SUPPORTING INFORMATION
for

Strategic applications of Baylis-Hillman adducts to general syntheses of 3-nitroazetidines

Ankita Rai, Lal Dhar S. Yadav*

Green Synthesis Lab, Department of Chemistry, University of Allahabad, Allahabad 211002, India
Tel.: (+91)-532-2500652; fax: (+91)-532-2460533; e-mail: ldsyadav@hotmail.com

TABLE OF CONTENTS

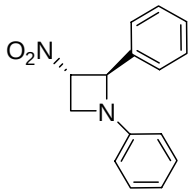
General Information: Reagents were obtained from commercial supplier, and used without further purification unless otherwise specified by a reference. All reactions were performed using oven-dried glassware under a nitrogen atmosphere. Organic solutions were concentrated using a Buchi rotary evaporator. Column chromatography was carried out over silica gel (Merck 100–200 mesh) and TLC was performed using silica gel GF254 (Merck) plates. Melting points were determined by open glass capillary method and are uncorrected. IR spectra in KBr were recorded on a Perkin-Elmer 993 IR spectrophotometer, ^{1}H NMR spectra were recorded on a Bruker AVII 400 spectrometer in $CDCl_3$ using TMS as internal reference with chemical shift value being reported in ppm. All coupling constants (*J*) are reported in Hertz (Hz). ^{13}C NMR spectra were recorded on the same instrument at 100 MHz in $CDCl_3$ and TMS was used as internal reference.

Mass (EI) spectra were recorded on a JEOL D-300 mass spectrometer. Elemental analyses were carried out in a Coleman automatic carbon, hydrogen and nitrogen analyzer.

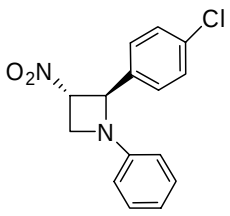
General procedure for the synthesis of 1,2,3-trisubstituted azetidines 4

To a solution of diethyl *N*-arylphosphoramidate **2** (5 mmol) in dry THF (5 mL) was added dropwise a suspension of NaH (240 mg, 10 mmol) in dry THF (10 mL) with stirring at rt. After the addition was complete and evolution of hydrogen gas (effervescence) had ceased, the reaction mixture was stirred at 60 ^{o}C for 30 min and then cooled to rt. Next, a solution of Baylis Hillman alcohol **1** (5 mmol) in dry THF (5 mL) was added, and the reaction mixture was stirred at rt for 3-5 h. Water (20 mL) was added, the mixture was extracted with ether (3 x 30 mL), the combined organic layers were dried over anhydrous sodium sulfate, filtered, and evaporated under reduced pressure. The crude product thus obtained was purified by silica gel column chromatography (hexane/EtOAc, 95:5) to afford an analytically pure sample of **4**.

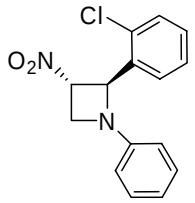
Spectroscopic and analytical data for compounds



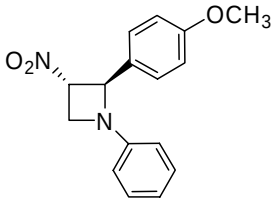
Compound ***trans*-4a:** White solid, yield 85%, mp 172-175 ^{o}C. IR (KBr) υ_{max} 3052, 2992, 1605, 1585, 1455, 750, 705 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.65 (ddd, *J* = 7.2, 6.5, 3.1 Hz, 1H, 3-H), 4.05 (dd, *J* = 8.1, 7.2 Hz, 1H, 4-H$_a$), 4.12 (dd, *J* = 8.1, 3.1 Hz, 1H, 4-H$_b$), 4.98 (d, *J* = 6.5 Hz, 1H, 2-H), 7.17-7.62 (m, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.4, 67.3, 80.9, 114.2, 118.5, 126.6, 128.4, 129.9, 130.7, 139.4, 149.3. EIMS (*m/z*) 254 (M^+). Anal. Calcd for $C_{15}H_{14}N_2O_2$: C, 70.85; H, 5.55; N, 11.02%. Found: C, 70.54; H, 5.75; N, 11.27 %.



