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Highly Diastereoselective Methylene Transfer from Diazomethane to the Carbonyl of β-Keto Sulfoxides. A General Approach to Synthetically Versatile Fluorine-Containing Chiral Building Blocks.

Alberto Arnone, Pierfrancesco Bravo,* Massimo Frigerio and Fiorenza Viani

C.N.R. - Centro di Studio per le Sostanze Organiche Naturali, Dipartimento di Chimica del Politecnico di Milano, via Mancinelli 7, I-20131 Milano, Italy

Vadim A. Soloshonok*

National Industrial Research Institute of Nagoya, Hirate-cho 1-1, Kita-ku, Nagoya City, Aichi Prefecture 462, Japan

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Abstract: This paper describes the reactions of diazomethane with α-alkyl and α-phenyl-substituted (R_S)-β-keto sulfoxides bearing difluoro-, trifluoro- and difluorochloromethyl groups on the terminal site, to afford the corresponding diastereo- and enantiomerically pure epoxides. A plausible mechanistic rationale for the origin of the stereochemical preferences in these reactions has been provided. Synthetic versatility of the resultant epoxides has been demonstrated by a series of key transformations of the epoxide ring and the sulfinyl group including ring-opening, reductive desulfurization and *syn*-elimination reactions.

INTRODUCTION

With the development of catalytic asymmetric methodology for epoxidation of olefins, enantiomerically pure epoxides have gained an eminent position in synthetic organic chemistry as versatile chiral building blocks and key intermediates in natural product synthesis.[1] However, despite the tremendous achievements in this area, enantioselective preparation of fluoro-substituted epoxides remains a challenging synthetic endeavor due to the unique electronic and stereochemical features of fluorine substituents.[2,3] In particular, it has been shown that an enhanced electrophilicity of fluorinated olefins would generally plague an application of the methods developed for epoxidation of hydrocarbon olefins to their fluorinated analogues.[4] Nevertheless, the lure of a synthetic versatility of fluorinated epoxides, as chiral building blocks for preparing fluorine-containing compounds of biomedicinal importance,[5] has stimulated much activity.[2] For example, the development of biocatalytic[6] and stoicheiometric[7] asymmetric approaches to both enantiomers of the trifluoromethyloxirane has provided ready availability of numerous synthetically and biologically valuable trifluoromethyl-containing compounds *via* conventional elaboration of this simple molecule.[8]

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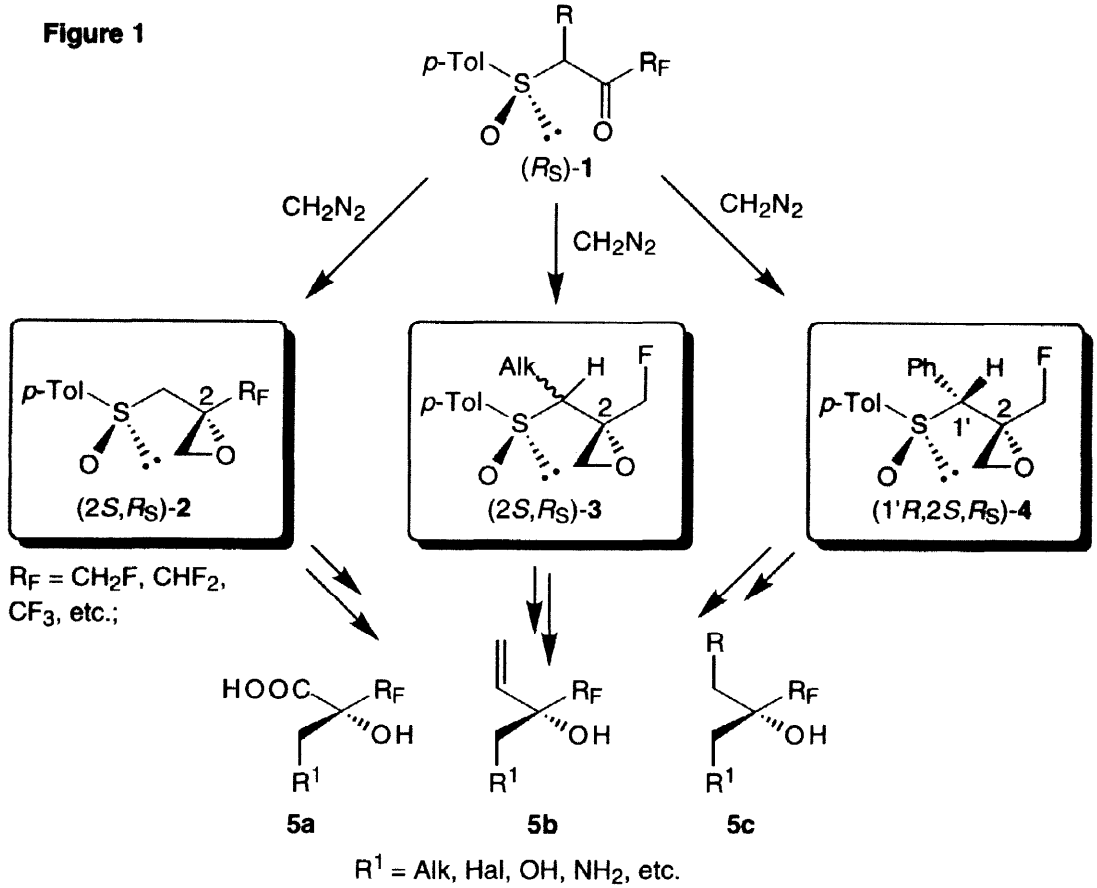
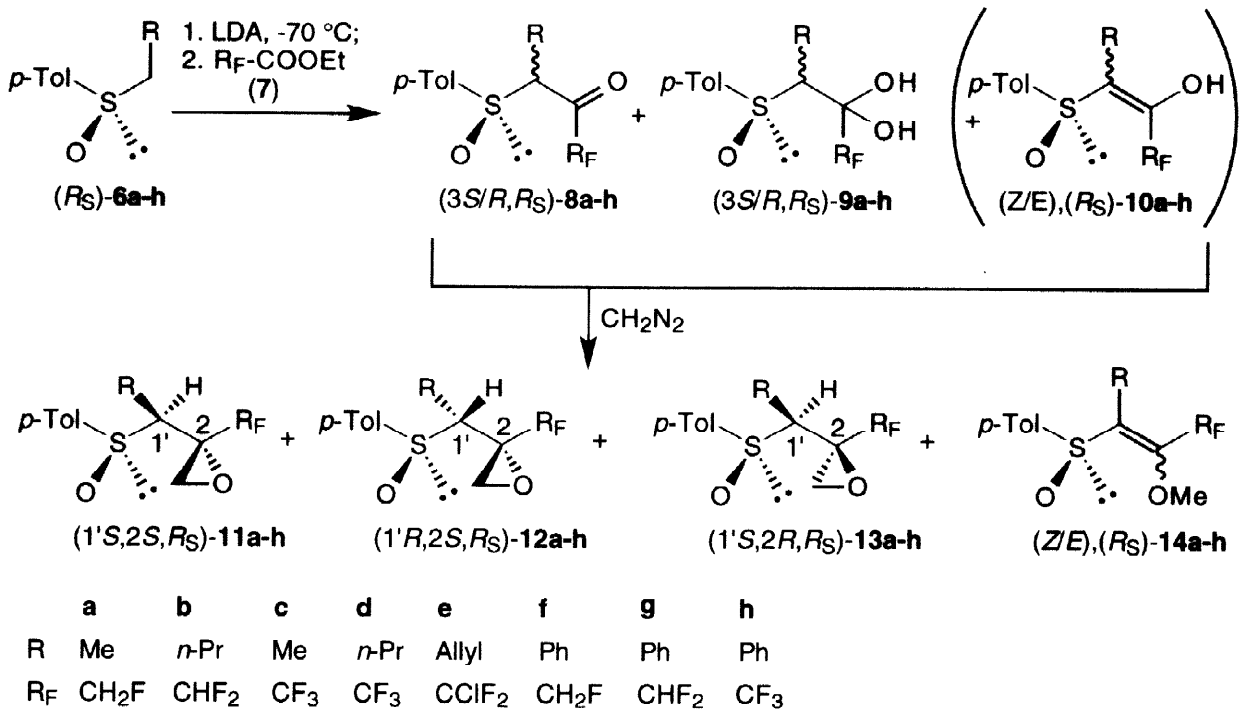
Figure 1



As a part of our own goal of developing practical synthetic methods for preparing selectively fluorinated and enantiomerically pure biologically relevant compounds[9,10] we have examined reactions between enantiopure β-keto-γ-fluoro-substituted sulfoxides and diazomethane as a general approach to asymmetric synthesis of the corresponding fluorinated epoxides possessing stereogenic tertiary carbon. The addition of methylene to the carbonyl π-bond of aldehydes and ketones with diazomethane to yield homologated carbonyl compounds and oxiranes is well established.[11] However, asymmetric version of this reaction using a chiral auxiliary on the starting carbonyl compound, to the best of our knowledge, has not been reported so far. We have shown[12] that (R_S)-β-keto-γ-fluoroalkyl sulfoxides **1** (Figure 1) readily react with diazomethane under mild conditions (rt) to afford a mixture of the corresponding oxiranes, as major products, in generally good chemical yields. Diastereoselectivity of the oxirane ring formation was found to be controlled by the stereochemistry of the sulfoxide moiety (1,3-asymmetric induction) giving rise to the (*S*) configured epoxides, with moderate-to-high de, starting from the (R_S)-sulfoxide. Previously, we have studied the reactions of diazomethane with three types of β-keto-γ-fluoroalkyl sulfoxides **1** to afford the corresponding chirons **2-4**, and demonstrated their synthetic versatility by preparing a series of fluorinated and enantiomerically pure tertiary alcohols, amino alcohols, hydroxy and amino carboxylic acids **5a-c**.[12] Despite the fact that the diastereofacial selectivity in the epoxide formation was common for the all three types of β-keto-γ-fluoroalkyl sulfoxides **1**, the reactions featured quite different patterns of reactivity and diastereomeric preferences at the stereogenic center alpha to the sulfoxide moiety. Thus, while the reaction of diazomethane with α-phenyl-substituted (R_S)-β-keto-γ-fluoropropyl sulfoxide **1** (R = Ph; R_F = CH_2F) afforded predominantly (1'*R*,2*S*,R_S)-configured diastereomer **4**,[12d] the addition of diazomethane to α-alkyl-substituted sulfoxides **1** (R = Alk; R_F = CH_2F) gave a mixture of

Scheme 1



	a	b	c	d	e	f	g	h
R	Me	*n*-Pr	Me	*n*-Pr	Allyl	Ph	Ph	Ph
R_F	CH_2F	CHF_2	CF_3	CF_3	$CClF_2$	CH_2F	CHF_2	CF_3

(1'*R*,2*S*,R_S)- and (1'*S*,2*S*,R_S)-diastereomers **3**, in a ratio dependent on the conditions used.[12e] Moreover, we have found that an increase of the fluorine substitution for hydrogen on the starting sulfoxide (sulfoxide **1** R_F = CH_2F, CHF_2, CF_3) facilitated the addition reactions (increase in the reaction rates) giving rise to epoxides **2** with a substantially enhanced diastereoselectivity.[12a,c] Following a systematic study we set about a series of additional experiments to account for the origin of stereogenesis in these reactions and to extend a family of the synthetically valuable chirons, available by this methodology.

In this paper, we a) describe the reactions of diazomethane with α-alkyl and α-phenyl-substituted (R_S)-β-keto sulfoxides bearing difluoro-, trifluoro- and difluorochloromethyl groups (Scheme 1); b) provide a plausible rationale for the origin of the stereochemical preferences in these reactions; and c) demonstrate the synthetic versatility of the resultant epoxides by a series of key transformations of the epoxide ring and the sulfinyl group.

