

Supporting Information

Practical access to planar chiral 1,2-(α -ketotetramethylene)-ferrocene by non-enzymatic kinetic resolution and conclusive confirmation of its absolute configuration

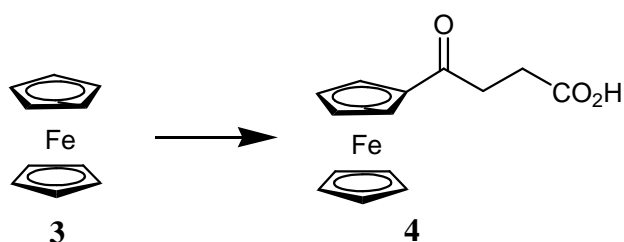
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General Information

All commercially obtained reagents and solvents were used without further purification. NMR spectra were recorded on Bruker 400 spectrometer. ^1H NMR, ^{13}C NMR spectra were measured at 400 MHz and 100 MHz in CDCl_3 . Data for ^1H NMR spectra are reported as follows: chemical shift (ppm, referenced to TMS; s = singlet, d = doublet, t = triplet, dd = doublet of doublets, dt = doublet of triplets, m = multiplet), coupling constant (Hz), and integration. Data for ^{13}C NMR are reported in terms of chemical shift (ppm) relative to residual solvent peak (CDCl_3 : 77.0 ppm) with complete proton decoupling. High performance liquid chromatography (HPLC) was performed on an Agilent 1260 series using Daicel Chiralpak OD-H column. Optical rotations were obtained on a Perkin-Elmer 343 polarimeter. In one case the alcohol and ketone were purified by flash chromatography using a Biotage Isolera One instrument, fitted with a UV-vis detector and running the Spektra package employing hexane (**A**) and EtOAc (**B**) as elution solvents on a silica gel column.

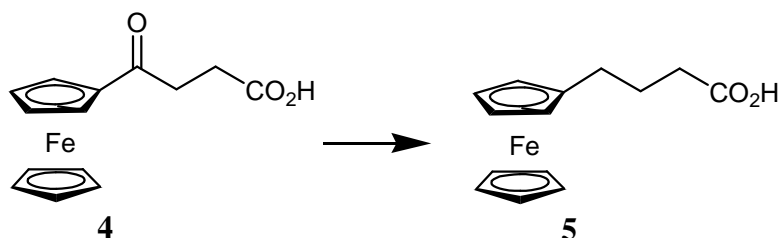
Ferrocenyl Ketocarboxylic Acid (**4**):



An oven-dried two-necked round-bottom flask was flushed with argon. AlCl_3 (22.68 g, 170.1 mmol) and CH_2Cl_2 (100 mL) were added. Ferrocene **3** (20 g, 107.5 mmol) in CH_2Cl_2 (100 mL) was then added dropwise via a cannula. The solution turned dark brown. After addition, succinic anhydride (9.7 g, 97.74 mmol) was added under positive argon pressure. The mixture was stirred at room temperature overnight. The reaction flask was cooled with an ice bath. Ice water (300 mL) was added to the mixture slowly over about 10 min. The mixture was transferred to a separation

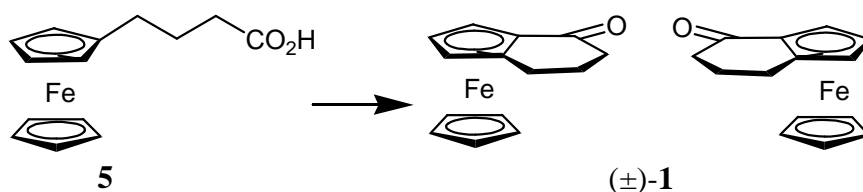
funnel. The organic and aqueous phases were separated. The organic phase was washed with water (150 mL×3), dried over anhydrous Na₂SO₄, and filtered. Solvents removed under reduced pressure. The residue was purified with flash column chromatography (SiO₂, EtOAc/PE =3/1) to give **4** as a red solid (14.81g,53%). ¹H NMR (400 MHz, CDCl₃): δ 4.84 (t, *J* = 1.9 Hz, 2H), 4.54 (t, *J* = 1.9 Hz, 2H), 4.26 (s, 5H), 3.11 (t, *J* = 6.4 Hz, 2H), 2.78 (t, *J* = 6.5 Hz, 2H).

Ferrocenyl Carboxylic Acid (**5**):



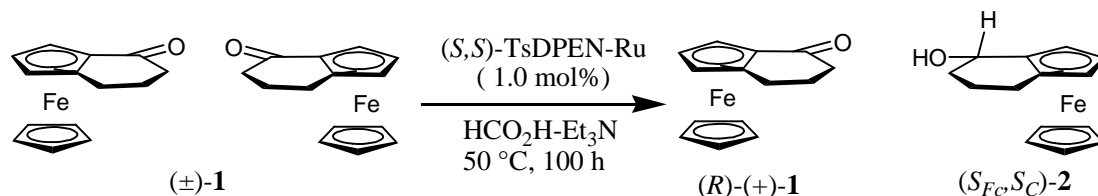
An oven-dried two-necked round -bottom flask containing was flushed with argon. Ferrocenyl ketocarboxylic acid **4** (10 g, 34.96 mmol) and trifluoroacetic acid (27.88 mL, 374.1 mmol) were added. Triethylsilane(13.93 mL, 87.4 mmol) was added dropwise at 50 ° C. The mixture was stirred overnight. TLC analysis showed the substrate was totally consumed. The reaction flask was cooled with an ice bath. Ice water (150 mL) was added to the mixture slowly. The mixture was transferred to a separation funnel. The organic and aqueous phases were separated. The organic phase was washed with water (100 mL×3), dried over anhydrous Na₂SO₄, and filtered. Solvents removed under reduced pressure. The residue was purified by flash column chromatography (SiO₂, EtOAc/PE=1/10) to give **5** as a dark green solid (7.6 g, 80%). ¹H NMR (400 MHz, CDCl₃): δ 4.13 (s, 5H), 4.10 – 4.07 (s, 4H), 2.42 (t, *J* = 7.5 Hz, 4H), 1.89 (m, *J* = 7.5 Hz, 2H).

Racemic 1,2-(α-ketotetramethylene)-ferrocene [(±)-**1**]:



An oven-dried two-necked round-bottom flask was charged with ferrocenyl carboxylic acid **5** (9.20 g, 33.8 mmol) and CCl₄ (150 mL). The solution was bubbled with argon for 10 min. After the solution was cooled to 0 °C, trifluoroacetic anhydride (19.32 mL, 137 mmol) was added *via* a syringe. The mixture was stirred on an ice bath and warmed to room temperature gradually. TLC analysis indicated that the reaction was complete in 3 h. The mixture was transferred into a separation funnel, and 10% NaOH (300 mL) and CH₂Cl₂ (250 mL) were added. The organic phase was separated and washed with brine (150 mL×3), dried over anhydrous Na₂SO₄ and filtered. Volatiles were removed under reduced pressure. The residue was purified by flash column chromatography (SiO₂, EtOAc/PE=1/10) to give (±)-**1** as a red solid (5.46 g, 63%). ¹H NMR (400 MHz, CDCl₃): δ 4.84 (dd, *J* = 2.6, 1.3 Hz, 1H), 4.48 (dt, *J* = 6.6, 2.4 Hz, 2H), 4.20 (d, *J* = 1.1 Hz, 5H), 2.71 – 2.62 (m, 2H), 2.44 (ddd, *J* = 15.1, 10.9, 4.5 Hz, 1H), 2.31 (tt, *J* = 11.4, 3.8 Hz, 1H), 2.25 – 2.10 (m, 2H); ¹³C NMR (101 MHz, CDCl₃): δ 204.9, 92.5, 72.4, 70.6, 70.3, 70.2, 65.2, 39.2, 24.1, 23.8.

General procedure for kinetic resolution of 1,2-(α -ketotetramethylene)-ferrocene:



An oven-dried Schlenk tube was charged with (±)-**1** (0.5 g, 1.97 mmol) and (S,S)-TsDPEN-RuCl(*p*-cymene) (12.5 mg, 19.7 μmol) under argon. A degassed mixture of triethylamine and formic acid with desired ratio (10 mL, corresponding to the molar ratio indicated in Table 1) was then added. The mixture was stirred at 50 °C, and a degassed mixture of triethylamine and formic acid with desired ratio (5 mL, corresponding to the molar ratio indicated in Table 1) was added in intervals of 24 h. After 100 h, the mixture was transferred to a separating funnel and partitioned with iced water and CH₂Cl₂. The organic phase was separated, washed with water, and dried over anhydrous Na₂SO₄. Volatiles were removed under reduced pressure. The residue was purified by flash column chromatography (SiO₂, EtOAc/PE=1/30) to give

(*R*)-(+)-**1** as red crystals and (*S*_{FC},*S*_C)-**2** as a yellow oil.

(*R*)-(+)-**1**: 99% *ee*, $[\alpha]_{\text{D}}^{25} = +638$ (*c* 0.1, EtOH) (lit $[\alpha]_{\text{D}} = +585^1$ (*c* 0.12, EtOH), $+550^2$ (*c* 0.3, CHCl₃), $+668^3$ (*c* 0.72, CHCl₃)); NMR spectra are identical with (±)-**1**.

(*S*_{FC},*S*_C)-**2**: 81% *ee*, $[\alpha]_{\text{D}}^{25} = -37.0$ (*c* 1, EtOH) (lit $[\alpha]_{\text{D}}^{20} = -30.7^4$ (*c* 0.81, EtOH) (71% *ee*)); ¹H NMR (400 MHz, CDCl₃): δ 4.20 (s, 6H), 4.17 – 4.13 (m, 1H), 4.10 (d, *J* = 2.5 Hz, 1H), 2.57 (ddd, *J* = 15.1, 7.7, 5.2 Hz, 1H), 2.25 (dt, *J* = 15.4, 5.9 Hz, 1H), 2.15 (d, *J* = 8.1 Hz, 1H), 2.01 – 1.80 (m, 3H), 1.57 (dt, *J* = 12.8, 5.9 Hz, 1H), 1.39 – 1.23 (m, 1H); ¹³C NMR (101 MHz, CDCl₃): δ 92.6, 87.6, 68.9, 66.2, 66.1, 64.1, 63.5, 33.7, 24.5, 20.5.

KR of (±)-**1,2**-(*α*-ketotetramethylene)-ferrocene at 10 grams scale:

An oven-dried 500 mL Schlenk tube was charged with (±)-**1** (10.00 g, 37.3 mmol) and (*S,S*)-TsDPEN-RuCl(*p*-cymene) (250 mg, 39.3 mmol) under argon. A degassed azeotropic mixture of formic acid and triethylamine (5:2) (40 ml) was then added. The mixture was stirred at 50 ° C, and a degassed azeotropic mixture of formic acid and triethylamine (5:2) (20 mL) was added in an interval of 24 h. The reaction was monitored by HPLC analysis using Daicel Chiralpak OD-H column (Daicel Chiralpak OD-H column, 93:7 Hex/*i*PrOH, 1 mL/min) until the >99% *ee* of (*R*)-(+)-**1** was achieved (95 h). The mixture was transferred to a separating funnel and partitioned with iced water (300 mL) and CH₂Cl₂ (200 mL). The organic phase was separated, washed with water (2×200 mL and brine (100 mL), and dried over anhydrous Na₂SO₄. Volatiles were removed under reduced pressure. The residue was purified by flash column chromatography (SiO₂, 200g, Φ = 5 cm, EtOAc/PE=1/30) to give (*S*_{FC},*S*_C)-**2** (5.31 g, 53%) [*R*_f = 0.76 (EtOAc/PE=1/3)] as a yellow oil and (*R*)-(+)-**1** (4.03 g, 40%) [*R*_f = 0.58 (EtOAc/PE=1/3)] as a red crystals.

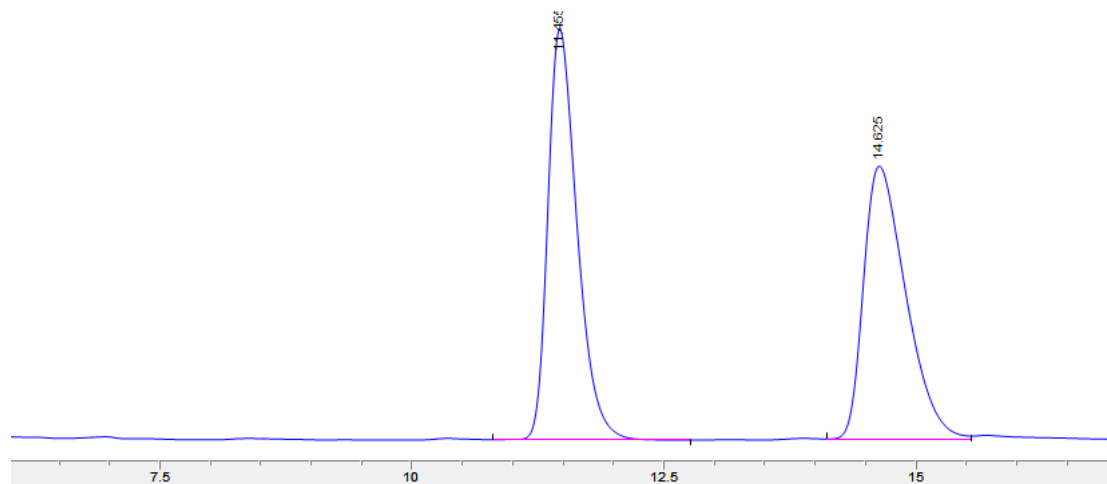
References

1. Schlögl, K.; Fried, M.; Falk, H. *Monatsh. Chem.* 1964, 95, 576.
2. Thomson, J. B. *Tetrahedron Lett.* 1959, 6, 26.
3. Kuehne, M. E.; Dai, W. N.; Li, Y. L. *J. Org. Chem.* 2001, 66, 1560.
4. Izumi, T.; Tamura, F.; Sasaki, K. *Bull. Chem. Soc. Jpn.* 1992, 65, 2784.

