Supporting Information

Gold-catalyzed intermolecular oxidation of o-alkynylbiaryls: an easy and practical access to functionalized fluorenes

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**General Information.** Ethyl acetate (ACS grade), hexanes (ACS grade) and anhydrous 1, 2-dichloroethane (ACS grade) were obtained commercially and used without further purification. Methylene chloride, tetrahydrofuran and diethyl ether were purified according to standard methods unless otherwise noted. Commercially available reagents were used without further purification. Reactions were monitored by thin layer chromatography (TLC) using silicycle pre-coated silica gel plates. Flash column chromatography was performed over silica gel (300-400 mesh). Infrared spectra were recorded on a Nicolet AVATER FTIR330 spectrometer as thin film and are reported in reciprocal centimeter (cm⁻¹). Mass spectra were recorded with Micromass QTOF2 Quadrupole/Time-of-Flight Tandem mass spectrometer using electron spray ionization.

¹H NMR spectra were recorded on a Bruker AV-400 spectrometer and a Bruker AV-500 spectrometer in chloroform-d₃. Chemical shifts are reported in ppm with the internal TMS signal at 0.0 ppm as a standard. The data is being reported as (s = singlet, d = doublet, t = triplet, m = multiplet or unresolved, brs = broad singlet, coupling constant(s) in Hz, integration).

¹³C NMR spectra were recorded on a Bruker AV-400 spectrometer and a Bruker AV-500 spectrometer in chloroform-d₃. Chemical shifts are reported in ppm with the internal chloroform signal at 77.0 ppm as a standard.

Compounds 1a-1m were prepared according to the known procedures.¹
4-methyl-N-((4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-N-phenylbenzenesulfonamide (1a)

\[ \text{C}_28\text{H}_{23}\text{NNaO}_2\text{S} \]

\( ^1\text{H} \text{ NMR (400 MHz, CDCl}_3 \) \( \delta 7.49 - 7.06 \) (m, 17H), 2.37 (s, 3H), 2.36 (s, 3H); \( ^{13}\text{C} \text{ NMR (100 MHz, CDCl}_3 \) \( \delta 144.6, 143.3, 138.8, 137.7, 136.8, 132.9, 132.6, 129.3, 129.0, 128.8, 128.7, 128.1, 127.9, 126.7, 126.1, 121.1, 85.3, 70.3, 21.6, 21.2; \) IR (neat): 3059, 3025, 2921, 2235, 1594, 1490, 1480, 1373, 1174, 758, 691, 576; MS (ES') Calculated for [C\(_{28}\)H\(_{23}\)NNaO\(_2\)S]: 460.1; Found: 460.1; HRMS (ES') Calculated for [C\(_{28}\)H\(_{23}\)NNaO\(_2\)S]: 460.1342; Found: 460.1350.

N-((4-fluoro-4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1b)

\[ \text{C}_28\text{H}_{23}\text{NNaO}_2\text{S} \]

\( ^1\text{H} \text{ NMR (400 MHz, CDCl}_3 \) \( \delta 7.36 - 7.21 \) (m, 8H), 7.16 – 6.97 (m, 8H), 2.37 (s, 3H), 2.35 (s, 3H); \( ^{13}\text{C} \text{ NMR (100 MHz, CDCl}_3 \) \( \delta 161.3 \) (d, \( J = 245.0 \) Hz), 144.8, 139.4 (d, \( J = 3.2 \) Hz), 138.5, 137.0, 136.8, 132.8, 130.8 (d, \( J = 8.6 \) Hz), 129.3, 129.0, 128.9, 128.8, 128.1, 128.0, 126.1, 122.7 (d, \( J = 9.8 \) Hz), 118.6 (d, \( J = 22.8 \) Hz), 115.1 (d, \( J = 21.2 \) Hz), 86.2, 69.5, 21.6, 21.1; IR (neat): 3064, 3028, 2922, 2235, 1596, 1487, 1374, 1175, 811,
N-((5-fluoro-4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1c)

