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New General Amination Method Using the Addition of Polyfunctional Arylmagnesium Reagents to Functionalized Arylazo Tosylates

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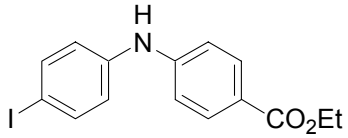
General All reactions were carried out under an argon atmosphere in oven dried glassware. Elemantal analyses were carried out on a Heraeus CHN-Rapid-Elementanalyzer in the microanalytical laboratories of the Department of Chemistry, Ludwig-Maximilians-Universität, Munich. All anilines and iodobenzenes were purchased from commercial sources and used without further purification. THF was continuously refluxed and freshly distilled from sodium benzophenone ketyl under nitrogen. Preparative flash chromatography was performed on silicagel 60 (0.040-0.063 mm) from Merck. Yields refer to isolated yields of compounds estimated to be > 95% pure as determined by ^{1}H-NMR, capillary GC and combustion analysis (new compounds).

1.) Typical Procedure for the preparation of arylazo tosylates (11) (TP)

Aromatic amine (10 mmol) was dissolved in 50% aq. HBF_4 (15 mL), cooled to 0°C and a solution of $NaNO_2$ (760 mg, 11 mmol) in 5 mL of water was added dropwise. After 30 min of stirring the reaction mixture was allowed to warm to room temperature, was stirred for an additional hour and the white precipitate was filtered off and washed subsequently with HBF_4, ethanol and diethyl ether. The white crystalline powder was dissolved in dichloromethane (50 mL) without further purification or drying, sodium toluenesulfinate (NaTs) (2.14 g, 12 mmol) was added and the reaction mixture was stirred overnight. The salts were removed by filtration and the crude reaction mixture was concentrated *in vacuo*. Recrystallization from ethanol yielded the desired arylazo tosylates **11** in analytical pure form.

Typical Procedure for the Amination (TP): A dry and argon flushed 25 mL round bottom flask, equipped with a magnetic stirrer and a septum, was charged with the corresponding iodide (1.1 mmol), dissolved in dry THF (5 mL) and cooled to –20 °C. *i*PrMgCl (1.15 mL, 1.1 mmol, 0.95 M in THF) was added dropwise and the I/Mg-exchange was checked by GC analysis of reaction aliquots until completion. The corresponding arylazo tosylate **11** (1 mmol) was dissolved in THF (3 mL) and added dropwise to the Grignard reagent. After 1 h of stirring at –20 °C, the reaction mixture was treated with allyl iodide (3 mmol) and NMP (2 mL) and stirred for additional 2 h at room temperature. The solvents were removed *in vacuo* and the residue taken up in 10 mL of glacial acetic acid. Zinc powder (10 mmol) and TFA (2 mL) were added and the reaction mixture was heated to 75 °C until no starting material was observed by TLC-analysis (typically 2 h). The reaction mixture was allowed to cool to room temperature and was poured on crushed ice and 20 mL of 2 M NaOH. The aqueous phase was extracted with diethyl ether (3 x 30 mL) and the combined organic phases were washed with sat. $NaHCO_3$-solution and brine successively. The organic phases were dried over Na_2SO_4, filtered and concentrated *in vacuo*. Flash chromatography on silica gel (pentane/diethyl ether) furnished diarylamines **1** in analytically pure form.

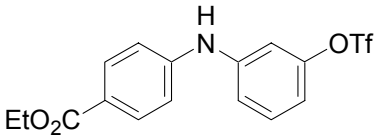
Preparation of ethyl 4-(4-iodoanilino)benzoate (1a):



Prepared according to **TP** from 1,4-diiodobenzene (362 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-carbethoxyphenylazo tosylate (332 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 3 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1a**) as a colourless solid (231 mg, 63 %).

mp.: 157-157.5 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.87 (d, ^3J(H,H) = 8 Hz, 2H), 7.53 (d, ^3J(H,H) = 8 Hz, 2H), 6.91 (d, ^3J(H,H) = 8 Hz, 2H), 6.83 (d, ^3J(H,H) = 8 Hz, 2H), 4.28 (q, ^3J(H,H) = 7 Hz, 2H), 1.30 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 165.3, 146.0, 139.9, 137.3, 130.4, 121.2, 120.7, 114.2, 83.9, 59.5, 13.4. **MS** (70 eV, EI): m/z (%): 367 (100) [M^+], 339 (30), 322 (48), 167 (70), 139 (17), 83 (17). **$C_{14}H_{15}INO_2$**: calc.: C: 49.07; H: 3.84; N: 3.81. found: C: 49.16; H: 3.89; N: 3.64.
Lit: [1]

Preparation of ethyl 4-(3-trifluoromethanesulfonyloxy-phenylamino)-benzoate (1b):

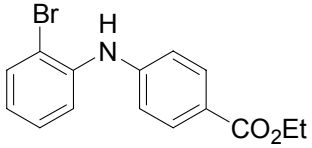


Prepared according to **TP** from trifluoro-methanesulfonic acid 3-iodo-phenyl ester (387 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-carbethoxyphenylazo tosylate (332 mg, 1 mmol). Reaction time: 1 h. Addition of allyl

iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 12 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1b**) as a colourless solid (296 mg, 76 %).

