The Enantioselective Total Synthesis of (−)-Myltaylenol

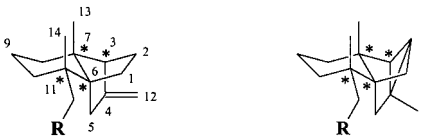
Sven Doye, Torsten Hotopp, Rudolf Wartchow, and Ekkehard Winterfeldt*

Abstract: The unusual sesquiterpenoid alcohol (−)-myltaylenol (**1**) is synthesized by an intramolecular [4+2] cycloaddition of a chiral diene accessible from Hajos–Wiechert ketone by a sequence of reactions including stereoselective alkylation of an unsaturated ketone with thiophenylmethyl iodide as alkylation agent. As the link between diene and olefin a sulfonic ester group is used. The link permits control of the stereoselectivity of the [4+2] cycloaddition. After this key step the sulfonic ester group can be removed under oxidative conditions by molecular oxygen as oxidation agent, leading directly to a hydroxyketone that can be converted to (−)-myltaylenol by successive Shapiro reaction, regioselective hydroboration and Wittig reaction.

Keywords: cycloadditions · natural products · oxidations · terpenoids · total synthesis

Introduction

In 1985 Matsuo et al. isolated the unusual sesquiterpenoid alcohol (−)-myltaylenol (**1**, Figure 1) from the liverwort *Mylia taylorii* and determined its structure by NMR techniques and



1: R=OH **3: R=OH**
2: R=H **4: R=H**

Figure 1. Structures of (−)-myltaylenol (**1**), myltaylene (**2**), (−)-cyclomyltaylenol (**3**), and cyclomyltaylene (**4**).

X-ray crystal structure analysis of the corresponding benzoate.[1] It was the first example of a new class of sesquiterpenes possessing the myltaylane framework. Other examples are (−)-cyclomyltaylenol (**3**), isolated from *Mylia taylorii*, and cyclomyltaylene (**4**), isolated from *Bazzania tridens*.[2, 3] All three compounds are characterized by at least four consecutive chiral centers (*), three of which are quartenary carbon atoms.

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In 1994 Srikrishna et al. communicated briefly a very short racemic synthesis of nonnatural myltaylene (**2**), which lacks the C15 hydroxyl group of myltaylenol, starting from cyclogeraniol. The key step of this synthesis is an impressive Lewis acid catalyzed cationic rearrangement leading directly to the target molecule.[4] Nevertheless, to the best of our knowledge no other synthesis and no enantioselective approach to this type of molecule has been reported until we published the first enantioselective synthesis of (−)-myltaylenol (**1**).[5] Herein we want to describe this synthesis in detail.

Results and Discussion

Our retrosynthetic analysis is outlined in Scheme 1. It reflects our experience in the formation of bridged structures similar to **1** by Diels–Alder reactions of dienophiles with chiral dienes[6] derived from Hajos–Wiechert ketone.[7] We have chosen an intramolecular [4+2] cycloaddition, building up two chiral centers in one step, as the key step in our synthesis. Cyclopentadiene **11** was supposed to be the key intermediate. In **11** two of the four desired chiral centers are established already. To synthesize **11** as a single enantiomer, the well-documented enantiopure tetrahydropyranyl (THP) ether **12** was considered as a perfect starting material.[8] The alcohol functionality in **11** should provide the possibility of controlling the stereochemical outcome of the Diels–Alder reaction by introducing a temporary tether (X in **7**, Y_n in combination with Z in **10**) between diene and the 2π system, which should lead to a highly stereoselective intramolecular α-attack of the olefin to the diene. After cycloaddition to **6** or **9** the tether should then be able to be removed totally (Y_n in **9**) or to be cleaved while forming a functional group such as a carbonyl

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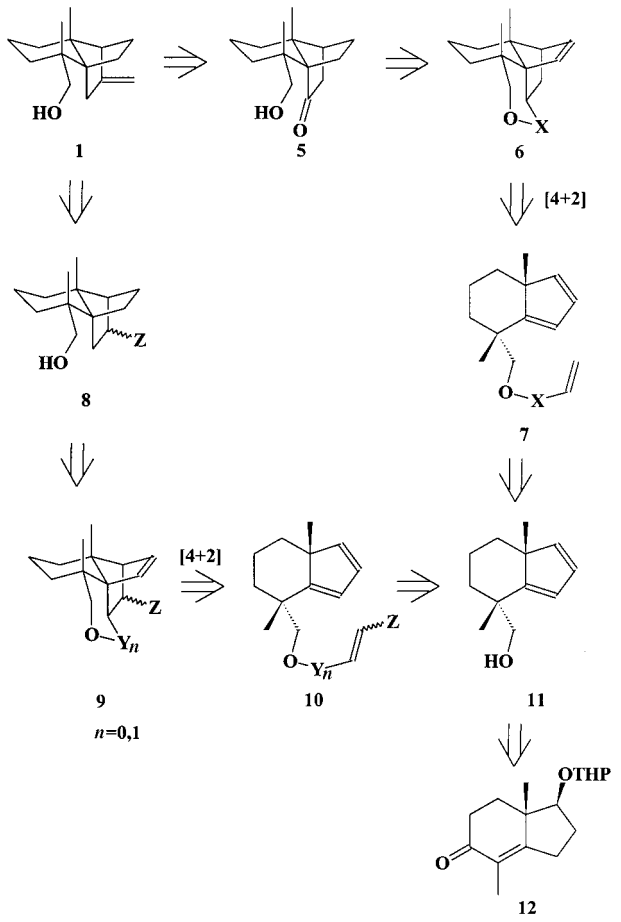
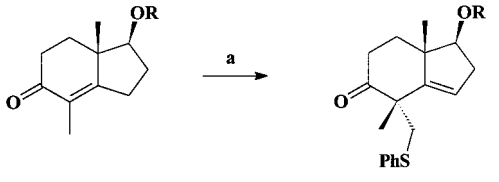


Scheme 1. Retrosynthetic analysis of (−)-myltaylenol (**1**).

group at the same position (X in **6**). To complete the synthesis it would be necessary to perform a 1,2-carbonyl shift and a following olefination reaction (**5** to **1**) or convert Z into an exocyclic double bond (**8** to **1**).

One possible tether X is the SO_2 unit, introduced by Metz et al., which can be removed under oxidative conditions leading to a carbonyl group.[9] Possibilities for Y_n in combination with Z are Me_2Si,[10] C=O,[11] or a direct bond between oxygen and the double-bond carbon, while Z could be an ester group.

The first step in our synthesis was a diastereoselective alkylation of an unsaturated ketone like **12** or **13** with a bifunctional alkylation agent. In order to avoid *O*-alkylation we chose the quite soft thiophenylmethyl halides ($PhSCH_2X$) as alkylation agents, which should be superior to the corrosponding ethers (Scheme 2). Owing to the sterically



12: R=THP
13: R=TMS

14: R=THP
15: R=TMS

Scheme 2. Diastereoselective alkylation of unsaturated ketones **12** and **13**. Reagents and conditions: a) KO*t*Bu (1.3 equiv), THF, 0 °C, 45 min, then $PhSCH_2X$ (1.4 equiv), −78 °C, 30 min.

demanding methyl group on the β-side of the molecule the functionalized sidechain was introduced on the α-side with high selectivity. First alkylation experiments were run with the trimethylsilyl (TMS) ether **13** and potassium *tert*-butoxide as a base in tetrahydrofuran (THF) with thiophenylmethyl chloride as the alkylation reagent at −78 °C. The diastereoselectivity *de* was 85%. In order to improve the selectivity we synthezised the corresponding bromide and iodide and used them as alkylation agents.[12] We found that the selectivity could be increased (Scheme 2, Table 1) by changing the halide

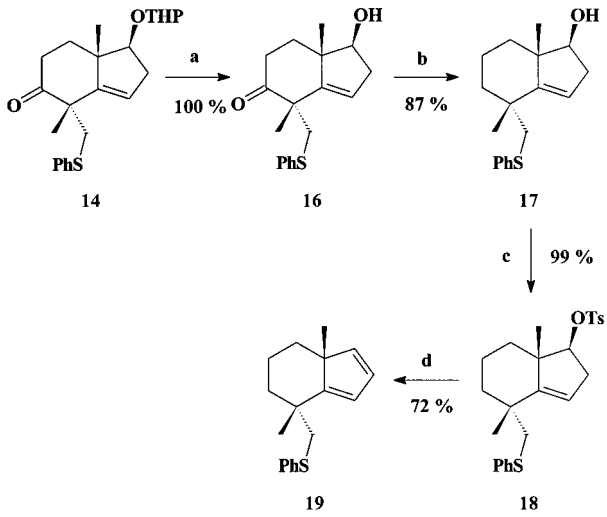
Table 1. Diastereoselective alkylation of unsaturated ketones **12** and **13**.

R	X	Yield	*de*
TMS	Cl	71%	85%
TMS	Br	61%	94%
TMS	I	82%	95%
THP	I	83%	96%

from chloride through bromide (*de* = 94%) to iodide (*de* = 95%). A slight improvement in selectivity (*de* = 96%) and an easier chromatographic separation of the resulting diastereomers were achieved with the THP ether **12** instead of the TMS ether **13**. The resulting thioethers **14** and **15** were isolated with yields between 61% and 83%. The *cis* configuration of the methyl groups was determined by NOE experiments. Using this procedure we were able to establish the first two chiral centers of the natural product.

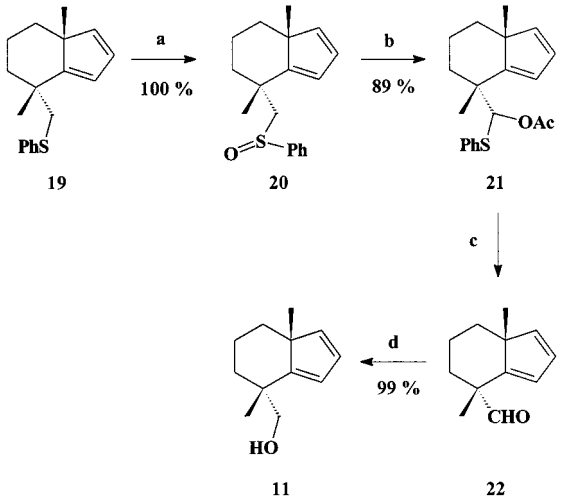
To generate the cyclohexane unit of (−)-myltaylenol **1** it was then necessary to remove the keto group of **14**. A direct Wolff–Kishner reduction of the thioether **14** gave cyclopentenol **17** in 80% yield. In order to increase the yield by eliminating possible side reactions caused by the acetal unit, we removed the THP protecting group under acidic conditions before conducting the Wolff–Kishner reduction. Using this strategy we were able to isolate cyclopentenol **17** in 87% yield over two steps. To generate the necessary diene unit, the tosylate **18** was formed under standard conditions in almost quantitative yield and treated with potassium *tert*-butoxide in THF at 65 °C; this resulted in the formation of diene **19** in 72% yield (Scheme 3).