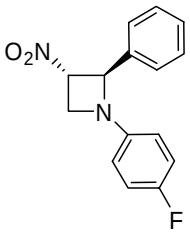
Compound ***trans*-4b:** White solid, yield 92%, mp 169-173 ^{o}C. IR (KBr) υ_{max} 3055, 2997, 1604, 1582, 1456, 754, 708 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.69 (ddd, *J* = 7.4, 6.7, 3.6 Hz, 1H, 3-H), 4.01 (dd, *J* = 8.9, 7.4 Hz, 1H, 4-H_a), 4.15 (dd, *J* = 8.9, 3.6 Hz, 1H, 4-H_b), 4.99 (d, *J* = 6.7 Hz, 1H, 2-H), 7.19-7.68 (m, 5H), 8.09-8.13 (m, 2H, 4-ClPh), 8.12-8.17 (m, 2H, 4-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.7, 67.1, 80.2, 114.6, 118.9, 129.1, 130.4, 131.6, 132.5, 137.9, 149.4. EIMS (*m/z)* 288 (M^+). Anal. Calcd for $C_{15}H_{13}ClN_2O_2$: C, 62.40; H, 4.54; N, 9.70%. Found: C, 62.69; H, 4.88; N, 9.52 %.



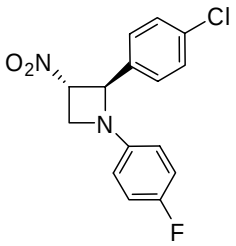
Compound ***trans*-4c:** White solid, yield 90%, mp 164-167 ^{o}C. IR (KBr) υ_{max} 3054, 2995, 1602, 1589, 1451, 757, 702 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.71 (ddd, *J* = 7.1, 6.7, 3.2 Hz, 1H, 3-H), 4.07 (dd, *J* = 8.5, 7.1 Hz, 1H, 4-H_a), 4.19 (dd, *J* = 8.5, 3.2 Hz, 1H, 4-H_b), 4.92 (d, *J* = 6.7 Hz, 1H, 2-H), 7.13-7.60 (m, 5H), 7.65–7.70 (m, 2H, 2-ClPh), 8.11-8.14 (m, 2H, 2-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.1, 57.2, 80.5, 114.8, 118.1, 126.9, 127.9, 129.2, 130.4, 131.2, 134.8, 139.1, 149.7. EIMS (*m/z)* 288 (M^+). Anal. Calcd for $C_{15}H_{13}ClN_2O_2$: C, 62.40; H, 4.54; N, 9.70%. Found: C, 62.77; H, 4.24; N, 9.35 %.



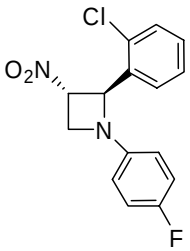
Compound ***trans*-4d:** White solid, yield 89%, mp 172-175 ^{o}C. IR (KBr) υ_{max} 3052, 2992, 1605, 1585, 1455, 750, 705 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.68 (ddd, *J* = 7.7, 6.5, 3.4 Hz, 1H, 3-H), 3.85 (s, 3H, OCH_3), 4.04 (dd, *J* = 8.1, 7.7 Hz, 1H, 4-H_a), 4.15 (dd, *J* = 8.1, 3.4 Hz, 1H, 4-H_b), 4.95 (d, *J* = 6.5 Hz, 1H, 2-H), 7.19-7.64 (m, 5H), 7.63-7.67 (m, 2H, 4-OCH_3Ph), 8.04-8.09 (m, 2H, 4-OCH_3Ph). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.6, 55.9, 67.6, 80.4, 114.2, 115.6, 118.9, 129.1, 130.2, 132.4, 149.2, 158.4. EIMS (*m/z)* 284 (M^+). Anal. Calcd for $C_{16}H_{16}N_2O_3$: C, 67.59; H, 5.67; N, 9.85%. Found: C, 67.40; H, 5.40; N, 10.17 %.



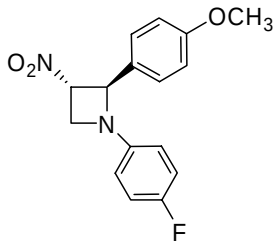
Compound ***trans*-4e:** White solid, yield 82%, mp 171-174 °C. IR (KBr) υ_{max} 3052, 2991, 1607, 1583, 1457, 751, 701 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 3.65 (ddd, *J* = 7.6, 6.9, 3.1 Hz, 1H, 3-H), 4.09 (dd, *J* = 8.2, 7.2 Hz, 1H, 4-H_a), 4.12 (dd, *J* = 8.2, 3.1 Hz, 1H, 4-H_b), 4.96 (d, *J* = 6.5 Hz, 1H, 2-H), 7.17-7.65 (m, 5H), 8.07-8.12 (m, 2H, 4-FPh), 8.15-8.18 (m, 2H, 4-FPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.9, 67.3, 80.2, 115.4, 115.9, 126.4, 127.9, 129.0, 139.6, 145.1, 152.7. EIMS (*m/z)* 272 (M^+). Anal. Calcd for $C_{15}H_{13}FN_2O_2$: C, 66.17; H, 4.81; N, 10.29%. Found: C, 65.97; H, 5.10; N, 10.54%.



