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Iron-catalyzed Enantioselective Hydrosilylation of Ketones

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Materials and Methods: All reactions were conducted under argon atmosphere using standard Schlenk techniques. All the substrates were purchased from commercial sources and were distilled over CaH_2 and stored under argon. Solid substrates were used as received. $Fe(OAc)_2$ was purchased from Aldrich with 99.995% purity. Phosphine Ligands were purchased from Strem Chemical Company. $(EtO)_2MeSiH$ and other silanes used were purchased from Aldrich and distilled under vacuum and stored under argon. PMHS was purchased from Aldrich and degassed before use. (PMHS: MW 1900, a 29mer, with one hydride per monomeric unit. Monomer weight = 60).[1] THF and Toluene were dried over sodium benzophenone, distilled and stored under argon. Melting points were determined on a Leica galen III melting point apparatus and were uncorrected. Optical rotations were measured on a Perkin Elmer 343 polarimeter at 25 °C in a 1-dm cell. Absolute configuration of product alcohols were assigned by comparison of the sign of optical rotation with reported values. NMR spectra were recorded on a Bruker ARX 300 spectrometer, operating at 300 MHz for ^1H NMR, 75 MHz for ^{13}C NMR. NMR spectra were reported downfield from $CDCl_3$ (d: 7.27 ppm) for ^1H NMR. For ^{13}C NMR chemical shifts were reported in the scale relative to the solvent of $CDCl_3$ (d: 77.0 ppm). Mass spectra were recorded on an AMD 402/3 or a HP 5989A mass selective detector. GC analyses were performed with a Hewlett Packard HP 6890 spectrometer. Column chromatography was performed with silica gel Merck 60 (70-230 mesh ASTM) using solvents of commercial grade. Isolated products were characterized by comparison of NMR data with reported values and GC-MS (showed >95% purity).

(Ligands **La**, **Lb** and **Lk** were obtained from Aldrich. Ligands **Lc**-**Lj** were prepared by the known procedure).[2]

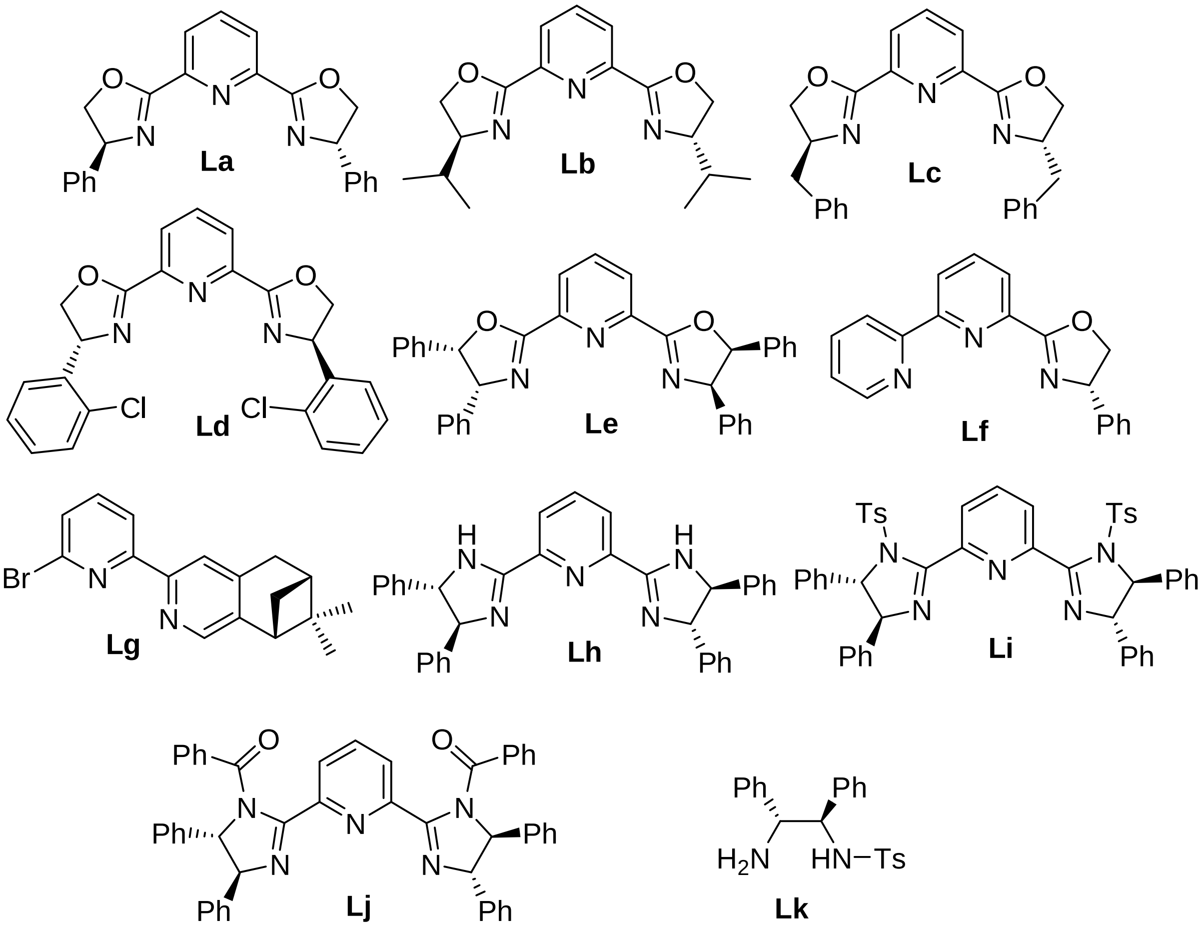
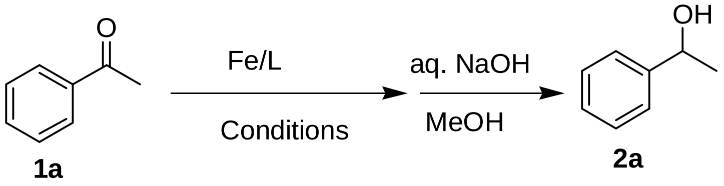


