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Remote stereocontrol by sulfinyl groups: asymmetric alkylation of chiral 2-*p*-tolylsulfinyl benzyl carbanions

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Abstract—Alkylation reactions of the benzyllithiums derived from enantiomerically pure 2-*p*-tolylsulfinyl alkylbenzenes have been carried out with excellent yields and high de. A lithiation-substitution sequence, stereochemically controlled by a remote sulfoxide, accounts for the experimental results.

1. Introduction

Many important classes of natural products with biological significance have benzylic carbon stereocenters that lack heteroatoms and bear an alkyl group, which is usually methyl.[1] The absence of any functionality at a such position reduces the number of possibilities for synthesizing them and converts the creation of these benzylic chiral centers in a significant challenge in asymmetric synthesis.[2] Enantioselective deprotonation/substitution processes of benzylic positions have been widely investigated in the last years.[3] The alkylation of benzylcarbanions with heteroatom-containing substituents at α position (O, N, Si, S) has been intensively explored employing several chiral auxiliaries such as formamidines,[4] oxazolines,[5] (*S*)-methoxymethyl pyrrolidine derivatives[6] or carbamates.[7] Tricarbonylchromium arene complexes[8] or chiral ligands, such as bis (oxazolines)[9] and (−)-sparteine,[10] have been also applied. The observed ee were variable and dependent on the alkylating agent.

In our continuing search for new applications of sulfoxides in asymmetric synthesis,[11] we found that *ortho*-*p*-tolylsulfinyl group can stabilize benzyllithium carbanions and promote highly diastereoselective reactions, according to asymmetric 1,4-induction processes. Their nucleophilic addition to carbonyl compounds[12] and *N*-sulfinyl imines[13] evolved with a complete control at the configuration of the benzylic center. The success of these reactions was attributed to the coordination of the electrophile to the benzyllithium as a previous step to the nucleophilic attack. The importance of these reactions for the asymmetric synthesis of benzylic centers prompted us to investigate the behavior of these prochiral benzyl carbanions in other type of reactions, such as those of nucleophilic substitution, where the electrophiles are not coordinating. Moreover, these reactions would provide compounds lacking of any other functionality. In this paper, we describe the results obtained in reactions of 2-*p*-tolylsulfinyl alkylbenzenes with different alkylating agents in the presence of LDA.

2. Results and discussion

Sulfoxides **1** and **2** were prepared in high ee (>98%) according to the procedure previously reported[12a] starting from *ortho*-bromo derivatives of ethylbenzene and *n*-propylbenzene, respectively. The last one is not commercially available and was prepared by reductive deoxygenation of benzylic alcohol **3** employing the combination of chlorodimethylsilane and a catalytic amount of $InCl_3$[14] (Scheme 1).[15]

We first studied the alkylation reactions on sulfoxide **1** (Table 1). The addition of LDA (1.2 equiv) to a solution of **1** in THF at −78 °C, immediately produces a colored solution indicative of formation of the anion. We further added the alkylating reagents and maintained the same temperature during 3 h. The alkylation with benzyl or allyl bromide proceeded with high yields and stereoselectivities to afford **5a** or **6a** as the major products, respectively (entries 1 and 4). Diastereoselectivity was not improved by decreasing the temperature till −90 °C (entries 2 and 5). Remarkable decreases in the de are observed when alkyl chlorides are

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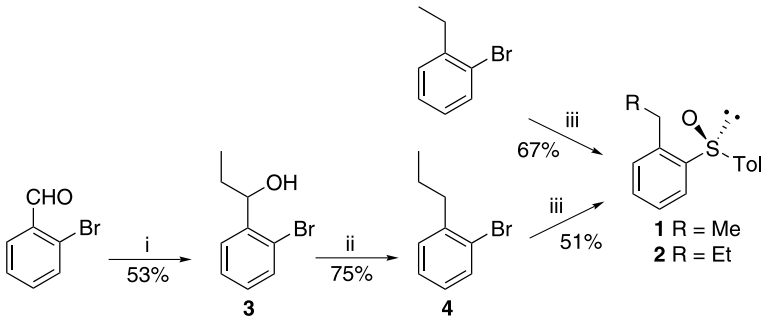
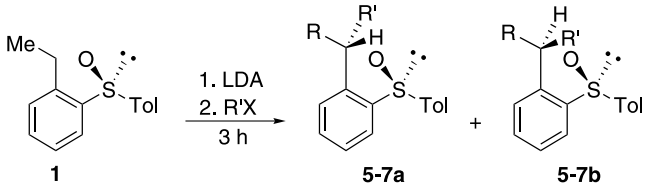


Scheme 1. Synthesis of the starting sulfoxides **1** and **2**.

