Stereoselective Synthesis of the Pheromone (*R*)-(–)-Sulcatol, and Its Enantiopure (*R*)- and (*S*)-1-Mono-, -1,1-Di-, and -1,1,1-Trifluoro Analogues[1]

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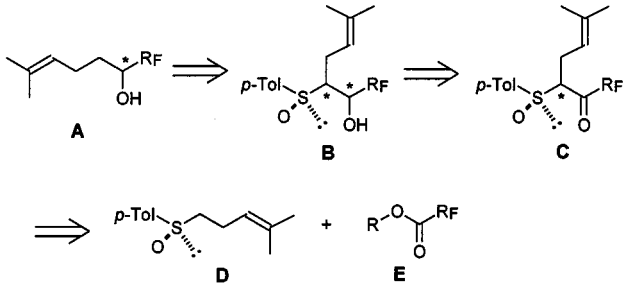
Keywords: Fluorine / Pheromones / Sulfoxides / Sulcatol / Asymmetric synthesis

The pheromone (*R*)-(–)-sulcatol (**10a**) and three of its enantiomeric mono-, di-, and trifluoro analogues **10b–d** have been synthesized, in six steps and with good overall yields, starting from chiral (*R*)-2-methyl-5-[(4-methylphenyl)sulfinyl]pent-2-ene (**1**) and commercially available fluorinated or *non*-fluorinated acetates.

Fluorination of organic compounds has been shown to be particularly important in a number of fields, such as medicinal chemistry, bio- and agrochemistry, and material sciences. Fluorine alters considerably the physico-chemical properties of organic compounds, thus modifying the activity of biologically important molecules.[2] Fluoro-substituted molecules often have reduced melting points and are more volatile and hydrophobic: For these reasons, when considering the different classes of bioactive compounds, the preparation of fluoro-substituted insect hormones, sex pheromones and biosynthetic inhibitors is continually a subject of interest for insect pest control.[3] Population aggregation pheromones have been identified in several species of *Scolytidae* Coleoptera:[4] Sulcatol is the male-produced aggregation pheromone which was first isolated from the boring dust of *Gnathotrichus Sulcatus*, an economically important ambrosia beetle of the Pacific Coast of North America.[5] *Gnathotrichus Sulcatus* is a timber pest which responds to this aggregation pheromone in a peculiar way: It can distinguish between the two enantiomeric forms of the pheromone and gives a positive response only when both enantiomers are present, in a 65:35 mixture of the (*S*)-(+) and (*R*)-(−) enantiomers. Therefore, in this case, the two enantiomers act synergistically to elicit a response.[6] Interestingly, *Gnathotrichus retusus*, which is the second species to share the pheromone sulcatol, responds only to (*S*)-(+)-sulcatol, whilst the (*R*)-(−) enantiomer seems, to some extent, to inhibit the response.[7]

In this paper we wish to report on the preparation of some enantiomerically pure, fluoro-substituted sulcatol analogues and of (*R*)-(−)-sulcatol itself,[8] by chiral sulfoxide chemistry.[9]

The straightforward synthetic plan shown in the Scheme 1 consists of three main steps: 1) the reaction of commercially available ethyl acetate and ethyl monofluoro-, difluoro-, and trifluoroacetates **E**, with the hexenyl *p*-tolyl sulfoxide **D**[10] to provide the key β-oxo sulfoxides **C**; 2) reduction of the β-oxo function of **C** to provide the β-hydroxy sulfoxides **B**; 3) reductive desulfinylation of **B**, leading to the targeted sulcatol and 1-fluoro-substituted analogues **A**.



Scheme 1. Retrosynthesis

Results and Discussion

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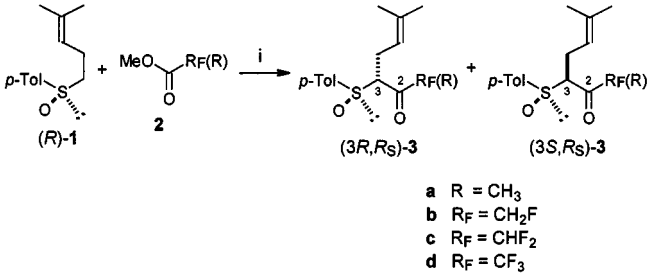
β-Oxo sulfoxides **3a−d** (Scheme 2) were obtained as nearly equimolar mixtures of C-3 epimers by reaction of the enantiopure lithiated sulfoxide (*R*)-**1**,[10] with the corresponding acetic esters **2**.[11] β-Oxo sulfoxide **3a** and the monofluoro derivative **3b** are stable compounds which can be purified by flash chromatography and stored for several days at 4°C, whereas the di- and trifluorinated derivatives **3c** and **3d** are quite unstable and had to be processed within a few hours without any intermediate purification.



Scheme 2. Reagents and conditions: i) LDA, THF, −60°C

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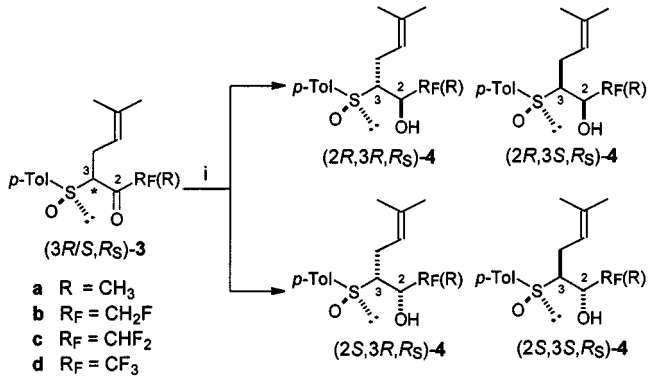
Reduction of the β-oxo sulfoxides **3a−d** to the corresponding β-hydroxy derivatives **4a−d** was a key-step in the synthetic sequence, and therefore carefully investigated.[12] Four diastereomers can be produced in this reaction. Modest stereoselectivities at the C-3 centre have sometimes been achieved in the reduction of epimeric mixtures of α-substituted β-oxo sulfoxides by means of dynamic kinetic resolution with the system $NaBH_4/NH_4OH/MeOH$.[12q] However, in this case the stereocentres C-3 are destroyed in the steps that follow (Scheme 1), therefore this study was undertaken with the aim of obtaining high diastereoselectivity in the formation of the carbinolic stereocentres C-2 (Scheme 3, Table 1). First, we investigated the reduction of the fluorine-free derivative **3a**. Following the modification of García Ruano[13] of the Solladié/Kosugi methodology,[12b,14] **3a** was treated first with $ZnBr_2$ (1.2 equiv.) for 2 h in THF at r.t., then with DIBAH at −60°C (Table 1, entry 1). Satisfactorily, the formation of the two C-3 epimers of **4a** having (*R*) stereochemistry at the newly created carbinolic centre C-2 was overwhelmingly preferred (12.3:1.0) (84% isolated yield). In contrast, $NaBH_4$ (in the presence of NH_4OH) proceeded with low stereocontrol, delivering an almost equimolar mixture of epimers at C-2 (Table 1, entry 2) (80%).



Scheme 3. Reagents and conditions: i) see Table 1

Reduction of the monofluoro derivative **3b** with DIBAH/$ZnBr_2$ occurred with lower chelation-control, as already reported in the literature for other monofluorinated β-oxo sulfoxides.[12p,13] The best result was obtained with 5 equiv. of $ZnBr_2$ (Table 1, entry 3), which produced a 3.8:1.0 ratio of (2*R*)/(2*S*) alcohols **4b** (90%). Slightly lower diastereoselectivity was achieved with 1.2 equiv. of $ZnBr_2$, namely (2*R*)/(2*S*) = 3.3:1.0 (Table 1, entry 4) (92%). Stereocontrol was modest in the absence of $ZnBr_2$, and treatment of the epimers **3b** with DIBAH at −78°C produced three diastereomers in comparable amounts (Table 1, entry 5) (95%).

Reduction of the epimeric difluoro β-oxo sulfoxides **3c** could not be accomplished under chelation-control conditions, because the substrates underwent extended decomposition in the presence of $ZnBr_2$ at r.t.. Treatment of **3c** with DIBAH (Table 1, entry 6) produced a mixture of the four corresponding alcohols, three of which could be obtained in a diastereomerically pure form by flash chromatography (95%).

Finally, attempts to reduce the trifluoro derivatives **3d** with DIBAH proved to be unsuccessful. Therefore, reduction was performed by means of $NaBH_4/NH_4OH$, providing the four corresponding hydroxy derivatives **4d**, with modest stereoselectivity (ca. 7:3) in favour of the (2*R*) diastereomers (Table 1, entry 7).

The high stereocontrol observed upon chelation conditions for the DIBAH reduction of the fluorine-free β-oxo sulfoxide **3a** can be interpreted in terms of the model proposed by Solladié and García Ruano[9e,13] (Figure 1) in which a chair-like transition state, having DIBAH associated with the lone pair at the sulfur atom, undergoes axial attack by the hydride, independent of the C-3 configuration. However, fluoro substitution is expected to decrease the electron density on the carbonyl oxygen atom, thus making the coordination by $ZnBr_2$ less efficient, moreover fluorine atoms may compete in the chelation with the sulfinyl group. Therefore, monofluoro compound **3b** can also be reduced by DIBAH under non-chelation conditions (Table 1, entry 5), providing lower stereocontrol, in line with other analogous examples reported in the literature, where the carbonyl oxygen atom could not be efficiently chelated[12p,13].

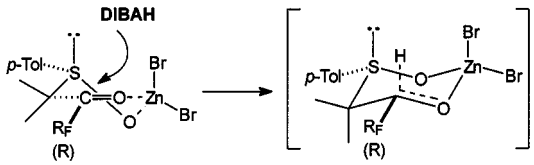


Figure 1. DIBAH reduction: chair-like transition state

Table 1. Reduction of β-oxo sulfoxides **3a−d**

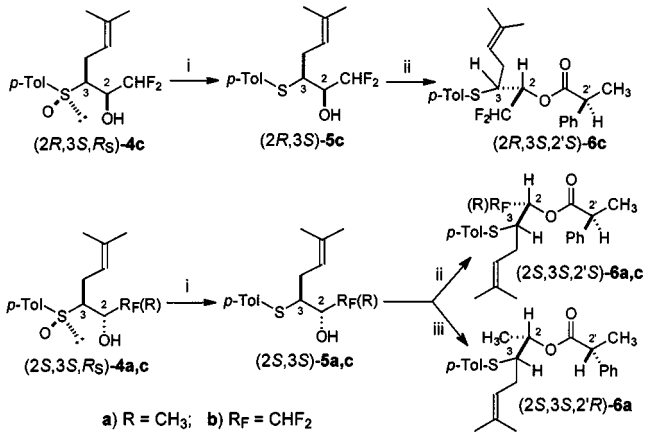
Entry	R_F(R)	Method	Diastereomeric ratio of alcohols (**4**)[a] (2*R*,3*S*)	(2*R*,3*R*)	(2*S*,3*R*)	(2*S*,3*S*)
1	CH_3	DIBAH/$ZnBr_2$ (1.2 equiv.)	6.8	5.5	1.0	−
2	CH_3	$NaBH_4$	7.2	1.0	−	6.7
3	CH_2F	DIBAH/$ZnBr_2$ (5 equiv.)	3.2	1.0	1.1	−
4	CH_2F	DIBAH/$ZnBr_2$ (1.2 equiv.)	3.0	1.0	1.2	−
5	CH_2F	DIBAH	1.3	−	1.0	2.3
6	CHF_2	DIBAH	1.3	1.0	1.2	4.5
7	CF_3	$NaBH_4$	3	4	2	1

[a] Determined by ^{19}F NMR and HPLC of the crude reaction mixtures.

Configurational Assignments

The absolute configurations of β-hydroxy sulfoxides (2*R*,3*S*,R_S)- and (2*S*,3*R*,R_S)-**4b**,**d** were previously determined.[11,12p] The stereochemistry of the remaining diastereomers (2*R*,3*R*,R_S)- and (2*S*,3*S*,R_S)-**4b**,**d** was also determined by correlation with the sulfur-free benzoyl esters (*R*)- and (*S*)-**9b**,**d**, obtained from the known diastereomers **4b**,**d** above (vide infra, Scheme 7).