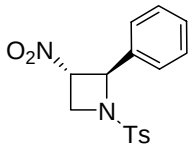
Compound ***trans*-4f:** White solid, yield 91%, mp 173-176 °C. IR (KBr) υ_{max} 3059, 2992, 1604, 1586, 1455, 750, 707 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 3.69 (ddd, *J* = 7.6, 6.5, 3.5 Hz, 1H, 3-H), 4.02 (dd, *J* = 8.4, 7.6 Hz, 1H, 4-H_a), 4.14 (dd, *J* = 8.4, 3.5 Hz, 1H, 4-H_b), 4.92 (d, *J* = 6.5 Hz, 1H, 2-H), 8.06-8.10 (m, 2H, 4-FPh), 8.09-8.13 (m, 2H, 4-ClPh), 8.10-8.17 (m, 2H, 4-ClPh), 8.12-8.19 (m, 2H, 4-FPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.6, 67.0, 80.3, 116.1, 117.4, 128.2, 129.5, 131.9, 138.5, 145.7, 152.1. EIMS (*m/z)* 306 (M^+). Anal. Calcd for $C_{15}H_{12}ClFN_2O_2$: C, 58.74; H, 3.94; N, 9.13%. Found: C, 59.05; H, 3.75; N, 9.34 %.



Compound ***trans*-4g:** White solid, yield 88%, mp 172-176 ^{o}C. IR (KBr) υ_{max} 3052, 2993, 1605, 1587, 1451, 754, 708 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.67 (ddd, *J* = 7.2, 6.6, 3.2 Hz, 1H, 3-H), 4.05 (dd, *J* = 8.2, 7.2 Hz, 1H, 4-H_a), 4.19 (dd, *J* = 8.2, 3.2 Hz, 1H, 4-H_b), 4.98 (d, *J* = 6.6 Hz, 1H, 2-H), 7.68–7.71 (m, 2H, 2-ClPh), 8.05-8.09 (m, 2H, 4-FPh), 8.11-8.15 (m, 2H, 2-ClPh), 8.12-8.17 (m, 2H, 4-FPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.3, 57.5, 80.7, 115.1, 116.9, 127.1, 128.0, 129.2, 130.5, 132.9, 140.1, 145.2, 152.6. EIMS (*m/z)* 306 (M^+). Anal. Calcd for $C_{15}H_{12}ClFN_2O_2$: C, 58.74; H, 3.94; N, 9.13%. Found: C, 59.00; H, 4.26; N, 8.80 %.

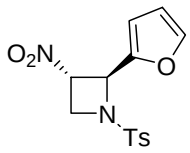


Compound ***trans*-4h:** White solid, yield 87%, mp 177-180 ^{o}C. IR (KBr) υ_{max} 3054, 2995, 1608, 1583, 1455, 759, 705 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.65 (ddd, *J* = 7.7, 6.5, 3.1 Hz, 1H, 3-H), 3.82 (s, 3H, OCH_3), 4.06 (dd, *J* = 8.1, 7.7 Hz, 1H, 4-H_a), 4.18 (dd, *J* = 8.1, 3.1 Hz, 1H, 4-H_b), 4.97 (d, *J* = 6.5 Hz, 1H, 2-H), 7.61-7.65 (m, 2H, 4-OCH_3Ph), 8.04-8.08 (m, 2H, 4-OCH_3Ph), 8.07-8.12 (m, 2H, 4-FPh), 8.12-8.17 (m, 2H, 4-FPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 53.1, 55.2, 67.6, 80.6, 114.5, 116.2, 117.4, 128.9, 132.1, 145.8, 152.2, 158.2. EIMS (*m/z)* 302 (M^+). Anal. Calcd for $C_{16}H_{15}FN_2O_3$: C, 63.57; H, 5.00; N, 9.27%. Found: C, 63.27; H, 4.79; N, 9.56%.



