DMAP-Catalysed Sulfinylation of Diacetone-D-Glucose: Improved Method for the Synthesis of Enantiopure *tert*-Butyl Sulfoxides and *tert*-Butanesulfinamides

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An improved method for the *tert*-butanesulfinylation of diacetone glucose with *tert*-butanesulfinyl chloride is reported. The method is based on a beneficial effect of catalytic DMAP, which enhances both the rate of the reaction and the enantioselectivity of the process to give (R_S)-diastereomer **2**R_S with a 94 % *de* and in quantitative yield. (R_S)-DAG sulfinate ester **2**R_S is an excellent intermediate for the synthesis of enantiopure *tert*-butyl sulfoxides. Grignard agents and organolithium reagents can displace smoothly the diacetone glucose moiety to give synthetically relevant enantiopure sulfoxides, including highly functionalized derivatives, in high yields and with high enantioselectivities. (R_S)-DAG sulfinate ester **2**R_S is also an excellent *N*-sulfinylating agent; simple addition of LiHMDS (lithium hexamethyldisilazide) in THF gives (S_S)-*tert*-butanesulfinamide, and *N*-*tert*-butanesulfinylimines are then formed in a two-step one-pot manner. *N*-Alkylated *tert*-butanesulfinamides are formed by the condensation of **2**R_S with lithium amides.

Introduction

The development of new efficient and effective synthetic methods that give access to a wide range of structurally diverse chiral sulfoxides has been a topic of great interest in recent years, as shown by the high number of publications in this field.[1] In part, this is due to the fact that there are a large number of biologically active compounds containing a chiral sulfinyl group.[2] Examples include the proton pump inhibitor esomeprazole,[3] the vigilance promoter armodafinyl,[4] the anti-inflammatory sulindac,[5] or the antitumoral sulforaphane.[6] Moreover, chiral sulfoxides have been shown to be excellent chiral inductors, as chiral auxiliaries,[7] and more recently as chiral organocatalysts[8] and as chiral ligands in metal-promoted asymmetric catalysis.[9]

Since the improvement made by Mioskowski and Solladié[10] on the Anderson methodology[11] until a few years ago, the chemistry of chiral sulfoxides was dominated by the *p*-toluenesulfinyl group. In some cases, the *p*-toluenesulfinyl group fails to promote a good chiral induction, and this leads to a low stereoselectivity. In most of these cases, the use of sulfinyl groups with hindered alkyl substituents at the sulfur results in a better stereochemical control than that seen with their aryl-substituted counterparts. Pioneering work from Casey's group has shown the superiority of the *tert*-butyl sulfoxide over the *p*-tolyl sulfoxide in Michael additions.[12] The same trend was reported in the synthesis of chiral amines,[13] in the aziridination of sulfinylimine,[14] in the Pauson–Khand reaction,[15] in the Cu-catalysed Diels–Alder reaction,[16] in the Reformatsky reaction,[17] in Suzuki–Miyaura cross-coupling,[18] and in the Rh-catalysed addition of boronic acids to activated ketones.[19] This has spurred the search for new and more hindered sulfinylating agents in general, and *tert*-butanesulfinylating agents in particular.

The direct enantioselective oxidation of sulfides to sulfoxides is a well-studied reaction. A wide variety of chemical or enzymatic oxidations have been tested, but the scope of these methods is limited.[20] The most practical methods developed to date are based on the use of an enantiopure or a diastereomerically pure *tert*-butanesulfinylating agent (**1**–**5**; Figure 1), obtained by a process of at least two steps. In this regard, the sulfite methodology, a diastereoselective approach reported by Kagan in 1991, was the first approach to solve some of the limitations of the traditional Anderson method for the synthesis of optically pure dialkyl sulfoxides, and it was particularly suitable for the synthesis of hydroxysulfinate **1** en route to *tert*-butyl sulfoxides.[21] The regioselectivity problems associated with Kagan's approach were elegantly solved by the Garcia-Ruano[22] and Senanayake[23] groups, who, almost at the same time, developed three-step approaches using activated 1,2,3-oxathiazolidine-2-oxides as intermediates for the synthesis of the corresponding *tert*-butanesulfinate esters (i.e., **4** and **5**).

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Of the limited number of enantiopure *tert*-butanesulfinylating agents developed to date,[24] the most widely used is *tert*-butyl *tert*-butanethiosulfinate (**3**). This compound is obtained by Ellman's methodology, which is based on the vanadium-catalysed monooxidation of *tert*-butyl disulfide (Figure 1).[25]

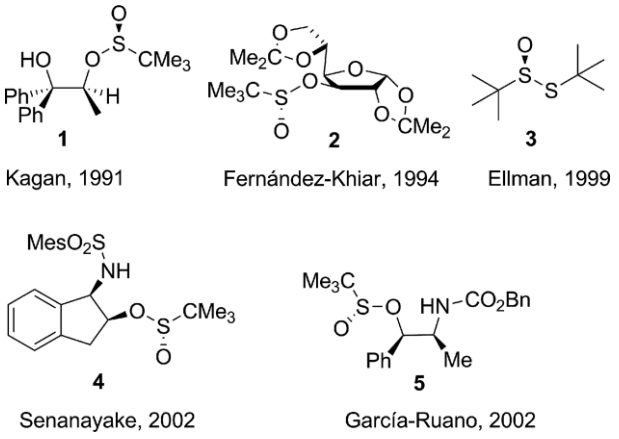


Figure 1. Most popular *tert*-butanesulfinylating agents.

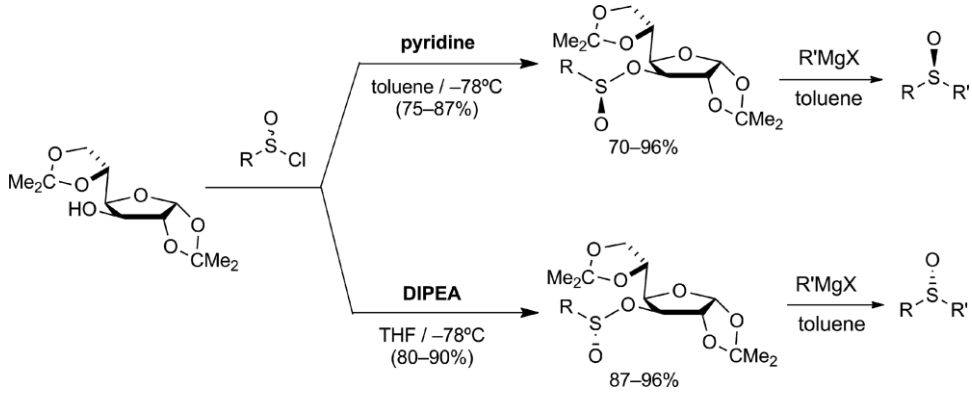
Ellman's methodology is, at present, the method of choice for the synthesis of chiral nitrogenated molecules from (*R*)-*tert*-butanesulfinamide, which is obtained in one step by addition of $LiNH_2$ in liquid ammonia and THF to enantioenriched **3**. Nevertheless, despite all this progress, there is still a need for efficient *tert*-butyl sufinylating agents that can give both enantiopure sulfoxides and sulfinamides under mild reaction conditions. In response to this need, and as part of a wider research program into the synthesis of chiral sulfinyl compounds of biological and synthetic interest, we introduced the (S_S)-DAG *tert*-butanesulfinate ester **2**S_S (DAG = diacetone-d-glucose). This compound is the first intermediate that has been used for the synthesis of enantiopure (*R*)-*tert*-butanesulfinamide and *N*-*tert*-butanesulfinylimine.[26] In this paper, we report an improved method for the large-scale synthesis of (R_S)-DAG-*tert*-butanesulfinate ester **2**R_S, the epimer at sulfur of compound **2**S_S. To demonstrate the suitability of compound **2**R_S as general *tert*-butanesulfinylating agent, its reaction with carbon and nitrogen nucleophiles was studied, and this led to the synthesis of a number of structurally different and synthetically relevant *C*- and *N*-*tert*-butanesulfinylated compounds.