Fig. 1: Ligands studied in the asymmetric hydrosilylation of acetophenone

Table 1. Asymmetric hydrosilylation of acetophenone - ligand screening[a]



Entry	Catalyst [mol%]	Ligand [mol%]	Silane [equiv.]	Conditions	Conv.[b] [%]	*ee*[c] [%]
1	$Fe(acac)_2$ (20)	**La** (20)	Ph_2SiH_2 (2)	Toluene, 100 °C, 20h.	68	22
2	$Fe(acac)_2$ (5)	**La**(10)	Ph_2SiH_2 (2)	THF, 100 °C, 20h.	5	1
3	$Fe(acac)_2$ (5)	**La** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	28	34
4	$Fe(OAc)_2$ (5)	**Lb** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	94	24
5	$Fe(OAc)_2$ (5)	**Lc** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	98	36
6	$Fe(OAc)_2$ (5)	**Lc**+PPh_3 (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	97	35
7	$Fe(OAc)_2$ (5)	**Ld** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	94	7
8	$Fe(OAc)_2$ (5)	**Le** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	97	6
9	$Fe(OAc)_2$ (5)	**Lf** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	98	24
10	$Fe(OAc)_2$ (5)	**Lg** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	31	1
11	$Fe(OAc)_2$ (5)	**Lh** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	15	2
13	$Fe(OAc)_2$ (5)	**Li** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	5	0
14	$Fe(OAc)_2$ (5)	**Lj** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	96	3
15	$Fe(OAc)_2$ (5)	**Lk** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 20h.	12	10
16	$Fe(OAc)_2$ (5)	none	$(EtO)_2MeSiH$ (2)	THF, 65 °C, 24h.	24	0

[a] Reactions were carried out under argon atomosphere using general conditions. [b] Determined by GC-FID using diethyleneglycol dimethyl ether as an internal standard. [c] Determined by GC with chiral phase.