Table 1. Alkylation of (*S*)-1-*p*-tolylsulfinyl-2-ethylbenzene (**1**)



Entry	RX	Temperature (°C)	Compound	a:b	Overall yield
1	BnBr	−78	**5**	92:8	87 (78)[a]
2	BnBr	−90	**5**	92:8	[b]
3	BnCl	−78	**5**	70:30	78
4	AllylBr	−78	**6**	87:13	86 (55)[a]
5	AllylBr	−90	**6**	86:14	[b]
6	AllylCl	−78	**6**	52:48	74
7	EtI	−78		—	—
8	EtOTf	−78	**7**	86:14	86

[a] Isolated yield of the major epimer.
[b] Yield not determined.

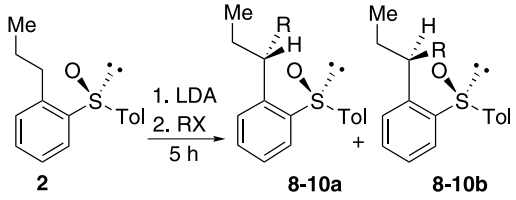
used as electrophiles instead of bromides (entries 3 and 6). This influence of the leaving group on the stereoselectivity had been also observed by Beak.[10e,f] These results show that the stereoselectivity is dependent on the leaving group of the alkyl halide. Less reactive alkylating agents are not efficient enough and thus ethyl triflate had to be used (entry 8) instead ethyl iodide, which afforded a complex mixture (entry 7).

Sulfoxide **2** was treated under the same conditions as **1**. Reactivity of **2** is clearly lower than that of **1** as it can be deduced from the presence of a significant amount of unreacted **2**, detected by ^{1}H NMR, in the crudes of all the performed experiences. After several modifications of the experimental conditions (temperature, solvent and reaction time) we determined that the best results were obtained by adding the electrophile in two batches with 2 h between the additions. However, even in these conditions, a variable residue of **2** remains unreacted. The results are collected in Table 2.

The previously commented lower reactivity of **2** is compensated by its higher stereoselectivity. Benzylation and allylation proceeded with around 90% de (entries 1 and 2) whereas methylation with MeOTf took place with 78% de (entry 3). Both, yield and diastereoselectivity slightly decreased with MeI (70% de, entry 4). The conversion was not complete in any case even when the reaction time is enlarged until 28 h. As it was expected, the ^{1}H NMR spectra for diastereoisomers **10a** and **7b** are identical, as well as those for **10b** and **7a**.

The separation of the obtained diastereoisomers was not an easy task. Compound **5a** was achieved diastereomerically pure by flash chromatography, whereas **6a** was separated from **6b** by crystallization. Diastereoisomers **7**–**10** had to be separated by chiral HPLC (see Section 4).

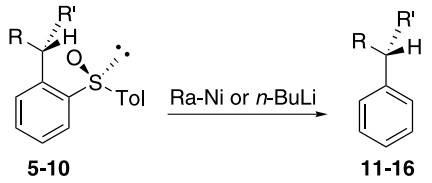
Table 2. Alkylation of (*S*)-1-*p*-tolylsulfinyl-2-propylbenzene (**2**)



Entry	RX	Product	a:b	Overall yield
1	BnBr	**8**	95:5	75[a]
2	AllylBr	**9**	94:6	80[b]
3	MeOTf	**10**	89:11	74[b]
4	MeI	**10**	85:15	65[b]

[a] Starting material (4%) was recovered.
[b] Starting material (10%) was recovered.

Table 3. Desulfinylation of *ortho*-sulfinyl alkylbenzenes **5–10**



Entry	R, R' (sulfoxide)	Method	Product	Yield	Configuration
1	Me, Bn (**5a**)	Ra-Ni	**11**	60	*R*
2	Et, Bn (**8a**:**8b**, 95:5)	Ra-Ni	**12**	59	*R*
3	Me, Et (**7a**:**7b**, 65:35)	*n*-BuLi	**13**	43	*R*
4	Et, Me (**10a**:**10b**, 93:7)	*n*-BuLi	**14**	22	*S*
5	Me, Allyl (**6a**)	*n*-BuLi	**15**	38	*R*
6	Et, Allyl (**9a**:**9b**, 91:9)	*n*-BuLi	**16**	52	*R*