Results and Discussion

In recent decades, we have introduced and developed the "DAG methodology" as one of the most general and efficient methods for the enantiodivergent synthesis of both enantiomers of biologically and synthetically relevant sulfinyl compounds (Scheme 1).

In this methodology, a single inducer of chirality, diacetone-d-glucose (DAG), is used for the stereoselective synthesis of both diastereomerically pure (R_S)- and (S_S)-sulfinate esters. This occurs by dynamic kinetic resolution of the corresponding sulfinyl chloride, and the stereochemical outcome [i.e., (R_S) or (S_S)] is a consequence of the the choice of base used to catalyse the reaction, as different bases have opposite stereodirecting effects.[27] Using Hünig's base, the (S_S)-DAG sulfinate esters are generally obtained in good to high yields, with *de*'s up to 96 %. With pyridine, the (R_S)-DAG sulfinate esters are formed in high yields, with 70–96 % *de* (Scheme 1). Theoretical studies at the ONIOM (Beckel3LYP:UFF) level reproduced the experimental results and showed that the base plays a dual role. It catalyses the interconversion of the enantiomers of the sulfinyl chlorides, and it assists the displacement of the chlorine by the hydroxy group of diacetone glucose.[28] Analysis of the optimized geometries revealed that the most sterically relevant substituent around the sulfur is the R group of the substrate when pyridine is used as the base, but it is the base itself when DIPEA (diisopropylethylamine) is used. This leads to an inversion of the chiral distribution of steric hindrance around the sulfur, and that in turn induces a reversal of the stereochemical outcome and results in the the observed enantiodivergence.[28c]

Consistently with the theoretical studies, treatment of diacetone-d-glucose with *tert*-butanesulfinyl chloride in the presence of DIPEA did not work and no reaction was observed, as a consequence of the steric hindrance of both the substituent and the base around the sulfur atom in the transition state. This issue was solved by using NEt_3, which



Scheme 1. "DAG methodology" for the enantiodivergent synthesis of both enantiomers of sulfoxides.

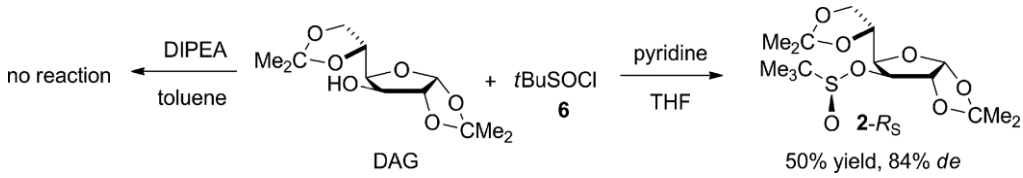
gave the (*S*)-*tert*-butanesulfinate in 74% yield and with a good 72 % *de*, although this *de* was lower than that obtained with other sulfinyl chlorides, which usually gave the sulfinate esters as single diastereoisomers. Interestingly, when pyridine was used as the base, the (*R*)-*tert*-butanesulfinate was predominantly obtained, with a higher diastereomeric excess (84 % *de*) than when NEt_3 was used, but in a lower yield (50 %). This is in direct contrast with the general behaviour of the reactions of less hindered alkanesulfinyl chlorides (Scheme 2).

Based on these results, and on our recent finding that C_2-symmetric ethane-bridged *tert*-butyl sulfoxides[19b] and *tert*-butanesulfinamido-olefin "sulfolefin" ligands are good catalyst precursors in the Rh-promoted addition of boronic acids to activated alkenes and ketones,[9j,9k,19a] we were interested in optimizing the synthesis of DAG-*tert*-butanesulfinate as an *N*- and *C*-sulfinylating agent. The theoretical studies clearly indicated that the lower reactivity and lower selectivity of the reaction are direct consequences of the great steric hindrance of both the chiral auxiliary and the *tert*-butyl group around the sulfur in the transition state. Consequently, in order to obtain a high diastereoselectivity, we have to use a small, unhindered amine, and to improve the kinetics of the reaction, we have to use a more reactive base.

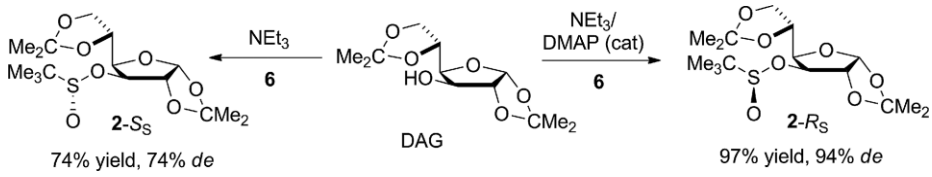
It has recently been shown that 4-(dimethylamino)pyridine (DMAP) catalyses the esterification of hindered and less reactive alcohols with carboxylic acid anhydrides.[29] Based on these results, and on recent reports describing amine-catalysed sulfinyl transfer,[30] we decided to study the effect of DMAP as an organocatalyst in the sulfinylation of diacetone glucose with *tert*-butanesulfinyl chloride. We found that the addition of a catalytic amount of DMAP to the unreactive DIPEA resulted in the formation of the (*R*)-sulfinate ester in a very high yield, and also with an improved selectivity (Scheme 2). The reaction can be achieved in dichloromethane or THF as solvent, at –78 °C. The addition of a catalytic amount of DMAP to a reaction using NEt_3 as base results in the formation, as the major product, of the sulfinate with the opposite configuration at sulfur compared to the result with NEt_3 alone. Thus, in the presence of DMAP, the (R_S)-diastereomer (i.e., **2***R*$_S$) was formed with a high diastereoselectivity (97:3 = **2***R*$_S$:**2***S*$_S$) in quantitative yield, and in a significantly lower reaction time.

These results greatly simplify the experimental work for the synthesis of both sulfinate esters. Two reactions can be carried out in parallel, using exactly the same conditions, except that in one of the flasks a catalytic amount of DMAP is added (Scheme 3). We tested these new reaction conditions with small and medium-sized sulfinyl chlorides, i.e., methanesulfinyl chloride (**7**) and isopropanesulfinyl chloride (**8**), in order to determine the generality of the catalytic effect of DMAP on the synthesis of DAG sulfinate esters, and to unravel the influence of steric factors on the stereoselectivity of the process. Our results are collected in Table 1.

