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Substituent effect on the diastereoselectivity in the chelation-controlled radical reactions of γ-(*p*-substituted-benzyloxy)-α-methylene esters with alkyl iodides

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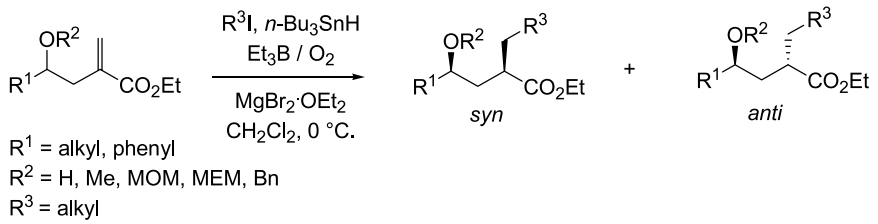
Abstract—A pronounced substituent effect on the diastereoselectivity in the chelation controlled radical reactions of ethyl γ-(*p*-substituted-benzyloxy)-α-methylenecarboxylates with alkyl iodides was observed. The *syn*-selectivity increased in the order of electron-donating ability NO_2<CN<CF_3<F<H<*i*-Pr, Me, OMe of the *p*-substituent, and the plot of the log(*syn*/*anti*) versus Hammett sigma constants gave a linear correlation. The complexation experiments of the substrates with Lewis acid using ^{1}H NMR spectroscopy and the competition experiments between *p*-isopropylbenzyloxy and *p*-trifluoromethylbenzyloxy esters showed that the electron-donating *p*-isopropyl group stabilized the seven-membered chelate ring to give high *syn*-selectivity.

1. Introduction

During the past decade the stereochemical control of acyclic radical reactions has received considerable attention and significant levels of diastereoselectivity in reactions involving stereogenic center adjacent to the radical center (1,2-asymmetric induction) have been achieved.[1] The use of mono- or bidentate Lewis acids expanded the scope of the stereoselective reactions.[2] However, to our knowledge, little is known about radical mediated 1,3-asymmetric induction.[3]

We have recently reported the chelation-controlled 1,3-asymmetric induction in the radical mediated additions to α-methylene-γ-oxycarboxylic acid esters (Scheme 1).[4] The radical reactions of γ-benzyloxy esters (R^2=Bn) with alkyl iodides performed in the presence of $MgBr_2{\cdot}OEt_2$ showed higher *syn*-selectivities compared to those of the corresponding γ-hydroxy, γ-methoxy, γ-methoxymethoxy and γ-methoxyethoxy esters (R^2=H, Me, MOM, MEM). Based on the conformational analysis of the radical intermediates obtained by combining CONFLEX and PM3 calculations,[5] we have revealed that the high *syn*-selectivity is referred to the H-atom transfer to the outside face of radical center in the sharply folded seven-membered chelate intermediates.[4c,d,6,7] In order to realize much higher diastereoselectivity in the radical reactions of γ-benzyloxy esters, we investigated the effect of *p*-substituent on the γ-benzyloxy group.

We report herein the substituent effect on the diastereoselectivity in the chelation controlled alkyl radical addition to γ-(*p*-substituted-benzyloxy)-α-methylenecarboxylic acid esters **3**–**12**. This work also includes experimental evidence for the origin of the substituent effect.



Scheme 1. Radical reactions of ethyl α-methylene-γ-oxycarboxylates with alkyl iodides.

Keywords: Radical reaction; 1,3-Asymmetric induction; Substituent effect; Seven-membered chelation.
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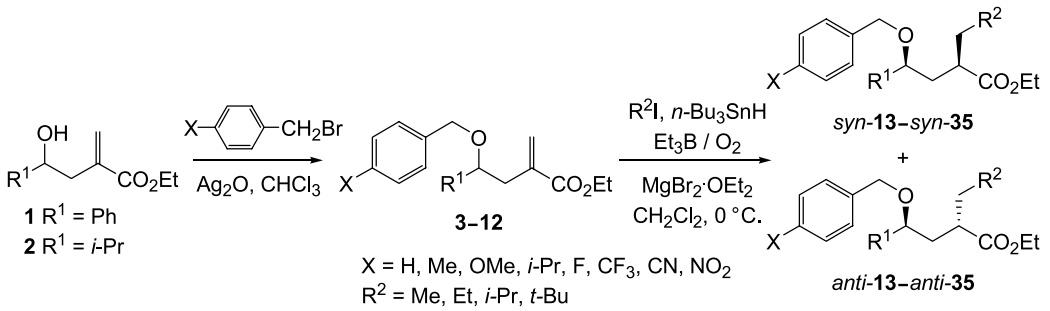


Scheme 2.

2. Results and discussion

The results of the radical reactions of γ-(*p*-substituted-benzyloxy)-α-methylene esters **3**–**12**, which were prepared by the benzylation of alcohols **1**[4a] and **2**[4b] with *p*-substituted benzyl bromides (Scheme 2), are shown in Table 1. All the reactions gave good yields except for the reaction of *p*-nitrobenzyloxy ester **3** (entry 1) and the diastereoselectivities were strongly affected by the benzyloxy substituents. In the reactions with isopropyl iodide, the *syn*-selectivity increased in the order of electron-donating ability NO_2<CN<CF_3<F<H<*i*-Pr, Me, OMe of the *p*-substituent (entries 1–8). The plot of the log(*syn*/*anti*) versus Hammett sigma constants[8,9] gave a linear correlation (r^2=0.94) with a negative slope ρ=−1.06 (Fig. 1). A similar tendency was observed in the reactions with ethyl iodide (entries 9–15) and the Hammett plot also showed a linear correlation (r^2=0.92, ρ=−1.00). Furthermore, in the reactions with methyl and *tert*-butyl radicals, the introduction of an electron-donating methyl group at the *p*-position enhanced *syn*-selectivities, however the increment of selectivity in the *tert*-butyl radical additions was smaller than those in the reaction with methyl, ethyl and isopropyl radicals (entries 16–19). The reactions of aliphatic substrate **12** with isopropyl and *tert*-butyl iodides showed that *p*-methyl substituent enhanced the *syn*-selectivities (entries 20–23). The lower *syn*-selectivity in the addition of methyl radical (entries 16 and 17) compared to the diastereoselectivities of the corresponding reactions with isopropyl and ethyl radicals (entries 5, 7, 12 and 14) has been explained by the conformational analysis of the seven-membered chelate intermediate, in which the ethoxy group of ester moiety with *E*-geometry shields the outside face of radical center.[4d,10] In the addition of *tert*-butyl radical (entries 18, 19, 22 and 23), however, the neopentyl group shields the outside face of radical center and consequently lowers the *syn*-selectivity.[4d,10]

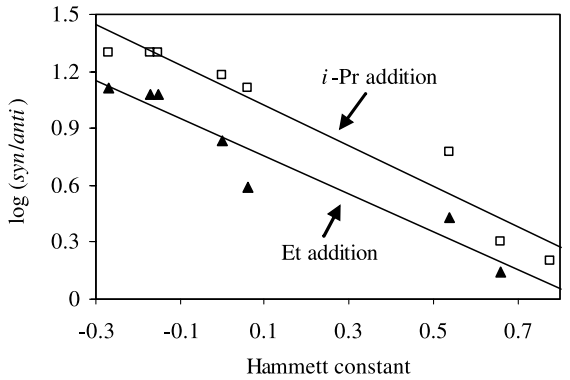


Figure 1. Plot of log(*syn*/*anti*) values versus Hammett sigma constants for the ethyl and isopropyl radical additions to **3**–**10**.

Table 1. Radical reactions of **3**–**12** with alkyl iodides R^2I in the presence of $MgBr_2{\cdot}OEt_2$[a]

Entry	Substrate	R^1	X	R^2	Product	Yield (%)	*syn*/*anti*[b]
1	**3**	Ph	NO_2	*i*-Pr	**13**	36	1.6:1
2	**4**	Ph	CN	*i*-Pr	**14**	84	2.0:1
3	**5**	Ph	CF_3	*i*-Pr	**15**	85	6.0:1
4	**6**	Ph	F	*i*-Pr	**16**	87	13:1
5[c]	**7**	Ph	H	*i*-Pr	**17**	86	15:1
6	**8**	Ph	*i*-Pr	*i*-Pr	**18**	94	>20:1
7	**9**	Ph	Me	*i*-Pr	**19**	86	>20:1
8	**10**	Ph	OMe	*i*-Pr	**20**	67	>20:1
9	**4**	Ph	CN	Et	**21**	63	1.4:1
10	**5**	Ph	CF_3	Et	**22**	97	2.7:1
11	**6**	Ph	F	Et	**23**	85	3.9:1
12	**7**	Ph	H	Et	**24**	82	6.8:1
13	**8**	Ph	*i*-Pr	Et	**25**	94	12:1
14	**9**	Ph	Me	Et	**26**	77	12:1
15	**10**	Ph	OMe	Et	**27**	63	13:1
16	**7**	Ph	H	Me	**28**	71	3.0:1
17	**9**	Ph	Me	Me	**29**	71	5.0:1
18	**7**	Ph	H	*t*-Bu	**30**	85	3.6:1
19	**9**	Ph	Me	*t*-Bu	**31**	77	4.0:1
20	**11**	*i*-Pr	H	*i*-Pr	**32**	75	11:1
21	**12**	*i*-Pr	Me	*i*-Pr	**33**	71	>20:1
22	**11**	*i*-Pr	H	*t*-Bu	**34**	67	3.7:1
23	**12**	*i*-Pr	Me	*t*-Bu	**35**	78	5.0:1

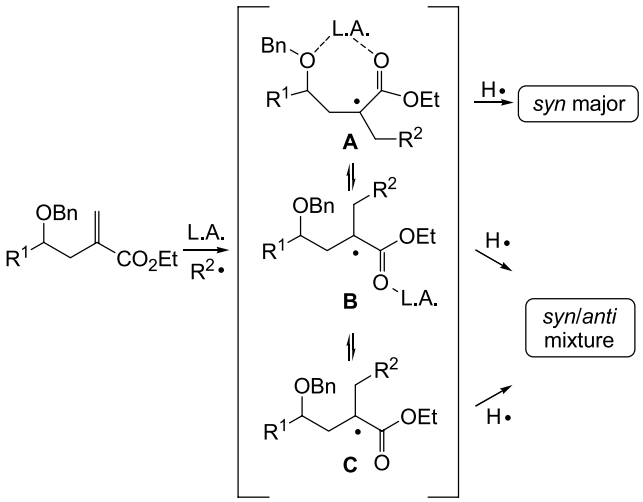
Reaction conditions: R^2I (3 equiv.), *n*-Bu_3SnH (2 equiv.), Et_3B (1 equiv.), $MgBr_2{\cdot}OEt_2$ (3 equiv.), CH_2Cl_2, 0 °C.

[a] For entries 5 and 18, see Ref. 4d; for entries 20 and 22, see Ref. 4e.

[b] The stereochemistries of the products **13**–**16**, **18**–**29** and **31** were determined by comparing their chemical shift values with those of **17** and **30**.[4d] The stereochemistries of the products **33** and **35** were determined by comparing their chemical shift values with those of **32** and **34**.[4e]

[c] Without Lewis acid, 35% yield and diastereomer ratio *syn*/*anti*=1:1.2. Use of $BF_3{\cdot}OEt_2$ (1 equiv.) instead of $MgBr_2{\cdot}OEt_2$ gave 82% yield and diastereomer ratio *syn*/*anti*=1.2:1.

The reactions would proceed through complexed radical intermediates **A** and **B** and non-complexed radical intermediate **C** being in equilibrium (Scheme 3). The seven-membered chelate intermediate **A** gives *syn*-product predominantly,[4d] while the intermediate **B** formed by monodentate coordination to the carbonyl oxygen atom and non-chelation intermediate **C** give *syn*/*anti* mixtures without stereoselectivity. The electron-donating substituents, *i*-Pr, Me and OMe, stabilize the seven-membered chelate ring and give a large population of chelate intermediate **A**. The *p*-substituents remote from the chelate ring would not affect the ring structure of intermediate **A**.



Scheme 3. Reaction pathways.

In order to gain insight into the chelate ring stability, we carried out complexation experiments of substrates **5**–**10** with $MgBr_2{\cdot}OEt_2$ using ^1H NMR spectroscopy.[11] The complexation of the substrate with 3 equiv. of $MgBr_2{\cdot}OEt_2$ in $CDCl_3$ was achieved by sonication at room temperature for 1 h.[4d] The $\Delta\delta$ values [δ_H(substrate+$MgBr_2{\cdot}OEt_2$)−δ_H(substrate)] of **5**–**10** are shown in Table 2. The chemical shift increments $\Delta\delta$ by adding the Lewis acid and in particular, the large difference of chemical shift increments between the diastereotopic β-methylene protons suggest the formation of bidentate complex. Figure 2 shows a plot of log(*syn*/*anti*) values in the ethyl and isopropyl radical additions to **5**–**10** versus $\Delta\delta$ values of one of the benzyl protons affording larger one. The increase of $\Delta\delta$ values with increasing the electron-donating ability CF_3<F<H<*i*-Pr, Me, OMe of the *p*-substituent suggests that the population of the chelate intermediates increases in the order.

