2.55-2.61 (m, 1H), 2.41-2.48 (m, 4H), 2.24 (ddt, 1H, *J* = 13.2, 4.5, 3.9 Hz), 1.87 (tdd, 1H, *J* = 12.6, 11.8, 4.8 Hz), 1.74-1.81 (m, 1H) ppm

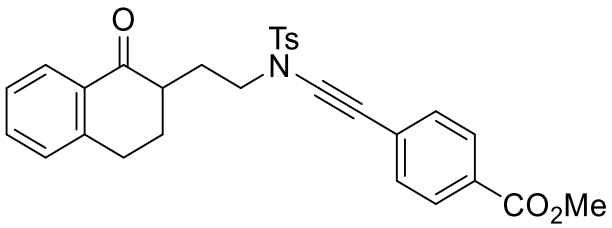
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.5, 148.6, 145.0, 143.9, 134.5, 133.5 (CH), 132.9 (2x CH), 132.5, 138.0 (2x CH), 128.9 (CH), 127.8 (2x CH), 127.5 (CH), 126.8 (CH), 121.8, 121.0 (2x CH), 120.5 (q, J_{C-F} = 256 Hz), 83.1, 69.9, 49.9 (CH_2), 44.7 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.6 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2236, 1681, 1598, 1365, 1158 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 550.1270; found: 550.1255

TLC (40% ethyl acetate in petroleum ether): 0.59 (UV, Vanillin)

methyl 4-(((4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)phenyl)sulfonamido) ethynyl)benzoate (1o)



$C_{29}H_{27}NO_5S$
MW: 501.60 g.mol^{-1}
Light yellow oil
54% (542 mg, 1.08 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.00 (dd, 1H, *J* = 7.7, 1.3 Hz), 7.95 (d, 2H, *J* = 8.3 Hz), 7.84 (d, 2H, *J* = 8.3 Hz), 7.46 (td, 1H, *J* = 7.6, 1.4 Hz), 7.40 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 7.30 (t, 1H, *J* = 7.6 Hz), 7.22 (d, 1H, *J* = 7.7 Hz), 3.91 (s, 3H), 3.62-3.71 (m, 2H), 2.94-3.07 (m, 2H), 2.58 (dtd, 1H, *J* = 12.6, 6.2, 4.1 Hz), 2.41-2.48 (m, 4H), 2.26 (ddt, 1H, *J* = 13.3, 4.8, 3.7 Hz), 1.90 (tdd, 1H, *J* = 12.9, 11.6, 4.8 Hz), 1.79 (ddt, 1H, *J* = 14.2, 6.9, 6.2 Hz) ppm

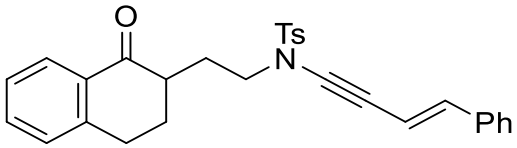
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.4, 166.7, 145.1, 143.9, 134.5, 133.5 (CH), 132.5, 130.7 (2x CH), 130.0 (2x CH), 129.6 (2x CH), 128.8 (CH), 128.8, 127.9, 127.7 (2x CH), 127.5 (CH), 126.8 (CH), 85.6, 71.2, 52.3 (CH_3), 49.9 (CH_2), 44.6 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.6 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 2229, 1717, 1680, 1603, 1365, 1272, 1168, 1108 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 524.1502; found: 524.1486

TLC (30% ethyl acetate in petroleum ether): 0.34 (UV, Vanillin)

(*E*)-4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-*N*-(4-phenylbut-3-en-1-yn-1-yl)benzenesulfonamide (1p)



$C_{29}H_{27}NO_3S$
MW: 469.60 $g.mol^{-1}$
Yellow oil
62% (600 mg, 1.24 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.95 (dd, 1H, *J* = 7.8, 1.3 Hz), 7.78 (d, 2H, *J* = 8.3 Hz), 7.41 (td, 1H, *J* = 7.4, 1.5 Hz), 7.17-7.31 (m, 9H), 6.78 (d, 1H, *J* = 16.2 Hz), 6.19 (d, 1H, *J* = 16.2 Hz), 3.53-3.57 (m, 2H), 2.89-3.02 (m, 2H), 2.49-2.55 (m, 1H), 2.32-2.39 (m, 1H), 2.36 (s, 3H), 2.18-2.23 (m, 1H), 1.79-1.87 (m, 1H), 1.67-1.73 (m, 1H) ppm

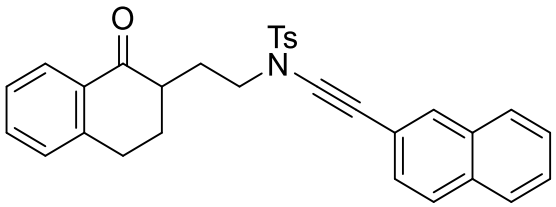
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.5, 144.8, 143.9, 139.6 (CH), 136.5, 134.6, 133.4 (CH), 132.5, 129.9 (2x CH), 128.8 (CH), 128.8 (2x CH), 128.4 (CH), 127.7 (2x CH), 127.5 (CH), 126.7 (CH), 126.1 (2x CH), 107.6 (CH), 84.3, 70.6, 50.0 (CH_2), 44.7 (CH), 29.2 (CH_2), 29.1 (CH_2), 28.5 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 2217, 1679, 1598, 1361, 1166 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 470.1784; found: 470.1785

TLC (30% ethyl acetate in petroleum ether): 0.70 (UV, Vanillin)

4-methyl-*N*-(naphthalen-2-ylethynyl)-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl) benzenesulfonamide (1q)



$C_{31}H_{27}NO_3S$
MW: 493.62 $g.mol^{-1}$
Yellow oil
33% (326 mg, 0.66 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.03 (dd, 1H, *J* = 7.8, 1.3 Hz), 7.89-7.90 (m, 3H), 7.75-7.81 (m, 3H), 7.42-7.49 (m, 4H), 7.34 (d, 2H, *J* = 8.2 Hz), 7.31 (t, 1H, *J* = 7.6 Hz), 7.23 (d, 1H, *J* = 7.7 Hz), 3.70 (td, 2H, *J* = 6.9, 2.3 Hz), 2.95-3.08 (m, 2H), 2.63 (dtd, 1H, *J* = 12.6, 6.3, 4.4 Hz), 2.50 (dq, 1H, *J* = 14.1, 6.8 Hz), 2.42 (s, 3H), 2.30 (dq, 1H, *J* = 13.3, 4.3 Hz), 1.81-1.96 (m, 2H) ppm

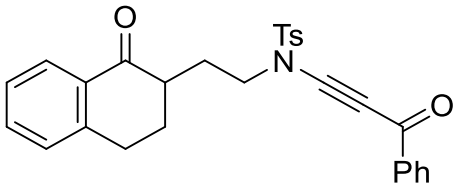
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.5, 144.8, 143.9, 134.6, 133.4 (CH), 133.1, 132.6, 132.5, 130.9 (CH), 129.9 (2x CH), 128.8 (CH), 128.4 (CH), 128.0 (CH), 127.8 (CH), 127.8 (2x CH), 127.7 (CH), 127.5 (CH), 126.7 (CH), 126.6 (CH), 126.5 (CH), 120.2, 82.6, 71.6, 50.0 (CH_2), 44.7 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.6 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 2232, 1680, 1598, 1363, 1168 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 516.1604; found: 516.1593

TLC (30% ethyl acetate in petroleum ether): 0.49 (UV, Vanillin)

4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-*N*-(3-oxo-3-phenylprop-1-yn-1-yl)benzenesulfonamide (1r)



$C_{28}H_{25}NO_4S$
MW : 471.57 g.mol^{-1}
Light yellow oil
58% (547 mg, 1.16 mmol)

N.B.: K_3PO_4 (2 equiv) was used instead of K_2CO_3 (2.5 equiv) and the heating was reduced to 70 °C for 1 h instead of 85 °C for 16 h.

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.18 (dd, 2H, *J* = 7.7, 1.5 Hz), 7.99 (dt, 1H, *J* = 7.7, 1.5 Hz), 7.84 (d, 2H, *J* = 8.3 Hz), 7.60 (t, 1H, *J* = 7.5 Hz), 7.52 (t, 2H, *J* = 7.6 Hz), 7.46 (td, 1H, *J* = 7.5, 1.4 Hz), 7.29-7.32 (m, 3H), 7.22 (dd, 1H, *J* = 7.7, 1.6 Hz), 3.76-3.79 (m, 2H), 2.93-3.05 (m, 2H), 2.44-2.50 (m, 1H), 2.31-2.37 (m, 4H), 2.18-2.24 (m, 1H), 1.83-1.94 (m, 2H) ppm

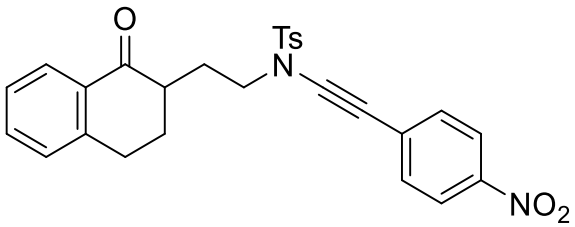
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.4, 177.0, 145.9, 143.9, 137.0, 134.2, 133.8 (CH), 133.6 (CH), 132.4, 130.4 (2x CH), 129.3 (2x CH), 128.9 (CH), 128.8 (2x CH), 127.8 (2x CH), 127.5 (CH), 126.8 (CH), 90.5, 76.8, 50.1 (CH_2), 44.6 (CH), 29.7 (CH_2), 29.2 (CH_2), 29.2 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2188, 1634, 1597, 1372, 1168 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 494.1396; found: 494.1381

TLC (40% ethyl acetate in petroleum ether): 0.40 (UV, Vanillin)

4-methyl-*N*-((4-nitrophenyl)ethynyl)-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl) benzenesulfonamide (1s)



$C_{27}H_{24}N_2O_5S$
MW: 488.56 g.mol^{-1}
Yellow oil
29% (283 mg, 0.58 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.15 (d, 2H, *J* = 8.8 Hz), 8.00 (dd, 1H, *J* = 7.9, 1.4 Hz), 7.84 (d, 2H, *J* = 8.2 Hz), 7.45-7.49 (m, 3H), 7.35 (d, 2H, *J* = 8.3 Hz), 7.31 (t, 1H, *J* = 7.6 Hz), 7.23 (d, 1H, *J* = 7.8 Hz), 3.63-3.74 (m, 2H), 2.95-3.07 (m, 2H), 2.57 (dtd, 1H, *J* = 12.7, 6.3, 4.6 Hz), 2.42-2.48 (m, 4H), 2.25 (dq, 1H, *J* = 13.2, 4.2 Hz), 1.90 (tdd, 1H, *J* = 12.9, 11.4, 4.8 Hz), 1.80 (dq, 1H, *J* = 14.1, 6.7 Hz) ppm

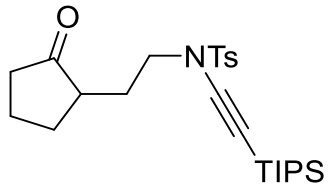
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.4, 146.4, 145.3, 143.9, 134.5, 133.6 (CH), 132.4, 131.0 (2x CH), 130.4, 130.2 (2x CH), 128.9 (CH), 127.8 (2x CH), 127.5 (CH), 126.8 (CH), 123.8 (2x CH), 88.3, 71.0, 49.9 (CH_2), 44.6 (CH), 29.3 (CH_2), 29.1 (CH_2), 28.8 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 2227, 1681, 1595, 1516, 1368, 1340, 1187 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 511.1298; found: 511.1306

TLC (30% ethyl acetate in petroleum ether): 0.51 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclopentyl)ethyl)-*N*-((triisopropylsilyl)ethynyl)benzenesulfonamide (1t)



$C_{25}H_{39}NO_3SSi$
MW: 461.74 g.mol^{-1}
Colorless oil
87% (803 mg, 1.74 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.72 (d, 2H, *J* = 8.2 Hz), 7.25 (d, 2H, *J* = 8.2 Hz), 3.36 (t, 2H, *J* = 6.6 Hz), 2.37 (s, 3H), 2.17-2.30 (m, 2H), 2.04-2.11 (m, 2H), 1.88-2.01 (m, 2H), 1.62-1.79 (m, 1H), 1.39-1.53 (m, 2H), 0.97 (s, 21H) ppm

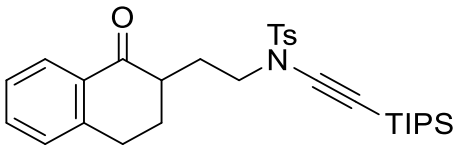
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 220.2, 144.9, 134.7, 130.0 (2x CH), 128.0 (2x CH), 96.4, 70.1, 50.3 (CH_2), 46.7 (CH), 38.0 (CH_2), 30.1 (CH_2), 28.3 (CH_2), 22.0 (CH_3), 18.9 (6x CH_3), 11.7 (3x CH)

IR (ATR): v = 2160, 1737, 1366, 1168 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 484.2312; found: 484.2270

TLC (20% ethyl acetate in petroleum ether): 0.52 (UV, Vanillin)

4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-*N*-((triisopropylsilyl)ethynyl) benzenesulfonamide (1u)



$C_{30}H_{41}NO_3SSi$
MW: 523.81 g.mol$_{-1}$
White solid
mp = 72 °C
82% (859 mg, 1.64 mmol)

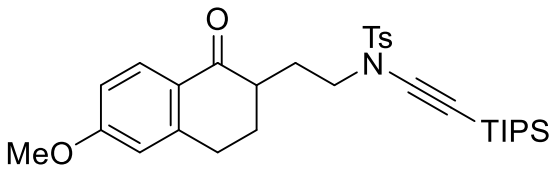
^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.99 (dd, 1H, *J* = 7.8, 1.5 Hz), 7.79 (d, 2H, *J* = 8.3 Hz), 7.45 (td, 1H, *J* = 7.4, 1.5 Hz), 7.26-7.30 (m, 3H, Hf), 7.22 (d, 1H, *J* = 7.6 Hz), 3.52-3.62 (m, 2H), 2.92-3.04 (m, 2H), 2.50-2.56 (m, 1H), 2.39 (s, 3H), 2.32-2.36 (m, 1H), 2.18-2.23 (m, 1H), 1.82-1.90 (m, 1H), 1.70-1.77 (m, 1H), 1.03 (s, 21H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.5, 144.7, 143.9, 134.6, 133.4 (CH), 132.5, 129.8 (2x CH), 128.8 (CH), 127.8 (2x CH), 127.4 (CH), 126.7 (CH), 96.3, 69.7, 49.9 (CH_2), 44.5 (CH), 29.4 (CH_2), 29.1 (CH_2), 28.5 (CH_2), 21.7 (CH_3), 18.7 (6x CH_3), 11.5 (3x CH) ppm

IR (ATR): v = 2159, 1683, 1366, 1168 cm^{-1}

TLC (20% ethyl acetate in petroleum ether): 0.69 (UV, Vanillin)

***N*-(2-(6-methoxy-1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)-4-methyl-*N*-((triisopropylsilyl) ethynyl)benzenesulfonamide (1v)**



$C_{31}H_{43}NO_4SSi$
MW: 553.83 g.mol^{-1}
Yellow oil
53% (587 mg, 1.06 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.96 (d, 1H, *J* = 8.7 Hz), 7.80 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 6.81 (dd, 1H, *J* = 8.7, 2.6 Hz), 6.66 (d, 1H, *J* = 2.6 Hz), 3.85 (s, 3H), 3.50-3.61 (m, 2H), 2.88-3.01 (m, 2H), 2.46-2.52 (m, 1H), 2.40 (s, 3H), 2.31-2.38 (m, 1H), 2.17-2.22 (m, 1H), 1.84 (dq, 1H, *J* = 12.3, 4.2 Hz), 1.68-1.75 (m, 1H), 1.03 (s, 21H) ppm

