Three-Component Reaction of Aryl Diazoacetates, Alcohols and Aldehydes (or Imines): Evidence of Alcoholic Oxonium Ylides Intermediates

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Supporting Information

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General methods. HRMS (ESI) Mass spectra were recorded on BRUCKER FT-MS. NMR spectra was recorded on a Bruker-300MHz spectrometer. Dichloromethane was distilled over calcium hydride. All reactions were handled under Ar.

General procedure for the three-component reaction of aryl diazoacetates, alcohols and aldehydes (or imines): To a 8 mL CH₂Cl₂ solution of Rh(II) catalyst (0.01 mmol), alcohol **2** (1.1 mmol or 1.0 mmol) and **3** (or **9**) (1.1 mmol or 1.5 mmol) was added methyl aryl diazoacetate **1** (1.0 mmol or 1.3 mmol) in 4 mL of CH₂Cl₂ 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. The crude product was purified by flash chromatography on silica gel by using petroleum ether:EtOAc=10:1 as eluent to give three-component products **7+8** (or **10+11**).

Diastereoisomers **7a/8a**, **7b/8b**, **7d/8d**, **7e/8e**, **7g/8g**, **7h/8h**, **7i/8i**, **7l/8l**, **10a/11a**, **10b/11b**, **10c/11c** and **10d/11d** cannot be separated by flash chromatography on silica gel and characterized as mixtures.

Procedure for preparation of 7i/8i: To a 8 mL CH₂Cl₂ solution of Rh₂(OAc)₄ catalyst (0.01 mmol), benzyl alcohol (1.1 mmol), *p*-anisaldehyde (1.1 mmol) and Ti(O^{*i*}Pr)₄ was added methyl phenyldiazoacetate (1.0 mmol) in 4 mL of CH₂Cl₂ via a syringe pump over 1 h under refluxing. After completed addition, the reaction mixture was cooled to room temperature and addition 10 mL CH₂Cl₂ was added, the reaction mixture was washed with 20 mL saturated aqueous NH₄Cl and the aqueous phase was extracted with 20 mL of CH₂Cl₂ (3×), and the combined organic phase was dried over anhydrous MgSO₄. After filtration, the solvent was removed, and a portion of crude product was subjected to ¹H NMR analysis for determination of the product ratio. The crude product was purified by flash chromatography on silica gel by using petroleum ether:EtOAc=10:1 as eluent to give three-component products **7i+8i**.

Table 1. The diagnostic ^1H NMR assignments ($J_{\text{CH-OH}}$) of compounds **7a-j** and **8a-j** ($J_{\text{CH-OH}}$ of isomers **7** larger than $J_{\text{CH-OH}}$ of **8**)

	7 ($J_{\text{CH-OH}}$ Hz) threo-	8 ($J_{\text{CH-OH}}$ Hz) erythro-
a	6.0	3.9
b	6.0	3.9
c	8.1	5.4
d	6.0	3.6
e	6.0	No detection.
f	7.5	5.4
g	6.3	4.2
h	6.0	3.9
i	6.3	4.5
j^a	6.3 (X-ray structure available)	4.8
k	6.0	3.6
l	6.0	3.3

^a The coupling constants were determined by the crude ^1H NMR of the reaction mixture, see S9.

Table 2. The diagnostic ^{13}C NMR assignments ($\delta_{\text{CH-NHAr}}$) of compounds **10a-d** and **11a-d** ($\delta_{\text{CH-NHAr}}$ of isomers **10** larger than $\delta_{\text{CH-NHAr}}$ of **11**)

	10 ($\delta_{\text{CH-NHAr}}$ ppm) erythro-	11 ($\delta_{\text{CH-NHAr}}$ ppm) threo-
a	64.2	65.5
b	64.0	65.3
c	65.4	66.5
d	68.1	68.2