Based on our previous studies, the best base for the synthesis of (S_S)-DAG sulfinate esters is Hünig's base, so it was used to develop an enantiodivergent and experimentally simple route to both epimers at sulfur of DAG sulfinate esters. Indeed, the reaction of sulfinyl chlorides **7** and **8** with diacetone-d-glucose (or dicyclohexylidene-d-glucose) using DIPEA as base led to the formation of **9***S*$_S$ (Table 1, entry 1) and **10***S*$_S$ (Table 1, entry 5) as single diastereoisomers, in 90 % and quantitative yields, respectively. The addition of a substoichiometric amount of DMAP to reactions run under the aforementioned conditions led to the formation of the sulfinate ester with the opposite configuration as the major product. Thus, (R_S)-DAG sulfinates **9***R*$_S$ (Table 1, entry 2) and **10***R*$_S$ (Table 1, entry 6) were formed as the major diastereoisomers. However, in these cases, the results obtained using the DIPEA/DMAP combination did not improve on those obtained with the previously reported procedure; lower *de*'s were obtained with DIPEA/DMAP than with pyridine as base (compare Table 1, entries 2 and 3, and entries 6 and 7). These results demonstrate unambiguously that it is the DMAP that controls the stereochemical outcome of the process. Indeed, when DMAP was used as the sole base in the reaction of diacetone glucose with methanesulfinyl chloride (**7**), (*R*)-sulfinate ester **9***R*$_S$ was formed

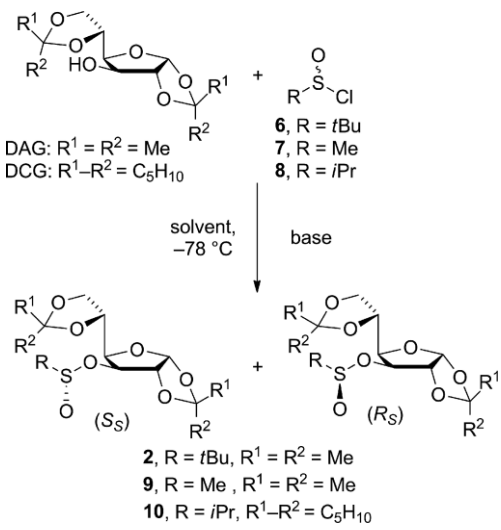


Scheme 2. Synthesis of (R_S)-DAG-*tert*-butanesulfinate **2**R_S.



Scheme 3. Enantiodivergent synthesis of (R_S)- and (S_S)-DAG *tert*-butanesulfinate **2**R_S and **2**S_S. .

Table 1. Effect of DMAP as organocatalyst on the diastereoselective synthesis of DAG sulfinate esters **2**, **9**, and **10**.[a]



Entry	R	Base[b]	DMAP (equiv.)	Time [h]	Product	*dr*[c] (*S*)/(*R*)	Yield[d] [%]
1	Me	A	none	1[e]	**9**	>98:<2	90
2	Me	A	0.4	0.5[f]	**9**	13:87	98
3	Me	B	none	1[e]	**9**	7:93	87
4	Me	–	1.2	1[f]	**9**	22:78	95
5	*i*Pr[g]	A	none	1[e]	**10**	>98:<2	quant.
6	*i*Pr[g]	A	0.4	0.5[f]	**10**	19:81	96
7	*i*Pr[g]	B	none	1[f]	**10**	7:93	97
8	*t*Bu	A	none	72[e]	**2**	–	–
9	*t*Bu	A	0.4	12[e]	**2**	3:97	97
10	*t*Bu	B	none	24[f]	**2**	8:92	50
11	*t*Bu	C	none	24[f]	**2**	87:13	74
12	*t*Bu	C	0.4	12[f]	**2**	3:97	97

[a] All reactions were run in either THF or toluene/dichloromethane (9:1) at –78 °C. [b] Base: A = DIPEA, B = pyridine, and C = NEt_3. [c] Determined by ^1H NMR spectroscopic analysis of the crude mixture. [d] Isolated yield of pure major sulfinate ester after column chromatography purification. [e] Reaction done in toluene/dichloromethane (9:1). [f] Reaction was run in THF. [g] Dicyclohexylidene-d-glucose was used as the chiral auxiliary.

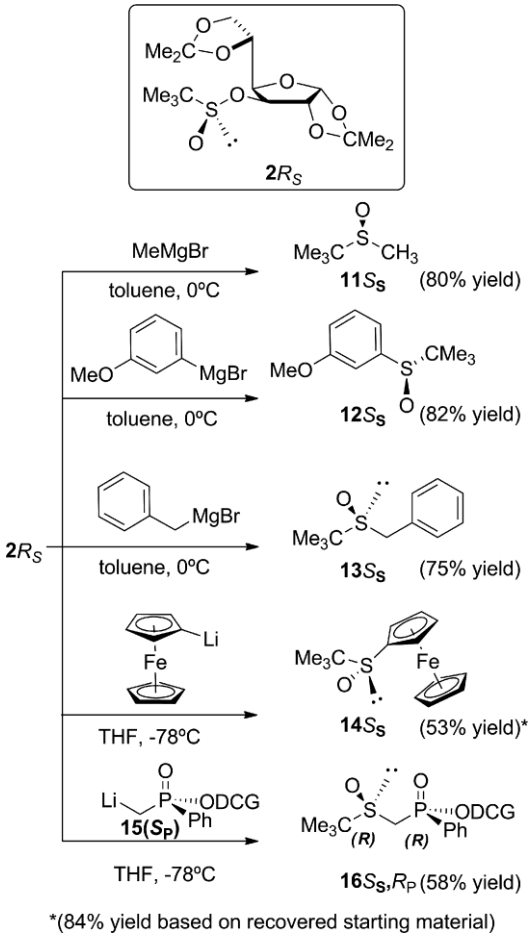
as the major diastereoisomer (Table 1, entry 4), albeit with a lower *de* than when DMAP was used in the presence of DIPEA. Our results also indicate that the mechanism of the reaction is different in the presence of DMAP, and that in this case the DIPEA (or NEt_3) catalyses the interconversion of the enantiomers of the sulfinyl chloride, while DMAP assists the displacement of the chlorine by the hydroxy group of diacetone glucose. The best results obtained so far using a substoichiometric amount of DMAP were with the bulkier *tert*-butanesulfinyl chloride (**6**). When DMAP was added to reactions involving **6**, run with either unreactive DIPEA (Table 1, entry 9) or triethylamine (Table 1, entry 12) as base, the reaction rate increased significantly (Table 1, entries 9 and 12), and also the enantioselectivity was better than that obtained with any base alone (i.e., in the absence of DMAP), including pyridine (Table 1, entry 10) and triethylamine (Table 1, entry 11). We carried out an optimization study of the reaction conditions for the synthesis of the (*R*)-DAG-*tert*-butanesulfinate on a large scale, including the solvent, the temperature, and the nature and the amount of the base. As a result, we concluded that the optimized reaction conditions are as follows: DIPEA or NEt_3 (2 equiv.) in the presence of DMAP (0.4 equiv.) in THF (or CH_2Cl_2) at –78 °C. Using these conditions, and thanks to the fact that **2***R*$_S$ and **2***S*$_S$ could be easily separated by column chromatography, 27 g of **2***R*$_S$ was readily prepared in excellent yield. Compound **2***R*$_S$ is stable at room temperature, and it can be stored in the fridge for months without any degradation.

Next, we focussed our attention on the use of sulfinate ester **2***R*$_S$ as a *C*- and *N*-sulfinylating agent for the synthesis of structurally relevant enantiopure *tert*-butyl sulfoxides and *tert*-butanesulfinamides.