Furthermore, we investigated the competition reactions of the substrates **5** and **8** bearing an electron-withdrawing trifluoromethyl group and an electron-donating isopropyl group, respectively (Scheme 4). The competition reactions

Table 2. ^1H NMR spectral data of **5**–**10** complexed with $MgBr_2{\cdot}OEt_2$

Entry	Substrate	Δδ values (ppm)			
	(X)	Bn	β-H	γ-H	Olefin
1	**5** (CF_3)	0.09 0.01	0.05 0.01	0.01	0.09 0.06
2	**6** (F)	0.20 0.01	0.15 0.02	0.01	0.18 0.15
3	**7** (H)	0.50 0.01	0.33 0.03	0.00	0.26 0.21
4	**8** (*i*-Pr)	0.56 0.02	0.34 0.05	0.22	0.22 0.19
5	**9** (Me)	0.62 0.02	0.38 0.09	0.25	0.25 0.21
6	**10** (OMe)	0.62 0.03	0.34 0.07	0.03	0.21 0.16

Δδ values: [δ_H(substrate+$MgBr_2{\cdot}OEt_2$)−δ_H(substrate)].

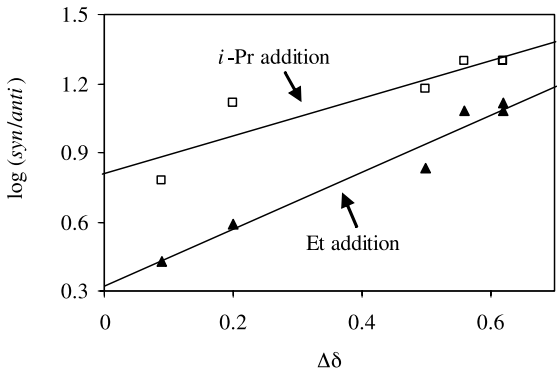


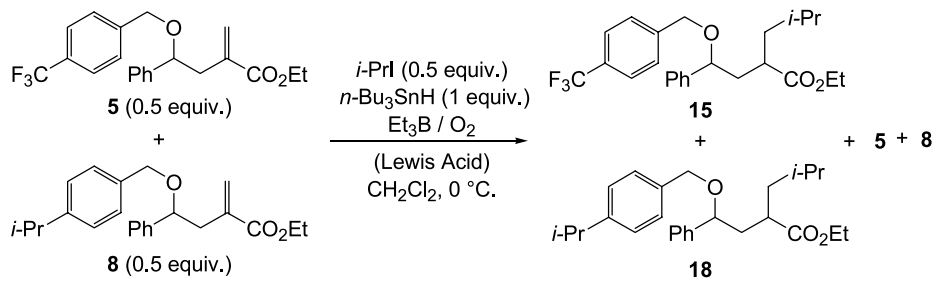
Figure 2. Plot of log(*syn*/*anti*) versus $\Delta\delta$ values [δ_H(substrate+$MgBr_2{\cdot}OEt_2$)−δ_H(substrate)] of benzyl proton for the ethyl and isopropyl radical additions to **5**–**10**.

of **5** (0.5 equiv.) and **8** (0.5 equiv.) with isopropyl iodide (0.5 equiv.), *n*-Bu_3SnH (1 equiv.) and Et_3B (1 equiv.) were carried out in the presence of Lewis acid, $MgBr_2{\cdot}OEt_2$ (3 equiv.) or $BF_3{\cdot}OEt_2$ (1 equiv.), and in the absence of Lewis acid. The unreacted substrates **5** and **8** were recovered and their ratios were obtained by integrating ^1H NMR signals. The substrates **5** and **8** showed equal reactivity in the absence of Lewis acid. The complexation with Lewis acids would lower the LUMO energy of the substrates and enhance the rate of the nucleophilic alkyl radical addition reactions.[12] Monodentate Lewis acid, $BF_3{\cdot}OEt_2$, coordinating to the carbonyl oxygen of the substrates **5** and **8**, enhanced the reactivity of both the substrates equally, but did not affect their diastereoselectivities (see, footnote c in Table 1). In the presence of $MgBr_2{\cdot}OEt_2$, however, substrate **8** reacted faster than **5**. The higher reactivity and higher *syn*-selectivity as well (Table 1, entries 3 and 6) of **8** represent the more efficient chelation of the *p*-isopropylbenzyloxy group with $MgBr_2{\cdot}OEt_2$ compared to *p*-trifluoromethylbenzyloxy group.

Finally, we compared the substituent effects with those of the chelation-controlled radical reactions of β-benzyloxy-α-methylene esters **36** and **37** derived from the corresponding Baylis–Hillman adducts (Scheme 5).[1,13] The isopropyl radical addition to β-benzyloxy-α-methylene ester **36** and *p*-methylbenzyloxy ester **37**[14] in the presence of $MgBr_2{\cdot}OEt_2$ performed at −78 °C gave **38** and **39** in good yields with *syn*-selectivities. Similarly to the reaction of **7** and **9** (Table 1, entries 5 and 7), the *syn*-selectivity of **37** was also higher than that of **36**. However, the reactions of **36** and **37** at 0 °C gave no substituent effect.

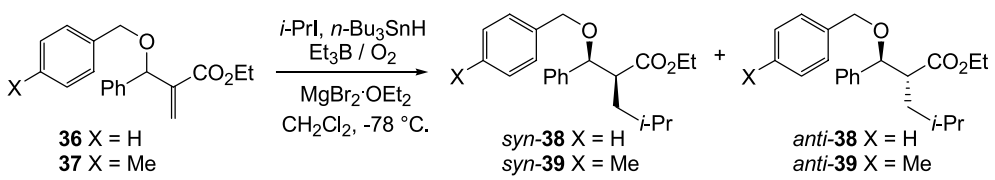
3. Conclusion

In summary, we have shown the substituent effect on chelation-controlled 1,3-asymmetric induction in the reactions of γ-(*p*-substituted-benzyloxy)-α-methylene esters with alkyl iodides. The *syn*-selectivity increased in the order of electron-donating ability NO_2<CN<CF_3<F<H<*i*-Pr, Me, OMe of the *p*-substituent, and the plot of log(*syn*/*anti*) versus Hammett sigma constants gave a linear correlation. The electron-donating substituents *i*-Pr, Me and OMe, stabilize the seven-membered chelate rings and yield *syn*-products predominantly.



	unreacted substrates 5 : 8
without Lewis Acid	1 : 1.1
with $BF_3{\cdot}OEt_2$	1.1 : 1
with $MgBr_2{\cdot}OEt_2$	1.7 : 1

Scheme 4. Competitive radical reactions of **5** and **8** with isopropyl iodide.



	yield (%)	*syn*	:	*anti*
X = H	88	4.6	:	1
X = Me	95	5.6	:	1

Scheme 5. Radical reactions of **36** and **37** with isopropyl iodide in the presence of $MgBr_2{\cdot}OEt_2$.

4. Experimental

4.1. General

^{1}H NMR spectra were recorded on a JEOL GSX-270 (270 MHz) or GSX-400 (400 MHz) spectrometer with $CDCl_3$ as the solvent and tetramethylsilane as an internal standard. ^{13}C NMR spectra were recorded on the instruments operating at 67.9 or 100.5 MHz with $CDCl_3$ as the solvent and internal standard (δ 77.0). IR spectra were taken on a SHIMADZU FTIR-8700 spectrometer. Mass spectra (EI^+) were obtained on a JEOL JMS-700 mass spectrometer. Precoated Merck Kieselgel 60 F_{254} and Kanto silica gel 60 (spherical neutral) were used for thin layer chromatography and flash chromatography, respectively.

4.2. Preparation of the substrates 3–6, 8–10, 12, 36 and 37

Substrates **3**–**6** and **8**–**10** were prepared from **1** and *p*-nitrobenzyl bromide, *p*-cyanobenzyl bromide, *p*-trifluoromethylbenzyl bromide, *p*-fluorobenzyl bromide, *p*-isopropylbenzyl bromide, *p*-methylbenzyl bromide and *p*-methoxybenzyl bromide, respectively, following the procedures reported previously.[4c] Substrate **12** was prepared from **2** and *p*-methylbenzyl bromide following the procedures reported previously.[4d] Treatment of ethyl 2-(hydroxyphenylmethyl)propenoate with benzyl trichloroacetimidate and *p*-methylbenzyl trichloroacetimidate gave **36** and **37**, respectively.[14]

4.2.1. Ethyl 2-[2-(*p*-nitrobenzyloxy)-2-phenylethyl]propenoate 3. ^{1}H NMR (270 MHz) δ 8.16 (2H, d, J=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.43 (2H, d, J=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.32 (5H, m, Ph), 6.20 (1H, d, J=1.4 Hz, =C*H*H), 5.54 (1H, d, J=1.4 Hz, =CH*H*), 4.58 (1H, dd, J=8.1, 5.1 Hz, CH), 4.53 (1H, d, J=13.5 Hz, C*H*HPh), 4.37 (1H, d, J=13.5 Hz, CH*H*Ph), 4.16 (2H, q, J=7.0 Hz, $CO_2CH_2CH_3$), 2.87 (1H, ddd, J=14.0, 8.4, 1.1 Hz, CHC*H*H), 2.71 (1H, ddd, J=14.0, 5.4, 1.1 Hz, CHCH*H*), 1.28 (3H, t, J=7.0 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (67.5 MHz) δ 166.8, 147.0, 146.1, 141.0, 136.8, 128.5, 127.9, 127.6, 127.5, 126.6, 123.4, 80.7, 69.3, 60.7, 41.2, 14.3; IR (neat) 2978, 2881, 2348, 1718, 1521, 1346, 1194, 1149, 1077, 855, 739, 702 cm^{-1}; MS *m*/*z* 310 (M^+−OEt, 1%), 242 (67), 173 (15), 167 (21), 136 (100), 129 (19), 105 (30), 91 (49); HRMS calcd for $C_{18}H_{16}NO_4$ [M^+−OEt] 310.1080, found 310.1101.

4.2.2. Ethyl 2-[2-(*p*-cyanobenzyloxy)-2-phenylethyl]propenoate 4. ^{1}H NMR (400 MHz) δ 7.60 (2H, d, J=8.1 Hz, *p*-$NCC_6H_2H_2$), 7.37 (2H, d, J=8.1 Hz, *p*-$NCC_6H_2H_2$), 7.30 (5H, m, Ph), 6.19 (1H, d, J=1.6 Hz, =C*H*H), 5.53 (1H, d, J=1.6 Hz, =CH*H*), 4.55 (1H, dd, J=8.4, 5.1 Hz, CH), 4.48 (1H, d, J=13.0 Hz, *p*-NCC_6H_4CHH), 4.32 (1H, d, J=13.0 Hz, *p*-NCC_6H_4CHH), 4.16 (2H, q, J=7.0 Hz, $CO_2CH_2CH_3$), 2.85 (1H, dd, J=14.0, 8.4 Hz, CHC*H*H), 2.69 (1H, dd, J=14.0, 5.1 Hz, CHCH*H*), 1.27 (3H, t, J=7.0 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.8, 144.0, 141.0, 133.3, 132.3, 131.9, 129.6, 128.4, 128.1, 127.5, 126.6, 111.0, 80.6, 69.5, 60.7, 41.1, 14.3; IR (neat) 2911, 2870, 2229, 1704, 1601, 1448, 1270, 1071, 1027, 950, 821, 703 cm^{-1}; MS *m*/*z* 290 (M^+−OEt, 4%), 223 (49), 219 (21), 173 (48), 129 (35), 116 (100), 105 (85), 91 (25); HRMS calcd for $C_{19}H_{16}NO_2$ [M^+−OEt] 290.1181, found 290.1176.

4.2.3. Ethyl 2-[2-(*p*-trifluoromethylbenzyloxy)-2-phenylethyl]propenoate 5. ^{1}H NMR (270 MHz) δ 7.55 (2H, d, J=8.1 Hz, p-$CF_3C_6H_2H_2$), 7.35 (2H, d, J=8.1 Hz, p-$CF_3C_6H_2H_2$), 7.33 (5H, m, Ph), 6.18 (1H, d, J=1.6 Hz, =C*H*H), 5.53 (1H, d, J=1.6 Hz, =CH*H*), 4.55 (1H, dd, J=8.0, 5.2 Hz, CH), 4.50 (1H, d, J=11.3 Hz, p-$CF_3C_6H_4$-C*H*H), 4.31 (1H, d, J=11.3 Hz, p-$CF_3C_6H_4CH$*H*), 4.14 (2H, q, J=7.0 Hz, $CO_2CH_2CH_3$), 2.83 (1H, dd, J=13.2, 8.0 Hz, CHC*H*H), 2.69 (1H, dd, J=13.2, 5.2 Hz, CHCH*H*), 1.25 (3H, t, J=7.0 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.9, 142.5, 141.3, 136.9, 129.5 (q, J_{C-F}=32 Hz), 128.4, 127.8, 127.5, 127.4, 126.6, 125.1 (q, J_{C-F}=3.6 Hz), 124.1 (q, J_{C-F}=270 Hz), 80.2, 69.6, 60.7, 41.2, 14.2; IR (neat) 2992, 2926, 1717, 1623, 1456, 1419, 1326, 1067, 1018, 823, 760, 702 cm^{-1}; MS m/z 219 ($M^+-CH_2C_6H_4CF_3$-p, 5%), 203 (7), 173 (13), 159 (10), 129 (13), 109 (25), 105 (29), 91 (19); HRMS calcd for $C_{13}H_{15}O_2$ [$M^+-CH_2C_6H_4CF_3$-p] 219.1021, found 219.0993.