Determination of the stereochemistry of the fluorine-free and the difluoro diastereomers **4a**,**c** was addressed as follows. The absolute configuration of the carbinolic centre C-2 of (2*R*,3*S*,R_S)-**4a** was assessed by chemical correlation: In fact this diastereomer provided (*R*)-sulcatol **10a** at the end of the synthetic sequence (vide infra, Scheme 5). Configurations at C-2 of (2*S*,3*S*,R_S)-**4a**, and of difluoro diastereomers (2*R*,3*S*,R_S)- and (2*S*,3*S*,R_S)-**4c** were determined by ^{1}H NMR with the method of the α-phenylpropionate derivatives (Scheme 4). The above compounds were deoxygenated to the corresponding sulfides **5a**,**c** with $(CF_3CO)_2O$/NaI (acetone, −20°C, 80−97%),[15] then transformed into the appropriate corresponding α-phenylpropionic esters **6a**,**c** (DCC, DMAP, CH_2Cl_2) (60−80%). The assignment was based on the upfield shift observed for the protons of the thio-substituted alkyl chain of compounds (2*S*,3*S*,2′*S*)-**6a**,**c** with respect to (2*S*,3*S*,2′*R*)-**6a** and (2*R*,3*S*,2′*S*)-**6c**, respectively (see Experimental Section), as a consequence of the well-known shielding effect exerted by the phenyl group of the ester residue in the preferred configuration of (2*S*,3*S*,2′*S*)-**6a**,**c**, as shown in Scheme 4.[16]



Scheme 4. Reagents and conditions: i) NaI, $(CF_3CO)_2O$, acetone, −20°C; ii) (+)-(*S*)-2-phenylpropionic acid, DCC, DMAP, CH_2Cl_2; iii) (−)-(*R*)-2-phenylpropionic acid, DCC, DMAP, CH_2Cl_2

With the C-2 stereochemistry in hand, the relative configuration between C-2 and C-3, and therefore the C-3 stereochemistry of diastereomers **4a**,**c**, were determined by comparing the ^{1}H-NMR data of these compounds with those of the known monofluoro derivatives **4b**. As can be seen from Table 2, all compounds **4a−c** having (2*S*,3*R*) and (2*R*,3*S*) configuration, namely a *syn* relationship between 2-H and 3-H, exhibited smaller $J_{H2\text{-}H3}$ values than those of the *anti* diastereomers (2*S*,3*S*) and (2*R*,3*R*). Smaller values of vicinal coupling constants were already observed in the case of many other *syn*-α-alkyl β-hydroxy sulfoxides in full agreement with our data.[13][17] It has been proposed that such an effect is a consequence of hydrogen bonding between the hydroxy and the sulfinyl oxygen atoms, which stabilizes the rotamers having 2-H and 3-H *gauche* disposed. In agreement with this, it must be noted that a smaller $J_{H2\text{-}H3}$ value for the *syn* diastereomers is not generally found for compounds **5−8**, when esterification of the hydroxy or deoxygenation of the sulfinyl group do not allow formation of any hydrogen bonding.

In agreement with the stereochemical assignments above, it should be noted that the protons of the pentenyl chains attached to C-3 resonated at lower fields (see Experimental Section) in the case of the (3*S*)-configurated β-hydroxy sulfoxides **4a−c**, probably due to the field effect exerted by the *p*-Tol ring attached to the stereogenic (*R*)-sulfur atom that shields the corresponding protons of the diastereomers (3*R*)-**4a−c**.

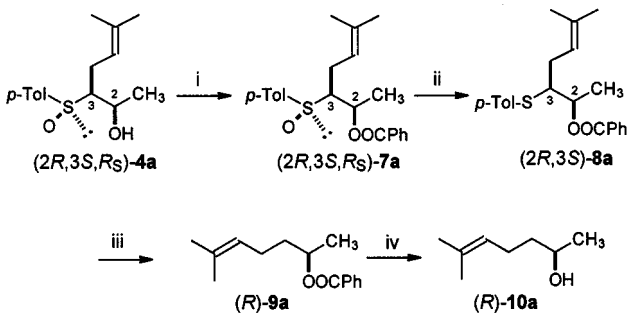
Synthesis of Sulcatol

Next step toward the synthesis of sulcatol (*R*)-**10a** (Scheme 5) was the reductive removal of the *p*-tolylsulfinyl

Table 2. Coupling constants $J_{H2\text{-}H3}$ [Hz] of some compounds **4−8**; n.d. = not determined

Compound	R_F(R)	Coupling constants $J_{H2\text{-}H3}$ [Hz] *syn*-(2*S*,3*R*)	*syn*-(2*R*,3*S*)	*anti*-(2*R*,3*R*)	*anti*-(2*S*,3*R*)
4a	CH_3	1.5	3.2	8.1	6.4
4b	CH_2F	1.4	3.7	6.9	6.4
4c	CHF_2	1.5	1.9	4.2	4.4
5c	CHF_2	4.9	4.9	3.1	3.1
6c	CHF_2	−	5.7	−	2.9
7a	CH_3	n.d.	3.3	4.7	3.3
7b	CH_2F	3.6	3.8	n.d.	4.2
7c	CHF_2	2.6	2.2	n.d.	2.6
7d	CF_3	1.1	1.5	6.2	1.6
8a	CH_3	4.8	4.8	3.5	3.5
8b	CH_2F	7.0	7.0	4.2	4.2
8c	CHF_2	6.3	6.3	3.0	3.0
8d	CF_3	2.7	2.7	4.8	4.8

group from the corresponding β-hydroxy sulfoxides (2*R*,3*R*/*S*,R_S)-**4a**. This transformation is normally accomplished by means of Raney-Ni. However, according to the literature, this reaction can produce partial racemization at the carbinolic centre, when performed on secondary alcohols.[18] Therefore, we decided to protect the hydroxy groups before treatment with Raney-Ni.[14a] The benzoates (2*R*,3*R*/*S*,R_S)-**7a** were prepared by reaction of unresolved mixtures of diastereomeric β-hydroxy sulfoxides **4a** with benzoic acid, DCC, and catalytic 4-(dimethylamino)pyridine (quantitative), and isolated in diastereomerically pure form by flash chromatography. Deoxygenation of (2*R*,3*S*,R_S)-**7a** with NaI/TFAA[15] provided the sulfide (2*R*,3*S*)-**8a**, that was reductively desulfenylated with Raney-Ni, and carefully washed with a nitrogen stream in the presence of cyclohexene, to minimize the concomitant hydrogenation of the C−C double bond.



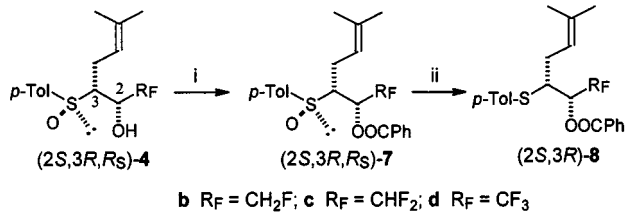
Scheme 5. Reagents and conditions: i) PhCOOH, DCC, DMAP, CH_2Cl_2, 0°C; ii) NaI, $(CF_3CO)_2O$, acetone, −20°C; iii) Raney-Ni, cyclohexene, N_2, ethanol, Δ*T*; iv) NaOH, H_2O/methanol, r.t.

Alkaline debenzoylation of the resulting *O*-benzoylsulcatol [(*R*)-**9a**] afforded enantiomerically pure sulcatol [(*R*)-**10a**], whose spectral data were identical to those of the natural product and whose optical rotatory power value $[\alpha]_D^{20} = -19.9$ substantially matched that of natural (*R*)-(−)-sulcatol.[19]

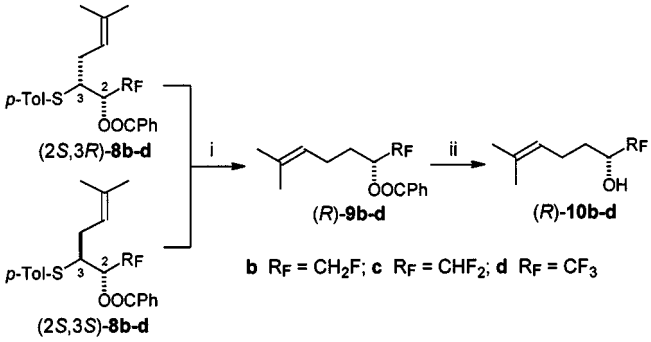
Synthesis of 1-Fluoro, 1,1-Difluoro, and 1,1,1-Trifluoro Analogues of Sulcatol

Both enantiomers of the mono-, di-, and trifluoro analogues of sulcatol were synthesized following an identical sequence of reactions. The preparation of the fluorinated *p*-tolylthio benzoates (2*S*,3*R*)-**8b−d** by benzoylation and subsequent deoxygenation of the corresponding β-hydroxy sulfoxides (2*S*,3*R*,R_S)-**4b−d** is shown in Scheme 6. The same procedure was successfully applied to all the examined diastereomers (see Experimental Section and Supporting Information).

The loss of the stereogenic centre C-3 in the next step (Scheme 7) allowed us to submit the mixtures of C-3 epimers **8b−d,** which have identical stereochemistry at C-2, to desulfenylation with Raney-Ni/cyclohexene, without tedious chromatographic separations, to afford the chiral sulfur-free *O*-benzoyl-fluorosulcatols (*R*)-**9b−d**. The final alkaline debenzoylation step gave the three couples of the mono-, di-, and trifluorosulcatols (*R*)-**10b−d** as enantiomerically pure compounds.



Scheme 6. Reagents and conditions: i) PhCOOH, DCC, DMAP, CH_2Cl_2, 0°C; ii) NaI, $(CF_3CO)_2O$, acetone, −20°C



Scheme 7. Reaction conditions: i) Raney-Ni, cyclohexene, N_2, ethanol, Δ*T*; ii) NaOH, H_2O/methanol, r.t.

Enantiomeric fluorosulcatols (*S*)-**10b−d** were prepared following an identical sequence of reactions, from the corresponding β-hydroxy sulfoxides **4b−d** having (*R*) stereochemistry at the carbinolic centre C-2 (see Experimental Section and Supporting Information).

Conclusion

The pheromone (−)-(*R*)-sulcatol (**10a**) and both enantiomers of its mono-, di-, and trifluoro analogues **10b−d** were stereoselectively synthesized in an enantiopure form following an operatively simple methodology. The sulfoxide group was used as chiral auxiliary, whilst introduction of fluorine was achieved by using commercially available mono-, di-, and trifluoacetic esters as cheap source of fluorine.

Experimental Section

General Details: Melting points (m.p.): uncorrected; capillary apparatus. − Polarimetric analyses: JASCO DIP-181 and PROPOL polarimeters. − Analytical TLC: routinely used to monitor reactions, plates precoated with E. Merck silica gel 60 F_{254} of 0.25 mm thickness were used. − Flash chromatographies (FC): silica gel 60 (230−400 ASTM mesh). − ^1H and ^{19}F NMR: Bruker AC 250L spectrometer (250 MHz, $CDCl_3$), chemical shifts in ppm (δ), tetramethylsilane (TMS) as internal standard for ^1H nucleus (δ_H = 0.00), C_6F_6 external standard (δ_F = −162.90) for ^{19}F, coupling

constants are expressed in Hz. − MS: TSQ 70 Finnigan Mat three-stage quadrupole instrument, DIS (Direct Inlet System) used for pure compounds. − IR: Perkin-Elmer System 2000 FT-IR (scan range: 15600 cm^{-1}; combined scan direction). − HPLC: Waters 600E System Controller instrument using a Lambda-Max Model 481 LC spectrophotometer operating at 260 nm. − Analytical data: Waters 745 Data Module instrument; analyses were performed on Hibar Pre-Packed column RT 250-4 (LiChrosorb Si 60-μm; Merck) and optical resolution on Chiracel OB (Daicel Chemical Industries, Ltd). − GC/MS: TSQ 70 Finnigan Mat mass spectrometer having a transfer line with Varian 3400 GC instrument. − GC: DB-5 Fused Silica Capillaries column [5% phenyl, 95% methyl silicone; 30 m × 0.25 mm; ∅ = 0.25 μm; carrier gas: He, 12 mL/min; temperature gradient operating: 40°C (1 min) → 200°C (1 min); 10°C/min → 285 (24 min)]. THF was freshly distilled from Na/benzophenone, diisopropylamine was freshly distilled from CaH_2; in all other cases, commercially available reagent-grade solvents were employed without purification. All reactions, where anhydrous organic solvents were employed, were performed under nitrogen, after flame-drying procedures of the glass apparatus. Synthesis of 1-fluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-one (**3b**),[12p] 1,1,1-trifluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-one (**3d**),[11] and 1,1,1-trifluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-ol (**4d**)[11] has already been described in detail.