Synthesis of Enantiopure *tert*-Butyl Sulfoxides

In addition to its enantiomeric or diastereomeric purity, the synthetic utility of a *tert*-butanesulfinylating agent heavily depends on its ability to transfer the *tert*-butanesulfinyl group. This is related to the ease of cleavage of the O–SO or S–SO bond in the sulfinate or thiosulfinate ester intermediate (Figure 1). To determine how useful **2***R*$_S$ is as a *C*-sulfinylating agent, we studied its reactivity towards various organometallic reagents for the formation of *tert*-butyl sulfoxides. The first *tert*-butyl sulfoxide we investigated was the simplest, i.e., (*S*$_S$)-methyl *tert*-butyl sulfoxide (**11***S*$_S$). Many of the stereochemical processes promoted by chiral sulfoxides, including a number of total syntheses of natural products, have used (*R*)-methyl *p*-tolyl sulfoxide (MeSOTol) as the starting material. As a consequence, there is great interest in the development of efficient methods for the synthesis of enantiopure methyl *tert*-butyl sulfoxide as a more sterically hindered analogue of MeSOTol, which could act as an improved chiral auxiliary. However, it has been difficult to synthesize methyl *tert*-butyl sulfoxide in enantiopure form. Furthermore, the stereochemical outcomes proposed for the reactions of *tert*-BuMgBr with various sulfinylating agents were contradictory,[22,27,31–33] and consequently the absolute configuration of the final methyl *tert*-butyl sulfoxide was confusing.

The condensation of MeMgBr with sulfinate ester **2***R*$_S$ in toluene at 0 °C took place with complete inversion of configuration at sulfur, and led smoothly to (*S*$_S$)-methyl *tert*-butyl sulfoxide (**11***S*$_S$) in excellent yield and in enantiopure form (Scheme 4). The absolute configuration of the sulfoxide product was determined by specific rotation, as proposed by us and others,[27] and was confirmed by circular dichroism.[34,35] The specific rotation of **11***S*$_S$ was determined using EtOH as solvent instead of chloroform, which was initially proposed, but which usually leads to inconsistent results. The enantiopurity of the obtained (*S*$_S$)-methyl *tert*-butyl sulfoxide (**11***S*$_S$) was determined by chiral HPLC.



Scheme 4. (R_S)-DAG-*tert*-butanesulfinate 2R_S as *C*-sulfinylating agent: synthesis of enantiopure sulfoxides. DCG = dicyclohexylidene glucose.

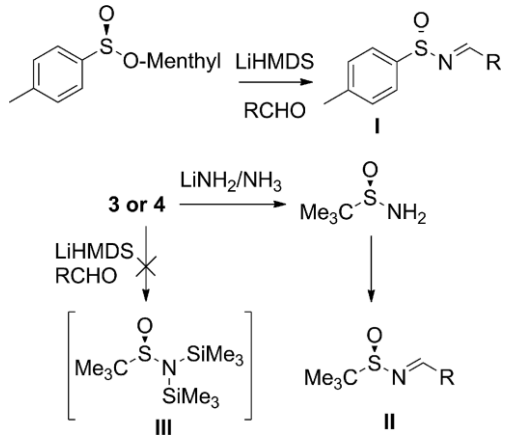
Condensation of the Grignard reagent derived from 3-bromoanisole with enantiopure (R_S)-diacetone-d-glucose *tert*-butanesulfinate gave the corresponding enantiopure sulfoxide (i.e., **12**S_S) in 82 % yield. Compound **12**S_S is an excellent intermediate for the synthesis of diastereomerically pure axially chiral biaryl compounds by Pd-catalysed Suzuki–Miyaura cross-coupling.[17] In the same way, the reaction of a benzyl Grignard reagent with (R_S)-diacetone-d-glucose *tert*-butanesulfinate led to benzyl *tert*-butyl sulfoxide (**13**S_S)[36] with no loss in enantiopurity, as shown by HPLC analysis.

Next, we studied the reactivity of (R_S)-diacetone-d-glucose *tert*-butanesulfinate 2R_S, towards organolithium reagents. Condensation of a suspension of freshly prepared ferrocenyllithium with 2R_S gave (S_S)-*tert*-butyl ferrocenyl sulfoxide (**14**S_S), an important intermediate in the synthesis of Fesulphos-based catalysts,[37] in good yield and in enantiopure form. As a result of our interest in the synthesis of enantiopure Lewis base organocatalysts[8d–8f] and in mixed P/S ligands for metal-promoted enantioselective catalysis,[38] we were interested in developing a modular approach for the synthesis of these kinds of intermediates. With this in mind, we tested the condensation of lithiated (R_P)-dicyclohexylidene glucose methylphenylphosphinate ester **15**S_P[39] with 2R_S and this gave the highly functionalized β-*tert*-butanesulfinyl phosphinate ester **16**S_S,R_P in diastereomerically pure form. Sulfoxide-phosphinate intermediates like **16**S_S,R_P are especially interesting as they can give access to a great number of bidentate ligands by nucleophilic substitution at the phosphinylic ester with different nucleophiles.

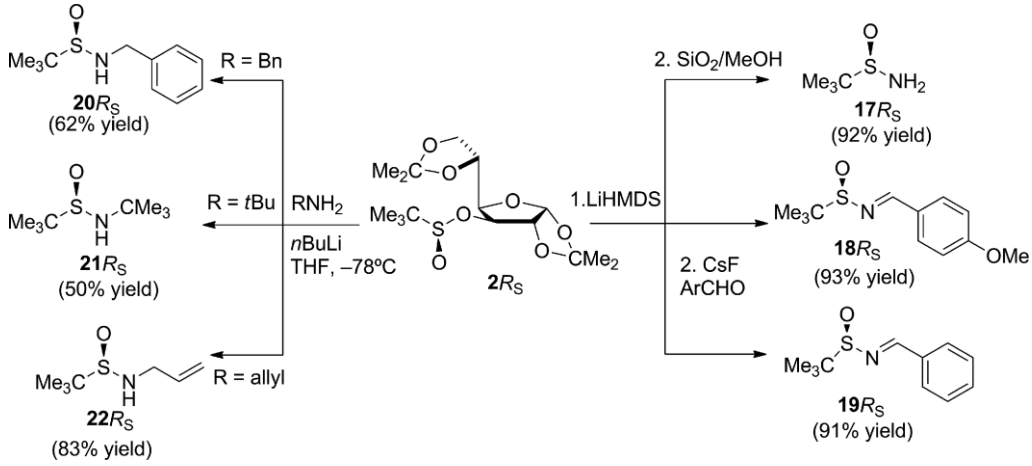
Synthesis of Enantiopure *tert*-Butanesulfinamides

One of the major breakthroughs in the synthesis of amines with an α chiral centre has been the development of efficient methods for the synthesis of enantiopure sulfinamides and the corresponding sulfinylimines. The exceptional behaviour of the chiral sulfinyl group in sulfinylimines, as an activator, a controller of chirality, and as a useful protective group, makes sulfinamides extremely versatile chiral intermediates in the construction of chiral amines. Until now, the most widely used sulfinylimines have been the *p*-toluenesulfinylimines **I** pioneered by Davis,[40] and the *tert*-butanesulfinylimines **II** developed by Ellman.[41]

Davis's approach has the big advantage that the *p*-toluenesulfinylimines **I** are formed in a one-pot manner from the menthyl *p*-toluenesulfinate ester, by condensation with LiHMDS (lithium hexamethyldisilazide) followed by in situ imination of the *N*-hexamethyldisilyl *p*-toluenesulfinamide intermediate similar to **III** (Scheme 5). However, the use of the *p*-toluenesulfinyl group as the imine substituent presents some drawbacks in the diastereoselective synthesis of chiral amines. Small organometallic reagents such as methylmagnesium bromide were reported to attack at sulfur rather than at carbon, while stabilized organometallic reagents such as benzylmagnesium chloride were reported to add with only moderate selectivity. The use of the more sterically hindered *tert*-butanesulfinyl group as the imine substituent solves most of these drawbacks, but Ellman's and Senanayake's approches both require harsh conditions for the synthesis of the sulfinamide intermediate. Indeed, attempted condensation of LiHMDS with *tert*-butanethiosulfinate (**3**) or with *N*-sulfonyl (1*R*,2*S*)-amino indanol de-



Scheme 5. General procedures of sulfinylimines.