Chiral HPLC analysis:

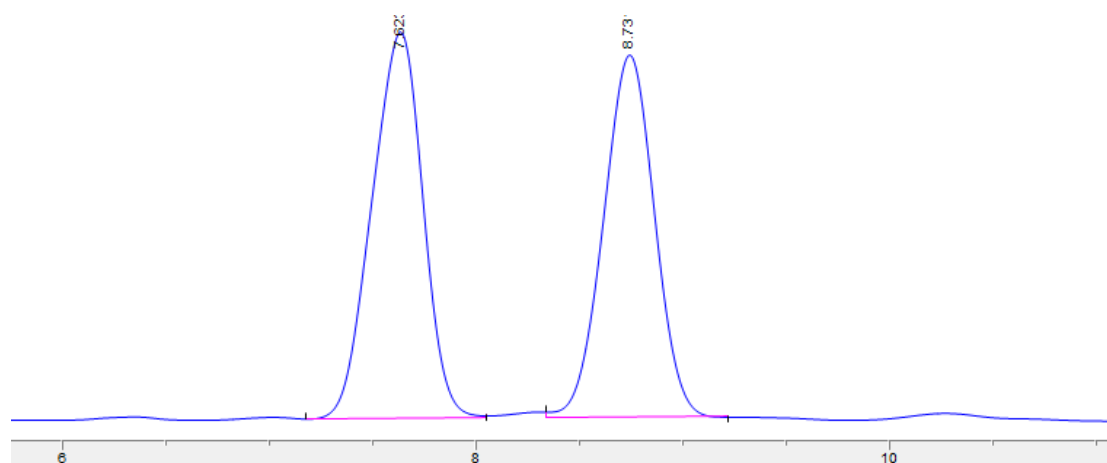
Conditions: Daicel Chiralpak OD-H column, Hexane/*i*-PrOH (93:7), 1 mL/min, 254 nm. Conversion was established by NMR.

Racemic 1,2-(α -ketotetramethylene)-ferrocene:



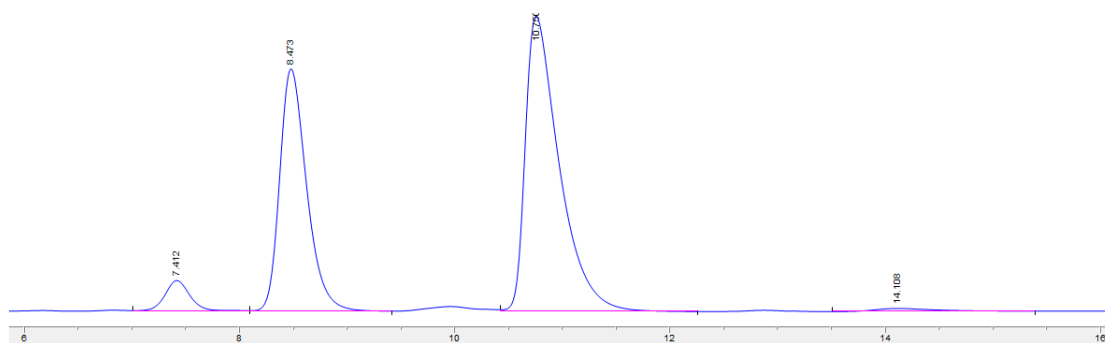
<i>NO.</i>	<i>Ret.Time</i> <i>min</i>	<i>Area</i> <i>mAU*min</i>	<i>Hight</i> <i>mAU</i>	<i>Width</i>	<i>Sym.factor</i>	<i>Rel.Area</i> <i>%</i>
1	11.455	14066.6	696.9	0.3095	0.644	50.808
2	14.625	13619.1	464.5	0.45	0.557	49.192

Racemic 1,2-(α -hydroxytetramethylene)-ferrocene:



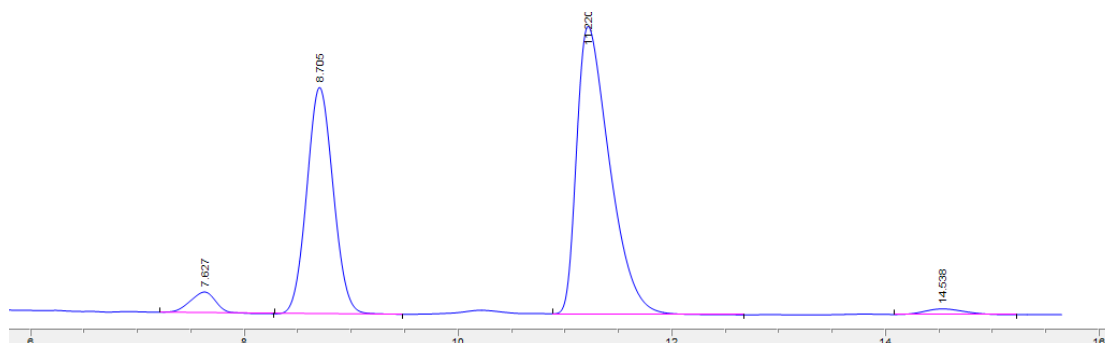
<i>NO.</i>	<i>Ret.Time</i> <i>min</i>	<i>Area</i> <i>mAU*min</i>	<i>Hight</i> <i>mAU</i>	<i>Width</i>	<i>Sym.factor</i>	<i>Rel.Area</i> <i>%</i>
1	7.623	11181.1	651.1	0.2793	1.226	51.542
2	8.731	10512.3	610.7	0.2678	1.033	48.458

HCOOH-NEt₃ (4:1) as hydrogen donor:



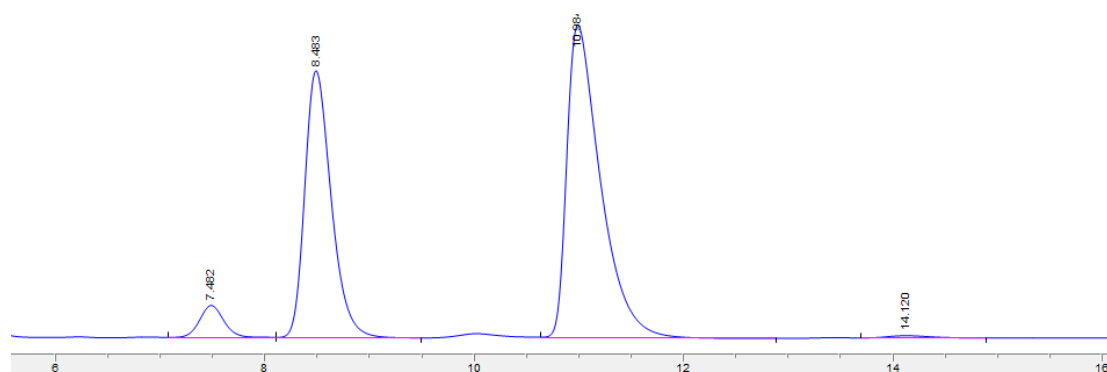
<i>NO.</i>	<i>Ret.Time</i> <i>min</i>	<i>Area</i> <i>mAU*min</i>	<i>Hight</i> <i>mAU</i>	<i>Width</i>	<i>Sym.factor</i>	<i>Rel.Area</i> <i>%</i>
1	7.412	3176.8	192	0.249	0.86	4.479
2	8.473	26457.6	1518.8	0.2662	0.685	37.3
3	10.75	40547.5	1852.2	0.3254	0.438	57.164
4	14.108	750	18.8	0.5826	0.529	1.057

HCOOH-NEt₃ (3:1) as hydrogen donor:



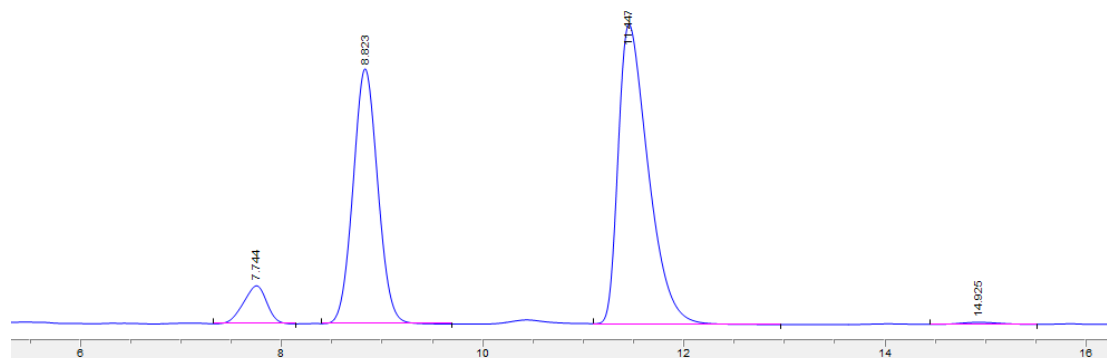
<i>NO.</i>	<i>Ret.Time</i> <i>min</i>	<i>Area</i> <i>mAU*min</i>	<i>Hight</i> <i>mAU</i>	<i>Width</i>	<i>Sym.factor</i>	<i>Rel.Area</i> <i>%</i>
1	7.627	2372.2	139.5	0.2654	1.257	3.376
2	8.705	25829.7	1502	0.2676	0.901	36.758
3	11.22	41027.9	1910.8	0.3265	0.498	58.387
4	14.538	1039.2	38.8	0.4152	0.838	1.479

HCOOH-NEt₃ (5:2) as hydrogen donor:



NO.	Ret.Time min	Area mAU*min	Hight mAU	Width	Sym.factor	Rel.Area %
1	7.482	2862.8	172	0.2532	0.872	4.371
2	8.483	24983.5	1418.5	0.2705	0.694	38.148
3	10.984	37241.3	1662.7	0.3343	0.449	56.864
4	14.12	404.2	13.3	0.461	0.785	0.617

HCOOH-NEt₃ (2:1) as hydrogen donor:

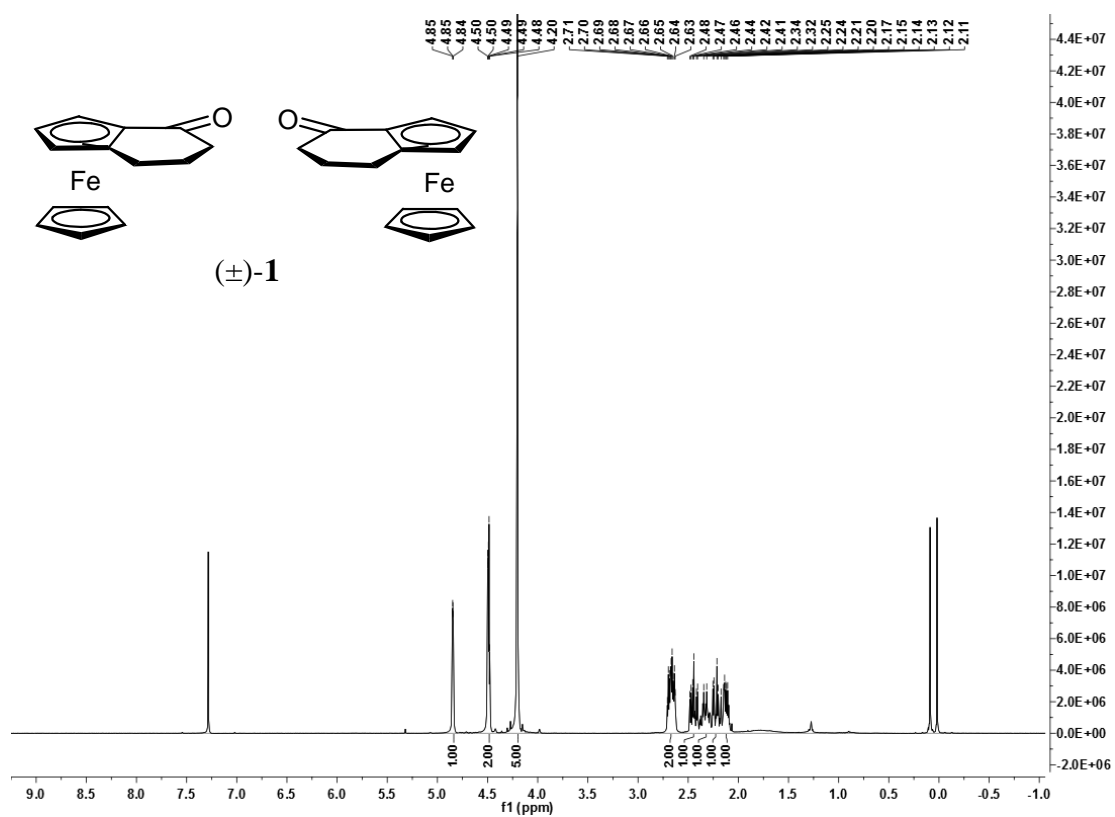
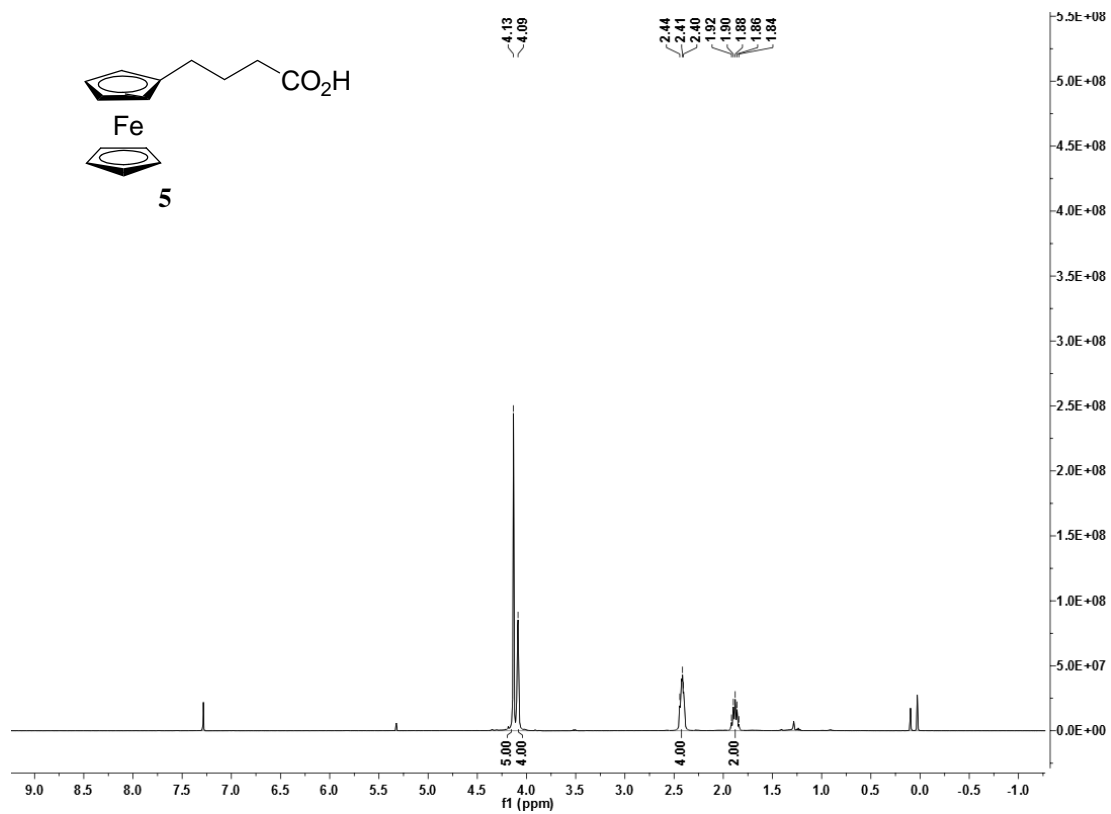