2.1. Desulfinylation reactions: configurational assignment

The configuration of the predominant diastereoisomers was established by conversion of compounds **5–10** into optically active alkylbenzenes. The structure determination had been established by comparison with authentic samples (ee), see Section 4. Desulfinylation of benzylic derivatives **5** and **8** with Raney nickel gave (*R*)-**11** and (*R*)-**12**, respectively (Table 3, entries 1 and 2). The reactions of dialkyl derivatives **7** and **10** with Ra-Ni only progress till sulfenyl derivatives even enlarging the reaction times. Therefore, it was necessary to perform the hydrogenolysis with *n*-BuLi[16] (entries 3 and 4) to afford (*R*)-**13** and (*S*)-**14**.[†] The low yields obtained with *n*-BuLi are not surprising on the basis of the large similarity of the aryl groups joined to the sulfinyl group. Treatment of allylic derivatives **6** and **9** with Ra-Ni afforded complex mixtures, being the sulfenyl derivatives with reduced double bound the major products. By enlarging the reaction times desulfurated products with no double bond could be isolated in low yields. The reactions of **6** and **9** with *n*-Bu–Li afforded better yields of **15** and **16**, respectively (entries 5 and 6).

2.2. Stereochemical discussion

The stereochemical outcome of the alkylations is in accordance with that previously proposed for reaction of *ortho*-*p*-tolylsulfinyl benzyllithium carbanions with aldehydes.[12] Taking into account steric effects, benzyllithium derivative **A** must be the most stable among all diastereomers and conformers since the most sized groups at sulfur (*p*-Tol) and benzyl carbon (*R*) lack of allylic strain with the *ortho* protons (Fig. 1). In the reactions of these species with aldehydes, the carbonyl oxygen becomes associated with the lithium as a previous step to the nucleophilic addition. As this association is not possible with alkyl halides or triflates, their reactivity is clearly lower (longer reaction times). However, the fact that the configuration at the benzylic carbon for the major diastereoisomer for alkylations was the same than that obtained in nuclephilic additions to aldehydes, suggests that both reactions proceed with retention in the configuration of the carbanions. The

[†] Compounds **13** and **14** are enantiomers of the same product. They are achieved from the use of enriched mixtures of diastereoisomers **7a** or **10a**, respectively.

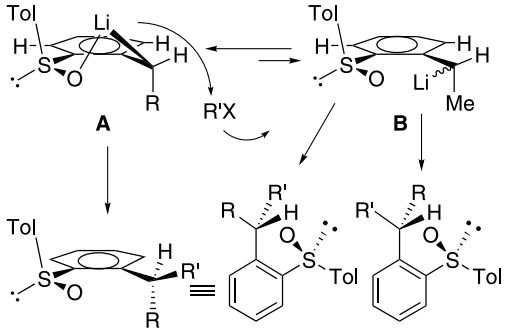


Figure 1. Stereochemical course of the reaction.

incomplete stereoselectivity observed for alkylations (de ranged between 70–90%) may be explained by assuming the lower reactivity of these electrophiles. This fact determines that they partially require to be attacked by the less stable but more reactive species **B**, without defined configuration (Fig. 1).

3. Conclusion

We have described the asymmetric alkylation of 2-*p*-tolylsulfinyl alkylbenzenes controlled by the remote sulfinyl group. Reactions are highly stereoselective and their de is higher by increasing the reactivity of the electrophiles and the length of the chain of the starting material. Desulfuration with Ra-Ni or *n*-BuLi yields compounds with chiral benzylic centers in high but not complete optical purity, which is probably due to some problems in the purification of the intermediates.

4. Experimental

4.1. General experimental methods

Solvents were purified according to standard procedures. Reactions were monitored by TLC on commercially available precoated plates (Merck silica gel 60 F_{254}). Flash chromatography was performed with Merck silica gel 60 (230–400 mesh ASTM). Melting points were measured using a Gallemkamp apparatus in open capillary tubes. Specific rotations were measured at room temperature on a Perkin-Elmer 241 MC polarimeter and concentrations

are expressed in g/100 mL. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ on a Bruker AC-300 spectrometer (300 and 75 MHz, respectively). Chemical shifts are reported in ppm and *J* values are given in Hz. The attributions are supported by double resonance experiments. IR spectra were obtained in film with a Bruker Vector 22 spectrometer (4000–400 cm^{-1}). Mass spectra were measured by electron impact (EI, 70 eV) or FAB with a VG AutoSpec spectrometer. Elemental analyses were obtained with a Perkin-Elmer 2400 CHNS/O series II. Daicel Chiralcel OD or Chiralpack AD columns and hexane/isopropanol as eluant by using an Agilent 1100 HPLC equipment.