mp.:114.5-115.5 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.99 (d, ^3J(H,H) = 8 Hz, 2H), 7.35 (t, ^3J(H,H) = 8 Hz, 1H), 7.15 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.2 Hz, 1H) 7.12-7.04 (m, 3H), 6.92 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.2 Hz, 1H), 6.23 (s_br, NH), 4.33 (q, ^3J(H,H) = 7 Hz, 2H), 1.37 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 165.3, 149.3, 145.0, 142.5, 130.5, 129.9, 124.1, 122.3, 119.8, 117.4, 115.6, 113.4, 110.3, 59.7, 13.4. **MS** (70 eV, EI): m/z (%): 389 (100)[M^+], 361 (12), 344 (36), 228 (8), 183 (17), 155 (21), 129 (5). **IR** (KBr): $\tilde{\nu}$ = 3342, 1690, 1602, 1534, 1486, 1409, 1250, 1221, 1200, 1144, 1108, 962, 855, 843, 768, 602. **$C_{16}H_{14}F_3NO_5S$**: calc.: C: 49.36; H: 3.62; N: 3.60; found: C: 3.54; H: 3.64; N: 3.54.**HRMS** for **$C_{16}H_{14}F_3NO_5S$**: calc.: 389.0545. found: 389.0526.

Preparation of ethyl 4-(2-bromoanilino)benzoate (1c):

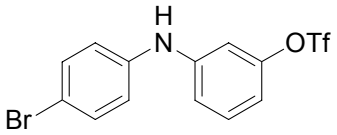


Prepared according to **TP** from ethyl 4-iodobenzoate (303 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 2-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 19:1) yielded the amine (**1c**) as a colourless oil (208 mg, 65 %).

^{1}H NMR (300 MHz, $CDCl_3$, 25 °C): δ = 7.98 (d, ^3J(H,H) = 8 Hz, 2H), 7.58 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz, 1H), 7.39 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz,

1H), 6.89 (dt, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz, 1H), 7.07 (d, ^3J(H,H) = 8 Hz, 2H), 6.87 (dt, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz, 1H), 6.24 (s_br, NH), 4.33 (q, ^3J(H,H) = 7 Hz, 2H), 1.38 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 145.4, 138.3, 132.3, 130.4, 127.2, 122.1, 122.0, 117.8, 115.4, 113.5, 87.7, 59.6, 13.4. **MS** (70 eV, EI): m/z (%): 319 (100)[M^+], 291 (25), 274 (89), 194 (18), 167 (99), 139 (25), 83 (20). **IR** (KBr): $\tilde{\nu}$ = 3394, 1704, 1608, 1591, 1502, 1462, 1366, 1276, 1175, 1105, 1023, 768, 748, 697. **$C_{15}H_{14}BrNO_2$** calc.: C: 56.27; H: 4.41; N: 4.37; found: C: 56.01; H: 4.50; N: 4.37. **HRMS** for **$C_{15}H_{14}BrNO_2$** calc.: 319.0208; found: 319.0186.

Preparation of trifluoro-methanesulfonic acid 3-(4-bromo-phenylamino)-phenyl ester (1d):

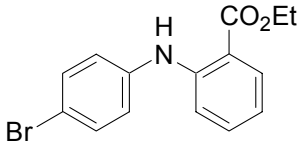


Prepared according to **TP** from trifluoro-methanesulfonic acid 3-iodo-phenyl ester (387 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 6 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1d**) as a colourless oil (277 mg, 70 %).

^{1}H NMR (300 MHz, $CDCl_3$, 25 °C): δ = 7.40 (d, ^3J(H,H) = 8 Hz, 2H), 7.29 (t, ^3J(H,H) = 8 Hz, 1H), 7.00-6.95 (m, 3H), 6.89 (t, ^4J(H,H) = 2.2 Hz, 1H), 6.79 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.2 Hz, 1H), 5.82 (s_br, NH). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 149.4, 144.0, 139.4, 131.5, 129.9, 119.8, 115.5, 113.9, 111.9, 108.3, 87.8. **MS** (70 eV, EI): m/z (%): 397 (100) [M^+], 234 (9), 183 (67), 155 (32). **IR** (KBr): $\tilde{\nu}$ = 3418, 1617, 1590, 1489, 1420, 1217, 1139, 1116, 865, 866, 608. **$C_{13}H_9BrF_3NO_3S$**

calc.: C: 39.41; H: 2.29; Br: 20.17; N: 3.54; found: C: 39.73; H: 2.22; Br: 20.28; N: 3.50. **HRMS** for **$C_{13}H_9BrF_3NO_3S$** calc.: 394,9439; found: 394.9445.

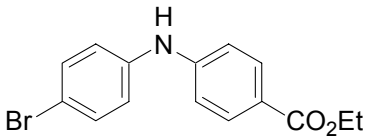
Preparation of ethyl 2-(4-bromoanilino)benzoate (1e):



Prepared according to **TP** from ethyl 2-iodobenzoate (303 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 49:1) yielded the amine (**1e**) as a pale yellow oil (255 mg, 80 %).