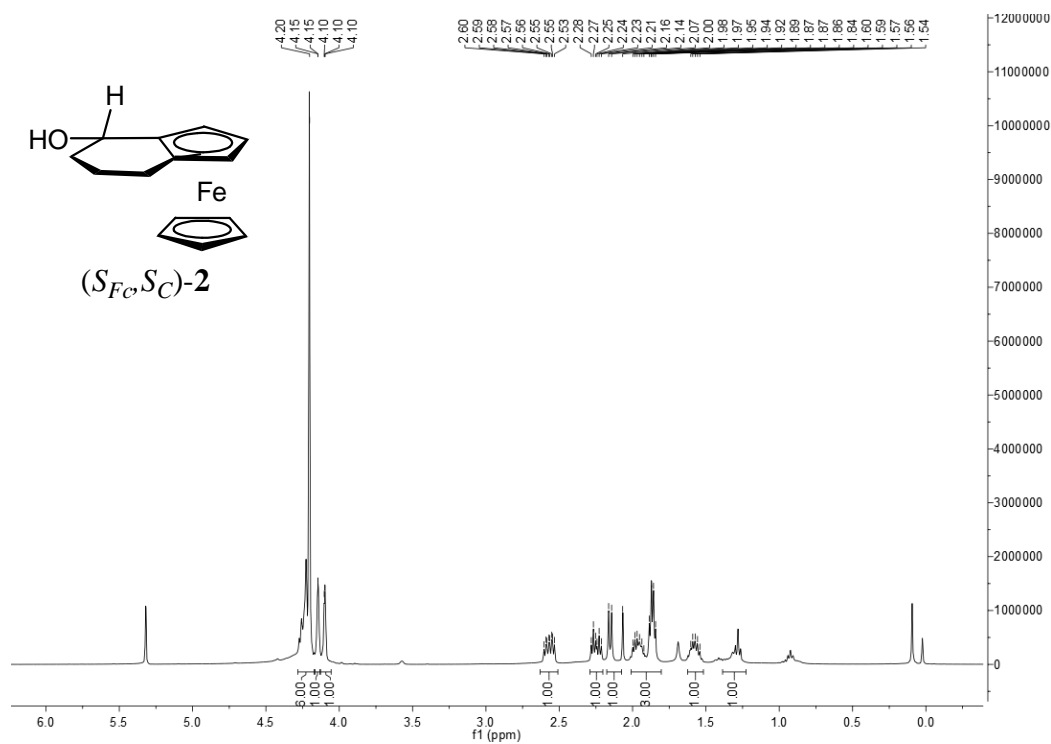
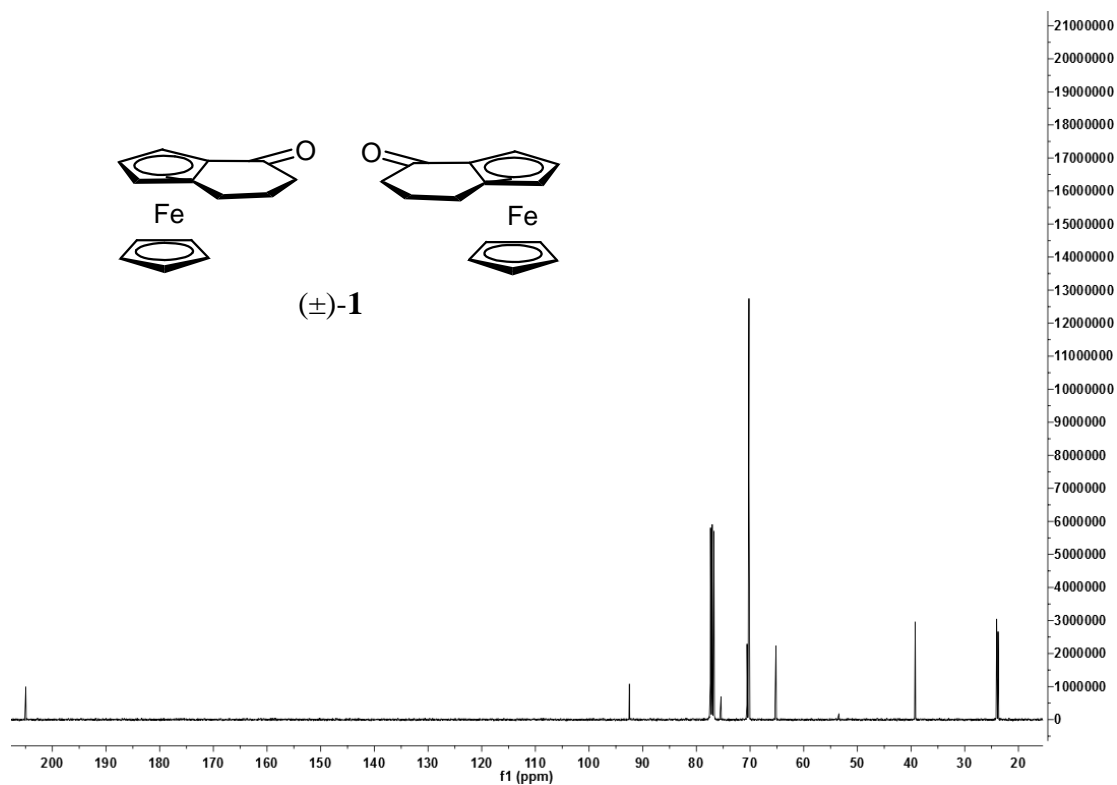
NO.	Ret.Time min	Area mAU*min	Hight mAU	Width	Sym.factor	Rel.Area %
1	7.744	3205.3	196.2	0.2496	1.256	5.524
2	8.823	22465.1	1313.7	0.2635	0.914	38.714
3	11.447	32030	1544.6	0.3169	0.524	55.197
4	14.925	328.4	11.3	0.4471	0.859	0.566

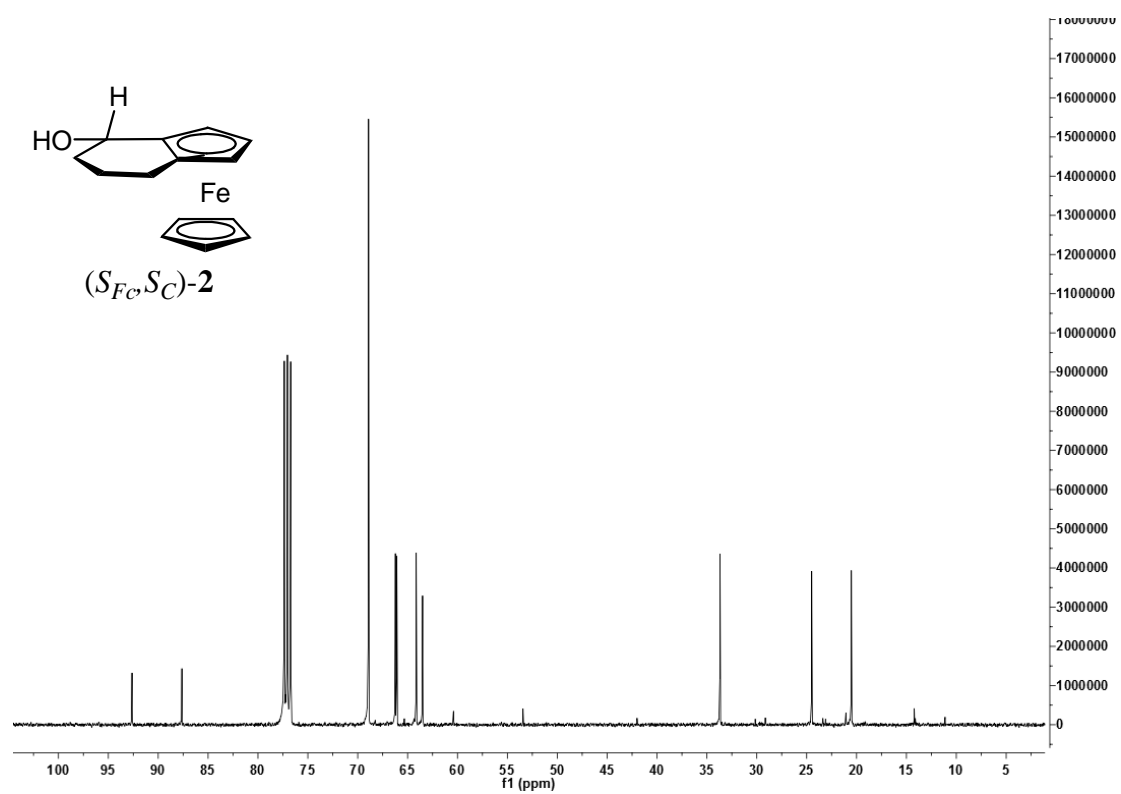
Mass spectrum of the sample showing relative intensity versus m/z . The base peak is at m/z 113.19. Other significant peaks are labeled at m/z 76.51, 87.44, and 147.82.

<i>NO.</i>	<i>Ret.Time</i> <i>min</i>	<i>Area</i> <i>mAU*min</i>	<i>Hight</i> <i>mAU</i>	<i>Width</i>	<i>Sym.factor</i>	<i>Rel.Area</i> %
1	7.651	3082	185.9	0.2524	1.295	5.156
2	8.744	231337	1357.1	0.2639	0.922	38.698
3	11.319	33346.7	1590.4	0.3196	0.521	55.782
4	14.782	218.1	7.8	0.436	0.905	0.365

Chemical structure of compound 4 is shown above the spectrum. The structure is a cyclopentadienylidene iron complex with a 3-oxopropyl substituent. The spectrum shows peaks corresponding to the protons in the molecule. The x-axis is labeled f1 (ppm) and ranges from -1.00 to 9.00. The y-axis represents intensity, ranging from -1.00E+07 to 1.80E+08. Integration values are provided for the main peaks: 2.00, 2.00, 2.00, 5.00, 2.00, and 2.00.