4.2. Synthesis of 2-*p*-tolylsulfinyl alkylbenzenes

4.2.1. 1-(2-Bromophenyl)-1-propanol (3). A solution of ethylmagnesium bromide, previously formed by addition of bromoethane (6.5 mL, 88.0 mmol) over Mg (1.9 g, 80.0 mmol) in anhydrous ether (20 mL), was added slowly over a solution of 2-bromobenzaldehyde (9.8 mL, 84.0 mmol) in anhydrous ether (10 mL) at 0 °C. After 5 h stirring at room temperature, the mixture was hydrolyzed (30 mL of saturated NH_4Cl), extracted (3×30 mL of ether), dried ($MgSO_4$), washed with brine and the solvent evaporated. The residue was purified by flash column chromatography (eluant, hexane/AcOEt 9:1). Yield: 53% as colorless oil. IR: 3385, 2967, 1466, 1020, 741 cm^{-1}. ^{1}H NMR: δ 7.52 (m, 2H, Ar), 7.33 (t, 1H, J=7.5 Hz, Ar), 7.11 (dt, 1H, J=1.6, 7.5 Hz, Ar), 5.00 (dd, 1H, J=4.8, 7.5 Hz, –C*H*–OH), 2.09 (broad s, 1H, –O*H*), 1.94–1.59 (m, 2H, CH_3–CH_2—), 1.00 (t, 3H, J=7.5 Hz, CH_3–CH_2–). ^{13}C NMR: δ 143.5, 132.6, 128.7, 127.6, 127.3, 122.1, 74.2, 30.5, 10.1. Anal. Calcd for $C_9H_{11}BrO$: C, 50.26; H, 5.15. Found: C, 50.36; H, 5.12. *m/z* (EI$^+$): 214 (M^+, 12), 185 (100), 157 (22), 105 (14), 84 (42), 77 (88). HRMS calcd for $C_9H_{11}BrO$: 213.9993. Found: 213.9986.

4.2.2. 1-Bromo-2-propylbenzene (4). A solution of alcohol **3** (4.3 g, 20.1 mmol) in freshly distilled CH_2Cl_2 (30 mL) was added to a solution of $InCl_3$ (5–10 mol%) and Me_2SiClH (6.0 mL, 54.2 mmol) in CH_2Cl_2 (50 mL) at room temperature under Ar atmosphere. After 45 min stirring, the mixture was hydrolyzed (50 mL of H_2O), extracted (3×50 mL of ether), dried ($MgSO_4$), washed with brine and the solvent evaporated. The residue was purified by flash column chromatography (eluant, hexane). Yield: 75% as colorless oil. IR: 2960, 2871, 1469, 1439, 1021, 748 cm^{-1}. ^{1}H NMR: δ 7.52 (d, J=7.5 Hz, 1H, Ar), 7.21 (m, 2H, Ar), 7.04 (m, 1H, Ar), 2.71 (m, 2H, –CH_2–Ar), 1.65 (sx, 2H, J=7.3 Hz, CH_3–CH_2–), 0.98 (t, 3H, J=7.3 Hz, CH_3–CH_2–). ^{13}C NMR: δ 141.8, 132.6, 130.3, 127.3, 127.2, 124.4, 38.2, 23.0, 13.8. Anal. Calcd for $C_9H_{11}Br$: C, 54.30; H, 5.57. Found: C, 54.49; H, 5.15.

4.2.3. (*S*)-1-*p*-Tolylsulfinyl-2-propylbenzene (2). The synthesis of this compound was performed starting from **4** according to the procedure previously reported for **1**.[12a] Yield: 51% as white solid. Mp: 29–30 °C (Et_2O/hexane). (α($^{20}_{D}$ −128.2 (*c* 1, $CHCl_3$). IR: 2961, 1642, 1467, 1085, 1033 cm^{-1}. ^{1}H NMR: δ 7.92 (m, 1H, Ar), 7.47 and 7.23 (AA′BB′ system, 4H, Tol), 7.39 (m, 2H, Ar), 7.19 (m, 1H, Ar), 2.82–2.55 (m, 2H, –CH_2–Ar), 2.35 (s, 3H, CH_3–Ar), 1.57 (m, 2H, –CH_2–CH_3), 1.14 (t, 3H, J=7.5 Hz, CH_3–CH_2). ^{13}C NMR: δ 142.7, 142.1, 141.9, 141.5, 130.9, 129.9, 129.5, 127.1, 125.9, 124.8, 33.8, 24.0, 21.3, 13.9. Anal. Calcd for $C_{16}H_{18}OS$: C, 74.38; H, 7.02; S, 12.41. Found: C, 74.38; H, 7.09; S, 12.26. *m/z* (EI$^+$): 258 (M^+, 6), 241 (100), 211 (44), 166 (41), 149 (74), 91 (51), 77 (18). HRMS calcd for $C_{16}H_{18}OS$: 258.1078. Found: 258.1070.

