Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.


# A Sustainable Catalytic Enantioselective Synthesis of Norstatine Derivatives

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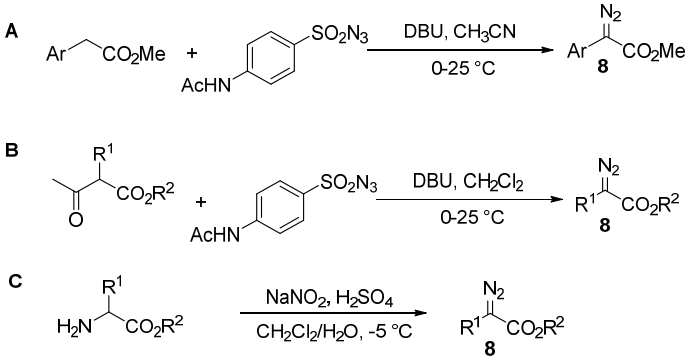
# A. General Information

All reactions were carried out under air with magnetic stirring. The $[\alpha]_D$ was recorded using PolAAr 3005 High Accuracy Polarimeter. All $^1H$ NMR, and $^{13}C$ NMR spectra were recorded using a Brucker-400 MHz or 500 MHz spectrometer in $CDCl_3$ unless otherwise noted. Tetramethylsilane (TMS) served as an internal standard (•δ•= 0) for $^1H$ NMR, and $CDCl_3$ was used as internal standard (δ = 77.0) for $^{13}C$ NMR. Chemical shifts are reported in parts per million as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br =broad). HRMS (ESI) Mass spectra were recorded on IonSpec FT-ICR mass spectrometer. HPLC analysis was performed on Dalian Elite (UV230+ UV/Vis Detector and P230P High Pressure Pump). Chiral columns include Chiralcel® IA columns.

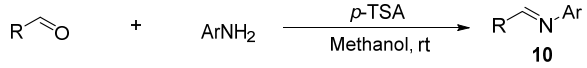
# B. Preparation of substrates

**General procedure for the synthesis of diazoacetates**: **Method A**: The aryldiazoacetates were prepared by reported procedures (Scheme S1, A).[1] Methyl arylacetates (10 mmol, 1.0 equiv) and *p*-ABSA (11 mmol, 1.1equiv) was dissolved in a 100 mL flask with 40 mL $CH_3CN$. After stirring for 10 min in an ice bath, DBU (1.1 mmol, 1.1 equiv) in 20 mL of $CH_3CN$ was added dropwise. After stirring for 12 hours at 25°C, the reaction mixture was quenched with saturated aqueous $NH_4Cl$ at 0°C. The mixture was then extracted with diethyl ether 3 times. The combined organic phase was washed with 60 mL brine and dried with anhydrous $Na_2SO_4$. After filtration, the solvent was removed to give the crude product. It was then purified by flash chromatography on silica gel with petroleum ether to give the pure product. **Method B**: The alkyldiazoacetates were prepared by reported procedures with modifications (Scheme S1, B).[2] 2-alkylacetoacetates (10 mmol, 1.0 equiv) and *p*-ABSA (11 mmol, 1.1equiv) was dissolved in a 100 mL flask with 40 mL dichloromethane. After stirring for 10 min in an ice bath, DBU (2.2 mmol, 2.2 equiv) in 20 mL of dichloromethane was added dropwise. After stirring for 12 hours at 25°C, the reaction mixture was quenched with saturated aqueous $NH_4Cl$ at 0°C. The mixture was then extracted with diethyl ether 3 times. The combined organic phase was washed with 60 mL brine and dried with anhydrous $Na_2SO_4$. After filtration, the solvent was removed to give the crude product. It was then purified by flash chromatography on silica gel with petroleum ether to give the pure product. **Method C**: The alkyldiazoacetates were prepared by reported procedures with modifications (Scheme S1, C).[3] amino esters (10 mmol, 1.0 equiv) and sodium nitrite (11 mmol, 1.1 equiv.) was dissolved in 20 mL $CH_2Cl_2$, then 3 drops of con. $H_2SO_4$ was added dropwise at -5°C in 1min. The reaction was worked up by adding saturated sodium bicarbonate when the sodium nitrite was consumed completely which was indicated by the halt of bubbling. The resulting mixture was extracted with 20 mL $CH_2Cl_2$ for 3 times. The combined $CH_2Cl_2$ phase was wash with brine. and further dried with sodium sulfate. Then the solvent was removed to give the crude product which is used directly in the next step without further purification.




Scheme S1. The preparation of diazoacetates.

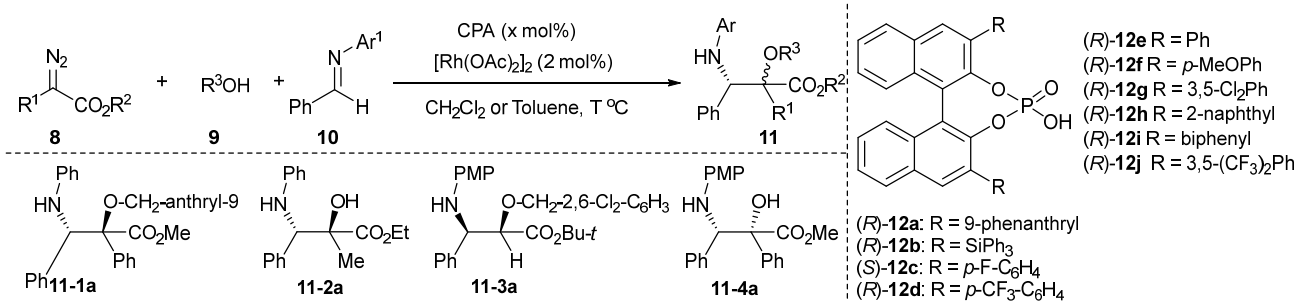
**General procedure for the synthesis of imines**: The imines were prepared by reported procedures (Scheme S2).[4] Aldehydes (10 mmol, 1.0 equiv), and *p*-TSA were dissolved in 20 mL methanol at room temperature. Then amines (11 mmol, 1.1 equiv.) dissolved in 20 mL methanol was added, followed by addition of magnesium sulfate (20 mmol, 2.0 equiv). The reaction was allowed to stir at room temperature overnight. Then methanol was removed via vacuum evaporation. The resulting mixture was treated with 60 mL $CH_2Cl_2$ and filter through celite pad to eliminate magnesium sulfate. The filtrate was concentrated and give the crude imines which is further purified by the recrystallization in methanol.




Scheme S2. The preparation of imines.

## C. Optimization of conditions for synthesis of *anti*- and *syn*-norstatines

Table S1 Optimization of conditions for synthesis of *anti*- and *syn*-norstatines.[a]




| Entry | CPA (loading, %) | Solvent | T (°C) | 11-1a (yield[b]/ *anti*:*syn*[c] /ee[d]) | 11-2a (yield[b]/ *anti*:*syn*[c] /ee[d]) | 11-3a (yield[b]/ *anti*:*syn*[c] /ee[d]) | 11-4a (yield[b]/ *anti*:*syn*[c] /ee[d]) |
|---|---|---|---|---|---|---|---|
| **1** | (*R*)-**12a** (10) | $CH_2Cl_2$ | 0 | 86%/>99:1/81% | - | - | |
| **2** | (*R*)-**12a** (5) | $CH_2Cl_2$ | 0 | 95%/>99:1/92% | - | | |
| **3** | (*R*)-**12a** (2) | $CH_2Cl_2$ | 0 | 97%/>99:1/91% | | - | 52%/24:76/62% |
| **4** | (*R*)-**12a (**2) | $CH_2Cl_2$ | -20 | **86%/>99:1/93%** | - | - | - |
| **5** | (*R*)-**12b** (2) | $CH_2Cl_2$ | 25 | - | 63%/54:46/35% | - | 66%/10:90/95% |
| **6** | (*R*)-**12b (**2) | $CH_2Cl_2$ | 40 | - | 62%/70:30/93% | - | **75%/8:92/95%** |
| **7** | (*R*)-**12b** (2) | Toluene | 25 | | **73%/71:29/94%** | | |
| **8** | (*S*)-**12c (**2) | $CH_2Cl_2$ | 0 | - | - | **68%/32:68/88%** | |
| **9** | (*R*)-**12d** (2) | Toluene | 25 | - | 63%/73:27/74% | - | |
| **10** | (*R*)-**12e** (2) | Toluene | 25 | - | 55%/66:34/59% | - | |
| **11** | (*R*)-**12f** (2) | Toluene | 25 | - | 54%/66:34/47% | - | |
| **12** | (*R*)-**12g** (2) | Toluene | 25 | - | 50%/60:40/69% | - | |
| **13** | (*R*)-**12h** (2) | Toluene | 25 | - | 52%/66:34/40% | - | |
| **14** | (*R*)-**12i** (2) | Toluene | 25 | - | 63%/54:46/35% | - | |
| **15** | (*R*)-**12j** (2) | Toluene | 25 | - | 52%/65:35/69% | - | |

[a] Reactions are performed with conditions according to the following table; [b] isolated yield; c the ratios of *anti*/*syn* were obtained with crude $^1$HNMR; [d] *ee*s were obtained via chiral HPLC.

**Discussion on the relationship of reaction condition parameters and reactivity and stereoselectivity in catalytic enantioselective synthesis of norstatine derivatives 11:** First, decrease in the loading of CPA (*R*)-**12a** from 10% to 5% or 2% improves the yield and enantioselectivity of **11-1a** (Table S1, entry 1 *vs* entry 2-3), and the trend is applied to **11-2a, 11-3a,** and **11-4a**. Second, in terms of temperature, **11-1a** gains higher ee at -20 °C than at 0 °C (Table S1, entry 3 *vs* entry 4). By contrast, for **11-2a**, **11-3a**, **11-4a**, higher temperature favors reactivity and enantioselectivity. 25°C, 0 °C, and 40 °C is optimal for **11-2a**, **11-3a**, **11-4a**, respectively (Table S1, entry 5-8). Last, the size of aromatic group on the 3,3'-position of CPA is critical to the diastereoselectivity and enantioselectivity of norstatines. 9-phenanthryl matches with **11-1a**, possibly due to the suitable π-π interactions between 9-phenanthryl group on CPA and 9-anthryl group on the alcohol **9-1a**. In the case of **11-2a**, bulky triphenlysilanyl group on the CPA gives the best enantioinduction and reactivity (Table S1, entry 7 *vs* entry 8-15). So does **11-4a**

need triphenlysilanyl group to achieve excellent enantioselectivity. But **11-3a** can be synthesized in high ee with CPA (*S*)-**12c** bearing smaller group at the 3, 3'-position.

## D. Catalytic enantioselective synthesis and characterization of *anti*- and *syn*-norstatines.

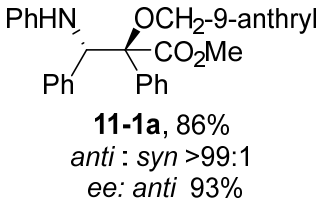
**General procedure of catalytic enantioselective synthesis of anti-norstatines 11-1:** A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*R*)-**12a** (0.005 mmol), alcohols **9-1a** (0.25 mmol) , imines **10** (0.275 mmol) and 4Å MS (100 mg) in 2 mL $CH_2Cl_2$ under an argon atmosphere was cooled to –20°C. Diazo compound **8** (0.25 mmol) in 1 mL $CH_2Cl_2$ was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction mixture was allowed to stirr for 3 h and followed by the workup with saturated aqueous $NaHCO_3$ (0.1 ml). $CH_2Cl_2$ was removed by vacuum evaporation to give the crude products, which were subjected to $^1H$ NMR spectroscopy analysis for the determination of diastereoselectivities. The crude products were purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:50 ~1:20) to give the pure products **11-1**. The resulting pure products were analyzed by chiral HPLC to determine enantioselectivities.

**General procedure of catalytic enantioselective synthesis of anti-norstatines 11-2:** A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*R*)-**12b** (0.005 mmol), water (0.25 mmol) , imines **10** (0.275 mmol) and 4Å MS (100 mg) in 2 mL toluene under open air was stirred at room temperature. Diazo compound **8** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction was workup with saturated aqueous $NaHCO_3$ (0.1 ml). Toluene was removed by vacuum evaporation to give the crude products, which were subjected to $^1H$ NMR spectroscopy analysis for the determination of diastereoselectivities. The crude products were purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:20 ~1:10) to give the pure products **11-2**. The resulting pure products were analyzed by chiral HPLC to determine enantioselectivities.

**General procedure of catalytic enantioselective synthesis of anti-norstatines 11-3:** A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*S*)-**12c** (0.005 mmol), alcohol **9-3a** (0.25 mmol) , imines **10** (0.275 mmol) and 4Å MS (100 mg) in 2 mL $CH_2Cl_2$ under an argon atmosphere was cooled to 0°C. Diazo compound **8** (0.25 mmol) in 1 mL $CH_2Cl_2$ was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction mixture was allowed to stirr for 0.5 h and followed by the workup with saturated aqueous $NaHCO_3$ (0.1 ml). $CH_2Cl_2$ was removed by vacuum evaporation to give the crude products, which were subjected to $^1H$ NMR spectroscopy analysis for the determination of diastereoselectivities. The crude products were purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:40~1:20) to give the pure products **11-3**. The resulting pure products were analyzed by chiral HPLC to determine enantioselectivities.

**General procedure of catalytic enantioselective synthesis of anti-norstatines 11-4:** A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*R*)-**12a** (0.005 mmol), water (0.25 mmol) , imines **10** (0.275 mmol) and 4Å MS (100 mg) in 2 mL $CH_2Cl_2$ under open air refluxed at 40°C. Diazo compound **8** (0.25 mmol) in 1 mL $CH_2Cl_2$ was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction mixture was allowed to stirr for 0.5 h and followed by the workup with saturated aqueous $NaHCO_3$ (0.1 ml). $CH_2Cl_2$ was removed by vacuum evaporation to give the crude products, which were subjected to $^1H$ NMR spectroscopy analysis for the determination of diastereoselectivities. The crude products were purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:20 ~1:10) to give the pure products **11-4**. The resulting pure products were analyzed by chiral HPLC to determine enantioselectivities.

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-2,3-diphenyl-3-(phenylamino)propanoate** (**11-1a**):[5] yield 86%; $[\alpha]_D^{20}$ = +67.3°(c = 1, EtOAc); 93% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 97 : 3, 254nm, Retention time: $t_{major}$ = 7.3 min, and $t_{minor}$ = 9.4 min.); 1H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.70 (s, 3H), 4.87 (d, *J* = 9.6 Hz, 1H), 5.17 (d, *J* = 9.6 Hz, 1H), 5.21 (d, *J* = 10.3 Hz, 1H), 5.76 (d, *J* =10.3 Hz, 1H), 6.41 (dd, $J_1$ = 1.0 Hz, $J_2$ = 8.6 Hz, 2H), 6.65 (m, 1H), 6.97 (m, 2H), 7.13 (m, 5H), 7.47-7.54 (m, 7H), 7.82 (m, 2H), 8.06 (m, 2H), 8.30 (m, 2H), 8.53 (s, 1H); $^{13}C$ NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.93, 60.60, 64.30, 87.90, 114.04, 117.63, 125.07, 125.11, 126.10, 127.59, 127.62, 128.37, 128.50, 128.96, 129.02, 129.15, 129.26, 131.17, 131.65, 136.41, 136.74, 146.25, 171.69; HRMS (EI) calcd for $C_{37}H_{31}NO_3$ $(M)^+$ 537.2304, found 537.2300.



**11-1a**, 86%
*anti* : *syn* >99:1
*ee: anti* 93%

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-2,3-diphenylpropanoate** (**11-1b**):[5] yield 83%; $[\alpha]_D^{20}$ = +57.6°(c = 1, EtOAc); 94% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol / EtOH / TFA = 450 : 25 : 25 :1, 254nm, Retention time: $t_{major}$ = 6.9 min, and $t_{minor}$ = 8.4 min.); $^1$HNMR ($CDCl_3$, 400 MHz) δ (ppm) 3.57 (s, 3H), 3.67 (s, 3H), 4.52 (bs, 1H), 5.06 (bs, 1H), 5.17 (d, *J* = 10.3 Hz, 1H), 5.68 (d, *J* = 10.3 Hz, 1H), 6.33 (d, *J* = 9.0 Hz, 2H), 6.53 (d, *J* = 9.0 Hz, 2H), 7.04 (m, 5H), 7.41-7.49 (m, 7H), 7.80 (m, 2H), 8.01 (d, *J* = 9.5 Hz, 2H), 8.27 (d, *J* = 9.5 Hz, 2H), 8.46(s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.90, 55.63, 60.55, 65.49, 87.96, 114.63, 115.45, 125.07, 126.04, 127.50, 128.24, 128.44, 128.77, 128.92, 129.09, 129.35, 129.47, 131.12, 131.61, 136.38, 138.76, 10.44, 152.20, 171.70; HRMS (ESI) calcd for $C_{38}H_{34}NO_4$ $(M+H)^+$, 568.2482, found 568.2489.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, Ph, Ph

**11-1b**, 83%
*anti* : *syn* >99:1
*ee: anti* 94%

**(2*S*,3*S*)-methyl 2-(9-anthryl)methoxy)-3-(4-bromophenyl)-2-phenyl-3-(4-methoxyphenylamino)propanoate (11-1c):[5]** yield 82%; $[\alpha]_D^{20}$ = +92.8°(c = 1, EtOAc); 94% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol = 90 : 10, 254nm, Retention time: $t_{major}$ = 6.6 min, and $t_{minor}$ = 8.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.69 (s, 3H), 3.81 (s, 3H), 4.53 (bs, 1H), 5.13 (bs, 1H), 5.27 (d, *J* = 10.5 Hz, 1H), 5.76 (d, *J* = 10.5 Hz, 1H), 6.40 (d, *J* = 9.0 Hz, 2H), 6.64 (d, *J* = 9.0 Hz, 2H), 7.00 (d, *J* = 8.0 Hz, 2H), 7.25 (d, *J* = 8.0 Hz, 2H), 7.52-7.62 (m, 7H), 7.87 (m, 2H), 8.12 (d, *J* = 8.5 Hz, 2H), 8.35 (d, *J* = 8.5 Hz, 2H), 8.57 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.96, 55.52, 60.50, 64.85, 87.57, 114.55, 115.49, 121.47, 124.80, 125.00, 126.02, 128.24, 128.45, 128.71, 128.89, 128.97, 129.18, 130.54, 130.57, 130.97, 131.49, 135.80, 137.74, 139.91, 152.33, 171.39; HRMS (ESI) calcd for $C_{38}H_{33}BrNO_4$, $(M+H)^+$ 646.1587, found 646.1589.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, *p*-Br-$C_6H_4$, Ph

**11-1c**, 82%
*anti : syn* > 99:1
*ee:anti* 94%

**(2*S*,3*S*)-methyl 2-(9-anthryl)methoxy)-3-(4-chlorophenyl)-2-phenyl-3-(4-methoxyphenylamino)propanoate (11-1d)**:[5] yield 83%; $[\alpha]_D^{20}$ = +86.1°(c = 1, EtOAc); 93% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol = 90 : 10, 254nm, Retention time: $t_{major}$ = 6.3 min, and $t_{minor}$ = 8.3 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.70 (s, 3H), 3.84 (s, 3H), 4.59 (bs, 1H), 5.19 (bs, 1H), 5.32 (d, *J* = 11.0 Hz, 1H), 5.81 (d, *J* = 11.0 Hz, 1H), 6.45 (d, *J* = 9.0 Hz, 2H), 6.68 (d, *J* = 9.0 Hz, 2H), 7.15 (m, 4H), 7.57-7.65 (m, 7H), 7.93 (m, 2H), 8.14 (d, J = 8.0 Hz, 2H), 8.41 (d, *J* = 9.0 Hz, 2H), 8.58 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.90, 53.35, 55.45, 60.45, 64.76, 87.60, 114.52, 115.47, 124.77, 124.96, 125.98, 127.57, 128.21, 128.41, 128.69, 128.86, 128.93, 129.16, 130.29, 130.94, 131.46, 133.14, 135.82, 137.21, 139.90, 152.29, 171.37; HRMS (ESI) calcd for $C_{38}H_{32}ClNNaO_4$ $(M+Na)^+$ 624.1912, found 624.1906.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, *p*-Cl-$C_6H_4$, Ph

**11-1d**, 83%
*anti : syn* > 99:1
*ee:anti* 93%

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-2-phenyl-3-p-tolylpropanoate (11-1e):[5]** yield 92%; $[\alpha]_D^{20}$ = +84.7°(c = 1, EtOAc); 98% ee, determined by HPLC (Daicel Chirapak IA, flow rate 0.9 mL/min, hexane / isopropanol / EtOH / TFA = 425 : 25 : 25 : 1, Retention time: $t_{major}$ = 7.0 min, and $t_{minor}$ = 8.2 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 2.19 (s, 3H), 3.57 (s, 3H), 3.68 (s, 3H), 4.52 (bs, 1H), 5.03 (bs, 1H) 5.16 (d, *J* = 10.4 Hz, 1H), 5.69 (d, *J* = 10.4 Hz, 1H), 6.32 (d, *J* = 8.9 Hz, 2H), 6.53 (d, *J* = 8.9 Hz, 2H), 6.85 (d, *J* = 8.0 Hz, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 7.41-7.50 (m, 7H), 7.82 (m, 2H), 8.00 (d, *J* = 9.2 Hz, 2H), 8.27 (d, *J* = 9.2 Hz, 2H), 8.46 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 21.17, 51.88, 55.64, 60.53, 65.14, 88.01, 114.63, 115.46, 125.06, 125.11, 126.02, 128.23, 128.27, 128.41, 128.86, 128.91, 128.94, 129.14, 129.39, 131.14, 131.61, 135.71, 136.54, 136.98, 140.54, 152.14, 171.78; HRMS (ESI) calcd for $C_{39}H_{35}KNO_4$ $(M+K)^+$ 620.2198, found 620.2215.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, *p*-$H_3C$-$C_6H_4$, Ph

**11-1e**, 92%
*anti : syn* > 99:1
*ee:anti* 98%

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-2-phenyl-3-(4-methoxy- phenylamino)-3-m-tolylpropanoate (11-1f)**:[5] yield 95%; $[\alpha]_D^{20}$ = +49.2°(c = 1, EtOAc); 90% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol = 80 : 20, 254nm, Retention time: $t_{major}$ = 4.9 min, and $t_{minor}$ = 5.6 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 2.05 (s, 3H), 3.57 (s, 3H), 3.67 (s, 3H), 4.48 (bs, 1H), 5.02 (bs, 1H), 5.18 (d, *J* = 10.3 Hz, 1H), 5.68 (d, *J* = 10.3 Hz, 1H), 6.33 (d, *J* = 9.0 Hz, 2H), 6.53 (d, *J* = 9.0 Hz, 2H), 6.86-6.93 (m, 4H), 7.41-7.48 (m, 7H), 7.79 (m, 2H), 7.99 (d, *J* = 9.5 Hz, 2H), 8.26 (d, *J* = 9.5 Hz, 2H), 8.45 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 21.35, 51.85, 55.63, 60.44, 65.38,

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, *m*-$H_3C$-$C_6H_4$, Ph

**11-1f**, 95%
*anti : syn* > 99:1
*ee: anti* 90%

87.94, 114.63, 115.44, 125.03, 126.06, 126.14, 127.24, 128.16, 128.26, 128.41, 128.84, 128.90, 129.12, 129.41, 129.84, 131.13, 131.60, 136.43, 138.64, 140.55, 152.14, 171.73; HRMS (ESI) calcd for $C_{39}H_{36}NO_4$ $(M+H)^+$ 582.2639, found 582.2617.

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-2-phenyl-3-o-tolylpropanoate (11-1g)**:[5] yield 95%; $[\alpha]_D^{20}$ = +33.2°(c = 1, EtOAc); 93% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol = 95 : 5, 254nm, Retention time: $t_{major}$ = 5.8 min, and $t_{minor}$ = 7.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 2.10 (s, 3H), 3.60 (s, 3H), 3.72 (s, 3H), 4.26 (bs, 1H), 5.20 (d, *J* = 10.3 Hz, 1H), 5.49 (bs, 1H), 5.53 (d, *J* = 10.3 Hz, 1H), 6.36 (d, *J* = 8.9 Hz, 2H), 6.55 (d, *J* = 8.9 Hz, 2H), 6.80-6.85 (m, 4H). 7.43-7.50 (m, 7H), 7.78 (m, 2H), 8.00 (d, *J* = 9.0 Hz, 2H), 8.30 (d, *J* = 9.0 Hz, 2H) 8.46 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 19.95, 51.98, 55.65, 60.61, 60.94, 88.47, 114.64, 115.95, 125.06, 125.09, 125.33, 126.04, 127.11, 128.10, 128.52, 128.83, 128.93, 129.62, 129.82, 131.10, 131.58, 136.24, 137.21, 137.46, 140.63, 152.50, 171.85; HRMS (ESI) calcd for $C_{39}H_{35}KNO_4$ $(M+K)^+$ 620.2198, found 620.2175.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, *o*-$H_3C$-$C_6H_4$, Ph
**11-1g**, 95%
*anti : syn* > 99:1
*ee: anti* 93%

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-3-cyclohexyl-2-(4-methoxyphenyl)propanoate (11-1h)**:[5] yield 34%; 49% ee, determined by HPLC (Daicel Chirapak AD-H, flow rate 1.0 mL/min, hexane / isopropanol / EtOH / TFA = 450 : 25 : 25 : 1, 254nm, Retention time: $t_{major}$ = 5.3 min, and $t_{minor}$ = 10.1 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 0.64-0.66 (m, 1H), 0.84-1.07 (m, 6H), 1.34-1.50 (m, 4H), 3.43 (d, *J* = 10.5 Hz, 1H), 3.67 (s, 3H), 3.81 (s, 3H), 3.87 (s, 3H), 4.01 (d, *J* = 10.5 Hz, 1H), 5.31 (d, *J* = 10.5 Hz, 1H), 5.51 (d, *J* = 10.5 Hz, 1H), 6.39 (d, *J* = 4.5 Hz, 2H), 6.60 (d, *J* = 4.0 Hz, 2H), 6.85 (d, *J* = 9.0 Hz, 2H), 7.44-7.50 (m, 4H), 7.60 (d, *J* = 9.0 Hz, 2H), 8.00 (d, *J* = 8.0 Hz, 2H), 8.32 (d, *J* = 8.5 Hz, 2H), 8.46 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 26.14, 26.18, 26.94, 27.82, 33.88, 41.25, 51.88, 55.29, 55.73, 60.56, 65.28, 88.53, 113.31, 114.18, 114.61, 124.93, 125.15, 125.76, 128.23, 128.39, 128.83, 129.38, 129.98, 130.89, 131.51, 142.73, 151.38, 159.45, 172.93.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, Cyclohexanyl, PMP
**11-1h**, 34%
*anti : syn* > 95 : 5
*ee: anti* 49%

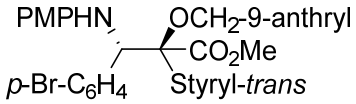
**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-2-(4-methoxyphenyl)-3-phenylpropanoate (11-1i)**:[5] yield 98%; $[\alpha]_D^{20}$ = +36.4°(c = 1, EtOAc); >99% ee, determined by HPLC (Daicel Chirapak AD-H, flow rate 1.0 mL/min, hexane / isopropanol / EtOH / TFA = 490 : 10 : 10 : 1, 254nm, Retention time: $t_{major}$ = 33.0 min, and $t_{minor}$ = 41.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.62 (s, 3H), 3.70 (s, 3H), 3.90 (s, 3H), 4.60 (bs, 1H), 5.07 (bs, 1H), 5.20 (d, *J* = 10.5 Hz, 1H), 5.70 (d, *J* = 10.5 Hz, 1H), 6.37 (d, *J* = 9.0 Hz, 2H), 6.58 (d, *J* = 8.5 Hz, 2H), 6.98 (d, *J* = 8.5 Hz, 2H), 7.07-7.15 (m, 5H), 7.50-7.55 (m, 4H), 7.78 (d, *J* = 8.5 Hz, 2H), 8.06 (d, *J* = 8 Hz, 2H), 8.33 (d, *J* = 8.5 Hz, 2H), 8.51 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.78, 55.31, 55.58, 60.27, 65.43, 87.54, 113.47, 114.58, 115.38, 124.99, 125.04, 125.95, 127.42, 128.30, 128.43, 128.84, 129.05, 129.15, 130.67, 131.07, 131.54, 138.80, 140.40, 152.09, 159.82, 171.83; HRMS (ESI) calcd for $C_{39}H_{35}KNO_5$ $(M+K)^+$ 636.2147, found 636.2151.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, Ph, $C_6H_4$-$OCH_3$-*p*
**11-1i**, 98%
*anti : syn* > 99:1
*ee: anti* >99%

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-3-(4-bromophenyl)-2-(4-methoxyphenyl)propanoate (11-1j)**:[5] yield 97%; $[\alpha]_D^{20}$ = +53.5°(c = 1, EtOAc); 95% ee, determined by HPLC (Daicel Chirapak AD-H, flow rate 1.0 mL/min, hexane / isopropanol / EtOH / TFA = 450 : 25 : 25 : 1, 254nm, Retention time: $t_{major}$ = 11.8 min, and $t_{minor}$ = 18.6 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.63 (s, 3H), 3.73 (s, 3H), 3.90 (s, 3H), 4.50 (bs, 1H), 5.03 (bs, 1H), 5.20 (d, *J* = 10.5 Hz, 1H), 5.68 (d, *J* = 10.5 Hz, 1H), 6.34 (d, *J* = 8.5 Hz, 2H), 6.59 (d, *J* = 8.5 Hz, 2H), 6.95 (d, *J* = 8.5 Hz, 2H), 6.80 (d, *J* = 9.0 Hz, 2H), 7.20 (d, *J* = 8.5 Hz, 2H), 7.50-7.56 (m, 4H), 7.74 (d, *J* = 8.5 Hz, 2H), 8.06 (d, *J* = 8 Hz, 2H), 8.30 (d, *J* = 8.5 Hz, 2H), 8.51 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 51.93, 55.33, 55.57, 60.31, 64.91, 87.25, 113.56, 114.61, 115.49, 121.46, 124.86, 125.02, 126.03, 127.90, 128.41, 128.90, 130.56, 130.61, 130.73, 131.02, 131.54, 137.89, 139.98, 152.32, 159.93, 171.63; HRMS (ESI) calcd for $C_{39}H_{34}BrKNO_5$ $(M+K)^+$ 714.1252, found 714.1243.

PMPHN, $OCH_2$-9-anthryl, $CO_2Me$, Ph, $C_6H_4$-Br-*p*
**11-1j**, 84%
*anti : syn* > 99:1
*ee: anti* 94%

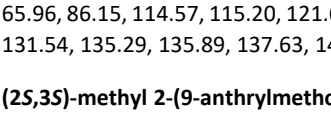
**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-3-(4-methoxyphenylamino)-2-(trans-styryl)-3-(4-bromophenyl)propanoate (11-1k)**:




**11-1k**, 43%
*anti : syn* > 99:1
*ee: anti* 95%

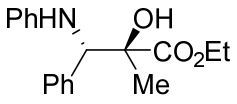
[5]yield 43%; $[\alpha]_D^{20}$ = +62.0°(c = 1, EtOAc); 95% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane / isopropanol / EtOH / TFA = 450 : 25 : 25 : 1, 254nm, Retention time: $t_{major}$ = 10.8 min, and $t_{minor}$ = 12.7 min.); $^1$HNMR ($CDCl_3$, 400 MHz) δ (ppm) 1.30 (t, *J* = 7.5 Hz, 3H),3.61 (s, 3H), 4.21-4.28 (m, 2H), 4 51 (d, *J* = 8.5 Hz, 1H), 4.68 (d, *J* = 8.0 Hz, 1H), 5.64 (dd, $J_1$ = 10.5 Hz, *J* = 22.0 Hz, 2H), 6.29 (d, *J* = 8.5 Hz, 2H), 6.54 (d, *J* = 9.0 Hz, 2H), 6.83 (m, 2H), 7.14 (d, *J* = 8.5 Hz, 2H), 7.28 (d, *J* = 8.5 Hz, 2H), 7.38-7.46 (m, 5H), 7.50-7.52 (m, 4H), 8.06 (m, 2H), 8.44 (m, 2H), 8.52 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 14.15, 55.60, 59.94, 61.72, 65.96, 86.15, 114.57, 115.20, 121.63, 124.80, 125.06, 126.16, 126.94, 128.48, 128.76, 128.96, 128.99, 130.71 130.82, 130.97, 131.54, 135.29, 135.89, 137.63, 140.69, 152.18, 170.84.

**(2*S*,3*S*)-methyl 2-(9-anthrylmethoxy)-2-(3-bromophenyl)-3-phenyl-3-(phenylamino)propanoate (11-1l)**:[5] yield 96%; $[\alpha]_D^{20}$ = +124.0°(c = 1, EtOAc); 84% ee, determined by HPLC (Daicel Chirapak OD-H, flow rate 0.6 mL/min, hexane / isopropanol / EtOH / TFA = 500 : 5 : 5 : 1, 254nm, Retention time: $t_{major}$ = 15.0 min, and $t_{minor}$ = 16.2 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.73 (s, 3H), 4.66 (d, *J* = 9.5 Hz, 1H), 5.03 (d, *J* = 9.5 Hz, 1H), 5.21 (d, *J* = 10.0 Hz, 1H), 5.70 (d, *J* = 10.5 Hz, 1H), 6.36 (m, 2H), 6.54 (m, 1H), 6.94 (m, 2H), 7.06-7.28 (m, 6H), 7.49-7.56 (m, 5H),7.75 (m,1H), 7.90 (s, 1H), 8.05 (d, *J* = 8.0 Hz, 2H), 8.27 (d, *J* = 8.0 Hz, 2H), 8.52 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 52.17, 60.75, 64.96, 87.48, 114.11, 117.86, 122.45, 124.81, 125.08, 126.31, 127.61, 127.73, 127.76, 128.45, 128.65, 128.94, 129.70, 131.00, 131.50, 131.94, 132.25, 138.02, 138.45, 146.13, 170.93; HRMS (ESI) calcd for C37H30BrKNO3 $(M+K)^+$ 654.1041, found 654.1041.



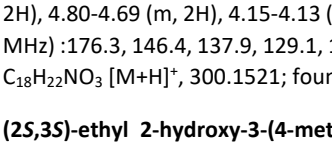

**11-1l**, 96%
*anti : syn* > 99:1
*ee: anti* 84%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(phenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2a)**: 73% yield as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 8.46 min, $t_{minor}$ = 7.91 min) gave the isomeric composition of the product: 94% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 12.27 min, $t_{minor}$ = 20.34 min) gave the isomeric composition of the product: 81% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2a**) 7.38 (d, *J* = 7.5 Hz, 2 H), 7.31-7.24 (m, 4 H), 7.07-7.03 (m, 2 H), 6.62-6.55 (m, 2H), 4.80-4.69 (m, 2 H), 4.25-4.23 (m, 2 H), 3.59 (s, 1H), 1.23-1.20 (m, 6 H); (*Syn*-**11-2a**) 7.38 (d, *J* = 7.5 Hz, 2H), 7.31-7.24 (m, 4H), 7.07-7.03 (m, 2H), 6.62-6.55 (m, 2H), 4.80-4.69 (m, 2H), 4.15-4.13 (m, 1H), 4.08-4.03 (m, 1H), 3.59 (s, 1H), 1.65 (s, 3H), 1.23-1.20 (m, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :176.3, 146.4, 137.9, 129.1, 129.0,128.6, 128.2, 127.7, 117.7, 114.0, 113.4, 76.7, 62.5, 62.4, 24.2, 14.1; HRMS: calcd for $C_{18}H_{22}NO_3$ $[M+H]^+$, 300.1521; found 300.1533.



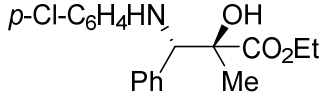

**11-2a**, 73%
*anti* : *syn* = 71:29
*ee: anti* 94% *syn* 81%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2b)**: 81% yield as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 12.04 min, $t_{minor}$ = 11.18 min) gave the isomeric composition of the product: 92% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 22.23 min, $t_{minor}$ = 27.81 min) gave the isomeric composition of the product: 79% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2b**) 7.38 (d, *J* = 7.5 Hz, 2H), 7.28-7.24 (m, 4 H), 7.22-7.21 (m, 1H), 6.69-6.67 (d, *J* = 10.0 Hz, 2H), 6.55-6.53 (d, *J* = 10.0 Hz, 2H), 4.57 (br, 1H),4.55 (s, 1H), 4.14-4.01 (m, 2H), 3.68 (s, 3H), 3.34 (s, 1H), 1.67 (s, 3H) 1.24 (t, *J* = 7.0 Hz, 3H).; $^{13}$C NMR($CDCl_3$, 125 MHz) :174.9, 152.0, 140.9, 138.8, 128.2, 127.8, 127.7, 114.8, 76.8, 63.6, 62.0, 55.7, 23.7, 14.1; HRMS: calcd for $C_{19}H_{23}NNaO_4$ $[M+Na]^+$, 352.1519; found 352.1536.




**11-2b**, 81%
*anti* : *syn* = 76:24
*ee: anti* 94% *syn* 79%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-chlorophenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2c)**: yield 60% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, iPrOH/hexane/EtOH = 3/96/1, 1.0 mL/min, 254 nm; $t_{major}$ = 11.00 min, $t_{minor}$ = 11.99 min) gave the isomeric composition of the product: 93% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, iPrOH/hexane/EtOH = 3/96/1, 1.0 mL/min, 254 nm; $t_{major}$ = 18.76 min, $t_{minor}$ = 27.60 min) gave the isomeric composition of the product: 71% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2c**) 7.36-7.35 (m, 2H), 7.31-7.29 (m, 2H), 6.62-6.55 (m, 2H), 6.98 (d, *J* = 10.0 Hz, 2H), 6.47 (d, *J* = 10.0 Hz, 2H), 4.82 (d, *J* = 10.0 Hz, 1H), 4.64 (d, *J* = 10.0 Hz, 1H), 4.29-4.20 (m, 2H), 3.58(s, 1H),




**11-2c**, 81%
*anti* : *syn* = 74:26
*ee: anti* 93% *syn* 71%

1.25-1.20 (m, 6 H); $^{13}$C NMR($CDCl_3$, 125 MHz) :174.6, 145.4, 138.2, 129.8, 128.9, 128.3, 128.2, 128.1, 128.0, 127.7, 122.0, 114.6, 76.8, 74.2, 62.7, 62.3, 61.8, 61.7, 23.8, 13.9; HRMS: calcd for $C_{18}H_{20}ClNNaO_3$ [M+Na]$^+$, 356.1132; found 356.1105.

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-bromophenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2d)**: yield 62% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, hexane/EtOH = 95/5, 1.0 mL/min, 254 nm; $t_{major}$ = 11.84 min, $t_{minor}$ = 15.90 min) gave the isomeric composition of the product: 91% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, hexane/EtOH = 95/5, 1.0 mL/min, 254 nm; $t_{major}$= 21.53 min, $t_{minor}$ = 20.31 min) gave the isomeric composition of the product: 70% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2d**) 7.26-7.21 (m, 5H), 7.14 (d, *J* = 15.0 Hz, 2H), 6.14 (d, *J* = 15.0 Hz, 2H), 4.94 (d, *J* = 8.0 Hz, 1H), 4.54 (d, *J* = 8.0 Hz, 1H), 4.13-4.08 (m, 1H), 4.03-4.00 (m, 1H), 3.35 (s, 1H), 1.65 (s, 3H), 1.27-1.22 (m, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :176.3, 145.4, 137.3, 131.7, 128.6, 128.2, 128.2, 127.9, 115.6, 109.4, 62.6, 62.4, 22.7, 14.1. HRMS: calcd for $C_{18}H_{20}BrNNaO_3$ [M+Na]$^+$ 400.0627; found 400.0614.

*p*-Br-$C_6H_4$HN, OH, $CO_2$Et, Ph, Me
**11-2d**, 62%
*anti* : *syn* = 76:24
*ee: anti* 91% *syn* 70%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(3-chlorophenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2e):** yield 62% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, hexane/EtOH = 95/5, 1.0 mL/min, 254 nm; $t_{major}$ = 9.01 min, $t_{minor}$ = 8.43 min) gave the isomeric composition of the product: 88% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, hexane/EtOH = 95/5, 1.0 mL/min, 254 nm; $t_{major}$ = 11.50 min, $t_{minor}$ = 13.40 min) gave the isomeric composition of the product: 57% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2e**) 7.27-7.22 (m, 5H), 6.96 (d, *J* = 8.0 Hz, 1H), 6.58-6.54 (m, 2H), 6.43 (t, *J* = 5.0 Hz, 1H), 4.98 (d, *J* = 10.0 Hz, 1H), 4.56 (d, *J* = 10.0 Hz, 1H), 4.13-4.08 (m, 1H), 4.03-3.99 (m, 1H), 3.33 (s, 1H), 1.64 (s, 3H), 1.30-1.23 (m, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :174.5, 147.9, 138.1, 134.8, 130.1, 128.3, 127.6, 113.1, 111.7, 76.8, 62.323.8, 14.0. HRMS: calcd for $C_{18}H_{20}ClNNaO_3$ [M+Na]$^+$, 356.1132; found 356.1121.

*m*-Cl-$C_6H_4$HN, OH, $CO_2$Et, Ph, Me
**11-2e**, 61%
*anti* : *syn* = 70:30
*ee: anti* 88% *syn* 57%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(4-bromophenyl)propanoate (11-2f):** yield 71% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 18.21 min, $t_{minor}$ = 20.17 min), gave the isomeric composition of the product: 93% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 30.07 min, $t_{minor}$ = 40.62 min), gave the isomeric composition of the product: 79% ee. $^1$H NMR ($CDCl_3$, 400 MHz): δ (*anti*-**11-2f**) 7.37 (d, *J* = 8.4 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.67 (d, *J* = 8.8 Hz, 2H), 6.50 (d, *J* = 8.8 Hz, 2H), 4.59 (br, 1H), 4.51 (s, 1H), 4.16-4.01 (m, 2H), 3.67 (s, 3H), 3.37 (s, 1H), 1.65 (s, 3H), 1.23 (t, *J* = 8.8 Hz, Hz, 3H); $^{13}$C NMR($CDCl_3$, 100 MHz) :174.8, 152.2, 140.5, 138.1, 131.4, 129.6, 121.8, 114.9, 63.0, 62.3, 55.7, 23.9, 14.1; HRMS: calcd for $C_{19}H_{22}BrNNaO_4$ [M+Na]$^+$, 430.0629; found 430.0624.

PMPHN, OH, $CO_2$Et, *p*-Br-$C_6H_4$, Me
**11-2f**, 62%
*anti : syn* = 76:24
*ee: anti* 93%, *syn* 79%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(3-chlorophenyl)propanoate (11-2g):** yield 89% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 12.74 min, $t_{minor}$ = 12.06 min) gave the isomeric composition of the product: 95% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 25.19 min, $t_{minor}$ = 24.04 min) gave the isomeric composition of the product: 85% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2g**) 7.26 (d, *J* = 5.8 Hz, 1H), 7.18 (m, 3H), 6.69 (d, *J* = 8.8 Hz, 2H), 6.542 (d, *J* = 8.8 Hz, 2H), 4.59 (br, 1H), 4.51(s, 1H), 4.16-4.06 (m, 2H), 3.80 (s, 3H), 3.37 (s, 1H), 1.65 (s, 3H), 1.28-1.23 (t, m, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :174.7, 152.2, 141.2, 140.5, 134.1, 129.4, 128.8, 128.2, 127.9, 126.9, 125.9, 115.5, 114.9, 114.8, 114.7, 76.7, 63.2, 62.6, 62.3, 55.7, 55.6, 24.2, 23.8, 14.1, 14.0; HRMS: calcd for $C_{19}H_{22}ClNNaO_4$ [M+Na]$^+$, 386.1130; found 386.1111.

PMP, OH, $CO_2$Et, *m*-Cl-$C_6H_4$, Me
**11-2g**, 89%
*anti : syn* = 76:24
*ee: anti* 95%, *syn* 85%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(4-nitrophenyl)propanoate (11-2h):** yield 73% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 27.97 min, $t_{minor}$ = 22.80 min) gave the isomeric composition of the product: 93% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 77.28 min, $t_{minor}$ = 22.71 min) gave the isomeric composition of the product: 55% ee. 1H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2h**) 7.72 (dd, $J_1$ = 4.0 Hz, $J_2$ = 4.0 Hz, 2 H), 7.48-7.30 (m, 2 H), 7.48-7.30 (m, 2 H), 6.75 (d, *J* = 8.8 Hz, 2H), 6.69 (d, *J* = 8.8 Hz, 2H), 4.82 (br, 1H), 4.18-4.14 (m, 1H), 3.89-3.85 (m, 1H), 3.66 (s, 3H), 3.42 (s, 1H), 1.57 (s, 3H), 1.20 (t, 7.0 Hz, 3H); $^{13}$C NMR($CDCl_3$, 125

PMPHN, OH, $CO_2$Et, *p*-$O_2$N-$C_6H_4$, Me
**11-2h**, 73%
*anti : syn* = 77:23
*ee: anti* 93%, *syn* 55%

MHz) :174.2, 151.9, 149.6, 139.7, 135.5, 134.2, 128.9, 128.1, 124.3, 114.5, 114.4, 76.3, 62.7, 52.7, 55.2, 23.5, 13.3; HRMS: calcd for $C_{19}H_{22}N_2NaO_6$ $[M+Na]^+$, 397.1370; found 397.1370.

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(3-nitrophenyl)propanoate (11-2i):** 81% yield as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 12.06 min, $t_{minor}$ = 13.00 min) gave the isomeric composition of the product: 91% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 26.83 min, $t_{minor}$ = 20.83 min) gave the isomeric composition of the product: 79% ee. $^1$H NMR ($CDCl_3$, 400 MHz): δ (*anti*-**11-2i**) 8.20 (s, 1 H), 8.10 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 7.6 Hz, 2H), 7.45 (d, *J* = 8.0 Hz, 2H), 6.71 (d, *J* = 8.8 Hz, 2H), 6.54 (d, *J* = 8.8 Hz, 2H), 4.71 (s, 2H), 4.20-4.08 (m, 2H), 3.70 (s, 3H), 3.50 (s, 1H), 1.71 (s, 3H), 1.33 (t, 7.0 Hz, 3H); $^{13}$C NMR($CDCl_3$, 100 MHz) :174.2, 151.9, 149.6, 139.7, 135.5, 134.2, 128.9, 128.1, 124.3, 114.5, 114.4, 76.3, 62.7, 52.7, 55.2, 23.5, 13.3; HRMS: calcd for $C_{19}H_{22}N_2NaO_6$ $[M+Na]^+$, 397.1370; found 397.1370.

PMPHN, OH, $CO_2Et$, *m*-$O_2N$-$C_6H_4$, Me
**11-2i**, 81%
*anti : syn* = 77:23
*ee: anti* 91%, *syn* 79%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(2-nitrophenyl)propanoate (11-2j):** yield 71% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 11.89 min, $t_{minor}$ = 15.41 min) gave the isomeric composition of the product: 92% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 25.17 min, $t_{minor}$ = 42.48 min) gave the isomeric composition of the product: 88% ee. $^1$H NMR ($CDCl_3$, 400 MHz): δ (*anti*-**11-2j**) 7.80 (d, *J* = 7.7 Hz 1 H), 8.69 (d, *J* = 7.7 Hz, 1H), 7.50 (dd, $J_1$= $J_2$= 7.4 Hz, 1H), 7.35 (dd, $J_1$= $J_2$= 7.4 Hz, 1H), 6.77 (d, *J* = 9.0 Hz, 2H), 6.71 (d, *J* = 9.0 Hz, 2H), 5.69 (s, 1H), 4.67 (br, 1H), 4.20-3.69 (m, 2H), 3.69 (s, 3H), 3.40 (s, 1H), 1.71 (s, 3H), 1.21 (t, 7.0 Hz, 3H); $^{13}$C NMR($CDCl_3$, 100 MHz) :174.7, 152.4, 150.1, 140.2, 134.0, 132.7, 129.4, 128.5, 124.8, 115.0, 76.7, 63.1, 56.2, 55.6, 23.9, 13.7; HRMS: calcd for $C_{19}H_{22}N_2NaO_6$ $[M+Na]^+$, 397.1370; found 397.1370.