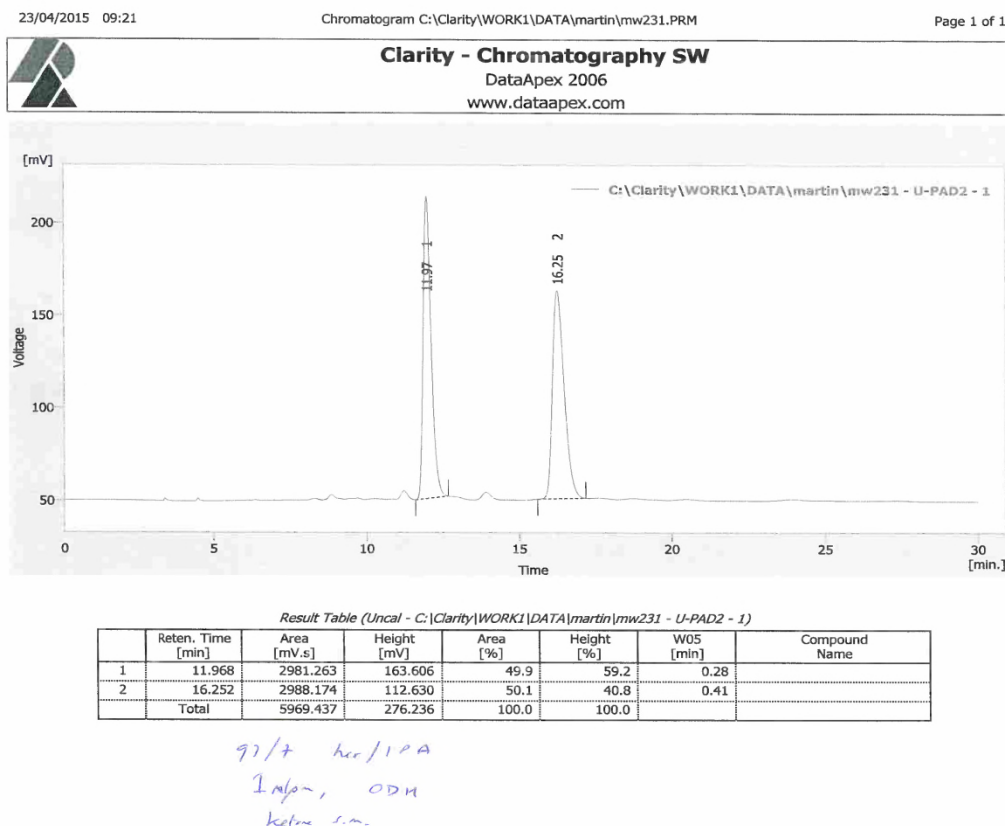




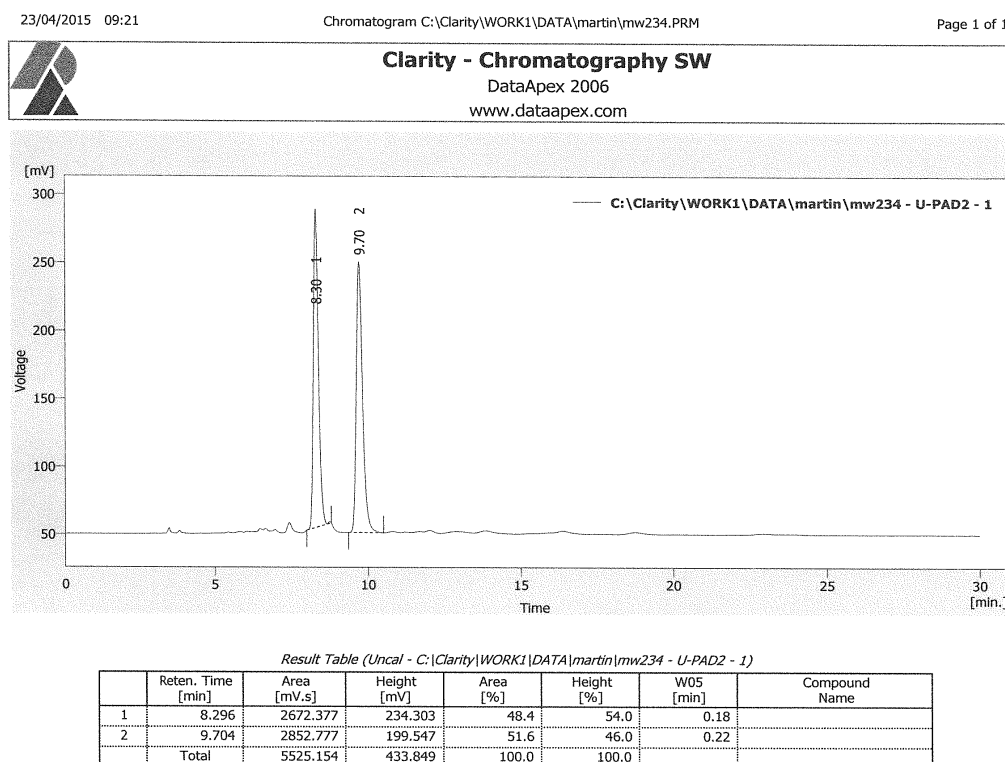


Reductions using tethered catalyst (*S,S*)-3.

HPLC of racemic ketone (ODH, 93:7 hexane:IPA, 1 mL/min, 30 °C). 254 nm.

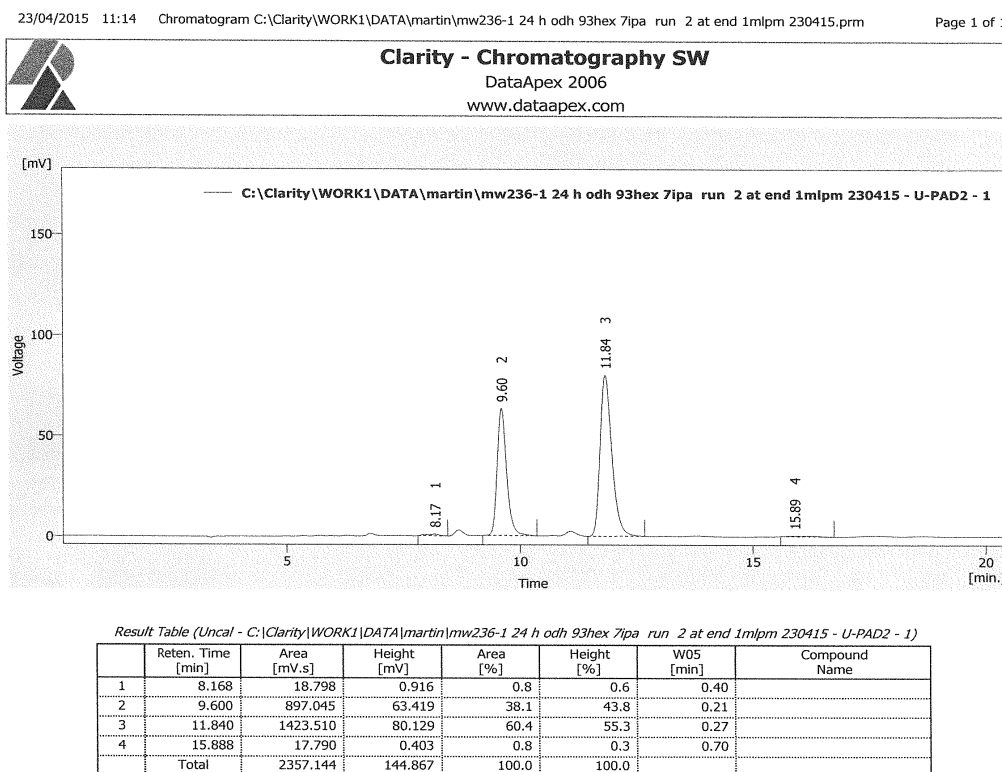


HPLC of racemic alcohol (ODH, 93:7 hexane:IPA, 1 mL/min, 30 °C). (sample prepared by reduction using sodium borohydride).



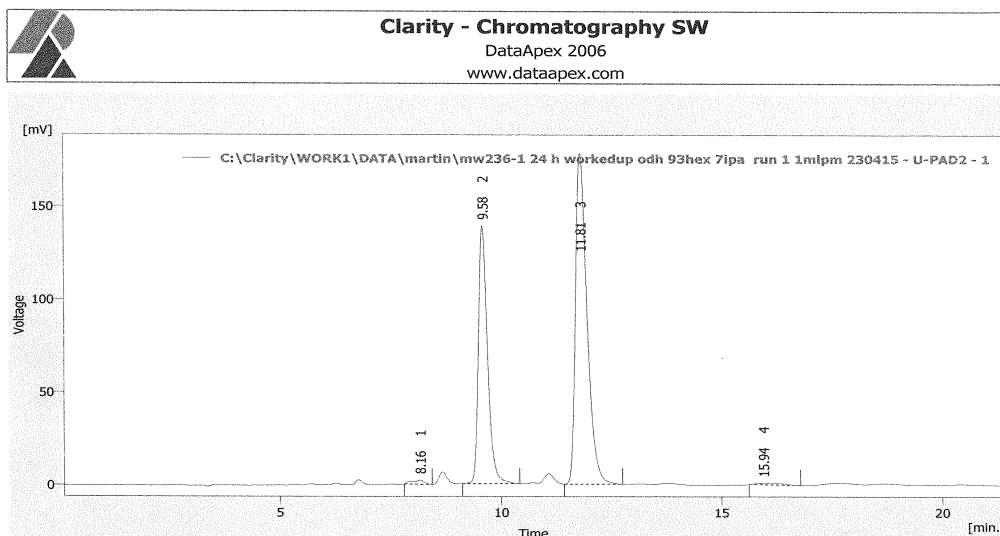
Initial asymmetric transfer hydrogenation using tethered catalyst (*S,S*)-**3**. The reduction was achieved following the procedure described above using (\pm)-**1** (51 mg, 0.20 mmol), (*S,S*)-**3** (2.4 mg, 4 μ mol, 2 mol%) and formic acid/trimethylamine (5:2, 0.2 mL), at 40 °C. After 20 h, the reaction was worked up as described in the procedure above. The residue was purified by flash column chromatography on a Biotage automated column (SiO₂ column, 100:0 – 60:40 hexane:EtOAc gradient) to give (*S_F*,*S_C*)-**2** (as a yellow oil and (*R*)-(+)-**1** (Rf 0.40 in 4/1 hexane/EtOAc on silica gel) as red crystals. Data matched that previously reported. (*R*)-(+)-**1**: 97% *ee*, $[\alpha]_D^{25} = +596$ (*c* 0.014, EtOH) (lit $[\alpha]_D = +585^1$ (*c* 0.12, EtOH), $+550^2$ (*c* 0.3, CHCl₃), $+668^3$ (*c* 0.72, CHCl₃)). The alcohol sample was used to create the isocyanate adduct used in the X-ray crystallographic structure determination. MW and THH thank Professor Peter Sadler and Dr Prinessa Chellan for use of the Biotage Instrument and for assistance with the separation.

HPLC of miniworkup product at end of reaction (Chiralcel ODH column 250 mmx 4.6 mm, 93:7 hexane:IPA, 1 mL/min, 30 °C, 254 nm uv detector):

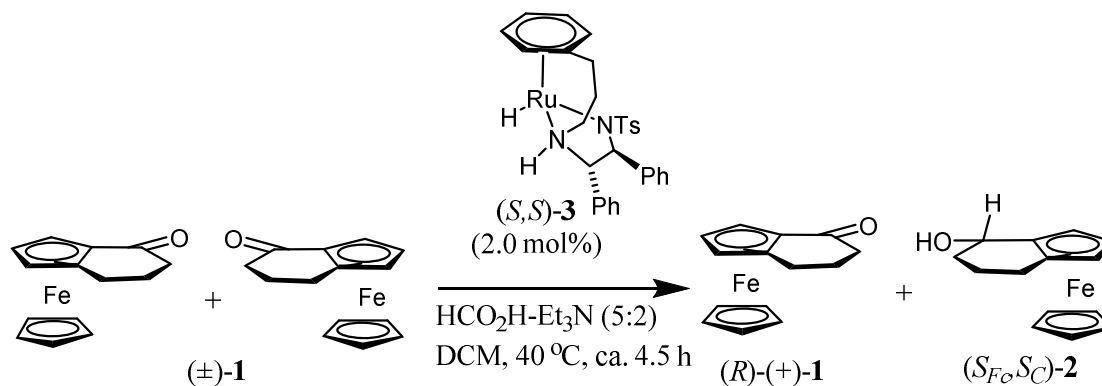


HPLC of full isolated product at end (ODH, 93:7 hexane:IPA, 1 mL/min, 30 °C) indicates ca. 50% conversion. Ee of ketone is 98%, ee of alcohol ca. 97%. The same major diastereoisomer of alcohol is assumed in each case but there may be a minor one in some cases. The highly selective reduction permitted the relative extinction coefficient at 254 nm to be established as ca 1.6:1.0 (ketone:alcohol).

23/04/2015 10:48 Chromatogram C:\Clarity\WORK1\DATA\martin\mw236-1 24 h workedup odh 93hex 7ipa run 1 1mlpm 230415.prm Page 1 of 1



Detailed example of Asymmetric transfer hydrogenation using tethered catalyst (*S,S*)-**3** with added DCM and chromatographic separation of the products.



Ketone (\pm)-**1** (225 mg, 0.886 mmol) was added to formic acid/triethylamine (5:2 azeotrope, 0.80 mL). DCM (ca. 0.50 mL) was added, followed after 10 min by (*S,S*)-**3** (11 mg, 18 μ mol, 2.0 mol%). The reaction was heated to 40 °C and samples were taken after 1h, 2h and 4h. A small sample (a small sample drawn into tip of a capillary), was partitioned between EtOAc (1 mL) and sat. aq.NaHCO₃ (1 mL). The upper EtOAc layer was removed, the solvent removed from this and the sample was taken up in ca 9:1 hexane:iPrOH for the HPLC analysis (EtOAc is not compatible with the OD-H column used in the analysis). After 4 h, HPLC indicated >98% ketone reduction without significant formation (<2%) of the minor alcohol enantiomer therefore the reaction was quenched and worked up at this point.* The reaction was diluted with EtOAc (20 mL) and washed with sat. aq.NaHCO₃ (3 x 30 mL), which serves to ionise the remaining formic acid (washed out with the aqueous phase) and neutralise the triethylamine salts. After drying with Na₂SO₄ and filtration, the solvent was removed under vacuum to give the crude product (triethylamine is removed under vacuum at this point but catalyst remains in the mixture). The residue was purified by manual flash column chromatography on silica gel (full details are given below) to give (*SFC,S_C*)-**2** (98 mg, 44%, R_f 0.70 in 9/1 pentane/EtOAc on silica gel, 97.6% ee) as a yellow oil and (*R*)-(+)-**1** (105 mg, 47%, R_f 0.45 in 9/1 pentane/EtOAc on silica gel, 98.4% ee) as a red solid.

* The final sample for HPLC analysis was taken at 4.0 h and the reaction was worked up after the HPLC result was obtained. However since the last HPLC required ca 30 min to be run, the true reaction time can be taken to be ca. 4.5h.

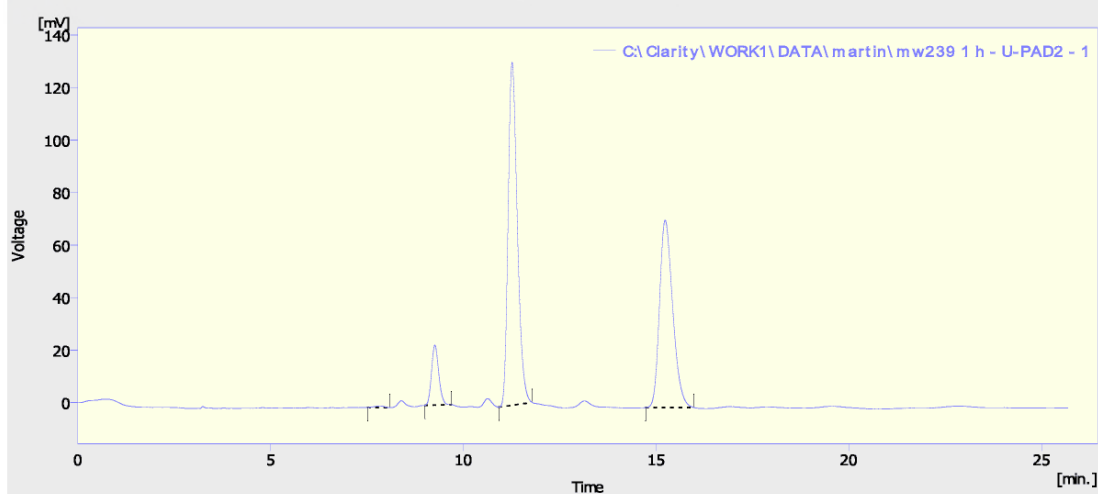
HPLC; (Chiralcel ODH column, 4/6 x 250 mm, 93:7 hexane:IPA, 1 mL/min, 30 °C, uv 254 nm detector). The conversion was calculated using the corrected response factors and the ees directly from the data.