\[
\begin{align*}
&\text{\textsuperscript{1}H NMR (500 MHz, CDCl}_3\text{) } \delta 7.45 (\text{dd}, 1\text{H}, J = 8.5 \text{ Hz}, J = 6.0 \text{ Hz}), 7.37 (\text{d}, 2\text{H}, J = 8.0 \text{ Hz}), 7.32 (\text{d}, 2\text{H}, J = 8.0 \text{ Hz}), 7.25 – 7.19 (\text{m}, 3\text{H}), 7.13 (\text{t}, 4\text{H}, J = 7.5 \text{ Hz}), 7.08 – 7.02 (\text{m}, 3\text{H}), 6.94 (\text{td}, 1\text{H}, J = 8.5 \text{ Hz}, J = 2.5 \text{ Hz}), 2.38 (\text{s}, 3\text{H}), 2.36 (\text{s}, 3\text{H}); \\
&\text{\textsuperscript{13}C NMR (125 MHz, CDCl}_3\text{) } \delta 162.1 (\text{d}, J = 247.9 \text{ Hz}), 145.8 (\text{d}, J = 8.0 \text{ Hz}), 144.7, 138.7, 137.4, 136.7, 134.5 (\text{d}, J = 8.5 \text{ Hz}), 133.0, 129.3, 128.9, 128.8(3), 128.8(2), 128.1, 128.0, 126.1, 117.1 (\text{d}, J = 3.1 \text{ Hz}), 116.2 (\text{d}, J = 34.6 \text{ Hz}), 114.0 (\text{d}, J = 21.8 \text{ Hz}), 84.9, 69.3, 21.5, 21.1; \\
&\text{IR (neat): 3063, 2922, 2237, 1597, 1488, 1371, 1355, 1175, 822, 772, 691, 579; MS (ES\textsuperscript{+}) Calculated for } [\text{C}_{28}\text{H}_{22}\text{FNNaO}_{2}\text{S}]^+: 478.1; \text{ Found: } 478.1; \text{ HRMS (ES\textsuperscript{+}) Calculated for } [\text{C}_{28}\text{H}_{22}\text{FNNaO}_{2}\text{S}]^+: 478.1247; \text{ Found: } 478.1255.
\end{align*}
\]

N-((4-chloro-4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1d)

\[
\begin{align*}
&\text{\textsuperscript{1}H NMR (500 MHz, CDCl}_3\text{) } \delta 7.45 (\text{dd}, 1\text{H}, J = 8.5 \text{ Hz}, J = 6.0 \text{ Hz}), 7.37 (\text{d}, 2\text{H}, J = 8.0 \text{ Hz}), 7.32 (\text{d}, 2\text{H}, J = 8.0 \text{ Hz}), 7.25 – 7.19 (\text{m}, 3\text{H}), 7.13 (\text{t}, 4\text{H}, J = 7.5 \text{ Hz}), 7.08 – 7.02 (\text{m}, 3\text{H}), 6.94 (\text{td}, 1\text{H}, J = 8.5 \text{ Hz}, J = 2.5 \text{ Hz}), 2.38 (\text{s}, 3\text{H}), 2.36 (\text{s}, 3\text{H}); \\
&\text{\textsuperscript{13}C NMR (125 MHz, CDCl}_3\text{) } \delta 162.1 (\text{d}, J = 247.9 \text{ Hz}), 145.8 (\text{d}, J = 8.0 \text{ Hz}), 144.7, 138.7, 137.4, 136.7, 134.5 (\text{d}, J = 8.5 \text{ Hz}), 133.0, 129.3, 128.9, 128.8(3), 128.8(2), 128.1, 128.0, 126.1, 117.1 (\text{d}, J = 3.1 \text{ Hz}), 116.2 (\text{d}, J = 34.6 \text{ Hz}), 114.0 (\text{d}, J = 21.8 \text{ Hz}), 84.9, 69.3, 21.5, 21.1; \\
&\text{IR (neat): 3063, 2922, 2237, 1597, 1488, 1371, 1355, 1175, 822, 772, 691, 579; MS (ES\textsuperscript{+}) Calculated for } [\text{C}_{28}\text{H}_{22}\text{FNNaO}_{2}\text{S}]^+: 478.1; \text{ Found: } 478.1; \text{ HRMS (ES\textsuperscript{+}) Calculated for } [\text{C}_{28}\text{H}_{22}\text{FNNaO}_{2}\text{S}]^+: 478.1247; \text{ Found: } 478.1254.
\end{align*}
\]
N-((4',5-dimethyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1e)

\[
1e
\]

\[1H \text{ NMR } (400 \text{ MHz, CDCl}_3) \delta 7.40 – 7.36 (m, 3H), 7.31 (d, 2H, } J = 8.0 \text{ Hz), 7.20 (d, 3H, } J = 8.0 \text{ Hz), 7.16 – 7.01 (m, 8H), 2.36 (s, 3H), 2.35 (s, 3H), 2.34 (s, 3H); } ^{13}\text{C NMR } (100 \text{ MHz, CDCl}_3) \delta 144.5, 143.4, 138.9, 138.0, 137.8, 136.7, 132.8, 132.6, 130.0, 129.2, 129.0, 128.7, 128.6, 128.0, 127.8, 127.6, 126.0, 117.9, 84.5, 70.2, 21.5, 21.3, 21.1; IR (neat): 3027, 2921, 2235, 1594, 1489, 1372, 1174, 817, 691, 579; MS (ES') Calculated for [C29H25NNaO2S]+: 474.2; Found: 474.2; HRMS (ES') Calculated for [C29H25NNaO2S]+: 474.1498; Found: 474.1505.