Table 2. Asymmetric hydrosilylation of acetophenone using $Fe(OAc)_2$ (mixed ligand system)[a]

Entry	Ligand	Silane [equiv.]	Conditions	Conv.[b]	*ee*[c]

	[mol%]			[%]	[%]
1	(*S*,*S*)-Me-DuPHOS (10)	$(EtO)_2MeSiH$ (2)	THF, 65 ºC, 20h.	>99	75
2	(*S*,*S*)-Me-DuPHOS + TMEDA(10)	$(EtO)_2MeSiH$ (2)	THF, 65 ºC, 20h.	>99	73
3	(*S*,*S*)-Me-DuPHOS + PPh_3(10)	$(EtO)_2MeSiH$ (2)	THF, 65 ºC, 20h.	>99	75
4	(*S*,*S*)-Me-DuPHOS + **Lc** (10)	$(EtO)_2MeSiH$ (2)	THF, 65 ºC, 20h.	>99	71

[a] Reactions were carried out under argon atomosphere using general conditions. [b] Determined by GC-FID using diethyleneglycol dimethyl ether as an internal standard. [c] Determined by GC with chiral phase.

Table 3. Asymmetric hydrosilylation of acetophenone - additive effect[a]

Entry	Additive [mol %]	Temp [ºC]	Conv.[b] [%]	*ee*[c][%]
1	AcOH (1)	65	12	76
2	TFA (1)	65	10	66
3	KO*t*Bu (1)	65	>99	5
4	4A-Molecular Sieves	65	>99	76
5	H_2O (10)	65	42	73
6	Air	50	75	7
7	Acetone (5)	65	67	75
8	Acetone (10)	65	33	76
9	Acetone (25)	65	10	76

[a] Reactions were carried out under argon atomosphere using general conditions. Additive was added at the beginning of the reaction followed by addition of the solvent. [b] Determined by GC-FID using diethyleneglycol dimethyl ether as an internal standard. [c] Determined by GC with chiral phase.

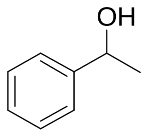
Table 4. Asymmetric hydrosilylation of acetophenone using $Fe(OAc)_2$ - catalyst loading[a]

Entry	$Fe(OAc)_2$ [mol%]	(*S*,*S*)-Me-DuPHOS [mol%]	Temp [ºC], *t* [h]	Conv.[b] [%]	*ee*[c] [%]
1	1	1	65 (16)	8	7
2	1	2	65 (16)	6	60

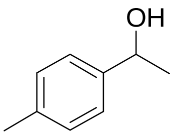
3	2	1	65 (16)	80	36
4	3	3	65 (16)	90	71
5	5	15	65 (16)	100	75
6	5	10	65 (16)	100	75
7	5	8	65 (16)	94	70
8	5	5	65 (16)	>99	70
9	2.5	5	65 (16)	>99	74
10	5	10	0 (32)	18	64
11	5	10	-78 (32)	6	78
12	5	10	RT (16)	45	79
13	5	10	RT (48)	88	79

[a] Reactions were carried out under argon atomosphere using general conditions. [b] Determined by GC-FID using diethyleneglycol dimethyl ether as an internal standard. [c] Determined by GC with chiral phase.

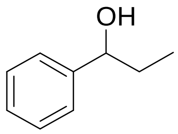
Spectroscopic and analytical data (compounds from Table 4 and Scheme 1):



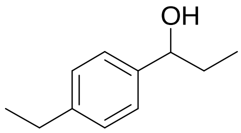
(*R*)-1-Phenylethanol (2a):[3] Obtained as clear liquid. ^{1}H NMR *d* 7.28-7.4 (m, 5H), 4.89 (q, *J* = 6.5 Hz, 1H), 2.05 (br. s, 1H), 1.5 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 145.8, 128.4, 127.4, 125.3, 70.3, 25.1; MS (EI): *m/z* 122 (M$^+$). The *ee* (79%, table 4, entry 1) was determined using GC with chiral column (25 m Lipodex E, 70-180 °C): t_R (min) = 58.8 (minor), 59.6 (major).



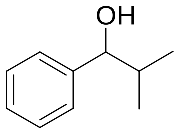
(*R*)-1-(4-Methylphenyl)ethanol (2b):[4] Obtained as clear liquid. ^{1}H NMR *d* 7.28 (d, *J* = 8.1 Hz, 2H), 7.18 (d, *J* = 8.1 Hz, 2H), 4.87 (q, *J* = 6.5 Hz, 1H), 2.37 (s, 3H), 1.93 (br s, 1H), 1.5 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 142.8, 137.1, 129.1, 125.3, 70.2, 25.0, 21.1; MS (EI): *m/z* 136 (M^{+}). The *ee* (81%) was determined using chiral HPLC (Chiralcel OJ-H, n-heptane-isopropanol (95:5; 0.5 ml/min.): t_{R} (min) = 26.3 (minor), 29.6 (major).