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(benzoxyl, phenyl)-3-hydroxyl-4-nitrophenylpropionate (7a+8a)
 (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (7.99 (d, $J = 8.7$ Hz, 2 H); threo-, **7a**), 7.93 (d, $J = 8.7$ Hz, 2 H; erythro-, **8a**), 7.37-7.19 (m, 10 H), (7.37-7.19 (m, 12 H)), 7.06 (d, $J = 8.7$ Hz, 2 H), 5.45 (d, $J = 3.9$ Hz, 1 H), (5.44 (d, $J = 6.0$ Hz, 1 H)), (4.94 (d, $J = 11.4$ Hz, 1 H)), 4.64 (d, $J = 11.4$ Hz, 1 H), (4.48 (d, $J = 11.4$ Hz, 1 H)), 4.46 (d, $J = 11.4$ Hz, 1 H), (3.79 (s, 3 H)), 3.79 (s, 3 H), (3.73 (d, $J = 6.0$ Hz, 1 H)), 3.65 (d, $J = 3.9$ Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ (172.3), 171.3, (147.5), 147.4, (145.8), 145.5, (138.2), 137.7, (135.4), 133.8, (129.0), (128.9), 128.81, (128.78), 128.6, 128.5(overlap), 128.2, 127.91, (127.88), (127.7), 127.34, (127.32), (127.2), (122.4), 122.2, (88.04), 88.00, (79.1), 77.7, (69.3), 68.3, (52.7), 52.5; HRMS: calcd for $\text{C}_{23}\text{H}_{21}\text{NO}_6$: 407.1369; found: 407.1358 $[\text{M}+\text{NH}_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-4-nitrophenylpropionate (7b+8b) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (7.98 (d, J = 9.0 Hz, 2 H); threo-, **7b**), 7.92 (d, J = 9.0 Hz, 2 H; erythro-, **8b**), (7.33-7.19 (m, 9 H)), 7.33-7.19 (m, 7 H), 7.04 (d, J = 9.0 Hz, 2 H), 6.89 (d, J = 9.0 Hz, 2 H), (6.87 (d, J = 9.0 Hz, 2 H)), (5.42 (d, J = 6.0 Hz, 1 H)), (5.42 (d, J = 3.9 Hz, 1 H)), (4.84 (d, J = 11.1 Hz, 1 H)), 4.55 (d, J = 10.8 Hz, 1 H), (4.39 (d, J = 11.1 Hz, 1 H)), 4.37 (d, J = 10.8 Hz, 1 H), (3.80 (s, 3 H)), 3.79 (s, 3 H), (3.74 (d, J = 6.0 Hz, 1 H)), 3.69 (d, J = 3.9 Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ (172.3), 171.3, 159.4, (159.3), (147.44), 147.37, (145.9), 145.6, (135.5), 134.0, (130.3), 129.8, 129.05, (129.04), 129.00, (128.82), 128.77, (128.70), (128.4), 128.3, 127.9, (127.3), (122.4), 122.1, 113.94, (113.87), 88.0, (87.9), (79.0), 77.7, (69.0), 68.0, 55.4, (55.4), (52.6), 52.4; HRMS: calcd for $\text{C}_{24}\text{H}_{23}\text{NO}_7$: 437.1475; found: 437.1464 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) Methyl 2,2-(hydroxyl, phenyl)-3-hydroxyl-4-nitrophenylpropionate (7c, threo-) ^1H NMR (300 MHz, CDCl_3) δ 7.93 (d, J = 8.7 Hz, 2 H), 7.47-7.43 (m, 2 H), 7.26-7.23 (m, 3 H), 7.19 (d, J = 8.7 Hz, 2 H), 5.50 (d, J = 8.1 Hz, 1 H), 4.09 (s, 1 H), 3.92 (s, 3 H), 3.31 (d, J = 8.1 Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ 174.0, 147.4, 145.5, 137.1, 128.9, 128.6, 128.5, 125.7, 122.6, 81.9, 77.6, 54.0; HRMS: calcd for $\text{C}_{16}\text{H}_{15}\text{NO}_6$: 317.0899; found: 317.0883 $[\text{M} + \text{NH}_4]^+$.