Abstract in German: *Das Sesquiterpen (−)-Myltaylenol **1** wird unter Nutzung einer intramolekularen [4+2]-Cycloaddition eines chiralen Diens, welches ausgehend von enantiomerenreinem Hajos–Wiechert-Keton leicht zugänglich ist, synthetisiert. Als Verbindungsglied zwischen Dien- und Olefin-Teil des Moleküls wird eine Sulfonsäureester-Einheit verwendet. Diese Brücke bietet neben einer perfekten Kontrolle der Stereoselektivität der [4+2]-Cycloaddition die Möglichkeit, hinterher oxidativ spaltbar zu sein. Mit molekularem Sauerstoff als Oxidationsmittel entsteht dabei direkt ein Hydroxyketon, welches durch schrittweise Shapiro-Reaktion, regioselektive Hydroborierung und Wittig-Reaktion in **1** überführt werden kann.*



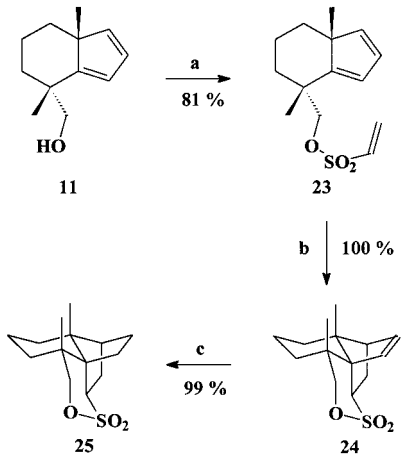
Scheme 3. Synthesis of cyclopentadiene **19**. Reagents and conditions: a) HCl, EtOH, 25 °C, 16 h; b) N_2H_4 (7.0 equiv), KOH (6.8 equiv), diglycol, 200 °C, 4 h; c) TsCl (1.5 equiv), DMAP (2.0 equiv), CH_2Cl_2, 25 °C, 16 h; d) KO*t*Bu (2.0 equiv), THF, 65 °C, 3.5 h.

The last problem in the synthesis of key intermediate **11** was the exchange of the thioether unit against an oxygen functionality. This was done by the Pummerer strategy. First the thioether **19** was oxidized with sodium metaperiodate in a mixture of water and methanol at room temperature in almost quantitative yield. A nearly 1:1 mixture of diastereomeric sulfoxides **20** was obtained. It was not necessary to separate these diastereomers for the following synthesis. The Pummerer rearrangement was carried out in acetic anhydride at 100 °C over a period of 62 hours. The yield was 89 %. Again two diastereomers **21** in a nearly 1:1 ratio were obtained but not separated. Hydrolysis of **21** in KOH/MeOH led to the very volatile and diastereomerically pure aldehyde **22**, which was reduced immediately with sodium borohydride at 0 °C to give the alcohol **11**, which was easily isolated. The yield for this one-pot conversion was 99 % (Scheme 4).



Scheme 4. Synthesis of alcohol **11**. Reagents and conditions: a) $NaIO_4$ (1.3 equiv), MeOH/H_2O 6:1, 0 °C–25 °C, 16 h; b) Ac_2O, 100 °C, 62 h; c) KOH (2.0 equiv), MeOH, 25 °C, 2 h; d) $NaBH_4$ (1.6 equiv), MeOH, 0 °C, 30 min.

After alcohol **11** had been obtained as a single enantiomer in multigram quantities, different olefin units were introduced into the molecule. Our first strategy was to use the Metz protocol, which consists of the formation of a vinylsulfonic ester **23** followed by an intramolecular Diels–Alder reaction and an oxidative ring cleavage of the resulting sultone **24**.[9] Alcohol **11** was reacted with ethenesulfonyl chloride[13] in methylene chloride at −15 °C to yield 81 % of the desired ester **23**, which underwent the intramolecular Diels–Alder reaction smoothly. Because of the control by the already established chiral centers, only α-attack of the dienophile unit was observed. This resulted in the formation of only one diastereomer, the sultone **24** with quantitative yield. The predicted α-configuration of **24** and **25** was secured by X-ray crystal structure analysis of sultone **25** (see Figure 2).[14] To avoid side reactions caused by the double bond in **24**, hydrogenation under one atmosphere H_2 was performed using palladium on carbon as a catalyst in THF at room temperature (Scheme 5).



Scheme 5. Synthesis of sultone **25**. Reagents and conditions: a) $ClSO_2CH{=}CH_2$ (1.25 equiv), $EtN(iPr)_2$ (1.2 equiv), CH_2Cl_2, −15 °C, 1.5 h; b) toluene, 111 °C, 20 h; c) 1 atm H_2, Pd/C, 25 °C, 16 h.

In order to achieve an oxidative cleavage of the sultone bridge, a number of procedures were tried. The goal was to

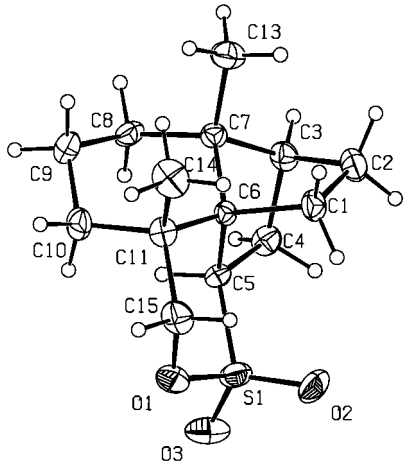


Figure 2. PLATON drawing of sultone **25**.

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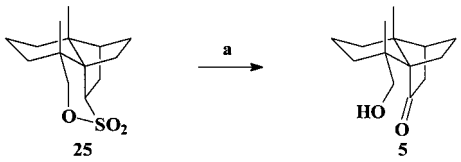
introducea hydroxyl group at the sulfur-bearing carbon atom by oxidizing the sultone anion, which is easily prepared by deprotonation of **25** with *s*BuLi. The carbon–sulfur bond of the resulting product should cleave to form the desired keto function in **5**. Unfortunately, the oxidation employing 2-methoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane, which had been used by Metz at al., failed.[9] Other reagents normally used for the oxidation of anions, like MoOPH[15] or *N*-sulfonyloxaziridines[16] were not useful either; only the starting material **25** was isolated. The reason for these failures is probably the fact that the oxidation should take place at a sterically very hindered center. For this reason we tried to use less sterically demanding oxidizing agents like molecular oxygen, which is usually used in combination with a reducing agent to reduce the primarily formed hydroperoxides.[17] However, the oxidation of the sultone anion generated from **25** and *s*BuLi with molecular oxygen at −78 °C produced the desired hydroxyketone **5** (Scheme 6) without the need for any additional reducing agent. Since it was possible to detect sulfate ions in the aqueous workup one may consider the sultone unit a reducing agent in an intra- or intermolecular redox process. The yield and the reproducibility of this reaction depended strongly on the solvent and the amount of base. A detailed investigation showed that the best solvent is a 7:1 mixture of THF and hexamethyl phosphoramide (HMPA). No other additives (for example *N,N,N′,N′*-tetramethyl 1,2-ethylenediamine (TMEDA), 1,3-dimethyl imidazolidin-2-one (DMPU), or 1,2-dimethoxyethane (DME)) influenced the yield, which was about 20% with or without these additives compared to 30 to 60% with THF/HMPA. Although the starting sultone **25** could be recovered, a further improvement was necessary because the reaction, which was first run with 3.0 equiv of *s*BuLi, was not very reproducible. The yield varied from 30 to 60%. Use of a much higher amount of base (10.0 equiv) made the reaction less sensitive and increased the yield. Now it was possible to isolate the hydroxyketone **5** absolutely reproducibly in 73% yield (Scheme 6, Table 2). A



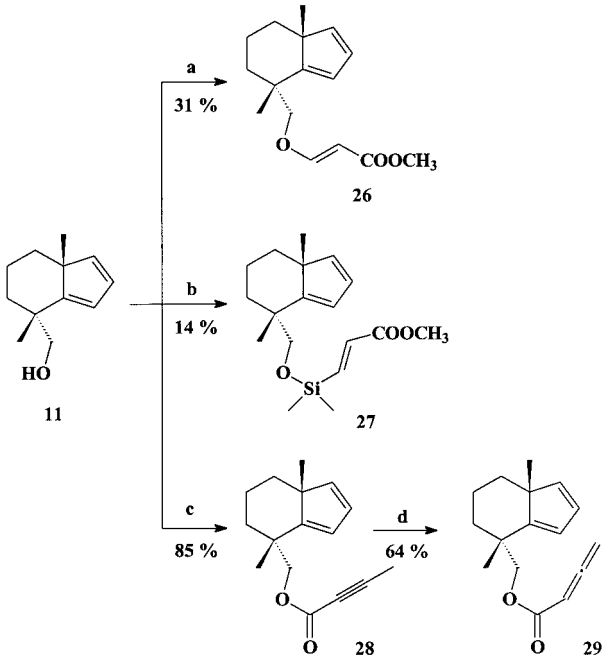
Scheme 6. Oxidative cleavage of sultone **25**. Reagents and conditions: a) *s*BuLi (equiv see Table 2), O_2, THF/HMPA 7:1, −78 °C, 3 h.

Table 2. Influence of different amounts of *s*BuLi.

Amount of *s*BuLi	Yield **5**	Recovered **25**
1.0 equiv	0%	92%
5.2 equiv	43%	36%
7.8 equiv	49%	24%
10.4 equiv	73%	12%

possible explanation for this behavior could be the formation of *sec*-butyl hydroperoxide in the reaction mixture, which can act as oxidizing agent. Experiments using *sec*-butyl hydroperoxide (formed in situ from *s*BuLi and oxygen at −78 °C followed by bubbling nitrogen through the solution to remove unconsumed oxygen) as oxidizing agent instead of molecular oxygen resulted in product formation too. Unfortunately in this case the yields were low (26%).