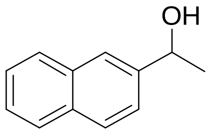
(*R*)-1-Phenylpropanol (2c):[4] Obtained as clear liquid. ^{1}H NMR *d* 7.26-7.40 (m, 5H), 4.6 (t, *J* = 6.5 Hz, 1H), 1.99 (br s, 1H), 1.70-1.91 (m, 2H), 0.93 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR *d* 144.5, 128.4, 127.4, 125.9, 76.0, 31.8, 10.1; MS (EI): *m/z* 136 (M^{+}). The *ee* (78%) was determined using chiral HPLC (Chiralcel OB-H, n-heptane-ethanol (98:2; 1 ml/min.): t_{R} (min) = 7.9 (minor), 10.1 (major).



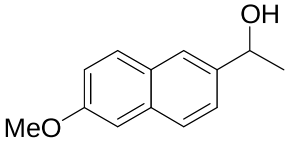
(*R*)-1-(4-Ethylphenyl)propanol (2d): Obtained as clear liquid. ^{1}H NMR *d* 7.33 (dd, *J* = 8.2 Hz, 4H), 4.57 (t, *J* = 6.9 Hz, 1H), 2.67 (q, *J* = 7.6 Hz, 2H), 1.94 (br s, 1H), 1.79 (m, 2H), 1.25 (t, *J* = 7.61, 3H), 0.93 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR *d* 143.5, 141.8, 127.8, 125. 9, 75.9, 31.7, 28.5, 15.6, 10.2; MS (EI): *m/z* 164 (M^{+}). The *ee* (82%) was determined using chiral HPLC (Chiralpak AD-H, n-heptane-ethanol (95:5; 0.8 ml/min.): t_{R} (min) = 9.1 (major), 9.6 (minor).



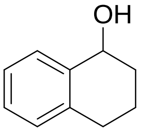
(*R*)-2-Methyl-1-phenylpropan-1-ol (2e):[5] Obtained as clear liquid. ^{1}H NMR *d* 7.25-7-33 (m, 5H), 4.36 (d, *J* = 6.9 Hz, 1H), 1.91-2.03 (m, 2H), 1.01 (d, *J* = 6.8 Hz, 3H), 0.81 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR *d* 143.6, 128.2, 127.4, 126.5, 80.0, 35.2, 18.9, 18.2; MS (EI): *m/z* 150 (M^{+}); The *ee* (67%) was determined using chiral HPLC (Chiralpak AD-H, n-heptane-ethanol (99.5:0.5; flow rate: 1 ml/min.): t_{R} (min) = 13.2 (major), 14.9 (minor).



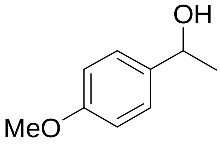
(*R*)-1-(Naphthalen-2-yl)ethanol (2f):[6] Obtained as thick liquid. ^{1}H NMR *d* 7.75-7-90 (m, 4H), 7.45-7.57 (m, 3H), 5 (q, *J* = 6.5 Hz, 1H), 2.85 (br s, 1H), 1.58 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 143.1, 133.2, 132.7, 128.1, 127.8, 127.5, 125.9, 125.6, 123.7, 123.6, 70.2, 24.9; MS (EI): *m/z* 172 (M$^+$). The *ee* (70%) was determined using chiral HPLC (Chiralcel OD-H, n-hexane-ethanol (95:5; 1 ml/min.): t_R (min) = 7.5 (minor), 8.3 (major).