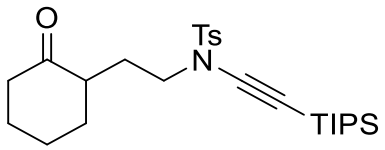
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 198.3, 163.5, 146.4, 144.7, 134.5, 129.9 (CH), 129.8 (2x CH), 127.8 (2x CH), 126.2, 113.3 (CH), 112.5 (CH), 96.3, 69.7, 55.6 (CH), 50.0 (CH_2), 44.3 (CH), 29.5 (CH_2), 29.4 (CH_2), 28.5 (CH_2), 21.7 (CH_3), 18.7 (6x CH_3), 11.5 (3x CH) ppm

IR (ATR): v = 2159, 1674, 1599, 1366, 1169 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 576.2574; found: 576.2575

TLC (30% ethyl acetate in petroleum ether): 0.67 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclohexyl)ethyl)-*N*-((triisopropylsilyl)ethynyl)benzenesulfonamide (1w)



$C_{26}H_{41}NO_3SSi$
MW: 475.76 $g.mol^{-1}$
White solid
74% (704 mg, 1.48 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.77 (d, 2H, *J* = 8.4 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 3.37-3.43 (m, 1H), 3.29-3.34 (m, 1H), 2.46-2.52 (m, 1H), 2.43 (s, 3H), 2.34-2.38 (m, 1H), 2.25-2.32 (m, 1H), 2.04-2.15 (m, 3H), 1.82-1.86 (m, 1H), 1.59-1.70 (m, 2H), 1.46-1.53 (m, 1H), 1.34 (qd, 1H, *J* = 12.4, 3.5 Hz), 1.03 (s, 21H) ppm

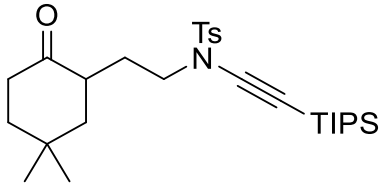
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 212.7, 144.9, 134.7, 130.0 (2x CH), 128.0 (2x CH), 96.5, 69.6, 49.9 (CH_2), 47.2 (CH), 42.6 (CH_2), 34.8 (CH_2), 28.5 (CH_2), 28.0 (CH_2), 25.6 (CH_2), 22.0 (CH_3), 18.9 (6x CH_3), 11.7 (3x CH) ppm

IR (ATR): v = 2160, 1710, 1368, 1186 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 498.2463; found: 498.2464

TLC (20% ethyl acetate in petroleum ether): 0.67 (UV, Vanillin)

***N*-(2-(5,5-dimethyl-2-oxocyclohexyl)ethyl)-4-methyl-*N*-((triisopropylsilyl)ethynyl)benzene sulfonamide (1x)**



$C_{28}H_{45}NO_3SSi$
MW: 503.82 $g.mol^{-1}$
Colorless oil
74% (745 mg, 1.48 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.77 (d, 2H, *J* = 8.2 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 3.33-3.44 (m, 2H), 2.55-2.61 (m, 1H), 2.41-2.47 (m, 4H), 2.21 (ddd, 1H, *J* = 13.9, 4.2, 2.6 Hz), 2.09 (sex, 1H, *J* = 6.9 Hz), 1.68-1.75 (m, 2H), 1.60 (td, 1H, *J* = 13.9, 4.8 Hz), 1.39-1.46 (m, 1H), 1.32 (t, 1H, *J* = 13.4 Hz), 1.19 (s, 3H), 1.04 (s, 3H), 0.98 (s, 21 h) ppm

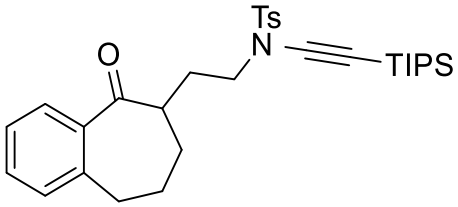
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 213.2, 144.9, 134.8, 130.0 (2x CH), 128.0 (2x CH), 96.5, 69.7, 49.9 (CH_2), 47.5 (CH_2), 42.7 (CH), 40.6 (CH_2), 38.8 (CH_2), 31.7 (CH_3), 31.3, 27.9 (CH_2), 24.7 (CH_3), 22.0 (CH_3), 19.0 (6x CH_3), 11.7 (3x CH) ppm

IR (ATR): v = 2160, 1712, 1370, 1170 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 526.2782; found: 526.2787

TLC (20% ethyl acetate in petroleum ether): 0.68 (UV, Vanillin)

4-methyl-*N*-(2-(5-oxo-6,7,8,9-tetrahydro-5*H*-benzo[7]annulen-6-yl)ethyl)-*N*-((triisopropylsilyl) ethynyl)benzenesulfonamide (1y)



$C_{31}H_{43}NO_3SSi$
MW:537.83 g.mol^{-1}
Yellow oil
77% (828 mg, 1.54 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.73 (d, 2H, *J* = 8.2 Hz), 7.69 (dd, 1H, *J* = 7.6, 1.4 Hz), 7.38 (td, 1H, *J* = 7.6, 1.5 Hz), 7.27-7.30 (m, 2H), 7.20-7.24 (m, 2H), 3.36-3.40 (m, 2H), 2.93-3.05 (m, 3H), 2.41 (s, 3H), 2.24-2.35 (m, 1H), 2.06-2.15 (m, 1H), 1.93-2.00 (m, 1H), 1.77-1.90 (m, 1H), 1.51-1.72 (m, 2H), 1.01 (s, 21H) ppm

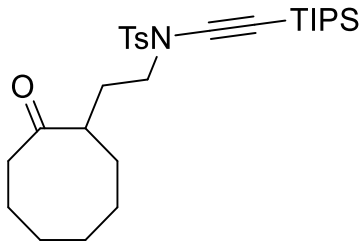
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 205.9, 144.7, 142.7, 139.6, 134.4, 131.5 (CH), 130.1 (CH), 129.7 (2x CH), 128.8 (CH), 127.8 (2x CH), 126.5 (CH), 96.1, 69.8, 49.4 (CH_2), 46.1 (CH), 33.9 (CH_2), 30.7 (CH_2), 29.1 (CH_2), 25.8 (CH_2), 21.8 (CH_3), 18.7 (6x CH_3), 11.5 (3x CH) ppm

IR (ATR): v = 2161, 1681, 1598, 1369, 1170 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 560.2625; found: 560.2616

TLC (30% ethyl acetate in petroleum ether): 0.70 (UV, Vanillin)

4-methyl-*N*-(2-(2-oxocyclooctyl)ethyl)-*N*-((triisopropylsilyl)ethynyl)benzenesulfonamide (1z)



$C_{28}H_{45}NO_3SSi$
MW: 503.81 g.mol^{-1}
Colorless oil
94% (947 mg, 1.88 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.74 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 3.26 (ddd, 1H, *J* = 12.7, 8.6, 5.8 Hz), 3.11 (dt, 1H, *J* = 12.8, 5.8 Hz), 2.81-2.90 (m, 1H), 2.52 (ddd, 1H, *J* = 14.1, 7.8, 3.1 Hz), 2.41 (s, 3H), 2.29 (ddd, 1H, *J* = 14.2, 11.0, 3.2 Hz), 1.97-2.08 (m, 2H), 1.34-1.88 (m, 10H), 1.02 (s, 21 H) ppm

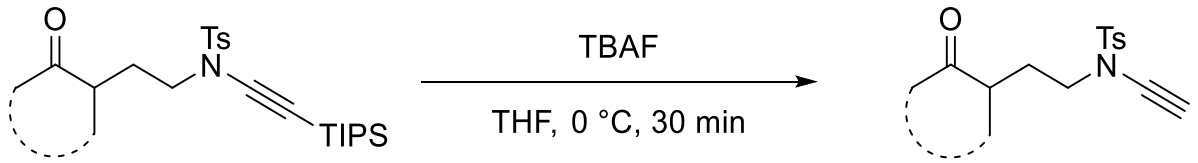
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 219.6, 145.0, 134.5, 130.0 (2x CH), 128.0 (2x CH), 96.3, 70.0, 49.7 (CH_2), 46.0 (CH), 43.5 (CH_2), 34.0 (CH_2), 30.0 (CH_2), 28.2 (CH_2), 25.4 (CH_2), 25.0 (CH_2), 24.8 (CH_2), 22.0 (CH_3), 18.9 (6x CH_3), 11.7 (3x CH) ppm

IR (ATR): v = 2159, 1699, 1369, 1169 cm^{-1}

ESI-HRMS: $[2M+Na]^+$ calc: 1029.5671; found: 1029.5711

TLC (20% ethyl acetate in petroleum ether): 0.55 (UV, Vanillin)

Experimental procedure and characterization data for keto-ynesulfonamides (5t-z)

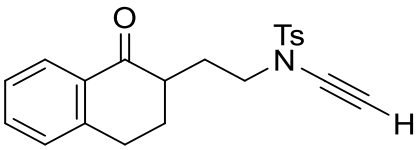


1t-z **5t-z**

General procedure: To a stirred solution of sulfonylynamide **1** (1 equiv, 1 mmol) in dry THF (conc = 0.15 M, 7 mL) cooled to 0 °C was added TBAF (1.3 equiv., 1.3 mmol, 1 M in THF). The resulting mixture was stirred at 0 °C until completion of starting material (monitored by TLC) and hydrolyzed with a saturated aqueous solution of NH_4Cl (10 mL). The aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic layers were washed with brine (30 mL), dried (Na_2SO_4), filtrated and concentrated under vacuum (15 mbar, 40 °C) to afford compounds **5**.

The crude material can be directly engaged into the spirocyclization reaction without further purification and without decreasing the yield.

***N*-ethynyl-4-methyl-*N*-(2-(1-oxo-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)benzenesulfonamide (5u)**



$C_{21}H_{21}NO_3S$
MW: 367.46 g.mol^{-1}
White solid
mp = 99 °C
90% (331 mg, 0.9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.98 (dd, 1H, *J* = 7.7, 1.5 Hz), 7.80 (d, 2H, *J* = 8.2 Hz), 7.45 (td, 1H, *J* = 7.5, 1.5 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 7.29 (t, 1H, *J* = 7.5 Hz), 7.22 (d, 1H, *J* = 7.6 Hz), 3.51-3.57 (m, 2H), 2.92-3.05 (m, 2H), 2.76 (s, 1H), 2.52 (dtd, 1H, *J* = 12.6, 6.4, 4.6 Hz), 2.32-2.40 (m, 4H), 2.22 (ddt, 1H, *J* = 13.1, 4.7, 3.9 Hz), 1.85 (tdd, 1H, *J* = 13.1, 11.5, 4.7 Hz), 1.72 (dq, 1H, *J* = 14.2, 6.5 Hz) ppm

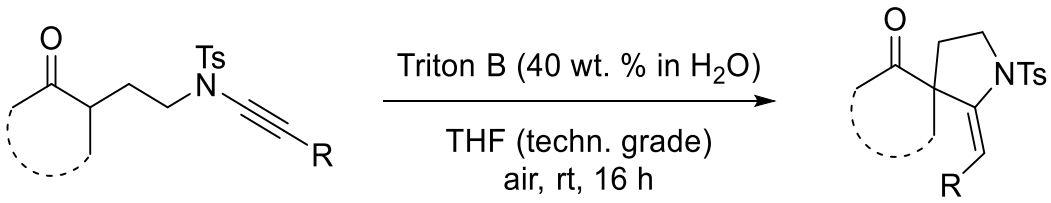
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.5, 144.9, 143.9, 134.4, 133.4 (CH), 132.4, 129.9 (2x CH), 128.8 (CH), 127.7 (2x CH), 127.4 (CH), 126.7 (C_{CH}), 75.9, 59.5 (CH), 49.5 (CH_2), 44.5 (CH), 29.2 (CH_2), 29.1 (CH_2), 28.2 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 3288, 2132, 1679, 1361, 1166 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 368.1315; found: 368.1308

TLC (30% ethyl acetate in petroleum ether): 0.43 (UV, Vanillin)

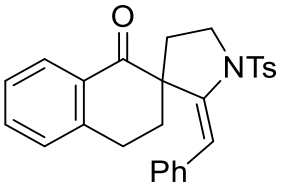
Experimental procedure and characterization data for spiro-enesulfonamides (2a-z, 4o, 6t-z)



1a-z **2a-z, 4o, 6t-z**

General procedure: To a stirred solution of sulfonylynamide **1** (1 equiv, 1 mmol) in THF (technical grade, conc = 0.15 M, 7 mL) was added Triton B (1.3 equiv., 1.3 mmol, 40 wt. % in H_2O). The resulting mixture was stirred at room temperature until completion of starting material (monitored by TLC) and hydrolyzed with a saturated aqueous solution of NH_4Cl (10 mL). The aqueous layer was extracted with Et_2O (3 x 15 mL). The combined organic layers were washed with brine (30 mL), dried (Na_2SO_4), filtrated and concentrated under vacuum (15 mbar, 40 °C). The crude material was purified by column chromatography using a step gradient of EtOAc in petroleum ether (0 to 50%) to afford the title compounds.

(*E*)-2'-benzylidene-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2a)



$C_{27}H_{25}NO_3S$
MW: 443.56 g.mol^{-1}
White solid
mp = 190 °C
95% (399 mg, 0.9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.89 (d, 2H, *J* = 8.2 Hz), 7.83 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.39 (td, 1H, *J* = 7.8, 0.9 Hz), 7.37 (d, 2H, *J* = 8.2 Hz), 7.24 (t, 1H, *J* = 7.8 Hz), 7.09 (s, 1H), 7.06 (d, 1H, *J* = 7.8 Hz), 7.00-7.02 (m, 3H), 6.89-6.91 (m, 2H), 3.99 (ddd, 1H, *J* = 9.8, 7.3, 2.9 Hz), 3.63 (td, 1H, *J* = 9.8, 6.5 Hz), 2.76-2.85 (m, 1H), 2.55-2.60 (m, 1H), 2.48 (s, 3H), 2.12-2.16 (m, 1H), 2.01-2.07 (m, 1H), 1.97 (td, 1H, *J* = 13.5, 4.6 Hz), 1.46-1.50 (m, 1H) ppm

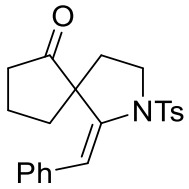
^{13}C RMN ($CDCl_3$, 125 MHz): δ = 197.2, 144.2, 142.5, 142.5, 136.7, 134.5, 133.6 (CH), 130.5, 129.6 (2x CH), 129.2 (2x CH), 128.5 (CH), 128.4 (CH), 128.3 (2x CH), 128.1 (2x CH), 126.9 (CH), 126.5 (CH), 110.5 (CH), 57.4, 47.7 (CH_2), 32.7 (CH_2), 32.1 (CH_2), 26.3 (CH_2), 21.9 (CH_3) ppm

IR (ATR) : v = 1679, 1342, 1162 cm^{-1}

ESI-HRMS : $[M+H]^+$ calc: 444.1628; found: 444.1615

TLC (30% ethyl acetate in petroleum ether): 0.56 (UV, Vanillin)

(*E*)-1-benzylidene-2-tosyl-2-azaspiro[4.4]nonan-6-one (2b)



$C_{22}H_{23}NO_3S$
MW: 381.49 g.mol^{-1}
White solid
mp = 111 °C
85% (324 mg, 0.85 mmol)
79% (3.01 g, 7.9 mmol) (**10 mmol scale**)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.2 Hz), 7.35 (d, 2H, *J* = 8.3 Hz), 7.19-7.25 (m, 3H), 7.05 (s, 1H), 6.93 (m, 2H), 3.78 (ddd, 1H, *J* = 10.0, 7.2, 5.9 Hz), 3.69 (ddd, 1H, *J* = 10.0, 7.3, 6.7 Hz), 2.47 (s, 3H), 2.00-2.05 (m, 1H), 1.90 (dt, 1H, *J* = 12.4, 7.2 Hz), 1.59-1.70 (m, 4H), 1.46-1.53 (m, 1H), 1.36-1.40 (m, 1H) ppm