PMPHN, OH, $CO_2Et$, *o*-$O_2N$-$C_6H_4$, Me
**11-2j**, 71%
*anti : syn* = 78 : 22
*ee: anti* 92%, *syn* 88%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(methyl)-3-(furanyl)propanoate (11-2k):** yield 80% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 16.64 min, $t_{minor}$ = 18.19 min) gave the isomeric composition of the product: 89% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 29.00 min, $t_{minor}$ = 19.33 min) gave the isomeric composition of the product: 68% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2k**) 7.26 (t, *J* = 3.6 Hz, 1H), 6.73 (d, *J* = 8.9 Hz, 2H), 6.62 (d, *J* = 8.9 Hz, 2H), 6.24-6.23 (m, 1H), 6.16 (d, *J* = 3.1 Hz, 1H), 4.65(s, 1H), 4.23 (br, 1H), , 4.21-4.17 (m, 2H), 3.71 (s, 3H), 3.46 (s, 1H), 1.61 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :174.7, 152.7, 152.6, 141.9, 140.8, 115.2, 114.8, 110.2, 108.1, 62.1, 58.8, 55.7, 22.9, 14.0; HRMS: calcd for $C_{19}H_{22}ClNNaO_4$ $[M+Na]^+$, 386.1130; found 386.1111.

PMPHN, OH, $CO_2Et$, Furanyl, Me
**11-2k**, 80%
*anti : syn* = 73 : 27
*ee: anti* 89% *syn* 68%

**(2*S*,3*S*)-Methyl 2-hydroxy-3-(phenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2l)**: yield 64%. Major diastereoisomer HPLC analysis (Chiralcel IA, iPrOH/hexane/EtOH = 2.5/95/2.5, 1.0 mL/min, 254 nm; $t_{major}$ = 10.56 min, $t_{minor}$ = 11.51 min, gave the isomeric composition of the product: 90% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, iPrOH/hexane/EtOH = 2.5/95/2.5, 1.0 mL/min, 254 nm; $t_{major}$ = 15.45 min, $t_{minor}$ = 13.77 min, gave the isomeric composition of the product: 84% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2l**) 7.38-6.56 (m, 10H), 4.87 (d, *J* = 10.0 Hz, 1H), 4.62 (d, *J* = 10.0 Hz, 1H), 3.67 (s, 3H), 3.27 (s, 1H), 1.66 (s, 3H); $^{13}$C NMR ($CDCl_3$, 125 MHz) :175.2, 146.7, 138.7, 129.1, 128.3, 127.9, 127.5, 117.4, 113.4, 76.7, 62.5, 52.6, 23.5,; HRMS: calcd for $C_{17}H_{19}NNaO_3$ $[M+Na]^+$, 308. 1270; found 308. 1257.

PhHN, OH, $CO_2Me$, Ph, Me
**11-2l**, 69%
*anti : syn* = 71:29
*ee: anti* 90%, *syn* 84%

**(2*S*,3*S*)-isopropyl 2-hydroxy-3-(phenylamino)-2-(methyl)-3-(phenyl)propanoate (11-2m)**: yield 64% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane/EtOH = 5/93/2, 1.0 mL/min, 254 nm; $t_{major}$ = 12.25 min, $t_{minor}$ = 11.51 min) gave the isomeric composition of the product: 93% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 5/95, 1.0 mL/min, 254 nm; $t_{major}$ = 20.44 min, $t_{minor}$ = 36.77 min) gave the isomeric composition of the product: 55% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2m**) 7.32-7.20 (m, 5H), 6.68 (d, *J* = 10.0 Hz, 2H), 6.54 (d, *J* = 10.0 Hz, 2H), 4.89-4.87 (m, 1 H), 4.64 (d, *J* = 10.0 Hz, 1H), 4.53 (d, *J* = 10.0 Hz, 2H), 3.67 (s 3H), 1.65 (s, 3H), 1.23 (d, *J* = 5.4 Hz, 3H); 1.16 (d, *J* = 5.4 Hz, 3H); $^{13}$C NMR ($CDCl_3$, 125 MHz) :174.3, 152.0, 140.9, 138.8, 128.1, 128.0, 127.7, 114.8, 114.7, 76.7, 63.5, 55.6, 23.8, 21.6; HRMS: calcd for $C_{19}H_{23}NNaO_3$ $[M+Na]^+$, 336.1583; found 336.1570.

PhHN, OH, $CO_2Pr$-*i*, Ph, Me
**11-2m**, 64%
*anti : syn* = 76:24
*ee:anti* 93%, *syn* 55%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(ethyl)-3-(pheneyl)propanoate (11-2n):** yield 61% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, $^{i}$PrOH/hexane/EtOH = 5/95/5, 1.0 mL/min, 254 nm; $t_{major}$ = 10.89 min, $t_{minor}$ = 9.56 min) gave the isomeric composition of the product: 89% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, $^{i}$PrOH/hexane/EtOH = 5/95/5, 1.0 mL/min, 254 nm; $t_{major}$ = 19.67 min, $t_{minor}$ = 34.02 min) gave the isomeric composition of the product: 81% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2n**) 7.30-7.18 (m, 5H), 6.67 (d, *J* = 8.9 Hz, 2H), 6.53 (d, *J* = 8.9 Hz, 2H), 4.62 (d, *J* = 10.0 Hz, 1H), 4.56-4.54 (m, 1H), 4.15-4.10 (m, 2H), 3.67 (s, 3H), 3.31 (s, 1H), 2.29 (q, *J* = 5.3 Hz, 1H ), 1.96 (q, *J* = 5.3 Hz, 1H ), 1.26 (t, *J* = 7.0 Hz, 3H), 0.89 (t, *J* = 7.0 Hz, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :174.2, 151.9, 140.9, 139.1, 128.1, 127.8, 127.7, 114.8, 114.7, 81.3, 76.7, 63.2, 62.0, 55.7, 14.1, 8.1, 1.0; HRMS: calcd for $C_{20}H_{25}NNaO_4$ [M+Na]$^+$, 366.1664; found 366.1676.

PMPHN, OH, $CO_2Et$, Ph, Et
**11-2n**, 61%
*anti : syn* = 81:19
*ee: anti* 89%, *syn* 81%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-(isopropyl)-3-(pheneyl)propanoate (11-2n):** yield 58% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, EtOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 12.01 min, $t_{minor}$ = 9.95 min) gave the isomeric composition of the product: 91% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, EtOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 7.65 min, $t_{minor}$ = 6.91 min) gave the isomeric composition of the product: 88% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2o**) 7.40-7.20 (m, 5H), 6.67 (d, *J* = 6.3 Hz, 2H), 6.53 (d, *J* = 6.3 Hz, 2H), 4.77 (s, 1H), 4.65 (br, 1H), 4.17-3.98 (m, 2H), 3.68 (s, 3H), 3.37 (s, 1H), 2.43 (m, 1H ), 1.31 (m, 6H), 0.98 (t, J = 5.9 Hz, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :173.7, 151.8, 140.6, 139.1, 128.5, 128.3, 128.0, 127.6, 116.4, 115.1, 114.8, 114.5, 83.1, 62.2, 61.8, 61.3, 59.9, 55.7, 34.3, 33.0, 17.7, 17.3, 16.2, 14.0; HRMS: calcd for $C_{21}H_{27}NNaO_4$ [M+Na] $^+$, 380.1818; found 380.1832.

PMPHN, OH, $CO_2Et$, Ph, Pr-*i*
**11-2o**, 58%
*anti : syn* =87:13
*ee: anti* 88%, *syn* 91%

**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-( benzyl)-3-(phenyl)propanoate (11-2p):** yield 68% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, EtOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 31.52 min, $t_{minor}$ =13.25 min) gave the isomeric composition of the product: 90% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2p**) 7.37-7.16 (m, 10H), 6.71 (d, *J* = 7.0 Hz, 2H), 6.61 (d, *J* = 7.0 Hz, 2H), 4.74 (s, 1H), 3.83 (s, 3H), 3.74-3.61 (m, 1H), 3.57 (s, 3H), 3.24-3.20 (m, 2H); $^{13}$C NMR($CDCl_3$, 125 MHz) :173.7, 152.1, 140.7, 138.7, 136.0, 130.1, 128.2, 128.1, 127.9, 126.8, 115.0, 114.9, 81.6, 76.7, 63.3, 55.7, 52.3, 42.9; HRMS: calcd for $C_{24}H_{26}NO_4$ [M+Na] $^+$, 392.1852; found 392.1856.

PMPHN, OH, $CO_2Et$, Ph, Bn
**11-2p**, 68%
*anti : syn* = 71:29
*ee: anti* 90%

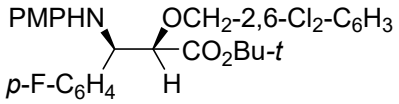
**(2*S*,3*S*)-ethyl 2-hydroxy-3-(4-methoxyphenylamino)-2-( benzyl)-3-(phenyl)propanoate (11-2p):** yield 68% as oil. Major diastereoisomer HPLC analysis (Chiralcel IA, EtOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 22.42 min, $t_{minor}$ =12.40 min) gave the isomeric composition of the product: 90% ee. Minor diastereoisomer HPLC analysis (Chiralcel IA, EtOH/hexane = 10/90, 1.0 mL/min, 254 nm; $t_{major}$ = 19.24 min, $t_{minor}$ = 24.45 min) gave the isomeric composition of the product: 87% ee. $^1$H NMR ($CDCl_3$, 500 MHz): δ (*anti*-**11-2q**) 7.31-7.07 (m, 10H), 6.68 (d, *J* = 8.8 Hz, 2H), 6.59 (d, *J* = 8.8 Hz, 2H), 4.70 (s, 2H), 3.97-3.87 (m, 2H), 3.72 (s, 3H), 3.67-3.59 (m, 1H), 3.24-3.10 (m, 2H),1.18 (t, *J* = 7.9 Hz, 3H); $^{13}$C NMR($CDCl_3$, 125 MHz) :173.2, 152.1, 140.8, 138.8, 136.1, 130.2, 128.4, 128.3, 128.1, 128.0, 127.7, 126.8, 115.0, 114.8, 81.3, 63.3, 61.9, 55.7, 42.9, 13.9; HRMS: calcd for $C_{25}H_{28}NO_4$ [M+Na] $^+$, 406.2014; found 406.2013.

PMPHN, OH, $CO_2Me$, Ph, Bn
**11-2q**, 68%
*anti : syn* = 71:29
*ee: anti* 90% *syn* 87%

**(2*S*,3*R*)-*tert*-butyl2-(2,6-dichlorobenzyloxy)-3-(4-methoxyphenylamino)-3 phenylpropanoate (11-3a):**[6] 68% yield 88% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20∶ 1, 254 nm, Retention time: $t_{minor}$ = 7.6 min, $t_{major}$ = 12.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3a**) 1.31 (s, 9H), 3.57 (s, 3H), 3.99 (d, *J* = 4.0 Hz, 1H), 4.62 (m, 2H), 4.87 (d, *J* = 8.0 Hz, 1H), 6.37 (d, *J* = 8.0 Hz, 2H), 6.54 (d, *J* = 8.0 Hz, 2H), 7.01-7.05 (m, 1H), 7.08-7.16 (m, 5H), 7.19-7.21 (m, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 27.9, 55.6, 60.5, 66.8, 82.0, 82.2, 114.5, 114.9, 127.1, 127.2, 128.1, 128.2, 130.0, 132.2, 136.9, 139.5, 141.3, 151.9, 169.3; HRMS (ESI) calcd for $C_{27}H_{29}Cl_2NNaO_4$ [M+Na]$^+$ = 524.1371, found 524.1362.

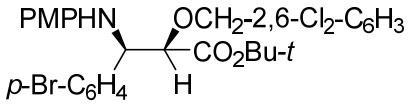
PMPHN, $OCH_2$-2,6-$Cl_2$-$C_6H_3$, $CO_2Bu$-*t*, Ph, H
**11-3a**, 73%
*anti : syn* = 36 : 64
*ee: syn* 88%

**(2*S*,3*R*)-*tert*-butyl-2-(2,6-dichlorobenzyloxy)-3-(4-fluorophenyl)-3-(4-methoxyphenylamino)propanoate (11-3b)**:[6] 61% yield; 81% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20 : 1, 254 nm, Retention time: $t_{minor}$ = 11.3 min, $t_{major}$ = 19.0 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3b**) 1.29 (s, 9H), 3.57 (s, 3H), 4.11 (d, *J* = 4.0 Hz, 1H), 4.48 (br, 1H), 4.60 (br, 1H), 4.76 (d, *J* = 12.0 Hz, 1H), 4.96 (d, *J* = 12.0 Hz, 1H), 6.34 (d, *J* = 8.0 Hz, 2H), 6.55 (d, *J* = 8.0 Hz, 2H), 6.83-6.88 (m, 2H), 7.09-7.27 (m, 5H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 27.9, 55.6, 58.7, 66.6, 79.6, 82.1, 100.5, 114.6, 114.8, 114.9, 115.0, 128.5, 129.8, 129.9, 130.3, 132.4, 134.1, 137.0, 140.2, 152.0, 161.0, 169.0; HRMS (ESI) calcdfor $C_{27}H_{28}Cl_2FNNaO_4$ $[M+Na]^+$ = 542.1277, found 542.1260.



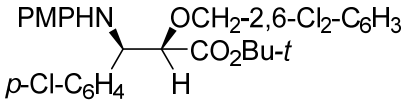

**11-3b**, 61%
*anti : syn* = 54:46
*ee: syn* 81%

**(2*S*,3*R*)-*tert*-butyl-2-(2,6-dichlorobenzyloxy)-3-(4-bromopheny)-3-(4-methoxyphenylamino) propanoate (11-3c):**[6] 72% yield; 83% ee, result after recrystallization $[\alpha]_D^{20}$ = -21.0° (c = 1.0 in $CH_2Cl_2$), >99% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20: 1, 254 nm, Retention time: $t_{minor}$ = 8.6 min, $t_{major}$ = 12.5 min.); mp 151– 153°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3c**) 1.42 (s, 9H), 3.67 (s, 3H), 4.02 (d, *J* = 4.0 Hz, 1H), 4.54 (br, 1H), 4.67 (br, 1H), 4.67 (d, *J* = 16.5 Hz, 2H), 4.96 (d, *J* = 16.5 Hz, 1H), 6.41 (d, *J* = 9.0 Hz, 2H), 6.63 (d, *J* = 9.0 Hz, 2H), 7.10-7.16 (m, 3H), 7.20-7.23 (m, 2H), 7. 26 (m, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 28.0, 55.7, 59.1, 60.2, 66.7, 79.7, 82.3, 114.7, 115.0, 121.5, 128.5, 128.5, 130.0, 130.3, 131.1, 132.4, 137.0, 137.6, 140.1, 152.2, 168.9; HRMS (ESI) calcd for $C_{27}H_{28}BrCl_2NNaO_4$ $[M+Na]^+$ = 602.0476, found 602.0462.



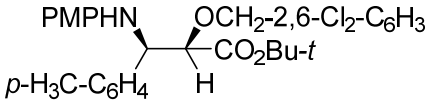

**11-3c**, 72%
*anti : syn* = 32 : 68
*ee: syn* 83% (>99%)[e]

**(2*S*,3*R*)-*tert*-butyl-2-(2,6-dichlorobenzyloxy)-3-(4-chlorophenyl)-3-(4-methoxyphenylamino)propanoate** (**11-3d**):[6] 64% yield; 82% ee, result after recrystallization $[\alpha]_D^{20}$ = -16.9° (c = 1.0 in $CH_2Cl_2$), >99% ee, was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/isopropanol = 20 : 1, 254 nm, Retention time: $t_{minor}$ = 8.1 min, $t_{major}$ = 11.8 min.); mp 149–151°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3d**) 1.42 (s, 9H), 3.66 (s, 3H), 4.03 (d, *J* = 4.0 Hz, 1H), 4.69 (m, 2H), 4.96 (d, *J* = 12.0 Hz, 1H), 6.41 (d, *J* = 12.0 Hz, 2H), 6.63 (d, *J* = 12.0 Hz, 2H), 7.11-7.20 (m, 3H), 7.21-7.25 (m, 4H); $^{13}$C NMR ($CDCl_3$, 100MHz) δ 28.0, 55.6, 59.8, 66.7, 81.7, 82.3, 114.6, 114.8, 128.2, 128.3, 128.5, 130.1, 132.0, 132.7, 136.9, 138.2, 140.8, 152.1, 169.2; HRMS (ESI) calcd for $C_{27}H_{28}Cl_3NNaO_4$ $[M+Na]^+$ = 558.0982, found 558.0973.



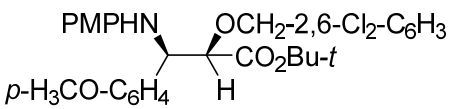

**11-3d**, 64%
*anti : syn* = 38 : 62
*ee: syn* 82% (>99%)[e]

**(2*S*,3*R*)-*tert*-butyl-2-(2,6-dichlorobenzyloxy)-3-(4-methoxyphenylamino)-3-*p*-tolylpropanoate (11-3e)**:[6] 63% yield; 88% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20 : 1, 254 nm, Retention time: $t_{minor}$ = 8.0 min, $t_{major}$ = 11.4 min.); mp 97– 98°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3e**) 1.32 (s, 9H), 2.20 (s, 3H), 3.58 (s, 3H), 3.97 (d, *J* = 4.0 Hz, 1H), 4.49 (br, 1H), 4.57 (br, 1H), 4.61 (d, *J* = 12.0 Hz, 1H), 4.86 (d, *J* = 12.0 Hz, 1H), 6.37 (d, *J* = 12.0 Hz, 2H), 6.54 (d, *J* = 12.0 Hz, 2H), 6.91-7.10 (m, 4H), 7.13-7.18 (m, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 27.9, 55.6, 60.3, 66.9, 81.9, 82.6, 114.5, 114.9, 127.1, 128.2, 128.8, 123.0, 132.3, 136.4, 136.6, 137.0, 141.5, 151.9, 169.4; HRMS (ESI) calcd for $C_{28}H_{31}Cl_2NNaO_4$ $[M+Na]^+$ = 538.1528, found 538.1519.



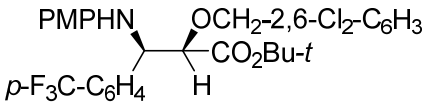

**11-3e**,63%
*anti : syn* = 34 : 66
*ee: syn* 86% (>99%)[e]

**(2*S*,3*R*)-*tert*-butyl-2-(2,6-dichlorobenzyloxy)-3-(4-methoxyphenyl)-3-(4-methoxyphenylamino)propanoate (11-3f):**[6] 61% yield; 82% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20: 1, 254 nm, Retention time: $t_{minor}$ = 6.4 min, $t_{major}$ = 10.0 min.); mp 94– 95°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3f**) 1.32 (s, 9H), 3.59 (s, 3H), 3.67 (s, 3H), 3.94 (d, *J* = 8.0 Hz, 1H), 4.49 (br, 1H), 4.55 (d, *J* = 8.0 Hz, 1H), 5.62 (d, *J* = 8.0 Hz, 1H), 4.88 (d, *J* = 8.0 Hz, 2H), 6.37 (d, *J* = 8.0 Hz, 2H), 6.855 (d, *J* = 8.0 Hz, 2H), 6.65 (d, *J* = 8.0 Hz, 2H), 7.06-7.18 (m, 5H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 27.9, 55.2, 55.6, 60.0, 66.8, 82.0, 82.5, 113.6, 114.5, 115.0, 128.3, 128.3, 130.1, 131.5, 132.3, 136.9, 141.4, 151.9, 158.7, 169.4; HRMS (ESI) calcd for $C_{28}H_{31}Cl_2NNaO_5$ $[M+Na]^+$ = 554.1477, found 554.1476.



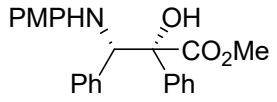

**11-3f**, 61%
*anti : syn* = 24:76
*ee: syn* 82% (>99%)[e]

**(2*S*,3*R*)-*tert*-butyl2-(2,6-dichlorobenzyloxy)-3-(4-methoxyphenylamino)-3-(4-(trifluoromethyl)phenyl)propanoate** (**11-3g**):[6] 70% yield; 91% ee, result after recrystallization $[\alpha]_D^{20}$ = -15.0° (c = 1.0 in $CH_2Cl_2$); >99:1 ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 20: 1, 254 nm, Retention time: $t_{minor}$ = 7.3 min, $t_{major}$ = 9.4 min.); mp 157–158°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-3g**) 1.36 (s, 9H), 3.60 (s, 3H), 3.98 (d, *J* = 4.0 Hz, 1H), 4.51 (br, 1H), 4.63 (d, *J* = 12.0 Hz, 1H), 4.73 (bs, 1H), 4.88 (d, *J* = 12.0 Hz, 1H), 6.35 (d, *J* = 8.0 Hz, 2H), 6.57 (d, *J* = 8.0 Hz, 2H), 7.04-7.09 (m, 3H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.2431 (d, *J* = 8.0 Hz, 2H); $^{13}$CNMR ($CDCl_3$, 100MHz) δ 28.0, 55.6, 59.9, 66.6, 81.1, 82.5, 114.6, 114.7, 125.0, 125.0, 127.3, 128.2, 130.2, 131.8, 136.8, 140.6, 152.1, 169.1; HRMS (ESI) calcd for $C_{28}H_{28}Cl_2F_3NNaO_4$ $[M+Na]^+$ = 592.1245, found 592.1237.



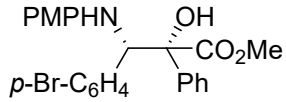

**11-3g**, 70%
*anti : syn* = 48 : 52
*ee: syn* 91% (>99%)[e]

**(2*R*,3*S*)-methyl-2-hydroxy-3-(4-methoxyphenylamino)-2,3-diphenylpropanoate (11-4a):**[7] 52% yield; dr (*anti* : *syn* = 8 : 92); 95% ee (*syn*) $[\alpha]_D^{20}$ = -139.0°(c = 1.0 in EtOAc); ee was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 13.1 min, $t_{minor}$ = 18.4 min); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4a**) 3.62 (s, 3H), 3.63 (s, 3H), 3.82 (s, 1H), 4.32 (br, 1H), 5.20 (s, 1H), 6.36 (d, *J* = 8.8 Hz, 2H), 6.58 (d, *J* = 8.8 Hz, 2H), 7.25-7.45 (m, 8H), 7.74 (d, 7.8 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.17, 55.64, 63.17, 81.31, 114.58, 114.63, 126.45, 128.03, 128.12, 128.30, 128.34, 128.43, 138.42, 138.72, 140.84, 151.88, 173.45; HRMS (ESI) calcd for $C_{23}H_{23}NNaO_4$ $[M+Na]^+$ = 400.1525, found 400.1519.



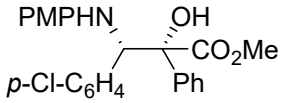

**11-4a**, 75%
*anti : syn* = 8 : 92
*ee: syn 95%, anti* 42%

**(2*R*,3*S*)-methyl-3-(4-bromophenyl)-2-hydroxy-3-(4-methoxyphenylamino)-2-phenylpropanoate (11-4b)**:[7] 62% yield; dr (*anti* : *syn* = 18 : 82); 94% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 18.4 min, $t_{minor}$ = 20.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4b**) 3.64 (s, 3H), 3.65 (s, 3H), 3.86 (s, 1H), 4.28 (br, 1H), 5.15 (s, 1H), 6.32 (d, *J* = 9.0 Hz, 2H), 6.58 (d, *J* = 9.0 Hz, 2H), 7.25-7.44 (m, 7H), 7.71 (d, 8.1 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.35, 55.64, 62.82, 81.09, 114.64, 114.67, 122.02, 126.31, 128.27, 128.43, 130.25, 131.43, 137.68, 138.51, 140.47, 152.09, 173.29; HRMS (ESI) calcd for $C_{23}H_{22}BrNNaO_4$ $[M+Na]^+$ = 478.0630, found 478.0624.



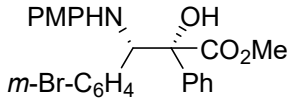

**11-4b**, 66%
*anti : syn* = 18 : 82
*ee: syn* 94%

**(2*R*,3*S*)-methyl-3-(4-chlorophenyl)-2-hydroxy-3-(4-methoxyphenylamino)-2-phenylpropanoate (11-4c)**:[7] 68% yield; dr (*anti*: *syn* = 17 : 83); 93% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90:5:5, 254 nm, Retention time: $t_{major}$ = 17.5 min, $t_{minor}$ = 18.8 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4c**) 3.64 (s, 3H), 3.65 (s, 3H), 3.86 (s, 1H), 5.17 (s, 1H), 6.33 (d, *J* = 8.9 Hz, 2H), 6.58 (d, *J* = 8.9 Hz, 2H), 7.25-7.40 (m, 7H), 7.71 (d, 8.6 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.31, 55.64, 62.77, 81.17, 114.65, 114.68, 126.31, 128.25, 128.42, 128.50, 129.90, 133.81, 137.16, 138.54, 140.52, 152.11, 173.31; HRMS (ESI) calcd for $C_{23}H_{22}ClNNaO_4$ $[M+Na]^+$ = 434.1135, found 434.1130.



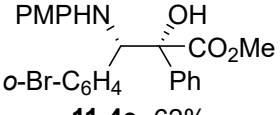

**11-4c**, 68%
*anti : syn* = 17 : 83
*ee: syn* 93%

**(2*R*,3*S*)-methyl-3-(3-bromophenyl)-2-hydroxy-3-(4-methoxyphenylamino)-2-phenylpropanoate (11-4d):**[7] 63% yield; dr (*anti* : *syn* = 16 : 84); 94% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 11.4 min, $t_{minor}$ = 14.9 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4d**) 3.65 (s, 3H), 3.67 (s, 3H), 3.87 (s, 1H), 4.27 (br, 1H), 5.14 (s, 1H), 6.34 (d, *J* = 8.8 Hz, 2H), 6.60 (d, *J* = 8.8 Hz, 2H), 7.16-7.40 (m, 6H), 7.61 (s, 1H), 7.71 (d, 8.8 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.35, 55.65, 63.00, 81.17, 81.17, 114.58, 114.72, 122.46, 126.33, 127.06, 128.27, 128.42, 129.83, 131.14, 131.67, 138.43, 140.48, 142.00, 152.12, 173.27; HRMS (ESI) calcd for $C_{23}H_{22}BrNNaO_4$ $[M+Na]^+$ = 478.0630, found 478.0624.



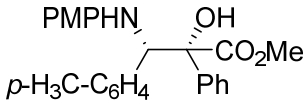

**11-4d**, 63%
*anti : syn* = 16: 84
*ee: syn* 94%

**(2*R*,3*S*)-methyl-3-(2-bromophenyl)-2-hydroxy-3-(4-methoxyphenylamino)-2-phenylpropanoate (11-4e)**: 62% yield; dr (*anti* : *syn* = 17 : 83); 93% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 11.9 min, $t_{minor}$ = 12.7 min.); $^1$HNMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4e**) 3.59 (s, 3H), 3.63 (s, 3H), 4.21 (s, 1H), 4.54 (m, 1H), 5.75 (m, 1H), 6.49 (d, *J* = 8.9 Hz, 2H), 6.60 (d, *J* = 8.9 Hz, 2H), 7.09-7.50 (m, 6H), 7.71 (d, *J* = 7.9 Hz, 1H), 7.79 (d, *J* = 8.0 Hz, 2H); 13C NMR (CDCl3, 100 MHz) δ 53.26, 55.60, 60.89, 80.55, 114.61, 114.90, 125.01, 126.39, 127.83, 128.09, 128.28, 129.49, 130.12, 130.35, 132.75, 139.12, 140.30, 152.05, 173.52; HRMS (ESI) calcd for $C_{23}H_{22}BrNNaO_4$[M+Na]$^+$ = 478.0630, found 478.0624.



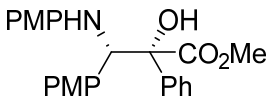

**11-4e**, 62%
*anti : syn* = 17 : 83
*ee: syn* 93%

**(2*R*,3*S*)-methyl-2-hydroxy-3-(4-methoxyphenylamino)-2-phenyl-3-p-tolylpropanoate (11-4f)**:[7] 76% yield; dr (*anti*: *syn* =14:86); 97% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 12.1 min, $t_{minor}$ = 19.9 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4f**) 2.29 (s, 3H), 3.62 (s, 3H), 3.63 (s, 3H), 3.80 (s, 1H), 4.29 (br, 1H), 5.17 (s, 1H), 6.35 (d, *J* = 8.9 Hz, 2H), 6.57 (d, *J* = 8.9 Hz, 2H), 7.09-7.37 (m, 7H), 7.73 (d, 7.9 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 21.15, 53.13, 55.63, 62.80, 81.35, 114.57, 114.62, 126.46, 128.05, 128.25, 128.31, 129.06, 135.25, 137.59, 138.79, 140.93, 151.84, 173.55; HRMS (ESI) calcd for $C_{24}H_{25}NNaO_4$ $[M+Na]^+$ = 414.1681, found 414.1676.



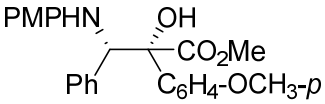

**11-4f**, 76%
*anti : syn* = 14 : 86
*ee: syn* 97%

**(2*R*,3*S*)-methyl-2-hydroxy-3-(4-methoxyphenylamino)-2-phenyl-3-(4-(trifluoromethyl)phenyl)propanoae (11-4g)**:[7] 82% yield; dr (*anti*: *syn* = 9 : 91); 94% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90:5:5, 254 nm, Retention time: $t_{major}$ = 18.9 min, $t_{minor}$ = 32.7 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4g**) 3.61 (s, 3H), 3.62 (s, 3H), 3.75 (s, 3H), 3.81 (s, 1H), 4.27 (br, 1H), 5.15 (s, 1H), 6.35 (d, *J* = 8.9 Hz, 2H), 6.57 (d, *J* = 8.9 Hz, 2H), 6.81 (d, *J* = 8.9 Hz, 2H), 7.33-7.36 (m, 5H), 7.72 (d, 7.3 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.11, 55.08, 55.61, 62.49, 81.39, 113.71, 114.59, 126.40, 128.04, 128.29, 129.47, 130.23, 138.79, 140.89, 151.83, 159.24, 173.51; HRMS (ESI) calcd for $C_{24}H_{25}NNaO_5$ $[M+Na]^+$ = 430.1630, found 430.1625.



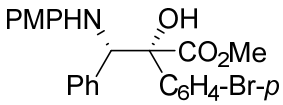

**11-4g**, 82%
*anti : syn* = 9 : 91
*ee: syn* 94%

**(2*R*,3*S*)-methyl-2-hydroxy-2-(4-methoxyphenyl)-3-(4-methoxyphenylamino)-3-phenylpropanoate (11-4h):**[7] 71% yield; dr (*anti* : *syn* = 9 : 91); 94% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 17.9 min, $t_{minor}$ = 27.5 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (*syn*-**11-4h**) 3.61 (s, 3H), 3.63 (s, 3H), 3.78 (s, 3H), 4.30 (br, 1H), 5.15 (s, 1H), 6.36 (d, *J* = 8.9 Hz, 2H), 6.58 (d, *J* = 8.9 Hz, 2H), 6.87 (d, *J* = 8.9 Hz, 2H), 7.24-7.44 (m, 5H), 7.63 (d, 8.9 Hz, 1H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.06, 55.20, 55.63, 63.11, 81.03, 113.72, 114.53, 114.64, 127.74, 127.98, 128.27, 128.41, 130.69, 138.51, 140.93, 151.87, 159.39, 173.65; HRMS (ESI) calcd for $C_{24}H_{25}NNaO_5$ $[M+Na]^+$ = 430.1630, found 430.1625.




**11-4h**, 75%
*anti : syn* = 9 : 91
*ee: syn* 94%

**(2*R*,3*S*)-methyl-2-(4-bromophenyl)-2-hydroxy-3-(4-methoxyphenylamino)-3-phenylpropanoate (11-4i)**:[7] 80% yield; dr (*anti*: *syn* = 14 : 86); 96% ee (*syn*) was determined by HPLC Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol/ alcohol = 90 : 5 : 5, 254 nm, Retention time: $t_{major}$ = 14.0 min, $t_{minor}$ = 19.2 min.); $^1$H NMR (CDCl3, 400 MHz) δ (*syn*-**11-4i**) 3.63 (s, 3H), 3.64 (s, 3H), 3.81 (s, 1H), 4.30 (br, 1H), 5.14 (s, 1H), 6.36 (d, *J* = 8.8 Hz, 2H), 6.59 (d, *J* = 8.8 Hz, 2H), 7.23-7.49 (m, 7H), 7.62 (d, 8.5 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ 53.34, 55.62, 63.12, 81.06, 114.63, 114.65, 122.34, 128.15, 128.28, 128.30, 128.36, 131.42, 137.88, 137.98, 140.49, 151.99, 172.99; HRMS (ESI) calcd for $C_{23}H_{22}BrNNaO_4$$[M+Na]^+$ = 478.0630, found 478.0624.




**11-4i**, 80%
*anti : syn* = 14 : 86
*ee: syn* 96%

## E. Catalytic asymmetric synthesis of *anti*-norstatine 11-2b with *in situ*-generated diazoesters

**One pot procedure for multi-component reaction of aryl imines 10b, 2-methyl-3-oxobutanoate 12, and water catalyzed by dirhodium acetate and CPA 12-b**.To the mixture of 4 mL water-saturated toluene and 2-methyl-3-oxobutanoate **12** (0.60 mmol) and *p*-ABSA (0.65 mmol), was added slowly 4 mL water solution of sodium hydroxide at 5 °C, and then stirred for 5 hours at room temperature. The yellow organic phase was extracted with a 5 mL toluene, which was subsequently added to a 8 mL water-saturated toluene solution of $Rh_2(OAc)_4$ (0.003 mmol), CPA (0.006 mmol), and imines **10b** (0.30 mmol) via a syringe pump over 1 h at rt. 0.1 ml saturated $NaHCO_3$ was added to quench the reaction. Solvent was removed, and a portion of crude product, after flash purification by a simple prepared TLC, was subjected to HPLC analysis for determination of the diastereoisomers ratio. The crude product was purified by flash chromatography on silica gel to provide the corresponding product **11-2b**, and then was analyzed by HPLC to determine enantiomer excess.

**One pot procedure for multi-component reaction of imine 10b, (L)-phenylalanine ethyl ester hydrochloride 13, and water catalyzed by dirhodium acetate and CPA 12-b.**To the mixture of 4 mL water-saturated toluene and (L)-phenylalanine ethyl ester hydrochloride **13** (0.60 mmol), was added slowly 4 mL water solution of sodium nitrite at -5 °C, until the halt of bubbling, the

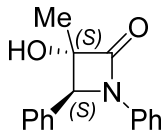
yellow organic phase was extracted with a 5 mL toluene, which was subsequently added to a 8 mLwater-saturated toluene solution of $Rh_2(OAc)_4$ (0.003 mmol), CPA (0.006 mmol), and imine **10b** (0.30 mmol) via a syringe pump over 1 h at rt. 0.1 ml saturated $NaHCO_3$ was added to quench the reaction. Solvent was removed via vacuum evaporation. A portion of crude product, after flash purification by a simple prepared TLC, was subjected to HPLC analysis for determination of the diastereoisomers ratio. The crude product was purified by flash chromatography on silica gel to provide the corresponding product **11-2o**, and then was analyzed by HPLC to determine enantiomer excess.

## F. Recycling $[Rh(OAc)_2]_2$ in the catalytic asymmetric synthesis of *anti*-norstatines 11-2

**General procedure of recycling $[Rh(OAc)_2]_2$ in the catalytic asymmetric synthesis of *anti*-norstatines 11-2:** A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*R*)-**12b** (0.005 mmol), imines **10** (0.275 mmol) and 4Å MS (100 mg) in the mixture of 1 mL toluene and 1 mL water under open air was stirred at room temperature. Diazo compound **8** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction was workup with saturated aqueous $NaHCO_3$ (0.1 ml). Toluene phase was separated by a funnel and was subsequently concentrated by vacuum evaporation to give the crude products. The aqueous phase containing $[Rh(OAc)_2]_2$ was used in the next round reaction. One time feed of $[Rh(OAc)_2]_2$ enables to finish 6 rounds of the reactions.

## G. Synthetic applications of norstatines and characterization of products.

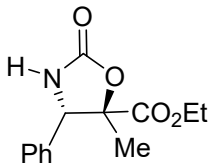
**Procedure for the synthesis of (3*S*,4*S*)-3-hydroxy-3-methyl-1,4-diphenylazetidin-2-one (14).** To the solution of compound **11-2a**



**14** 72%
93% *ee*

(0.5 mmol, 145 mg) in 5 mL THF, was added dropwise the solution of LiHMDS (1.0 mmol) in 417 $\mu$L THF at 0 °C, then warm up to room temperature in 1 hour, 2 hours later, the starting material was consumed completely by TLC analysis. 5 mL $NH_4Cl$ (aq) was added to quench the reaction at 0 °C, then the reaction mixture was extracted with 20 mL ethyl acetate for 3 times, combined the organic phase, washed with 20 mL brine, and dried with anhydrous $Na_2SO_4$. After vaporization of solvent, the crude product was purified with by flash chromatography on silica gel to provide the corresponding product **14** as a mixture of diastereomers which was separated with prepared TLC. Then the pure product analyzed by optical rotation machine to determine the absolute configuration of the product by comparing with the reported compound. **(3*S*,4*S*)-3-hydroxy-3-methyl-1,4-diphenylazetidin-2-one (14):** Column chromatography afforded the desired product **14** in 72% yield as white solid. Major diastereomer HPLC analysis (Chiralcel OD-H, $^i$PrOH/hexane = 1/19, 0.8 mL/min, 254 nm; $t_{major}$ = 19.14 min, $t_{minor}$ = 11.90 min) gave the isomeric composition of the product: 93% ee. $[\alpha]_D^{20}$ = +110.3 (*c* = 0.33, $CHCl_3$) Minor diastereomer HPLC analysis (Chiralcel OD-H, $^i$PrOH/hexane = 1/19, 0.8 mL/min, 254 nm; $t_{major}$ = 11.36 min, $t_{minor}$ =12.96 min) gave the isomeric composition of the product: 80% ee. $[\alpha]_D^{20}$ = +55.7 (*c* = 0.19, $CHCl_3$). $^1$H NMR ($CDCl_3$, 400 MHz): major diastereomer (*anti*-**14**): δ 7.10-7.40 (m, 10H), 5.11 (s, 1H), 3.50 (br, 1H), 1.10 (s, 3H); $^{13}$C NMR ($CDCl_3$, 100 MHz) :169.1, 137.1, 134.1, 129.1, 128.8, 128.4, 126.6, 124.4 117.9, 85.7, 69.3, 18.5. minor diastereomer (*syn*-**14**): δ 7.10-7.40 (m, 10H), 5.00 (s, 1H), 2.23 (br, 1H), 1.70 (s, 3H); $^{13}$C NMR ($CDCl_3$, 100 MHz) :168.2, 137.2, 133.7, 129.3, 129.2, 129.0, 127.0, 124.4 117.6, 83.6, 68.7, 21.7.

**Procedure for the synthesis of Ethyl (4*S*,5*S*)-5-methyl-2-oxo-4-phenyloxazolidine-5-carboxylate (15):** To the solution of

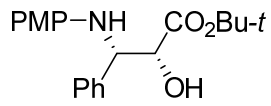


**15** 70% for two steps, 90% *ee*

norstatine **11-2b** (329 mg, 0.2 mmol) in 4 mL THF, was added DBU (61 mg, 0.4 mmol) and then the solution of triphosgene (118mg, 0.4 mmol) in 4 mL in 30 mins, the reaction mixture was stirred at 60 °C, 6 hours later, the starting material **11-2b** disappeared by TLC analysis. Cooling to 0 °C, 10 mL $NH_4Cl$ (aq) was added to quench the reaction. The reaction mixture was extracted with 20 mL ethyl acetate for 3 times, combined the organic phase, washed with 20 mL brine, and dried with anhydrous $Na_2SO_4$. After vaporization of solvent, the crude product was dissolved in 4 mL acetonitrile and 2 mL water at 0 °C, and then solution of CAN (259 mg, 0.4 mmol) in 2 mL water was added dropwise, the solution tured orange, in 30 mins, the organed color fade into light orange, the material reacted completely analyzing by TLC, To the reaction mixture was added 20 mL ethyl acetate, and then washed with 10 mL $NaHCO_3$ (aq) for 3 times, and then the inorganic phase was extracted with 30 mL ethyl acetate for 3 times, combined the organic phase, washed with 20 mL brine, and dried with anhydrous $Na_2SO_4$. After vaporization of solvent, the crude product was purified with by flash chromatography on silica gel to provide compound **15** as colorless oil. **Ethyl (4*S*,5*S*)-5-methyl-2-oxo-4-phenyloxazolidine-5-carboxylate (15):** Column chromatography afforded the desired product **15** in 70% yield as oil. Major diastereomer (*anti*-**15**) HPLC analysis (Chiralcel IA, $^i$PrOH/hexane = 1/5, 1.0 mL/min, 254 nm; $t_{major}$ = 25.68 min, $t_{minor}$ = 35.85 min) gave the isomeric composition of the product: 90% ee. $^1$H NMR ($CDCl_3$, 400 MHz): δ 7.42-7.31 (m, 5H), 5.85 (s, 1H), 5.13 (s, 1H), 4.34 (q, *J* = 8.0 Hz 2H), 1.37 (t, *J* = 8.0 Hz, 3H), 1.13 (s,

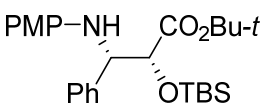
3H); $^{13}$C NMR($CDCl_3$, 100 MHz) :171.8, 157.80, 135.8, 129.5, 129.5, 129.0, 127.1, 84.4, 81.8, 76.7, 62.6, 62.2, 20.3, 14.1; HRMS: calcd for $C_{13}H_{15}NNaO_4$ $[M+Na]^+$, 272.1001; found 272.1009.

**(2*R*,3*S*)-tert-butyl-2-hydroxy-3-(4-methoxyphenylamino)-3-phenylpropanoate (16a)**:[6] The protected phenylpropanoate 5e (84% ee) was hydrogenolyzed separately using ammonium formate (3 equivalents) and 10% Pd/C (1 equiv.) in methanol (15 mL/g) for 12 h at 35°C. The catalyst was filtered and washed with methanol twice. The combined washings and filtrate were evaporated in vacuo and the residue taken into CHCl3, washed with water, and dried over $Na_2SO_4$. The solvent was removed under reduced pressure and get the white solid product, and recrystallized by the solvent (EA:n-hex = 1:50) in the yield of 48% (two steps). $[\alpha]_D^{20}$ = -9.5° (c = 1.0 in $CH_2Cl_2$), >99% ee was determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 70 : 30, 254 nm, Retention time: $t_{minor}$ = 15.5 min, $t_{major}$ = 7.7 min); mp 140– 141°C; $^1$H NMR ($CDCl_3$, 400 MHz) δ 1.41 (s, 9H), 3.23 (d, *J* = 4.0 Hz, 1H) , 3.67 (s, 3H), 4.38 (br, 1H), 4.46 (br, 1H), 4.80 (br, 1H), 6.50 (d, *J* = 12.0 Hz, 2H), 6.66 (d, *J* = 12.0 Hz, 2H), 7.23-7.38 (m, 5H); $^{13}$C NMR ($CDCl_3$, 100MHz) δ 27.9, 55.6, 59.9, 74.6, 83.4, 114.7, 114.9, 127.0, 127.3, 128.4, 139.6, 140.8, 152.1, 172.2; HRMS (ESI) calcd for $C_{20}H_{25}NNaO_4$ $[M+Na]^+$ = 366.1681, found 366.1676.



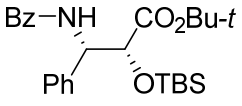
**16a** 48% yield, >99% ee

**(2*R*,3*S*)-tert-butyl-2-(tert-butyldimethylsilyloxy)-3-(4-methoxyphenylamino)-3-phenylpropanoate (16b):[6]** To a solvent of the hydroxyl phenylpropanoate 8 and TBSCl (1.5 equiv.) in $CH_3CN$ (20 mL/g) was stirred at room temperature and DBU (1.2 equiv.) was added dropwise to the solution. After the reaction mixture was stirred for 10 h, the solvent was removed under reduced pressure and the remains washed with water and extracted with ethyl acetate. After a usual work, the crude product was chromatographed on flash silica gel to afford the desired protected phenylpropanoate 9 in quant yield. $^1$H NMR ($CDCl_3$, 400 MHz) δ -0.22 (s, 3H), 0.00 (s, 3H), 0.93 (s, 9H), 1.55 (s, 9H), 3.82 (d, *J* = 4.0 Hz, 1H), 3.67 (s, 3H), 4.38 (br, 1H), 4.46 (br, 1H), 4.80 (br, 1H), 6.50 (d, *J* = 12.0 Hz, 2H), 6.66 (d, *J* = 12.0 Hz, 2H), 7.23-7.38 (m,5H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ -6.1, -5.5, 1.0, 18.2, 25.5, 28.0, 55.6, 61.1, 81.6, 114.4, 114.6, 127.2, 127.3, 128.2, 140.3, 141.2, 151.7, 170.8.



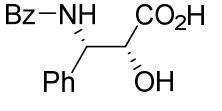
**16b**, 100%

**(2*R*,3*S*)-*tert*-butyl-3-benzamido-2-hydroxy-3-phenylpropanoate (16c)**:[6] To a solution of (2*R*,3*S*)-*tert*-butyl-2-(tert-butyldimethylsilyloxy)-3-(4-methoxyphenylamino)-3-phenyl-propanoate (**16b**) (457 mg, 1 mmol) in the wet $CH_3CN$ (20 mL) was added the solution of cerium ammonium nitrate (CAN, 2.19 g, 4 mmol) in wet $CH_3CN$ (5 mL) at 0°C. After the reaction mixture was stirred for 1h, the mixture was added saturated $NaHCO_3$ aqueous until the *p*H is greater than 7. Insoluble materials were filtered and the aqueous layer was extracted with ethyl acetate and dried over $Na_2SO_4$. The solvent was removed under reduced pressure and the crude product directly dissolved in the $CH_2Cl_2$ (20 mL), then the Triethylamine (3.03 g, 3 mmol) was added dropwise to the solution and the mixture stirred for 15 min at room temperature. Freshly distilled benzoyl chloride (140 mg, 1 mmol) in the $CH_2Cl_2$ (2 mL) was added dropwise to the resultant solution and stirring was continued at room temperature for 2h. The solution was then diluted with $CH_2Cl_2$ (20 mL) and water (20 mL) was added. The organic layer was separated, and aqueous layer extracted with further $CH_2Cl_2$ (2 × 20 mL). The combined organic extracts were dried ($MgSO_4$), filtered and evaporated under reduced pressure, the crude product was chromatographed on flash silica gel to afford the desired product. To a solution of the product in anhydrous tetrahydrofuran (10 mL) was treated with TBAF (260 mg, 1 mmol). After the mixture was stirred for 2 h at room temperature, the mixture was evaporated and the crude product was chromatographed on flash silica gel to afford the desired compound 10 as a white solid (156 mg, 46%, three steps). $[\alpha]_D^{20}$ = -21.3°(c = 1.0 in $CH_2Cl_2$), >99% ee, determined by HPLC (Daicel Chirapak IA, flow rate 1.0 mL/min, hexane/ isopropanol = 70 : 30, 254 nm, Retention time: $t_{minor}$ =13.7 min, $t_{major}$ = 6.9 min.); mp 111–112°C; $^1$H NMR ($CDCl_3$, 500 MHz) δ 1.49 (s, 9H), 3.34 (br, 1H), 4.54 (s, 1H), 5.77 (dd, $J_1$ = 1.6 Hz, $J_2$ = 10.9 Hz, 1H), 6.98 (br, 1H), 7.26-7.51(m, 8H), 7.76-7.78 (m, 2H); $^{13}$CNMR ($CDCl_3$, 100MHz) δ 27.8, 54.5, 73.4, 84.1, 126.8, 127.0, 127.6, 128.5, 128.6, 131.6, 134.2, 138.8, 166.8, 172.0; HRMS (ESI) calcd for $C_{20}H_{23}NNaO_4$ $[M+Na]^+$ = 364.1525, found 364.1520.