Scheme 6. (R_S)-DAG-*tert*-butanesulfinate **2**R_S as *N*-sulfinylating agent: synthesis of enantiopure sulfinamides and sulfinylimines.

rivative **4** failed to give the bis-silylated intermediate (i.e., **III**). Thus, these approaches cannot be used for the one-pot synthesis of sulfinylimines (Scheme 5). This issue has been solved by using a two-step approach; in the first step, the *tert*-butanesulfinamide intermediate is synthesized by condensation of **3** or **4** with NH_2Li/NH_3 in THF (Scheme 5). The NH_2Li/NH_3 is obtained by dissolving lithium metal in liquid ammonia at –78 °C. But these conditions are harsh, and there is the additional drawback that large amounts of hazardous NH_2Li/NH_3 must be handled and disposed of. During the course of our work, Senanayake reported a phenol-based *tert*-butanesulfinylating agent that is able to smoothly give the sulfinamide intermediate.[42] We found that the addition of LiHMDS to (R_S)-DAG-*tert*-butanesulfinate ester **2**R_S in THF at 0 °C, followed by treatment with methanol and silica, gave the desired enantiopure (R_S)-*tert*-butanesulfinamide (**17**R_S) in 92% yield (Scheme 6).

Next, we have evaluated the possibility of obtaining *N*-*tert*-butanesulfinylimines from **2**R_S in a one-pot manner following the methodology pioneered by Davis. After the addition of LiHMDS to sulfinate ester **2**R_S, the resulting *N*-hexamethyldisilyl sulfinamide intermediate was added to a suspension of CsF and an aldehyde in THF. In this way, sulfinylimines **18**R_S, and **19**R_S were obtained in good yields (Scheme 5).

Finally, we investigated a third mode of reactivity of sulfinate ester **2**R_S, i.e., its reactivity with lithium amides for the synthesis of *N*-alkyl-*tert*-butanesulfinamides. The addition of freshly prepared lithium *tert*-butylamide or lithium benzylamide to diastereomerically pure sulfinate ester **2**R_S at –78 °C gave (R_S)-*N*-*tert*-butyl *tert*-butanesulfinamide (**20**R_S), and (R_S)-*N*-benzyl *tert*-butanesulfinamide (**21**R_S), in good yields and with good enantioselectivities (Scheme 6). In the same way, the addition of lithium allylamide to sulfinate ester **2**R_S gave the mixed ligand sulfinamido olefin **22**R_S (Scheme 6). This compound is a representative of a new family of ligands called "sulfolefins", which have recently[9j,9k,19a] been shown to be excellent catalyst precursors for the Rh-catalysed addition of boronic acids to activated ketones, including α,β-unsaturated ketones, α-diketones, α-keto esters, and trifluoromethyl ketones.

Conclusions

These results demonstrate the dramatic and beneficial effect of the addition of substoichiometric amounts of DMAP to reactions in the "DAG methodology". In the special case of the *tert*-butanesulfinylation of diacetone glucose with *tert*-butanesulfinyl chloride, the rate the reaction was dramatically increased, but also the enantioselectivity observed was better than that obtained with any of the other bases tested, including pyridine and triethylamine. Using NEt_3 as base in the presence of a catalytic amount of DMAP induces a reversal of the sulfur configuration of the major sulfinate product compared to when NEt_3 is used alone. The reaction with DMAP gives (R_S)-diastereomer **2**R_S with a 94 % *de* in quantitative yield in a significantly shorter reaction time. This result greatly simplifies the experimental work for the synthesis of both sulfinate esters **2**S_S and **2**R_S, as it allows the two reactions to be carried out in parallel, using exactly the same conditions, except that in one of the flasks a catalytic amount of DMAP is added. The beneficial effect of DMAP allows the synthesis of the desired sulfinate ester on a multigram scale, and 28 g of **2**R_S was readily prepared in a single batch. (R_S)-DAG sulfinate ester **2**R_S is an excellent intermediate for the synthesis of enantiopure *tert*-butyl sulfoxides. Grignard agents and organilithium reagents can smoothly displace the diacetone glucose moiety to give synthetically relevant enantiopure sulfoxides, including highly functionalized derivatives, in high yields and with high enantioselectivities. On the other hand, (R_S)-DAG sulfinate ester **2**R_S gave (R_S)-*tert*-butanesulfinamide, an important intermediate in the synthesis of chiral amines, by simple addition of LiHMDS in THF. Additionally, *tert*-butanesulfinylimines can be obtained in a two-step/one-pot manner by the addition of aldehydes to the *N*-hexamethyldisilylsulfinamide intermediate

formed upon addition of LiHMDS to (R_S)-DAG sulfinate ester **2**R_S. Finally, condensation of lithium amides to sulfinate ester **2**R_S directly gave alkylated sulfinamides, including mixed sulfinamido olefin "sulfolefin" ligands, important precursors of Rh-based catalysts.

Experimental Section

General Methods: All reactions were run under an atmosphere of dry argon using oven-dried glassware and freshly distilled and dried solvents. Toluene, CH_2Cl_2, and diethyl ether were dried using molecular sieves, and highest quality solvents were used. Chemicals were obtained from Sigma–Aldrich, and were used without further purification. TLC was carried out on silica gel GF254 (Merck), and compounds were detected by charring with phosphomolybdic acid/EtOH. For flash chromatography, Merck 230–400 mesh silica gel was used. Chromatographic columns were eluted with a positive pressure of air, and eluents are given as volume to volume ratios (v/v). NMR spectra were recorded with Bruker Avance 300 and 500 spectrometers, using Me_4Si as an internal reference. Chemical shifts are reported in ppm, and coupling constants are reported in Hz. High-resolution mass spectra (HRMS) were recorded in the Centro de Investigación, Tecnología e Innovación in the University of Seville with a Kratos MS-80RFA 241-MC apparatus. Optical rotations were determined with a Perkin–Elmer 341 polarimeter. Elemental analyses were measured with a LECO TruSpect CHNS-932 apparatus. Melting points were measured with a Stuart SMP3 apparatus in open-ended capillary tubes. Enantiomeric excesses were measured with a Waters alliance 2695 and Agilent Technologies 1200 series apparatus with stationary chiral phase columns (Chiralcel®).