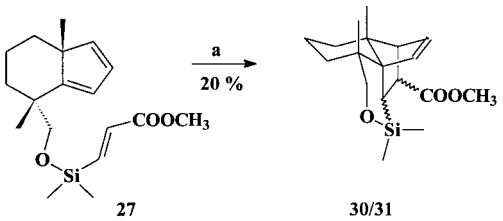
Since the outcome of the oxidative cleavage of the sultone bridge in **25** remained uncertain for quite a long period of time, we started a parallel investigation using enol ether **26**, silyl ether **27** and esters **28** and **29** as alternative intermediates for the intramolecular [4+2] cycloaddition just to keep additional options. All compounds were prepared in one or two steps from cyclopentadiene **11** (Scheme 7; yields were not optimized).



Scheme 7. Alternative starting materials for intramolecular Diels–Alder reactions. Reagents and conditions: a) $HCCCOOCH_3$ (1.2 equiv), NEt_3 (2.0 equiv), THF, 25 °C, 3.5 h; b) $ClSi(CH_3)_2-CH{=}CHCOOCH_3$ (2.0 equiv), NEt_3 (3.0 equiv), CH_2Cl_2, 25 °C, 20 h; c) $CH_3CCCOOH$ (1.2 equiv), DCCI (1.2 equiv), DMAP (1.2 equiv), CH_2Cl_2, 25 °C, 5 h; d) LDA (2.2 equiv), THF/HMPA 12:1, −78 °C, 1 h, then NH_4Cl.

Unfortunately enol ether **26** and the esters **28** and **29** did not undergo intramolecular cycloaddition at all, either under thermal (180 °C) or under Lewis acid catalyzed conditions ($ZnCl_2 \cdot Et_2O$, $BF_3 \cdot Et_2O$). Silyl ether **27** underwent cycloaddition at 180 °C over a period of 90 hours to give a 2:1 mixture of diastereomers **30** and **31**. However, owing to the harsh reaction conditions the yield was only 20%. The relative stereochemistry of **30** and **31** could not be determined reliably by NOE experiments. Nevertheless, in analogy to the cycloaddition of **23** we believe that **30** and **31** are both products resulting from α-attack of the dienophile, which differ only in the configurations at C4 and C5. Regarding the low yield of the cycloaddition, which precludes **30** and **31** as useful synthetic intermediates, no further effort was made to determine the stereochemistry at these carbon atoms (Scheme 8).

Obviously it was necessary to have four atoms in the bridge between ene and diene unit to form a six-membered ring in



Scheme 8. Intramolecular Diels–Alder reaction of **27**. Reagents and conditions: a) *o*-dichlorobenzene, 180 °C, 90 h.

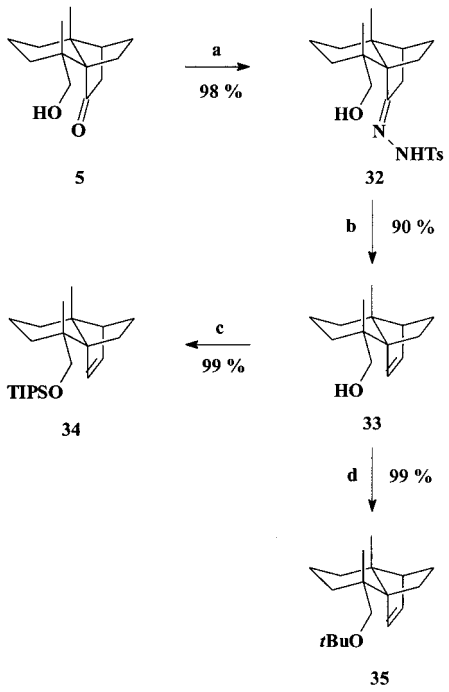
the transition state of the cycloaddition. Furthermore these four atoms had to be sp^3 centers leading to a comparatively unstrained transition state.[18] The difference in reactivity between silyl ether **27** and sulfonic ester **23** can be explained by the strong acceptor property of the SO_2 unit, which activates the olefin in **23** for Diels–Alder reactions. With these results available we decided to concentrate on the oxidative cleavage of the sultone bridge in **25**; this finally led to good results after the detailed investigation described above.

The following 1,2-carbonyl shift was approached by transformation of the hydroxyketone **5** into the olefin **33** by a Shapiro reaction with tosylhydrazone **32**. The synthesis of this hydrazone proceeded in 98% yield and produced only one isomer, probably the sterically less crowded **32**. No effort was made to determine the geometry of this product. The following Shapiro reaction was run at 75 °C in THF with 5.0 equiv of *n*BuLi as a base. The yield was 90%. When the reaction was performed at lower temperatures (−78 °C to 25 °C) no product was observed.

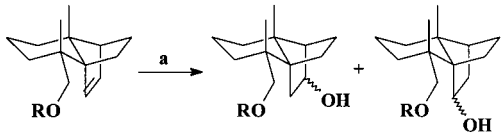
Because of its usually high regioselectivity we chose hydroboration to functionalize olefin **33**.[19] Since it was hoped that a very bulky protecting group on the primary alcohol would change it into a large and inert moiety, which should result in high selectivity for the subsequent borane attack, the hydroxyl group was silylated using triisopropyl (TIPS) triflate in the presence of triethylamine giving the silyl-ether-protected olefin **34** in 99% yield. As another bulky protecting group the *tert*-butyl group was introduced by means of isobutene in the presence of amberlite giving the *tert*-butyl ether protected olefin **35** in 99% yield (Scheme 9).

Interestingly the following hydroboration showed a surprisingly low regioselectivity. Even with the bulky TIPS or *tert*-butyl ether groups shielding one side of the double bond, the highest observed selectivity was 1.5:1 in favor of the desired product. The TIPS ether **34** showed a slightly higher selectivity than the *tert*-butyl ether **35**. In general diborane·THF delivered the best results, whereas 9-BBN and thexylborane led to no or incomplete conversion with lower selectivity (Scheme 10, Table 3). The desired alcohol **36**, a mixture of two diastereomers which were only separated for spectroscopic characterization, was isolated after chromatography in 53% yield.

Having the right functionality at the right position we were able to oxidize alcohol **36** under Swern conditions to the corresponding ketone **40** in 93% yield. The subsequent Wittig reaction proceeded in 87% yield and established the last missing carbon atom of (−)-myltaylenol. The final step, the



Scheme 9. Shapiro reaction. Reagents and conditions: a) TsN_2H_3 (1.0 equiv), TsOH (0.18 equiv), molecular sieves 3 Å, EtOH, 78 °C, 2 h; b) *n*BuLi (5.0 equiv), THF, 75 °C, 50 min; c) iPr_3SiOTf (1.1 equiv), NEt_3 (1.8 equiv), CH_2Cl_2, −78 °C; d) isobutene, amberlite 15, cyclohexane, 25 °C.



34: R=TIPS **36: R=TIPS** **38: R=TIPS**
35: R=*t*Bu **37: R=*t*Bu** **39: R=*t*Bu**

Scheme 10. Hydroboration of olefins **34** and **35**. Reagents and conditions: a) see Table 3.

Table 3. Hydroboration of olefins **34** and **35**.

R	Conditions	Yield	Ratio **36**:**38** or **37**:**39**
*t*Bu	1) BH_3·THF, THF, 0 °C, 27 h 2) EtOH, H_2O_2, NaOH, 50 °C, 3 h	70%	1.3:1.0
*t*Bu	1) thexylborane, THF, 25 °C, 28 h 2) EtOH, H_2O_2, NaOH, 78 °C, 0.5 h	82%	1.2:1.0
*t*Bu	9-BBN, Toluene, 111 °C, 48 h	no reaction	–
TIPS	1) BH_3·THF, THF, 0 °C, 27 h 2) EtOH, H_2O_2, NaOH, 50 °C, 3 h	89%	1.5:1.0
TIPS	1) thexylborane, THF, 25 °C, 48 h 2) EtOH, H_2O_2, NaOH, 78 °C, 0.5 h	traces	–
TIPS	9-BBN, THF, 25–50 °C, 7 h	no reaction	–

desilylation with tetrabutylammonium fluoride (TBAF), gave access to the target compound **1** in an overall yield of 6.5% (Scheme 11).

The comparison of all spectra of **1** with authentic spectra kindly provided by Dr. Matsuo proved **1** to be identical to the natural product. The $[\alpha]_D^{20} = -59.0°$ of synthetic **1** was exactly the same as reported by Matsuo et al.[1] NMR shift experi-

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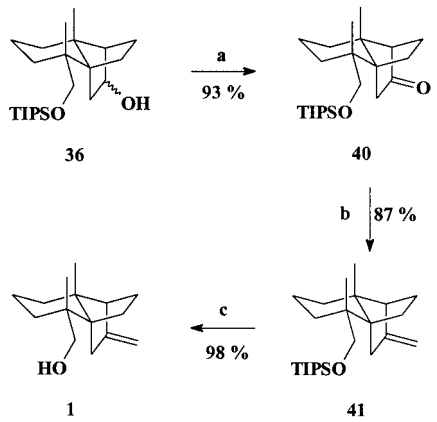

Scheme 11. Synthesis of (−)-myltaylenol (**1**). Reagents and conditions: a) $(COCl)_2$ (1.5 equiv), DMSO (3.0 equiv), CH_2Cl_2, −60 °C, 30 min, then NEt_3 (5.6 equiv), 25 °C, 10 min; b) Ph_3PCH_3Br (7.0 equiv), KO*t*Bu (5.0 equiv), benzene, 25 °C, 44 h; c) TBAF (2.0 equiv), THF, 25 °C, 18 h.

ments showed an enantiomeric purity of 94 %, which was the same as in the starting material **12**. However, the melting point of 69–70.5 °C could not be reproduced. The melting point of synthetic **1** was 64 °C.

Conclusion

In this article an enantioselective route to (−)-myltaylenol **1** is described. An intramolecular Diels–Alder reaction building up the three consecutive quartenary carbon atoms of the product is used as the key step of the synthesis. This is followed by a novel oxidative ring cleavage employing molecular oxygen and giving rise to a hydroxyketone directly. The overall yield of the synthesis is 6.5 %. The synthetic compound turned out to be identical with the natural product.