Synthesis of β-Oxo Sulfoxides (3*R*/*S*,R_S)-3a,c. − General Procedure: A solution of (R_S)-2-methyl-5-[(4-methylphenyl)sulfinyl]pent-2-ene (**1**) (5.4 mmol, 1.2 g) in THF (4 mL) was added dropwise to a solution of LDA (5.4 mmol) in THF (10 mL) at −70°C. The temperature was allowed to reach 0°C. The yellow solution was then cooled at −60°C and neat ethyl difluoroacetate (**2c**) (5.4 mmol, 670 mg) added dropwise by syringe. After 10 min, the reaction was quenched by adding a satd. aqueous solution of NH_4Cl. The mixture was extracted with AcOEt and the extract was dried with anhydrous sodium sulfate and concentrated to dryness.

6-Methyl-3-[(4-methylphenyl)sulfinyl]-hept-5-en-2-ones [(3*R*/*S*,R_S)-3a]: Yield 1.03 g (72%), obtained as an equimolar mixture of C-3 epimers by FC (*n*-hexane/AcOEt, 7:3); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.60 and 1.67 (br. s, 6 H, 2 × 6-CH_3), 1.96 and 2.12 (s, 3 H, 1-H_3), 2.40 (br. s, 3 H, ArCH_3), 2.4−2.9 (m, 2 H, 4-H_2), 3.53 and 3.72 (dd, 1 H, *J* = 9.1 and 6.1 Hz, *J* = 10.0 and 4.7 Hz, 3-H), 5.00 (m, 1 H, 5-H), 7.32 and 7.50 (m, 4 H, ArH). − MS (DIS EI); *m/z* (%): 265 [(M + H)$^+$] (70), 223 [$C_{12}H_{14}O_2S^+$] (9), 195 [$C_{12}H_{14}O_2S^+$] (18), 140 [*p*TolSOH$^{+\cdot}$] (27), 139 [*p*TolSO$^+$] (47), 125 [(M + H − *p*TolSOH)$^+$] (100), 107 [$C_8H_{11}^+$] (14), 43 [CH_3CO^+] (21). − $C_{15}H_{20}O_2S$ (264): calcd. C 68.14, H 7.62; found C 68.18, H 7.60.

1,1-Difluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]-hept-5-en-2-ones [(3*R*/*S*,R_S)-3c]: Yield 1.4 g (87%), obtained as a 2:1 mixture of C-3 epimers by FC (*n*-hexane/AcOEt, 7:3); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.56 and 1.66 (br. s, 6 H, 2 × 6-CH_3), 2.4−2.7 (m, 2 H, 4-H_2), 2.43 (br. s, 3 H, ArCH_3), 4.33 and 4.37 (m, 1 H, 3-H), 4.95 and 4.98 (m, 1 H, 5-H), 5.82 and 5.89 (t, 1 H, *J* = 54.5 Hz, 1-H), 7.3−7.6 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −130.60 and −129.30, −131.0 and −130.30 (dd, 2 F, *J* = 306.5 and 54.5 Hz). − MS (DIS EI, 70 eV); *m/z* (%): 301 [(M + H)$^+$] (5), 161 [(M + H − *p*TolSOH)$^+$] (24), 140 [*p*TolSOH$^{+\cdot}$] (54), 139 [*p*TolSO$^+$] (100), 123 [*p*TolS$^+$] (29), 91 [$C_7H_7^+$] (44), 79 (50), 51 [CHF_2^+] (44), 41 [$C_3H_5^+$] (50).

Synthesis of 6-Methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-ols (4a). − Method A (Table 1, Entry 1): A mixture of (3*S*/*R*,R_S)-**3a** (1.1 mmol, 300 mg) and anhydrous $ZnBr_2$ (1.4 mmol, 307 mg) in dry THF (5 mL) was stirred at r.t. for 2 h, then cooled at −65°C. A 1.0 M solution of DIBAH in *n*-hexane (1.4 mmol, 1.4 mL) was slowly added by syringe. After 10 min, the reaction was quenched with a satd. aqueous solution of NH_4Cl. The pH was adjusted to 2 with diluted aqueous HCl. The mixture was extracted with AcOEt and the extract was dried with anhydrous sodium sulfate and concentrated to dryness. ^{1}H-NMR analysis of the crude showed the following d.r.: (2*S*,3*R*)-/(2*R*,3*R*)-/(2*R*,3*S*)-**4a** = 1.0:5.5:6.8. After FC ($CHCl_3$/AcOEt, 75:25), the following enantiomerically pure compounds were obtained: (2*S*,3*R*,R_S)-**4a** (17 mg, 6%), (2*R*,3*R*,R_S)-**4a** (102 mg, 35%) and (2*R*,3*S*,R_S)-**4a** (126 mg, 43%). Overall isolated yield: 245 mg (84%).

Method B (Table 1, Entry 2): $NaBH_4$ (88 mg, 2.3 mmol), suspended in methanol/NH_4OH (9:1) (2 mL), was added to a solution of **3a** (1:1 epimeric mixture) (400 mg, 1.52 mmol) in methanol (9 mL) and 30% NH_4OH (1 mL) stirred at 0°C. After 10 min, the reaction was quenched by adding dropwise a diluted aqueous HCl solution until neutral pH was achieved. The solvent was evaporated, the residue diluted with AcOEt, washed with water (3 × 5 mL), the combined organic layers were dried with anhydrous sodium sulfate and, after filtration, the solvent was evaporated in vacuo. ^{1}H-NMR analysis of the crude showed the following d.r.: (2*R*,3*R*)-/(2*R*,3*S*)-/(2*S*,3*S*)-**4a** = 1.0:7.2:6.7. Overall isolated yield: 323 mg (80%). FC was carried out as described above (Method A).

(2*S*,3*R*,R_S)-4a: R_f = 0.40; $[\alpha]_D^{20}$ = + 165.7 (*c* = 0.5, $CHCl_3$); yellowish oil. − ^{1}H NMR ($CDCl_3$): δ = 1.17 (d, 3 H, *J* = 6.6 Hz, 1-H_3), 1.68 and 1.75 (br. s, 6 H, 2 × 6-CH_3), 2.34 (ddd, 1 H, *J* = 9.6, 5.3 and 1.5 Hz, 3-H), 2.43 (br. s, 3 H, ArCH_3), 2.53 and 2.70 (m, 2 H, 4-H_2), 2.71 (br. signal, 1 H, OH), 4.29 (dq, 1 H, *J* = 1.5 and 6.6 Hz, 2-H), 5.21 (m, 1 H, 5-H), 7.35 and 7.50 (m, 4 H, ArH). − MS (DIS EI); *m/z* (%): 267 [(M + H)$^+$] (11), 140 [*p*TolSOH$^{+\cdot}$] (50), 139 [*p*TolSO$^+$] (70), 127 [(M + H − *p*TolSOH)$^+$] (20), 109 [$C_8H_{13}^+$] (100), 92 [PhC$H_3^{+\cdot}$] (33), 91 [$C_7H_7^+$] (50), 83 [$C_6H_{11}^+$] (45), 69 [$C_5H_9^+$] (72), 55 [$C_4H_7^+$] (16), 43 [$C_3H_7^+$] (18).

(2*R*,3*R*,R_S)-4a: R_f = 0.35; $[\alpha]_D^{20}$ = + 44.1 (*c* = 2.0, $CHCl_3$); m.p. 45−47°C (from diethyl ether). − ^{1}H NMR ($CDCl_3$): δ = 1.29 (d, 3 H, *J* = 6.3 Hz, 1-H_3), 1.53 and 1.68 (br. s, 6 H, 2 × 6-CH_3), 2.1−2.4 (m, 2 H, 4-H_2), 2.42 (br. s, 3 H, ArCH_3), 2.85 (dt, 1 H, *J* = 8.1 and 5.6 Hz, 3-H), 3.73 (br. signal, 1 H, OH), 4.36 (dq, 1 H, *J* = 8.1 and 6.3 Hz, 2-H), 5.04 (m, 1 H, 5-H), 7.32 and 7.59 (m, 4 H, ArH). − $C_{15}H_{22}O_2S$ (266): calcd. C 67.63, H 8.32; found C 67.60, H 8.30.

(2*R*,3*S*,R_S)-4a: R_f = 0.32; $[\alpha]_D^{20}$ = + 108.1 (*c* = 2.0, $CHCl_3$); m.p. 65−67°C (from diethyl ether). − ^{1}H NMR ($CDCl_3$): δ = 1.41 (d, 3 H, *J* = 6.6 Hz, 1-H_3), 1.46 and 1.53 (br. s, 6 H, 2 × 6-CH_3), 2.0−2.4 (m, 2 H, 4-H_2), 2.40 (br. s, 3 H, ArCH_3), 2.59 (ddd, 1 H, *J* = 6.3, 5.8 and 3.2 Hz, 3-H), 2.78 (br. signal, 1 H, OH), 4.41 (dq, 1 H, *J* = 3.2 and 6.6 Hz, 2-H), 4.76 (m, 1 H, 5-H), 7.30 and 7.47 (m, 4 H, ArH).

(2*S*,3*S*,R_S)-4a: R_f = 0.35; $[\alpha]_D^{20}$ = + 39.6 (*c* = 1.5, $CHCl_3$); m.p. 42−43°C (from diethyl ether). − ^{1}H NMR ($CDCl_3$): δ = 1.38 (d, 3 H, *J* = 6.5 Hz, 1-H_3), 1.50 and 1.65 (br. s, 6 H, 2× 6-CH_3), 2.1−2.4 (m, 2 H, 4-H_2), 2.43 (br. s, 3 H, ArCH_3), 2.77 (ddd, 1 H, *J* = 7.6, 6.8 and 6.4 Hz, 3-H), 4.14 (dq, 1 H, *J* = 6.4 and 6.5 Hz, 2-H), 5.01 (m, 1 H, 5-H), 7.35 and 7.49 (m, 4 H, ArH). − IR (KBr): $\tilde{\nu}$ = 2930 cm^{-1} (O−H), 1690 (C=C), 1425 (δ C−H), 1292 (S=O), 1180 (C−O), 1027 (S=O), 667 (C−S).

Synthesis of 1-Fluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]-hept-5-en-2-ols (4b). − Method A (Table 1, Entry 3): A solution of (3*S*/*R*,R_S)-**3b** (3.0 mmol, 845 mg) and anhydrous $ZnBr_2$ (15.0 mmol, 3.38 g) in dry THF (15 mL) was stirred at r.t. for 2 h. The mixture

was cooled at −60°C, then a 1.0 M solution of DIBAH in *n*-hexane (15.0 mmol, 15.0 mL) was slowly added by syringe. After 10 min, the reaction was quenched by adding a satd. aqueous solution of NH_4Cl. The pH was adjusted to 2 with diluted aqueous HCl. The mixture was extracted with AcOEt and the extract was dried with anhydrous sodium sulfate and concentrated to dryness. HPLC and ^{19}F-NMR analyses of the crude reaction mixture showed the following d.r.: (2*R*,3*R*)-/(2*S*,3*R*)-/(2*R*,3*S*)-**4b** = 1.0:1.1:3.2. After FC (*n*-hexane/AcOEt, 6:4), the following enantiomerically pure compounds were obtained: (2*S*,3*R*,R_S)-**4b** (153 mg, 18%), (2*R*,3*S*,R_S)-**4b** (460 mg, 54%), whereas (2*R*,3*R*,R_S)-**4b** was only isolated in a mixture. Overall isolated yield: 767 mg (90%).