***tert*-Butanesulfinyl Chloride (6):**[43] Hydrogen peroxide (30 % aq. solution; 50 mL, 0.48 mol) was added slowly to a solution of di-*tert*-butyl disulfide (85 mL, 0.44 mol, 1 equiv.) in glacial acetic acid (440 mL, 2 equiv.) at 0 °C. After the addition, the reaction was stirred overnight, and the temperature was allowed to rise slowly to room temperature. Then, the reaction was quenched by adding ice/water (500 mL), and the mixture was extracted with CH_2Cl_2 (2 × 100 mL). The organic layer was washed with saturated $NaHCO_3$ (100 mL) and water (100 mL), and dried, and the solvents were evaporated under vacuum.

The resulting *tert*-butylthiosulfinate (50 g, 0.25 mol) was dissolved in CH_2Cl_2 (300 mL), and the solution was cooled to 0 °C. A solution of SO_2Cl_2 (56.11 mL, 0.25 mol) in CH_2Cl_2 (300 mL) was added dropwise. After the addition was complete, the reaction mixture was stirred for 1 h, during which time the temperature was allowed to rise slowly to room temperature. Finally, the volatiles were removed by evaporation in a rotary evaporator without heating, to give *tert*-butanesulfinyl chloride (**6**) as a yellow liquid and in good purity, which was used in the next reaction without further purification. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.42 (s, 9 H) ppm.

(*S*)-3-Deoxy-1,2:5,6-di-*O*-isopropylidene-*α*-D-glucofuranos-3-yl *tert*-Butanesulfinate (2S_S):[25] Anhydrous Et_3N (3.33 mL, 23.8 mmol) was added to a solution of *tert*-butanesulfinyl chloride (3 mL, 11.57 mmol) in toluene (45 mL) at –78 °C. The mixture was stirred for 40 min, then a solution of diacetone glucose (3 g, 11.57 mmol) in toluene/CH_2Cl_2 (45/5 mL) was slowly added dropwise by cannula (over 40 min) to the mixture at –78 °C. The resulting mixture was stirred overnight, then HCl (10 % aq.) was added, and the aqueous phase was extracted with CH_2Cl_2 (3 × 70 mL). The organic phase was washed with saturated aqueous $NaHCO_3$ solution and saturated aqueous NaCl solution, and dried with anhydrous Na_2SO_4. The solvent was removed under vacuum to give sulfinate **2**S_S in a 87:13 *dr*. Purification by column chromatography (hexane/diethyl ether, 3:1) gave diastereomerically pure sulfinate **2**S_S (3.68 g, 8.56 mmol, 74 %) as a yellow oil. $[\alpha]_D^{20}$ = –64 (*c* = 1.3, acetone). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 5.89 (d, *J* = 3.6 Hz, 1 H), 4.72 (d, *J* = 2.4 Hz, 1 H), 4.58 (d, *J* = 3.6 Hz, 1 H), 4.37–4.26 (m, 2 H), 4.13–3.94 (m, 2 H), 1.50, 1.42, 1.33, 1.31 (4 s, 12 H), 1.20 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 112.3, 109.4, 105.3, 83.6, 82.6, 81.3, 71.8, 67.9, 58.5, 26.7, 26.2, 25.2, 21.5 ppm.

(*R*)-3-Deoxy-1,2:5,6-Di-*O*-isopropylidene-*α*-D-glucofuranos-3-yl *tert*-Butanesulfinate (2R_S):[26] A solution of *tert*-butanesulfinyl chloride (21.58 g, 153.6 mmol) in anhydrous THF (250 mL) was cooled to –78 °C under argon, and DIPEA (28.1 mL, 161.25 mmol) or Et_3N (22.45 mL, 161.25 mmol) was slowly added dropwise over 15 min. Then a solution of DMAP (896 mg, 0.4 equiv.) in THF (30 mL) was added over 30 min. The resulting mixture was stirred for 50 min at –78 °C, then a solution of diacetone glucose (20 g, 76.8 mmol) in THF (220 mL) is slowly dropwise over 5 h. The reaction mixture was stirred overnight, and then it was quenched with HCl (10 % aq.). The aqueous phase was extracted with CH_2Cl_2 (3 × 300 mL), and the organic phase was washed with saturated aqueous $NaHCO_3$ solution and saturated aqueous NaCl solution, and dried with anhydrous Na_2SO_4. The solvent was removed under vacuum to give products **2**R_S and **2**S_S (97 % yield, 97:3 *dr*). This mixture was purified by column chromatography (hexane/diethyl ether, 9:1) to give pure **2**R_S (27 g, 97 %) as an oil. $[\alpha]_D^{20}$ = +8.0 (*c* = 4.7, acetone). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 5.89 (d, *J* = 3.5 Hz, 1 H), 4.81 (d, *J* = 3.57 Hz, 1 H), 4.69 (d, *J* = 2.3 Hz, 1 H), 4.16–4.13 (m, 3 H), 4.95–3.93 (m, 1 H), 1.50, 1.41 (2 s, 6 H), 1.30 (s, 6 H), 1.22 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 112.3, 109.4, 105.3, 83.6, 82.6, 81.3, 71.8, 67.9, 58.5, 26.7, 26.2, 25.2, 21.5 ppm.

Methyl *tert*-Butyl (*S*)-Sulfoxide (11S_S):[25,34,44] A solution of **2**R_S (10 g, 31.04 mmol) in toluene (100 mL) was treated with a 1 m methylmagnesium bromide solution in diethyl ether (43.46 mL, 43.46 mmol). The mixture was stirred for 1 h, then saturated aqueous NH_4Cl was added. The organic phase was extracted with CH_2Cl_2 (4 × 50 mL). The organic phased was washed with brine, and solvent was removed under vacuum. The residue was purified by column chromatography (diethyl ether) to give sulfoxide **11**S_S (2.97 g, 24.8 mmol, 80 %) as an oil. $[\alpha]_D^{20}$ = +8.7 (*c* = 1.6, $CHCl_3$); Lit. +7.8 (*c* = 1.6, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 2.35 (s, 3 H), 1.25 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 52.6, 31.5, 22.5 ppm. HRMS: calcd. for $C_5H_{12}OS$ 120.0608; found 120.0609. HPLC [Chiralcel® AS-H (2-propanol/hexane, 10:90; 0.7 mL/min)]: t_R = 33.89 min (*R* isomer), 39.85 min (*S* isomer).

3-Methoxyphenyl *tert*-Butyl Sulfoxide (12R_S): A suspension of Mg (202 mg, 8.30 mmol) in diethyl ether (4 mL) was treated dropwise with 3-bromanisole (1.05 mL, 8.30 mmol), and the mixture was stirred for 30 min. The resulting Grignard reagent was added to a solution of (R_S)-DAG *tert*-butanesulfinate ester **2**R_S (2.75 g, 7.55 mmol) in toluene (10 mL) at 0 °C. After 2 h, the reaction was quenched with NH_4Cl, and the organic phase was extracted with EtOAc (4 × 60 mL). The organic phase was washed with a saturated solution of NaCl, dried with Na_2SO_4, and concentrated. The residue (3.85 g) was purified by flash chromatography (EtOAc/hexane, 1:2) to give **12**R_S (628 mg, 82 %), m.p. 87 °C. $[\alpha]_D^{20}$ = –111.0 (*c* = 0.85, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.35 (t, *J* = 8 Hz, 1 H), 7.17 (m, 1 H), 7.08 (d, *J* = 8 Hz, 1 H), 6.9 (dd, *J* = 8, *J* = 2 Hz, 1 H), 3.83 (s, 3 H), 1.17 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 159.8, 141.5, 129.2, 118.7, 117.5, 110.7, 55.9, 55.5, 22.9 ppm. HRMS: calcd. for $C_{11}H_{16}O_2S$ $[M]^+$ 213.0949; found 213.0955.