4.2.4. Ethyl 2-[2-(*p*-fluorobenzyloxy)-2-phenylethyl]propenoate 6. ^{1}H NMR (400 MHz) δ 7.23–7.30 (9H, m, Ph, C_6H_4), 6.17 (1H, d, J=1.6 Hz, =C*H*H), 5.50 (1H, d, J=1.6 Hz, =CH*H*), 4.53 (1H, dd, J=8.0, 5.2 Hz, CH), 4.41 (1H, d, J=11.3 Hz, p-FC_6H_4C*H*H), 4.21 (1H, d, J=11.3 Hz, p-FC_6H_4CH*H*), 4.14 (2H, q, J=7.0 Hz, $CO_2CH_2CH_3$), 2.81 (1H, dd, J=14.0, 8.0 Hz, CHC*H*H), 2.66 (1H, dd, J=14.0, 5.2 Hz, CHCH*H*), 1.26 (3H, t, J=7.0 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.9, 162.1 (d, J_{C-F}=239 Hz), 141.5, 137.0, 134.1 (d, J_{C-F}=2.8 Hz), 129.2, 128.4, 127.7, 127.4, 126.7, 115.0 (d, J_{C-F}=21 Hz), 79.8, 69.8, 60.6, 41.2, 14.2; IR (neat) 2978, 1718, 1628, 1603, 1509, 1307, 1223, 1193, 1148, 1074, 948, 824, 759 cm^{-1}; MS m/z 219 ($M^+-CH_2C_6H_4F$-p, 12%), 215 (97), 173 (25), 129 (26), 110 (55), 109 (100), 105 (32), 91 (40); HRMS calcd for $C_{13}H_{15}O_3$ [$M^+-CH_2C_6H_4F$-p] 219.1021, found 219.0992.

4.2.5. Ethyl 2-[2-(*p*-isopropylbenzyloxy)-2-phenylethyl]propenoate 8. ^{1}H NMR (270 MHz) δ 7.18–7.35 (9H, m, Ph, C_6H_4), 6.18 (1H, d, J=1.6 Hz, =C*H*H), 5.51 (1H, d, J=1.6 Hz, =CH*H*), 4.55 (1H, dd, J=8.4, 5.4 Hz, C*H*Ph), 4.55 (1H, d, J=11.6 Hz, p-i-PrC_6H_4C*H*H), 4.22 (1H, d, J=11.6 Hz, p-i-PrC_6H_4CH*H*), 4.13 (2H, q, J=7.3 Hz, $CO_2CH_2CH_3$), 2.89 (1H, sep, J=7.0 Hz, C*H*$(CH_3)_2$), 2.81 (1H, dd, J=14.3, 8.4 Hz, CHC*H*H), 2.66 (1H, dd, J=14.3, 5.4 Hz, CHCH*H*), 1.24 (6H, d, J=7.0 Hz, CH$(CH_3)_2$), 1.24 (3H, t, J=7.3 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.9, 148.0, 144.0, 141.8, 137.0, 128.3, 127.7, 127.5, 127.4, 126.7, 126.2, 79.7, 70.4, 60.6, 41.2, 33.9, 24.1, 14.3; IR (neat) 2956, 2869, 1716, 1634, 1456, 1305, 1146, 1019, 817, 760, 701 cm^{-1}; MS m/z 219 ($M^+-CH_2C_6H_4i$-Pr-p, 8%), 204 (73), 173 (31), 158 (24), 149 (42), 134 (85), 133 (100), 129 (41), 118 (49), 105 (66), 91 (63); HRMS calcd for $C_{13}H_{15}O_3$ [$M^+-CH_2C_6H_4i$-Pr-p] 219.1021, found 219.0993.

4.2.6. Ethyl 2-[2-(*p*-methylbenzyloxy)-2-phenylethyl]propenoate 9. ^{1}H NMR (270 MHz) δ 7.09–7.35 (9H, m, Ph, C_6H_4), 6.17 (1H, d, J=1.4 Hz, =C*H*H), 5.51 (1H, d, J=1.4 Hz, =CH*H*), 4.54 (1H, dd, J=8.2, 5.1 Hz, CH), 4.42 (1H, d, J=11.6 Hz, p-MeC_6H_4C*H*H), 4.20 (1H, d, J=11.6 Hz, p-MeC_6H_4CH*H*), 4.13 (2H, q, J=7.3 Hz, $CO_2CH_2CH_3$), 2.80 (1H, dd, J=14.2, 8.2 Hz, CHC*H*H), 2.65 (1H, dd, J=14.2, 5.1 Hz, CHCH*H*), 2.33 (3H, s, p-Me), 1.23 (3H, t, J=7.3 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.9, 141.8, 137.0, 135.3, 128.8, 128.3, 127.7, 127.5, 127.4, 126.7, 126.2, 79.5, 70.3, 60.6, 41.1, 21.2, 14.2; IR (neat) 2986, 2926, 1718, 1634, 1456, 1307, 1191, 1148, 1074, 941, 803, 757, 702 cm^{-1}; MS m/z 219 ($M^+-CH_2C_6H_4$-Me-p, 5%), 209 (67), 149 (84), 129 (17), 117 (13), 105 (100), 91 (54); HRMS calcd for $C_{13}H_{15}O_2$ [$M^+-OCH_2C_6H_4$Me-p] 203.1072, found 203.1071.

4.2.7. Ethyl 2-[2-(*p*-methoxybenzyloxy)-2-phenylethyl]propenoate 10. ^{1}H NMR (270 MHz) δ 7.26–7.36 (5H, m, Ph), 7.18 (2H, d, J=12.8 Hz, p-$MeOC_6H_2H_2$), 6.84 (2H, d, J=12.8 Hz, p-$MeOC_6H_2H_2$), 6.15 (1H, d, J=1.6 Hz, =C*H*H), 5.49 (1H, d, J=1.6 Hz, =CH*H*), 4.53 (1H, dd, J=8.4, 4.9 Hz, CH), 4.39 (1H, d, J=11.6 Hz, p-$MeOC_6H_4$-C*H*H), 4.18 (1H, d, J=11.6 Hz, p-$MeOC_6H_4CH$*H*), 4.13 (2H, q, J=7.3 Hz, $CO_2CH_2CH_3$), 3.79 (3H, s, p-MeO), 2.80 (1H, dd, J=14.0, 8.4 Hz, CHC*H*H), 2.64 (1H, dd, J=14.0, 4.9 Hz, CHCH*H*), 1.25 (3H, t, J=7.3 Hz $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 166.9, 159.0, 141.8, 137.0, 129.3, 129.2, 128.3, 127.5, 127.3, 126.7, 113.6, 79.4, 71.5, 60.6, 55.3, 41.1, 14.3; IR (neat) 2836, 1714, 1612, 1513, 1302, 1248, 1135, 820, 758, 702 cm^{-1}; MS m/z 340 (M^+, 2%), 258 (22), 219 (2), 203 (3), 137 (35), 121 (100); HRMS calcd for $C_{21}H_{24}O_4$ [M^+] 340.1674, found 340.1677.

4.2.8. Ethyl 2-[2-(*p*-methylbenzyloxy)-3-methylbutyl]propenoate 12. ^{1}H NMR (270 MHz) δ 7.10–7.24 (4H, m, C_6H_4), 6.19 (1H, d, J=1.6 Hz, =C*H*H), 5.63 (1H, d, J=1.6 Hz, =CH*H*), 4.43 (2H, s, p-$MeC_6H_4CH_2$), 4.18 (2H, q, J=7.0 Hz, $CO_2CH_2CH_3$), 3.38 (1H, dd, J=8.4, 4.1 Hz, i-PrC*H*), 2.56 (1H, dd, J=10.5, 4.1 Hz, CHC*H*H), 2.41 (1H, dd, J=13.4, 8.4 Hz, CHCH*H*), 2.32 (3H, s, p-Me), 1.89 (1H, m, C*H*$(CH_3)_2$), 1.29 (3H, t, J=7.0 Hz, $CO_2CH_2CH_3$), 0.95 (3H, d, J=6.8 Hz, CHCH_3), 0.94 (3H, d, J=6.8 Hz, CHCH_3); ^{13}C NMR (67.5 MHz) δ 167.2, 138.1, 136.8, 135.8, 128.8, 127.7, 126.9, 82.3, 72.0, 60.6, 34.0, 31.0, 21.2, 18.3, 17.9, 14.3; IR (neat) 2874, 1716, 1610, 1270, 1181, 1021, 808, 755 cm^{-1}; MS m/z 290 (M^+, 13%), 217 (15), 185 (3), 169 (3), 144 (18), 121 (18), 105 (100); HRMS calcd for $C_{18}H_{26}O_3$ [M^+] 290.1882, found 290.1843.

4.2.9. Ethyl 2-benzyloxyphenylmethyl propenoate 36. ^{1}H NMR (400 MHz) δ 7.21–7.40 (10H, m, 2×Ph), 6.35 (1H, s, CH), 6.01 (1H, s, =C*H*H), 5.34 (1H, s, =CH*H*), 4.48 (2H, s, CH_2Ph), 4.15 (2H, dq, J=7.3, 11.2 Hz, CO_2CH*H*CH_3), 4.12 (2H, dq, J=7.3, 11.2 Hz, CO_2CH*H*CH_3), 1.22 (3H, t, J=7.3 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 165.7, 141.4, 139.5, 138.1, 128.4, 128.2, 127.8, 127.7, 127.6, 127.5, 124.9, 78.6, 70.8, 60.7, 14.1; MS m/z 205 (M^+-Bn, 22%), 203 (7), 190 (41), 178 (16), 159 (17); HRMS calcd for $C_{12}H_{13}O_3$ [M^+-Bn] 205.0865, found 205.0873.

4.2.10. Ethyl 2-(*p*-methylbenzyloxy)phenylmethyl propenoate 37. ^{1}H NMR (400 MHz) δ 7.29–7.39 (5H, m, Ph), 7.21 (2H, d, J=7.3 Hz, $C_6H_2H_2$), 7.13 (2H, d, J=7.3 Hz, $C_6H_2H_2$), 6.35 (1H, s, CH), 6.00 (1H, s, =C*H*H), 5.33 (1H, s, =CH*H*), 4.44 (2H, s, CH_2Ph), 4.13 (2H, dq, J=7.3, 12.2 Hz, CO_2CH*H*CH_3), 4.10 (2H, dq, J=7.3, 12.2 Hz, CO_2CH*H*CH_3), 2.34, (3H, s, p-Me), 1.22 (3H, t, J=7.3 Hz, $CO_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 165.7, 141.4, 139.6, 137.1, 135.0, 128.9, 128.2, 127.7, 127.6, 127.5, 124.8, 78.4, 70.6, 60.7, 21.2, 14.1; MS m/z 205 $M^+-CH_2C_6H_4$Me-p,

5%), 190 (68), 144 (19), 121 (32), 116 (33); HRMS calcd for $C_{12}H_{13}O_3$ [$M^+-CH_2C_6H_4Me$-*p*] 205.0865, found 205.0873.

4.3. Radical reactions

General procedure of the radical reactions. To a solution of α-methylene ester (0.15 mmol) in dry CH_2Cl_2 (1.5 cm^3) was added $MgBr_2{\cdot}OEt_2$ (0.45 mmol, 3 equiv.), and the mixture was stirred at room temperature for 10 min. To the suspension cooled to 0 °C were added alkyl iodide (0.45 mmol, 3 equiv.), *n*-Bu_3SnH (0.30 mmol, 2 equiv.) and Et_3B (1.06 mol dm^{-3} in hexane; 0.15 mmol, 1 equiv.). The mixture was stirred at 0 °C for 3 h. KF and water were added and the reaction mixture was stirred at room temperature for 3 h. After filtration, the solvent was evaporated in vacuo. The residue was purified by flash chromatography on silica gel to give the product as an oily inseparable diastereomeric mixture.