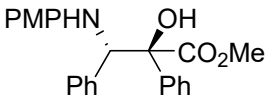
**16c** 46% yield

**(2*R*,3*S*)-3-benzamido-2-hydroxy-3-phenylpropanoic acid (16d):[6]** A solution of the *tert*-butyl ester **16b** (68.0 mg, 0.2 mmol) and trifluoroacetic acid (0.4 mL) in $CH_2Cl_2$ (1 mL) was stirred at room temperature for 6 h. The solvent was evaporated and the residue crystallized from ethyl acetate (2 mL) to give the acid **16d** (47.4 mg, 83%). ($[\alpha]_D^{20}$ = -38.6° (c = 1.05 in EtOH); mp 158– 160°C; $^1$H NMR (DMSO-$d_6$, 500 MHz) δ 4,39 (br, 1H), 5.46 (dd, $J_1$ =4.0 Hz, $J_2$ = 13.0 Hz, 1H), 5.53 (br, 1H), 7.23-7.57 (m, 8H), 7.84 (m, 2H), 8.53 (d, *J* = 9.0 Hz, 1H), 12.73 (s, 1H); $^{13}$C NMR ($CDCl_3$, 100MHz) δ 55.8, 73.6, 127.0, 127.2, 127.4, 128.1, 128.4, 131.4, 134.4, 140.3, 166.1, 173.5; HRMS (ESI) calcd for $C_{16}H_{16}NO_4$ $[M+H]^+$ =286.1079, found 286.1079.



**16d** yield 83%

**(2*S*,3*S*)-methyl-2-hydroxy-3-(4-methoxyphenylamino)-2,3-diphenylpropanoate (17):**[5] To a solution of compound 11-1b (0.05 mmol) and NaI (15 mg, 2 equiv.) in 0.5 mL of $CH_3CN$ was added 15 µl TMSCl (2-2.5 equiv) via a syringe pump at room temperature under an argon atmosphere. The reaction temperature was warmed to 50 °C and stirred over night. The reaction mixture was poured into water and stirred for 10 min. The aqueous phase was extracted with EtOAc. The organic phase was separated, washed with saturated aqueous $Na_2S_2O_3$, and dried over anhydrous $MgSO_4$. After evaporating the solvents, the crude product was purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:30~1:20) to give norstatine derivative *anti*-**11-4a**. yield 75%; $[\alpha]_D^{20}$ = -136.0°(c = 1, EtOAc); 93% ee was determined by HPLC (Daicel Chirapak IA, flow rate 0.9 mL/min, hexan/ isopropanol / EtOH / TFA = 425 : 25 : 25 : 1, 254nm, Retention time: $t_{major}$ = 16.2 min, and $t_{minor}$ = 23.2 min.); $^1$H NMR ($CDCl_3$, 400 MHz) δ (ppm) 3.63 (s, 3H), 3.64 (s, ), 3.84 (bs, 1H), 4. (bs, 1H), 5.21 (bs, 1H), 6.38 (d, *J* = 9.0 Hz, 2H), 6.60 (d, *J* = 9.0 Hz, 2H), 7.25-7.45 (m, 6H), 7.76 (d, *J* = 7.5 Hz, 2H); $^{13}$C NMR ($CDCl_3$, 100 MHz) δ (ppm) 53.21, 55.62, 63.08, 81.26, 114.54, 114.59, 126.45, 128.03, 128.12, 128.31, 128.34, 128.41, 138.37, 138.67, 140.79, 151.83, 173.4 HRMS (ESI) calcd for $C_{23}H_{24}NO_4$ $(M+H)^+$ 378.1700, found 378.1702.



**17** 75% yield 93% ee

## H. Mechanistic experiments

**Procedure of demonstration of synergy of Rhodium catalyst and CPA 12b:** A solution of $[Rh(2S\text{-}MEPY)_2]_2$ (0.005 mmol), water (0.25 mmol) , imines **10-2a** (0.275 mmol) and 4Å MS (100 mg) in 2 mL toluene under open air was stirred at room temperature. Diazo compound **8-2a** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction was workup with saturated aqueous $NaHCO_3$ (0.1 ml). Toluene was removed by vacuum evapration to give the crude products, which were subjected to $^1$H NMR spectroscopy analysis for the determination of diastereoselectivities. The crude products were purified by flash chromatography on silica gel (eluent: EtOAc/light petroleum ether = 1:20 ~1:10) to give the pure products **11-2a**. The 0% ee of resulting pure product was determined by chiral HPLC.

A solution of CPA (*R*)-**12b** (0.005 mmol), water (0.25 mmol), imines **10-2a** (0.275 mmol) and 4Å MS (100 mg) in 2 mL toluene under open air was stirred at room temperature. Diazo compound **8-2a** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, the reaction was workup with saturated aqueous $NaHCO_3$ (0.1 ml). TLC analysis of the reaction mixture indicates the desired product **11-2a** doesn't form.

**Procedure of control experiments to indicate the reactions go through the trapping of oxonium ylides with imines**: A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), water (0.25 mmol) , and 4Å MS (100 mg) in 2 mL toluene under open air was stirred at room temperature. Diazo compound **8-2a** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, CPA (*R*)-**12b** (0.005 mmol) and imine **10-2a** (0.275 mmol) was added to the reaction. TLC analysis after 1h indicates no formation of desired product **11-2a**.

A solution of $[Rh(OAc)_2]_2$ (0.005 mmol), CPA (*R*)-**12b** (0.005 mmol), and imine **10-2a** (0.275 mmol), and 4Å MS (100 mg) in 2 mL toluene under open air was stirred at room temperature. Diazo compound **8-2a** (0.25 mmol) in 1 mL toluene was then added dropwise over 1 h via a syringe pump. After completion of the addition, water (0.25 mmol) was added to the reaction. TLC analysis after 1h indicates no formation of desired product **11-2a**.

## I. References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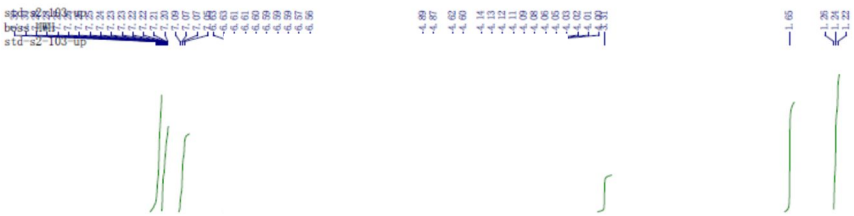
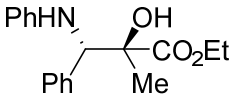
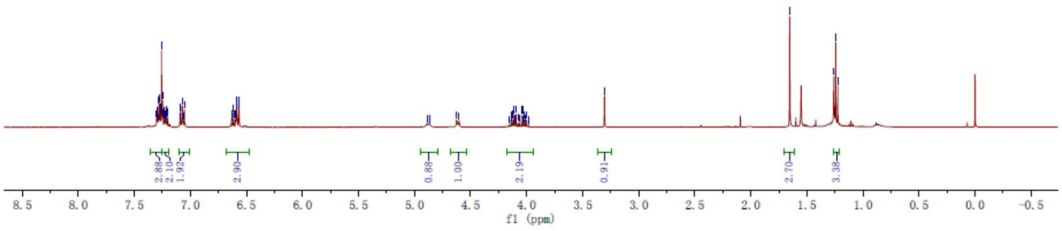
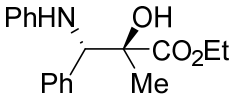
## J. **NMR spectra**



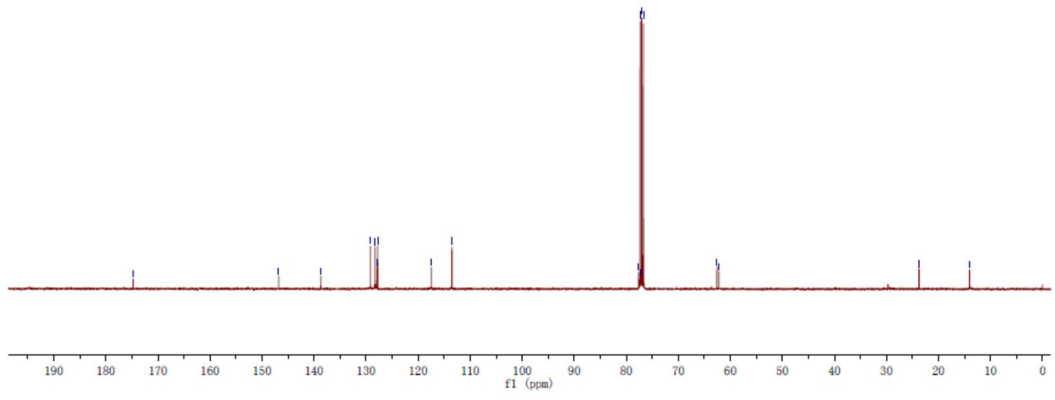


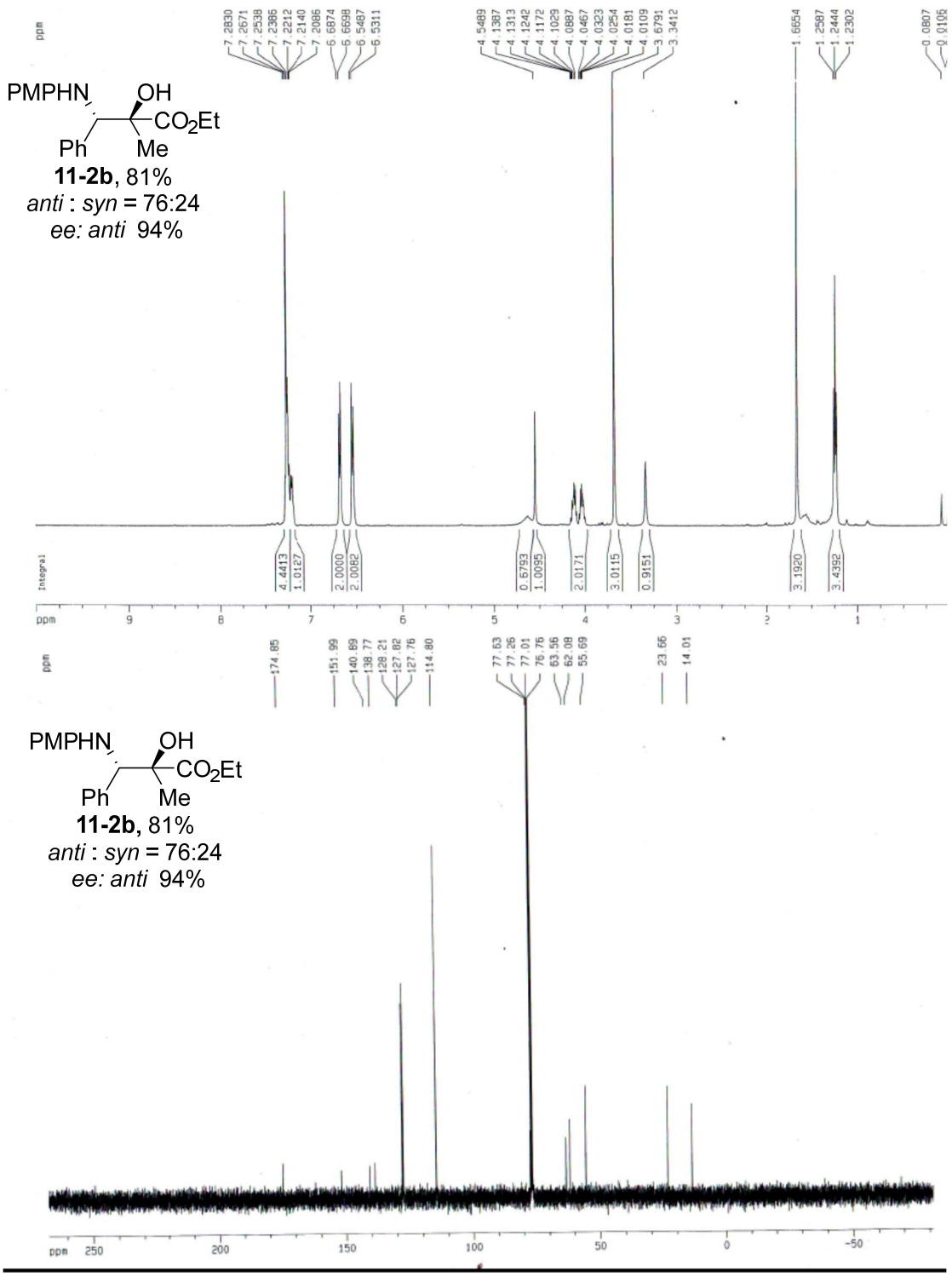
**11-2a**, 73%
*anti* : *syn* = 71:29
*ee: anti* 94% *syn* 81%





**11-2a**, 73%
*anti* : *syn* = 71:29
*ee: anti* 94% *syn* 81%




PMPHN
OH
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Me
11-2b, 81%
anti : syn = 76:24
ee: anti 94%
ppm
Integral
PMPHN
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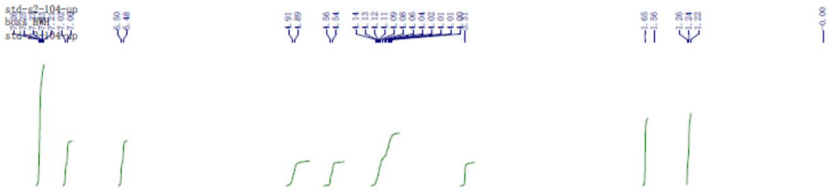
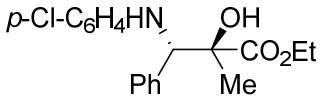
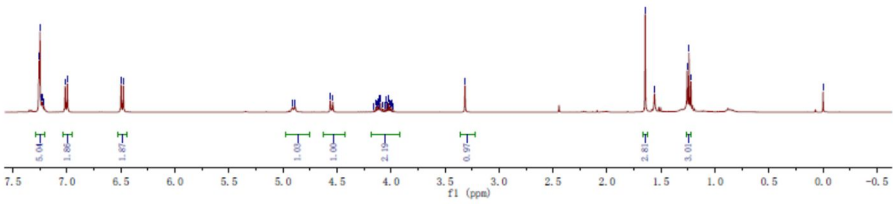
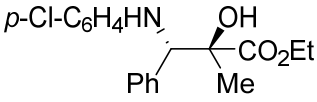
CO2Et
Ph
Me
11-2b, 81%
anti : syn = 76:24
ee: anti 94%
ppm



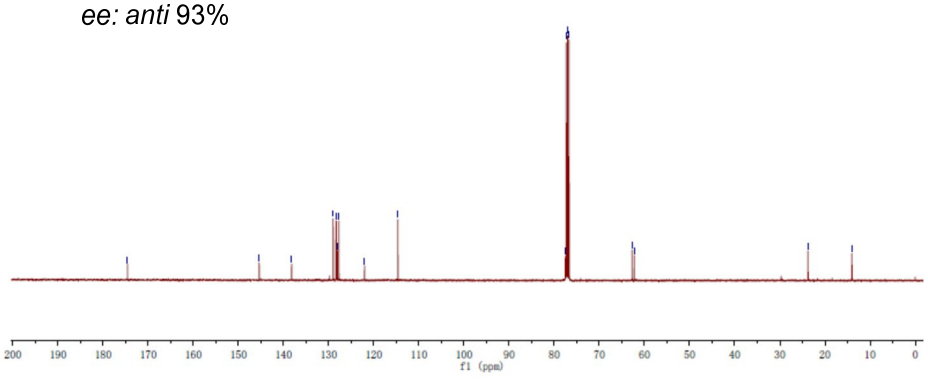


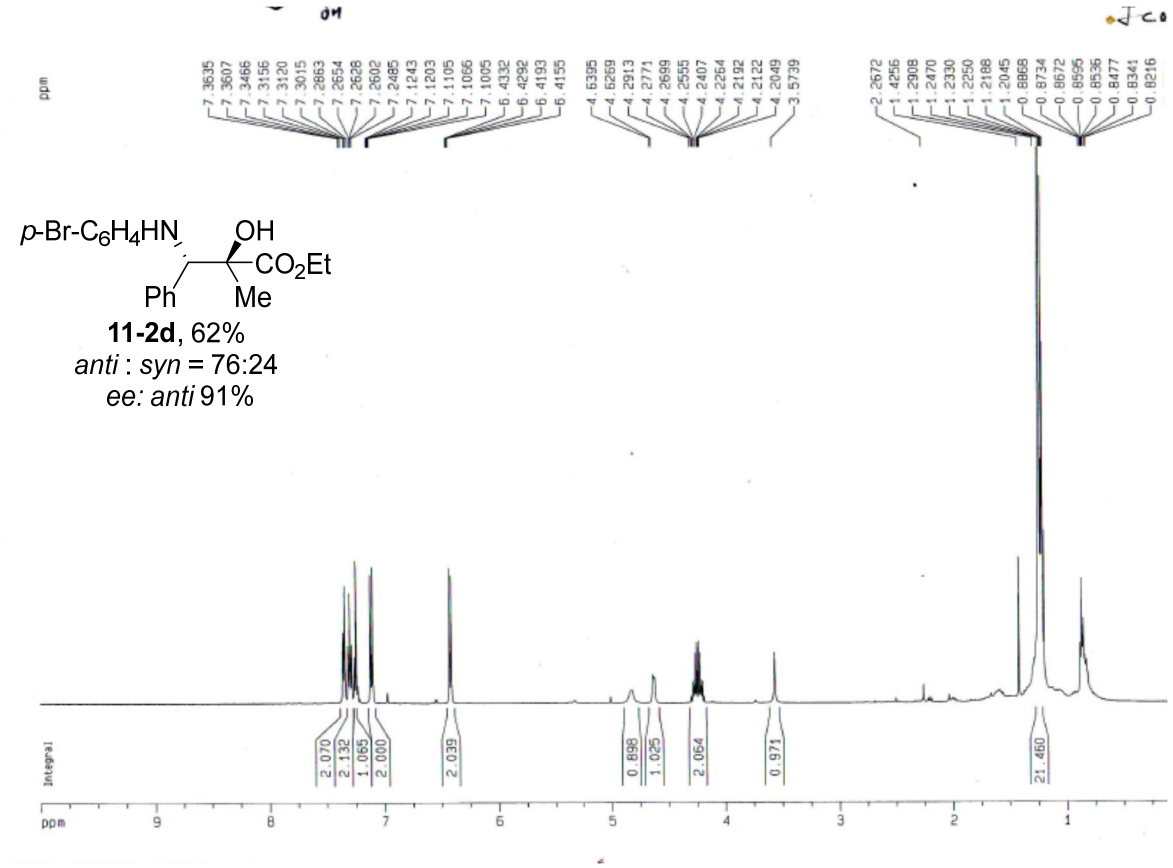

**11-2c**, 81%
*anti* : *syn* = 74:26
*ee: anti* 93%

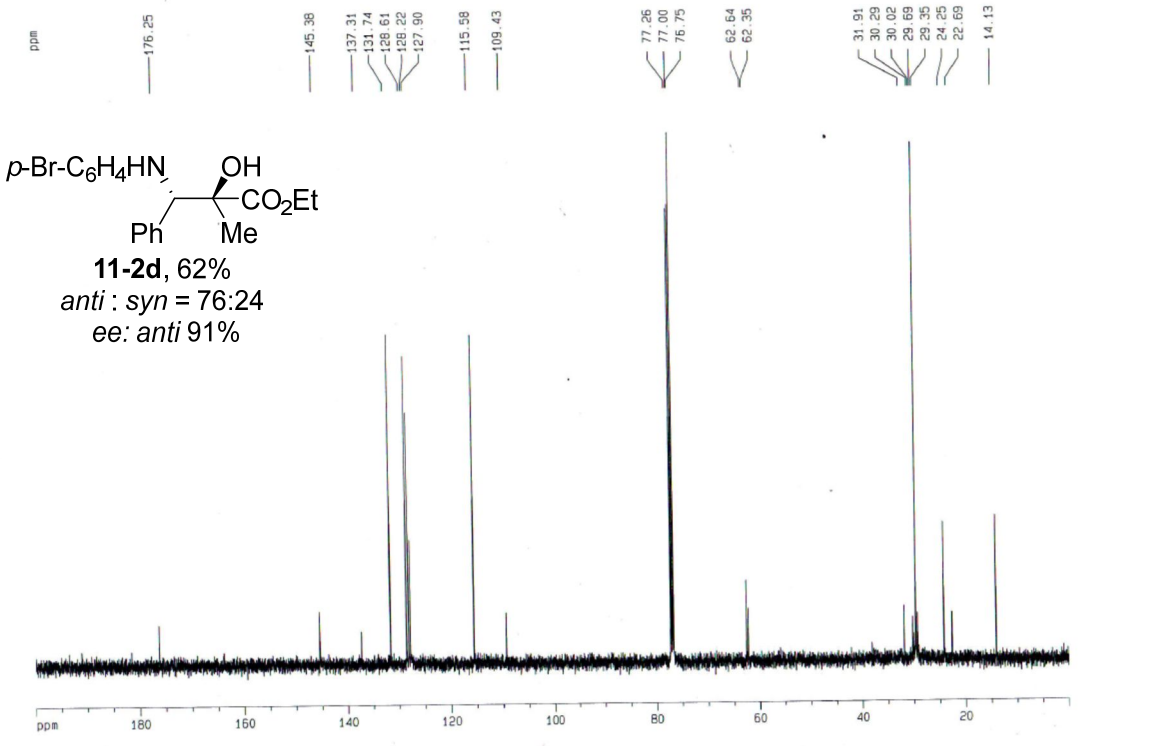


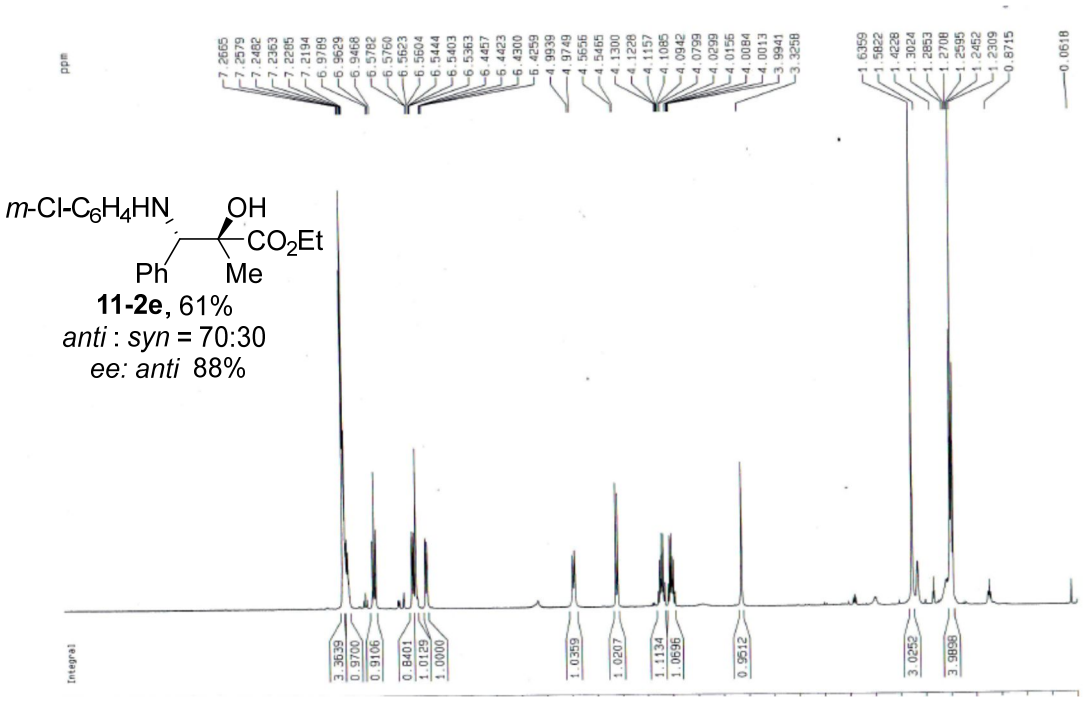



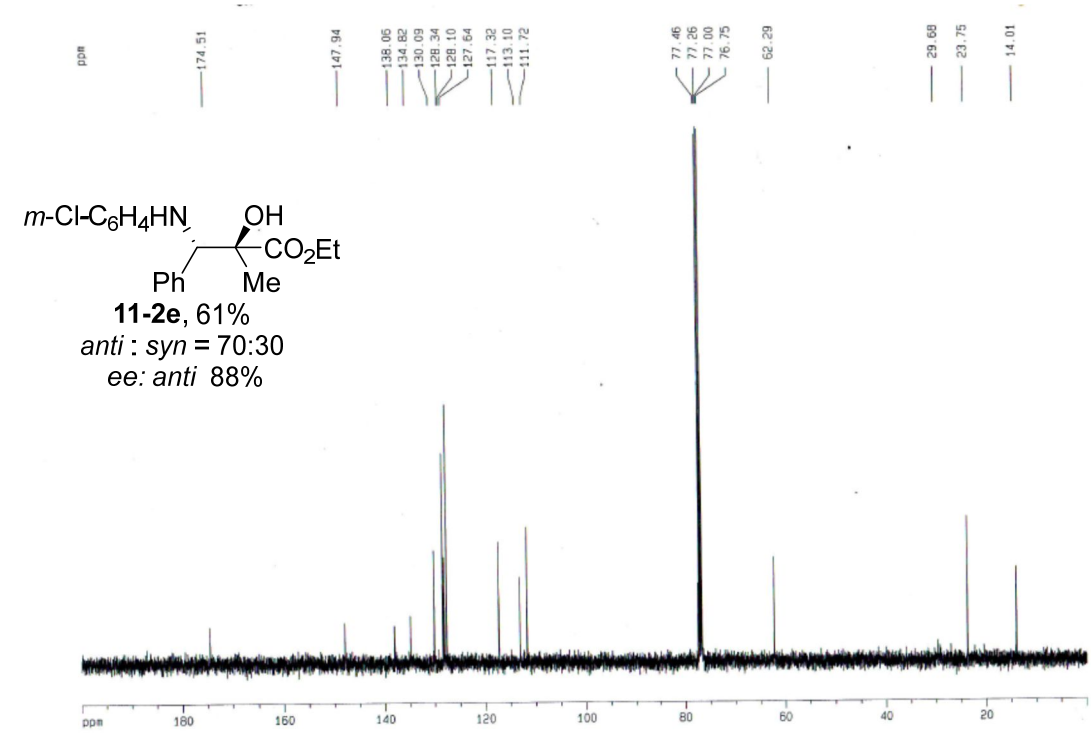

**11-2c**, 81%
*anti* : *syn* = 74:26
*ee: anti* 93%

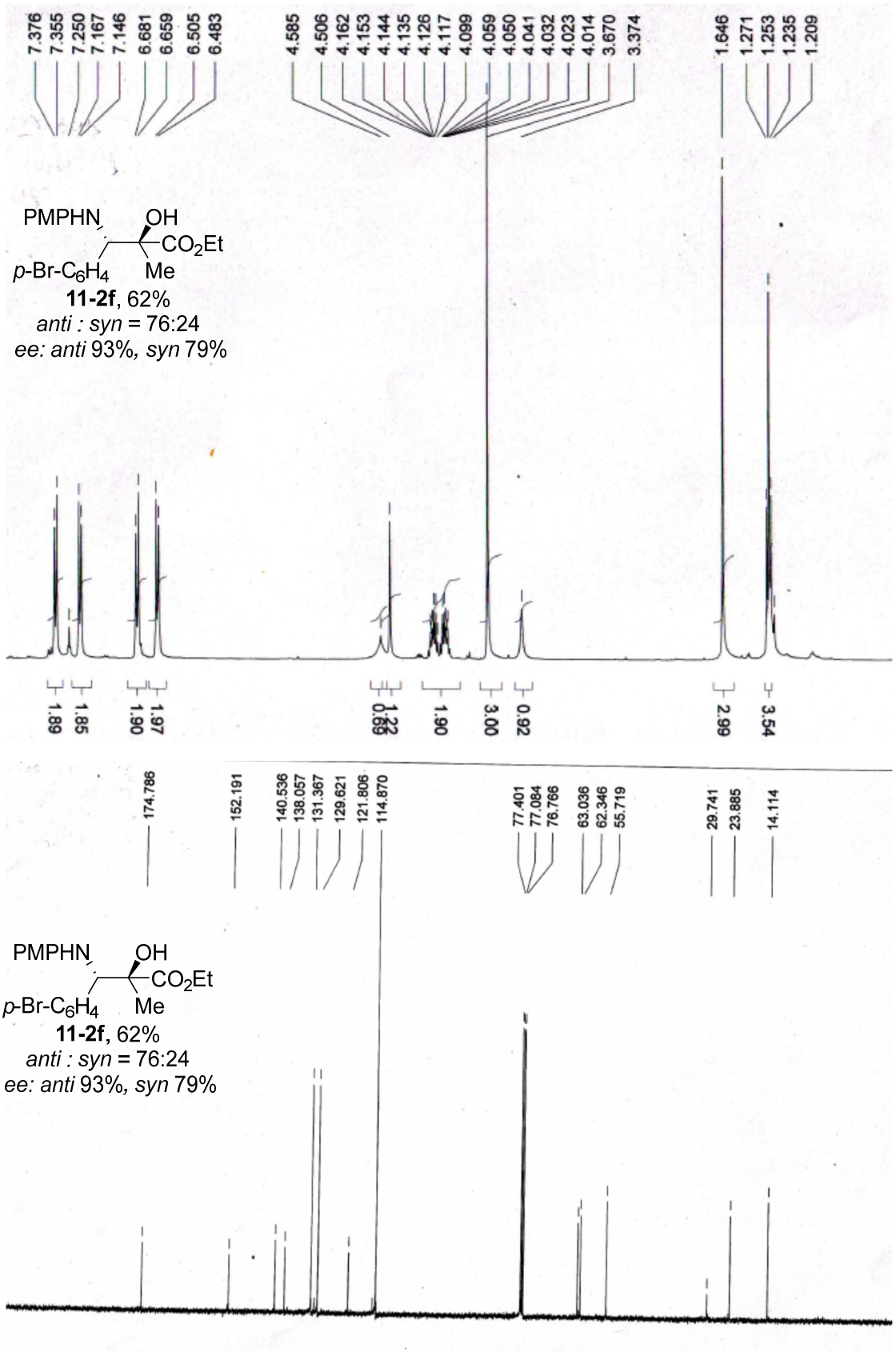


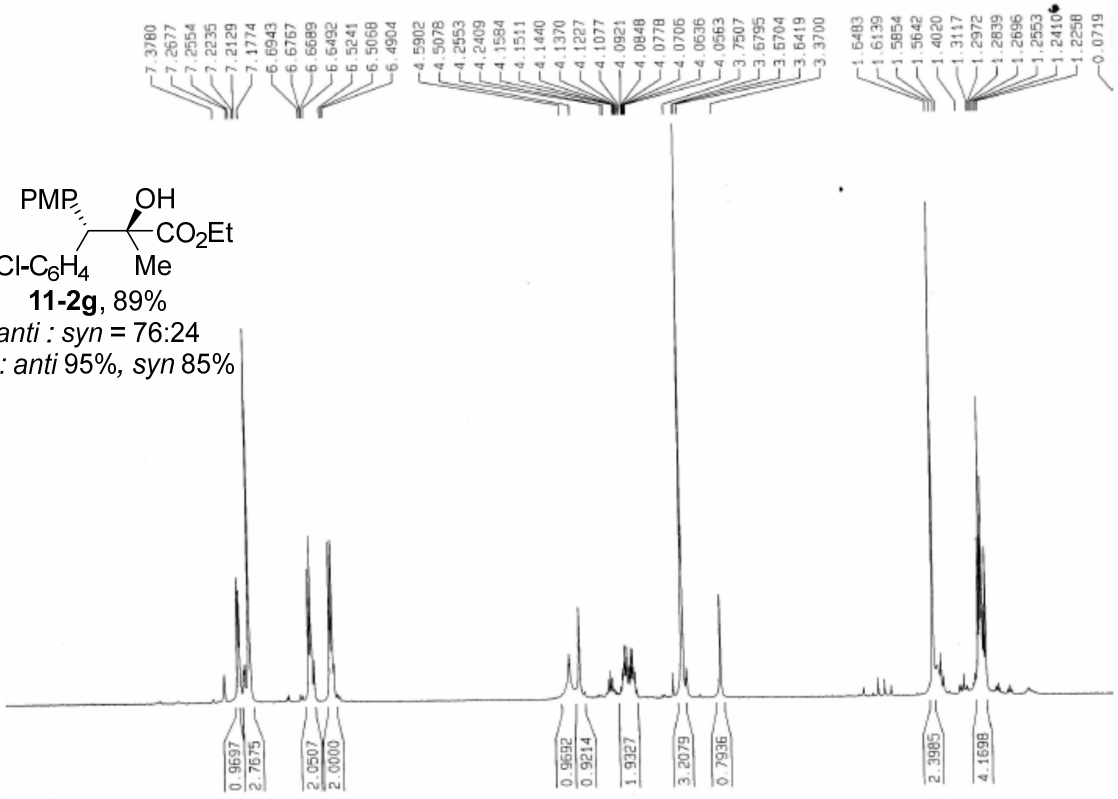

p-Br-C6H4HN
OH
CO2Et
Ph
Me
11-2d, 62%
anti : syn = 76:24
ee: anti 91%


p-Br-C6H4HN
OH
CO2Et
Ph
Me
11-2d, 62%
anti : syn = 76:24
ee: anti 91%

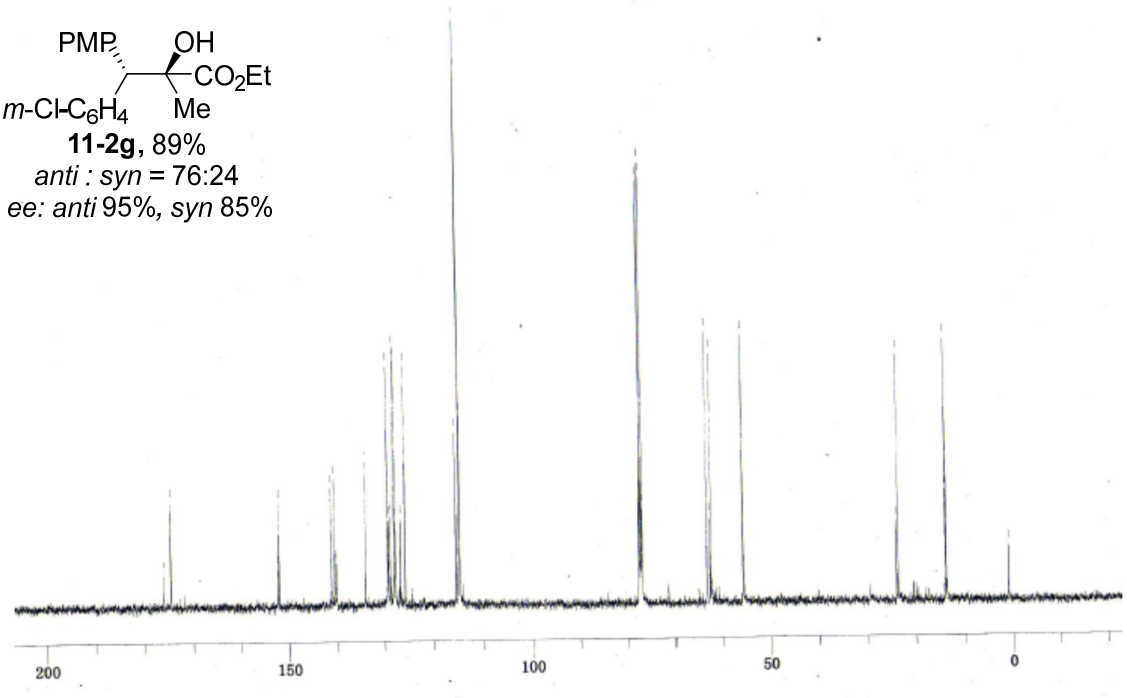

m-Cl-C6H4HN
OH
CO2Et
Ph
Me
11-2e, 61%
anti : syn = 70:30
ee: anti 88%


m-Cl-C6H4HN
OH
CO2Et
Ph
Me
11-2e, 61%
anti : syn = 70:30
ee: anti 88%

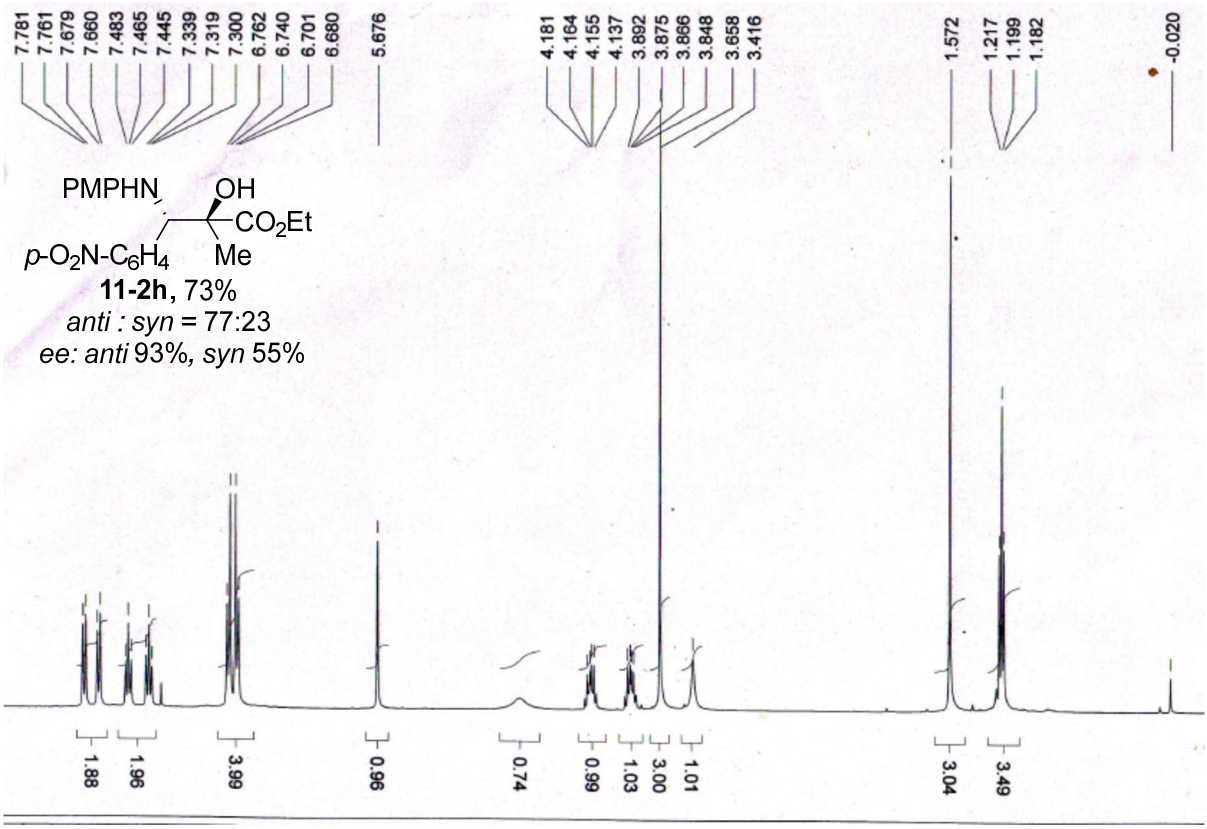

7.376
7.355
7.250
7.167
7.146
6.681
6.659
6.505
6.483
4.585
4.506
4.162
4.153
4.144
4.135
4.126
4.117
4.099
4.059
4.050
4.041
4.032
4.023
4.014
3.670
3.374
1.646
1.271
1.253
1.235
1.209
PMPHN
OH
CO2Et
p-Br-C6H4
Me
11-2f, 62%
anti : syn = 76:24
ee: anti 93%, syn 79%
1.89
1.85
1.90
1.97
0.89
1.22
1.90
3.00
0.92
2.99
3.54
174.786
152.191
140.536
138.057
131.367
129.621
121.806
114.870
77.401
77.084
76.766
63.036
62.346
55.719
29.741
23.885
14.114
PMPHN
OH
CO2Et
p-Br-C6H4
Me
11-2f, 62%
anti : syn = 76:24
ee: anti 93%, syn 79%

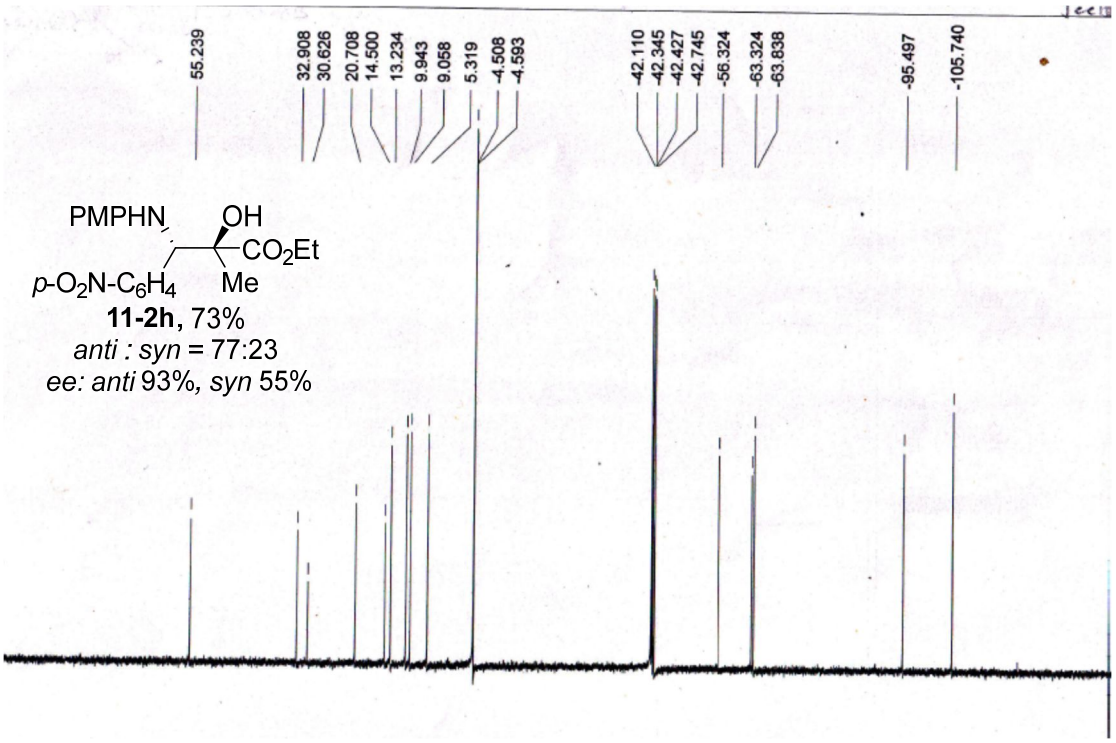


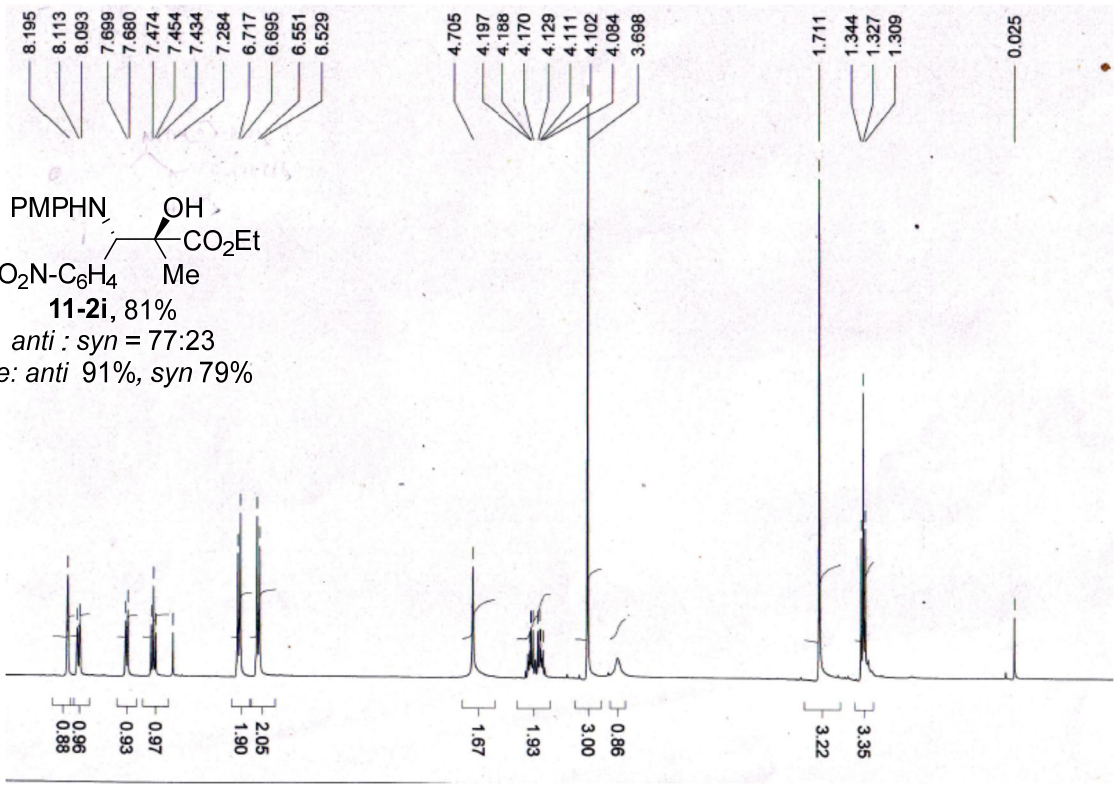

**11-2g**, 89%
*anti : syn* = 76:24
*ee: anti* 95%, *syn* 85%




**11-2g**, 89%
*anti : syn* = 76:24
*ee: anti* 95%, *syn* 85%

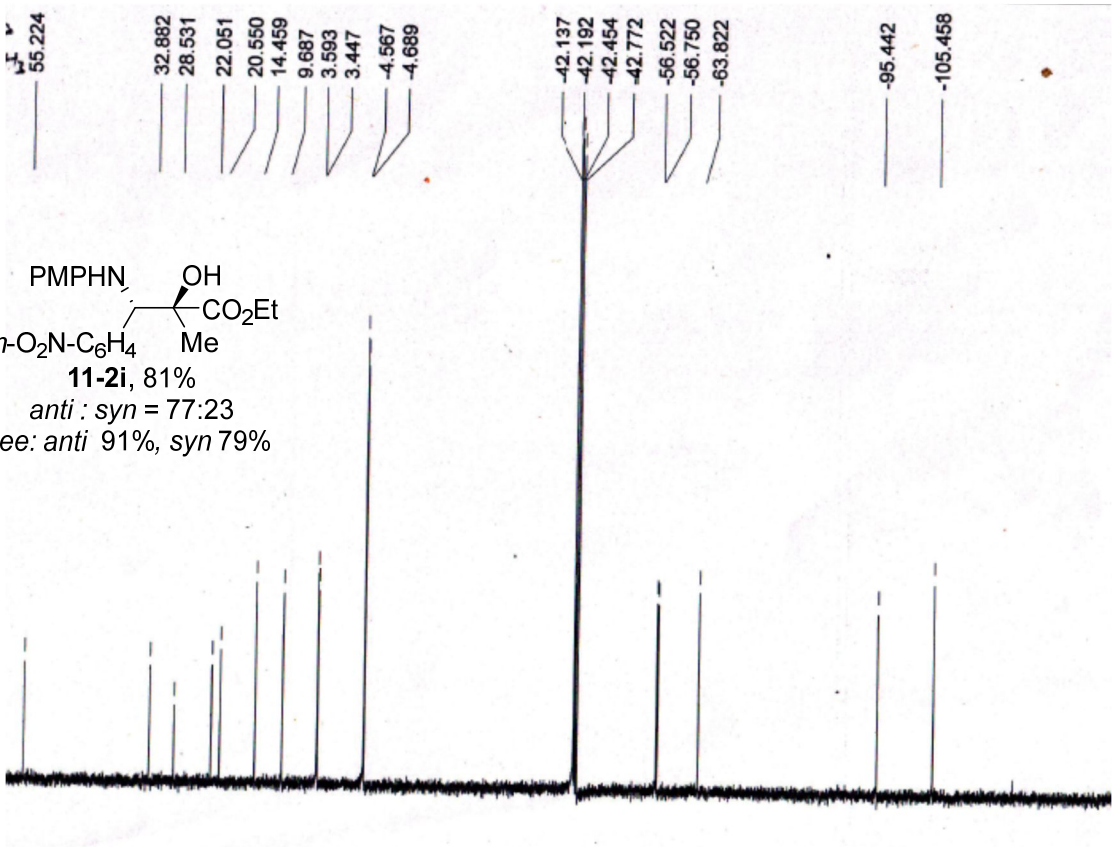

7.781
7.761
7.679
7.660
7.483
7.465
7.445
7.339
7.319
7.300
6.762
6.740
6.701
6.680
5.676
4.181
4.164
4.155
4.137
3.892
3.875
3.866
3.848
3.658
3.416
1.572
1.217
1.199
1.182
-0.020
PMPHN
OH
CO2Et
p-O2N-C6H4
Me
11-2h, 73%
anti : syn = 77:23
ee: anti 93%, syn 55%
1.88
1.96
3.99
0.96
0.74
0.99
1.03
3.00
1.01
3.04
3.49