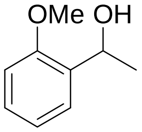
(*R*)-1-(6-Methoxynaphthalen-2-yl)ethanol (2g):[7] Obtained as white solid. mp 110-112 ºC; ^{1}H NMR *d* 7.70-7.76 (m, 3H), 7.48 (dd, *J* = 8.7 & 1.8 Hz, 1H), 7.13-7.18 (m, 2H), 5.04 (q, *J* = 6.5 Hz, 1H), 3.93 (s, 3H), 1.99 (br s, 1H), 1.58 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 157.6, 140.9, 134.0, 129.4, 128.7, 127.1, 124.3, 123.7, 118.9, 105.6, 70.5, 55.3, 25.0; MS (EI): *m/z* 202 (M$^+$). The *ee* (79%) was determined using chiral HPLC (Chiralpak AD-H, n-heptane-ethanol (95:5; flow rate: 1 ml/min.): t_R (min) = 11.4 (minor), 12.7 (major).



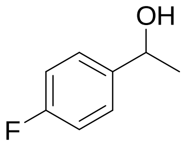
(*R*)-1,2,3,4-Tetrahydronaphthalen-1-ol (2h):[8] Obtained as clear liquid. ^{1}H NMR *d* 7.36-7.48 (m, 1H), 7.18-7.26 (m, 2H), 7.08-7.16 (m, 1H), 4.78 (t, *J* = 4.5 Hz, 1H), 2.67-2.91 (m, 2H), 1.72-2.1 (m, 5H); ^{13}C NMR *d* 138.7, 137.1, 128.9, 128.6, 127.5, 126.1, 68.0, 32.2, 29.2, 18.7; MS (EI): *m/z* 148 (M$^+$). The *ee* (75%) was determined using chiral HPLC (Chiralcel OJ-H, n-heptane-isopropanol (95:5; 0.5 ml/min.): t_R (min) = 21.6 (minor), 31.3 (major).



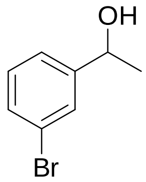
(*R*)-1-(4-Methoxyphenyl)ethanol (2i):[6] Obtained as clear liquid. ^{1}H NMR *d* 7.27-7.33 (m, 2H), 6.85-6.91 (m, 2H), 4.85 (q, *J* = 6.5 Hz, 1H), 3.81 (s, 3H), 1.92 (br s, 1H), 1.48 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 158.9, 137.9, 126.6, 113.8, 69.9, 55.6, 25.0; MS (EI): *m/z* 152 (M$^+$). The *ee* (78%) was determined using chiral HPLC (Chiralcel OB-H, n-heptane-ethanol (98:2; 2 ml/min.): t_R (min) = 13.1 (minor), 16.1 (major).



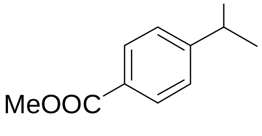
(*R*)-1-(2-Methoxyphenyl)ethanol (2j):[6] Obtained as clear liquid. ^{1}H NMR *d* 7.35 (dd, *J* = 7.9 & 1.9 Hz, 1H), 7.26 (ddd, *J* = 7.8 & 1.9 Hz, 1H), 6.86-7.04 (m, 2H), 5.1 (q, *J* = 6.5 Hz, 1H), 3.87 (s, 3H), 2.7 (br s, 1H), 1.52 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 156.5, 133.6, 128.2, 126.0, 120.7, 110.4, 66.5, 55.4, 22.8; MS (EI): *m/z* 152 (M^{+}). The *ee* (77%) was determined using chiral HPLC (Chiralcel OB-H, Heptane-ethanol (98:2; 1 ml/min.): t_{R} (min) = 9.2 (minor), 16.7 (major).



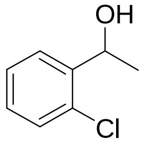
(*R*)-1-(4-Fluorophenyl)ethanol (2k):[9] Obtained as clear liquid. ^{1}H NMR *d* 7.3-7.37 (m, 2H), 6.99-7.1 (m, 2H), 4.88 (q, *J* = 6.5 Hz, 1H), 1.99 (br s, 1H), 1.48 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 162.1 (d, $J_{C\text{-}F}$ = 245 Hz), 141.5 (d, $J_{C\text{-}F}$ = 3.2 Hz), 127 (d, $J_{C\text{-}F}$ = 8.3 Hz), 115.2 (d, $J_{C\text{-}F}$ = 21.2 Hz), 69.7, 25.3; MS (EI): *m/z* 140 (M^{+}). The *ee* (62%) was determined using GC with chiral column (50 m Lipodex E, 70-180 °C): t_{R} (min) = 16.7 (major), 18.8 (minor).