Experimental Section

General techniques: Melting points: Gallenkamp apparatus, uncorrected. MS spectra and high resolution mass spectra: Finnigan MAT 312 and VG Autospek (EI) with an ionization potential of 70 eV. IR spectra: Perkin–Elmer 580 and FT 1710. ^{1}H NMR spectra: Bruker AM 400, chemical shifts relative to Me_4Si or $CHCl_3$ (in $CDCl_3$), chemical shift signals (δ) are quoted as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broad). ^{13}C NMR spectra including DEPT: Bruker AM 400, chemical shifts relative to $CDCl_3$. UV spectra: Beckman 3600 spectrophotometer. Optical rotations were recorded with a Perkin–Elmer 241 polarimeter. All reactions were performed under an inert atmosphere of nitrogen or argon in oven- or flame-dried glassware. Dry solvents: THF, benzene, and toluene were distilled from sodium/benzophenone, methylene chloride was distilled from calcium hydride. All commercially available reagents were used without further purification unless otherwise noted. All reactions were monitored by thin-layer chromatography (TLC) carried out on Merck $^{60}F_{254}$ (silica) sheets visualized with UV light or Ce(IV)/molybdatophosphoric acid. Preparative flash chromatography was performed on Baker silica gel (particle size 30–60 μm) under positive air pressure. Yields refer to chromatographically and spectroscopically (^{1}H NMR) homogeneous materials, unless otherwise noted. PE: light petroleum, b.p. 40–60 °C. MTBE: methyl *tert*-butyl ether.

THP ether 14: A solution of KO*t*Bu (7.50 g, 66.9 mmol) in THF (60 mL) was added slowly to a solution of **12**[6] (13.51 g, 51.1 mmol) in THF (100 mL) at 0 °C. The resulting brown solution was stirred for 45 min at 0 °C and then cooled to −78 °C. A solution of freshly prepared thiophenylmethyl iodide (17.94 g, 71.3 mmol) in THF (30 mL) was added dropwise. The resulting solution was stirred at −78 °C until the starting material was consumed (30–45 min) and quenched with saturated aqueous $NaHCO_3$. The mixture was extracted with MTBE. The organic layer was washed with saturated aqueous NH_4Cl, saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. After concentration under reduced pressure, purification by flash chromatography (PE/EtOAc, 10:1) afforded **14** (16.00 g, 81 %) as a colorless oil (mixture of two diastereomers). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.39–7.33 (m, 4H; Ar), 7.30–7.23 (m, 4H; Ar), 7.19–7.12 (m, 2H; Ar), 5.50–5.46 (m, 2H; HC=C), 4.70–4.65 (m, 2H; HCO_2), 4.08 (dd, J = 9.0, 7.3 Hz, 1H; HC–O), 4.00 (dd, J = 9.0, 7.5 Hz; HC–O), 3.95–3.85 (m, 2H; H_2C–O), 3.56–3.47 (m, 2H; H_2C–O), 3.37–3.27 (m, 4H; CH_2–SPh), 2.65–2.52 (m, 4H), 2.49–2.36 (m, 3H), 2.26 (ddd, J = 15.6, 9.0, 1.6 Hz, 1H), 2.04–1.79 (m, 6H), 1.78–1.67 (m, 2H), 1.67–1.48 (m, 8H), 1.33 (s, 3H; CH_3), 1.32 (s, 3H; CH_3), 1.18 (s, 6H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): 213.4 (C_{quart}), 213.2 (C_{quart}), 151.1 (C_{quart}), 150.3 (C_{quart}), 137.6 (C_{quart}), 137.6 (C_{quart}), 130.0 (CH), 128.8 (CH), 126.2 (CH), 126.2 (CH), 122.4 (CH), 121.6 (CH), 99.9 (CH), 97.1 (CH), 86.8 (CH), 84.0 (CH), 62.7 (CH_2), 62.3 (CH_2), 52.7 (C_{quart}), 52.7 (C_{quart}), 46.4 (C_{quart}), 46.0 (C_{quart}), 43.1 (CH_2), 36.7 (CH_2), 35.9 (CH_2), 35.7 (CH_2), 34.7 (CH_2), 33.2 (CH_2), 32.6 (CH_2), 31.0 (CH_2), 28.1 (CH_3), 27.9 (CH_3), 25.5 (CH_2), 25.5 (CH_2), 19.8 (CH_2), 19.6 (CH_2), 17.7 (CH_3), 17.6 (CH_3); IR ($CHCl_3$): $\tilde{\nu}$ = 3000, 2940, 2852, 1708, 1480, 1452, 1372, 1340, 1260, 1132, 1076, 1028, 976, 868 cm^{-1}; MS (90 °C): m/z (%) = 387 (28) [M^+], 302 (33), 284 (20), 277 (23), 194 (30), 175 (33), 161 (16), 147 (21), 133(29), 123 (100), 105 (30), 85 (99); UV/Vis (CH_3CN): λ_{max} = 256, 209 nm; HRMS: calcd for $C_{23}H_{30}O_3S$ 386.1916; found 386.1917.

Thiophenylmethyl iodide: Thiophenylmethyl chloride (15.9 g, 100 mmol) was dissolved in acetone (140 mL). Dry NaI (18.7 g, 125 mmol) was added at 25 °C. The mixture was stirred in the dark at 25 °C for 2 h, diluted with ether, washed with saturated aqueous $Na_2S_2O_3$ and brine. A small amount of Cu powder was added to the organic layer while it was dried over $MgSO_4$. Evaporation of the solvent at temperatures below 30 °C afforded thiophenylmethyl iodide (25.0 g, 100 mmol) as an extremely noxious orange liquid. The product was used immediately in the alkylation reaction described above. ^{1}H NMR (80 MHz, $CDCl_3$): δ = 7.55–7.25 (m, 5H; Ar), 4.58 (s, 2H; I–CH_2–SPh).

Hydroxyketone 16: A mixture of THP ether **14** (15.30 g, 39.6 mmol) and HCl (16.0 mL, 37 % in water) in EtOH (100 mL) was stirred for 2 h at 25 °C. The solution was diluted with MTBE, washed with water (2 ×) and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 2:1) afforded hydroxyketone **16** (11.97 g, 100 %) as a colorless solid. M.p. 44 °C; $[\alpha]_D^{20} = -20.3°$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.40–7.33 (m, 2H; Ar), 7.30–7.23 (m, 2H; Ar), 7.20–7.12 (m, 1H; Ar), 5.47 (dd, J = 3.4, 1.7 Hz, 1H; HC=C), 4.08 (dd, J = 9.1, 7.5 Hz, 1H; HC–OH), 3.35 (d, J = 12.3 Hz, 1H; CH_2–SPh), 3.31 (d, J = 12.3 Hz, 1H; CH_2–SPh), 2.63–2.51 (m, 2H), 2.42 (dt, J = 16.9, 5.2 Hz, 1H), 2.31 (ddd, J = 15.3, 9.1, 1.7 Hz, 1H), 1.96–1.80 (m, 2H), 1.32 (s, 3H; CH_3), 1.16 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): δ = 213.0 (C_{quart}), 150.8 (C_{quart}), 137.5 (C_{quart}), 130.0 (CH), 128.8 (CH), 126.3 (CH), 121.9 (CH), 81.3 (CH), 52.7 (C_{quart}), 46.2 (C_{quart}), 43.1 (CH_2), 37.8 (CH_2), 35.8 (CH_2), 32.3 (CH_2), 27.9 (CH_3), 16.9 (CH_3); IR ($CHCl_3$): $\tilde{\nu}$ = 3612, 3060, 2976, 2932, 2868, 1708, 1584, 1480, 1452, 1260, 1124, 1076, 1024 cm^{-1}; MS (100 °C): m/z (%) = 302 (33) [M^+], 274 (4), 246 (4), 193 (37), 175 (28), 151 (28), 149 (28), 133 (38), 123 (100), 105 (43), 91 (39); UV/Vis (CH_3CN): λ_{max} = 253, 206 nm; HRMS: calcd for $C_{18}H_{22}O_2S$ 302.1341; found 302.1342; $C_{18}H_{22}O_2S$ (302.4): calcd C 71.49, H 7.33; found C 71.10, H 7.45.

Alcohol 17: A solution of **16** (11.63 g, 38.4 mmol), KOH (14.60 g, 260 mmol) and N_2H_4 (16.0 mL, 85 % in water, 270 mmol) in diglycol (220 mL) was heated to 100 °C for 1 h and then to 200 °C for 4 h. During this time water was removed by distillation. After cooling down to 25 °C the mixture was diluted with MTBE and washed with saturated aqueous NH_4Cl, saturated aqueous $NaHCO_3$ and brine, and dried over $MgSO_4$. After concentration under reduced pressure, purification by flash chromatography (PE/EtOAc, 5:1) afforded **17** (9.64 g, 87 %) as a colorless solid. M.p. 77 °C; $[\alpha]_D^{20} = -28.3°$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.37–7.32 (m, 2H; Ar), 7.28–7.23 (m, 2H; Ar), 7.17–7.12 (m, 1H; Ar), 5.36 (dd, J = 3.3, 1.5 Hz, 1H; HC=C), 3.90 (dd, J = 9.4, 7.5 Hz, 1H; HC–OH), 3.21 (d, J = 12.0 Hz, 1H; CH_2–SPh), 3.06 (d, J = 12.0 Hz, 1H; CH_2–SPh), 2.46 (ddd, J = 15.0, 7.5, 3.5 Hz, 1H), 2.13 (ddd, J = 15.0, 9.5, 1.7 Hz, 1H), 1.84–1.54 (m, 5H), 1.43 (dt, J = 13.5, 4.0 Hz, 1H), 1.23 (s, 3H; CH_3),

1.07 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 153.7$ (C_{quart}), 138.6 (C_{quart}), 129.1 (CH), 128.8 (CH), 125.6 (CH), 118.0 (CH), 83.7 (CH), 47.6 (CH_2), 46.8 (C_{quart}), 38.7 (CH_2), 38.4 (C_{quart}), 36.8 (CH_2), 36.7 (CH_2), 26.7 (CH_3), 18.7 (CH_2), 17.3 (CH_3); IR ($CHCl_3$): $\tilde{\nu} = 3612$, 3060, 3000, 2932, 2868, 2848, 1580, 1480, 1464, 1376, 1080, 1024 cm^{-1}; MS (70 °C): m/z (%) = 288 (48) [M^+], 179 (11), 165 (100), 146 (39), 135 (24), 121 (82), 107 (44), 93 (48); UV/Vis (CH_3CN): $\lambda_{max} = 255$, 206 nm; HRMS: calcd for $C_{18}H_{24}OS$ 288.1548; found 288.1550; $C_{18}H_{24}OS$ (288.5): calcd C 74.95, H 8.39; found C 74.84, H 8.36.