Compound ***trans*-4i:** White solid, yield 91%, mp 171-173 ^{o}C. IR (KBr) υ_{max} 3057, 2990, 1605, 1582, 1457, 756, 705 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 2.41 (s, 3H, CH_3), 3.67 (ddd, *J* = 7.1, 6.6, 3.2 Hz, 1H, 3-H), 4.05 (dd, *J* = 8.4, 7.1 Hz, 1H, 4-H_a), 4.15 (dd, *J* = 8.4, 3.2 Hz, 1H, 4-H_b), 4.94 (d, *J* = 6.5 Hz, 1H, 2-H), 7.17-7.62 (m, 5H, Ph), 7.30 (d, *J* = 8.0 Hz, 2H, Ts), 7.72 (d, *J* = 8.5 Hz, 2H, Ts). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 24.7, 42.9, 55.8, 79.4, 126.1, 127.5, 128.9,

129.8, 131.4, 135.6, 138.6, 141.5. EIMS (*m/z)* 332 (M^+). Anal. Calcd for $C_{16}H_{16}N_2O_4S$: C, 57.82; H, 4.85; N, 8.43%. Found: C, 58.04; H, 4.54; N, 8.13 %.

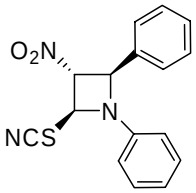


Compound ***trans*-4j:** White solid, yield 88%, mp 167-170 ^oC. IR (KBr) υ_{max} 3052, 2999, 1601, 1585, 1456, 751, 709 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 2.43 (s, 3H, CH_3), 3.65 (ddd, *J* = 7.2, 6.5, 3.1 Hz, 1H, 3-H), 4.05 (dd, *J* = 8.1, 7.2 Hz, 1H, 4-H_a), 4.12 (dd, *J* = 8.1, 3.1 Hz, 1H, 4-H_b), 4.98 (d, *J* = 6.5 Hz, 1H, 2-H), 6.62 (dd, *J* = 3.3, 1.8 Hz, 1H, 3-Furyl), 6.99 (d, *J* = 3.3 Hz, 1H, 3-Furyl), 7.70 (dd, *J* = 1.8 Hz, 1H, 3-Furyl), 7.34 (d, *J* = 8.1 Hz, 2H, Ts), 7.73 (d, *J* = 8.3 Hz, 2H, Ts). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 24.1, 39.4, 54.2, 78.5, 105.2, 110.8, 126.7, 129.8, 136.5, 142.4, 144.8, 152.5. EIMS (*m/z)* 322 (M^+). Anal. Calcd for $C_{14}H_{14}N_2O_5S$: C, 52.17; H, 4.38; N, 8.69%. Found: C, 52.50; H, 4.57; N, 8.25 %.

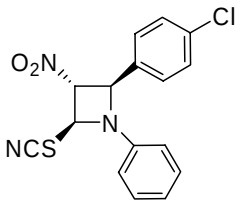
General procedure for the synthesis of 1,2,3,4-tetrasubstituted azetidines 6

To a solution of Baylis Hillman adduct **1** (5 mmol) in dry THF (4 mL) was added IBX (5 mmol) and stirred at rt for 5 h to get α,β-unsaturated aldehyde **3**. Then, to a solution of diethyl *N*-arylphosphoramidate **2** (5 mmol) in dry THF (5 mL) was added dropwise a suspension of NaH (240 mg, 10 mmol) in dry THF (10 mL) with stirring to rt. After the addition was complete and evolution of hydrogen gas (effervescence) had ceased, the reaction mixture was stirred at 60 ^oC for 30 min and then cooled to rt. In this solution was added α,β-unsaturated aldehyde **3** followed by [bmim]X (5 mmol) and the reaction mixture was stirred at rt for 2-4 h. Water (20 mL) was added, the mixture was extracted with ether (3 x 30 mL), the combined organic layers were dried over anhydrous sodium sulfate, filtered, and evaporated under reduced pressure. The crude product thus obtained was purified by silica gel column chromatography (hexane/EtOAc, 95:5) to afford an analytically pure sample of **6**.

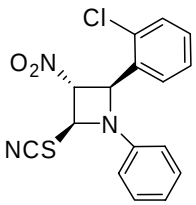
Spectroscopic and analytical data for compounds



Compound ***trans*-6a:** White solid, yield 87%, mp 186-187 ^{o}C. IR (KBr) υ_{max} 3055, 2991, 2198, 1602, 1587, 1455, 755, 700 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.69 (dd, *J* = 7.3, 6.5 Hz, 1H, 3-H), 4.09 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.95 (d, *J* = 6.5 Hz, 1H, 2-H), 7.20-7.61 (m, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 64.4, 65.7, 87.1, 111.4, 114.9, 118.5, 126.7, 127.9, 128.9, 130.1, 138.9, 149.5. EIMS (*m/z)* 311 (M^+). Anal. Calcd for $C_{16}H_{13}N_3O_2S$: C, 61.72; H, 4.21; N, 13.50 %. Found: C, 61.39; H, 3.95; N, 13.74 %.