RESULTS AND DISCUSSION

Synthesis of (R_S)-β-keto/hydrate-γ-fluoroalkyl sulfoxides 8/9a-h (Scheme 1). The starting (R_S)-β-keto/hydrate-γ-fluoroalkyl sulfoxides **8/9a-h** were prepared by the reaction of the α-lithio derivatives of (*R*)-4-methylphenyl alkyl sulfoxides **6** with the corresponding fluorinated ethyl acetate **7**, according to our standard method (Scheme 1).[13] Monofluoro-substituted derivatives (3*S*/*R*,R_S)-**8a,f** were isolated in keto forms,[12d,13] while the difluoro-, chlorodifluoro- and trifluoromethyl compounds were obtained as keto/hydrate mixtures (3*S*/*R*,R_S)-**8/9b-e,g,h**. In all cases, regardless keto/hydrate composition, sulfoxides **8/9a-h** were obtained as mixtures of the corresponding (3*S*/*R*,R_S)-diastereomers. Isolation of (3*S*/*R*,R_S)-**8/9a-h** by flash chromatography (FC) did not allow separation of the diastereomers, but gave mixtures partially enriched in the (3*S*,R_S)-configured compounds.

Reactions of sulfoxides 8/9a-h with diazomethane (Scheme 1). The reactions between the diastereomeric mixtures of sulfoxides (3*S*/*R*,R_S)-**8/9a-h** and diazomethane were performed under standard

conditions using four different solvents. The reactions of polyfluoro derivatives (3*S*/*R*,*R*S)-**8/9b-e,g,h** were found to proceed with notably higher rates as compared with that of monofluoro analogs (3*S*/*R*,*R*S)-**8a,f**. Chemical and stereochemical outcomes of the reactions were studied by NMR analysis on crude reaction mixtures. Isolation of the individual reaction products was accomplished by FC. The stereochemistry of the products obtained in the reactions of monofluoro derivatives **8a,f** was previously established by X-ray analyses.[12d,e] Since we have shown that the fluorine substitution for hydrogen does not influence the sense of the diastereochemical preferences in the reactions under study, and on the basis of chemical correlations between diastereomeric and/or enantiomeric products, and similarity in the patterns of NMR spectra of the homochiral compounds, the absolute configurations of epoxides **11-13** were assign as depicted on Scheme 1. In all cases apart from the target epoxides, the corresponding enol ethers **14**, presumably resulting from the reactions of enols **10** with diazomethane, were isolated in yields ranging from 4 to *ca* 20%, depending on the substrate and reaction conditions used. The results of the reactions are summarized in Table 1.

As reported previously,[12e] the stereochemical outcome of the reaction of diazomethane with monofluoro derivative of α-methyl β-keto sulfoxide (3*S*/*R*,*R*S)-**8a** was shown to be dependent on the conditions used. Thus, (1'*S*,2*S*,*R*S)-configured epoxide **11a** was obtained as a major product in the reaction conducted in methanol (Table 1, entry 1), while the reaction in diethyl ether favored a formation of (1'*R*,2*S*,*R*S)-**12a** diastereomer (entry 2). The stereoselectivity of the oxirane ring formation was also influenced by the solvent used ranging from 50% to 72% de, entries 1,2, respectively. The same pattern of stereochemical preferences was observed also for the reactions of diazomethane with the corresponding monofluoro derivative of α-*n*-Pr-β-keto sulfoxide, albeit with lower level of stereoselectivity at both stereogenic centers [in methanol: (1'*S*/1'*R*) ratio 60/40, (2*S*/2*R*) - 80/20; in diethyl ether: (1'*S*/1'*R*) ratio 40/60, (2*S*/2*R*) - 78/22].[12e] In contrast to these data, the reactions of difluoro derivative (3*S*/*R*,*R*S)-**8/9b** afforded (1'*S*,2*S*,*R*S)-configured epoxide **11b** regardless the solvent used (entries 3, 4). The stereoselectivity of the oxirane formation was only slightly influenced by the reaction conditions varying from 60 to 70% de. Introduction of one more fluorine atom on the starting β-keto sulfoxide, the reactions of trifluoromethyl derivatives (3*S*/*R*,*R*S)-**8/9c,d**, allowed preparation of the targeted (2*S*)-configured oxiranes with higher de. Thus, the reaction of diazomethane with trifluoromethyl-containing α-Me-β-keto/hydrate sulfoxide (3*S*/*R*,*R*S)-**8c**, performed in methanol, afforded a mixture of (2*S*)-configured epoxides with 82% de (entry 5). Any appreciable improvement of the diastereoselectivity was not observed by varying reaction conditions such as solvent and temperature (entries 6-9). Substitution of the α-methyl group by a bulkier *n*-Pr one, the reaction of (3*S*/*R*,*R*S)-**8/9d**, was found to decrease the stereochemical outcome giving rise to the epoxides with 62-64% de at the α-stereogenic center and only 56-58% de at the oxirane ring (entries 11, 12). In contrast, an increase in a steric bulk on the terminal site of the starting sulfoxide, the reaction of chlorodifluoro derivative (3*S*/*R*,*R*S)-**8/9e**, substantially enhanced the stereoselectivity of the process. The reaction of (3*S*/*R*,*R*S)-**8/9e**, conducted in a methanol solution (entry 13), gave rise to the corresponding (2*S*)-configured oxiranes in 90% de and with 74% de at the α-stereogenic center. Finally we investigated the series of α-phenyl substituted derivatives (3*S*/*R*,*R*S)-**8/9f-h** reactions with diazomethane. Previously we reported that the reaction of α-phenyl-γ-monofluoro-β-keto sulfoxide (3*S*/*R*,*R*S)-**8f** gave rise to (1'*R*,2*S*,*R*S)-**12f** diastereomer, as a major product, regardless of the diastereomeric composition of the starting ketone and conditions used (entries 14, 15).[12d] We have found that the reaction of difluoro derivative (3*S*/*R*,*R*S)-**8/9g** proceeded in more highly diastereoselective manner, in both methanol and diethyl ether solutions, giving rise to oxiranes (1'*S*,2*S*,*R*S)-**11g** and (1'*R*,2*S*,*R*S)-**12g** with preferable formation of the latter (70-80% de) (entries 16, 17). The addition of diazomethane to trifluoro-

Table 1. Reactions of (3*S*/*R*,*R*S)-β-Keto/hydrate Sulfoxides **8/9a-h** with Diazomethane

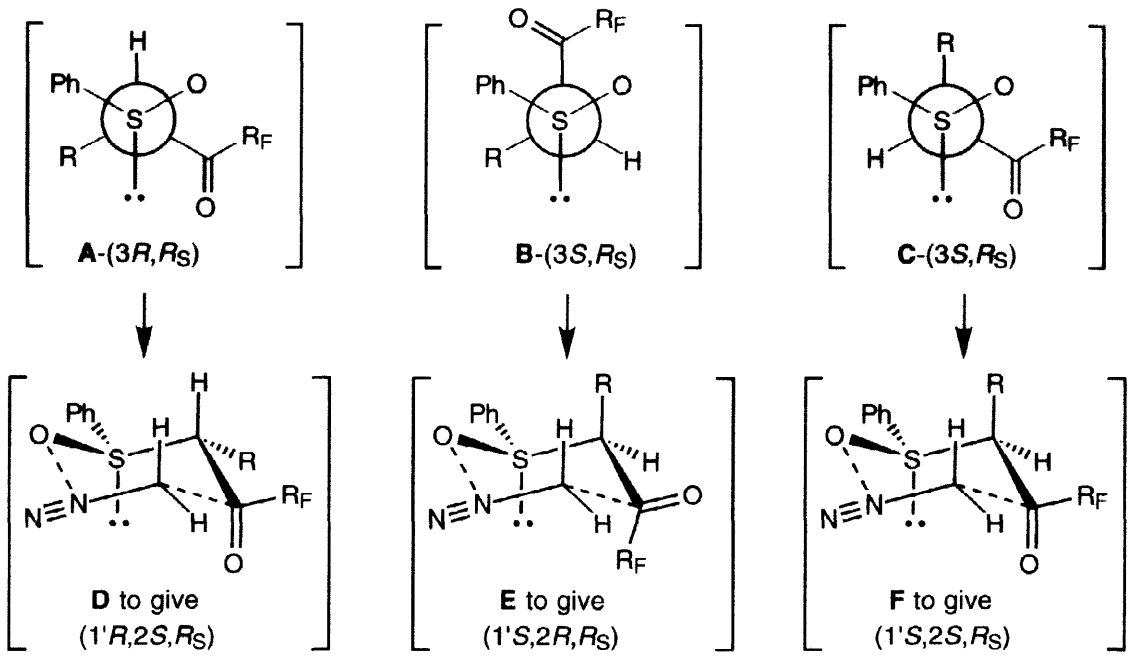
Entry		Sulfoxides **8/9a-h** R	R_F	Solvent[a]	Yield,[b] (%)	Epoxides[c] **11a-h** (1'*S*,2*S*)	**12a-h** (1'*R*,2*S*)	**13a-h** (1'*S*,2*R*)	ratio (1'*S*/1'*R*)	ratio (2*S*/2*R*)
1	(**a**)	Me	CH_2F[d]	A	87	46	29	23	69/31	75/25
2	(**a**)	Me	CH_2F[d]	C	75	23	64	10	33/67	86/14
3	(**b**)	*n*-Pr	CHF_2	A	83	60	20	20	80/20	80/20
4	(**b**)	*n*-Pr	CHF_2	C	80	65	20	15	80/20	85/15
5	(**c**)	Me	CF_3	A	83	68	23	9	77/23	91/9
6	(**c**)	Me	CF_3	A[e]	87	70	20	10	80/20	90/10
7	(**c**)	Me	CF_3	A[f]	80	72	13	15	87/13	85/15
8	(**c**)	Me	CF_3	B	88	62	25	13	75/25	87/13
9	(**c**)	Me	CF_3	C	75	60	23	17	77/23	73/17
10	(**c**)	Me	CF_3	D	78	56	25	19	75/25	81/19
11	(**d**)	*n*-Pr	CF_3	A	87	60	18	22	82/18	78/22
12	(**d**)	*n*-Pr	CF_3	C	78	60	19	21	81/19	79/21
13	(**e**)	Allyl	$CClF_2$	A	86	82	13	5	87/13	95/5
14	(**f**)	Ph	CH_2F[g]	A	91	17	78	5	22/78	95/5
15	(**f**)	Ph	CH_2F[g]	C	94	11	79	10	21/79	90/5
16	(**g**)	Ph	CHF_2	A	80	10	90	-	10/90	>98/2
17	(**g**)	Ph	CHF_2	C	82	15	85	-	15/85	>98/2
18	(**h**)	Ph	CF_3	A	88	25	75	-	25/75	>98/2
19	(**h**)	Ph	CF_3	C	79	33	67	-	33/67	>98/2

[a] All reactions were performed by addition of an ethereal solution of the diazomethane to a solution of the corresponding substrate; A = methanol, B = ethanol, C = ethyl ether, D = benzene. [b] Total yield of all reaction products. [c] Ratio of epoxides **11-13** determined by NMR on crude reaction mixtures. Apart from the epoxides the corresponding enol ethers **14** were isolated; see experimental part. [d] See ref. 12e. [e] The reaction was performed at –70 °C. [f] Reaction was performed in CH_3OH/H_2O 1:1 (vol) mixture. [g] See ref. 12d.

substituted sulfoxide (3*S*/*R*,*R*S)-**8/9h** also featured virtually complete stereoselectivity of the oxirane ring formation affording only (2*S*)-configured epoxides **11h** and **12h** (entries 18, 19). However, the stereoselectivity at the α-stereogenic center was substantially lowed in both methanol and diethyl ether.