Tosylate 18: A solution of **17** (11.29 g, 39.1 mmol), 4-*N*,*N*-dimethylaminopyridine (DMAP, 9.56 g, 78.3 mmol), and *p*-toluenesulfonylchloride (11.19 g, 58.7 mmol) in CH_2Cl_2 (230 mL) was stirred at 25 °C for 16 h. The mixture was washed with citric acid (2 N), saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. After concentration under reduced pressure, purification by flash chromatography (PE/MTBE, 2:1) afforded **18** (17.21 g, 99 %) as a colorless oil. $[\alpha]_D^{20} = -23.6°$ ($c = 1.0$ in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 7.80$ (d, $J = 8.2$ Hz, 2H; Ar), 7.36 – 7.29 (m, 4H; Ar), 7.29 – 7.21 (m, 2H; Ar), 7.18 – 7.12 (m, 1H; Ar), 5.29 (t, $J = 2.5$ Hz, 1H; HC=C), 4.47 (t, $J = 8.5$ Hz, 1H; HC – O), 3.17 (d, $J = 12.1$ Hz, 1H; CH_2 – SPh), 2.98 (d, $J = 12.1$ Hz, 1H; CH_2 – SPh), 2.44 (s, 3H; CH_3), 2.33 (dd, $J = 8.5$, 2.5 Hz, 2H), 1.70 – 1.45 (m, 4H), 1.45 – 1.33 (m, 1H), 1.20 (s, 3H; CH_3), 1.12 (s, 3H; CH_3), 0.95 (m, 1H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 152.5$ (C_{quart}), 144.5 (C_{quart}), 138.3 (C_{quart}), 134.1 (C_{quart}), 129.7 (CH), 129.2 (CH), 128.8 (CH), 127.9 (CH), 125.7 (CH), 117.6 (CH), 90.1 (CH), 47.5 (CH_2) 46.9 (C_{quart}), 38.5 (C_{quart}), 38.1 (CH_2), 36.3 (CH_2), 34.0 (CH_2), 26.7 (CH_3), 21.6 (CH_3), 18.3 (CH_2), 18.1 (CH_3); IR ($CHCl_3$): $\tilde{\nu} =$ 2976, 2936, 2856, 1596, 1580, 1480, 1452, 1400, 1364, 1188, 1176, 972, 872 cm^{-1}; MS (100 °C): m/z (%) = 442 (26) [M^+], 332 (1), 317 (18), 287 (3), 270 (41), 255 (2), 240 (2), 200 (3), 172 (7), 161 (41), 147 (100), 135 (24), 123 (45), 119 (46), 105 (46), 91 (52); UV/Vis (CH_3CN): $\lambda_{max} = 256$, 224, 210 nm; HRMS: calcd for $C_{25}H_{30}O_3S_2$ 442.1636; found 442.1635.

Cyclopentadiene 19: A solution of **18** (16.52 g, 37.3 mmol) and KO*t*Bu (8.38 g, 74.6 mmol) in THF (300 mL) was heated to 65 °C for 3.5 h. The cold mixture was diluted with MTBE, washed with water and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **19** (8.29 g, 82 %) as a colorless oil. $[\alpha]_D^{20} = +83.9°$ ($c = 1.0$ in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 7.41 – 7.36$ (m, 2H; Ar), 7.30 – 7.23 (m, 2H; Ar), 7.18 – 7.12 (m, 1H; Ar), 6.25 – 6.21 (m, 2H; HC=C), 6.05 (t, $J = 1.6$ Hz, 1H; HC=C), 3.33 (d, $J = 12.0$ Hz, 1H; CH_2 – SPh), 3.20 (d, $J = 12$ Hz, 1H; CH_2 – SPh), 2.00 – 1.93 (m, 1H), 1.91 – 1.77 (m, 2H), 1.65 – 1.57 (m, 1H), 1.31 (s, 3H; CH_3), 1.18 (s, 3H; CH_3), 1.08 (dt, $J = 13.2$, 4.0 Hz, 1H), 0.89 (dt, $J = 13.3$, 3.6 Hz, 1H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 159.8$ (C_{quart}), 147.1 (CH), 138.6 (C_{quart}), 129.0 (CH), 128.8 (CH), 126.7 (CH), 125.6 (CH), 121.5 (CH), 53.9 (C_{quart}), 48.3 (CH_2), 40.1 (CH_2), 39.9 (C_{quart}), 36.6 (CH_2), 21.8 (CH_3), 20.1 (CH_3), 19.4 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3060$, 3000, 2960, 2932, 2868, 1580, 1480, 1436, 1376, 1088, 1024 cm^{-1}; MS (25 °C): m/z (%) = 270 (33) [M^+], 241 (1), 224 (1), 205 (1), 191 (2), 178 (5), 161 (22), 147 (100), 131 (29), 119 (41), 105 (39), 91 (36), 77 (31); UV/Vis (CH_3CN): $\lambda_{max} = 256$, 208 nm; HRMS: calcd for $C_{18}H_{22}S$ 270.1442; found 270.1440.

Sulfoxides 20: A solution of $NaIO_4$ (9.06 g, 42.4 mmol) in water (75 mL) was added to a solution of **19** (8.81 g, 32.6 mmol) in MeOH (450 mL) at 0 °C. The mixture was stirred at 0 °C for 30 min and at 25 °C for 16 h. The reaction was quenched by dilution with water, followed by extraction (3 ×) with MTBE. The combined organic layers were washed with water and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 2:1) afforded **20** (9.33 g, 100 %) as a colorless oil (mixture of two diastereomers). ^1H NMR (400 MHz, $CDCl_3$): $\delta = 7.72 –$ 7.65 (m, 4H; Ar), 7.58 – 7.47 (m, 6H; Ar), 6.26 – 6.22 (m, 2H; HC=C), 6.21 – 6.17 (m, 2H; HC=C), 5.88 (t, $J = 1.5$ Hz, 1H; HC=C), 5.85 (t, $J = 1.5$ Hz, 1H; HC=C), 3.28 (d, $J = 13.5$ Hz, 1H; CH_2 – SOPh), 3.12 (d, $J = 13.5$ Hz, 1H; CH_2 – SOPh), 3.04 (d, $J = 13.5$ Hz, 1H; CH_2 – SOPh), 2.97 (d, $J =$ 13.5 Hz, 1H; CH_2 – SOPh), 2.19 – 2.06 (m, 2H), 2.05 – 1.81 (m, 4H), 1.77 – 1.62 (m, 2H), 1.57 (s, 3H; CH_3), 1.51 (s, 3H; CH_3), 1.23 (s, 3H; CH_3), 1.22 (s, 3H; CH_3), 1.35 – 1.10 (m, 2H), 1.00 – 0.80 (m, 2H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 159.1$ (C_{quart}), 159.0 (C_{quart}), 147.6 (CH), 147.4 (CH), 145.9 (C_{quart}), 145.9 (C_{quart}), 130.7 (CH), 129.3 (CH), 129.3 (CH), 126.5 (CH), 126.4 (CH), 124.0 (CH), 123.9 (CH), 121.8 (CH), 121.4 (CH), 74.2 (CH_2), 74.0 (CH_2), 53.9 (C_{quart}), 53.9 (C_{quart}), 40.7 (CH_2), 40.3 (CH_2), 39.4 (C_{quart}), 39.3 (C_{quart}), 36.6 (CH_2), 36.3 (CH_2), 22.7 (CH_3), 22.2 (CH_3), 20.3 (CH_3), 20.1 (CH_3), 19.2 (CH_2), 19.1 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3064$, 3000, 2932, 2868, 1596, 1444, 1376, 1088, 1032 cm^{-1}; MS (25 °C): m/z (%) = 286 (9) [M^+], 270 (40), 234 (1), 220 (2), 200 (2), 175 (4), 161 (93), 147 (79), 131 (46), 119 (69), 105 (100), 91 (61); UV/Vis (CH_3CN): $\lambda_{max} = 253$, 208 nm; HRMS: calcd for $C_{18}H_{22}OS$ 286.1391; found 286.1392.

Acetoxy sulfides 21: A solution of **20** (9.08 g, 31.7 mmol) in acetic anhydride (200 mL) was heated to 100 °C for 62 h. Then the acetic anhydride was removed under reduced pressure. Water was added to the residue. The mixture was allowed to stand for 2 h. Then it was extracted with MTBE (3 ×). The combined organic layers were washed with water, saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 10:1) afforded **21** (9.24 g, 89 %) as a colorless oil (mixture of two diastereomers). ^1H NMR (400 MHz, $CDCl_3$): $\delta = 7.63 – 7.58$ (m, 2H; Ar), 7.56 – 7.52 (m, 2H; Ar), 7.34 – 7.26 (m, 6H; Ar), 6.39 (br s, 1H; HC(SPh)OAc), 6.35 (br s, 1H; HC(SPh)OAc), 6.27 – 6.18 (m, 6H; HC=C), 2.04 (s, 3H; CH_3), 2.01 (s, 3H; CH_3), 1.99 – 1.76 (m, 5H), 1.68 – 1.58 (m, 3H), 1.39 (s, 3H; CH_3), 1.34 (s, 3H; CH_3), 1.19 (s, 6H; CH_3), 1.10 – 0.78 (m, 4H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 170.0$ (C_{quart}), 170.0 (C_{quart}), 155.9 (C_{quart}), 155.0 (C_{quart}), 147.1 (CH), 147.1 (CH), 133.9 (C_{quart}), 133.8 (C_{quart}), 133.7 (CH), 132.8 (CH), 129.0 (CH), 129.0 (CH), 128.0 (CH), 127.9 (CH), 126.8 (CH), 123.5 (CH), 122.2 (CH), 90.8 (CH), 89.6 (CH), 54.3 (C_{quart}), 54.1 (C_{quart}), 45.4 (C_{quart}), 44.9 (C_{quart}), 38.0 (CH_2), 37.2 (CH_2), 36.8 (CH_2), 36.1 (CH_2), 27.0 (CH_3), 21.3 (CH_3), 21.0 (CH_3), 20.3 (CH_3), 19.9 (CH_3), 19.0 (CH_2), 19.0 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3064$, 3000, 2976, 2936, 2868, 2340, 1740, 1584, 1464, 1440, 1372, 1236, 1016 cm^{-1}; MS (25 °C): m/z (%) = 328 (17) [M^+], 303 (2), 268 (34), 253 (4), 219 (10), 190 (28), 181 (34), 177 (28), 159 (39), 147 (100), 131 (30), 120 (36), 105 (37), 91 (36); UV/Vis (CH_3CN): $\lambda_{max} = 254$, 215 nm; HRMS: calcd for $C_{20}H_{24}O_2S$ 328.1497; found 328.1502.