Method B (Table 1, Entry 4): A solution of (3*S*/*R*,R_S)-**3b** (3.0 mmol, 845 mg) and anhydrous $ZnBr_2$ (4.4 mmol, 997 mg) in dry THF (19 mL) was stirred at r.t. for 2 h. The mixture was cooled at −60°C, then a 1.0 M solution of DIBAH in *n*-hexane (3.6 mmol, 3.6 mL) was slowly added by syringe. After the usual workup, HPLC and ^{19}F-NMR analyses of the crude reaction mixture showed the following d.r.: (2*R*,3*R*)-/(2*S*,3*R*)-/(2*R*,3*S*)-**4b** = 1.0:1.2:3.0. After FC (*n*-hexane/AcOEt, 6:4), the following enantiomerically pure compounds were obtained: (2*S*,3*R*,R_S)-**4b** (170 mg, 20%), (2*R*,3*S*,R_S)-**4b** (451 mg, 53%), whereas (2*R*,3*R*,R_S)-**4b** was only isolated in mixture. Overall isolated yield: 784 mg (92%).

Method C (Table 1, Entry 5): A 1.0 M solution of DIBAH in *n*-hexane (3.5 mmol, 3.5 mL) was added by syringe to a solution of (3*S*/*R*,R_S)-**3b** (3.0 mmol, 845 mg) in THF (15 mL), cooled at −60°C. After the usual quenching, workup and purification (see Method A), the crude mixture was submitted to HPLC and ^{19}F-NMR analyses, which showed the following d.r.: (2*S*,3*R*)-/(2*R*,3*S*)-/(2*S*,3*S*)-**4b** = 1.0:1.3:2.3. The following enantiomerically pure compounds were isolated: (2*S*,3*R*,R_S)-**4b** (170 mg, 20%), (2*R*,3*S*,R_S)-**4b** (213 mg, 25%), (2*S*,3*S*,R_S)-**4b** (426 mg, 50%). Overall isolated yield: 809 mg (95%).

(2*S*,3*R*,R_S)-4b: R_f = 0.35; $[\alpha]_D^{20}$ = + 199.7 (*c* = 0.9, $CHCl_3$). − ^1H NMR ($CDCl_3$): δ = 1.68 and 1.75 (br. s, 6 H, 2 × 6-CH_3), 2.43 (br. s, 3 H, ArCH_3), 2.53 (dddd, *J* = 9.0, 5.7, 1.4, and 1.1 Hz, 3-H), 2.63 and 2.74 (m, 2 H, 4-H_2), 4.00 (br. signal, 1 H, OH), 4.28 (ddd, 1 H, *J* = 46.8, 9.0, and 6.3 Hz, 1a-H), 4.35 (ddd, 1 H, *J* = 47.0, 9.0, and 5.6 Hz, 1b-H), 4.42 (dddd, 1 H, *J* = 15.5, 6.3, 5.6, and 1.4 Hz, 2-H), 5.20 (m, 1 H, 5-H), 7.36 and 7.51 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −228.44 (br. ddd, *J* = 47.0, 46.8, and 15.5 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 285 [(M + H)$^+$] (100), 145 [(M + H − *p*TolSOH)$^+$] (37), 140 [*p*TolSOH$^{+\cdot}$] (43), 139 [*p*TolSO$^+$] (26), 127 [$C_8H_{12}F^+$] (83), 107 [$C_8H_{11}^+$] (16), 91 [$C_7H_7^+$] (31), 83 [$C_6H_{11}^+$] (37), 69 [$C_5H_9^+$] (91), 55 [$C_4H_7^+$] (44), 41 [$C_3H_5^+$] (64). − HPLC analysis: t_r = 12.07 min (*n*-hexane/AcOEt, 3:2; 0.8 mL/min).

(2*R*,3*S*,R_S)-4b: R_f = 0.40; $[\alpha]_D^{20}$ = + 115.6 (*c* = 0.5, $CHCl_3$). − ^1H NMR ($CDCl_3$): δ = 1.46 and 1.55 (br. s, 6 H, 2 × 6-CH_3), 2.28 and 2.44 (m, 2 H, 4-H_2), 2.38 (br. s, 3 H, ArCH_3), 2.81 (dddd, 1 H, *J* = 8.2, 5.6, 3.7, and 1.5 Hz, 3-H), 4.38 (dddd, 1 H, *J* = 18.4, 7.1, 3.8, and 3.7 Hz, 1a-H), 4.53 (ddd, 1 H, *J* = 47.0, 9.7, and 3.8 Hz, 1b-H), 4.65 (ddd, 1 H, *J* = 48.0, 9.7, and 7.1 Hz, 2-H), 4.88 (m, 1 H, 5-H), 7.29 and 7.50 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −225.79 (br. ddd, *J* = 48.0, 47.0, and 18.4 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 285 [(M + H)$^+$] (100), 145 [(M + H − *p*TolSOH)$^+$] (25), 140 [*p*TolSOH$^{+\cdot}$] (42), 139 [*p*TolSO$^+$] (34), 127 [$C_8H_{12}F^+$] (73), 107 [$C_8H_{11}^+$] (17), 91 [$C_7H_7^+$] (39), 83 [$C_6H_{11}^+$] (29), 69 [$C_5H_9^+$] (89), 55 [$C_4H_7^+$] (51), 41 [$C_3H_5^+$] (87). − HPLC analysis: t_r = 15.78 min (*n*-hexane/AcOEt, 3:2; 0.8 mL/min). − $C_{15}H_{21}FO_2S$ (284): calcd. C 63.35, H 7.44; found C 63.38, H 7.40.

(2*S*,3*S*,R_S)-4b: R_f = 0.50; $[\alpha]_D^{20}$ = + 119.9 (*c* = 0.9, $CHCl_3$). − ^1H NMR ($CDCl_3$): δ = 1.50 and 1.65 (br. s, 6 H, 2 × 6-CH_3), 1.97 and 2.37 (m, 2 H, 4-H_2), 2.43 (br. s, 3 H, ArCH_3), 2.98 (br. dt, 1 H, *J* = 6.4 and 7.2 Hz, 3-H), 3.70 (br. signal, 1 H, OH), 4.17 (dddd, 1 H, *J* = 19.2, 6.4, 5.0, and 4.6 Hz, 1a-H), 4.54 (ddd, 1 H, *J* = 46.8, 9.8, and 4.6 Hz, 1b-H), 4.63 (ddd, 1 H, *J* = 47.3, 9.8 and 5.0 Hz, 2-H), 4.98 (m, 1 H, 5-H), 7.37 and 7.49 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −230.41 (br. ddd, *J* = 47.3, 46.8, and 19.2 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 285 [(M + H)$^+$] (100), 145 [(M + H − *p*TolSOH)$^+$] (7), 140 [*p*TolSOH$^{+\cdot}$] (27), 139 [*p*TolSO$^+$] (24), 127 [$C_8H_{12}F^+$] (47), 107 [$C_8H_{11}^+$] (12), 91 [$C_7H_7^+$] (26), 77 [Ph$^+$] (11), 83 [$C_6H_{11}^+$] (18), 69 [$C_5H_9^+$] (47), 55 [$C_4H_7^+$] (31), 41 [$C_3H_5^+$] (54). − HPLC analysis: t_r = 25.83 (*n*-hexane/AcOEt, 3:2; 0.8 mL/min).

(2*R*,3*R*,R_S)-4b: R_f = 0.40. − ^1H NMR ($CDCl_3$): δ = 1.54 and 1.68 (br. s, 6 H, 2 × 6-CH_3), 2.1−2.5 (m, 2 H, 4-H_2), 2.42 (br. s, 3 H, ArCH_3), 3.05 (br. ddd, 1 H, *J* = 6.9, 6.7, and 5.6 Hz, 3-H), 4.2−4.8 (m, 3 H, 1-H_2 and OH), 5.04 (m, 1 H, 5-H), 7.32 and 7.59 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −230.45 (br. dt, *J* = 24.2 and 47.8 Hz). − HPLC analysis: t_r = 14.39 min (*n*-hexane/AcOEt, 3:2; 0.8 mL/min).

Synthesis of 1,1-Difluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]-hept-5-en-2-ols (4c) (Table 1, Entry 6): A 1.0 M solution of DIBAH in *n*-hexane (18.8 mmol, 10.8 mL) was added by syringe to a solution of difluoro ketones (3*S*/*R*,R_S)-**3c** (9.0 mmol, 2.7 g) in THF (57 mL) at −60°C. The usual quenching, workup (see compound **4b**, Method A), and FC with *n*-hexane/AcOEt (65:35) afforded the following diastereomerically pure compounds: (2*S*,3*R*,R_S)-**4c** (489 mg, 18%), (2*R*,3*S*,R_S)-**4c** (544 mg, 20%), (2*S*,3*S*,R_S)-**4c** (870 mg, 32%), and (2*R*,3*R*,R_S)-**4c**, which was isolated in a mixture with (2*R*,3*S*,R_S)-**4c**. Overall isolated yield: 2.6 g (95%).

(2*S*,3*R*,R_S)-4c: R_f = 0.35; $[\alpha]_D^{20}$ = + 193.4 (*c* = 0.8, $CHCl_3$); m.p. 67.8−68.5°C (from diisopropyl ether). − ^1H NMR ($CDCl_3$): δ = 1.70 and 1.76 (br. s, 6 H, 2× 6-CH_3), 2.45 (br. s, 3 H, ArCH_3), 2.63 (dddd, 1 H, *J* = 9.0, 6.0, 1.5, and 1.4 Hz, 3-H), 2.72 and 2.81 (m, 2 H, 4-H_2), 4.24 (m, 1 H, 2-H), 4.35 (br. signal, 1 H, OH), 5.22 (m, 1 H, 5-H), 5.68 (ddd, 1 H, *J* = 56.5, 55.9 and 5.1, Hz, 1-H), 7.39 and 7.49 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −130.43 (br. ddd, 1 F, *J* = 291.2, 55.9, and 8.9 Hz, F-1a), −128.40 (br. ddd, 1 F, *J* = 291.2, 56.5, and 12.0 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%): 303 [(M + H)$^+$] (100), 163 [(M + H − *p*TolSOH)$^+$], (14), 145 [$C_8H_{11}F_2^+$] (12), 140 [*p*TolSOH$^{+\cdot}$] (11), 139 [*p*TolSO$^+$] (27), 91 [$C_7H_7^+$] (17), 69 [$C_5H_9^+$] (40), 51 [CHF_2^+] (15), 41 [$C_3H_5^+$] (44). − $C_{15}H_{20}F_2O_2S$ (302): calcd. C 59.58, H 6.67; found C 59.53, H 6.62.