55.239
32.908
30.626
20.708
14.500
13.234
9.943
9.058
5.319
-4.508
-4.593
-42.110
-42.345
-42.427
-42.745
-56.324
-63.324
-63.838
-95.497
-105.740
PMPHN
OH
CO2Et
p-O2N-C6H4
Me
11-2h, 73%
anti : syn = 77:23
ee: anti 93%, syn 55%



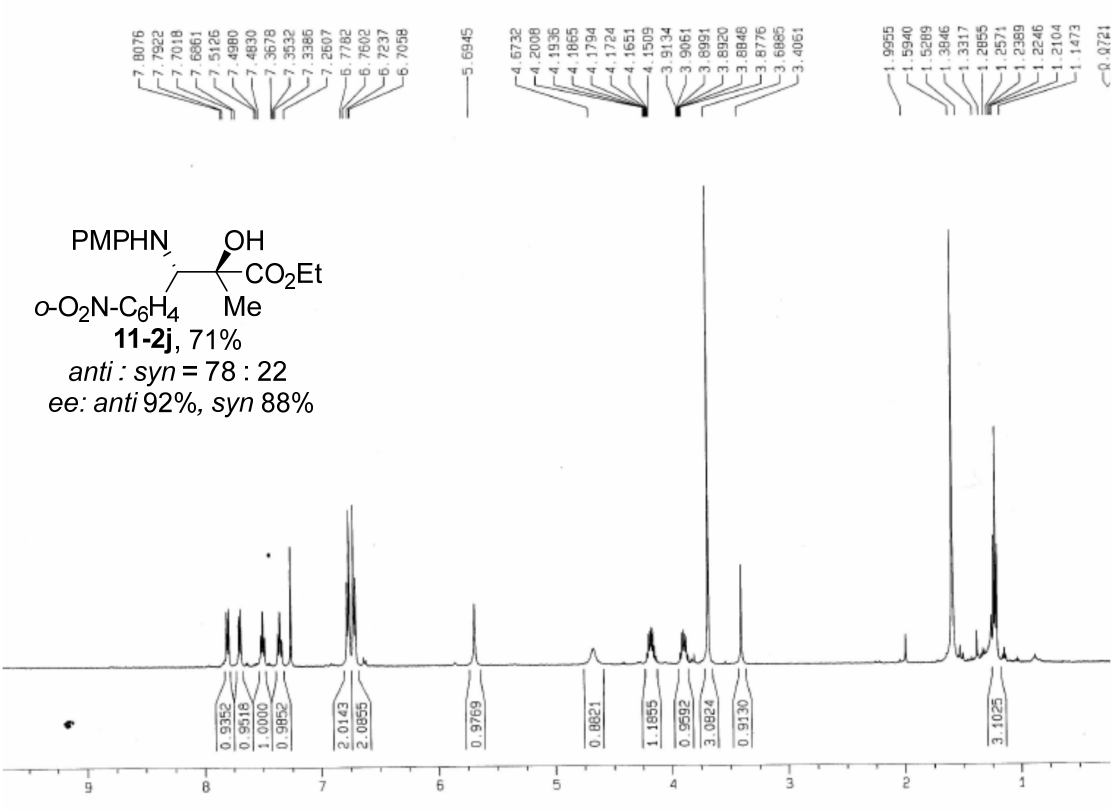

PMPHN OH
$CO_2Et$
*m*-$O_2N$-$C_6H_4$ Me

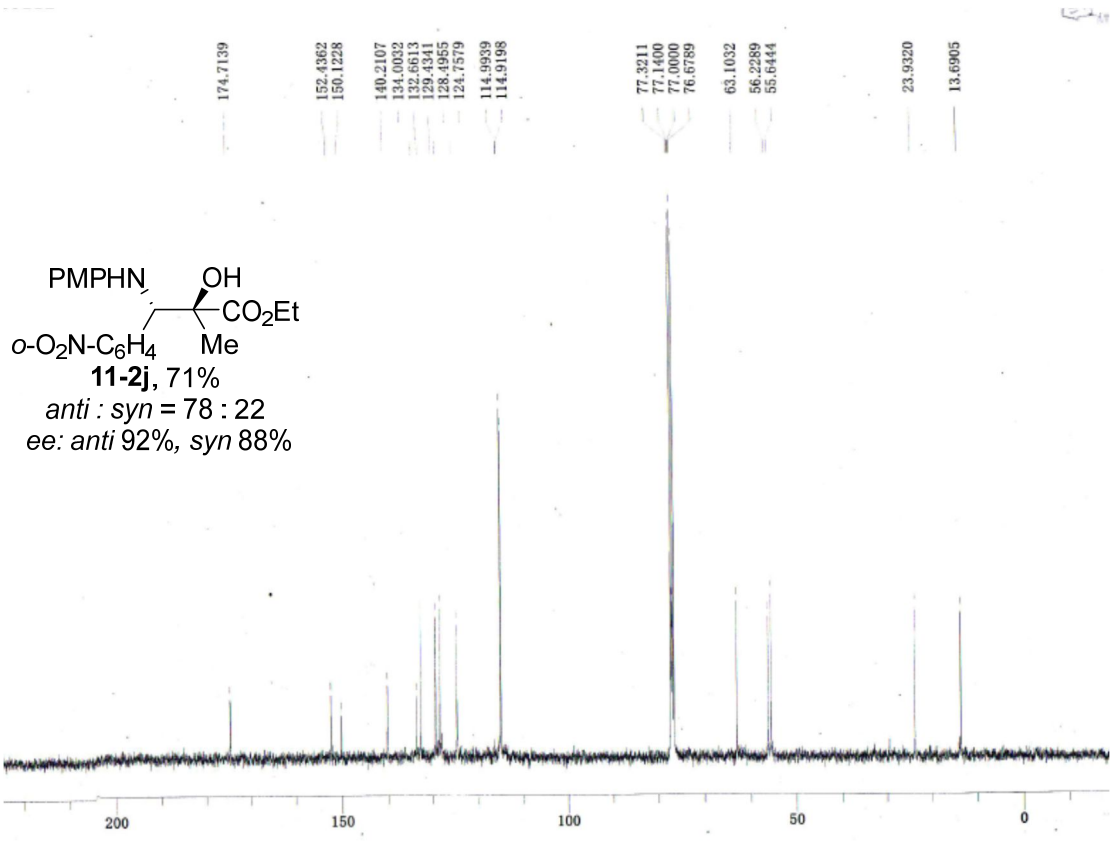
**11-2i**, 81%
*anti : syn* = 77:23
*ee: anti* 91%, *syn* 79%

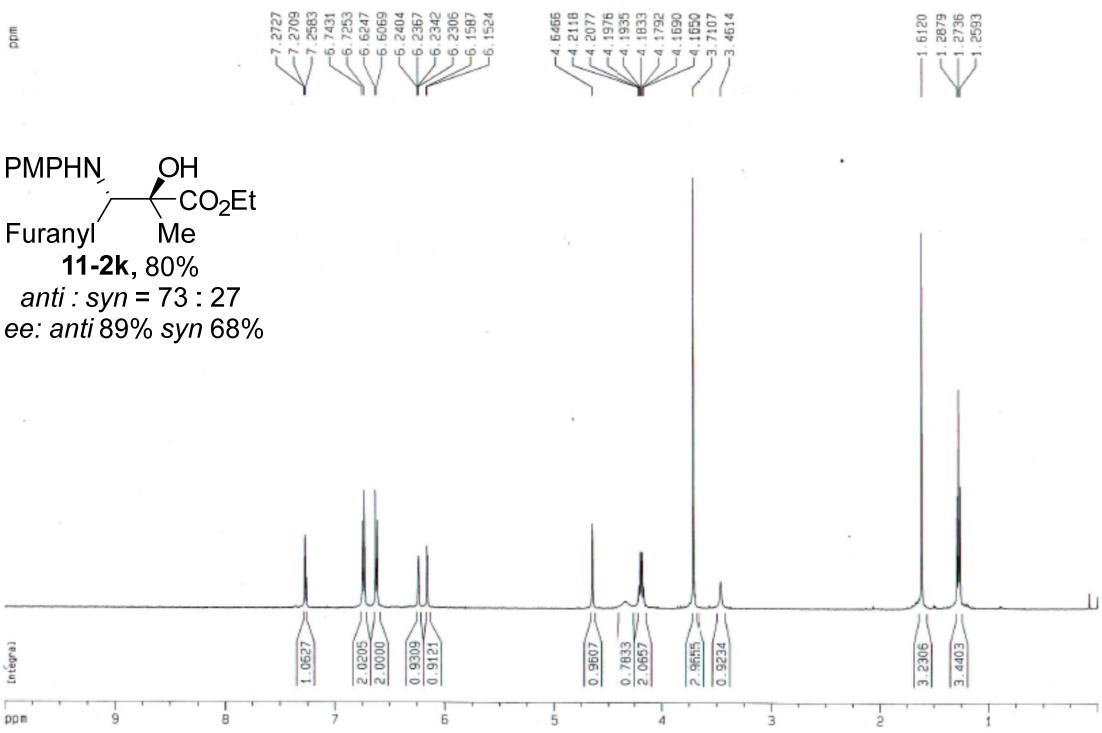


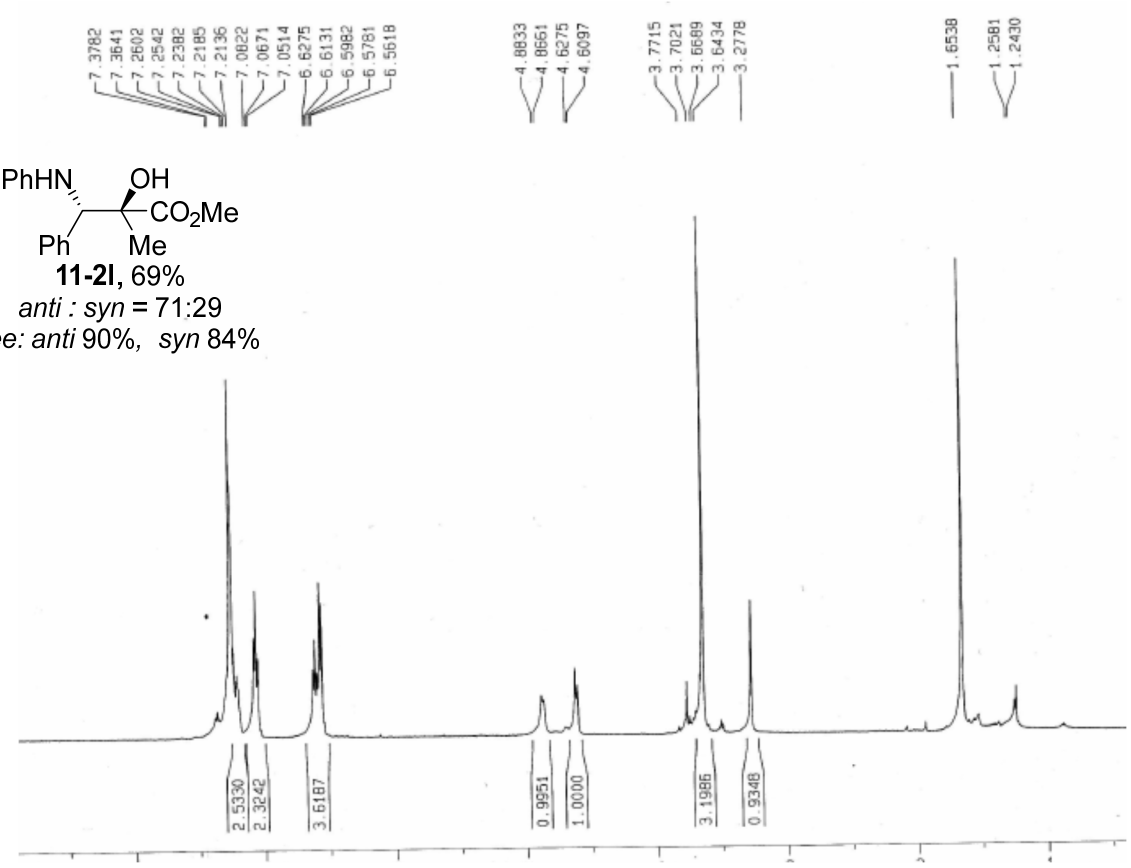

PMPHN OH
$CO_2Et$
*m*-$O_2N$-$C_6H_4$ Me

**11-2i**, 81%
*anti : syn* = 77:23
*ee: anti* 91%, *syn* 79%


PMPHN
OH
CO2Et
o-O2N-C6H4
Me
11-2j, 71%
anti : syn = 78 : 22
ee: anti 92%, syn 88%

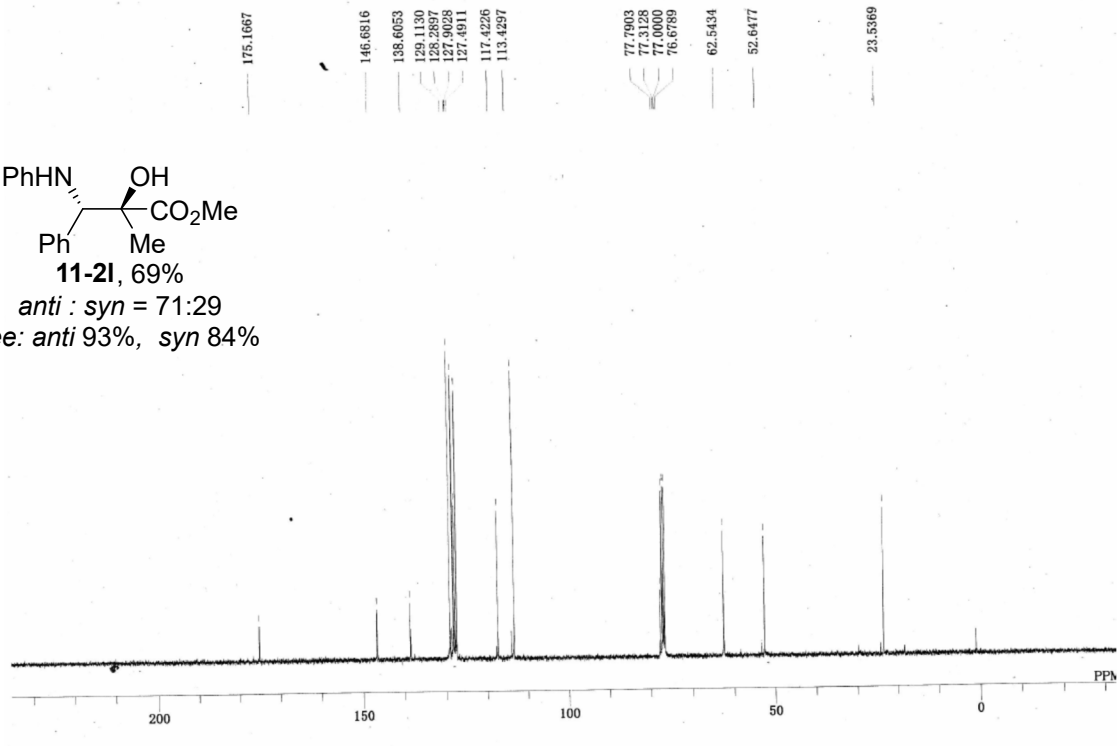

PMPHN
OH
CO2Et
o-O2N-C6H4
Me
11-2j, 71%
anti : syn = 78 : 22
ee: anti 92%, syn 88%


ppm
7.2727
7.2709
7.2583
6.7431
6.7253
6.6247
6.6069
6.2404
6.2367
6.2342
6.2306
6.1597
6.1524
4.6466
4.2118
4.2077
4.1976
4.1935
4.1833
4.1792
4.1690
4.1650
3.7107
3.4614
1.6120
1.2879
1.2736
1.2593
PMPHN
OH
CO2Et
Furanyl
Me
11-2k, 80%
anti : syn = 73 : 27
ee: anti 89% syn 68%
Integral
1.0627
2.0205
2.0000
0.9309
0.9121
0.9607
0.7833
2.0657
2.9655
0.9234
3.2306
3.4403
ppm
9
8
7
6
5
4
3
2
1



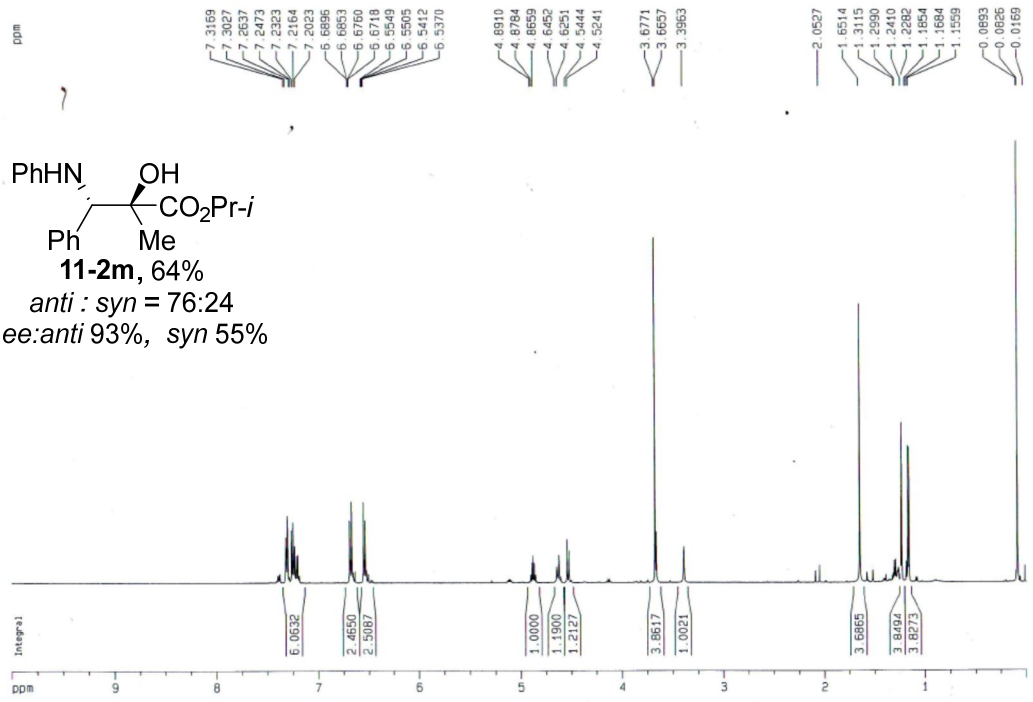

PhHN OH
$CO_2Me$
Ph Me

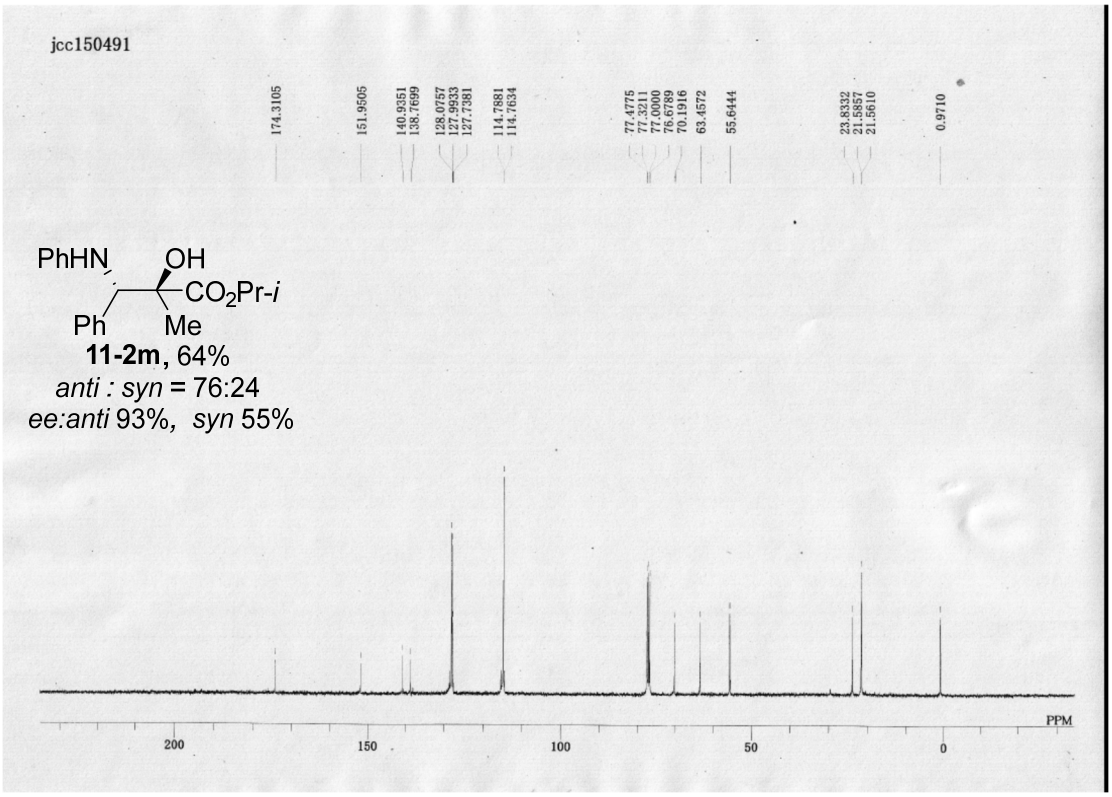
**11-2l**, 69%
*anti : syn* = 71:29
*ee: anti* 90%, *syn* 84%

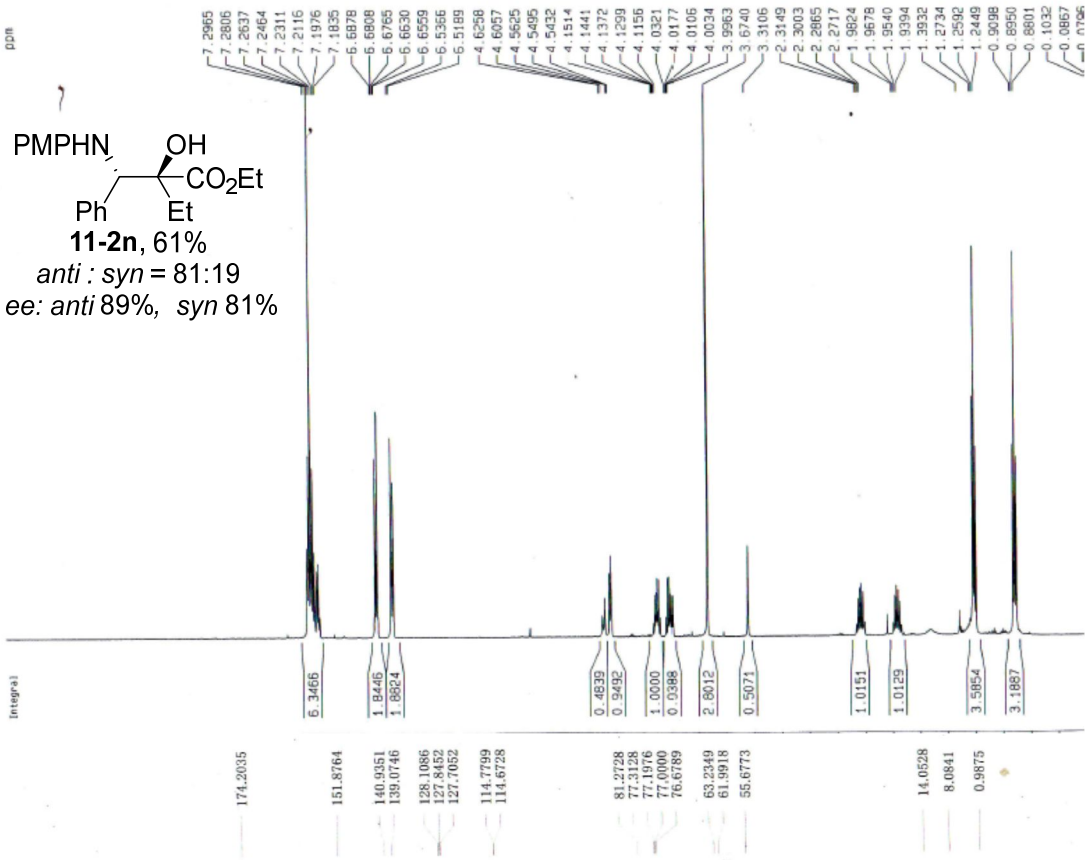


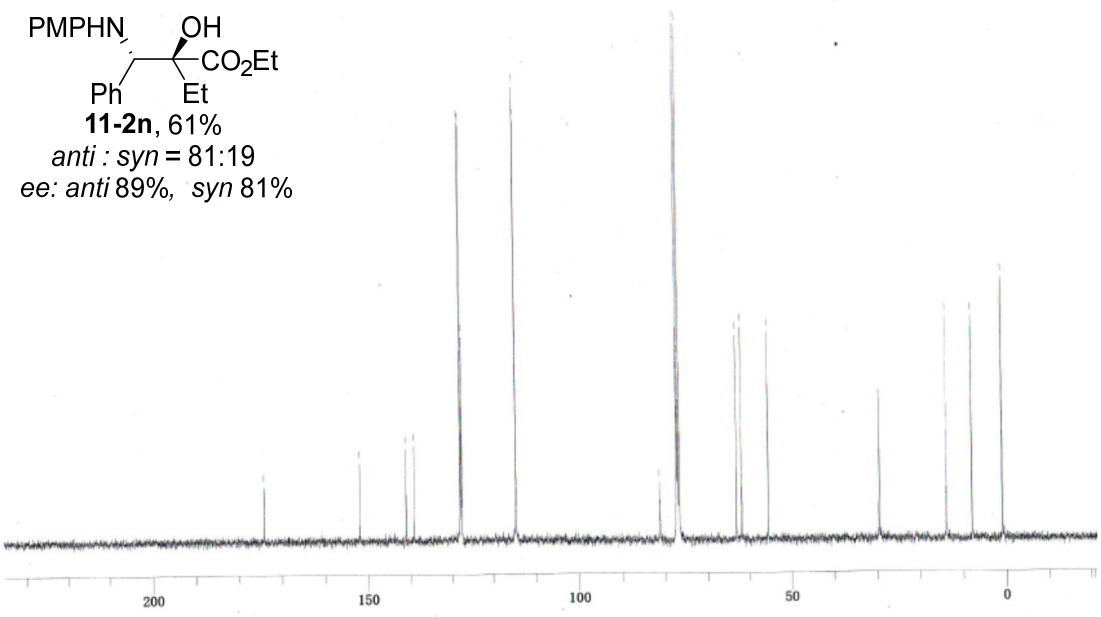

PhHN OH
$CO_2Me$
Ph Me

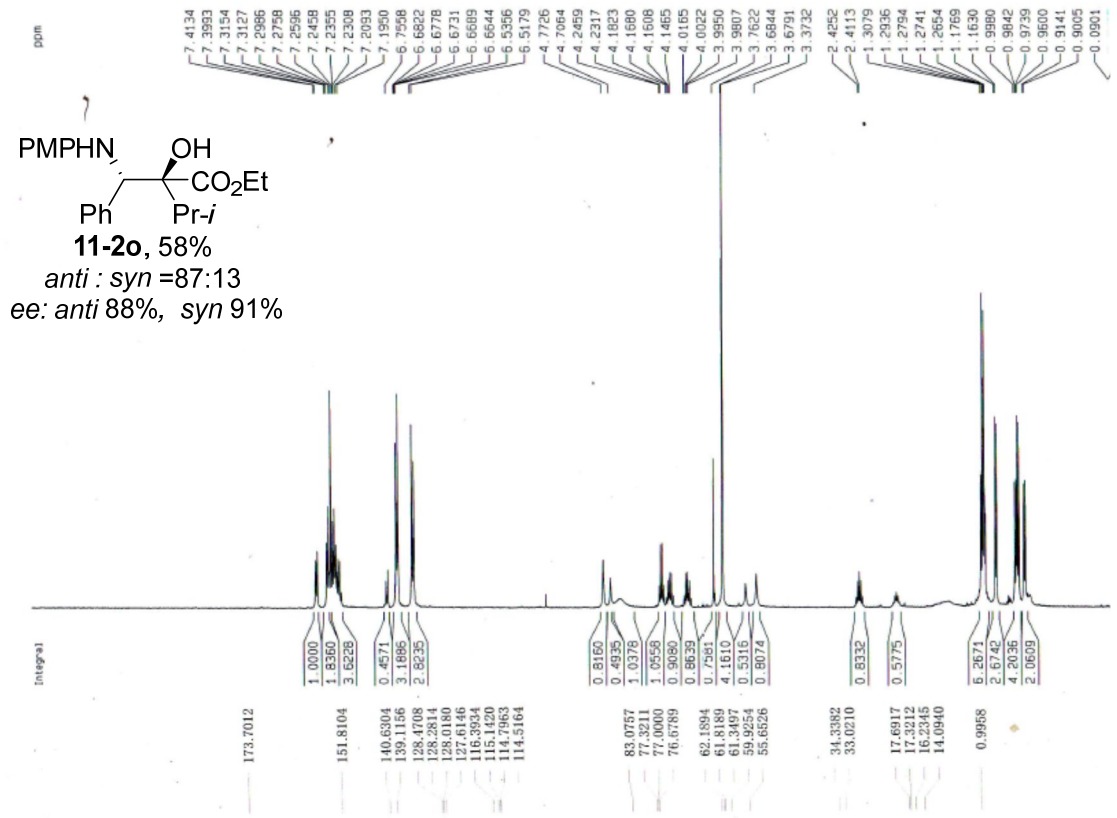
**11-2l**, 69%
*anti : syn* = 71:29
*ee: anti* 93%, *syn* 84%


PhHN
OH
CO2Pr-i
Ph
Me
11-2m, 64%
anti : syn = 76:24
ee:anti 93%, syn 55%


jcc150491
PhHN
OH
CO2Pr-i
Ph
Me
11-2m, 64%
anti : syn = 76:24
ee:anti 93%, syn 55%
PPM