4.3.1. Ethyl 4-methyl-2-[2-(*p*-nitrobenzyloxy)-2-phenylethyl]pentanoate 13 (*syn* and *anti*). IR (neat) 2870, 1726, 1606, 1522, 1453, 1364, 1097, 1015, 844, 739, 702 cm^{-1}; MS *m*/*z* 354 (M^+-OEt, 3%), 263 (16), 242 (83), 217 (71), 203 (17), 136 (100), 105 (40), 91(15); HRMS calcd for $C_{21}H_{24}NO_3$ [M^+-OEt] 354.1706, found 354.1720. *syn*: ^1H NMR (270 MHz) δ 8.16 (2H, d, *J*=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.43 (2H, d, *J*=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.32 (5H, m, Ph), 4.44 (1H, d, *J*=13.5 Hz, *p*-$NO_2C_6H_4CHH$), 4.34 (2H, m, PhC*H*, *p*-$NO_2C_6H_4CHH$), 4.03 (2H, m, $CO_2CH_2CH_3$), 2.83 (1H, m, $CHCO_2Et$), 1.96 (2H, m, $CHCH_2CH$), 1.58 (3H, m, $CH(CH_3)_2$, *i*-$PrCH_2$), 1.23 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.90 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.88 (3H, d, *J*=6.4 Hz, $CHCH_3$). *anti*: ^1H NMR (270 MHz) δ 8.16 (2H, d, *J*=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.43 (2H, d, *J*=8.9 Hz, *p*-$NO_2C_6H_2H_2$), 7.32 (5H, m, Ph), 4.44 (1H, d, *J*=13.5 Hz, *p*-$NO_2C_6H_4CHH$), 4.34 (2H, m, *p*-$NO_2C_6H_4CHH$, PhC*H*), 4.03 (2H, m, $CO_2CH_2CH_3$), 2.47 (1H, m, $CHCO_2Et$), 2.32 (1H, m, $CHCHHCH$), 1.74 (1H, m, $CHCHHCH$), 1.58 (3H, m, $CH(CH_3)_2$, *i*-$PrCH_2$), 1.19 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.85 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.80 (3H, d, *J*=6.4 Hz, $CHCH_3$).

4.3.2. Ethyl 2-[2-(*p*-cyanobenzyloxy)-2-phenylethyl]-4-methylpentanoate 14 (*syn* and *anti*). IR (neat) 2966, 2870, 2228, 1729, 1456, 1269, 1176, 1021, 821, 703 cm^{-1}; MS *m*/*z* 334 (M^+-OEt, 3%), 263 (14), 247 (16), 222 (31), 217 (48), 116 (91), 105 (48), 91 (11); HRMS calcd for $C_{22}H_{24}NO_2$ [M^+-OEt] 334.1807, found 334.1768. *syn*: ^1H NMR (400 MHz) δ 7.28–7.69 (9H, m, Ph, C_6H_4), 4.44 (1H, d, *J*=12.8 Hz, *p*-NCC_6H_4CHH), 4.34 (1H, m, PhC*H*), 4.30 (1H, d, *J*=12.4 Hz, *p*-NCC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.82 (1H, m, $CHCO_2Et$), 1.95 (2H, m, $CHCH_2CH$), 1.55 (2H, m, *i*-$PrCH_2$), 1.26 (1H, m, $CH(CH_3)_2$), 1.23 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.90 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.87 (3H, d, *J*=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.1, 143.9, 141.5, 132.0, 128.5, 128.4, 128.2, 127.8, 126.6, 111.0, 80.4, 69.8, 60.1, 42.2, 41.7, 40.4, 20.1, 22.9, 22.3, 14.3. *anti*: ^1H NMR (400 MHz) δ 7.28–7.69 (9H, m, Ph, C_6H_4), 4.44 (1H, d, *J*=12.8 Hz, *p*-NCC_6H_4CHH), 4.34 (1H, m, PhC*H*), 4.30 (1H, d, *J*=12.4 Hz, *p*-NCC_6H_4CHH), 4.00 (2H, m, $CO_2CH_2CH_3$), 2.46 (1H, m, $CHCO_2Et$), 2.28 (1H, ddd, *J*=13.6, 8.4, 8.4 Hz, $CHCHHCH$), 1.73 (1H, ddd, *J*=14.0, 4.8, 4.8 Hz, $CHCHHCH$), 1.55 (2H, m, *i*-$PrCH_2$), 1.26 (1H, m, $CH(CH_3)_2$), 1.18 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.85 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.80 (3H, d, *J*=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.1, 143.9, 141.1, 132.0, 128.6, 128.4, 128.0, 127.7, 126.4, 111.0, 80.8, 69.4, 60.1, 42.5, 41.2, 41.1, 25.0, 22.9, 22.1, 14.4.

4.3.3. Ethyl 4-methyl-2-[2-phenylethyl-2-(*p*-trifluoromethylbenzyloxy)]pentanoate 15 (*syn* and *anti*). IR (neat) 2958, 2871, 2331, 1733, 1455, 1326, 1165, 1125, 1066, 1018, 823, 702 cm^{-1}; MS *m*/*z* 393 (M^+-Et, 17%), 377 (3), 265 (61), 247 (11), 217 (97), 159 (100), 109 (12), 105 (34); HRMS calcd for $C_{22}H_{24}O_3F_3$ [M^+-Et] 393.1678, found 393.1700. *syn*: ^1H NMR (400 MHz) δ 7.59 (2H, d, *J*=8.1 Hz, *p*-$CF_3C_6H_2H_2$), 7.43 (2H, d, *J*=8.1 Hz, *p*-$CF_3C_6H_2H_2$), 7.30 (5H, m, Ph), 4.46 (1H, d, *J*=11.3 Hz, *p*-$CF_3C_6H_4CHH$), 4.31 (1H, dd, *J*=9.6, 3.6 Hz, PhC*H*), 4.29 (1H, d, *J*=11.3 Hz, *p*-$CF_3C_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.84 (1H, m, $CHCO_2Et$), 1.97 (1H, ddd, *J*=14.0, 9.6, 4.0 Hz, $CHCHHCH$), 1.90 (1H, ddd, *J*=14.0, 9.2, 3.6 Hz, $CHCHHCH$), 1.55 (2H, m, *i*-$PrCH_2$), 1.25 (1H, m, $CH(CH_3)_2$), 1.22 (3H, t, *J*=7.0 Hz, $CO_2CH_2CH_3$), 0.90 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.87 (3H, d, *J*=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.1, 142.4, 141.7, 129.6 (q, J_{C-F}=32 Hz), 129.4, 128.5, 127.6, 126.4, 125.1 (q, J_{C-F}=3.6 Hz), 124.1 (q, J_{C-F}=270 Hz), 80.3, 70.0, 60.1, 42.2, 41.0, 40.4, 26.1, 22.9, 22.3, 14.4. *anti*: ^1H NMR (400 MHz) δ 7.59 (2H, d, *J*=8.1 Hz, *p*-$CF_3C_6H_2H_2$), 7.43 (2H, d, *J*=8.1 Hz, *p*-$CF_3C_6H_2H_2$), 7.30 (5H, m, Ph), 4.46 (1H, d, *J*=11.3 Hz, *p*-$CF_3C_6H_4CHH$), 4.33 (1H, dd, *J*=9.6, 3.6 Hz, PhC*H*), 4.29 (1H, d, *J*=11.3 Hz, *p*-$CF_3C_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.47 (1H, m, $CHCO_2Et$), 2.27 (1H, ddd, *J*=14.0, 9.6, 9.6 Hz, $CHCHHCH$), 1.72 (1H, ddd, *J*=14.0, 3.6, 3.6 Hz, $CHCHHCH$), 1.55 (2H, m, *i*-$PrCH_2$), 1.25 (1H, m, $CH(CH_3)_2$), 1.17 (3H, t, *J*=7.0 Hz, $CO_2CH_2CH_3$), 0.85 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.80 (3H, d, *J*=6.4 Hz, $CHCH_3$).

4.3.4. Ethyl 2-[2-(*p*-fluorobenzyloxy)-2-phenylethyl]-4-methylpentanoate 16 (*syn* and *anti*). IR (neat) 2870, 2359, 1734, 1509, 1224, 1016, 824, 702 cm^{-1}; MS *m*/*z* 327 (M^+-OEt, 3%), 263 (20), 247 (4), 219 (96), 144 (68), 125 (62), 109 (100), 101 (50); HRMS calcd for $C_{21}H_{24}O_2F$ [M^+-OEt] 327.1760, found 327.1754. *syn*: ^1H NMR (400 MHz) δ 7.26–7.38 (7H, m, Ph, *p*-$FC_6H_2H_2$), 6.99 (2H, m, *p*-$FC_6H_2H_2$), 4.37 (1H, d, *J*=11.2 Hz, *p*-FC_6H_4CHH), 4.28 (1H, dd, *J*=9.4, 4.0 Hz, PhC*H*), 4.19 (1H, d, *J*=11.2 Hz, *p*-FC_6H_4CHH), 4.06 (2H, m, $CO_2CH_2CH_3$), 2.83 (1H, m, $CHCO_2Et$), 1.91 (2H, m, $CHCH_2CH$), 1.54 (2H, m, *i*-$PrCH_2$), 1.24 (1H, m, $CH(CH_3)_2$), 1.23 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.89 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.86 (3H, d, *J*=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.2, 162.1 (d, J_{C-F}=243 Hz), 142.0, 134.0, 129.7 (d, J_{C-F}=8.2 Hz), 128.4, 127.8, 126.4, 115.0 (d, J_{C-F}=21 Hz), 79.6, 69.5, 59.7, 42.3, 41.6, 40.4, 26.0, 22.9, 22.2, 14.4. *anti*: ^1H NMR (400 MHz) δ 7.26–7.38 (7H, m, Ph, *p*-$FC_6H_2H_2$), 6.99 (2H, m, *p*-$FC_6H_2H_2$), 4.37 (1H, d, *J*=11.2 Hz, *p*-FC_6H_4CHH), 4.28 (1H, dd, *J*=9.4, 4.0 Hz, PhC*H*), 4.19 (1H, d, *J*=11.2 Hz, *p*-FC_6H_4CHH), 4.06 (2H, m, $CO_2CH_2CH_3$), 2.46 (1H, m, $CHCO_2Et$), 2.24 (1H, m, $CHCHHCH$), 1.70 (1H, m, $CHCHHCH$), 1.54 (2H, m, *i*-$PrCH_2$), 1.24 (1H, m, $CH(CH_3)_2$), 1.19 (3H, t, *J*=7.2 Hz, $CO_2CH_2CH_3$), 0.85 (3H, d, *J*=6.4 Hz, $CHCH_3$), 0.79 (3H, d, *J*=6.4 Hz, $CHCH_3$).

4.3.5. Ethyl 2-[2-(*p*-isopropylbenzyloxy)-2-phenylethyl]-4-methylpentanoate 18 (*syn* and *anti*). IR (neat) 2868, 2362, 1733, 1456, 1177, 1019, 818, 701 cm^{-1}; MS *m*/*z* 280 (M^+-CO_2Et-*i*-Pr, 4%), 247 (12), 217 (32), 149 (24), 133 (100), 101 (37); HRMS calcd for $C_{20}H_{24}O$ [M^+-CO_2Et-*i*-Pr] 280.1827, found 280.1828. *syn*: ^1H NMR (400 MHz) δ 7.17–7.36 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.29 (1H, dd, J=9.2, 4.4 Hz, PhC*H*), 4.22 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.90 (1H, sep, J=6.8 Hz, $CH(CH_3)_2$), 2.86 (1H, m, $CHCO_2Et$), 1.90 (2H, m, $CHCH_2CH$), 1.55 (3H, m, *i*-$PrCH_2$, $CH(CH_3)_2$), 1.24 (6H, d, J=6.8 Hz, $CH(CH_3)_2$), 1.23 (3H, t, J=7.6 Hz, $CO_2CH_2CH_3$), 0.89 (3H, d, J=6.4 Hz, $CHCH_3$), 0.86 (3H, d, J=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.3, 148.1, 142.3, 135.6, 128.4, 127.9, 127.5, 126.4, 126.3, 79.5, 70.7, 60.0, 42.3, 41.8, 40.4, 26.1, 24.1, 23.0, 22.2, 14.4, 14.1. *anti*: ^1H NMR (400 MHz) δ 7.17–7.36 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.29 (1H, dd, J=9.2, 4.4 Hz, PhC*H*), 4.22 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.90 (1H, sep, J=6.8 Hz, $CH(CH_3)_2$), 2.51 (1H, m, $CHCO_2Et$), 2.22 (1H, m, $CHCHHCH$), 1.55 (4H, m, *i*-$PrCH_2$, $CHCHHCH$, $CH(CH_3)_2$), 1.24 (6H, d, J=6.8 Hz, $CH(CH_3)_2$), 1.18 (3H, t, J=7.6 Hz, $CO_2CH_2CH_3$), 0.84 (3H, d, J=6.4 Hz, $CHCH_3$), 0.78 (3H, d, J=6.4 Hz, $CHCH_3$).