(2*R*,3*S*,R_S)-4c: R_f = 0.40 (0.35 in $CHCl_3$/AcOEt, 85:15); $[\alpha]_D^{20}$ = + 91.3 (*c* = 0.8, $CHCl_3$); m.p. 61−63°C (from diisopropyl ether). − ^1H NMR ($CDCl_3$): δ = 1.52 and 1.61 (br. s, 6 H, 2 × 6-CH_3), 2.22 and 2.60 (m, 2 H, 4-H_2), 2.43 (br. s, 3 H, ArCH_3), 2.77 (d, 1 H, *J* = 3.8 Hz, OH), 2.89 (m, 1 H, 3-H), 4.48 (ddddd, 1 H, *J* = 12.6, 7.8, 5.7, 3.8, and 1.9 Hz, 2-H), 4.91 (m, 1 H, 5-H), 5.81 (ddd, 1 H, *J* = 56.7, 55.5, and 5.7 Hz, 1-H), 7.33 and 7.48 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −129.02 (br. ddd, 1 F, *J* = 289.8, 55.5, and 7.8 Hz, F-1a), −127.42 (br. ddd, 1 F, *J* = 289.8, 56.7, and 12.6 Hz, F-1b). − IR (nujol): $\tilde{\nu}$ = 3250 cm^{-1} (O−H), 1063 (C−O), 1020 (S=O), 1007 (C−S), 812 (C−F). − MS (DIS EI, 70 eV); *m*/*z* (%): 303 [(M + H)$^+$] (100), 163 [(M + H − *p*TolSOH)$^+$] (18), 145 [$C_8H_{11}F_2^+$] (21), 140 [*p*TolSOH$^{+\cdot}$] (21), 139 [*p*TolSO$^+$] (10), 91 [$C_7H_7^+$] (7), 69 [$C_5H_9^+$] (14); 51 [CHF_2^+] (3).

(2*S*,3*S*,R_S)-4c: R_f = 0.43; $[\alpha]_D^{20}$ = +160.8 (*c* = 0.6, $CHCl_3$); m.p. 77−78°C (from diisopropyl ether). − ^1H NMR ($CDCl_3$): δ = 1.51 and 1.66 (br. s, 6 H, 2 × 6-CH_3), 1.94 and 2.58 (m, 2 H, 4-H_2),

2.44 (br. s, 3 H, $ArCH_3$), 2.87 (br. ddd, 1 H, J = 9.1, 5.8, and 4.4 Hz, 3-H), 4.10 (ddddd, 1 H, J = 12.0, 11.0, 6.0, 4.5, and 4.4 Hz, 2-H), 4.52 (d, 1 H, J = 6.0 Hz, OH), 4.94 (m, 1 H, 5-H), 6.06 (dt, 1 H, J = 4.5 and 55.5 Hz, 1-H), 7.37 and 7.47 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −130.10 (br. ddd, 1 F, J = 288.5, 55.5, and 11.0 Hz, F-1a), −127.80 (br. ddd, 1 F, J = 288.5, 55.5, and 12.0 Hz, F-1b).

(2*R*,3*R*,*R*$_S$)-4c: R_f = 0.40 (*n*-hexane/AcOEt, 65:35). − ^{1}H NMR ($CDCl_3$): δ = 1.55 and 1.69 (br. s, 6 H, 2 × 6-CH_3), 2.3−2.7 (m, 2 H, 4-H_2), 2.43 (br. s, 3 H, $ArCH_3$), 3.03 (br. ddd, J = 8.0, 6.0 and, 4.2 Hz, 3-H), 4.20 (dddd, 1 H, J = 14.2, 7.7, 5.2, and 4.2 Hz, 2-H), 4.99 (m, 1 H, 5-H), 6.13 (ddd, 1 H, J = 57.2, 55.2, and 5.2 Hz, 1-H), 7.33 and 7.60 (m, 4 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −130.31 (br. ddd, 1 F, J = 291.0, 55.2, and 7.7 Hz, F-1a), −126.28 (br. ddd, 1 F, J = 291.0, 57.2, and 14.2 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%): 303 [(M + H)$^+$] (100), 163 [(M + H − *p*TolSOH)$^+$] (1), 145 [$C_8H_{11}F_2^+$] (5), 140 [*p*TolSOH$^{+\cdot}$] (5), 139 [*p*TolSO$^+$] (1), 91 [$C_7H_7^+$] (1), 83 [$C_6H_{11}^+$] (13), 69 [$C_5H_9^+$] (40), 55 [$C_4H_7^+$] (6).

Deoxygenation Reaction. − General Procedure: A solution of trifluoroacetic anhydride (3.0 mmol) in acetone (2 mL) was added dropwise to a suspension of difluoro sulfinyl alcohol **4c** (1.0 mmol, 302 mg) and NaI (2.0 mmol) in acetone (10 mL) stirred at −40°C under nitrogen. After 10 min, an aqueous satd. solution of sodium sulfite and $NaHCO_3$ was added. The mixture was extracted with diethyl ether and the extract was dried with anhydrous sodium sulfate. After filtration, the solvent was removed in vacuo. FC (eluent mixtures indicated in the Supporting Information) allowed the isolation of the pure diastereomers **5c**. Physical and spectroscopic data for (2*S*,3*S*)-**5a**, (2*R*,3*S*)-**5c**, (2*S*,3*S*)-**5c** are reported in the Supporting Information.

Esterification of 4a−d with Benzoic Acid and 5a,c with Enantiopure Phenylpropionic Acid. − General Procedure: Neat benzoic acid (134 mg, 1.1 mmol) was added to a solution of sulfinyl alcohol **4** (1.0 mmol) and dicyclohexylcarbodiimide (DCC) (224 mg, 1.1 mmol) in CH_2Cl_2 (40 mL) stirred at 0°C After 5 min, dimethylaminopyridine (DMAP) (12 mg, 0.1 mmol) was added and a white suspension formed. The reaction was stirred at r.t. for the appropriate time (see below and Supporting Information), then the white precipitate was filtered off, and the solution concentrated in vacuo. FC (see below and Supporting Information) of the crude reaction mixtures allowed the isolation of the pure products **7**.

Physical and spectroscopic data for (2*S*,3*S*,*R*$_S$)-**7a**, (2*R*,3*R*,*R*$_S$)-**7a**, (2*S*,3*S*,*R*$_S$)-**7b**, (2*R*,3*S*,*R*$_S$)-**7b**, (2*R*,3*R*,*R*$_S$)-**7b**, (2*S*,3*S*,*R*$_S$)-**7c**, (2*R*,3*S*,*R*$_S$)-**7c**, (2*S*,3*S*,*R*$_S$)-**7d**, (2*R*,3*R*,*R*$_S$)-**7d**, (2*R*,3*S*,*R*$_S$)-**7d** are reported in the Supporting Information.

6-Methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-yl Benzoate (7a): Reaction carried out on mixtures of diastereomers **4a** obtained from **3a** by both Method A and B. Purification by FC (*n*-hexane/AcOEt, 75:25), quantitative overall yields.

(2*R*,3*S*,*R*$_S$)-7a: R_f = 0.30; $[\alpha]_D^{20}$ = −30.5 (*c* = 1.0, $CHCl_3$); yellowish oil. − ^{1}H NMR ($CDCl_3$): δ = 1.56 and 1.65 (br. s, 6 H, 2 × 6-CH_3), 1.57 (d, 3 H, J = 6.7 Hz, 1-H_3), 2.27 (br. s, 3 H, $ArCH_3$), 2.39 and 2.50 (m, 2 H, 4-H_2), 2.90 (ddd, 1 H, J = 8.6, 5.6, and 3.3 Hz, 3-H), 5.08 (m, 1 H, 5-H), 5.51 (dq, 1 H, J = 3.3 and 6.7 Hz, 2-H), 7.2−8.0 (9 H, m, ArH).

1-Fluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*,*R*$_S$)-7b]: Yield 55% from (2*S*,3*R*,*R*$_S$)-**4b**, after overnight stirring and FC (*n*-hexane/AcOEt, 7:3); R_f = 0.35; $[\alpha]_D^{20}$ = +126.4 (*c* = 1.2, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.59 and 1.69 (br. s, 6 H, 2 × 6-CH_3), 2.33 (br. s, 3 H, $ArCH_3$), 2.57 and 2.63 (m, 2 H, 4-H_2), 3.13 (ddt, 1 H, J = 3.9, 1.2, and 6.7 Hz, 3-H), 4.63 (ddd, 1 H, J = 47.4, 10.1, and 4.3 Hz, 1a-H), 4.66 (ddd, 1 H, J = 47.5, 10.1, and 5.5 Hz, 1b-H), 5.18 (m, 1 H, 5-H), 5.76 (dddd, 1 H, J = 20.0, 5.5, 4.3, and 3.6 Hz, 2-H), 7.2−8.0 (9 H, m, ArH). − ^{19}F NMR ($CDCl_3$): δ = −226.86 (dddd, J = 47.5, 47.4, 20.0, and 1.2 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 389 [(M + H)$^+$] (88), 249 [(M + H − *p*TolSOH)$^+$] (100), 140 [*p*TolSOH$^{+\cdot}$] (10), 139 [*p*TolSO$^+$] (18), 127 [$C_8H_{12}F^+$] (54), 105 [PhCO$^+$] (84), 91 [$C_7H_7^+$] (13), 77 [Ph$^+$] (27).

1,1-Difluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*,*R*$_S$)-7c]: Yield 58% from (2*S*,3*R*,*R*$_S$)-**4c**, after overnight stirring and FC (*n*-hexane/AcOEt, 8:2); R_f = 0.33; $[\alpha]_D^{20}$ = +88.5 (*c* = 1.0, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.60 and 1.70 (br. s, 6 H, 2 × 6-CH_3), 2.40 (br. s, 3 H, $ArCH_3$), 2.64 and 2.69 (m, 2 H, 4-H_2), 3.07 (br. dt, 1 H, J = 2.6 and 7.0 Hz, 3-H), 5.19 (m, 1 H, 5-H), 5.77 (dddd, 1 H, J = 13.5, 11.3, 3.8, and 2.6 Hz, 2-H), 5.97 (dt, 1 H, J = 3.8 and 55.5 Hz, 1-H), 7.3−8.1 (m, 9 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −129.88 (br. ddd, 1 F, J = 288.0, 55.5, and 13.5 Hz, F-1a), −128.02 (br. ddd, 1 F, J = 288.0, 55.5, and 11.3 Hz, F-1b). − IR (nujol): $\tilde{\nu}$ = 1733 cm^{-1} (C=O), 1257 (O=S), 1095 (C−O), 811 (C−F), 710 (C−S). − MS (DIS EI, 70 eV); *m*/*z* (%): 407 [(M + H)$^+$] (15), 267 [(M + H − *p*TolSOH)$^+$] (100), 247 [(M + H − *p*TolSOH − HF)$^+$] (11), 145 [$C_8H_{11}F_2^+$] (42), 140 [*p*TolSOH$^{+\cdot}$] (10), 139 [*p*TolSO$^+$] (2), 105 [PhCO$^+$] (40), 77 [Ph$^+$] (5), 51 [CHF_2^+] (1), 41 [$C_3H_5^+$] (1). − $C_{22}H_{24}F_2O_3S$ (406): calcd. C 65.01, H 5.95; found C 65.03, H 5.92.

1,1,1-Trifluoro-6-methyl-3-[(4-methylphenyl)sulfinyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*,*R*$_S$)-7d]: Yield 58% from (2*S*,3*R*,*R*$_S$)-**4d**, after 3.5 h and FC (*n*-hexane/AcOEt 85:15); R_f = 0.33; $[\alpha]_D^{20}$ = +162.9 (*c* = 0.5, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.65 and 1.72 (br. s, 6 H, 2 × 6-CH_3), 2.44 (br. s, 3 H, $ArCH_3$), 2.77 and 2.83 (m, 2 H, 4-H_2), 2.91 (br. ddd, 1 H, J = 8.4, 4.8, and 1.1 Hz, 3-H), 5.23 (m, 1 H, 5-H), 6.01 (dq, J = 1.1 and 7.6 Hz, 2-H), 7.3−8.2 (m, 9 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −76.38 (br. d, J = 7.6 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 425 [(M + H]$^+$] (18), 285 [(M + H − *p*TolSOH)$^+$] (100), 163 [$C_8H_{10}F_3^+$] (56), 140 [*p*TolSOH$^{+\cdot}$] (28), 139 [*p*TolSO$^+$] (14), 123 [*p*TolS$^+$] (18), 105 [PhCO$^+$] (66), 91 [$C_7H_7^+$] (5), 77 [Ph$^+$] (17). − $C_{22}H_{23}F_3O_3S$ (424): calcd. C 62.25, H 5.46; found C 62.23, H 5.50.