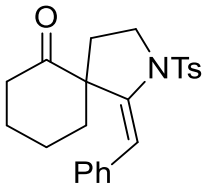
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 217.4, 144.4, 141.9, 136.5, 134.1, 129.7 (2x CH), 129.5 (2x CH), 128.2 (2x CH), 128.1 (2x CH), 127.0 (CH), 111.9 (CH), 58.5, 48.2 (CH_2), 37.3 (CH_2), 34.6 (CH_2), 34.4 (CH_2), 21.8 (CH_3), 19.5 (CH_2) ppm

IR (ATR): v = 1735, 1343, 1161 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 382.1471; found: 382.1478

TLC (50% ethyl acetate in petroleum ether): 0.52 (UV, Vanillin)

(*E*)-1-benzylidene-2-tosyl-2-azaspiro[4.5]decan-6-one (2c)



$C_{23}H_{25}NO_3S$
MW: 395.52 g.mol^{-1}
White solid
mp = 66 °C
90% (356 mg, 0.9 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.3 Hz), 7.32 (d, 2H, *J* = 8.1 Hz), 7.15-7.23 (m, 3H), 7.10 (s, 1H), 6.96 (d, 2H, *J* = 8.1 Hz), 3.92 (ddd, 1H, *J* = 9.9, 7.4, 2.2 Hz), 3.37 (ddd, 1H, *J* = 10.8, 9.9, 6.3 Hz), 2.45 (s, 3H), 2.25-2.39 (m, 3H), 2.14 (ddd, 1H, *J* = 12.8, 6.3, 2.2 Hz), 1.86 (ddd, 1H, *J* = 12.8, 10.8, 7.4 Hz), 1.77-1.80 (m, 1H), 1.61-1.66 (m, 1H), 1.48-1.51 (m, 1H), 1.26-1.40 (m, 2H) ppm

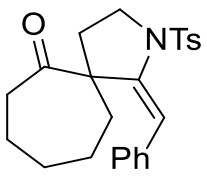
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 209.9, 144.2, 142.2, 137.1, 134.3, 129.4 (2x CH), 129.2 (2x CH), 128.3 (2x CH), 128.2 (2x CH), 126.6 (CH), 110.5 (CH), 60.7, 47.7 (CH_2), 38.3 (CH_2), 35.6 (CH_2), 35.5 (CH_2), 24.7 (CH_2), 21.9 (CH_3), 21.7 (CH_2) ppm

IR (ATR): v = 1704, 1336, 1160 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 418.1447; found: 418.1454

TLC (30% ethyl acetate in petroleum ether): 0.24 (UV, Vanillin)

(*E*)-1-benzylidene-2-tosyl-2-azaspiro[4.6]undecan-6-one (2d)



$C_{24}H_{27}NO_3S$
MW: 409.54 g.mol^{-1}
White solid
mp = 132 °C
87% (356 mg, 0.87 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.82 (d, 2H, *J* = 8.3 Hz), 7.34 (d, 2H, *J* = 8.3 Hz), 7.22-7.26 (m, 3H),

6.94 (s, 1H), 6.90-6.91 (m, 2H), 3.80 (dd, 2H, *J* = 7.7, 5.9 Hz), 2.46 (s, 3H), 2.15 (dt, 1H, *J* = 12.7, 6.0 Hz), 2.07 (dd, 1H, *J* = 13.5, 8.0 Hz), 1.78-1.91 (m, 2H), 1.54-1.69 (m, 3H), 1.41-1.46 (m, 1H), 0.97-1.25 (m, 4H) ppm

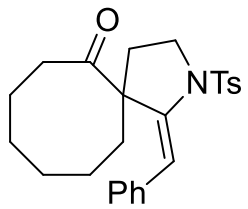
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 214.6, 145.6, 144.2, 136.8, 134.1, 130.0 (2x CH), 129.4 (2x CH), 128.2 (4x CH), 127.0 (CH), 109.8 (CH), 61.0, 48.7 (CH_2), 44.1 (CH_2), 33.8 (2x CH_2), 30.6 (CH_2), 25.2 (CH_2), 24.7 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1689, 1306, 1160 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 432.1604; found: 432.1597

TLC (50% ethyl acetate in petroleum ether): 0.74 (UV, Vanillin)

(*E*)-1-benzylidene-2-tosyl-2-azaspiro[4.7]dodecan-6-one (2e)



$C_{25}H_{29}NO_3S$
MW: 423.57 $g.mol^{-1}$
White solid
mp = 143 °C
73% (309 mg, 0.73 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.73 (d, 2H, *J* = 8.1 Hz), 7.32 (d, 2H, *J* = 8.2 Hz), 7.25-7.29 (m, 3H), 7.13 (s, 1H), 7.01-7.03 (m, 2H), 3.99 (ddd, 1H, *J* = 9.4, 8.8, 7.9 Hz), 3.80 (ddd, 1H, *J* = 9.3, 9.0, 2.4 Hz), 2.46 (s, 3H), 2.28-2.34 (m, 2H), 1.82 (ddd, 1H, *J* = 14.6, 12.8, 3.6 Hz), 1.68 (ddd, 1H, *J* = 12.8, 9.6, 9.2 Hz), 1.18-1.50 (m, 8H), 0.64-0.83 (m, 2H) ppm

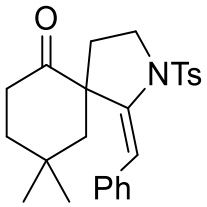
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 214.6, 144.1, 140.5, 135.7, 134.5, 130.1 (2x CH), 129.2 (2x CH), 128.3 (2x CH), 127.9 (2x CH), 127.2 (CH), 114.8 (CH), 61.9, 49.2 (CH_2), 37.7 (CH_2), 32.5 (CH_2), 30.6 (CH_2), 30.2 (CH_2), 25.6 (CH_2), 25.3 (CH_2), 24.3 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1696, 1343, 1160 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 424.1941; found: 424.1926

TLC (50% ethyl acetate in petroleum ether): 0.74 (UV, Vanillin)

(*E*)-1-benzylidene-9,9-dimethyl-2-tosyl-2-azaspiro[4.5]decan-6-one (2f)



$C_{25}H_{29}NO_3S$
MW: 423.57 $g.mol^{-1}$
White solid
mp = 141 °C
84% (356 mg, 0.84 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.82 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 7.22-7.25 (m, 2H), 7.17-7.19 (m, 1H), 7.03 (s, 1H), 6.91 (m, 2H), 3.92 (ddd, 1H, *J* = 9.9, 7.5, 2.8 Hz), 3.47 (ddd, 1H, *J* = 10.2, 9.9, 6.6 Hz), 2.45 (s, 3H), 2.35-2.42 (m, 1H), 2.06-2.15 (m, 2H), 1.88 (ddd, 1H, *J* = 12.9, 10.1, 7.7 Hz), 1.63 (d, 1H, *J* = 14.5 Hz), 1.33-1.38 (m, 1H), 1.19-1.25 (m, 1H), 1.05 (dd, 1H, *J* = 14.5, 3.0 Hz), 0.94 (s, 3H), 0.55 (s, 3H) ppm

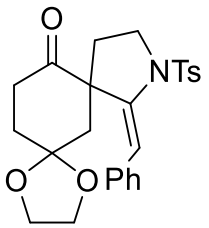
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 211.1, 144.3, 143.9, 137.1, 134.1, 129.4 (2x CH), 129.3 (2x CH), 128.3 (2x CH), 128.3 (2x CH), 126.8 (CH), 110.0 (CH), 58.5, 48.4 (CH_2), 47.0 (CH_2), 37.5 (CH_2), 36.1 (CH_2), 35.2 (CH_2), 32.6 (CH_3), 29.9, 26.2 (CH_3), 21.8 (CH_3) ppm

IR (ATR): v = 1700, 1340, 1162 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 446.1760; found: 446.1776

TLC (50% ethyl acetate in petroleum ether): 0.70 (UV, Vanillin)

(*E*)-8-benzylidene-9-tosyl-1,4-dioxa-9-azadispiro[4.1.4^7.3^5]tetradecan-12-one (2g)



$C_{25}H_{27}NO_5S$
MW: 453.55 $g.mol^{-1}$
White solid
mp = 150 °C
92% (417 mg, 0.92 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.81 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 7.22-7.35 (m, 2H), 7.17-7.20 (m, 1H), 7.10 (s, 1H), 6.93 (dd, 2H, *J* = 7.1, 1.4 Hz), 3.84-3.92 (m, 3H), 3.77-3.79 (m, 2H), 3.38 (ddd, 1H, *J* = 10.4, 9.9, 6.3 Hz), 2.64 (ddd, 1H, *J* = 16.8, 13.8, 6.1 Hz), 2.45 (s, 3H), 2.20-2.27 (m, 2H), 2.01 (ddd, 1H, *J* = 13.8, 10.4, 7.5 Hz), 1.93 (d, 1H, *J* = 14.4 Hz), 1.72 (ddd, 1H, *J* = 13.4, 6.1, 3.4 Hz), 1.59 (td, 1H, *J* = 13.8, 5.1 Hz), 1.38 (dd, 1H, *J* = 14.4, 3.2 Hz) ppm

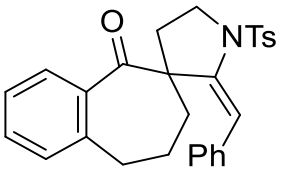
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 208.8, 144.3, 142.0, 136.8, 134.0, 129.4 (2x CH), 129.0 (2x CH), 128.4 (2x CH), 128.3 (2x CH), 127.0 (CH), 110.4 (CH), 107.0, 64.7 (CH_2), 64.3 (CH_2), 59.0, 48.1 (CH_2), 41.6 (CH_2), 37.0 (CH_2), 35.6 (CH_2), 32.4 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1703, 1340, 1161, 1119 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 454.1683; found: 454.1694

TLC (50% ethyl acetate in petroleum ether): 0.51 (UV, Vanillin)

(*E*)-2'-benzylidene-1'-tosyl-8,9-dihydrospiro[benzo[7]annulene-6,3'-pyrrolidin]-5(7*H*)-one (2h)



$C_{28}H_{27}NO_3S$
MW: 457.59 $g.mol^{-1}$
White solid
mp = 158 °C
83% (380 mg, 0.83 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.84 (d, 2H, *J* = 8.3 Hz), 7.36 (d, 2H, *J* = 8.3 Hz), 7.26 (td, 1H, *J* = 7.3, 1.3 Hz), 7.04-7.12 (m, 5H), 6.91-6.95 (m, 3H), 6.54 (d, 1H, *J* = 7.7 Hz), 3.75-3.84 (m, 2H), 2.53-2.65 (m, 2H), 2.47 (s, 3H), 2.25 (dt, 1H, *J* = 12.6, 6.4 Hz), 2.07 (dt, 1H, *J* = 12.6, 7.2 Hz), 1.65-1.74 (m, 1H), 1.54-1.62 (m, 2H), 1.03-1.07 (m, 1H) ppm

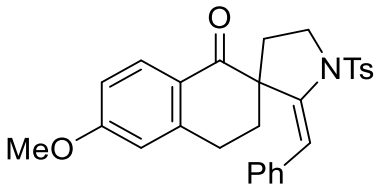
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 208.4, 114.3, 144.2, 139.5, 137.1, 136.5, 133.8, 131.6 (CH), 129.4 (2x CH), 129.4 (2x CH), 129.2 (CH), 128.6 (CH), 128.2 (2x CH), 128.2 (2x CH), 126.7 (CH), 126.4 (CH), 117.7 (CH), 59.3, 48.1 (CH_2), 32.3 (CH_2), 31.3 (CH_2), 30.4 (CH_2), 22.5 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1679, 1346, 1160 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 458.1784; found: 458.1755

TLC (50% ethyl acetate in petroleum ether): 0.73 (UV, Vanillin)

(*E*)-2'-benzylidene-6-methoxy-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2i)



$C_{28}H_{27}NO_4S$
MW: 473.59 g.mol^{-1}
White solid
mp = 165 °C
79% (374 mg, 0.79 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.89 (d, 2H, *J* = 8.2 Hz), 7.82 (d, 1H, *J* = 8.6 Hz), 7.36 (d, 2H, *J* = 8.2 Hz), 7.07 (s, 1H), 7.01-7.03 (m, 3H), 6.90-6.92 (m, 2H), 6.76 (dd, 1H, *J* = 8.8, 2.6 Hz), 6.50 (d, 1H, *J* = 2.6 Hz), 4.00 (ddd, 1H, *J* = 9.9, 7.3, 2.8 Hz), 3.81 (s, 3H), 3.64 (ddd, 1H, *J* = 9.9, 9.6, 6.5 Hz), 2.80 (ddd, 1H, *J* = 16.9, 13.4, 4.0 Hz), 2.53 (ddd, 1H, *J* = 16.9, 4.5, 3.1 Hz), 2.47 (s, 3H), 2.13 (ddd, 1H, *J* = 12.6, 6.5, 2.8 Hz), 2.02 (ddd, 1H, *J* = 12.6, 9.6, 7.3 Hz), 1.98 (ddd, 1H, *J* = 13.5, 13.4, 4.5 Hz), 1.46 (ddd, 1H, *J* = 13.5, 4.0, 3.1 Hz) ppm

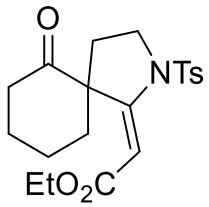
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 196.2, 163.7, 145.0, 144.2, 142.6, 136.8, 134.5, 131.0 (CH), 129.5 (2x CH), 129.2 (2x CH), 128.2 (2x CH), 128.1 (2x CH), 126.4 (CH), 123.9, 113.5 (CH), 112.3 (CH), 110.2 (CH), 57.2, 55.5 (CH_3), 47.8 (CH_2), 32.9 (CH_2), 32.2 (CH_2), 26.7 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1598, 1339, 1162, 1057 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 496.1553; found: 496.1525

TLC (50% ethyl acetate in petroleum ether): 0.60 (UV, Vanillin)

ethyl (*E*)-2-(6-oxo-2-tosyl-2-azaspiro[4.5]decan-1-ylidene)acetate (2j)



$C_{20}H_{25}NO_5S$
MW: 391.48 g.mol^{-1}
White solid
mp = 146 °C
34% (133 mg, 0.34 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.77 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 6.15 (s, 1H), 4.02-4.08 (m, 2H), 3.93-3.97 (m, 1H), 3.63 (td, 1H, *J* = 10.2, 6.7 Hz), 2.59-2.62 (m, 1H), 2.43 (s, 3H), 2.05-2.12 (m, 3H), 1.82-1.89 (m, 2H), 1.72-1.80 (m, 2H), 1.35-1.48 (m, 2H), 1.23 (t, 3H, J = 7.1 Hz) ppm

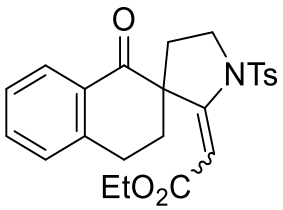
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 206.7, 167.0, 159.6, 145.1, 134.0, 129.9 (2x CH), 127.6 (2x CH), 95.1 (CH), 60.4, 60.0 (CH_2), 48.7 (CH_2), 39.8 (CH_2), 33.1 (CH_2), 32.2 (CH_2), 23.2 (CH_2), 21.8 (CH_3), 21.5 (CH_2), 14.4 (CH_3) ppm

IR (ATR): v = 1699, 1619, 1342, 1168, 1147 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 392.1526; found: 392.1515

TLC (30% ethyl acetate in petroleum ether): 0.22 (UV, Vanillin)

ethyl (*E*)-2-(1-oxo-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-2'-ylidene)acetate (2k)



$C_{24}H_{25}NO_5S$
MW: 439.53 g.mol^{-1}
Yellow solid
90% *E/Z* ratio (77/23) (395 mg, 0.9 mmol)