(*S*)-Benzyl *tert*-Butyl Sulfoxide (13S_S):[24] Benzylmagnesium chloride (2 m solution in THF; 3.89 mL, 7.78 mmol) was added to a solution of **2**R_S (1.89 g, 5.18 mmol) in toluene (20 mL). After 1 h, the reaction was quenched with NH_4Cl, and the organic phase was extracted with EtOAc (4 × 60 mL). The organic phase was washed with a saturated solution of NaCl, dried with Na_2SO_4, and concentrated. Purification by flash chromatography (EtOAc/hexane, 1:2), gave optically pure sulfoxide **13**S_S (760 mg, 3.88 mmol, 75 %) as a white solid. $[\alpha]_D^{20}$ = –244.8 (*c* = 0.8, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.38–7.29 (m, 5 H), 3.74 (AB system, *J* = 12.8 Hz, 2 H), 1.33 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 132.1, 130.0, 129.1, 128.8, 127.97, 53.6, 53.0, 23.0 ppm. HRMS: calcd. for $C_{11}H_{16}OS$ [M + H]$^+$ 197.1000; found 197.0987. $C_{11}H_{16}OS$ (196.31): C 67.30, H 8.22; found C 67.45, H 8.09. HPLC [Chiralcel® AD (2-propanol/hexane, 10:90; 0.7 mL/min)]: t_R = 15.01 min (*S* isomer), 16.56 min (*R*-isomer).

(*S*)-*tert*-Butanesulfinylferrocene (14S_S):[45] Ferrocene (651 mg, 3.43 mmol) was dissolved in THF (6 mL), and the solution was cooled to 0 °C. *tert*-BuLi (1.3 m solution in THF; 3.02 mL, 3.02 mmol) was added. The reaction mixture was stirred 2 h at 0 °C, and the resulting suspension of ferrocenyllithium was transferred by cannula to a second flask containing a solution of **2**R_S (500 mg, 1.37 mmol) in THF (4 mL) that had previously been cooled to –78 °C. The mixture was stirred for 2 h at –78 °C, then it was quenched with saturated aqueous NaCl solution, and the aqueous layer was extracted with EtOAc (5 × 10 mL). The organic layer was dried with Na_2SO_4, and the solvent was evaporated under vacuum. The residue was purified by flash chromatography (EtOAc/hexanes, 1:2), to give **14**S_S (1.6 g, 53 %) as a yellow solid. Analysis of the sulfoxide by HPLC showed that the *ee* of the product was 90 %: HPLC [Chiralpack AD (*i*PrOH/hexane, 3:97; 0.8 mL/min), 30 °C]: t_R = 37.1 min (*R* isomer), and 39.9 min (*S* isomer). A single recrystallization from EtOAc/hexane gave optically pure **14**S_S (1.12 g, 35 %), m.p. 114 °C. $[\alpha]_D^{20}$ = +347.0 (*c* = 0.5, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 500 MHz): δ = 4.68 (s, 1 H), 4.40 (br. s, 2 H), 4.36 (s, 5 H), 4.32 (s, 1 H), 2.75 (m, *J* = 6.8 Hz, 1 H), 1.16 (d, *J* = 8.6 Hz, 3 H), 0.98 (d, *J* = 8.6 Hz, 3 H) ppm. ^{13}C NMR ($CDCl_3$, 125 MHz): δ = 88.4, 70.0, 69.9, 69.6, 68.8, 64.7, 54.4, 15.3, 15.1 ppm. $C_{13}H_{16}FeOS$ (276.18): C 56.54, H 5.84; found C 56.24, H 5.75.

Phosphinate 16S_S,S_P: (*S*)-Dicyclohexylideneglucose-methylphenylphosphinate **15**R_P (500 mg, 1.04 mmol) was dissolved in THF (10 mL), and the solution was cooled to –78 °C under argon. LiHMDS (1 m solution in THF; 3 mL, 3 mmol) was added. The mixture was stirred for 2 h at –78 °C, then the resulting suspension was added by cannula to a solution of **2**R_S (380 mg, 1.04 mmol) in THF (10 mL) that had been cooled to –78 °C. The resulting mixture was stirred for 2 h, then saturated aqueous NH_4Cl solution was added, and the mixture extracted with EtOAc (5 × 40 mL). The organic phase was dried with anhydrous Na_2SO_4, and the solvent was removed under vacuum. The residue was purified by column chromatography (EtOAc) to give optically pure **16**S_S,S_P (300 mg, 50 %) as a white solid, m.p. 76 °C. $[\alpha]_D^{20}$ = –95.0 (*c* = 1, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.07–8.03 (m, 2 H), 7.63 (td, *J* = 1.2, *J* = 7.4 Hz, 1 H), 7.52 (td, *J* = 3.7, *J* = 7.8 Hz, 1 H), 6 (d, *J* = 3.5 Hz, 1 H), 5.14 (d, *J* = 3.5 Hz, 1 H), 4.67 (dd, *J* = 2.6, *J* = 6.4 Hz, 1 H), 4.45–4.41 (m, 1 H), 4.14 (dd, *J* = 6.2, *J* = 8.7 Hz, 1 H), 4.05 (dt, *J* = 2.6, *J* = 8.9 Hz, 1 H), 4 (dd, *J* = 4.6, *J* = 8.6 Hz, 1 H), 3.2 (t, *J* = 14.6 Hz, 1 H), 2.99 (dd, *J* = 14.5, *J* = 13.35 Hz, 1 H), 1.66–1.35 (m, 20 H), 1.17 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 133.7 (d, *J* = 2.5 Hz), 133.1 (d, *J* = 10.8 Hz), 128.9 (d, *J* = 13.3 Hz), 127.6 (d, *J* = 132.1 Hz), 113.1, 110.2, 104.9, 83.3, 81 (d, *J* = 8.5 Hz), 79.2 (d, *J* = 6.4 Hz), 71.7, 67.4, 55.2 (d, *J* = 8.1 Hz), 48.7 (d, *J* = 100.6 Hz), 36.8, 36.5, 35.8, 34.9, 25.3, 24.9, 24.1, 24, 23.9, 23.6, 22.6 ppm. ^{31}P NMR (72 MHz, $CDCl_3$): δ = +37.39 ppm. HRMS: calcd. for $C_{29}H_{43}O_8NaPS$ 605.2310; found 605.2314.

(*R*)-*tert*-Butanesulfinamide (17R_S):[13b] (R_S)-DAG-*tert*-butanesulfinate ester **2**R_S (12.6 mmol) was dissolved in THF (50 mL), and the solution was cooled to 0 °C. LiHMDS (1 m solution in THF; 63 mL, 63 mmol) was added. The reaction mixture was stirred for 48 h, then MeOH (20 mL) was added, followed by silica gel, and the mixture was stirred for 15 min. The solvent was evaporated, and the residue was purified by flash chromatography (EtOAc/hexane, 1:4) to give (R_S)-*tert*-butanesulfinamide **17**R_S (1.39 g, 11.59 mmol, 92 %) as a white solid. $[\alpha]_D^{20}$ = +4.0 (*c* = 1.0, $CHCl_3$). Lit.[16] $[\alpha]_D^{20}$ = +4.9 (*c* = 1.0, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 3.82 (br. s, 2 H), 1.18 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 55.3, 22.1 ppm.