(2*S*,3*S*,2′*S*)-6a: 80% from (2*S*,3*S*)-**5a** and (*S*)-PPA, after FC (*n*-hexane/AcOEt, 90:10); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.34 (d, 3 H, J = 6.2 Hz, 1-H_3), 1.38 and 1.63 (br. s, 6 H, 2× 6-CH_3), 1.49 (d, 3 H, J = 7.3 Hz, 3′-H_3), 2.04 and 2.10 (m, 2 H, 4-H_2), 2.31 (br s, 3 H, $ArCH_3$), 3.01 (ddd, 1 H, J = 8.4, 6.0, and 3.4 Hz, 3-H), 3.69 (br. q, 1 H, J = 7.3 Hz, 2′-H), 5.01 (m, 1 H, 5-H), 5.04 (dq, 1 H, J = 3.4 and 6.2 Hz, 2-H), 7.0−7.4 (m, 9 H, ArH). − MS (DIS EI, 70 eV); *m*/*z* (%): 382 [M$^{+\cdot}$] (100), 313 [$C_{19}H_{21}SO_2^+$] (15), 259 [$C_{17}H_{23}O_2^+$] (11), 233 [$C_{15}H_{21}S^+$] (58), 232 [$C_{15}H_{20}S^{+\cdot}$] (40), 109 [$C_8H_{13}^+$] (59), 105 [$PhC_2H_4^+$] (63).

(2*S*,3*S*,2′*R*)-6a: 70% from (2*S*,3*S*)-**5a** and (*R*)-PPA, after FC (*n*-hexane/AcOEt, 90:10); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.24 (d, 3 H, J = 6.2 Hz, 1-H_3), 1.49 (d, 3 H, J = 7.3 Hz, 3′-H_3), 1.52 and 1.69 (br s, 6 H, 2× 6-CH_3), 2.15 and 2.34 (m, 2 H, 4-H_2), 2.32 (br. s, 3 H, $ArCH_3$), 3.10 (ddd, 1 H, J = 8.2, 6.0, and 3.9 Hz, 3-H), 3.65 (br. q, 1 H, J = 7.3 Hz, 2′-H), 5.04 (dq, 1 H, J = 3.9 and 6.2 Hz, 2-H), 5.18 (m, 1 H, 5-H), 7.0−7.4 (m, 9 H, ArH). − MS (DIS EI, 70 eV); *m*/*z* (%): 383 [(M + H)$^+$] (25), 382 [M$^{+\cdot}$] (100), 313 [$C_{19}H_{21}SO_2^+$] (18), 259 [$C_{17}H_{23}O_2^+$] (13), 233 [$C_{15}H_{21}S^+$] (59), 232 [$C_{15}H_{20}S^{+\cdot}$] (43), 109 [$C_8H_{13}^+$] (44), 105 [$PhC_2H_4^+$] (72).

(2*R*,3*S*,2′*S*)-6c: 60% from (2*R*,3*S*)-**5c** and (*S*)-PPA after FC (*n*-pentane/diethyl ether, 100:1); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.53 (d, 3 H, J = 7.3 Hz, 3′-H_3), 1.54 and 1.72 (br. s, 6 H, 2× 6-

CH_3), 2.16 and 2.37 (m, 2 H, 4-H_2), 2.33 (br. s, 3 H, $ArCH_3$), 3.23 (br. ddd, 1 H, J = 8.6, 5.7, and 5.4 Hz, 3-H), 3.73 (br. q, 1 H, J = 7.3 Hz, 2′-H), 5.19 (dddd, 1 H, J = 15.1, 7.2, 5.7, and 3.9 Hz, 2-H), 5.23 (m, 1 H, 5-H), 5.98 (ddd, 1 H, J = 55.5, 54.5, and 3.9 Hz, 1-H), 7.1−7.4 (m, 9 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −131.09 (br. ddd, 1 F, J = 292.0, 54.5, and 15.1 Hz, F-1a), −128.98 (br. ddd, 1 F, J = 292.0, 55.5, and 7.2 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%) 418 [$M^{+\cdot}$] (100), 349 [$C_{19}H_{19}SO_2F_2^+$] (8), 329 [$C_{19}H_{18}SO_2F^+$] (84), 268 [$C_{15}H_{18}SF_2^{+\cdot}$] (8), 123 [*p*$TolS^+$] (3), 105 [$PhC_2H_4^+$] (40), 69 [$C_5H_9^+$] (14).

(2*S*,3*S*,2′*S*)-6c: 66% from (2*S*,3*S*)-**5c** and (*S*)-Phenylpropionic acid, after FC (*n*-pentane/diethyl ether, 100:1); R_f = 0.35. − ^{1}H NMR ($CDCl_3$): δ = 1.31 and 1.62 (br. s, 6 H, 2 × 6-CH_3), 1.55 (d, 3 H, J = 7.2 Hz, 3′-H_3), 1.99 and 2.05 (m, 2 H, 4-H_2), 2.32 (br. s, 3 H, $ArCH_3$), 3.09 (dtt, 1 H, J = 1.1, 7.6 and 2.9 Hz, 3-H), 3.79 (br. q, 1 H, J = 7.2 Hz, 2′-H), 4.96 (m, 1 H, 5-H), 5.26 (dddd, 1 H, J = 12.8, 5.8, 5.6, and 2.9 Hz, 2-H), 6.16 (ddd, 1 H, J = 57.0, 54.9, and 5.6 Hz, 1-H), 7.1−7.4 (m, 9 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −131.23 (br. ddd, 1 F, J = 293.5, 54.9, and 12.8 Hz, F-1a), −128.40 (br. ddd, 1 F, J = 293.5, 57.0, and 5.8 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%): 418 [$M^{+\cdot}$] (85), 349 [$C_{19}H_{19}SO_2F_2^+$] (11), 329 [$C_{19}H_{18}SO_2F^+$] (100), 268 [$C_{15}H_{18}SF_2^{+\cdot}$] (5), 105 [$PhC_2H_4^+$] (33), 69 [$C_5H_9^+$] (8).

Deoxygenation of Benzoic Esters 7a−d. − General Procedure: Sulfenyl benzoic esters **8a−d** were prepared according to the same general procedure described for the preparation of the sulfenyl alcohols **5c** from **4c**.

Physical and spectroscopic data for (2*R*,3*S*)-**8b**, (2*S*,3*S*)-**8b**, (2*R*,3*R*)-**8b**, (2*R*,3*S*)-**8c**, (2*S*,3*S*)-**8c**, (2*S*,3*S*)-**8d**, (2*R*,3*R*)-**8d**, (2*R*,3*S*)-**8d** are reported in the Supporting Information.

6-Methyl-3-[(4-methylphenyl)sulfenyl]hept-5-en-2-yl Benzoate [(2*R*,3*S*)-8a]: Yield 87% from (2*R*,3*S*,R_S)-**7a** after FC (*n*-hexane/diethyl ether, 9:1); R_f = 0.35; $[\alpha]_D^{20}$ = −75.5 (*c* = 1.6, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.45 (d, 3 H, J = 6.4 Hz, 1-H_3), 1.61 and 1.72 (br. s, 6 H, 2 × 6-CH_3), 2.26 (br. s, 3 H, $ArCH_3$), 2.34 and 2.44 (m, 2 H, 4-H_2), 3.37 (ddd, 1 H, J = 8.0, 6.2, and 4.8 Hz, 3-H), 5.29 (dq, 1 H, J = 4.8 and 6.4 Hz, 2-H), 5.32 (m, 1 H, 5-H), 7.02 and 7.33 (m, 4 H, *p*TolH), 7.3−7.9 (m, 5 H, PhH). − MS (DIS EI); *m*/*z* (%): 354 [M^+] (6), 285 [$C_{17}H_{17}O_2S^+$] (1), 232 [(M − $PhCOOH)^{+\cdot}$] (20), 230 [(M − *p*$TolSH)^{+\cdot}$] (4), 123 [*p*$TolS^+$] (10), 109 [$C_8H_{13}^+$] (85), 105 [$PhCO^+$] (100), 91 [$C_7H_7^+$] (10), 77 [$C_6H_5^+$] (27). − $C_{22}H_{26}O_2S$ (354): calcd. C 74.54, H 7.39; found C 74.58, H 7.40.

1-Fluoro-6-methyl-3-[(4-methylphenyl)sulfenyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*)-8b]: Yield 83% from (2*S*,3*R*,R_S)-**7b** after FC (*n*-hexane/diethyl ether, 9:1); R_f = 0.35; $[\alpha]_D^{20}$ = +42.6 (*c* = 1.5, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.56 and 1.71 (br. s, 6 H, 2 × 6-CH_3), 2.28 (br. s, 3 H, $ArCH_3$), 2.36 and 2.50 (m, 2 H, 4-H_2), 3.49 (ddd, 1 H, J = 8.0, 7.0, and 5.4 Hz, 3-H), 4.75 (ddd, 1 H, J = 47.5, 10.4, and 3.1 Hz, 1a-H), 4.90 (ddd, 1 H, J = 47.0, 10.4, and 5.0 Hz, 1b-H), 5.32 (m, 1 H, 5-H), 5.38 (dddd, 1 H, J = 21.6, 7.0, 5.0, and 3.1, 2-H), 7.07 and 7.35 (m, 4 H, *p*TolH), 7.41, 7.55, and 7.96 (m, 5 H, PhH). − ^{19}F NMR ($CDCl_3$): δ = −232.91 (br. ddd, J = 47.5, 47.0, and 21.6 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 372 [$M^{+\cdot}$] (18), 303 [$C_{17}H_{16}SO_2F^+$] (1), 283 [$C_{17}H_{15}SO_2^+$] (22), 250 [(M − $PhCOOH)^{+\cdot}$] (18), 248 [(M − *p*$TolSH)^+$] (3), 228 [(M − *p*TolSH − $HF)^+$] (6), 161 [$C_{10}H_9S^+$] (7), 127 [$C_8H_{12}F^+$] (34), 105 [$PhCO^+$] (100), 77 [Ph^+] (26). − $C_{22}H_{25}FO_2S$ (372): calcd. C 70.94, H 6.76; found C 70.90, H 6.77.

1,1-Difluoro-6-methyl-3-[(4-methylphenyl)sulfenyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*)-8c]: Yield 83% from (2*S*,3*R*,R_S)-**7c** after FC (*n*-hexane/ethyl ether, 98:2); R_f = 0.36; $[\alpha]_D^{20}$ = +54.2 (*c* = 1.5, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.58 and 1.72 (br. s, 6 H, 2 × 6-CH_3), 2.31 (br. s, 3 H, $ArCH_3$), 2.36 and 2.55 (m, 2 H, 4-H_2), 3.42 (br. ddd, 1 H, J = 8.4, 6.3, and 5.4 Hz, 3-H), 5.32 (m, 1 H, 5-H), 5.46 (dddd, 1 H, J = 15.6, 7.2, 6.3, and 3.6 Hz, 2-H), 6.27 (dt, 1 H, J = 3.6 and 54.7 Hz, 1-H), 7.10 and 7.36 (m, 4 H, *p*TolH), 7.43, 7.60, and 8.00 (m, 5 H, PhH). − ^{19}F NMR ($CDCl_3$): δ = −131.59 (br. ddd, 1 F, J = 289.9, 54.7, and 15.6 Hz, F-1a), −129.08 (br. ddd, 1 F, J = 289.9, 54.7, and 7.2 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%): 390 [$M^{+\cdot}$] (100), 321 [$C_{17}H_{15}SO_2F_2^+$] (7), 301 [$C_{17}H_{14}SO_2F^+$] (25), 281 [$C_{17}H_{13}SO_2^+$] (6), 268 [(M − $PhCOOH)^{+\cdot}$] (6), 266 [(M − *p*$TolSH)^+$] (1), 246 [(M − *p*TolSH − $HF)^+$] (4), 145 [$C_8H_{11}F_2^+$] (7), 105 [$PhCO^+$] (18). − $C_{22}H_{24}F_2O_2S$ (390): calcd. C 67.67, H 6.19; found C 62.90, H 7.06.