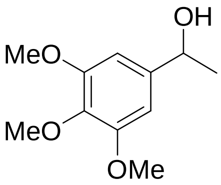
(*R*)-1-(3-Bromophenyl)ethanol (2l):[10] Obtained as clear liquid. ^{1}H NMR *d* 7.52-7.55 (m, 1H), 7.38-7.43 (m, 1H), 7.19-7.31 (m, 2H), 4.87 (q, *J* = 6.5 Hz, 1H), 2.0 (br s, 1H), 1.48 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 148.1, 130.5, 130.1, 128.5, 124, 122.6, 69.7, 25.2; MS (EI): *m/z* 200 (M^{+}). The *ee* (49%) was determined using chiral GC (50 m Lipodex E, 120-180 °C): t_{R} (min) = 36.2 (major), 38.2 (minor).



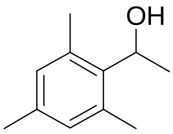
Methyl 4-(1-hydroxyethyl)benzoate (2m):[11] Obtained as thick liquid. ^{1}H NMR *d* 8.0 (m, 2H), 7.43 (m, 2H), 4.95 (q, *J* = 6.5 Hz, 1H), 3.9 (s, 3H), 2.2 (br s, 1H), 1.49 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR *d* 167.0, 150.9, 129.8, 129.2, 125.3, 69.9, 52.1, 25.3; MS (EI): *m/z* 180 (M^{+}). The *ee* (48%) was determined using chiral GC (50 m Lipodex E, 100-180 °C): t_{R} (min) = 49.1 (major), 50.0 (minor).



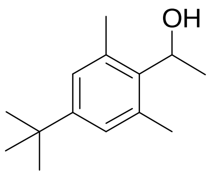
(*R*)-1-(2-Chlorophenyl)ethanol (2n):[6] Obtained as clear liquid. ^{1}H NMR *d* 7.53-7.57 (m, 1H), 7.12-7.38 (m, 3H), 5.25 (q, J = 6.5 Hz, 1H), 2.18 (br s, 1H), 1.45 (d, J = 6.5 Hz, 3H); ^{13}C NMR *d* 143.0, 131.6, 129.4, 128.3, 127.2, 126.4, 66.9, 23.5; MS (EI): *m/z* 156 (M$^+$). The *ee* (55%) was determined using chiral GC (50 m Lipodex E, 70-180 °C): t_R (min) = 38.4 (minor), 39.3 (major)



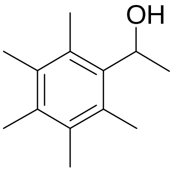
(*R*)-1-(3,4,5-Trimethoxyphenyl)ethanol (2o):[12] Obtained as a viscous liquid. ^{1}H NMR *d* 6.6 (s, 2H), 4.83 (q, J = 6.5 Hz, 1H), 3.87 (s, 6H), 3.84 (s, 3H), 1.97 (br s, 1H), 1.49 (d, J = 6.5 Hz, 3H); ^{13}C NMR *d* 153.2, 141.7, 137.0, 102.2, 70.6, 60.8, 56.0, 25.2; MS (EI): *m/z* 212 (M$^+$). The *ee* (89%) was determined using chiral HPLC (Chiralpak AD-H, n-hexane-ethanol (95:5; flow rate: 1 ml/min.): t_R (min) = 30.1 (major), 31.7 (minor).



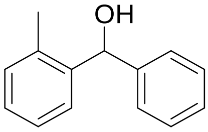
(*R*)-1-Mesitylethanol (2p):[13] Obtained as white solid. mp 65-67 ºC; ^{1}H NMR *d* 6.85 (s, 2H), 5.38 (q, J = 6.8 Hz, 1H), 2.44 (s, 6H), 2.28 (s, 3H), 1.86 (br s, 1H), 1.54 (d, J = 6.8 Hz, 3H); ^{13}C NMR *d* 137.6, 136.3, 135.6, 130.1, 67.4, 21.5, 20.6, 20.5; MS (EI): *m/z* 164 (M$^+$). The *ee* (99%) was determined using HPLC with chiral column (Chiralpak-AD-H, n-heptane-ethanol, 98:2; flow rate: 0.8 ml/min.): t_R (min) = 6.2 (major), 6.9 (minor).