PMPHN
OH
CO2Et
Ph
Et
11-2n, 61%
anti : syn = 81:19
ee: anti 89%, syn 81%

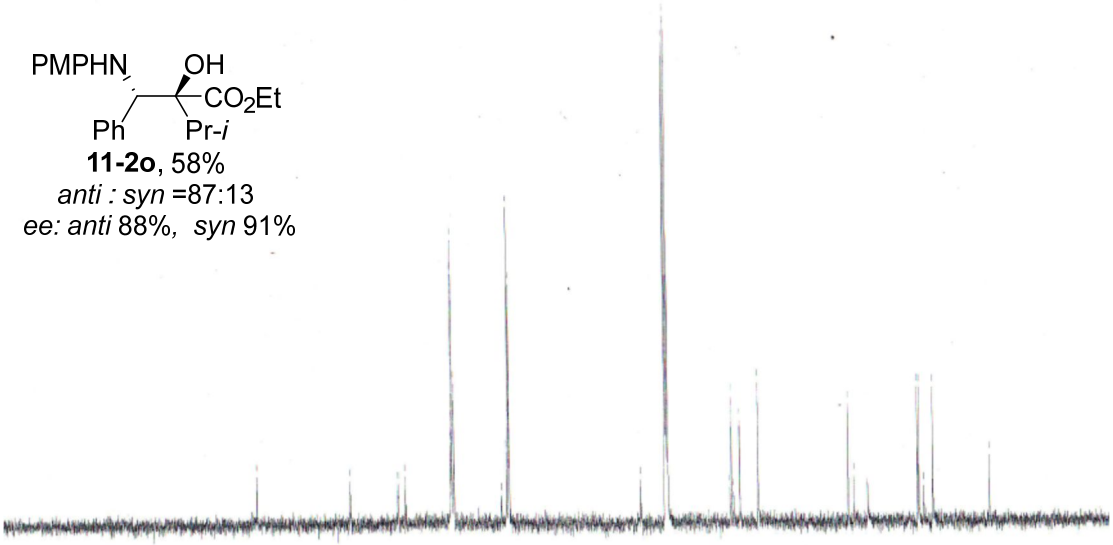

PMPHN
OH
CO2Et
Ph
Et
11-2n, 61%
anti : syn = 81:19
ee: anti 89%, syn 81%




**11-2o**, 58%

*anti : syn* =87:13

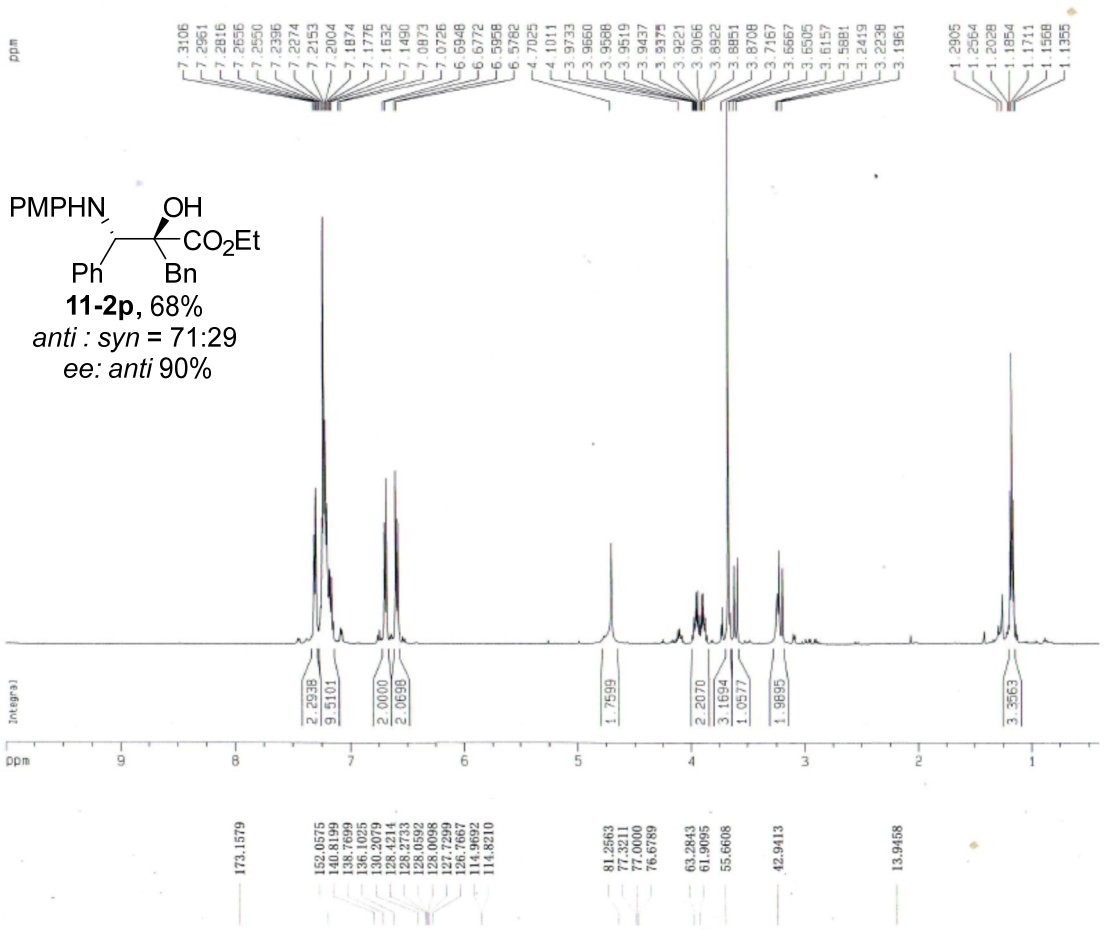
*ee: anti* 88%, *syn* 91%

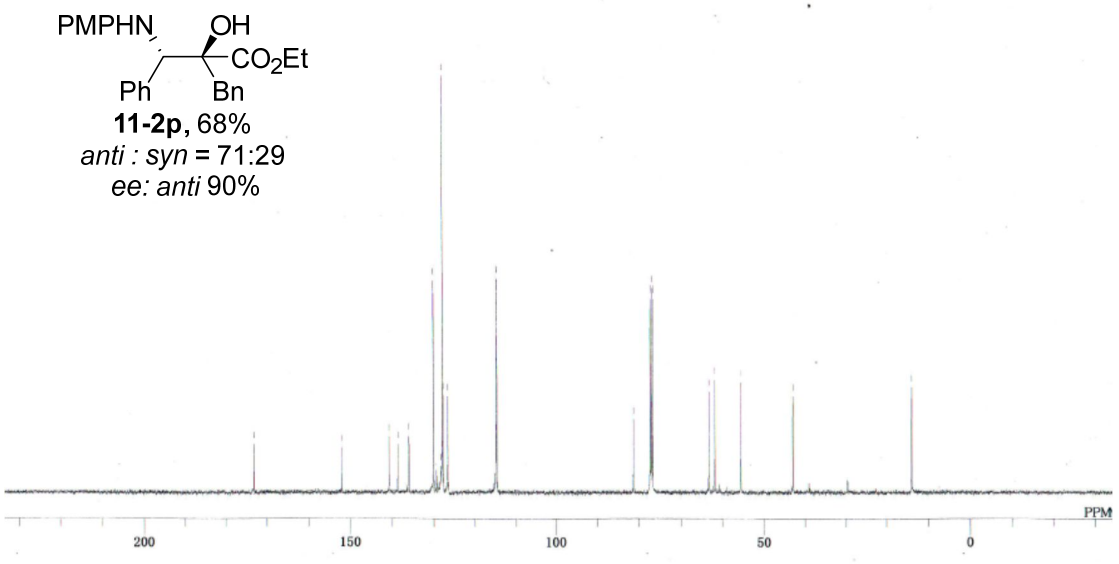


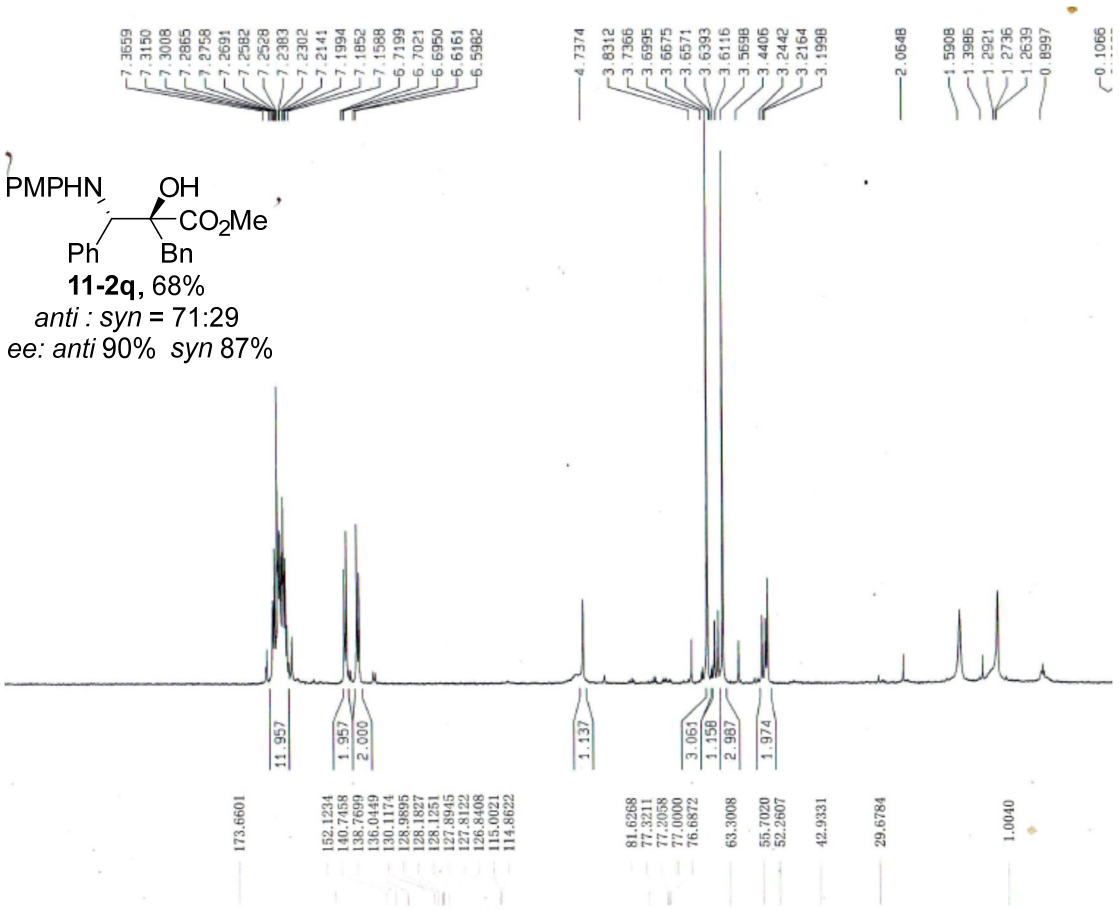

**11-2o**, 58%

*anti : syn* =87:13

*ee: anti* 88%, *syn* 91%


PMPHN
OH
CO2Et
Ph
Bn
11-2p, 68%
anti : syn = 71:29
ee: anti 90%

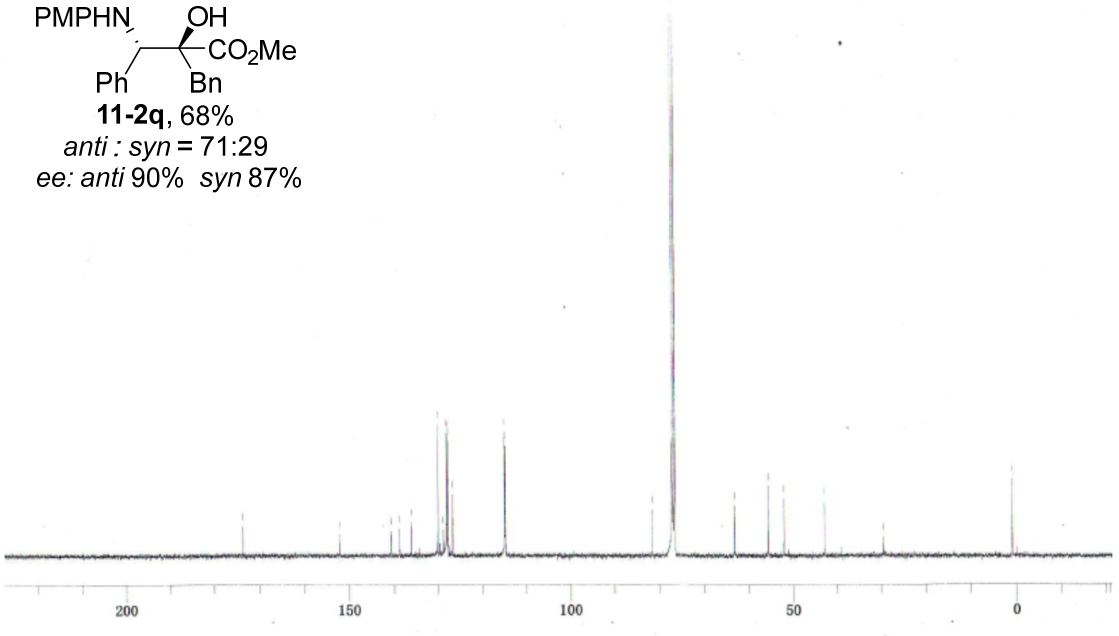

PMPHN
OH
CO2Et
Ph
Bn
11-2p, 68%
anti : syn = 71:29
ee: anti 90%




**11-2q,** 68%

*anti : syn* = 71:29

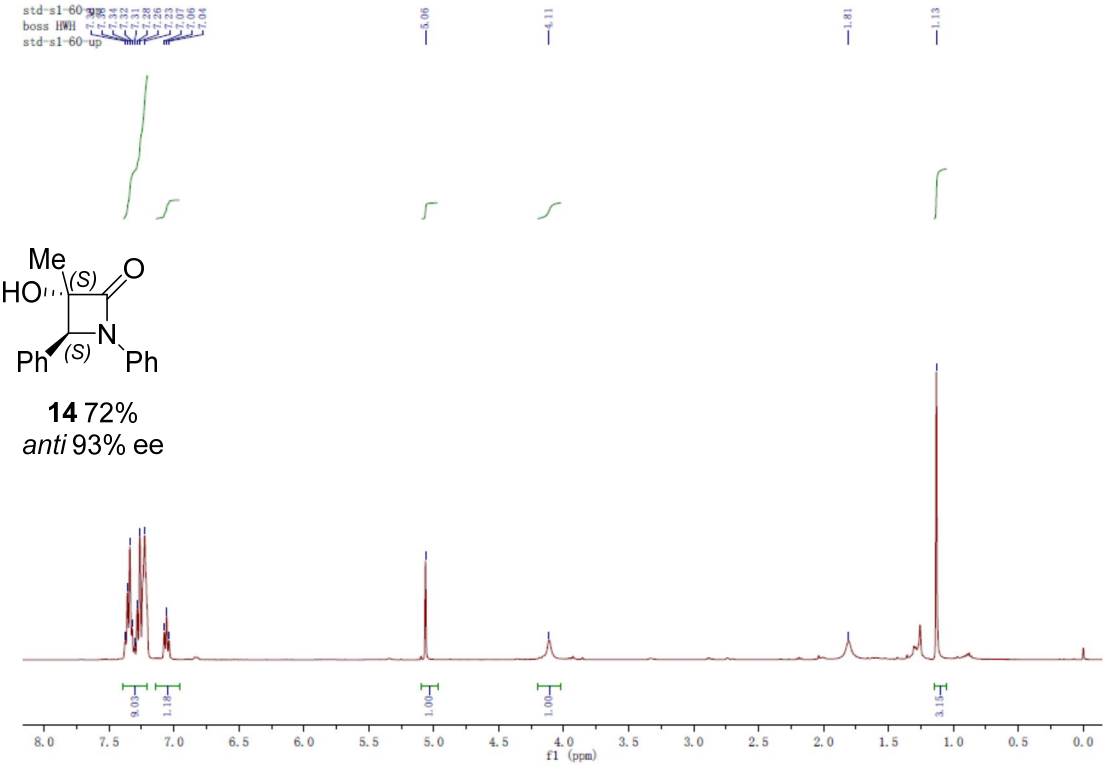
*ee: anti* 90%  *syn* 87%



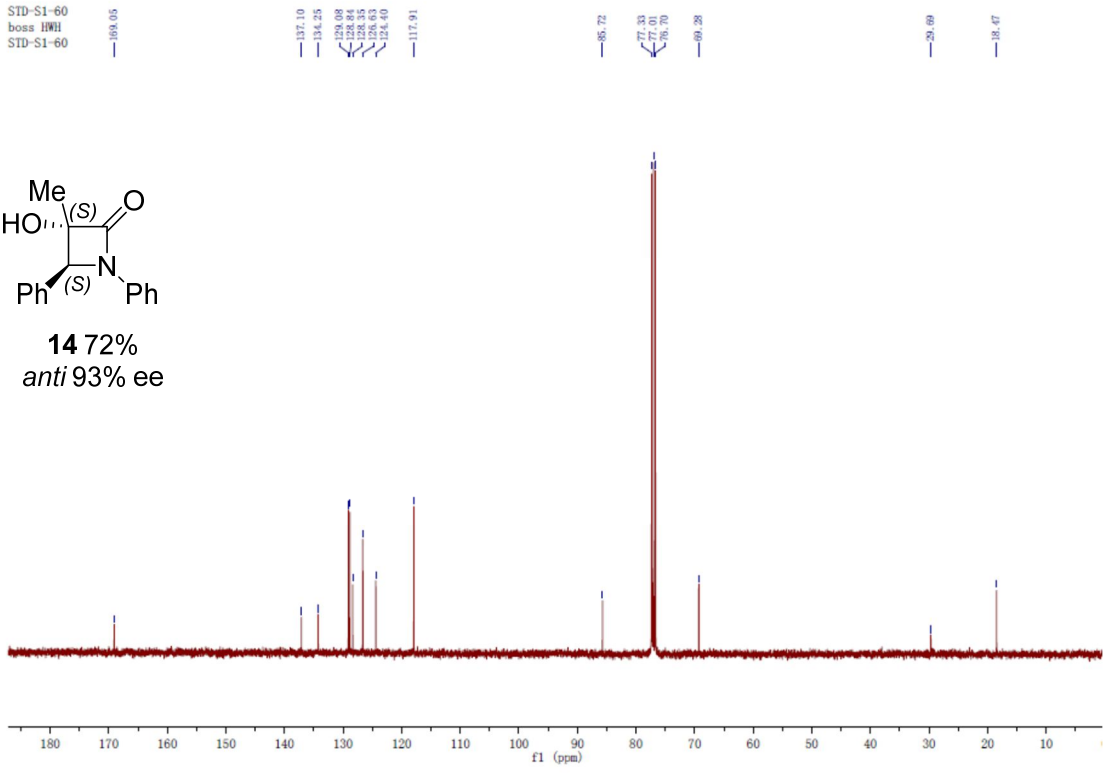

**11-2q**, 68%

*anti : syn* = 71:29

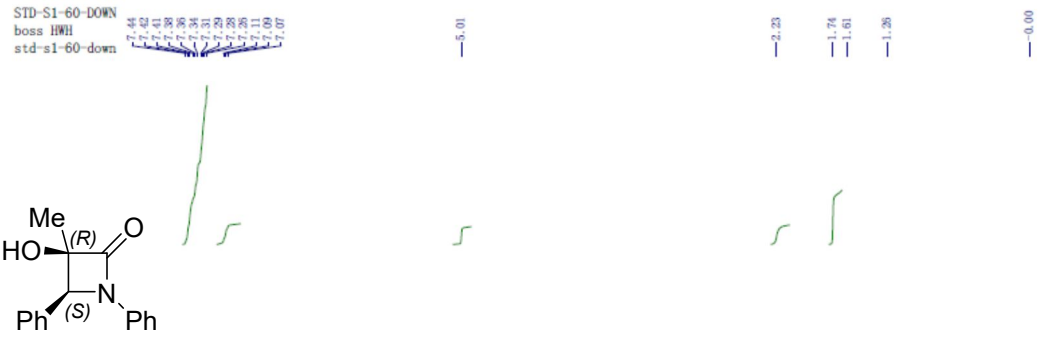
*ee: anti* 90%  *syn* 87%



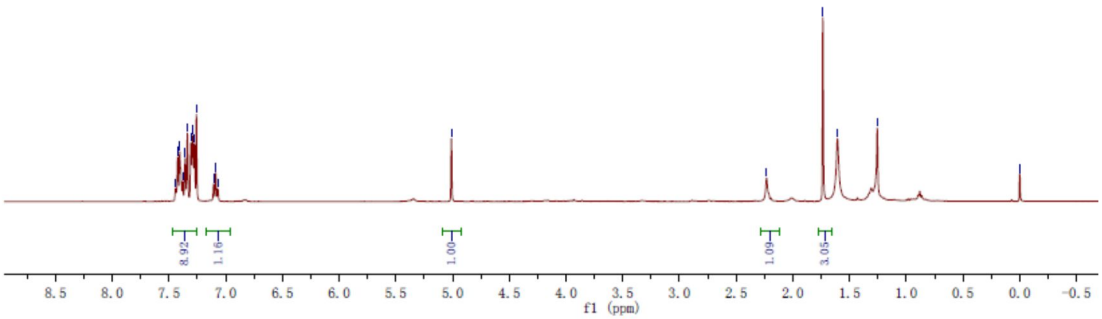

**14** 72%
*anti* 93% ee

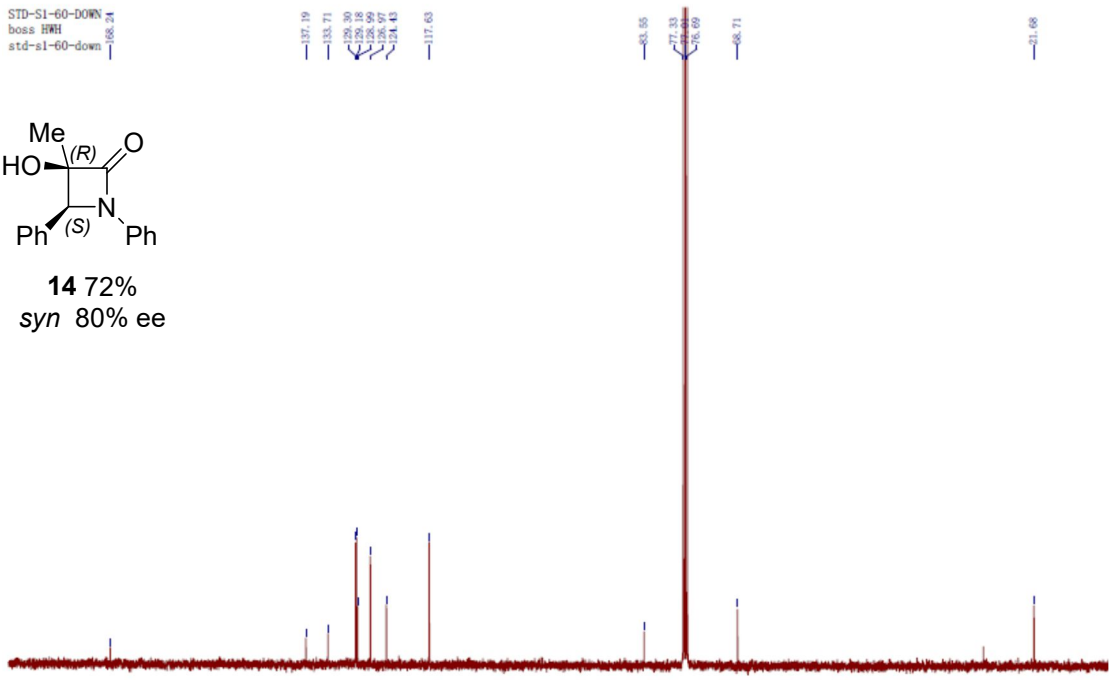



**14** 72%
*anti* 93% ee

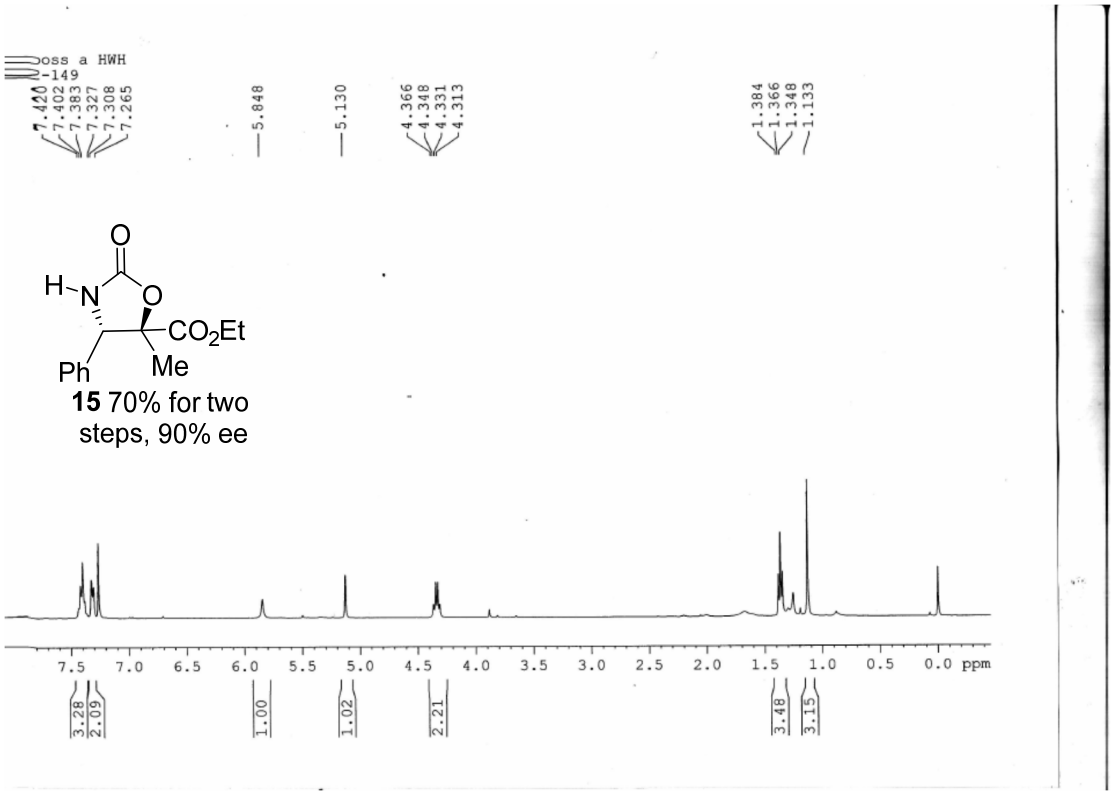


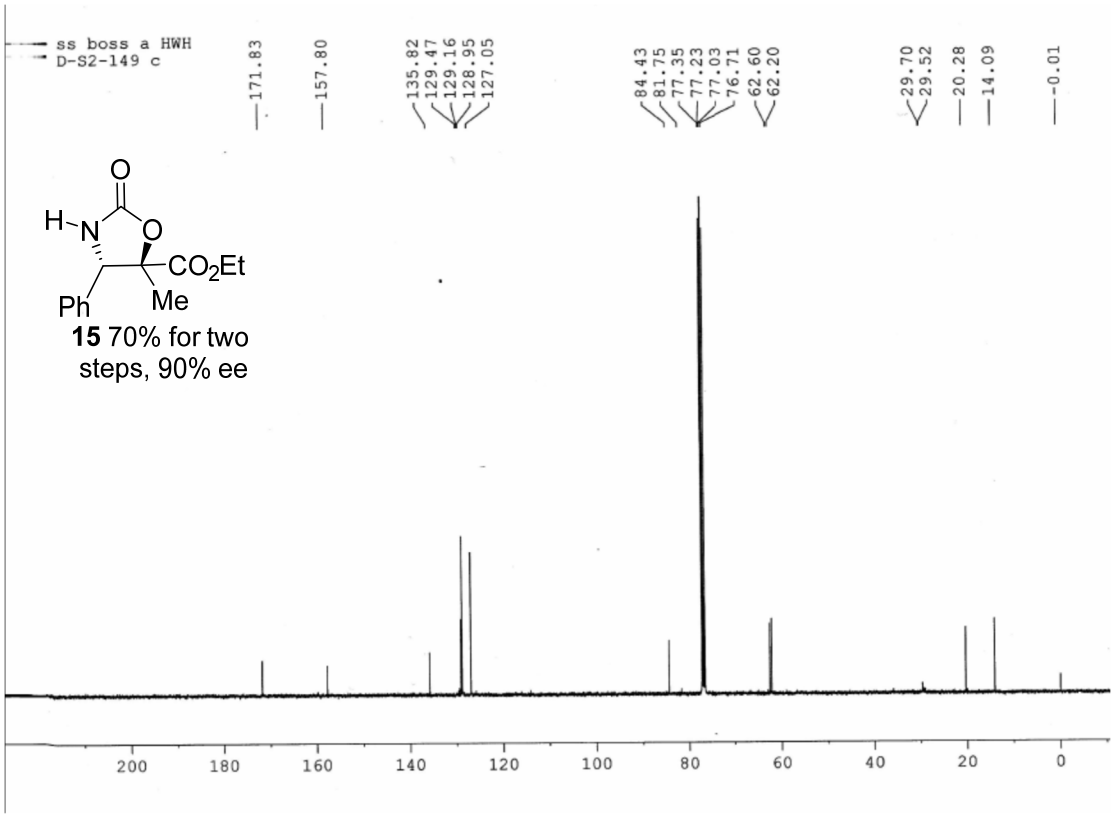

**14** 72%
*syn* 80% ee



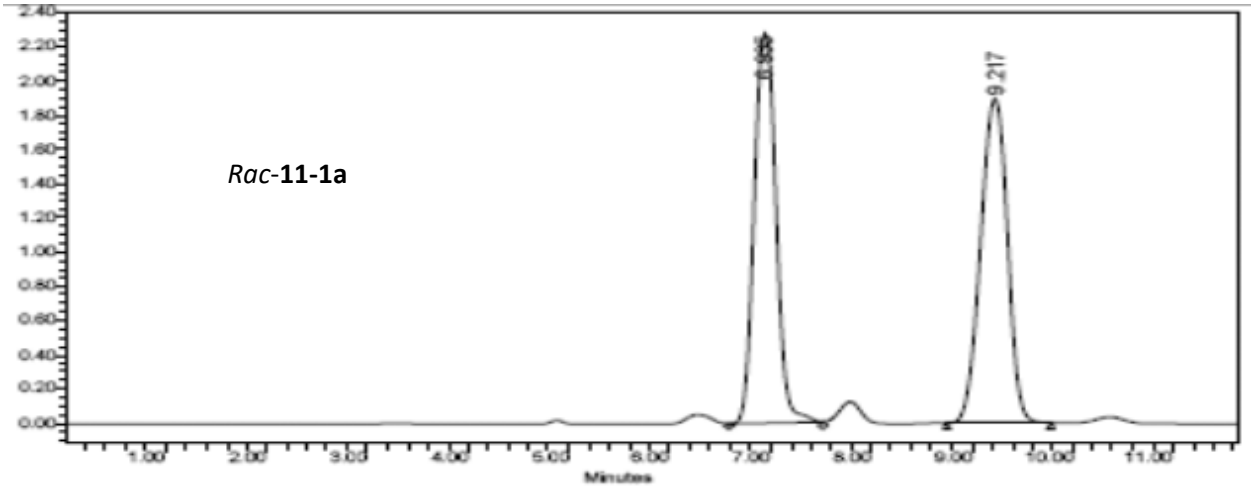




**14** 72%
*syn* 80% ee

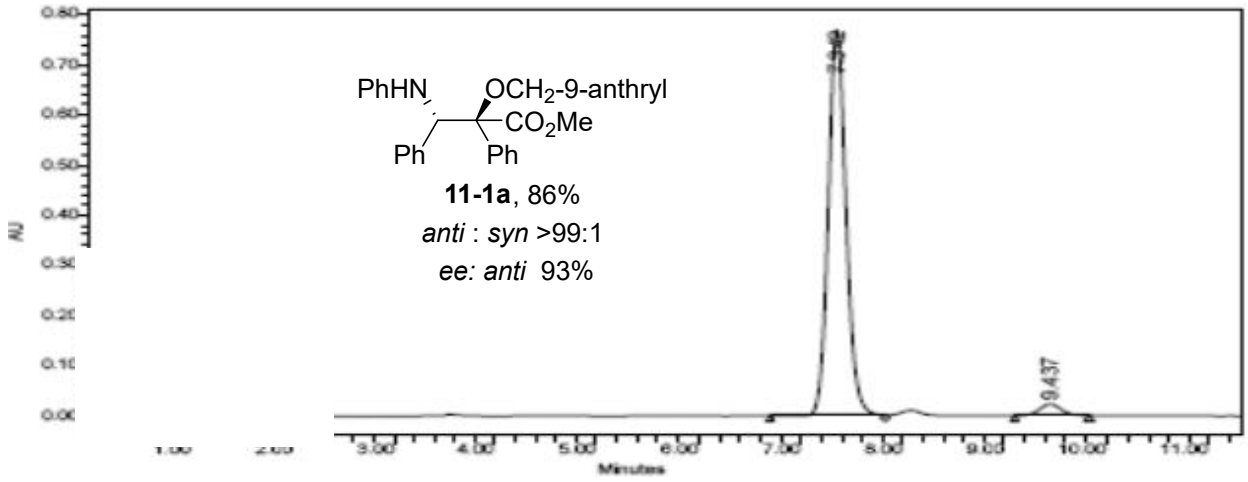

oss a HWH
-149
7.420
7.402
7.383
7.327
7.308
7.265
5.848
5.130
4.366
4.348
4.331
4.313
1.384
1.366
1.348
1.133
O
H–N
O
CO2Et
Ph
Me
15 70% for two steps, 90% ee
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 ppm
3.28
2.09
1.00
1.02
2.21
3.48
3.15


ss boss a HWH
D-S2-149 c
171.83
157.80
135.82
129.47
129.16
128.95
127.05
84.43
81.75
77.35
77.23
77.03
76.71
62.60
62.20
29.70
29.52
20.28
14.09
-0.01
O
H–N
O
CO2Et
Ph
Me
15 70% for two steps, 90% ee
200 180 160 140 120 100 80 60 40 20 0

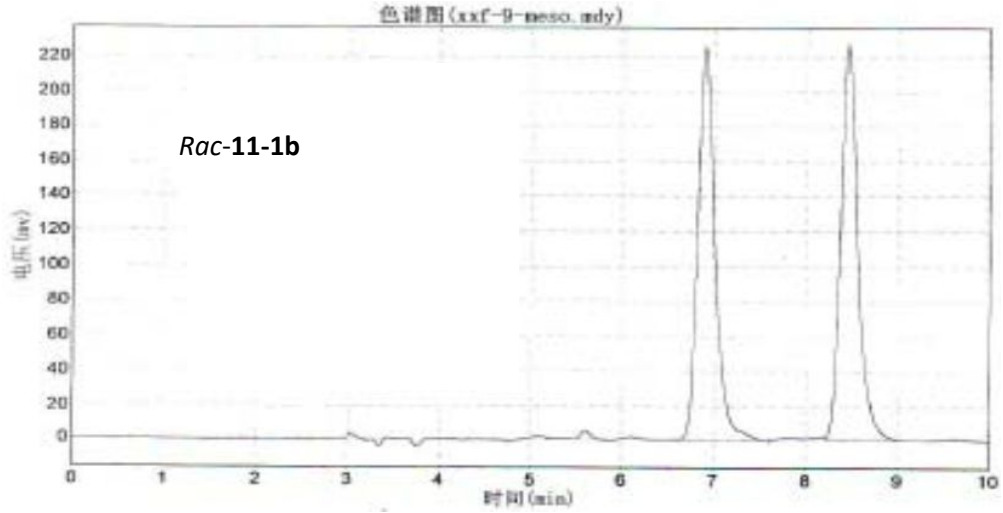
## K. HPLC



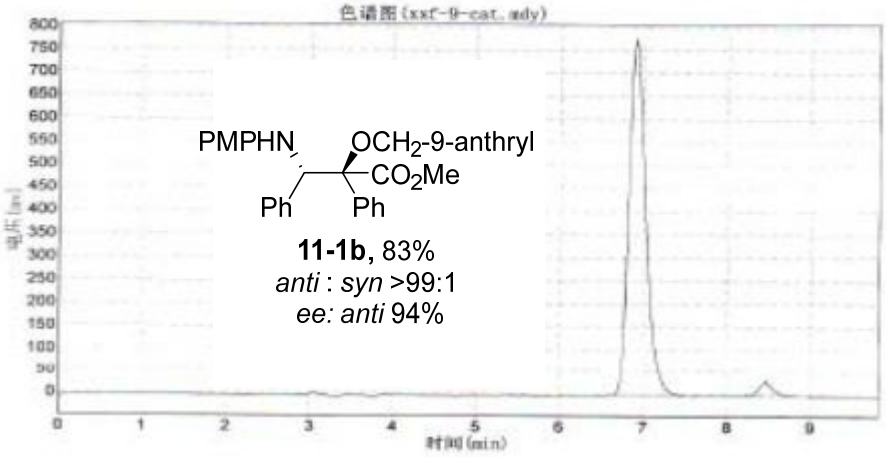

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.94 | 34593324 | 49.61 |
| 2 | 9.22 | 35144505 | 50.39 |



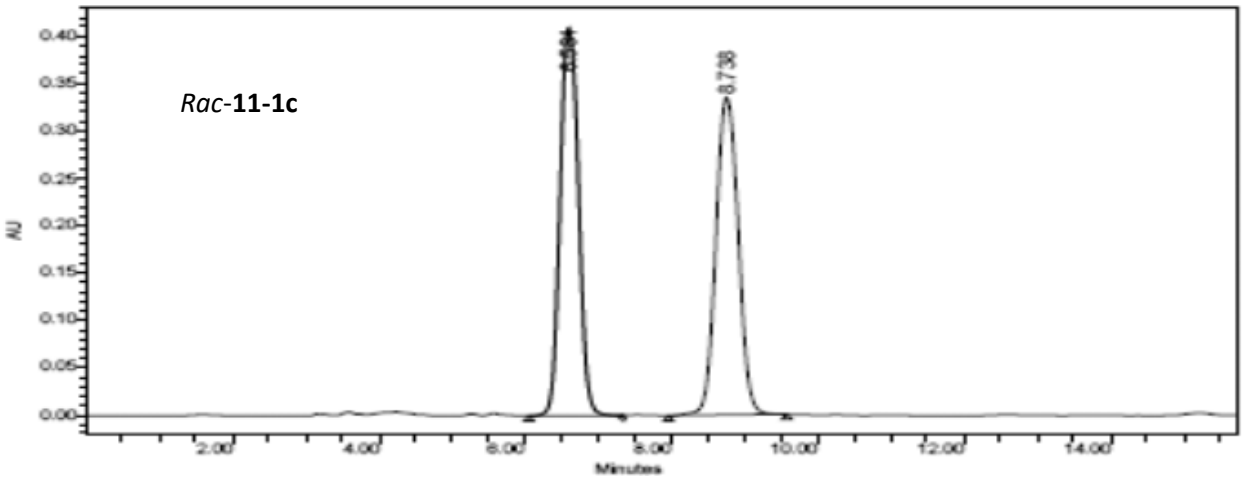

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.31 | 775072 | 96.46 |
| 2 | 9.44 | 23144 | 3.54 |



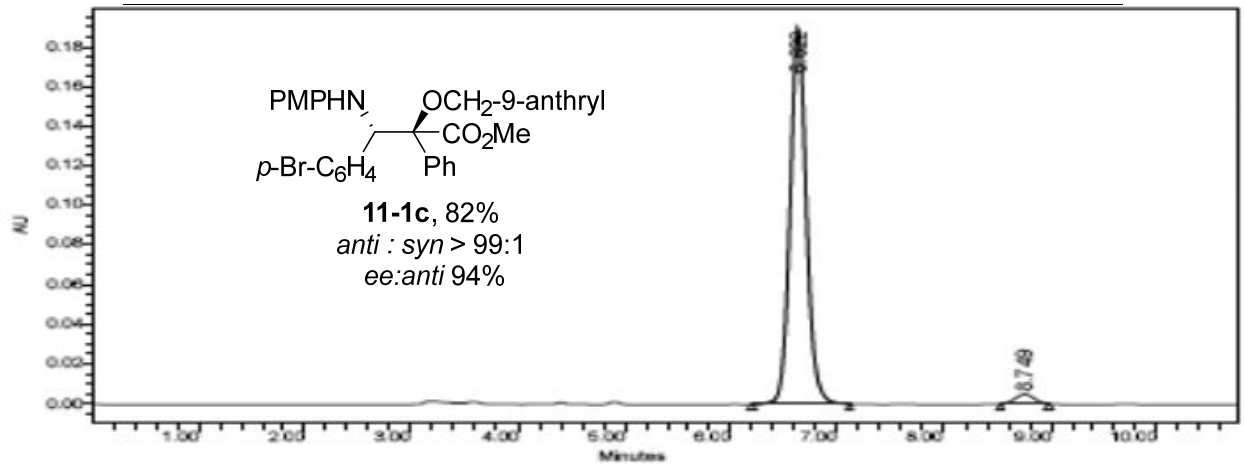

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.90 | 224327 | 50.22 |
| 2 | 8.45 | 225109 | 49.78 |



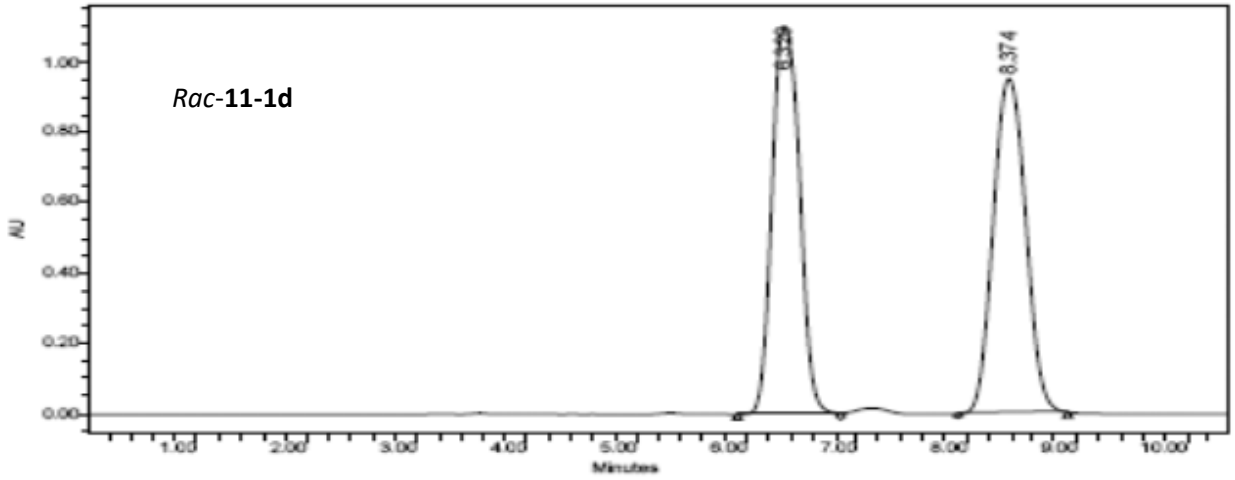

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.91 | 772720 | 96.76 |
| 2 | 8.46 | 28462 | 3.23 |



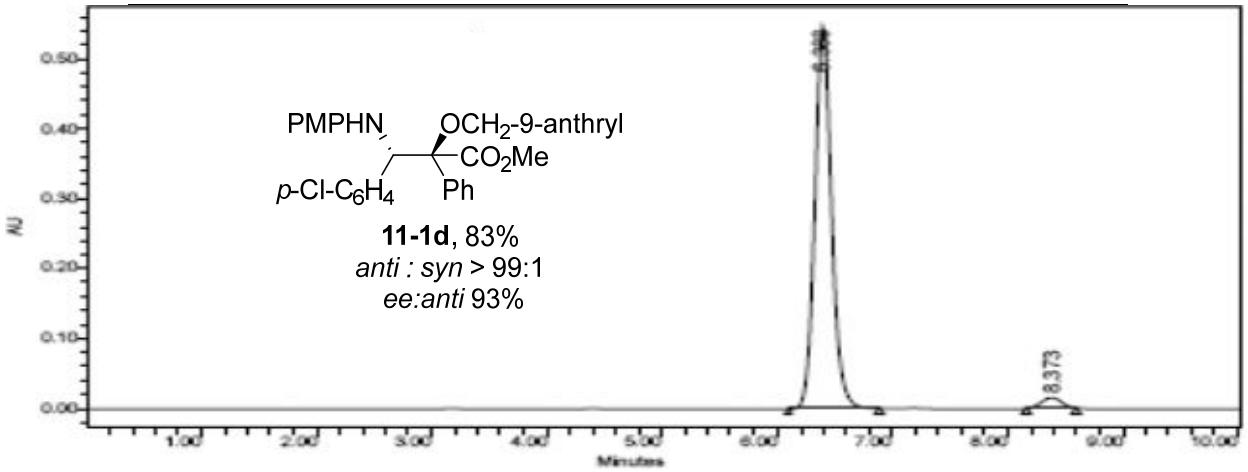

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.58 | 7195984 | 50.17 |
| 2 | 8.74 | 7145098 | 49.83 |



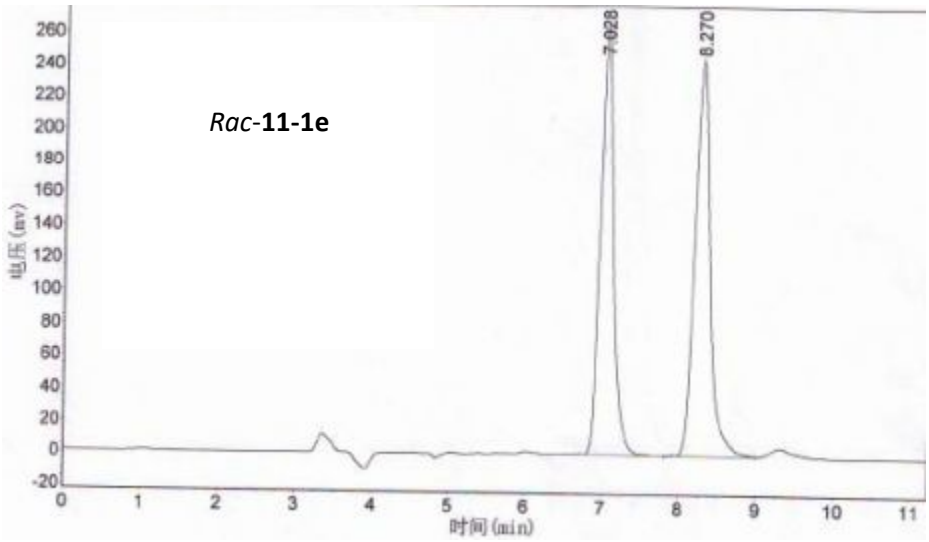

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.62 | 2015616 | 97.11 |
| 2 | 8.75 | 60049 | 2.89 |



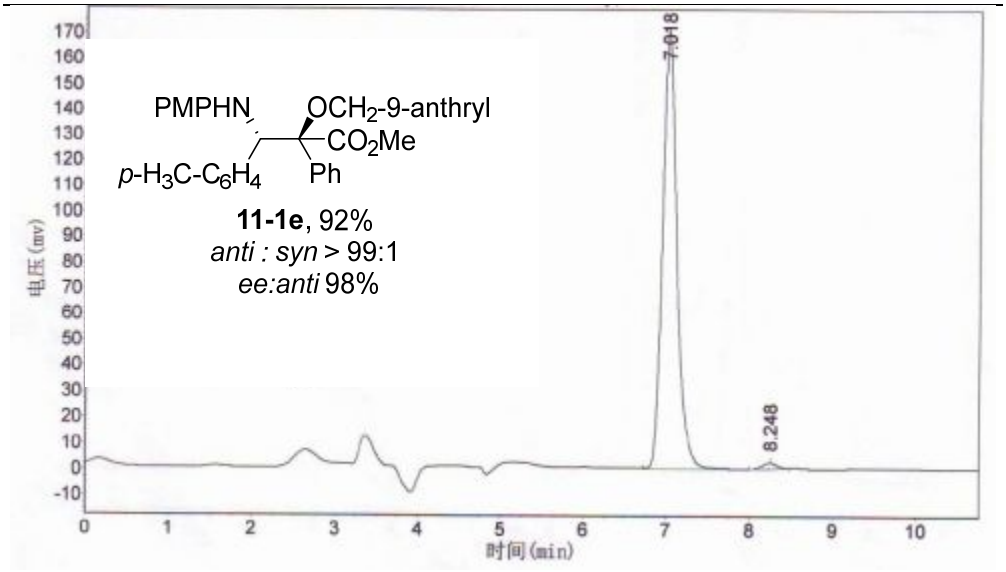

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.33 | 19213140 | 49.63 |
| 2 | 8.37 | 19500215 | 50.37 |



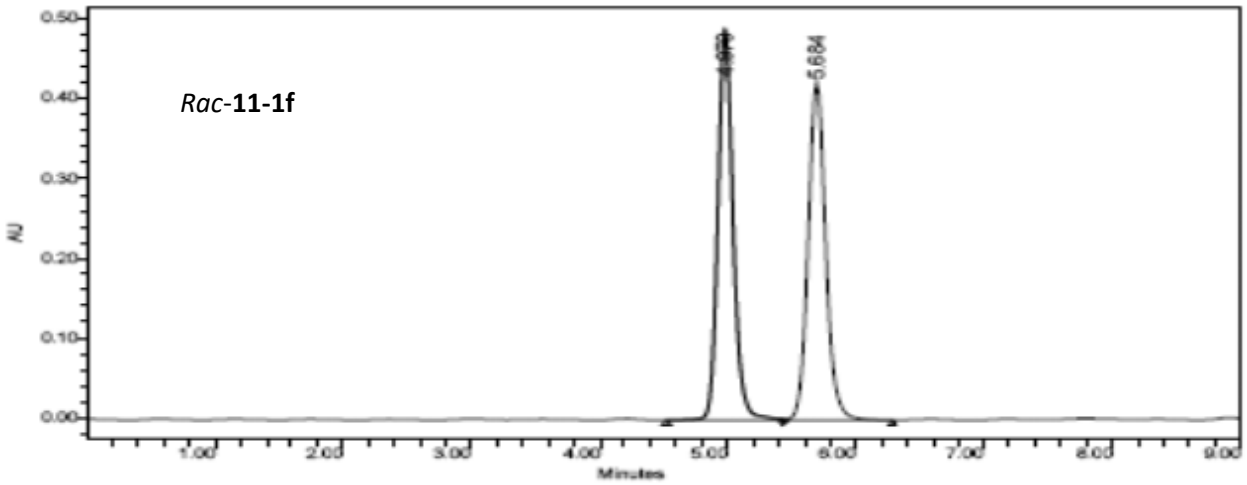

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.39 | 5540602 | 96.77 |
| 2 | 8.37 | 184793 | 3.23 |



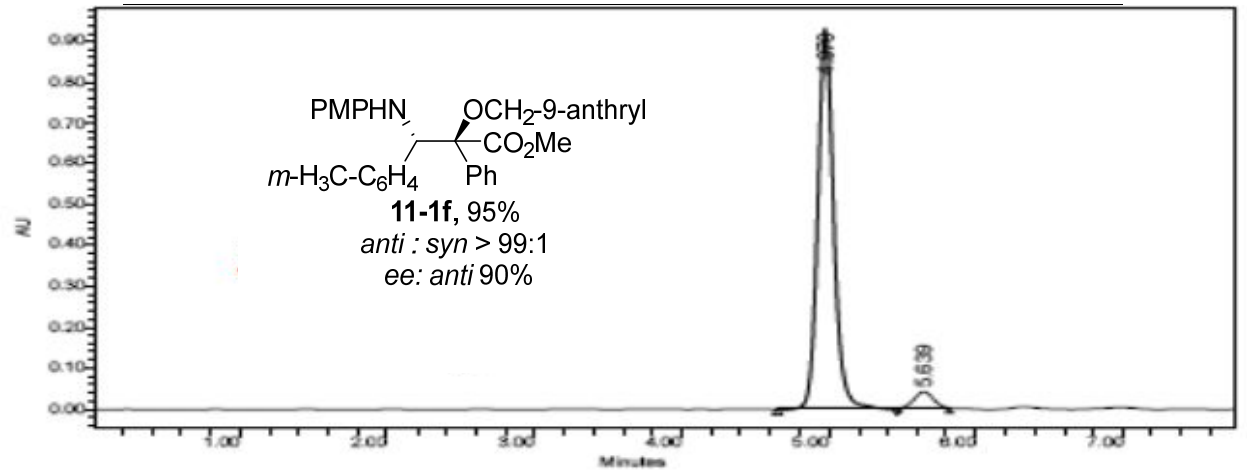

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.03 | 3132674 | 48.08 |
| 2 | 8.27 | 3382768 | 51.92 |



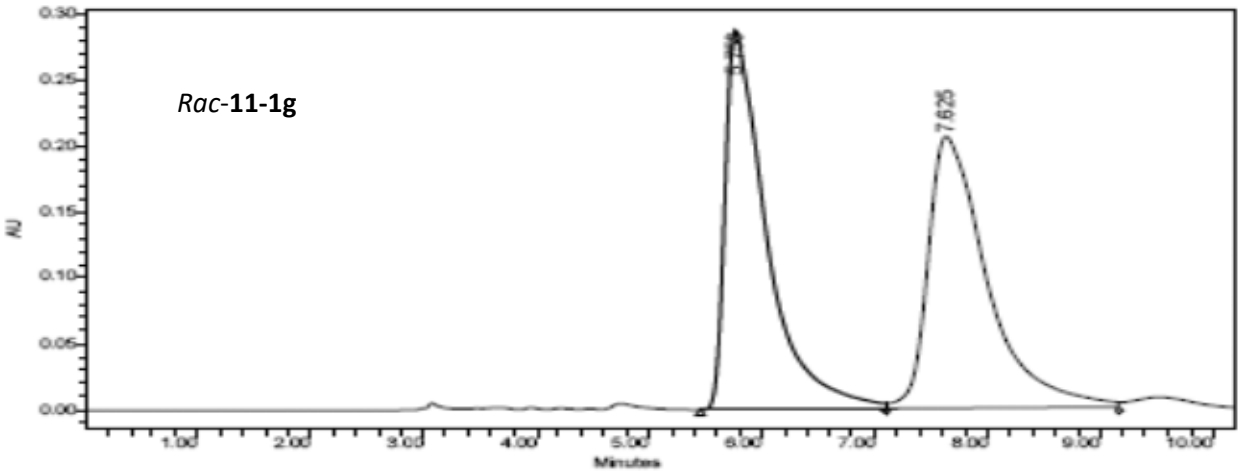

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.02 | 2001834 | 98.81 |
| 2 | 8.24 | 24032 | 1.19 |



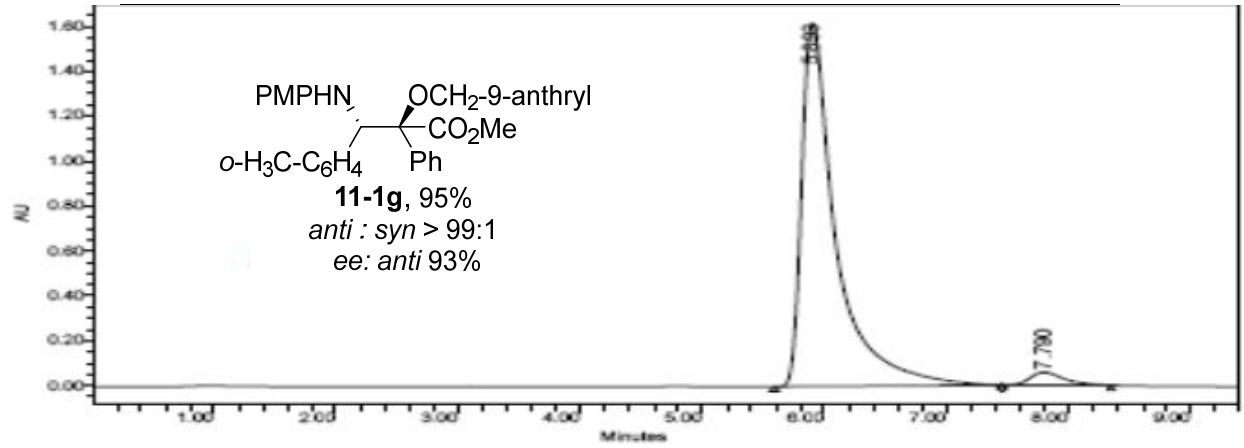

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 4.97 | 4035472 | 50.09 |
| 2 | 5.68 | 4021114 | 49.91 |



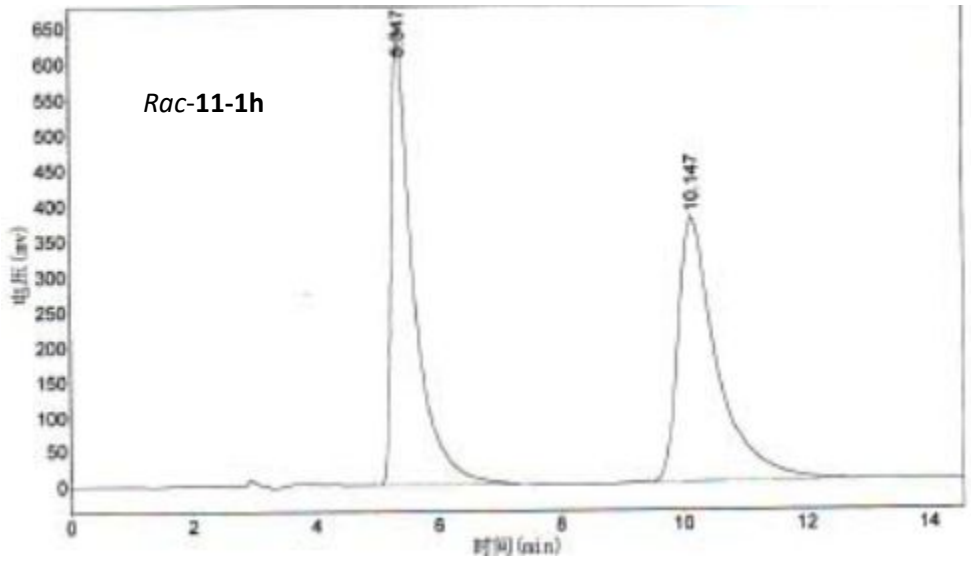

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 4.97 | 6998815 | 95.02 |
| 2 | 5.64 | 367002 | 4.96 |



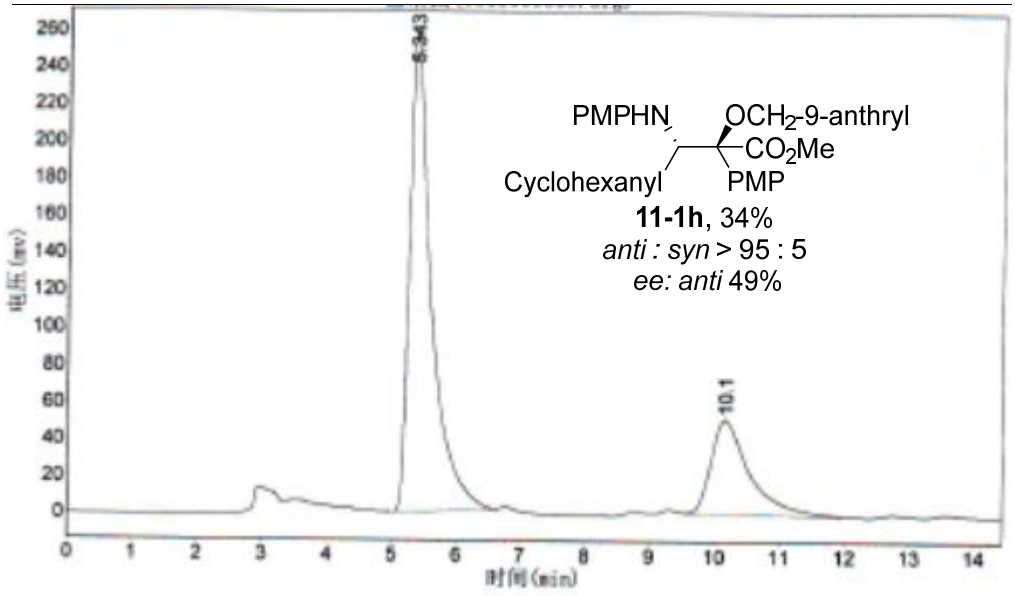

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 5.76 | 7368389 | 49.31 |
| 2 | 7.63 | 7575566 | 50.69 |



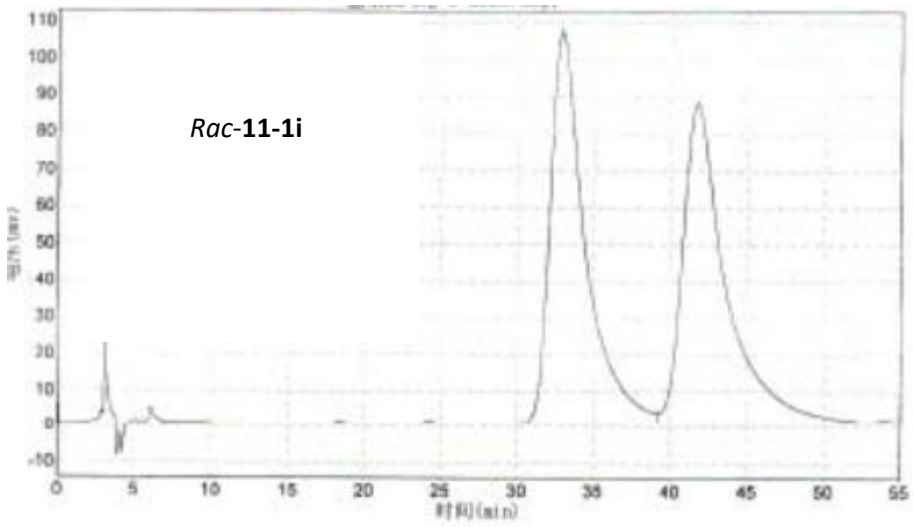

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 5.89 | 31741322 | 96.39 |
| 2 | 7.79 | 1189308 | 3.61 |



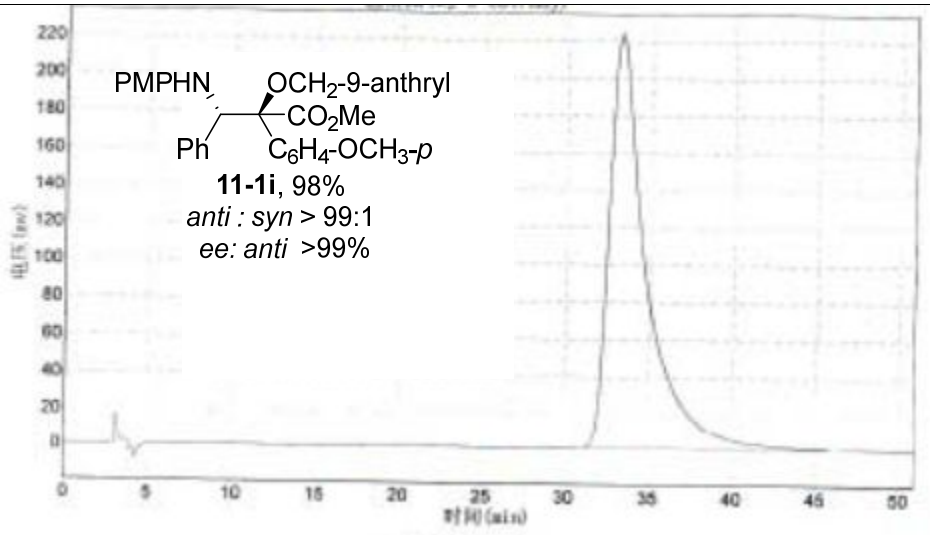

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 5.35 | 16290088 | 49.87 |
| 2 | 10.15 | 16374709 | 50.13 |



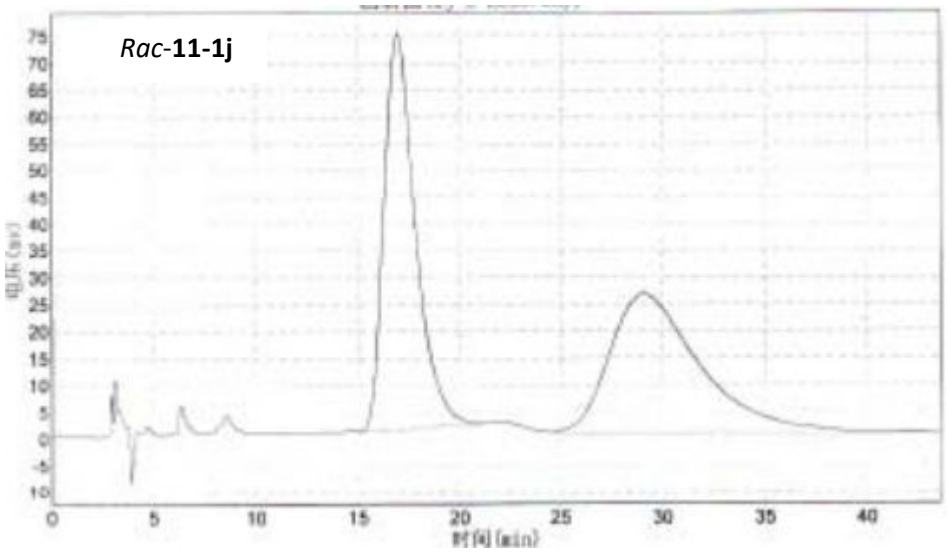

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 5.34 | 6044993 | 74.56 |
| 2 | 10.16 | 2063106 | 25.44 |