Alcohol 11: A solution of **21** (8.79 g, 26.8 mmol) and KOH (3.00 g, 53.5 mmol) in MeOH (200 mL) was stirred at 25 °C for 3 h. After cooling to 0 °C $NaBH_4$ (1.62 g, 42.8 mmol) was added and the mixture was stirred at 0 °C for 30 min. After acetone (70 mL) was added, the mixture was allowed to reach 25 °C. The solution was diluted with MTBE, extracted with water and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **11** (4.77 g, 99 %) as a colorless solid. M.p. 36 °C; $[\alpha]_D^{20} = +72.8°$ ($c = 1.0$ in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 6.23$ (d, $J = 1.8$ Hz, 1H; HC=C), 6.23 (d, $J = 1.5$ Hz, 1H; HC=C), 5.94 (br t, $J = 1.5$ Hz, 1H; HC=C), 3.68 (d, $J = 10.7$ Hz, 1H; CH_2OH), 3.62 (d, $J = 10.7$ Hz, 1H; CH_2OH), 2.00 – 1.92 (m, 1H), 1.86 (tq, $J = 13.8$, 3.5 Hz, 1H), 1.67 – 1.59 (m, 2H), 1.58 – 1.51 (m, 1H), 1.18 (s, 3H; CH_3), 1.17 (s, 3H; CH_3), 1.14 (dt, $J = 13.0$, 4.2 Hz, 1H), 0.91 (dt, $J = 13.3$, 3.7 Hz, 1H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 158.8$ (C_{quart}), 147.1 (CH), 126.8 (CH), 120.3 (CH), 72.2 (CH_2), 53.9 (C_{quart}), 40.5 (C_{quart}), 36.5 (CH_2), 36.3 (CH_2), 20.3 (CH_3), 20.2 (CH_3), 18.8 (CH_2); IR ($CHCl_3$): $\tilde{\nu} =$ 3628, 3000, 2932, 2868, 1464, 1396, 1372, 1236, 1032, 1012 cm^{-1}; MS (25 °C): m/z (%) = 178 (32) [M^+], 163 (9), 147 (100), 145 (28), 131 (30), 119 (51), 105 (46), 91 (44), 83 (17), 76 (34); UV/Vis (CH_3CN): $\lambda_{max} = 254$ nm; HRMS: calcd for $C_{12}H_{18}O$ 178.1358; found 178.1358; $C_{12}H_{18}O$ (178.1): calcd C 80.85, H 10.18; found C 80.85, H 10.09.

Vinylsulfonic ester 23: A solution of iPr_2NEt (3.87 g, 30.0 mmol) in CH_2Cl_2 (25 mL) was added to a solution of **11** (4.48 g, 25.1 mmol) and ethenesulfonyl chloride (3.98 g, 31.4 mmol) in CH_2Cl_2 (100 mL) at −15 °C over a period of 30 min. The solution was stirred at −15 °C for 1 h. The reaction was stopped by quenching with citric acid (2 N, 100 mL). The mixture was extracted with MTBE (3 ×) and the combined organic layers were washed with water, saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **23** (5.47 g, 81 %) as a colorless solid. M.p. 46 °C; $[\alpha]_D^{20} = +63.6°$ ($c = 1.0$ in $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): $\delta = 6.58$ (dd, $J = 16.6$, 9.9 Hz, 1H; HC=C), 6.45 (d, $J = 16.6$ Hz, 1H; HC=C), 6.23 (dd, $J = 5.2$, 1.5 Hz, 1H; HC=C), 6.21 (dd, $J = 5.2$, 2.0 Hz, 1H; HC=C), 6.16 (d, $J =$ 9.9 Hz, 1H; HC=C), 5.90 (br t, $J = 1.5$ Hz, 1H; HC=C), 4.21 (d, $J = 9.0$ Hz, 1H; CH_2 – O), 4.05 (d, $J = 9.0$ Hz, 1H; CH_2 – O), 2.10 – 1.94 (m, 1H), 1.91 – 1.77 (m, 1H), 1.74 – 1.59 (m, 2H), 1.25 (s, 3H; CH_3), 1.17 (s, 3H; CH_3), 1.01 (dt, $J = 13.5$, 4.5 Hz, 1H), 0.89 (dt, $J = 13.0$, 3.5 Hz, 1H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 156.2$ (C_{quart}), 147.2 (CH), 132.4 (CH), 130.2 (CH_2), 126.8 (CH), 120.9 (CH), 78.8 (CH_2), 53.8 (C_{quart}), 39.0 (C_{quart}), 36.9 (CH_2), 36.3 (CH_2), 20.0 (CH_3), 19.8 (CH_3), 18.7 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3064$, 3000, 2936, 2868, 2848, 1720, 1464, 1364, 1172, 964, 848 cm^{-1}; MS (25 °C): m/z (%) = 268 (28) [M^+], 220 (1), 207 (2), 191 (2), 177 (3), 160 (28), 147 (100), 131 (32), 119 (37), 105 (38), 91 (11); UV/Vis (CH_3CN): $\lambda_{max} =$

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254, 204 nm; HRMS: calcd for $C_{14}H_{20}O_3S$ 268.1133; found 268.1128; $C_{14}H_{20}O_3S$ (268.4): calcd C 62.66, H 7.51; found C 62.55, H 7.50.

Sultone 24: A solution of **23** (4.85 g, 18.1 mmol) in toluene (1000 mL) was heated under reflux to 111 °C for 22 h. Evaporation of the solvent afforded crude **24** (4.85 g, 100%) as a purple solid which was pure enough for the next reaction. For elemental analysis the crude product was washed with cold MTBE. Sultone **24** (4.80 g, 99%) was isolated as a colorless solid. M.p. 229 °C; $[\alpha]_D^{20} = +76.3°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta =$ 6.35 (dd, $J = 5.9$, 3.3 Hz, 1H; HC=C), 6.10 (d, $J = 5.9$ Hz, 1H; HC=C), 4.38 (d, $J = 12.0$ Hz, 1H; CH_2-O), 4.07 (dd, $J = 9.4$, 5.7 Hz, 1H; HC–SO_2), 3.85 (d, $J = 12.0$ Hz, 1H; CH_2-O), 2.57 (t, $J = 3.5$ Hz, 1H), 2.30 (ddd, $J = 12.6$, 9.5, 3.5 Hz, 1H), 2.17 (dt, $J = 14.0$, 5.7 Hz, 1H), 1.86–1.67 (m, 2H), 1.46–1.36 (m, 2H), 1.33–1.24 (m, 2H), 1.09 (s, 3H; CH_3), 0.99 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 137.7$ (CH), 130.2 (CH), 79.3 (CH_2), 61.7 (C_{quart}), 58.7 (C_{quart}), 57.2 (CH), 52.4 (CH), 34.0 (C_{quart}), 28.2 (CH_2), 28.1 (CH_2), 26.0 (CH_2), 19.2 (CH_3), 18.0 (CH_3), 17.3 (CH_2); IR ($CHCl_3$): $\tilde{\nu} =$ 3000, 2972, 2944, 2880, 1456, 1356, 1312, 1264, 1176, 968, 912, 824 cm^{-1}; MS (90 °C): m/z (%) = 268 (1) [M^+], 203 (11), 185 (4), 173 (8), 157 (13), 147 (76), 131 (70), 118 (49), 105 (100), 91 (60); HRMS: calcd for $C_{14}H_{20}O_3S$ 268.1133; found 268.1132; $C_{14}H_{20}O_3S$ (268.37): calcd C 62.66, H 7.51; found C 62.61, H 7.47.

Sultone 25: Pd/C (1.50 g, 0.15 g Pd) was added to a solution of **24** (3.85 g, 14.2 mmol) in THF (210 mL). The mixture was stirred under 1 atm of H_2 at 25 °C for 48 h. Filtration, concentration, and purification by flash chromatography (PE/Et_2O, 7:3) afforded **25** (3.80 g, 99%) as a colorless solid. Crystals acceptable for X-ray crystal structure analysis were obtained by slow evaporation of the solvent (PE/Et_2O, 7:3). M.p. 238 °C; $[\alpha]_D^{20} = +31.9°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 4.24$ (d, $J = 11.8$ Hz, 1H; CH_2-O), 4.01 (ddd, $J = 10.0$, 7.4, 2.5 Hz, 1H; HC–SO_2), 3.74 (d, $J =$ 11.8 Hz, 1H; CH_2-O), 2.65 (dddd, $J = 13.5$, 9.5, 4.0, 1.0 Hz, 1H), 2.19–2.07 (m, 2H), 1.89–1.48 (m, 7H), 1.36–1.28 (m, 2H), 1.22 (ddd, $J = 14.8$, 5.0, 2.3 Hz, 1H), 1.12 (s, 3H; CH_3), 0.97 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 78.9$ (CH_2), 57.5 (CH), 52.9 (C_{quart}), 49.0 (C_{quart}), 45.3 (CH), 36.0 (C_{quart}), 28.9 (CH_2), 28.6 (CH_2), 27.6 (CH_2), 26.3 (CH_2), 19.4 (CH_2), 18.9 (CH_3), 17.9 (CH_2), 17.1 (CH_3); IR ($CHCl_3$): $\tilde{\nu} =$ 2944, 2884, 1464, 1388, 1356, 1316, 1176, 964 cm^{-1}; MS (110 °C): m/z (%) = 270 (4) [M^+], 255 (17), 241 (3), 223 (2), 205 (17), 189 (15), 176 (25), 161 (100), 147 (68), 133 (71), 119 (55), 105 (93), 91 (99); HRMS: calcd for $C_{14}H_{22}O_3S$ 270.1290; found 270.1292; $C_{14}H_{22}O_3S$ (270.4): calcd C 62.19, H 8.20; found C 62.16, H 8.18.