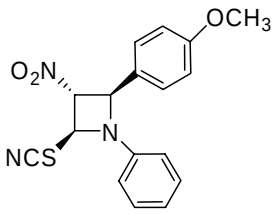


Compound ***trans*-6b:** White solid, yield 94%, mp 181-183 ^{o}C. IR (KBr) υ_{max} 3053, 2991, 2190, 1604, 1585, 1456, 758, 704 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.66 (dd, *J* = 7.7, 6.9 Hz, 1H, 3-H), 4.10 (dd, *J* = 7.7 Hz, 1H, 4-H), 4.91 (d, *J* = 6.9 Hz, 1H, 2-H), 7.22-7.61 (m, 5H), 8.08-8.12 (m, 2H, 4-ClPh), 8.13-8.17 (m, 2H, 4-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 64.5, 65.7, 87.1, 112.1, 114.5, 118.1, 128.7, 129.6, 130.7, 131.9, 137.5, 149.2. EIMS (*m/z)* 345 (M^+). Anal. Calcd for $C_{16}H_{12}ClN_3O_2S$: C, 55.57; H, 3.50; N, 12.15 %. Found: C, 55.76; H, 3.87; N, 11.94%.

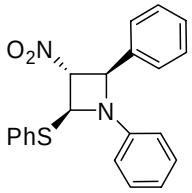


Compound ***trans*-6c:** White solid, yield 88%, mp 179-183 ^{o}C. IR (KBr) υ_{max} 3057, 2995, 2196, 1602, 1582, 1454, 755, 706 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.62 (dd, *J* = 7.5, 6.5 Hz, 1H, 3-H), 4.04 (dd, *J* = 7.5 Hz, 1H, 4-H), 4.98 (d, *J* = 6.5 Hz, 1H, 2-H), 7.24-7.67 (m, 5H), 7.69–7.71 (m, 2H, 2-ClPh), 8.11-8.14 (m, 2H, 2-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 54.4, 65.2, 86.9, 111.5, 114.9, 118.5, 126.9, 127.8, 129.4, 130.6, 131.9, 133.5, 139.2, 149.6. EIMS (*m/z)* 345

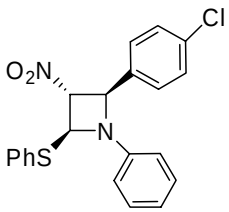
(M^+). Anal. Calcd for $C_{16}H_{12}ClN_3O_2S$: C, 55.57; H, 3.50; N, 12.15 %. Found: C, 55.30; H, 3.72; N, 11.97 %.



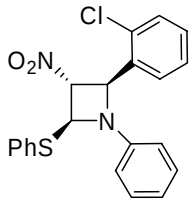
Compound ***trans*-6d:** White solid, yield 91%, mp 185-187 ^oC. IR (KBr) υ_{max} 3055, 2994, 2197, 1601, 1583, 1452, 759, 705 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 3.68 (dd, *J* = 7.6, 6.8 Hz, 1H, 3-H), 3.86 (s, 3H, OCH_3), 4.06 (dd, *J* = 7.6 Hz, 1H, 4-H), 4.97 (d, *J* = 6.8 Hz, 1H, 2-H), 7.19-7.60 (m, 5H), 7.60-7.65 (m, 2H, 4-OCH_3Ph), 8.04-8.09 (m, 2H, 4-OCH_3Ph). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 55.4, 64.2, 65.9, 87.7, 112.2, 114.7, 115.9, 118.5, 128.7, 129.6, 131.9, 148.7, 157.5. EIMS (*m/z)* 341 (M^+). Anal. Calcd for $C_{17}H_{15}N_3O_3S$: C, 59.81; H, 4.43; N, 12.31 %. Found: C, 60.05; H, 4.16; N, 12.61 %.



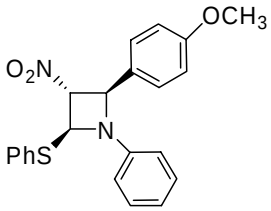
Compound ***trans*-6e:** White solid, yield 84%, mp 189-191 ^oC. IR (KBr) υ_{max} 3059, 2990, 2193, 1605, 1584, 1458, 757, 702 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 3.64 (dd, *J* = 7.2, 6.9 Hz, 1H, 3-H), 4.11 (dd, *J* = 7.2 Hz, 1H, 4-H), 4.95 (d, *J* = 6.9 Hz, 1H, 2-H), 7.20-7.65 (m, 15H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 63.4, 66.3, 86.1, 114.9, 118.2, 125.7, 126.9, 127.8, 129.1, 130.2, 131.0, 132.5, 136.4, 139.2, 149.4. EIMS (*m/z)* 362 (M^+). Anal. Calcd for $C_{21}H_{18}N_2O_2S$: C, 69.59; H, 5.01; N, 7.73 %. Found: C, 69.80; H, 5.28; N, 7.36 %.