On the basis of the previous,[12c-e] and present results, we attempted to summarize some general features of the stereochemical outcome of the reactions. The most obvious conclusion is that the stereochemistry of the epoxide ring stereogenic center is overwhelmingly controlled by the chirality of the sulfoxide moiety affording the (2*S*)-configured epoxides as long as the (*R*S)-sulfoxide used. Importantly, the sense of stereochemical preferences at C2 of the epoxide ring is not influenced by the pattern of substitution on the starting sulfoxide that renders the present method generally useful for asymmetric synthesis of 2-alkyl-2-fluoroalkyl epoxides, since the stereogenic center alpha to the sulfoxide group has no particular importance from a synthetic point of view, as it might be cleared upon elaboration of the resultant epoxides to the target sulfur-free compounds. The fluorine

Figure 2

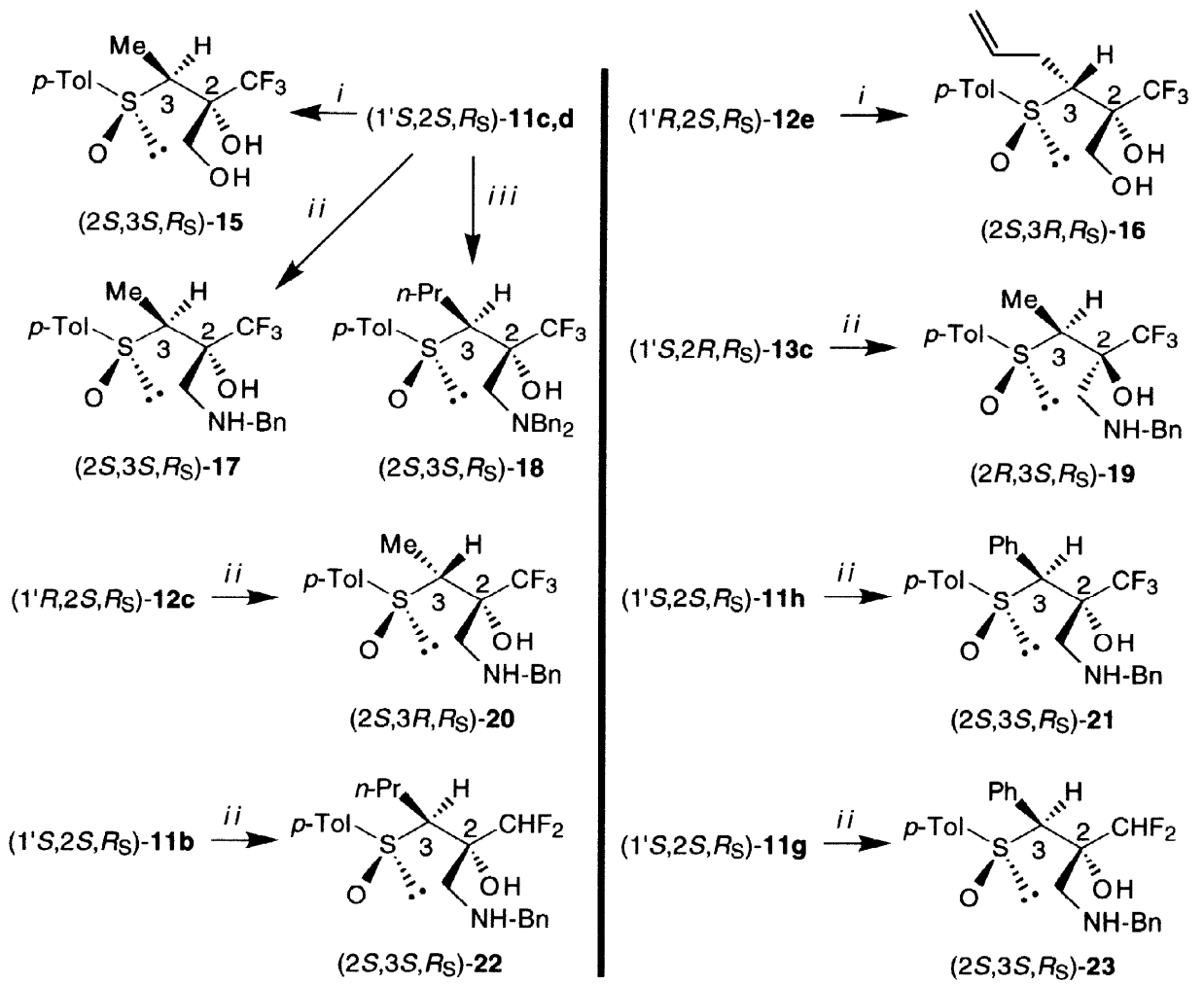


substitution for hydrogen increases the reaction rates (an electronic effect) and generally enhances a magnitude of the stereoselectivity (a steric effect) of the epoxide ring formation. Since the carbon stereogenic center on starting β-keto sulfoxides is highly configurationally unstable, prone to racemization through the corresponding enols **10** (Scheme 1),[12d,e] it would be difficult to rationalize the sense of the stereochemical preferences at this stereogenic center. Thus, the observed (1'*S*/1'*R*) ratio in the resultant epoxides might be a function of a) the starting diastereomeric composition, b) the epimerization rates of the diastereomers and c) the rates of each diastereomer reaction with diazomethane. Obviously, the combined effect of these factors should heavily depend on the nature of substitution on the starting sulfoxide and reaction conditions used. Unfortunately, due to the conformational instability mentioned above, polyfluorinated sulfoxides **8/9** cannot be isolated in diastereomerically pure form. However, considering transition states available for the reactions under study (Figure 2), one can draw some speculative conclusions. For (3*R*,*R*S)-**8** diastereomers the most thermodynamically favorable conformation, as supported by molecular mechanics calculations performed for the monofluoro derivatives **8a**,**f**,[12d] would be conformation **A** in which steric interactions between the substituents are minimized. In contrast, for the (3*S*,*R*S)-configured diastereomers there is no single thermodynamically favorable conformer as one of the substituents, CO-R_F or R, must occupy a sterically unfavorable position. That is, structures **B** and **C** should be considered. Accordingly, the reactions of (3*R*,*R*S)-**8** diastereomers with diazomethane could proceed *via* a single transition state **D**, to afford (1'*R*,2*S*,*R*S)-configured oxiranes **12**, while for the reactions of (3*S*,*R*S)-**8** diastereomers two transition states **E** and **F** should be organized to give oxiranes (1'*S*,2*R*,*R*S)-**13** and (1'*S*,2*S*,*R*S)-**11**, respectively. It follows, that the reactions of (3*R*,*R*S)-**8** diastereomers with diazomethane might afford only one reaction product, oxirane (1'*R*,2*S*,*R*S)-**12**,[12d] while the stereochemical outcome of the reactions of (3*S*,*R*S)-**8** diastereomers would reflect a balance between a relative thermodynamic stability of conformers **B**, **C** and the corresponding transition states **E** and **F**, as a function of the nature of the substitution on the starting β-keto sulfoxide.

Elaboration of the epoxides. Previously we described general routes for elaboration of α-unsubstituted polyfluoroalkyl-containing synthons (2*S*,*R*S)-**2** and α-alkyl, α-phenyl-substituted monofluoro synthons (2*S*,*R*S)-**3** and (1'*R*,2*S*,*R*S)-**4** (Figure 1), respectively.[12] As one can assume, the same chemistry might be also applicable to transformations of the synthons available by this study. Therefore, we have studied only key reactions of the oxiranes **11-13**, including epoxide ring-opening reactions, reductive desulfurization, and *syn*-elimination reactions, to afford synthetically and biologically interesting compounds. Since the α-stereogenic center in epoxides (1'*R*,2*S*,*R*S)-**12** and (1'*S*,2*S*,*R*S)-**11** might be cleared upon their transformation to the target sulfur-free compounds, these epoxides could be elaborated simultaneously in a mixture available directly by the reaction of the corresponding β-keto sulfoxide with diazomethane. However, to obtain stereochemically individual products allowing proper characterization we studied the reactions of the diastereomerically pure compounds.

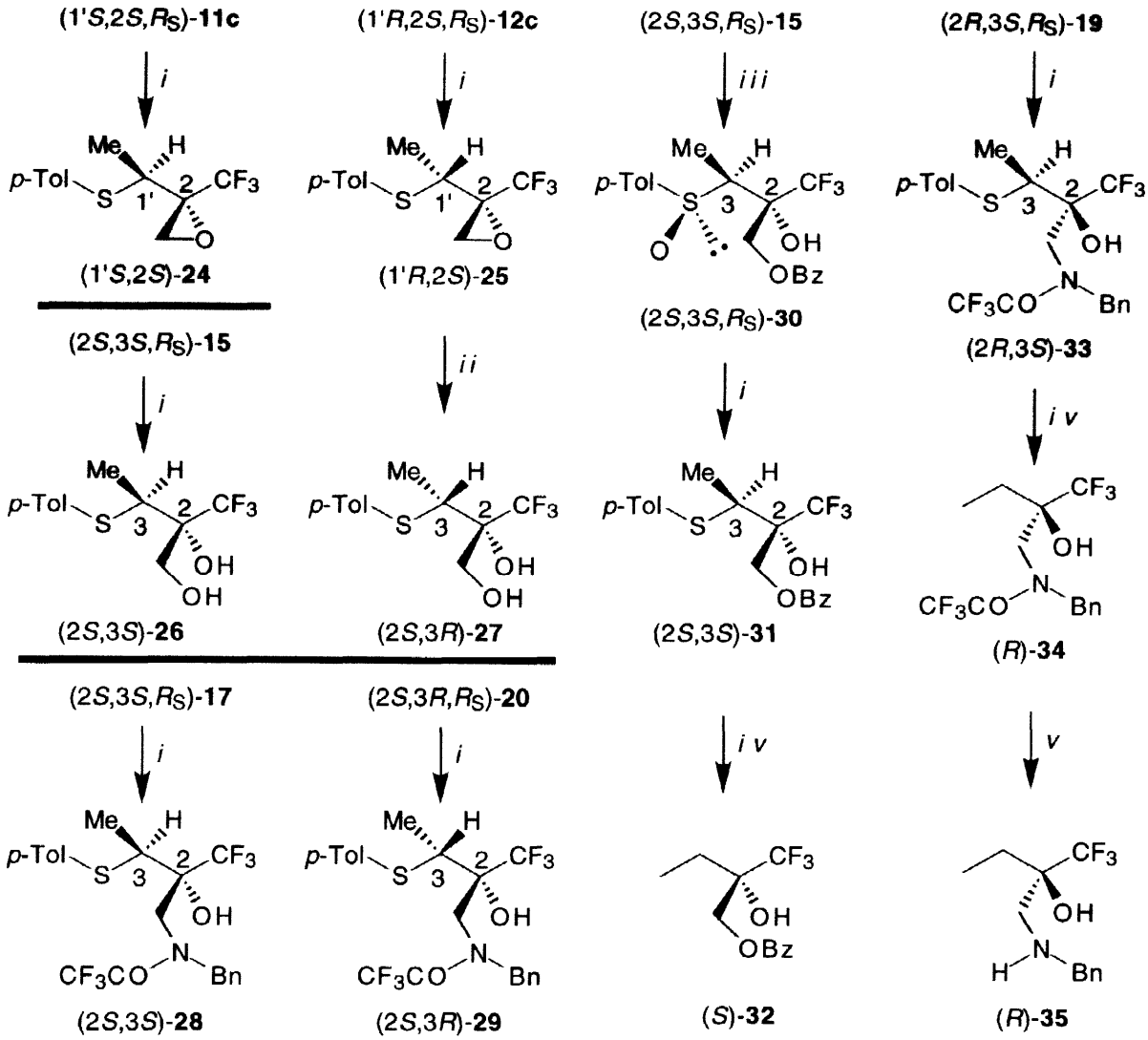
***Epoxide ring-opening reactions*. Ring-openings with water** (Scheme 2). Recently we have shown that due to a relatively high CH acidity of the proton alpha to the sulfoxide group, base-catalyzed ring-

Scheme 2



Key: (*i*) $HClO_4$, H_2O/THF, rt, 5 d; (*ii*) $BnNH_2$, THF, rt, 1 d; (*iii*) Bn_2NH, THF, rt, 3 d

Scheme 3



Key: (*i*) NaI, $(CF_3CO)_2O$, acetone, -20 °C; (*ii*) $HClO_4$, H_2O/THF, rt, 5 d; (*iii*) $PhCO_2H$, DCC, DMAP, CH_2Cl_2, rt; (*iv*)Ni-*Raney*/H_2, EtOH, reflux; (*v*) NaOH, MeOH/H_2O, rt, 5 min.

opening reactions of the synthons **2-4** could be accompanied by the corresponding rearrangement to give open-chained allylic alcohols.[12c-e] Therefore, we developed the acid-catalyzed protocol using $HClO_4$ in aqueous THF.[12c-e] Under these reaction conditions trifluoromethyl-containing epoxides (1'*S*,2*S*,*R*S)-**11c** and (1'*R*,2*S*,*R*S)-**12e** were cleanly transformed to diols (2*S*,3*S*,*R*S)-**15** and (2*S*,3*R*,*R*S)-**16**, respectively (Scheme 2). The reactions proceeded slowly (5 d, rt), however the target products were isolated in high yields (80-89%).