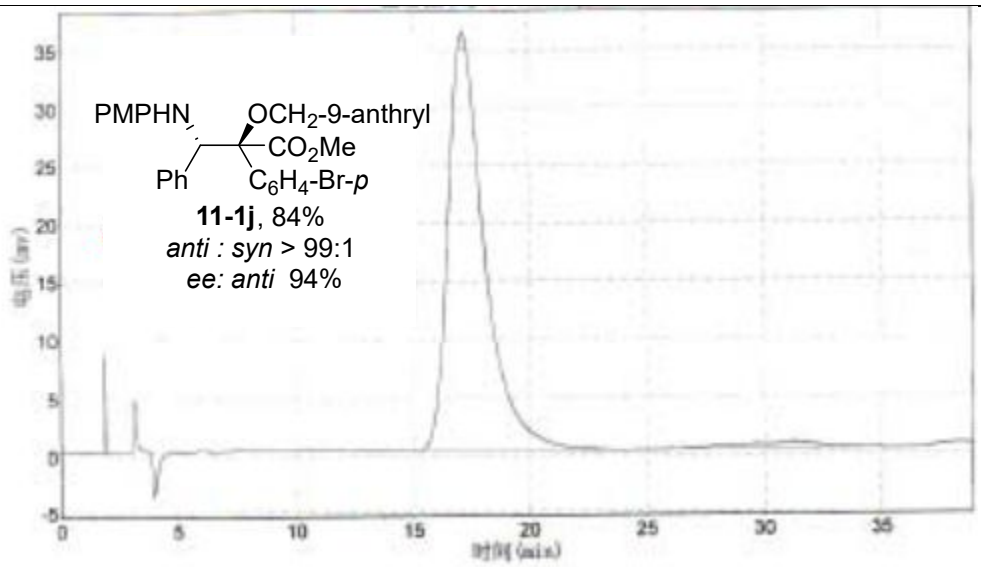

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 32.92 | 17039950 | 50.26 |
| 2 | 41.72 | 16862408 | 49.74 |



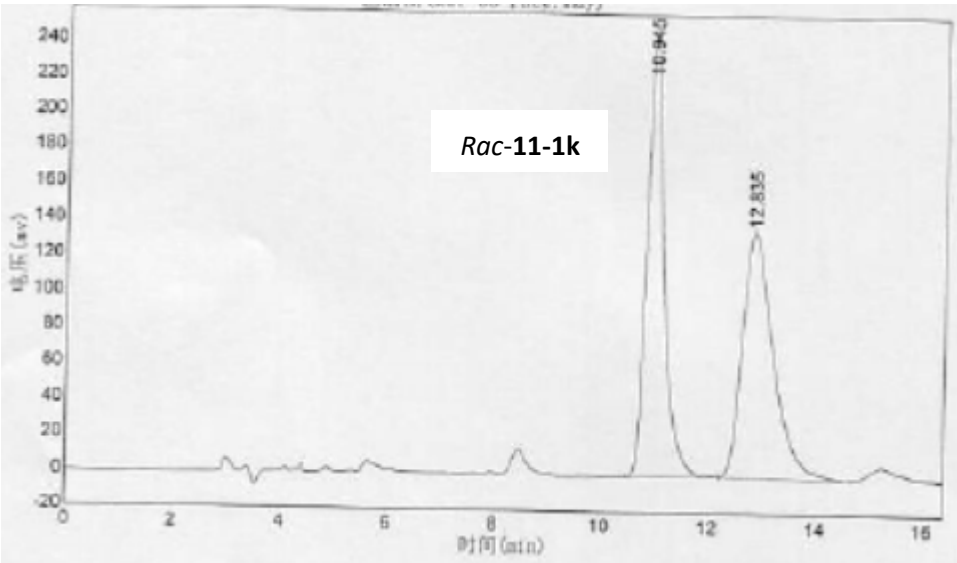

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 33.18 | 34551700 | 100 |
| 2 | - | - | - |



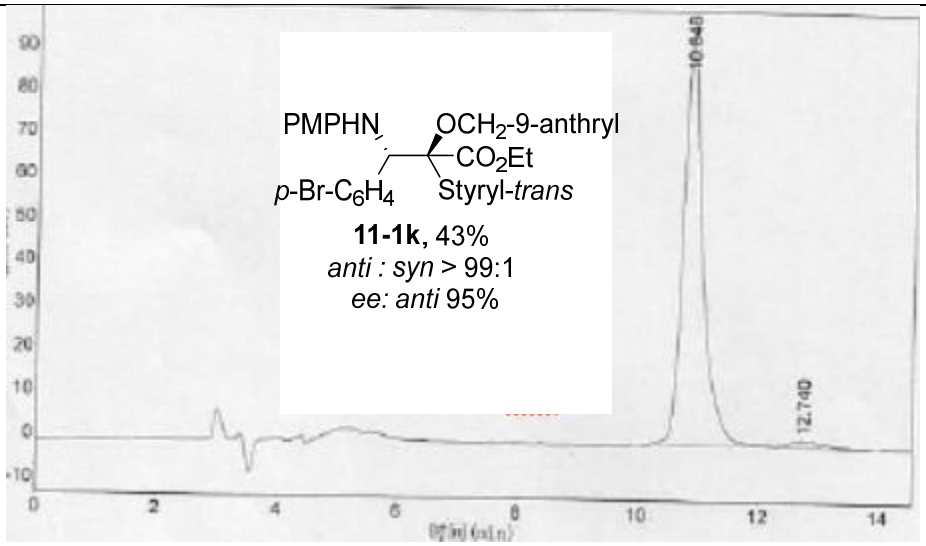

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 16.92 | 7920455 | 50.20 |
| 2 | 29.07 | 7856708 | 49.80 |



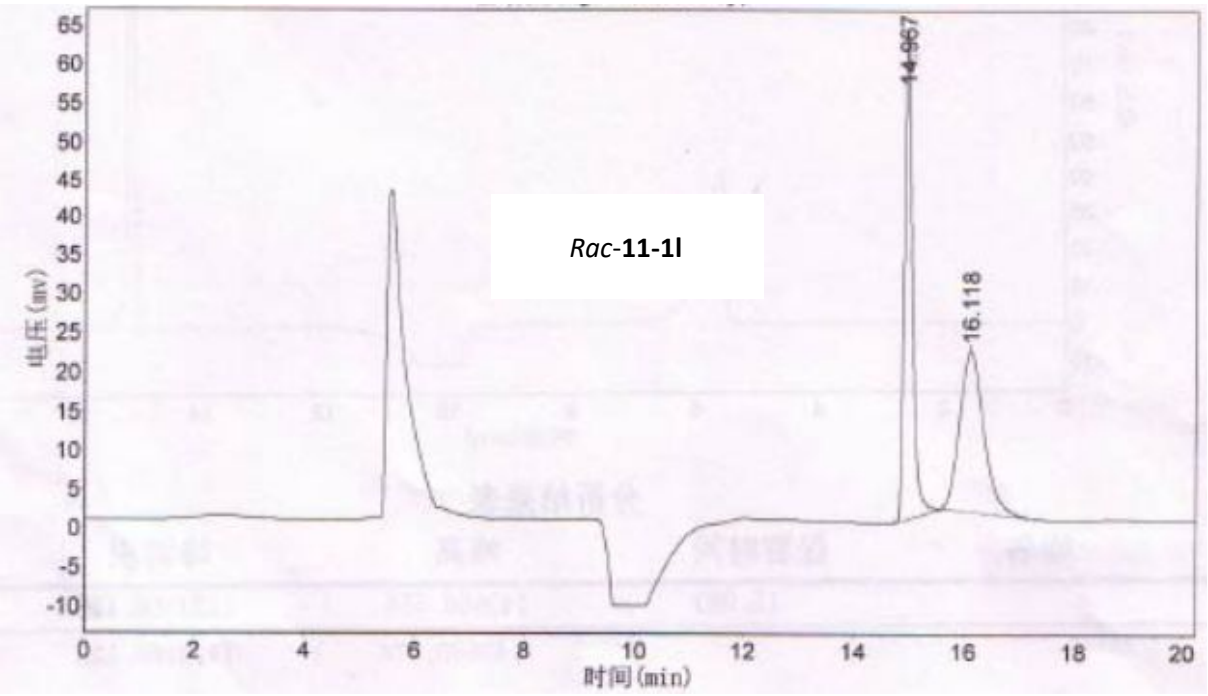

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 17.18 | 3905776 | 97.05 |
| 2 | 31.28 | 118436 | 2.94 |



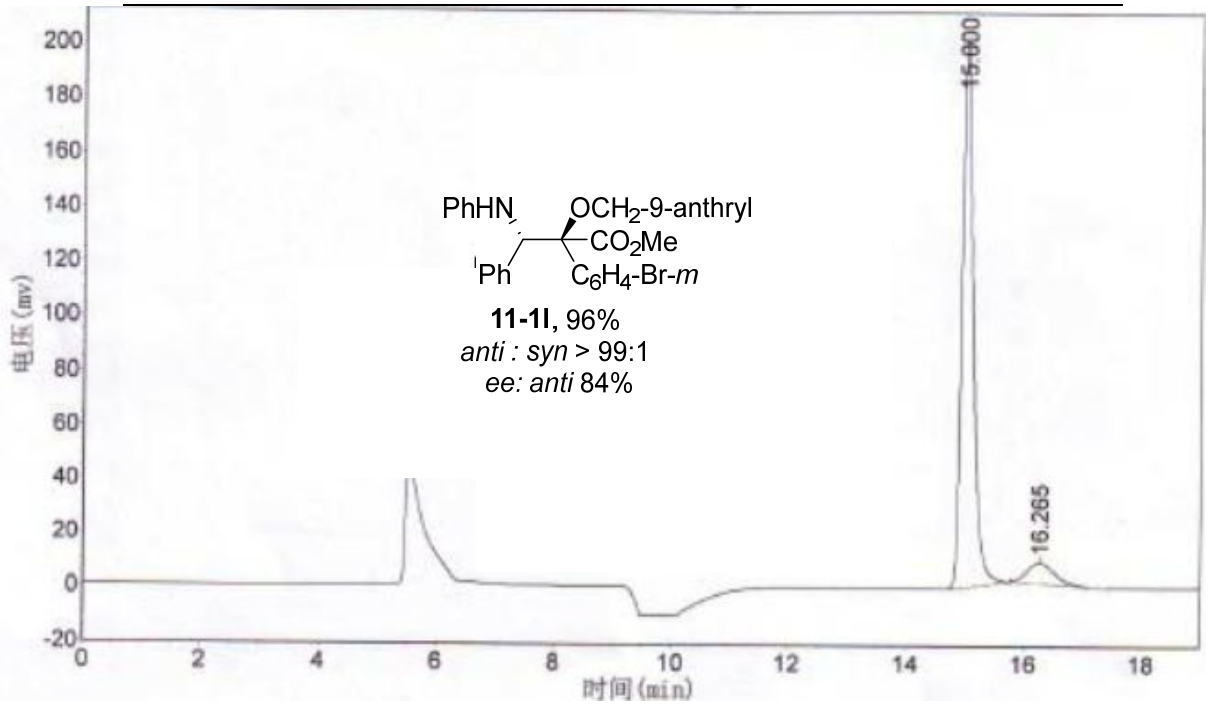

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 10.95 | 5467471 | 50.20 |
| 2 | 12.84 | 5424989 | 49.80 |



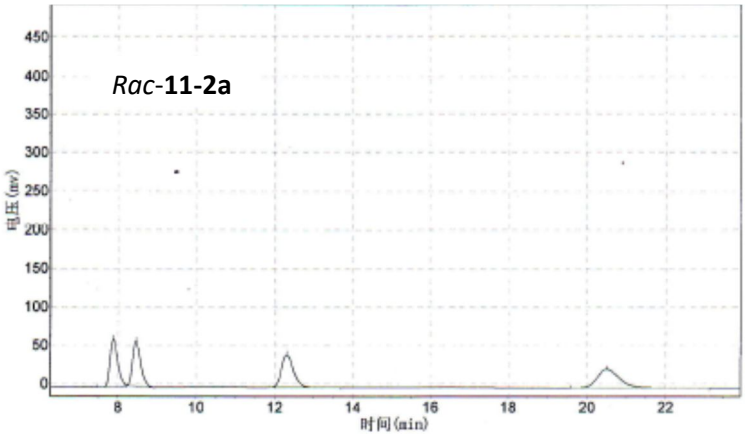

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 10.85 | 2158424 | 97.65 |
| 2 | 12.74 | 52003 | 2.35 |



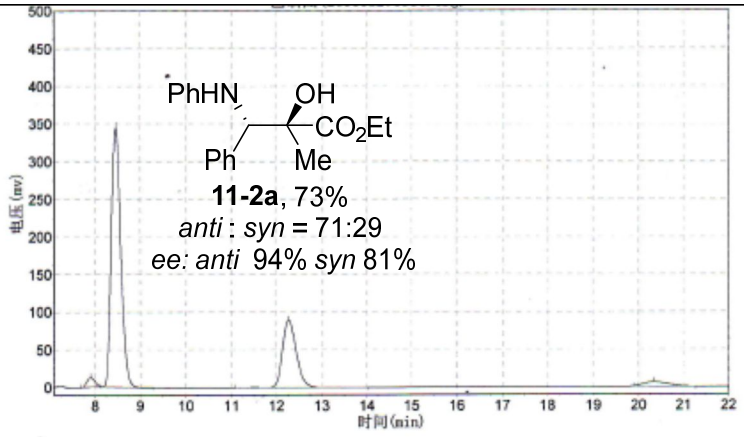

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 14.97 | 641803 | 50.37 |
| 2 | 16.12 | 632169 | 49.62 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 15.00 | 2669268 | 91.93 |
| 2 | 16.27 | 234360 | 8.07 |

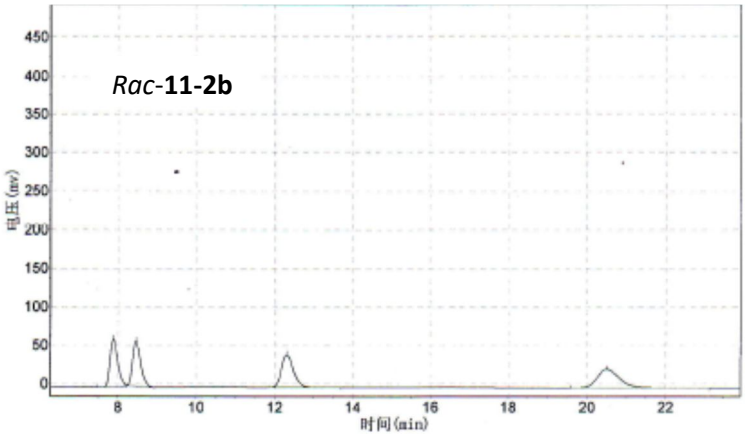



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.90 | 805621 | 23.40 |
| 2 | 8.47 | 822517 | 23.89 |
| 3 | 12.31 | 904974 | 26.29 |
| 4 | 20.50 | 909380 | 26.42 |

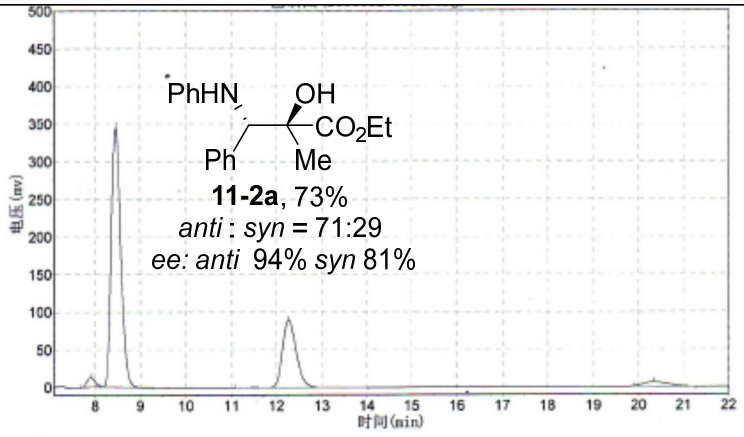



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 7.91 | 142386 | 2.79 |
| *Anti*-2 | 8.46 | 4967617 | 97.21 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 12.27 | 1877082 | 90.67 |
| *Syn*-2 | 20.34 | 193690 | 9.33 |

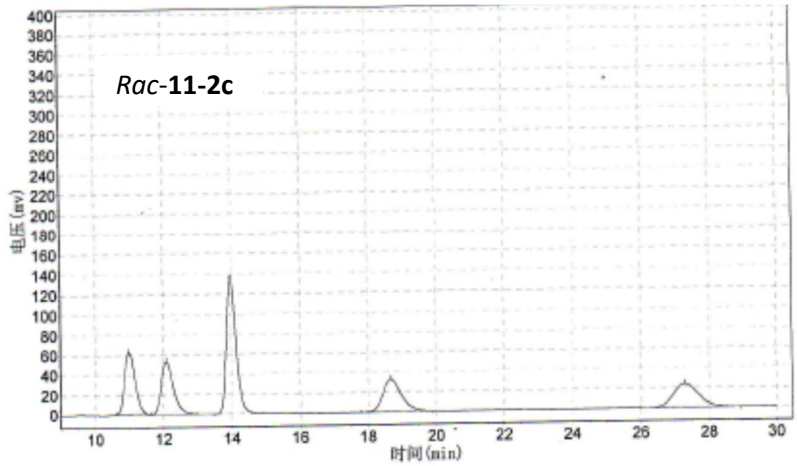



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.90 | 805621 | 23.40 |
| 2 | 8.47 | 822517 | 23.89 |
| 3 | 12.31 | 904974 | 26.29 |
| 4 | 20.50 | 909380 | 26.42 |

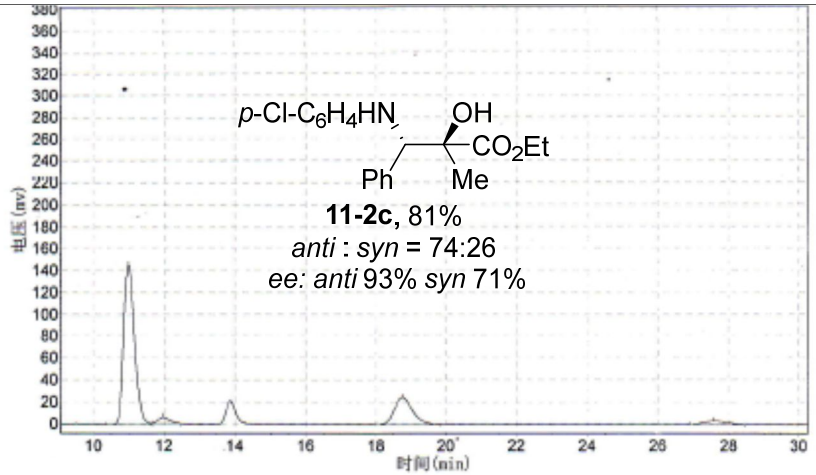



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 7.91 | 142386 | 2.79 |
| *Anti*-2 | 8.46 | 4967617 | 97.21 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 12.27 | 1877082 | 90.67 |
| *Syn*-2 | 20.34 | 193690 | 9.33 |

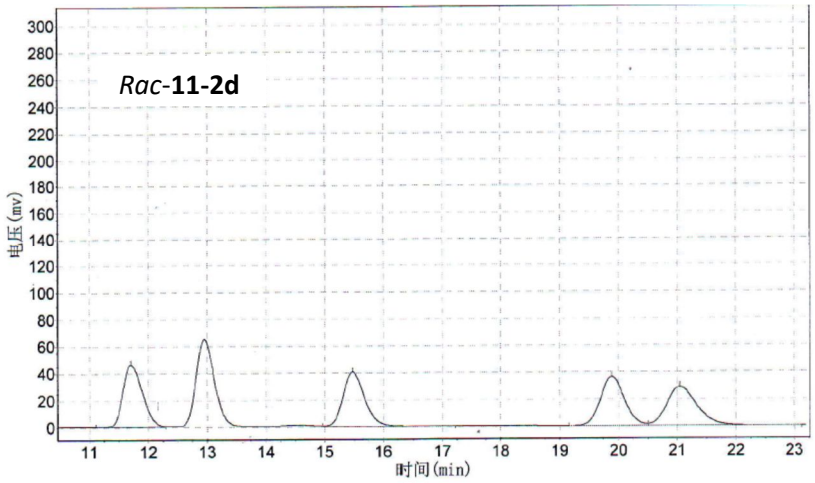



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.00 | 1307965 | 25.78 |
| 2 | 12.09 | 1296007 | 25.54 |
| 3 | 18.67 | 1227606 | 24.19 |
| 4 | 27.29 | 1242316 | 24.48 |

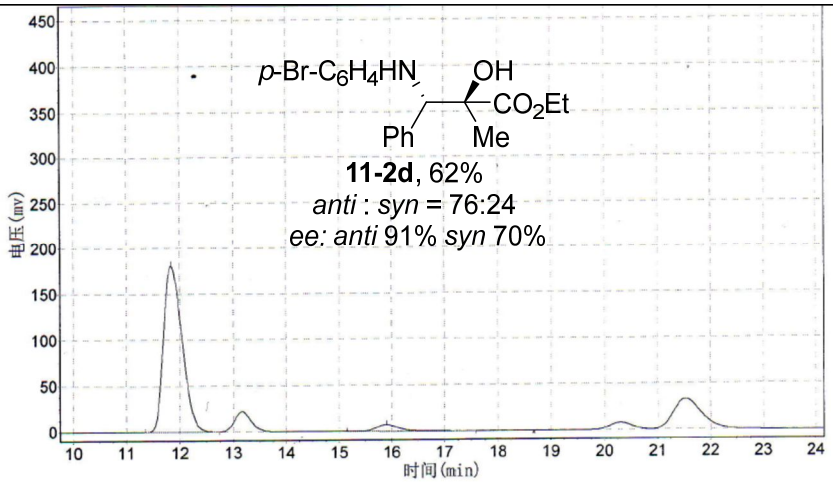



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 11.00 | 145303 | 96.28 |
| *Anti*-2 | 12.00 | 5646 | 3.72 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 18.76 | 24130 | 85.89 |
| *Syn*-2 | 27.60 | 3048 | 14.11 |

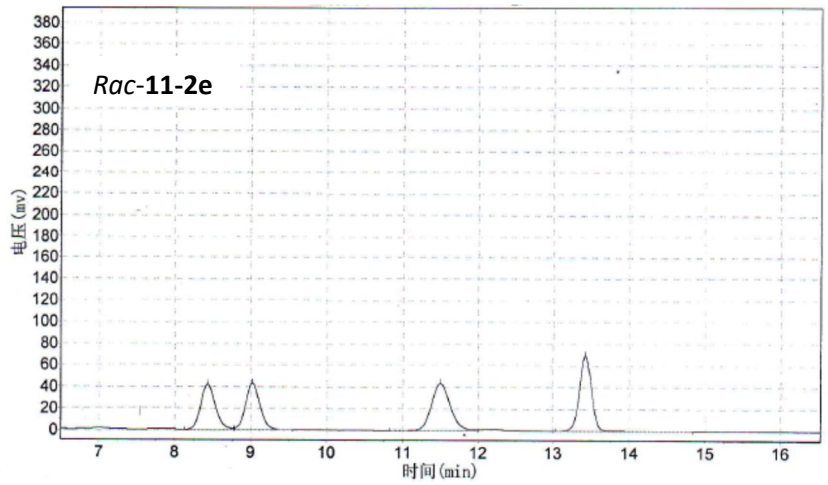



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.71 | 46010 | 25.24 |
| 2 | 15.48 | 40547 | 25.39 |
| 3 | 19.89 | 36437 | 24.62 |
| 4 | 21.05 | 28911 | 24.75 |

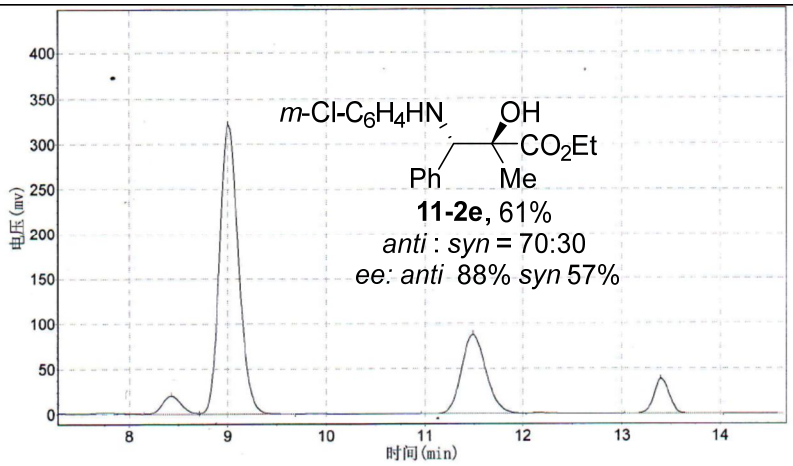



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 11.84 | 180634 | 95.58 |
| *Anti*-2 | 15.90 | 7000 | 4.42 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 20.31 | 7680 | 14.92 |
| *Syn*-2 | 21.53 | 32907 | 85.08 |

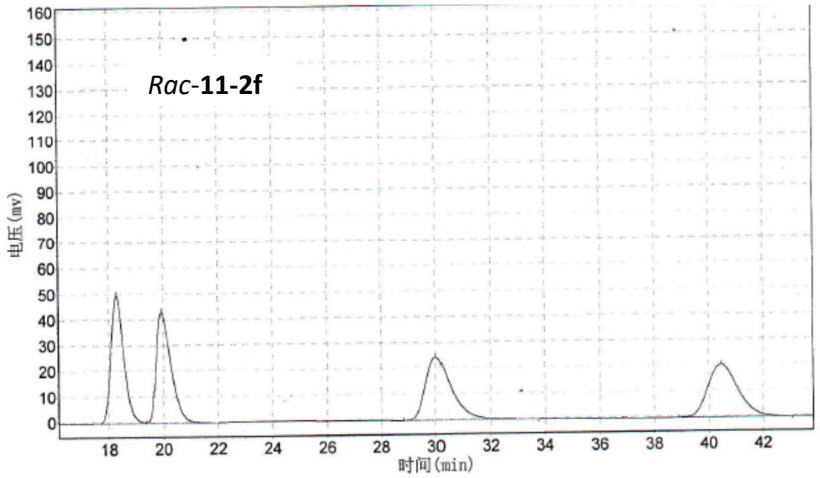



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.43 | 41845 | 21.68 |
| 2 | 9.02 | 42722 | 21.31 |
| 3 | 11.50 | 43151 | 28.44 |
| 4 | 13.42 | 68944 | 28.57 |

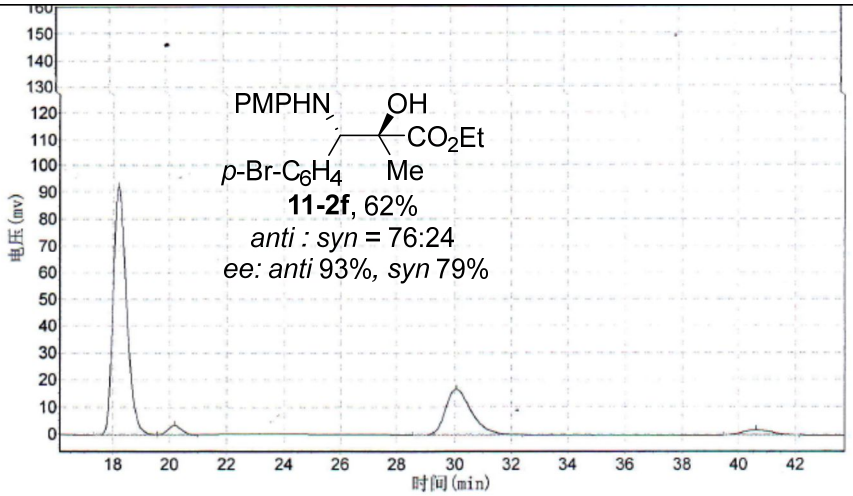



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 8.43 | 20291 | 5.97 |
| *Anti*-2 | 9.01 | 320860 | 94.03 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 11.49 | 87175 | 78.62 |
| *Syn*-2 | 13.40 | 38216 | 21.38 |

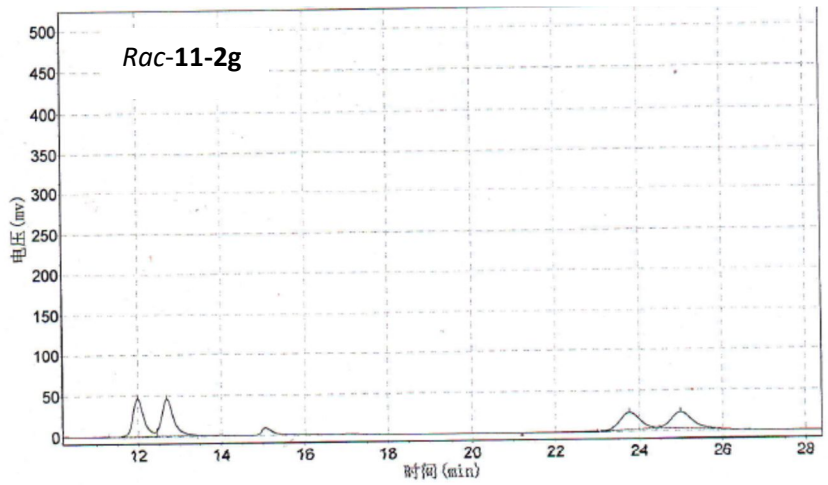



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 18.29 | 49744 | 25.33 |
| 2 | 19.94 | 43157 | 25.27 |
| 3 | 30.01 | 24496 | 24.74 |
| 4 | 40.46 | 20449 | 24.66 |

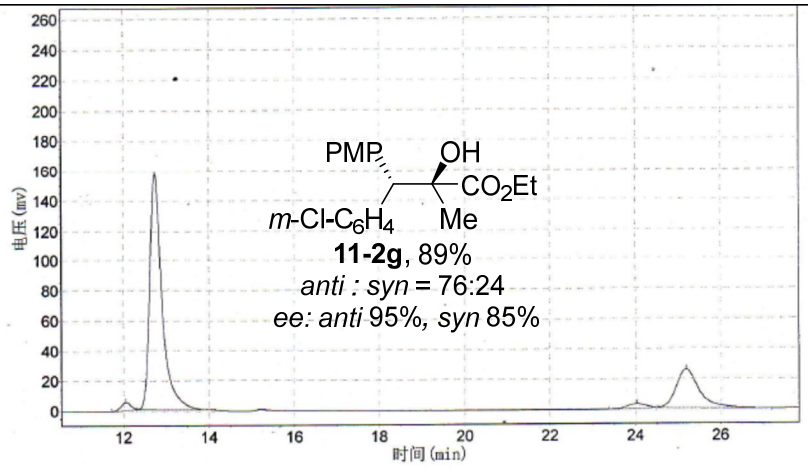



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 18.21 | 92297 | 96.61 |
| *Anti*-2 | 20.18 | 3268 | 3.39 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 30.07 | 16691 | 89.36 |
| *Syn*-2 | 40.62 | 1743 | 10.64 |

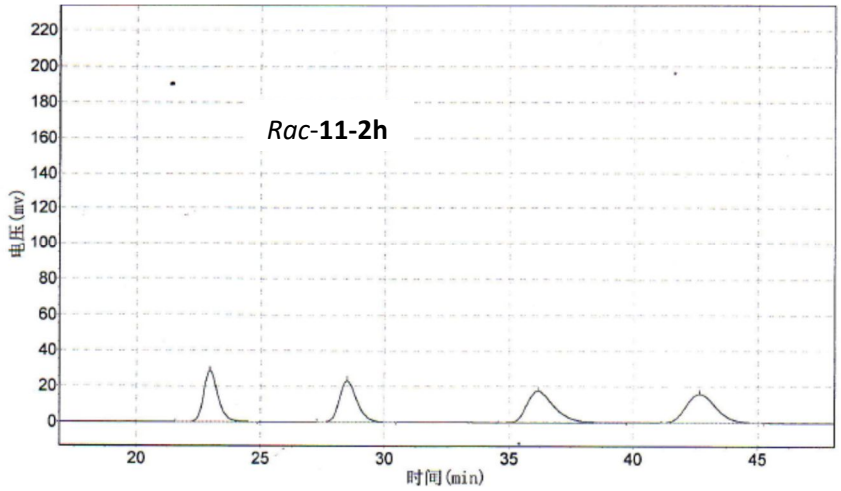



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.99 | 841509 | 28.01 |
| 2 | 12.70 | 859921 | 28.62 |
| 3 | 23.78 | 648699 | 21.59 |
| 4 | 24.99 | 654285 | 21.78 |

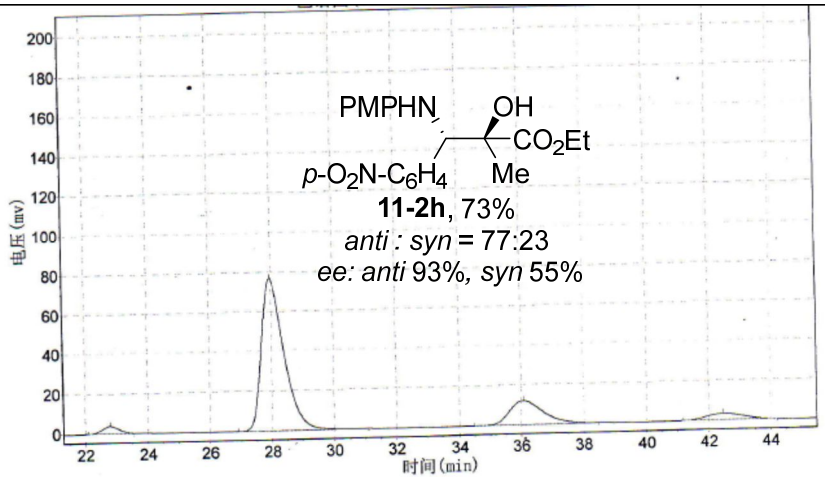



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 12.06 | 76260 | 2.38 |
| *Anti*-2 | 12.74 | 3122393 | 97.62 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 24.04 | 78031 | 7.61 |
| *Syn*-2 | 25.19 | 947168 | 92.39 |

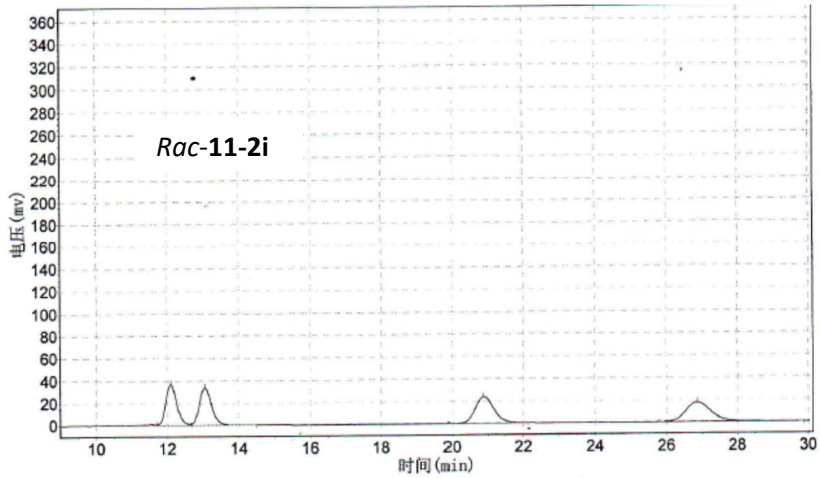



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 22.96 | 1115330 | 22.89 |
| 2 | 28.48 | 1113760 | 22.85 |
| 3 | 36.17 | 1325377 | 27.20 |
| 4 | 42.66 | 1318882 | 27.06 |

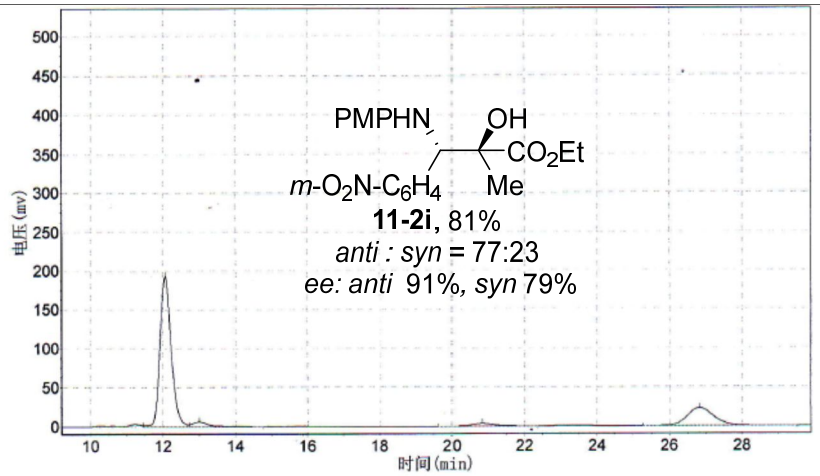



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 22.80 | 135236 | 3.40 |
| *Anti*-2 | 27.97 | 3836491 | 96.40 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 36.07 | 895877 | 77.29 |
| *Syn*-2 | 42.47 | 263337 | 22.71 |

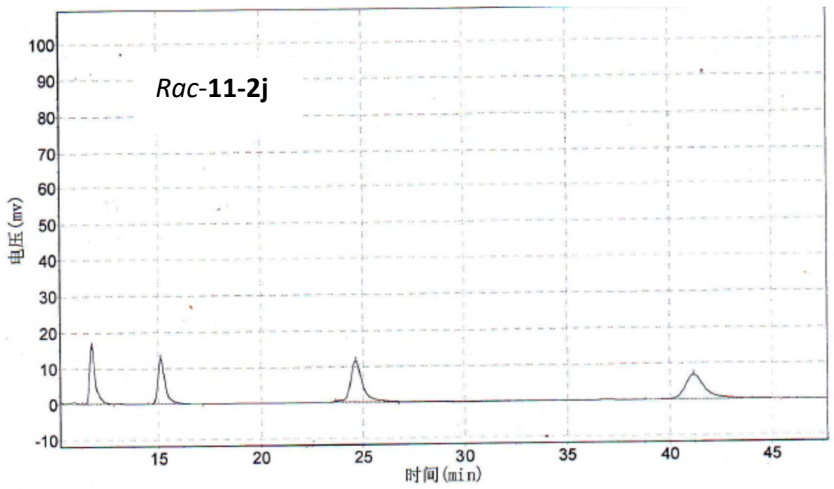



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 12.06 | 788262 | 23.71 |
| 2 | 13.00 | 795148 | 23.91 |
| 3 | 20.83 | 870469 | 26.18 |
| 4 | 26.83 | 871295 | 26.20 |

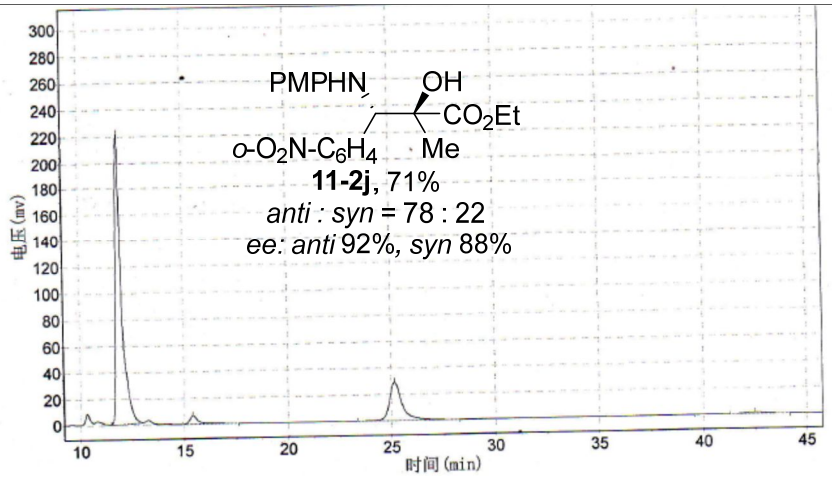



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 12.06 | 4156486 | 95.52 |
| *Anti*-2 | 13.00 | 195019 | 4.48 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 20.83 | 135920 | 10.42 |
| *Syn*-2 | 26.83 | 1167381 | 89.58 |

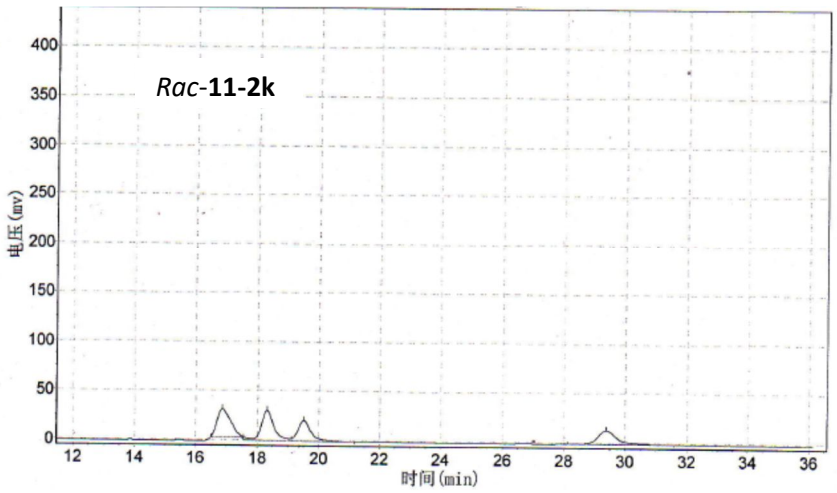



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.75 | 309973 | 20.44 |
| 2 | 15.12 | 313062 | 20.65 |
| 3 | 25.65 | 441338 | 29.11 |
| 4 | 42.16 | 451968 | 29.81 |

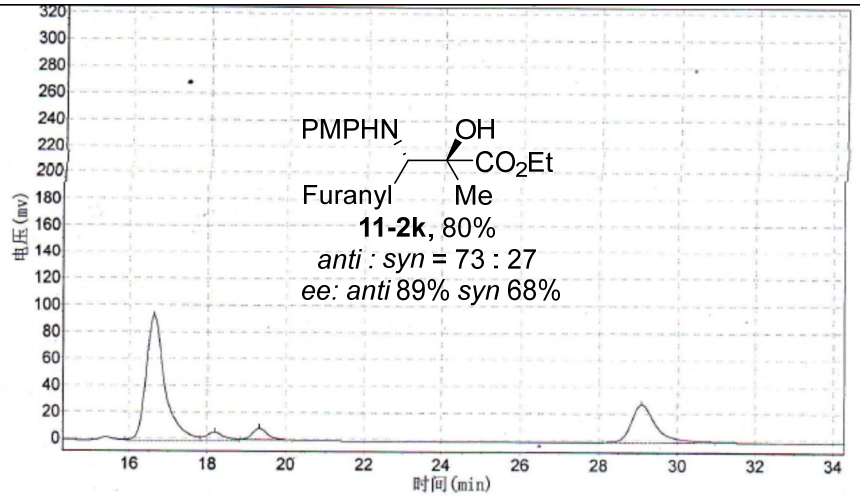



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 11.89 | 4396461 | 96.02 |
| *Anti*-2 | 15.41 | 6538 | 3.98 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 25.17 | 28906 | 94.07 |
| *Syn*-2 | 42.48 | 1224 | 5.93 |

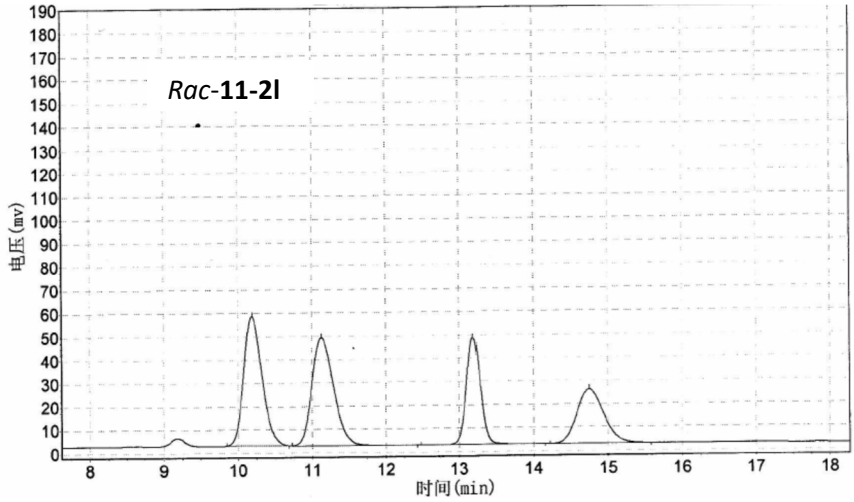



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 16.86 | 28007 | 29.10 |
| 2 | 18.31 | 29766 | 29.54 |
| 3 | 19.52 | 20560 | 20.62 |
| 4 | 29.38 | 13781 | 20.74 |

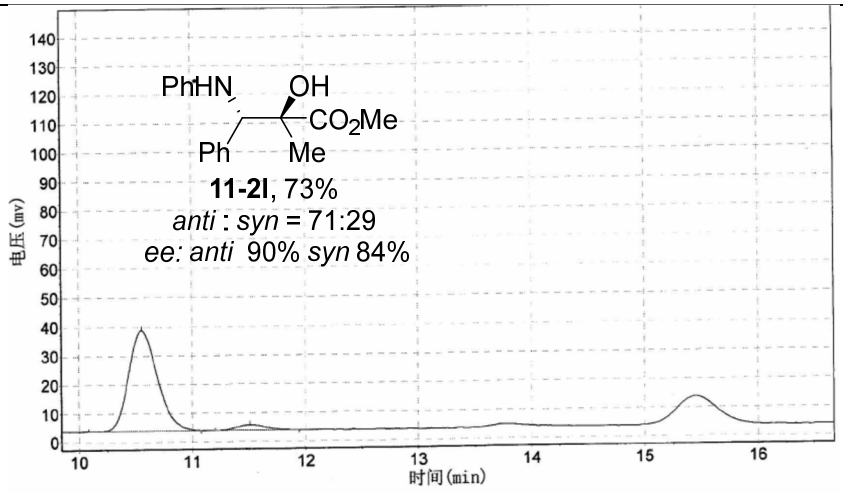



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 16.64 | 3122503 | 94.34 |
| *Anti*-2 | 18.19 | 187450 | 5.66 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 19.33 | 8585 | 15.98 |
| *Syn*-2 | 29.10 | 27984 | 84.02 |

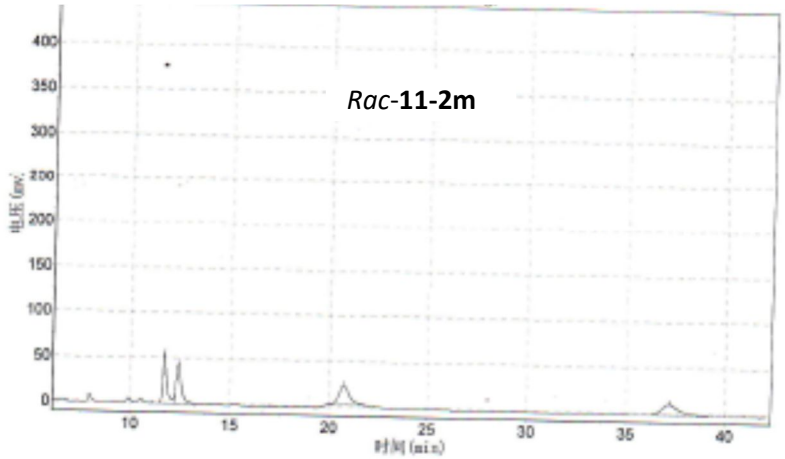



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 10.19 | 951329 | 30.95 |
| 2 | 11.13 | 950932 | 30.94 |
| 3 | 13.19 | 587015 | 19.10 |
| 4 | 14.75 | 584534 | 19.01 |

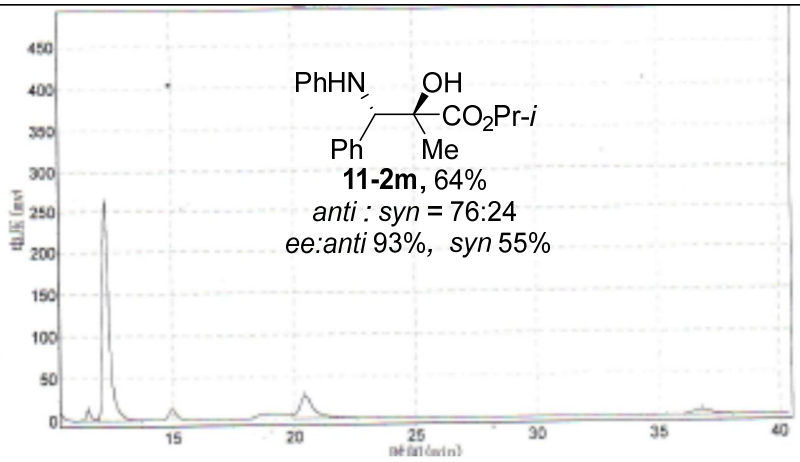



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 10.56 | 612014 | 94.84 |
| *Anti*-2 | 11.51 | 33286 | 5.16 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 13.77 | 21252 | 8.08 |
| *Syn*-2 | 15.45 | 241907 | 91.92 |