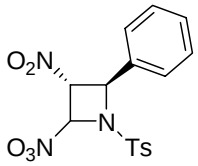
Compound ***trans*-6f:** White solid, yield 93%, mp 184-187 ^{o}C. IR (KBr) υ_{max} 3052, 2992, 2195, 1605, 1584, 1457, 755, 709 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.69 (dd, *J* = 7.1, 6.8 Hz, 1H, 3-H), 4.07 (dd, *J* = 7.1 Hz, 1H, 4-H), 4.91 (d, *J* = 6.8 Hz, 1H, 2-H), 7.19-7.61 (m, 10H), 8.07-8.12 (m, 2H, 4-ClPh), 8.12-8.17 (m, 2H, 4-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 63.5, 66.3, 86.7, 114.1, 118.2, 125.5, 126.9, 128.5, 129.3, 130.6, 131.7, 132.9, 136.4, 138.7, 149.9. EIMS (*m/z)* 396 (M^+). Anal. Calcd for $C_{21}H_{17}ClN_2O_2S$: C, 63.55; H, 4.32; N, 7.06 %. Found: C, 63.23; H, 4.61; N, 7.30 %.



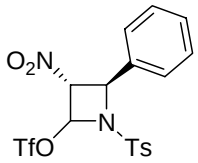
Compound ***trans*-6g:** White solid, yield 87%, mp 188-191 ^{o}C. IR (KBr) υ_{max} 3051, 2996, 2194, 1603, 1581, 1454, 752, 701 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.69 (dd, *J* = 7.3, 6.6 Hz, 1H, 3-H), 4.05 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.99 (d, *J* = 6.6 Hz, 1H, 2-H), 7.23-7.68 (m, 10H), 7.66–7.70 (m, 2H, 2-ClPh), 8.13-8.16 (m, 2H, 2-ClPh). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 54.9, 66.1, 85.5, 114.5, 118.4, 125.7, 126.9, 127.9, 128.8, 130.0, 131.9, 132.8, 133.6, 134.5, 136.4, 139.2, 149.6. EIMS (*m/z)* 396 (M^+). Anal. Calcd for $C_{21}H_{17}ClN_2O_2S$: C, 63.55; H, 4.32; N, 7.06 %. Found: C, 63.29; H, 4.12; N, 7.40 %.



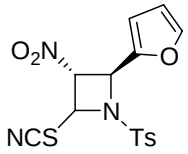
Compound ***trans*-6h:** White solid, yield 90%, mp 183-187 ^{o}C. IR (KBr) υ_{max} 3055, 2995, 2191, 1609, 1583, 1452, 756, 705 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.64 (dd, *J* = 7.4, 6.6 Hz, 1H, 3-H), 3.84 (s, 3H, OCH_3), 4.09 (dd, *J* = 7.4 Hz, 1H, 4-H), 4.93 (d, *J* = 6.6 Hz, 1H, 2-H), 7.20-7.64 (m, 10H), 7.61-7.65 (m, 2H, 4-OCH_3Ph), 8.06-8.10 (m, 2H, 4-OCH_3Ph). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 56.1, 63.2, 66.1, 86.7, 114.3, 115.4, 118.5, 124.9, 126.7, 128.9, 129.7, 130.9, 132.2, 136.5, 149.8, 158.4. EIMS (*m/z)* 392 (M^+). Anal. Calcd for $C_{22}H_{20}N_2O_3S$: C, 67.33; H, 5.14; N, 7.14 %. Found: C, 67.54; H, 5.45; N, 6.95 %.



Compound ***trans*-6i:** White solid, yield 84%, mp 165-167 ^{o}C. IR (KBr) υ_{max} 3054, 2993, 2195, 1601, 1589, 1452, 759, 702 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 2.44 (s, 3-H, CH_3), 3.65 (dd, *J* = 7.5, 6.5 Hz, 1H, 3-H), 4.09 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.95 (d, *J* = 6.5 Hz, 1H, 2-H), 7.20-7.61 (m, 5H), 7.34 (d, *J* = 8.3 Hz, 2H, Ts), 7.71 (d, *J* = 8.5 Hz, 2H, Ts). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 24.6, 49.9, 73.4, 81.5, 126.9, 128.5, 129.8, 131.2, 132.4, 136.9, 139.5, 142.4. EIMS *(m/z)* 393 (M^+). Anal. Calcd for $C_{16}H_{15}N_3O_7S$: C, 48.85; H, 3.84; N, 10.68 %. Found: C, 48.56; H, 3.47; N, 11.04 %.