(2S*,3S*) Methyl 2,2-(hydroxyl, phenyl)-3-hydroxyl-4-nitrophenylpropionate (8c, erythro-) ^1H NMR (300 MHz, CDCl_3) δ 8.14 (d, J = 8.7 Hz, 2 H), 7.66-7.63 (m, 2 H), 7.49 (d, J = 8.7 Hz, 2 H), 7.42-7.36 (m, 3 H), 5.44 (d, J = 5.4 Hz, 1 H), 3.72 (s, 3 H), 3.70 (s, 1 H), 3.03 (d, J = 5.4 Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.9, 147.9, 145.6, 137.4, 129.0, 128.9, 128.7, 126.5, 123.0, 81.2, 77.3, 53.5. HRMS: calcd for $\text{C}_{16}\text{H}_{15}\text{NO}_6$: 317.0899; found: 317.0886 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(4-methoxyl, phenyl)-3-hydroxyl-4-nitrophenylpropionate (7d+8d) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (8.04-7.99 (m, 2 H); threo-, **7d**), 7.96-7.93 (m, 2 H; erythro-, **8d**), 7.31-7.14 (m, 5 H), (7.34-7.14 (m, 7 H)), 7.06-7.02 (m, 2 H), 5.36 (d, J = 4.5 Hz, 1 H), (5.36 (d, J = 4.5 Hz, 1 H)), 3.83 (s, 3 H), (3.83 (s, 3 H)), (3.68 (d, J = 6.0 Hz, 1 H)), 3.67 (d, J = 3.6 Hz, 1 H), (3.48 (s, 3 H)), 3.38 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3) δ (172.3), 171.4, (147.44), 147.38, (145.8), 145.6, (135.1), 133.8, (129.0), (128.8), 128.7, 128.6, (128.3), 128.1, 127.8, (127.2), (122.4), 122.2, 88.04, (88.02), 79.1, (77.4), (55.4), 54.3, (52.7), 52.5. HRMS: calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_6$: 331.1056; found: 331.1047 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(tert-butoxyl, phenyl)-3-hydroxyl-2,4-dinitrophenylpropionate (7e+8e) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ 8.67 (d, J = 2.4 Hz, 1 H; threo-, **7e**), (8.62 (d, J = 2.1 Hz, 1 H; erythro-, selected NMR data of **8e**)), 8.34 (dd, J = 8.7, 2.4 Hz, 1 H), (7.88 (dd, J = 8.4, 2.1 Hz, 1 H)), 7.76 (d, J = 8.7 Hz, 1 H), 7.64-7.60 (m, 2 H), 7.42-7.36 (m, 2 H), 6.34 (d, J = 6.0 Hz, 1 H), (3.94 (s, 3 H)), 3.63 (s, 3 H), 3.46 (d, J = 6.0 Hz), (1.11 (s, 9 H)), 1.00 (s, 9 H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.3, 150.4, 147.2, 141.3, 138.4, 130.2, 129.0, 128.6, 128.4, 125.5, 119.4 (118.9, selected NMR data of isomer **8e**), 86.1, 80.5, 74.6, (52.9) 51.9, 29.8. HRMS: calcd for $\text{C}_{20}\text{H}_{22}\text{N}_2\text{O}_8$: 418.1376; found: 418.1364 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-2-nitrophenylpropionate (7f, threo-) ^1H NMR (300 MHz, CDCl_3) δ 7.65-7.61 (m, 2 H), 7.50-7.45 (m, 1 H), 7.36-7.24 (m, 6 H), 7.14 (d, J = 8.4 Hz, 2 H), 6.84 (d, J = 8.4 Hz, 2 H), 6.41 (d, J = 7.5 Hz, 1 H), 4.67 (d, J = 11.1 Hz, 1 H), 4.24 (d, J = 11.1 Hz, 1 H),

3.86 (d, $J = 7.5$ Hz, 1 H), 3.79 (s, 3 H), 3.76 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.2, 159.1, 149.9, 135.2, 133.3, 131.8, 130.2, 129.6, 129.2, 128.8, 128.5, 128.4, 127.6, 123.9, 113.6, 88.2, 73.1, 68.9, 55.3, 52.5; HRMS: calcd for $\text{C}_{24}\text{H}_{23}\text{NO}_7$: 437.1475; found: 437.1464 $[\text{M} + \text{NH}_4]^+$.