Ring-openings with amines (Scheme 2). Due to a particular biomedicinal relevance of 1,2-amino alcohols we used a more wide range of the substrates for preparing the corresponding amino derivatives. All three available diastereomeric trifluoromethyl-containing oxiranes (1'*S*,2*S*,*R*S)-**11c**, (1'*R*,2*S*,*R*S)-**12c** and (1'*S*,2*R*,*R*S)-**13c**, as well as trifluoromethyl 1'-phenyl-containing epoxide (1'*S*,2*S*,*R*S)-**11h**, were treated with benzylamine to afford amino alcohols (2*S*,3*S*,*R*S)-**17**, (2*S*,3*R*,*R*S)-**20**, (2*R*,3*S*,*R*S)-**19** and (2*S*,3*S*,*R*S)-**21**, respectively, in excellent isolated yields. The reactions proceeded with a relatively high rates, as compared with

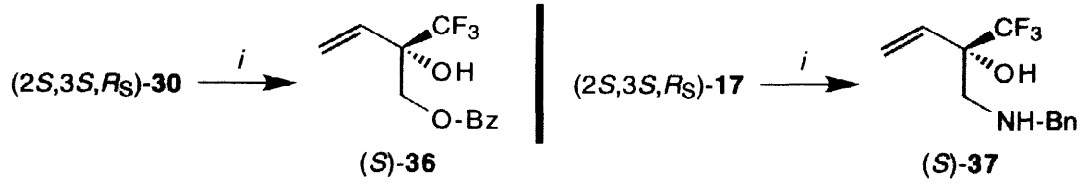
the acid-catalyzed openings by water, and without any noticeable differences in the behavior of the diastereomeric starting oxiranes. Application of dibenzyl amine for opening the epoxide ring was demonstrated by the transformation of trifluoromethyl 1'-*n*-propyl derivative (1'*S*,2*S*,R_S)-**11d** to amino alcohol (2*S*,3*S*,R_S)-**18**. The reaction occurred slowly to give the *N*,*N*-dibenzyl derivative in a moderate chemical yield. The ring-opening reactions of difluoromethyl-containing oxiranes (1'*S*,2*S*,R_S)-**11b** and (1'*S*,2*S*,R_S)-**11g** showed a similar reactivity giving rise cleanly to the target amino alcohols (2*S*,3*S*,R_S)-**22** and (2*S*,3*S*,R_S)-**23**, respectively.

All the ring-opening reactions studied featured complete regioselectivity and did not influence the stereochemical integrity of the compounds involved.

Reductive desulfurization (Scheme 3). For reductive desulfurization[14] we followed our standard two-reductive-steps protocol including first transformation of a sulfinyl to a thio group *via Oae* procedure,[15] followed by *Raney* nickel-promoted desulfenylation reaction to afford sulfur-free derivatives. The sulfinyl-to-sulfenyl reduction was studied on three types of substrates, including epoxides and their ring-opened products, the corresponding diols and amino alcohols. Treatment of diastereomeric trifluoromethyl-containing epoxides (1'*S*,2*S*,R_S)-**11c** and (1'*R*,2*S*,R_S)-**12c** in an acetone solution with NaI and trifluoroacetic anhydride for 20 min at -20 °C gave sulfenyl derivatives (1'*S*,2*S*)-**24** and (1'*R*,2*S*)-**25**, respectively, in excellent isolated yield; no ring-opened products were detected in the reaction mixtures. Under the same reaction conditions, diol (2*S*,3*S*,R_S)-**15** was cleanly reduced to afford product (2*S*,3*S*)-**26**. Its (2*S*,3*R*)-diastereomer **27** was prepared by the ring opening of sulfenyl epoxide (1'*R*,2*S*)-**25** with water to confirm the diastereomeric relations between compounds (2*S*,3*S*)-**26** and (2*S*,3*R*)-**27** and their precursors. The reduction of the amino alcohols was demonstrated by preparing also diastereomeric sulfenyl derivatives (2*S*,3*S*)-**28** and (2*S*,3*R*)-**29** starting from (2*S*,3*S*,R_S)-**17** and (2*S*,3*R*,R_S)-**20**, respectively. In this case the reduction was accompanied by trifluoroacetylation of the amino group to afford the corresponding amides. The two-reductive-steps procedure was conducted to show preparation of the enantiomerically pure trifluoromethyl-containing diols and amino alcohols. Sulfoxide diol (2*S*,3*S*,R_S)-**15** was first benzoylated to afford derivative (2*S*,3*S*,R_S)-**30** which was reduced under the standard conditions to give sulfenyl (2*S*,3*S*)-**31**. The reductive desulfenylation[16] of (2*S*,3*S*)-**31** was performed in an ethanol solution in the presence of *Raney*-Ni under hydrogen atmosphere at 80 °C to afford sulfur-free diol derivative (*S*)-**32** in high isolated yield. The same protocol was applied for preparing sulfur-free amino alcohol (*R*)-**34** through the corresponding sulfenyl derivative (2*R*,3*S*)-**33**. Compound (*R*)-**34** was further detrifluoroacetylated under a base-catalyzed conditions to afford (*N*-benzyl)amino alcohol (*R*)-**35**.

syn-*Elimination reactions* (Scheme 4). Application of the thermal *syn*-elimination reactions of the *p*-tolyl sulfoxide group[17] to the synthons under study, to afford sulfur-free vinyl compounds, were demonstrated using homochiral trifluoromethyl-containing diol and amino alcohol derivatives. Thus, heating of *p*-xylene solutions of sulfoxides (2*S*,3*S*,R_S)-**30** and (2*S*,3*S*,R_S)-**17** at 150° C for 10 min resulted in elimination of the sulfinyl group to give the corresponding vinyl derivatives (*S*)-**36** and (*S*)-**37**, respectively, as major reaction products. Despite the drastic conditions, the reactions occurred quite smoothly to afford compounds (*S*)-**36** and (*S*)-**37** in high isolated yields (78-82%).

Scheme 4



Key: (*i*) *p*-Xylene, 150 °C, 10 min.

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EXPERIMENTAL SECTION

General. For standard laboratory praxis and techniques see the related papers, ref. 12. Unless otherwise stated, yields refer to isolated yields of products of greater than 95% purity as estimated by ^{1}H and ^{19}F NMR spectrometry. All new compounds were characterized by ^{1}H NMR, ^{19}F NMR, and elemental analyses. Unless otherwise stated, R_f refers to a hexane/ethyl acetate 4:1 mixture. The product ratios were determined by ^{1}H and ^{19}F NMR analyses on crude reaction mixtures. The syntheses of 1,1,1-trifluoro-3-[(4-methylphenyl)sulfinyl]butan-2-one/hydrate **8/9c**,[13b] 1,1,1-trifluoro-3-[(4-methylphenyl)sulfinyl]hexan-2-one/hydrate **8/9d**,[13b] 1-chloro-1,1-difluoro-3-[(4-methylphenyl)sulfinyl]hex-5-en-2-one/hydrate **8/9e**,[13d] and 1,1,1-trifluoro-3-[(4-methylphenyl)sulfinyl]-3-phenylpropan-2-one/hydrate **8/9h**[13c] were accomplished according to the literature methods.

***Reactions of Alkyl* p-*Tolyl Sulfoxides* (*R*S)-6 *with Esters* 7. *Synthesis of ketones/gem-hydrates* 8/9. General procedure.** To a solution of LDA (10.4 mmol) in THF (10 mL) at -70 °C a solution of sulfoxide (*R*S)-**6** (10.0 mmol) in THF (10 mL) was added dropwise. Temperature was allowed to reach 0 °C, then the yellow solution was cooled to -60 °C and neat fluorinated ethyl ester **7** (10.0 mmol) was added dropwise by syringe. After 10 min, the reaction was quenched by adding a saturated solution of ammonium chloride, organic layers were extracted by ethyl acetate, dried over anhydrous sodium sulfate and evaporated to dryness.

(3*R*/*S*,*R*S)-1,1-difluoro-3-[(4-methylphenyl)sulfinyl]hexan-2-one/hydrate (8b/9b): Starting from (*R*S)-1-[(4-methylphenyl)sulfinyl]butane (**6**), after FC (hexane/ethyl acetate 6:4) product **8b/9b** was isolated as a 1:1 mixture of (3*R*)- and (3*S*)- diastereoisomers in the keto form **8b** and as a 2:1 diastereomeric mixture in the hydrate one **9b**; hydrate **9b** and ketone **8b** were in 1:4 ratio, respectively; 92% yield; R_f = 0.35; ketone **8b**: ^{1}H NMR ($CDCl_3$) δ 0.89-2.40 (7H, m), 2.43 and 2.44 (3H, br.s), 4.17 and 4.43 (1H, m), 5.34 and 5.55 (1H, t, *J* = 52.5 Hz), 7.2-7.6 (4H, m); ^{19}F NMR ($CDCl_3$) δ -130.81 and -128.96 (dd, *J* = 309.0 and 52.5 Hz), -130.83 (d, *J* = 52.5 Hz); hydrate **9b**: ^{1}H NMR ($CDCl_3$) δ 0.8-2.4 (7H, m), 2.43 (3H, br.s), 2.80 and 2.97 (1H, m), 5.71 and 5.82 (1H, t, *J* = 54.0 Hz), 7.2-7.6 (4H, m); ^{19}F NMR ($CDCl_3$) δ -141.29 and -132.00 (dd, *J* = 283.5 and 54.0 Hz), -139.90 and -131.80 (*J* = 283.5 and 54.0 Hz).

(3*R*/*S*,*R*S)-1,1,1-trifluoro-3-[(4-methylphenyl)sulfinyl]butan-2-one/hydrate (8/9c). Starting from (*R*S)-[(4-methylphenyl)sulfinyl]ethane (**6**) and ethyl trifluoroacetate **5** after FC (hexane/ethyl acetate 1:1) the product **8c/9c** was isolated as a 4.5:1 mixture of (3*R*)- and (3*S*)-diastereoisomers in keto form **8c** and as a 18:1 diastereomeric mixture in the hydrate one **9c**; hydrate **9c** and the ketone **8c** were in 10.5:1 ratio,

respectively; 95% yield; R_f = 0.35; ketone **8c**: ^{1}H NMR ($CDCl_3$) δ 1.35 and 1.53 (3H, d, *J* = 7.1 Hz), 2.45 (3H, br.s), 4.07 and 4.40 (1H, q, *J* = 7.1 Hz), 7.37, 7.50 and 7.71 (4H, m); ^{19}F NMR ($CDCl_3$) δ -79.34 and -79.28 (br.s); hydrate **9c**: ^{1}H NMR ($CDCl_3$) δ 1.09 (3H, d, *J* = 7.1 Hz), 2.45 (3H, br.s), 3.03 and 3.15 (1H, q, *J* = 7.1 Hz), 4.61, 5.20 and 5.86 (2H, br.s), 7.37, 7.44 and 7.45 (4H, m); ^{19}F NMR ($CDCl_3$) δ -84.04 and -83.54 (br.s).