N-((4,4'-dimethyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1f)

\[1f\]
1H NMR (500 MHz, CDCl₃) δ 7.37 (d, 2H, J = 8.0 Hz), 7.33 – 7.29 (m, 3H), 7.23 – 7.05 (m, 11H), 2.34 (s, 3H), 2.33 (s, 3H), 2.29 (s, 3H); 13C NMR (125 MHz, CDCl₃) δ 144.5, 140.5, 138.8, 137.6, 136.5, 136.4, 132.9, 132.8, 129.2, 129.1, 129.0, 128.8, 128.7, 128.6, 128.0, 127.8, 126.0, 120.7, 84.9, 70.4, 21.5, 21.1, 20.6; IR (neat): 3023, 2921, 2858, 2233, 1595, 1489, 1372, 1174, 811, 691, 575; MS (ES⁺) Calculated for [C₂₉H₂₅NNaO₂S]⁺: 474.2; Found: 474.2; HRMS (ES⁺) Calculated for [C₂₉H₂₅NNaO₂S]⁺: 474.1498; Found: 474.1505.

N-((4'-methoxy-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1g)

1H NMR (500 MHz, CDCl₃) δ 7.50 – 7.40 (m, 3H), 7.36 – 7.17 (m, 8H), 7.13 – 7.03 (m, 4H), 6.85 (d, J = 8.5 Hz, 2H), 3.77 (s, 3H), 2.35 (s, 3H); 13C NMR (125 MHz, CDCl₃) δ 159.0, 144.6, 143.0, 138.8, 133.0, 132.9, 132.6, 130.2, 129.3, 129.2, 128.8, 128.0, 127.9(3), 127.9(2), 126.5, 126.0, 120.9, 85.3, 70.3, 55.1, 21.5; IR (neat): 2924, 2851, 2235, 1609, 1516, 1480, 1372, 1175; MS (ES⁺) Calculated for [C₂₈H₂₃NNaO₃S]⁺: 476.1; Found: 476.1; HRMS (ES⁺) Calculated for [C₂₈H₂₃NNaO₃S]⁺: 476.1291; Found: 476.1295.
4-methyl-N-((3'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-N-phenylbenzenesulfonamide (1h)

![Chemical Structure](image)

1H NMR (400 MHz, CDCl3) δ 7.47 (d, 1H, J = 7.6 Hz), 7.36 – 7.16 (m, 11H), 7.16 – 7.02 (m, 5H), 2.33 (s, 3H), 2.29 (s, 3H); 13C NMR (125 MHz, CDCl3) δ 144.6, 143.3, 140.6, 138.8, 137.6, 132.7, 132.4, 129.9, 129.3, 129.2, 128.8, 127.9(8), 127.9(5), 127.9(2), 127.8, 126.8, 126.1, 125.9, 121.0, 85.3, 70.2, 21.5, 21.3; IR (neat): 3062, 2921, 2236, 1594, 1490, 1454, 1373, 1176; MS (ES+) Calculated for [C28H23NNaO2S]+: 460.1; Found: 460.1; HRMS (ES+) Calculated for [C28H23NNaO2S]+: 460.1342; Found: 460.1351.

N-((3',5'-dimethyl-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1i)

![Chemical Structure](image)

1H NMR (400 MHz, CDCl3) δ 7.49 – 7.45 (m, 1H), 7.34 – 7.19 (m, 8H), 7.04 – 6.95 (m, 6H), 6.97 (s, 1H), 2.34 (s, 3H), 2.27 (s, 6H); 13C NMR (100 MHz, CDCl3) δ 144.5, 143.4, 140.6, 138.8, 137.5, 132.7, 132.4, 129.4, 129.2, 128.9, 128.8, 128.0, 127.9, 127.8, 127.0, 126.8, 125.9, 121.0, 85.2, 70.4, 21.5, 21.2; IR (neat): 3062, 3029, 2920, 2857, 2236, 1596, 1490, 1374, 1175, 759, 691, 584; MS (ES+) Calculated for [C29H25NNaO2S]+: 474.2; Found: 474.2; HRMS (ES+) Calculated for [C29H25NNaO2S]+: 474.1498; Found: 474.1507.
N-((1,1'-biphenyl)-2-ylethynyl)-4-methyl-N-phenylbenzenesulfonamide (1j)

\[ \text{N-(Ts)(Ts=Ph)Ph} \]