*N.B.: Due to their identical polarity, the proton and/or carbon spectra interpretation could not be performed entirely because of the signals superposition. For a better understanding, only the major isomer **E** is fully described. For more explanations, see our previous works.*[20]

- ***E* isomer (major product)**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.01 (d, 1H, *J* = 7.7 Hz), 7.83 (d, 2H, *J* = 8.3 Hz), 7.44 (td, 1H, *J* = 7.4, 0.9 Hz), 7.37 (d, 2H, *J* = 8.3 Hz), 7.30 (t, 1H, *J* = 7.6 Hz), 7.18 (d, 1H, *J* = 7.6 Hz), 6.22 (s, 1H), 3.94-4.00 (m, 2H), 3.87-3.91 (m, 1H), 3.78-3.83 (m, 1H), 2.95-3.02 (m, 1H), 2.82-2.86 (m, 1H), 2.64 (td, 1H, *J* = 13.5, 5.1 Hz), 2.46 (s, 3H), 2.23-2.28 (m, 1H), 1.97-2.04 (m, 1H), 1.51-1.55 (m, 1H) ppm

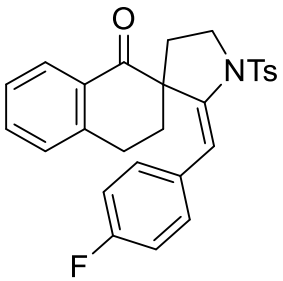
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 194.8, 166.5, 158.3, 145.2, 141.0, 134.0, 133.4 (CH), 132.3, 130.0 (2x CH), 128.8 (CH), 127.9 (CH), 127.6 (2x CH), 127.2 (CH), 96.5 (CH), 60.0 (CH_2), 58.4, 48.9 (CH_2), 30.4 (CH_2), 28.5 (CH_2), 25.7 (CH_2), 21.9 (CH_3), 14.3 (CH_3) ppm

IR (ATR): v = 1684, 1619, 1343, 1166, 1143 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 478.1085; found: 478.1087

TLC (30% ethyl acetate in petroleum ether): 0.38 (UV, Vanillin)

(*E*)-2'-(4-fluorobenzylidene)-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2l)



$C_{27}H_{24}FNO_3S$
MW: 461.55 g.mol^{-1}
White solid
mp = 180 °C
84% (388 mg, 0.84 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.88 (d, 2H, *J* = 8.3 Hz), 7.80 (dd, 1H, *J* = 7.7, 1.2 Hz), 7.40 (td, 1H, *J* = 7.5, 1.2 Hz), 7.37 (d, 2H, *J* = 8.3 Hz), 7.24 (t, 1H, *J* = 7.6 Hz), 7.07 (s, 1H), 6.84-6.86 (m, 2H), 6.68-6.71 (m, 2H), 3.96 (ddd, 1H, *J* = 9.9, 7.5, 3.4 Hz), 3.63 (ddd, 1H, *J* = 9.9, 9.4, 6.6 Hz), 2.81 (ddd, 1H, *J* = 17.0, 13.1, 4.5 Hz), 2.59 (ddd, 1H, *J* = 17.0, 4.7, 3.1 Hz), 2.15 (ddd, 1H *J* = 12.6, 6.5, 3.4 Hz), 2.03 (ddd, 1H, *J* = 12.6, 9.4, 7.6 Hz), 1.90 (ddd, 1H, *J* = 13.6, 13.1, 4.9 Hz), 1.49 (ddd, 1H, *J* = 13.6, 4.4, 3.0 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.2, 161.5 (d, $J_{C\text{-}F}$ = 245 Hz), 144.3, 142.9, 142.5, 134.5, 133.7 (CH), 132.6 (d, $J_{C\text{-}F}$ = 3 Hz), 130.8 (d, $J_{C\text{-}F}$ = 8 Hz, 2x CH), 130.5, 129.6 (2x CH), 128.6 (CH), 128.3 (CH), 128.2 (2x CH), 127.0 (CH), 115.0 (d, $J_{C\text{-}F}$ = 21 Hz, 2x CH), 109.4 (CH), 57.4, 47.7 (CH_2), 32.6 (CH_2), 32.1 (CH_2), 26.2 (CH_2), 21.9 (CH_3) ppm

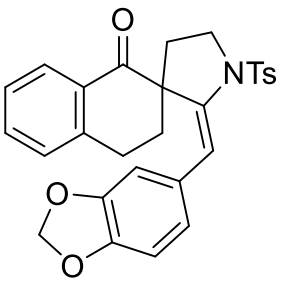
[20] Beltran, F.; Fabre, I.; Ciofini, I.; Miesch, L. *Org. Lett.* **2017**, *19*, 5042-5045.

IR (ATR): v = 1680, 1343, 1163, 1071 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 462.1534; found: 462.1551

TLC (30% ethyl acetate in petroleum ether): 0.49(UV, Vanillin)

(*E*)-2'-(benzo[*d*][1,3]dioxol-5-ylmethylene)-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2m)



$C_{28}H_{25}NO_5S$
MW: 487.57 $g.mol^{-1}$
White solid
mp = 167 °C
85% (414 mg, 0.85 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.87 (d, 2H, *J* = 8.2 Hz), 7.81 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.36-7.41 (m, 3H), 7.23 (t, 1H, *J* = 7.8 Hz), 7.07 (d, 1H, *J* = 7.8 Hz), 6.98 (s, 1H), 6.43 (s, 1H), 6.40 (d, 1H, *J* = 7.8 Hz), 6.28 (d, 1H, *J* = 7.8 Hz), 5.80 (s, 2H), 3.94 (ddd, 1H, *J* = 9.7, 7.6, 3.4 Hz), 3.62 (td, 1H, *J* = 9.7, 6.6 Hz), 2.78-2.84 (m, 1H), 2.58-2.63 (m, 1H), 2.48 (s, 3H), 2.12-2.17 (m, 1H), 1.96-2.05 (m, 2H), 1.47-1.51 (m, 1H) ppm

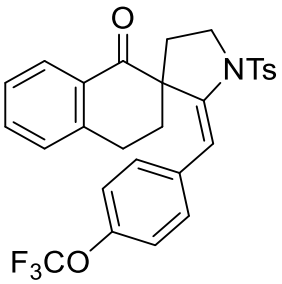
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.2, 147.3, 146.2, 144.2, 142.5, 142.4, 134.4, 133.6 (CH), 130.7, 130.5, 129.5 (2x CH), 128.5 (CH), 128.4 (CH), 128.2 (2x CH), 126.9 (CH), 122.6 (CH), 110.3 (CH), 109.6 (CH), 107.9 (CH), 100.9 (CH_2), 57.3, 47.7 (CH_2), 32.6 (CH_2), 32.1 (CH_2), 26.3 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1667, 1341, 1183, 1092, 1035 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 510.1346; found: 510.1324

TLC (30% ethyl acetate in petroleum ether): 0.35 (UV, Vanillin)

(*E*)-1'-tosyl-2'-(4-(trifluoromethoxy)benzylidene)-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2n)



$C_{28}H_{24}F_3NO_4S$
MW: 527.56 $g.mol^{-1}$
White solid
mp = 61 °C
93% (491 mg, 0.93 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.87 (d, 2H, *J* = 8.2 Hz), 7.76 (dd, 1H, *J* = 7.8, 1.3 Hz), 7.37-7.42 (m, 3H), 7.23 (t, 1H, *J* = 7.7 Hz), 7.07 (d, 1H, *J* = 7.7 Hz), 7.02 (s, 1H), 6.91 (d, 2H, *J* = 8.8 Hz), 6.84 (d, 2H, *J* = 8.3 Hz), 3.95 (ddd, 1H, *J* = 9.9, 7.2, 4.1 Hz), 3.67 (ddd, 1H, *J* = 9.9, 8.9, 6.5 Hz), 2.81 (ddd, 1H, *J* = 16.9, 13.0, 4.7 Hz), 2.60 (ddd, 1H, *J* = 16.9, 3.9, 3.2 Hz), 2.49 (s, 3H), 2.17 (ddd, 1H, *J* = 12.7, 6.5, 4.1 Hz), 2.05 (ddd, 1H, *J* = 12.7, 8.9, 7.2 Hz), 1.90 (ddd, 1H, *J* = 13.7, 13.0, 3.9 Hz), 1.50 (ddd, 1H, *J* = 13.7, 4.7, 3.2 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.1, 147.7, 144.4, 143.5, 142.4, 135.4, 134.4, 133.8 (CH), 130.7, 130.6 (2x CH), 129.6 (2x CH), 128.5 (CH), 128.3 (CH), 128.1 (2x CH), 127.0 (CH), 120.5 (2x CH),

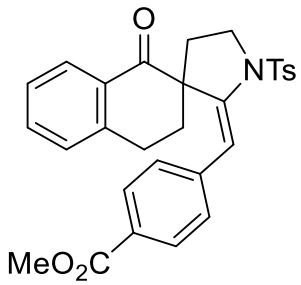
120.4 (q, J_{C-F} = 257 Hz), 109.1 (CH), 57.1, 47.8 (CH_2), 32.5 (CH_2), 32.1 (CH_2), 26.1 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1679, 1599, 1365, 1254, 1158 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 528.1451; found: 528.1454

TLC (40% ethyl acetate in petroleum ether): 0.56 (UV, Vanillin)

methyl (*E*)-4-((1-oxo-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-2'-ylidene) methyl)benzoate (2o)



$C_{29}H_{27}NO_5S$
MW: 501.60 $g.mol^{-1}$
White solid
mp = 164 °C
9% (45 mg, 0.09 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.84-7.88 (m, 3H), 7.68 (d, 2H, *J* = 8.3 Hz), 7.42 (td, 1H, *J* = 7.5, 1.4 Hz), 7.37 (d, 2H, *J* = 8.3 Hz), 7.24-7.27 (m, 1H), 7.07-7.08 (m, 2H), 6.97 (d, 2H, *J* = 8.3 Hz), 4.01 (ddd, 1H, *J* = 9.8, 7.3, 2.5 Hz), 3.83 (s, 3H), 3.62 (ddd, 1H, *J* = 10.1, 9.8, 6.5 Hz), 2.85 (ddd, 1H, *J* = 16.9, 13.2, 4.4 Hz), 2.60 (ddd, 1H, *J* = 16.9, 4.6, 2.3 Hz), 2.48 (s, 3H), 2.16 (ddd, 1H, *J* = 12.8, 6.5, 2.5 Hz), 2.07 (ddd, 1H, *J* = 12.8, 10.1, 7.3 Hz), 2.00 (ddd, 1H, *J* = 13.7, 13.2, 4.6 Hz), 1.52 (ddd, 1H, *J* = 13.7, 4.3, 2.3 Hz) ppm

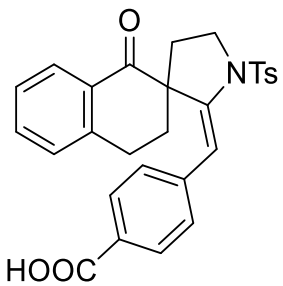
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.0, 167.0, 144.4, 143.8, 142.5, 141.8, 134.4, 133.9 (CH), 130.2, 129.6 (2x CH), 129.4 (2x CH), 129.1 (2x CH), 128.7 (CH), 128.5 (CH), 128.2 (2x CH), 128.0, 127.1 (CH), 109.2 (CH), 57.7, 52.1 (CH_3), 47.8 (CH_2), 32.6 (CH_2), 32.1 (CH_2), 26.2 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1718, 1679, 1600, 1343, 1278, 1161, 1099 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 502.1683; found: 502.1679

TLC (40% ethyl acetate in petroleum ether): 0.40 (UV, Vanillin)

(*E*)-4-((1-oxo-1'-tosyl-3,4-dihydro-1H-spiro[naphthalene-2,3'-pyrrolidin]-2'-ylidene)methyl) benzoic acid (4o)



$C_{28}H_{25}NO_5S$
MW: 487.57 $g.mol^{-1}$
White solid
mp = 216 °C
79% (385 mg, 0.79 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.87 (d, 2H, *J* = 8.2 Hz), 7.84 (dd, 1H, *J* = 7.8, 1.4 Hz), 7.73 (d, 2H, *J* = 8.2 Hz), 7.42 (td, 1H, *J* = 7.4, 1.4 Hz), 7.37 (d, 2H, *J* = 8.2 Hz), 7.24-7.27 (m, 1H), 7.07-7.08 (m, 2H), 6.99 (d, 2H, *J* = 8.2 Hz), 4.01 (ddd, 1H, *J* = 9.9, 7.4, 2.6 Hz), 3.64 (ddd, 1H, *J* = 9.9, 9.7, 6.5 Hz), 2.85 (ddd, 1H, *J* = 16.9, 13.2, 4.0 Hz), 2.61 (ddd, 1H, *J* = 16.9, 4.5, 2.8 Hz), 2.48 (s, 3H), 2.17 (ddd, 1H, *J* = 12.8, 6.5, 2.6 Hz), 2.08 (ddd, 1H, *J* = 12.8, 9.7, 7.4 Hz), 2.00 (ddd, 1H, *J* = 13.5, 13.2, 4.5 Hz), 1.53 (ddd, 1H, *J* = 13.5, 4.0, 2.8 Hz) ppm

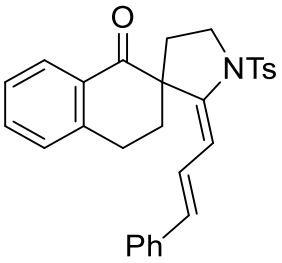
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.0, 171.6, 144.5, 144.1, 142.7, 142.4, 134.3, 134.0 (CH), 130.1, 130.0 (2x CH), 129.6 (2x CH), 129.1 (2x CH), 128.7 (CH), 128.5 (CH), 128.2 (2x CH), 127.1 (CH), 127.0, 109.0 (CH), 57.7, 47.8 (CH_2), 32.6 (CH_2), 32.0 (CH_2), 26.2 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1719, 1682, 1601, 1342, 1265, 1159, 1094 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 488.1526; found: 488.1537

TLC (40% ethyl acetate in petroleum ether): 0.09 (UV, Vanillin)

(*E*)-2'-((*E*)-3-phenylallylidene)-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2p)



$C_{29}H_{27}NO_3S$
MW: 469.60 $g.mol^{-1}$
Yellow solid
mp = 147 °C
75% (352 mg, 0.75 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.11 (dd, 1H, *J* = 7.8, 1.5 Hz), 7.81 (d, 2H, *J* = 8.2 Hz), 7.56 (td, 1H, *J* = 7.5, 1.5 Hz), 7.42 (t, 1H, *J* = 7.7 Hz), 7.34 (d, 2H, *J* = 8.3 Hz), 7.24 (d, 1H, *J* = 7.7 Hz), 7.06-7.08 (m, 3H), 6.79-6.81 (m, 2H), 6.75 (d, 1H, *J* = 11.6 Hz), 6.41 (d, 1H, *J* = 15.2 Hz), 6.23 (dd, 1H, *J* = 15.2, 11.6 Hz), 3.95 (ddd, 1H, *J* = 10.3, 8.3, 2.5 Hz), 3.62 (ddd, 1H, *J* = 10.3, 9.9, 6.5 Hz), 2.69-2.80 (m, 2H), 2.45 (s, 3H), 2.29 (ddd, 1H, *J* = 12.6, 9.9, 8.2 Hz), 1.96 (ddd, 1H, *J* = 12.6, 6.5, 2.5 Hz), 1.81 (ddd, 1H, *J* = 13.7, 10.0, 5.1 Hz), 1.57-1.62 (m, 1H) ppm