(3*R*/*S*,*R*$_S$)-1,1-difluoro-3-[(4-methylphenyl)sulfinyl]-3-phenylpropan-2-one/hydrate (8g/9g). Starting from (*R*$_S$)-[(4-methylphenyl)sulfinyl]phenylmethane (**6**), after FC (hexane/ethyl acetate 8:2) product **8g/9g** was isolated as a 4:1 mixture of (3*R*)- and (3*S*)- diastereoisomers in the keto form **8g** and as a 10:1 diastereomeric mixture in the hydrate one **9g**; hydrate **9g** and ketone **8g** were in 1:2.4 ratio, respectively; 90% yield; R_f = 0.35; ketone **8g**: ^{1}H NMR ($CDCl_3$) δ 2.42 and 2.43 (3H, br.s), 5.16 and 5.18 (1H, brd, *J* = 2.0 Hz), 5.55 and 5.90 (1H, t, *J* = 53.0 Hz), 7.0-7.6 (9H, m); ^{19}F NMR ($CDCl_3$) δ -130.39 and -127.17 (br.dd, *J* = 315.0 and 53.0Hz), -130.04 and -127.81 (br.dd, *J* = 315.0 and 53.0 Hz); hydrate **9g** (selected signals): ^{1}H NMR ($CDCl_3$) δ 2.42 (3H, br.s), 4.00 and 4.03 (1H, br.d, *J* = 2.0 Hz), 4.85 (2H, br.m), 5.21 (1H, t, *J* = 55.0 Hz), and 7.0-7.6 (9H, m); ^{19}F NMR ($CDCl_3$) δ -145.10 and -132.68 (br.dd, *J* = 284.0 and 54.0 Hz), -144.24 and -133.75 (br.dd, *J* = 284.0 and 54.0 Hz).

***Reactions of Keto/Hydrate Sulfoxides* 8/9 *with Diazomethane. Synthesis of oxiranes* 11-13. General procedure.** An ethereal solution of diazomethane (CH_2N_2, *ca* 0.5 M) was added portionwise to a stirred solution of the starting ketone/hydrate **8/9** (10.0 mmol) in the corresponding solvent (80 mL) at 0 °C up to persistence of the diazomethane yellow color. Nitrogen was bubbled to remove the excess of diazomethane and the solvent was then evaporated *in vacuo* to give a mixture of the oxiranes **11-13** and the corresponding enol-ethers **14**. Reaction conditions, yields, and the products ratios are listed in Table 1.

(1'*S*,2*S*,*R*$_S$)-2-difluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (11b): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 3, Table 1; yield 48.1%; R_f 0.48; ^{1}H NMR ($CDCl_3$) δ 0.83 (3H, t, *J* = 7.2 Hz), 1.24, 1.42, 1.65 and 1.93 (4H, m), 2.43 (3H, br.s), 2.84 (2H, m), 2.95 (1H, d, *J* = 4.5 Hz), 5.55 (1H, t, *J* = 54.0 Hz), 7.35 and 7.55 (4H, m); ^{19}F NMR ($CDCl_3$) δ -125.57 and -124.70 (br.dd, *J* = 290.0 and 54.0 Hz).

(1'*R*,2*S*,*R*$_S$)-2-difluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (12b): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 3, Table 1; yield 16.6%; R_f 0.46; ^{1}H NMR ($CDCl_3$) δ 0.85 (3H, t, *J* = 7.0 Hz), 1.0-2.0 (4H, m), 2.44 (3H, br.s), 3.02 (1H, d, *J* = 4.5 Hz), 3.11 (1H, dd, *J* = 8.5 and 4.5 Hz), 3.27 (1H, dt, *J* = 4.5 and 1.8 Hz) 5.68 (1H, t, J = 55.0 Hz), 7.36 and 7.57 (4H, m); ^{19}F NMR ($CDCl_3$) δ -131.57 (br.d, J = 55.0 Hz).

(1'*S*,2*R*,*R*$_S$)-2-difluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (13b): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 3, Table 1; yield 10.6%; R_f 0.50; ^{1}H NMR ($CDCl_3$) δ 0.75 (3H, t, *J* = 7.0 Hz), 0.9-2.4 (4H, m), 2.44 (3H, br.s), 2.95 (1H, dd, *J* = 9.0 and 2.5 Hz), 3.02 (1H, d, *J* = 4.5 Hz), 3.17 (1H, dt, *J* = 4.5 and 1.8 Hz), 5.67 (1H, t, J = 55.0 Hz), 7.35 and 7.47 (4H, m); ^{19}F NMR ($CDCl_3$) δ -126.53 and -124.84 (br.dd, *J* = 295.0 and 55.0 Hz).

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11b** (1'*R*,2*S*,*R*$_S$)-**12b** (1'*S*,2*R*,*R*$_S$)-**13b**, the corresponding enol ethers **14b** were isolated.

(*E,Z*),(*R*$_S$)-1,1-difluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]hex-2-ene: first isomer; 4.9% yield; R_f 0.50; ^{19}F NMR ($CDCl_3$) δ -115.30 and -120.40 (br.dd, J = 317.0 and 53.0 Hz). Second isomer; 12.4% yield; R_f 0.48; ^{19}F NMR ($CDCl_3$) δ -116.80 and -122.20 (br.dd, J = 316.0 and 53.0 Hz).

(1'*S*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]ethyloxirane (11c): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 5, Table 1; 56.4% yield; R_f 0.45; yellowish oil; $[\alpha]_D^{20}$ = +168.0 (*c* 1.9, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.28 (3H, dq, J = 6.8 and 1.1 Hz), 2.41 (3H, br.s), 3.02 (1H, q, J = 6.8 Hz), 3.11 (1H, br.d, J = 4.4 Hz), 3.16 (1H, dq, J = 4.4 and 1.7 Hz), 7.33 and 7.46 (4H, m); ^{19}F NMR ($CDCl_3$) δ -76.15 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.76; H, 4.73; F, 20.49.

(1'*R*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]ethyloxirane (12c): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 5, Table 1; 19.1% yield; R_f 0.40; yellowish oil; $[\alpha]_D^{20}$ = +140.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.06 (3H, d, J = 7.2 Hz), 2.44 (3H, br.s), 3.20 (1H, br.d, J = 4.2 Hz), 3.25 (1H, dq, J = 4.2 and 1.7 Hz), 3.44 (1H, q, J = 7.2 Hz), 7.36 and 7.56 (4H, m); ^{19}F NMR ($CDCl_3$) δ -76.78 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.83; H, 4.73; F, 20.44.

(1'*S*,2*R*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]ethyloxirane (13c): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 5, Table 1; 7.5% yield; R_f 0.55; mp 68-70 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +150.0 (*c* 1.1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 0.95 (3H, t, J = 7.2 Hz), 2.44 (3H, br.s), 3.13 (1H, q, J = 7.2 Hz), 3.24 (1H, br.d, J = 4.4 Hz), 3.37 (1H, dq, J = 4.5 and 1.8 Hz), 7.36 and 7.45 (4H, m); ^{19}F NMR ($CDCl_3$) δ -76.73 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.78; H, 4.72; F, 20.45.

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11c**, (1'*R*,2*S*,*R*$_S$)-**12c** and (1'*S*,2*R*,*R*$_S$)-**13c**, the corresponding enol ethers **14c** were isolated.

(*E,Z*),(*R*$_S$)-1,1,1-trifluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]but-2-ene: first isomer; yield 4.0%; R_f 0.60; yellowish oil; $[\alpha]_D^{20}$ = –358.0 (*c* 1.2, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.85 (3H, q, J = 2.8 Hz), 2.41 (3H, br.s), 3.89 (3H, q, J = 1.2 Hz), 7.31 and 7.52 (4H, m); ^{19}F NMR ($CDCl_3$) δ -64.57 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.80; H, 4.0; F, 20.50. Second isomer; yield 5.3%; R_f 0.55; yellowish oil; $[\alpha]_D^{20}$ = –38.4 (*c* 1.2, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.79 (3H, q, J = 2.1 Hz), 2.40 (3H, br.s), 3.74 (3H, br.s), 7.32 and 7.46 (4H, m); ^{19}F NMR ($CDCl_3$) δ -60.52 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.78; H, 4.70; F, 20.51.

(1'*S*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (11d): isolated by FC (chloroform/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 11, Table 1; yield 51.3%; R_f 0.54; yellowish oil; $[\alpha]_D^{20}$ = +149.8 (*c* 1.3, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 0.82 (3H, t, J = 7.2 Hz), 1.06, 1.37, 1.64 and 2.01 (4H, m), 2.43 (3H, br.s), 2.84 (1H, dq, J = 4.4 and 1.8 Hz), 2.86 (1H, dd, J = 8.5 and 4.8 Hz), 3.08 (1H, d, J = 4.4 Hz), 7.34 and 7.52 (4H, m); ^{19}F NMR ($CDCl_3$) δ -75.85 (br.s). Anal. calcd for $C_{14}H_{17}F_3O_2S$: C, 54.89; H, 5.59; F, 18.60. Found: C, 54.85; H, 5.58; F, 18.63.

(1'*S*,2*R*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (13d): isolated by FC (chloroform/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in

entry 11, Table 1; yield 19.1%; R_f 0.50; $[\alpha]_D^{20}$ = +112.5 (*c* 0.3, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 0.73 (3H, t, *J* = 6.9 Hz), 0.8-2.2 (4H, m), 2.43 (3H, br.s), 2.89 (1H, dd, *J* = 9.8 and 2.9 Hz), 3.26 (1H, d, *J* = 4.6 Hz), 3.42 (1H, dq, *J* = 4.6 and 1.9 Hz), 7.36 and 7.46 (4H, m); ^{19}F NMR ($CDCl_3$) δ -77.22 (br.s). Anal. calcd for $C_{14}H_{17}F_3O_2S$: C, 54.89; H, 5.59; F, 18.61. Found: C, 54.87; H, 5.60; F, 18.60.

(1'*R*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]butyloxirane (12d): isolated by FC (chloroform/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 11, Table 1; yield 15.7%; R_f 0.48; ^1H NMR ($CDCl_3$) δ 0.85 (3H, t, *J* = 7.0 Hz), 0.9-2.1 (4H, m), 2.43 (3H, br.s), 3.12 (1H, d, *J* = 4.6 Hz), 3.18 (1H, dd, *J* = 9.0 and 4.8 Hz), 3.55 (1H, dq, *J* = 4.6 and 1.8 Hz), 7.34 and 7.51 (4H, m); ^{19}F NMR ($CDCl_3$) δ -77.81 (br.s).

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11d**, (1'*R*,2*S*,*R*$_S$)-**12d** and (1'*S*,2*R*,*R*$_S$)-**13d**, the corresponding enol ethers **14d** were isolated.