\( ^1 \text{H NMR (400 MHz, CDCl}_3 \) \( \delta \) 7.53 – 7.49 (m, 3H), 7.36 – 7.33 (m, 5H), 7.30 – 7.21 (m, 6H), 7.11 (d, 2H, \( J = 8.4 \) Hz), 7.07 (d, 2H, \( J = 8.0 \) Hz), 2.38 (s, 3H); \( ^{13} \text{C NMR (100 MHz, CDCl}_3 \) \( \delta \) 144.6, 143.3, 140.7, 138.8, 132.8, 132.6, 129.4, 129.3, 129.2, 128.9, 128.1, 128.0, 127.2, 127.0, 126.1, 121.1, 85.4, 70.2, 21.6; IR (neat): 3060, 2924, 2236, 1593, 1490, 1374, 755, 692, 568; MS (ES\(^+\)) Calculated for [C\(_{27}\)H\(_{21}\)N\(_3\)O\(_2\)S\(^+\)]: 446.1; Found: 446.1; HRMS (ES\(^+\)) Calculated for [C\(_{27}\)H\(_{21}\)N\(_3\)O\(_2\)S\(^+\)]: 446.1185; Found: 446.1193.

N-((4'-chloro-[1,1'-biphenyl]-2-yl)ethynyl)-4-methyl-N-phenylbenzenesulfonamide (1k)

\[ \text{Cl} \text{N-(Ts)(Ts=Ph)Ph} \]

\( ^1 \text{H NMR (400 MHz, CDCl}_3 \) \( \delta \) 7.52 (d, 1H, \( J = 7.6 \) Hz), 7.42 (d, 2H, \( J = 8.0 \) Hz), 7.37 – 7.23 (m, 10H), 7.16 (d, 2H, \( J = 8.0 \) Hz), 7.07 (d, 2H, \( J = 7.6 \) Hz), 2.41 (s, 3H); \( ^{13} \text{C NMR (100 MHz, CDCl}_3 \) \( \delta \) 144.8, 141.9, 138.9, 138.5, 133.1, 132.8, 132.6, 130.4, 129.3, 129.0, 128.9, 128.0, 127.8, 127.3, 126.0, 120.9, 85.7, 69.6, 21.5; IR (neat): 3063, 2920, 2849, 2234, 1594, 1490, 1476, 1374, 1173, 760, 691, 585; MS (ES\(^+\)) Calculated for [C\(_{27}\)H\(_{20}\)ClN\(_3\)O\(_2\)S\(^+\)]: 480.1; Found: 480.1; HRMS (ES\(^+\)) Calculated for [C\(_{27}\)H\(_{20}\)ClN\(_3\)O\(_2\)S\(^+\)]: 480.0795; Found: 480.0802.
4-bromo-N-((4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-N-phenylbenzenesulfonamide (1l)

\[
\text{1H NMR (500 MHz, CDCl}_3\text{) } \delta 7.50 - 7.46 (m, 1H), 7.46 - 7.38 (m, 4H), 7.35 - 7.30 (m, 2H), 7.28 - 7.16 (m, 8H), 7.10 - 7.06 (m, 2H), 2.39 (s, 3H); \text{13C NMR (125 MHz, CDCl}_3\text{) } \delta 143.5, 138.5, 137.8, 137.0, 134.6, 132.6, 131.9, 129.4, 129.4, 129.1, 129.0, 128.9, 128.8, 128.2, 128.2, 126.8, 126.1, 120.7, 84.7, 70.6, 21.2; \text{IR ( neat): 3059, 2921, 2853, 2236, 1572, 1489, 1390, 1378, 1181, 821, 742, 604;} \text{ MS (ES}^+\text{) Calculated for [C}_{27}H_{20}BrNaO_2S]^+: 524.0; Found: 524.0; \text{ HRMS (ES}^+\text{) Calculated for [C}_{27}H_{20}BrNaO_2S]^+: 524.0290; Found: 524.0299.}
\]

4-methoxy-N-((4'-methyl-[1,1'-biphenyl]-2-yl)ethynyl)-N-phenylbenzenesulfonamide (1m)

\[
\text{1H NMR (400 MHz, CDCl}_3\text{) } \delta 7.47 (dd, 1H, J = 7.2 Hz, J = 6.4 Hz), 7.39 (d, 2H, J = 8.0 Hz), 7.36 - 7.18 (m, 8H), 7.14 (d, 2H, J = 8.0 Hz), 7.08 (dd, 2H, J = 8.0 Hz, J = 1.6 Hz), 6.75 (d, 2H, J = 8.8 Hz), 3.77 (s, 3H), 2.35 (s, 3H); \text{13C NMR (100 MHz, CDCl}_3\text{) } \delta 163.6,}
\]
143.2, 138.8, 137.7, 136.8, 132.5, 130.2, 129.2, 129.0, 128.8, 128.7, 127.9, 127.2, 126.7, 126.1, 121.0, 113.8, 85.4, 70.3, 55.5, 21.1; IR (neat): 3058, 3023, 2922, 2234, 1593, 1495, 1371, 1112, 832, 691, 674; MS (ES⁺) Calculated for [C₂₈H₂₃NNaO₃S]⁺: 476.1; Found: 476.1; HRMS (ES⁺) Calculated for [C₂₈H₂₃NNaO₃S]⁺: 476.1291; Found: 476.1294.