General Procedure for the Synthesis of *N*-*tert*-Butanesulfinylimines, 18R_S and 19R_S: A solution of LiHMDS in THF (1.2 equiv.) was added to a solution of (*R*)-DAG-*tert*-butanesulfinate (**2**S_S) (5.8 g, 16.08 mmol, 1 equiv.) in THF (20 mL) at 0 °C under argon, and the reaction mixture was allowed to reach room temperature. After 15 min, the mixture was cooled again to 0 °C, and then it was added to a solution of the corresponding aldehyde (24.12 mmol, 1.5 equiv.) and CsF (19.29 mmol, 1.2 equiv.) in THF (10 mL). After the starting material had been consumed, the reaction was quenched with saturated aqueous NH_4Cl solution, and the mixture was extracted with ethyl acetate (4 × 80 mL). The organic phase was washed with brine, dried with anhydrous Na_2SO_4, and concentrated under vacuum. The residue was purified by column chromatography (EtOAc/hexane, 1:9) to give the corresponding enantiopure *N*-*tert*-butanesulfinylimine.

(–)-(*R*,*E*)-*N*-(4-Methoxybenzylidene)-*tert*-butanesulfinamide (18R_S):[13a] The reaction of 4-methoxybenzaldehyde and **2**R_S following the general procedure, after purification by column chromatography (hexane/EtOAc, 4:1), gave **18**R_S (3.57 g, 14.95 mmol, 93 %) as a white solid, m.p. 91–93 °C. $[\alpha]_D^{20}$ = –70.2 (*c* = 1.0, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.51 (s, 1 H), 7.79 (d, *J* = 8.7 Hz, 2 H), 6.96 (d, *J* = 8.7 Hz, 2 H), 3.87 (s, 3 H), 1.24 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 162.7, 160, 135.4, 129.9, 122.5, 118.8, 113.2, 57.8, 55.5, 22.6 ppm.

(–)-(*R*,*E*)-*N*-(Benzylidene)-*tert*-butanesulfinamide (19R_S):[13a] The reaction of benzaldehyde and **2**R_S following the general procedure, after purification by column chromatography (hexane/EtOAc, 6:1), gave **19**R_S (3.05 g, 14.63 mmol, 91 %) as a yellow oil. $[\alpha]_D^{20}$ = –122.0 (*c* = 1.0, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.59 (s, 1 H), 7.85 (m, 2 H), 7.55–7.44 (m, 3 H), 1.26 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 157.6, 128.9, 127.2, 124.2, 123.7, 52.5, 17.4 ppm.

General Procedure for the Synthesis of *N*-Alkyl-*tert*-butanesulfinamides 20R_S–22R_S: *n*BuLi (1.92 mL of a 1.7 m solution in hexane, 3.28 mmol) was added to a solution of the corresponding amine (3.28 mmol) in THF (7 mL) at –78 °C. The solution was stirred at –78 °C for 30 min, and then it was added to a solution of (R_S)-DAG *tert*-butanesulfinate (**2**R_S) (1.64 mmol, 1 equiv.) in THF. This mixture was stirred until TLC ($EtOAc/CH_2Cl_2$, 1:4) indicated that all the starting material had been consumed, i.e., between 0.5 and 1 h. Then the reaction was quenched with saturated aqueous NH_4Cl solution, the mixture was extracted with EtOAc, and the organic phase was washed with saturated aqueous $NaHCO_3$ solution and brine. The organic phase was dried with Na_2SO_4, and the solvent was evaporated. The residue was purified by flash chromatography.

(*R*)-*N*-Benzyl-*tert*-butanesulfinamide (20R_S):[7] Reaction time 45 min. Purified by flash chromatography (EtOAc/hexane, 1:1, to EtOAc) to give **20**R_S (211 mg, 1 mmol, 62 %) as a white solid, m.p. 64–65 °C. $[\alpha]_D^{20}$ = –31 (*c* = 1.0, $CHCl_3$). ^1H NMR (500 MHz, $CDCl_3$): δ = 7.38–7.30 (m, 5 H), 4.39 (dd, *J* = 13.7, *J* = 4.7 Hz, 1 H), 4.29 (dd, *J* = 13.7, *J* = 4.7 Hz, 1 H), 1.29 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 138.53, 128.64, 128.12, 127.71, 55.95, 49.46, 22.69 ppm. HRMS: calcd. for $C_{11}H_{17}NOS$ $[M + H]^+$ 212.1110; found 212.1109. The *ee* was determined by HPLC [Chiralcel® AD (*i*PrOH/hexane, 2:98; 1 mL/min)]: t_R = 19.8 min (*R* isomer) and 24.1 min (*S* isomer).

(*R*)-*N*-*tert*-Butyl-*tert*-butanesulfinamide (21R_S): Reaction time 45 min. Purified by flash chromatography (EtOAc/hexane, 1:1, to EtOAc) to give **21**R_S (145 mg, 0.82 mmol, 50 %) as a white solid, m.p. 79–81 °C. $[\alpha]_D^{20}$ = –38 (*c* = 2.0, $CHCl_3$). ^1H NMR (500 MHz, $CDCl_3$): δ = 3.01 (br. s, 1 H), 1.31 (s, 9 H), 1.20 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 55.1, 53.1, 31.0, 22.4 ppm. HRMS: calcd. for $C_8H_{20}NOS$ $[M + H]^+$ 178.1266; found 178.1265.

(*R*)-*N*-Allyl-*tert*-butanesulfinamide (22R_S): Reaction time 2 h. Purified by flash chromatography (hexane/EtOAc, 1:1) to give **22**R_S (219 mg, 1.36 mmol, 83 %) as a yellow oil. $[\alpha]_D^{20}$ = +12.3 (*c* = 0.6, $CHCl_3$). ^1H NMR (500 MHz, $CDCl_3$): δ = 5.95–5.86 (m, 1 H), 5.26 (d, *J* = 17.1 Hz, 1 H), 5.16 (d, *J* = 10.2 Hz, 1 H), 3.74–3.65 (m, 1 H), 3.47–3.39 (m, 1 H), 1.22 (s, 9 H) ppm. ^{13}C NMR (125 MHz, $CDCl_3$): δ = 135.2, 117.0, 55.7, 48.1, 22.5 ppm. $C_7H_{15}NOS$ (161.27): C 52.13, H 9.38, N 8.69, S 19.88; found C 52.36, H 9.26, N 8.39, S 20.10. The *ee* was determined by HPLC [Chiralcel® AS-H (*n*-hexane/2-propanol, 90:10; 0.7 mL/min)]: t_R = 13.8 min (*S*-isomer), 24.7 min (*R*-isomer).

Supporting Information (see footnote on the first page of this article): Experimental procedures for the synthesis of compounds **9**R_S, **9**S_S, **9**R_S, and **9**S_S. Copies of ^1H and ^{13}C NMR spectra.

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