Supplementary Material (ESI) for Chemical Communications

Novel C-C bond formation through addition of ammonium ylides to aldehydes: An facile approach to the β-aryl-β-hydroxy α-amino acids framework

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Supporting Information

General Information. All reactions were carried out under an atmosphere of argon in flame-dried glassware with magnetic stirring. CH_2C1_2 was freshly distilled over calcium hydride. Purification of reaction products was carried out by flash chromatography using 230-400 mesh silica gel 60 (Qindao, China). Analytical thin layer chromatography was performed on silica gel 60 F_{254} plates. Visualization was accomplished with UV light and phosphomolybic acid followed by heating. Melting points are uncorrected. Infrared spectra were recorded on a NICOLET MX-1E FT-IR spectrometer. NMR spectra were obtained on a Bruker spectrometer operating at 300 MHz for ^{1}H NMR and 75 MHz for ^{13}C NMR. Data are reported as s = singlet, d = doublet, t = triplet, q = quartet, m = multiple, br = broad; coupling constant(s) in Hz. Chemical shifts were reported in ppm using tetramethylsilane as

internal standard. High-resolution mass spectra data were obtained on a BRUKER FT-MS spectrometer. Low-resolution mass spectra data were obtained a Finnigan LCQMS spectrometer. Single crystal X-ray data were collected using a Siemens P-4X four-circle diffractometer.

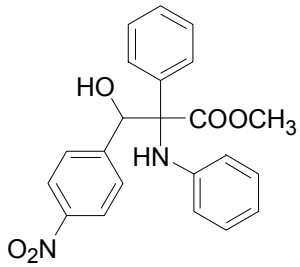
Rhodium(II) acetate was purchased from Strem Chemical Company. Ethyl diazoacetate was purchased from Fluka Chemical Company and used without purification. Methyl Aryl-diazoacetates **1a-c** were prepared according to literature procedures.[1]

General Experimental Procedure for the Rhodium(II)-Catalyzed Reaction:

To a CH_2Cl_2 solution of $Rh_2(OAc)_4$ (0.01 mmol), aldehyde(1.1 or 3 mmol) and arylamine (1.1 mmol) was added methyl phenyl diazoacetate (1.0 mmol) in CH_2Cl_2 via a syringe pump over 1 h under refluxing. After completed addition, the reaction mixture was cooled to room temperature. Solvent was removed and a portion of crude product was subjected to ^1H NMR analysis for determination of the product ratio and diastereoselectivities. The crude product was purified by flash chromatography on silica gel by using EtOAc-light petroleum as eluent to give desired product**.**

Analytical Data:

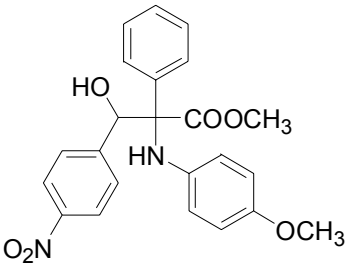
The data of all separable diastereomers (**5c, 5e, 5f, 6b**) and representative inseparable diastereomers (**5b, 5k, 6a**) were reported.



Analytical data for **5b**:

Obtained as a mixture of diastereomers.

R_f = 0.28 (30% EtOAc/ light petroleum); IR (KBr) 3524, 3493, 3392, 3366, 1712, 1693, 1600,1509 cm^{-1}; ^1H NMR (300 MHz, $CDC1_3$): δ 3.65 (s, 3H, erythro, OCH_3), 3.70 (s, 3H, threo, OCH_3), 4.23 (d, J = 5.1 Hz , 1H, erythro, OH), 4.42 (d, J = 2.6 Hz , 1H, threo, OH), 4.84 (br, 1H, NH), 5.13 (br, NH), 5.44 (d, J = 2.3 Hz, 1H, threo, CH), 5.69 (d, J = 4.7 Hz, 1H, erythro, CH), 6.58–6.66 (m, 4H), 6.73-6.82 (m, 2H), 7.00-7.25 (m, 18H), 7.90 (d, J = 8.7 Hz, 2H), 7.99 (d, J = 8.7 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 52.8, 53.0, 71.0, 71.7, 76.7, 78.4, 115.7, 116.9, 119.3, 119.4, 122.2, 122.4, 127.9, 128.1, 128.4, 128.5, 128.6, 128.8, 129.0, 129.2, 135.2, 135.5, 144.6, 144.8, 145.1, 145.5, 147.4, 147.6, 174.3, 174.6. MS (m/z, ESI): 393.0 $[M+H]^+$ (100%).