1,1,1-Trifluoro-6-methyl-3-[(4-methylphenyl)sulfenyl]hept-5-en-2-yl Benzoate [(2*S*,3*R*)-8d]: Yield 79% from (2*S*,3*R*,R_S)-**7d**, after FC (*n*-hexane/diethyl ether, 9:1); R_f = 0.34; $[\alpha]_D^{20}$ = +94.6 (*c* = 1.1, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.65 and 1.77 (br. s, 6 H, 2 × 6-CH_3), 2.31 (br. s, 3 H, $ArCH_3$), 2.37 and 2.76 (m, 2 H, 4-H_2), 3.43 (br. ddd, 1 H, J = 10.2, 3.7, and 2.7 Hz, 3-H), 5.40 (m, 1 H, 5-H), 5.69 (dq, 1 H, J = 2.7 and 7.5 Hz, 2-H), 7.13 and 7.37 (m, 4 H, *p*TolH), 7.49, 7.62, and 8.08 (m, 5 H, PhH). − ^{19}F NMR ($CDCl_3$): δ = −74.06 (br. d, J = 7.5 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 408 [$M^{+\cdot}$] (27), 339 [$C_{17}H_{14}SO_2F_3^+$] (5), 319 [$C_{17}H_{13}SO_2F_2^+$] (6), 286 [(M − $PhCOOH)^{+\cdot}$] (5), 284 [(M − *p*$TolSH)^{+\cdot}$] (1), 264 [(M − *p*TolSH − $HF)^+$] (2), 163 [$C_8H_{10}F_3^+$] (17), 123 [*p*$TolS^+$] (16), 105 [$PhCO^+$] (100), 77 [Ph^+] (31), 41 [$C_3H_5^+$] (15). − $C_{22}H_{23}F_3O_2S$ (408): calcd. C 64.69, H 5.67; found C 64.70, H 5.66.

Reductive Desulfenylation Reaction. − Synthesis of Benzoates 9a−d. − General Procedure: Through a solution of sulfenyl benzoates **8a−d** (1.0 mmol) in ethanol (10 mL) was bubbled for 30 min a strong nitrogen flow, then cyclohexene (0.5 mL) and Raney-Ni [three-fold weight, washed with ethanol (3 ×) and submitted to a nitrogen flow for 1 h] were added. The black slurry was stirred at reflux for 1 h under nitrogen, then the Raney-Ni was carefully filtered off and the ethanolic solution was concentrated under vacuum.

6-Methylhept-5-en-2-yl Benzoate [(*R*)-9a]: Yield 80% from (2*R*,3*S*)-**8a** after FC (*n*-hexane/diethyl ether 98:2); R_f = 0.35; $[\alpha]_D^{20}$ = −46.5 (*c* 0.8, $CHCl_3$); $[\alpha]_{365}^{20}$ = −150.2 (*c* = 0.8, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.34 (d, 3 H, J = 6.2 Hz, 1-H_3), 1.57 and 1.67 (br. s, 6 H, 2 × 6-CH_3), 1.64 and 1.78 (m, 2 H, 3-H_2), 2.09 (m, 2 H, 4-H_2), 5.13 (m, 1 H, 5-H), 5.15 (m, 1 H, 2-H), 7.4−8.1 (m, 5 H, ArH). − MS (GC EI); *m*/*z* (%): 233 [(M + H)$^+$] (0.1), 110 [$C_8H_{13}^{+\cdot}$] (84), 105 [$PhCO^+$] (38), 95 [$C_7H_{11}^+$] (100), 77 [$C_6H_5^+$] (20), 69 [$C_5H_9^+$] (7), 55 [$C_4H_7^+$] (4). − GC/MS; t_r, *m*/*z* (%): 17.13 min, 232 (99.9) [M^+]. − $C_{15}H_{20}O_2$ (232): calcd. C 77.55, H 8.68; found C 77.58, H 8.70.

1-Fluoro-6-methyl-hept-5-en-2-yl Benzoate [(*R*)-9b]: Yield 80% from (2*S*,3*R*)-**8b** and/or (2*S*,3*S*)-**8b** after FC (*n*-hexane/diisopropyl ether, 100:5); R_f = 0.35; $[\alpha]_D^{20}$ = +47.0 (*c* = 1.4, $CHCl_3$); $[\alpha]_{365}^{20}$ = +172.0 (*c* = 1.4, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.62 and 1.72 (br. s, 6 H, 2 × 6-CH_3), 1.83 and 1.93 (m, 2 H, 3-H_2), 2.18 (m, 2 H, 4-H_2), 4.61 (ddd, 1 H, J = 47.6, 10.3 and 4.6 Hz, 1a-H), 4.65 (ddd, 1 H, J = 48.0, 10.3 and 3.2 Hz, 1b-H), 5.17 (m, 1 H, 5-H), 5.35 (ddddd, 1 H, J = 22.5, 8.1, 5.7, 4.6, and 3.2 Hz, 2-H), 7.4−8.2 (m, 5 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −232.02 (br. ddd, J = 48.0, 47.6, and 22.5 Hz). − MS (DIS EI, 70 eV); *m*/*z* (%): 250 [$M^{+\cdot}$] (3), 128 [(M − $PhCOOH)^{+\cdot}$] (100), 113 [$C_7H_{10}F^+$] (17), 105 [$PhCO^+$] (76), 95 [$C_7H_{11}^+$] (69), 77 [Ph^+] (67), 55 [$C_4H_7^+$] (13), 41 [$C_3H_5^+$] (72). − GC/MS; t_r, *m*/*z* (%): 17.46 min, 250 (98.0) [M^+]. − HPLC analysis: t_r = 3.72 min (*n*-hexane/AcOEt, 4:1, 1.0 mL/

min); t_r = 20.04 min (Chiracel OB, *n*-hexane/2-propanol, 98:2, 0.3 mL/min). − $C_{15}H_{19}FO_2$ (520): calcd. C 71.97, H 7.65; found C 71.94, H 7.62.

(*S*)-9b: 80% from (2*R*,3*R*/*S*)-**8b** after FC (*n*-hexane/diisopropyl ether, 100:5); R_f = 0.35; $[\alpha]_D^{20}$ = −48.2 (*c* = 1.2, $CHCl_3$). − ^{1}H- and ^{19}F-NMR spectra ($CDCl_3$) were overimposable to those of (*R*)-**9b**. − GC/MS; t_r, *m*/*z* (%): 17.46 min, 250 (97.4) [M^+]. − HPLC analysis: t_r = 3.72 min (*n*-hexane/AcOEt, 4:1, 1.0 mL/min); t_r = 19.11 min (Chiracel OB, *n*-hexane/2-propanol, 98:2, 0.3 mL/min).

1,1-Difluoro-6-methylhept-5-en-2-yl Benzoate [(*R*)-9c]: Yield 70% from (2*S*,3*R*)-**8c** and/or (2*S*,3*S*)-**8c** after FC (*n*-hexane/diisopropyl ether, 100:5); R_f = 0.35; $[\alpha]_D^{20}$ = +43.9 (*c* = 1.0, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.54 and 1.65 (br. s, 6 H, 2 × 6-CH_3), 1.85 and 1.90 (2 H, m, 3-H_2), 2.11 and 2.17 (2 H, m, 4-H_2), 5.10 (m, 1 H, 5-H), 5.29 (m, 1 H, 2-H), 5.89 (ddd, 1 H, *J* = 56.0, 54.9, and 3.2 Hz, 1-H), 7.4−8.1 (m, 5 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −132.32 (br. ddd, 1 F, *J* = 291.0, 56.0, and 13.2 Hz, F-1a), −128.60 (br. ddd, 1 F, *J* = 291.0, 54.9, and 9.4 Hz, F-1b). − MS (DIS EI, 70 eV); *m*/*z* (%): 268 [$M^{+\cdot}$] (24), 248 [(M − HF)$^{+\cdot}$] (6), 146 [(M − PhCOOH)$^{+\cdot}$] (100), 131 [$C_7H_9F^+$] (3), 126 [(M − PhCOOH − HF)$^{+\cdot}$] (4), 105 [$PhCO^+$] (41), 95 [$C_7H_{11}^+$] (62), 77 [Ph^+] (11), 68 [$C_5H_8^+$] (8), 51 [CHF_2^+] (1). − GC/MS; t_r, *m*/*z* (%): 16.53 min, 268 (95.0) [M^+]. − HPLC analysis: t_r = 4.07 min (*n*-hexane/AcOEt, 9:1, 1.0 mL/min); t_r = 29.29 min (Chiracel OB, *n*-hexane/2-propanol, 100.0:0.5, 0.3 mL/min). − $C_{15}H_{18}F_2O_2$ (268): calcd. C 67.15, H 6.76; found C 67.14, H 6.72.

(*S*)-9c: 85% from (2*R*,3*S*)-**8c** after FC (*n*-hexane/diisopropyl ether, 100:5); R_f = 0.35; $[\alpha]_D^{20}$ = −45.8 (*c* = 1.2, $CHCl_3$). − ^{1}H- and ^{19}F-NMR data ($CDCl_3$) were identical to those of the already described (*R*)-**9c** enantiomer. − GC/MS; t_r, *m*/*z* (%): 16.53 min, 268 (98.7) [M^+]. − HPLC analysis: t_r = 4.07 min (*n*-hexane/AcOEt, 9:1, 1.0 mL/min); t_r = 24.52 min (Chiracel OB, *n*-hexane/2-propanol, 100.0:0.5, 0.3 mL/min).

1,1,1-Trifluoro-6-methylhept-5-en-2-yl Benzoate [(*R*)-9d]: Yield 60% from (2*S*,3*R*)-**8d** and/or (2*S*,3*S*)-**8d** after FC (*n*-hexane/diisopropyl ether, 100:3); R_f = 0.35; $[\alpha]_D^{20}$ = +64.9 (*c* = 1.1, $CHCl_3$); $[\alpha]_{365}^{20}$ = +253.0 (*c* = 1.1, $CHCl_3$). − ^{1}H NMR ($CDCl_3$): δ = 1.53 and 1.64 (br. s, 6 H, 2 × 6-CH_3), 1.7−2.2 (m, 4 H, 3- and 4-H_2), 5.08 (m, 1 H, 5-H), 5.55 (m, 1 H, 2-H), 7.4 and 8.2 (m, 5 H, ArH). − ^{19}F NMR ($CDCl_3$): δ = −78.22 (d, *J* = 7.2 Hz). − IR (nujol): $\tilde{\nu}$ = 1746 cm^{-1} (C=O), 1380 (CH), 1452 (CH), 1280 (C=S), 1182 [$(CH_3)_2C$], 1107 (C−O), 810 (C−F), 709 (C−S). − MS (DIS EI, 70 eV); *m*/*z* (%): 286 [$M^{+\cdot}$] (26), 266 [(M − HF)$^{+\cdot}$] (6), 258 (10), 243 (7), 164 [(M − PhCOOH)$^{+\cdot}$] (100), 149 [$C_7H_8F_3^+$] (26), 122 [$PhCOOH^+$] (5), 105 [$PhCO^+$] (38), 95 [$C_7H_{11}^+$] (12), 77 [Ph^+] (26), 55 [$C_4H_7^+$] (8), 43 [$C_3H_7^+$] (21), 41 [$C_3H_5^+$] (30). − GC/MS; t_r, *m*/*z* (%): 15.22 min, 286 (98.0) [M^+]. − HPLC analysis: t_r = 5.13 min (*n*-hexane/AcOEt, 98:2, 1.0 mL/min); t_r = 17.09 min (Chiracel OB, *n*-hexane/2-propanol, 100.0:0.5, 0.3 mL/min). − $C_{15}H_{17}F_3O_2$ (286): calcd. C 62.93, H 5.84; found C 62.94, H 5.82.