4.3. General procedure for alkylations

A solution of *n*-BuLi 2.5 M in hexane (0.60 mmol, 1.2 equiv) was added over *i*-Pr_2NH (0.90 mmol, 1.8 equiv) in THF (3 mL) at 0 °C. After 45 min stirring, the mixture was cooled at −78 °C and a solution of the sulfoxide **1** or **2** (0.50 mmol, 1.0 equiv) in THF (2 mL) was added and purple anion formed. After 1 h stirring, the electrophile (1.5 mmol, 3.0 equiv) was added. 3 h later, the mixture was hydrolyzed at that temperature (5 mL of saturated NH_4Cl), extracted (3×5 mL of CH_2Cl_2), dried (Na_2SO_4), washed with brine and the solvent evaporated. The residue was purified by flash column chromatography. For sulfoxide **2** two further equivalents were added after 2 h of reaction and 3 h later the mixture was hydrolyzed. Conditions of separation by HPLC are indicated in any case.

4.3.1. [2*R*,(*S*)*S*]-2-[2-(*p*-Tolylsulfinyl)phenyl]-1-phenylpropane (5a). This compound was obtained starting from sulfoxide **1**. Eluant for chromatography: hexane/AcOEt 1:3. Yield **5a**+**5b** (92:8): 87%. The mixture of **5a** and **5b** resulting from the chromathography of the crude reaction was newly chromatographied (eluant:hexane/EtOAc 3:2) to give **5a** with de>98% (yield 78%). Daicel Chiralpack AD (hexane/*i*-PrOH 90:10, flow rate 1 mL/min): t_S=23.4 min and t_R=24.9 min. (α($^{20}_{D}$ −174.7 (*c* 2, $CHCl_3$). IR: 3026, 2963, 2925, 1595, 1493, 1083, 1030 cm^{-1}. ^{1}H NMR: δ 7.79 (d, 1H, J=7.4 Hz, Ar), 7.50–7.35 (m, 3H, Ar), 7.25–7.16 (m, 7H, Ar), 6.91 (m, 2H, Ar), 3.60 (sx, 1H, J=6.9 Hz, CH_3–C*H*–), 2.72 (d, 2H, J=7.5 Hz, Ph-CH_2–), 2.36 (s, 3H, CH_3–Ar), 1.26 (d, 3H, J=6.9 Hz, CH_3–CH–). ^{13}C NMR: δ 145.5, 142.2, 141.7, 141.3, 139.7, 131.3, 129.8, 129.0, 128.1, 127.3, 126.5, 125.9, 125.7, 43.1, 36.3, 21.9, 21.3. Anal. Calcd for $C_{22}H_{22}OS$: C, 79.00; H, 6.63; S, 9.59. Found: C, 78.89; H, 6.68; S, 9.99. *m/z* (EI$^+$): 334 (M^+, <1), 317 (100), 243 (24), 225 (95), 211 (31), 135 (24), 91 (79), 77 (15). HRMS calcd for $C_{22}H_{22}OS$: 334.1391. Found: 334.1379.

4.3.2. [4*R*,(*S*)*S*]-4-[2-(*p*-Tolylsulfinyl)phenyl]-1-pentene (6a). This compound was obtained starting from sulfoxide **1**. Eluant for chromatography: hexane/AcOEt 4:1. Yield **6a**+**6b** (87:13): 86%. The mixture of **6a** and **6b** resulting from the chromathography of the crude reaction was crystallized to give **6a** with de>98% (yield 55%). Mp: 67–68 °C (Et_2O/hexane, white solid). Daicel Chiralpack AD (hexane/*i*-PrOH 87:13, flow rate 1 mL/min): t_S=11.4 min and t_R=12.4 min. (α($^{20}_{D}$ −120.0 (*c* 1, $CHCl_3$). IR: 2961, 2931, 1593, 1472, 1081, 1027 cm^{-1}. ^{1}H NMR: δ 7.96 (m, 1H, Ar), 7.48 and 7.23 (AA′BB′ system, 4H, Tol), 7.47–7.38 (m, 2H, Ar), 7.28 (m, 1H, Ar), 5.49–5.35 (m, 1H, –C*H*=CH_2), 4.86–4.81 (m, 2H, CH_2=CH–), 3.26 (sx, 1H, J=6.7 Hz, CH_3–C*H*–), 2.36 (s, 3H, CH_3–Ar), 2.15–1.92 (m, 2H, –CH_2–CH–), 1.25 (d, 3H, J=6.9 Hz, CH_3–CH–). ^{13}C NMR: δ 145.1, 142.0, 141.6, 135.8, 131.1, 129.9, 127.2, 126.4, 126.3, 124.7, 116.5, 41.2, 34.2, 21.6, 21.3. Anal.