General procedure:

8-Ethylquinoline N-oxide (103.9 mg, 0.60 mmol) and BrettPhosAuNTf₂ (15.3 mg, 0.015 mmol) were added to a solution of the o-alkynylbiaryls 1 (0.30 mmol) in DCE (6.0 mL) at room temperature. The reaction mixture was stirred at 80 °C and the progress of the reaction was monitored by TLC. The reaction typically took 2 h. Upon completion, the mixture was then concentrated and the residue was purified by chromatography on silica gel (eluent: hexanes/ethyl acetate) to afford the desired products 2.

2-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2a)

Compound 2a was prepared in 77% yield according to the general procedure (Table 2, entry 1). ¹H NMR (400 MHz, CDCl₃) δ 7.88 (d, 2H, J = 8.0 Hz), 7.40 – 7.29 (m, 5H), 7.26 – 7.13 (m, 4H), 7.10 – 7.00 (m, 3H), 6.75 (d, 2H, J = 7.6 Hz), 4.76 (s, 1H), 2.44 (s,
3H), 2.37 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 171.5, 144.8, 141.6, 141.1, 140.7, 138.9, 137.3, 135.7, 133.7, 130.7, 129.3, 129.2, 128.9, 128.5, 128.0, 126.8, 124.7, 124.1, 121.6, 119.9, 119.9, 56.1, 21.6, 21.5; IR (neat): 2924, 2853, 1695, 1591, 1485, 1350, 1137, 747, 697, 567; MS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_3$S]$^+$: 476.1; Found: 476.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_3$S]$^+$: 476.1291; Found: 476.1295.

2-fluoro-7-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2b)

![Structure of 2b](image)

Compound 2b was prepared in 75% yield according to the general procedure (Table 2, entry 2). $^1$H NMR (400 MHz, CDCl$_3$) δ 7.88 (d, 2H, $J = 8.4$ Hz), 7.37 – 7.17 (m, 6H), 7.14 – 7.01 (m, 4H), 7.00 – 6.93 (m, 1H), 6.80 (d, 2H, $J = 7.6$ Hz), 4.75 (s, 1H), 2.47 (s, 3H), 2.38 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 170.9, 162.1 (d, $J = 244.8$ Hz), 145.1, 142.6 (d, $J = 8.4$ Hz), 141.1, 138.0, 137.7 (d, $J = 1.7$ Hz), 137.1, 135.6, 133.8, 130.7, 129.4, 129.3, 129.1, 128.7, 124.8, 120.8 (d, $J = 8.7$ Hz), 119.7, 115.1 (d, $J = 22.8$ Hz), 111.6 (d, $J = 23.3$ Hz), 56.0, 21.6, 21.5; IR (neat): 2919, 2850, 1698, 1464, 1367, 1172, 810, 701, 573; MS (ES$^+$) Calculated for [C$_{28}$H$_{22}$FNNaO$_3$S]$^+$: 494.1; Found: 494.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{22}$FNNaO$_3$S]$^+$: 494.1197; Found: 494.1207.

6-fluoro-2-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2c)

![Structure of 2c](image)
2c
Compound 2c was prepared in 56% yield according to the general procedure (Table 2, entry 3). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.87 (d, 2H, $J = 8.0$ Hz), 7.34 – 7.24 (m, 4H), 7.22 – 7.17 (m, 2H), 7.11 (d, 1H, $J = 7.6$ Hz), 7.08 – 7.00 (m, 3H), 6.89 (td, 1H, $J = 8.8$ Hz, $J = 2.4$ Hz), 6.73 (d, 2H, $J = 7.6$ Hz), 4.73 (s, 1H), 2.45 (s, 3H), 2.38 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 171.2, 163.2 (d, $J = 244.0$ Hz), 145.0, 143.8 (d, $J = 9.2$ Hz), 142.1, 138.2, 138.0 (d, $J = 3.0$ Hz), 136.2 (d, $J = 2.5$ Hz), 135.6, 133.7, 130.7, 129.4, 129.3(2), 129.2(9), 129.1, 128.6, 125.2 (d, $J = 9.3$ Hz), 124.9, 120.2, 113.6 (d, $J = 23.2$ Hz), 107.0 (d, $J = 23.2$ Hz), 55.6, 21.7, 21.6; IR (neat): 2921, 2851, 1691, 1594, 1487, 1364, 1171, 694, 565; MS (ES$^+$) Calculated for [C$_{28}$H$_{22}$FNNaO$_3$S]$^+$: 494.1; Found: 494.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{22}$FNNaO$_3$S]$^+$: 494.1197; Found: 494.1206.