(2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-2-nitrophenylpropionate (8f, erythro-) ^1H NMR (300 MHz, CDCl_3) δ 7.67-7.64 (m, 1 H), 7.30-7.25 (m, 2 H), 7.24-7.14 (m, 5 H), 7.03-7.00 (m, 2 H), 6.88-6.84 (m, 3 H), 6.46 (d, $J = 5.4$ Hz, 1 H), 4.40 (s, 2 H), 3.80 (s, 3 H), 3.59 (s, 3 H), 3.33 (d, $J = 5.4$ Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ 171.7, 159.1, 150.1, 133.8, 132.5, 131.1, 129.9, 129.8, 129.0, 128.6, 128.4, 128.2, 127.4, 123.5, 113.7, 87.9, 70.8, 68.3, 55.3, 52.5; HRMS: calcd for $\text{C}_{24}\text{H}_{23}\text{NO}_7$: 437.1475; found: 437.1468 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-4-trifluoromethylphenylpropionate (7g+8g) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ 7.43-7.17 (m, 9 H; erythro-, **8g**), (7.43-7.17 (m, 11 H); threo-, **7g**), 7.03 (d, $J = 8.4$ Hz, 2 H), 6.90 (d, $J = 8.4$ Hz, 2 H), (6.89 (d, $J = 8.4$ Hz, 2 H)), 5.38 (d, $J = 4.2$ Hz, 1 H), (5.37 (d, $J = 6.3$ Hz, 1 H)), (4.84 (d, $J = 11.1$ Hz, 1 H)), 4.57 (d, $J = 10.8$ Hz, 1 H), 4.36 (d, $J = 10.8$ Hz, 1 H), (4.35 (d, $J = 11.1$ Hz, 1 H)), 3.802 (s, 3 H), (3.796 (s, 3 H)), (3.78 (s, 3 H)), 3.76 (s, 3 H), (3.61 (d, $J = 6.3$ Hz, 1 H)), 3.57 (d, $J = 4.2$ Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ (172.5), 171.5, 159.4, (159.3), (142.5), 142.3, (135.7), 134.5, (130.5), 130.1, 129.9 (q, $^2J(\text{C},\text{F}) = 32$ Hz), (129.8 (q, $^2J(\text{C},\text{F}) = 32$ Hz)), 129.1, (129.0), (128.7), 128.6, (128.52), 128.47, 128.32, (128.29), 127.9, (127.5), 124.33 (q, $^1J(\text{C},\text{F}) = 270$ Hz), (124.32 (q, $^1J(\text{C},\text{F}) = 270$ Hz)), (124.2 (q, $^3J(\text{C},\text{F}) = 4$ Hz)), 124.0 (q, $^3J(\text{C},\text{F}) = 4$ Hz), 114.0, (113.9), (88.2), 88.0, (79.2), 78.1, (68.9), 67.9, (55.4), 55.4, (52.6), 52.3; HRMS: calcd for $\text{C}_{25}\text{H}_{23}\text{F}_3\text{O}_5$: 460.1498; found: 460.1490 $[\text{M} + \text{NH}_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-4-cyanophenylpropionate (7h+8h) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (7.43 (d, $J = 8.4$ Hz, 2 H); threo-, **7h**), 7.37 (d, $J = 8.4$ Hz, 2 H; erythro-, **8h**), 7.33-7.15 (m, 7 H), (7.33-7.15 (m, 9 H)), 6.99 (d, $J = 8.4$ Hz, 2 H), 6.92-6.87 (m, 2 H), (6.91-6.86 (m, 2 H)), 5.38 (d, $J = 3.9$ Hz, 1 H), (5.38 (d, $J = 6.0$ Hz, 1 H)), (4.83 (d, $J = 11.1$ Hz, 1 H)), 4.56 (d, $J = 10.8$ Hz, 1 H), (4.38 (d, $J = 11.1$ Hz, 1 H)), 4.36 (d, $J = 10.8$ Hz, 1 H), 3.82 (s, 3 H), (3.81 (s, 3 H)), 3.79 (s, 3 H), (3.79 (s, 3 H)), (3.62 (d, $J = 6.0$ Hz, 1 H)), 3.58 (d, $J = 3.9$ Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ (172.2), 171.3, 159.24, (159.16), (143.8), 143.7, (135.4), 134.0, (131.0), 130.7, (130.3), 129.8, 129.92, (128.89), 128.8, (128.7), 128.6, (128.5), (128.3), 128.2, 127.7, (127.3), 118.94, (118.87), 113.83, (113.76), (113.3), 111.2, 87.9, (87.9), (79.0), 77.6, (68.8), 67.8, 55.3, (55.3), (52.5), 52.3; HRMS: calcd for $\text{C}_{25}\text{H}_{23}\text{NO}_5$: 417.1576; found: 417.1563 $[\text{M} + \text{Na}]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-hydroxyl-4-methoxyphenylpropionate (7i+8i) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (7.36-7.14 (m, 10 H); threo-, **7i**), 7.36-7.24 ((m, 10 H); erythro-, **8i**), (7.01 (d, $J = 8.7$ Hz, 2 H)), 6.87 (d, $J = 8.7$ Hz, 2 H), (6.71 (d, $J = 8.7$ Hz, 2 H)), 6.67 (d, $J = 8.7$ Hz, 2 H), (5.31 (d, $J = 6.3$ Hz, 1 H)), 5.30 (d, $J = 4.5$ Hz, 1 H), (4.92 (d, $J = 11.7$ Hz, 1 H)), 4.65 (d, $J = 11.4$ Hz, 1 H), (4.44 (d, $J = 11.7$ Hz, 1 H)), 4.42 (d, $J = 11.4$ Hz, 1 H), (3.80 (s, 3 H)), (3.76 (s, 3 H)), 3.75 (s, 3 H), 3.74 (s, 3 H), (3.37 (d, $J = 6.3$ Hz, 1 H)), 3.33 (d, $J = 4.5$ Hz, 1 H); ^{13}C NMR (75 MHz, CDCl_3) δ 172.6, (171.8), (159.25), 159.23, 138.7, (138.3), 135.8, (135.0), (130.5), 130.4, 129.3, (129.2), (128.6), (128.44), 128.39, 128.36, 128.1, (128.1), 117.7, (127.7), (127.6), 127.5, 127.3, (127.3), 112.9,

(112.7), 88.6, (88.1), 79.5, (78.4), 68.9, (68.0), 55.3, (55.2), 52.5, (52.2); HRMS: calcd for $C_{24}H_{24}O_5$: 392.1624; found: 392.1607 $[M+Na]^+$.

(2S*,3R*) Methyl 2,2-(benzoxyl, phenyl)-3-hydroxyl-2,4-dinitrophenylpropionate (7j, threo-) 1H NMR (300 MHz, $CDCl_3$) δ 8.47 (d, $J = 2.4$ Hz, 1 H), 8.30 (dd, $J = 8.7, 2.4$ Hz, 1 H), 7.90 (d, $J = 8.7$ Hz, 1 H), 7.39-7.17 (m, 10 H), 6.49 (s, 1 H), 4.71 (d, $J = 11.4$ Hz, 1 H), 4.34 (d, $J = 11.4$ Hz, 1 H), 4.10-3.92 (br, 1 H), 3.78 (s, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.9, 149.6, 147.2, 140.3, 137.4, 134.6, 131.5, 129.4, 128.9, 128.4, 127.9, 127.7, 127.5, 125.8, 119.3, 87.9, 73.1, 69.6, 52.8; HRMS: calcd for $C_{23}H_{20}N_2O_8$: 452.1220; found: 452.1211 $[M+NH_4]^+$.