Calcd for $C_{18}H_{20}OS$: C, 76.01; H, 7.09; S, 11.27. Found: C, 76.38; H, 7.22; S, 11.12. *m/z* (EI^+): 284 (M^+, 2), 267 (91), 243 (30), 225 (100), 211 (24), 143 (55), 135 (32), 91 (47), 77 (20). HRMS calcd for $C_{18}H_{20}OS$: 284.1235. Found: 284.1233.

4.3.3. [2*R*,(*S*)*S*]-2-[2-(*p*-Tolylsulfinyl)phenil]-butane (7a). This compound was obtained from the reaction of sulfoxide **1** with ethyl triflate. Eluant for chromatography: hexane/AcOEt 4:1. Yield **7a**+**7b** (86:14): 86%. Daicel Chiralcel OD (hexane/*i*-PrOH 98:2, flow rate 1 mL/min): t_S= 27.9 min and t_R=30.3 min. Only the NMR parameters of major diastereoisomer **7a** are indicated. IR: 2957, 1463, 1082, 1057, 1028 cm^{-1}. ^1H NMR: δ 7.97 (m, 1H, Ar), 7.49 and 7.24 (AA′BB′ system, 4H, Tol), 7.45–7.36 (m, 2H, Ar), 7.28 (m, 1H, Ar), 3.10 (sx, 1H, J=6.9 Hz, CH_3–C*H*–), 2.36 (s, 3H, C*H*$_3$-Ar), 1.52–1.26 (m, 2H, CH_3–C*H*$_2$–), 1.24 (d, 3H, J=6.9 Hz, C*H*$_3$–CH–), 0.60 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2–). ^{13}C NMR: δ 145.6, 141.9, 141.2, 130.9, 129.5, 126.6, 125.9, 124.4, 123.9, 35.5, 29.4, 21.5, 20.9, 11.5. Anal. Calcd for $C_{17}H_{20}OS$: C, 75.50; H, 7.24; S, 11.52. Found: C, 75.21; H, 7.46; S, 11.76.

4.3.4. [2*R*,(*S*)*S*]-2-[2-(*p*-Tolylsulfinyl)phenyl]-1-phenyl-butane (8). This compound was obtained starting from sulfoxide **2**. Eluant for chromatography: hexane/AcOEt 3:1. Yield **8a**+**8b** (95:5): 75%. Daicel Chiralpack AD (hexane/*i*-PrOH 87:13, flow rate 1 mL/min): t_2=18.5 min, t_S= 19.6 min and t_R=23.2 min. The ^1H NMR parameters of minor diastereoisomer are indicated in italics. These values are required to establish the de. ($\alpha(^{20}_{D}$ −190.6 (*c* 1, $CHCl_3$). IR: 2961, 1644, 1454, 1083, 1032 cm^{-1}. ^1H NMR: δ 7.96 (m, 1H, Ar, minor diastereoisomer), 7.75 (m, 1H, Ar), 7.51–7.34 (m, 3H, Ar), 7.17–7.10 (m, 7H, Ar), 6.87 (m, 2H, Ar), 3.44 (m, 1H, –CH_2–C*H*–CH_2–), 2.80 and 2.69 (d AB system, 2H, J=7.5, 13.5 Hz, Ph-C*H*$_2$–), 2.35 (s, 3H, C*H*$_3$-Ar), 1.83–1.15 (m, 2H, CH_3–C*H*$_2$–), 0.81 (t, 3H, J=7.5 Hz, C*H*$_3$–CH_2–), 0.39 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2, minor diastereoisomer). ^{13}C NMR: δ 143.9, 143.7, 141.7, 141.1, 139.8, 131.2, 129.8, 129.1, 128.1, 127.4, 126.7, 125.9, 125.7, 43.5, 42.0, 29.2, 21.3, 11.7. *m/z* (EI^+): 348 (M^+, <1), 331 (100), 241 (36), 211 (37), 91 (62), 77 (9). HRMS calcd for $C_{23}H_{24}OS$: 348.1548. Found: 348.1521.