Sample taken after 1h (conversion 11.2%, alcohol 94.5% ee, ketone 11.9% ee):



Clarity - Chromatography SW

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Result Table (Uncal - C:\Clarity\WORK1\DATA\martin\mw239 1 h - U-PAD2 - 1)

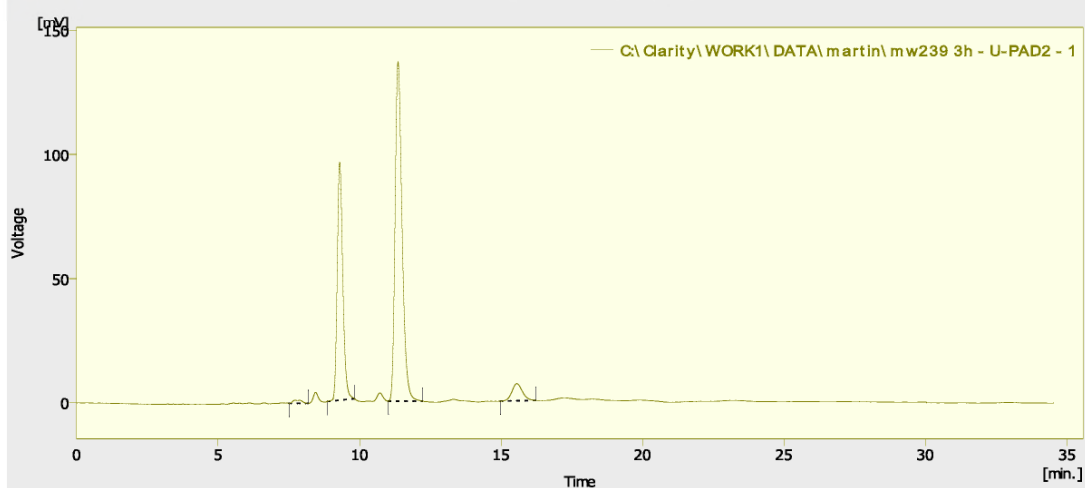
	Reten. Time [min]	Area [mV.s]	Height [mV]	Area [%]	Height [%]	W05 [min]	Compound Name
1	7.840	10.200	0.585	0.2	0.3	0.30	
2	9.260	296.947	22.831	7.1	10.1	0.21	
3	11.264	2160.408	130.637	51.8	57.9	0.26	
4	15.236	1699.547	71.402	40.8	31.7	0.37	
Total		4167.103	225.455	100.0	100.0		

Sample taken after 3h (conversion 45.7%, alcohol 93.2% ee, ketone 85.6% ee):



Clarity - Chromatography SW

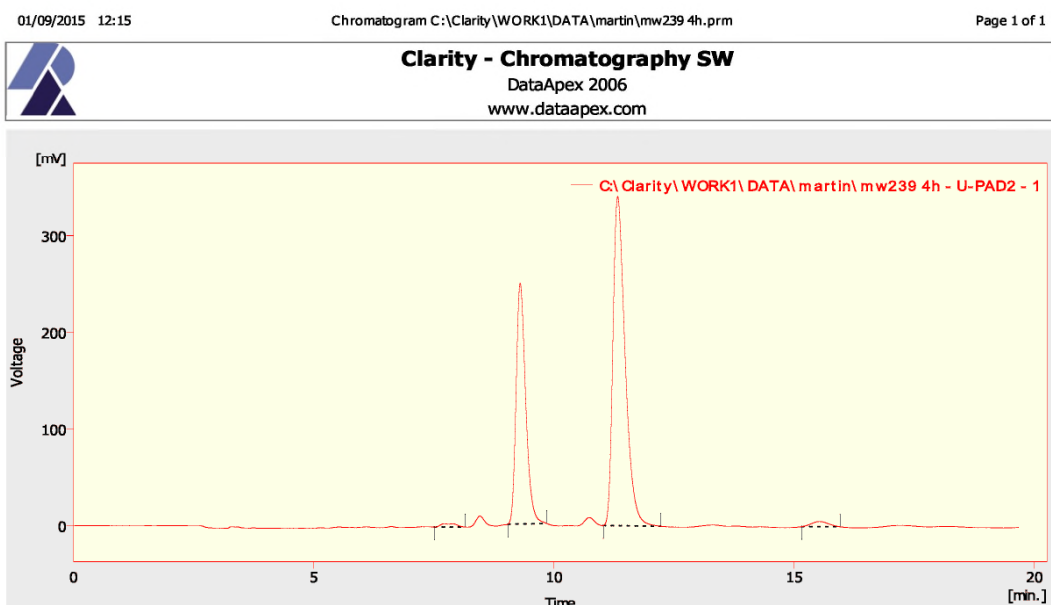
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Result Table (Uncal - C:\Clarity\WORK1\DATA\martin\mw239 3h - U-PAD2 - 1)

	Reten. Time [min]	Area [mV.s]	Height [mV]	Area [%]	Height [%]	W05 [min]	Compound Name
1	7.720	27.188	1.225	0.7	0.5	0.37	
2	9.300	1303.366	95.770	33.8	39.8	0.21	
3	11.360	2343.768	136.693	60.8	56.8	0.26	
4	15.564	179.284	6.913	4.7	2.9	0.40	
Total		3853.607	240.600	100.0	100.0		

Sample taken after 4h (conversion 48.0%, alcohol 95.6% ee, ketone 95.6% ee):

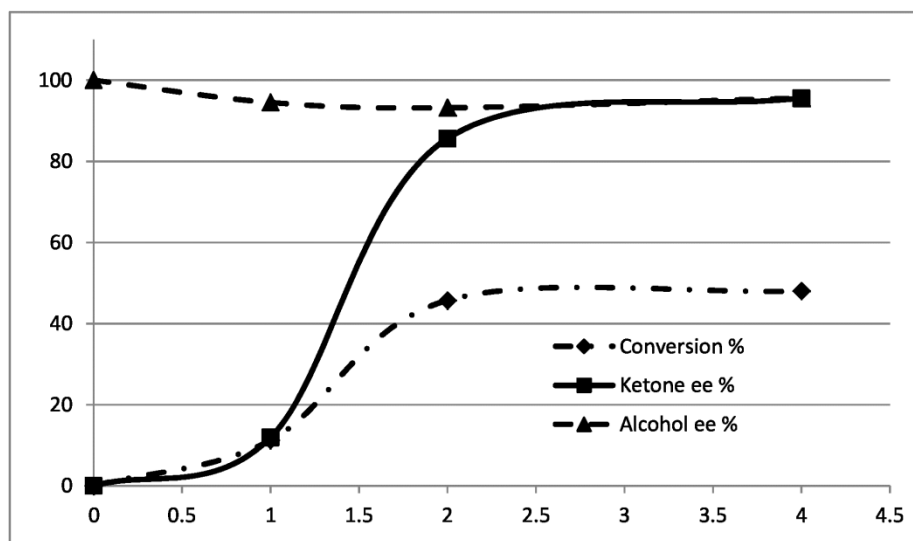


Result Table (Uncal - C:\Clarity\WORK1\DATA\martin\mw239 4h - U-PAD2 - 1)

	Reten. Time [min]	Area [mV.s]	Height [mV]	Area [%]	Height [%]	W05 [min]	Compound Name
1	7.712	76.866	3.462	0.8	0.6	0.38	
2	9.296	3439.461	248.814	35.6	41.6	0.22	
3	11.324	6006.916	340.404	62.2	56.9	0.27	
4	15.524	130.973	5.393	1.4	0.9	0.40	
Total		9654.216	598.074	100.0	100.0		

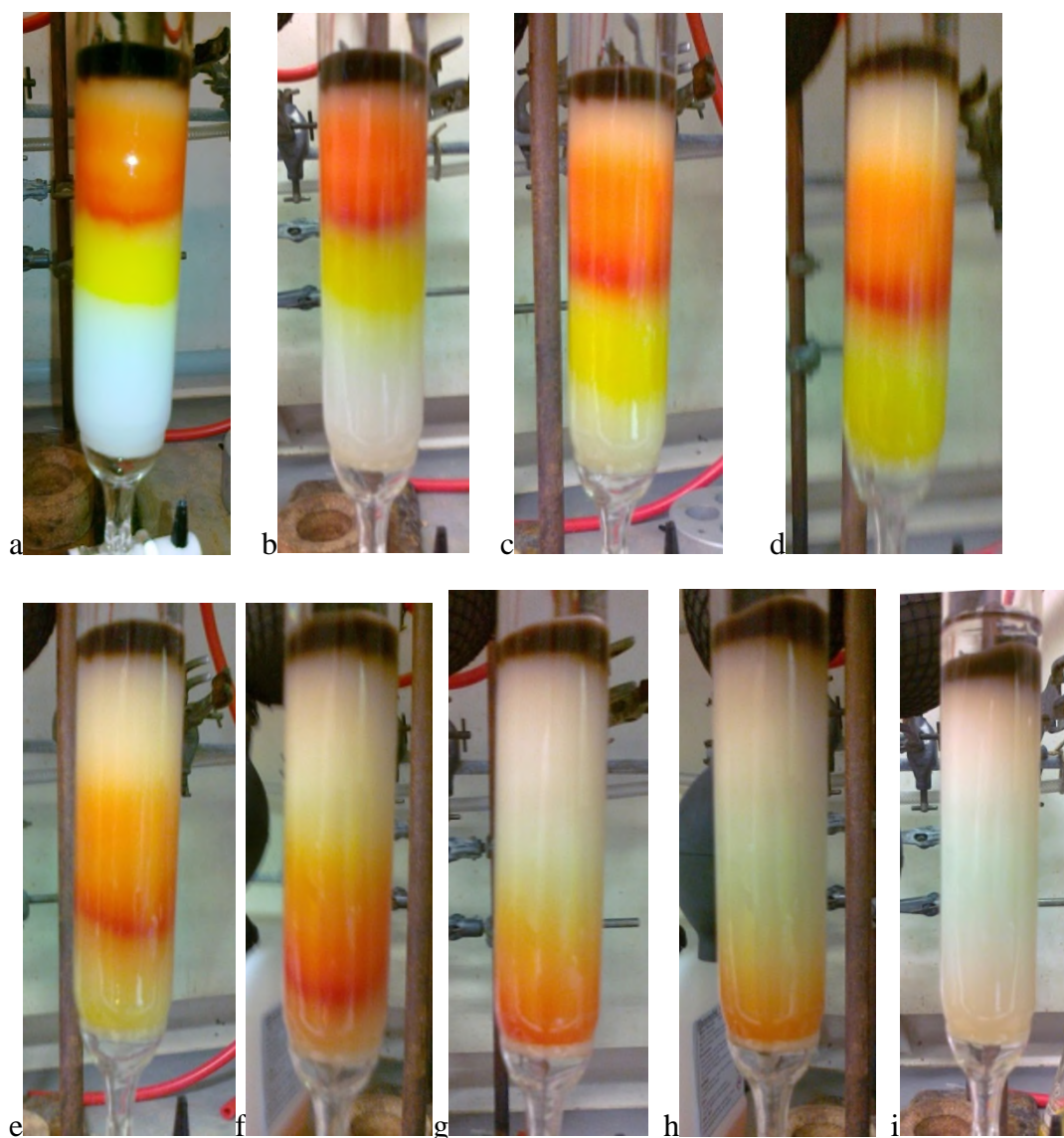
Graphical illustration of conversion:

time /h	Conv /%	ketone ee /%	alcohol ee /%
0	0	0	100
1	11.2	11.9	94.5
2	45.7	85.6	93.2
4	48	95.6	95.6



Notes: The use of a small amount of DCM appears to reduce the reaction time, probably due to improved solubility (previously observed for reaction followed over time). The combination of pentane/EtOAc gives improved resolution by TLC and is efficient in column separation (see below).

Column separation is illustrated below:



Column prepared in pentane and run with pentane:EtOAc as a gradient.

Mass/dimensions of silica: ca. 33g 25 mm diameter, 135 mm height.

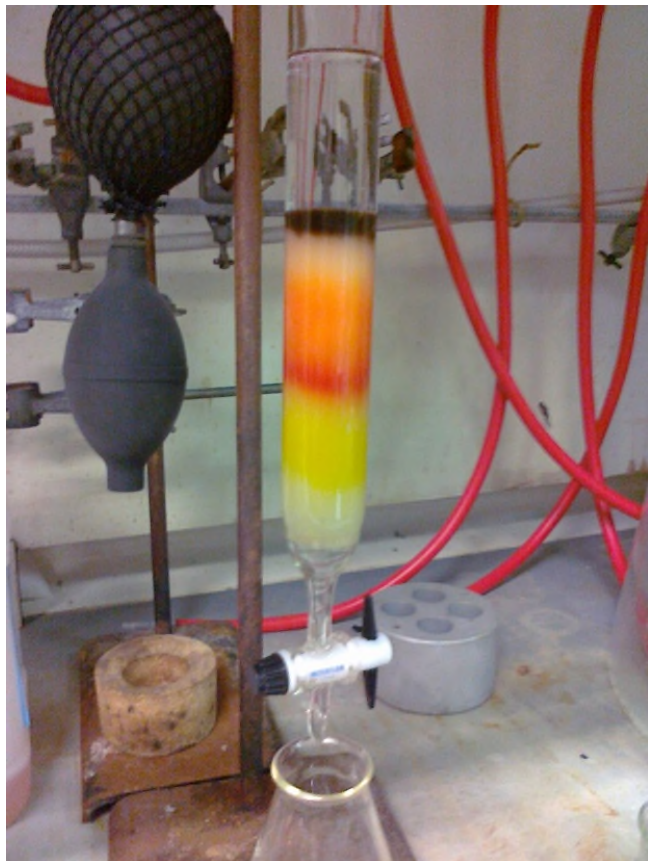
Solvent was added in 50 mL portions as a stepwise gradient starting from 100% pentane, in which the column was prepared, through 49:1, 48:2, 47:3 (x 2), 45:5 (x 2), 43:7, 40:10, 35:15, 30:20, 25:25 pentane:EtOAc portions.