Hydroxyketone 5: *s*BuLi (32 mL, 1.3 M in hexane, 44.8 mmol) was added dropwise to a solution of **25** (1.08 g, 4.0 mmol) in THF (56.0 mL) and HMPA (8.0 mL) at −78 °C. The mixture was stirred at −78 °C for 30 min. Then dry oxygen was bubbled through the solution at −78 °C for 3 h. The cooling bath was removed and after reaching 25 °C the mixture was diluted with MTBE, washed with saturated aqueous NH_4Cl (2×), saturated aqueous $NaHCO_3$ (2×), and dried over $MgSO_4$. Concentration and purification by fast flash chromatography (PE/EtOAc, 2:1) afforded **5** (649 mg, 73%) as a colorless solid. M.p. 172 °C; $[\alpha]_D^{20} = -18.2°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 3.71$ (d, $J = 11.6$ Hz, 1H; CH_2-OH), 3.57 (d, $J = 11.6$ Hz, 1H; CH_2-OH), 2.50–2.42 (m, 1H), 2.06–1.88 (m, 3H), 1.83 (d, $J = 18.5$ Hz, 1H), 1.73–1.53 (m, 3H), 1.52–1.40 (m, 1H), 1.46–1.33 (m, 2H), 1.30–1.21 (m, 2H), 1.14 (s, 3H; CH_3), 0.93 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 223.1$ (C_{quart}), 70.4 (CH_2), 64.2 (C_{quart}), 49.2 (C_{quart}), 43.3 (CH_2), 42.6 (CH), 38.4 (C_{quart}), 31.3 (CH_2), 30.7 (CH_2), 27.5 (CH_2), 22.7 (CH_2), 21.4 (CH_3), 19.8 (CH_3), 18.3 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3628$, 3396, 2996, 2944, 2872, 1720, 1452, 1384, 1236, 1068, 1024 cm^{-1}; MS (25 °C): m/z (%) = 222 (2) [M^+], 192 (100), 177 (15), 163 (86), 147 (56), 133 (9), 121 (11), 107 (28), 93 (26), 79 (23); HRMS: calcd for $C_{14}H_{22}O_2$ 222.1620; found 222.1624; $C_{14}H_{22}O_2$ (222.3): calcd C 75.63, H 9.97; found C 75.57 H 9.92.

Tosylhydrazone 32: A mixture of **5** (1.27 g, 5.71 mmol), $TsNHNH_2$ (1.08 g, 5.80 mmol), *p*-toluenesulfonic acid, molecular sieves (3 Å, 2.0 g) and EtOH (50 mL) was heated under reflux at 78 °C for 3 h. The mixture was filtered after dilution with MTBE. The resulting solution was washed with water, saturated aqueous $NaHCO_3$ (3×), and brine, and dried over $MgSO_4$. After evaporation of the solvent, the crude product was usually used in the next step without further purification. For elemental analysis purification by flash chromatography (PE/EtOAc, 2:1) afforded **32** (2.18 g, 98%) as a colorless solid. M.p. 141 °C; $[\alpha]_D^{20} = -3.8°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 7.93-7.89$ (m, 2H; Ar), 7.40–7.36 (m, 2H; Ar), 3.63 (d, $J = 12.0$ Hz, 1H; CH_2-OH), 3.49 (d, $J = 12.0$ Hz, 1H; CH_2-OH), 2.47 (s, 3H; CH_3), 2.39–2.30 (m, 1H), 1.95–1.76 (m, 4H), 1.69–1.55 (m, 1H), 1.45–1.24 (m, 4H), 1.20–1.13 (m, 1H), 1.12–0.87 (m, 2H), 1.08 (s, 3H; CH_3), 0.98 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 172.8$ (C_{quart}), 144.3 (C_{quart}), 135.3 (C_{quart}), 129.8 (CH), 127.9 (CH), 71.0 (CH_2), 59.6 (C_{quart}), 50.3 (C_{quart}), 43.6 (CH), 38.9 (C_{quart}), 33.5 (CH_2), 30.3 (CH_2), 30.1 (CH_2), 27.7 (CH_2), 25.4 (CH_2), 21.6 (CH_3), 21.2 (CH_3), 21.1 (CH_3), 18.3 (CH_2); IR ($CHCl_3$): $\tilde{\nu} = 3292$, 3216, 2948, 2868, 1656, 1596, 1388, 1340, 1164, 1092, 1072 cm^{-1}; MS (180 °C): m/z (%) = 390 (1) [M^+], 361 (10), 331 (4), 235 (17), 220 (32), 205 (76), 190 (8), 175 (47), 161 (15), 147 (25), 133 (26), 119 (29), 105 (48), 91 (100); HRMS: calcd for $C_{21}H_{30}N_2O_3S$ 390.1977; found 390.1994; $C_{21}H_{30}N_2O_3S$ (390.5): calcd C 64.58, H 7.74; found C 64.50, H 7.72.

Olefin 33: *n*BuLi (15.6 mL, 1.6 M in hexane, 25 mmol) was added to a solution of **32** (2.00 g, 5.12 mmol) in THF (150 mL) at 25 °C. The solution was immediately heated up to 75 °C and stirred continually at this temperature for 50 min. After cooling of the solution to 30 °C, saturated aqueous NH_4Cl (20 mL) was added. The mixture was diluted with MTBE, washed with saturated aqueous NH_4Cl and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **33** (950 mg, 90%) as a colorless solid. M.p. 72 °C; $[\alpha]_D^{20} = +2.6°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 5.97$ (d, $J = 5.9$ Hz, 1H; HC=CH), 5.87 (1H, dd, $J = 5.9$, 3.1 Hz, HC=CH), 3.67 (d, $J = 10.8$ Hz, 1H; CH_2-OH), 3.44 (d, $J = 10.8$ Hz, 1H; CH_2-OH), 2.23 (br t, $J = 3.0$ Hz, 1H), 1.91–1.75 (m, 3H), 1.54 (tq, $J = 13.5$, 4.0 Hz, 1H), 1.46–1.39 (m, 1H), 1.34–1.28 (m, 1H), 1.22 (dt, $J = 13.3$, 4.2 Hz, 1H), 1.04 (s, 3H; CH_3), 1.20–0.89 (m, 3H), 0.95 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta =$ 136.0 (CH), 133.8 (CH), 72.4 (CH), 57.9 (C_{quart}), 56.9 (C_{quart}), 52.7 (CH), 37.8 (C_{quart}), 33.1 (CH_2), 29.5 (CH_2), 25.4 (CH_2), 24.0 (CH_2), 21.1 (CH_3), 18.4 (CH_2), 17.0 (CH_3); IR ($CHCl_3$): $\tilde{\nu} = 3628$, 3064, 2956, 2868, 1448, 1368, 1206, 1172, 1060, 1024, 924 cm^{-1}; MS (25 °C): m/z (%) = 206 (3) [M^+], 188 (1), 175 (13), 159 (3), 147 (100), 131 (9), 119 (19), 105 (27), 91 (25); HRMS: calcd for $C_{14}H_{22}O$ 206.1671; found 206.1662; $C_{14}H_{22}O$ (206.3): calcd C 81.50, H 10.75; found C 81.55, H 10.54.

TIPS ether 34: *i*Pr_3OTf (919 mg, 3.00 mmol) was added to a solution of **33** (582 mg, 2.82 mmol) and NEt_3 (508 mg, 5.02 mmol) in CH_2Cl_2 (10 mL) at −78 °C. The mixture was stirred at −78 °C for 3 h. The reaction was quenched by dilution with MTBE and washing with citric acid (2 N), saturated aqueous $NaHCO_3$ and brine. After drying the organic layer over $MgSO_4$, concentration and purification by flash chromatography (PE) afforded **34** (1.01 g, 99%) as a colorless oil. $[\alpha]_D^{20} = -5.8°$ ($c = 1.0$ in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 6.00$ (d, $J = 5.9$ Hz, 1H; HC=CH), 5.83 (dd, $J = 5.9$, 3.1 Hz, 1H; HC=CH), 3.67 (d, $J = 9.4$ Hz, 1H; CH_2-O), 3.46 (d, $J = 9.4$ Hz, 1H; CH_2-O), 2.19 (br t, $J = 3.0$ Hz, 1H), 1.87–1.71 (m, 3H), 1.53 (tq, $J = 13.6$, 3.8 Hz, 1H), 1.44–1.35 (m, 1H), 1.34–1.15 (m, 2H), 1.15–1.04 (m, 24H), 1.01 (s, 3H; CH_3), 0.93 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): $\delta = 136.7$ (CH), 133.3 (CH), 72.4 (CH_2), 58.1 (C_{quart}), 56.8 (C_{quart}), 52.9 (CH), 38.3 (C_{quart}), 33.4 (CH_2), 29.7 (CH_2), 25.4 (CH_2), 24.0 (CH_2), 21.2 (CH_3), 18.6 (CH_2), 18.2 (CH_3), 18.1 (CH_3), 17.5 (CH_3), 12.0 (CH); IR ($CHCl_3$): $\tilde{\nu} = 3060$, 2944, 2864, 1460, 1380, 1112, 1088, 1012, 996 cm^{-1}; MS (25 °C): m/z (%) = 363 (2) [M^+], 334 (4), 319 (76), 291 (9), 277 (12), 249 (4), 237 (5), 223 (7), 209 (5), 187 (16), 171 (15), 159 (10), 145 (26), 131 (100), 117 (10), 103 (43), 91 (21); HRMS: calcd for $C_{23}H_{42}OSi$ 362.3005; found 362.2994.