2-chloro-7-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2d)

2d
Compound 2d was prepared in 67% yield according to the general procedure (Table 2, entry 4). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.88 (d, 2H, $J = 8.0$ Hz), 7.35 (d, 2H, $J = 8.0$ Hz), 7.30 (d, 2H, $J = 7.6$ Hz), 7.25 (d, 2H, $J = 6.0$ Hz), 7.21 (d, 2H, $J = 8.8$ Hz), 7.10 (t, 3H, $J = 7.6$ Hz), 6.83 (d, 2H, $J = 7.6$ Hz), 4.74 (s, 1H), 2.47 (s, 3H), 2.39 (s, 3H); $^{13}$C NMR (125 MHz, CDCl$_3$) $\delta$ 170.8, 145.1, 142.4, 141.2, 140.3, 137.9, 137.8, 135.6, 133.9, 132.4, 130.8, 129.5, 129.4, 129.3, 129.2, 128.8, 128.3, 124.9, 124.5, 120.8, 120.0, 55.8, 21.7, 21.6; IR (neat): 2920, 2851, 1679, 1594, 1459, 1363, 1166, 814, 694, 568; MS (ES$^+$) Calculated for [C$_{28}$H$_{22}$ClNNaO$_3$S]$^+$: 510.1; Found: 510.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{22}$ClNNaO$_3$S]$^+$: 510.0901; Found: 510.0910.

2,6-dimethyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2e)
Compound 2e was prepared in 58% yield according to the general procedure (Table 2, entry 5). 1H NMR (400 MHz, CDCl₃) δ 7.87 (d, 2H, J = 8.0 Hz), 7.34 – 6.99 (m, 11H), 6.80 (d, 2H, J = 7.6 Hz), 4.71 (s, 1H), 2.44 (s, 3H), 2.37 (s, 3H), 2.35 (s, 3H); 13C NMR (100 MHz, CDCl₃) δ 171.7, 144.8, 141.8, 141.6, 139.0, 138.0, 137.9, 137.2, 135.8, 134.0, 130.8, 129.3, 129.2, 128.8, 128.6, 127.7, 124.8, 123.8, 120.5, 119.8, 55.7, 21.6, 21.5, 21.4; IR (neat): 2921, 2852, 1697, 1596, 1488, 1364, 1171, 801, 694, 573; MS (ES⁺) Calculated for [C₂₉H₂₅NNaO₃S]⁺: 490.1; Found: 490.1; HRMS (ES⁺) Calculated for [C₂₉H₂₅NNaO₃S]⁺: 490.1447; Found: 490.1456.

2,7-dimethyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2f)

Compound 2f was prepared in 64% yield according to the general procedure (Table 2, entry 6). 1H NMR (400 MHz, CDCl₃) δ 7.89 (d, 2H, J = 8.4 Hz), 7.35 – 7.06 (m, 11H), 6.82 (d, 2H, J = 7.6 Hz), 4.72 (s, 1H), 2.46 (s, 3H), 2.36 (s, 6H); 13C NMR (100 MHz, CDCl₃) δ 171.7, 144.8, 141.1, 139.0, 136.8, 135.8, 134.0, 130.8, 129.3, 129.3, 128.8, 128.6, 124.7, 119.7, 55.9, 21.7, 21.5; IR (neat): 2923, 2853, 1703, 1596, 1487, 1469, 1361, 1171, 808, 695, 565; MS (ES⁺) Calculated for [C₂₉H₂₅NNaO₃S]⁺: 490.1; Found: 490.1; HRMS (ES⁺) Calculated for [C₂₉H₂₅NNaO₃S]⁺: 490.1447; Found: 490.1455.
4-methyl-N-(4-oxospiro[cyclohexa[2,5]diene-1,1'-inden]-2'-yl)-N-phenylbenzenesulfonamide (2g')

![Chemical Structure of 2g']

Compound 2g' was prepared in 86% yield according to the general procedure (Table 2, entry 7). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.71 (d, 2H, $J$ = 8.4 Hz), 7.39 (d, 1H, $J$ = 7.6 Hz), 7.37 – 7.23 (m, 6H), 7.21 – 7.15 (m, 3H), 7.13 (s, 1H), 6.90 (d, 1H, $J$ = 7.6 Hz), 6.08 (d, 2H, $J$ = 10.0 Hz), 6.00 (d, 2H, $J$ = 10.0 Hz), 2.47 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 185.8, 146.5, 145.3, 144.4, 142.0, 139.1, 138.2, 136.2, 130.0, 129.9, 129.6, 128.9, 128.8, 128.3, 126.8, 126.6, 123.3, 122.1, 59.8, 21.6; IR (neat): 3062, 2921, 2236, 1594, 1490, 1454, 1373, 1176; MS (ES$^+$) Calculated for [C$_{27}$H$_{21}$NNaO$_3$S$^+$]: 462.1; Found: 462.1; HRMS (ES$^+$) Calculated for [C$_{27}$H$_{21}$NNaO$_3$S$^+$]: 462.1134; Found: 462.1131.