Approximate solvent compositions corresponding to stages illustrated.

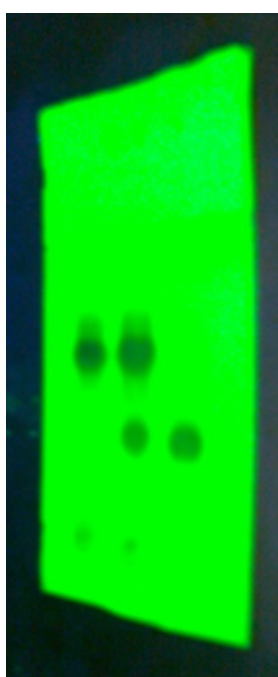
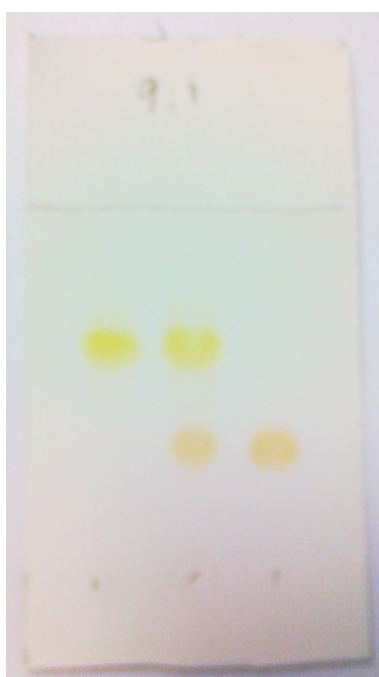
a) 47:3. b) 47:3. c) 45:5. d) 45:5. e) 43:7.

f) 40:10.g) 35:15. h) 30:20. i) 25:25.

Full picture for scale illustration; 250 mL flask below.



TLC of separated products:



Solvent = 9:1 pentane:EtOAc, Silica gel.

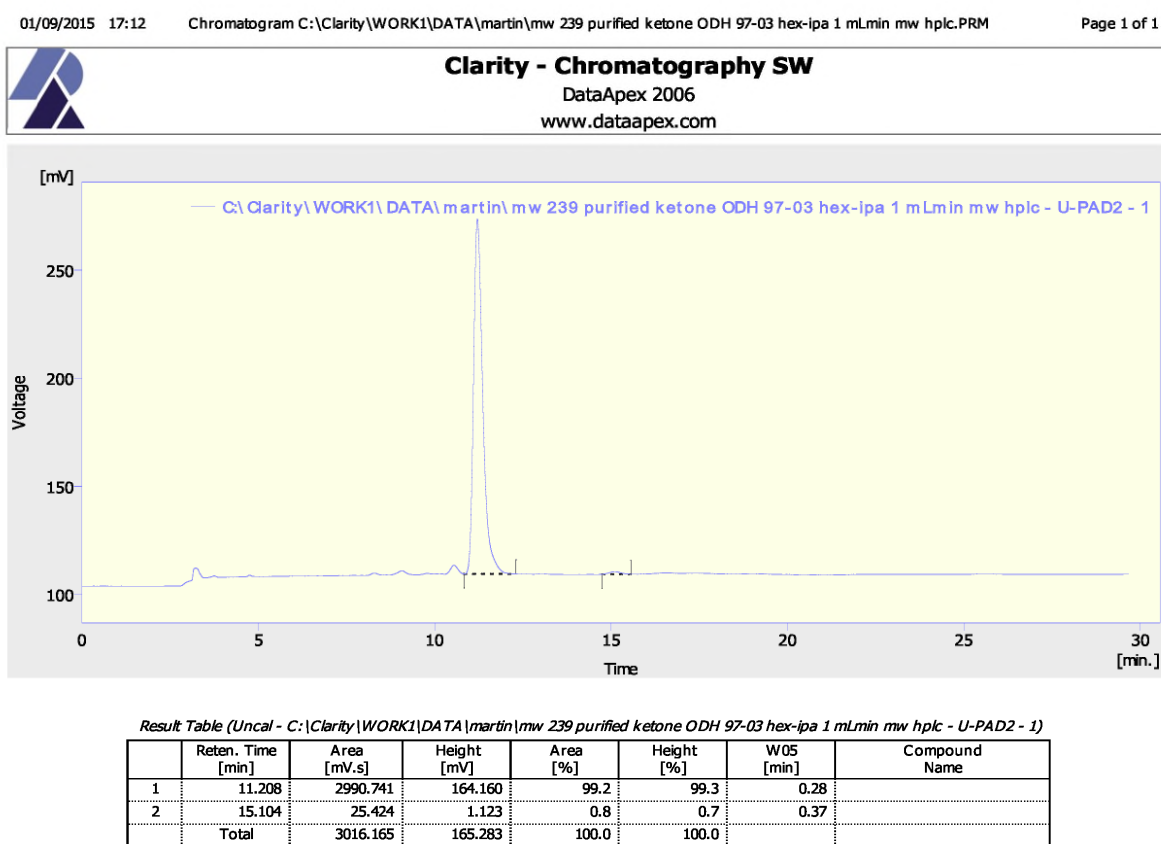
Order of spots: Left-alcohol (Rf ca 0.70), middle-co spot, right-ketone (Rf ca 0.45).

Left hand plate – in visible light, right hand plate – in uv light.

Alcohol is spotted at higher concentration than ketone to make the colour clearly visible.

HPLC of separated products; (Chiralcel ODH column, 4/6 x 250 mm, 93:7 hexane:IPA, 1 mL/min, 30 °C).

Ketone (98.4% ee):



Alcohol (97.6% ee).

01/09/2015 14:18

Chromatogram C:\Clarity\WORK1\DATA\martin\mw 239 purified alcohol ODH 97-03 hex-ipa 1 mLmin mw hplc.prm

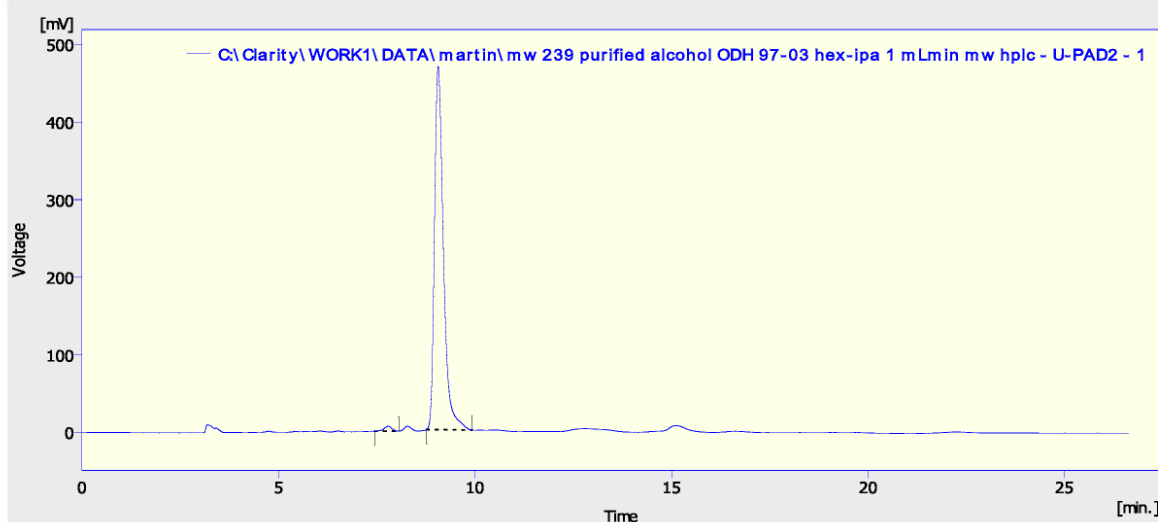
Page 1 of 1



Clarity - Chromatography SW

DataApex 2006

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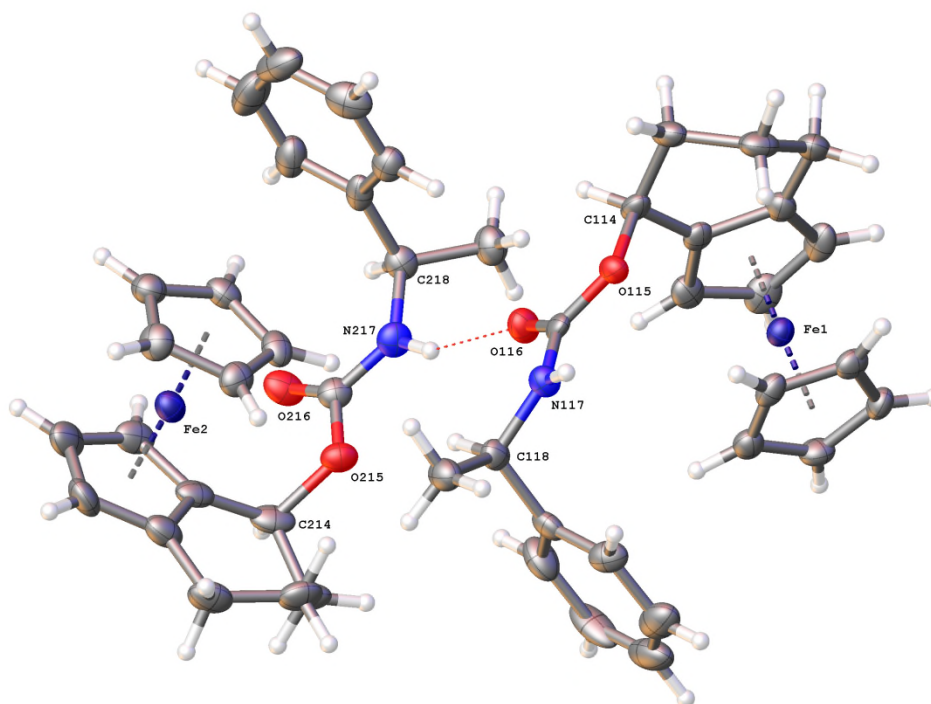


Result Table (Uncal - C:\Clarity\WORK1\DATA\martin\mw 239 purified alcohol ODH 97-03 hex-ipa 1 mLmin mw hplc - U-PAD2 - 1)

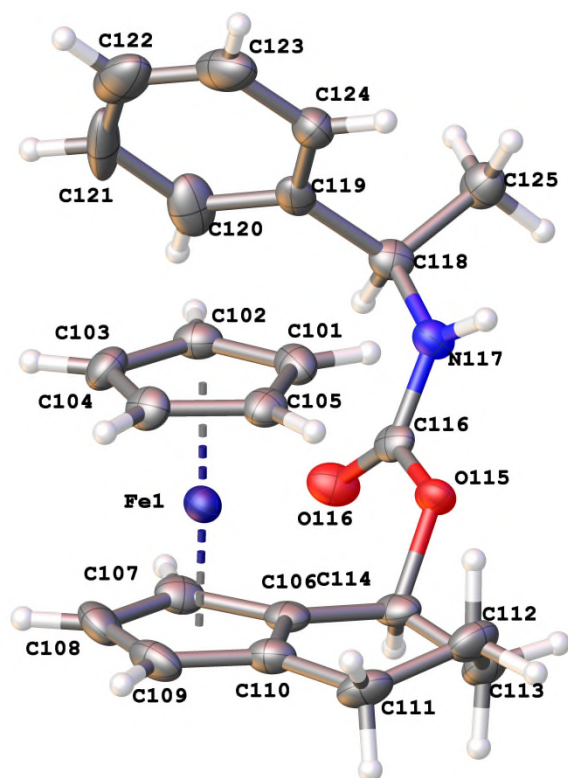
	Reten. Time [min]	Area [mV.s]	Height [mV]	Area [%]	Height [%]	W05 [min]	Compound Name
1	7.788	89.381	6.406	1.2	1.3	0.21	
2	9.064	7427.907	468.343	98.8	98.7	0.24	
	Total	7517.288	474.749	100.0	100.0		

Although an efficient chromatographic purification was employed in our studies, the authors believe that a selective purification through crystallization could, in principle, be achieved due to the significant difference in solubility between the ketone and alcohol, coupled to the very high selectivity of the reduction.

Procedure for synthesis of 5 (mw8) CCDC 1406081. Alcohol (S_{Fe}, S_C)-2 (18 mg, 0.070 mmol) was dissolved in DCM (1 mL) at room temperature in a dry schlenk tube under a nitrogen atmosphere. DMAP (a few crystals) and (*R*)-isocyanate **4** were added. The reaction mixture was stirred overnight. At the end of this time the isocyanate adduct **5** was purified by direct chromatography on silica gel (100:0 - 60:40 pentane:EtOAc) and was recrystallized from DCM/hexane at 0 °C. Procedure adapted from A.F. Simpson, C. D. Bodkin, C. P. Butts, M. A. Armitage and T. Gallagher, *J. Chem. Soc., Perkin Trans. 1*, 2000, 3047-3054.



Solid state structure of the two crystallographically independent but chemical identical molecules in the asymmetric unit of mw8. Only chiral carbons, hetero atoms and metals have been labeled for clarity. Thermal parameters are drawn at 50% probability level.