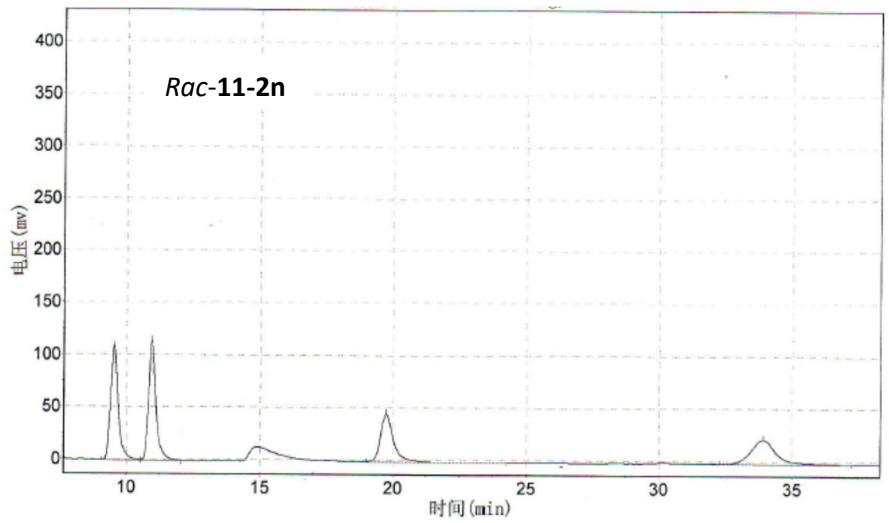



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.72 | 761707 | 25.13 |
| 2 | 12.42 | 766084 | 25.28 |
| 3 | 20.74 | 748744 | 24.71 |
| 4 | 37.18 | 754167 | 24.88 |

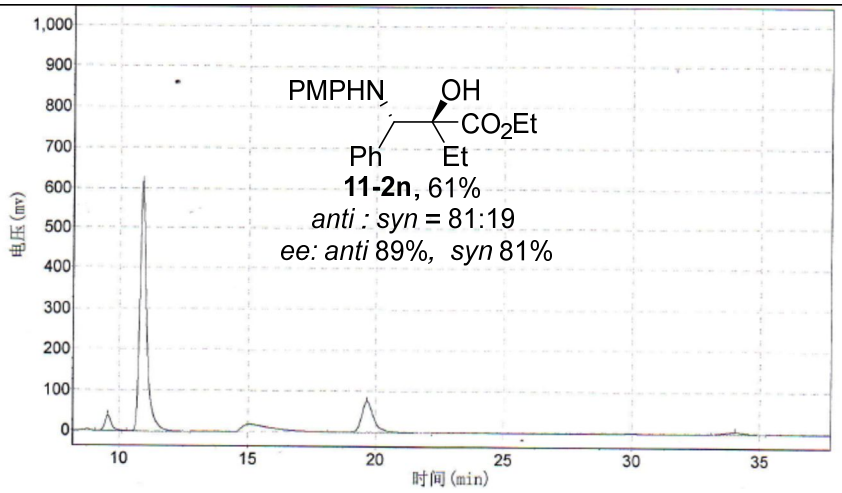



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 11.51 | 189293 | 3.75 |
| *Anti*-2 | 12.44 | 4852484 | 96.25 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 20.44 | 1106461 | 77.70 |
| *Syn*-2 | 36.77 | 317463 | 22.30 |

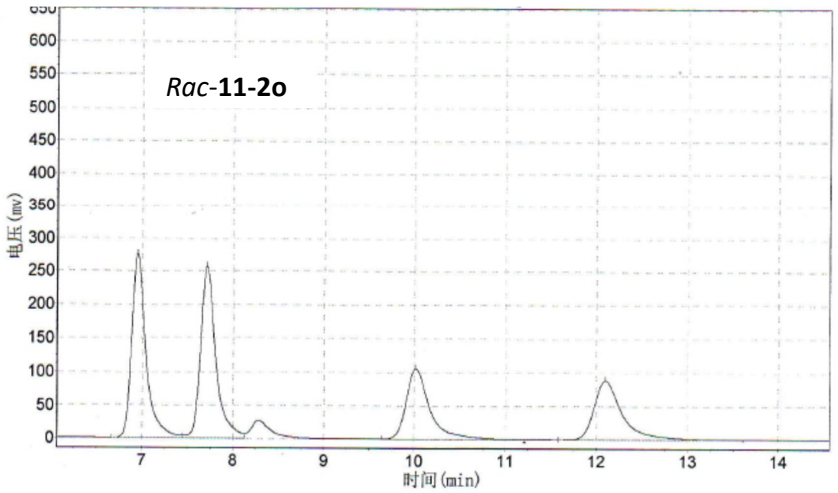



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 9.53 | 2197661 | 29.47 |
| 2 | 10.94 | 2175357 | 29.17 |
| 3 | 19.75 | 1560700 | 20.93 |
| 4 | 33.90 | 1523937 | 20.43 |

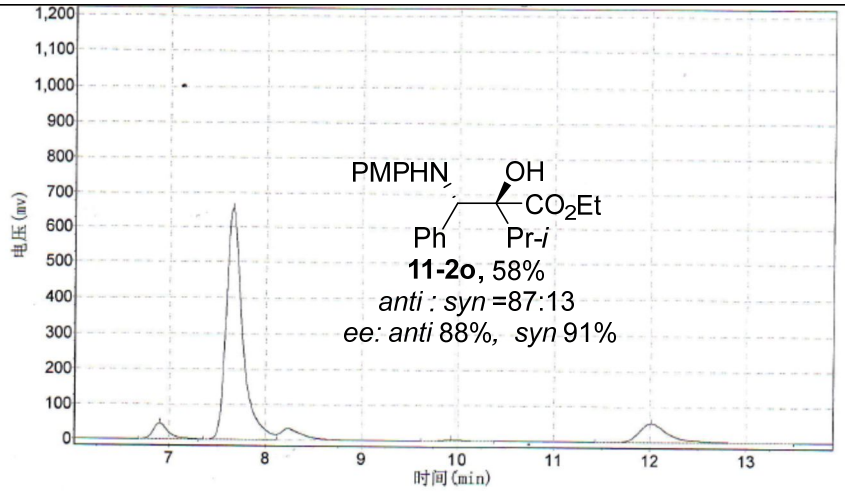



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 9.56 | 644152 | 5.34 |
| *Anti*-2 | 10.89 | 11422244 | 94.66 |

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 19.67 | 2530053 | 90.50 |
| *Syn*-2 | 34.02 | 265685 | 9.50 |

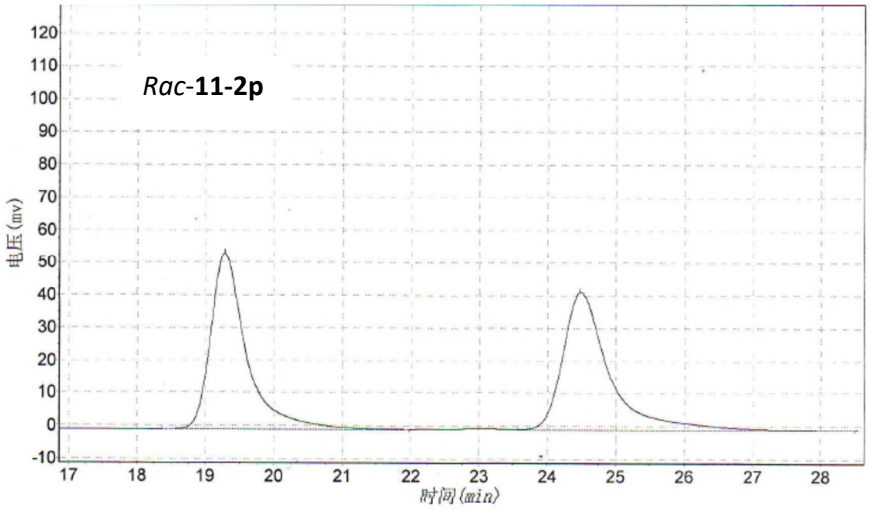



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.95 | 3016797 | 30.85 |
| 2 | 7.71 | 2981852 | 30.50 |
| 3 | 10.02 | 1893900 | 19.37 |
| 4 | 12.10 | 1885103 | 19.28 |

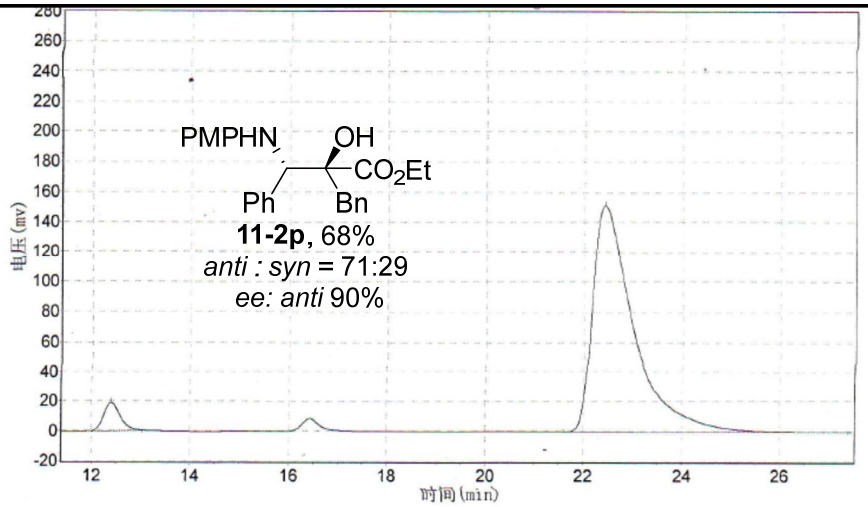



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 6.91 | 481294 | 5.77 |
| *Anti*-2 | 7.65 | 7671600 | 94.23 |

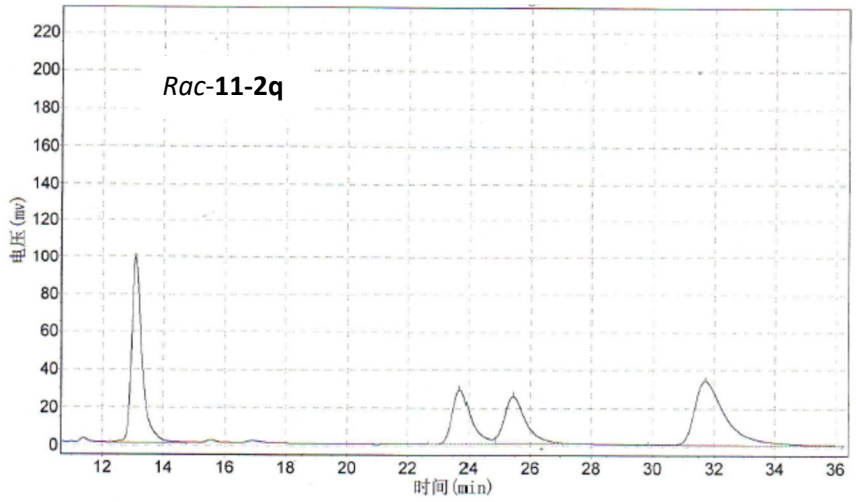
| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 9.95 | 56203 | 4.70 |
| *Syn*-2 | 12.01 | 1137805 | 95.30 |



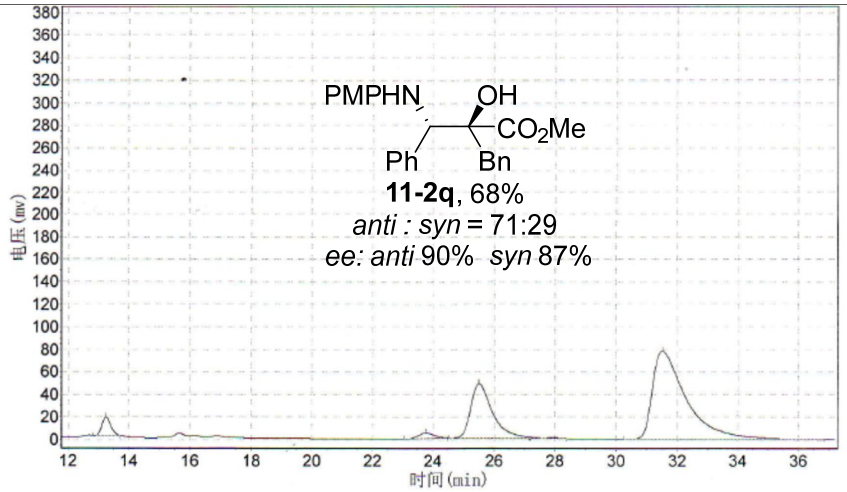

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 19.28 | 53797 | 49.71 |
| 2 | 24.49 | 41977 | 50.29 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 12.40 | 445324 | 4.81 |
| *Anti*-2 | 22.42 | 8805902 | 95.19 |

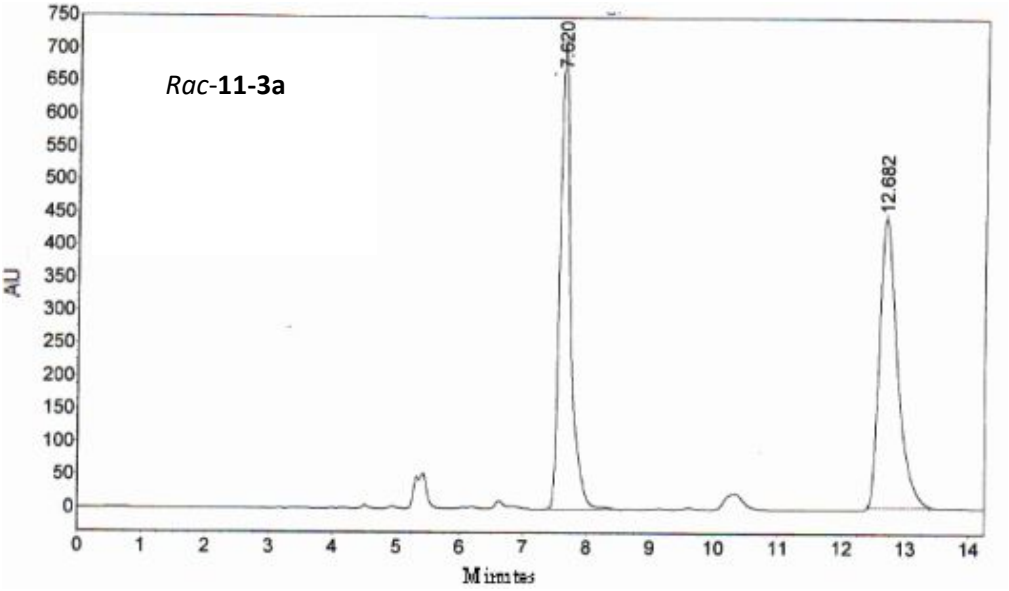



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 13.09 | 2327789 | 33.13 |
| 2 | 23.71 | 1177112 | 16.75 |
| 3 | 25.44 | 1190099 | 16.94 |
| 4 | 31.71 | 2331655 | 33.18 |

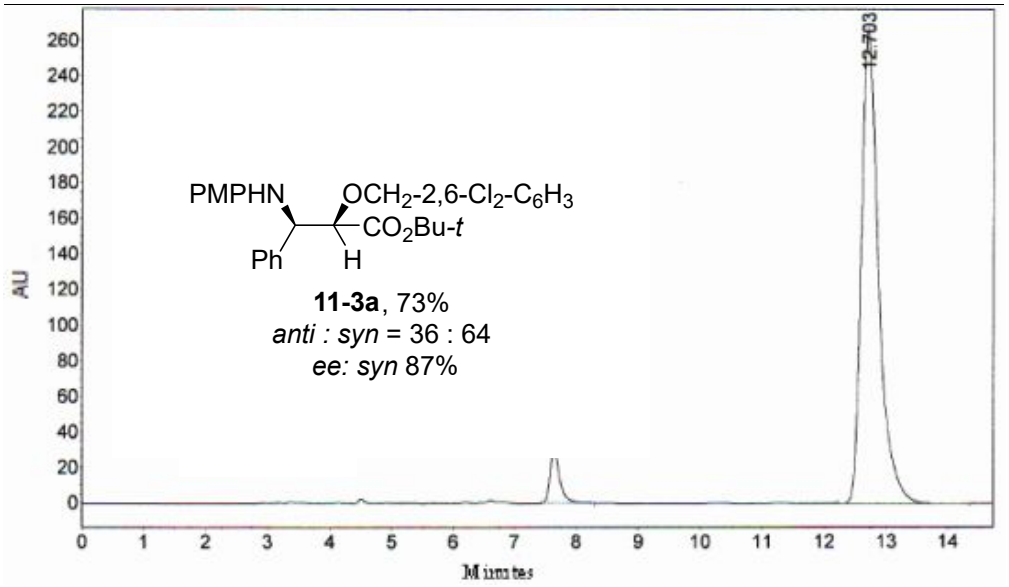



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 13.25 | 324022 | 5.21 |
| *Anti*-2 | 31.52 | 5884643 | 94.79 |

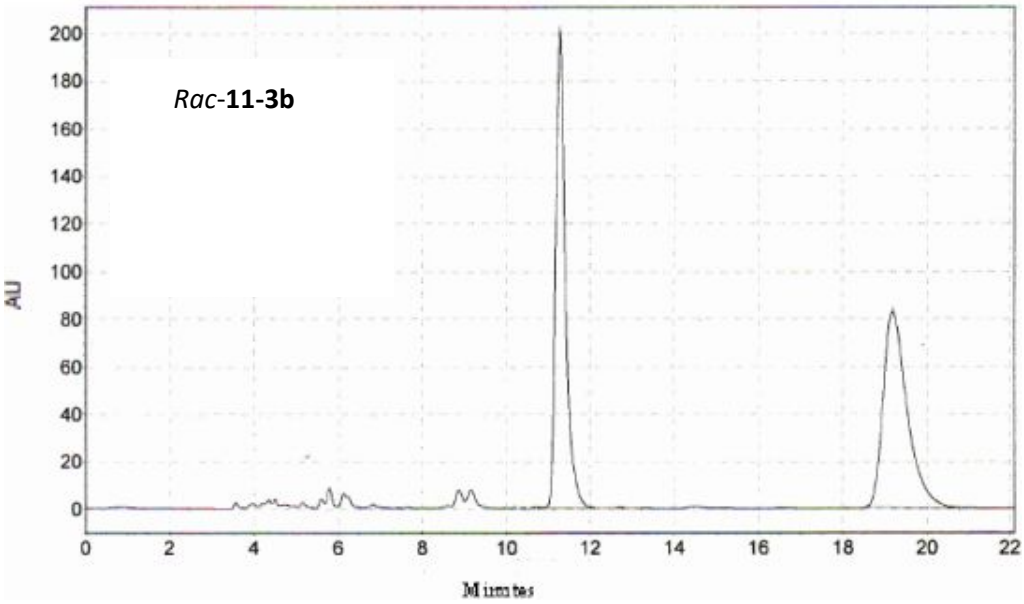
| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 23.78 | 168145 | 6.50 |
| *Syn*-2 | 25.49 | 2416703 | 93.50 |



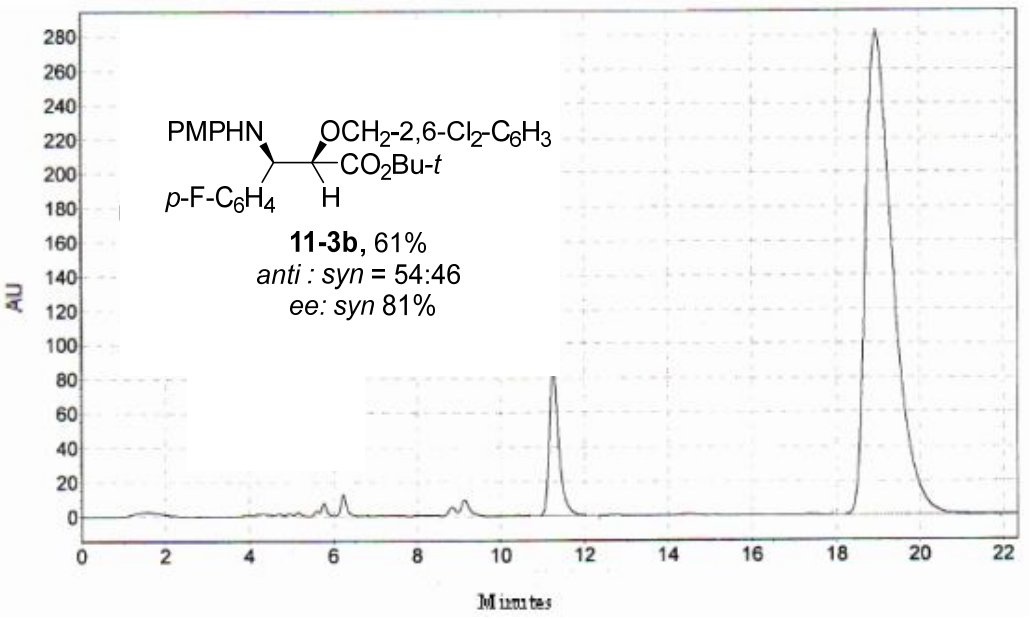

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.62 | 8607811 | 49.92 |
| 2 | 12.68 | 8636488 | 50.08 |



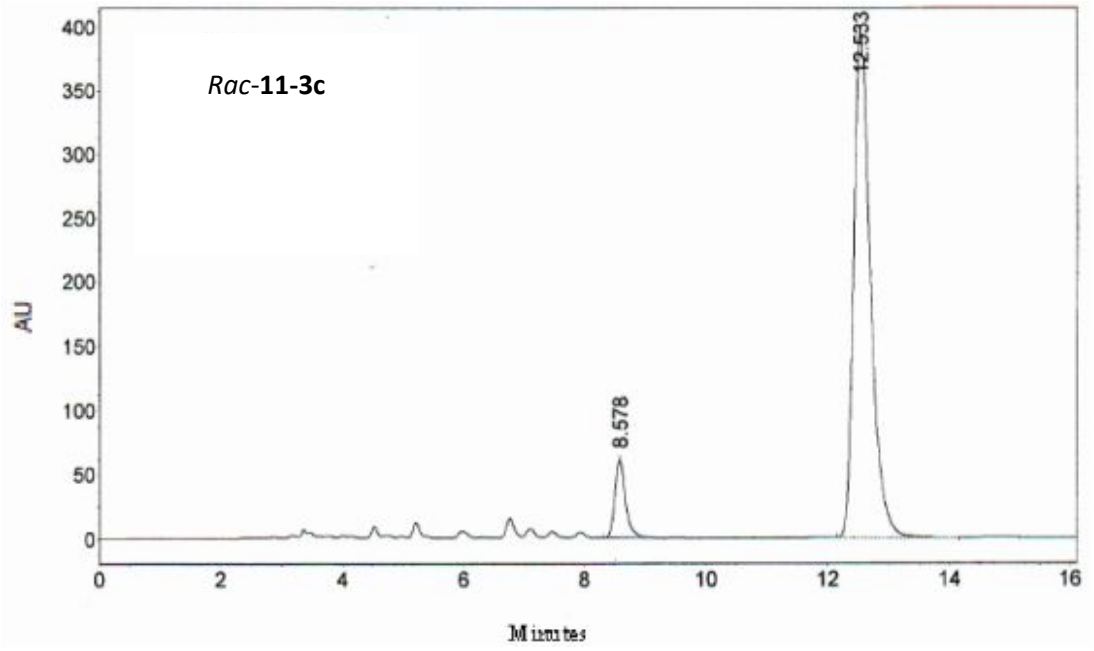

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.64 | 328917 | 6.02 |
| 2 | 12.70 | 5134867 | 93.98 |



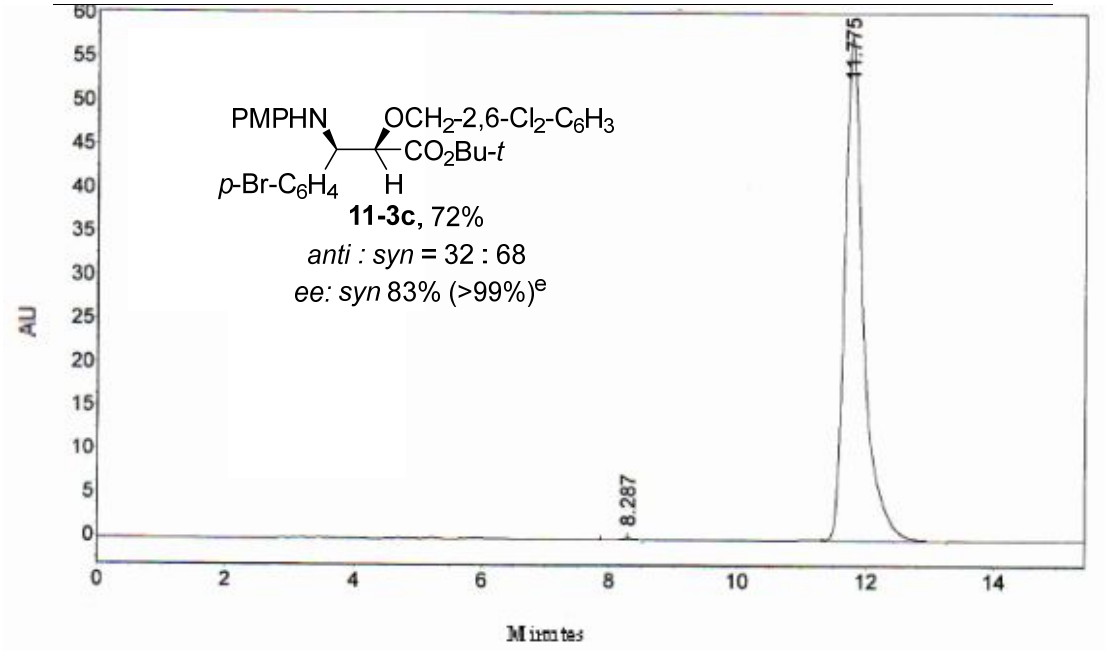

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.28 | 3259838 | 49.91 |
| 2 | 19.19 | 3270534 | 50.09 |



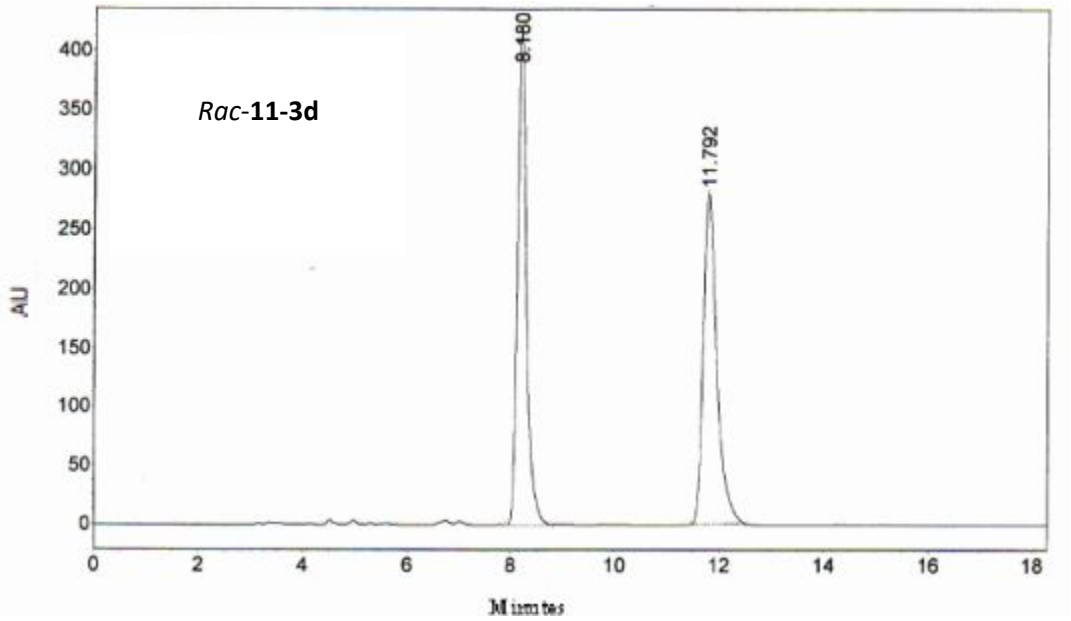

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.27 | 1359848 | 9.65 |
| 2 | 18.97 | 12727724 | 90.35 |



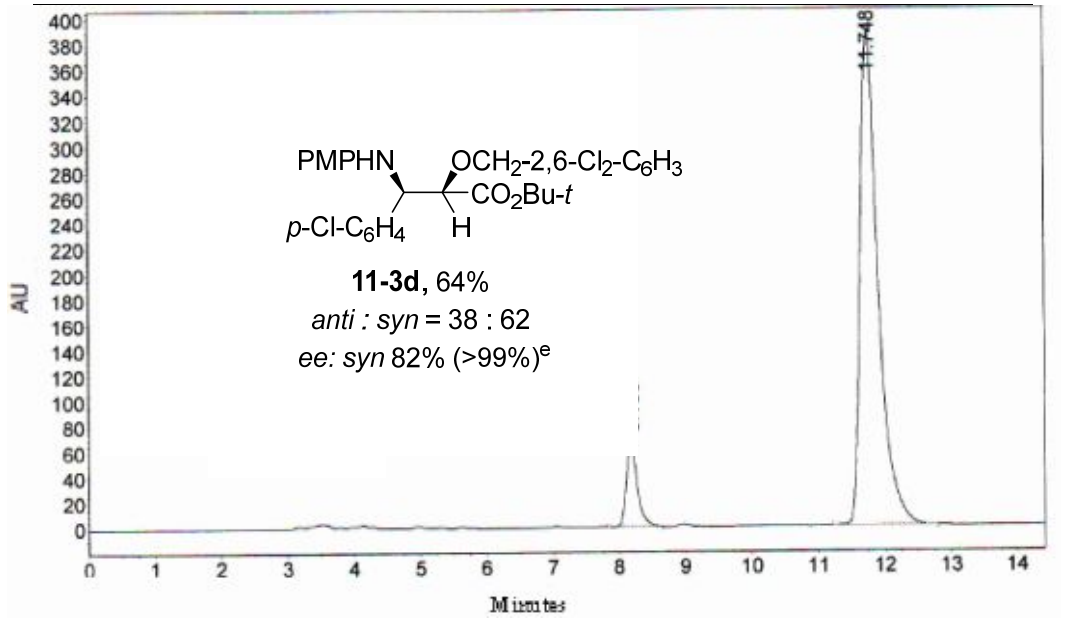

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.58 | 703950 | 8.59 |
| 2 | 12.53 | 7495566 | 91.41 |



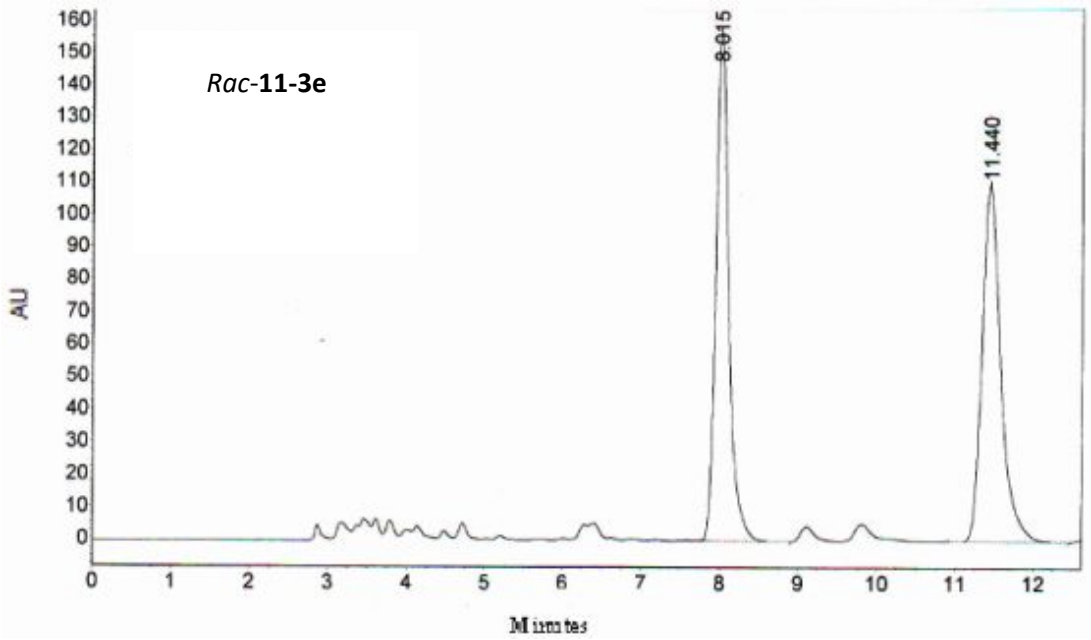

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.29 | 1491 | 0.13 |
| 2 | 11.78 | 1161075 | 99.87 |



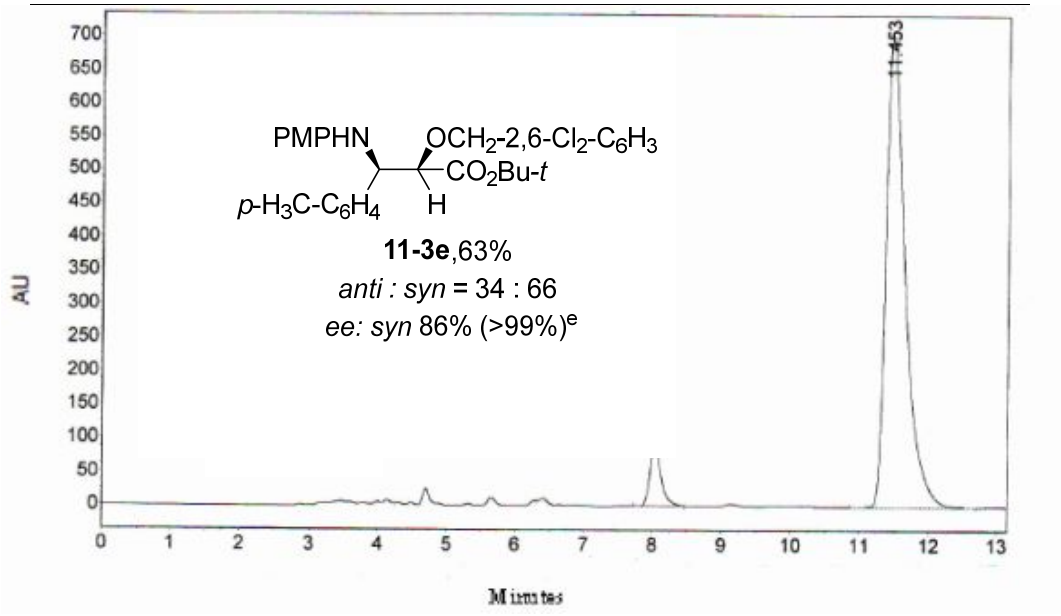

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.18 | 5035677 | 49.74 |
| 2 | 11.79 | 5087670 | 50.26 |



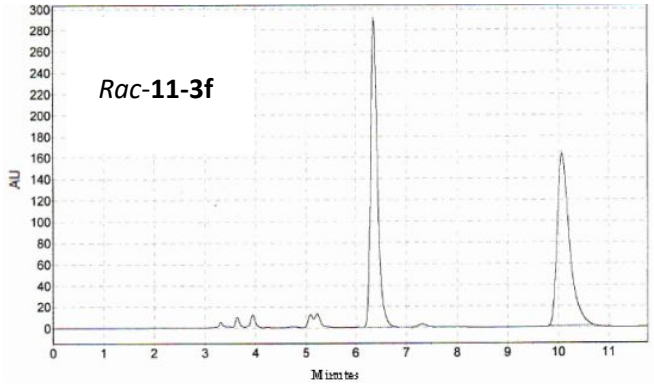

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.18 | 744687 | 9.25 |
| 2 | 11.75 | 7303312 | 90.75 |



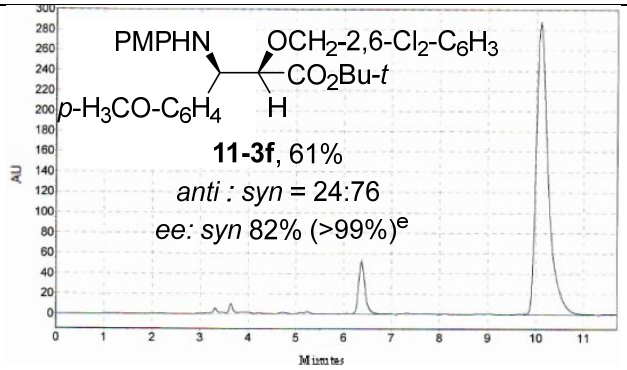

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.02 | 1818903 | 49.82 |
| 2 | 11.44 | 1831544 | 50.17 |



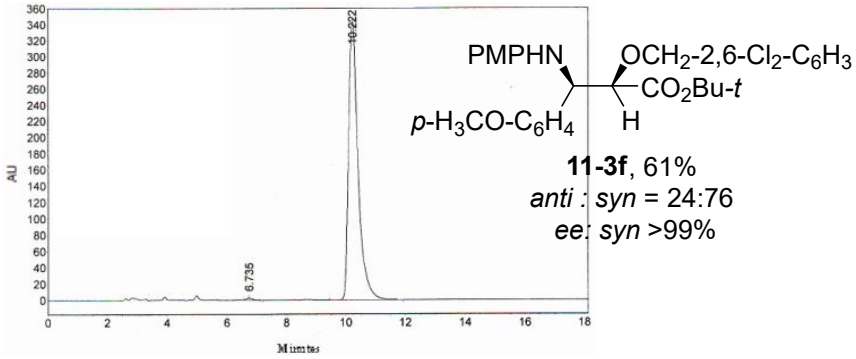

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 8.04 | 1006706 | 6.86 |
| 2 | 11.45 | 13674739 | 93.14 |



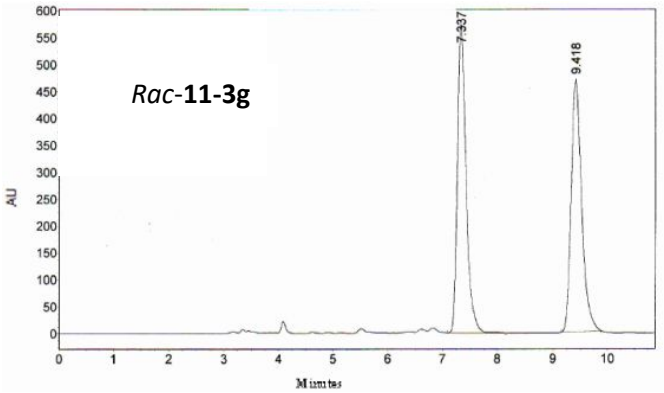

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.36 | 2718898 | 49.90 |
| 2 | 10.07 | 2730324 | 50.10 |



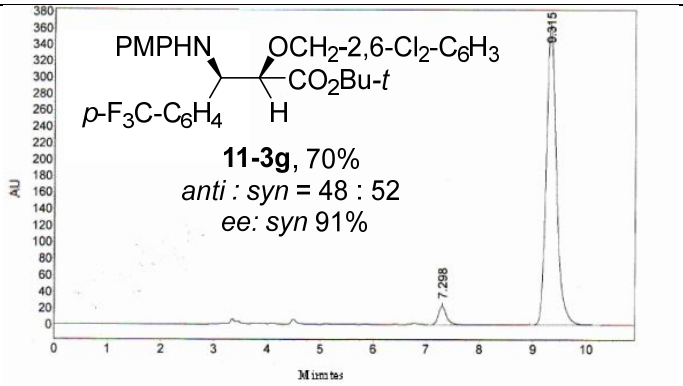

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 6.38 | 492333 | 8.97 |
| 2 | 10.10 | 4996751 | 91.03 |



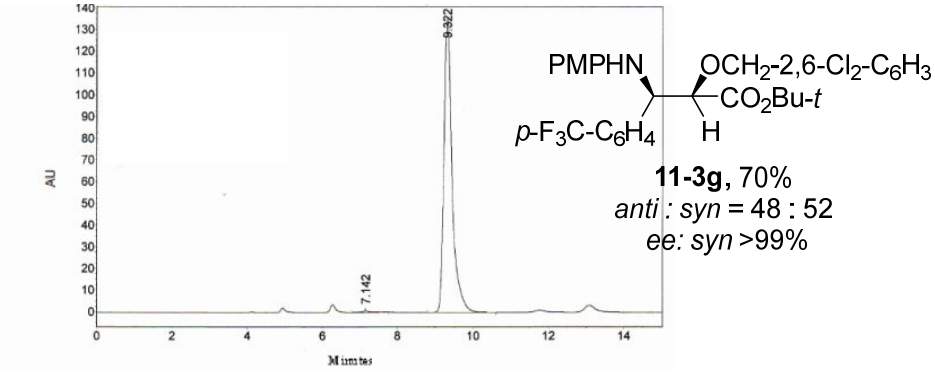

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| Crystal-1 | 6.74 | 27489 | 0.36 |
| Crystal-2 | 10.22 | 7544034 | 99.64 |



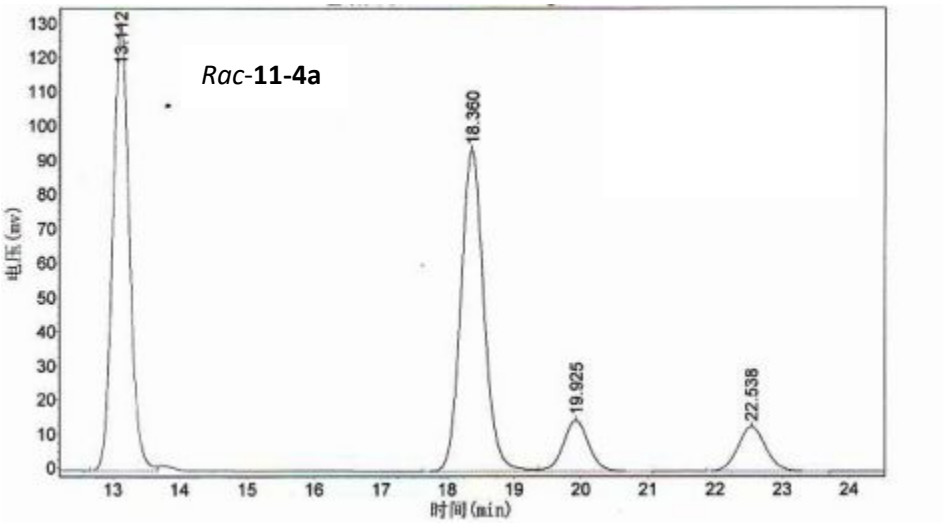

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.34 | 6231988 | 49.86 |
| 2 | 9.42 | 6265446 | 50.13 |



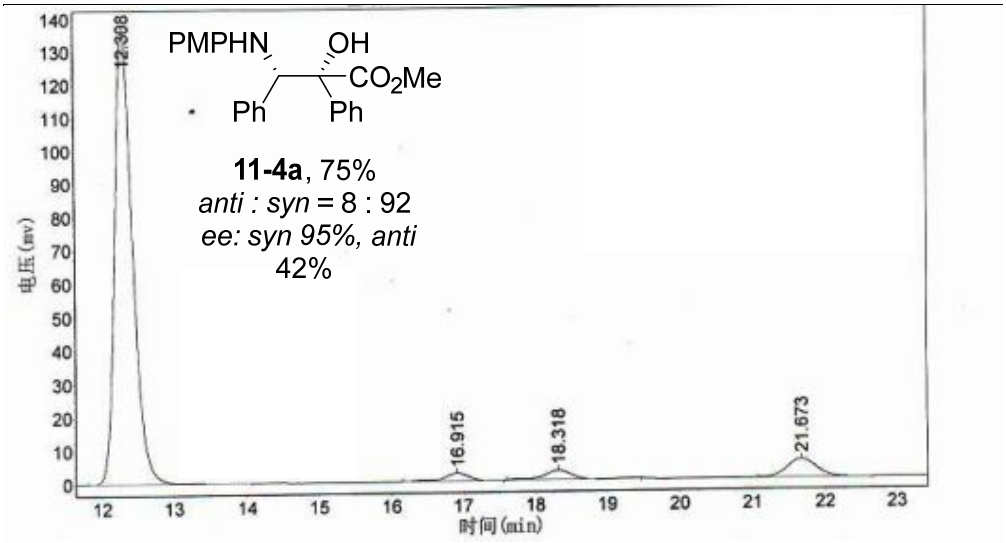

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 7.30 | 22384 | 4.31 |
| 2 | 9.32 | 363969 | 95.69 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| Crystal-1 | 7.14 | 7851 | 0.39 |
| Crystal-2 | 9.32 | 2030582 | 99.61 |

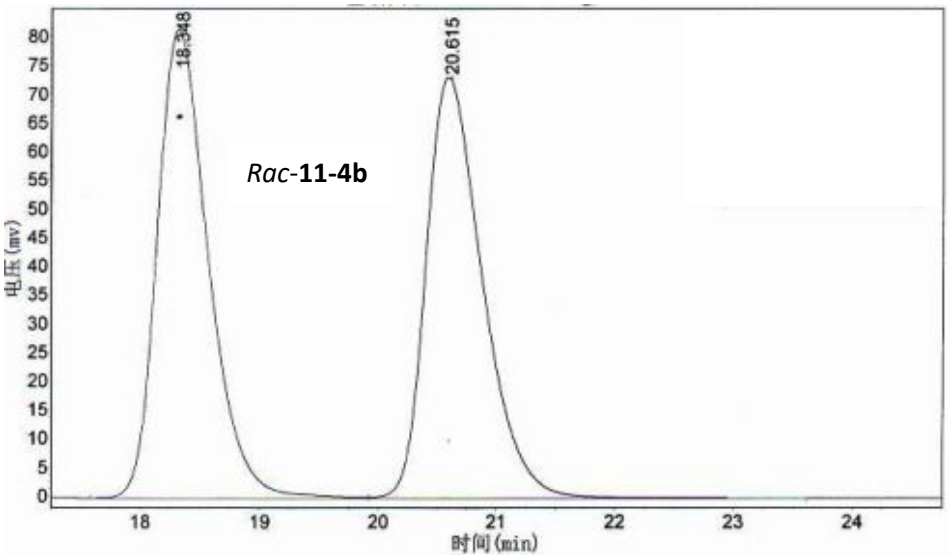



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 13.11 | 2250544 | 42.58 |
| 2 | 18.36 | 2265024 | 42.85 |
| 3 | 19.93 | 394234 | 7.46 |
| 4 | 22.54 | 375732 | 7.11 |

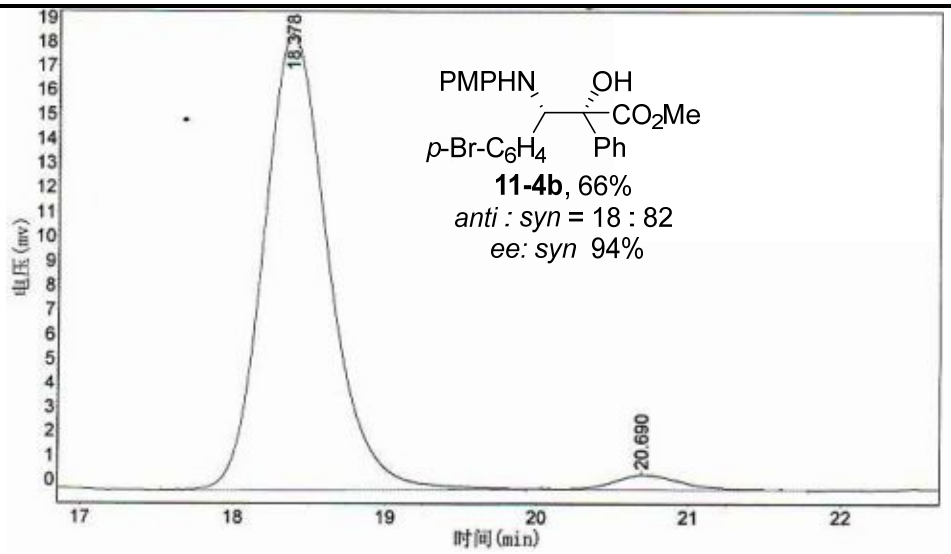



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 12.31 | 2337875 | 97.65 |
| Syn-2 | 16.92 | 56364 | 2.35 |