(2S*,3S*) Methyl 2,2-(benzoxyl, phenyl)-3-hydroxyl-2,4--dinitrophenylpropionate (8j, erythro-) 1H NMR (300 MHz, $CDCl_3$) δ 8.53 (d, $J = 2.4$ Hz, 1 H), 7.96 (dd, $J = 8.7, 2.4$ Hz, 1 H), 7.38-7.19 (m, 8 H), 6.99 (d, $J = 8.7$ Hz, 1 H), 6.91 (d, $J = 8.7$ Hz, 2 H), 6.60 (s, 1 H), 4.55 (d, $J = 12.3$ Hz, 1 H), 4.47 (d, $J = 12.3$ Hz, 1 H), 3.55 (s, 3 H), 3.39 (s, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.4, 149.7, 147.0, 139.4, 137.3, 132.9, 131.6, 128.9, 128.5, 128.3, 127.9, 127.7, 127.4, 124.9, 118.9, 87.9, 70.6, 69.1, 52.8; HRMS: calcd for $C_{23}H_{20}N_2O_8$: 452.1220; found: 452.1205 $[M+NH_4]^+$.

(2S*,3R*) Methyl 2,2-(benzoxyl, 4-methoxyphenyl)-3-hydroxyl-4-nitrophenylpropionate (7k, threo-) 1H NMR (300 MHz, $CDCl_3$) δ 8.04-8.01 (m, 2 H), 7.35-7.25 (m, 7 H), 7.20-7.17 (m, 2 H), 6.85-6.82 (m, 2 H), 5.39 (d, $J = 6.0$ Hz, 1 H), 4.87 (d, $J = 11.4$ Hz, 1 H), 4.42 (d, $J = 11.4$ Hz, 1 H), 3.80 (s, 3 H), 3.78 (s, 3 H), 3.63 (d, $J = 6.0$ Hz, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.4, 159.9, 147.5, 146.0, 138.3, 129.1, 128.8, 128.5, 127.7, 127.4, 127.1, 122.5, 113.8, 87.9, 79.1, 69.0, 55.4, 52.7; HRMS: calcd for $C_{24}H_{23}NO_7$: 437.1475; found: 437.1460 $[M+NH_4]^+$.

(2S*,3S*) Methyl 2,2-(benzoxyl, 4-methoxyphenyl)-3-hydroxyl-4-nitrophenylpropionate (8k, erythro-) 1H NMR (300 MHz, $CDCl_3$) δ 7.95 (d, $J = 9.0$ Hz, 2 H), 7.36-7.30 (m, 5 H), 7.15 (d, $J = 9.0$ Hz, 2 H), 7.09 (d, $J = 9.0$ Hz, 2 H), 6.81 (d, $J = 9.0$ Hz, 2 H), 5.41 (d, $J = 3.6$ Hz, 1 H), 4.61 (d, $J = 11.4$ Hz, 1 H), 4.42 (d, $J = 11.4$ Hz, 1 H), 3.80 (s, 3 H), 3.78 (s, 3 H), 3.64 (d, $J = 3.6$ Hz, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.3, 159.8, 147.4, 145.7, 137.8, 129.6, 128.8, 128.5, 127.8, 127.4, 125.8, 122.2, 113.3, 87.9, 78.0, 68.1, 55.3, 52.4; HRMS: calcd for $C_{24}H_{23}NO_7$: 437.1475; found: 437.1462 $[M+NH_4]^+$.