(*Z*,*E*),(*R*$_S$)-1,1,1-trifluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]hex-2-ene: first isomer; 13.9% yield; R_f 0.38 (chloroform/ethyl acetate 4:1); yellowish oil; $[\alpha]_D^{20}$ = –90.5 (*c* 0.9, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 0.77 (3H, t, *J* = 6.8 Hz), 1.10, 1.37, 2.02 and 2.30 (4H, m), 2.39 (3H, br.s), 3.86 (3H, q, *J* = 1.0 Hz), 7.31 and 7.55 (4H, m); ^{19}F NMR ($CDCl_3$) δ -64.96 (br.s). Anal. calcd for $C_{12}H_{13}F_3O_2S$: C, 51.81; H, 4.71; F, 20.47. Found: C, 51.80; H, 4.68; F, 20.50. Second isomer; 5.2% yield; R_f 0.35 (chloroform/ethyl acetate 4:1); ^1H NMR ($CDCl_3$) δ 0.82 (3H, t, *J* = 7.2 Hz), 0.82, 1.37, 2.02 and 2.30 (4H, m), 2.40 (3H, br.s), 3.77 (3H, q, *J* = 1.0 Hz), 7.31 and 7.48 (4H, m); ^{19}F NMR ($CDCl_3$) δ -59.07 (br.s).

(1'*S*,2*S*,*R*$_S$)-2-chlorodifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]but-2'-enyloxirane (11e): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 13, Table 1; yield 63.6%; R_f 0.35; yellowish oil; $[\alpha]_D^{20}$ = +123.3 (*c* 0.8, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 2.43 (3H, br.s), 2.44 and 2.62 (2H, m), 3.19 (1H, ddd, *J* = 4.3, 2.6 and 1.1 Hz), 3.24 (1H, dd, *J* = 7.9 and 5.2 Hz), 3.31 (1H, d, *J* = 4.3 Hz), 4.98 and 5.00 (2H, m), 5.49 (1H, m), 7.34 and 7.53 (4H, m); ^{19}F NMR ($CDCl_3$) δ -65.10 and -62.22 (br.d, *J* = 167.0 Hz). Anal. calcd for $C_{14}H_{15}ClF_2O_2S$: C, 52.42; H, 4.71; F, 11.84. Found: C, 52.40; H, 4.73; F, 11.83.

(1'*R*,2*S*,*R*$_S$)-2-chlorodifluoromethyl-2-1'-[(4-methylphenyl)sulfinyl]but-2'-enyloxirane (12e): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 13, Table 1; yield 10.3%; R_f 0.40; ^1H NMR ($CDCl_3$) δ 2.06 and 2.20 (2H, m), 2.44 (3H, br.s), 3.09 (1H, dd, *J* = 9.6 and 3.6 Hz), 3.37 (1H, d, *J* = 4.6 Hz), 3.57 (1H, ddd, *J* = 4.6, 2,6 and 1.1 Hz), 4.87 and 4.93 (2H, m), 5.60 (1H, m), 7.37 and 7.48 (4H, m); ^{19}F NMR ($CDCl_3$) δ -63.71 and -65.10 (br.d, *J* = 166 Hz).

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11e** and (1'*R*,2*S*,*R*$_S$)-**12e**, the corresponding enol ethers **14e** were isolated.

(*E*,*Z*),(*R*$_S$)-1-chloro-1,1-difluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]hexa-2,5-diene: first isomer; 2.6% yield; R_f 0.40; ^1H NMR ($CDCl_3$) δ 2.39 (3H, br.s), 2.94 and 3.07 (2H, m), 3.83 (3H, t, *J* = 1.2 Hz), 4.82 and 4.84 (2H, m), 5.32 (1H, m), 7.30 and 7.50 (4H, m); ^{19}F NMR ($CDCl_3$) δ -51.87 and -43.57 (br.d, *J* = 168.0 Hz). Anal. calcd for $C_{14}H_{15}ClF_2O_2S$: C, 52.42; H, 4.71; F, 11.85. Found: C, 52.43; H, 4.73; F, 11.80. Second isomer; 4.3% yield; R_f 0.38; ^1H NMR ($CDCl_3$) δ 2.41 (3H, br.s), 3.10 and 3.25 (2H,m), 3.96 (3H, br.s), 4.85 and 4.91 (2H, m), 5.41 (1H, m), 7.28 and 7.54 (4H, m); ^{19}F NMR ($CDCl_3$) δ -55.90, -52.09 (br.d, *J* = 170.0 Hz).

(1'*S*,2*S*,*R*$_S$)-2-difluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]benzyloxirane (11g): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 17, Table 1; yield 8.2%; R_f 0.40; ^{1}H NMR ($CDCl_3$) δ 2.31 (3H, br.s), 3.02 (1H, d, *J* = 4.5 Hz), 3.92 (1H, dt, *J* = 1.8 Hz), 3.99 (1H, br.s), 5.66 (1H, t, *J* = 55.0 Hz), 7.0-7.4 (9H, m); ^{19}F NMR ($CDCl_3$) δ -131.17 (1F, br.dd, *J* = 290.0 and 55.0 Hz), -125.87 (1F, br.dd, *J* = 290.0 and 55.0 Hz).

(1'*R*,2*S*,*R*$_S$)-2-difluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]benzyloxirane (12g): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 16, Table 1; yield 62%; R_f 0.33; yellowish oil; $[\alpha]_D^{20}$ = –216.6 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 2.31 (3H, br.s), 3.29 (1H, d, *J* = 4.5 Hz), 4.00 (1H, dt, *J* = 4.5 and 1.7 Hz), 4.26 (1H, br.d, J = 1.3 Hz), 5.60 (1H, dd, *J* = 56.0 and 55.0 Hz), 6.9-7.4 (9H, m); ^{19}F NMR ($CDCl_3$) δ -133.09 (1F, br.dd, *J* = 291.0 and 56.0 Hz), -127.09 (1F, br.dd, *J* = 291.0 and 55.0 Hz); Anal. calcd for $C_{17}H_{16}F_2O_2S$: C, 63.34; H, 5.00; F, 11.79. Found: C, 63.30; H, 5.04; F, 11.80.

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11g** and (1'*R*,2*S*,*R*$_S$)-**12g**, the corresponding enol ethers **14g** were isolated.

(*E*,*Z*),(*R*$_S$)-1,1-difluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]-3-phenylprop-2-ene: first isomer; 4.1% yield; R_f 0.40; ^{1}H NMR ($CDCl_3$) δ 2.41 (3H, br.s), 4.28 (3H, q, *J* = 2.0 Hz), 5.52 (1H, t, *J* = 54.0 Hz), 6.8-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -122.22 and -118.35 (br.dd, *J* = 316.0 and 54.0 Hz). Second isomer; 23% yield; R_f 0.38; ^{1}H NMR ($CDCl_3$) δ 2.38 (3H, br.s), 4.08 (3H, q, *J* = 2.0 Hz), 5.85 (1H, t, *J* = 52.5 Hz), 6.8-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -121.30 and -116.95 (br.dd, *J* = 316.0 and 52.5 Hz).

(1'*S*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]benzyloxirane (11h): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 19, Table 1; 16.6% yield; R_f 0.45; ^{1}H NMR ($CDCl_3$) δ 2.35 (3H, br.s), 3.35 (1H, dd, *J* = 4.6 and 1.0 Hz), 3.98 (1H, br.s), 4.03 (1H, dq, *J* = 4.6 and 1.7 Hz), 6.8-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -75.51 (br.s).

(1'*R*,2*S*,*R*$_S$)-2-trifluoromethyl-2-[1'-(4-methylphenyl)sulfinyl]benzyloxirane (12h): isolated by FC (hexane/ethyl acetate 4:1) of the reaction mixture obtained under the conditions specified in entry 18, Table 1; yield 53.7%; R_f 0.39; yellowish oil; $[\alpha]_D^{20}$ = –136.0 (*c* 1.1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 2.30 (3H, br.s), 3.45 (1H, d, *J* = 4.0 Hz), 4.12 (1H, dq, *J* = 4.0 and 1.9 Hz), 4.23 (1H, br.s), 6.9-7.3 (9H, m); ^{19}F NMR ($CDCl_3$) δ -75.04 (br.s); Anal. calcd for $C_{17}H_{15}F_3O_2S$: C, 59.99; H, 4.44; F, 16.74. Found: C, 60.03; H, 4.40; F, 16.70.

Apart from oxiranes (1'*S*,2*S*,*R*$_S$)-**11h** and (1'*R*,2*S*,*R*$_S$)-**12h**, the corresponding enol ethers **14h** were isolated (entry 19).

(*E*,*Z*),(*R*$_S$)-1,1,1-trifluoro-2-methoxy-3-[(4-methylphenyl)sulfinyl]-3-phenylprop-2-ene: first isomer; 3.9% yield; R_f 0.45; ^{1}H NMR ($CDCl_3$) δ 2.43 (3H, br.s), 3.50 (3H, q, *J* = 1.5 Hz), 7.0-7.6 (9H, m); ^{19}F NMR ($CDCl_3$) δ -60.75 (br.s). Second isomer; 26% yield; R_f 0.43; ^{1}H NMR ($CDCl_3$) δ 2.40 (3H, br.s), 4.04 (3H, q, *J* = 1.5 Hz), 7.0-7.6 (9H, m); ^{19}F NMR ($CDCl_3$) δ -63.42 (br.s).

Ring-opening reactions of oxiranes with water. Synthesis of 1,2-diols. **General procedure.** To a solution of the corresponding oxirane (2.0 mmol) in a 1:1 mixture of THF/H_2O (12 mL), perchloric acid (70%, 0.1 mmol) was added. After 5 d at rt, pH of the reaction medium was adjusted to 7 by adding a diluted (0.1 *N*) solution of $NaHCO_3$, then the solvent was evaporated *in vacuo* to dryness and the residue was purified by FC.

(2*S*,3*S*,*R*$_S$)-2-trifluoromethyl-3-[(4-methylphenyl)sulfinyl]butan-1,2-diol (15). Starting from (1'*S*,2*S*,*R*$_S$)-**11c** diol (2*S*,3*S*,*R*$_S$)-**15** was obtained in 89% yield; R_f 0.38 (chloroform/ethyl acetate 1:1); mp 116.0-118.5 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +147.3 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.10 (3H, d, *J* = 7.1 Hz), 2.39 (3H, br.s), 3.02 (1H, q, *J* = 7.1 Hz), 3.93 and 4.14 (2H, br.d, *J* = 12.2 Hz), 4.97 (1H, br.m) 5.66 (1H, br.s), 7.32 and 7.46 (4H, m); ^{19}F NMR ($CDCl_3$) δ -77.68 (br.s); Anal. calcd for $C_{12}H_{15}F_3O_3S$: C, 48.66; H, 5.10; F, 19.23. Found: C, 48.60; H, 5.13; F, 19.24.

(2*S*,3*R*,*R*$_S$)-2-chlorodifluoromethyl-3-[(4-methylphenyl)sulfinyl]hex-5-en-1,2-diol (16). Starting from (1'*R*,2*S*,*R*$_S$)-**12e** diol (2*S*,3*R*,*R*$_S$)-**16** was obtained in 80% yield: R_f 0.30 (hexane/ethyl acetate 4:1); $[\alpha]_D^{20}$ +106.5 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$), δ: 2.08 and 2.52 (2H, m), 2.44 (3H, br.s), 2.85 (1H,br.m), 3.57 (1H, dd, *J* = 6.0 and 5.2 Hz), 3.80 and 3.85 (2H, m), 4.78 and 4.79 (2H, m), 5.17 (1H, m), 7.30 (1H, br.m), 7.36 and 7.72 (1H, br.m); ^{19}F NMR ($CDCl_3$), δ -58.79 (br.s).