3-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2h)

1-methyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2h')

![Chemical Structures of 2h and 2h']

Compound 2h and 2h' (2h/2h' = 3/1) were prepared in 72% yield according to the general procedure (Table 2, entry 8). Compound 2h: $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.86 (d, 2H, $J$ = 8.0 Hz), 7.38 (d, 2H, $J$ = 7.6 Hz), 7.36 – 7.12 (m, 7H), 7.12 – 6.94 (m, 3H),...
6.73 (d, 2H, J = 7.6 Hz), 4.76 (s, 1H), 2.43 (s, 3H), 2.36 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 171.6, 144.8, 141.6, 141.5, 141.3, 138.1, 137.9, 135.7, 133.8, 130.7, 129.3, 129.2, 129.1, 128.4, 128.2, 128.0, 127.2, 124.2, 123.8, 120.8, 120.1, 56.0, 21.6, 21.4; IR (neat): 3039, 2923, 2855, 1716, 1698, 1596, 1488, 1450, 1365, 1171; MS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_3$S]$^+$: 476.1; Found: 476.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_3$S]$^+$: 476.1291; Found: 476.1294. Mixtures of compound 2h and compound 2h': $^1$H NMR (400 MHz, CDCl$_3$) δ 7.91 – 7.86 (m, 2H), 7.44 – 7.15 (m, 8H), 7.07 – 6.98 (m, 3H), 6.88 – 6.78 (m, 1H), 6.74 – 6.70 (m, 1H), 6.54 – 6.43 (m, 1H), 4.79 (s, 0.5H), 4.77 (s, 0.5H), 2.47 (s, 1.5H), 2.46 (s, 1.5H), 2.38 (s, 1.5H), 2.33 (s, 1.5H).

1,3-dimethyl-N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2i)

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\text{Ts} \quad \text{N}_{\text{Ph}}
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2i

Compound 2i was prepared in 88% yield according to the general procedure (Table 2, entry 9). $^1$H NMR (400 MHz, CDCl$_3$) δ 7.89 (d, 2H, J = 8.4 Hz), 7.41 (d, 1H, J = 7.2 Hz), 7.32 (d, 3H, J = 8.0 Hz), 7.25 – 7.18 (m, 2H), 7.09 (t, 1H, J = 7.2 Hz), 6.99 (s, 1H), 6.86 (s, 3H), 6.54 (s, 2H), 4.73 (s, 1H), 2.46 (s, 3H), 2.33 (s, 3H), 2.26 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 171.2, 144.8, 141.8, 141.5, 140.9, 138.0, 136.7, 136.0, 134.1, 133.2, 130.4, 129.6, 129.3, 129.2, 129.0, 127.9, 126.9, 123.8, 120.2, 118.3, 56.2, 21.6, 21.2, 18.8; IR (neat): 2921, 2852, 1688, 1595, 1487, 1363, 1170, 694, 563; MS (ES$^+$) Calculated for [C$_{29}$H$_{25}$NNaO$_3$S]$^+$: 490.1; Found: 490.1; HRMS (ES$^+$) Calculated for [C$_{29}$H$_{25}$NNaO$_3$S]$^+$: 490.1447; Found: 490.1454.

N-phenyl-N-tosyl-9H-fluorene-9-carboxamide (2j)
Compound 2j was prepared in 54% yield according to the general procedure (Table 2, entry 10). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.87 (d, 2H, $J = 8.4$ Hz), 7.40 (d, 4H, $J = 7.6$ Hz), 7.33 – 7.19 (m, 6H), 7.13 (t, 1H, $J = 7.6$ Hz), 6.96 (t, 2H, $J = 7.6$ Hz), 6.68 (d, 2H, $J = 7.6$ Hz), 4.81 (s, 1H), 2.44 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 171.4, 144.9, 141.4, 140.8, 135.7, 133.5, 130.8, 129.3, 129.2, 129.2, 128.4, 128.0, 127.3, 124.2, 120.2, 56.5, 21.6; IR (neat): 2924, 2853, 1693, 1595, 1449, 1359, 1172, 742, 681, 570; MS (ES$^+$) Calculated for [C$_{27}$H$_{21}$NNaO$_3$S]$^+$: 462.1; Found: 462.1; HRMS (ES$^+$) Calculated for [C$_{27}$H$_{21}$NNaO$_3$S]$^+$: 462.1134; Found: 462.1145.