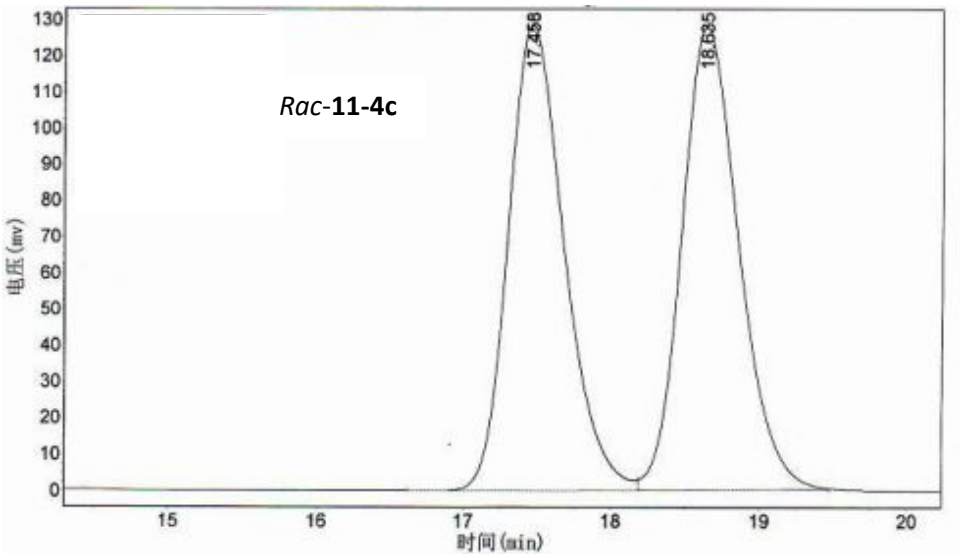
| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 18.32 | 64177 | 70.95 |
| Anti-2 | 21.67 | 155804 | 29.15 |



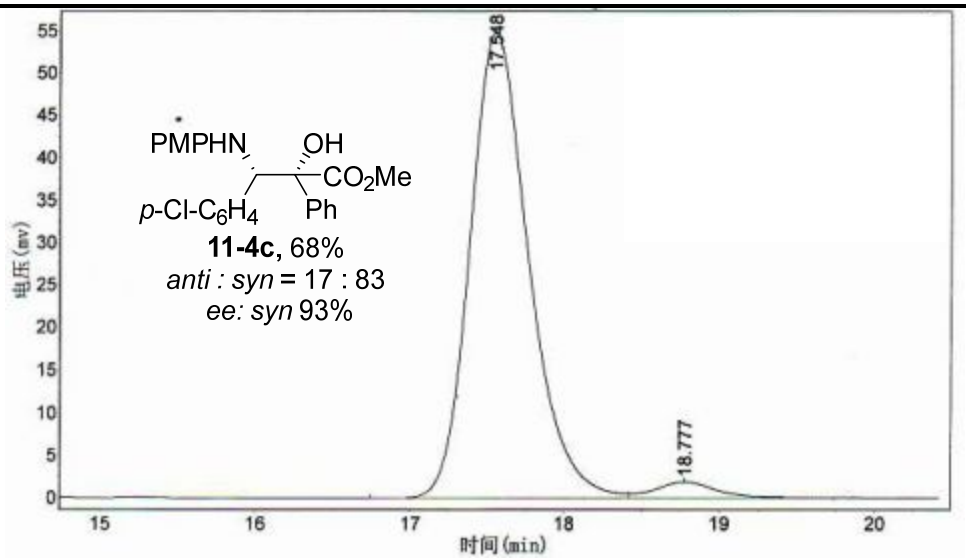

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 18.35 | 2425027 | 49.96 |
| 2 | 20.62 | 2429213 | 50.04 |



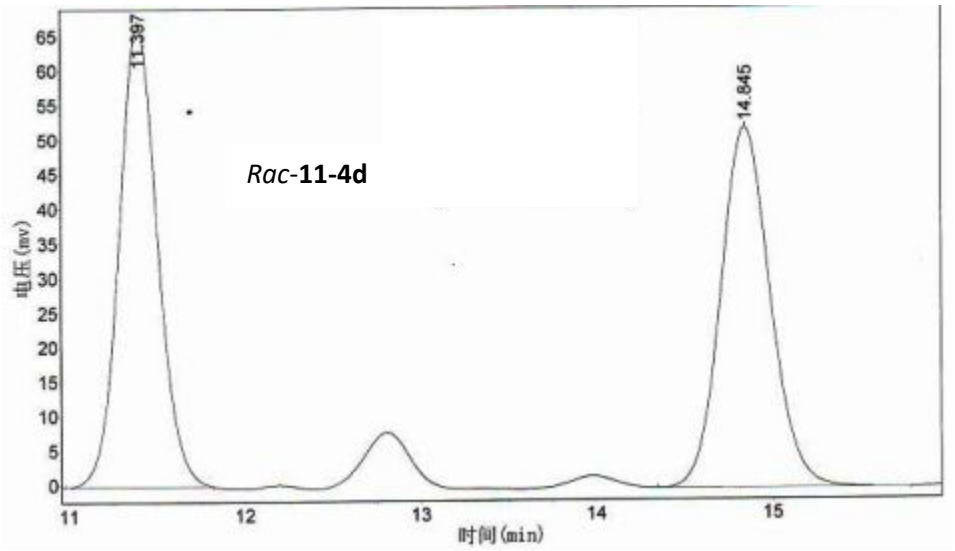

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 18.38 | 553534 | 96.86 |
| 2 | 20.69 | 17924 | 3.14 |



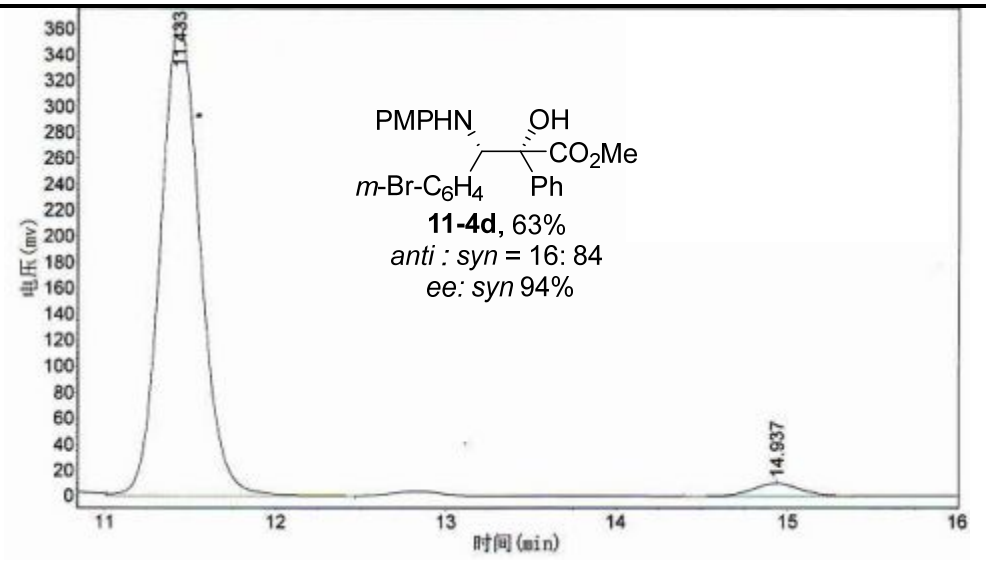

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 17.46 | 3389956 | 49.94 |
| 2 | 18.64 | 3397138 | 50.05 |



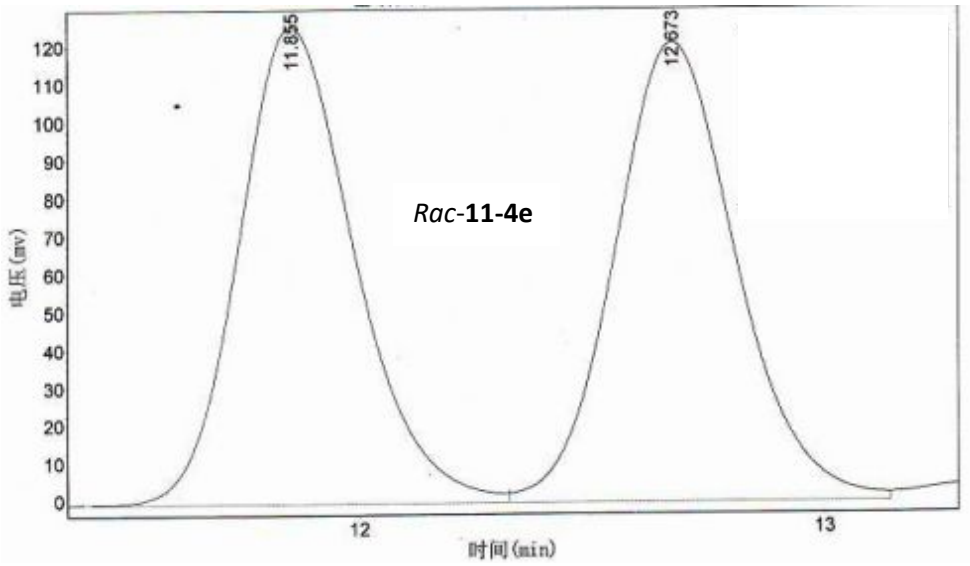

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 17.55 | 1445644 | 96.59 |
| 2 | 18.78 | 50982 | 3.40 |



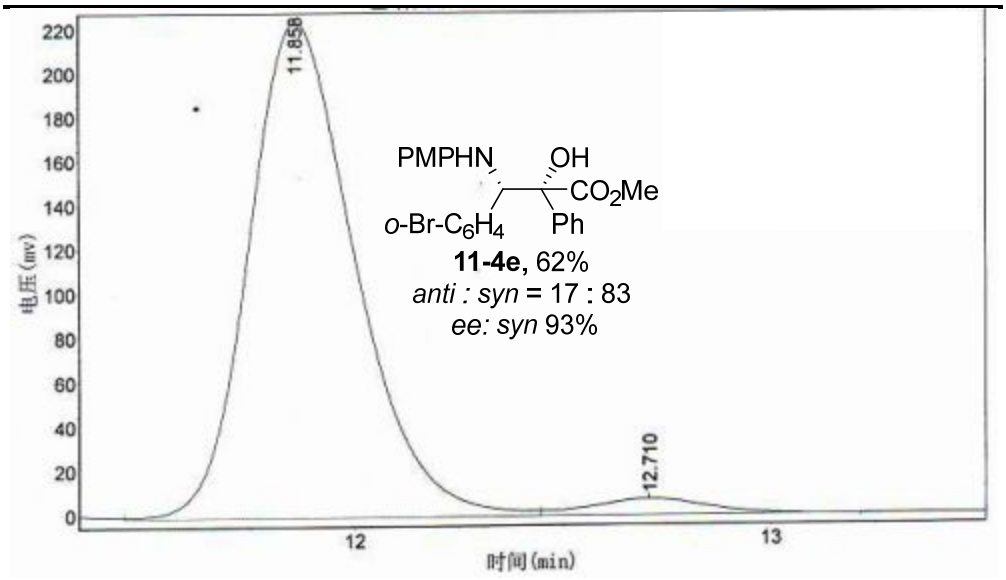

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.40 | 1017905 | 50.09 |
| 2 | 14.85 | 1014272 | 49.91 |



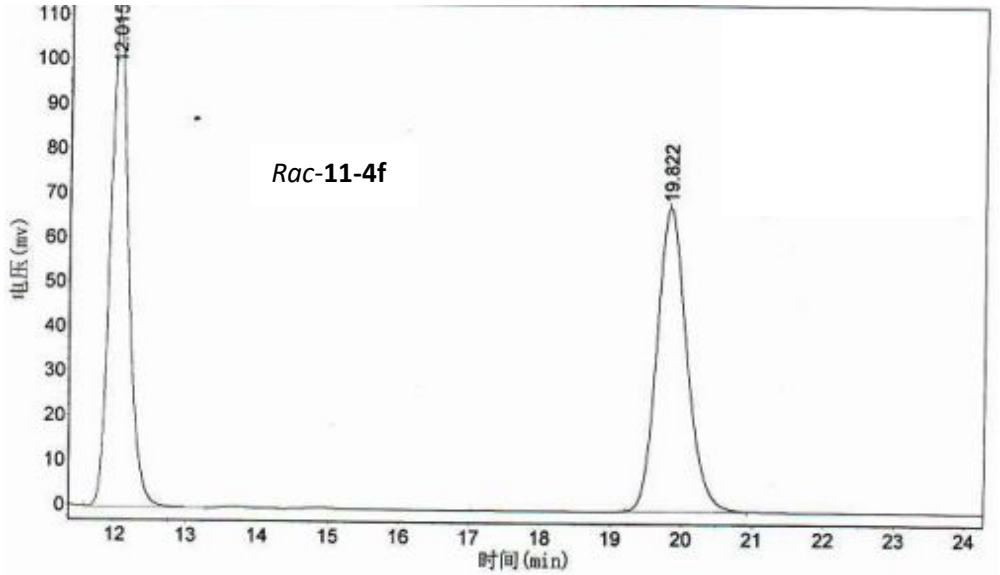

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.43 | 5850097 | 96.97 |
| 2 | 14.94 | 182788 | 3.03 |



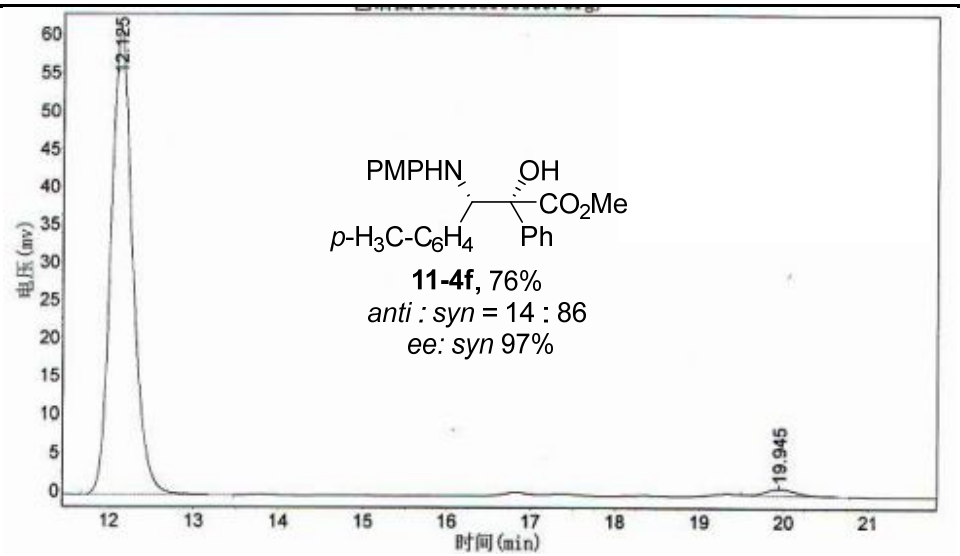

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.86 | 2171783 | 49.68 |
| 2 | 12.67 | 2200137 | 50.32 |



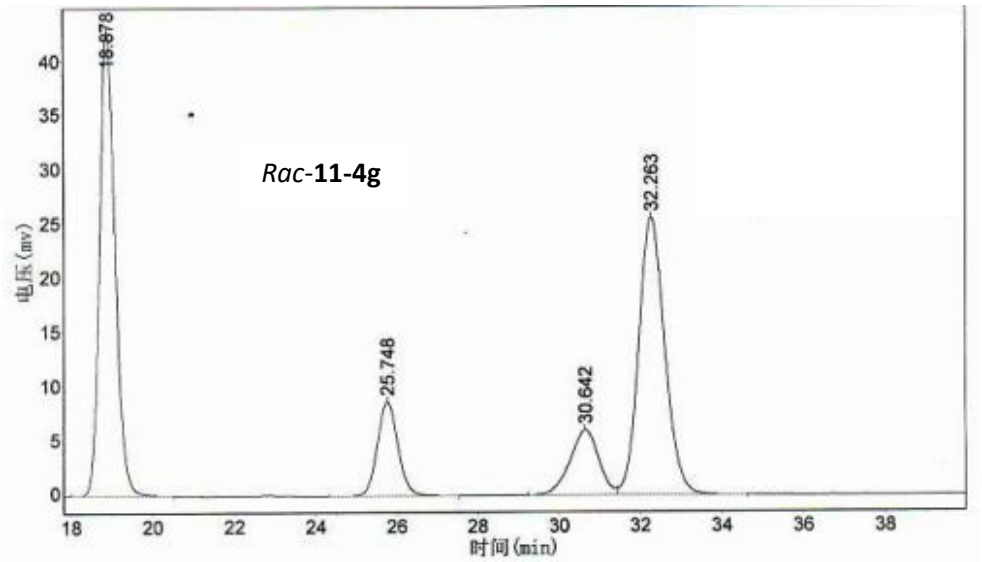

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.86 | 3956580 | 96.51 |
| 2 | 12.71 | 143266 | 3.49 |



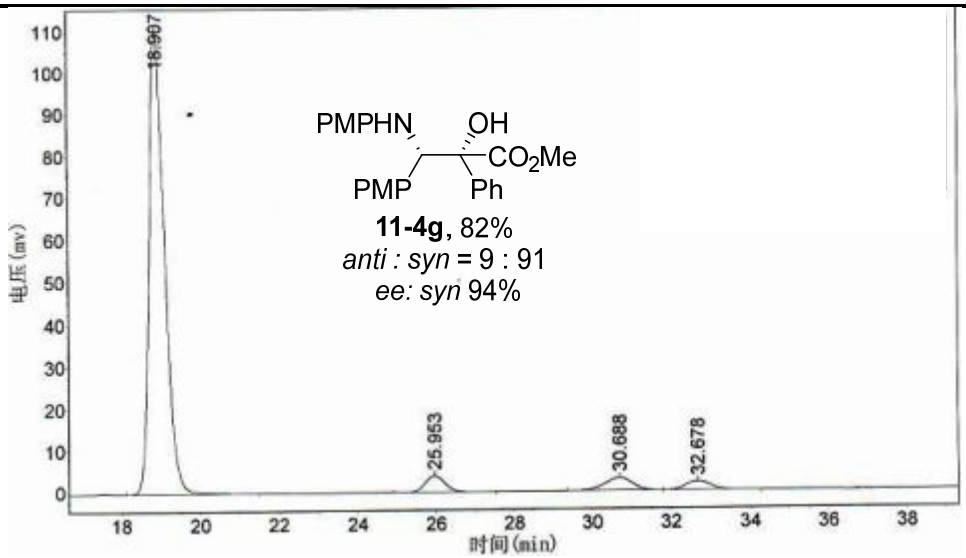

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 12.02 | 1985180 | 50.02 |
| 2 | 19.82 | 1983511 | 49.98 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 12.13 | 1098463 | 98.39 |
| 2 | 19.95 | 17943 | 1.61 |

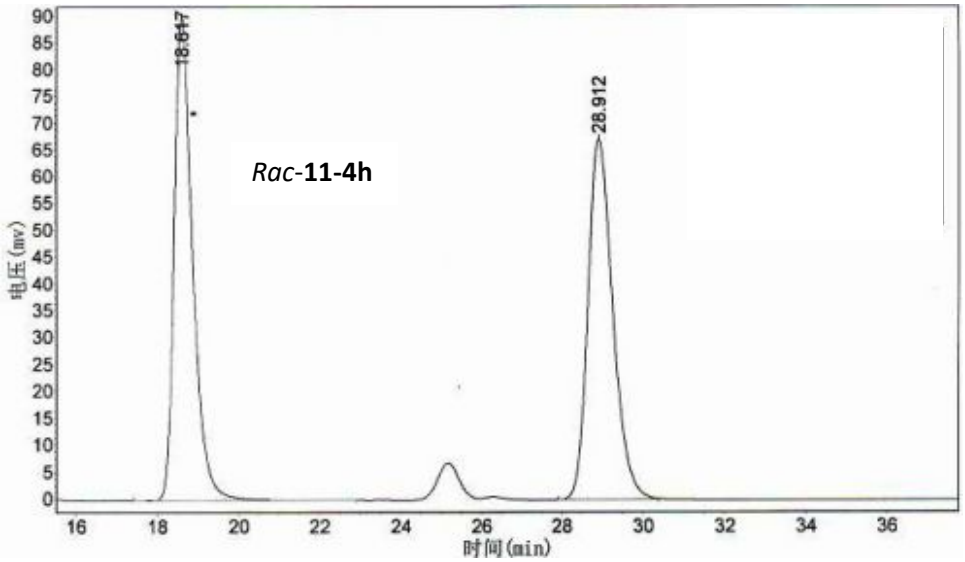



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 18.88 | 1133051 | 39.32 |
| 2 | 25.75 | 307977 | 10.69 |
| 3 | 30.64 | 300302 | 10.42 |
| 4 | 32.26 | 1140270 | 39.57 |

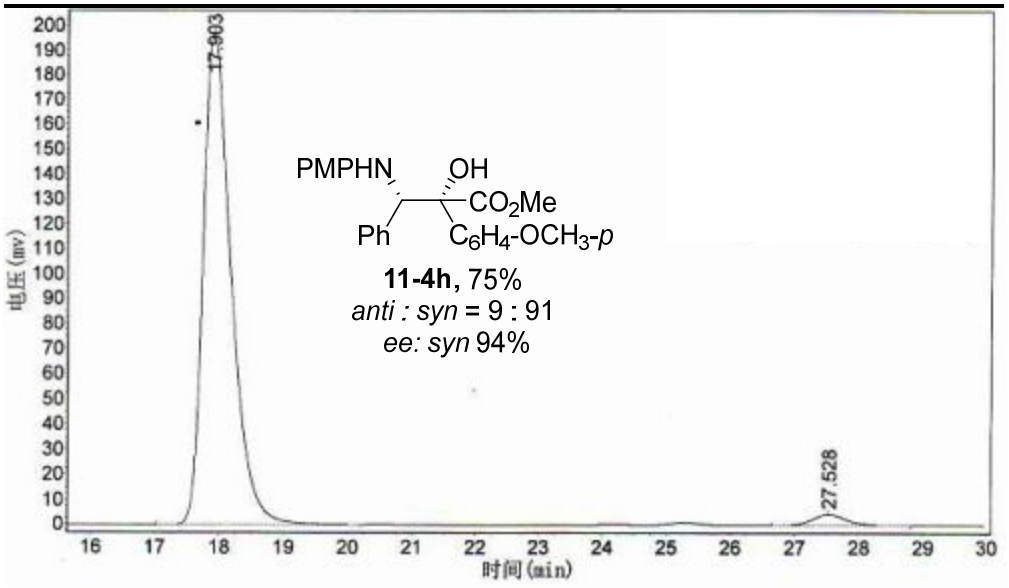



| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 18.91 | 3008016 | 96.85 |
| *Syn*-2 | 32.68 | 97824 | 3.15 |

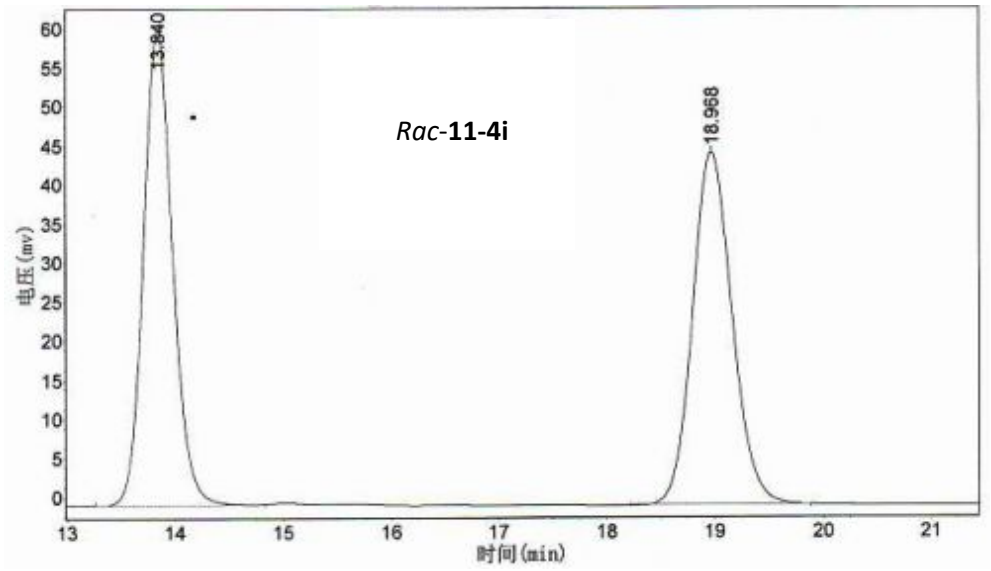
| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 25.95 | 156273 | 48.31 |
| *Anti*-2 | 30.69 | 145988 | 51.79 |



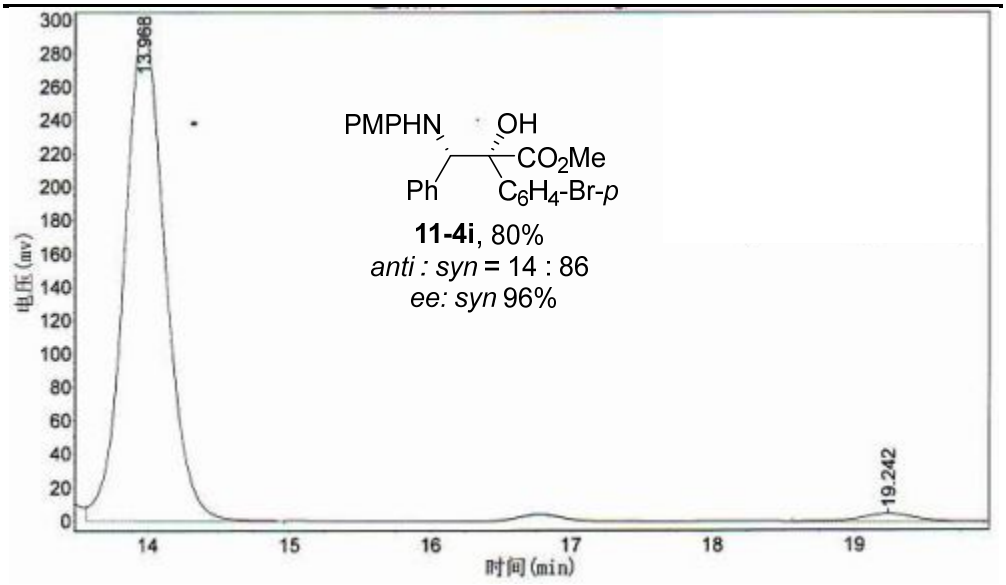

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 18.62 | 2821159 | 49.89 |
| 2 | 28.91 | 2833430 | 50.10 |



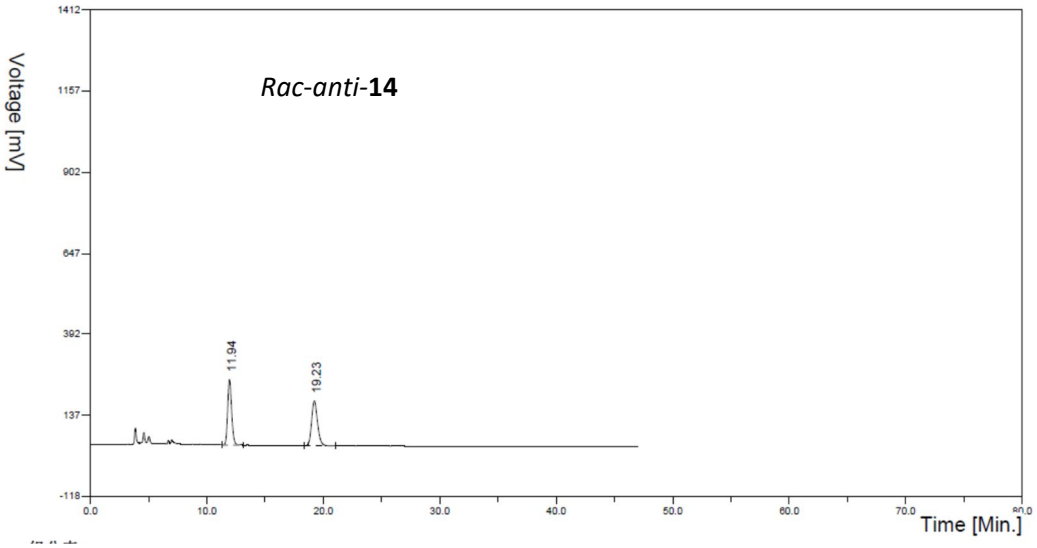

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 17.90 | 5923906 | 97.24 |
| 2 | 27.83 | 167846 | 2.76 |



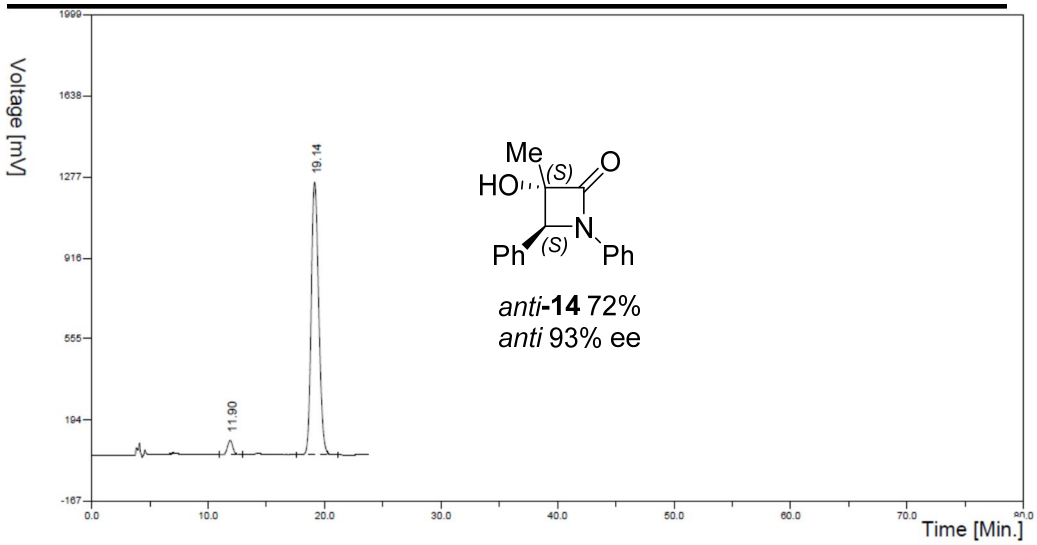

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 13.84 | 1136210 | 49.96 |
| 2 | 18.97 | 1137973 | 50.04 |



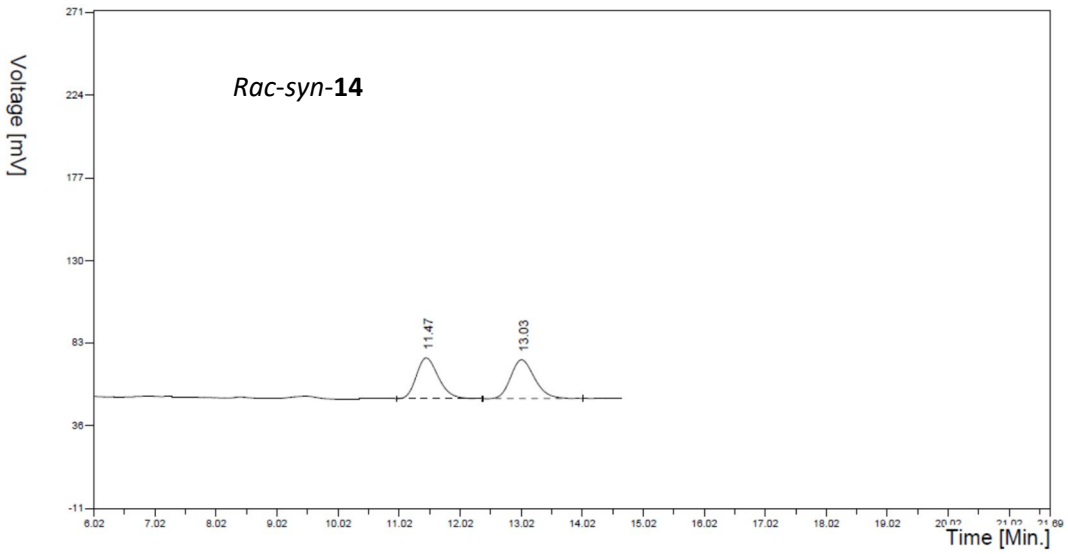

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 13.97 | 5958431 | 97.81 |
| 2 | 19.24 | 133644 | 2.19 |



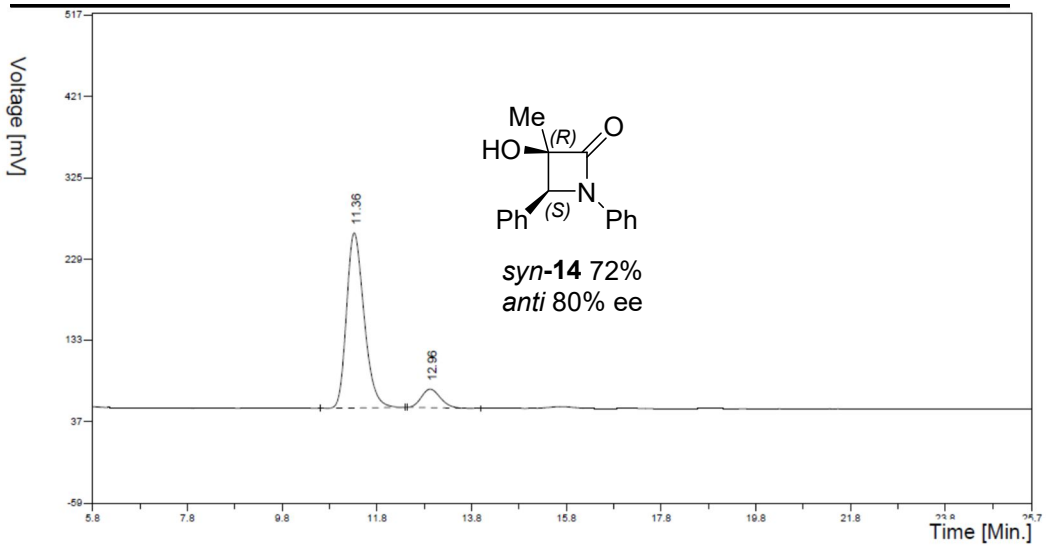

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 11.94 | 4875 | 49.87 |
| 2 | 19.23 | 4900 | 50.13 |



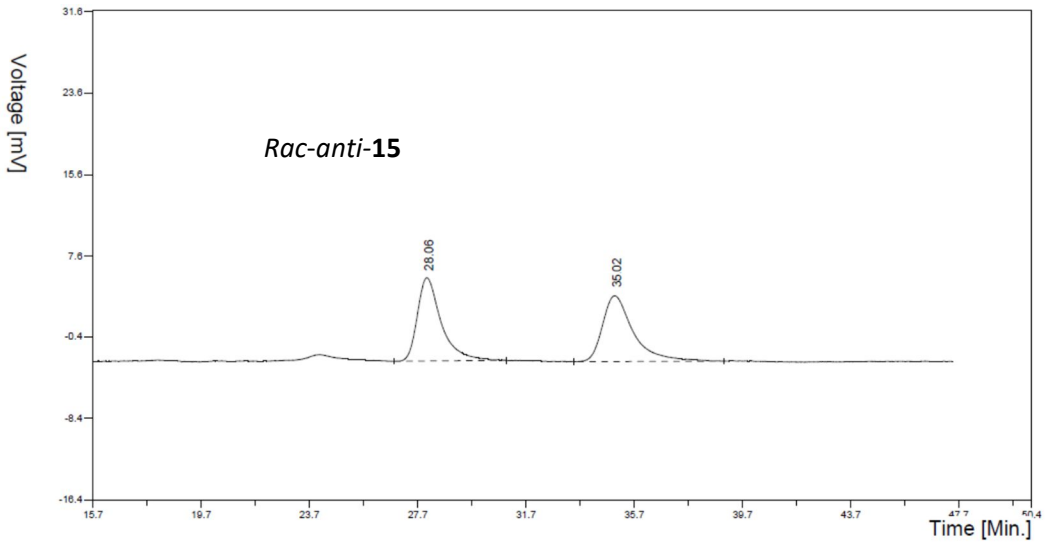

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 11.90 | 1961 | 3.49 |
| *Anti*-2 | 19.14 | 54233 | 96.51 |



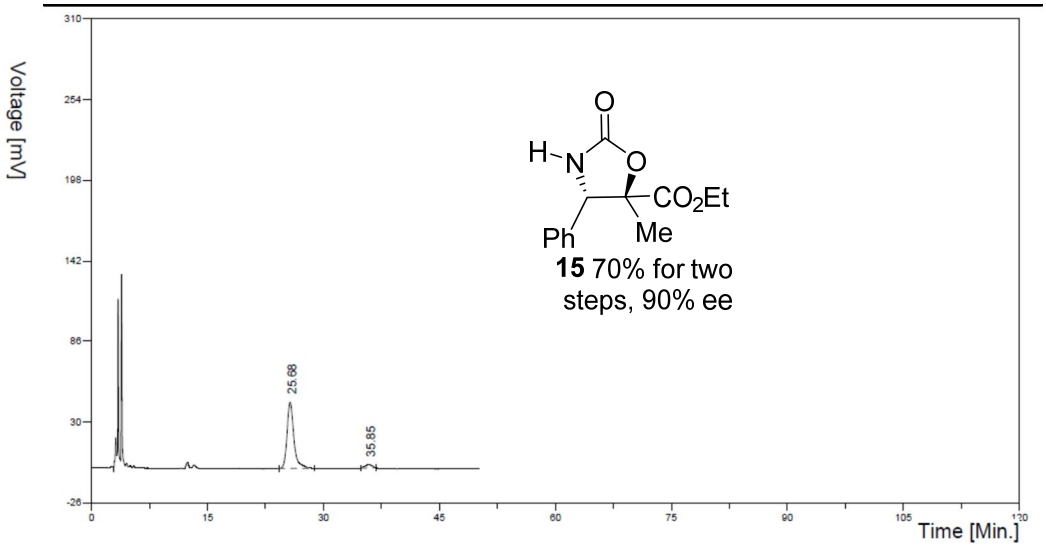

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 23.12 | 583 | 49.38 |
| 2 | 21.98 | 597 | 50.62 |



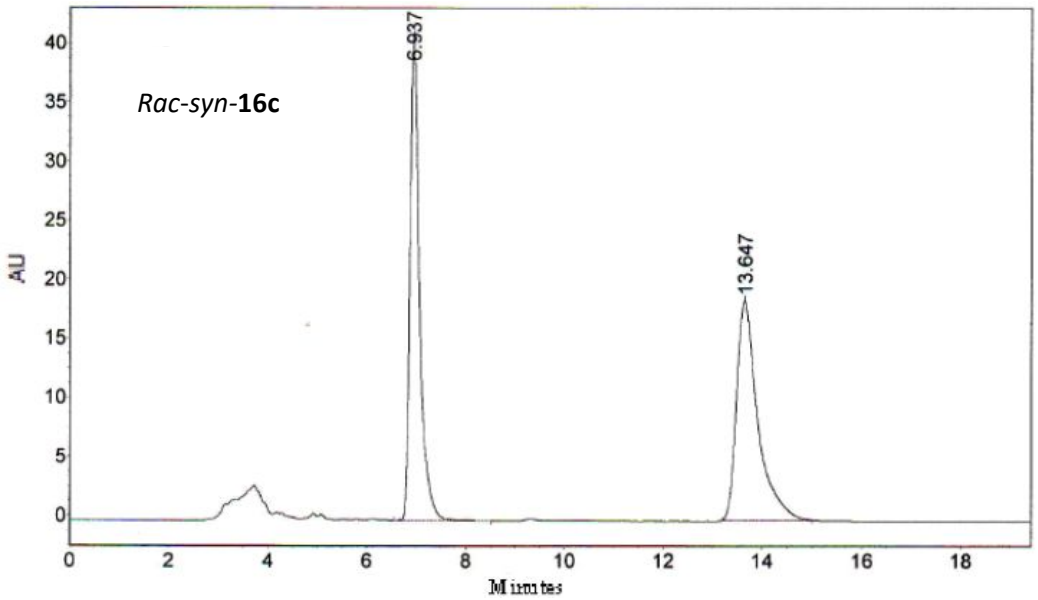

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Syn*-1 | 11.36 | 5315 | 89.83 |
| *Syn*-2 | 12.96 | 602 | 10.17 |



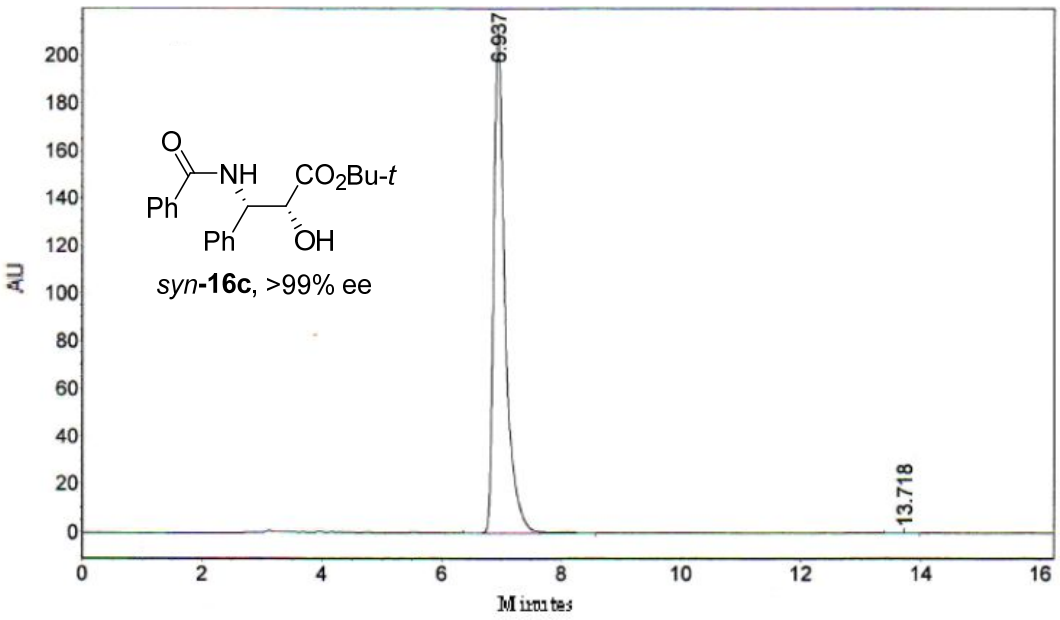

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 28.06 | 498 | 49.59 |
| 2 | 35.02 | 506 | 50.41 |



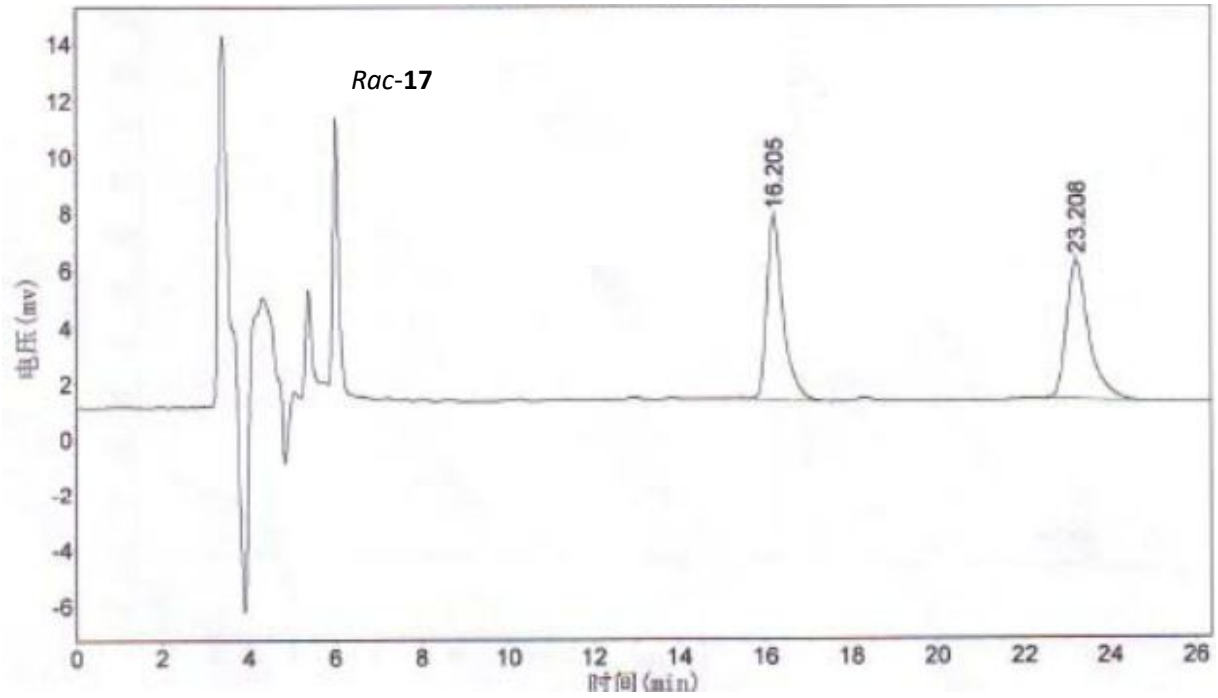

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 25.68 | 2787 | 95.06 |
| *Anti*-2 | 35.85 | 145 | 4.94 |



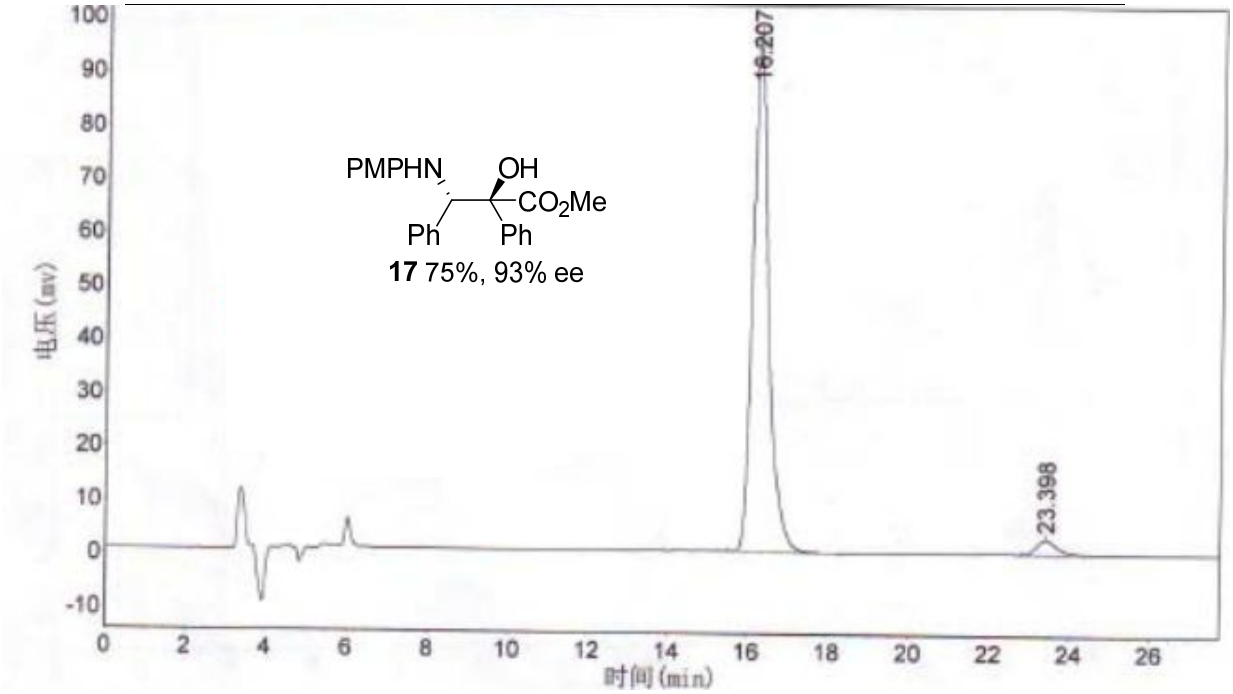

| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 6.94 | 543271 | 49.61 |
| *Anti*-2 | 13.65 | 551915 | 50.39 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| *Anti*-1 | 6.94 | 2810082 | 99.98 |
| *Anti*-2 | 13.72 | 457 | 0.02 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 16.21 | 169131 | 49.28 |
| 2 | 23.21 | 174050 | 50.72 |




| Peak NO. | Retention time (min) | Peak area (mV.sec) | Percentage of area (%) |
|---|---|---|---|
| 1 | 16.21 | 2625663 | 96.57 |
| 2 | 23.40 | 93185 | 3.43 |