(2S*,3R*) and (2S*,3S*) Methyl 2,2-(benzoxyl, styryl)-3-hydroxyl-4-nitrophenylpropionate (7l+8l) (mixture of diastereomers) 1H NMR (300 MHz, $CDCl_3$) δ 8.11-8.08 (m, 2 H; threo-, **7l**), (8.10-8.07 (m, 2 H; erythro-, **8l**)), (7.49-7.46 (m, 2 H)), 7.47-7.44 (m, 2 H), 7.36-7.21 (m, 10 H), (7.36-7.21 (m, 10 H)), 6.59 (d, $J = 16.5$ Hz, 1 H), (6.57 (d, $J = 16.5$ Hz, 1 H)), (6.40 (d, $J = 16.5$ Hz, 1 H)), 6.09 (d, $J = 16.5$ Hz, 1 H), 5.16 (d, $J = 6.0$ Hz, 1 H), (5.10 (d, $J = 3.3$ Hz, 1 H)), 4.69 (d, $J = 11.1$ Hz, 1 H), (4.56 (s, 2 H)), 4.54 (d, $J = 11.1$ Hz, 1 H), 3.82 (s, 3 H), (3.75 (s, 3 H)), (3.72 (d, $J = 3.3$ Hz, 1 H)), 3.59 (d, $J = 6.0$ Hz, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.4, (170.7), 147.7, (147.7), 145.6, (145.5), 137.9, (137.7), (135.7), 135.6, 135.3, (134.8), (129.0), (128.83), 128.83, 128.81, 128.62, (128.58), (128.52), 128.47, 127.92, (127.87), 127.71, (127.69), (126.80), 126.75, (123.2), 122.72, 122.68, (122.63), 86.8, (86.7), (79.6), 78.6, 68.3, (68.0), 52.7, (52.5); HRMS: calcd for $C_{25}H_{23}NO_6$: 433.1525; found: 443.1513 $[M+H]^+$.

(2S*,3S*) Methyl 2,2-(benzoxyl, phenyl)-3-phenylamino-4-nitrophenylpropionate (10a+11a) (mixture of diastereomers) 1H NMR (300 MHz, $CDCl_3$) δ 8.00-7.97 (m, 2 H; erythro-, (8.00-7.97 (m, 2 H); threo-, 7.45-7.21 (m, 12 H), (7.45-7.21 (m, 12 H)), 7.07-6.99 (m, 2 H), (7.07-6.99 (m, 2 H)), 6.68-6.63 (m, 1 H), (6.59-6.61

(m, 1 H)), 6.50 (d, $J = 7.8$ Hz, 2 H), (6.42 (d, $J = 7.8$ Hz, 2 H)), 5.36 (s, 1 H), (5.15 (s, 1 H)), (4.92 (d, $J = 11.4$ Hz, 1 H)), 4.61 (br, 1 H), 4.54 (d, $J = 11.4$ Hz, 1 H), 4.38 (d, $J = 11.4$ Hz, 1 H), (4.28 (d, $J = 11.4$ Hz, 1 H)), (3.80 (s, 3 H)), 3.71 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3) δ (171.7), 170.6, (147.6), 147.5, (146.1), 146.0, (145.9), 145.8, (138.5), 137.8, (134.6), 134.4, (130.4), (130.10), 130.08, 129.34, (129.28), 129.1, 128.7, 128.60, (128.54), (128.44), 128.36, (127.92), 127.89, (127.7), 127.40, (127.37), (122.71), 122.70, 118.9, (118.3), 114.5, (113.7), (88.7), 87.4, (68.6), 68.4, (65.5), 64.2, (52.6), 52.5; HRMS: calcd for $\text{C}_{29}\text{H}_{26}\text{N}_2\text{O}_5$: 482.1842; found: 482.1835 $[\text{M}+\text{H}]^+$.

(2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-phenylamino-4-nitrophenylpropionate (10b+11b) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ 7.96 (d, $J = 8.7$ Hz, 2 H; erythro-), (7.96 (d, $J = 8.7$ Hz, 2 H); threo-), 7.46-7.19 (m, 9 H), (7.46-7.19 (m, 9 H)), 7.05-6.87 (m, 4 H), (7.05-6.87 (m, 4 H)), 6.65-6.60 (m, 1 H), (6.60-6.55 (m, 1 H)), 6.50 (d, $J = 7.8$ Hz, 2 H), (6.41 (d, $J = 7.8$ Hz, 2 H)), 5.34 (d, $J = 8.7$ Hz, 1 H), (5.14 (s, 2 H)), (4.82 (d, $J = 10.8$ Hz, 1 H)), 4.64 (d, $J = 8.7$ Hz, 1 H), 4.48 (d, $J = 10.8$ Hz, 1 H), 4.29 (d, $J = 10.8$ Hz, 1 H), (4.18 (d, $J = 10.8$ Hz, 1 H)), (3.79 (s, 3 H $\times$ 2)), 3.78 (s, 3 H), 3.69 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3) δ (171.7), 170.6, 159.3, (159.2), (147.7), 147.3, (146.1), 146.0, (145.9), 145.7, (134.7), 134.5, (130.4), (130.3), 130.0, 129.8, 129.22, (129.17), 129.0, (128.94), 128.91, (128.91), 128.6, (128.3), 128.2, (127.9), 122.6, (122.6), 118.7, (118.1), 114.4, 113.9, (113.8), (113.6), (88.5), 87.2, (68.2), 68.0, (65.3), 64.0, (55.3), 55.3, (52.5), 52.3; HRMS: calcd for $\text{C}_{30}\text{H}_{28}\text{N}_2\text{O}_6$: 512.1947; found: 512.1942 $[\text{M}+\text{H}]^+$.