4.3.5. [4*R*,(*S*)*S*]-4-[2-(*p*-Tolylsulfinyl)phenil]-1-hexene (9). This compound was obtained starting from sulfoxide **2**. Eluant for chromatography: hexane/AcOEt 3:1. Yield **9a**+**9b** (94:6): 80%. Daicel Chiralpack AD (hexane/*i*-PrOH 90:10, flow rate 1 mL/min): t_S=13.1 min, t_R=14.0 min and t_2=15.9 min. The ^1H NMR parameters of minor diastereoisomer are indicated in italics. These values are required to establish the de. ($\alpha(^{20}_{D}$ −94.2 (*c* 1, $CHCl_3$). IR: 2962, 2929, 1640, 1469, 1084, 1033 cm^{-1}. ^1H NMR: δ 7.98 (m, 1H, Ar), 7.91 (m, 1H, Ar, minor diastereoisomer), 7.47 and 7.22 (AA′BB′ system, 4H, Tol), 7.45–7.39 (m, 2H, Ar), 7.25–7.20 (m, 1H, Ar), 5.37–5.24 (m, 1H, –C*H*=CH_2), 4.79–4.75 (m, 2H, C*H*$_2$=CH–), 3.05 (m, 1H, CH_2–C*H*–), 2.35 (s, 3H, C*H*$_3$-Ar), 2.19–1.90 (m, 2H, –C*H*$_2$–CH–), 1.87–1.45 (m, 2H, CH_3–C*H*$_2$–), 0.82 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2–), 0.47 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2, minor diastereoisomer). ^{13}C NMR: δ 143.4, 142.1, 141.7, 135.9, 131.1, 129.9, 127.2, 126.6, 126.5, 124.5, 116.4, 41.3, 39.8, 29.1, 21.4, 11.7. *m/z* (EI^+): 298 (M^+, 1), 281 (100), 257 (10), 241 (70), 239 (53), 149 (46), 91 (52), 77 (27). HRMS calcd for $C_{19}H_{22}OS$: 298.1391. Found: 298.1389.

4.3.6. [2*S*,(*S*)*S*]-2-[2-(*p*-Tolylsulfinyl)phenil]-butane (10a). This compound was obtained from the reaction of sulfoxide **2** with methyl triflate. Eluant for chromatography: hexane/AcOEt 4:1. Yield **10a**+**10b** (89:11): 86%. Only the NMR parameters of major diastereoisomer **10a** are indicated. ^1H NMR: δ 7.99 (m, 1H, Ar), 7.46 and 7.22 (AA′BB′ system, 4H, Tol), 7.41 (m, 2H, Ar), 7.25 (m, 1H, Ar), 3.06 (sx, 1H, J=6.9 Hz, CH_3–C*H*–), 2.35 (s, 3H, C*H*$_3$–Ar), 1.63 (quint, 2H, J=7.3 Hz, CH_3–C*H*$_2$–), 0.88 (d, 3H, J=6.9 Hz, C*H*$_3$–CH–), 0.84 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2–). ^{13}C NMR: δ 145.3, 142.7, 142.4, 141.5, 131.1, 129.9, 127.0, 126.1, 126.0, 124.1, 35.9, 31.3, 21.3, 20.9, 12.0.

4.4. General procedure for desulfynilations summarized in Table 3

Method A The sulfoxide was dissolved in a minimal amount of ethanol and excess of Raney nickel was added. The reaction mixture was vigorously stirred at room temperature and was monitored by TLC. When no starting material remained, stirring was stopped and the solvent was carefully decanted and filtered on Celite. The solvent was evaporated and the product was obtained from the residue in high purity (Table 3).

Method B A solution of *n*-BuLi in hexane (10 equiv) was added over a solution of sulfoxide in THF at −78 °C under Ar atmosphere. After 3 min stirring, the mixture was hydrolyzed at that temperature (saturated NH_4Cl), extracted (CH_2Cl_2), dried (Na_2SO_4), washed with brine and the solvent evaporated. The residue was purified by flash column chromatography with hexane as eluant.

4.4.1. (*R*)-1,2-Diphenylpropane (11).[17] This compound was obtained according to method A starting from sulfoxide **5a**. Yield: 60%. ($\alpha(^{20}_{D}$ −73.7 (*c* 1, $CHCl_3$). Lit.[17b] ($\alpha(^{20}_{D}$ −78.6 (*c* 2.02, $CHCl_3$) to ee>99%. ^1H NMR: δ 7.34–7.08 (m, 10H, Ar), 3.11–2.91 (m, 2H, Ph–C*H*$_2$–), 2.84–2.71 (m, 1H, CH_3–C*H*–), 1.25 (d, 3H, J=7.0 Hz, C*H*$_3$–CH–). ^{13}C NMR: δ 146.9, 140.8, 129.1, 128.2, 128.1, 127.0, 126.0, 125.8, 45.0, 41.8, 21.1.