(*S*)-9d: 75% from (2*R*,3*R*/*S*)-**8d**, after FC (*n*-hexane/diisopropyl ether, 100:3); R_f = 0.35; $[\alpha]_D^{20}$ = −66.3 (*c* = 0.9, $CHCl_3$). − ^{1}H- and ^{19}F-NMR data ($CDCl_3$) were identical to those of (*R*)-**9d**. − GC/MS; t_r, *m*/*z* (%): 15.22 min, 286 (95.0) [M^+]. − HPLC analysis: t_r = 5.13 min (*n*-hexane/AcOEt, 98:2, 1.0 mL/min); t_r = 14.56 min (Chiracel OB, *n*-hexane/2-propanol, 100.0:0.5, 0.3 mL/min).

Benzoate Hydrolysis Reactions.− Synthesis of 10a−d. − General Procedure: A solution of NaOH (1.0 mmol) in water (2 mL) was added to a solution of benzoates **4a** and **9b−d** (1.0 mmol) in methanol (10 mL) stirred at r.t., and stirring was continued for half an hour. Then the reaction mixture was diluted with water (20 mL), brine was added, the mixture was extracted with diethyl ether (3 × 10 mL), dried with anhydrous sodium sulfate, filtered, and the solvent was evaporated in vacuo.

6-Methylhept-6-en-2-ol [(*R*)-sulcatol, (*R*)-(−)-10a]: Yield 70% from (*R*)-**9a** after FC (*n*-pentane/diethyl ether 7:3); R_f = 0.35; yellowish oil; $[\alpha]_D^{20}$ = −19.9 (*c* = 1.2, EtOH)[19]; $[\alpha]_{365}^{20}$ = −33.8 (*c* = 1.2, EtOH). − ^{1}H NMR ($CDCl_3$): δ = 1.22 (d, 3 H, *J* = 6.1 Hz, 1-H_3), 1.3−1.6 (m, 2 H, 3-H_2), 1.62 (br. signal, 1 H, OH), 1.65 and 1.72 (br. s, 6 H, 2 × 6-CH_3), 2.10 (m, 2 H, 4-H_2), 3.83 (tq, 1 H, *J* = 6.6 and 6.1 Hz, 2-H), 5.16 (m, 1 H, 5-H). − MS (GC EI); *m*/*z* (%): 128 [$M^{+\cdot}$] (20), 110 [$C_8H_{13}^{+\cdot}$] (27), 95 [$C_7H_{11}^+$] (100), 69 [$C_5H_9^+$] (40), 55 [$C_4H_7^+$] (20). − GC/MS; t_r, *m*/*z* (%): 7.32 min, 128 (94.1) [M^+]; 14.47 min, 220 (3.7) [(2 M − 2 H_2O)$^+$].

1-Fluoro-6-methylhept-5-en-2-ol [**(*R*)-10b]:** Yield 67% from (*R*)-**9b** after FC (petroleum ether/diethyl ether, 85:15); R_f = 0.35; $[\alpha]_D^{20}$ = +26.3 (*c* = 0.7, EtOH); $[\alpha]_{365}^{20}$ = +81.0 (*c* = 0.7, EtOH). − ^{1}H NMR ($CDCl_3$): δ = 1.48 and 1.53 (m, 2 H, 3-H_2), 1.63 and 1.70 (br. s, 6 H, 2 × 6-CH_3), 2.01 (d, 1 H, *J* = 4.6 Hz, OH), 2.11 and 2.17 (m, 2 H, 4-H_2), 3.89 (m, 1 H, 2-H), 4.28 (ddd, 1 H, *J* = 48.2, 9.4, and 6.8 Hz, 1a-H), 4.42 (ddd, 1 H, *J* = 47.2, 9.4, and 3.0 Hz, 1b-H), 5.11 (m, 1 H, 5-H). − ^{19}F NMR ($CDCl_3$): δ = −229.34 (br. ddd, *J* = 48.2, 47.2, and 18.3 Hz). − MS (GC EI, 70 eV); *m*/*z* (%): 146 [$M^{+\cdot}$] (7), 128 [(M − H_2O)$^{+\cdot}$] (12), 113 [$C_7H_{10}F^+$] (16), 95 [$C_7H_{11}^+$] (100), 69 [$C_5H_9^+$] (61), 55 [$C_4H_7^+$] (37), 41 [$C_3H_5^+$] (70). − GC/MS; t_r, *m*/*z* (%): 7.58 min, 146 (84.6) [M^+, (*R*)-**10b**]; 7.14 min, 142 (1.8) [decane$^+$]; 8.55 min, 156 (4.8) [undecane$^+$], 10.31 min, 170 (4.8) [dodecane$^+$]; 12.02 min, 184 (4.0) [tridecane$^+$]. − $C_8H_{15}FO$ (146): calcd. C 65.72, H 10.34; found C 65.74, H 10.32.

(*S*)-10b: Yield 82% from (*S*)-**9b** after FC (*n*-pentane/diethyl ether, 85:15); R_f = 0.35; $[\alpha]_D^{20}$ = −30.2 (*c* = 0.8, EtOH). − ^{1}H- and ^{19}F-NMR spectra ($CDCl_3$) were identical to those already described for (*R*)-**10b**. − MS (GC EI, 70 eV); *m*/*z*: 146 [$M^{+\cdot}$] (2), 128 [(M − H_2O)$^{+\cdot}$] (5), 113 [$C_7H_{10}F^+$] (8), 95 [$C_7H_{11}^+$] (55), 69 [$C_5H_9^+$] (44), 55 [$C_4H_7^+$] (41), 41 [$C_3H_5^+$] (100). − GC/MS; t_r, *m*/*z* (%): 7.58 min, 146 (94.1) [M^+, (*S*)-**10b**].

1,1-Difluoro-6-methylhept-5-en-2-ol [**(*R*)-10c]:** Yield 62% from (*R*)-**9c** after FC (petroleum ether/diethyl ether, 9:1); R_f = 0.35; $[\alpha]_D^{20}$ = +20.8 (*c* = 0.8, EtOH). − ^{1}H NMR ($CDCl_3$): δ = 1.30 and 1.60 (m, 2 H, 3-H_2), 1.65 and 1.73 (br. s, 6 H, 2 × 6-CH_3), 1.92 (d, 1 H, *J* = 5.1 Hz, OH), 2.18 and 2.23 (2 H, m, 4-H_2), 3.77 (m, 1 H, 2-H), 5.14 (m, 1 H, 5-H), 5.64 (dt, 1 H, *J* = 4.8 and 56.4 Hz, 1-H). − ^{19}F NMR ($CDCl_3$): δ = −130.96 (br. dd, *J* = 56.4 and 11.0 Hz). − MS (GC EI, 70 eV); *m*/*z* (%) 164 [$M^{+\cdot}$] (53), 146 [(M − H_2O)$^{+\cdot}$] (12), 131 [$C_7H_{11}F_2^+$] (14), 113 [$C_7H_{10}F^+$] (3), 95 [$C_7H_{11}^+$] (82), 69 [$C_5H_9^+$] (97), 55 [$C_4H_7^+$] (58), 43 [$C_3H_7^+$] (17), 41 [$C_3H_5^+$] (100). − GC/MS; t_r, *m*/*z* (%): 7.30 min, 164 (82.6) [M^+, (*R*)-**10c**]; 7.14 min, 142 (1.9) [decane$^+$]; 8.55 min, 156 (6.4) [undecane$^+$], 10.31 min, 170 (5.5) [dodecane$^+$]; 12.02 min, 184 (3.4) [tridecane$^+$]. − $C_8H_{14}F_2O$ (164): calcd. C 58.52, H 8.59; found C 58.54, H 8.62.

(*S*)-10c: 82% from (*S*)-**9c** after FC (*n*-pentane/diethyl ether, 95:5); R_f = 0.35; $[\alpha]_D^{20}$ = −17.6 (*c* = 0.3, EtOH). − ^{1}H- and ^{19}F-NMR spectra ($CDCl_3$) were identical to those already described for (*R*)-**10c**. − MS (GC EI); *m*/*z*: 164 [$M^{+\cdot}$] (10), 146 [(M − H_2O)$^{+\cdot}$] (3), 131 [$C_7H_{11}F_2^+$] (3), 113 [$C_7H_{10}F^+$] (1), 95 [$C_7H_{11}^+$] (35), 69 [$C_5H_9^+$] (57), 55 [$C_4H_7^+$] (45), 41 [$C_3H_5^+$] (100). − GC/MS; t_r, *m*/*z* (%): 7.30 min, 164 (73.6) [M^+, (*S*)-**10c**], 7.14 min, 142, (0.5) [decane$^+$]; 8.55 min, 156 (16.5) [undecane$^+$]; 10.31 min, 170 (6.6) [dodecane$^+$]; 12.02 min, 184 (2.7) [tridecane$^+$].

1,1,1-Trifluoro-6-methylhept-5-en-2-ol [(*R*)-10d]: Yield 52% from (*R*)-**9d** after FC (*n*-pentane/diethyl ether, 95:5); R_f = 0.35; $[\alpha]_D^{20}$ =

+29.8 (c = 0.9, EtOH). – ^{1}H NMR ($CDCl_3$): δ = 1.60 and 1.70 (m, 2 H, 3-H_2), 1.64 and 1.71 (br. s, 6 H, 2 × 6-CH_3), 2.17 and 2.23 (m, 2 H, 4-H_2), 3.85 (m, 1 H, 2-H), 5.11 (m, 1 H, 5-H). – ^{19}F NMR ($CDCl_3$): δ = −81.19 (br. d, J = 7.0 Hz). – MS (GC EI, 70 eV); m/z (%): 182 [$M^{+\cdot}$] (12), 164 [($M - H_2O^{+\cdot}$)] (1), 149 [$C_7H_8F_3^+$] (4), 129 [$C_7H_7F_2^+$] (1), 95 [$C_7H_{11}^+$] (7), 69 [$C_5H_9^+$] (57), 55 [$C_4H_7^+$] (41), 41 [$C_3H_5^+$] (100). – GC/MS; t_R, m/z (%): 6.33 min, 182 (69.0) [M^+, (*R*)-**10d**]; 7.14 min, 142 (2.3) [decane$^+$]; 8.55 min, 156 (8.7) [undecane$^+$], 10.31 min, 170 (9.9) [dodecane$^+$]; 12.02 min, 184 (10.1) [tridecane$^+$]. – $C_8H_{13}F_3O$ (182): calcd. C 52.74, H 7.19; found C 52.74, H 7.22.

(*S*)-10d: 70% from (*S*)-**9d**, after FC (*n*-pentane/diethyl ether, 95:5); R_f = 0.35; $[\alpha]_D^{20}$ = −15.7 (c = 0.3, EtOH). – ^{1}H- and ^{19}F-NMR spectra ($CDCl_3$) were identical to those already described for (*R*)-**10d**. – MS (GC EI); m/z (%): 182 [$M^{+\cdot}$] (59), 164 [($M - H_2O$)$^{+\cdot}$] (4), 149 [$C_7H_8F_3^+$] (14), 129 [$C_7H_7F_2^+$] (5), 95 [$C_7H_{11}^+$] (15), 69 [$C_5H_9^+$] (100), 55 [$C_4H_7^+$] (46), 41 [$C_3H_5^+$] (71). – GC/MS; t_R, m/z (%): 6.33 min, 182 (38.8) [M^+, (*R*)-**10d**]; 7.14 min, 142 (8.7) [decane$^+$]; 8.55 min, 156 (23.1) [undecane$^+$], 10.31 min, 170 (17.9) [dodecane$^+$]; 12.02 min, 184 (11.4) [tridecane$^+$].

Acknowledgments

C.N.R. "Progetto Finalizzato per i Beni Culturali" is gratefully acknowledged for financial support. Ing. Simona Boffi and Ing. Emanuele Peveri are gratefully acknowledged for experimental work.

[1] Preliminary results of this work were part of "Sintesi di Sulcatolo e suoi Analoghi Fluorurati Enantiomericamente Puri". Simona Boffi and Emanuele Peveri: Tesi di Laurea in Ingegneria Chimica; Politecnico di Milano; Dipartimento di Chimica; Anno Accademico **1996**–**1997**.

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Received August 6, 1998
[O98375]