Solid state structure with atom labeling of one of the crystallographically independent molecules in the asymmetric unit of mw8. Thermal ellipsoids are drawn at 50% probability.

Crystal structure determination of CCDC 1406081 (mw8):

The asymmetric unit contains two crystallographically independent but chemical identical ferrocene carbamates.

The NHs were placed at calculated positions and form H bonds with neighbouring carbamate carbonyls shown below (they form infinite H bonded chains that run a axis of the cell)

Specified hydrogen bonds (with esds except fixed and riding H)

D-H	H...A	D...A	<(DHA)	
0.88	2.32	3.154(7)	158.1	N217-H217...O116
0.88	2.38	3.195(7)	153.6	N117-H117...O216_\$1

Symmetry operators used to generate equivalent atoms in above contacts was
\$1 x-1, y, z

The stereochemistry of the alpha methylbenzyl amine is fixed from synthesis (R). The stereochemistry of the ferrocene alcohol is S

The Flack parameter refined to

Flack x: -0.02(8) (Shelx 2014) (so small and zero within experimental error so you can be confident in the assignment but doesn't matter as synthesised from a known chiral starting material)

Hooft y: -0.041(11) (Olex2)

Experimental

Single crystals of $C_{23}H_{25}FeNO_2$ (**mw8**, **CCDC 1406081**) were grown from DCM/petrol. A suitable crystal was selected and mounted on glass fibre with Fromblin oil and placed on an Xcalibur Gemini diffractometer with a Ruby CCD area detector. The crystal was kept at 150(2) K during data collection. Using Olex2 [1], the structure was solved with the ShelXT [2] structure solution program using Direct Methods and refined with the XL [3] refinement package using Least Squares minimisation.

- 1 Dolomanov, O.V., Bourhis, L.J., Gildea, R.J., Howard, J.A.K. & Puschmann, H. (2009), J. Appl. Cryst. 42, 339-341.
- 2 Sheldrick, G.M. (2015). Acta Cryst. A71, 3-8.
- 3 Sheldrick, G.M. (2008). Acta Cryst. A64, 112-122.

Crystal Data for $C_{23}H_{25}FeNO_2$ ($M = 403.29$ g/mol): monoclinic, space group $P2_1$ (no. 4), $a = 10.1373(7)$ Å, $b = 16.5727(11)$ Å, $c = 11.4438(9)$ Å, $\beta = 95.265(7)^\circ$, $V = 1914.5(2)$ Å³, $Z = 4$, $T = 150(2)$ K, $\mu(\text{MoK}\alpha) = 0.805$ mm⁻¹, $D_{\text{calc}} = 1.399$ g/cm³, 44850 reflections measured ($4.724^\circ \leq 2\theta \leq 61.436^\circ$), 10921 unique ($R_{\text{int}} = 0.1044$, $R_{\text{sigma}} = 0.1331$) which were used in all calculations. The final R_1 was 0.0640 ($I > 2\sigma(I)$) and wR_2 was 0.1554 (all data).

Table 1 Crystal data and structure refinement for mw8.

Identification code	mw8
Empirical formula	$C_{23}H_{25}FeNO_2$
Formula weight	403.29
Temperature/K	150(2)
Crystal system	monoclinic
Space group	$P2_1$
$a/\text{\AA}$	10.1373(7)
$b/\text{\AA}$	16.5727(11)
$c/\text{\AA}$	11.4438(9)
$\alpha/^\circ$	90
$\beta/^\circ$	95.265(7)
$\gamma/^\circ$	90
Volume/Å ³	1914.5(2)
Z	4
$\rho_{\text{calc}}/\text{g/cm}^3$	1.399

μ/mm^{-1}	0.805
F(000)	848.0
Crystal size/ mm^3	$0.22 \times 0.11 \times 0.01$
Radiation	$\text{MoK}\alpha$ ($\lambda = 0.71073$)
2Θ range for data collection/ $^\circ$	4.724 to 61.436
Index ranges	$-14 \leq h \leq 14, -23 \leq k \leq 23, -15 \leq l \leq 16$
Reflections collected	44850
Independent reflections	10921 [$R_{\text{int}} = 0.1044, R_{\text{sigma}} = 0.1331$]
Data/restraints/parameters	10921/1/489
Goodness-of-fit on F^2	1.048
Final R indexes [$I \geq 2\sigma(I)$]	$R_1 = 0.0640, wR_2 = 0.1164$
Final R indexes [all data]	$R_1 = 0.1428, wR_2 = 0.1554$
Largest diff. peak/hole / $e \text{ \AA}^{-3}$	0.57/-0.48
Flack parameter	-0.02(3)

Table 2 Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for mw8. U_{eq} is defined as 1/3 of the trace of the orthogonalised U_{ij} tensor.

Atom	x	y	z	$U(\text{eq})$
Fe1	5104.0(8)	3113.8(5)	6202.3(8)	22.9(2)
C101	3584(7)	3401(4)	4959(6)	29.3(15)
C102	4554(7)	2928(4)	4456(6)	30.5(16)
C103	4665(7)	2180(4)	5064(6)	32.3(16)
C104	3778(7)	2197(4)	5923(6)	29.4(15)
C105	3110(6)	2957(4)	5875(6)	29.0(16)
C106	6063(6)	4150(4)	6794(6)	26.1(15)
C107	6982(7)	3573(5)	6378(6)	31.7(16)
C108	6915(7)	2859(4)	7061(7)	37.0(18)
C109	5961(7)	2974(4)	7869(6)	37.8(18)
C110	5421(7)	3771(4)	7710(6)	30.0(16)
C111	4407(7)	4191(4)	8361(6)	36.3(17)
C112	3871(7)	4932(5)	7688(7)	37.5(18)
C113	5024(8)	5438(4)	7324(6)	33.1(17)
C114	5842(7)	5012(4)	6448(6)	28.5(15)
O115	5104(4)	5106(3)	5294(4)	25.5(10)
C116	5819(6)	5030(4)	4357(6)	24.2(14)
O116	7016(4)	4931(3)	4427(4)	33.6(11)
N117	5025(5)	5109(3)	3350(5)	27.6(12)
C118	5513(6)	4953(4)	2212(6)	27.5(15)
C119	5296(7)	4080(4)	1859(6)	28.1(15)
C120	6337(9)	3564(5)	1758(7)	45(2)
C121	6080(12)	2738(6)	1438(8)	58(3)
C122	4823(12)	2465(6)	1250(7)	58(3)

C123	3783(9)	2972(5)	1365(7)	51(2)
C124	4010(8)	3780(4)	1664(6)	35.1(18)
C125	4900(8)	5535(5)	1302(6)	35.8(18)
Fe2	9742.9(9)	6839.3(6)	1008.7(8)	28.5(3)
C201	9570(7)	7088(4)	2737(6)	31.5(16)
C202	8469(7)	6635(4)	2268(6)	32.9(17)
C203	7823(7)	7072(4)	1321(7)	34.2(17)
C204	8534(7)	7810(4)	1203(7)	35.7(17)
C205	9624(7)	7816(4)	2084(6)	33.8(17)
C206	10561(7)	5761(5)	538(6)	33.3(17)
C207	11561(7)	6329(5)	921(7)	36.6(18)
C208	11405(7)	7026(5)	189(7)	44(2)
C209	10314(7)	6897(6)	-650(6)	41.6(18)
C210	9784(7)	6116(5)	-438(7)	38.1(19)
C211	8632(7)	5679(5)	-1104(7)	43.3(19)
C212	8197(8)	4980(5)	-364(7)	44(2)
C213	9395(8)	4466(5)	84(7)	44(2)
C214	10373(7)	4924(5)	940(7)	37.7(19)
O215	9806(4)	4873(3)	2089(4)	31.1(11)
C216	10677(6)	4994(4)	3054(6)	29.1(15)
O216	11862(4)	5085(3)	3010(4)	37.0(12)
N217	10050(6)	4983(4)	4021(5)	32.4(14)
C218	10740(6)	5139(4)	5179(6)	29.8(15)
C219	10632(7)	6014(4)	5524(6)	29.8(16)
C220	11754(8)	6488(5)	5640(7)	43(2)
C221	11682(10)	7293(6)	5945(8)	60(3)
C222	10474(11)	7636(5)	6135(8)	56(3)
C223	9348(9)	7158(5)	6034(7)	45(2)
C224	9419(7)	6356(4)	5725(6)	33.7(17)
C225	10231(7)	4568(5)	6065(7)	37.6(19)

Table 3 Anisotropic Displacement Parameters ($\text{\AA}^2 \times 10^3$) for mw8. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\dots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
Fe1	22.3(4)	21.7(5)	24.1(5)	1.6(4)	-0.6(4)	-1.3(4)
C101	28(4)	24(3)	34(4)	3(3)	-6(3)	-5(3)
C102	32(4)	32(4)	26(4)	-1(3)	-2(3)	-8(3)
C103	36(4)	28(4)	33(4)	-9(3)	4(3)	1(3)
C104	34(4)	22(3)	32(4)	3(3)	1(3)	-7(3)
C105	22(3)	31(4)	34(4)	-6(3)	-1(3)	-5(3)
C106	24(3)	28(4)	24(4)	-1(3)	-5(3)	-8(3)
C107	22(4)	41(4)	31(4)	-1(3)	-2(3)	-5(3)
C108	26(4)	37(4)	44(5)	6(3)	-12(3)	2(3)
C109	43(4)	36(5)	32(4)	14(3)	-13(3)	-8(3)

C110	35(4)	33(4)	21(4)	1(3)	-2(3)	-6(3)
C111	46(4)	41(4)	22(4)	-6(3)	4(3)	-11(4)
C112	39(4)	44(5)	30(4)	-15(3)	5(3)	0(4)
C113	49(4)	28(4)	22(4)	-4(3)	0(3)	0(3)
C114	35(4)	27(4)	22(3)	-1(3)	-6(3)	-10(3)
O115	32(2)	24(2)	20(2)	2(2)	0(2)	-1(2)
C116	33(4)	14(3)	25(3)	0(3)	2(3)	-7(3)
O116	27(3)	43(3)	31(3)	2(2)	2(2)	-6(2)
N117	26(3)	31(3)	25(3)	2(3)	1(2)	2(2)
C118	22(3)	34(4)	27(4)	0(3)	4(3)	-4(3)
C119	36(4)	33(4)	15(3)	5(3)	4(3)	7(3)
C120	43(5)	52(5)	43(5)	10(4)	20(4)	12(4)
C121	92(8)	47(5)	42(5)	13(4)	35(5)	46(6)
C122	105(9)	41(6)	26(5)	-1(4)	6(5)	1(6)
C123	75(6)	44(6)	31(4)	5(4)	-12(4)	-12(5)
C124	42(5)	31(4)	30(4)	-1(3)	-5(3)	6(3)
C125	50(5)	29(4)	29(4)	3(3)	5(4)	0(3)
Fe2	24.3(5)	35.9(6)	25.4(5)	0.7(5)	2.9(4)	-2.0(4)
C201	31(4)	40(4)	24(4)	0(3)	5(3)	6(3)
C202	34(4)	30(4)	37(4)	4(3)	15(3)	6(3)
C203	26(3)	38(4)	40(4)	-2(3)	5(3)	-1(3)
C204	37(4)	30(4)	39(4)	5(3)	2(3)	5(3)
C205	36(4)	36(4)	29(4)	-4(3)	4(3)	0(3)
C206	26(4)	47(5)	28(4)	-14(3)	7(3)	3(3)
C207	19(4)	55(5)	37(5)	-11(4)	3(3)	1(3)
C208	32(4)	64(6)	37(4)	-7(4)	13(3)	-15(4)
C209	44(4)	57(5)	25(4)	8(4)	12(3)	-7(4)
C210	31(4)	58(5)	26(4)	-6(4)	6(3)	-2(4)
C211	37(4)	63(6)	29(4)	-10(4)	-5(3)	1(4)
C212	40(4)	50(5)	39(5)	-17(4)	-8(3)	-7(4)
C213	49(5)	47(5)	35(5)	-18(4)	-6(4)	4(4)
C214	32(4)	48(5)	34(4)	-16(4)	3(3)	13(4)
O215	29(3)	34(3)	30(3)	-6(2)	-3(2)	2(2)
C216	27(4)	29(4)	32(4)	-2(3)	1(3)	5(3)
O216	26(3)	52(3)	34(3)	-4(2)	3(2)	8(2)
N217	24(3)	38(4)	34(4)	2(3)	-4(3)	0(3)
C218	24(3)	35(4)	30(4)	3(3)	0(3)	4(3)
C219	27(4)	37(4)	23(4)	12(3)	-7(3)	-8(3)
C220	42(5)	47(5)	39(5)	12(4)	-3(4)	-13(4)
C221	69(7)	55(6)	53(6)	10(5)	-19(5)	-30(5)
C222	93(8)	32(5)	39(5)	1(4)	-18(5)	-6(5)
C223	52(5)	49(5)	33(5)	3(4)	-5(4)	18(4)
C224	35(4)	35(4)	30(4)	6(3)	-3(3)	-2(3)
C225	38(4)	37(4)	37(5)	10(3)	3(4)	2(3)

Table 4 Bond Lengths for mw8.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Fe1	C101	2.055(7)	Fe2	C201	2.044(7)
Fe1	C102	2.048(7)	Fe2	C202	2.049(7)
Fe1	C103	2.046(7)	Fe2	C203	2.047(7)
Fe1	C104	2.035(7)	Fe2	C204	2.047(7)
Fe1	C105	2.038(6)	Fe2	C205	2.043(7)
Fe1	C106	2.058(6)	Fe2	C206	2.062(7)
Fe1	C107	2.043(7)	Fe2	C207	2.039(7)
Fe1	C108	2.045(7)	Fe2	C208	2.026(7)
Fe1	C109	2.036(7)	Fe2	C209	2.036(7)
Fe1	C110	2.041(7)	Fe2	C210	2.048(8)
C101	C102	1.420(10)	C201	C202	1.410(10)
C101	C105	1.402(10)	C201	C205	1.423(10)
C102	C103	1.422(10)	C202	C203	1.413(10)
C103	C104	1.392(10)	C203	C204	1.432(10)
C104	C105	1.428(10)	C204	C205	1.426(10)
C106	C107	1.446(10)	C206	C207	1.422(10)
C106	C110	1.429(10)	C206	C210	1.433(10)
C106	C114	1.493(9)	C206	C214	1.479(12)
C107	C108	1.423(10)	C207	C208	1.427(11)
C108	C109	1.412(11)	C208	C209	1.413(11)
C109	C110	1.435(10)	C209	C210	1.430(12)
C110	C111	1.495(10)	C210	C211	1.518(10)
C111	C112	1.523(11)	C211	C212	1.524(12)
C112	C113	1.527(11)	C212	C213	1.533(11)
C113	C114	1.531(10)	C213	C214	1.530(10)
C114	O115	1.465(8)	C214	O215	1.485(9)
O115	C116	1.355(8)	O215	C216	1.365(8)
C116	O116	1.219(8)	C216	O216	1.216(8)
C116	N117	1.349(8)	C216	N217	1.326(9)
N117	C118	1.458(9)	N217	C218	1.464(9)
C118	C119	1.513(10)	C218	C219	1.509(10)
C118	C125	1.511(10)	C218	C225	1.512(10)
C119	C120	1.372(10)	C219	C220	1.379(10)
C119	C124	1.394(10)	C219	C224	1.392(10)
C120	C121	1.434(13)	C220	C221	1.383(12)
C121	C122	1.351(14)	C221	C222	1.386(14)
C122	C123	1.364(14)	C222	C223	1.385(13)
C123	C124	1.395(11)	C223	C224	1.379(11)

Table 5 Bond Angles for mw8.