^{1}H NMR (300 MHz, C_6D_6, 25 °C): δ = 9.80 (s_br, NH), 8.05 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 1.5 Hz, 1H), 7.11 (d, ^3J(H,H) = 8 Hz, 2H), 7.10-7.03 (m, 2H), 6.70 (d, ^3J(H,H) = 8 Hz, 2H), 6.59 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 1.5 Hz, 1H), 4.04 (q, ^3J(H,H) = 7 Hz, 2H), 1.00 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 168.6, 147.8, 149.3, 134.2, 132.5, 131.9, 123.8, 117.8, 115.8, 114.3, 113.1, 60.7, 14.2. **MS** (70 eV, EI): m/z (%): 319 (30)[M^+], 273 (5), 194 (100), 166 (22), 139 (6), 83 (3). **IR** (KBr): $\tilde{\nu}$ = 3340, 1686, 1613, 1587, 1531, 1489, 1368, 1352, 1308, 1287, 1174, 1129, 825, 766, 502. **$C_{15}H_{14}BrNO_2$** calc.: C: 56.27; H: 4.41; N: 4.37; found: C: 56.24; H: 4.07; N: 4.27. **HRMS** for **$C_{15}H_{14}BrNO_2$** calc.: 319.0208; found: 319.0250.

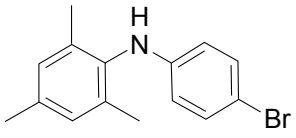
Preparation of ethyl 4-(4-bromoanilino)benzoate (1f):



Prepared according to **TP** from ethyl 4-iodobenzoate (303 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1f**) as a colourless solid (265 mg, 83 %).

mp.:154.5-155 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.92 (d, ^3J(H,H) = 8 Hz, 2H), 7.42 (d, ^3J(H,H) = 8 Hz, 2H), 7.03 (d, ^3J(H,H) = 8 Hz, 2H), 6.98 (d, ^3J(H,H) = 8 Hz, 2H), 4.33 (q, ^3J(H,H) = 7 Hz, 2H), 1.37 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 166.8, 147.7, 140.6, 132.8, 131.9, 122.5, 122.0, 115.4, 114.9, 60.9, 14.8. **MS** (70 eV, EI): m/z (%): 319 (100) [M^+], 292 (33), 273 (62), 167 (65), 139 (12), 83 (12). **IR** (KBr): $\tilde{\nu}$ = 3340, 1686, 1613, 1587, 1531, 1489, 1368, 1352, 1308, 1287, 1174, 1129, 825, 766, 502. **$C_{15}H_{14}BrNO_2$** calc.: C: 56.27; H: 4.41; N: 4.37; found: C: 56.24; H: 4.07; N: 4.27. **HRMS** for **$C_{15}H_{14}BrNO_2$** calc.: 319.0208; found: 319.0200.
Lit:[1]

Preparation of (4-bromo-phenyl)-(2,4,6-trimethyl-phenyl)-amine (1g):

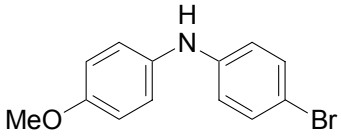


Prepared according to **TP** from mesitylmagnesium bromide (1.5 mL, 1.1 mmol, 0.75 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h.

Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 49:1) yielded the amine (**1g**) as a colourless oil (199 mg, 69 %).

^{1}H NMR (300 MHz, C_6D_6, 25 °C): δ = 7.13 (d, ^3J(H,H) = 8 Hz, 2H), 6.78 (s, 2H), 6.04 (d, ^3J(H,H) = 8 Hz, 2H), 4.21 (s_br NH), 2.16 (s, 3H), 1.97 (s, 6H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 146.6, 136.7, 136.3, 135.7, 132.7, 130.0, 115.2, 113.8, 110.1, 21.3, 18.5. **MS** (70 eV, EI): m/z (%): 289 (100)[M^+], 274 (19), 208 (25), 194 (29), 180 (18), 91 (8). **IR** (KBr): $\tilde{\nu}$ = 3399, 2918, 1593, 1489, 1314, 1287, 1174, 853, 815, 749, 726, 577, 560, 494. **$C_{15}H_{16}BrN$** calc.: C: 62.08; H: 5.56; N: 4.83; found: C: 62.46; H: 4.81; N: 5.37. **HRMS** for **$C_{15}H_{16}BrN$** calc.: 289.0466; found: 289.0483.