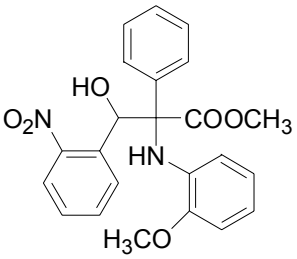


Analytical data for **5c**.

***erythro*-5c:** R_f = 0.18 (30% EtOAc/ light petroleum); mp = 116.0-116.1 °C; IR (KBr) 3489, 3408, 1695, 1606, 1516 cm^{-1}; ^1H NMR (300 MHz, $CDC1_3$): δ 3.63 (s, 3H), 3.73 (s, 3H), 5.62 (s, 1H),), 6.60–6.73 (m, 4H), 7.04 (d, J = 8.7 Hz, 2H), 7.11–7.31 (m, 5H), 7.98 (d, J = 8.7 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 52.7, 55.7, 71.5, 76.5, 114.5, 117.7, 122.3, 127.8, 127.9, 128.4, 128.9, 135.7, 138.2, 145.6, 147.5, 153.4, 174.9.

***threo*-5c**: R_f = 0.25 (30% EtOAc/ light petroleum); mp = 107.6-107.8 °C; IR (KBr) 3514, 3350, 1708, 1595, 1512 cm^{-1}; ^1H NMR (300 MHz, $CDC1_3$): δ 3.65 (s, 3H), 3.72 (s, 3H), 4.56 (d, J = 2.3 Hz , 1H), 4.79 (br, 1H), 5.44 (d, J = 2.1 Hz , 1H), 6.63–6.68 (m, 4H), 7.03–7.27 (m, 7H), 7.90 (d, J = 7.0 Hz , 2H), ^{13}C NMR (75 MHz, $CDC1_3$): δ 52.5, 55.5, 72.6,

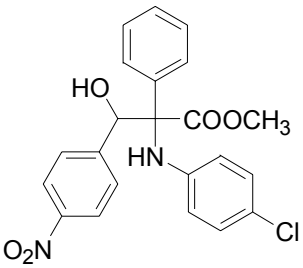
77.5, 114.1, 119.3, 122.1, 127.9, 128.0, 128.3, 128.9, 135.8, 137.7, 145.2, 147.3, 153.9, 174.1. MS (m/z, ESI): 423.0 $[M+H]^+$ (100%).



Analytical data for **5e**.

***erythro*-5e:** R_f = 0.44 (30% EtOAc/ light petroleum); mp = 138.8-139.2 °C; IR (KBr) 3521, 3382, 1731, 1601, 1509 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ 3.58 (s, 3H), 3.74 (d, J = 5.1 Hz, 1H), 3.89 (s, 3H), 5.74 (s, 1H), 6.31-6.34 (m, 2H), 6.55-6.80 (m, 4H), 6.95 –6.98 (m, 1H), 7.21-7.37 (m, 7H), 7.80 (d, J = 8.0 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 52.8, 55.8, 71.5, 71.6, 109.7, 114.1, 118.4, 120.3, 123.9, 127.6, 128.0, 128.5, 128.6, 130.3, 131.7, 133.1, 134.4, 134.8, 147.9, 149.4, 173.7. HRMS (ESI) calcd for $C_{23}H_{23}N_2O_6$ (M+H) 423.1556, Found: 423.1553.