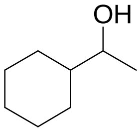
(*R*)-1-(4-*tert*-Butyl-2,6-dimethylphenyl)ethanol (2q):[14] Obtained as white solid. mp 104-106 ºC; ^{1}H NMR *d* 7.03 (s, 2H), 5.38 (q, J = 6.2 Hz, 1H), 2.47 (s, 6H), 1.79 (br s, 1H), 1.55 (d, J = 6.8 Hz, 3H), 1.32 (s, 9H); ^{13}C NMR *d* 149.5, 137.6, 135.3, 126.4, 67.5, 34.1, 31.3, 21.4, 20.9. MS (EI): *m/z* 206 (M$^+$). The *ee* (99%) was determined using HPLC with chiral column (Chiralpak-AD-H, n-heptane-ethanol, 99:1; flow rate: 1 ml/min.): t_R (min) = 11.2 (minor), 12.1 (major). The absolute configuration for this compound is tentatively assigned on the basis of other substrates in table 4.



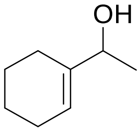
(*R*)-1-(2,3,4,5,6-Pentamethylphenyl)ethanol (2r): Obtained as white solid. mp (86-88) ºC; ^{1}H NMR *d* 5.55 (q, *J* = 6.7 Hz, 1H), 2.45 (s, 6H), 2.32 (s, 3H), 2.30 (s, 6H), 2.0 (br s, 1H), 1.64 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR *d* 138.2, 133.9, 133.3, 131.4, 67.9, 21.9, 16.9, 16.8, 16.5. MS (EI): *m/z* 192 (M^+). The *ee* (99%) was determined using HPLC with chiral column (Chiralcel-OD-H, n.heptane-ethanol, 99:1; flow rate: 1 ml/min.): t_R (min) = 9.2 (minor), 11.2 (major). The absolute configuration for this compound is tentatively assigned on the basis of other substrates in table 4.



(*R*)-Phenyl(*o*-tolyl)methanol (2s):[15] Obtained as white solid. mp 95-97 ºC; ^{1}H NMR *d* 7.52-7.56 (m, 4H), 7.71-7.35 (m, 8H), 6.02 (d, *J* = 3.5 Hz, 1H), 2.27 (s, 3H), 2.17 (d, *J* = 3.5 Hz, 1H); ^{13}C NMR *d* 142.8, 141.4, 135.4, 130.5, 128.5, 127.6, 127.5, 127.1, 126.2, 126.1, 73.3, 19.4. MS (EI): *m/z* 198 (M^+). The *ee* (51%) was determined using HPLC with chiral column (Chiralpak-AD-H, n-heptane-ethanol, 99:1; flow rate: 1 ml/min.): t_R (min) = 27.9 (major), 30.3 (minor)



(*R*)-1-Cyclohexylethanol (2t):[10,16] Obtained as clear liquid. ^{1}H NMR *d* 3.54 (m, 1H), 1.62-1.88 (m, 5H), 1.43 (br s, 1H), 0.93-1.32 (m, 9H); ^{13}C NMR *d* 72.2, 45.1, 28.7, 28.3, 26.5, 26.2, 26.1, 20.4; MS (EI): *m/z* 128 (M^+). The *ee* (45%) was determined using GC with chiral column (25 m Lipodex E, 60-180 °C): t_R (min) = 74.6 (minor), 76.9 (major).



(*R*)-1-(1-Cyclohexenyl)ethanol (2u):[39] Obtained as viscus liquid. ^{1}H NMR *d* 5.62-5.67 (m, 1H), 4.14 (q, J = 6.4 Hz, 1H), 1.93-2.07 (m, 4H), 1.5-1.68 (m, 5H), 1.23 (d, J = 6.5 Hz, 3H); ^{13}C NMR *d* 141.2, 121.4, 72.1, 24.9, 23.6, 22.6, 22.5, 21.4. MS (EI): *m/z* 126.The *ee* (79%) was determined using chiral GC (25m, Lipodex E, 70-180 °C); t_R (min) = 27.6 (minor), 28.4 (major).

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