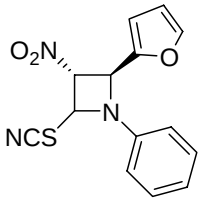


Compound ***trans*-6j:** White solid, yield 89%, mp 162-164 ^{o}C. IR (KBr) υ_{max} 3055, 2996, 2199, 1602, 1581, 1452, 755, 707 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 2.47 (s, 3-H, CH_3), 3.67 (dd, *J* = 7.3, 6.8 Hz, 1H, 3-H), 4.04 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.91 (d, *J* = 6.8 Hz, 1H, 2-H), 7.21-7.64 (m, 5H), 7.31 (d, *J* = 8.2 Hz, 2H, Ts), 7.75 (d, *J* = 8.6 Hz, 2H, Ts). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 24.2, 49.3, 69.1, 83.6, 118.5, 126.7, 127.9, 129.2, 130.9, 132.2, 135.8, 139.4, 141.9. EIMS *(m/z)* 480 (M^+). Anal. Calcd for $C_{17}H_{15}F_3N_2O_7S_2$: C, 42.50; H, 3.15; N, 5.83 %. Found: C, 42.82; H, 3.29; N, 5.67 %.



Compound ***trans*-6k:** White solid, yield 92%, mp 178-180 ^{o}C. IR (KBr) υ_{max} 3056, 2991, 2195, 1607, 1587, 1458, 752, 706 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 2.45 (s, 3-H, CH_3), 3.69 (dd, *J* = 7.3, 6.5 Hz, 1H, 3-H), 4.07 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.94 (d, *J* = 6.5 Hz, 1H, 2-H), 6.64 (dd, *J* = 3.5, 1.8 Hz, 1H, 3-Furyl), 6.95 (d, *J* = 3.5 Hz, 1H, 3-Furyl), 7.72 (dd, *J* = 1.8 Hz, 1H, 3-Furyl), 7.35 (d, *J* = 8.1 Hz, 2H, Ts), 7.74 (d, *J* = 8.4 Hz, 2H, Ts). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 24.8,

51.2, 52.6, 84.1, 105.7, 110.5, 112.4, 126.8, 129.1, 136.8, 140.5, 141.9, 152.5. EIMS (*m/z)* 379 (M^+). Anal. Calcd for $C_{15}H_{13}N_3O_5S_2$: C, 47.48; H, 3.45; N, 11.08 %. Found: C, 47.74; H, 3.16; N, 10.88 %.



Compound ***trans*-6l:** White solid, yield 91%, mp 175-177 ^oC. IR (KBr) υ_{max} 3056, 2994, 2199, 1602, 1583, 1452, 758, 704 cm^{-1}. ^1H NMR (400 MHz; $CDCl_3$) δ = 3.65 (dd, *J* = 7.7, 6.9 Hz, 1H, 3-H), 4.11 (dd, *J* = 7.7 Hz, 1H, 4-H), 4.98 (d, *J* = 6.9 Hz, 1H, 2-H), 6.61 (dd, *J* = 3.2, 1.8 Hz, 1H, 3-Furyl), 6.94 (d, *J* = 3.2 Hz, 1H, 3-Furyl), 7.70 (dd, *J* = 1.8 Hz, 1H, 3-Furyl), 7.20-7.61 (m, 5H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 62.1, 63.4, 85.7, 105.4, 110.4, 112.5,114.1,118.9, 129.2,142.5,148.7, 152.9. EIMS (*m/z)* 301 (M^+). Anal. Calcd for $C_{14}H_{11}N_3O_3S$: C, 55.80; H, 3.68; N, 13.95 %. Found: C, 55.47; H, 4.05; N, 13.68 %.

General procedure for conversion of compound 6a to 6e:

To a solution of compound **6a** (5 mmol) in dry THF (4 mL) was added [bmim]SPh (5 mmol) and the reaction mixture was stirred at rt for 5 h. Water (10 mL) was added, the mixture was extracted with ether (3 x 15 mL), the combined organic layers were dried over anhydrous sodium sulfate, filtered, and evaporated under reduced pressure. The crude products thus obtained was purified by silica gel column chromatography (hexane/EtOAc) to afford an analytically pure sample of **6a** and **6e**.