***threo*-5e:** R_f = 0.40 (30% EtOAc/ light petroleum); mp = 118.0-118.3 °C**;** IR (KBr) 3471, 3383, 1704, 1600, 1519 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$): δ 3.69 (s, 3H), 3.96 (s, 3H), 4.18 (d, J = 3.1 Hz, 1H), 6.08 (s, 1H), 6.17-6.20 (m, 1H), 6.51-7,51 (m, 11H), 7.87 (d, J = 8.0 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 52.6, 55.8, 71.3, 71.8, 109.5, 115.3, 118.0, 120.2, 123.5, 127.8, 128.0, 128.1, 128.4, 130.2, 131.8, 132.5, 134.1, 134.4, 148.1, 149.1,174.2. HRMS (ESI) calcd for $C_{23}H_{23}N_2O_6$ (M+H) 423.1556, Found: 423.1552.

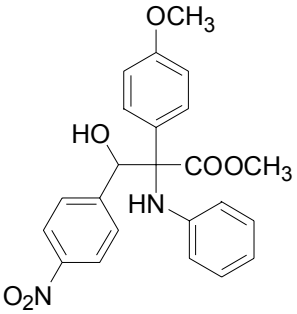


Analytical data for **5f**.

***erythro*-5f:** R_f = 0.31 (50% EtOAc/ light petroleum); IR (KBr) 3501, 3410, 1721, 1604, 1518 cm^{-1}; ^1H NMR (300 MHz, $CDC1_3$): δ

3.66 (s, 3H), 3.98 (d, J = 5.1 Hz, 1H), 4.97 (br, 1H), 5.58 (d, J = 5.0 Hz, 1H), 6.53 (d, J = 8.7 Hz, 2H), 7.05–7.36 (m, 9H), 8.03 (d, J = 8.6 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 29.8, 53.1, 71.2, 77.5, 117.1, 122.6, 128.1, 128.4, 128.7, 129.0, 129.1, 135.3, 143.4, 145.4, 147.8, 173.9.

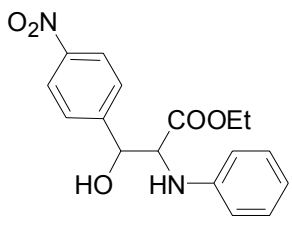
***threo*-5f**: R_f = 0.37 (50% EtOAc/ light petroleum); IR (KBr) 3470, 3380, 1701, 1595, 1501 cm^{-1}; ^{1}H NMR (300 MHz, $CDC1_3$): δ 3.74 (s, 3H), 4.25 (d, J = 2.9 Hz, 1H), 5.17 (br, 1H), 5.43 (d, J = 2.9 Hz, 1H), 6.49 (d, J = 8.8 Hz, 2H), 6.98-7.21 (m, 9H), 7.92 (d, J = 8.6 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 29.8, 52.9, 71.8, 78.7, 118.1, 122.4, 128.0, 128.3, 128.5, 128.7, 128.8, 134.8, 143.3, 144.7, 147.6, 174.2. MS (m/z, ESI): 426.5 $[M]^+$(100%).



Analytical data for **5k**:

Obtained as a mixture of diastereomers.

R_f = 0.44 (50% EtOAc/ light petroleum); IR (KBr) 3404 (br), 1727 (br), 1602, 1512 cm^{-1}; ^{1}H NMR (300 MHz, $CDC1_3$ + D_2O): δ 3.63 (s, 3H, erythro, OCH_3), 3.69 (s, 2.5H, threo, OCH_3), 3.77 (s, 2.5H, threo, OCH_3), 3.80 (s, 3H, erythro, OCH_3), 5.41(s, 1H, threo, CH), 5.61 (s, 1H, erythro, CH), 6.56-6.79 (m, ArH), 7.00-7.26 (m, ArH), 7.94 (d, J = 8.8 Hz, 1.6H), 8.00 (d, J = 8.8 Hz, 2H); MS (m/z, ESI): 422.7 $[M]^+$(100%).