4.3.6. Ethyl 4-methyl-2-[2-(*p*-methylbenzyloxy)-2-phenylethyl]pentanoate 19 (*syn*). ^1H NMR (270 MHz) δ 7.13–7.37 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.3 Hz, *p*-MeC_6H_4CHH), 4.28 (1H, dd, J=9.3, 4.1 Hz, PhC*H*), 4.17 (1H, d, J=11.3 Hz, *p*-MeC_6H_4CHH), 4.06 (2H, m, $CO_2CH_2CH_3$), 2.84 (1H, m, $CHCO_2Et$), 2.34 (3H, s, *p*-Me), 1.86 (2H, m, $CHCH_2CH$), 1.58 (2H, m, *i*-$PrCH_2$), 1.37 (1H, m, $CH(CH_3)_2$), 1.23 (3H, t, J=7.3 Hz, $CO_2CH_2CH_3$), 0.89 (3H, d, J=6.8 Hz, $CHCH_3$), 0.86 (3H, d, J=6.8 Hz, $CHCH_3$); ^{13}C NMR (67.5 MHz) δ 176.4, 142.4, 137.3, 135.3, 128.9, 128.4, 128.0, 127.5, 126.5, 79.4, 70.6, 60.0, 42.3, 41.7, 40.3, 26.0, 22.9, 22.2, 21.2, 14.3; IR (neat) 2868, 1730, 1517, 1453, 1367, 1178, 1022, 801, 756, 702 cm^{-1}; MS *m*/*z* 368 (M^+, 2%), 247 (17), 225 (22), 217 (39), 209 (37), 144 (85), 133 (17), 121 (11), 105 (100); HRMS calcd for $C_{16}H_{23}O_2$ [$M^+-OCH_2C_6H_4Me$-*p*] 247.1699, found 247.1697.

4.3.7. Ethyl 2-[2-(*p*-methoxybenzyloxy)-2-phenylethyl]-4-methylpentanoate 20 (*syn* and *anti*). IR (neat) 2953, 2173, 1730, 1507, 1278, 1174, 1037 cm^{-1}; MS *m*/*z* 247 ($M^+-OCH_2C_6H_4OMe$-*p*, 7%), 222 (56), 217 (87), 144 (11), 116 (100), 105 (43), 101 (18); HRMS calcd for $C_{16}H_{23}O_2$ [$M^+-OCH_2C_6H_4OMe$-*p*] 247.1698, found 247.1718. *syn*: ^1H NMR (400 MHz) δ 7.33 (5H, m, Ph), 7.23 (2H, d, J=12.8 Hz, *p*-$MeOC_6H_2H_2$), 6.86 (2H, d, J=12.8 Hz, *p*-$MeOC_6H_2H_2$), 4.35 (1H, d, J=11.2 Hz, *p*-$MeOC_6H_4CHH$), 4.28 (1H, dd, J=9.2, 4.0 Hz, PhC*H*), 4.16 (1H, d, J=11.2 Hz, *p*-$MeOC_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 3.80 (3H, s, OMe), 2.84 (1H, m, $CHCO_2Et$), 1.89 (2H, m, $CHCH_2CH$), 1.54 (2H, m, *i*-$PrCH_2$), 1.28 (1H, m, $CH(CH_3)_2$), 1.24 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.89 (3H, d, J=6.4 Hz, $CHCH_3$), 0.86 (3H, d, J=6.4 Hz, $CHCH_3$); ^{13}C NMR (100 MHz) δ 176.2, 159.0, 142.3, 130.4, 129.4, 128.4, 127.5, 126.4, 113.0, 79.3, 70.5, 60.0, 55.3, 42.3, 41.8, 40.4, 26.1, 23.0, 22.2, 14.4. *anti*: ^1H NMR (400 MHz) δ 7.33 (5H, m, Ph), 7.23 (2H, d, J=12.8 Hz, *p*-$MeOC_6H_2H_2$), 6.86 (2H, d, J=12.8 Hz, *p*-$MeOC_6H_2H_2$), 4.35 (1H, d, J=11.2 Hz, *p*-$MeOC_6H_4CHH$), 4.28 (1H, dd, J=9.2, 4.0 Hz, PhC*H*), 4.16 (1H, d, J=11.2 Hz, *p*-$MeOC_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 3.77 (3H, s, OMe), 2.48 (1H, m, $CHCO_2Et$), 2.22 (1H, m, $CHCHHCH$), 1.65 (1H, m, $CHCHHCH$), 1.54 (2H, m, *i*-$PrCH_2$), 1.28 (1H, m, $CH(CH_3)_2$), 1.19 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.84 (3H, d, J=6.4 Hz, $CHCH_3$), 0.79 (3H, d, J=6.4 Hz, $CHCH_3$).

4.3.8. Ethyl 2-[2-(*p*-cyanobenzyloxy)-2-phenylethyl]-pentanoate 21 (*syn* and *anti*). IR (neat) 2931, 2873, 2228, 1729, 1454, 1269, 1176, 1070, 820, 702 cm^{-1}; MS *m*/*z* 320 (M^+-OEt, 4%), 249 (25), 233 (5), 222 (46), 203 (99), 116 (100); HRMS calcd for $C_{21}H_{22}NO_2$ [M^+-OEt] 320.1650, found 320.1602. *syn*: ^1H NMR (400 MHz) δ 7.30–7.64 (9H, m, Ph, C_6H_4), 4.44 (1H, d, J=12.4 Hz, *p*-NCC_6H_4CHH), 4.32 (1H, dd, J=9.6, 4.0 Hz, PhC*H*), 4.29 (1H, d, J=12.4 Hz, *p*-NCC_6H_4CHH), 4.08 (2H, m, $CO_2CH_2CH_3$), 2.76 (1H, m, $CHCO_2Et$), 2.01 (1H, ddd, J=14.0, 9.6, 3.2 Hz, $CHCHHCH$), 1.92 (1H, ddd, J=14.0, 9.6, 4.0 Hz, $CHCHHCH$), 1.60 (1H, m, $CHHEt$), 1.42 (1H, m, $CHHEt$), 1.32 (2H, m, $CH_2CH_2CH_3$), 1.23 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.89 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.8, 143.9, 141.5, 132.0, 128.5, 127.8, 127.7, 126.3, 118.8, 111.1, 80.3, 69.8, 60.1, 42.0, 41.1, 35.2, 20.5, 14.4, 14.0. *anti*: ^1H NMR (400 MHz) δ 7.30–7.64 (9H, m, Ph, C_6H_4), 4.41 (1H, d, J=12.8 Hz, *p*-NCC_6H_4CHH), 4.32 (1H, dd, J=8.8, 5.2 Hz, PhC*H*), 4.29 (1H, d, J=12.8 Hz, *p*-NCC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.38 (1H, m, $CHCO_2Et$), 2.32 (1H, ddd, J=13.6, 8.8, 8.8 Hz, $CHCHHCH$), 1.75 (1H, ddd, J=13.6, 5.2, 5.2 Hz, $CHCHHCH$), 1.54 (1H, m, $CHHEt$), 1.40 (1H, m, $CHHEt$), 1.27 (2H, m, $CH_2CH_2CH_3$), 1.19 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.85 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.9, 144.0, 141.3, 132.0, 128.6, 127.8, 127.7, 126.6, 118.8, 111.1, 80.8, 69.4, 60.1, 42.8, 40.7, 35.0, 20.4, 14.3, 14.0.

4.3.9. Ethyl 2-[2-(*p*-trifluoromethylbenzyloxy)-2-phenylethyl]pentanoate 22 (*syn* and *anti*). IR (neat) 2873, 1729, 1326, 1165, 1126, 1066, 1019, 823, 702 cm^{-1}; MS *m*/*z* 363 (M^+-OEt, 5%), 265 (40), 249 (30), 233 (22), 203 (88), 159 (100), 105 (38); HRMS calcd for $C_{21}H_{22}O_2F_3$ [M^+-OEt] 363.1572, found 363.1536. *syn*: ^1H NMR (400 MHz) δ 7.59 (2H, d, J=8.0 Hz, *p*-$CF_3C_6H_2H_2$), 7.43 (2H, d, J=8.0 Hz, *p*-$CF_3C_6H_2H_2$), 7.25–7.35 (5H, m, Ph), 4.45 (1H, d, J=12.0 Hz, *p*-$CF_3C_6H_4CHH$), 4.32 (1H, dd, J=9.6, 4.0 Hz, PhC*H*), 4.28 (1H, d, J=12.0 Hz, *p*-$CF_3C_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.77 (1H, m, $CHCO_2Et$), 2.00 (1H, ddd, J=14.0, 9.6, 4.0 Hz, $CHCHHCH$), 1.91 (1H, dd, J=14.0, 9.6, 4.0 Hz, $CHCHHCH$), 1.59 (1H, m, $CHHEt$), 1.43 (1H, m, $CHHEt$), 1.32 (2H, m, $CH_2CH_2CH_3$), 1.22 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.89 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.9, 142.4, 141.8, 129.6 (q, J_{C-F}=32 Hz), 128.5, 127.7, 127.5, 126.4, 125.1 (q, J_{C-F}=3.6 Hz), 124.1 (q, J_{C-F}=270 Hz), 80.0, 70.0, 60.1, 42.0, 41.2, 35.3, 20.5, 14.4, 14.0. *anti*: ^1H NMR (400 MHz) δ 7.59 (2H, d, J=8.0 Hz, *p*-$CF_3C_6H_2H_2$), 7.42 (2H, d, J=8.0 Hz, *p*-$CF_3C_6H_2H_2$), 7.25–7.35 (5H, m, Ph), 4.43 (1H, d, J=12.0 Hz, *p*-$CF_3C_6H_4CHH$), 4.32 (1H, dd, J=8.0, 4.8 Hz, PhC*H*), 4.28 (1H, d, J=12.0 Hz, *p*-$CF_3C_6H_4CHH$), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.39 (1H, m, $CHCO_2Et$), 2.30 (1H, ddd, J=14.0, 8.0, 8.0 Hz, $CHCHHCH$), 1.74 (1H, ddd, J=14.0, 4.8, 4.8 Hz,

CHCH*H*CH), 1.59 (1H, m, C*H*HEt), 1.43 (1H, m, CH*H*Et), 1.32 (2H, m, $CH_2CH_2CH_3$), 1.18 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.84 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.9, 142.5, 141.4, 129.6 (q, J_{C-F}=32 Hz), 128.5, 127.7, 127.5, 126.7, 125.9 (q, J_{C-F}=3.6 Hz), 124.1 (q, J_{C-F}=270 Hz), 80.4, 69.5, 60.1, 42.8, 40.7, 34.9, 20.4, 14.3, 14.0.

4.3.10. Ethyl 2-[2-(*p*-fluorobenzyloxy)-2-phenylethyl]-pentanoate 23 (*syn* and *anti*). IR (neat) 2956, 2873, 1729, 1511, 1455, 1223, 1157, 824, 759, 702 cm^{-1}; MS *m*/*z* 249 ($M^+-CH_2C_6H_4F$-*p*, 15%), 233 (2), 203 (69), 130 (50), 109 (100), 105 (32); HRMS calcd for $C_{15}H_{21}O_3$ [$M^+-CH_2C_6H_4F$-*p*] 249.1490, found 249.1526. *syn*: ^{1}H NMR (400 MHz) δ 7.26–7.38 (7H, m, Ph, *p*-$FC_6H_2H_2$), 7.01 (2H, m, *p*-$FC_6H_2H_2$), 4.37 (1H, d, J=11.2 Hz, *p*-FC_6H_4-C*H*H), 4.29 (1H, dd, J=10.0, 3.6 Hz, PhC*H*), 4.18 (1H, d, J=11.2 Hz, *p*-FC_6H_4CHH), 4.08 (2H, m, $CO_2CH_2CH_3$), 2.75 (1H, m, C*H*CO_2Et), 1.92 (2H, m, CHCH_2CH), 1.58 (1H, m, C*H*HEt), 1.42 (1H, m, CH*H*Et), 1.30 (2H, m, $CH_2CH_2CH_3$), 1.24 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.88 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.9, 162.1 (d, J_{C-F}=243 Hz), 142.1, 134.0, 129.6 (d, J_{C-F}=7.3 Hz), 128.4, 127.6, 126.4, 115.0 (d, J_{C-F}=21 Hz), 79.6, 70.1, 60.1, 42.0, 41.2, 35.3, 20.5, 14.4, 14.1. *anti*: ^{1}H NMR (400 MHz) δ 7.26–7.38 (7H, m, Ph, *p*-$FC_6H_2H_2$), 7.01 (2H, m, *p*-$FC_6H_2H_2$), 4.35 (1H, d, J=11.2 Hz, *p*-FC_6H_4-C*H*H), 4.29 (1H, dd, J=10.0, 3.6 Hz, PhC*H*), 4.18 (1H, d, J=11.2 Hz, *p*-FC_6H_4CHH), 4.04 (2H, m, $CO_2CH_2CH_3$), 2.38 (1H, m, C*H*CO_2Et), 2.25 (1H, ddd, J=13.6, 8.8, 8.8 Hz, CHC*H*HCH), 1.71 (1H, ddd, J=14.0, 5.2, 5.2 Hz, CHCH*H*CH), 1.55 (1H, m, C*H*HEt), 1.37 (1H, m, CH*H*Et), 1.24 (2H, m, $CH_2CH_2CH_3$), 1.19 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.83 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 175.9, 162.1 (d, J_{C-F}=243 Hz), 141.6, 134.1, 129.4 (d, J_{C-F}=7.3 Hz), 128.4, 127.8, 126.7, 115.0 (d, J_{C-F}=21 Hz), 79.8, 69.6, 60.1, 42.7, 40.7, 34.7, 20.4, 14.3, 14.0.