N-((4-methoxyphenyl)sulfonyl)-2-methyl-N-phenyl-9H-fluorene-9-carboxamide (2m)

Compound 2m was prepared in 71% yield according to the general procedure (Table 2, entry 13). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.94 (d, 2H, $J = 8.8$ Hz), 7.45 – 7.14 (m, 7H), 7.10 (d, 1H, $J = 8.0$ Hz), 7.08 – 6.93 (m, 4H), 6.76 (d, 2H, $J = 7.6$ Hz), 4.76 (s, 1H), 3.88 (s, 3H), 2.39 (s, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 171.6, 163.8, 141.6, 141.2, 140.8, 138.9, 137.4, 134.0, 131.6, 130.8, 130.0, 129.2, 128.9, 128.6, 128.0, 126.8, 124.8, 124.1, 120.0, 119.9, 113.8, 56.1, 55.6, 21.6; IR (neat): 2921, 2951, 1697, 1592, 1488, 1346, 1133, 696, 568; MS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_4$S]$^+$: 492.1; Found: 492.1; HRMS (ES$^+$) Calculated for [C$_{28}$H$_{23}$NNaO$_4$S]$^+$: 492.1240; Found: 492.1246.
2-(4'-methyl-[1,1'-biphenyl]-2-yl)-2-oxo-N-phenyl-N-tosylacetamide (3a)

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\text{N} \\
\text{O} \\
\text{O} \\
\text{Ts} \\
\text{Ph}
\]

\[3a\]

\[1^H \text{NMR (500 MHz, CDCl}_3) \delta 7.96 (d, 1H, } J = 7.5 \text{ Hz), 7.66 (d, 2H, } J = 8.3 \text{ Hz), 7.55 (td, 1H, } J = 7.5 \text{ Hz, 1.0 Hz), 7.44 (t, 1H, } J = 7.5 \text{ Hz), 7.38 – 7.16 (m, 10H), 6.83 (d, 2H, } J = 7.5 \text{ Hz), 2.44 (s, 3H), 2.39 (s, 3H), }^{13}C \text{ NMR (125 MHz, CDCl}_3) \delta 187.9, 166.0, 145.4, 144.3, 137.4, 136.9, 134.1, 133.5, 133.1, 132.0, 131.3, 131.2, 130.5, 129.8, 129.5, 129.4, 129.1, 129.0, 128.8, 127.2, 21.6, 21.2; IR (neat): 2958, 2931, 2872, 1737(s), 1713(s), 1642, 1489, 1408, 1306, 1173, 1049, 1012, 913, 743; MS (ES^+) Calculated for [C\text{28H23NNaO4S}^+] : 492.1; Found: 492.1; HRMS (ES^+) Calculated for [C\text{28H23NNaO4S}^+] : 492.1240; Found: 492.1248.

4-methyl-N-(7-methylphenanthren-9-yl)-N-phenylbenzenesulfonamide (3a’)

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\text{N} \\
\text{Ts}
\]

\[3a’\]

\[1H \text{ NMR (400 MHz, CDCl}_3) \delta 8.55 (d, 1H, } J = 8.4 \text{ Hz), 8.49 (d, 1H, } J = 8.4 \text{ Hz), 8.13 (s, 1H), 7.75 – 7.47 (m, 8H), 7.42 (d, 1H, } J = 8.0 \text{ Hz), 7.31 – 7.10 (m, 5H), 2.49 (s, 3H), 2.40 (s, 3H); }^{13}C \text{ NMR (100 MHz, CDCl}_3) \delta 143.7, 141.3, 137.2, 137.1, 135.6, 130.8, 130.6, 130.4, 129.6, 129.4, 129.0, 128.9, 128.7, 128.5, 128.0, 127.5, 126.6, 126.4, 124.2, 122.7, 122.4, 21.8, 21.50; IR (neat): 2919, 2850, 1640, 1630, 1485, 1353, 1164, 749, 692, 571;\]
MS (ES⁺) Calculated for [C₂₈H₂₃NNaO₂S]⁺: 460.1; Found: 460.1; HRMS (ES⁺)
Calculated for [C₂₈H₂₃NNaO₂S]⁺: 460.1342; Found: 460.1352.

Reference:
lb
If
2a
The image contains a chemical structure labeled as 2c with a nuclear magnetic resonance (NMR) spectrum. The NMR spectrum shows various peaks at different ppm values, indicating the chemical shifts of different protons or other nuclei in the molecule.
2f