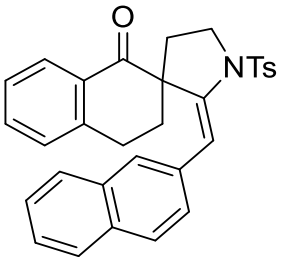
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.2, 144.4, 143.6, 143.3, 137.6, 134.3, 134.1 (CH), 132.5, 131.3 (CH), 129.7 (2x CH), 128.9 (CH), 128.6 (CH), 128.5 (2x CH), 127.7 (2x CH), 127.5 (CH), 127.1 (CH), 126.0 (2x CH), 124.4 (CH), 111.0 (CH), 57.1, 48.4 (CH_2), 32.6 (CH_2), 32.2 (CH_2), 26.0 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1676, 1596, 1341, 1161 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 470.1784; found: 470.1797

TLC (30% ethyl acetate in petroleum ether): 0.46 (UV, Vanillin)

(E)-2'-(naphthalen-2-ylmethylene)-1'-tosyl-3,4-dihydro-1H-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2q)



$C_{31}H_{27}NO_3S$
MW: 493.62 $g.mol^{-1}$
White solid
mp = 171 °C
71% (350 mg, 0.71 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.92 (d, 2H, *J* = 8.2H), 7.84 (dd, 1H, *J* = 7.7, 1.3 Hz), 7.65 (d, 1H, *J* = 8.0 Hz), 7.54 (d, 1H, *J* = 8.4 Hz), 7.37 (d, 2H, *J* = 8.2 Hz), 7.24-7.37 (m, 5H), 7.16-7.20 (m, 2H), 7.11 (dd, 1H, *J* = 8.5, 1.7 Hz), 7.00 (d, 1H, *J* = 7.5 Hz), 4.03 (ddd, 1H, *J* = 9.9, 7.5, 3.0 Hz), 3.71 (ddd, 1H, *J* = 9.9, 9.4, 6.5 Hz), 2.80 (ddd, 1H, *J* = 17.1, 13.0, 4.1 Hz), 2.50-2.55 (m, 1H), 2.48 (s, 3H), 2.19 (ddd, 1H, *J* = 12.9, 6.5, 3.0 Hz), 2.03-2.10 (m, 2H), 1.50 (ddd, 1H, *J* = 13.9, 4.1, 3.0 Hz)

ppm

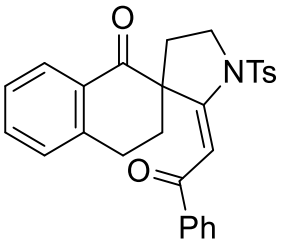
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 197.3, 144.3, 143.0, 142.5, 134.6, 134.2, 133.7 (CH), 133.1, 132.0, 130.7, 129.6 (2x CH), 128.5 (CH), 128.2 (3x CH), 127.7 (3x CH), 127.6 (CH), 127.5 (CH), 127.0 (CH), 126.0 (CH), 125.7 (CH), 110.3 (CH), 57.5, 47.9 (CH_2), 32.9 (CH_2), 32.1 (CH_2), 26.2 (CH_2), 21.9 (CH_3) ppm

IR (ATR): v = 1679, 1598, 1343, 1162 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 516.1604; found: 516.1601

TLC (30% ethyl acetate in petroleum ether): 0.41 (UV, Vanillin)

(*E*)-2'-(2-oxo-2-phenylethylidene)-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2r)



$C_{28}H_{25}NO_4S$
MW: 471.57 $g.mol^{-1}$
White solid
mp = 202 °C
82% (387 mg, 0.82 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.05 (d, 1H, *J* = 7.8 Hz), 7.82-7.85 (m, 4H), 7.45-7.50 (m, 2H), 7.38-7.40 (m, 3H), 7.32-7.35 (m, 3H), 7.21 (dd, 1H, *J* = 7.8, 1.8 Hz), 4.07 (ddd, 1H, *J* = 9.6, 8.4, 3.8 Hz), 3.90 (ddd, 1H, *J* = 9.6, 8.9, 6.9 Hz), 3.02 (ddd, 1H, *J* = 17.7, 13.1, 3.9 Hz), 2.86 (ddd, 1H, *J* = 17.7, 4.8, 2.1 Hz), 2.65 (ddd, 1H, *J* = 13.6, 13.1, 4.8 Hz), 2.43 (s, 3H), 2.32 (ddd, 1H, *J* = 12.5, 6.9, 3.8 Hz), 2.11 (ddd, 1H, *J* = 12.5, 8.9, 8.4 Hz), 1.53 (ddd, 1H, *J* = 13.6, 4.8, 2.1 Hz) ppm

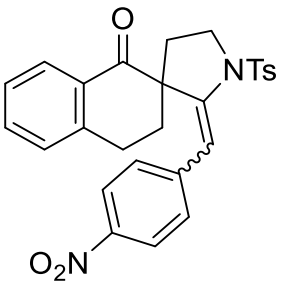
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 193.9, 188.0, 159.7, 145.4, 140.9, 139.4, 134.0, 133.3 (CH), 132.6, 132.3 (CH), 130.1 (2x CH), 128.8 (CH), 128.5 (2x CH), 128.2 (2x CH), 128.0 (CH), 127.6 (2x CH), 127.2 (CH), 99.7 (CH), 58.8, 48.9 (CH_2), 30.4 (CH_2), 28.1 (CH_2), 25.7 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1680, 1582, 1352, 1162 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 494.1396; found: 494.1385

TLC (40% ethyl acetate in petroleum ether): 0.41 (UV, Vanillin)

2'-(4-nitrobenzylidene)-1'-tosyl-3,4-dihydro-1H-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2s)



$C_{27}H_{24}N_2O_5S$
MW: 488.56 $g.mol^{-1}$
Yellow solid
92% (*E/Z* ratio 82/18) (449 mg, 0.92 mmol)

*N.B.: Due to their identical polarity, the proton and/or carbon spectra interpretation could not be performed entirely because of the signals superposition. For a better understanding, the major isomer **E** is fully described and only the characteristic signals for the minor isomer **Z** are given.*

- ***E* isomer (major product)**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.86 (m, 4H), 7.83 (dd, 1H, *J* = 7.9, 1.3 Hz), 7.42-7.46 (m, 1H), 7.38 (d, 2H, *J* = 8.3 Hz), 7.24-7.27 (m, 1H), 7.10 (d, 1H, *J* = 7.5 Hz), 7.06 (s, 1H), 7.04 (d, 2H, *J* = 8.8 Hz), 4.01 (ddd, 1H, *J* = 9.8, 7.4, 3.2 Hz), 3.65 (ddd, 1H, *J* = 9.8, 9.6, 6.4 Hz), 2.88 (ddd, 1H, *J* = 17.0, 13.1, 4.6 Hz), 2.64 (ddd, 1H, *J* = 17.0, 4.7, 2.8 Hz), 2.49 (s, 3H), 2.19 (ddd, 1H, *J* = 12.5, 6.4, 3.2 Hz), 2.11 (ddd, 1H, *J* = 12.5, 9.6, 7.4 Hz), 1.96 (ddd, 1H, *J* = 13.5, 13.1, 4.7 Hz), 1.57 (ddd, 1H, *J* = 13.5, 4.6, 2.8 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 196.8, 146.1, 145.3, 144.7, 144.0, 142.4, 134.3 (CH), 130.1, 129.7 (2x CH), 129.7 (2x CH), 129.5 (CH), 128.1 (2x CH), 127.6 (CH), 127.3 (CH), 123.2 (CH), 123.4 (2x CH), 107.8 (CH), 57.9, 47.8 (CH_2), 32.5 (CH_2), 32.1 (CH_2), 26.1 (CH_2), 21.9 (CH_3) ppm

- ***Z* isomer (minor product)**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.05 (d, 1H, *J* = 7.9, 1.3 Hz), 7.98 (d, 2H, *J* = 8.7 Hz), 7.51-7.55 (m, 3H), 7.24-7.27 (m, 3H), 5.74 (s, 1H), 3.94-3.97 (m, 1H), 3.70-3.75 (m, 1H), 3.08-3.14 (m, 1H), 2.44-2.46 (m, 1H), 2.44 (s, 3H), 1.89-1.92 (m, 1H), 1.66-1.71 (m, 1H) ppm

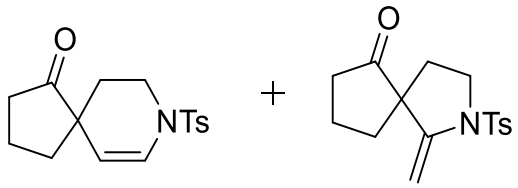
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 196.9, 146.0, 144.6, 144.3, 144.1, 143.6, 135.9, 134.2 (2x CH), 131.6, 129.1 (CH), 128.8 (2x CH), 128.5 (2x CH), 128.5 (CH), 127.3 (CH), 127.3 (2x CH), 116.0 (CH), 57.6, 48.6 (CH_2), 32.9 (CH_2), 29.8 (CH_2), 26.3 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 1679, 1594, 1513, 1338, 1294, 1160 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 489.1479; found: 489.1461

TLC (30% ethyl acetate in petroleum ether): 0.34 (UV, Vanillin)

8-tosyl-8-azaspiro[4.5]dec-6-en-1-one (6t)
1-methylene-2-tosyl-2-azaspiro[4.4]nonan-6-one (2t)



$C_{16}H_{19}NO_3S$
MW: 305.39 $g.mol^{-1}$
White solid (*endo*, mp = 75 °C)
67% (*endo/exo* 87/13) (205 mg, 0.67 mmol)

*N.B.: Compounds **6t** and **2t** were obtained as a mixture. Only compound **6t** could be isolated, the proton and carbon spectra interpretation were fully performed.*

*Compound **2t** couldn't be isolated from **6t / 2t** mixture**,** due to their identical polarity, the proton and/or carbon spectra interpretation could not be performed entirely because of the signals superposition. For a better understanding, only the characteristic signals for the compound **2t** are given.*

■ **Compound 6t**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.65 (d, 2H, *J* = 8.2 Hz), 7.30 (d, 2H, *J* = 8.2 Hz), 6.80 (d, 1H, *J* = 8.4 Hz), 4.64 (d, 1H, *J* = 8.4 Hz), 3.42-3.50 (m, 2H), 2.41 (s, 3H), 2.24-2.27 (m, 3H), 1.76 (dd, 1H, *J* = 12.0, 5.3 Hz), 1.67-1.72 (m, 1H), 1.46 (ddd, 1H, *J* = 13.8, 8.9, 4.8 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 219.8, 144.0, 134.8, 129.9 (2x CH), 127.1 (2x CH), 126.7 (CH), 108.0 (CH), 47.0, 40.4 (CH_2), 37.7 (CH_2), 37.2 (CH_2), 28.6 (CH_2), 21.7 (CH_3), 18.5 (CH_2) ppm

IR (ATR): v = 1732, 1349, 1163 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 306.1158; found: 306.1171

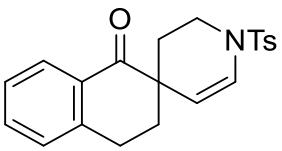
TLC (40% ethyl acetate in petroleum ether): 0.68 (UV, Vanillin)

■ **Compound 2t (characteristic signals)**

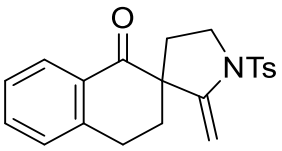
^{1}H NMR ($CDCl_3$, 500 MHz): δ = 5.16 (d, 1H, *J* = 2.0 Hz), 4.16 (d, 1H, *J* = 2.0 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 216.9, 147.0, 134.5, 90.7 (CH_2), 35.4 (CH_2), 32.0 (CH_2), 21.8 (CH_3) ppm

1'-tosyl-2',3,3',4-tetrahydro-1*H*,1'*H*-spiro[naphthalene-2,4'-pyridin]-1-one (6u)
2'-methylene-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2u)



Compound 6u
$C_{21}H_{21}NO_3S$
MW: 367.46 g.mol^{-1}
Yellow oil
75% (275 mg, 0.75 mmol)



Compound 2u
$C_{21}H_{21}NO_3S$
MW: 367.46 g.mol^{-1}
Yellow solid
mp = 134 °C
13% (48 mg, 0.13 mmol)

*N.B.: Compounds **6u** and **2u** were obtained as a separable mixture.*

■ **Compound 6u**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.91 (d, 1H, *J* = 7.8 Hz), 7.68 (d, 2H, *J* = 8.2 Hz), 7.46 (t, 1H, *J* = 7.8 Hz), 7.32 (d, 2H, *J* = 8.2 Hz), 7.28 (t, 1H, *J* = 7.8 Hz), 7.22 (d, 1H, *J* = 7.8 Hz), 6.82 (d, 1H, *J* = 8.4 Hz), 4.90 (d, 1H, *J* = 8.4 Hz), 3.59-3.63 (m, 1H), 3.42-3.47 (m, 1H), 3.06-3.12 (m, 1H), 2.92-2.97 (m, 1H), 2.44 (s, 3H), 2.16-2.20 (m, 1H), 1.97-2.00 (m, 2H), 1.50-1.55 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 199.2, 144.0, 142.8, 135.1, 133.6 (CH), 131.5, 130.0 (2x CH), 128.9 (CH), 128.4 (CH), 127.1 (2x CH), 127.0 (CH), 126.9 (CH), 107.2 (CH), 43.4, 40.9 (CH_2), 35.6 (CH_2), 29.5 (CH_2), 25.3 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 1682, 1353, 1168 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 390.1134; found: 390.1125

TLC (30% ethyl acetate in petroleum ether): 0.60 (UV, Vanillin)

■ **Compound 2u**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.94 (dd, 1H, *J* = 7.8, 0.9 Hz), 7.83 (d, 2H, *J* = 8.2 Hz), 7.46 (td, 1H, *J* = 7.8, 0.9 Hz), 7.36 (d, 2H, *J* = 8.2 Hz), 7.29 (t, 1H, *J* = 7.8 Hz), 7.19 (d, 1H, *J* = 7.8 Hz), 5.20 (d, 1H, *J* = 1.9 Hz), 4.10 (d, 1H, *J* = 1.9 Hz), 3.69-3.74 (m, 1H), 3.76-3.80 (m, 1H), 2.77-2.83 (m, 1H), 2.87-2.92 (m, 1H), 2.44-2.49 (m, 1H), 2.47 (s, 3H), 1.84-1.88 (m, 2H), 1.75-1.80 (m, 1H) ppm

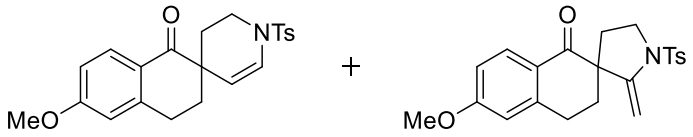
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 196.4, 146.6, 144.3, 143.4, 134.6, 133.9 (CH), 131.3, 129.6 (2x CH), 128.8 (CH), 128.5 (CH), 127.8 (2x CH), 127.1 (Ch), 91.6 (CH_2), 56.6, 47.8 (CH_2), 32.4 (CH_2), 31.1 (CH_2), 25.8 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1681, 1342, 1164 cm^{-1}

ESI-HRMS: $[M+K]^+$ calc: 406.0874; found: 406.0867

TLC (30% ethyl acetate in petroleum ether): 0.46 (UV, Vanillin)

6-methoxy-1'-tosyl-2',3,3',4-tetrahydro-1*H*,1'*H*-spiro[naphthalene-2,4'-pyridin]-1-one (6v)
6-methoxy-2'-methylene-1'-tosyl-3,4-dihydro-1*H*-spiro[naphthalene-2,3'-pyrrolidin]-1-one (2v)



$C_{22}H_{23}NO_4S$
MW: 397.49 g.mol^{-1}
White solid (*endo*, mp 144 °C)
74% (*endo/exo* 85/15) (294 mg, 0.74 mmol)

*N.B.: Compounds **6v** and **2v** were obtained as a mixture. Only compound **6v** could be isolated, the proton and carbon spectra interpretation were fully performed.*