4.3.11. Ethyl 2-(2-benzyloxy-2-phenylethyl)pentanoate 24 (*syn* and *anti*). IR (neat) 2928, 2871, 1722, 1494, 1454, 1229, 1150, 1078, 736, 700 cm^{-1}; MS *m*/*z* 249 (M^+-Bn, 7%), 233 (19), 203 (23), 200 (12), 197 (40), 181 (37), 176 (17), 129 (12), 117 (33), 105 (82), 91 (100); HRMS calcd for $C_{15}H_{21}O_3$ [M^+-Bn] 249.1490, found 249.1507. *syn*:^{1}H NMR (400 MHz) δ 7.18–7.35 (10H, m, 2×Ph), 4.42 (1H, d, J=11.0 Hz, C*H*HPh), 4.31 (1H, dd, J=9.6, 4.3 Hz, BnOC*H*), 4.22 (1H, d, J=11.0 Hz, CH*H*Ph), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.79 (1H, m, C*H*CO_2Et), 1.94 (2H, m, CHCH_2CH), 1.40 (4H, m, CH_2Et, CH_2CH_3), 1.23 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.88 (3H, t, J=7.2 Hz, CH_2CH_3); ^{13}C NMR (100 MHz) δ 176.0, 142.2, 138.3, 128.4, 128.2, 127.8, 127.5, 127.4, 126.4, 79.6, 70.8, 60.0, 42.0, 41.3, 35.3, 20.5, 14.4, 14.1. *anti*: ^{1}H NMR (400 MHz) δ 7.18–7.35 (10H, m, 2×Ph), 4.42 (1H, d, J=11.0 Hz, C*H*HPh), 4.31 (1H, dd, J=9.6, 4.3 Hz, BnOC*H*), 4.20 (1H, d, J=11.0 Hz, CH*H*Ph), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.41 (1H, m, C*H*CO_2Et), 2.27 (1H, m, CHC*H*HCH), 1.40 (5H, m, CH_2Et, CHCH*H*CH, CH_2CH_3), 1.19 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.83 (3H, t, J=7.2 Hz, CH_2CH_3).

4.3.12. Ethyl 2-[2-(*p*-isopropylbenzyloxy)-2-phenylethyl]pentanoate 25 (*syn* and *anti*). IR (neat) 2958, 2872, 2330, 1730, 1456, 1176, 1067, 818, 701 cm^{-1}; MS *m*/*z* 382 (M^+, 2%), 249 (9), 233 (50), 203 (41), 159 (21), 149 (28), 133 (100); HRMS calcd for $C_{25}H_{34}O_3$ [M^+] 382.2508, found 382.2517. *syn*: ^{1}H NMR (400 MHz) δ 7.17–7.35 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4C*H*H), 4.31 (1H, dd, J=10.4, 3.2 Hz, PhC*H*), 4.19 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.08 (2H, m, $CO_2CH_2CH_3$), 2.90 (1H, sep, J=6.8 Hz, C*H*$(CH_3)_2$), 2.80 (1H, m, C*H*CO_2Et), 1.97 (1H, ddd, J=14.0, 10.4, 3.6 Hz, CHC*H*HCH), 1.88 (1H, ddd, J=14.0, 9.6, 3.2 Hz, CHCH*H*CH), 1.59 (1H, m, C*H*HEt), 1.43 (1H, m, CH*H*Et), 1.29 (2H, m, $CH_2CH_2CH_3$), 1.24 (6H, d, J=6.8 Hz, CH$(CH_3)_2$), 1.23 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.88 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 176.1, 142.4, 135.6, 128.4, 128.0, 127.9, 127.5, 126.4, 126.3, 79.5, 70.7, 60.0, 42.0, 41.4, 35.4, 33.9, 24.1, 20.5, 14.4, 14.1. *anti*: ^{1}H NMR (400 MHz) δ 7.17–7.35 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4C*H*H), 4.31 (1H, dd, J=10.0, 3.2 Hz, PhC*H*), 4.19 (1H, d, J=11.2 Hz, *p*-*i*-PrC_6H_4CHH), 4.08 (2H, m, $CO_2CH_2CH_3$), 2.90 (1H, sep, J=6.8 Hz, C*H*$(CH_3)_2$), 2.41 (1H, m, C*H*CO_2Et), 2.24 (1H, m, CHC*H*HCH), 1.70 (1H, m, CHCH*H*CH), 1.59 (1H, m, C*H*HEt), 1.43 (1H, m, CH*H*Et), 1.29 (2H, m, $CH_2CH_2CH_3$), 1.24 (6H, d, J=6.8 Hz, CH$(CH_3)_2$), 1.18 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.83 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$).

4.3.13. Ethyl 2-[2-(*p*-methylbenzyloxy)-2-phenylethyl]-pentanoate 26 (*syn* and *anti*). IR (neat) 2930, 2872, 1729, 1454, 1379, 1176, 1067, 1022, 758, 702 cm^{-1}; MS *m*/*z* 354 (M^+, 6%), 307 (12), 249 (5), 233 (23), 209 (87), 130 (61), 105 (93); HRMS calcd for $C_{23}H_{30}O_3$ [M^+] 354.2195, found 354.2181. *syn*: ^{1}H NMR (400 MHz) δ 7.12–7.35 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=11.2 Hz, *p*-MeC_6H_4C*H*H), 4.29 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.17 (1H, d, J=11.2 Hz, *p*-MeC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.78 (1H, m, C*H*CO_2Et), 2.34 (3H, s, *p*-Me), 1.97 (1H, ddd, J=13.6, 10.2, 3.6 Hz, CHC*H*HCH), 1.86 (1H, ddd, J=13.6, 9.6, 3.6 Hz, CHCH*H*CH), 1.57 (1H, m, C*H*HEt), 1.42 (1H, m, CH*H*Et), 1.28 (2H, m, $CH_2CH_2CH_3$), 1.23 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.87 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 176.0, 142.3, 137.0, 135.2, 128.8, 128.3, 127.9, 127.4, 126.4, 79.4, 70.6, 60.0, 42.0, 41.3, 35.3, 21.2, 20.4, 14.4, 14.0. *anti*: ^{1}H NMR (400 MHz) δ 7.12–7.35 (9H, m, Ph, C_6H_4), 4.47 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.37 (1H, d, J=11.2 Hz, *p*-MeC_6H_4C*H*H), 4.16 (1H, d, J=11.2 Hz, *p*-MeC_6H_4CHH), 4.07 (2H, m, $CO_2CH_2CH_3$), 2.43 (1H, m, C*H*CO_2Et), 2.31 (3H, s, *p*-Me), 2.22 (1H, m, CHC*H*HCH), 1.70 (1H, m, CHCH*H*CH), 1.57 (1H, m, C*H*HEt), 1.42 (1H, m, CH*H*Et), 1.28 (2H, m, $CH_2CH_2CH_3$), 1.19 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.83 (3H, t, J=7.2 Hz, $CH_2CH_2CH_3$); ^{13}C NMR (100 MHz) δ 176.0, 141.9, 136.9, 135.1, 128.8, 128.5, 127.8, 127.6, 126.8, 79.2, 70.1, 60.4, 42.5, 40.8, 34.5, 21.1, 20.4, 14.3, 14.0.

4.3.14. Ethyl 2-[2-(*p*-methoxybenzyloxy)-2-phenylethyl]-pentanoate 27 (*syn* and *anti*). IR (neat) 2933, 2782, 1729, 1612, 1514, 1455, 1302, 1279, 1174, 1035, 822, 758, 702 cm^{-1}; MS *m*/*z* 370 (M^+, 3%), 234 (5), 203 (12), 137 (45), 121 (100); HRMS calcd for $C_{23}H_{30}O_4$ [M^+] 370.2144, found 370.2133. *syn*: ^{1}H NMR (400 MHz) δ 7.20–7.34 (7H, m, Ph, *p*-MeOCH_2H_2), 6.86 (2H, m, *p*-MeOCH_2H_2), 4.35

(1H, d, J=11.2 Hz, p-MeOC$_6$H$_4$C*H*H), 4.29 (1H, dd, J=9.2, 3.2 Hz, PhC*H*), 4.15 (1H, d, J=11.2 Hz, p-MeOC$_6$H$_4$CH*H*), 4.07 (2H, m, CO$_2$C*H*$_2$CH$_3$), 3.81 (3H, s, OMe), 2.77 (1H, m, C*H*CO$_2$Et), 1.96 (1H, ddd, J=14.0, 9.2, 3.6 Hz, CHC*H*HCH), 1.85 (1H, ddd, J=14.0, 9.6, 3.2 Hz, CHCH*H*CH), 1.57 (1H, m, C*H*HEt), 1.42 (1H, m, CH*H*Et), 1.30 (2H, m, CH$_2$C*H*$_2$CH$_3$), 1.24 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.87 (3H, t, J=7.2 Hz, CH$_2$CH$_2$C*H*$_3$); ^{13}C NMR (67.5 MHz) δ 176.0, 142.4, 130.6, 130.4, 129.4, 128.4, 127.4, 126.4, 113.6, 79.3, 70.5, 60.0, 55.3, 42.1, 41.4, 35.4, 20.5, 14.4, 14.0. *anti*: ^{1}H NMR (400 MHz) δ 7.20–7.34 (7H, m, Ph, p-MeOC*H*$_2$H$_2$), 6.86 (2H, m, p-MeOCH$_2$*H*$_2$), 4.29 (1H, d, J=11.2 Hz, p-MeOC$_6$H$_4$-C*H*H), 4.22 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.13 (1H, d, J=11.2 Hz, p-MeOC$_6$H$_4$CH*H*), 4.07 (2H, m, CO$_2$C*H*$_2$CH$_3$), 3.80 (3H, s, OMe), 2.39 (1H, m, C*H*CO$_2$Et), 2.23 (1H, ddd, J=14.4, 9.6, 3.6 Hz, CHC*H*HCH), 1.69 (1H, ddd, J=13.6, 9.6, 3.6 Hz, CHCH*H*CH), 1.57 (2H, m, C*H*$_2$Et), 1.26 (2H, m, CH$_2$C*H*$_2$CH$_3$), 1.20 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.83 (3H, t, J=7.2 Hz, CH$_2$CH$_2$C*H*$_3$); ^{13}C NMR (67.5 MHz) δ 176.0, 141.9, 130.4, 129.3, 127.6, 127.6, 126.8, 126.4, 113.7, 79.1, 70.0, 60.0, 57.8, 42.6, 40.8, 34.6, 20.4, 14.3, 14.0.

4.3.15. Ethyl 4-benzyloxy-2-ethyl-4-phenylbutanoate 28 (*syn* and *anti*). IR (neat) 2955, 2873, 1729, 1455, 1177, 1028, 735, 700 cm^{-1}; MS m/z 281 (M$^+$−OEt, 1%), 270 (18), 220 (15), 197 (22), 181 (100), 179 (62), 165 (31), 130 (12), 116 (27), 105 (30), 91 (96); HRMS calcd for C$_{19}$H$_{21}$O$_2$ [M$^+$−OEt] 281.1542, found 281.1523. *syn*: ^{1}H NMR (400 MHz) δ 7.18–7.35 (10H, m, 2×Ph), 4.42 (1H, d, J=11.0 Hz, C*H*HPh), 4.32 (1H, dd, J=9.6, 3.5 Hz, PhC*H*), 4.22 (1H, d, J=11.0 Hz, CH*H*Ph), 4.07 (2H, m, CO$_2$C*H*$_2$-CH$_3$), 2.71 (1H, m, C*H*CO$_2$Et), 1.93 (2H, m, CHC*H*$_2$CH), 1.57 (2H, m, C*H*$_2$CH$_3$), 1.23 (3H, t, J=7.2 Hz, CO$_2$CH$_2$-C*H*$_3$), 0.89 (3H, t, J=7.2 Hz, CH$_2$C*H*$_3$); ^{13}C NMR (100 MHz) δ 175.8, 142.2, 138.3, 128.4, 128.2, 127.8, 127.5, 127.4, 126.4, 79.6, 70.8, 60.0, 43.6, 40.9, 26.3, 14.4, 11.6. *anti*: ^{1}H NMR (400 MHz) δ 7.18–7.35 (10H, m, 2×Ph), 4.42 (1H, d, J=11.0 Hz, C*H*HPh), 4.31 (1H, dd, J=9.6, 3.5 Hz, PhC*H*), 4.21 (1H, d, J=11.0 Hz, CH*H*Ph), 4.07 (2H, m, CO$_2$C*H*$_2$CH$_3$), 2.46 (1H, m, C*H*CO$_2$Et), 2.29 (1H, m, CHC*H*HCH), 1.57 (3H, m, CHCH*H*CH, C*H*$_2$CH$_3$), 1.19 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.84 (3H, t, J=7.2 Hz, CH$_2$C*H*$_3$); ^{13}C NMR (100 MHz) δ 176.0, 141.8, 139.3, 128.3, 128.1, 127.7, 127.5, 127.3, 126.8, 79.6, 70.3, 59.1, 43.7, 41.3, 25.5, 14.3, 11.5.