Ato m	Ato m	Ato m	Angle/°
C101	Fe1	C106	109.6(3)
C102	Fe1	C101	40.5(3)
C102	Fe1	C106	121.6(3)
C103	Fe1	C101	68.2(3)
C103	Fe1	C102	40.6(3)
C103	Fe1	C106	155.5(3)
C104	Fe1	C101	67.8(3)
C104	Fe1	C102	67.5(3)
C104	Fe1	C103	39.9(3)
C104	Fe1	C105	41.1(3)
C104	Fe1	C106	163.9(3)
C104	Fe1	C107	152.9(3)
C104	Fe1	C108	118.2(3)
C104	Fe1	C109	106.3(3)
C104	Fe1	C110	125.6(3)
C105	Fe1	C101	40.1(3)
C105	Fe1	C102	68.0(3)
C105	Fe1	C103	68.4(3)
C105	Fe1	C106	126.7(3)
C105	Fe1	C107	164.8(3)
C105	Fe1	C108	153.3(3)
C105	Fe1	C110	107.4(3)
C107	Fe1	C101	127.9(3)
C107	Fe1	C102	108.6(3)
C107	Fe1	C103	119.4(3)
C107	Fe1	C106	41.3(3)
C107	Fe1	C108	40.7(3)
C108	Fe1	C101	164.4(3)
C108	Fe1	C102	126.1(3)
C108	Fe1	C103	106.4(3)
C108	Fe1	C106	68.8(3)
C109	Fe1	C101	154.7(3)
C109	Fe1	C102	162.2(3)
C109	Fe1	C103	124.0(3)
C109	Fe1	C105	119.2(3)
C109	Fe1	C106	68.8(3)
C109	Fe1	C107	68.7(3)
C109	Fe1	C108	40.5(3)
C109	Fe1	C110	41.2(3)
C110	Fe1	C101	120.8(3)
C110	Fe1	C102	155.9(3)
C110	Fe1	C103	161.9(3)

Atom	Atom	Atom	Angle/°
C201	Fe2	C202	40.3(3)
C201	Fe2	C203	68.0(3)
C201	Fe2	C204	68.4(3)
C201	Fe2	C206	120.0(3)
C201	Fe2	C210	155.6(3)
C202	Fe2	C206	109.6(3)
C203	Fe2	C202	40.3(3)
C203	Fe2	C206	128.4(3)
C203	Fe2	C210	110.0(3)
C204	Fe2	C202	68.4(3)
C204	Fe2	C203	40.9(3)
C204	Fe2	C206	165.6(3)
C204	Fe2	C210	127.2(3)
C205	Fe2	C201	40.8(3)
C205	Fe2	C202	68.4(3)
C205	Fe2	C203	68.6(3)
C205	Fe2	C204	40.8(3)
C205	Fe2	C206	153.0(3)
C205	Fe2	C210	163.2(3)
C207	Fe2	C201	106.8(3)
C207	Fe2	C202	126.7(3)
C207	Fe2	C203	164.8(3)
C207	Fe2	C204	152.2(3)
C207	Fe2	C205	117.5(3)
C207	Fe2	C206	40.6(3)
C207	Fe2	C210	68.4(3)
C208	Fe2	C201	124.5(3)
C208	Fe2	C202	162.8(3)
C208	Fe2	C203	153.7(3)
C208	Fe2	C204	117.5(3)
C208	Fe2	C205	104.8(3)
C208	Fe2	C206	68.9(3)
C208	Fe2	C207	41.1(3)
C208	Fe2	C209	40.7(3)
C208	Fe2	C210	68.6(3)
C209	Fe2	C201	161.7(3)
C209	Fe2	C202	156.1(3)
C209	Fe2	C203	120.7(3)
C209	Fe2	C204	106.8(3)
C209	Fe2	C205	124.2(3)
C209	Fe2	C206	69.0(3)
C209	Fe2	C207	68.8(3)

C110	Fe1	C106	40.8(3)
C110	Fe1	C107	69.2(3)
C110	Fe1	C108	68.9(3)
C102	C101	Fe1	69.5(4)
C105	C101	Fe1	69.3(4)
C105	C101	C102	108.1(6)
C101	C102	Fe1	70.0(4)
C101	C102	C103	108.0(6)
C103	C102	Fe1	69.6(4)
C102	C103	Fe1	69.8(4)
C104	C103	Fe1	69.6(4)
C104	C103	C102	107.5(6)
C103	C104	Fe1	70.5(4)
C103	C104	C105	109.0(6)
C105	C104	Fe1	69.6(4)
C101	C105	Fe1	70.6(4)
C101	C105	C104	107.4(6)
C104	C105	Fe1	69.3(4)
C107	C106	Fe1	68.8(4)
C107	C106	C114	129.1(6)
C110	C106	Fe1	69.0(4)
C110	C106	C107	107.5(6)
C110	C106	C114	123.2(6)
C114	C106	Fe1	131.0(5)
C106	C107	Fe1	69.9(4)
C108	C107	Fe1	69.7(4)
C108	C107	C106	107.8(6)
C107	C108	Fe1	69.5(4)
C109	C108	Fe1	69.4(4)
C109	C108	C107	108.5(6)
C108	C109	Fe1	70.1(4)
C108	C109	C110	108.5(6)
C110	C109	Fe1	69.6(4)
C106	C110	Fe1	70.2(4)
C106	C110	C109	107.7(6)
C106	C110	C111	122.7(6)
C109	C110	Fe1	69.2(4)
C109	C110	C111	129.6(7)
C111	C110	Fe1	127.4(5)
C110	C111	C112	110.7(6)
C111	C112	C113	109.5(6)
C112	C113	C114	113.6(6)
C106	C114	C113	110.1(6)
O115	C114	C106	113.1(5)

C209	Fe2	C210	41.0(3)
C210	Fe2	C202	122.2(3)
C210	Fe2	C206	40.8(3)
C202	C201	Fe2	70.1(4)
C202	C201	C205	108.6(6)
C205	C201	Fe2	69.6(4)
C201	C202	Fe2	69.6(4)
C201	C202	C203	108.3(6)
C203	C202	Fe2	69.7(4)
C202	C203	Fe2	69.9(4)
C202	C203	C204	108.0(6)
C204	C203	Fe2	69.5(4)
C203	C204	Fe2	69.5(4)
C205	C204	Fe2	69.4(4)
C205	C204	C203	107.6(6)
C201	C205	Fe2	69.7(4)
C201	C205	C204	107.5(6)
C204	C205	Fe2	69.7(4)
C207	C206	Fe2	68.8(4)
C207	C206	C210	107.1(7)
C207	C206	C214	129.3(7)
C210	C206	Fe2	69.1(4)
C210	C206	C214	123.3(7)
C214	C206	Fe2	131.7(5)
C206	C207	Fe2	70.6(4)
C206	C207	C208	108.5(7)
C208	C207	Fe2	69.0(4)
C207	C208	Fe2	69.9(4)
C209	C208	Fe2	70.0(4)
C209	C208	C207	108.3(7)
C208	C209	Fe2	69.3(4)
C208	C209	C210	107.7(7)
C210	C209	Fe2	69.9(4)
C206	C210	Fe2	70.1(4)
C206	C210	C211	122.6(7)
C209	C210	Fe2	69.1(4)
C209	C210	C206	108.4(7)
C209	C210	C211	129.1(7)
C211	C210	Fe2	127.8(5)
C210	C211	C212	109.4(6)
C211	C212	C213	110.3(7)
C214	C213	C212	112.7(7)
C206	C214	C213	111.2(7)
C206	C214	O215	113.6(6)

O115	C114	C113	106.2(5)	O215	C214	C213	104.9(6)
C116	O115	C114	115.9(5)	C216	O215	C214	115.7(5)
O116	C116	O115	124.2(6)	O216	C216	O215	123.6(6)
O116	C116	N117	125.5(6)	O216	C216	N217	126.0(6)
N117	C116	O115	110.3(6)	N217	C216	O215	110.4(6)
C116	N117	C118	121.4(6)	C216	N217	C218	121.8(6)
N117	C118	C119	110.9(5)	N217	C218	C219	111.5(6)
N117	C118	C125	110.5(6)	N217	C218	C225	109.4(6)
C125	C118	C119	112.7(6)	C219	C218	C225	112.9(6)
C120	C119	C118	121.6(7)	C220	C219	C218	119.5(7)
C120	C119	C124	118.7(7)	C220	C219	C224	119.0(7)
C124	C119	C118	119.7(6)	C224	C219	C218	121.4(6)
C119	C120	C121	119.5(9)	C219	C220	C221	120.8(9)
C122	C121	C120	120.5(8)	C220	C221	C222	120.2(9)
C121	C122	C123	120.3(9)	C223	C222	C221	119.1(8)
C122	C123	C124	120.2(9)	C224	C223	C222	120.7(9)
C119	C124	C123	120.8(8)	C223	C224	C219	120.2(8)

Table 6 Hydrogen Bonds for mw8.

D	H	A	d(D-H)/Å	d(H-A)/Å	d(D-A)/Å	D-H-A/°
N117	H117	O216 ¹	0.88	2.38	3.195(7)	153.6
N217	H217	O116	0.88	2.32	3.154(7)	158.1

¹-1+X,+Y,+Z

Table 7 Hydrogen Atom Coordinates (Å×10⁴) and Isotropic Displacement Parameters (Å²×10³) for mw8.

Atom	x	y	z	U(eq)
H101	3305	3927	4716	35
H102	5044	3085	3824	37
H103	5239	1747	4911	39
H104	3640	1772	6455	35
H105	2464	3129	6373	35
H107	7531	3656	5760	38
H108	7427	2384	6985	44
H109	5718	2588	8425	45
H11A	4812	4357	9145	44
H11B	3670	3816	8474	44
H11C	3328	5258	8188	45
H11D	3300	4762	6982	45
H11E	5612	5577	8034	40
H11F	4670	5948	6970	40
H114	6719	5288	6444	34
H117	4196	5259	3382	33
H118	6490	5052	2294	33

H120	7223	3752	1900	54
H121	6799	2381	1357	70
H122	4663	1918	1036	69
H123	2902	2775	1242	61
H124	3279	4129	1735	42
H12A	3942	5444	1188	54
H12B	5287	5449	558	54
H12C	5074	6090	1569	54
H201	10174	6933	3382	38
H202	8206	6124	2541	39
H203	7053	6906	847	41
H204	8318	8221	639	43
H205	10269	8230	2211	41
H207	12221	6256	1557	44
H208	11943	7496	255	52
H209	9990	7263	-1247	50
H21A	8905	5472	-1857	52
H21B	7885	6057	-1279	52
H21C	7549	4641	-843	52
H21D	7759	5193	310	52
H21E	9081	3981	481	53
H21F	9859	4283	-593	53
H214	11246	4639	998	45
H217	9195	4879	3965	39
H218	11700	5017	5133	36
H220	12586	6258	5508	52
H221	12464	7612	6025	72
H222	10419	8191	6332	67
H223	8519	7386	6179	54
H224	8638	6037	5648	40
H22A	9285	4668	6120	56
H22B	10719	4656	6834	56
H22C	10357	4010	5816	56

Refinement model description

Number of restraints - 1, number of constraints - unknown.

Details:

1. Fixed Uiso

At 1.2 times of:

All C(H) groups, All C(H,H) groups, All N(H) groups

At 1.5 times of:

All C(H,H,H) groups

2.a Ternary CH refined with riding coordinates:

C114(H114), C118(H118), C214(H214), C218(H218)

2.b Secondary CH2 refined with riding coordinates:

C111(H11A,H11B), C112(H11C,H11D), C113(H11E,H11F),
C211(H21A,H21B), C212(H21C,
H21D), C213(H21E,H21F)

2.c Aromatic/amide H refined with riding coordinates:

C101(H101), C102(H102), C103(H103), C104(H104), C105(H105),
C107(H107),
C108(H108), C109(H109), N117(H117), C120(H120), C121(H121),
C122(H122),
C123(H123), C124(H124), C201(H201), C202(H202), C203(H203),
C204(H204),
C205(H205), C207(H207), C208(H208), C209(H209), N217(H217),
C220(H220),
C221(H221), C222(H222), C223(H223), C224(H224)

2.d Idealised Me refined as rotating group:

C125(H12A,H12B,H12C), C225(H22A,H22B,H22C)

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