Preparation of *N*-(4-bromophenyl)-4-methoxyaniline (1h):



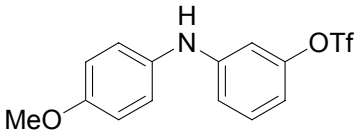
Prepared according to **TP** from *p*-methoxyphenylmagnesium bromide (1.2 mL, 1.1 mmol, 0.9 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 29:1) yielded the amine (**1h**) as a colourless solid (238 mg, 86 %).

mp.: 87-88 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.19 (d, ^3J(H,H) = 9 Hz, 2 H), 6.96 (d, ^3J(H,H) = 9 Hz, 2 H), 6.78 (d, ^3J(H,H) = 9 Hz, 2 H), 6.67 (d, ^3J(H,H) = 9 Hz, 2 H), 5.38 (br s, 1 H), 3.71 (s, 3 H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 156.1, 144.9, 135.4, 132.5, 123.2, 117.4, 115.2, 111.4, 56.0. **MS** (70 eV, EI): m/z (%): 277

(84) [M^+], 262 (100), 183 (10), 154 (34), 128 (6). **IR** (KBr): $\tilde{\nu}$ = 3419, 1596, 1515, 1493, 1298, 1250, 1177, 1032, 817. **$C_{13}H_{12}BrNO$** calc.: C: 56.14; H: 4.35; N: 5.04; found: C: 56.22; H: 4.09; N: 4.89. **HRMS** for **$C_{13}H_{12}BrNO$** calc.: 277.0102. found: 277.0117.

Lit:[1]

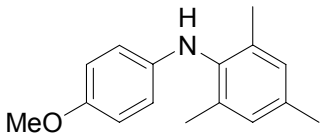
Preparation of trifluoro-methanesulfonic acid 3-(4-methoxy-phenylamino)-phenyl ester (1i):



Prepared according to **TP** from trifluoro-methanesulfonic acid 3-iodo-phenyl ester (387 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-methoxyphenylazo tosylate (290 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1i**) as a colourless solid (281 mg, 81 %).

mp.:69-70.5 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.23 (t, ^3J(H,H) = 8 Hz, 1H), 7.09 (d, ^3J(H,H) = 8 Hz, 2H), 6.92 (d, ^3J(H,H) = 8 Hz, 2H), 6.82 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.2 Hz, 1H), 6.71 (t, ^4J(H,H) = 2.2 Hz, 1H), 6.67 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.2 Hz, 1H), 5.56 (s_br, NH), 3.81 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 155.4, 149.6, 146.6, 132.6, 129.6, 122.9, 119.8, 115.6, 113.9, 113.4, 109.9, 105.9, 54.5. **MS** (70 eV, EI): m/z (%): 347 (100) [M^+], 332 (10), 214 (12), 186 (24), 155 (6). **IR** (KBr): $\tilde{\nu}$ = 3386, 1613, 1513, 1404, 1321, 1297, 1321, 1205, 1141, 1111, 876, 850, 680, 612, 511. **$C_{14}H_{12}F_3NO_4S$** calc.: C: 48.41; H: 3.48; N: 4.03; found: C: 48.61; H: 3.71; N: 4.02. **HRMS** for **$C_{14}H_{12}F_3NO_4S$** calc.: 347.0439; found: 347.0434.

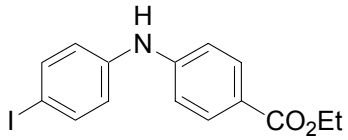
Preparation of (4-methoxy-phenyl)-(2,4,6-trimethyl-phenyl)-amine (1j):



Prepared according to **TP** from mesitylmagnesium bromide (1.5 mL, 1.1 mmol, 0.75 M in THF) and 4-methoxyphenylazo tosylate (290 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 49:1) yielded the amine (**1j**) as a colourless solid (200 mg, 83 %).

mp.:100.5-101.5 °C. **^{1}H NMR** (300 MHz, C_6D_6, 25 °C): δ = 6.84 (s, 2H), 6.75 (d, ^3J(H,H) = 8 Hz, 2H), 6.40 (d, ^3J(H,H) = 8 Hz, 2H), 4.45 (s_br NH), 3.35 (s, 3H), 2.19 (s, 3H), 2.10 (s, 6H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 153.7, 141.4, 137.5, 136.0, 135.1, 130.0, 128.7, 115.6, 115.3, 55.6, 21.3, 18.6. **MS** (70 eV, EI): m/z (%): . **IR** (KBr): $\tilde{\nu}$ = 3352, 1509, 1462, 1308, 1289, 1230, 1174, 1031, 853, 824, 640, 630, 501. **$C_{16}H_{19}NO$** calc.: C: 76.63; H: 7.94; N: 5.80. found: C: 76.28; H: 7.73; N: 5.89. **HRMS** for **$C_{16}H_{19}NO$** calc.: 241.1467; found: 241.1461.