*Compound **2v** couldn't be isolated from **6v / 2v** mixture**,** due to their identical polarity, the proton and/or carbon spectra interpretation could not be performed entirely because of the signals superposition. For a better understanding, only the characteristic signals for the compound **2v** are given.*

■ **Compound 6v**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.89 (d, 1H, *J* = 8.8 Hz), 7.67 (d, 2H, *J* = 8.2 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 6.81 (d, 1H, *J* = 8.5 Hz), 6.79 (dd, 1H, *J* = 8.8, 2.4 Hz), 6.65 (d, 1H, *J* = 2.4 Hz), 4.89 (d, 1H, *J* = 8.5 Hz), 3.83 (s, 3H), 3.59 (ddd, 1H, *J* = 12.1, 6.2, 4.1 Hz), 3.46 (ddd, 1H, *J* = 12.2, 9.9, 3.0 Hz), 3.04 (ddd, 1H, *J* = 17.4, 7.2, 6.4 Hz), 2.90 (dt, 1H, *J* = 17.5, 6.0 Hz), 2.43 (s, 3H), 2.16 (ddd, 1H, *J* = 14.1, 6.0, 3.4 Hz), 1.95 (dd, 2H, *J* = 6.9, 6.1 Hz), 1.50 (ddd, 1H, *J* = 13.8, 9.7, 3.8 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 198.0, 163.7, 145.3, 143.9, 135.1, 130.7 (CH), 130.0 (2x CH), 127.1 (2x CH), 126.8 (CH), 124.9, 113.6 (CH), 112.4 (CH), 107.7 (CH), 55.6 (CH_3), 43.1, 40.9 (CH_2), 35.7 (CH_2), 29.6 (CH_2), 25.7 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 1671, 1598, 1349, 1167 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 398.1412; found: 398.1429

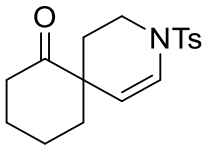
TLC (30% ethyl acetate in petroleum ether): 0.55 (UV, Vanillin)

■ **Compound 2v (characteristic signals)**

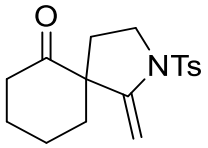
^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.92 (d, 1H, *J* = 8.8 Hz), 7.83 (d, 2H, *J* = 8.2 Hz), 7.35 (d, 2H, *J* = 8.2 Hz), 6.63 (d, 1H, *J* = 2.5 Hz), 5.18 (d, 1H, *J* = 2.5 Hz), 4.08 (d, 1H, *J* = 2.1 Hz), 3.74 (td, 2H, *J* = 6.8, 1.0 Hz), 2.73 (dt, 1H, *J* = 17.0, 6.4 Hz), 2.49 (ddd, 1H, *J* = 12.6, 7.4, 6.6 Hz), 2.46 (s, 3H), 1.80 (t, 2H, *J* = 6.2 Hz), 1.73 (dt, 1H, *J* = 12.7, 6.7 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 195.2, 163.9, 146.7, 145.9, 144.2, 134.6, 131.0 (CH), 129.6 (2x CH), 127.7 (2x CH), 125.0, 112.5 (CH), 91.6 (CH_2), 47.9 (CH_2), 43.1, 32.5 (CH_2), 31.2 (CH_2), 26.2 (CH_2), 21.8 (CH_3) ppm

3-tosyl-3-azaspiro[5.5]undec-1-en-7-one (6w)
1-methylene-2-tosyl-2-azaspiro[4.5]decan-6-one (2w)



Compound 6w
$C_{17}H_{21}NO_3S$
MW: 319.42 g.mol^{-1}
White solid
65% (207 mg, 0.65 mmol)



Compound 2w
$C_{17}H_{21}NO_3S$
MW: 319.42 g.mol^{-1}
Colorless oil
32% (102 mg, 0.32 mmol)

*N.B.: Compounds **6w** and **2w** were obtained as a separable mixture.*

■ **Compound 6w**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.62 (d, 2H, *J* = 8.2 Hz), 7.29 (d, 2H, *J* = 8.2 Hz), 6.73 (d, 1H, *J* = 8.5 Hz), 5.14 (dd, 1H, *J* = 8.5, 1.5 Hz), 3.63-3.67 (m, 1H), 3.12 (td, 1H, *J* = 11.8, 3.0 Hz), 2.43-2.49 (m, 1H), 2.41 (s, 3H), 2.16-2.25 (m, 2H), 1.97-2.03 (m, 1H), 1.81-1.87 (m, 1H), 1.60-1.69 (m, 3H), 1.20-1.26 (m, 2H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 212.0, 144.0, 134.9, 130.0 (2x CH), 127.1 (2x CH), 126.2 (CH), 107.4 (CH), 47.2, 41.5 (CH_2), 40.6 (CH_2), 39.5 (CH_2), 30.2 (CH_2), 28.2 (CH_2), 21.7 (CH_3), 21.0 (CH_2) ppm

IR (ATR): v = 1707, 1355, 1167 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 320.1315; found: 320.1280

TLC (30% ethyl acetate in petroleum ether): 0.52 (UV, Vanillin)

■ **Compound 2w**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.67 (d, 2H, *J* = 8.3 Hz), 7.31 (d, 2H, *J* = 8.3 Hz), 5.31 (d, 1H, *J* = 1.9 Hz), 4.42 (d, 1H, *J* = 1.9 Hz), 3.81 (ddd, 1H, *J* = 9.9, 7.8, 2.3 Hz), 3.39 (td, 1H, *J* = 9.9, 6.5 Hz), 2.43 (s, 3H), 2.28-2.31 (m, 2H), 2.21-2.25 (m, 1H), 1.87-1.91 (m, 1H), 1.81-1.86 (m, 2H), 1.70-1.74 (m, 3H), 1.60-1.66 (m, 1H) ppm

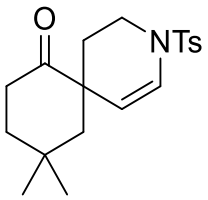
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 209.4, 147.3, 144.2, 134.5, 129.4 (2x CH), 127.9 (2x CH), 92.5 (CH_2), 60.2, 47.9 (CH_2), 38.5 (CH_2), 37.1 (CH_2), 33.0 (CH_2), 26.6 (CH_2), 21.9 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1709, 1342, 1185 cm^{-1}

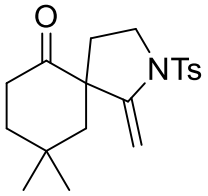
ESI-HRMS: $[M+H]^+$ calc: 320.1315; found: 320.1337

TLC (30% ethyl acetate in petroleum ether): 0.35 (UV, Vanillin)

10,10-dimethyl-3-tosyl-3-azaspiro[5.5]undec-1-en-7-one (6x)
9,9-dimethyl-1-methylene-2-tosyl-2-azaspiro[4.5]decan-6-one (2x)



Compound 6x
$C_{19}H_{25}NO_3S$
MW: 347.47 g.mol^{-1}
Colorless oil
44% (153 mg, 0.44 mmol)



Compound 2x
$C_{19}H_{25}NO_3S$
MW: 347.47 g.mol^{-1}
White solid
mp = 108 °C
22% (76 mg, 0.22 mmol)

*N.B.: Compounds **6x** and **2x** were obtained as a separable mixture.*

■ **Compound 6x**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.61 (d, 2H, *J* = 8.2 Hz), 7.28 (d, 2H, *J* = 8.2 Hz), 6.67 (d, 1H, *J* = 8.6 Hz), 5.05 (d, 1H, *J* = 8.6 Hz), 3.51 (ddd, 1H, *J* = 12.1, 5.7, 3.9 Hz), 3.21 (ddd, 1H, *J* = 12.1, 10.2, 3.1 Hz), 2.55 (ddd, 1H, *J* = 14.6, 10.9, 5.5 Hz), 2.40 (s, 3H), 2.23 (ddd, 1H, *J* = 14.5, 6.2, 4.8 Hz), 2.05 (dddd, 1H, *J* = 13.8, 6.0, 2.9, 1.1 Hz), 1.74 (dtd, 1H, *J* = 13.3, 5.8, 2.2 Hz), 1.62 (ddd, 1H, *J* = 13.9, 11.0, 4.9 Hz), 1.55 (dd, 1H, *J* = 13.9, 2.2 Hz), 1.47 (d, 1H, *J* = 13.9 Hz), 1.31 (ddd, 1H, *J* = 13.8, 10.1, 4.0 Hz), 1.15 (s, 3H), 0.95 (s, 3H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 213.1, 143.9, 134.7, 129.9 (2x CH), 127.0 (2x CH), 125.8 (CH), 109.3 (CH), 53.1 (CH_2), 46.5, 40.9 (CH_2), 39.5 (CH_2), 35.7 (CH_2), 31.5 (CH_3), 31.5 (CH_2), 31.0, 29.0 (CH_3), 21.7 (CH_3) ppm

IR (ATR): v = 1707, 1352, 1164 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 348.1628; found: 348.1626

TLC (20% ethyl acetate in petroleum ether): 0.51 (UV, Vanillin)

■ **Compound 2x**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.79 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 5.25 (d, 1H, *J* = 2.2 Hz), 4.25 (d, 1H, *J* = 2.2 Hz), 3.89 (ddd, 1H, *J* = 9.5, 7.8, 1.5 Hz), 3.34 (ddd, 1H, *J* = 10.9, 9.5, 6.3 Hz), 2.48 (ddd, 1H, *J* = 16.3, 9.4, 8.7 Hz), 2.44 (s, 3H), 2.25 (ddd, 1H, *J* = 13.0, 6.3, 1.8 Hz), 2.19 (dt, 1H, *J* = 16.2, 4.8 Hz), 1.93 (d, 1H, *J* = 14.4 Hz), 1.84 (ddd, 1H, *J* = 12.6, 10.8, 8.0 Hz), 1.63-1.66 (m, 2H), 1.55 (d, 1H, *J* = 14.4 Hz), 1.10 (s, 3H), 1.01 (s, 3H) ppm

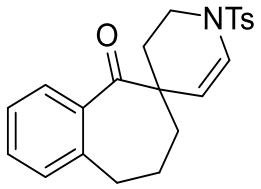
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 210.5, 148.0, 144.2, 134.5, 129.4 (2x CH), 128.0 (2x CH), 91.0 (CH_2), 58.9 (CH_2), 49.6 (CH_2), 48.1 (CH_2), 37.8 (CH_2), 35.3 (CH_2), 34.9 (CH_2), 32.6 (CH_3), 30.5, 26.5 (CH_3), 21.8 (CH_3) ppm

IR (ATR): v = 1697, 1333, 1160 cm^{-1}

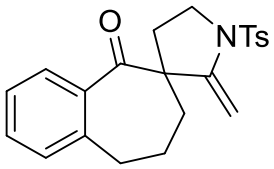
ESI-HRMS: $[M+H]^+$ calc: 348.1628; found: 348.1639

TLC (20% ethyl acetate in petroleum ether): 0. 40 (UV, Vanillin)

1'-tosyl-2',3',8,9-tetrahydro-1'*H*-spiro[benzo[7]annulene-6,4'-pyridin]-5(7*H*)-one (6y)
2'-methylene-1'-tosyl-8,9-dihydrospiro[benzo[7]annulene-6,3'-pyrrolidin]-5(7*H*)-one (2y)



Compound 6y
$C_{22}H_{23}NO_3S$
MW: 381.49 g.mol^{-1}
Colorless oil
35% (133 mg, 0.35 mmol)



Compound 2y
$C_{22}H_{23}NO_3S$
MW: 381.49 g.mol^{-1}
White solid
mp = 146 °C
35% (133 mg, 0.35 mmol)

*N.B.: Compounds **6y** and **2y** were obtained as a separable mixture.*

■ **Compound 6y**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.62 (d, 2H, *J* = 8.2 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 7.29 (td, 1H, *J* = 7.5, 1.2 Hz), 7.16 (td, 1H, *J* = 7.5, 1.1 Hz), 7.10 (d, 1H, *J* = 7.5 Hz), 6.83 (dd, 1H, *J* = 7.5, 1.1 Hz), 6.64 (d, 2H, *J* = 8.5 Hz), 4.87 (dd, 1H, *J* = 8.5, 1.1 Hz), 3.58 (ddd, 1H, *J* = 12.3, 5.3, 3.8 Hz), 3.09 (ddd, 1H, *J* = 12.3, 10.8, 3.2 Hz), 2.73-2.83 (m, 2H), 2.44 (s, 3H), 2.28-2.33 (m, 1H), 1.92-2.00 (m, 1H), 1.81-1.88 (m, 1H), 1.75-1.80 (m, 1H), 1.67-1.72 (m, 1H), 1.43 (ddd, 1H, *J* = 13.5, 10.8, 4.1 Hz) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 210.0, 144.0, 141.3, 136.9, 134.6, 130.5 (CH), 129.9 (2x CH), 129.1 (CH), 127.5 (CH), 127.1 (2x CH), 126.5 (CH), 125.7 (CH), 108.9 (CH), 48.5, 41.2 (CH_2), 39.5 (CH_2), 34.8 (CH_2), 30.5 (CH_2), 23.3 (CH_2), 21.7 (CH_3) ppm

IR (ATR): v = 1683, 1639, 1355, 1165 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 382.1471; found: 382.1470

TLC (30% ethyl acetate in petroleum ether): 0.65 (UV, Vanillin)

■ **Compound 2y**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.80 (d, 2H, *J* = 8.2 Hz), 7.33-7.36 (m, 3H), 7.20 (td, 1H, *J* = 7.5, 1.0 Hz), 7.07 (d, 1H, *J* = 7.5 Hz), 6.83 (dd, 1H, *J* = 7.5, 1.0 Hz), 5.18 (d, 1H, *J* = 2.2 Hz), 4.04 (d, 1H, *J* = 2.2 Hz), 3.92 (dd, 2H, *J* = 8.8, 5.3 Hz), 2.72 (ddd, 1H, *J* = 14.0, 5.2, 4.1 Hz), 2.60-2.66 (m, 1H), 2.45 (s, 3H), 2.30 (dt, 1H, *J* = 12.5, 5.1 Hz), 1.76-1.84 (m, 4H), 1.53-1.56 (m, 1H) ppm

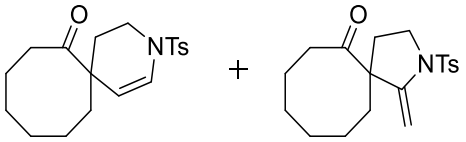
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 209.7, 148.5, 144.2, 140.0, 136.4, 134.2, 131.3 (CH), 129.4 (2x CH), 128.4 (CH), 127.9 (2x CH), 127.1 (CH), 126.8 (CH), 91.8 (CH_2), 59.2, 49.8 (CH_2), 33.3 (CH_2), 31.5 (CH_2), 30.3 (CH_2), 21.8 (CH_3), 21.7 (CH_2) ppm

IR (ATR): v = 1683, 1634, 1343, 1165 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 382.1471; found: 382.1484

TLC (30% ethyl acetate in petroleum ether): 0.58 (UV, Vanillin)

3-tosyl-3-azaspiro[5.7]tridec-1-en-7-one (6z)
1-methylene-2-tosyl-2-azaspiro[4.7]dodecan-6-one (2z)



$C_{19}H_{25}NO_3S$
MW: 347.47 g.mol^{-1}
White solid
92% (*endo/exo* 16/84) (307 mg, 0.92 mmol)

*N.B.: Compounds **6z** and **2z** were obtained as an inseparable mixture. Due to their identical polarity, the proton and/or carbon spectra interpretation could not be performed entirely because of the signals superposition. For a better understanding, the major compound **2z** is fully described and only the characteristic signals for the minor compound **6z** are given.*