4.3.16. Ethyl 2-ethyl-4-(*p*-methylbenzyloxy)-4-phenylbutanoate 29 (*syn* and *anti*). IR (neat) 2874, 3356, 1728, 1683, 1455, 1179, 1093, 807, 757, 702 cm^{-1}; MS m/z 235 (M$^+$−CH$_2$C$_6$H$_4$Me-p, 4%), 219 (4), 189 (33), 130 (10), 121 (13), 116 (51), 105 (100), 91 (18); HRMS calcd for C$_{14}$H$_{19}$O$_3$ [M$^+$−CH$_2$C$_6$H$_4$Me-p] 235.1334, found 235.1286. *syn*: ^{1}H NMR (400 MHz) δ 7.12–7.38 (9H, m, Ph, C$_6$H$_4$), 4.38 (1H, d, J=11.2 Hz, p-MeC$_6$H$_4$C*H*H), 4.31 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.17 (1H, d, J=11.2 Hz, p-MeC$_6$H$_4$CH*H*), 4.08 (2H, m, CO$_2$C*H*$_2$CH$_3$), 2.71 (1H, m, C*H*CO$_2$Et), 2.33 (3H, s, p-Me), 1.97 (1H, ddd, J=13.6, 10.0, 3.6 Hz, CHC*H*HCH), 1.86 (1H, ddd, J=13.6, 9.6, 3.6 Hz, CHCH*H*CH), 1.58 (2H, m, CHC*H*$_2$CH$_3$), 1.24 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.88 (3H, t, J=7.2 Hz, CHCH$_2$-C*H*$_3$); ^{13}C NMR (100 MHz) δ 175.9, 142.3, 137.1, 135.2, 128.9, 128.4, 127.9, 127.5, 126.4, 79.4, 70.6, 60.0, 43.6, 41.3, 26.3, 21.2, 14.4, 11.6. *anti*: ^{1}H NMR (400 MHz) δ 7.12–7.38 (9H, m, Ph, C$_6$H$_4$), 4.47 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.38 (1H, d, J=11.2 Hz, p-MeC$_6$H$_4$C*H*H), 4.16 (1H, d, J=11.2 Hz, p-MeC$_6$H$_4$CH*H*), 4.08 (2H, m, CO$_2$C*H*$_2$-CH$_3$), 2.48 (1H, m, C*H*CO$_2$Et), 2.33 (3H, s, p-Me), 2.18 (1H, m, CHC*H*HCH), 1.71 (1H, m, CHCH*H*CH), 1.58 (2H, m, CHC*H*$_2$CH$_3$), 1.20 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.84 (3H, t, J=7.2 Hz, CHCH$_2$C*H*$_3$); ^{13}C NMR (100 MHz) δ 176.0, 142.3, 137.0, 134.4, 128.8, 128.5, 127.9, 127.8, 126.7, 79.3, 71.7, 61.7, 42.0, 41.3, 25.5, 20.4, 14.0, 11.5.

4.3.17. Ethyl 4,4-dimethyl-2-[2-(*p*-methylbenzyloxy)-2-phenylethyl]pentanoate 31 (*syn* and *anti*). IR (neat) 2954, 2867, 1733, 1317, 1454, 1366, 1154, 1064, 1028, 802, 756, 701 cm^{-1}; MS m/z 277 (M$^+$−CH$_2$C$_6$H$_4$Me-p, 3%), 262 (14), 261 (9), 231 (35), 209 (7), 158 (84), 121 (15), 117 (11), 105 (100), 101 (62), 91 (21); HRMS calcd for C$_{17}$H$_{25}$O$_3$ [M$^+$−CH$_2$C$_6$H$_4$Me-p] 277.1803, found 277.1788. *syn*: ^{1}H NMR (400 MHz) δ 7.10–7.37 (9H, m, Ph, C$_6$H$_4$), 4.35 (1H, d, J=11.0 Hz, p-MeC$_6$H$_4$C*H*H), 4.24 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.21 (1H, d, J=11.0 Hz, p-MeC$_6$H$_4$CH*H*), 4.07 (2H, m, CO$_2$C*H*$_2$CH$_3$), 2.85 (1H, m, C*H*CO$_2$Et), 2.34 (3H, s, p-Me), 1.91 (2H, m, CHC*H*$_2$CH), 1.76 (2H, dd, J=14.4, 9.2 Hz, t-BuC*H*$_2$), 1.24 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.87 (9H, s, t-Bu); ^{13}C NMR (100 MHz) δ 177.1, 142.2, 137.0, 135.3, 128.9, 128.4, 127.9, 127.5, 126.4, 79.6, 70.8, 60.1, 47.0, 44.2, 39.0, 31.0, 29.5, 21.2, 14.3. *anti*: ^{1}H NMR (400 MHz) δ 7.10–7.37 (9H, m, Ph, C$_6$H$_4$), 4.30 (1H, dd, J=9.6, 3.6 Hz, PhC*H*), 4.35 (1H, d, J=11.0 Hz, p-MeC$_6$H$_4$C*H*H), 4.19 (1H, d, J=11.0 Hz, p-MeC$_6$H$_4$CH*H*), 4.07 (2H, m, CO$_2$C*H*$_2$CH$_3$), 2.52 (1H, m, C*H*CO$_2$Et), 2.33 (3H, s, p-Me), 2.20 (1H, m, CHC*H*HCH), 1.71 (1H, m, CHCH*H*CH), 1.65 (2H, dd, J=14.4, 9.2 Hz, t-BuC*H*$_2$), 1.19 (3H, t, J=7.2 Hz, CO$_2$-CH$_2$C*H*$_3$), 0.82 (9H, s, t-Bu); ^{13}C NMR (100 MHz) δ 177.0, 141.9, 136.9, 135.2, 128.8, 128.6, 127.9, 127.6, 126.7, 79.2, 70.2, 60.1, 46.1, 43.4, 39.3, 30.9, 29.4, 20.5, 14.1.

4.3.18. Ethyl 2-isobutyl-5-methyl-4-(*p*-methylbenzyloxy)hexanoate 33 (*syn* and *anti*). IR (neat) 2871, 1731, 1471, 1174, 1088, 797 cm^{-1}; MS m/z 334 (M$^+$, 5%), 291 (10), 264 (94), 234 (33), 213 (24), 209 (28), 121 (7), 105 (100); HRMS calcd for C$_{21}$H$_{34}$O$_3$ [M$^+$] 334.2508, found 334.2528. *syn*: ^{1}H NMR (400 MHz) δ 7.26 (2H, d, J=7.8 Hz, p-MeC$_6$H$_4$C*H*$_2$H$_2$), 7.15 (2H, d, J=7.8 Hz, p-MeC$_6$H$_4$CH$_2$*H*$_2$), 4.49 (1H, d, J=10.4 Hz, p-MeC$_6$H$_4$-C*H*H), 4.40 (1H, d, J=10.4 Hz, p-MeC$_6$H$_4$CH*H*), 4.10 (2H, m, CO$_2$C*H*$_2$CH$_3$), 3.10 (1H, m, i-PrC*H*), 2.67 (1H, m, C*H*CO$_2$Et), 2.33 (3H, s, p-Me), 1.95 (1H, m, C*H*(CH$_3$)$_2$), 1.76 (1H, ddd, J=14.0, 11.2, 2.4 Hz, CHC*H*HCH), 1.54 (4H, m, CHCH*H*CH, C*H*(CH$_3$)$_2$, i-PrC*H*$_2$), 1.23 (3H, t, J=7.2 Hz, CO$_2$CH$_2$C*H*$_3$), 0.90 (12H, m, 2×CH(C*H*$_3$)$_2$); ^{13}C NMR (100 MHz) δ 176.7, 136.9, 135.8, 128.8, 127.8, 82.3, 72.1, 59.9, 42.8, 40.3, 33.9, 30.5, 26.2, 23.1, 21.9, 18.6, 17.2, 14.4. *anti*: ^{1}H NMR (400 MHz) δ 7.26 (2H, d, J=7.8 Hz, p-MeC$_6$H$_4$C*H*$_2$H$_2$), 7.15 (2H, d, J=7.8 Hz, p-MeC$_6$H$_4$CH$_2$*H*$_2$), 4.49 (1H, d, J=10.4 Hz, p-MeC$_6$H$_4$-C*H*H), 4.40 (1H, d, J=10.4 Hz, p-MeC$_6$H$_4$CH*H*), 4.10 (2H, m, CO$_2$C*H*$_2$CH$_3$), 3.20 (1H, m, i-PrC*H*), 2.54 (1H, m, C*H*CO$_2$Et), 2.33 (3H, s, p-Me), 1.95 (1H, m, C*H*(CH$_3$)$_2$), 1.76 (1H, ddd, J=14.0, 11.2, 2.4 Hz, CHC*H*HCH), 1.54 (4H, m, CHCH*H*CH, C*H*(CH$_3$)$_2$, i-PrC*H*$_2$), 1.23 (3H, t,

J=7.2 Hz, $CO_2CH_2CH_3$), 0.90 (12H, m, 2×CH(CH_3)$_2$); ^{13}C NMR (100 MHz) δ 175.3, 137.1, 135.2, 129.0, 127.7, 81.5, 71.7, 59.9, 42.7, 40.8, 33.4, 29.9, 26.2, 23.3, 21.9, 18.0, 16.7, 14.1.

4.3.19. Ethyl 5-methyl-4-(*p*-methylbenzyloxy)-2-(2,2-dimethypropyl)hexanoate 35 (*syn* and *anti*). IR (neat) 2871, 1731, 1470, 1173, 1078, 796 cm^{-1}; MS *m*/*z* 227 ($M^+-CH_2C_6H_4Me$-*p*, 8%), 203 (5), 158 (88), 121 (20), 105 (100), 101 (63); HRMS calcd for $C_{14}H_{27}O_2$ [$M^+-CH_2C_6H_4Me$-*p*] 277.2011 found 277.2052. *syn*: ^{1}H NMR (400 MHz) δ 7.27 (2H, d, J=8.3 Hz, *p*-MeOC$_6$H$_4$CH_2H$_2$), 7.14 (2H, d, J=8.3 Hz, *p*-MeOC$_6$H$_4$CH$_2H_2$), 4.48 (1H, d, J=10.4 Hz, *p*-MeC$_6$H$_4$C*H*H), 4.43 (1H, d, J=10.4 Hz, *p*-MeC$_6$H$_4$CH*H*), 4.09 (2H, m, $CO_2CH_2CH_3$), 3.07 (1H, m, *i*-PrC*H*), 2.74 (1H, m, C*H*CO$_2$Et), 2.34 (3H, s, *p*-Me), 1.95 (1H, m, C*H*(CH_3)$_2$), 1.78 (2H, m, CHCH_2CH), 1.50 (2H, m, *t*-BuCH_2), 1.24 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.88 (6H, d, J=6.8 Hz, CH(CH_3)$_2$), 0.87 (9H, s, *t*-Bu); ^{13}C NMR (100 MHz) δ 177.5, 136.9, 135.9, 128.9, 127.9, 82.3, 72.1, 60.0, 47.5, 38.8, 36.4, 31.0, 29.5, 21.2, 18.6, 17.2, 14.3. *anti*: ^{1}H NMR (400 MHz) δ 7.27 (2H, d, J=8.3 Hz, *p*-MeOC$_6$H$_4$CH_2H$_2$), 7.23 (2H, d, J=8.3 Hz, *p*-MeOC$_6$H$_4$-CH$_2H_2$), 4.48 (1H, d, J=10.4 Hz, *p*-MeC$_6$H$_4$C*H*H), 4.43 (1H, d, J=10.4 Hz, *p*-MeC$_6$H$_4$CH*H*), 4.01 (2H, m, CO_2-CH_2CH$_3$), 3.18 (1H, m, *i*-PrC*H*), 2.52 (1H, m, C*H*CO$_2$Et), 2.35 (3H, s, *p*-Me), 1.95 (1H, m, C*H*(CH_3)$_2$), 1.78 (2H, m, CHCH_2CH), 1.50 (2H, m, *t*-BuCH_2), 1.20 (3H, t, J=7.2 Hz, $CO_2CH_2CH_3$), 0.88 (6H, d, J=6.8 Hz, CH(CH_3)$_2$), 0.83 (9H, s, *t*-Bu); ^{13}C NMR (100 MHz) δ 177.5, 137.0, 135.2, 128.8, 127.8, 81.5, 71.0, 60.1, 46.3, 39.1, 35.3, 30.5, 29.5, 21.4, 18.0, 17.5, 14.1.