Preparation of ethyl 4-(4-iodoanilino)benzoate (1k):

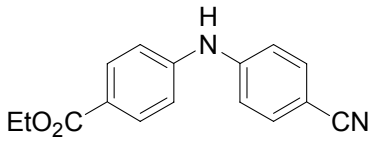


Prepared according to **TP** from ethyl 4-iodobenzoate (303 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-iodophenylazo tosylate (386 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 2 h. Purification by flash

chromatography (pentane/diethyl ether = 9:1) yielded the amine (**1a**) as a pale yellow solid (261 mg, 71 %).

mp.:156-157 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.93 (d, ^3J(H,H) = 8 Hz, 2H), 7.59 (d, ^3J(H,H) = 8 Hz, 2H), 6.98 (d, ^3J(H,H) = 8 Hz, 2H), 6.92 (d, ^3J(H,H) = 8 Hz, 2H), 4.34 (q, ^3J(H,H) = 7 Hz, 2H), 1.37 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 165.4, 146.0, 139.9, 137.3, 130.4, 121.2, 120.7, 114.2, 83.9, 59.6, 13.4. **MS** (70 eV, EI): m/z (%): 367 (100) [M^+], 339 (26), 322 (42), 167 (28), 139 (9), 82 (5).
Lit: [1]

Preparation of ethyl 4-(4-cyanoanilino)benzoate (1l):

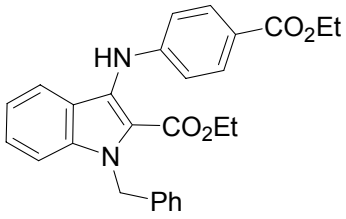


Prepared according to **TP** from ethyl 4-iodobenzoate (303 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-cyanophenylazo tosylate (286 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 12 h. Purification by flash chromatography (pentane/diethyl ether = 2:1) yielded the amine (**1l**) as a pale yellow solid (172 mg, 71 %).

mp.: 154.5-155.5 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 8.01 (d, ^3J(H,H) = 9 Hz, 2 H), 7.54 (d, ^3J(H,H) = 9 Hz, 2 H), 7.16-7.10 (m, 4 H), 6.42 (s_br, NH), 4.32 (q, ^3J(H,H) = 7 Hz, 2 H), 1.38 (t, ^3J(H,H) = 7 Hz, 3 H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 166.1, 145.9, 144.7, 133.8, 131.4, 124.4, 119.4, 117.8, 116.9, 103.6, 60.8, 14.3. **MS** (70 eV, EI): m/z (%): 266 (77) [M^+], 238 (29), 221 (100), 192 (37), 166 (7), 139 (4), 110 (4), 83 (3). **IR** (KBr): $\tilde{\nu}$ = 3332, 2216, 1688, 1615, 1592, 1498, 1364, 1345, 1281, 1249, 1173, 1107, 836, 769, 547. **$C_{16}H_{14}N_2O_2$** calc.: C: 72.16; H: 5.30; N:

10.52; found: C: 72.52; H: 5.47; N: 10.42. **HRMS** for $\mathbf{C_{16}H_{14}N_2O_2}$ calc.: 266.1055; found: 266.1048.

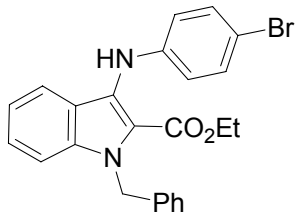
Preparation of 1-benzyl-3-(4-ethoxycarbonyl-phenylamino)-1H-indole-2-carboxylic acid ethyl ester (15a):



Prepared according to **TP** from 1-benzyl-3-iodo-1H-indole-2-carboxylic acid ethyl ester (487 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-carbethoxyphenylazo tosylate (332 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 4:1) yielded the amine (**15a**) as a pale yellow solid (314 mg, 71 %).

mp.: 96.5-98 °C. **^{1}H NMR** (300 MHz, C_6D_6, 25 °C): δ = 8.15 (d, ^3J(H,H) = 9 Hz, 2 H), 7.56 (m, 2 H) 7.13-6.91 (m, 10 H), 6.84 (d, ^3J(H,H) = 9 Hz, 2 H), 5.48 (s, 2 H), 4.19 (q, ^3J(H,H) = 7 Hz, 2 H), 3.87 (q, ^3J(H,H) = 7 Hz, 2 H), 1.05 (t, ^3J(H,H) = 7 Hz, 3 H), 0.74 (t, ^3J(H,H) = 7 Hz, 3 H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 166.6, 162.7, 149.1, 139.4, 139.0, 129.2, 128.7, 127.2, 127.1, 126.7, 123.3, 123.1, 121.3, 120.6, 117.3, 116.2, 111.5, 60.9, 60.7, 48.7, 14.8, 14.3. **MS** (70 eV, EI): m/z (%): 442 (22)[M^+], 351 (33), 279 (13), 277 (39), 261 (15), 233 (78), 205 (41), 178 (11), 103 (12), 91 (100), 65 (28). **IR** (KBr): $\tilde{\nu}$ = 3414, 1707, 1664, 1606, 1549, 1457, 1371, 1341, 1277, 1258, 1173, 1104, 768, 741. $\mathbf{C_{27}H_{26}N_2O_4}$: calc.: C: 73.28; H: 5.92; N: 6.33; found: C: 72.97; H: 5.97; N: 6.17. **HRMS** for $\mathbf{C_{27}H_{26}N_2O_4}$ calc.: 442.1893; found: 442.1897.