■ **Compound 2z**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.62 (d, 2H, *J* = 8.2 Hz), 7.24 (d, 2H, *J* = 8.2 Hz), 5.35 (d, 1H, *J* = 2.2 Hz), 4.54 (d, 1H, *J* = 2.2 Hz), 3.82 (t, 1H, *J* = 9.1 Hz), 3.75 (ddd, 1H, *J* = 10.7, 9.1, 6.9 Hz), 2.64-2.70 (m, 1H), 2.35-2.43 (m, 2H), 2.41 (s, 3H), 1.63-1.76 (m, 3H), 1.54-1.60 (m, 2H), 1.42-1.50 (m, 4H), 1.16-1.25 (m, 1H), 0.71-0.79 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 213.2, 146.2, 144.0, 134.1, 129.2 (2x CH), 127.7 (2x CH), 93.7 (CH_2), 61.2, 49.8 (CH_2), 36.4 (CH_2), 32.7 (CH_2), 30.3 (CH_2), 28.8 (CH_2), 25.5 (CH_2), 25.0 (CH_2), 24.1 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1698, 1343, 1164 cm^{-1}

ESI-HRMS: $[M+H]^+$ calc: 348.1628; found: 348.1635

TLC (30% ethyl acetate in petroleum ether): 0.49 (UV, Vanillin)

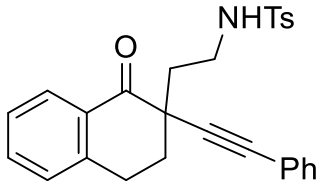
■ **Compound 6z (characteristic signals)**

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.28 (d, 2H, *J* = 8.2 Hz), 6.73 (d, 1H, *J* = 8.4 Hz), 4.80 (dd, 1H, *J* = 8.4, 1.5 Hz), 3.67 (dt, 1H, *J* = 12.3, 4.7 Hz), 3.16 (td, 1H, *J* = 11.9, 3.0 Hz), 2.23-2.28 (m, 1H), 2.13-2.18 (m, 2H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 216.4, 144.0, 134.9, 129.9 (2x CH), 127.1 (2x CH), 126.5 (CH), 108.4 (CH), 48.5, 41.5 (CH_2), 37.5 (CH_2), 35.8 (CH_2), 30.1 (CH_2), 27.9 (CH_2), 24.4 (CH_2), 21.7 (CH_3) ppm

Characterization data for α-alkynyl-keto-sulfonamide (3a)

4-methyl-*N*-(2-(1-oxo-2-(phenylethynyl)-1,2,3,4-tetrahydronaphthalen-2-yl)ethyl)benzene sulfonamide (3a)



$C_{27}H_{25}NO_3S$
MW: 443.56 g.mol^{-1}
Yellow oil
25% (111 mg, 0.25 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 8.04 (dd, 1H, *J* = 7.6, 1.1 Hz), 7.74 (d, 2H, *J* = 8.2 Hz), 7.49 (td, 1H, *J* = 7.5, 1.1 Hz), 7.32 (t, 1H, *J* = 7.6 Hz), 7.23-7.30 (m, 8H), 5.26 (t, 1H, *J* = 6.0 Hz, NH), 3.31-3.45 (m, 3H), 2.93 (dt, 1H, *J* = 17.1, 4.0 Hz), 2.38 (s, 3H), 2.24-2.31 (m, 2H), 2.13-2.17 (m, 1H), 1.99-1.93 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 195.1, 143.6, 143.3, 137.0, 134.0 (CH), 131.8 (2x CH), 130.9, 129.8 (2x CH), 128.9 (CH), 128.3 (CH), 128.6 (CH), 128.3 (2x CH), 127.3 (2x CH), 127.0 (CH), 122.3, 86.6, 86.1, 46.2, 40.3 (CH_2), 36.1 (CH_2), 35.1 (CH_2), 26.6 (CH_2), 21.6 (CH_3) ppm

IR (ATR): v = 3274, 1685, 1326, 1155 cm^{-1}

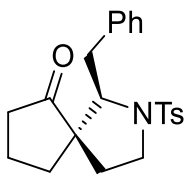
ESI-HRMS: $[M+H]^+$ calc: 444.1628; found: 444.1593

TLC (50% ethyl acetate in petroleum ether): 0.55 (UV, Vanillin)

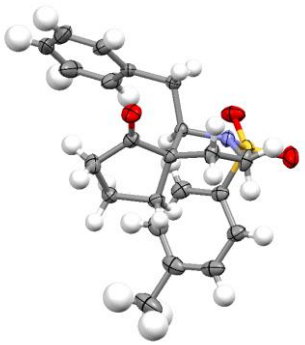
Experimental procedure and characterization data for spiro-sulfonamide (13)

Procedure: To a stirred solution of spiro-enamide (1 equiv, 1 mmol) in dry CH_2Cl_2 (conc = 0.05 M, 20 mL) was added Et_3SiH (10 equiv, 10 mmol), then was added dropwise $BF_3.Et_2O$ (10 equiv, 10 mmol) and the resulting mixture was stirred at room temperature for 16 h. The mixture was hydrolyzed with a saturated aqueous solution of $NaHCO_3$ (20 mL). The aqueous layer was extracted with CH_2Cl_2 (3 x 20 mL). The combined organic layers were dried (Na_2SO_4), filtrated and concentrated under vacuum (15 mbar, 40 °C). The crude material was purified by column chromatography using a step gradient of EtOAc in petroleum ether (0 to 30%) to afford the title compound **13**.

(1*R*,5*R*)-1-benzyl-2-tosyl-2-azaspiro[4.4]nonan-6-one (13)



$C_{22}H_{25}NO_3S$
MW: 383.51 g.mol^{-1}
White solid
mp = 143°C
57% (219 mg, 0.57 mmol)



1H NMR (CDCl3, 500 MHz): δ = 7.79 (d, 2H, *J* = 8.2 Hz), 7.36 (d, 2H, *J* = 8.2 Hz), 7.25-7.28 (m, 2H), 7.17-7.19 (m, 3H), 3.87 (dd, 1H, *J* = 10.9, 2.9 Hz), 3.57 (ddd, 1H, *J* = 9.6, 7.8, 2.9 Hz), 3.24 (dd, 1H, *J* = 14.0, 2.9 Hz), 3.14 (ddd, 1H, *J* = 10.3, 9.6, 6.5 Hz), 2.87 (dd, 1H, *J* = 14.0, 10.9 Hz), 2.45 (s, 3H), 2.40 (ddd, 1H, *J* = 13.2, 10.3, 7.8 Hz), 1.76-1.84 (m, 1H), 1.50-1.56 (m, 1H), 1.37 (ddd, 1H, *J* = 13.2, 6.5, 2.9 Hz), 1.21-1.33 (m, 2H), 1.10-1.61 (m, 1H), 0.98-1.02 (m, 1H) ppm

13C NMR (CDCl3, 125 MHz): δ = 217.3, 143.9, 137.4, 134.6, 130.4 (2x CH), 129.9 (2x CH), 128.5 (2x CH), 127.7 (2x CH), 126.6 (CH), 68.3 (CH), 58.2, 46.8 (CH_2), 39.8 (CH_2), 37.6 (CH), 36.1 (CH_2), 33.3 (CH_2), 21.8 (CH_3), 18.5 (CH_2) ppm

IR (ATR): v = 1729, 1685, 1342, 1158 cm^{-1}

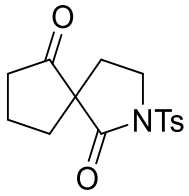
ESI-HRMS: $[M+H]^+$ calc: 384.1628; found: 384.1625

TLC (50% ethyl acetate in petroleum ether): 0.64 (UV, Vanillin)

Experimental procedure and characterization data for β-spiro-lactams (14b-d)

General procedure: Spiro-enamide (1 equiv, 1 mmol) was dissolved in dry CH_2Cl_2 (conc = 0.02 M, 50 mL) and cooled to -78 °C. Ozone was bubbled through the solution for 2 min or until total consumption of starting material (TLC monitoring). The reaction mixture was degassed with Argon for 10 min. Then Me_2S (10 equiv, 10 mmol) was added and the reaction mixture is slowly warmed to room temperature. After stirring for 10 min, the reaction mixture was concentrated in vacuum (15 mbar, 40 °C). The crude material was purified by column chromatography using a step gradient of EtOAc in petroleum ether (0 to 30%) to afford the title compounds **14**.

2-tosyl-2-azaspiro[4.4]nonane-1,6-dione (14b)



$C_{15}H_{17}NO_4S$
MW: 307.36 g.mol^{-1}
White solid
mp = 114 °C
99% (304 mg, 0.99 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.89 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 3.95-3.98 (m, 2H), 2.43-2.47 (m, 4H), 2.25-2.33 (m, 3H), 2.13-2.23 (m, 1H), 1.95 (dt, 1H, *J* = 12.9, 8.8 Hz), 1.83-1.89 (m, 2H) ppm

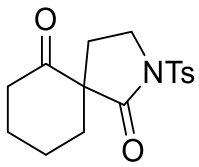
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 214.8, 171.9, 145.4, 134.8, 129.8 (2x CH), 128.2 (2x CH), 59.5, 45.0 (CH_2), 37.8 (CH_2), 33.5 (CH_2), 29.1 (CH_2), 21.9 (CH_3), 19.7 (CH_2) ppm

IR (ATR): v = 1746, 1711, 1355, 1167 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 330.0770; found: 430.0750

TLC (40% ethyl acetate in petroleum ether): 0.31 (UV, Vanillin)

2-tosyl-2-azaspiro[4.5]decane-1,6-dione (14c)



$C_{16}H_{19}NO_4S$
MW: 321.39 g.mol^{-1}
Colorless oil
96% (308 mg, 0.96 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.88 (d, 2H, *J* = 8.2 Hz), 7.33 (d, 2H, *J* = 8.2 Hz), 3.89 (ddd, 1H, *J* = 9.8, 8.2, 4.2 Hz), 3.72 (dt, 1H, *J* = 9.8, 7.7 Hz), 2.67 (ddd, 1H, *J* = 12.8, 7.7, 4.2 Hz), 2.61 (ddd, 1H, *J* = 14.3, 10.8, 5.6 Hz), 2.44 (s, 3H), 2.36 (ddd, 1H, *J* = 14.1, 5.6, 5.1 Hz), 2.08-2.22 (m, 2H), 1.92-1.97 (m, 1H), 1.68-1.78 (m, 2H), 1.55-1.66 (m, 2H) ppm

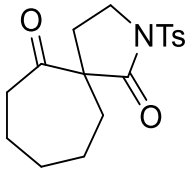
^{13}C NMR ($CDCl_3$, 125 MHz): δ = 206.5, 171.9, 145.5, 134.8, 129.8 (2x CH), 128.2 (2x CH), 60.3, 44.5 (CH_2), 39.4 (CH_2), 36.4 (CH_2), 28.8 (CH_2), 26.6 (CH_2), 21.9 (CH_3), 20.9 (CH_2) ppm

IR (ATR): v = 1738, 17103, 1356, 1171 cm^{-1}

ESI-HRMS: $[M+Na]^+$ calc: 344.0927; found: 344.0909

TLC (50% ethyl acetate in petroleum ether): 0.52 (UV, Vanillin)

2-tosyl-2-azaspiro[4.6]undecane-1,6-dione (14d)



$C_{17}H_{21}NO_4S$
MW: 335.42 g.mol^{-1}
White solid
mp = 111 °C
98% (329 mg, 0.98 mmol)

^{1}H NMR ($CDCl_3$, 500 MHz): δ = 7.86 (d, 2H, *J* = 8.2 Hz), 7.31 (d, 2H, *J* = 8.2 Hz), 3.89 (td, 1H, *J* = 9.3, 3.0 Hz), 3.82 (dt, 1H, *J* = 9.3, 7.9 Hz), 2.75 (td, 1H, *J* = 11.7, 2.6 Hz), 2.61 (ddd, 1H, *J* = 12.7, 7.5, 3.0 Hz), 2.42 (s, 3H), 2.33 (ddd, 1H, *J* = 11.7, 7.3, 2.5 Hz), 2.17 (dd, 1H, *J* = 14.7, 10.8 Hz), 1.70-1.91 (m, 5H), 1.47-1.56 (m, 1H), 1.36-1.45 (m, 1H), 1.16-1.24 (m, 1H) ppm

^{13}C NMR ($CDCl_3$, 125 MHz): δ = 209.2, 172.1, 145.4, 134.8, 129.7 (2x CH), 128.1 (2x CH), 63.1, 45.0 (CH_2), 41.7 (CH_2), 33.8 (CH_2), 30.4 (CH_2), 29.2 (CH_2), 26.4 (CH_2), 25.0 (CH_2), 21.8 (CH_3) ppm

IR (ATR): v = 1729, 1699, 1356, 1167 cm^{-1}

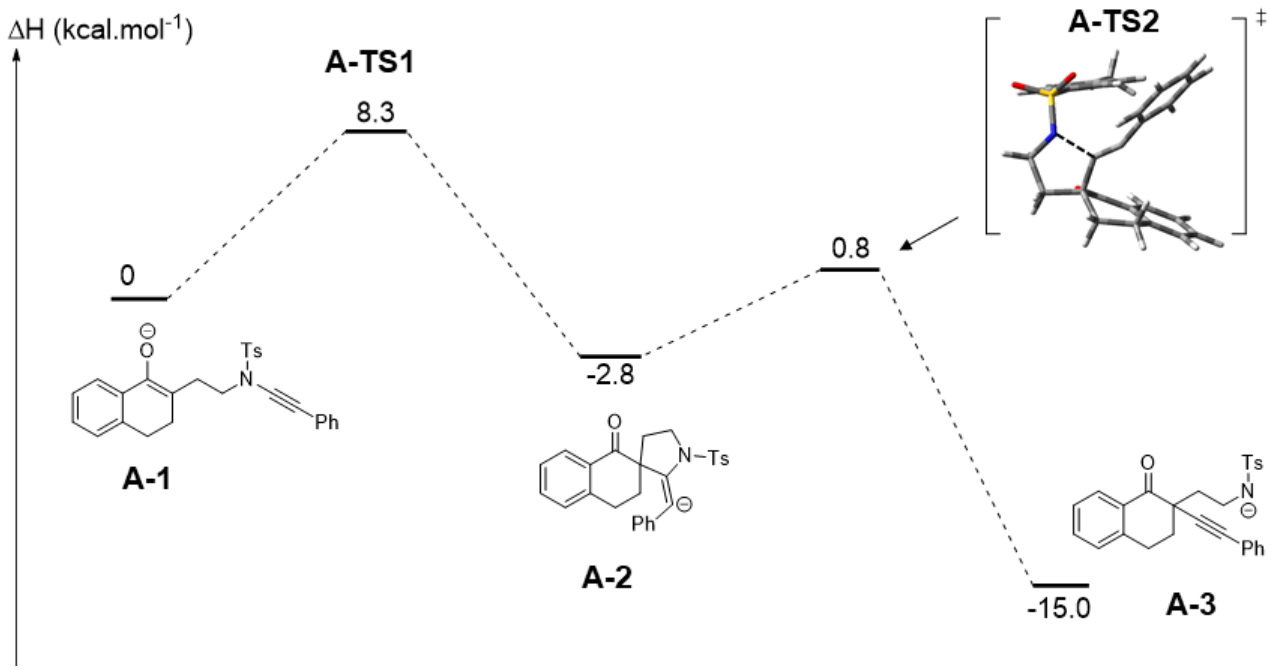
ESI-HRMS: $[M+Na]^+$ calc: 358.1083; found: 358.1087

TLC (40% ethyl acetate in petroleum ether): 0.38 (UV, Vanillin)

DFT studies

Computational details

All calculations were performed using the Gaussian 09 program (Revision A.02)[i]. All geometric structures were fully optimized using the B3LYP functional.[ii] Subsequent frequency calculations were performed in order to assess the nature of each intermediate (minimum or transition state). 6-311+G(d,p)[iii] basis sets were used for all main group atoms. Bulk solvent effects (toluene) were introduced using a Polarizable Continuum model (PCM)[iv]. Computed intermediates structures are reported below. IRC calculations[v] were used to confirm the minima linked by the transition states. Enthalpies and free energies were calculated for standard conditions at 298.15 K.