(2S*,3S*) Methyl 2,2-(4-methoxybenzoxyl, phenyl)-3-(4-methoxyphenylamino)-4-nitrophenylpropionate (10c+11c) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ (7.98 (d, $J = 8.7$ Hz, 2 H); threo-), 7.96 (d, $J = 8.7$ Hz, 2 H; erythro-), 7.46-7.15 (m, 9 H), (7.46-7.15 (m, 7 H)), (6.90 (d, $J = 8.4$ Hz, 2 H)), 6.89 (d, $J = 8.4$ Hz, 2 H), (6.88 (d, $J = 8.4$ Hz, 2 H)), 6.63 (d, $J = 9.0$ Hz, 2 H), (6.60 (d, $J = 9.0$ Hz, 2 H)), 6.46 (d, $J = 9.0$ Hz, 2 H), (6.38 (d, $J = 9.0$ Hz, 2 H)), 5.27 (br, 1 H), (5.06 (br, 1 H)), (4.84 (d, $J = 11.1$ Hz, 1 H)), 4.45 (d, $J = 10.8$ Hz, 1 H), 4.32 (br, 1 H), 4.29 (d, $J = 10.8$ Hz, 1 H), (4.19 (d, $J = 11.1$ Hz, 1 H)), (3.82 (s, 3 H)), (3.81 (s, 3 H)), 3.80 (s, 3 H), 3.73 (s, 3 H), 3.63 (s, 3 H), (3.62 (s, 3 H)); ^{13}C NMR (75 MHz, CDCl_3) δ (171.9), 170.8, 159.4, (159.3), 153.1, (152.6), (147.52), 147.47, (146.4), 146.3, (140.2), 139.8, (134.9), 134.6, (130.7), 130.5, 130.1, (130.0), 129.1 (overlap), (129.0 (overlap)), 128.8, (128.4), 128.3, (128.0), (122.72), 122.67, 116.2, (116.2), (115.2), 114.9, 114.03, (113.99), (88.8), 87.4, (68.3), 68.1, (66.5), 65.4, 55.7, (55.7), 55.5, (55.5), (52.6), 52.5; HRMS: calcd for $\text{C}_{31}\text{H}_{30}\text{N}_2\text{O}_7$: 542.2053; found: 542.2045 $[\text{M}+\text{H}]^+$.

(2S*,3S*) Methyl 2,2-(benzoxyl, 4-methoxyphenyl)-3-phenylamino-4-nitrophenylpropionate (10d+11d) (mixture of diastereomers) ^1H NMR (300 MHz, CDCl_3) δ 8.01-7.97 (m, 2 H; erythro-), (8.01-7.97 (m, 2 H; threo-)), 7.38-7.02 (m, 11 H), (7.38-7.02 (m, 11 H)), 6.87-6.84 (m, 2 H), (6.76-6.73 (m, 2 H)), 6.67-6.64 (m, 1 H), (6.64-6.62 (m, 1 H)), 6.52-6.49 (m, 2 H), (6.43-6.41 (m, 2 H)), 5.33 (br, 1 H), (5.12 (br, 1 H)), (4.88 (d, $J = 11.7$ Hz, 1 H)), 4.64 (br, 1 H), 4.52 (d, $J = 11.4$ Hz, 1 H), 4.34 (d, $J = 11.4$ Hz, 1 H), (4.23 (d, $J = 11.7$ Hz, 1 H)), 3.80 (s, 3 H), (3.79 (s, 3 H)), (3.76 (s, 3 H)), 3.69 (s, 3 H); ^{13}C NMR (75 MHz, CDCl_3) δ (171.9), 170.7, 159.94, (159.88), (147.5), 147.4, (146.2), 146.1, (145.9), 145.8, (138.6), 137.9, (130.4), 130.1, 130.0, (129.33), 129.30, (129.2), 128.53, (128.48), 127.8, (127.6), 127.4, (127.3), (126.4), 126.2, (122.7), 122.6, 118.8, (118.1), 114.4, (114.4), (113.7), 113.6, (88.4), 87.0, (68.2), 68.1, (65.4), 64.2, 55.35, (55.32), (52.5), 52.4; HRMS: calcd for $\text{C}_{30}\text{H}_{28}\text{N}_2\text{O}_6$: 512.1947; found: 512.1941 $[\text{M}+\text{H}]^+$.

Procedure for multigram scale production of **12c**

(1) To a 300 mL CH₂Cl₂ solution of Rh₂(OAc)₄ (352 mg, 0.8 mmol), PMBOH (13 g, 88 mmol) and N-(*p*-methoxyphenyl) *p*-nitrophenylimine (20 g, 80 mmol) was added methyl phenyl diazoacetate (14 g, 80 mmol) in 100 mL of CH₂Cl₂ over 3 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. The ratio of three-component coupling products to O-H insertion is 97:3, and diastereoselective ratio is 83:17. The crude product was purified by flash chromatography on silica gel by using petroleum ether:EtOAc=10:1 as eluent to give three-component products **10c+11c** 30.4 g (70% yield).