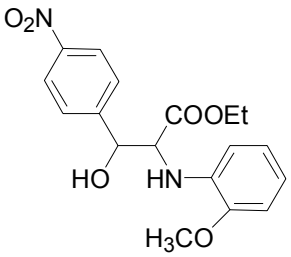


Analytical data for **6a**:

Obtained as 34:66 mixture of diastereomers.

Major diastereomer:

R_f = 0.28 (30% EtOAc/ light petroleum); ^{1}H NMR (300 MHz, $CDC1_3$): δ 1.55 (t, *J* = 7.1 Hz 3H), 3.41 (br, 1H), 4.09-4.18 (m, 2H), 4.21 (d, *J* = 4.5 Hz, 1H), 5.16 (d, *J* = 4.5 Hz, 1H), 6.55–6.57 (m, 2H), 6.69–6.78 (m, 1H), 7.10–7.19 (m, 2H), 7.60 (d, *J* = 8.6 Hz, 2H), 8.18 (d, *J* = 8.7 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$) δ 14.1, 62.0, 65.6, 73.5, 114.5, 119.8, 123.6, 127.4, 129.5, 146.3, 147.3, 171.8. MS (m/z, ESI): 331.1$[M+1]^+$(100%).



Analytical data for **6b**.

Major diastereomer: R_f = 0.31 (30% EtOAc/ light petroleum); IR (film) 3377, 1727, 1597, 1510 cm^{-1}; ^{1}H NMR (300 MHz, $CDC1_3$): δ 1.06 (t, *J* = 7.1 Hz 3H), 3.87 (s, 3H), 3.38 (d, *J* = 6.6 Hz, 1H, OH), 4.02-4.06 (m, 2H), 4.40-4.44 (m, 1H), 5.08 (d, *J* = 8.9 Hz, 1H, NH), 5.25–5.29 (m, 1H), 6.67–6.83 (m, 4H), 7.58 (d, *J* = 8.7 Hz, 2H), 8.23 (d, *J* = 8.7 Hz, 2H); ^{1}H NMR (300 MHz, $CDC1_3$ + D_2O): δ 1.06 (t, *J* = 7.1 Hz 3H), 3.87 (s, 3H), 3.38 (d, *J* = 6.6 Hz, 1H, OH), 4.02-4.06 (m, 2H), 4.41 (d, *J* = 4.7 Hz, 1H), 5.26 (d, *J* = 4.6 Hz, 1H), 6.67–6.83 (m, 4H), 7.58 (d, *J* = 8.7 Hz, 2H), 8.23 (d, *J* = 8.7 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 14.4, 55.7, 61.7, 62.6, 73.3, 110.3, 111.8, 119.2, 121.3, 123.6, 127.3, 135.9, 147.4, 147.8, 171.1.

Minor diastereomer: R_f = 0.27 (30% EtOAc/ light petroleum); IR (film) 3409, 1717, 1658, 1601, 1509 cm^{-1}; ^{1}H NMR (300 MHz, $CDC1_3$): δ 1.13 (t, *J* = 7.1 Hz 3H), 3.87 (s, 3H), 4.06-4.16 (m, 2H), 4.22 (d, *J* = 5.1 Hz, 1H), 5.15 (d, *J* = 5.1 Hz, 1H), 6.41–6.44 (m, 1H), 6.73–6.81 (m, 3H), 7.61 (d, *J* = 8.7 Hz, 2H), 8.21 (d, *J* = 8.7 Hz, 2H); ^{13}C NMR (75 MHz, $CDC1_3$): δ 14.2, 55.7, 61.9, 63.5, 73.7, 110.2, 111.7, 119.2, 121.1, 123.7, 127.5, 136.1, 147.3, 147.8, 171.7.

Supplementary Material (ESI) for Chemical Communications

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1. H. M. L. Davies, T. J. Clark, H. D Smith, *J. Org. Chem*., 1991, **56,** 3817.