(2*S*,3*R*)-2-Trifluoromethyl-3-[(4-methylphenyl)sulfenyl]butan-1,2-diol (27). From (1'*R*,2*S*)-**25** the corresponding diol (2*S*,3*R*)-**27** was obtained in 97% yield; R_f 0.27; yellowish oil; $[\alpha]_D^{20}$ = –42.7 (*c* 1.3, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.44 (3H, dq, *J* = 7.3 and 1.2 Hz), 2.32 (3H, br.s), 2.66 (1H, t, *J* = 6.5 Hz), 3.52 (1H, q, *J* = 7.3 Hz), 3.91 (2H, m), 4.03 (1H, br.s), 7.12 and 7.38 (4H, m); ^{19}F NMR ($CDCl_3$) δ -76.00 (br.s); Anal. calcd for $C_{12}H_{15}F_3O_2S$: C, 51.42; H, 5.39; F, 20.33. Found: C, 51.47; H, 5.42; F, 20.34.

Ring-opening reactions of oxiranes with mono- or dibenzylamine. Synthesis of 1,2-aminoalcohols. **General procedure.** Mono- or dibenzylamine (10.0 mmol) was added at rt to the corresponding oxirane (1.0 mmol) and the reaction was stirred at rt for one or three days, respectively. The resultant mixture was evaporated *in vacuo* and the residue was purified by flash chromatography (hexane/ethyl acetate 4:1).

(2*S*,3*S*,*R*$_S$)-1-(*N*-Benzyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)sulfinyl]butan-2-ol (17). From (1'*S*,2*S*,*R*$_S$)-**11c** amino-alcohol (2*S*,3*S*,*R*$_S$)-**17** was obtained in 91.0% yield; R_f 0.35; mp 103.0-104.5 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +77.7 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$ + drop D_2O) δ 1.02 (3H, d, *J* = 7.2 Hz), 2.41 (3H, br.s), 2.95 (1H, q, *J* = 7.2 Hz), 2.95 and 3.33 (2H, br.d, *J* = 14.0 Hz), 3.91 (2H, br.s), 7.2-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -78.85 (br.s); Anal. calcd for $C_{19}H_{22}F_3NO_2S$: C, 59.21; H, 5.75; F, 14.79. Found: C, 59.25; H, 5.72; F, 14.75.

(2*S*,3*S*,*R*$_S$)-1-(*N*,*N*-Dibenzyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)sulfinyl]-hexan-2-ol (18). From (1'*S*,2*S*,*R*$_S$)-**11d**, by the reaction with dibenzylamine the corresponding compound (2*S*,3*S*,*R*$_S$)-**18** was obtained in 55% yield: R_f 0.25 (hexane/diethyl ether 4:1); yellowish oil; $[\alpha]_D^{20}$ = +31.0 (*c* 0.8, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 0.62 (3H, m), 0.65, 1.02, 1.98, and 2.03 (4H, m), 2.37 (3H, br.s), 2.94 (1H, dd, *J* = 8.0 and 6.4 Hz), 3.01 and 3.51 (2H, d, *J* = 15.4 Hz), 3.77 and 3.89 (4H, br.d, *J* = 13.9 Hz), 6.30

(1H, br.s), 7.2-7.5 (14H, m); ^{19}F NMR ($CDCl_3$) δ -77.88 (br.s); Anal. calcd for $C_{28}H_{32}F_3NO_2S$: C, 66.78; H, 6.40; F, 11.32. Found: C, 66.73; H, 6.40; F, 11.36.

(2*R*,3*S*,*R*S)-1-(*N*-Benzyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)sulfinyl]butan-2-ol (19). From (1'*S*,2*R*,*R*S)-**13c** compound (2*R*,3*S*,*R*S)-**19** was obtained in 90.0% yield: R_f 0.35; mp 112-113 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +98.1 (*c* 1.1, $CHCl_3$); ^1H NMR ($CDCl_3$ + drop D_2O) δ 1.06 (3H, d, *J* = 7.0 Hz), 2.39 (3H, br.s), 2.96 (1H, q, *J* = 7.0 Hz), 3.06 and 3.35 (2H, br.d, *J* = 14.0 Hz), 3.83 and 3.91 (2H, br.d, *J* = 13.1 Hz), 7.2-7.4 (9H, m); ^{19}F NMR ($CDCl_3$) δ -77.71 (br.s); Anal. calcd for $C_{19}H_{22}F_3NO_2S$: C, 59.21; H, 5.75; F, 14.79. Found: C, 59.23; H, 5.70; F, 14.76.

(2*S*,3*R*,*R*S)-1-(*N*-Benzyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)sulfinyl]butan-2-ol (20). From (1'*R*,2*S*,*R*S)-**12c** amino derivative (2*S*,3*R*,*R*S)-**20**, was obtained in 90.0% yield; ^1H NMR ($CDCl_3$ + drop D_2O) δ 0.88 (3H, br.d, *J* = 7.2 Hz), 2.46 (3H, br.s), 2.88 and 2.97 (2H, br.d, *J* = 13.0 Hz), 3.56 (1H, br.q, *J* = 7.2 Hz), 3.74 and 3.90 (2H, d, *J* = 13.2 Hz), 7.2-7.7 (9H, m); ^{19}F NMR ($CDCl_3$) δ -75.68 (br.s).

(2*S*,3*S*,*R*S)-1-(*N*-Benzyl)amino-2-trifluoromethyl-3-phenyl-3-[(4-methylphenyl)-sulfinyl]propan-2-ol (21). From (1'*S*,2*S*,*R*S)-**11h** amino compound (2*S*,3*S*,*R*S)-**21** was obtained in 83% yield: R_f 0.31; yellowish oil; $[\alpha]_D^{20}$ = -62.8 (*c* 0.8, $CHCl_3$); ^1H NMR ($CDCl_3$ + drop D_2O) δ 2.30 (3H, br.s), 2.99 and 3.35 (2H, br.d, *J* = 13.0 Hz), 3.86 and 3.89 (2H, br.d, *J* = 13.3 Hz), 4.21 (1H, br.s), 7.0-7.4 (14H, m); ^{19}F NMR ($CDCl_3$) δ -76.10 (br.s); Anal. calcd for $C_{24}H_{24}F_3NO_2S$: C, 64.41; H, 5.41; N, 3.13. Found: C, 64.43; H, 5.40; N, 3.15.

(2*S*,3*S*,*R*S)-1-(*N*-Benzyl)amino-2-difluoromethyl-3-[(4-methylphenyl)sulfinyl]hexan-2-ol (22). From (1'*S*,2*S*,*R*S)-**11b** amino derivative (2*S*,3*S*,*R*S)-**22** was obtained in 60% yield: R_f 0.27; yellowish oil; $[\alpha]_D^{20}$ = –70.2 (*c* 1.1, $CHCl_3$); ^1H NMR ($CDCl_3$ + drop D_2O) δ 0.52, 0.93, 1.24 and 1.91 (4H, m), 0.57 (3H, br.t, *J* = 6.9 Hz), 2.40 (3H, br.s), 2.75 (1H, dd, *J* = 5.8 and 3.2 Hz), 2.82 and 3.12 (2H, br.d, *J* = 13.2 Hz), 3.88 (2H, br.s), 5.71 (1H, t, *J* = 55.5 Hz), 7.2-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -131.69 and -129.84 (br.dd, *J* = 284.0 and 55.5 Hz); Anal. calcd for $C_{21}H_{27}F_2NO_2S$: C, C, 63.77; H, 6.88; N, 3.54. Found: C, 63.75; H, 6.87; N, 3.52.

(2*S*,3*S*,*R*S)-1-(*N*-Benzyl)amino-2-difluoromethyl-3-phenyl-3-[(4-methylphenyl)-sulfinyl]propan-2-ol (23). From (1'*S*,2*S*,*R*S)-**11g** derivative (2*S*,3*S*,*R*S)-**23** was obtained in 70% yield: R_f 0.32; yellowish oil; $[\alpha]_D^{20}$ = –96.2 (*c* 1.1, $CHCl_3$); ^1H NMR ($CDCl_3$ + drop D_2O) δ 2.29 (3H, br.s), 3.10 and 3.56 (2H, br.d, *J* = 12.8 Hz), 3.85 (1H, d, *J* = 3.0 Hz), 3.93 (2H, br.s), 5.35 (1H, dd, *J* = 57.5 and 54.5 Hz), and 7.0-7.4 (14H, m); ^{19}F NMR ($CDCl_3$) δ -136.98 (1F, br.dd, *J* = 284.0 and 57.5 Hz) and -132.80 (1F, br.dd, *J* = 284.0 and 54.5 Hz); Anal. calcd for $C_{24}H_{25}F_2NO_2S$: C, 67.11; H, 5.87; N, 3.26. Found: C, 67.13; H, 5.90; N, 3.24.

Reduction of sulfoxide into sulfide group. **General procedure.** NaI (2.0 mmol) and the substrates (1.0 mmol) were suspended in acetone (10 mL) under N_2 atmosphere and stirred at -20 °C for 10 min. Then a solution of $(CF_3CO)_2O$ (3.0 mmol) in the same solvent (5 mL) was added dropwise and stirring was continued at the same temperature for 20 min. Saturated solutions of Na_2SO_3 and $NaHCO_3$ (1:1 vol) were added and the organic layers were extracted with ethyl ether, dried over Na_2SO_4, filtered and evaporated *in vacuo* to dryness. The targeted products were purified by FC.

(1'*S*,2*S*)-2-Trifluoromethyl-2-[1'-(4-methylphenyl)sulfenyl]ethyloxirane (24). From (1'*S*,2*S*,R_S)-**11c** sulfenyl derivative (1'*S*,2*S*)-**24** was obtained in 92% yield; R_f 0.28 (hexane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = +24.6 (*c* 1.5, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.36 (3H, br.d, *J* = 7.2 Hz), 2.33 (3H, br.s), 3.02 (1H, dq, *J* = 4.8 and 1.7 Hz), 3.05 (1H, d, *J* = 4.8 Hz), 3.68 (1H, q, *J* = 7.2 Hz), 7.12 and 7.31 (4H, m); ^{19}F NMR ($CDCl_3$) δ -75.00 (br.s); Anal. calcd for $C_{12}H_{13}F_3OS$: C, 54.95; H, 5.00; F, 21.73. Found: C, 54.93; H, 5.00; F, 21.76.

(1'*R*,2*S*)-2-Trifluoromethyl-2-[1'-(4-methylphenyl)sulfenyl]ethyloxirane (25): From (1'*R*,2*S*,R_S)-**12c** sulfenyl derivative (1'*R*,2*S*)-**25** was obtained in 90% yield; R_f 0.35 (hexane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = –7.7 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.49 (3H, dq, *J* = 7.2 and 1.2 Hz), 2.33 (3H, br.s), 2.75 (1H, dq, *J* = 4.7 and 1.8 Hz), 3.00 (1H, br.d, *J* = 4.7 Hz), 3.39 (1H, q, *J* = 7.2 Hz), 7.12 and 7.37 (4H, m); ^{19}F NMR ($CDCl_3$) δ -72.78 (br.s); Anal. calcd for $C_{12}H_{13}F_3OS$: C, 54.95; H, 5.00; F, 21.73. Found: C, 54.95; H, 4.96; F, 21.70.

(2*S*,3*S*)-2-Trifluoromethyl-3-[(4-methylphenyl)sulfenyl]butan-1,2-diol (26). From (2*S*,3*S*,R_S)-**15** sulfenyl derivative (2*S*,3*S*)-**26** was obtained in 95% yield; R_f 0.25; yellowish oil; $[\alpha]_D^{20}$ = +52.6 (*c* 1.2, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.51 (3H, dq, *J* = 7.4 and 1.7 Hz), 2.31 (3H, br.s), 2.87 (1H, dd, *J* = 8.9 and 5.0 Hz), 3.56 (1H, q, *J* = 7.4 Hz), 3.79 (1H, dd, *J* = 11.9 and 8.9 Hz), 3.93 (1H, dd, *J* = 11.9 and 5.0 Hz), 4.27 (1H, br.s), 7.12 and 7.36 (4H, m); ^{19}F NMR ($CDCl_3$) δ -75.29 (br.s); Anal. calcd for $C_{12}H_{15}F_3O_2S$: C, 51.42; H, 5.39; F, 20.33. Found: C, 51.45; H, 5.36; F, 20.30.