Alcohols 36: $BH_3 \cdot$THF (1.0 mL, 1.0 M in THF, 1.0 mmol) was added dropwise to a solution of **34** (60 mg, 0.17 mmol) in THF (4.0 mL) at 0 °C. The resulting solution was stirred at 0 °C for 27 h. After complete conversion, EtOH (3.0 mL) was added and the cooling bath was removed. At 25 °C, aqueous NaOH (3.0 mL, 3 M) was added and the mixture was stirred for 15 min at the same temperature. Then the flask was cooled again to 0 °C and H_2O_2 (8.0 mL, 35% in H_2O) was added slowly. Now the mixture was stirred at 0 °C for 10 min, at 25 °C for 1.5 h and at 60–70 °C for 1 h. After cooling, the mixture was diluted with MTBE and washed with water (3×), saturated aqueous NaS_2O_3, saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **36** (34 mg, 53%) as a colorless oil (mixture of two diastereomers, which could be separated for spectroscopic characterization by flash chromatography (PE/EtOAc, 10:1)). Major diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 3.78$ (dd, $J = 8.2$, 3.0 Hz, 1H; CH–OH), 3.47 (d, $J = 9.5$ Hz, 1H; CH_2-O), 3.22 (d, $J = 9.5$ Hz, 1H; CH_2-O), 2.28 (ddd, $J = 13.0$, 13.0, 4.2 Hz, 1H), 2.08–1.93 (m, 1H), 1.84–0.85 (m, 14H), 1.06 (s, 21H), 1.00 (s, 3H); IR ($CHCl_3$): $\tilde{\nu} = 3612$, 2944, 2864,

1464, 1380, 1244, 1188, 1112, 1092, 1068, 1024, 880 cm^{-1}; MS (50 °C): *m*/*z* (%) = 380 (3) [M^+], 337 (27), 319 (8), 292 (2), 263 (1), 189 (46), 175 (11), 161 (16), 149 (100), 131 (48), 119 (92), 109 (26), 95 (39); HRMS: calcd for $C_{23}H_{44}O_2Si$ 380.3111; found 380.3109. Minor diastereomer: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.47 – 4.34 (m, 1H; CH – OH), 3.42 (d, *J* = 9.0 Hz, 1H; CH_2 – O), 3.20 (d, *J* = 9.0 Hz, 1H; CH_2 – O), 2.46 (ddd, *J* = 13.8, 10.4, 3.8 Hz, 1H), 2.01 – 0.85 (m, 12H), 1.05 (s, 24H), 1.01 (s, 3H); IR ($CHCl_3$): $\tilde{\nu}$ = 3612, 2944, 2864, 1464, 1380, 1240, 1096, 1072, 1016, 880 cm^{-1}; MS (110 °C): *m*/*z* (%) = 379 (1) [$M^+ - 1$], 337 (100) [$M^+ - i$Pr], 318 (3), 293 (2), 239 (8), 225 (3), 199 (3), 189 (30), 175 (11), 161 (13), 148 (74), 131 (86), 119 (92), 109 (53), 95 (71), 81 (48); HRMS: calcd for $C_{20}H_{37}O_2Si$ ($M^+ - i$Pr) 337.2563; found 337.2561.

Ketone 40: DMSO (181 mg, 2.32 mmol) was added to a solution of $(COCl)_2$ (147 mg, 1.16 mmol) in CH_2Cl_2 (5.0 mL) at – 60 °C. The mixture was stirred at the same temperature for 20 min. Then a solution of **36** (294 mg, 0.77 mmol) in CH_2Cl_2 (2.0 mL) was added at – 60 °C. Stirring was continued at – 60 °C for 30 min before Et_3N (0.6 mL, 4.3 mmol) was added at the same temperature. After 15 min at – 60 °C the cooling bath was removed. At 25 °C water (3.0 mL) was added and 10 min later MTBE. The layers were separated and the organic layer was washed twice with citric acid (2N), with saturated aqueous $NaHCO_3$, and with brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 10:1) afforded **40** (272 mg, 93%) as a colorless solid. M.p. 43 °C; $[\alpha]_D^{20}$ = + 8.6° (*c* = 0.67 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.43 (d, *J* = 9.4 Hz, 1H; CH_2 – O), 3.32 (d, *J* = 9.4 Hz, 1H; CH_2 – O), 2.49 (dd, *J* = 18.4, 3.2 Hz, 1H), 2.10 – 1.93 (m, 3H), 1.83 (d, *J* = 18.4 Hz, 1H), 1.80 – 1.53 (m, 3H), 1.52 – 1.19 (m, 5H), 1.11 (s, 3H; CH_3), 1.09 (s, 3H; CH_3), 1.07 – 1.03 (m, 21H); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): δ = 217.2 (C_{quart}), 72.6 (CH_2), 61.5 (CH), 51.3 (C_{quart}), 47.1 (C_{quart}), 45,7 (CH_2), 39.1 (C_{quart}), 30.8 (CH_2), 30.4 (CH_2), 28.4 (CH_2), 22.9 (CH_2), 18.8 (CH_3), 18.3 (CH_3), 18.1 (CH_3), 18.1 (CH_3), 18.1 (CH_2), 11.9 (CH); IR ($CHCl_3$): $\tilde{\nu}$ = 2944, 2892, 2864, 1736, 1464, 1380, 1196, 1000, 1044, 880, 816 cm^{-1}; MS (70 °C): *m*/*z* (%) = 378 (5) [M^+], 335 (100), 306 (2), 291 (2), 279 (2), 265 (2), 227 (3), 213 (13), 201 (3), 187 (47), 173 (5), 159 (8), 145 (28), 131 (26), 119 (11), 103 (27); HRMS: calcd for $C_{23}H_{42}O_2Si$ 378.2954; found 378.2957; $C_{23}H_{42}O_2Si$ (378.7): calcd C 72.95, H 11.18; found C 72.96, H 11.04.

Olefin 41: A solution of **40** (221 mg, 0.58 mmol), Ph_3PCH_3Br (1.45 g, 4.06 mmol) and KO*t*Bu (328 mg, 2.92 mmol) in benzene (10 mL) was stirred at 25 °C for 44 h. After dilution with MTBE the mixture was washed with citric acid (2N), saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE) afforded **41** (191 mg, 87%) as a colorless oil. $[\alpha]_D^{20}$ = – 25.4° (*c* = 1.1 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.72 (dd, *J* = 3.7, 2.3 Hz, 1H; H_2C=C), 4.53 (dd, *J* = 3.7, 1.8 Hz, 1H; H_2C=C), 3.46 (d, *J* = 9.3 Hz, 1H; CH_2 – O), 3.23 (d, *J* = 9.3 Hz, 1H; CH_2 – O), 2.58 – 2.50 (m, 1H), 2.05 (d, *J* = 4.2 Hz, 1H), 1.98 – 1.77 (m, 3H), 1.72 – 1.58 (m, 1H), 1.55 – 1.45 (m, 1H), 1.45 – 1.16 (m, 6H), 1.07 (s, 21H), 1.06 (s, 3H; CH_3), 1.02 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): δ = 154.8 (C_{quart}), 101.3 (CH_2), 72.4 (CH_2), 57.0 (CH), 51.3 (C_{quart}), 47.4 (C_{quart}), 39.6 (CH_2), 39.1 ($C_{quart.}$), 31.0 (CH_2), 30.0 (CH_2), 29.3 (CH_2), 28.0 (CH_2), 19.3 (CH_3), 18.4 (CH_2), 18.1 (CH_3), 18.1 (CH_3), 17.9 (CH_3), 11.9 (CH); IR ($CHCl_3$): $\tilde{\nu}$ = 2994, 2864, 1660, 1616, 1608, 1464, 1380, 1096, 1012, 996, 880 cm^{-1}; MS (70 °C): *m*/*z* (%) = 376 (10) [M^+], 347 (10), 332 (100), 304 (10), 289 (9), 240 (10), 201 (16), 189 (11), 175 (9), 161 (13), 145 (21), 131 (82), 119 (22), 103 (53), 91 (23); HRMS: calcd for $C_{24}H_{44}OSi$ 376.3161; found 376.3163.

(–)-Myltaylenol (1): A solution of **41** (120 mg, 0.32 mmol) and TBAF (201 mg, 0.64 mmol) in THF (6.0 mL) was stirred at 25 °C for 18 h. MTBE was added and the mixture was washed with water, saturated aqueous $NaHCO_3$, and brine, and dried over $MgSO_4$. Concentration and purification by flash chromatography (PE/EtOAc, 5:1) afforded **1** (69 mg, 98%) as a colorless solid. M.p. 64 °C; $[\alpha]_D^{20}$ = – 59.0° (*c* = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.75 – 4.72 (m, 1H; H_2C=C), 4.56 – 4.53 (m, 1H; H_2C=C), 3.45 (d, *J* = 10.7 Hz, 1H; CH_2 – OH), 3.23 (d, *J* = 10.7 Hz, 1H; CH_2 – OH), 2.59 – 2.51 (m, 1H), 2.08 (d, *J* = 4.2 Hz, 1H), 2.02 – 1.92 (m, 1H), 1.90 – 1.78 (m, 2H), 1.74 – 1.59 (m, 1H), 1.56 – 1.48 (m, 1H), 1.44 – 1.18 (m, 7H), 1.06 (s, 3H; CH_3), 1.02 (s, 3H; CH_3); ^{13}C NMR (100.6 MHz, DEPT, $CDCl_3$): δ = 154.1 (C_{quart}), 101.7 (CH_2), 72.3 (CH_2), 56.8 (CH), 51.1 (C_{quart}), 47.4 (C_{quart}), 39.5 (CH_2), 38.6 (C_{quart}), 30.8 (CH_2), 29.9 (CH_2), 29.2 (CH_2), 27.9 (CH_2), 19.2 (CH_3), 18.2 (CH_2), 17.4 (CH_3); IR ($CHCl_3$): $\tilde{\nu}$ = 3628, 3068, 2956, 2932, 2872, 1772, 1660, 1468, 1380, 1340, 1296, 1236, 1164, 1060, 1028, 992, 876 cm^{-1}; MS (25 °C): *m*/*z* (%) = 220 (15) [M^+], 205 (4), 189 (56), 174 (10), 165 (66), 152 (27), 147 (27), 133 (40), 119 (57), 107 (68), 93 (94), 86 (15); HRMS: calcd for $C_{15}H_{24}O$ 220.1827; found 220.1826; $C_{15}H_{24}O$ (220.4): calcd C 81.76, H 10.98; found C 81.60, H 10.86.

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