(2) Subject all of products of step 1 to hydrolysis: To a 150 mL THF solution of **10c+11c** (30.4 g) was added the aqueous KOH (30 g KOH solved in 100 mL water) and 100 mL MeOH at rt, stirred the solution overnight. The THF and MeOH was removed under reduce pressure, the residue was extracted with 75 mL hexane (2×) and the organic phase was discarded, the aqueous phase was acidified to PH=1 with 6 M aqueous HCl and then extracted with 75 mL of CH₂Cl₂ (3×), and the combined organic phase was dried over anhydrous MgSO₄. After filtration, the solvent was removed under reduced pressure to give the needed products 26.8 g (90% yield) as a pair of diastereoisomers and the crude products was recrystallized with CH₂Cl₂/petroleum ether to give only one isomer **12c** (the major isomer) 16.5 g (65% yield) as yellow solid.

(2S*,3S*) 2,2-(4-methoxybenzoxyl, phenyl)-3-(4-methoxyphenylamino)-4-nitrophenylpropionate acid (12c) ¹H NMR (300 MHz, CDCl₃) δ 7.94 (d, *J* = 8.7 Hz, 2 H), 7.42-7.33 (m, 5 H), 7.24 (d, *J* = 8.7 Hz, 2 H), 7.11 (d, *J* = 8.7 Hz, 2 H), 6.92-6.87 (m, 2 H), 6.66-6.57 (m, 4 H), 6.00 (br, 2 H), 5.16 (s, 1 H), 4.55 (d, *J* = 10.5 Hz, 1 H), 4.38 (d, *J* = 10.5 Hz, 1 H), 3.82 (s, 3 H), 3.66 (s, 3 H); ¹³C NMR (75 MHz, CDCl₃) δ 172.6, 159.6, 154.5, 147.7, 144.1, 137.9, 133.8, 130.3, 129.5, 129.4, 129.2, 128.7, 128.4, 122.9, 118.7, 114.9, 114.1, 86.9, 68.3, 66.7, 55.7, 55.5; HRMS: calcd for C₃₀H₂₈N₂O₇: 528.1897; found: 528.1876 [M+H]⁺.

L040610A1

L040616B

L040621A1

L040609B1

L040622B2

L040622B1

L040623A1

L040622C2R

L04070BB2

L040601A2

Current Data Parameters
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 PROCNO 1

F2 - Acquisition Parameters
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 FIDRES 0.346004 Hz
 AQ 1.445188 sec
 RG 8192
 CW 22.050 usec
 DE 6.00 usec
 TE 300.0 K
 D1 2.0000000 sec
 d11 0.0300000 sec
 d12 0.0002000 sec

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 P1 5.50 usec
 PL1 -6.00 dB
 SF01 75.4775598 MHz

***** CHANNEL f2 *****
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 NUC2 1H
 PCPD2 80.00 usec
 PL2 -2.00 dB
 PL12 17.70 dB
 PL13 17.71 dB
 SF02 300.1312005 MHz

F2 - Processing parameters
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 SF 75.4677445 MHz
 WDW EM
 SSB 0
 GB 1.00 Hz
 GB 0
 PC 1.40

F0 MRS c11: parameters
 C1 20.00 Hz
 C2 13.00 Hz
 C3 220.000 Hz
 C4 16602.90 Hz
 C5 0.000 Hz
 C6 0.00 Hz
 C7 11.00000 ppm/cm
 C8 830.14514 Hz/cm

DDM

L04060141

L040708B2

L040708B1

L040726A1

L040602B2R

L04063081

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Current Data Parameters
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EXPNO     2
PROCNO    1

F2 - Acquisition Parameters
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TD         65536
SOLVENT   DMSO-d6
NS         188
DS         4
SWH        22675.736 Hz
FIDRES     0.346004 Hz
AQ         1.4451188 sec
RG          8192
RGX         22.050 usec
RGY         6.00 usec
TE         300.0 K
D1          2.0000000 sec
d11         0.0300000 sec
d12         0.0002000 sec

===== CHANNEL f1 =====
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P1         13C
PL1        5.50 usec
PR1        -6.00 dB
SFO1       75.4775598 MHz

===== CHANNEL f2 =====
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NUC2        1H
PCPD2       80.00 usec
PL2        -2.00 dB
PL12       17.70 dB
PL13       17.71 dB
PL14       17.71 dB
SFO2       300.1312005 MHz

F2 - Processing parameters
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GB         0
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1D NMR plot parameters
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CY         10.00 cm
CZ         180.000 ppm
F1         13564.20 Hz
F2         -0.500 ppm
F3         -37.73 Hz
PPMCM      9.02500 ppm/cm
HZCM       681.09637 Hz/cm

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L040714B1

L040805substrate