General procedure for the isolation of alkoxide 8a (Ar^1 = Ar^2 = Ph, EWG = NO_2) as its parent alcohol 9a and its conversion into the corresponding azetidine 4a:

The procedure followed was the same as described above for the synthesis of **4** except that the time of stirring at rt was 2 h instead of 3–5 h for **4**. The alcohol **9a** was obtained with *trans* stereoselectivity. Its *trans* stereochemistry was assigned on the basis of ^1H NMR spectrum and literature precedent. A mixture of NaH (48 mg, 2 mmol) and **9a** (2 mmol) was stirred at rt in dry

THF (15 mL) for 4 h. The product **4a** was isolated in 96% yield, following the same work–up procedure as described above for **4.**

Compound 9a: White solid, yield 42%, mp 156-161 ^{o}C. IR (KBr): υ_{max} 3056, 2997, 1691, 1601, 1589, 1451, 756, 702 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$): δ = 1.29 (t, 6H, *J* = 7.7 Hz, 2 x Me), 3.27 (ddd, 1H, *J* = 6.7, 4.9, 3.6 Hz, 2-H), 3.44 (dd, 1H, *J* = 12.4, 6.7 Hz, 1-Ha), 3.52 (dd, 1H, *J* = 12.4, 3.6 Hz, 1-Hb), 4.16 (q, 4H, *J* = 7.7 Hz, 2 x CH_2), 4.88 (d, 1H, *J* = 4.9 Hz, 3-H), 7.12–7.51 (m, 10H arom.). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 15.2, 41.9, 58.1, 60.4, 92.5, 113.2, 117.8, 126.5, 128.4, 129.7, 130.9, 138.4, 144.6. EIMS (*m/z)* 408 (M^+). Anal. Calcd for $C_{19}H_{25}N_2O_6P$: C, 55.88; H, 6.17; N, 6.86%. Found: C, 55.64; H, 6.47; N, 7.07%.

General procedure for the detosylation of representative azetidines 4i and 6j:

To a solution of compound **4i** (or **6j)** (1 mmol) in dry THF (4 mL) was added SmI_2 (6 mmol), N,N$^{'}$-dimethylpropylene urea (DMPU) (1 mmol) and the reaction mixture was refluxed 1 h. Then, the reaction mixture was cooled and water (10 mL) was added, the mixture was extracted with ether (3 x 15 mL), the combined organic layers were dried over anhydrous sodium sulfate, filtered, and evaporated under reduced pressure. The crude products thus obtained was purified by silica gel column chromatography (hexane/EtOAc) to afford corresponding analytically pure sample of 3-nitro-2-phenyl-1-tosylazetidine and 3-nitro-4-phenyl-1-tosylazetidin-2-yl-trifluoromethanesulfonate respectively.

3-Nitro-2-phenyl-1-tosylazetidine: White solid, yield 84%, mp 145-147 ^{o}C. IR (KBr) υ_{max} 3053, 2992, 1607, 1584, 1452, 751, 702 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.70 (ddd, *J* = 7.1, 6.6, 3.2 Hz, 1H, 3-H), 4.08 (dd, *J* = 8.4, 7.1 Hz, 1H, 4-H_a), 4.19 (dd, *J* = 8.4, 3.2 Hz, 1H, 4-H_b), 4.97 (d, *J* = 6.5 Hz, 1H, 2-H), 7.19-7.65 (m, 5H, Ph). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 44.9, 60.4, 83.7, 126.5, 128.9, 130.1, 139.8. EIMS (*m/z)* 178 (M^+). Anal. Calcd for $C_9H_{10}N_2O_2$: C, 60.66; H, 5.66; N, 15.72%. Found: C, 60.97; H, 5.95; N, 15.40%.

3-Nitro-4-phenyl-1-tosylazetidin-2-yl-trifluoromethanesulfonate: White solid, yield 79%, mp 139-142 ^{o}C. IR (KBr) υ_{max} 3059, 2996, 2194, 1604, 1580, 1452, 759, 701 cm^{-1}. ^{1}H NMR (400 MHz; $CDCl_3$) δ = 3.69 (dd, *J* = 7.3, 6.5 Hz, 1H, 3-H), 4.12 (dd, *J* = 7.3 Hz, 1H, 4-H), 4.96 (d, *J* =

6.5 Hz, 1H, 2-H), 7.24-7.66 (m, 5H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 54.1, 74.3, 86.9, 118.5, 126.2, 128.6, 129.9, 139.4. EIMS (*m/z)* 326 (M^+). Anal. Calcd for $C_{10}H_9F_3N_2O_5S$: C, 36.81; H, 2.78; N, 8.59 %. Found: C, 36.57; H, 3.07; N, 8.89%.