(2*S*,3*S*)-1-(*N*-Benzyl-*N*-trifluoroacetyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)-sulfenyl]butan-2-ol (28). From (2*S*,3*S*,R_S)-**17** sulfenyl derivative (2*S*,3*S*)-**28** was obtained in 91% yield; R_f 0.28 (hexane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = –15.3 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.39 (3H, dq, *J* = 7.3 and 1.3 Hz), 2.33 (3H, br.s), 3.44 (1H, q, *J* = 7.3 Hz), 3.66 and 3.98 (2H, d, *J* = 15.2 Hz), 4.62 and 5.06 (2H, br.d, *J* = 16.4 Hz), 4.88 (1H, br.m), 7.0-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -75.16 (3F, br.s), -69.31 (3F, s); Anal. calcd for $C_{21}H_{21}NF_6O_2S$: C, 54.18; H, 4.55; N,3.01. Found: C, 54.17; H, 4.52; N, 3.02.

(2*S*,3*R*)-1-(*N*-Benzyl-*N*-trifluoroacetyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)sulfenyl]butan-2-ol (29). From (2*S*,3*R*,R_S)-**20** sulfenyl derivative (2*S*,3*R*)-**29** was obtained in 95% yield; R_f 0.39 (*n*-hexane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = –70.3 (*c* 0.7, $CHCl_3$); for ^1H and ^{19}F NMR data of (2*S*,3*R*)-**32** see those described below for its enantiomer (2*R*,3*S*)-**33**. Anal. calcd for $C_{21}H_{21}NF_6O_2S$: C, 54.19; H, 4.55; N, 3.01. Found: C, 54.12; H, 4.56; N, 3.03.

(2*S*,3*S*)-1-*O*-Benzoyl-2-trifluoromethyl-3-[(4-methylphenyl)sulfenyl]butan-1,2-diol (31). ***Benzoylation reaction.*** Benzoic acid (183 mg, 1.5 mmol) and DCC (226 mg, 1.1 mmol) were added to a solution of (2*S*,3*S*,R_S)-**15** (296 mg, 1.0 mmol) in dichloromethane (10.0 mL), stirred at rt. After 5 min, DMAP (12.2 mg, 0.1 mmol) was added: immediately the solution became white and precipitates formed. After 2 h, the reaction mixture was filtered and the filtrate was evaporated *in vacuo* to dryness to give a residue that was purified by FC (hexane/ethyl acetate 7:3). *O*-Benzoyl derivative (2*S*,3*S*,R_S)-**30** was isolated in 81% yield; R_f 0.35; mp 146-148 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +64.3 (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 1.17 (3H, d, *J* = 7.2 Hz), 2.42 (3H, br.s), 2.99 (1H, q, *J* = 7.2 Hz), 4.71 and 4.86 (2H, br.d, *J* = 12.7 Hz), 4.98 (1H, br.m), 7.34, 7.46, 7.48, 7.62 and 8.05 (9H, m); ^{19}F NMR ($CDCl_3$) δ -76.02 (br.s); Anal. calcd for $C_{19}H_{19}F_3O_4S$: C, 56.99; H, 4.78; F, 14.23. Found: C, 56.92; H, 4.76; F, 14.20.

O-Benzoyl derivative (2*S*,3*S*,*R*$_S$)-**30** was reduced under the conditions described above to afford (2*S*,3*S*)-**31** in 80% yield; R_f 0.35; mp 68.5-69.5 °C (di-*i*-propyl ether); $[\alpha]_D^{20}$ = +34.2 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.58 (3H, br.d, *J* = 7.3 Hz), 2.28 (3H, br.s), 3.62 (1H, q, *J* = 7.2 Hz), 3.70 (1H, br.m), 4.61 and 4.70 (2H, br.d, *J* = 12.0 Hz), 7.05, 7.36, 7.43, 7.60 and 7.97 (9H, m); ^{19}F NMR ($CDCl_3$) δ -74.86 (br.s); Anal. calcd for $C_{19}H_{19}F_3O_3S$: C, 59.37; H, 4.98; F, 14.83. Found: C, 59.35; H, 4.96; F, 14.83.

(2*R*,3*S*)-1-(*N*-Benzyl-*N*-trifluoroacetyl)amino-2-trifluoromethyl-3-[(4-methylphenyl)-sulfenyl]butan-2-ol (33). From (2*R*,3*S*,*R*$_S$)-**19** sulfenyl derivative (2*R*,3*S*)-**33** was obtained in 98% yield; R_f 0.39 (hexane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = +70.8 (*c* 0.6, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.58 (3H, dq, *J* = 7.3 and 1.9 Hz), 2.34 (3H, br.s), 3.30 (1H, br.q, *J* = 7.3 Hz), 3.38 and 4.16 (2H, d, *J* = 14.7 Hz), 4.80 and 5.02 (2H, br.d, *J* = 16.4 Hz), 4.83 (1H, br.m), 7.0-7.5 (9H, m); ^{19}F NMR ($CDCl_3$) δ -75.95 (3F, br.s), -69.14 (3F, s); Anal. calcd for $C_{21}H_{21}NF_6O_2S$: C, 54.19; H, 4.55; N, 3.01. Found: C, 54.20; H, 4.58; N, 3.00.

Hydrogenolytic removal of the sulfenyl group. **General procedure.** The corresponding sulfenyl derivative (1.0 mmol) was dissolved in ethanol (5 mL) and *Raney*-Ni was added (three times wt.). The mixture was stirred at reflux under H_2 atm, then the black powder was removed by filtration. The filtrate was concentrated *in vacuo* and the residual product was purified by FC. Initially, the column was packed in pentane or hexane, then eluted with a gradient solvent system indicated for each case.

(*S*)-2-Trifluoromethyl-1-(*O*-benzoyl)butan-1,2-diol (32). Starting from (2*S*,3*S*)-**31** product (*S*)-**32** was obtained in 72% yield; R_f 0.35 (chloroform/ethyl acetate 97:3); yellowish oil; $[\alpha]_{365}^{20}$ = –1.5 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 1.08 (3H, t, *J* = 7.6 Hz), 1.85 (2H, br.q, *J* = 7.6 Hz), 2.95 (1H, br.m), 4.48 and 4.53 (2H, br.d, *J* = 12.3 Hz), 7.48, 7.58 and 8.02 (5H, m); ^{19}F NMR ($CDCl_3$) δ –80.22 (br.s); Anal. calcd for $C_{12}H_{13}F_3O_3$: C, 54.96; H, 5.00; F, 21.73. Found: C, 54.98; H, 4.98; F, 21.71.

(*S*)-1-(*N*-Benzyl-*N*-trifluoroacetyl)amino-2-trifluoromethylbutan-2-ol (34). Starting from (2*R*,3*S*)-**33** compound (*R*)-**34** was obtained in 65% yield; R_f 0.35 (hexane/ethyl acetate 9:1); yellowish oil; $[\alpha]_D^{20}$ = +40.3 (*c* 1.3, $CHCl_3$); $[\alpha]_{365}^{20}$ = +125.8 (*c* 1.3, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 0.99 (3H, br.t, *J* = 7.5 Hz), 1.64 and 1.78 (2H, br.dq, *J* = 14.5 and 7.5 Hz), 3.37 and 3.82 (2H, br.d, *J* = 15.2 Hz), 4.51 (1H, br.m), 4.61 and 4.95 (2H, br.d, *J* = 16.6 Hz), 7.1-7.5 (5H, m); ^{19}F NMR ($CDCl_3$) δ -79.70 (3F, br.s), -69.40 (3F, s); Anal. calcd for $C_{14}H_{15}F_6NO_2$: C, 48.99; H, 4.40; N, 4.08. Found: C, 48.98; H, 4.37; N, 4.06.

(*S*)-1-(*N*-Benzyl)amino-2-trifluoromethylbutan-2-ol (35). A 1 *N* solution of NaOH in a 1.1 mixture of water and methanol (1.0 mL) was added at rt to a solution of (*R*)-**34** (1.0 mmol, 272 mg) in methanol (10.0 mL) and the stirring was continued at rt for 5 min. Then 1.0 mL of water was added and the organic layers were extracted with ethyl acetate (3 x 1.0 mL). The combined organic extracts were dried over anhydrous sodium sulfate and, after filtration, the solvent was evaporated *in vacuo* to dryness to give a residue that was purified by FC (hexane/ethyl acetate 4:1). (*R*)-**35** was obtained in 87% yield; R_f 0.35; yellowish oil; $[\alpha]_D^{20}$ = –10.7 (*c* 1.2, $CHCl_3$); $[\alpha]_{365}^{20}$ = –39.2 (*c* 1.2, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 0.91 (3H, br.t, *J* = 7.6 Hz), 1.54 and 1.78 (2H, br.dq, *J* = 14.4 and 7.6 Hz), 2.52 and 3.06 (2H, br.d, *J* = 13.4 Hz), 3.00 (2H, br.m), 3.83 and 3.87 (2H, br.d, *J* = 13.4 Hz), 7.2-7.4 (5H, m); ^{19}F NMR ($CDCl_3$) δ –80.86 (br.s); Anal. calcd for $C_{12}H_{16}F_3NO$: C, 58.29; H, 6.52; N, 5.66. Found: C, 58.30; H, 6.55; N, 5.67.

Thermal syn-elimination of sulfoxide group. **General procedure.** A solution of substrate (1.0 mmol) in *p*-xylene (20 mL) was heated at 150 °C under N_2 atmosphere for 10 min. Then the solution was concentrated *in vacuo* and the residue was purified by FC. Initially, the column was packed in pentane or hexane, then eluted with a gradient solvent system indicated for each case.

(*S*)-3-Trifluoromethyl-4-(*O*-benzoyl)but-1-en-3,4-diol (36). Starting from (2*S*,3*S*,R_S)-**30** olefinic derivative (*S*)-**36** was obtained in 78% yield; R_f 0.35 (pentane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = –3.8 (*c* 0.6, $CHCl_3$); $[\alpha]_{365}^{20}$ = –15.2 (*c* 0.6, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 3.41 (1H, br.s), 4.51 and 4.60 (2H, br.d, *J* = 11.9 Hz), 5.56 and 5.78 (2H, m), 5.98 (1H, dd, *J* = 16.8 and 10.5 Hz), and 7.48, 7.61 and 8.02 (5H, m); ^{19}F NMR ($CDCl_3$) δ –80.30 (br.s); Anal. calcd for $C_{12}H_{11}F_3O_3$: C, 55.39; H, 4.26; F, 21.90. Found: C, 55.41; H, 4.28; F, 21.93.

(*S*)-4-(*N*-Benzyl)amino-3-trifluoromethylbut-1-en-3-ol (37). Starting from (2*S*,3*S*,R_S)-**17** olefinic derivative (*S*)-**37** was obtained in 82% yield; R_f 0.35 (pentane/diethyl ether 9:1); yellowish oil; $[\alpha]_D^{20}$ = –7.8 (*c* 1.2, $CHCl_3$); $[\alpha]_{365}^{20}$ = –28.8 (*c* 1.2, $CHCl_3$); ^1H NMR ($CDCl_3$) δ 2.69 and 3.10 (2H, br.d, *J* = 12.8 Hz), 3.10 (2H, br.m), 3.83 (2H, br.s), 5.41 and 5.69 (2H, m), 5.84 (1H, dd, *J* = 16.6 and 10.2 Hz), 7.2-7.4 (5H, m); ^{19}F NMR ($CDCl_3$) δ -80.95 (br.s); Anal. calcd for $C_{12}H_{14}NF_3O$: C, 58.77; H, 5.75; N, 5.71. Found: C, 58.78; H, 5.71; N, 5.70.

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