Scheme C. Cyclization and ring opening of the 5-membered ring

Cartesian coordinates of the intermediates structures

Compound A-1

C	-1.87899929	0.92867755	-0.04920333
C	-2.14059829	-0.22647545	0.68716667
C	-3.44108729	-0.73458945	0.80510467
C	-4.49302529	-0.06251245	0.14699467
C	-4.22299829	1.09648455	-0.58318033
C	-2.92416929	1.60040955	-0.68421433
H	-0.86351729	1.30666355	-0.12446533
H	-1.34927829	-0.77194445	1.18760267
H	-5.04091229	1.61002155	-1.08214333
H	-2.73265729	2.50483955	-1.25328333

C	-5.87986129	-0.65907945	0.20717567
H	-5.96943429	-1.41214345	-0.59069333
H	-6.63392329	0.11112655	0.00772667
C	-6.13289129	-1.34856745	1.54974167
H	-6.28890229	-0.56823645	2.32275567
H	-7.07857129	-1.90074645	1.49115767
C	-5.00118029	-2.28223545	1.92634367
C	-3.68261929	-1.97330245	1.63474367
O	-2.65332729	-2.63448945	2.04093567
C	-5.30667829	-3.42543145	2.85929967
H	-6.38065229	-3.45925545	3.07650767
H	-4.79847029	-3.28994445	3.82917067
C	-4.84617429	-4.82262645	2.41423667
H	-3.76615429	-4.79086245	2.26465567
H	-5.09482529	-5.56631545	3.17980167
N	-5.44558629	-5.25689845	1.11091267
C	-6.72553129	-4.98893345	0.80969267
S	-4.79924929	-6.69928645	0.42308567
O	-5.52273629	-6.91558945	-0.83068333
O	-4.78708229	-7.77947045	1.41791467
C	-3.10065629	-6.24502445	0.08690967
C	-2.10484729	-7.17576745	0.37485567
C	-2.80420829	-5.03011745	-0.52588633
C	-0.78979329	-6.88093145	0.02700867
H	-2.35718929	-8.10832845	0.86380767
C	-1.48423429	-4.75579145	-0.86091433
H	-3.58265029	-4.29974345	-0.70586133
C	-0.45959729	-5.67205245	-0.59390233
H	-0.00933029	-7.60063745	0.24964167
H	-1.24663529	-3.80201945	-1.31561233
C	0.97191171	-5.34129045	-0.93508433
H	1.38331071	-4.62510745	-0.21598233
H	1.60231871	-6.23295845	-0.91720933
H	1.04811471	-4.88624245	-1.92604133
C	-7.86893129	-4.71905745	0.52048567
C	-9.18563329	-4.35416945	0.11693867
C	-10.23747629	-4.27250345	1.04866667
C	-9.46058329	-4.05712545	-1.23249533
C	-11.51436929	-3.89596145	0.64521667

H	-10.03987629	-4.50550845	2.08940367
C	-10.74225529	-3.69464345	-1.63136833
H	-8.65720829	-4.11355945	-1.95650933
C	-11.77405529	-3.60744745	-0.69521733
H	-12.31069229	-3.83147645	1.38079567
H	-10.93476729	-3.47099845	-2.67629033
H	-12.77092229	-3.31762245	-1.00724433

Intermediate A-TS1

C	1.99851414	1.12184248	0.00000000
C	1.29940914	0.14404748	-0.70179900
C	1.96486514	-0.93800452	-1.29440700
C	3.36400614	-1.03145852	-1.17415200
C	4.05768314	-0.04146552	-0.47306500
C	3.38654914	1.03120348	0.11446500
H	1.46703714	1.95330448	0.45205300
H	0.22302614	0.19355848	-0.81321400
H	5.13784414	-0.11595052	-0.38382200
H	3.94349614	1.79022448	0.65421400
C	4.07982714	-2.22514052	-1.75618100
H	4.13648714	-2.99846252	-0.98445900
H	5.11238214	-1.95744952	-2.00528500
C	3.36492614	-2.79759552	-2.98445400
H	3.54801014	-2.13483252	-3.84890000
H	3.81481714	-3.76345552	-3.23993800
C	1.87262314	-2.97238552	-2.77787400
C	1.16611014	-1.93735352	-2.09024500
O	-0.08458086	-1.79089352	-2.14463600
C	1.12129814	-3.65802352	-3.89816200
H	1.81415514	-4.29390152	-4.46005300
H	0.68630014	-2.93674752	-4.60414000
C	-0.02178986	-4.51416452	-3.35070100
H	-0.85846186	-3.86857752	-3.08118200
H	-0.35098986	-5.26182552	-4.07395300
N	0.49454714	-5.21143852	-2.14712900
C	1.71642214	-4.81069052	-1.60067100
S	-0.64955686	-5.98578652	-1.17376800
O	0.05370014	-6.85476352	-0.23451400
O	-1.63468786	-6.55140152	-2.10465700

C	-1.49723686	-4.71899952	-0.21852200
C	-2.74168186	-4.25980652	-0.64359200
C	-0.89526786	-4.19644452	0.92460200
C	-3.38753286	-3.26788052	0.08864800
H	-3.19663786	-4.68376052	-1.52922600
C	-1.55360386	-3.20111152	1.63998200
H	0.06899414	-4.56514852	1.24769300
C	-2.80547086	-2.72179952	1.23742100
H	-4.35570686	-2.90955252	-0.24394300
H	-1.08260286	-2.78461952	2.52391400
C	-3.52119486	-1.65963352	2.04016600
H	-4.13177686	-1.01626652	1.39649300
H	-4.18786286	-2.11460452	2.78018300
H	-2.81409986	-1.02664752	2.58271300
C	2.61094914	-5.23448052	-0.84265700
C	3.72438114	-5.44133952	-0.02071000
C	4.94228914	-5.96650052	-0.54021500
C	3.69593814	-5.15474552	1.37336200
C	6.04639114	-6.17635052	0.27153900
H	4.99605014	-6.20166852	-1.59478200
C	4.80660314	-5.37904452	2.17232700
H	2.78629314	-4.75342152	1.80504800
C	5.99810514	-5.88696352	1.63439800
H	6.95910514	-6.57296452	-0.16408000
H	4.74625414	-5.14894452	3.23140900
H	6.86172414	-6.05803552	2.26677400

Compound A-2

C	2.25111445	0.33432392	0.00000000
C	3.35676745	-0.36654008	-0.45670900
C	3.42758645	-0.81873208	-1.78564300
C	2.36223845	-0.56075908	-2.66645200
C	1.24757645	0.13944592	-2.18762000
C	1.18757145	0.58649092	-0.87278500
H	2.21042445	0.68306192	1.02620800
H	4.19091545	-0.58082508	0.19997600
H	0.42303745	0.34112692	-2.86419600
H	0.31518645	1.13035292	-0.52581800
C	2.43088045	-0.98841108	-4.10777900

H	2.73601445	-0.12597908	-4.70670000
H	1.42863845	-1.26220608	-4.45427800
C	3.38962245	-2.15724308	-4.34273300
H	2.91260945	-3.07420008	-3.97077500
H	3.54878545	-2.29610008	-5.41571900
C	4.76087445	-2.04706708	-3.65265100
C	4.63114945	-1.60616208	-2.20186800
O	5.49270945	-1.88824708	-1.37107400
C	5.50079945	-3.40257908	-3.73057100
H	5.27879845	-3.85222908	-4.70283800
H	5.17707645	-4.09534308	-2.95053300
C	6.99796945	-3.10164808	-3.62263100
H	7.34378845	-3.16201108	-2.59143000
H	7.59318345	-3.78160408	-4.23684700
N	7.07893945	-1.72409908	-4.13088700
C	5.78528745	-1.06768808	-4.36025200
S	8.53261845	-0.92988608	-4.15923800
O	8.90571345	-0.50271208	-5.51235300
O	9.47297745	-1.82018008	-3.44998000
C	8.33023245	0.56010592	-3.16788100
C	8.29549145	0.44557992	-1.78084600
C	8.23917545	1.80273392	-3.78767100
C	8.17052445	1.59772292	-1.00820300
H	8.36064045	-0.52811808	-1.31261900
C	8.12001345	2.94458192	-3.00050600
H	8.24944145	1.86258192	-4.86712200
C	8.08437145	2.86152092	-1.60296600
H	8.13647545	1.50966092	0.07291500
H	8.03903845	3.91324292	-3.48290300
C	7.97874645	4.10919592	-0.75987200
H	7.55116145	3.89167692	0.22145700
H	8.96632445	4.55584592	-0.59787800
H	7.35522745	4.86420392	-1.24491600
C	5.65562845	0.05276192	-5.02030400
C	4.74665945	1.04999792	-5.37981600
C	4.12213545	1.08830092	-6.67002800
C	4.45036345	2.16034392	-4.52208500
C	3.27472645	2.12067892	-7.04435200
H	4.33248545	0.28449692	-7.36821300

C	3.60494445	3.18573692	-4.91845000
H	4.90518345	2.18504392	-3.53777300
C	2.99772545	3.19081992	-6.18214000
H	2.82351145	2.09653492	-8.03332400
H	3.40845045	3.99998192	-4.22524600
H	2.34037345	3.99818092	-6.48468700

Intermediate A-TS2

C	0.05200594	1.32986625	0.00000000
C	1.09287294	1.55896225	-0.88745400
C	1.01049594	2.58284025	-1.84456700
C	-0.13939906	3.38820825	-1.91255800
C	-1.18867806	3.13449225	-1.01978500
C	-1.09831706	2.12164425	-0.07160800
H	0.12857694	0.54191025	0.74109600
H	1.99169394	0.95529025	-0.86033600
H	-2.08382906	3.74665125	-1.07078100
H	-1.92225806	1.94724525	0.61239600
C	-0.23442906	4.52131225	-2.90055600
H	0.01074094	5.44657925	-2.36982800
H	-1.26476306	4.61118725	-3.26134200
C	0.72277094	4.37009925	-4.08295600
H	0.35171094	3.58172425	-4.75161100
H	0.74499394	5.29787625	-4.66169500
C	2.17583494	4.00573025	-3.69180300
C	2.14999394	2.74661925	-2.80554800
O	3.01654494	1.88957725	-2.87854200
C	3.01034794	3.76077225	-4.96079500
H	2.72482094	4.51372225	-5.70212200
H	2.81339694	2.77318225	-5.38394000
C	4.48856594	3.92963825	-4.60940900
H	4.87296094	3.00180725	-4.17230800
H	5.08041394	4.16491425	-5.49926300
N	4.49850394	5.04470825	-3.66334800
C	2.84303694	5.11434925	-2.88291800
S	5.88911994	5.34964425	-2.89011200
O	5.75569494	6.62457625	-2.17356500
O	7.02726194	5.18676425	-3.82666300
C	6.13358494	4.07686725	-1.62027100

C	6.88396494	2.93987325	-1.90646100
C	5.53041094	4.22508925	-0.37028500
C	7.02257594	1.94376725	-0.93949500
H	7.36612594	2.84590625	-2.87091800
C	5.67940494	3.22489125	0.58418500
H	4.96063594	5.11890325	-0.15073900
C	6.42347394	2.06758525	0.31649600
H	7.60770094	1.05863025	-1.16890600
H	5.20945394	3.34545125	1.55571400
C	6.59175894	1.00226825	1.37361600
H	7.32567694	1.30855425	2.12743700
H	5.65132294	0.81048325	1.89759700
H	6.93657694	0.06173625	0.93880700
C	2.47108994	5.93314025	-1.99346100
C	2.59979994	7.02964825	-1.12442200
C	2.55054994	8.36881625	-1.60329600
C	2.69305994	6.86601725	0.28550800
C	2.59701594	9.45026425	-0.73488700
H	2.48864194	8.53594125	-2.67277200
C	2.75199894	7.95852025	1.14114300
H	2.70471494	5.86099525	0.69352100
C	2.70030894	9.26642525	0.64879700
H	2.56532194	10.45627725	-1.14381600
H	2.83104094	7.78734325	2.21114600
H	2.74224394	10.11607725	1.32105700

Compound A-3

C	1.04754831	1.35958393	0.00000000
C	2.30843531	1.06731493	-0.49817200
C	2.69255131	1.50188393	-1.77644500
C	1.79117031	2.23006093	-2.57266900
C	0.51699731	2.50415793	-2.06120600
C	0.14683731	2.08094093	-0.78931700
H	0.76202731	1.02947693	0.99239500
H	3.02306431	0.50314093	0.08888700
H	-0.19050769	3.05535193	-2.67275100
H	-0.84467069	2.30832593	-0.41260600
C	2.18629731	2.71779893	-3.94589200
H	2.42992331	3.78482593	-3.87763800

H	1.33119631	2.63810293	-4.62425000
C	3.38797831	1.96973393	-4.52108000
H	3.10242631	0.94455493	-4.78493700
H	3.73215031	2.45607593	-5.43656500
C	4.58201131	1.89232493	-3.52390600
C	4.06231931	1.14195793	-2.26689100
O	4.72064031	0.28848693	-1.70578400
C	5.75947731	1.13036493	-4.19659600
H	5.84675031	1.49752993	-5.22246700
H	5.45755131	0.07857893	-4.24617000
C	7.16200131	1.21754393	-3.56346800
H	7.07191731	1.11852493	-2.47348100
H	7.71056131	0.33214893	-3.91464300
N	7.83972631	2.46367393	-3.92898600
C	4.96896331	3.23812293	-3.09624700
S	9.37463131	2.37997993	-4.22689300
O	9.84786231	3.71556093	-4.68679200
O	9.82892931	1.22938993	-5.07101000
C	10.27346031	2.10487993	-2.64730500
C	9.86458631	2.78726993	-1.50073300
C	11.35792331	1.23468693	-2.57839300
C	10.54542631	2.60540393	-0.30021300
H	9.00800131	3.44960493	-1.55422300
C	12.03420631	1.05686893	-1.37005500
H	11.66055231	0.69924893	-3.46992500
C	11.64148531	1.73619993	-0.21323500
H	10.21780531	3.14310993	0.58506800
H	12.88039831	0.37699393	-1.32837300
C	12.35702731	1.52305693	1.10027200
H	12.53481431	2.47098193	1.61653500
H	11.76741331	0.89250393	1.77519600
H	13.32210531	1.03308693	0.95120700
C	5.33294631	4.34118293	-2.76691900
C	5.92909531	5.60162193	-2.46231100
C	7.25043931	5.84214593	-2.88647300
C	5.23909731	6.60244793	-1.75722000
C	7.85603731	7.06323493	-2.60643900
H	7.77580631	5.06062993	-3.42634800
C	5.85685231	7.81938493	-1.48157100

H	4.22274331	6.41745893	-1.42854400
C	7.16570131	8.05411993	-1.90525900
H	8.87356231	7.23818993	-2.93819400
H	5.31620431	8.58499093	-0.93532400
H	7.64468031	9.00317693	-1.68977200

[i] M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, O. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, D. J. Fox, Gaussian, Inc., Wallingford CT, 2009.

[ii] Lee, C.; Yang, W.; Parr, R. G. *Phys. Rev. B* **1988**, *37* (2), 785–789; Becke, A. D. **1988**, *38* (6), 3098–3100; Becke, A. D. *J. Chem. Phys.* **1993**, *98* (7), 5648–5652.

[iii] R. Krishnan, J. S. Binkley, R. Seeger and J. A. Pople, *J. Chem. Phys.*, **1980**, *72*, 650–654.

[iv] J. Tomasi, B. Mennucci and R. Cammi, *Chem. Rev.*, **2005**, *105*, 2999–3094.

[v] K. Fukui, *Acc. Chem. Res.*, 1981, **14**, 363–368; H. P. Hratchian and H. B. Schlegel, *Theory and Applications of Computational Chemistry: The First 40 Years*, Elsevier: Amsterdam, Eds. C. E. Dykstra, G. Frenking, K. S. Kim, and G. Scuseria, **2005**.