4.3.20. Ethyl 4-methyl-2-(benzyloxyphenylmethyl)-pentanoate 38 (*syn* and *anti*). To a solution of α-methylene ester **36** (0.15 mmol) in dry CH_2Cl_2 (1.5 cm^3) was added $MgBr_2$·OEt_2 (0.75 mmol, 5 equiv.), and the mixture was stirred at room temperature for 10 min. To the suspension cooled to −78 °C were added isopropyl iodide (0.45 mmol, 3 equiv.), *n*-Bu_3SnH (0.30 mmol, 2 equiv.) and Et_3B (1.06 mol dm^{-3} in hexane; 0.03 mmol, 0.2 equiv.). The mixture was stirred at −78 °C for 6 h. KF and water were added and the reaction mixture was stirred at room temperature for 3 h. After filtration, the solvent was evaporated in vacuo. The residue was purified by flash chromatography on silica gel to give the product as an oily inseparable diastereomeric mixture. The stereochemistry was determined by comparing their chemical shift values with those of methyl 2-methyl-3-benzyloxy-3-phenyl-propanoate.[12] MS *m*/*z* 249 (M^+-Bn, 5%), 234 (24), 197 (82), 178 (19), 160 (24), 105 (26); HRMS calcd for $C_{15}H_{21}O_3$ [M^+-Bn] 249.1491, found 249.1503. *syn*:^{1}H NMR (400 MHz) δ 7.18–7.40 (10H, m, 2×Ph), 4.44 (1H, d, J=10.4 Hz, PhC*H*H), 4.39 (1H, d, J=8.8 Hz, BnOC*H*), 4.23 (1H, d, J=10.4 Hz, PhCH*H*), 3.82 (2H, q, J=6.8 Hz, $CO_2CH_2CH_3$), 2.84 (1H, m, C*H*CO$_2$Et), 1.75 (2H, m, CHCH_2CH), 1,50 (1H, m, C*H*(CH_3)$_2$), 0.99 (3H, d, J=6.2 Hz, CHCH_3), 0.90 (3H, t, J=6.8 Hz, $CO_2CH_2CH_3$), 0.87 (3H, d, J=6.2 Hz, CHCH_3); ^{13}C NMR (100 MHz) δ 173.4, 139.6, 138.1, 128.2, 128.1, 127.9, 127.7, 127.6, 127.5, 82.5, 70.5, 59.9, 52.4, 38.4, 26.6, 23.7, 21.6, 13.9. *anti*: ^{1}H NMR (400 MHz) δ 7.18–7.40 (10H, m, 2×Ph), 4.42 (1H, d, J=9.0 Hz, BnOC*H*), 4.35 (1H, d, J=10.4 Hz, PhC*H*H), 4.19 (1H, d, J=10.4 Hz, PhCH*H*), 4.21 (2H, q, J=6.8 Hz, $CO_2CH_2CH_3$), 2.87 (1H, m, C*H*CO$_2$Et), 1.50 (2H, m, CHCH_2CH), 1,37 (1H, m, C*H*(CH_3)$_2$), 1.26 (3H, t, J=6.8 Hz, $CO_2CH_2CH_3$), 0.75 (3H, d, J=6.2 Hz, CHCH_3), 0.73 (3H, d, J=6.2 Hz, CHCH_3); ^{13}C NMR (100 MHz) δ 174.8, 139.2, 138.0, 128.4, 128.2, 128.0, 127.8, 127.6, 127.3, 83.6, 70.5, 60.4, 51.6, 38.0, 26.1, 23.6, 21.1, 14.4.

4.3.21. Ethyl 4-methyl-2-[(*p*-methylbenzyloxy)phenyl-methyl]pentanoate 39 (*syn* and *anti*). The radical reaction of **37** was carried out according to the procedure as described above. MS *m*/*z* 249 ($M^+-CH_2C_6H_4Me$-*p*, 2%), 234 (62), 190 (35), 178 (36), 160 (44), 121 (30); HRMS calcd for $C_{15}H_{21}O_3$ [$M^+-CH_2C_6H_4Me$-*p*] 249.1491, found 249.1503. *syn*:^{1}H NMR (400 MHz) δ 7.06–7.40 (9H, m, Ph, C_6H_4), 4.37 (1H, d, J=8.8 Hz, PhC*H*), 4.32 (1H, d, J=11.8 Hz, PhC*H*H), 4.14 (1H, d, J=11.8 Hz, PhCH*H*), 3.80 (2H, q, J=6.8 Hz, $CO_2CH_2CH_3$), 2.84 (1H, m, C*H*CO$_2$Et), 2.34 (3H, s, *p*-Me), 1.74 (2H, m, CHCH_2CH), 1,49 (1H, m, C*H*(CH_3)$_2$), 0.93 (3H, t, J=6.8 Hz, CO_2CH_2-CH_3), 0.75 (3H, d, J=6.8 Hz, CHCH_3), 0.73 (3H, d, J=6.2 Hz, CHCH_3); ^{13}C NMR (100 MHz) δ 174.8, 139.7, 137.1, 135.0, 128.9, 128.1, 127.8, 127.7, 127.5, 82.3, 70.3, 59.9, 52.4, 38.4, 26.6, 23.7, 21.6, 21.2, 13.9. *anti*:^{1}H NMR (400 MHz) δ 7.06–7.40 (9H, m, Ph, C_6H_4), 4.42 (1H, d, J=11.8 Hz, PhC*H*H), 4.39 (1H, d, J=8.8 Hz, PhC*H*), 4.19 (1H, d, J=11.8 Hz, PhCH*H*), 4.14 (2H, m, $CO_2CH_2CH_3$), 2.85 (1H, m, C*H*CO$_2$Et), 2.32 (3H, s, *p*-Me), 1.49 (2H, m, CHCH_2CH), 1,35 (1H, m, C*H*(CH_3)$_2$), 1.26 (3H, t, J=6.8 Hz, $CO_2CH_2CH_3$), 0.89 (3H, d, J=6.8 Hz, CHCH_3), 0.87 (3H, d, J=6.2 Hz, CHCH_3); ^{13}C NMR (100 MHz) δ 174.8, 139.6, 139.3, 135.0, 128.9, 128.1, 127.8, 127.7, 127.5, 83.3, 70.2, 60.3, 51.5, 38.0, 26.1, 23.6, 21.6, 21.2, 14.4.

References and notes

1. For reviews and books, see: (a) Smadja, W. *Synlett* **1994**, 1–26. (b) Porter, N. A.; Giese, B.; Curran, D. P. *Acc. Chem. Res.* **1991**, *24*, 296–304. (c) RajanBabu, T. V. *Acc. Chem. Res.* **1991**, *24*, 139–145. (d) Renaud, P.; Sibi, M. P. *Radicals in Organic Synthesis*; VCH: Weinheim, 2001; Vols. 1–2. (e) Curran, D. P.; Porter, N. A.; Giese, B. *Stereochemistry of Radical Reactions*; VCH: Weinheim, 1996.
2. For reviews, see: (a) Sibi, M. P.; Porter, N. A. *Acc. Chem. Res.* **1999**, *32*, 163–171. (b) Renaud, P.; Gerster, M. *Angew. Chem. Int. Ed.* **1998**, *37*, 2562–2579. (c) Guindon, Y.; Guérin, B.; Rancourt, J.; Chabot, C.; Makintosh, N.; Ogilvie, W. W. *Pure. Appl. Chem.* **1996**, *68*, 89–96. For recent examples, see: (d) Iserloh, U.; Curran, D. P.; Kanemasa, S. *Tetrahedron: Asymmetry* **1999**, *10*, 2417–2428. (e) Watanabe, Y.; Mase, N.; Furue, R.; Toru, T. *Tetrahedron Lett.* **2001**, *42*, 2981–2984. (f) Halland, N.; Jørgensen, K. A. *J. Chem. Soc., Perkin Trans. 1* **2001**, 1290–1295.
3. For a review on 1,3-asymmetric induction, see: (a) Mengel, A.; Reiser, O. *Chem. Rev.* **1999**, *99*, 1191–1223. For radical mediated 1,3-asymmetric inductions via eight-membered chelate rings, see: (b) Hayen, A.; Koch, R.; Metzger, J. O. *J. Am. Chem. Soc.* **2000**, *122*, 12458–12468.
4. (a) Nagano, H.; Toi, S.; Yajima, T. *Synlett* **1999**, 53–54. (b) Nagano, H.; Hirasawa, T.; Yajima, T. *Synlett* **2000**,

1073–1075. (c) Nagano, H.; Matsuda, M.; Yajima, T. *J. Chem. Soc., Perkin Trans. 1* **2001**, 174–182. (d) Nagano, H.; Toi, S.; Hirasawa, T.; Matsuda, M.; Hirasawa, S.; Yajima, T. *J. Chem. Soc., Perkin Trans. 1* **2002**, 2525–2538. (e) Nagano, H.; Ohkouchi, H.; Yajima, T. *Tetrahedron* **2003**, *59*, 3649–3663.

5. (a) Goto, H.; Osawa, E. *J. Am. Chem. Soc.* **1989**, *111*, 8950–8953. (b) Goto, H.; Osawa, E. *J. Chem. Soc., Perkin Trans. 2* **1993**, 187–198.
6. For the reaction via seven-membered chelation with Lewis acid, see:(a) Yang, M. G.; Modi, D. P.; Wexler, R. R.; Olson, R. E. *Tetrahedron Lett.* **2004**, *45*, 111–112. (b) Krafft, M. E.; Dasse, O. A.; Jarrett, S.; Fievre, A. *J. Org. Chem.* **1995**, *60*, 5093–5101. (c) Angert, H.; Kunz, T.; Reissig, H.-U. *Tetrahedron* **1992**, *48*, 5681–5690.
7. For the conformation of seven-membered cyclic radicals, see; (a) Sibi, M. P.; Asano, Y.; Sausker, J. B. *Angew. Chem. Int., Ed.* **2001**, *40*, 1293–1296. For examples of five and six-membered cyclic radicals, see: (b) Giese, B. *Angew. Chem. Int. Ed. Engl.* **1989**, *28*, 969–980. (c) Damm, W.; Giese, B.; Hartung, J.; Hasskerl, T.; Houk, K. N.; Hüter, O.; Zipse, H. *J. Am. Chem. Soc.* **1992**, *114*, 4067–4079. (d) Cai, Y.; Roberts, B. P. *J. Chem. Soc., Perkin Trans. 1* **1998**, 467–476.
8. Hammett, L. P. *J. Am. Chem. Soc.* **1937**, *59*, 96–99.
9. For the correlations of diastereoselectivities versus Hammett sigma constants, see: (a) Galardon, E.; Le Maux, P.; Simonneaux, G. *Tetrahedron* **2000**, *56*, 615–621. (b) Morgan, A. J.; Masse, C. E.; Panek, J. S. *Org. Lett.* **1999**, *1*, 1949–1952. (c) Gugelchuk, M. M.; Chan, P. C.-M.; Sprules, T. J. *J. Org. Chem.* **1994**, *59*, 7723–7731. (d) Chini, M.; Crotti, P.; Minutolo, F.; Dezi, E.; Lombardozzi, A.; Pizzabiocca, A.; Renzi, G. *Tetrahedron* **1993**, *49*, 5845–5858. (e) Kunieda, N.; Nokami, J.; Kinoshita, M. *Bull. Chem. Soc. Jpn* **1992**, *65*, 526–529. (f) Kunieda, N.; Nakanishi, T.; Kinoshita, M. *Bull. Chem. Soc. Jpn* **1989**, *62*, 2229–2234. (g) Chini, M.; Crotti, P.; Ferretti, M.; Macchia, F. *Tetrahedron* **1988**, *44*, 2001–2014.
10. The radical reaction of **7** with *i*-PrI using *n*-Bu_3SnD showed the D-atom abstraction of the radical α to the ester carbonyl group. An alternative reaction mechanism involving the intramolecular 1,5-hydrogen atom transfer from the benzylic position was thus excluded. For the 1,5-hydrogen transfer from benzylic position, see: (a) Kunishima, M.; Hioki, K.; Kono, K.; Kato, A.; Tani, S. *J. Org. Chem.* **1997**, *62*, 7542–7543. (b) Benati, L.; Capella, L.; Montevecchi, P. C.; Spagnolo, P. *J. Org. Chem.* **1994**, *59*, 2818–2823. (c) Rochigneux, I.; Fontanel, M.-L.; Malanda, J.-C.; Doutheau, A. *Tetrahedron Lett.* **1991**, *32*, 2017–2020.
11. NMR studies on complexation of β-benzyloxy aldehyde with $MgBr_2{\cdot}OEt_2$, see: (a) Keck, G. E.; Castellino, S. *J. Am. Chem. Soc.* **1986**, *108*, 3847–3849. (b) Keck, G. E.; Castellino, S.; Wiley, M. R. *J. Org. Chem.* **1986**, *51*, 5480–5482.
12. Brown, D. J. *J. Appl. Chem. (London)* **1952**, *2*, 202–203.
13. Guindon, Y.; Rancourt, J. *J. Org. Chem.* **1998**, *63*, 6554–6565.
14. (a) Aggarwal, V. K.; Mereu, A. *Chem. Commun.* **1999**, 2311–2312. (b) Wessel, H.-P.; Iversen, T.; Bundle, D. R. *J. Chem. Soc., Perkin Trans. 1* **1985**, 2247–2249.