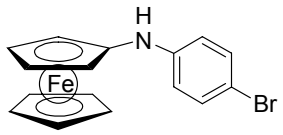
Preparation of 1-benzyl-3-(4-bromo-phenylamino)-1H-indole-2-carboxylic acid ethyl ester (15b):



Prepared according to **TP** from 1-benzyl-3-iodo-1H-indole-2-carboxylic acid ethyl ester (487 mg, 1.1 mmol) *i*PrMgCl (1.16 mL, 1.1 mmol, 0.95 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 9:1) yielded the amine (**15b**) as a yellow solid (233 mg, 52 %).

mp.: 103-104 °C. **^{1}H NMR** (300 MHz, C_6D_6, 25 °C): δ = 7.66 (s_br, NH), 7.50 (d, ^3J(H,H) = 8 Hz, 1 H), 7.16-6.86 (m, 10 H), 6.63 (d, ^3J(H,H) = 8 Hz, 2 H), 5.46 (s, 2 H), 3.90 (q, ^3J(H,H) = 7 Hz, 2 H), 0.76 (t, ^3J(H,H) = 7 Hz, 3 H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 162.6, 143.6, 139.1, 138.8, 132.2, 130.8, 128.8, 127.3, 126.7, 123.1, 120.3, 119.8, 119.5, 115.6, 113.1, 112.8, 111.1, 60.4, 48.4, 13.9. **MS** (70 eV, EI): m/z (%): 450 (100) [M^+], 359 (60), 313 (20), 285 (41), 206 (12), 91 (23). **IR** (KBr): $\tilde{\nu}$ = 3412, 1697, 1658, 1585, 1549, 1490, 1457, 1338, 1371, 1250, 1169, 1123, 741, 696. **$C_{24}H_{21}BrN_2O_2$** calc.: C: 64.15; H: 4.71; Br: 17.78; N: 6.23; found: C: 64.10; H: 4.58; N: 6.16; Br: 17.72. **HRMS** for **$C_{24}H_{21}BrN_2O_2$** calc.: 448.0786; found: 448.0805.

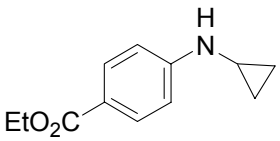
Preparation of (4-bromo-phenyl)-ferrocenyl amine (18):



Prepared from tri-*n*-butyltinferrocen (524 mg, 1.1 mmol) and *n*-BuLi (0.75 mL, 1.1 mmol, 1.5 M in hexane) following the procedure from Kagan[2]. Subsequent transmetalation with $MgBr_2 \cdot Et_2O$ (280 mg, 1.1 mmol) afforded the Grignard species that was brought to reaction according to **TP** with and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 2 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and TFA (2 mL) and heating to 75 °C for 1 h. Purification by flash chromatography (pentane/diethyl ether = 49:1) yielded the amine (**18**) as a yellow solid (205 mg, 58 %).

mp.: 109-110 °C. **^{1}H NMR** (300 MHz, C_6D_6, 25 °C): δ = 7.24 (d, ^3J(H,H) = 8 Hz, 1 H), 6.50 (d, ^3J(H,H) = 9 Hz, 2 H) 4.24 (s_br, NH), 4.00 (s, 5 H), 3.91 (t, ^3J(H,H) = 2.5 Hz, 2 H), 3.80 (t, ^3J(H,H) = 2.5 Hz, 2 H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 145.6, 132.5, 117.0, 111.1, 100.4, 69.6, 65.2, 62.6, 62.2. **MS** (70 eV, EI): m/z (%): 355 (100) [M^+], 233 (22), 220 (11), 186 (12), 154 (94), 128 (25), 102 (9) 76 (7). **IR** (KBr): $\tilde{\nu}$ = 3421, 1587, 1509, 1305, 1232, 816, 488. **$C_{16}H_{14}BrFeN$** calc.: C: 53.97; H: 3.96; Br: 22.44; N: 3.93; found: C: 54.11; H: 3.69; N: 3.85; Br: 22.32. **HRMS** for **$C_{16}H_{14}BrFeN$**: calc.: 354.9659; found: 354.9689.

Preparation of 4-cyclopropylamino-benzoic acid ethyl ester (20a):

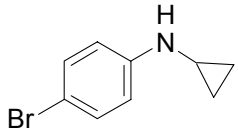


Prepared according to **TP** from cyclopropylmagnesium bromide (1.4 mL, 1.1 mmol, 0.8 M in THF) and 4-carbethoxyphenylazo tosylate (332 mg, 1 mmol). Reaction time:

1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 19:1) yielded the amine (**20a**) as a yellow solid (127 mg, 62 %).

mp.:68-69 °C. **^{1}H NMR** (300 MHz, C_6D_6 , 25 °C): δ = 8.25 (d, ^3J(H,H) = 8 Hz, 2H), 6.50 (d, ^3J(H,H) = 8 Hz, 2H), 4.23 (q, ^3J(H,H) = 7 Hz, 2H), 3.70 (br s, NH), 1.89 (m, 1H), 1.09 (d, ^3J(H,H) = 7 Hz, 3H), 0.26 (m, 2H), 0.10 (m, 2H). **^{13}C-NMR** (75 MHz, C_6D_6, 25 °C): δ = 166.7, 152.7, 131.7, 120.1, 112.4, 60.1, 24.7, 14.5, 7.5. **MS** (70 eV, EI): m/z (%): 205 (100) [M^+], 176 (48), 160 (85), 132 (88), 117 (19), 105 (9), 65 (8). **IR** (KBr): $\tilde{\nu}$ = 3355, 2978, 1682, 1605, 1522, 1365, 1310, 1286, 1170, 1105, 1022, 841, 772, 702. **$C_{12}H_{15}NO_2$** calc.: C: 70.22; H: 7.37; N: 6.82; found: C: 70.44; H: 7.28; N: 6.58. **HRMS** for **$C_{12}H_{15}NO_2$**: calc.: 205.1103, found: 205.1086.