4.4.2. (*R*)-1,2-Diphenylbutane (12).[18] This compound was obtained according to method A starting from a mixture of sulfoxides **8a**:**8b** (95:5). Yield: 59%. ($\alpha(^{20}_{D}$ −101.9 (*c* 1, $CHCl_3$). Lit.[18] ($\alpha(^{20}_{D}$ +12.5 (*c* 0.3, $CHCl_3$) to *S* configuration. The ee was not determined by the authors in that report. ^1H NMR: δ 7.43–7.18 (m, 10H, Ar), 3.04 (m, 2H, Ph–C*H*$_2$–), 2.92–2.83 (m, 1H, CH_2–C*H*–CH_2–), 1.96–1.69 (m, 2H, CH_3–C*H*$_2$–), 0.92 (t, 3H, J=7.3 Hz, C*H*$_3$–CH_2). ^{13}C NMR: δ 145.0, 140.8, 129.1, 128.1, 128.0, 127.8, 125.9, 125.7, 49.8, 43.5, 28.3, 12.1.

4.4.3. (*R*)-2-Rhenylbutane (13).[19] This compound was obtained according to method B starting from a mixture of sulfoxides **7a**:**7b** (65:35). Yield: 43%. ($\alpha(^{20}_{D}$ −6.2 (*c* 0.5, $CHCl_3$). Lit.[19a] ($\alpha(^{20}_{D}$ +28.4 (neat) to *S* configuration. The ee was not determined by the authors in that report. ^1H NMR: δ 7.35–7.14 (m, 5H, Ar), 2.60 (sx, 1H, J=7.0 Hz,

CH_3–C*H*–), 1.61 (quint, 2H, –CH_2–CH–), 1.25 (d, 3H, J= 7.0 Hz, CH_3–CH–), 0.84 (t, 3H, J=7.5 Hz CH_3–CH_2–).

4.4.4. (*S*)-2-Phenylbutane (14).[19] This compound was obtained according to method B starting from a mixture of sulfoxides **10a**:**10b** (3:97). Yield: 22%. (α($^{20}_{D}$ +10.4 (*c* 0.5, $CHCl_3$). Lit.[19a] (α($^{20}_{D}$ +28.4 (neat). The ee was not determined by the authors in that report.

4.4.5. (*R*)-4-Phenylpentene (15).[20] This compound was obtained according to method B starting from sulfoxide **6a**. Yield: 38%. (α($^{20}_{D}$ −21.4 (*c* 1, $CHCl_3$). Lit.[20a] (α($^{20}_{D}$ −19.3 (neat) to ee=97.4%. ^{1}H NMR: δ 7.32–7.14 (m, 5H, Ar), 5.75–5.61 (m, 1H, –C*H*=CH_2), 5.00–4.89 (m, 2H, CH_2=CH–), 2.57–2.34 (m, 3H, –CH_2–C*H*–), 1.81–1.49 (m, 2H, CH_3–CH_2–), 0.79 (t, 3H, J=7.3 Hz, CH_3–CH_2–). ^{13}C NMR: δ 145.2, 137.2, 128.2, 127.8, 125.9, 115.7, 47.6, 40.9, 28.8, 12.0.

4.4.6. (*R*)-4-Fenilhexeno (16).[19a,21] This compound was obtained according to method B starting from a mixture of sulfoxides **9a**:**9b** (95:5). Yield: 52%. (α($^{20}_{D}$ −8.0 (*c* 1, $CHCl_3$). Lit.[19a] (α($^{20}_{D}$ −8.99 (neat), ee∼86–89%. ^{1}H NMR: δ 7.32–7.14 (m, 5H, Ar), 5.75–5.61 (m, 1H, –C*H*=CH_2), 5.00–4.89 (m, 2H, CH_2=CH–), 2.57–2.34 (m, 3H, –CH_2–C*H*–), 1.81–1.49 (m, 2H, CH_3–CH_2–), 0.79 (t, 3H, J= 7.3 Hz, CH_3–CH_2–). ^{13}C NMR: δ 145.2, 137.2, 128.2, 127.8, 125.9, 115.7, 47.6, 40.9, 28.8, 12.0.

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