Preparation of (4-bromo-phenyl)-cyclopropyl-amine (20b):

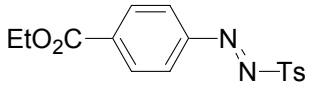


Prepared according to **TP** from cyclopropylmagnesium bromide (1.4 mL, 1.1 mmol, 0.8 M in THF) and 4-bromophenylazo tosylate (339 mg, 1 mmol). Reaction time: 1 h. Addition of allyl iodide (510 mg, 3 mmol) and NMP (2 mL) stirring for 2 h at rt followed by *in vacuo* solvent removal. Addition of AcOH (10 mL), Zn (650 mg, 10 mmol) and heating to 75 °C for 2 h. Purification by flash chromatography (pentane/diethyl ether = 19:1) yielded the amine (**20b**) as a colourless solid (142 mg, 67 %).

mp.: 25 °C. **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.25 (d, ^3J(H,H) = 8 Hz, 2H), 6.66 (d, ^3J(H,H) = 8 Hz, 2H), 4.15 (s_br, NH), 2.38 (quint, ^3J(H,H) = 7 Hz, 1H), 0.72 (m, 2H), 0.49 (m, 2H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 147.6, 131.8, 114.7, 109.3, 25.2, 7.4. **MS** (70 eV, EI): m/z (%): 211 (5)[M^+], 184 (30), 155 (13), 132 (100), 117

(20), 105 (17), 91 (15), 76 (28), 65 (21), 56 (22), 50 (28). **IR** (KBr): $\tilde{\nu}$ = 3390, 2965, 1594, 1531, 1494, 1450, 1364, 1312, 1262, 1174, 1072, 814, 500. **$C_9H_{10}BrN$** calc.: C: 50.97; H: 4.75; N: 6.60; found: C: 51.25; H: 4.92; N: 6.57. **HRMS** for **$C_9H_{10}BrN$** calc.: 210.9997 found: 211.0006.

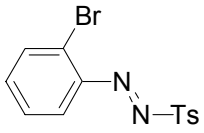
Preparation of 4-carbethoxyphenylazo tosylate (11a):



Prepared according to **TP** from ethyl 4-aminobenzoate (1.65 g, 10 mmol). Reaction time: 16 h. Recrystallisation from ethanol (30 mL) yielded product **11a** as orange solid (2.66 g, 80 %).

mp.: 102.5-104 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 8.15 (d, ^3J(H,H) = 8 Hz, 2H), 7.86-7.81 (m, 4H), 7.38 (d, ^3J(H,H) = 8 Hz, 2H), 4.33 (q, ^3J(H,H) = 7 Hz, 2H), 2.41 (s, 3H), 1.30 (d, ^3J(H,H) = 7 Hz, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 164.2, 150.4, 145.3, 134.4, 129.7, 129.5, 129.0, 128.7, 128.5, 123.1, 60.7, 20.8, 13.2. **MS** (70 eV, FAB): m/z (%): 335 (9) [M^+]. **$C_{16}H_{16}N_2O_4S$** calc.: 335.1066 [M+3H]; found: 335.1106.

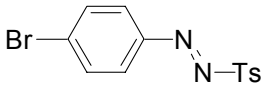
Preparation of 2-bromophenylazo tosylate (11b):



Prepared according to **TP** from 2-bromoaniline (1.72 g, 10 mmol). Reaction time: 16 h. Recrystallisation from ethanol (30 mL) yielded product **11b** as orange solid (2.92 g, 86 %).

mp.: 115-116.5 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.84 (d, ^3J(H,H) = 8 Hz, 2H), 7.69 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz, 1H), 7.61 (dd, ^3J(H,H) = 8 Hz, ^4J(H,H) = 2.0 Hz, 1H), 7.43-7.33 (m, 4H), 2.46 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 141.3, 134.5, 133.4, 129.9, 128.8, 128.2, 127.3, 127.2, 117.2, 87.6, 20.8. **MS** (70 eV, FAB): m/z (%): 341 (3) [M^+]. **IR** (KBr): $\tilde{\nu}$ = 1595, 1477, 1340, 1163, 1151, 1083, 882, 809, 764, 667, 607, 557, 529. **$C_{13}H_{11}BrN_2O_2S$** calc.: C: 46.03; H: 3.27; N: 8.26; found: C: 46.29; H: 3.29; N: 8.26.**$C_{13}H_{11}BrN_2O_2S$** calc.: 338.9803 [M+1H]; found: 338.9771.

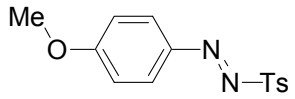
Preparation of 4-bromophenylazo tosylate (11c):



Prepared according to **TP** from 4-bromoaniline (1.72 g, 10 mmol). Reaction time: 16 h. Recrystallisation from ethanol (30 mL) yielded product **11b** as orange solid (2.76 g, 82 %).

mp.: 111-112 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.86 (d, ^3J(H,H) = 8 Hz, 2H), 7.69-7.61 (m, 4H), 7.37 (d, ^3J(H,H) = 8 Hz, 2H), 2.40 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 148.3, 146.6, 134.5, 133.3, 132.2, 130.8, 130.3, 129.8, 129.2, 127.8, 126.2, 87.6, 27.2. **MS** (70 eV, FAB): m/z (%): 341 (3) [M^+]. **IR** (KBr): $\tilde{\nu}$ = 3436, 1595, 1480, 1399, 1348, 1166, 1149, 1009, 883, 832, 811, 702, 671, 621, 548. **$C_{13}H_{11}BrN_2O_2S$** calc.: C: 46.03; H: 3.27; N: 8.26; S: 9.62; found: C: 46.03; H: 3.38; N: 8.25, S: 9.45. **$C_{13}H_{11}BrN_2O_2S$** calc.: 338.9803 [M+1H] ; found: 338.9776.

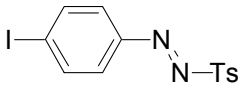
Preparation of 4-methoxyphenylazo tosylate (11d):



Prepared according to **TP** from 4-methoxyaniline (2.46 g, 20 mmol). Reaction time: 16 h. Recrystallisation from ethanol (50 mL) yielded product **11d** as yellow solid (5.21 g, 90 %).

mp.: 114.5-115.5 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.79-7.72 (m, 4H), 7.30 (d, ^3J(H,H) = 8 Hz, 2H), 6.86 (d, ^3J(H,H) = 8 Hz, 2H), 3.81 (s, 3H), 2.40 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 165.4, 145.6, 143.4, 130.8, 129.8, 127.3, 114.7, 55.9, 21.8. **MS** (70 eV, FAB): m/z (%): 291 (10) [M^+]. **IR** (KBr): $\tilde{\nu}$ = 3436, 1602, 1580, 1502, 1463, 1420, 1341, 1265, 1162, 1146, 1086, 888, 844, 817, 733, 660, 590, 552, 526. **$C_{14}H_{14}N_2O_3S$** calc.: C: 57.92; H: 4.86; N: 9.65; S: 11.04; found: C: 58.06; H: 4.80; N: 9.61; S: 11.32. **$C_{14}H_{14}N_2O_3S$** calc.: 291.0803 [M+1H]; found: 291.0891.

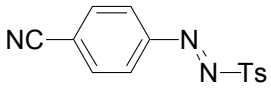
Preparation of 4-iodophenylazo tosylate (11e):



Prepared according to **TP** from 4-iodoaniline (2.19 g, 10 mmol). Reaction time: 18 h. Recrystallisation from ethanol (30 mL) yielded product **11e** as orange solid (3.2 g, 83 %).

mp.: 103-105 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.80-7.76 (m, 4H), 7.45 (d, ^3J(H,H) = 8 Hz, 2H), 7.30 (d, ^3J(H,H) = 8 Hz, 2H), 2.40 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 147.4, 145.2, 138.3, 137.9, 129.4, 128.9, 128.7, 124.6, 112.6, 102.0, 87.7, 20.8. **MS** (70 eV, FAB): m/z (%):388 (2) [M^+]. **$C_{13}H_{11}IN_2O_2S$** calc.: C: 40.43; H: 2.87; N: 7.25; S: 8.30; found: C: 40.62; H: 2.90; N: 7.27; S: 8.23. **$C_{13}H_{11}IN_2O_2S$** calc.: 386.9664 [M+1H]; found: 386.9630.

Preparation of 4-cyanophenylazo tosylate (11f):



Prepared according to **TP** from 4-aminobenzonitrile (1.18 g, 10 mmol). Reaction time: 16 h. Recrystallisation from ethanol (30 mL) yielded product **11f** as orange-red solid (2.42 g, 85 %).

mp.: 138-140 °C (decomp.). **^{1}H NMR** (300 MHz, $CDCl_3$, 25 °C): δ = 7.93-7.81 (m, 6H), 7.45 (d, ^3J(H,H) = 8 Hz, 2H), 2.42 (s, 3H). **^{13}C-NMR** (75 MHz, $CDCl_3$, 25 °C): δ = 151.3, 147.0, 133.9, 130.9, 130.5, 129.5, 129.1, 125.1, 117.9, 117.8, 22.2. **MS** (70 eV, FAB): not possible.

[1] I. Sapountzis, P. Knochel *J. Am. Chem. Soc.* **2002**, *124*, 9390.
[2] D. Giullaneux, H. B. Kagan, *J. Org. Chem.* **1995**, *60*, 2502.